1966 ELECTRONIC EXPERIMENTER'S HANDBOOK

POPULAR ELECTRONICS

FALL EDITION

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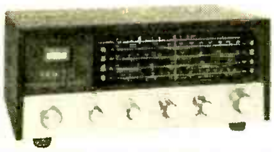

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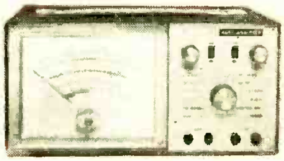

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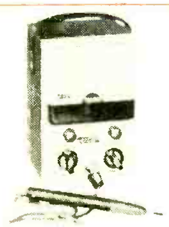

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FALL EDITION 1966 POPULAR ELECTRONICS ELECTRONIC EXPERIMENTER'S HANDBOOK

IN VIEW OF THE PRESSING DEMAND FOR TRAINED ELECTRONICS TECHNICIANS, A SPECIAL TWO-PART STORY HAS BEEN ADDED TO THIS EDITION—THE TWELFTH—OF THE **ELECTRONIC EXPERIMENTER'S HANDBOOK.** THE UNDISGUISED PURPOSE OF THIS PARTICULAR STORY IS TO ENCOURAGE MORE ELECTRONICS HOBBYISTS TO SERIOUSLY CONSIDER A FULL-FLEDGED CAREER IN THIS EXPANDING FIELD. THE STORY DISCUSSES HOME-STUDY TRAINING VS. ATTENDING A RESIDENT ELECTRONICS TRAINING INSTITUTE. I URGE YOU TO READ THIS IMPORTANT STORY. FURTHERMORE, THERE IS A FOLLOW-UP STORY BY THE SAME AUTHOR IN THE OCTOBER, 1966, ISSUE OF **POPULAR ELECTRONICS.** THIS LATTER STORY IS AN ANALYSIS OF JOB OPPORTUNITIES FOR HOME-STUDY AND RESIDENT SCHOOL GRADUATES. IF YOU ARE INTERESTED IN ESTABLISHING A WELL-PAYING TECHNICIAN'S CAREER IN ELECTRONICS, THESE ARTICLES WILL TELL YOU HOW MUCH TIME AND MONEY YOU CAN EXPECT TO SPEND AND WHAT YOUR EARNING POTENTIAL WILL BE AFTER GRADUATION.

AS ALWAYS, THE EDITORIAL STAFF OF THE **ELECTRONIC EXPERIMENTER'S HANDBOOK** WILL APPRECIATE YOUR COMMENTS AND SUGGESTIONS FOR THE NEXT EDITION.

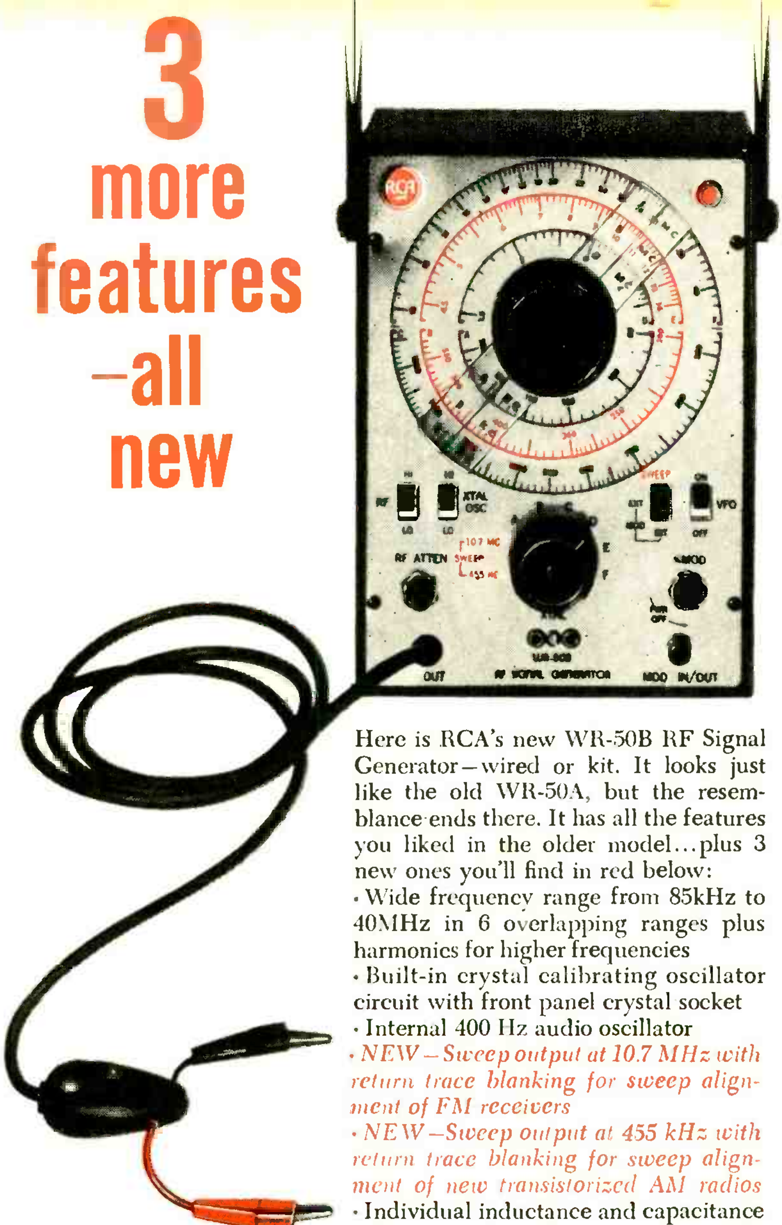
OLIVER P. FERRELL
EDITOR

INTERNATIONAL CRYSTALS

the first choice of the Radio Amateur

CHAPTER

3 more features —all new



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- Two-step RF attenuator switch plus a continuously-variable attenuator control
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- The Optional Distributor Resale Price is only $65.00. Kit Form, $45.00, includes pre-assembled range switch with pre-aligned coils and trimmers. See the RCA WR-50B at your authorized RCA Test Equipment Distributor.

RCA ELECTRONIC COMPONENTS AND DEVICES, HARRISON, N. J.

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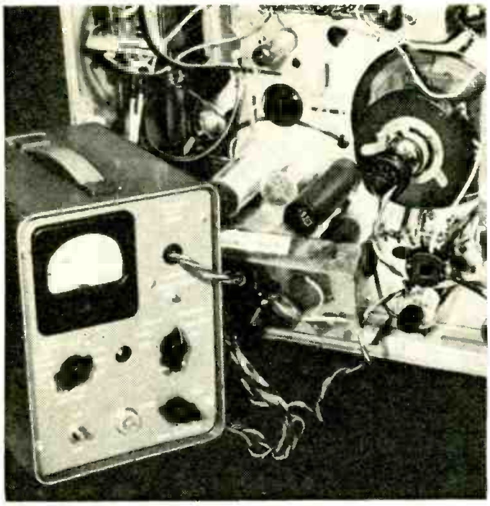
CHAPTER

1

USEFUL HOUSEHOLD PROJECTS

It is not unlikely that the arbitrary definition of "Household" projects has been stretched out of shape in this edition of the ELECTRONIC EXPERIMENTER'S HANDBOOK. However, the common denominator in selecting these projects is still valid—they are all things that might be seen around the electronically-oriented household. The projects have been mixed so that there is something here for father or brother in his workshop, a couple of pre-teen projects, at least two that should delight your mother, and a couple that are just plain general-purpose units.

Our cover photo shows the very popular version of the hi-fi color organ designed and constructed by Leon Wortman ("Christmas Lights Twinkle to Music"). Unlike the lights for many other color organs, these are not something you buy extra—they're the lights on your Christmas tree. If you're looking for something novel and attractive, we urge you to give this particular project consideration.



BUILD A TV PICTURE TUBE

DOES YOUR TV set "smear" when you try to turn up the brightness to a comfortable viewing level? Do the whites seem to become silvery? Is your picture so dim that you have to pull the shades or wait for nightfall to watch a program? Does it take a long time for the brightness level to come up? Is it impossible to vary the brightness level? Does the picture tube seem to go on and off? If the answer is yes to any or all of these questions, you probably have a "sick" picture tube.

While there are many different types of tests performed by the picture tube manufacturer, three types are usually made in the field: open-short, emission, and grid control tests. You can make all of these tests reliably and quickly, and also "rejuvenate" a "tired" picture tube with this easy-to-build TV Picture Tube Tester and Rejuvenator. The parts are inexpensive and readily available.

HOW IT WORKS

Opens and Shorts. The open-short test is shown in the simplified diagram in Fig. 1. In this test a.c. voltage is applied to the cathode, and to each element in the tube, one at a time, through a neon lamp. Each of the elements acts like an anode with respect to the cathode, as in an ordinary diode. Since half the a.c. voltage waveform is passed by the diode so formed, only one half of the neon lamp will glow.

Should the element be shorted to the cathode, current will flow in both directions and both halves of the lamp will glow. Should the element be open, no current will flow and the lamp will not glow.

In the heater-cathode check, however, the lamp will not glow even on one side when conditions are normal. The inside of the cathode cylinder is not coated with the activated emitting material and very little current will flow. A shorted condition will be indicated as in the other tests . . . both halves of the neon lamp will glow.

Emission. The emission check is shown in the simplified diagram in Fig. 2. The control grid is tied to the cathode and an a.c. voltage is applied to G_2 through a d.c. ammeter and series resistor. The amount of current that flows (during each positive half cycle) is a relative indication of the electron emission capability of the cathode.

Grid Control. The grid control test is similar to the emission test except that instead of having a zero grid bias as used in the emission test, a negative voltage is applied to the control grid as shown in Fig. 3. As the control grid voltage is made more negative, less G_2 current flows. When the control grid (G_1) voltage is made sufficiently negative, no current will flow and the tube will be cut off.

The amount of negative voltage required to achieve cutoff indicates the relative contrast range of the picture

It's easier to plug in
a tester than it is
to change a picture tube

By JEFF H. TAYLOR

TESTER AND REJUVENATOR

SIMPLIFIED CIRCUITS

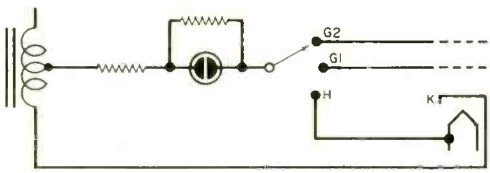


Fig. 1. Neon lamp indicator shows leakage, shorts, and opens between each element and the cathode.

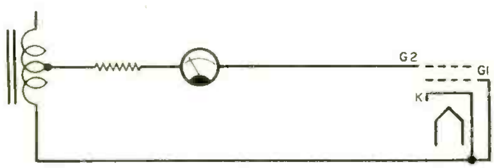


Fig. 2. Meter reads relative emission. Tests made at 1-minute intervals show warm-up characteristics.

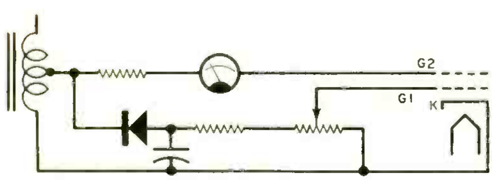


Fig. 3. Grid control is determined by the amount of negative voltage needed on G1 to obtain cutoff.

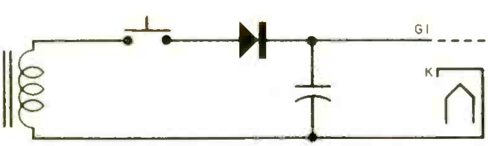


Fig. 4. Momentary application of a high d.c. potential across the cathode and G1 can boost emission.

tube. A tube that will cut off with a small voltage will produce a more contrasty picture than one that requires a larger voltage. In a 3-gun color tube, it is possible to determine if all the guns will cut off at the same potential, or the degree of imbalance, if any.

Rejuvenation. The cathode of a picture tube is a small metal cylinder with an external coating of emitting material. The heater is essentially a coiled wire and is placed inside the cathode cylinder. As the picture tube is used, the outermost activated material on the cathode becomes deactivated and its ability to emit is reduced accordingly. The process of rejuvenating the picture tube removes some of the deactivated coating from the cathode and allows the unused material beneath this "scab" to once again emit a good electron beam. This is accomplished by causing a heavy current to flow from the cathode to G_1—by placing a relatively high potential across the control grid and the cathode, for a very short period of time, as shown in Fig. 4.

If the tube is very weak, sufficient current may not flow to rejuvenate the cathode. Increase the filament voltage one step and try again. When the *REJUVENATE* button is depressed, you may see sparks fly inside the picture tube in the vicinity of the cathode. This is caused by the "dead" material being "stripped" off the cathode.

In a 3-gun color CRT, each gun in

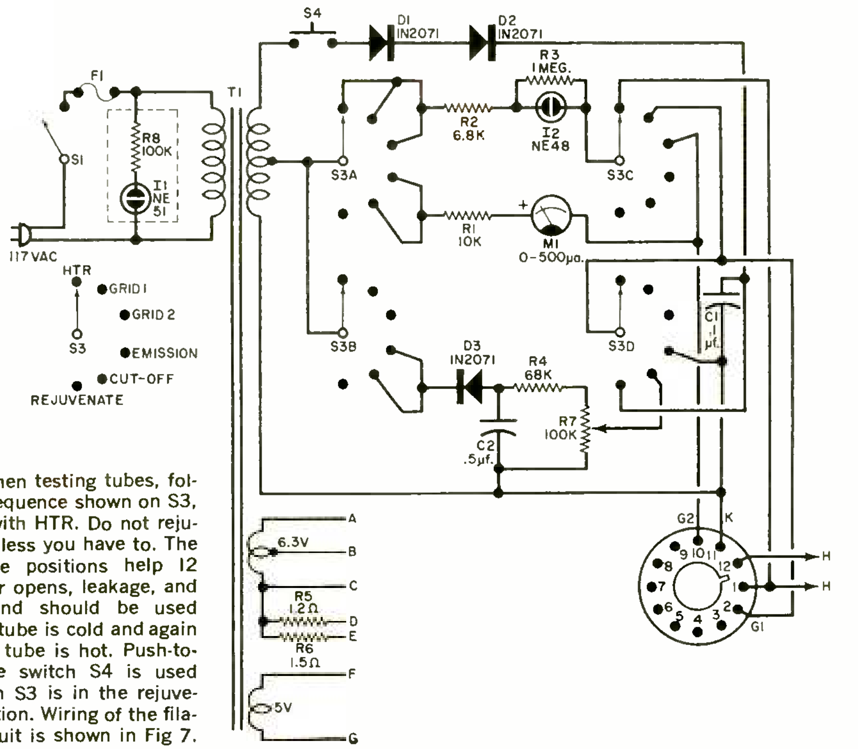


Fig. 5. When testing tubes, follow the sequence shown on S3, starting with HTR. Do not rejuvenate unless you have to. The first three positions help I2 "look" for opens, leakage, and shorts, and should be used when the tube is cold and again when the tube is hot. Push-to-rejuvenate switch S4 is used only when S3 is in the rejuvenate position. Wiring of the filament circuit is shown in Fig 7.

PARTS LIST

C1—0.1-μf., 1000-volt paper capacitor (two 0.2-μf., 600-volt capacitors in series or two 0.05-μf., 1600-volt capacitors in parallel)
C2—0.5-μf., 600-volt paper capacitor
D1, D2, D3—1N2071 silicon rectifier
F1—1½-ampere fuse
I1—NE-51 neon lamp
I2—NE-48 neon lamp
M1—0-500 microampere meter (Simpson Model 27 or equivalent)
R1—10,000-ohm, ½-watt resistor
R2—6800-ohm, ½-watt resistor
R3—1000-ohm, ½-watt resistor
R4—68,000-ohm, ½-watt resistor
R5—1.2-ohm, 2-watt resistor
R6—1.5-ohm, 2-watt resistor
R7—100,000-ohm potentiometer
S1—S.p.s.t. toggle switch
S2—4-pole, 9-position rotary switch (Centralab PA 2013 or equivalent)
S3—4-pole, 6-position rotary switch (Centralab PA 2011 or equivalent)
S4—Normally-open push-button switch (Grayhill 23-1 or equivalent)
T1—Power transformer: primary, 117 volts; secondaries, 470 volts CT @ 40 ma.; 5 volts @ 2 amp.; and 6.3 volts CT @ 2 amp. (Stancor PC 8401 or equivalent)
1—Cabinet (Bud WA1540 or equivalent)
1—2" x 5" x 7" chassis
Misc.—CRT sockets and adapters, fuse holder, line cord, knobs, etc.

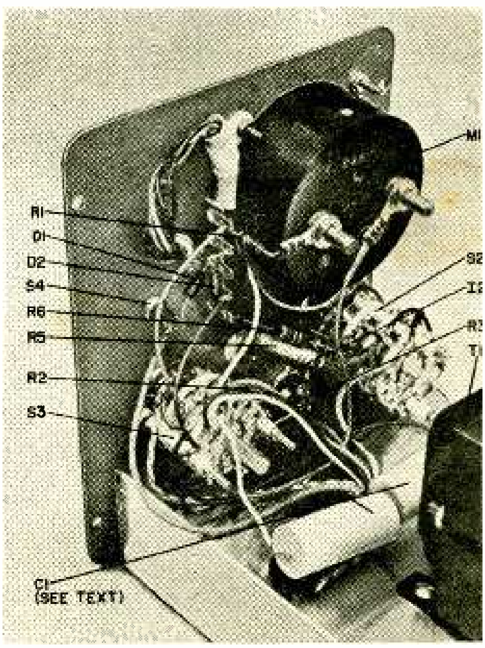


Fig. 6. Nothing is critical here, except for meter polarity. Most of the components are panel-mounted.

turn can be treated in this manner. Appropriate adapters and switching arrangements to accommodate multi-gun tubes, or any tube having a different base or basing arrangement, can be added to the tester. If you are careful, and if you don't have an appropriate socket, you can use clip leads or patch cords to make connections to the CRT pins.

CONSTRUCTION

Any convenient layout of parts can be used in building the tester/rejuvenator. The wiring is straightforward, except for the filament wiring. The phase of the transformer's filament windings must be determined before the filament switch can be wired.

To determine the phase, first tape the leads from the high-voltage secondary winding to avoid accidental contact, and do the following:

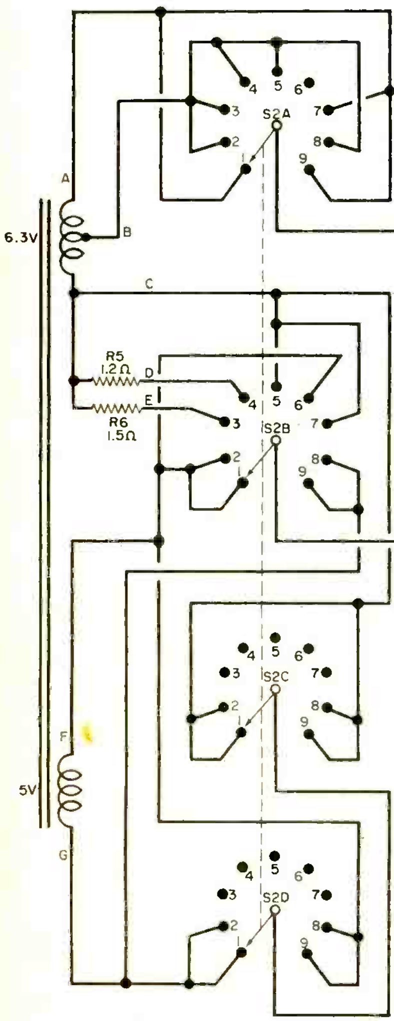
(1) Connect one of the 6.3-volt leads (not the C.T.) to one of the 5-volt leads.

(2) Connect the primary to 117 volts. (Be sure that the other transformer leads are not touching each other.)

(3) If an a.c. voltmeter is available, measure the voltage between the two unconnected (not the C.T.) filament leads. If this voltage measures about 11 or 12 volts, label the 6.3-volt lead to which the meter is attached "A"; label the 5-volt lead to which the meter is attached "G"; label the other 6.3-volt lead "C", and the other 5-volt lead "F". If the meter voltage measures 1 or 2 volts, label the 6.3-volt lead to which the meter is attached "A"; label the 5-volt lead to which the meter is attached "F"; label the other 6.3-volt lead "C", and the other 5-volt lead "G".

In the absence of a voltmeter, a 12-volt panel lamp can be used as a voltage indicator. The bulb will glow brightly when the winding phase produces 11 volts, and will glow almost imperceptibly—if at all—when the winding phase produces 1 volt.

Wiring is considerably easier if the switches are wired before installation. The neon lamp is supported by its terminals.



POSITION	VOLTAGE
1	1.3
2	1.85
3	2.25(600ma.)
4	2.61(450ma.)
5	3.15
6	5
7	6.3
8	8.15
9	11.3

Fig. 7. Windings are made to aid or oppose each other to obtain six more filament voltage levels.

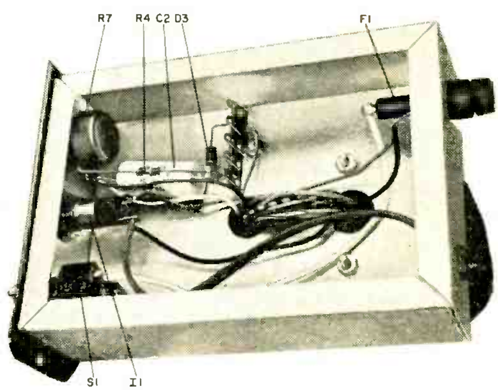


Fig. 8. Observe polarity of D3 or you'll put a positive voltage on G1 and possibly ruin your meter.

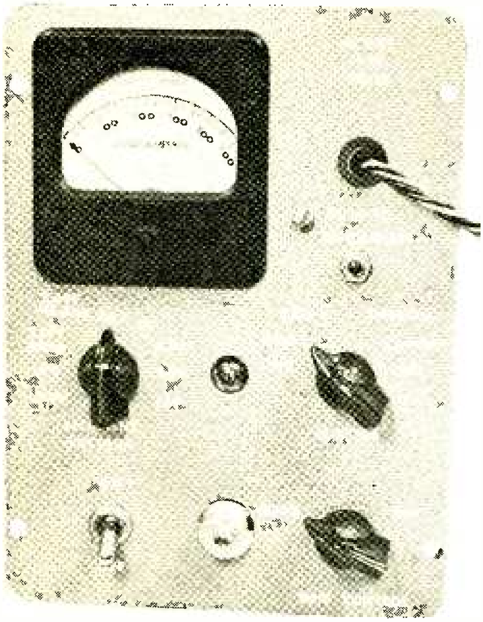


Fig. 9. Test cable can be fed through the panel, or plugged into a front-mounted octal socket. Picture tube socket adapters can be added as needed.

The on-off switch, panel lamp, and grid-bias potentiometer are mounted through the front panel and the chassis, and serve to hold the panel and chassis together. The filament and function switch are mounted on the front panel and are held securely in place with lock washers.

OPERATING INSTRUCTIONS

Open and Short Tests

(1) Select proper filament voltage.

(2) Connect the socket to the CRT.

(3) Turn the power switch to *ON* and allow approximately 30 seconds for the tube to warm up. Look at the neck of the tube to see if the heater is glowing. If it is not, the problem may be a loose connection in the picture tube base. Often this condition can be corrected by resoldering with solder containing noncorrosive flux.

(4) Turn the selector switch to *HTR*. If the heater is not shorted to the cathode, the neon lamp (*I2*) in the center of the tester will not glow. If it is shorted, both sides of the lamp will glow.

(5) Turn the selector switch to *GRID 1*. If grid 1 is not shorted to the cathode, one side of the neon bulb will glow. If it is shorted, both sides of the lamp will glow. If it is open, or if cathode emission is extremely low, the lamp will not glow.

(6) Turn the selector switch to *GRID 2*. If grid 2 is normal, one side of the neon lamp will glow. If this grid is shorted to the cathode, both sides of the lamp will glow. If grid 2 is open, or if cathode emission is too low, the lamp will not glow.

Emission Test

(7) Turn the selector switch to *EMISSION*. The meter should indicate approximately 300 microamperes or more for a good tube; however, a tube that conducts 100 microamperes or more will probably produce an acceptable picture. (Some of the newer type picture tubes designed to use higher G_2 voltages may indicate "weak" when they actually are not.)

Grid Control Test

(8) Turn the selector to *CUT-OFF*. With the *GRID CONTROL* knob turned fully counterclockwise, the meter should indicate the same value as it did on the emission check. Now advance the control clockwise until the meter registers no current (or an extremely small current). If the potentiometer has not advanced beyond the vertical mark, the tube cutoff characteristic is acceptable. In most cases, the tube will cut off well below this mark.

Rejuvenation

(9) If the emission check indicated a weak tube, turn the selector switch to *REJ*. Depress the *REJUVENATE* button for approximately ½ second and release, then turn the *SELECTOR* switch to *EMISSION*. If the tube now appears normal, remove the tester. If the tube still appears weak, increase the filament voltage to the next higher voltage and rejuvenate again. Reduce the filament voltage to its normal value, wait about a minute, and retest. If it does not now appear usable, increase the filament voltage one step higher and rejuvenate again. If this all-out try doesn't help, check emission with a higher than normal filament voltage. If this works, but rejuvenation doesn't, install a picture tube brightener. -30-

THE CURTAIN RISES and the spotlight falls on the slender girlish figure of the performer as she strolls gracefully towards the center of the stage. She stops behind a thin narrow box perched atop a microphone stand and turns to face the audience. Like a symphony conductor, she raises her hands . . . and on the downbeat rich musical tones, changing in pitch and intensity with each wave of the hand, fill the auditorium. She plays marches, polkas, and operatic themes—without once ever touching the music box.

Magic? No. "Lumemin" is the word. Using a pair of sensitive photocell "eyes," the Lumemin "sees" our performer as she moves her hands up and down, causing varying amounts of light and shadows to fall on its "eyes." In operation, one photocell controls loudness while the other controls the musical tones which are rich in harmonics and sound somewhat like conventional brass, woodwind, and string instruments.

The UJTO Circuit. The heart of the Lumemin is a versatile UJTO (Unijunction Transistor Oscillator) module (Fig. 1), driven by a power supply and its photoconducting circuit. The UJTO pro-

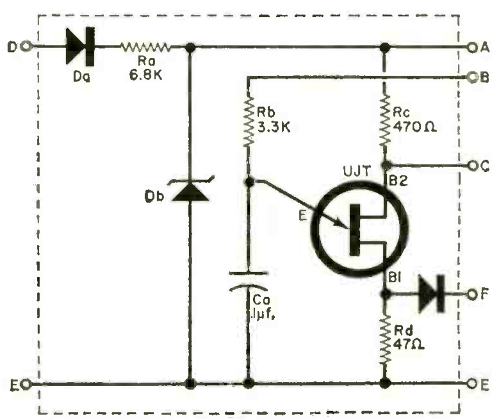


Fig. 1. Modified sawtooth signal across points B and E is fed to an external amplifier and speaker.

LUMEMIN STEALS THE SHOW

This easy-to-build musical instrument reads your hands like a Gypsy

By LOUIS E. GARNER, JR.

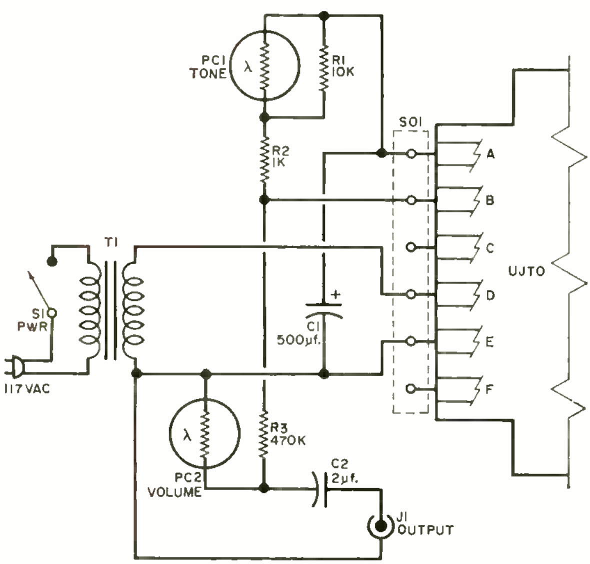


Fig. 2. Diagram of power supply and timing network shows wiring connections to UJTO plug-in module.

duces square-wave pulses as well as a modified sawtooth signal rich in harmonics. The latter is fed to an external audio amplifier and speaker.

Referring to Fig. 1, an a.c. input applied across *D* and *E* is rectified by diode *Da* and smoothed out by *Ra* and a 500-µf. capacitor (*Ca*) in the power supply circuit. Zener diode *Db* limits any voltage surges from the power supply to maintain a constant potential at the unijunction transistor (UJT) base electrodes through *Rc* and *Rd*.

Without emitter bias, the UJT is in a nonconducting (high-resistance) state. Capacitor *Ca* charges up through *Rb* and a resistor in the power supply circuit that appears effectively across *A* and *B*. As *Ca* begins to charge, the emitter voltage increases gradually until its point of conduction is reached. At this time, the UJT is triggered and switches from its nonconducting to a conducting state.

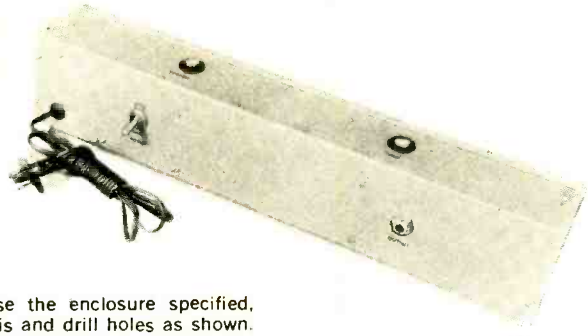
As the UJT conducts, *Ca* discharges rapidly through the UJT and *Rd*, developing a positive-going pulse at *B1* across *Rd*, and a negative-going pulse at *B2* across *Rc*. At the same time, a modified sawtooth waveform appears between terminals *B* and *E*. With *Ca* discharged, the UJT reverts to its high-resistance (nonconducting) state and the entire cycle is repeated.

The frequency (or repetition rate) of the circuit is dependent on the *RC* time constant of the components in the UJT emitter circuit. Basically, this boils down to the values of *Ca*, *Rb*, and the external resistance between *A* and *B*, as mentioned earlier. The output appears across points *B* and *E*.

The Other Components. Now, let's look at the rest of the Lumemin's circuit (Fig. 2). The major components are an isolating transformer (*T1*) and photocells *PC1* and *PC2*. Photocell *PC1* is part of the UJTO's timing network. It is shunted by *R1*, and this shunt combination is in series with *R2*. Therefore, *PC1* serves as the external frequency control resistor. As *PC1*'s resistance changes with different light intensities, corresponding changes take place in the UJTO's frequency. Thus, the instrument's *tone* is controlled essentially by *PC1*.

Recall from Fig. 1 that a modified

Fig. 3. Rear view of box used by author shows attractive slide cover design finished in gray aluminum. However, the builder can select practically any size or shape enclosure consistent with good appearance.



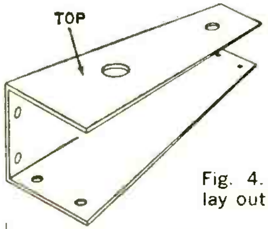
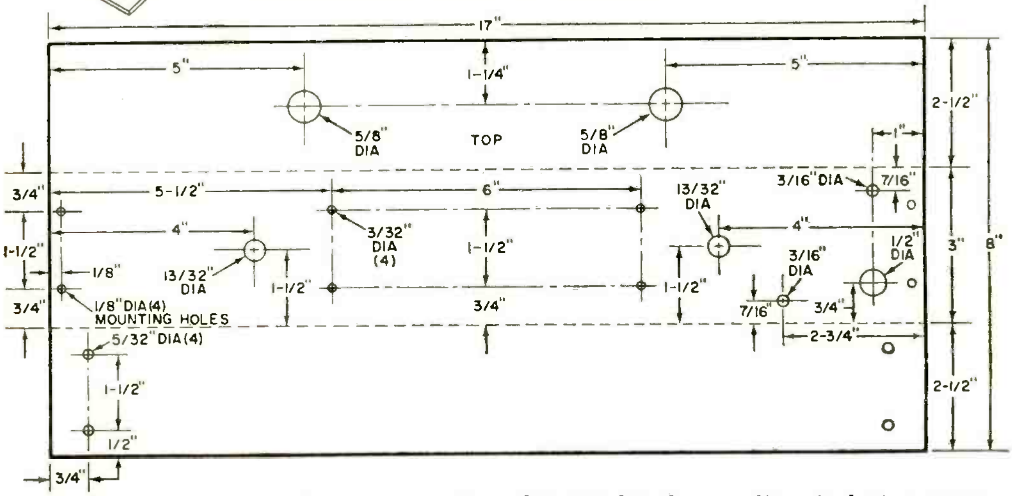


Fig. 4. If you use the enclosure specified, lay out the chassis and drill holes as shown.



sawtooth signal appears between terminals *B* and *E*. It can be seen from Fig. 2 that this signal appears across *R3* and *PC2* which are in series. The signal across *PC2* is coupled through *C2* to output jack *J1* which feeds an audio amplifier. Operation of *PC2* is such that its resistance decreases with the intensity of the light shining on it. Therefore, the amplitude of the output signal is directly proportional to *PC2*'s instantaneous resistance, and thus inversely proportional to the light falling on the device. Accordingly, maximum *volume* is obtained with reduced lighting, while a strong light produces little or no output.

Although the UJTO can be powered directly by the a.c. line, isolation transformer *T1* is used to insure greater safety and shock-free operation. Terminals *C* and *F* on the UJTO's circuit board (Fig. 1) are not used in this application.

Construction. Although the model shown in Fig. 3 has been designed around an attractive slide cover gray aluminum box, and all layout and construction details are centered around this design, the instrument can be housed in practically any type of enclosure, including a wooden cabinet or plastic box.

Remove the cover and drill the holes in the box following the layout and hole dimensions given in Fig. 4. Mount *J1*, *S1*, *T1*, *PC1* and *PC2* on the chassis as

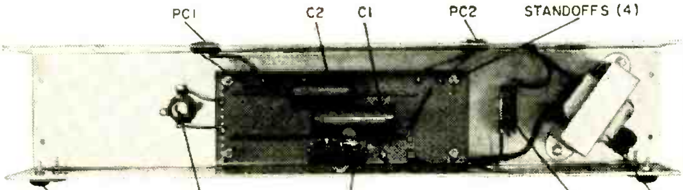


Fig. 5. Electrical components are first mounted on the perforated phenolic board which is then mounted on the chassis with four standoff spacers. Orientation must be as shown in diagram.

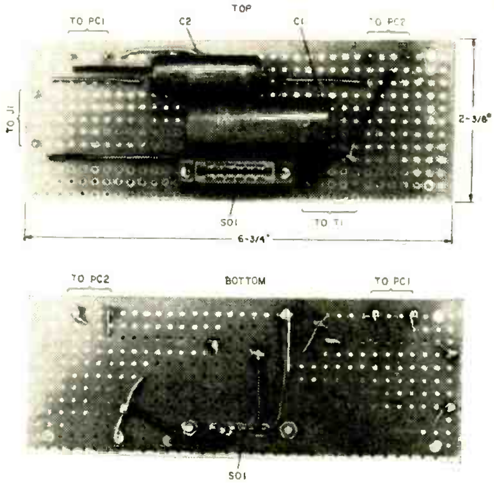


Fig. 6. Phenolic board showing components mounted on one side (top) and wiring details on other side.

PARTS LIST

C1—500-µf., 15-volt electrolytic capacitor
C2—2-µf., 200-volt paper capacitor
J1—Open circuit phone jack
PC1, PC2—CdS photocell (GE Type X6)
R1—10,000-ohm, ½-watt resistor—see text
R2—1000-ohm, ½-watt resistor—see text
R3—470,000-ohm, ½-watt resistor—see text
S1—S.p.s.t. toggle switch
SO1—Cinch-Jones bifurcated-contact edge connector, Series 250, Type 50-6A-20 (Newark Electronics Stock No. 29F952 or Allied Electronics Stock No. 40 H 319)
T1—115-volt isolation transformer (Lafayette Stock No. 33 G 7502)
UJTO—Unijunction transistor oscillator module (MS Type 5100-4A—available for $5 from Midland Standard, 161 E. Chicago St., Elgin, Ill. 60120)
1—3⅛" x 2⅝" x 17" slide cover utility box (LMB No. 19)
1—6¾" x 2⅜" perforated phenolic board
Misc.—Line cord and plug, rubber feet (4), standoff spacers (4), push-in terminals, rubber grommets (3), machine screws, nuts, wire, solder, etc.

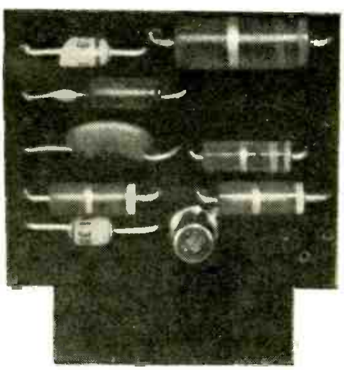


Fig. 7. When installing the UJTO module in the Cinch-Jones connector (SO1), make sure it is positioned with foil side of the board facing the chassis rim as shown in Fig. 5, or circuit will not work.

shown in Fig. 5. The photocells are mounted in tight-fitting rubber grommets, and the rubber feet can be put on at this time. Use No. 6 self-tapping screws, or if you prefer, machine screws with nuts and flat washers. Transformer *T1* can be mounted with the same size hardware. Then put the chassis aside, temporarily.

You can now begin to assemble the electronic components on the phenolic board as shown in Fig. 6. On one side of the board, mount the Cinch-Jones socket (*SO1*), and capacitors *C1* and *C2*, as shown in the top view. Wire the other side of the board as shown in the lower view. Refer to Fig. 2 for detailed wiring information.

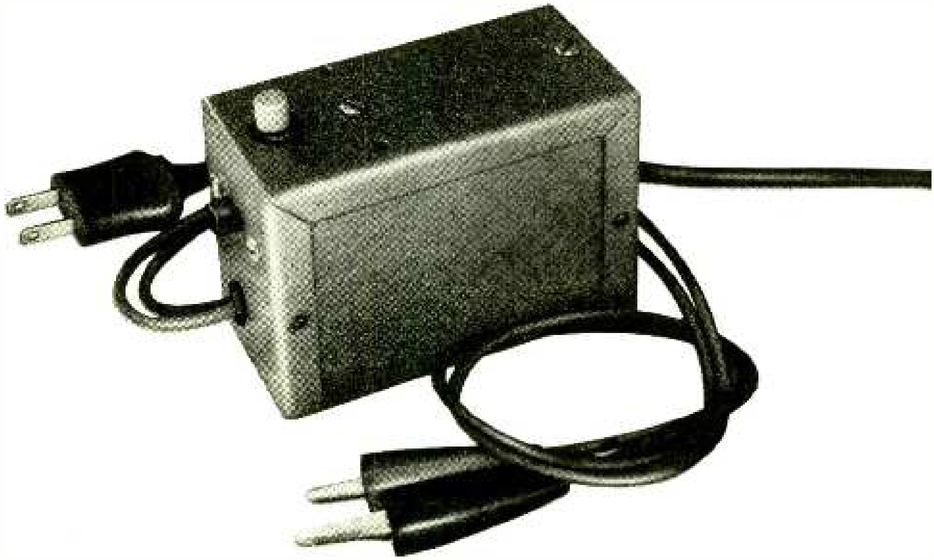
The only thing left for you to do is to plug the UJTO module (Fig. 7) into socket *SO1* (Fig. 6), and mount the electronic component board on the chassis using four standoff spacers (Fig. 5). Be sure to insert the module with the foil side facing the chassis rim. Then complete the interconnection wiring.

As a final touch, you can use decals to label the controls and thus give the instrument a commercially built appearance. After the decals are put on, they should be protected with two or three coats of clear lacquer or acrylic plastic.

Using the Instrument. For personal use or individual practice, a pair of high-impedance magnetic or crystal headphones can be plugged into *J1*. For parties, or audience entertainment, you will need a suitable audio amplifier/loudspeaker system such as a guitar amplifier, a public address system, or a standard hi-fi system. Simply connect a suitable cable between *J1* and the amplifier's high-impedance *microphone* jack.

The Lumemin should be placed in an area where a moderately strong light will fall on its photocells. The light source can be an overhead lamp or a sharply focused spotlight, as you prefer. Since no warm-up is required (except for the reproduction equipment used), the moment you turn the instrument on you can play individual notes by using your hands to cast appropriate shadows on the photocells. The lowest frequency note is obtained when the *tone* photocell (*PC1*) is in complete darkness, and the

(*Continued on page* 138)



BUILD A
FAIL-SAFE TRANSISTOR POWER SUPPLY

By EDWARD NAWRACAJ and FRED FORMAN

It halts runaway transistors . . . eliminates batteries . . . restores itself instantly . . . and dead shorts can't kill it

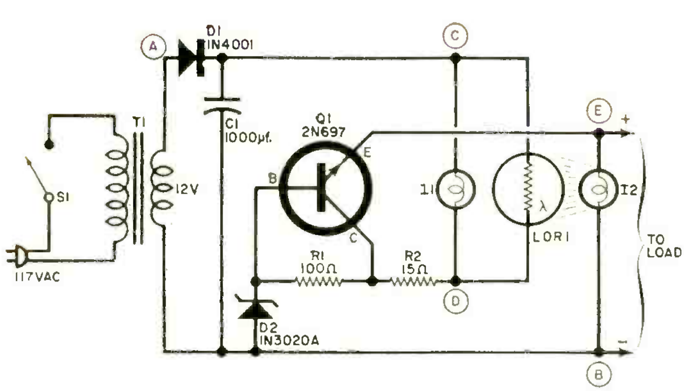
BY COMBINING a transistorized series-regulated power supply with a light-dependent resistor (*LDR1*), it is possible to obtain a fail-safe power supply that is regulated, short-proof, and self-restoring. There are no fuses to replace or circuit breakers to reset. Even a dead short across the load line cannot damage this power supply.

Before you say, "So what?" . . . keep in mind that short-circuited, series-regulated power supplies generally cause the base-emitter junction of the series transistor to rupture, and end further use of the supply until the transistor is replaced. This does not happen with the fail-safe supply.

The components selected enable this supply to provide you with a 9-volt output at 0 to 100 milliamperes. It is ideal for transistor projects, radios and other 9-volt battery-operated devices whose current requirements do not exceed 100 ma.

In addition to the fail-safe feature, the supply tends to protect the devices being powered. Suppose you had a defect which could cause a runaway condition in one of your transistor projects . . . chances are that with a battery supply your transistors would draw destructive currents. With the fail-safe supply, maximum current is 100 ma. And, of course, a big advantage is that the power supply serves as a battery eliminator: it works off the 117-volt line.

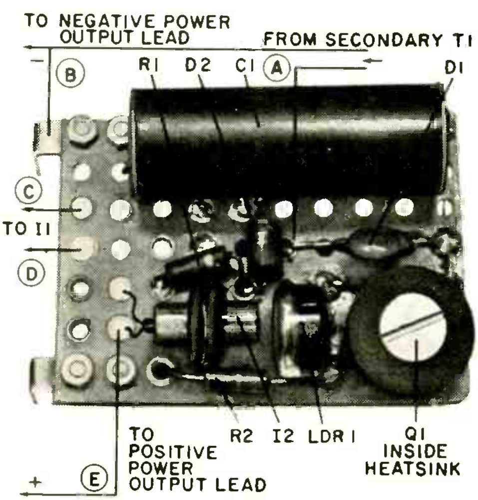
An overload brightens I1 and darkens I2. You see I1 and LDR1 "sees" I2. If you don't remove the overload, the LDR biases Q1 to cut down the output current. Removal of overload darkens I2 and output voltage jumps back to normal.



An overload indicator quickly alerts you to operating conditions. Here's what happens. Under normal load conditions the indicator light *I1*, protruding through the top of the cabinet, is off and the output voltage is correct. Under excessive load conditions, *I1* glows and the output voltage is down sharply. When you remove the excess load, *I1* will stop glowing and the output voltage will come up to normal almost instantly.

How It Works. Diode *D1* rectifies, and *C1* filters the 12-volt a.c. output from *T1*. The main current path can be traced from the bottom of the secondary winding of *T1* through the parallel path of *I2* and the load, through the emitter-collector circuit of *Q1* through *R2*, through the parallel paths of *I1* and *LDR1*, through *D1*, and finally back to *T1*.

A small secondary current path through *R1* and zener diode *D2*, which is dependent upon the total effective resistance of all the other components and the load, establishes and varies *Q1*'s base bias, which in turn varies *Q1*'s dynamic resistance, the main current flow, the respective voltage drops across the various components in the circuit, and the load. Output voltage variations due to larger or smaller loads are compensated for by these changes in bias, so long as



Press-fit I2 into a grommet and position the assembly close to and "facing" LDR1. A wire loop holds the grommet in place. Observe polarity of diodes.

PARTS LIST

C1—1000-µf., 25-volt electrolytic capacitor
D1—50-PIV, 300-ma. diode (1N2482, 1N4001, or 1N2610)
D2—10-volt, 1-watt, 10% zener diode (1N3020A)
I1—18-volt miniature lamp (Sylvania 18ES or equivalent)
I2—10-volt miniature lamp (Sylvania 10ES or equivalent)
LDR1—Light-dependent resistor, 100 footcandle-100 ohms, (Sigma 4116 or equivalent, 1-watt, 300-volt r.m.s. rating)
Q1—2N697, 2N1420, or 2N1613 transistor
R1—100-ohm, ½-watt resistor
R2—15-ohm, 2-watt resistor
S1—S.p.s.t. slide switch
T1—Filament transformer: primary, 117 volts; secondary, 12 volts, 1 amp. or greater (Stancor P8130 or equivalent)
1—4" x 2¾" x 2" aluminum box
1—1¾" x 2½" perforated circuit board
Misc.—Transistor heat sink for TO-5 transistor housing (Thermalloy 2211 or equivalent), grommets (3), right-angle brackets (2), color cap for I1, line cord, output leads, wire, screws, etc.

the load does not demand more than the maximum 100 ma. of current.

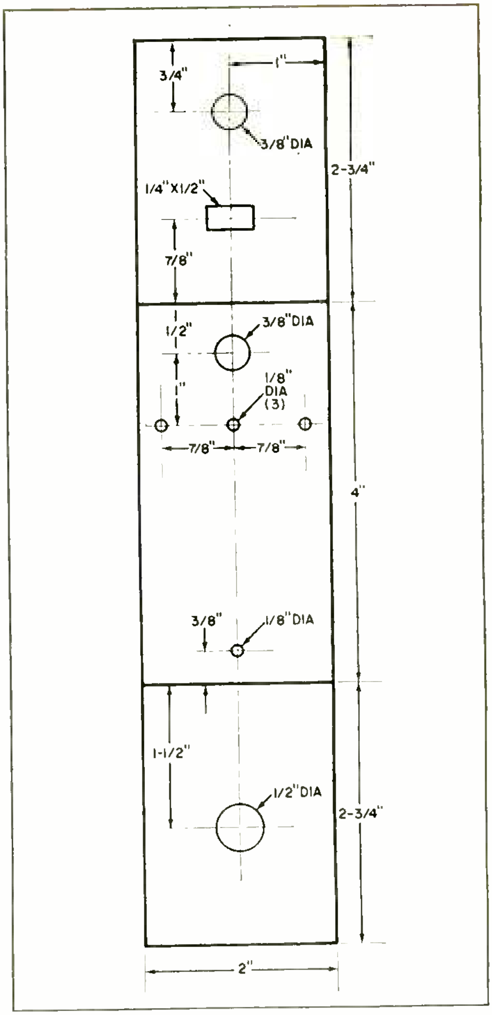
Excessive loads reduce *Q1*'s forward bias to a very low value and sharply limit the amount of main current flow. The resulting drop in voltage across the load extinguishes *I2*. The loss of light on *LDR1* increases its resistance and further limits the main current flow. The voltage drop across *LDR1* is now sufficient to light *I1* and alert you to the overloaded condition.

When the excessive load is removed, current flow through *I2* will increase sufficiently to once again illuminate *LDR1*, reduce *LDR1*'s resistance, and increase *Q1*'s forward bias. This servo-like action has a regenerative characteristic and quickly responds to almost instantaneous load variations.

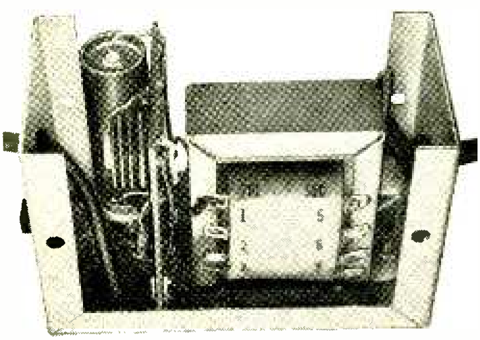
Construction. Prepare a 2″ x 2¾″ x 4″ aluminum box as shown and install the three grommets, switch, transformer and *I1*. Preassemble all the other components on a 1¾″ x 2½″ perforated phenolic or other suitable circuit board. Transistor *Q1* should be enclosed in its heat sink before you mount it on the board.

Pressure-fit *I2* into a grommet and position it close to and "facing" the sensitive side of *LDR1*. Stand the grommet upright on the board and tie it into place with a small length of bare wire.

Now attach two small right-angle brackets to the edge of the board as shown. Because some of the negative leads are connected to one bracket and some to the other, this circuit is completed when the board is fastened to the box. Therefore, you should avoid contact between the box and the positive lead or the load.

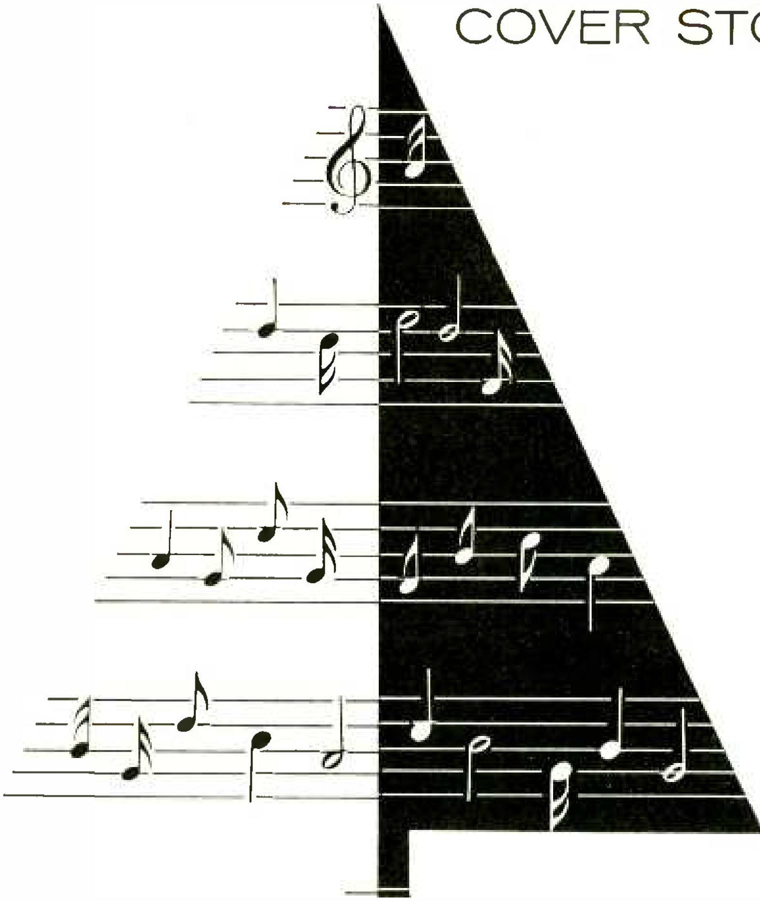


Drill holes in the outer portion of the aluminum box as shown. The size of the rectangular opening can be modified to accommodate any s.p.s.t. switch.


Preassemble the circuit board and install after S1, I1, and T1 (in that order) are mounted. Connect all leads and check the circuit before closing box.

Install the subassembly in the box, and hook up the transformer, line cord, and output leads. Double-check to see that all wire and components are properly arranged so that there are no unwanted short circuits.

You can now plug in the unit and check its operation. Touch the output leads together and watch the action. Do the same with the leads apart. If you followed instructions, the action will be as described. —30—



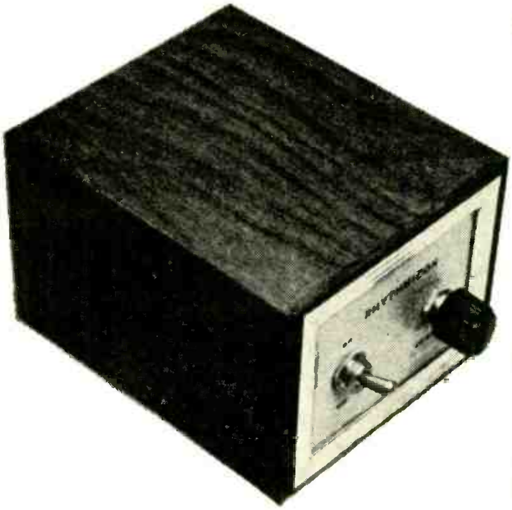
Add a new dimension to your holiday lighting—just use any radio or record player and the "Rhythmicon"

Christmas Lights Twinkle to Music

By LEON A. WORTMAN

HERE'S a little project we have dubbed the "Rhythmicon," for with it you can make your Christmas lights twinkle in time to the music from your radio, phonograph, hi-fi or p.a. amplifier. The possibilities the Rhythmicon offers are endless: Use it to control tree lights, floodlights, spotlights, or conventional electric bulbs—indoors or out.

Simply connect the two clip leads from the Rhythmicon to the loudspeaker leads of the sound source, and play carols or other seasonal material through it. The lights plugged into the socket on the box will automatically fol-



Christmas Lights Twinkle to Music

low the sounds, going from off to full on, getting instantly brighter and dimmer as the music gets louder and softer; going off completely when the music stops. The music plays, and the lights dance automatically.

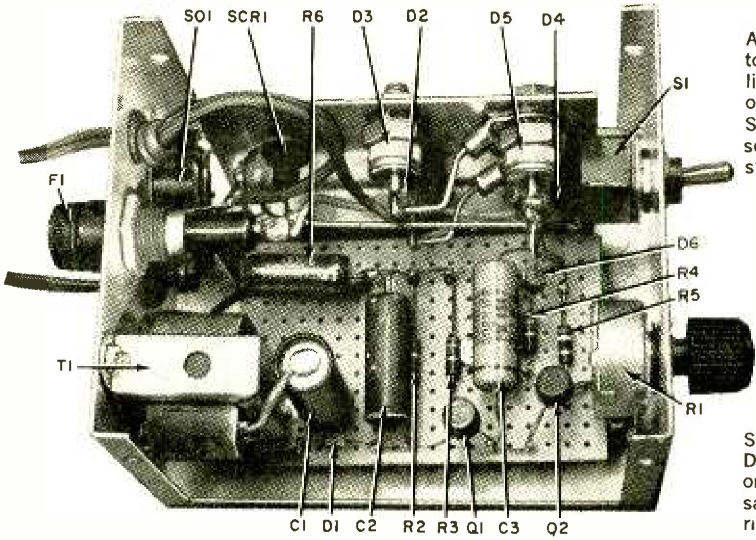
Construction. Basically, the Rhythmicon makes use of the ability of a silicon controlled rectifier to act as a "rheostat," controlling large amounts of current in a circuit in response to pulses applied to its "gate" electrode. Unijunction transistor *Q2*, in combination with *Q1*, acts as a pulse generator to turn *SCR1* on. The pulse frequency (and, consequently, the brightness of the lamps controlled by *SCR1*) depends on the amplitude of the audio signal applied to *T1* (see "How It Works," page 24).

A 3″ x 4″ x 5″ Minibox holds all of the circuitry and components for the Rhythmicon. The SCR and the four silicon rectifier diodes must be mounted on a heat sink. First, fabricate the heat sink from a piece of 1/16″ aluminum, cutting it to 2½″ x 3¾″. A ¼″ flange is bent along the 3¾″ dimension for mounting the heat sink, and five holes are drilled in it for mounting *SCR1* and *D2-D5*. The holes must be large enough for complete clearance of the mounting studs.

Referring to the photos on page 23, mount *D2* and *D3* directly in the two center holes without insulating washers. A solder lug is placed under the mounting nut of *D2* to connect the cathodes of *D2* and *D3* directly to the lamp socket, *SO1*. Diodes *D4* and *D5* (as well as *SCR1*) must be electrically insulated from the heat sink with mica washers on either side. Between the mica washers and the bodies of these three semiconductors, use solder lugs as shown in the upper photo on page 23. Use heavy metal washers between the outer mica washers and the mounting nuts. When *SCR1* and *D4* and *D5* are mounted, check with an ohmmeter to insure that their cases are not shorted to the heat sink.

The heat sink *must* be electrically isolated from the Minibox. In the author's unit, *6-32* holes for machine screws were drilled and tapped into opposite sides of a 3¾″ x ½″ x ½″ bar of Bakelite. The heat sink was mounted on the Bakelite through holes in the ¼″ flange made previously, and the Bakelite was then secured to the inside of the Minibox in the same way. Polystyrene or any similar insulating material can also be used for this, or the heat sink can be mounted with machine screws using extruded shoulder washers to insulate it.

As shown in the top photo, most of the remaining components are mounted to a 2¼″ x 3½″ piece of perforated circuit board (with the exception of *SO1*, *F1*, *T1*, *S1*, and *R1*, which are mounted at the ends of the box). "Flea clips" are inserted into the perforated board at suitable points to provide rigid terminals for connecting the transistors and other components. The perforated circuit board is mounted to the box with several machine screws and ½″ stand-



Aluminum heat sink is mounted to one side of box on a Bakelite strip; PC board is mounted on ½" spacers. Only rear of SO1—the socket for lights—is seen. Heat sink and components should not contact metal box.

Studs at left (below) are D4-D5. Mount with mica washers on both sides of heat sink; use same method for SCR1 seen at right. At center are D2-D3; no washers are needed for them.

offs to provide clearance for the tips of the "flea clips" which protrude through the board.

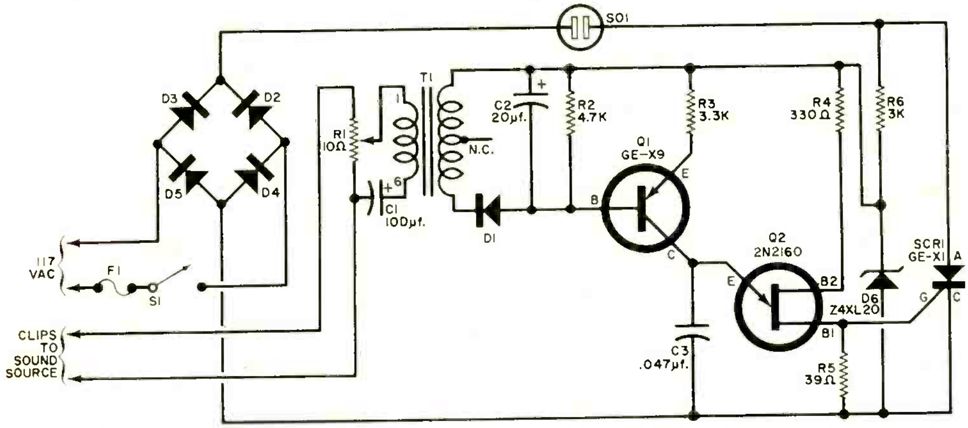
Before mounting the circuit board and heat sink, drill holes in the Minibox for the remaining components. At one end of the box, mount *SO1*, *F1*, and *T1*; at this same end, drill holes for the a.c. line cord and audio clip leads (these can also be made with a.c. lamp cord), and line them with rubber grommets. Drill holes for *S1* and *R1* in the opposite end of the box.

Final Wiring. Because some of the components of the Rhythmicon are at the potential of the a.c. line, it is essential that no part of the circuit makes electrical contact with the Minibox. The one exception to this is the audio lead which is connected to the bottom end of *R1*; connect this lug of *R1* to the box by placing a solder lug on the control shaft. Also, connect the ground terminal of *C1* directly to the box (rather than to the lower terminal of *R1*) using a lug under one of the nuts holding the perforated circuit board.

Transformer *T1*, a universal push-pull-plates-to-voice-coil audio output type, is used to couple the audio source to the Rhythmicon. It is connected so the secondary or voice coil side becomes the *input*. Connect the center lug of *R1* and the positive terminal of *C1* to the transformer terminals that give the highest impedance—with the unit used by the author, terminals 1 and 6. Connect the push-pull plate side as shown in the schematic; the center tap is not used and can be cut short.

Since transistors *Q1* and *Q2* are soldered into the circuit, be sure to use alligator clips or other heat sinks to avoid heat damage. Observe similar precautions with the diodes and *SCR1*. Component values are not critical, and may vary plus or minus 10%; it is desirable to select a resistor for *R6* that is within 5% of 3000 ohms, however.

Operation. It takes less than half a watt of audio at 4 ohms impedance to operate the Rhythmicon, and even a transistor radio can be used to demon-



Rhythmicon consists of bridge rectifier, audio pulsing circuit (Q1-Q2), and power control (SCR1)

PARTS LIST

C1—100 µf., 50-volt electrolytic capacitor
C2—20 µf., 25-volt electrolytic capacitor
C3—.047 µf., 200-volt paper capacitor
D1—1N34A germanium diode
D2-D5—Silicon diode rectifier (GE-X4 or Lafayette Stock No. 19G4208 or equivalent)
D6—20-volt, 1-watt zener diode (GEZ4XL20 or equivalent)
F1—5-ampere, 125-volt "slow-blow" fuse and fuseholder (Littlefuse Type 3AG or equivalent)
Q1—GE-X9 pnp transistor
Q2—2N2160 unijunction transistor (GE)
R1—10-ohm, 5-watt wire-wound potentiometer
R2—4700-ohm, ½-watt resistor
R3—3300-ohm, ½-watt resistor
R4—330-ohm, ½-watt resistor
R5—39-ohm, ½-watt resistor
R6—3000-ohm, 5-watt wire-wound resistor, 10% or better
S1—S.p.s.t. toggle switch
SCR1—Silicon controlled rectifier (GE-X1 or equivalent)
SO1—Panel-mounting a.c. socket
T1—Universal push-pull output transformer (Lafayette 33G7503 or equivalent—see text)
1—3" x 4" x 5" Minibox
Misc.—Sheet of 1/16" aluminum for heat sink; perforated circuit board; flea clips; Bakelite bar for mounting heat sink; mica washers for mounting SCR1, D4 and D5; solder lugs; 6-32 hardware; ½" spacers; alligator clips; line cord; grommets; wire; solder, etc.

strate its functioning. No modification is required at the audio source; simply connect the clip leads to the amplifier speaker terminals, or to the voice coil leads of a speaker. Any impedance between 4 and 16 ohms will do, with 8 ohms as optimum.

Potentiometer *R1* is the sensitivity or light amplitude control for the Rhythmicon. After setting the audio amplifier for the best listening level, adjust *R1* to the point where the lights follow variations in sound volume; turn it too high and the lights will stay on with little variation, going off when the sound stops.

Lovely lighting effects can be created by connecting up to four 100-watt Par-38 lamps (available in red, blue, and green) at the base of the Christmas tree, or as part of an outdoor display. Plugging in strings of conventional tree lights further enhances the effect. The 4.7-ampere rating of *SCR1* gives a total of 450 watts of power handling capability—that's a lot of dancing, twinkling, decorative light! —30—

HOW IT WORKS

Audio is applied to *T1*, and rectified and filtered by *D1-C2*; the resulting polarized voltage appearing across *R2* biases *Q1*, following audio amplitude variations. Unijunction *Q2*, *C3*, *R4*, and *R5* comprise a pulse generator. The frequency of the pulses depends on the d.c. potential applied to *Q2*'s emitter by *Q1*. The greater the audio amplitude, the higher the pulse rate. Resistor *R6* and zener diode *D6* form a voltage divider across the output of the bridge rectifier (*D2-D5*), and provide stable, low potentials for *Q1-Q2*. The *SCR* begins conducting when a pulse is applied to its gate: current flows until the pulsating d.c. delivered by *D2-D5* reaches zero. At that point, another pulse from *Q2* is required to again start conduction. The greater the pulse rate, the higher the average current through *SCR1* and the lights connected to *SO1*.

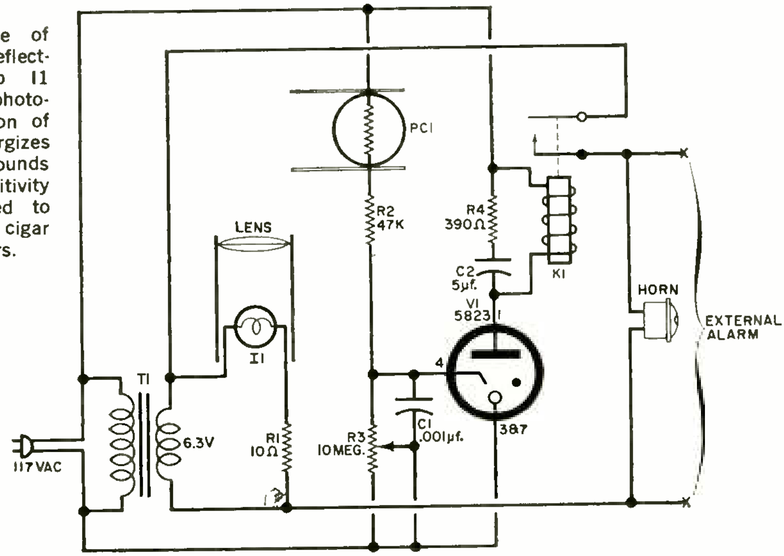
Where there's smoke,
there's fire;
where there's fire,
it may be too late;
this detector
"sees" the smoke
and warns you

BUILD A SMOKE ALARM FOR YOUR HOME

By H. ST. LAURENT

SMOKE can cause as much as, or more, loss of life and property damage than fire. In many instances, smoke is present long before a fire is actually detected. Homes and business establishments are often equipped with either simple or elaborate fire alarms, but relatively few of them have any provision for smoke detection. Early warning of the presence of smoke can give you enough time to either put out a fire and minimize damage, or—escape.

Fortunately, most smoke is lighter than air, and rises. It will accumulate

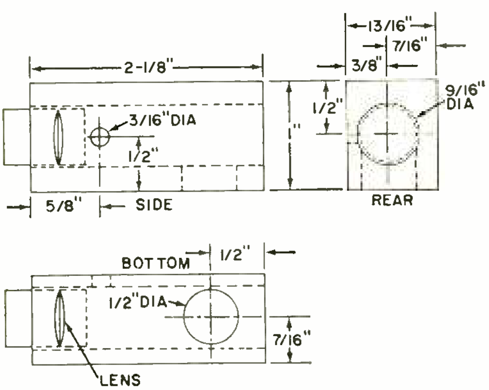


In the presence of smoke, light reflected from lamp I1 reaches the photocell (PC1). Action of PC1 fires V1, energizes the relay, and sounds the alarm. Sensitivity can be adjusted to allow for heavy cigar and pipe smokers.

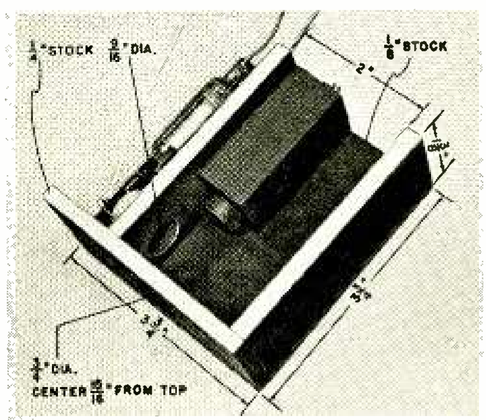
on the ceiling and build down. A room almost filled with smoke may have an area close to the floor that will allow a safe crawl space for escape. By the same token, if a smoke alarm were located near the ceiling, it would sound an alert long before a dangerous concentration of smoke accumulated. Here's a smoke detector you can construct complete with a built-in alarm for about $10.00.

How It Works. A light source consisting of a lamp, lens, and shield aims a narrow beam of light about 1 inch in front of, and at a right angle to, the "line-of-sight" of a cadmium sulphide photocell. The cell is recessed in a lighttight cylinder and does not "see" enough of the light to trigger the alarm under normal conditions.

When smoke enters the chamber, it interferes with the light beam and causes the light to be reflected in many directions. Some of these reflections strike the photocell. Under the influence of light, the resistance of the photocell decreases and causes a higher voltage to appear across *R3* and on the starter electrode (pin 4 of *V1*). When the starter



Light-source barrel is made from a block of wood. Size of lens opening can be varied to accommodate your lens. Use a cardboard tube as an extension.



Photocell is mounted at right angles to the sharply focused light. Paint inside of the wooden smoke chamber flat black to minimize light reflections.

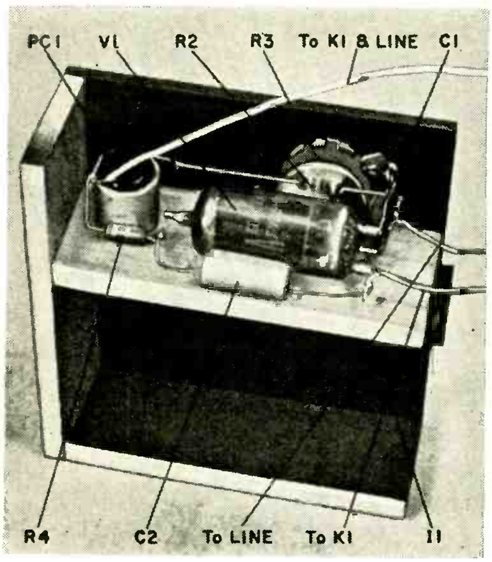
electrode voltage reaches the firing point (approximately 50 volts), the tube conducts, energizes the relay, and activates the alarm. The alarm will shut off when the smoke has cleared the chamber in the smoke detector.

Potentiometer *R3* serves as a sensitivity control and is usually adjusted to require a fairly large volume of smoke to trip the alarm in order to prevent a false alarm, which could be caused by a number of people smoking in a confined area. Transformer *T1* provides 6.3 volts to the lamp (*I1*) and to the horn; *R1* is a current limiter, and tends to protect and increase the life of *I1*; *R2* serves as a makeup resistor and prevents the resistance divider network across the 117-volt line from drawing too much current in the event that *R3* is inadvertently adjusted too close to minimum resistance; capacitors *C1, C2* and resistor *R4* are uncritical circuit stabilizing components.

Construction. The smoke chamber is made of wood stock lattice strips or other suitable 1/4" x 1 3/4" lumber and 1/8" Masonite or other tempered board. The lens and photocell holders are made of a heavy manila paper and glued in place. If necessary, you can modify the diameter of the holders and the openings in the lens block to allow the lens and photocell to fit properly. The distance between the lens and the lamp will vary in accordance with the focal length of the lens, and should be adjusted to give the sharpest beam of light possible.

Attach the lamp socket to the lens block with a small 1/4" wood screw. A green or red plastic window can be placed over the front opening of the lens block to cut down some of the glare from the lamp. This light from the front opening only serves as a pilot to let you know that the lamp and power are on. Cover the smoke chamber and other internal surfaces with a flat black paint to minimize stray reflections.

The cabinet is made of standard 2 1/2" x 3/8" pine panel stock. A slot cut about 1/8" from the edge of the panel stock, and about 3/16" deep holds a metal grille in place when the sides are assembled, and dresses up the appearance of the cabinet. An alternate method is to rabbet the top edge of the four sides so that the grille can be set flush, then topped off with 1/2" half-round molding. All cabinet and smoke chamber parts are glued in place, with the exception of the back cover which has a 3/8" hole near the top, center, to accommodate a hook

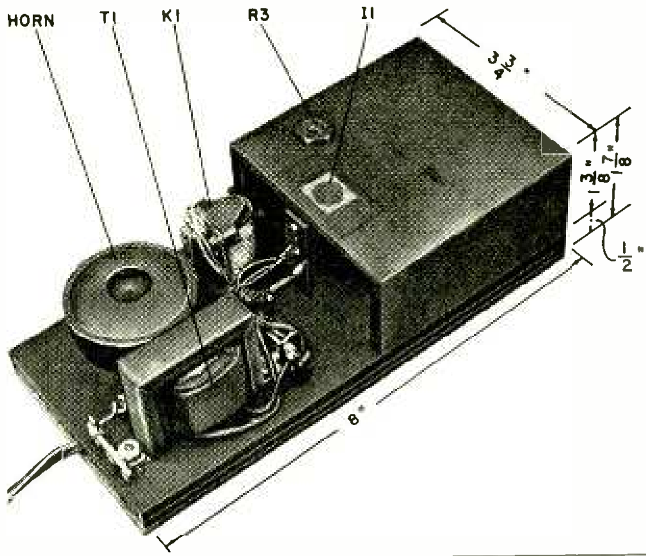


Remove unused tube pins and use a drop of cement to hold the tube in place. Lamp I1 is inside the barrel. A cardboard tube holds the photocell (PC1).

PARTS LIST

C1—0.001-µf. ceramic capacitor
C2—4- or 5-µf., 50-volt electrolytic capacitor
I1—Pilot lamp (GE 12 or equivalent)
K1—3500-ohm, s.p.s.t., N.O., miniature relay (Guardian E-3772 or equivalent)
PC1—Cadmium sulphide cell (Clairex Cl-504 or equivalent)
R1—10-ohm, 1/2-watt resistor
R2—47,000-ohm, 1/2-watt resistor
R3—10-megohm potentiometer, linear taper
R4—390-ohm, 1/2-watt resistor
T1—117-volt to 6.3-volt, 1-ampere filament transformer
V1—5823 glow tube
1—Horn (imported type used on bicycles)
1—14-mm. x 34-mm. focal-length lens (any double convex lens that fits is suitable)
1—Lamp socket (Dialco 19-07 or equivalent)
Misc.—Tube pin sockets (3) removed from miniature socket, wood, 4" x 8" metal grid, quick-setting glue, wood screws, etc.

The electronic components including the smoke chamber complete (not wired), machined cabinet parts, grille, base and cover, hardware, line cord, wire, etc., are available for $15 postpaid in the U.S.A. from Lectromek Co., 166 Wendell Rd., Warwick, Rhode Island 02888. No C.O.D. Price list for individual parts available.



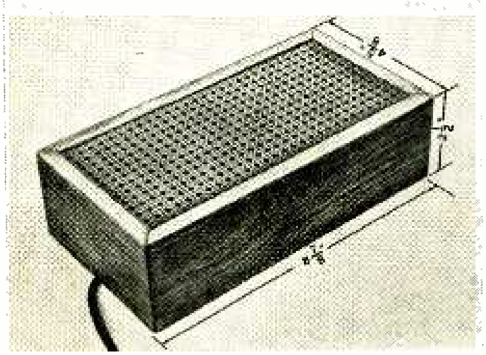
The smoke chamber should be as lighttight as possible to keep the detector immune to outside light. The plastic window lets you see if the lamp and power supply are in working order.

or other wall hanger for holding the finished smoke alarm. Complete all wiring and mounting of parts before you screw down the back cover.

When the back cover is secured, slip the unit into the cabinet. It should fit snugly. Two 6 x ¾" half-round head wood screws on each side of the cabinet will hold the alarm in the cabinet.

Installation and Adjustment. Installation is simple—you just hang the unit in an upright position, as high as you can on a wall of the area to be protected, and plug the line cord into the nearest 117-volt a.c. outlet. Be sure smoke chamber inside cabinet is pointing up.

Before adjusting the unit, set the sensitivity control in the minimum position (counterclockwise) to keep the alarm off, and allow about five minutes of warm-up time for the detector to stabilize itself. Then all you have to do is rotate the sensitivity control until the alarm sounds, and back off slowly until the alarm stops. That's all there is to it. You can check this setting by blowing some smoke through the lower half of the metal grid and waiting for the smoke to reach the chamber: if all is well, the alarm will go on.



Completed unit is mounted vertically, as close to the ceiling as possible. Rising smoke enters smoke chamber through metal grille to set off the alarm.

Sometimes line voltage variations will modify the sensitivity characteristic after you have set the sensitivity control. So, from time to time, blow some smoke into the unit to see that it is working. If the unit tends to "false alarm" because of a normally smoky room condition, or because of upward line voltage variations, densensitize the detector a bit by a slight counterclockwise adjustment of the control.

Another way to adjust the detector is to use a Variac and step up the line voltage to 125 volts, then slowly rotate the control until the alarm just sounds off. With the control in this position, the alarm should function properly over a line voltage range of 105 to 120 volts. If, for some reason, line voltages in excess of 125 volts are regularly encountered, the Variac voltage should be adjusted accordingly. -30-

SUPER-SENS

By LOUIS E. GARNER, JR.

Versatile electronic relay provides unlimited control functions

DO YOU need a burglar alarm, a fire alarm, an automatic fan control, an automatic light switch, a liquid level control, an automatic dehumidifier control, a photoelectric counter, a radio remote control, a lawn sprinkler control, an automatic door opener, a time delay relay, an electronic latching relay, or a sound-actuated relay?

Would you like to amaze your friends and neighbors, gain the respect of your teachers or co-workers, assemble a Science Fair project that is different, or build a basic control that can be used in hundreds of applications?

If you can answer yes to any of these questions, you'll enjoy building and using *Super-Sens*, an easy-to-wire, inexpensive electronic relay so sensitive that it can be tripped by a pencil line drawn on a piece of paper.

Electronic relays are not new. They have been designed and manufactured for years. You can purchase a variety of types at prices ranging from $20 to $50 or more, or you can build *Super-Sens* for less than $10.00.

One popular "supersensitive" electronic relay offered by a leading laboratory supply house requires a signal current of 50 microamperes at a little under 10 volts. *Super-Sens*, in contrast, will trip with a miniscule control current of about 0.2 μa. at approximately 1 volt. Using its built-in bias circuitry, the device can trip with as much as 50 megohms between its input terminals.

Super-Sens can be actuated by many input devices: photocells, humidity detectors, microswitches, thermostats, magnetic contacts, pressure switches, thermistors, and almost any high or low resistance type of sensor or probe, as well as the comparatively low level signals obtained from a carbon microphone or a simple radio receiver.

Super-Sens, in turn, can be used to actuate almost any type of electrically operated equipment: lamps, solenoid valves, buzzers, bells, power relays, fan motors, pumps, door openers, heating systems, etc.

HOW IT WORKS

Super-Sens is essentially a two-transistor, high-gain, direct-coupled d.c. amplifier driving a standard sensitive-type electromagnetic relay. See Fig. 1. Transistors *Q1* and *Q2* are connected in a modified Darlington circuit. (A Dar-

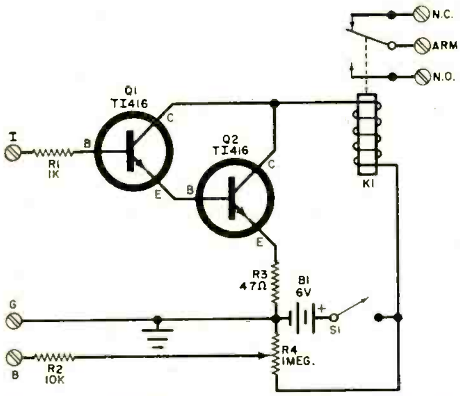


Fig. 1. As little as 0.2 μa. at 1 volt is enough to trigger relay; up to 50 megohms can be sensed.

lington circuit is a circuit having two or more transistors connected in such a manner as to have a single input, a common load and a current gain which is the product of the current gain of each transistor.)

Series resistor *R1* tends to limit base current to prevent accidental damage to the transistors by excessively strong input signals. Unbypassed emitter resistor *R3* stabilizes circuit operation, and provides a degree of temperature compensation. Sensitivity control *R4* and current limiting resistor *R2* are parts of a bias and control circuit to permit the use of external resistive-type and switch-type sensors. Circuit power is supplied by *B1* and is turned on and off with s.p.s.t. switch *S1*.

When a signal or bias voltage of proper polarity (base positive with respect to emitter) is applied to the base emitter circuits of *Q1* and *Q2*, the transistors conduct and energize *K1*. Bias voltage can be taken from the internal *R2*, *R4*, *B1* circuit (*B* terminal) or it can be derived from an external circuit.

There are essentially three basic types of input circuit control devices that *Super-Sens* will cater to: those that look like a voltage source, those that look like a resistor, and those that look like a switch. The voltage source devices are hooked up to *I* and *G*.

The resistor control types are given special consideration: high-resistance devices are connected across terminals *I* and *B* (in series with the internal

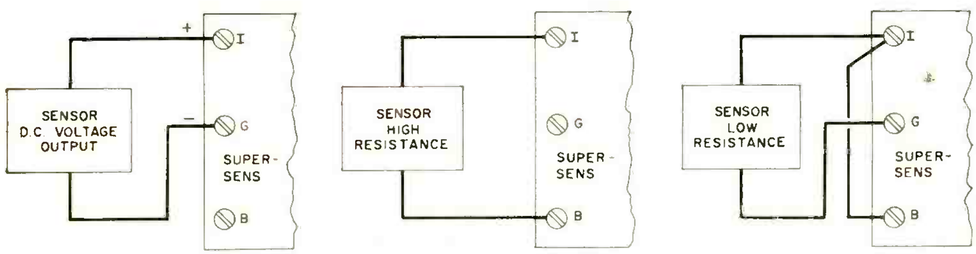


Fig. 2. Any one of three basic types of sensors can be used: those that look like a voltage, such as a photovoltaic cell, etc.; those that look like high or low resistors; and those that act like a switch.

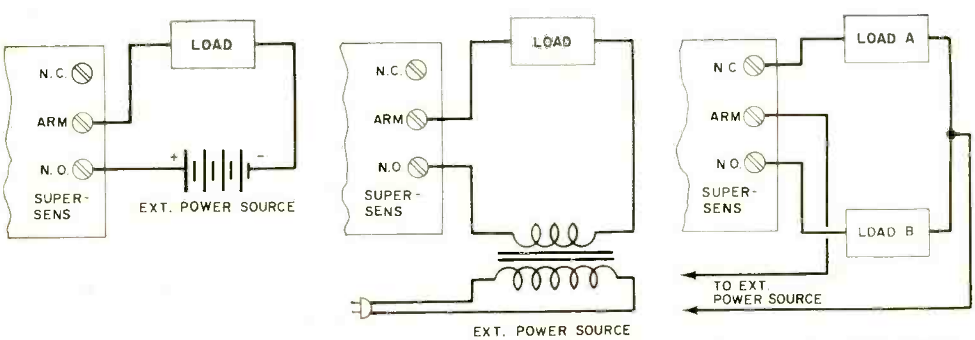


Fig. 3. Controlled external load circuit can utilize almost any source of power. If power requirements exceed the relay contact's rating, a power relay can be added. One or two loads can be switched.

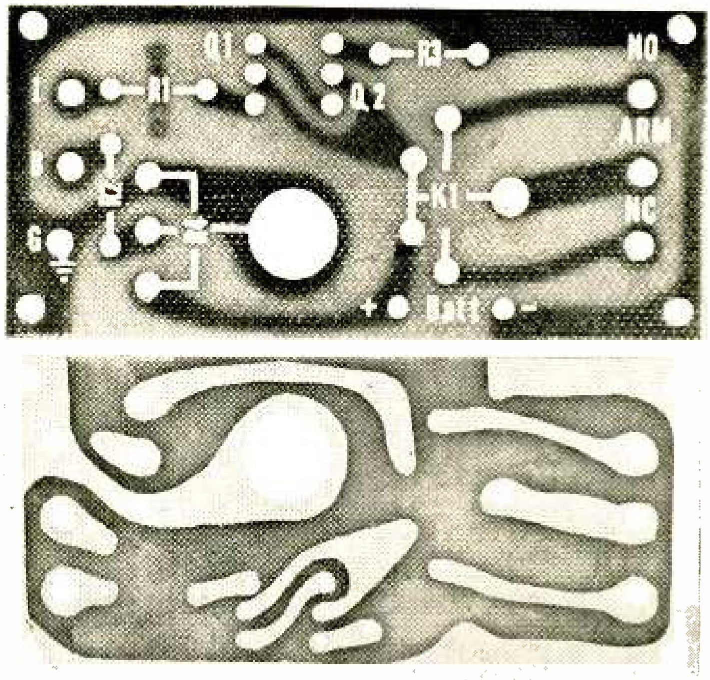


Fig. 4. Etched circuit board construction provides a mounting base for all the components, including the relay. Conventional chassis-type construction is also quite suitable. If you want to make your own printed circuit board, you can use these actual size photos as guides. All components are mounted on one side of the board (top). The foil side (bottom) must be clean to prevent leakage between conductors.

bias circuit) and low-resistance types are placed between terminals *I* and *G* with a jumper from terminals *I* and *B*, as shown in Fig. 2. Actually, the resistive devices are made to function like a voltage source, since terminal *B* has sufficient voltage of proper polarity to forward-bias the transistors.

Switch-type devices can be connected between points *I* and *B*, and *R4* adjusted to provide just enough voltage to pull in the circuit when the switch is closed. Conversely, these switches can also be made to drop out the circuit. A jumper between *I* and *B*, and *R4* adjusted to pull in the circuit, will keep the circuit on until a switch across *I* and *G* causes the circuit to drop out when it is closed.

The relay can be hooked up to provide either a normally open, or normally closed control circuit, or both, as shown in Fig. 3.

CONSTRUCTION

Since the basic unit is the same for all applications, let's put the thing together, and then we'll consider some of the many applications. All components are standard and readily available through most electronics supply houses.

PARTS LIST

B1—6-12 volt battery
K1—Relay (JAICO GS-100 or equivalent)
Q1, Q2—T1416 transistor
R1—1000-ohm, ½-watt resistor
R2—10,000-ohm, ½-watt resistor
R3—47-ohm, ½-watt resistor
R4—1-megohm potentiometer, linear-taper
S1—S.p.s.t. toggle or slide switch
*1—Etched circuit board**
1—Cabinet (Minibox 2102)
Misc.—Small knob, screws, nuts, hardware, wire, solder, etc.

*A pre-etched circuit board on an epoxy-glass base is available from DEMCO, Box 16041, San Antonio, Texas 78216 for $2.00. This firm can also supply: a "basic" kit (board, relay, transistors) for $7.50; a complete kit for $9.50; and a pre-etched moisture sensor for $1.50.

If you etch your own board, follow the actual size layout shown in Fig. 4. Wiring is not critical, but special precautions should be taken. First, be sure there is ample separation between the *I*, *B*, and *G* terminals. Second, use an epoxy-glass rather than a paper-base phenolic copper-clad base board, (moisture absorption in the latter material may cause erratic operation). Third, be sure to remove all of the unused copper during the etching process, for an al-

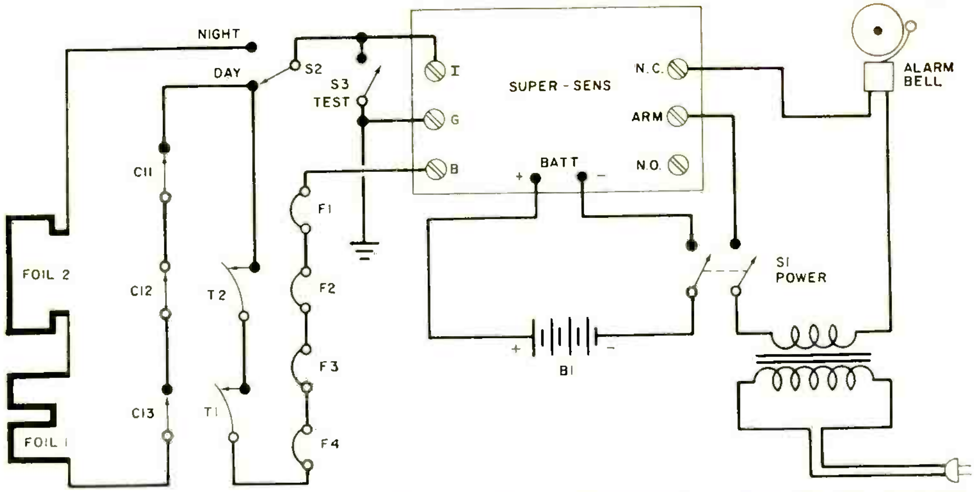


Fig. 5. Fire alarm circuit has fusible links F1 to F4, and thermostatic contacts T1, T2. Door and window contacts C1 to C3 and foil patterns make up burglar alarm. Place sensors in strategic locations.

most invisible, microscopically thin layer of copper can provide sufficient conduction to actuate the relay.

To avoid accidental mechanical damage, mount the relay last. Heat-sink the transistor leads with a pair of long-nose pliers to prevent heat damage when soldering. The *Sensitivity* control can be mounted on either side of board.

The completed board can be mounted in a small Minibox as a self-contained instrument, or in another piece of equipment, depending on the device's ultimate use. Mount the board on spacers to provide air space between the board and the cabinet. Power supply *B1* can be built in or externally connected.

A number of component changes can be made to meet individual needs. General Electric GE-10 transistors will serve as direct replacements for the specified *T1* units. A Sigma 4F-1000/S-SIL relay can be used in place of the JAICO type, although a new layout and larger circuit board would be required. If maximum sensitivity is needed at all times, omit *R4* and connect *R2* directly to the *S1, K1* junction.

A variety of power supplies can be employed. The total current drain when the relay is closed is only a few milliamperes, permitting the use of small transistor-type batteries.

As might be expected, the instrument's ultimate sensitivity depends on supply voltage, component tolerance, and the gain of the transistors. With the components specified in the Parts List, the current sensitivity (for relay closure) will vary between 0.15 and 0.45 μa., using a 9-volt power supply.

(*Continued on page* 36)

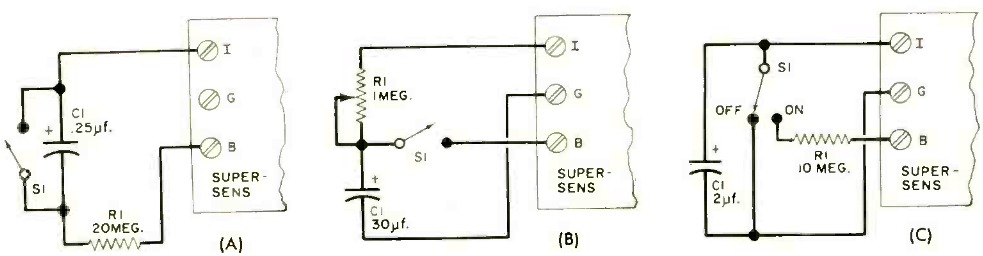


Fig. 6. An RC network can be added to make a time-delay relay. Circuits (A) and (B) stay on for a desired time after the switch is opened. "Turn on" is delayed in circuit (C) when the switch is closed.

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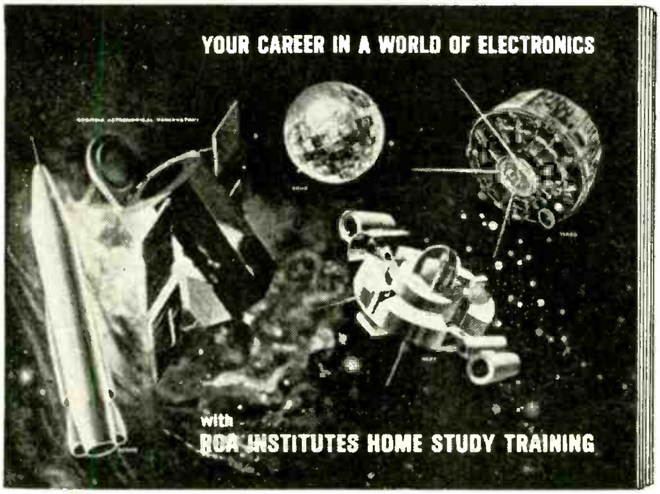

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If higher gain transistors are used, the overall sensitivity may be as great as 0.1 (or less) μa., while lower gain units may provide a sensitivity of 0.75 μa.

APPLICATIONS

Burglar and Fire Alarm. An easily installed alarm system, suitable for a home or place of business, is shown in Fig. 5. It offers fire alarm protection during the day, and both fire and burglar alarm protection at night.

A break in any part of the external series circuit will trigger the alarm. A "push-to-test" switch (*S3*), when depressed, will sound the alarm if the relay circuit is in working order.

Fire protection is afforded by fusible links *F1* to *F4* and by thermostatic contacts *T1* and *T2* placed on ceilings in strategic locations. Door and window contacts *C1* to *C3*, together with the foil patterns, provide burglar protection. Any combination of switches, contacts, or links can be used, so long as the circuit forms a closed loop and the total resistance of the loop isn't great enough to prevent an adequate amount of voltage from terminal *B* to be applied to terminal *I*. The sensitivity control can be adjusted to compensate for loop resistance and battery conditions.

Switch *S2* skips the door and window detectors during the day, and *S1*, which can be lock-protected, serves as a master on/off control. If switching *S2* from night to day or day to night causes a momentary but undesirable alarm, connect the *Night* side of the switch to the switch's center arm. In this mode of operation, *Super-Sens* is on all the time, the relay is energized, and the normally closed contacts are held open.

Occasionally, a latch or alarm-hold type of operation is desirable . . . that is, once the alarm is triggered, it sounds continuously even after a break in the loop is restored. In this type of operation, the alarm can be reset only at the main panel, which could be located inside a locked cabinet. To build in the latch feature, connect a 1-megohm, ½-watt resistor in series with terminal *I* and *S2*. Adjust the *Sensitivity* control until the relay just pulls in (silencing the alarm), then back off slightly. Use the test switch and control alternately, and adjust until the desired action is achieved.

Time Delay Relays. Controls which can switch a circuit "ON" or "OFF" for preset or adjustable periods of time are used extensively in experimental work, photography, laboratory tests, chemical processing and manufacturing. *Super-Sens* can be used in such applications by adding a relatively simple "time delay" accessory. Typical circuit arrangements are shown in Fig. 6.

A 20-megohm resistor connected in series with a 0.25-μf. capacitor in Fig. 6 (A) sets up a time delay on the order of 3 to 9 seconds, depending on the setting of the *Sensitivity* control. A momentary normally open contact switch connected across the capacitor allows the circuit to conduct when the switch is pressed and released. The relay closes and remains closed until *C1* is charged up and stops drawing current.

The circuit in Fig. 6 (B) permits a wider range of control. When *S1* is de-

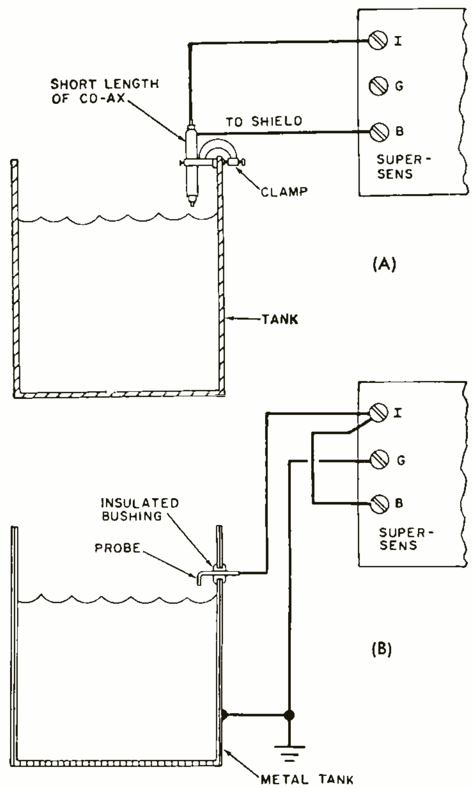
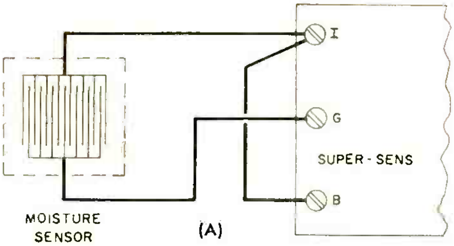


Fig. 7. Levels of low- and high-conductive liquids can be monitored by easily made probes.



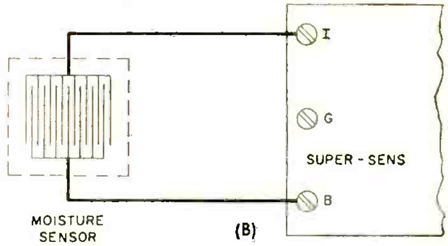


Fig. 8. These circuits can be used to control humidifiers and lawn sprinklers. Just a drop of rain on the sensor will release the relay in circuit (A). Circuit (B) can detect slightest trace of moisture.

pressed and released, *C1* is charged by the bias supply and then discharges slowly through the instrument's input circuit, holding the relay closed until *C1* loses most of its charge. The time delay varies with *R1*'s setting, and ranges from about 25 seconds with *R1* set at 0 resistance to as much as 1 minute and 45 seconds when *R1* is set at 1 megohm. The timing range can be changed if you use different values for *C1* and *R1*. The larger the time constant (*R1* x *C1*), the longer the time delay.

In Fig. 6 (C), a delay in "turn on" time takes place after the slide switch is thrown. When *S1* is switched to the "ON" position, the relay does not close until the current through *R1* and *C1* falls off enough to reduce the voltage drop across *R1*.

Liquid Level Control. Farmers, chemical engineers, food processors, electroplaters, beverage manufacturers, industrial plant operators and others need to check or maintain liquid levels in large tanks or vats from time to time. *Super-Sens* can do an excellent job in such applications when used with suitable sensor probes. Typical techniques are shown in Fig. 7.

A short length of rigid coaxial cable can be used as a simple liquid sensor probe if clamped to the side of a tank. If the cable's shield is connected to the instrument's *B* terminal and the center conductor to the *I* terminal, the relay will close when the liquid reaches the exposed lower end of the cable. Connections are as shown in Fig. 7 (A).

If a metal tank is used, the sensor probe may be a short length of conductor mounted in an insulated, liquid-tight bushing at an appropriate point on the side of the tank, as illustrated in Fig. 7 (B). If the liquid is highly conductive, connections can be made to the *I* and *G* terminals, with a jumper between the *I* and *B* terminals. With these connections, the *Sensitivity* control is adjusted until the relay just closes. The relay will open when the liquid level reaches the probe.

Other types of probes can be used, of course, including insulated metal strips cemented inside the tank or short parallel metal rods mounted on an insulating block and attached to the tank. Regardless of the probe used or the type of liquid handled, *Super-Sens* can control pumps or solenoid valves, or activate remote signaling devices.

Rain Alarm. A standard moisture sensor plate will make *Super-Sens* serve as a rain alarm. The sensor plate leads are connected as shown in Fig. 8 (A) and operate in the same way as the level control in Fig. 7 (B). Just a drop or two of rain on the sensor plate is enough to cause the relay to open.

Humidity Control. A modification of the "rain alarm" circuit is shown in Fig. 8 (B). Here, the moisture sensor plate is connected and operated in the same manner as the circuit shown in Fig. 7 (A). With this arrangement, *Super-Sens'* high sensitivity will respond to the slightest trace of moisture and close the relay. It can detect the small amount of moisture condensed from a person's breath and can be used, among other applications, for controlling a dehumidifier.

Lawn Sprinkler Control. If the moisture sensor plate used in the "rain alarm" and "humidity control" circuits is replaced by a pair of semi-insulated spike-type probes driven into the ground, *Super-Sens* will serve as an automatic lawn sprinkler control. Its output terminals (ARM and either N.O. or N.C. contacts) are connected to switch an appropriate solenoid valve in the automatic sprinkler system.

Either the low-resistance connections or high-resistance connections can be used, depending on soil conductivity, electrode (probe) spacing, and desired soil moisture content. In any case, the instrument's *Sensitivity* control can be finely adjusted to achieve the desired operating characteristics.

Acoustic Relays. Add an easily-built, low-cost accessory, and *Super-Sens* becomes a sound-operated relay. Three types of circuits are shown in Fig. 9.

In Fig. 9 (A), a low-impedance single-button carbon microphone (Shure R10), a 6-volt battery, an 8-ohm to 500-ohm output transformer (Argonne AR-164), a 1N34A general-purpose diode, and a 2-μf., 15-volt electrolytic capacitor apply a positive-going signal to energize the relay.

A single-transistor amplifier, in Fig. 9 (B), enables the use of a high-impedance (Philmore M-55), or a low-impedance carbon microphone. A 1-megohm resistor (*R1*) is used with high-impedance microphones and a 47,000-ohm resistor for low impedance types. The *Sensitivity* control is adjusted until the relay closes and is then backed off slightly. Thereafter, a sudden sharp sound will cause the relay to "latch" open.

A crystal microphone cartridge, or a magnetic headphone element can be used as a microphone with the circuit shown in Fig. 9 (C). The diode and transistor are the same as in the previous circuits. The *Sensitivity* control is set in the same manner as in the circuit in Fig. 9 (B).

The acoustic relay circuits shown here are moderately sensitive, requiring a fairly loud signal for operation. Where extreme sensitivity is needed, *Super-Sens* can be coupled to a 3- or 4-transistor audio amplifier. The hookup would be the same as in Fig. 9 (A).

Radio Control. *Super-Sens* can be operated by remote radio signals provided that a suitable control circuit is connected to its input terminals, as shown in Fig. 10.

The values of tuned circuit *L1* and *C1* are chosen to resonate at the desired control frequency. A general-purpose

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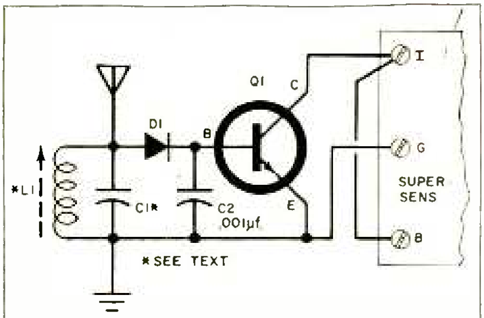


Fig. 10. Radio control can be achieved with simple detector. Tune C1, L1 to desired frequency.

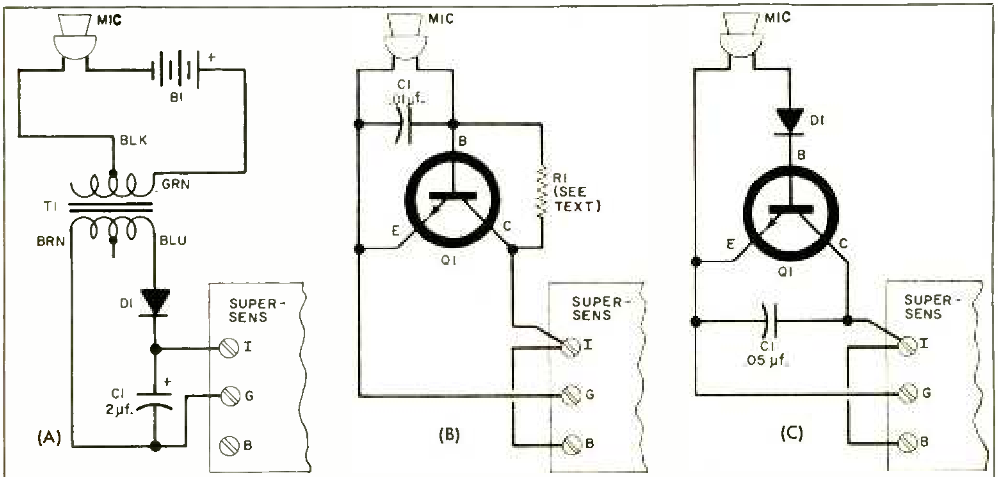
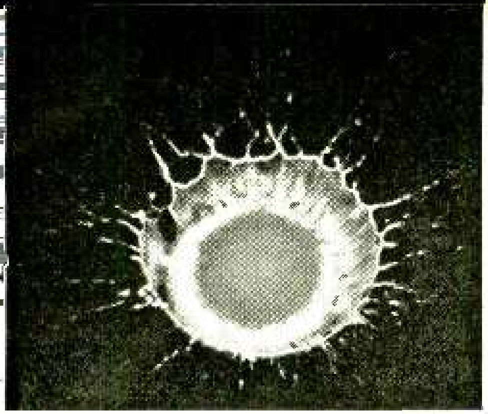
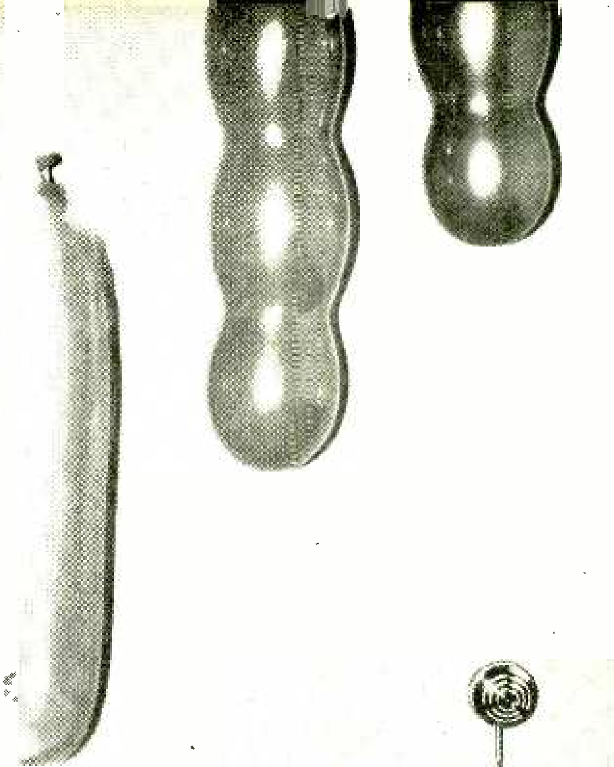
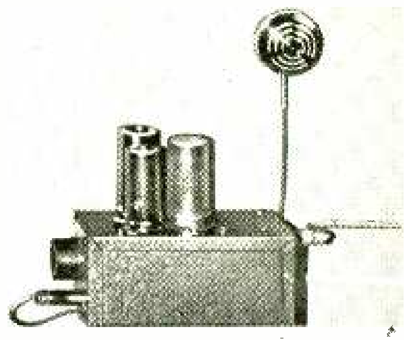


Fig. 9. Sound-actuated relays can be made. If microphone is low-impedance type, use circuit (A); high-impedance pickups work well in circuit (C); a low- or high-impedance unit can be used in circuit (B).





FREEZE MOTION WITH SOUND



Like to try your hand at the fascinating field of high-speed photography? All it takes is a simple trip unit and a strobe

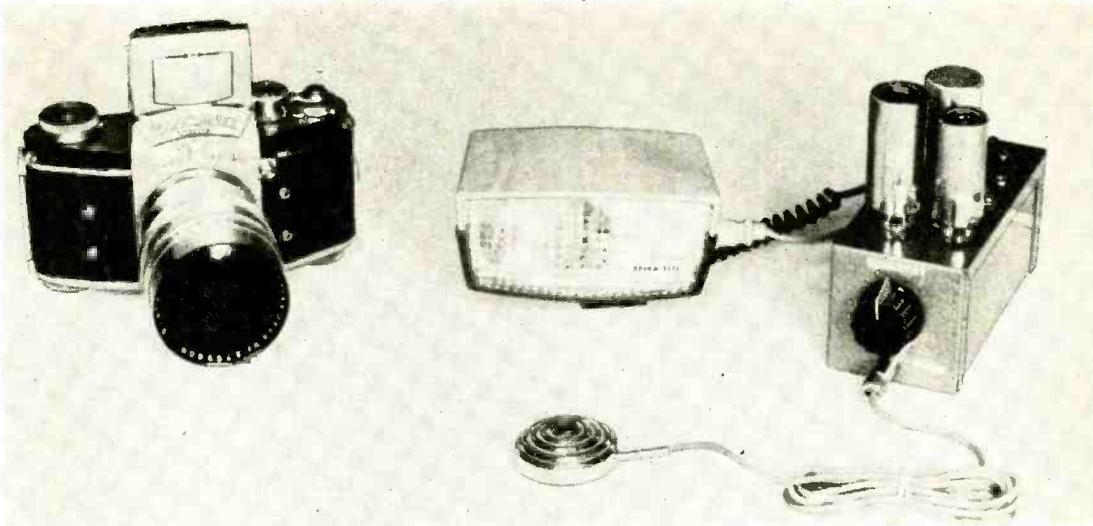
Sound-actuated unit (lower right) flashes strobe as first balloon, hit with dart, bursts. Insert shows drop of milk hitting black background; mike was 10" away, sensitivity of trip unit reduced to just half.

By ROY E. PAFENBERG

HAVE YOU ever wondered just exactly how glass breaks, liquids splash, balloons burst, or a ball bounces? The electronic flash trip unit featured here will answer these and a host of other intriguing questions that can only be explored through the use of high-speed photographic techniques.

Adaptable to almost any camera and electronic flash, this simple sound-actuated unit provides a means of obtaining unusual and striking photographs. The experimenter, research worker, or technician will find it a valuable low-cost laboratory accessory, and the student can use it as the ideal basis for a science project and/or science fair exhibit.

Although the fact is not widely known, the 1/1000 to 1/2000 second flash duration of the conventional hobby or professional electronic flash unit is fast



Trip unit fits neatly in 2¼" x 2¼" x 5" box; since layout is compact, it's best to copy author's model. Strobe light is the inexpensive unit described in text.

enough to capture all but the highest speed events on film. The problem is one of timing. With the method described here, sound produced by, or associated with, the event to be photographed is used to trigger the electronic flash. Since the camera shutter must be open, photography is done in subdued lighting or in a darkened room. After the flash captures the high-speed event on film, the shutter is manually closed.

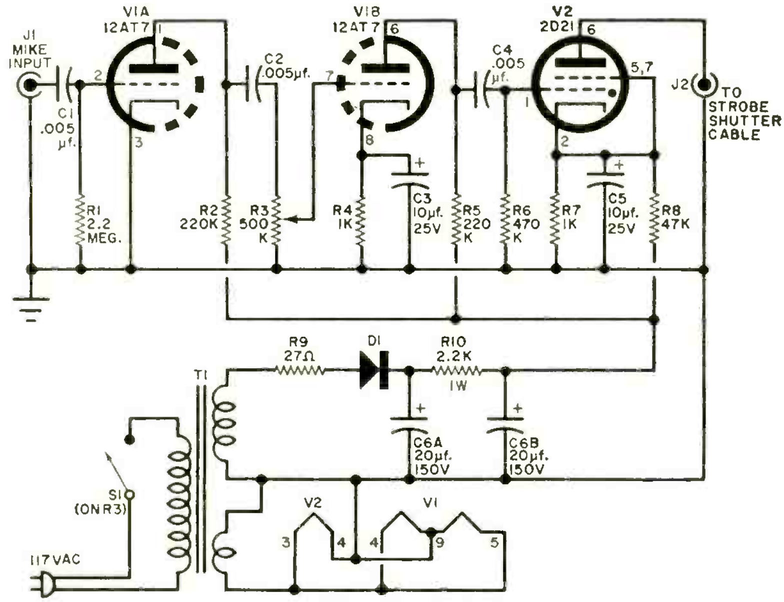
The exact instant the flash occurs relative to the noise that actuates it can be controlled by the way in which the microphone is positioned. Since sound travels relatively slowly, placing the microphone close to, or away from, the object will introduce an adjustable time delay.

Construction. In essence, the flash trip unit incorporates two stages of audio amplification (a single 12AT7) that triggers the 2D21 thyratron in response to sounds picked up by the microphone (see "How It Works," page 42). Since a thyratron acts like a switch or short-circuit when it conducts, it fires a flash unit connected to *J2*.

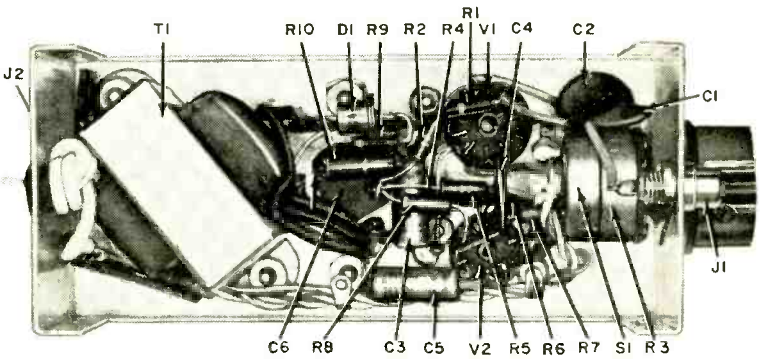
Although the sound-actuated trip unit may take any form that gives due consideration to layout, wiring, and the shielding requirements of high-gain amplifier circuits, the prototype unit is neat, compact, and rugged. The two tubes (*V1* and *V2*) and tab-mounting filter capacitor *C6* are mounted on top of the 2¼" x 2¼" x 5" Minibox used as a chassis, while the power transformer fits inside and as close to the back as possible. Sensitivity control *R3* and mike input jack *J1* are at the front of the box; output jack *J2* (for connection to the

PARTS LIST

C1, C2, C4—0.005-μf., 500-volt ceramic disc capacitor
C3, C5—10-μf., 25-volt electrolytic capacitor
C6—20/20-μf., 150-volt dual electrolytic capacitor
D1—500-ma., 400-PIV silicon diode
J1, J2—Phono jack, single-hole mounting type
R1—2.2-megohm, ½-watt resistor
R2, R5—220,000-ohm, ½-watt resistor
R3—500,000-ohm potentiometer, audio taper, with s.p.s.t. switch S1
R4, R7—1000-ohm, ½-watt resistor
R6—470,000-ohm, ½-watt resistor
R8—47,000-ohm, ½-watt resistor
R9—27-ohm, ½-watt resistor
R10—2200-ohm, ½-watt resistor
S1—S.p.d.t. switch; part of R3
T1—Power transformer: primary, 117 volts; secondaries, 125 volts @ 15 ma., and 6.3 volts @ 0.6 amp. (Stancor PS-8415 or equivalent)
V1—12AT7 vacuum tube
V2—2D21 thyratron tube
1—2¼" x 2¼" x 5" Minibox
1—7-pin miniature tube socket with shield
1—9-pin miniature tube socket with shield
1—Crystal lapel microphone (or similar)
Misc.—Knob, terminal strips, solder lugs, hardware, grommets, a.c. line cord, wire, solder, etc.



Two stages of audio (V1a and V1b) amplify mike input to trigger 2D21 thyratron (V2).

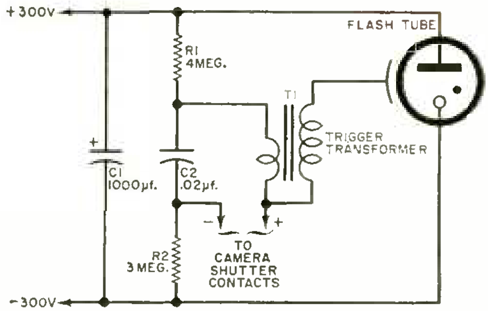


Locate T1 as close to the back of box as possible; note location of tube sockets, and mounting hole for C6. Jack J2 (for strobe connection) is hidden at rear of box.

strobe shutter cable) and the a.c. line cord entry are at the rear.

Two two-lug terminal strips are used—one for mounting silicon diode *D1* and the other for terminating the a.c. line cord. Chassis ground connections are made to soldering lugs installed under the tube socket mounting screws. Use insulated hookup wire for connecting the a.c. switch and filament circuits; the balance of the wiring can be done point-to-point using component leads. It's a good idea to use spaghetti on the leads as required to avoid possible shorts.

With the components mounted and wired, carefully check your work before installing the tubes and applying power. Check to see that the tube filaments light, and measure the B-plus at the



Flash shutter contacts are polarized. Check with a voltmeter, and connect positive side to V2's plate.

junction of *R10-C6b*. It should be slightly in excess of 150 volts. Finally, check for a reading of approximately 3 volts at pin 2 of the 2D21. Secure a crystal microphone such as the Lafayette Radio 99 G 4510 and terminate its cord in a phono plug.

The Flash Unit. The small schematic on this page is a simplified diagram of a typical electronic flash. Normally, the camera shutter discharges capacitor *C2*—charged through isolating resistors *R1* and *R2*—through the primary of trigger transformer *T1*. The very high voltage pulse produced by *T1*'s secondary is applied to the external starter anode of the flash tube, partially ionizing the gas inside it. The energy stored in *C1* flows through the ionized gas, producing an intense flash of light. In this application, the shutter leads from the flash unit are connected to *J2* of the trip adapter. The cord and connector are wired so that the positive terminal from the flash is connected to the 2D21 plate.

Mike was one foot away for photo of golf ball falling into bowl of water. Fracture pattern of bulb is seen below; despite its looks, it exploded violently.

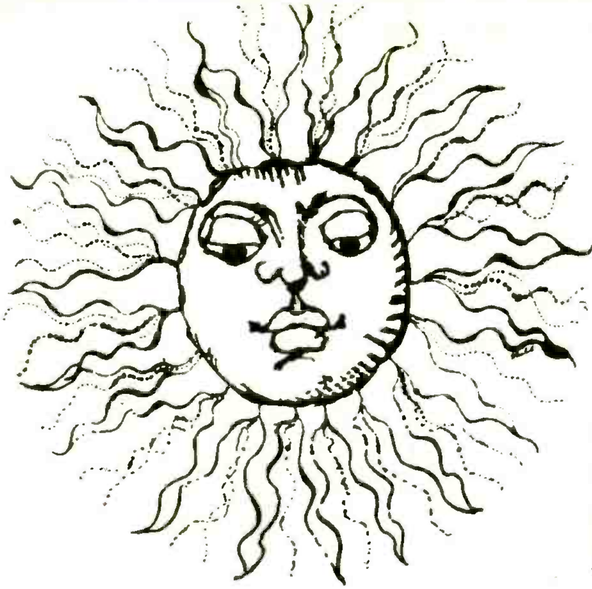
Almost any electronic flash unit will work with the trip unit, so if you already own one or can borrow one, you're in business. If you must buy one, remember that a.c. power will be required for the trip unit, so it would be foolish to pay extra for a battery-operated flash. Small but adequate a.c.-operated flash units are quite reasonable—the unit shown in the photo on page 40 is available from Spiratone, Inc., 135-06 Northern Blvd., Flushing 54, N.Y., for $12.95 plus postage.

Take a close look at the camera shutter on your flash unit, and secure an extension cord to fit it. Cut the camera fitting off of the other end, strip the wires, and turn the flash unit on. Touch a voltmeter set to a high range to the bared leads, and observe the polarity. Connect the positive lead of the cord

(*Continued on page* 142)

HOW IT WORKS

As shown in the schematic on page 41, the input signal from a high-impedance crystal microphone is amplified by a conventional 12AT7 (*V1*) twin-triode audio amplifier. A sensitivity control, *R3*, is provided between the first and second audio stages, and serves to determine the input signal level required to trigger *V2*, the 2D21 thyratron trigger stage. This stage serves as an electronic switch to close the contacts of the electronic flash unit. The firing circuit voltage developed in the flash is used as the plate supply voltage for the 2D21. Resistance network *R7-R8* biases the cathode of the 2D21 to a positive value of approximately 3 volts. When the positive peak of the audio signal applied to the control grid of the 2D21 appreciably exceeds the cathode bias, the tube conducts or fires, triggering the flash unit. The power supply is entirely conventional. The 6.3-volt winding of *T1* supplies filament voltage to *V1* and *V2*, while the output of the 125-volt winding is rectified by *D1* and filtered by *C6-R10* to supply bias voltage and 150 volts of B-plus for the audio amplifier plate circuits.



Why depend on batteries when you can get all the energy you need free of charge? How?

LET THE SUN POWER YOUR PORTABLE

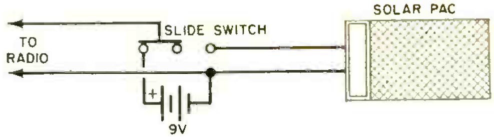
By HOMER L. DAVIDSON

YOU CAN USE the sun to power your small transistor radio—or, if it's raining, you can use a 100-watt light bulb. The only other element you really need is International Rectifier Corporation's "Solar Pac," which can be hooked up to charge the radio's battery, or to operate the radio, or to do both. The "Solar Pac" comes in two models: SP5C26C (4.5 volts at 26 ma.) and SP9C13C (9 volts at 13 ma.), and is available from electronic supply houses for $9.95.

There are many ways you can connect the solar pack to your radio. You may

want to add a switch (see schematic) to provide a choice of either solar or battery power. Or you can simply connect the pack's 6″ leads to the battery connections inside the radio. You can even use the solar pack as a plug-in supply by connecting an earphone jack and cord to the pack, removing the existing wires from the radio's earphone plug, and running a pair of wires from the plug to the battery connections.

Mounting the pack is no problem as it is supplied with mounting pads which can be attached easily to any radio case

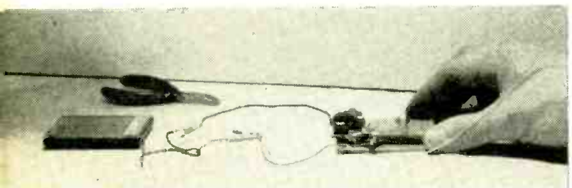


Your portable can be switched to either battery or sun operation by adding a slide s.p.d.t. switch.

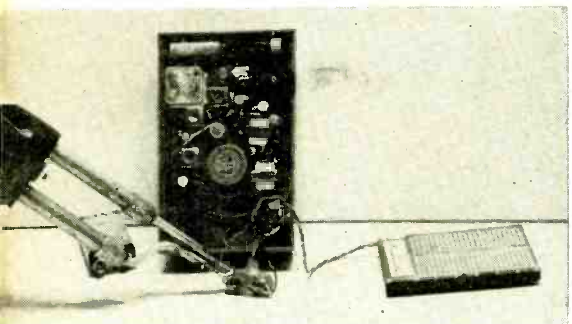
or cover. But for a more permanent installation, place the pack against the plastic back of your radio, outline its shape with a scribe, carefully cut out the required area with a knife-tipped soldering iron or jeweler's saw, fit the pack into place, and seal around the edges with cement.

If you plan to use the solar pack as a universal power supply for more than one radio or transistor project, add alligator clips to the pack's leads for easy handling. Should circumstances require lower voltages than that provided by the solar pack, insert an inexpensive 100-ohm potentiometer in series with the output to reduce the voltage.

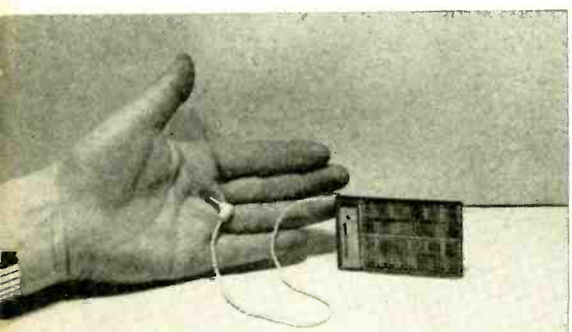
Once you know how much resistance you need in a given circuit (by measuring the pot's resistance in the circuit), you can substitute a fixed resistor. Add a resistor only when no battery is in the circuit, and only when the unit is to be used out-of-doors. A resistor is not required indoors as you can move closer to or further away from the light source to obtain a desired voltage. —30—



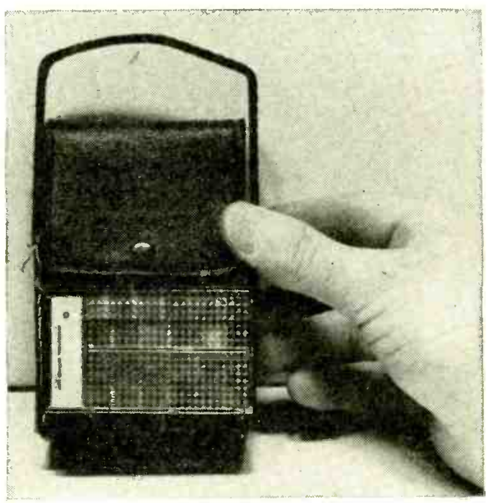
Hook up a couple of alligator clips to the leads of the solar pack to make easy-to-connect power supply.



By connecting the solar pack in parallel with the battery, you can charge the battery while operating the radio, or run the radio without the battery.



The earphone jack connections of your transistor radio can be modified to accommodate the solar pack.



The solar pack can be cemented to the radio case, and the leads can be slipped under the case flap.

BUILD . . .

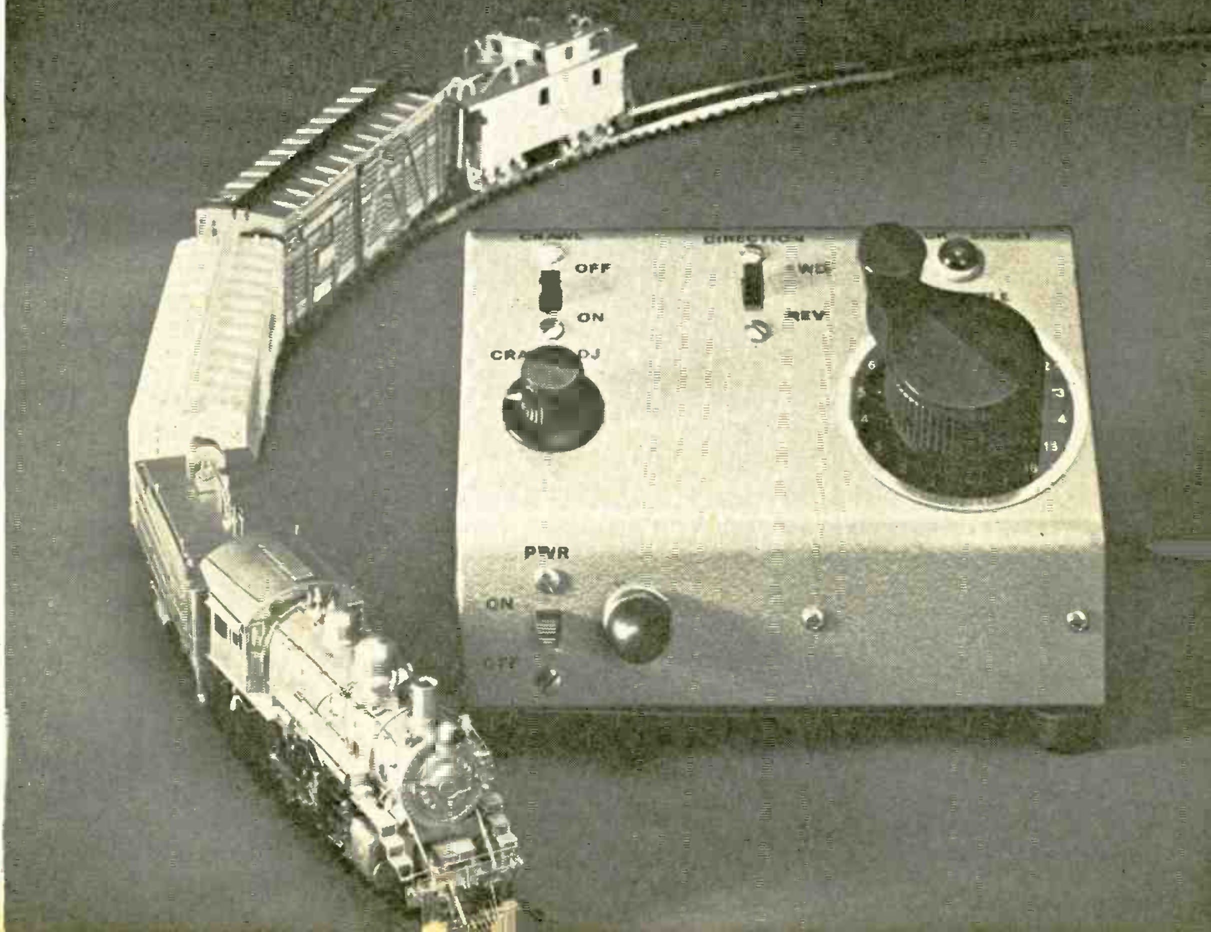
THE SUPER-X PULSE POWER PACK FOR HO RAILROADING

. . . and get the feel of the real thing

By WOODROW POPE
Design Engineer,
Collins Radio Company

SAY Mr. Model Railroad Engineer, can you start your loco without jumping to 10 scale miles per hour? You can, you know, without equipping your locomotive with flywheels or high gear ratios. How? Easy . . . just build and use a new transistor throttle power pack on your pike for the ultimate in model railroading.

With it you get pulse power for smoother stall-free starts, and your loco



can crawl, or hi-ball, or couple—without crashing. You also get lots of power to operate signal lights, switch machines, or other accessories . . . all with circuit overload protection.

Just What is Pulse Power? To understand pulse power, you must first understand the nature and operation of the conventional d.c. power pack. Your loco is equipped with a tiny d.c. motor that operates off power supplied to the tracks by the power pack. When you man the throttle, which is nothing more than a rheostat, you are regulating the voltage across the track, and hence the motor speed.

Assume your throttle is turned all the way down and your loco is sitting still. You now begin to turn up the throttle, gradually increasing the voltage applied across the tracks. But notice, your loco does not start immediately; it waits until the proper operating voltage is reached, and until all magnetic and mechanical locking has been overcome. By this time the voltage is too high for a slow, smooth start, so the loco lunges ahead.

Figure 1 shows, graphically, how late a typical loco might start after you begin cranking up the throttle. You will note that a certain minimum voltage must be reached to overcome the inertial load on the motor before it will even begin to turn.

Now let's assume you are using one of the latest power packs to hit the scene—you know, like the one we're telling you about right now—your loco will start to crawl, like real trains do, the moment you hit the throttle. How come? Well, with pulse power you get maximum voltage in the form of narrow pulses the instant you flip the primary power switch. This is shown, graphically, in Fig. 2. Here the average power consumed by the motor is a direct func-

PARTS LIST

C1—1000-μf., 15-volt electrolytic capacitor (Sprague TVL 1165 or equivalent)
C2, C3—0.47-μf., 35-volt capacitor (Kemet KR47C35K or equivalent)
C4—1-μf., 35-volt capacitor (Kemet K1C35K, or equivalent)
D1, D2, D3, D4, D6, D7—1N2069 silicon diode, or equivalent)
D5—1N276 diode, or equivalent
F1—1-ampere fuse
I1—#47 lamp, 6-8 volts, 0.15-amp.
I2, I3—12-volt, 1.2-amp. automobile dome lamp, or equivalent (two required)
Q1, Q2, Q3, Q7—2N404 transistors
Q4, Q8—2N1382 transistors
Q5, Q6—2N456A transistors
R1, R6—2200-ohm, ½-watt resistor
R2, R3—22,000-ohm, ½-watt resistor
R4—Not used
R5—6800-ohm, ½-watt resistor
R7—10,000-ohm, 2-watt carbon potentiometer, linear taper
R8—390-ohm, ½-watt resistor
R9, R15, R16—1000-ohm, ½-watt resistor
R10, R14—10,000-ohm, ½-watt resistor
R11—10-ohm, ½-watt resistor
R12—1000-ohm, 2-watt carbon potentiometer, linear taper (with switch S3)
R13—330-ohm, ½-watt resistor
S1—D.p.s.t. slide switch
S2—S.p.s.t. slide switch
S3—S.p.s.t. switch (mounted on R12)
S4—D.p.d.t. slide switch
T1—Power transformer: primary, 115 volts; secondary, 12.6 volts with center tap, (Stancor P-8130, or equivalent)
1—Cabinet (Bud AC-1613-A or other suitable sized cabinet)
Misc.—Fuse clip; pilot light holder; red lens (Dialco series 1006); binding posts (4—2 red, 2 black); throttle knob (Raytheon 175-6-2G); crawl adjust knob (Raytheon 90-3-2G); power transistor mounting kit (Motorola MK-15)

Fig. 1. The ordinary power pack is nothing more than a full-wave rectifier whose output is a pulsating d.c. voltage with peaks that look like the waveform above. For most locos, the average power required for starting is much too high for a smooth start, and the trains pull out with a sudden jerk, and at a speed not akin to real railroading.

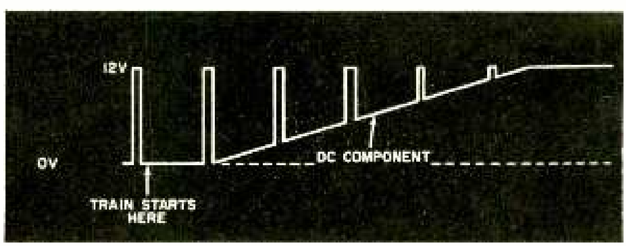


Fig. 2. The pulse power pack produces a train of narrow pulses in addition to variable d.c. power. The pulses are fully visible when the throttle is turned down, but disappear gradually as the throttle voltage builds up to full power. Instant rise of pulse from zero to maximum provides immediate power to operate train when crawl knob is turned up.

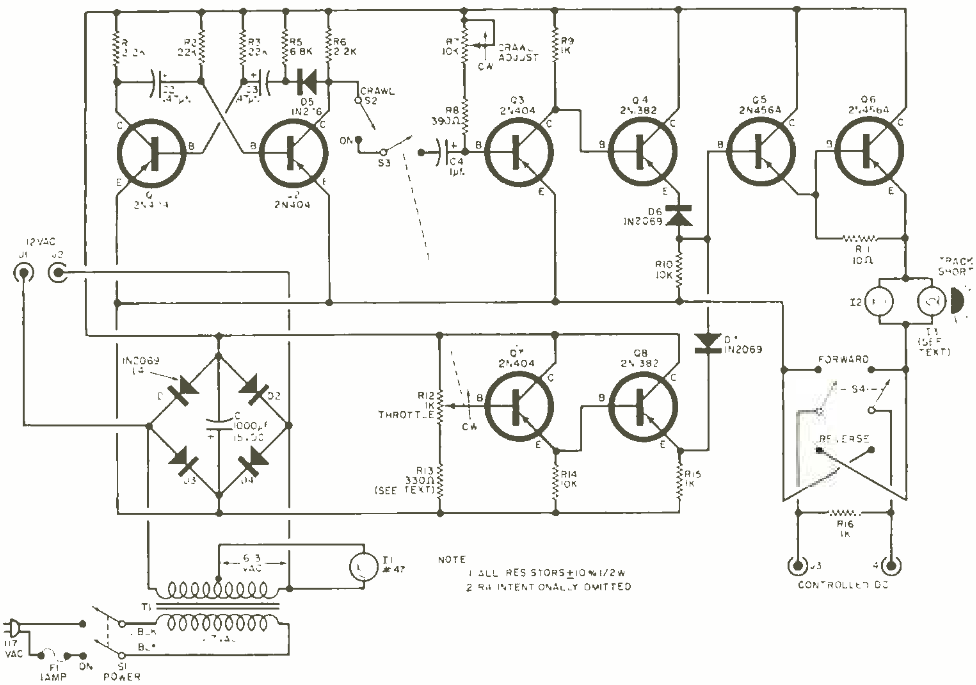


Fig. 3. Crawl control R7 adjusts pulse width to give desired crawl speeds when S2 and S3 are turned on. Throttle R12 is part of a voltage divider that drives emitter followers Q7 and Q8 with varying d.c.

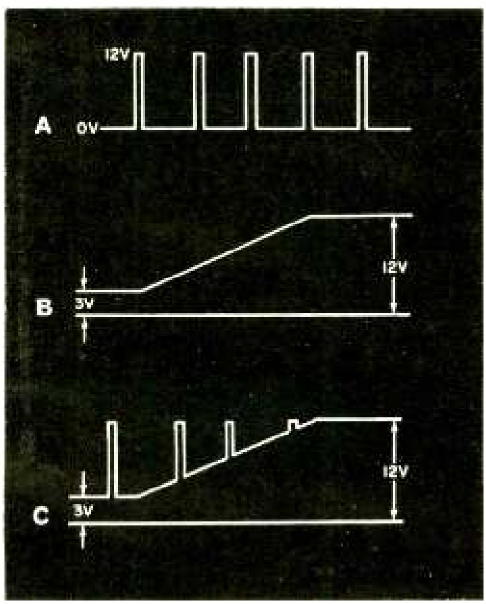


Fig. 4. Pulses rise to maximum as soon as power is turned on (a), providing immediate train start. Crawl knob adjusts pulse width for varying train loads and desired crawl speeds. Throttle adjusts d.c. at emitter of Q8 (b) to run train at desired speeds. With throttle turned down (c), pulses appear prominently, then fade away as d.c. is turned up.

tion of the pulse width which you adjust with a crawl control. This varies the circuit RC time constant.

How It Works. From Fig. 3 it is apparent that pulse power, which makes your trains run like a dream, calls for a rather sophisticated circuitry. Let's give the circuit a once-over and see what we mean. First, we have transformer *T1* stepping down the 117-volt a.c. primary power to approximately 12.6 volts. This 12.6-volt supply branches off to jacks *J1* and *J2*, where it is available to operate switch machines, signal lights, and other accessories. Some of this power is also tapped off and applied to the bridge rectifier circuit (*D1* through *D4*), from where it will eventually operate your trains.

The 6-volt #47 pilot lamp (*I1*), wired from the center tap to one side of the transformer secondary winding, is merely an indicator to tell you when the power is on. You can break down the rest of the power pack into its pulse forming and control circuits, the variable d.c. circuit, and the short-circuit protection circuit. If you care to, you can throw in polarity switch *S4* (forward and reverse) for good measure.

The Pulse Circuits. These circuits begin with *Q1* and *Q2* which comprise a free-running multivibrator. The collector of *Q2* puts out a 60-cycle square wave which is fed through *S2* and *S3* to pulse generator *Q3* for conversion to narrow pulses. These pulses are then amplified by *Q4* and appear as shown in Fig. 4(a). *CRAWL ADJ* potentiometer *R7* adjusts the pulse width to suit varying train loads and desired crawl speed. The *CRAWL ON-OFF* switch (*S2*) is used to disable the crawl feature, if desired. Switch *S3* is ganged to the main throttle so that it cuts off the pulses when the throttle is turned all the way down to where you hear a "click."

Variable D.C. Circuit. In the variable d.c. function generator circuit, *R12* and *R13* form a variable voltage divider, the output of which is fed to emitter followers *Q7* and *Q8*. The emitter followers provide a low impedance source for the voltage. The output voltage at the emitter of *Q8* is variable from about 3 volts to 12 volts, as shown in Fig. 4(b), depending on the setting of *R12*, the speed control potentiometer.

Diodes *D6* and *D7* are used to mix the two functions (pulse and variable d.c.) together. The pulses and variable d.c. are fed to emitter followers *Q5* and *Q6*

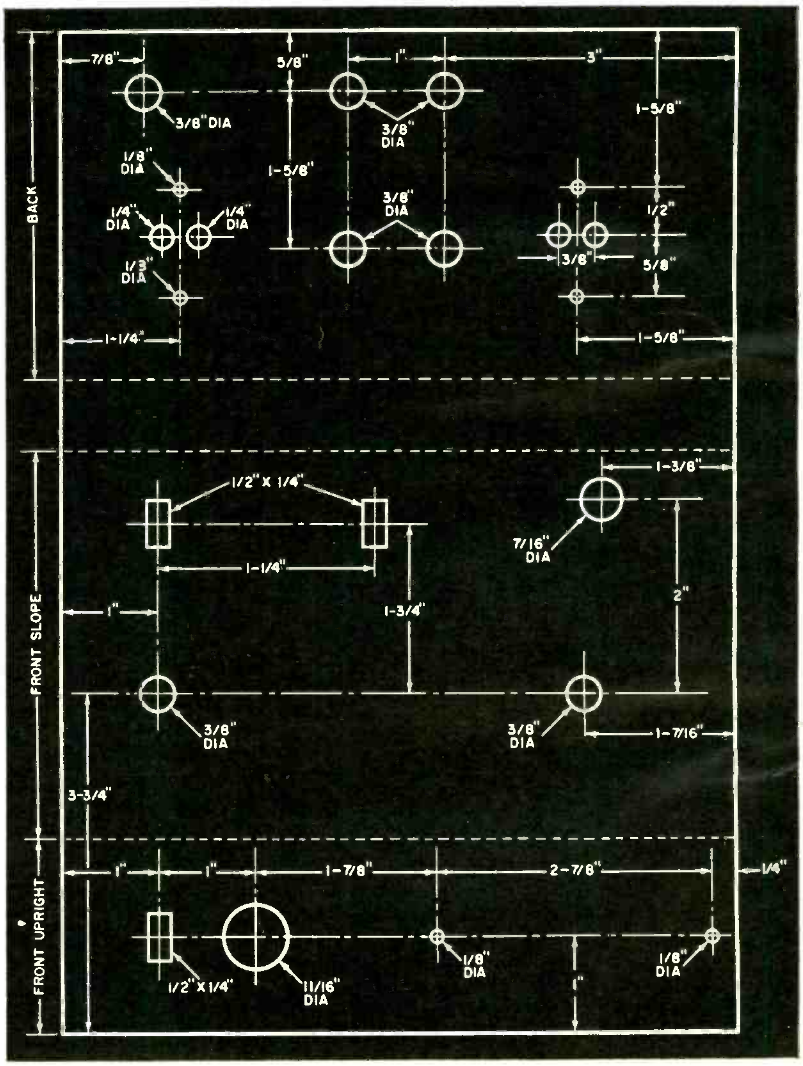


Fig. 5. This layout and accompanying dimensions are valid only if the recommended Bud cabinet is used. Lay out, drill, and punch all holes as shown. If you use another cabinet, this layout can still serve as a guide. The transistor mounting holes remain the same, regardless of cabinet dimensions.

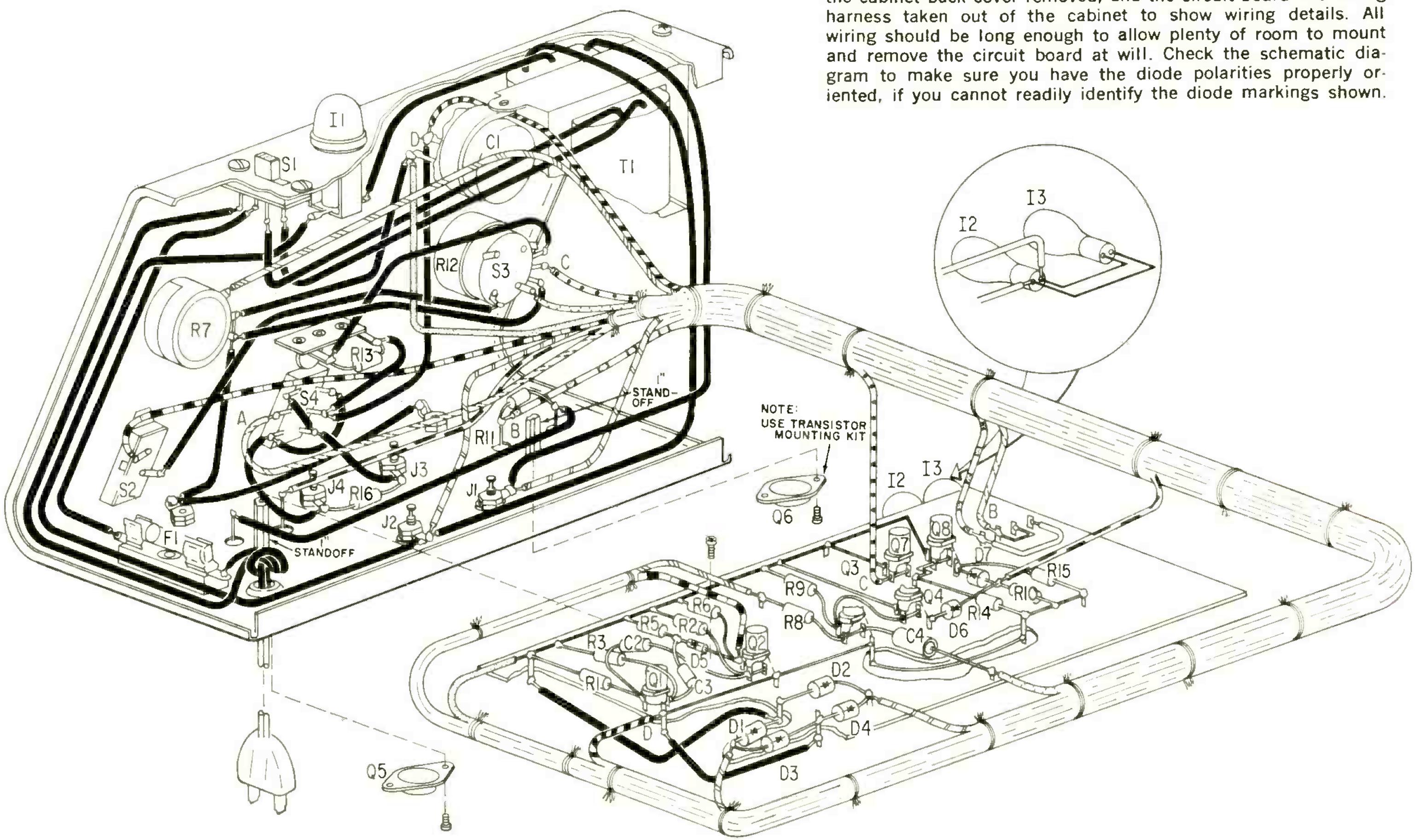
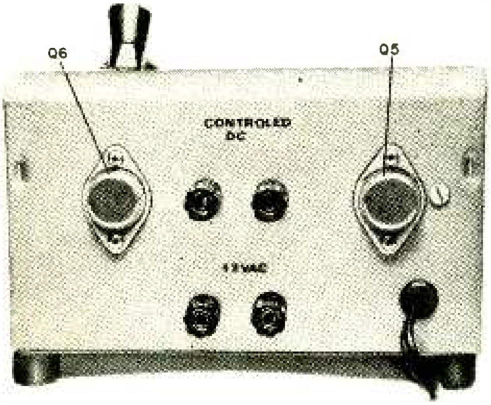


Fig. 6. Pictorial diagram of the completely assembled unit with the cabinet back cover removed, and the circuit board and wiring harness taken out of the cabinet to show wiring details. All wiring should be long enough to allow plenty of room to mount and remove the circuit board at will. Check the schematic diagram to make sure you have the diode polarities properly oriented, if you cannot readily identify the diode markings shown.



Rear view of transistor power pack showing location of power transistors Q5 and Q6. Be sure to use a rubber grommet to protect line cord from damage.

which provide a high current output. Their output waveform is as shown in Fig. 4(c).

Short Circuit Protection. Lamps *I2* and *I3* in the emitter circuit of *Q6* protect the entire unit against accidental short circuits or overloading. Together with a red jewel mounted on the front panel, they also double as a track short indicator. These lamps are of the ordinary 12-volt auto dome light type, each rated at 1.2 amperes. Putting them in parallel, however, increases the circuit capacity to 2.4 amperes.

When the filaments are cold, the lamps exhibit a very low resistance, and therefore act like a piece of wire. When your loco or other load begins to draw about 1 ampere of current from the power pack, the lamps begin to glow and their filament resistance goes up rather sharply to form a protective load for the power pack. Thus, even if the output leads at *J3* and *J4* were to be shorted together, no damage would result to the power pack. But because one of the lamps is mounted under the red jewel, you would know there was an overload when it lit up.

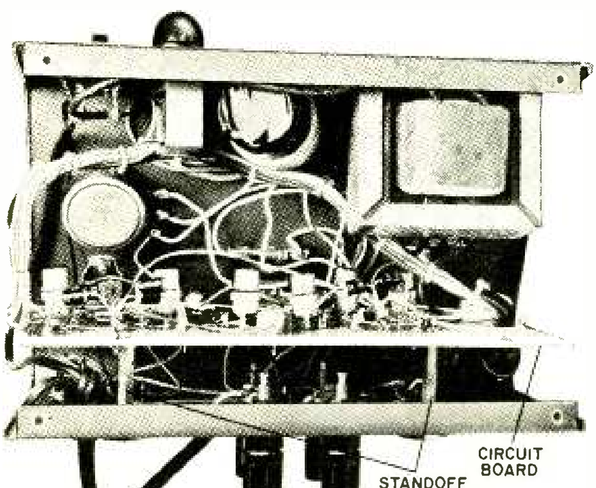
The *FWD-REV* switch (*S4*) is an ordinary d.p.d.t. switch wired to reverse the polarity of the d.c. voltage as it is flipped from one direction to the other.

Construction. Assuming you have obtained the Bud cabinet called for in the Parts List, you now proceed to lay out and drill the holes as shown in Fig. 5. After drilling all holes and deburring them, mount the power transistors on the back panel, making certain you use the mica strip and washers supplied with the mounting kit to insulate the transistors from the case.

Figure 6 shows the general layout of the wiring and other circuit components. Electrolytic capacitor *C1* should be wrapped with electrical tape to insulate it from the case. Notice that it is mounted with a plastic clamp.

The circuit board is made from a piece of 2¾" x 6¾" Vectorbord. Observe the location and mounting position of *I1* and *I2*. Bring out long leads to the panel mounted components, and use a

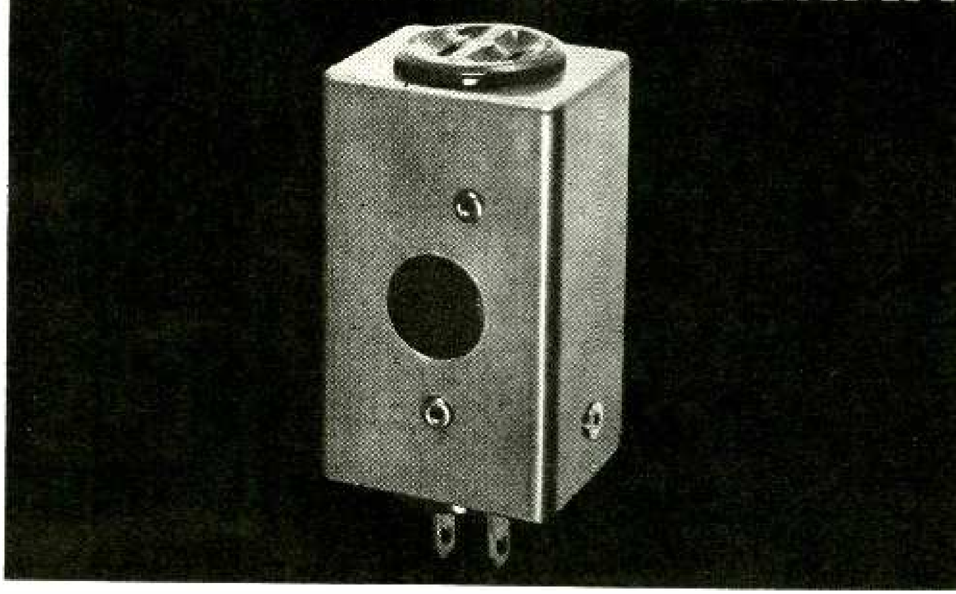
(*Continued on page* 137)



With bottom plate removed, laced wiring harness can be tucked away to one side during repair or maintenance of the unit. The component circuit board is supported with metallic or insulated standoffs. To install the line cord, thread free end through grommet at rear of cabinet. Separate ends of cord back 12 inches and tie into a knot to take up any strain on cord.

BUILD THE LI'L DUSKER

THE LIGHT WATCHMAN



This light sensor turns your lights on at dusk, and off at dawn, automatically—without a timer

By DON LANCASTER

HERE'S A CLEVER, useful, and economical photoelectric controller you will want to build. Li'l Dusker, the "light watchman," will earn its keep turning on lights for you in dark driveways, stairways, and halls at night, and then turning them off at dawn when they are no longer needed. And while you are away from home, Li'l Dusker will turn on that important "there's somebody home" light that will deter *all* but the most persistent intruder.

But Li'l Dusker has many more talents. It can serve as an automatic door opener, or a light-operated relay. And if you want an automatic flasher with adjustable frequency, or a low-cost touch control for a desk or table lamp, call on Li'l Dusker.

About the Circuit. Although Li'l Dusker acts like a magician, the circuit is really a simple one, as Fig. 1 shows. It is just a d.c. power supply (*R1*, *D1*, and *C1*), and a limiting resistor (*R2*), a cadmium sulfide photocell (*PC1*), and a d.c. relay (*K1*), all connected in series.

The cadmium sulfide photocell has a low resistance in the presence of light and a high resistance in darkness. This characteristic enables the Dusker to tell night from day. Therefore, as light increases with the break of dawn, the photocell resistance decreases, increasing the current in the relay coil, and causing the relay to pick up.

The relay sensitivity—the light intensity that will cause the relay to pick up—is established by the value chosen for the current-limiting resistor (*R2*). The circuit application determines which set of relay contacts is used. For dusk-to-dawn control, the *NC* (normally closed)

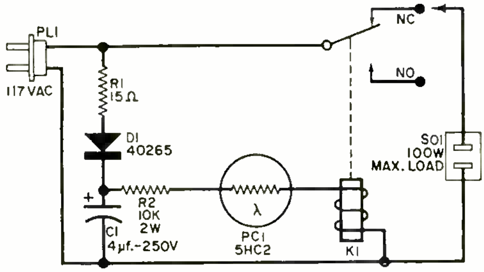


Fig. 1. For dusk-to-dawn control, connect load circuit to the NC relay contacts; for photocell relay application, connect load to the NO contacts.

PARTS LIST

C1—4-μf., 250-volt electrolytic capacitor
D1—130-ma., 400-PIV rectifier (RCA 40265 or equivalent)
K1—Phillips-Advance #1524-1C relay, 24-volt, 1100-ohm coil, 1 amp contacts (Newark 60 F 1749 or equivalent)
PC1—200-volt, ½-watt cadium sulfide photocell (RCA 4403—Allied Radio 7 Z 435 or Polaris Maj-1—Allied Radio 7 Z 565)
PL1—100-volt, 2-pole standard plug (Amphenol 61-M or equivalent)
R1—15-ohm, ½-watt resistor
R2—10,000-ohm, 2-watt resistor
SO1—110-volt, 2-pole universal receptacle (Amphenol 61-F or equivalent)
1—Case made from Millen 74400 octal base and shield (Newark 40 F 734)
Misc.—"Pop" rivets (4), 1¾"-square piece of 1/16" single-sided PC board, funnel eyelets for PC board (24). ½" x ⅞" aluminum sheet (2), 2" x 1½" plastic sheet or film, glue or sealant, wire, solder

contacts are used; for door-opening operation, the *NO* (normally open) contacts are employed instead.

Construction Pointers. Li'l Dusker can be encased for mounting on a windowsill or anywhere outdoors, and can be plugged into a standard wall receptacle or octal socket. In Fig. 2(A), the Dusker has its own line cord and is mounted on a windowsill where it can "look" outside. For general outdoor use, BX, ROMEX, or other approved wiring can be brought in through the top of the unit. To make the Dusker weatherproof, the outlet can be recessed and the entire unit mounted as shown in Fig. 2(B) in a sheltered area.

If Li'l Dusker is to serve as a door opener, the case is used as it comes, with only slight modification. You can then make a companion light source, perhaps with a 6.3-volt filament transformer and an automobile 6-volt lamp bulb and socket. You might want to add a low-cost

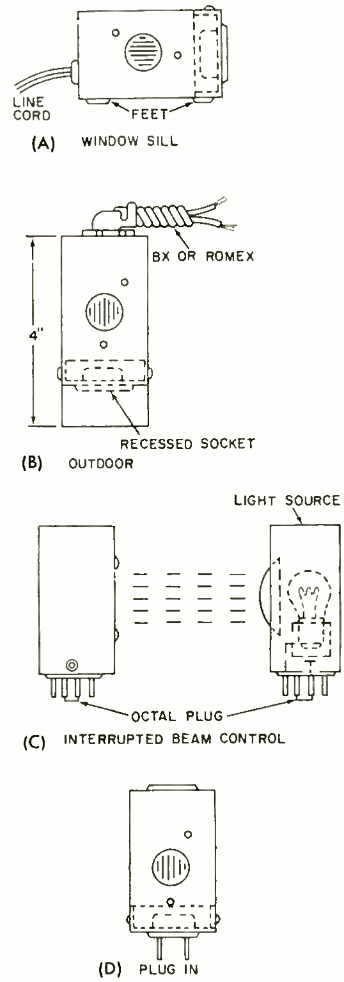


Fig. 2. Select one of these four case configurations for the Dusker. For table or desk lamp touch control applications, the outer casing is not used.

lens to focus the beam and thus provide for greater separation between the Dusker and the light source.

For touch control applications, you can omit the case altogether and mount the circuit directly inside the base of a table or desk lamp.

Construction Details. Using a Millen #74400 octal base and shield, cut the case for the plug-in configuration following the details given in Fig. 3. In addition, two mounting brackets will be required. These can be made out of a small strip of aluminum sheet cut as shown in Fig. 3(D). Drill the holes first, then bend the bracket into shape using long-nose pliers, or a vise, if one is available.

You will also need a piece of tough plastic film to serve as a protective window for the photocell. Acetate, Mylar, or anything similar will do. Avoid using brittle material that will crack or break.

The parts are mounted on a small (1¾-inch-square) printed circuit board laid out, drilled, and cut as shown in Fig. 4. Eyelets are used in the holes where shown to give the circuit board some extra ruggedness. The aluminum brackets are riveted to the circuit board in the locations indicated in Fig. 5, again using eyelets.

The photocell is glued to the back of the printed circuit board with silicone

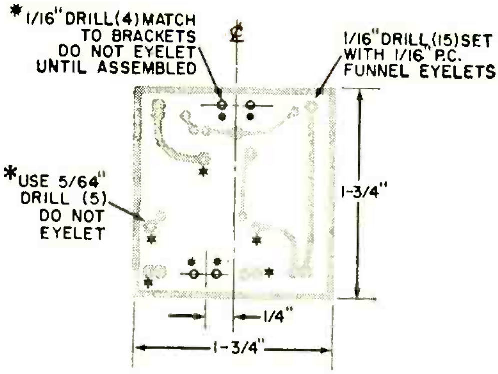


Fig. 4. This is foil side of printed circuit board. Numbers in parentheses indicate holes required.

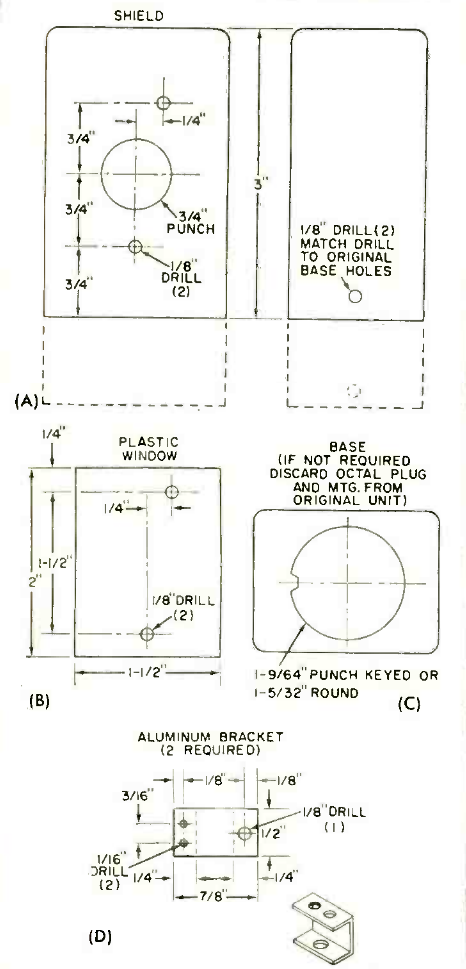


Fig. 3. The base and shield of case are cut and punched as shown. Then they are finished with lacquer or paint, or are anodized. The two brackets at bottom are made from 1/32-inch aluminum sheet. Window is made from heavy plastic film such as Mylar; avoid using brittle material.

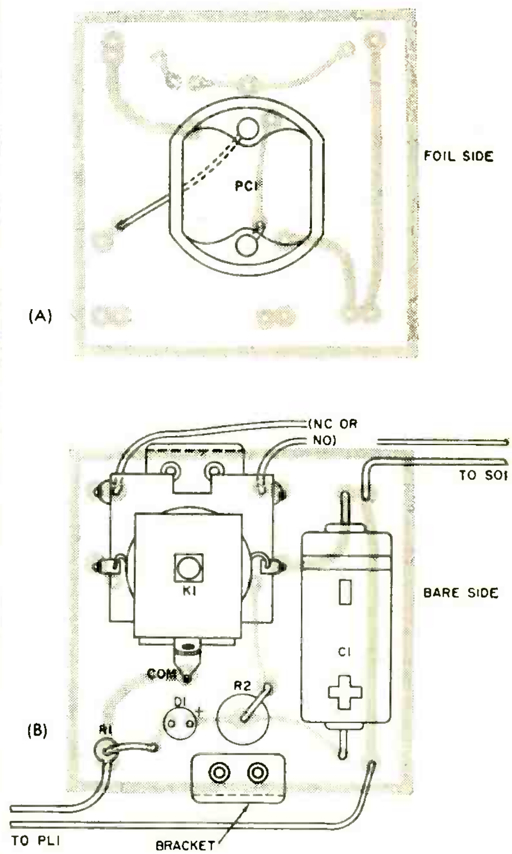


Fig. 5. Here's the component layout. Photocell PC1 is mounted on the foil side of the circuit board as shown in (A). All of the other parts are mounted on the bare side of the board as shown in (B).

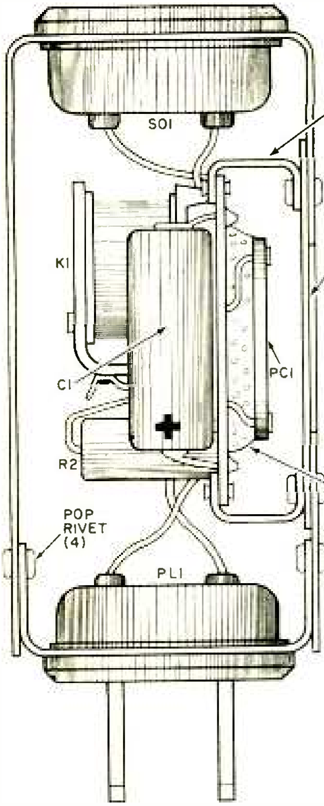


Fig. 6. After all the parts are preassembled on the circuit board, and the unit has been fully wired and tested, install the plastic window and pop-rivet the aluminum brackets to the case shield.

rubber sealant (Fig. 6). The plastic window is glued in place and allowed to dry before the aluminum brackets are riveted on.

Before making connections to the relay, refer to the Special Applications section at the end of this article to determine the proper relay terminals to employ. In general, the *NC* contacts are used when decreasing light must energize the load, and the *NO* contacts are used when increasing light is to energize the load.

Checkout and Final Assembly. Before final assembly, you will want to check out the circuit to make sure it works the way you want it to. For this you can use a flashlight or other suitable light source. If it becomes necessary to change the sensitivity of the unit, change the value of *R2* as necessary. But you can decrease the sensitivity by merely reducing the amount of light reaching the photocell. A filter made of colored cellophane, Polaroid material, or tinted acetate placed over the light window will work well.

Once you have obtained just the right sensitivity for the particular application, complete the assembly by "pop"-riveting the circuit board and bottom plate to the case. Once pop-riveted, the Dusker becomes tamperproof and there's no way to take the case apart without using an electric drill. If it becomes necessary to open the case again, use a 1/8" high-speed bit to drill out the rivets.

Once assembled, operation of the Dusker is a snap. Just plug it into a convenience outlet, plug the load or lamp into its receptacle, and away you go.

Special Applications. For operation as a light flasher, the Dusker must be wired as a dusk-to-dawn control. This makes it essentially an oscillator with negative feedback. The Dusker must be positioned

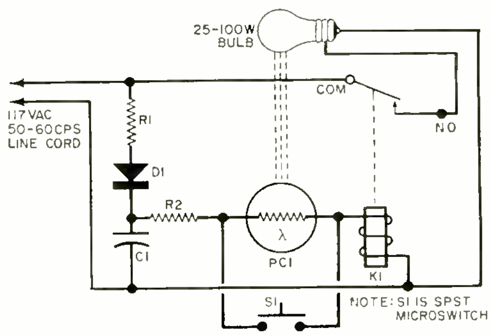


Fig. 7. This low-cost touch control circuit can easily be wired to any desk or table lamp by adding a microswitch across PC1. To turn on lamp, touch S1 gently. To turn off lamp, bring hand near PC1, shielding it from light. For proper operation, PC1 must be shielded from other strong light sources.

in such a way that the light shines in its "eyes." Initially, when the light is *off*, the photocell turns it *on*: the Dusker "sees" it and turns it *off* again. This cycle can go on as long as the unit is plugged in. To adjust the *on-off* rate (frequency), adjust the amount of light that gets fed back. Changing the bulb size will usually do the trick.

For "touch control" operation, mount the circuit board (less case) in the base of a lamp so that only the lamp light—

(*Continued on page* 139)

BUILD...

SOLID-STATE SLOT CAR SPEED CONTROL

Turn your slot racing car into a mighty fast cat, yet maintain absolute speed control every inch of the way

By JAMES FISHBECK

SIMPLE TO BUILD, inexpensive to own, a dream to operate! We're talking about a transistorized slot racing speed controller that lets you run your model racing car almost like the pros do at Le Mans. From the instant you start, all the way through the sloping, winding, pretzel-shaped speedway, till your car zooms across the finish line, you'll enjoy the full pleasure of instant and complete control over your racing car's speed and performance.

Because the push-button type of speed controller controls the car's speed by applying a series of pulses, the acceleration is in steps, rather than through a smooth, linear variation from low speed to top speed. This new solid-state speed controller uses a carbon potentiometer wired to a d.c. amplifier to provide a

smooth variation in resistance, which gives your car finger-tip speed control and all the power it needs to perform with style and class.

How It Works. The speed controller consists of a dual amplifier and two separate potentiometer throttles—one for each amplifier (Fig. 1). Each amplifier output drives a separate lane of the speedway.

Potentiometer *R1* is shown connected across the d.c. power pack supplied with the racing car set. Its center tap is wired to the base of emitter follower *Q1*, thereby controlling the output of this stage. The output of *Q1* is directly coupled to the base of *Q2*, the power output stage, which supplies power to the track through *F1*. The other amplifier operates in the same way.

Since the power pack is nothing more than a step-down transformer feeding into a full-wave rectifier, it puts out an unfiltered d.c. which is quite suitable to run racing cars. Because the transistor amplifiers do not perform well with pulsating d.c., a filter capacitor (*C1*) is put across the power pack output to filter out the ripples before they get to the amplifier.

If you operate a speedway with more than two lanes, you can build a separate amplifier for each lane with no degradation in performance (as long as you don't exceed the wattage rating of the power pack). Just be sure you use identical components in all the amplifiers and speed control potentiometers.

Construction. Except for the two speed controller potentiometers, all parts, including the power pack supplied with the slot racing set, are mounted on a 2" x 5" x 7" aluminum chassis (Figs. 2 and 3). The two speed controller po-

PARTS LIST

C1—500-µf., 25-volt electrolytic capacitor (Cornell Dubilier BBR 500-25 or equivalent)
F1, F2—1-ampere fuse (Littelfuse 3AG)
Q1, Q3—2N109 transistor
Q2, Q4—2N554 transistor
R1, R3—5000-ohm carbon potentiometer, linear taper (IRC-CTS Q11-114 or equivalent)
R2, R4—1000-ohm, 1-watt, 10% resistor
TS1—4-terminal screw-type terminal strip (Cinch-Jones 17-4 or equivalent)
1—2" x 5" x 7" aluminum chassis base (Bud AC-402)
2—3¼" x 2⅛" x 1⅛" aluminum Miniboxes (Bud CU-3017A)
Misc.—Two miniature fuse posts (Littlefuse 342014), multiple-conductor intercom cable, power pack from existing racing set, two knobs, mounting hardware, transistor sockets, rubber grommets, hookup wire, etc.

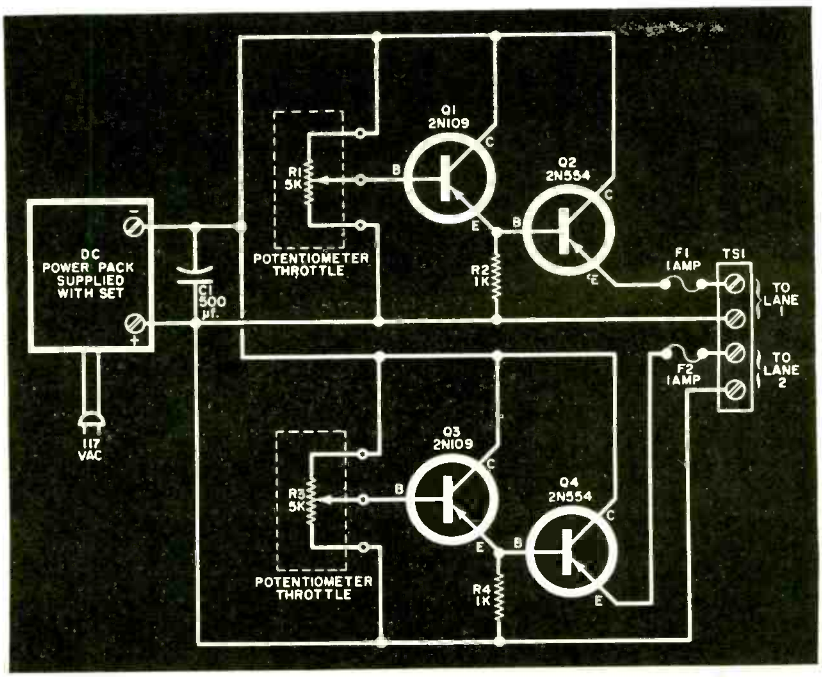


Fig. 1. In this two-lane speed controller, each channel is a mirror image of the other. The speed control potentiometers are mounted on individual chassis, and are connected to the amplifier circuit by long cables. For compactness, mount the slot racer power pack on top of the amplifier chassis.

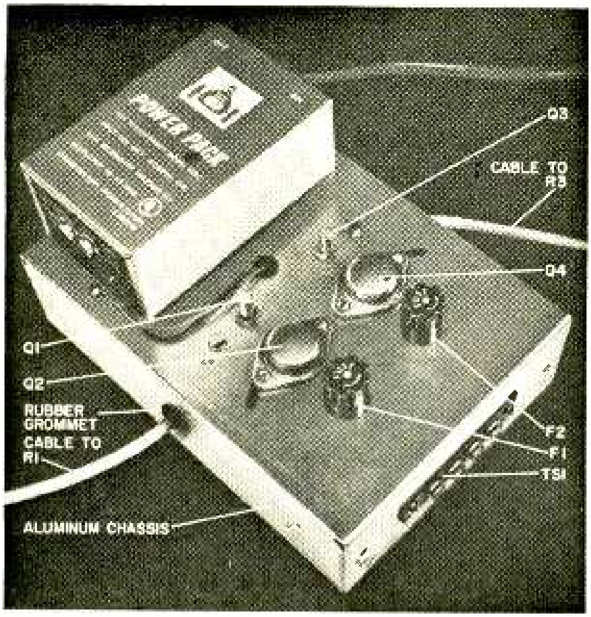


Fig. 2. Large chassis allows plenty of room for mounting the power pack. Use mounting kit for Q2 and Q4, and be sure to mount Q1 and Q3 on sockets. Cables at sides of chassis go to speed controllers.

tentiometers are mounted on individual 3¼" x 2⅛" x 1⅛" aluminum Miniboxes. After drilling, punching, and deburring the chassis, insert rubber grommets through all cable entrance holes.

If your power pack is too large to fit on the size chassis recommended, get a bigger chassis. The size suggested happens to be convenient, but you have complete freedom to select the packaging that best suits your needs. Incidentally, the layout of components is not critical, either. Just use good practices to come up with a professional looking job. You *must* mount the two small transistors (*Q1* and *Q3*) on sockets, however, and you *must* use mounting kits for the power transistors (*Q2* and *Q4*).

After you have mounted each potentiometer on its Minibox, wire it up as shown in Fig. 1 using the three-conductor flexible cable (you can make the cable any length you wish). Connect the other end of the cable to the main chassis.

Check It Out First! Having completed all your wiring, you are now itching to fire up the unit and race away . . . but don't, yet. You'd better go over all the wiring, very carefully, and check it out against the schematic. Above all, you'll want to make certain you haven't reversed any of the leads to the power pack, as this could play havoc with your transistors. If everything's okay so far, wire the output terminals to the track and plug the unit in.

If either car runs in the wrong direction, reverse the track leads to that lane. Do not reverse the leads at the power pack to correct this condition. Should either controller potentiometer work backwards, that is, if the car increases speed when the knob is rotated counterclockwise, reverse the two cable leads across the potentiometer end terminals.

If one car tends to run slowly when the potentiometer controlling that car is all the way off, one of the transistors in the amplifier associated with that lane is defective. To determine which transistor is at fault, remove the smaller transistor (*Q1* or *Q3*) from its socket. (CAUTION: always turn the power off when removing or inserting any transistor.) If the car still runs slow with the transistor removed, replace the larger transistor. If the car doesn't run at all now, replace the smaller transistor. –30–

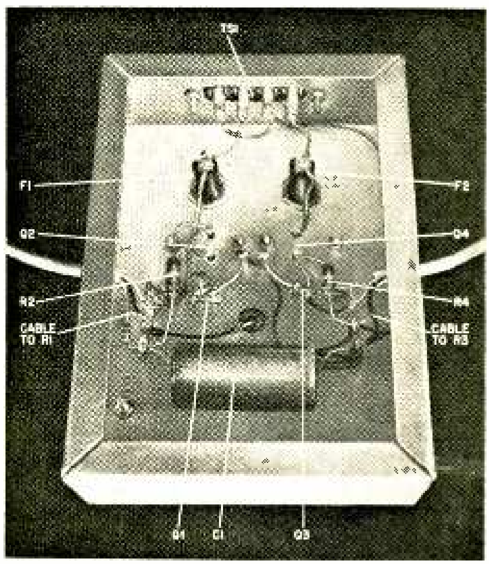


Fig. 3. This underchassis view shows parts layout and wiring. Capacitor C1 is wired across the power pack output to provide filtered d.c. to the amplifiers. Use rubber grommet at all cable entrances.

BUILD THE
ELECTROLOCK

By **MURRAY E. COULTES**

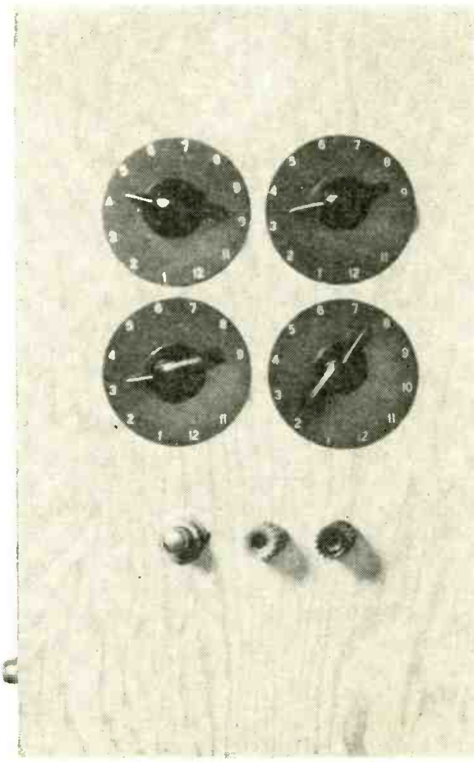
A keyless wonder—
you just dial
the secret combination
to open it

THEY SAY daisies don't tell. Perhaps the same can be said of the "Electrolock." Unlike conventional locks which give tell-tale sounds when the right combination registers or which can be easily jimmied, the Electrolock is electronic and can't be opened by anyone but yourself. It uses no key; instead, you dial the four correct digits, and presto—it opens.

As seen in Fig. 1, the Electrolock is a series circuit consisting of a battery, a solenoid, a push-button switch, and four rotary switches. The plunger of the solenoid is connected to a small barrel bolt, and a small spring holds the bolt closed when the solenoid is not activated. But when you dial the right four numbers and depress the push button, you complete the circuit, current flows through the solenoid, and the plunger pulls back the barrel bolt. When the push button is released, the spring pulls the bolt into the closed position again.

There are many ways in which you can construct the Electrolock. The combination that will open the lock depends on the switch connections you use. Usually, a 4.5-volt battery suffices, but for more snap you could try a 6- or 9-volt battery.

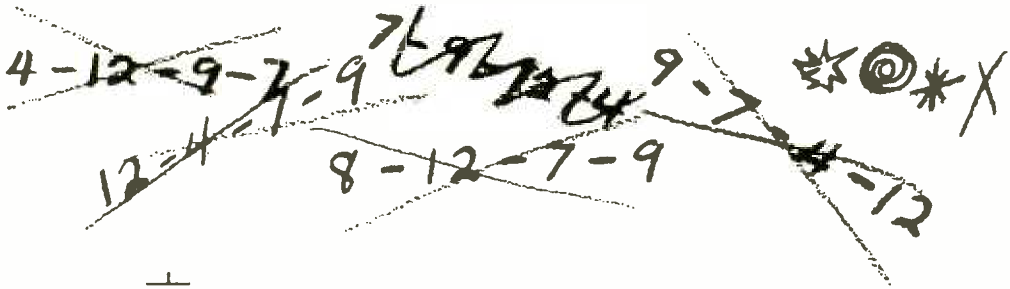
Drill a hole through the barrel bolt the same size as the hole through the plunger of the solenoid, and fasten them together as shown in Fig. 2. Be sure to drill the hole parallel to the knob so that the bolt will not be turned down when the plunger is connected to the bolt. The spring is fastened between the screw connecting the solenoid plunger and barrel together to another screw mounted



External battery can be connected to the banana jacks to overcome a weak internal battery. However, the lock cannot be opened without the combination.

on the barrel lock frame. If you can't find a suitable spring, use two or three smaller ones tied together.

To operate the Electrolock, dial the correct combination and depress the push-button switch. The bolt should



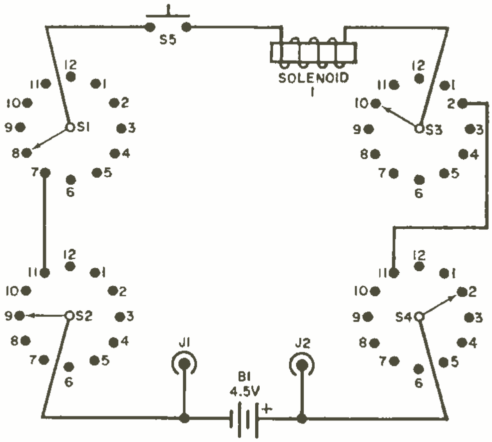


Fig. 1. Any combination can be made by selecting different switch positions. As there are more than 20,000 possible combinations, chances of "picking" the lock are discouraging. Furthermore, if you add a fifth switch, you can get 248,832 combinations.

PARTS LIST

B1—4.5-volt battery
J1, J2—Banana jack
S1, S2, S3, S4—12-position rotary switch
S5—Push-button switch, normally open
1—6-volt d.c. type solenoid (Guardian Model 11 or equivalent)
Misc.—Barrel bolt, aluminum strip battery mount, machine screws, hookup wire, solder

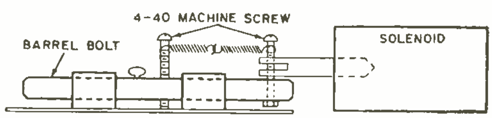


Fig. 2. Spring holds barrel bolt in closed position. Solenoid retracts the bolt when the proper combination is dialed and the push button is depressed.

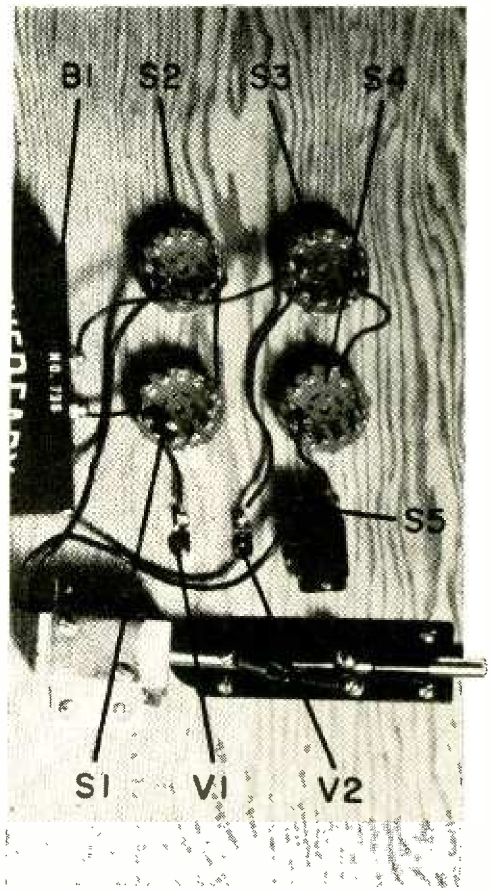
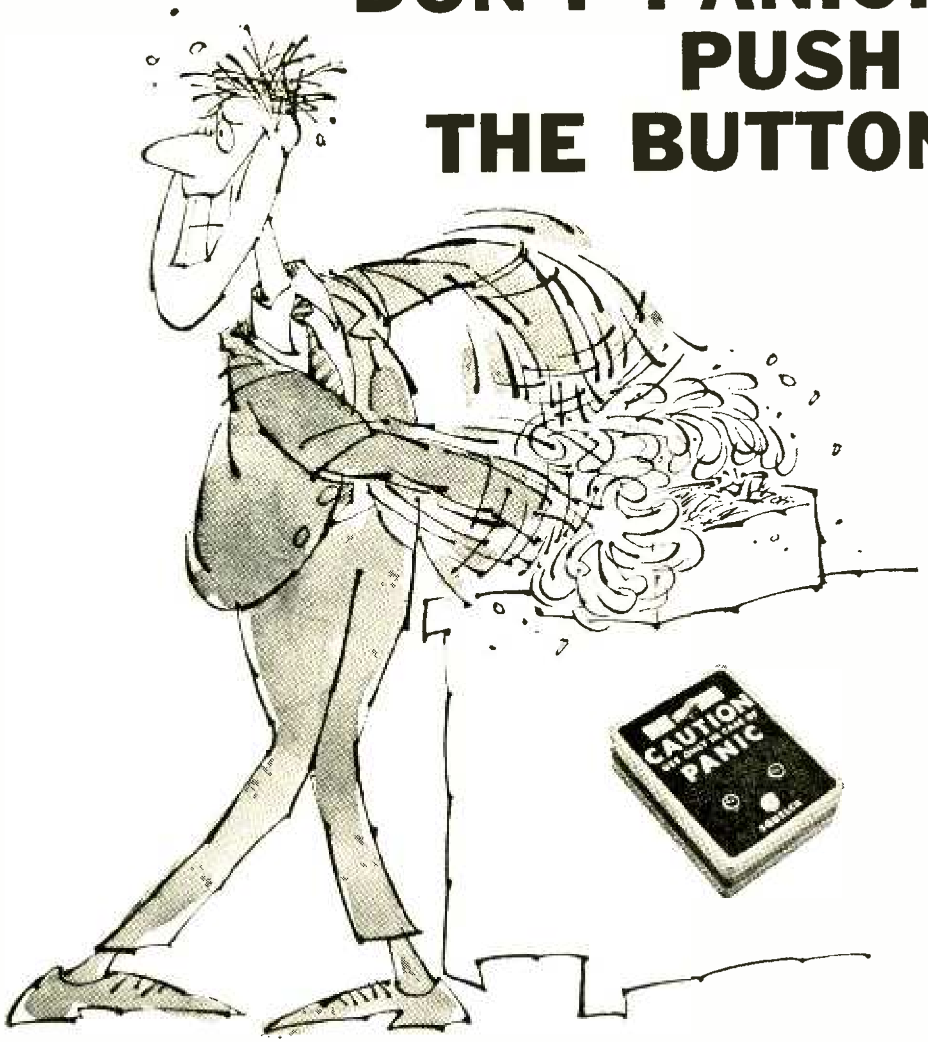


Fig. 3. Align barrel bolt with solenoid to obtain smooth action without bolt rotation. Battery and switches can be mounted in any convenient position.

snap open. If it doesn't, check your wiring, particularly the switches. You may have to adjust alignment and spring tension to get smooth, positive action.

You've probably guessed the reason for putting the two banana jacks on the front panel. In case the battery inside the unit hasn't the energy left to open the lock, you just connect a fresh battery across the terminals and dial the combination. Remember, you can't open the lock if you forget the combination. —30—

DON'T PANIC... PUSH THE BUTTON!



Don't you dare build this box . . . . unless you want to create pandemonium

By BRUNO M. LARSEN

THIS PANIC siren is guaranteed to set the most blasé individual or "stuffed shirt" on his ear, and cause the unwitting "victim" who sets it off a moment or two of embarrassed concern. For it is a certainty that if this box is left alone some venturous soul will be tempted to throw that switch. And when he does, you are sure to see a panic in the making.

Once the main switch is thrown, and after a one- or two-second delay, the box lets out a wailing sound akin to that of a fire engine, ambulance, or police siren. Lights go on and, within a second or two, start to blink like mad. The "victim" will snap the switch back to OFF, only to find, to his chagrin, that the switch has no effect whatsoever on the rising siren wail, or on the lights.

If the switch thrower can keep a cool head, he'll "push the panic button"—the one innocently labeled *SQUELCH*—and sigh with relief as the siren starts on its downward wail. If he releases the button while the siren is dying down, as he probably will, the siren immediately starts up again, whereupon the "victim" quickly presses the panic (*SQUELCH*) button again. But this time he isn't taking any chances—he's going to keep his fingers on that button until the sound ceases completely. As it does, he smiles triumphantly. (All this time the lights are still blinking—the squelch button has no effect on the lights.) Once again he releases the button—and once again the siren starts.

What the "victim" doesn't know is that the contraption will go off by itself once the main switch is thrown to *OFF* and a preset time has elapsed. Every time he throws the switch he recycles the panic box, and when he presses the button he only interrupts the sound, without affecting the cycle.

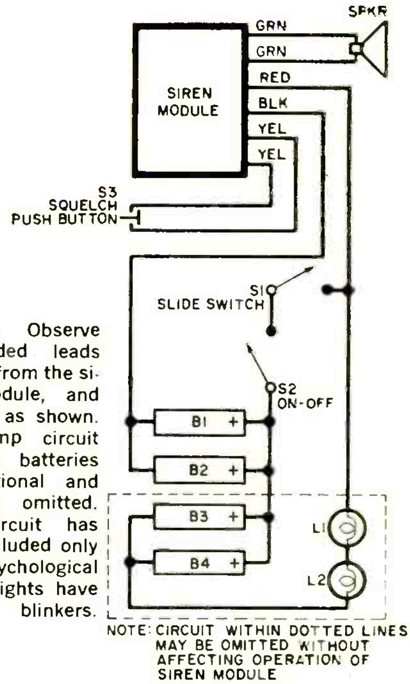


Fig. 2. Observe color-coded leads coming from the siren module, and connect as shown. The lamp circuit and its batteries are optional and can be omitted. This circuit has been included only for psychological effect. Lights have built-in blinkers.

How It Works. The secret of the panic box is a delay incorporated in the *ON-OFF* switch that causes the siren and light circuits to remain activated for from 60 to 90 seconds after the switch is turned off. Pressing the SQUELCH button is the only "known" action that can be taken to start the siren on its downward wail.

The heart of the panic box is a siren module (Fig. 1) connected to a speaker and a battery. The module contains a relaxation oscillator (*Q1*) and a direct-coupled output stage (*Q2*). The oscillator creates a tone which rises from 5 to 3000 cycles within 30 seconds, and creates a downward wail after the delay switch shuts itself off.

Switch *S1* is a concealed slide switch that is normally left *ON*. It is used only by those in the know to shut the works down. You can have fun in another way—leave the switch off and your "victim" won't be able to victimize someone else.

An 8-ohm, 2½″ PM speaker serves as the siren horn, and the entire unit is powered by two or four 9-volt batteries, as shown in Fig. 2. Two of these batteries—in parallel—provide power for the siren, and the other two—also in parallel—provide power for the lights.

Construction. The box, a $6\frac{15}{16}''$ x $5\frac{9}{32}''$ x $2\frac{5}{16}''$ plastic meter case, houses all the components, including the speaker and the batteries. The box also functions as a resonant cavity and greatly amplifies the siren sound. What's more, the same

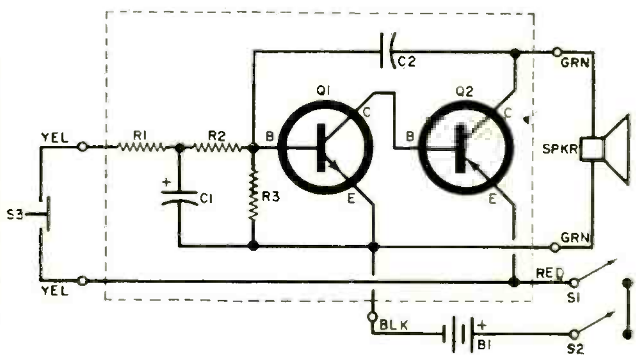
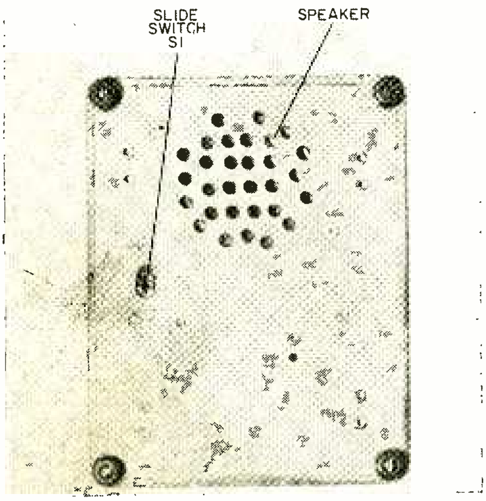


Fig. 1. Secret of continuous panic-making noise output is the built-in delay in switch S2; outwardly it seems to be an ordinary on-and-off toggle switch. Switch S1 is concealed and normally left on. Only you know where to find it and shut the thing off in case of panic. Panic button S3 has no effect on the delay action of S2 and opens the siren circuit only as long as it is held down. If the victim's patience runs out before the delay cycle is completed, he is most likely to recycle the unit so that it will not cut out by itself.

loudness is maintained during the upward and downward wails of the siren.

Other types of enclosures can be used, provided care is taken to select a box that will resonate properly. Metal boxes are generally poor resonators, while wooden boxes make ideal resonators. The arrangement of the components is left to the discretion of the builder.

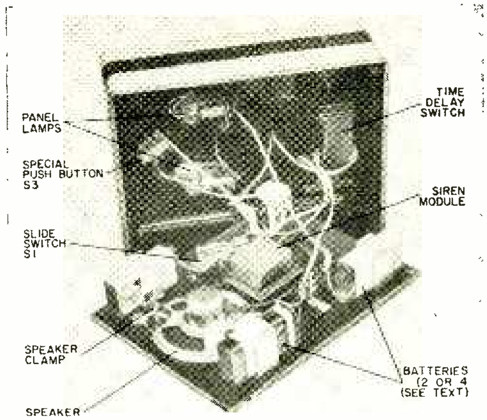


Speaker and "hidden switch" are mounted on back of box. Better chain the box in place lest your victim heave it out the window when the alarm sounds off.

The slide switch (*S1*) can be wired so that it opens only the siren cycle, or both the lights and the siren. To make this switch less conspicuous, the protruding stem can be cut off flush with the plastic box. You can use 6-32 hardware to mount the components, or you can fasten them permanently to the box cover with pop rivets.

PARTS LIST

B1, B2, B3, B4—9-volt transistor radio battery (Eveready 216, or equivalent)
L1, L2—4.9-volt, 0.3-amp. flasher bulb (GE-407 or equivalent)
S1—S.p.s.t. slide switch
S2—60-second delayed action light switch (Lafayette Radio 34 R 3805, or equivalent)
S3—Normally-closed momentary push-button switch
SPKR—2½", 8-ohm speaker (Philmore TS-25, or equivalent)
1—Siren module (Lafayette Radio 19-0105, Olson Radio TR 71, or Saxton Hi-tron Model HS available at parts distributors)
1—6-15/16" x 5-9/32" x 2-5/16" plastic meter case (Allied Radio 87 P 886 or equivalent)
1—Matching panel (cover) for above case (Allied Radio 87 P 888 or equivalent)
2—Bulb sockets with red-faceted jewel lenses (DIALCO 510M or equivalent)
4—Type 5D battery clips (Cinch-Jones, or equivalent)
4—Battery brackets (Keystone No. 95, or equivalent)
Misc.—Rubber feet, wire, solder, hardware and terminal strips



Parts layout and box dimensions are not critical. Paint the outside fireman's red and use large bold letters. Battery mounting brackets are optional.

The small speaker has no mounting holes or flanges (actually, there are a number of speakers available *with* mounting holes), but you can use a couple of mounting clips with washers to secure the speaker to the back cover of the meter case. Before mounting the speaker, drill a number of holes in the mounting surface to vent the speaker cone to the outside of the enclosure. Size of the holes is not critical. Also, to make certain that the batteries clear the main *ON-OFF* switch and the light sockets, install battery mounting brackets near the edge of the box cover.

There is nothing critical in the wiring. Nor is there anything functional about the blinking lights, which are included purely for psychological purposes —you can omit this circuit if you wish.

The outside of the box can be finished and stenciled in any manner you wish. For example, the *SQUELCH* button can be labeled *PRESS HERE*, or *PANIC BUTTON*. Or *WARNING*, *DANGER*, etc., can be substituted for *CAUTION*.

Setting the Trap. Make sure that the concealed slide switch is in *ON* position, and the master *ON-OFF* switch is set to *OFF*. Then lay the box in a conspicuous place, and be ready when the fun starts. Happy panic! —30—

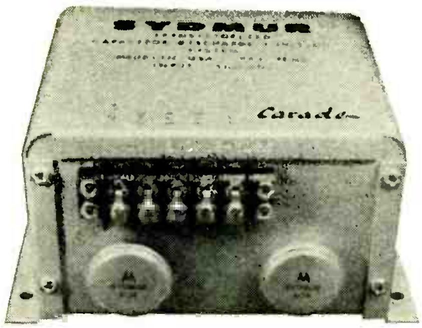
CHAPTER

2 AUTOMOTIVE ELECTRONICS

Only 2½ years ago, when POPULAR ELECTRONICS published a product-by-product analysis of the transistorized ignition market, there were about 30 different manufacturers in business. And they were offering products based on 11 different designs. Thirty months later there appears to be only a half dozen active manufacturers selling three or four different designs. What happened?

The answer to the above question is plain and simple—the 1964 transistorized ignition systems were dropped like the proverbial hot potatoes. Some systems were so poorly designed as to be almost unbelievable. One or two apparently unscrupulous manufacturers turned in a "fast" buck and got out of business. The good products suffered because of class association and several manufacturers switched to the production of other goods. But possibly the one major contributing cause to the downfall of transistorized ignition was that many 1964 circuits weren't the very best.

The Editors of EEH have had the opportunity to exhaustively test the only logical answer to the transistorized ignition problems—the capacitive discharge circuit. In the pages that follow are the plans for one of the best ignitions systems we have ever published. Although specialized components are called for, this is one system (among the two or three that survived from 1964) that we feel deserves your unqualified attention.



NOW! A UNIVERSAL CD IGNITION SYSTEM

By MURRAY GELLMAN

Modified unit fits 12- or 6-volt cars, including positive ground ignition

Because of the excellent response to the article on a "Transistorized Capacitor Discharge Ignition System" by Murray Gellman (in the 1966 Spring Edition of ELECTRONIC EXPERIMENTER'S HANDBOOK*), the author has provided construction details to modify the basic 12-volt negative ground circuit for operation with 6- or 12-volt positive, or 6-volt negative ground ignition systems. On page 66 you'll find some representative excerpts from our reader mailbag, with the appropriate answers.*

THE EDITORS

WHETHER YOU ARE the owner of a foreign car with a 6-volt ignition system, or an American car with a 12-volt positive or negative ground ignition, you can now enjoy the advantages of increased gas mileage, quicker starting even in cold weather, longer life for breaker points and spark plugs, and more power at high speeds with a transistorized capacitor discharge ignition system. You can build the system from scratch for the car you presently own, and modify it later, if you wish, to fit any other car you might buy. The 12-volt negative ground system (and how to build it) was described in the 1966 Spring Edition of the ELECTRONIC EXPERIMENTER'S HANDBOOK. The following instructions tell you how to modify the basic design to fit your car.

Six-Volt Negative Ground Ignition. The basic 12-volt transistorized capacitor discharge ignition system can be modi-

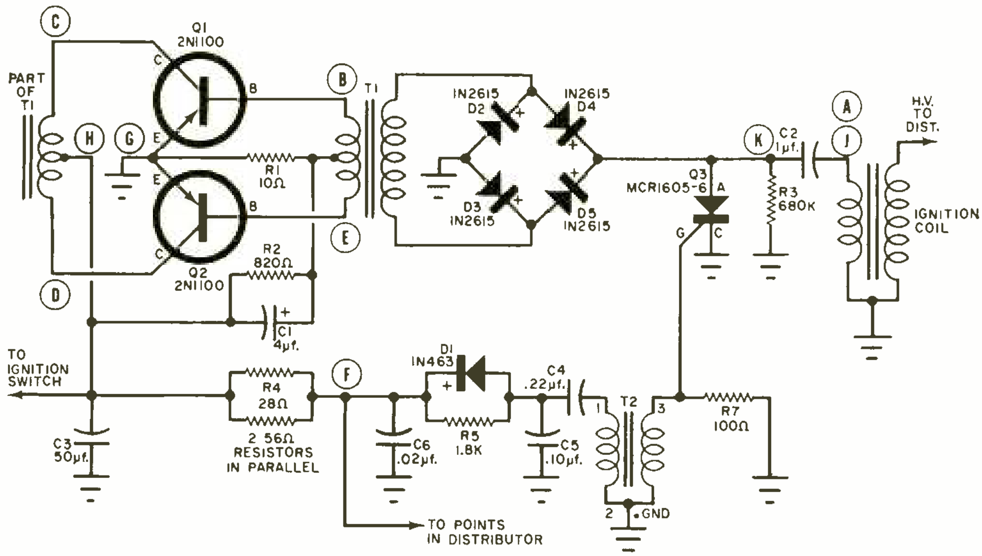
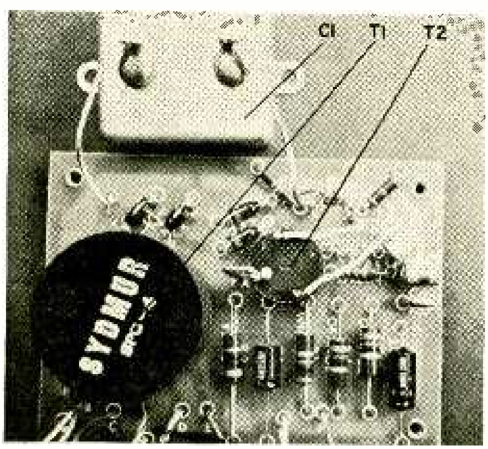


Fig. 1. In this positive ground ignition system, the d.c. resistance of pulse transformer T2 replaces resistor R6 in negative ground circuit. Also, positions of R1 and R2 are reversed, as is polarity of diode D1.



Component side of positive ground circuit board showing parts location and orientation. All components are color-coded, and the appropriate colors marked on the circuit board to facilitate assembly.

fied to operate on six volts by making the following changes: (1) add another 10-ohm resistor in parallel with *R1*; (2) add another 820-ohm resistor in parallel with *R2*; (3) short out *R6* (27 ohms) by connecting a heavy jumper wire across it; and (4) replace the SPC-4 transformer (*T1*) with six-volt transformer SPC-4A (available from SYDMUR, P. O. Box 25A, Midwood Station, Brooklyn, N.Y. for $14.95).

Positive Ground Ignition. To convert the 6- or 12-volt negative ground system to positive ground (see Fig. 1) using the same printed circuit board, the collector center tap must be removed from ground. This can be done by cutting the copper strip above and below the letter *G* with a single-edge razor blade. Hold a clean soldering iron—one having no solder on the tip—on the copper strip next to the letter *G*. Remove the strip using the razor blade. Drill a hole (using a #52

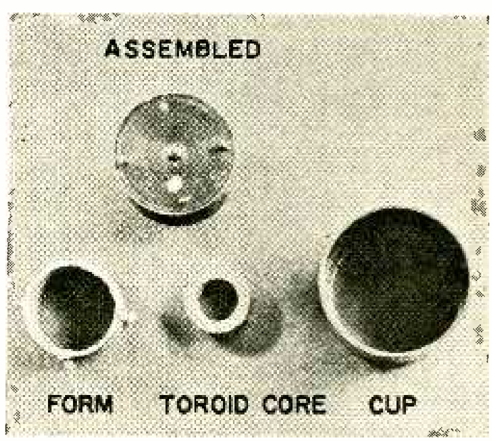


Fig. 2. Fabrication details of positive ground pulse transformer. Shown are a completely assembled unit, the ferrite toroid core, and coil assembly forms.

MORE ABOUT CAPACITOR DISCHARGE IGNITION SYSTEMS

Q Can I substitute a new ignition coil with a 250:1 turns ratio for my 100:1 coil now in the car?

A Yes, but you wouldn't gain enough to merit the extra cost. Your present coil used with a CD system will produce adequate voltage at all engine speeds.

Q Must the "condenser" across the breaker points be removed?

A No. It does no harm—leave it there.

Q I want to wind my own toroid transformer. How about revealing the winding details?

A Sorry, but this transformer is something special and a patent has been "applied for" to cover its construction.

Q What temperatures will the CD system withstand?

A It has been tested at 60 degrees below zero (F) and 200 degrees-plus under the hood.

Q Why no heat sinks on the transistors?

A The transistors are rated to operate above the ambient temperature under the hood, and, besides, the metal box acts as a heat sink.

Q Must I replace the distributor cap and ignition wiring harness?

A You might find it advisable to clean out the cap and check the harness for breaks or worn spots. Replacement is not a prerequisite.

Q Do I change the engine timing?

A No. Just be sure it meets the manufacturer's specs. The CD system will not upset the timing.

Q Must I use a printed circuit board?

A Why not? What have you got against space-age engineering?

Q I used your transformer in another CD circuit that I saw published this year. The transistors gave up the ghost. What happened?

A The toroid in this CD system was designed to match the transistors. Substitution could lead to a lot of headaches.

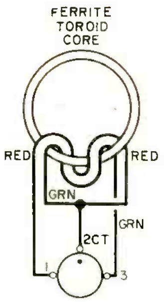


Fig. 3. Pulse transformer is wound on ferrite toroid core with 300 turns of bifilar-wound #40 Polyurethane insulated wire. Wire terminals are soldered to the lugs on the coil form.

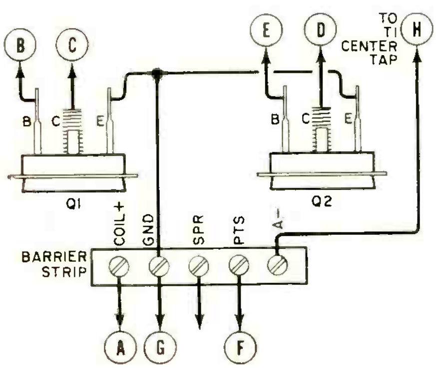


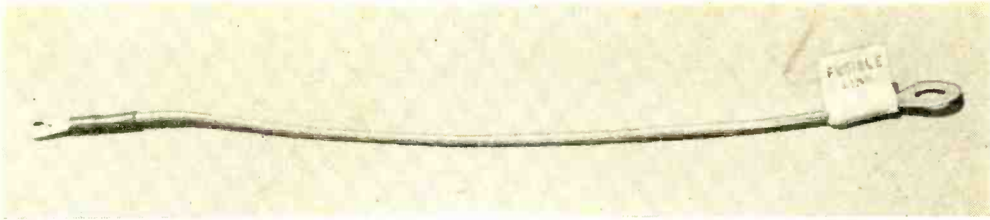
Fig. 4. Wiring details of transistors and barrier strip connections for positive ground ignition system. Terminal marked A− connects to ignition switch.

bit) in the copper strip ¼-inch away from the end that was cut, and another hole near the letter *Y* in the ground strip. Then, using a #42 bit, drill a hole above the letter *U* on top of the printed circuit board; this hole is used to mount the pulse transformer (*T2*).

The pulse transformer is made by winding 300 turns of bifilar-wound #40 Polyurethane insulated wire on a ½-inch ferrite toroid core. (See Fig. 2.) After the wire is wound, it should be placed in a form and the leads connected to the lugs (see Fig. 3). The wire leads can be wrapped around the lugs without removing the insulation (the heat melts away the insulation), and then soldered. After this is done, the form is placed in a small cup form and filled with epoxy cement. (SYDMUR will supply the toroid, form, and cup form for $2.50, or the completed pulse transformer for $4.50.)

The pulse transformer reverses the polarity of the incoming negative pulse to the positive pulse that is required at the gate to make the SCR conduct. No attempt should be made to drop the B+

(*Continued on page* 74)



PROTECT YOUR CAR'S ELECTRICAL SYSTEM

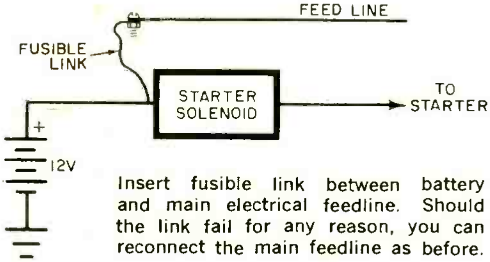
By CHARLES ERWIN COHN

Forty-five-cent link provides under-the-hood fire protection

MOST VEHICLE lighting and electrical accessory circuits are well-protected by fuses or circuit breakers. However, the main feedline which connects the battery to the generator and to all circuits, except the starter, and the circuit wiring up to the fuse block or circuit breaker very often go unprotected. Should a short occur at a point ahead of the protective devices, the high currents would cause extensive wire damage, battery damage, and possible fire.

At a cost of only 45 cents, it is now possible to minimize this hazard. A fusible link introduced by Chrysler Corporation on its 1965 autos can be adapted for use in any car equipped with a 12-volt battery system. The part number is 2580389, and it can be obtained from any Chrysler dealer.

The link is a short length of 16-gauge wire which behaves like a fuse. Because the regular wiring in the car is much heavier, the link will burn out before the regular wiring has a chance to do extensive damage in the event of a short. At 30 or so amperes, the link runs hot; and at about 40 amperes, it quickly melts. Normal total current requirements in a car rarely exceed 30 amperes. For the system to operate again, once the link fuses, it must be replaced. Special heat-resistant insulation is used to safely contain the hot link.



Insert fusible link between battery and main electrical feedline. Should the link fail for any reason, you can reconnect the main feedline as before.

As shown in the diagram, the link is connected as close to the battery in the electrical system as possible. It should not be inserted in the starter circuit. Usually, the link can be attached to the "hot" terminal of the starter relay. As a safety precaution, disconnect the battery before you install it, and reconnect the battery after the job is done.

Disconnect the feedline from the solenoid, and connect the end of the link with the larger terminal lug to the solenoid and the other end to the feedline. A small nut and bolt can be used to connect both wires. All connections should be firm. The junction of the link and the feedline should be taped, and positioned so that it will not accidentally cause a short circuit.

In the event the link gives way when you are miles away from a service station, reconnect the feedline as it was originally—after you have cleared the short circuit. —30—

HEADLIGHTS-ON ALARM

Alarm sounds if the lights are left on after the ignition is switched off

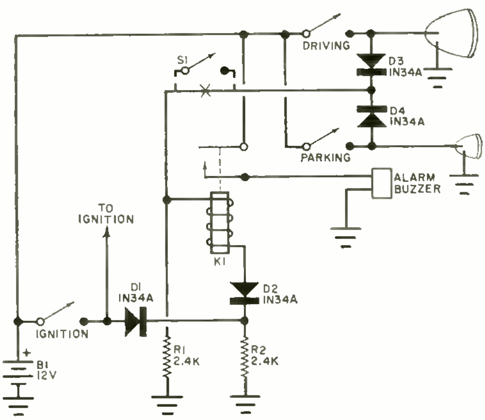
By THOMAS R. YOCOM

HOW MANY TIMES have you jumped into your car, turned on the ignition switch, ready to go somewhere, only to have nothing happen—a dead battery! Why? Because the lights were left on after the car was parked; during the winter months the chance of this happening is greatly increased. You can put this annoying situation behind you for good by installing a "Headlights-On Alarm." It is small enough to be tucked under the dashboard, and it will sound an alarm if you leave your lights on when you turn off the ignition switch.

How It Works. A warning bell or buzzer goes on when current runs through relay *K1*. When the ignition switch is turned on, a small current on the order of 5 ma. will flow through *R2*. No current can flow through *K1* because *D2* is reverse-biased at essentially full battery voltage. The ignition system and any other electrical devices connected through the ignition switch operate in a normal manner.

When the parking or driving lights are turned on, current runs through the lights as usual, and also goes through *R1*. Current cannot go through *K1* because of the reverse-biased condition of *D2*. However, if the ignition switch is turned off, the bias on *D2* is removed, and if the headlight switch is still on, current will run through *K1*, *D2*, and *R2*, and energize the relay to turn on the alarm.

Diodes *D3* and *D4* prevent interaction between the parking and driving lights; otherwise both lights would go on when either light switch was closed.



Should you forget to turn off your lights when you turn off the ignition switch, the alarm will sound—unless you install a disabling switch (S1).

PARTS LIST

D1, D2, D3, D4—1N34A diode or equivalent
K1—5000-ohm remote-control relay, s.p.s.t., pull in at 1.4 ma., drop out at 1.2 ma. (Lafayette 99 R 6091 or equivalent)
R1, R2—2400-ohm, ½-watt resistor
S1—S.p.s.t. switch (optional—see text)
1—12-volt buzzer

Installation. Parts can be mounted on a small chassis or clustered around the relay. The alarm circuit shown in the schematic is for cars having a negative ground electrical system. For positive ground systems, reverse the polarity of all the diodes.

Should you want to operate the lights without having the alarm sound off and without having to turn on the ignition switch, break the line at point *X* in the diagram and add *S1*.

Another innovation is to use the taillight circuit instead of the headlights and parking lights. Since the taillights go on when either the parking or driving lights are on, you only need to monitor the taillights. In this case, eliminate *D4* and connect the anode of *D3* to the taillight bus instead of to the driving lights circuit. -30-

AUTO VOLTMETER SHOWS YOU'LL GO

Keep tabs on your charging system—catch battery failures before they happen

By JOSEPH TARTAS

EVER stop to wonder what your automobile battery voltage is? "Why twelve volts, of course," you say (unless you have a 6-volt system and answer "six"). It seems like a silly question—until you examine it closely. The fact of the matter is that battery voltage varies over a range centered around 12 (or 6) volts: Exactly what it is, and when, are facts that can tell you a great deal about the health of your car's electrical system.

If your car or boat is equipped with an ammeter or indicator light, you might automatically assume that you need only be concerned when the "Battery" light stays on, or if the meter shows discharge when the engine is running. While it is important to know, as these devices indicate, that your generator is supplying a charging current to the battery, it is equally important to know the battery voltage under load and no-load conditions, as well as the voltages actually available at the starter, ignition system, etc. Voltage drop across cables can be enough to cause trouble. The voltmeter can tell you where your trouble is without "cutting" into any of the circuits. It can also alert you to potential trouble.

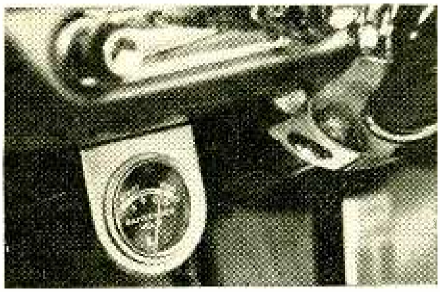
Storage Battery Theory. Let's review, for a moment, the typical characteristics of a lead-acid storage battery. It consists of several cells each having a potential of about 2 volts. The exact voltage of each cell will depend on the proportion of acid to water in the electrolyte, and the condition of charge or discharge of the cell.

One standard method of checking a lead-acid cell is to measure the specific gravity of the electrolyte. This electrolyte is a mixture of sulphuric acid and distilled water with a specific gravity of 1.260 at 77° F for automotive service, and ranging from 1.275 for heavy industrial uses to 1.210 for batteries in standby or emergency service. The specific gravity is measured by means of a hydrometer. The *open-circuit* voltage of the cell is directly related to its specific gravity:

$$Voltage = specific\ gravity + .84$$

A voltmeter, therefore, can be used to continuously monitor the specific gravity of the battery as a whole.

Because the proportion of water to acid is increasing as the cell discharges, the specific gravity is gradually reduced (water alone has a specific gravity of



This illuminated voltmeter is one of several types for use in cars. Panel meters will also serve; in some cars, they can be mounted in dash. Meter above is sold by Lafayette Radio.

1.000) and the relative state of charge will be indicated by the hydrometer reading. For the sake of accuracy, the correct specific gravity is designated at 77° F, with a small correction factor of about 15 points for temperature variations over the usually encountered range of 32 to 110°. Some hydrometers have a built-in thermometer with the necessary correction indicated.

As a cell discharges, the terminal voltage begins to drop due to internal resistance. The heavier the current, the greater the internal voltage drop and the lower the terminal voltage due to the heating effect on the battery resistance. If there is excessive resistance in the battery cables due to broken strands in the conductors or poor terminal connections (due to loose or corroded joints), there is a further drop under high current drain conditions, and little voltage appears at the starter terminals or at other equipment such as the radio or lights.

One voltage appears at the battery terminals under no-load conditions, a lower voltage under starting conditions (or with the lights, heater, or radio on) and a still lower voltage at the starter or equipment due to the normal cable drop. When an ammeter is used as the indicator, it will show at a glance whether or not there is a load on the battery by its discharge rate, but it does not give any indication of the battery voltage or its condition of charge, nor does it indicate excessive *IR* drops.

The "idiot light" does not even give this amount of information, but usually tells no more than the fact that there is an output from the generator. When it is lit, the generator output is nil or inadequate. When the light is out, the generator output exceeds some preset current level *at the generator terminals.* Neither the ammeter nor the light necessarily show battery condition.

Enter the Voltmeter. A d.c. voltmeter connected *directly* to the battery terminals will tell you at a glance the charge condition of the battery, the condition of your voltage and current regulator, and if the generator is functioning properly.

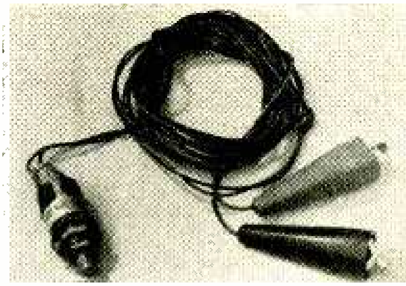
A typical 6-volt battery will read 6.3 volts with no load when fully charged. If it reads below that, the percentage of charge left will depend upon current drain, the length of time the discharge occurs, and the final voltage acceptable (the point at which the battery is considered discharged but not damaged). The final voltage, below which the cells are considered exhausted, depends upon the time and discharge current rate. This final voltage may vary from 1.0 to 1.85 volts per cell, but the most used value is 1.75 volts for typical applications.

Any of several voltmeters can be used in an automobile or boat. An 8- or 10-volt d.c. voltmeter is suitable for a 6-volt system, and a 15-volt meter for a 12-volt system. There are a number of special meters available from automotive supply and electronics parts houses, some types already mounted in brackets, with or without a panel light, and some types that include trouble-shooting charts. These meters have expanded scales to make it easy to read battery voltage while driving.

One type that includes both illumination and trouble-shooting information is the Lafayette Radio voltmeter (Stock No. 11 R 8002); another is the Stewart-Warner "Volt-Guard." The latter is advertised as a voltmeter and electrical system analyzer, which, in effect, is what it really is. The Stewart-Warner meter has a meter bracket and light socket, but these are sold separately as accessories.

Unlike the regular d.c. panel voltmeter, the automotive types draw about 50 ma. of current, but this small drain is insignificant compared to the current capacity of a car battery. The normal leakage across the top of the battery due to dirt and acid probably equals or exceeds this drain. The meter is wired directly to the battery terminals with small-gauge insulated wire (#20 is more than adequate); alternatively, the ground lead can be connected to the engine block where the battery is connected. In either case, the meter leads should be soldered to solder-lugs and connections to the battery or block should be *clean and tight.*

It is a good idea to check voltages at the various terminals (battery, engine block, voltmeter on panel) with a portable voltmeter or VOM to determine if there are any undesirable voltage drops in the cables or connections after the meter is installed. You may avert trouble later on.



Simple gadget for turning over engine consists of two clip leads connected to normally-open push-button switch. Leads are connected to starter control terminals of starter solenoid.

What the Readings Mean. Each time you start your car you should check your indicator lights and watch the voltmeter for abnormal indication. Remember that the battery drain is heavier in winter and the battery voltage (if you keep your car outside) will be lower to start with.

(*Continued on page* 147)

BATTERY VOLTAGE TABLE

BATTERY VOLTS[1]		ENGINE OFF OR IDLING[2]	ENGINE STARTING (Battery Condition)	ENGINE RUNNING[3] (Generator Condition)
Below 5.0	Below 10 or no reading	Dead or disconnected battery, meter disconnected or not wired properly	Disconnected, defective, or improperly wired meter. If the engine will start, or run, the battery is not at fault	
4.5-6.0	9-12	Undercharged battery; engine might not start	Normal range for winter and summer	Generator not charging, regulator not working, or current drain from equipment (lights, radio, etc.) exceeds generator output
6-6.4	12-12.8	Fully charged battery. Generator and regulator operating properly		Battery fully charged, but generator or regulator not working properly
6.7-7.6	13.5-15.2	Normal for short period after driving due to battery "surface charge," or meter reads high		Normal when battery, generator, and regulator are working properly. Meter reading varies with charge in battery, engine speed, temperature, and regulator setting
Above 7.6	Above 15.2			Voltage regulator contacts stuck together, or voltage regulator set too high. File and clean contacts and check battery fluid for level and specific gravity

1. The minimum voltage reading possible will depend upon the type of meter used.
2. Idling speed below that which causes the cut-out relay to pull in.
3. Normal driving speeds.

All voltages are approximate, and will vary with temperature, condition of regulator contacts, accuracy of meter, and other conditions.

IGNITION SYSTEM

(Continued from page 66)

from the power supply in order to supply a positive pulse to the gate. This would result in regeneration of the SCR due to large current feedback.

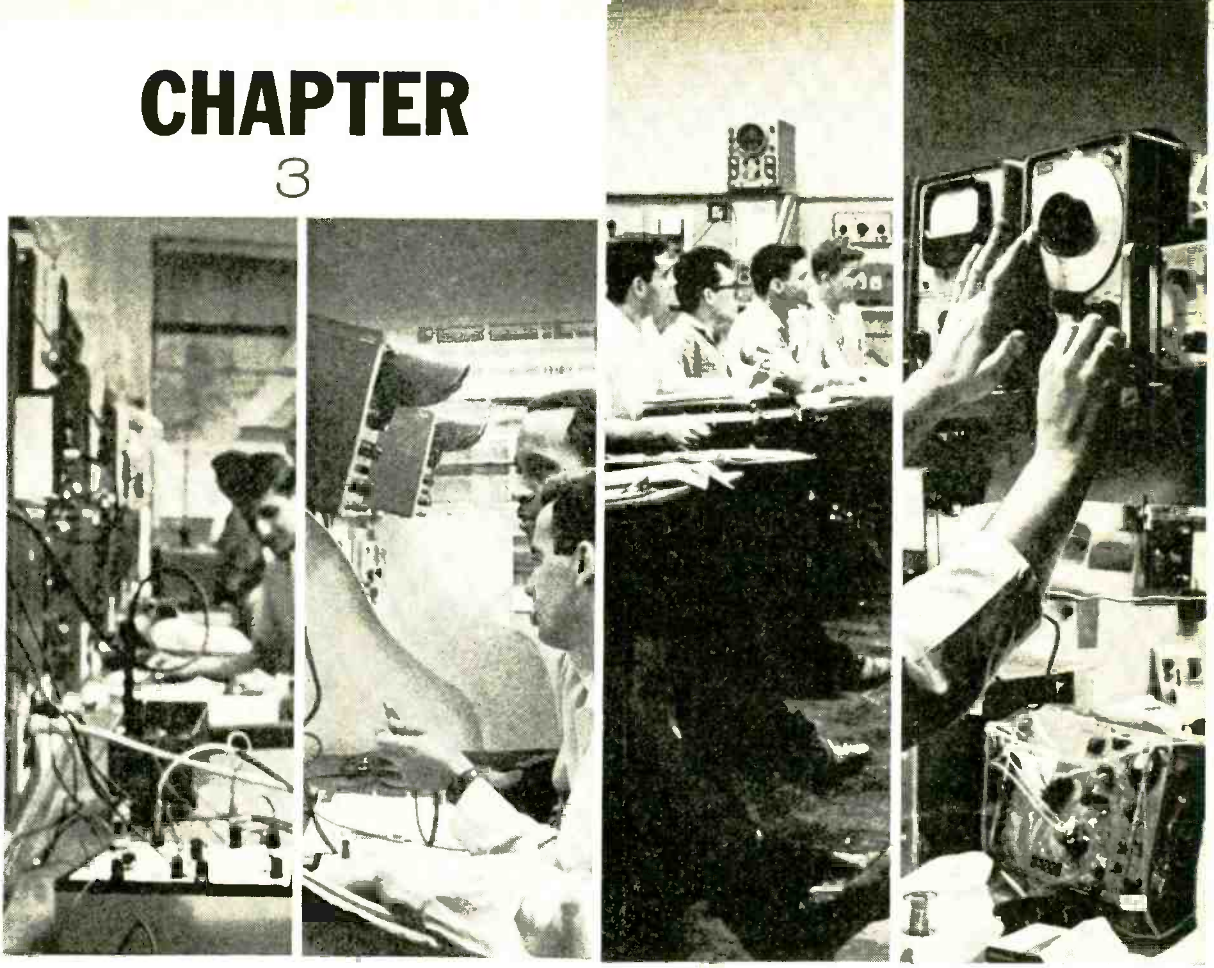
Wiring the P-C Board. With the pulse transformer completed, proceed with the wiring of the printed circuit board. The only changes that are made to the negative ground circuit are as follows. In order for the transistors (*Q1* and *Q2*) to be properly forward-biased, it is necessary for resistors *R1* (10 ohms) and *R2* (820 ohms) to shift positions; *R1* replaces *R2* and *R2* replaces *R1*. Capacitors *C1* (4 μf.) and *C3* (50 μf.) are reversed in polarity so that the plus (+) side of the capacitors are grounded. Diode *D1* (1N463) is reversed so that the anode goes to the plus (+) mark on the printed circuit board. The 27-ohm gate current limiting resistor (*R6*) is not required since the d.c. resistance of *T2* takes its place.

Cut two 1½" long pieces of heavy wire. Insert the end of one wire in the hole vacated by *R6*, and the end of the other wire in the remaining hole. Now, connect the free ends of the wires respectively to terminals 1 and 3 of transformer *T2*. The center lug (white dot) on the pulse transformer goes to the hole in the ground strip (near the letter *Y*).

Installation. The wired printed circuit board and capacitor *C2* (1 μf.) are placed in the cabinet. Wires from *G* as well as from the emitters go to ground on the barrier strip. The wires coming from *H* and the collector center tap go to *A*— on the barrier strip, the *A* wire to coil plus (+) and *F* wire to *PTS* on the barrier strip. The wires coming from *B*, *C*, *D*, *E* and the transistors are connected as shown in Fig. 4.

Other items available from SYDMUR are a complete kit for negative ground ignition, including a specially made cabinet ($44.50), and a completely wired system ($60.00). A kit for positive ground ignition can be obtained for $47.50. —30—

CHAPTER 3



OPERATION ACTIVATE

How to get moving toward a successful career in the field of electronics

PART 1: GETTING YOUR TRAINING IN RESIDENT SCHOOLS

(see page 83 for an analysis of home-study training)

By KEN GILMORE

IN Whippany, New Jersey, Richard J. Ewalt carefully checks out a complex piece of computer test gear he helped design. The equipment will become part of the Nike-Zeus anti-missile system developed by Bell Laboratories, Ewalt's company.

In Edwards, California, Loren E. Hirman sets up a series of subcarrier oscillators in a telemetry system. The device is used to transmit data from planes being tested by Hirman's company, General Dynamics.

In Albuquerque, New Mexico, Harry F. Chaney shoves a batch of tubes on a special test board into an oven, checks their performance at different heat levels to see how they'll operate under extreme temperatures. He works for the Electron Tube and Semiconductor Devices Division of Sandia Corporation, a leading company in atomic energy development.

Photos taken at RCA Institutes by Christopher Sheridan

All three of these men—Ewalt, Hirman, and Chaney—are electronics technicians, vital members of today's electronics team. For men—and women—interested in electronics, it's a good team to join. The industry is advancing rapidly; new people are needed badly. Pay is good, working conditions usually top rate, and jobs are almost universally interesting.

But there's a catch. If you're untrained, don't bother to apply. A few decades ago, a bright young man could pick up enough know-how working around the local radio repair shop to qualify for a job chasing electrons. Or he could work in a plant and with a little study on the side eventually learn enough to get promoted to an electronics job. But no more. Today, you've got to know what you're doing. That means a good technical school education.

The first thing to decide is where you want to fit into the electronics picture. In general, today's technical school programs are designed on three different levels.

Engineering Technology. To become an engineering technician, you'll spend two to three years at one of the top technical institutes, a junior college, or a division of a regular four-year college that provides an engineering technology program. In most cases, you'll end up with an A. S. (Associate in Science), an A. S. E. E. (Associate in Science, Electrical Engineering), an A. A. S. (Associate in Applied Science), or some similar degree. The course will cover virtually the same areas in math, the sciences, and engineering that regular electronics engineers study. And as with engineers, you'll spend most of your time— 60 to 80 percent of it—in class. Lab courses account for the other 20 to 40 percent.

Toward the end of your training, you'll have the opportunity to specialize. At New York's RCA Institutes, for example, you can become an expert in communications or computers. At Capitol Institute of Technology in Washington, D. C., you might choose communications engineering, nuclear instrumentation, or control systems as your field of concentration.

The engineering technician's program, while at college level, is designed for the man who wants to work with hardware. "It depends on what he wants to do after graduation," says Edward Norman, Capitol's Dean. "Does he want to hold down a desk and let paper be the prime result of his effort? Then he'd probably be happier as an engineer. But if he wants the more practical type of employment where he can actually get his hands on a few parts now and then, he'd probably like being an engineering technician better."

"There is heavy emphasis on math and physics in an engineering technology course," adds Mike Terzian, Dean of Administration at RCA Institutes. "Since it's a college level course, a student can get credit for most of the work he does if he should later decide to go to college for an engineering degree.

"Meanwhile, after a little over two years, the man who finishes our T-3 course [RCA's program at the engineering technology level] is ready to go to work. The majority of our graduates get jobs in research and development. A project engineer will design something—say a piece of data processing equipment which is supposed to meet certain specifications. Now it's up to the engineering technician to build the prototype from scratch. He punches out the chassis, lays out the circuit, builds it and tests it to see if it meets specifica-

"Just how far you're able to get depends on . . . how hard you're willing to work"

tions. If not, he may recommend modifications."

"Engineering technicians also do other types of jobs," says Richard Ungrodt, Dean of Engineering of the Milwaukee School of Engineering. "They might be part of a team that works out production techniques. And some of them work in sales and maintenance. You'll frequently find engineering technicians assigned to computers, for example. In the old days, you'd find an engineer doing this job, and sometimes you still do. But a lot of this work can be done by top-level engineering technicians. So they're really doing engineering level work."

Industrial Technology. "This program is designed for the fellow who wants to do service type work," says C. L. Foster, president of Central Technical Institute of Kansas City, Missouri. "He may maintain two-way radios in a fleet of trucks, or enter the broadcast field. Or he may work for the same company as the engineering technician, doing work on a less complex level."

"There's not so much math in his curriculum," says RCA's Terzian, "and there's more lab work. His training is aimed toward analysis and troubleshooting, rather than design. It's a good course for the guy who doesn't have college in the back of his mind, and there's a steady demand for people with this training."

A man preparing for an industrial technician's job may spend a year to a year and a half in school. He'll get a diploma or certificate when he finishes, but if he ever decides to go to college, he'll have to start at the beginning; his credits won't be transferable.

Service Technology. A service technician may work in a service shop, troubleshooting radio and TV sets and hi-fi gear. In industry, he might do routine production testing or wiring on a production line. But because his skills aren't up to those of the engineering or industrial technician, he's not able to compete for jobs as well as his more highly trained colleagues.

"As the demands of industry have increased in the last ten or fifteen years," says Mike Terzian, "technicians have needed more training. The man with only a service technician's background isn't likely to be able to hold down more than a routine job. And demand isn't too strong; sometimes we have trouble placing them."

"The only place we offer a radio and television servicing course per se is in our night school," says J. J. Gershon, Dean of Chicago's DeVry Technical Institute. "We feel that competition being what it is, our graduates need more than just a background in radio and TV."

Of course, it's one way to get started in electronics. If you can't afford to take a longer course, you might become a service technician, then go on with further schooling on a part-time basis after you get a job. Generally, a service technician's training takes 6 to 12 months of full-time schooling, up to two-and-a-half years in night school.

Can I prepare for a technician's job through home study?

The answer to this controversial question depends on whom you ask. Generally, most schools agree that you can't reach the engineering technician's level or get an associate degree through the mail.

"There's no comparison between resident and home-study training," says DeVry's Gershon. "Resident training is certainly more desirable. But if a man has a family or can't leave a certain area, then he has no choice. He can profit from home study, even though he can't attain the same level that he could in resident school."

"Home study is more oriented toward radio-TV servicing and manufacturing—assembly line work—than residence schools," says Harry Rice, Dean of RCA Institutes home study division. "But home study graduates also get jobs as broadcast engineers and technicians in industry, and they open their own businesses."

A different view is taken by one resident school official who asked that his name not be used. "I don't recommend correspondence training to any young man who is seriously interested in a career in electronics," he says flatly. "If he's lucky, he might get a job on a production line doing routine wiring or testing. But it would be very difficult for him to get a real technician's job."

Some schools take another view. "The main difference between residence and correspondence schools is that in residence school you learn the material in a much shorter time," says Norman of Capitol Institute. "And, of course, the lab work can't be the same." Capitol Radio, a home study school formerly affiliated with Capitol Institute, requires that a home-study student be actively working in the electronics industry. Therefore, the reasoning goes, he doesn't need the same laboratory work as students fresh out of high school. But this is a unique requirement on the part of Capitol Radio.

Foster of Central Tech also claims advanced standing for his home-study curriculum. "Our home-study program very closely approaches the engineering technician's program," he says. "We can't say it's absolutely equivalent, because we do not go into higher math and practical laboratory work is limited. But a home-study graduate is certainly prepared for a job at the industrial technician's level."

How's the job outlook?

If you're trained as an electronics technician, job finding won't be a problem. The Technical Institute Division of the American Society for Engineering Education estimates that some 16,000 engineering technicians are graduated each year. But the Bureau of Labor Statistics of the U. S. Department of Labor places the *demand* at about 80,000 a year. That

Training You'll Need For Various Jobs In Electronics

TRAINING LEVEL	JOBS QUALIFIED FOR*	DEGREE OR CERTIFICATE	LENGTH OF TRAINING	TRANSFER CREDIT TO COLLEGE
Service technician	Radio-TV service Communications trouble-shooting, maintenance Broadcast engineer Sound system trouble-shooter Assembly line wiring Routine production line testing	Certificate	6-12 months	No
Industrial technician	Field service technician Computer technician Junior R&D engineering technician Communications installation, maintenance Broadcast engineer Production line testing supervisor	Certificate	1-1½ years	No
Engineering technician	Field service technician Computer technician R&D Engineering technician Senior engineering technician Associate engineer	Certificate or Associate Degree	2-3 years	Yes (exact number of credits transferable depends on college)

**There may be some overlap, but in general each level of technician is fitted for a certain range of duties.*

"The engineering technician's program . . . is designed for the man who wants to work with hardware."

means more than five jobs available for each man trained.

Milwaukee School of Engineering says it could easily place twice as many graduates if it had them. RCA reports that 90 percent of its industrial and engineering technicians have jobs lined up even before they graduate. The other ten percent aren't looking for jobs; they're foreign students returning home, young men going into the service, and so on. Other top schools report a similar situation.

By the way, the door is open for girls. "They can work in electronics as well as men," says Terzian. "And in most places they have no trouble getting a job."

How much can I make?

Starting salaries vary, of course, in different parts of the country, at different companies, and for technicians with varying amounts of training. Generally, though, an engineering technician might start in the vicinity of $500 a month. Some, of course, don't make that much; others make more. An industrial technician might earn $50 or $75 less to start with; a service technician could average about $325 a month.

There's almost no limit to how far you can advance, and most technical graduates tend to do well. DeVry made a survey recently of 43 graduates picked at random. They had graduated from two to fifteen years earlier. About 35% were in military service or just out, or were in the process of attending other schools, or just didn't answer. Of the remainder of these 43 graduates, two had become vice presidents of companies, three held the title of chief engineer, one was a principal engineer (assigned to handle projects other engineers couldn't), six were engineers, and one was working toward his master's degree. Other titles: one senior design engineer, one supervisory engineer, one district engineering sales manager, one international marketing manager, one field service administrator, four engineering assistants, two technical staff assistants, and one senior technical writer.

Sometimes technical school graduates even reach top management positions. Cyril J. Statt, who graduated from Central Technical Institute in 1940, is now manager of manufacturing at General Electric's computer plant in Phoenix, Arizona. And Richard Wainwright, a 1954 graduate of Capitol Institute of Technology, is president of his own company, I-TEL, Inc., of Wheaton, Md, which designs and manufactures microwave filters. Just how far you're able to get depends on your ability, your training, and how hard you're willing to work.

What does it take to qualify for a technical school?

While schools vary somewhat in their admission requirements, most of them that will train you to be a high-level engineering technician accept only high school graduates with at least a C average. They usually also require one or two years of algebra, one of geometry, and one of physics or chemistry.

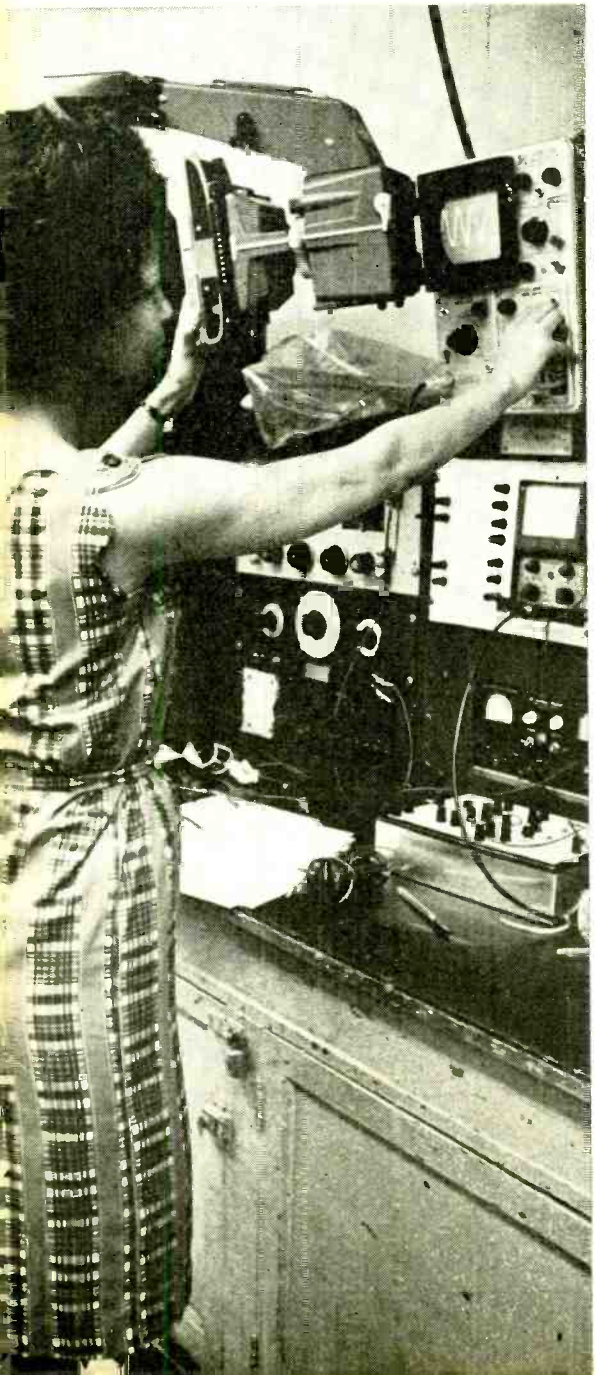
Requirements do vary, though. Milwaukee wants a background with four years of high school math through trigonometry; others have their own additional requirements. It's a good idea to check with schools you're interested in while you're still in high school, so your courses can be tailored to meet the requirements. If that's not practical, then get all the math and science you can. But don't neglect English, either. Most schools emphasize technical report writing.

Many schools give entrance examinations. If you're not up to the minimum level in any subject, you may be required to take remedial courses before you can enroll in the regular technician's program.

If you enter industrial or service technician's training, some or all of these requirements may be waived. Check with the schools you're considering for entrance requirements at the various levels.

Incidentally, most physical handicaps won't stop you in electronics. One that

"If you're trained . . .
finding a job
won't be a problem."



will keep you out of some jobs: color blindness. Many technicians must be able to read the color codes on resistors and other parts.

And don't think you have to be fresh out of high school to qualify. Many schools have older students who worked for a while before deciding what to do. RCA had one graduate in 1960 who had been a locomotive engineer for 20 years when he quit his job to become a technician. He has recently been promoted by his company to the job of master technician, and was invited this year to read a technical paper describing some of his work at a conference of military electronics experts.

How much will it cost?

Generally, tuition for an engineering technology course, lasting two to three years, will cost anywhere from a little under \$2000 to almost \$3000. You can pay as you go along, by the week (\$20-\$25) or by the month or semester. Two-year courses, naturally, tend to cost less than three-year programs.

Living expenses vary considerably, depending on the city. RCA Institutes, for example, estimates that it costs students \$30 to \$50 a week to live in New York. Central in Kansas City, on the other hand, says that students get along for \$25 a week. All schools will help you find a place to room and board; some have school dormitories.

Incidentally, the tuition at a given school is generally the same, no matter what level training you're taking. The difference comes in length; you'll spend six months in some of the simpler service technician's courses, three years in the more rigorous engineering technology programs.

If the total cost of going to school and living in a city away from home is too much for your budget, you might be able

to work part time. "At least 75 percent of our full-time students work," says Foster of Central.

"If a student wants to work," adds Gershon of DeVry, "we'll help him find a part-time job. A student who works can usually earn enough to pay for either his tuition or his living expenses, but not both. On a normal day, he'll spend two hours in lab, four hours in class, and have two or three hours of homework. That's eight or nine hours on weekdays, and then we load him up with homework for the weekend. So anyone who wants to work in addition to this heavy load is going to be a busy fellow."

Terzian of RCA agrees. "It's very difficult to work and complete the T-3 program. But some students do it."

Ungrodt of Milwaukee is more pessimistic. "It's really practical only if a student is willing to take more than two years to get through a two-year course. If a student works half time—20 hours a week—and is a very good student, he might be able to carry a 14-credit load instead of the usual 18-20 quarter hour credits. But he shouldn't plan to do it on a regular basis."

If you do have to work, though, most schools have facilities for helping you find a part-time job that will interfere least with your studies.

How about holding down costs by starting your training through the mail, then finishing up in residence? You'll have to check with the individual school here. Central has a regular program designed to let you learn as much as possible at home, some others will work out such a schedule on an individual basis, others discourage it. But if the school you want to attend does offer such a plan, you can cut down the total cost of your technician's training by taking advantage of it.

How do I choose a technical school?

It isn't easy. There are hundreds of schools across the country that teach electronics; some are excellent, others barely passable. And it's not always easy to tell which is which.

If you must stay at home, and if your town has only one school, then you have no problem. You'll take whatever is available, and hope it's a good school. But if you can pick and choose, here are some guidelines.

First, if you're still in high school, go to the guidance department. Chances are they'll have detailed information about many schools both in your neighborhood and farther away. Second, if you're going to take an engineering technology course, find out whether the curriculum at the school you're considering is accredited, either nationally or regionally. Ask local educators—school or college officials—about regional accreditation. For national listings, see the *Where To Write For More Information* section of this article. Lack of accreditation doesn't necessarily mean it's not a good school, but you'll want to check more carefully if the school isn't an accredited one.

Third, write the schools you're considering and ask for their catalogs. Compare the courses listed. You'll find that some schools offer a far broader program and courses on a much higher level—calculus, digital circuits, microwaves, telemetering and servomechanisms, for example—than others. Even among accredited schools, some obviously give far more than others. Incidentally, you'll generally find that those with broader courses take longer—and, of course, cost more. Finally, check the faculty listing. Faculty members of top-rated schools have impressive qualifications, both in academic degrees and experience.

WHERE TO WRITE FOR MORE INFORMATION

National Directory of Schools and Vocations. Miller & Brown, State School Publications, N. Springfield, Pa. One of the most complete lists of technical schools. $12 in hard cover, or see at library or vocational counselor.

List of Accredited Curricula Leading to First Degrees in Engineering Technology in the United States. Engineers' Council for Professional Development, 345 E. 47 St., New York, N.Y. 10017. 25 cents.

Characteristics of Excellence in Engineering Technology Education. Professor W. Leighton Collins, Executive Secretary, American Society for Engineering Education, University of Illinois, Urbana, Ill. 61801. 25 cents.

The Engineering Technician. Secretary, American Society for Engineering Education, University of Illinois, Urbana, Ill. 25 cents.

How To Choose Your Technical Institute, by Hartung. Bellman Publishing Co., Cambridge 38, Mass. $1.00.

The following can be ordered from National Council of Technical Schools, 1507 M St., N.W., Washington 5, D.C.:

Directory of Approved Technical Institute Courses. Free.

Admission Requirements for Approved Technical Institute Programs of Higher Education. A review of the high school background best suited for success in technical institute programs. 5 cents.

Code of Minimum Standards. This code sets forth the requirements of the NCTS for approval of Technical Institutes. 3 cents.

The Electronic Technician. Electronics has become a major field of employment with electronic technicians in great demand. This monograph details the work of these technicians and the industry which employs them. 5 cents.

The Engineering Technician: His Education, Entrance Into Industry, and Place on the Engineering Team. A set of charts placing the technical institute program and the engineering technician in proper relations. 5 cents.

The Technician and the Engineer. Reprint of an address by Dean C. J. Freund, University of Detroit. 3 cents.

The Technical Institute: Its Relation to Engineering Education and Trade Training. Reprint of an address by the late Dean C. W. Beese of Purdue University. 9 cents.

Have I got what it takes for technical training?

Experienced teachers and administrators at the best technical institutes can tell almost at once whether an enrolling student is going to complete his technological training successfully. Certain characteristics show up in almost every successful student. Here are the signs some leaders in the industry look for:

Norman of Capitol Institute of Technology: "Good math background or aptitude. Inclination toward practical work. And a great deal of motivation."

R. E. Baird of the Oregon Technical Institute: "While in school, he will work. If he doesn't understand, he will let you know in no uncertain terms, and will hound you until he does understand. He really wants to learn."

Terzian of RCA Institutes: "First, a sincere interest in the field. Second, self discipline; the ability to sit down and do the assignments, prepare the reports, do the homework. He doesn't have to be exceptionally brilliant, but it helps if he enjoys math and physics and is good at them."

Gershon of DeVry Technical Institute: "Perseverance and desire are more important than high academic ability. I'd rather give the poorer student who wants to work a lot of help to bring him up to the proper level than have the gifted one who won't work or just isn't interested."

Foster of Central Technical Institute: "We look for a man who is primarily interested in technical rather than research type employment. He'll have to like to work with his hands."

Ungrodt of Milwaukee School of Engineering: "Ability to work and interest in the subject matter. He should be a good math and science student. But the ability to work is the most important thing. A man who wants to get something can really work. And he has something when he's through."

What he has, of course, is the key to a career in electronics. Do you have the qualifications? If so, pick out a good school and prepare yourself for a lifetime of employment in one of the most exciting fields on earth. —30—

OPERATION ACTIVATE

If you can only study at home, you still can obtain excellent training to become an electronics technician

PART 2: HOME-STUDY TRAINING

By KEN GILMORE

IN electronics today, it's what you know that counts. There's no room for the half educated, the basement tinkerer, the guy who isn't serious enough to prepare himself with a first-rate education.

And preparation is just the beginning; learning doesn't stop once you're on the job. One educational authority, borrowing the language of nuclear physics, estimates that the "half-life" of even the best technical education is just *ten years*. To put it another way, 50 percent of what you learn today will be as out-of-date as the crystal set ten years from now.

All of this adds up to one thing: If you want to be a member of today's fast-moving electronics team, you'll have to get good basic electronics training, then keep re-educating yourself from there on out.

There are two ways you can get a technical education. One is to attend a regular electronics residence school—a trade school, technical institute, or college. It's a good way—especially for basic training.

But suppose you can't. There's no school in your town, or you have a family to support and can't leave your job. Or you just don't have the cash to go to a full-time school or college. These days, you can get a first-rate electronics education at home. Scores of top-notch correspondence schools now offer an incredibly rich variety of courses, designed to make you anything from a radio repairman to an expert in space communications. And once you're on the job, education through the mails is one of the best ways to keep your knowledge up to date.

Before you go rushing off to the nearest post office to get your application in, however, you'll have to make a couple of basic decisions: (1) Exactly what kind of job—among the many fascinating ones available in the field of electronics—do you want to land, and (2) Which school, which courses, will best prepare you to reach this goal?

To make the right decision, you need information. And that's what you'll find in the following pages. The Editors have talked to scores of education authorities across the country; we've queried home-study school officials and talked to their students and graduates. Here are their answers to the questions you'll be asking:

What can I learn at home?

The answer is—almost anything. Various schools approach the subject of electronics in different ways, at different levels. Some concentrate in one area. Hollywood's Grantham School of Electronics home study division, for example, specializes in preparing you to get an FCC First Class Radiotelephone license—your ticket to a job in radio or TV broadcasting or as a communications technician. Massey Technical Institute of Jacksonville, Florida, and Chicago's Coyne Electronics Institute emphasize training that will help you go into the radio-TV service business on your own.

International Correspondence Schools (ICS) of Scranton, Pennsylvania, on the other hand, offers a wide variety of courses: electronics fundamentals, hi-fi and stereo servicing, radio-electronic telemetry, industrial electronics, and many more. At Chicago's DeVry Technical Institute, you can choose among all the standard courses and such up-to-the-minute fields as computer technology and space and missile instrumentation.

Many schools offer courses on several levels. "We advise beginners to take courses in one of our career programs," says Jack W. Friedman, director of the RCA Institutes Home Study School. "These courses begin with basic electronics and lead through advanced material in television, communications, automation and industrial electronics, transistors, or electronics drafting. Our advanced courses, on the other hand, serve more specific needs, such as helping a technician update himself or move to a higher level."

Some schools offer *only* advanced programs. "Many courses are keyed for the rank beginner," says G. O. Allen, president of the Cleveland Institute of Electronics (CIE). "Courses of that type serve a much-needed purpose, but we prefer to leave the manual training to them. For the man who has progressed well beyond the intermediate level, we offer a college-level course in communications engineering." Courses at Philco's Technical Institute in Philadelphia and Capitol Radio Engineering Institute in Washington are also designed for the working electronics technician or graduate engineer who wants to upgrade his skills or keep up to date in this fast-moving field.

What jobs can I prepare for?

There's almost no limit. Home-study graduates of Central Technical Institute of Kansas City, for example, hold such positions as engineering technicians in aerospace research and manufacturing, TV cameramen, studio and recording technicians, maintenance and operating technicians with airlines, police departments, railroads, and public utilities. Some own their own radio-TV repair shops. Virtually every major electronics company in the country and many small ones have on their staffs men working in research and development, in manufac-

turing, in testing—men who got their training or updated their skills through correspondence study.

Take a few isolated examples from one school—National Radio Institute in Washington, D. C. NRI graduate David F. Conrad of Reseda, California, is a senior engineering aide for Litton Systems; he checks out magnetic recording devices for a living. Robert L. L'Heureux of Southboro, Massachusetts, works for the data-processing division of Minneapolis-Honeywell. Walter G. Higgins of Portland, Oregon, was a mailman when he studied electronics at home; after his course, he transferred to the Department of the Interior as an electronics technician and now maintains UHF and VHF communications links. Jim Davis of Long Branch, New Jersey, troubleshoots transistorized chopper-stabilized d.c. amplifiers at Electronics Associates, Inc. The list could go on endlessly.

Most schools claim that between 90% and 100% of their graduates obtain employment in electronics. Says R. Parma of National Technical Schools in Los Angeles, "About 30% of our students are currently employed in electronics. These students feel that they lack the technical skills to achieve advancement in their company. Another 60% of our students are employed outside of electronics, but desire to change their jobs because of the increasing opportunities in this industry."

How long does it take, and how much will it cost?

Time to completion depends on three main things: the contents of the course, how fast you learn, and how much time you put in. Here are some typical examples.

Major programs at Capitol Radio Engineering Institute (CREI) in Washington, D. C., take about three years to complete for the average student studying two to three hours a day. Costs—depending on the subject—hover in the vicinity of $500 to $550 for the entire course. DeVry estimates that the average student studying its $560 course seven to ten hours a week can finish in a year and a half. At CIE an FCC license course costs $325 and ordinarily takes nine to ten months. Coyne's TV servicing course costs $165, will occupy the average student a year and a half.

National Technical Schools in Los Angeles offers a 150-lesson master course in radio, TV, and industrial electronics for $367. Each lesson takes three to four hours, and National Tech urges students to finish at least one a week. Most, however, move faster and complete the course in one to two years.

All times quoted above are average; some students learn faster, some slower. Put in twice as much time, and you'll finish twice as fast. Most schools have a time limit on finishing, too, but will grant an extension if you need it.

One final point: Most schools give substantial discounts for speeded-up payment, even lower prices for cash in advance. All prices given here are for the most extended payment plans the schools offer on a so-much-down, so-much-a-month basis.

By the way, you don't have to hesitate to pay in advance. All reputable schools have fair refund policies if something happens to keep you from finishing.

Once I've received my diploma, are jobs easy to get? Will the school help me land one?

If you don't already have a job in electronics (many home-study students do), most schools will help you find one. Many have formal placement bureaus (some invite you to use their services for the rest of your life); others will simply forward your grades and a letter of recommendation to prospective employers, leaving the bulk of the job up to you. No reputable school, of course, *guarantees* you a job on graduation, any more than reputable universities do.

Just how hard—or how easy—you'll find it to land a job with good pay depends on several things. The training you select is one of the big ones. Naturally, you can't expect to get the same job—or the same pay—after finishing a six-month course in basic electronics as you could after a comprehensive three-year course in industrial electronics or advanced communications systems.

One vital factor in job hunting is frequently overlooked. CIE's Allen puts it this way: "For CIE and other well-trained students," he says, "job placement is not much of a problem—if they will face realities. It seems obvious, but many young men from rural areas or small towns expect to find suitable employment at home. They *may* find it, but they should be prepared to go to the job—the job will seldom come to them. A college graduate seldom works in his home town. The same is true of a highly-skilled professional."

Can home-study graduates compete for jobs with those who get their training in resident schools? "What we're really talking about here," says John Sivatko of ICS, "is what does the employer think. If an industry is unfamiliar with the quality of home-study training, there may be some prejudice against it. The *competence* of the students is not that different; the *attitude of the employer* is the pertinent factor."

W. A. Robinson of DeVry makes another point. "The resident student has the advantage of meeting recruiters from various industries who come to the school to interview. The home-study student, however, must go to the employer for his interview. Where home-study programs compare closely with resident programs, employment will probably depend on how effectively the student presents himself to a prospective employer."

In the past, some employers who hired resident-school graduates regularly were hesitant about putting home-study grads on the payroll. To some extent, the situation still exists. "It is only fair to say that correspondence education does not yet receive the recognition it should as adequate preparation for initial employment in the field," says CREI Executive Vice President L. M. Upchurch. But the situation is changing—rapidly. "I'm happy to say the closed-door attitudes exhibited by many employers in the past have been cast out by progressive companies," says D. A. Lockmiller, Executive Secretary, National Home Study Council. "Now we hear this question: 'What does he know and can he use it well?' That's a far cry from the old insistence on pedigree—'Where did you go to school?' "

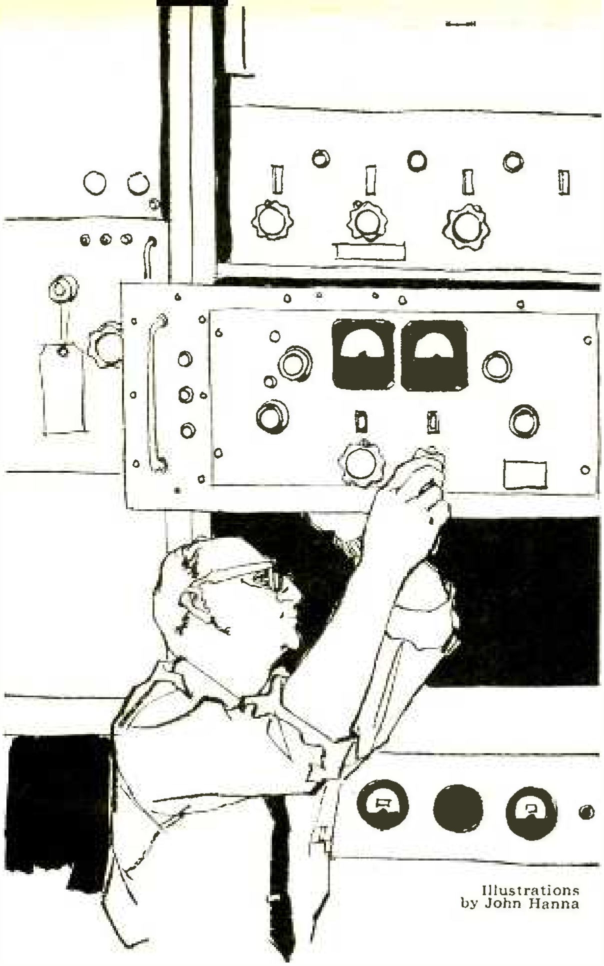
Correspondence school graduates have achieved high-ranking positions in business and industry, too. The national service manager of a large mail order store is a veteran of home study, as are many radio and TV station chief engineers, manufacturers, and company executives. In fact, some educators think that men and women with enough drive, ambition, and self-discipline to complete correspondence courses are likely to be a notch above average. Recently, just on a hunch, ICS sent questionaires to several thousand company presidents around the country, asking how many were former ICS students. About half answered. And of those, an astonishing seven percent were, indeed, ICS alumni. If all former correspondence students had been counted, the number would have been higher.

How about pay?

It's impossible to give precise figures; there's too much variation according to geographical area, amount of training, branch of industry—even the state of business. But here are some samples that will give you an idea of the range. The U. S. Department of Labor's *Occupational Outlook Quarterly* shows average technicians' salaries in private industry starting in the vicinity of $4900 a year. Also, ICS reports that its graduates average $80-$110 a week.

The range, however, can be far wider. "Some of our recent graduates are well over the $10,000-a-year level already," says Allen of CIE. "At the other extreme we have men who, because they are not willing to relocate or enjoy a certain type of electronics work, are making as low as $2 per hour."

Don't overlook the possibility of working for the federal government. Electronics technicians from GS3 to GS9 earn from $4005 to $9425. You may want to apply for a civil service rating at the



Illustrations by John Hanna

end of your schooling to see if you can qualify.

There's virtually no limit to what you *can* make. Start your own business and your ultimate earnings are determined only by the sweat you're willing to put into it and your ability as a businessman. You can advance rapidly working for others, too. Listen to Charles J. Roesle of Washington, D. C.:

"Six years ago I was at the end of any advancement at $5500 per year. But after completing a National Radio Institute course I passed a Civil Service exam for an Electronics Production Engineer at $7000 per year. In May, 1961, I was promoted to Guided Missile Project Officer at $9000 per year. Recently, I was promoted to Guided Missile Supervisor, with a salary of $11,500 per year."

Incidentally, while you're dreaming of future riches, you can begin making your home-study course pay its own way. Peter Cooke of Coyne surveyed the school's 500 most recent graduates not long ago and asked each one how much money—if any—he had made repairing radios and TV sets in his spare time *before* he finished his course. Among them, the 500 students had picked up *more than $100,000* while studying. That's an average of better than $200 each—more than the total cost of the course.

Can I qualify for enrollment?

You can for most home-study courses if you can read and write and really want to get into electronics. The only additional requirements come from schools that offer advanced courses.

For example, CREI expects students to have a high-school diploma and a job or prior experience in electronics. The whole course, in fact, is designed for the working technician who wants to increase his skill and his pay check, not for the beginner.

Several other schools have similar requirements, virtually all for advanced courses. It wouldn't do you much good to take a course in servomechanism theory if you weren't yet on speaking terms with Ohm's law.

How can I pick the right school for me?

It isn't easy. There are hundreds of schools across the country offering thousands of courses. Prices, estimated time to completion, and many other factors vary widely. But the job, while difficult, isn't impossible. Here's advice from the experts on how to proceed.

Says William B. Callahan, president of Chicago's Commercial Trades Institute: "Look for the schools offering courses in the field you want to study. Compare tuition prices, look for accreditation, state licensing, and a good Better Business Bureau record." Adds J. F. Thompson of NRI: "Compare prices, faculty, and reputation. If you're still in doubt,

Where can I get more information?

For more information on who offers which course and on accreditation, write to the National Home Study Council, 1601 Eighteenth St., N. W., Washington, D. C. 20009, and ask for the Directory of Accredited Private Home Study Schools. It's free.

Should kits be included in a home-study course?

A good case can be made either way. "At best," says M. E. Houghton of DeVry Technical Institute, "a kit is a laboratory, a teaching device that's carefully built into the rest of the course. Our students don't just assemble a kit. Eventually they understand exactly why the kit is built as it is."

Another point in favor: The kits to be constructed in many courses are multimeters, signal generators, scopes, and other useful test instruments. If you're planning to go into servicing, these instruments can form the basis of your equipment.

Some schools, such as Coyne Electronics Institute, feel that kits aren't necessary. A kit's primary purpose, the school maintains, is to familiarize the student with actual electronic hardware. "But most of our students begin to repair radios and TV sets almost immediately," says Peter Cooke of Coyne. "So they don't need kits."

Capitol Radio Engineering Institute offers another reason for the non-kit course. "While we recognize the value of properly integrated kit construction in conjunction with correspondence study, we know that many of our students would find the use of kits impractical because of military restrictions, travel, space limitations, and so on," says L. M. Upchurch, Jr. "Further, since our students are already employed in electronics, their daily work frequently gives them the advantages they might otherwise get from working with kits."

One guideline, then, might be this: If you're a beginner with no electronics experience and no prospect of having a chance to work with equipment during your course, you'll probably do well to select a course with kits. If you *will* be working with equipment, or if you're already a practicing technician taking advanced courses, then kits are far less important, and in many cases may not be needed at all.

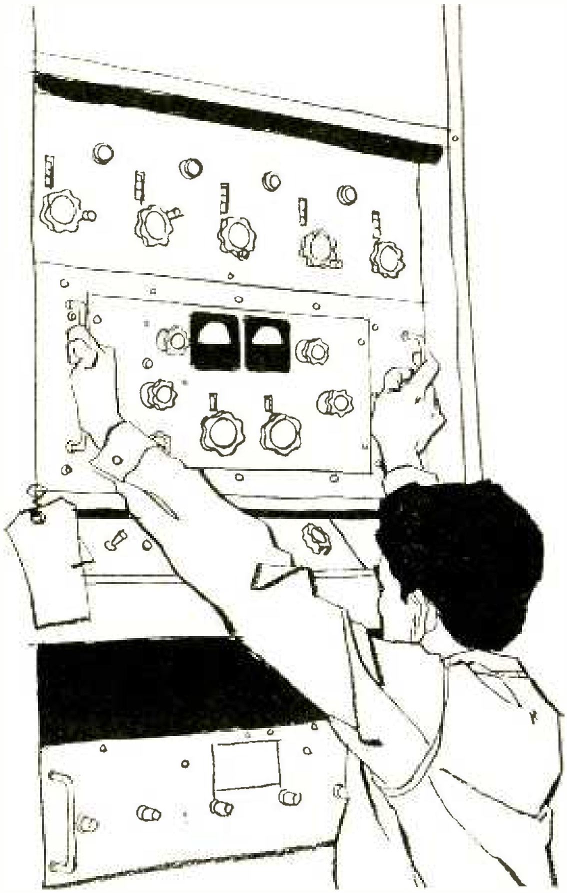
And, of course, there's one other important aspect: Courses without kits, all other things being equal, are certainly far cheaper than those with kits. Some schools offer courses either way.

write one or more graduates." Many schools will supply lists of graduates.

David Lockmiller of the NHSC offers this thought: "First, the school should be accredited by a nationally-recognized accrediting agency. There may be one or two good schools that are not accredited, but it is difficult to evaluate these schools. Look for such things as proof of performance, price, length of the course. Examine a sample lesson, check the employment features. No one of these criteria is conclusive, but they will help you to reach a final decision."

When you're making comparisons, don't overlook some of the special or bonus features a school might offer. Some of these "extras" may not be of value to you, but check to see what's being featured by the school in addition to the regular curriculum. Here are some examples—by no means complete:

- Consultation service. If you have a problem on the job—say in the design of a circuit or repairing a particularly knotty trouble—some schools will have a whack at helping you solve it.
- Schematic service. One school maintains a file of more than a million schematics—from old Atwater-Kent radios of more than three decades ago to the latest color TV sets. For a small fee, the school will copy any schematic and send it to you—an invaluable aid in troubleshooting.
- Course tailoring. Some schools fit the course precisely to your needs. If you already have some background in math or electronics, you can get a series of tests from some schools to see where you stand. Then you start at the right place and don't waste time repeating material you are already familiar with.
- Special devices. A midwest school supplies a projector and training films. Another school sends a transistor trainer—a special board that allows you to rig experimental circuits rapidly. Some



schools offer programmed lessons; others supply slide rules and other devices to help you learn. No one feature should determine which course you select, of course, but consider them along with all other factors.

What does it take to complete a home-study course successfully?

No reputable school will tell you it's easy. But it can be challenging, interesting, rewarding. The completion average for home-study students is higher than the national college average. The drop-out rate in colleges is high—in some cases going up to a peak of 80%—but one out of every three students completes his home-study course.

Why do so many fall by the wayside? "The two most important reasons," says G. O. Allen of CIE, "are motivation of the student and length of the course involved. For example, we conduct many courses for industrial concerns. These courses often take from 18 months to two years. Despite this rather formidable assignment, we frequently have completion percentages for individual companies as high as 90 to 95 percent—sometimes 100 percent. These men are highly motivated because the company provides funds and often company time for training, and is certainly in a position to influence the student's future employment. On the other hand, we sometimes encounter completion rates as low as 10 to 15 percent for students enrolling individually for these same courses. Self-discipline simply does not produce the same results as discipline administered by an employer. In some courses that run up to three years, we experience similar results from our group enrollments, but an even lower completion rate for individual students."

Despite these gloomy statistics, you'll have a lot going for you. "Any reputable school will do all it can to help the student finish the training he has selected," says DeVry's W. A. Robinson. "Most schools keep a steady flow of inspirational and motivational material in the mail, particularly to students who lag. In fact, most schools bend over backwards offering extra help to those they feel need it. In the final decision, however, it is the student himself who makes the decision to complete his training."

"The difference between a completer and a non-completer," adds R. Parma of National Tech, "is the degree to which he allows himself to procrastinate. Procrastination is the student's worst enemy, but the fault does not always lie with the student. Home study competes with the family, sports, TV, etc. But whether or not a student completes his course depends on how he rationalizes the importance of his time and career."

Just who can benefit from home study?

"Anyone who is interested in improving himself," says Robinson of DeVry. "Anyone who will bend his mind and back to the task," adds Hal Kelly of the National Home Study Council.

"The question should be," says John Sivatko of ICS, " 'Who can benefit from study?' *Home* study is just a technique. If you can benefit from any kind of learning, you can benefit from home study."

There's no doubt that the country needs more trained people. "Our economic progress today is being hampered by an increasing shortage of skilled men and women," says NRI's Thompson. "At a time when four million people are jobless, newspapers are crammed with ads for workers who can connect an electronic circuit, program a computer, service aircraft and missile equipment—or even *qualify* for training in hundreds of new skills that were unheard of 20 years ago. To put it another way, there would be virtually no unemployment if today's four million jobless obtained the skills to match business and industry's needs."

Correspondence education could play an increasingly important role in training men and women for tomorrow's ever-more-demanding jobs. In fact, the whole notion got some pretty high-level endorsement recently, as President Johnson voiced this opinion: "Home-study courses are an important link in the ever-lengthening chain of educational services our nation provides for its citizens. They represent an important resource in our society's commitment to provide unlimited opportunities for every American to reach his highest potential."

"We need correspondence education in this country now more than at any time in our past," says G. O. Allen of CIE, who is also the recently-elected president of the National Home Study Council. "We have a tremendous shortage of classroom facilities and qualified teachers, and this shortage is bound to get worse. Correspondence education can easily help fill the gap."

Maybe it can fill a gap in your life, too, and start you on a rewarding career in the important and fascinating field of electronics. —30—

Should I study at home or go to a residence school?

If you're looking for controversy, this is the question to ask. Of course, if you have a job and a family and can't simply take off and go to a residence school, your choice is easy. You'll study by mail.

But what if you do have a choice? There's no doubt that home study has important advantages. Among them: You can study in your spare time, at odd hours, or while traveling. You don't have to leave home or lose income. You can study at your own pace. You don't miss classes; they wait for you if you're sick or busy. You can move from one city to another without missing a beat. And home study is certainly far less expensive than residence training. You'll probably spend less for an entire electronics course lasting two years or more by mail than for one semester in college.

But would you learn more in a regular classroom? Actually, the evidence shows it's the other way around. One study by the dean of the College of Education of the University of Michigan showed that correspondence students did slightly better on exams than others who learned the same material in the classroom. Several other studies showed similar results. "You learn by doing, not by copying someone else," says Richard S. Frazer, president of Christy Trades School. "You learn more thoroughly because you do it all yourself."

Then should you study by mail in *preference* to residence school? "If a home-study student is willing to put forth some effort toward self-improvement, we feel it is comparable to the best resident-school training to be found," says J. F. Thompson of National Radio Institute. "It depends on the individual," says John Sivatko of International Correspondence Schools. "Some people can get more out of a home-study course than they can in residence, and vice versa." G. O. Allen of Cleveland Institute of Electronics agrees. "Much depends on the person," he says, "his goals and motivation, his geographical location, his time availability, the nature of the subject to be learned, etc. I will state, however, that other things being equal, I do believe the student who learns through a good home-study

program not only learns better, but retains it longer."

But C. L. Foster of Central Technical Institute says: "We recommend resident school training if it is at all possible. If resident school is not practical, we recommend home-study courses because we believe that worthwhile education can be obtained through home study." And W. A. Robinson of DeVry Technical Institute brings up another point: "Some types of training are offered at a more advanced level in our resident school than through home-study programs. In such cases, we could not provide equivalent home-study training."

Finally, L. M. Upchurch, Jr., of Capitol Radio Engineering Institute sums up his feeling. "We do not know of any authoritative comparative study of correspondence—as opposed to classroom—learning that has indicated any significant superiority of class attendance. Several studies, on the other hand, have shown slightly better results from home study.

"Comparing correspondence and classroom study of technical subjects is difficult in one respect: laboratory work. Because CREI students are, as a condition of enrollment, employed in the field of electronics, we know that to a considerable extent their practical experience gained on the job is a satisfactory substitute for supervised laboratory work. This is not invariably true, however.

"In any case, we would not ordinarily recommend correspondence study to a prospective student with the qualifications, the means, and the opportunity to attend a good residence school in the same field. (Nevertheless, there are some students for whom home study would be the better choice.) Neither would we claim that the average correspondence student completing our course is as well prepared as the average graduate of a comparable program in residence.

"The value of home study," Mr. Upchurch concludes, "is not as a competitor of residence school instruction, but as a valid educational method for individuals who want and need further education, but whose circumstances are such as to make class attendance undesirable or impossible."

CHAPTER

4

AUDIO STEREO HI-FI PROJECTS

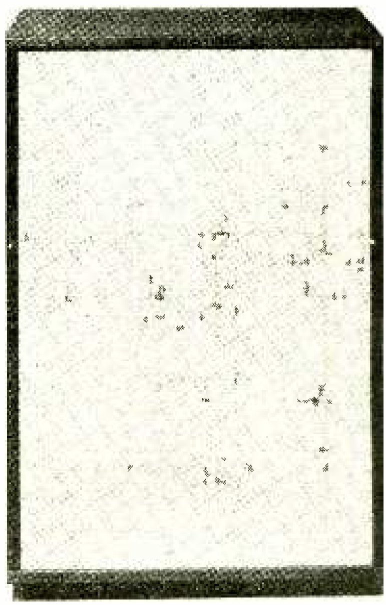
Six months ago, when the introduction to this chapter in the Spring 1966 Edition of the ELECTRONICS EXPERIMENTER'S HANDBOOK was being written, the Editors discovered that Dave Weems had had speaker enclosure projects in the six preceding issues. With one more project in the Spring Edition, and two different designs in this Fall Edition, Dave has certainly carved a niche for himself and ranks—in our estimation—as the number one designer and writer on build-it-yourself hi-fi speaker enclosures. A tip of our hat to Dave!

Besides enclosures, the Editors selected for publication in this edition of EEH the "Hi-Fi à Go-Go" color organ circuit developed by Don Lancaster. At first glance, this circuit might appear to compete with our cover photo project, but the two construction projects are quite dissimilar. The "à Go-Go" lamps are high-wattage bulbs, as compared to the low-intensity but very attractive Christmas lights of the Wortman project on page 21.

TOTEM POLES FOR STEREO

Go the "Sweet Sixteen" one better with a column speaker system and a separate bass speaker enclosure

By DAVID B. WEEMS



MOST stereo speaker systems are simply two mono speakers connected to a stereo amplifier. Any good system, when duplicated, can be expected to perform well in stereo. But good stereo presents unique requirements.

The first requirement is that the system be able to provide perspective, or give direction to the sound of individual voices or instruments. Some of the early stereo recordings seemed engineered for this purpose alone, with the result that we got a "ping-pong" effect. It was probably exaggerated effects such as this one that caused some audiophiles to condemn stereo hi-fi as inferior to mono hi-fi. Regardless of the misuse of directionality, however, without it there would be little reason for stereo recording and reproduction.

There are a number of factors which influence the ability to locate sound sources, such as the difference between sound intensity, waveform, and arrival time at each ear. Another factor, and one which influences the others, is the ratio of arrival times of direct to reflected sound. If this ratio is made very high, the sound source can be easily located. In an extreme case, the ping-pong effect is the result, with the music coming from two widely spaced "holes in the wall."

A second important requirement for good stereo sound is an apparent enlargement of the source. One way to accomplish this is to simply enlarge the source itself, i.e., use a large multiple speaker system. Another way is to utilize reflected sound (reverberation) to augment the direct sound from the speakers. Properly utilized, reverberation can give the effect of a sound source even larger than the room itself.

Other requirements for stereo include the suitability of room acoustics, of course, as well as the usual high-fidelity characteristics of wide and smooth frequency response, low distortion, good transient response, and wide dynamic range.

Control of Reflections. It would appear, in looking back over the above requirements, that there is a conflict. For directionality, we need a high ratio of direct sound to reflected sound, but for enlargement, we need a mixture of reflected sound with the direct sound. The trick, then, is to control the reflections.

One way of controlling reflections is to limit the dispersion of sound to one plane, either horizontal or vertical. The choice of which to use is an easy one since horizontal dispersion gives good distribution of sound over the listening area, whereas vertical distribution does little except bounce the sound waves off the floor and ceiling. If we can limit dispersion in the vertical plane and increase it in the horizontal plane, we can achieve two benefits: more efficient use of sound energy and an opportunity to control the ratio of direct sound to reflected sound simply by positioning the speakers properly.

Excellent horizontal dispersion of sound can be obtained from a vertical line source. A single loudspeaker acts like a point source, radiating sound in the form of a spherical wave, which spreads out in all directions at once. The sound wave propagated from a line source, however, travels outward in a cylindrical pattern. If we use several speakers to produce the sound and mount them in a straight line, we can approximate a line source. By making the line a vertical one, we can concentrate the sound into horizontal dispersion and conserve some of the energy that a point source squirts out in the vertical direction. Reflections from ceilings and floors are minimized.

A vertical column, of course, is not a new idea in sound reproduction; column speakers have been known and appreciated for years by the manufacturers of public address systems and by the sound engineers who install them. Perhaps one reason for the acceptance of column speakers by public address people was the fact that their p.a. systems had to be used in such impossible acoustic environments as half-empty gymnasiums with their hard reflective surfaces.

"Sweet Sixteen" Concept. The benefits of using multiple small speakers for low distortion are well argued by the popularity of such systems as the "Sweet Sixteen" (POPULAR ELECTRONICS, January and April, 1961). Critics of these multiple speaker systems insist that they produce no measurable low frequency bass or extreme highs. However, pro-

For awhile, when the "totem poles" were being developed, the workshop looked like a hi-fi supply house. The single woofer gave way to separate woofers.

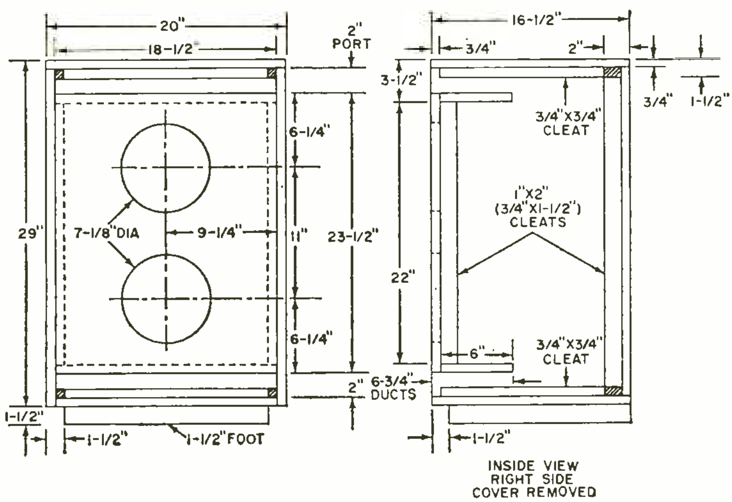
ponents go right on building Sweet Sixteens, indicating that there are benefits that can't be measured. One reason, perhaps, is the apparent enlargement of the sound source. Those who have heard a multiple system usually admit that the speaker arrangement does have something to offer.

One deficiency multiple speaker systems have is that the speakers must be mounted in a concentrated pattern, such as a square. This results in identical distances between identical speakers, which causes certain points in their frequency range to be boosted or cut, and peaks or valleys appear in the response curve. These variations are measurable and have contributed to the criticism of the whole idea of multiple speakers.

An obvious answer to this deficiency is to use the Sweet Sixteen concept where it is strongest and to eliminate its weaknesses. The prescription for changing the Sweet Sixteen into something really great is to install a crossover network, add woofers and tweeters, and string the mid-range speakers to create a line source of sound.

Speaker Selection. If you already have a Sweet Sixteen system that you want to update, you can split the speakers into two groups of eight each. Ten speakers were used in the system shown here to obtain an 8-ohm impedance, but omitting one pair would not appreciably affect performance.

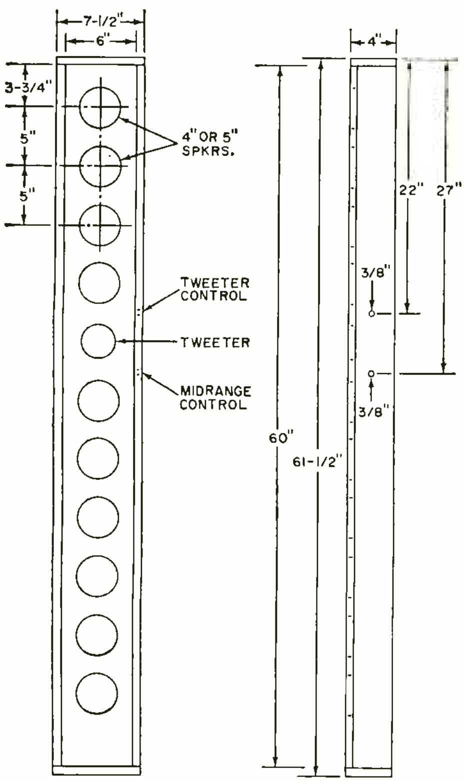
Either 4- or 5-inch speakers can be used with the design shown. If you are buying new speakers, choose them by magnet weight rather than size. Avoid consideration of arbitrary phrases such as "heavy duty," "heavy magnet," etc. Magnet weight should be about 1 ounce or more. Actually, magnet weight by itself is not a foolproof way of determining magnet size. Look for the gauss rating—the larger it is, the better.



These drawings show all the necessary woodworking details. A Bill of Materials is given on page 98. Width and depth of the ports in the combined bass speaker enclosure are somewhat critical as ports are cut for the Electro-Voice speakers. The author attached poles to his column speakers so the systems could be rotated and aimed at the audience. Sound radiation from column speakers is mostly horizontal with little vertical dispersion.

The small speakers can all be of a single brand and model, but a slight improvement will be gained by using two different brands. If you do, pair off the unlike speakers and connect them in parallel, then connect these pairs in series. Ten speakers, each having a 3.2-ohm voice coil, provide a final impedance of 8 ohms when wired in this manner.

There are small foreign-made speakers available with 8-ohm voice coils. If you want to use some of these, you'll need a different wiring arrangement. To obtain an impedance of 8 ohms, you can parallel three speakers in one set, and wire three sets in series for a total of nine speakers to handle the mid-range instead of ten. For a 16-ohm hookup, use eight 8-ohm speakers—four parallel pairs in series. Don't try to use speakers of mixed impedance ratings in the same system unless you are sure you can design a circuit that will provide equal power to each speaker. You might end up with one or two speakers doing all the work.



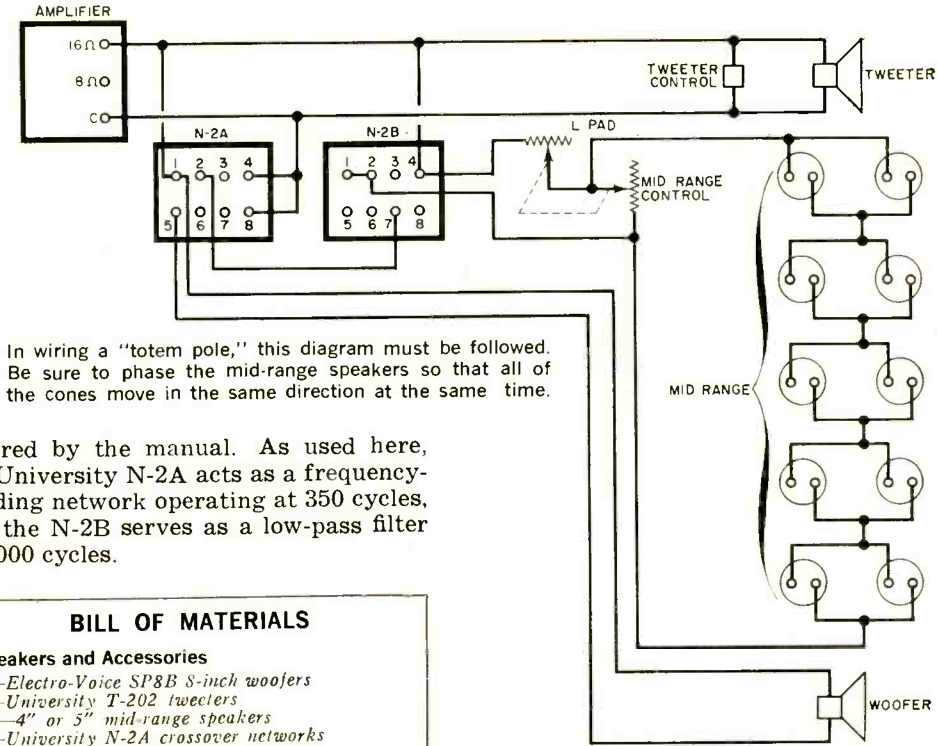
DIAMETER OF SPEAKER HOLES IS 3-1/2" FOR 4" SPKRS.
4" FOR 5" SPKRS.
TWEETER HOLE IS 2-15/16"

While you can substitute other woofers with good results, the Electro-Voice SP8B specified in the Bill of Materials is highly recommended. It was the final choice over the other 8-inch woofers that were tested for this particular application. Of course, you can use separate woofer systems, or other quality brands of woofers in the manufacturer's enclosures, if you don't mind having two woofer cabinets plus two columns in your living room. The compelling reason to put the two 8-inch woofers in a single enclosure is to keep the cabinet population within acceptable limits. You also gain the advantage of mutual coupling between the two woofers with improved low-frequency performance.

There is an alternative, though, particularly if you have an amplifier that will tolerate mixing of the two stereo channels (some transistor amplifiers won't). The alternative is to use one woofer for both channels, but the woofer should have either a dual voice coil or an added mixer transformer to which the bass from each channel is fed. For the latter method, a possible choice is the Electro-Voice XT-1 transformer with an E-V SP12B either in the manufacturer's enclosure or in "Mr. Thuras' Magic Box" (Spring, 1966, ELECTRONIC EXPERIMENTER'S HANDBOOK).

It is also possible to substitute other tweeters for the University T-202 specified, but you must check for similar wide-angle dispersion characteristics first. (Note that the totem pole control of dispersion angle is essentially for mid-range sound.) The T-202 has its own built-in filter network and is hooked directly across the output of the amplifier. If you substitute a tweeter without a high-pass filter or with a filter operating at a different crossover frequency (other than 3000 cycles), then you'll have to change the wiring or the crossover network to obtain the required crossover frequency.

Some of you may note that the wiring of the crossover network is unusual and somewhat different than any shown in University's instruction book. The changes were made necessary by the use of a 16-ohm woofer and a tweeter with a high-pass filter set at a frequency not



In wiring a "totem pole," this diagram must be followed. Be sure to phase the mid-range speakers so that all of the cones move in the same direction at the same time.

covered by the manual. As used here, the University N-2A acts as a frequency-dividing network operating at 350 cycles, and the N-2B serves as a low-pass filter at 3000 cycles.

BILL OF MATERIALS

Speakers and Accessories

2—Electro-Voice SP8B 8-inch woofers
2—University T-202 tweeters
20—4" or 5" mid-range speakers
2—University N-2A crossover networks
2—University N-2B crossover networks
2—University AP-8 controls for mid-range speakers

Lumber for Two Columns

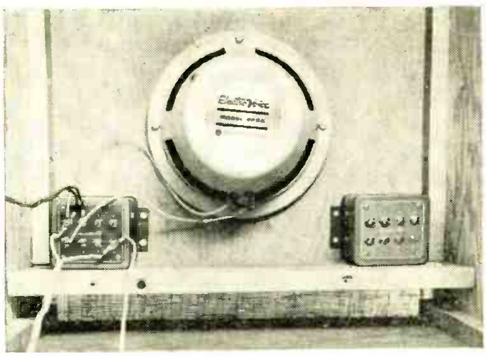
2—6" x 60" pieces of ¾" fir plywood (for speaker panels)
4—4" x 60" pieces of ¾" fir plywood (for sides)
4—4" x 7½" pieces of ¾" fir plywood (for tops and bottoms)
2—7½" x 61½" pieces of ¾" fir plywood (for backs—optional)

Lumber for Woofer Enclosure

1—18½" x 23½" piece of ¾" fir plywood (for speaker panel)
1—18½" x 27½" piece of fir plywood (for back)
2—16½" x 28¼" pieces of ¾" fir plywood (for sides)
1—16½" x 18½" piece of ¾" fir plywood (for bottom)
1—16½" x 20" piece of ¾" fir plywood (for top)
2—6" x 18½" pieces of ¾" fir plywood (for duct panels)
2—1½" x 22" pieces of ¾" pine (for cleats on speaker panel)
2—1½" x 26" pieces of ¾" pine (for back cleats)
2—1½" x 18½" pieces of ¾" pine (for back cleats)
4—¾" x 14¼" pieces of ¾" pine (for corner cleats)

Miscellaneous

104—#8 x ½" sheet metal screws (for small speakers and crossover networks)
84—#8 x 1¼" wood screws (for woofer enclosure)
2—Tool or "gripper" clips (to fit lamp poles, if used)
Grille cloth, plastic veneer, glue, finishing nails, fiberglass



A peek inside of an unfinished bass reflex cabinet shows the two University N-2A crossovers attached to the front panel. See the wiring diagram above.

Construction. The speaker enclosures, both the woofer box and the columns, are constructed from ¾-inch plywood. The columns are quite simple in design, and should cause no difficulty, but you should wait until you decide whether you need a back or not before putting on the plastic veneer covering (see Speaker Placement section of this article).

(Continued on page 145)

HI-FI À GO-GO LAMPS

Add a new dimension to your hi-fi ... in color

By DON LANCASTER

WHY BE SATISFIED with just listening to hi-fi programs when for a sawbuck you can have the added enjoyment of seeing what you're hearing, and intriguing all your friends. A pair of ten dollar bills will get you two sets of audio controlled lights to let your stereo system really brighten up the place. For those who want something different, it's quite a conversation piece.

With the *À Go-Go* circuit, the brightness of one or more incandescent lamps is controlled by an audio signal. Its full-range proportional control is capable of bringing the lights from full darkness to full brilliance; the louder the sound, the brighter the lamps. You can use it to control up to 200 watts of light, and with modification and a few dollars more, up to 2000 watts. The unit is about the size of two ice cubes.

How It Works. Sounds fed into *J1* are stepped up by *T1,* rectified by *D1* and filtered by *C2* only to become a control voltage for trigger diode *D3*. (See Fig. 1.) It takes 30 volts to make *D3* conduct. The time required to build up 30 volts on *C3* depends upon the amplitude of the sound and the values of *C3* and *R2*. The louder the sound, the quicker the voltage buildup; the larger the resistor or capacitor, the longer it takes to build up the voltage.

When *D3* fires, it triggers the SCR into conduction only if the SCR anode also has a positive voltage on it. Once the SCR fires, it continues to conduct until the anode voltage drops down to about 0. This happens each time the line voltage waveform goes through zero. The SCR will remain off until another pulse is applied to its gate. The sooner the gate pulse occurs when anode voltage is present determines the amount

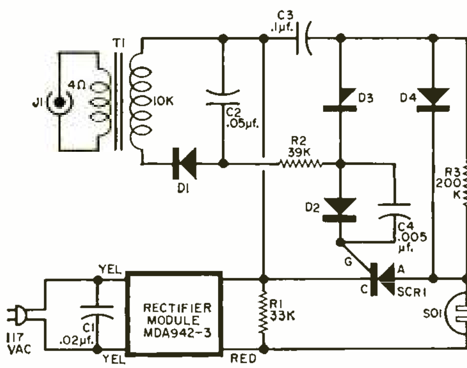


Fig. 1. Ratio of "on time" to "off time" of SCR1 changes in step with music levels, and brightens or darkens different colored bulbs plugged into SO1.

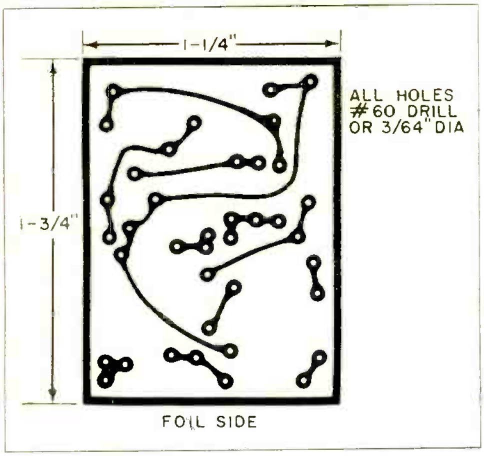


Fig. 2. Printed circuit board is shown actual size to help you make your own. However, almost any suitable chassis or breadboard arrangement can be used.

PARTS LIST

C1—0.02-µf., 200-volt Mylar capacitor
C2—0.05-µf., 200-volt Mylar capacitor
C3—0.1-µf., 200-volt Mylar capacitor
C4—0.005-µf., 600-volt disc capacitor
D1, D2, D4—1N4003 diode
D3—Trigger diode (Texas Instruments TI-42 or equivalent)
J1—Phono jack
R1—33,000-ohm, ½-watt resistor
R2—39,000-ohm, ¼-watt resistor
R3—200,000-ohm, ¼-watt resistor
SCR1—2N3528 silicon-controlled rectifier
SO1—Chassis-mounted a.c. socket (Amphenol 61-F or equivalent)
T1—Output transformer, 4 ohms primary to 10,000 ohms secondary (Thordarson TR-203 or equivalent)
1—Full-wave bridge rectifier module, 1.5 amp., 200 volts (Motorola MDA942-3)
1—Chassis-mounting a.c. plug (Amphenol 61-M or equivalent)
1—Case (Millen 74400 or equivalent)
1—2" square of 1/16" single-sided circuit board
Misc.—Silicon potting compound, hookup wire, solder, pop rivets or screws

of time during each half-wave that current can flow through the lamps plugged into *SO1*.

Neither the eye nor the lamps can follow the 120-cycle unfiltered pulsating voltage out of the rectifier module, but the lamps do respond in a proportional manner. The brilliance of the lamps is a function of the ratio of "on" time to "off" time; or the louder the music, the brighter the lights.

Capacitor *C1* serves as a filter to prevent the switching transients in the *A Go-Go* from getting back into the power line and causing AM-type radio interference. The other components optimize the circuit to prevent premature turn-on of the SCR and allow more accurate proportional control by discharging *C3* before a new "on" cycle begins.

As the audio is used for bias only, little audio power is consumed. The *A Go-Go* has high sensitivity and very little volume is needed to drive it.

Construction. Start construction by laying out and etching the printed circuit board shown in Fig. 2. Drill holes and mount components as shown in Fig. 3. Watch the polarity—one wrong connection can destroy the semiconductors.

After you've finished the wiring, connect an a.c. socket and plug to the board and test the *A Go-Go* with a 25-watt bulb. The bulb should glow slightly with no audio. A fairly low level audio signal should drive the lamp to full brilliance. If this test checks out okay, test the board using the lamps and audio source

(*Continued on page* 104)

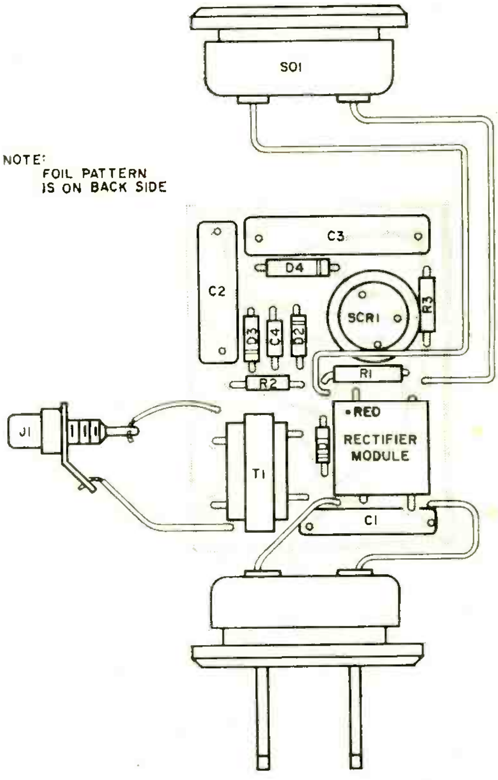


Fig. 3. Mount the jack and sockets in the case before connecting them to the circuit. If space is not a factor you can add more features. See text.

you plan to have in the permanent installation.

For best appearance and greatest sensitivity, the display lamps should barely light with no audio input. A different background level can be obtained by changing the value of *R2*; increasing its value will decrease the background light level. You might also experiment with *C2*—use too small a value, and you'll have a choppy response; too large, and the response will become mushy.

The components are mounted inside a modified Millen octal base and shield. Cut the shield to about $1\frac{3}{4}''$ long (see Fig. 4), and drill or punch a $1\frac{9}{64}''$ keyed or $1\frac{5}{32}''$ round hole in the top for the socket. Drill a $\frac{17}{64}''$ hole in one side of the shield for the audio jack. Screws or rivets can be used to fasten the two parts of the case.

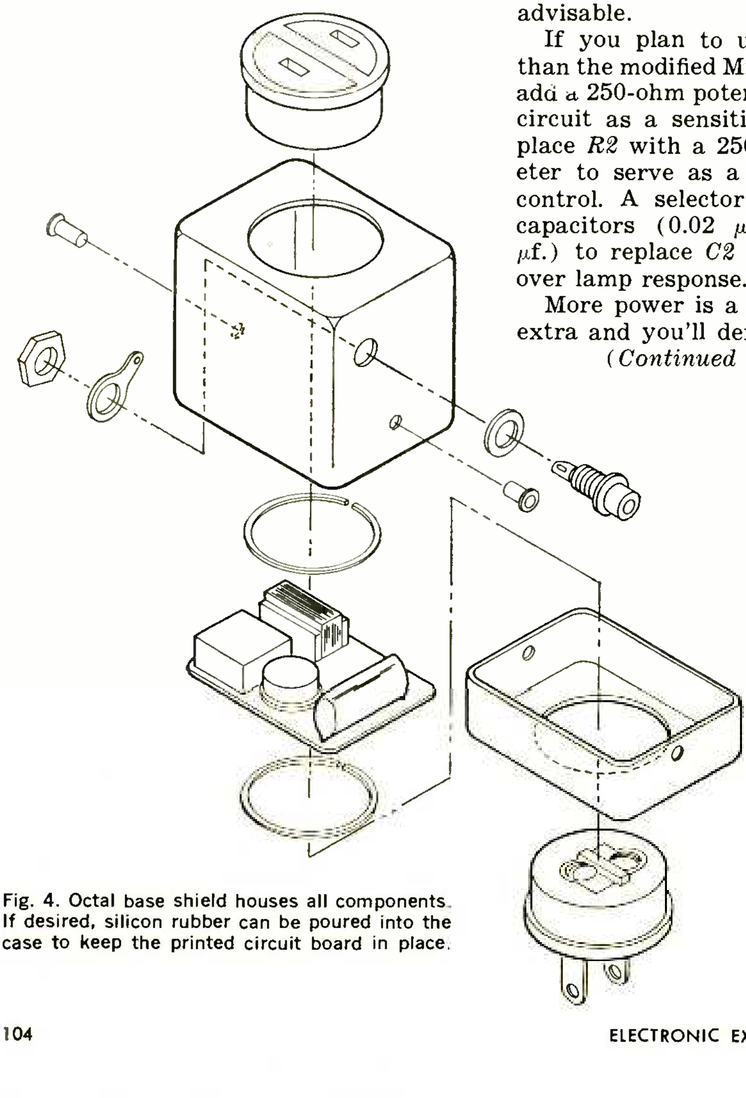


Fig. 4. Octal base shield houses all components. If desired, silicon rubber can be poured into the case to keep the printed circuit board in place.

Once you've wired the board, socket, and audio jack, you can pot the circuit in silicon rubber. To do this, turn the *À Go-Go* upside down and place small bits of tape over the inside openings of *J1* and *S1*. Then pour in about half an inch of rubber and let it set. The printed circuit board is then positioned in place and another half inch of rubber added. Complete the assembly by connecting the plug.

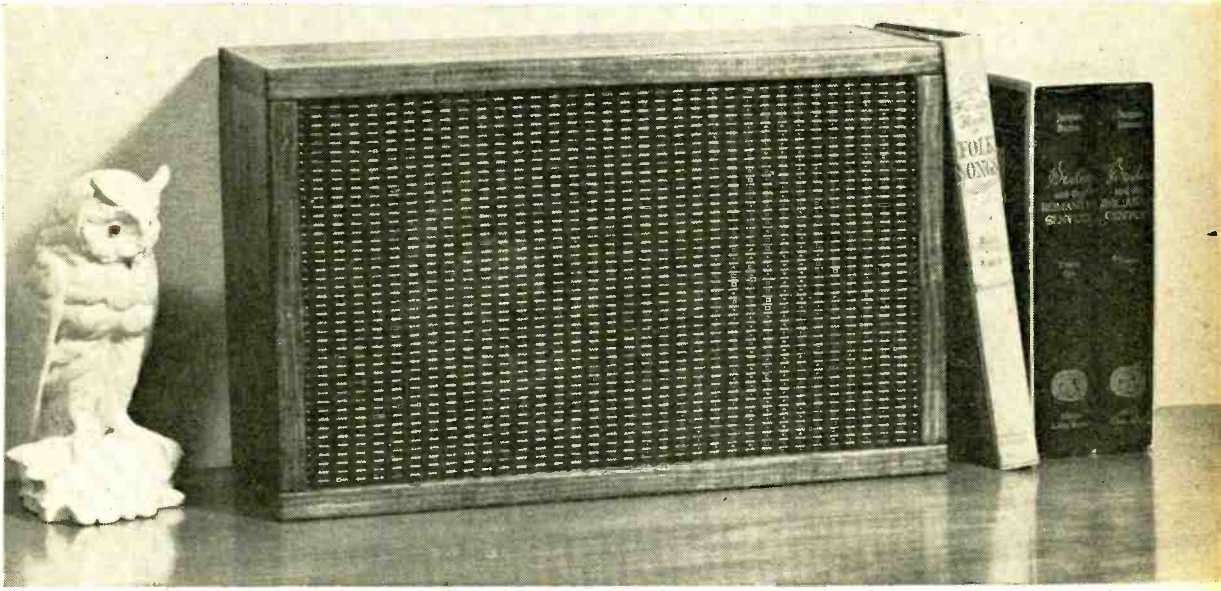
Modifications. The *À Go-Go* operates on 117-volt, 60-cycle lines and utilizes incandescent lamps only. For the unmodified unit, you can use a total of 200 watts maximum, but for cooler operation and longer life, 100 watts or less is advisable.

If you plan to use a bigger package than the modified Millen shield, you might add a 250-ohm potentiometer in the input circuit as a sensitivity control, and replace *R2* with a 250,000-ohm potentiometer to serve as a variable background control. A selector switch with several capacitors (0.02 µf., 0.05 µf. and 0.1 µf.) to replace *C2* will give you control over lamp response.

More power is a snap, but it will cost extra and you'll definitely need a bigger

(*Continued on page* 114)

Build The "CINDERELLA"



By DAVID B. WEEMS

Half-cubic foot sealed enclosure costs under $10

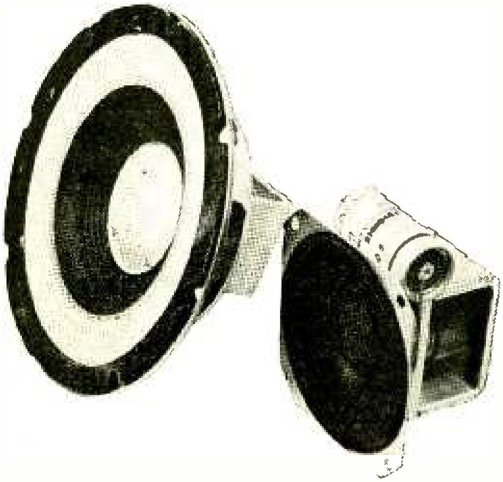
IF YOU'RE thinking of putting down $30 or more for one of those department store "no name" speakers in a box, wait. Here is a little hi-fi speaker system that can save you money and will probably sound better. At least you will know what went into the box! And you won't find a similarly well-constructed enclosure with a good-quality small speaker system on the market for anything like this price. If your idea of what $10 will buy in speaker systems is based on what was available just a few years ago, the *Cinderella* system will amaze you.

The secret of the *Cinderella* is in the design and construction of its XS-5052 woofer. This woofer's distinctive qualities are noticeable in two ways. The first is the obvious visual differences between it and a normal 6-inch speaker. Second, and more important, there is a distinct aural difference, which can be made apparent by a frequency test run.

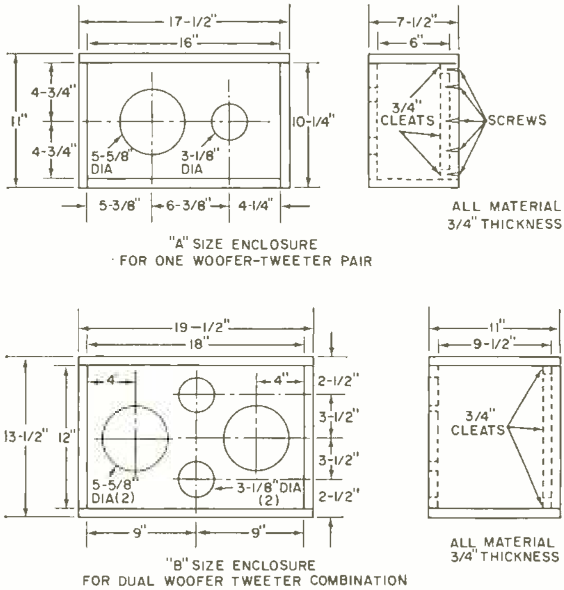
Test Results. I set one of these woofers on my workbench and hooked it up for the usual bass resonance frequency test, starting downward from 200 cycles. Although most 6-inch speakers resonate at about 120 to 150 cycles, a few "hi-fi" 6-inchers have a bass resonance of around 70 cycles, and, frankly, that is where I expected this woofer to fall. Low resonance is the crucial characteristic for woofers to be used in small sealed enclosures; the restricted air volume in such systems will raise the point of resonance.

My eyes were glued to the oscilloscope screen as the audio generator dial passed 70 cycles, then 60. Not until 48-49 cycles did the voltage across the speaker reach a peak, indicating resonance. A remarkably low frequency for a $4 speaker.

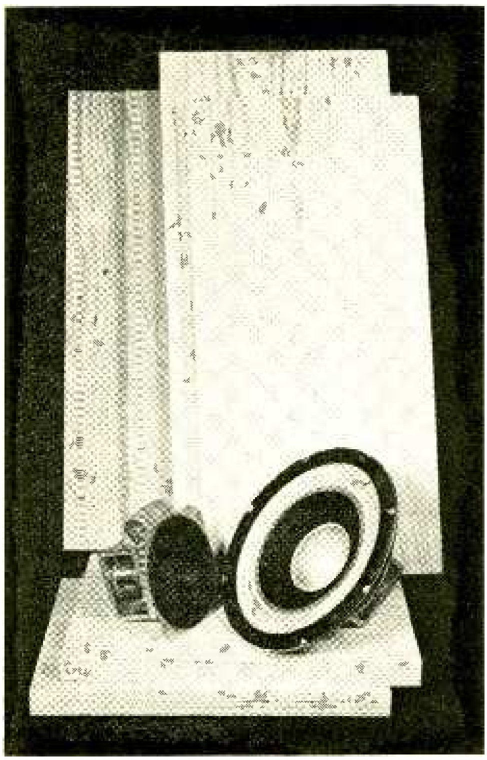
The remainder of the system consists of a small cone tweeter with its self-contained capacitor which acts as a high-pass filter, and an enclosure that occupies



Six-inch woofer costs only $3.95 but has surprising low end response. Tweeter is not sold separately.



Most builders may be satisfied with single woofer-tweeter combination, but dual system sounds better.



The Cinderella enclosure is caulked and sealed, requiring use of sturdy front, top, back, and side panels. The author was satisfied with ¾-inch pine.

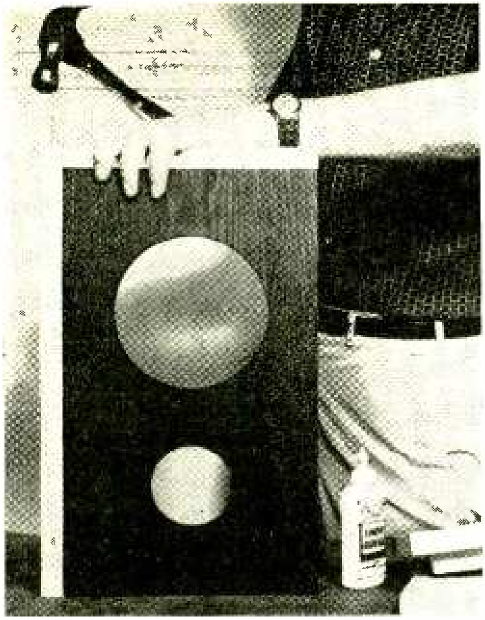
BILL OF MATERIALS

"A" System—Total cost, $10

1—Woofer-tweeter combination (Stock No. XS-TS-63, McGee Radio Co., 1901 McGee St., Kansas City 8, Mo.; woofer available separately as XS-5052 for $3.95)
2—9½" x 16" pieces of ¾" fir plywood for front and back
1—7½" x 17½" piece of ¾" clear pine for top (1 x 8)
1—7½" x 16" piece of ¾" clear pine for bottom (1 x 8)
2—7½" x 10¼" pieces of ¾" clear pine for sides (1 x 8)
2—¾" x 9½" pieces of ¾" pine (side cleats for back)
2—¾" x 14½" pieces of ¾" pine (top and bottom cleats for back)
12—#8 x 1¼" wood screws for back
8—#6 x ½" sheet metal screws for speakers
1—1" x 24" x 30" sheet of fiberglass
Misc.—#6 finishing nails (¼ lb.), caulking material, glue, and grille cloth

"B" System—Total cost, $18

2—Woofer-tweeter combinations (Stock No. XS-TS-63, McGee Radio)
2—12" x 18" pieces of ¾" fir plywood for front and back
2—11" x 19½" pieces of ¾" fir plywood for top and bottom
2—11" x 12" pieces of ¾" fir plywood for sides
2—¾" x 12" pieces of ¾" pine (side cleats for back)
2—¾" x 16½" pieces of ¾" pine (top and bottom cleats for back)
14—#8 x 1¼" wood screws for back
16—#6 x ½" sheet metal screws for speaker mounting
1—1" x 24" x 60" sheet of fiberglass
Misc.—#6 finishing nails (½ lb.), caulking material, glue, and grille cloth



Nail side to bottom and front of the enclosure. Good fit and a liberal use of glue are important.

only ¾ sq. ft. of shelf space. The system is called the *Cinderella* because, while it bears no apparent pedigree, it does show inborn quality. For example, even in the small enclosure, the *system* resonance is a little over 70 cycles. The transient response is surprisingly good for a low-cost system. As in all small sealed enclosure systems, efficiency is lower than in a large system, but a 7-watt amplifier supplied all the sound you would want in a very large but very live room. The *Cinderella* is rated at 12 watts.

Budgeting Your Money. The enclosure is sturdy, contains sufficient damping material, and is thoroughly sealed. Any one of these features may be missing from a department store box. For the skeptic, here is a rundown of how to budget your money to build the *Cinderella* "A" system for only $10.

Speakers	$6.90
Plywood for front and back	.55
Pine for top, bottom and sides	.75
Screws	.26
Glue	.25
Fiberglass	.66
Caulking material	.20
Nails	.06
Total	$9.63

That leaves 37 cents to squander on grille cloth and trim. You can use screen molding for trim (as I did—15 cents for a cabinet) and decorator burlap will serve as grille cloth at 49 cents a yard (17 cents). If anyone mentions finishing the wood, you will find that 5 cents is still available, and that is just about the amount of shoe polish I used to stain and "oil finish" the model shown. For very little more, you can use a veneer plastic, such as Contact. Or choose a hardwood if you want fine cabinetry.

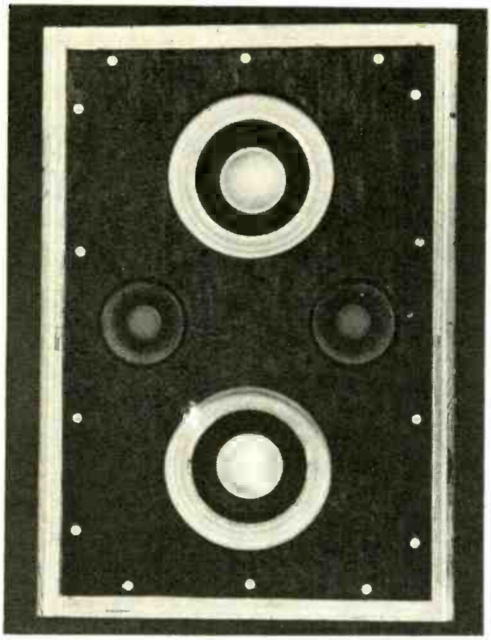
The sound can be improved by putting two sets of the woofer-tweeter combination ($12.95) in one "B" size cabinet (see page 52) at a cost of about $18. Used in multiples, these little speakers sound even better. There is more solidarity in the bass and somewhat smoother sound throughout the whole spectrum. Also, the impedance curve tends to flatten out when two woofers are hooked in parallel.

In buying material, note that the ¾" x 7½" pine shown in the drawing is, of course, what lumber yards sell as "1 x 8". When you have cut all parts to the specifications shown, set them up as in the finished enclosure. At this time you can trim any of them that do not fit satisfactorily. One of the economies in this system, in time as well as money, is the avoidance of many cleats which would require the use of extra screws, nails, and glue. The nailing system shown in the diagram is quite adequate for such a small enclosure, but a good fit is necessary.

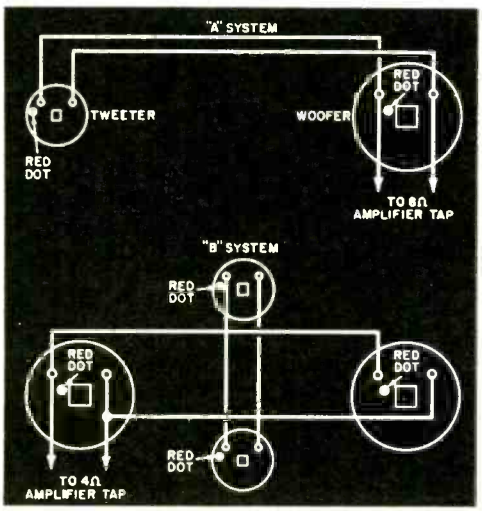
Construction. Begin construction by nailing the bottom to the front, using plenty of glue between these two parts. Next, nail one end to the bottom and front. Continue with the other end, and finally nail down the top to the sides and front.

The cleats for the back can now be attached, using glue and nails as with the exterior parts; but if you use the same kind of nails, they must be cut just short enough so they will not penetrate the outer surface of the sides and top. A somewhat easier method is to use a different nail, such as sheet rock nails which have a large head and are the correct length.

The joints should be caulked even



Front view of an experimental "B" system built by the author to test front and side panel vibration. This enclosure was built using cleats and screws, unlike the plans on page 106. Fir plywood was also used and the enclosure covered with a plastic veneer. It was determined that gluing and nailing of the panels would be adequate if care was exercised in fitting the panels together. A grille cloth was later installed to protect the speakers. Wiring of the "B" speaker arrangement is shown below. Try the 8-ohm tap instead of the 4-ohm output of your amplifier if the bass response seems a little thin.



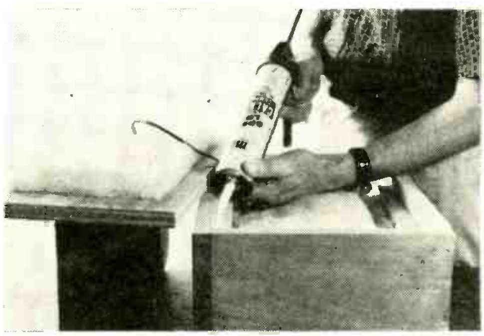
Be sure to follow this wiring diagram to keep the speakers in phase. Once the enclosure is sealed, you may find it fairly difficult to change the wires.

though they seem to be thoroughly sealed by glue. The caulking material can be purchased in a cylinder for use with a gun, or in a squeeze tube. Most building supply stores have guns to loan, but some rent them. Force the caulking material along the joint and wipe away excess with a rag so it won't flow onto the speakers.

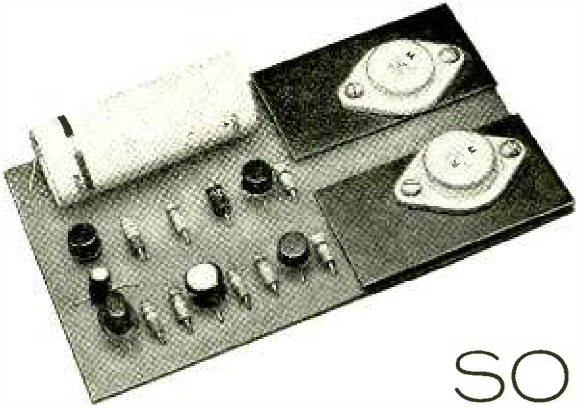
The speakers are mounted and wired as shown in the diagram. The back should be drilled to allow speaker connections to pass through. The wires can be brought out through a small hole which is later filled with caulking material or sawdust and glue, but a better method is to use small bolts as connectors through the back.

Padding is extremely important in a small sealed enclosure. Tests indicated that the *Cinderella*'s resonance could be lowered 10 cycles or more and the bass range greatly extended by the use of proper padding. The whole interior of the model shown is lined with a 1-inch layer of fiberglass. You can get fiberglass from most electronics stores; a common size measures 1" x 24" x 60", enough for two cabinets. Cut the fiberglass to fit all interior surfaces, except the front baffle, and secure it in place with tacks or glue. Then fold the remainder of your sheet of fiberglass so that it will fit into the enclosure loosely. This should fill the enclosure.

Now fasten the back in place with the screws specified, hook the *Cinderella* up to your amplifier, and try on the "glass slipper." That, naturally, is a suitable wide range program source. When you do, you'll be glad you didn't settle for a pig in a poke. —30—



After filling cavity behind speakers with padding, cleats should be caulked and back-nailed into place. The usual household caulk works out just right.



By CHARLES E. FENOGLIO

SOLID-STATE 6-WATT AMPLIFIER FOR 10 BUCKS

All-purpose push-pull audio amplifier operates on wide range of input voltage and output impedance without bias adjustments

IF YOU would like to have a quality, low-cost amplifier for a hi-fi or public address system—one you can use at home or in your car, and can convert into a speech amplifier, modulator, or high-power intercom—then try your hand at this transistorized "Six-Watter." You can build it in less than two hours, at a cost of about $10.00. All components can be mounted on a printed circuit board, and construction is easy.

Several novel circuit features make it possible to use few parts, eliminate transformers, and achieve high efficiency. A unique d.c. bias stabilizing network eliminates the bias adjustments normally found on this type of amplifier and permits operation with a wide range of supply voltages without modification.

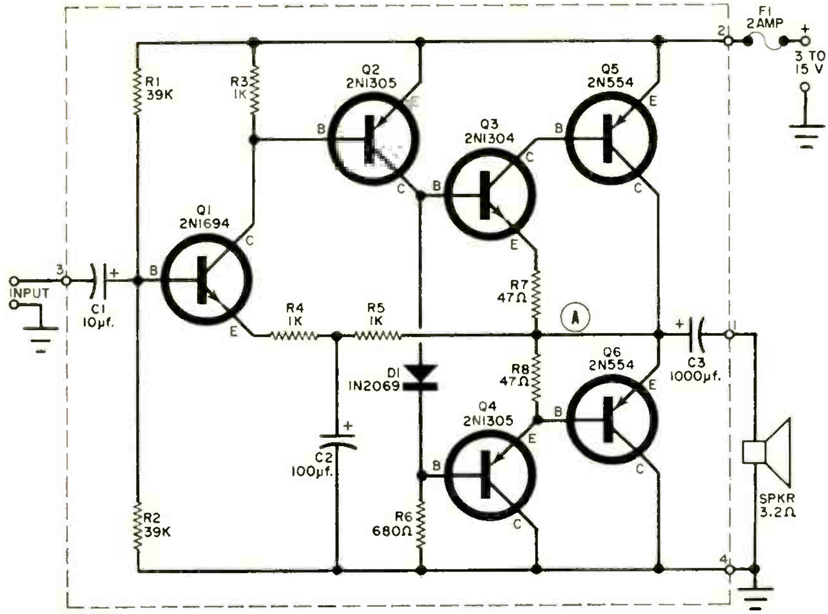
The excellent low-frequency response of the Six-Watter is due in part to the absence of transformers and the use of high-value coupling capacitors as well as direct coupling. High-efficiency Class B operation makes it ideal for use wherever battery life is an important consideration. Power consumption from a 12-volt battery under no-signal conditions is less than ½ watt.

While the amplifier can work on any supply voltage ranging from 3 to 15 volts, the higher the voltage source, the greater the audio power output you can get. An input signal of less than 0.2 volt is sufficient to drive the Six-Watter to full output. This is more than adequate gain for most tuners, and crystal or ceramic phono cartridges.

How It Works. Audio input is coupled to the base of transistor *Q1* through capacitor *C1*. The amplified signal at *Q1*'s collector is direct-coupled to the base of *Q2*. Here again, the signal is amplified and directly coupled to *Q3* and *Q4*. Transistors *Q3* and *Q4* work in opposite directions; while one is conducting more, the other is conducting less—their output signals are 180° out of phase with each other. This type of circuit makes it possible to drive a push-pull output stage without the aid of a transformer.

The signals from *Q3* and *Q4* are directly coupled to *Q5* and *Q6* respectively. Transistors *Q5* and *Q6* operate as Class B power amplifiers. Balanced operation requires that the product of the current gain of *Q3* and *Q5* be equal to that of *Q4* and *Q6*.

The filter network, *C2* and *R4*, prevents audio voltage variations at point



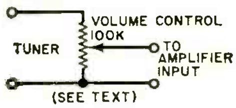


Fig. 1. The audio amplifier uses a novel six-transistor circuit requiring neither transformers nor bias adjustments. It operates with supply voltages of between 3 and 15 volts. An input signal of 0.2 volt is sufficient to drive it to full output. Volume control can be added if desired.

PARTS LIST

C1—10-µf., 10-volt electrolytic capacitor
C2—100-µf., 10-volt electrolytic capacitor
C3—1000-µf., 15-volt electrolytic capacitor
D1—1N2069 (or any 750-ma. silicon diode)
F1—2-ampere fuse
Q1—2N1694 transistor (or 2N167, or 2N2925)
Q2, Q4—2N1305 transistor
Q3—2N1304 transistor
Q5, Q6—2N554 or 2N2148 transistor
R1, R2—39,000-ohm, ½-watt resistor
R3, R4, R5—1000-ohm, ½-watt resistor
R6—680-ohm, ½-watt resistor
R7, R8—47-ohm, ½-watt resistor
1—Printed circuit board, available from Hazleton Scientific Co., Box 163, Hazel Park, Mich. 48030 for $2.85 postpaid with all holes drilled and for $1.95 postpaid undrilled
2—1⅜" x 2½" x 1/16" heat sinks, copper or aluminum

A in Fig. 1 from reaching *Q1*'s emitter. This results in a high degree of d.c. stability without affecting the a.c. gain of the amplifier.

Any speaker impedance ranging from 1.6 to 16 ohms can be used. Because power output is a function of speaker impedance, and source voltage, stick to a 3.2-ohm speaker and a 12-volt source, if possible.

Construction. You can make your own circuit board, or purchase one for $2.85

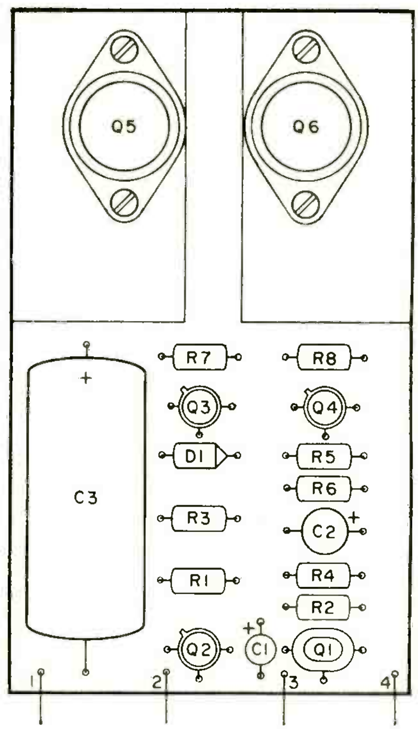


Fig. 2. Carefully locate and solder all of the components onto the printed circuit board as shown.

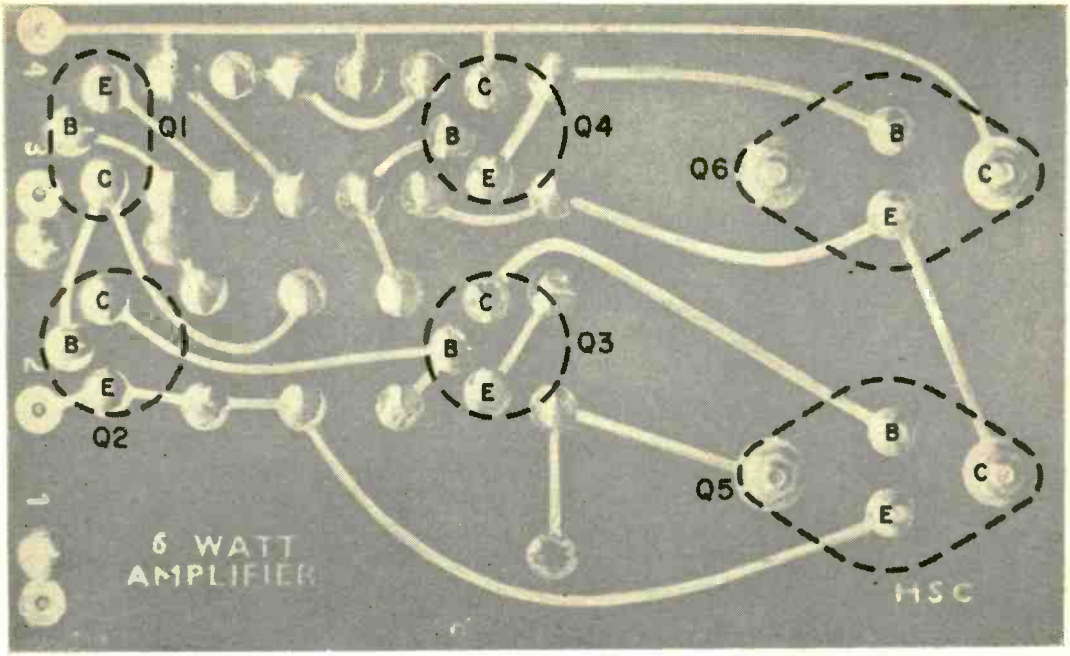


Fig. 3. Use this full-size guide in making your printed circuit board. Space the transistors about ½" above the board and hold transistor leads on top side of board with a pair of long-nose pliers when soldering.

(see Parts List), or you can mount and wire the components on a small (approximately 4" x 6") conventional type chassis. If you use the board, locate and solder the parts in place as shown in Fig. 2. Space the transistors about ½" above the board and hold the transistor lead on the top side of the board with a pair of long-nose pliers while soldering.

Heat sinks for *Q5* and *Q6* can be cut from a 1/16" copper or aluminum sheet,

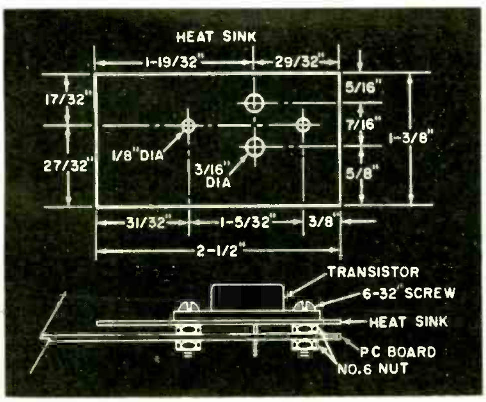


Fig. 4. Use thin copper or aluminum stock to make heat sinks and mount with the transistor as shown.

and should measure 1⅜" x 2½". Drill holes as shown in Fig. 3. Two holes are used to mount each heat sink on the board, and two are used for the transistor pins. Paint the heat sinks black to increase thermal dissipation. If you plan to use the amplifier continuously at high power levels and high ambient temperatures, increase the size of the heat sinks.

Final Check. After completing construction, feed a 6- to 12-volt d.c. source to terminals 2 and 4 (positive voltage to terminal 2) and measure the d.c. voltage between point *A* and terminal 4.

It should be one-half the supply voltage. If it is not, *R1* and *R2* may not be matched closely enough. In this case, temporarily replace *R1* with a 100,000-ohm potentiometer and adjust the pot until the voltage at point *A* measures one-half the supply voltage. Then measure the resistance of the potentiometer and replace it with a fixed resistor of that value.

Modifications. You can add a volume control to the amplifier by connecting a potentiometer to the circuit between the

(*Continued on page* 140)

UNIQUE 99¢ SPEAKER ENCLOSURE

By JOHN N. AYRES

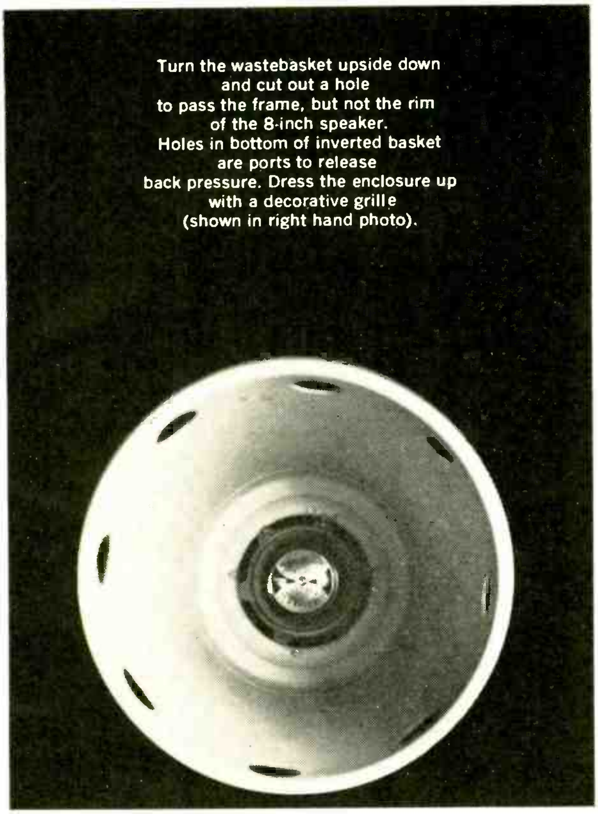
Simple plastic baffle uses inverted wastebasket

WANT a cheap, effective, and reasonably attractive enclosure for an 8″ speaker? Although the "99¢ Enclosure" grew out of the need for a temporary setup, the unit is quite appropriate for permanent home hi-fi systems, especially where positioning of conventional enclosures for best stereo listening is hampered by furniture placement or peculiarities of the room's general layout. The portability and durability of this unit makes it practical to store a couple of them out of the way, then move them into position each time they are used.

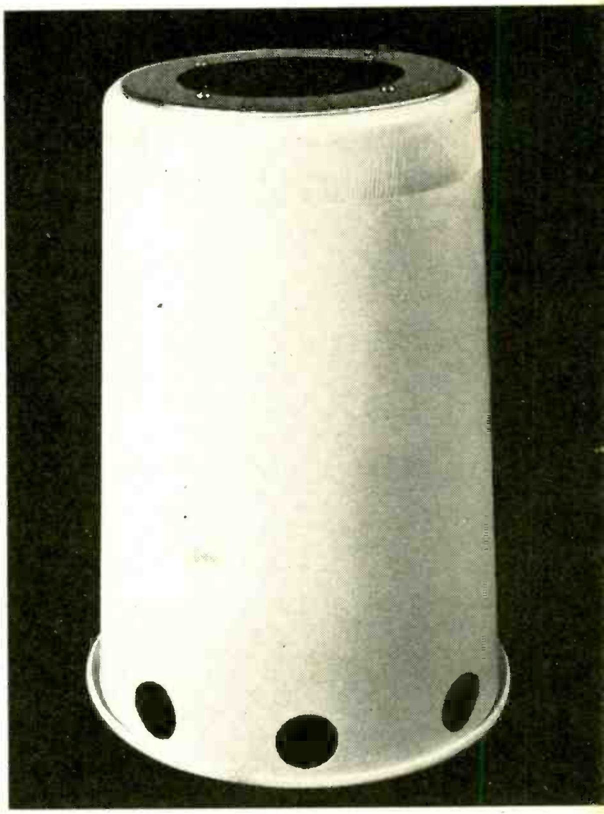
The speaker used by the author was a Lafayette SK-128, but any other full-range 8″ speaker would be equally appropriate for use in this unique enclosure. Construction can be completed in five or ten minutes with the aid of a drawing compass, measuring tape, and penknife.

Construction. The "enclosure" is available, practically ready for use, in almost any department or variety store, in the form of a "Steri-lite" 44-quart polyethylene wastebasket (U. S. Plastic Company Model #1040). Prices may vary but the pilot model was obtained at a cost of 99 cents. This container is approximately 20″ tall and tapers from a diameter of about 14″ at the top to a little over 11″ at the bottom. It comes in three colors: beige, turquoise, and yellow. The material is sufficiently soft so that undesirable resonances are avoided, yet firm enough to easily support the heaviest 8″ speaker.

The general idea is to place the wastebasket on the floor, upside down, and mount the speaker in the bottom. To prepare the basket, first determine the actual diameter of the speaker cone (it will be about 7″), then adjust your drawing compass to half that amount—the radius—and draw a circle on the bottom of the basket. Be sure the pivot of the compass is in the exact center. Now, using a penknife, cut the opening for the speaker following the line as closely as possible, but don't worry about minor irregularities since the edge will not show. Punch the mounting holes using



Turn the wastebasket upside down and cut out a hole to pass the frame, but not the rim of the 8-inch speaker. Holes in bottom of inverted basket are ports to release back pressure. Dress the enclosure up with a decorative grille (shown in right hand photo).



the speaker itself as a template; a paper punch or any sharp, pointed instrument will do the job.

Using the Enclosure. Connect the speaker leads to your amplifier, and sit back and listen to a familiar record. You will find the upward firing arrangement quite desirable, for the sound spreads out in all directions—obscuring the fact that you are listening to a small 8″ speaker. Use of a pair of them imparts an amazing stereo effect, totally eliminating any "hole-in-the-middle."

A decided improvement in bass response will be observed if the enclosure is supported about two inches above the floor. But instead of rigging up an elaborate support, the same effect can be had by cutting six or eight equally spaced 2″ holes around the circumference of what now serves as the bottom of the enclosure (originally the top of the basket). Keep the holes as close to the bottom as possible, using a tape measure and drawing compass for layout and a penknife for cutting as before. This time, however, take pains to make your cuts as clean as possible, since they will not benefit from concealment as does the big opening for the speaker. Very fine sandpaper can be used to smooth off the edges.

You can also install a suitable protective and decorative cover for the speaker if you are willing to exceed your 99¢ budget. Radio stores have grilles for wall or ceiling installations that will do nicely. However, be sure the one you select has an overall diameter not exceeding 10½″, so that it will fit the basket properly. (Electro-Products' #SG-8CO, among others, makes a good fit and is attractive as well). Four pan-head machine screws, washers, and nuts secure the works.

Bearing testimony to the value of the finished product as both a unique, attractive conversation piece and an acoustical device of commendable performance, the author's dentist extracted his two SK-128 speakers from their factory enclosures and put them into a pair of the 99¢ wastebaskets. -30-

HI-FI À GO-GO LAMPS

(*Continued from page* 104)

container. All you have to do is replace the rectifier module and SCR with models rated to handle the increased wattage. The accompanying table lists components needed for 200, 600, 1000, and 2000 watts. Cost of *SCR1* and rectifier for 200 and 600 watts runs a little over four bucks. But for 1000 watts it jumps up to about $7, and for 2000 watts, $8.50.

MODIFICATION TABLE FOR MORE POWER

Power Level (watts)	Rectifier Module	Heat Sink?	SCR1	Heat Sink?
200	1.5 amp. Motorola MDA942-3	No	2.0 amp. RCA 2N3528	No
600	6.0 amp. Motorola MR1032B (4 req'd.)	No	5.0 amp. RCA 2N3228	Yes
1000	10 amp. Motorola MDA962-3	No	8.0 amp. Motorola MCR1305-4	Yes
2000	18 amp. Varo Inc. 1N4436	Yes	18 amp. Motorola MCR808-4	Yes

How To Use It. There are many ways in which you might use the *À Go-Go* lamps. For instance, to make stereo listening fun to watch, you can install an *À Go-Go* in each channel. In the right channel use four red and two green 25-watt bulbs; in the left channel use four yellow and two green ones. Arrange all the lamps in a row in a reflective enclosure (crumbled aluminum foil will do) or behind a translucent screen. The green lamps should be in the middle, the red on the right, and the yellow on the left.

Audio signals for the *À Go-Go* can be taken directly from the speaker leads. If the sound is too loud for the amount of light you want, try a lower impedance tap on the amplifier or add a resistor of 5 to 200 ohms in series with the unit's input and the amplifier. —30—

CHAPTER

5

COMMUNICATIONS SWL CB HAM

Editors often have the feeling that they are making a strong case for a particular story, or project, that they "know" should attract widespread attention. When the project doesn't catch fire, three questions come to mind: was it a bad guess by the Editor, wasn't the story sufficiently detailed, or did the project pass unnoticed? We are convinced that Chuck Caringella's story on page 121 passed unnoticed—though there is every reason in the world why it shouldn't.

In Chuck's story—it's really too simple to be called a full-fledged construction project—he shows how any ham, SWL, or CB'er with a receiver having a 455-kHz i.f. strip can make a vast improvement in receiver selectivity. This is no gimmicky device, for the mechanical filter was developed about 15 years ago by one of the topnotch communications equipment manufacturers—the Collins Radio Company. We urge you to read how simple it is to add a mechanical filter to your present receiver; then go ahead and try it. When you do, you'll be in for a surprise.

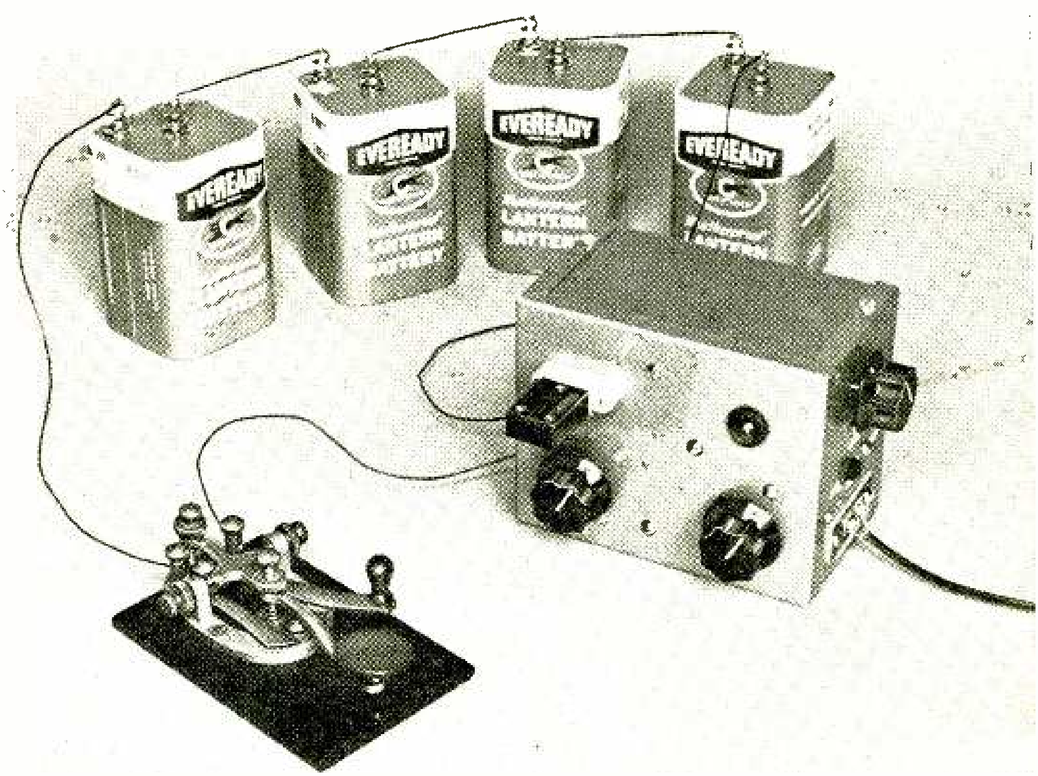
THE CAMPER'S SPECIAL

By HARTLAND B. SMITH
W8VVD

Battery-operated 80-meter CW transmitter for use in the field, or as a standby back in the shack, can be built for less than $10.00

INEXPENSIVE medium-power r.f. transistors make it possible to construct a low-cost but effective dry-battery-powered c.w. transmitter. The "Camper's Special" is a 3.5-mc. portable rig with an input rating of almost 5 watts, yet it can be built for less than $10, plus batteries, key, and crystal. Operating expense is insignificant, running in the neighborhood of three cents per hour when ordinary lantern batteries are used as a power source.

While the transmitter is especially well suited to operate miles from a conventional power source, it also is a worthwhile addition to the shack of the conscientious ham who has been searching for a simple rig for emergency backup. Its signal is strong enough to provide reception of solid copy at a distance of 20 miles or more on ground wave, and up to 1000 miles when skip conditions are optimum. Keep in mind that a 5-watter is only two S-units weaker than a 100-watter. Performance, if the QRM isn't excessive, can be surprisingly good.



How It Works. Resistors *R1* and *R2* form a voltage divider to provide a small amount of forward bias for the base of *Q1*. Current flows in the emitter-collector circuit and through *L1* when the key is closed. The application of power causes the crystal to vibrate at its resonant frequency and varies the emitter bias at an r.f. rate. If *L1* and *C1* are now resonated near the crystal frequency and *Q1* amplifies sufficiently to overcome circuit losses, the stage will go into sustained oscillation.

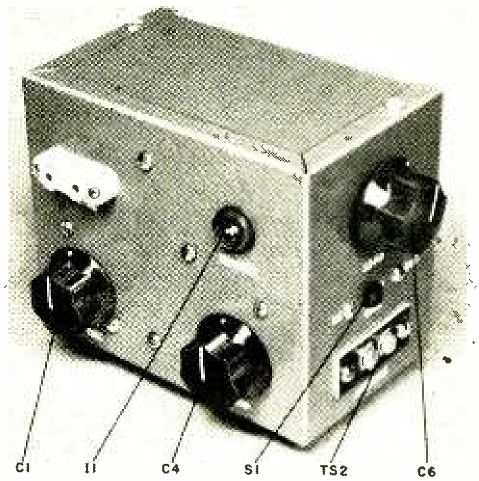
Capacitor *C3* couples the signal from *Q1* to *Q2*. Transistor *Q2* and its tank circuit (*L2* and *C4*) amplify the signal. Resonant tank circuit *L3, C6* picks off the signal and couples it to the antenna. This is a basic master oscillator, power amplifier (MOPA) configuration.

A tap on *L3* matches the low impedance of the antenna feed line to the high impedance of the tank. When *S1* is open, current flowing to the antenna passes through pilot light *I1*, which serves as a relative indicator of transmitter tuning and power output. Tune all stages for maximum brightness. Keep the switch closed when on the air.

Construction. The larger half of a 5″ x 4″ x 3″ Minibox is both chassis and front panel for the transmitter. Since lead length and parts layout aren't overly critical on the 80-meter band, you needn't worry about precisely duplicating the component arrangement. As long as your version resembles the prototype, it should perform satisfactorily.

In order to save both space and money, mica trimmer capacitors are used for *C1*, *C4* and *C6*. Mount these capacitors behind 3/8″ holes drilled in the Minibox cover. Note that one trimmer terminal is fastened to the plate which is directly beneath the adjusting screw in each case; fasten this terminal to a grounded solder lug. Support the other terminal on a one-terminal insulated tie strip. If you don't like to do your tuning with a screwdriver, solder 3/4″ lengths of 1/4″ brass shafting, salvaged from old volume controls, to the capacitor adjusting screws.

Larger half of box serves both as chassis and front panel. Shafts mounted on capacitors C1 and C4 accommodate knobs to eliminate screwdriver tuning.



Then you can put knobs on the shafts, as shown. A large soldering iron is needed for this particular job. Don't let excess solder dribble down and short out the trimmer plates or damage the mica insulation.

No socket is required for *I1*. Merely press the bulb into a ⅜" grommet and solder leads from *S1* directly to the base and tip.

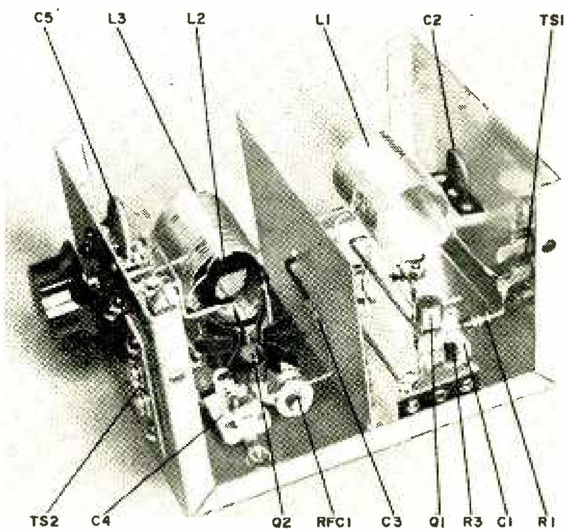
Cover *L2* with a layer of plastic electrical tape and slide it part way into *L3*. The exact position of the coil will be determined later when the transmitter is adjusted. As you wire the coils, make sure that the collector end of *L2* and the ground end of *L3* are nearest *Q2*. This arrangement minimizes capacitive coupling, thus keeping harmonic radiation at a minimum. Put spaghetti over the lead at the *C5* end of *L2*. Thread this wire through the center of the coil and then run it over to the capacitor.

Since the transistor cases are 24 volts above ground, be certain that the fins on *Q2*'s heat sink do not contact nearby uninsulated objects. Bend the fins near *TS2* and the edge of the chassis at right angles so that there will be no chance of them shorting out the batteries. For the same reason, position *Q1* where it will clear the side of the assembled Minibox.

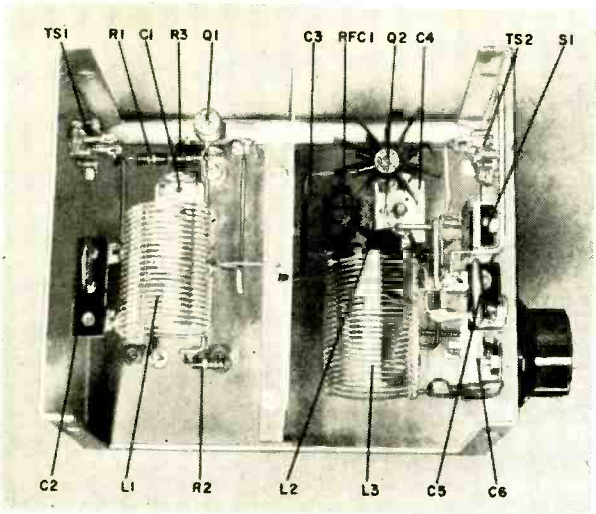
Before plugging the transistors into their respective sockets, trim the leads to a length of ⅜". Grip the wires tightly with a pair of long-nosed pliers, close to the transistor body, to take up the mechanical shock that results from the snipping action. Failure to do this can sometimes fracture the silicon wafer inside the transistor.

PARTS LIST

B1—Four 6-volt lantern batteries in series
C1, C4, C6—80-480 pf. mica trimmer capacitor
C2, C5—0.01-µf. ceramic disc capacitor
C3—100-pf. ceramic disc capacitor
I1—#47 pilot light
L1—22 turns of #20 wire, 1" diameter x 1⅜" long, tapped 11 turns from C2 end (B. & W. 3015 Miniductor, or equivalent)
L2—14½ turns of #24 wire, ¾" diameter x ½" long—see text (B. & W. 3012 Miniductor or equivalent)
L3—23 turns of #20 wire, 1" diameter x 1⅜" long, tapped 7 turns from ground end (B. & W. 3015 Miniductor, or equivalent)
Q1, Q2—2N3053 transistor
R1—82,000-ohm, ½-watt resistor



Center shield isolates oscillator from amplifier. Coil L2 is suspended inside L3 and cemented in place after it has been tuned for maximum output.



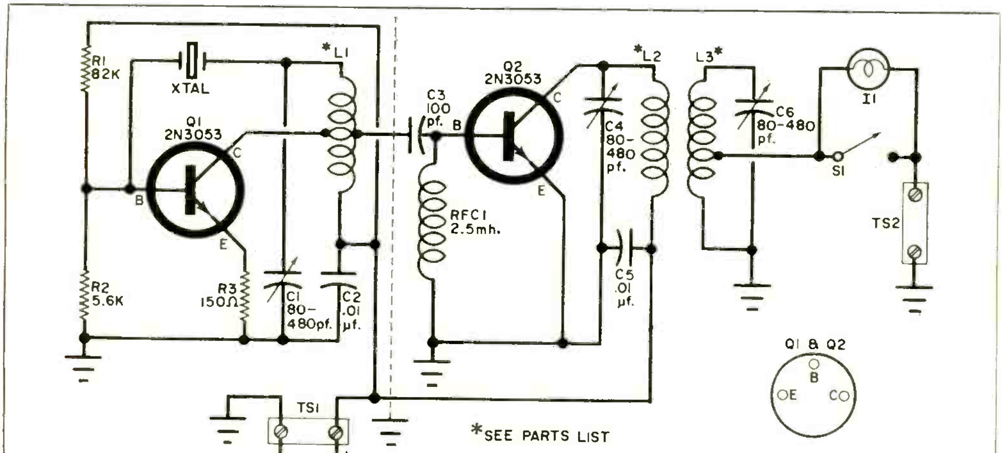
Bend fins on Q2's heat sink to avoid contact with cabinet and leads. For best results, locate components as shown. Lead dress is not too critical.

R2—5600-ohm, ½-watt resistor
R3—150-ohm, ½-watt resistor
RFC1—2.5-mh. r.f. choke
S1—S.p.s.t. slide switch
TS1, TS2—Two-screw terminal strip
KEY—Telegraph key
XTAL—3.5- to 3.8-mc. quartz transmitting crystal
1—5" x 4" x 3" Minibox (Bud CU-2105-A, or equivalent)
1—Transistor heat sink (Wakefield Engrg. NF-209)
Misc.—Knobs (3), crystal socket, 2¾" x 3¾" shield (aluminum or tin), 1-terminal insulated tie points (4), 2-terminal insulated tie points (2), transistor sockets (2), grommet, solder lugs, machine screws and nuts, wire, solder, spaghetti, etc.

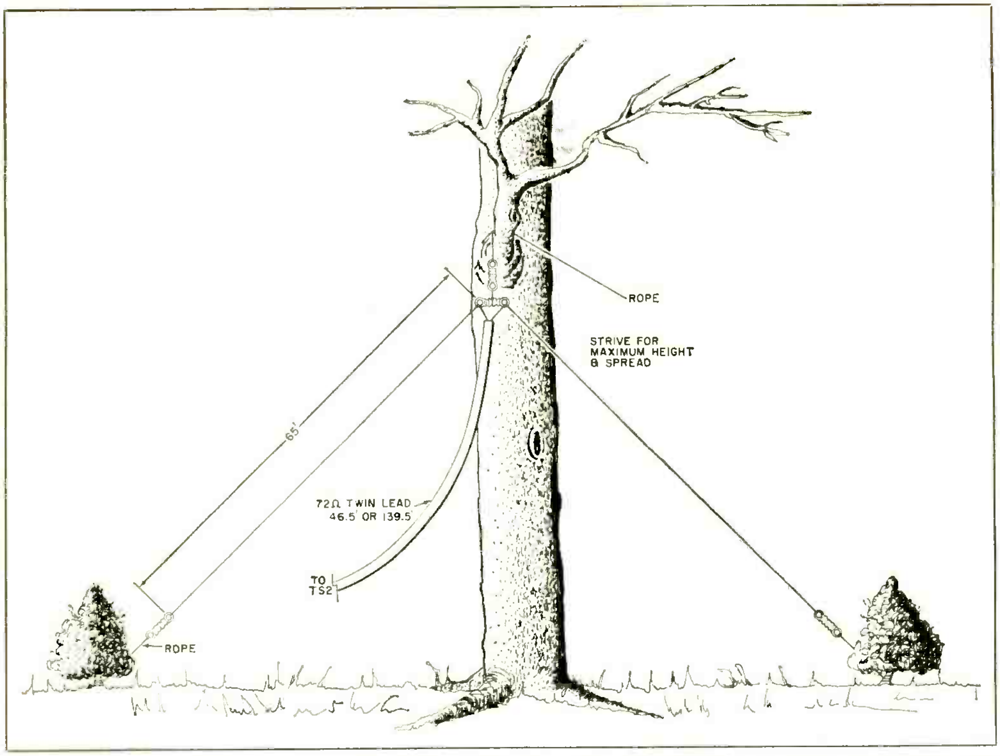
A 2¾" x 3¾" metal shield with a ¼" mounting flange isolates the amplifier from the oscillator stage. Either thin aluminum or coffee can tin may be used for the purpose. Drill a small hole near the center of the shield to pass the spaghetti-covered lead of *C3*.

Precautions: The amplifier transistor generates quite a bit of heat during normal operation. Consequently, never use the rig unless a heat sink is slipped over *Q2*, and don't hold the key down for more than 15 seconds at a time while tuning up. Watch the battery polarity, too; accidentally reversing the battery leads can destroy the transistors.

Adjustment. Connect a 100-ohm, 1-watt composition resistor across the terminals of *TS2* to act as a dummy antenna. Attach a key and battery to *TS1*. Set *C1* at low capacity and tighten down *C4* and *C6*. Then open *S1*. Tune your receiver to



Transistor Q2 amplifies the output of Q1, which acts as a crystal-controlled master oscillator. All coils, with the possible exception of L1, are tuned for maximum output. If the oscillator does not "start" reliably, detune L1 slightly.



Sling the center of the antenna over the highest limb of a tree, and spread it as much as possible. The more horizontal the line, the better. Radiation angle is north and south if the wire runs east and west.

the crystal frequency, and depress key.

Slowly tighten *C1* until the oscillator can be heard in the receiver. Do not advance *C1* beyond the point where consistent oscillation occurs each time the key is pushed. Adjust *C4* and *C6* for maximum volume on the receiver. By now, *I1* should start to glow. Slide *L2* in and out of *L3*, while adjusting *C4* and *C6* for the brightest indication. Then cement *L2* in place.

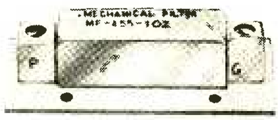
A milliammeter temporarily connected in series with the key should read somewhere between 175 and 225 ma. with both transistors plugged in. Removal of *Q2* should drop the reading to 10 or 15 ma.

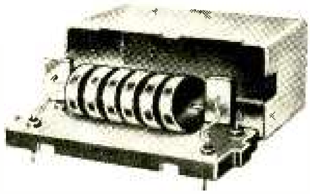
Now remove the dummy load and hook up the regular antenna. Stick to the specified dimensions. Do not attempt to use a random length of end-fed wire, as it will load the transmitter incorrectly and will radiate a very poor signal. The most important part of the antenna is its center so far as height is concerned. Consequently, as long as you have the center at least 30 feet off the ground, you can tie the ends to any convenient tree or bush.

If possible, use a 46½-foot feeder, rather than a 139½-footer. In either case, however, do not coil up the excess line. Instead, let it "meander" back and forth on its way to the transmitter with no sharp bends.

Operation. Working with low power on a crowded band requires a certain amount of skill. When arranging schedules with stations back home, try to choose a time when conditions are optimum between the two locations. If skeds are impractical, pick a net frequency where the gang has been previously alerted to listen for your signals.

During random operation, don't bother to call CQ. Wait for a strong station to come on the air within 3 or 4 kc. of your frequency and then tap out a reply. With a little patience, and operating know-how, you'll be surprised and pleased at the number of QSO's that the Camper's Special will produce. —30—





SUPER SELECTIVITY FOR YOUR RECEIVER

By CHARLES CARINGELLA
W6NJV

Mechanical filter sharpens bandwidth for optimum reception of AM, CW, and SSB

IF your receiver or transceiver employs a 455-kc. i.f. strip, sharp selectivity can be achieved by substituting a recently introduced mechanical filter (Lafayette 99 K 0123) for the first i.f. transformer to help you cope with today's crowded radio bands. Several important advantages make this installation highly desirable.

Steep skirt selectivity makes it possible to overcome the masking effects of strong or local signals as little as 5 kc. away. Once the filter is installed, it doesn't need to be adjusted while the receiver is in operation. No objectionable effects such as ringing or hollow sounds commonly associated with crystal filters are present. The filter can be installed in most vacuum-tube-type amateur, commercial, or CB equipment. Finally, it works well in AM, CW, and SSB receivers.

How It Works. The mechanical filter is basically an electromechanical device. It consists of an input transducer, a resonant mechanical section having several metal discs, and an output transducers, as shown above. Both transducers are crystal types. An electrical signal applied to the input transducer is converted into mechanical vibrations which travel through the resonant mechanical section to the output transducer, where they are reconverted to electrical signals.

The selectivity characteristics of the filter are determined by the resonant metal discs. Each disc is carefully machined to extremely close tolerances to make it vibrate at a desired frequency, such as 455 kc. The discs are made of a ferro-nickel chromium alloy for extreme hardness and resistance to corrosion. Each is supported by—and coupled to the others with—a thin rod. The rod runs the entire length of the filter, and is attached to the transducer at each end. Only those signals within the filter's passband can get through.

Nominal bandpass characteristics of the filter used in this project are shown in Fig. 1. At 6 db down on the response curve, the bandwidth is approximately 2 kc.; and at 60 db down, the bandwidth is approximately 6 kc.

It is natural for mechanically resonant elements, such as metal discs, to have multiple resonances which allow spurious transmissions through the filter at frequencies other than those in the primary passband. By employing conventional type i.f. transformers at the input and output ends of the filter, these spurious signals are attenuated. Signal frequencies of plus or minus 20 kc. from the i.f. (435 kc. and 475 kc.) are cut by a minimum of 40 db. Frequencies above 475 kc. and below 435 kc. are far enough away from the rest of the receiver's passband to be blocked, and thus be of no consequence.

Input and output impedance is 10,000 ohms. Capacitive coupling is required to prevent B+ on the input side from getting to the output side, which is in the grid circuit of the next stage, and to prevent B+ from shorting to ground. In order to minimize the number of connections to the filter, the bottom leads of the windings in both transformers are already connected to the ground foil on the filter's printed circuit board. Only three connections are needed: plate, grid, and ground.

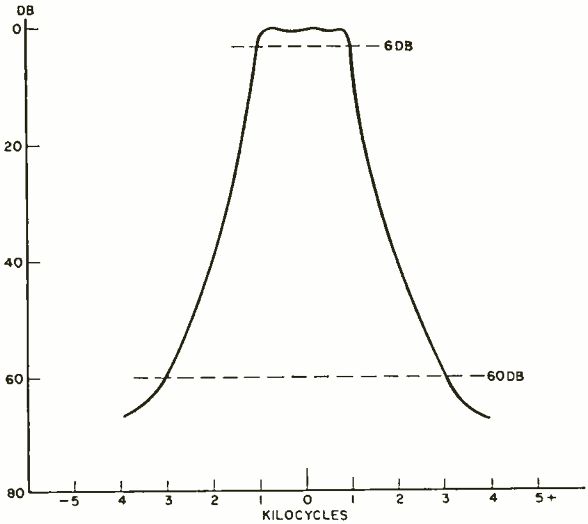


Fig. 1. Bandwidth of 2 kc. at 6 db expands slowly to 6 kc. at 60 db. Steep skirt characteristic makes it possible to separate closely spaced stations.

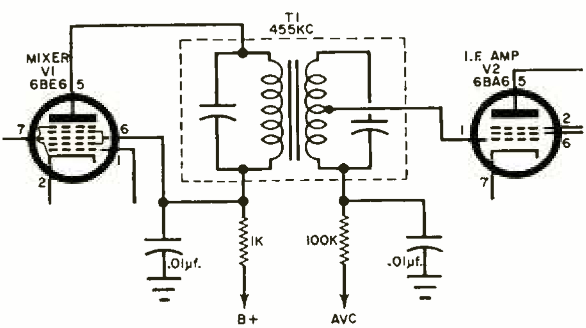


Fig. 2. Typical receiver first i.f. stage before modification. Internal circuitry of transformer can be ignored. However, the frequency of the mechanical filter should be the same as the transformer to be replaced.

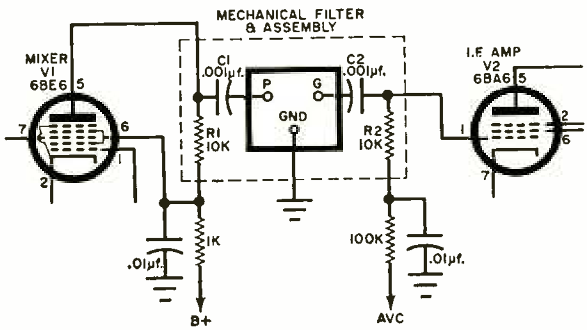


Fig. 3. In addition to the mechanical filter, only two capacitors and two resistors are added (within the dotted lines). Once the filter is installed and the remaining i.f. transformers have been peaked, no further adjustments need be made.

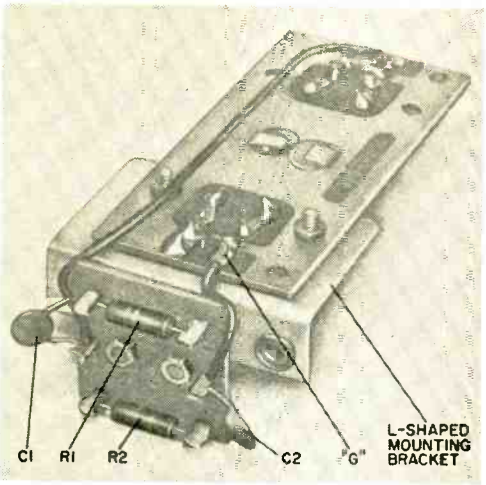


Fig. 4. Mechanical filter and added components are grouped together into a subassembly and mounted in the same manner as the original i.f. transformer.

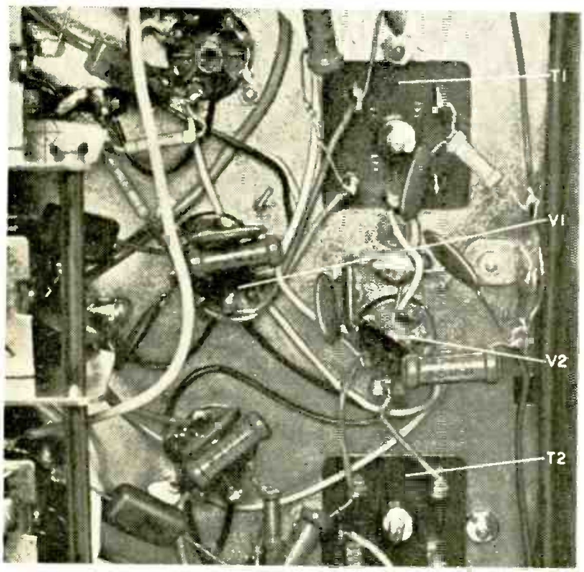


Fig. 5. Bottom view of receiver before the first i.f. transformer (T1) is removed. It is not necessary to disturb any other part of the receiver.

Construction. The only parts you will need, in addition to the mechanical filter, are two 10,000-ohm, ½-watt resistors, (*R1* and *R2*), two 0.001-μf. ceramic disc capacitors (*C1* and *C2*), a 1" x 1" piece of Vectorbord or other suitable material, six push-in terminals, and an L-shaped mounting bracket.

Except for the removal of the first i.f. transformer, all components and connections in your receiver or transceiver remain the same. A typical circuit before modifications is shown in Fig. 2. Variations in component values or in i.f. transformer design in different receivers are not critical and will not adversely affect the installation of the filter. Figure 3 shows the same portion of the receiver after the filter has been installed.

The actual filter and additional components are mounted on a subassembly as shown in Fig. 4. While it is not necessary to shield the filter—its components are already housed in metal cans which have been grounded to the printed circuit board—it *is* necessary to have a good ground connection between the board and the receiver's chassis.

The one-inch-square piece of Vectorbord is bolted to the bottom of the L-

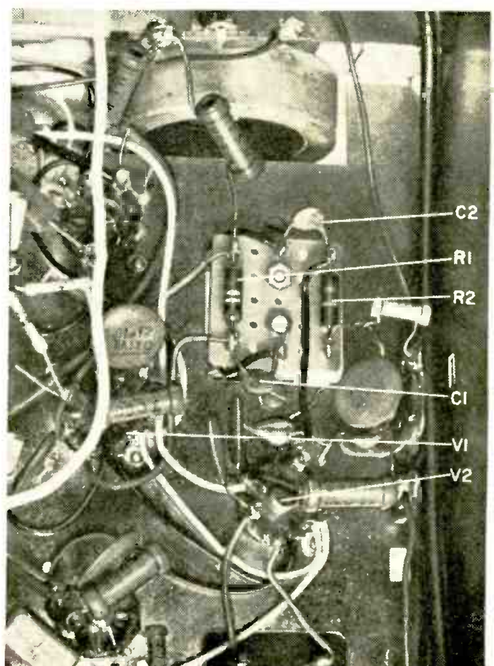


Fig. 6. After the first i.f. transformer is removed, the mechanical filter subassembly is installed, and held in place by two screws. The board should be made small enough to pass through chassis opening.

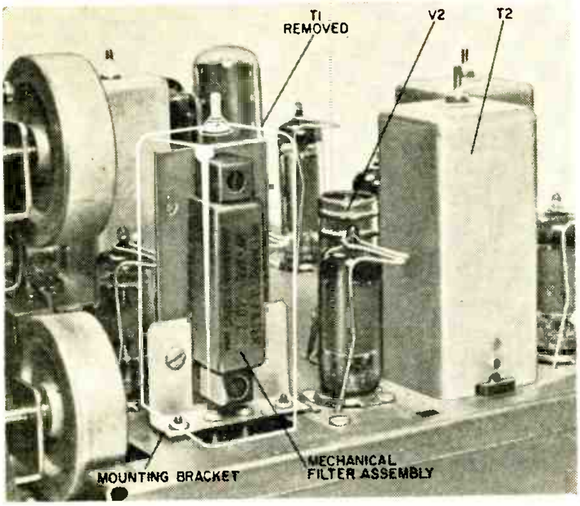
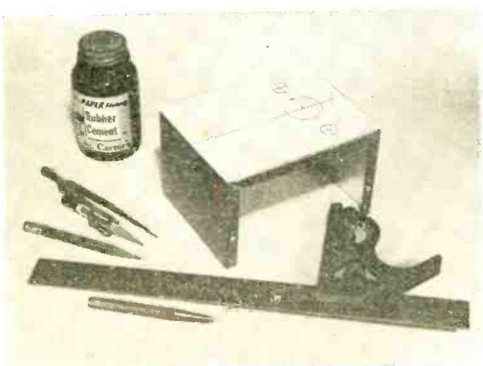


Fig. 7. Above-the-chassis view of mechanical filter mounted in place of T1. Insertion loss is on the order of 1.5 to 3 db.

shaped bracket. Resistors *R1* and *R2* and capacitors *C1* and *C2* are mounted on the board. The push-in terminals serve to hold the components and the connections to the receiver. Before and after photos show how the subassembly is mounted on the chassis. Check to see that the board fits in the chassis opening, to fully seat the bracket.

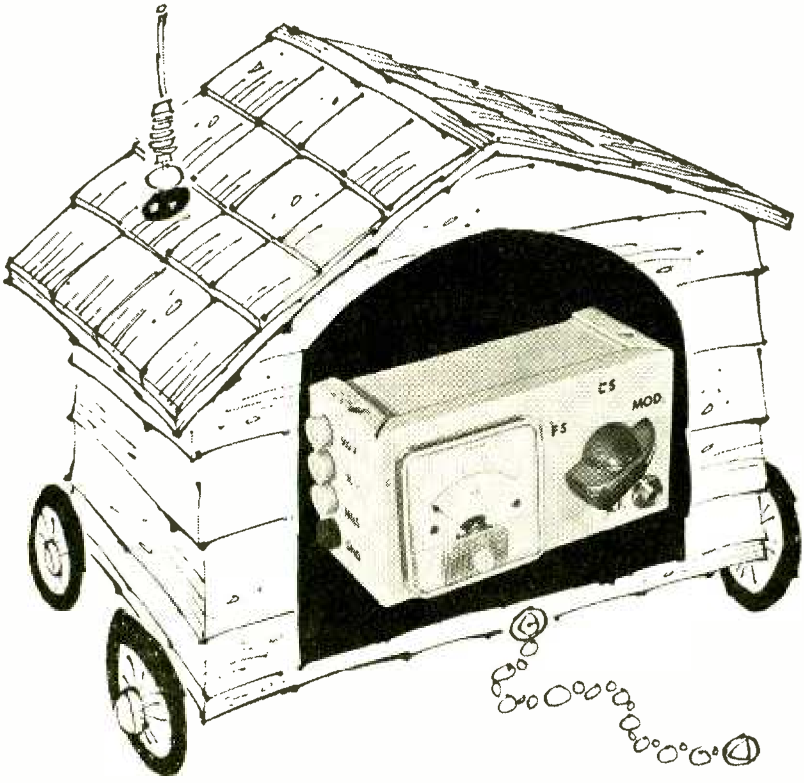
Alignment. Generally, once the filter assembly has been installed, no further alignment is necessary. However, you might try to peak the remaining i.f. transformers in the receiver. Just in case the two transformers on the filter have been diddled with, they too should be aligned for maximum output at the designated intermediate frequency. —30—

CLEAN LAYOUT TECHNIQUE



TO GIVE your finished project that professional look, take care not to damage the painted surface of the cabinet when you locate the various mounting holes. Cut a piece of graph paper to cover the area to be drilled or punched and seal it down temporarily with rubber cement. Then lay out your drilling pattern using a sharp-pointed, soft-lead pencil. Centerpunch hole locations and drill (or punch) through the graph paper. When all machine work—including deburring— is finished, simply peel off the paper pattern. Excess cement can be removed by rubbing the surface with a finger or a soft eraser. The resulting surface should be smooth and clean. If you use decals or painted labels, protect them with two or three coats of clear lacquer or acrylic plastic.

—*E. G. Louis*



"WATCHDOG" MOBILE MONITOR

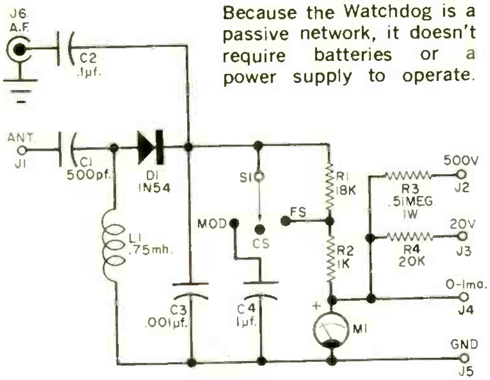
A real watchdog, this miniscule tester functions as a field strength meter, carrier-shift indicator, and modulation checker. The perfect companion piece for your mobile rig, it also measures voltages and current.

By HOWARD BURGESS

THE "WATCHDOG" is a self-contained, unpowered monitor to help you squeeze the last legal milliwatt out of your transmitter. The circuit was designed to enable measurement of relative field strength, determine if carrier shift is taking place, and give an audio check of modulation quality. As a bonus feature, the watchdog can serve as an emergency d.c. voltmeter. If you rush out and buy all new parts, you might be set back about $9, but many—if not most—of the necessary parts are probably right in your junk box.

Construction. Because the greatest value of the *Watchdog* is in mobile operation, the circuit has been squeezed into a 2⅛" x 1⅝" x 4" aluminum box (Premier PMC-1002). A bigger—or even a smaller—aluminum box could be used, depending on the size of the 0-1 ma. meter. A 1¾" square face meter of the imported variety was used. These meters are commonly available and you should have no difficulty in duplicating the exact layout of the parts shown in the accompanying photographs.

Only two parts in the circuit need spe-



Because the Watchdog is a passive network, it doesn't require batteries or a power supply to operate.

PARTS LIST

- C1—500-pf. mica capacitor
- C2—0.1-µf., 200-volt capacitor
- C3—0.001-µf. ceramic disc capacitor
- C4—1-µf. low-voltage capacitor
- D1—1N54 diode
- J1, J2, J3, J4, J5—Phono tip jack
- J6—Miniature phone jack
- L1—0.75-mh. r.f. choke
- M1—0-1 ma. d.c. meter (1¾" square)
- R1—18,000-ohm, ½-watt resistor
- R2—1000-ohm, ½-watt resistor
- R3—0.51-megohm, 1-watt resistor
- R4—20,000-ohm, ½-watt resistor
- S1—Single-pole, 3-position switch
- 1—1⅝" x 2⅛" x 4" aluminum box
- Misc.—Insulated tie point, wire, solder, etc.

cial attention. One of these is silicon diode *D1*, which must be suitable for detector operation up through 30 mc. Capacitor *C3* must be of the low-leakage variety (Mylar-type) and must have a capacity of at least 1.0 µf. The voltage rating of *C3* is not important.

The components built into the circuit for voltage measurements are not an absolute necessity and may be left out if you wish. No effort was made to alter the meter scale; instead, a conversion table was pasted on the back of the box.

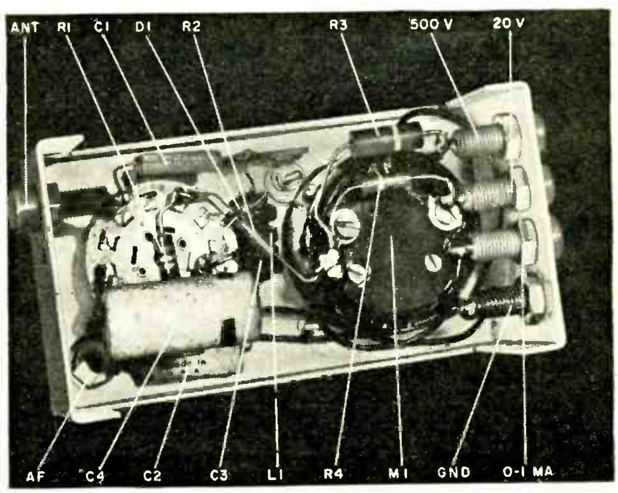
One final construction suggestion: after the case has been drilled and the meter hole cut out—but before the parts are mounted—spray-paint the box to match the interior colors of your car. Spray enamel paints are readily available at all automotive supply stores.

Operation. The *Watchdog* has three operating positions. With switch *S1* in the *FS* position, the watchdog becomes a field strength meter and will indicate the relative carrier level output of your transmitter. A short piece of wire plugged into the antenna jack, *J1*, is more than ample to drive the meter off-scale with even a 5-watt input CB rig. The *Watchdog* requires no tuning and will work on any of the ham bands up through 10 meters. With *S1* in the *FS* position, the *Watchdog* can be used to peak up the pi-network of your transmitter or tune your antenna for maximum efficiency.

When *S1* is in the *CS* position, the "talk power" of your transmitter is being measured, and the circuit has become a linear detector. It will be necessary to close-couple the output of the transmitter to the *Watchdog* by bringing a lead from *J1* close to the transmitter. If the transmitter is well shielded, or very low powered, it may be necessary to place the end of the lead inside the case of the transmitter. The coupling between the *Watchdog* and the transmitter should be arranged so that the meter reads about 0.8 ma. The exact reading is not important—just be sure that the coupling is not too tight to damage the meter.

If the transmitter is properly modulated, the meter should have a slight upward kick for normal voice transmission. The movement of the meter needle should not be more than 10% of the unmodulated (about 0.8 ma.) value. A larger than 10% upward kick indicates overmodulation, and a downward shift says that the transmitter has insufficient drive to the final amplifier.

(*Continued on page* 150)



Parts placement depends on size of meter used. With a very small meter, lay out components as shown.

DUAL-SENSITIVITY FIELD STRENGTH AND ABSORPTION METER

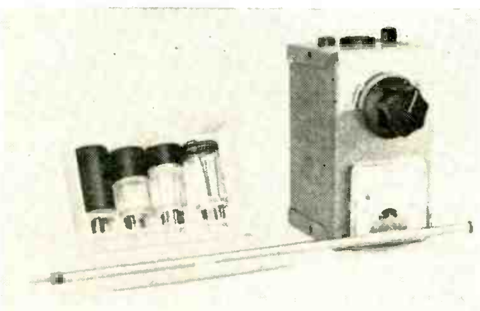
By ROBERT N. TELLEFSEN
W7SMC/Ø

PERHAPS the simplest yet most underestimated item of test equipment found in the ham shack is the absorption meter. It's impossible to calculate the number of hams who have been spared FCC pink tickets for being on the wrong band because they took care to monitor their own frequency. But this is just one of many applications of the field strength and absorption meter, or "wavemeter." It can be used as a neutralization indicator or as a null indicator for adjusting balanced modulators in SSB transmitters. It can also be used to determine if an oscillator circuit is working, and to compare transmitter signal output before and after adjustments are made.

Easy to build, the absorption meter consists of a variable-tuned single transistor amplifier powered by a 1½-volt penlight battery. (It works with and without the battery; with the battery in the circuit, sensitivity increases by a factor of 10.) Resonance is indicated by a front-panel-mounted 0-1 ma. meter. Four plug-in coils are used to cover the 160-meter to 6-meter bands.

Parts cost is less than $8 and it shouldn't take you more than an evening to put the whole thing together.

How It Works. A small amount of r.f. energy is absorbed by tuned circuit *C1*, *L1* when the coil or antenna is placed in the vicinity of an r.f. field. The amount of energy absorbed depends upon the strength of the r.f. field, the extent of coupling of the meter to the field, and the resonant condition of the meter's tuned circuit.



Only four coils are needed to cover the 160- to 6-meter amateur bands. Whip antenna extends effective range of the field strength and absorption meter.

COIL TABLE

160 Meters	
L1 =	140 turns of #32 enameled wire
L2 =	13 turns of #32 enameled wire
80 and 40 Meters	
L1 =	44 turns of #26 enameled wire
L2 =	6 turns of #26 enameled wire
20 and 15 Meters	
L1 =	17½ turns of #22 enameled wire
L2 =	3 turns of #22 enameled wire
10 and 6 Meters	
L1 =	4½ turns of #18 enameled wire
L2 =	1 turn of #22 enameled wire

Use Amphenol 24-5H forms

The r.f. energy in the tuned circuit is coupled to the base of *Q1* by *L2*, and is detected in the base-emitter circuit, as shown in Fig. 1. The greater the signal strength, the higher the meter reading.

Detection and current flow take place even when *S1* is off. By switching *S1* on, the battery is placed into the circuit and permits *Q1* to function as a transistor amplifier instead of just as a diode. Sensitivity goes up because of the transistor's gain characteristic. It takes only 1/10 as much signal to obtain full-scale deflection when the battery is in the circuit.

Construction. A 2¼" x 2¼" x 4" aluminum box (Fig. 2) houses all the components except the plug-in coils and a whip antenna. Parts can be located as shown, or in any other convenient arrangement. However, it is necessary to observe polarity of the meter and battery. A ½"-diameter plastic clamp and a right angle bracket serve as a battery holder. The battery ends should be taped to prevent electrical contact with the sides of the box.

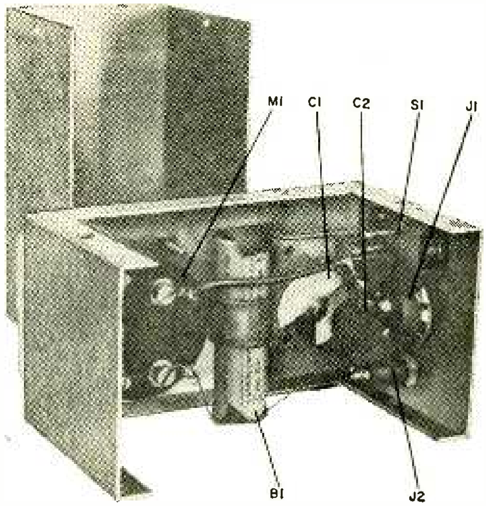


Fig. 2. When mounting components, consider clearance space required for the variable capacitor. Tape battery ends to prevent contact with metal case.

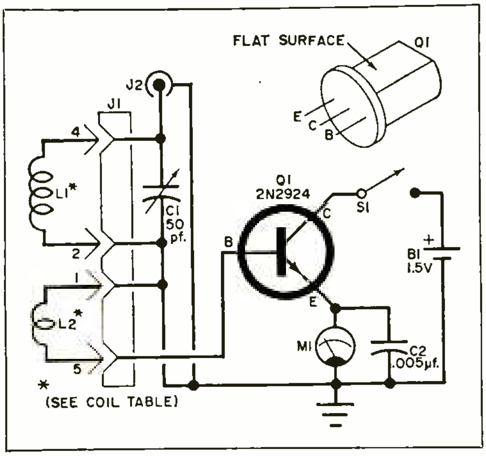


Fig. 1. Base-emitter circuit of Q1 functions as a simple diode detector when battery is not connected; with battery, sensitivity increases tenfold.

PARTS LIST

B1—1.5-volt penlight battery
C1—50-pf. variable capacitor (Hammarlund HF-50 or equivalent)
C2—0.005-µf. disc ceramic capacitor
J1—5-pin miniature socket (Amphenol 78-S5S or equivalent)
J2—Phono tip jack
L1, L2—Plug-in coils (see Coil Table)
M1—0-1 ma. meter
Q1—2N2924 transistor, or equivalent
S1—S.p.s.t. slide switch
1—2¼" x 2¼" x 4" aluminum box (Bud CU-2103A or equivalent)
Misc.—5-prong polystyrene plug-in coil forms (4), knob, solder, etc.

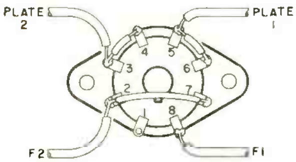
Since the transistor leads are soldered into place, be sure to heat-sink the leads when soldering. Wind the four coils on ¾"-diameter polystyrene plug-in coil forms using the data in the coil table. Avoid overheating the coil pins, as the plastic melts easily.

Calibration and Use. Calibrate the absorption meter with a signal generator or grid dip oscillator. Plug in the appropriate coil, loosely couple the absorption meter to the signal source and rotate the variable capacitor to obtain a maximum meter reading. Then mark the dial scale. By selecting frequencies at the top and bottom ends of the band, you will be able to determine quickly if your transmitter is within legal limits. The purpose of the absorption meter, in this case, is to spot the band rather than an exact frequency within the band.

You can make a dial by cementing a small piece of white paper to the box as shown, and marking it with an ink pen. Low meter readings can be raised by switching in the battery, or by increasing the coupling, or both. Signal pickup can be through the plug-in coil, or from the whip antenna when it is plugged in. -30-

REWIRE RECTIFIER SOCKETS FOR QUICK TUBE SUBSTITUTION

The rectifier tube sockets in your power supply can be modified to accommodate different tubes by wiring them as shown in the diagram.



Be careful not to exceed transformer and tube ratings when substituting tubes. The tubes that can be used include: the 5AR4, 5AS4, 5AT4, 5AU4, 5AW4, 5AX4, 5AZ4, 5CG4, 5R4, 5T4, 5U4, 5V3, 5V4, 5W4, 5X4, 5Y3, 5Y4, 5Z4, 5931, 6087, and 6106. *—Jim Vasbinder*

TOOLBOX GIMMICK HAS 1001 USES

This handy gimmick for your toolbox can replace a fuse holder, hold a cartridge rectifier, connect an antenna lead-in to a TV set, and

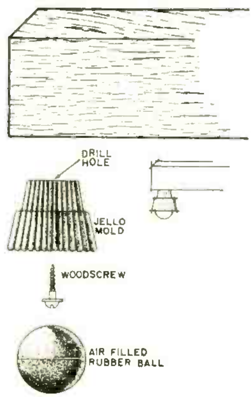
serve as a heat sink or as a third hand for soldering. It can even be used to hold construction notes or a schematic near a project being worked on. The gimmick is made with two clips and a small (3-4) terminal strip. To secure the clips to the strip, remove the fastening screws from the clips and pass them through two terminals. Hold the clips in place while you tighten the screws. You can attach a couple of leads to the screws and install a similar gimmick or separate clips on the other end of the wire to serve as a jumper or "quickee" patch cord. *—Albert Koehler*

ADJUSTABLE RESISTOR KEEPS MODEL RACER ON TRACK

Racing model cars has become a popular indoor sport for grown-ups as well as for the kids, but Pop usually winds up repeatedly replacing cars that Junior lets fly end over end as he cranks the rheostat control to full throttle. Such "accidents" can be prevented by inserting a 20-ohm, 10-watt, variable-tap resistor in series with the rheostat, thus limiting the speed of the car. The resistor is adjusted to keep the racer on the track at full throttle. A switch connected in parallel with the resistor will eliminate it from the circuit if Pop and his friends want to get down to some serious racing. *—Ken Greenberg*

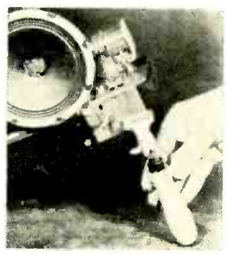
GELATIN MOLDS AND RUBBER BALLS SHOCK-MOUNT HI-FI EQUIPMENT

Make use of several homemade air suspension mounts to isolate your record player or other hi-fi equipment from annoying vibrations — particularly those which travel along the floor and hi-fi furniture. Each mount consists of a small gelatin mold, a woodscrew, a washer, and an air-filled rubber ball just large enough to fit into the wide end of the mold. Drill a hole in the bottom of the mold just large enough to accommodate the screw. Place washer between the screw head and mold, and screw the mold into



place on a side of the base. Then cement the rubber ball in place inside the mold. If the sides of the base are too thin to hold the screws, you can build up the cabinet with a block of wood. *—Harry Goldman*

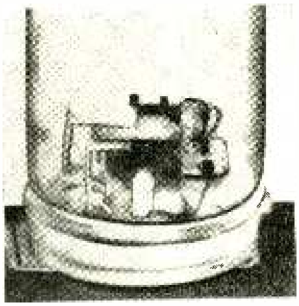
HAND VISE "FOOTS" CHASSIS ON THE BENCH



A small hand vise can be used to support a radio, amplifier or TV chassis in almost any convenient position, to facilitate assembling or servicing. If more "feet" are needed, two or more vises can be employed. Three or four vises will support a record changer and enable you to observe the action both above and below the deck. *—H. Leeper*

RELAY GATHERING DUST? BOTTLE IT UP FOR PROTECTION

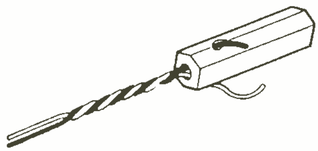
Relays that must be used in dusty locations are subject to failures resulting from dirty contacts. To prevent such failures, enclose your relay in an airtight housing. Suitable housings can be made from a variety of containers such as screw cap jars, coffee cans with plastic snap-on covers, or for the really small relay, small vials. The lid, or cap, of the container with relay attached is mounted on the chassis, and the wiring for the relay is run through a hole in the cap which is then sealed. Finally, the container is screwed or snapped onto the cap to effectively seal the relay against dust.



—*Wm. B. Rasmussen*

TWISTED PAIRS COME EASY USING A HOMEMADE DIE

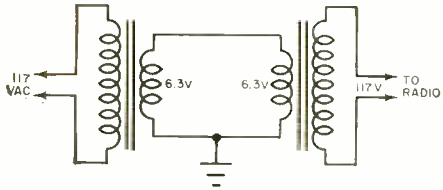
Here's a way to make professional-looking twisted pairs which are often used in wiring filament and a.c. circuits to minimize radiation or pickup of stray signals, hum, noise, etc. Obtain a short brass rod about ¼" in diameter and drill three holes in it as shown in the diagram. Hole size depends on the gauge of the wire you intend to twist; side holes should be drilled at angles of less than 45° for best results. To use, simply insert the two wires in the side holes and pull them from the center hole. Connect one end of the wires to be twisted in a vise and place the die in a hand drill. Then simply rotate the drill and work the die along wires until the lengths of wire are properly twisted.



—*Roman A. Scheidel*

ISOLATED LINE VOLTAGE FROM FILAMENT TRANSFORMERS

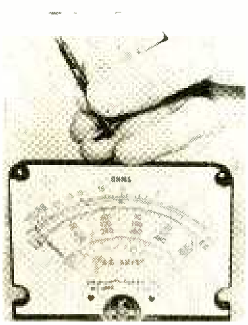
Experimenters are well aware of the dangers of a hot chassis, such as the a.c./d.c. radios and the transformerless TV sets. Besides shock hazard, test equipment can be damaged when you're working on a hot chassis that isn't isolated. Two 6.3-volt transformers can be connected back-to-back to do the work of a 1 to 1 isolation-type transformer, as shown in the diagram. A certain amount of noise filtering is also realized from this type



of hookup. But don't drive any equipment which requires more wattage than the lowest watt-rated winding. The transformer case and one side of the low-voltage windings can be grounded; however, the hookup will work satisfactorily without the ground connection.

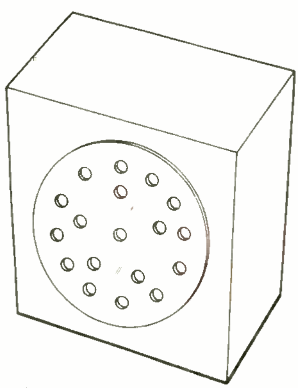
—*Robert B. Kuehn*

FILM SPOOL MAKES SAFE METER ADJUSTMENT TOOL



When it is necessary to straighten indicating meter pointers or to make slight adjustments of meter springs, a delicate tool and a delicate touch are required to avoid damage to moving parts. An empty camera film spool, with one flange removed and the tips which held the flange filed down, will do the job; the slot in the spool shaft fits over the meter pointer. A second spool can be used to hold the pointer near the coil or at any other suitable location. —*H. Leeper*

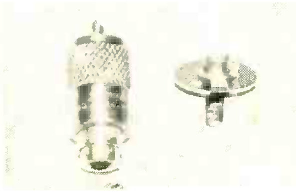
SINK-DRAIN STRAINER PROTECTS SMALL SPEAKER



Small perforated sink drain strainers — the type found at corner hardware shops — make excellent protective grilles for small speakers. Chrome-plated and convex in shape, they come in many sizes and sell for about 25 cents each. To install one, glue it in place with a few drops of epoxy cement. —*Henry R. Rosenblatt*

HYBRID ADAPTER PATCHES PHONO PLUG TO COAX CONNECTOR

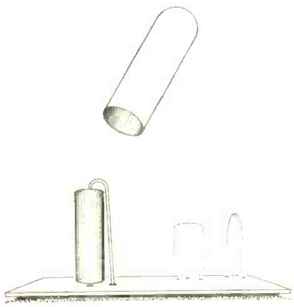
Phono plug connections can be made directly to equipment having coaxial terminals of the SO-139 type, thus avoiding hum and stray r.f. pickup from exposed leads. The necessary adapter is constructed from a Cinch-Jones 81A or Switchcraft 3501F phono jack, and an Amphenol PL-259 coaxial plug. Straighten the lugs of the phono jack and remove the fiber base. Grind the base down to a diameter of ½" and remount it—but leave the lugs extended. Then solder a 2" wire to the jack's center lug and cover with protective tubing. Insert the wire into the plug's center connection and solder. Finally, bend the outer shell and solder. Be sure not to short out the inner connections to the shell. —*F. W. Chesson*



HEAT-SHRINKABLE PLASTIC COVERS COMPONENTS COMPLETELY

We often run the risk of short circuits for the sake of miniaturization. For instance, when mounting a capacitor or resistor on a printed circuit board, it's a common practice to bend the lead parallel to the component and mount the component standing erect. A real space-saver—but that long lead is a potential troublemaker! One neat way of preventing a short is to cover the component and the lead with a plastic "Fit-Cap," such as manufactured by the Alpha Wire Co., and apply a bit of heat. The shrinkable plastic reduces in size, grips and insulates the component.

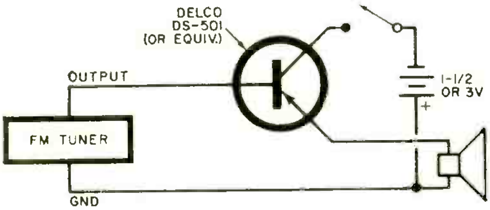
—*Byron G. Wels, K2AVB*



SINGLE-TRANSISTOR AUDIO MONITOR

Designed for low-level monitoring of tuners and tape decks whose output signal requires an external amplifier to be heard, this

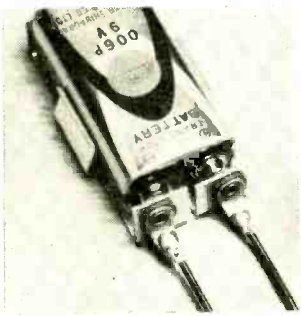
simple "audio monitor" doesn't provide much gain, but will match an 8-ohm speaker to the program source. A power transistor is used in an emitter follower circuit as



shown. The amplifier runs on a 1.5- to 3-volt battery and no heat sink is necessary. —*Carl Dunant*

TRANSISTOR BATTERY HOLDER MADE FROM TWIN PENLIGHT CLIPS

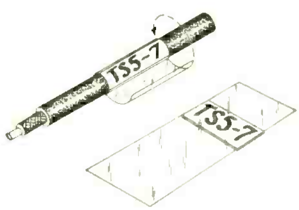
You can easily construct a holder to accommodate the popular 9-volt transistor battery by modifying a twin AA holder. With just a pair of pliers, bend and break off the inside prongs of the holder's U-clips to make room for the larger battery. Then bend the outside prongs inward so they can get a good



grip on the battery. When inserting the battery in the holder, be careful not to short the terminals against the frame of the holder. —*Art Trauffer*

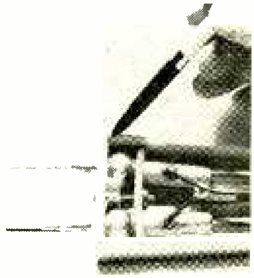
"MAGIC" TAPE MARKS CABLES LIKE MAGIC

A professional-looking lead or cable marker can be made with Scotch "Magic" tape. You just print the desired information on the tape using almost any medium and wrap it around the cable. For durability, the tape should be long enough to cover the printing a couple of times when wrapped around the cable. Better contrast can be obtained by sticking a small strip of paper on the tape behind the printing. —*Don E. Watson*



BEEF UP THOSE FLOPPY RABBIT-EAR ANTENNAS

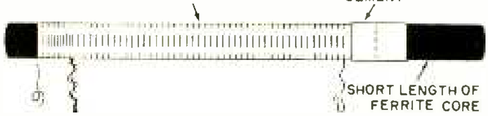
If the small swivel balls inside of the telescoping-type antenna mounted on the rear of your TV set should break through the plastic case, you can put them back in place with two small metal strips. Drill a 1/8" hole in each strip to allow the antenna sections to pass through, shape the strips with tin snips to fit inside the case, and insert them between the swivel balls and the top of the case as shown. Make the center screw just snug enough to provide sufficient friction to hold the antenna elements at any desired angle when they are fully extended.



—*Homer L. Davidson*

USE FERRITE CORE RODS TO BOLSTER INDUCTANCE

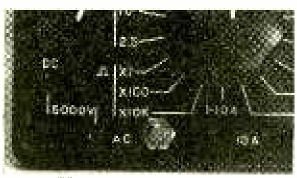
Say you've just wound a coil, soldered it into a circuit, and find you need more inductance. What do you do? Just insert a short length of ferrite core into the coil form. Then adjust it for the correct inductance and cement it in place. The same technique can be used if you need a few extra turns of wire on a ferrite core. Simply tape or cement a short length of ferrite core to the coil end as shown; this will have the same effect as adding more turns to the coil.



—*Art Trauffer*

ADD PUSH-BUTTON ZEROING TO YOUR OHMMETER

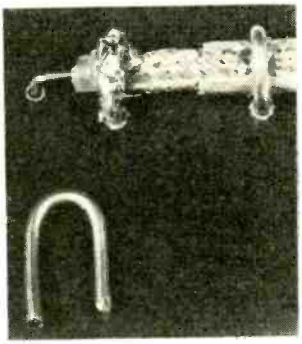
You can add an instant zeroing feature to your ohmmeter by inserting a push-button s.p.s.t. switch in the ohms or positive input line to the range selector of the meter. Break the existing line going to the input jack and connect the normally closed contacts across the break, with the fixed pole toward the jack and the movable throw toward the meter. Wire the normally open



contact to the common input line. Depressing the button will now short both input terminals of the meter and enable you to set the ohms-adjust control to obtain a zero reading without having to remove the test leads from the circuit under test. —*Stanley E. Bammel*

U-SHAPED CLAMPS HOLD COAX TO CIRCUIT BOARD

To connect a coaxial cable to a printed circuit board securely, form two U-shaped clamps of heavy-gauge wire. Make one U-clamp wide enough to fit snugly over the insulation; make the other one slightly narrower to hold and connect the braid. Position the coaxial cable and drill five holes in the board as shown. Then insert the cable and clamps, and solder the clamp in contact with the braid to the braid and to the circuit board. —*Don Lancaster*



PULSE POWER PACK

(*Continued from page* 50)

different color wire for each lead to avoid confusion. It's also a good idea to lace the wires as shown, to facilitate mounting and removal of the circuit board.

As a final word, observe that the two 1" standoffs are secured with the bottom screws of the power transistors. If you happen to use metal standoffs, do not let them come in contact with any of the components on the circuit board. If you can get non-metallic standoffs, you should do so.

Operation. After you have completed the wiring, check out the unit thoroughly before plugging it in, and thus save yourself from a possible headache later on. Connect the output jacks (*J3* and *J4*) to the tracks (at this point polarity doesn't matter).

Before turning the power switch *on*, set the *CRAWL* switch (*S2*) to the *off* position, and flip the *DIRECTION* switch (*S4*) to *FWD*. Also, turn the *THROTTLE* control fully counterclockwise but without turning off the switch that's ganged to it (you will hear a distinct "click" if the switch is turned off).

Now, flip the *PWR* switch to *on*. If the trains move at all, *R13* is too high in value and must be reduced. Successively try a smaller resistor (reduce the resistance by about 10% in each step) in place of *R13* until you find one that will just cause the train to stand still. When you do, leave that resistor in. Slowly rotate the *THROTTLE* clockwise; the train should start up and run forward. If it runs backwards, simply reverse the leads to the tracks.

Turn the throttle counterclockwise, but without flipping *S3* off. Then turn the *CRAWL ADJ* knob fully counterclockwise and flip *CRAWL* switch *S2* to *on*. Your train might growl a little but it should not move. Now slowly rotate the *CRAWL ADJ* knob clockwise until the train begins to crawl real nice and slow. As you give it some throttle, your train will increase in speed realistically—as if it were coming out of Grand Central Station.

Slow down the throttle as you come in to a station and let the train crawl a bit. When you are ready to stop, just rotate the throttle fully counterclockwise until *S3* clicks off for a full stop. With a bit of practice you'll soon be driving your train like the old pros and enjoying many hours of real pleasure. Man, that's railroading! —30—

LUMEMIN STEALS THE SHOW

(*Continued from page* 17)

highest pitched note when it is fully illuminated. Similarly, maximum volume is obtained when the *volume* photocell (*PC2*) is completely in the dark, and minimum volume when it is exposed to the brightest light.

If you happen to be a skilled musician, you should be able to play a recognizable tune with as little as a half-hour's practice. Generally speaking, however, considerable practice, skill, and patience are required to play the Lumemin, as with other musical instruments. Tremolo, vibrato, sliding tone, and similar special effects can be obtained.

Possible Circuit Variations. After using the Lumemin for a while, you may find it desirable to change certain component values to meet your individual playing techniques. As you can see from Fig. 2, the lowest pitched note that can be produced depends on the value of *R1*, while the highest pitched note for a given light intensity depends on the value of *R2*. Therefore, the ratio of these two resistors establishes the basic tonal range of the instrument. With the presently assigned values, the instrument's range is about three octaves, the lowest frequency being about 800 cycles (this will vary with component tolerances).

If you want to drop the lower frequency limit, use a larger value resistor for *R2*. The exact value will have to be determined experimentally. One way to do this is to put a potentiometer in place of the resistor, and adjust it for different effects. Later you can either leave the potentiometer in the circuit at the desired setting, or you can measure the resistance at the desired setting, and substitute an appropriate resistor.

In some cases, it may be necessary to change the value of *R3*. Here a larger value resistor will reduce the output volume, while a smaller value will increase the loudness for a given light level on *PC2*. Values as high as one megohm and as low as 250,000 ohms can be tried.

There seems to be no end to the number of circuit changes you can make. For example, you can arrange a bank of different value resistors for both *R1* and *R2*, and, by means of an appropriate switching circuit, select the best combination for the piece to be played. One other possibility is to combine the Lumemin's circuit with a modular audio amplifier and loudspeaker in a single cabinet as a self-contained instrument. Finally, for more precise performance, you can incorporate a built-in light source by mounting a suitable lamp over the photocells.

Regardless of the final modifications you may wish to make, or even if you use the design as is, the Lumemin can provide you with many exciting hours of music and sheer pleasure. —30—

LI'L DUSKER

(*Continued from page* 54)

and no other room light—shines on it. Add a microswitch across the photocell, and connect the relay so that increasing light energizes the load (Fig. 7). The microswitch will short out the photocell when pressed.

Here's how the touch control works: While the light is out, the photocell "sees" no light and the relay is not activated. A gentle touch of the switch energizes the relay and the light goes on. The photocell "sees" the light and holds the relay energized. The light stays on. Now, how do you turn the light back off? Just pass your hand between the bulb and the photocell to create a shadow. Presto! The lamp goes out and stays out. —30—

6-WATT AMPLIFIER

(*Continued from page* 111)

signal source and amplifier input as shown in Fig. 1.

If plans call for the amplifier to be employed with a low-impedance input device, say about 1000 ohms, reduce the value of *R4*—or even eliminate it. This will give you a substantial increase in gain. There's no point in reducing the value of *R4* for a high-impedance input, as no appreciable gain will be realized. A 150-ohm resistor placed in series with *C2* introduces negative feedback, and lowers the output impedance still more, and reduces distortion, but sacrifices gain. The higher the resistance, the greater the feedback and the lower the gain.

BIAS NETWORK

A closer look at the biasing arrangement of the various transistors in the Six-Watter is needed for a better understanding of how the circuit operates and how balanced operation can be achieved even if the d.c. current gain of the transistors differs.

Resistors *R1* and *R2* maintain the bias voltage at the base of *Q1* at approximately one-half the supply voltage. If the voltage at point *A* in Fig. 1 drops, the potential difference across *Q1*'s base-emitter junction increases and causes *Q1* to conduct more heavily. The greater current flow through *R3* increases the voltage drop across *R3*, and increases the forward bias of *Q2*. This makes *Q2* conduct more heavily and increases the forward bias on *Q3* and *Q5*, at the same time decreasing the forward bias on *Q4* and *Q6*.

Transistors *Q5* and *Q6* act like a voltage divider across the power supply, and the biasing action just described reduces the dynamic resistance of *Q5*, and increases the dynamic resistance of *Q6*. This raises the voltage at point *A* and tends to restore it to its former value.

If, on the other hand, the voltage at point *A* rises above normal, the forward bias on *Q2* decreases, reducing the bias on *Q3* and *Q5*, increasing the bias on *Q4* and *Q6*, increasing the dynamic resistance of *Q5*, decreasing the dynamic resistance of *Q4*, and, finally, decreasing the voltage at point *A* to its normal value.

Diode *D1* also affects the bias of *Q3* and *Q4*. The voltage drop across *D1* places a small forward bias on *Q3* and *Q4*, which in turn places a small forward bias on *Q5* and *Q6*. This forward bias reduces crossover distortion and serves to thermally stabilize the amplifier. Changes in voltage drop across the diode due to changes in temperature tend to compensate for similar temperature changes in the base-to-emitter voltages of the transistors. The voltage drop across *D1* is essentially independent of supply voltage and therefore is able to maintain the same bias over a relatively wide range of supply voltage.

The amplifier's high-frequency response can be substantially improved by substituting 2N2148 transistors for the 2N554's in the output stage. They cost about $1 more each; the 2N554's were used because of their low cost. Should you decide to substitute "bargain" transistors for *Q5* and *Q6*, you may run into higher than normal leakage currents. To overcome this situation, you can connect a 100-ohm, ½-watt resistor between the base and emitter of *Q5* on the bottom side of the board.

If you plan to use the Six-Watter as a narrow-band speech amplifier, reduce the value of *C2* and place a small capacitor in parallel with *R5* to cut the amplifier's response at both the high and low ends.

The amplifier can also be used as a modulator for small transmitters. An ordinary output transformer connected backwards makes a reasonably good match as a modulation transformer. Use an output transformer which can match the impedance of the final stage of your transmitter to the amplifier's nominal 3.2-ohm load. —30—

SUPER-SENS

(*Continued from page* 38)

diode (1N34A) and an *npn* transistor (2N169) can be used. Adjust the *Sensitivity* control until the relay just closes in the absence of the radio signal. An incoming radio signal will open the relay.

Bench tests with the remote control circuit were made using a standard AM broadcast-band ferrite-core antenna coil (Superex "Vari-Loopstick") for *L1* and a 270-pf. ceramic capacitor for *C1*. With a relatively short antenna, positive relay operation was obtained when a strong local broadcast station was tuned in.

Photocells of all types can be used with *Super-Sens* to make it respond to variations in illumination and color. Invisible infrared rays can be used as intruder alarms. Smoke detectors and industrial counting devices can also be made. Regardless of the intended application, whether specific or general, the only limit to *Super-Sens* is your imagination and skill. —30—

FREEZE MOTION WITH SOUND

(*Continued from page* 42)

to the center conductor of a phono plug, and the negative lead to the shell. Connect the plug to *J2* on the trip unit.

Operation. Any camera can be used with the trip unit and flash as long as time or bulb exposures are possible. If your camera has only a bulb shutter position, you'll need a locking-type shutter release cable. A 35-mm. camera is ideal for use in high-speed photography. Fine cameras are available at reasonable prices, depth of field is excellent, film costs are low, and you can project your results in the form of 35-mm. color slides.

Set your experiment up in a room that can be darkened somewhat. While total darkness is not required, the lighting level must be reduced to the point where room illumination will not register on the film during the period the shutter is open. Install the electronic flash on the camera and mount the camera on a tripod. Focus the camera on the object to be photographed and adjust the camera iris for normal flash exposure of the film used at the object-to-flash distance. Follow the instructions supplied with the electronic flash for this setting.

Position the microphone near the object to be photographed—the distances given for the various photos shown in this article will give you a rough idea as to how mike placement affects results. Advance the sensitivity control on the trip unit until the noise developed by the event to be photographed triggers the flash. Now dim the lights, open the camera shutter, initiate the event, note that the flash fires, and close the camera shutter. If you want to record a time-graduated series, move the mike away from the object to be photographed in increments of a few inches and shoot a series of photographs.

The results that can be achieved with this simple piece of equipment are almost unbelievable. If the initial results are short of your expectations, keep experimenting. Make sure that extraneous noises are not tripping the flash prematurely. Good shooting! —30—

TOTEM POLES FOR STEREO

(*Continued from page 98*)

The woofer enclosure is somewhat unorthodox, but very easy to build, particularly if you plan to cover it with a plastic veneer. First cut out all the parts, and before joining the major components, glue and screw the cleats to their proper places on the sides; this will eliminate the need to struggle with them later inside the cabinet. Attach the cross cleats to the rear of the top and bottom pieces, and you are ready to glue and screw together the top, bottom, and sides. Next, make the speaker cutouts in the proper locations in the front, then glue and screw the duct panels to each end of the front panel. Slip the front panel into the enclosure and secure it in place. If you are covering the sides of the enclosure, you can fasten the duct panels more securely by driving some finishing nails through the sides directly into the edges of the duct panels.

Grille cloth and molding can be selected to fit in with your decor, and you can add feet or legs to the basic enclosure as desired. Both crossover networks are mounted just above the lower duct as shown in the photo. After you mount and wire the speakers, the enclosure should be padded with "kimsul," felt, cotton batting, or fiberglass wrapped in cheesecloth. Don't pad within the duct area, but other exposed surfaces of the back, sides, top, or bottom can be covered as desired, leaving no two opposing surfaces uncovered. If you wish, the totem poles can be attached to decorative pole lights or other room dividers.

Wiring Considerations. Wire the nine or ten mid-range units first, so that they can be handled as a unit. They must be checked first for proper phasing, and a single flashlight battery will do for this job. Connect it in series with the speaker, reversing the leads if necessary, until the speaker cone moves forward when the circuit is completed and to the rear when broken. Now mark the speaker terminal to which the positive battery terminal is connected. This marked terminal will correspond to the red coding or "+" sign on the other speakers.

Follow the wiring diagrams, and make a final phasing check between the units in a channel and between the two channels. For an excellent method of phasing a complex system such as this one, see "Phasing Speaker Systems" by John Dewar (POPULAR ELECTRONICS, September, 1965). If you don't have an audio generator available, any good recording will do. First, check the phasing in each channel, reversing the leads of either the woofer or mid-range unit, then the tweeter. If you use a dummy load in the other channel, as suggested by Dewar, be sure that its switch is turned on to avoid having an open circuit. For the final phasing of the two channels, a mono record is probably more useful than a stereo record.

Speaker Placement. Now you have to make a decision on speaker placement and whether to enclose the backs of the columns or not. For maximum dispersion of sound the back panel should be eliminated, but placement is somewhat more important in that case due to sound reflections from the rear. By experimenting with various locations for the columns as well as by aiming them at various angles, you will appreciate the enormous range of possibilities, some of which should solve any acoustic problems your living room can present.

When the columns are aimed outward, toward the side walls of the room, maximum reverberation is obtained in the listening area. If the sound is consistently too "big," or too reverberant and nondirectional, a back should be used. Also, if it is necessary to place the columns very close to a wall with the front parallel to the wall, it is advisable to cover the back with a 1-inch layer of fiberglass or other open acoustic damping material. (This material is always necessary when a back is added.) The more experiments you perform, the closer the final system will match your special acoustical situation and tastes.

The totem pole system offers superb stereo from any good stereo source, but for a final test put on a good stereo record of a large orchestra or chorus. It is in reproducing massed instruments or voices that this system excels. —30—

AUTO VOLTMETER

(*Continued from page 73*)

Once the engine is running, the voltage should rise to full charge at higher speeds, gradually coming down to the lower running limit, which indicates that the battery has fully recharged from the starting drain. The final regulated voltage varies with temperature due to the temperature-sensitive elements built into the voltage regulator itself, so it's a good idea to consult the service manual for your own car to acquaint yourself with the range of voltages for the expected range of temperatures normally encountered by the accessories under the hood. Temperature could vary from 20° below zero to 150° F when you start off on a subzero morning and then drive in the early afternoon sun with a 180° thermostat in the cooling system. An occasional idling period at a long traffic light or busy intersection could send the temperature up quite high, even in cold weather.

Acquaint yourself with the high and low voltage limits for a good battery with the engine running, for both summer and winter, as well as the meaning of abnormal indications and how to recognize them. The battery voltage table shows typical voltage ranges for both 6- and 12-volt systems. Note the relationship between the two sets of figures: The values for a 12-volt system are approximately double those of the 6-volt system. This is understandable, when you consider that both are made up of the same type of individual 2-volt cells.

Because of normal deterioration in the plates of the battery, small particles flake off and fall to the bottom of the cell. As this process continues, the resistance of the battery goes up, and it is often possible to predict failure of a battery long before it dies. Under the usual starting conditions, the battery drain is not too excessive, and the battery will charge up normally. However, the time that it takes to regain the charge will increase as deterioration gets worse.

When the first cold weather comes,

the demand upon the battery is considerably greater, and due to the large internal resistance, the voltage at the battery terminals is small. The battery must dissipate the power expanded in its internal resistance in the form of heat. If this heat is great, the plates buckle and the cell shorts and breaks down. It is interesting to note that most battery troubles show up during the first cold spell of winter.

A thorough check of a doubtful battery can be made as follows:

1. Check the liquid level, and measure the specific gravity of each cell before adding any water. Regardless of the state of charge (as indicated by the specific gravity), they should all read about the same. (The gravity will vary with the level of liquid.)

2. Unless the battery is discharged or near the lower limit voltage, measure the voltage across *each cell* while turning the engine over by means of the starting switch. (Disconnect the high-voltage lead from the coil to prevent the engine from starting.) This puts a heavy load on the battery and simulates actual starting conditions. If, under these conditions, each cell reads low but there is less than .1 volt difference between any two cells, the battery is good. If the voltage is low, the battery needs charging. If the cell measurements differ by more than .1 volt, the battery should be replaced.

3. Reconnect the high-voltage lead to the coil and start the engine. Measure the voltage across the battery with the engine idling. Now race the engine. The voltage should rise sharply from open-circuit voltage to normal charging voltage (depending on the state of charge of the battery) and drop back again as the engine slows down.

If the voltage does not increase sharply, the fault lies in the charging system (either the generator or voltage regulator). If it increases but remains high when the battery is known to be fully charged and good, the voltage regulator contacts are stuck closed. Prolonged running under these conditions can damage the battery. One symptom of this trouble is the need for excessive refilling of the cells with distilled water.

The lack of charging may indicate nothing more than worn generator brushes (or open rectifiers in alternator circuits), a dirty commutator, or burned or pitted contacts in the voltage regulator (the voltage regulator consists of a cutout relay, a current regulator element, and a voltage regulator unit, all with contacts). The correct method of cleaning and adjusting these contacts is outlined in the manufacturer's service manual. Quite often, a gas-station attendant will replace the whole unit rather than attempt a minor adjustment or cleaning of the contacts in a voltage regulator.

A convenient gadget for turning over the engine while working under the hood consists simply of a momentary-contact push-button switch, a pair of wire leads long enough to reach across the car (about 6 feet should be adequate) and a small battery clip on the end of each lead. The leads are connected across the starter control terminals of the starter solenoid. The push-button then does the same job as the ignition switch, but the engine will not start with the ignition switch in the off position. With this gadget, the high voltage lead need not be disconnected from the ignition coil.

The Payoff. You may be interested to hear that, as this article was being written, the author discovered that his charging system was not functioning—with the help of a panel-mounted voltmeter. The "Charge" panel light would come on, but as the engine speed increased with the car rolling along the highway, the light became very dim and appeared to have gone out. As a matter of fact, everything seemed normal—except the voltmeter reading, which was slightly under 12 volts.

Naturally, the charging system failed on a Saturday when the auto service department was closed (according to "Murphy's Law"). However, close and continuing checks of battery voltage showed that there was adequate charge left in the battery to last the weekend if all driving was done during the day, and if accessories were not used. By Monday, the voltmeter had more than earned its keep! —30—

MOBILE MONITOR

(*Continued from page* 126)

The last switch position is for a modulation check (*MOD*). The *Watchdog* circuit has now become an r.f. voltmeter with a time constant long enough to show audio modulation peaks. The coupling between the *Watchdog* and the transmitter must be adjusted to give a meter reading of about 0.5 ma. (unmodulated carrier). On high level modulation peaks, the meter reading may almost double; and on positive modulation, the peaks should reach the 100% (1.0-ma. point).

The operator can check his own modulation quality by plugging a headset into the *A.F.* jack on the front panel of the *Watchdog*. Turn *S1* to the *CS* position, and what you will hear in the headset will be a perfect reproduction of the signal being transmitted. At your home station, the output of this jack can be used to feed an oscilloscope to look for residual a.c. hum, parasitics, or distortion.

Emergency Voltmeter. In an emergency, the *Watchdog* may be used as a voltmeter by connecting test leads to the tip jacks mounted in one end of the box. In series with the tip jacks are resistors *R3* and *R4*, providing a 1000 ohms-per-volt range at two different voltage scales. With the test leads connected to tip jacks *J3* and *J5*, the meter scale can be converted into a range of 0-20 volts. With the leads between tip jacks *J4* and *J5*, the meter scale can be converted to a range of 0-500 volts. In addition, tip jacks *J6* and *J5* can be used to connect the 0-1 ma. meter to any transmitter that has built-in current multipliers and provisions for tuning up with a low-range milliamp meter. —30—

VOLTAGE CONVERSION TABLE

Meter Reading (ma.)	20-Volt Scale (volts)	500-Volt Scale (volts)
0.2	4	100
0.4	8	200
0.6	12	300
0.8	16	400
1.0	20	500

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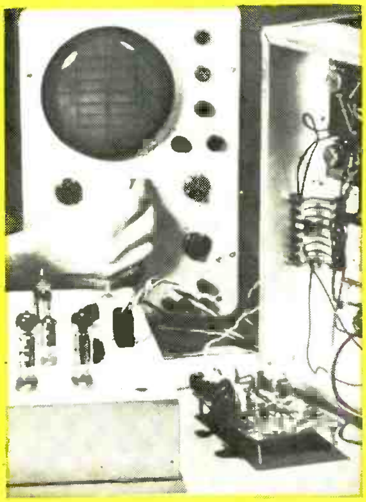

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