

WINTER EDITION

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1974

POPULAR  
ELECTRONICS

# ELECTRONIC EXPERIMENTER'S HANDBOOK

## CONSTRUCTION PROJECTS...

**DISTANT-TV ANTENNA PREAMP**

Beats Sports Blackouts

**ELECTRONIC RHYTHM SECTION**

Waltz-to-Funk Versatility

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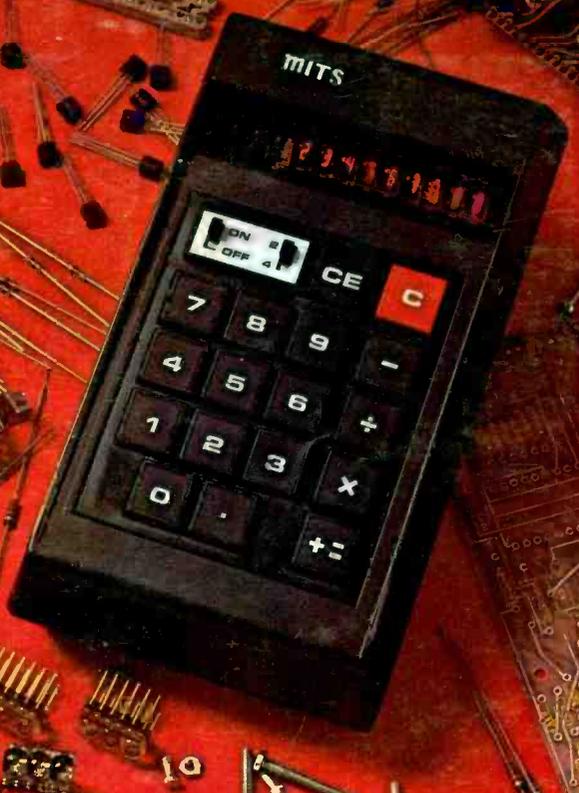
Easy PC-Board Stenciling

The Hobby Shop

Decibel Table

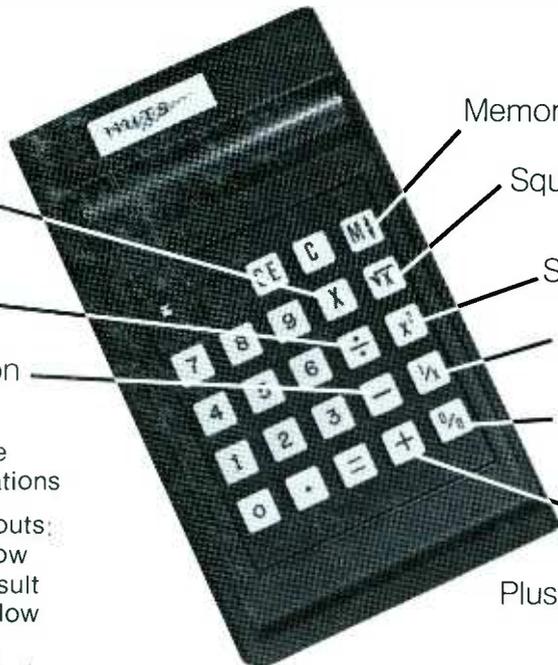
Color Codes Chart

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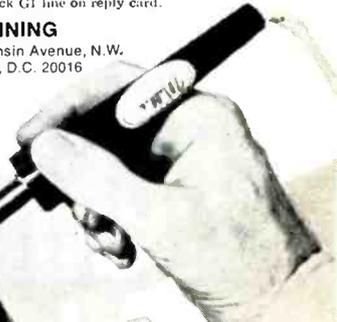
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## WINTER EDITION

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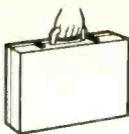
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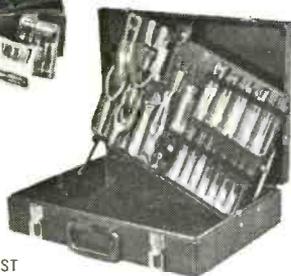
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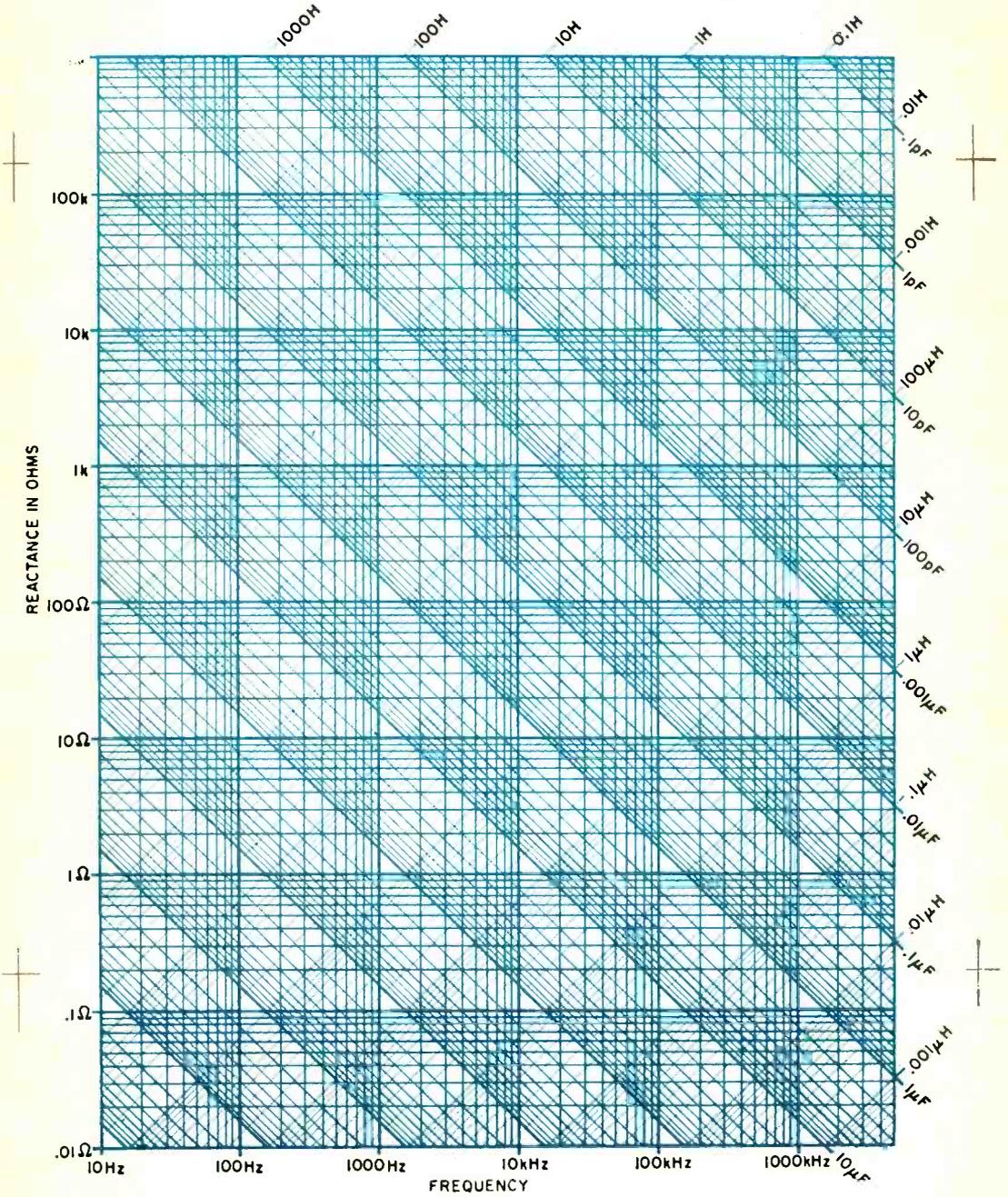
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ELECTRONIC EXPERIMENTER'S HANDBOOK

# DECIBEL TABLE

Voltage Ratio (Equal Impedance)	Power Ratio	← -- db + --→	Voltage Ratio (Equal Impedance)	Power Ratio
1.000	1.000	0	1.000	1.000
0.989	0.977	0.1	1.012	1.023
0.977	0.955	0.2	1.023	1.047
0.966	0.933	0.3	1.035	1.072
0.955	0.912	0.4	1.047	1.096
0.944	0.891	0.5	1.059	1.122
0.933	0.871	0.6	1.072	1.148
0.923	0.851	0.7	1.084	1.175
0.912	0.832	0.8	1.096	1.202
0.902	0.813	0.9	1.109	1.230
0.891	0.794	1.0	1.122	1.259
0.841	0.708	1.5	1.189	1.413
0.794	0.631	2.0	1.259	1.585
0.750	0.562	2.5	1.334	1.778
0.708	0.501	3.0	1.413	1.995
0.668	0.447	3.5	1.496	2.239
0.631	0.398	4.0	1.585	2.512
0.596	0.355	4.5	1.679	2.818
0.562	0.316	5.0	1.778	3.162
0.531	0.282	5.5	1.884	3.548
0.501	0.251	6.0	1.995	3.981
0.473	0.224	6.5	2.113	4.467
0.447	0.200	7.0	2.239	5.012
0.422	0.178	7.5	2.371	5.623
0.398	0.159	8.0	2.512	6.310
0.376	0.141	8.5	2.661	7.079
0.355	0.126	9.0	2.818	7.943
0.335	0.112	9.5	2.985	8.913
0.316	0.100	10	3.162	10.00
0.282	0.0794	11	3.55	12.6
0.251	0.0631	12	3.98	15.9
0.224	0.0501	13	4.47	20.0
0.200	0.0398	14	5.01	25.1
0.178	0.0316	15	5.62	31.6
0.159	0.0251	16	6.31	39.8
0.141	0.0200	17	7.08	50.1
0.126	0.0159	18	7.94	63.1
0.112	0.0126	19	8.91	79.4
0.100	0.0100	20	10.00	100.0
$3.16 \times 10^{-2}$	$10^{-3}$	30	$3.16 \times 10^1$	$10^3$
$10^{-2}$	$10^{-4}$	40	$10^2$	$10^4$
$3.16 \times 10^{-3}$	$10^{-5}$	50	$3.16 \times 10^2$	$10^5$
$10^{-3}$	$10^{-6}$	60	$10^3$	$10^6$
$3.16 \times 10^{-4}$	$10^{-7}$	70	$3.16 \times 10^3$	$10^7$
$10^{-4}$	$10^{-8}$	80	$10^4$	$10^8$
$3.16 \times 10^{-5}$	$10^{-9}$	90	$3.16 \times 10^4$	$10^9$
$10^{-5}$	$10^{-10}$	100	$10^5$	$10^{10}$
$3.16 \times 10^{-6}$	$10^{-11}$	110	$3.16 \times 10^5$	$10^{11}$
$10^{-6}$	$10^{-12}$	120	$10^6$	$10^{12}$

# REACTANCE CHART



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STRAUSS: Festive Prelude, Op. 61 (excerpt) DGG • DEBUSSY: feu d'artifice (excerpt) Connoisseur Society • BEETHOVEN: Wellington's Victory (Battle Symphony), (excerpt from the first movement) Westminster • MASSING: Conzona XXXV à 16 (complete) DGG Archive • CORRETTE: Concerto Comique Op. 8, No. 6, "Le Plaisir des Dames" (third movement) Connoisseur Society • KHAN: Raja Chandranandan (excerpt) Connoisseur Society • RODRIGO: Concerto—Serenade for Harp and Orchestra (excerpt from the first movement) DGG • MANITAS DE PLATA: Gypsy Rhumba (complete) Connoisseur Society • MARCELLO: (arr. King): Psalm XVII "The Heavens are Telling" (complete) Connoisseur Society • PRAETORIUS: Tertschore-La Bourée XXXII (complete) DGG Archive • BERG: Wozzeck (excerpt from Act III) DGG • BARTOK: Sonata for two pianos and Percussion (excerpt from the first movement) Cambridge • BEETHOVEN: Wellington's Victory (Battle Victory) (excerpt from the last movement) Westminster.

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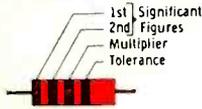
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# COLOR CODE CHARTS

## COLOR BAND SYSTEM



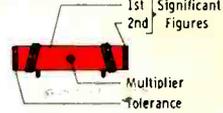
Resistors With Black Body Color Are Composition, Non-Insulated. Resistors With Colored Bodies Are Composition, Insulated. Wire-Wound Resistors Have The 1st Digit Color Band Double Width.

## RESISTOR CODES (RESISTANCE GIVEN IN OHMS)

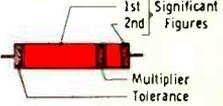
COLOR	DIGIT	MULTIPLIER	TOLERANCE
BLACK	0	1	±20%
BROWN	1	10	±1%
RED	2	100	±2%
ORANGE	3	1000	±3%*
YELLOW	4	10000	GMV**
GREEN	5	100000	±5% (EIA Alternate)
BLUE	6	1000000	±6%*
VIOLET	7	10000000	±12 1/2%*
GRAY	8	.01 (EIA Alternate)	±30%*
WHITE	9	.1 (EIA Alternate)	±10% (EIA Alternate)
GOLD		.1 (JAN and EIA Preferred)	±5% (JAN and EIA Preferred)
SILVER		.01 (JAN and EIA Preferred)	±10% (JAN and EIA Preferred)
NO COLOR			±20%

\*GMV = guaranteed minimum value, or -0 - 100% tolerance.  
 ±3, 6, 12 1/2, and 30% are ASA 40, 20, 10, and 5 step tolerances.

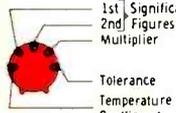
## BODY-END-DOT SYSTEM



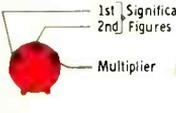
## BODY-END BAND SYSTEM



## DISC CERAMICS (5-DOT SYSTEM)



## DISC CERAMICS (3-DOT SYSTEM)

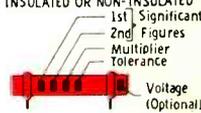


## CERAMIC CAPACITOR CODES (CAPACITY GIVEN IN pF)

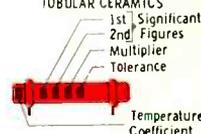
COLOR	DIGIT	MULTIPLIER	TOLERANCE	TEMPERATURE COEFFICIENT	EXTENDED RANGE
			10 pF or LESS	PPM/°C	TEMP. COEFF. SIGNIFICANT FIGURE
BLACK	0	1	±2.0 pF	±20%	0(NPO)
BROWN	1	10	±0.1 pF	±1%	-31(N33)
RED	2	100		±2%	-75(N75)
ORANGE	3	1000		±2.5%	-150(N150)
YELLOW	4	10000			-220(N220)
GREEN	5		±0.5 pF	±5%	-330(N330)
BLUE	6				-470(N470)
VIOLET	7				-750(N750)
GRAY	8	.01	±0.25 nF		-30(P30)
WHITE	9	.1	±1.0 nF	±10%	General Purpose
SILVER					Bypass & Coupling
GOLD					+100 (P100, JAN)

Voltage ratings are standard 500 volts for some manufacturers, but 1000 volts for other companies.

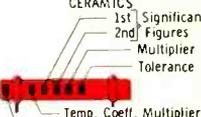
## HIGH CAPACITY TUBULAR CERAMIC INSULATED OR NON-INSULATED



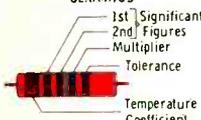
## TEMPERATURE COMPENSATING TUBULAR CERAMICS



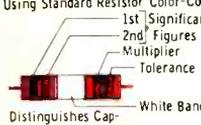
## EXTENDED RANGE T.C. TUBULAR CERAMICS



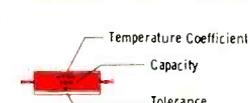
## MOLDED-INSULATED AXIAL LEAD CERAMICS



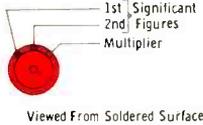
## MOLDED CERAMICS



## TYPOGRAPHICALLY MARKED CERAMICS

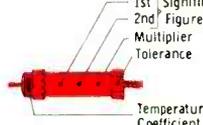


## BUTTON CERAMICS

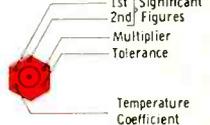


JAN LETTER	TOLERANCE
	10 pF or LESS
C	±0.2 pF
D	±0.5 pF
F	±1.0 pF
G	±2.0 pF
J	±5%
K	±10%
M	±20%

## STAND-OFF CERAMICS



## FEED-THRU CERAMICS

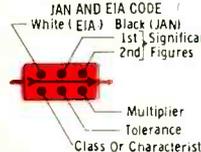


## MOLDED MICA CAPACITOR CODES

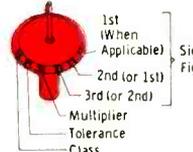
COLOR	DIGIT	MULTIPLIER	TOLERANCE	CLASS OR CHARACTERISTIC
BLACK	0	1	20%	A
BROWN	1	10	1%	B
RED	2	100	2%	C
ORANGE	3	1000	3%	D
YELLOW	4	10000		E
GREEN	5		5% (EIA)	F (JAN)
BLUE	6			G (JAN)
VIOLET	7			H (EIA)
GRAY	8			I (EIA)
WHITE	9			J (EIA)
GOLD		.1	5% (JAN)	
SILVER		.01	10%	

Class or characteristic denotes specifications of design involving Q factor, temperature coefficients, and production test requirements. All axial lead mica capacitors have a voltage rating of 300, 500, or 1000 volts. \*or ±1.0 pF whichever is greater.

## CURRENT STANDARD JAN AND EIA CODE



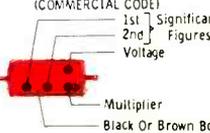
## BUTTON SILVER MICA



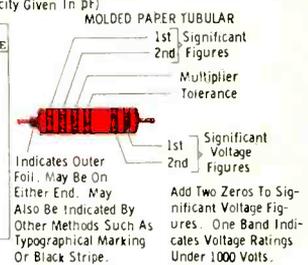
## MOLDED PAPER CAPACITOR CODES

COLOR	DIGIT	MULTIPLIER	TOLERANCE
BLACK	0	1	20%
BROWN	1	10	
RED	2	100	
ORANGE	3	1000	
YELLOW	4	10000	
GREEN	5	100000	5%
BLUE	6	1000000	
VIOLET	7		
GRAY	8		10%
WHITE	9		5%
GOLD			10%
SILVER			20%
NO COLOR			

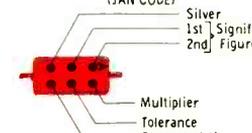
## MOLDED FLAT PAPER CAPACITORS (COMMERCIAL CODE)

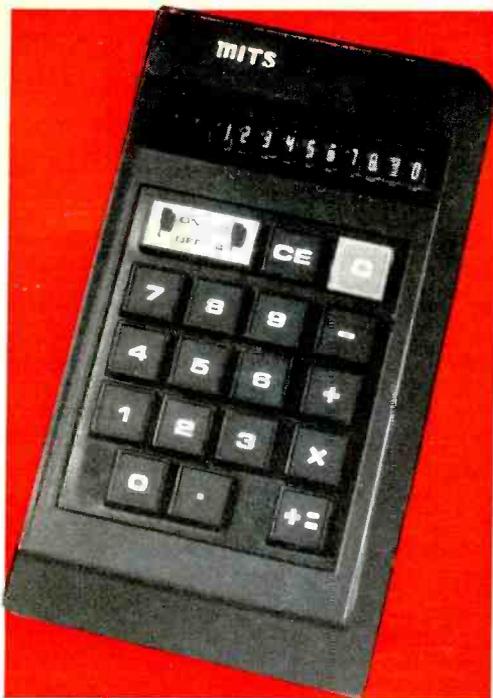


## MOLDED PAPER TUBULAR



## MOLDED FLAT PAPER CAPACITORS (JAN CODE)





# HOW TO BUILD A HAND-HELD ELECTRONIC CALCULATOR

*MOS/LSI integrated circuit  
simplifies construction of  
this versatile calculator.*

By LORINDA RUSSELL & BILL YATES  
MITS, Inc.

**T**HERE'S no doubt that we've entered the electronic calculator era. A wide variety of these sophisticated devices are being offered to shoppers for home and business use.

Probably the most popular model at the moment is the hand-held, or "mini," calculator. Now you can build one for yourself, if you are handy with a soldering iron.

The mini calculator presented here gives you a choice of six, nine, or twelve digit displays depending on which version you wish to build. The readout can display true credit balance, display overflow, calculation overflow, math error, and a battery override condition. And you can select two or four decimal places. As an added feature, if you allow the LED readouts to operate without performing any functions, the display will be extinguished after 30-45 seconds. An "H" display will then appear. The logic still remains in the calculator, however, and as soon as you start up operations again, the last calculation will be displayed.

The basic logic flow, shown in Fig. 1, consists of four major circuits: the keyboard and its diode encoding matrix, clock, MOS/LSI chip, and display (LED readouts and associated electronics). To understand the operation of a calculator, you must understand the functions of these four circuits. The schematic is shown in Figs. 2 and 3.

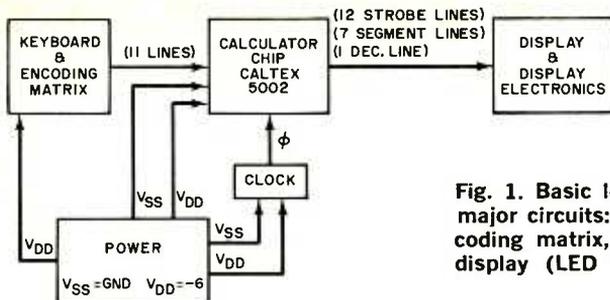
**Keyboard and Encoding Matrix.** The keyboard enables the operator to input data and commands to the chip; a diode matrix codes the data so that it is compatible with the chip. The actual keyboard consists of 10 digit keys (0 through 9); four function keys displaying "+=", "-", "x," and "÷;" keys designating clear ("C"), clear entry ("CE"), and the decimal point (".").

All of the inputs to the calculator chip use negative logic; that is, an active input is indicated by  $V_{DD}$  (-6 volts), while an inactive input is designated by  $V_{SS}$  (0 volts or Gnd).

The four function keys, plus "C," "CE," and "." are tied directly to corresponding pins of the chip. If a switch is open, the corresponding pin will be at  $V_{SS}$ , therefore inactive. When a key is operated, the corresponding pin will be at  $V_{DD}$ , the active state. This latter operation is recognized by the chip as an input to be acted upon.

The 10 digit keys are not tied directly to the chip, but feed a 13-diode encoding matrix that supplies four logic inputs (1, 2, 4, 8) to the chip. A basic circuit is shown in Fig. 4. The diode matrix encodes key closures as shown in Table 1.

The 1's and 0's are represented by  $V_{DD}$  and  $V_{SS}$ , respectively. The code used is a modified binary, where "0" is represented



**Fig. 1. Basic logic flow consisting of four major circuits: keyboard and its diode encoding matrix, clock, MOS/LSI chip, and display (LED readouts and electronics).**

by 1010 (which in conventional binary represents 10). The actual binary representation of zero (0000) could not be used as a chip input since this code would be present on the chip input lines when no keys were depressed. The "0" binary code (1010) is automatically decoded back to 0000 inside the chip.

The operation of the diode encoding matrix can be followed using Fig. 4. Keep in mind that chip lines 1, 2, 4, and 8 are normally maintained at  $V_{SS}$  (inactive) when all keys are open. Consider what happens when key "3" is depressed. Diodes  $D_3$  and  $D_4$  are forward-biased, consequently, they conduct and connect lines "1" and "2" to  $V_{DD}$ , activating these lines. The four chip lines are then in the following states:

Line	Voltage	Logic
1	$V_{DD}$	1
2	$V_{DD}$	1
4	$V_{SS}$	0
8	$V_{SS}$	0

The input to the chip will then be 0011, or the binary representation of the digit 3. You can use Fig. 4 to see how the other keys are decoded.

**Clock.** The chip processes the binary inputs at a rate determined by a two-transistor "clock" or square-wave generator, switching between  $V_{DD}$  and  $V_{SS}$ . These are transistors  $Q1$  and  $Q2$  in Fig. 2. This circuit oscillates at approximately 42 kHz, as determined by the values of  $R3-C1$  and  $R5-C2$ . The upper clock frequency is determined by the chip used. Forty-two kHz is within specifications and makes for rapid calculations.

**Integrated Circuit.** The calculating portion of the unit is an extremely complex MOS/LSI integrated circuit, one of several four-function calculator chips on the market. This chip has several features which make it suitable for use in a pocket calculator. It

needs only one operating voltage, 6 volts  $\pm 1.5$  volts, and a 20-50 kHz square wave with a rise and fall time of less than one microsecond (but greater than 0.05 microsecond), which is taken care of by the clock circuit.

The chip incorporates a debounce circuit for all inputs, freeing the input lines from any external debounce capacitors. This chip is designed to compensate for a maximum of 5 milliseconds of keyboard bounce. Bounce time is the interval during which a keyboard switch makes and breaks contact. These intervals are accounted for in the chip through proper delays, thus avoiding what appears to be several switch closures instead of just one. There are no provisions for simultaneous depression of two or more keys—all inputs will be accepted, usually generating an erroneous result.

The output of the chip is positive logic; that is, the active output (1) is  $V_{SS}$  and the inactive output (0) is  $V_{DD}$ . The output is configured to drive the display in a multiplex mode and consists of 12 digit strobe lines (lines prefixed with a "D" in Fig. 3), 8 segment lines (7-segment display plus the decimal), and one sign line (1 implies a negative number to the display and 0 implies a positive number). The chip output data is a standard 7-segment format so that no external BCD-to-7-segment decoder is required. The chip automatically keeps track of where the decimal point is located and the decimal-point segment line will go active when the appropriate digit is strobed on to correctly position the decimal.

**Readouts.** This particular calculator uses LED-type readouts, arranged in the familiar 7-segment configuration, as shown in the readout portion of Fig. 3.

Electrically, a LED is just like any other diode. When it is sufficiently forward-biased, it will conduct. Unlike conventional diodes, when a LED conducts, it emits monochro-

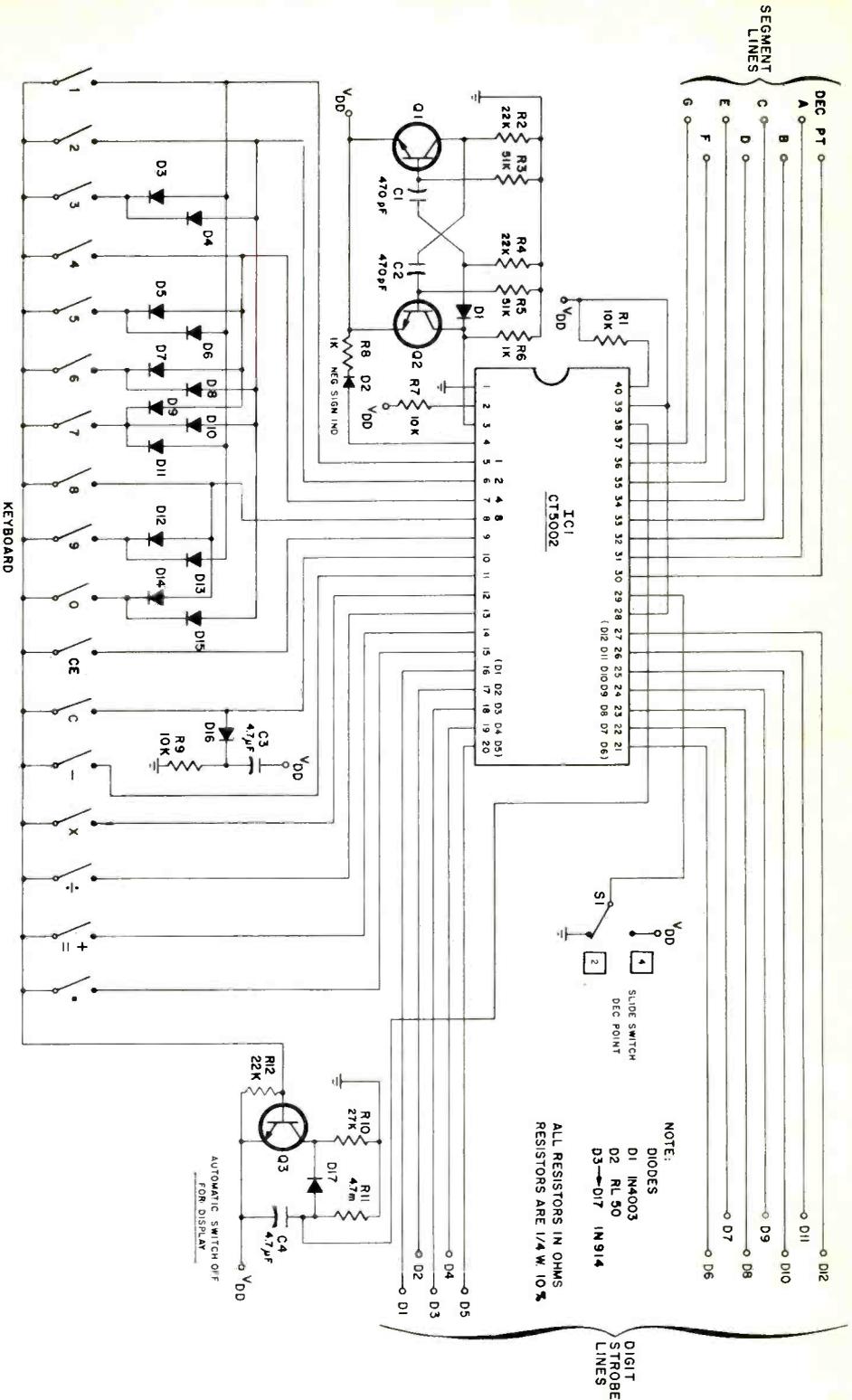


Fig. 2. Schematic of the hand-held "mini" calculator which can be built with six, nine, or twelve digit displays. The negative-sign indicator (D2) is the only LED in this portion of the circuit.

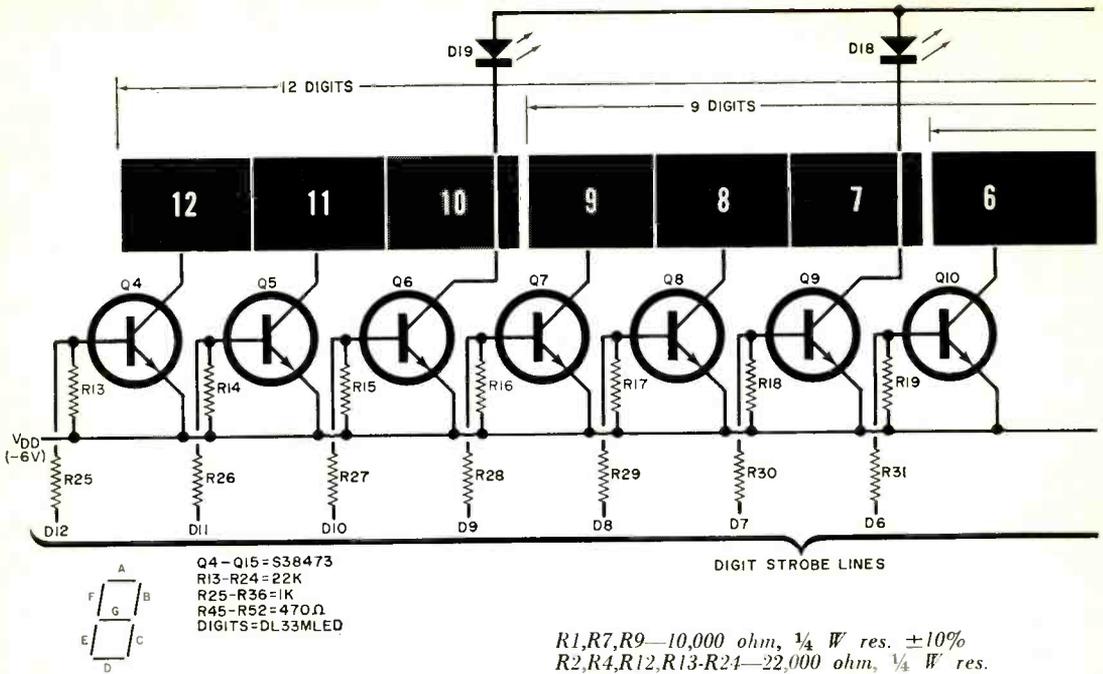


Fig. 3. Schematic and parts list for calculator. Wiring for the various display options is included. Refer to the article.

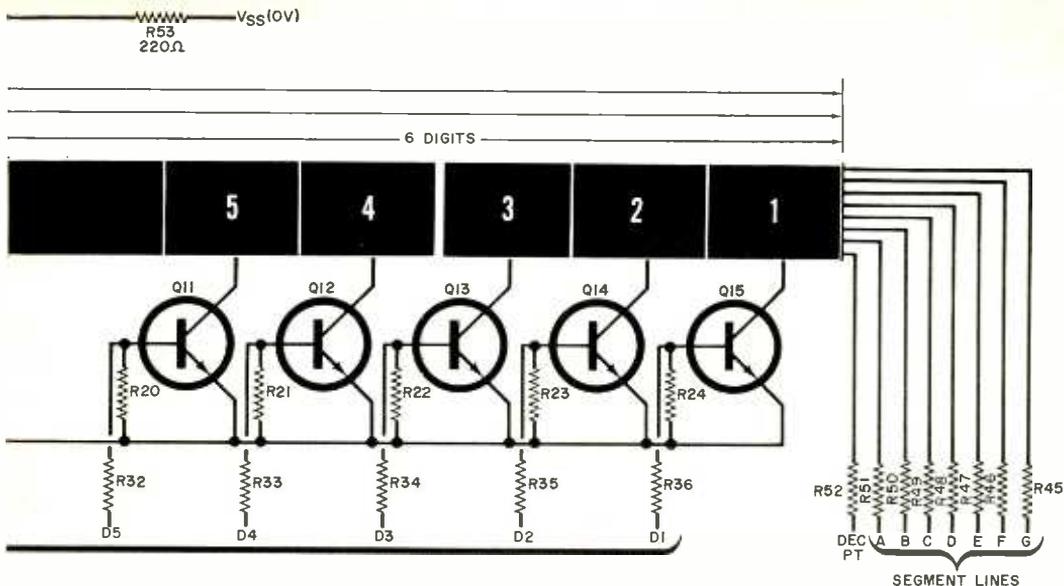
matic light (usually red, but some devices glow green). By forward-biasing selected elements of the 7-segment array, any digit between 0 and 9 can be formed. For example, to create the digit "5," segments A, C, D, F, and G must be driven on.

The MOS calculator chip cannot drive the LED readouts directly for two reasons. The chip digit or strobe lines do not have sufficient current capacity to cause the LED segments to glow; and the output drive signal does not have the correct polarity. The active output of the chip is zero volts while the inactive output is -6 volts. If you check the readout portion of Fig. 3, you will note transistors Q4 through Q15. These transistors supply the LED drive by providing current amplification and signal inversion. All similar segments of each readout are connected in parallel and are driven by a single segment line (A through G of Fig. 3). However, all segments within a given digit have common cathodes which are connected to the collector of the digit driver transistor for that particular digit. A basic

circuit is shown in the diagram of Fig. 5.

As an example of how the foregoing works, assume a particular segment line is at zero ( $V_{ss}$  or logic 1 for the chip), and that the digit drive line is strobed on to zero ( $V_{ss}$ ). The strobe pulse on the base of Q1 will turn that transistor on, driving it into saturation, which effectively couples the common cathodes of that digit to the minus supply. This forward-biases the particular LED segment whose anode is connected to the zero segment line, causing it to glow. The amount of current flowing to produce the glow is determined by the value of R1 and the voltage level of  $V_{DD}$ .

There is one more unique circuit in Fig. 2. This is the circuit of Q3 and its associated components. Capacitor C4 charges via R11. When the junction of these two reaches a certain level, a signal is applied to pin 38 of IC1 that causes all the readouts to turn off, and produces the letter "H" on the right-most display. Operation of the keyboard keys keeps transistor Q3 saturated, thus keeping C4 discharged via D17.



*C1,C2—470 pF disc capacitor*  
*C3,C4—4.7 μF, 25-V elec. capacitor*  
*D1—1N4003*  
*D2,D18,D19—LED RL50*  
*D3-D17—1N914*  
*IC1—CT5002 calculator chip (Caltex)*  
*LED1-LED4—7-segment LED readout*  
*(Litronix DL33M), 3 digits to module.*  
*Q1-Q15—S38473 or 2N2222*  
*S1—Spdt switch (part of keyboard)*  
*Keyboard—Wild Rover Microthik C1547*  
*Misc.—Case, 40-pin IC socket, battery clips,*

*hookup wire, fine solder, mounting hardware*  
*The following are available from MITS, Inc.,*  
*6324 Linn, N.E., Albuquerque, N.M.*  
*87108. Keyboard, \$15; LED readouts, \$15*  
*per module; IC1, \$15; plastic case and*  
*filter (MITS 1200), \$4.50; drilled and*  
*etched plated PC board, \$7. Insurance extra.*  
*A complete kit of parts for a 6-digit version*  
*(1206) is \$49.95; a 9-digit version (1209)*  
*is \$69.95; while a 12-digit model (1212)*  
*costs \$89.95.*

When the keys are not in use, Q3 cuts off and allows C4 to charge. This circuit is used to reduce battery drain when a number of digits are being displayed, and the operator allows the calculator to stand idle for more than 30 to 45 seconds.

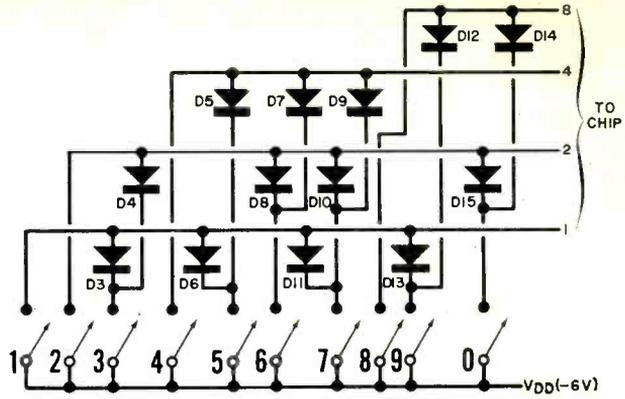
**Construction.** Other than the keyboard, the entire calculator is built up on one double-sided, plated-through PC board. Because of the complexity of this board, and the fact that it must be double-sided with plated-through holes, it is almost impossible to make on the experimenter's bench. A source for a completed board is given in the Parts List. This board also comes with component installation screened on the top side. Component installation is in accordance with Fig. 6. All components, except for the IC, LED's and their associated driver transistors (Q4 through Q15), should be correctly mounted and soldered in place using a 25-30 watt soldering iron and fine solder.

Depending on the model you wish to construct (6, 9, or 12 digits), there are up to

four LED display assemblies to be installed. You can start with six readouts. Each "stick" of readouts contains three digits—so you will need two display packages. In this case, they will be mounted at LED positions 1 and 2 of Fig. 6. As you only need drivers for six digits, install only Q10 through Q15 and their associated resistors. At some later date, you may want to increase the number of digits, so all you have to do then is install the LED readouts (in "sticks" of three) and their associated drive transistors and resistors. The installation technique is the same as for the original six.

If you examine the LED readout, you will note that it has a single notch on one side, and two notches on the other. The "top" of the digit has one notch and is installed in accordance with Fig. 6. Install the first "stick" so that the side towards the transistors is flush with the board and the upper end spaced about 1/8" above the board (you can use a 1/8" drill bit as a temporary spacer). This tilt will enable the readouts to be clearly visible through the case window. Install

Fig. 4. Basic circuit showing the diode encoding matrix that supplies logic inputs from the digit keys to calculator chip.



the second "stick" exactly like the first, making sure that they both have the same tilt angle and their adjacent sides are parallel to avoid "waviness" of the display. In the 6- and 9-digit versions only, before soldering the second LED display in place, clip off the top left-hand pin (looking down from the top) close to the body of the display package. This is to allow mounting of a LED "overflow" indicator near display 2. When you install three "sticks" of readouts (9 digits) do the same for the last readout package. Do *not* clip off any pins in the 12-digit version.

The LED overflow indicator (*D19*) has a small crossbar on the anode side while the cathode lead is plain. Install the LED at readout 2 so that the cathode lead goes in the hole for pin 14 of the LED readout (cut off in the previous step), while the anode lead fits into the marked hole alongside. Before soldering in place, bend the diode around the LED assembly until it is even with the top of the LED's. These overflow indicators are used only in the 6- and 9-digit versions.

Next, install the negative-sign LED (*D2*), at its position on the left-hand side of the board, as shown in Fig. 6. Fit the top (round) end of the diode so that it is the same height as the LED readouts.

The last component to be installed is *IC1*. Separate the two halves, and install the

socket at the position marked "IC1" on the board. Carefully solder each pin.

The MOS/LSI chip is extremely sensitive to static electricity so should not be removed from its conducting foam until ready for installation. Before removing the IC from the foam, tape a piece of aluminum foil to the underside of the PC board. This is to prevent the IC from being shorted during installation.

Remove the IC from the conductive foam and check that the pins are straight. If any are bent, use needle-point pliers to align one at a time—do not use your fingers. Orient the IC notch with the notch shown at "IC1" in Fig. 6. Align the 20 pins on one side with the socket holes and start them in. Do the same on the other side, using a pencil tip to align the pins with their socket holes. When all 40 pins have been started in, rock the IC back and forth while pressing it into the holes until it is firmly seated. After the IC is seated, remove the aluminum foil from the underside of the board.

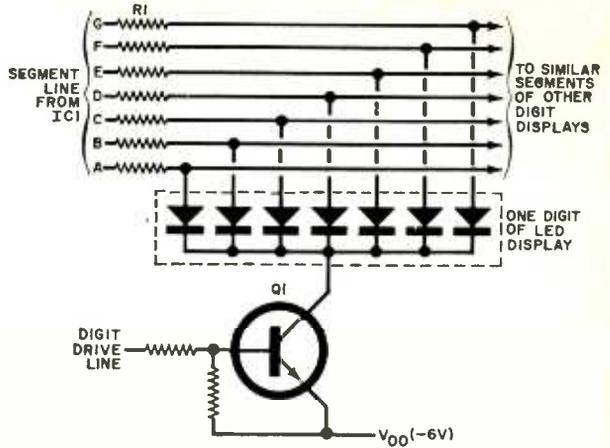
Connect an 8-inch-long length of thin, flexible black wire to the "-" battery pad on the board, and an 8-inch-long thin, flexible length of red wire to the "+" terminal. These wires, like the following, are inserted from the component side of the board. Solder the loose ends of these two wires to individual battery clips. Connect 23 4½-inch thin, flexible wires to the 23 pads on the bottom end of the board. This completes the board assembly. Carefully inspect both sides of the board for correct polarity of component installation and check that no solder bridges exist between adjacent portions of the foil pattern.

Orient the keyboard so that the L-shaped lip is towards the bottom of the PC board. The 23 keyboard wires coming from the

TABLE 1

Key Closed	Output Code	Key Closed	Output Code
	8 4 2 1		8 4 2 1
1	0 0 0 1	6	0 1 1 0
2	0 0 1 0	7	0 1 1 1
3	0 0 1 1	8	1 0 0 0
4	0 1 0 0	9	1 0 0 1
5	0 1 0 1	0	1 0 1 0

Fig. 5. Basic circuit showing how all segments within given digit have common cathodes connected to the collector of the digit driver transistor for that particular digit. See text.



bottom of the PC board run "under" the keyboard and are soldered to similar pads on the keyboard, that is, the first wire ("ON") is connected to the first pad on the keyboard starting on the left, looking down on the keyboard. Connect the remaining 22 wires, making sure that they run under the keyboard and are installed in the proper sequence. Note that the four tubular extrusions on the keyboard exactly fit the four holes drilled in the board.

Install the keyboard in the case top and secure with four #2 self-tapping screws, being careful not to crack the plastic supports. Arrange the 23 keyboard-to-PC board wires down the center of the PC board, then align the PC board mounting holes with the

four keyboard bosses and secure carefully, using #2 self-tapping screws. The two battery leads (one black, one red) should pass through the PC board, exiting from the rear (foil) side of the PC board via a vacant hole close to where the two leads are soldered to the board.

The battery connectors should be installed in the receptacles provided in the case cover and interconnected to form a series circuit. Before installing the rear cover, fit a piece of thin plastic insulating material over the foil pattern. This is done to avoid possible electrical contact between the board and the batteries.

**Check Out.** To test the calculator, set

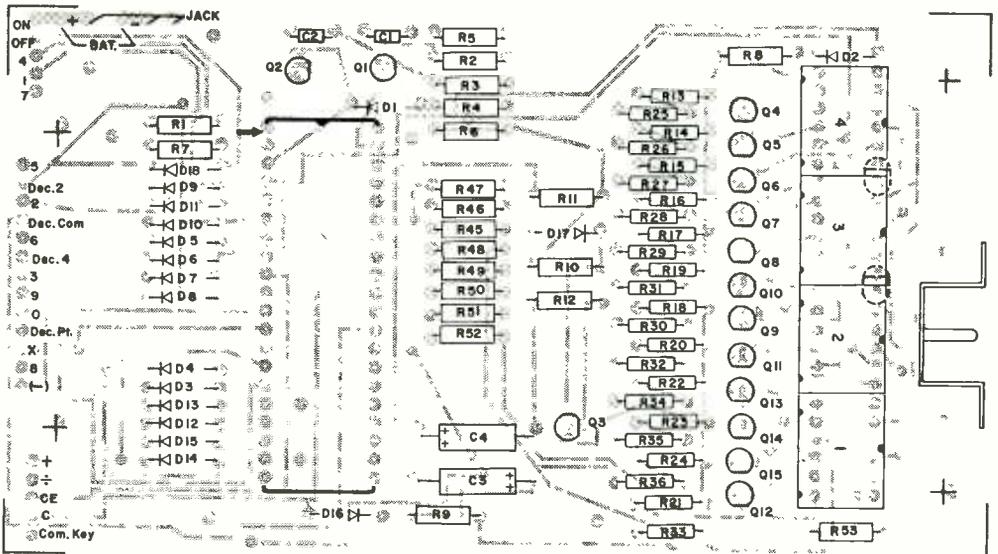


Fig. 6. Parts placement. Plated-through PC board cannot be home-built. See parts list.

the decimal "2/4" switch to either position, depending on the number of decimal places you desire. Turn the power on. If you selected two decimal places, then the display should indicate 0.00; if four decimal places, it will show 0.0000. If you leave the display on and do not touch any keys for 30-45 seconds, the zeroes should fade out and a letter "H" will appear on the extreme right-hand display. Depressing the "+=" key will restore the display.

To add:  $A + B = C$

Press the appropriate digit key (s) to enter the first number (A); press "+=" key; enter B by pressing the appropriate digit keys; press "+=" key again; read C on the display.

To subtract:  $A - B = C$

Press the appropriate digit key (s) to enter the first number (A); press "+=" key; enter B by pressing the appropriate digit key (s); press "-" key; read C on the display.

To multiply:  $A \times B = C$

Press the appropriate digit key (s) to enter the first number (A); press "x" key; enter B by pressing the appropriate digit key (s); press "+=" key; read C on the display.

To divide:  $A \div B = C$

Press the appropriate digit key (s) to enter the first number (A); press "+" key; enter B by pressing the appropriate digit key (s); press "+=" key, then read C.

Here are some precautions to remember when operating this calculator. Once you have begun a calculation do not change the setting of the 2/4 decimal switch because this can cause an erroneous answer. When you are entering a calculation in the machine, you must keep in mind that there are at least two or possibly four decimal places, depending on the position of the 2/4 switch. You should not exceed the capacity of the machine. If for some reason you are interrupted during a calculation and enough time elapses for the battery override to operate, those decimal places will be in the display when you press the "+=" key to return the display.

If you have a 6-digit display, or a 9-digit display, and a larger number is entered into the calculator, the overflow of the display will be indicated by a dot immediately to the left of the numbers on the display (not to be confused with the negative sign which appears to the far left of the display).

Happy assembling! ♦

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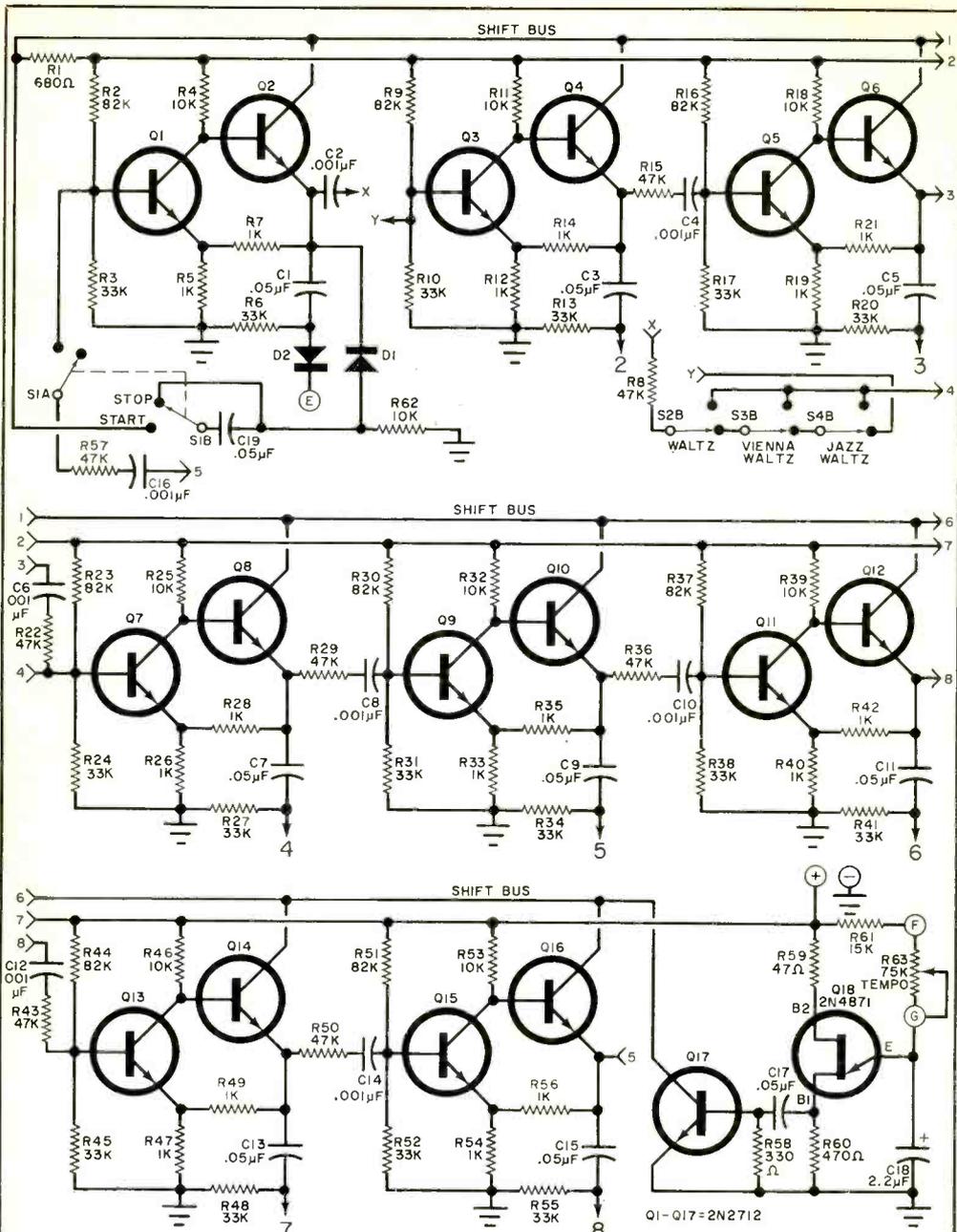


Fig. 1. Generated by Q18, the shift pulses are passed down the counter.

### PARTS LIST RING COUNTER AND SWITCHING CIRCUITS

C1,C3,C5,C7,C9,C11,C13,C15,C17,C19—  
0.05- $\mu$ F disc capacitor  
C2,C4,C6,C8,C10,C12,C14,C16—0.001- $\mu$ F disc  
capacitor  
C18—2.2- $\mu$ F, 15-volt electrolytic capacitor  
D1-D41—1N914 diode (or similar)

Q1-Q17—2N2712 transistor  
Q18—2N4871 transistor  
R1—680-ohm,  $\frac{1}{2}$ -watt resistor  
R2,R9,R16,R23,R30,R37,R44,R51—82,000-  
ohm  $\frac{1}{2}$ -watt resistor  
R3, R6, R10, R13, R17, R20, R24, R27, R31,  
R34, R38, R41, R48, R52, R55—33,000  
ohm,  $\frac{1}{2}$ -watt resistor  
R4,R11,R18,R25,R32,R39,R46,R53,R62—  
10,000-ohm,  $\frac{1}{2}$ -watt resistor

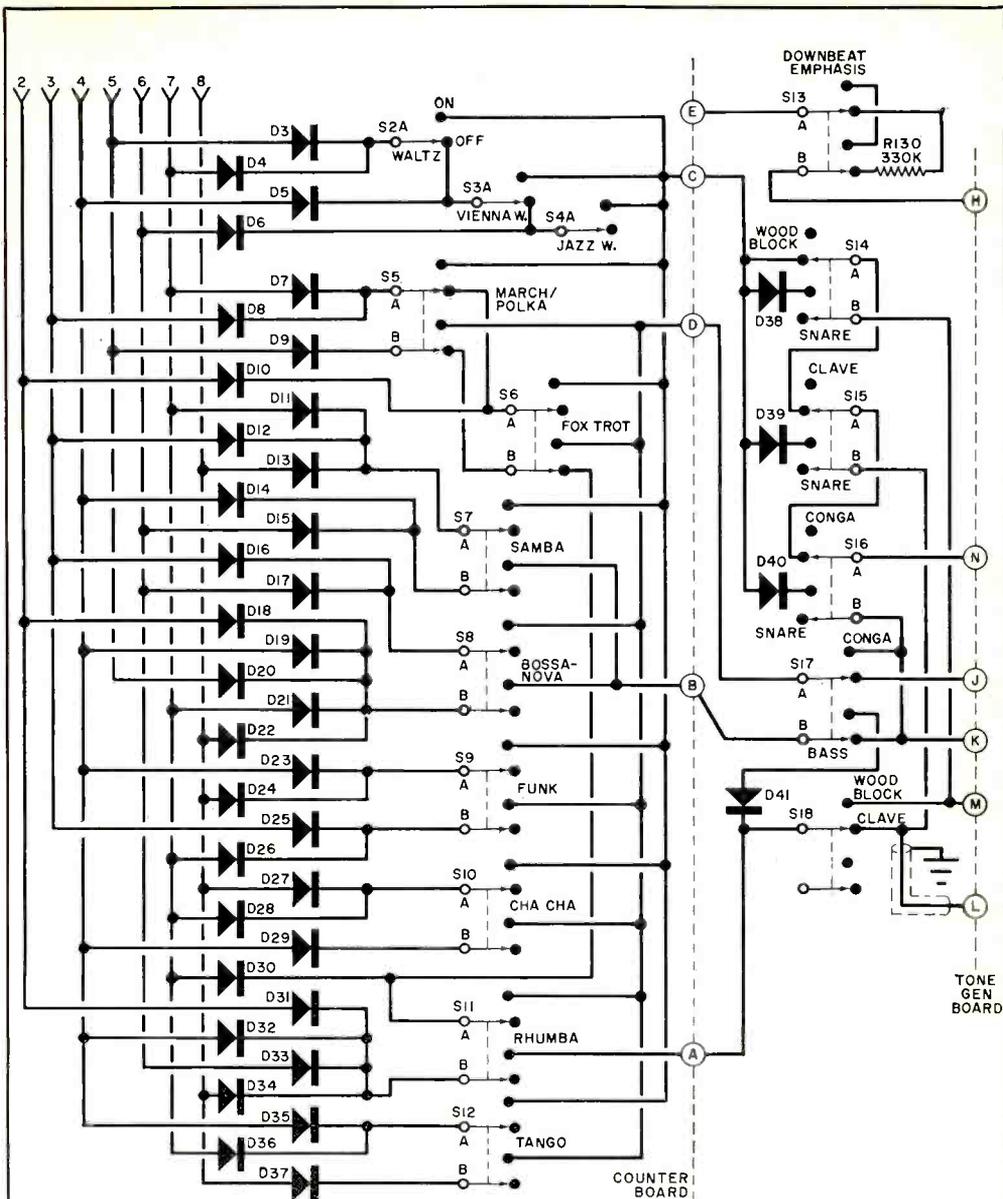


Fig. 2. The diode matrix determines the number and spacing of the pulses and after selection, the groups are passed to the tone generator.

- R5, R7, R12, R14, R19, R21, R26, R28, R33, R35,  
 R40, R42, R47, R49, R51, R56—1000-ohm, 1/2-watt resistor  
 R8, R15, R22, R29, R36, R43, R50, R57—  
 47,000 ohm, 1/2-watt resistor  
 R58—330-ohm, 1/2-watt resistor  
 R59—47-ohm, 1/2-watt resistor  
 R60—470-ohm, 1/2-watt resistor  
 R61—15,000-ohm, 1/2-watt resistor

- R63—75,000-ohm, reverse audio taper potentiometer  
 R130—330,000-ohm, 1/2-watt resistor  
 S1-S18—Dpdt rocker switch  
 Misc.—Switch mounting brackets (2), mounting hardware, two-lug terminal strip, etc.  
 Note—An etched and drilled PC board is available (#7701A) at \$5.00, postpaid, from the address given in Parts List for Fig. 3.

Essentially, the Drummer Boy is a variable speed digital counter that has 11 different beats—ranging from a slow waltz to a fast cha-cha—played either by a bass drum, wood block, clave, conga, snare drum, or a combination. Self-powered and having both variable tempo and volume control, the Drummer Boy is easily connected to an instrument power amplifier.

On the other hand, if you construct only the tone generator board and couple it to a finger-operated switch system (also described here), you can simulate an entire rhythm section with one hand—in any type of beat.

**Ring Counter.** The circuit of the Drummer Boy can be divided into three sections: an eight-stage ring counter, a switching and decoding system, and an electronic tone generator.

In the ring counter (see Fig. 1), the basic timing is provided by Q18, a conventional UJT relaxation oscillator whose frequency is determined by capacitor C18 and by the setting of the tempo control, R63. Each time the UJT fires, a positive pulse is generated across R60. The pulse turns on Q17, which momentarily causes the shift buss to be shorted to ground.

With the exception of a modification in the start circuit of stage 1 (Q1, Q2), the eight ring counter stages are identical. With switch S1 off, Q1 is biased on by the combination of R2 and R3; and Q2 is off. When S1 is turned to Start, the momentary surge of charging current on C19 causes a voltage spike across R62. This positive-going spike is passed through D1 to the emitters of Q1 and Q2 causing them to change their states. As long as Q2 is on, the current flow through the common emitter resistors, R7 and R5, keeps Q1 off.

When a pulse from Q17 occurs on the shift buss, the collector of Q2 is effectively grounded and the emitter of Q1 is lowered to the point where it turns on. Simultaneously, while Q2 was on, C2 accumulated a charge so that, when Q2 turns off, C2 discharges through R5 and R7 and the biasing resistor on Q3. This causes Q3 to turn off. When the shift buss returns to normal (Q17 not triggered), Q2 will not turn on because Q1 is saturated. At the same time, Q3 is off and Q4 is on.

## PARTS LIST TONE GENERATOR

C20, C22, C26, C31, C36, C39, C40, C41—0.05- $\mu$ F disc capacitor  
 C21, C27, C32, C37, C42—0.1- $\mu$ F disc capacitor  
 C23, C24, C33, C43, C48, C49—0.01- $\mu$ F disc capacitor  
 C25, C28, C34, C35, C44, C45—0.005- $\mu$ F disc capacitor  
 C29, C30, C50—0.001- $\mu$ F disc capacitor  
 C38, C57—0.22- $\mu$ F, Mylar capacitor  
 C46—0.1- $\mu$ F, Mylar capacitor  
 C47, C51—2.2- $\mu$ F, 6-volt electrolytic capacitor  
 C52, C53—30- $\mu$ F, 10-volt electrolytic capacitor  
 C54, C55—30- $\mu$ F, 15-volt electrolytic capacitor  
 C56—100- $\mu$ F, 15-volt electrolytic capacitor  
 D42—1N914 diode (or similar)  
 J1—Open-circuit phone jack  
 Q19, Q29, Q31, Q34—2N2712 transistor  
 Q30—2N5139 transistor  
 R64—270,000-ohm,  $\frac{1}{2}$ -watt resistor  
 R65, R74, R79, R80, R83, R93, R102, R122—68,000-ohm,  $\frac{1}{2}$ -watt resistor  
 R66, R75, R84, R88, R89, R94, R98, R99, R103, R118—39,000-ohm,  $\frac{1}{2}$ -watt resistor  
 R67, R73, R76, R85, R95, R104, R117—1-megohm,  $\frac{1}{2}$ -watt resistor  
 R68, R77, R86, R96, R105—4700-ohm,  $\frac{1}{2}$ -watt resistor  
 R69, R70, R71, R78, R87, R106, R107, R108—100,000-ohm,  $\frac{1}{2}$ -watt resistor  
 R72, R81, R90, R100, R109, R115—50,000-ohm trimmer potentiometer, printed circuit type  
 R82, R92—470,000-ohm,  $\frac{1}{2}$ -watt resistor  
 R91—150,000-ohm,  $\frac{1}{2}$ -watt resistor  
 R97, R121—47,000-ohm,  $\frac{1}{2}$ -watt resistor  
 R101, R116—330,000-ohm,  $\frac{1}{2}$ -watt resistor  
 R110, R112, R113, R120—10,000-ohm,  $\frac{1}{2}$ -watt resistor  
 R111, R125—2200-ohm,  $\frac{1}{2}$ -watt resistor  
 R114, R124—6800-ohm,  $\frac{1}{2}$ -watt resistor  
 R119—680-ohm,  $\frac{1}{2}$ -watt resistor  
 R123—15,000-ohm,  $\frac{1}{2}$ -watt resistor  
 R126, R127—330-ohm,  $\frac{1}{2}$ -watt resistor  
 R128—100-ohm,  $\frac{1}{2}$ -watt resistor  
 R129—1000-ohm potentiometer with spst switch (S1)  
 T1—Miniature driver transformer 10K:2K; secondary not used

Note—The following are available from PAIA Electronics, Inc., PO Box 14359, Oklahoma City, OK 73114: etched and drilled tone generator board (#7701B) at \$4.25 post-paid; complete kit of parts for tone generator at \$17.75, plus postage for 1 lb.; complete kit for Drummer Boy including circuit boards, hardware, and finished case (#7701K) at \$59.00, plus postage for 10 lb. Oklahoma residents, add 2% sales tax.

Each time a pulse occurs on the shift buss, this same procedure is repeated down the string of eight counters. Thus, a pulse appears to walk down the outputs numbered 2 through 8 on Fig. 1. When the last stage is reached, the output goes through switch S1 back to the first stage and the counting continues. The process continues until S1 is turned off, which

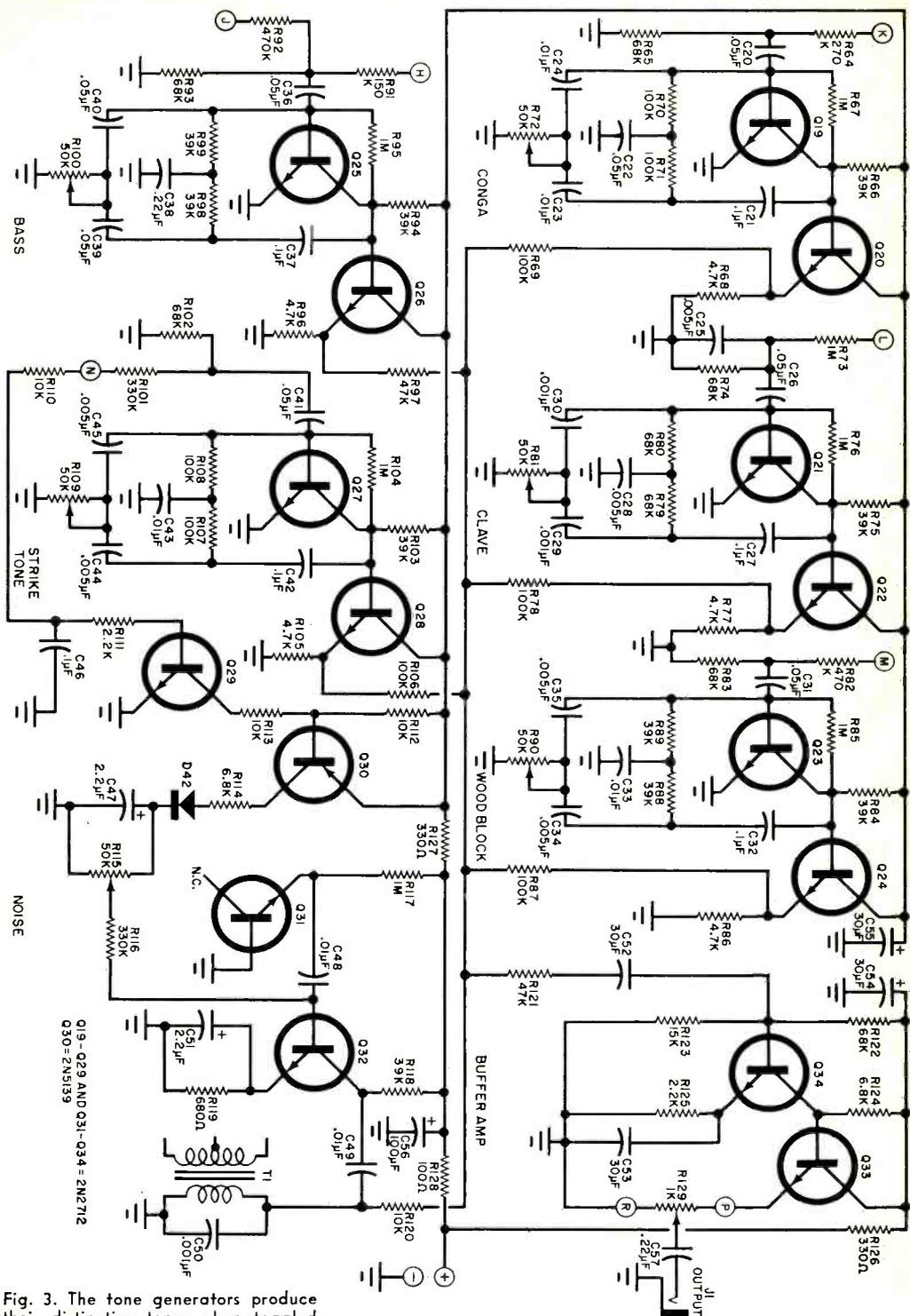


Fig. 3. The tone generators produce their distinctive tones when toggled by the switch-selected pulse groups.

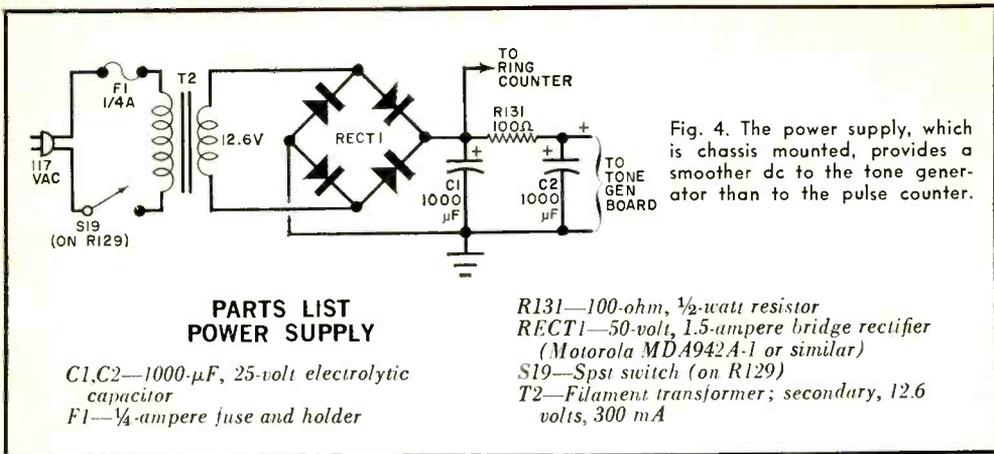


Fig. 4. The power supply, which is chassis mounted, provides a smoother dc to the tone generator than to the pulse counter.

also shorts out C19 to insure that it will be completely discharged for the next sequence.

An RC differentiating network is connected to the output of each pair (for example, C3 and R13 for Q3 and Q4) to convert the square-wave output to spikes. These are used in the diode matrix to decode the selected rhythm patterns and trigger the various tone oscillators.

Since the ring counter normally counts in eight beats, a waltz tempo using six-beats is obtained by bypassing stages three and four with the closing of switch S2, S3, or S4.

**Decoding and Switching.** The output from stage one of the ring counter (terminal E) is the downbeat signal and is processed in a special way which will be described later. The other seven outputs (2 through 8) are coupled to the diode matrix shown in Fig. 2. The diodes are arranged to pick up the correct beats for the selected rhythm. (The use of diode coupling permits more than one ring counter output to be tied to a single tone generator without intercoupling.) Rocker switches S2 through S12 are used to select the desired rhythm, while switches S14 through S18 and their associated coupling diodes select the tones. Switch S13 permits emphasis on the downbeat when desired and couples the first ring stage to the bass tone generator.

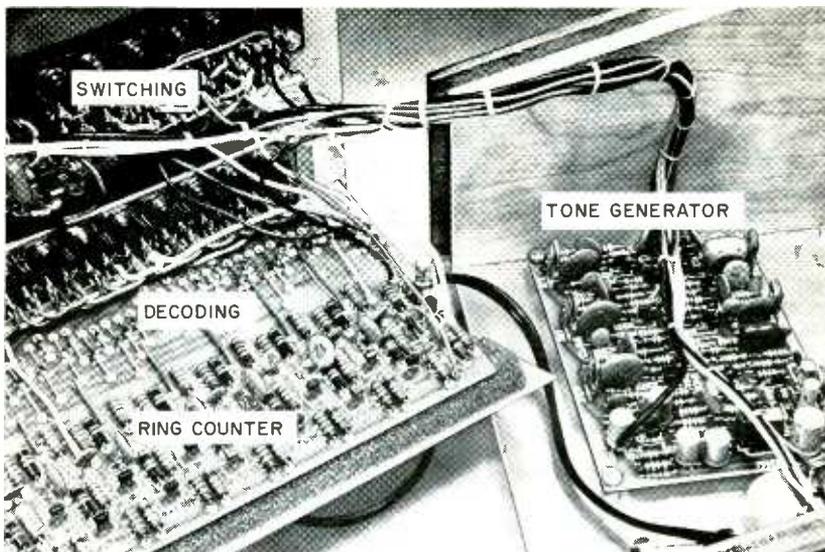
**Tone Generator.** When a percussion instrument is struck, it generates a tone which is dependent on the instrument's size and the material out of which it is

made. The tone then dies away. A similar effect can be obtained electronically by applying a sharp pulse to a parallel-T audio oscillator that is normally just below the point of oscillation. Once triggered, the circuit oscillates at its resonant frequency, with the oscillation decaying just as in a musical instrument. By selecting suitable time constants for the oscillator circuits, almost any tone can be simulated. Those used in the Drummer Boy are shown in Fig 3.

As an example, note that in the conga drum circuit, the oscillator consists of a single high-gain transistor (Q19) stabilized by feedback through R67. A second feedback loop consisting of a parallel-T RC notch filter made up of R70, R71, R72, C22, C23, and C24 is used. Normally,

### CONTROL IDENTIFICATIONS

S1	Start/Stop
S2	Waltz
S3	Vienna Waltz
S4	Jazz Waltz
S5	Polka (March)
S6	Fox Trot
S7	Samba
S8	Bossa Nova
S9	Funk (Watusi)
S10	Cha-Cha
S11	Rhumba
S12	Tango
S13	Downbeat Emphasis/Off
S14	Wood Block/Snare
S15	Clave/Snare
S16	Conga/Snare
S17	Conga/Bass
S18	Wood Block/Clave
R63	Tempo/Off
R129	Volume



The prototype was assembled within a sloping-front chassis with the layout shown here. The decoding and ring counter board is soldered directly to the lugs of the associated switches. The other end is cemented to a length of conventional rubber strip.

the circuit is quiescent. When a voltage spike appears at the input, it passes through R64 and the R65/C20 combination to put the circuit into oscillation. The spike is brief so that the circuit starts to oscillate quickly and dies away rapidly. The frequency of oscillation is determined by the component values in the parallel-T circuit. The "lossiness" of the circuit is preset by R72. Emitter follower Q20 couples the output to the common audio line.

Circuits for the clave, wood block and bass drum are similar but the snare drum presents a special problem. In this case, we need the sound of the striking of the drumhead by the stick and also the sound of the snares striking the bottom drumhead. This problem is solved by using "white noise", which is similar to the interstation hiss heard on an FM receiver.

There are six transistors (Q27 through Q32) in the snare drum circuit. Transistor Q31, the white noise generator, is used as a reverse-biased pn junction operated above its breakdown potential. As the junction avalanches, the resulting shot noise closely approximates the Gaussian distribution of white noise. The noise is amplified by Q32, which is normally biased off. A voltage spike at input N excites a ring from the parallel-T oscillator

Q27 and Q28 to generate the drum striking tone and also turns on Q29 and Q30. Due to the action of capacitor C46, both Q29 and Q30 stay on long enough to accumulate a charge on C47 and a resulting voltage envelope across R115. This envelope biases, Q32 to turn it on and transmit the white noise to a voicing circuit consisting of C50 and the primary of T1. The time constants of the triggering envelope and T1 and C50 are selected to achieve the desired sound of the snares.

Each tone generator is coupled to the common audio line through an isolating resistor and the outputs are amplified by Q34, with Q33 acting as an emitter follower for coupling.

A power supply consisting of a bridge rectifier and suitable filters for the Drummer Boy is shown in Fig. 4

**Construction.** The major portion of the Drummer Boy is assembled on two printed circuit boards whose foil patterns and layouts are shown in Figs. 5 and 6. Be sure to align the semiconductors properly; get the proper polarities on the electrolytic capacitors; and use a low-power soldering iron and fine solder.

The accompanying photos show how the prototype was assembled; though any arrangement can be used. In the proto-

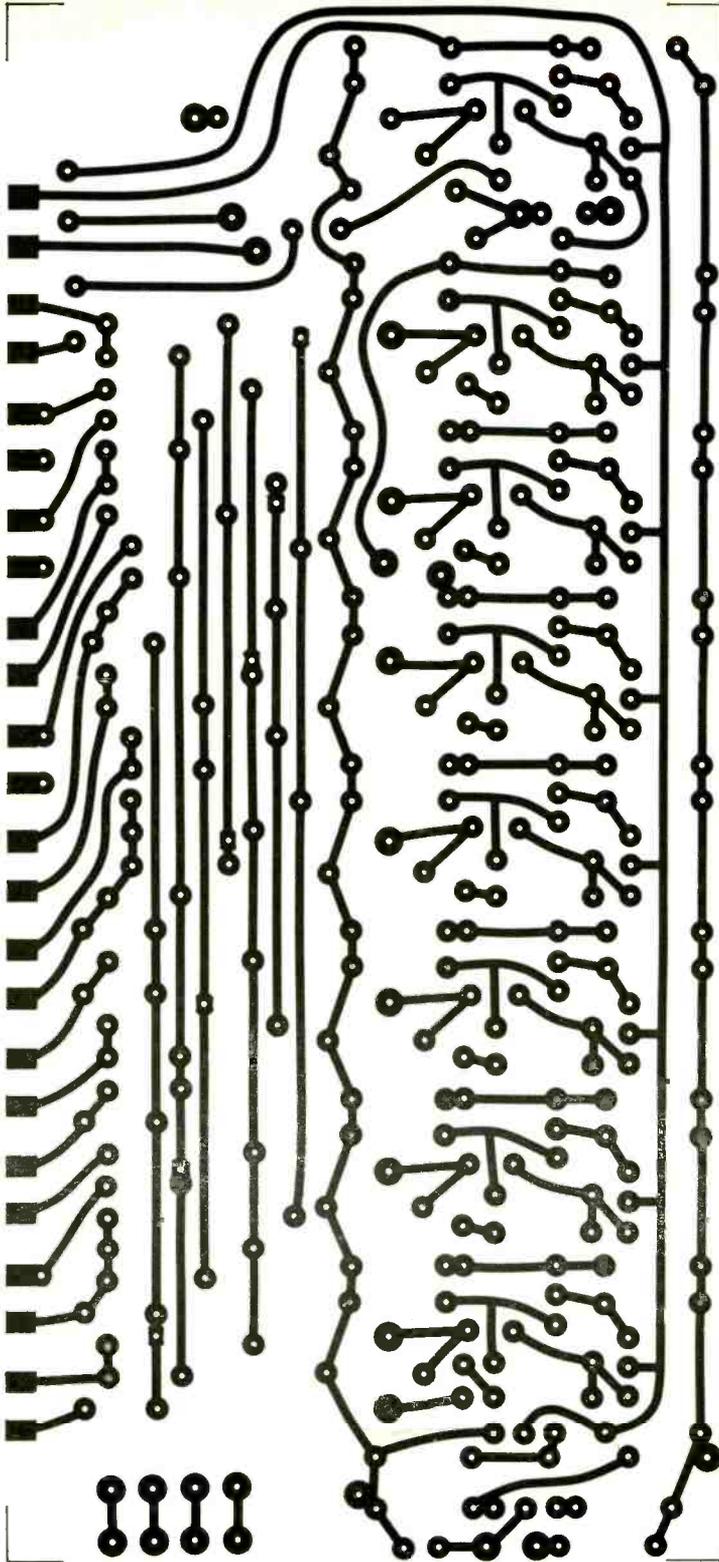
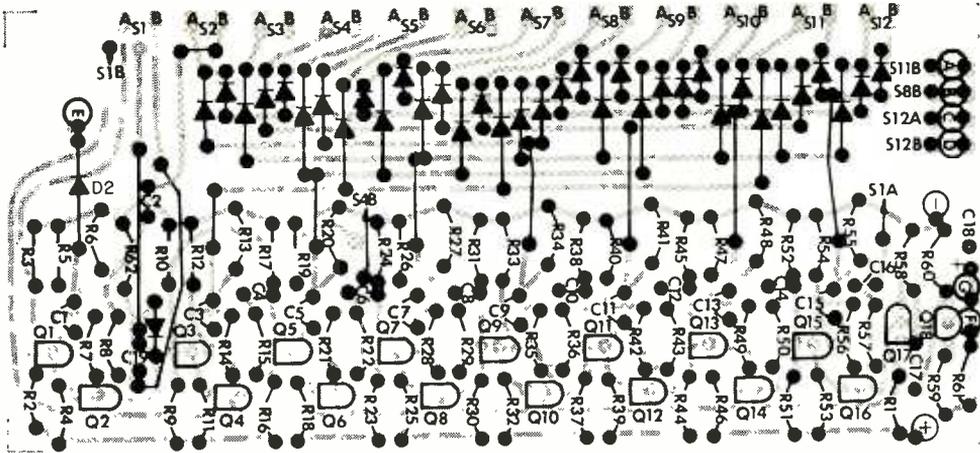


Fig. 5 (Above and opposite top right). Actual size foil pattern for pulse generator and diode matrix.



Component installation and external connections to the pulse generator.

type, a bracket was constructed to hold the 11 rocker switches (S2 through S12) that select rhythms and S1 the start-stop switch. The physical arrangement of these switches is such that the edge connector pads for the ring counter board may be soldered directly to the pertinent switch contacts to form the support for the board. To make a good mechanical connection, bend the center solder lugs on the switches 90 degrees. The various jumpers between the top row of switch contacts are made of insulated wire with connections to the appropriate tie points on the circuit board.

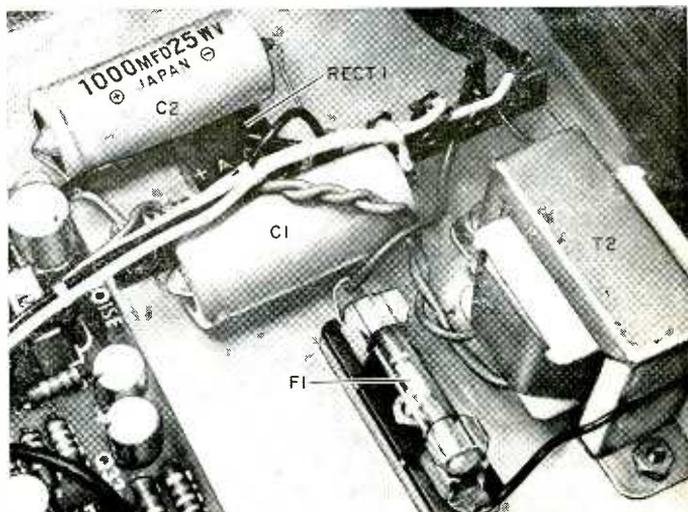
Another support bracket was made to hold the six instrument selection switches (S13 through S18) and the tempo

and volume controls (R63 and R129). The switches are interconnected as shown in Fig. 2 with resistor R130 and diodes D38 through D41 soldered directly to the switch lugs. Secure a two-lug terminal strip (one grounded) to the bracket adjacent to R129. Use the ungrounded lug to mount one end of C57 and the grounded lug for the ground on the output coaxial cable to J1.

In the prototype, the tone generator board was mounted on four spacers on the bottom of the chassis and the power supply components were mounted beside it, with a nine-lug terminal strip for the small components.

Once the mechanical assembly is complete, interconnect the four major sub-

The power supply can be mounted in any convenient place within the chassis. A terminal strip is used to mount the rectifier, and terminate the electrolytics, and the power line connections.



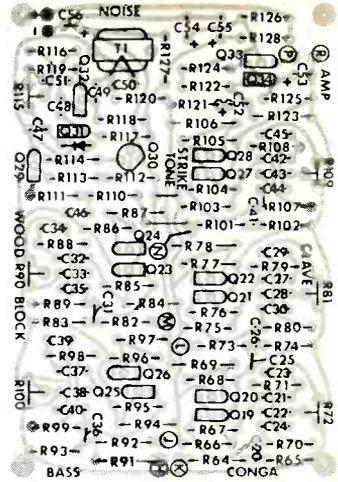
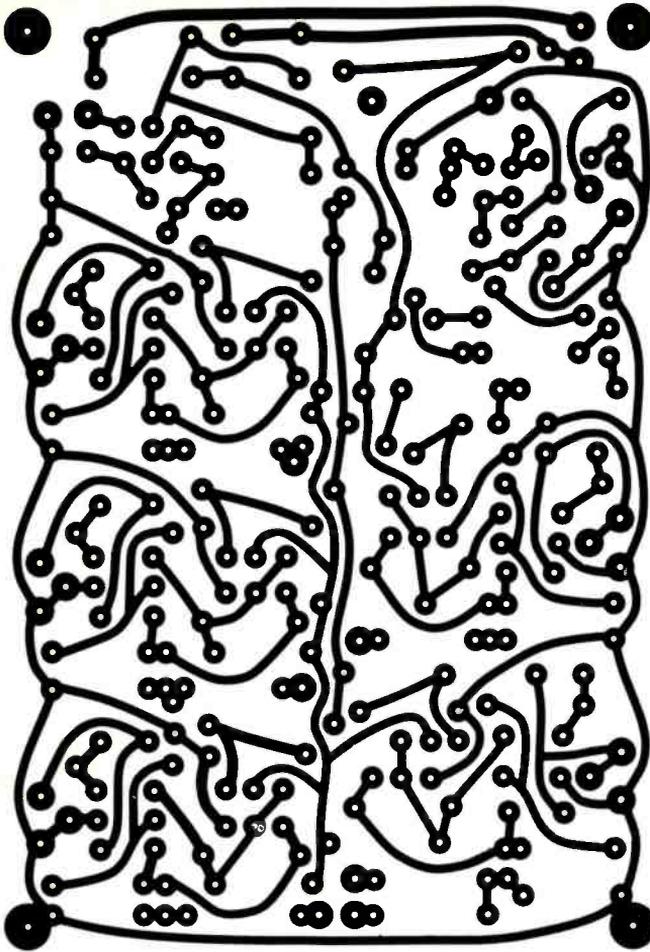


Fig. 6. Actual size foil pattern for the tone generator, and the component installation (above).

assemblies (counter, tone generator, switches, and power supply). Although the wiring from the six tone selector switches to the tone generator may be bundled and laced together to make a neat appearance, don't bundle the leads from the rhythm selector switches to the ring counter. There is always the possibility of mutual coupling between these leads and a trigger pulse intended for one tone generator can accidentally activate another. Note also that small diameter coaxial or other shielded audio cable is used to connect S18 to the clave oscillator. Because of its relatively high frequency and long sustain, this oscillator is particularly susceptible to erroneous triggering.

Shielded audio cable or small-diameter coaxial cable should be used to make the connection between the output ca-

pacitor C57 and the output connector J1. When completed, check all wiring and check printed circuit boards for solder bridges and cold solder joints.

Using press-on type or some other form of lettering, identify the various switches and controls as shown in the Table. Note that S14, S15, and S16 have a common "snare" designation. The lettering for the rhythm selectors should be located at the on position of the switches.

**Checkout and Tuning.** Connect the Drummer Boy to a suitable audio amplifier and speaker. Place all tone generator controls in the full counterclockwise position (looking into the PC board). Turn on the power switch (through the Tempo control) and advance the volume until sounds are heard. All rhythm selector switches should be off.



If you want to control the tone generator manually, a set of independent normally open switches can be used and connected directly to the tone generator. A typical switching circuit is shown at upper right.

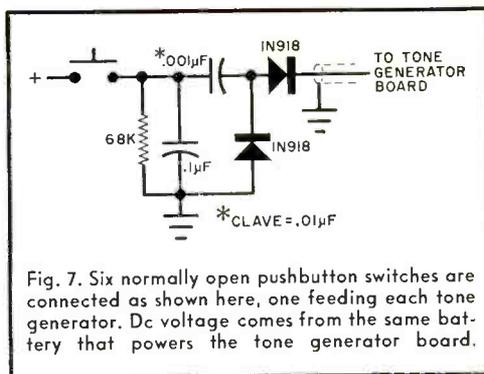


Fig. 7. Six normally open pushbutton switches are connected as shown here, one feeding each tone generator. Dc voltage comes from the same battery that powers the tone generator board.

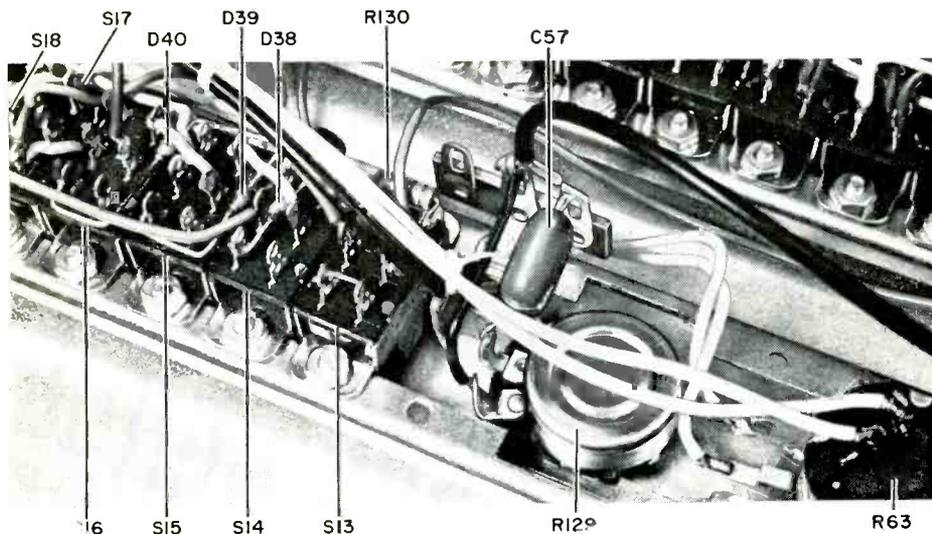
the individual oscillators fails to operate, the problem is within that stage.

Once all the oscillators are operating, place S14, S15, and S16 in the snare position, S2 on waltz and S1 on start. You should hear the familiar waltz rhythm, with the tempo adjustable through R63. You should also hear the bass drum on the downbeat and probably a distorted snare drum on the other two beats. Adjust both R109 and R115 to get a true snare drum sound. The level of the bass downbeat can be changed by switching S13.

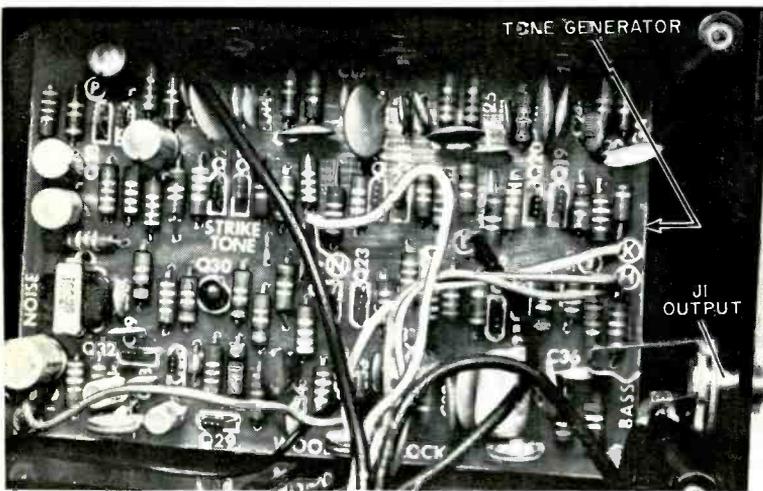
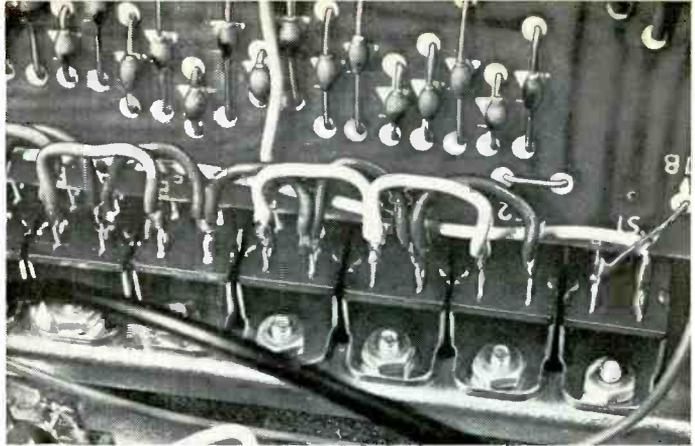
With the waltz rhythm still operating, set S14 to the wood block position, and then adjust R90 on the tone generator to get the best wood block sound. (Note also that taking either S14, S15 or S16 off the snare position removes the snare completely.) With S14 back on snare, set S15

If a tone cannot be heard at all, look for trouble in the audio preamplifier (Q33, Q34) or the power supply. If one of

The author's prototype used a pair of metal brackets to support the various switches and controls.



As the rhythm switches are frequently operated, they should be mounted as firm as possible:



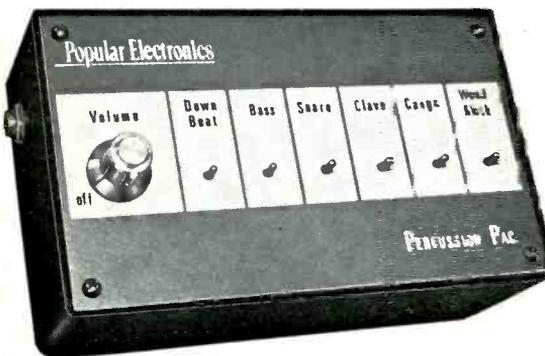
In the hand-held unit, tone generator board will fit snugly in a conventional plastic utility case.

to the clave position and adjust R81 for the best clave sound. Put S15 back to snare and set S16 for conga. Adjust R72 to get the best conga sound. All the tone generators have now been adjusted.

Turn off the waltz switch and turn on each rhythm switch one at a time. Note

that the rhythms are properly generated. Turn off the main switch and see if the pattern in progress completes itself before stopping.

**Operation.** Obviously, the best thing to do is experiment. Bear in mind that more



The six finger-operated rhythm pushbuttons are mounted to the top panel with the volume control, while the output jack is mounted on one side. The batteries fit inside.

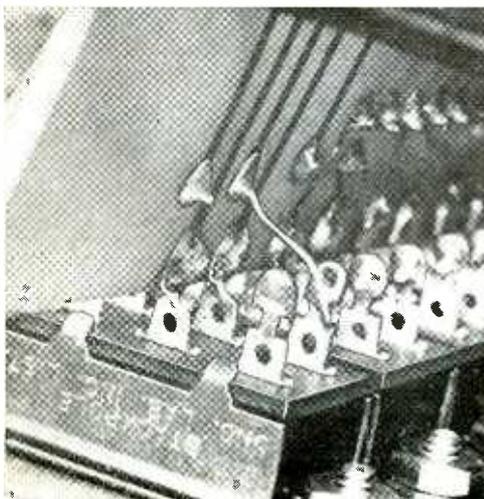
than one of the rhythm switches can be used at a time to produce unusual beats. Operating either of switches S14, S15, and S16 removes the snare and substitutes the wood block, clave, or conga, respectively. However, neither of the switches takes precedence over the others.

The conga-bass switch (S17) allows the substitution of a conga for the bass on any beat except the downbeat, where the bass drum is permanent. At the same time that the conga-bass switch substitutes the conga for the bass in a pattern, it also substitutes for the conga either the clave or wood block as selected by S18.

The tone generator can be used by itself and operated manually by using the circuit shown in Fig. 7. Six similar circuits are needed for all of the tone functions. The switches are normally open with snap action. The circuits are identical except for the snare drum which uses a 0.01- $\mu$ F series capacitor instead of the 0.001- $\mu$ F capacitor shown in the diagram.

Both this board and the tone generator board may be driven by a pair of 9-volt transistor radio batteries in series. The tone generator board can then be connected to the main audio amplifier through a length of audio cable. The manual toggle, the tone generator, and the batteries can be put in a small case and connected to the amplifier.  $\blacklozenge$

Lugs of the switches associated with the decoder-matrix board are bent 90 degrees so that they can be soldered directly to the pads on the boards.



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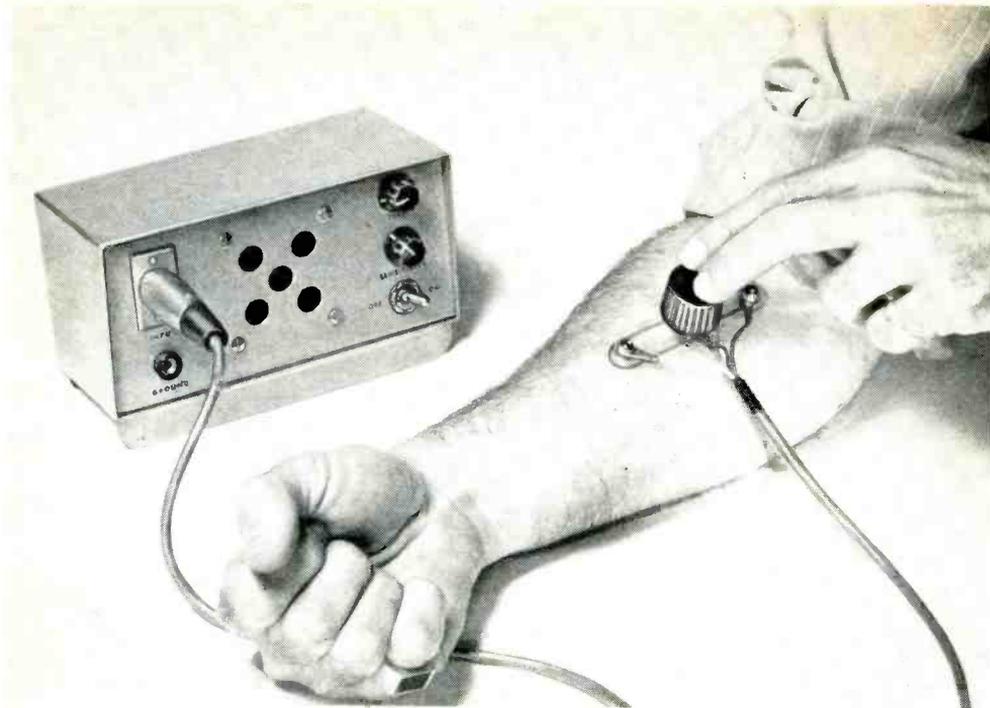
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LISTEN TO YOUR BICEPS DO THEIR THING

BY HARRY GARLAND  
AND ROGER MELEN

**T**HERE are 656 muscles in the human body and all of them generate a small voltage potential when they are activated. This voltage, called myoelectricity or EMG, is present on the surface of the skin surrounding the muscle. The detection of this signal is important in both clinical medicine and medical research.

Reaction time, for example, can be measured by noting the time lag between a stimulus and the onset of EMG activity. Audible EMG monitoring has been used experimentally in training athletes—it has been hypothesized that athletes can learn complicated, coordinated muscle skills faster by listening to their muscles during training.

The Muscle Whistler, described here, can monitor many of the muscles in the

body, producing a whistling tone each time a muscle is activated. Try it, for instance, with the electrodes on the biceps muscle (upper arm) and lift a heavy object. Signals can also be picked up with the electrodes on the triceps (back of upper arm) when you try to push something. The flexor muscles (on the front of the lower arm) are active when you clench your fist, and the gastrocnemius muscle (in the calf of the lower leg) is active when you stand on your toes. You may be surprised to hear muscle activity even when you think a muscle is relaxed. This is called "muscle tone" and is characteristic of all muscles.

Whether you listen to the Muscle Whistler to monitor the force generated by your muscles, measure your reaction

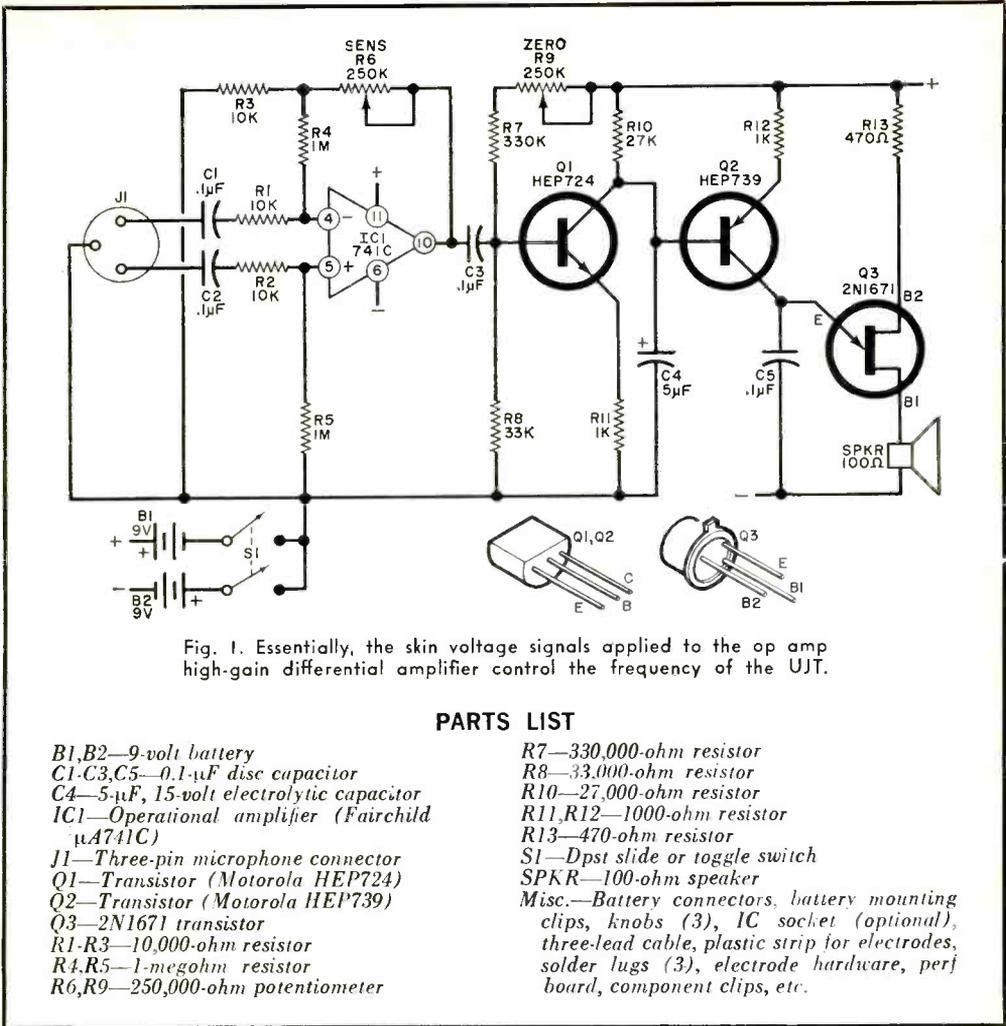


Fig. 1. Essentially, the skin voltage signals applied to the op amp high-gain differential amplifier control the frequency of the UJT.

### PARTS LIST

B1,B2—9-volt battery  
 C1-C3,C5—0.1- $\mu$ F disc capacitor  
 C4—5- $\mu$ F, 15-volt electrolytic capacitor  
 IC1—Operational amplifier (Fairchild  $\mu$ A741C)  
 J1—Three-pin microphone connector  
 Q1—Transistor (Motorola HEP724)  
 Q2—Transistor (Motorola HEP739)  
 Q3—2N1671 transistor  
 R1-R3—10,000-ohm resistor  
 R4,R5—1-megohm resistor  
 R6,R9—250,000-ohm potentiometer

R7—330,000-ohm resistor  
 R8—33,000-ohm resistor  
 R10—27,000-ohm resistor  
 R11,R12—1000-ohm resistor  
 R13—470-ohm resistor  
 S1—Dpst slide or toggle switch  
 SPKR—100-ohm speaker  
 Misc.—Battery connectors, battery mounting clips, knobs (3), IC socket (optional), three-lead cable, plastic strip for electrodes, solder lugs (3), electrode hardware, perf board, component clips, etc.

time, or improve your golf swing, this project will provide an entertaining introduction to an important area of medical electronics.

**Construction.** The circuit of the Muscle Whistler is shown in Fig. 1. The prototype was built on a piece of perf board, though any other method may be used. The components are mounted on small clips, except that a 14-pin dual in-line socket may be used for the IC if desired. The input connector (J1), the speaker, the zero and sensitivity potentiometers (R9 and R6, respectively), and the on-off switch (S1) are mounted on the front panel of the selected chassis.

A conventional three-lead microphone

jack with an associated three-lead microphone connector and a few feet of three-lead cable are used to connect the muscle electrodes to the circuit.

The electrodes are fashioned from two screws mounted 3 or 4 inches apart on a narrow piece of plastic as shown in Fig. 2. A third screw midway between the other two forms the ground electrode. Solder lugs under the nuts are used to connect the three color-coded leads from the circuit. The center screw is longer than the other two so that a knob, or handle, can be attached.

**Operation.** With power applied to the circuit, adjust R9 so that there is no output from the speaker when there is no

input signal. The output varies from a whistle down to a series of slow clicks. Adjust  $R9$  until the clicks just stop. With the sensitivity control ( $R6$ ) turned up slightly, touching one of the end electrodes on the muscle probe should cause the circuit to squeal due to imbalance in the operational amplifier circuit. (It is actually pickup from the field created by the 60-Hz power line.) However, when both electrodes are touching the skin, virtually all of this ambient noise is rejected by the differential amplifier.

Good electrical contact must be made between the electrodes and the skin. Use a commercial electrode paste or make your own by mixing salt, water, and flour in a good pasty consistency. The paste is rubbed into the area of skin where the electrodes are to be applied.

Before the electrodes are placed against the skin, set  $R6$  partially up and be sure  $R9$  is adjusted to give no output. Place the electrodes against the skin. There will be a change in the tone of the output. Adjust  $R9$  just below the oscillation point and adjust  $R6$  until the output changes frequency as the muscle is activated. Each time the muscle is flexed, the whistle changes frequency—the tenser the muscle, the higher the frequency.

**Theory of Circuit Design.** Operational amplifier  $IC1$  is a very high gain differential amplifier whose gain (sensitivity) is controlled by feedback potentiometer  $R6$ . The differential input to the op amp is picked up by the electrodes applied to the skin.

Unijunction transistor  $Q3$  is wired in the classical UJT oscillator config-

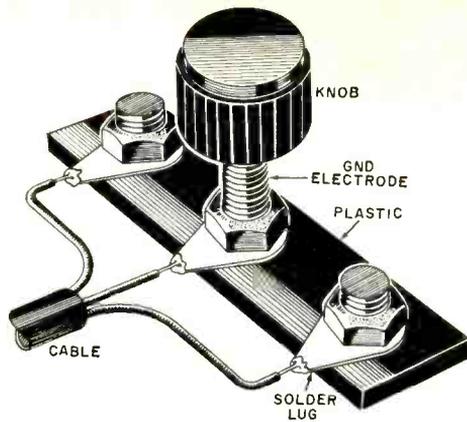


Fig. 2. Electrodes are mounted on a small length of plastic as shown here. An insulated knob on the ground screw acts as the handle.

uration with  $C5$  determining the frequency and the emitter-collector resistance of  $Q2$  (with limiting resistor  $R12$ ) acting as the charging resistor. The interelement resistance of  $Q2$  is a function of the applied base current and the voltage to move this current is stored in capacitor  $C4$ , which is charged up by amplifier  $Q1$ . The size of the steady-state charge on  $C4$  is determined by the setting of  $R9$ .

When a muscle voltage is amplified by  $IC1$  and fed to  $Q1$ , the collector voltage on  $Q1$  varies, thus changing the charge on  $C4$ . This, in turn, varies the UJT oscillator frequency. The speaker forms the load for  $Q3$ , and the audible tone consists of a series of spikes, each occurring as the UJT fires. ♦

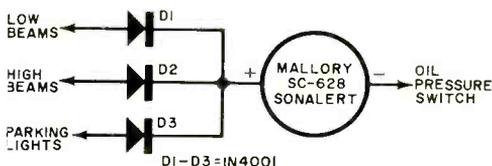
# LIGHT MINDER

ALERTS YOU TO TURN OFF CAR LIGHTS WHEN ENGINE IS SHUT DOWN

BY STEPHEN J. ERST

REPLACING a dead battery resulting from having left your car lights on overnight is an expensive and time-consuming propo-

sition. Detroit has remedied the “forgotten ignition key syndrome” with a buzzer; now you can remedy the “forgotten light syndrome” with a similar alerting system. With a Light Minder installed in your car, you will be alerted to turn off parking and headlights whenever you turn off the engine without first switching off the lights. ♦



# Build a GENERAL-PURPOSE ALARM

SIREN-LIKE WAIL CAN BE TRIGGERED BY A NUMBER OF SOURCES

BY TRUETT BROWN

THERE ARE many different types of intrusion alarms. They all have one purpose—to detect the presence of an intruder and sound the alarm.

However, there are many applications for alarms that do not involve an intruder. These include signalling the presence of unwanted moisture or liquids, the presence or absence of light, the removal of a small object, and the unwanted opening of a door by a child or animal. What is needed then, is a general-purpose alarm that can be triggered by a variety of stimuli.

The circuit for a basic alarm is shown in Fig. 1. Transistors Q1 and Q2 form an audio oscillator with the speaker representing the collector load for Q2. The frequency of oscillation is determined by C4 and the voltage across C3. The charge on C3 comes from the positive line through R3, R4, and

R5. When the dc voltage across C2 reaches a level determined by the spring adjustment of K1, the relay pulls in allowing the contacts to open so that both C2 and C3 discharge. As C3 discharges, it causes the audio tone to go down in frequency. As the voltage across C2 drops, the point is reached where the relay contacts close to repeat the cycle. As C2 and C3 charge and discharge, the oscillator frequency simulates the rising and falling wail of a siren.

The circuit is triggered into operation only when SCR1 is in a conducting mode. This, of course, means that some positive going voltage must be applied to the gate input connector of TBI (positive with reference to the neg input). Figure 2 shows some examples of how such toggling can be obtained.

In Fig. 2A (a break-wire trigger), when

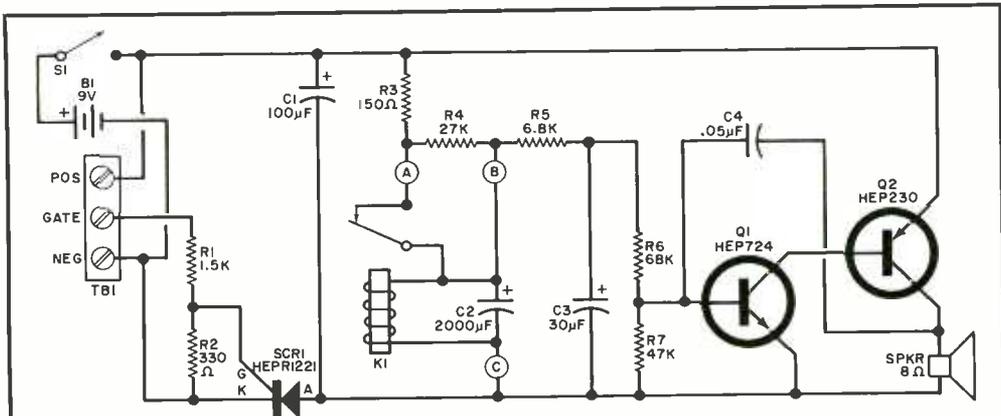


Fig. 1. The siren-like wail is produced by the changing voltage on capacitor C3, which is controlled by the operation of K1. Operation of SCR1 turns on the system.

## PARTS LIST

B1—9-volt battery  
 C1—100- $\mu$ F, 10-volt electrolytic capacitor  
 C2—2000- $\mu$ F, 15-volt electrolytic capacitor  
 C3—30- $\mu$ F, 6-volt electrolytic capacitor  
 C4—0.05- $\mu$ F ceramic disc capacitor  
 K1—1000-ohm, 50-mW sensitive relay  
 (Sigma 11F-1000-G/SIL or similar)  
 Q1—2N2712, HEP724 transistor  
 Q2—HEP230 transistor  
 R1—1500-ohm,  $\frac{1}{2}$ -watt resistor  
 R2—330-ohm,  $\frac{1}{2}$ -watt resistor

R3—150-ohm,  $\frac{1}{2}$ -watt resistor  
 R4—27,000-ohm,  $\frac{1}{2}$ -watt resistor  
 R5—6800-ohm,  $\frac{1}{2}$ -watt resistor  
 R6—68,000-ohm,  $\frac{1}{2}$ -watt resistor  
 R7—47,000-ohm,  $\frac{1}{2}$ -watt resistor  
 S1—Spst switch  
 SCR1—HEP R1221 silicon controlled  
 rectifier  
 SPKR—8-ohm speaker (see text)  
 TBI—Three-lug terminal strip  
 Misc.—Battery clip, mounting hardware,  
 suitable chassis, etc.

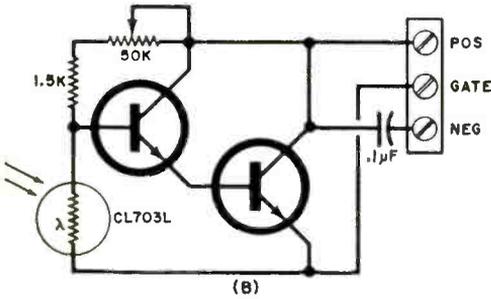
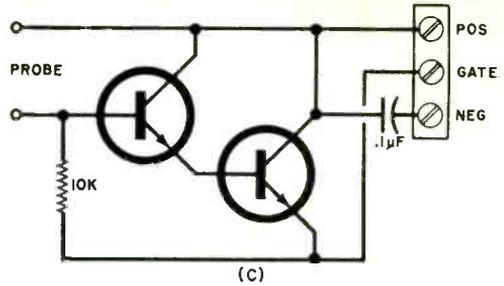
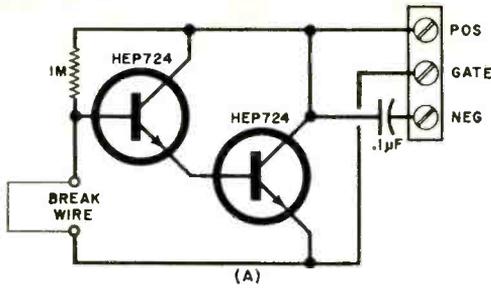


Fig. 2. Three typical trigger circuits. (A) is for break-wire; (B) is light controlled; (C) is water level sensor.

the wire is opened, a positive-going pulse is applied to the gate of SCR1. This circuit can be used for closet doors, toy chests, etc. If desired, a magnet-operated, normally open reed switch can be used. Since it is battery-operated, this system can be mounted over a hotel or motel door to signal the opening of the door.

The photo-trigger sensor shown in Fig. 2B can be used to signal the presence of unwanted light in an unattended photography darkroom or the illicit turning on of a light in any room. The potentiometer is used as the sensitivity control. The water-level sensor shown in Fig. 2C can be used in basements, boat bilges, etc. to sound the siren-like wail when water gets above a predetermined level.

You can also connect a simple normally open switch between the positive and gate

terminals of TBI to turn on the alarm when the switch is closed. There are any number of mechanical arrangements for this application. In an automobile, the alarm can be powered from the vehicle battery and used to signal the presence of voltage on any desired line—turn signals, parking lights, backup lights, etc. If wired to the dome light with the siren output capacitor coupled to an audio amplifier, the circuit serves as a burglar alarm.

**Construction.** Although any type of construction can be used, the foil pattern and layout shown in Fig. 3 provide a good, trouble-free arrangement. Note that K1 and C2 are mounted off the board.

In the prototype, an 8-ohm speaker was connected to the board, but you can increase the volume somewhat if you use a conventional transistor output transformer, with the secondary matched to the speaker impedance. For coupling to an audio amplifier, interconnect the common negatives and use capacitor coupling from the collector of Q2. Adjust the pull-in spring of the relay so that it cuts in and out at the upper and lower voltages (charge on C2) desired. ♦

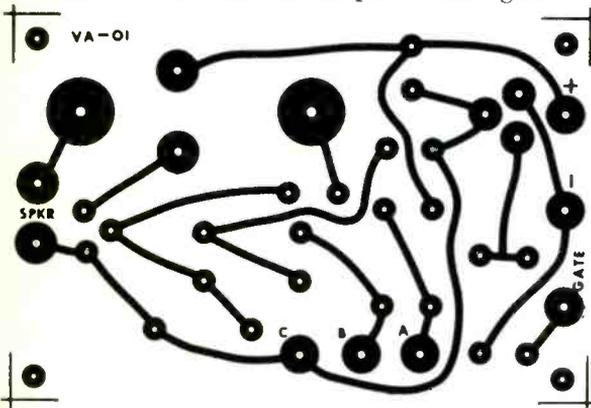
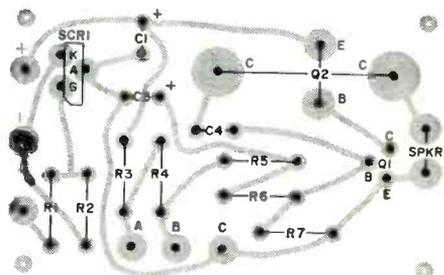


Fig. 3. Foil pattern and component layout. K1 and C2 are not on board.



# all american sports amplifier

## HIGHLY SELECTIVE TV ANTENNA PREAMP BRINGS IN DISTANT STATIONS

BY ROBERT B. COOPER, President  
CADCO, INC.

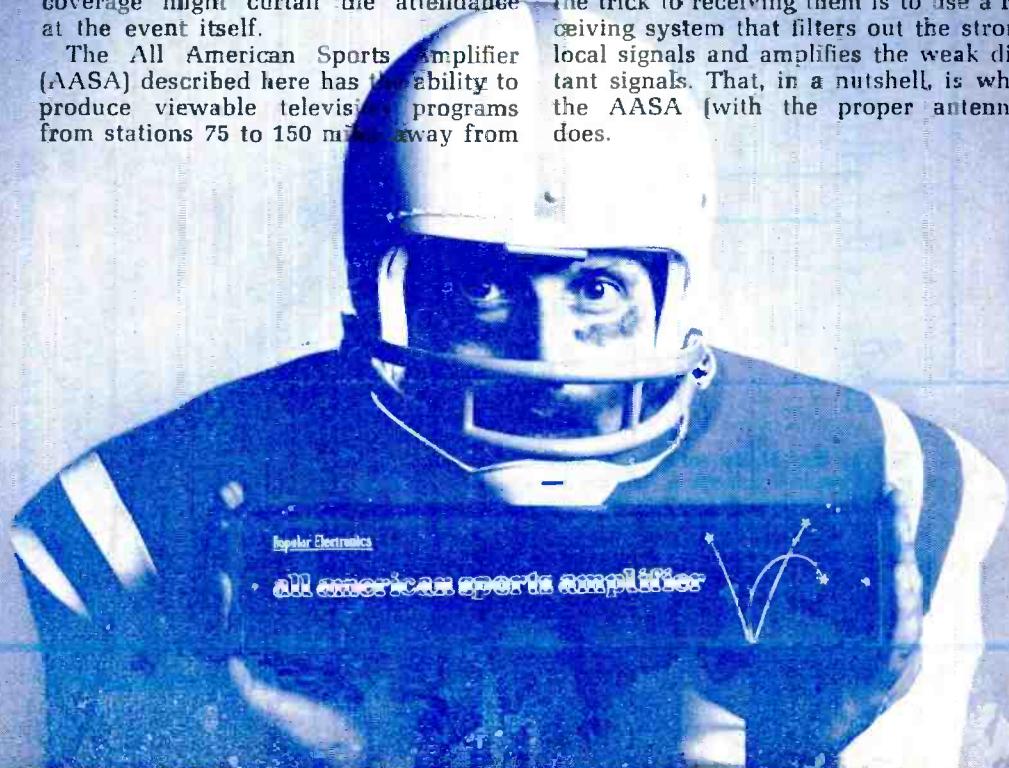
**T**HERE COMES a time when the sports fan—especially the pro-football fan—wishes he could tune in on a TV station outside his immediate area. This happens when his favorite local pro team is playing at home and there is no local TV coverage.

Under the present, federally sanctioned pro-football "blackout," television stations within 75 miles of the stadium are prevented from televising a home game; the reason being, of course, that local TV coverage might curtail the attendance at the event itself.

The All American Sports Amplifier (AASA) described here has the ability to produce viewable television programs from stations 75 to 150 miles away from

your receiver—provided it is driven by a properly designed and installed outdoor antenna. (See page 42.) Of course, the AASA was not designed merely to "beat the TV blackout." Rather it is intended to improve substantially the reception from stations 75 to 150 miles away, and, in some cases, to make such reception a real possibility.

Since the signals from distant (up to 150 miles) stations are normally "there," but blocked out by stronger local signals, the trick to receiving them is to use a receiving system that filters out the strong local signals and amplifies the weak distant signals. That, in a nutshell, is what the AASA (with the proper antenna) does.



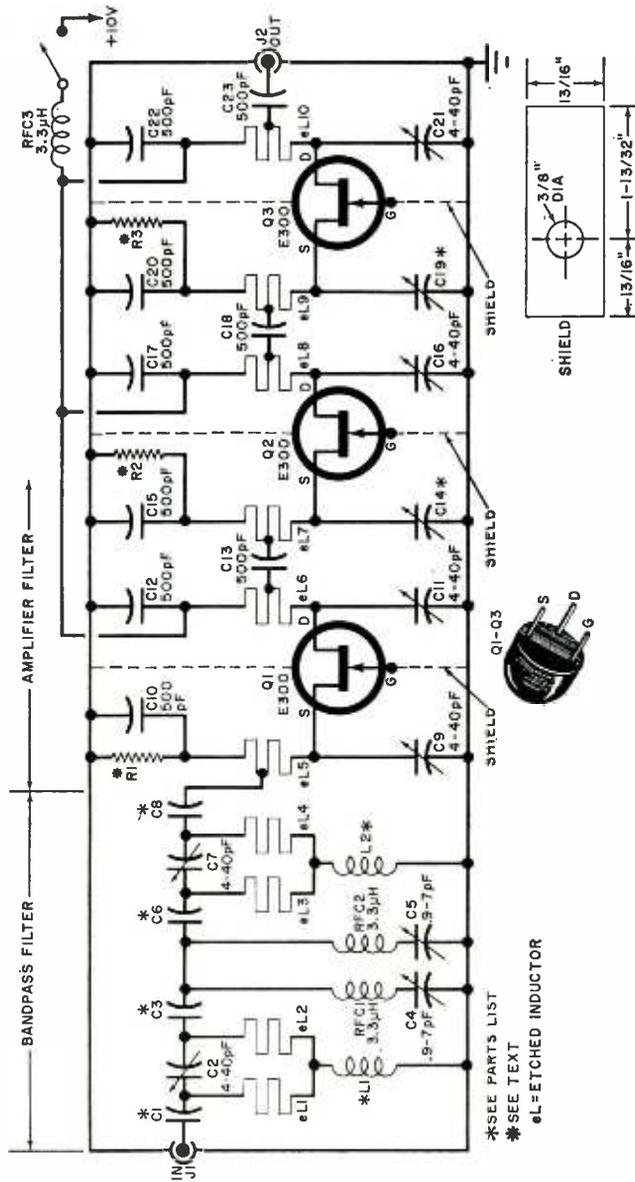


Fig. 1. The highly selective amplifier for channels 2 through 6. The squared-off coils (called eL) are etched on the PC board. The channels are selected by choice of L1, L2, C1, C3, C6, and C8.

**PARTS LIST  
LOW-BAND AASA**

- C1, C3, C6, C8—5.6-pF, 5% disc ceramic capacitor
- channels 5-6: 4.7-pF, 5% disc ceramic capacitor
- C2, C7, C9, C11, C16, C21—4.40-pF trimmer capacitor (Elmenco/Arco 422)
- C4, C5—0.9-7pF trimmer capacitor (Elmenco/Arco 400)
- C10, C12, C15, C17, C20, C22—500-pF uhj stud-mounting, feedthrough capacitor (Sprague BH-105, Centralab, MFT)
- C13, C18, C23—500-pF, 10% disc ceramic capacitor
- C14, C19—channels 2-4: 9.180-pF trimmer ca-

- channels (Elmenco/Arco 463)
- channel 5-6: 4.40-pF trimmer capacitor (Elmenco/Arco 422)
- eL1-eL10—Etched inductors on PC board
- J1, J2—G-F-59 F chassis mounting connectors
- L1, L2—channel 2: 9 turns #16, 5/16" form, close spaced with 0.2" mounting pigtails
- channel 3: 7 turns same as above
- channel 4: 5 turns same as above
- channel 5: 6 turns same as above
- channel 6: 5 turns same as above
- Q1-Q3—Field effect transistor (Siliconix E-300)
- R1-R3—91-560-ohm, 1/4-watt resistor (see text)

RFC1, RFC3—3.3-µH molded choke (J. W. Miller R9310-24)

Misc.—Suitable chassis, mounting hardware, interstage shields, spst switch, etc.

Note—The following are available from CADCO, P.O. Box 18904, Oklahoma City, OK 73118: actual size foil pattern and component layout guide at \$4 (specify channel); etched and drilled circuit board LB24 (channels 2-4) or LB56 (channels 5-6) at \$14, postpaid; complete kit of all parts including power supply, pre-drilled mounting case, base plate, wooden end caps, prewound coils, E-300's with matched source resistors, LB24K or LB56K at \$49.50 plus postage for 4 lb. (Specify channel.)

In practical terms, let's consider a situation where your locality has TV transmitters on (among others) channels 2 and 4. In your home, both channels are so strong that, when you tune to channel 3 and rotate your fine tuning control, you receive a mixture of channel 2 sound and channel 4 picture. Both signals are overloading the receiver and bleeding into channel 3.

If you had a channel 3 antenna pointed at a 100-mile distant station, and either or both of channel 2 and 4 left the air while channel 3 was still transmitting, you would see a typical fringe signal: fairly weak, snowy, and fading up and down in level. With both channels 2 and 4 (or even just one of them) on the air, however, the bleeding would cover channel 3—even with a special antenna.

The AASA, installed between the antenna and receiver, filters out channels 2 and 4 (and all others except channel 3) and, at the same time, amplifies and filters channel 3. It reduces channels 2 and 4 levels by 20 to 50 dB and amplifies the channel 3 signal by 22 to 25 dB.

Since most television receivers have no more than 40 dB or adjacent channel rejection in their i-f strips, when your local station is 40 dB or more stronger than a distant one, the receiver is not capable of separating the two on adjacent channels. And, while any distant station needs amplification to be viewed comfortably, the receiver must "see" (from the antenna system) a better ratio of signal levels. Merely installing a signal booster and a cut-to-channel antenna for the distant signal is not enough since the booster amplifies the already strong local signals as well as the distant signal; and the existing ratio of signal levels between local and distant becomes more intolerable.

**Construction and Alignment.** The All American can be built for either the low channels (2 through 6) or the high ones (7 through 13). The respective schematics are shown in Figs. 1 and 2. A printed circuit board is required in either case and may be ordered as noted in the Parts Lists. (The foil pattern is too large to be reproduced here but may also be ordered from the source given in the Parts List.)

A schematic of the power supply is shown in Fig. 3. See Fig. 4 for assembly.

## PATENT NOTICE

The All American Sports Amplifier (title copyright CADCO 1971) is covered by one or more patents issued to the author by the U. S. Patent Office. Individual (non-commercial use of the designs and products covered here is permitted by the author and CADCO. Commercial use is the subject of numerous licensing agreements entered into by CADCO and/or the author, and all commercial rights are retained. "Interdigital Pre-Amplifier" and "Amplifilter" are registered trademarks of CADCO, Inc.

## TECHNICAL SPECIFICATIONS

### LOW-BAND AASA

**Total Gain:** 22-25 dB

**Noise Figure:**\* 3-4 dB

**Bandwidth** ( $\pm 0.25$  dB): 4.5 MHz

**Dynamic Range:** 100 dB

**Rejection** lower adjacent aural,  
upper adjacent visual carriers: 16-24 dB

**Rejection** lower adjacent visual,  
upper adjacent aural carriers: 40-50 dB

**Input/Output Impedance:** 75 ohms,  
unbalanced

**Input Match:** 16-18 dB

**Output Match:** 15-17 dB

**Frequency Range** LB24: 54-72 MHz  
LB56: 76-88 MHz

### HIGH-BAND AASA

**Total Gain:** 22-26 dB

**Noise Figure:** 5.0 dB

**Bandwidth** ( $\pm 0.25$  dB): 5.0 MHz

**Dynamic Range:** 100 dB

**Rejection** lower adjacent aural,  
upper adjacent visual carriers: 6-10 dB

**Rejection** lower adjacent visual,  
upper adjacent aural carriers: 35-50 dB

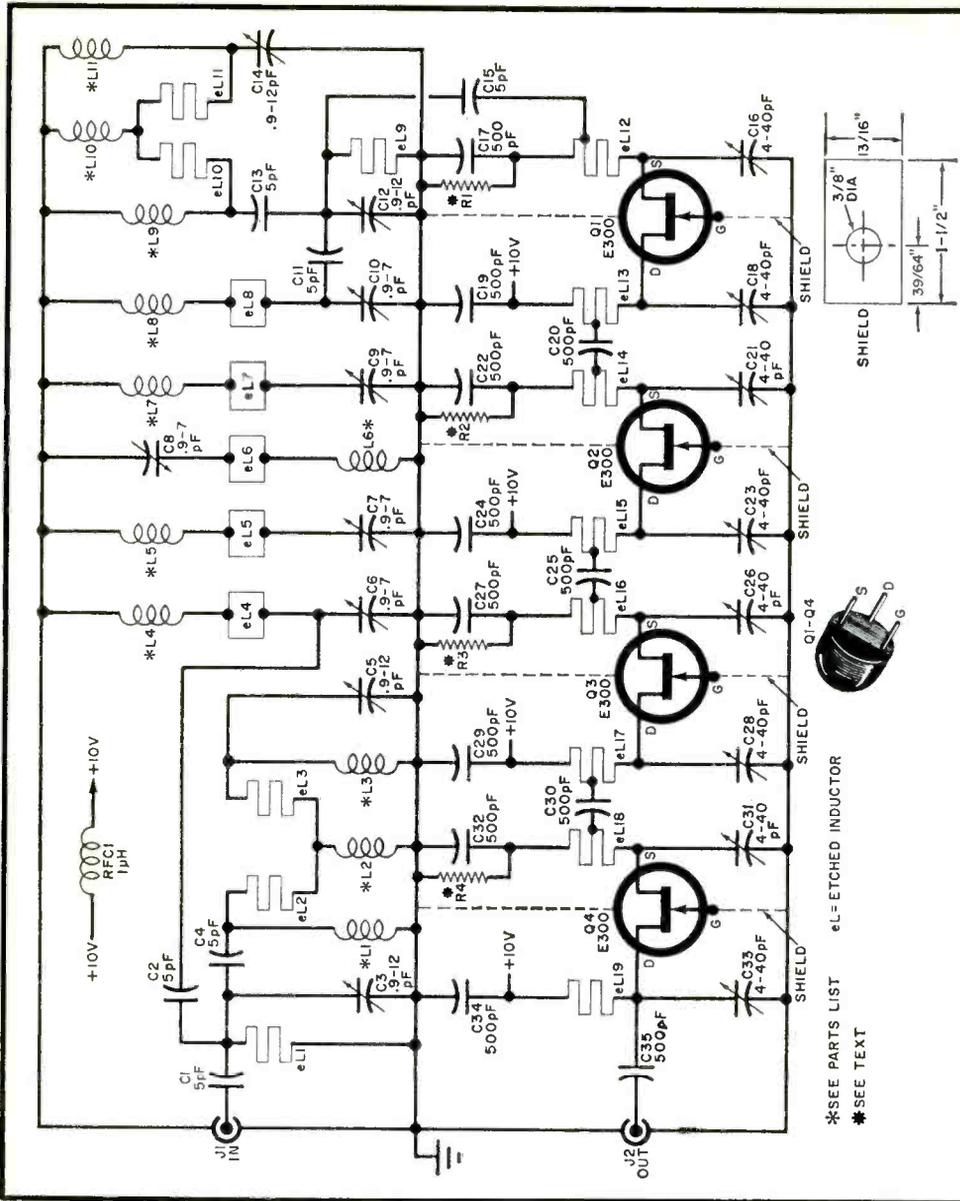
**Input/Output Impedance:** 75 ohms, unbalanced

**Input Match:** 17-19 dB

**Output Match:** 15-17 dB

**Frequency Range:** 174-216 MHz

\*Noise figure is computed as loss in the passive bandpass filter section plus electronic noise figure of first amplifier stage, as measured by a suitable noise figure test set.



For the low-band version, the values of  $L1$  and  $L2$  are determined by the distant channel you want to draw in. Study Figs. 5 through 7 carefully to determine component placement. Remember that lead dress and parts orientation are very important at these frequencies.

Begin by mounting the bandpass filter components (Fig. 5). An etched "R" appears on the circuit board between the last filter section and the amplifier. Mount a temporary coaxial fitting here on a 1"

piece of solder-tinned braid with the center of the coax connected to  $C8$ . This fitting will be used later in alignment. Solder the interstage shield down to the board ground with the transistor hole opposite the inner etched conductor (Fig. 6). Make sure that the shields are mounted at  $90^\circ$  to the board.

The vhf bypass capacitors ( $C10$ ,  $C12$ ,  $C15$ ,  $C17$ ,  $C20$ , and  $C22$ ) are mounted next. Note that these are really feed-through capacitors with two tips and a

## PARTS LIST HIGH-BAND AASA

C1, C2, C4, C11, C13, C15—5-pF, 5% disc ceramic capacitor  
 C3, C5, C12, C14—0.9-12-pF trimmer capacitor (Elmenco/Arco 402)  
 C6-C10—0.9-7-pF trimmer capacitor (Elmenco/Arco 400)  
 C16, C18, C21, C23, C26, C28, C31, C33—4—40-pF trimmer capacitor (Elmenco/Arco 422)  
 C17, C19, C22, C24, C27, C29, C32, C34—500-pF, uhj stud-mounting, feedthrough capacitor (Sprague BH-105, Centralab MFT)  
 C20, C25, C30, C35—500-pF, 10% disc ceramic capacitor  
 eL1-eL19—Etched inductors on circuit board  
 J1, J2—C-F-59 F chassis mounting connector  
 L1, L4, L8, L10—4 turns, #16, 1/4" form, close spaced  
 L2, L3, L9, L11—4 turns, #18, 3/16" form, close spaced  
 Q1-Q4—Field effect transistor (Siliconix E-300)  
 R1-R4—91-560-ohm, 1/4-watt resistor (see text)  
 RFC1—1- $\mu$ H choke (J. W. Miller 9310-12)  
 Misc.—Suitable chassis, mounting hardware, interstage shields, etc.  
 Note—The following are available from CADCQ, P.O. Box 18904, Oklahoma City, OK 73118: actual size foil pattern and component layout guide at \$4.00 (specify channel); etched and drilled circuit board HB713 at \$14.00 postpaid; complete kit of all parts including power supply, anodized pre-drilled case, base plate, wooden end caps, prewound coils, E-300's with matched source resistors, HB713K, at \$49.50 plus postage for 4 lb. (Specify channel.)

Fig. 2. The selective amplifier for channels 7 through 13. Note the use of more extensive bandpass filtering.

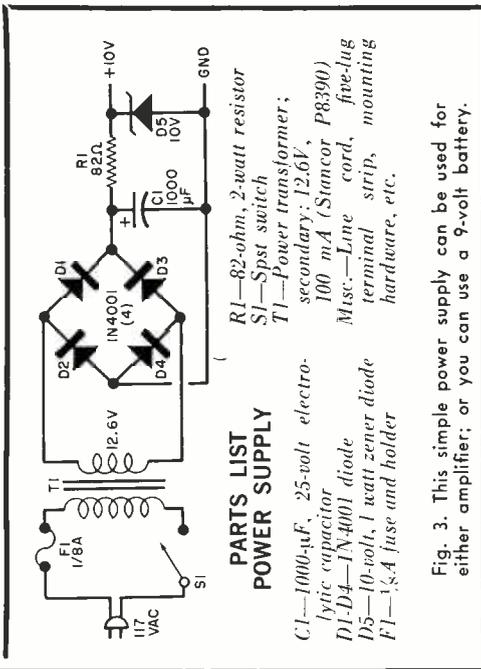


Fig. 3. This simple power supply can be used for either amplifier; or you can use a 9-volt battery.

center ring. One tip goes to the connection dot on the etched inductor nearest the shield, while the bulge (ring) leans against the shield and is soldered to it. The opposite tip floats free.

The FET's are mounted in their holes in the shields with the gate lead facing the bypass capacitors. Use a heat sink on the FET leads when soldering. Mount the six input-output trimmers (C9, C11, C14, C16, C19, and C21) using the leaf terminal as the rotor and soldering it to

ground. The stationary terminal is soldered to the dot on the inner end of the etched inductor. Solder the FET source and drain leads to the appropriate trimmers, using a heat sink.

The interstage coupling capacitors are installed using Table 1 for proper tap points. Keep the leads as short as possible.

Short jumpers are used to connect the power buss to the FET stages. Mount all components except for source resistors R1, R2, and R3. Performance curves for the E-300 FET call for 5 mA of current per stage for optimum noise figure and gain (with 9-to-10-volt operation). Connect a 10-mA meter in series with a resistor of 91 to 560 ohms. Connect the combination in the position for R1. Adjust the value of the resistor until the current is 5 mA. Use this resistor for R1. Do the same to determine the values for R2 and R3. Solder these resistors in place between ground and the outer dot on the etched inductor on the source side of the FET.

To align the bandpass filter, connect the antenna (aimed toward the distant station) to J1 and connect the temporary jack at C8 to the TV receiver. The fine tuning control on the receiver is very important now. In many cases it has not been used on this channel before and the local oscillator slug may have to be adjusted in the tuner. If your receiver has automatic fine tuning (aft), it must be dis-

(Continued on page 44)

## CHOOSING AN ANTENNA FOR THE ALL AMERICAN

When it comes to picking up a distant TV station, most people think it is only necessary to rotate their present antenna in the direction of the station and maybe hook up some type of signal booster. However, if you attempt this, you will most likely find that you still don't have much in the way of a useful signal. The rules given here for choosing and installing an antenna for the All American Sports Amplifier are equally applicable to any situation involving the reception of distant signals.

**Station Selection.** Probably more than one station within a 75- to 150-mile range carries the program of interest. A low-band (channels 2 through 6) station is a better choice than one in the high band (7 through 13) because most TV sets have better selectivity and sensitivity at the low end. In addition, low-band signals tend to fill in behind buildings, hills, and trees better than the high-frequency signals. Low-band signals are probably at a higher level at a distance than high-band signals. In most cases, a low-band station 100 miles off may well be a better choice than a high-band one that is 75 miles away.

**Antenna Selection.** The best antenna for a single channel is the single-channel yagi, with all of its parameters optimized for that one channel. Virtually all antenna manufacturers have such items in their line. Here are the preferred configurations:

Distance to station	Channels 2-6	Channels 7-13
75 miles	5-element, 40-50 feet high	10-element, 40-50 feet high
100 miles	10-element, 40-50 feet high	10-element, 60 feet high
125 miles	Stacked 5-element, 50-60 feet high	Stacked 10-element, 60 feet high
150 miles	Stacked 10-element, 60 feet or higher	4 stacked 10-element, 60-70 feet high

**Antenna Orientation.** Since a single-channel yagi is very directional, try to choose a distant station that lies in a different direction from your local TV outlets. The built-in directional pattern of the yagi can greatly assist in the rejection of the local stations. All directional antennas have a maximum pickup from their front and minimum pickup on each side. Do a little map reading and carefully choose the best direction for your purpose.

**Antenna Height.** A typical suburban neighborhood is described as being 35 or 40 feet "tall"—the height of most residential buildings, utility poles, trees, etc. Anything below that level is described as being in the "clutter level." So, unless your house is on a hill, your antenna

**TABLE 1  
TAP POINTS FOR ETCHED INDUCTORS**

Channel	eL5	eL6	eL7	eL8	eL9	eL10
2	4 out	outside	2 out	outside	2 out	2 in
3	"	"	"	"	"	"
4	"	"	"	"	"	outside
5	2 out	1 in, side	2 out	1 in, side	2 out	outside
6	"	"	"	"	"	3 in, corner
	eL12,eL16	eL14,eL18	eL13,eL15,eL17,eL19			
7-13	2 out	1 out	outside			

Note: Input inductors eL5, eL7, eL9 (low-band) and eL12, eL14, eL16, eL18 (high-band) start the inductor turn count on the inside (center) and count out with the first full turn (not the partial final inner turn) as turn number one, etc. Output inductors eL6, eL8, eL10 (low-band) and eL13, eL15, eL17, eL19 (high-band) start the inductor turn count on the outside and count in with the outer most turn being number 1.

must be above the clutter level. A large antenna 20 feet above the ground is not as good as a smaller one 40 feet up, simply because the height brings freedom from signal absorption by the surroundings. Once you get above the clutter, signal reception improves slowly until the antenna is 60 or 70 feet up, where reception begins to improve markedly again.

**Antenna Installation.** Be sure that you know the impedance of both the antenna and your TV set and use a good quality low-loss transmission line of suitable impedance. If necessary, use a matching transformer at one or both ends to get the correct impedance matching. Remember that there are both indoor and outdoor (weatherproof) matching transformers.

**Incidentals.** Before mounting a high antenna, be sure that the ends of the elements are closed to avoid the "pipe organ effect"—wind blowing past the open tube and causing it to hum. This can be very annoying when the antenna mast transmits the noise to the roof of the house.

Use guy wires when the antenna is 15 or 20 feet high. The cost of guy wires is small compared to that of a good antenna. Waterproof the connection between the transmission line and antenna to avoid electrolysis and wind damage.

Another good tip is to connect a 100,000-ohm resistor across the antenna before you put it up. Then all you need is an ohmmeter to test the circuit from the

TV receiver to the antenna without lowering the antenna. The high resistance value will not affect the antenna's performance.

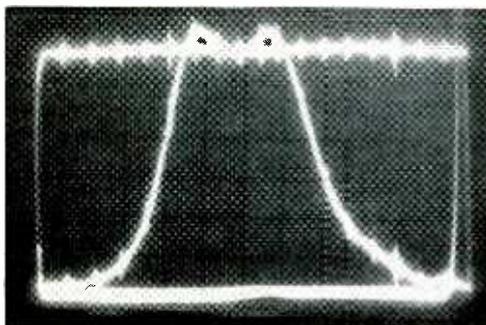
Rotators are always useful for locating distant signals. Sometimes the signal may not be the strongest when it comes directly from the station. Reflections from a hill or tall building may be stronger. There is more than one case of a signal being bounced off a hilltop roadside billboard (having a metal backing) to be received down in the valley.

If you do your own TV servicing, try different tubes (of the same type naturally) in front-end and first i-f amplifier. This is where the bulk of the snow comes from, and having a couple of extra tubes permits you to select the one with the lowest noise. (Unfortunately, you can't do this easily if your set is all solid state.)

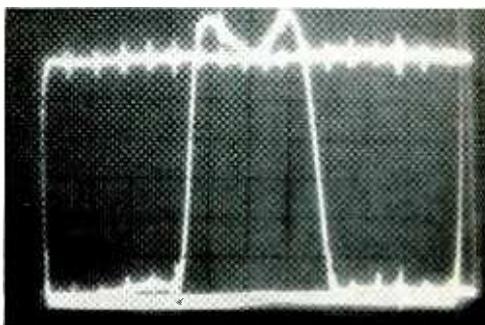
In using an old TV receiver for distant reception (and if you have the test gear), try reducing the bandwidth, which increases the gain. A less snowy 2.5-MHz picture is better than a snowy 3.5-MHz one. Be sure that the other tubes in the set are up to snuff, especially in the i-f strip where all the signal gain occurs.

Don't use staples to hold the transmission lines. You can damage an internal conductor or change the impedance. Use the mounting procedure recommended by the cable manufacturer. Finally, don't forget to waterproof the hole where the line enters the house. Your team may lose but you'll still have a dry floor.

Channel 3 circuit without traps showing the channel 2 aural and channel 4 visual markers down the skirt. Although they are far down the skirt, such carriers cause interference.



Here is the same channel 3 circuit with its adjacent channel double traps installed. Note the sharpened bandpass characteristic and vastly improved adjacent channel rejection.



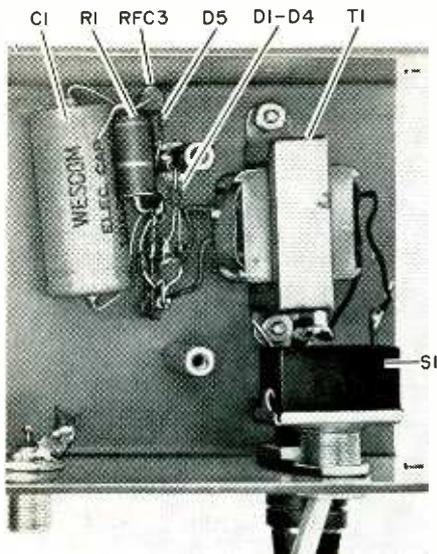


Fig. 4. The power supply can be tucked into one corner of the metal cabinet.

abled. Turn on the receiver. In most cases, you will have "spillover" from the adjacent channels. Using a plastic alignment tool, loosen the rotors on C4 and C5 to minimum capacitance. Adjust C2 and C7 to get maximum signal from the distant station. (You may have only sync bars to work with.) Adjust the receiver fine tuning for best reception. Slowly increase the capacitance of C4 (screw in) until the signal from the lower adjacent channel is a minimum. Adjust C5 to get the same effect on the upper adjacent channel. Readjust the fine tuning and the other filter capacitors to get the best re-

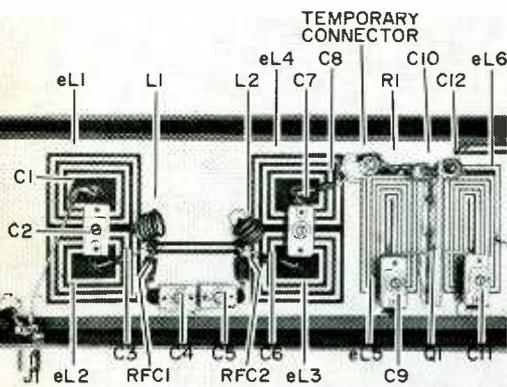


Fig. 5. Component installation at input end of low-band unit shows temporary connector.

move picture. Remove the temporary connector from C8 and connect C8 to its tap on eL5.

Connect the TV receiver to output jack J2 and turn on all power. Using an insulated alignment tool, adjust C11, C16, and C21 for maximum distant signal reception. Then adjust C9, C14, and C19 for the same effect. Trimmers C9, C14, and C19 affect the flatness of the band-pass curve (best sound and picture together), while C11, C16, and C21 affect the total gain. If absolutely necessary, you may have to readjust C4 and C5 slightly to reduce any adjacent channel interference. The alignment process can be done faster and easier if you have an r-f sweep generator, a marker, and a scope.

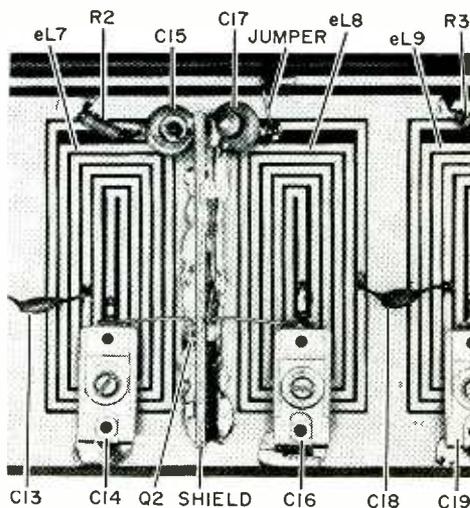


Fig. 6. The mid-section of the low-band amplifier showing how the bypass capacitors and the jumper for the FET power are connected.

Component installation for the high-band All American is shown in Figs. 8 through 10. The same precautions must be used in assembly as were described for the low-band version.

Alignment of the high-band bandpass filter is a little tricky. Temporarily connect an output coaxial connector to point R on the board with the center conductor connected to the output of C11. Temporarily disconnect C1 from J1 and connect C2 to J1. With the antenna connected to J1 and properly aimed and with the TV receiver connected to the temporary output from C11, adjust C6 and C10, then

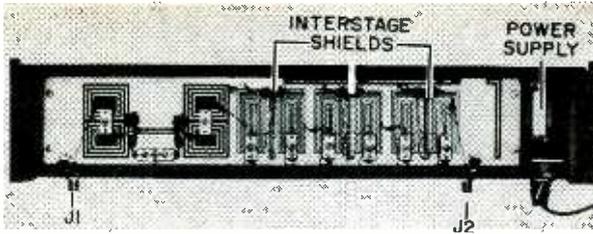


Fig. 7. Overall view of the low-band amplifier showing shields.

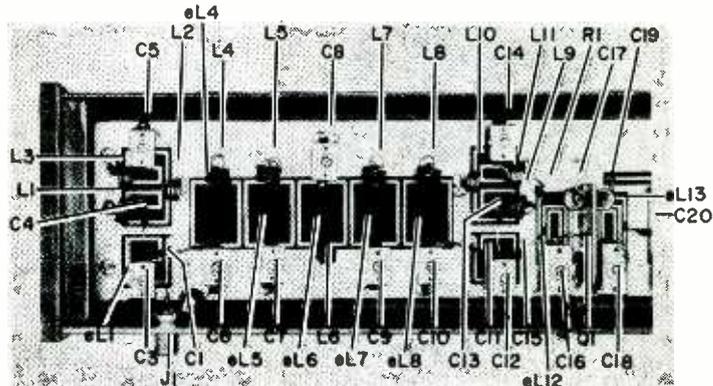


Fig. 8. Input end of the high-band amplifier showing component placement. Note the five mutually coupled etched-circuit coils.

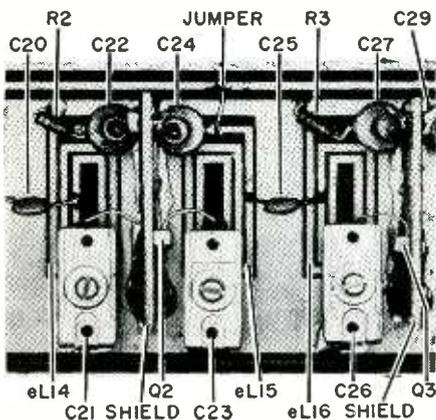


Fig. 9. Mid section of the high-band board showing components.

C7, C8, and C9 for maximum reception of the distant signal.

Reconnect C1 and C2 as shown in the schematic and connect the temporary output to C15. Adjust C3 and C5 for minimum lower adjacent channel bleed and C12 and C14 for minimum upper channel bleed. Retouch C7, C8, and C9 for best reception. Reconnect C15 according to the schematic. Now the entire circuit is in operation. With power applied, adjust C18, C23, C28, and C33 for maximum signal. Then adjust C16, C21, C26, and C31 for best reception.

**Theory of Circuit Design.** In the low-band version of the All American (Fig. 1), the 75-ohm antenna line is connected to

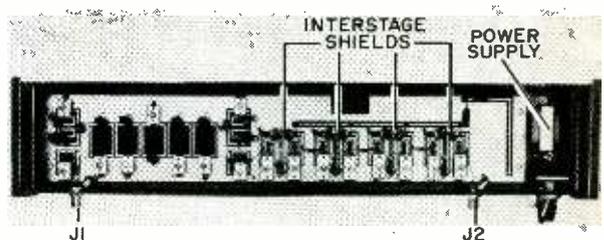
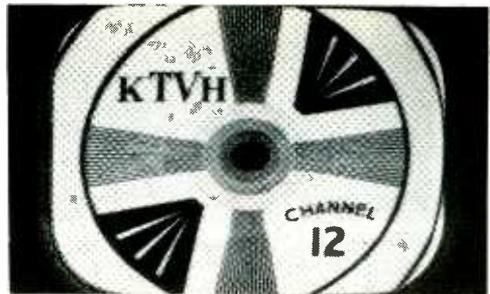
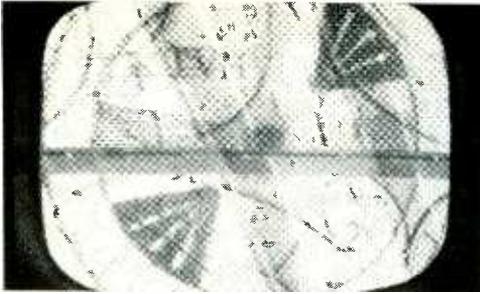


Fig. 10. Overall view of the high-band board showing the shields.



Actual reception (left) of KTVH, channel 12, Hutchinson, Kan. (155 miles) using only an outdoor antenna cut for that channel. Note severe adjacent channel interference from channel 13 (2.1 miles). Right is reception of channel 12 using the All American unit.

a three-section bandpass filter. The first section is composed of  $C1$ ,  $C2$ ,  $C3$ ,  $eL1$ ,  $eL2$ , and  $L1$ ; the third is  $C6$ ,  $C7$ ,  $C8$ ,  $eL3$ ,  $eL4$ , and  $L2$ . Between these are two series trap circuits;  $RFC1-C4$  traps out the lower adjacent channel and  $RFC2-C5$  traps out the upper adjacent channel. The combined filters permit only the selected channel to pass and severely attenuate the interference from the adjacent channels.

Following the bandpass filter are three stages of FET amplifiers. Using the E-300,

a plastic-case, low-cost version of the 2N5397, the three stages provide a total gain of 22 to 25 dB. The E300's, in common-gate operation, have only a 1.3-dB noise figure at 100 MHz; at 216 MHz (channel 13) the figure is 2.0 dB. Additional bandpass filtering is provided in these stages by the etched inductors.

In the high-band (channels 7-13) of the All American, the same principle of operation is used. The bandpass filter, however, contains 11 sections and there are four stages of FET amplification. ♦

## A SIMPLE SW CONVERTER

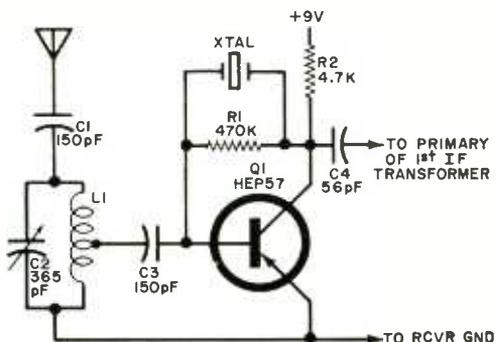
**B**UCKING the trend toward more complexity in circuits, the simple converter shown here (submitted by Larry Lisle) is to be used with a portable transistor radio to pick up shortwave signals. The radio provides the i-f and audio amplifier, and any crystal in the shortwave frequencies can be used in the converter (crystal frequency 455 kHz difference on either side of the desired shortwave).

In operation, the shortwave signals are picked up by the antenna and coupled to tuned circuit  $L1-C2$ . The inductor is 13 turns of #22 wire wound on a  $\frac{1}{4}$ " diameter,  $1\frac{1}{16}$ " long ferrite core, tapped 4 turns up from the ground end. Capacitor  $C3$  connects to  $L1$  at the best point for impedance matching. The signal is amplified by  $Q1$  and mixed with the frequency generated by the crystal to produce an i-f at the difference between the two. This is passed on to the receiver i-f.

Any one of several types of transistors can be used for  $Q1$  as long as it is of the high frequency type. Use a receiver with a transformer to avoid the possibility of shock.

To use the converter, hook up an outdoor antenna (20 feet is enough), turn on the power and start with  $C2$  fully meshed. Slowly decrease  $C2$  until shortwave signals are heard. As the frequency of the crystal is reached, the converter will go dead and then come on again as the frequency is passed. If the crystal frequency is lower than the desired signal, the first sensitive point is the image and the second is the real signal; and vice versa if the crystal frequency is higher.

—Larry Lisle





# EL PANEL DRIVER

CHANGING VOLTAGE AND FREQUENCY ON  
ELECTROLUMINESCENT PANELS

CHANGES BRIGHTNESS AND COLOR / BY NORMAN P. HUFFNAGLE

**A**LTHOUGH IT is widely hailed as one of the great breakthroughs in modern lighting design, electroluminescence (EL) remains something of an enigma to the scientist as well as the layman. The first demonstration (performed by Lossev) showing that a single crystal of zinc sulfide would emit light when under the influence of an electric field occurred back in 1923. In 1936, G. Destriau reported that electroluminescence had been obtained from a thin layer of fine particles placed between two electrodes—either with or without a dielectric suspension medium. The light was so faint that, at first, some researcher doubted its existence, but verification was forthcoming and practical uses began to evolve.

Electroluminescent lamps are now used

in the form of panels as night lights and to illuminate instrument panels in aircraft and space vehicles. In the future they will probably be used on automobile dashboards and other instrument panels where a nonglaring, yet highly visible cold light in various colors is required.

Despite its acceptance and use, however, there remains some doubt as to just how electroluminescence actually works. Like its cousin the light-emitting diode (LED), the EL lamp is a solid-state device and, as such, is immune to catastrophic failures due to vibration, environmental extremes, etc. Also, since it is solid-state, it can be used in conjunction with solid-state power supplies providing a homogeneous overall system.

However, unlike the LED, which uses

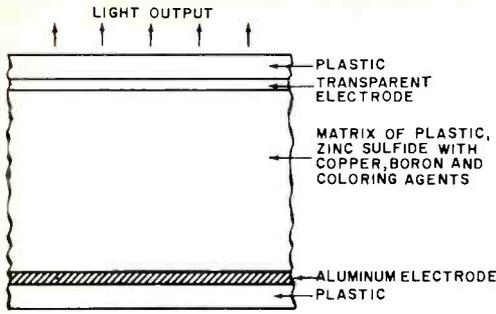


Fig. 1. This enlarged view of a thin electroluminescent panel shows how "sandwich" is created.

low-voltage dc power, the EL device requires a high-voltage ac supply. Electroluminescent panels now available operate in excess of 10,000 hours at 60 Hz and 117 volts, delivering 1 to 1.5 footlamberts of light. If the operating voltage and frequency for such panels are changed, they can produce up to 100 footlamberts.

All of this results from a phenomenon whereby light is emitted from a thin layer of crystalline phosphor (usually zinc sulfide) situated in a "capacitor sandwich" as shown in Fig. 1. This particular phosphor emits a green light when stimulated and also makes an excellent host crystal for a number of color-changing additives. You have probably seen zinc sulfide (ZnS) a number of times since it is the basic phosphor used to coat the screens of oscilloscope CRT's. (In this case, the phosphor is excited by high-speed electrons from the CRT gun.)

As shown in Fig. 1, the phosphor compound is sandwiched between a thin aluminum foil and a transparent, although conductive, electrode. The aluminum also provides some reflection, increasing the light output, while the transparent electrode permits the light to escape. The entire EL panel is then sealed within a moisture-proof plastic which also provides electrical isolation. The overall assembly is approximately  $\frac{1}{32}$ " thick with a 1- to 5-mil separation between the two electrodes.

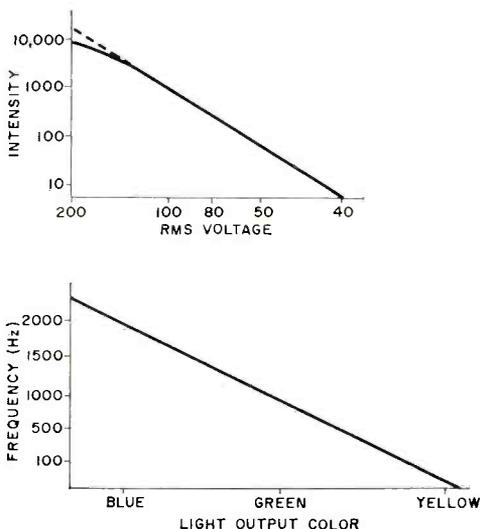
**Electron Impacts.** Although a background in solid-state physics is necessary to a full understanding of the presently known mechanisms whereby an EL panel emits light, a not too rigorous, yet ac-

ceptable explanation is that, under the application of an intense electric field, electrons are removed from the surface of the phosphor particles, accelerated by the applied field, and caused to collide with other phosphor particles. These impacts cause energy to be given up in the form of light. In the case of zinc sulfide, this light falls in the green portion of the optical spectrum.

The electrical field strength necessary to perform this phenomenon is between 200 and 800 volts dc applied between the two parallel electrodes spaced 1 mil apart. For the panels that are available (such as night lights), the conventional power line peak voltage of about 300 volts is sufficient to cause light emission.

Although the first EL phosphors used the green emission of ZnS:Cu (zinc sulfide with a copper additive), it was soon found that adding other elements created a range of different colors. One other fact turned up: many EL phosphors exhibit an unusual emission property called "frequency color shift." For example, one of the most efficient and easily made phosphors, ZnS:Cu:C1 has a broad green emission band when excited at a frequency of 100 Hz and 100 volts rms per mil. As the frequency is raised, however, the emission band broadens and moves toward the shorter wavelengths, and at

Fig. 2. There is a relationship between intensity and voltage, and between color and frequency as shown here. These curves are illustrative only.



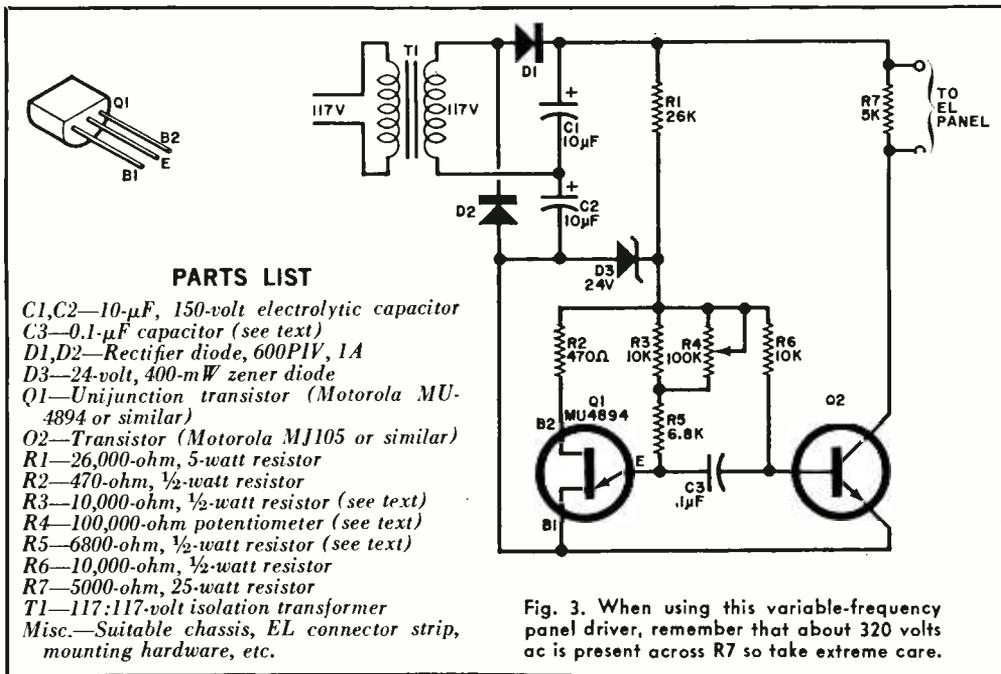


Fig. 3. When using this variable-frequency panel driver, remember that about 320 volts ac is present across R7 so take extreme care.

20 kHz, the peak wavelength is in the deep blue region.

This spectrum shift is primarily a frequency characteristic and is essentially independent of the applied electric field. The curves in Fig. 2 show the effects of such changes on an arbitrary panel.

With an ac supply, the light output from an EL panel occurs in two bursts per cycle—one near each peak of the sine-wave excursion. The quantity of light emitted is a function of the applied frequency and the voltage. For a fixed frequency, increasing the voltage in-

creases the brightness. For a fixed voltage, increasing the frequency increases the light output and, over a small range, changes the color.

**Building an EL Power Supply.** To see more clearly how electroluminescence works, it is helpful to build a small variable frequency power supply. This can be done in one of two ways. A schematic for the first supply is shown in Fig. 3. In this circuit, D1, D2, C1, and C2 form a voltage doubler having a dc output of about 320 volts. (Ripple is not im-

(On next two pages are some uses for EL panels. Continuation of article follows.)

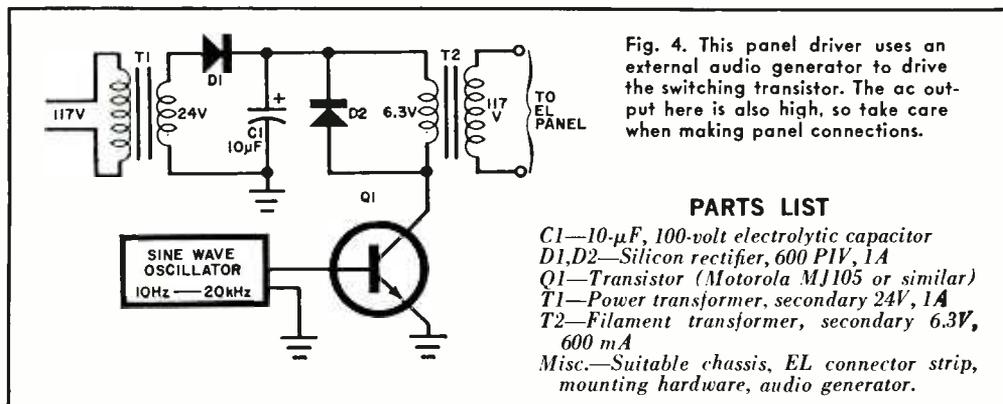
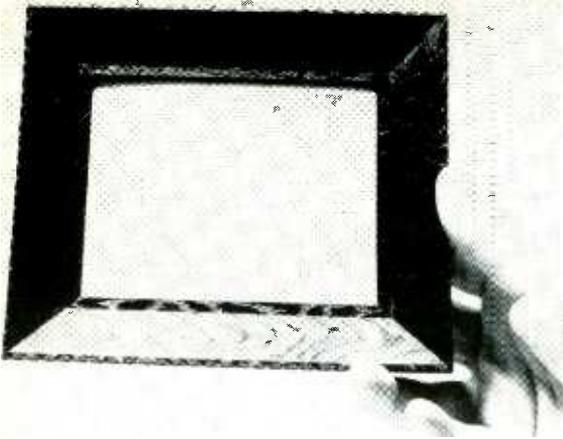
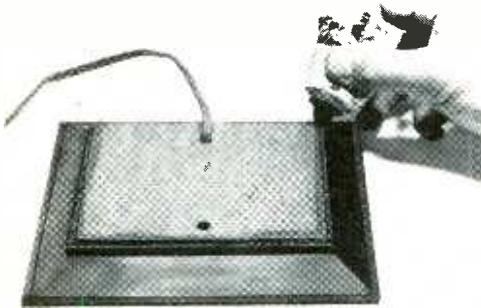
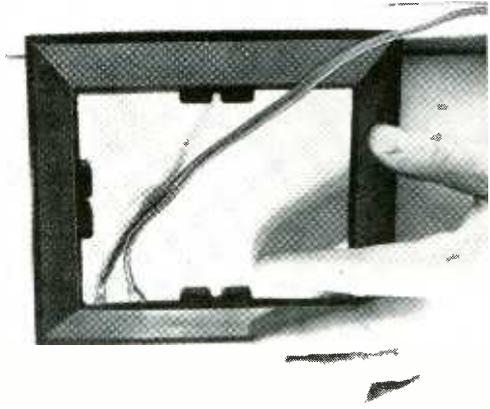


Fig. 4. This panel driver uses an external audio generator to drive the switching transistor. The ac output here is also high, so take care when making panel connections.

# USES FOR EL PANELS

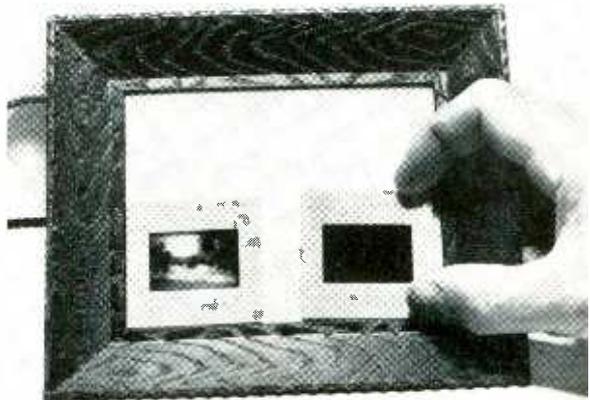


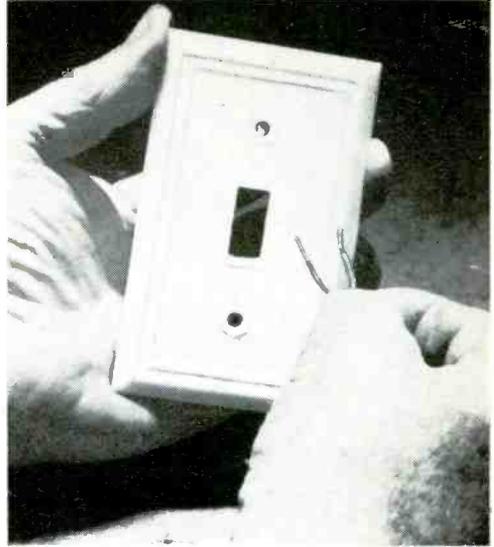
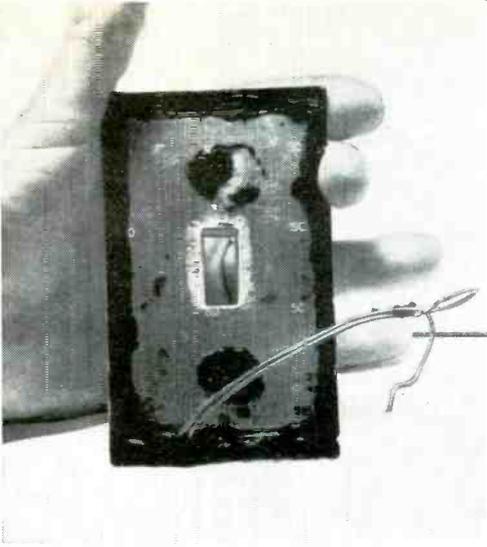
Plastic or wood (not metal) picture frame (above), fitted with electroluminescent panel becomes convenient light-box viewer for slides and photo negatives. Before fitting EL panel into frame (right), solder a-c line cord to metal tabs on the panel.



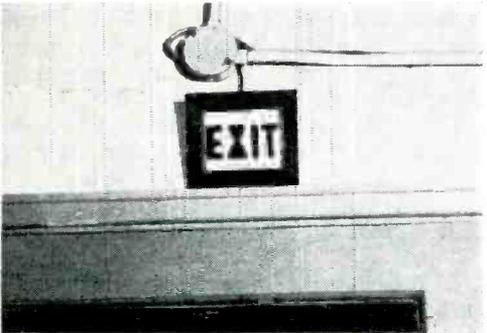
Next, fit piece of Masonite or hardboard over rear of frame, cementing into place with silicone rubber compound (left). Also, fill line cord exit hole with cement to provide strong strain relief.

Evenly distributed soft light from EL panel reduces eye strain when viewing slides and negatives as shown at right.



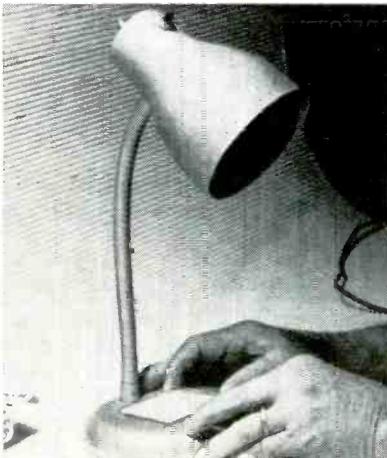


Locate light switches quickly in a darkened room with a back-lighted switch plate. Cement EL panel to the rear of a translucent switch plate (above) and use a sharp knife to make clearance holes through the panel for mounting screws. Make sure that the power to the switch is shut down; then connect the wire leads from the EL panel to the power line terminals on the switch (not the switched) terminals. Properly mounted behind the switch plate, the EL panel is invisible as shown upper right.

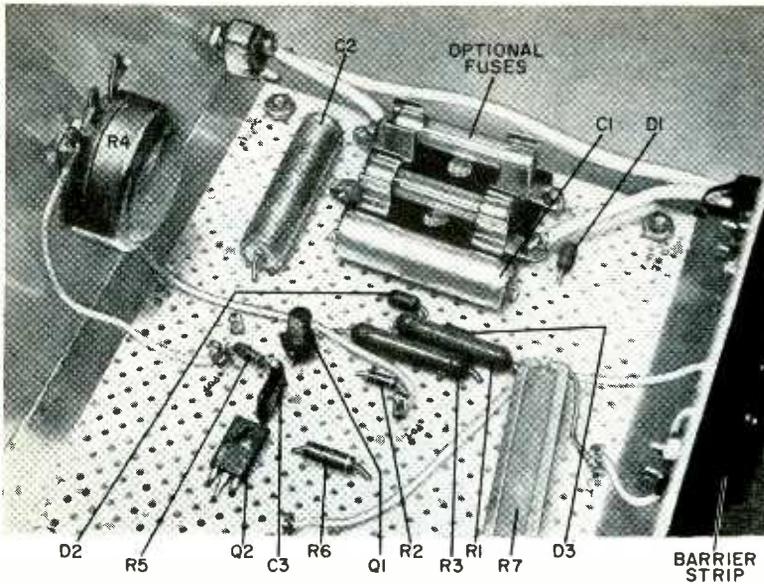


Opaque black or translucent colored tape turns the viewer described on the appasite page into custom-made exit signs. Leads from the sign connect directly to a-c power line for constant-on operation.

Framed EL panel mounted inside hi-fi console provides illumination for you to see what you're doing. For this application, use a white or a yellow electroluminescent panel which has brighter output.



Panel mounted on base of desk lamp at left serves same function as panel mounted behind switch plate. Leads from EL panel pass through holes previously drilled through base and connect to line cord with wire nut. Cement panel to lamp base after making absolutely certain that the panel and the wires are electrically insulated from the base of the lamp.



The circuit may be built up on perf board as layout is not critical. Connection to the EL panel is through barrier strip on rear of chassis. The line isolation transformer is mounted at one end of the chassis and must be used for safety.

portant in this case.) Resistor R1 and zener diode D3 form a 24-volt supply for the oscillator circuit containing unijunction transistor Q1. Transistor Q2 is a driving amplifier. The period of oscillation is a function of the interstage coupling components of the two transistors, with potentiometer R4 adjusted to vary the frequency. For the values shown, the frequency is adjustable from about 200 to 800 Hz. By operating Q2 in the switching mode, dissipation and losses are cut to a minimum.

The output pulse across R7 is a square wave having an amplitude of about 320 volts with a variable duty cycle and repetition rate. If it is desired to modify the frequency, reducing the value of C3 or the R3, R4, R5 network increases the frequency and vice versa. The maximum frequency is reached when Q2 cannot turn off. Tests on the circuits show that

using a value of 10,000 ohms for R6 and a series combination of a 3900-ohm fixed resistor and a 5-megohm potentiometer for R3, R4, and R5, permits operation from about 20 Hz to nearly 2 kHz.

The UJT used in this circuit may be of almost any type as long as it can take the 24-volt supply. Any npn transistor can be used for the driver as long as it has a collector-emitter breakdown rating over 320 volts.

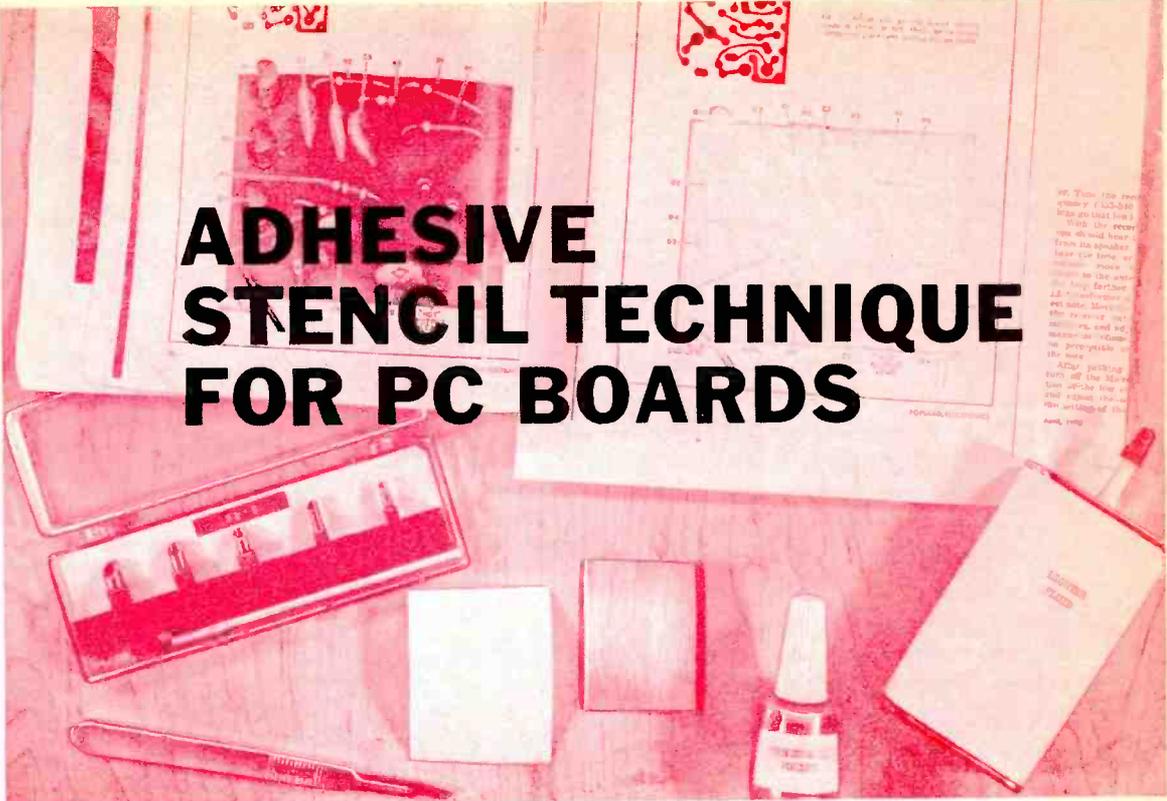
The circuit of another supply is shown in Fig. 4. Here, an external sine wave generator is used as the driving source, with a voltage step-up produced by filament transformer T2. In this, as in the first circuit, remember that a high ac voltage is present on the EL test points so handle them with care. The EL panel output and connectors should be well insulated.

The supply may be constructed in any way desired. Construction of a prototype is shown in the photos.

Some EL panels are fitted with slender electrical connections. Do not bend them back and forth too many times or you will break them off at panel.



**Operation.** Connect the EL panel to the driver being careful not to cause accidental shorting between the high-voltage leads. With the driver turned on, note that varying the frequency changes the brightness of the panel and, in some cases, the color. ♦



# ADHESIVE STENCIL TECHNIQUE FOR PC BOARDS

GET PROFESSIONAL QUALITY  
FROM MAGAZINE FOIL PATTERNS

BY THOMAS ANDERSON

**T**HE ELECTRONICS HOBBYIST often has to prepare printed circuit boards from actual size etching guides published in magazines. This process involves point-by-point transfer of dimensions from the printed page to the copper foil on the board blank, a tedious process to say the least. And, even though his intentions may be good, the results of his efforts have more often than not yielded rather untidy PC boards made by the easiest method available—free-hand application of resist.

Until now, to obtain a professional-looking board, either dry-transfer resist or photographic techniques had to be used, neither of which is economical and both of which employ materials with limited storage lives. Clearly, a faster, more convenient, and less expensive method of making professional-quality PC boards is in order.

This article describes a new adhesive-stencil ("Ad-Sten") technique of preparing blank boards for etching. The tech-

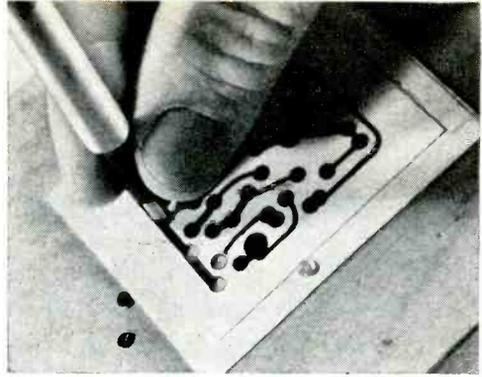
nique is suitable for all but very intricate patterns. And you can, if desired, use the same stencil to make multiple copies of the same PC board. Inexpensive materials, available from any dime store, are used throughout. These materials also have unlimited storage lives.

With the "Ad-Sten" (for Adhesive-Stencil) technique described in these pages, a typical PC board can be readied for etching in less than an hour at a cost of only 15¢, exclusive of the board blank. To top it off, the finished product will have the appearance of being professionally made, even though the point-by-point transfer of dimensions has been completely eliminated.

**Basic Materials & Tools.** It would be pointless to describe the Ad-Sten technique of making printed circuit boards without first enumerating what materials and tools you will need. In the category of materials needed, there are "Con-  
(Text continued on page 56)

## THE 7-STEP "AD-STEN" TECHNIQUE

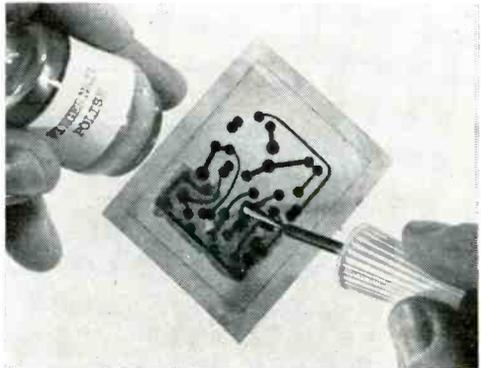
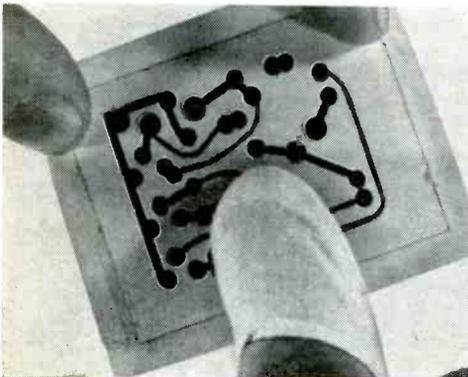
On these two pages are illustrated the seven steps required to translate an actual size etching guide on a printed page to a finished printed circuit board that can hardly be distinguished from a commercially made board. The procedure flows from left to right across both pages, first along the top and then along the bottom. The steps shown are of a general nature and apply to all board layouts. Special cases are discussed in detail on page 56. The quality of the work you do depends on the care you take in preparing the stencil. So, take your time and work in a well-lighted area.

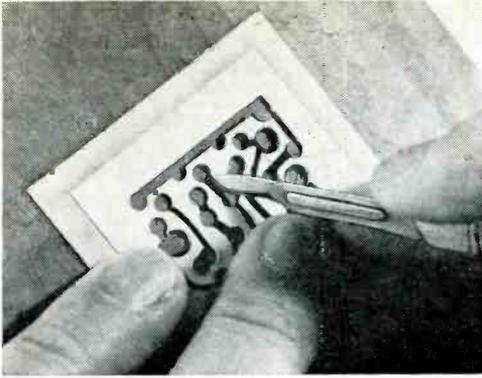


The first step in the Ad-Sten procedure is to make an actual size copy of the etching guide from the printed page. This is best done with the aid of tracing paper and a soft-lead pencil. Since the etching guide will be destroyed in the following steps, it is not advisable to use the original guide here. Once the tracing is made, use rubber cement to adhere it to an oversize piece of Con-Tact. Tape this to your soft-wood working surface and use your circle cutter or punch to cut out the solder pads. It is essential that you cut cleanly and completely through the stencil in this step.

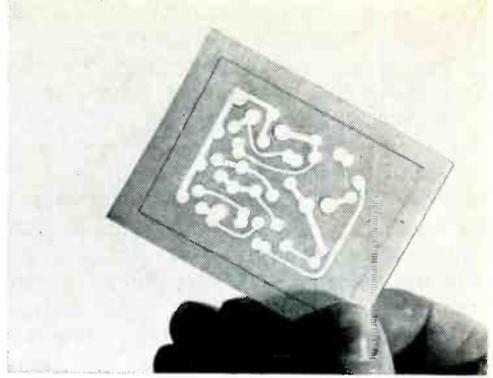
The board blank to be used with the stencil should be no less than  $\frac{1}{4}$ " more in length and width than the finished printed circuit board is to be. Furthermore, it must be scoured to completely remove all traces of dirt, grease, and oil. Once the copper surface is cleaned, do not handle it with your bare hands. Now, starting at one corner, and taking care to prevent any folds or air bubbles, apply the stencil to the bare copper. Then, with your finger wrapped in a soft, clean cloth, firmly go over the entire stencil to securely fix the Con-Tact's adhesive backing to the raw copper surface.

Next, liberally apply the nail polish resist to all exposed copper surfaces, working it into every bend and corner until it completely covers the copper. There is no need to be artistic or neat since the stencil will assure a well-defined and accurate resist pattern. Allow the nail polish to set for at least 20 minutes. Then use a very sharp knife to score the resist around all edges of the stencil, and slowly peel off the stencil. Take care not to tear the stencil if you wish to make multiple copies of the same board. If you do not plan to reuse the stencil, discard it after removal.





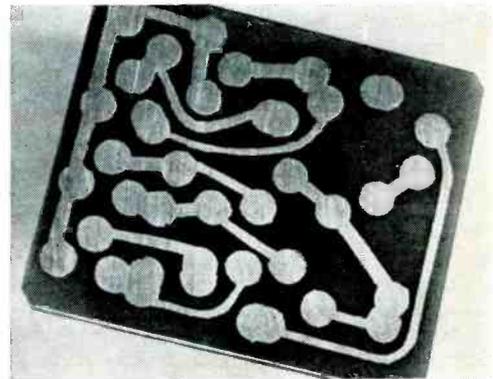
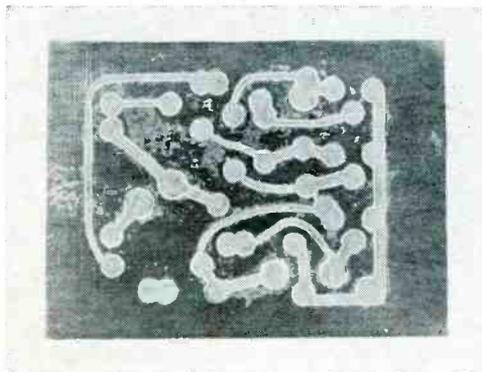
Once the solder pads are made, use a very sharp hobby knife to cut away the material to make the interconnections between the pads. Go slowly at first until you get the "feel" of the cutting process. Make very short cuts along the edges of the outlines, cutting no more than  $\frac{1}{8}$ " at a stroke. In this manner you will soon find that you can easily and accurately cut curves and intricate patterns with little effort. Do not give in to the temptation to rush; haste at this point will almost certainly result in a torn or ragged stencil that will defeat your purposes. All lines must be smooth.



When all cutting is completed, check the stencil against the original etching guide on the printed page to make sure that you have not missed anything. Be especially observant of those short conductors between closely spaced solder pads. This is also a good time to clean up any fuzzy areas with the hobby knife. Now, remove the stencil from your working surface. On close inspection, the stencil should very closely resemble, if not exactly duplicate, the original etching guide. You can check this out by laying the stencil over the published etching guide and aligning the patterns.

Do not be alarmed if, after removing the stencil, you notice that a great deal of adhesive has been left behind. The adhesive must be removed before etching, but the job is simplified by the fact that lighter fluid makes a good solvent. After the nail polish has completely dried, moisten a tissue with the lighter fluid and clean away the adhesive. When working with lighter fluid, practice extreme caution. Work in a well-ventilated area where no open flame or burning ember exists. Lighter fluid is extremely flammable, and careless handling can quickly result in an uncontrollable fire.

After etching the board in the conventional manner, you can remove the nail-polish resist either by scouring it away with a medium-grade steel wool or with nail polish remover. Use the first method only if the nail polish has been laid on fairly thin. If the coat of polish is thick, it is better to use the latter method and follow up with a good cleaning in soap and water to remove the moisturizer left behind by the remover. Then, after drilling component lead holes and making any necessary cutouts, trim the board to size with a nibbling tool or other suitable cutter to prevent cracking.



Tact" (an adhesive-backed vinyl sheet commonly used for shelf covering; the pattern or color is unimportant), rubber cement, tracing paper and pencil, tape, soft-wood working surface, nail polish and nail polish remover, and one or more grades of steel wool. You do not have to buy the "best" or top-rated brands; just get the least expensive materials that will assure a good job.

In the category of tools, there are just two items. The first is a set of circle punches or cutters for making component-lead solder pads in the stencil. These can be homemade or store bought. The homemade punches, for which you will also need a small hammer to drive home, can be made from lengths of telescoping antenna elements of various diameters. The punches are cut to a length of about 5" then chucked into a drill and sharpened with a file. A set of circle cutters, ranging in diameter from  $\frac{1}{8}$ " to  $\frac{1}{4}$ ", can be purchased from most art or drafting supply stores. The homemade punches, however, are less expensive, easier and faster to work with, and, if well sharpened, produce a cleaner hole in the stencil.

The second tool you need is a good hobby knife. When buying the knife, be

sure to stock up on extra cutting blades. The best blades to obtain are those that come to a very sharp point.

**Special Cases.** One special case that might arise is a PC board which contains one or more conductors completely surrounded by other continuous conductors. Obviously, in a case like this, your stencil will have to consist of two or more pieces. This is no problem, however. Unlike other stencils, the Ad-Sten's adhesive will keep all pieces in place regardless of their number. Care in positioning the pieces relative to each other is required. Additionally, in cases where shielding is unnecessary or unimportant, you can redesign the conductor pattern to eliminate surround conductors.

Another special case is that of a PC card designed to plug into an edge connector. The trick here is not to cut the stencil slots for the matching conductor stripes right to the edge of the stencil. Make the conductor cutouts that will mate with the connector contacts just long enough to extend slightly beyond the edge of the finished board. You can trim the conductors to the desired length at the same time you finalize the dimensions of the PC card. ♦

### LASER LIGHT SUPPORTS TINY GLASS SPHERES

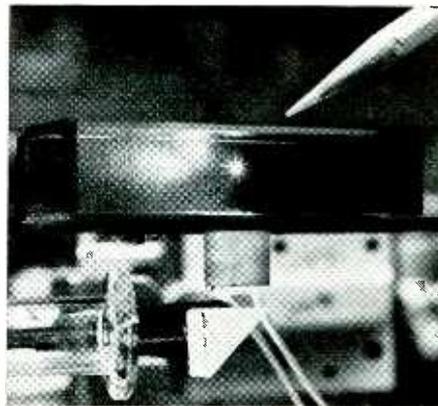
Using a beam of laser light, Bell Labs scientists have raised small transparent glass spheres off a glass surface and held them aloft for hours in a stable position. The experiments, which demonstrated optical levitation for the first time, were conducted by Arthur Ashkin and Joseph Dziedzic.

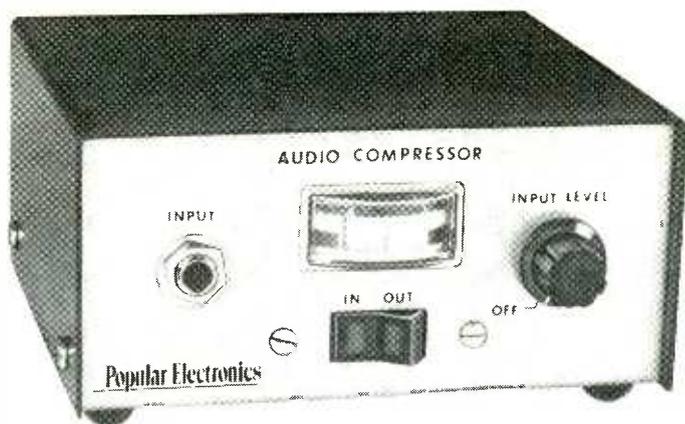
The new technique is expected to provide simple, precise methods for manipulating small particles without mechanical support. It could be useful in communications research to measure the scattering loss caused by particles, either in the atmosphere or in other transmission media.

The laser beam is focused upward on the glass sphere which is about 20 microns in diameter. Radiation pressure from the light not only counteracts gravity and raises the particle, but also traps the sphere in the beam and prevents it from slipping out of the beam sideways. The experiment has been demonstrated in air and in a partial pressure.

The sphere is launched by lifting it

off a transparent glass plate with the light beam. However, initial molecular attraction between the sphere and the glass plate is broken acoustically by vibrating a ceramic cylinder attached to the plate. Once aloft, the sphere can be moved up and down or sideways very precisely by changing the position of the focus of the laser beam.





# ***Distortionless Audio Compressor***

JUST THE THING FOR HAMS, CB'ers,  
AND TAPE RECORDING FANS

BY CHARLES CARINGELLA, W6NJV

**T**HE AUDIO COMPRESSOR is an important engineering instrument in every recording, television, and radio studio. By holding the output of a device at a given level for a given increase in input signal level, the compressor assures a smooth listenable product, without booms and overloading distortion. You can see how valuable a contribution a compressor would make to your own audio equipment—be it tape recorder, amateur radio or CB transmitter.

Once set up to operate with a tape recorder, the audio compressor will hold the recording level constant, without introducing noise or distortion. You can ignore the recording level meter on your recorder and there is no need to "ride" the recorder gain control. The compressor is particularly valuable when recording lectures, press conferences, family groups, etc. Smooth, professional results can be achieved when making stereo or multiple channel recordings. All it takes is one compressor in each channel and the work is done for you.

When used with amateur radio and CB transmitters, an audio compressor can provide as much as a 10-dB increase in signal strength at the receiving end. This is the next best thing to adding a kilowatt linear amplifier to your transmitter! The automatic limiting action also prevents overmodulation, without adding distortion to the transmitted signal.

Still another application for the audio compressor is with public address amplifiers. Here, the output of the system can be held constant regardless of input variations due to difference in voice levels and distance from the microphone. The unit also minimizes annoying feedback.

You can build your own audio compressor for less than \$50 and it will be the equivalent of commercial units costing 4 or 5 times as much. Although the compressor is somewhat complex in theory, it is easy to build and use. It is simply installed between the microphone and the equipment. There is no need to dig into the equipment circuitry.

Besides having a large dynamic com-

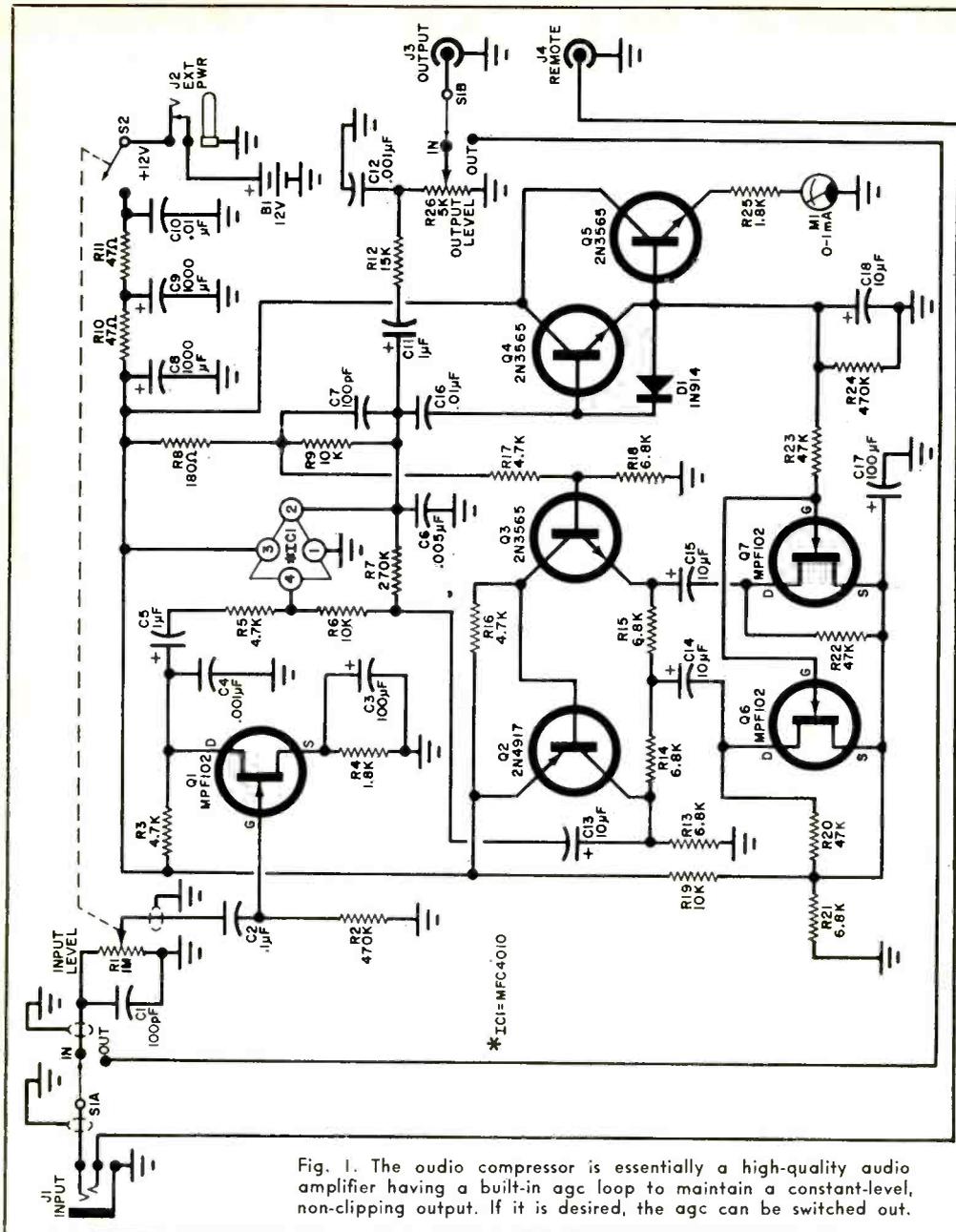


Fig. 1. The audio compressor is essentially a high-quality audio amplifier having a built-in agc loop to maintain a constant-level, non-clipping output. If it is desired, the agc can be switched out.

pression range (45 dB or more), the compressor described here also serves as a high gain preamplifier with approximately 46 dB of gain. This permits the use of practically any type of microphone, from low-impedance dynamics (200 ohms or more) to high-impedance crystal, ceramic, and dynamic types. An FET input provides a very low noise figure.

The completed unit, housed in a cabinet 5" × 2½" × 4½", can be operated from an internal 12-volt mercury battery for portable applications or any other 12-volt external supply.

**Theory of Circuit Design.** The compressor is basically an audio amplifier with an automatic gain control (agc) feedback

## PARTS LIST

- B1*—12-volt mercury battery (Mallory 289 or similar)  
*C1, C7*—100-pF ceramic disc capacitor  
*C2*—0.1- $\mu$ F miniature ceramic disc capacitor  
*C3, C17*—100- $\mu$ F, 12-volt miniature printed circuit electrolytic capacitor  
*C4, C12*—0.001- $\mu$ F ceramic disc capacitor  
*C5, C11*—1- $\mu$ F, 12-volt miniature printed circuit electrolytic capacitor  
*C6*—0.005- $\mu$ F ceramic disc capacitor  
*C8, C9*—1000- $\mu$ F, 12-volt miniature printed circuit electrolytic capacitor  
*C10, C16*—0.01- $\mu$ F ceramic disc capacitor  
*C13, C14, C15, C18*—10- $\mu$ F, 12-volt miniature printed circuit electrolytic capacitor  
*D1*—1N914 silicon diode  
*IC1*—Amplifier integrated circuit (Motorola MFC4010)  
*J1*—3-way phone jack  
*J2*—Closed-circuit coaxial power jack  
*J3, J4*—Phono jack  
*M1*—Milliammeter, 0-1 mA, 2800-ohm coil (Emico Model 12)  
*Q1, Q6, Q7*—FET, n-channel (Motorola MPF102)  
*Q2*—Pnp transistor (Fairchild 2N4917)  
*Q3, Q4, Q5*—Npn transistor (Fairchild 2N3565)  
*R1*—1-megohm potentiometer with spst switch for S2  
*R2, R24*—470,000-ohm, 1/2-watt 10% resistor  
*R3, R5, R16, R17*—4700-ohm, " " "  
*R4, R25*—1800-ohm " " "  
*R6, R9, R19*—10,000-ohm " " "  
*R7*—270,000-ohm " " "  
*R8*—180-ohm " " "  
*R10, R11*—47-ohm " " "  
*R12*—15,000-ohm " " "  
*R13, R14, R15, R18, R21*—6800-ohm " "  
*R20, R22, R23*—47,000-ohm " " "  
*R26*—5000-ohm potentiometer  
*S1*—Dpdt rocker-type slide switch  
*S2*—Spst switch, part of R1  
*Misc.*—Chassis (5" x 2 1/4" x 4 1/2"), knob, angle brackets (6), battery clips (2), rubber feet (4), hardware, wire solder, etc.  
*Note:* The following are available from Caringella Electronics, Inc., P.O. Box 327, Upland, CA 91786; etched and drilled printed circuit board at \$5.95; complete kit of parts less battery but including PC board, chassis, assembled power supply, and all hardware at \$49.95 plus \$1.50 for U.S.A. shipping. California residents, add 5% sales tax.

loop (see Fig. 1). The feedback provides a very fast attack time and a slow decay time. The fast attack means that the compressor can respond to a 20-dB increase in signal at 1 kHz in less than 1 millisecond. At 10 kHz, the attack time response is less than 100 microseconds. The fast attack time results in no loss of information at the beginnings of words or sounds.

More important, since there is no "overshoot" of the signal associated with the attack, there is no evidence of popping or clicks in the audio signal, which is a drawback in many compressors.

Compression is accomplished by a form of negative feedback, part of the output signal being fed back out of phase with the input. The amount of negative feedback increases as the signal level goes up and vice versa. The net result is that the compressor output remains constant as the input signal varies.

Field effect transistor Q1 provides a high input impedance (on the order of 0.5 megohm) and keeps the "front end" noise to an almost unmeasurable level so that there is none of the "rushing" sound commonly associated with transistor amplifiers. The input level control is adjusted by potentiometer R1.

Integrated circuit IC1 is a high-gain amplifier with low output noise. The IC package contains three npn transistors and five resistors. The audio signal from the output of IC1 is coupled to the output level control, R26. The combination of R12 and C12 provides high frequency roll off above 20,000 Hz.

Part of the output signal is also fed to the base of transistor Q3. Resistors R8, R9, R17, and R18 set the forward bias for Q3 and also divide the output signal so that it is at the proper level. Transistors Q2 and Q3 form a variable gain amplifier whose output provides negative feedback to the input of IC1. The gain of the feedback amplifier is varied by changing the effective resistance in series with bypass capacitors, C14 and C15. This resistance is provided by Q6 and Q7, which are controlled by a dc voltage that is a function of the output signal.

Part of the output is fed to diode D1 and transistor Q4 through capacitor C16. The diode and transistor form a voltage doubling rectifier (with very low output impedance) which controls Q6 and Q7. The time constant of R24 and C18 determines the decay time of the compressor.

Transistor Q5 serves as a dc current amplifier to drive the compression indicating meter. The meter indicates only during compression and not when the circuit is amplifying in the linear region.

Capacitors C8 and C9 and resistors R10 and R11 provide filtering for the 12-volt supply so that a simple transformer and

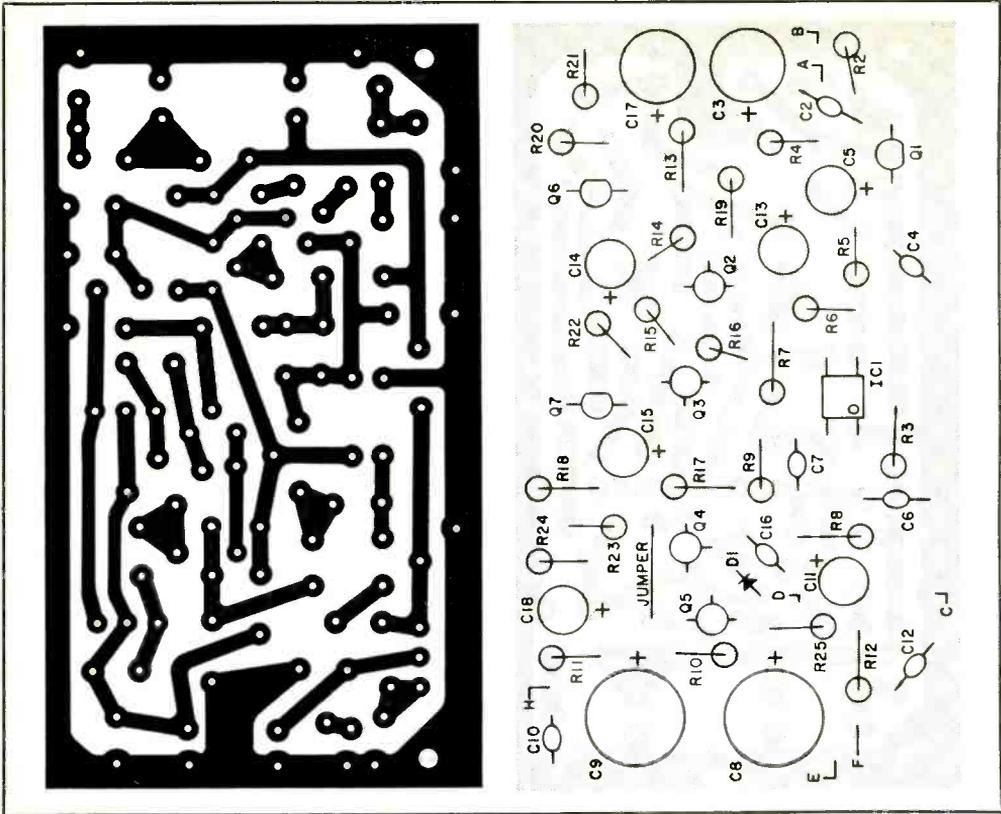


Fig. 2. Actual size foil pattern and component installation for the audio compressor. Observe the current polarity of electrolytic capacitors and all semiconductors including IC audio amplifier.

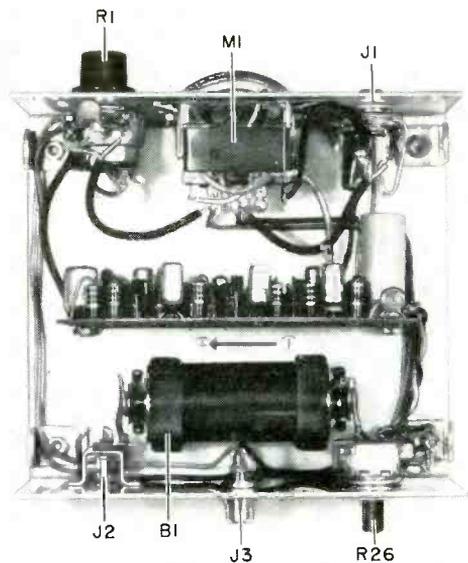
full-wave rectifier can be used as a supply instead of the battery. Capacitor C10 provides r-f bypassing when the compressor is used in conjunction with transmitting equipment.

A 3-way jack is used for the input connection. The remote line, running to J4, is used for push-to-talk operation. The compressor can be bypassed by placing S1 in the OUT position.

Although the compressor is rated at 45 dB compression range, it is capable of producing as much as 50 dB. Total harmonic distortion is extremely low and must be measured with sophisticated laboratory equipment. It cannot be seen on an oscilloscope.

**Construction.** All of the circuit components, with the exception of C1, are mounted on a circuit board whose foil pattern is shown in Fig. 2. Capacitor C1 (r-f bypass) is mounted directly across the input level control R1, as shown in Fig. 3.

Fig. 3. Although any method of installation may be used, this is a view of prototype.



## HIRSCH-HOUCK LABORATORIES Project Evaluation

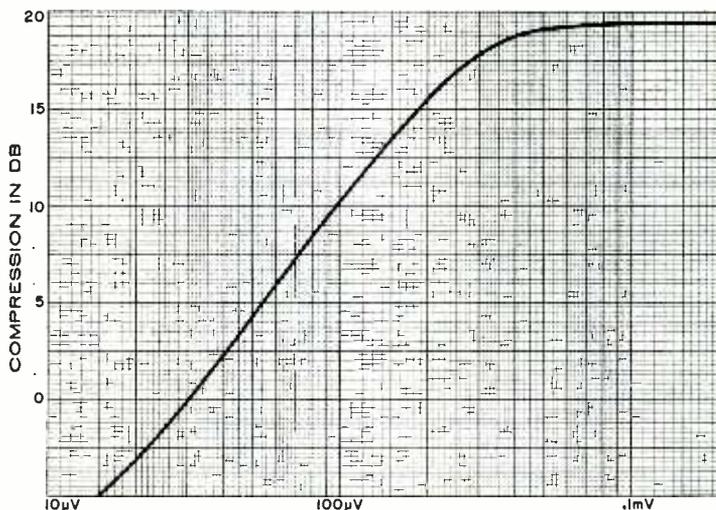
As claimed, this is a nondistorting compressor. The maximum output level was too low for us to make distortion measurements, but visually it looked perfect on a scope no matter what the degree of compression.

The gain in the linear portion is very good, 45 microvolts being required for 10 millivolts output—about 46 dB. Compression begins at about 300 microvolts. The maximum output at full compression is 60 millivolts.

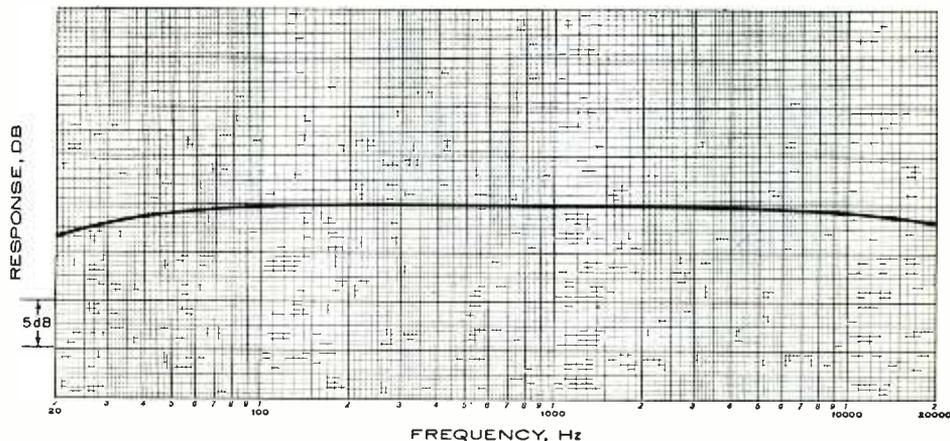
We passed a 10-kHz tone burst through the compressor to measure the attack time. It would seem to be about 100 microseconds.

When the input level control is set below maximum (the usual condition), the frequency response is quite flat—down 1.5 dB at 35 Hz and 20 kHz. However, at maximum input level, the highs rise and keep rising to a maximum of +9 dB at 30 kHz. The rather high input impedance seems to be responsible for the rolloff, which is of little practical importance since one would hardly use it "wide open."

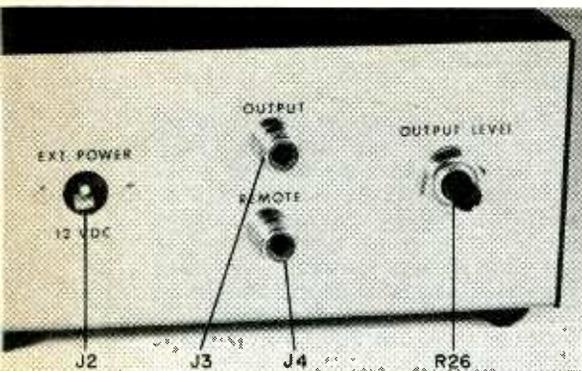
We made tape recordings of voice with the compressor, and they sounded fine—no distortion, just a bit of "breathing" on extreme compression.



Input versus compression showing the smooth curve of an excellent no-distortion setup.



The frequency response of the compressor is just as good as most high-quality audio systems so that it is top notch for musical recordings.



The rear apron of the compressor chassis showing the jack for external power supply input, terminals, and output level control.

Mount all of the transistors first. Space each one about  $\frac{1}{4}$ " away from the board and make sure they are properly oriented. The IC should rest flat against the board. Mount *D1* vertically. Use a heat sink on all semiconductor leads during the soldering operation.

The capacitors should be flush against the board. Observe the polarities of electrolytics. All of the resistors are mounted vertically with one end flush against the board. Use shielded wire between *J1* and *S1* and between *S1* and *R1*.

Attach all the connecting leads to the board before installing it in the cabinet. Use shielded wire for the input line.

The prototype cabinet was made of two pieces of 0.050" sheet aluminum, though a standard chassis box can be used. The circuit board was mounted vertically using two angle brackets. Due to the high gain and high input impedance of the circuit, it is extremely important that the entire circuit be completely shielded in a metal box. This is important if you plan

#### TECHNICAL SPECIFICATIONS

**Compression Range:** 45 dB minimum  
**Sensitivity:** Approximately 300 microvolts for compression  
**Frequency Response:** -3 dB at 20 Hz, -1.5 dB at 20,000 Hz, in linear region of amplification and in compression region  
**Total Harmonic Distortion:** At 1 kHz, 0.1% in linear region, 1.5% in compression  
**Input Impedance:** 0.5 megohm  
**Output Impedance:** 5000 ohms  
**Attack Time:** Less than 1 millisecond for 20 dB change at 1kHz  
**Release Time:** Approximately 2 seconds

to use the compressor in a custom installation or within existing equipment.

Use shielded cable for the input and output connections.

**Use.** With a 12-volt battery installed, or some other 12-volt supply attached, plug a microphone into the compressor and connect the compressor output to the equipment to be used. Place *S1* in the OUT position to bypass the compressor. Talk into the microphone at close range and set the gain control on your equipment for the proper operating level. If you are using a tape recorder, you will be watching the recording level meter; if you are using a transmitter, you will probably be watching a modulation indicating meter.

Now, turn on *S2* but leave *R1* and *R26* fully counterclockwise. Place *S1* on the IN position. While speaking into the mike, advance *R1* until the compression meter begins to kick upward. Now advance the output level control, *R26*, until the meter on your equipment reads the same as when the compressor was bypassed. Flip *S1* back and forth to see how the signal looks with and without compression.

The compression meter not only indicates the fact that the signal is being compressed, but also when the signal is overdriving the compressor. In that case the meter reads off scale. Compression will begin at an input of about 300 microvolts; and the compressor will be overdriven when the input exceeds about 60 millivolts. When the meter on your recorder or transmitter indicates the presence of a signal but there is no indication on the compression meter, the compressor is simply acting as an amplifier.

While operating the compressor, adjust the input level control (*R1*) for the amount of sensitivity required. This will vary according to the type of microphone used, background noise, etc. A 200-ohm dynamic mike will drive the unit into compression but is not as sensitive as a high-impedance dynamic mike or a crystal or ceramic one. If you need more sensitivity from a low-impedance mike, use a step-up transformer on the input to the compressor.

Telephone conversations can be recorded by hooking the input of the compressor either directly to the phone line or to a telephone pickup coil. ◆

# CRYSTAL CALIBRATOR FOR THE HAM and SWL

PROVIDES ACCURATE FREQUENCY CHECKS

25 and 100 kHz APART

BY WILLIAM L. BLAIR  
Cubic Corporation

IN NOVEMBER OF 1969, the Federal Communications Commission completed a program of frequency reallocation in the amateur radio bands. The results created licensing incentives for Advanced and Extra class hams by providing operating privileges over wider frequency bands than are permitted to General class ticket holders. These sub-bands are defined in increments of 25 kHz.

To assure himself that he is transmitting within the limits of his class of license, the operator using narrower bands must have a calibration oscillator that works in two modes. The first mode should supply outputs every 100 kHz from 100 kHz to 30 MHz; in the alternate mode, outputs need to be spaced every 25 kHz to identify precisely the sub-band limits.

The Dual-Mode Ham/SWL Crystal Calibrator described here fulfills the requirements for a stable, precise signal source for transmitter and receiver calibration. The finished project is compact enough

to be built right into most modern receivers. And, except for the crystal, the cost of the project comes to only about \$7.25.

**Theory of Circuit Design.** Transistors Q1 and Q2 in Fig. 1, working with the 100-kHz crystal, constitute the series-mode oscillator stage. Trimmer capacitor C2 allows the operating frequency of the oscillator to be varied approximately 50 Hz on either side of the crystal's center frequency so that the oscillator can be accurately beat against a frequency standard such as WWV.

The output signal at the collector of Q2 is essentially a clipped sine wave. Since the harmonic content of this type of waveform is not particularly good, this circuit by itself is not especially useful for generating marker signals at the higher ham band frequencies. This situation can be compensated for by the addition of the Q3/Q4 multivibrator stage.

Both ac and dc coupling are employed

in the multivibrator: dc from the collector of Q3 to the base of Q4 and ac between the emitters of the transistors. In the 100-kHz position, S1B powers all four stages, while S1A switches C4 out of the coupling circuit. The time constants provided by R8-R11 and C3 allow the multivibrator to operate at 100 kHz, and the extremely fast switching times (typically between 40 and 100 ns) provide a harmonically rich output.

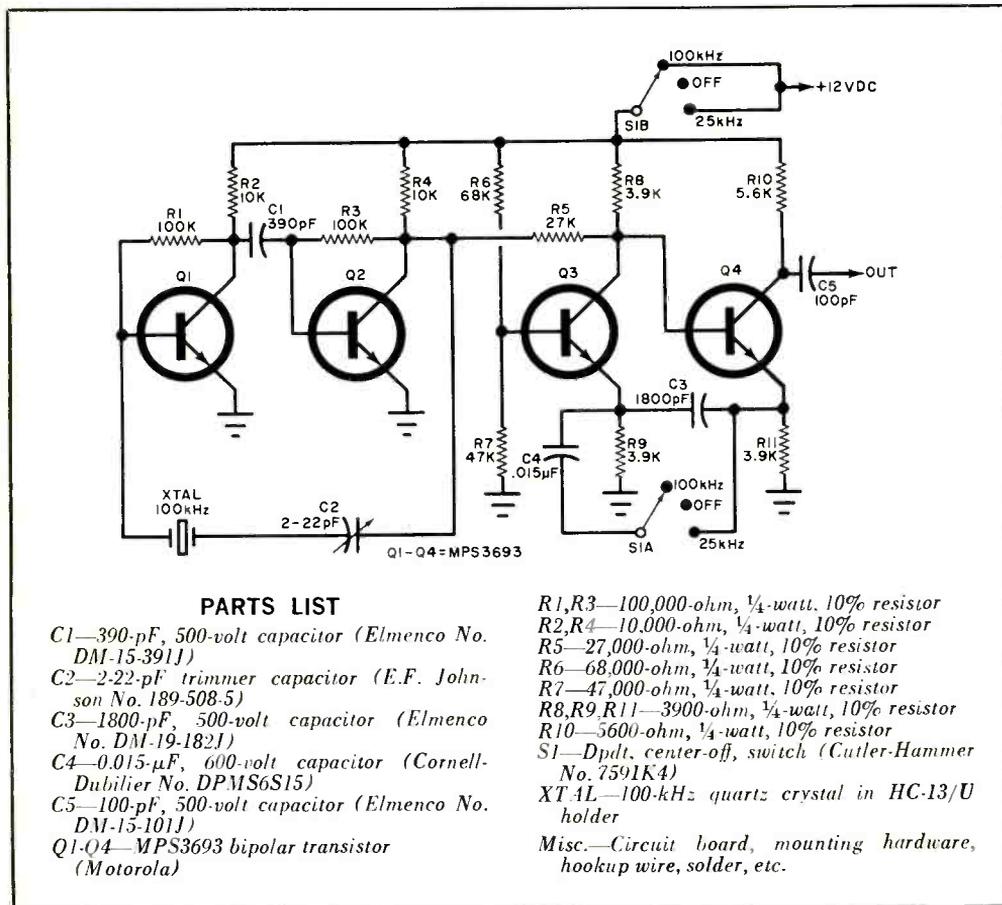
When S1 is in the 25-kHz position, C4 is switched into the circuit to slow down the multivibrator so that it switches at one-fourth of the input frequency. The fast transitions are still maintained and the harmonics are quite strong to 30 MHz and beyond.

Multivibrators operate on the principle that the transistor pair is connected for

regenerative (positive) feedback. Assume that Q3 is saturated and that its subsequent low collector voltage cuts off Q4. The drop in the Q4 emitter circuit is coupled as a negative transient to the emitter of Q3 through C3/C4. This negative-going spike has sufficient amplitude to saturate Q3 further. However, since this signal is capacitively coupled, the value of the voltage holding on Q3 decreases with time as C3 and C4 charge through R8 and R11.

When the voltage level increases beyond a critical point, the next pulse from the crystal oscillator stage causes Q3 to cut off and Q4 to saturate. Since the feedback is again regenerative, the emitter-coupled signal accelerates the transition and the change in state occurs very rapidly, producing fast rise and fall

Fig. 1. Transistors Q1 and Q2, with the crystal, form a series-mode oscillator, while Q3 and Q4 form a multivibrator with switching to operate at two frequencies.



### PARTS LIST

- C1—390-pF, 500-volt capacitor (Elmenco No. DM-15-391J)
- C2—2-22-pF trimmer capacitor (E.F. Johnson No. 189-508-5)
- C3—1800-pF, 500-volt capacitor (Elmenco No. DM-19-182J)
- C4—0.015- $\mu$ F, 600-volt capacitor (Cornell-Dubilier No. DPMS6S15)
- C5—100-pF, 500-volt capacitor (Elmenco No. DM-15-101J)
- Q1-Q4—MPS3693 bipolar transistor (Motorola)

- R1,R3—100,000-ohm,  $\frac{1}{4}$ -watt, 10% resistor
- R2,R4—10,000-ohm,  $\frac{1}{4}$ -watt, 10% resistor
- R5—27,000-ohm,  $\frac{1}{4}$ -watt, 10% resistor
- R6—68,000-ohm,  $\frac{1}{4}$ -watt, 10% resistor
- R7—47,000-ohm,  $\frac{1}{4}$ -watt, 10% resistor
- R8,R9,R11—3900-ohm,  $\frac{1}{4}$ -watt, 10% resistor
- R10—5600-ohm,  $\frac{1}{4}$ -watt, 10% resistor
- S1—Dpdt. center-off, switch (Cutler-Hammer No. 7591K4)
- XTAL—100-kHz quartz crystal in HC-13/U holder
- Misc.—Circuit board, mounting hardware, hookup wire, solder, etc.

times for the collector voltages. Now, the time constant that determines how long the transistors remain conducting is a function of the values of  $R_9$ ,  $R_{10}$ , and  $C_3/C_4$ .

Again, the emitter-coupled signal desensitizes the multivibrator temporarily to the next oscillator pulse and does not allow immediate return to the initial states until the charge curve nears the threshold voltage level. When this occurs, the very next pulse does initiate a rapid transition. The desired output is available at the collector of Q4, synchronized with the 100-kHz oscillator and with the same percentage of accuracy.

The output signal is not a symmetrical square wave (on/off ratio is approximately 5/7) owing to the different values selected for the Q3 and Q4 collector load resistors. This was done intentionally because a perfect square wave contains only odd harmonics of the basic frequency, which would not have been useful in generating 25-kHz markers. The asymmetrical waveform generated by the calibrator overcomes this situation and is rich in *all* harmonics.

The waveforms in Fig. 2 show circuit operation when S1 is in the 25-kHz position. The voltage at the collector of Q2 is a clipped 100-kHz sine wave. At the emitter of Q4, two capacitor charge curves are apparent; one is positive going, the other negative. Superimposed on these curves are transients of the 100-kHz oscillator signal. These transients are of insufficient amplitude to toggle the multivibrator except as the charge curve approaches the stage threshold. The final waveform is that of the output signal present at the collector of Q4.

**Construction.** The use of a printed circuit board for assembling the calibrator capitalizes on the advantage of project compactness. An actual size etching and drilling guide, accompanied by a components placement photo, are provided in Fig. 3. You will note from the components placement photo that the physical layout of the parts is roughly similar to the parts layout in the schematic diagram.

Once the circuit board is etched and cleaned, use a  $\frac{3}{8}$ " drill for the four mounting holes. The five medium size holes should be made with a No. 60 drill,

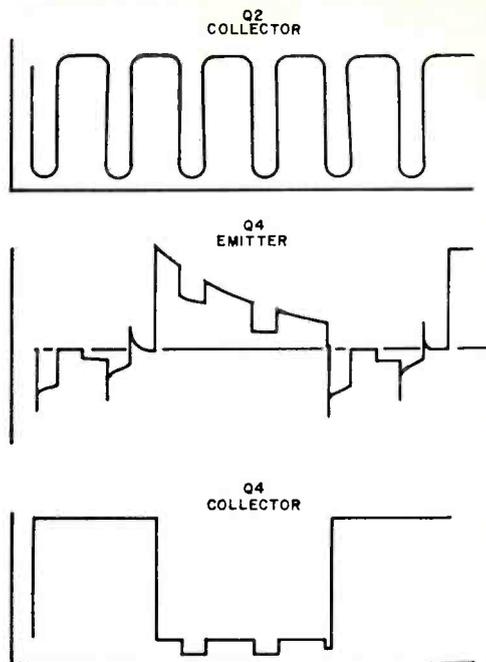


Fig. 2. Waveforms for various points in the circuit during operation in 25-kHz mode.

while all other holes should be made with a No. 66 or No. 67 drill.

If you prefer not to make a printed circuit board and would rather use perforated board, you can use the components layout diagram to help in locating the parts on the board according to the hole pattern. Wiring should be performed on the bottom of the circuit board.

**Installation and Use.** Installing the Dual-Mode Ham/SWL Crystal Calibrator in your equipment is simple. A single  $\frac{3}{8}$ " hole, drilled through the front panel of the equipment, will accommodate S1. Before drilling this hole, however, be sure that when the switch is mounted it will not interfere with the equipment's controls and normal operation.

Locate and mount the circuit board assembly as close as possible to S1 to keep lead lengths short. Use 4-40 machine hardware and  $\frac{1}{4}$ " to  $\frac{3}{8}$ " spacers when mounting the circuit board.

Power is applied to the circuit via S1B from any convenient +9- to +12-volt source within the equipment in which the calibrator is used. There is no need to worry about the power drain on the

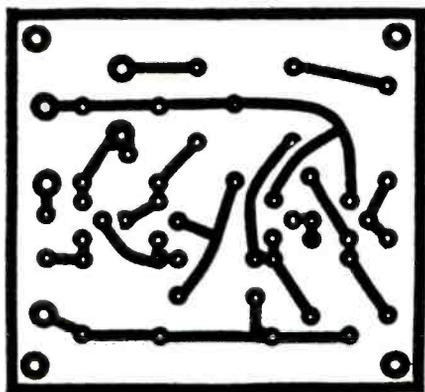
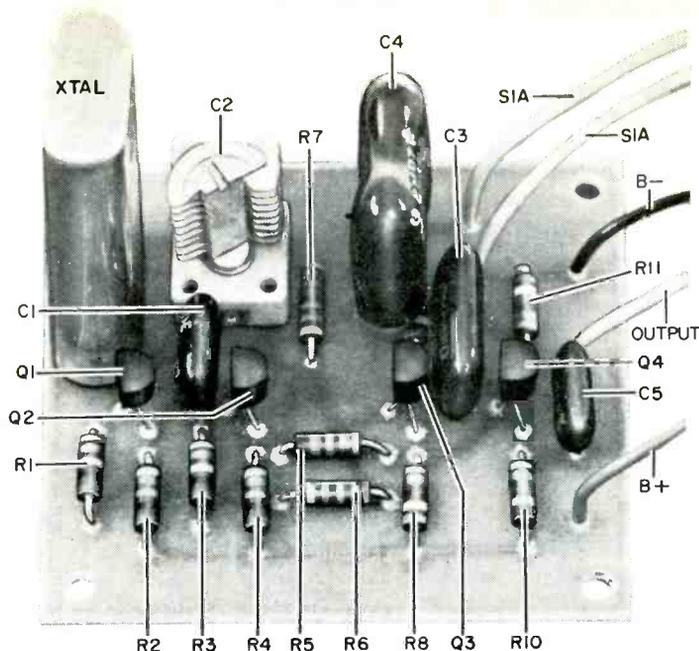


Fig. 3. If you want to make a printed circuit board, use the foil pattern at left. Lay out the components as shown above. A perforated board can be used instead of a printed circuit board.

equipment's supply since the calibrator draws very little current.

Next, solder one end of a length of insulated stranded hookup wire to the free end of C5. Route the other end of this wire as directly as possible to the equipment's input. If the insulation is left intact and the open end of this wire is wrapped a few times around the antenna lead-in wire, the low capacity thus provided between the two wires will provide light loading on the calibrator and supply plenty of signal level across the entire band from 100 kHz to 30 MHz. This cou-

pling has the further advantage of being easily adjusted for optimum performance simply by adding or removing a few turns of the hookup wire as required.

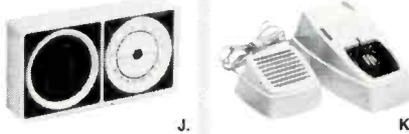
Setting C2 for the exact frequency required is accomplished by tuning your receiver to any frequency standard station, such as WWV. While listening to the station, wait until the background tone is removed; turn on the calibrator by switching it to the 100-kHz position and adjust C2 until you hear a zero beat. (It is well to perform this check periodically to correct for long-term aging of the crystal.)◆

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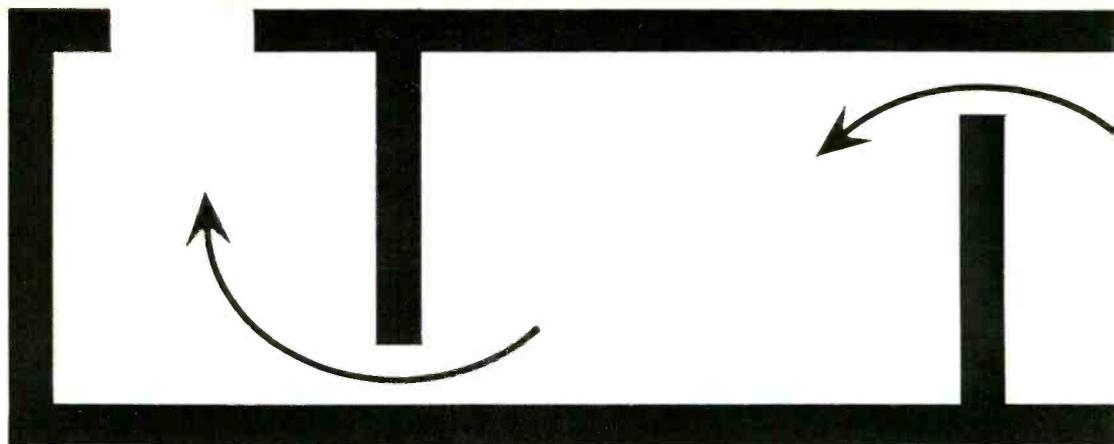
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# Labyrinth Speakers for HI-FI

SOME PROBLEMS  
AND SOLUTIONS  
ALONG WITH  
ADVICE  
TO EXPERIMENTERS

BY DAVID B. WEEMS

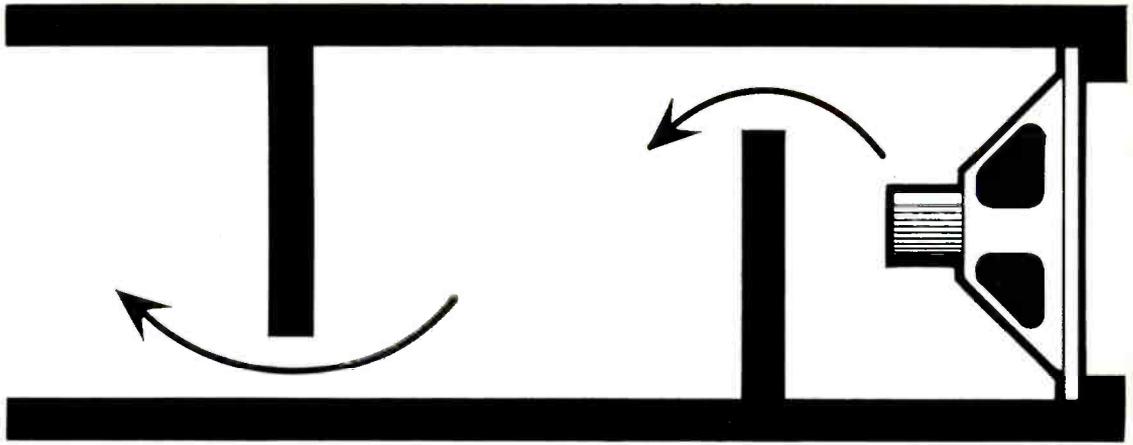
OF THE BASIC types of loudspeaker enclosures, most are produced as classic designs by the various manufacturers of speaker systems. However, one basic design is carefully avoided. A representative of one manufacturer recently offered praise for the neglected design, although he concluded: "Of course, it isn't commercially practical." He was speaking about the labyrinth, an open-ended pipe connected to the back of a speaker.

In the 1970's, any speaker enclosure to appear on the market must compete in size, cost, and performance with the simplest of enclosures: the sealed box. According to the rules of the game, the large labyrinth comes up to bat with two strikes against it. Hence, it must win on performance alone.

**Pro's and Con's.** When Benjamin Olney first developed the labyrinth for Stromberg-Carlson in 1936, the chief competition was the boomy open-backed cabinet of the console radio. In the 1950's S-C introduced their "acoustical labyrinth" to the component hi-fi market. But later S-C abandoned the consumer market, and the commercial life of the labyrinth came to a tentative end. In recent years, however, it has been revived by Admiral Corp. and IMF Products.

Partisans of the labyrinth claim that its dual bass source delivers more impact with less of the "boxy" sound of other enclosures. Britain's E. J. Jordan, for example, states that it offers the purist probably the cleanest method of absorbing back radiation from a speaker.

One measurable difference between the labyrinth and the sealed box is the former's



extremely smooth impedance curve. Many engineers contend that because modern amplifiers operate as constant-voltage sources, the impedance curve is not too important. Labyrinth partisans retort that transistor amplifiers are incapable of delivering their rated power into a high-impedance load. So, they say, the single high-impedance peak of a speaker in a sealed box may cause an amplifier to choke its output power or go into distortion at the critical low frequencies.

Labyrinth users also claim a more extended low-frequency response that is not even limited by the speaker's resonant frequency. A panel of British engineers listed the labyrinth and large (25' long) horn as the enclosures most capable of reproducing the extremely low frequencies. And John J. Virva of Admiral, developer of the company's "tunnel reflex," says, "When a high-compliance speaker is tuned in a tunnel reflex enclosure, it has its effective low-frequency power delivery extended by at least one octave."

But what about the power handling ability of a high-compliance speaker in an open-ended pipe? Virva states that the greater efficiency of the pipe takes care of the problem. "Because there is such a significant increase in the sound output from such a system, the power input requirements or driving power are substantially reduced," he says, adding that the emphasis should be on the advantage of reduced input requirements; the listener should be interested in maximum sound output as opposed to maximum electrical power input.

Virva's statements are based on experi-

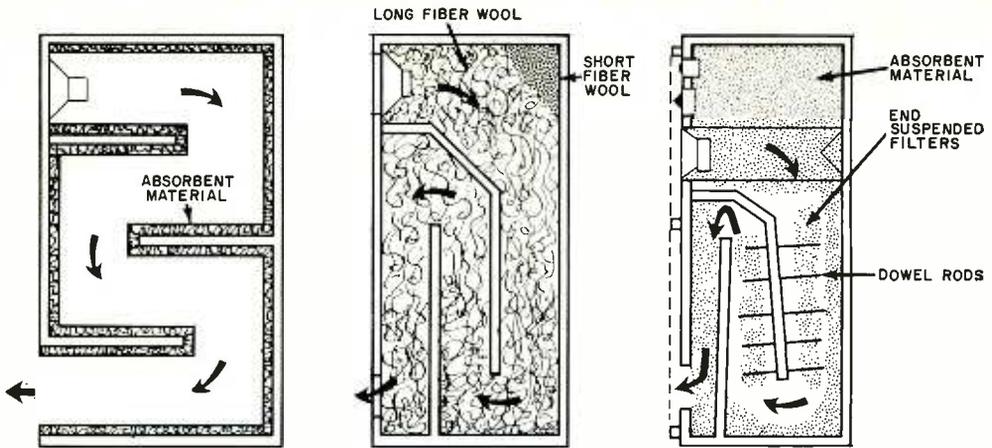
ments with existing small high-compliance speakers. A designer of large sealed-box systems is free to design a woofer with a subsonic resonance. Such a woofer would not need the extra octave of bass if the system resonance were planned to fall at the bottom of the desired frequency range.

Why have American hi-fi loudspeaker system manufacturers ignored the full-size labyrinth? This question was put to representatives of Electro-Voice, JBL, Jensen, and University Sound. Their answers were somewhat varied but boiled down to cost and complexity.

The labyrinth is in little danger of becoming extinct. Each time it has been commercially discontinued, the design was carried on by amateurs until it reappeared in some form. Fred Nichols of E-V states, "As long as there is a hobby aspect to high-fidelity, there will be interest in the labyrinth enclosure."

**Labyrinth Operation.** The labyrinth is a tuned pipe with one open end. When the wave from the speaker reaches the end of the pipe, it spreads out into the listening environment, causing a sudden pressure drop which reflects back through the pipe to the speaker as a rarefaction. At the quarter-wave frequency ( $\lambda/4$ ) of the sound, the air in the mouth of the pipe is at minimum velocity but maximum pressure (Bernoulli's Theorem). This condition produces an accompanying maximum rarefaction reflected back to the speaker cone. Here, the anti-resonant action of the pipe offers maximum damping to the speaker.

At the frequency at which the length of the pipe is a half-wavelength ( $\lambda/2$ ), of the



Drawings show, left to right, interior details of Olney's original labyrinth (1936), Bailey's transmission line (1965) and IMF's "Studio" loudspeaker system (current design). In all cases, the small arrows indicate the direction of the rear radiation from the speaker.

sound, the air in the mouth is at low pressure but high velocity. Because there is no sudden change in pressure as the wave moves out of the pipe, there is no anti-resonant action by the pipe, and the speaker cone is able to move freely. And, because of the  $\lambda/2$  phase shift ( $180^\circ$ ) within the pipe, the emerging wave is in-phase with that coming from the front of the cone, adding to the speaker's output.

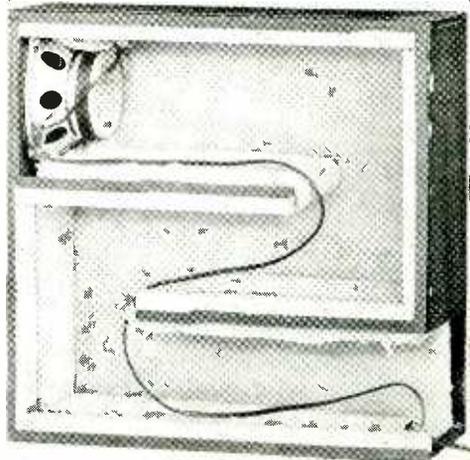
The Olney labyrinth utilized a pipe cut to  $\lambda/4$  at the speaker's resonant frequency. The  $\lambda/4$  action of the pipe damped the speaker's resonance, reducing boom; the  $\lambda/2$  action added to the speaker's output in the octave above resonance. Olney chose the  $\lambda/2$  frequency to be about 75 Hz. His 8" speaker had a 50-Hz free-air resonance, reduced to 40 Hz by the labyrinth. (The labyrinth is unique in its ability to lower the speaker's resonant frequency.)

Olney noted the presence of objectionable resonances which were produced as harmonics of the fundamental resonance of the enclosure. To counter this, he lined the walls with sound-absorbing material which, combined with bends in the pipe, eliminated the output from the labyrinth at frequencies greater than 150 Hz.

**Recent Developments.** Lined tubes were the fashion until Prof. A. R. Bailey of Bradford Institute of Technology developed a "stuffed transmission line." The theory behind it is that an infinitely long acoustic line, or pipe, will absorb the backwave from the speaker without troublesome reflections

that can produce standing waves behind the cone. A line of infinite length, of course, would be impractical; so, Bailey substituted stuffing for length. His long-fiber wool stuffing attenuated the back wave so effectively that the sudden pressure changes at the mouth, with their attendant reflections, were avoided. Extremely low frequencies were not attenuated and escaped to increase bass output. Bailey claimed that his transmission line, with its less abrupt low-end cutoff, produced less ringing than conventional ported enclosures.

As shown, Admiral's sound system employs 5/4" high-compliance speaker in quarter-wave tunnel reflex enclosure. Rear wave follows path of the wiring.



IMF has carried the transmission line concept a step further. Irving M. Fried of IMF says, "The transmission line, as we have designed it, is a tapered pipe with variable-density damping . . . which critically damps three resonances—air in the top chamber resonating with the mass and compliance of the driver, tube resonance, and free-air resonance of the driver—thus broadening and extending the bandpass."

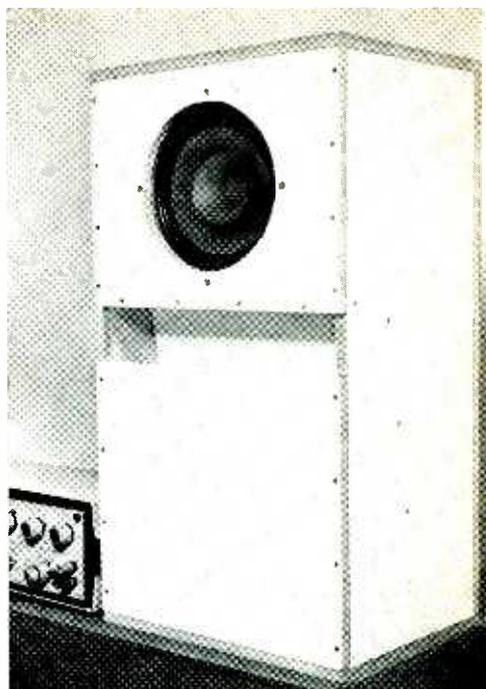
IMF also employs suspended filters, slabs of fiberglass oriented so that the edges of the filter receive the back wave from the cone. The reason for the end suspension is that the flat surface of roll damping material can be reflective at certain frequencies.

**Labyrinth Design.** The designer of a labyrinth enclosure for a particular speaker must first decide which type of labyrinth to use. He must then consider such problems as optimum cross-sectional area and pipe length. Finally, he must do considerable experimentation to test his design.

Most designers make the cross-sectional area at least equal to the effective piston area of the driver. The figures for effective cone area, however, are generally based on the assumption that the cone acts as a flat piston. A safety factor should be added to a speaker's effective cone area to avoid choking the pipe too much.

An additional safety factor is necessary for IMF's "free-flow" concept. The term implies that the area of the pipe must be equal to the cone area plus the area occupied by the stuffing. There is no simple way to determine exactly how much space is occupied by the solid fibers in a given damping material. But a rough estimate can be obtained by compressing a sample of the damping material to be used to simulate the solid fiber area. The figure obtained from this rough process can then be added to the minimum pipe area.

The classic labyrinth is a  $\lambda/4$  pipe. Fred Nichols suggests that it should not be used with some modern component quality speakers, stating that the speakers of the 1930's were underdamped and needed the damping of the pipe to avoid booming at resonance. Component speakers (e.g. E-V's SP12 and SP15) can be used in a labyrinth of  $\lambda/4$  to  $\lambda/2$  at speaker resonance. "The increase in level from the use of the labyrinth could restore flat response to something approaching the free-air resonance, if done correctly. This could be a spectacu-



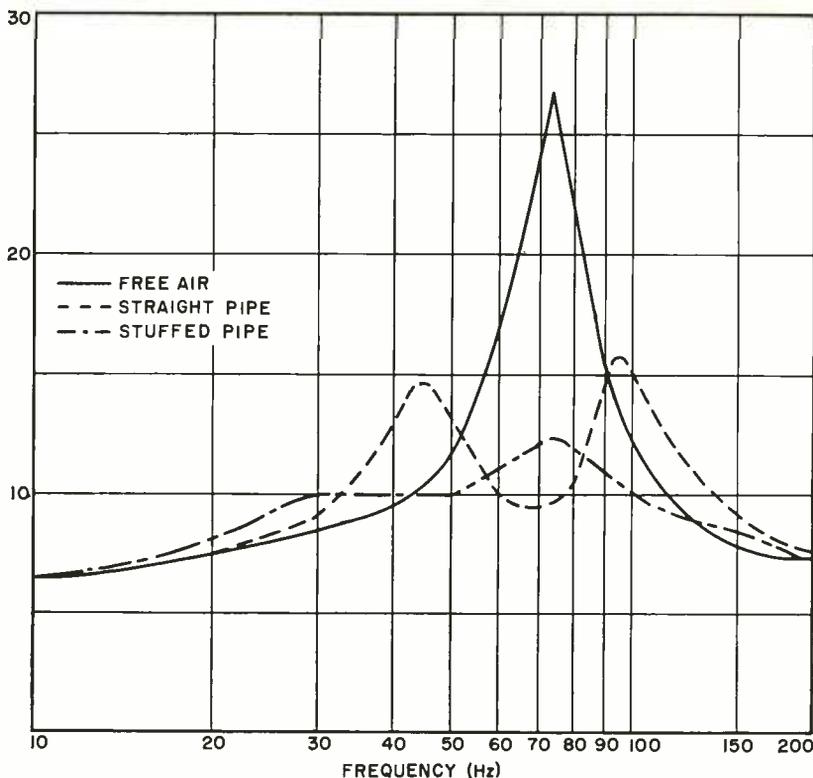
Before cutting wood members, it is suggested you first assemble temporary labyrinth from Celotex and run impedance checks. Some typical curves obtained by author are shown on next 2 pages.

lar low end once the proper combination of ingredients is found," says Nichols.

A  $\lambda/2$  design for an unstuffed pipe should be used only when recommended by the speaker manufacturer (see table). Most manufacturers base their recommendations on Olney's  $\lambda/4$  design. Although Admiral uses a  $\lambda/4$  pipe, John Virva says that this is only one mode of operation for the tunnel reflex system. He states that the mean path of the column is chosen to properly augment the low-frequency response of the high-compliance speaker as well as to provide substantial loading for it.

Dr. Bailey's transmission line was set, perhaps arbitrarily, at 7 ft in length. Jordan states that the minimum length of the stuffed labyrinth should be set at  $\lambda/4$  for the lowest frequency produced. Using this specification, the pipe would be 7 ft long for a frequency of 40 Hz. But a stuffed pipe 7 ft long will almost certainly act longer since the stuffing retards the passage of sound and effectively lengthens the pipe.

Dale Nussdorfer (University Sound) mentions another gremlin that can increase ef-



Impedance (ohms) of speaker in quarter-wavelength straight pipe. Action of unstuffed pipe is similar to that of the classic bass-reflex enclosure.

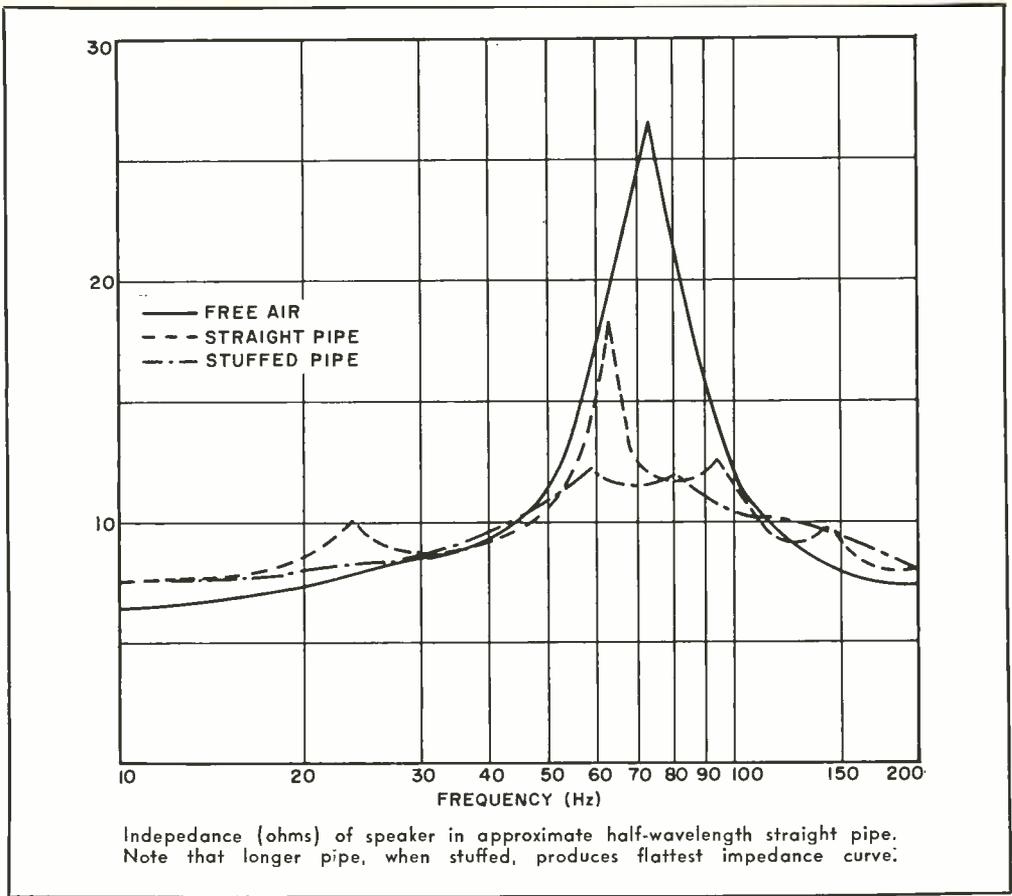
### MANUFACTURER-RECOMMENDED SPEAKERS FOR LABYRINTH

- Admiral Corp.:** (Markets only complete systems using small high-compliance speakers)
- Electro-Voice:** Models SP12, SP15;  $\lambda/4$  to  $\lambda/2$  suggested labyrinth length
- IMF Products:** (Markets only complete systems: "Studio" and "Monitor")
- JBL:** (None recommended)
- Jensen:** High-compliance Models W15LF, W15NF, L12LF, W12NF, etc.;  $\lambda/4$  suggested labyrinth length
- University Sound:** All cone speakers except Model GS-100;  $\lambda/4$  suggested labyrinth length

fective length: "The effective length of a tube is longer due to the friction of the air against the walls. But a bent tube has sharp corners for the air to pass around, and this will cause the friction to increase."

The factors of stuffing and bending may explain why the IMF speakers operate at  $\lambda/8$ . The performance of a straight open pipe can be predicted, but for a pipe that is folded and stuffed, one needs a crystal ball.

**Practical Approach.** If you want to experiment with the labyrinth, a good way of negotiating the difficulties is to build a straight pipe of the length, cross-sectional area, and type desired and run an impedance curve with the speaker installed. Then make adjustments on the folded pipe until similar results are obtained. Cost and time can be saved by using Celotex as the material for the temporary enclosure; one 4 × 8' sheet will be enough for an 8 ft pipe



with maximum internal cross-sectional area of about 120 sq in.

The results of some experiments with an 8-in. speaker are shown in the two graphs on these pages. Note that in each the speaker's free-air resonance occurred at 74 Hz. First a straight  $\lambda/4$  pipe was built, the speaker installed, and an impedance curve run. The curve is similar to that of a bass reflex enclosure tuned to the speaker's free-air resonance. This is not surprising since both types of boxes offer maximum damping at resonance.

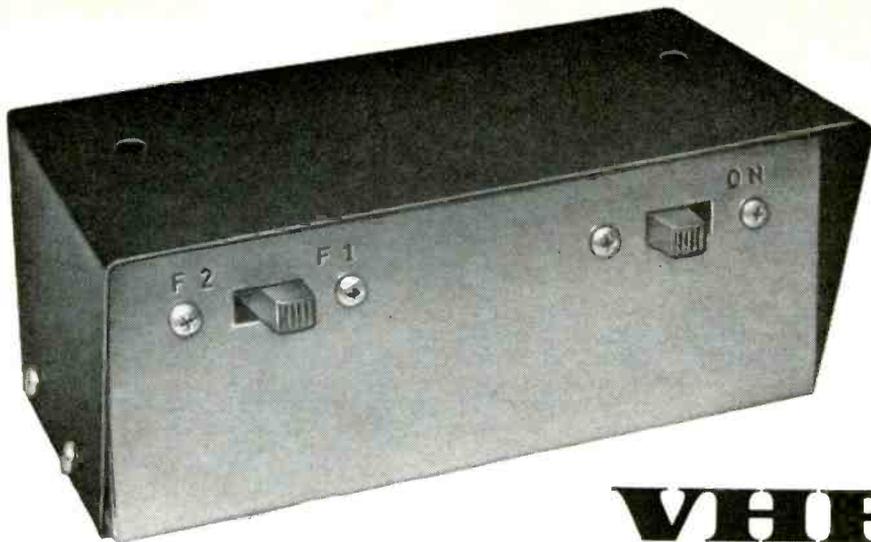
Next, the  $\lambda/4$  pipe was loosely stuffed with fiberglass. Note that the new impedance curve is much flatter with a single peak at about the original free-air resonance point. It seems that for this particular combination of speaker, pipe, and stuffing, the system's impedance behavior is similar to that of a closed-box system—with one big exception. Instead of the enclosure raising the resonant frequency, resonance is back to where it

was in free air. This combination should provide good response down to the speaker's resonant frequency, although too much stuffing could produce excessive bass rolloff at that point.

The speaker was then installed in a pipe of about twice the length of the first one and another impedance curve was run. Finally, the longer pipe was loosely stuffed and another test was run. The results of this combination yielded the flattest impedance curve of all tests.

The stuffing used for the tests consisted of house insulation grade fiberglass which was ripped from its backing sheet to leave a rough absorptive surface. An alternate method is to cut the fiberglass into angular wedges so that they fit together loosely.

For those who wish to experiment with the labyrinth enclosure, the suggestions of various manufacturers on which of their speakers might be suitable are given in the table opposite. ♦



# VHF FREQUENCY CONVERTER

ADD SERVICE BANDS TO YOUR CAR RADIO

BY LYMAN E. GREENLEE

**F**OR THE PERSON interested in monitoring the various service bands (volunteer fire, police, CD, CAP, etc.) installing a vhf receiver in his automobile can be an expensive proposition. It is much less costly and easier to install a frequency converter so that the regular BCB car radio can be used; and the prospects are even brighter if the simple one-IC converter circuit described here is used. This crystal-controlled converter is powered by the vehicle's 12-volt battery and can be set accurately to the desired frequency (between 25 and 225 MHz) so that the BCB receiver need only be tuned to one particular spot on the dial. If the vehicle receiver has push-button tuning, one button can be used for the desired vhf station. The conventional vehicle antenna can be used, or a special vhf antenna can be installed to feed both the converter and the BCB receiver.

Many vhf-to-BCB converters use manu-

ally tuned oscillators. This presents a problem in a moving vehicle. Drift, accidental tuning movement due to vibration, and the usual short duration of vhf transmissions make manual tuning impractical. With crystal control, only the vehicle's BCB radio need be adjusted and crystals are relatively immune to vibration problems.

**Construction.** The basic circuit of the frequency converter is shown in Fig. 1 and the component values for the various frequencies are given in the Table. The layout shown in Fig. 2 should be followed for best results. All connecting leads, especially those carrying r-f must be kept short. Be sure to observe the polarities of the diodes and the pin locations on the IC. Some type of clamp (or spring) must be used to keep the crystal holder seated. Note that the IC is mounted on standoff clips with the leads fanned out.

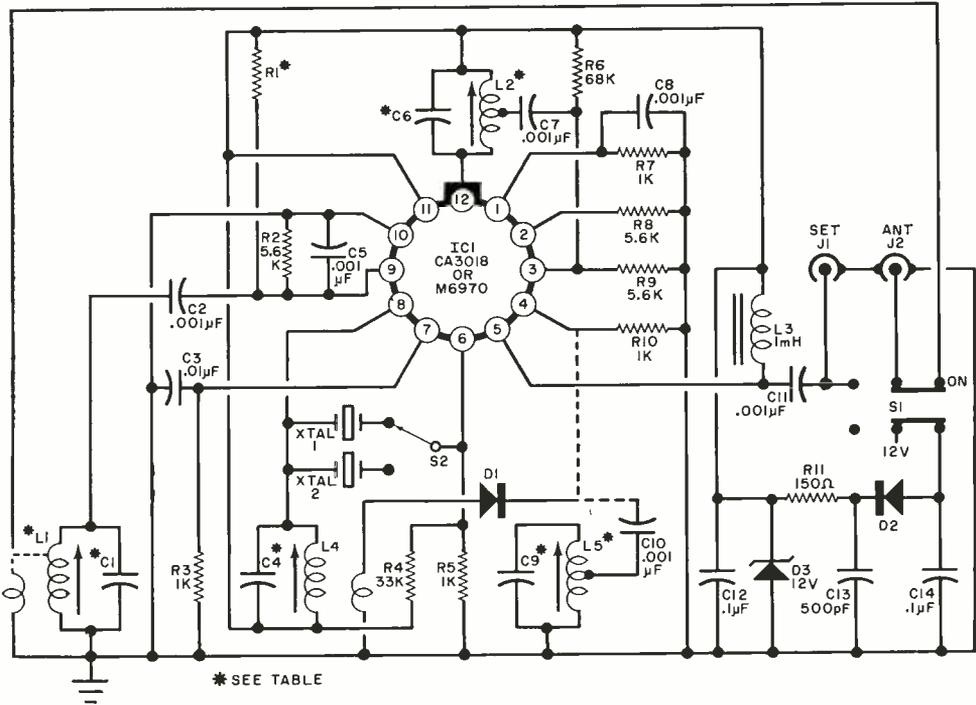


Fig. 1. This one-IC vhf converter is used with a conventional vehicle radio enabling monitoring of CAP, CD, volunteer fire and police bands.

### PARTS LIST

C1,C4,C6,C9—See table  
 C2,C5,C7,C8,C10,C11—0.001-µF disc capacitor  
 C3—0.01-µF disc capacitor  
 C12,C14—0.1-µF capacitor  
 C13—500-pF capacitor  
 D1—Signal diode  
 D2—Rectifier diode: 1A, 400V  
 D3—Zener diode: 12V, 1W  
 IC1—Integrated circuit (RCA-CA3018  
 J1,J2—Shielded antenna connector  
 L1,L2,L5—See table  
 L3—1-mH r-j choke  
 L4—12 and 3 turns, #24 enameled wire  
 R1—See table

R2,R8,R9—5600-ohm, ½-watt resistor  
 R3,R5,R7,R10—1000-ohm, ½-watt resistor  
 R4—33,000-ohm, ½-watt resistor  
 R6—68,000-ohm, ½-watt resistor  
 R11—150-ohm, ½-watt resistor  
 S1—Dpdt slide or toggle switch  
 S2—Spdt slide or toggle switch  
 Misc.—Suitable board, mounting terminals,  
 crystal socket, knobs, spacers, enclosure,  
 mounting hardware, etc.  
 Note—Complete kit of parts, less crystal, is  
 available for \$39.95, postpaid, from Mobil  
 Electronics, Inc., P.O. Box 1132, Anderson,  
 IN 46015 (USA only). The M6970 (similar  
 to RCA CA3018) integrated circuit is  
 also available for \$3.50, postpaid.

### COMPONENT TABLE

Frequency MHz	L1 Turns	L2 Turns	L5 Turns	C1 pF	C4 pF	C6 pF	C9 pF	R1 Kilohms
25-35	12&3	12	—	15	56	33	—	220
35-55	12&3	12	—	10	33	15	—	220
60-80	6	6	6	86	43	33	33	68
80-110	5	5	5	15	10	10	10	68
150-170	3	3	3	25	10	10	10	68
200	2	2	2	22	10	12	12	68

Note: Use #24 enameled wire for the 12 and 3 turns on L1; #18 bus wire on all other inductors. Antenna connects to 3-turn winding on L1 when there are two windings and directly to winding when there is only one.

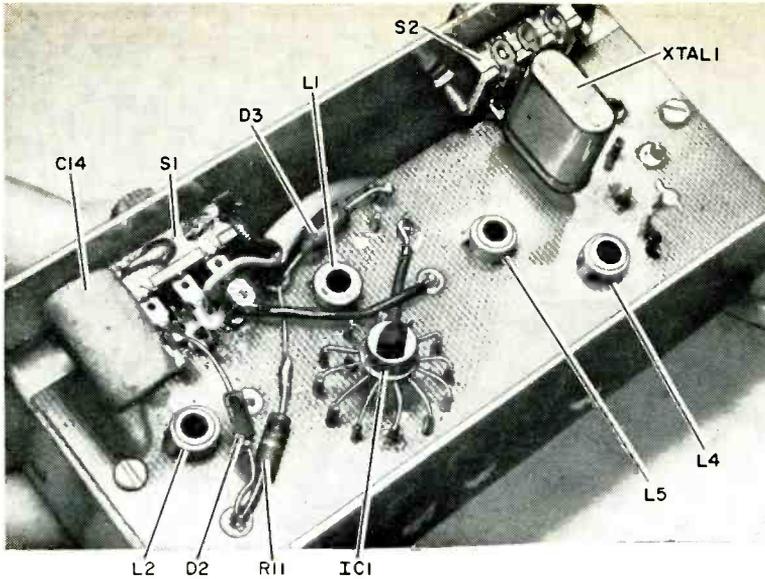


Fig. 2. Perf board construction was used in the prototype, observing good vhf wiring practice. Any connecting leads carrying r-f must be kept as short as possible. An etched board can also be designed and used. Note how IC leads are fanned out and soldered to standoff clips. Although only one crystal is shown, the other fits into a socket adjacent to XTAL1. More crystals may be used within same frequency range.

Any type of board can be used to assemble the circuit, with the board mounted in a small metal enclosure that fits easily in the vehicle. The antenna bypass switch and the crystal selector switch (if used) should be mounted on the front of the enclosure so that they are accessible. When the antenna switch is in the bypass position, power is removed from the converter and the antenna is connected directly to the BCB radio.

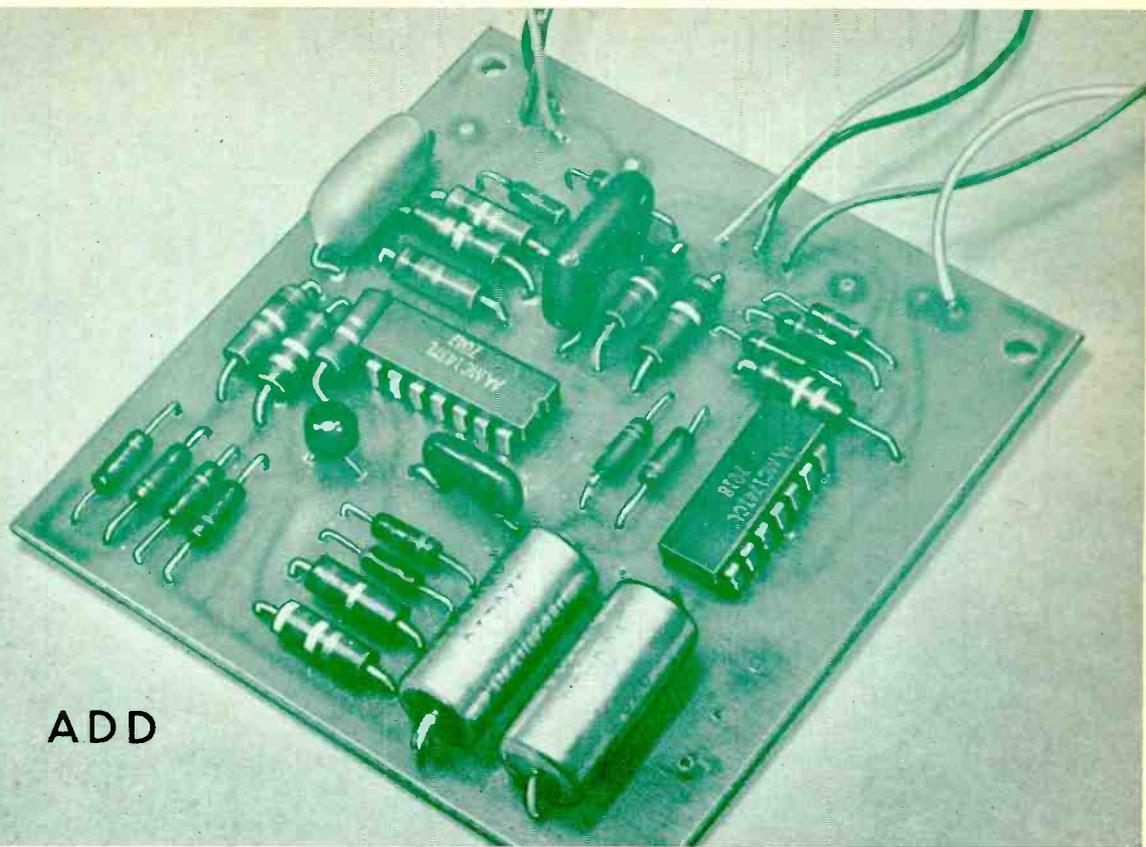
The connections to *D1* and *C9* are shown as dashed lines in Fig. 1. For the frequency range between 25 and 55 MHz, *L5* can be omitted and diode *D1* connected directly to pin 4 of the IC. With *L5* omitted, *C9* can also be left out. For other frequencies, both *L5* and *C9* are used.

In selecting a crystal choose one whose harmonic is between 600 to 1600 kHz different from the desired frequency. The frequency between 600 and 1600 kHz is the intermediate frequency to which the BCB receiver is tuned. If possible, work backwards. That is, pick a spot on the radio dial that is quiet, with no strong signals nearby, and then pick

a crystal whose frequency is that amount different from the desired vhf frequency. Two crystals (switch selectable) can be used in the converter if the two signals are not more than 4 MHz apart in the same band.

**Alignment.** Connect the converter (through *J1*) to the antenna input of the vehicle receiver, using shielded line to avoid pickup. Connect the vehicle antenna to *J2* on the converter. For the best reception, the antenna height should be about 42". Place *S1* in the on position and tune the vehicle receiver to the correct frequency on the standard broadcast band between 600 and 1600 kHz.

Connect a high impedance dc voltmeter between pin 7 (+) on *IC1* and ground. Using an insulated alignment tool, adjust *L4* for a maximum indication, then back off one to two turns. The voltage should be about 4 to 6 volts. Connect the voltmeter between pin 4 (+) on *IC1* and ground, and adjust *L5* for a maximum indication. Remove the voltmeter. Adjust *L1* and *L2* for a maximum signal from a station or signal generator at the desired frequency. ♦



ADD

# TRIGGERED SWEEP TO YOUR SCOPE

NEW LIFE, NEW USES FOR INEXPENSIVE SCOPES

BY HARRY GARLAND AND ROGER MELEN

**O**NE OF THE BEST features of expensive oscilloscopes is that they usually have a built-in triggered sweep. Without a triggered sweep—using only the conventional free-running time base found in lower-priced scopes—it is very frustrating to try to get some waveforms to stand still. Built-in triggering also eliminates erratic multi-triggering; and, due to the extremely good linearity found in triggered sweep circuits, accurate time and/or frequency measurements may be made along the horizontal axis. Once a signal is displayed on the scope, it can easily be expanded horizontally without losing sync.

In any triggered sweep system, the sweep does not start until the reference signal (usually the signal to be displayed on the vertical axis), reaches some predetermined level. Once triggered into operation, the sweep becomes immune to any other input signal for the duration of that trace. After retracing, the sweep is once again triggered and the process is repeated. Since the horizontal sweep is then very linear, the trace can be calibrated in microseconds, milliseconds, or seconds per division, enabling time and frequency measurements to be made during the display period. Nonperiodic wave-

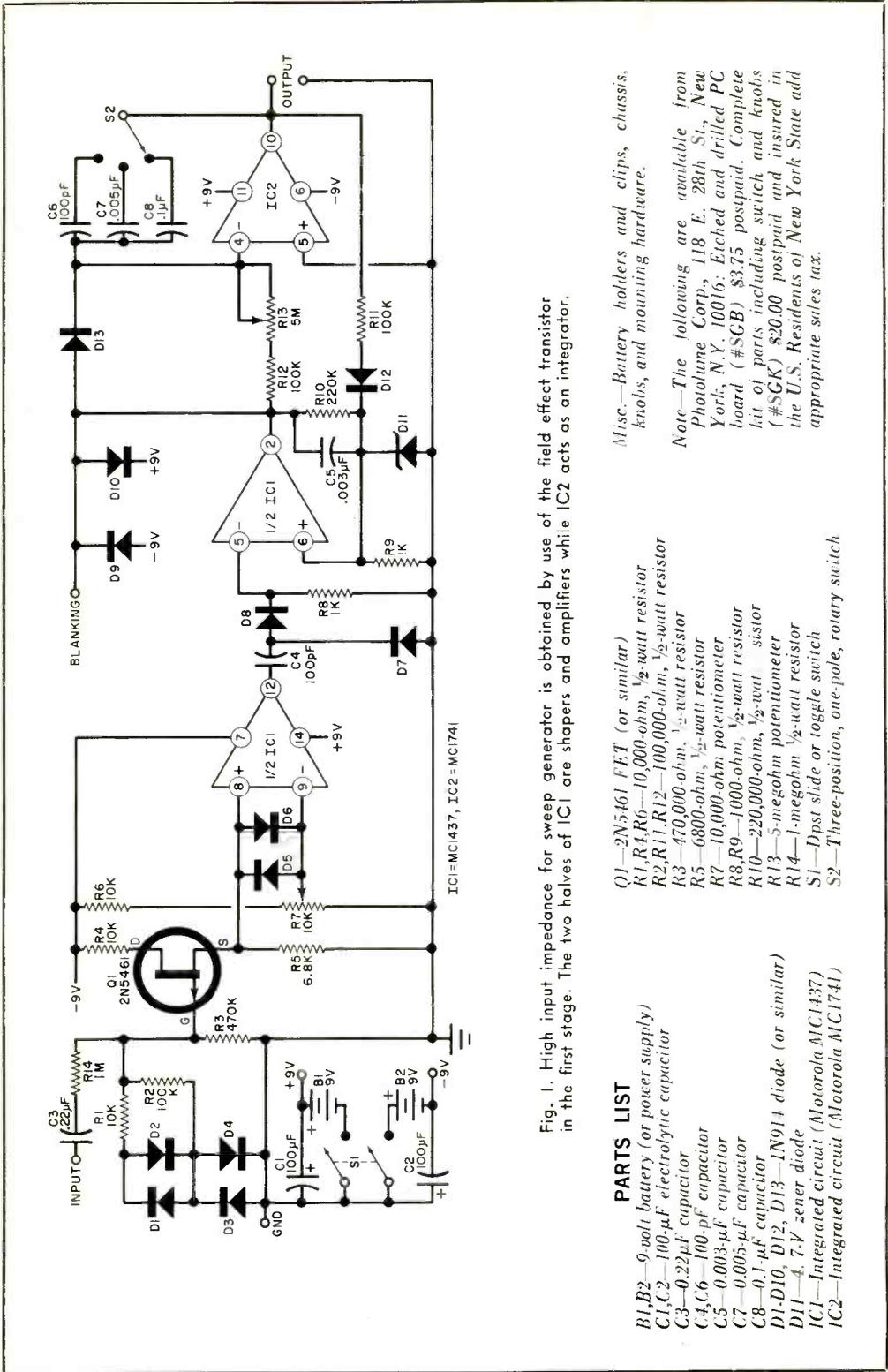


Fig. 1. High input impedance for sweep generator is obtained by use of the field effect transistor in the first stage. The two halves of IC1 are shapers and amplifiers while IC2 acts as an integrator.

#### PARTS LIST

- B1, B2—9-volt battery (or power supply)  
 C1, C2—100- $\mu$ F electrolytic capacitor  
 C3—0.22- $\mu$ F capacitor  
 C4, C6—100-pF capacitor  
 C5—0.003- $\mu$ F capacitor  
 C7—0.005- $\mu$ F capacitor  
 C8—0.1- $\mu$ F capacitor  
 D1, D10, D12, D13—1N914 diode (or similar)  
 D11—4.7-V zener diode  
 IC1—Integrated circuit (Motorola MC1437)  
 IC2—Integrated circuit (Motorola MC1741)

- Q1—2N5461 FET (or similar)  
 R1, R4, R6—10,000-ohm,  $\frac{1}{2}$ -watt resistor  
 R2, R11, R12—100,000-ohm,  $\frac{1}{2}$ -watt resistor  
 R3—470,000-ohm,  $\frac{1}{2}$ -watt resistor  
 R5—6800-ohm,  $\frac{1}{2}$ -watt resistor  
 R7—10,000-ohm potentiometer  
 R8, R9—1000-ohm,  $\frac{1}{2}$ -watt resistor  
 R10—220,000-ohm,  $\frac{1}{2}$ -watt resistor  
 R13—5-megohm potentiometer  
 R14—1-megohm  $\frac{1}{2}$ -watt resistor  
 S1—Upst slide or toggle switch  
 S2—Three-position, one-pole, rotary switch

Misc.—Battery holders and clips, chassis, knobs, and mounting hardware.

Note—The following are available from Photolame Corp., 118 E. 28th St., New York, N.Y. 10016: Etched and drilled PC board (#SGB) \$3.75 postpaid. Complete kit of parts including switch and knobs (#SCK) \$20.00 postpaid and insured in the U.S. Residents of New York State add appropriate sales tax.

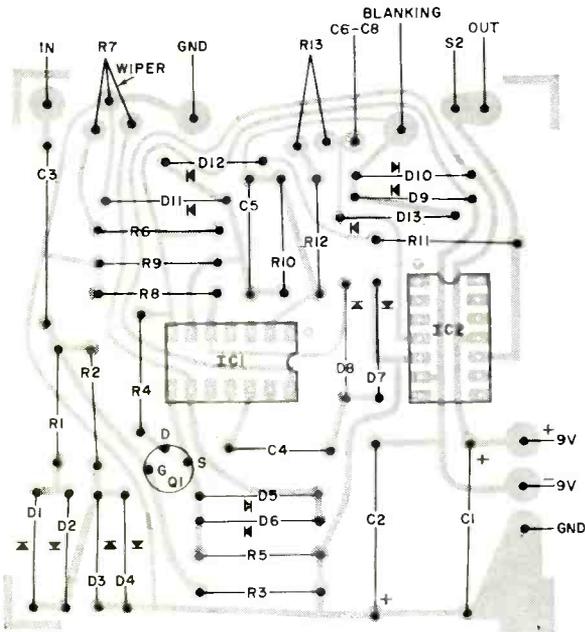
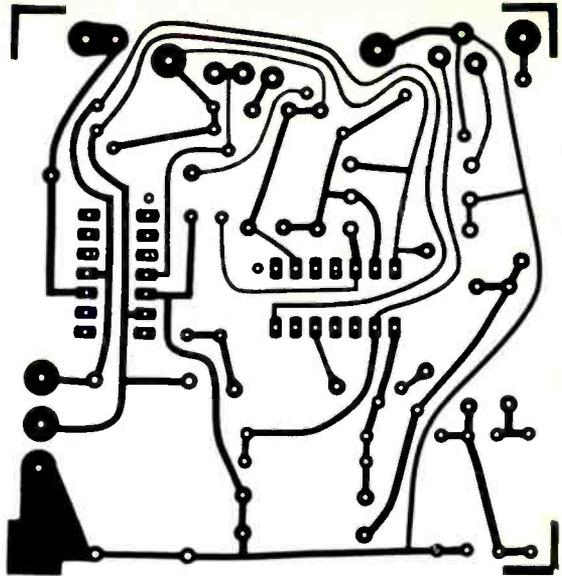


Fig. 2. The actual size foil pattern above can be used to make a printed circuit board, with the components mounted on it as shown at left. Control components S2 (with C6, C7, and C8), R7, and R13 are located off the circuit board. Add R14 in series with input capacitor C3.

forms, such as those found in many digital pulse circuits can be displayed properly only on a triggered sweep scope.

The triggered sweep generator whose schematic is shown in Fig. 1 has a high input impedance, a 100-mV triggering sensitivity, three switch-selected sweep rates with provisions for vernier control, and a sweep linearity of better than 0.01%.

**Construction.** The circuit can be assembled on a printed circuit board such as that shown in Fig. 2. Be sure to observe the coding on the IC's and use a low-wattage soldering iron and fine solder for installing all components.

There are two ways of mounting the board. A small chassis can be used with three operating controls (sweep switch S2, sweep vernier R13, and sensitivity

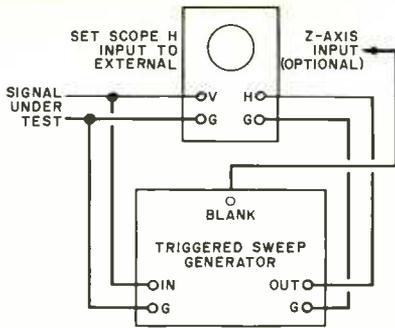


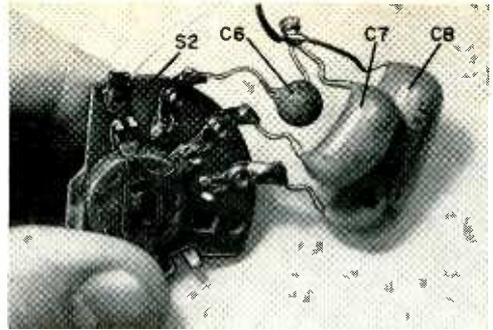
Fig. 3. When sweep generator is assembled outside of scope, make connections to scope as shown here.

control R7) mounted on the front panel and with another switch used to turn the power on and off. A pair of 9-volt batteries can be used for power in this case. The sweep generator is connected to the scope as shown in Fig. 3.

The second approach is to mount the sweep generator directly in a scope, locating the printed circuit board in any suitable spot (away from heat if the scope uses vacuum tubes). A pair of silicon rectifier diodes and filter capacitors may be used to obtain the necessary dc operating voltages from the scope filament supply, or if the scope is all-solid-state, a look at the schematic will show where the suitable voltages can be picked off.

The input to the sweep generator may be derived from the existing scope input or from the scope sync leads. In the latter case, the high-input impedance FET stage may be omitted and the circuit shown in Fig. 4 used for the input. The 100,000-ohm potentiometer in this circuit is used as the sensitivity control. The blanking output may be connected to the scope blanking circuit if desired.

**Operation.** With the desired input signal connected (using an audio generator for testing), and the triggered sweep not turned on, only a vertical trace will be seen on the scope. Adjust the height to some convenient value. When the triggered sweep is turned on, a horizontal trace may appear. If it does, adjust both the sweep rate selector switch, S2 and sweep vernier R13 until the display shows some multiple stationary signals. If the trace does not appear, adjust the sensitivity control, R7, until it does. Low-



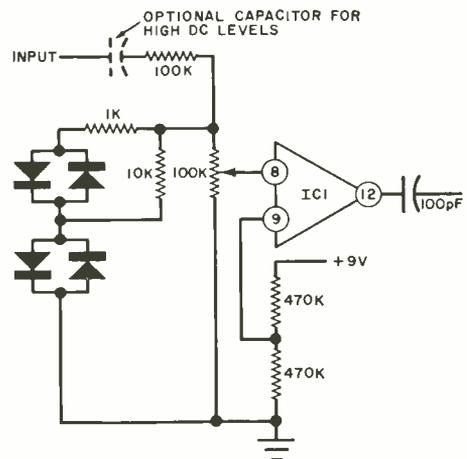
Shown here is method of attaching capacitors C6, C7, and C8 to the sweep rate selector switch S2.

er the input level from the generator and keep adjusting the sensitivity control until the sweep triggers at some low level. Once the lowest trigger level is established, the sensitivity control may be left alone. The scope horizontal gain control determines sweep length.

With a steady signal now displayed, note that manipulation of the sweep vernier and sweep rate switch produces a stationary signal from a small part of a sine wave to any desired number of sine waves, without losing sync lock at any time. Also, with a single sine wave displayed, it is possible to adjust the audio frequency generator over a wide range of frequencies without losing sync lock.

**Calibration.** If you want to calibrate sweep vernier R13 and sweep rate S2, an

Fig. 4. If scope sync leads are used for sweep input, omit Q1 and use this circuit for first stage.



## THEORY OF CIRCUIT DESIGN

To avoid loading the input circuit (which is also applied to the scope), the first stage of the sweep generator uses a field effect transistor. Resistors *R1* and *R2* and diodes *D1* through *D4* provide automatic range selection. As the input voltage rises, the diodes conduct to shunt the input and reduce the signal applied to the FET. If high-level inputs are used constantly, a series resistor will reduce the loading effect.

The output of the FET source follower is coupled to the first op amp which is half of *IC1*. The sweep cycle begins when the signal to pin 8 exceeds the bias set by the threshold potentiometer *R7* at pin 9. The high-gain op amp amplifies the difference signal until its output is +9 volts. The positive output of the first op amp appears at the minus input of the second op amp, causing its output to swing to -9 volts. This level is held to -9 volts by the feedback action of *R10*. The next stage (*IC2*) is known as a Miller integrator and produces an ultra-linear ramp voltage when the negative signal is applied to pin 4. The speed of the sweep is determined by the value of the switch-selected feedback capacitor (*C6*, *C7*, or *C8*) and the value of *R13*.

When the sweep voltage ramp reaches its maximum value, the feedback signal through *R11* and *D12* causes the output of the second op amp to change from -9 to +9 volts. Diode *D13* is then forward biased and the selected feedback capacitor is rapidly discharged. During the discharge of the capacitor, the scope trace returns to the left side of the screen, where it remains until the trigger cycle starts again.

accurate source of frequencies must be available. To calibrate the horizontal graticule, apply a known frequency to the input and establish a steady trace. Adjust the scope horizontal shift to start the trace at some known mark on the left side of the horizontal graticule. Ad-

The sweep switch *S2*, with *C6*, *C7*, and *C8*, sensitivity control *R7*, and sweep vernier *R13* are connected by wires of suitable length to appropriate points on PC board. Note that leads from *R7* are twisted together.

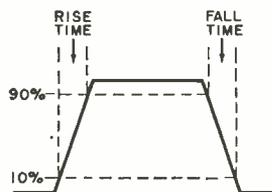
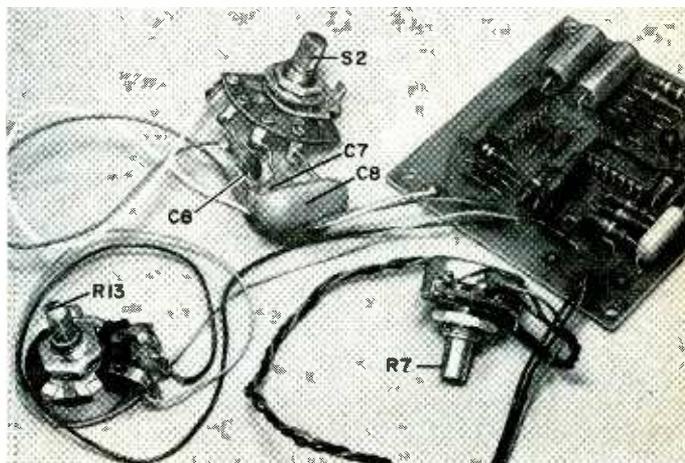
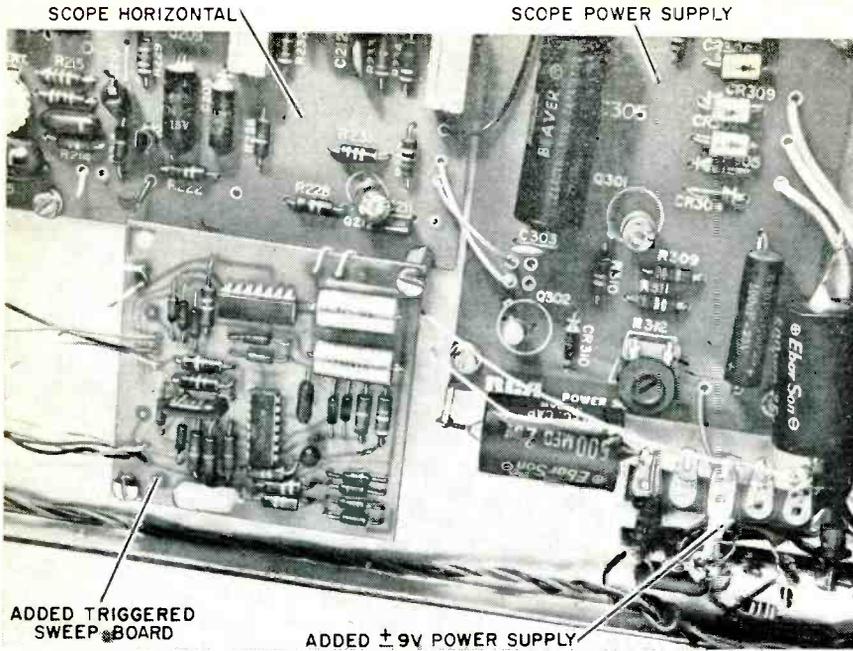


Fig. 5. To measure rise or fall time of an applied pulse, count time between 10% and 90% points.

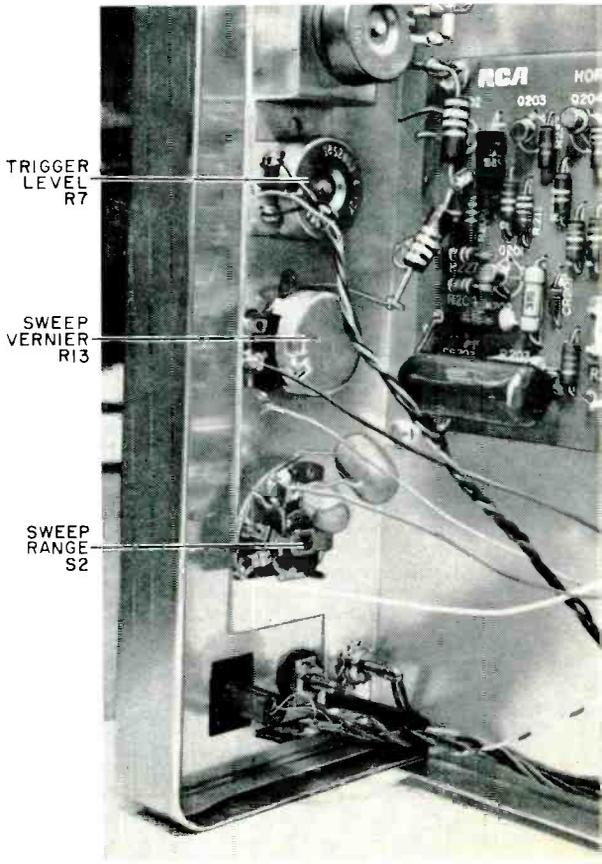
just the scope horizontal gain until the trace reaches another known mark on the right side of the screen. Determine the time period of the input frequency by using the equation  $T = 1/f$ , where *T* is the period and *f* is the frequency. For example, using a 100-kHz sine wave, each cycle is 10 microseconds long. Adjust *R13* until one cycle occupies exactly one division on the scope graticule. Mark the knob position on *R13* 10  $\mu$ s/div. Other points on either *R13* or *S2* can be found using the same technique. For example, 60 Hz is 16.6 milliseconds and 15,750 Hz (TV line frequency) is 63.6 microseconds. If desired, a series of fixed resistors and trimmer pots may be used for *R13* (with a selector switch).

Once calibration is complete, it is easy to determine the frequency of an applied waveform or to measure the rise or fall time of an applied pulse. In the latter case, note that measurement is made between the 10% and 90% points of the waveform (see Fig. 5). Adjust the triggered sweep for at least one complete pulse. The rise (or fall) time is calculated by determining how many divisions and parts of a division lie between the two



This is a typical installation of triggered sweep generator in a scope. Location is not critical but it should be away from heat if the scope uses tubes. In the case illustrated here, a 9-volt power supply was added.

In the installation shown here, the "phase," "sync," and "sweep" controls on the front of the existing scope were removed and replaced by three controls for the sweep generator. Blanking output can be connected if desired.



measuring points and multiplying this number by the time scale of the controls.

Frequency is measured by determining the exact number of divisions (and parts of a division) in one cycle of a known waveform and then measuring the number of divisions occupied by an unknown waveform. The frequency is then found from the equation  $f = 1/T$  where T is the number of divisions occupied by the unknown multiplied by the calibration factor determined with the known wave. ♦



# LOW-VOLTAGE Remote Power Control

AVOID SAFETY PROBLEMS AND COSTLY REWIRING

BY NEIL JOHNSON

**M**OST HOUSES and apartments come with an adequate (if you're lucky) wiring system already concealed within the walls and floors. There usually comes a time, however, when what you have isn't enough and you need a two-way switching system for remote control.

The first thing that comes to mind is a conventional two-way circuit that involves running a pair of power-carrying leads from the remote to the local switching point—sort of a super extension cord.

Such a system is definitely out, since you are creating a real safety hazard, not to mention violating the National Electrical Code and running the risk of making your insurance man very unhappy.

Of course, you can hire an electrician and do the thing properly; but you may not want to spend that much money—and there is a way out, for less than \$10.

The secret of this remote power switching unit is a step-down transformer that also contains a relay. It is perfectly safe

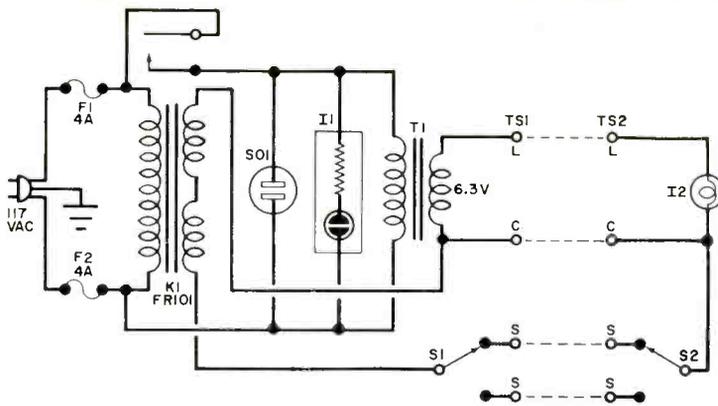


Fig. 1. Relay K1 also contains a step-down transformer. Wiring to I2 and S2 is low-voltage type. Power can be switched from either end of circuit.

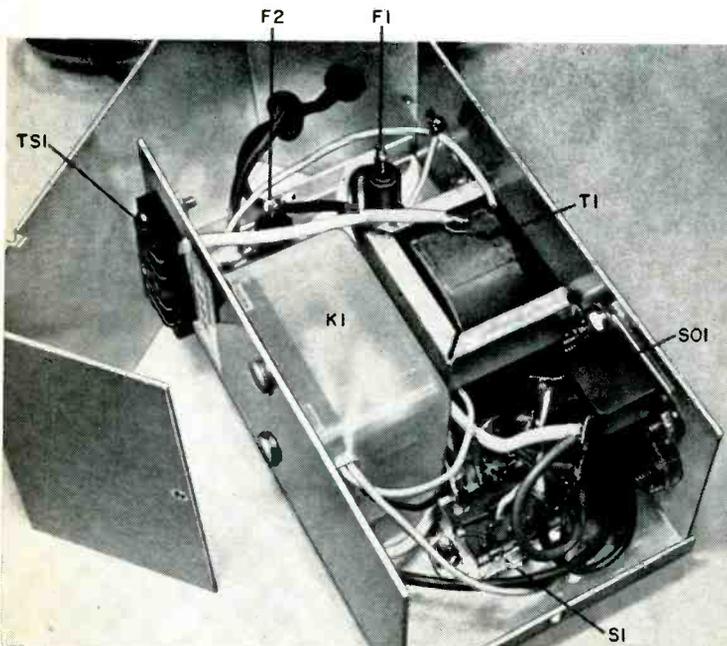
### PARTS LIST

F1,F2—4-ampere fuse and holder  
 I1—117-volt neon indicator lamp  
 I2—6.3-volt indicator lamp  
 K1—Remote control isolation relay (ALCO FR-101, Lafayette 30F12002)

S1,S2—Spdt slide or toggle switch  
 SO1—120-volt ac chassis mounted outlet  
 T1—6.3-volt, 1-ampere filament transformer  
 TS1,TS2—4-terminal barrier strip  
 Misc.—Suitable enclosures (2), length of 4-wire cable (Belden 8741 or similar), 3-lead ac power line, mounting hardware.

to run low-voltage, low-current wiring around the house without elaborate protection—the high-power portion of this system is located as close as possible to the 117-volt outlet. A typical circuit using

the transformer relay is shown in Fig. 1. The relay contacts can handle up to 600 watts at 120 volts ac, but the control winding is safely isolated from the power line. When the control winding has a very



Enclosure for power unit must be either non-metallic or units must be properly insulated to avoid contact. Both sides of power line are fused with ground conductor connected to chassis.

low resistance in its circuit, there is sufficient pull-in power in the relay winding to close the contacts.

The system is divided into two sections: (1) the high-power circuit with transformer, relay contacts and the component to be controlled (plugged into SO1); and (2) the low-power remote section containing a switch and indicator lamp. A conventional 4-wire intercom cable can be used for the connections to the remote circuit. If 4-wire intercom cable is not available use 4-conductor cable such as that commonly used for antenna rotators.

**Construction.** The power circuit should be constructed in a non-conductive housing to avoid any chance of making contact with the power line. If a metal housing is used, the components must be mounted to avoid accidental contact with the enclosure. Make sure that the power line ground lead is directly connected to the metal enclosure. Mount a 4-terminal barrier strip, socket(s) SO1, local power indicator I1 and local on-off switch S1 on the power unit chassis. The fuses should be mounted on insulated holders and the power line should have a grommited hole in the chassis.

The remote control unit can be mounted in any small enclosure, insulated or not, since no appreciable power flows through it. Mount a 4-terminal barrier strip, remote on-off switch S2, and remote indicator I2 on this enclosure.

**Operation.** Plug the main unit into the commercial power line. Note that I1 is not lit and there is no power at SO1. Remove the power. Connect the 4-wire cable to the power unit, noting which lead is which and then connect it to the remote control unit. Plug the power cord in again. Either switch S1 or S2 can now be operated to apply or remove power from SO1. Try to keep the total resistance of the four-wire cable at a reasonably low ohmage to get reliable operation. The indicator lamps, one at each end, give visual indication that the system is working properly.

When the remote and local units are in place and the wiring between the two has been installed carefully and securely, check the entire system with a load plugged into SO1. ◆

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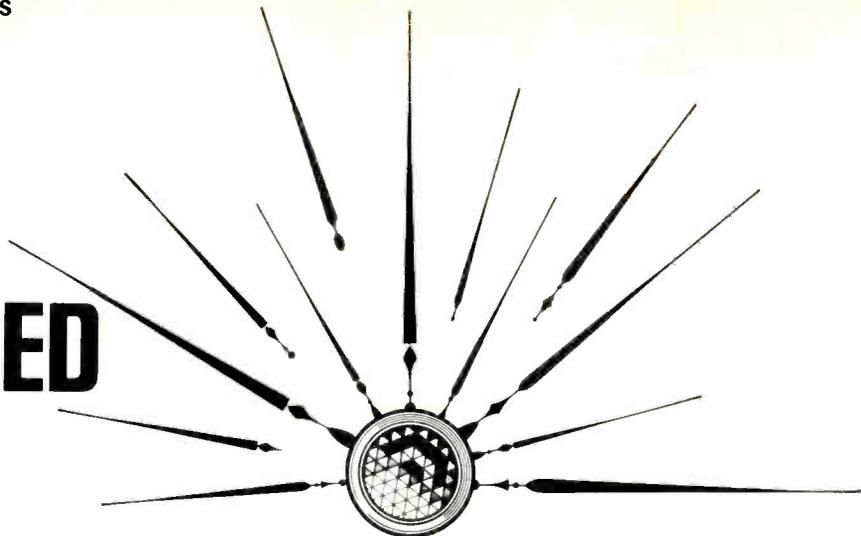
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# RUGGED AUTO

# EMERGENCY FLASHER

NEITHER RAIN, NOR DUST,  
NOR BUMPS WILL STAY ITS ACTION



**A**LTERNATELY flashing blue lights used on emergency vehicles (and increasingly on campers, trailers, etc.) are either mechanically or electronically driven and they operate fine as long as the going is smooth and they are not subjected to extremes of temperature and humidity. But the vehicles that use such lights are just those that are required to travel occasionally where adverse environmental conditions are encountered.

Little can be done to improve the reliability of mechanical flashers due to their sensitivity to vibration but electronic units can be made to be quite dependable. This is achieved through good circuit design, careful selection of components, and rigorous assembly techniques.

The improved electronic flasher whose circuit is shown on the next page was designed to eliminate thermal problems—primarily by separating the timing function (Q1 and Q2 multivibrator circuit) from the lamp switching function (Q3 and Q4).

Silicon transistors are used for Q1 and

Q2 in the symmetrical multivibrator circuit. Transistors Q3 and Q4, the lamp drivers, are germanium power types, biased well into cut-off to prevent continuous conduction at high temperatures. Further protection against thermal damage is obtained by mounting Q3 and Q4 on the project case and using small slip-on heat radiators on Q1 and Q2.

No “revolutionary new” design principles are employed in the improved flasher. Simple reliability and ruggedness under difficult conditions were the only really important requirements looked for in the design stages. Fortunately, it was found that the simple no-nonsense multivibrator/power switching system more than adequately filled the bill if certain common-sense assembly techniques were applied.

When selecting components for the improved auto flasher, get the best. For example, use only metal-cased transistors for Q1-Q4. Substituting plastic-encapsulated “equivalent” transistors will likely cause erratic operation under changing

humidity environments. Also, use silicone paste when mounting Q3 and Q4 to the project case and when slipping onto Q1 and Q2 Thermalloy No. 2230C-5 heat radiators.

The flash rate of the system is determined by the time constant of the C1/R3 and C2/R4 combinations. The flash rate is determined by the formula:  $F = 1 / (1.4RC)$ , where R is R3 or R4 and C is C1 or C2; R is in megohms, C is in microfarads, and F is in hertz. For the values given, the flash rate will be about once every second. Slower and faster flash rates can be obtained by increasing or decreasing the values of R3 and R4, or by decreasing or increasing the values of C1 and C2. The flash rate, however, should not exceed five times/second. Remember, if you change either R or C in one side of the circuit, the same change must also be made in the other side to obtain symmetry.

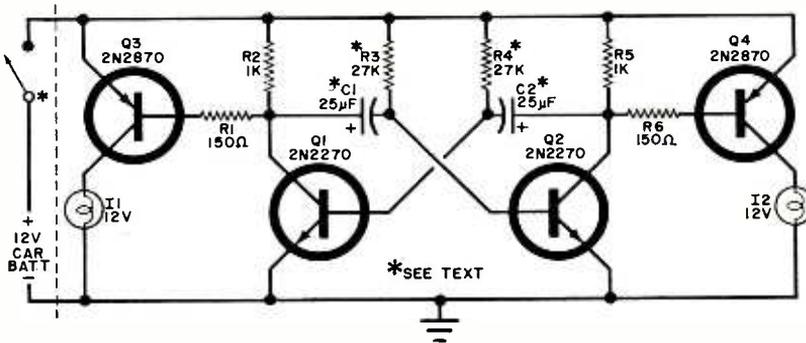
The capacitors used in the prototype for C1 and C2 are Sprague Atom Type TVA 1205. These capacitors demonstrate somewhat more resistance to temperature extremes than the manufacturer

guarantees. Their effective temperature range is from about  $-50^{\circ}$  F to about  $200^{\circ}$  F. Low temperatures do not harm the capacitors; when the capacitors warm up again, they operate within specifications. However, temperatures exceeding  $200^{\circ}$  F will usually cause these capacitors to exhibit permanent high leakage, requiring their immediate replacement.

Another item you should take care in selecting is the circuit board. Phenolic boards just do not stand up to vibration stresses and environmental conditions as well as do epoxy-glass boards. The epoxy glass board you select should be of the heavy-duty variety with solder connectors to match.

Now, you can begin assembling the flasher system. Use an aluminum case to house the components after painting all outer surfaces of the case a flat black to improve heat radiation. Mount Q3 and Q4 to one wall of the case with mica insulators and appropriate hardware. The best lockwashers to use here and wherever mounting is to take place are stainless steel. They bite better, assuring a more vibration-resistant anchor.

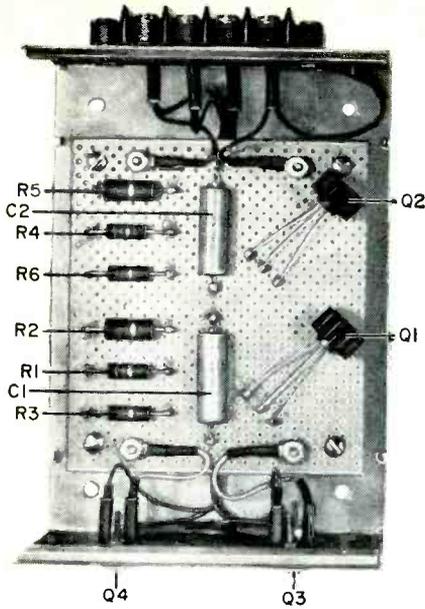
Transistors Q1 and Q2 in multivibrator circuit are silicon types, while Q3 and Q4 lamp drivers are germanium power types. The flash rate of the system is determined by the RC time constants of the R3/C1 and R4/C2 combinations.



### PARTS LIST

- C1,C2—25- $\mu$ F, 25-volt electrolytic capacitor (Sprague Atom Type TVA 1205—see text)
- I1,I2—12-volt lamp (see text)
- Q1,Q2—2N2270 silicon transistor
- Q3,Q4—2N2870 germanium power transistor
- R1,R6—150-ohm, 1-watt resistor
- R2,R5—1000-ohm, 2-watt resistor
- R3,R4—27,000-ohm, 1-watt resistor (see text)

Misc.—7"  $\times$  5"  $\times$  3" aluminum utility box; epoxy-glass circuit board with push-in solder terminals; 4-lug barrier block Cinch-Jones No. 4-142-Y; Teflon tubing; heat radiators for Q1 and Q2 (Thermalloy No. 2230C-5); mica insulators for Q3 and Q4; machine hardware with stainless steel lockwashers; flat black paint; potting compound (optional—see text); hookup wire; spacers; brass strip; solder; etc.



Use perforated G-10 epoxy-glass board and heavy-duty push-in connectors to assure rugged assembly. Heat radiators on Q1 and Q2 bolt down to board.

On the opposite end of the case, mount the barrier block. Make the clearance holes for the solder terminals to the barrier block a bit oversize to permit plastic sleeving to be slipped over the

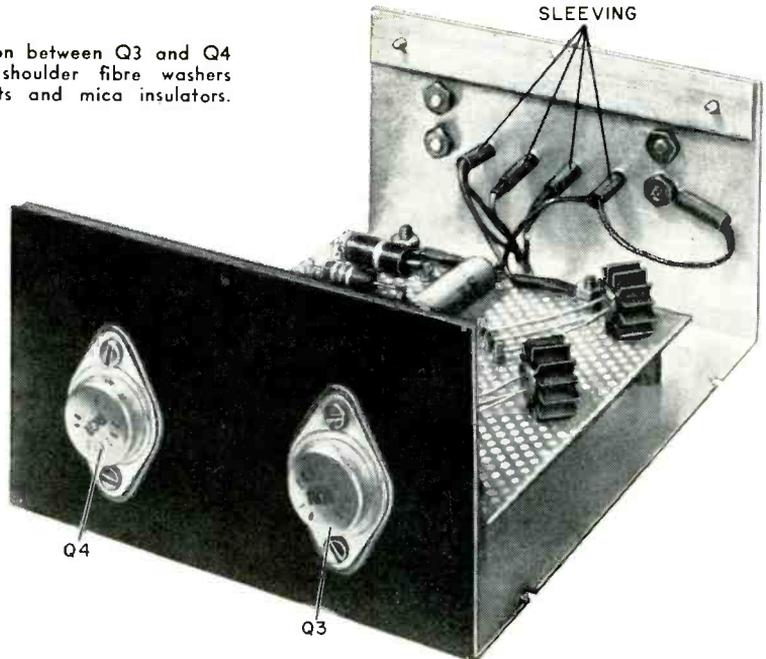
lugs after hookup wires are soldered to the lugs.

Referring to circuit diagram, wire components on the circuit board, making all interconnections with hookup wire from the bottom side of the board. To insure good vibration resistance, pinch shut the push-in terminals after the component leads are inserted and before soldering. Likewise, firmly wrap around the terminals all wire leads on the underside of the board before soldering. With these steps taken, even if the solder eventually crystallizes under vibration, the occurrence of connection failure will be greatly minimized. Before mounting the circuit board to the floor of the chassis, you can add additional protection against the elements and make the assembly even more rugged by dipping it in or coating it with a semi-solid plastic or silicone-rubber compound to seal it. However, if you take this step, make certain that the compound used does not require heat curing and is an electrical insulator.

Once the circuit board is mounted in place, connect and solder the wires coming from it to the appropriate points on the terminal block and switching transistors.

The aluminum case is not designed to withstand heavy vibration. To overcome

To provide insulation between Q3 and Q4 and chassis, use shoulder fibre washers or transistor sockets and mica insulators.



this deficiency, it is a good idea to back up the upper lip of the chassis channel with strips of hard brass or bronze bar stock that has been drilled and tapped to accept the cover screws. Two lengths of  $\frac{5}{8}$ "  $\times$   $\frac{3}{32}$ " stock will do nicely. An alternative approach would be to fasten the case together with pop rivets at 2" intervals and place electrician's rubber tape between the metal surfaces to be joined to provide an almost air-, water-, and dust-tight assembly.

**The lights** to be operated by the improved auto flasher are standard blue truck clearance lights (DoRay No. 1130) designed to use GE No. 67 1J lamps which draw about 0.6 ampere at 12 volts. If you wish, you can substitute GE No. 1156 lamps which are about three times as bright and draw about 1.7 amperes. Even brighter lamps can be used—for up to 5 amperes of current drain—if you wish in this circuit. But you had better check the traffic laws in your locality before installing the brighter lamps. In general, clearance and identification lights exceeding 25 watts tend to be distracting to oncoming drivers.

The more rugged a switch that is used the better will be the reliability of the flasher system. For this reason, it is suggested that you invest in a "Mil Spec" or heavy-duty industrial switch. If you go the route of selecting an automobile switch, the reliability of the system will be compromised. The auto switches are designed to withstand the relatively minor vibrational stresses of paved-surface roadways—just barely.

Finally, if a pilot lamp is desired to tell you when the system is being operated, you can connect a 33-ohm, 2-watt resistor in series with a #44 lamp and connect the assembly directly between the negative and positive buses on the barrier block.

**Preventive maintenance** with the flasher consists of routine checks before and after each use, a routine check every 2000 miles, and blowing out the dust each time the mud is dumped out of the air filter and the oil is replaced. The capacitors, which reputedly have a service life of two years, gradually lose capacitance and increase their leakage with age. The result is an increase in flashing rate which signals the need for replacement. Actual service life of modern electrolytic capacitors considerably exceeds ten years in some cases.

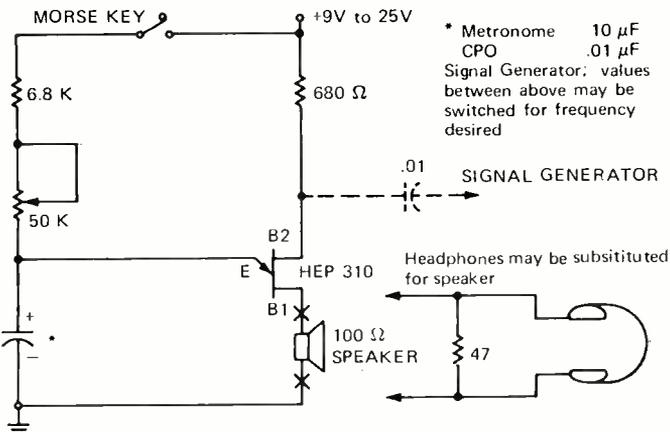
This flasher should be more than rugged enough for most needs—unless you continually travel over rock-strewn, rutted terrain that would tax even a mountain goat. The prototype flasher has withstood the rigors of summer off-road driving in the Mojave Desert; in the sand dunes along the Gulf of California; and many miles of winter off-road driving in the mountains of Arizona and New Mexico.

Designed originally for use in search and rescue vehicles, the improved flasher is equally at home in campers, Jeeps and Rovers, boats, etc.—anywhere where the going gets rough and vibration and the elements can spell the end of the conventional flasher system. ♦

## METRONOME-CODE PRACTICE OSCILLATOR - GENERATOR

### PARTS LIST:

- 1 HEP 310
- 1 Resistor, 6.8K, 1/2 Watt
- 1 Resistor, 680 ohms, 1/2 Watt
- 1 Potentiometer, 50K
- 1 Capacitor, 10 mfd or 0.01 as needed for desired circuit
- 1 Speaker, 100 ohm or Headphones with 47 ohm Resistor
- 1 Battery as Desired



# UNIQUE STEREO DECODER

A BRAND-NEW IC AND A HANDFUL OF PARTS,  
MAKE A FIRST-CLASS MULTIPLEX DECODER

BY SEYMOUR REICH  
RCA Linear Applications

**N**OW IS THE TIME to update your FM receiver to include multiplex stereo—or to improve your present stereo FM receiver with the latest circuit advances. Why now? Because there is a new integrated circuit component which needs only 12 other low-cost standard components (13 if you want an indicator light) to make up a complete stereo decoder. The decoder circuit using the new RCA SK3078 IC, can be made operational without any instrumentation and requires only one adjustment that can be adequately set by an off-the-air signal.

The decoder circuit, shown in Fig. 1, has a single tuned circuit made up of capacitor C2 and inductance coil L1 tuned to 76 kHz. A built-in phase locked loop places minimum reliance on the accuracy of the initial adjustment of the oscillator, obviating the need for elaborate alignment procedures. Characteristics of the decoder circuit include:

- Automatic switching from mono to stereo.
- Automatic energizing of the indicator light when stereo is present.
- Operation over a range of power supply voltages from 10 to 16 volts.
- Internally regulated power supply with current drain (typically 22 mA) virtually independent of supply voltage.
- Typical output (with 200 mV input) of 400 mV across 10,000-ohm load—sufficient to drive most output stages.
- System gain of 6 dB.
- Nominal 40-dB channel separation

without necessity for decoder balance adjustment.

- Small size—IC is in a 16-lead quad in-line plastic package.

**Theory of Circuit Design.** The functions performed in the SK3078 IC are shown in the block diagram in Fig. 2. The composite signal is applied to pin 1 of the low distortion preamplifier. The amplified composite signal is then applied to the 19-kHz detectors, the 38-kHz L-R detector and the matrix circuits. The L-R detector and the lamp driver amplifier are normally off unless energized by the Schmitt trigger.

A local VCO (voltage controlled oscillator) is adjusted, by means of an external coil, for free running at 76 kHz and this signal is fed to a divide-by-two counter. The 38-kHz output from this stage is fed to the L-R detector and to the divide-by-two counters that provide 19 kHz. (Two of the latter counters are required because the phase relationships of the reference signals required by the two detectors must be different. The reference for the phase lock detector must differ from the pilot by 90°, while the reference for the pilot presence detector must be in phase with the pilot.)

The 19-kHz pilot carrier, contained in the composite signal from the preamplifier is compared to the locally generated 19-kHz signal in the phase lock detector. A phase difference results in a dc output voltage that is impressed on a re-

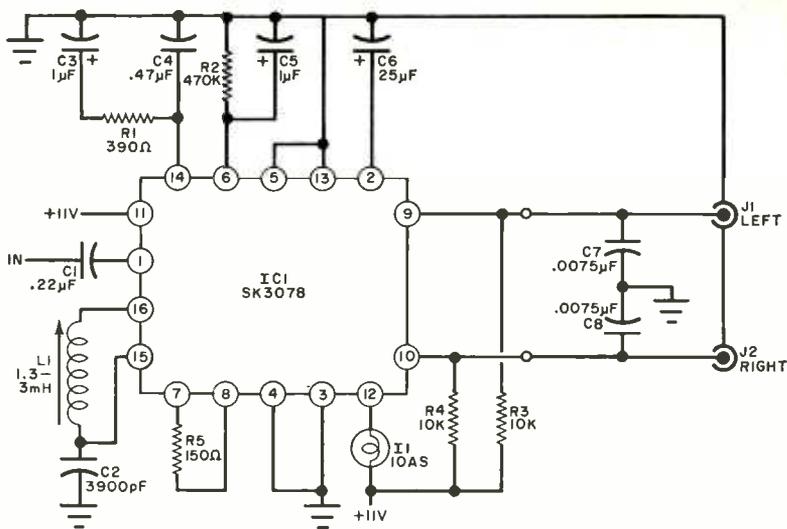


Fig. 1. The high-quality, yet very simple multiplex adaptor can be aligned from an off-the-air signal, and includes a stereo-on lamp.

#### PARTS LIST

- C1—0.22- $\mu$ F Mylar disc capacitor  
 C2—3900-pF silver mica capacitor  
 C3,C5—1- $\mu$ F, 12-volt Mylar or tantalum capacitor  
 C4—0.47- $\mu$ F, 25-volt Mylar capacitor  
 C6—25- $\mu$ F, 25-volt electrolytic capacitor  
 C7,C8—0.0075- $\mu$ F disc capacitor  
 I1—10-volt, 10-mA pilot lamp (Sylvania 10AS or similar, see text)

- IC1—SK3078 integrated circuit (RCA)  
 J1,J2—Phono connector  
 L1—1.3-3-mH adjustable inductor (Miller 9059-1 or similar)  
 R1—390-ohm,  $\frac{1}{4}$ -watt resistor  
 R2—470,000-ohm,  $\frac{1}{4}$ -watt resistor  
 R3,R4—10,000-ohm,  $\frac{1}{4}$ -watt resistor  
 R5—150-ohm,  $\frac{1}{4}$ -watt resistor  
 Misc.—Printed circuit board, wire, solder, etc.

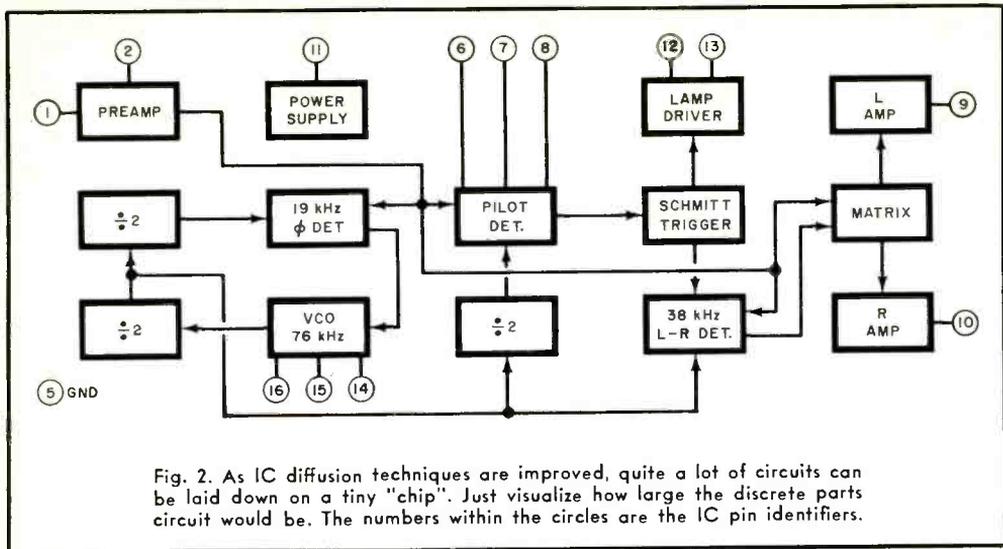
actance control network within the 76-kHz VCO that corrects the discrepancy. Similarly, a dc output from the pilot presence detector activates the Schmitt trigger, enabling the L-R detector and energizing the lamp driver.

The matrix circuit mixes the L+R (monophonic) information with the L-R (demodulated 38-kHz signals) to provide the left and right outputs. The matrix circuit passes only mono in the absence of the 19-kHz pilot carrier (no output from the 38-kHz L-R detector). Hence the system automatically switches between stereo and mono. The difference in output level when switching takes place is about 0.1 dB, and the circuit eliminates the annoying "thumping" frequently detected in stereo systems during the automatic stereo-mono switchover.

**Construction.** The decoder prototype

was built on a PC board using the foil pattern and component layout shown in Fig. 3. Note that the 75-microsecond de-emphasis network, comprising capacitors C7 and C8, is not mounted on the PC board. The PC board is not an absolute necessity; discrete wiring to the integrated circuit is entirely feasible.

When assembly is complete, the only adjustment required is to set L1 so that the free-running frequency of the VCO is close to 76 kHz. With the pilot present, the phase-lock detector captures the VCO and locks it in on frequency if the free-running frequency is within 6 kHz of 76 kHz. Of course, capture performance is optimal when the VCO is properly adjusted to begin with. This can be done easily by connecting a frequency measuring instrument to pin 15 through an isolation resistor of greater than 47,000 ohms and adjusting L1 to get 76 kHz. If

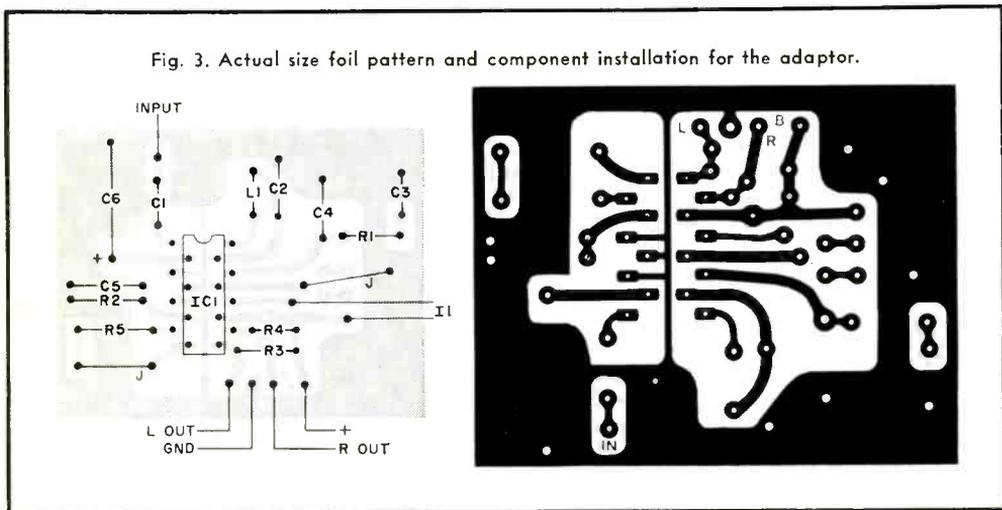


you don't have the proper instrumentation for this, you can use one of the two following procedures:

An accurate alignment can be achieved by using a signal generator and an oscilloscope having an input impedance over 1 megohm. The output of the 76-kHz oscillator is then compared with that of the signal generator by connecting pin 15 through a 47,000-ohm isolation resistor to the vertical input of the scope and the signal generator to the horizontal input. Set the signal generator to the lowest obtainable multiple of 76 kHz (76, 152, or 228), and adjust *L1* to obtain the appropriate Lissajou pattern on the scope. (Since the two fre-

quencies are not synchronized some drift in the pattern can be expected.) Greater accuracy can be obtained by calibrating the signal generator with the 19-kHz pilot and then touching up the VCO using the calibrated generator. This is done by driving the decoder from an on-air stereo signal with oscilloscope and signal generator connected as described before. If the pilot light comes on, the VCO is phase locked to 76 kHz. Now adjust the signal generator to get the proper Lissajou pattern on the scope. This means the signal generator is calibrated for 76 kHz and the free-running VCO can be adjusted with the on-air signal removed.

The second method of adjusting the



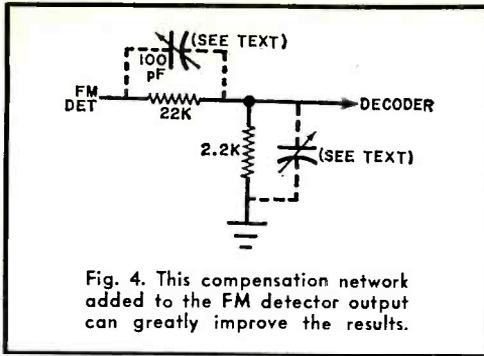


Fig. 4. This compensation network added to the FM detector output can greatly improve the results.

VCO uses only the on-air signal. If the stereo indicator light is on, rotate *L1* counterclockwise until the light goes off. Then rotate *L1* clockwise and note the exact position where the pilot light comes on. Continue to advance the slug in *L1* clockwise until the light again goes off. Record the total number of turns of the *L1* slug from light on to light off. Rotate the *L1* slug counterclockwise and count the number of turns before the light goes on. Subtract this number from the number for clockwise adjustment. Divide this difference by two to determine the slug position required for centering *L1* in the VCO pull-in range. Continue to advance the slug counterclockwise to reach the desired position.

**Additional Factors.** The typical 40-dB stereo channel separation that can be provided by the IC used in this decoder may be adversely affected by improper bandpass characteristics in the FM tuner detector. Most FM detectors have a 1-dB rolloff at 38 kHz and this is the design criterion for the decoder IC. If the decoder is to be used with an FM detec-

tor having different characteristics, the compensation network shown in Fig. 4 should be used.

If the characteristic curve is flat to above 38 kHz, then the trimmer capacitor should be connected across the 2200-ohm resistor; if there is a rapid falloff at 38 kHz, then the trimmer should be connected across the 22,000-ohm resistor. In either case, the trimmer capacitor is adjusted until the detector output curve shows about 1 dB drop at 38 kHz. Though it is not an absolute necessity, the compensation network should be used when circumstances warrant.

The stereo outputs are intended to drive audio amplifiers that incorporate the required 75-microsecond de-emphasis networks. If your amplifier(s) is not so equipped, add *C7* and *C8* as shown in Fig. 1. Failure to use a de-emphasis network will create excessive high-frequency levels.

The circuit shown in Fig. 1 requires a composite input signal of 150 to 200 mV. If it is desired to widen the dynamic range, remove resistor *R5* and substitute a series tuned LC network consisting of a 4.7-mH coil and a 0.015- $\mu$ F capacitor. This change permits the input signal to range from 30 to 400 mV.

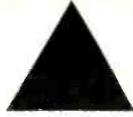
If it is desired to add a "high-power" pilot light to act as a stereo signal detector, connect pin 12 directly to the positive side of the supply, disconnect pin 13 from ground and connect it to the base of an npn transistor (such as 2N32-41). Ground the emitter of this transistor and hook a 10-volt, 50-to-150-mA pilot lamp between the collector and the positive side of the power supply. Provision for this change is included in the board in Fig. 3. ♦

### A PROFESSIONAL TOUCH FOR SWITCH-POSITION MARKINGS

The more professional looking your project, the more eye appeal it has. Even a really well-built project can look second rate if the front panel's switch position markings are irregular in size, shape, or location. However, you can convert a potentially difficult task to an easy job with the aid of a drill and some escutcheon pins, the latter available from most hardware stores. First mount the switch on the panel, being careful to properly orient it. Place a pointer or index knob on

the shaft; then rotate the knob to each position, marking each location with a scribe or pencil. Locate each mark  $\frac{1}{8}$ "- $\frac{3}{16}$ " from the index or pointer to achieve a regular arc or circle. Remove the switch and carefully drill a hole at each location. The holes should be just small enough to provide a driving fit for the pins. Cut the pins to the panel thickness length, and carefully drive them into the holes with light taps of a hammer.

—Gerald Larocque, WA1FRV



**BUILD A**

**MINI-**

**PYRAMIDAL**

**UHF TV ANTENNA**



GET SHARP, GHOST-FREE RECEPTION LOCALLY,  
IN FRINGE AREAS, AND EVERYWHERE IN BETWEEN

BY GEORGE J. MONSER

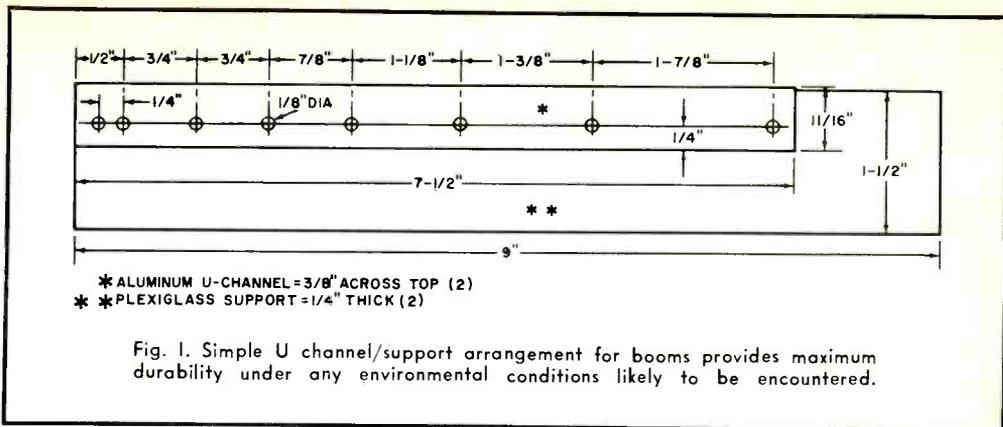
**T**HE LOWLY UHF TV ANTENNA has been almost lost in the shuffle for bigger, better, and more complex VHF arrays. Yet, the UHF antenna is somewhat of a phenomenon. Roughly one-tenth the size of its VHF counterpart, the UHF antenna is a great deal easier to install and use. The question is: How well does the properly designed UHF antenna operate?

To find the answer, a VHF log periodic antenna of known operating ability was trimmed down for operation in the UHF band. Since the new antenna retained the "pyramidal" shape, it was dubbed the "Mini-Pyramidal UHF TV Antenna." Performance-wise, it excels.

In initial tests, the Mini-Pyramidal an-

tenna pulled in two UHF channels from San Diego, a distance of about 185 miles from where it was set up in Santa Barbara. On less distant and local stations, reception was clear and sharp. There can be little doubt that the 10-dB log Mini-Pyramidal antenna will cover the entire UHF TV band with nearly constant gain. The antenna is well matched to 300-ohm twin-lead cable and, therefore, will provide ghost-free reception if set up within about 190 miles of a UHF station.

**Construction.** Building the Mini-Pyramidal UHF TV antenna is a simple procedure, requiring the use of only a drill, a hacksaw, and a screwdriver. The raw



materials needed for the various parts that make up the antenna are available from any well-stocked hardware store.

The first step is to prepare the aluminum U-channel booms and Plexiglass supports. After cutting these parts to the dimensions specified in the Bill of Materials, refer to Fig. 1 and mark the locations for the holes that will be used to mount the elements and attach the down-lead to the booms. Slip one of the booms onto a support as shown. Then use a 1/8" drill to bore through the boom and support at each marked hole location. Repeat this procedure for the remaining boom and support.

Next, fabricate the antenna elements from 1/2" x 1/32" aluminum stripping (do not attempt to substitute narrower stripping or tubing for the elements since neither will provide the proper bandwidth for color reception), referring to Fig. 2 for fabrication details and a table of element lengths. Note that two elements of each length are required and that the lengths listed include the 1/2" of stripping used for the element mounting tabs. The actual element lengths will be 1/2" shorter than the dimensions given in the second column in the table.

Now, referring to Fig. 3, arrange the boom assemblies so that they form a 50° throat angle. Drill a pair of 1/8" holes at the throat. Then drill a 1/8" hole through each boom support at the ends opposite the throat. The first pair of holes will be used to anchor the booms at the proper throat angle, while the second pair of holes will be used for mounting the antenna to a mast. Use 6-32 x 3/4" machine screws and nuts to fasten to-

gether the boom supports at the throat.

Starting from the throat end of one of the booms, slip the mounting tab of one of the shortest elements between the boom and support (see Fig. 4). Align the tab hole with the second hole in the boom and use a 6-32 x 5/8" machine screw and the appropriate lockwasher and nut to anchor the pieces together. In the same manner, mount at the third hole location on the boom one of the second shortest elements on the opposite side of the boom. Working on alternate sides of the boom, mount one of each successive length element in place.

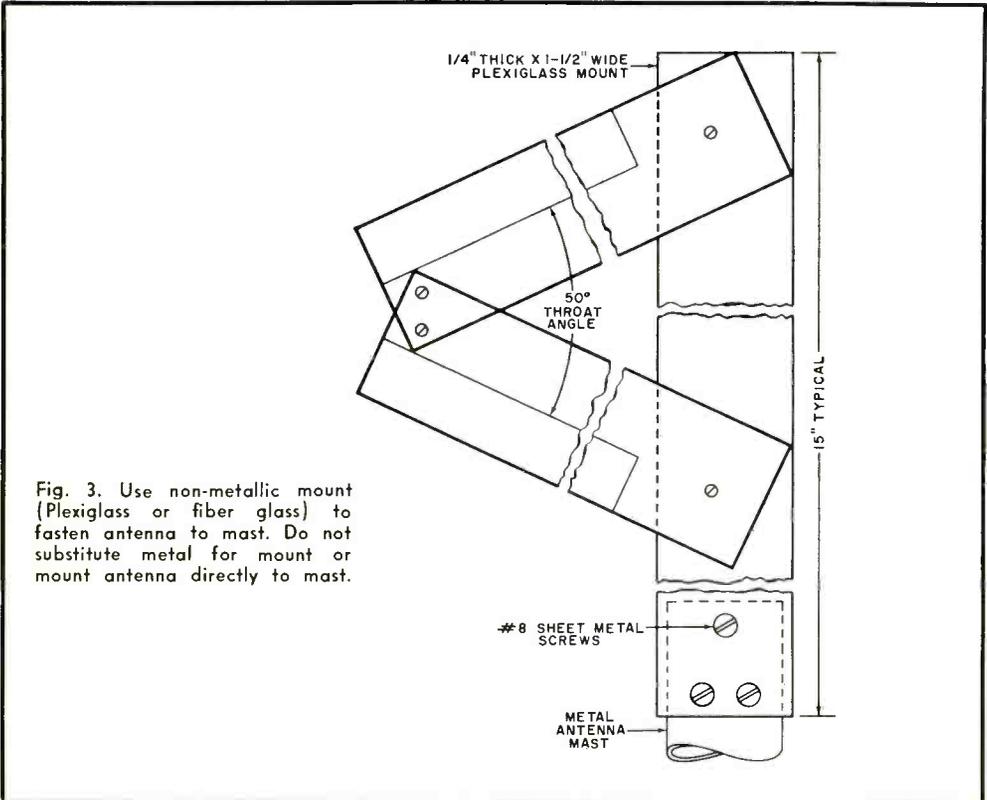
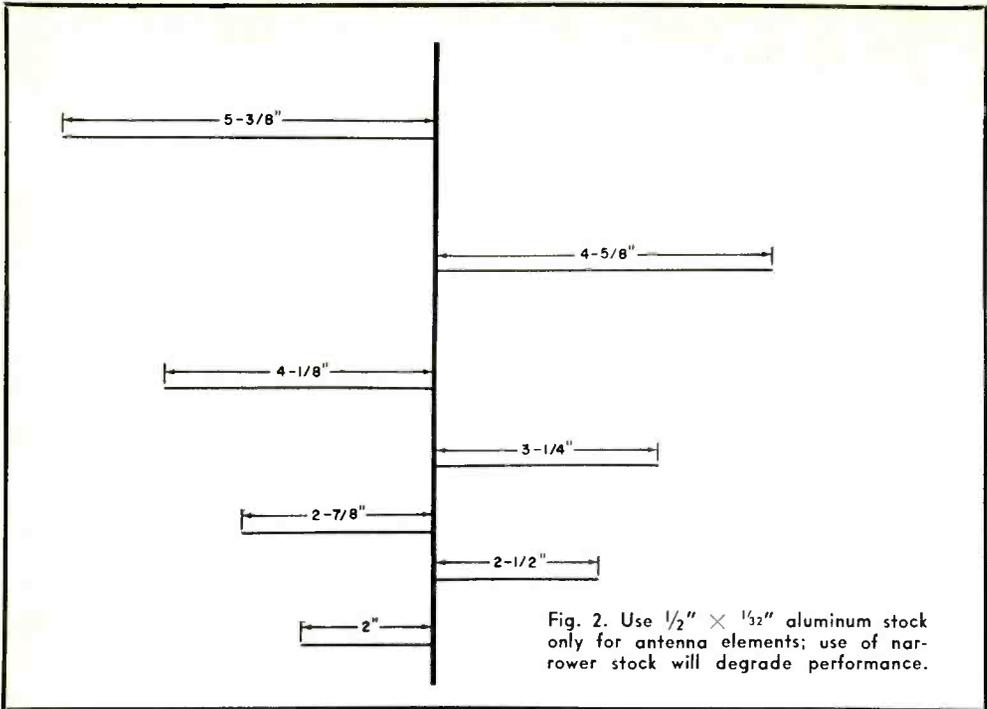
Again starting at the throat end of the antenna, mount the second set of elements as described above. However, when mounting these elements, they must be located on the opposite sides of the boom from those on the first boom. For example, if element No. 1 on the first boom projects to the left, element No. 1 on the second boom must project to the right.

#### ANTENNA ELEMENT LENGTHS

Element No.	Element length in inches*
1	2"
2	2 1/2"
3	2 7/8"
4	3 1/4"
5	4 1/8"
6	4 5/8"
7	5 3/8"

\*Overall dimension; actual element length is 1/2" shorter than dimensions given.

Note: two of each length are required



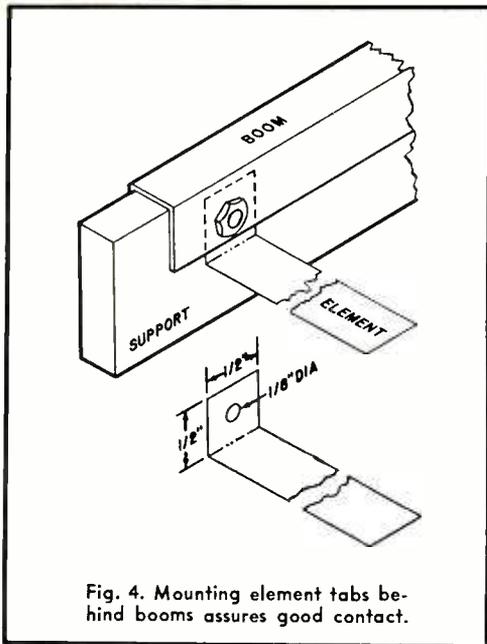


Fig. 4. Mounting element tabs behind booms assures good contact.

Pass a 6-32  $\times$   $\frac{3}{4}$ " machine screw through each of the unoccupied holes near the throat end of each boom. Place a lockwasher (preferably steel or bronze) on each screw and follow up with a 6-32 nut. Securely tighten each screw so that the lockwashers bite deeply into the metal booms without cracking the Plexiglass supports. Loosely screw on a pair of nuts. The antenna is now ready for installation and testing.

**Installation.** The Mini-Pyramidal UHF TV Antenna is designed for outdoor use. If you already have a VHF antenna mounted on a mast, the UHF antenna can be mounted above—NOT below—it with a simple Plexiglass mounting arrangement as shown in Fig. 3. Use #6  $\times$   $\frac{5}{8}$ " sheet metal screws to anchor the Plexiglass antenna mount to the metal antenna mast.

Once the antenna is mounted, attach 300-ohm twin-lead cable to it by wrapping the cable conductors around the screws at the throat and tightening down on the nuts. Connect the other end of the twin-lead to the UHF antenna terminals on your TV receiver. Turn on the receiver and tune across the UHF band while observing the TV screen. At various points across the band, depending

### BILL OF MATERIALS

- 2—10"  $\times$  1½" pieces of ¼" Plexiglass for boom supports
- 1—15"  $\times$  1½" piece of ¼" Plexiglass for antenna mount
- 1—60" length of ½"  $\times$  ½" aluminum molding strip for antenna elements
- 2—8½" lengths of ⅝"  $\times$  ¼" (inside dimensions) aluminum U-channel for booms
- Misc.—300-ohm twin-lead cable; 6-32 machine hardware (see text); #6  $\times$  ⅝" sheet metal screws for mounting antenna; etc.

on the number of stations within the range of the antenna, you should observe pictures pop in and out. Tune for the strongest station (sharpest picture and color and least distorted sound). If you have a rotor in your antenna system, try repositioning the Mini-Pyramidal antenna for improved reception.

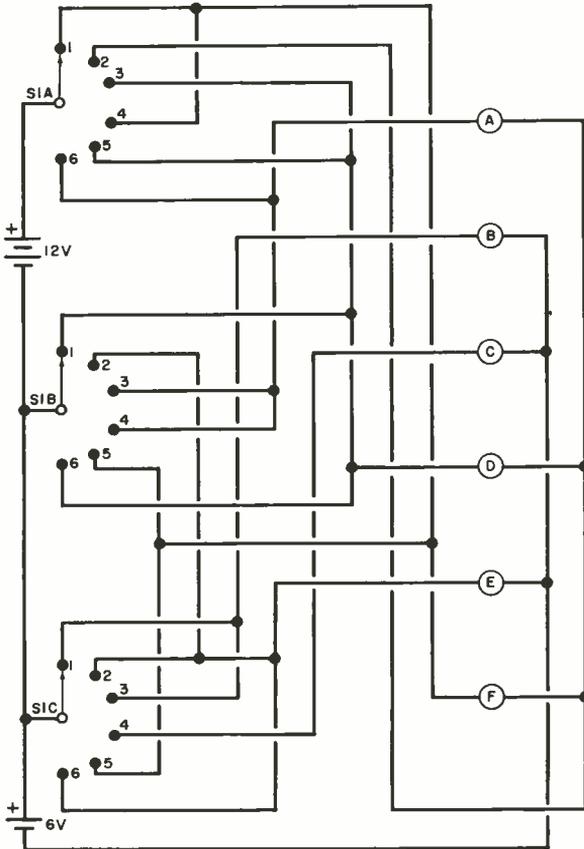
Now tune for a weaker, snowy station and reposition the antenna for the clearest reception. You will soon realize that there are more UHF TV stations within range of your antenna than can be picked up by conventional UHF antennas. The pictures will be sharper, the colors more vivid, and the sound clearer. ♦



"You're welcome, dear. I got a substantial raise, so why shouldn't I buy my wife something with it!"

# Ganged Switching Quiz

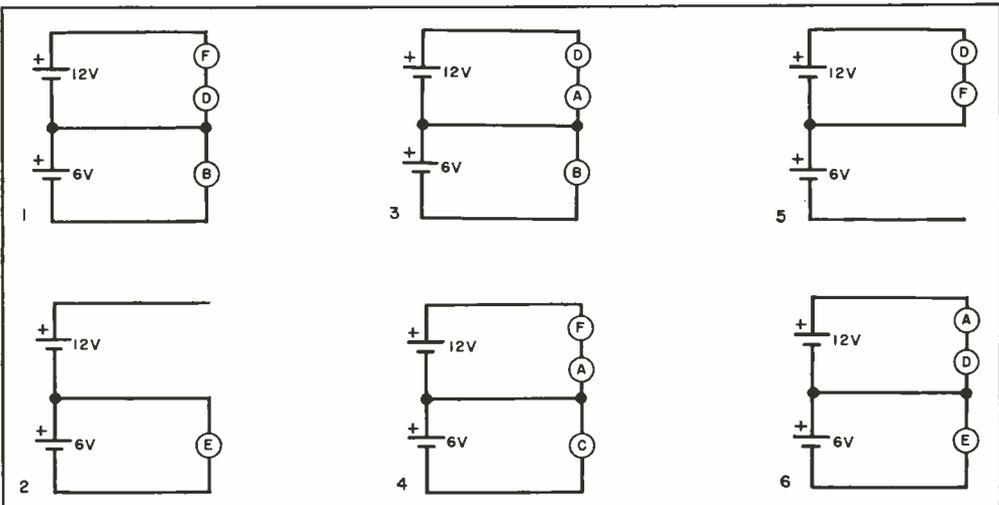
BY ROBERT P. BALIN



**E**LECTRONICS hobbyists, especially troubleshooters, can always use some practice in tracing out circuits that include ganged switches. Unless you are careful and systematic, it is easy to get confused, lose your way or overlook a component. Here's a chance to practice this important skill.

The schematic at left contains a 6-position, 3-pole switch, six 6-volt lamps and 6- and 12-volt batteries. As the switch is rotated, determine what combinations of lamps will light—each to full brightness. The answers are below so cover them up while you work out the circuit.

Note that although the switching function which this circuit performs can be done by a much simpler circuit (a single 6-volt battery can do the job) such a circuit would be too simple to be challenging and only unnecessary schematic zig-zagging could make it look more complicated. Since this quiz is intended to be a training problem, practical considerations have been ignored. ♦





# Build the Charge Now

RECHARGES ANY NICKEL-CADMIUM OR  
ALKALINE AA, C, OR D CELL

BY A. A. MANGIERI

**N**AME your battery charging problem! The "Charge Now" solves them all—with some added extras. With a Charge Now in your workshop or lab, you have all the advantages of an expensive commercial unit—at much less cost.

Here are some of the uses to which you can put the Charge Now. It provides dc currents in values from less than 1 mA to 1 A in ten ranges for recharging nickel-cadmium cells. It recharges any alkaline AA, C, or D cell in fourteen hours using voltage limited, tapered charging to automatically prevent overcharging. With a well-filtered dc output available at a pair of binding posts, the charger serves as a fully adjustable constant-current source for testing semiconductors and many other components and circuits. And with a zener diode across the output, a well-

regulated, low-voltage source is available for other testing. (For a handy dual-voltage op-amp supply source, connect two series-connected zener diodes across the output and a filter capacitor across each.)

**Construction.** The schematic of the battery charger is shown in Fig. 1. Wiring and layout are not critical. In the prototype shown in the photos, a piece of perf board  $3\frac{1}{2}'' \times 4''$  was used to support most of the components. Layout is shown in Fig. 2. Optional transistor sockets were used in the prototype. Note that the metal cases of *R27*, *R28*, and *R29* provide negative return to terminal ZZ.

Another piece of perf board  $2'' \times 2''$  was mounted directly on the meter terminals to hold all of the components directly associ-

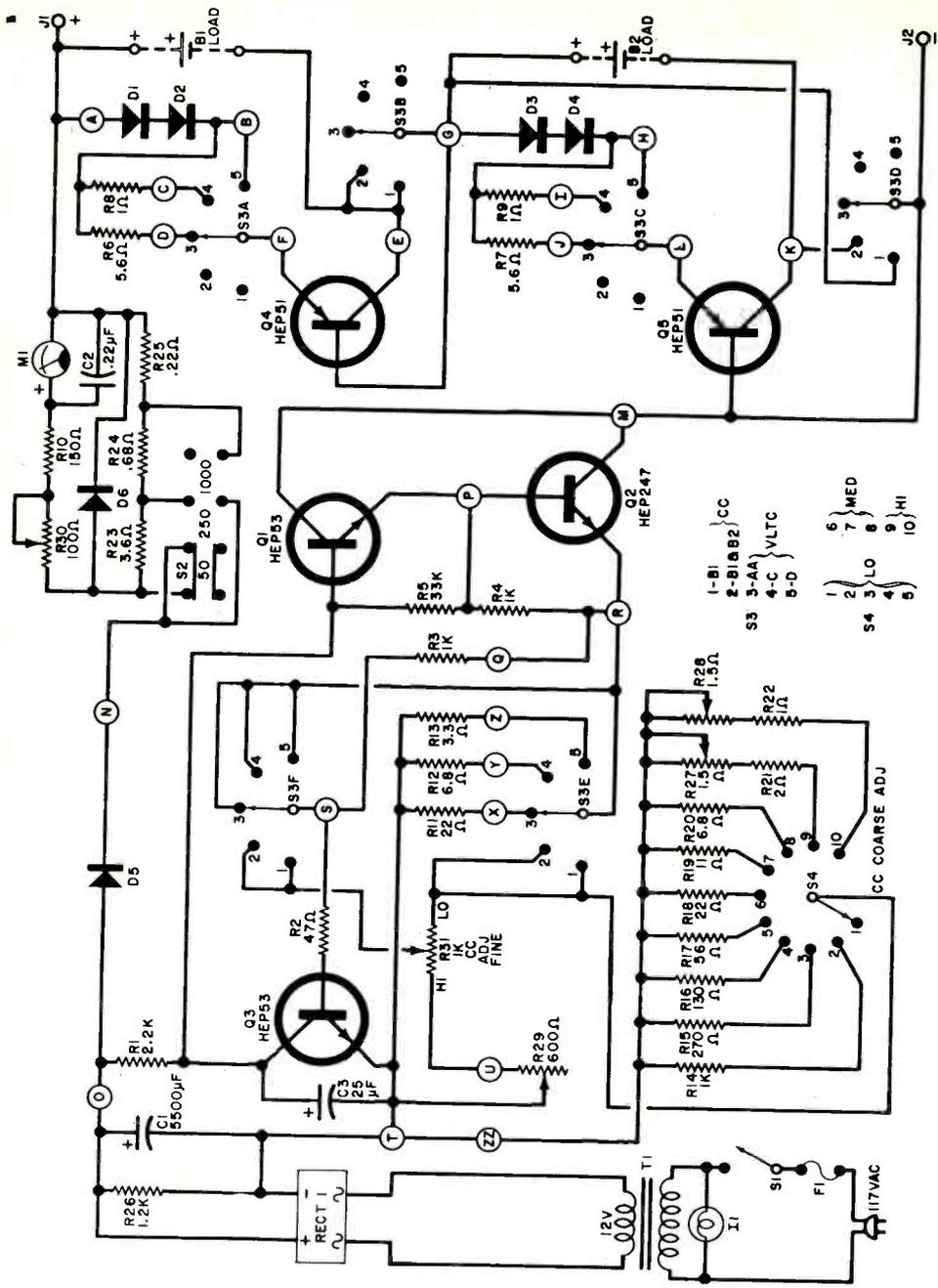


Fig. 1. The letters in circles are terminals on the main perf board. The position identifiers for S3 and S4 should be duplicated at these front-panel controls.

## PARTS LIST

- C1—5500- $\mu$ F, 25-volt electrolytic capacitor  
 C2—0.22- $\mu$ F disc capacitor  
 C3—25- $\mu$ F, 25-volt electrolytic capacitor  
 D1-D6—1-ampere, 50-PIV silicon diode  
 (HEP154 or similar)  
 F1—1-ampere fuse and holder  
 I1—117-volt ac neon lamp  
 J1,J2—Five-way binding post (one red,  
 one black)  
 M1—1-mA dc milliammeter  
 (Allied Electronics 701-0020 or similar)  
 Q1,Q3—Transistor (HEP53 or similar)  
 Q2—Transistor (HEP247 or similar)  
 Q4,Q5—Transistor (HEP51 or similar)  
 R1—2200-ohm  
 R2—47-ohm  
 R3,R4—1000-ohm  
 R5—33,000-ohm  
 R6,R7—5.6-ohm  
 R8,R9—1-ohm  
 R10—150-ohm  
 R11—22-ohm (see text)  
 R12—6.8-ohm (see text)  
 R13—3.3-ohm (see text)  
 R14—1000-ohm  
 R15—270-ohm  
 R16—130-ohm  
 R17—56-ohm  
 R18—22-ohm  
 R19—11-ohm, 2-watt resistor  
 R20—6.8-ohm, 2-watt resistor  
 R21—2-ohm, 5-watt resistor  
 R22—1-ohm, 5-watt resistor  
 R23—3.6-ohm, 2-watt 5% resistor  
 R24—0.68-ohm, 2-watt, 5% resistor  
 R25—0.22-ohm, 2-watt, 5% resistor  
 R26—1200-ohm, 1-watt resistor  
 R27,R28—1.5-ohm, 2-watt, wirewound  
 potentiometer (Centralab V-1.5 or similar)  
 R29—600-ohm, 2-watt wirewound  
 potentiometer (Centralab V-600 or similar)  
 R30—100-ohm, 2-watt wirewound  
 potentiometer (Centralab V-100 or similar)  
 R31—1000-ohm, wirewound potentiometer  
 (Centralab WW-102 or similar)  
 RECT1—1-ampere, 200-PIV rectifier  
 (HEP176 or similar)  
 S1—Spst slide or toggle switch  
 S2—Double-pole triple-throw slide switch  
 (Wirt G128L, Allied Electronics 760-0004,  
 or similar)  
 S3—6-pole, 6-position non-shorting rotary  
 switch (Centralab PA-2023, Allied Elec-  
 tronics 747-2023, or similar)  
 S4—One-pole, 10-position, non-shorting  
 rotary switch (Centralab PA-1001, Allied  
 Electronics 747-1001, or similar)  
 T1—12-volt, 2-ampere filament transformer  
 Misc.—Heat sink and mounting kit (Motorola  
 HEP500 or similar), plastic case with cover  
 for cell holder, 2" corner braces, perf  
 board, eye bolts, springs, capacitor mount-  
 ing bracket, lug strips, thin sheet brass or  
 stainless steel, line cord, mounting hard-  
 ware, copper sheet for RECT1 mounting,  
 $\frac{1}{2}$ " wood V blocks, vinyl tape, solder lugs,  
 etc.

All resistors  $\frac{1}{2}$ -watt

All resistors  
1-watt

ated with the meter circuit. Terminals on the board should be identified for making connections.

When assembling the power supply within the chassis, makes sure that filter capacitor C1 is completely insulated from the metal chassis by a plastic sleeve. The rectifier (RECT1) is mounted on four heat sinks, one attached to each leg, so that sufficient heat is conducted away during use with 1 ampere drain. The heat sinks were made of four copper L brackets mounted on perf board with the bottom of the L up. The leads of the rectifier were then soldered to their respective heat sinks. Also on this perf board was the fuse holder.

The large heat sink for Q2 can be mounted on the rear wall of the chassis using four insulated shoulder washers for support. It is then possible to omit the usual mica washer, but use silicone grease between the transistor and the heat sink. The transistor was fitted into a socket on the other side of the heat sink and a three-lug terminal strip was mounted on one of the heat sink nuts for connections to the transistor. Include some vent holes if the rear wall of the chassis is solid metal.

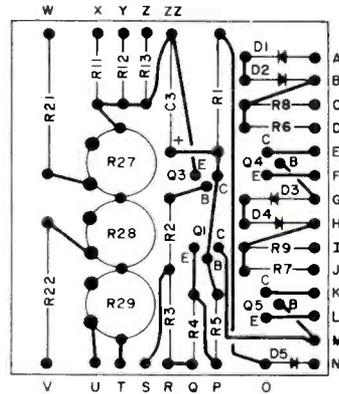


Fig. 2. Component installation on the perf board. The dark lines duplicate the insulated wire connections made between the various mounting clips

**Cell Holders.** Before building the chassis, determine what type of cell holders you prefer. Obviously, conventional holders for AA, C, and D cells may be used. In this case, simply mount the cell holders to an outboard wooden frame and connect them to the charger through short lengths of insulated wire. To duplicate the prototype, a special cell holder must be made as follows.

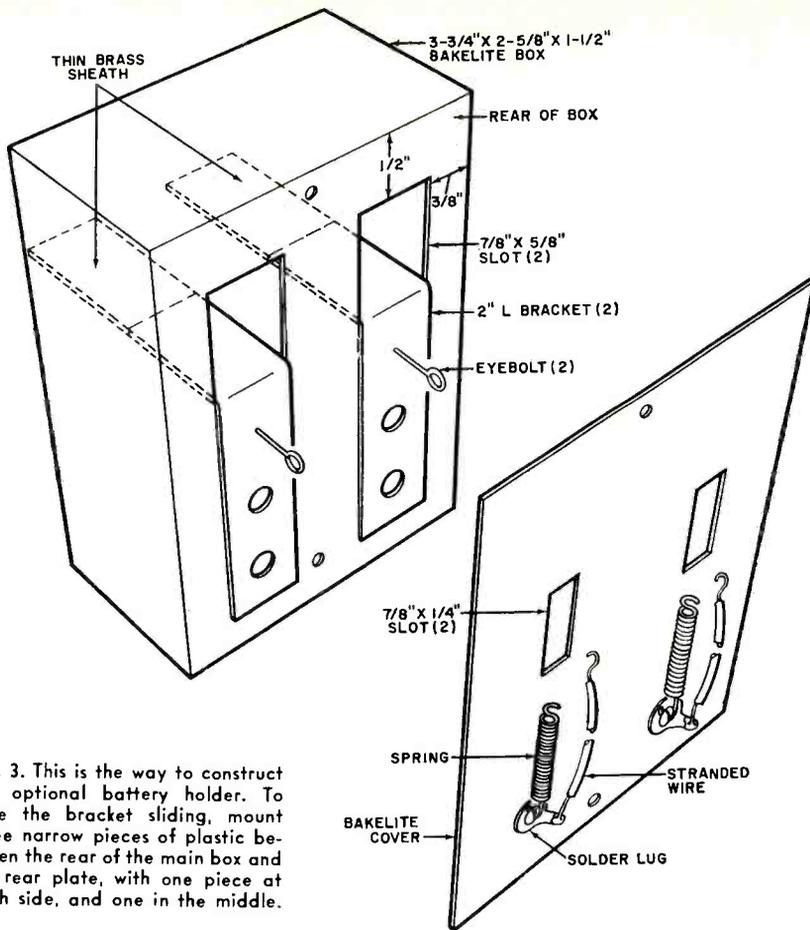


Fig. 3. This is the way to construct the optional battery holder. To ease the bracket sliding, mount three narrow pieces of plastic between the rear of the main box and the rear plate, with one piece at each side, and one in the middle.

Obtain a  $1\frac{1}{2}$ " deep  $\times$   $2\frac{5}{8}$ "  $\times$   $3\frac{3}{4}$ " plastic utility box with plastic cover. Cut two holes in the rear of the box as shown in Fig. 3.

Two-inch steel corner braces must be made and filed smooth; also make a thin brass or stainless steel cover for the arm that protrudes into the case. Make sure that both braces slide smoothly up and down in their slots. Swage a conventional solder eyebolt to the rear of each slide as shown. Cut two slots in the plastic cover so that the eyebolts can slide up and down to the maximum travel of the steel braces. Then secure a pair of solder lugs to the bottom of the cover directly under each slot. Use small spacers to attach the cover to the rear of the box so that, when assembled, the two braces can slide up and down unhindered. Mount a spring to each soldering lug and attach the other end to the

eyebolt. The electrical connection is made through a short length of insulated wire.

The interior of the case is fitted with wood V blocks faced with black vinyl tape. These blocks are cemented in place after test aligning a cell. Use double-sided tape to attach the blocks while aligning them. Then use cement or epoxy for final mounting.

With an AA cell in place on the V blocks and with the steel braces partially up in their slots (the rear spring providing tension), locate the lower minus contact button and use  $6-32 \times \frac{3}{4}$  hardware and a spacer to mount it. With a cell in place, the brace should automatically clamp the cell between the brace and lower minus contact.

Because of different cell diameters, two sets of minus contacts should be provided for each side of the cell holder. Electrical con-

nections to these contacts are made through a soldering lug at each minus contact. Identify the cell holders as B1 and B2 and identify the PLUS and MINUS sides of the holder.

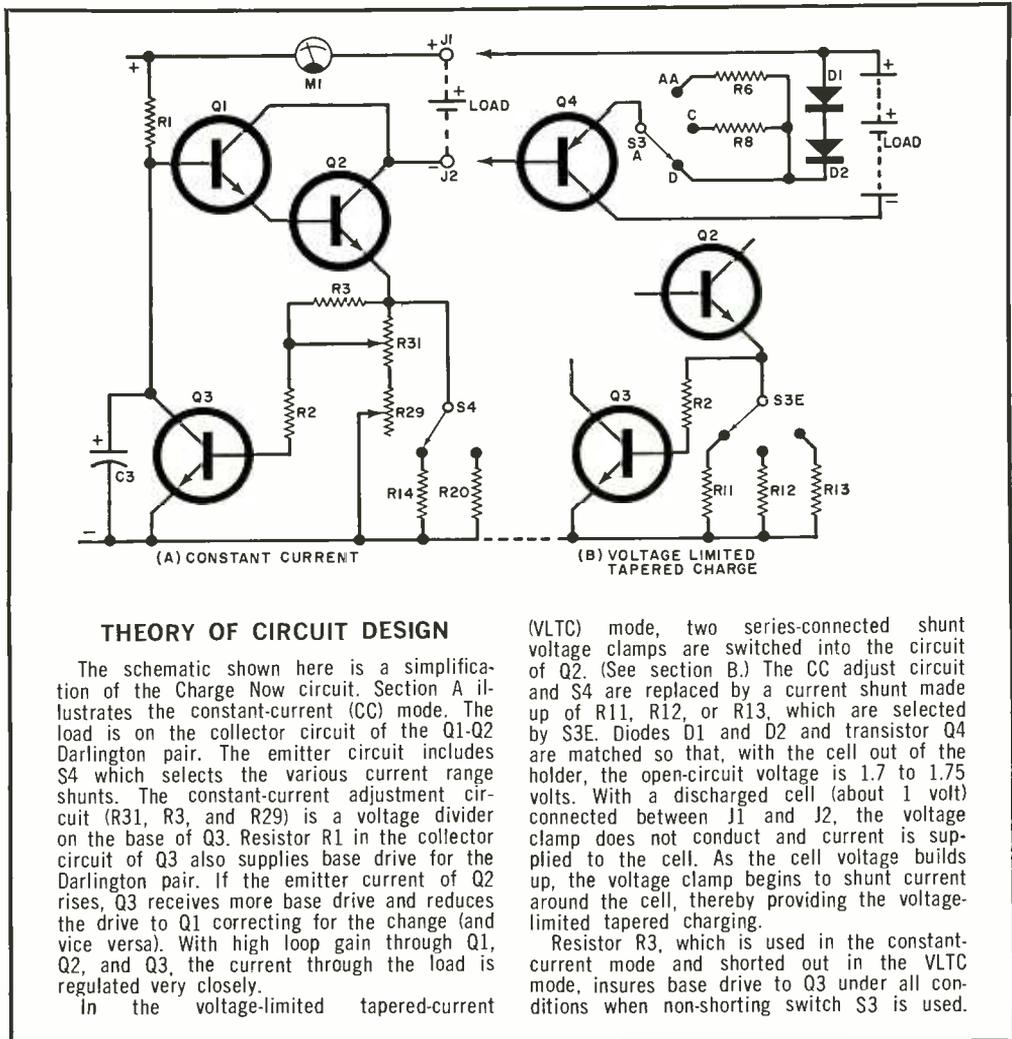
The face of meter *M1* must be retouched to add two more scales. The original 0-1 scale will be used for the 1000-mA range. Using some form of press type, add the numbers 50, 100, 150, 200, and 250 over the original indications for .2, .4, .6, .8, and 1.0 respectively. This is the 250-mA scale. Similarly, add 10, 20, 30, 40, and 50 for the 50-mA scale. When making these additions, take care not to damage the meter movement or the needle.

The front panel of the charger is shown in the photographs. Note the cutout for the plastic cell holder which is supported by four

mounting screws. Switch *S3* is marked for VLTC (voltage-limited tapered charge) on three positions and CC (constant current) on two positions. The CC positions are further identified by a line going to the *R31* (FINE) and *S4* (COARSE) controls. This aids in setting up the correct switches.

Note the placement of the other switches and controls on the panel and inside the chassis. Since lead length and placement are not critical, it is not necessary to duplicate the prototype exactly; but the arrangement has been found to be convenient.

**Adjustment.** Before making any adjustments, connect a 5-to-10-watt, 20-ohm resistor between the plus of the power supply and the remainder of the circuit to test the



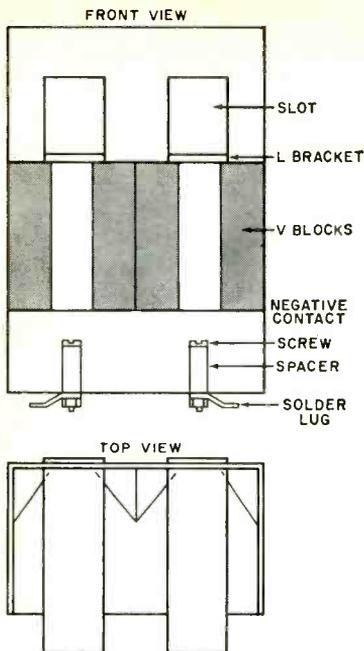
### THEORY OF CIRCUIT DESIGN

The schematic shown here is a simplification of the Charge Now circuit. Section A illustrates the constant-current (CC) mode. The load is on the collector circuit of the Q1-Q2 Darlington pair. The emitter circuit includes S4 which selects the various current range shunts. The constant-current adjustment circuit (R31, R3, and R29) is a voltage divider on the base of Q3. Resistor R1 in the collector circuit of Q3 also supplies base drive for the Darlington pair. If the emitter current of Q2 rises, Q3 receives more base drive and reduces the drive to Q1 correcting for the change (and vice versa). With high loop gain through Q1, Q2, and Q3, the current through the load is regulated very closely.

In the voltage-limited tapered-current

(VLTC) mode, two series-connected shunt voltage clamps are switched into the circuit of Q2. (See section B.) The CC adjust circuit and S4 are replaced by a current shunt made up of R11, R12, or R13, which are selected by S3E. Diodes D1 and D2 and transistor Q4 are matched so that, with the cell out of the holder, the open-circuit voltage is 1.7 to 1.75 volts. With a discharged cell (about 1 volt) connected between J1 and J2, the voltage clamp does not conduct and current is supplied to the cell. As the cell voltage builds up, the voltage clamp begins to shunt current around the cell, thereby providing the voltage-limited tapered charging.

Resistor R3, which is used in the constant-current mode and shorted out in the VLTC mode, insures base drive to Q3 under all conditions when non-shorting switch S3 is used.



The V-blocks are used to center the cells in the holder so that good contact is made between the two electrical connectors. After final positioning, cover the wood blocks with black plastic tape.

VLTC ranges and check the CC mode for positions 1 through 9 of *S4*. For position 10 of *S4*, use a 10-to-15 ohm resistor.

Set *R29* for a resistance of about 300 ohms

and *R27*, *R28*, and *R30* for maximum resistance. Place *S3* in the CC mode, *S4* in the first LO position, and *S2* on 1000.

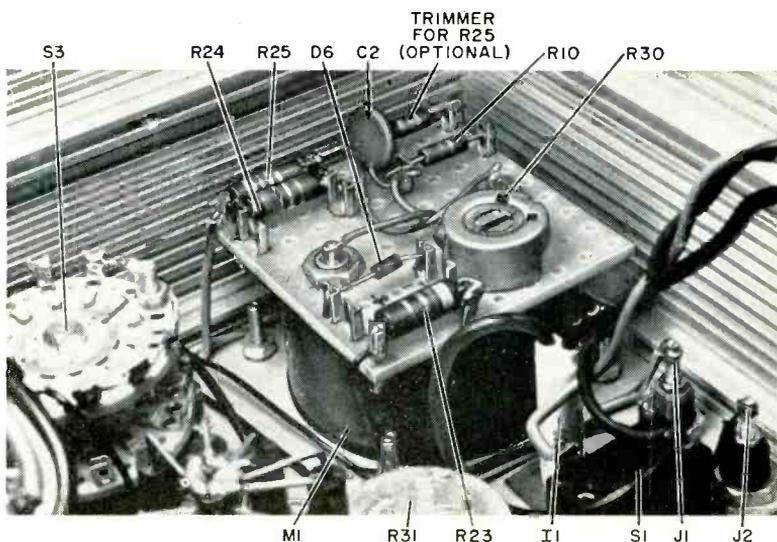
Connect a multi-range milliammeter between *J1* and *J2* and turn on the power. As *S4* is advanced from position 1 to position 9, observe an increasing output current from less than 1 mA to several hundred mA with variable control through *R31* in each position. Set the output current to 200 mA, place *S2* on 250 and adjust *R30* until the meter on the front panel indicates 200 mA.

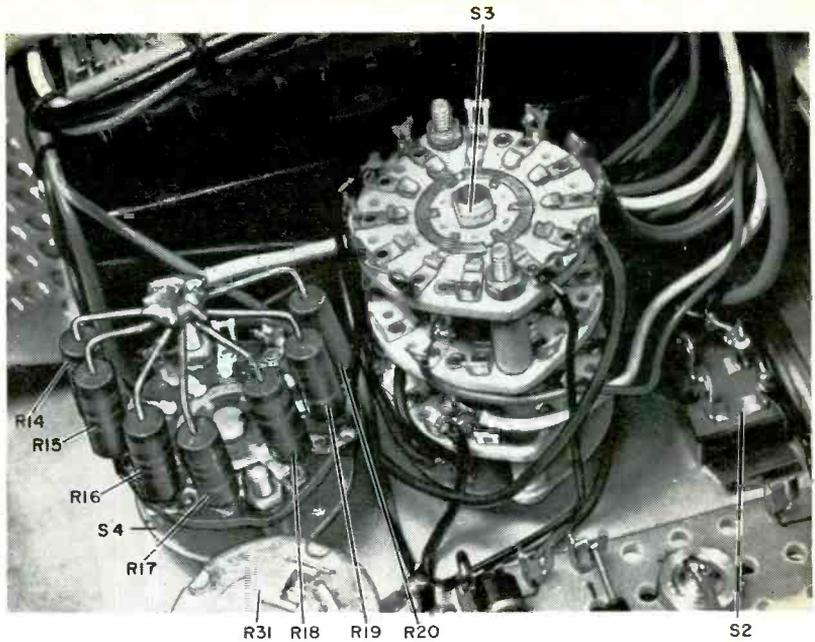
With *R31* set for low current, place *S4* on HI. Adjust *R28* until the meter indicates 400 mA. Shut down the power and replace the external 20-ohm resistor with a 10-ohm resistor. Turn on the power, and slowly advance *R31* and *R29* until the meter indicates one ampere with *R31* fully clockwise. Repeat these steps until *R31* controls the current from 400 to 1000 mA. Then set *S4* to position 9 and adjust *R27* until *R31* covers the range up to 500 mA. Check that all lower ranges have a slight overlap.

Check that the meter on the charger tracks the external milliammeter on the three major ranges of *S4*. Potentiometer *R30* is used to make any necessary scale adjustments. It may be advantageous to set *R30* so that the high range (1000 mA) is correct, and then trim the shunts of the lower ranges (*R23-R25*) for reasonably close meter indications.

In the VLTC mode, diodes are paired off

The various components that are associated with the meter circuit are mounted on a small piece of perf board, that in turn, is mounted on the meter terminals.





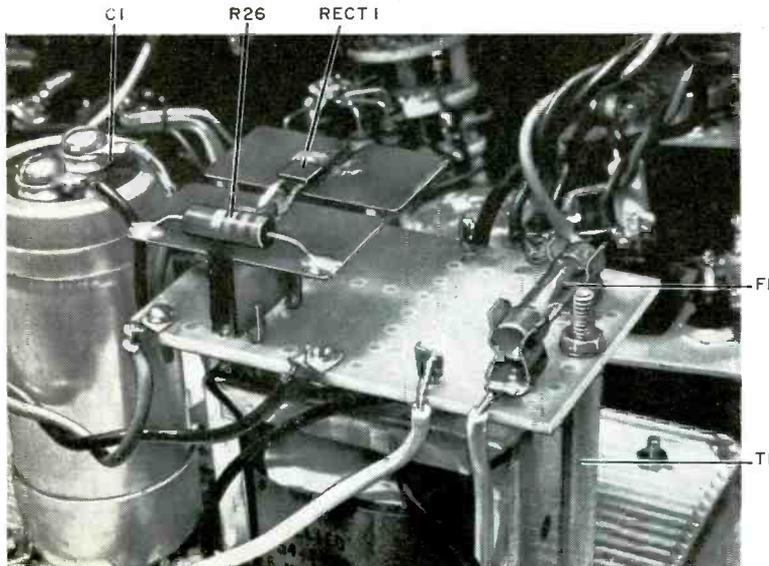
Arrangement of the resistors associated with S4 shows an easy method of mounting.

with *Q4* and *Q5* and resistors *R11* through *R13* are sized to set the charge rates indicated in the Table. Use a 20-ohm resistor in the plus lead of the power supply and remove the outboard meter from *J1* and *J2*. Allow a 5-to-10 minute warmup for the diodes and transistors.

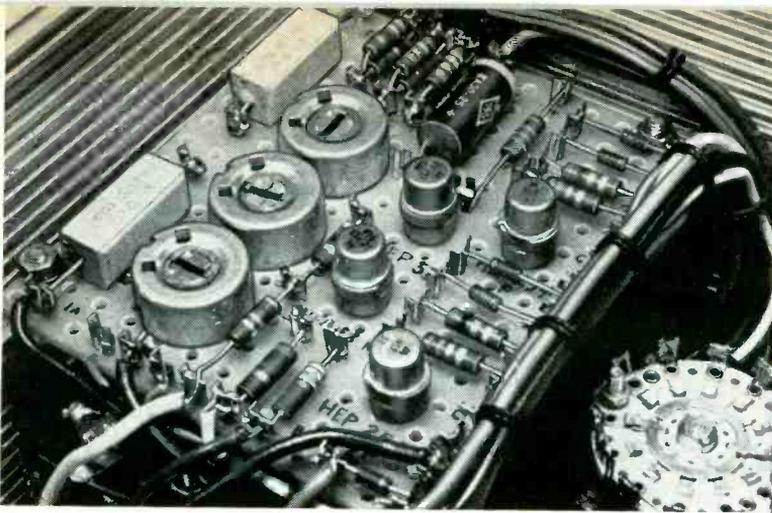
Accuracy is more important in setting the

voltage limit than in measuring the charge rate. Check the accuracy of the low-voltage dc range (5 volts) of the external VOM you are going to use.

Place *S3* on position 5 (VLTC-D) and, if necessary change the value of *R13* until *M1* indicates 200 mA. Then measure the voltage across the B1 and B2 holders. It should be



Each terminal of the rectifier is soldered to a copper plate that acts as a heat sink during heavy power consumption. Each segment is individually mounted. Capacitor C1 is insulated from chassis by a plastic wrap.



Although the author used sockets for the transistors, they are optional. To avoid wiring errors, clearly identify each terminal and component. To create a neat appearance, leads going to a common area are bundled together to form a wiring harness.

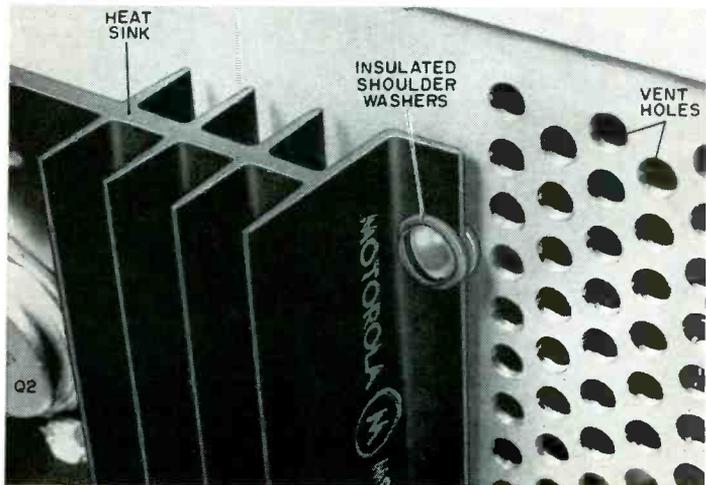
### CURRENT AND VOLTAGE LIMITS VLTC MODE

Mallory Type	Rated Capacity (mA-hr)	Charging Rate (mA)
SA-15AA	300	30-37.5
SA-14C	1000	100-115
SA-13D	2000	200-230

Charge open-circuit voltage limits (volts): 1.7-1.75.

about 1.7 volts. The diodes in each circuit may be interchanged to get a better match. If the voltage is less than 1.7, increase the charge rate using *R13*. If the matched voltages are above 1.75, set the charge rate slightly under 200 mA or select other diodes.

Power transistor Q2 is mounted directly to its heat sink, and the heat sink is insulated from the metal chassis. Vent holes allow cooling air to circulate within the closed container.



Just make sure that the voltages on the B1 and B2 holders are matched.

Set *S3* to position 4 (VLTC-C) and adjust the value of *R12* to obtain 100 mA on *M1*. The voltage on the holders should remain the same. If not, interchange or change the values of *R8* and *R9*. To increase the voltage, it is preferable to raise the charge rate rather than use higher resistances.

Follow the same procedure with *S3* in position 3 (VLTC-AA). In this case, it will probably be necessary to set the charge rate toward the high limit of the Table.

**Application.** To charge a single nickel-cadmium cell, set *S3* to position (CC-B1) and place the cell in the B1 holder. For two identical cells, place *S3* in position 2 (CC B1 + B2). Recharge nickel-cadmium cells at

the rate and for the time marked on the cell or as specified by the manufacturer. Both *S4* and *R31* can be adjusted for the correct values, with the current indicated on *M1*. If the charging information is not specified, but the milliampere-hour rating is known, divide this rating by 10 and charge at that rate for 14 hours. Cells should have been discharged to 1.1 volts before recharging. To recharge nickel-cadmium multicell batteries, run leads to *J1* and *J2* and observe the correct polarities of the leads and battery terminals.

Recharge Mallory SA-15AA, SA-14C, and SA-13D cells in the VLTC mode using *S3* set for the appropriate cell size. For a single cell, use either the B1 or B2 battery holder and charge for 12 to 14 hours. The built-in voltage limiter permits each cell to take what it needs at the maximum rate. Therefore, the cells need not be discharged nor in the same state of charge before placing them on charge. The meter indicates the total current to the VLTC circuit and cell and not the cell current alone. A quick way to check the charging progress is to connect a voltmeter across the cell with *S1* off. If the voltage is above 1.65, the cell is fairly well charged. As cells age, the final voltage drops to below 1.7.

Although only three VLTC charge rates are provided, other cells may be recharged by using the nearest lower rate and increasing the charging time accordingly.

**Drifting.** Due to the base-emitter characteristics of *Q3* there is a certain amount of drift during warmup. For instance, with a load of 1 ampere (output terminals shorted), there may be a drift of 7% for the first 20 minutes. At ½ ampere, drift is about 4%, essentially finished in 10 minutes. At 100 mA, drift is about 1%, with stabilization in about 5 minutes. Although such drifts are of no consequence in charging, the current may have to be reset after a short warmup.

Charger "backleak," or cell discharge back into the circuit when *S1* is off, is less than one microampere, which permits storage of the cells in the charger. Nickel-cadmium batteries may be kept on continuous trickle charge, as specified by the maker.

**Constant-Current Use.** The Charge Now may be used as a constant-current source for values up to one ampere. The current is taken from *J1* and *J2* with *S3* in the CC position. Tests may then be made on various types of semiconductors and other circuits. ◆

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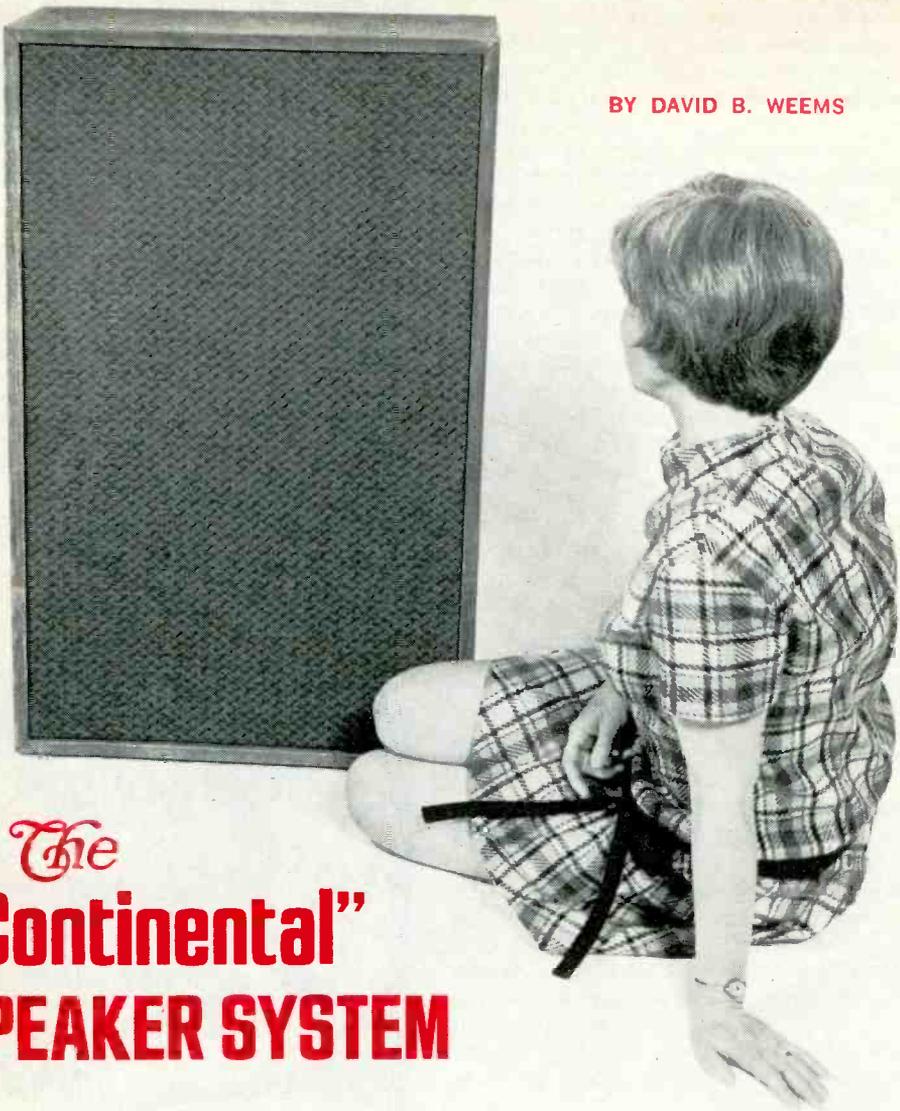
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## The "Continental" SPEAKER SYSTEM

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**T**HE U.S. MARKET for high-fidelity component loudspeakers was dominated by American and British manufacturers until the Japanese grabbed a piece of the action in recent years. The only serious continental European challenge to the market came in the 1950's when Philips of Holland sent over the Norelco FRS

speakers. ("FRS" stood for "Full-Response Speakers.") The Norelco speakers were popular for a while, then faded from the scene.

Now the Norelco loudspeakers are back. The new line, imported by Amperex Division of North American Philips Co., is good news for those hi-fi buffs who build

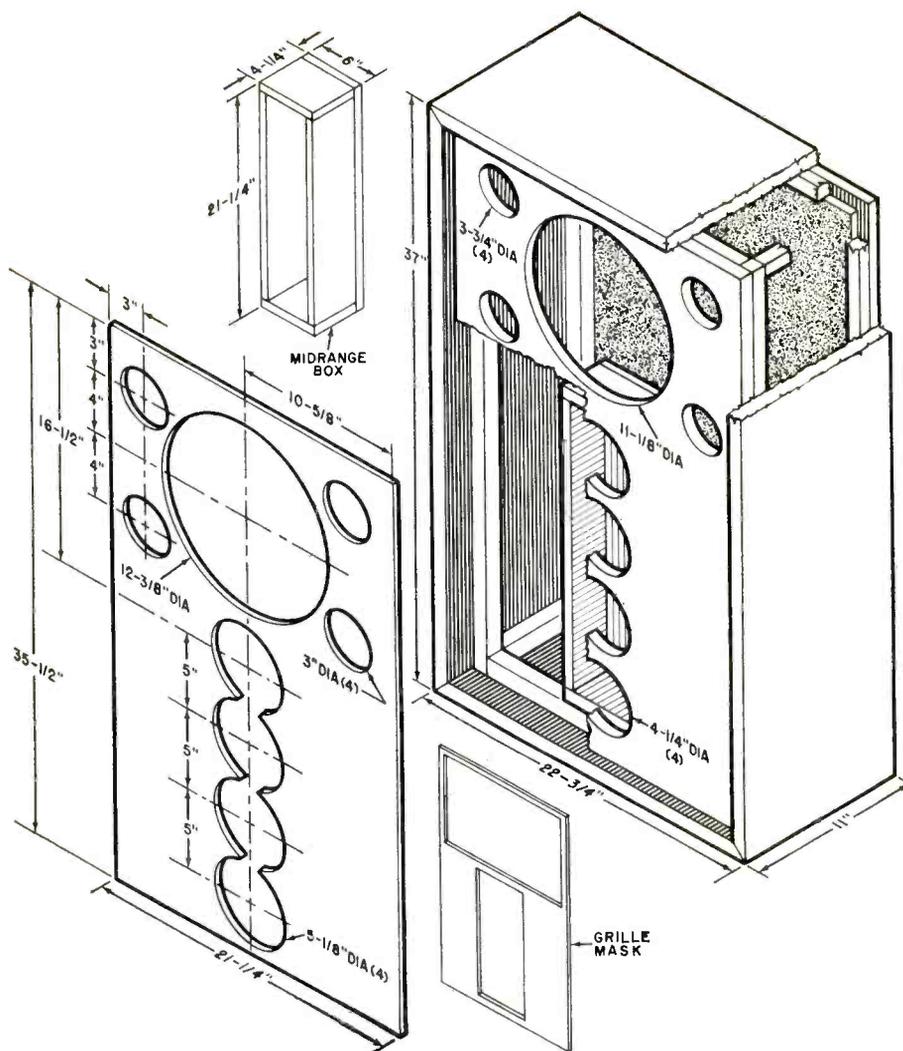


Fig. 1. Unconventional design and layout of speakers requires use of two-thickness speaker mounting board and rear panel for stiffening the shallow enclosure.

their own speaker systems. Norelco's components for sealed-box systems, woofers, midrange speakers, tweeters, and crossover networks fill a real need ignored by many manufacturers.

Amperex sells a book which is quite useful for the speaker system constructor, although the measurements provided in the plans are all based on the metric system. ("Building Hi-Fi Speaker Systems," M.D. Hull & K.R. de Vries, N.V.

Philips' Gloeilampenfabrieken, Eindhoven, The Netherlands, 1970.) The speaker system described in these pages, which we have called the "Continental" as a result of the origin of the speakers used, is No. 23 of 24 different two- and three-way systems described in the Amperex book.

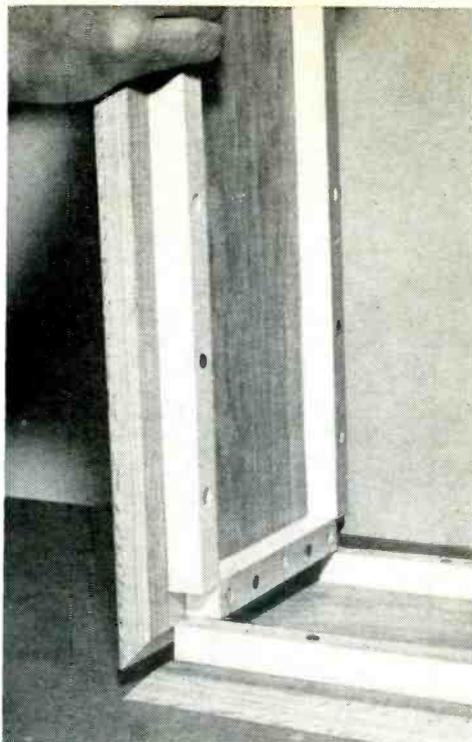
The Continental is a three-way system, employing a total of nine loudspeakers (one 12" woofer, four 5" midrange

## BILL OF MATERIALS

- 1—12" woofer (Norelco No. AD 1256/W)\*
  - 4—5" midrange speakers (Norelco No. AD 5060/W 8)\*
  - 4—1" tweeters (Norelco No. AD 0160/T)\*
  - 1—Crossover network (Norelco No. 4304-078-71971)\*
  - 2—37" × 11" pieces of  $\frac{3}{4}$ " fir plywood for enclosure sides
  - 2—22 $\frac{3}{4}$ " × 11" pieces of  $\frac{3}{4}$ " fir plywood for enclosure top and bottom
  - 2—35 $\frac{1}{2}$ " × 21 $\frac{1}{4}$ " pieces of  $\frac{3}{4}$ " fir plywood for enclosure rear panel and speaker mounting board
  - 1—35 $\frac{1}{2}$ " × 21 $\frac{1}{4}$ " piece of  $\frac{1}{4}$ " interior plywood for front panel
  - 1—Piece of Celotex (approximately 33 $\frac{1}{2}$ " × 19 $\frac{1}{2}$ " ×  $\frac{1}{2}$ ") for rear panel stiffener
  - 4—6' lengths of  $\frac{3}{4}$ " ×  $\frac{3}{4}$ " pine for cleats and corner blocks
  - 2—19 $\frac{3}{4}$ " × 3 $\frac{1}{2}$ " pieces of  $\frac{3}{4}$ " pine for midrange column sides
  - 2—6" × 3 $\frac{1}{2}$ " pieces of  $\frac{3}{4}$ " pine for midrange column top and bottom
  - 1—21 $\frac{1}{4}$ " × 6" piece of  $\frac{3}{4}$ " pine for rear of midrange column
  - 1—Piece of  $\frac{1}{4}$ " Masonite (approximately 35 $\frac{1}{2}$ " × 21 $\frac{1}{4}$ " ×  $\frac{3}{4}$ ") for grille frame
  - 1—Package of  $\frac{3}{4}$ "-wide ribbon veneer trim
  - 12—doz. #8 × 1 $\frac{1}{4}$ " flathead wood screws
  - 3—doz. #8 × 1 $\frac{1}{2}$ " flathead wood screws
  - 1—doz. #8 × 2" flathead wood screws
  - 2—doz. #8 ×  $\frac{3}{4}$ " flathead wood screws
  - 2—doz. #10 × 1" panhead sheet metal screws
  - 4—8 × 1" round head brass screws (for mounting crossover network)
  - 32—#8 ×  $\frac{1}{2}$ " panhead sheet metal screws for mounting midrange speakers
  - 8—#10 ×  $\frac{3}{4}$ " panhead sheet metal screws for mounting woofer
  - 12—#10 ×  $\frac{3}{4}$ " panhead sheet metal screws for mounting tweeter
  - 12—Heavy-duty oval service cable straps ( $\frac{3}{8}$ "-wide with 1" mounting flange and 1"-long ×  $\frac{3}{8}$ " high cavity) for tweeter mounting
  - Misc.—Grille cloth; glue and contact cement; silicone rubber compound; speaker zip cord; two-lug screw-type terminal strip;  $\frac{3}{8}$ "-long standoffs; fiberglass wool; solder; etc.
- \* The nine speakers and crossover network are available as Norelco System 23 for \$84.95, plus shipping, from McGee Radio Co., 1901 McGee St., Kansas City, Mo. 64108.

speakers, and four 1" tweeters) and an appropriate crossover network. It is rated at 40 watts, and system resonance is a low 40 Hz—which qualifies the Continental for real high-fidelity duty.

**About System.** The layout of component loudspeakers in the Continental (see Fig. 1) is a bit unconventional—but not without purpose. Interaction between



Sides, top, and bottom panels should be miter cut to provide invisible joints when enclosure is assembled with corner blocks.

speakers can be a serious problem in any speaker system which utilizes more than one midrange speaker or more than one high-frequency speaker (tweeter). In the Continental, the problem is avoided in the high-frequency range by placing the tweeters far apart (with reference to the wavelength of the sound).

For the midrange, another solution was found: arranging the speakers in a vertical column. This effectively restricts to the vertical plane interactions between the speakers.

The offbeat speaker arrangement leads to another unusual characteristic: The inside of the enclosure from front to rear is extremely shallow, requiring special bracing of the speaker mounting board and the rear panel of the enclosure. The limited depth was dictated by the size of the speaker mounting board and the cubic volume requirement. A deeper enclosure (with no change in the dimensions of the speaker board) would have a larger-than-optimum volume, limiting the power-handling capability of the woofer.

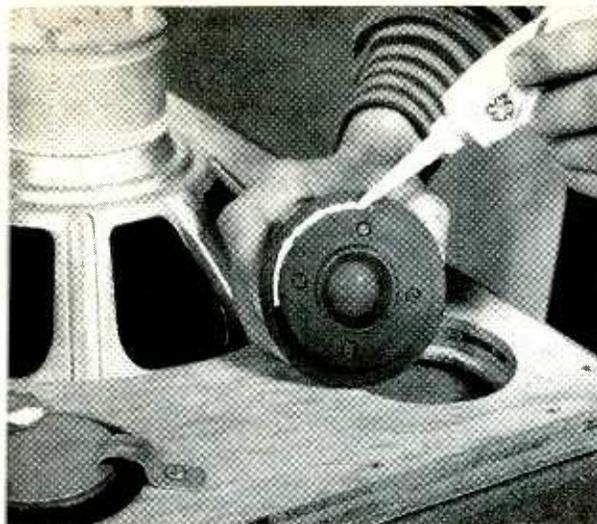


Fig. 2. Smear of silicone rubber compound on speaker serves as gasket. Note use of special cable clamps in mounting tweeters.

**Assembling Enclosure.** Except for the panels that make up the speaker mounting board, the construction of the enclosure is along conventional lines. All permanent assemblies must be fastened together with glue and screws. Use a  $7/64$ " drill for guide holes and a  $3/64$ " drill for pilot holes. And, unless otherwise specified, use #8  $\times$   $1/4$ " flathead wood screws throughout.

The first step to be performed is to cut to the dimensions specified in Fig. 1 and in the Bill of Materials the six  $3/4$ " and

one  $1/4$ " panels that make up the enclosure proper. Do NOT, however, at this time make the speaker cutouts in either the front  $3/4$ " or  $1/4$ " plywood panels.

When cutting the panels to size, remember to miter cut the ends of the top, bottom, and side panels at  $45^\circ$  angles to provide "invisible" joints when the enclosure is assembled. Assemble the enclosure shell (top, sides, and bottom), using corner blocks and cleats. Set the rear panel into place on the appropriate cleats and mark the cleat outline on the inside surface of the panel.

Remove the rear panel from the enclosure shell and lay it on a flat surface. Drill guide holes through the panel at 4"-6" intervals, starting 2" from each corner, spaced  $3/8$ " from all four edges. Next, cut a piece of  $1/2$ "-thick Celotex to just fit within the cleat outline. Then cut a  $1" \times 2"$  slot out of the Celotex, locating the slot in the center of the panel and about one-third of the way from the bottom edge.

Coat the mating surfaces of the rear panel and the Celotex with glue and fasten the two pieces together with #10  $\times$  1" panhead sheet metal screws. Place the assembly, Celotex side down, on a flat surface and heavily weight it until the glue thoroughly sets.

Meanwhile, proceed to work on the front panel assembly. An extra sheet of  $1/4$ " plywood serves the double purpose of strengthening the speaker board and permitting flush mounting of the tweeters and midrange speakers. First sandwich

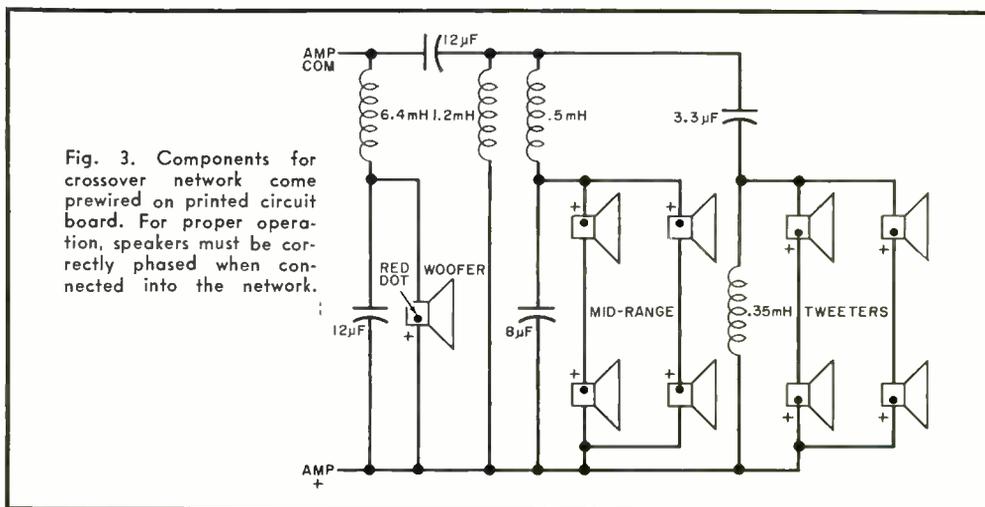


Fig. 3. Components for crossover network come prewired on printed circuit board. For proper operation, speakers must be correctly phased when connected into the network.

the  $\frac{3}{4}$ " and  $\frac{1}{4}$ " plywood panels together with the aid of C clamps or small finishing nails driven through the  $\frac{1}{4}$ " and into the  $\frac{3}{4}$ " panels at the corners. Now, referring back to Fig. 1, locate the centers for each of the nine speaker cutouts and at each location drill a small guide hole through both panels.

Separate the two panels and identify the guide hole pairs so that when they are reassembled the appropriate cutout pairs mate perfectly. Set aside the  $\frac{1}{4}$ " panel. Then use a compass to strike the cutout outlines on the  $\frac{3}{4}$ " panel. Working carefully, use a router or sabre saw with a fine blade to remove the wood for the cutouts. These cutouts should be as close to circular as possible.

Next, prepare the  $\frac{1}{4}$ " panel as described above. When you are finished, the woofer and midrange speaker cutouts will be larger in diameter than the cutouts for the same speakers in the  $\frac{3}{4}$ " panel. Conversely, the tweeter cutouts will be smaller in diameter.

Cut to size the parts that make up the midrange column box. Then assemble the box shell (sides, top, and bottom) with glue and screws. Prepare but do not mount the rear panel of the column box just yet.

Temporarily set the  $\frac{3}{4}$ " speaker board panel in place in the front of the enclosure shell. With a pencil, mark the cleat outline on the inside surface of the panel. Remove the panel and set it on a flat surface. Center the column box shell over the midrange speaker cutouts, locating the shell so that its bottom surface just clears the line for the bottom cleat. Mark the outline of the column shell on the panel. Remove and set aside the column shell.

Next, strike lines parallel to and spaced  $\frac{3}{8}$ " in from the four lines marked for the column box outline. Starting 1" from each corner made by the new lines, drill guide holes at 2" to 3" intervals.

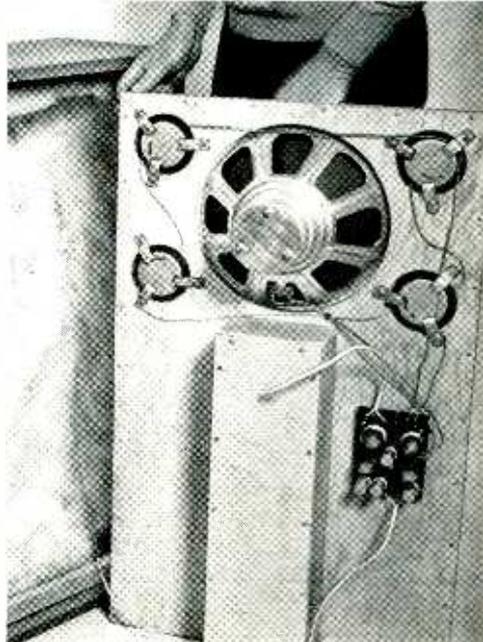
Sandwich together the  $\frac{1}{4}$ " and  $\frac{3}{4}$ " plywood panels that make up the speaker mounting board. Now, exercising extreme care when handling the speakers, use a tweeter to test each pair of cutouts for proper fit. Adjust the panel orientations so that the tweeter fits properly at each of the four locations. Similarly, use a midrange speaker to check for proper fit

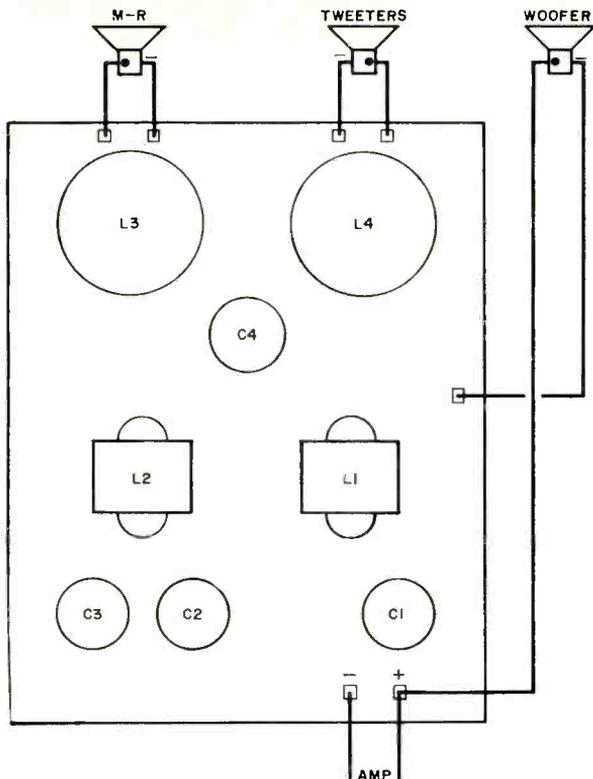
at each of its cutout locations. If any adjustments have to be made when the midrange speaker is being used, the tweeter cutouts will have to be rechecked.

When you are satisfied that all speakers fit properly in their cutouts, drive a finishing nail through the  $\frac{1}{4}$ " panel into the  $\frac{3}{4}$ " panel at all four corners to prevent them from slipping around and to serve as reference points when the panels are finally glued together. Now, drill pilot holes through the  $\frac{1}{4}$ " panel and into the  $\frac{3}{4}$ " panel, but do not completely penetrate through the thicker panel. Locate these holes at 4" to 6" intervals over the entire surface of the board, including the spaces between the speaker cutouts. Invert the panel assembly and extend the guide holes for the midrange column box to completely penetrate the  $\frac{1}{4}$ " panel. Remove the clamps and partially withdraw the nails at the corners to separate the two panels. Then enlarge the pilot holes in the  $\frac{1}{4}$ " panel to guide hole size.

Drive the corner nails far enough through the  $\frac{1}{4}$ " panel to hold the panels apart until the points of the nails are fitted into the reference holes. Evenly coat with glue the mating surfaces of

Crossover network is mounted to right of midrange box on the speaker board assembly. Acoustical padding in cabinet is important.





Proper phasing must be carefully observed when connecting speakers to crossover network. Woofer (W), tweeter (T), midrange (M-R), and amplifier (AMP) lugs are clearly marked according to polarity (phasing) in illustration at the left.

both panels. Then fit the panels together by aligning the nails with the holes, and hammer the nails down. Drive #8 × 3/4" flathead wood screws through the guide holes to securely anchor the panels together. Then install the midrange speaker column shell on the speaker mounting board with #8 × 2" flathead wood screws. Lay the assembly, 1/4" panel side down, on a flat surface and heavily weight it until the glue sets.

Assuming the rear panel assembly is ready to be worked on, unweight it and drill a pair of 1/2"-diameter holes through the plywood panel within the slot. Locate these holes on centers which mate with the lugs on a two-contact screw-type terminal strip. Feed one conductor of a 36" length of speaker zip cord through each hole and solder to the lugs on the terminal strip.

Slide the terminal strip into place on the rear panel and fasten it down with small brass screws. Screw down the screws on the terminal strip. Then fill the cavities around the solder lugs and screw ends with silicone rubber compound to

provide an air-tight seal. Mount the rear panel assembly in the enclosure shell with #8 × 1" wood screws, using caulking compound to provide an air seal.

When the speaker mounting board is ready to be worked on, round the front edges of the tweeter cutouts in the 1/4" panel. Now, measure in 3/8" on all four sides of the panel, strike lines parallel to the edges, and sink guide holes at 4" to 6" intervals along the lines. This done, apply a coat or two of flat black to the front surface of the speaker mounting board assembly.

Using contact cement, apply a ribbon of wood veneer edge trim to the exposed raw edges of the plywood panels at the front of the enclosure. Then smoothly sand, stain, and finish the enclosure as desired.

Line the interior walls of the enclosure with a minimum of 1" thickness of fiberglass wool or other acoustical damping material. Then attach to the bottom of the enclosure self-sticking rubber feet.

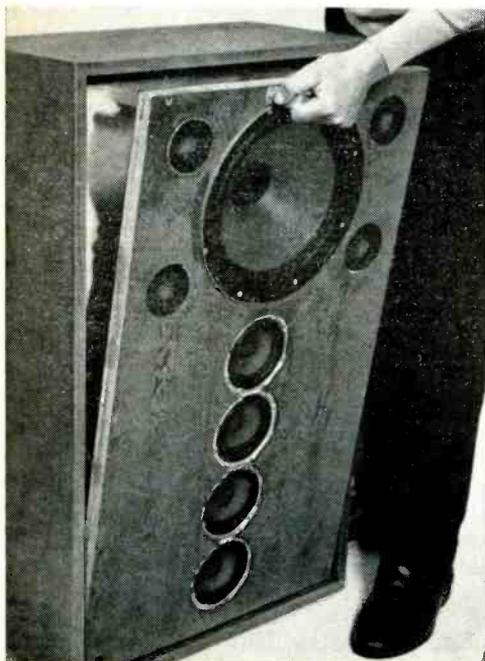
**Speaker Installation.** Set the speaker

mounting board on a pair of sawhorses or other convenient supports, face up. Apply a thick bead of silicone rubber compound around the rear rims of the speakers. Install the woofer and midrange speakers with screws from the front of the board. The tweeters mount through the rear of the board with the aid of special oval service cable straps as shown in Fig. 2. It is important that you use only those cable straps described in the Bill of Materials.

Install the crossover network to one side of the midrange speaker column, using brass screws and  $\frac{3}{8}$ " spacers. Then begin wiring the speakers together as shown in Fig. 3. First wire the midrange speakers in series-parallel and check to make sure that all cones move in a common direction when a 1.5-volt battery is connected across the network.

Connect and solder one end of an 18" long piece of zip cord to the midrange speaker network. Drill a  $\frac{1}{4}$ " hole through the center of the rear panel of the column, and pass the free end of the cord through. Mark the lead connected to the red dot terminals on the speakers. Then fasten the panel down on the rear of the

Speaker board must be slowly eased into enclosure to prevent damaging the woofer cone.



column shell with glue and screws, and fill in the zip cord exit hole with silicone rubber compound.

Wire together the tweeters, relying exclusively on the red dot markings for proper polarity. (Do not use the battery to check out the tweeters.) Finish wiring, connecting the speaker networks to the crossover network and the crossover network to the free end of the speaker cable coming from the screw-type terminal strip.

Check out the speaker wiring by connecting an amplifier or other source to the Continental via the terminal strip and listening to each speaker in turn at low volume levels to make sure each speaker is operating. If all seems to be okay, install the speaker board assembly in the enclosure, using caulking compound, if necessary, to insure a good seal.

The large speaker board will produce a tremendous compression of the air inside the shallow enclosure if it is carelessly inserted. In fact, the sudden rise in pressure can even rupture the woofer cone. So, go slow and give the air time to escape. Ease the speaker board assembly slowly into the enclosure to allow sufficient time for the air pressure to stabilize before screwing down and sealing the board.

Finally, staple or tack a piece of grille cloth over the Masonite frame and fit the grille assembly into the front of the enclosure. If you miscalculated with the dimensions of the assembly and the fit isn't tight enough, you can use a few drops of silicone rubber compound on the back of the frame to hold it in place.

You will find that the sound of the Continental is extremely wide range. The high-frequency response is particularly open and nondirectional. There is no sense of veiled sound, nor masking of high notes, nor of distortion.

The Norelco engineers are apparently opposed to the idea of mixing-level controls with speaker systems; so, the Continental has none of the usual midrange or tweeter L-pads. If the high frequencies are too pronounced for your listening room, use the treble control on your amplifier to compensate. There will be a slight loss in the midrange in many situations due to the low placement of the midrange speakers. This is a "listenable" speaker system, well worth building. ♦

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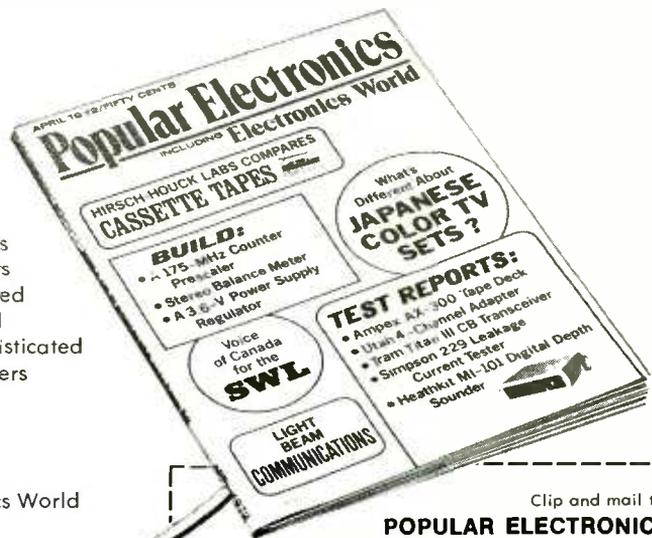
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# HI-FI AMPLIFIER MODULE

NEW COMMERCIAL UNIT SIMPLIFIES CONSTRUCTION

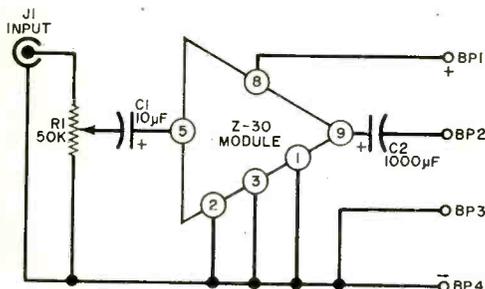


Fig. 1. Complete amplifier contains only module, two capacitors, and potentiometer.

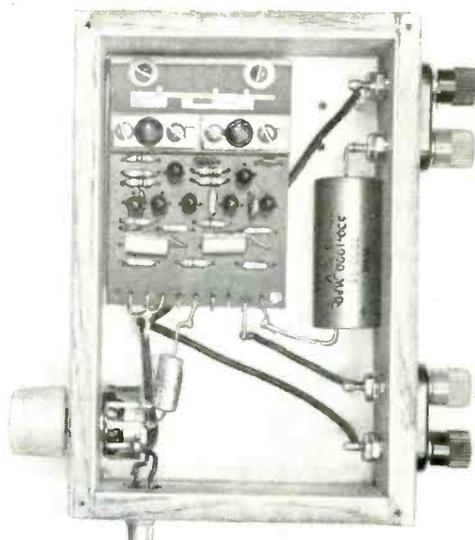
## PARTS LIST

- BP1-BP4—Five-way binding post
- C1—10- $\mu$ F, 10-volt electrolytic capacitor
- C2—1000- $\mu$ F, 35-volt electrolytic capacitor
- IC1—Sinclair Model Z-30 audio amplifier module (available from Audionics, Inc., 8600 Northeast Sandy Blvd., Portland, Or. 97220. \$15.95.)
- J1—Phono jack
- R1—50,000-ohm audio taper potentiometer

most any AM or FM tuner or with a ceramic phono cartridge. It is also useful as a signal tracer or in a number of other audio applications.

The module (on a printed circuit board) can be made into a complete amplifier with the addition of a couple of capacitors and a volume control as shown in Fig. 1. It is only necessary to solder six wire "lugs" to the module terminals as shown in Fig. 2. Use heavy-duty solid wire and let them overlap the

Fig. 2. The module can be mounted easily in a small case with other components attached.



**WHEN** doesn't it pay to design and build your own solid-state hi-fi amplifier? When you can buy a better one than you can design—for less money than it takes to build one. This was the reaction upon seeing the specifications of the Sinclair Model Z-30 audio amplifier presently being imported from England.

This excellent general-purpose audio amplifier module can be housed in a small enclosure and can be used with al-

## TECHNICAL SPECIFICATIONS

**Power output:** 15 watts continuous sine wave (30 watts peak) into 8 ohms with regulated 35-volt supply; 20 watts rms into 3-4 ohms with regulated 30-volt supply

**Frequency response:** 30-50,000 Hz  $\pm$ 1 dB

**Distortion:** 0.02% or less up to and including full output at 8 ohms

**Sensitivity:** 250 mV into 100,000 ohms

**Signal-to-noise ratio:** -70 dB unloaded with class AB output

**Power requirements:** 8-35 volts dc regulated (power output level decreases with decrease in supply voltage)

end of the board about  $\frac{1}{4}$ ". All ground leads are soldered to one point.

The power supply for the amplifier module can be between 8 and 35 volts dc. The amplifier shown in Fig. 2 was built to have an external power supply, but the supply could easily be incorporated in the same enclosure.

A loudspeaker of 8 or 16 ohms is recommended. If you want to use a 3.2-ohm speaker, be sure that the power supply is not over 25 volts and that the module has adequate heat sinking.

The Z-30 amplifier module comes with an operating manual, which should be consulted for further instructions.  $\diamond$

# Leakage Current & Electrical Shock

BY PAUL B. JARRETT, MD

**T**HE SENSITIVITY of man to electric shock and electric currents is well established. Until recently, physicians could discount the effects of minute currents and low voltages because of the insulating properties of the skin. When dry and calloused, the skin has an average resistance of about 100,000 ohms. Skin wet with perspiration, however, may have a resistance of less than 1000 ohms. Skin resistance varies with body area and vasomotor (flushing or capillary constriction) response.

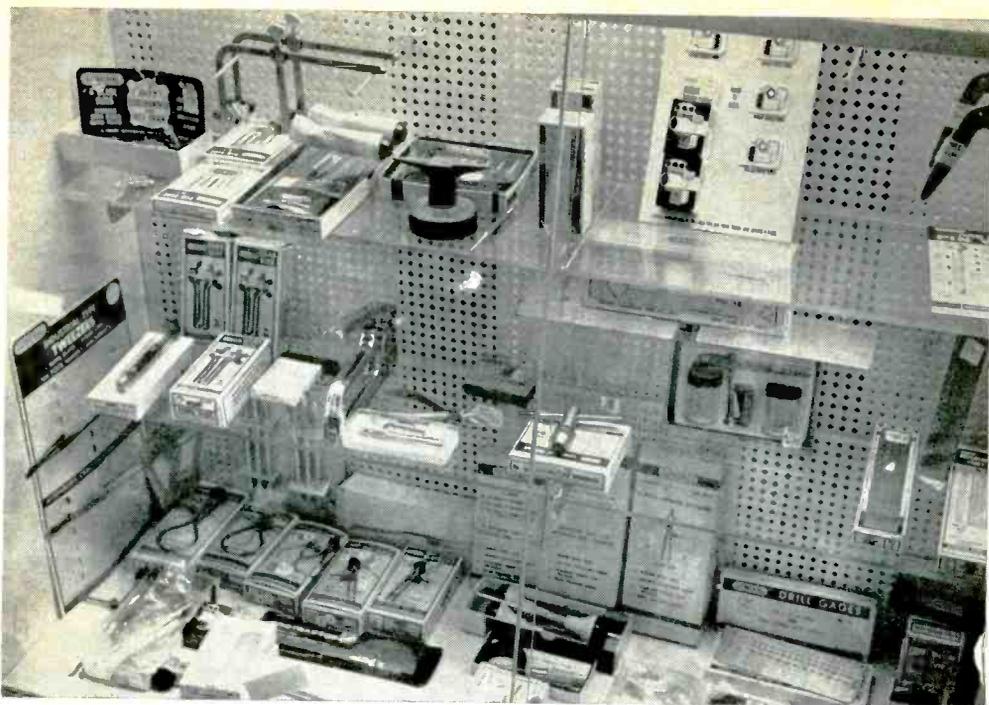
A current flow of from 9 to 14 mA produces discomfort. With a current of 15 to 25 mA, the victim loses his ability to release the conductors due to muscle contraction in tetany. At 25 to 50 mA, respiratory paralysis can occur (depending on the current path) and the victim is in pain. If the current reaches 75 to 100 mA, ventricular fibrillation (heart irregularity) ensues and at 200 mA, or over, there is total cardiac standstill.

**No Skin Insulation.** A source of current acting on the body from under the skin is another matter. At 20  $\mu$ A this current, if applied directly to myocardium (heart muscle) for more than 3 milliseconds, will produce fatal ventricular fibrillation.<sup>1</sup> In medical circles particular emphasis is now being placed on external cardiac pacemakers with transverse bipolar electrodes inserted through the right jugular vein. An engineering analysis of the death of one such patient has recently been discussed in the literature.<sup>2</sup>

It was determined that the external pacemaker had not been grounded, but instead was being supplied ac power from a 2-prong, 10-foot extension cord. Measurement of the leakage current of the pacemaker including the 3-wire power cable of the instrument itself, plus the 10-foot extension cord, revealed a current of 54  $\mu$ A. Unfortunately, the patient with the pacemaker had been placed on an electrically operated bed that had been grounded to the hospital power system. The leakage current passed from the electrode into the patient's heart through his body and into the ground connection on the bed.

This accident has emphasized the growing interest in safety problems associated with medical electronic apparatus. Hospital personnel must be properly instructed about electrical safety.<sup>3</sup> Patients with internally placed electrodes must not be placed in beds with ground connections that are accessible to the patient. The pacemakers should only be used with a current limitations device of 5  $\mu$ A under any condition. Untrained hospital personnel should also be taught the use of a new electrometer which permits safety monitoring of electronic equipment for leakage currents, static charges, and insulation resistance.<sup>4</sup>—Dr. Paul B. Jarrett

1. J. M. R. Bruner, *Anesthesiology*, 28/2, 1967.
2. Von Der Mosel, *Measurement & Data News*, Vol. 4 No. 4, July & August 1970.
3. Von Der Mosel, *Medical-Surgical Review*, Oct.-Nov. 1970.
4. Roveti Instruments (Mod EP-3), Annapolis, Md.



# DON'T BYPASS THE HOBBY SHOP

A GOLD MINE OF HARD-TO-FIND TOOLS

AND MATERIALS

FOR THE ELECTRONICS EXPERIMENTER

BY FRANK H. TOOKER

**Y**OUR HOBBY interests may not extend to model railroading, airplanes, or ships, but that is no reason for you to pass right by the model hobby shop when you are out shopping for items for your electronics hobby. When you browse around a modern, well-stocked hobby shop, you will be amazed at the variety of items you find that are useful in electronics.

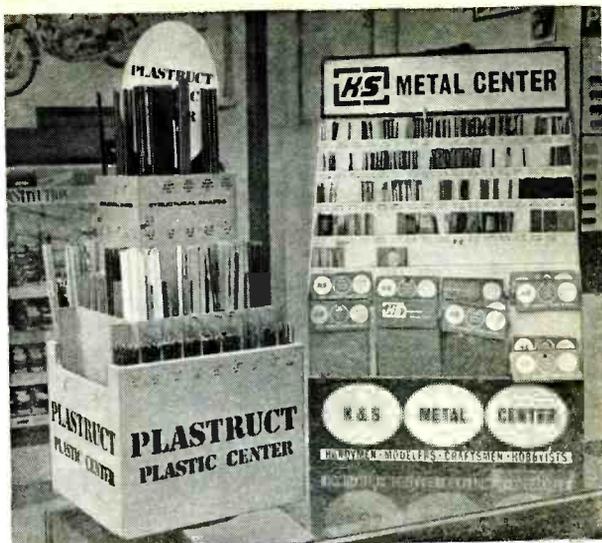
Materials and tools that are obtainable only with difficulty or perhaps not at all from electronics suppliers and hardware stores are right there on display in the hobby shop. To give you an idea of what you can expect to find, let's discuss some examples.

**Basic Materials.** Precision-made telescoping brass tubing, round or square, is a standard item in any hobby model shop. Available in a wide variety of diameters and square dimensions, these tubes fit one inside another so precisely that they can be used anywhere as bearings.

Short lengths of tubing can be used to increase control shaft diameters—say, from  $\frac{1}{8}$ " to  $\frac{1}{4}$ "—to allow the use of readily available knobs. And the tubing can be used as extension shafts, too; the extensions are lightweight, yet sufficiently strong, for most electronics applications.

The tubing can be quickly formed to

Useful hobby shop offerings for experimenters include wide variety of sizes of brass, aluminum, and plastic round and square tubing, angles, strips, and sheets.



make attractive handles for projects. Tubing benders for this purpose are probably right there on the same shelf with the tubing.

Available diameters for brass tubing cover a range of from 1/16" to 1/2" with a 1/64" wall thickness. And you can obtain the tubing either plain or nickel plated. Small-diameter aluminum and plastic tubing are also available in hobby shops. Most of the better places have both 12" and 36" lengths.

Looking for sheet metal for any purpose from shim stock to a small chassis? The hobby shop is the place to get it. Brass, copper, aluminum, even lightweight magnesium sheet stock are there for the picking. And don't forget the various thicknesses of plastic sheets and brass, aluminum, and plastic angle stock.

Model hobby shops also carry "music wire" in a wide range of diameters. This is a very high-quality steel wire preferred by industry for making coil springs. And you know how difficult it is to buy a spring with just the right tension and dimensions even for standard dial cord assembly replacement. With a reasonable selection of music-wire sizes, you can actually make small coil springs to order for just about any application. (NOTE:

Do not attempt to cut music wire with diagonal cutters; you will only damage the cutters. Instead, use a carbide saw or grinding wheel to cut the wire.)

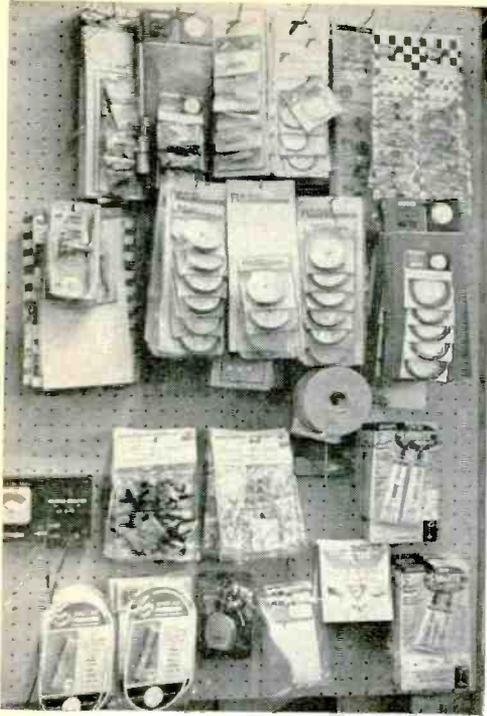
Maybe you need some especially tiny screws, nuts, and washers. You will not find them in a hardware store or an electronics parts supply store. But the hobby shop has them in abundance in dozens of sizes—some so small you need a jeweler's loupe and screwdriver to work with them.

Have you ever looked high and low for small pulleys for stringing dial cords in a home-brewed project? If so, you already know that such a basic item is often the hardest thing to find. Excellent "pulleys" (known to the modeler as "sheaves") can be had from any hobby store in 3/32", 1/8", 3/16", and 5/16" diameters. You won't find much use for the first two sizes, but the latter two are really handy.

This is by no means the end of the list of materials you can find in hobby shops that you can put to good use in electronics project building. There are dozens and dozens of other materials you have probably long since given up on trying to find.

**Special Tools.** The model hobby store excels in its variety of special-purpose tools. Don't be misled into believing that modeling tools are cheaply made, inaccurate, and made of poor quality mate-

*The photographs in this article were taken by Ed Burbaum in, and with the kind cooperation of, Polk's Hobbies, Fifth Ave., New York, N.Y.*



Many items on peg-board displays are packaged in clear plastic bags so contents can easily be seen, simplifying buyer selections.

rials. While there are certainly some "cheap" tools available for the infrequent user, serious modelers own and use some

Small items, among them hardware, tools, cutters, etc., are generally kept in glass display cases under counters to afford browsers and buyers easy view of offerings.



of the finest hand tools you'll find anywhere.

What most significantly distinguishes modeling tools from most others is that the former are designed to do small, fine work accurately. (Just think of some of the really close work you have had to do in some of your most recent projects, and you'll appreciate how handy modeling tools can really be.)

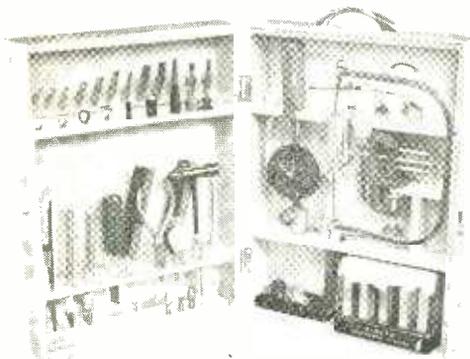
Modelers work in miniature, so their tools are often miniature in size. Such tools, of course, can be obtained from jewelers' supply houses, but for a one-place source, the hobby shop is the place to go.

A simple but pressing example of a tool that is desperately needed for modern electronics work is a No. 67 drill. This drill is extensively used in making component lead holes in printed circuit boards. Some hardware stores handle this size drill, but *all* hobby stores have it as a standard item. When buying such fine drills, add the extra few cents and get the high-speed steel ones; they are well worth the extra cost.

Now you will need a device to let you use such a small drill with a standard drill chuck. Get a collet-type pin vise when you pick up the drill. A word of caution: Don't try to use fine drills in your portable electric drill (a drill press is okay); you will just bend or break them one after another.

When working with fine drills, invest in a geared-type cordless electric drill, another hobby shop standard. Your \$6 or \$7 investment in the drill will more than pay for itself in drills and reduced labor when drilling many holes.

Most electronics supply houses now have jewelers' screwdrivers, but in the hobby shop you can also get wrenches and nutdrivers for hardware as fine as No. 00. You can also buy a saw with a fine Swedish-steel blade that is only 0.008" thick (that's roughly half of 1/64"! ) for about \$1.25. Look around in the hand



Tools are available individually and in kits. Example of modeler's tool kit is shown above.

tool section, and you'll find a wide variety of miniature pliers and cutters and tweezers that seem to be just made to order for your electronics workbench.

**Visit Your Local Hobby Shop.** But take along only the amount of money you intend spending. This is no light admonition. The vast array of materials and tools (not to mention model kits) are too tempting to pass up.

Here's a good idea: Make your first trip a browsing visit in which you familiarize yourself with the items available. Don't buy; just look. Then come back another day to make your purchases. Either way, allot a good four hours for your first visit; more if the hobby shop is really first class. You'll need that much time to just look.

If you live in an area not serviced by a well-stocked model hobby shop, you can do your browsing and purchasing by mail. You will have to pay for a catalog, but it is well worth the nominal investment. ♦



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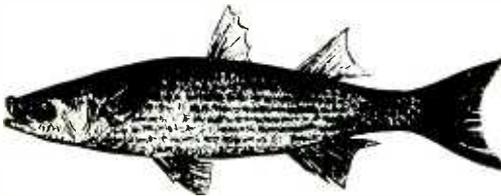
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**CIRCLE NO. 8 ON READER SERVICE CARD**

# Aquarium Heater Control for Fish Fanciers

AND PHOTOGRAPHERS,  
CHEMISTS, AND ANYONE ELSE  
WHO NEEDS STABLE,  
PRECISE TEMPERATURE CONTROL



**W**HILE virtually all IC's were originally designed for commercial applications, quite a few have filtered down to the hobbyist and experimenter. One of the more interesting IC's to follow this route is RCA's CA3059 trigger circuit for the control of thyristors. Almost by itself, this IC is a complete electronic control system for immersible and non-immersible heaters. This means that the tropical fish keeper, the amateur and professional photographer, and the chemist can now have an inexpensive, highly accurate heater control.

The CA3059 eliminates the instabilities present in the typical bimetallic thermostatic heater by replacing the mechanical contacts with a triac and em-

ploying a totally electronic interface. Among its many features, the IC includes zero-voltage switching; which means that triggering for the triac is provided only at the points where the 60-Hz line power voltage crosses the zero axis. Hence, rf noise is eliminated without having to resort to bulky and expensive line filters.

The electronic heater control described here will maintain any preset temperature within its range of control to very tight limits. With the components specified, the system will handle output loads (heaters) rated at up to 200 watts. However, a higher power triac can be substituted to cope with higher power requirements.

**Theory of Circuit Design.** The CA3059 is a fairly unique integrated circuit. In addition to its triggering circuit, the IC also contains a power supply and a differential amplifier. This minimizes the external circuitry to a handful of components as can be seen in Fig. 1.

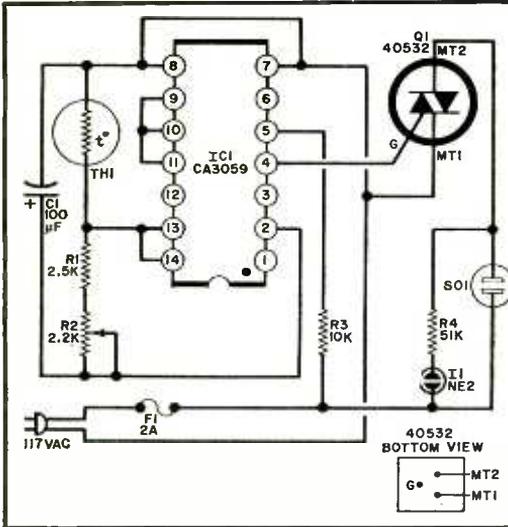
The only external components needed are thermistor temperature sensor *TH1*, temperature control resistor and potentiometer *R1* and *R2*, triac *Q1*, and the dropping resistor and filter capacitor *R3* and *C1* for the power supply. The power line is fused by *F1* as a safety measure, and neon lamp/resistor assembly *I1/R4* are optional items that give a visual indication of the operational status of *Q1*.

In operation, the heater to be used with the system is plugged into *SO1* and the line cord is plugged into any convenient 117-volt ac receptacle. Both temperature sensor *TH1* and the heater are then immersed in the same water or solution (but no less than 2" apart), and *R2* is adjusted to the position that will maintain the water at the desired temperature.

Assuming that the water was originally cooler than desired, the system should trigger on as soon as the heater and *TH1* are immersed and power is applied to the circuit. While the system is active and triggering *Q1* into conduction, *I1* will light to show that power is being applied to the heater.

At some time during the heating process, the water will attain the desired temperature, at which time *TH1* will initiate action to stop the IC from trigger-

BY A. E. DONKIN



### PARTS LIST

*C1*—100- $\mu$ F, 35-volt electrolytic capacitor

*FI*—2-ampere fuse

*I1*—NE2 neon lamp

*IC1*—CA3059 integrated circuit (RCA)

*Q1*—40532 triac (RCA)—see text

*R1*—2200-ohm,  $\frac{1}{2}$ -watt resistor

*R2*—2500-ohm, linear-taper potentiometer

*R3*—10,000-ohm, 2-watt resistor

*R4*—47,000-ohm,  $\frac{1}{2}$ -watt resistor

*SO1*—Chassis-mounting ac receptacle

*TH1*—Fenwall JA33J1 thermistor

Misc.—8"-long glass tube; perforated phenolic board and push-in solder clips; Bakelite chassis box; fuse holder; ac line cord with plug; solid and stranded hookup wire; lamp bezel with lens for *I1*; insulating tubing and air hose; solder; hardware; etc.

Fig. 1. Only a few external components are needed with IC1 to make control.

ing *Q1* into conduction and shut off the heater. As long as the water temperature remains constant at the preset level, the system will remain passive. However, if the water temperature should fall below the preset level, *TH1* will sense the event and initiate the process for resuming triggering *Q1* and turning on the heater.

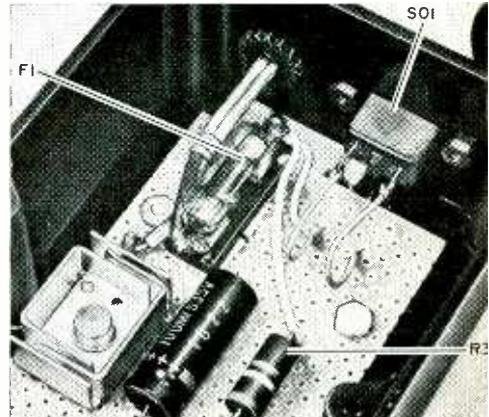
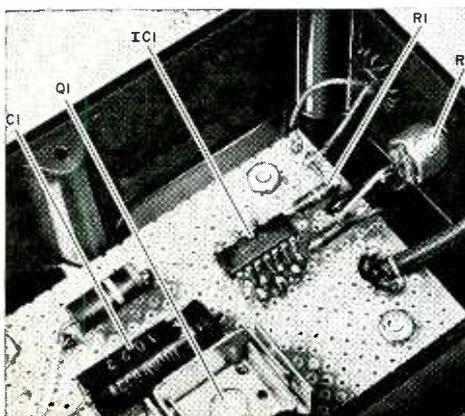
**Assembly.** There is nothing critical about the layout and wiring of the main circuit just as long as proper soldering precautions are exercised. In Fig. 2 can be seen how the prototype was assembled using a small piece of perforated phenolic board and push-in solder clips.

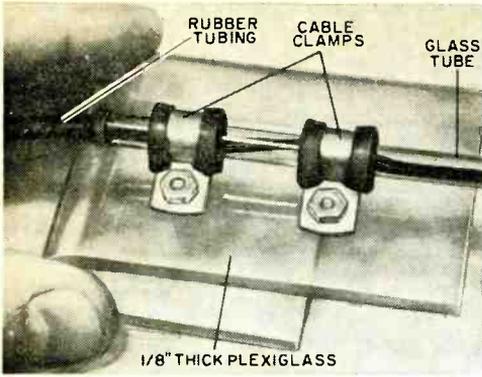
Interconnecting wiring was routed along the bottom side of the board.

The sensing element probe assembly consists of a 0.01"-diameter disc thermistor mounted inside a glass tube one end of which is sealed. To make this assembly, use a high-heat flame to bring the end of the glass tube to red-hot temperature and draw out the softened glass until it seals itself. Then hold the sealed end of the tube in the flame again until the sharp point rounds off.

Twist together two 36" lengths of flexible stranded hookup wire. Slip a 3" length of insulated sleeving over the end of one wire, and solder both conductors at this end to the thermistor leads. Slide

Fig. 2. Simplicity of circuit is responsible for easy layout of components on perforated board. Note that, since line voltages are exposed in several places in circuit, insulating Bakelite box should be used for the chassis enclosure.





**Fig. 3.** Sensing probe assembly mounts on plastic bracket with cable clamps and #6 hardware. Do not overtighten clamps or the glass tube will break.

the sleeving down over the thermistor lead. Then check to make sure that the thermistor's leads do not short out against each other with the sleeving in place.

Now, carefully slide the thermistor into the open end of the tube until it sits against the closed end. Fashion a mounting bracket for the probe assembly from  $\frac{1}{8}$ "-thick Plexiglass and mount the probe assembly to it with a pair of plastic-lined cable clamps as shown in Fig. 3. Then slip a 6" length of plastic or rubber air hose over the free end of the twisted wires and force it down over the open end of the glass tube for about  $\frac{1}{4}$ " as shown. Connect and solder the free ends of the wires to the appropriate points on the circuit board.

**Test and Use.** After the control system

is assembled, an easy test to check out its operation can be performed with the aid of a 40- or 60-watt incandescent lamp as the load. (Note: Since line voltage is used at several points in the circuit, exercise extreme caution when working with the circuit without the cover on.) Turn up the heat control, R2, until the lamp lights.

Bring the sensing probe near the lighted lamp; after a short lag, the lamp should extinguish as a result of the heat transfer from the lamp to the thermistor. Keep the probe assembly near the lamp after it goes out, and a few seconds later, the lamp should again trigger on. If the probe is held near the lamp for a considerable time, the lamp should cycle on and off.

Now you are ready to put the control system into service. If you already have a bimetallic thermostatic heater, turn its control up for a high temperature. Plug it into SO1 on the control box. (If you do not have a heater, use one of the non-controlled submersible heaters found in pet stores.)

Advance the heat control to the desired setting, making sure that the probe and heater are both immersed in water. Wait until the water temperature stabilizes before making any small adjustments of the control.

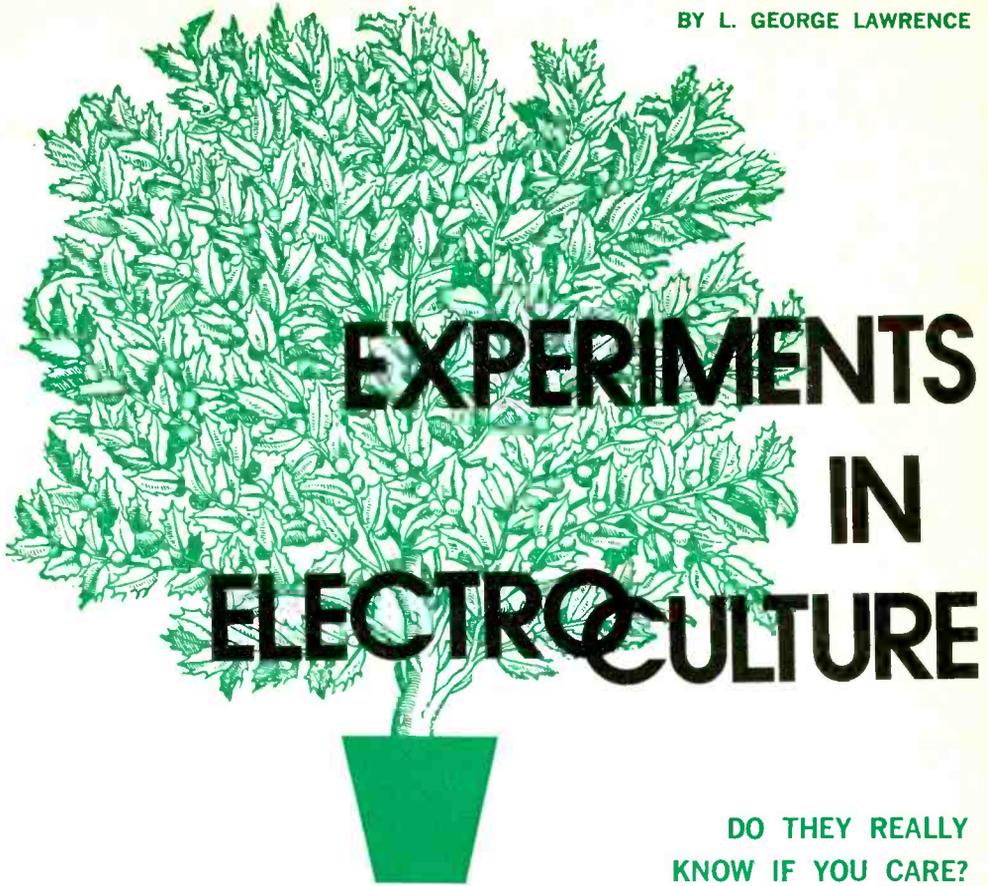
If the control system is to be used just for tropical fish aquariums, rough setting of R2 will suffice. However, for more critical photography bath and chemical solutions, it is advisable to calibrate the control setting with the aid of an accurate thermometer. ♦

## CONTACT PROTECTS PANEL MARKINGS

Dry-transfer lettering kits have made a simple job of prettying up front panels of home-made projects. But keeping the markings from wearing away or scratching off is a big problem. However, there is a simple way of ruggedizing the markings to bear up under even extra-heavy usage. After finishing off the front panel and applying the lettering and markings, cut some transparent Contact (a flexible adhesive-backed vinyl) to dimensions  $\frac{1}{2}$ " larger than the length and width of the panel.

Strip off the protective backing and tack the Contact, adhesive side up, on a flat surface. Now, carefully lower the front panel onto the Contact, roughly centering it. Do not attempt to lift the Contact off the panel from this point on or the lettering and markings will be destroyed. Remove the tacks and firmly burnish down the Contact, pricking any air bubbles with a sharp pin as you proceed. Finally, use a sharp knife to trim away the excess Contact flush with the panel edges.—Richard A. Kunc

BY L. GEORGE LAWRENCE



DO THEY REALLY  
KNOW IF YOU CARE?  
FIND OUT ELECTRONICALLY

**E**XPERIMENTING on living organisms is exciting and—as history shows—often rewarding. But there just aren't many people, dogs, birds, fish, etc., that you can (or would want to) subject to tests to determine such things as emotional reactions, nervous response, or sensorial perception. So, how about plants? They are after all, living things, and there are many indications that when stimulated, they have sensitive, sensible reactions which can be measured on ordinary electronic equipment. Before going into the details of the equipment (which you can build for yourself), let's get to know a little more about plants and how they tick.

**Do They Just Sit?** On first thought, plants appear to be quite remote from life as we know it. Their sedentary exis-

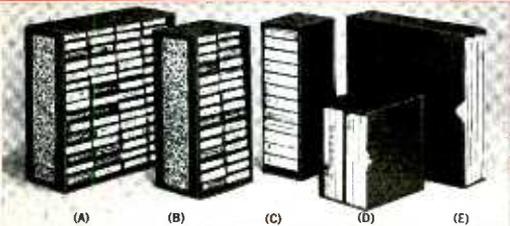
tence stands in strong contrast to energetic animals, which are endowed with a massive inventory of sensory capacities, fast reflex movements, and many active organs.

However, recent research has revealed that many of the same environmental factors and stimulations that affect animals also affect plants. Of course, here we find modified abilities to sense, feel, and react. Also, since a plant cannot run away from a threat to its existence, it would appear that special internal forces are set in motion to protect the organism from shock and possible death. These phenomena are akin to states of anxiety in animals and are evidenced by changes in the plant's psychogalvanic or electric states which occur in threatening situations. The recently discovered "Backster Effect," seems to provide evidence that



## PARTS LIST

- B1-B3—9-volt battery  
 B4—1.5-volt D battery  
 BP1-BP6—Five-way binding post  
 C1—0.047- $\mu$ F capacitor  
 C2—0.1- $\mu$ F, 50-volt paper capacitor  
 C3—0.005- $\mu$ F capacitor  
 C4—0.01- $\mu$ F capacitor  
 C5,C6—50- $\mu$ F, 10-volt electrolytic capacitor  
 D1,D2—Silicon diode (RCA SK-3016)  
 I1—2.2-volt lamp (222)  
 IC1—Op amp IC (Fairchild  $\mu$ A741C)  
 M1—1-mA dc meter (Calectro D1-912)  
 Q1—Transistor (RCA SK-3011)  
 Q2—Transistor (RCA SK-3003)  
 R1—75,000-ohm resistor (see text)  
 R2—100,000-ohm linear potentiometer (see text)  
 R3—100,000-ohm linear potentiometer  
 R4—100,000-ohm resistor  
 R5,R6,R15—1000-ohm resistor  
 R7—240,000-ohm resistor  
 R8—3-megohm linear potentiometer  
 R9—82-ohm resistor  
 R10,R11—470,000-ohm resistor  
 R12—3300-ohm resistor  
 R13—10,000-ohm resistor  
 R14—4700-ohm resistor  
 R16,R19,R20—100-ohm resistor  
 R17—3.5-ohm, 1-watt resistor  
 R18—10-ohm resistor  
 R21—8-ohm potentiometer L pad  
 S1,S3,S5,S9—Spst switch  
 S2,S6—Dpdt switch  
 S4—Dpst switch  
 S7,S8—Normally open pushbutton switch  
 T1—Audio transformer; 250/8-ohm, 200-mW (Calectro D1-726 or similar)  
 Misc.—Suitable chassis and cabinet, battery holders, pilot-lamp mounting assembly, clamp support, machine clamp, clam insulators, metal electrodes, twin shielded lead, rubber feet, plastic pot for plant, knobs, mounting hardware, etc.
- Note—The  $\mu$ A741C op amp is available from PolyPaks, PO Box 942W, Lynnfield, MA 01940, for \$0.41.



- (A) 60-unit cassette case. 13½" high x 12¾" deep x 5½" wide.  
 (B) 30-unit cassette case. 13½" high x 6½" deep x 5½" wide.  
 (C) 12-unit cartridge case. 13¼" high x 6½" deep x 4¼" wide.  
 Units A, B and C have tilted compartments to prevent spillage and include pressure sensitive labels for titling.  
 (D) 6-unit 7" reel case. 8" high x 7½" deep x 5" wide. Holds reels in original boxes.  
 (E) 20-unit 12" record case. 13¼" high x 12½" deep x 3½" wide. Holds records in original jackets.

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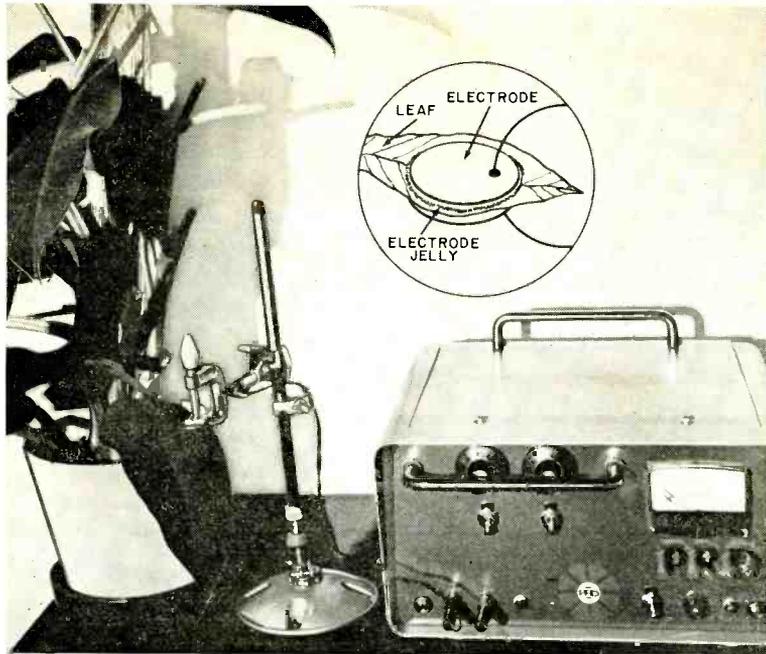


Fig. 2. Leaf contact is made through a highly conductive metal disc and electrode jelly of the same type used by physicians to make medical electronic tests. Take care not to crush the leaf when making the contact, and use a stable support system.

plants have some ability to function in a mode of supersensory perception. This, of course, invites a host of exciting and unique investigations.

However, prior to engaging in plant-oriented experiments, you should realize that living systems frequently produce maverick results. While a plant may be regarded as an organic semiconductor having variable resistance and self-generating properties, it also has elements of apparent cellular consciousness. Electronic and mechanical response profiles are not uniform.

#### TRANSMITTER EFFECT

The behavior of plants in strong r-f fields has been studied only superficially. Although excessive energy levels induce heating and death and although plants are (electrically speaking) dc-oriented organisms, they nevertheless incorporate mechanisms which allow them to survive in the immediate vicinity of high-power radio transmitters of all types. To our knowledge, no tests have been performed to detect psychogalvanic behavior in plants under these conditions.

Some plants (such as the *Mimosa Pudica*) react rapidly; others give no discernable reactions to stimuli and still others exhibit strangely delayed responses. Remember that typical electrical signals provided by plants are in the low millivolt/microampere range. The equipment described here for making experiments should give you a good start, but for some extremely sensitive tests, you should avail yourself of an ultra-high gain electrometer with input impedances of  $10^{10}$  ohms or higher.

Another factor to remember is the importance of repetition. If, for example, a plant specimen is stimulated continuously, badly injured by burns or cuts, infrequently watered, etc., it is bound to tire quickly, perhaps lapse into shock and die. Terminal conditions are indicated by wilting, and discoloration usually forecasts death. Depending on the plant's overall chemistry and the amount of moisture retained in leaves and stem structures, a dead specimen is little else than a simple conductor of the carbon type and no psychogalvanic response of any kind should be expected. In short,

be gentle and allow plants to recuperate after they have served your purpose.

Some 350,000 plant species are known to science. At this time, we have no concise information as to which group is psychogalvanically superior to others. In general, however, it has been discovered (Lund, 1931) that the distribution of gradients of electrical potentials in large plants (such as trees) is more complex than in small plants. Apparently, each individual cell in a plant is electrically polarized and acts as a tiny, variable battery. The electrical potentials occurring in tissues are summation effects of the potentials of individual cells which may act either in series or in parallel (Rosene, 1935). Various mechanisms of correlation are involved here; but, as you are bound to discover, there is no complete uniformity from one specimen to the next, either in looks or reactions.

**Plant Response Detector.** The basic instrument for plant experimentation is a

### MAGNETO-TROPISM

This phenomenon was discovered by Dr. L. J. Audus, of Bedford College, London, in 1959, and reported by him in "Nature" in 1960.

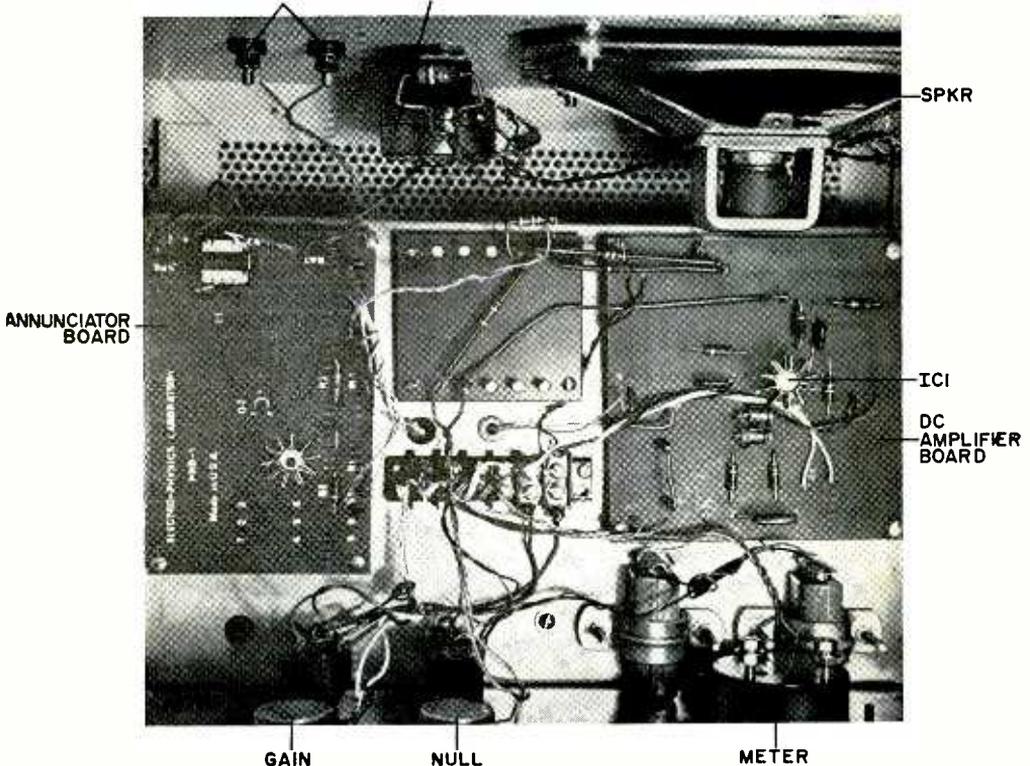
In tests, a viable seed of any plant is inserted in a small plastic container which is then placed between the poles of a strong magnet (of the magnetron type). For control purposes, another similar seed and container are placed far away from the magnet but with all other conditions being the same.

The "magnetized" seedling should show some bending effects plus a more emphatic growth than the control.

It is also possible to "quick-ripen" fruit with a 900-gauss magnet. For example, a number of tomatoes placed at various distances around the magnet poles (anywhere from 3 to 17 inches away) will show varying rates of ripening. Those closest to the magnet will be the first to turn red. Horticulturists at the University of Utah believe that the earth's magnetic field activates an enzyme system inside fruits and vegetables causing them to ripen and artificially when the fruit is placed near a powerful magnet.

The prototype was constructed in sections on independent circuit boards, but any other physical arrangement may be used as well as any type of cabinet.

AUDIO OUTPUT L PAD VOLUME CONTROL



### DC BOOSTER

In tests performed on a tree by the U. S. Department of Agriculture at the University of California in 1964, the application of about 58 volts dc (negative electrode high in the tree, positive attached to stainless steel nail driven in the base of the trunk) showed that leaf density on the electrified branches increased substantially after 28 days. Over a much longer period of time, the leaf growth was 300% over that on the non-electrified branches.

It was also noticed that when a sensitive dc voltmeter was connected between two conductors driven into a living branch (one at the center of a cut-off portion; the other in the layer just under the bark), cutting twigs or branches in any other part of the tree produced a sudden fluctuation on the meter. Even burning a leaf produced a noticeable effect. Not only did the natural voltage rise and fall; at times it even reversed polarity. There is no explanation for this effect.

response detector whose schematic is shown in Fig. 1. The detector has both visual (meter) and acoustical (speaker) indications of plant reaction. The audio tone output can also be connected to a conventional audio tape recorder and a pen-type recorder can be connected to the dc amplifier output to make permanent records of results.

The schematic is divided into four operational sections: the Wheatstone bridge input with exciter and input-output polarizer; an op amp guard circuit having a disabling feature; a high-gain dc operational amplifier; and an audio tone generator whose frequency varies with the potential generated in the plant. The op amp used has a large-signal gain of 100,000 and has built-in short circuit protection.

The circuit can be assembled on perf board or a printed circuit board. Be careful to avoid heat damage when soldering the IC and other semiconductors. Observe the polarity of the electrolytic capacitors. Either a well-filtered dual 9-volt power supply or 9-volt batteries may be used for the power source. Use a suitable metal chassis to house the detector, with the meter and all controls on the front panel.

**Connections to Plant.** The pickup electrodes which are attached to the plant (see Fig. 2) can be of almost any shape and any metal that has good conductivity. Stainless steel or silver electrode pairs

will work very well. Use of dissimilar metals can cause undesirable electrolysis. The effective size of the electrodes can be determined experimentally, but normally would be less than one inch in diameter. If it is found that the leaf resistance is very high, a larger diameter on the electrodes is required. If the plant has thin, moist, semi-opaque leaves, a smaller electrode is used. Leaf conductance can be enhanced by using electrocardiographic electrode contact cream, such as ECG KONTAX (Cat No. 391, Birtcher Corp., Los Angeles, CA 90032). It is water soluble and should be wiped off plant leaves after the experiment is complete. Give the leaf a good rinse after that. Connections to the electrodes are made through a shielded pair cable. The electrodes are insulated from the metal clamp by pieces of plastic with the leaf gently compressed between the electrodes. Using the bridge resistor values shown in Fig. 1, the resistance between the electrodes should not exceed 250,000 ohms. Also keep in mind that the plant generates a small current of its own which, depending on the setting of switch S2, is superimposed on the excitation current flowing in the circuit.

### THE BACKSTER EFFECT

Cleve Backster, one of this country's leading authorities on the polygraph (lie detector) connected a pair of electrodes to a leaf of a *dracaena massangeana* while it was being watered. Surprisingly, the plant's psychogalvanic reaction pattern resembled that of a human subject exposed to emotional stimulation.

In further tests, Backster decided to ignite a match and burn the leaf to which the electrodes were attached. At the instant that the thought image occurred in his mind, a dramatic change appeared on the plant's polygraph readout. Tests were carried out on other living matter including paramecium, fresh fruits and vegetables, amoeba, mold cultures, scrapings from the roof of a human mouth, and yeast. All showed similar results. It would appear that there is an unknown communication between all living things, outside the orthodox electromagnetic spectrum. For example, placing plants in lead-lined, Faraday-screened cages, fails to suppress the phenomenon.

It also appears that plants form some sort of emotional attachment to their owners. Cleve Backster has reported that one plant responded to his emotional attitude at a distance of over 1000 miles. Obviously, much work remains to be done in this area.

**Theory of Circuit Design.** The resistance of the plant leaf, connected to BP1 and BP2, forms part of a Wheatstone bridge with the other arms formed by R1 and the two portions of R2. Power for the bridge is supplied by B1 controlled by R3. The final values of R1 and R2 are determined by the type of plant leaf being used. The resistances must be increased when the leaf is thin and sensitive to avoid over-excitation and undesirable side effects.

The input/output polarizer switch S2 permits reversal of the current applied to the plant leaf since living matter tends to saturate and gradually cease to function as an organic resistor.

The offset signal from the bridge is amplified in IC1, which is guarded by diodes D1 and D2. When S3 is closed, these diodes limit the input voltage to the op amp and protect it from large signals. However, once the circuit is operational and maximum sensitivity is required after M1 has been nulled, S3 can be opened. The output of the dc amplifier is indicated on a meter and can be used to drive a dc pen recorder if a permanent record is desired. The output also drives an audio oscillator (Q1 and Q2) whose frequency is a function of the dc signal. Transformer T1 couples the audio tone to an optional audio tape recorder and to an internal speaker. Capacitor C3 and resistor R16 provide feedback for the oscillator.

The circuit is sensitive to a few micro-amperes of input current, and when this current changes as a result of plant stimulation, the bias on Q1 changes to alter the pitch of the oscillator. Indicator lamp I1 momentarily activated by pushbutton switch S7, permits intermittent tests of battery voltage and provides for the injection of cue markers on a tape recorder since the pitch increases when S7 is activated. Power to the audio oscillator is controlled by switch S5.

Transformer T1 provides an audio output for the tape recorder at all times regardless of the position of S6. In one position of S6, R17 serves as a load; while in the other position, R21, an 8-ohm pad, is the load. Volume control is essential since the beep in the audio tone is annoying to listen to and can produce an undesired stimulus to the plant.

While performing a particular experi-

ment, the audio signal can be fed to one channel of a conventional stereo tape recorder, while the other channel is supplied with time markers (from WWV or CHU) or vocal announcements. This permits recording of vocal stimulus to the plant as well as the plant's response.

**Conducting Tests.** In connecting the electrodes to the leaf, apply just enough pressure to make a good contact with the leaf without crushing it. Place the guard switch (S3) in the closed position to protect the IC from an excessive input signal.

When S1 is turned on, power is applied to the bridge circuit at a level determined by R3. Then turn on S4 to activate the op amp IC. Potentiometer R2 is adjusted for a meter null indication. This null may have to be re-adjusted when the plant is in a non-stimulated condition. Note the pitch of the audio tone coming from the speaker when the plant is quiescent. A change in pitch, as well as in the meter indication, may result when the plant's well-being is threatened.

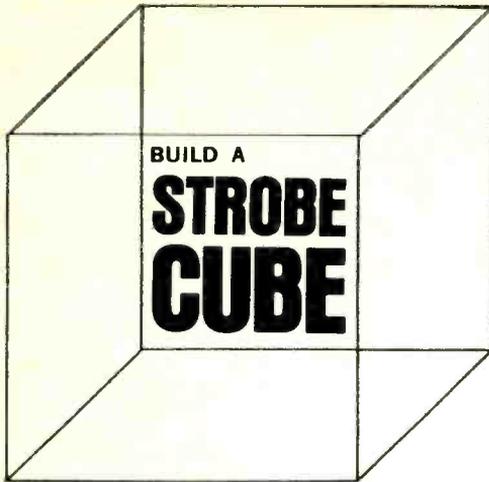
The amount of excitation (via R3), and the state of the input/output polarizer switch S2 must be determined by actual use. Obviously, the gain control (R8) can be adjusted to obtain more or less sensitivity, and S3 can be opened to increase the gain of the dc amplifier.

There is very little more to be said about the use of the response detector. Patience and repetition are the key words. Obviously, also, controlled conditions are a must. The area in which the plant lives must be quiet so that stimuli can be applied. There should be a minimum of power-line noise to avoid fluctuations in the audio and meter indications. There should be no r-f transmitters in the vicinity to cause faulty indications. ♦

---

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## FLASHER FOR POP MUSIC OR MOTION-STOPPING STROBE

BY RICHARD M. FISHER

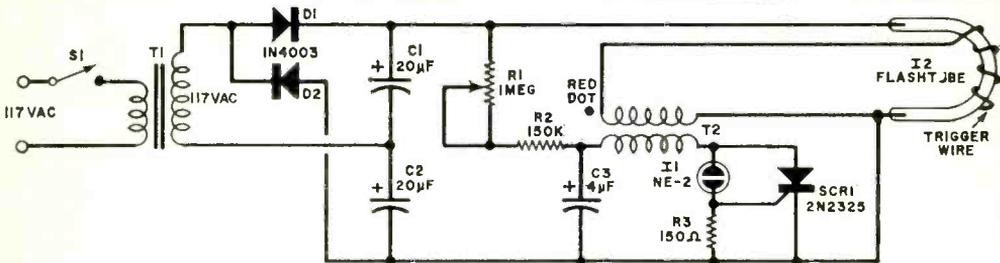
**A**LTHOUGH electronic strobes are most often used in industrial and photographic applications, the dramatic effect of a flashing light makes a nice complement to the modern pop-music scene. It also makes a good, hard-to-miss, obstruction warning light.

The Strobe Cube described here can be used for both purposes, and it has a variable flashing rate (with a maximum that does

not do harm to the eye). Any type of container can be used though the kit mentioned in the Parts List includes a square translucent plastic box.

**Theory of Operation.** The circuit is shown in Fig. 1. Isolation transformer *T1* is optional, but its use is recommended in the interest of safety. When the power is on, capacitor *C3* is charged up through the combination of *R1* and *R2*. The voltage across *R2* is also coupled through *T2* to the anode of SCR1. As soon as the voltage reaches the flashover potential of neon lamp *I1*, a positive pulse is applied to the SCR gate. This causes the SCR to turn on and *C3* is discharged through the primary of *T2*. A high-voltage spike is then generated across the secondary of *T2* and is applied to the trigger electrode of the flashtube. The main dc power is also applied across the flashtube, so that as soon as the trigger pulse occurs, the gas in the tube ionizes producing a bright flash of white light. Capacitor *C3* is discharged, and the process repeats. The flash rate is determined by the resistance setting of *R1*.

**Construction.** A PC board foil pattern and component layout are shown in Fig. 2. Optional transformer *T1* is not on the board. Install all the components except the flashtube, observing the proper polarities.



### PARTS LIST

- C1, C2*—20- $\mu$ F, 250-volt electrolytic capacitor
- C3*—4- $\mu$ F, 150-volt electrolytic capacitor
- D1, D2*—Diode (1N4003)
- I1*—NE-2 neon lamp
- I2*—5-watt flashtube (see note)
- R1*—1-megohm linear-taper potentiometer (with integral *S1*)
- R2*—150,000-ohm,  $\frac{1}{2}$ -watt resistor
- R3*—150-ohm,  $\frac{1}{2}$ -watt resistor
- S1*—Spst switch (on *R1*)
- SCR1*—Silicon controlled rectifier (2N2325)

*T1*—117V:117V isolation transformer (optional)

*T2*—Trigger transformer (see note)

Misc.—Suitable translucent plastic cube, mounting brackets, TV cheater assembly, knob, mounting hardware, etc.

Note—The following are available from DEC, 45 First Ave., New York, NY 10003: 5-watt flashtube (FT-10A), \$3.75; trigger transformer (TR-1A), \$2.00; SCR1, \$2.00; PC board, \$4.00; PC board and all parts (except *T1*), \$15.95; Plexiglass cube, \$5.95; complete kit, \$20.95. Add \$1.35 on all orders to cover postage and handling.

Fig. 1. Flashtube is triggered when SCR1 turns on and charge on *C3* leaks off through *T2*.

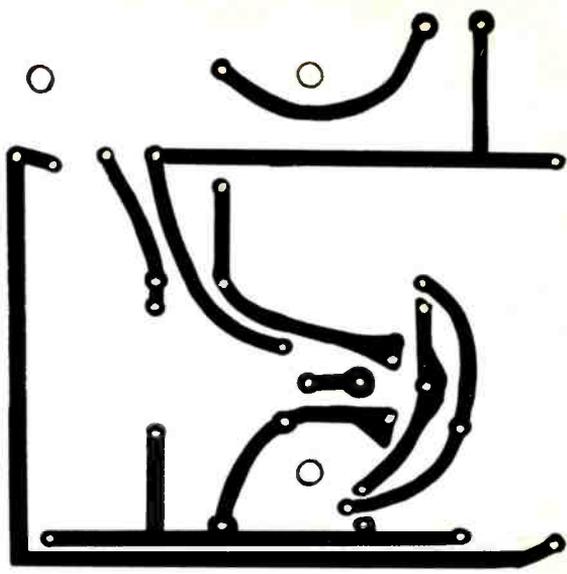
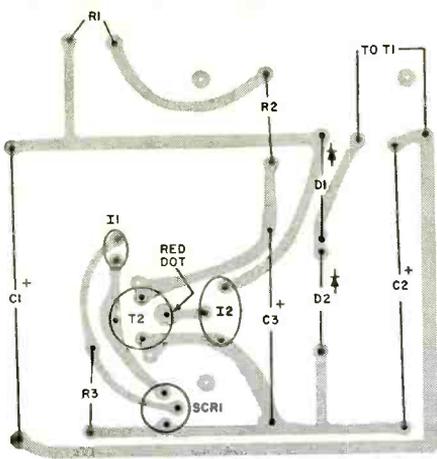


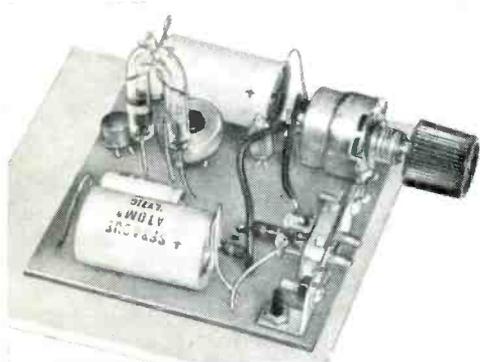
Fig. 2. Actual size foil pattern for the strobe cube is shown at right. Components are mounted as shown above.

The flashtube has three leads, one at each end of the U tube and one connected to a strap around the tube. The latter connection is the trigger electrode. Solder a short length of thin wire to this electrode and wrap it around the tube four times, making sure that the wire does not contact either of the other two leads. Wrapping the wire around the tube increases the trigger lead surface contact. Mount the flashtube in place, noting that the cathode has the large electrode and should be connected to the minus side of the power supply. Trigger transformer *T2* has a red dot at one pin (the high-voltage pulse terminal) and must be connected as shown.

A conventional TV "cheater" connector was used on the prototype to make the ac contacts.

**Testing and Installation.** Connect the ac cord to the isolation transformer and turn on *S1* (located on *R1*). A 3-ampere fuse may be used to protect the circuit until you are sure that it works properly. Do not touch the circuit until you have made sure that all capacitors have been discharged. Changing the setting of *R1* will cause the strobe to flash at different rates.

If you make the cube, mount the PC board on the bottom plate, remembering that the potentiometer mounting hardware is used to hold the bottom plate to the remainder of the cube. Cut a small hole in the side of the cube where the potentiometer is located. The rest of the cube is cemented together and a small piece of plastic is cemented to the side opposite the potentiometer hole so that a small holding screw can be inserted through the bottom. ♦



All components except *T1* are mounted on PC board as shown on prototype.

**OPERATING CONDITIONS**

The equivalent series capacitance of *C1* and *C2* is 10  $\mu$ F. The energy input to the tube, per flash, is  $E = \frac{1}{2}CV^2 = \frac{1}{2}(10 \times 10^{-6})(340)^2 = 0.578$  joule. At six flashes per second, the total power to the tube is 6 times the energy per flash or  $3\frac{1}{2}$  watts, which is well within the 5-watt rating of the flashtube. Approximately 9 flashes per second will hit the 5-watt limit. With the circuit enclosed, any heat generated remains in the enclosure. Therefore, if the flasher is to run continuously near its maximum rate, ventilation holes must be used.

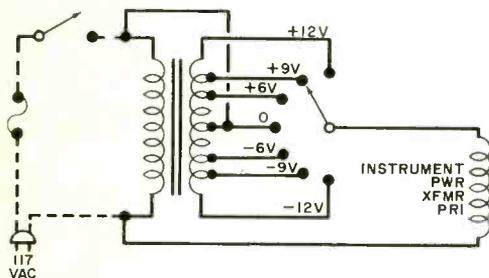
# POWER-LINE BOOSTER/REDUCER

OFFSET VOLTAGE FLUCTUATIONS  
SIMPLY AND INEXPENSIVELY

BY FRANK H. TOOKER

**P**OWER-LINE fluctuations are common occurrences these days. In some localities, periodic voltage increases can be observed. In other localities, especially in large urban areas where peak demand can exceed the power company's ability to supply, voltage reductions are a way of life. Whether they are increases or decreases, changes in the line voltage that is supplied to some test instruments can have adverse effects on the instruments' operation.

It is necessary, therefore, to supply any voltage-sensitive instruments on your workbench with a facility for offsetting power line fluctuations. To accomplish this, you can install a booster/reducer right in the equipment by connecting a transformer in the primary circuit of each instrument.



Instruments that are voltage-sensitive must be protected from power-line fluctuations. This circuit does it easily with only a transformer and rotary switch. Addition or subtraction of 12 volts is obtained in 3-volt increments taken from taps on transformer.

Ordinarily, a power-line booster/reducer requires several switches to provide the needed functions. This makes the setup shown in the schematic diagram especially interesting inasmuch as the boosting, reducing, and in/out functions are all accomplished by means of a single 7-position rotary switch. A multi-tap transformer, with

three outputs on each side of the center-tap, makes the simplification possible.

With the switch set at its center position, the output voltage from the transformer into the instrument's power transformer primary is unchanged from that supplied by the ac line. However, when the switch is set to any other position, the system adds or subtracts the amount of voltage selected from the line-voltage level. By this means, a maximum addition and subtraction of 12 volts can be obtained in 3-volt increments, starting at 6 volts. Electrically, whether addition or subtraction takes place is a matter of phasing.

The Burstein-Applebee Co. Stock No. 13A-902 transformer, which can be purchased for \$4.99 plus postage, is rated at 1 ampere. It is very well made, with the primary and secondary wound on a nylon bobbin. When selecting a rotary switch, get one with contacts rated at 1 ampere at 117 volts. If possible, choose a ceramic type over the phenolic type.

Most test instruments have more than enough space inside their cabinets to accommodate the extra transformer. If this is the case in your instrument, locate the booster/reducer transformer as close to both the instrument's power transformer and fuse assembly as possible.

Unless the front panel of the instrument is extremely crowded—and few are—the add-on rotary switch can be mounted in any convenient location on the panel. However, when mounting the switch, make absolutely certain that it does not interfere with the operation of other switches and controls nearby. Also, when wiring the switch to the booster/reducer transformer and the primary of the instrument's power transformer, use No. 18 stranded wire. If practical, use the heavy wire leads on the add-on transformer to connect it to the switch. Do not ground any part of the add-on assembly. ♦

# Testing Power Supplies

SIMPLE CIRCUIT IS HIGHLY ACCURATE

BY JAMES N. DEMAS

**A**T ONE TIME or another it becomes important to be able to check the line and load regulation of low-voltage power supplies. Besides being of intrinsic interest, such data are highly practical. Many circuits are fussy about their power requirements, and poor performance or blown components may result if power regulation is off.

For supplies of modest performance (0.1 to 2% regulation), checking the output can get to be a bit sticky. Multi-meters do not have the necessary resolution; and better meters are usually too expensive. Consequently, performance is

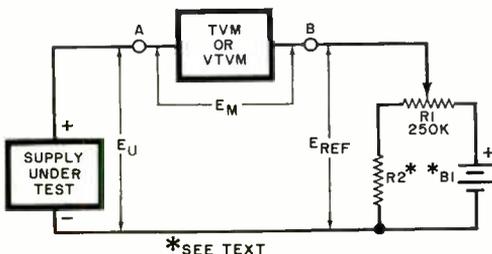
rarely verified; the experimenter just crosses his fingers and suffers the consequences if something goes wrong.

Fortunately, a neat, inexpensive solution to this problem exists for supplies delivering five or more volts. All you need is a suitable battery, a potentiometer, a fixed resistor, and a high-input impedance TVM or VTVM with a low dc voltage full-scale readout.

**How It Works.** The circuit (shown in Fig. 1) can be breadboarded quite easily in a few minutes. Potentiometer  $R1$  and resistor  $R2$  are in series across the battery,  $B1$ . Thus, depending on the setting of  $R1$ , a wide range of dc voltage is possible between the rotor of  $R1$  and the negative battery terminal. The voltage of the battery should be slightly higher than that of the supply being measured. Resolution is improved if  $R1$  is a multi-turn potentiometer.

The voltage from the battery ( $E_{REF}$ ) and the supply to be tested ( $E_U$ ) are connected as shown. A voltmeter connected between points A and B indicates the difference between the two voltages. The difference can be nulled by adjusting the reference voltage. As long as the refer-

Fig. 1. Reference voltage bucks out tested voltage until the voltmeter indicates zero.



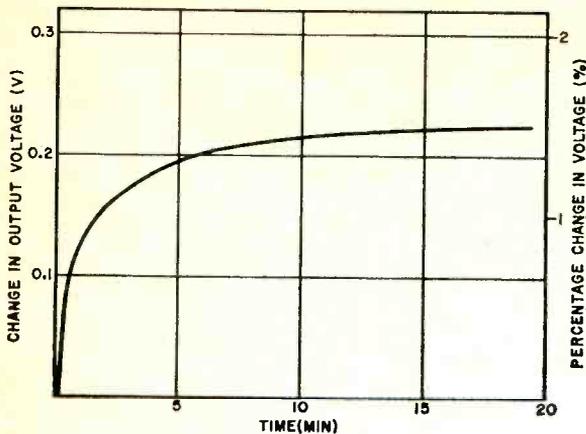


Fig. 2. A typical chart of variation of the output of a homemade power supply over 20-min period.

ence is stable, any changes in  $E_V$  (resulting from warm-up drift, line or load variations, etc.) appear as meter indications. For example, if  $E_V$  is 10 volts and the voltmeter is set to its 0.3-volt range, a deflection to 0.1 volt would mean a 1% change in  $E_V$ . A change of 0.01 volt, which is easily read, corresponds to a 0.1% change in  $E_V$ . Thus, even a well regulated supply can be checked.

**Comments on Use.** The voltage of  $B1$  must be high enough for  $E_{REF}$  to equal  $E_V$ . Because of the low current drain, ordinary 9-volt transistor radio batteries may be used: one for supplies of 5 to 9 volts, two for 8 to 18 volts, and 3 for 17 to 27 volts. Resistor  $R2$  should be about 175,000 ohms for one or two batteries; 350,000 ohms for 3 batteries. Even low-cost batteries have a stability better than 0.05% over a period of one hour.

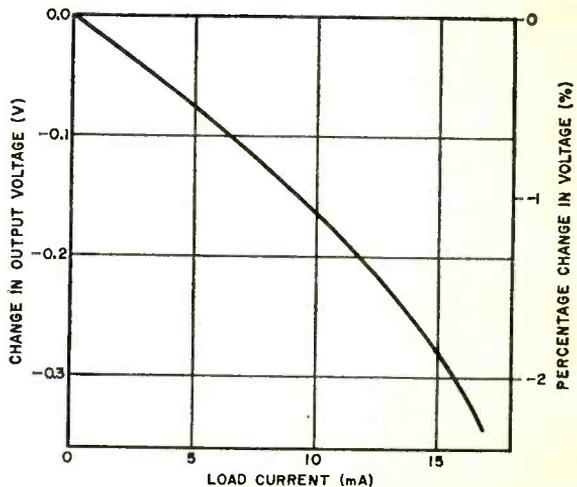
Keep in mind that the voltmeter may drift with time. To zero the meter, remove one lead from the test circuit and short it to the other. Do not short the meter while it is in the circuit. As  $B1$  ages, it will become too unstable for meaningful data to be obtained. If drift is noted when a new battery is put in, then you can be sure that a new one was needed.

Allow the reference supply to warm up for about 15 minutes; then adjust  $R1$  to obtain a null on the meter when  $E_V$  is turned on. When the zero is obtained, call it time zero. Note the meter indications at appropriate time intervals (every five minutes, for example) and record

them. The percent regulation is  $(E_M/E_V) \times 100\%$ . A chart of variations will look somewhat like that shown in Fig. 2.

Output regulation as a function of load can also be plotted as shown in Fig. 3. In both of these examples, the supply was a homemade low-cost 15-volt circuit. Line regulation can be also checked by using a Variac or similar voltage-variable source in the input. In this case, a 10% change in line voltage produced a regulation of 0.45% (67 mV). This shows that accurate measurements can be made, even with supply changes under 1%.  $\diamond$

Fig. 3. Output regulation as a function of load current can be plotted as shown here.



# Build a DIGITAL LOGIC TRAINER



BABY COMPUTER PERFORMS 32 FUNCTIONS  
AND TEACHES BOOLEAN ALGEBRA

BY JACK CAZES

**T**HERE have been quite a number of articles appearing in various magazines covering digital logic. In most cases, they dealt with simple applications of logic in clocks, frequency counters, or digital multimeters. However, there are very few articles covering the use of digital logic in computation—such as the construction of real digital computers.

The digital logic computer described here is an arithmetic/logic function generator that can perform 16 binary arithmetic operations including addition, subtraction, decrement, and straight transfer and 16 logic functions including AND, NAND, OR, NOR, Exclusive-OR, and comparator. Not only will this combination allow you to learn and use binary arithmetic, it will also enable you to study logic and Boolean algebra.

To use the computer, all you do is set the appropriate selector switches and enter the data as two 4-bit words. There is no re-wiring or patching required for any of the 32 available functions.

The computer is designed around a medium-cost IC (75 equivalent gates on a single chip) and a multi-contact rotary switch.

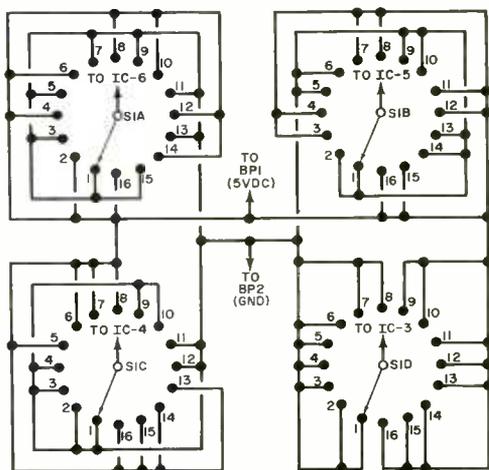
**Construction.** There are no special construction techniques required and lead dress is not critical. Of course, neat layout of the leads will result in a more esthetically appealing unit as well as one that is easier to troubleshoot, should the need arise. In the prototype shown in the photographs, many of the leads (those interconnecting the IC, the function

selector switch, the binding posts, the lamp-driver board, the output lamps, and the bank of data input switches) were tagged with  $\frac{1}{8}$ "-wide numbered wire markers.

The computer is housed in a 7" × 5" × 3" aluminum case, with the 16-position function selector switch mounted horizontally at one end. All other switches, lamps, and binding posts are located on the front. The case should be drilled, painted, and marked, using dry transfer lettering, before mounting the components.

The function selector switch, *S1*, should be wired first, as shown in Fig. 1. It is convenient to complete this wiring outside the

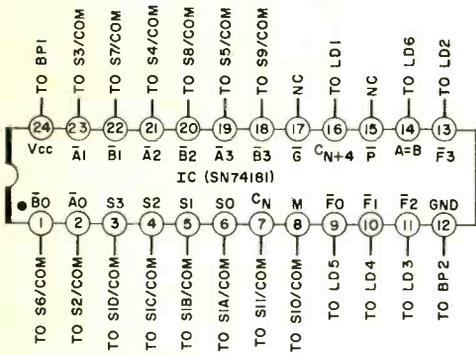
Fig. 1. Wire *S1* as shown here with connections to the IC, BP1 and BP2.



case, leaving leads 8 or 10 inches long, to be connected to the IC and *BPI* and *BP2*. Label these leads appropriately and mount the switch in the case.

Insert the 24-pin IC socket in the center of a 2" x 2" piece of perforated phenolic board (hole spacing, 0.100"). It is advisable to use a socket for the integrated circuit to prevent possible heat damage resulting from soldering directly to the IC. Connect the four leads from the rotors of *S1A*, *S1B*, *S1C*, and *S1D* to the IC socket according to Figs. 1 and 2. Connect long leads to all other IC socket pins except #15 and #17, marking them with their respective pin numbers, and then mount the board in the case.

Wire the six lamp-driver circuits as shown in Fig. 3. Here again, it's convenient to use



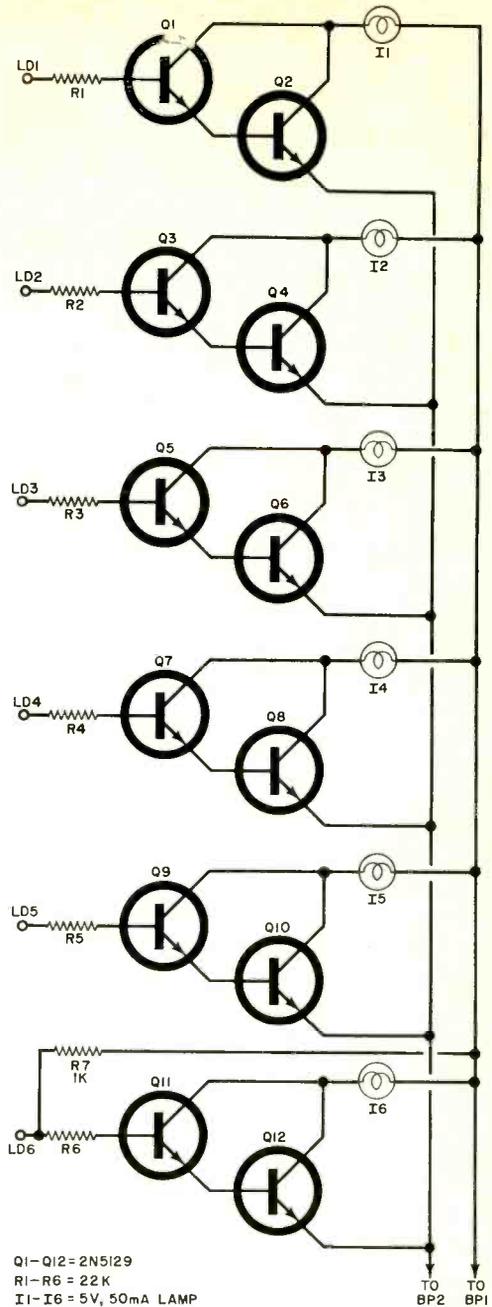
NOTE: S6/COM MEANS "THE COMMON TERMINAL OF S6"  
NC = "NO CONNECTION"

Fig. 2. Top view of connections to the IC. It is best to use a socket.

a small piece of perf board to mount the resistors and transistors. The lamp assemblies are mounted in the front of the case and then wired to the driver circuits inside the case.

Using Fig. 4 as a guide, install all of the wiring that interconnects *S2* through *S11*. The leads running from the IC socket to *S2* through *S11* should now be connected. The only remaining task is to connect all leads going to the two binding posts and the lamp-driver circuits (*LD1-LD6*) from *S1*, *S2* through *S11*, and the IC socket. Wiring is now complete. Check all of your wiring carefully and, when you're sure all is correct, plug in the integrated circuit. You're now ready to try out your computer.

**Testing and Operation.** Connect a regulated 5-volt dc supply to *BPI* (pos.) and *BP2* (neg.). This will provide supply voltage to the IC and the lamp-driver circuits, and



Q1-Q12 = 2N5129  
R1-R6 = 22 K  
I1-I6 = 5V, 50mA LAMP

Fig. 3. Lamp drivers with high input impedance display the final result.

logic 1 level voltage to the input and function selector switches. Internal grounding represents the logic 0 state at the various inputs. In actual operation, outputs at a logic 0 level will be near zero volts, whereas outputs at a logic 1 level will be well above zero (3 volts).

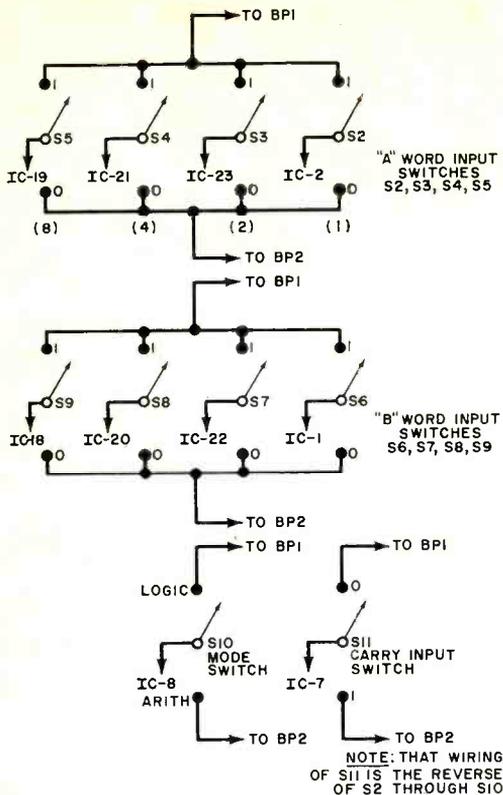


Fig. 4. Wiring of mode of operation switches and those for word inputs.

A logic 0 state will result in an unlit lamp, whereas a 1 state will turn the lamp on.

Arithmetic functions are obtained by setting *S10* to ARITH and *S11* to the logic 0 position. The desired function is then selected from Table I and function selector *S1* is set to the appropriate position.

For logic functions, *S10* must be set to the LOGIC position. Setting of *S11* is irrelevant in this case. The desired logic function is selected from Table II and *S1* is set to the appropriate position. In this mode of operation, the internal carry is disabled. Thus, one can enter four different combinations of input conditions and observe their respective outputs simultaneously.

Exhaustive testing of the computer would require going through each of the 32 available functions, setting the "A" and "B" input switches to all of their possible combinations and seeing that the result is what it should be. This would be beyond the scope of this article and is probably unnecessary. However, using Tables III and IV as guides to typical operation, set the input

TABLE I—ARITHMETIC FUNCTIONS

S1 Position	Function
1	A
2	A + B
3	A + $\overline{AB}$
4	Minus 1*
5	A plus $\overline{AB}$
6	(A + B) plus $\overline{AB}$
7	A minus B minus 1**
8	$\overline{AB}$ minus 1
9	A plus AB
10	A plus B
11	(A + $\overline{B}$ ) plus AB
12	AB minus 1
13	A plus A***
14	(A + B) plus A
15	(A + B) plus A
16	A minus 1

General Note: Plus signs are logic OR functions (as in positions 1, 2, and 3 of switch *S1*). Arithmetic functions are spelled out.

\*Displayed as its 2's complement.

\*\*Also used for comparator function, A=B.

\*\*\*Each bit in binary A shifts to the next more significant position.

switches as shown and check to see that your output levels correspond to those given in the tables.

The expressions shown in Tables I through IV are written in Boolean algebra. Let's briefly review the notational system used:

1. A "high" or "yes" logic level is written as 1, whereas a "low" or "no" logic level is written as 0. An exception to this notation is at the CARRY OUT. Here, because of the way in which the IC was designed, the reverse is true. Thus, when CARRY OUT is 0, its voltage level is high, (lamp turned on),

TABLE II—LOGIC FUNCTIONS

S1 Position	Function
1	$\overline{A}$ (Inversion of A)
2	$\overline{A + B}$ (NOR)
3	AB
4	Logic 0
5	$\overline{AB}$ (NAND)
6	$\overline{B}$ (Inversion of B)
7	$A \oplus B$ (Exclusive OR)
8	$\overline{AB}$
9	$\overline{A + B}$
10	$A \oplus B$
11	B
12	AB (AND)
13	Logic 1
14	A + B
15	A + B (OR)
16	A

**TABLE III—  
ARITHMETIC FUNCTION TESTS  
(Set S10 to ARITH, S11 to 0)**

S1	A input B input		Output		
	8421	8421	Carry	8421	A = B
1	1010	0101	1	1010	0
2	0011	1010	1	1011	0
3	0011	1010	1	0111	0
4	0000	0000	1	1111	1
	1111	1111	1	1111	1
5	1111	0000	0	1110	0
6	0101	0100	1	0110	0
7	0000	0000	1	1111	1
	1000	0011	0	0100	0
	0011	1000	1	1010	0
8	0000	0000	1	1111	1
9	0110	1001	1	1100	0
10	1000	1100	0	0100	0
11	1110	1001	0	0110	0
12	1111	1011	0	1010	0
13	0101	0000	1	1010	0
14	0100	0001	1	1001	0
15	0100	0001	0	0010	0
16	1000	0000	1	1111	0

and vice versa. If this becomes annoying, you can reverse the output by inserting an inverter stage between pin 15 of the SN74181 and *LD1*.

2. A line over an expression means "not." Thus,  $\bar{A}$  is read as not A, and  $\bar{B}$  is read as not B. If  $A = 1$ , then  $\bar{A} = 0$ , and vice versa.

3.  $AB$  is read as A and B.  $\overline{AB}$  is read as A and not B.

4.  $A + B$  is read as A or B.  $A + \bar{B}$  is read as A or not B.

5.  $A \oplus B$  is read as exclusively A or B.

**TABLE IV—LOGIC FUNCTION TESTS  
(Set S10 to Logic, S11 irrelevant)**

S1	A input B input		Output		
	8421	8421	Carry	8421	A = B
1	0101	0000	1	1010	0
2	1001	1100	1	0010	0
3	1010	0011	1	0001	0
4	0000	0000	1	0000	0
	1111	1111	1	0000	0
5	1001	1010	1	0111	0
6	0000	1111	1	0000	0
	0000	0000	1	1111	1
7	0101	0110	1	0011	0
8	0101	0110	0	0001	0
9	1100	1010	0	1011	0
10	1100	1010	0	1001	0
11	0101	1001	1	1001	0
12	0101	1001	0	0001	0
13	0101	1001	1	1111	1
14	1100	1010	0	1101	0
15	0101	1001	1	1101	0
16	0101	1001	0	0101	0

6. Arithmetic addition and subtraction are written as "plus" and "minus", respectively.

**Using the Computer (Addition).** Binary addition of two 4-bit numbers is accomplished by entering them as A and B and reading the result directly. If the result is greater than 15 there will be a "carry out" (CARRY OUT = 1, lamp off). Thus:

```

1 0 1 1 A (BINARY 11)
0 0 1 1 B (BINARY 3)
-----
1 1 1 0 SUM (NO CARRY OUT)

```

```

BUT 1 0 1 1 A (BINARY 11)
    1 1 0 0 B (BINARY 12)
    -----
    0 1 1 1 SUM (WITH CARRY OUT)

```



**Subtraction.** Enter the two numbers with which subtraction is to be performed into A and B inputs. The result, for Function 7 in Table I, will be A minus B minus 1, rather than only A minus B. The reason for this can be understood by examining the procedure by which subtraction is performed within the integrated circuit. We must first, however, define a couple of terms.

1. If each bit in a binary number is inverted (i.e., zeroes changed to ones, and vice versa) the result is known as the "1's complement" of the number. For example, given the binary number 1 1 0 1, its 1's complement would be 0 0 1 0. Note that the sum of a binary number and its 1's complement is always a binary number composed of all ones (1 1 0 1 plus 0 0 1 0 = 1 1 1 1). A number can be converted to its 1's complement in the computer with S1 in logic position 1 for a binary number entered into A and with S1 in logic position 6 for a binary number entered into B. Set your computer for LOGIC with S1 on 1. Enter binary 1100 into A and observe that the output reads 0 0 1 1, the 1's complement of the entered number.

2. If the 1's complement of a number is increased by one (i.e., add 1 to it) the result is called the 2's complement. Thus, the 2's complement of 1 1 0 1 would be

```

1 1 0 1 GIVEN NUMBER
0 0 1 0 1'S COMPLEMENT
-----
PLUS 1 ADD 1
-----
0 0 1 1 2'S COMPLEMENT

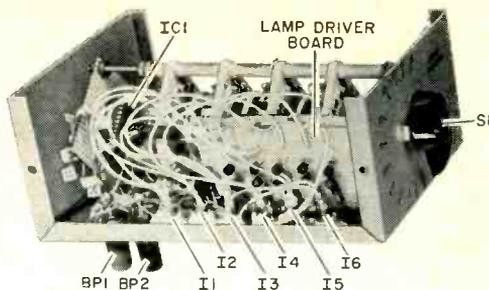
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Now let's return to the mechanism by which subtraction is performed. To subtract B from A, the 1's complement of B is added



**Comparator Functions.** To use the A = B comparator function, set the computer up for subtraction (*S10*: ARITH; *S11*: 0; *S1*: 7). Whenever A is equal to B, the A=B output will be in a 1 logic state (lamp on). A second comparator function works as follows. With *S10* on ARITH and *S1* on 7, there are four possible conditions: (1) with *S11* = 0 and CARRY OUT on, A is less than or equal to B; (2) with *S11* = 1 and CARRY OUT on, A is less than B; (3) with *S11* = 0 and CARRY OUT off, A is greater than B; and (4) with *S11* = 1 and CARRY OUT off, A is equal to or greater than B.

**Logic Functions.** The sixteen available logic functions shown in Table II as Boolean algebra expressions will accept four different sets of input conditions and provide the four resultant outputs simultaneously; this is because when the computer is set up in the logic mode, the internal carry is disabled.



The computer is simple to build when wired in sections as in Figs. 1 to 4.

Equivalent logical block diagrams are shown in Fig. 5 for some of the available functions. To use them, set *S10* to LOGIC and *S1* to the desired function. Enter input conditions via A and B, as required by the function selected; up to four conditions may be entered simultaneously. Observe the resultants at the four outputs. ♦

# NOVEL USE for LED

AN AID FOR THE HARD OF HEARING

BY ROLAND J. McMAHAN

Light-emitting diodes (LED's) are now widely used as power-on indicators or state readouts, or in other reasonably complex indicator circuits. However, an LED can also be fun and very handy when used in some non-critical and unusual circuits.

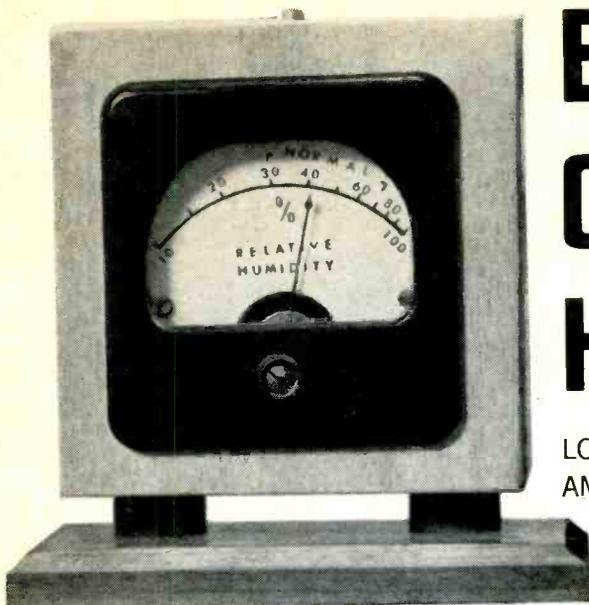
A typical LED operates in the potential range between 1.2 and 3 volts and requires a maximum current of about 20 mA. Considering its small size, it can generate a surprising amount of useful light.

The voltage required for the one watt of power for a conventional 8-ohm speaker is within the LED range. Try clipping an LED across the speaker voice coil and watch the light flicker with the program material. With LED's available in different colors, here is a chance to make the world's simplest and smallest color organ.

**For the Handicapped.** If you connect an LED to the speaker terminals of a telephone amplifier, it makes an interesting and helpful item for the deaf. With the phone in

the amplifier cradle, the LED will glow steadily if the volume is brought up and there is a dial tone. A busy signal is indicated by a fast flashing; ringing by a long steady, intermittent glow; and a received voice produces a variable-strength glow. Deaf people have easily recognized the signal difference between "no" and "OK." Thus, by judicious questioning, they can find out if their spoken message has been understood. If the deaf person is also mute, a buzzer or an audio oscillator at each end of the line permits Morse code conversation over the telephone easily and without assistance.

An LED connected to the speaker terminals of a record player, in conjunction with a Morse code record, has been successfully used to teach the code to a group of deaf people. One deaf student will soon have her novice license; and with an LED at the audio output of her receiver, will have no problem holding conversations with other hams all over the world. ♦



# Electro- Chemical Hygrometer

LOW-COST UNIT MEASURES  
AMBIENT RELATIVE HUMIDITY

BY JOSEPH GIANNELLI

**W**HEN IT comes to determining how the current weather will affect us, the relative humidity is almost as important as the temperature. (Isn't that why the weather bureau gives us the temperature-humidity index every day?) There are many sophisticated ways of measuring the relative humidity; but if you would like to have your own hygrometer, here's a good direct-reading, fast-responding unit that can be built easily and cheaply.

Many salts, such as common table salt (sodium chloride), are hygroscopic in nature. That is, if the ambient atmosphere has a higher water vapor content (high humidity) than the salt, the salt absorbs the moisture until the vapor pressure of the salt equals the vapor pressure of the atmosphere. At that point the absorption stops, and the salt has some definite ohmic resistance. When the ambient atmosphere drops in humidity, the salt gives up its moisture, and has a higher ohmic resistance.

This change in resistance with humidity can be used in a standard bridge circuit with a meter that is calibrated in percent humidity. However, since salts exhibit some form of polarization to dc current, manifested by a continual resistance change as long as the dc is applied, it is necessary to use ac current in the circuit (see Fig. 1).

**Circuit Operation.** Transistor *Q1* and its associated components are arranged in a

twin-T oscillator configuration. With the values shown in Fig. 1, the frequency is about 400 Hz. The output of the emitter of *Q1* provides the ac signal to the bridge. Power is supplied to the meter during the positive half cycles. The two variable controls (*R5* and *R6*) are used to set the two ends of the meter scale.

**Construction.** The circuit can be assembled on a small PC board using the foil pattern shown in Fig. 2. The board is mounted directly on the meter terminals through the two holes on top of the board. Large solder lugs are used to make the electrical connections to the meter terminals.

Construction of the sensor is shown in Fig. 3. A 1/2"-wide strip of fiberglass cloth (about the same weight as a handkerchief) is mounted as shown. After clamping both ends in the brass plates, the weave threads are removed from the cloth to improve the response time. The completed sensor is dipped into a solution of lithium chloride (a mound of the salt about the size of a dime dissolved in a tablespoon of water). After soaking the sensor, shake off the excess solution and allow the sensor to dry.

**Calibration and Test.** When assembly is complete and the sensor is dry, attach about 8 inches of insulated wire to each end of the sensor, connect it to the circuit, and suspend the sensor in an 8-ounce jar contain-

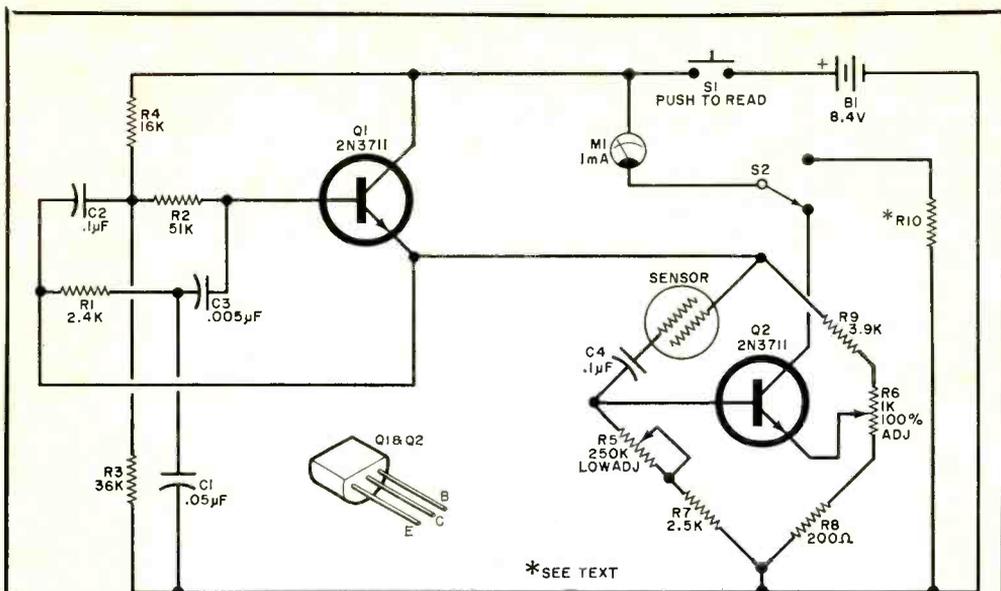


Fig. 1. Twin-T oscillator circuit (Q1) provides the depolarization current for the humidity sensor which is one leg of a bridge circuit, with meter driver Q2.

### PARTS LIST

B1—4.2-volt mercury battery (2 required)  
 (Mallory TR133 or similar)  
 C1—0.05- $\mu$ F Mylar capacitor  
 C2, C4—0.1- $\mu$ F Mylar capacitor  
 C3—0.005- $\mu$ F Mylar capacitor  
 M1—1-mA (or less) meter  
 Q1, Q2—2N3711 or 2N3392 transistor  
 R1—2400-ohm resistor  
 R2—51,000-ohm resistor  
 R3—36,000-ohm resistor  
 R4—16,000-ohm resistor  
 R5—250,000-ohm, PC-type potentiometer

R6—1000-ohm, PC-type potentiometer  
 R7—2500-ohm resistor  
 R8—200-ohm resistor  
 R9—3900-ohm resistor  
 R10—(see text)  
 S1—Normally open pushbutton switch  
 S2—Spdt slide switch  
 Misc.—Battery holder, 25,000-ohm potentiometer for 100% check, suitable chassis, fiberglass cloth (handkerchief weight), lithium chloride (1 oz, available at chemical supply houses or Conso-Lab Supply Co., 7 Endo Blvd., Garden City, NY 11533), hardware for sensor, mounting hardware, etc.

ing a wad of water-soaked tissue. Do not allow the sensor to touch the wet tissue. The sensor leads can be brought out under the jar lid. After a few minutes, place S2 in the bridge position, depress pushbutton S1, and adjust R6 to obtain a 100% indication on the meter scale. When you are satisfied that the reading repeats after a few more minutes, remove the sensor from the jar, disconnect it from the circuit, and substitute a 25,000-ohm potentiometer for the sensor. Adjust this potentiometer to obtain a 100% indication on the meter. Dry the sensor by placing it in the air stream from a fan.

Without disturbing the setting of the 25,000-ohm 100% humidity potentiometer, remove it from the circuit (for use in later checks), and re-connect the dried sensor.

To determine the local ambient humidity, use a conventional bulb thermometer to record the temperature. Then wrap the bulb with water-soaked tissue and place it in the

### PSYCHROMETRY TABLE

Percent Humidity	Dry Bulb	Wet Bulb	Dry Bulb	Wet Bulb	Dry Bulb	Wet Bulb
10	75	50	70	47	65	44
20		53		50		47
30		56.5		53		48.5
40		60		56		52
50		62.5		58		54
60		65		61		56.5
70		68		63		59
80		70		65.5		61
90		72.5		68		63

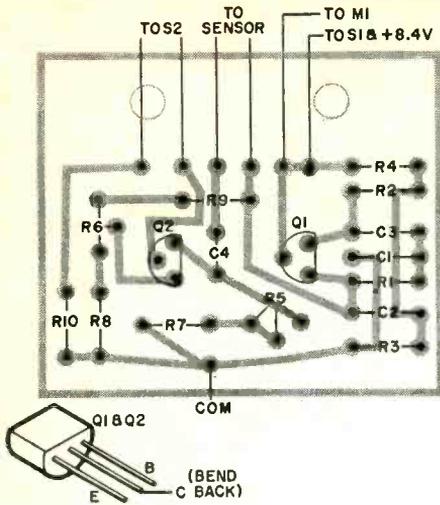
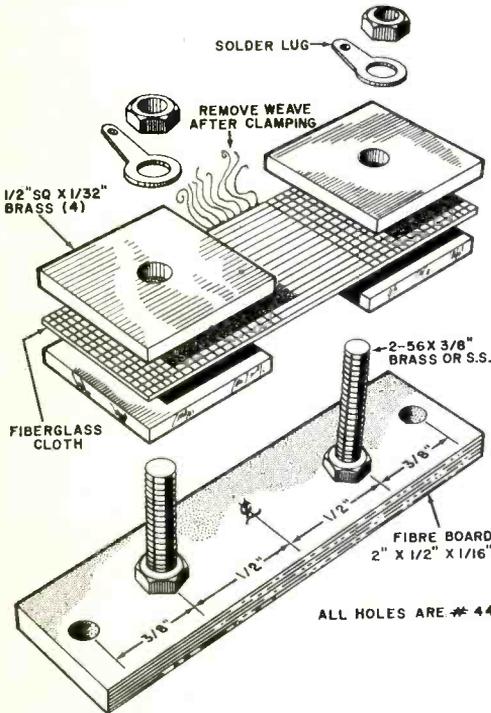


Fig 2. Foil pattern (right) and component layout (above). The board is mounted right on the meter terminals.

air stream from a fan. Record the lower temperature. The accompanying table is a greatly simplified psychrometric table that relates dry-bulb temperatures to wet-bulb temperatures and converts the two

Fig. 3. Sensor is a small piece of  $\frac{1}{2}$ " fiberglass with some weave removed.



readings to percent humidity. A more detailed psychrometric chart can be found in almost any book on air conditioning in your local library.

After a short period of time, the sensor will have taken on the local humidity and potentiometer *R5* can be adjusted so that the meter reads the same as the humidity determined from the dry and wet thermometer readings. Using the previously set 25,000-ohm potentiometer in place of the sensor, recheck the 100% point and adjust *R6* if necessary. Recheck the local humidity and adjust *R5* again if necessary. The two potentiometers (*R5* and *R6*) are set to obtain the best compromise. The two calibrated points will repeat accurately at room temperatures between 68° and 78°F, but will be off by about 10% at other temperatures. If you require better accuracy, many wet/dry-bulb readings may be made at different times, with required corrections noted. Then a new meter scale can be fabricated.

An increase in humidity will require about  $\frac{1}{2}$  to 1 second to register, but a decrease will require about 3 minutes to register.

Resistor *R10* is used to keep tabs on the battery. Use a value that will produce about a  $\frac{1}{4}$ -scale indication on the meter, with a new battery and *S2* in the battery test position. Mark this point on the meter scale. Typical values for *R10* are 11,000 ohms for a 1-mA meter movement and 22,000 ohms for a 0.5-mA meter. ♦

# TODAY'S Surplus-Equipment Dealers

BY ALEXANDER W. BURAWA

**M**ANY "new" electronics hobbyists have a distorted picture of what surplus parts and equipment dealers are and what type of wares they have to offer. They have a stereotyped picture of a dingy, dark shop crammed full of disorganized piles of junk.

While this may have been an accurate picture in the years immediately following World War II when military gear created a big surplus glut, today's surplus dealers have done much to change the picture and improve their images. Most of them operate out of fairly modern warehouses and stores. A few have even grown so big that they occupy entire multi-storied buildings.

There are literally dozens of dealers doing business in the surplus market. Obviously,

for a first crack out of the barrel, you needn't write to all of them. But you will need a short list of companies to get you started collecting catalogs. We have compiled a short list that is relatively complete insofar as covering the whole range of items currently offered:

For true military and surplus gear, you can obtain a catalog from G&G Radio Supply Co., 45 Warren St., New York, NY 10007. For computer and other commercial items, a good catalog to have on hand is one from Delta Electronics Co., Box 1, Lynn, MA 01903.

Solid-state items are currently the "big thing" in experimenter electronics. So, for transistors, diodes, and linear and digital IC's (including readouts), you will want to have catalogs from Solid State Systems, Inc., P.O. Box 773, Columbia, MO 65201; and Solid State Sales, P.O. Box 74A, Somerville, MA 02143.

While almost all of the companies in the surplus electronics business feature small parts offers (resistors, capacitors, transformers, etc.) Poly-Paks, P.O. Box 942E, Lynnfield, MA 01940, has made a specialty of supplying quantity assortments of everything from resistors and capacitors to transistors and diodes to knobs and hardware. They also have fairly extensive listings in their flyers of digital and linear operational amplifier IC's.

The catalog put out by Fair Radio Sales Co., 1016 E. Eureka St., Lima, OH 45802, reads like a military communications, test equipment, and spare parts master list.

As you become familiar with dealing in the surplus market, you will undoubtedly add more companies to your list of suppliers—especially when you begin to realize that surplus dealers can often supply immediately items you might have to wait for on back order from other local and mail-order suppliers. Many surplus dealers advertise in electronics magazines, especially those written for service and ham radio readers. ♦

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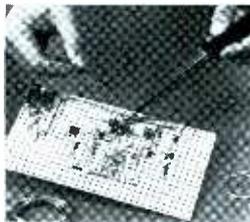
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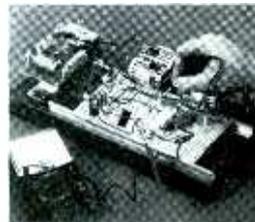
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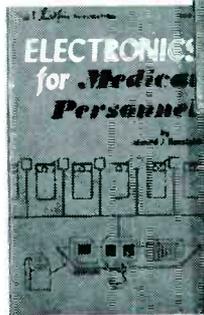
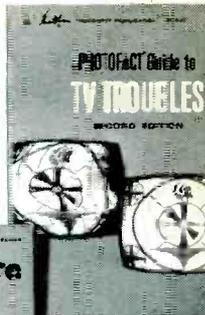
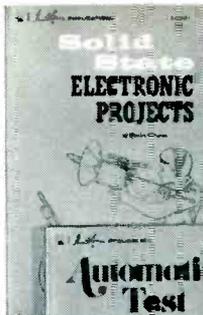
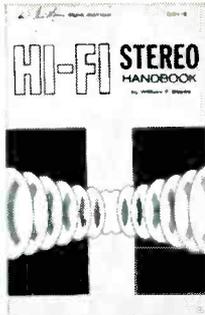
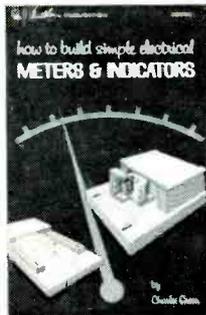
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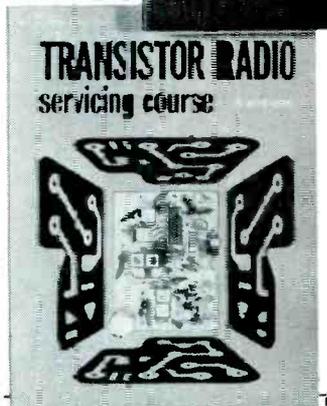
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