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Special Projects is dedicated to the electronics constructor—*you*—the project builder. It is filled with never-before published construction projects. This issue, our second one, again delivers just what you need and want.

You will find, as you flip through the pages, 22 new articles. You'll discover how you can build projects that include an Ultrasonic Listener, Step Attenuator Volume Controls, and a Pool-Table Scorekeeper (digital display of course). There's also a Temperature Meter, a Burglar Alarm, Dual-Mode Power Supply and even a Picture-Tube Rejuvenator.

All of these projects can be successfully completed. None of them are overly complex. All are useful and we hope you'll find them fun to use after you've had the pleasure of building them.

As a constructor, you have probably designed and built projects of your own. Projects that other readers would like to build too. So why don't you tell us about that favorite project of yours. If we like it, we'll ask you to write it up for us and, who knows, it might appear in our next issue.

We enjoy bringing Special Projects to you. We want it to be your kind of magazine. So whatever your comments, both good ones and bad ones; tell them to us. We need your input to keep Special Projects delivering the kinds of articles you want to read.

Larry Steckler

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PUBLISHER

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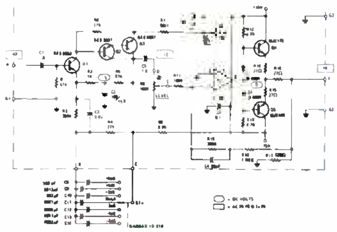

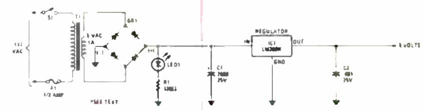

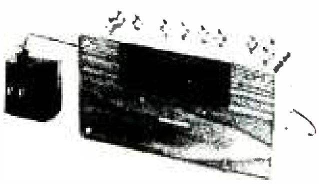

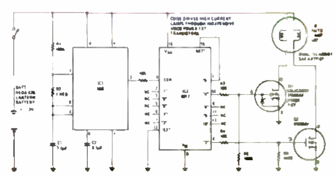

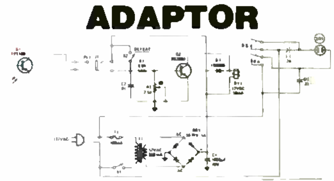

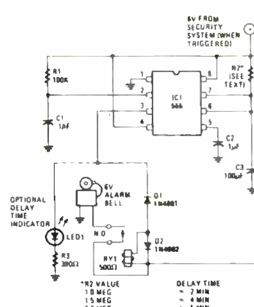

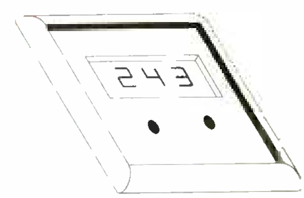

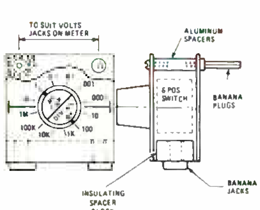

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Larry Steckler
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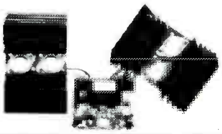
100W CLASS A POWER AMP KIT

Dynamic Bias Class "A" circuit design makes this unit unique in its class. Crystal clear, 100 watts power output will satisfy the most picky fans. A perfect combination with the TA-1020 low T.I.M. stereo pre-amp.

Specifications:
- Output power: 100W RMS into 8-ohm 125W RMS into 4-ohm
- Frequency response: 10Hz - 100 KHz
- T.H.D.: less than 0.008%
- S/N ratio: better than 80dB
- Input sensitivity: IV max.
- Power supply: ±40V @ 5 amp



TA-1000 KIT $51.95
Power transformer $18.00 each

REGULATED VARIABLE D.C. POWER SUPPLY KIT

Uses UA723 I.C. and 2N3055 power transistor as regulator. Output voltages can be adjusted from 0~30V at an internal resistance of less than 0.005 ohm; ripple and noise less than 1 MV; with built on board LED and audible overload indicator. Kit comes with P.C. board; all electronic components, transformer, connectors; 2 panel meters for voltage and amp: a professional look metal cabinet and instructions.

Model TR-88A 0~15V D.C. 3 amp
Model TR-88B 0~30V D.C. 2 amp

$59.50 per kit

NEW

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Model 968 $4.50 each

SUB MINI SIZE FET CONDENSER MICROPHONE

Specification:
Sensitivity: − 65dB ± 3db
FEQ. Response: 50 Hz 8 KHz
Output Impedance: 1K ohm max.
Polar Pattern: Omni-directional
Power Supply: 1.5V 10V D.C.
Sound Pressure Level: Max. 120dB
EM4RP **$2.50** ea. or 2 for **$4.50**

NEW MARK III

9 Steps 4 Colors

LED VU

Stereo level indicator kit with arc-shape display panel!!! This Mark III LED level indicator is a new design PC board with an arc-shape 4 colors LED display (change color from red, yellow, green and the peak output indicated by rose). The power range is very large, from −30dB to +5dB. The Mark III indicator is applicable to 1 watt - 200 watts amplifier operating voltage is 3V - 9V DC at max 400 MA. The circuit uses 10 LEDs per channel. It is very easy to connect to the amplifier. Just hook up with the speaker output!

IN KIT FORM $18.50

2 WATT AUDIO AMP

Pre assembled units. All you need is to hook up the speaker and the volume control. Supply voltage from 9~15V D.C. measures only 2" x 3½", making it good for portable or discrete applications. Comes with hook up data.

BUY 2 FOR **$4.99**

MARK IV 15 STEPS LED POWER LEVEL INDICATOR KIT

This new stereo level indicator kit consists of 36 4-color LED (15 per channel) to indicate the sound level output of your amplifier from −36dB ~ +3dB. Comes with a well-designed silk screen printed plastic panel and has a selector switch to allow floating or gradual output indicating. Power supply is 6~12V D.C. with THG on board input sensitivity controls. This unit can work with any amplifier from 1W to 200W!

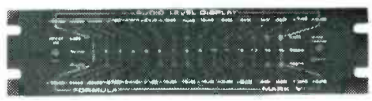
Kit includes 70 pcs. driver transistors, 38 pcs. matched 4-color LED, all other electronic components, PC board and front panel.

MARK IV KIT **$31.50**

NEW

MARK V 15 STEPS LED POWER OUTPUT INDICATOR KIT

All functions same as Mark IV but this is with heavy duty aluminum front plate and case. Can be easily slot into the front panel of your auto, truck or boat. Operates on 12V DC.



$41.50 EACH KIT

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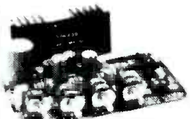
MODEL 888 R

FEATURES
- Circuitry: designed for operation by high efficient, high power silicon transistor which enable illumination maintain in a standard level even the battery supply drops to a certain low voltage.
- 9" 6W cool/daylight miniature fluorescent tube.
- 8 x 1.5V UM-1 (size D) dry cell battery.
- Easy sliding door for changing batteries.
- Stainless reflector with wide angle increasing lumination of the lantern.

$10.50 EA

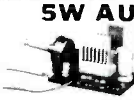
30W+30W STEREO HYBRID AMPLIFIER KIT

It works in 12V DC as well! Kit includes 1 PC SANYO STK-043 stereo power amp. IC LM 1458 as pre amp, all other electronic parts, PC Board, all control pots and special heat sink for hybrid. Power transformer not included. It produces ultra hi-fi output up to 60 watts (30 watts per channel) yet gives out less than 0.1% total harmonic distortion between 100Mz and 10KHz.



$32.50 PER KIT

5W AUDIO AMP KIT



2 LM 380 with Volume Control
Power Suply 6 18V DC
ONLY $6.00 EACH

PROFESSIONAL PANEL METERS

Type MU-52E

A.	0-50UA	**8.50 ea.**
B.	0-30VDC	**8.50 ea.**
C.	0-50VDC	**8.50 ea.**
D.	0-3ADC	**9.00 ea.**
E.	0-100VDC	**9.00 ea.**

All meters white face with black scales. Plastic cover.

SPECIAL SALE

0.5" LED ALARM CLOCK MODULE

ASSEMBLED! NOT A KIT!

Features: • 4 digits 0.5" LED Displays • 12 hours real time format • 24 hours alarm audio output • 59 min. countdown timer • 10 min. snooze control.

ONLY $7.00 EACH
SPECIAL TRANSFORMER FOR CLOCK
$2.50

DIGITAL AUTO SECURITY SYSTEM

4 DIGITS PERSONAL CODE!!

SPECIAL $19.95

- proximity triggered
- voltage triggered
- mechanically triggered

This alarm protects you and itself! Entering protected area will set it off, sounding your car horn or siren you add. Any change in voltage will also trigger the alarm into action. If cables within passenger compartment are cut, the unit protects itself by sounding the alarm. **3-WAY PROTECTION!**

All units factory assembled and tested — Not a kit!

SANYO HYBRID AUDIO POWER AMPLIFIER I.C.

Typical ratings
Operating case temp. 85°C
T.H.D. = 0.5% f = 20~20KHZ
Input resistance Po = 0.1W 30KΩ
Power band width 20HZ~20KHZ
Freq. response 10HZ~100KHZ
Output resistance = 8Ω
With built in protection circuit.
All units come with data sheet.

PART	OUTPUT (W)	SUPPLY VOLTAGE	PRICE
STK040	10W+10W Stereo	±16V D.C.	**$14.50**
STK041	15W+15W Stereo	±20V D.C.	**$18.50**
STK043	20W+20W Stereo	±22V D.C.	**$22.50**
STK054	23 WATTS	±23V D.C.	**$13.50**
STK056	30 WATTS	±22V D.C.	**$18.50**
STK050	50 WATTS	±35V D.C.	**$26.50**
STK070	70 WATTS	±42V D.C.	**$32.50**
STK1050	100 WATTS	±50V D.C.	**$40.50**

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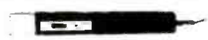
TECT model WEM-16 is a factory assembled FM wireless microphone powered by an AA size battery. Transmits in the range of 88-108MHz with 3 transistor circuits and an omni-directional electric condenser. Element built-in plastic tube type case; mike is 6¼" long. With a standard FM radio, can be heard anywhere on a one-acre lot; sound quality was judged very good.

$16.50



FOR DECODER BUILDERS

Pre-Drilled PC Board			**$17.50**
Tolriod Coils (Set of 4)			**$ 3.00**
Multi Turn Trim-Pots 10K ohm			**$ 2.50**
Trimmer Capacitor 6-35pF			**$ 0.60**
MC1358	**$ 2.50**	RC1458	**$ 1.00**
MC1350	**$ 2.00**	LM380	**$ 1.80**
MC1330	**$ 3.50**	LM340T-15	**$ 1.20**
		NE565	**$ 2.00**

We also have transformer, capacitors set, resistors set antenna transformer. Please call for price.

LCD CLOCK MODULE!

• 0.5" LCD 4 digits display • X'tal controlled circuits • D.C. powered (1.5V battery) • 12 hr. or 24 hr. display • 24 hr. alarm set • 60 min. countdown timer • On board dual back-up lights • Dual time zone display • Stop watch function.

NIC1200 (12 hr) $24.50 EA.
NIC2400 (24 hr) $26.50 EA

SANYO UHF VARACTOR TUNER

For UHF CH 14~83
Tuning voltage + 1V~+ 28V/D.C. Input impedance 75 OHM. I.F. band width 7~16 MHZ. Noise figure 11.5 dB MAX. Size 2⅝" x 1¼" x ¾". Supply voltage 15V D.C. Sound I.F. = 58.0 MHZ. Video I.F. = 62.5 MHZ

All units are brand new from Sanyo.
MODEL 115-B-405A
$35.00 EACH

CIRCLE 402 ON FREE INFORMATION CARD

CIRCLE 402 ON FREE INFORMATION CARD

BROADCAST-QUALITY PHONO PREAMP

Variable equalization, low noise, and low distortion are just some of the features of this high-quality instrument.

JOHN MAMIS

THIS BROADCAST-QUALITY PHONO PREAMP IS A STATE-of-the-art instrument in terms of performance and low noise. In addition it offers several new features not available in most commercial products.

Many phono preamps have three limitations. They are:

a. High output impedance
b. Fixed equalization
c. Gain irregularities

Let's take a brief look at each of these problems.

Output impedance: Broadcast requirements specify either 600- or 150-ohm balanced lines between electronic equipment. The reason for this is that low-impedance lines are less susceptible to noise which permits running long distances without loss of fidelity. Most preamps on the market have unbalanced outputs with impedances of 4,000—10,000 ohms and therefore, are not capable of driving low-impedance lines. The preamp described below is capable of driving either 600- or 150-ohm lines and provides for either balanced or unbalanced configurations.

Equalization: All modern phonograph records are supposedly cut using the RIAA standard which was adopted in the early 1950's. Yet there seems to be great variation in modern recordings even from a given recording company. These variations occur in the upper end of the frequency spectrum. On some recordings the highs overpower the rest of the spectrum resulting in a very shrill sound. On others the highs are suppressed resulting in a "tubby" sound reminiscent of the old 78 recordings. Most phono preamps provide only RIAA equalization. This limitation prevents proper equalization of signals during dubbing of records onto tape. The preamp described here provides a variable equalizer which includes the RIAA standard.

Gain: Most designs use a single-stage high-gain preamp which can lead to problems at low frequencies. A preamp with a gain of 60 dB at 1 kHz requires a closed-loop gain of 80 dB at 20 Hz and obviously a higher open-loop gain. This is difficult to achieve without design compromises. The design described below solves this problem by using a preamp with a gain of 34 dB and a line amplifier with a 26 dB gain. A trim pot between these two stages sets the overall gain to any desired level. This approach permits optimizing the preamp for low noise and low distortion while the line amp provides a low output impedance at any gain selected. The complete schematic is shown in Fig. 1. Specifications are giving in Table 1.

Circuit description

The circuit is essentially divided into two parts; the preamp and the line-amp. The preamp is a classical transistor arrangement. Transistor Q1 was selected and biased for low noise, while Q2 and Q3 are tied in a Darlington configuration for high gain to prevent the loading of Q1. Resistors R2, R5, and R8 establish DC bias. Equalization is determined by the feedback loop consisting of R3, R4, C3, and C4. The value of C4 is selected by switch S1 to provide RIAA equalization with a variation of up to ±8 dB at 10 kHz.

Trim pot R9 which is used to set the output level is

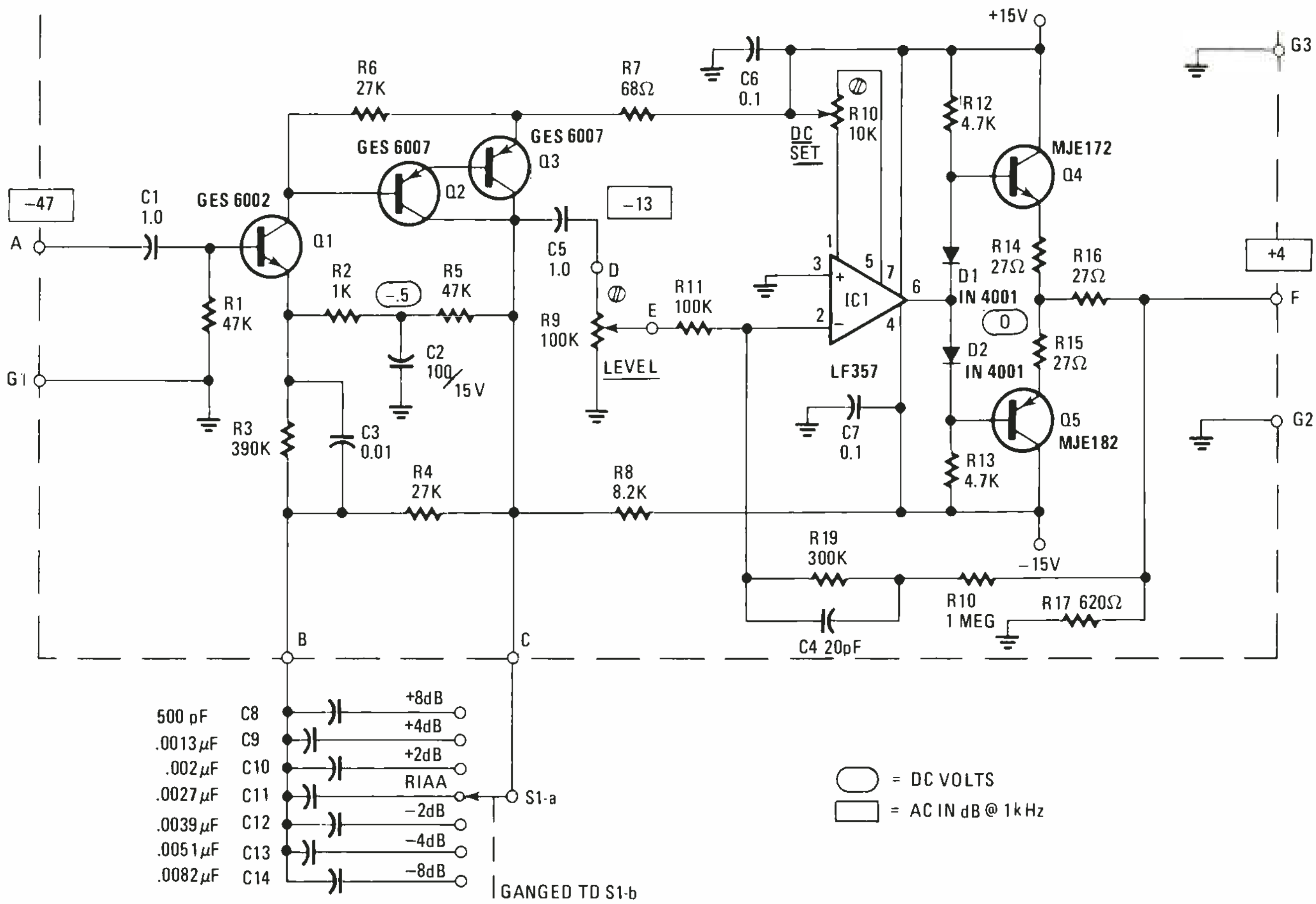


FIG. 1—SCHEMATIC DIAGRAM of the broadcast-quality phono preamp. The equalization can be adjusted ±8 dB to compensate for deviations from the RIAA recording curve.

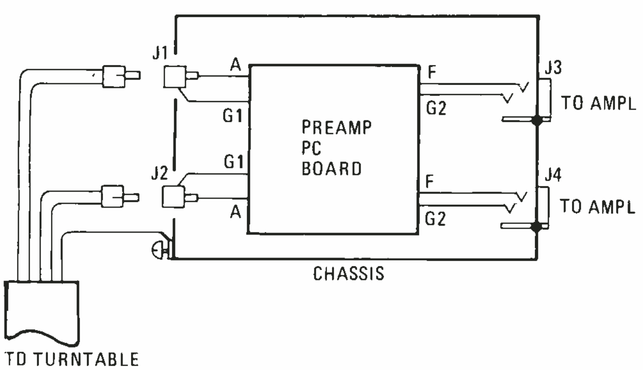


FIG. 2—BLOCK DIAGRAM SHOWS THE CONNECTIONS to the preamp for unbalanced low-impedance outputs.

placed between the preamp and the line-amp. The output of channels A and B can thus be set to exact and equal levels.

The LF357 operational amplifier was chosen for the line-amp because of its linearity, high slew-rate, and wide bandwidth. Transistors Q4 and Q5 were added to provide drive capability into 150- and 600-ohm loads. The line-amp uses direct coupling and is flat from DC to 200 kHz; C8 is used in the feedback loop to roll off the highs at 50 kHz, while trim pot R10 sets the DC level at the output to zero. For proper operation the line-amp must be terminated in a load of at least 600 ohms. The load resistor can be placed at either the

TABLE 1
TECHNICAL SPECIFICATIONS

Preamp:
1. Preamp gain
   a. 70 dB open loop
   b. RIAA ±0.5 dB 20—20,000 Hz
   c. RIAA ±2 dB @ 10 kHz
   d. RIAA ±4 dB @ 10 kHz
   e. RIAA ±8 dB @ 10 kHz
2. Distortion less than 0.1%
3. Input impedance 47,000 ohms/50 pF

Line-amp:
1. Gain +26 dB
2. Maximum output
   a. +18 dBm unbalanced
   b. +24 dBm balanced
3. Output impedance 150 ohm or 600 ohms
4. Input impedance 100,000 ohms
5. Distortion less than 0.15%

Preamp & Line-amp:
1. Gain 51 dB @ 1 kHz
2. Distortion less than 0.25%
3. Power source ±15 VDC @ 25 mA per channel
4. Overload margin 25 dB
5. Noise:

Filter	Output	Noise	Equivalent Input	Equivalent Noise
	mV	dBm	μV	dBm
20-20 kHz	0.5	−63	1.5	−114
ASA "A"	0.08	−79	.25	−130

POWER SUPPLY PARTS LIST

R1—47,000 ohms, ¼ watt
F1—fuse, 1 ampere, with holder
NE1—neon lamp, NE-2 or equal
T1—power transformer; 36-volt center tapped secondary or two 18-volt secondaries
D1—D6—1N4003
IC1—LM341P-15, 15-volt, 3-terminal positive-voltage regulator
IC2—LM320MP-15, 15-volt, 3-terminal negative-voltage regulator
C1, C2—1000 μF, 30 volts, electrolytic
C3—1.0 μF, 25 volts, tantalum
C4—10 μF, 25 volts, electrolytic
PC board, line cord and plug.

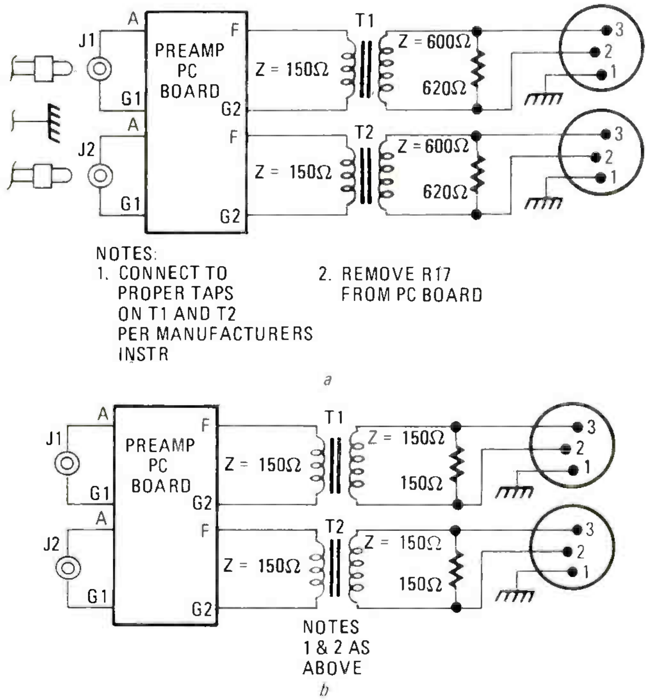


FIG. 3—TO DRIVE BALANCED LINES a high-grade line transformer must be used in each channel. Figure 3-a shows connections for 600-ohm balanced lines; (*b*) shows connections for 150-ohm balanced lines. Select taps on transformer primary and secondary for desired output impedances.

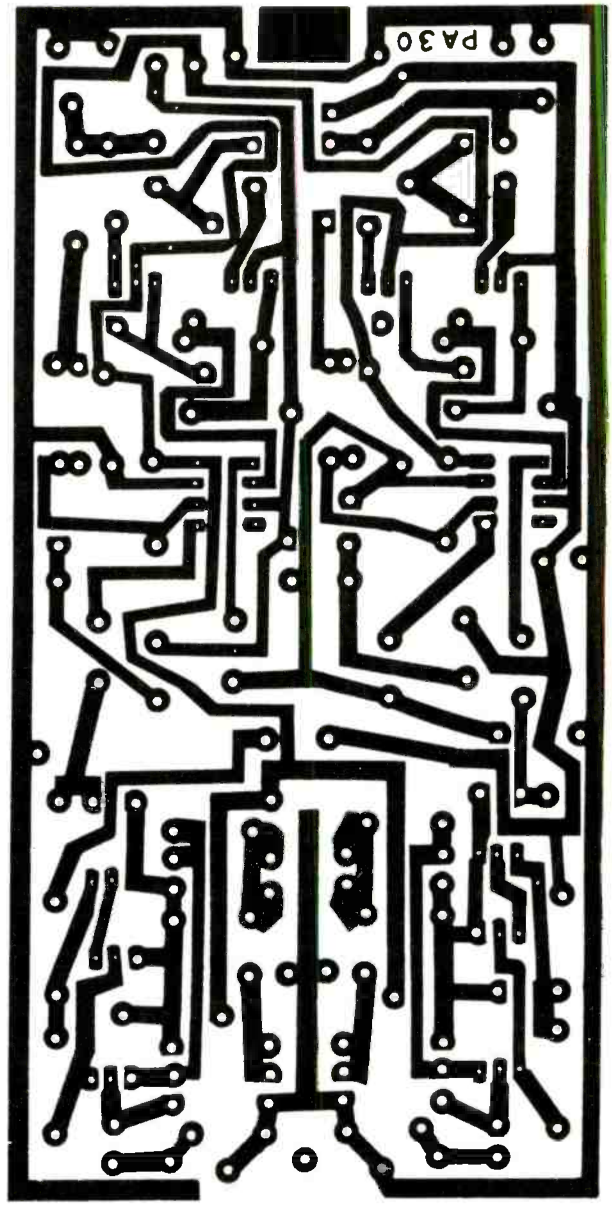


FIG. 5—FOIL PATTERN for the preamp PC board. Top and bottom halves of the board are almost mirror images of each other.

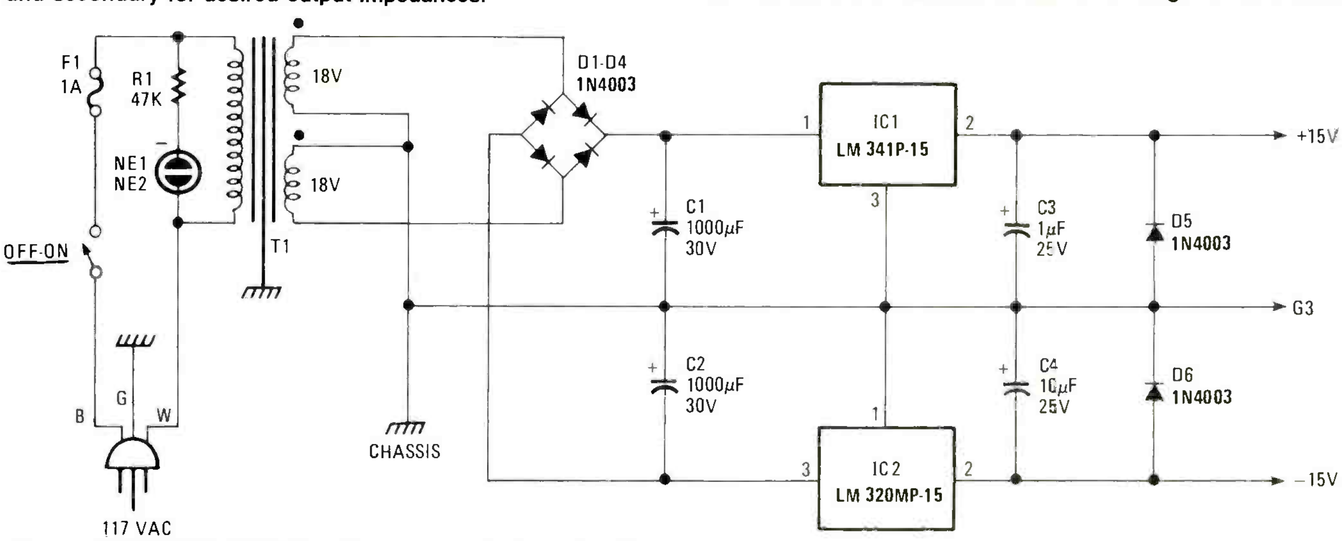


FIG. 4—THE POWER SUPPLY delivers plus and minus 15 volts to the preamp and line amplifiers. Both branches are regulated.

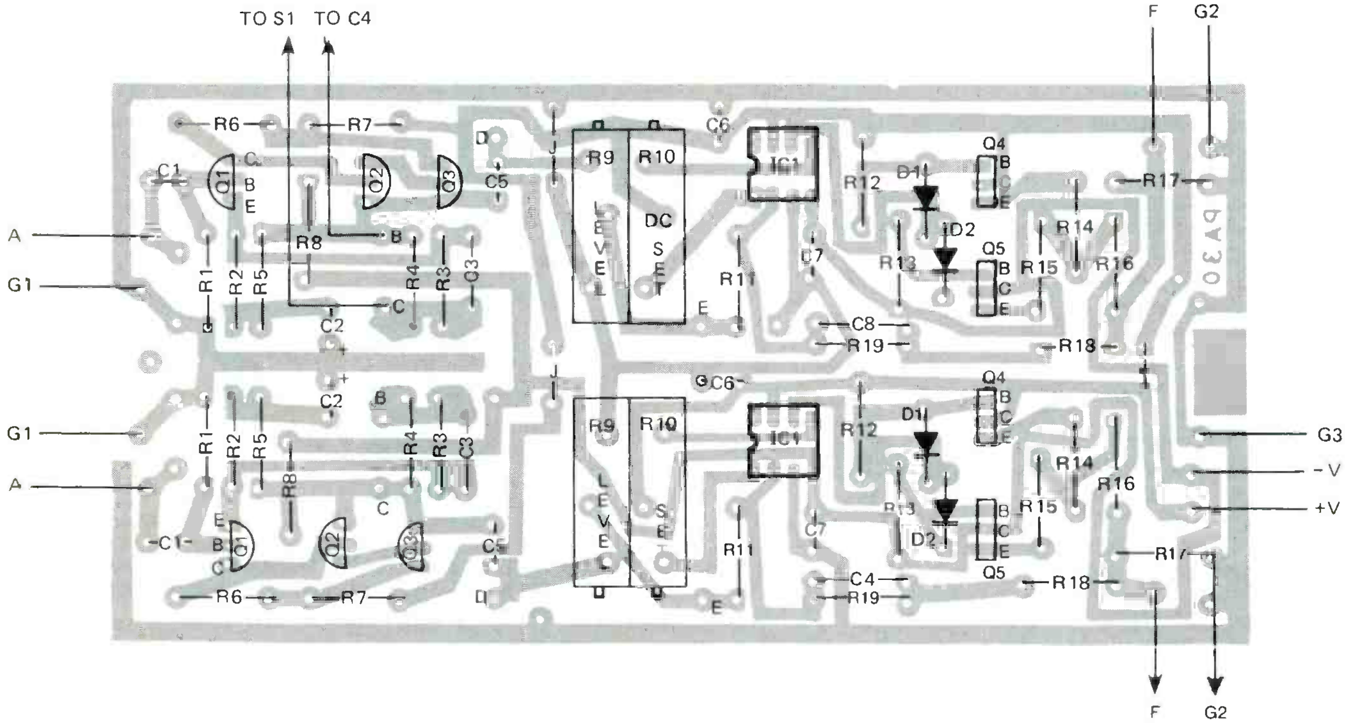


FIG. 6—PARTS PLACEMENT GUIDE for the preamp PC board. The trimmer pots are mounted so adjusting screws are easily accessible.

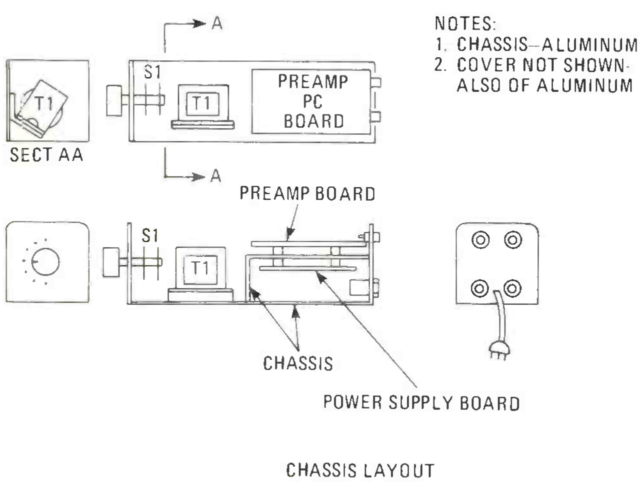


FIG. 7—TOP AND SIDE VIEWS show placement of parts within the metal case. Note the metal shield between the preamp and power supply PC boards.

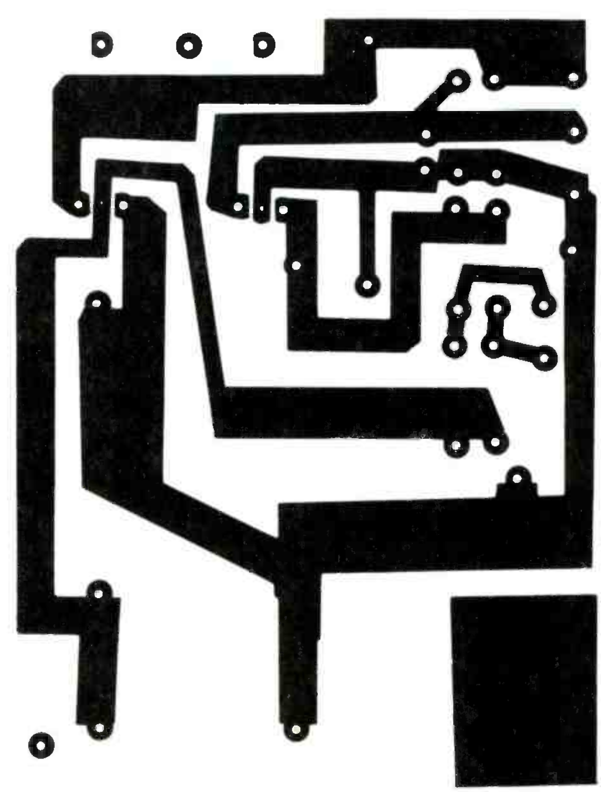


FIG. 8—FOIL PATTERN for the power-supply PC board. The power transformer is not on the board.

PARTS LIST

For a stereo preamp use two of each of the parts listed below

RESISTORS

Resistors ¼ watt, 5% unless otherwise noted

R1, R5—47,000 ohms
R2—1000 ohms
R3—390,000 ohms
R4, R6—27,000 ohms
R7—68 ohms
R8—8200 ohms
R9—100,000 ohms, 10-turn trimmer potentiometer
R10—10,000 ohms, 10-turn trimmer potentiometer
R11—100,000 ohms
R12, R13—4700 ohms
R14—R16—27 ohms
R17—620 ohms
R18—1 megohm
R19—300,000 ohms

CAPACITORS

C1, C5—1 μF Mylar
C2—100 μF. 15 volt, PC-mount electrolytic
C3—.01 μF ceramic disc
C4—20 pF ceramic disc
C6, C7—0.1 μF ceramic disc
C8—500 pF ceramic disc
C9—.0013 μF ceramic disc
C10—.002 μF ceramic disc
C11—.0027 μF ceramic disc
C12—.0039 μF ceramic disc
C13—.0051 μF ceramic disc
C14—.0082 μF ceramic disc

SEMICONDUCTORS

Q1—GES 6002 (General Electric)
Q2, Q3—GES 6007 (General Electric)
Q4—MJE 172 (Motorola)
Q5—MJE 182 (Motorola)
IC1—LF357 (National)
D1, D2—1N4001

MISCELLANEOUS

Preamp PC board (only one needed), double-pole 7-position shorting-type rotary switch; input and output jacks as needed to mate with existing equipment. Metal enclosure and shield (see text and Fig. 7). Transformers (UTC A20 or equal) for balanced output lines.
Printed circuit boards are available from SEOL, PO Box 1, Blacklick, OH 43004. Preamp board type PA-30 $12.00; power supply board type PW-30 $7.00.

line-amp or at the far end of the line.

Figure 2 shows the connections for the unbalanced case. To provide a balanced line a high-quality transformer is required for each channel as shown in Fig. 3. This arrangement provides a balanced line of 150 or 600 ohms.

The power supply shown in Fig. 4 is simply a standard split supply with three terminal regulators yielding ±15 volts DC.

Construction

Two channels can be constructed on one printed circuit board. The foil pattern and parts layout are in Figs. 5 and 6, respectively. The PC board should be housed in a metal case to insure low noise. The power supply can be mounted in the same case with a metal shield between the power supply and the preamp. See Fig. 7.

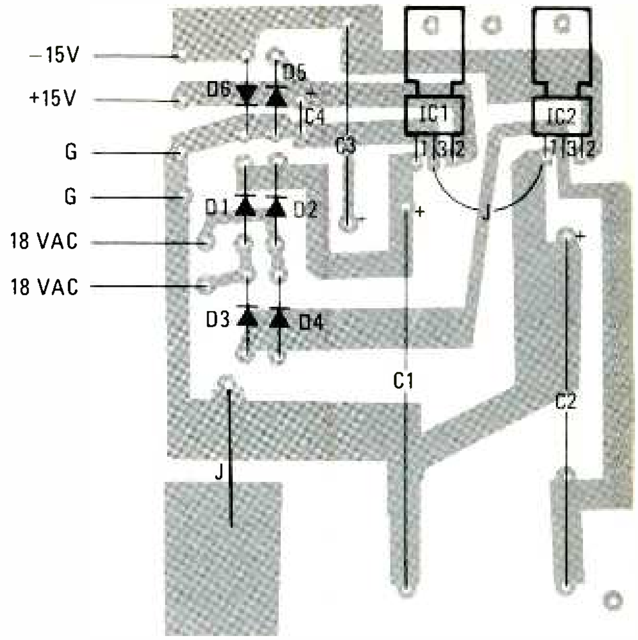


FIG. 9—PARTS LAYOUT FOR THE POWER SUPPLY. Note the jumper that must be added to connect the common terminals of the regulator IC's.

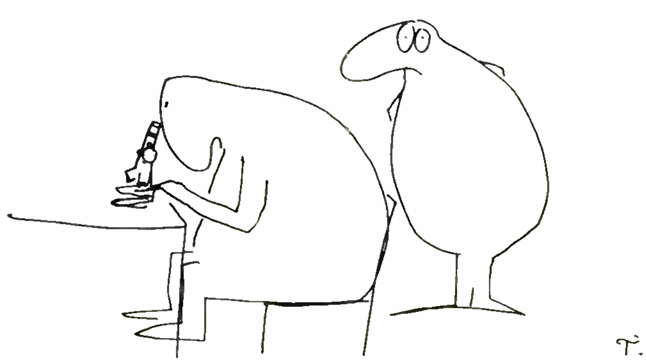
Grounding is especially important in reducing noise. The ground system for the electronics should be tied to chassis only at one point. This is accomplished on the power supply.

The separation of electronic ground from the chassis imposes the following restrictions.

a. The phono cartridge return leads must not be tied to chassis.
b. The output ground lead must not be tied to chassis.
c. The turntable chassis must be tied to the PA-30 chassis.

These arrangements are shown in Figs. 2 and 3.

The power supply foil pattern are in Fig. 8 and the parts layout is shown in Fig. 9. Any residual hum can be totally eliminated by rotating the power transformer and moving its location on the chassis to an optimum position. A tested layout is shown in Fig. 7. **SP**



"I really hate some of this microelectronics repair work. Okay, I'm removing the chassis."

ROBERT N. BEABER

POOL-TABLE SCOREKEEPER

This electronic scorekeeper will add some real class to your game.

THIS SCOREKEEPER WAS DESIGNED FOR THE AVERAGE pool player and the true pool shark. With it you can add or subtract any whole number from one to 15, and keep a running total score for two players. The subtract function can be used to correct a players mistake in entering an incorrect score or to subtract one point when a player scratches. This provides scorekeeping for games of straight pool or rotation. It uses low-power integrated circuits (IC's) with two LED seven-segment displays for each player. The total score recordable for each player is 99.

Circuit operation

Circuit operation enters around the 74C193,C4 down counter and two 74C192 up/down counters for each score, shown in Fig. 1. An input number is selected by depressing any or all of the push buttons labeled "1", "2", "4", "8". These four switches provide a latched binary "1" input to the down counter through four 4013 flip-flop latches (B3 and B4). Once a number is selected either of the two players may add or subtract it from his score by pushing his plus or minus push button. When either switch is depressed a pulse is sent from a 4013 configured one-shot to latch open a 4011 NAND gate (G2); through a NOR gate (C3) to load the count into the 74C193 down counter, and to initiate the down-counting sequence. The down-counting sequence is necessary to transfer the count from the 74C193 down-counter to the chosen 74C192 up/down counter.

The down-count sequence begins when a "1" pulse is received at pin 6 of the 4013 (A3) flip-flop latch. This latches open NAND gate 4011,A1 at pin 1. This allows the oscillator output from 555 (A4 pin 3 to toggle the 4013 flop, (A3) at pin 11. To understand what the toggling does examine the two outputs from the toggle flip-flop pins 12 and 13. These are the Q and the $\overline{Q}$ (NOT) outputs and when toggling occurs they alternate being a "1" or "0". One of these two outputs goes to the count-down line pin 4 on the down-counter and the other goes to pin 13 of the 4081, D2 AND gate. When pin 13 of this AND gate goes to a "1" and a "1" is present on any of the down-counter output lines, a "1" is also put on all four NAND gates of the 4011, (G2) that feed the up- or down-count lines of the 74C192 units counters. Only one of these NAND gates should be

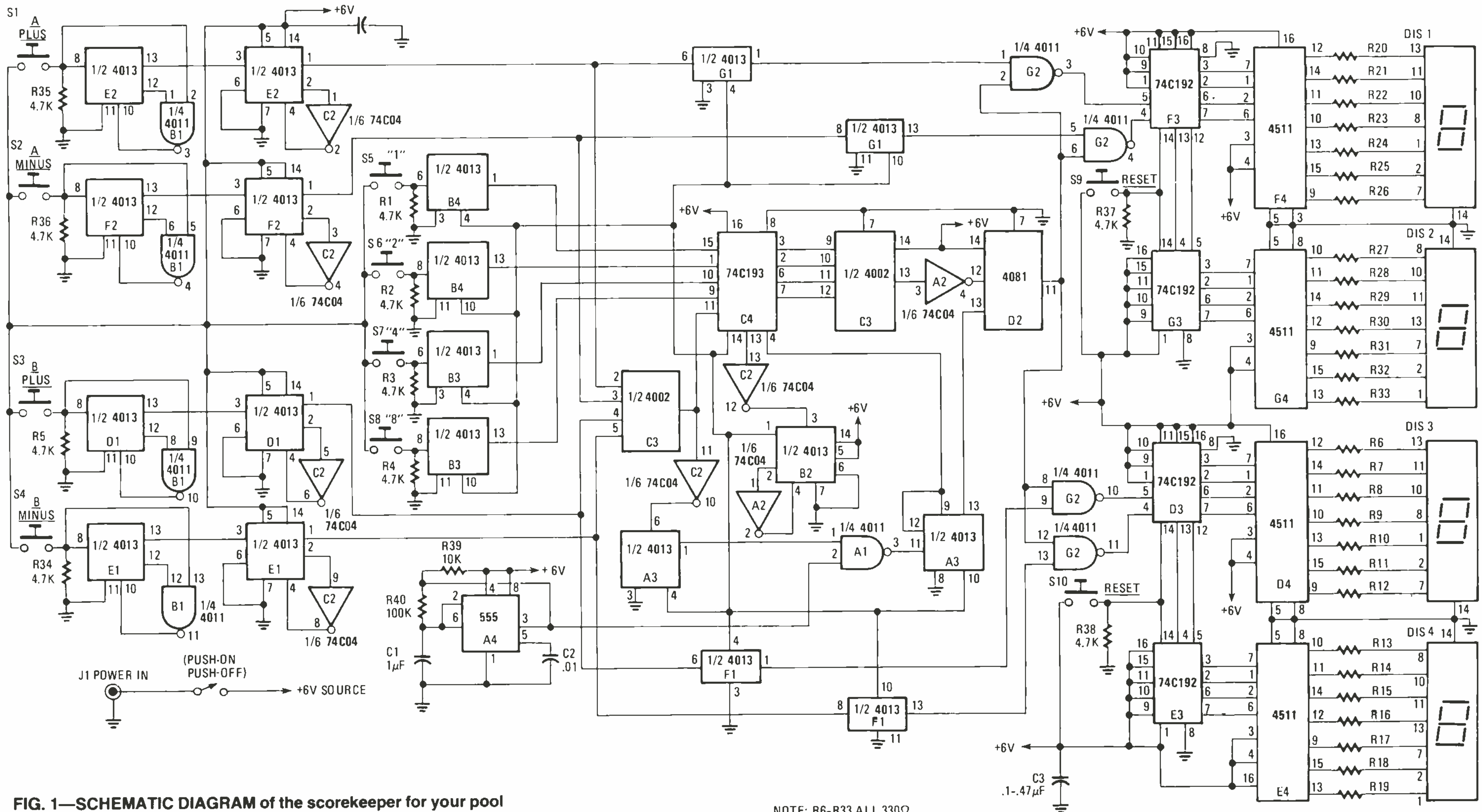


FIG. 1—SCHEMATIC DIAGRAM of the scorekeeper for your pool table. Keeps running total up to 99; and includes subtract-function for correcting mistakes.

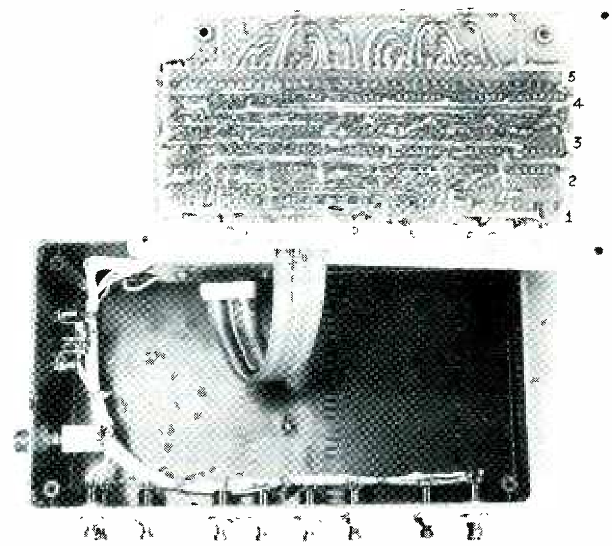
active and it corresponds to the plus or minus switch selected. This active NAND gate allows a count of "1" to be put into the selected units counter. When the count-down line pin 4 of the 74C193 (C3) goes to "1" it bumps the down-counter down 1 count.

The next toggle of the 4013 flip-flop (A3) causes pin 13 of the AND gate 4081 (D2) to go to a "1". If any of 4 output lines from the down-counter are still at a "1" then the AND gate will place another count of "1" into the selected units counter. This action continues until the down-counter reaches a 0 count. When this occurs the borrow line, pin 13, of 74C193 (C4) triggers the 4013, configured as a 1-shot, (B2) that pulses all the reset lines for the 4013 flip-flop latches. At this point, since all of the count that was stored in the down-counter has been transferred to the selected units counter, the down-counting sequence must be stopped and all input latches reset.

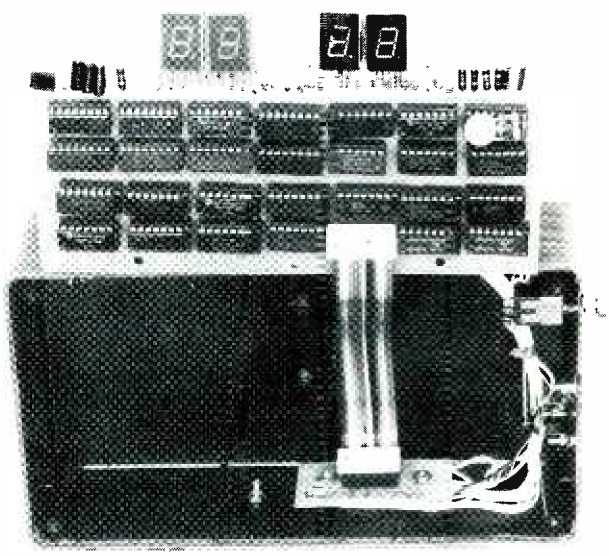
The 74C192 units and tens counters hold the count transferred to them from the down-counter and are reset to 0 only with the reset switches or when the two-stage counters exceed a count of 99. The output from these two-stage counters is decoded and displayed on two LED seven-segment readouts.

PARTS LIST

RESISTORS
Resistors, ¼ watt, 5% unless otherwise noted
R1—R5, R34—R38—4700 ohms
R6—R33—330 ohms
R39—10,000 ohms
R40—100,000 ohms
C1—1 μF, tantalum
C2—.01 μF ceramic disc
C3, C4—0.1—.47 μF, 15 volts, ceramic disc
SEMICONDUCTORS
DIS1—DIS4—7-segment, common-cathode LED displays
A4—555 timer
C3—CD4002 dual 4-input NOR gate
A1, B1, G1—CD4011 quad 2-input NAND gate
A3, B2, B3, B4, D1, E1, E2, F1, F2, G1—CD4013 dual D flip-flop
D2—CD4081 quad 2-input AND gate
D4, E4, F4, G4—CD4511 BCD-to-7-segment latch decoder/driver
A2, C2—74C04 hex inverter
D3, E3, F3, G3—74C192 4-bit up/down decade counter
C4—74C193 4-bit up/down binary counter
S1—S10—miniature normally open push-button switch (Radio Shack 275-1547 or equal)
S11—SPST push-on/push-off switch (Radio Shack 275-617 or equal)
J1—chassis-mount power connector (Radio Shack 274-1549 or equal)
MISCELLANEOUS
1)—16-pin DIP jumper cable 8 inches long
11)—16-pin wire-wrap DIP socket
17)—14-pin wire-wrap DIP socket
4)—14-pin solder-tab DIP socket
1)—14-pin solder-tab DIP socket
1)—bezel and lens, 1 × 3-9/16 inch (Radio Shack 270-301 or equal)
1)—plastic utility box with metal cover, 7-3/4 × 4-3/8 × 2-3/8 inch (Radio Shack 270-232 or equal)
1)—50-foot spool 30-gauge wire-wrap
1)—AC adapter, 6 volts DC, 300 mA output
1)—6×9-inch copper-clad (1 side) board for circuit board



WIRE SIDE of the main PC board. A row and column numbering system locates each IC.


THE MAIN PC BOARD is connected to the PC interface board by a 16-conductor cable.

Construction

I implemented this design using a PC board with wire-wrap DIP sockets. Most of the short jumpers and the distribution of power is provided on the PC board. The remaining connections were made with wire-wrap between DIP sockets. Figure 2 shows the foil pattern for the main PC board. The location for each IC Fig. 3 is identified by columns (letters A,B,C,D,E,F,G) and rows (numbers 1,2,3,4,5). At the intersection of a column and a row a specific IC is placed. For example, the 74C193 down-counter, labeled C4 in Fig. 1, is placed in column C at row 4. Pin 1 of each IC is located at the bottom right hand corner of each 14 or 16 pin

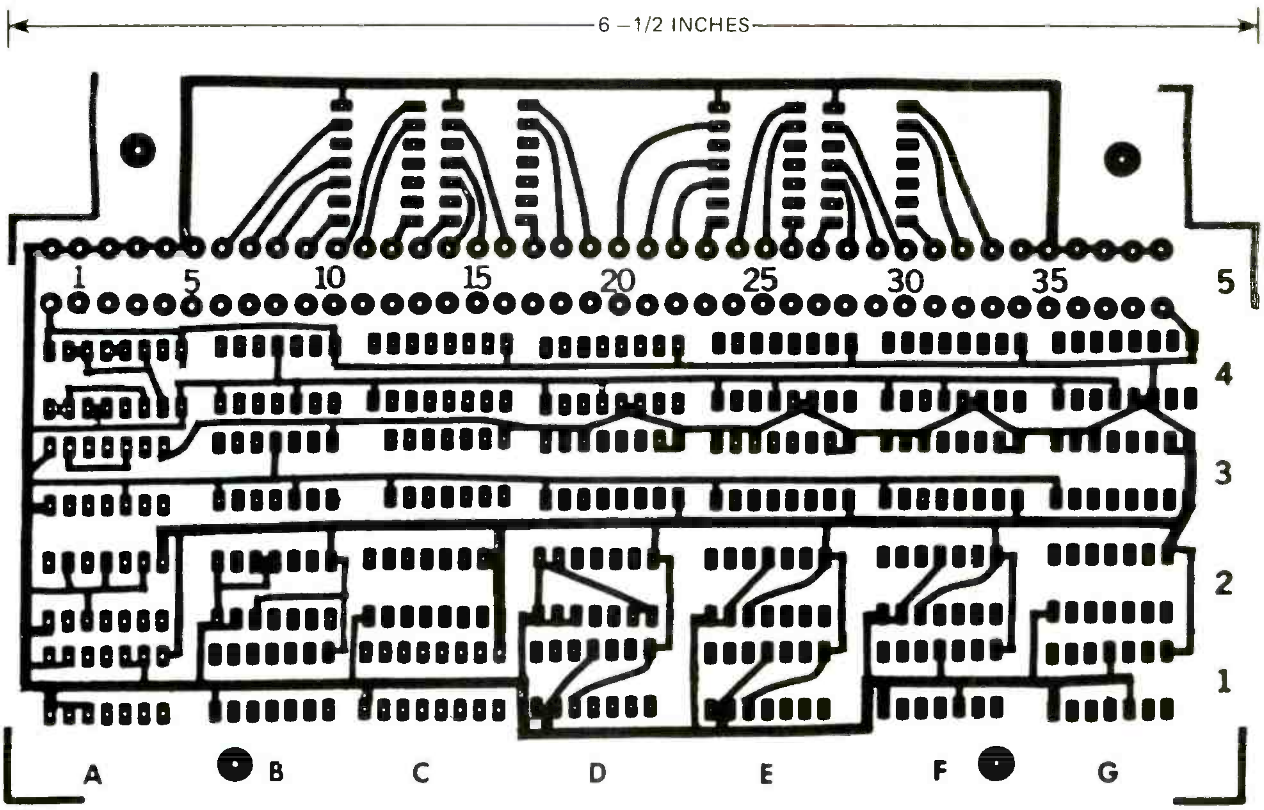


FIG. 2—FOIL PATTERN for the scorekeeper circuit. Printed circuit and wire-wrap techniques are combined in assembling this device.

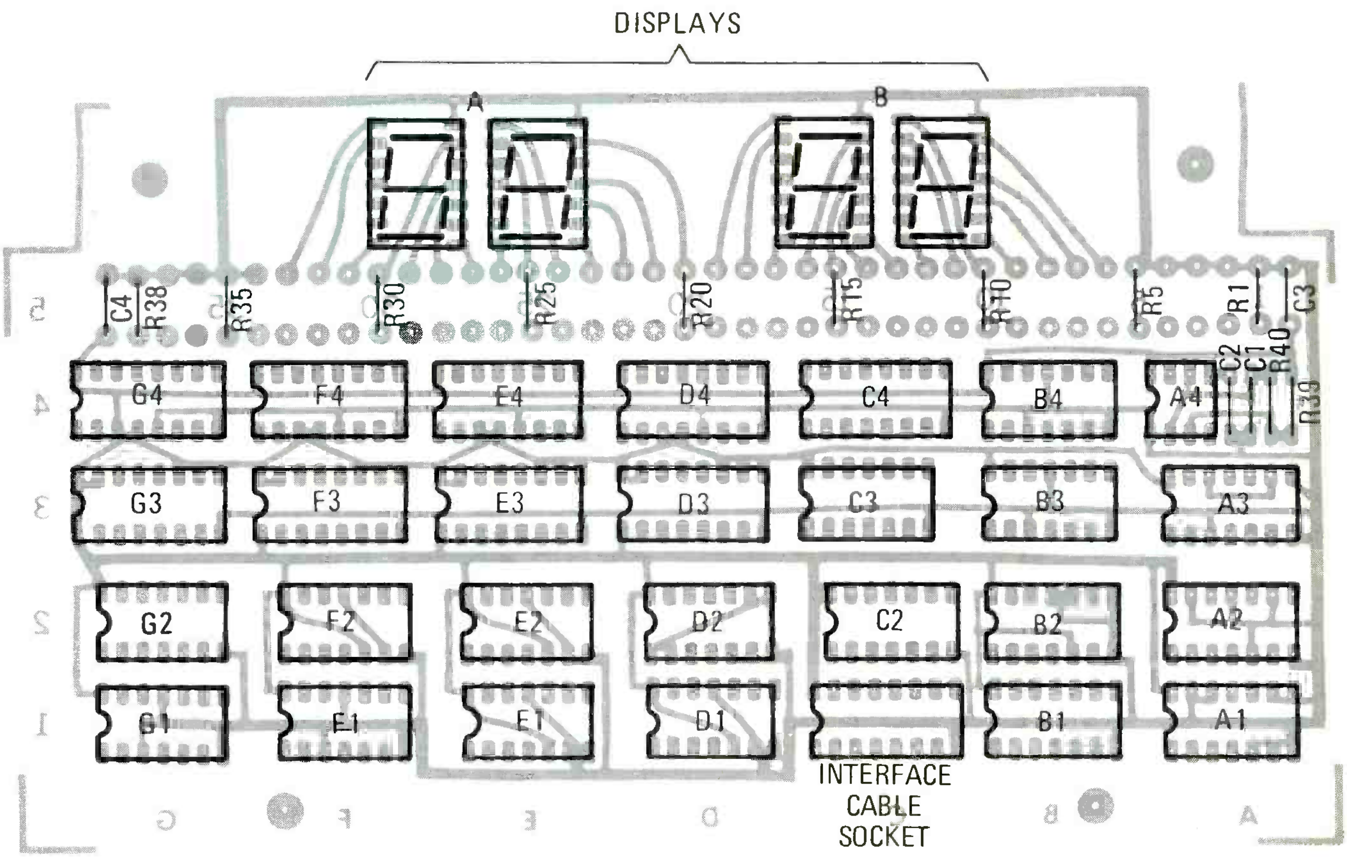


FIG. 3—WHERE COMPONENTS ARE MOUNTED on the circuit board. IC identification codes are based on their locations on the circuit board. These codes are useful when detailing the wire-wrap procedures.

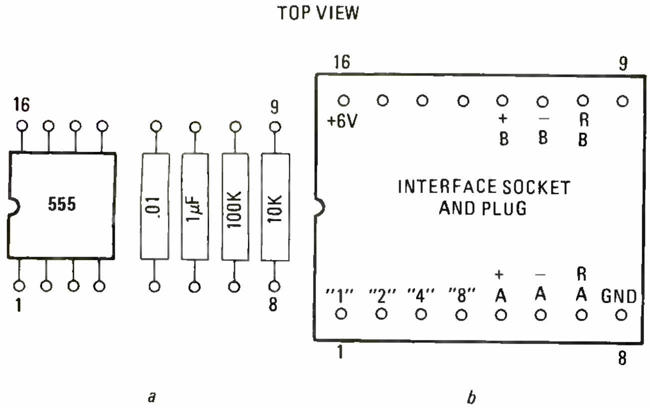


FIG. 4—THE TIMER IC (a) and its discrete components are all mounted on a 16-pin DIP socket. Call-outs (b) identify the terminals on the board used for switch and power interface.

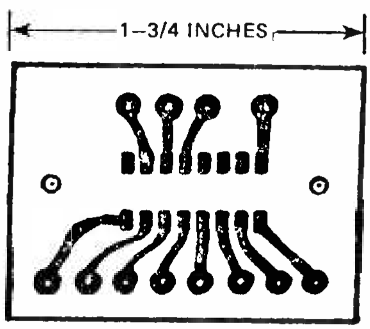


FIG. 5—PC foil pattern for the interface socket connected to the switches and power source.

DIP pattern *shown from the foil side in Fig. 2.* The numbers shown in row 5 identify locations where resistors are placed. In locations 1 thru 5 are placed five pull-down resistors for input latches 4013, B3 and B4 and the 4013, D1 1-shot. In locations 6 thru 33 are placed the 28 current-limiting resistors for the LED displays. In locations 34 thru 38 are placed five resistors for the input 1-shots and the reset lines on the 74C192 counters.

A decoupling capacitor is placed at each end of row 5 across the +6 volts and ground. These capacitors can be in a range from .1 μf to .47 μf and the working voltage can be any value higher than +6 volts. The four LED displays are placed at the top of the PC board with pin 1 located at the top right-hand corner of each DIP pattern. These displays do not fit a standard 4-pin DIP socket so sockets, if used, can be fabricated from a standard DIP socket by cutting the socket lengthwise. It is not necessary for the four LED DIP sockets to be the wire-wrap type since all of the connections to the resistors are made on the PC board foil.

The resistors and capacitors for the 555 oscillator (A4) are plugged into the DIP socket as shown in Fig. 4-a. This figure (Fig. 4-b) also shows the pin assignment for the switch and power interface. This interface is used to connect from the main PC board to input power and the switches. This is accomplished using a 16 conductor ribbon cable, with standard DIP plugs attached, plugged into position C1 on the board. The other end of this cable is connected to the respective switches and the input power plug through a PC interface board shown in Fig. 5.

TABLE 1
WIRE WRAP LIST

FROM	TO	FROM	TO	FROM	TO	FROM	TO
R1	B4-6	F4-7	F3-3	F1-6	D1-1	A3-10	A3-4
R2	B4-8	F4-1	F3-2	D1-1	C3-4	E2-2	C2-1
R3	B3-6	F4-2	F3-6	F1-8	E1-1	C2-2	E2-4
R4	B3-8	F4-6	F3-7	E1-1	C3-5	E2-3	E2-13
R5	D1-8	G4-7	G3-3	D2-12	A2-4	E2-12	B1-1
R6	D4-12	G4-1	G3-2	A2-3	C3-13	B1-2	E2-8
R7	D4-14	G4-2	G3-6	D2-13	A3-13	B1-3	E2-10
R8	D4-11	G4-6	G3-7	C3-9	C4-3	F2-2	C2-3
R9	D4-10	F3-14	G3-14	C3-10	C4-2	C2-4	F2-4
R10	D4-13	F3-13	G3-4	C3-11	C4-6	F2-3	F2-13
R11	D4-15	F3-12	G3-5	C3-12	C4-7	F2-12	B1-6
R12	D4-9	D4-7	D3-3	C4-4	A3-9	B1-5	F2-8
R13	E4-10	D4-1	D3-2	A3-9	A3-12	B1-4	F2-10
R14	E4-11	D4-2	D3-6	C4-13	C2-13	D1-2	C2-5
R15	E4-14	D4-6	D3-7	C2-12	B2-3	C2-6	D1-4
R16	E4-12	E4-7	E3-3	C4-11	C3-1	D1-3	D1-13
R17	E4-9	E4-1	E3-2	C3-1	C2-11	D1-12	B1-8
R18	E4-15	E4-2	E3-6	C2-10	A3-6	B1-9	D1-8
R19	E4-13	E4-6	E3-7	B2-5	B2-14	B1-10	D1-10
R20	F4-12	D3-14	E3-14	B2-2	A2-1	E1-2	C2-9
R21	F4-14	D3-13	E3-4	A2-2	B2-4	C2-8	E1-4
R22	F4-11	D3-12	E3-5	A3-11	A1-3	E1-3	E1-13
R23	F4-10	F3-4	G2-4	A1-1	A3-1	E1-12	B1-12
R24	F4-13	F3-5	G2-3	A1-2	A4-3	B1-13	E1-8
R25	F4-15	D3-4	G2-11	C4-15	B4-1	B1-11	E1-10
R26	F4-9	D3-5	G2-10	C4-1	B4-13	B4-6	C1-1
R27	G4-10	G2-12	G2-8	C4-10	B3-1	B4-8	C1-2
R28	G4-11	G2-8	D2-11	C4-9	B3-13	B3-6	C1-3
R29	G4-14	D2-11	G2-2	G1-4	G1-10	B3-8	C1-4
R30	G4-12	G2-6	G2-2	G1-10	F1-4	B1-2	C1-5
R31	G4-9	G2-1	G1-1	F1-4	F1-10	B1-5	C1-6
R32	G4-15	G2-5	G1-13	F1-10	B2-1	F3-14	C1-7
R33	G4-13	G2-9	F1-1	B2-1	C4-14	D3-14	C1-10
R34	E1-8	G2-13	F1-13	C4-14	B4-10	B1-13	C1-11
R35	E2-8	G1-6	E2-1	B4-10	B4-4	B1-9	C1-12
R36	F2-8	E2-1	C3-2	B4-4	B3-10	A4-4	A4-16
R37	G3-14	G1-8	F2-1	B3-10	B3-4		
R38	E3-14	F2-1	C3-3	B3-4	A3-10		

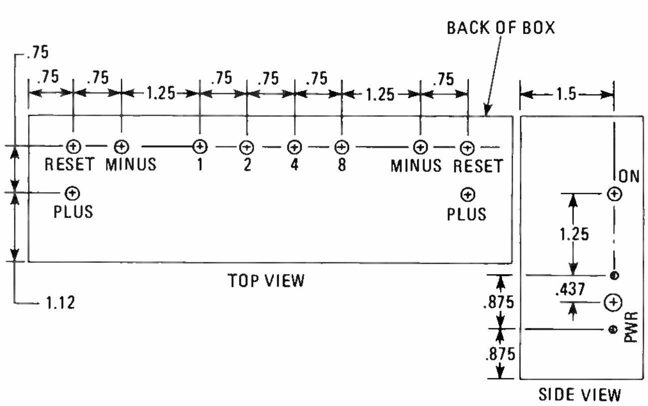


FIG. 6—DIMENSIONS for locating the switches and power connector on the enclosure.

You can make the PC board using the patterns in Figs. 2 and 5. The next step is to mount the resistors in row 5 and solder. Next, insert all the wire-wrap DIP sockets and the LED sockets and solder all pins that connect to foil on the PC board. Clean the board to remove all solder flux and put in the wire-wrap con-

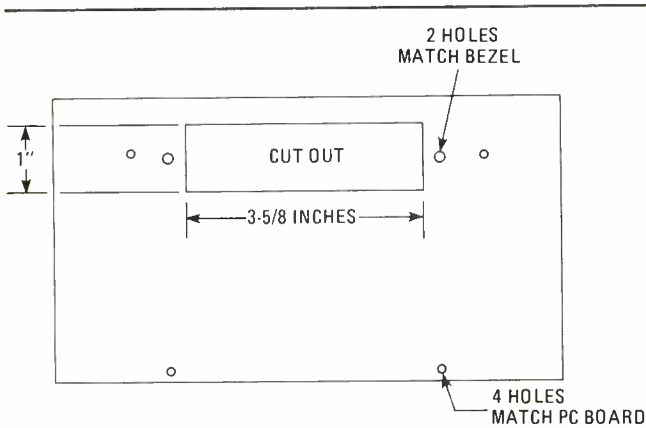


FIG. 7—CUTOUT for the bezel and filter and mounting holes for the circuit board. Use mounting holes in the PC board and the LED displays as aids when finishing the front panel.

nections as shown in Table 1. This completes the fabrication of this board.

Plug the main board with the respective integrated circuits and LED displays according to Fig. 3. Remember pin 1 for each DIP socket is located at the bottom right hand corner of the DIP pattern **as seen from the foil side of the board.** The discrete resistors and capacitors for the oscillator should be plugged into their respective sockets as shown in Fig. 4-a at this time. The PC board is complete at this time and may be put aside.

Next prepare the chassis and cover. Drill hole as shown in Figs. 6 and 7. The box and cover may be covered with wood-grained contact paper if desired for a richer looking finished product. Next label the switches and power plug opening with press-on letters. Mount the switches and the power plug. Connect hookup wire from the switches and power plug to the interface board. Then, install the interface board in the chassis. Connections on the interface board should be the same as that shown in Fig. 4 for C1 on the main PC board.

Mount the LED filter assembly to the chassis cover. Next, mount the main PC board on stand-offs so that the LED displays can be seen through the LED filter. Plug the interface cable from C1 to the interface board socket. The scorekeeper is now complete and ready for power on.

Plug in power and turn on power switch. The LED display should light. Press reset switches for both A and B. Both displays should read 00. Next, press switches "1", "2", "4", "8" and switch PLUS A. the A side of the LED display will count up to 15 and stop. This may be repeated for side B with the same results. Select other numbers and add or subtract from the respective display.

Now that you have built your own scorekeeper and have it on display invite your pool buddies over and challenge them to a game of serious pool. SP

PENNY PINCHING HINTS FOR EXPERIMENTERS

How some old fashioned Yankee ingenuity can save you money

HAVE WALLET-FLATTENING PRICES HELD UP YOUR latest electronics project? If so, here are some ideas to help you get that project going with very little money. Every electronics tinkerer has, at one time or another, had to find a substitute for some part called for in a project, so the problem of finding substitutes is not new.

Resistors, transistors, IC's and so on, are generally the least expensive parts in most projects. The real money eaters are circuit-board supplies, cabinets, connectors, and similar hardware. The secret of finding substitutes for the expensive items is to stay away from the electronic store, and look for them in such odd places as drugstores, supermarkets and hardware stores.

The cheap breadboard

The first problem in starting an electronics project is a breadboard or PC board. You can make a practical and inexpensive breadboard using materials available in any hardware store and most chain drugstores. The cheap breadboard uses 1/4-inch Masonite as a substrate, and brass-plated linoleum nails for terminals.

Figure 1 shows how it works. The linoleum nails are available at a cost of about three for a penny in hardware and chain drugstores.

The nails are rugged, easy to solder, and in many ways superior to some of their commercial equivalents. A coat of paint can give the board a bit of class. Royal blue makes an attractive complement to the brass nails. Masonite is nearly impossible to paint unless you use a primer first. Automotive primer is a good choice. The primer also provides an insulating layer that helps keep the paint from discoloring when you solder the brass nails.

The pattern for the nails should be layed out on the board before painting. The nails fit snugly into a 1/16-inch pre-drilled hole. The nails are short and it is hard to drive them with a hammer. Drilling is easier and neater. The nails can be soldered and unsoldered a number of times, and can be easily replaced when they get too messy.

What about integrated circuits?

To use an integrated circuit, drill a hole pattern like one of those in Fig. 2. A metal drilling template is a good idea if you intend to use more than one IC. Insert brass nails in the outside oval and insert a wire-wrap IC socket in the hole pattern inside the ring. Bend the socket wires as shown in Fig. 2. Wrap each wire around its respective nail and solder.

Printed circuit boards

Blank copper-clad boards are inexpensive and easy to get. Professional-type art supplies for board layout are expensive and often hard to find. Artwork kits for the experimenter are fairly easy to find, but tend to be frustrating. They always seem to come up short with the patterns you need, while you pay for a bunch

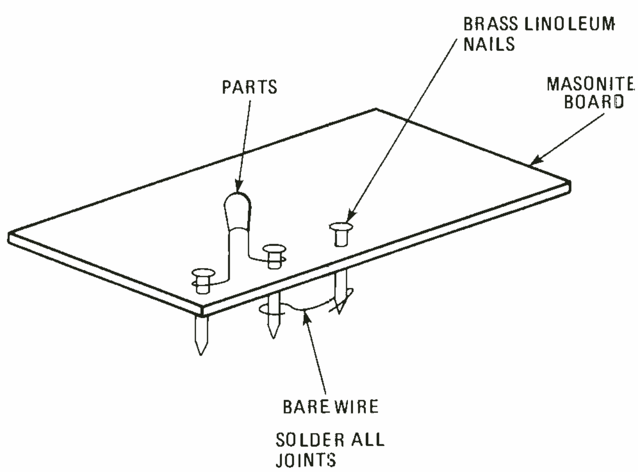
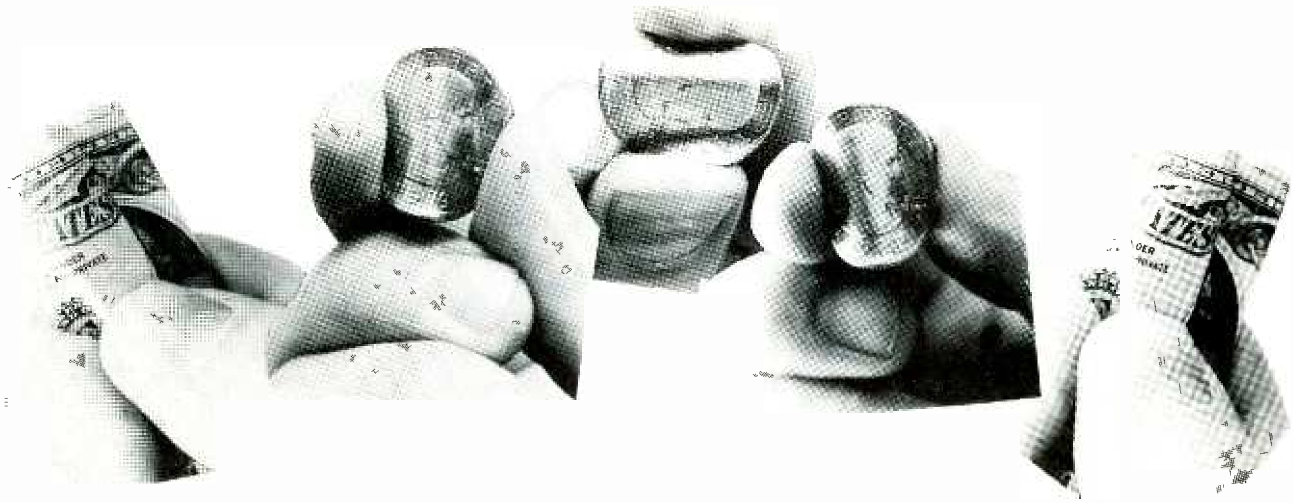


FIG. 1—THE "CHEAP BREADBOARD" has tie points made of brass-plated linoleum nails or brads forced into Masonite or similar pressed board. Point-to-point wiring is below the board; components are on top.



GERALD E. WILLIAMS

you don't need. I usually purchase a couple of packets of full-size 14- and 16-pin DIP paste-on patterns and use more common materials for the rest of the circuit.

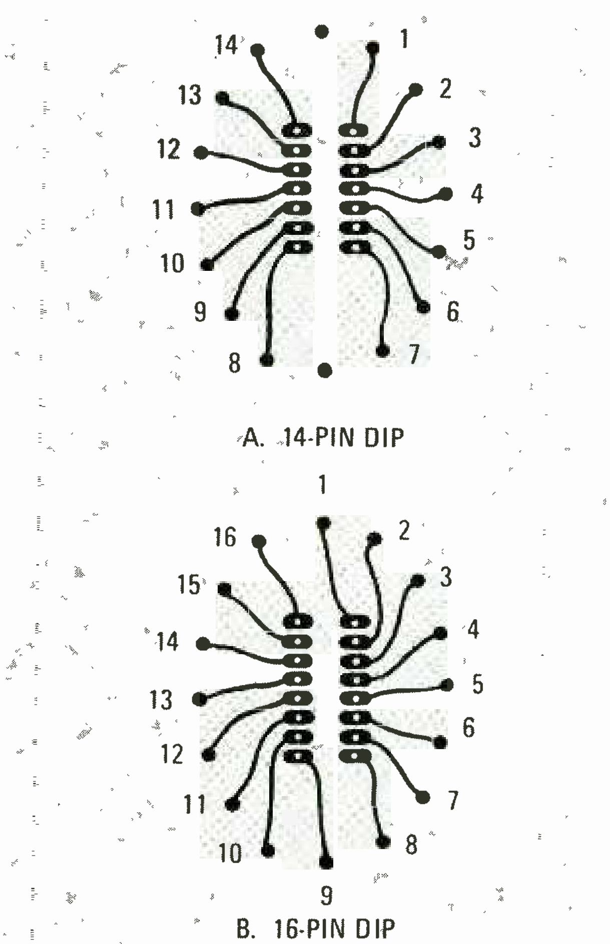


FIG. 2—HOW IC'S ARE BREADBOARDED. A full-size DIP pattern is used to position the holes for a wire-wrap IC socket. One-eighth-inch dots form the drilling pattern for the brass pins. Socket pins are wrapped around brass pins and soldered.

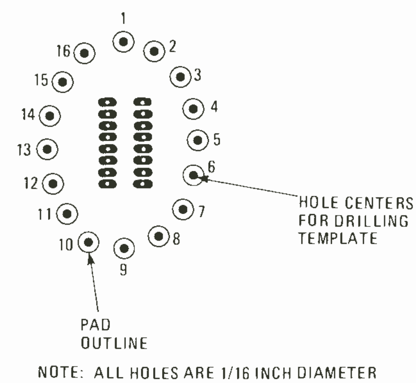


FIG. 3—ON A PC BOARD ¼-inch pads are spaced as shown around the IC pattern. One sixteenth-inch holes are drilled in each ¼-inch pad.

If your project is not a high-density one and you are willing to use a bit more board space, you can buy your supplies at your local office-supply store.

All you actually need for most layouts are spots and tape. The spots are used to color-code file folders. They are available in diameters from 1/4 to 1 inch. The 1/4-inch spot is the most useful, but occasionally, the larger diameters can serve a special need. The tape is 1/8-inch wide and is intended for the secretary and her typewriter. It is called correction tape, but like the color-coding labels, it has a self-adhesive backing. Note; this is not the strike-over kind. Automotive striping tape works as well or better than the correction tape. Figure 3 shows a pattern made with a DIP pattern and 1/4-inch pads.

Both self-adhesive labels and automotive striping tape can be used for either photographic layout or for sticking directly to the copper-clad board. The paper part of the self-adhesive labels may float off in the etching solution, but the adhesive will stay to mask the copper. You will need a solvent such as denatured alcohol or lacquer thinner to clean the adhesive off after etching the board.

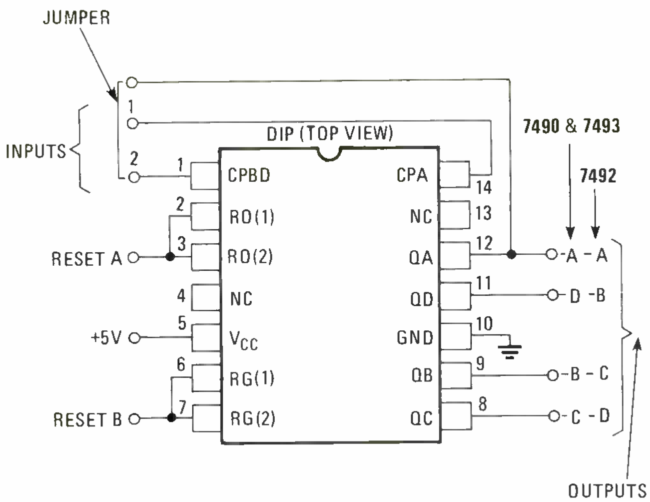


FIG. 4—SCHEMATIC DIAGRAM of a simple counter. Pin-out designations depend on the type of device that you use.

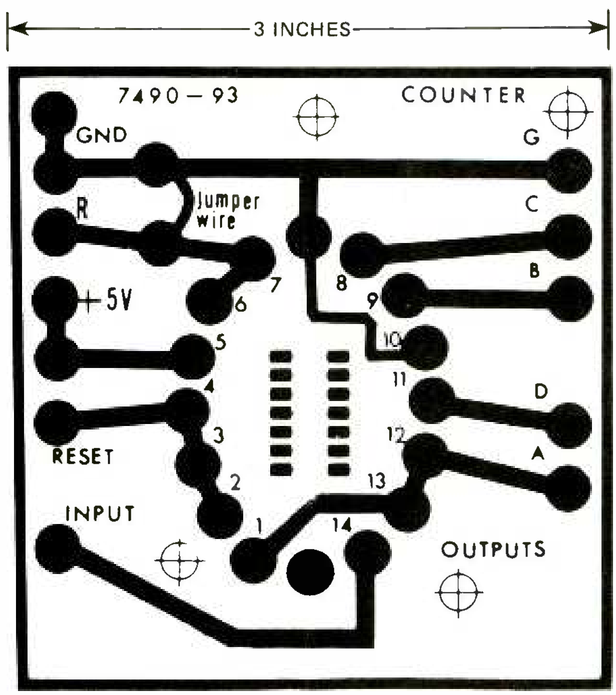


FIG. 5—PC BOARD FOIL PATTERN for a simple counter. Can be adapted for decade, divide-by-twelve, and 4-bit binary counters.

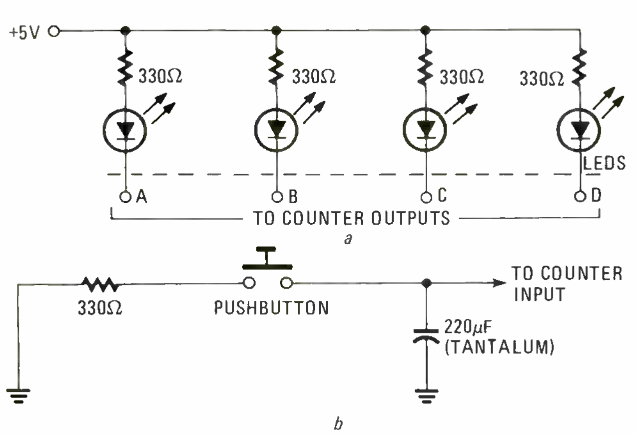


FIG. 6—COUNTER TEST CIRCUITS. Circuit (*a*) shows how output states are shown by LED's. Circuit (*b*) is a simple input test or trigger switch.

TABLE 1

TYPE	COUNT	RESET A	RESET B
7490	0-9 (MOD 10)	1. +5 VOLTS RESETS COUNTER TO ZERO. 2. MUST BE GROUNDED FOR COUNTING	1. +5 VOLTS SETS COUNTER TO 9. 2. MUST BE GROUNDED FOR COUNTING
7492	0-11 (MOD 12)	NOT USED	1. +5 VOLTS RESETS TO ZERO. 2. MUST BE GROUNDED TO COUNT
7493	0-15 (MOD 16)	1. +5 VOLTS RESETS TO ZERO 2. GROUNDED FOR COUNTING	NOT USED

How to put integrated circuits on the board

You can put integrated circuits on the board by using a wire-wrap socket and an oval pattern like the one we used in the cheap breadboard. See Fig. 3.

Figure 4 shows the schematic diagram for a simple IC counter and Fig. 5 the circuit board layout for it.

If you are interested in building the counter, Fig. 6 shows a simple input and output test circuits. Table 1 provides essential information about the three 7400-series counters the board will accommodate.

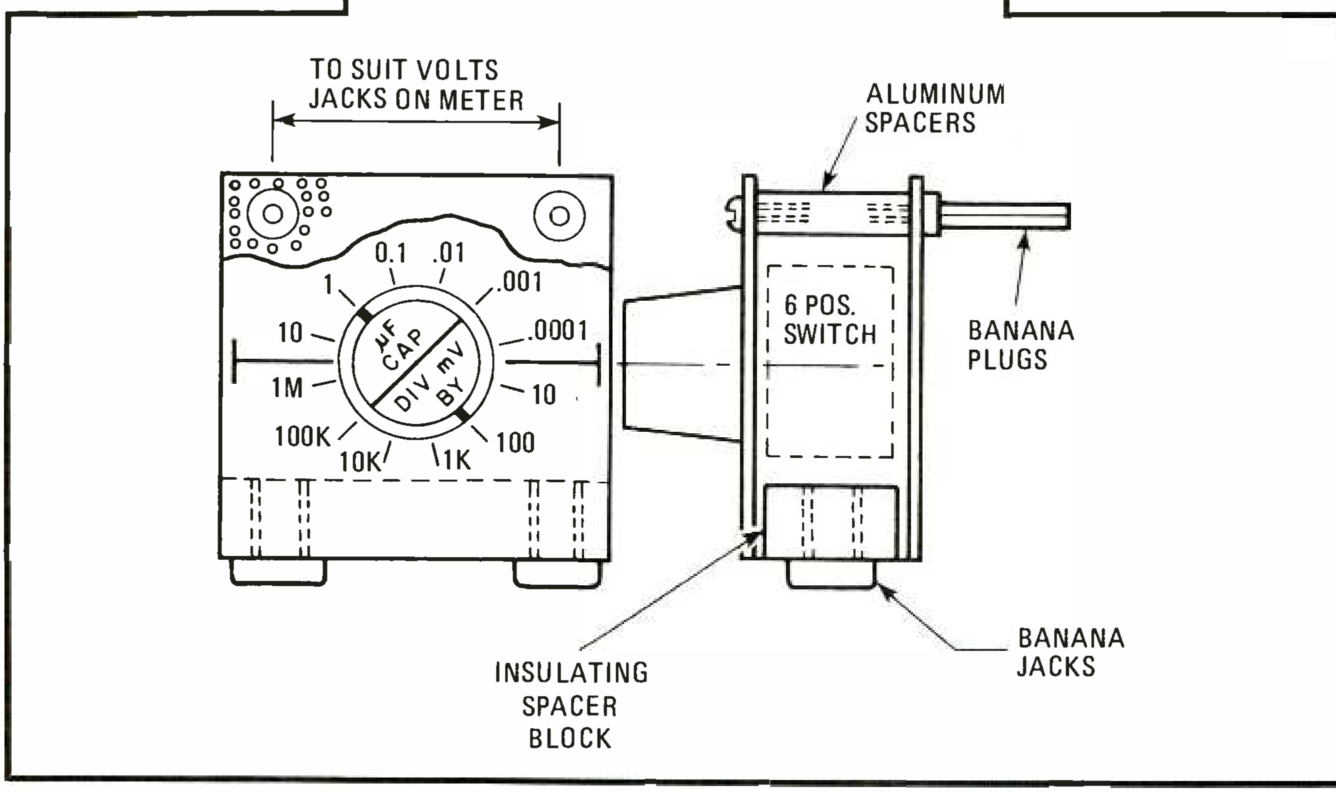
Most of the commercially available PC layout kits use very narrow tape and small spots. This makes etching difficult, and yields a circuit board with fine traces and small solder pads. Such delicate wiring is fine if you are going to assemble the board and leave it alone. However, if you want to experiment with different component values and so on, you will find 1/4-inch pads and 1/8-inch traces to be far more tolerant of your tinkering.

Some practical hints

1. Lay the spots out first, and then run tape between them.
2. Cut the tape near the center of the spot.
3. Use a ball-point pen to press the tape firmly to the board where the tape joins the spot.
4. Use a dab of fingernail polish to touch up where your knife cuts through a spot.
5. Use vinyl contact paper to mask large areas. Stick an over-size piece to the board. Use a stencil knife to cut the desired shape, and peel off the excess.
6. Use dry transfer (rub-on) letters and numbers to label the board. Dry transfer lettering has a wax base and will resist the etchant. Dry transfer lettering sheets are available in office-supply and art-supply stores.

Happy circuit boarding. **SP**

USE A DMM TO MEASURE CAPACITANCE



Here's a simple, low-cost way of making your DMM perform tasks that you'd think would require an expensive capacitance meter

DON R. KING

EXPERIMENTERS OCCASIONALLY NEED A CAPACITANCE meter, but the limited use doesn't warrant the expense of buying one. If you have a DMM with a 200-mV AC range—as on most of the better instruments—here is an easy, $5.00 way to hook it up for checking capacitance. It won't do a laboratory job, but it is quite adequate for sorting out that box of capacitors with the markings rubbed off, or making other practical measurements of capacitance.

The circuit, shown in Fig. 1, is essentially a type of "ohmmeter" with the capacitive reactance as part of a voltage divider in an AC-powered circuit. Because capacitive reactance is an inverse function, you get a straightforward, linear readout, in contrast to the inverse, non-linear scale of the conventional moving-coil ohmmeter. The disadvantage of this circuit has been that the shunt resistance must be very low in proportion to the unknown value, and thus requires either a very sensitive meter, or excessively high currents in the circuit. With the availability of sensitive AC meters such as the digital, it becomes a more practical method. It could also be adapted to moving-coil types of meters having ranges as low as 0.2- or 0.3-AC volts, but their poorer resolution makes it more diffi-

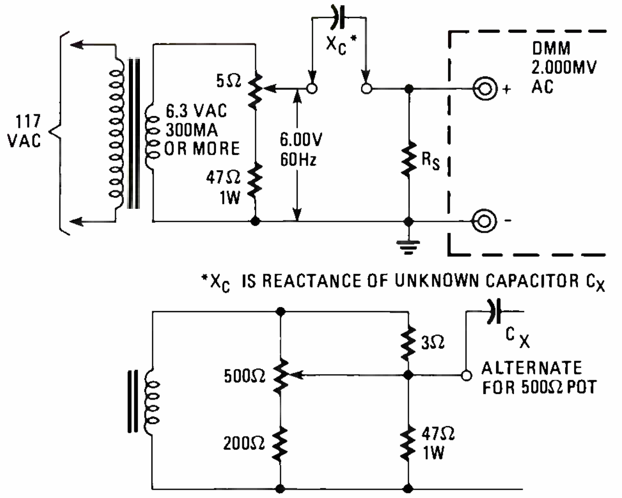


FIGURE 1—THE CAPACITANCE IN MICROFARADS will always be the numerical reading in millivolts divided by 100.

PARTS LIST-5 OHM POTENTIOMETER

Resistors ¼ watt, 5% unless otherwise noted
R1—5 ohms, potentiometer
R2—47 ohms, 1 watt
R_S—see table 1
Miscellaneous
T1—6.3 volts, 300 mA or better
PC board, spacers, banana plugs and jacks, six-position rotary switch, knobs, hardware, etc.

PARTS LIST—ALTERNATE FOR 500 OHM POTENTIOMETER

R1—500 ohms, potentiometer
R2—200 ohms
R3—32 ohms
R4—47 ohms, 1 watt
Note: all remaining parts are the same as in the 5 ohm potentiometer version.

cult to read low values.

Power is supplied by any small 6.3 volt transformer with a secondary rated at 300 mA or more. The voltage is reduced to exactly 6.00 volts by an adjustable voltage divider. The resistance values are low enough so that the voltage source is mostly resistive, and the inductive reactance of the transformer is minimized. The value of 6.00 volts is arbitrarily chosen as being: a) conveniently available from a common 6.3-volt transformer; b) low enough to be well within the working voltage limits of most capacitors; and c) high enough to give reliable indications with reasonable shunt values. Other voltages—within those limits—can be used by altering the value of the shunt resistor R_S. The value of R_S is determined as follows:

In the capacitor/resistor voltage divider of Fig. 1, the AC voltage output to the meter will be:

$$\frac{6.00 \times R_S}{X_C + R_S}$$

Setting that equal to 0.1 volt (100.0 mV, or mid-scale on the meter), and using 2653 ohms as the reactance X_C of a 1.0 μF capacitor at 60 Hz, the required shunt will be 44.96 ohms. Thus with that value shunt, a 6.00-volt input, and a capacitor of exactly 1.0 μF, the meter will read 100.0 mV AC. The capacitance in microfarads will always be the numerical reading in millivolts divided by 100. The complete relationship for different values of shunts is shown in Table 1.

TABLE 1

SHUNT RESISTANCE (R_S)	NOMINAL CAPACITANCE RANGE	CAPACITY IN μF = mV DIVIDED BY:
4.496 ohms	20 (19.99) to 0.1 μF	10
44.96 ohms	2.0 (1.199) to .01 μF	100
449.6 ohms	0.2 (.1999) to .001 μF	1,000
4,496 ohms	.02 (.0199) to .0001 μF	10,000
44,960 ohms	.002 (.0019) to .00001 μF	100,000
449,600 ohms	200 (199.9) to 1.0 pF	1,000,000 or pF direct.

The first of those odd values shown for R_S can be made from a combination of two selected 10-ohm resistors, and one selected 47-ohm in parallel. The next four values can be made up from selected 47-, 470-, 4700-, and 47,000-ohm resistors by paralleling each with a selected 1000-, 10,000-, 100,000-ohm and 1-megohm resistor, respectively. The shunt resistor for the last (lowest) range can use a 470 K resistor alone, as the meter's own internal resistance of 10 megohms will bring it down to the stated value.

For a convenient, permanent arrangement, you can mount the shunt resistors on a 2-inch-square PC board, with a six-position rotary switch, and with mounted banana plugs spaced to plug directly into the DMM jacks. A suggested construction layout is shown in Fig. 2. With this plug-in construction, all you need is a transformer rigged as a variable voltage source, and

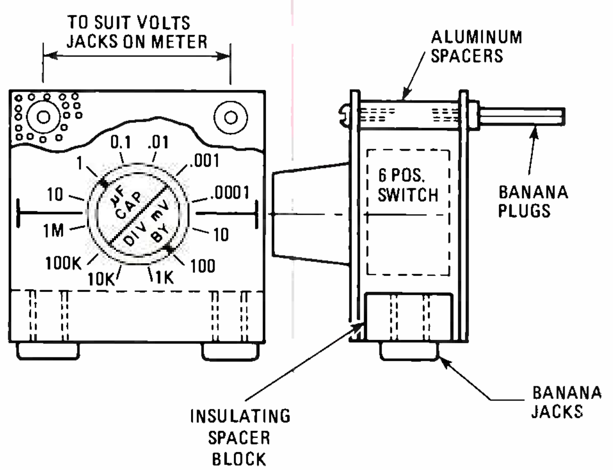


FIG. 2—SUGGESTED CONSTRUCTION LAYOUT; when plugged in, you can set up to check capacitance in minutes.

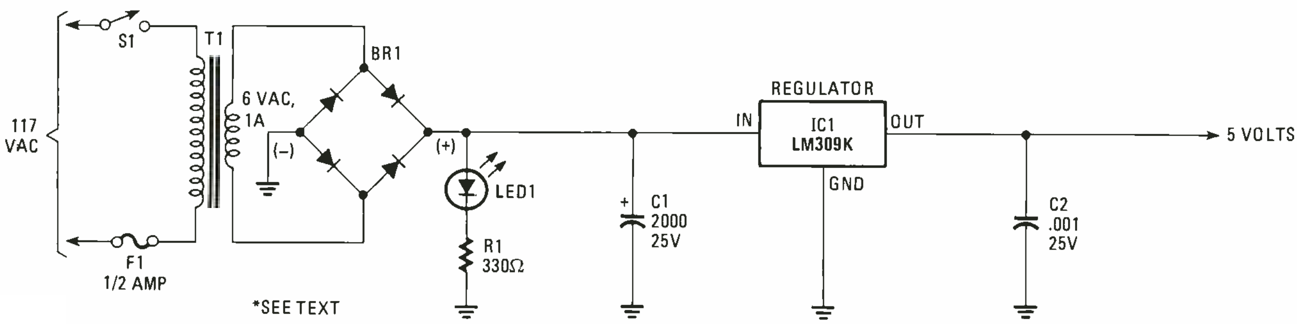
you can set up to check capacitance in minutes. While plugged in, transformer voltage may be verified by just switching to one of the two lowest capacitance ranges. In those ranges, the high values of R_S will have no effect on the 6.00 volt reading.

It would be possible to extend the capacitance range upwards another ten times by using a shunt of 0.4496 ohms, but that is a difficult value to obtain. If you must have a slightly higher range occasionally, it is simpler to use the 4.496-ohm shunt and switch to the 2.000-

A ¢HEAP POWER SUPPLY

You'll find that you already have most of the parts you're going to need

GREG MEAD



THIS CIRCUIT USES a 2000-μF electrolytic capacitor for the filter and a .001 disc capacitor to keep out radio interference.

PARTS LIST

SEMICONDUCTORS
IC1—LM309K voltage regulator—7805 can be substituted
LED1—general-purpose LED
CAPACITORS
C1—2000 μF, 25 volts, electrolytic
C2—.001 μF, ceramic disc
RESISTOR
R1—330 ohms ¼ watt
BR1—full-wave bridge rectifier, 1 amp (Radio Shack 276-1161 or 176-1151 or equal)
MISCELLANEOUS
T1—power transformer, 6 VAC, 1 amp (Radio Shack 273-050 or equal)
F1—Fuse, 0.5 amp with holder
S1—SP ST switch

A WHILE AGO, I BUILT A POWER SUPPLY FOR ALL MY digital circuits. It was inexpensive, easy to build and puts out 5 volts at 1 amp. Most of the parts you should already have in your possession. The 5-volt regulator I used was the LM309K, but you can use the 7805. Both of those must be connected to a heat sink.

The transformer should be rated at 6 volts at 1 amp. Radio Shack's (273-050) will do nicely.

Since it is for digital circuits, you need a full-wave bridge rectifier that has a rating of 1 amp. Either of Radio Shack's (276-1161) or (276-1151) will do the job.

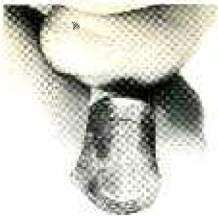
This circuit uses a 2000-μF electrolytic capacitor for the filter and a .001 disc capacitor to keep out radio interference. Both capacitors need to have a 25 WVDC rating or higher.

The LED is optional, but I have found it quite useful to indicate when the power supply is on. **SP**

volt scale on the meter. Note that due to the meter's own decimal point shift, the capacitance in μF now becomes 100 *times* the numerical readout on the meter. Using the meter's 2.000-volt scale in that way allows you to stretch the high range enough to take in 22 μF, but beyond that the accuracy begins to suffer. At least, you can tell a 22-μF capacitor from a 47 μF unit. That is about all you need to know in that range of capacitance.

Within the range of values in Table 1, the accuracy depends mostly on the accuracy of setting the 6.00 volts and the accuracy of the shunt resistors. Ideally, it will be within about 2%, with this possible exception: In checking larger electrolytics (above 5 or 10 μF) there could be just enough current drain to pull down the transformer voltage slightly. With a fairly heavy transformer, it may be negligible. In any case, it can be compensated for by monitoring the 6.00 volts during the test with a separate meter and readjusting. Because they may draw moderately high current, be careful not to overheat large-value capacitors of very small dimentions such as tantalums.

In adjusting the 6.00 volts, or calibrating the set-up, it should be noted that the 120-volt line can be quite jumpy in some locations. If you have trouble holding the calibration voltage setting, it may be better to wait for a quieter period on the line, then adjust the voltage and quickly make the capacitance check before the voltage can change. Also, at the millivolt range, meters are very sensitive to stray fields. You may get small residual readings with no capacitance connected. That will affect the accuracy. Try an earth ground to minimize stray pickup. The next step in reducing stray pickup is to try reversing the polarity of the line plug, and/or the polarity of the transformer secondary. When you find the best condition, mark it for future use. A short, shielded lead to the high side of the meter is also helpful. **SP**



USING WHAT'S AVAILABLE PLUGS SWITCHES & HARDWARE

More ways to save on your experimental projects. This time we'll show some make-shift plugs, sockets, and mounting hardware.

GERALD E. WILLIAMS

DRESSMAKER'S SNAPS MAKE AN EXCELLENT PLUG assembly for either PC boards or the cheap breadboard described earlier. Dressmaker's snaps are available in both sew-on and stake-on types. Stake-on types are slightly more expensive but better suited for printed-circuit boards. The stake-on type also allows you to use a common push-pin as a handle. Figure 1-a shows how the plug is assembled on a PC board and Fig. 1-b shows how the snap socket mounts on the cheap breadboard.

If you need a multiple-contact plug, make one by soldering a row of snap sockets to the board, and staking a corresponding row of studs to a leather or heavy vinyl strip. A flexible mounting strip avoids the need for precision alignment of studs and sockets. This technique is used in 9-volt battery connectors. Figure 2 shows how.

Speaking of 9-volt batteries, a couple of snaps and a vinyl strip will do a good job of securing a 9-volt battery to a circuit board. See Fig. 3.

On-off switch for your circuit board

The simple cam operated switch shown in Fig. 4 requires a common safety pin, a push-pin, a machine screw and nut, and a brass-plated linoleum nail. Push-pins come in assorted colors, including clear. The plastic used will stand the heat of soldering with just a little care. File a flat side on the pin as shown in Fig. 4. If a detent is desired, you can file a notch on the flat side and another on the round side of the push-pin. The bent-up safety pin will fall into the notches to provide the desired feel. When the end of the safety pin rides on the flat of the push-pin, it touches the linoleum nail to close the circuit. Twist the push-pin so the safety-pin wire moves away from nail and opens the circuit.

The skirt of the push-pin is sharp. It is a good idea to file a small flat around the base of the skirt to keep the safety pin from riding up to the narrow part of the pin.

The push-pin can be secured to the board with a drop of solder or preferably, a tiny washer and a drop of solder. A left-over snap half can also be used as a washer.

Stand-offs and brackets

If you need an insulated spacer or stand off between your circuit board and and a cabinet or chassis, the push-pin assembly in Fig. 5 will do the job rather nicely.

This plastic bracket (Fig. 6) has a hundred uses. It is intended for mounting heavy mirrors so it is rugged. You can use these brackets to make a circuit-board holder that allows the board to slide in and out, or you can use it as an insulated spacer to bolt down circuit boards or any number of other items. A little imagination will find a number of uses for this neat little plastic bracket.

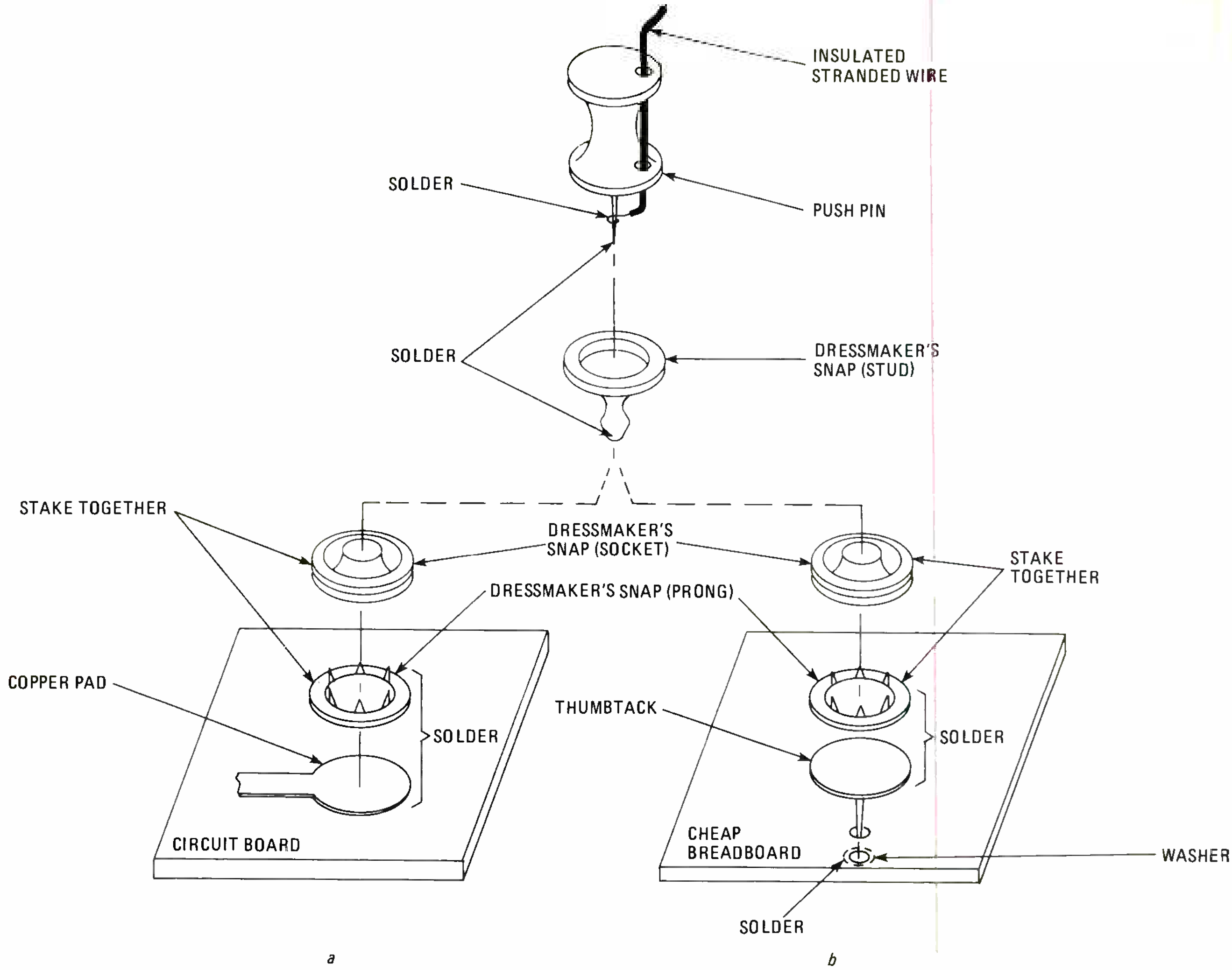


FIG. 1—DRESSMAKER'S SNAP with push-pin as a handle, makes a unique electrical connector. Drawing (*a*) shows the idea applied to a PC board and (*b*) shows how the connector is used on the "cheap breadboard."

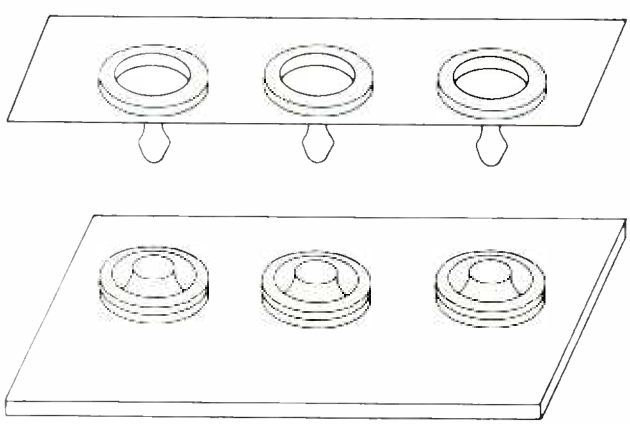


FIG. 2—MULTIPLE-CONTACT CONNECTOR has a row of snaps soldered to the circuit board and a corresponding row of studs staked to a thin leather or heavy vinyl strip.

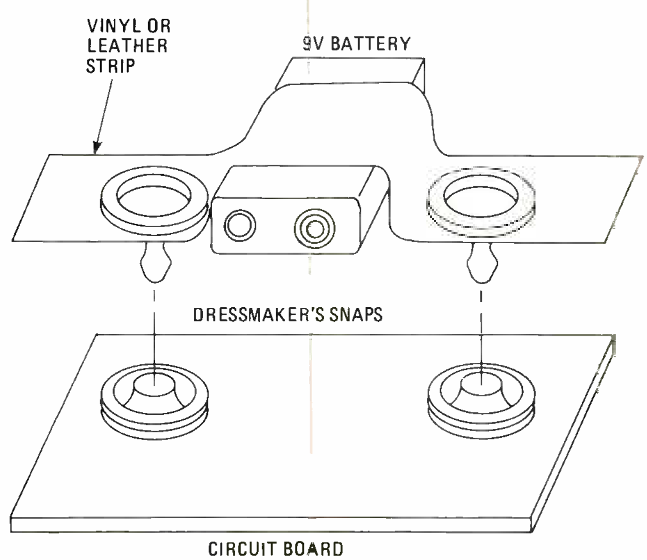


FIG. 3—A COUPLE OF SNAPS and a vinyl strip make a handy hold-down for a 9-volt radio battery.

Mounting light-emitting diodes

A simple wooden block can do a fine job of mounting light-emitting diodes. The thickness of the wood can be selected for the particular task. One-quarter inch Masonite will allow just the dome of the lens to poke through. See Fig. 7-a. If you want a really fancy lens, use a thick block. Insert the LED into one side of the block and a stud of colored plastic rod into the

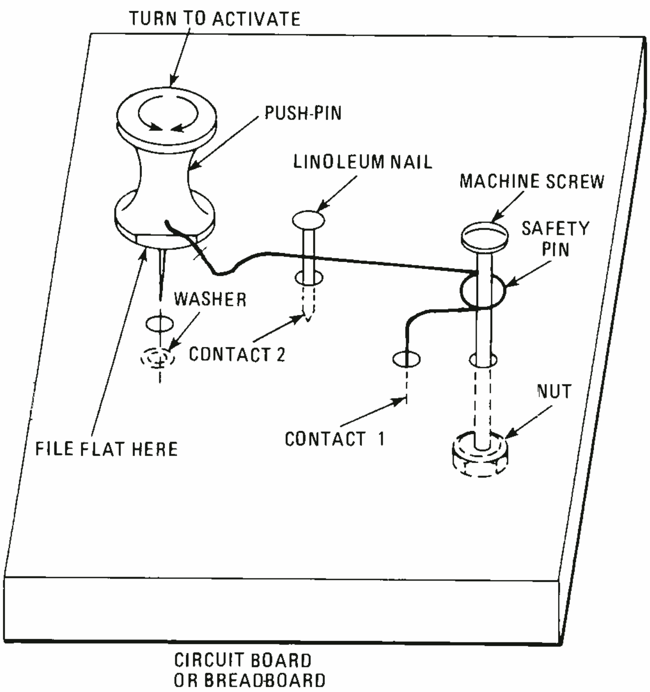


FIG. 4—A CAM-OPERATED SWITCH can be made from a few ordinary components.

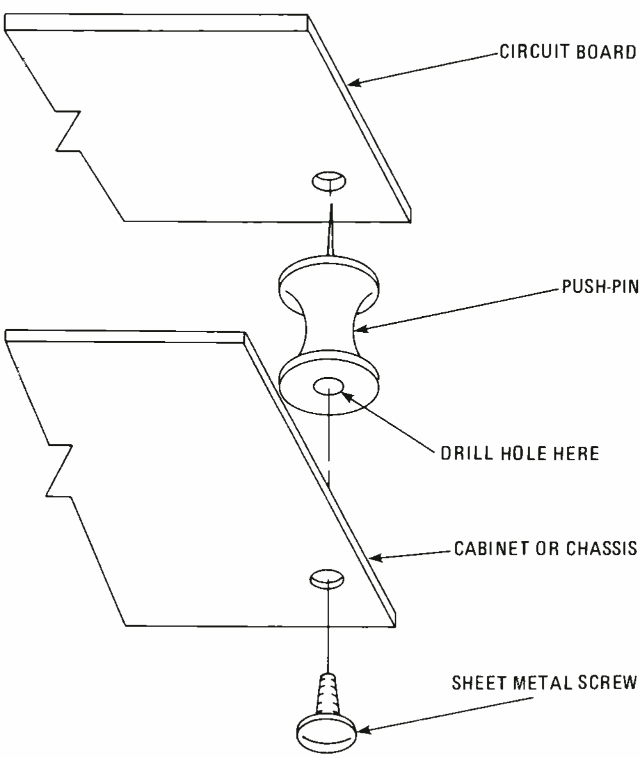


FIG. 5—A COMMON PUSH-PIN makes a handy stand-off or spacer for use between two circuit boards or between a circuit board and chassis.

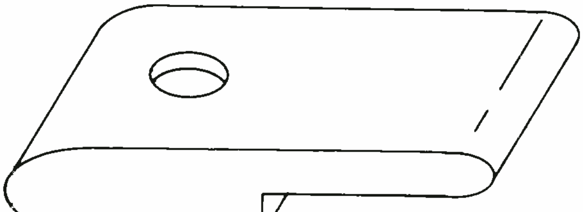


FIG. 6—PLASTIC MIRROR BRACKET can be used as a hold-down for circuit boards. Among other uses is as a holder for a filter shielding various types of numerical readouts.

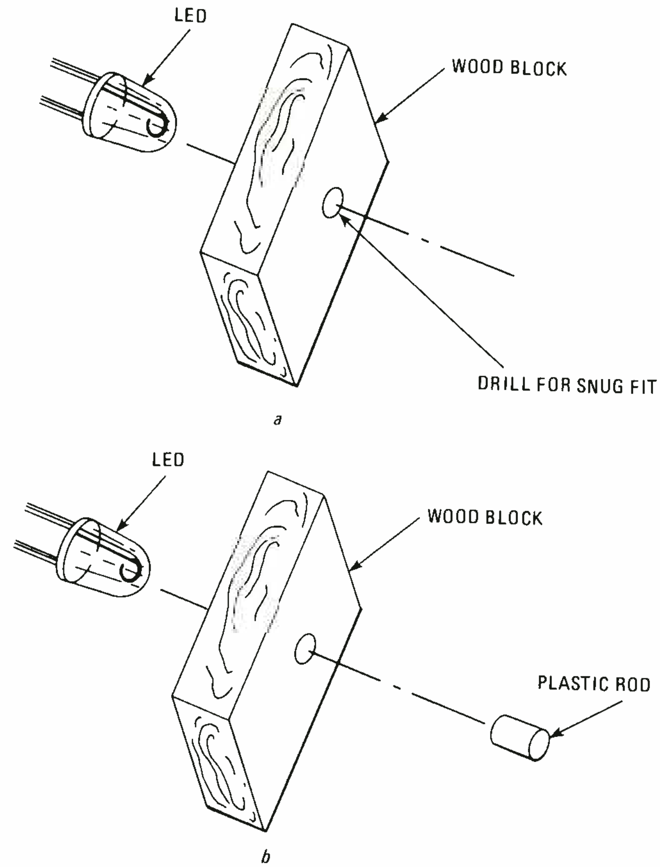


FIG. 7—SIMPLE MOUNTINGS for LED's. Poke it through a thin pressed-wool panel or mount in a thicker slab with piece of plastic rod for a lens.

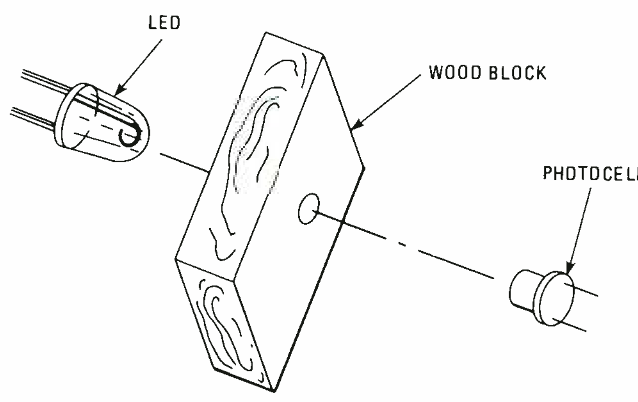


FIG. 8—OPTICAL COUPLER made by inserting an LED and a photocell in opposite ends of hold drilled in a block of wood.

other as shown in Fig. 7-b. Sandpaper the end of the plastic stud that faces the LED. The viewing end of the stub must also be roughened. You can use sandpaper again, but a more interesting effect will result from a few cross cuts in the end with a hacksaw or tiny triangular file.

Need some optical couplers? A single optical coupler won't crimp your budget, but if you need several, bargain LED's and photo-transistors or cadmium sulphide photocells mounted in a wooden block (Fig. 8) can save you some money. Don't forget that linoleum nail. It can provide a string of anchor pins for the LED's or photocells.

Happy tinkering. **SP**

A REMOTE CONTROL FOR

Operate up to four appliances from a single remote-control receiver with this device.

DAVID LEITHAUSER

THERE ARE A NUMBER OF PLANS AND COMPONENTS available for building sound-activated switches and similar remote control devices for various types of appliances and equipment. Now it is fairly simple to build a device that lets you control up to four appliances with a single remote-control receiver, whether it is a sound-activated switch, a photocell, or a radio receiver. The remote control receiver's output can be any voltage to which you can add positive-going (or negative-going) pulses. This is possible because the device counts the number of pulses to determine which appliance to turn on.

About the circuit

The output of the remote control receiver is fed into the inverting input of comparator IC1 (Fig. 1). This voltage is compared to a reference voltage applied at the non-inverting input of the comparator through potentiometer R5. When the output voltage of the remote control receiver has a positive pulse that goes higher than the reference voltage, the output of the comparator (it is normally positive) has a negative pulse. If the remote control receiver can produce only negative pulses, reverse the inverting and non-inverting comparator leads. This will cause a negative pulse from the remote control receiver to produce a negative pulse from the comparator.

The negative pulse from the comparator triggers two monostable multivibrators (555 timers IC2 and IC3). Note that each of these monostable multivibrators has a diode from pin 6 and pin 2. These diodes keep capacitors C1 and C2 discharged when the comparator output is negative, so that the on-time of the monostable multivibrators continues for a preset period after the end of a negative pulse from the comparator.

The first multivibrator (IC2) is really just a debouncer, to properly condition the pulses fed to the 74193. The second multivibrator (IC3) has a much longer time-constant (about 3 seconds) and serves two purposes. First, on the first pulse it clears (resets) the 74193 counter to zero so that it can begin counting. Second, it inhibits the relays through the 74368 tri-state control so that the relays do not start turning appliances on until all the pulses have been counted. It does not allow the relays to be energized until there have been no pulses for 3 seconds.

The 74193 produces a binary output that represents the number of pulses it has received, minus the first pulse because IC3 was resetting the 74193 to zero at the same time the first pulse came in. This binary output is used to control the relays, after being inverted by the tri-state inverters in the 74368.

Table 1 gives the condition of the relays after the train of pulses. In order to change any of the relays, it is necessary to begin a new train of pulses and create the new combination from scratch.

Examples of Operation

Let's use this as a sound-controlled device. The amplifier in Fig. 2 makes a good input. The output of the op-amp goes to the inverting input of the comparator. When the sound strikes the mike (the 8-ohm speaker), voltage variations are produced at the output of the op-amp. Potentiometer R5 should be adjusted so that the reference voltage at the non-inverting input of the comparator is a little higher than the voltage at the amplifier output when there is no sound present. That way the comparator output will normally be positive. However, when sound strikes the mike, the voltage swings produced by the amplifier cause the voltage at the comparator's inverting input to go higher than the reference voltage. This will cause a negative pulse at

TABLE 1

Number of Pulses	Relays Activated
1	None, all relays turned off
2	RY1
3	RY2
4	RY1 and RY2
5	RY3
6	RY3 and RY1
7	RY3 and RY2
8	RY3, RY2, and RY1
9	RY4
10	RY4 and RY1
11	RY4 and RY2
12	RY4, RY2 and RY1
13	RY4 and RY3
14	RY4, RY3 and RY1
15	RY4, RY3 and RY2
16	RY4, RY3, RY2 and RY1

HOUSEHOLD
APPLIANCES

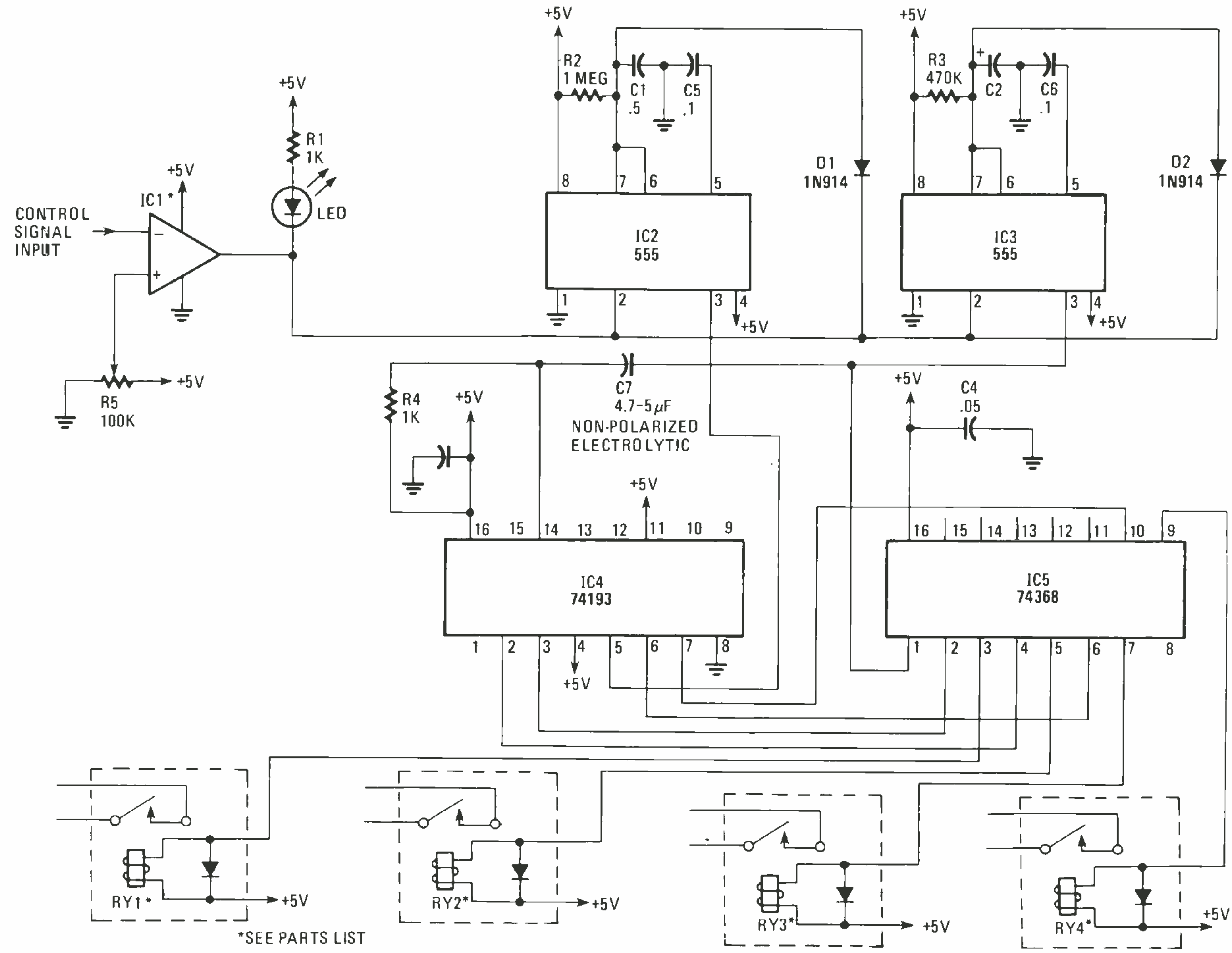
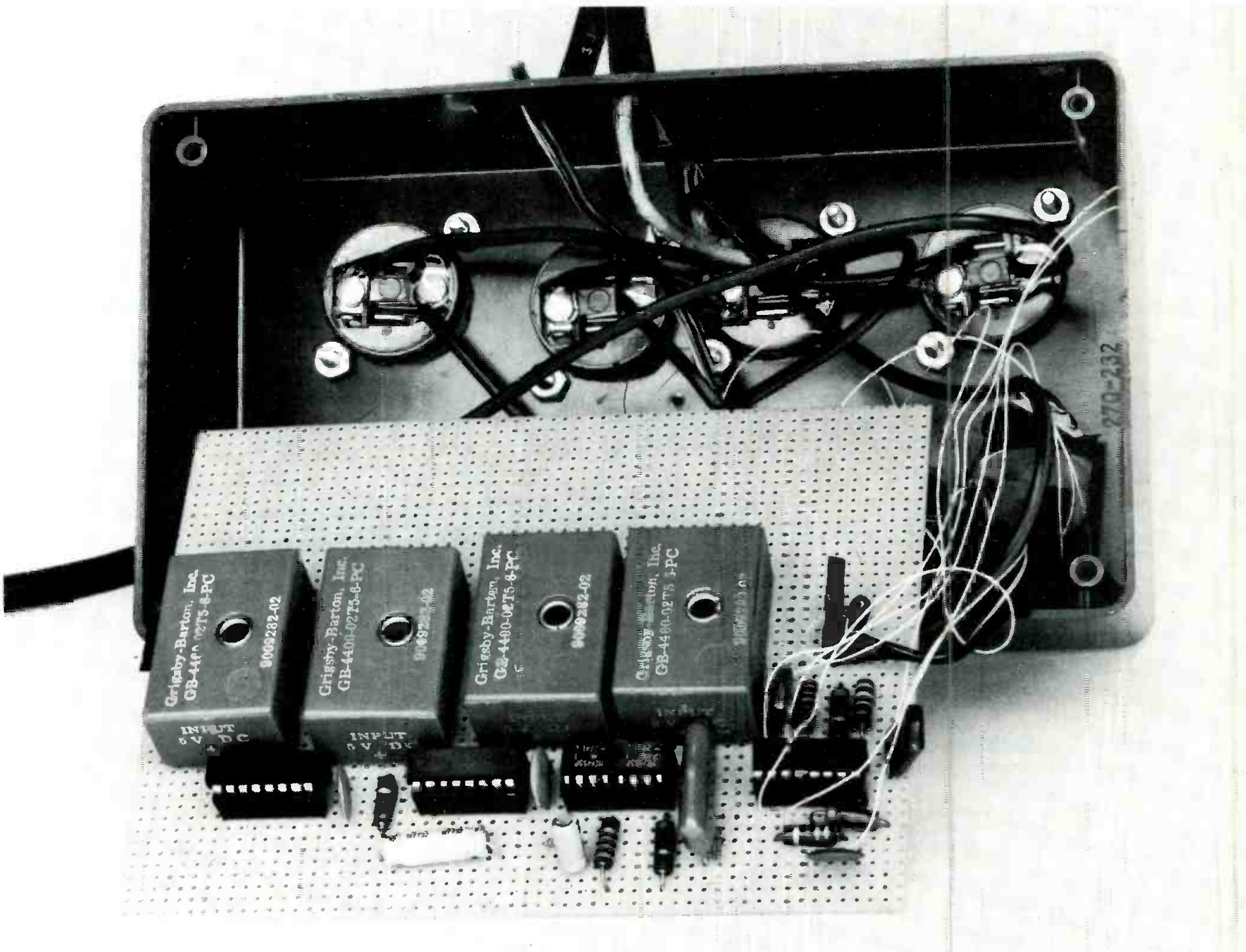


FIG. 1—SCHEMATIC DIAGRAM of the remote-control device. Up to four separate appliances may be controlled.

the comparator output. Actually, it will produce a burst of pulses, but multivibrator IC2 will condition these into one pulse provided there is no pause in the sound. That is, each clap or word counts as one pulse, while the pause between claps or words (if you speak each word distinctly) allows IC2 to reset and wait for a new pulse.

The reference-voltage control (R5) will act as a sensitivity control, since setting it at a high voltage means that a loud sound is required to produce voltage oscillations large enough to pass this voltage level. The sensitivity control must not be set too high or glitches will register as pulses. When this happens, glitches produced by the relays—as they are energized—will be "read" as a single pulse; thus turning off all relays

Assembled remote control switch. Note the four controlled outlets on the back panel. Unit is powered by AC low-voltage transformer supply.



Internal view shows how the parts are arranged inside the cabinet. Assembly is not critical and therefore easy to duplicate.

PARTS LIST

Resistors, ¼ watt or larger, 10% or better
R1, R4—1000 ohms
R2—1 megohm
R3—470,000 ohms
R5—100,000 ohms, potentiometer

CAPACITORS
C1—0.5 μF
C2—5 μF Mylar or other low-leakage electrolytic
C3, C4—.05 μF, disc
C5, C6—0.1 μF disc
C7—4.7 or 5 μF non-polarized electrolytic, 35 volts

SEMICONDUCTORS
IC1—any comparator that will work off 5 volts DC and has a low output impedance should be satisfactory. I used a 308 op-amp without a feedback resistor. A 741 will work OK here also.
IC2, IC3—555
IC4—74193 or 74LS193 counter
IC5—74368 or 74LS368 tri-state inverter
D1, D2—1N914 diode
RY1—RY4—solid-state normally open relay, input 5 volts DC, 10 mA; load 120-240 volts AC, 1.5 amps. Suitable relays are the BG 14420-05S by Gordos-Arkansas, 1000 N. 2nd St., Rogers, AR 72756 and the 226RE7-5DC by Sigma Instruments, Switching Products Div., Braintree, MA 02184. These relays are approximately $10.00 each. A line to their respective manufacturers will get you the name and address of the retailers nearest to you.

MISCELLANEOUS:
1N4001 diode for each relay if the solid-state relays used do not include internal diode protection. A 5-volt regulated power supply, suitable housing, chassis-mount AC receptacles.

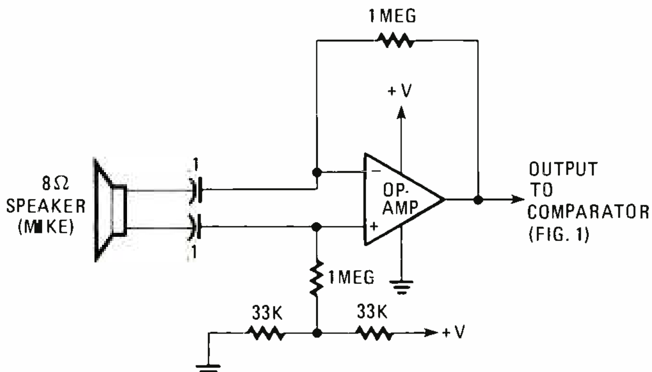


FIG. 2—MICROPHONE and preamplifier may be used to operate the remote-control device.

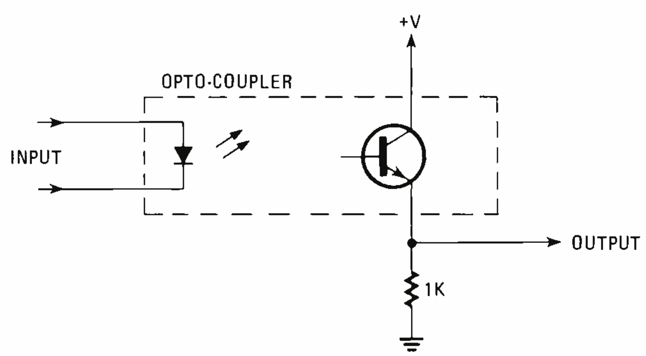


FIG. 4—OPTO-COUPLER will couple almost any remote-control receiver to the device.

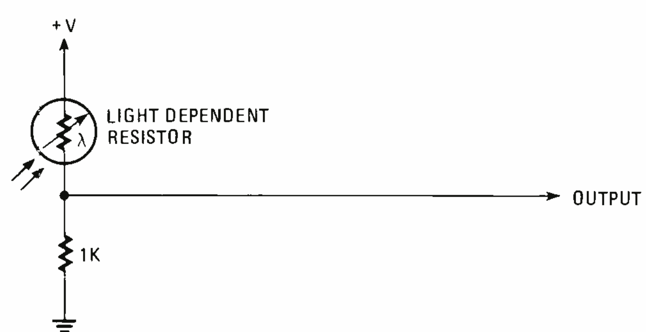


FIG. 3—PHOTOCELL VOLTAGE DIVIDER allows you to operate the remote-control device with a flashlight.

the instant they are energized.

The sensitivity could be adjusted so the LED is normally out but lights up when a pulse is applied to the comparator. This indicates that the reference voltage to the non-inverting input is properly adjusted.

Another useful control device is the photocell voltage divider shown in Fig. 3. Light striking the photocell drives the output high enough to pass above the reference voltage. Using an ordinary flashlight to send flashes of light to the photocell, you can operate four appliances by remote control.

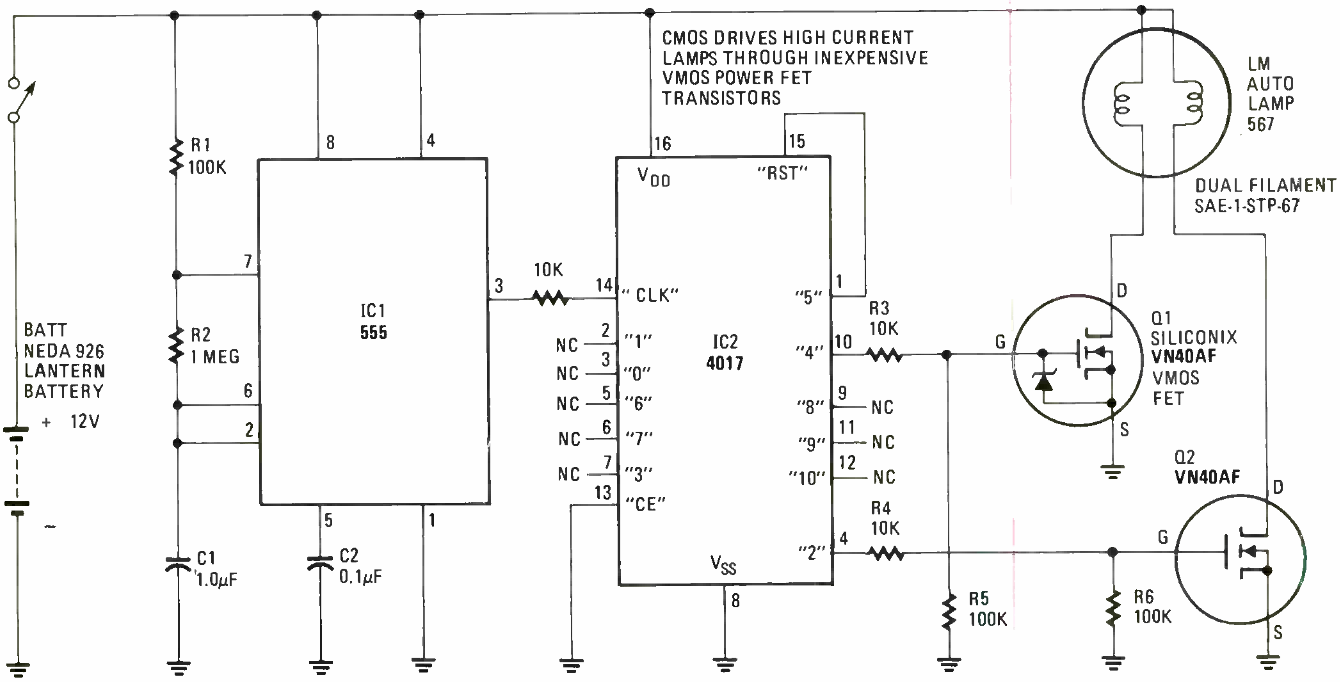
If you wish to use this device with a remote control device that cannot be run on 5 volts, the circuit in Fig. 4 will couple virtually any remote control receiver to this device.

Construction

This circuit can be wired using a printed circuit, wire wrapping or point-to-point wiring. Wires should be kept as short as possible around the TTL counter. The solid-state relays should not require heat sinks unless the appliances they control draw a considerable amount of current. Be sure to include anti-glitching capacitors C3 and C4 on the 74193 and 74368. Install additional anti-glitching capacitors as needed. **SP**

VMOS FLASHER

Drive high-current loads from CMOS? Use VMOS!



TAILLIGHT FLASHER CIRCUIT is made possible by VMOS technology. With VMOS FET's, CMOS IC's can be used to switch high-current loads.

MARTIN BRADLEY WEINSTEIN

JUST A FEW YEARS AGO, RUNNING A FET AT A WATT OR more was all but unthinkable. But a new technique, developed just recently, has more than broken that barrier.

A V-shaped groove in the transistor substrate (cut before metals are deposited) is the physical characteristic of this transistor technology, called VMOS for *vertical* MOS.

It's a bit too long a story to go into detail here and explain all the subtleties of VMOS, but here's a look at some of the benefits it offers.

Current capabilities now extend to multiple amperes, but at negligible drive—typically less than 100 nA. Switching delay times are on the order of a few nanoseconds. And because current reduces with rising temperature (not increases, as in bipolar), not only is thermal runaway eliminated, but devices can be paralleled without ballasting resistors for even higher current capabilities. Finally, prices are very reasonable, with one manufacturer, Siliconix (2201 Laurelwood Road, Santa Clara, CA 95054), advertising one model at 50¢ in production quantities.

It almost sounds too good to be true. So we gave VMOS a trial by breadboard. The results, if you will pardon the pun, were enlightening.

We got a couple of VN40AF VMOS power FET's from Siliconix (less than a buck each). The specs were mildly incredible:

Maximum drain-source or drain-gate voltage—40V; maximum continuous drain current—2.0-A (3.0-A pulsed); −40 to + 150°C operating range; input Zener-protected against static; fan-out from CMOS of 100 (!!) or more; and on and on and on.

So we set a mildly incredible task—driving an add-on taillight assembly from CMOS levels using only a VMOS FET and a couple of resistors in between.

It worked.

We clocked a 4017 decade counter (with ten decoded outputs) with a 555. The circuit counts to five before resetting. Two VN40AF's tied to the "two" and "four" outputs drive the two filaments in the light assembly.

The 10K series resistors limit the current to the transistor gates and, with the 100K resistors, not only help define the CMOS output load, but help the VMOS switch hard to the supply rails; these could be eliminated with only minor effect.

It's almost disgusting—a TO-220 between a lantern battery and a large-current taillight taking its orders from CMOS. Well, that's progress! **SP**

PARTS LIST

RESISTORS
All resistors ¼ watt
R1, R5, R6—100,000 ohms; R2—1 megohm
R3, R4—10,000 ohms

CAPACITORS
C1—1.0 *uF*; C2—0.1 *uF*

SEMICONDUCTORS
IC1—555; IC2—4017; Q1, Q2—VN40AF

MISCELLANEOUS
BATT—12V lantern battery (NEDA 926)
LM-Auto lamp 567 (dual filament); S—SPST toggle
Breadboard or perfboard; Wire; Solder

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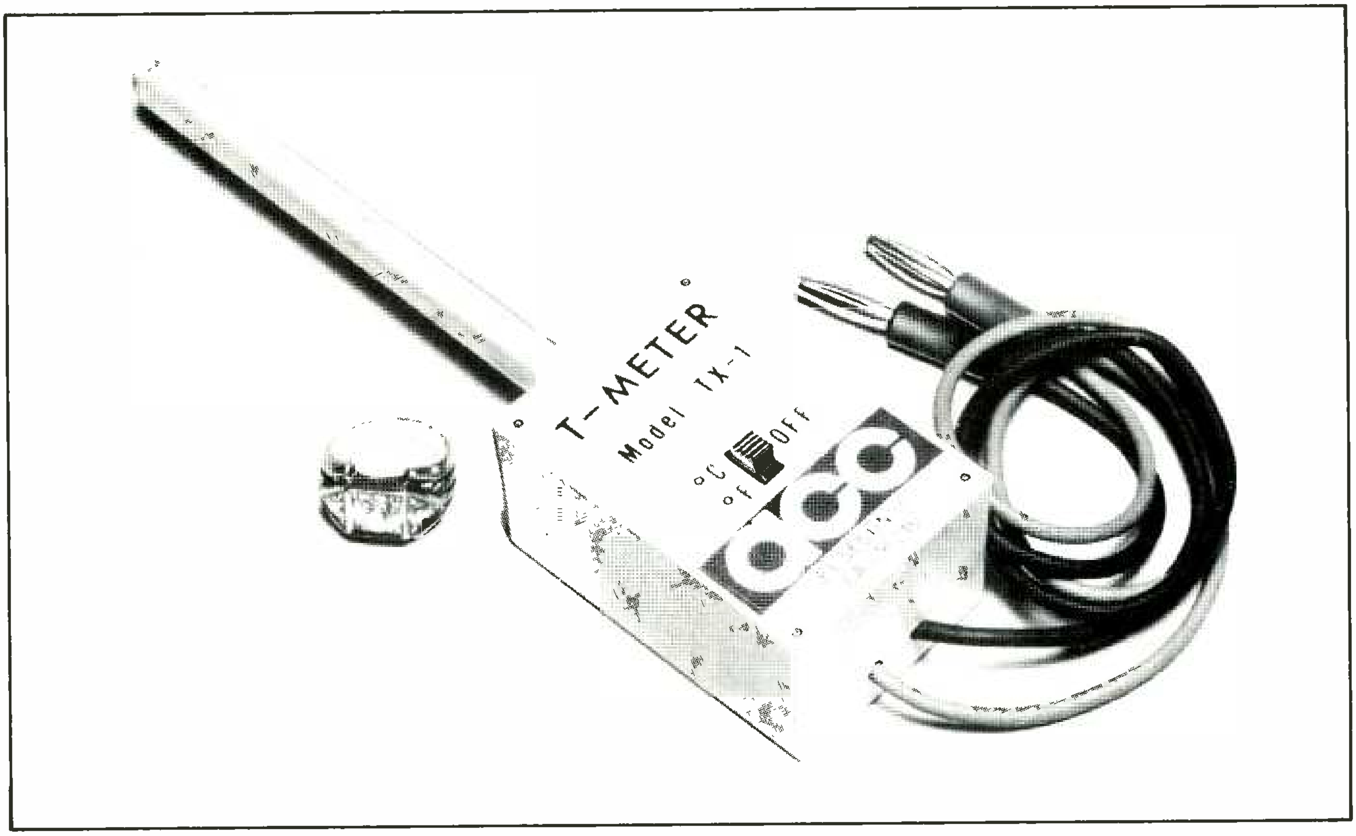


TEMPERATURE ADD-ON FOR YOUR DMM

This accessory measures temperature in °F or °C with your digital multimeter

J.T. CATALDO

WHEN TESTING ELECTRONIC EQUIPMENT WE OFTEN need to know the accurate temperature. This must be quickly and easily ascertained. The temperature of semiconductors is an example where this information is vital for good circuit design. Mercury thermometers, although accurate, are fragile and easily broken. Moreover, it is difficult to assure good contact with the surface being tested. Independently packaged electronic thermometers are, in general, too expensive for limited use. Consequently, T-Meter is an economical answer to the problem. It has the advantage of a rugged probe simplifying good surface contact plus the economy of utilizing a digital multimeter to display the temperature directly in either degrees Celsius or Fahrenheit (°C or°F) as selected by the user. Temperatures can be measured from −55° to 125°C or −67° to 257°F.

The circuit uses two unique IC's. One, an adjustable current source, is used as the temprature sensing element. Its operating voltage is directly proportional to absolute temperature, degrees Rankin or Kelvin. The other IC is a three-terminal programmable Zener. The third terminal allows setting of a reference voltage which is required to calibrate the T-Meter to Fahrenheit and Celsius instead of absolute temperature.

Block Diagram

A block diagram of the basic circuit is shown in Fig. 1. The section of the circuit on the left serves as the temperature sensor. The sensor IC is mounted in the tip of the probe and converts the sensor current to a voltage proportional to the temperature. On the right-hand side is an offset voltage source to convert absolute temperature to degrees F or degrees C.

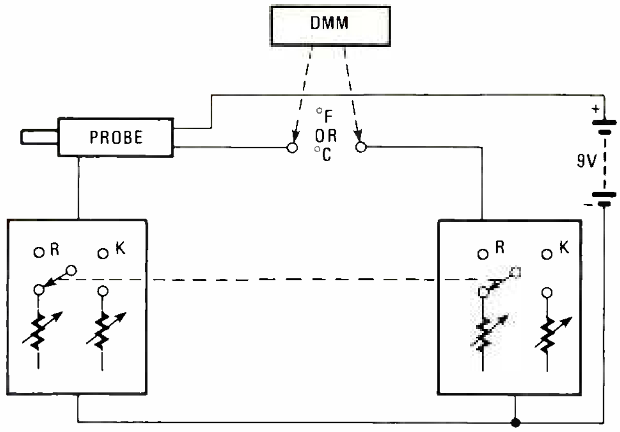


FIG. 1—BLOCK DIAGRAM OF THE T-METER. A sensor in the probe develops a temperature-dependent voltage that is compared to a fixed stabilized reference voltage. A digital multimeter reads the voltage difference as temperature in °F or °C.

How it works

The complete schematic is shown in Fig. 2. Resistor R13 establishes the operating current for the LM134H sensor. The resistive load, R1, R3 and R5, converts this current to a voltage of 10 mV/°Rankin measured from V1 to common. Similarly, the load R2, R4 and R6 produces a voltage of 10 mV/°Kelvin.

Since absolute zero is −460 degrees Fahrenheit, trimmer R3, is adjusted so that the voltage V1 to common is 4.60 volts plus ambient temperature in degrees R. For example, at an ambient temperature of 68° F, voltage V1 should be set for 5.28 volts (4.60 + 0.68).

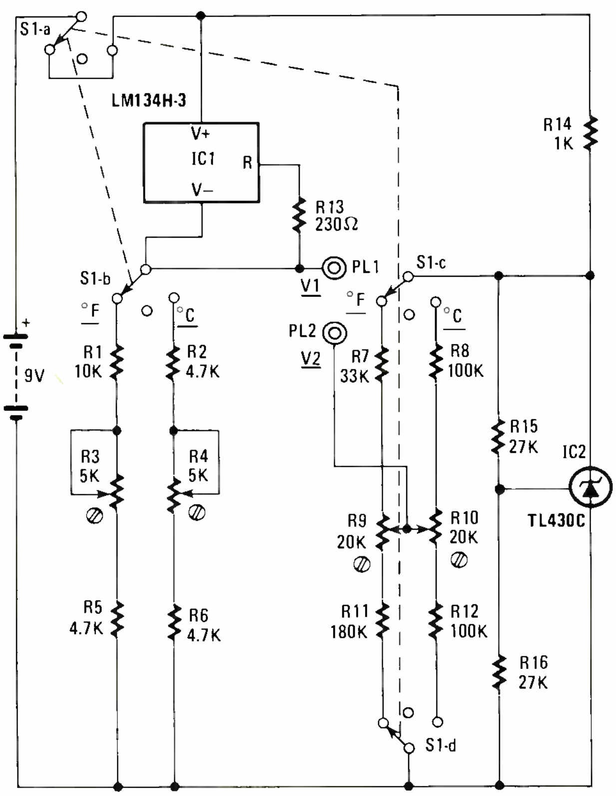


FIG. 2—SCHEMATIC SHOWS THE SIMPLICITY of the T-Meter. IC1 is mounted in the probe. All other parts except the battery are on a PC board hardly larger than 1¼ by 2½ inches.

PARTS LIST

RESISTORS

Resistors ¼ watt, 5% or better unless otherwise noted

R1—10,000 ohms
R2, R14—1000 ohms
R3, R4—5000 ohms, trimmer potentiometer, PC mount Cermet type
R5, R6—4700 ohms
R7—33,000 ohms
R8, R12—100,000 ohms
R9, R10—20,000 ohms, trimmer potentiometer, PC mount Cermet type
R11—180,000 ohms
R13—230 ohms, Dale CMF55
R15, R16—27,000 ohms

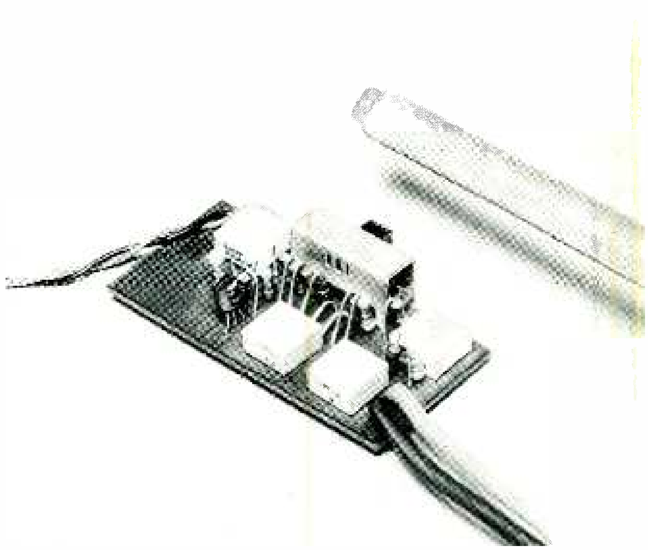
SEMICONDUCTORS

IC1—LM134H-3 (National)
IC2—TL430C (Texas Instruments)
S1—switch, 4P3T, Alco MSS4300R

MISCELLANEOUS HARDWARE

Transistor insulator for IC1 (Delbert Blinn No. P31034-1); aluminum tubing, 0.375 in. OD, 0.065 in. wall, 4½ in. long with nuts and washer. Case and cover (Pomona Electronics No. 3850-9); 9-volt transistor battery (rechargeable type with charger recommended for heavy duty); red and black banana plugs; red and black test-lead wire; PC board, etched and drilled.

The following are available from Alpha Components Corp., PO Box 306, El Segundo, CA 90245: PC board etched and drilled with switch S1 and resistor R13 mounted and soldered, $8.00 plus $2.50 shipping. Complete kit (less battery) $42.00 plus $3.50 shipping. T-Meter completely assembled and factory wired (less battery) $59.95 plus $3.50 for shipping. California residents add 6% sales tax.



COMPONENT SIDE OF THE BOARD with all parts in place. Note that resistors are mounted upright.

The offset voltage, V2, is set to 4.60 volts by adjusting trimmer R9. With the test leads of the T-Meter plugged into the DMM which is set on the 10-volt DC scale, the display will indicate 0.68 volt or 68°F. It is simply; V1−V2 = temperature reading (5.28 volts −4.60 volts = 0.68 volts) (0.68 × 100°/V = 68°F). This holds true for degrees Celsius except that absolute zero is −273 degrees Celsius. In this case, the voltage V1 set for 2.93V (273 + 20) and V2 for 2.73V. Hence, (V1−V2) = 0.20 or 20°C (the equivalent of 68°F).

The power source for the unit is an ordinary 9-volt transistor radio battery. Because the device draws only a few milliamperes, the battery should last over 500 hours or more, with ordinary usage. (If the T-Meter is used for extended periods daily on the service bench, we recommend rechargeable nickel cadmium batteries and a charger.)

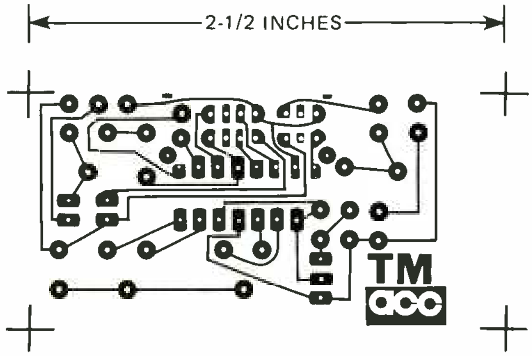


FIG. 3—FOIL PATTERN for the T-Meter PC board.

Construction

Only normal soldering and assembly procedures are required. The PCB foil pattern is shown in Fig. 3 and the placement of components in Fig. 4. Note that the switch (°F - OFF - °C) is mounted and soldered to the PCB. Precision resistors are not necessary. However, it is wise to use 5% deposited carbon-film resistors since they have a better temperature coefficient than composition carbon resistors. The trimmers are the one-turn square Cermet type having a temperature coefficient of plus or minus 100 ppm/°C. Furthermore,

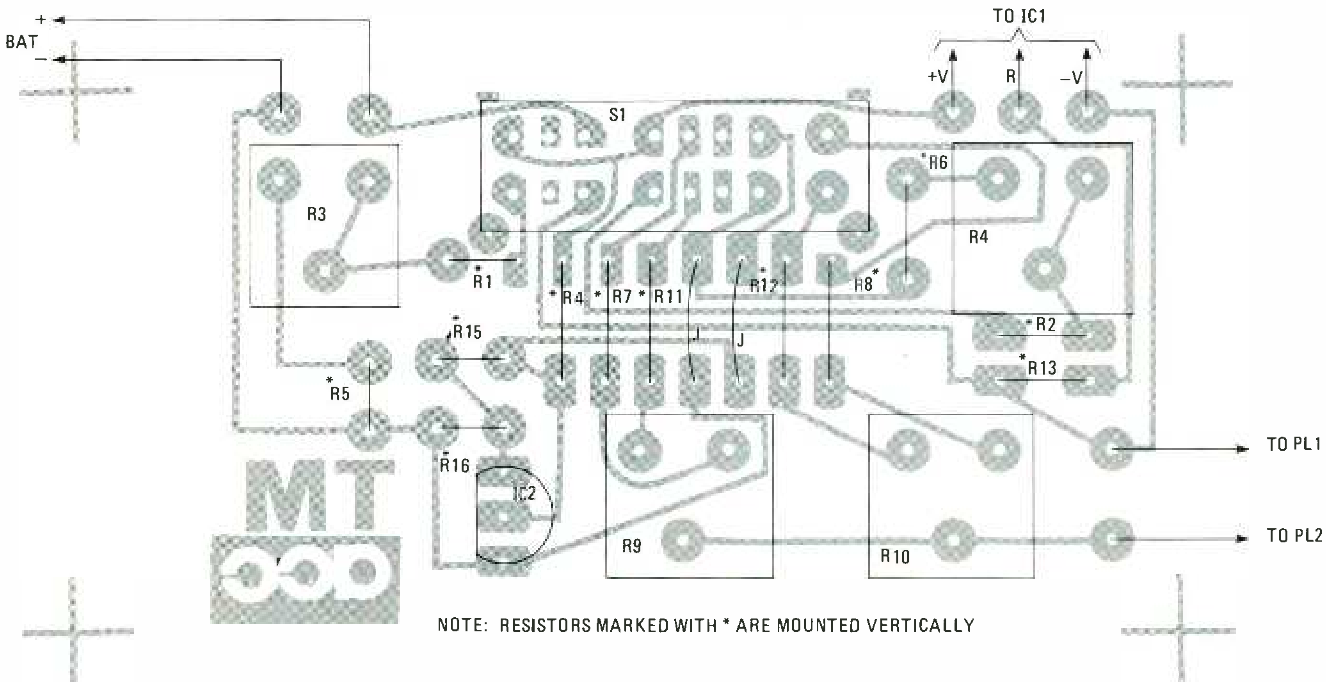


FIG. 4—COMPONENT SIDE OF THE PC BOARD shows the locations of the parts. Note the two jumpers that must be added. They are between R11 and R12.

INTERIOR VIEW SHOWS HOW PARTS FIT into the enclosure. The case cover is drilled so switch handle protrudes.

with the terminals of these units on 0.1-inch grid, it is convenient for perf board point-to-point assembly. However, the switch will pose a problem for perf board assembly as the terminals are metrically spaced. The resistor specified for R13 was selected for its excellent temperature stability.

The probe, in addition to the sensor, consists of a 4-½-inch piece of aluminum tubing threaded for half an inch at one end, a nylon transistor insulator, an internal tooth lockwasher and two nuts threaded to fit the end of the tube. Three color coded No. 24 gauge wires (required for pin-out identification) are soldered to the sensor pins and insulated with shrink tubing. The sensor case tab is cut off. The leads are passed through the insulator from the large end and the sensor is pressed in. One nut is threaded onto the tubing with the sensor leads being inserted from the opposite end and pushed through. The sensor and the insulator are seated in the tube end.

The leads and tube are mounted in the case through the hole provided. The assembly is completed by means of the second nut and lockwasher. The three colored wires are soldered to appropriate pads on the PC board.

Calibration

The LM134 sensing element has a linear output characteristic with temperature, so the T-Meter may be calibrated at a single point. The most convenient temperature is 32°F. A temperature bath consisting of crushed ice and water can easily be made. To minimize heat loss, a polyurethane foam coffee cup may be used. The water should be just sufficient to fill the voids between the ice chips. Too much water may not lower the temperature to 32°F.

The bath should stabilize in 15 to 20 minutes with occasional stirring; this can be checked with a thermometer, if available. With the switch in the °F position, immerse the sensor probe in the ice water bath, adjust trimmer, R3, until the voltage V1 to common equals 4.92 volts (4.60 + 32) °F.

Insert the banana plug leads, observing polarity, into the DMM. Adjust potentiometer, R9, to obtain a reading of 0.32 volt on the 10-volt scale, which is 32°F, the temperature of the bath. To calibrate Celsius, push the switch to °C. Adjust trimmer, R4, for V1 to common to equal 2.73V. With the leads from the T-Meter plugged into the DMM, adjust trimmer, R10, until the reading is 0.000 volts or 0°C.

Operation

Insert the banana plugs of the T-Meter into the DMM, observing polarity and set it on the 10-volt DC scale. Slide the T-Meter switch to °F. The display will now read the room temperature in °F. Apply the probe to the component to be measured. Since semiconductors are rated in °C, you should set the switch to this position. A temperature of, say, 90°C will read 0.9 volt which is 90°C when multiplied by 100.

For temperatures below 100, you can set the DMM to 1.0-volt scale. In this case, the DMM would read tenths of a degree. Assuming that the temperature is between 90 and 91, you may read 0.903 or 90.3°C. Since the T-Meter was calibrated on the 10-volt scale, accuracy of readings on the 1.0-volt scale depends on the relative accuracy of the two scales. The resolution of he T-Meter is plus or minus 1 degree on the 10-volt scale and plus or minus 0.1 degree on the 1.0-volt scale, plus or minus one digit of your meter. With the T-Meter you an determine thermal performance of your electronic circuit design. You can verify operating temperatures of semiconductors, resistors, transformers and other components. Furthermore, you can evaluate heat dissipation efficiency of heat sinks.

You will also find your unit is invaluable in troubleshooting malfunctioning equipment. For example, shorts can be located by searching out hotspots, such as drivers or output transistors. Absence of heat on any component indicates no current flow due to an open circuit. And, of course, the ingenious reader can develop many other applications. **SP**

THE LATEST WAY TO DO NOTHING

NOEL NYMAN

This new version of the popular Do-Nothing box uses just a PROM and simple IC's to randomly select among several display routines.

PEOPLE HAVE BEEN BUILDING DO-NOTHING BOXES FOR many years. In addition to being fairly simple to build, their shifting light patterns have an almost hypnotic effect. In this article, I would like to present a state-of-the-art version of this popular device, a do-nothing box that randomly selects among several display routines.

An obvious way to do this is to use a microprocessor. By putting the display routines in memory along with a random-number-generator program, the processor could produce a constantly changing display. But even with today's inexpensive processors, the cost of the do-nothing box would go up sharply. By using a PROM with the display routines arranged in a particular manner, you can achieve the random-display effect with simple IC's.

Let's review the display format briefly. Some routines look best with a straight line display, others look better with a circle. Figure 1 shows a display using thirteen LED's to combine the two. There are seven LED's in the circle and seven in the line. The circle and line share LED 6. The LED's in the circle are spaced about 51 degrees apart. Although there are eight data bits available from the PROM, only seven are used to control LED's. The last bit is used to select the circle or line display. For this discussion, a logic 1 in the PROM bit 0 location indicates a line display.

Now we'll look at the memory arrangement. In computer memories, an 8 × 512 section of memory is called a page. This page can be divided into 32 sections or paragraphs. Each paragraph has sixteen words or bytes in it, see Figure 2. Each of these paragraphs has a five bit address, 00000 through 11111. Each word within the paragraph has a four-bit address, 0000 through 1111.

For the do-nothing display, I used each paragraph to hold a display routine of fifteen steps or less. Five address lines are used to select a paragraph. The selection is done on a "random" basis. Then this paragraph address is latched and each word in the paragraph is addressed in sequences starting with 0000 at a pleasing display rate—2 Hz is about right. When the routine ends, a reset pulse latches a new random five-bit address to select a new paragraph and the four-bit word address starts from 0000 again.

Figure 3 shows the schematic of a circuit that does this. IC1 is a 556 dual timer with both timers in an astable mode. Capacitor C2 and resistors R2 and R3 give an output frequency around 2 Hz. Resistor R2 is made adjustable for the most pleasing display rate. The output from this "slow" clock goes to IC2, a synchronous up-counter used as a divide-by-sixteen counter. The outputs of IC2 go to the four low address lines of the PROM, IC3. As the counter counts up, each address in the paragraph will be selected.

Capacitor C4 along with resistors R4 and R5 form a timing network that produces a frequency near 250 kHz from the "fast" clock. The fast clock output goes to IC4 wired as a divide-by-thirty-two counter. It's five outputs will select the paragraph. A latch, IC5, is used between the counter and the PROM. At the start of a routine, the output of IC4 is latched by IC5 and becomes the paragraph address. IC5 holds this information until the end of the display routine. At that time a reset signal latches a new address from the constantly changing output of IC4 through a one-shot, IC6. The IC6 output brings pin 9 of IC5 high briefly to latch the new address and also resets the word-address counter, IC2 pin 7, to start the display at the beginning of the paragraph.

The eight outputs of the PROM connect to inverters,

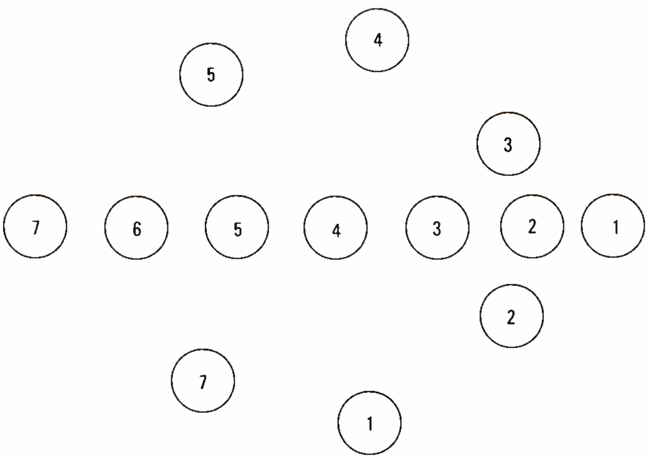


FIG. 1—DISPLAY FOR THE DO-NOTHING BOX has thirteen LED's laid out as shown so the random display can be in either the form of a circle or a straight line.

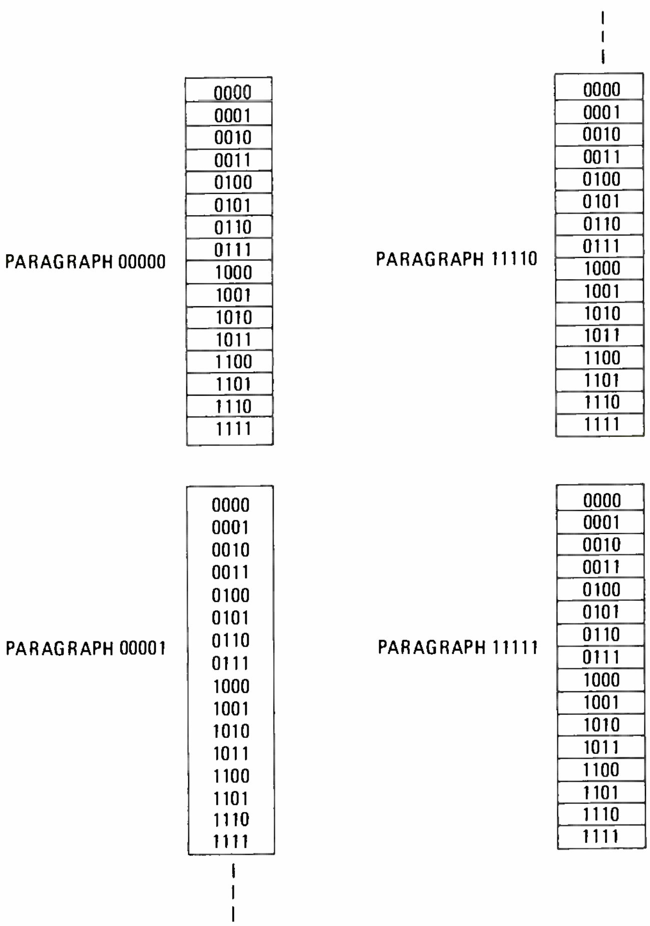


FIG. 2—HOW THE THIRTY-TWO PARAGRAPHS are programmed. The selection is random and each holds a display routine of up to fifteen steps.

PARTS LIST

RESISTORS
Resistors ¼ watt, 5% unless otherwise noted
R1—2700 ohms
R2—100,000 ohms, potentiometer
R3—10,000 ohms
R4, R5—1000 ohms
R5—27,000 ohms
R7, R8—2000 ohms
R9—R15—390 ohms

CAPACITORS
C1, C2—2.2 µF, electrolytic 10 VDC or higher
C3—1000 µF, electrolytic, 10 VDC or higher
C4—.002 µF, ceramic disc
C5—.05 µF, ceramic disc

SEMICONDUCTORS
IC1—556 dual timer
IC2—CD4520B dual synchronous up counter
IC3—MM2758Q-A EPROM (National)
IC4—CD4024B 7-stage binary counter
IC5—74174 hex D-type flip-flop with clear
IC6—74121 monostable (one-shot) multivibrator
IC7, IC8—7404 hex inverter
IC9—7430 8-input NAND gate
IC10—7805 voltage regulator
LED's—13 TIL228 or equal
Q1, Q2—2N4402 or equal

The following is available from Noel Nyman, PO Box 88868, Seattle, WA 98188: 2758Q-A, $25.00. Washington residents include sales tax.

TTL for high output current and a bright display. The outputs of seven inverters go to the display LED's through current-limiting resistors. LED 6 is common to both circle and line displays. The anodes of the circle LED's are connected together and driven by transistor Q1. Transistor Q2 drives the line display LED's. The PROM bit 0 output controls the transistors through inverters and current-limiting resistor. A logic 1 on bit 0 turns Q2 on and Q1 off, a zero on bit 0 reverses this.

The reset signal (fed through IC6) comes from IC9. The seven NAND gate inputs are wired to each LED. When all LED's are off and the display routine is over, the NAND output goes low and triggers the one-shot. The reset output from the one-shot (IC6) resets the word address counter and latches the new paragraph address as described, starting a new sequence. This happens fast enough that it's not visible in the display. Resistor R1 and capacitor C1 produce a reset pulse when the power is first applied.

To build this circuit you'll need a programmed PROM. The only restriction on the type of PROM you use is the price you want to pay and the complexity of your power supply. The cheaper PROM's often need three supply voltages. This isn't hard to achieve, but the extra regulators and filter capacitors may offset the original cost savings on the PROM.

I found what may be a good compromise. Both Intel and National make an EPROM called a 2758. This is an 8 × 1024 memory that uses a 5-volt DC power supply. The 2758 bears a striking resemblance to the more expensive 2716 except that it has only half the

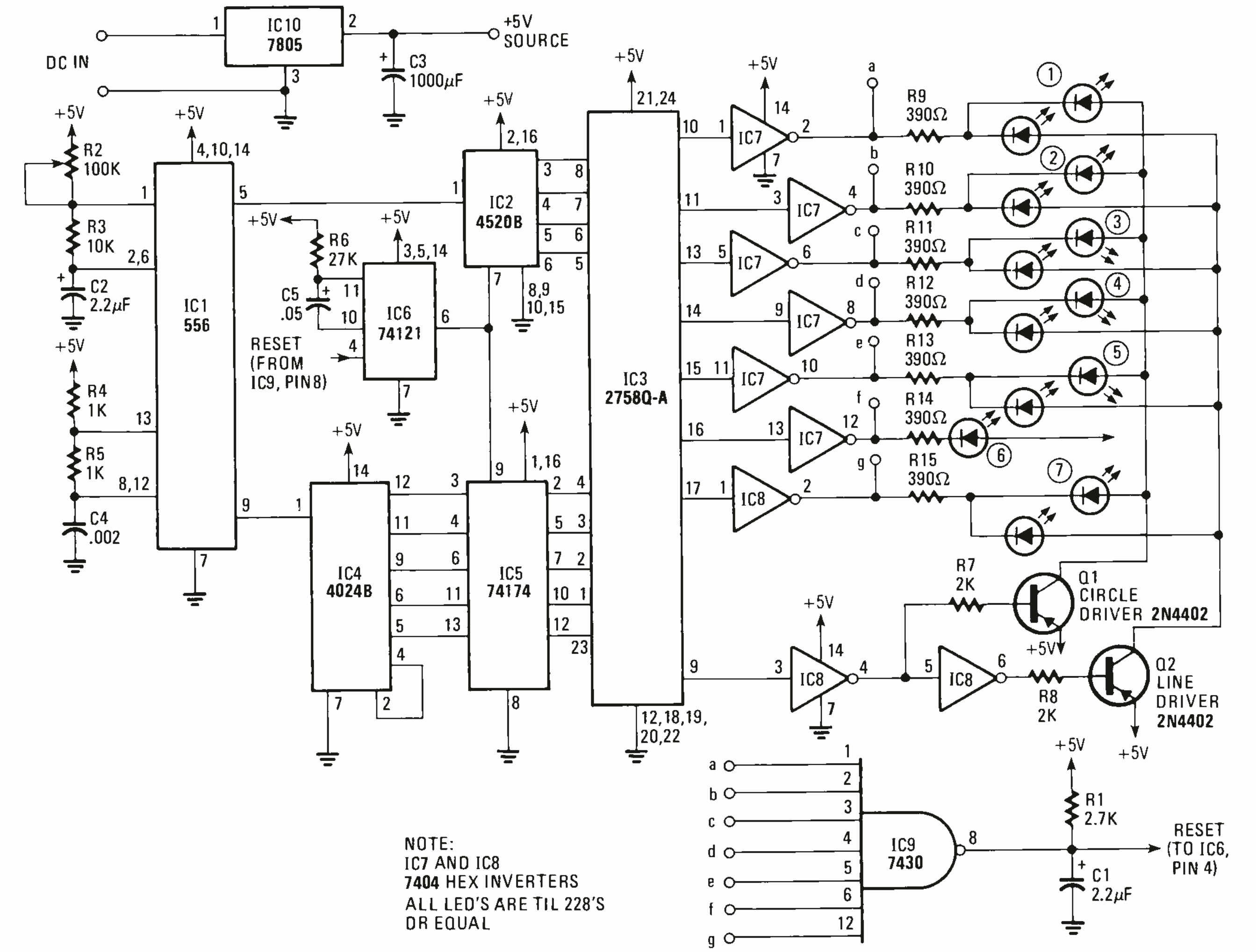


FIG. 3—SCHEMATIC DIAGRAM of the revised do-nothing box. The PROM can hold up to sixty-four different programs but only thirty-two are used here.

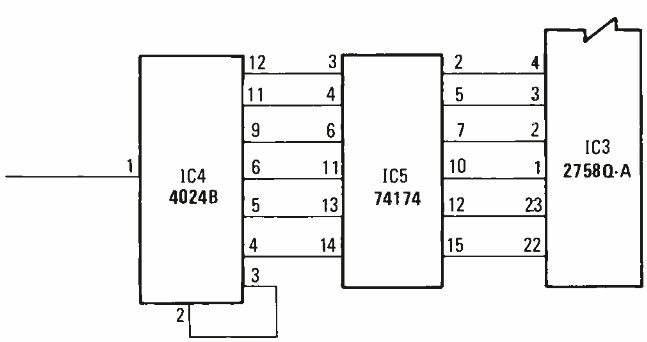


FIG. 4—YOU CAN USE BOTH PAGES OF THE PROM if you make the circuit modifications shown here.

memory size. The 2758 is actually a rejected 2716 that has half it's memory usable. The other half didn't meet manufacturing specs. Depending on the letter designation following the 2758 number, either the top half or the bottom half of the 16K of memory will be usable. For a 2758Q-A (National number) the highest address line, pin 19, is tied to ground and the lower 8K of memory is used. With a 2758Q-B, pin 19 is tied to V_{cc}.

Since the 2758 PROM is an 8 × 1024, it can contain 64 paragraphs if you wish. I had trouble coming up with that many original display routines and used 32. As shown in the schematic, pin 22 is grounded to limit the PROM to the bottom page. You could use all 64 paragraphs, both pages, by making the changes shown in Fig. 4.

Figure 5 shows some program examples. A circle lighting clockwise and unlighting counterclockwise is shown in hexadecimal in Fig. 5-a. A dot moving left to right along the line is shown in Fig. 5-b. Fig. 6 is a hexadecimal listing of the 8 × 512 page I used. Notice that some paragraphs repeat a sequence twice. If you make up your own routines, don't use over fifteen steps or you'll lose the reset signal and the box will repeat the same paragraph over and over.

The power supply is a plug-in battery eliminator. Any unit supplying over 6 volts DC at 300 mA or more will work fine. The regulator (IC10) provides the 5 volts required by the IC's. Use a heat sink. The LED's specified are high light output, but any type will work. Nearly any small-signal PNP transistors will work for Q1 and Q2.

You'll notice I used CMOS counter IC's rather than TTL. TTL counters are noise sensitive. A printed-circuit board for TTL would require wide power-supply lines

40	81
60	41
70	21
78	11
7C	09
7E	05
FE	03
7E	00
7C	00
78	00
70	00
60	00
40	00
00	00
00	00
00	00
a	*b*

FIG. 5—TWO PROGRAMS for setting up displays. A circle lighting clockwise and blacking-out counterclockwise is shown in hexadecimal at a. Program *b* is the hexadecimal representation of a dot of light moving left to right along the line.

```
                 DUMP VERSION 1.0 - OFFSET=7400
0000    40 20 10 08 04 02 20 00 00 00 00 00 00 00 00 00    @
0010    40 80 02 04 08 10 20 00 00 00 00 00 00 00 00 00    @
0020    40 20 10 08 04 02 80 02 04 08 10 20 40 00 00 00    @           @
0030    40 80 02 04 08 10 20 10 08 04 02 80 40 00 00 00    @           @
0040    40 60 70 78 7C 7E FE 7E 7C 78 70 60 40 00 00 00    @@PX\^^^\XP@@
0050    40 C0 C2 C6 CE DE FE DE CE C6 C2 C0 40 00 00 00    @@BFN^^^NFB@@
0060    40 04 20 02 10 80 08 40 00 00 00 00 00 00 00 00    @      @
0070    40 04 20 02 10 80 08 40 04 20 02 10 80 08 40 00    @      @      @
0080    40 08 80 10 02 20 04 40 00 00 00 00 00 00 00 00    @      @
0090    40 08 80 10 02 20 04 40 08 80 10 02 20 04 40 00    @      @      @
00A0    40 C0 C2 C6 CE DE FE 7E 7C 78 70 60 40 00 00 00    @@BFN^^^\XP@@
00B0    40 60 70 78 7C 7E FE DE CE C6 C2 C0 40 00 00 00    @@PX\^^^NFB@@
00C0    81 41 21 11 09 05 03 00 00 00 00 00 00 00 00 00     A'
00D0    81 41 21 11 09 05 03 81 41 21 11 09 05 03 00 00     A'      A'
00E0    03 05 09 11 21 41 81 00 00 00 00 00 00 00 00 00         'A
00F0    03 05 09 11 21 41 81 03 05 09 11 21 41 81 00 00         'A      'A
0100    81 41 21 11 09 05 03 05 09 11 21 41 81 00 00 00     A'          'A
0110    03 05 09 11 21 41 81 41 21 11 09 05 03 00 00 00         'A A'
0120    81 C1 E1 F1 F9 FD FF FD F9 F1 E1 C1 81 00 00 00     AAQY] ]YQAA
0130    03 07 0F 1F 3F 7F FF 7F 3F 1F 0F 07 03 00 00 00         ?   ?
0140    03 07 0F 1F 3F 7F FF FD F9 F1 E1 C1 81 00 00 00         ?  ]YQAA
0150    81 C1 E1 F1 F9 FD FF FD F9 F1 E1 C1 81 00 00 00     AAQY] ]YQAF
0160    83 45 29 11 00 00 00 00 00 00 00 00 00 00 00 00     E)
0170    11 29 45 83 00 00 00 00 00 00 00 00 00 00 00 00     )E
0180    83 45 29 11 83 45 29 11 00 00 00 00 00 00 00 00     E)  E)
0190    11 29 45 83 11 29 45 83 00 00 00 00 00 00 00 00     )E  )E
01A0    83 C7 EF FF 7D 39 11 00 00 00 00 00 00 00 00 00     GO. }9
01B0    11 39 7D FF EF C7 83 00 00 00 00 00 00 00 00 00     9}. OG
01C0    81 40 20 10 08 03 00 00 00 00 00 00 00 00 00 00     @
01D0    81 40 80 02 04 03 00 00 00 00 00 00 00 00 00 00     @
01E0    81 40 20 10 08 05 09 11 21 40 80 02 04 03 00 00     @        '@
01F0    03 05 09 11 21 40 80 02 04 08 10 20 40 81 00 00         '@      @
```

FIG. 6—A HEXADECIMAL LISTING of the 8 × 512 page used in this version of the do-nothing box.

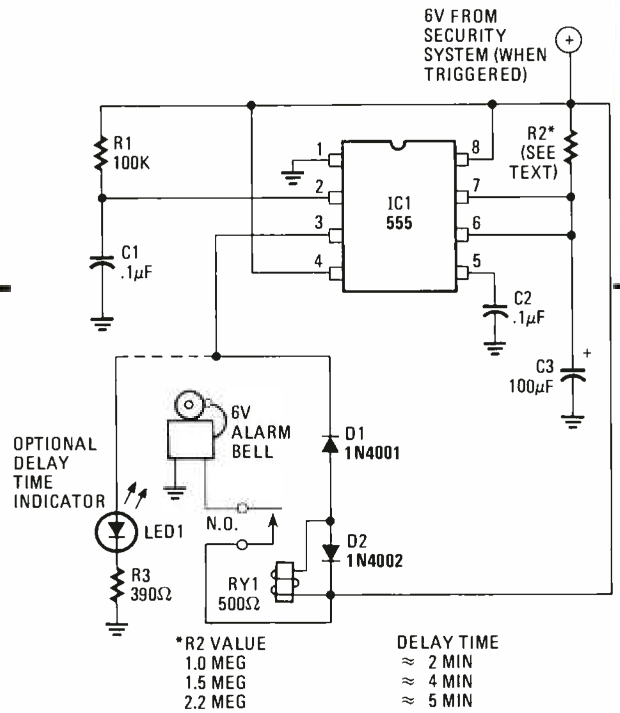
to minimize noise. But I used wire-wrap to build the Do-Nothing Box and noisy power lines are hard to avoid with that technique. That's why I used CMOS counters. They are less noise susceptible and the frequencies involved here are well withing their range. Be sure to use B-series IC's (a letter B follows the type number) to insure TTL drive-capability, and observe proper handling techniques.)

A 4 × 5 box holds everything nicely and gives a fair size display. I used red plastic in place of the regular box cover. This was done for improved contrast. You could use a larger display, or even incandescent lamps if you wish, by replacing the LED's with transistor drivers. But whatever format you chose, this circuit will create an interesting "do-nothing" display. **SP**

1-IC BURGLAR-ALARM DELAY

You want burglars caught, not scared away with part of the loot

CRAIG ANDERSON



THE VOLTAGE that would normally go the bell is now applied to point (+), delaying the sound.

RECENTLY, A FRIEND APPROACHED ME WITH A HOME-security problem. He had installed a complete electronic security system, including an alarm and police-dialing service. However, there was a problem; as soon as the alarm went off, the thieves took what they could get and then cleared out before the police arrived. What my friend needed was a circuit that would delay the sounding of the alarm bell for a few minutes—just long enough for the police to arrive, and we hope, catch the thieves red-handed.

The diagram shows the circuit I devised to solve the problem. Normally, as soon as the intrusion detector is tripped, the police dialer goes into action, and 6 volts DC is applied to the alarm bell. With the circuit shown, the voltage normally going to the bell is now applied to the point labelled (+) on the schematic. After a delay set by the value of resistor R2, the bell—now connected to the delay circuit's relay—turns on.

There are a few points worth mentioning about the circuit. First of all, R1—C1 insure that the trigger pin (pin 2) will be at ground potential when power reaches the 555 in order to trigger it reliably. After a few milliseconds, C1 charges up and pin 2 goes high again.

The optional delay-time indicator LED starts glowing as soon as the circuit is tripped, and remains lit for the duration of the delay. When the alarm bell goes off, the LED extinguishes.

The relay has a 500-ohm coil and normally open contacts. With pin 3 in the high state, the relay coil is non-energized. After pin 3 goes to ground at the end of the delay cycle, the coil energizes by sinking to ground through the 555 output stage and connects the bell to the 6-volt supply. The protective diodes are used to prevent latch-up with an inductive load such as the relay coil.

Note that the 555 must be a standard type; the low-power version (L555) is not suitable for this circuit. Also note that the leakage of C3 must be fairly low if R2 is going to be any greater than 2.2 megohms. Finally, the timing accuracy of this circuit is dependent on the value of C3. With different capacitors, you might have slightly different timing intervals from the ones listed. You may need to vary the value of R2 a little bit in order to compensate for variations in C3. Of course, you could always replace R2 with a 2- to 5-meg trimmer if you want to set a specific delay time.

That's about all there is to it; we can now hope that, if my friend's house is broken into again, the police will be ready and waiting when the would-be thieves start their getaway. **SP**

PARTS LIST

RESISTORS
R1—100,000 ohms, ¼ watt, 10%
R2—1 megohm to 2.2 megohms, ¼ watt, 10%. See text
CAPACITORS
C1, C2—0.1 µF, 10 volts or higher, ceramic disc
C3—100 µF, 10 volts or higher, electrolytic
SEMICONDUCTORS
D1, D2—1N4001 or equal silicon diode
IC1—555 timer
RY1—relay, 6 VDC coil, normally open single-pole contact
OPTIONAL
R3—390 ohms, ¼ watt, 10%
LED1—general-purpose red LED

VCR/TV PROGRAMMING ADAPTOR

Here's how you can use your VCR to make your TV set programmable, for less than $25.

KIRK VISTAIN

PROGRAMMABLE TV SETS ARE HERE. NOW YOU CAN SET them up and forget them. They come on automatically, change channels, and shut themselves off, all without human intervention after initial programming. What is that good for? Well, for one thing, they can turn themselves on when your favorite shows are on and turn themselves off when they're over. A less publicized, but useful application is to make the house seem lived in when you are on vacation. Most burglars won't chance a break-in if they hear voices, or notice that the TV is on just as when you're home.

Of course, those programmable sets are expensive. But with the device outlined in this article, you can use your VCR to turn any television set into a programmable one, whose versatility is limited only by the programming abilities of your VCR's timer. All that will cost you less than $25 and your time. Installation is simple and requires no internal wiring changes to TV or VCR. In fact, you don't have to open up either unit at all.

How to use it

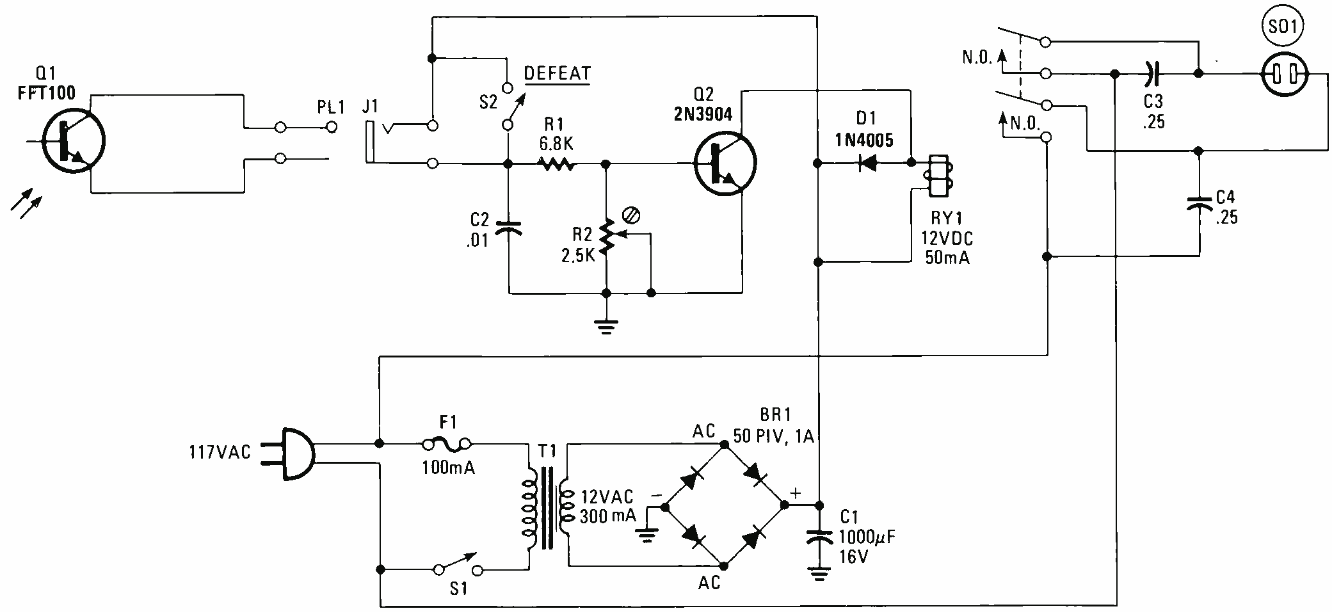
This unit was specifically designed to turn on the TV automatically and play a videotape at pre-arranged times as part of an over-all programmed entertainment system. It also works well as strictly a TV programmer, thanks to the tuners built into most VCR's. I know some of you are thinking, "It's going to wear my heads out, having the machine on all the time." Fortunately that is not the case with most of the seven-day programmable VCR's, which can turn the tuner on by itself. The motors and heads on most models rotate only when the unit is in play or record modes.

You must, of course, remember to set the TV's tuner for whatever channel the VCR uses to broadcast. If your TV has a rotary selector or locking pushbuttons, there is no problem. But, if yours has momentary-contact type channel selector, you may have to put a small shim between the channel button and the cabinet to hold the channel selection. Remember that all power is removed from the machine and thus any "last-channel-selected" memory will be erased. Switch S1 (Fig. 1) turns the programming adaptor on, and S2 provides a defeat function, which allows the TV to operate normally.

How it works

The TV programming adaptor uses a phototransistor to sense when the pilot light on the VCR comes on. Current through the base of Q2 is insufficient to cause conduction when phototransistor Q1 is not illuminated. (VCR is off). As soon as the pilot light on the VCR is energized its light strikes Q1, which then conducts and supplies current to the base of Q2. Transistor Q2 conducts and energizes relay RY1. The relay contacts close and supply power to the TV set. Then, whatever program has been selected on the VCR appears on the TV screen.

A relay was used, rather than a triac, in order to keep circuitry as simple as possible, and to provide total isolation from the power line for safety. The diode across RY1's coil protects Q2 by damping the



SWITCH S1 turns the programming adaptor on, and S2 provides a defeat function, which allows the TV to operate normally.

inductive kickback which occurs when the relay is de-energized. The capacitors across the relay contacts are arc suppressors, which protect the contacts and reduce switching noise. Switches S1 and S2 provide power and manual/auto switching. Pot R2 is an optional sensitivity control, which I did not find necessary, but which might prove useful if other transistors are used to build the circuit.

The best way to wire-up this device is with perforated board and solder clips. As an alternative, you can etch a board to include all parts except the phototransistor and AC socket. A small project box contains the device. Be sure J1 is insulated from the chassis if you use a metal enclosure.

A word of caution here: Many TV's have polarized AC plugs, which are designed to fit into matching sockets. Don't defeat that system! Observe proper polarity throughout! Failure to observe that precaution may result in the TV chassis being connected to the high side of the AC line, and that is just asking for an electric shock. You can identify a polarized plug by comparing the blades. One is wider than the other or has tabs that prevent it from being inserted the wrong way. If your TV doesn't have a polarized plug, you needn't worry about it.

The design of the remote phototransistor probe is really dependent upon the type of VCR you have. Just remember that the interface between Q1 and the pilot light must be light-tight. I mounted the sensor in an assembly composed of a couple of grommets and some shrink tubing. That slipped around the pilot lamp, which was raised from the surface of my particular VCR. Finally, be sure you have a reddish pilot. Due to its spectral response, Q1 does not work well with green ones.

That completes your TV programming adapter. Good luck, and happy viewing!

PARTS LIST

RESISTORS
R1—6800 ohms, ¼ watt
R2—2500 ohms, trimmer pot
CAPACITORS
C1—1000 μF, 16 volts
C2—.01 μF
C3, C4—0.25 μF, 250 volts
SEMICONDUCTORS
Q1—FPT100 or equal photo-transistor
Q2—2N3904
D1—1N4005
MISCELLANEOUS
T1—power transformer, 12 VAC, 300 mA (Radio Shack 273-1385)
RY1—miniature relay, 12 VDC, DPDT contacts (Radio Shack 275-206)
S1, S2—SPST switch
F1—quick-blow fuse, 0.1 amp with holder
SO1—chassis-mount polarized AC receptacle
PL1—miniature phone plug or RCA phono plug to match J1
J1—miniature phone jack or RCA-type phono jack to match PL1

COMMON PRODUCTS MAKE HANDY CABINETS

You can beat the housing shortage with a little imagination and some common items.

GERALD E. WILLIAMS

IN EARLIER STORIES WE DESCRIBED unique methods of making circuit boards, connectors and other electronic components. Now let's consider housings. Survey your local supermarket and hardware stores for any plastic or metal object that can be adapted to house your electronic project. I will give you a few examples, but most of it will be up to you. The procedure is simply to think about what size and shape will fit your needs, and then go and see if you can find something that will look nice and do the job. It is not always easy. You must first forget the purpose for which the plastic or metal goodie was originally designed. Secondly, you must pick up any likely candidate and turn it upside-down and backwards to see if it will do your job in some strange position. Here are some examples.

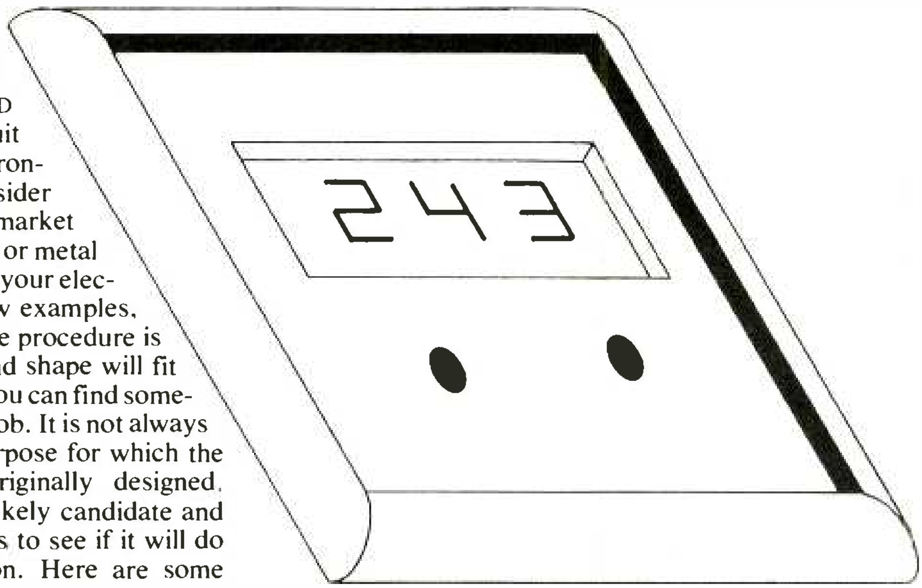


FIG. 1—PICTURE FRAMES make handy and attractive housings for some types of projects.

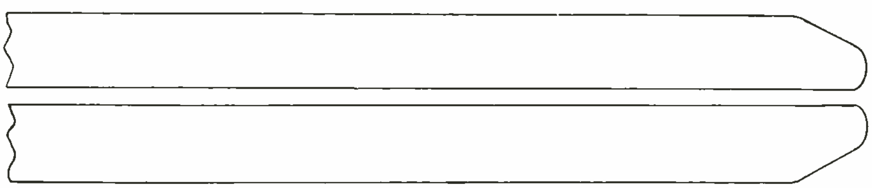


FIG. 2—TWO PICTURE FRAMES back-to-back provide the extra depth you'll need for some projects. For a modern up-to-date look, consider the box-like clear plastic picture frames.

Let picture frames house your projects

Picture frames are available in many sizes and shapes. Cut a piece of Masonite to fit in place of the picture for the control panel. Add four rubber feet and you have an attractive housing for those projects that can be set flat on a table. See Fig. 1.

If you need more depth, use two identical frames back-to-back. If you use frames with the general shape shown in Fig. 2, the housing will give the illusion that it is much more shallow than it really is.

Low-profile cabinet from a paint-thinner can

An empty paint thinner can, a couple of scraps of wood, some vinyl contact paper, a small scrap of Formica, and a couple of short lengths of wood dowel make up the bill of material for an attractive modern

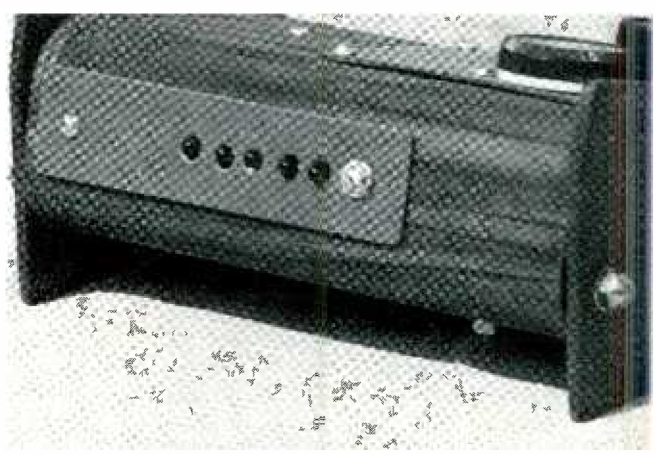


FIG. 3—ELECTRONIC PROJECT housed in a cabinet made from a paint-thinner can.

cabinet. Figure 3 shows the finished product and Fig. 4 shows how it is made.

Front and back panels can be made from solid color Formica, brass, copper, aluminum, or whatever suits your decorators taste. Front and back panels also add necessary stiffness to the light-weight metal used in the can. You can use an ordinary electric drill to make holes for controls and so on, but be careful of sharp edges.

Using PVC plastic pipe

Plastic pipe can be used to house probes, or for more imaginative purposes like the tester unit and flashlight support shown in Figs. 5 and 6.

I built the tester unit as a project for junior high students[1]. It is made from a 1½-inch plastic tee, a couple of caps, a ¾-inch nipple, and a cast iron pipe flange for a weighted base. The folding stand was designed to support a lantern-type flashlight that was used for a light-beam communications system. It is made of thick wall ½-inch plastic pipe and standard fittings. All parts are glued with PVC cement except for the moveable joints.

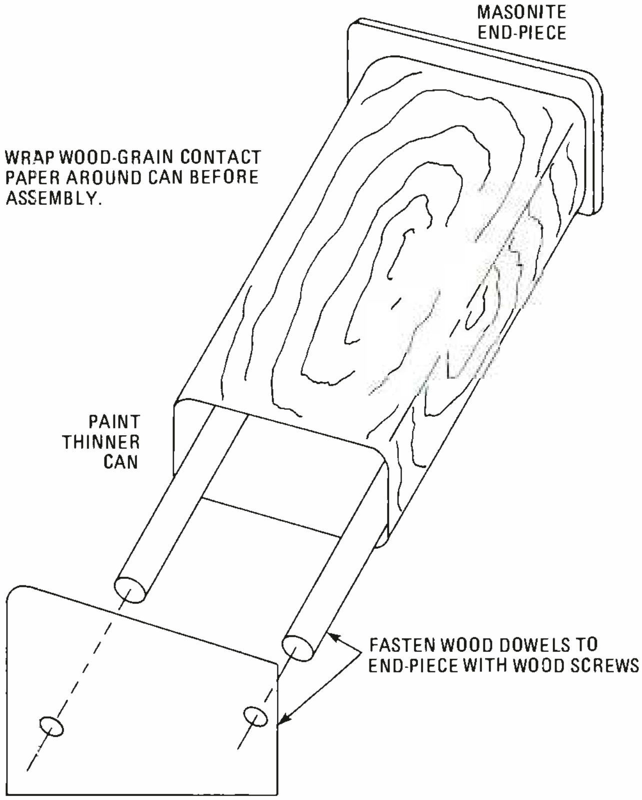


FIG. 4—HOW THE TIN-CAN ENCLOSURE GOES TOGETHER. A one-quart can makes a housing about 7 inches wide, 4¼ inches deep and 2 inches high. Scraps of oak, mahogany or similar hardwood make attractive end-pieces.

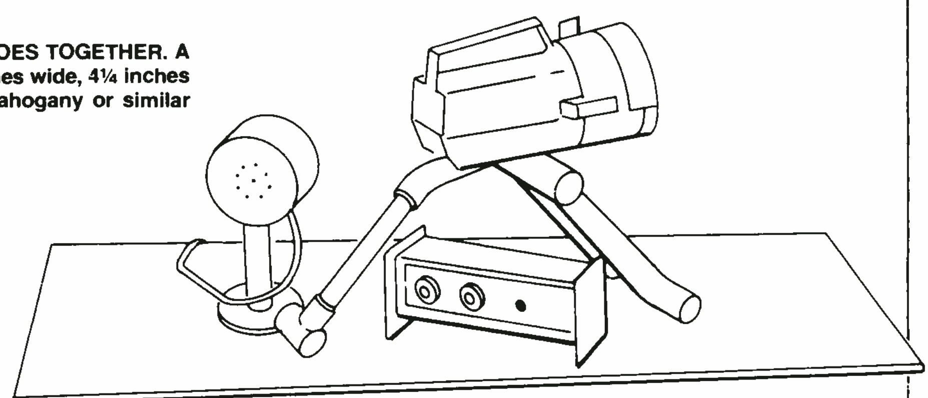


FIG. 6—PLASTIC PIPE with ells tees and similar fittings can be used for mechanical devices such as this tripod used to support an electronic project.

FIG. 5—PLASTIC PIPE forms a handy housing for probes and testers. (Photo; courtesy of American Technical Society)

Take some time to browse in the plastic pipe section of your local building supply store and see if you don't come up with some other novel uses for this versatile plastic.

Housings from your supermarket

Your local supermarket carries a variety of plastic and metal trays, boxes, and so on. An aluminum baking tin makes an excellent chassis. Some plastic items are stiff enough and rugged enough to make excellent housings for electronics projects. Figure 7 shows a silverware drainer used as a cabinet for an electronic darkroom timer. With this one example, I leave the rest to your ingenuity. Good luck in beating the housing shortage. **SP**

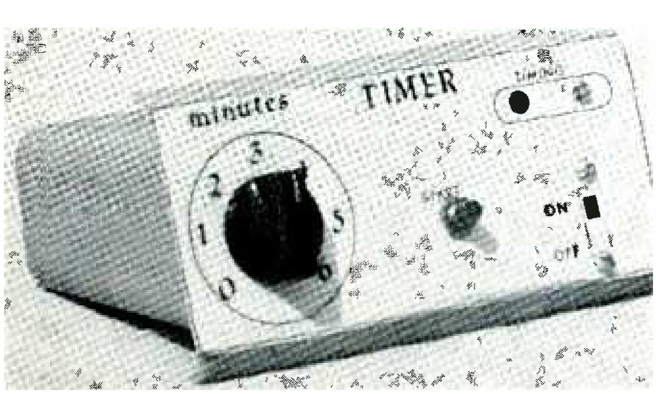


FIG. 7—SILVERWARE DRAINER is the basis for the attractive housing for an electronic timer.

[1] "The Basic Book of Electricity and Electronics" by Gerald E. Williams, Industrial Arts Series, American Technical Society

RELIABLE BURGLAR ALARM

This alarm system works well in the home or car, uses commonly available parts, and is inexpensive to build.

EDWARD R. CONNER

TO BE COMPLETELY SATISFACTORY, A BURGLAR ALARM should fill a variety of needs. It must develop a loud attention-getting sound that will be heard by neighbors, but only when a break-in occurs. It should remind the returning owner that it is on and needs to be turned off before a false alarm is sounded. It should also signify that no intruder has entered during the owner's absence. It should operate with either normally open or normally closed momentary-action switches and should have a "panic mode" so the outside alarm can be instantly started when the need arises. If, and when, it is set off, the alarm should shut itself off after a reasonable period. It should be compact, inexpensive and use readily available components.

This system meets these requirements in a highly reliable manner. Briefly, system operation consists of:

1. **Latching on** after counting two entry-switch operations. The first actuation occurs when you turn on the system and leave the house or vehicle. The second occurs at the next entry.
2. **When you re-enter** the protected area, a low-noise-level alarm starts. This signal tells you two things. (A) The alarm is still on and needs to be turned off before the out-door alarm sounds off. (B) No one has been in the protected area in your absence. The interior alarm also tells an intruder that he has set something off. To prevent his finding and silencing the alarm, this phase of operation is of short duration. About 15 seconds is used in a vehicle while abut 45 seconds is used when protecting a more spacious area.
3. **At the end of** the selected period the interior alarm turns off and the attention-getting outside alarm is turned on.
4. **Approximately 6 minutes** after re-entry, the exterior alarm shuts off.
5. **Anytime that the alarm** system is turned on, a panic switch can be used to immediately start the siren. Again, it will be automatically shut off after about 6 minutes.

The schematic of the logic and output-drive circuits in the control box is in Fig. 1. Figure 2 shows how the switches and alarms connect to the logic and drive systems in the control box while Fig. 3 is a photo of the control box. Note that is small enough to be easily concealed. Figure 4 shows the shorting bar used to determine interior-alarm duration.

Entry switches

The alarm system is designed to be triggered by the closure of any one of a number of parallel-connected open switches or by the opening of one of a number of closed momentary switches. See Fig. 2. (The closed switches can be normally *open* switches that are held closed by a door or window when it is secured. Similarly, the open switches can be normally *closed* types that are held open by a door or window.) The open switches form a path to ground when closed. This pulls the input of the Schmitt-trigger connected NAND gate (IC1-d) to logic 0 via diode D1. The open switches must be connected in parallel and any number can be used. This switching mode was designed to be operated by normally closed switches set into the door jambs of most automobiles. (Note: The door switch must be wired so it closes and completes a path directly to ground when the door is opened. Most older cars have this type of hookup; some newer models do not.) These switches turn on the car's courtesy lights when the door is opened so full battery voltage appears across the switch when the door is closed. Diode D1 is back-biased and blocks this voltage (up to +75 volts) and the input to the gate is held at logic 1 by V_{DD} applied through the 1-megohm resistor.

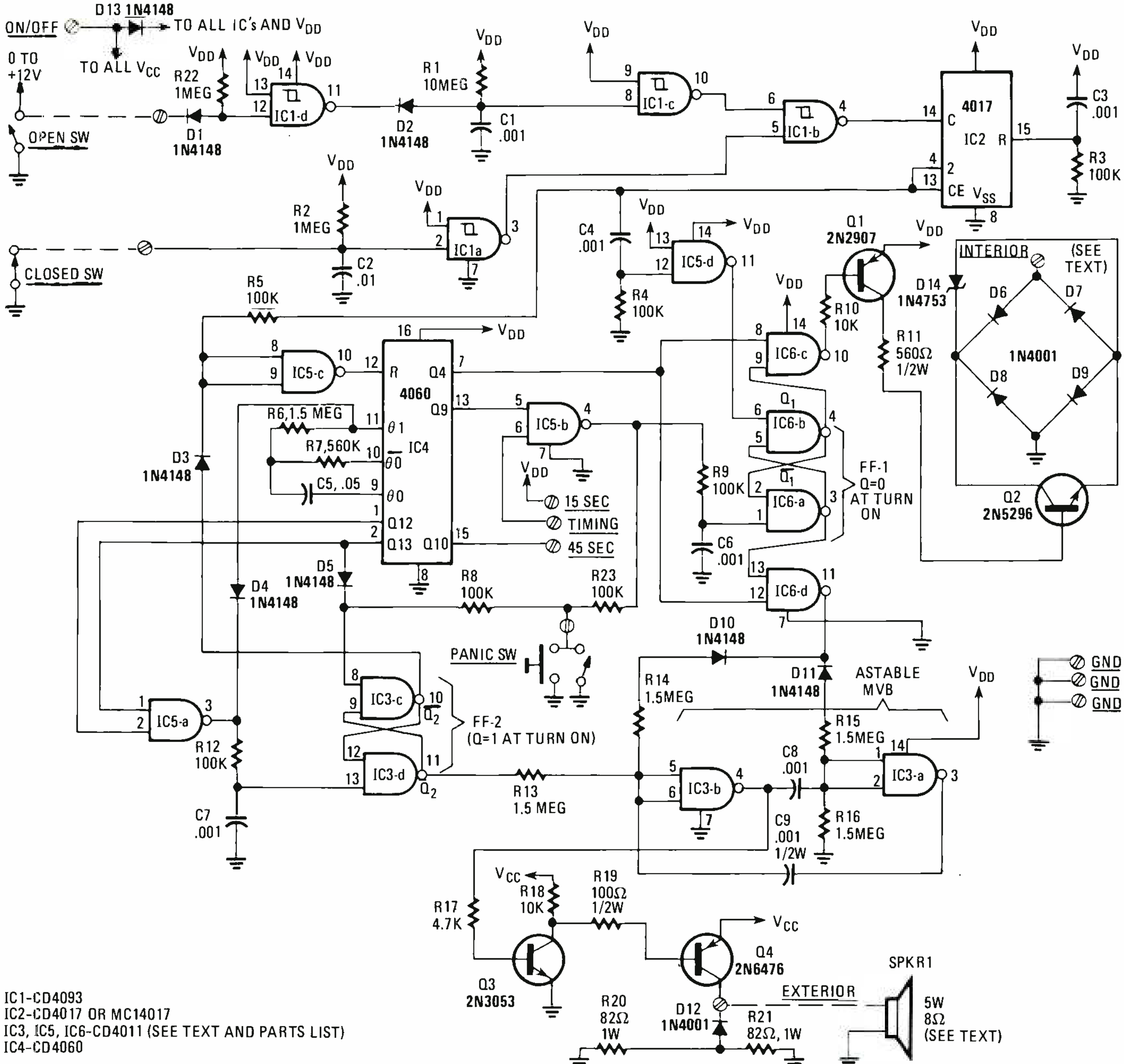


FIG. 1—SCHEMATIC DIAGRAM OF THE CONTROL LOGIC and drive circuits for the intruder alarm system. Device includes a low-level interior alarm that reminds you to disable the circuit before the loud alarm siren sound outside.

Any other type of normally open momentary switch can be used. A common type in residential and business installations is the type of pad that goes under a rug and the contacts close when stepped on. Open switches need not have DC applied to them. All they must do is make and break a path to ground.

The normally closed switches also complete a path to ground. In this case it short-circuits C2 to ground and clamps the input of Schmitt trigger IC1-a at logic 0. (Any number of closed switches can be used and must all be connected in series.) This switching mode was designed to use the popular and highly reliable magnet-operated reed switch. Usually, this type of switch is normally open and will have its contacts closed when the magnet is close to it. Any other switch that provides a closed path when the system is first turned on can be used. The conductive foil around a window serves as this type of switch. If no closed switches are used in the system, connect a shorting jumper between the CLOSED SWITCH and GROUND terminals to pull C2 and the input gate to logic 0.

Alarm operation

When an open switch is closed the input to gate IC1-d goes to logic 0 and switches its output to logic 1 and reverse-biases diode D2. This allows V_{DD} to start charging C1 through R1. The input gate of Schmitt trigger IC1-c will rise to triggering level after a switch de-bouncing RC time interval. Now the output of IC1-c switches to logic 0. This causes IC1-b's output to switch from logic 0 to logic 1. This rising voltage clocks the 4017 decade counter (IC2) for one count.

If, instead, a closed-type switch is opened, V_{DD} charges C2 through R2 and the gate input rises gradually to trigger level. The output of gate IC1-a goes to logic 0, causing the output of IC1-b to switch to logic 1 and clock a count into the 4017. (Note that with an open switch left closed or a closed switch left open, actuating any other switch of either type will not send an addi-

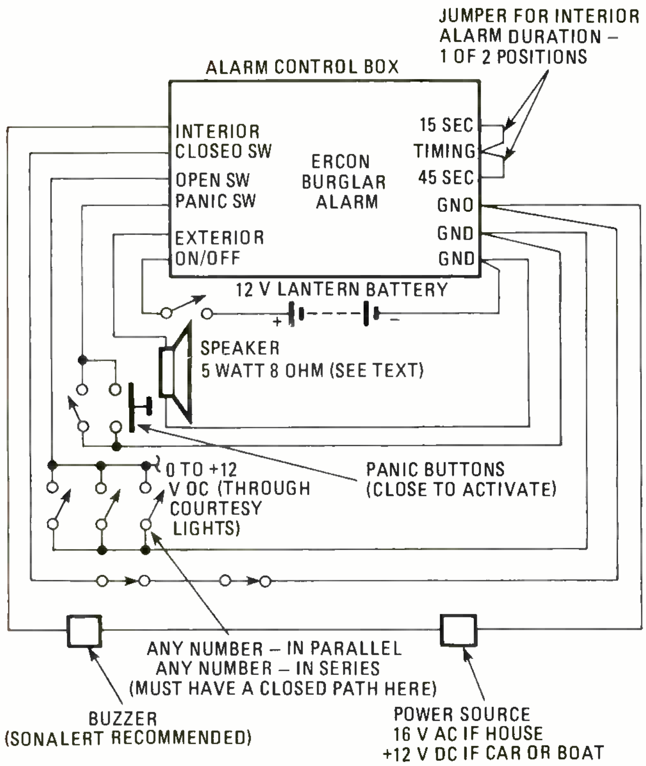


FIG. 2—BLOCK DIAGRAM SHOWS HOW the alarms and various switches connect to control box. The same terminal markings are used on the schematic diagram and the actual control box.

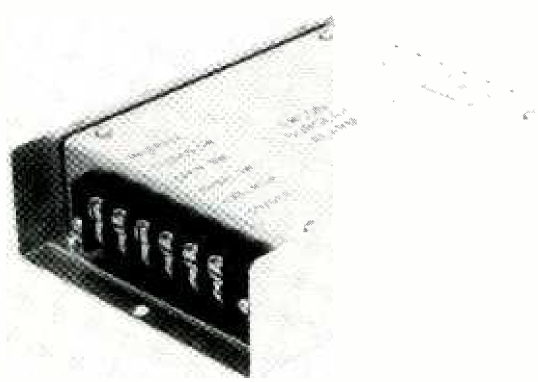


FIG. 3—EXTERIOR VIEW OF THE CONTROL BOX. The enclosure is 1.4 × 3.8 × 6 inches—easy to conceal from prying eyes.

tional clocking pulse to the 4017.)

At system turn-on the C3-R3 network resets the 4017 to a count of zero. The effective pulse width here is less than 1/100 of the de-bouncing rise time for triggering either IC1-a or IC1-c. This means that the system can be turned on at count of 0 and about 9 ms later go into a count of 1 because a door was inadvertently left open at the time of turn-on. If all switches are not subsequently put into the correct condition, the alarm cannot be given that all-important second count that starts it.

The 4017 counter advances one count on each up-going of a clock pulse providing the Clock Enable input (CE) is held at logic 0. Pre-setting the counter at a count of 0 starts it with its count-2 output at logic 0. At the

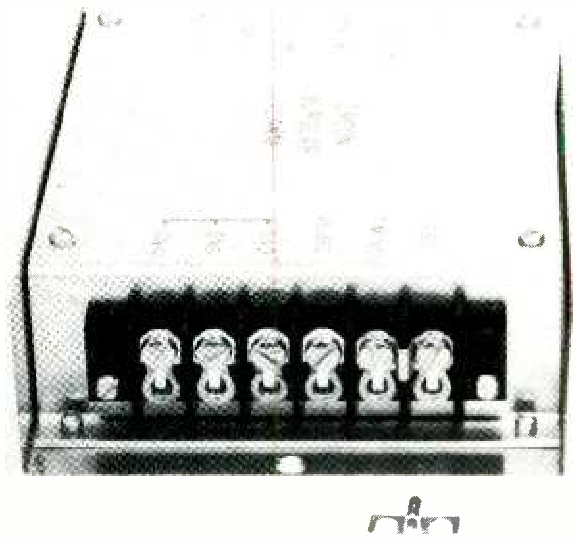


FIG. 4—SHORTING BAR between two selected terminals determines how long the interior alarm sounds. In this photo, the bar is set for 15-second timing. Extra shorting bar in the foreground is slotted for easy changing. Exact style depends on manufacturer used.

second clocking this output goes high. Connecting the CE terminal to the count-2 output causes the 4017 to stop at a count of 2. This means the alarm is latched on a 2 count and anything done with the entry switches is no longer significant. The system will now run its full cycle unless the power is shut off.

When the count-2 output goes high it applies V_{DD} to C4 and R4 at the input to gate IC5-d, to both inputs of gate IC5-c and reverse-biases diode D3. At this time, resistor R5 serves no useful function. When the inputs to IC5-c go high, its output and the reset terminal of the 4060 binary counter (IC4) go low.

A high on its reset pin sets all ten 4060 outputs at 0 and prevents any counting activity. When the reset is taken low, an internal oscillator then starts clocking the counter. Oscillator frequency is set to about 16 Hz by R6, R7 and C5. The Q_4 output divides this down to produce a squarewave of about 1 Hz with the first "high" starting one-half second after the 2-count on the 4017.

When the 4017's output high is applied to C4-R4, it pulses gate IC5-d low at its output. This low is applied to the input of a flip-flop made up of IC6-a and IC6-b. This the flip-flop's Q_1 output to go high. Consequently, gate IC6-c's output goes low whenever the 1-Hz squarewave from the 4060 is high. A low to the base of transistor Q1 turns on the inside alarm. This alarm sounds for one-half second, is silent for one-half second, etc.

The diode bridge around transistor Q2 will operate either AC or DC powered interior alarms. The intent is to power the inside alarm from either the doorbell/chime transformer in a building or the storage battery in a car or boat. This conserves the battery that powers the alarm system and the outdoor alarm siren. Note that during the negative half-cycle of an AC voltage, the current through R11 is due to V_{DD} plus the AC voltage level. The ½-watt rating for R11 is adequate for use with the common 16-volt chime transformers. At higher voltages you must determine the currents and power dissipation and upgrade R11's wattage rating accordingly. Be sure to observe supply polarity when operating the interior alarm from a DC source. Positive to the alarm; negative to ground. The Zener diode across Q2 protects it from overloads and transients developed when power to an inductive load is suddenly shut off.

Successive counter stages fed from the Q_4 output in the 4060 divide down the 1-Hz square wave into progressively lower frequencies and give longer times before a high occurs. Also, as each stage goes high, all preceeding stages go low. Additional outputs used to control the alarm system's action and the *nominal times* to go high are Q_9 at 16 seconds, Q_{10} at 32 seconds, Q_{12} at 128 seconds and Q_{13} at 256 seconds.

NAND gate IC5-b has the Q_9 output of the binary counter connected directly to one of its inputs while the other can be connected, via a jumper, to either V_{DD} or to IC4's Q_{10} output terminal. With inputs from Q_9 and V_{DD} IC5-b's output goes low at a *theoretical* 16 seconds. With inputs from Q_9 and Q_{10} IC5-b's output goes low after 16 + 32 or 48 seconds. When IC5-b's output goes low it causes flip-flops FF1 and FF2 to go to condition $\overline{Q}=1$.

(The actual time delays mentioned above depend on the supply voltage and the "stiffness" of its source. When a 12-volt battery is used, its output voltage drops under load and the time delays vary. When a small motorcycle or marine storage battery is used the time delays are more predictable.)

When FF1 switches to $Q_1=0$, the Q=1 the output of IC6-c will be a steady high which silences the interior alarm and the output of IC6-d becomes a 1-Hz squarewave.

At turn-on, FF2 (IC3-c and IC3-d) is pulsed by R2-C7 to a condition of $Q_2=1$ which inhibits oscillation of the astable multivibrator. When IC5-b switches FF2 to $\overline{Q}=1$, Q=0, the astable multivibrator starts sending a squarewave to the speaker through amplifier transistors Q3 and Q4. When IC6-d's output is high, D10 and D11 are back-biased and the multivibrator frequency will be about 700Hz. When IC6-d's output is low, it puts R13, R14, R15 and R16 all in parallel and the multivibrator's frequency is raised to about 1400 Hz. The result is a "hee-haw" siren sound from the speaker.

The diode/resistor combination across the speaker may seem odd—particularly in view of the use of two paralleled 1-watt resistors. The design for extreme drive conditions called for a 41-ohm resistor and showed that ½-watt resistors would be marginal. Allowing for component tolerance, I used two 82-ohm 1-watt resistors.

When the binary counter (IC4) counts to a condition of $Q_{12}=1$ after Q_{13} has previously gone to logic 1, a nominal time of 256+128=384 seconds (6 minutes and 24 seconds) will have elapsed. The output from gate IC5-a now goes low. This switches FF2 back to a condition of $Q_2=1$. This shuts off the astable multivibrator and shuts off the siren. As the output of IC5-a goes low, it also cuts off the oscillator in the 4060 through D4. At this point, power is still applied to the alarm but is silent and will remain so until it is shut off and then restarted.

Panic mode

The panic-mode capability simply requires the addition a number of normally open switches. They start things going when the junction of R8 and R23 is pulsed or pulled to ground. Simple doorbell switches make good panic switches in the home or shop.

With power on and the alarm not triggered, output 2 of the 4017 is low. Throwing or pressing a panic switch changes FF2 to $Q_2=0$. This starts the astable and the siren noise. Also, $Q_2=0$ also says $\overline{Q}_2=1$ which is routed to the inputs of gate IC5-c through D3. Resistor R5 is now needed to prevent the low input of the 4017 from shorting out the inputs to IC5-c. The output of IC5-c now goes low, allowing the 4060 to start counting toward system shut-off. Diode D4 and resistor R8 are needed to shut down the system if a panic switch remains as a path to ground. The system shuts down after the Q_{13} and Q_{12} outputs of IC4 have both gone low. Note that the siren comes on the instant a panic switch is closed and remains on for the full time period. The interior alarm is not heard in this mode of operation.

ALARM SYSTEM PARTS LIST

RESISTORS
Resistors ¼ watt, 10% unless otherwise noted
R1—10 megohms
R2, R22—1.0 megohms
R3, R4, R5, R8, R9, R12, R23—100,000 ohms
R6, R13—R16—1.5 megohms
R7—560,000 ohms
R10, R18—10,000 ohms
R11—560 ohms, ½ watt
R17—4700 ohms
R19—100 ohms, ½ watt
R20, R21—82 ohms, 1 watt

CAPACITORS
C1, C3, C4, C6—C9—0.001 µF
C2—0.01 µF
C5—0.05 µF

SEMICONDUCTORS
IC1—CD4093BE (RCA) or CD4093BCN (National) quad 2-input NAND Schmitt trigger
IC2—CD4017 or MC14017 decade counter/divider with 10 decoded decimal outputs
IC3—CD4011AE (RCA), CD4011BCN (National) or MC4011BCP (Motorola), quad 2-input NAND gates
IC4—CD4060—14-stage ripple-carry binary counter
IC5, IC6—CD4011 or MC14011 quad 2-input NAND gates
Q1—2N2907
Q2—2N5296
Q3—2N3053
Q4—2N6476
D1, D2—D5, D10, D11, D13—1N4148 or 1N914
D6—D9, D12—1N4001
D14—1N4753, Zener diode, 36 volts, 1 watt

MISCELLANEOUS:
Speaker (see text), interior alarm (see text), switches as needed PC board, case, hardware.

The following are available from Ercon Co., 6744 48 Avenue SW, Seattle, WA 98136:
BA-5PC—PC board etched and drilled—$6.95
BA-5K—hardware kit including PC board, name plate, housing, barrier strips, shorting bar, screws—$24.50
BA-5—Fully assembled and tested control box (does not include batteries, alarms, switches)—$47.50
All items post paid anywhere in the U.S. Washington residents please add 5.3% King county sales tax.

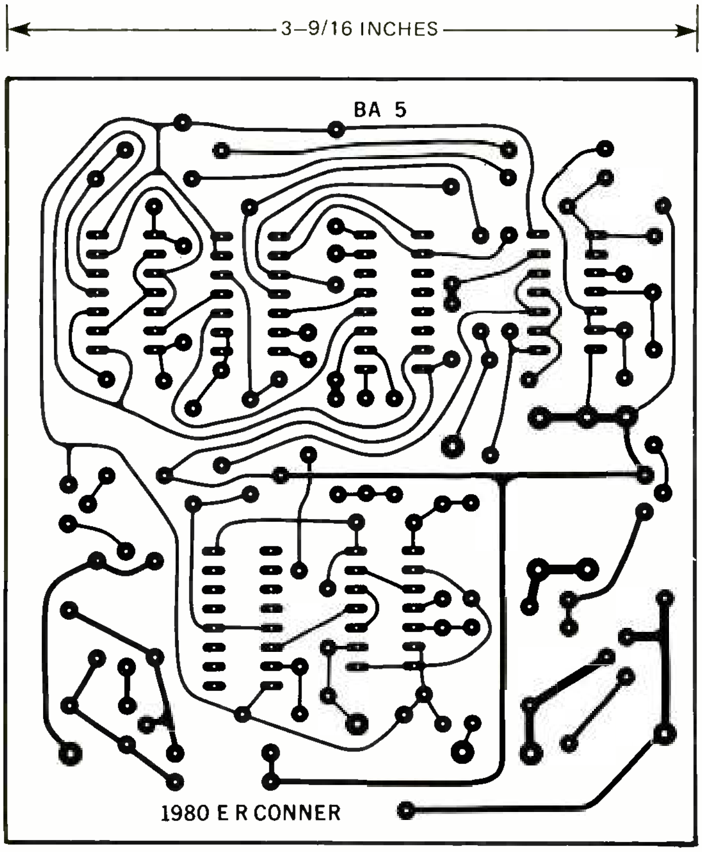


FIG. 5—FOIL PATTERN FOR THE PC BOARD. The layout is easy to duplicate. An inexpensive etched and drilled board is available from a source given in the parts list.

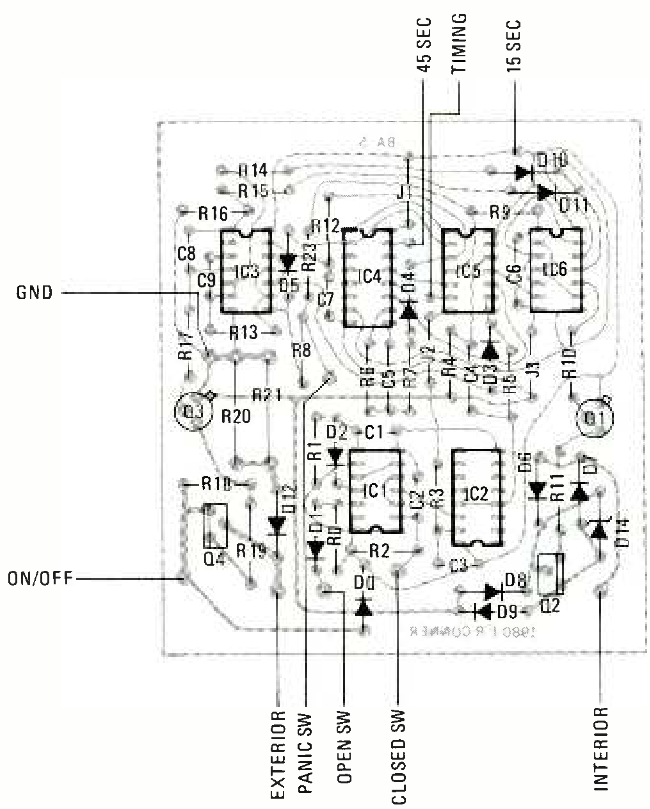


FIG. 6—HOW PARTS ARE PLACED on the PC board. CD4011 IC's are used in three positions. The type used for IC3 is critical. See text and parts list.

The simple addition of bed-side panic switches provides an added measure of security for the homeowner as he retires for the night. For a shop keeper with people coming and going, an additional switch must be added to the entry-switch system. Adding a toggle switch across the open switch string will take D1 to ground and hold the 4017 at a count of 1. Similarly, the same results can be had by adding a switch across the closed switching network. When leaving the shop this added switch must be returned to its normal position or the alarm system will be left disabled.

Powering the alarm

This alarm system was designed to be powered by a 12-volt lantern battery and use a single 8-ohm speaker for siren output. Upper-limit capability will allow two paralleled 12-volt lantern batteries to drive the system with two paralleled 8-ohm speakers for siren output. A 12-volt automotive or marine storage battery and a single 8-ohm speaker is also acceptable. Going beyond these limits is possible but you do so at the risk of burning out transistor Q4.

When the system is powered by a 12-volt lantern battery the siren drive voltage starts at about 11 volts and drops during operation. This directly acts to limit heating in Q4. The dropping voltage also tends to speed up the oscillator in the 4060 so that a time of about 5 minutes and 45 seconds for total operation is generally obtained. This too, limits heating in Q_4.

A fully charged automotive or marine battery will actually apply about 13.4 volts throughout a full operating sequence: even with two 8-ohm speakers in parallel. To survive, Q4 needs heat sinking. This can be obtained by tying Q4 to the aluminum case of the alarm and keeping the case isolatec from ground.

Don't use a regulated 12-volt supply. Not only is there a danger from AC line transients but even a momentary interruption of AC power will shut off the alarm and turn it back on with a zero count on the 4017. It is then possible for an intruder to enter and leave without having set off the alarm.

A fresh lantern battery will operate the system for more than two years. However, because of battery shelf-life limitations, I recommend changing the battery every twelve months.

Accessories

When operated within the limits of its accessory components a semiconductor control such as this has a tremendous reliability. Consequently, overall reliability is determined by the quality of the accessory components in the system. For the ON/OFF switch, the entry switches and the panic buttons, about all that can be said is "Buy quality." For the speaker, a good quality 5-watt unit is recommended. Going much above 5 watts is not only a waste, but will also increase the inductive loading on the Q4 output network.

The noise maker for the interior alarm is harder to specify. Modern automobiles have several warning buzzers that hold up surprisingly well and can be used in automotive and marine applications. Most hardware stores stock small inexpensive doorbells and buzzers. These can be used in home and shop installations. Note well that all of the devices mentioned above will eventually give problems due to contacts sticking because of arcing or failure of moving parts. In one alarm system, a doorbell fell apart after about five weeks. However, in another installation two buzzers are used in series. These have been in service for more than four years and are still in good working order.

At only a small increase in system cost a solid-state buzzer such as the Sonalert will provide the utmost in system reliability. A wide variety of both AC and DC Sonalerts are available. If an AC Sonalert is used, a drive voltage of up to 24 volts RMS is acceptable.

Construction

The complete control circuit will fit on a 3.6 × 4.0-inch single-sided PC board. This in turn, fits in a simple two-piece enclosure with overall dimensions of 1.4 × 3.8 × 6.0 inches. A 6-terminal feed-through barrier block is mounted on each end. Two Pop Rivets at each end fasten the enclosure together. Figure 5 shows the foil pattern for the PC board and Fig. 6 shows parts placement.

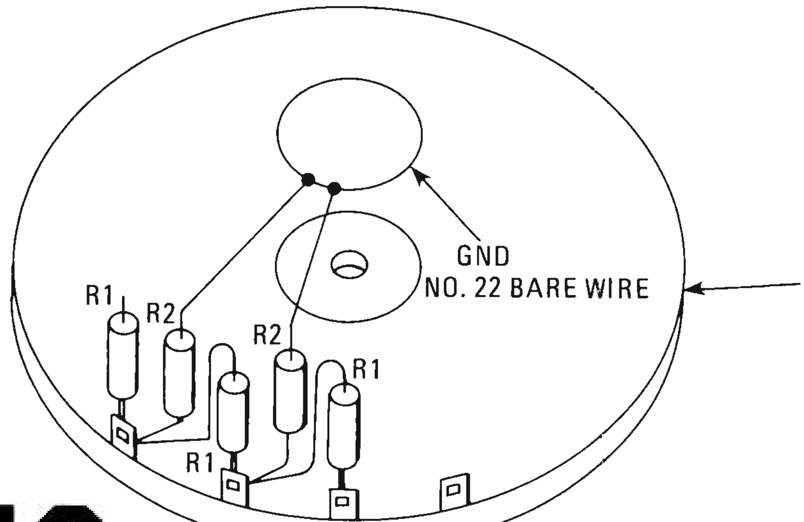
A full kit of parts is not offered because some types of CMOS IC's are just not available in quantity. Back-orders of several months are common. You can proceed much faster by shopping around locally or by ordering from mail-order suppliers advertising in this magazine and its sister publication **Radio-Electronics.**

Instead of using 5% tolerance resistors throughout, you can use 10%'ers with minimal affect on system timings. For IC2, IC4, IC5 and IC6 either the A series or B series devices are acceptable. For IC1 the Motorola MC14093 part will work, but the wide-hysteresis-voltage devices like those by National or RCA are preferred. When the CD4011 is used as an astable multivibrator, as in IC3, particular stresses are applied to the input circuit and the RCA A series type of protective network is needed to avoid trouble. Transistors Q2 and Q4 are RCA types selected because of performance data given in the handbook. No doubt there is a wide range of possible substitutes but we know that the ones specified will work.

Conclusion

When a good reliable alarm system has been installed, our reward is in having something that the neighbors can really trust and believe in. They will never hear it unless it is necessary that they do so. They should then have no cause to delay calling the police. But, perhaps even more rewarding is the intermittent buzzing of the interior alarm telling you, "Welcome home, no one has been here in your absence." It's a nice thing to hear. **SP**

STEP ATTENUATORS MAKE GREAT VOLUME CONTROLS



JOHN MAMIS

A volume control that does not become noisy with age is one advantage in building a step-attenuator.

VOLUME CONTROL STEP-ATTENUATORS HAVE RECENTLY come into vogue in stereo equipment. The step-attenuator is not new. Ampex Corporation introduced it in the early 1950's in their professional recorders; and the telephone industry used the step attenuator as early as 1930.

The step-attenuator has distinct advantages over the potentiometer. These are:

1. Does not become noisy (scratchy) with age.
2. Can be made a constant-impedance device.
3. Can be calibrated for accurate attenuation.
4. Can be designed for any desired loss curve (i.e., linear, logrithmic, inverse log, etc.).
5. Can be gauged for multichannel use.

In audio systems, advantage number one is probably the most important. Everyone has experienced scratchy volume controls after a couple years of use. Even the very best volume controls will become noisy with age. The step-attenuator is essentially a switch and its metal-to-metal contacts do not develop noise. Step-attenuators are easy to design and build and can be used for volume controls as well as balance controls.

The network

The simplest type of attenuator is the potentiometer-type where resistors are connected between contacts of the switch. This arrangement uses the minimum number of resistors but has two drawbacks. First it is not a constant-impedance device; second it is difficult to build an attenuator which has a predetermined loss (2dB, for example) per step. The problem here is that every resistor value is different and most will have odd values. For instance it is difficult to find a resistor with a value of, say, 345 ohms.

The ladder-type network shown in Fig. 1 overcomes these problems. Its only drawback is that is uses two resistors per step; really not that big a penalty to pay. The attenuator shown in Fig. 1 is excellent for audio volume controls. Its input and output impedances are approximately 28,000 ohms and the design requires only six different resistor values, all of which are standard values. It attenuates the input signal at 2dB per step with a log taper on the last three steps which is desirable for volume controls.

Other impedance values can be derived using the formulas that follow. The key thing to remember is to adjust the impedance value slightly so as to wind up with standard resistor values. For instance an impedance of 27.2K was used to derive the values shown in Fig. 1.

Design procedure

This section presents the necessary formulas to design any desired step-attenuator. In addition a computer program (for the HP-25 programmable calculator) is presented to speed calculations.

First let us develop the basic formulas for the network. We can simplify the network to two resistors (see Fig. 2). Resistor R1 is the first series resistor while RE represents the rest of the network.

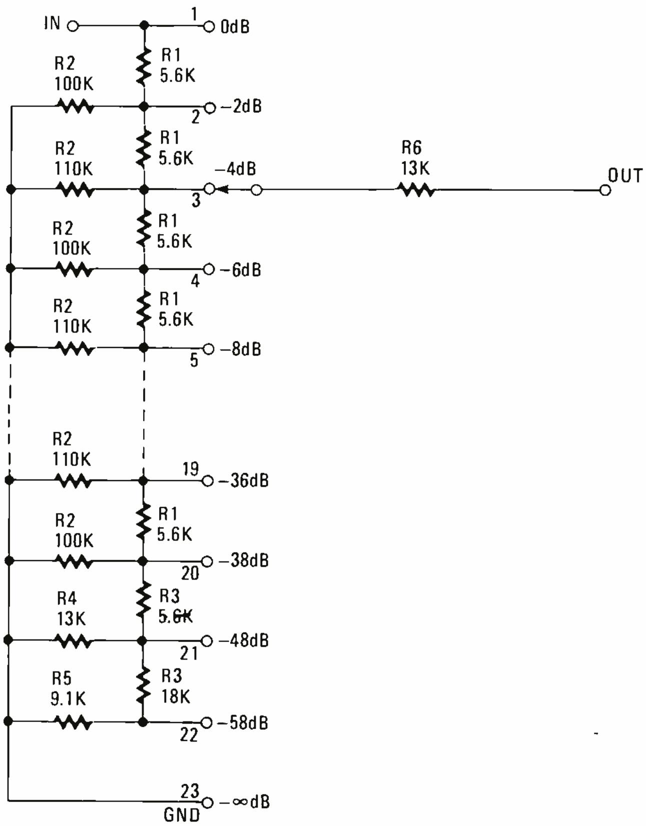


FIG. 1—STEP-ATTENUATOR, a design you can use in your hi-fi preamp. Input impedance is 27,000 ohms. All steps are linear except the last two. They provide a log (or audio) taper.

From this simple network:

1. Input impedance Z = R1+RE
2. Loss (in dB) L = 20 log (RE/R1+RE).

But loss per step is usually known and we need to know R1 and R2; so (2) can be rewritten as:

3. K = RE/(R1+RE) = 10(L/20)

Solving for RE.

4. RE = A (R1) where A = K/(1-K).
5. Z = R1+RE = (R1) (1+A)
6. R1 = Z/(1+A)

With these formulas we can begin calculating the values of the network. First let us state what is needed in terms of loss and impedance, and then make the proper calculations.

Given	Calculated
L = 2dB per step	K = .794328
	A = 3.86212
Z ≅ 25K	R1 = 5.14K

But 5.14K is not a standard value; so let us select the nearest standard value. When R1 = 5.6K, Z = 27.2278K and RE = 21.6278K.

RE is not a real resistor, it represents the rest of the network. The network can now be presented as shown in the lower half of Fig. 2.

Here RE is split into its component parts—namely R2 in parallel with Z. R2 is the real resistor in the network.

The value of R2 can now be calculated.

R2 = Z(R2)/(Z-R2) = Z(R2)/R1 = A(1+A)R1

For this case R2 = 105K. Of course this is not a standard value. To solve this problem the first R2 in the network is selected as 100K and the second as 110K. This averaging technique works very well and introduces very little error.

This defines all the 2dB-per-step sections. The log taper at the end of the network can be done in a similar manner: keeping Z = 27.2278K and setting the loss to 10dB-per-step.

Given	Calculated	Actual
L = 10dB per step	K = .316228	—
	A = .462475	—
Z = 27.2278K	R3 = 18.6K	18K
	R4 = 12.6K	13K
	R5 = 8.6K	9.1K
	R6 = 13.6K	13K

Where R5 = Z −R3 and is the last resistor in the network, and R6 = Z/2.

The calculated values are not standard values but are very close to them. Testing this network with the nearest standard values has shown that very little error has been introduced.

HP 25 PROGRAM

1. ÷	17. RCL 6	33. STO 7
2. g(10^x)	18. X	34. g(1/x)
3. STO 6	19. STO 2	35. RCL 0
4. CHS	20. GTO 00	36. X
5. 1	21. ÷	37. STO 3
6. +	22. g(10^x)	38. RCL 6
7. g(1/x)	23. STO 6	39. RCL 7
8. RCL 6	24. CHS	40. X
9. X	25. 1	41. RCL 3
10. STO 6	26. +	42. X
11. 1	27. g(1/x)	43. STO 4
12. +	28. RCL 6	44. RCL 0
13. STO 7	29. X	45. RCL 3
14. RCL 1	30. STO 6	46. −
15. X	31. 1	47. STO 5
16. STO 0	32. +	48. GTO 00

HP 25 PROGRAM
(2)

To execute the program for R1, R2.

R1 STO 1 R1 = Value of R1 (example 5600 STO 1)
L ENT L = dB loss for linear portion (example 2 ENT)
20 CHS
R/S

To execute the program for R3, R4, R5

L ENT (example 10 ENT)
20 CHS
GTO 21
R/S

The results can be read by recalling the following registers.

Register	Value
0	Z
1	R1
2	R2
3	R3
4	R4
5	R5

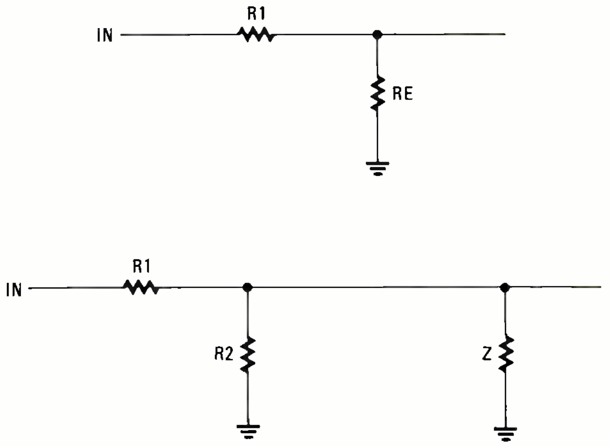


FIG. 2—SIMPLIFIED **representations of a ladder network. RE is split into its component parts in the lower drawing.**

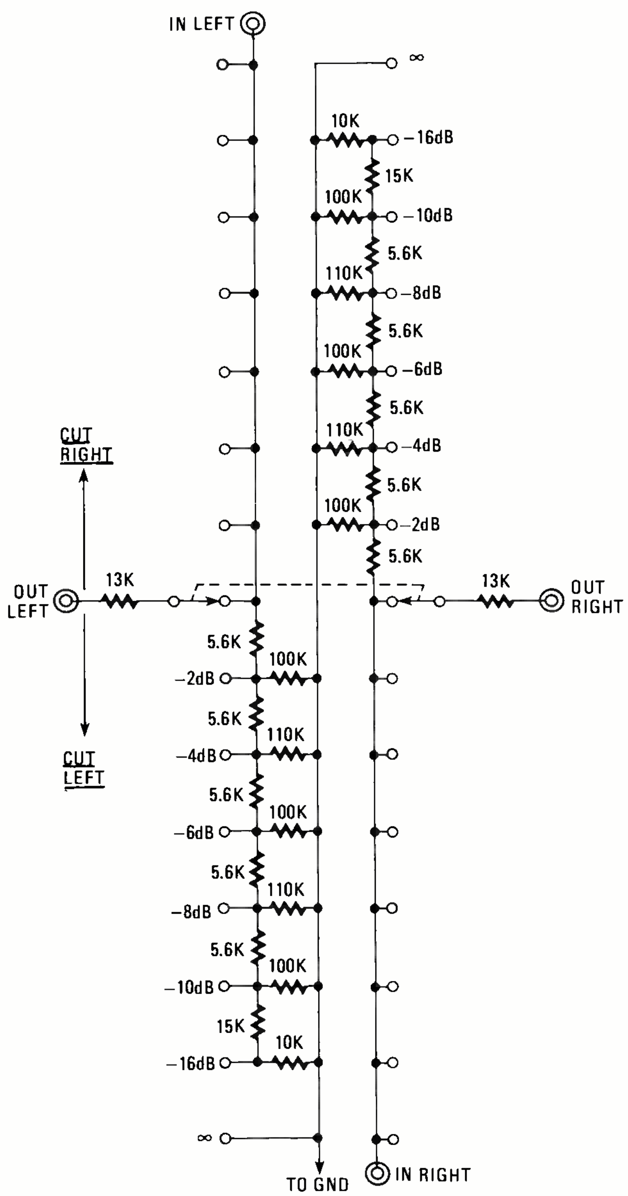


FIG. 3—BALANCE CONTROL FOR A STEREO PREAMP is designed around a 15-position 2-circuit switch. Last two positions provide a degree of log taper.

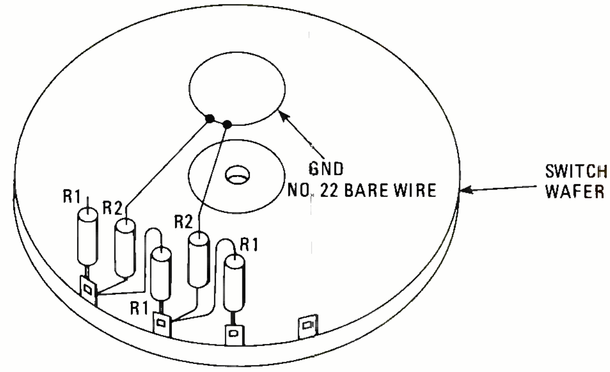


FIG. 4—HOW TO ASSEMBLE A SIMPLE ATTENUATOR on a single switch wafer. If you can find a switch with a second wafer, strap the terminals together on the second wafer and use the strapped terminals as the common ground. The wiper or rotor terminal will be the connection to ground.

Here is a summary of the equations developed above:

1. Z = (1+A)R1
2. R2 = A(1+A)R1—Linear sections
3. R3 = (1+A)Z—Log-Taper sections
4. RE = A(R1) where A = K/(1-K).
5. R5 = Z−R3—Log-taper sections
6. R6 = Z/2
7. A = K/(1−K)
8. K = 10(L/20)

This procedure can be used to design a balance control. Figure 3 shows a typical balance control derived by using formulas 1—8.

PARTS LIST

RESISTORS

All ¼ watt, 5% unless otherwise noted

R1(19)—5600 ohms; R2(19)*—110,000 ohms; R3(2)—18,000 ohms; R4, R6—13,000 ohms; R5—9100 ohms.

MISCELLANEOUS

17 or 24 position switch, knob, hardware, wire, etc.

*105,000 ohms is not a standard value, author alternated 100,000 and 105,000 ohm resistors, see text.

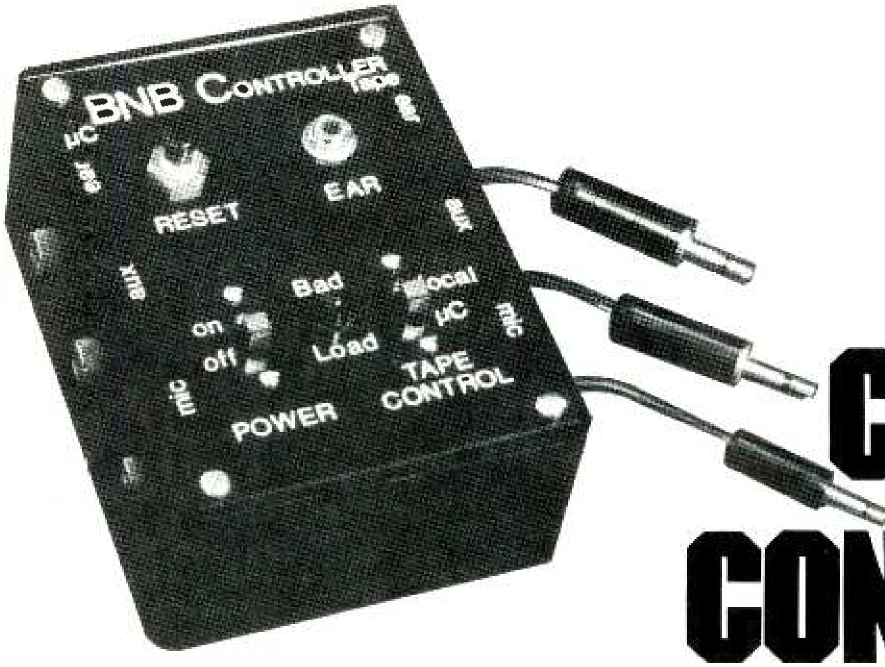
NOTE: These are the author's values, yours may differ, see text.

Construction hints

A rotary switch with 17 or 24 position is best suited for step-attenuators. A 12-position switch just does not have enough range. The switch should also have shorting contacts to provide continuity as you switch from one position to another. The Centralab PA3002 or PA4002 is a good choice. Multiple wafers can be mounted on one shaft for multichannel use.

Resistors for the attenuator can be either 1/2- or 1/4-watt units with a tolerance of five percent. The 1/4-watt type make a more compact assembly and are therefore preferred. These can be economically obtained from mail-order houses advertising in the magazine.

Figure 4 shows an efficient assembly technique. There are others so don't be afraid to experiment. In this case, the ground ring is held in place by the leads from the R2 resistor elements. **SP**



TRS-80 CASSETTE CONTROLLER

JAMES J. BARBARELLO

Monitor cassette tapes for dropouts and other defects with this inexpensive and easy-to-build instrument.

CASSETTE TAPE RECORDERS PROVIDE AN INEXPENSIVE and convenient method for computer program and data storage, although they do have some shortcomings. With microcomputers, such as Radio Shack's TRS-80, you must unplug the recorder cables to regain manual control of the recorder or to listen to what (if anything) was recorded. That problem, though, is minor when compared to the loss of a complete program or data file because of cassette-tape "dropout."

Dropout can be defined as the result of an imperfection in the magnetic coating of the tape which, in turn, causes the signal strength to fall to a level so low that the computer cannot accept it. Thus, you cannot load the program back into the computer and, in effect, have completely lost it. If that happens, you are faced with the laborious task of re-entering the information manually.

One solution to the tape dropout problem is to use only "certified" (specially manufactured and pretested) tapes. This, however, is expensive and still does not solve the recorder-control problem. The controller described here solves both problems. It provides for a choice of manual or computer-control of the recorder, allows monitoring of the tape contents with an earphone, and also contains a peak-level detector/memory circuit which can determine if your tape contains dropouts. The controller is easy to build and should cost under $25.00

How it works

A typical cassette recorder accepts data through the AUX or MIC input, outputs data from the EAR output, and allows computer control of the tape transport by means of the REMOTE jack. Typically, a "save" command energizes a relay in the computer that starts the recorder's motor. The digital information is then transformed into a form which can be recorded on an audio-frequency cassette recorder. That signal (output at a constant amplitude) is then supplied to the recorder's AUX connector.

In microcomputers such as the TRS-80, a "load" command overwrites what is stored in the computer's memory with what it "hears" from the recorder. If any portion of the recorded information is below the proper volume level, the computer will ignore or misinterpret it and the program or data will not be entered into memory correctly.

As shown in the schematic diagram of Fig. 1, the controller contains a peak-level detector/memory circuit consisting of IC1, IC2, and their associated components. The signal from the recorder is AC-coupled through C1 to the input of IC1, a 555 timer set up as a monostable multivibrator (one-shot). Also applied to the input of IC1 is a DC voltage. By adjusting that DC voltage, the data signal can be made to trigger the one-shot to produce a train of high duty-cycle, positive-going pulses. Those wide pulses are smoothed by C3 to a reasonably constant DC level. Diode D1 isolates the smoothing circuit from IC1 during the time its output is low, to prevent C3 from discharging. If the data signal momentarily decreases to the point where it will not trigger IC1, C3 rapidly discharges through R4, producing a negative-going pulse. That negative pulse triggers a RS flip-flop made up of IC2-a and IC2-b.

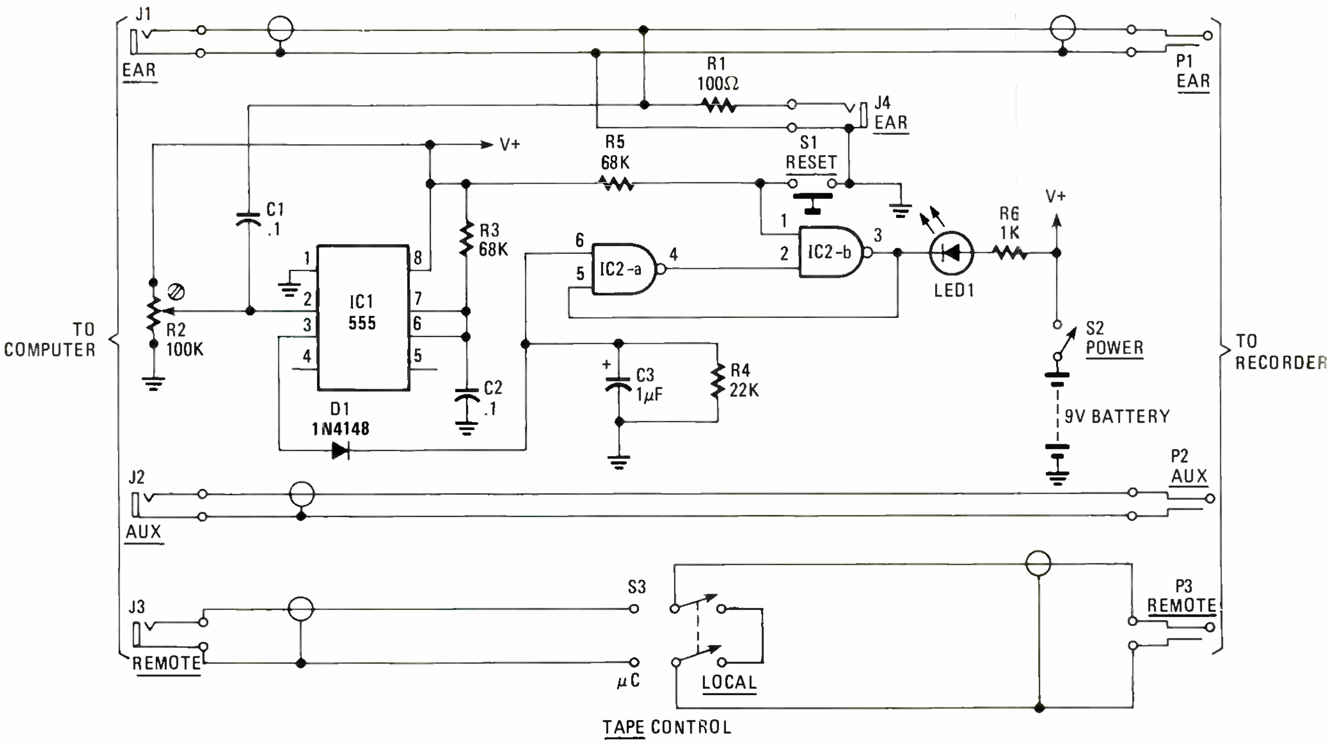


FIG. 1—THE SCHEMATIC DIAGRAM for the TRS-80 cassette controller.

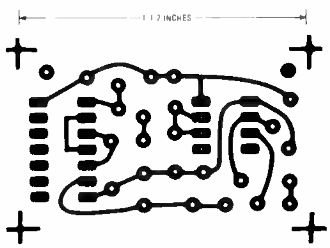


FIG. 2—FOIL PATTERN layout is shown actual size.

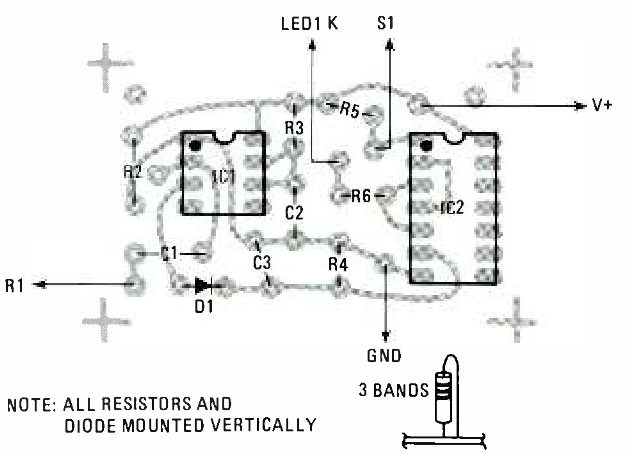


FIG. 3—PARTS PLACEMENT guide for the PC board. Be sure to observe polarities during construction.

PARTS LIST

***Resistors,** ¼-watt, 5% unless otherwise noted*
R1—100 ohms, ½-watt
R2—100,000 ohms, PC-mount trimmer
R3, R5—68,000 ohms
R4—22,000 ohms
R6—1000 ohms

Capacitors
C1, C2—0.1 μF, 25-volt ceramic disc
C3—1 μF, 16-volt, radial-lead electrolytic

Semiconductors
D1—1N4148 or 1N914
LED1—.200 in. red LED
IC1—555 timer
IC2—4011 CMOS quad, 2-input, NAND gate
S1—normally-open pushbutton switch
S2—SPST switch
S3—DPDT switch
J1, J2—miniature phono jack
J3—subminiature phono jack
P1, P2—miniature phono plug
P3—subminiature phono plug

Miscellaneous: PC board, enclosure, shielded cable, battery clip, wire, solder, hardware, etc.

MATCH GAME—(LEVEL I)

```
10 CLS:P. "*****MATCH GAME*****":P.
20 P. "THE GAME STARTS WITH 21
  MATCHES. YOU (THE HUMAN) AND"
30 P. "I (THE MACHINE) EACH CHOOSE TO
  ELIMINATE BETWEEN 1 AND 3"
40 P. "MATCHES ON OUR TURN. THE ONE
  TO TAKE THE LAST MATCH LOSES."
50 FOR I=5 TO 105 STEP 5
60 SET (I,19): SET (I+1,19)
70 FOR J=21 TO 25
80 SET (I,J): SET (I+1,J)
90 NEXT J: NEXT I
100 M=0;H=1:N=21
110 P. AT 640, "WHO GOES FIRST,
  HUMAN(H) OR MACHINE (M)";:IN.S
120 IF S=0 THEN 215
130 P. AT 640, "CHOOSE A NUMBER
  BETWEEN 1 AND 3";:IN.G
150 IF G > 3 THEN 130
160 FOR I=1 TO G
170 FOR J=19 TO 25:RESET (N*5+1,J):
  RESET(N*5,J): NEXT J
200 IF N=0 THEN 330
210 N=N-1: NEXT I
215 P.AT640, "MY TURN"
220 FOR Z=1 TO 1000:NEXT Z
230 IF(N=21)+(N=17)+(N=13)+(N=9)+
  (N=5)+(N=1) THEN 250
240 A=(4-G):GOTO 260
250 A=RND(3)
260 FOR I=1 TO A
270 FOR J=19 TO 25: RESET (N*5+1,J):
  RESET(N*5,J): NEXT J
290 IF N=0 THEN 340
300 N=N-1: NEXT 1
310 IF N=1 THEN 330
320 GOTO 130
330 P.AT640, "SORRY OLD BUDDY. SINCE
  IT'S YOUR TURN, YOU LOSE!"
335 P.AT704, "—— -- ---- —— ---- —— —— ---
  -----":END
340 P.AT640, "PRETTY SMART FOR A
  HUMAN ! YOU WIN !!!
350 P.AT704, "—— ---- -- - —— --- ---"
```

MATCH GAME—(LEVEL II)

```
10 CLS:PRINT "*****MATCH GAME*****":PRINT
20 PRINT "THE GAME STARTS WITH 21
  MATCHES. YOU (THE HUMAN) AND"
30 PRINT "I (THE MACHINE) EACH CHOOSE
  TO ELIMINATE BETWEEN 1 AND 3"
40 PRINT "MATCHES ON OUR TURN. THE
  ONE TO TAKE THE LAST MATCH LOSES."
50 FOR I=5 TO 105 STEP 5
60 SET(I, 19): SET (I+1, 19)
70 FOR J=21 TO 25
80 SET (I,J):SET(I+1,J)
90 NEXTJ: NEXTI
100 M=0:H=1:N=21
110 PRINT @640, "WHO GOES FIRST,
  HUMAN OR MACHINE":INPUTA$
120 IF LEFT$(A$,1)="M" THEN 210
130 PRINT@640, "CHOOSE A NUMBER
  BETWEEN 1 AND 3";:INPUTG
140 PRINT@640,"                        "

150 IF G > 3 THEN 130
160 FOR I=1 TO G
170 FOR J=19 TO 25:RESET(N*5+1,J):RESET
  (N*5,J):NEXTJ
180 FOR Z=1 TO 100:NEXT Z
190 IF N=0 THEN 320
200 N=N-1:NEXT I
210 PRINT@640, "MY TURN"
220 FOR Z=1 TO 1000:NEXT Z
230 IF(N=21)+(N=17)+(N=13)+(N=9)+
  (N=5)+(N=1) THEN 250
240 A=(4-G):GOTO260
250 A=RND(3)
260 FOR I=1 TO A
270 FORJ=19 TO 25:RESET(N*5+1,J):RESET
  (N*5,J):NEXT J
280 FOR Z=1 TO 100:NEXT Z
290 IF N=0 THEN 340
300 N=N-1:NEXTI
310 IF N=1 THEN 320 ELSE IF N=0 THEN
  340 ELSE 130
320 PRINT@640, "SORRY OLD BUDDY.
  SINCE IT'S YOUR TURN, YOU LOSE!"
330 PRINT@704, "---- --- ---- ----- --- --- ----
  -- ----":END
340 PRINT@640, "PRETTY SMART FOR A
  HUMAN ! YOU WIN !!!
350 PRINT@704, "----- ---- -- - ----- -- ---"
```

With the flip-flop in this state, the output of IC2-b is at a logic-low level, which causes LED1 to light. The LED will remain lit until the flip-flop is reset by depressing S1. If LED1 is lit, it indicates that a less-than-acceptable signal-level was present for a time.

The AUX signal line is routed directly through the controller. The REMOTE line, however, goes to TAPE CONTROL switch S3. In the μC mode, the REMOTE line

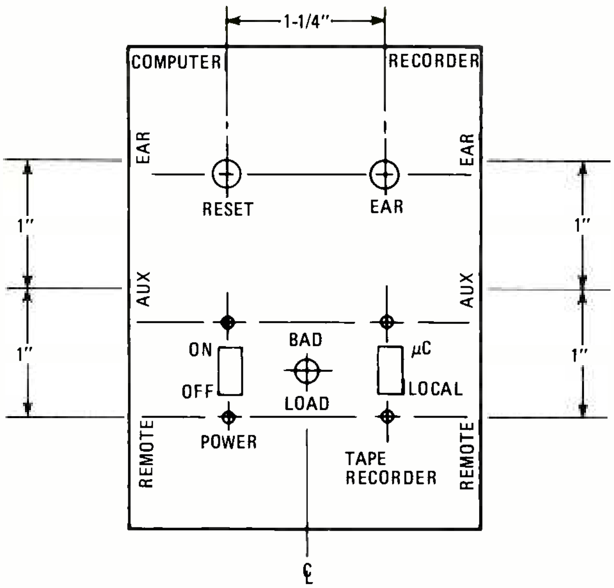


FIG. 4—DRILLING TEMPLATE and typical mounting dimensions for the controller.

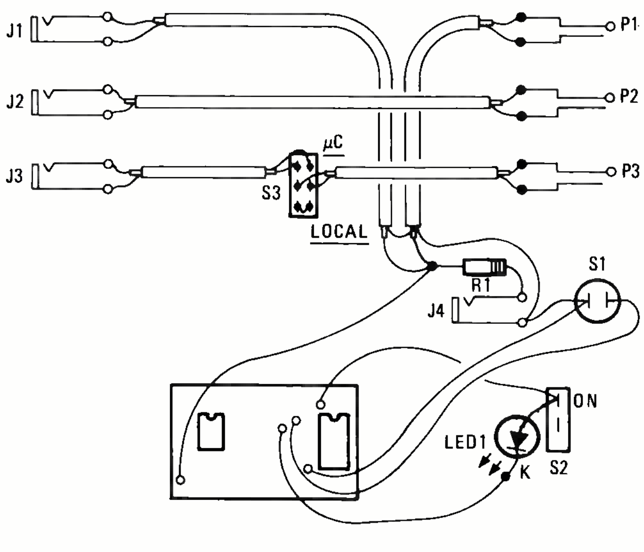


FIG. 5—WIRING DIAGRAM for off-the-board components. Use of this diagram will result in quick assembly.

is connected to the computer's microcomputer jack. In the manual mode, the terminals going to the recorder are closed. That completes the power circuit to the recorder's motor and allows normal operation. Power for the peak-detector/memory circuit is provided by a single 9-volt battery.

Construction

A major portion of the project is point-to-point wiring. All connections between jacks and plugs should employ shielded cable to minimize hum pickup. Connections to and from the peak-level detector/memory circuit can be made with standard hookup wire. A PC-board layout is provided for the detector (Fig. 2), although perforated prototyping-board construction would serve as well. Figure 3 shows parts placement for the PC board. Be sure to observe the polarities of IC1, IC2, D1, LED1, and C3 during installation. The CMOS IC is diode-protected, but reasonable care should be used when handling this device.

Any standard enclosure may be used to house the project. Typical mounting dimensions as well as a drilling template are given in Fig. 4. Use of the wiring diagram to connect off-the-board components (Fig. 5) will result in a quick and trouble-free assembly.

Initial adjustment

Connect the unit to the computer as indicated on the top plate shown in Fig. 4, and install a 9-volt battery. Leave the PC board accessible to allow for adjustment of R2. Place a tape that you know loads reliably into your cassette recorder and set the volume control to the level recommended for use with the computer. Place TAPE CONTROL switch S3 to LOCAL, and connect an earphone to J7. Play the tape. As soon as you hear the recorded data, press RESET switch S1, and check to see whether LED1 lights. If it does, rotate the wiper of R2 towards pin 4 of IC1, press S1 again and check again. Repeat that procedure until the LED stays dark. Next, reduce the volume slightly and readjust R2, if necessary, so that the LED lights after the unit has been reset. Check to see that it stays dark when the volume control is returned to its former level. Adjustment is now complete.

Use

With the controller connected to the proper plugs and jacks, and with S3 set to μC, operation is normal. To advance or rewind tape, simply set S3 to the LOCAL postion. Monitoring the "save" or "load" process is as simple as plugging an earphone into the EAR jack. To use the BAD LOAD check facility, save a program or data on tape. Place S3 to LOCAL and, with the volume control set as before, play the recorded information back. As soon as you hear the data, press S1 and the LED will go out. If it stays dark during the playback, the tape should load properly into your computer. If it remains on during playback, try again at a slightly higher volume level. If it *still* lights, you should try switching to a different portion of the tape or using another tape altogether.

NOTE: With some "bargain" tapes, you may have to increase the volume level significantly to keep the LED dark. However, if it stays off, you know that the tape is providing a good signal to the computer.

Here's an interesting program with which to try out your new controller. It's an old game, known by many names, which we'll call the Match Game. Each player, in turn, deducts up to three matches from the original quantity of 21. The object is not to be the one to take the last match since, if you do, you lose. You must, however, take at least one match each turn.

If the "Human" goes first, the computer will always win. However, if the "Machine" goes first, *you* can win. You must, however, figure out the game strategy used by the computer and use it to your advantage. The program is presented in both Level I and Level II BASIC's as used by the TRS-80, and use about 1 K of memory. The graphics are quite interesting, employing the "SET", "RESET" and "PRINT AT" graphics commands. A hint in determining the computer's game strategy is to note where a random number is selected in the program for the computer's move. **SP**

IC'S FOR SERVO CONTROL

MARTIN BRADLEY WEINSTEIN

New IC's are bringing down the cost of R/C modeling. Here's a look at three that are leading the way

ONE OF THE REASONS RADIO CONTROLLED PLANES, cars, tanks, boats, robots and other models and toys have become so much more inexpensive and available is the development of new IC's to simplify their control. Here's a look at a few of them.

There are now a number of integrated circuits available that very much simplify the design of systems for the control of servos, specifically the position-control servos used to adjust such things as throttle position, rudder position, aileron position, wing flap position, landing gear position, steering and so forth.

We will be looking at three of these ICs: The NE544/644 from Signetics Corporation (P.O. Box 9052, 811 East Arques Avenue, Sunnyvale, California 94086); the XR-2266 from Exar Integrated Systems, Incorporated (750 Palomar Avenue, P.O. Box 62229, Sunnyvale, California 94088); and the ZN419CE from Ferranti Electronics Limited (Ferranti Electric Incorporated, 87 Modular Avenue, Commack, New York 11725).

The Signetics NE544/644 servo amplifier

A block diagram of the NE544 is shown in Fig. 1, an equivalent circuit schematic in Fig. 2 and a typical circuit using it in Fig. 3. You can see that a minimum of external components is required; in addition to the servo motor and position feedback potentiometer, only five resistors and seven capacitors. The IC itself can drive loads up to 500 mA (8 ohms minimum recommended load impedance over a supply range of 3.2 to 6 VDC), or external PNP transistors can be added as shown to drive larger loads.

This IC is available three ways: the 14-pin NE544N DIP; the 16-pin NE644N DIP with separate signal and power grounds; and the miniature 16-pin NE644W package, intended for use with external PNP drivers for miniature servos and high accuracy applications.

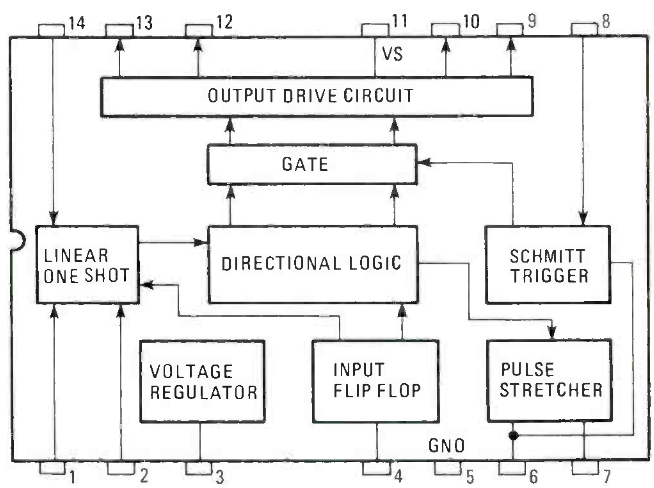


FIG. 1—BLOCK DIAGRAM of the NE544/644 servo amplifier from Signetics.

An overview of the IC's operation begins with the pin 4 input, where a positive pulse sets the *input flip-flop*, which both triggers the *linear one-shot* and sets the *directional logic*. The *linear one-shot* is controlled by a timing resistor (pin 2), a timing capacitor (pin 1), and the arm of the position feedback potentiometer (pin 14), which is connected between the output of the on-chip *voltage regulator* (pin 3) and ground (pin 5). The length of the pulse from the *linear one-shot* is compared to the length of the *input* pulse and stores

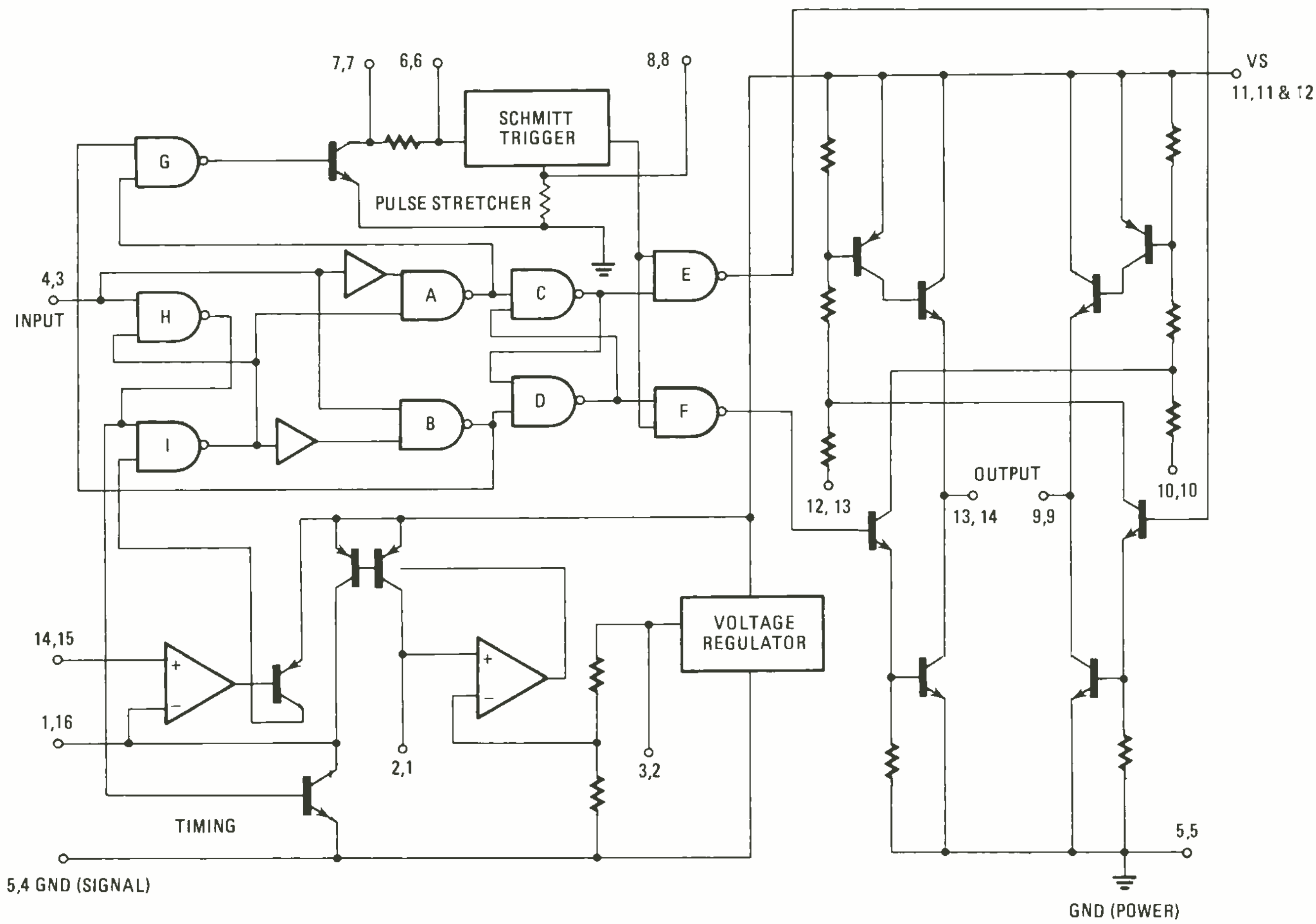


FIG. 2—EQUIVALENT SCHEMATIC circuit diagram of the NE544/644. This IC is capable of driving loads of up to 500 mA.

Pulse formats for hobby servos

The small servomotors used in model airplanes, cars, boats and so forth are actually packages that include small permanent magnet DC motors, a position-feedback potentiometer, linking gears, an output actuator-arm and some controlling electronics.

The input to the servomotor is a pulse train, in which the pulse width is maintained between 1 and 2 milliseconds. The swing of the actuator arm is over 180°, which is considered as −90° through rest to +90°. With a 1 millisecond pulse width, the arm is fully to one extreme, at −90°; with a 2 millisecond pulse width, the arm is fully at its other extreme, at +90°. The position of the actuator-arm between these two extremes is proportional to the width of the input pulse—hence the term *digital proportional* in reference to pulse width modulated *(PWM)* signals. A pulse width less than 1 millisecond wide or more than 2 milliseconds wide can cause damage to the servo through a condition called *stalling*. Also, the servo is designed so that the actuator arm returns to its rest (or *neutral*) position with no signal to the servo; this is a failsafe that causes a model airplane, for example, to fly straight and level in the event of a signal dropout or loss.

Most systems are designed to include a *dead band* (a region of no response) when the actual servo position is close to the desired servo position in order to avoid *hunting*, a phenomenon typified by back-and-forth motion as the servo seeks its position, overshoots it, drives itself the other way, overshoots and so on.

Most IC servo controls incorporate a pulse width comparison scheme, in which the input pulse width is compared to a pulse generated by an on-chip monostable multivibrator which is triggered by the input pulse edge and has a period determined by the position feedback potentiometer. The output of the comparator is an error pulse, which both determines the status of a direction flip-flop and, after stretching, provides the drive signal to the motor—if, that is, the width is greater than the designated *dead band*.

Readers desiring additional information are referred to the following:

"A Monolithic Pulse-Proportional Servo IC for Radio Control Applications" by Joel Silverman, *IEEE Transactions on Consumer Electronics*, Vol. CE-25, August 1979.

And the following books by Edward L. Safford, Jr., available from Tab Books: *Model Radio Control; Radio Control Manual; Advanced Radio Control; Flying Model Airplanes & Helicopters by Radio Control.*

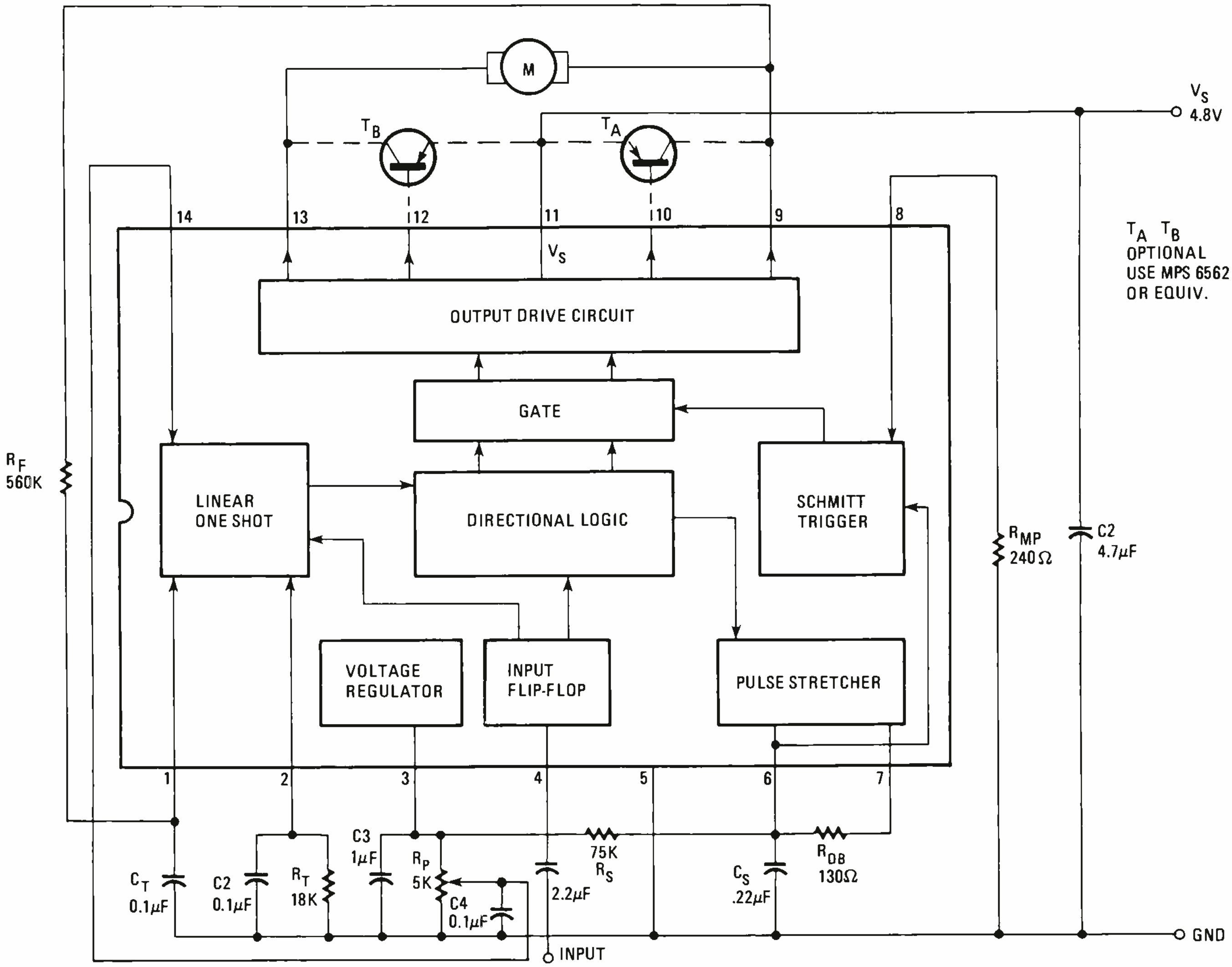


FIG. 3—TYPICAL APPLICATIONS CIRCUIT using the NE544/644 as a high performance servo amplifier.

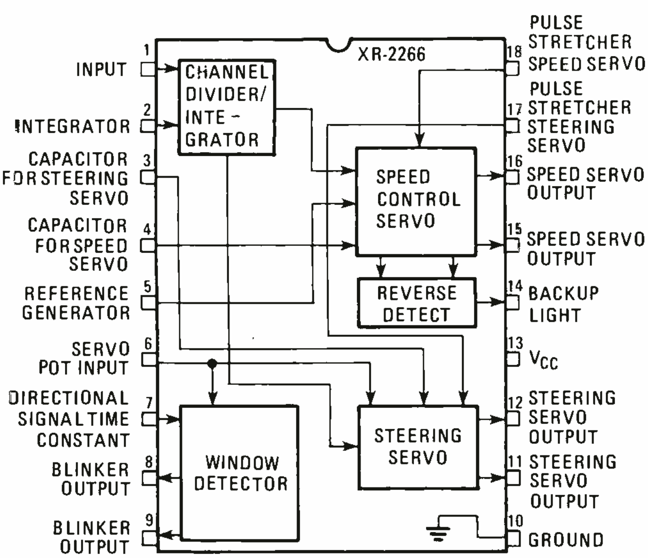


FIG. 4—FUNCTIONAL BLOCK DIAGRAM of the XR-2266 monolithic servo controller from Exar.

the result of the comparison in the *directional logic* flip-flop. This difference pulse goes to the *pulse stretcher* (pins 6 and 7), then to the *Schmitt trigger;* C_S and R_S (pin 6) determine the amount of stretching, R_{DB} (pin 7) the deadband and R_{MP} (at the *Schmitt trigger*, pin 8) varies the hysteresis at the *Schmitt trigger* as well as the minimum output pulse length. The output pulse is gated to the appropriate output drivers at the *output drive circuit* through the gates in the *gate* block, which are controlled by the *directional logic*. The *output drive circuit* (refer to Fig. 2) is a *bridge* of *H-type* drive, which controls motor direction by turning on diagonally-opposite transistors; this causes power polarity to the motor (and thus its direction) to be selected, as well as turned on and off.

That pretty well explains how these little gems operate. You may want to reread the last paragraph while looking at the diagrams to fully appreciate what's going on.

The Exar XR-2266 monolithic servo controller

The XR-2266 was designed specifically for radio-controlled model cars. It includes a channel driver that separates two channels, one that controls the steering

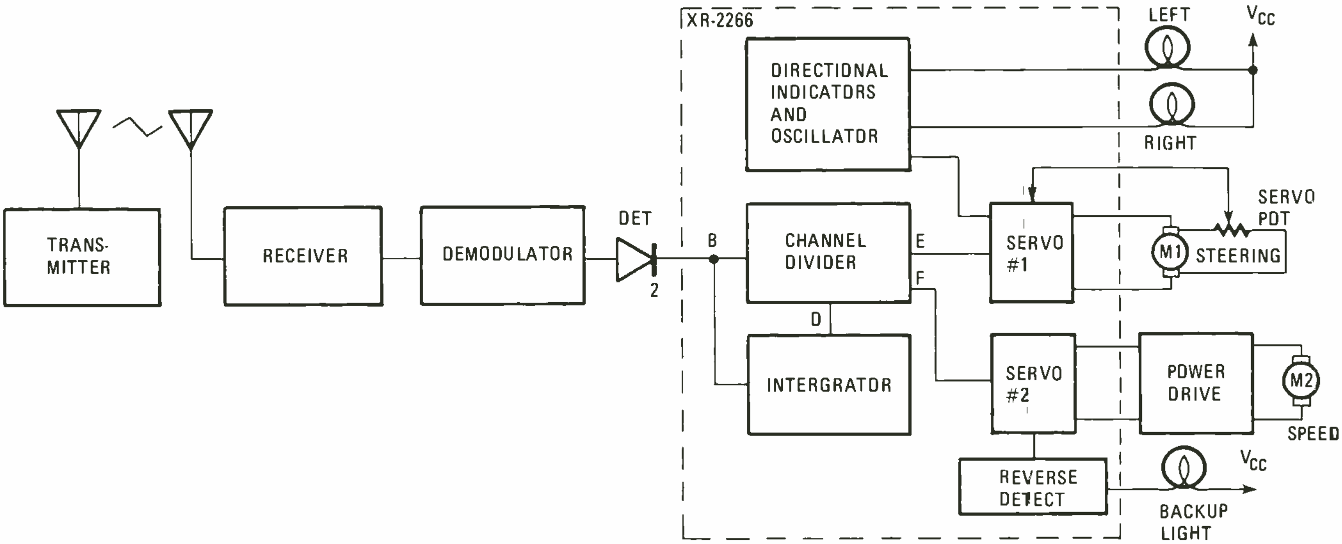


FIG. 5—BLOCK DIAGRAM of a radio control system using the XR-2266. This IC was designed specifically for model car control.

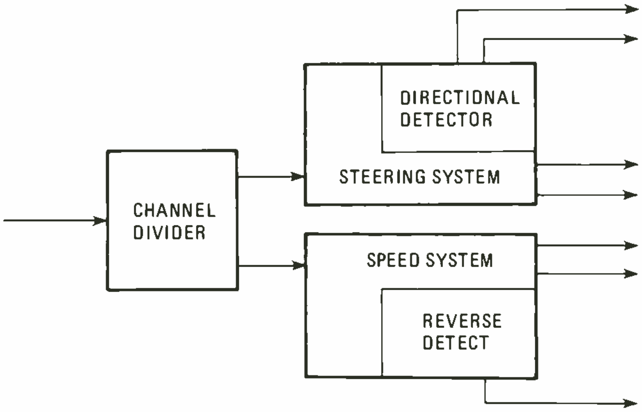


FIG. 6—THREE INDEPENDENT SYSTEMS make up the XR-2266. They work together to completely control the car.

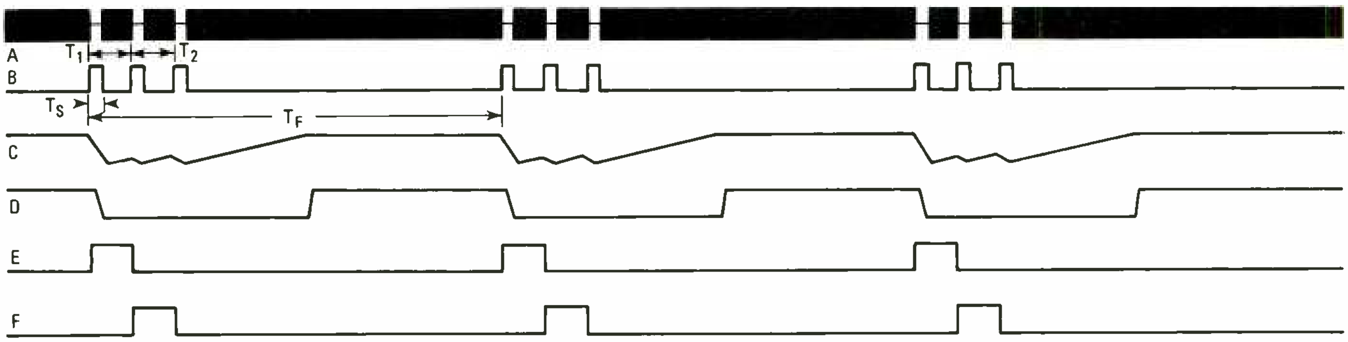


FIG. 7—TIMING DIAGRAM for the XR-2266. These waveforms correspond to the points shown in Fig. 5.

and the other that controls speed and direction. In addition, window detectors turn on outputs intended to light turn signal blinkers and backup lights, as appropriate.

An overview of this IC appears in its block diagram, Fig. 4. Here you can see the *channel divider;* the *speed control servo* and *reverse detect;* the *steering servo* and turn signal *window detector*. Fig. 5 shows how these elements work together in a system, and Fig. 6 shows how the major subsystems are organized. Typical waveforms (with letters corresponding to the points shown in Fig. 5) are shown in Fig. 7.

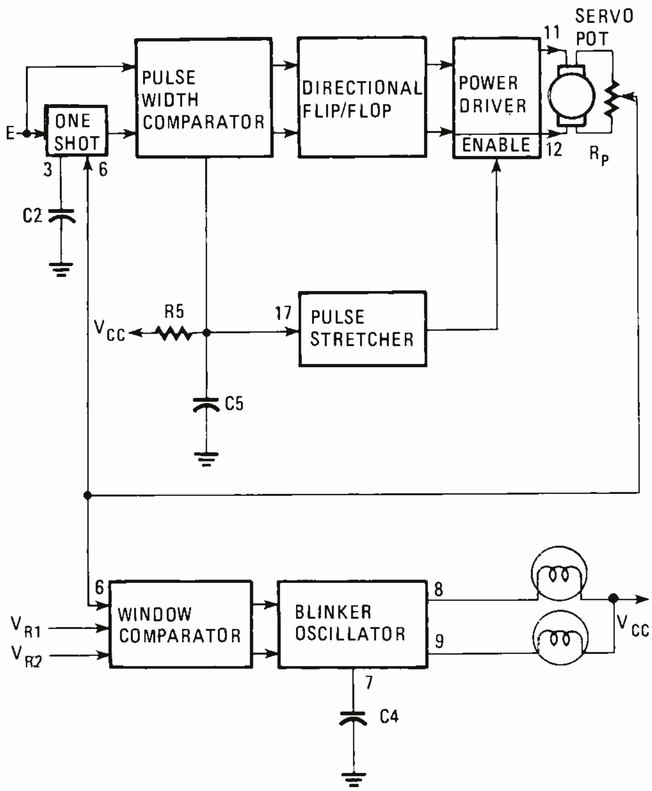


FIG. 8—STEERING SERVO AMPLIFIER. This system's function is to control a R/C car's front wheels.

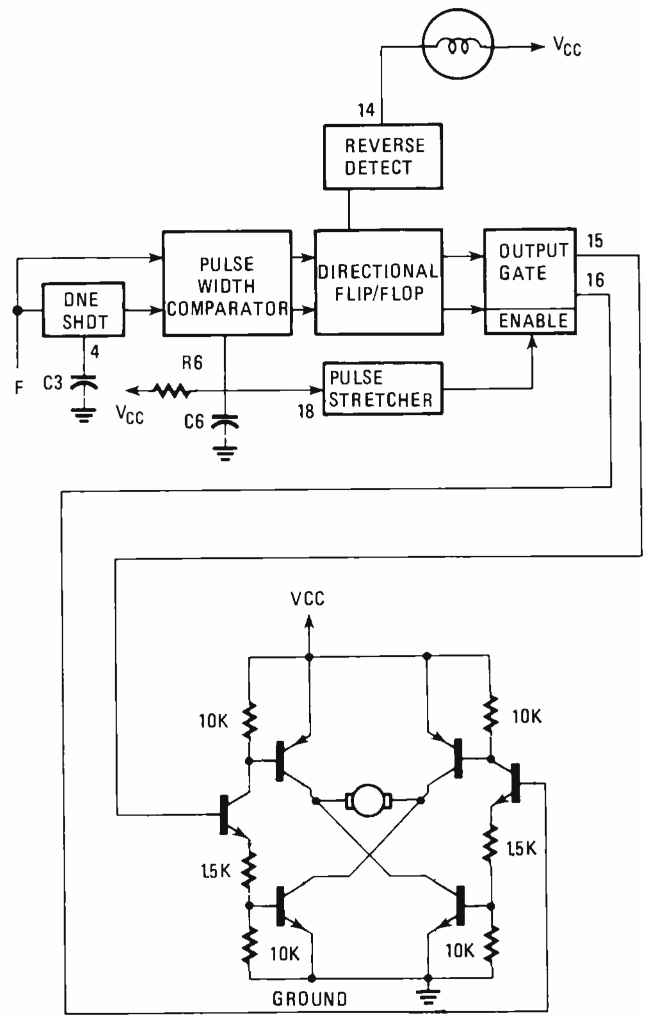


FIG. 9—SPEED CONTROL servo system is shown with a connection for external driver transistors.

The input signal is characterized by frame time T_F, pulse separation T_S, steering servo information T_1 (decoded at E) and speed/direction servo information T_2 (decoded at F). We can follow the signals at E and F into their respective servo circuits in Fig. 8 and Fig. 9.

The operation of these two servo circuits is straightforward, and conforms to a large extent to the operation of the NE544, as described above; there are, however, two exceptions worth noting. In Fig. 8, you'll notice that the slider of the position feedback potentiometer reaches the window comparator at pin 6, which compares this input voltage to internally-generated references V_{R1} and V_{R2}. When the steering servo is toward either end of its travel, the appropriate blinker is enabled through the *blinker oscillator;* the blinking rate is controlled by the capacitor between pin 7 and ground.

The other noteworthy addition is the *reverse detect* block shown in Fig. 9. Very simply, this looks at the state of the *directional flip-flop,* and when it detects reverse, it drives pin 14 low to turn on a back-up light. An application circuit is shown in Fig. 10.

Detroit—watch out for Sunnyvale!

The Ferranti ZN419CE precision servo IC

In the block diagram of the ZN419CE (Fig. 11), you can see many of the same circuit functions we've discussed for our first examples, but a slightly different organization. Let's follow this through, then see what difference, if any, this makes.

The input signal comes into pin 14; while either AC or DC coupling is permissible, Ferranti recommends AC to avoid the problem of continuous commanded rotation which could occur if a DC input were to remain latched high for any reason; a value of 2.2 μF is recommended. The input is first conditioned by a *Schmitt trigger,* which allows good triggering even with slow or sloppy edges on the input waveform.

The *deadband* circuit uses a capacitor at pin 13 to add to the deadband already designed into the *pulse expansion circuit.* In Fig. 12, C_D is the deadband-determining capacitor. Capacitor C_E and resistor R_E determine the characteristics of the *pulse expansion circuit,* which incorporates a Schmitt trigger to help overcome motor inertia and reduce overall current consumption.

The rest of the circuit falls neatly in line with what we've seen earlier. We should note here (as earlier) that a feedback resistor is incorporated to sample the motor's back-EMF (the voltage the motor generates, proportional to its speed) which is added to the position feedback potentiometer's wiper voltage in such a way that the motor slows as it nears its target position; this dynamic feedback helps the motor settle into position without undue hunting.

C1	.1	C3	.33	C5	.47	C7	.0022	C9	.001
C2	.47	C4	33	C6	1	C8	.001	C10	100

R1	510K	R5	910K	RP	5K POT
RF	510K	R6	430K	R2	1K POT

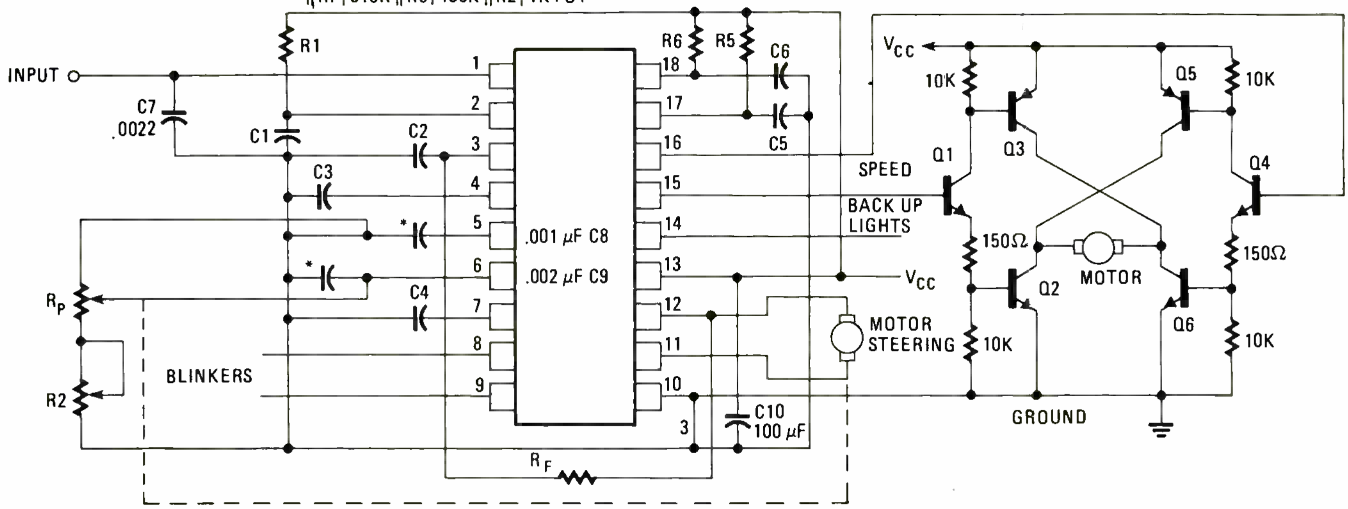


FIG. 10—SCHEMATIC of a typical applications circuit that includes control for such functions as turn signals and back-up lights.

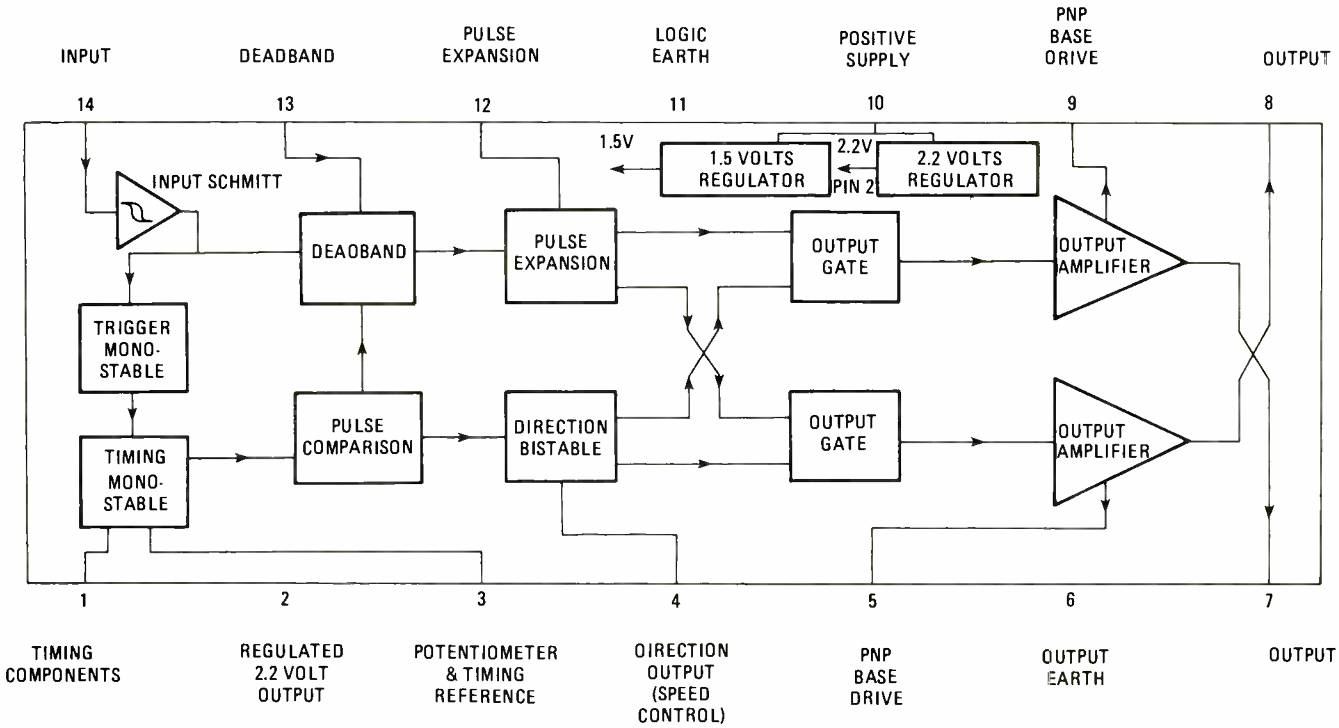
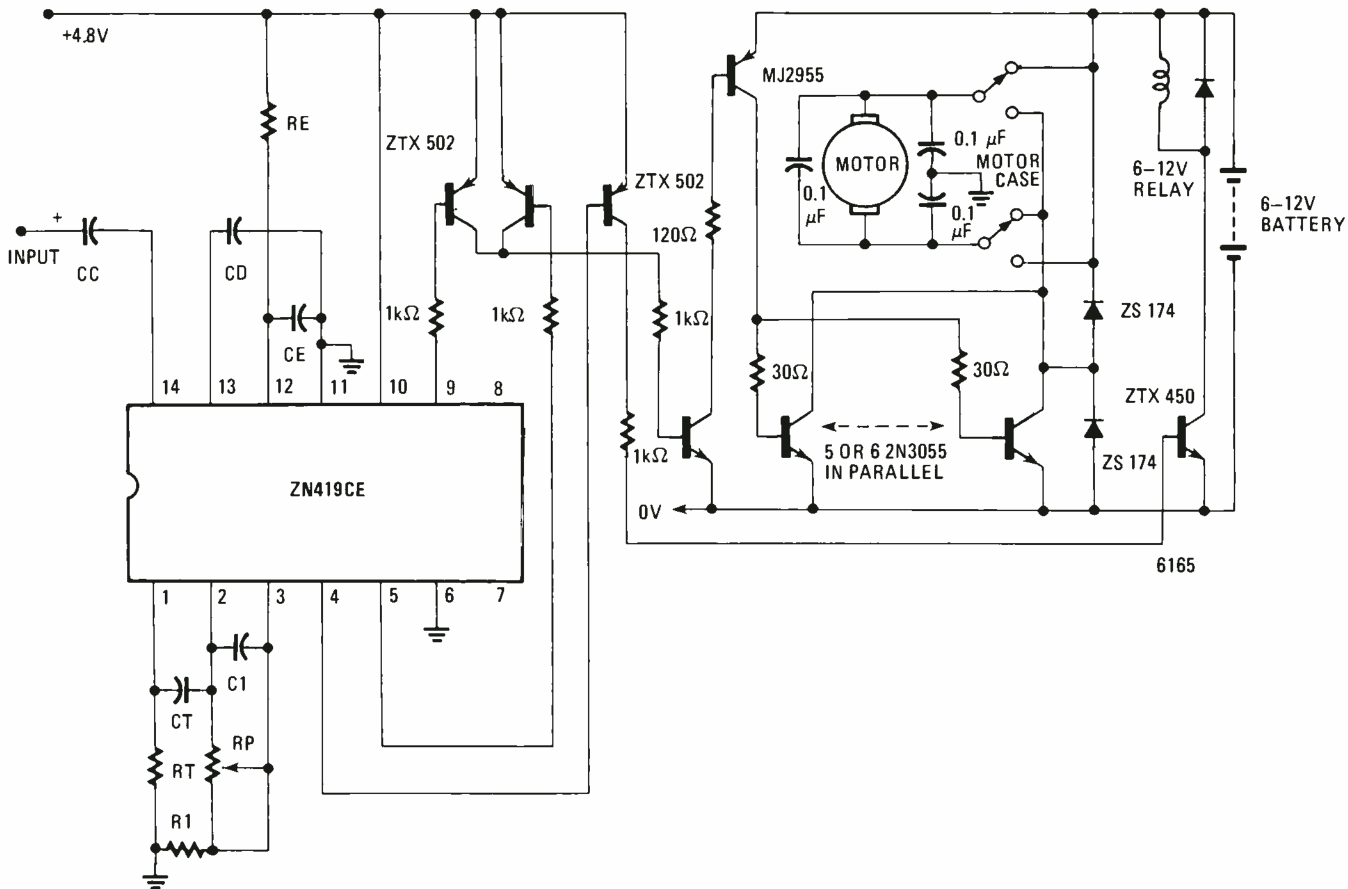


FIG. 11—BLOCK DIAGRAM of the ZN419CE precision integrated circuit from Ferranti Electronics.



HIGH PERFORMANCE proportional motor speed control. In this application the ZN419CE is used as a linear pulse-width amplifier.

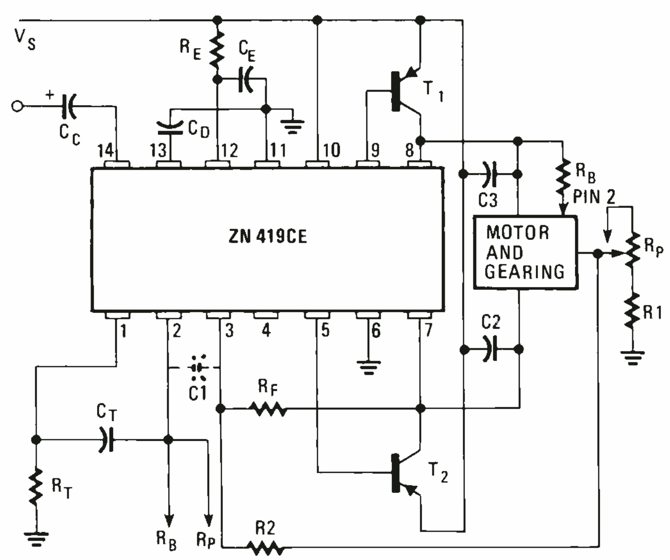


FIG. 12—SERVO SYSTEM using the ZN419CE. Capacitor C_D is the deadband determining capacitor.

Other applications

The usefulness of these circuits extends far beyond models and toys. With larger motors, for example, complete teleoperators (remote control mechanisms, like the material manipulators in nuclear facilities) can be built and precisely controlled. You could easily build an X-Y grid with potentiometers on each axis that control motors on a corresponding, remotely-located grid that drive a pen—voila! a remote plotter!

Or use X-Y axis motors to position a pen under computer control for a do-it-yourself plotting peripheral.

If you're building a robot or android, servo circuits under the control of a harness-wire control box, a wireless remote control or an on-board or remotely-located computer can move the arms, rotate the head or trunk, run the thing in forward or reverse, turn it around, whatever you like.

Or with a feedback voltage derived from temperature, for example, instead of a position feedback potentiometer, you could control the speed and direction of a fan in specific heating or cooling ventilation applications.

It's time for you to experiment. Since these ICs are priced from a few dollars each and up, there's never been a better opportunity to begin. **SP**

SHORT WAVE BOOSTER

HERB FRIEDMAN

This short-wave preamplifier gives you a little extra when you are fighting the noise level.

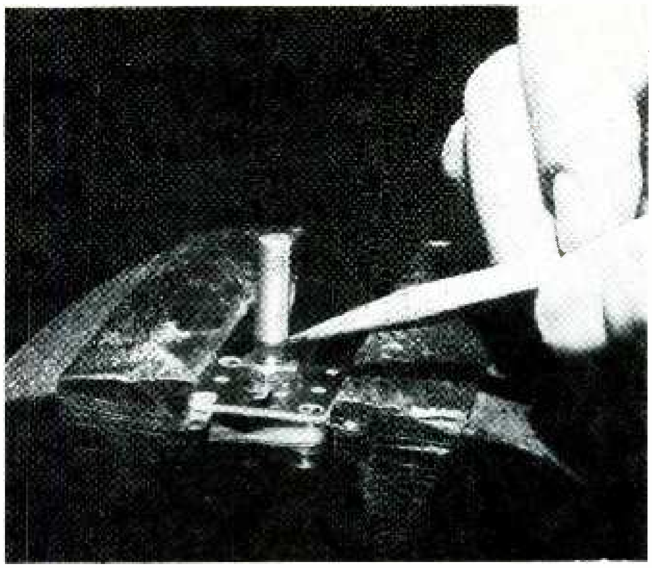
THOUGH WE ARE IN THE AGE OF THE SUPERPOWER transmitter and supersensitive receiver there are still times when we can use a little "extra" in the way of gain to dig out signals lying just over the noise level—and sometimes right smack in the noise level.

The way to get extra, or additional, receiver gain is to connect some form of booster amplifier between the antenna and the receiver. The booster can be either *broadband*—amplifying all frequencies and therefore often generating its own interference from very strong adjacent stations—or *selective* (tuneable), which actually attenuates all frequencies other than the one to which it's tuned.

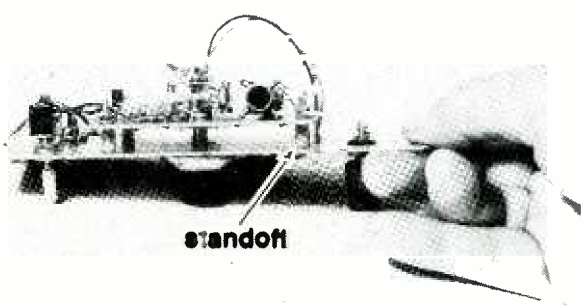
A trouble-free way of getting additional receiver gain is with the Short Wave Booster, a tuneable booster amplifier providing approximately 20 dB of receiver system gain—about 3 S-units of extra sensitivity. We say *trouble-free* gain because the booster causes no problems of its own, either in construction of operation. It is free of spurious signals and instability unless you go out of your way to louse things up by deliberately connecting its output to its input; it is virtually overload-immune (unless the interfering transmitter is literally "down the block"); and best of all, there is almost nothing critical about assembly, and that includes the printed circuit board.

The booster's input is intended for "long wire" antennas. It will not, however, reject reception if you use 300 ohm or even 50 ohm transmission line (replace BP1 with a two-terminal or coax connector). You'll just get a little less overall sensitivity. The booster's output is intended for standard receiver antenna inputs, but again it's not all that critical. It will drive just about any normally-used receiver input from 50 ohms to a telescopic-whip's high impedance; again, there might be a slight reduction in overall "extra" gain. If connected to a receiver's whip make certain you wire a "common" or "ground" connection from the booster to the receiver.

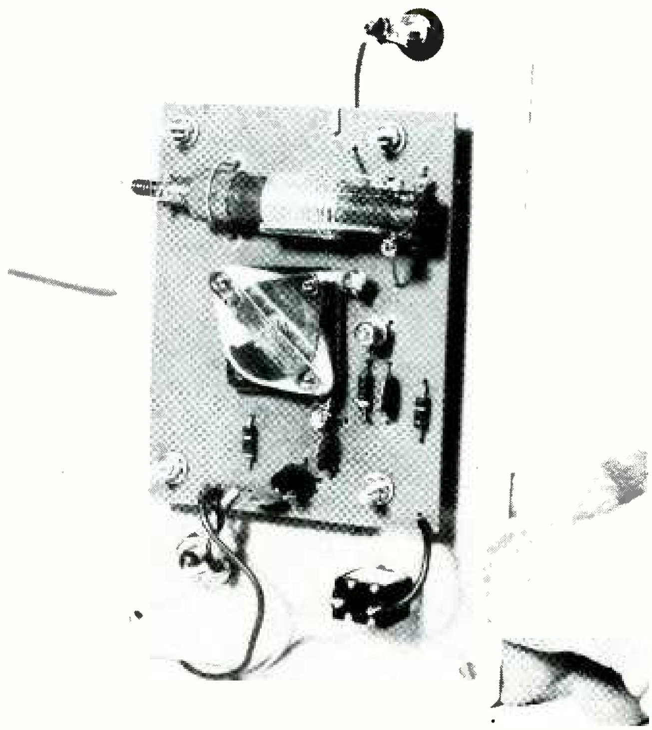
The tuning range is determined by C1 and L1. In the model shown L1 is a Miller C-5495-A 5.5-15 MHz antenna coil which actually provides a tuning range with the specified C1 of about 5-16 MHz. You can freely substitute any Miller coil in the 5495-A series. For example, the A-5495-A coil will give you a broadcast-band booster covering 0.5 to about 1.7 MHz. The D-5495-A coil provides a tuning range of approximately 15-30 MHz. Feel free to substitute as long as you use



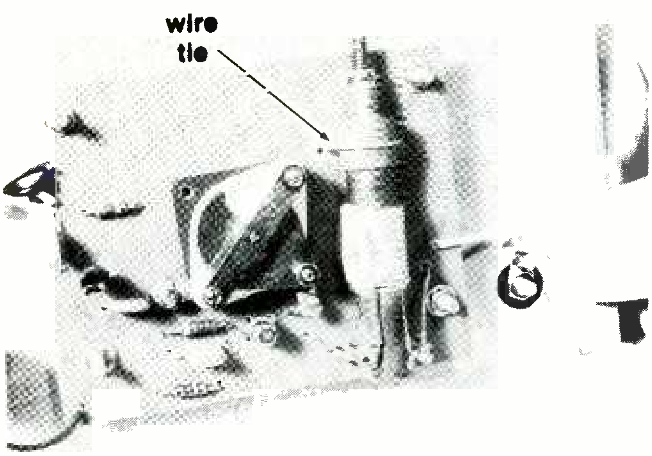
LENGTHENING the shaft of capacitor C1. Using a vise makes the job easier.



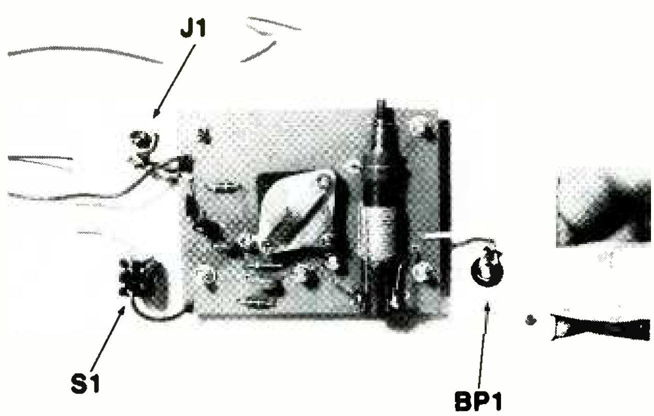
USE ¼-inch standoffs between the circuit board and the front panel.



AFTER ALL PARTS are in place, the circuit board is mounted on the front panel of the case.



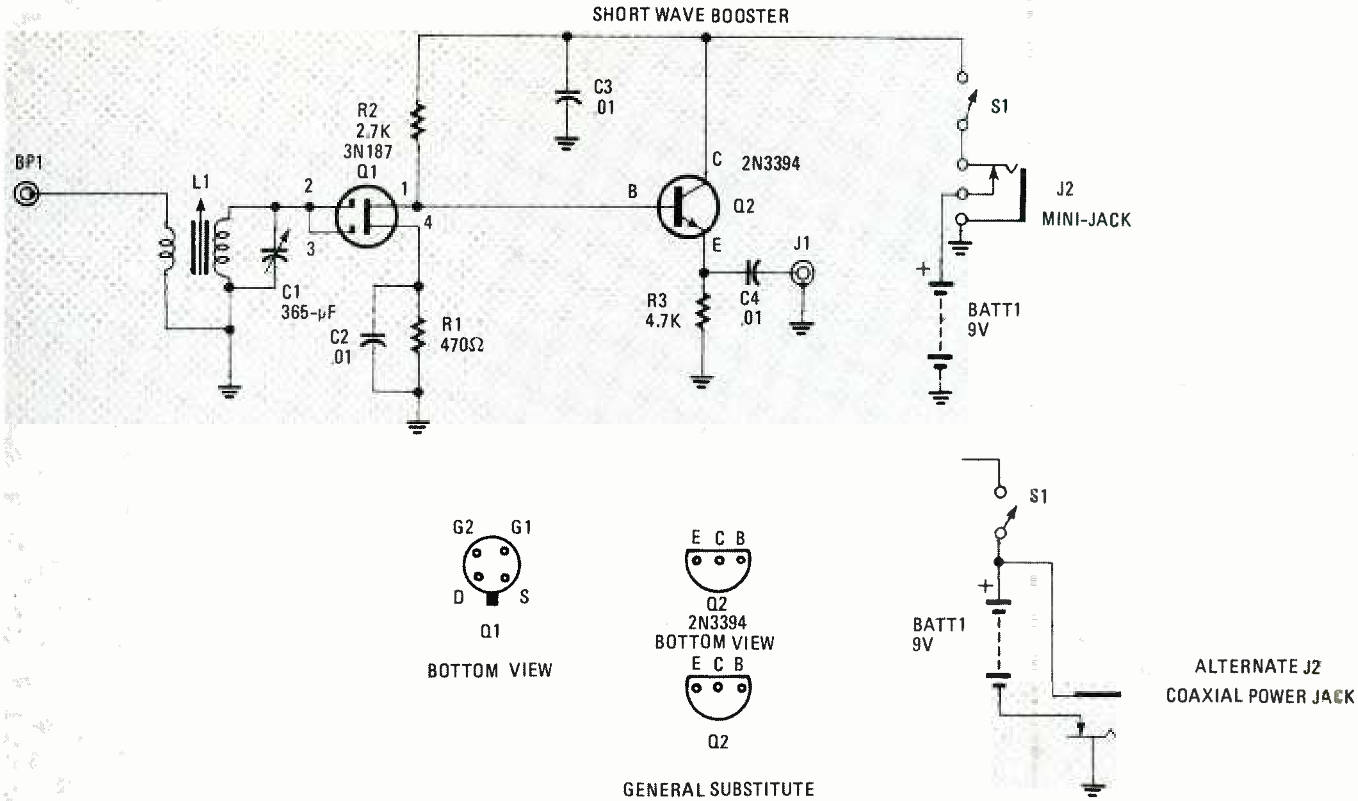
COIL L1 mounts flat and is secured to the circuit board with a wire tie.



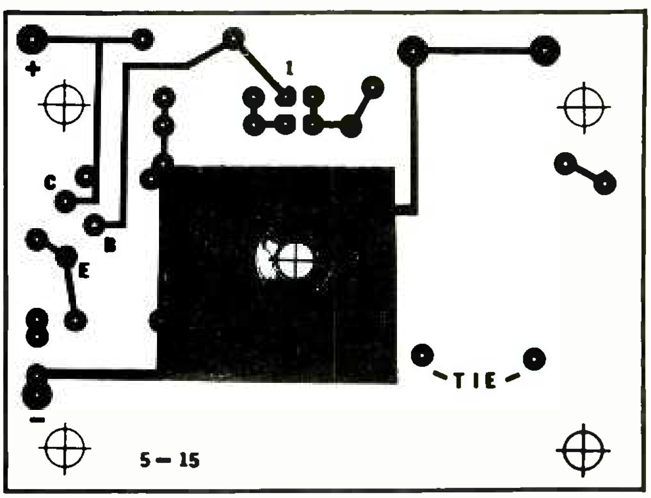
BINDING POST BP1 may be replaced with a coax connector if coax transmission line is used.

the *antenna coil* from the series, as indicated by the final letter "A". Do not use an RF coil, which is designated as X-5495-RF, the "X" representing A, B, C, or D.

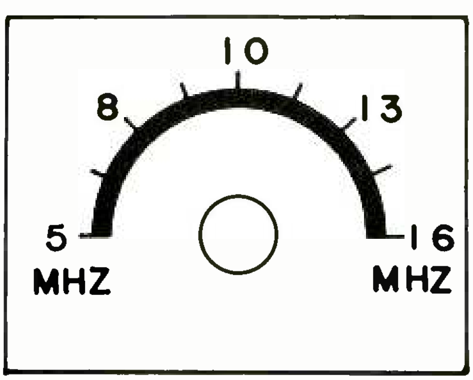
Capacitor C1 is a sub-miniature 365-pF poly-varicon. At one time it was generally available. This is no longer true in many areas of the country. If you have difficulty obtaining C1 locally it can be ordered from



SCHEMATIC DIAGRAM for the short-wave booster. Transistor Q1 is a dual-gate MOSFET type.



FOIL PATTERN for the circuit board. Layout is not critical as long as the general pattern is followed.



TUNING DIAL for the booster using coil L1. Changing the coil would require a different dial.

PARTS LIST

RESISTORS

Resistors 1/4-watt, 10%
R1—470 ohms
R2—2700 ohms
R3—4700 ohms

CAPACITORS

C1—365-pF subminiature tuning capacitor (see text)
C2,C3,C4—0.01-μF ceramic disc rated 25 VDC or higher

SEMICONDUCTORS

Q1—FET, RCA 3N187, 40673, or direct substitute
Q2—2N3394 or equal (see text)

MISCELLANEOUS

L1—5.5-15 MHz antenna coil, Miller C-5495-A (see text)
S1—SPST switch
BP1—Insulated binding post
J1—phono jack
J2—closed-circuit power jack, see text
BATT1—9-volt battery, type 006P or equal
Misc.-Printed circuit material, cabinet, etc.

(Note. C1, a 365-pF Poly-Cap capacitor is available for $4.95 from Custom Components, Box 153, Malverne, NY 11565. Add $2 postage and handling per total order. NY State residents must add sales tax. Canada $2 additional. No foreign orders.)

the source given in the parts list.

How it works

The tuned signal from L1's secondary is fed to Q1, a dual-gate MOSFET wired with both gates shorted together. This is the only critical component and is used for several reasons not too readily apparent. For one, it's input impedance is hundreds of megohms, which effectively provides an unloaded C1/L1. This results in the highest possible "Q" of the tuned circuit and therefore the narrowest possible bandpass without using complex positive feedback circuitry. Tuning is actually so sharp that if reception is desired say, at 6 MHz, and the booster is tuned to say, 12 MHz, the only 6-MHz signal that gets through to the receiver will be mostly "leakage" from the wiring itself.

The specified Q1, the RCA 3N187 or 40673, and the direct replacement, the RCA SK3065/222, has diode protected gates. That is, there are internal back to back diodes from each gate to the source which "ground" transients—such as from static voltage discharge from the antenna—that would "blow" unprotected MOS FETs. The 3N187 family of FETs is immune to almost everything except a direct lightening hit.

Finally, the 3N187 is one of those "legendary" devices that always seem to work no matter what mistakes the builder makes. It can tolerate wide component value tolerances with little effect on overall performance (in this circuit).

Q2 is a low gain NPN RF transistor with an h_{fe} in the range of 30-50. It can be almost any device as long as the h_{fe} range is correct. Do not substitute a "general replacement" transistor if the gain exceeds 50, perhaps 60. When the gain reaches 100-300 it's possible you will actually get less signal out of the booster than was coupled from the antenna.

Q2 serves as an impedance matching device and a current (power) drive for the receiver. It is an "emitter follower" circuit, the base input providing a high impedance load for Q1's drain, the emitter output providing a relatively low impedance drive for the receiver's antenna input terminals. (Whereas L1/C1 and Q1 provide voltage gain; Q2 provides current gain.)

Overall stability of the booster is assured because there is but one tuned circuit; there is no coil in the output to "radiate" back to the input.

The project is powered by a 9-volt transistor radio type (006P) battery, or a 9 volt battery eliminator. Total current drain is slightly under 2-mA so: A) the battery will give almost self-life service; B) the smallest low-cost "surplus" battery eliminator you can find will work just fine.

Even if battery powered, the battery is automatically disconnected when the battery eliminator is plugged in. If your battery eliminator has a mini-plug use the wiring shown for a mini-jack, with the normal-through on the tip connection. If your eliminator has a coaxial power plug such as used on many portable cassette recorders use the alternate wiring shown for a coaxial jack, with the normal-through connection made through the sleeve. Take particular note that when using a mini-jack it is the battery's positive connection that is broken when the eliminator is connected. When using a coaxial jack it is the battery's negative connection

THE COMPLETED short-wave booster. Any type of case may be used.

that is opened.

No bypass switch has been provided because there's virtually no chance of overloading the booster. But if you want a bypass switch wire it in any way you choose as long as you keep input and output wires positioned on their own side of the switch and cabinet.

Making the circuit board

The circuit board (PCB) is not critical as long as you follow the general layout. Keep L1 on one side of the board and Q2 and its connections on the other. L1 is mounted flat on the PCB. The connecting terminals secure one end, the other end is secured by a piece of No. 20 or No. 22 solid wire wrapped around the top of the coil form and secured in the two holes used for a "tie". If you don't want to solder the tie to solder pads around the holes simply twist the wire ends together on the flip side of the PCB. Whatever, make certain L1 is secure; the tuning sensitivity "drifts" on the higher frequencies if something causes L1 to move or vibrate away from the PCB. (There is no problem below 10 MHz).

PCB neatness does not count in this project. it will work as long as the foils bear a reasonable resemblence to the template, so make the PCB the easiest way possible. You can even freehand the resist with a resist pen. Just make certain you provide a foil shield at least the dimensions of C1; it prevents hand capacitance from causing detuning if the PCB is installed in an all-plastic cabinet. (More on the cabinet later.)

All the PCB holes except for C1 and the four corner mounting screws can be made with a #56 to #60 drill bit. If you don't have numbered drills use a 1/16" bit. C1's mounting hole is anything close to, but larger than 1/4": 9/32, 5/16", etc. Do not go to 3/8". The corner mounting holes should provide clearance for #4 or #6 screws; which ever you prefer to use.

If you can obtain a 365-pF miniature poly-varicon capacitor with a standard length shaft, that is, one long enough to accept a knob (about 3/4-inch) by all means use it. More likely, the C1 you can locate will have a short stubby threaded shaft originally meant to accept a tuning dial. You will have to extend the shaft. This is easily done by simply cutting a length (about 3/4 to 1 inch) from the shaft of an old or salvaged volume control and cementing it to the C1 stub-shaft with epoxy.

Do it this way. Use a fast setting epoxy such as Duro *5-minute Epoxy*—it comes in individual "one-shot" packaging (about 5-for-$1). Clamp C1 in a vise so the stub is exactly vertical. Using a toothpick or similar "tool", fill the hole in the stub with epoxy and apply a very thin layer to the top of the stub; don't let the epoxy run down the stub or you will end up with a permanently fixed C1 adjustment. Carefully apply the shaft section to the top of the stub. Make certain the end of the stub is the original end from the control's shaft. The end you cut might not be exactly at right angles to the shaft and you will end up with a peculiar shaft alignment if you cement the cut end. When the shaft is on the stub rotate it about 180° to seat it into the epoxy, check the alignment, and allow a full 24 hours for the epoxy to set rock hard. Then install C1 on the PCB.

The PCB can be installed in any type of cabinet: plastic or metal...it doesn't matter. A good low cost housing is a plastic cabinet with an aluminum front panel. The cabinet shown in the photographs is 6-1/4 × 2 × 3-3/4", a convenient size. External power jack J2 mounts on the side of the cabinet.

If you use a metal panel make certain the PCB is spaced off the panel about 1/4" by metal or plastic spacers, or a stack of washers or nuts at each mounting screw.

Calibration is easy

A full scale template for a 5-16-MHz dial is shown. You can make a tracing or cut it out from the page and secure it to the panel with rubber cement. If you build a broadcast booster version simply place a "period" in front of the numerals for proper calibration (.5, 1.0, 1.6). For other frequency ranges you'll have to redo the calibration.

The tuning range will more or less match the dial if L1's tuning slug is set so it sticks out about 1/8" above the top of the form. Tweak the slug either way to get the exact calibration you want.

Using the booster

Connect the booster output to the receiver using the shortest possible length of "thin" coaxial cable. And if you don't have a short length of coax around you can get away with using ordinary shielded cable—the type used for "audio patch cords." Like everything else about this project, the cable is not critical.

Connect your antenna to BP1. If you have used a plastic cabinet L1 might well serve as a "loop antenna" and you might not need any antenna; it all depends on the station(s) you want to receive.

Preset C1 to the approximate signal frequency and then tune the signal on the receiver. Finally, peak the signal with C1.

While the booster can be left connected for both weak and strong signals bear in mind it will appear to have no effect on strong signals because the "extra" gain is taken up by the receiver's AGC (automatic gain control). It's when the received signal is so weak the AGC is "wide open" and there's still insufficient sensitivity that the "extra" booster gain will appear to raise the signal out of a "dead band." **SP**

HAND-HELD LOGIC PROBE & KIT, the *model 205* "Catch-A-Pulse" and *model 205K kit,* provide an inexpensive means of analyzing and troubleshooting logic gates and sequential circuits such as flip-flops, counters, registers, and microprocessors. The probe is the size of a felt-tip marker pen, and has a shirt-pocket clip. There is a very bright LED display of HI-LOW, pulsing, or open-circuit logic states, which are referred to on the probe's truth table.

The "Catch-A-Pulse" logic probe adjusts automatically to the proper DTL, TTL, MOS, CMOS, or microprocessor circuit threshold when its leads are connected to the IC-circuit power supply. Power-supply reverse polarity is also provided. The input impedance of the probe's tip becomes a slave to the circuit under test, causing it to react to whatever signal or logic condition is present. The probe's memory resets automatically every 50 microseconds to observe and display another pulse. The logic-probe circuitry has built-in current limiting for intermittant or low duty-cycle over-voltages.

The *model 205* has a detachable 6-foot coiled cord with mini-alligator clips; it comes with an instruction manual and a clear plastic carrying case. The price is $49.50.

The *model 205-K kit,* in addition to the "Catch-A-Pulse" logic probe, includes a high-voltage adapter *model 79-465* for 15- to 25-volt circuit applications, and *model 79-466* coiled cord, with micro-hooks for direct IC-pin attachment. The price of the kit is $59.00.—**Triplett Corporation,** One Triplett Drive, Bluffton, OH 45817.

FOR MORE INFO CIRCLE 438 ON FREE INFORMATION CARD

ETCO 1981 CATALOG, new winter edition, has 96 pages listing bargains, discounts, unusual items, and thousands of hard-to-find parts. The winter edition offers what could be the world's largest assortment of cable-TV converters and accessories.

Other new items include: microwave radiation detectors, wireless intercoms, wireless mcirophones and telephones, long-distance parabolic and shotgun microphones, VTR accessories, and disco items. There are also TV-screen magnifiers, educational kits, hundreds of new surplus offerings, metric hardware, printed-circuit materials, and one of the world's largest assortments of receiving and transmitting tubes, including hundreds of obsolete types, almost impossible to find elsewhere.

This "K" issue of the Etco Catalog is available free on request to **Special Projects** readers.—**Etco Electronics,** Dept. 280, Box 796, Plattsburgh, NY 12901.

FOR MORE INFO CIRCLE 439 ON FREE INFORMATION CARD

DUAL MODE POWER SUPPLY

This easy-to-build power supply gives you constant-current or constant-voltage outputs at the flip of a switch.

RALPH TENNY

IT IS FREQUENTLY CONVENIENT TO HAVE AN ADjustable power supply that isn't dedicated to any other purpose except for that first trial of our latest bright idea. Here is a quickly built and very inexpensive power supply which has either voltage or current output. (I call it Chameleon because of its quick-change dual-mode capabilities.) When 2.0 volts to 15 volts at up to 300 milliamps will do the job, the voltage output is ready at the flick of the power switch. If you need to charge a Nicad battery pack, form a capacitor, test LED's or any other job for a current source, just switch the "hot" lead to the current output jack and go to it.

The LM317 is the heart of this power supply. It is a new adjustable voltage regulator from National Semiconductor, and it has a number of advantages over the usual three-terminal regulators we have come to know and love, in spite of its somewhat higher cost. Figure 1 shows the basic diagram of the regulator. It consists of the normal series regulator and voltage reference, but the LM317 uses a 1.25-volt reference instead of the usual 5 volts. Thus, when you use it like a normal three-terminal regulator (Fig. 2) its output is only 1.25 volts. (Note that R1 is necessary for proper operation.)

So, to get the more useful voltages from 5 volts up, we must connect two resistors or a potentiometer and a resistor (R1 and R2) to the basic regulator as shown in Fig. 3. Now, it may not seem like an advantage to use three parts instead of one, but I like the versatility

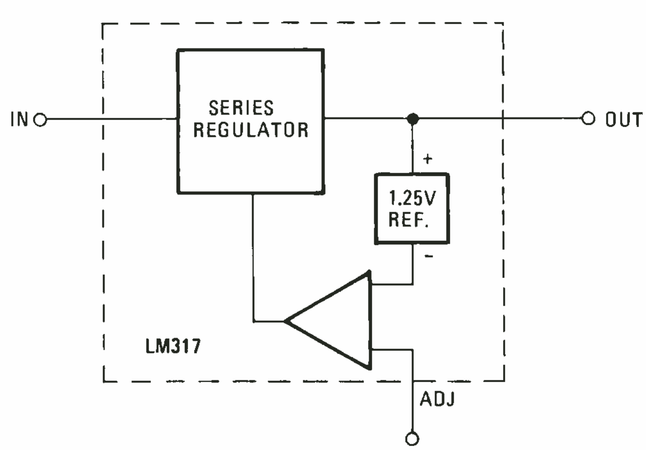


FIG. 1—THE LM317 is a three-terminal regulator with a 1.25-volt-internal reference.

the LM317 gives me. In the first place, I only need one type of regulator for a number of purposes. And, when I need a variable voltage, as with Chameleon, it should be possible to get as low as 1.25 volts (instead of 5 volts minimum) with this basic circuit. However, due to a design compromise discussed later, Chameleon's low end is about 2 volts.

One major advantage of the low reference voltage of the LM317 is that a very efficient current source is

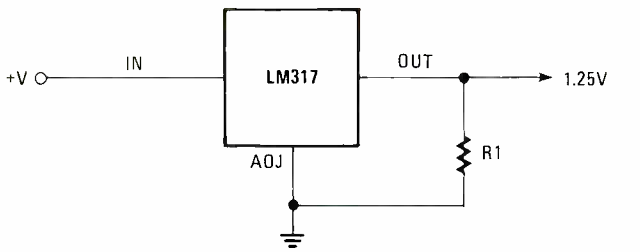


FIG. 2—MINIMUM OUTPUT VOLTAGE for the LM317 is 1.25 volts. Resistor R1 is needed for proper operation.

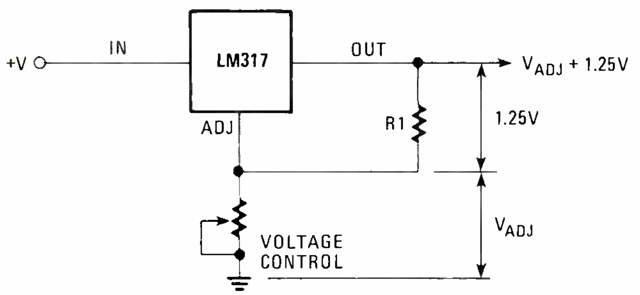


FIG. 3—ADD A POT to Fig. 2 and the LM317 becomes a wide-range adjustable voltage regulator.

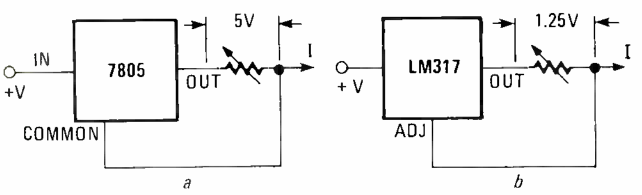


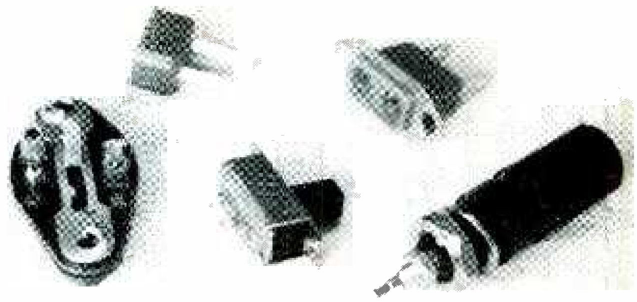
FIG. 4—ALL THREE-TERMINAL regulators can be used as constant-current sources.

possible. The current-source circuit is shown in Fig. 4. Figure 4-a shows a 7805 regulator, which requires 5-volt drop across the current shunt, because the older regulator design uses a 5-volt reference. In Fig. 4-b the LM317 requires only 1.25 volts, which means that the energy lost in the regulator and circuitry is about one-fourth that of the older circuit. Note that in Fig. 4-b, the variable resistance must not be allowed to go to zero: this would imply infinite output current. In the practical development, a small series resistor sets the minimum circuit resistance.

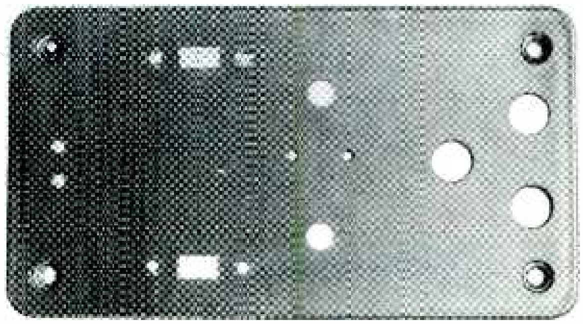
Current or voltage

As I designed the supply, it was apparent that only a few additional parts would give me either voltage or current output capability. Therefore, in Fig. 5 we see a circuit which can give either voltage or current output by changing one switch. Note that the voltage output terminal should not be used with current mode selected, and that any load between the current output terminal and common will reduce the output voltage if Chameleon is being used in voltage mode.

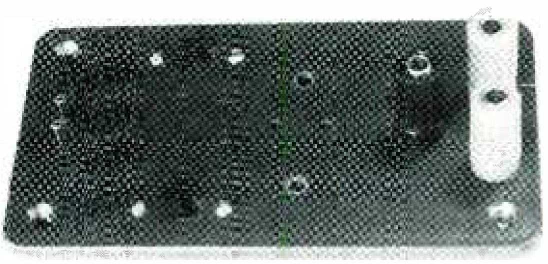
All the previous illustrations have omitted two important parts from the schematics. These are the input (C2) and output (C3) capacitors in the complete Chameleon schematic shown in Fig. 6. Capacitor C2 can be omitted unless the leads from the filtered DC



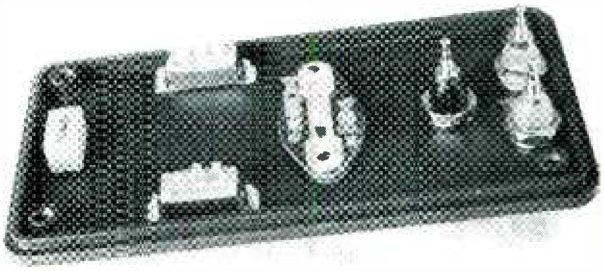
SOME OF THE HARDWARE needed to build the Chameleon. All parts are readily available.



TOP VIEW of the plastic project box chassis lid showing the suggested layout of the mounting holes.



PLASTIC project box chassis lid with all of the top hardware in place.



BOTTOM VIEW of the lid. The power connector (far left) should be locked in place with epoxy.

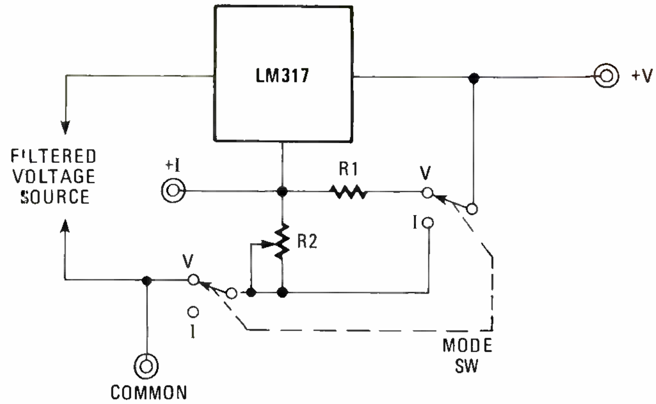
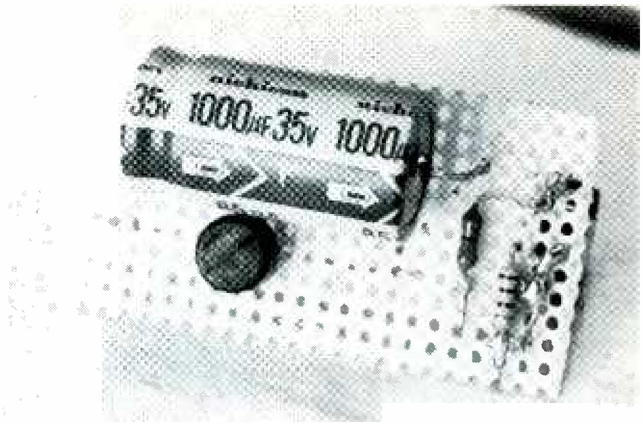


FIG. 5—ADDING COMPONENTS makes the LM317 into a switch-selectable constant-current or constant-voltage source.



MOST OF THE CIRCUITRY fits on a small perforated board. The bridge rectifier is just below the capacitor.

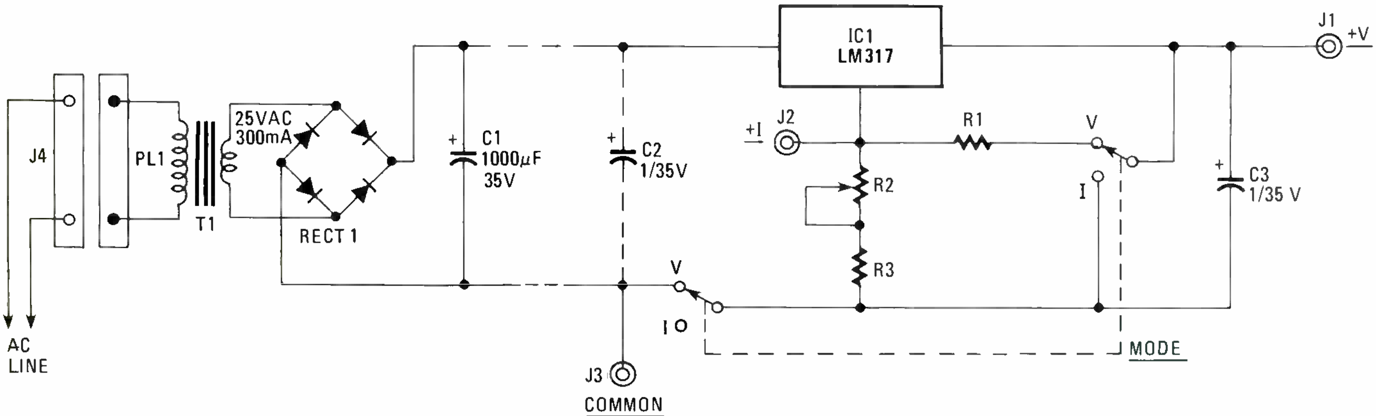


FIG. 6—SCHEMATIC of the Chameleon. Capacitor C2 is needed only if the leads from the filtered DC supply are over 5 inches long.

PARTS LIST

RESISTORS

Resistors, ¼ watt, 10% or better
R1—100 ohms
R2—1000 ohms, potentiometer, PC mount
R3—27 ohms
R4—(see Fig. 7)—100,000 ohms, potentiometer

CAPACITORS

C1—1000 µF 35 volts electrolytic
C2, C3—1 µF, 35 volts, tantalum

SEMICONDUCTORS

IC1—LM317
Q1—(see Fig. 7)—2N5210 or equal NPN transistor
RECT1—full-wave bridge rectifier, 50 PIV, 1.4 amp, Radio Shack 276-1151 or equal

MISCELLANEOUS

T1—transformer, 24 volts AC, 300 mA secondary, Radio Shack 273-1386
J1, J2, J3—insulated 5-way binding post
J4—line-type AC receptacle (TV cheater cord or equal)
PL1—chassis-mount AC plug to match J4.
case—plastic project box, 4-3/4 × 2-1/2 × 1-2/5 inches, Radio Shack 270-222 or equal

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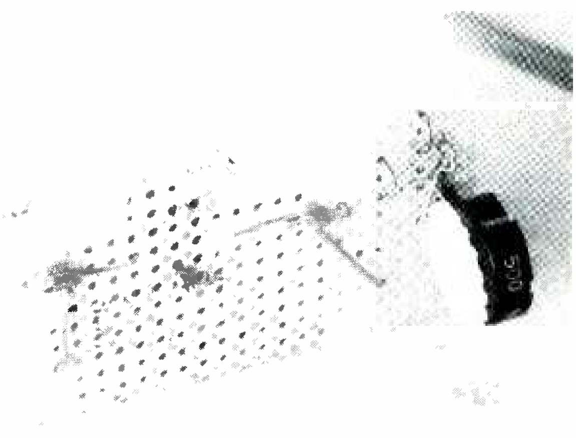
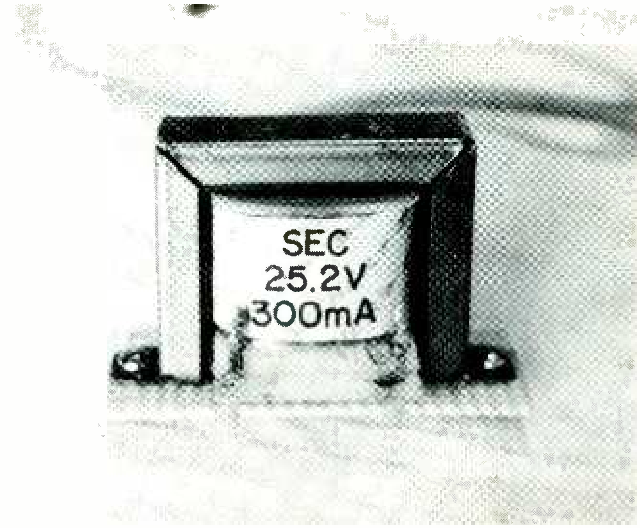
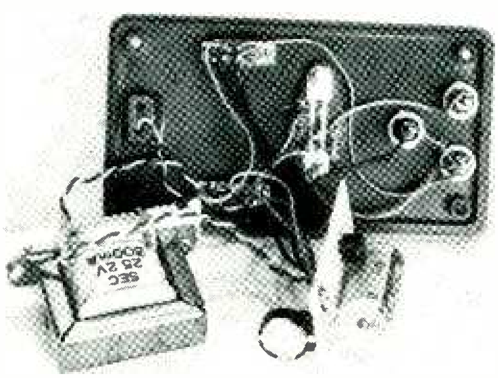


REAR VIEW of the board. Note that each lead is bent to form a loop to which connections are made.

supply are over 5 inches long. Capacitor C3 makes a big improvement in the recovery time of the regulator if a sudden change in the load current occurs. No special layout precautions are needed for Chameleon, and, except for good soldering and construction practice, nothing is critical about the circuit layout. In the version shown in the photos, C2 was omitted due to the small box and short leads.



TRANSFORMER mounts on a separate piece of perforated board that slides into a slot in the case.



THE COMPLETELY WIRED unit just before it is installed in its case.

One more component was added to the final schematic (Fig. 6); R3 sets an upper limit on the output current furnished to the load. The limiting factor is the power rating of R2; the part specified in the parts list is a 1/4-watt potentiometer. This simply means that there is a maximum current which any part of R2 can handle, and maximum load current occurs when R2 is set to the lowest resistance. This can be computed using the following formula:

$$\text{Power (watts)} = I^2 \text{ (amps)} \times R \text{ (ohms)}$$

From the formula we can compute that about 22 mA current in R2 would be the maximum. Since the wattage rating on components is for continuous use, we can fudge some and assume that about 50 mA load current is acceptable for short-time applications.

Potentiometer R2 was chosen for its availability, even though a potentiometer with a shaft would have been preferable. The lack of shaft is solved by mounting R2 so that a hole in the side of the box allows screwdriver adjustment of the output. If a larger value of current is needed from Chameleon, you sould substitute a 100-ohm, 1-watt potentiometer, and use a 10-ohm unit for R3. This combination will give you a maximum current of 300 mA, which is much more

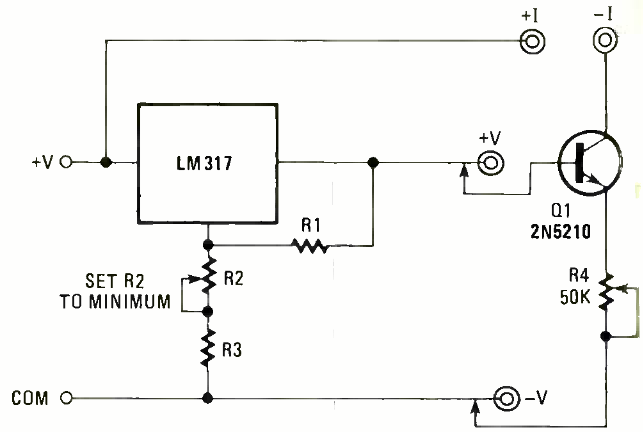


FIG. 7—ALTERNATE HOOKUP allows the unit to be used as a very-low-current source.

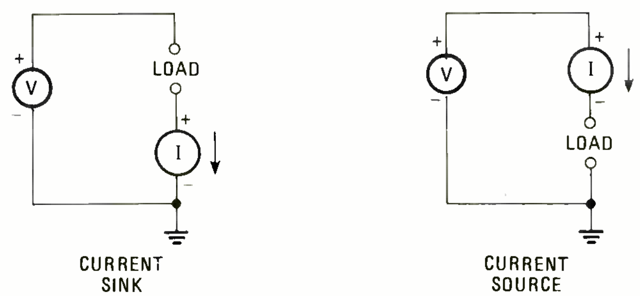


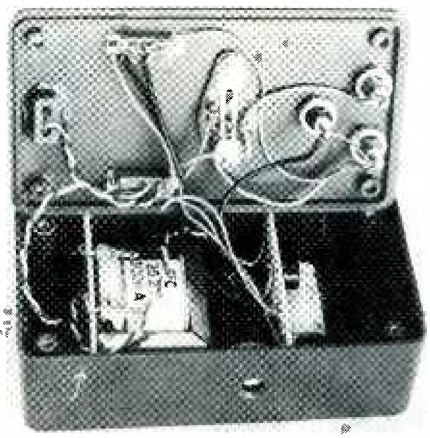
FIG. 8—A CONSTANT-CURRENT source may be used as either a constant-current source or constant-current sink.

than the LM317 should be called on to deliver without a heat sink. With the high current configuration installed, Chameleon will deliver about 3-volts maximum in the voltage mode, unless R1 is much smaller. However, with R1 set to 27 ohms, the maximum output will be about 6-volts; at this output level, the R1-R2-R3 string will pull over 40 mA. Therefore, if a heavy current source is needed, it should be a separate unit.

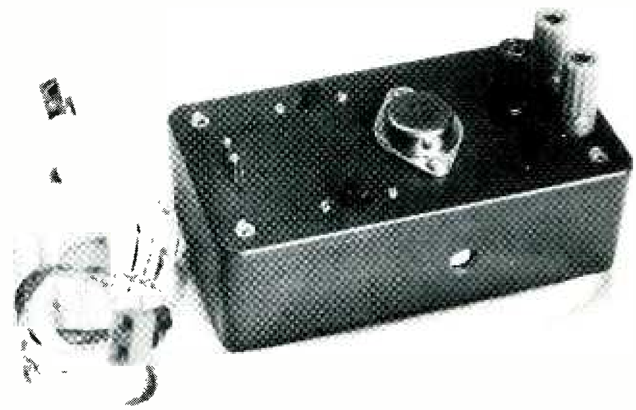
Test the current mode

When you test Chameleon's current mode (using the circuit in Fig. 6), you will note that about 3 mA is the lower limit of adjustment. This is due to the current used by the circuitry inside the LM317. However, Fig. 7 shows an alternate hookup which can give an arbitrarily small current (down to 100 microamps or less, if Q2 is a low-leakage transistor). What happens is that the LM317 serves as a voltage reference for Q2 and R4. The accuracy of this current source is directly dependent upon the current gain (h_{FE}) of Q2 at any collector current. That is, if the h_{FE} is only 10 at a collector current of 100 microamps, the actual load current will be 110 microamps, or a 10% error. For a h_{FE} of 250, the error is only 0.4%. Of course, the error is proportional to the h_{FE} at any collector current, instead of just at low currents as in the example chosen.

Just looking at the circuits in Figs. 4 and 7, it would seem that Fig. 4 shows a current source and Fig. 7 a current sink. Actually, Fig. 8 shows the same two-terminal current generator connected as both a current source and a current sink. The difference is in which



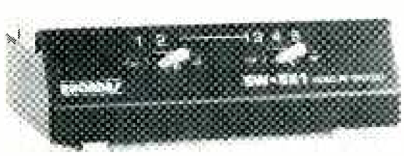
INSIDE VIEW of the Chameleon. Be sure to tuck in any stray wires as you close the lid.



THE FINISHED PRODUCT with the power transistor installed. At high current-levels heat sinking is advisable.

terminal is referenced to which terminal of the main circuit. All you need to remember in applying Chameleon as a current generator is that the + current terminal is a current source and the − terminal is a current sink, and to reference the appropriate terminal to the desired place in the circuit under test.

Chameleon is constructed entirely from readily available parts for convenience. If you choose the same chassis box (Radio Shack 270-222) as I did, the photos show one way to assemble the pieces. My bench testing of new circuits is a lot quicker since I have Chameleon around. **SP**



VIDEO SWITCH, *model SW-5x1,* is for those whose TV or VTR needs more than one source. With this low-loss, high isolation switch, you can plug in any five sources from VTR, game, antenna, pay-TV, computer, video disc or cable into the inputs 1 through 5 on the back of the *model SW-5x1*.

The load-compensated inputs mean that those inputs are switched into 75-ohm loads when not switched into the circuit; that is important for maintaining correct impedance loads on hybrid transformers and the outputs of your video components. The aluminum cabinet shields RF frequencies and the rubber cushion feet assure scratch proofing and stable positioning on the top of any surface.

The switch is 5½ × ⅛ × 1¾ inches. Switches: three-position toggle, 50,000 operations; terminals: F-type; impedance 75 ohm; frequency, 0-900 MHz; isolation better than 60 DB, and there is a two-year warranty. The *model SW-5x1* is priced at $49.95.—**Rhoades National Corporation,** PO Box 1052, Highway 99 East, Columbia, TN 38401.

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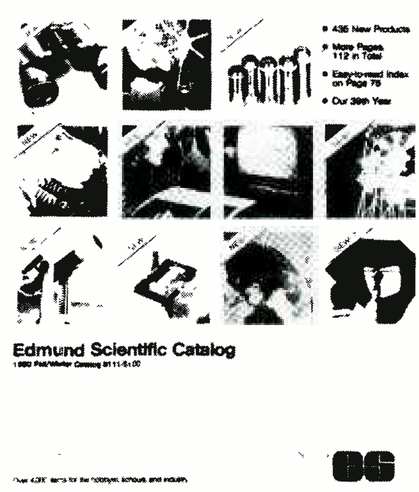
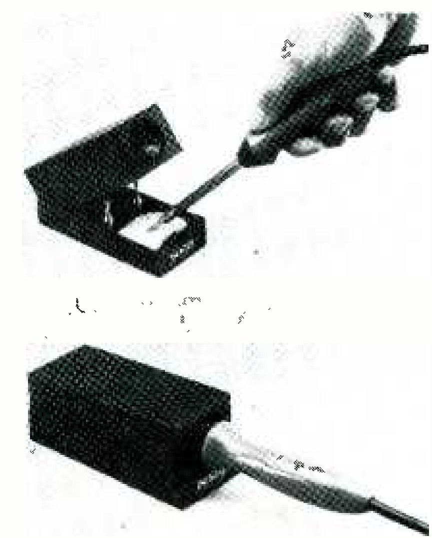


EDMUND SCIENTIFIC CATALOG, Fall/Winter 1980 introduces 435 new products. The catalog is 112 pages, many in color, and measures 9¾ × 8¼ inches. Design engineers, research laboratories, industrial plant managers, purchasing agents, experimenters, and hobbyists will find a wide variety of cost-cutting, time-saving bargains.

A full page in the catalog has been devoted specifically to OEM and instrument components. Other sections include industrial components such as lab equipment, lenses, fiber optics, comparators, lasers, reticles, infra-red viewing systems, microscopes, cobalt rare-earth magnets, optical testing equipment, and more.

The catalog is available free upon request.—**Edmund Scientific Co.,** 7082 Edscorp Bldg., Barrington, NJ 08007.

FOR MORE INFO CIRCLE 434 ON FREE INFORMATION CARD



SOLDERING-IRON STAND, lets you transport a hot iron. The new stand is a combination soldering-iron stand and caddy. When closed, the stand contains the soldering-iron shaft and tip within the closed metal compartment, thus allowing an iron that has not yet completely cooled down to be placed in a tool box or caddy without damage to adjacent compartments. The stand/caddy also protects the shaft and tip from possible damage in transit.

In the "open" position, the stand functions as a standard soldering-iron stand, holding the iron within easy reach between uses. It also features a tip-wiping sponge and well. The soldering-iron stand is priced at $6.95.—**Wahl Clipper Corporation,** Sterling, IL 61801.

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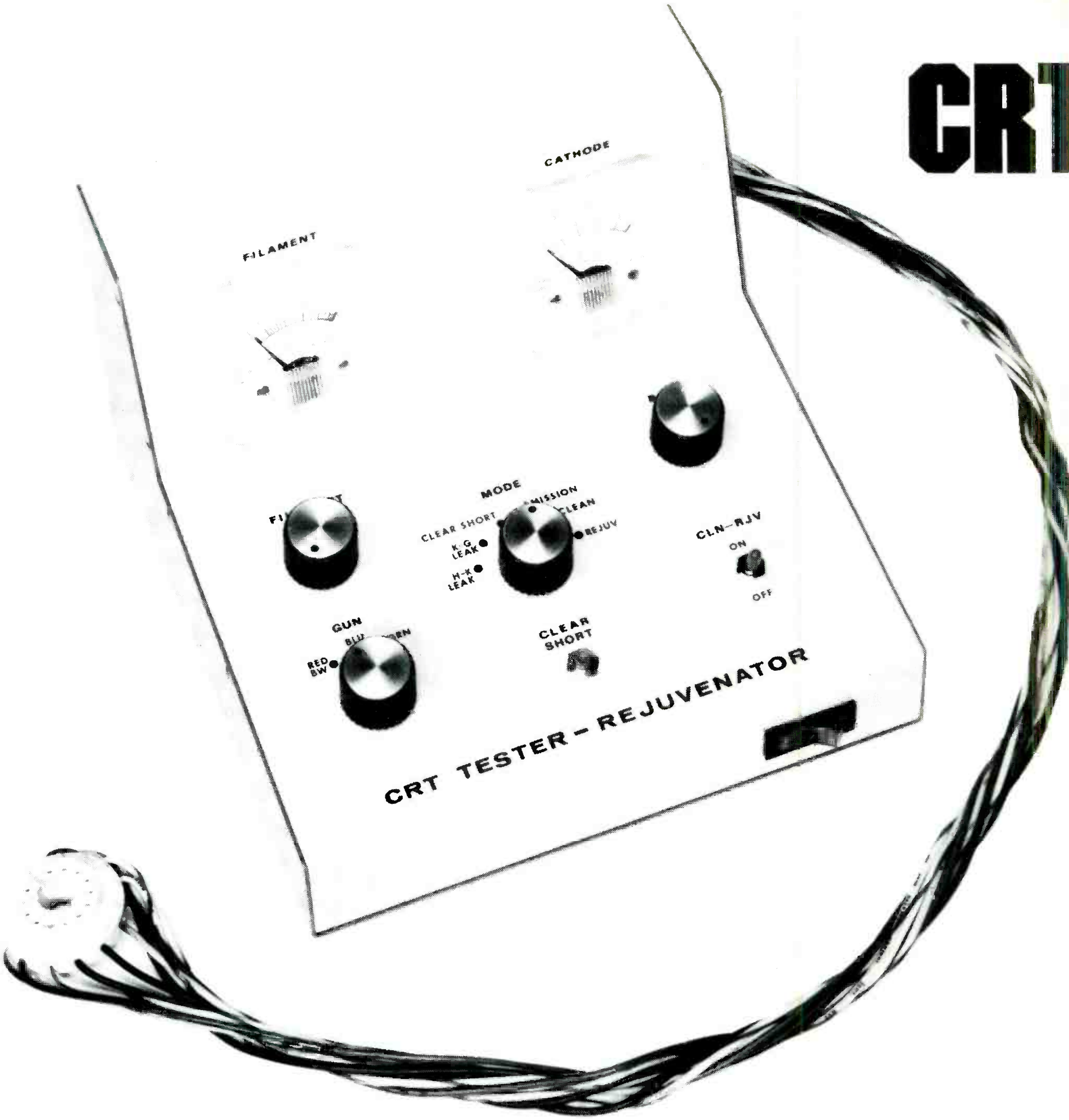
CRT



WHEN A PICTURE TUBE GETS OLD AND TIRED, THE USUAL remedy is to trade it in for a replacement. But you might be able to bring it back to life with a rejuvenator. If you take a few minutes to perform the restoration procedure on the tube, you may well add a year to its life, and save the trouble of installing a new one. In addition to restoring the tube, the rejuvenator shows you the condition of the tube by measuring the emission of each gun, and detecting interelectrode leakage. Shorts will be found and removed in most cases. How does it do all of this? Well, read on, and you'll find a little theory on cathodes and rejuvenators, and construction details for a rejuvenator you can call your own.

The cathode

Electrons emitted by the heated cathode are focused into a beam, accelerated by high voltage, and swept across the phosphor-coated tube face to produce a picture. For good brightness the cathode current must be adequate. The lower the current, the darker the picture. But let's forget about the picture for now, and move back to the neck of the tube and take a closer look at the gun to see how the cathode works, and why it gets weak.

A simplified drawing of a gun is shown in Fig. 1. The grids G1, G2, and G3 are not made of wire mesh as are the grids in regular receiving tubes. Instead,

TESTER-REJUVENATOR

MARVIN SMITH

This handy CRT tester-rejuvinator can save you time and money by extending the life of your television picture tube.

they are short sheet metal cylinders. G1 and G2 have a closed end with a hole (aperture) in the center, while G3 is open on both ends. The cathode K is a small cylindrical sleeve closed on one end, and is heated by the filament F. The effective electron-emitting surface is the end near the G1 aperture. Voltage is applied to G2 to accelerate the electrons from the cathode through the G1 aperture. After the beam passes through G2 it is accelerated again in the fields produced by the voltage on G3 and the high voltage on the second anode A2.

The phenomenon of electron emission from a heated cathode is called thermionic emission. This current is proportional to three things: (1) cathode temperature, (2) accelerating voltage, and (3) cathode efficiency. Although metal is a good choice for a cathode because of its conductivity and durability, it must be operated at very high temperatures since its efficiency is low. In fact, in the first vacuum tubes the filament itself acted as the cathode. Later it was found that coating the metal with an alkaline-earth oxide such as barium oxide increased the efficiency of the cathode. With this coating the cathode could be operated at the familiar cherry-red temperature rather than incandescent white. However, there is one disadvantage to the oxide—it is delicate and susceptible to contamination from residual gas and outgassing of internal parts. This lowers the cathode efficiency and the beam current. Cathode contamination is the major cause of weak picture tubes.

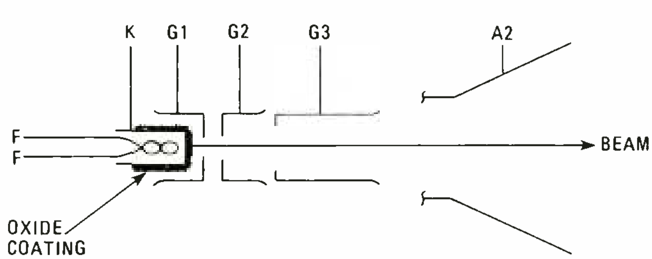


FIG. 1—SIMPLIFIED DRAWING of a picture tube gun. There are three such guns in a color picture tube.

Here is what can be done to increase the beam current:

1. Raise the cathode temperature. A picture tube brightener does this by increasing the filament voltage, but the improvement may not be adequate;

2. Increase the accelerating voltage. This adjustment range, however, is limited, or

3. Make the cathode more efficient. This is what a rejuvenator does by removing the contamination from the cathode.

We've been talking about the cathode as if there were only one. Of course, this is true for a black-and-white tube, but a color tube has a cathode for each of the colors—red, blue, and green. This brings up a subject called tracking. For a good color picture at all levels of brightness, the emissions of the guns should be about equal. Setting a value on how much they can differ is arbitrary, but it has been found that the ratio of the emission of the strongest gun to that of the weakest one should be no more than 1.5.

The rejuvenator

Basically, a rejuvenator applies a voltage between the G1 grid and the cathode, and raises the filament voltage to generate an abnormally high cathode current. This raises the cathode temperature above normal which removes the contamination, leaving the active oxide exposed.

There are two levels of restoration depending on the condition of the tube. The mild type, called cleaning, increases the emission of relatively good cathodes. The object here is to use just enough current to vaporize the contamination. This method will not always improve the emission sufficiently. In these cases the more powerful type of restoration called rejuvenation uses a higher current to boil the coating in an attempt to bring some of the good buried oxide to the surface.

Sometimes the restoration current does not flow when the filament is warmed up and the restoration voltage is applied. It is then necessary to increase the filament voltage to start current flow. Once started, the current will usually increase to the desired value.

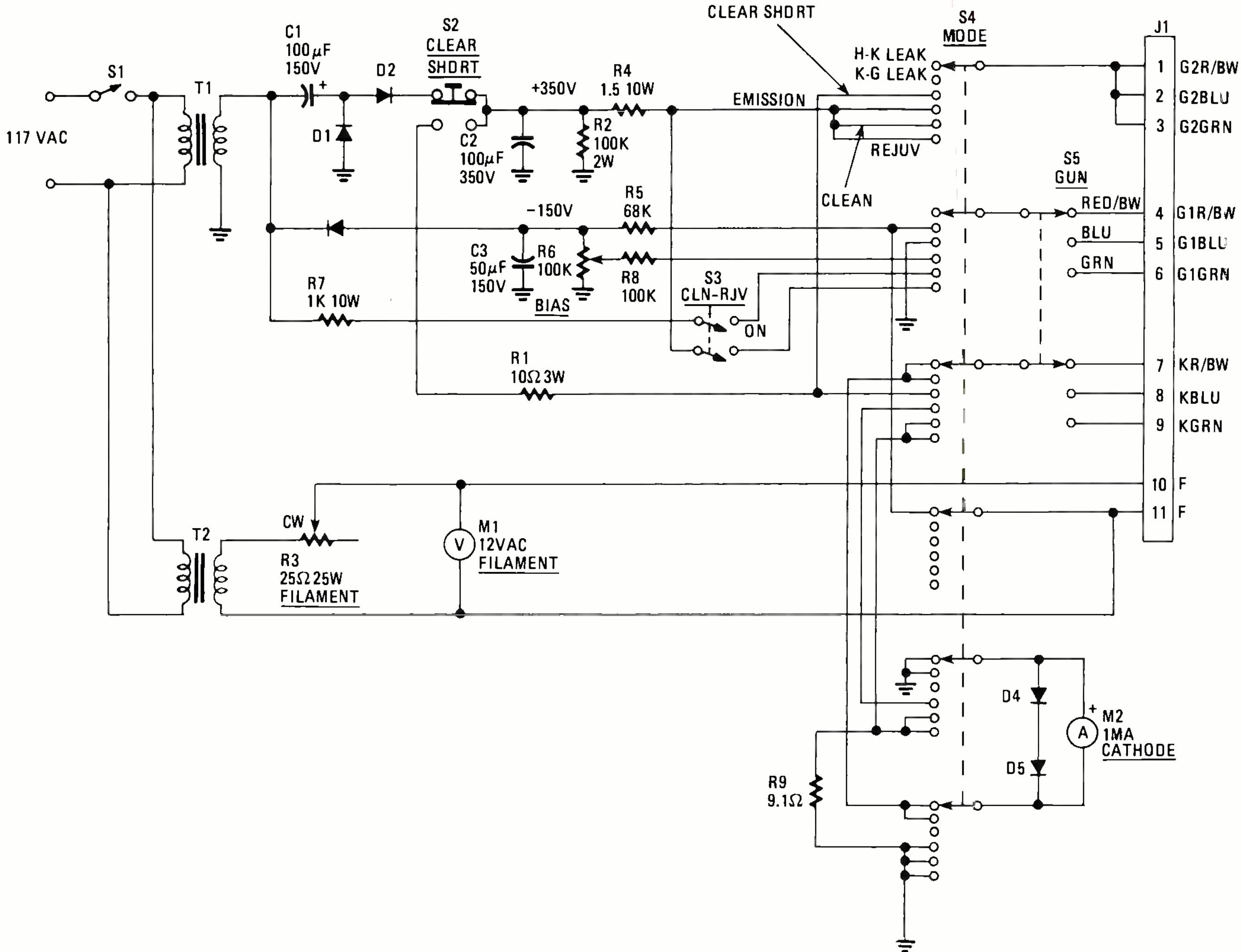


FIG. 2—SCHEMATIC DIAGRAM of the CRT tester-rejuvinator. Switch S4 is a six-pole, six-position miniature rotary switch.

Restoring the cathode is just one of the functions of the rejuvenator. It measures emission and leakage in a manner similar to that of a regular tube checker. The emission test indicates which guns require the restoration procedure. You may wonder at this point what is used as the "plate" for the emission test. The answer is the G2 *grid*, not the A2 anode, because we want to measure the current that passes through the G1 aperture from the cathode; this can be done by applying voltage to the nearest element, the G2 grid.

There are two leakage tests. One measures heater-to-cathode leakage; the other, interelement leakage. If excessive interelement leakage is detected, an attempt to clear away the leakage path is made by applying a charged capacitor between the elements which dislodges pieces of the oxide coating or other debris that bridge the elements.

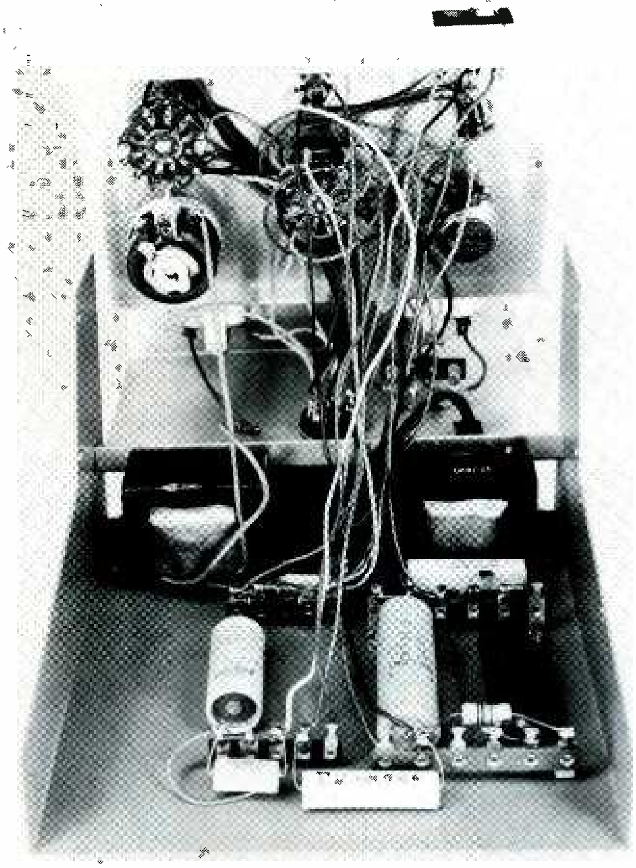
Some precautions

It should be pointed out that the restoration operation is not without its hazards, and in rare cases it may cause permanent damage to the tube. There is always the possibility of damaging the cathodes because of the high currents used. The result is that the emission is lowered, not increased. Some steps in the procedure call for increasing the filament voltage above the rated value. Usually, filaments can take twice the rated voltage for a short time, but they may burn out above the rated value because of manufacturing defects, or just plain old age.

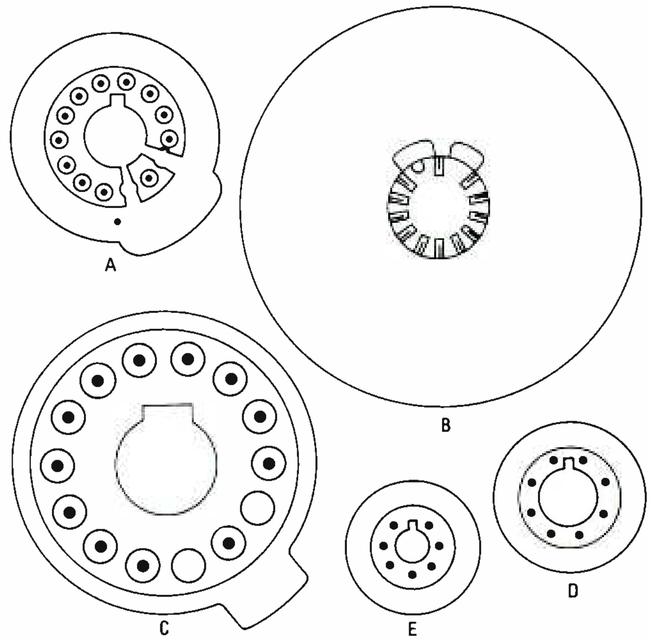
Sometimes poor picture quality is blamed on the picture tube, when the real cause might be low line voltage, or incorrect focus or high voltages. So, before working on the picture tube, it is a good idea to take a few minutes to check these voltages to make sure that the chassis is supplying the correct voltages to the tube.

Let's build one

The schematic for the CRT Tester-Rejuvenator is shown in Fig. 2. The voltage doubler comprised of T1, C1, C2, D1, and D2 produces the 350 VDC required for the emission test and restoration functions. The CLEAR SHORT switch S2 serves a dual purpose determined by its position. Normally, C2 filters the 350 VDC, but when S2 is pressed it acts as a source of stored energy to remove shorts between K and G1, and between G1 and G2. Resistor R1 limits the current when S2 is pressed. Resistor R2 discharges C2 when



INTERIOR VIEW of the CRT tester-rejuvinator. Point-to-point wiring is used throughout.



ADAPTER	TUBE TYPE
A	12-PIN 90 DEG. COLOR TUBE. MOST COMMON SOCKET FOR COLOR TUBES.
B	12-PIN 110/90 DEG. IN-LINE COLOR TUBE. REWORK NEEDED—SEE TEXT.
C	12-PIN 70 DEG. COLOR TUBE. FOR OLD ROUND COLOR TUBES.
D	7-PIN LARGE BW TUBE. MOST COMMON SOCKET FOR LARGER BW TUBES.
E	7-PIN SMALL BW TUBE. MOST COMMON SOCKET FOR SMALLER BW TUBES.

FIG. 3—FIVE most common sockets in use. For other sockets, refer to the set schematic for pin assignments.

PARTS LIST

RESISTORS

All resistors ½ watt, 10% unless noted

R1—10 ohms, 3 watts
R2—100,000 ohms, 2 watts
R3—25-ohm, 25-watt wirewound potentiometer
R4—1,500 ohms, 10 watts
R5—68,000 ohms
R6—100,000-ohm, 2-watt carbon potentiometer
R7—1,000 ohms, 10 watts
R8—100,000 ohms
R9—9.1 ohms

CAPACITORS

C1—100 μF, 150 volts, electrolytic
C2—100 μF, 350 volts, electrolytic
C3—50 μF, 150 volts, electrolytic

DIODES

D1-D5—1N4004

MISCELLANEOUS

S1—SPST toggle switch
S2—SPDT pushbutton switch
S3—SPST miniature toggle switch
S4—6-pole, 6-position miniature rotary switch (Centralab PSA-223)
S5—2-pole, 3-position rotary switch
M1—0-15 volts ac meter (Emico 6337)
M2—0-1 milliampere dc meter (Emico 2320)
T1—15 VA isolation transformer (Triad N-48X)
T2—12.6-volt, 2-amp. transformer (Triad F-44X)
J1—11-pin octal type relay socket
Knobs, line cord, case (LMB MDDC 885), hardware.

the power is removed to eliminate shock hazards when the adapter cable is disconnected from the picture tube. Restoration currents are limited by R4 and R7 to minimize damage to the gun. The negative voltage required for grid bias and the leakage tests is produced by D3 and C3.

The variable filament supply is comprised of 12.6-volt transformer T2 and FILAMENT potentiometer R3. FILAMENT meter M1 indicates the voltage applied across the filament. If the filament is open, or if no tube is connected, M1 will indicate 12.6 VAC regardless of the FILAMENT control setting because R3 is connected in series with T2.

CATHODE meter M2 has two ranges depending on the setting of the MODE switch S4. When reading leakage or emission, the full scale indication is 1 mA, but when the MODE switch is in the CLEAN or REJUV positions, full scale is 100 mA since the meter is then shunted by R9. Diodes D4 and D5 protect M2 against excessive current when the emission is high, or if there is a short in the tube. Resistor R5 limits the current through M2 when measuring leakage.

Resistor R8 limits the current through BIAS potentiometer R6 if there is a cathode-to-grid short. Restoration voltages are applied by the CLN-RJV switch S3. The GUN switch S5 selects the red, blue, or green gun. For black-and-white tubes the GUN switch is set to RED-BW. The MODE switch S4 selects the functions in the sequence they should be performed.

Since there are many types of picture tube sockets, the rejuvenator uses adapter cables that have a tube socket on one end and a plug P1 on the other that connects to the output connector J1, a round 11-pin relay socket. Figure 3 illustrates the five most common sockets in use. The wiring chart for the adapter cables is shown in Fig. 4. Cables with the tube socket on one end are available as replacement items at electronic stores. If the picture tube requires a socket other than those shown, refer to the set schematic or a tube manual for pin assignments. Then connect the adapter cable leads to the corresponding P1 pins using the first two columns of Fig. 4. In all cases, though, always check the pin assignments even though the socket in the set looks like one of those shown since the same socket will fit other tube types with different internal connections. The socket for adapter B must be reworked because it is made with 1K current-limiting resistors. Carefully open the socket, and install jumpers across the resistors, then reassemble.

P1 PINS	GUN ELEMENT	PICTURE TUBE SOCKET PINS A	B	C	D	E
1	G2 RED/BW	4	10	3	3	6
2	G2 BLU	13	5	11	-	-
3	G2 GRN	5	11	7	-	-
4	G1 RED/BW	3	9	2	2	1
5	G1 BLU	12	4	12	-	-
6	G1 GRN	7	13	6	-	-
7	K RED/BW	2	8	4	7	2
8	K BLU	11	3	13	-	-
9	K GRN	6	12	5	-	-
10	HEATER	1	6	1	1	3
11	HEATER	14	7	14	8	4

FIG. 4—ADAPTER WIRING CHART

Let's try it

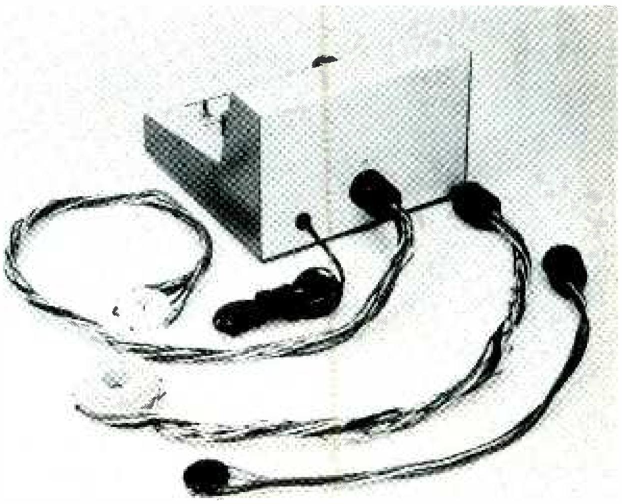
This procedure for using the CRT Tester-Rejuvenator is written for color picture tubes that have 6.3-volt filaments. If your picture tube uses a different filament voltage, adjust the FILAMENT control for the rated voltage. For black-and-white tubes, set the GUN switch to RED-BW, and disregard all other references to the GUN switch.

PREPARATION

1. **Turn off the TV** set and the Tester.
2. **Unplug the TV** set from the ac outlet.
3. **Remove the back cover** from the TV set.
4. **Discharge the second anode** on the bell of the picture tube with a screwdriver connected by a test lead to the chassis near the high voltage cage. Be sure to connect the chassis end first. This step is important for safety and accurate emission measurements.
5. **Remove the socket** from the picture tube.
6. **Connect the appropriate adapter cable** between the Tester and the picture tube.
7. **Plug the Tester line cord** into an AC outlet.
8. **Set the controls** as follows:
   FILAMENT fully ccw
   GUN to RED-BW
   MODE to H-K LEAK
   BIAS fully cw
   CLN-RJV to OFF
9. **Turn on the Tester.**

TRACKING

1. **Set the MODE** switch to EMISSION.
2. **Set the FILAMENT control** for 6.3 volts.
3. **Set the GUN switch** alternately to RED-BW, BLU, and GRN. Adjust the BIAS control until the CATHODE meter indicates 1.0 (full scale) for the strongest gun. Set the GUN switch to the other guns. The CATHODE meter should indicate more than 0.7. If it does, the tracking is acceptable. If it does not, the ratios of the emissions is greater than the tracking limit of 1.5. In this case, perform step 4 below.
4. **Attempt to make the tracking ratios** less than 1.5 by performing the "Cleaning" and, if necessary, the "Rejuvenation" procedures on the guns that indicated less than 0.7.



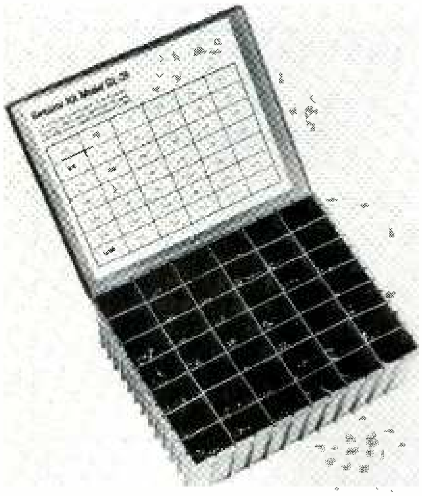
TUBE SOCKET and cable assembly is connected to the rear of the CRT tester-rejuninator through connector J1.

LEAKAGE-SHORTS

1. **Set the MODE switch to H-K LEAK** to measure filament-to-cathode leakage.
2. **Set the FILAMENT control for 6.3 volts** on the FILAMENT meter.
3. **The CATHODE meter should indicate** less than 0.1 mA for all positions of the GUN switch. If more, there is excessive filament-to-cathode leakage, but this cannot be corrected by the Tester since there is physical contact between the filament and cathode caused by insulation breakdown. All is not lost, though. You could try a tube brightener since it has a transformer which will isolate the filament.
4. **Set the MODE switch to K-G LEAK** to measure cathode-to-G1 and G1-to-G2 leakage.
5. **The CATHODE meter should indicate** less than 0.1 mA for all positions of the GUN switch. If more, there is a path caused most likely by flaking of the cathode oxide. Attempt to dislodge the debris by setting the MODE switch to CLEAR SHORT, and pressing and releasing the CLEAR SHORT pushbutton. A flash in the neck of the tube indicates that the short has been removed. If no flash is seen, repeatedly press and release the CLEAR SHORT pushbutton in an attempt to produce an arc through the leakage path. Set the MODE switch to K-G LEAK to see if the CATHODE meter now indicates less than 0.1 mA. If not, repeat this step. It may happen that you will have no success in removing a short because some shorts are mechanical in nature, and cannot be corrected.

EMISSION-CLEANING-REJUVENATION

1. **Set the MODE switch** to EMISSION.
2. **Set the BIAS control** fully clockwise.
3. **Set the FILAMENT control** for 6.3 volts on the FILAMENT meter. Allow 30 seconds for warmup.
4. **The CATHODE meter should indicate** more than 0.8 mA for all positions of the GUN switch. Guns with high emission will peg the meter, but the movement will not be damaged. Record the meter readings for the guns that indicate less than 0.8 mA for reference later.
5. ***Cleaning.* Try to restore the emission** of weak guns by first using the "cleaning" type of restoration. Set the MODE switch to CLEAN. Select the desired gun with the GUN switch. Set the CLN-RJV switch to ON. The CATHODE meter should gradually increase to about 30 mA (remember, full scale is 100 mA when the MODE switch is in CLEAN or REJUV). If the meter indicates little or no current, increase the setting of the FILAMENT control, but do not exceed twice the rated voltage. Set the CLN-RJV switch to OFF when the current has been at 30 mA for 10 seconds.
6. **Set the FILAMENT control for 6.3 volts** if it was increased in the previous step, and wait 30 seconds for the filament temperature to stabilize.
7. **Recheck the emission in each gun** that was cleaned. Set the MODE switch to EMISSION, and see if the CATHODE meter now indicates more than 0.8 mA. If it does, the gun has been restored; go to step 10. If it does not, but is more than what you recorded in step 4, go on to step 8. However, if the emission is now less than what you recorded, do not perform step 8 as the rejuvenation procedure may further degrade the emission; instead, go to step 10.
8. ***Rejuvenation.* If the emission is still below 0.8 mA,** the cathode requires the "rejuvenation" type of restoration. Set the MODE switch to REJUV. Select the desired gun with the GUN switch. Set the CLN-RJV switch to ON. The CATHODE meter should increase to full scale. Increase the FILAMENT control, if necessary. After the meter has indicated full scale for 5 seconds, set the CLN-RJV switch to OFF. Wait 5 seconds, then set the CLN-RJV switch to ON for 5 seconds, then OFF. Wait another 5 seconds, then set the CLN-RJV switch to ON for 5 seconds, then OFF.
9. **Recheck the emission of each gun** that was rejuvenated. Set the MODE switch to EMISSION, and see if the CATHODE meter indicates more than 0.8 mA. If it does, the gun has been restored. If it does not, the gun is so weak that it cannot be restored. One last resort for weak tubes is to try a picture tube brightener if one is made for your particular tube type.
10. **Now go back and rerun the Leakage-Shorts test** to make sure the restoration procedure did not create any leakage paths.
11. **Set the BIAS control** fully counterclockwise. The CATHODE meter should indicate 0 mA for all positions of the GUN switch. Any reading indicates that the tube is gassy or has an enlarged G1 aperture; these conditions cannot be corrected. **SP**



RESISTOR ORGANIZER, *model GL-25* Econo-Pak, contains 840 top quality ¼-watt resisters in 42 of the most commonly used resistance values for the home hobbyist as well as for the shop and factory repairman. Each resistor value is prepackaged in its individual compartment, thus assuring fast and accurate selection of any desired value. The compact Econo-Pak Resistor Organizer, *model GL-25,* measures 7½ × 6⅛ × 3 inches and is priced at $29.95, FOB, Factory.—**Century Electronics Corporation,** 3511 N. Cicero Ave., Chicago, IL 60641.

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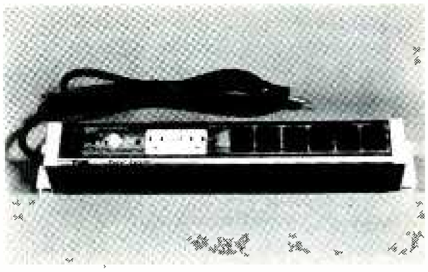
INDUSTRIAL TEST-INSTRUMENT CATALOG, *BK-181,* from B&K Precision, has 44 pages, featuring more than 50 instruments. There is a broad range of high-quality test instruments for engineering, production line, MRO, and other industrial applications.

New products listed include a 100-MHz quadruple trace scope; a portable, dual-trace mini-scope; an autoranging microcomputer-controlled DMM; autoranging capacitance meters; a bench-top DMM, and new 30-MHz scopes. Catalog *BK-181* is available free upon request.—**B&K Precision,** Dynascan Corporation, 6460 W. Cortland St., Chicago, IL 60635.

FOR MORE INFO CIRCLE 431 ON FREE INFORMATION CARD



MULTIPLE-OUTLET BOX, the *Power Console,* features a built-in General Electric ground fault interrupter; it is intended for use with equipment, instruments, or tools in areas where there is shock potential, such as wet labs, instrument and equipment repair shops, home workshops, or any others where shock protection is needed.

The unit features 8 three-wire outlets, 6-foot three-wire heavy-duty line cord, main ON-OFF switch and indicator light, and a 15-amp resettable circuit breaker. The ground fault interrupter is wired to all eight outlets and trips instantaneously at 5 milliamps (±1) to ground. The interrupter has built-in TEST and RESET buttons and comes with instructions for use and test recording. The *Power Console* is made of walnut vinyl-covered steel and black aluminum and weighs 2½ lbs; dimensions are 16 × 2¼ × 2½ inches. All components are UL-listed.

The *Power Console* is priced at $109.50—**PMC Industries,** 1043 Santa Florencia, Solana Beach, CA 92075.

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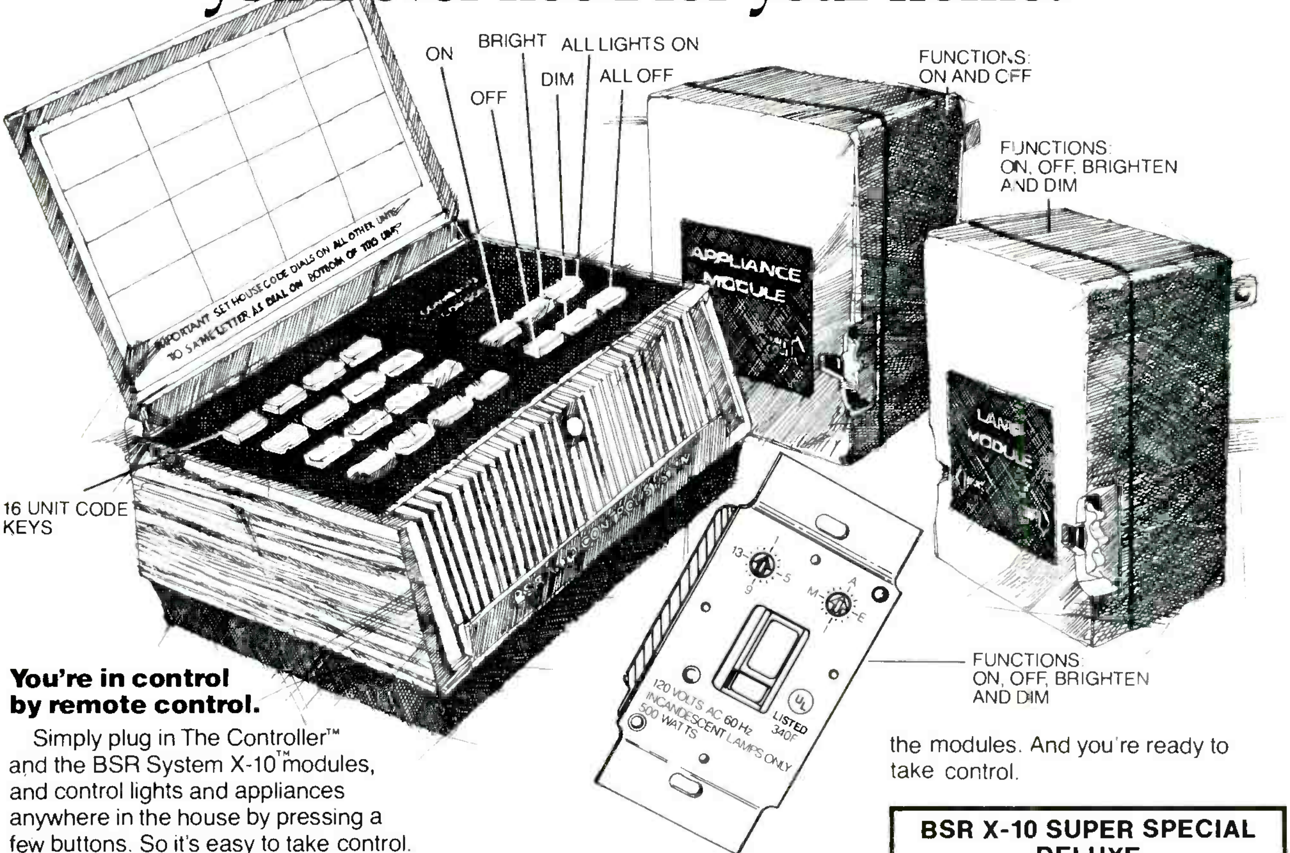
An in-depth look at the only "plug-in" remote control system you'll ever need for your home.



You're in control by remote control.

Simply plug in The Controller™ and the BSR System X-10™ modules, and control lights and appliances anywhere in the house by pressing a few buttons. So it's easy to take control.

There's no end to all of the control you've got.

You can turn on the TV, radio or stereo in the morning to help you wake up without getting up from bed. Or at night, turn on the lights before going downstairs so you don't have to fumble in the dark. Turn off unnecessary lights and help get your electric bill under control. Or, dim the lights and save energy, too.

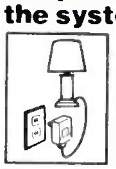
And when it's time to turn in, just push a button and turn everything off. And sleep soundly. But, if you hear a strange noise in the middle of the night, you can press a button to turn on all the lights and scare the daylights out of an intruder.

The Controller is designed to control every room in the house.

By pressing the buttons on the Command Console keyboard, command signals are transmitted over existing household wiring to the module of your choice. The Lamp Module turns on, off or dims any incandescent lamp up to 300 watts. The Appliance Module turns appliances like TVs, window fans or stereos on and off. And the Wall Switch Module is designed to turn on, off or dim any light or lamp up to 500 watts normally operated by a wall switch.

There's even a Cordless Controller that transmits signals to an Ultrasonic Command Console from up to 30 feet away. So there's plenty of control for everyone.

Simplicity is built into the system.



No special wiring is needed. Simply plug The Controller Command Console into any wall outlet in any room of the house. Then plug your lamps and appliances into the appropriate modules. Plug in the modules. And you're ready to take control.

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MARTIN BRADLEY WEINSTEIN

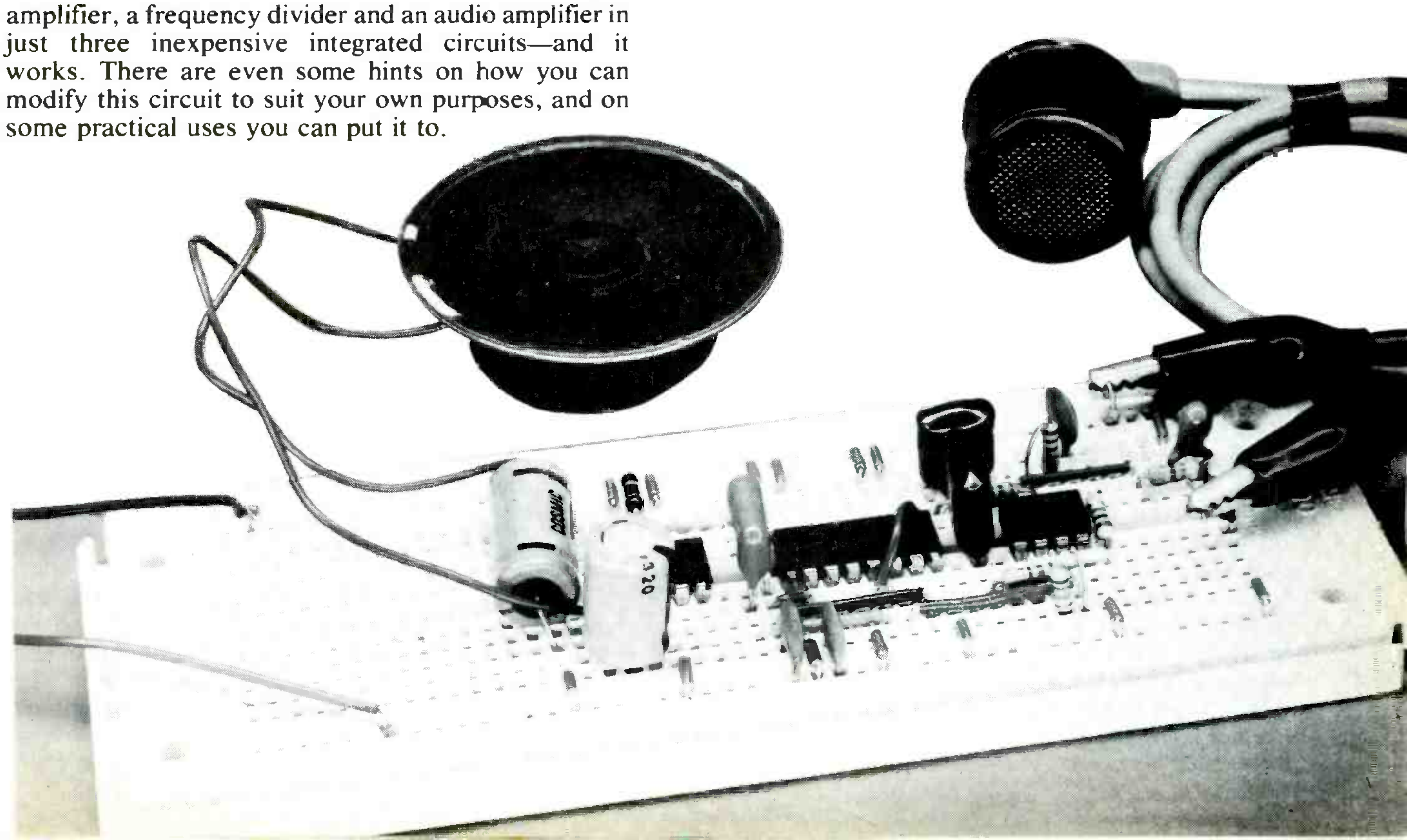
YOU'VE SEEN THEM ADVERTISED IN THE SURPLUS AND parts catalogs: ultrasonic transducers, originally designed for burglar alarms. But unless you were planning on building an ultrasonic burglar alarm of your own, why get one?

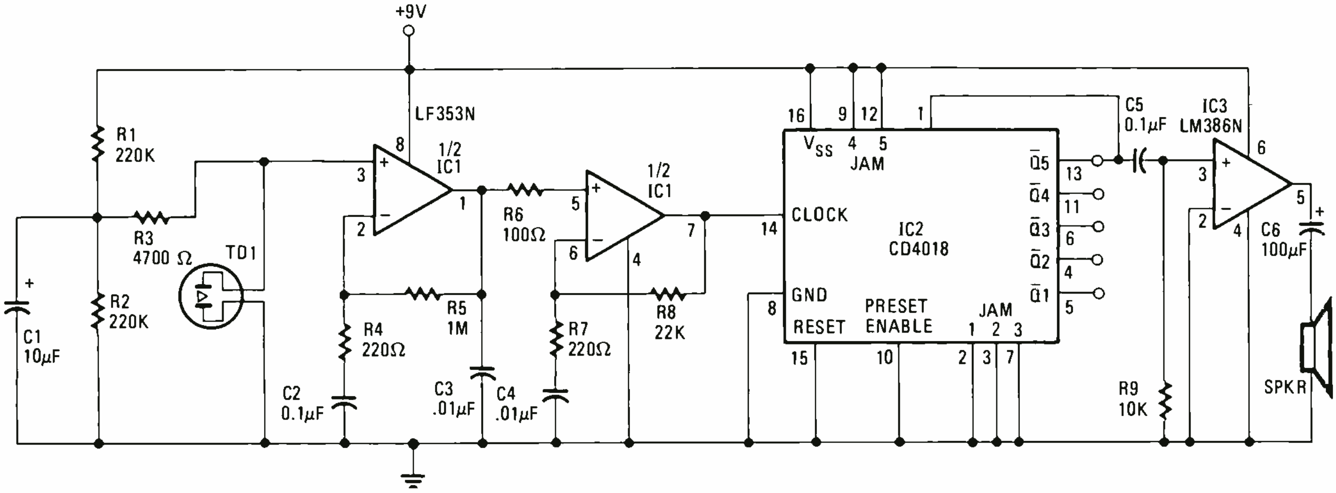
Why not! Because there are lots of signals and squeaks and squawks beyond the range of human hearing that make for interesting—and useful—listening. With this simple circuit, you can bring the ultrasonics down to frequencies you can hear. The circuit shown can hear well above 100 kHz (and so can you!), and you can follow its lead to develop your own circuit to listen in on even higher frequencies.

This Ultrasonic Listener includes a sensitive preamplifier, a frequency divider and an audio amplifier in just three inexpensive integrated circuits—and it works. There are even some hints on how you can modify this circuit to suit your own purposes, and on some practical uses you can put it to.

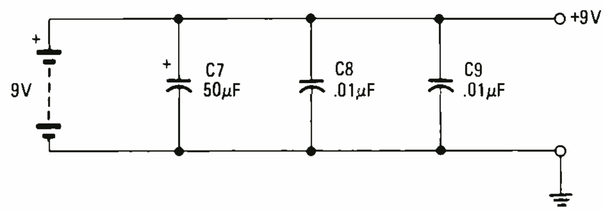
How it works

TD1 is an ultrasonic transducer. The one shown is Massa MK-109, one of the most available surplus piezoelectric ultrasonic transducers, but by no means the only one that will work here. Indeed, both the Massa Division Dynamics Corporation of America and Linden Laboratories, two of the one-time leaders in the manufacture of these devices, have since gone out of business. Still, these are the transducers you will most often see advertised at bargain prices in the fliers. This particular one has a peak response near 40 kHz, but in the circuit shown performs reasonably well from





TO DIVIDE INPUT BY	CONNECT DATA TO
10	$\overline{Q}5$
8	$\overline{Q}4$
6	$\overline{Q}3$
4	$\overline{Q}2$
2	$\overline{Q}1$



SCHEMATIC DIAGRAM of the ultrasonic listener. Transducer TD1 should be connected to the device using coaxial cable.

35 to 45 kHz and demonstrates some sensitivity beyond this range. The frequency limitations of your transducer are by far the largest limiting factor in determining the bandwidth of your listener, and other transducers near 23 kHz, 100 kHz or the high audio range all work well, producing interesting results.

IC1 is a National Semiconductor LF353N dual JFET-input op amp, which performs as a sensitive high gain preamplifier and a lower gain buffer amplifier. IC2 is a CD4018B presettable divide-by-N counter; we've disabled the presettable feature and configured it as a decade divider—you'll see how to make it divide by 2, 4, 6 or 8 intead with just the change of a jumper in just a bit. IC3 is an LM386N audio amplifier IC, which boosts the output to adequate speaker-driving power levels with a minimum of parts.

R1 and R2 provide a center reference for the input signal and permit single supply operation of the op amp. R3 provides the proper load for the transducer against this center reference. The first stage of IC1 yields a gain of 73 dB, the second stage an additional 40 dB. The signal then goes to the clock input of IC2.

IC2, as we've said, performs as a decade divider because we've fed the $\overline{Q}5$ (pin 13) output back to the *data* input. If we pesent the *data* input with the output of $\overline{Q}4$ instead, IC2 divides by 8 instead of 10; similarly, Q3 prompts a divide by 6, $\overline{Q}2$ a divide by 4 and $\overline{Q}1$ a divide by 2. Each time you cut the division factor in half, the output sound goes up an octave in pitch. A 40-kHz tone, for example, comes out at 4 kHz following a divide by 10, 5 kHz if divided by 8, 6.67 kHz if divided by 6, 10 kHz if divided by 4 and 20 kHz if divided by 2.

The *jam* inputs are tied to convenient power buses and the *preset enable* is disabled by tying it low, since we're not using the *presettable* features of this IC. The *reset* input is also disabled by tying it low.

The frequency-divided output of IC2 is coupled through C5 to the input of IC3, which provides a gain of 20 and about half a Watt of drive for the speaker.

C7, C8 and C9 are included as bypass and ballast filters to keep switching transients from wreaking havoc with the circuit.

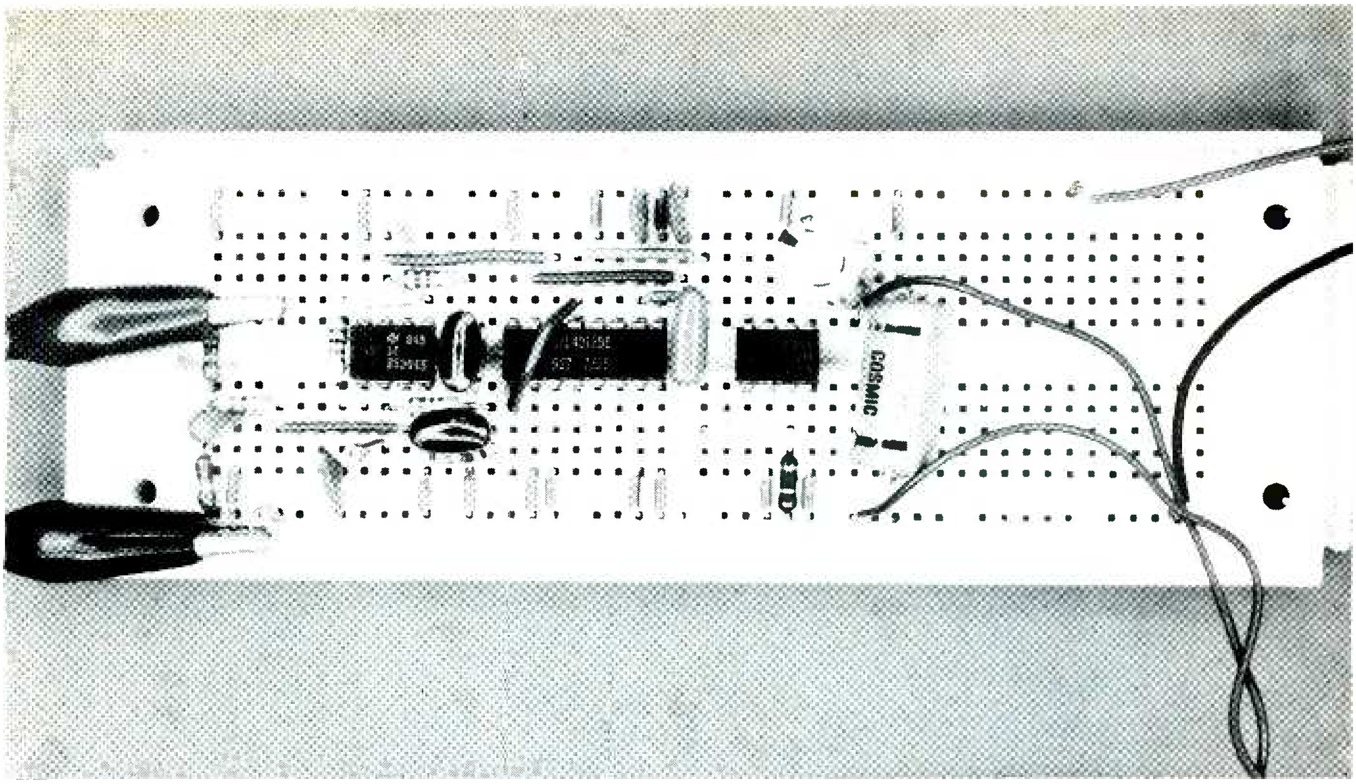
Checking it out

One of the difficulties involved in building a circuit that listens in on the ultrasonics is that you can't hear them yourself; so when it doesn't hear anything, it may be because it isn't working properly, or it may be because there's nothing there to hear. Fortunately, we can cheat as a starter, then double check with a "50¢ Special" ultrasonic generator.

An audio tone generator (you could even use the signal from a transistor radio or cassette player) should generate a tone when connected between ground and pin 3 of IC3. Moving it to pin 14 should dramatically alter the pitch of the signal, dropping it by 3⅓ octaves and "fuzzing" it up a bit (due to the hard, fast switching of the CMOS logic); if the audio isn't at a lower pitch, double check the wiring of the divider.

Next check at pin 5 of IC1 (you may want to drop the level of your signal source in this and the next step) to make sure this amplifier is working and you've connected it properly. Finally, do the same with the source at pin 3 of IC1—the connection point for your transducer.

These transducers are capacitive in nature, and should be connected into the circuit through coaxial cable; a phone plug termination will mate with most transducers directly, but don't push them in all the way or you may damage the transducer's electrostatic element (these devices have been designed for use



ANY CONSTRUCTION technique can be used to build the ultrasonic listener as the layout is not critical.

with short-tip phono plugs).

Now, with everything connected (and your signal source put away), it's time for our "cheat test". If you've ever worked extensively with sensitive receivers (especially the older vacuum tube versions) or high gain amplifiers, you may be familiar with the phenomenon of *microphonics,* which is a usually undesired coupling of mechanical vibration into the signal chain of the device. With microphonics, scratching or banging on a tube or chassis surface or control shaft can be heard through the speaker output of the receiver or amplifier.

Luckily for our purposes here, piezoelectric transducers are prone to microphonics. Scratching, tapping or banging on their housings creates a noise (electrically) that you can hear at the output of our Ultransonic Listener, 3⅓ octaves lower than the noise you actually make. Try it.

Now it's time to try our "50¢ Special" ultrasonic generator, which is guaranteed to cost you exactly that, no matter what the state of the economy or inflation. All you need is two quarters.

Set the Ultrasonic listener on a hard surface, like a kitchen tabletop or hard floor, and set the transducer down near a small, clear area. Place one of the quarters near the transducer, and drop the other quarter onto the first. In "live" audio, you'll hear two quarters clinking; this clinking also produces some ultrasonic ringing, which you'll hear coming out of the speaker of your Ultrasonic Listener. The sound of two quarters clinking, as you'll hear it coming out of the speaker, is more like the sound of two silver dollars clinking—and no matter how much the dollar is worth that's one of today's biggest bargains, a four-to-one return on your investment.

Applications and other ideas

If you're like me, the first thing you're going to do with your ultrasonic listener is to poke around the house, seeing what does and doesn't generate transcendearful vibrations. You'll learn that no matter how hard you try, you can't whistle that high; but if you make a "kissing sound" (keeping you lips together while energetically pulling in air), you'll find it does reach high into the ultrasonic region.

Many motors generate ultrasonics, especially those with bad bearings (which makes this a great technique for getting an early warning of worn bearings). Squeaky hinges—especially on metal-to-metal contacting surfaces, like oven doors—can reach into this frequency territory, again providing an early warning of a need for lubrication.

A number of electronic devices generate ultrasonics, including remote controls (with some, you can play an unhearable concerto, and hear it with your Ultrasonic Listener) and alarm systems. This is a great way to double check their operation.

If you use one of the lower frequency transducers—23 kHz, for example—you can listen to the oscillators squeaking and squawking in your tv set (thanks to a phenomenon called *singing*).

There are interesting sounds under the hood of your car, too, including belts and bearings squeaking and squealing, fluids hissing and air whistling. You can also take advantage of the transducer's susceptibility to microphonics to listen in on the internal action by pressing it against selected engine parts.

The other things you hear in this range of the unheard are as surprising to you as any new sense might be. Build and enjoy—there's no telling what uses you can put an Ultransonic Listener to. **SP**

Mark C. Worley

THIS FREQUENCY MULTIPLIER WILL MULTIPLY INPUT FRE- quencies within its range by 10 or 100 and add an equivalent amount of resolution to your frequency counter. It can also be used to count frequencies to within 0.01 Hz with only a 1 second count period.

Communications technicians and hams who use CTCSS (tone coded squelch) or other tone signalling methods will find this instrument invaluable for measuring and adjusting those tones with ease. Frequency counters with a low cutoff frequency of 50 or 100 Hz can now have that range extended down to 2 Hz. Additionally, anyone who has taken several minutes while adjusting an audio generator to a precise frequency can now make those adjustments in about one-tenth the time.

Its low-power CMOS circuitry, small size and 9-volt battery operation make the instrument ideally suited for portable or bench-top use. The easy construction and low cost should help fit it into your test equipment budget.

About the circuit

Let's first go to the heart of the circuit, IC2, the 4046 phase-locked-loop (PLL). See Fig. 1. The PLL contains two comparators and a voltage-controlled oscillator (VCO). In this application phase comparator 2 is used since it is a positive edge-triggered circuit that makes it immune to duty-cycle variations. Also it will not lock onto harmonics of the input signal as will phase comparator 1.

Refer to the block diagram. The circuit is in lock when the two input signals on pins 3 and 14 are the same frequency and phase. Any error between the two signals causes the error output voltage of the phase comparator to shift in a directon that will force the VCO to be in step with the frequency on pin 14 of the IC. The filter between the comparator and the VCO removes the AC component in the error voltage to prevent noise in the VCO output. (**Note:** Only tantalum capacitors are used in the filter due to their low leakage current in this high impedance curcuit.)

A selectable divide by 10 or 100 is connected between the VCO output and the comparator input. This forces the VCO to oscillate at an exact multiple of 10 or 100 times the input frequency before the two signals will lock and be equal. Therefore the output of the VCO is equal to the input frequency times 10 or 100. In the ×10 mode, an input frequency of 100 Hz will cause the VCO to oscillate at 1000 Hz due to the divide by 10 in the feedback loop. When this 1000 Hz signal is divided by 10 in IC3 and applied to pin 3 or IC2, the two frequencies at the comparator input will be equal and in phase even though the VCO outputs is 10 times the fundamental input frequency of 100 Hz.

The VCO frequency limits are set by resistors R9, R10 and capacitor C4 (See Fig. 2). With these values, the VCO range is about 200 Hz to 20 KHz. This results in a lock range of 20 Hz to 2 Hz in the ×10 mode. The ×100 lock range is from 2 Hz to 200 Hz. Phase jitter than 2 Hz.

BUILD A FREQUENCY MULTIPLIER

This easy to build, low-cost frequency multiplier is suitable for portable or bench use.

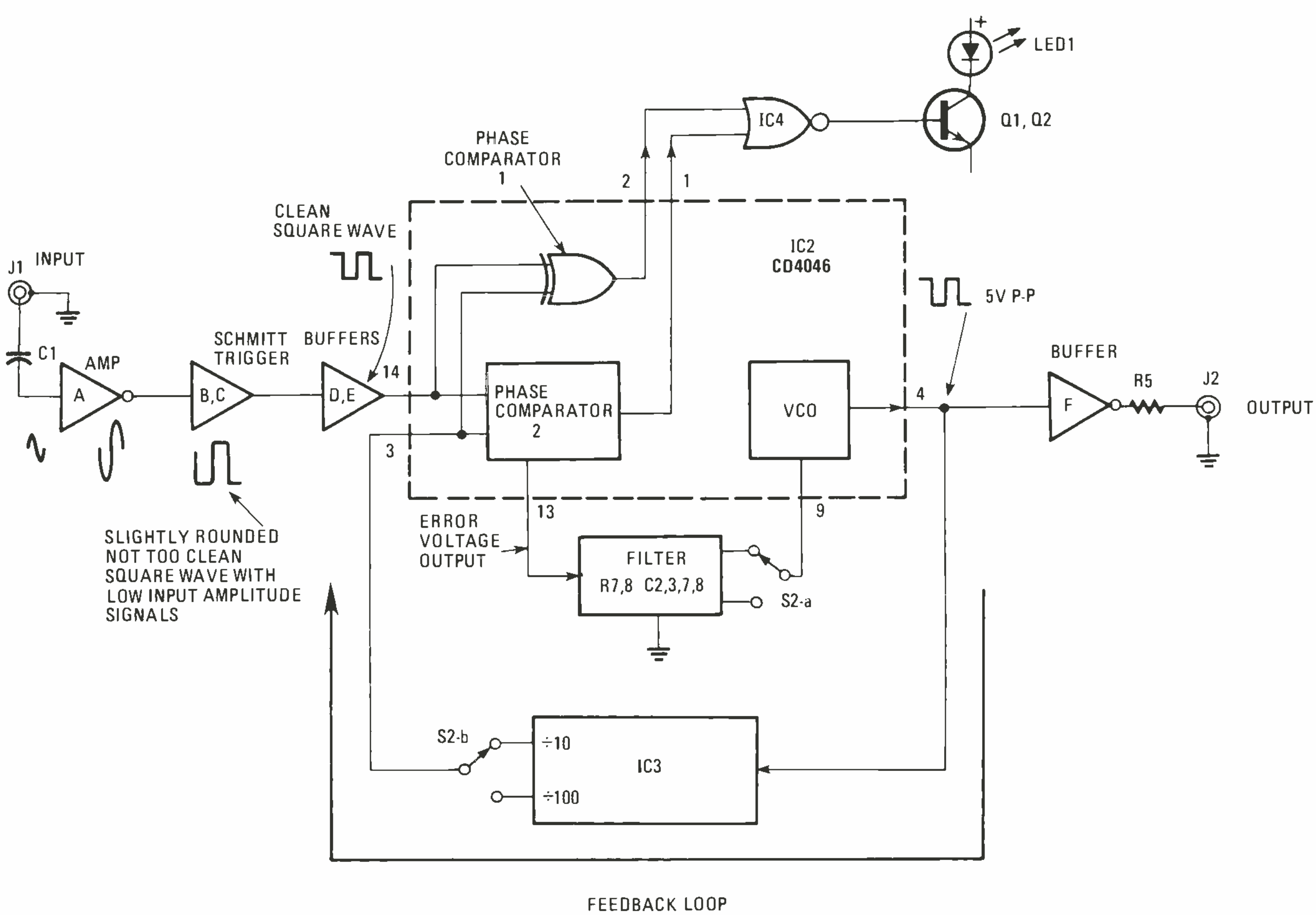


FIG. 1—BLOCK DIAGRAM of the frequency multiplier. The phase-locked-loop (PLL) uses two comparators.

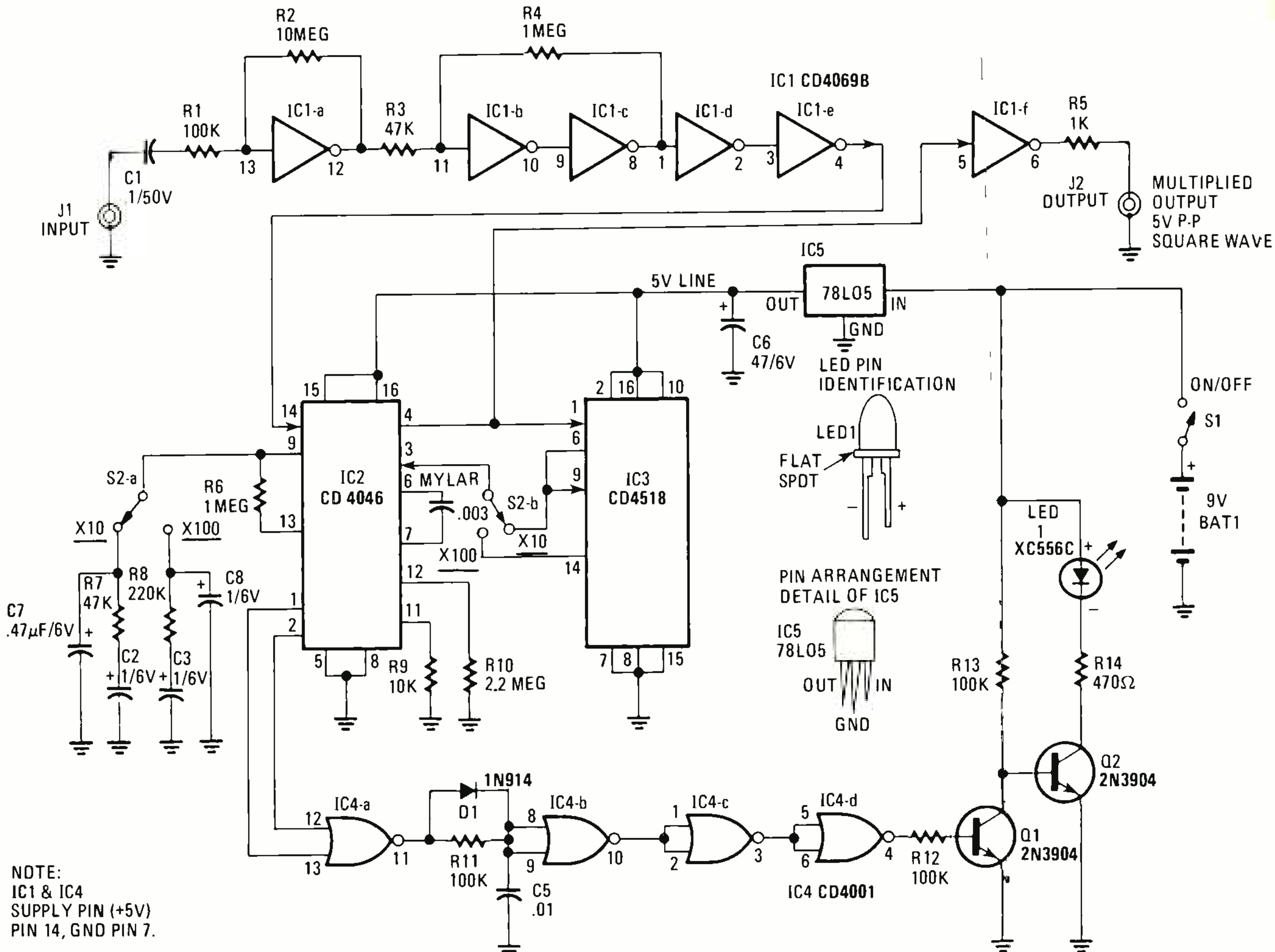


FIG. 2—FREQUENCY LIMITS for the voltage-controlled oscillator (IC2) are set by resistors R9 and R10, and capacitor C4.

The rest of the circuit is straightforward although possibly unique to some of you. The CMOS hex inverter, IC1 has several functions. IC1-a is used as a preamp, a Schmitt trigger is formed from inverters IC1-b and IC1-c. Sections IC1-d, -e and -f are buffers.

Resistor R2 biases inverter IC1-a into its linear range and allows it to amplify the input signal coupled through capacitor C1. Since a single inverter is used, there is negative feedback to the input similar to an op-amp circuit, but with lower gain. The Schmitt trigger two inverters, IC1-b and -c with resistor R4 for positive feedback. The ratio of resistors R3 and R4 sets the trip points of the Schmitt trigger to a very sensitive level so that a small input signal will result in a large squarewave output. Inverters IC1-d and IC1-e additionally shape and clean the squarewave applied to the PLL. Inverter IC1-f buffers the output and isolates the VCO from the output jack, J2. Resistor R5 is a current limiter for protection against output shorts to ground. Note that only "B" series 4069 inverters should be used since they have higher internal gain that allows them to be used as amplifiers.

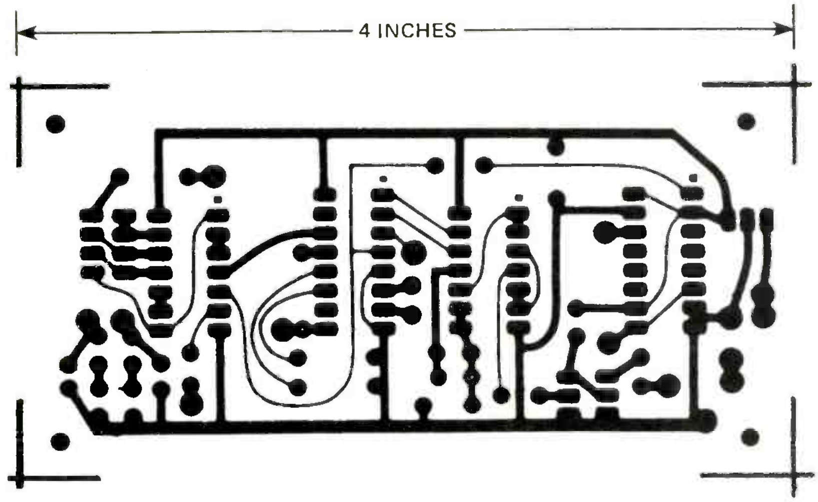
The four 2-input NOR gates in IC4 form an out-of-lock indicator by comparing the phase pulses of comparators 1 and 2. Transistors Q1 and Q2 act as a level shifter and current drive for LED1. The LED is connected to the battery side of the circuit to prevent current surges in the 5-volt supply line.

Integrated circuit IC5 regulates the supply voltage for the four IC's. CMOS IC's can operate with supply voltages from 3 to 15 volts and require less regulation than do TTL IC's, however the VCO in IC2 is affected by supply variations and requires a steady supply voltage. A Zener diode could have been used to regulate the 5-volt supply at the cost of additional current drain and poorer regulation.

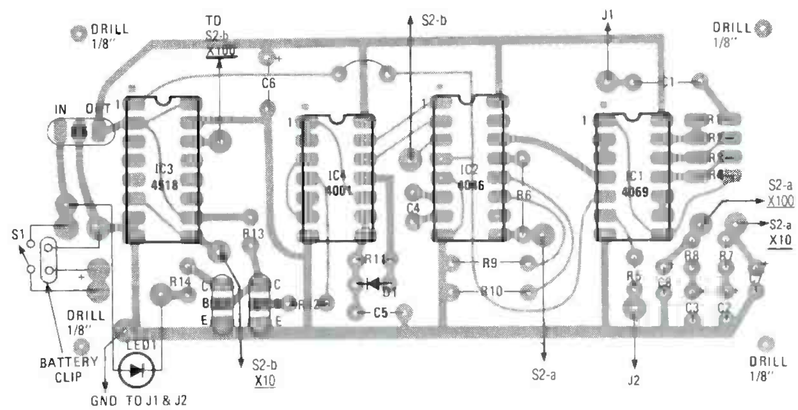
The input sensitivity of the frequency multiplier is 50 mV P-P with any waveform over the entire operating range. Typical current drain while locked to an input frequency of 500 Hz in the ×10 mode is 4.5 mA. The unlocked current drain rises to 20 mA due to the current through LED1. The maximum input amplitude should be limited to less than 50 volts P-P. Lock-time varies from a few milliseconds at high frequencies to over two seconds at the lower limit frequencies in the ×100 mode.

Circuit assembly

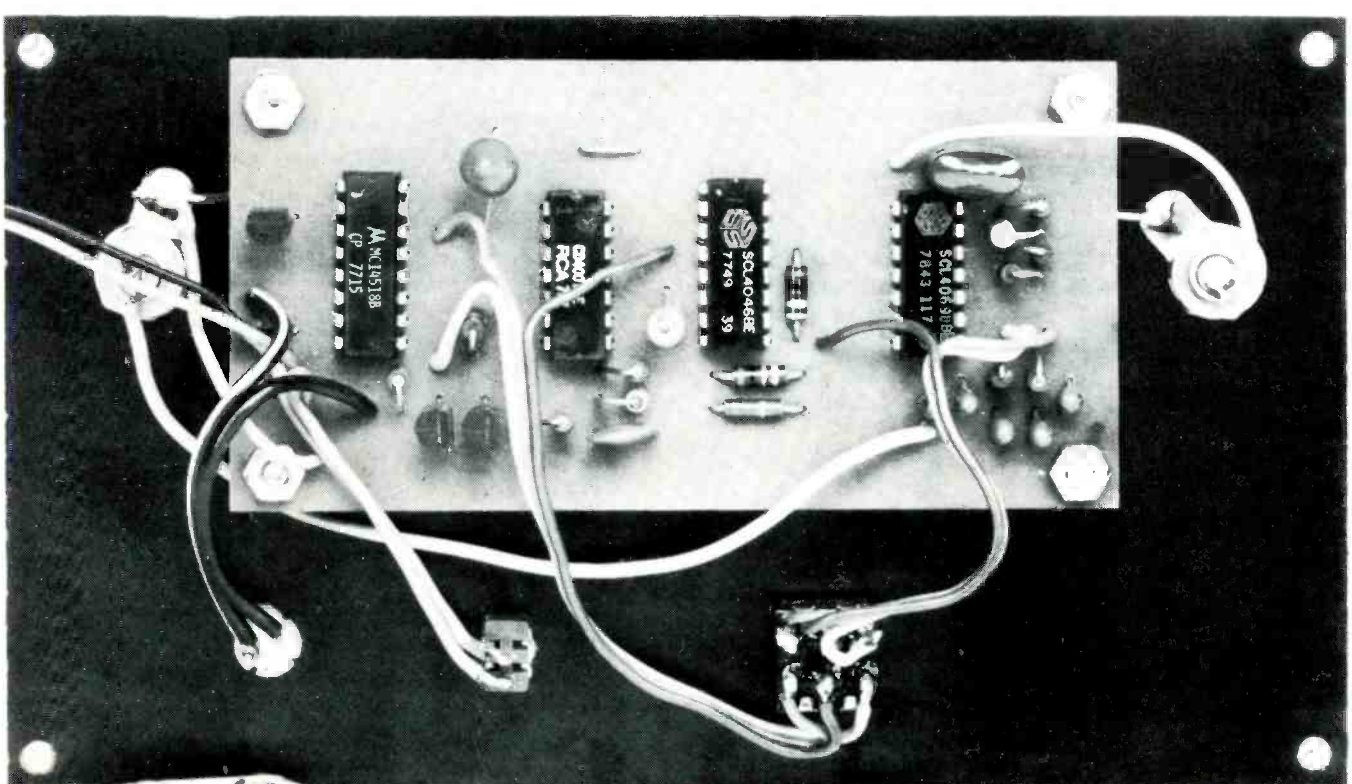
A PC board is strongly recommended since point-to-point wiring of CMOS IC's is sure to damage them from excessive handling. IC sockets should not be used since the board mounts with the parts side down which



ACTUAL SIZE foil pattern for the multiplier.



PARTS PLACEMENT guide indicating connections to off-board components.



COMPLETED PC board. IC sockets should not be used as the board mounts with the component side down.

PARTS LIST

RESISTORS
All resistors ¼ watt, 10% or better
R1, R11—R13—100,000 ohms
R2—10 megohms
R3, R7—47,000 ohms
R4, R6—1 megohm
R5—1000 ohms
R8—220,000 ohms
R9—10,000 ohms
R10—2.2 megohms
R14—470 ohms

CAPACITORS
C1—0.1 µF, 50 volts, ceramic or Mylar
C2, C3, C8—1 µF, 6 volts, tantalum, radial mount
C4—.003 µF, 50 volts, Mylar
C5—.01 µF, ceramic
C6—47 µF, 6 volts, tantalum, radial mount
C7—0.47 µF, 6 volts, tantalum, radial mount

SEMICONDUCTORS
D1—1N914, 1N4138 or equal
LED1—XC556C clean lens, red LED
IC1—CD4069B CMOS hex inverter
IC2—CD4046 CMOS phase-locked loop
IC3—CD4518 CMOS dual synchronous up counters
IC4—CD4001 CMOS quad 2-input NOR gates
IC5—78L05 5-volt, 200 mA voltage regulator

MISCELLANEOUS
S1—SPST toggle switch
S2—DPDT toggle switch
Box: Keystone No. 700 with lid or equivalent
Battery holder, battery clip, phono jacks or equivalent connections, four ¼-inch standoffs, PC board.

allow the IC's to loosen and fall out.

Install and solder all parts except the four CMOS IC's. Be sure to observe the polarity of capacitors C2, 3, 6, 7 and 8, and diode D1. Solder the CMOS IC's one at a time while using care to avoid touching the pins any more than necessary. A static-free, well grounded bench and soldering iron will help prevent damage to the static sensitive IC's.

After all parts and leads have been soldered in place, use a suitable solvent to clean the foil side of the board. Use caution since most solvents are flammable, toxic or both. Mount the PC board to the cover with 4-40 screws and ¼-inch spacers. Complete the assembly by wiring the switches, jacks and LED to the PC board. Refer to the photograph for suggested layout and wiring.

Checkout and use

Turn the power switch off and connect a good 9-volt battery. Turn on the multiplier and monitor the output at J2 with an oscilloscope. A 5-volt P-P squarewave at about 200 Hz should be present with no input at J1 and mode switch S2 in either position. Now, connect a known frequency to the input jack, J1. The 60-Hz output of a 6.3- or 12.6-volt transformer is a good choice for the reference frequency. Move the mode switch back and forth between ×10 and ×100 a few times while monitoring the output at J2. The circuit should readily lock onto the signal and output a frequency at 10 and 100 times the input frequency. The out-of-lock indicator, LED1, will flash on when switching between the two ranges and will stay on until the circuit resumes an in-lock condition. With no signal applied, the LED will stay on steadily as a reminder that the instrument has been left on.

If you monitor the circuit's current drain, you will notice that input signals of moderate to high peak-to-peak voltages cause a lowered current requirement. This is caused by inverters IC1-a, -b and -c moving out of the linear bias into the more efficient digital switching action. This can cause a 50% reduction in power consumption, but since this is only about 2 mA, it won't have a noticeable effect on battery life.

After assuring yourself that the circuit is working properly, it is a good idea to use an audio range signal generator to test the upper and lower frequency limits of the two multiplier ranges. Parts tolerances and substitutions will have an effect on the performance of the frequency multiplier. Keep in mind that any time the out-of-lock LED glows it is an indication that either the input frequency is too high or too low, or the input amplitude is too low or absent.

Some of you may prefer to use BNC connectors or banana jacks instead of the phono jacks specified. This is quite acceptable and will have no effect on the instrument's performance.

With the Multiplier in the ×10 mode you will now find that 0.01 Hz resolution is possible with a 1-second count. If you use a 10-second count, the resolution increases to 0.01 Hz. Switching to ×100, you can now have a display to 0.001 Hz with a 10-second count for frequencies up to 200 Hz. For example, 60 Hz input will be displayed as 6000.0 Hz. You will have to mentally reposition the decimal point when using the frequency multiplier.

The instrument will not add any significant error to the multiplied frequency except possibly at the lowest lock range when multiplying by 100. Keep in mind that it is usually unnecessary to achieve an accuracy greater than 0.1 Hz. Also, warm-up drift of your frequency source will become much more apparent when using the frequency multiplier. **SP**

NAT CAM CATALOG of hard-to-find tools and supplies is now available in a new edition. This 56-page 8½ × 11 inch booklet is the first full catalog published by the new owners. It contains hundreds of items such as quality hand tools, measuring instruments, electronic test instruments, soldering equipment, and unique shop supplies. Over 100 new items are included, and many products are available only from NAT CAM. The new catalog is the successor to the tool catalog formerly published by National Camera.

The NAT CAM catalog is available free upon request.—**NAT CAM CATALOG,** 1835 W. Union Ave., Unit 15, Englewood, CO 80110.

FOR MORE INFO CIRCLE 436 ON FREE INFORMATION CARD

TEMPERATURE-MEASUREMENT PROBE, is a Weston Instruments' accessory to expand applications of its 3½-digit LCD display audio-response DMM, the Roadrunner. The probe has a low-impedance output and can be used with both analog VOM's and DMM's. There is a switch that enables users to go back and forth between Celsius and Fahrenheit. Typical uses are hot-spot trouble-shooting of cir-

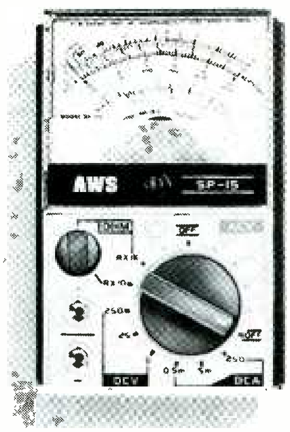
continued on next page

cuits, determining heat rise of transformers and motors, thermostat calibration, PC-board testing, and checking true-RMS instruments.

The switch-selectable range is −50°C to +150°C, −58°F to +302°F; maximum temperature: probe tip 160°C (320°F); maximum voltage: 500 volts peak between probe tip and circuit. Response time is 10 seconds maximum to settle within 1°C for a 100°C temperature change. Accuracy is ± 1.7°C (± 3.0°F) over full temperature scale, and the sensitivity is 10 mV per °C or F. There is a 9-volt carbon zinc battery, Type 1604, 216 or equivalent, and the warning indicator produces a continuous high negative reading of about −100°C or F regardless of temperature.

The temperature-measurement probe is priced at $119.00.—**Weston Instruments,** 614 Frelinghuysen Ave., Newark, NJ 07114.

FOR MORE INFO CIRCLE 428 ON FREE INFORMATION CARD



MINI-METERS, *model SP-10* and *model SP-15,* are the latest additions to A. W. Sperry Instruments Mini-Meter V-O-mA series. Both models are shirt-pocket size, with everyday job capability and are safety-fused, with safety "off" positions, and safety front-panel layouts. They are shaped for full-hand grasp, and have easy-to-read 3-color scales, diode-protected meters, and positive-action ball-detented range switches.

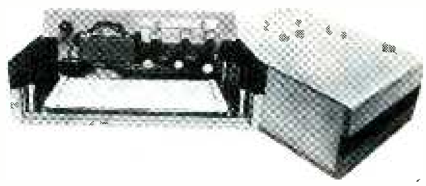
The *model SP-10* features a low-ohm range with 5 ohms midscale. The ranges are 10/50/250/500 volts AC and DC; 250 mA; 500/5K/50K ohms; 2DB Rangerson scale.

The *model SP-15* features a separate continuity range that gives audio-tone check, independent of meter. The range is 5/25/250 volts DC; 5/25/250/1000 amps AC; o.5/5/250 ma DC; 5K/500K ohms; 2B Rangerson scale.

Both models come fully equipped with test leads, battery and fuse installed, ready to use.

The *model SP-10* costs $16.75; the *model SP-15* is $19.75.—**A. W. Sperry Instruments, Inc.,** 245 Marcus Blvd., Hauppauge, NY 11787.

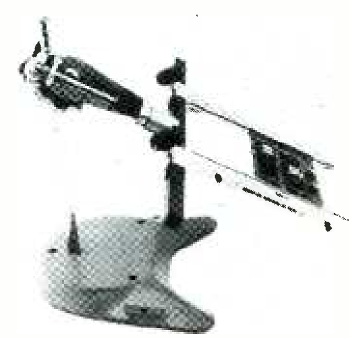
FOR MORE INFO CIRCLE 430 ON FREE INFORMATION CARD



THE IDEA BOX is the latest of Global Specialties design-aid products. It combines three fully regulated, low-ripple, power supplies; a choice of a solderless breadboard; a pre-etched, pre-drilled printed-circuit board or a blank-foil PC board; and the best of Global's cases with expanding capabilities. That combination of features allows quick construction of a prototype or a once-only device.

The suggested price of The Idea Box is $149.95. Replacement front panels and printed-circuit layout pads are also available, prices ranging from $4.96 to $44.95.—**Global Specialties Corporation,** 70 Fulton Terrace, New Haven, CT 06509.

FOR MORE INFO CIRCLE 433 ON FREE INFORMATION CARD



CIRCUIT-BOARD HOLDER, rapid assembly, *model 333,* features an eight-position rotating adjustment, indexing at 45-degree increments, and six positive-lock positions in the vertical plane. The holder gives you a full 10-inch height adjustment for comfortable working. With crossbars available up to 30 inches in length, the rapid-assembly circuit-board holder will contain circuit boards up to 28 inches in width. Extra arms can be added for dual or multiple board holding. The board holder is spring-loaded, allowing for fast one-hand position changes. There is a heavy cast-iron base to provide stability and prevent tipping. It is pre-drilled for easy bench mounting and there are two flanges pre-drilled and tapped for accessory mounting. The *model 333* costs $35.95.—**Panavise Products, Inc.,** 14024 Sylvan St., Van Nuys, CA 91401.

FOR MORE INFO CIRCLE 426 ON FREE INFORMATION CARD

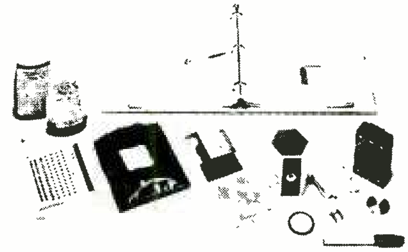
RADIO SHACK'S 1981 CATALOG celebrates their 60th anniversary and has 176 pages, with 120 of them in full color. The catalog features the latest in everything electronic, from computers and stereo components to toys and electronic games, parts and accessories for home entertainment, and other items for hobbyists and experimenters.

Among the products being offered for the first time are the *TRS-80* Pocket Computer, the *TRS-80* Color Computer, and the *TRS-80 model III* Desk Top Computer. In addition, there are six new stereo receivers, two with digital quartz tuning, and five stereo-cassette tape decks featuring Dolby noise-reduction circuitry.

Radio Shack has also expanded its line with the addition of 12 new telephone products, including a cordless handset telephone. There is the latest in home-alarm systems, one of which (microprocessor-controlled) enables homeowners to protect all openings without any wiring required. And, of course, the new catalog includes the *TRS-80* line of microcomputers, stereo components, CB equipment, radios, tape recorders, electronic calculators, digital clocks, test instruments, and ArcherKit and Science Fair hobby kits, etc.

The catalog is now available free on request from more than 6000 participating stores and dealers nationwide.

FOR MORE INFO CIRCLE 437 ON FREE INFORMATION CARD



CIRCUIT-BOARD SELF-INSTRUCTION COURSE from Heathkit shows novice electronics hobbyists how to make their own printed-circuit boards. The *EI-3134*

Printed Circuit Boards Course explores types of PC-board materials, the different manufacturing processes, and layout design, as well as both the direct pattern and photographic methods of making PC boards.

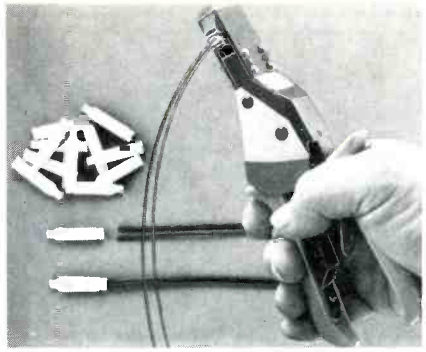
In the course of experiments, the student will construct circuit boards for two useful Heathkit products: the *Model GD-600* Automatic Lamp Switch, which turns lamps (up to 150 Watts) on at dusk and off at dawn, and the *Model GD-1787* Touch Control Switch, which lets you turn television sets (up to 225 Watts) and fans (up to 180 Watts) on and off with just a light touch—and no rewiring. All parts (including cases) necessary to complete those projects come with the study course.

All materials necessary for experiments are also provided. They include an etch-resist pen, rub-on transfers, art tape, etchant, and plastic bags to make PC boards by the direct-pattern method.

The course, mail-order, is available *only* in the continental U.S.A., and is priced at $64.95.—**Heathkit/Zenith Educational Systems,** Dept. 57-720, Benton Harbor, MI 49022.

FOR MORE INFO CIRCLE 432 ON FREE INFORMATION CARD

"D" CONNECTOR TOOL, *model CP-200,* is designed to crimp "B"-type insulated wire connectors onto the ends of unstripped wires. Metal "teeth" within the connector penetrate the wire insulation



and engage the conductor when the connector is crimped. A built-in ratchet assures that a complete pressing cycle is made before the handles are released. A factory-set mechanical stop prevents overpressing, thus assuring a high-quality conductive joint.

"B" connectors are available both plain and "jelly"-filled. The latter features "silicone-type grease packing" which wards off contamination of the connection and inhibits oxidation. Both types of connectors are available in packages of 250, 500, and 1000 pieces. Prices: *CP-200*—$55.00; 250 "B" Connectors—$12.00 for the plain, $17.33 for the jelly-filled.—**OK Machine and Tool Corporation,** 3455 Conner Street, Bronx, NY 10475.

FOR MORE INFO CIRCLE 440 ON FREE INFORMATION CARD

CIRCLE 401 ON FREE INFORMATION CARD

CIRCLE 410 ON FREE INFORMATION CARD

ADVERTISING INDEX

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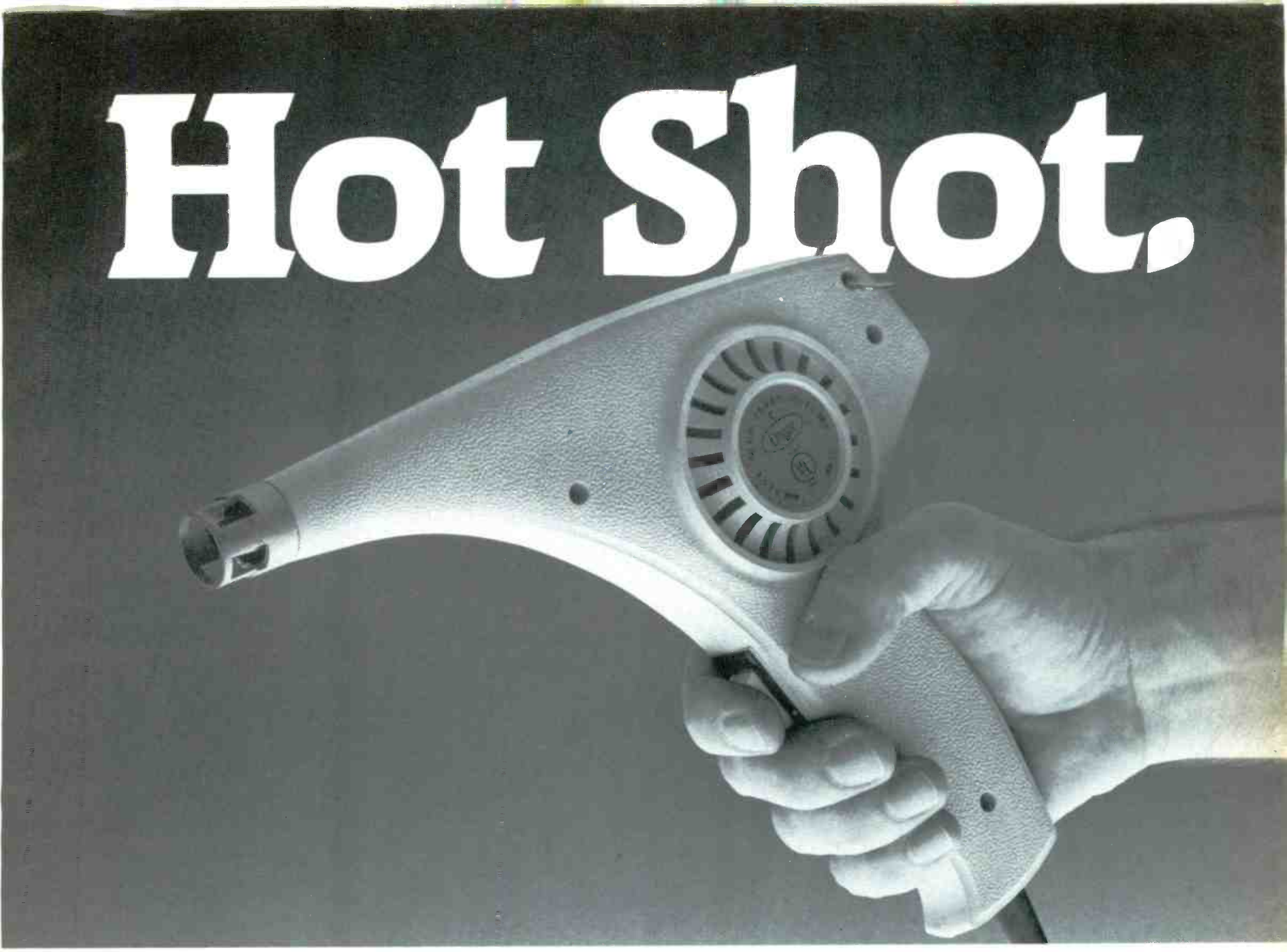


Our heat gun is light, tough and very easy to control. You get easier handling with precise hot air direction and built-in durability.

Weighing only 13 ounces, including its 3-wire cord, the heat gun sits comfortably in your hand. Its handle stays cool even during long hours on the job.

You can put the hot air stream exactly where you want it because the nozzle is smaller. And the four baffles that are included with the gun adapt it for a wide variety of uses.

There's a 3-way trigger switch with hot and cool positions. The nozzle temperature reaches 750° 800°F in seconds. And you can get our optional stand to hold the heat gun securely in several work positions.

In its high impact, heat resistant molded case, the heat gun can withstand the rigors of industrial, service shop or laboratory use.

Try our versatile, economical heat gun for everything from shrink tubing, to reflow soldering, to repairing plastics. You'll see why half of our heat guns are bought by or on the recommendation of a satisfied user.

For our new catalog, write to Ungar, Division of Eldon Industries, Inc., P.O. Box 6005, Compton, CA 90220.

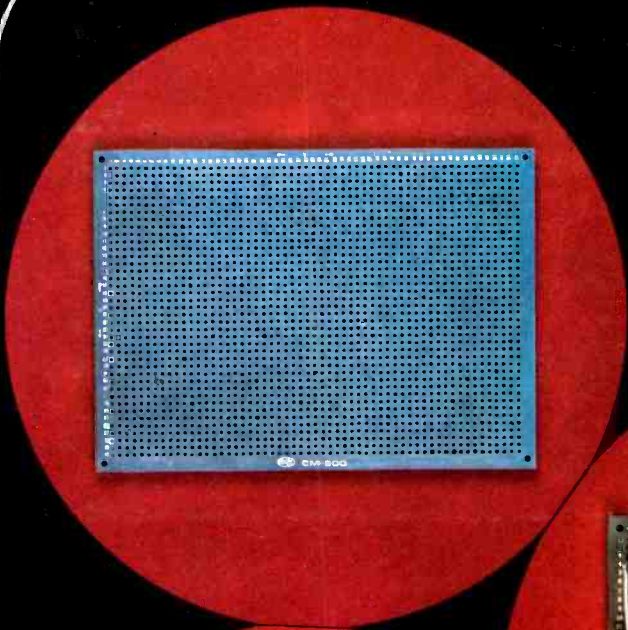
Ungar.

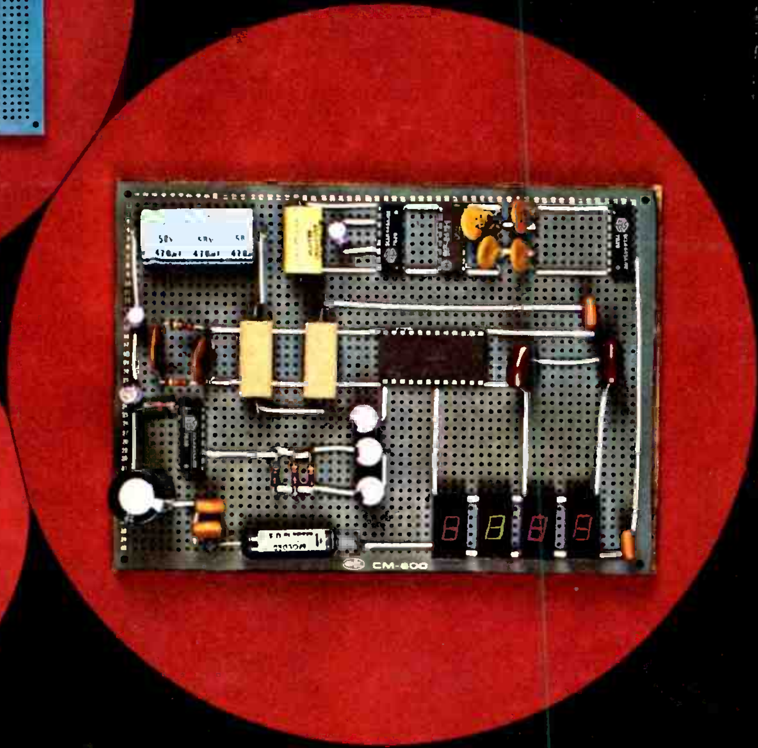
The Heat Gun. For Precise Control Of Hot Air.

CIRCLE 411 ON FREE INFORMATION CARD

Asbestos-Free!

CM-600 Circuit Mount





CM-600 $6.95*
RW-50 $2.98*

NEW CM-600 SOLDERLESS PROTOTYPE BOARD

CM-600 is a unique system for solderless construction of circuit prototypes, useful to both engineers and hobbyists. The CM-600 is a neoprene board 4½" (114mm) x 6" (152mm) with 2280 holes on .100" (2.54mm) centers. Standard components including DIP's are mounted by simply inserting leads into the holes in the long life neoprene material. Interconnections are easily made using 20 or 22 AWG (0,8 or 0,65mm) wire jumpers. Positive contact is assured by the elasticity of the hole, which compresses the leads together. To remove components or leads, simply pull out. This facilitates easy circuit changes making it ideal for breadboarding experimental circuits. CM-600 also features numbered rows and columns for easy reference.
Accessory Kit RW-50 contains 50 pcs of AWG 20 (0,8mm) insulated jumper wires of assorted lengths from ½" (13mm) to 4" (100mm). Both ends are stripped and bent 90° for easy insertion. In stock directly from

OK Machine & Tool Corporation
3455 Conner St., Bronx, N.Y. 10475 U.S.A.
Tel. (212) 994-6600 Telex 125091

*Minimum billings $25.00, add shipping charge $2.00
New York State residents add applicable tax

CIRCLE 403 ON FREE INFORMATION CARD