1966 ELECTRONIC EXPERIMENTER'S HANDBOOK

SPRING EDITION

$1.25

100% CONSTRUCTION PROJECT ISSUE

AUDIO & HI-FI
RADIO CONTROL
HAM RADIO
TEST EQUIPMENT
AUTOMOTIVE
HOUSEHOLD GADGETS
GAMES
PHOTOGRAPHY

BUILD ELECTRONIC FLASH
(uses either house current or batteries)
BETTER THAN EVER!
Mail the Card Today for Your FREE Catalog
No Money Down • Easy Pay Terms

1966
CATALOG NO. 660

Live Better Electronically With
LAFAyETTE
RADIO ELECTRONICS

Over 500 Pages FREE!

- TV Tubes and Parts
- Electronic Parts
- Test Equipment
- Citizens Band
- Tools
- Ham Gear
- Stereo Hi-Fi
- Tape Recorders
- Walkie-Talkies
- Auto Accessories

Featuring Everything in Electronics for
• HOME • INDUSTRY • LABORATORY

from the
"World's Hi-Fi & Electronics Center"

LAFAyETTE Radio ELECTRONICS
Dept. EHB-6, P.O. Box 10
Syosset, L.I., N.Y. 11791

Name ____________________________
Address __________________________
City __________________ State _______
Zip ______________________________
(Please Give Your Zip Code No.)

Send FREE Lafayette Catalog

CIRCLE NO. 12 ON READER SERVICE CARD

111 Jericho Turnpike
Syosset, Long Island, New York

OTHER LOCATIONS

NEW YORK—45th ST.
71 West 45 St.
BROOKLYN, NEW YORK
2255 Bedford Avenue
NEW YORK, NEW YORK
17 Union Square W.
(cor. 15 St.)
JAMAICA, NEW YORK
165-08 Liberty Avenue
SCARSDALE, NEW YORK
691 Central Avenue
BRONX, NEW YORK
542 E. Fordham Road

MT. RAINIER/HYATTSVILLE, MD.
3131 Queens Chapel Road
NEWARK, NEW JERSEY
24 Central Avenue
PLAINFIELD, NEW JERSEY
135 West 2 Street
PARAMUS, NEW JERSEY
182 Route 17
BOSTON, MASS.
584 Commonwealth Avenue
NATICK, MASS.
1400 Worcester Street
Your ticket to a high-pay job in electronics

AN FCC LICENSE issued by the UNITED STATES GOVERNMENT

These men will tell you how to get it!

Matt Stuczynski, Senior Transmitter Operator, Radio Station WBOE.

"The Commercial FCC License is a 'must' for a career in broadcasting. I took CIE's Home Study Electronics Course and, thanks to their 'Auto-Programmed' teaching method, passed the 1st Class FCC License Exam on my first try! I now have a good job in studio operation, transmitting, proof of performance, equipment servicing."

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

"My Cleveland Institute Course enabled me to pass both the 2nd and 1st Class License Exams on my first attempt... even though I'd had no other electronics training. I'm now in charge of Division Communications and we service 119 mobile units and six base stations. It's an interesting, challenging and extremely rewarding job."

Glenn Horning, Local Equipment Supervisor, Western Reserve Telephone Company.

"I owe my 2nd Class FCC License to Cleveland Institute. Their FCC License Program really teaches you theory and fundamentals... is particularly strong on transistors, mobile radio, troubleshooting and math. Our Company has 10 other men enrolled with CIE and it's going to help every one of them just like it helped me."

How about you? If lack of an FCC License is holding you back, it's time you looked into Cleveland Institute of Electronics Home Study. All you have to do is send us the coupon... and in a few days, you'll have the complete story. And remember... Cleveland Institute backs their programs with this exclusive, money-back warranty: "A CIE License Course will quickly prepare you for a Commercial FCC License exam. If you complete the course but fail to pass the exam on your first attempt, CIE will refund all tuition."

Get started now. Send coupon for free booklet "How To Get an FCC License." There's no obligation.

Cleveland Institute of Electronics

1776 E. 17th St., Dept. EH-2 • Cleveland, Ohio 44114

Yes! I want to know how to get a Commercial FCC License. Please send me your FREE booklet... without obligation.

My Occupation is... Age...

Address... County...

City... State... Zip...

A leader in Electronics Training... since 1934

1966 Spring Edition
LIGHT UP THE NIGHT
With RCA's EXPERIMENTER'S KIT

Build Your Own Light-Operated Switch
for Dozens of Applications Around the House

Just let your imagination soar—and you'll trigger your own application ideas for any of the 14 control circuits you can build with only three RCA Experimenter's Kits. For instance, you can build a light-operated switch for a garage light, a yard or path light, or even an advertising sign that can be activated with lights from an approaching automobile! You can also build a model race car speed control, an electronic heat control and other interesting circuits with hundreds of applications. All these circuits with easy-to-follow directions are described in the RCA Experimenter's Manual, KM-70, available from your RCA Semiconductor Distributor.

HERE IS WHAT YOU NEED...
- RCA Basic Experimenter's Kit (KD2105). Containing one silicon controlled-rectifier; two transistors; five rectifiers.
- RCA Experimenter's Manual (KM-70). 80 pages profusely illustrated; 14 circuits—how they operate and how to build them.
- RCA Add-On Heat Sensor Kit (KD2110). Containing three thermistors for different temperature ranges; special solder for heat control circuits.
- Readily available passive components and hardware.

HERE IS WHAT YOU CAN MAKE...

If you want to build one circuit or all 14, check with your RCA Distributor where kits and RCA Experimenter's Manual are on display. He'll be glad to help you select the kit or kits for the solid-state circuit you have in mind. Do it today!

AVAILABLE FROM YOUR RCA SEMICONDUCTOR DISTRIBUTOR
RCA Electronic Components and Devices, Harrison, N. J.

CIRCLE NO. 19 ON READER SERVICE CARD
ELECTRONIC EXPERIMENTER'S HANDBOOK
If you have read the past 10 issues of the ELECTRONIC EXPERIMENTER'S HANDBOOK, you will be aware of two significant things. First, the phenomenal interest in electronics continues unabated and two editions of the HANDBOOK are being published each year. Secondly, at the request of our avid readers, this edition has been devoted solely to construction projects—34 of them. Each project has been carefully checked by the author, and in most instances the project itself tested by the staff of the HANDBOOK. At a rate of $3.50 per copy, this Spring Edition is one of the best bargains you can find in electronics magazines or handbooks.

Due to the season of the year, our Science Fair chapter has been replaced in this edition by a chapter on Radio Control. Several Science Fair projects are now scheduled for the Fall Edition that will go on sale in October 1966.

The cover of this edition features a universally powered electronic flash. This flash has been designed to incorporate as many safety features as possible. The circuit is straightforward, and it is expected that many readers will study this flash to gain some idea of how electronic flash guns operate. Your Editors were impressed by the performance of this flash and believe that nothing like it has ever appeared in print before.

—THE EDITORS
When you want QUALITY 2-way radio—check Johnson first!

Look to Johnson for the most versatile, most reliable 2-way radio equipment available today! For personal or business use, choose from a broad CB equipment line…compact, hand-held Personal Messengers; portable field packs; and popular-priced tube-type or all solid-state transceivers for base station or mobile applications. For demanding business applications, Johnson's Business/Industrial 2-way radio line offers a true systems approach for communications in depth!

Check Johnson First! Put a "Messenger" to work for you!
CONTENTS

1 USEFUL HOUSEHOLD PROJECTS


2 AUDIO STEREO HI-FI PROJECTS

55 Transistor FM Multiplexer—Mr. Thuras' Magic Box—Slim Twosome—Bargain Page Amplifier—Stereo Bal

3 RADIO CONTROL PROJECTS

79 Miniature R/Ceiver—R/C Transmitter

4 COMMUNICATIONS SWL CB HAM


5 TEST EQUIPMENT PROJECTS


ELECTRONICS MARKET PLACE

Copyright 1966 by Ziff-Davis Publishing Company. All rights reserved.
AOC Multivibrators are free running sawtooth oscillators designed to lock on a stabilized signal source for division of 10.

Multivibrator units may be obtained in a number of combinations or single units. Each multivibrator has isolation amplifier to stabilize lock. Complete series allows 1,000 kc crystal to produce a 1 cycle per second pulse. Both 1,000 kc and 100 kc crystal oscillator units are available.

Crystal oscillators AOM-100X and AOM-1000X provide a stabilized signal source to drive the multivibrator chain. Each oscillator has regulator tube and crystal oven to insure maximum stability. Short term stability, 1 part in 10^6.

<table>
<thead>
<tr>
<th>UNIT</th>
<th>DESCRIPTION</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOM-101</td>
<td>100 kc</td>
<td>$19.95</td>
</tr>
<tr>
<td>AOM-102</td>
<td>10 kc</td>
<td>19.95</td>
</tr>
<tr>
<td>AOM-103</td>
<td>1 kc</td>
<td>19.95</td>
</tr>
<tr>
<td>AOM-104</td>
<td>100 cps</td>
<td>19.95</td>
</tr>
<tr>
<td>AOM-105</td>
<td>10 cps</td>
<td>19.95</td>
</tr>
<tr>
<td>AOM-106</td>
<td>1 cps</td>
<td>19.95</td>
</tr>
<tr>
<td>AOM-201</td>
<td>100 kc and 10 kc</td>
<td>35.00</td>
</tr>
<tr>
<td>AOM-202</td>
<td>10 kc and 1 kc</td>
<td>35.00</td>
</tr>
<tr>
<td>AOM-301</td>
<td>100 cps, 10 cps, 1 cps</td>
<td>49.50</td>
</tr>
<tr>
<td>AOM-100X</td>
<td>100 kc oscillator</td>
<td>32.50</td>
</tr>
<tr>
<td>AOM-1000X</td>
<td>1,000 kc oscillator</td>
<td>32.50</td>
</tr>
</tbody>
</table>

Shipping weight: 5 lbs. each
In this Spring 1966 Edition of the ELECTRONIC EXPERIMENTER'S HANDBOOK, a 3-part emphasis has been placed on "Household" projects. Two of the projects are strictly photographic—including one of the few published stories on the home construction of an electronic flash. This particular story was especially prepared for the Spring '66 EEH, and nothing like it has appeared in print before. The second photographic story concerns a very capable strobe or electronic flash slave unit.

Automotive electronics takes up a sizable share of this chapter with projects like the POPULAR ELECTRONICS capacitive discharge ignition system (page 19); a simple dwell meter (page 36); a novel engine idle calibrator (page 39); and a 12-volt d.c.-operated fluorescent lamp (page 16).

There are a number of distinctive home projects, and your family will be impressed by the electronic "versatility" of the "Lighting Controller" (page 41) or the "Dymwatt" (page 50). Just for fun and games, investigate the "Coin Tosser" (page 46). Last, but not least, is the "Fence Charger," a project frequently requested by the thousands of EEH readers.

8  ELECTRONIC FLASH ................................................ Charles Caringella
16  D.C.-OPERATED FLUORESCENT LIGHT ............ Ben Richards
19  TRANSISTORIZED CAPACITOR DISCHARGE IGNITION SYSTEM ........... Murray Gellman
25  WIRELESS RE-BROADCASTER ............... Ken Dobler
29  ELECTRIC FENCE CHARGER ....................... Lyman E. Greenlee
36  SIMPLE DWELL METER .......................... T. C. Penn
39  TACHOMETER AND ENGINE IDLE SPEED CALIBRATOR ................ James S. Shreve
41  SELF-REGULATING LIGHTING CONTROLLER ....... Edward P. Nawracaj and Fred Forman
43  STROBELIGHT SLAVE ....................... W. F. Gephart
46  ELECTRONIC COIN TOSER ...................... Woodrow Pope
50  THE DYMWATT .................................. Don Lancaster
The electronic flash, or speedlight, is a basic necessity for the serious-minded amateur and professional photographer. If you have an interest in photography—as well as electronics—you will find this construction project of considerable interest.

Very few build-it-yourself articles on electronic flash units have appeared in print. There have been two reasons for this absence of construction projects: (1) the performance of a unit was not commensurate with the building cost, and (2) the unit was unsafe. The project described below easily overpowers both of these objections. Its performance is equal to that of professional speedlights costing more money; and if the builder carefully follows the construction and wiring instructions, this unit is as safe as any flash now sold in a photography store.

How the Circuit Works. The schematic diagram of the shoulder pack is shown in Fig. 1. Basically, the circuit consists of an a.c./d.c. power supply that charges a photoflash storage capacitor.

A special feature of the main power transformer, T2, is dual primary windings: one for a.c. and the other for d.c. operation. The a.c. winding is connected to the 117-volt a.c. line when power
ELECTRONIC FLASH

Universally powered photoflash can be constructed from these carefully engineered detailed plans.

Switch S1 is in the "AG" position. A second transformer, T1, operates in conjunction with the center-tapped winding of T2, as part of a simple d.c.-to-d.c. converter. Transistors Q1 and Q2 serve as the converter's switching transistors. While T1 provides the necessary feedback for oscillator action. A 6-volt battery, B1, powers the d.c.-d.c. converter section and is switched into the circuit when switch S1 is in the "DC" position.

High-voltage a.c. appears across the secondary of T2 when S1 is in either the "AC" or "DC" position. Neon glow lamp I1 indicates the presence of high voltage across the secondary. This lamp serves a dual purpose. It not only indicates the presence of high voltage, but it indirectly indicates the condition of battery B1. The lamp glow diminishes as the batteries get weaker.

Fig. 1. The shoulder pack is the power supply for the electronic flash. A transistorized d.c. to d.c. converter boosts the battery voltage to the value necessary to charge flash capacitor C2. On house current the pack operates like a simple voltage doubler circuit.

Fig. 2. This is the circuit of the flash head. Operation of all the components in these two diagrams is explained in text.
The secondary output voltage of $T_2$ is about 200 volts a.c. Diodes $D_1$ and $D_2$, along with capacitors $C_1$ and $C_2$, form a voltage doubler network, which rectifies and doubles the secondary output voltage. Photoflash capacitor $C_2$ charges to almost 450 volts d.c. The energy stored in $C_2$ is used to flash the flash-tube.

One of the connections from the secondary of $T_2$ (pin 6) is routed through the power jack, $J_2$, and back to the input of the voltage doubler network. A jumper wire, located between pins 1 and 3 of $P_1$, completes the circuit when $P_1$ is plugged into $J_2$. This arrangement serves as a safety interlock to keep $C_2$ from being charged when $P_1$ is disconnected.

A schematic diagram of the flash head is given in Fig. 2. When $C_2$ is charged, the full d.c. voltage appears across the flash-tube. The flash-tube, however, is designed not to flash (due to its "hold-off" voltage rating) until a high-voltage pulse is applied to the trigger electrode. The high-voltage pulse is derived from $C_4$ and $T_3$. Capacitor $C_4$ is charged through the divider network consisting of $R_3$, $R_4$, and $R_5$. One side of $C_4$ is also connected to the camera shutter contacts via $J_3$. When the shutter contacts close, $C_4$ is discharged and the pulse is stepped up by $T_3$ to a peak value of approximately 6000 volts.

The 6000-volt pulse is applied to the trigger electrode of the flash-tube. Once the pulse is applied, the gas within the flash-tube is immediately ionized, making it highly conductive. The photoflash capacitor, $C_2$, then discharges all of its energy into the flash-tube, causing the brilliant flash of light.

**PARTS LIST**

| B1 | Four D-size batteries—see text |
| C1 | 4-pf., 450-volt electrolytic capacitor |
| C2 | 32-pf., 450-volt electrolytic capacitor (Corwell-Dubilier FWSX-10001 or Acrovex FF-2)* |
| C3 | 0.05-pf., 400-volt paper capacitor |
| C4 | 0.25-pf., 400-volt capacitor |
| D1, D2 | TX-547 rectifiers |
| P1 | 1-ampere fuse, type 3AG |
| J1, J2 | NE-51 neon lamp |
| J3 | Chassis-mounting a.c. male receptacle, with recessed shell (Amphenol 61-M10 or equivalent) |
| J4, J5, J6 | Four-contact, chassis-mounting socket (Cinch-Jones S-304 or equivalent) |
| T1 | Rectangular chassis-mounting a.c. female socket (Cinch-Jones SR2 or equivalent) |
| T2 | Tip jack (one red, one black) |
| P1 | Four-contact plug with cable clamp (Cinch-Jones P-304 or equivalent) |
| P2, P3 | Phone tip plug |
| Q1, Q2 | Germanium power transistor (Texas Instruments 213029 or equivalent)* |
| R1 | 220-ohm, 1-watt resistor |
| R2 | 100,000-ohm, 1/2-watt resistor |
| R3 | 1.5-megohm, 1/2-watt resistor |
| R4, R5 | 3.3-megohm, 1/2-watt resistor |
| S1 | Double-pole, 3-position, single-section miniature phenolic rotary switch (Centralab PA-1003 or equivalent) |
| S2 | Miniature normally-open push-button switch (Grabill 23-1 or equivalent) |
| T1 | Inverter transformer (UTC PF-6)** |
| T2 | AC/DC photoflash power transformer (UTC PF-5)** |
| T3 | Trigger transformer (UTC PF-7)** |
| T4 | General Electric PT-118 flash-tube (available from photo stores)* |
| T5 | Reflector, type 165-P-157 (Weber Brass Co., 3344 Payne Ave., Cleveland, Ohio, $4 post-paid)* |
| T6 | 2-3/4" x 2-1/4" x 2-1/2" aluminum chassis box (LMB 100 or equivalent) |
| T7 | 1-7/8" x 3" x 3" aluminum chassis box (LMB 145, or equivalent) |
| T8 | Dual battery holders for D cells (Keystone 176 or equivalent) |
| T9 | Transistor mounting kits (Motorola MK-15, or equivalent)* |
| T10 | Fuse holder (Buss HKP, or equivalent) |
| T11 | Pilot light holder for NE-51 lamp |
| T12 | Coiled cable, three-conductor, with one conductor not used, extends from 10" to 4/5" (Relden 8405 or equivalent) |
| T13 | 1-6" x 2-3/4" strip of 0.050"-thick aluminum strip—Rubber feet (4), 1/8" grommets (2), solder, screws, etc. |

*A kit of parts containing these components is available from Caringella Electronics, Box 327, Upland, Calif. 91786, for $26 ($6 below cost of parts if purchased separately). Shipping weight, 3 lb. California residents must add 4% sales tax. The reflector collar may be purchased separately for $2.00. **These transformers, if not available locally, can be obtained from Harvey Radio, 103 West 43 St., New York, N.Y. 10036, for approximately $17.25, plus shipping cost.

---

Fig. 3. Only a part of the necessary metal work is shown in this drawing of the power supply sub-chassis. Read the text on the facing page for details.
The "Ready" light is neon glow lamp \( I_2 \). The "Ready" light blinks on and off when the photoflash capacitor has sufficient charge to flash the flashtube. This value can be anywhere from 400 to 450 volts d.c. A simple relaxation oscillator circuit \((C_3\) and \(R_3\)) causes \( I_2 \) to blink at a rate proportional to the charge on \( C_2 \). The greater the voltage, the faster the rate.

Switch \( S_2 \) is in parallel with the shutter contacts. It can be used to "open" or "flash" the circuit. You can test the flash with it at any time without operating the camera shutter.

**Construction.** Before beginning construction, round up all the needed components. You can save more than $6 by ordering a kit of parts rather than buying some of the parts separately. The kit consists of photoflash capacitor \( C_2 \), diodes \( D_1 \) and \( D_2 \), transistors \( Q_1 \) and \( Q_2 \)—plus their mounting kits, the FT-118 flashtube, plus reflector and collar.

Begin construction of the electronic flash with the power supply subchassis. This subassembly chassis is partially detailed in Fig. 3. Besides the holes shown in this drawing, holes must be drilled in the 2\( \frac{3}{4}'' \times 3'' \) face to mount the transistors and their sockets. Because of differences in size of switches, hardware, and other components, the holes for mounting \( Q_1 \) and \( Q_2 \) have not been drawn. However, once you have all the

![Image](image-url)
subassembly components and before you do any drilling, lay out the parts, scribe the chassis, and use a center-punch. Work carefully and neatly. The unit was purposely made to be compact.

Particular care is necessary in drilling the holes for Q1 and Q2 to be sure that clearance for the base and emitter pins and hold-down screws is on at least a 1\(\frac{1}{8}\)" radius. When mounting the transistors, use a mica insulator, and if silicon grease is available, coat both sides of the insulator to obtain better heat transfer.

After mounting the transistor sockets, push the shaft of S1 through a lock washer, then the hole in the subchassis, and temporarily mount it in place with a nut. Solder diodes D1 and D2 to a 3-terminal tie strip, then mount the strip in between P2 and P3 as shown in the photos. One of the bolts holding T2 also holds the terminal strip. If you cannot find a 3-terminal strip that mounts vertically, you can fabricate one from a 3-
or 4-terminal strip by cutting off one mounting leg and rotating the other leg to the position shown.

Then wire in S1, T1, T2, R1, C1, Q1, Q2, J4, and J5. Solder two 10" lengths of black insulated wires, one to terminal 1 of T2 and the other to the long contact on switch S1b. Let these leads

These two photos show how the power supply or shoulder pack is mated. In the photo above, the D cells—mounted in battery clips—are bolted to the two end plates of the shoulder pack wraparound. The batteries are wired in series and, for convenience, the positive and negative leads end in color-coded insulated tip plugs. The power supply subchassis and capacitor C2 must be positioned so that the batteries will slip into the small space available.

Fig. 5. Although the components in the flash head are not cramped, the builder should follow this metal working drawing as closely as possible.
WHERE CAN YOU EQUAL THIS OPPORTUNITY?

TO EARN A GOOD PAYING JOB IN A FAST GROWING FIELD?

DeVRY'S "BIG 3" AIDS TO PROGRESS ARE DESIGNED TO SPEED YOU QUICKLY TO A REAL FUTURE IN ELECTRONICS

1. EFFECTIVE TRAINING!
   LEARN AT HOME in spare time, or day or evening in one of our RESIDENT SCHOOLS.

   ELECTRONICS is one field that spells OPPORTUNITY in big capital letters for many men 18 to 45. This widespread but FAST GROWING field offers trained men some of today's finest, good-paying job opportunities — or a chance to start a profitable servicing shop!

   Even if you don't have previous technical experience or an advanced education, DeVry's "BIG 3" aids to progress may very well be YOUR stepping stones to a BETTER FUTURE. You can learn at home in your spare time, while keeping your present job. Or, in a day or evening program in our U.S. or Canadian resident school, you can develop the very skills needed to make wonderful progress. We even work to get resident students part-time jobs to help with tuition or living expenses, if necessary!

WE PREPARE YOU NOT FOR ONE JOB BUT FOR JOBS IN MANY DIVISIONS OF THE FASCINATING FIELD OF ELECTRONICS

SPACE & MISSILE TV — RADIO RADAR MICROWAVES AUTOMATION

COMMUNICATIONS COMPUTERSROADCASTING INDUSTRIAL ELECTRONICS ELECTRONIC CONTROL

MAIL COUPON TODAY!

DeVry Technical Institute
4141 Belmont Avenue, Chicago, Ill. 60641 Dept. EEH-1-W

Please give me your two free booklets, "Pocket Guide to Real Earnings" and "Electronics in Space Travel"; also include details on how to prepare for a career in Electronics. I am interested in the following opportunity fields (check one or more):

☐ Space & Missile Electronics ☐ Television and Radio
☐ Microwaves ☐ Radar
☐ Automation Electronics ☐ Communications
☐ Computers ☐ Broadcasting
☐ Industrial Electronics ☐ Electronic Control

Name
Address
City State Zip
Apt

ZIP Code

☐ Check here if you are under 16 years of age

HOME STUDY AND RESIDENT SCHOOL TRAINING AVAILABLE IN CANADA

DeVRY TECHNICAL INSTITUTE
4141 Belmont Avenue, Chicago, Ill. 60641 Dept. EEH-1-W

Send coupon for these two factual booklets NOW!

EFFECTIVE TRAINING!

INDUSTRY RECOGNITION!

EMPLOYMENT SERVICE!

FREE

Regardless of how you complete your educational program with DeVry, you can count on industry-recognized, effective training aimed directly at providing on-the-job-type "know-how." This is followed by actual EMPLOYMENT SERVICE to help you get started in Electronics. Or, if you are in the field already, remember that a DeVry recommendation has meant plenty of ADDING DOLLARS to income to many who made themselves more valuable to employers.

See for yourself how you, too, may prepare for the INCOME, the PRESTIGE and the FINE FUTURE that goes with the title of Electronics Technician. Mail the coupon NOW for facts without obligation.

CIRCLE NO. 7 ON READER SERVICE CARD
dangle free; they will be connected later. Now set the subchassis aside and go to work on the main chassis.

Use Fig. 4 as a guide to cut out and drill the main chassis, but check the actual component fit before you do any sheet metal work. Mount J1, F1, I1, J2, and C2.

Before mounting C2, attach two 11" lengths of good insulated wire to its terminals. To avoid damage, observe polarity; make the positive wire red, and the negative wire black. Run these two wires around the subassembly to J2. Be sure that the wires and the capacitor terminals do not short to the chassis or any other components or hardware. For safety’s sake, tuck these wires between the chassis and C2 and T2. (Caution: Do not touch C2’s terminals or its leads, even with the power disconnected, unless you are absolutely certain there is no voltage present. The only way you can be sure is to place a jumper across C2’s terminals.)

Secure the subassembly to the main chassis by first removing the nut that holds S1 in place, pass S1’s shaft through the opening in the chassis, position the subassembly as shown in the photographs, and replace the nut. A 3/8" flat washer placed under the nut protects the chassis against wrench marks and adds to the professional look.

Solder the 10" black lead from terminal 1 on T2 to F1 and the other 10" black lead to J1. Now add a wire between the remaining terminals of F1 and J1 to complete the 117-volt a.c. input circuit. The rest of the wiring is straightforward—just make certain that you observe polarity of the capacitors, diodes and the batteries, and that all connections are soldered and well insulated.

The four D cell batteries are retained in holders bolted to the sides of the chassis cover. Here again, you should gauge the location of the battery holders to be sure they clear the components on the chassis when the cover is screwed into place. Wire the holders so that all the batteries are in series. Solder 10" lengths of red and black hookup wire to the positive and negative battery output terminals respectively. Connect appropriate colored tip plugs (P3 and P2) to the other end of these leads.

The Flash Head. Figure 5 details the metal work necessary to assemble the flash head. The dimensions shown are reasonably critical—especially if you intend to make a carbon copy of the unit shown here.

Resistors R3, R4, and R5, and capacitor C3 are mounted on a Cinch-Jones 2006 terminal strip before the strip is installed. Looking at the strip from the top down (in the photograph of the flash head), mount C3 and R3 between terminals 1 and 3; R4 between terminals 3 and 4; and R5 between terminals 4 and 6. Clip off terminal 5 for the extra room needed to slip the lead from the flash trigger pin to terminal 3 of T3.

There is no socket for I2, just short flexible leads soldered to the base of the bulb and to terminals 1 and 3 of the tie point strip. The location and wiring of the other components (Fig. 2) is obvious once the terminal strip has been installed. The flash tube and its wafer base is fitted into the neck of the reflector and crimped into place.

Mounting the reflector to the box can be accomplished in two ways: it can be attached with three or four small right-
angle brackets, or with a retaining collar similar to that shown in Fig. 6. This collar can be machined from plastic or aluminum, and fastened to the small box with four 4-40 x 5/8" machine screws. The neck of the reflector is inserted into the collar and protrudes about 1/8" into the box. A setscrew on the collar holds the reflector in place.

Connections are made to the flashtube by soldering directly to its pins. Avoid excessive use of solder flux to prevent high-voltage leakage paths. The lead from the trigger electrode to T3 must be short and very well insulated (it carries more than 6000 volts). The coiled cable with PI connected to it is routed through a grommet in the box. (Use a restraining clamp to prevent the cable from slipping out of the box.)

Operating Information. The "Ready" light (12) will start blinking when the charge on C2 has reached about 425 volts. If the batteries are fresh and the power supply is running, C2 will continue to charge to about 450 volts. This charge can be held by C2 for 10-15 minutes, and during this period the photographer should have the power supply switched off. This is a good habit to learn as it will add many flashes to the life of your D cells. Of course, if recycling is important, leave the power supply running.

The blinking rate of the "Ready" light is determined by the charge on C2. At maximum charge, the blinking rate should be about 30-40 flashes per second. As the voltage on C2 drops, the blinking rate will also drop until it reaches 4-6 flashes per second. Don't shoot when the blinking rate is less than 4 flashes.

The choice of the kind of D cell determines the recycling time in the d.c. mode of operation. The author evaluated three types of D cells and arrived at the following conclusions.

Ordinary D cells: Average 40 flashes before becoming useless. Average recycling time was 40 seconds with fresh batteries and 60-70 seconds near the end of battery life.

Alkaline D cells: Tested were the Eveready E95 and Burgess AL-2. Average of 60 flashes and a recycling time of 12 seconds with fresh batteries and 20 seconds near the end of useful battery life.

Nickel-Cadmium D cells: Tested were the Eveready N57 and Burgess CD10. These excellent batteries recycle in 5-7 seconds until discharged. The user should expect to get at least 300 flashes per battery charge (not per set of batteries).

It is possible to recharge regular and alkaline D cells to extend useful life before it's necessary to throw them away. The nickel-cadmium battery is quite expensive, but this is all in initial cost since under average conditions you can recharge these batteries over 100 times. One set of nickel-cadmium batteries should last for many years.

(Continued on page 134)
Portable emergency light doubles as luminescence detector

Made to Order for wherever a portable light is needed, this battery-operated fluorescent light will find favor with sportsmen, hobbyists, and rock collectors alike. The light works off a 12-volt battery and uses a 6-watt tube. By substituting a “black light” for the white tube, rock hunters can use it to locate mineral specimens.

Since the light can be used in many different ways, construction should be tailored to satisfy your needs. For instance, those rock hunters may find it desirable to enclose the unit in a light-tight box with a tray and viewing hood to permit daylight sorting of rocks. Motorists will find it advantageous to use a cigarette lighter type of plug to obtain a quick power connection in the event of an emergency. Sportsmen and campers may want to add a Watertight battery compartment to the unit to hold a lantern-type battery.

How It Works. Operating fluorescent lamps from d.c. usually presents a problem: the supply voltage must be higher than the “striking” voltage of the lamp and power is wasted in the resistive ballast which must be used to limit lamp current. Not so if an efficient transistorized inverter steps up low voltage d.c. to high voltage and high frequency a.c. —a simple series capacitor can then serve as a reactance-type current limiter. The circuit used here produces more than half again as much light output as an incandescent bulb drawing the same battery power, a feature which campers and boaters who are concerned with conserving their batteries will appreciate.
The circuit, shown in Fig. 1, incorporates two transistors and a saturable core transformer with feedback windings to produce an audio oscillation at a frequency determined primarily by the transformer. The a.c. output voltage is connected to the fluorescent lamp (11) through capacitor C4, which serves to limit load current.

The type of lamp employed has filaments at both ends of the tube to “pre-heat” the gas in order to facilitate lamp ignition. Note that the function of S2 is to allow current to flow through both filaments as long as it is closed. The hot filaments heat and ionize the gas in the lamp, so that current can flow through the gas from one end of the lamp to the other. The hotter the gas, the more current that can flow; the more current that flows, the hotter the gas becomes. The external current limiter prevents “runaway” and destruction of the lamp and other circuit components.

Capacitor C3 and coil L1 are optional and are used to cut down radio interference. If you do not use C3 and L1, connect the switch directly to the brown lead on TI. Do not connect the brown lead to the negative side of the battery. A 2- or 3-ampere fuse can be placed in series with the switch. However, the fuse may not act fast enough to protect the transistors if you apply too much voltage or fail to observe polarity.

**PARTS LIST**

- C1, C2—5-µf., 25-volt capacitor
- C3—100-µf., 25-volt electrolytic capacitor—optional
- C4—0.1-µf., 10%, 600-volt tubular capacitor (Sprague 6PS-10 or equivalent)
- L1—6-watt fluorescent lamp (Sylvania F6T5/CW cool white or F6T5/BL black light, or equivalent)
- R1—56-ohm, ½-watt resistor
- R2, R4—8200-ohm, ½-watt resistor
- R3—56-ohm, ½-watt resistor
- S1—S.p.s.t. switch
- S2—Momentary-contact, push-to-close switch
- S01, S02—Miniature two-pin fluorescent lamp socket (GE 9X276 or equivalent)
- TI—Type EC-0104-IP saturable transformer (available from Milwaukee Electromagnetics, P. O. Box 4744, Milwaukee, Wis. 53207, for $3.00 postpaid)
- Misc.—Wood parts, aluminum, celluloid shield
Fig. 2. Celluloid shield forms a window and insulates the side panels from the aluminum chassis. The unit can be fastened to a container built to hold two 6-volt lantern-type batteries connected in series.

Fig. 3. Layout is not critical, but space transistors as far apart as possible to dissipate the heat.

**Construction.** Assemble the base, ends, aluminum reflector, and sockets as shown in Fig. 2. Note that the same screws hold the lamp sockets and reflector to the soft wood ends. The transistors are mounted on an aluminum bracket which in turn is mounted on the reflector. The transformer is mounted on another bracket and attached to the reflector in the same manner. The on-off switch and starter button can be installed on either aluminum side panel. Most of the components are connected between terminal strips mounted on the wood base.

Connections to the two transistors can be made by soldering directly to the pins. Care must be exercised not to damage the transistors with excessive heat; use a pair of long-nose pliers as a heat sink when soldering. Transistor layout is not critical, but they should be spaced as far apart as possible to allow for dissipation of heat when in operation.

If the small amount of audible noise from the unit is disturbing, pack some foam rubber, styrofoam, or other acoustic absorbent material around the transformer. When installing the celluloid (or plastic) shield, be sure it insulates the aluminum side panels from the reflector in order to isolate and completely enclose the electrical circuit.

**Testing and Use.** If you are sure of your wiring and supply voltage polarity, turn the unit on and depress the starter button for a few seconds. The lamp should operate with normal brilliance if battery voltage is about 12 volts. Current drawn should be around 0.9 ampere. The circuit should work on 9 to 15 volts with lamp brightness corresponding to voltage; higher voltage levels tend to shorten lamp life.
INCREASED gas mileage, quicker starting even in cold weather, longer life for breaker points and spark plugs, more power at high speed, and less ignition interference on ham and CB rigs are claimed for the transistorized Capacitor Discharge Ignition System. A one-two punch has been delivered to conventional ignition systems, and it's beginning to look as though they will be replaced by electronic systems in the very near future.

The first blow was struck with the introduction of the transistor system. The transistor system relieves the breaker points from having to carry all the current in the ignition coil's primary circuit, but still depends upon a large magnetic field around the ignition coil. The size of the field, among other things, depends upon the amount of time available between sparks. This time is shorter at higher engine speeds and it is quite normal for the high voltage to fall off at the higher speeds.

Until the transistor was put to work, a practical limit on the amount of current that could flow through the primary circuit to build up the magnetic field was determined by the size of breaker points. In order for the points to handle more current, larger points are needed, but there is a practical limit to point size. The transistor ignition system eliminates the points as a stumbling block so far as current is concerned, although breaker points still have to be in good condition and properly timed.

More than enough current is now available to the coil. But the regular coil wasn't designed to take much more current, so a new coil became desirable, one with a higher turns ratio, that is, one that would take all the current from the transistor in the amount of time between sparks. The drawback now is that the same high current is drawn at slow speeds and while starting. The battery has all it can do to satisfy the starter motor and chances are when you need it most, like on a cold winter morning, you'll be looking for a battery booster.

Several things have been done to overcome this effect: use of ballast resistor jumpers when starting, relays to connect the battery more directly to the coil, etc. But even before the designers had a chance to fully eliminate the bugs in the original transistor ignition system, the second blow was struck. Another system was brought out for public consideration and use: the transistorized capacitor discharge ignition system which uses the original ignition coil and associated equipment. It draws very little current, and makes cold-weather starting much easier.

The capacitor discharge system, by no means a newcomer, was originally a thyratron operated device; it now takes...
on a completely new look and promises to become the new standard in a very short time. This transistorized capacitor discharge ignition system has a transistor power supply and a capacitor to fire the ignition coil. As there is never any d.c. on the ignition coil, the coil works more effectively, and remains much cooler in the system. A negative-ground, 12-volt system is described here.

Construction. Assembly of the entire ignition system can be accomplished in less than half an hour. A printed circuit board, made of G 10 (fiberglass impregnated) material and heavy copper foil, simplifies the construction considerably.

The most important parts required are the SCR (Q3) and the transistor transformer (T1). This transformer is a special type, and can be purchased directly from SYDMUR (P. O. Box 25A, Midwood Station, Brooklyn, N. Y., 11230) for $14.95. The SCR can be purchased locally. SYDMUR claims their SCR’s are pretested and exceed manufacturer’s specifications. A special selection of

Fig. 1. Component side of circuit board (left) shows parts location and orientation. SYDMUR kit has all components color-coded, and the appropriate colors marked on the board to speed assembly. Actual size photo of board (below) will help you make your own. Do not change alignment of conductor paths.
Fig. 2. Locate and drill all holes accurately. Large 1" hole is for screened air vent. Size and spacing of holes for terminal strip can vary. Mounting sequence is: Q1, Q2, terminal strip, completed board, and bathtub capacitor. Transistors must not touch the cabinet.
SCR’s is made to insure optimum performance; they are priced at $7.45 each, including a heat sink. The other parts are not critical, and they can be obtained from your local parts dealer.

Should you decide to make your own printed circuit board, follow the actual size and layout as shown in Fig. 1. Do not change any lines, or false triggering of the SCR can result.

First install all the components on the printed circuit board or other suitable chassis, and put it aside. Use rosin core solder and observe polarity of all diodes. Next, prepare the cabinet as shown in Fig. 2 and mount the transistors and terminal strip. Do not mount the bathtub capacitor until the circuit board has been put in place.

When installing the transistors, coat both sides of a mica insulator with silicon grease to act as a heat conductor and electrical insulator between the transistors and the cabinet. Line up the holes of the mica insulator with the holes in the cabinet. Next, insert the transistors (they can fit only one way). Then place a fiber washer over each transistor bolt, and follow with a metal washer and solder lug. Bolt the entire assembly into place.

Be certain that the transistor pins do not touch the metal cabinet. Use an ohmmeter to check this out. Connect one lead to the cabinet and the other to the transistor case and then to the pins. If there is a reading on the ohmmeter, recenter the transistor.
**PARTS LIST**

C1—4-µf., 50-volt electrolytic capacitor  
C2—1-µf., 600-volt bathtub capacitor  
C3—50-µf., 25-volt electrolytic capacitor  
C4—0.22-µf., 25-volt ceramic capacitor  
C5—0.1-µf., 100-volt ceramic capacitor  
C6—0.02-µf., 150-volt ceramic capacitor  
D1—1N463 silicon diode  
D2, D3, D4, D5—1N2615 silicon diode (SYDMUR ER61A)  
Q1, Q2—2N1100 power transistor  
Q3—Motorola MCR1605-6 silicon-controlled rectifier (SYDMUR SCR 1268 with heat sink)  
R1—10-ohm, 2-watt resistor  
R2—820-ohm, 1-watt resistor  
R3—680,000-ohm, ½-watt resistor  
R4—28-ohm resistor (two 56-ohm, 2-watt resistors in parallel)  
R5—1800-ohm, ½-watt resistor  
R6—27-ohm, ½-watt resistor  
R7—100-ohm, ½-watt resistor  
T1—SYDMUR SPC-4 special transformer*  
I—3" x 4" x 5" cabinet  
Misc.—1" wire-screen snap-in plug, 5-terminal barrier-type terminal strip, circuit board, 4 3/16" spacers, machine screws, terminals, etc.

*The following parts are available from SYDMUR, P.O. Box 153, Midwood Station, Brooklyn, N.Y.: ER61A (6) $1.80; transformer T1, $14.95 (T1 is a proprietary product of SYDMUR . . . no coil winding information available); SCR 1268, $7.45; complete kit including a specially made cabinet, $44.50; and a completely wired unit, $60.00. A positive ground system at $47.50, and a 6-volt system at $44.50 are available completely wired (not in kit form).

Mount the board into place with machine screws and be sure that there is enough clearance on all sides and top and bottom to prevent short circuits. Connect a wire from point C (next to T1) to the collector and a wire from point B to the base of Q1. Connect a wire from point D to the collector; a wire from point E to the base; and a wire from point H to the emitter of Q2. The emitters of both transistors should be connected together and to the A+ terminal on the terminal strip. Finally, connect a wire from point A on the board to the Coil+ terminal on the strip; a wire from point G to the GND terminal; and a wire from point F to the PTS terminal.

*How It Works.* When the ignition switch is turned on, the battery voltage is applied to the emitters of Q1 and Q2. (See Fig. 3.) Transistors Q1 and Q2 are forward-biased through the resistive divider (R1 and R2). Usually, whichever transistor has the most gain will conduct first. First one transistor conducts, and then the other, in a flip-flop manner. This form of oscillation repeats itself regularly and continuously; transformer action steps up the voltage to about 375 volts, which is then rectified by the full-wave bridge (D2, D3, D4 and D5).

The d.c. voltage output from the bridge rectifier then charges capacitor C2. Capacitor C2 stores this d.c. energy until the SCR (Q3) conducts. Resistor R3 improves regulation and acts as a bleeder to discharge C2 when the ignition switch is turned off.

When the points in the distributor are closed, the SCR (Q3) is an open circuit across the power supply. Also, when the points are closed, R4 allows about 500 ma. of current to flow across the points to help keep them clean. When the points open, current flow through R4, D1, C4, R6 and R7 causes a positive pulse to be applied to the gate of Q3, which then flips into conductivity very rapidly (approximately 1 microsecond), discharging C2 through the primary of the ignition coil.

Notice that the voltage impressed across the primary is on the order of 375 volts and not the usual 6 or 12 volts. The ignition coil can now produce a
much hotter and "faster" spark. Actually, "faster" spark simply means a steeper slope (rise time) of the spark's waveform as it would appear on an oscilloscope. It is this very short rise time, inherent in a capacitor discharge system, that makes it possible to fire fouled and defective spark plugs. Another important gain is the fact that the coil does not have to draw current while the breaker points are closed to build up a large magnetic field as in conventional ignition systems.

At high engine speeds in conventional systems, not enough time is available to build up the magnetic field to maximum, and so there is a very definite drop in voltage, as shown in Fig. 4. Note that in this capacitor discharge system there is essentially no drop in voltage up to 15,000 rpm. Since engine speeds rarely exceed 5000 rpm, there is no drop in voltage over the entire range of usable engine speeds.

At the instant Q3 conducts, it also shorts out the power supply, forcing the power transistors (Q1 and Q2) into a quiescent state. The transformer (T1) is specially designed to prevent high transients and self-oscillation of the power transistors when Q3 conducts. After C2 discharges through the coil and Q3, the ignition coil—because of a flywheel type of action and its sinusoidal type of response—sets up a reverse current which develops a negative voltage on the anode of Q3 and positively halts conduction. The SCR would normally shut off as the anode voltage approached zero. Polarity of the bridge rectifier happens to be just right to remove any residual negative voltage and to keep it within safe limits.

As soon as Q3 stops conducting, the power supply turns on. By this time the same sinusoidal action of the ignition coil is now heading in the other direction and tends to aid the power supply in charging up C2, further reducing the charging time. All this is accomplished in less than 300 microseconds.

To prevent the SCR from conducting on point bounce or high impulse noise, the voltage on C4 and C5 back-biases D1 and bleeds off through R5 at a slower rate than the charge time (about 0.5 millisecond). Capacitor C6 helps to prevent any high-frequency noise that may create r.f. interference from getting out of the ignition system.

Note that the original coil is used and that the unit will perform on a battery voltage range from 9 to 16 volts.

Checking It Out. Before installing the system, you may want to satisfy yourself that all is in working order. The system can be tested if there is an ignition coil and a 12-volt battery available. Follow the installation instructions.

Care must be exercised when connecting the coil. A wire from the high voltage output should be gapped a maximum of 1" from the minus side of the ignition coil. There is a possibility of breaking down the internal insulation of the ignition coil if you omit this step.

Instead of using the breaker points, a wire can be connected from the GND terminal and brushed along the PTS terminal on the strip. Do not touch the ignition coil or high voltage lead while you are making this test, or you might get a nasty jolt.

Installation. Mount the unit close to the ignition coil, but as far as possible from the manifold. Remove all wires from the ignition coil. Also remove any capacitors if they are attached to the coil. Reconnect the wire or wires and the capacitor (if any) that were on the coil's plus terminal, to the A+ terminal on the unit. Connect a wire from the COIL + on the unit to the + on the ignition coil. See Fig. 5.

Now connect a wire from the engine ground (the coil's clamp can serve as a ground) to the other side of the ignition coil—and to the GND terminal on the unit. Connect the wire from the terminal on the distributor to the PTS terminal on the unit. Be sure all connections are tight and well insulated, and do not let wires or metal touch the transistors.

It is advisable to install a new set of breaker points, and to clean the distributor head and the rest of the ignition system. Follow the car manufacturer's recommendations as to timing and gapping of points. If the spark plugs are shot, they'll work, but it is better to begin with your best foot forward.

When you turn the ignition switch on, a slight hum will be heard from the unit. Start the engine.
Wireless Re-Broadcaster

Broadcast music or sound from your hi-fi, FM tuner, or TV set to every AM radio in the house—all it takes is a simple one-tube unit

By KEN DOBLER

REBROADCAST anything that comes out of a loudspeaker. You can get FM programs on all the AM radios in your home. Television sound and music from your tape recorder or phonograph can be heard on the kitchen radio. Your portable transistor radio can become another listening end of a paging or intercom system. You can remote-monitor your CB, amateur or short-wave receiver on any AM radio within range of the Wireless Re-Broadcaster (WRB). The WRB can be attached to the speaker leads of any program source (PS).

The speakers at the PS can be switched off or left on while you are rebroadcasting. When the WRB is shut off, the PS is not affected in any way and will function in a normal manner. The WRB is also equipped with a Modulation level control and a visual Level indicator to handle the high-level signals taken directly from loudspeaker leads, and can function properly over a wide range of input signal strengths.

The circuitry is easy to understand and easy to put together. Parts are standard, few in number, and readily available. Use only enough antenna length to transmit a signal to your own sets. Part 15 of the FCC regulations and a neighbor's complaint can put an end to your rebroadcasting days if you cause interference. So keep it down and find a spot...
Wireless Re-Broadcaster

Unique use of “S”-type fuse clip is shown below: it’s soldered directly to the chassis and holds neon lamp 11. Grommets protect wires at various feedthrough points. Lamp 12, also grommet-held, can be moved up or down to line up with opening in front panel.

Parts List

- C1a/C1b—40-μf., 150-volt, and 20-μf., 25-volt dual electrolytic capacitor
- C2—0.047-μf., 200-volt capacitor
- C3—150-pf. ceramic disc capacitor
- C4, C5, C6—400-pf., 400-volt capacitor
- D1—1N3254 diode or equivalent
- F1—3-ampere fuse (optional)
- L1—NE-2 neon lamp
- L2—NE-51 neon lamp
- R1, R6—100,000-ohm, 1/4-watt resistor
- R2—10,000-ohm, 1/2-watt resistor

Construction. A wooden cabinet (8” x 4” x 4”) can be made and stained to match existing furniture. The chassis is fabricated from a piece of sheet metal cut and bent to the proper shape. A separate chassis pan and front panel could be put together instead.

Cut a notch rather than a hole in the front panel for the neon lamp modulation Level indicator. The outer groove of the grommet holding the lamp can now act as a runway to grip the sides of the slot. The lamp can then be moved up or down to line up with an opening in front panel.

How It Works. Signals taken from the speaker circuit of a PS are fed to the Modulation level control, potentiometer R4, through switch S1b and S1c. More or less signal (depending upon the control setting) is passed to the cathode of the modulation portion of the tube (V1b). Triode section V1b is hooked up as a...
grounded-grid amplifier. The grounded grid shields the input from the output circuit and prevents oscillation. Input signals applied to the cathode vary cathode potential with respect to the grid in "step" with the signal. This action varies and controls current flow through the tube, making the tube work like an ordinary amplifier.

Triode section V1a functions as part of a typical Hartley oscillator. The tuned tank circuit consisting of coil L1 and capacitor C3 is across the grid and plate of this triode while the signal at the coil's tap is at cathode potential. Capacitors C5 and C6 serve as d.c. blocks. The values of the components in the tank circuit determine the generated fre-
frequency. Varying the adjustment of coil L1 will enable you to select a quiet spot on the AM broadcast band.

The generated radio frequency in tube section V1a is amplitude-modulated by the signals from section V1b and then "piped" into the atmosphere by the antenna. Capacitor C4 serves as an antenna coupler.

The modulation Level indicator circuit is also very simple. In the presence of an audio signal, plate voltage of triode section V1b varies with the applied signal. As the cathode goes more negative, the tube conducts more and plate voltage goes down; as the signal goes more positive, the tube conducts less and plate voltage goes up. Neon lamp I2 "looks" at this varying plate voltage through capacitor C2. Resistor R6 is a current limiter. When plate voltage goes down, the voltage across I2 increases and "fires," provided that the applied signal is of the proper level. The lamp should flicker on and off in "step" with the program. Too high a volume level will cause the lamp to stay on, even during very low signal passages.

Transformer T1 provides heater voltage to the tube as well as an isolated line voltage to the rectifier. Actually it is stepped down a bit from 117 volts to 110 volts. While the exact voltage is not critical, it is best not to deviate too much. Neon lamp I1, across the secondary of transformer T1, serves as a pilot light.

The B+ developed by half-wave rectifier D1 and the filter components (resistor R2 and capacitor C1a) is fed to the plate of tube V1a through the top half of coil L1. Both tube sections act as a dynamic voltage divider between B+ and ground. The exact distribution of voltage depends upon the way each section conducts.

Installation. To connect the WRB to the PS, follow the schematic diagram. Connect line 3 to one side of the speaker. Open the lead going to the other side of the speaker at any convenient point and connect line 1 to the end closest to the output transformer, and line 2 to the end nearest the speaker. This completes the project, except for setting the frequency of the WRB.

Turn on the PS and an AM radio. If you are working alone, place the AM radio, the PS, and the WRB close to each other to cut down the leg work. Set the selector switch in the Both position and the Modulation level control in the fully counterclockwise position on the WRB. Turn up the program on the PS to a moderate volume level and advance the Modulation level control on the WRB until the Level indicator flashes in "step" with the program. Tune the radio to a clear spot on the dial and adjust the oscillator coil on the back of the WRB until the signal is heard in the radio. If you don't get the signal on one end of the band, try the other end.

When the selector switch is in the Off position, the PS operates normally. In the Both position, the PS operates normally and the WRB transmits the program. In the Remote position, the speakers at the PS are cut off, but the WRB continues to transmit the signals from the speaker line.

The Modulation level control need only be used when the selector switch is in the Both position. Its main function is to limit the amount of signal sent to the broadcaster when the PS volume level is high. In the Remote position, the Modulation level control should normally be turned fully counterclockwise and the PS volume adjusted for proper level.

Since too much bass can cause distortion, it is better to keep the bass control at a minimum setting during preliminary adjustments and then advance it for the most pleasing tone.

After becoming familiar with the operation of the controls and the best setting for your AM radio, you will find the WRB easy to operate, mystifying to friends, and loads of fun.

Chassis shown is made from one piece of sheet metal. Separate pan and front piece could be employed. Tabs on apron act as backstops.
FENCE CHARGER

Marauder monitor curbs canine capers. Stop garden invasions and garbage can inspections at four o'clock in the morning

By LYMAN E. GREENLEE

Keep your disposition from going to the dogs by charging up a few things. You can build a small fence charger that will deliver a wallop big enough to make any self-respecting dog or cat think twice before investigating the contents of your garbage can a second time. The punch is a high-voltage shock of short duration and is harmless to man or beast. Cost of construction is low—you may already have most of the parts on hand.

How It Works. A small isolation transformer (T1) isolates the fence charger from the house power line for safety, as shown in the schematic diagram. A 1/8-ampere “slow-blow” fuse carries the small normal load of the charger and also withstands the initial current surge which may occur when the unit is first turned on. This is normal for equipment having capacitor input filtering in the power supply.

Capacitors draw relatively large current as they go from 0-to-operating voltage levels. The output from the transformer secondary goes through a current limiting resistor (R1) to the silicon rectifier (D1). Resistor R1 protects the rectifier from starting current surges. The rectifier’s pulsating d.c. output is smoothed by capacitors C1 and C2 and by resistor R3. The NE-2 neon light (I1) serves as a pilot light—it not only shows whether
the charger is on or off, it also tells you if the B+ power supply is working up to this point in the circuit. Resistor R2 limits the amount of current that can be passed by the neon light. Output from this half-wave rectifier power supply is approximately 140 volts.

The relay coil (K1) is a normally closed s.p.s.t. type with a coil resistance of from 3000 to 8000 ohms. Upon application of power, the relay tends to become energized almost immediately and to open the circuit through itself and transformer T2. Since enough time must be allowed for the current to build up, and, in turn, for the magnetic field to go to maximum in transformer T2, capacitor C4 is used to hold the relay armature down for about one second. Timing depends upon the values of the capacitor and the coil resistance, as well as the characteristics of the relay. Spring tension on the relay armature can be changed to increase or decrease the on-off time. Relays with coil resistance varying from 1000 to 10,000 ohms have been tried by the author and all of them have worked. Variations in hold-down time ranged from about 0.1 to 3 seconds.

When the relay points open, current ceases to flow through T2, the magnetic field collapses and induces a voltage across what is now the transformer’s secondary winding, and the voltage appears at terminals BP1 to BP3. The quicker the magnetic field collapses and the higher the turns ratio of the transformer, the higher the voltage produced. Small unit teaches hounds to behave. Short duration pulses are harmless.

Note that this transformer was originally intended for audio output work and is used in the reverse manner in this project. Therefore, what was originally the primary winding is now the secondary.

Capacitor C3 serves the same purpose as the capacitor across the points in a conventional automobile ignition system. It overcomes the inertial effects of the current, minimizes arcing across the points, and takes on a charge which series-aid the voltage from the power supply when the contacts close.

The second neon light (12) connected across the secondary of T2 flashes momentarily with each pulse applied to the fence if all is well. Resistors R4 and R5 are current limiters for I2. The spark gap protects the transformer against damage from internal arcing and also from electrostatic or lightning charges that might be picked up on a long length of fence wire connected to the charger. The shock pulse generated is completely safe due to its short duration. Any possibility of a dangerous or lethal voltage being applied to the fence because of component failure is remote. Transformer T2 can pass only a small current and is isolated from the house power line. The B+ component is “chopped up” by the relay. If the relay contacts stick open or closed, no high voltage can be developed on the fence. Should transformer T1, diode D1, or capacitors C1, C2, and C4 short, the fuse would probably blow or resistor R1 would burn out. In any event, there would still be no high voltage on the fence.

Construction. The charger should be built in a Bakelite or plastic box, or at least on an insulated board, as shown in the illustrations. Provide a good ground connection for terminal BP1. All parts are mounted on the cover. Keep in mind the 2½” space between the cover and the bottom of the case when
Mount all parts before wiring, and keep depth of case in mind when mounting them. The panel fits into case when completed.

PARTS LIST

BP1—Black binding post
BP2, BP3—Red binding post
C1, C2—40-40 µf., 150-volt dual electrolytic capacitor
C3—0.03-µf., 600-volt mica capacitor
C4—40-µf., 150-volt electrolytic capacitor
D1—1N1763, 400-PIV, 500-ma. silicon rectifier
F1—3/4-amp. "slow-blow" fuse
I1, I2—NE-2 neon light
K1—S.p.s.t., normally-closed relay with 5000-ohm coil (Potter & Brumfield LBS or equivalent)
R1—100-ohm, 1-watt resistor
R2—100,000-ohm, 1/2-watt resistor
R3—1000-ohm, 1-watt resistor
R4, R5—2.2-megohm, ½-watt resistor
S1—S.p.s.t. toggle switch

T2—4-watt universal output transformer (Allied Radio 62 G 023 or equivalent)
1—2 5/32" x 5 9/32" x 6 13/16" Bakelite instrument case and cover
Misc.—Line cord, 3/8" grommets, fuse holder, 4-terminal strip, neon-light sockets, hookup wire, machine screws and nuts, etc.

NOTE: A complete kit of parts with drilled and finished box, ready for easy assembly, is available from Mobil Electronics, Inc., 3023 Mounds Rd., P. O. Box 1132, Anderson, Ind., for $21.95; postpaid.

Relay acts like points in a conventional automobile ignition system. Circuit is isolated from the a.c. power line for safety.
mounting the various parts. The cover has to fit into the case when the instrument is completed.

Prearrange the parts in the cover, as shown in the photos, and mark the position of the various mounting holes. All parts should be mounted before wiring. The 6-volt filament wires from the isolation transformer are not used; the ends of these wires should be taped and folded around the transformer and tucked out of the way.

The output transformer has a series of taps for impedance matching. Locate the two outer ends of the tapped winding and wire them into the circuit. One way to identify the outer ends is to use an ohmmeter. Select the two terminals that have the most resistance between them.

The high-voltage side of the output transformer has three insulated wires which may be colored red for the center tap, blue for one end, and brown or green for the other end of the winding. Connect the brown or green wire to the black binding post (BP1), the red wire to the middle red binding post (BP2), and the blue wire to the end red binding post (BP3).

You can construct a spark gap by soldering a fairly stiff wire about 2" long to each lug on the outer binding posts. Shape the two wires so that their ends are about \( \frac{1}{4} \)" apart and suspended in air away from other terminals and cabinet, as shown in the pictorial.

Check the wiring when completed. If you're satisfied with it, place the cover in the case, plug in the unit, and flip the switch. If all is well, the relay will start pulsing. Don't screw down the cover until you have checked the spark gap to see that it is not firing. Normally the gap should be just big enough to prevent no more than occasional arcing. You may also want to vary the armature tension by adjusting the spring to get the right timing cycle. Spring tension should be strong enough to insure a good contact when the relay trips out. The relay should stay closed for about 0.1 second.

**Operation.** Connect the black binding post to a suitable ground connection, and connect the fence to be charged to one of the red binding posts. Use the middle binding post for wet weather and the outer one for dry weather. On a dry day a higher voltage is needed to force current through dry ground. In wet weather a high voltage could be a disadvantage because the current would tend to leak across the insulators. The higher the voltage, the higher the leakage. When the ground is wet, a low voltage is just as effective. Approximately half the voltage and twice the amperage is available from the black and middle red post. Maximum high voltage is obtained from the black and outer red post.

To test for leakage in the fence circuit, connect a NE-2 neon light in series with the fence and the red binding post being used. The higher the intensity of the flashes, the greater the leakage. To

(Continued on page 145)

ELECTRONIC EXPERIMENTER'S HANDBOOK
SOMEONE SHOULD DEVELOP AN EASY WAY TO LEARN ELECTRONICS AT HOME

RCA INSTITUTES DID!

RCA introduces new CAREER PROGRAMS—beginning with the student-proved "AUTOTEXT" Programmed Instruction Method—the faster, easier way to learn. You start to learn the field of your choice immediately. No previous training or experience needed.

Pick the career of your choice—and RCA Institutes will do the rest! RCA's new, revolutionary "Career Programs" help you go directly to the career you want! You waste no time learning things you'll never use on your job! Each Career Program is designed to get you into the kind of job you want in the fastest, easiest possible way!

SEPARATE COURSES
In addition, in order to meet specific needs, RCA Institutes offers a wide variety of separate courses which may be taken independently of the above Career Programs, on all subjects from Electronics Fundamentals to Computer Programming. Complete information about these courses will be sent with your other materials.

CHOOSE A CAREER PROGRAM NOW
Your first step to the job of your choice!
- Television Servicing
- Telecommunications
- FCC License Preparation
- Automation Electronics
- Automatic Controls
- Digital Techniques
- Industrial Electronics
- Nuclear Instrumentation
- Solid State Electronics
- Electronics Drafting

RCA INSTITUTES BONUS EXTRAS
Only RCA Institutes offers you a Liberal Tuition Plan, one of the most economical ways to learn. Plus, you get top quality equipment in all kits furnished to you with your courses—yours to keep and use on the job. And now, RCA's NEW PROGRAMMED ELECTRONIC BREADBOARD GIVES YOU LIMITLESS EXPERIMENTATION—scientific laboratory procedures right in your own home! You build a working signal generator, AM Receiver, Multimeter, Oscilloscope, and other valuable equipment—ALL AS A PART OF YOUR COURSE! Get the facts today!

Classroom Training Also Available. Day and Evening Classes are available to you in New York City at RCA Institutes Resident School. You may be admitted without any previous technical training; prep courses are available if you haven't completed high school. Coeducational classes start four times a year.

SEND ATTACHED POSTCARD TODAY FOR COMPLETE INFORMATION. NO OBLIGATION. NO SALESMAN WILL CALL. FREE BOOK INCLUDED. CHECK HOME STUDY OR CLASSROOM TRAINING.

RCA INSTITUTES, INC., Dept. 33-76
A Service of the Radio Corporation of America
350 West 4th St., New York City 10014

The Most Trusted Name in Electronics

1966 Spring Edition

CIRCLE NO. 21 ON READER SERVICE CARD

35
SIMPLE DWELL METER

By T. C. PENN

Best possible gasoline engine performance results from a combination of many ingredients—not least of which is the dwell angle.

The use of a dwell meter to adjust the spacing of the breaker points of an automobile is well known to mechanics and is now becoming familiar to the "do-it-yourself'er." Several transistor circuits of varying complexity have been published for dwell meters. In view of these previously published circuits, a circuit as simple as the one to be described here might well be viewed with skepticism. But in addition to justifying the simpler circuit on the basis that it has been used successfully for the past two years, it will be shown that this dwell meter is even more accurate than some of the circuits that have been published in the past.

Before touching on the details, some discussion of what a dwell meter can and cannot do might be worthwhile. For example, a dwell meter will not insure "up to 20% more horsepower" nor "up to 5 more miles per gallon of gas." A dwell meter by itself is useful only in adjusting the breaker-point gap in the distributor. It is very useful with modern engines which provide for such adjustment while the distributor cap remains in place. A dwell meter is also useful in checking the breaker point condition of older engines since it replaces the function of a gap gauge.

Each time the cam lobe of the distributor pushes open the breaker points, a spark plug ignites. Changing the dwell angle (during which the points remain closed) changes the point spacing and obviously changes the angle the cam makes when the points first open. In other words, it should be appreciated that any adjustment of the breaker-point gap requires that the engine be re-timed.

The mechanical-electrical characteristics of most single breaker point ignition systems are chosen to hold the points closed (dwell) twice as long as they are open. The dwell duty cycle is therefore two-thirds and that is really all that needs to be remembered regardless of...
in the primary of the ignition coil does not reach its proper amplitude at high speeds. This causes the ignition coil voltage to decrease. In addition, the breaker points are thrown open so wide that severe contact bounce results when they close. If the dwell angle is too large, the points are not opened wide enough and arcing will take place across the points, resulting in decreased point life and low voltage.

How It Works. The dwell meter to be described is based on the same principle as that illustrated by the old electronics riddle. “An electrical black box has three terminals accessible for an ohmmeter check. Terminals 1 and 2 read open circuit, both terminals 2 and 3 as well as 1 and 3 give a half-scale reading on all ranges. What is in the box?” The usual answer is a vibrator or chopper. The duty cycle of the chopper is

[Diagram of a circuit diagram]

Fig. 2. Simplicity is the key word in the design of this dwell meter. “Plus” lead goes to “hot” or plus terminal of the ignition coil in negative ground systems. This circuit has provisions to measure dwell angle when the ignition coil cannot be reached. See text for details.

the number of cylinders. Not every model of every car has been checked, so you are encouraged to check the specs of your own car.

An eight-cylinder engine has a timing cam which turns 45° between the successive firings of spark plugs. The nominal dwell angle is two-thirds of this angle, or 30°. In a six-cylinder engine, the timing cam rotates 60° between ignition times, and thus the nominal dwell angle is 40°. A tolerance of ±5% is quite acceptable.

Faulty dwell settings produce undesired results, as might be expected. If the dwell angle is too small, the current 50%, so the meter reads halfway between open and short circuit.

Unfortunately, the voltage waveform appearing across the breaker points of an automobile is not quite as ideal as a chopper. Figure 1 illustrates a typical waveform of the point voltage in a negative-ground system. (For positive-ground systems the waveform is inverted.) Note the large magnitude transients caused by resonance of the coil with capacitor C across the points. If one is tempted to use a clipper or a Schmitt trigger to produce a rectangular pulse of the same length as the open time, the negative transient will momentarily turn off the
clipper or reverse the Schmitt trigger. The shaped waveform will therefore not be representative of the open time of the points.

Figure 2 is a schematic of the dwell meter. When the meter is connected across the points of an automobile, the internal batteries drive the meter to full-scale as long as the points remain closed. As the points open, the 200- to 300-volt positive spike is unable to produce current flow through the meter due to the diode. At the same time the $RC$ product chosen is such that the subsequent negative voltage spikes are also unable to cause current to flow through the meter. When the points again close, $C1$ is discharged through $R1$ and $R2$ via the points. The internal batteries again drive the meter toward full-scale. The meter reads linearly in duty cycle, 0 being points fully open, and 100% deflection, fully closed. A linear angular scale may be added for dwell if preferred, although two-thirds full-scale is the nominal dwell reading, as mentioned previously. Inasmuch as almost any meter movement up to 10 ma. is suitable for this application (a 2" Weston 500-$\mu$A. meter with internal resistance of 235 ohms was used by the author), the following rules of thumb are included for the constructor:

1. Choose a battery voltage which requires a limiting resistance ($R1$ plus $R2$) that is at least ten times larger than the internal resistance of the meter.
2. Choose $C1$ so that the product of the limiting resistance (in ohms) $\times C1$ (in $\mu$f.) is approximately 250.
3. Choose $C2$ approximately eight times larger than $C1$.

If these rules are followed, the dwell meter can be used with reliability over a wide speed range and not just at idle speed where dwell adjustments are being made. This permits checking for "point bounce" and "floating." Capacitors $C2$ and $C3$ have been included to facilitate adjusting the points of automobiles not having external access to a point-adjusting screw.

Operation. To use the dwell meter on an automobile engine with negative ground, having external access to the points, the following instructions apply:
2. Connect the "plus" lead of the dwell meter to the junction of the ignition-coil primary and the points. This terminal is readily available on the ignition coil.
3. Connect the "minus" lead to a ground.
4. Turn on ignition switch without starting. If the points are closed, the dwell meter will read up-scale. If points are open, momentarily crank engine until points stay closed.
5. With ignition switch still on and the points closed, adjust $R2$ for exactly full-scale deflection.
6. Start engine and read dwell meter directly for duty cycle (or add degree scale if preferred).
7. Set the point-adjusting screw for two-thirds full-scale (6.7 if your meter reads 10 full-scale).
8. Reset engine timing.

These instructions are also applicable for positive-ground ignition systems by merely reversing the meter leads.

For engines not having external access to the points, the following instructions apply:
2. Perform steps 2, 3, 4, and 5 as before with due regard to polarity of ground.
3. Remove center wire (high tension) from distributor and place on or near a ground away from the carburetor. This minimizes chance of coil damage due to internal arcing.
4. Remove distributor cap and rotor.
5. Crank engine with starter and read dwell while cranking. (If necessary, meter may be damped by switching in $C3$.) Stop, adjust points, crank again until satisfied.
6. Reassemble distributor, insert high-tension wire, and time engine.

This dwell meter is very handy for checking point condition of any car by simply clipping the meter in, calibrating, then starting the engine. It has been used with satisfaction by several persons in the past two years on engines with 4-, 6-, and 8-cylinders; one of these autos had a transistor ignition system.

A chassis box was chosen for the housing with the switches mounted for one-hand operation as shown in the photo. The meter shown is a readily available surplus unit. Leads should be unplugged when not in use to conserve batteries, or a power switch could be added.
Low cost, easy-to-make tester calibrates tachometers under actual conditions without any other equipment.

This simple circuit enables you to calibrate automobile tachometers and check their accuracy. In many cases it also provides an independent means for setting the idle speed of your automobile engine. In use, the calibrator is connected only to the engine and a 60-cycle, 117-volt line. The tachometer to be calibrated is connected to the engine in the normal manner to establish actual operating conditions.

Faults leading to improper readings, which sometimes escape detection when a tachometer is bench-tested instead of tested in the car, have no place to hide. For this reason, the calibrator described here is especially good for testing accuracy of new tachometer designs.

How It Works. The calibrator has two neon lamps which alternately flash on and off when the unit is properly connected to the car and the a.c. power line. The rate of flash diminishes as the engine speed approaches either 450 rpm or 900 rpm for an 8-cylinder car, or 600 rpm or 1200 rpm for a 6-cylinder car. When each lamp flashes about once per second, engine speed is off by only 1.7%.

1966 Spring Edition
As the engine reaches exactly one of the test speeds given above, one of the lamps will stay on and the other will stay off.

Figure 1 shows the hookup to the car and Fig. 2 is a schematic diagram of the calibrator. The principle of operation is rather simple: the whole idea is based on a coincidence of pulses from the distributor and the 60-cycle a.c. line voltage.

The ringing voltage produced in the primary circuit when the ignition points open passes through CI and appears across R3. Every positive swing of the ringing voltage passes through diode D1 and attempts to ignite the neon lamps (in some cases the lamps do go on from ignition pulses only). At the same time, the voltage from the secondary winding of T1 is also applied to the neon lamps. Therefore, at any given instant the potential across the neon lamps will be increased or decreased by T1.

While the potential across one lamp is increased, the potential across the other lamp is decreased by the same amount. The “favored” lamp fires at intervals or continues to fire and the other lamp is either extinguished at intervals or remains off. The speed of the alternate on-and-off action varies with the degree of out-of-sync conditions between the two comparison voltages.

When the distributor pulses are synchronized with the 60-cycle line, only one lamp is favored each time and appears to remain on all the time. Its partner never receives adequate voltage to fire; and thus it remains off all the time. A slight change in engine speed, either faster or slower, will again result in first one lamp, then the other, being in the favored position.

The lower of the two sync points for a given engine takes place when one ignition pulse occurs for every two cycles of line current. The higher sync point shows up when one ignition pulse occurs for every cycle.

The calibrator will not work when primary circuit pulses are too low, too high, or of very short duration. Short duration pulses are found in transistor and capacitor ignition systems, but not in the conventional ignition system. High and low voltage pulses normally will not have to be reckoned with in an ignition system that is operating properly. If the pulse is too low, the neon lamps will not ignite; if the pulse is too high, the lamps will not shut off.

Construction. Layout of parts is not critical. A terminal strip supports all of the components except the transformer. It is desirable, if space permits, to install the calibrator in the tachometer’s housing. Otherwise, a small metal or plastic cabinet can be used. The neon

(Continued on page 148)
Self-Regulating
Lighting Controller

Get even light even when
day changes to night—
build this automatic device

By EDWARD P. NAWRACAJ
and
FRED FORMAN

TURN off the lights and the regulated
lamp goes on. Turn on the lights and
the regulated lamp goes off. Let the
overall ambient illumination vary be-
tween daytime and nighttime, and the
regulated lamp will vary in intensity in
the opposite way. The lighting control-
er "wants to see" the same amount of
light regardless of how bright or dim
the day or night, and will automatically
compensate for varying levels of illumi-
nation. You can establish an average
round-the-clock light level limited only
by the power-handling capabilities
of the controller.

How it Works. Photoconductive cells
PC1 and PC2 are in series with re-
sistors R1 and R2 respectively, and form
simple voltage dividers to apply trig-
gering voltages to the gates of silicon-
controlled rectifiers SCR1 and SCR2.
When the ambient light level is low, the
resistance of the photoconductive cells
is high. Proportionally higher voltages
are developed across the cells and ap-
plied to the appropriate SCR gate.
The SCR's fire when the gates and
anodes are sufficiently positive with re-
spect to the cathodes. The higher the

Point the "eyes" away from direct
light to automatically compensate
for varying ambient light levels.

Simplicity of construction is the
keynote of the controller. Only
four components are on the chassis.
positive voltages, the sooner the SCR's conduct, and the longer they stay on. The longer the SCR's stay on, the brighter the regulated lamp.

Once the SCR's conduct, the gates have no further control and conduction takes place until the anode voltage is removed or reduced below the holding point. This happens each time the 60-cycle line voltage reverses. When the line voltage reverses, the SCR that was on—or conducting—switches off, and the SCR that was off switches on. When ambient light levels increase, the resistance of the cells decrease, and so down goes the amount of control voltage applied to the gates of the SCR's.

The 22,000-ohm resistors establish a preset range of overall operation. Variable controls of about 50,000 or 75,000 ohms can be substituted to shift the range to satisfy most requirements.

Construction. Any available box—even a cigar box—can be used to house the controller. There is nothing critical about construction or location of the parts. Only four parts (the SCR's and resistors) are mounted on a perforated phenolic board used as a chassis. The cells are mounted on the case, as is the regulated lamp's socket.

Aim the cells away from any direct light, including the regulated lamp, in order to get them to respond to ambient conditions. The regulated lamp will flicker on and off if you point it at the photocells. Differences in parts values, due to normal commercially accepted tolerances, may cause one photocell to do more work or be more responsive than the other. To prevent this possibility, you should use matching components.

The SCR's used by the author are RCA 2N3228's, costing less than $2 each (Motorola MCR 1304-4's and Texas Instruments TI 3012's will also work). The photocells are Clairex CI 505's at about $3 each (the Lafayette 99 G 6322 at 99 cents will serve as well). Resistors $1 and $2 are 22,000-ohm, 1/2-watt units. A 4" x 2 1/4" x 2 1/4" metal box and other miscellaneous small hardware are also needed.

The 2N3228, without a heat sink, has a 1.57-ampere maximum rating when it is conducting for half the time, as is the case when the controlled lamp is full on. With less than half conduction time, greater current-handling ability is possible. With a suitable heat sink, the same SCR can safely handle up to 3.2 amperes or about 375 watts of power.

Other Uses. Many other applications are possible for the controller. It can be used to activate a relay which, in turn, would switch on or off other types of loads, such as alarm devices, appliances, and motor-driven machinery. Larger lamp loads could also be turned on or off by such a relay.

When the controller is used in this manner, however, it becomes a simple on/off triggering device, and you will not get varying and intermediate levels of illumination from the lamp.

Brilliance of regulated lamp depends on how long each SCR is on.
HOW OFTEN have you wished you had more convenient and better flash units to provide fill-in light for photographs of large groups, sports events, or in other critical spots where the light is unfavorable? When you talk about "better," chances are you mean electronic strobe units with their reliability, quick recycling time, and (in recent years) relatively low cost. When it comes to convenience, a prime requisite is the elimination of awkward, hazardous, unreliable cables.
In addition to the inherent problems cables present, different strobe units cannot always be wired together—in some cases damage may result. Even if the units are similar and designed for parallel operation, polarities must be carefully observed.

What the foregoing list of factors adds up to is the "Strobelight Slave," a simple adapter, described here in two versions, which can be used to convert any electronic flash into a light-operated slave unit. With the slave, the strobe-light can be remotely located, responding instantly to the flash from the master strobe fired by the camera shutter.

**Typical Strobe Operation.** Figure 1 shows the firing arrangement used in most electronic flash units. High voltage is applied to the flash tube between its plate and cathode, while the starter anode is connected to ignition coil L. Capacitor C is charged to a certain percentage of the high voltage through the voltage divider consisting of Ra, Rb, and Rc. When the shutter contacts (S) close, the capacitor discharges through the lower part of the coil, inducing a very high voltage in the upper part, and causing the flash tube to fire.

**Basic Slave Circuit.** A look at the Strobelight Slave Circuit shown in Fig. 2 reveals how it works. The 5823 (V2), a gas-filled triode, operates as a switch. At least 150 volts must be applied between the plate (pin 1) and the cathode (pin 7 or pin 3). No conduction occurs until a certain voltage appears on VI's
Basic Strobelight Slave is shown connected to strobe with a cord terminating in plugs on both ends. Both plugs and the sockets on the strobe unit and either slave unit should be marked with plus signs to avoid damage from cross-polarizing units.

Fig. 2. Basic Strobelight Slave is self-powered, can be used if charging voltage is 150 volts or more.

Fig. 3. Booster slave uses batteries to fire V2 with low-voltage type strobes.

darter anode (pin 4). When this happens, the tube then fires, and conducts to such an extent that the plate and cathode are literally shorted. Of course, this condition causes the remote strobe unit plugged into SO1 to flash.

The trigger voltage for V2 is generated by V1, a 929 phototube, in response to the light from the master strobelight. The basic Strobelight Slave shown in Fig. 2 is, therefore, completely self-powered, and may be used with any strobe having a shutter capacitor charging voltage of at least 150 volts.

**Booster Slave.** The second version of the Strobelight Slave shown in Fig. 3 provides supplemental voltage for the slave trigger tube when the capacitor charging voltage of the strobe is less than 150 volts. Here, B1 is used to charge C1 through R2. This insures that the full battery voltage is available to fire V2 when light strikes V1, since, when fully charged, C1 bolsters the current capacity of B1. Diode D1 isolates the internal slave voltage from the strobe unit, but permits current to flow in a forward direction when V2 fires, firing the strobe connected to SO1.

The second version of the Strobelight Slave also includes switch S1 to cut B1 out of the circuit when the slave is used with units having high shutter contact charging voltages—normally S1 is on only when used with units having low charging voltages. However, when a strobe unit has a charging voltage over (Continued on page 147)
HERE'S a clever computer-type gadget that will provide hours of fun for "youngsters" of all ages, and at the same time teach basic computer logic. A good science fair project, the "Electronic Coin Tosser" simulates electronically the toss of a coin. The probability of the HEADS lamp lighting is 50:50. That is, if the game is played one hundred times, the heads will come up approximately fifty times.

To play the game, turn the power switch on and allow time for the lights to quit blinking. Now make your call by throwing the CALL toggle toward HEADS or TAILS. Toss the coin by pressing the TOSS button momentarily. The lamps begin to blink, and increase in speed; suddenly the blinking stops; and just as suddenly you win or lose, for the HEADS or TAILS lamp goes on, and so does the appropriate WIN or LOSE lamp.

Theory of Operation. A computer-type logic diagram for the game is shown in Fig. 1. Like a double-throw switch, the flip-flop circuit places a signal first on one side, then on the other. Looking at the switch or the flip-flop circuit at any given instant, you will find that when there is an on condition on one side there is an off condition on the other, and vice versa. Actually, any binary type of indication can be programmed, such as 1 and 0; on and off, plus and minus, hot and cold, black and white, heads and tails, etc.

In this project, the readout is HEADS and TAILS, and WIN and LOSE. If the flip-flop in our game stops on heads, the HEADS output will be a 1 and the
TAILS output will be a 0. These signals as well as the signals from the CALL heads and tails switch are fed to a series of logic gates. There are four AND gates ($G_1$, $G_2$, $G_3$, $G_4$) and 2 OR gates ($G_5$, $G_6$). Each gate has provisions for two input signals and one output signal. The output signal depends upon the input signal.

To simplify matters, consider heads to be 1 and tails to be 0 when heads are called. When tails are called, tails become a 1 and heads a 0. The AND gate requires a 1 on both inputs to give a 1 on the output; a 1 and a 0, or a 0 and a 0, on the inputs gives a 0 on the output. An OR gate requires a 1 on either input to give a 1 on the output; a 0 and a 0 on the inputs give a 0 on the output.

In order to light the WIN lamp, a logic 1 on its input is needed. This means the OR gate ($G_5$) must have a logic 1 on at least one of its inputs. To reach this condition, one of the AND gates must have logic 1's on both its inputs.

Assume heads is called. This puts a logic 1 on input #1 of gate $G_1$ and gate $G_4$. It also puts a logic 0 on input #1 of gate $G_2$ and on input #2 of gate $G_3$ (logic 0 means tails was not called). Also assume that the flip-flop circuit stops on heads, putting out a 1 on the heads output and a 0 on the tails output.

So now we have: a 1 on inputs #1 and #2 of gate $G_1$, and it puts out a 1; and both inputs of gate $G_2$ have 0's, and it puts out a 0. Gate $G_5$ now has a 1 on input #1 and a 0 on input #2 and so it puts out a 1. and causes the WIN lamp to light. What about gates

---

Rear view of Electronic Coin Tosser shows simplicity of wiring and assembly. Battery can be held in place with a dash of glue, or a suitable bracket.
G3 and G4? Gate G3 has a 1 on input #1 and a 0 on input #2, so its output is a 0. Gate G4 has a 1 on input #1 and a 0 on input #2, so it too puts out a 0. Gate G6 has 0's on both inputs, so its output is 0 and the LOSE lamp does not light. Try your hand at the three other possible combinations.

**How It Works.** The circuit consists of an astable and a bistable multivibrator, as shown in Fig. 2. The astable multivibrator looks like an ordinary collector-coupled circuit except that the two bias resistors (R3 and R4) are connected to a 150-μF capacitor (C1). When the TOSS button (S1) is closed, C1 takes on a charge from BI through R1 and applies this voltage to R3 and R4 and allows the astable multivibrator to oscillate. Oscillations continue until the voltage across C1 falls below the level required to forward-bias Q1 and Q2.

The output from the collector of Q2 is fed to the inputs of the bistable multivibrator through C4 and C5. The signal at this point is in the form of a square wave and triggers the bistable multivibrator (Q3 and Q4). In the absence of an input signal, either Q3 or Q4 is conducting all the time. When Q3 conducts, Q4 is off, I3 is on, and I4 is off. When Q4 conducts, Q3 is off, I3 is off, and I4 is on.

![Diagram of the circuit showing action required to light WIN or LOSE lamps.](image)

**Fig. 1.** Computer logic diagram shows action required to light WIN or LOSE lamps. Selection of heads with the CALL switch places a 1 on input #1 of G1 and G4. If the flip-flop oscillator stops on heads, it places a 1 on the inputs of G2 and G3. All other inputs on G1 through G4 have a 0. Since G1 is the only gate with a 1 on both inputs, its output is a 1. AND gates have an output of 1 when both inputs are 1. OR gates (G5 and G6) require at least a 1 on either of the inputs to signal a 1 on the output. A 1 output from an OR gate is needed to light the WIN or LOSE lamps. Since G5 has a 1 on one of its inputs, its output is 1 and the WIN lamp lights. See text and try your hand at logic.

![Diagram of the circuit showing action required to light WIN or LOSE lamps.](image)
is on. In the presence of an input signal, Q3 and Q4 cycle on and off continuously. When the input signal is removed, the circuit reverts back to one of its two possible stable states.

Switch S3 connects I1 and I2 in series with the appropriate circuit. When the call is heads, I1 is in series with I3 and I2 is in series with I4. If tails is called, the series connections are interchanged; I1 and I4 are in series, and I2 and I3 are in series. If the manual selection of heads or tails coincides with the random electronic selection of heads or tails, the WIN light (I1) goes on; otherwise the LOSE light (I2) lights up.

Construction. A 2" x 7" x 9" aluminum chassis is used to hold the game. The circuit is built on a piece of 13/8" x 8" Vectorbord using push-in terminals.

Layout is not critical but care should be taken when soldering diodes and transistor leads so that they do not become overheated. Polarity of diodes and electrolytic capacitors must be observed. Transistor sockets are convenient to use and eliminate the possibility of ruining a transistor with a soldering iron.

A d.p.s.t. switch (S2) is used as an on/off switch, but a s.p.s.t. unit will do just as well. Connect the positive side of the battery directly to the lead serving as ground.

The chassis is finished with flat white paint and lettered with rub-on decals. Lenses for the WIN and LOSE lamps are colored green and red respectively. HEADS and TAILS lens color could be either amber or white.

---

Fig. 2. Bistable multivibrator flip-flops from heads to tails only when the astable multivibrator is in action. Position of S3 and electronic selection of heads or tails determines the win or lose indication.

1966 Spring Edition
Build a full-wave motor speed control and light dimmer with new Triac semiconductor and four other components

MEET the "Dymwatt." It's a no-nonsense light dimmer and power-tool speed control that provides up to 600 watts of 117-volt a.c. with a symmetrical waveform and full-range, variable power output. The circuit uses only five electronic parts and fits in the palm of your hand.

With the Dymwatt, you can get precise control of incandescent lights, photofloods, soldering guns and irons, and electric drills. It will also control any motor rated up to ½ horsepower and equipped with brushes—including most, but not all, sanders, fans, and electric mixers. The only things this control can't handle are fluorescent lights and induction motors—but neither can most of the ordinary power controls.

The two special parts in the circuit, Q1 and D1, price out at $4.65 and $1.02 respectively. This puts the Dymwatt's cost at less than $6 if you've got a volume control, a box, and two stock capacitors.

The "Triac." Older control designs call for SCR's. A single SCR provides a half-range type of control, as between half and full brightness, or between zero and half brightness. To provide full-wave, full-range control, you have to add parts—usually a second SCR, a single mechanically switched diode, or a full-wave bridge rectifier.

The "Triac" is a new semiconductor which makes possible full-wave control without the need for all the extra components. The electrical equivalent of SCR's back to back, it operates equally well in both current directions, and with either a positive or negative gate pulse!

Two of the Triac's three leads (T1 and T2) are connected in series with the load. The third connection is the gate lead (G). (The designations T1 and T2 simply mean terminal 1 and terminal 2. Designations of anode and cathode, unfortunately, cannot apply in this case. An equivalent set of components for the Triac would contain seven transistors and several resistors.)

A small signal pulse can trigger the Triac so that it will fire just like a thyatron, and switch on full or partial...
power to the load. Conduction stops when the current through the load circuit drops to zero. This happens every time the a.c. voltage goes through zero. It also happens when the load is removed, or the circuit is opened.

**How It Works.** Current through potentiometer $R1$ (see Fig. 1) charges capacitor $C1$ up to 30 volts, which is the breakdown voltage of the special pulse diode ($D1$). At 30 volts, the pulse diode “snaps” on and delivers a pulse to the Triac gate. The Triac then turns on, allows full current flow through the load, and shorts out the $R1$, $C1$ circuit. Diode $D1$ keeps conducting until $C1$ is discharged, and then turns off. The Triac continues to conduct until the a.c. line voltage alternates and goes through a zero.

The larger $R1$ is, the longer it takes to charge $C1$ and the longer it takes to turn on the Triac. The fact that the Triac shuts off at the end of each $1/2$ cycle of line voltage, plus the delayed start of conduction, reduces the conduction time and the effective voltage (r.m.s.) accordingly. Thus, it becomes apparent that increasing or decreasing the value of $R1$ controls the r.m.s. voltage. See Fig. 2.

If $R1$ is nearly zero in value, $C1$ charges very rapidly, and nearly full power reaches the load. If $R1$ is very large in value, $C1$ never reaches 30 volts within the 60-cycle swing. With each alternation of voltage, $C1$ starts to charge in the other direction. Under this condition, gate pulses cannot be

---

**Fig. 1.** The Triac ($Q1$) will conduct in either direction. A positive or negative gate pulse can trigger conduction and control r.m.s. output voltage.

**Fig. 2.** When $C1$ reaches 30 volts, $D1$ conducts and triggers $Q1$. The sooner the gate pulse is developed with respect to the 60-cycle line voltage, the higher the effective output voltage. With little or no resistance in the circuit, the output is maximum. As the resistance increases, the output decreases. If the resistance is made high enough, the output is 0.

---

**Finished Dymwatt can be plugged into one opening of a duplex receptacle without obstructing the other. You have a choice of using the controlled or noncontrolled outlet. Cost of this full-wave unit is less than that of commercially available half-wave controllers.**

---

**Diagrams showing voltage across $C1$ and the output voltage with varying $R1$.**
produced and the Triac remains cut off. By making \( R1 \) variable, it is possible to adjust for maximum or minimum power output.

Capacitor \( C2 \) is directly across the line to prevent any high-frequency pulse, which might be set up by the fast switching action of the Triac, from radiating down the power line and becoming a source of radio interference.

**Construction.** The Triac should be mounted on an aluminum heat sink. A \( \frac{1}{8}'' \)-thick piece of aluminum will do the trick. Bend it in a vise or small brake and then drill the holes. Use insulated mounting hardware and silicone grease to mount the Triac, as shown in Fig. 3. The Triac must be electrically insulated from the heat sink. Test the setup with

(Continued on page 144)

**Fig. 3.** Silicone grease, two mica washers, and a nylon bushing are used to mount Triac on heat sink to get thermal conduction without electrical contact.

**Fig. 4.** Terminal lug attached to \( T2 \) (it should not touch heat sink or case) provides easy connection to \( R1 \) and SO1. The end terminal of \( R1 \) can be left disconnected as shown in the schematic, but for smoother operation the center and end terminals should be connected together as shown here.

**PARTS LIST**

- \( C1 \): 0.1-µf., 600-volt capacitor
- \( C2 \): 0.05-µf., 600-volt capacitor
- \( D1 \): Texas Instruments T1-43 bilateral trigger diode
- \( P1 \): A.c. plug (Amphenol 61-M or equivalent)
- \( Q1 \): General Electric SC 40B Triac
- \( R1 \): 250,000-ohm carbon potentiometer, linear taper
- \( SO1 \): A.c. socket (Amphenol 61-F or equivalent)
- Misc.: Silicone grease, knob, \( \frac{1}{8}'' \) "Pop" rivets, spaghetti, solder, wire, nameplate, and \( \frac{1}{8}'' \) solderless terminal. \( 2\frac{1}{4}'' \times \frac{13}{16}'' \times \frac{7}{8}'' \) piece of aluminum, etc.
The famous RCA 5-inch scope

NOW WITH MORE FEATURES
TO SIMPLIFY YOUR JOB

Here's the latest model of the famous RCA 5-inch scope: the NEW WO-91B

- Provision for connecting signals directly to the vertical deflection plates of the CRT. Permits observation of high frequency RF waveforms, such as trapezoidal and wave-envelope modulation patterns.
- Two-stage sync separator simplifies checking of TV horizontal and vertical sweep synchronization...provides exceptionally solid lock-in action on composite TV signals.
- Choice of wide-band or high-sensitivity, narrow-band display.
- Complete with RCA WG-300B Direct/Low Cap. Probe and Cable.

- Optional at slight extra cost: RCA WG-354A slip-on capacitance-type voltage-divider probe that extends the range of the scope to permit observation of signal pulse amplitudes up to 5000 volts. RCA WG-302A slip-on RF/IF/VF signal tracing probe for RF applications from 100 Kc to 250 Mc.

<table>
<thead>
<tr>
<th>Product</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>WO-91B Scope</td>
<td>$249.50*</td>
</tr>
<tr>
<td>WG-354A Probe</td>
<td>$ 7.50*</td>
</tr>
<tr>
<td>WG-302A Probe</td>
<td>$ 8.20*</td>
</tr>
</tbody>
</table>

*Optional distributor resale price. All prices subject to change without notice. Prices may be slightly higher in Alaska, Hawaii and the West.

RCA Electronic Components and Devices, Harrison, N.J.
BUILD 20 RADIOS CIRCUITS AT HOME with the New Improved PROGRESSIVE RADIO "EDU-KIT"®

A Practical Home Radio Course

Now Includes
★ 12 RECEIVERS
★ 12 TRANSMITTERS
★ SQ. WAVE GENERATOR
★ SIGNAL TRACER
★ AMPLIFIER
★ SIGNAL INJECTOR
★ CODE OSCILLATOR

You DON'T HAVE TO SPEND HUNDREDS OF DOLLARS FOR A RADIO COURSE

The "EDU-KIT" offers you an outstanding PRACTICAL HOME RADIO COURSE at a rock-bottom price. Our Kit is designed to teach you how to build radios and practically anything else in electronics. You will learn to build radios, using regular schematics; how to wire and solder in a professional manner; how to service radios. You will work with the standard type of printed circuit chassis as well as the latest development of Printed Circuit boards. You will construct, study and learn the latest development of Printed Circuit boards. You will also learn to use the latest development of Printed Circuit boards. You will also learn to use the latest development of Printed Circuit boards. You will also learn to use the latest development of Printed Circuit boards. You will also learn to use the latest development of Printed Circuit boards. You will also learn to use the latest development of Printed Circuit boards.

FREE EXTRA
★ No Knowledge of Radio Necessary
★ No Additional Parts or Tools Needed
★ EXCELLENT BACKGROUND FOR TV
★ SCHOOL INQUIRIES INVITED
★ Sold in 79 Countries

FREE SERVICING LESSONS

You will learn trouble-shooting and servicing in a progressive manner. We will practice repairs on the sets that you construct. You will learn symptoms and causes of trouble in home, portable and car radios. You will learn to use the professional Signal Tracer, the unique Signal Generator and the dynamic Radio & Electronics Tester. While you learn you will be able to do many repairs yourself for your friends and neighbors, and charges which will far exceed the price of the "EDU-KIT." Our Consultation Service will help you with any technical problems you may have.

FROM OUR MAIL BAG

J. Sullins, 25 5th Pl., Waterbury, Conn.: "I have repaired several receivers, I have made money. The "EDU-KIT" paid for itself. I was really surprised to find the "EDU-KIT," but I found your address and sent for your Kit."

Ben Valerio, P. O. Box 21, Magna, Utah: "I am sending you the questions and the answers which are your "EDU-KIT" preserved in a "Kong" file. I have been in the Radio for the last seven years and have tried to work with Radio & Electronic kits, but never got a new machine to work with. I have put the Signal Tracer to work every minute I worked with the "EDU-KIT." I would have to say that the Signal Tracer is the finest. Also like to let you know that I am proud of becoming a member of your Radio-TV Club." Robert L. Shuff, 1534 Monroe Ave., Huntington, W. Va.: "Thought I would drop you a line to say that I received my "EDU-KIT," and it really surprised me. The "EDU-KIT" is worth the price of the "EDU-KIT.""

CIRCLE NO. 18 ON READER SERVICE CARD

PROGRESSIVE "EDU-KITS" INC.
1186 Broadway, Dept. 51298 Hewlett, N. Y. 11557

UNCONDITIONAL MONEY-BACK GUARANTEE

ORDER FROM AD-RECEIVE FREE BONUS RADIO & TV PARTS JACKPOT WORTH $15

- Send "EDU-KIT" postpaid. I enclose full payment of $26.95.
- Send "EDU-KIT" C.O.D. I will pay $26.95 plus postage.
- Rush me FREE descriptive literature concerning "EDU-KIT."

Name
Address
City, State

ELECTRONIC EXPERIMENTER'S HANDBOOK

54
Diversity is the key word for this chapter, and all the projects have been selected for maximum reader interest. There are two unusual speaker enclosures, a multiplex adapter, a small public address or intercom amplifier, and a handy stereo balance indicator.

Both of the major electronics construction project stories involve the use of printed circuit boards. Both authors sell these boards at very reasonable prices and both projects have been exhaustively tested by the ELECTRONIC EXPERIMENTER'S HANDBOOK staff. It is the consensus of staff opinion that use of the printed circuit boards absolutely insures easy reproduction of the projects by the home builder and virtually eliminates faulty performance. Sufficient detail has been provided in both articles to enable the do-it-yourselfer with printed circuit board etching facilities to make his own.

Our favorite speaker enclosure designer has returned (Dave Weems has had enclosure designs in each of the last six issues of the HANDBOOK) with a modernized version of a bass reflex patented many years ago. From all reports, the sound from this design is most pleasant and the bass well-rounded.

---

56 TRANSISTOR FM MULTIPLEXER ........................ O. D. Carlson

61 MR. THURAS' MAGIC BOX ................................. David B. Weems

66 THE SLIM TWOSOME .................................. Harold Hufnagel

71 THE BARGAIN PAGE AMPLIFIER ...................... Daniel Meyer

76 STEREO BAL .............................................. Dave Gordon
By O.D. CARLSON

MANY tried and true mono tuners can die a premature death because their owners want stereo reception. However, the addition of a suitable multiplex adapter can prolong the tuner's life. The Transistor FM Multiplexer is a quality, high-fidelity component utilizing a widely accepted time-sharing concept to reconstitute stereo programs in the home. The adapter features a stereo indicator to show when a stereo program is coming through, a switchless stereo-to-mono capability, and a separation of 25 to 30 db across the audio band.

Audio passing through this time-sharing type of multiplexer is not subjected to the nonlinear phase distortion of bandpass filters, as is the case with some matrix-type adapters. Both mono and stereo programs are played through the adapter and electronically switched back and forth, from left to right, at a 38-kc. rate, without any discernible depreciation of quality. Stereo, when it is present, comes out like magic.

**How It Works.** Signals from an FM tuner are fed to the base of Q1. (See Fig. 1.) The 19-kc. pilot component in the stereo multiplexed signal is filtered out in the emitter tank circuit (T1 and C3). All remaining signals are amplified and fed through the 67-kc. filter (T3) to an emitter follower (Q2). The audio signal is then fed to the collectors of switching transistors Q5 and Q6.

As these transistors are switched on and off, the signal appears first at one emitter and then at the other at a...
38-kc. rate. If this switching rate is precisely synchronized with the 19-kc. pilot signal of a stereo station, the left and right components of a stereo program are separated and recovered.

From the switching transistors, the signal passes through the appropriate de-emphasis networks (C14, R16, C15 and C16, R17, C17). Standard 75-microsecond de-emphasis is employed, effectively filtering out any 38-kc. signal that may be introduced by the switching action. For that matter, all frequencies greater than 20 kc. are reduced or eliminated by the de-emphasis network. This is fine for the audio signals going to the loudspeakers, but no good for the signals from the tuner to the multiplexer. The multiplexer has to see the total stereo signal, which also has components greater than 20 kc. and so the signal take-off point in the tuner is before the de-emphasis network but after the detector.

Returning to the emitter tank circuit of Q1 in the multiplexer, the 19-kc. pilot signal is fed to two identical amplifiers (Q3 and Q7). Transistor Q3 amplifies the signal to synchronize the 19-kc. oscillator (Q4). The collector tank circuit of this transistor is tuned to the second harmonic of the amplified 19-kc. pilot signal and passes a 38-kc. signal to the switching transistors via T4.

To see how the stereo indicator works, let us go back again to the emitter tank circuit of Q1 and follow the signal path through Q7. The amplified 19-kc. pilot signal from Q7 is rectified by D1, providing a negative-going signal to the base of Q8, and causing it to conduct and illuminate II. Since the pilot signal is present only on multiplexed broadcasts, the lamp will go on when the receiver is tuned to an operating stereo

![Fig. 1. Switching action of Q5 and Q6 separates right and left channels of sound; very small cutoff current makes the 2N327A transistors desirable for this application. Mono programs are also switched from side to side, but without any undesirable listening effects.](image-url)
station. Pilot signal input levels of less than 0.2 volt are sufficient to operate the lamp driver circuit.

**Construction.** A printed wiring board can be made from the full-scale drawing. However, you can use any other conventional wiring technique and type of chassis. A 6” x 3” undrilled phenolic circuit board containing all internal wiring is available from the author. (See Parts List.)

First, mount the transformers; connect only one spade-type projection on each transformer can to ground, and cut off the other one. Resistors, capacitors, and interconnecting leads for power and indicator lamp follow in just this order. Bend the lead ends slightly to hold them in place and then solder. You can cut off excessive lead lengths either before or after soldering, depending upon which is easier for you. For best results, do a neat soldering and wiring job and avoid lifting the foil with excessive heat and pressure.

Leave the installation of the transistors and the diode for last. If a transistor socket is used for Q4, the oscillator can be easily disconnected during alignment of the adapter simply by removing the transistor. All other semiconductors are soldered directly to the circuit board. Allow approximately ⅛” of air space above the board for clamping a heat sink to each transistor lead as it is soldered.

**Connection to FM Tuner.** Reception of stereo FM programs places more stringent requirements on a tuner and its antenna than for mono broadcasts. Greater bandwidth and sensitivity is needed for stereo receivers. The extra bandwidth allows for the standard spread of mono signal frequencies plus the stereo signal frequencies. The need for increased sensitivity is evident from the fact that a portion of a given stereo radio station’s overall signal strength contains stereo signals. The main channel, therefore has less than maximum power.
**PARTS LIST**

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1, C2</td>
<td>0.1 µf.</td>
</tr>
<tr>
<td>C3, C8</td>
<td>0.01 µf.</td>
</tr>
<tr>
<td>C4, C7, C9</td>
<td>0.01 µf.</td>
</tr>
<tr>
<td>C5</td>
<td>470 pf.</td>
</tr>
<tr>
<td>C6, C18</td>
<td>0.05 µf.</td>
</tr>
<tr>
<td>C10</td>
<td>50 µf.</td>
</tr>
<tr>
<td>C11</td>
<td>2 µf.</td>
</tr>
<tr>
<td>C12</td>
<td>3300 µf.</td>
</tr>
<tr>
<td>C13, C14, C16</td>
<td>0.001 µf.</td>
</tr>
<tr>
<td>C15, C17</td>
<td>0.005 µf.</td>
</tr>
<tr>
<td>D1</td>
<td>1N457 diode</td>
</tr>
<tr>
<td>Q1, Q2, Q3, Q4, Q7, Q8</td>
<td>2N1374 transistor</td>
</tr>
<tr>
<td>Q5, Q6</td>
<td>2N327A transistor</td>
</tr>
<tr>
<td>R1</td>
<td>150,000 ohms</td>
</tr>
<tr>
<td>R2</td>
<td>560,000 ohms</td>
</tr>
<tr>
<td>R3, R4, R7, R11, R15</td>
<td>10,000 ohms</td>
</tr>
<tr>
<td>R5, R9, R14</td>
<td>100,000 ohms</td>
</tr>
<tr>
<td>R6, R10, R18</td>
<td>22,000 ohms</td>
</tr>
<tr>
<td>R8, R12</td>
<td>4700 ohms</td>
</tr>
<tr>
<td>R13</td>
<td>2200 ohms</td>
</tr>
<tr>
<td>R16, R17</td>
<td>15,000 ohms</td>
</tr>
<tr>
<td>R19</td>
<td>100 ohms</td>
</tr>
<tr>
<td>R20, R21</td>
<td>22,000 ohms</td>
</tr>
<tr>
<td>T1, T2</td>
<td>Oscillator coil (J.W. Miller 1354-PC)</td>
</tr>
<tr>
<td>T3</td>
<td>Bandpass filter (J.W. Miller 1352-PC)</td>
</tr>
<tr>
<td>T4</td>
<td>Output transformer (J.W. Miller 1355-PC)</td>
</tr>
<tr>
<td>T5</td>
<td>Circuit board (ODC 1664*)</td>
</tr>
<tr>
<td>T6</td>
<td>7&quot; x 5&quot; x 2&quot; metal cabinet</td>
</tr>
<tr>
<td>Misc.</td>
<td>Lamp socket, phono jacks, hardware, etc.</td>
</tr>
</tbody>
</table>

All capacitors other than C10 and C11 ceramic disc or mica, 15 volts or better

<table>
<thead>
<tr>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>580K</td>
<td>1mA</td>
</tr>
<tr>
<td>100K</td>
<td>10A</td>
</tr>
<tr>
<td>10K</td>
<td>±10%</td>
</tr>
<tr>
<td>100K</td>
<td>±0.01%</td>
</tr>
<tr>
<td>22K</td>
<td>±10%</td>
</tr>
<tr>
<td>470K</td>
<td>±0.1%</td>
</tr>
<tr>
<td>470K</td>
<td>±1%</td>
</tr>
<tr>
<td>2200 ohms</td>
<td>±10%</td>
</tr>
</tbody>
</table>

*As undrilled 6" x 3" phenolic circuit board is available for $2.50 from O. D. Carlson, 414 Edgewood Ave., Linwood, N. J.*

---

**Fig. 5.** Component side of board shows parts layout. In spite of its miniature size, there is ample space between the components.

**Fig. 6.** Actual size of the printed circuit board. Materials are available from your local parts distributor to enable you to make your own board. Or undrilled boards having both sides printed in foil, as shown here and in Fig. 5, can be purchased directly from the author.
Tuners having a cathode follower output tube are easily modified to supply proper stereo signals, since this type of circuit already has a low output impedance. All you have to do is hook up the multiplexer in front of the de-emphasis network, as shown in Fig. 2. For a permanent installation, disconnect the de-emphasis network in the tuner (usually an 0.001- or 0.003-µf. capacitor on the output end of the 68,000- or 22,000-ohm resistor which is attached to the grid of the first stage after the detector), and turn the tuner’s volume control to maximum (if it affects the signal take-off point).

Volume is not adjusted at this point in the system unless the signal to the multiplexer is in excess of 0.5 volt, because reduction here could diminish the 19-ke. pilot signal needed for the oscillator and other circuits in the adapter. On the other hand, excessive signal strength will cause distortion. About 0.3 volt makes the unit work just fine.

Since the multiplexer is used for both mono and stereo programs, de-emphasis of all signals is reinserted in the multiplexer.

Tuners not equipped with multiplexer outputs are generally not satisfactory for stereo reception due to narrow bandwidth and sometimes lack of sensitivity, but with certain modifications and a good antenna can be made to work. In a (Continued on page 137)
The distributed port bass reflex was invented 35 years ago; with a modern-day hi-fi speaker, it sounds better than ever.

My introduction to hi-fi occurred about 15 years ago when I heard a speaker in a bass reflex enclosure. I was so impressed I bought some plywood and started building bass reflex cabinets, finally owning more boxes than I had speakers to fit. A few years later, I learned about the use of ducts or "tunnels," which permitted a reduction of enclosure volume for a given resonant frequency. Since just about all commercial cabinets of the era had only single ports, the ducted port was apparently a new development of vague and mysterious origin.

Another variation in the bass reflex cabinets of the '50s was the "distributed port," consisting of several small holes drilled in the face of the baffle to replace the single large hole. The proponents of the distributed port claimed that a smoother hi-fi response...
resulted from the resistive force that the multiple small holes exerted on the flow of air through them.

Then the stereo age arrived, and the need for double speaker systems created a demand for compact enclosures. We began to hear less about distributed ports and more about the ducted port, which now finally had its day. Those pioneers of the 1950's who had advocated them were simply ahead of their time.

Recently I became curious about the origin of the bass reflex. I knew that its invention by A. L. Thuras of Bell Telephone Laboratories had probably had greater influence on high-fidelity speaker systems than any other development, but details on just what he invented seemed non-existent. Finally after a fruitless search in hi-fi books and several libraries, I sent 25 cents to the U.S. Patent Office and received a copy of Patent No. 1,869,178, "A Sound Translating Device."

I eagerly examined the drawings, expecting to find the typical boxed-in speaker with a rectangular port below it in the front panel. To my surprise there was instead a series of short pipes surrounding the speaker. Not only did Thuras invent the bass reflex, but a "distributed duct" bass reflex. But the real shocker came when I looked at the patent filing date: August 15, 1930!

The more I studied the patent specifications, the more intriguing they became. The enclosure had esthetic drawbacks, such as a square face and a volume of more than 9 cubic feet, but I was convinced that the original design had unusual merit if only it could be matched to present-day speakers. Finally I decided to try, and here is the result—a smooth-operating "sound translating device" of the highest order. It is designed to operate with the University "Mustang" series of speakers.

**Construction.** The box itself is conventional. You may make minor changes in construction, but you should not change the inside dimensions. If you make any significant volume changes, good luck, but don't expect to predict a match for any particular speaker or resonant frequency from the published bass reflex charts you might have on hand. Those charts apply to single ports or ducts and are not valid for the multiple pipe baffle. I found this out when the indicated pipe length proved to be too short.

Except for the cardboard tubes, the materials are conventional and readily available. You can probably find tubes of the diameter listed at a neighborhood furniture store or rug dealer, but if the store is a small one, you may have to ask the owner to reserve one or two for you. My nearest furniture store had two empty tubes twelve feet long standing in a corner waiting for the trash collector. If you can't find tubes with the same inside diameter, you may have to use larger ones, changing the number of tubes to maintain approximately the same cross-sectional area. Or you can cut square openings and fabricate plywood ducts with inside dimensions of 1\frac{3}{16}" x 1\frac{3}{16}".
Outline drawings above show the general arrangement to use in building a duplicate of A. L. Thuras' distributed port reflex. A University "Mustang" speaker was tested in this enclosure and sounded fine. If more highs are desired because of room acoustics, mount a separate tweeter as shown at the lower right.

The first step after cutting out the parts is to screw and glue the braces or cleats to the top and bottom. The sides are then fastened to the top and bottom, using glue and screws through the corner braces into the sides. It is then possible to cut the side cleats, which serve as anchors for the front and back, to fit exactly. Incidentally, if your lumber dealer does not have pre-cut 2 x 2's, he may supply you with pieces that have been ripped from 2 x 4's. In that case the dimensions may be slightly different and require longer or shorter screws. Be sure to check the screw length.

The only part of the design which re-

---

BILL OF MATERIALS
Cut from 3/4" plywood:
2—23" x 33" pieces for front and back panels
2—15⅛" x 33⅛" pieces for sides
1—15⅜" x 24½" piece for top
1—15½" x 23" piece for bottom
Cut from fir or pine 2 x 2's (actually 1½" x 1½"):
4—10⅛" pieces for corner cleats
4—2½" pieces for top and bottom cleats
4—30" pieces (approx.—cut to fit) for side cleats
12—2½"-o.d., 1½"-i.d., 7"-long pieces of cardboard mailing tubes for pipes
1—8-1/16" x 6-1/16" piece of cardboard or wood for pattern board
1—2-3/4" x 8-5/16" piece of cardboard or wood for pattern board
Misc.—7 doz. #0 x 2" flat-head wood screws (see text), glue, grille cloth, trim, legs—if desired

1966 Spring Edition
Centers for port holes are marked out using two pattern boards. Dimensions of the boards are given in the Bill of Materials. How they are used is described below.

Bore the port holes using a heavy-duty "fly" or circle cutter with a low-speed electric drill. An Arco hole saw can be employed if the diameter of the saw matches the outside diameter of the cardboard tubes.

quires careful planning and measuring is the front baffle. I found that "pattern boards" made from scraps of plywood greatly simplified the location of the 12 holes for the pipes. First locate and draw the circle for the speaker cutout; then divide the circle into quadrants, extending the lines to the edges of the board. The middle hole in each quadrant can then be located by positioning the 6\(\frac{3}{4}\)"-square pattern board with one corner at the center of the circle and the sides bounded by the quadrant lines as shown in the photo. The other two holes in each quadrant are located by positioning the other pattern board with the longer side first on one quadrant line, then the other, keeping a corner at the circle's center (see photo).

The holes can be easily cut with a circle cutter and a large portable drill. It's possible to cut them with a small high speed drill, but such an operation is hazardous. Keep a firm control on the drill at all times and a safe distance between it and your knees or feet. Cut some sample holes in waste plywood first and check for a tight fit with a piece of tubing. When the cutting of the port holes and speaker opening is completed, glue the 7-inch tubes in place so that
The cardboard tubes should fit snugly into the port holes. The length of the tubes recommended for use with a University “Mustang” speaker is 7 inches. Glue each of the tubes in place so that the end of the tube is exactly flush with the front panel.

Ordinary plastic grille cloth is carefully tacked to the front of the enclosure. Mitered strip of molding covers the tacks and frayed ends of the cloth.

the end of each tube is flush with the front of the board. Mount the board, and you are ready to finish the cabinet.

Don't forget to use padding on at least the top, one side, and back—more if you wish. The pipes offer a convenient anchor for a particularly effective placement of padding. I made a “doughnut” of heavy cotton batting sandwiched between layers of cheesecloth and cut openings in the cheesecloth for the pipes; this suspends the sheet of batting just in back of the speaker without totally enclosing the speaker and putting a pressure compartment around it.

**Variations.** For a full-range speaker such as the University M-12T or M-12D, construct the enclosure as shown here. If you want to use a separate woofertweeter arrangement such as the M-12 "Mustang" woofer plus the T-202 super tweeter, the front panel can be inverted with the woofer and pipes in the lower part and a tweeter opening cut near the top. If you substitute other speakers, the bass resonance of the speaker should be similar to that of the "Mustang" series, or about 40-50 cycles.

If you build this enclosure, you can honestly tell your friends that it's 35 years ahead of its time.
THE SLIM

Two-speaker enclosure can be used on its side as above, or on end as seen below. Novel filters (the slotted boards) and ports furnish bass boost.

WANT to know how to pack good, strong bass, as well as clear, sparkling highs, into a speaker cabinet measuring just 10" x 10" x 36"? Interested in economy? Would you like to have a speaker system that can proudly take its place among your living room furniture, or on a convenient bookshelf? If your answer is "yes" to these questions, "The Slim Twosome" is for you.

A combination of filters and a decomposition chamber increase air column length and enhance bass response without detracting from the highs. Two full-range 6" speakers pumping in phase can move as much air as a larger speaker. The filters dampen speaker action without a build-up of excessive back pressure. The ports relieve the cabinet of internal pressures and, when properly tuned, can improve bass response, as in a bass-reflex enclosure.

Construction. Ordinary 1/2" plywood can be used for the front, back, sides, and ends. However, you may choose—as did the author—to use hardwood or veneered plywood for the "sides" (top and bottom if the cabinet is laid flat). The remaining exposed surfaces are covered with grille cloth.

First cut the two 10" x 36" side panels, taking care not to mar the outside surfaces. The cleats used to hold the

(Continued on page 70)
FREE
CATALOG.
250 "Do-It-Yourself"
Electronic Kits At
Up To 50% Savings

WHY BUILD HEATHKIT ELECTRONICS? A desire
for top-quality products at 50% savings, to be sure. But
it goes beyond that. The reason people choose Heathkit
is pride. Not just the pride of owning something new, but
something a bit better that you have created yourself!
From watching your Heathkit grow and take shape from
your own efforts. It's a labor of love and a lot of fun. The
large pictorial diagrams and simple, step-by-step instruc-
tions make it easy. And when you finish and turn it on
you'll know that unique self-satisfaction that comes with
"do-it-yourself." You will have joined the millions of peo-
ple, from ages 11 to 79, people with no special electronic
skills or knowledge, who successfully build Heathkits.
People like you! Give it a try. Your FREE Heathkit
catalog is waiting for you now.

World's Largest Selection Of Electronic Kits

NEW Low Price On Heathkit
21" Color TV . . . Only $375.00

NEW Transistor FM Stereo
Tuner That Assembles In 6
Hours Or Less . . . Only $49.95

NEW Low Prices On
Many Heathkit Stereo/Hi-Fi
Components

NEW Deluxe Shortwave
Radio . . . Only $84.95

NEW 23-Channel, 5-Watt
All-Transistor CB Transceiver . . .
Only $89.95

* See The Vast Selection Of Portable And Table
Model AM, FM and Shortwave Radios
* See The Famous Heathkit/Thomas Transistor
Electronic Organs
* See A Complete Selection Of Home & Hobby
Items . . . Intercoms, Garage Door Opener, Auto-
mobile Kits, Tools, Color TV Sets
* See All Heathkit Stereo/Hi-Fi Components . . .
Tuners, Amplifiers, Speakers, Turntables,
Car-
tidges, Furniture
* See The Full Complement Of Heath Marine
Electronics
* See The Complete Line Of Citizen's Band Radio
Gear . . . Transceivers, Walkie-Talkies, Accessories
* See The Wide Selection Of Heath Educational
Kits For Home Or Classroom Study
* See The World's Largest Line Of Amateur Radio
Gear
* See The Full Line Of Heathkit Lab & Test Instru-
ments For Home Workshop, Industrial & Educa-
tional Use

MAIL
COUPON
FOR YOUR
FREE COPY

HEATH COMPANY, Dept. 110-1
Benton Harbor, Michigan 49023
In Canada: Daysstrom, Ltd., Cooksville, Ontario
☐ Please send FREE 1966 Heathkit Catalog

Name

Address

City . . . State . . . Zip

Prices & specifications subject to change without notice

CIRCLE NO. 13 ON READER SERVICE CARD

1966 Spring Edition
Construction of enclosure is detailed at left. All panels can be made from ½” plywood, with ½”-square stock making up the cleats. Cut all pieces exactly to size; place cleats as shown for easy assembly.

tween the cleats as shown, and firmly screw them to the adjacent cleats to prevent any vibration.

Final Assembly. The ports are made of three 6” pieces of mailing tube 2” in diameter. First give them several coats of shellac, then glue them in place, filling any openings around them with sawdust and glue. Line the speaker chambers with a ¾” layer of acoustic padding on the ends, sides, and the back panel area that will cover the speaker chambers; no padding is placed on the filters or in the decompression chamber.

The front and ends of the author’s cabinet were finished by covering them with grille cloth after the bare wood was painted flat black so that shadows would not show through the cloth. The side panels can be finished to your liking.

If plywood is used for the sides, you can finish the edges very easily by covering them with “flexible wood trim” available from most lumberyards. The trim is simply glued in place with contact cement. Fit grille cloth between the sides, stapling it to the rear edge of the ends and near the edges around the front. Gold cording or molding will conceal the staples.

While the exact type of speakers you choose for your “Slim Twosome” is not overly critical, be sure to get wide-range types such as the Lafayette Radio 99 R 0028, priced at $6.25. There are other similar units which can be used.

Install the speakers, and wire them to a terminal strip on the rear panel, taking care to connect them both in the same phase—i.e., so both cones move in or out together. Small both in terms of size and the investment required, “The Slim Twosome” can be counted on to give big listening pleasure.
IF YOU are like most electronics experimenters, you spend considerable time browsing through catalogs and flyers from parts dealers and distributors. Also, if you're like the author, those tempting packages of bargain-priced transistors are just too much to resist. Sometimes we get stung, but this amplifier has proven to be an extraordinary exception—the push-pull power output transistors are commonly available TO-3 (diamond shape) types that can be purchased surplus from Poly-Paks, TAB, Transistors Unlimited, etc. The following transistors will all work well in this circuit: 2N250, 2N251, 2N256, 2N276, 2N301, 2N553, and 2N1046.

All of these transistors will give you a power output of about 3 watts without excessive distortion. (If you feel that improved performance above 10,000 cycles is necessary, use 2N1046 transistors at Q4 and Q5.) Don't forget to check the leakage of surplus transistors. Some, but not all, transistors sold for bargain prices are "seconds" and will not give you the maximum possible performance from this amplifier.

The "Bargain Page Amplifier" is a versatile little package of audio power. It may be operated from either a positive- or negative-ground 12-volt automotive supply. It can be used as a mobile public address system, modulator,
Amplifier schematic; the terminals shown with dotted lines indicate connections only—they are not actually on PC board.

PARTS LIST

C1, C2—10-μF, 15-volt electrolytic capacitor
C3—50-μF, 15-volt electrolytic capacitor
C4—1000-μF, 12-volt electrolytic capacitor
D1—1N34A germanium diode (or equivalent)
Q1, Q3—2N404 transistor (or equiv.—see text)
Q2—2N1302 transistor (or equivalent—see text)
Q4, Q5—2N250 transistor (or equivalent)
R1, R7—1000 ohms
R2—27,000 ohms
R3, R6—4700 ohms
R4—470 ohms
R5—100 ohms
R8, R9—220 ohms
R10—15,000 ohms
R11, R12—0.5-ohm (wind 15" length of #36 magnet wire on a ½-watt, 10,000-ohm resistor to shunt internal resistance)
R13—25,000 ohm trimmer potentiometer

Optional Power Supply

C5—500-μF, 12-volt electrolytic capacitor
C6—1000-μF, 12-volt electrolytic capacitor
D2, D3—50-PIV @ 1-amp. silicon diode (Mallory S-50 or equivalent)
D4—1N3022 zener diode, 12 volts at 1 watt (Texas Instruments)
Q6—2N256 transistor (or equivalent)
R11—100-ohm, ½-watt resistor
S1—S.p.s.t. toggle switch
T1—Filament transformer; primary, 117 volts a.c.; secondary, 24 volts a.c. CT

or audio amplifier. The amplifier makes a neat, practical audio system for use with a low-cost portable phonograph. The setup for such a project can be very simple—a pair of 6-volt lantern batteries, plus the amplifier tucked away in the back of a speaker baffle.

Because this unit has a wide frequency response, it can be used with wide-range speakers in a hi-fi system.

How It Works. The output transistors, Q4 and Q5, although in series with the 12-volt power supply, look like push-pull amplifiers to an audio signal. These two transistors are slightly forward-biased to minimize distortion at low volume levels. With no signal input, Q4 and Q5 draw about 15 ma. At full volume output with this circuit, the output transistors will draw up to 400 ma. The mode of operation is Class AB2; transistor Q4 can be thought of as amplifying the negative portion of the audio signal and Q5 as amplifying the positive portion.

Transistor Q2 is a phase inverter as
Using template above, you can etch your own circuit board—or you can get one from DEMCO (see photograph below). The address is given in the Parts List at left.

Using dirt-cheap transistors, this amplifier can produce 3 watts without a heat sink by running the power output transistors far below their maximum rating.

well as a low-impedance driver amplifier. Transistor Q3 performs a similar function sans the phase inversion. Voltage amplification to drive these two transistors is provided by Q1. The collector of Q1 is fed directly to the base of Q2 and through D1 and R5 to the base of Q3.

Diode D1 performs two functions: it provides slight forward bias (with R5) and also acts as a temperature compensator. The voltage drop across the diode decreases as the temperature of the whole amplifier increases. This counters the thermal runaway possibilities of this type of circuit.

Both d.c. and a.c. feedback are used between the output and input transistors. Resistor R2 provides a d.c. path and capacitor C1 an a.c. path. Feedback lowers distortion, improves stability, and broadens the frequency response. Total feedback is about 20 db.

Construction. A printed circuit board on which to build this amplifier is available from the author at a modest charge. Construction time is thereby reduced to less than one hour and the chances of wiring errors or unwanted feedback are eliminated completely. A board can be made in your own workshop following the layout shown above. Point-to-point wiring with Vectorbord® and push-in terminals can be used if care is exer-
with 74 ELECTRONIC
rent or power supply and
stalling the
ments and selling
transistors manufactured
Q5
and
substitutions
work
transistors will
indicate
The amplifier can be
driven from any source
providing 0.5 volt of
signal; connect a carbon
mike as shown here.

Check your power trans-
sistors for leakage with
the simple circuit
right. A zero read-
ing, or more than 1
ma. of leakage current,
indicates that the
transistors will not
work in the amplifier.
cised to reduce the possibility of the
wiring introducing feedback.
You can make a number of possible
substitutions at Q1, Q2, and Q3. Each
must have at least a 12-volt breakdown
(V_{CEO} in the RCA Transistor Manual),
and in the case of Q2 and Q3, a current
gain of 50 or more. Transistors Q4 and
Q5 are equivalent to 2N1038-1 transis-
tors manufactured by Texas Instruments and selling for about $3 apiece.

Testing and Installation. Before install-
ing your bargain transistors, it is a good
idea to test them for excessive leakage
using the circuit shown above. If the
meter reading is either zero or over 1
ma., the transistor should not be used in
this amplifier. Transistors with leak-
age currents of between 0.1 and 0.8 ma.
are O.K.

After assembling the amplifier and in-
stalling the transistors, connect a 0-100
milliammeter in series with the battery
or power supply and the amplifier. Cur-
rent drain should be from 20 to 50 ma.
with no signal input. If the drain ex-
ceeds 50 ma., reduce the value of R5 to
47 or 68 ohms. On the other hand, if the
current drain is below 20 ma., increase
R5 to 120 or 150 ohms.

Emitter stabilizing resistors R11 and
R12 reduce the chances of thermal run-
away of Q4 and Q5. These very low ohm
resistors are wound from 15" lengths
of ±36 magnet wire on the body of a 1/2-
watt resistor with a value of 10,000 ohms
or greater. Solder the ends of the mag-
net wire to the resistor leads so that the
length of wire shunts the internal resist-
ance.

Another test to improve the fidelity of
your “Bargain Page Amplifier” may be
performed after it is assembled. Cou-
ple the amplifier to a 1000-cycle audio
input source and a 4-ohm resistive out-
put load. Also connect the input of an
oscilloscope across the output and drive
the amplifier from the 1000-cycle source
until sine-wave clipping occurs. If the
clipping is not symmetrical on the posi-
tive and negative portions of the wave-
form. Adjust R13 for symmetrical clip-
ing. If no signal generator or oscillo-
scope is available, adjust R13 to obtain
a 6-volt reading at the collector terminal
of output transistor Q5.

Using the Amplifier. The printed cir-
cuit board may be mounted on metal or
insulated standoffs and bolted to an ap-
propriate size chassis. The small size
of the amplifier and the modest power
requirements make it suitable for many
applications. If a power supply for 117-
volt a.c. operation is not available, a
power supply with zener diode regula-
tion can be built using the parts and
circuit shown at the top of this page.

The power output of the “Bargain
Page Amplifier” will depend upon the
speaker impedance—even though the
amplifier can be used with any 4-, 8-, or
16-ohm voice coil speaker. However,
the amplifier is a good match for a 4-
ohm speaker. If an 8-ohm speaker is
used, the maximum power output will
only be 1.5 watts; and with a 16-ohm
speaker, the output will be 0.75 watt
maximum. Of course, you can always
parallel two 8-ohm speakers for opti-
mum output.

WARNING: Do not short the output
connections. Do not submit the ampli-
tier to sine-wave inputs of 10 kc. or more
for over two seconds.
What most people don’t know about hi-fi kits could fill a book.

This one. (And it’s free!)

FREE! $1.50 VALUE! 32 PAGES! The New Kit Builder’s Manual is a completely new version of the authoritative Fisher guide to high-fidelity kit construction. It is new in format, twice as long in content, and contains detailed specifications of all Fisher StrataKits. Here is an introduction to kit building presented in a manner so nontechnical and lucid, even your wife will understand it. Included are comprehensive, illustrated articles on every phase of assembly, wiring and soldering. The New Kit Builder’s Manual is the handiest tool a do-it-yourself audiophile can have: the first thing you need before investing in stereo amplifier, tuner or loudspeaker kits.

Mail this coupon today for your free copy of The New Kit Builder’s Manual!

Fisher Radio Corporation
11-35 45th Road, Long Island City, N.Y. 11101
Please send me The New Kit Builder’s Manual without charge or obligation.

Name
Address
City State

OVERSEAS RESIDENTS PLEASE WRITE TO FISHER RADIO INTERNATIONAL, INC., LONG ISLAND CITY, N.Y. 11101.

The Fisher

CIRCLE NO. 10 ON READER SERVICE CARD
THE Stereo Bal is designed to solve two common hi-fi/stereo problems. The first concerns system balance. Unless your stereo speakers are fed a balanced diet of power—the same amount to each speaker—you'll get off-center sound, and musical instruments will be reproduced either with incorrect perspective or incorrect volume.

The second problem that the Stereo Bal will solve involves FM-stereo broadcasts. Very few of the early FM-stereo tuners or receivers had built-in indicators to tell you whether or not the station being received was broadcasting in stereo. And even fewer of the multiplex adapters that converted standard FM tuners to stereo were equipped with stereo indicators.

What was needed was a simple, inexpensive (under $4), and practically foolproof gadget that could do both those jobs—and that is how the P.E. Stereo Bal came to be.

How It Works. To achieve stereo reproduction, there obviously must be a difference between the signals fed to the two speakers. Let's call the signal fed to the right speaker "A" and the signal fed to the left speaker "B." Any difference between the two signals represents the stereo information and is usually referred to as the "difference" signal or the A—B signal.

If an a.c. voltmeter were connected to the speaker terminals of a stereo amplifier (from the 16-ohm tap of one to the 16-ohm tap of the other), the meter would read no voltage as long as the same signal at the same strength appeared across the two 16-ohm terminals. However, as soon as there was any difference between the signals coming out of the amplifiers, the meter would respond.

That explains where the difference signal comes from, but how do we use it in the Stereo Bal? Instead of an expensive, easily damaged meter, we use a step-up transformer (T1) to soup up the very small difference voltage sufficiently to light a neon lamp.

Construction. An inexpensive type of transformer that proved ideal for the soup-up job is one that normally serves as an input transformer for tube intercoms. Transformer T1 is connected with its high-impedance side to the neon lamp. Control R1 adjusts the sensitivity of the Stereo Bal in accordance with the loudness of the program being played.

Depending upon the type of neon-lamp pilot assembly used for I1, you may find that resistor R2 is already built into the assembly and hence need not be added. As an inexpensive alternative to using a pilot-lamp assembly, you can make a socketless mounting by press-fitting an NE-2 lamp into a rubber grommet. In that case, simply solder R2 to one lead of the lamp. Do not use an NE-51 as this lamp is quite fragile.

Parts layout is not critical. In fact, the Stereo Bal's few components can be mounted on a panel rather than in the small metal box shown in the model. The sole precaution that might be
It's a tight fit, but all of the Stereo Bal components can be squeezed into a miniature aluminum box. Although the author used a small wire-wound potentiometer for R1, a carbon unit could be employed.

The Stereo Bal is fed from the 16-ohm output taps of each amplifier. There's no common ground return.

**PARTS LIST**

- **I1**—NE-2 neon lamp or neon-lamp pilot assembly—see text
- **R1**—75- or 100-ohm potentiometer (taper and value not critical)
- **R2**—33,000- or 47,000-ohm, 1/2-watt resistor—see text
- **T1**—Intercom input transformer, voice coil to grid (Stancor A-4744 or Thordarson 20A04)
- **Cabinet** (Premier ECM-1000)
- **Misc.**—Two-conductor speaker wire to reach from Stereo Bal to amplifier, hardware, etc.

necessary is to avoid mounting T1 too close to a power transformer or phono motor.

The leads from the Stereo Bal should be connected to the highest impedance speaker taps on your amplifier irrespective of which taps the speakers are connected to. If you are using two separate (Continued on page 133)
NOW...GET THE FINEST
STEREO TEST RECORD ever produced
for just ...$4.98

Featuring Tests Never Before Available
To The Hobbyist

Why We Make the Model 211 Available Now

Although there are many stereo test records on the market today, most critical checks on existing test records have to be made with expensive test equipment. Realizing this, HiFi/STEREO REVIEW decided to produce a record that allows you to check your stereo rig, accurately and completely, just by listening! A record that would be precise enough for technicians to use in the laboratory—and versatile enough for you to use in your home.

The result: the HiFi/STEREO REVIEW Model 211 Stereo Test Record!

Stereo Checks That Can Be Made With the Model 211

- Frequency response—a direct check of eighteen sections of the frequency spectrum, from 20 to 20,000 cps.
- Pickup tracking—the most sensitive tests ever available to the amateur for checking cartridge, stylus, and tone arm.
- Hum and rumble—foolproof tests that help you evaluate the actual audible levels of rumble and hum in your system.
- Flutter—a test to check whether your turntable’s flutter is low, moderate, or high.
- Channel balance—two white-noise signals that allow you to match your system’s stereo channels for level and tonal characteristics.
- Separation—an ingenious means of checking the stereo separation at seven different parts of the musical spectrum—from mid-bass to high treble.

ALSO:

Stereo Spread
Speaker Phasing
Channel Identification

PLUS SUPER FIDELITY MUSIC!

The non-test side of this record consists of music recorded directly on the master disc, without going through the usual tape process. It’s a superb demonstration of flawless recording technique. A demonstration that will amaze and entertain you and your friends.

UNIQUE FEATURES OF HIFI/STEREO REVIEW'S MODEL 211 STEREO TEST RECORD

- Warble tones to minimize the distorting effects of room acoustics when making frequency-response checks.
- White-noise signals to allow the stereo channels to be matched in level and in tonal characteristics.
- Four specially designed tests to check distortion in stereo cartridges.
- Open-air recording of moving snare drums to minimize reverberation when checking stereo spread.

All Tests Can Be Made By Ear

HiFi/STEREO REVIEW’s Model 211 Stereo Test Record will give you immediate answers to all of the questions you have about your stereo system. It’s the most complete test record of its kind—contains the widest range of check-points ever included on one test disc! And you need no expensive test equipment. All checks can be made by ear! Note to professionals: The Model 211 can be used as a highly efficient design and measurement tool. Recorded levels, frequencies, etc. have been controlled to very close tolerances—affording accurate numerical evaluation when used with test instruments.

DON’T MISS OUT—ORDER NOW

The Model 211 Stereo Test Record is a disc that has set the new standard for stereo test recording. There is an overwhelming demand for this record and orders will be filled by POPULAR ELECTRONICS promptly upon receipt. At the low price of $4.98, this is a value you won’t want to miss. Make sure you fill in and mail the coupon together with your check ($4.98 per record) today.

FILL IN AND MAIL TODAY!

Stereo Test Record
POPULAR ELECTRONICS—Dept. SD
One Park Ave., New York 16, N.Y.

Please send me _______ test records at $4.98 each. My check (or money order) for $___________ is enclosed. I understand that you will pay the postage. (Orders from outside the U.S.A. add 50c to partially defray postage and handling costs.) N.Y.C. residents please add 5% sales tax. N.Y. State residents 2% sales tax.

Name ___________________________ (Please Print)
Address__________________________
City __________________ Zone ______ State ________

Sorry—No charges or C.O.D. orders!

78
The two articles in this chapter were written to take the mystery out of radio control circuitry. Both the transmitter and receiver are transistorized and have been designed for printed circuit board construction. Your editors believe that use of printed circuit boards is mandatory to insure faultless operation.

Construction of these two projects will give the builder a good idea of how radio control works and will probably suggest many uses for it other than models or garage door openers.

In the Fall 1966 issue of this HANDBOOK, your Editors will present several Science Fair projects instead of R/C projects.

BUILD A MINIATURE R/C RECEIVER

By DANIEL MEYER

You can control models and other gadgets on land, at sea, or in the air, with this 1 1/2-ounce, three-transistor receiver.
LESS THAN half the size of a package of cigarettes, this lightweight, three-transistor radio-control receiver can be used in cars, boats, and in the home. It's suitable for remote operation of toys, models, garage doors, or any other control application you might have. The receiver circuitry contains a sensitive superregenerative detector, a tone-modulated selector, and a relay in the output. Its small size is made possible by the use of transistors and a printed circuit board—which allows quick assembly of components.

The R/C receiver is operated by a 600- to 800-cycle tone-modulated carrier on the 27-mc. remote-control channels. This type of operation makes it possible to use the rather broad tuning superregenerative detector without interference problems. Voice modulation even on the same channel will almost never energize the receiver relay. A continuous tone in the proper frequency range must be received before the relay will operate.

How it Works. Transistor Q1 acts as a superregenerative detector, which oscillates at a frequency determined by tuned circuit LI and C4. Oscillation is quenched (cut off) at an ultrasonic rate, which is determined by the values of the base bias and emitter resistors and their associated bypass capacitors (R2, R3, C3 and C6). Capacitor C5, connected to the emitter and collector of Q1, provides the feedback needed to sustain oscillation.

The antenna is loosely coupled to the tuned circuit by C1. The loose coupling reduces antenna loading effects on the tuned circuit. Capacitor C2 filters out the r.f. carrier and quench signals, and leaves just the detected tone modulation across the primary of T1.

The tone signal is transformer-coupled to the base of audio amplifier Q2. Transformer T2 delivers the signal from the collector of Q2 to the base of Q3. Transistor Q3 conducts in the presence of

Flexible wire connected between the external components and relay board will prevent breakage due to vibration. Shock-mount unit with foam rubber.

Detail drawing shows location and connection of R7 and C11, as well as how to hook up external circuit. Do not exceed current rating of relay contacts.

80 ELECTRONIC EXPERIMENTER'S HANDBOOK
Transistor Q1 is part of a sensitive superregenerative detector which demodulates a tone-modulated control signal. The tone burst only is then amplified by Q2 and passed on to Q3 to activate the relay.

**PARTS LIST**

- C1—10-pf, ceramic capacitor
- C2, C9—0.02-mf, 50-volt ceramic capacitor
- C3—0.001-mf, ceramic capacitor
- C4, C5—62-pf., NPO ceramic capacitor
- C6, C8, C11—0.01-mf, 50-volt ceramic capacitor
- C7, C10—30-mf, 15-volt electrolytic capacitor
- K1—100-ohm sensitive relay (Jasco Products Co., Chicago, or equivalent)*
- L1—7¾ turns of #26 enameled wire on 0.20" diameter coil form. with powdered iron tuning core*
- Q1—2N2188 transistor
- Q2, Q3—2N2430 transistor
- R1, R4—4700-ohm, ½-watt resistor
- R2—1000-ohm, ½-watt resistor
- R3—330-ohm, ½-watt resistor
- R5—470-ohm, ½-watt resistor
- R6—100-ohm, ½-watt resistor
- R7—10-ohm, ½-watt resistor
- RFC1—22-µh, r.f. choke*
- T1, T2—Miniature interstage transformer: primary, 10,000 ohms; secondary, 2000 ohms*
- T1—Printed circuit board*

* A set of parts consisting of a predrilled printed circuit board, T1, T2, L1, RFC1, and K1 is available for $9 pp. from Daniel Meyer, Box 16041, San Antonio, Texas 78216
the tone signal, specifically the positive half cycles, and energizes the relay 

(\textit{K1}).

\textbf{Construction.} Use of a printed circuit fiberglass board makes the receiver very rugged and compact, and easy to build. Start construction by mounting the transformers. Be careful not to pull the leads out of the transformers or to cut the wires when stripping the insulation. The blue and red leads are the primary side and should be installed in the transformer lead holes next to \textit{C2} and \textit{C9}. Bend the tabs on the transformer brackets to grip the board.

Next, install the tuning coil (\textit{L1}) and the r.f. choke (\textit{RFC1}). Do not use too much force on the coil, to avoid pulling the lugs out of the coil form. Install the three transistors, making sure that the leads are in the correct holes. Basing for all three transistors is shown on the schematic. Some transistors have a red dot next to the collector lead.

Now install the capacitors and observe polarity, particularly for \textit{C7} and \textit{C10}. Install the resistors and mount the relay. The relay coil is connected to the holes in the board with short pieces of bare wire.

Bend all component leads to grip the board, and trim. Solder all connections and avoid bridging adjacent conductors.

The antenna lead can be any piece of wire 18 inches or longer. Use of lightweight wire on the order of No. 26 AWG to interconnect the receiver to external components will keep the wiring bundle small and flexible and better able to withstand vibration. Mount the receiver in a small plastic box to prevent dust from getting into the relay.

Almost any type of actuator used with this receiver will require an arc suppression network to protect the relay contacts. This network consists simply of a 10-ohm resistor (\textit{R7}) and a 0.01-\mu\textit{f.} capacitor (\textit{C11}) across the relay points.

\textbf{Using the R/Ceiver.} If the R/Ceiver is to be used in a model airplane, it should be shock-mounted with foam or rubber material. There are many types of actuators available for use in model airplanes, cars and boats. Airborne actuators are usually of the rubber-band powered escapement type and are light in weight. Motor-driven types are generally used in cars or boats where more power is needed and weight is not a problem.

Self-neutralizing types of actuators provide alternate right and left control. Compound types provide right-side control on the first burst of tone signal, left with the second, and motor control with the third. This makes it unnecessary to remember what the last control position is. You just press the transmitter key once for right, twice for left, or three times for motor. The mechanism cycles back to neutral when the tone signal stops.

If the R/Ceiver is to be used for garage door operation or some other application requiring maximum security, cut down the size of the antenna. The receiver should not be allowed to pick up any signals that are weaker than your own weakest signal. You can make this adjustment by transmitting a signal at maximum range, then trimming the antenna and increasing the relay spring tension until the receiver will just operate.

\textbf{Final Adjustments.} The receiver needs 2.8 to 3.6 volts to operate. Two standard 1.5-volt cells in series can be used. (A separate power supply should be employed for the device being controlled.)

To check out the receiver, connect the batteries and put a weak signal on the air from your transmitter, or from a signal generator tuned to the proper frequency. The signal is amplitude (600- to 800-cycle) tone-modulated at a frequency within the range of 26.995 to 27.255 mc., in conformance with proper Class C operation. Modulation should be at least 85%.

Tune \textit{L1} until the relay pulls in. Use a fiber or plastic-tip tuning tool to avoid loading and detuning effects. As you rotate the core into the coil, count the number of turns from the point where the relay first pulled in to the point where the relay drops out. Back up the core to a mid position, half the number of turns you counted.

It is very important to use a weak signal when tuning. If the signal is too strong, the tuning range will seem to be very broad, and it will be hard to find the best core setting. An alternate method of tuning is to connect a high-impedance phone across the secondary of \textit{T2} and tune for the loudest tone. 

82

\textit{ELECTRONIC EXPERIMENTER'S HANDBOOK}
R/C TRANSMITTER

By DANIEL MEYER

Transmitter sends tone-modulated signals up to 1 mile to energize miniature R/Cceiver

THIS TRANSMITTER is designed to operate with the miniature R/Cceiver described on pages 79-82. It can also activate any other receiver using tone-modulated signals in the Citizens Band, and can be operated without a license under Part 15.205 of the FCC Regulations. Transmitter output is approximately 90 milliwatts, more than enough to control a model up to one mile, line of sight, with the proper receiver.

The unit is powered by a 9-volt battery, and up to 20 hours of operation can be had with a No. 276 Eveready battery or equivalent. Weight of the complete transmitter including battery is a trifle over 1½ pounds. Cost of parts should not be more than $10 to $12.

Construction. Thanks to the availability of a special printed circuit board and pre-wound coils, construction is easy. The parts are mounted in the positions indicated by the part numbers printed on the top side of the printed circuit board. (See Figs. 1 and 2.)

The primary side of coil L1, indicated by a red dot, should be installed next to capacitor C2. Coil L2's connections are between point B and RFC1. When installing the coils, be careful not to apply too much pressure on the lugs. Work
the lugs into the holes slowly, by rock-
ing the form as it is pushed down. Rough handling can break the lugs loose from the coil form base.

After all parts are installed, bend the leads flush to the foil side of the board and cut them off so that they do not bridge any gaps between conductors. Solder the leads to the etched foil with a 25- to 50-watt iron. Use only rosin-core solder. Heat the lead being soldered and the foil at the same time and let the solder flow onto the connection. Avoid excess heat: it can cause the foil to separate from the board.

Drill out all the openings in the metal cabinet as shown in Fig. 4. Use a file to square off the opening for the switch. And use a wooden block behind the metal to prevent distorting the case when drilling or filing. The prototype transmitter is covered with a white self-adhesive vinyl plastic sheet.

Mount the rubber feet, switches, threaded spacers and antenna post as shown in Fig. 4. The antenna post is an 8-32 x ¾” panhead machine screw. It should be installed with a fiber shoulder washer on one side and a flat fiber washer on the other side of the metal to insulate the antenna from the case. Don't forget the solder lug between the head of the antenna screw and the fiber washer. Then wire in the battery clip and other leads.

Mount the circuit board on the two threaded spacers with 6-32 x ¾” machine screws as shown in Fig. 5. Connect the wires from the antenna, switches, and battery to points A, B, C and D as indicated on the board.

**How It Works.** Transistor Q1 acts as a crystal-controlled oscillator operating on the channel determined by the crystal. Coil L1 and capacitor C2 form a resonant circuit at the crystal frequency. The crystal provides a feedback path from the collector to the base of Q1. Resistors R1 and R2 establish the bias at the base of Q1. Capacitors C1 and C3 bypass r.f., as shown in Fig. 6.

The output stage (Q2) operates as a Class C amplifier. The base is link-coupled by L1, and resistor R4 limits the current through Q2 to a safe value. Collector voltage is obtained by way of T1 and the r.f. choke. The tuned output stage consists of L2 and stray antenna capacitance connected in series; this has a bearing on antenna resonance.
The tone generator stage (Q3) is an audio power oscillator. The auto-transformer (T1) provides feedback to the transistor base by way of R7 and C5. Capacitor C4 acts as an r.f. bypass. The emitter of Q3 is connected to the Tone switch. Closing this switch completes the emitter circuit and operates the tone oscillator.

**Tuning the Transmitter.** The transmitter can be tuned with a field strength meter, or if one is not available, with a tuning meter you can easily make. The circuit is shown in Fig. 7.

The field strength meter can be loosely coupled to the transmitter circuit, while the less sensitive tuning meter would have to be connected to the antenna. You may or may not get a reading on the meter when the transmitter is turned on for the first time. If no reading is noted, turn the core in coil L1 until you do get a maximum reading. Use a non-metallic tuning tool to make adjustments.

If everything is working normally, the output should reach a maximum and then suddenly drop to zero as you rotate the core. When this happens, return the core to a point a bit less than maximum. If you attempt to peak the oscillator, it will probably refuse to start after the power is turned off and then turned on. Then tune coil L2 for maximum output.

All adjustments should be made while you are holding the case. Your body is part of the antenna circuit on this type of transmitter and adjustments must be made under in-use conditions.

After adjusting the coils, press switch 32. If the meter reading drops slightly...
THE MOST COMPLETE AND UP-TO-DATE GUIDE TO THE EXCITING WORLD OF SPECIALIZED RADIO COMMUNICATIONS!

ONLY $1.25

4 FACT-PACKED SECTIONS
Short Wave Listening
Amateur Radio
Citizens Radio Service
Business Radio Service
148 PAGES...

All-new and better than ever, the 1966 COMMUNICATIONS HANDBOOK brings you exclusive information on such vital subjects as getting started in SWL—buying equipment and station reporting; establishing your CB station, public service activities; ham license applications procedures, learning the code; typical business radio installations;...

PLUS a special nation-wide listing of 250 amateur radio clubs offering code and theory courses and a roster of 400 CB clubs—both lists available nowhere else!...

...and much, much more. Everything you need to know about your specialty is covered by a leading authority in the field—from basic instruction for the beginner through the most advanced data and techniques.

Complete with charts, tables and illustrations galore, it's a big, valuable "encyclopedia" of communications information you'll use all year long.

Just what you've been looking for? Then clip the handy coupon below and send for your copy today!

Ziff-Davis Service Division • Dept. CH
589 Broadway • N.Y., N.Y. 10012

YES! Send me a copy of the 1966 COMMUNICATIONS HANDBOOK, as checked below:

$1.25 enclosed, plus 15¢ for shipping and handling. Send me the regular edition. ($1.50 for orders outside the U.S.A.)

$3.00 enclosed. Send me the Deluxe Leatherflex-bound edition, postpaid. ($3.75 for orders outside the U.S.A.) Allow three additional weeks for delivery.

NAME
ADDRESS

CITY STATE ZIP

PAYMENT MUST BE ENCLOSED WITH ORDER.
the audio oscillator is probably working. This can be confirmed with a CB receiver if one is available.

**Operation.** Extend the antenna all the way, turn on the switch, and press the Tone button. Reduced antenna length will reduce the output. Check the battery periodically. If the battery voltage drops below 8 volts with the transmitter and the tone oscillator on, replace the battery.
COMMUNICATIONS ANTENNAS
...where all BIG signals come from!

High Frequency Antennas For 10 Thru 80 Meters
Anywhere in the world you want to talk, there's a Hy-Gain antenna designed to provide you with maximum performance from your Amateur Radio equipment. Automatic Band Switching Verticals—Duo-Beams—Tri-Bander Beams—Multi-Band Trap Doublets—Famous "Topper" Mobile Whips PLUS many, many more ranging from standard ground planes to the incomparable DX "Long John" optimum spaced beams for the Ham who wants the whole world at his fingertips. All pictured and described in Hy-Gain's FREE 16-page Catalog No. 200.

VHF Antennas For 6 and 2 Meters
For maximum performance across town or using moon bounce, Hy-Gain VHF antennas will deliver the strongest signals for you. Gain Ground Planes—Gain Stacked Jay-Poles—Mono-Band Beams—Base Station and Mobile Halos—Duo-Band Beams—Duo-Band Mobile Whips—and, a host of others. All pictured and completely described in Hy-Gain's FREE 16-page Catalog No. 100.

Base Station and Mobile Antennas for CITIZENS BAND
Fabulous New Directional Duo-Beams—Deliver up to 120 watts "Talk Power"—Effectively block off signals from the side and back—Rotate to concentrate maximum power with pinpoint accuracy 360° on the compass—Guaranteed to out-perform any other base station antenna for Citizens Band. Three models to choose from...all pictured and fully described with important comparison data in Hy-Gain's FREE Catalog No. 13.

World Famous CLR2—Delivers all-directional "Talk-Power" of 12.55 watts—Keeps you constantly alert to signals from all directions surrounding your station—Has 9% wavelength radiator acknowledged as essential for maximum efficiency—Guaranteed to out-perform any other all-directional antenna for Citizens Band. Completely described with important comparison data in Hy-Gain's FREE Catalog No. 16.

Pace Setting Mobile "Toppers"—Roof Mounts, Trunk Mounts, Fender Mounts, Cowl Mounts, Marine Mounts, AM-CB combinations. All models guaranteed to out-perform any other mobile antenna of comparable length and mount. Each model pictured and fully described with important comparison data in Hy-Gain's FREE Catalog No. 15.

Short Wave Listener Antennas
Precision engineered and tuned antennas designed to provide maximum short wave listening enjoyment on all of the popular bands from 1.8 thru 30 mc. Two popular models to choose from for world-wide performance...one for outdoor or attic installation...one for window sill or portable applications where space is a factor. Both models completely described in Hy-Gain's FREE Catalog No. 20.

Hy-Gain ELECTRONICS CORPORATION
8575 N.E. Highway 6—Lincoln, Nebraska 68501
Rush the following literature to me:
□ HF Catalog No. 200 □ "Topper" Catalog No. 15 □ CLR2 Catalog No. 16
□ Duo-Beam Catalog No. 13 □ VHF Catalog No. 100 □ SWL Catalog No. 20

NAME
ADDRESS
CITY STATE ZIP

SEND COUPON TODAY
Indicate the material you wish to receive—or, contact your Hy-Gain distributor!
The World's Largest Manufacturer of Communications Antennas

CIRCLE NO. 14 ON READER SERVICE CARD
There’s a very definite 2-meter ham band tone to this chapter. It is by no means accidental; rather, it was arranged by intent so that the article describing W8VVD’s 144-mc. transmitter would be supplemented by suitable ideas on antennas.

For local work, try the “Stacked Halos” (page 103). For modest DX’ing, the “Swiss Quad” (page 104), a distant relative of the famous Cubical Quad, is worth an afternoon’s construction. Another ham, W6FPO, presents some very interesting experimental broadcast-band DX’ing antennas (page 101).

The avid builder who likes to “roll his own” should try the “Miniature Receiver” (page 97) built around the J.W. Miller ceramic i.f. module. The “Auto Light Minder” was slipped into this chapter at the last moment—simply to fill out the page: it really belongs under the Chapter 1 heading.
BUILD
THE
PARAGON 144

Would you like to put a truly effective phone signal on 2 meters? Here's a little rig that's ideally suited for Novice, Technician, or General

By HARTLAND B. SMITH, W8VVD

WHETHER you're a Novice weary of pounding brass, a Technician fed up with 6-meter TVI complaints, or a General tired of ear-shattering QRM, there's an answer to your problem: 2-meter phone. Even if you don't live in an area where there's much 2-meter activity, it will pay you to keep a 2-meter rig on the shelf just to take advantage of VHF band openings, and possibly the satellite repeater capabilities of OSCAR III and other ham satellites to follow.

As long as you're going to give 2 meters a whirl, you'll want a transmitter that radiates a truly effective signal. The "Paragon 144," rated at 20 watts input on AM phone, has been designed to do just that. Thanks to its relatively simple circuitry, straightforward parts layout and ease of adjustment, any reader who can drill, file, saw and solder will have little difficulty in putting it on the air.

The Circuit. Referring to the schematic on page 93, V1a, a triode oscillator, utilizes third-overtone crystals cut for about 36 mc. Pentode V1b doubles the oscillator frequency to around 72 mc.; V2 serves as a second doubler, boosting the frequency to 144 mc. An Amperex 6360 twin-tetrode, V3, is used as a self-neutralized push-pull final power amplifier.

Audio from the microphone is amplified by V4a and V4b and is then applied to the grid of the Class A Heising modulator, V5. An ordinary filter choke, rather than an expensive modulation transformer, superimposes audio from the modulator onto the d.c. power fed to the final amplifier.

An 0-5 ma. meter (M1) may be clipped across a number of different shunt resistors to indicate final plate current, final grid current, and the plate currents of either the first or second doubler. (These test points are indicated on the schematic as "TP1," "TP2" etc.) Silicon diodes D1 through D6 serve as power supply rectifiers.

Chassis Preparation. Long leads and haphazard parts placement cannot be tolerated in a 2-meter transmitter: carefully follow the layout diagramed in Fig. 1 and Fig. 2. The 3" x 8" x 12" chassis should be of aluminum rather than steel—aluminum is easier to work and exhibits better conductivity than steel.

Before mounting the tube sockets, study Fig. 3 to make certain the pins are correctly oriented. The rotor of C13 is hot with r.f., so it cannot be fastened directly to the chassis. Cut a ¾" x 1¼" piece of insulation from a sheet of %" polystyrene or Bakelite. Mount C13 in a hole drilled at the center of the insulator and then fasten the insulator to the chassis as shown in Fig. 7. Make certain the %" nut on the threaded shaft bushing of C13 clears the edges of the %" chassis hole (see Fig. 5) through which it protrudes.

Wiring. Wire the heaters first. Cut the green-yellow transformer wire to a length of about an inch and tape the end to prevent it from shorting against another wire or component. Ground one green wire to the mounting foot of the 4-
Fig. 1. Diagram shows cutouts, mounting holes in top of chassis. At front, from left to right, are V4, V1, V2, V3. Large hole at top left is for mounting V5; opposite are cutouts for T1 and for capacitor C25.

Fig. 2. Cutouts in front panel are (left to right) for mike jack, audio gain control, meter, on-off switch, and send-receive switch. Those on the rear are for mounting TS1, the a.c. line cord, and TS2.
### PARTS LIST

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS1, TS2</td>
<td>2-screw terminal strip</td>
</tr>
<tr>
<td>V1</td>
<td>6AU8A vacuum tube</td>
</tr>
<tr>
<td>V2</td>
<td>5763 vacuum tube</td>
</tr>
<tr>
<td>V3</td>
<td>Amperex 6360 or 6360A vacuum tube</td>
</tr>
<tr>
<td>V4</td>
<td>12AX7A vacuum tube</td>
</tr>
<tr>
<td>V5</td>
<td>6L6GC vacuum tube</td>
</tr>
<tr>
<td>Xtal</td>
<td>Third overtone crystal for a frequency between 36 and 37 mc. (36.250 mc to 36.750 mc for technicians and Novices)</td>
</tr>
</tbody>
</table>

---

**R1** - 39,000-ohm resistor  
**R2** - 100,000-ohm, 1-watt resistor  
**R3** - 100,000-ohm resistor  
**R4, R7** - 68,000-ohm, 1-watt resistor  
**R5, R8** - 82-ohm resistor  
**R6** - 47,000-ohm resistor  
**R9** - 15,000-ohm resistor  
**R10** - 150,000-ohm resistor  
**R11** - 56,000-ohm, 1-watt resistor  
**R12** - 20,000-ohm, 1-watt resistor  
**R13** - 39-ohm resistor  
**R14** - 100,000-ohm, 20-watt resistor  
**R15, R16, R17, R18, R19, R20** - 220,000-ohm resistor  
**R21** - 100-ohm, 20-watt resistor  
**R22** - 270,000-ohm, 2-watt resistor  
**R23, R27** - 120,000-ohm resistor  
**R24** - 2.2-megohm resistor  
**R25, R31** - 330,000-ohm resistor  
**R26** - 500,000-ohm potentiometer  
**R27** - 8200-ohm resistor  
**R29** - 1000-ohm resistor  
**R32** - 150,000-ohm resistor  
**R33** - 200-ohm, 10-watt resistor  
**RFC1, RFC2** - 1.5-µf., r.f. choke (Ohmite Z-144)  
**S1** - S.p.s.t. slide switch  
**S2** - D.p.d.t. slide switch  

---

**All resistors**  
½-watt, 10%, unless otherwise specified.
Fig. 4. The Paragon 144 uses V1a as a triode crystal-controlled oscillator, V1b as doubler, and V2 as second doubler. The 144-mc. output of V2 is fed to V3, a 636G twin-tetrode serving as a push-pull power amplifier. In the speech section, V4a and V4b amplify the mike output, while V5 serves as a Heising modulator. A total of 20 watts input can be run with the unit.
Fig. 5 (top). View of chassis top shows location of r.f. coils and capacitors, as well as other major components. Text describes how to tune up stages.

Fig. 6 (center). Photo of left side of chassis, as viewed from bottom, shows sockets of V1 and V4 and associated components; also note J1, R26, and M1.

Fig. 7 (bottom). Right side of chassis (from below) shows shield across 6360 socket, polystyrene insulator used to mount C13. Note coils L3, L4, L5, L6.

lug terminal strip on the rear edge of the chassis (see Fig. 3). Run the other green wire to pin 4 of V1. Connect one branch of the heater line to pin 5 of V2, and then to pins 4 and 5 of V3. Run the other branch first to pins 4 and 5 of V4, and then to pin 2 of V5. Cut off and tape the yellow transformer wires.

The long wires going to S1 and S2, as well as those carrying d.c. to various parts of the circuit, should be kept out of the way by running them along the chassis edge. Be sure to observe correct polarity when wiring in diodes D1 through D6, and the electrolytic capacitors (including C14).

Solder all chassis connections associated with V1, V2, V3, and V4 directly to the socket mounting flanges. Run each ground lead from the specified tube pin to the nearest point on the flange. Ground the metal center post of each miniature socket. Shorten the leads of the 0.001-µf. bypass capacitors until they barely reach the appropriate terminals and the socket flanges.

Wind all coils, except L5 and L6, with No. 20 solid tinned wire obtained by stripping insulation from the hookup wire you are using. Space the winding of L1 (wound on a slug-tuned coil form) sufficiently to prevent the turns from shorting against one another. Coat the finished coil with polystyrene cement.

Use a penlight cell as a temporary winding form for the balance of the coils. After each has been completed, stretch it lengthwise until the turns are spaced 1/4" apart.
Solder one end of L2 to C5’s stator support rod nearest V1 (see Fig. 6). The opposite end of this coil goes to the nearest terminal of a 4-lug tie strip located directly behind M1. Capacitor C6 and R5 also go to this same terminal, as shown in Fig. 6. Connect the ground end of C6 to the rotor lug of C5. Solder one end of L3 to a stator support rod on C9 (see Fig. 7). The opposite end of this coil goes to pin 1 of V2. Attach RFC1 to the coil, one turn from C9. Connect L4 to the stator lugs of C11, rather than to the stator rods. The ends of L5, on the other hand, go to the rods, rather than to the lugs, of C12. Both the grid and plate leads of V3 run to the stator lugs of C11 and C12.

A few words of explanation will clear up any confusion which may exist as a result of the foregoing discussion of lugs and rods. Each miniature variable capacitor used in the Paragon 144 has small solder lugs for making electrical connections to both the rotor and stator plates. In those cases where it is impractical to utilize the stator lugs, connections can be made to the stator support rods which extend about 3/16” beyond the rear of the capacitors.

To prevent self-oscillation, the input and output circuits of V3 must be shielded from each other. Suitable material may be obtained from a well-tinned vacuum-type coffee can. Make the shield 1/4” x 2 1/4”. Scrape the paint off the printed label side of the tin and solder the shield to the center post and terminal 9 of V3’s socket. Cut a small notch in it to clear terminals 4 and 5. The shield’s position is illustrated in Figs. 3 and 7.

Solder L6 to the two center lugs of a 4-lug terminal strip. Install 300-ohm twin-lead between the terminal strip and TS1. Solder a 5” length of stranded hookup wire to each terminal of M1; attach miniature alligator clips to the free ends of these wires.

Note that R23, C26, R27, and C29 filter out r.f. energy which might otherwise be rectified by the first two audio amplifier stages and cause annoying r.f. feedback to develop in the modulator section of the transmitter. These capacitors and resistors will function effectively only if they are installed in the proper manner. Cut one lead of each resistor to a length of 1/4”. Connect the short lead of R23 to pin 2, V4a, and the long lead to J1. The short lead of R27 goes to pin 7 of V4b, while the long one goes to the center terminal of R26. Trim the leads of C26 and C29 to 3/4”. Capacitor C26 goes between pins 2 and 3 of V4a. Connect C29 to pins 7 and 8 of V4b.

Adjustment. First carefully check the completed transmitter for wiring errors, then plug in a 36-mc. crystal, V1, V4, and V5. Connect M1 across R5 (TP1), and plug in the a.c. cord. Set R26 for minimum gain and turn the slug of L1 fully counterclockwise when viewed from the top of the chassis. Throw S1 to “On,” and, after a one-minute warm-up, throw S2 to “Send.” If the crystal is oscillating, the meter needle will rise to about 1. As you screw the coil slug clockwise, the reading will slowly drop to about 0.8, and then suddenly jump to approximately 1.5 when the crystal goes out of oscillation.

If the meter reads 1.5 at all settings of L1, the crystal is not oscillating. Check for either a wiring error associated with V1, or too many turns on L1. When you finally have V1 working properly, set L1 for a meter reading between 0.9 and 1. Flick S2 up and down several times to make sure the crystal starts up readily.

During the following tune-up procedure, refer to the chart on page 96 when you want to know the actual value of current indicated by M1 as it is clipped across the different shunt resistors.

Disconnect the a.c. plug and connect the meter leads across R8 (TP2). (Caution! Never touch the meter leads without first removing the a.c. plug from the wall socket!) When changing the leads to a different test point, make certain the clips do not short against other components. Always keep them as far as possible from the coils and tuning capacitors.

Replace the a.c. plug and insert V2 in its socket. After warm-up, throw S2 to “Send.” As you tune C5, the meter indication should vary between about 1.6 and 2.4. Set C5 for the lowest meter reading, cut the power, and turn the chassis over and examine it. If C5’s plates are somewhere between minimum and maximum capacity, L2 has the proper inductance.
**CURRENT MEASUREMENTS**

<table>
<thead>
<tr>
<th>Test Point and Measurement</th>
<th>Typical Reading</th>
<th>Multiply By</th>
<th>Actual Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP1—V1b plate current</td>
<td>.9</td>
<td>20</td>
<td>18 ma.</td>
</tr>
<tr>
<td>TP2—V2 plate current</td>
<td>1.6</td>
<td>20</td>
<td>32 ma.</td>
</tr>
<tr>
<td>TP3—V3 grid current</td>
<td>1.6</td>
<td>2</td>
<td>3.2 ma.</td>
</tr>
<tr>
<td>TP4—V3 plate current</td>
<td>2.3</td>
<td>40</td>
<td>92 ma.</td>
</tr>
</tbody>
</table>

*Note: Variations of ±15% are normal*

Measurements shown in chart are made by clipping leads from M1 across appropriate test points. After initial tuning, meter can be connected permanently across TP4 for monitoring final plate current.

If minimum current occurs at minimum capacity, less inductance is needed. If full capacity is required for a current dip, the inductance is too small. Squeeze the turns together to increase the inductance, or pull them apart to lower it. If there is no current change as C5 is tuned, recheck the wiring associated with V1b and V2.

The next step is to move the meter clips to R10 and connect a 15-watt light bulb across TS1. Plug in V3. Turn the power on and tune C9 and C11 for the highest meter indication. It should be in the neighborhood of 2 if L3 and L4 have been correctly wound and installed. If the highest reading is obtained with either C9 or C11 at the extremes of their ranges, stretch or squeeze the coils as suggested in the previous paragraph.

Slowly tune C12 and C13 until the light bulb glows most brightly. Use a nonmetallic screwdriver on C13. Now, adjust L1 counterclockwise until the meter drops to approximately 1.6.

After pulling out the power plug, connect the meter clips across R13 (TP4). Re-install the plug and experiment with various settings of C12 and C13, and the position of L6 with respect to L5. In this way, you’ll become thoroughly familiar with how these adjustments affect transmitter output as indicated by the meter needle and bulb brightness.

Plug a crystal or ceramic microphone into J1. Advance R26 until the meter needle flickers very slightly and the bulb intensity increases noticeably as you speak into the mike. Do not raise the gain beyond this level. More audio will merely result in excessive distortion and a broad signal.

The transmitter is now ready to go on the air. Connect a 300-ohm feedline between TS1 and a good 2-meter beam antenna. Adjust C12 and C13 so that the meter reads between 2 and 2.5 at resonance dip. This indicates an input power of between 16 and 20 watts.

**Tips On Operation.** Most 2-meter operators use crystal-controlled rigs and tend to stick to a single frequency. However, if you decide to purchase a number of crystals in order to hop around the band, it will pay you to put knobs on C12 and C13 so you won’t have to hunt up a screwdriver to QSY.

You can ignore the other adjustments when changing crystals if you stagger-tune them. To do this, set L1 and C9 for a meter indication of 1.5 with your lowest frequency crystal in the socket. For this tuning operation, the meter is connected across R10 (TP3). Peak C5 and C11 for a 1.5 reading with your highest frequency crystal, and from then on, just retune C12 and C13 slightly when you change frequency.

Once you have the transmitter working properly, the meter clips can be connected permanently across R13 to permit you to monitor plate current during each transmission. The antenna change-over and receiver muting relays in your shack may be controlled by S2b, thereby providing you with one switch operation. Access to S2b is provided by TS2.

**Results.** When the prototype was first put on the air, it produced 18 QSO’s from 20 calls, a 90 percent batting average. Comments received over the air were uniformly complimentary with regard to signal strength and audio quality.

If you live in relatively flat country and use a 6- to 8-element beam mounted 40 or so feet in the air, the Paragon 144 will provide consistently strong signals at a distance of about 30 miles. Usable signals can be expected up to 40 or more miles under normal day-to-day conditions. A higher tower and larger antenna, or a hill-top location, will stretch these figures significantly. However, when skip conditions are good, you’ll be able to work 300 miles and beyond, even with a low-gain, chimney-mounted antenna array.

---

ELECTRONIC EXPERIMENTER'S HANDBOOK
Miniature I.F. Module
Superheterodyne
Pocket Receiver

By CHARLES CARINGELLA

Modern electronics module concept gets more elements into less space and greatly reduces number of tie points. Two i.f. amplifiers and detector take up only 0.375 cubic inch.

ROUND-THE-CLOCK listening pleasure will be your reward for doing a good building job on this modern transistor superheterodyne broadcast-band radio. It is a complete unit and can be put into your pocket. It can also give your phonograph or tape recorder the ability to sound off with broadcast-band programs. No test or alignment equipment is needed to construct the radio.

A pre-aligned i.f. amplifier module only 1 1/2" x 1/2" x 1/2" in size speeds construction and simplifies wiring. The module contains 24 parts including a ceramic filter, two transistors, two transformers and a diode detector.
Fig. 1. Variable capacitors C1a and C1b are held in place by machine screws. The antenna loopstick can be cemented to the case, or just allowed to “float” in place.

Except for the antenna loopstick, variable capacitor and phono jack, all components including the i.f. module are mounted on a small board, measuring just 2 7/8" x 1 1/16", as shown in Fig. 2. This is not a printed circuit. All the components are hand-wired.

How It Works. Transistor Q1 serves as an r.f. amplifier, local oscillator and mixer. (See Fig. 4.) The input circuit, consisting of a variable capacitor (C1a) and an antenna ferrite loopstick (L1), tunes the broadcast band. Local oscillator coil L2 is tuned by variable capacitor C1b to a frequency that is always 455 kc. above the frequency of the incoming signal. Capacitors C1a and C1b are ganged.

The incoming r.f. signal and the local oscillator signal are mixed in transistor Q1. Sum and difference frequencies as well as the r.f. and oscillator signals appear at the output of Q1. The miniature i.f. transformer (L3) is tuned to 455 kc., and allows only the difference frequency to pass on to the next stage. The primary of L3 is part of the collector load circuit of Q1; the tap on this winding is not used.

The next two i.f. stages are in the module, as is the detector stage, as shown in Fig. 6. Bandwidth is fairly narrow, thanks to the ceramic filter between pin 2 and the 390-ohm resistor, but not narrow enough to prevent good reception of music. The bandwidth is about 8 kc. at -6 db. It is therefore possible to obtain good selectivity. The 455-kc. i.f. signal is amplified by each of the two pre-tuned transistor stages and then demodulated by the crystal diode detector. The audio signal goes through a low-pass filter to pin 7 and then to the top of the volume control, potentiometer R6. From the volume control the signal is fed directly to an earphone jack. Additional transistor stages can be added, if desired, to drive a loudspeaker. A patch cord could be used to connect the radio earphone jack to the input of a tape recorder or phonograph. A feedback loop from the detector to the base of the first transistor in the module provides a.v.c. action. Overall gain of the i.f. module is about 55 db.

A loudspeaker is usually preferred, but there are several advantages to using an earphone: fewer transistors are needed, battery life is longer because power consumption is lower, and you can listen without disturbing anybody. An earphone can also provide exceptionally good fidelity—bass notes, which can not be reproduced by a small speaker, can be heard in an earphone, because the earphone is directly coupled to the ear and does not have to move a large vol-

Fig. 2. Bottom view of the circuit board. Notch permits volume control to work without undue stress. The slot in the case allows volume control knob to turn freely.
PARTS LIST

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>6- to 9-volt transistor radio battery (NEDA 1606 or equivalent)</td>
</tr>
<tr>
<td>C1a/C1b</td>
<td>Miniature 2-gang variable capacitor; 117.1-pf. r.f. section, and 74.4-pf. a.c. section</td>
</tr>
<tr>
<td>C2</td>
<td>0.02 µf., 3 volts miniature ceramic</td>
</tr>
<tr>
<td>C3</td>
<td>0.01 µf., 3 volts disc capacitors</td>
</tr>
<tr>
<td>C4</td>
<td>0.05 µf., 10 volts disc capacitors</td>
</tr>
<tr>
<td>C5</td>
<td>10-pf., 12-volt electrolytic capacitor</td>
</tr>
<tr>
<td>L1</td>
<td>Ferrite antenna loopstick (Miller 2010 or equivalent)</td>
</tr>
<tr>
<td>L2</td>
<td>Oscillator coil, miniature (Miller 2065 or equivalent)</td>
</tr>
<tr>
<td>L3</td>
<td>1.1-transformer, miniature (Miller 8901 or equivalent)*</td>
</tr>
<tr>
<td>Q1</td>
<td>2N1087 transistor</td>
</tr>
<tr>
<td>R1</td>
<td>15,000 ohms</td>
</tr>
<tr>
<td>R2</td>
<td>10,000 ohms</td>
</tr>
<tr>
<td>R3</td>
<td>1500 ohms</td>
</tr>
<tr>
<td>R4, R5</td>
<td>1000 ohms</td>
</tr>
<tr>
<td>R6</td>
<td>5000-ohm potentiometer with s.p.s.t. switch (Lafayette 99 G 6019 or equivalent)</td>
</tr>
<tr>
<td>S1</td>
<td>S.p.s.t. switch (on R6)</td>
</tr>
<tr>
<td>J1</td>
<td>1-f. amplifier module (Miller 8902)*</td>
</tr>
<tr>
<td>J2</td>
<td>1-f. amplifier module (Miller 8002)*</td>
</tr>
<tr>
<td>J3</td>
<td>1-f. oscillator coil, miniaturized (Miller 8901 or equivalent)*</td>
</tr>
<tr>
<td>J4</td>
<td>3000- to 7000-ohm dynamic earphone</td>
</tr>
<tr>
<td>J5</td>
<td>4½&quot; x 1½&quot; x 1&quot; plastic box</td>
</tr>
</tbody>
</table>

*The Miller 8902 module and the Miller 8901 transformer are available together as the 8903

Fig. 3. Top view of circuit board. Allow enough clearance between battery and phono jack. Leads to battery can be spot-soldered; avoid overheating.

Fig. 4. Optional 0.1 ma. meter at point X serves as tuning indicator. Superhet circuit can give AM broadcast "voice" to tape recorder or record player.

Fig. 5. Tuning dial can be mounted under knob on finished radio. High-impedance earphone provides good audio frequency response.

If you wish, you can add a tuning meter to the circuit. Insert a 0.1 milliampere meter in series with the lead going to terminal 10 on the i.f. module.
(See point X in Fig. 4.) The radio draws only 3 milliamperes.

**Construction.** The completed broadcast radio is shown in Fig. 5. It was built to fit into a small plastic box, which is readily available. You can choose any size box, as long as all the parts fit and are arranged in an orderly manner—the best thing to do is follow the photographs. Do not use a metal case. A shielded antenna usually develops into a situation of apparent radio silence.

Mount C1 directly to the case. L1 can be held in place by a dab of cement or just allowed to "float." The black and white wires from L1 are soldered directly to the capacitor frame. The clear wire is soldered to C1a, the capacitor with a greater number of plates. The green lead is attached to C2 on the circuit board later.

The circuit board assembly is shown in Figs. 2 and 3. Parts location is not critical, but here again it is best to follow the layout as shown. Keep the leads short and avoid overheating the transistors when soldering. Notch out the board to allow the volume control (R6) to be mounted without undue stress or strain. Enough of the knob should protrude so that it can be easily reached when the assembly is finally placed into the case.

A $\frac{3}{4}" \times \frac{1}{8}"$ slot is cut out on the side of the case to allow the knob to stick out about $\frac{1}{16}"$.

Connect all the metal cans to a common ground line. This line is also connected to the frame of the variable capacitor. Short leads can be soldered directly to the battery. Next to the slot in the case, install the miniature phono jack.

Position the board in the case when completed. Connect the green wire to C2 and two wires from the volume control to the phono jack.

**Alignment.** If all is well with your radio, you will hear background noise or, hopefully, a radio station or two when you first turn it on. The alignment and peaking adjustments are made from off-the-air signals. All you need is a non-metallic screwdriver. Do not force any of the screws or slugs; they should turn easily. Try to get any station and adjust L3 for maximum. In the absence of a station, adjust for maximum noise.

Rotate the knob until the plates are almost fully meshed. This is the low end of the broadcast band. With the aid of another radio, as a "standard," locate a station at the lowest end of the band. Adjust the slug in oscillator coil L2 until (Continued on page 138)
TRADITIONALLY, the rule applied to broadcast-band antennas has been "the longer the better." While this rule still holds, it is also true that when antenna length is already short compared to the wavelength of the signal being received (as is the case with most practical BCB antennas), a further reduction in length, within certain limits, has little effect on antenna efficiency.

Almost any single wire antenna of random length will give good results when used with one of the antenna couplers which were described in the 1965 Fall Edition of the ELECTRONIC EXPERIMENTER'S HANDBOOK ("Soup Up That AM Broadcast Receiver"). In the author's case, tests made with a 100-foot horizontal, a 50-foot horizontal, and a 33-foot vertical antenna showed little difference in performance when DX'ing the BCB with a medium-priced communications receiver.

"Loaded" Whip. Since most antennas for BCB reception are "short" anyway, why not "load" the antenna with an inductance above its center for greater efficiency? To try this idea, the author used a 9-foot whip mounted on a pole with a 24-foot down-lead making up the rest of a 33-foot vertical. An adjustable ferrite antenna coil was connected at the base of the whip as shown in Fig. 1, and the base of the antenna grounded. A transistor radio held near the antenna wire was used to resonate the antenna. The radio was tuned to a weak station at the high-frequency end of the band, and the coil slug adjusted for maximum volume.

To tune such an antenna across the broadcast band and also couple it to the receiver, one of the antenna couplers featured in the article mentioned above should be used, and is shown in Fig. 1 within the dotted lines. The capacitor used in the tuner is a 100-pf. mica unit, and the coil is simply another ferrite antenna coil. Tests with the loaded whip showed a very worthwhile improvement in signal strength—WMAQ, Chicago (670 kc.), for example, was three "S" units higher in Los Angeles with the loading coil in the circuit.

Loop Antenna Cuts QRM. What about adjacent-channel DX? If the strength of strong local stations can be reduced somewhat, it becomes possible to copy...
stations in the background. Wave traps were tried but were of little use. In some instances the trap acted more like an antenna than a trap, and merely aggravated the interference problem.

A loop antenna was considered next. If properly built, it would have reasonably good signal pickup and a sharp null at right angles to the plane of the loop. Its directional characteristics would make it possible to null out, to some extent, strong ground-wave signals from local stations.

Although the author's loop looks like a throwback to the 1920's, it performs better than expected. In Los Angeles, for example, it is possible to reduce the signal of a powerful local, KMPC on 710 kc., to receive Chicago, WGN on 720 kc., with little or no interference. After playing around with this circuit for a while, you will often be able to separate and identify distant stations on the same frequency by rotating the loop antenna for a null on one of the signals.

**Loop Construction.** At its largest, the loop measures 42" across, and consists of 13 turns of stranded wire spaced 1/2" apart. Construct the crossarms of the loop as described in the caption above.

To couple the loop to the receiver, wind a separate one-turn coupling coil on the back of the cross-arms opposite the center turn and as close to it as possible.

The best way to tune the loop is with a salvaged four-section variable capacitor of the type used in older receivers. When you pair the sections by connecting them in parallel, the effective maximum capacity of the two resulting sections is well over 600 pf. A similar arrangement can be worked out by ganging two double-section TRF variable capacitors, which are readily available from most electronic parts houses.

Connect the capacitor sections as shown in Fig. 2, and make the three connections to the receiver (to the antenna terminals and ground). With the center tap disconnected, turn the loop for minimum signal on a strong local station. Next, place the center tap at approximately the center of the loop, and tune the variable for maximum signal. Adjust the tap for minimum signal, and, again, tune the capacitor for maximum. The variable capacitor is retuned as you tune across the broadcast band.

You'll be surprised at the improvement in your BCB DX score! —170—

Crossarms of loop are made with 1/4" x 1 1/2" x 44" plywood strips—the vertical arm in one piece and the horizontal in two pieces. Join the three strips together with 6"-square pieces of plywood nailed and glued on each side of the joint. In the author's unit, the loop was mounted in a wooden block fastened to the base holding the tuning capacitor. The loop itself, which is wound 1" in from the ends of the arms, is supported with wire brads. The one-turn coupling coil is wound on the back of the arms opposite the center turn of the loop and as close to it as possible. Three connections are made to the receiver as shown in the diagram on p. 101, two to the antenna terminals and one to the chassis. Note: do not ground the loop to the chassis of an a.c.-d.c. radio due to the shock hazard which might result.
2 Halos Stacked for 2 Meters

Easy-to-build high-gain antenna for fixed or mobile use

By BOB SARGENT, WAØ661

HALO ANTENNAS are like ½-wave-length dipoles in many ways. They are cut to the same size, they are horizontally polarized, and they can be stacked for additional gain. However, the bidirectional characteristic of the dipole changes to an omnidirectional pattern when the dipole is curved to form a halo.

Horizontally polarized antennas favor horizontally polarized signals and are less susceptible to ignition noise and vertically polarized waveforms. Gain of a halo over a ¼ wavelength vertical Marconi type is usually about 8 db. A gain of 12 db can be expected from a two-halo stack.

At 2 meters a stacked halo arrangement becomes manageable and suitable for mobile work, since the higher frequencies make it possible to employ smaller size antenna elements. The om-

(Continued on page 143)
BUILD A 144-MC. SWISS QUAD ANTENNA

By HERBERT S. BRIER, W9EGQ

All-metal, 2-meter cubical quad uses new ideas proposed by HB9CV—front-to-back and front-to-side ratios are over 25 db

ALTHOUGH the "Cubical Quad" directional antenna has several obvious advantages, including high gain and economy of construction, the mechanical strength to cope with high winds is not an outstanding feature of the Quad constructed of bamboo and wire. The all-metal "Swiss Quad" described in "Across the Ham Bands" in the April, 1965, issue of POPULAR ELECTRONICS (page 74) has generated great interest among the ham fraternity.

The Swiss Quad retains the electrical advantages of the usual Quad, but adds strength and durability. A 144-mc. Swiss Quad can be built in a few hours at a cost of less than $4.00. It will give a real hop to your signals.

Design. If the centers of the horizontal members of a two-element Quad are pushed in until they touch, they may be joined—both electrically and mechanically—to the central support pipe. If the horizontal members are metal tubing, the Quad becomes a self-supporting structure without an auxiliary framework.

Coupling the centers of the horizontal members of the Quad together and to the support pipe is permissible, because these points are at zero r.f. potential. But, because a portion of the elements are partially bent back upon themselves, the overall dimensions of the antenna should be approximately 10% greater than for a conventional Quad cut for the same frequency.

The designer of the Swiss Quad, Rudolf Baumgartner, HB9CV, accommodated this increased size by adding to both the horizontal and vertical dimensions. I have found, however, that there is no significant difference in results if either the horizontal or vertical dimensions are kept the same as in a conventional Quad, and the other dimensions are increased sufficiently to restore resonance at the desired frequency.

Construction. The 144-mc. Swiss Quad is made of copper wire and tubing which is available in hardware and plumbing supply houses. To build a duplicate of my Swiss Quad, first straighten the $2\frac{1}{8}$" copper tubing by rolling it on a flat surface while tapping it lightly with a wooden mallet. Cut off four 21" lengths.

Now take the hard-drawn $2\frac{1}{8}$"-diameter copper tubing and drill a $1\frac{1}{8}$" hole a half inch from the top end. Line up the drill so that the bit passes through the diameter of the tubing and comes out on the opposite wall. Drill another pair of $1\frac{1}{8}$" holes 22" below the first pair in the same manner. Then rotate the tubing a quarter turn, and drill a third pair of $1\frac{1}{8}$" holes $3\frac{1}{2}$" from the top end and at right angles to the first pair; and drill a fourth pair 22" below the third pair. Finally, drill a $\frac{3}{4}$" hole a half inch below the bottom $3\frac{1}{8}$" hole and in line with the first and second pairs.

Mount the standoff insulator in the $\frac{3}{4}$" hole on the supporting rod. Place a solder lug under and on top of the insulator. You may have to do a bit of juggling to line up the screw through the $\frac{3}{4}$" hole from the inside to catch the insulator, but it can be done.

Slide the four pieces of $3\frac{1}{10}$" tubing through the $1\frac{1}{8}$" holes, and position them so that they all extend 10" from the center of the $2\frac{1}{8}$" supporting rod to one side and 11" from the center to the
You can build a Swiss Quad in a few hours using readily available copper wire and tubing. The mast can be any convenient length. Sweat elements to the support pole with a heavy soldering iron or butane torch.

**BILL OF MATERIALS**

1-7' length of 3/16" copper tubing
1-3' length of 3/8" hard-drawn copper tubing
1-12' length of #10 plastic-insulated copper wire
1-3/4" cone-type standoff insulator (E. F. Johnson #135-501 or equivalent)
2-Solder lugs

other side. Solder them in place, using a husky soldering iron (250 watts or larger) or a small torch.

Measure 5½" from the center of the supporting rod along the 3/16" tubing, and bend the 3/16" tubing horizontally 45° so that the end sections of each adjacent 10" and 11" length are parallel and spaced eight inches apart. It is not necessary that the bends be sharp; slightly rounded corners are preferred.

Remove the plastic insulation from a 14" length of #10 wire which serves as the gamma matching rod. The rod is approximately 12" long and soldered at each end to the radiating elements; it is spaced an inch away from the elements. Do not solder the ends of the gamma rod until you have had an opportunity to adjust it, as described below. Cinch the solder lug on top of the standoff insulator around the center of the gamma rod, and solder it and the center conductor of the 50-ohm (nominal) coaxial feed line to the gamma rod. Solder the cable shield to the other solder lug.

Slice the insulation off the remainder of the #10 wire, and cut four 30" lengths. Four inches from each end of these lengths, bend the wire at right angles to form shallow U's 22" wide. Slip the ends of these U's into the corresponding top and bottom 3/16" copper tubing to the dimensions shown in the drawing.

**Adjustment.** Place an SWR bridge in the coax line and feed a small amount of r.f. into the line. Slide the wire U's (Continued on page 136)
SMALL boat owners, fishermen, technicians, and others who own, use, or service and install marine band radio equipment will want to duplicate this simple wavemeter designed for monitoring and tuning up shipboard transmitters in the 2-3 mc. range. The unit does not use any batteries, and can be left on to monitor transmitter output and insure that it is set to the proper channel.

How It Works. To simplify matters, the wavemeter was constructed inside a small plastic box; in most cases, enough r.f. energy will be picked up by the internal coil to operate the device. If not, the rod antenna specified in the Parts List can be added to the unit.

The bottom four turns of coil L1 act as a coupling between the tuned circuit, consisting of C1, C2, and L1, and diode D1. The coupling coil prevents overloading of the tuned circuit so that the main dial (C2) tunes sharply and accurately. The r.f. is rectified by D1, and the resulting d.c. current indicated by M1 (the meter can be made more or less sensitive by adjusting R1).

Construction. A small plastic instrument case (Lafayette 19 G 2001 or similar) was used to house the meter; an

As shown below, all components are mounted on front panel of wavemeter. Connections to the optional external antenna are not shown here; simply add a 10-pf. coupling capacitor and wire the antenna to the stator of C2. The top end of the coil must be mounted on an insulator as shown. Calibrate the wavemeter as described in text, using accurate generator.

Wavemeter is simply tuned circuit coupled to rectifier-meter circuit by bottom four turns of coil. Circuit tunes sharply to indicate frequency of transmitter.
aluminum cover was made for the box. As shown in the photos, all of the components are mounted on this aluminum cover: $C_2$ at right; the coil in the center with the above-ground end fastened to an insulator; and the meter at left. Potentiometer $R1$ is just below $M1$.

It is necessary that the coil be of the dimensions specified in the Parts List, tapped at four turns, and that a 240-pf. capacitor be placed across the variable and not some other value. This will insure that the wavemeter covers the correct range.

**Calibration.** After the wavemeter has been assembled, it can be tested and calibrated by placing it near some r.f. source in the 2-3 mc. band. One of the best methods is to use the radiophone set itself, a crystal oscillator, a grid dip oscillator, or other signal generator of known accuracy. If the meter should read backwards, reverse either the diode or the meter.

A rough dial can be made by placing a piece of paper under $C2$'s knob, and marking off frequencies in pencil. You can then ink in a finished dial and install it on the wavemeter; it should look much like that shown in the photo. A piece of clear plastic mounted over the dial will keep it clean and free from smudges.

As mentioned earlier, you can use the unit for peaking your transmitter, as well as for monitoring, if you have a commercial FCC license. For monitoring only, you can bolt the wavemeter to a bulkhead wall to keep an eye on transmitter output. A log of readings from day to day will serve as an indication that your antenna is radiating as it should be.

### PARTS LIST

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_1$</td>
<td>240-pf. silver mica capacitor</td>
</tr>
<tr>
<td>$C_2$</td>
<td>400-pf. variable capacitor</td>
</tr>
<tr>
<td>$C_3$</td>
<td>0.001-µf. ceramic disc capacitor</td>
</tr>
<tr>
<td>$C_4$</td>
<td>10-pf. ceramic or mica capacitor</td>
</tr>
<tr>
<td>$D1$</td>
<td>1N277 silicon diode</td>
</tr>
<tr>
<td>$L1$</td>
<td>37 turns of #12 to #18 wire, $\frac{1}{4}$&quot;-diameter form, 16 turns per inch, tapped at 4 turns (B &amp; W Minderator 5011 or equivalent)</td>
</tr>
<tr>
<td>$M1$</td>
<td>0-1 amp. meter</td>
</tr>
<tr>
<td>$R1$</td>
<td>500-ohm, potentiometer</td>
</tr>
<tr>
<td>$I$</td>
<td>2&quot; x 3 1/2&quot; x 6 1/2&quot; plastic box</td>
</tr>
<tr>
<td>$L_2$</td>
<td>Extension antenna—optional (Lafayette No. G 4541 or 50 cents equivalent)</td>
</tr>
<tr>
<td>Misc.</td>
<td>Wire, solder, mounting insulator for coil, aluminum sheet, pointer knob, etc.</td>
</tr>
</tbody>
</table>

**Simple Auto Light Minder**

Both $R1$ and $D1$ can be mounted under buzzer cover.

**It's easy** to forget that your headlights are still on—easier still to forget the parking lights if you turn them on while driving on a rainy or foggy day.

You can eliminate the whole memory problem entirely by building this simple Auto Light Minder that requires only three components—a 10-ohm, 1-watt resistor, the cheapest silicon diode rectifier you can locate (the author used a 1N2069), and an inexpensive code practice buzzer. The rectifier and resistor can be mounted under the buzzer cover for compactness.

Connect one lead of the Light Minder to the light switch, and the other to the ignition switch as shown in the diagram. The correct terminals can be identified by observing which ones show a voltage to ground when the switches are operated (avoid the accessory lead on the ignition switch, however). When the lights and ignition are both off, both sides of the buzzer are at ground potential and there is no sound. Likewise, when both lights and ignition are on, there is no potential difference.

Diode $D1$ blocks current flow with the lights off and ignition on, but with the lights on and ignition off, one side of the buzzer is grounded through the low-resistance ignition system. $D1$ is forward-biased by the battery, and the buzzer sounds.

Eliminate $R1$ for 6-volt cars, and reverse the light and ignition leads for positive ground cars.

—R. L. Winklepleck

1966 Spring Edition

107
A PUBLISHING FIRST

... THE ONLY COMPLETE GUIDE FOR SERVICEMEN AND HOBBYISTS TO EVERY MAJOR PHASE OF CONSUMER ELECTRONICS SERVICING!

For the progressive serviceman who wants to find out how to service better and faster... how to expand his business by handling a wider variety of electronics equipment.

For the "do-it-yourself" hobbyist who wants to save hundreds of dollars by installing and repairing his own equipment.

The 1966 ELECTRONICS INSTALLATION & SERVICING HANDBOOK has arrived! The only comprehensive and authoritative guide to every major phase of consumer electronics servicing. There's nothing like it anywhere!

A handy, on-the-bench reference volume containing over 150 illustrations, charts and tables—on how to spot, analyze and correct trouble... quickly, efficiently and economically!

Complete, in-depth coverage of: the fundamentals of servicing • servicing b/w & color TV • AM-FM household radios • stereo/hifi • CB equipment • intercoms and PA systems • antennas • transistorized ignition systems.

Hundreds of money-saving techniques and shortcuts. Every up-to-date method and procedure. All in easy-to-understand language for the novice... yet thorough enough to answer the professional's most complex question!

You'd have to purchase several expensive manuals to equal this kind of incisive, all-inclusive coverage. But now you get it all in the 1966 ELECTRONICS INSTALLATION & SERVICING HANDBOOK. A small investment that will pay for itself many times over with just one practical application. Only $1.25

--- FILL IN, CLIP & MAIL THIS FORM TODAY! ---

20th-Davis Service Division • Dept. IS
589 Broadway • New York, N.Y. 10012

YES! Send me a copy of the 1966 ELECTRONICS INSTALLATION & SERVICING HANDBOOK, as checked below:

☐ $1.25 enclosed, plus 15¢ for shipping and handling. Send me the regular edition. ($1.50 for orders outside the U.S.A.)
☐ $3.00 enclosed. Send me the Deluxe Leatherflex-bound edition, postpaid. (3.75 for orders outside the U.S.A.) Allow three additional weeks for delivery.

Name __________________________
Address __________________________
City ____________________________ State ______ Zip Code ______

--- PAYMENT MUST BE ENCLOSED WITH ORDER. ---

GET THE EXQUISITE LEATHERFLEX BOUND EDITION for just $3 POSTPAID!

The 1966 ELECTRONICS INSTALLATION & SERVICING HANDBOOK is also available in an attractive, gold-embossed, Leatherflex-bound edition—a superb addition to your library of permanent reference books. This deluxe volume will be mailed to your home, postpaid, for just $3.00, when you check the appropriate box on the order form.
CHAPTER 5

TEST EQUIPMENT PROJECTS

A test equipment construction project should be an exceptional item—something not commonly available as a kit. Such projects can be used in conjunction with existing test equipment to extend the usefulness of such equipment or to adapt present testing gear to new applications. This philosophy has been expounded in previous editions of the ELECTRONIC EXPERIMENTER'S HANDBOOK and is continued in this one.

The article titles below are largely self-explanatory, and only one requires any comment. Don Lancaster's "Meter Face" story should be one of those articles you immediately read from start to finish. The surplus markets are still loaded with excellent meter buys—meters which would cost three or four times as much if purchased retail. The only thing wrong with a surplus meter is the scale—it generally has some military significance, but nothing whatsoever to do with the milliamps or volts you want to measure. The article tells you how to change the scale and achieve a professional appearance.

This chapter ends with some "Tips and Techniques" from POPULAR ELECTRONICS.

110 MINIATURE VTVM ........................................ Ryder Wilson

113 MASTER CONTROL SCR SWITCHING CENTER .......... Harold Reed

116 SIMPLE SIMON VOLTAGE CALIBRATORS ............... Fred Chapman

117 PUT YOUR BEST METER FACE FORWARD ............... Don Lancaster

119 EXPERIMENTER'S L BRIDGE ............................... Charles Green, W3IKH

122 TRANSISTOR REPLACEMENT TECHNIQUE .............. Roy E. Pafenberg, W4WKM

123 THE EXALTED POT ........................................ Forrest H. Frantz, Sr.

125 FOUR-WAY OSCILLATOR ................................. L. E. Byfield, K9ADD

126 THE CASE OF THE ALUMINUM ALLOY ................. Homer L. Davidson

127 THE BEST OF TIPS AND TECHNIQUES

1966 Spring Edition
d.c. voltages in five or six ranges, depending on whether a 5- or 6-point switch is used. Up to 500 volts can be measured directly; audio, r.f. and other a.c. voltages can also be measured with the demodulator probes. The miniature unit is completely self-contained in a 5" x 4" x 3" metal utility box and has a large, easy-to-read, reasonably-priced, 50-µa. meter movement.

How It Works. A CK6088 subminiature beam-power-pentode vacuum tube (V1) is “triode”-operated in a d.c. bridge circuit. The quiescent voltage drop across resistor R8 is balanced out by applying just enough bucking voltage to zero the meter. You simply adjust potentiometer R11 for a zero meter reading. Potentiometer R9 serves as a current limiter and calibrator for the meter circuit.

A positive d.c. voltage applied to the grid of tube V1 through resistor R7 causes a proportional up-scale deflection. The more positive the grid, the more the tube conducts and the greater the voltage drop across resistor R8. The greater the voltage drop, the greater the deflection of the meter. The rotary switch (S1) specified in the Parts List selects one of the five voltage ranges from 5 to 500 volts. Precision ±5% resistors are used in the input voltage divider network. The VTVM’s accuracy is dependent upon the selection of the proper value of resistors, as well as the quality of the meter movement.

If you can get a 6-position, single-circuit switch that will fit, you can wire the input voltage divider as shown in Fig. 3, to get a very desirable 1-volt range. Actually, no change in the arrangement of the resistors in this circuit would have to be made to accommodate the 6-position switch. Jack J1 would be connected to the first contact which would become the position for the 1-volt range. All other positions would

MINIATURE VTVM

Unit measures voltage in a.g.c., grid bias, oscillator and other high-impedance circuits without loading

By RYDER WILSON

ONE of the most useful test instruments in the electronics enthusiast’s workshop is the vacuum-tube voltmeter. The VTVM enables the experimenter to measure small voltages accurately, especially in high-impedance grid bias, a.g.c., detector and oscillator circuits. Unlike the 1000- or 20,000-ohms-per-volt voltmeters which present different resistances on different ranges, the miniature VTVM to be described here has a constant resistance of 10 megohms on all ranges.

The miniature VTVM is a low-cost construction project and operates economically on batteries. It can measure
follow in the same consecutive order as in the 5-position switch.

Because of its d.c. operation, the miniature VTVM is relatively stable and free of drift. It does not require constant resetting of the zero control.

Construction. The interior view of the VTVM shows the layout of the various components. The tube (V1) is held in place by a cable clamp. The circuit board is mounted on the meter terminals. Resistors R7, R8, R9 and filament battery B2 are mounted on the board. Resistors R1 through R6 are mounted, turret style, directly on S1. (See Fig. 6.) Position the meter as close as possible to the top of the case to allow room for the range selector switch and panel markings. Zero-adjust control R11 and tube V1 are then positioned to avoid interference with other components. Place battery B1 on the bottom of the case and hold it in position with a suitable friction clip.

The d.c. probe shown with the meter is made from a 2' length of 52-ohm co-axial cable and a test prod connected to the center conductor. An alligator clip and a short length of insulated wire are connected to the shield inside the probe handle. In use, the test prod point is connected to the positive side and the alligator clip to the negative side of the voltage to be measured.

Fig. 1. The voltage drop across the cathode resistor is in proportion to voltage being measured. The more positive the applied voltage to the grid, the greater the voltage on the resistor.

Calibration. Any known source of voltage can be used to calibrate the VTVM. A simple setup is shown in Fig. 5. However, before turning the instrument on, check for mechanical zero of the VTVM's meter. Next, set the range-selector switch to the 5-volt scale and adjust zero control R11 until the switch just clicks on. The meter will probably read about 1.25 volts. Continue turning R11 slowly, clockwise, until the meter reads zero. Do this with the probe connected to the meter and the alligator clip on the test prod's point, to prevent readings of stray voltages.

Adjust the 1000-ohm potentiometer on the calibrator rig to 5 volts, and apply the probe. Adjust calibrating potentiometer R9 for full-scale deflection (the 5-volt mark on the VTVM). By successively reducing the input voltage to 4, 3, 2 and 1 volt, linearity of the meter can be compared with the meter in the test circuit. A slight nonlinearity may be observed as the input voltage is decreased, with an approximate error of ±0.1 volt at the low end of the scale.

Fig. 2. Demodulator probe measures low a.c. peak voltages. Capacitance of probe leads acts as filter.

Fig. 3. Alternate hookup of voltage divider provides extra 0- to 1-volt range.

Fig. 1. The voltage drop across the cathode resistor is in proportion to voltage being measured. The more positive the applied voltage to the grid, the greater the voltage on the resistor.
Fig. 4. Divider in demodulator probe delivers about 70% of peak voltage to meter circuit to enable direct readout of r.m.s. voltages.

Fig. 5. Variable voltage divider circuit used to calibrate the miniature VTVM.

Fig. 6. Preassemble the resistors and the switch in "turret" fashion before mounting.

**PARTS LIST**

<table>
<thead>
<tr>
<th>PART</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>22.5-volt battery (NEDA No. 215)</td>
</tr>
<tr>
<td>B2</td>
<td>1.35-volt mercury cell battery (Mallory RM-12R or equivalent)</td>
</tr>
<tr>
<td>J1</td>
<td>Single-contact, male, panel-mounted mike connector</td>
</tr>
<tr>
<td>M1</td>
<td>0-50 microammeter (Lafayette 99 G 5042 or equivalent)</td>
</tr>
<tr>
<td>R1</td>
<td>8-megohm, 1/2-watt resistor* (selected from 8.2-megohm stock)</td>
</tr>
<tr>
<td>R2</td>
<td>1-megohm, 1/2-watt resistor*</td>
</tr>
<tr>
<td>R3</td>
<td>800,000-ohm, 1/2-watt resistor* (selected from 820,000-ohm stock)</td>
</tr>
<tr>
<td>R4</td>
<td>100,000-ohm, 1/2-watt resistor*</td>
</tr>
<tr>
<td>R5</td>
<td>80,000-ohm, 1/2-watt resistor* (selected from 82,000-ohm stock)</td>
</tr>
<tr>
<td>R6</td>
<td>20,000-ohm, 1/2-watt resistor*</td>
</tr>
<tr>
<td>R7</td>
<td>4.7-megohm, 1/2-watt resistor</td>
</tr>
<tr>
<td>R8</td>
<td>10,000-ohm, 1/2-watt resistor</td>
</tr>
<tr>
<td>R9</td>
<td>10,000-ohm miniature potentiometer with d.p.s.t. switch (S2)</td>
</tr>
<tr>
<td>R10</td>
<td>4700-ohm, 1/2-watt resistor*</td>
</tr>
<tr>
<td>R11</td>
<td>110,000-ohm miniature potentiometer with d.p.s.t. switch (S2)</td>
</tr>
<tr>
<td>S1</td>
<td>2-circuit, 5-position switch (Lafayette 99 G 6164 or equivalent; use only 1 circuit)</td>
</tr>
<tr>
<td>S2</td>
<td>D.p.s.t. switch (on R11)</td>
</tr>
<tr>
<td>V1</td>
<td>CK6088 vacuum tube</td>
</tr>
<tr>
<td>Misc.</td>
<td>Probe tip, wire, battery clamps, etc.</td>
</tr>
</tbody>
</table>

*Resistors are ± 5% or better

If a greater error occurs, it could be due to a poor tube, or nonlinearity of the calibrator meter.

Use the same procedure only to check the VTVM on the other voltage scales. Actually, this is not necessary; once one scale is calibrated, all the other scales take their proper relative position. Significant errors on the other ranges would be due to employing wrong values (one or more) for resistors R1 through R6. When the calibration is completed, the meter is ready for use.

Higher voltages applied to the tube’s grid, beyond a certain point, have less and less effect on tube current, and at saturation have none. The meter cannot be subjected to “burn-out” currents no matter how high the voltage being tested or how low the selected voltage range on the meter. But don’t poke the unit into a 16,000-volt circuit without a suitable high-voltage probe!
BUILD THE

MASTER CONTROL SCR SWITCHING CENTER

You can control equipment from a remote or local position with automatic or manual go—no-go type switch, photocell, or sensor

By HAROLD REED

THE silicon-controlled rectifier (SCR) is one of the most recently introduced types of semiconductors presently performing electronic miracles. It works like a high-current on/off switch, yet has no moving parts. Many devices, such as electric light dimmers and motor speed controllers, are already taking advantage of the SCR. As the demand for new semiconductors builds up, prices come down. They have already done so to a considerable extent. The SCR used in the Switching Center is a 2N2323 and costs less
than $3.50, which is below the cost of many vacuum tubes.

The Switching Center can be used as the heart of burglar alarms, fire alarms, photographic control equipment, door openers, motor driven controls, etc. Control can be automatic or manual, local or remote, and can be triggered by Microswitches, magnetic reed or thermal switches, photocells, etc. The switches can be used in combination, say a magnetic reed switch to close the controller and a Microswitch to open it.

The controller is extremely sensitive; a photoconductive cell connected directly to its binding posts can actuate the relay just by "seeing" a lit match 12 inches away.

How It Works. Like a thyatron, the SCR (Q1) conducts when the anode is sufficiently positive with respect to the cathode. Under normal operating conditions the anode voltage is not high enough to start conduction, but is high enough to maintain current flow once it starts. The gate on the SCR performs the same function as the grid of the thyatron. When a small positive voltage is applied to the gate, the SCR fires (provided that the correct anode-to-cathode voltage is also present).

Thereafter, the gate has no control and cannot stop current flow. The only way to extinguish the SCR is to remove or reduce the anode-to-cathode voltage below the holding point. When current flow is stopped and plate voltage is restored, the gate once again is in a position to exercise control.

Relay K1 has a four-pole, double-throw switch to provide numerous control applications. If desired, a s.p.d.t. relay can be used and is noted in the Parts List for your convenience. Both relays have a 2500-ohm coil.

The relay is energized when d.c. flows through the circuit consisting of T1, D1, K1 and Q1. About 25 volts a.c. from T1 is rectified by D1, filtered by C1 and applied to K1 and Q1. The d.c. control voltage applied to Q1's gate is developed by the voltage divider action of R2 and R3. Diode D2 stabilizes relay action and cuts down the high inductive kick from the relay coil when the unit is switched off. Excessive voltage peaks could damage Q1.

In the nonconducting state, Q1 exhibits a very high internal resistance and only a very small leakage current flows; thus, Q1's anode voltage is approximately equal to the d.c. supply voltage. Since this voltage is below the rated peak forward voltage of Q1, it will not trigger.

Under this circumstance, all it takes to fire Q1 is a small positive d.c. pulse applied to Q1's gate. As mentioned before, this comes from the junction of R2 and R3 via S1. Switch S1 may be manually controlled or paralleled by any external switching devices attached to BP1 and BP2. Internal resistance of Q1

A positive voltage at the gate of the SCR causes it to conduct and close the relay; to stop conduction, a negative pulse is applied to the anode.

ELECTRONIC EXPERIMENTER'S HANDBOOK

PARTS LIST

BP1 to BP4—5-way binding post (Lafayette 32 G 6430C or equivalent)
C1—100-µf., 50-volt capacitor
C2—0.5-µf., 200-volt capacitor
D1—Silicon diode (International Rectifier SD91 or equivalent)
D2—Germanium diode (General Electric 1N91)
Mount the parts on the panel before working on the chassis, so you'll be sure to have adequate clearance. A single terminal strip can be substituted for sockets S01 and S02.

Construction. The unit shown in the photos is built in a 4" x 5" x 6" box which has a self-contained chassis attached to the front panel. All parts are easy to obtain and inexpensive. Transformer T1 and relay K1 are mounted on the chassis; smaller parts are soldered to terminal strips. Switches S1 and S2, the binding posts, and power switch S3 are attached to the front panel.

Two 6-contact sockets to extend the relay contactors to a convenient outlet are also mounted on the front panel. Any type of connector or terminal strip could be used for this purpose.
INTERESTED in a versatile voltage-step calibrator that has, literally, hundreds of uses? While designing a wide-range VTVM the author found a need for some means of feeding calibrated millivolt signals to the meter. The answer was a simple voltage divider, whipped up around a handful of 10% resistors as shown in Fig. 1.

Jacks J1 through J15 are banana jacks, and the resistors are $\frac{1}{2}$-watt units unless otherwise specified. A separate pair of jacks (J3 and J4) accommodates the meter, while the voltage output is taken between the bottom jack (J15) and the jack at the desired percentage level. If you want to work with higher voltage levels, it will be necessary to increase the wattage rating of most of the components.

Figure 2 shows a grown-up version of the calibrator that you might want to put together. Note the provision for a.c. or d.c. voltages from 0.1 mv. to 1 volt with a 1-volt input; for a 6-volt input, the steps will range from 0.6 mv. to 6 volts. You simply multiply the input voltage by the percentage indication at the desired position of switch S2.

Transformer T1 is a 6.3-volt filament (Continued on page 142)
Before and After. Can you determine which of the meter faces above is homemade and which is the manufacturer’s original? The only tip-off is the trademark under the title.

**PUT YOUR BEST METER FACE FORWARD**

You can make professional-looking scales with little effort and a small investment

By DON LANCASTER

WANT to change the scale of that panel meter sitting in your junk box? Or how about that surplus bargain, an 0-50 d.c. microammeter . . . calibrated as 0-75 MR/HR/FT or something equally mysterious? Help stamp out sloppy meter faces! Get rid of wrong scales! You don’t have to be an artist—all you need is $2.15 and some time. You’ll wind up with a meter face as good as the factory original, and to your exact specifications. And each duplicate face will cost just 15 cents.

What’s the catch? You simply work five times life size. In this king-size world, mistakes are few and far between, and easily corrected. Any misalignment that might creep in gets reduced 5:1 in the final reproduction. You use all prefab letters and numerals—no ink and no mess. A nearby photolithography firm then gives you the required reduction.

**Measurements.** The first step in making a new meter face is to carefully remove the original, and make all the measurements shown in Fig. 1. Multiply each one by five (except c, the scale angle), and record the results. Dimension a is the distance in inches between the pivot point or center and mounting screw; b the distance between the pivot point and title; c the scale angle in degrees; d the numeral radius in inches; e the lower division radius; f the middle division radius; and g the upper division radius.

Decide what the full-scale reading of the new meter scale will be, and choose a reasonable number of major divisions. Every major division, or every other one,
Fig. 1. Carefully measure dimensions "a" through "g" on original meter face and multiply by five. All measurements are in inches except the angle "c," which is measured in degrees with a protractor.

Materials and Layout. Go to the art store and buy a sheet of 1 1/2"-high instant transfer letters and numerals. You can also pick up a 15" x 20" sheet of white illustration board, although white cardboard or painted plywood will do. (For a meter face larger than 3 1/2", get a 20" x 30" illustration board.)

Lay out the new face as in Fig. 3, keeping all pencil lines very light so they can be easily erased. Start with a vertical center line and add a horizontal line 2" up from the bottom; use a square to insure that these two lines are perpendicular. The point where the two lines cross is the pivot point of the meter, and the basis of all the measurements detailed in Fig. 1.

Carefully and accurately locate the meter mounting holes with two 3/8"-diameter dots (black printed circuit dots are ideal for this). Using a beam compass (or a pencil and some string), swing the arcs corresponding to the tops and bottoms of the minor divisions. Using a large protractor, locate the zero and full-scale points.

Next, with dividers (or just a ruler), lay out all the major division marks on the

(Continued on page 146)

Fig. 4. High-contrast photolith negative (top) is a 5:1 reduction of art work. After negative is made, it is a simple matter to get photographic contact prints (below). Mount new face as described in text.
INDUCTANCE measurements are not difficult to make, but they can fool you, especially if you have been using just an ohmmeter. A few shorted turns won't make enough of a difference to show up in a simple resistance test, yet it takes only one shorted turn to ruin a coil or choke. At times you may wish to know only if a part is good or bad. At other times you may be looking for a specific value. Either way, the "L Bridge" is a worthwhile addition to your line-up of test equipment.

In all fairness to the ohmmeter test method, it does quickly indicate open windings, shorts to iron cores and frames, and shorts between two different coils wound in close contact with each other, such as primary and secondary transformer windings. It can also spot relatively large changes in a coil's resistance, but it does all this under d.c. conditions. Most of the coils we use have to function in an a.c. circuit of one type or another.

An obvious improvement, then, would be to break away from d.c. and go to an a.c. procedure, applying an a.c. signal to an unknown inductance and determining its value by its performance in the test circuit. The easiest, cheapest way to do this is to employ a Maxwell bridge which uses an a.c. signal to measure inductance in terms of resistance and capacitance. The "Experimenter's L Bridge" is just such a unit with the ability to measure inductance values from about 1 mh to 100 h (100,000 mh) in five ranges.

How It Works. The test signal from the 1 kc. oscillator, the pentode section of V3b, is amplified by the triode sec-
Connect unknown coil to terminals X₁. Inductance values from 1 mh to 100,000 mh can be measured. Sensitive eye tube sees amplified and rectified signal output from bridge.

**PARTS LIST**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C₁, C₇</td>
<td>0.1-µf., 100-volt capacitor, ±10%</td>
</tr>
<tr>
<td>C₂-C₆</td>
<td>0.005-µf., 600-volt ceramic capacitor</td>
</tr>
<tr>
<td>C₈, C₉, C₁₀</td>
<td>500-µf., 1000-volt ceramic capacitor, ±10%</td>
</tr>
<tr>
<td>C₁₁</td>
<td>20-20 µf., 330-volts-per-section electrolytic capacitor</td>
</tr>
<tr>
<td>R₁</td>
<td>10,000-ohm wire-wound potentiometer, linear taper</td>
</tr>
<tr>
<td>R₂</td>
<td>19 ohms</td>
</tr>
<tr>
<td>R₃</td>
<td>390 ohms</td>
</tr>
<tr>
<td>R₄</td>
<td>3000 ohms</td>
</tr>
<tr>
<td>R₅</td>
<td>10,000 ohms</td>
</tr>
<tr>
<td>R₆</td>
<td>100,000 ohms</td>
</tr>
<tr>
<td>R₇</td>
<td>10,000-ohm potentiometer</td>
</tr>
<tr>
<td>R₈</td>
<td>1.0-megohm potentiometer with S₁</td>
</tr>
<tr>
<td>R₉</td>
<td>10 megohms</td>
</tr>
<tr>
<td>R₁₀, R₁₃</td>
<td>470,000 ohms</td>
</tr>
<tr>
<td>R₁₁</td>
<td>3.3 megohms</td>
</tr>
<tr>
<td>R₁₂, R₁₅</td>
<td>1 megohm</td>
</tr>
<tr>
<td>R₁₄, R₁₆</td>
<td>1000 ohms</td>
</tr>
<tr>
<td>R₁₇</td>
<td>330,000 ohms</td>
</tr>
<tr>
<td>R₁₈</td>
<td>10,000 ohms</td>
</tr>
<tr>
<td>R₁₉</td>
<td>56,000 ohms</td>
</tr>
<tr>
<td>R₂₀, R₂₁, R₂₂</td>
<td>100,000-ohm, 1/2-watt resistor, ±10%</td>
</tr>
<tr>
<td>R₂₃</td>
<td>1000-ohm, 2-watt resistor</td>
</tr>
<tr>
<td>D₁, D₂</td>
<td>65-ma., 130-volt a.c. input selenium rectifier (ITT 1234.1H or equivalent)</td>
</tr>
</tbody>
</table>

**ELECTRONIC EXPERIMENTER'S HANDBOOK**
Easy construction: angle brackets support flat chassis plate. Keep leads short for R20-R22 and C8-C10, in the oscillator circuit. Other wiring is not critical.

S1—1-pole, 5-position rotary switch
S2—S.p.s.t. switch (part of R8)
T1—Power transformer: primary, 117 volts; secondaries, 250 volts, CT @ 25 ma., and 6.3 volts @ 1 amp (Stancor PS 8416 or equivalent)
T2—Universal output transformer (Merit A-2902 or equivalent)
V1—6A(6 tube
V2—6U5 tube
V3—6A(8 tube
I—4½” x 6” x 8” utility box (LMB #146)
1—4½” x 8” chassis, sheet aluminum
Misc.—Two 8-32x4” threaded rods, wire, etc.

1966 Spring Edition

condition to cancel the effects of lagging current caused by the coil. When reactance and resistance conditions across the XL leg and the S1, R2-R6 leg balance conditions across the R1 leg and the C1, R7 leg, no signal will appear at R8.

When the bridge is not in balance, a voltage appears across R8. It is amplified by V1, then coupled to the diode section of the same tube through C3, then rectified and direct-coupled to V2. The voltage is negative going and tends to close the eye. When the bridge is balanced, the tuning eye is wide open because the rectified voltage is then at a minimum. The values selected make it possible for each 1000-ohm division on the dial to indicate another mh on the lowest range. The five ranges are x1 mh, x10 mh, x100 mh, x1 h, and x10 h, as resistors from R2 to R6 are switched in respectively.

The 6AN8 oscillator (V3b) has an RC phase shift network consisting of R20, C9, R21, C10, R22 and C8 connected between plate and grid and forms a 180° shift in phase at 1 kc. It provides the positive feedback needed to maintain (Continued on page 135)
TRANSISTOR REPLACEMENT in commercially wired gear has always been a tricky business. Not only do you have to find the bad transistor and wrestle it out of the circuit board, but you have the problem of finding a replacement transistor that will work as well as the original. This latter step can get a bit sticky if you can't identify the original transistor, or if the circuit involved is a bit critical and refuses to work with just any replacement you happen to have in the junk box.

If trial and error substitution is the only answer, you can save yourself time, trouble, and a damaged circuit board by installing an inexpensive transistor socket. Since most of these sockets are equipped with four contacts, remove the contact that does not mate with the drilling pattern of the circuit board, and carefully work the remaining pins into the holes in the board. Solder the pins to the foil, and insert a substitute transistor in the socket.

When you find a suitable replacement transistor that performs to perfection, you can either leave it installed in the socket, or remove the socket and solder the transistor to the circuit board.

—Roy E. Pafenberg, W4WKM

The first step is to isolate the bad transistor (circled), clip it out, and clean the solder out of the holes in the printed circuit board. Replace it on the board with an inexpensive imported transistor socket with the metal mounting ring and extra pin removed.

Transistor Replacement Technique

Why solder in a doubtful replacement when this trick allows a variety of substitutes?

To install the socket, carefully push the leads through the holes in the board, making sure that the orientation matches that of the bad transistor. Plug in a substitute, and you're back in business.
THE EXALTED POT

Sometimes even the simplest of electronic gadgets can save you countless hours of needless effort

By FORREST H. FRANTZ, Sr.

The versatile "Exalted Pot" is so simple you'll wonder why you didn't think of it yourself. All that's required to build the unit are two ganged potentiometers, a d.p.d.t. switch, assorted connectors, and a small aluminum box.

You can use it as a 1000-ohm and a 10,000-ohm resistance adjustable divider, as a substitution adjustable resistor for any value up to 10,000 ohms, or as a substitute volume control in transistor circuits. In combination with a VTVM and an audio signal generator, you can even use it for measuring capacity and inductance.

Construction Details. The unit is housed in a 2½" x 3" x 5¼" Minibox. The dual potentiometer (R1-R2) is made by using a 10,000-ohm linear unit (IRC-CTS Q11-116) and an add-on multi-section (IRC-CTS M11-108) which is a linear 1000-ohm unit. After cutting the shaft of R2 (the 10,000-ohm unit), attach R1 to the back of R2, but be careful that the wiper arm finger of R1 is properly seated in the wiper slot of R2 before bending the tabs and sealing the units together.

Now attach this ganged pot to the Minibox cover, and place the knob on the shaft, repositioning the potentiometer as necessary to maintain the same overshoot at each end of rotation.

Terminal posts B, C, T and GND are available from Lafayette Radio in a kit of 10 pieces (MS-566), and each requires a ¾" hole. The GND post is grounded to the Minibox, but the other three are insulated with fiber washers. Subminiature phone jack J1 is a Lafayette 99 G 9905, and needs a ¾" hole also. Switch S1 is a d.p.d.t. miniature toggle switch and requires a ¾" hole. Mount all components and wire them as shown in the diagram on the next page.

Calibration. The "Exalted Pot" dial scale can be calibrated by measuring resistance at various knob settings with an ohmmeter of known accuracy. The inner scale will be calibrated from zero at one extreme to 1.0 at the other, and interpreted to mean 1000 ohms full scale or 10,000 ohms full scale, depending on the setting of switch S1.

The outer (capacity) scale is calibrated from 1.9 to 30µf. These capaci-
Simple instrument measures values of coils and capacitors. Adjust pots to match voltage across unknown parts.

Tor markings actually correspond to capacitive reactance at a test frequency of 100 cycles. Potentiometers R1 and R2, as well as the test frequencies of 100 and 10,000 cycles, were selected to provide a wide range of measurements without having to resort to many scales. Capacitance values of 0.0019 to 30 µf. can be measured.

While not shown in the photo, the dial can also be calibrated to read values of inductance. For the values of the resistors and frequencies selected, the instrument's range is from 1 mh. to 15 h. (15,000 mh.).

First calibrate the resistance scale. Set S1 in the 1K position. Rotate the control and mark the dial at each 100-ohm point. Do this carefully and use a good ohmmeter to measure the resistance as you proceed around the dial. No further calibration is needed for resistance.

The other range is essentially now calibrating (Continued on page 139)
Almost nothing is critical about this one—parts values may be varied to give different frequencies and waveforms. CK722's were used for Q1 and Q2.

IF YOU'D like to try your hand at a very intriguing, easy to build, inexpensive transistor project, the "Four-Way Oscillator" is for you. It generates square waves comparable in quality to those produced by a commercial audio square-wave generator, and at least several other waveforms of different frequencies, shapes and strengths. The unit can also serve as a CPO, a grid dipper modulator, or as a go-no-go transistor tester.

A quick look at the schematic tells the story—the Four-Way Oscillator is actually a simplified free-running multivibrator, unusual in that only ten components are required. With the parts values shown, square-wave output of about 800 cps can be taken from the first two terminals at the top. Varying the value of C1 will change the output frequency. Taking the output from different combinations of terminals will give different waveforms and different frequencies. Actually, output can be taken from almost any point in the circuit—it's fascinating to experiment while watching a 'scope or while monitoring the signals with a pair of headphones.

The Four-Way Oscillator makes an excellent tester for small-signal pnp transistors. Defective units—including those with excessive leakage—will simply not work when used to replace either Q1 or Q2—CK722's in the author's unit. Power supply voltage is not critical, but better square-wave linearity was obtained with 9 volts than with 6. The value of C2 can be made considerably smaller without affecting the circuit; changing resistor values will change the waveforms obtainable.

To keep the cost down, the author's unit was built on a small chip of Formica (kitchen cabinet dealers use them for samples, and they should be available for the asking) measuring 2½" x 3". Holes were drilled to accommodate component leads, transistor sockets, and Fahnestock clips for battery leads and output terminals.

The oscillator makes a handy addition to any test bench.

—L. E. Byfield, K9ADD
THE CASE OF THE ALUMINUM ALLY

THE PLASTIC CASES used in the construction of low-cost multi-testers such as the VOM have brought into existence a new breed of electronics experimenter—the "cracked-case VOM carrier." Replacement cases simply aren't available. The solution to the situation? Just call on your aluminum ally, the utility chassis box, to house the useful remains of your VOM.

Going about it is quite easy. First, examine the damaged case. In most instances, the plastic box itself is the damaged part; if it is, discard the box. If the front plastic piece which holds the meter, switch, and pin jacks is also damaged, carefully cement this piece with a good-quality epoxy resin.

Now select an aluminum chassis box about 1/2" larger in each dimension than the original meter case. Measure a hole in the cover of the case that will pass the parts mounted on the VOM, leaving a good margin of safety. But remember, if you cut too large a hole, you'll have to start all over again with a new box.

Once the VOM face fits neatly in its new case, secure it in place. The author's VOM had pre-drilled holes which permitted the use of 1/4"-long screws and nuts to bolt the meter face to the case. Do not drill any holes in the delicate plastic VOM face. Instead, resort to epoxy resin cement—you'll have to wait from 4 to 12 hours for the cement to take hold.

Before fitting on the rear cover of the chassis box, weigh the assembly in your hand. If the VOM lacks "heft," you may want to bolt down an old audio or power transformer in the bottom of the case to prevent it from tipping over while in use.

—Homer L. Davidson

You can cut the VOM mounting hole in the aluminum box face by using the tried-and-true method of drilling many holes edge to edge, knocking out the unwanted center piece, and filing the rough edges smooth. But the job will be much quicker and easier with a square chassis punch or an Adel hand "nibbling" tool. Author took advantage of existing holes in VOM to secure it to the front panel of the "aluminum ally."
SNAP LEADS FOR WORKBENCH POWER SUPPLY

A standard transistor battery can be used as a power supply for experimental projects as well as for equipment tests on the workbench by attaching a pair of snap leads to the battery and the equipment. To make your own connector leads, salvage the terminals from a discarded type 2N6 battery or equivalent, or get a pair from your dealer. If the terminals are mounted on a terminal strip, cut the strip in half to enable them to fit on any size battery using this type of terminal. Connect the terminals to two wires, preferably one red and one black to indicate polarity. The wires should be flexible and durable. Finally, connect an insulated alligator clip to the other end of each wire.

—Luis Vicenc

PEG-BOARD TOOL HOLDERS MADE FROM SCRAP MATERIALS

Peg-board tool holders can be made from readily available scrap materials, such as a convenient length of angle iron or aluminum. Along one side of the metal, drill a series of holes or slots to hold the tools. On the other side, fashion two peg-board hooks by hacksawing two slots about \( \frac{1}{4}'' \) apart approximately 2'' in from each end and bend to shape. These newly formed hooks should be spaced to line up with the peg-board holes. For an easy fit, use a file or grindstone to round off the edges and reduce the diameter of the hooks if necessary. A scrap block of wood can also be utilized as a tool holder, as shown in the photo.

—Carleton A. Phillips

SIMPLE GDO MODULATOR FITS INTO PHONE PLUG

Do you need a modulator for your grid dipper? The circuit below is that of a simple neon lamp oscillator with an output from 200 to 1000 cycles. Resistor \( R_1 \) can be increased or decreased to compensate for any variation in B-plus. Coupling is accomplished through \( C_2 \), whose reactance is negligible at these frequencies. Resistor \( R_2 \) controls the amount of modulation, and can be adjusted to give a pleasant sound. (A 1000-ohm potentiometer could be used instead of a fixed resistor.) The entire circuit can be built into a PL-55 phone plug. A suitable socket should be mounted on the front or rear of the GDO case and connected to a convenient B-plus point on the GDO power supply. The B-plus lead from the modulator can then be conveniently connected. If the PL-55 won't fit into your GDO, mount a suitable plug on any small container—such as a 35-mm film container—that will hold the modulator parts.

—David W. Beatty, K7MNC

SPEED UP KIT ASSEMBLY WITH A SEAFOOD PARTS TRAY

The next time you buy frozen seafood at the supermarket, look closely at the package. Some of this frozen food—notably fish cakes and patties, and such delicacies as flounder stuffed with crab meat—are packed in plastic trays like the one in the photo (on p. 128). The trays have 4 compartments, each of which is just the right size for small components such as resistors, capaci-

1966 Spring Edition
TUNING THE TRAP
WITH YOUR TRANSMITTER

In the absence of a signal generator, tunable traps designed to operate within the frequency range of an available transmitter can be tuned accurately with the aid of a field strength meter and the transmitter. Simply connect one side of the trap to a short length of wire and the other side to a field strength meter, set the transmitter on the desired frequency, and tune the trap for a null reading. Watch your signal strength, keeping it down to a minimum, and rock the trap adjustment to be sure you are at the bottom of the response curve.

—Richard Mollentine

CUT CLIP CLUTTER
WITH SHOWER CURTAIN RINGS

You can rack up assorted test clips on one or more shower curtain rings and keep them handy on the tool-board behind your workbench. A ring can be hung on any

...
ERSATZ PRESS-TO-DO-SOMETHING SWITCH

The next time you are stuck for a press-to-do-something / release-to-do-something-else type of switch, and all you have is a slide switch, fashion a small piece of springy metal into a "V" shape, drill a hole in it to accommodate the machine screw on the appropriate side of the slide switch, and mount it as shown. Cut or file a small notch in the slide handle to keep the spring in place. A normally open or normally closed switch can be improvised as required.

A. Rosenblum

GROMMET-TIRED TRANSISTORS PREVENT SHORT CIRCUITS

Grommets can be used to protect lead-mounted transistors against vibration and short circuits. You simply fit a grommet over a transistor in much the same way as you would fit a tire over a wheel. This technique will also permit you to leave longer leads on the component and provide a little more protection against heat damage from the soldering iron. Use of a grommet may slightly increase operating temperatures, but ordinarily will not create a problem in small current circuits. A 3/16"-i.d. grommet is suitable for the smaller TO-18 transistor case and a 1/4"-i.d. unit can be stretched to fit over the larger TO-5 container.

--Don Lancaster

PLASTIC DRAIN TRAYS
IDEAL FOR PROJECT BREADBOARDING

Plastic cutlery drainage trays stolen from the kitchen make breadboarding experimental circuits easier and quicker. The holes will accommodate all the nuts and bolts and other hardware you need. Hook-up wire can be conveniently threaded through the holes.

CTS Knights, Inc. has the right crystal for all CB applications.

CTS Golden Line CB crystals are manufactured to the same exacting specifications as military units...an accuracy of ±.003% of frequency. Crystals are hermetically sealed and are unaffected by wide temperature extremes. All crystals are made from virgin quartz...only "first cuts" are used.
from your distr./dealer ... TRANSISTOR SELECT-A-SPEC ($3.95 retail) ... the only complete specs and substitution book ... FREE with the purchase of three or more TECHPRESS books. Stock your library now.

Take coupon to distr./dealer; or send to TECHPRESS, INC. Brownsburg, Ind. adding 25¢ for postage.

Please RUSH more information. My distr. dealer doesn't stock TECHPRESS Publications.

For my FREE TRANSISTOR SELECT-A-SPEC I choose the following:

☐ Radar—Principles and Practice .................. $1.95
☐ Semiconductor Circuits Handbook Vol. 1 ............... $2.95
☐ Semiconductor Circuits Handbook Vol. 2 ............... $1.95
☐ Selected Semiconductor Circuits .................. $1.25
☐ Transistor Specifications & Substitution Handbook .... $1.95
☐ Diode Select-A-Spec ................................ $2.95
☐ Receiving Tube Specifications and Substitution .... $1.95

TECHPRESS,
INC.
Brownsburg,
Indiana
46112

_____ Name
_____ Address
_____ City and State

LEARN ELECTRONICS
AT HOME
IN YOUR SPARE TIME

It is fun to learn when you can set your own pace. Whether you want a beginner's course that teaches the basic fundamentals of solid state and tube electronics, or an advanced course that will equip you to move up the ladder in your chosen field of electronics, you can select just the courses you want to take ... and take those courses at your own speed.

EARN MORE, learn about Missiles, Computers, Transistors, Automation, Printed Circuits.

Over 30,000 graduates now employed by industry. Resident school also available at our Chicago Campus.—Founded in 1954.

Send for our FREE course catalog.

AMERICAN INSTITUTE OF ENGINEERING & TECHNOLOGY
1137-1139 W. Fullerton Parkway—Chicago, Illinois 60614

CIRCLE NO. 1 ON READER SERVICE CARD

through the holes and run on both sides of the tray. You can easily cut larger holes for controls and tube sockets with a pocket knife. The sides of the tray are deep enough to provide sufficient clearance for many components. —Margie V. Erickson

CHEATER CORD CONNECTS PROJECTS CONVENIENTLY, SAFELY

Do the line cords on your experimental circuits keep getting shorter? Each time you "borrow" a cord from one project to use on a newer circuit, the number of cordless old projects grows larger, and you wind up with a shoebox full of three-inch line cords. One simple solution to the problem is to install a cheater cord connector on everything you build. In addition, a certain margin of safety can be derived from the use of a cheater cord. If something happens that requires a quick disconnect, a tug on the line cord will cut off the power. —Don Lancaster

CATWHISKER DETECTOR ECHOES YESTERYEAR

For a nostalgic return to the pioneering days of radio, try your hand at making a catwhisker crystal detector. Carefully break the glass of either a new or discarded 1N34A germanium diode and keep the cathode end containing the little wafer of germanium. Solder the lead to a Fahnestock clip and screw the clip to a small wood base. When soldering the crystal, grip the lead with a pair of pliers (which acts as a heat sink). Also solder a 2" length of thin, stiff wire to another Fahnestock clip and fasten
this clip to the base as shown. File the free end of the wire to a point and bend it to contact the crystal. You can use this catwhisker detector in your favorite circuit and have fun finding the most sensitive spots.

—Art Trauffer

MAKE YOUR OWN PLUG-IN CAPACITORS

When building new equipment from scratch, you can make your own plug-in capacitors if space on the chassis permits. They will simplify replacement should it become necessary. First salvage the bases from old octal tube sockets, carefully removing all the old glass and cement. A hot soldering iron will clear the tube pins, and you can rewire the base to accommodate your capacitor. Just be careful to note the pin numbers and the correct polarity. With an octal socket wired to hold the plug-in capacitor, you can change capacitors without soldering or de-soldering—as easily as tubes.

—James V. Conklin

RESISTOR STORAGE BLOCK

A handy way to keep resistors ready for instant use is to build a storage block for them. Three rows of holes drilled in the block will allow three resistors of each value to be stored; the hole spacing should be the same as the line spacing of the typewriter used for the identification slip which is cemented to the side of the block. Six lines to the inch is just right for ½-watt resistors, and double or triple spacing can be used for 1-watt or 2-watt resistor blocks. Drill the holes 1½" deep using a 5/64" drill. You may want to apply a coat of clear lacquer or varnish to the resistor value slip to keep it clean.

—Thomas H. Charters
HALF-PRICE
on a subscription to
Popular Electronics!
18 exciting issues $3.00 only

At the regular subscription rate these same 18 issues would cost all of $6.00! BUT NOT FOR YOU. Your cost is only $3.00—HALF-PRICE!

Every month POPULAR ELECTRONICS brings you a wealth of fascinating features aimed especially at experimenters and do-it-yourselfers like yourself. (Just glance to the right for a sample!)

You’ll enjoy being right on top of the fast-growing world of electronics with up-to-the-minute new product reports, lab tests, buying guides, and electronics breakthroughs you want to know about. Plenty of articles on hi-fi, money-saving test equipment, tape recorders, electronic games, computers, photo-aids, short wave receivers, antenna systems, solar powered and transistorized equipment—and much more.

Construction projects galore! Clear-as-crystal diagrams guide you each step of the way through fun-to-build projects you can put together in just a few hours... for pennies! Turn friends green with envy by building a super hi-fi rig they couldn’t match in the stores for hundreds of dollars! Or throw together a fool-proof photoelectric burglar alarm to protect your home and loved ones...or a remote control switch that actually turns lights on and off when you whistle a bar of your favorite tune!

POPULAR ELECTRONICS is definitely for men like YOU. Take advantage of this HALF-PRICE OFFER to readers of the Experimenter’s Handbook. Just complete and mail the card facing this page. Or, if someone has already used the card, write to: POPULAR ELECTRONICS, Dept. 4086, Portland Place, Boulder, Colorado 80311

EXCLUSIVE HAM, SW & CB ARTICLES IN POPULAR ELECTRONICS
Amateur Radio and SWL
Make Your Signal Reports More Accurate
Safety in the Ham Station
Amateur License Fees and ARRL Petitions
Take Advantage of Changing Propagation Conditions
Operating Another Ham’s Station
Calling All SWL DX’ers
DX Awards
English-Language Newscasts to North America
Radio Marathon Broadcasts Truth To Cuba
Satellites on the Air
Short-Wave Broadcast Predictions
Short-Wave Report
North American Alliance of SWL Clubs
Welcome to the SWL Newcomer
Sure Cure for Ham/CB Mobile Noise
Citizens Band Radio
“DSRC,” New CB Features
Equipment Buyer’s Guide
Transmitters and Transceivers
Station Accessories
Antennas
Microphones
Hand-Held Transceivers
FCC Report
On the Citizens Band
Sure Cure for Ham/CB Mobile Noise
Vibrator Hash, Wipe Out
Build-It-Yourself
Antenna, 40-Meter, for Small Roof
Antenna Adapter, Power Line
Code Bander
Crystal Super Calibrator
Double-Duty EICO 772
Hula-Hoop—a Ham or CB Antenna
Idento-Minder
Q-Multiplier, Nuvistor
Screen Modulator, One-Tube
Transmitter Crystal Switch, Plug-in
2-Meter Simple Superhet
amplifiers, it may be necessary to run a lead between the two amplifier chassis. However, don't run the lead unless it appears that the Stereo Bal won't work without it.

**How to Use the Stereo Bal:** *As an FM Stereo Indicator and Output Balance.*

With the tuner switched to mono, tune in a known mono station. Set the amplifier balance control to center or normal balance. Tune in a station and adjust the tuner's two output controls (if your tuner has output controls) for minimum flickering of the Stereo Bal's lamp. (When there is a separate output control for each channel of your stereo tuner, the best technique is to turn one control about 9/10 full up and then adjust the other control for balance.) Now switch the tuner to stereo and the bulb should flicker only on stereo program material; the brightness and duration of the flicker will depend upon the amount of stereo separation in the program material. It may also be possible to use the lamp's flickering to adjust the stereo separation of those tuners that have a control for that purpose.

**For Phono and Overall System Balance.** If you have a stereo preamplifier and stereo power amplifiers with input level controls, set the preamplifier for mono and center the preamp's balance control. Play a record and adjust the power amplifier's two input level controls using the same technique as given above to balance the tuner's outputs. If the power amplifier doesn't have input level controls, simply adjust the preamp's balance control for minimum lamp flicker. Incidentally, whenever there are both power amplifier input level controls and tuner output or other program source level controls to be balanced, the power amplifier should always be adjusted first.

While the Stereo-Bal works well in most stereo systems, it may not respond too well when used with certain high-efficiency speakers. Some sensitivity has been sacrificed for simplicity and economy.
A treasury of SOUND advice.

SELECTING THE RIGHT RECORDER • SOUND EFFECTS • ACCESSORIES • RECORDING LIVE STEREO AT HOME • TAPE EDITING • PORTABLES • VIDEO RECORDERS

It's easy to be an authority on tape with a copy of HiFi/Stereo Review's 1966 TAPE RECORDER ANNUAL handy.

This fact-filled volume contains over 130 pages, more than 20 complete features, covering every aspect of tape recording. You get expert tips by the dozens, on equipment—making better tapes—editing— copying—sound—on everything you want and need to know about tape recording.

Plus a complete directory of the latest monaural and stereo recorders—the only complete buyer's guide available in the tape recorder field!

Over 100 photos—full data on 220 models from 30 different manufacturers! All the model numbers, specifications, dimensions and prices...every vital statistic you need to compare the newest recorders and select the finest one in your price range.

The 1966 TAPE RECORDER ANNUAL is an indispensable guide for everyone who wants better performance, greater versatility and a lot more fun from his tape recorder...month after month...tape after tape!

GET THE DELUXE GOLD-EMBOSSED LEATHERFLEX EDITION...for just $3.00 POSTPAID!

Ziff-Davis Service Division • Dept. TR
589 Broadway • New York, N.Y. 10012

Send me a copy of the 1966 TAPE RECORDER ANNUAL...as checked below:

☐ $1.25 enclosed, plus 15c for shipping and handling. Send me the regular edition. ($1.50 for orders outside the U.S.A.)

☐ $3.00 enclosed. Send me the Deluxe Leatherflex-bound edition, postpaid. $3.75 for orders outside the U.S.A.) Allow three additional weeks for delivery.

name ____________________________
address __________________________
city _____________________________ state _______ zip code __________

PAYMENT MUST BE ENCLOSED WITH ORDER.

Electronic Flash

(Continued from page 15)

Using the Electronic Flash. There are four things you should consider when using the electronic flash: camera sync, shutter speed, guide number and type of film.

Your camera must have X sync to work properly with this flash. A few cameras have F sync (5-millisecond delay) or the more common M sync (20-25 millisecond delay). Neither of these sync settings can be used with an electronic flash. Shutter speed is related to sync, but only because most quality focal plane shutter cameras have a 1/500-second X sync speed. Generally speaking, a good focal shutter plane camera is useful up to 1/250 second. Some of the more modern shutters (metal leaves) can be used at any shutter speed, up to 1/5000 or 1/1000 second.

Film exposure with different types of film using the electronic flash is calculated from a guide number in the same fashion as with ordinary flash bulbs. You can define guide number as the lamp-to-subject distance times the f-stop. The guide number changes with each ASA film rating. There is no filter factor or color correction factor for the electronic flash.

You can determine the guide number for your electronic flash and your most frequently used films in the following fashion:

1. Load the camera and connect the flash. Set your model exactly 10 feet in front of the lens and be sure the flash reflector is centered on the model.

2. Be sure that the Ready light is blinking before you take a picture.

3. To determine the guide numbers (usually 40 for Kodachrome II, and 150 for plus-X film), take a picture at all openings (f4 through f22) with your model holding a lettered card calling out the film type and f-stop without changing distance or shutter speed. Develop the film and examine the pictures for best exposure. If the best exposure is say at f4, your guide number is 40 (f4 x 10 feet).

4. The guide number remains the
same when the flash gun is operated on batteries or house current.

Once the guide number for the film you will most likely use has been established, you will be on the way to much better indoor (or even outdoor) photography.

Experimenter's L Bridge
(Continued from page 121)

oscillation. To minimize loading effects on the oscillator, the signal is taken from the junction of $R17$ and $R18$. The output transformer delivers approximately 4 volts to the bridge circuit, which varies with the range setting. The lower MHz ranges place a heavier load on the output transformer and cause a drop in voltage. The power supply is a conventional full-wave rectifier circuit.

Construction. A 4½" x 8" chassis plate is held in place by two angle brackets about 1½" from the bottom of a 4½" x 6" x 8" utility box. The tuning eye socket is secured to the front panel by two 8-32 x 4" rods. A single-terminal lug for the other ends of the five resistors attached to the range switch is mounted on the rod nearest the switch. Connect the circuit leads to $R7$ so that the resistance increases as the control is rotated clockwise. (Note: do not connect the L control ($R1$) until calibration is completed.)

The L dial is a 4" metal disc; a cardboard or plastic dial can also be used. A sheet metal screw positioned below the tuning eye and just above the dial and with the slot in a vertical position serves as an indicator. Paint or ink in the slot on the screw head to make it easy to see. Drill several rows of ¼" or ⅜" holes in the rear panel to allow for ventilation. Wiring is not critical, but keep the leads short in the phase shift network of $V3b$. Terminals $X_L$ should be insulated from the front panel.

Calibration. An ohmmeter or multimeter with an 0-10,000-ohm range is needed for calibration. Rotate the still disconnected L control to the full counterclockwise position. Connect the ohm-
Send in 2 high mounted between Ceramic coil CIRCLE NO.

Save money on GAS! COILS! SPARK PLUGS! TUNE-UPS!

Give your CAR, TRUCK or BOAT more PEP when NEW!
You're going to be amazed at the performance of your car, truck or boat! More spark in your gasoline engine means substantially improved performance. You START regardless of weather! You get MORE MILEAGE with MORE POWER at high speeds! And you'll drive 40,000 miles before your engine will need a tune-up!

This is the Famous Sydmur System that was the subject of a special article in Popular Electronics, June and Oct., 1965. Engineered to last, all parts thoroughly pre-tested with specially designed power transformer. Fiberglass printed circuit board, color coded for easy assembly. Functions perfectly at temperatures below freezing or with highest engine temperatures. Built to MIL. Specs. Eliminates ballast resistor and condenser. Weighs less than 2 lbs. Small. 3 x 4 x 5/8.

KIT – Guaranteed One Full Year, Neg. Grd., 6 or 12 V.................................$44.50
KIT–Positive Ground, 6 or 12 V.................................$47.50
ASSEMBLED–GUARANTEED TWO FULL YEARS
6 or 12 V ..............................................$60.00

Send Check or M.O. or ask for FREE literature — TODAY!

SYDMUR ELECTRONIC SPECIALTIES
P.O. BOX 258, Midwood Station, Brooklyn, N.Y. 11230
CIRCLE NO. 24 ON READER SERVICE CARD

Ceramic Coil Forms In Stock/In Depth

Ceramic coil forms in .205", .260", .375" and .500" diameters are now stocked in depth for applications in frequency ranges between 50 kc and 300 mc. Bushing mounted forms with fiberglass collars for high "Q". /low loss applications are available in 2-terminal and 4-terminal configurations.

Write for 20-page Coil Form catalog.

J.W. MILLER CO.
5917 So. Main St. Los Angeles, Calif. 90003
NOW GET FACTORY PRICES IN QUANTITIES TO 750 FROM YOUR LOCAL DISTRIBUTOR

CIRCLE NO. 32 ON READER SERVICE CARD

Now get factory prices in quantities to 750 from your local distributor.

In and out to obtain the lowest possible SWR. Move the U's no more than a quarter inch at a time, and keep the ratio between the "director" and "reflector" dimensions constant.
After the SWR is reduced to a minimum by adjusting the U's, vary the length of the gamma for a possible further reduction in SWR. It should be a simple matter to reduce the SWR to well below 1.2:1. These adjustments can be made in any reasonably clear space, as long as there is a separation of five feet or more between the antenna and the nearest large object. Be sure to solder all joints and connections.

Results. The front-to-back ratio of the Swiss Quad is about 25 db; its front-to-side ratio is over 35 db. In operation, a moderately strong signal from the front of the antenna will disappear off the back and sides. Indicated gain is a minimum of a solid 6 db over a reference dipole antenna. For its size and cost, the "Swiss Quad" is an excellent performer. By the way, it radiates a horizontally polarized signal.

Transistor FM Multiplexer

(Continued from page 60)

strong signal area, tuner sensitivity is usually not a problem. Some tuners have high-impedance detector circuits which are not suitable for connecting directly to the relatively low impedance transistor circuit in the FM multiplexer. The circuit shown in Fig. 3 can be added to a tuner not equipped with a cathode follower.

Power requirements for the multiplexer are -12 to -17 volts at approximately 25 ma. for stereo, and 11 ma. for mono operation. Less current is needed for mono reception because, in this mode, the stereo indicator lamp is normally off. Various power supplies can be used, but one simple way to get power is to draw it from the tuner's supply as shown in Fig. 4.

The response and separation curves on page 56 were derived from a quality report by Hirsch-Houck Laboratories.

Alignment and Operation. Alignment is begun by removing Q4 from its socket to kill the 19-kc. oscillator and make it easier to follow the 19-kg. input signal. (See Fig. 1.) Feed into the input jack a 19-kg., 1/4-volt signal, and tune T1 and
The Lively Sound of the Mustang
—University's newest and liveliest line of slim profile speakers.
Enjoy more-than-you-pay-for top performance. Send for University's "Guide To Component Stereo High Fidelity"—It's Free.

UNIVERSITY SOUND
Dept. Y, Free Ave., Belmont, Calif.
Oklahoma City, Oklahoma

Name ____________________________
Address ____________________________
City ____________________________
State __________ Zip __________

CIRCLE NO. 26 ON READER SERVICE CARD

GIGANTIC CB SALE!!!

SONAR Mod. FS-23 (Reg. $299.95) ...... SALE $239.95
SONAR Mod. "G" (Reg. $229.95) ...... SALE $179.95
SONAR Mod. "E" (Reg. $179.95) ...... SALE $139.95
PACE II CB Set (Reg. $169.00) ...... SALE $149.95
EICO SENTINEL 23 (Reg. $169.95) ...... SALE $149.95
HALLMARK BANNER model 85
CB Set with AM Radio ...... SALE $99.95
MIDLAND Walkie Talkie (11 trans) ...... SALE $29.95
MIDLAND Walkie Talkie (Mod. 13-103) ...... PAIR $15.99
ROSS WALKIE TALKIE (11 transistor) ...... SALE $29.95
+2 TURNER MICROPHONE ...... SALE $26.99
NEW-TRONICS PRO-27
Base Antenna (Reg. $32.95) ...... SALE $27.95
CB Crystal Activity Checker ...... SALE $22.95
COMMAND CB CRYSTALS (.002%) ...... EACH $1.79
(Specify Make, Model, Channel) 12 or more at EACH $1.69

MIDLAND AM/FM AUTO RADIO (transistorized)
Works on 6V or 12V DC; Tone Control;
Push button; Built-in Speaker;
w/mounting bkt. ...... EACH $49.99
ROSS 6 transistor AM Radio ...... SALE $3.99
ROSS 9 transistor AM/FM Pocket Radio ...... SALE $15.95
KX Car Reverberation Unit (Reg. $26.95) ...... SALE $19.95
Trumpet Horn Speaker (5" round—paging) ...... SALE $6.99
SN-3 Mobile Noise Suppressor Kit (15 pc) ...... SALE $4.99

DEALERS! Write for quantity prices on your letterhead!

SEND FOR BIG FREE GROVE 1966 CATALOG!

Send check or money order, include postage, excess refunded. Minimum order $5.00. 30% service charge under $10.00. 50% deposit on COD's.

GROVE ELECTRONIC SUPPLY COMPANY
4107 W. Belmont Ave. Chicago, Ill. 60641

CIRCLE NO. 11 ON READER SERVICE CARD

T2 for maximum indication on a scope or VTVM attached to point A. The indicator lamp should light. Be careful not to overload the circuits with too strong an input signal.

Next, with the generator still set on 19 kc., replace Q4, and tune T4 while looking with a scope at point C for the largest 38-kc. signal. Then reset the generator to 67 kc. and tune T3 for minimum signal at point B. If a signal generator is not used, leave T3 at its factory setting—unless you are bothered by a whistle when tuned to a station broadcasting both stereo and SCA signals; in this case, tune T3 to eliminate the whistle.

Now, connect the multiplexer into a hi-fi system and tune in a stereo station. The indicator lamp will go on when a stereo program is coming through. Because of the sensitivity of the indicator lamp and bandpass characteristics of the lamp circuit, the lamp will light on interstation hiss and will flicker occasionally on high-frequency modulation in a mono program. If this should happen, ignore it, as it does not create any confusion once you know about it.

If possible, tune in a station known to broadcast portions of its program on one channel only, and during such a broadcast retune T4 very carefully to reduce the audio output from the unused channel to an absolute minimum. Decrease the volume level of the in-use channel and raise the volume of the unused channel to get the best possible setting for this critical adjustment.

Now all you need is a pair of slippers, a pipe, an easy chair, and a stereo FM disc jockey who shares your taste.

Module Pocket Receiver

(Continued from page 100)

this station is heard at maximum level. Now find a station at the high end of the band on the standard radio. Rotate the knob until the plates are fully open.

(Note: whether the plates should be fully open or less than fully open depends upon the actual position on the dial occupied by the station. The same
is true for the position of the plates and the radio station at the low end of the band. If the standard radio has, say, 10% rotation from maximum, adjust the radio you have just built to 10% from maximum in a similar manner. Unless you are working with a pre-marked tuning dial, the exact position of the variable capacitors is not critical, so long as you can tune in all the stations.)

When the plates are fully open, the trimmer capacitors on C1a and C1b have their maximum effect. Adjust the trimmer on C1b until the station on the upper end of the band comes in, then adjust the trimmer on C1a for maximum volume.

Now go back to the low end of the band and repeat the entire procedure. “Rock” and peak all the adjustments. You can align the set in less than five minutes. If desired, either the case or a small dial mounted under the tuning knob can be marked to show the location of the stations in your area.

As the volume level goes up during the alignment procedure, reduce the level with the volume control to enable you to more easily detect variations in signal level.

brated also, because both pots are of the linear type. Simply switch S1 to 10K and multiply readings by 1000. With S1 in the 1K position, you would of course multiply the readings by 100.

To calibrate a capacitance scale, find the capacitance value and mark the appropriate resistance point. At 836 ohms, mark 1.9; at 800 ohms, mark 2; etc. No further calibration for capacitance is required. The other three ranges of capacitance fall into line because the controls are linear. With a 100-cycle test signal, the C or C/10 scale applies, depending on S1’s position. With a 10,000-cycle signal, the ranges become C/100 and C/1000. Simply flip S1 to the desired range. Consult the calibration charts on page 124 as you work.

An inductance scale is calibrated simi-

Exalted Pot
(Continued from page 124)
Fill in coupon for a FREE One Year Subscription to OLSON ELECTRONICS' Fantastic Value Packed Catalog—Unheard of LOW, LOW PRICES on Brand Name Speakers, Changers, Tubes, Tools, Stereo Amps, Tuners, CB, and other Values. Credit plan available.

NAME
ADDRESS
CITY ZONE STATE

If you have a friend interested in electronics send his name and address for a FREE subscription also.

OLSON ELECTRONICS INCORPORATED
451 S. Forge Street Akron, Ohio 44308

CIRCLE NO. 16 ON READER SERVICE CARD

Simple Voltage Calibrators
(Continued from page 116)

To use the "Exalted Pot" as a variable resistor, terminals B and C are employed. For 0-1000 ohms, set S1 to the 1K position. For 0-10,000 ohms, set S1 to the 10K side.

To operate the unit as a low-current voltage divider, apply the voltage to terminals B and T. Take the divided voltage from terminals B and C. Either the 1000-ohm or 10,000-ohm potentiometer can be used depending upon the position of S1. Do not exceed the ½-watt rating of R1 and R2.

At 62.8 ohms, mark 1; at 125.6 ohms, mark 2; etc. Refer to the first two columns in the calibration table. Here again, because the controls are linear, the other ranges do not require further calibration. With a test signal of 10,000 cycles, and with S1 at position L, you can read 1 to 15 mh directly. With S1 in the Lx10 position, multiply readings by 10 and read 10 to 150 mh. The ranges at 100 cycles are: Lx100 for readings from 0.1 to 1.5 henrys, and Lx1000 for values from 1 to 15 henrys.

Operation. Connect the generator output to jack J1 and the unknown component to terminals C and Gnd. Connect your VTVM first to C and Gnd, and then to B and C. Adjust the knob to obtain the same voltage readings. When the voltages are equal, the scale can be read. Keep in mind that the applicable scale depends upon using the correct test frequency and position of the range switch. Also remember that electrolytic capacitors are polarized and are designed for d.c. operation—you may not be able to determine their values with this technique.

To operate the unit as a low-current voltage divider, apply the voltage to terminals B and T. Take the divided voltage from terminals B and C. Either the 1000-ohm or 10,000-ohm potentiometer can be used depending upon the position of S1. Do not exceed the ½-watt rating of R1 and R2.

-30-

Simple Voltage Calibrators
maximum resistance in the circuit to protect the diode against current surge. Electrolytic capacitor C1 can have a working voltage rating of 150 volts or as low as 20 volts.

A voltmeter at the output jacks can be used to set up the desired input voltage on the 100% range. All the other positions will, without further adjustment, provide the indicated voltage steps; accuracy is limited only by the initial meter reading and the variations in values of the resistors. Both the meter reading and output voltage are taken from J1 and J2.

One precaution to observe when taking voltage readings is to avoid the loading effect of a low ohms-per-volt meter. A simple check on the accuracy of your reading on the 100% level is to measure the voltage on the next lower step, which is the 50% level, and then multiply your reading by 2. If the answer is the same, you are on firm ground; otherwise, you should accept the reading on the lower scale as being the more accurate one.

2 Halos for 2 Meters

(Continued from page 103)

The two halos are spaced \( \frac{1}{2} \) wavelength apart, horizontally levelled and oriented in the same direction. See the diagram on page 103 for actual dimensions.

Carefully form the halos to prevent flat spots, kinks and just plain out-of-roundness. There are machines for this purpose and for a small fee you can get a sheet metal shop to form the halos.

Bolt the halos securely to the mast cutouts as shown in the halo mounting detail diagram. Do not tighten enough to distort the mast or halo tubing, and use lock washers. Connect the halos to each other with 52-ohm coaxial cable. Stranded internal conductor transmission line is preferable to the solid conductor type to reduce breakage from vibration.

---

Surplus Bargains

ANALOG OUTPUT electronic timer. 2 electric motors, one with gear train driving precision pot., the other for re-set. One rev. per 8 hours, output on precision pot. Made for Veeder Root. $1.50

RUNNING TIME METER indicates total running time to 9999.99 hours. Use it for time-in-use of motors, oil burners, machines, etc. Operates from 115 volt AC 60 cycle. $4.50

CANADIAN AIR FORCE carbon mike noise cancelling, made by Electro Voice. Unused $1.25

MARINE-POLICE-FIRE CONVERTERS. 3 models 2-3 mc, 30-50 mc, 100-200 mc. Simple to use with any car radio. Build it yourself kit with instructions $5.00 any model. Completely built, ready to use $15.00 any model.

T-45 US AIR FORCE LIP MIKE, unused................... .75

PHOTOCONDUCTIVE cell by Clairex, all glass sealed, new small style, 500 series. New......................... 1.50

USA OPTICAL PRISM, 5 inches, used on Army Tanks. $1.00

POWER SUPPLY KIT, 6-12-24 volts DC 6 amps from 115 volt 60 cycle AC. Easy to build, with transformer. Operate surplus equipment, plating, battery charging, etc. $12.00

FIELD EFFECT TRANSISTORS (FET) w/sheet $1.50 ea.

40" TELEPHOTO LENS 18, w/iris & shutter .......... $50.00

IBM MEMORY, WIRED PLANES, First class cond w/specs. 1,000 bit......$10.00; 4096 bit......$12.50; 8192 bit......$15.00; 16,384 bit......$35.00

US SNIPERSCOPE M-3, infra red, ready to use........ $225.00

SNIPERSCOPE IR CONVERTER tube #6032 w/specs. $5.50

GYRO, 28 VOLT DC drive. Excellent for marine auto-pilot experimentation, etc. Electric Cage & Uncage, electric drive positioning, pot with 4 take-offs. $8.75

INFRA-RED FILTER 5 inch, use with your light .......... $1.75

INFRA-RED SENSOR DETECTOR, brand new............ $1.25

US NAVY INFRA RED VIEWER, optical device........ $12.00

SOLAR CELLS, electricity from the sun. Assortment with experimentation instruction book........................... $1.50

The above sampling represent but a very few of the hundreds of unusual surplus items listed in our illustrated catalog. All offered at a fraction of original cost. We believe this is the most interesting catalog of its type in the world. Send 25¢ and get yours.

All material listed above sold FOB Lynn, Mass. (you pay shipping)

JOHN MESHNA JR.
19 Allerton St., Lynn, Mass.
CIRCLE NO. 31 ON READER SERVICE CARD

---

1966 Spring Edition
Two lengths of cable, each about 21" long, connect the halos. The center conductor on one end of each cable is attached to the terminal connected to the small mica capacitor on each halo. Connect each outer shield to the adjacent ground terminal. The other end of each cable is terminated in a PL-259 or equivalent type coaxial connector and screwed into an appropriate coaxial "T" fitting. The transmission line from the antenna to the transmitter is also screwed into this fitting.

**Gamma Match.** To construct the gamma match, install a clamp on each halo at a point 4½" to the right of center. The gamma match on each halo should be located on the same side of the mast.

The capacitors should be shielded from the weather. As a matter of fact, a coat of acrylic paint over the entire antenna and fittings will protect it from the elements. The wire forming the gamma match should follow the outside curvature of the halo. About #13 AWG tinned copper bus wire will do. Place nothing within the center of the halo.

An easy way to tune the antenna is with the aid of an SWR meter or field strength meter. Another method is to connect the halos to a receiver and adjust the gamma match for maximum volume or reading of an “S” meter if available.

---

**The Dymwatt**

(Continued from page 52)

an ohmmeter to be sure there is no electrical connection.

An aluminum case will help the heat sink do its work. Do not use a smaller box than the one specified—it might get too hot to touch and could damage the Triac. The case used by the author remains relatively cool for all but the heaviest power loads; above 400 watts it becomes noticeably warm.

See Fig. 4 for parts layout. The heat sink on the inside and a dial plate on the outside of the case are held in place with a "Pop" rivet and the mounting nut of the potentiometer. Avoid overheating either Q1 or D1 when you are
soldering. If you wish, a NE-83 neon lamp can be substituted for DI to reduce cost, but it will also reduce the control range.

As long as the Dymwatt is used within its ratings and only for its intended types of loads, it is capable of long life and trouble-free service.

Electric Fence Charger

(Continued from page 32)

find out if the fence is being charged, connect the neon tester between the ground and the fence. The higher the intensity of the flash, the greater the charge. To minimize the possibility of shock, first connect the tester's lead to ground.

To keep a garbage can from being raided, place a small sheet of thin plastic material (the kind that plastic bags are made of) under the can. The plastic sheet should be just large enough to insulate the garbage can from the ground.

If the can is to be placed on a dry cement or gravel walk, first lay down a piece of metal screen, about 2' x 2', to serve as a ground. It should be big enough so that a dog will have to stand on it when he reaches out a paw for the can. Cover the screen with a piece of cardboard, then place the sheet of plastic over the cardboard, and then place the can over this "sandwich." The cardboard keeps the screen from puncturing or tearing the plastic. Both the cardboard and the piece of plastic are just a little bit bigger than the can but not big enough to prevent the dog from standing on the bare screen.

Run an insulated wire from the garbage can to the red post on the charger, and either a bare or insulated wire from the ground to the black binding post. (Better turn off the charger before the garbage collector arrives, or he may decide to take you in along with the garbage.)

One shock per invader should be enough. You will probably see some of the most surprised pooches you ever saw in your life.

What can you expect from an automatic turntable under $70?

[Image of a turntable]

The most (If it's a Dual)

and your franchised United Audio dealer will be glad to show you the many reasons why.

[United Dual logo]

CIRCLE NO. 25 ON READER SERVICE CARD

1966 Spring Edition

[Box with bullet points:
- At $69.50, the Dual 1010 Auto/Standard Turntable is more than an outstanding value... it's a remarkable engineering achievement. [Because it delivers essentially the same performance as the Dual 1009, but at a considerably lower price," reports Julian Hirsch in HiFi/Stereo Review. [As for the 1010's wow, flutter and rumble, The American Record Guide rates them "specifications for a fine manual turntable, but not for a low price automatic." [Not surprising. For the 1010 offers the same Continuous-Pole motor and precision engineering (though fewer features) as the widely acclaimed Dual 1009. [Tracking is flawless as low as 2 grams, with ½ gram click stops so precise, no stylus gauge is needed. [Plus automatic and manual start with either the single play or changer spindle. [Clearly, there's only one medium-price turntable for the discriminating audiophile...]

535 Madison Ave, New York, N.Y. 10022
Dollar-stretch-er ...1966 edition!

If you’re in the market for photography equipment and you want to get the most for your money, send for the 1966 PHOTOGRAPHY DIRECTORY & BUYING GUIDE right now! Then just sit back and be as choosy as you like!

You’ll have access to over a thousand different items—with complete, point-by-point information on manufacturer, model number, size, special characteristics and price.

And the 1966 edition of this big, valuable factbook is more comprehensive than ever before. A large, new 8½” x 11” format now brings you virtually every category of photo gear you want to know about...160 pages of all the latest equipment!

Expert tips on how to buy and what to look for in...still cameras, flash equipment, meters, lenses, movie cameras, projectors, super-8, titlers, editors, slide equipment, tape recorders, enlargers, films, filters...and more!

The 1966 PHOTOGRAPHY DIRECTORY & BUYING GUIDE has been compiled by the editors of POPULAR PHOTOGRAPHY. That means authoritative, precise information. Dollar-stretching data that will help you select the best equipment in your price range, consistently, all through the next twelve months!

This year, play it smart. Shop before you buy, confidently, with the 1966 PHOTOGRAPHY DIRECTORY & BUYING GUIDE.

First Time Ever Offered! A DELUXE, GOLD-EMBOSSED LEATHERFLEX-BOUND EDITION ...just $3.00 postpaid.

Best Meter Face Forward
(Continued from page 118)

top arc. Then lay out each minor division by dividing each major division into a suitable number of parts. Guide lines are drawn through each of these division points, aimed radially toward the meter pivot point. Add the actual scale markings using ¾”-wide black printed circuit tape for the major divisions, and ⅛”-wide tape for the minor ones. Carefully cut the tape squarely across each arc with a razor blade or a sharp knife.

Transfer the scale numerals into place, being very careful about centering. Note that the center of a 20 is exactly between the “2” and “0,” while the center of a 10 is just inside the “0.” The center of each numeral group should exactly correspond to the axis of that major division. The title baseline is drawn parallel to the original baseline, and the title pressed into place. To center the title, add up all the space required for each letter and space, and then start the lettering half this distance away from the centerline.

Nonlinear Scales. Nonlinear scales require more thought. If the scale is clearly defined mathematically, the scale divisions may be determined by suitable algebra or geometry. An ohmmeter scale is started with infinity and ends with a zero at full scale. The exact center of the scale is equal to R, the internal resistance of the ohmmeter; 2R is located one-third of the way up the scale; 3R is one-fourth, 4R is one-fifth of the way up the scale, etc. For a 1-10 log scale, lightly lay out a linear 0-10 scale. Divisions for each log point are then placed on the log of each desired number. This means the 1 goes at 0, the 2 at 3.01, the 3 at 4.77, etc. Decibel scales work in much the same manner.

Photolith Negatives. Most towns have at least one photolithographer who can make a 5:1 reduction of your art work in the form of a photographic negative. The cost of this service is about $1.00. Don’t go to an ordinary photographer, as it will cost much more, and the film used will not have nearly the contrast ratio that lithography film has (the negative is either perfectly transparent or else jet black). Take the negative to a photo store and have semigloss contact prints made; the cost of each print should be about 15 cents.

To mount a new meter face, cut the print to size, align it carefully, and cement it with rubber cement to the back of the original meter face. If you ever need the original again, you’ll have it handy. —50—
150 and less than 180, turning Si on will make the slave more sensitive to low light levels without danger of damaging the strobe.

Construction. To determine which Strobelight Slave you should build, turn on the strobe you intend to use with it, and carefully measure the d.c. voltage across the contacts of the shutter socket when the "ready" light comes on. While you're at it, observe the polarity of the voltage at the shutter socket, and permanently mark the positive contact with a plus sign.

The assembly of both slave units is simple and straightforward; the basic Strobelight Slave is housed in a 2½" x 2½" x 4" box, while a 3" x 4" x 5" box is used for the booster model. Simply mount the parts as shown in the photographs, using spacers to hold V2's socket away from the bottom of the box. With the booster slave, be sure to mount the parts so that the batteries can be secured in the back of the case; a battery retaining strap can be made from scrap aluminum.

Make a shield can with a window in it for V1 to minimize triggering of the slave by stray light. A tube shield or cover from an old i.f. transformer can be used for this purpose. For some applications, however, it may be desirable to remove the shield to obtain greater sensitivity.

Both versions of the Strobelight Slave are designed to work without any modifications to the strobe unit itself. Just make sure that the connecting cord between the two is properly polarized by marking a plus sign on the positive contact of the socket on the strobe and the positive contact of the socket on the slave. In Figs. 2 and 3, the positive contact of SO1 is the upper one, and is connected to V2 or D1 respectively. Damage may result to one or both units if the cord is incorrectly polarized.

The basic slave shown in Fig. 2 can be built for about $6, and the booster slave for about $16, the primary increase being in the cost of the batteries. —50—

Strobelight Slave
(Continued from page 45)

Zip through Scott's new solid state FM stereo tuner kit in one afternoon

Four to six hours! That's all you need to zip through Scott's new LT-112 FM stereo tuner kit. Start after lunch... enjoy superb stereo at dinner. ■ Scott solid state circuitry is the key to the LT-112's superior performance. Costly silicon transistors give performance unapproached by any other kit on the market. The LT-112 is kit-brother to Scott's best-selling 312 solid state stereo tuner, of which Audio said, "... one of the finest tuners anywhere." ■ Your LT-112 arrives with all critical circuitry pre-wired, pre-tested, pre-aligned, and mounted on heavy-duty printed circuit boards. Scott's exclusive life-size, full-color construction book details every step... makes perfect wiring almost automatic. ■ You'd never believe a kit so easy to build could be so packed with features. Built into the LT-112 is a new Scott invention... the Tri-modulation meter, used for a Signal Strength Indicator, Zero Center Indicator, and Alignment Meter. ■ See your Scott dealer today, and pick up an LT-112 tuner kit... $179.95 plus one enjoyable afternoon will net you a lifetime of listening pleasure.

For complete information on Scott's kits & components write:
H. H. Scott, Inc., 111 Powdernmill Road,
Maynard, Mass. Dept. 521-1

Export: Scott International, Maynard, Mass. Cable HIFI.
Prices slightly higher west of Rockies. Prices and specifications subject to change without notice.

CIRCLE NO. 23 ON READER SERVICE CARD

1966 Spring Edition
if you snap with this...

it's a snap with this!

1966 POLAROID LAND PHOTOGRAPHY

If you own a Polaroid Land camera, or are in the market for one, sign up now for the most important "excursion" of your picture-taking career. An exciting tour through the miraculous world of "instant" pictures.

Your guide is the all-new 1966 edition of POLAROID LAND PHOTOGRAPHY — the only comprehensive and up-to-date handbook on the subject. The one knowledgeable guide that delivers the skill and know-how for the most rewarding Polaroid Land photographs you've ever taken!

Your tour begins the moment you open your copy... with a detailed inspection of the complete line of Polaroid Land cameras, accessories and film... next, a valuable course in photography basics... an important discussion on Polacolor... followed by 77 fascinating uses for Polaroid Land photography.

PLUS—gallery after gallery of masterful, enchanting Polaroid Land photographs—including 16 pages in glorious color.

All in all, 116 fact-and-photo-packed pages of the most extensive, authoritative, important-to-you information available. Sign up today, just clip the coupon below and return it with your remittance. $1.25

ALSO AVAILABLE—AN EXQUISITE LEATHERFLEX-BOUND EDITION FOR JUST $3 POSTPAID!

Tachometer Calibrator
(Continued from page 40)

148 lamps can be mounted in grommet-lined holes on the front of the case, or in regular small sockets.

Substitutions of components can be made. However, two things should be kept in mind: (1) the peak inverse voltage rating of the diode must be at least 300 volts and (2) the transformer voltage should be well over any possible difference in firing voltage of the two neon lamps, but not so high as to fire the lamps unaided by the ignition pulses. Transformer voltage on the order of 22 volts works very well.

Operation. To calibrate the tachometer, connect the newly made calibrator as shown in Fig. 1, one wire going to any convenient chassis ground and the other going to the coil's terminal which is connected to the distributor points. Plug the power cord into any 117-volt, 60-cycle a.c. outlet.

Start the car, and adjust the motor speed until the lamps indicate synchro-nism. Note the tachometer reading, then adjust the motor speed until the lamps indicate the synchronism for the second point, and again note the tachometer reading. You now have two accurate calibration points for the tachometer. The difference between each reading and the corresponding true figures (450 and 900 rpm for an 8-cylinder engine and 600 and 1200 rpm for a 6-cylinder job) is the tachometer error.

No trouble should be encountered in identifying the two points of synchro-nization. The lower speed is a slow idle, and the upper speed is much faster than idle. As either point is approached from either a higher or lower engine speed, the blinking rate of the lamps will slow down, indicating that you are approaching the calibration speed.

In the event your car specifications show that one of the calibration speeds is the proper idling speed, the calibrator can be used to set the idle adjustment without the aid of a tachometer. Many V-8's with automatic transmission idle at 450 rpm when the transmission is in Drive and the parking brake is on. ~30
ELECTRONICS MARKET PLACE

FOR SALE

JAPAN & Hong Kong Electronics Directory. Products, components, supplies. 50 firms—just $1.00. Ippano Kaisha Ltd., Box 6266, Spokane, Washington 99207.

LOWEST Prices Electronic Parts. Confidential Catalog Free. KNAPP, 3174-EHB 8th Ave. S.W., Largo, Fla.

CALEMCO—The diversified line of transformers. Box 585, San Fernando, Calif.

IT'S SUPERCALIFRAGILISTICEXPIALIDOCIOUS, Free information on Kit-of-the-Month Club and new catalog of etched circuit boards and radio books. Many exclusive items. Leader Enterprises, Box 44718KI, Los Angeles 90044.

RECTIFIERS & TRANSISTORS—Send for catalog of semiconductors and other components, 10¢. Electronic Components Co., P. O. Box 2902, Baton Rouge, La.

TRANSISTORCOM AMPLIFIER KIT $2.95 ppd. Manufacturers surplus. Complete with switch & PC board. Assembled in 1 hour. Detailed instructions, multi-remotes. Assembled—tested $1.00 extra. DART ELECTRONIC DEVICES, BOX 214, JERICHO, N.Y.

REGULATED POWER SUPPLY—Twin Outputs 0-22 Volts At 1 Amp. Ideal for Transistors! Write Parrish Electronics, Box 1785, Melbourne, Florida.


PLANS AND KITS

PLANS for building computer circuits and catalog of inexpensive computer modules. 10¢. Diotron, Box 112, Somerville, Mass. 02145.

TUBES

ELECTRONIC TUBES—LARGEST STOCK IN USA. ELECTRONIC COMPONENTS AND EQUIPMENT. WRITE FOR "BARRY GREEN SHEET" CATALOG. SEND 10¢. Barry Electronics, 512 Broadway, N.Y.C., N.Y. 10012. (We also buy unused tubes, and good commercial equipment. Write details.)

MAGNETS

MAGNETS. Alnico, ceramic, flexible, assemblies. What you want, we have. Maryland Magnets, 5412L Gist, Baltimore, Maryland 21215.

EMPLOYMENT INFORMATION


INVENTORS

INVENTIONS WANTED. All Types. Global Marketing Service, 2420V 77th, Oakland, Calif.

1966 Spring Edition

INSTRUCTION

ENGINEERING and Art Degrees earned through home study. Electronics, Mechanical, Liberal Arts. When writing specify course desired. Pacific International College of Arts & Sciences, primarily a correspondence school. Resident classes also available. 5507-C Santa Monica Blvd., Hollywood, Calif. 90038.

ENGINEERING MATHEMATICS, TRANSISTOR ELECTRONICS. Pay as you learn. Satisfaction guaranteed. Free brochure. Indiana Home Study, Dept. EH1, Box 1189, Panama City, Fla.

BUSINESS OPPORTUNITIES

ELECTROPLATING Equipment, Supplies, Instructions. Home workshop and Industrial. DC Power Units from 10 Amps, to 3,000 Amps. Transformers, Meters, Rectifiers. 100 Amps., $29.50. Send $1.00 (Refundable) for Formulas, Equipment Guide, Catalog & Schematic. HBS, Dept 8, 3543 East 16th Street, Los Angeles, Calif. 90023.

INCREASE YOUR BUSINESS OPPORTUNITIES by featuring a low cost, highly productive classified ad in any or all Ziff-Davis electronics magazines or annuals. The steady growth of each publication's classified advertising section serves to indicate that advertisers are getting results—results that only active electronics enthusiast can produce. For complete details concerning classified advertising in any Ziff-Davis publication write: Hal Cymes, Classified Advertising Manager, Ziff-Davis Publishing Company, One Park Avenue, New York, New York 10016.

BOOKS


MAGIC TRICKS


CLUBS

COUPON BOOK, special offers from various firms. Latest Membership Benefit of Electronic Experimenters' Club. Dues $2.00. Further Information FREE. Box 5332N, Inglewood, Calif. 90310.

RUBBER STAMPS

RUBBER ADDRESS STAMP $1.00. Signature $2.88. Catalog, Jackson Stamps, 1433 Winnemac, Chicago, Ill. 60640.

MUSICAL INSTRUMENTS

SWISS MUSICAL MOVEMENTS. Electrical-Mechanical. Spielman, 131 West 42nd, New York 10036.
UNUSUAL BARGAINS

Bargain! 3" Astronomical Telescope

See the stars, moon, phases of Venus, planets close up to 186 power—famous Mt. Palomar Reflecting type. Universal joint equipped with Equatorial mount; finder telescope; hardwood tripod. Included FREE: "STAR CHART"; 272 page "HANDBOOK OF HEAVENS"; "HOW TO USE YOUR TELESCOPE" book. Stock No. 85,050-GD $79.95 pulpit, 4½" Reflecting Telescope—up to 255 Power. All-metal pedestal mount.

Stock No. 85,105-GD $79.50 F.O.B.
Superb 6" Reflector Telescope
Up to 575 Power, Equatorial mount and Pedestal Base.
Stock No. 85,086-GD $199.50 F.O.B.

Brand New, Quick-Charge, Industrial Surplus NICKEL-CADMIUM BATTERY

Unparalleled Values
For the first time a light, light-weight nickel-cadmium battery in stainless steel, strap type casing. 4 amp hour capacity. Almost unlimited life—thousands of discharge-charge cycles. Practical for high current demands. Charges fully in appox. 1 hr. with Edmund charger kit. Just a few drops of water per year provide full maintenance. Hundreds of uses for hobbyists, amateur photographers, campers, model builders, etc. Non-rechargeable internal, c-volt, iron cadmium, and lead-lithium; portable fluorescent and ultra-violet lights; electronic flash units. Non-corrosive, the top of this nature, is easy to handle and delivers nearly 100% of output at below freezing temperatures compared to lead-lead batteries. No corrosive fumes under ordinary stage of recharge. Can't be damaged by accidental charge in reverse (but don't recommend). Short type terminals on top 1½", spirt-marked for polarity: 0/32 thread, nuts and lock-washers. $15.00

Charger Kit for 6-Volt Battery. Charger in approx. 1 hr. with Edmund charger kit. Stock No. 70.$7.00
Charger Kit for Nickel-Cadmium Cell
Charger Kit for Nickel-Cadmium Cell
Stock No. 79,807-GD $8.00 Pnd.
Stock No. 40,798-GD $3.95 Pnd.

Binocular-to-Camera Holder
Will Fit Any Camera
Bring distant objects 7 times nearer with a 35mm camera, 7x50 binocular and our NEW, CAMERA-TO-BINOCULAR HOLDER. Ideal for long range photos of wildlife, ships, people, planes, etc. Camera and binocular attach easily. Use any binocular or monocular—any camera, still or movie. Take color or black and white shots. Attractive gray, black and white finish. Full directions for taking telephotos.
Stock No. 70,223-GD $11.50 Postpaid

GRADUATED MECHANICAL STAGE
Easily Attaches to Microscope
Eliminates awkward handling when slide must be moved. Has 30 mm. front to back and 50 mm. left to right evursions. Fixed verniers read to 0.1 mm. Dual control knobs horizontally positioned, conveniently located on right. Slide holder with adjustable pins and spring clip accepts large and small glass slides. Max. movement when locked is 2½". Metal unit finished in black and chrome. Microscope stage easily drilled to attach with two locating pins and thumb-screws. Turn thumbscrews for simple removal.
Stock No. 30,056-GD in wooden case $31.50 postpaid

NEW! STATIC ELECTRICITY GENERATOR
Sturdy, Improved Model
See a thrilling spark display as you set off a miniature bolt of lightning. Sturdily made—stands 14" high. Two 9 plastic discs rotate in opposite directions. Metal collector box lifts up the static electricity, store it in the Leyden jar type condenser until discharged by the jumping spark. 2½" page illustrated booklet included.
Order Stock No. 20,070-GD $12.95 Postpaid

Order by Stock No.—Send Check or M.O.—Money-Back Guarantee
EDMUND SCIENTIFIC CO., Barrington, New Jersey

MAIL COUPON FOR FREE CATALOG "GD"


Name ____________________________
Address ____________________________
City __________ Zip Code ______ State ______

CIRCLE NO. 8 ON READER SERVICE CARD

PRINTED IN U.S.A. ELECTRONIC EXPERIMENTER'S HANDBOOK

READER SERVICE NO. ADVERTISER PAGE NO.
1 American Institute of Engineering & Technology 130
2 Burstein-Applebee Co. 128
3 CTS Knights, Inc. 129
4 Conar 131
5 Cleveland Institute of Electronics 1
6 Datuk Corporation, The 133
7 DeVry Technical Institute 13
8 Edmund Scientific Co. 150
9 Electro-Voice, Inc. 135
10 Fisher Radio Corporation 75
11 Grove Electronic Supply Company 138
13 Heath Company 69
14 Hy-Gain Electronics Corporation 88
30 International Crystal Mfg. Co., Inc. 6
29 Johnson Company, E.F. 4
12 Lafayette Radio Electronics ... SECOND COVER 1
31 Meshna Jr., John 143
32 Miller Co., J.W. 136
15 Multicore Sales Corp. 140
117 Radio Institute THIRD, FOURTH COVERS
16 Olson Electronics Incorporated 140
17 Poly Pak 128
18 Progressive "Edu-Kits" Inc. 54
19 RCA Electronic Components and Devices 2
20 RCA Electronic Components and Devices 53
21 RCA Institutes, Inc. 35
22 Sams & Co., Inc., Howard W 139
23 Scott, Inc., H.H. 147
28 Semiconics Corp 144
24 Sydnum Electronic Specialties 136
25 United Audio 145
26 University Sound 138
27 Xcelite, Inc 137

ELECTRONIC EXPERIMENTER'S HANDBOOK SPRING 1966
BUILD YOUR OWN PHONE/CODE TRANSMITTER
This is just one of seven training kits programmed into NRI's Complete Communications course. You get actual practice in building your own crystal-controlled, phone/code transmitter and putting it on the air. You experiment with modulation, "clamping" circuits, key filters, other aspects of commercial transmitter operation. Can be put on the air simply by attaching an antenna and complies with FCC regulations. As with all NRI training kits, you get the most modern features and parts.

BUILD ACTUAL ANALOG COMPUTER CIRCUITS
Industry, business offices, the government and military all need trained Electronics Technicians. NRI's Industrial Electronics course prepares you. You progress through 10 carefully designed training kits, topping off your practical experience phase of training by experimenting with feedback control systems, analog computers and digital computer elements. You actually solve problems on this analog computer you build yourself. This is the practical, fast way to a good paying, career position.

BUILD A CUSTOM-ENGINEERED TELEVISION RECEIVER
Want to earn $3 to $5 an hour in spare time? Want your own part-time or full-time business? In Radio-TV Servicing you learn to install, maintain, service radios, TV sets, hi-fi and stereo, other home Electronics equipment. In your training are eight training kits, including this complete, modern, slim-line TV receiver. You build it yourself, become familiar with components and circuits, learn servicing procedures...and earn extra money as you train. National Radio Institute, Washington, D.C.

SEE OTHER SIDE
GET FAST START WITH NEW ACHIEVEMENT KIT
Delivered to your door—everything you need to make a significant start in the Electronics field of your choice. An outstanding, logical way to introduce you to home-study training. It includes your first set of lesson texts and all the “classroom tools” you need. No other school has anything like the new NRI Achievement Kit.

ELECTRONICS COMES ALIVE WITH NRI TRAINING KITS
Nothing is as effective as learning by doing... and NRI pioneered the “home lab” technique of training. NRI invites comparison with training equipment offered by any other school. Begin NOW this exciting program of practical learning. Make the skills of the finest Electronic Technicians your own. Mail card below.

"BITE SIZE" TEXTS PROGRAM YOUR TRAINING
Certainly, lesson texts are necessary. NRI’s programmed texts are as simple, direct and well illustrated as 50 years of teaching experience can make them. They are carefully programmed with NRI training kits to make the things you read about come alive. You experience all the excitement of original discovery.

HOBBY? CAREER?
MAIL CARD NOW TO NRI
Whatever your need... whatever your education... there’s an NRI training plan to fit your requirements. Choose from three major courses or select one of seven special courses in particular Electronics subjects. Check the postage-free card below, fill in and mail. National Radio Institute, Washington, D.C.

DISCOVER THE EASE AND EXCITEMENT OF LEARNING ELECTRONICS THE NRI WAY

SEE OTHER SIDE

National Radio Institute, Electronics Div.
Washington, D.C. 20016 13-026

Please send me your catalog. I have checked the field(s) of most interest to me. (No salesman will call.)

☐ TV-Radio Servicing ☐ Basic Electronics
☐ Industrial Electronics ☐ Electronics for Automation
☐ Complete Communications ☐ Aviation Communications
☐ FCC License ☐ Marine Communications
☐ Math for Electronics ☐ Mobile Communications

Name ___________________________________ Age ____________________

Address______________________________

City _______ State _______ Zip Code _______.

Accredited Member National Home Study Council

PICK THE TRAINING PLAN OF YOUR CHOICE AND MAIL CARD FOR FREE CATALOG

OUR 50TH YEAR OF LEADERSHIP IN ELECTRONICS TRAINING