Radio-Electronics special Projects

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Computer tape controller p.46

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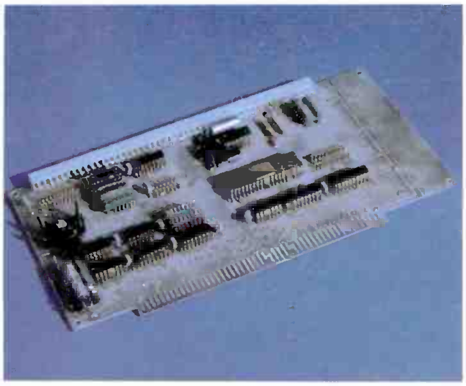
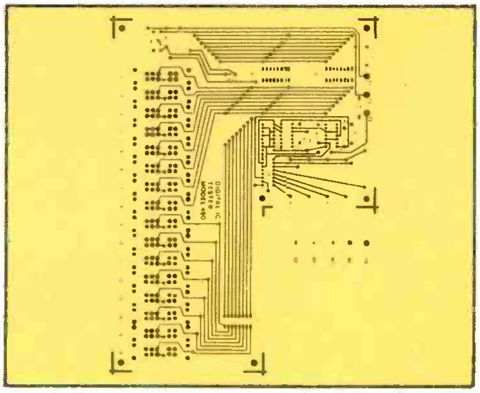
Electronic Music. . .Hobby Circuits. . .and more

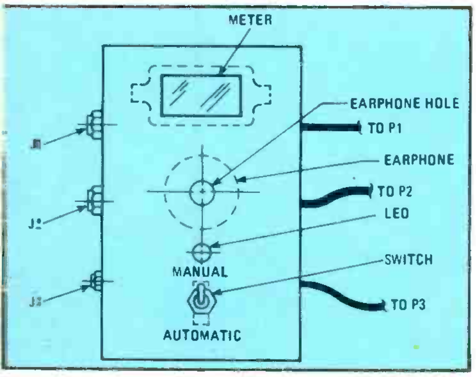
Digital display for communications p. 65



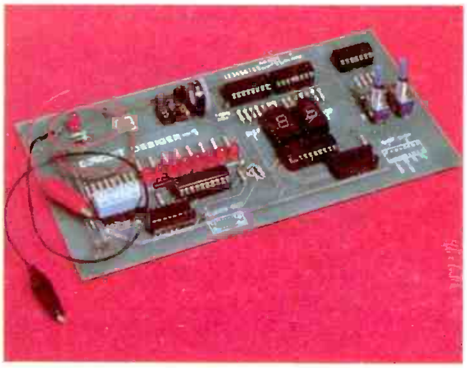
Programmable sound generator p. 92



Digital IC tester p. 40



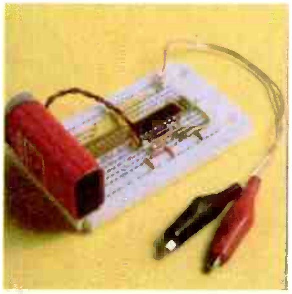
TRS-80 control box p. 14



Digital logic trainer p. 32

RETAILER:
SEE PAGE 39 FOR SPECIAL
DISPLAY ALLOWANCE PLAN.

4-channel adapter p. 5



Bargraph voltmeter p. 59

Digital do-nothing box p. 10

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$79.95 kit

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Model 2015A Bench/Portable DMM:
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#NB-120 NiCd Battery Set $18.75

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Also available Model 8110A, same as 8610A except maximum frequency is 100MHz and without battery charging circuit: $69.95 kit

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Something New

Welcome to the premier issue of Special Projects!

Special Projects is a magazine dedicated to the electronics constructor, activist and experimenter. It is chock full of never-before-published construction projects. Each article has been carefully selected and screened by the editorial staff.

Whether you're a newcomer or oldtimer to the exciting world of electronics; whether you're a shirt sleeve tinkerer or a blue-sky experimenter; you will find many of the articles in this issue of major interest. But be careful, it's likely that you'll find several that will force you to heat up your soldering iron.

The projects have been selected to cover a broad spectrum of subject areas, including computer accessories, test equipment, communications, electronic music, hobby circuits and more. For example, if you would like to learn more about digital circuuits, there's a digital logic trainer on page 32. Or how about an adapter that will convert your present oscilloscope into a 4-trace logic scope. Own a personal computer? There's a programmable sound generator on page 92 that will fit three popular computer busses, including the TRS-80. There's even a digital do-nothing box on page 10.

By the time you finish this issue, you'll be ready for the Spring 1981 issue of Special Projects. That's because Special Projects is a quarterly publication. And the second issue is going to be filled with more of the same kind of never-before-published projects that you see here.

If I seem enthusiastic, it's because I feel that we've put together the kind of electronics magazine that's missing from the electronics scene. If you'd like to express your opinion, please drop me a postcard or letter with your comments to the Editor, Special Projects, 200 Park Avenue South, New York, NY 10003.

Art Kleiman

Art Kleiman
Managing Editor

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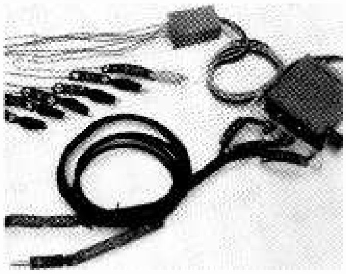
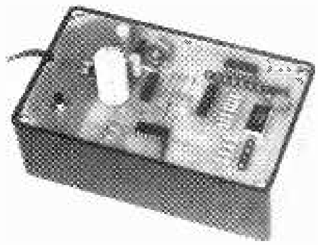
Radio-Electronics Special Projects

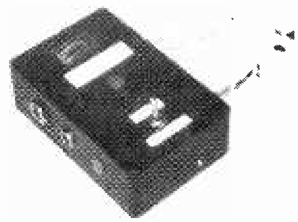
VOL 1, NO 1



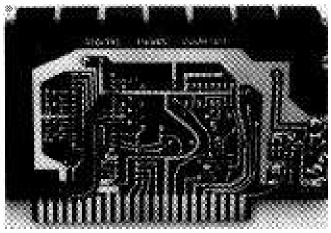
5
SCOPE MULTIPLEXER
It's a simple device that let's you turn a single-trace scope into a four-channel digital scope. With the optional CMOS head, also detailed, the unit can be used with almost all logic families.



10
DIGITAL DO-NOTHING
Eye-catching electronic gadget is an exercise in numeric displays. It takes output pulses from an oscillator and displays 0 to 9, endlessly, in three different modes. It is one of those gadgets that is both easy to build and fun to use.



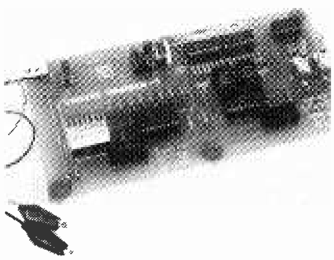
14
AUDIO-VISUAL CONTROL
Eliminates plug handling; allows you to listen to tape signals; provides a signal-lever meter; and visually alerts you when the recorder operates. Makes your tape-fed TRS-80 easier to use and at the same time helps you keep tabs on what you are trying to do.



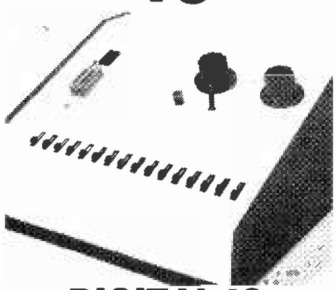
20
DIGITAL PANEL COUNTER
A digital frequency counter so small, that you can build it into almost any piece of equipment. It has a 7-digit LED display and reads frequencies from DC to more than 135-MHz. Two separate inputs too—one for low-frequency inputs; the other for high-frequency inputs.

28
MIKE COUPLER
Coupling the speaker of one piece of equipment to the microphone of another is easier/harder than you think. But this article presents a one-evening project that will solve the problem once and for all. Try it out for yourself. It's well worth the effort.

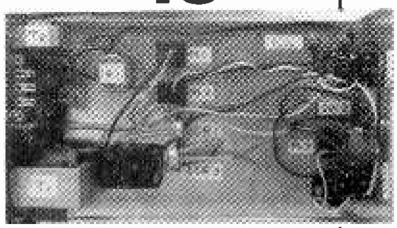
30
CAR TEST PROBE
Carry it around in your car for on-the-spot electrical system troubleshooting. Your choice of perf-board or printed-circuit card construction. The convenient and available probe case speeds assembly and leaves you with a very professional-looking piece of test gear.



32
CIRCUIT DESIGNER
An affordable device that supplies and monitors the functions necessary to explore the theories and operation of digital and microprocessor IC's. It can also be used as an aid in teaching digital and microprocessor techniques. You should have one for yourself.



40
DIGITAL IC TESTER
Provides a permanent setup, so you can test all kinds of digital IC's without having to spend a lot of time on wiring breadboards first. If you use IC's in your projects you'll approve of the amount of time that this not-so-simple project can save you.



48
SAFETY COOKER
It's a fast, easily adjustable circuit-breaker that lets you "cook" equipment on your bench without a need for you to be there. It protects against damage that might be otherwise caused due to unexpected faults that cause sudden, excessive current drain.

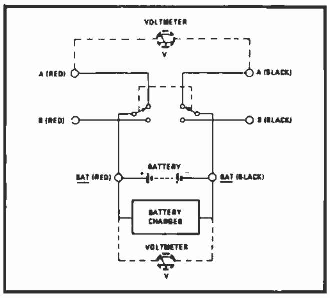
46
CASSETTE JUNCTION BOX
A handy interface between your microcomputer and its cassette recorder memory. LED's indicate the states of the signal and the control lines. A two-evening project for hobby computer buffs.

54
CHORD EGG
That's EGG as in Encephalo-Gratification Generator. Produces one musical chord after another.

59
BARGRAPH BATTERY TESTER
Two major components is all it takes to assemble this novel battery tester. Great for checking out single cells, it gives quick evidence of a battery's condition.

61
BATTERY BOX

A handful of components and a single evening of assembly time builds this useful battery switching box. It is equipped with its own rechargeable batteries and has a thousand and one more uses that you can possibly think up for it.



65
DIGITAL DISPLAY

Add it to your communications receiver or even to your older FM receiver and you'll have the latest equipment. Three circuit boards house all of the parts and simplify construction. Once you read the article, we're sure you are going to want to build one for yourself—so don't blame us.

76
BIG SOUND

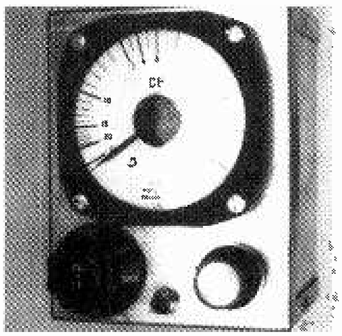
How to give an electromechanical chord organ a new lease on its musical life by adding a few IC's and related components. The result can be as satisfying as the purchase of a complex all-electronic organ and a lot less expensive.

78
MIKE SUBSTITUTE

Foot switch give you an extra hand for making transmitter tests while a silent signal gives your ears a rest. There's no worry about critical lead length or parts placement to make this more than a simple project with oodles of applications.

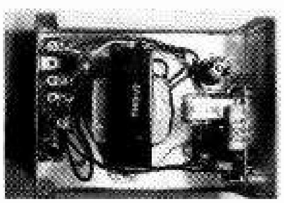
81
FUDGE-FACTOR BOX

dB measurements can be easy to make. Here's a team of instruments—a simple dB meter and a Fudge-Factor box that combine to solve this persistent problem faced by many experimenters. You'll wonder why you haven't thought of it yourself.



85
LINE REGULATOR

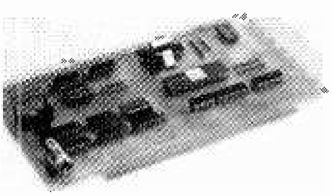
Don't let voltage dips put your TV out of business. Here's an automatic stepping device that will boost line voltage by 6.3VAC and does it automatically whenever the line voltage drops below a level you preset. A simple readily-available transformer does the job when it is coupled in this circuit.



88
WORDS AND MUSIC

COSMOS counters coupled to displays and tone-generating circuits form simple audio-visual devices with hundreds of applications. They include programmable doorbells, warning and security annunciators, novelty displays of all kinds, and much much more.

92



SOUND GENERATOR

A programmable sound generator on a circuit card that is designed to immediately interface with your choice of computer systems—S100, TRS-80, or SWTPC 6800. Take a careful look at this one, it's much more interesting than the title would have you believe. And the sounds that it creates.....WOW!

99
NEW PRODUCTS

A selection of products and literature that should be of particular interest to the readers of this new magazine. We think you'll find them interesting. The Free Information Card at the rear of this book makes it easy for you to get more data direct from the manufacturer.

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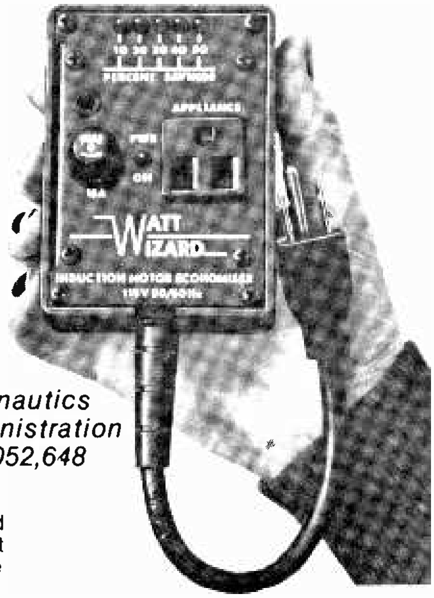


MERCURY 1980©

National Aeronautics and Space Administration Patent No. 4,052,648

For over a year now, in magazines and newspapers the world over, there have been enthusiastic write-ups on a remarkable new device that can cut your electric bill while helping the U.S. save huge quantities of fuel.

"The NASA/Nola power saver," wrote a **Popular Science** senior editor, "was developed by Frank Nola at NASA's Flight Center in a program to reduce power consumption in spacecraft motors. Nola calls it a PFC — power-factor controller. I prefer to call it a power saver, however, because that's what it does."

NASA TESTED IT

According to NASA documents, "The device has been tested at Marshall Center on over 40 types of motors, with power savings ranging up to 60%, depending on the loading. The motors tested were both single-phase and three-phase, ranging from ½ H.P. to 5 H.P. Most motors will show up to 40 — 50% savings when running lightly loaded or unloaded, and some will show 5-to-7% savings at rated load."

NASA's Technical Support Package showed that "The Power Factor Controller applies to induction type electric motors — the most commonly used type in all major home appliances and the most commonly used by industry."

HOW IT SAVES POWER

Popular Electronics explained it this way: "AC induction motors characteristically run at a nearly constant speed that's fixed by power-line frequency and independent of load and supply voltage. When heavily loaded, the motor draws line current that is nearly in phase with the applied voltage...Under light load conditions, the motor develops less torque by allowing more lag between the voltage and the current. This reduces the power factor while leaving the current essentially the same in magnitude.

"To minimize this waste, Nola's device monitors the motor's power factor and when it detects light load conditions, it reduces the supply voltage...... The current, now more nearly in phase with the voltage, therefore does as much useful work as before, but it and the voltage are smaller, resulting in a net savings of electric power."

THE SAVINGS CAN ADD UP

The cost of electric power keeps going up. In 1980-81 and beyond you'll pay more and more for the privilege of running your electric appliances.

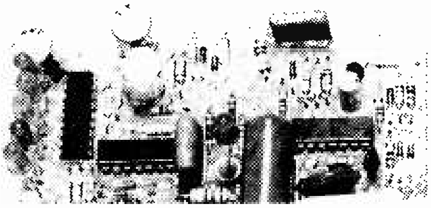
Right now, the typical consumer pays about $8 per month to operate a 16.5 cu. ft. frost-free freezer...$10 to run a 17.5 cu ft. frost-free refrigerator...and about $60 for an air conditioner used during summer months. That's what you're paying to run just **one** of these appliances per year.

Nola's power saver can soon pay for itself, then start reducing your electric bills. Until now, the device has not been **available** — except for industrial models priced at $80 or more.

INTRODUCING THE WATT WIZARD

Cynex, an American manufacturer of electrical and electronic products and a prime contractor for the U.S. Army, has been licensed by NASA to manufacture Frank Nola's power saver. Cynex calls it the Watt Wizard.

The "Watt Wizard" says Ray Beauchea, the firm's **Marketing Director**, regulates the voltage fed into an induction motor making the motors run more efficiently and quieter, while lengthening motor life.



The Watt Wizard features a unique, constant power saving readout. So you can constantly monitor you're energy savings.

SIMPLE TO USE

Cynex makes several models of the Watt Wizard (all with solid state design), including the 110 v. AC plug-in model we're offering. It's for single phase fractional H.P. motors (less than 1 H.P.) used in most freezers, refrigerators, fans, swimming pool pumps, vacuum cleaners, sewing machines, etc.

Simply plug the Watt Wizard into any electrical outlet, then plug the appliance into the Watt Wizard. There's no wiring required. Unlike some competitor's models (if and when available), the appliance does **not** have to be turned on before being plugged into the power saver. You can leave the appliance — whether on or off — plugged into the Watt Wizard all the time. Or you can move the Watt Wizard to various locations.

OTHER MODELS AVAILABLE

Air conditioners, washers and dryers require wire-in model. If you lack mechanical skill, you probably need an electrician to install it. We also offer it in 220 VAC single or three-phase.

EXCLUSIVE ADVANCE FEATURES

The Watt Wizard also includes two more unique features which no **competitor** has. It's fused so if you accidently overload the device, it won't burn out. Just change the fuse, which is available at any auto supply store.

And Watt Wizard features a unique LED readout, so you can actually tell, at any moment, exactly how much power you're saving — 10%, 20%, 30%, 40% or 50%. This feature is **available only on the Watt Wizard.**

There's a "**power-on**" light, too. And the Watt Wizard comes with the manufacturers 1 year limited warranty.

LOW COST — AND A TAX CREDIT

We're offering the Watt Wizard for only **$39.95**, with **immediate delivery.** Want two? Then its just **$37.95** each. Or splurge and get three at **$34.95** each. Wire-in models for heavy duty motors are **$6** more for each unit. Add just **$2.50** postage/handling for each **order** (not each unit).

And next year, when you fill out your tax return, you can deduct a full 15% energy tax credit-for additional savings.

30-DAY MONEY-BACK GUARANTEE

Try the Watt Wizard for up to 30 days. If not completely satisfied, return it (insured) for a full refund.

The sooner you send for the Watt Wizard, the more you can save on your electric bills. To order, send your check or money order to the address below. Or charge it to your Visa, MasterCharge, American Express, or Carte Blanche credit card. If using your charge card, you can also order via our toll-free phone number:

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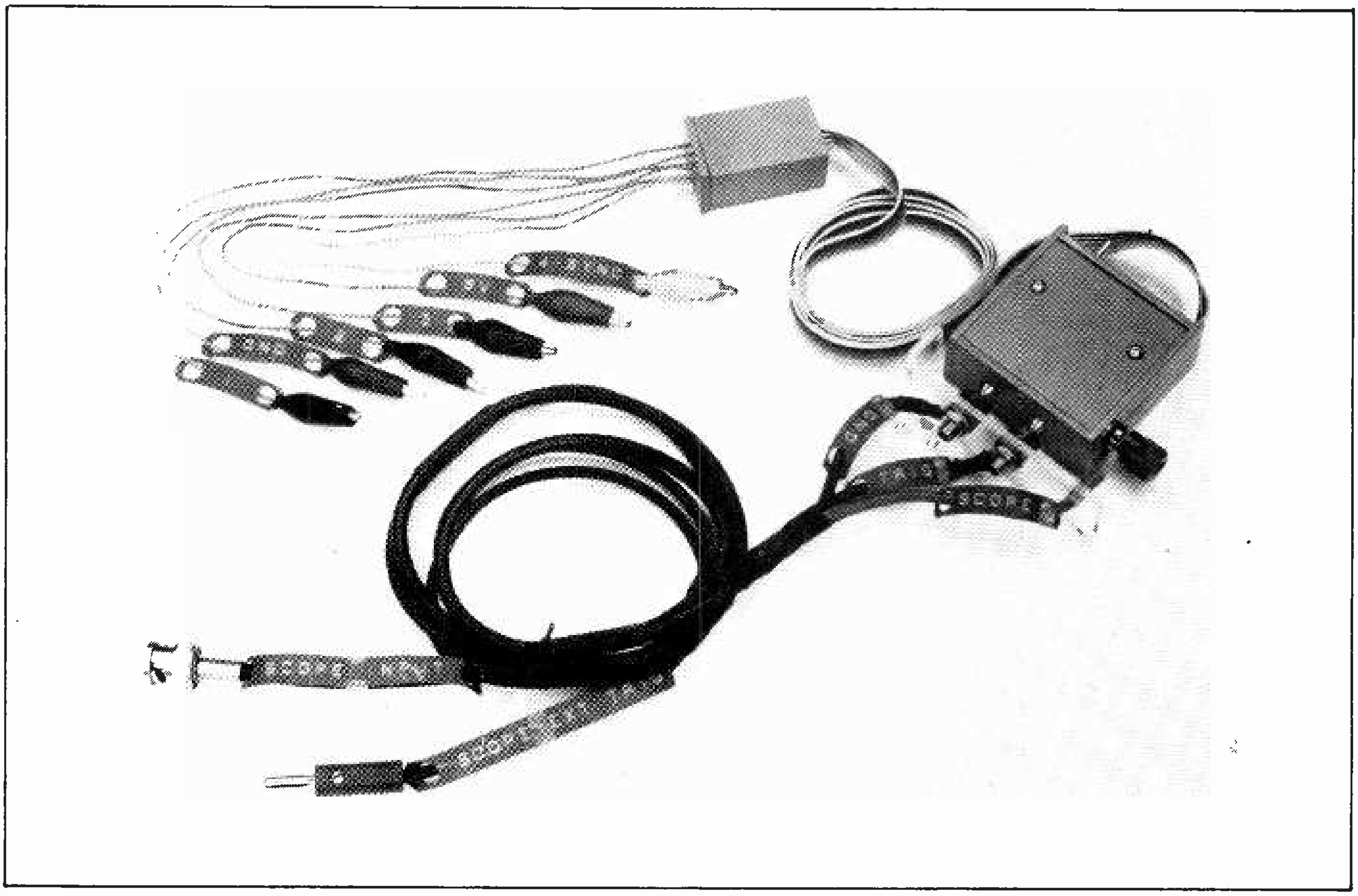


4-TRACE SCOPE MULTIPLEXER

Turns almost any scope into a 4-channel instrument

CARLO A. FACCA

TROUBLESHOOTING DIGITAL CIRCUITS IS GENERALLY quite simple. Low-frequency circuits can be monitored using conventional logic probes. Higher frequency circuits require, at minimum, an oscilloscope. Even the scope has its shortcomings. For most hobbyists, designing and troubleshooting digital circuits requires monitoring several signals simultaneously. Most experimenters' scopes are single-trace units (at best some are dual trace).

The multiplexer described in this article will make it possible for your single-channel oscilloscope to display four digital signals, greatly expanding its flexibility.

The basic multiplexer is a TTL compatible device. The optional CMOS head described in this article allows the multiplexer to be used with CMOS, TTL, and other logic families. The head increases the sensitivity of the multiplexer, reducing its loading effect on the circuits being monitored; and it also provides input overvoltage protection.

How it's built

The multiplexer is built using a modified bricklaying method. (see "*IC Bricklaying*", **Radio-Electronics,** December 1977). The IC leads are bent so they point straight out of the package. The IC's are stacked on top of each other and fastened together using two-sided adhesive tape, as shown in Fig. 1. All connections are made using standard wire-wrap wire. Connections are point to point and in most cases can be

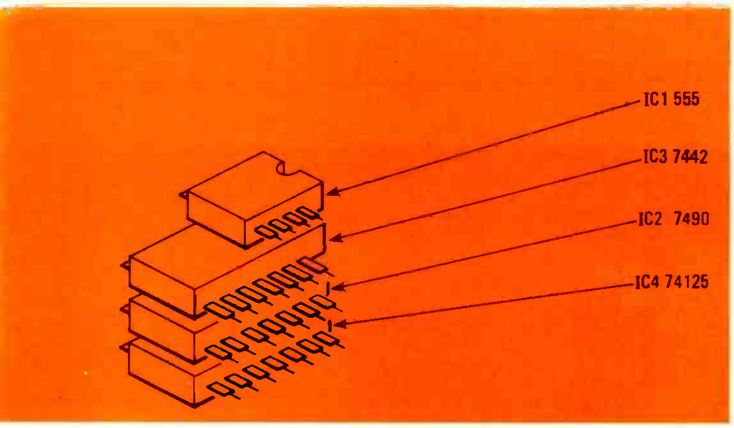


FIG. 1—DETAILS OF IC BRICKLAYING arrangement. The CMOS head is not shown here.

wire-wrapped directly onto the IC pins. Resistors and capacitors are soldered onto the pins. No PC board is used. The prototype was built in a 2 × 2 × 1-inch (50 × 50 × 25-mm) plexiglass box. The box was fitted with terminations to plug into the author's oscilloscope; however, you can modify the physical arrangement of the plugs and jacks to suit your particular scope.

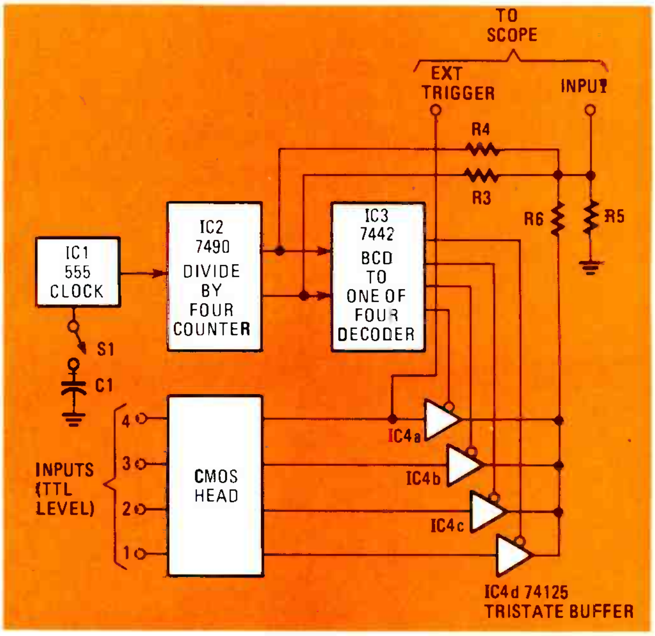


FIG. 3—SIMPLIFIED BLOCK DIAGRAM aids understanding how this 4-channel multiplexer works.

How it works

The multiplexer is shown in schematic form in Fig. 2. A block diagram is shown in Fig. 3. Refer to Fig. 4 for details on the CMOS head. IC1 is the system clock. In the ALTERNATE mode the clock operates at 200 Hz, while in the CHOP mode the frequency is 250 kHz. IC2 divides the clock pulses by four, producing a binary coded decimal (BCD) output. IC3 decodes the BCD, generating individual low states on its four output lines corresponding to the BCD input. The four sections of IC4, a tri-state buffer, are turned on individually by IC3. In so doing the four digital signals being monitored are sampled sequentially.

Resistors R3, R4, R5 and R6 form a simple D/A converter. R3 and R4 position the beam in the correct vertical location corresponding to input being sampled. R6 modulates this location depending on the state of

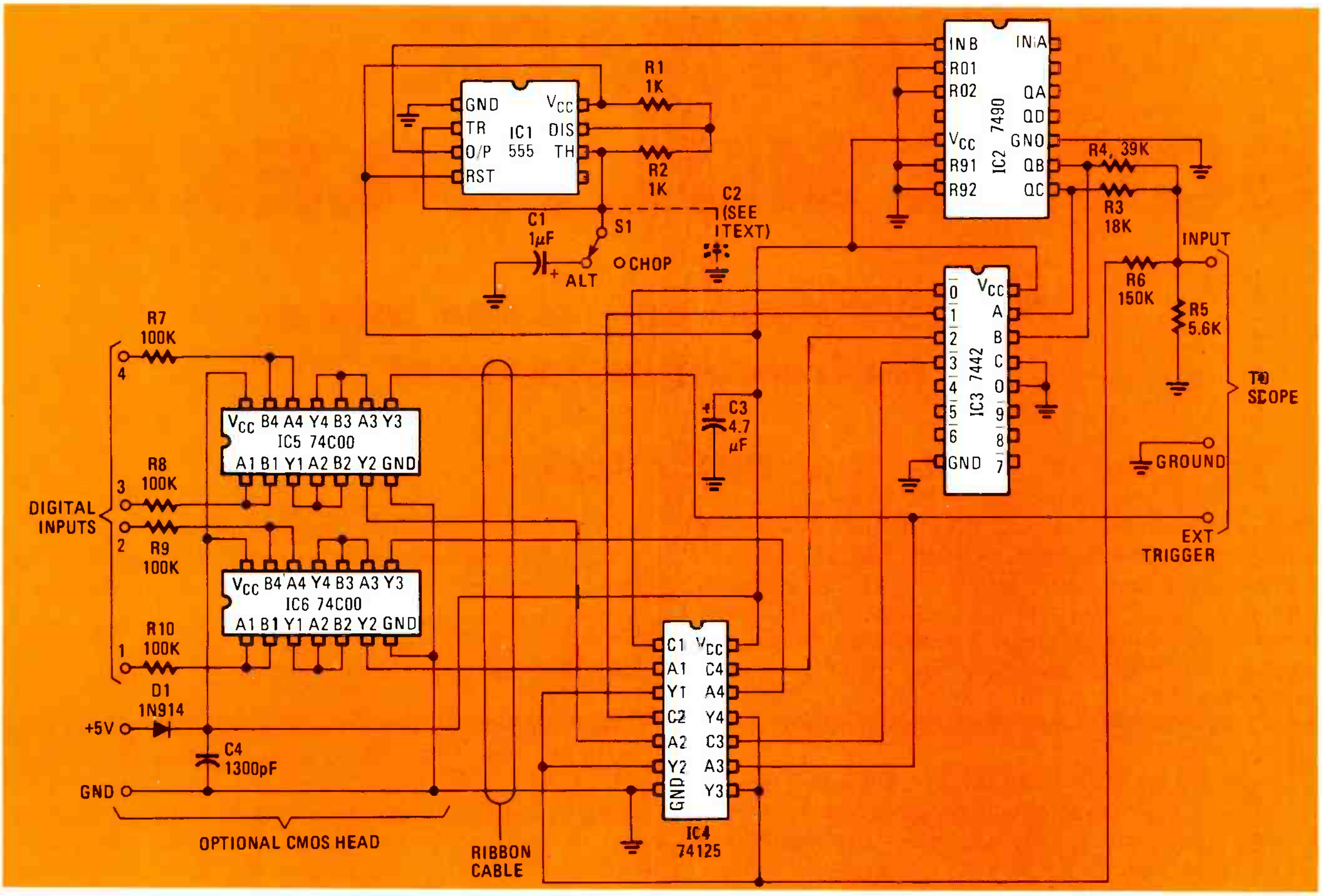


FIG. 2—COMPLETE SCOPE MULTIPLEXER SCHEMATIC includes the optional CMOS head.

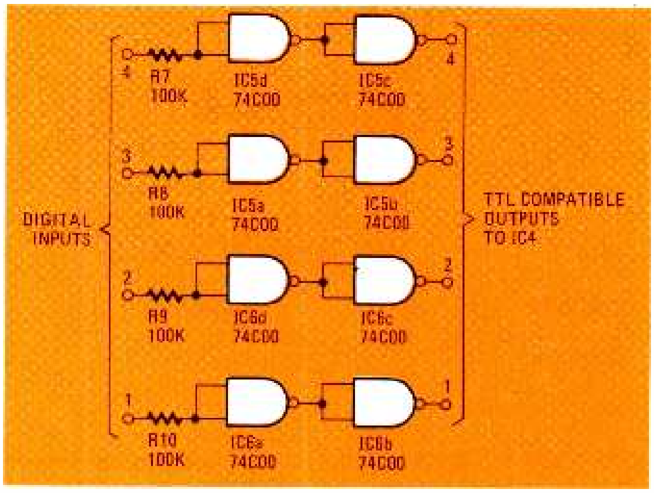


FIG. 4—DETAILED SCHEMATIC OF CMOS HEAD. Only 2 IC's are needed to couple digital inputs to the multiplexer.

the input. The oscilloscope is triggered directly from input 4. Diode D1 provides reverse supply-voltage protection. Capacitors C3 and C4 act as power-supply bypass devices.

Since many hobbyist scopes do not have provisions for external blanking, the multiplexer does not use a blanking circuit.

The CMOS head acts as a high-input impedance buffer. In each of the four input channels, two NAND gates are connected as inverters and in series so that the net effect is to produce no signal inversion.

The inputs can exceed +5 volts without damaging the CMOS IC's—their internal protection will take care of that. The 100K resistors act as current-limiting devices. With the specified components the input threshold is about 1.8 volts.

Constructing the case

The case design is shown in Fig. 5. Using 3mm (1/8") plexiglass, cut two pieces of the following sizes: 2-1/4" × 1", 2" × 1", 1-7/8" × 3/4" and 1-15/16" × 2".

Drill the top, bottom and front panels as shown. File a notch into the front panel to accommodate a 6-wire

PARTS LIST

CAPACITORS

C1—1-μF 6-VDC (or greater)
C2—50-100 pF (see text)
C3—4.7-μF 6-VDC (or greater)
C4—1300 pF
D1—1N914

SEMICONDUCTORS

IC1—555 Timer
IC2—7490 TTL Decimal Counter
IC3—7442 TTL BCD to one of ten decoder
IC4—74125 TTL Quad Tristate Buffer
IC5, IC6—74C00 CMOS Quad NAND gates

RESISTORS

All 1/4w 5%
R1, R2—1000 ohms
R3—18,000 ohms
R4—39,000 ohms
R5—5600 ohms
R6—150,000 ohms
R7, R8, R9, R10—100,000 ohms
S1—SPST Subminiature Switch

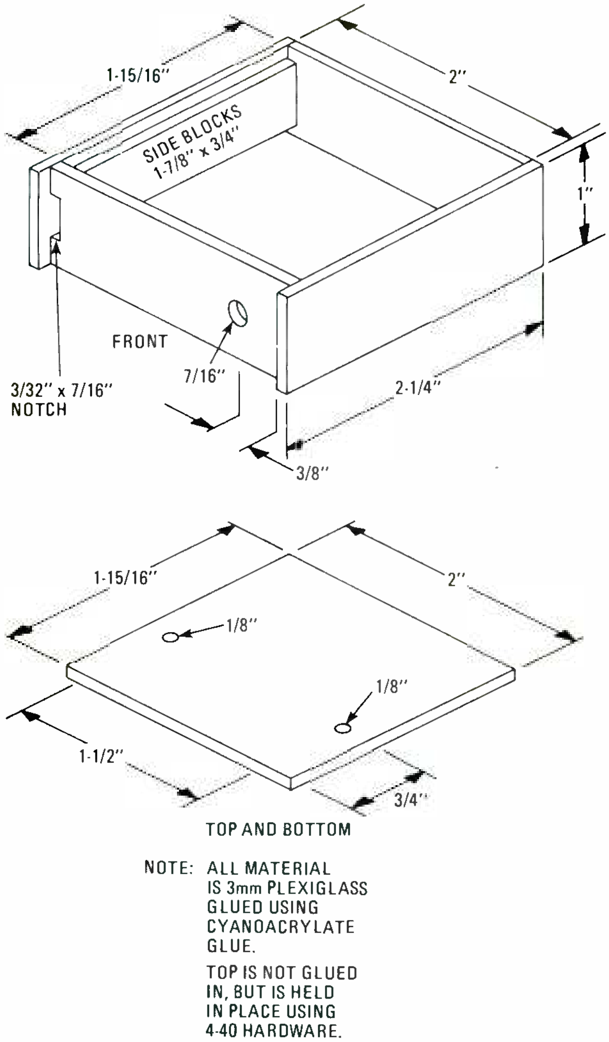


FIG. 5—DETAILS OF PLEXIGLASS MODULE. This housing is for the multiplexer and does not include the CMOS head.

ribbon cable. Fig. 5 shows this notch on the left side of the front panel. Glue the bottom, sides, front, and back together using cyanoacrylate glue. Don't get any glue on your fingers as they will bond instantly. Glue both side blocks in place but make sure the ribbon cable will pass through the notch and by the side block. If not, file the side block to suit. Carefully glue two 4-40 nuts over the holes on the bottom panel. Secure the top with 4-40 screws.

Mount banana plugs, BNC connectors or whatever hardware required to mate the case to your oscilloscope's input, ground and external trigger connectors.

If you are making the CMOS head, cut four pieces of 3 mm (1/8") plexiglass 1-1/2" × 3/4" and two pieces 1" × 3/4". Glue the four larger pieces together as in Fig. 6. Do not glue on the end caps yet.

Wiring the multiplexer

Stack the IC's as shown in Fig. 1 and wire the device as shown in Fig. 2. Do not install C1, D1, or S1 yet. Prepare a 4-foot (1.2 m) length of 6-conductor ribbon cable. Connect one end of the cable to IC4. Install switch S1 on the front panel. Solder capacitor C1 directly to S1 and connect to IC1. Temporarily apply power (+5V) to the circuit. Monitor pin 3 on IC1 using an oscilloscope. With S1 in the ALT mode, a pulse train

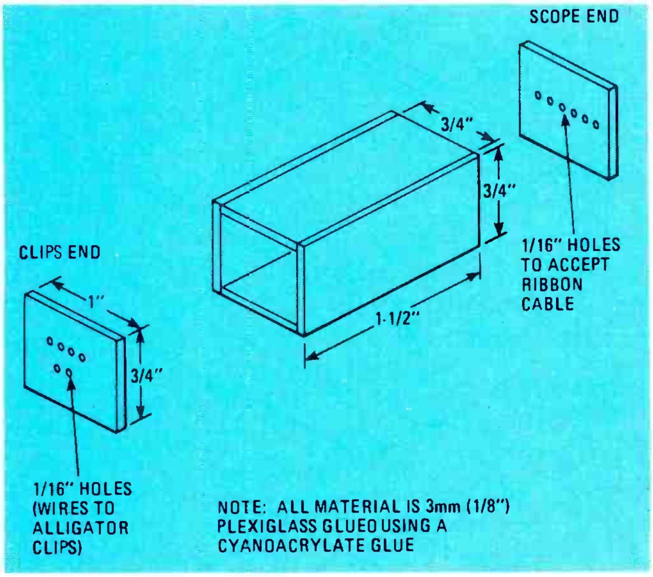
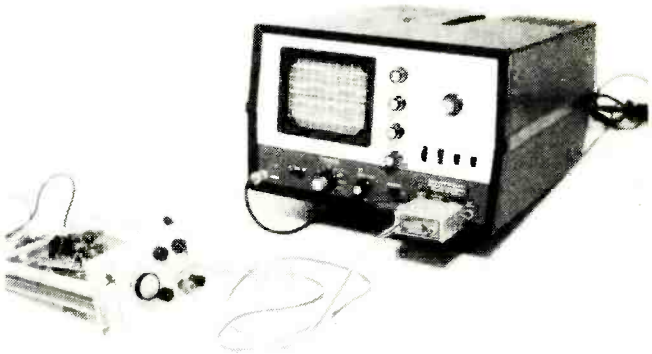


FIG. 6—A SEPARATE CASE IS USED FOR THE CMOS HEAD. Details of its construction are shown here.



THE FOUR-TRACE MULTIPLEXER plugged into a Heathkit IO-4541 scope. The screen displays the four signals from a TTL pulse generator.

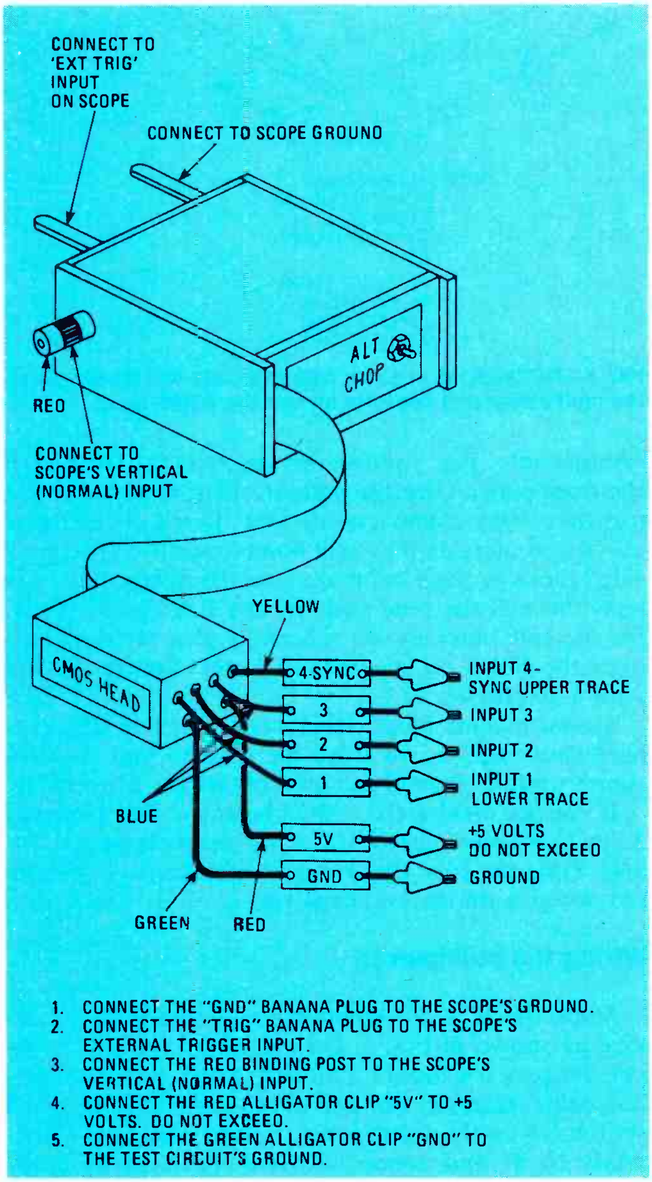


FIG. 7—HOW THE MULTIPLEXER CONNECTS TO YOUR SCOPE. Details are in the text.

with a frequency of about 200 Hz should be present. Move S1 to the CHOP position. The pulse train should now have a frequency of about 250 kHz. If no output appears, install C2 as shown. C2's value should be small, 50 to 100 pF. Disconnect the power supply. Connect the input, ground, and external trigger connectors to the circuit.

Building the cmos head

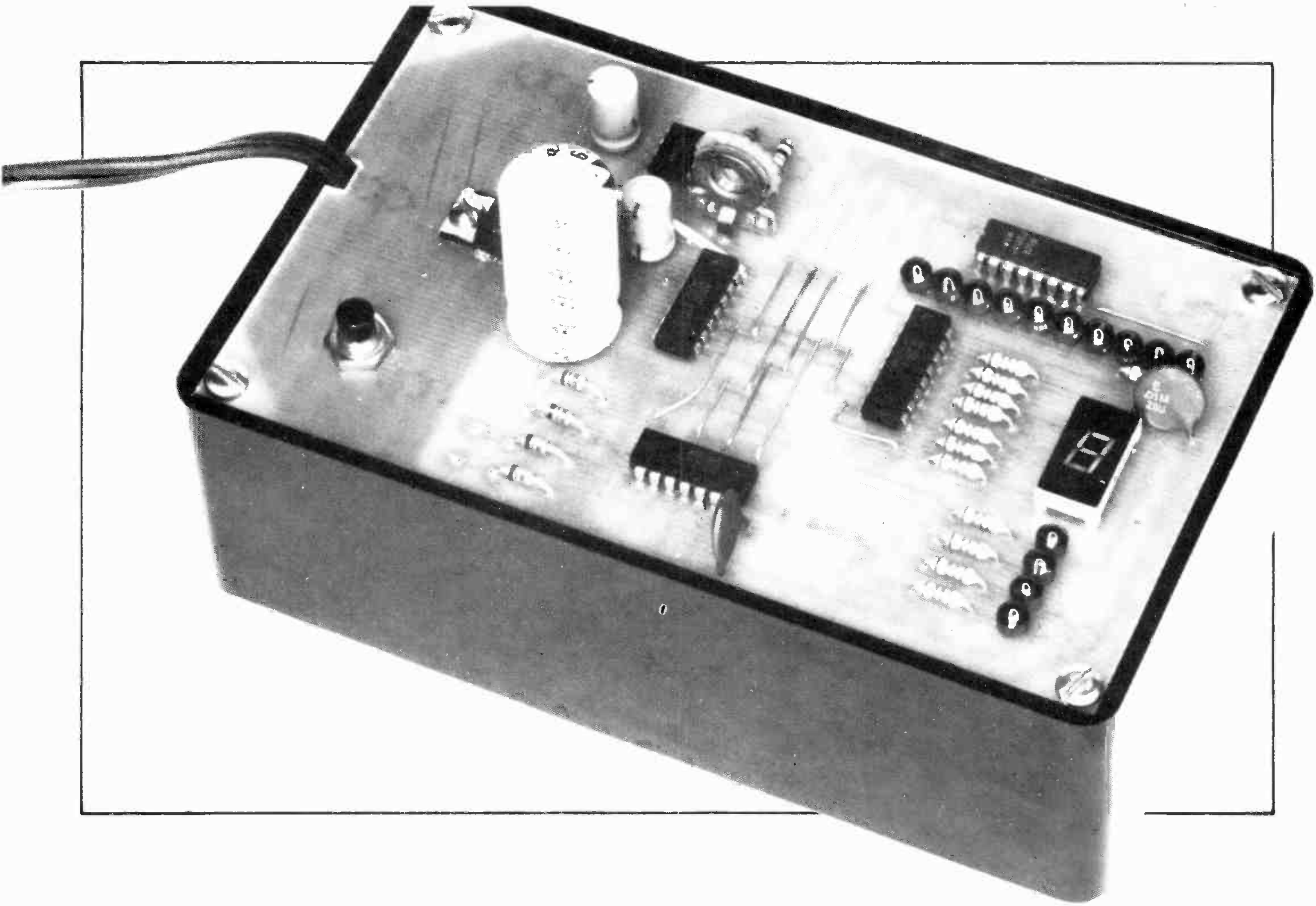
Stack IC5 and IC6 vertically as in the case of the other IC's. Pin-to-pin connections can be made by simply bending the IC pins and soldering them together. Solder C4 across the power-supply connections of either IC. Fit the free end of the ribbon cable through one end cap on the CMOS head case. Solder the wires to IC5 and IC6 as shown in Fig. 2. Install IC5 and IC6.

Prepare six 12" (30 cm) lengths of flexible wire. Fit these wires through the other end cap. Solder these wires to IC5 and IC6. They will connect the CMOS head to the input alligator clips. Install resistors R7, R8, R9 and R10 as well as diode D1 at the foot of each one of 5 alligator clips. Connect these to the appropriate wires. Now connect an alligator clip to the ground wire. Glue the end caps to the CMOS head cabinet.

If you are not building the CMOS head do not install R7, R8, R9 and R10 in the input alligator heads.

Using the multiplexer

Connect the multiplexer to the scope's input, external trigger and ground connections (see Fig. 7). Set the scope vertical sensitivity to 0.2-volt/division. Set the scope to the external trigger mode. Connect the four inputs to the circuit being monitored (4-sync goes to the lowest-frequency signal being monitored. This is the upper trace, but more important, it provides the trigger pulses.) and connect the other two clips to ground and +5 volts. Adjust the trigger level and sweep rate controls on your scope for a stable display. Remember, the scope is being triggered from input 4, so it's important that the lowest frequency signal be connected to input 4. If the sweep rate is 200 μS/div, or faster, set switch S1 to ALT; if it is below 200 μS/div, select the CHOP mode. The four traces will appear on the CRT, input 4 on top and input 1 on the bottom. **SP**



DIGITAL DO-NOTHING

This eye-catching electronic gadget is an exercise in numerical displays. It takes output pulses from an oscillator and displays 0 to 9 in three modes.

MARK C. WORLEY

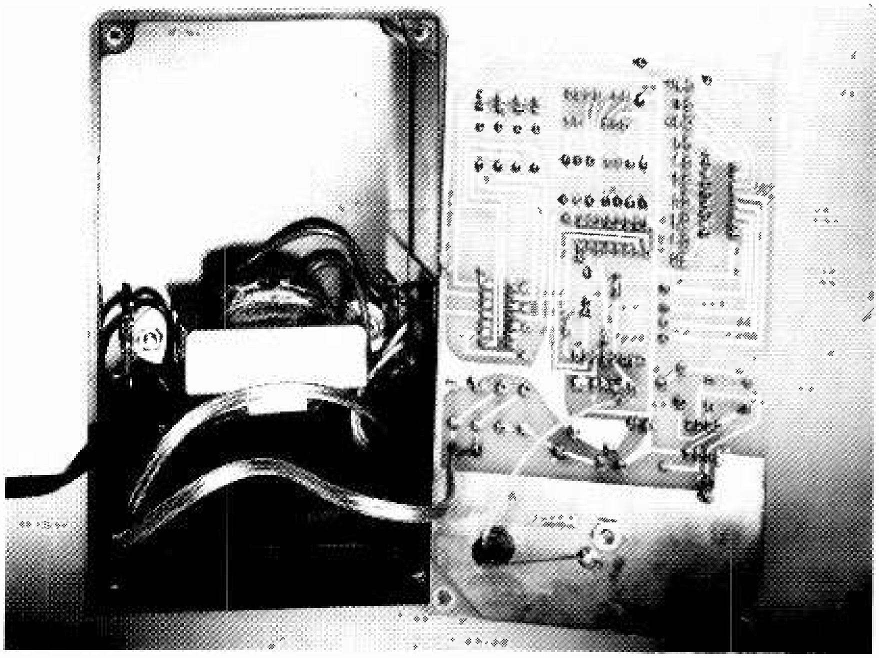
THE DIGITAL DO-NOTHING IS A LOT MORE THAN THE name implies. It's a fascinating, almost hypnotizing gadget to amuse yourself and friends, and a sure conversation piece to have flashing and rythmically changing on a shelf or coffee table.

For those of us having less frivolous and more studious natures, it's a learning and training device in BCD (*B*inary *C*oded *D*ecimal) code and simple TTL digital circuitry. Whatever your nature, it's an easy-to-build project that won't dent your budget too heavily.

About the circuit

Figure 1 is a schematic diagram of the Digital-Do-Nothing. A full-wave bridge rectifier and 5-volt regulator (IC6) power the circuit.

A variable clock generator, IC5, sequences the 7490 decade counter through its ten BCD-coded steps. Pins 12, 9, 8 and 11 are outputs A, B, C and D, or BCD code 1, 2, 4 and 8, respectively. These BCD outputs are connected to the three decoder/display IC's 2, 3 and 4.



INTERIOR VIEW of the Digital Do-Nothing. Off-the-board components can be positioned and mounted as you see fit. In this version, the power transformer is bolted to the bottom of the enclosure.

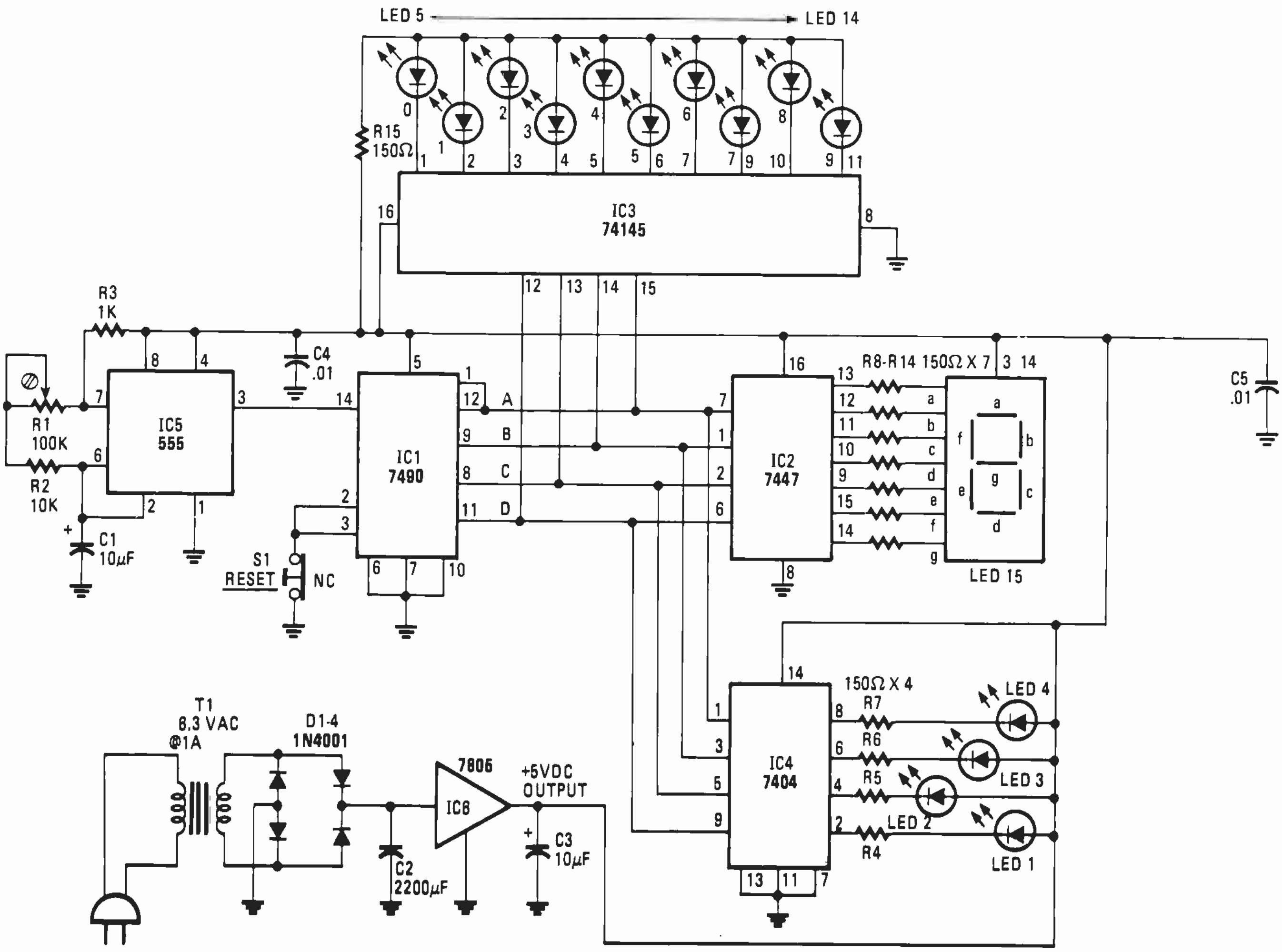


FIG. 1—SCHEMATIC DIAGRAM OF THE DIGITAL DO-NOTHING. Timer IC5 is used as a variable clock generator that drives the decade counter. The BOD-coded output is fed to IC's 2, 3 and 4 to display the count in BCD, 7-segment and 0-9 formats.

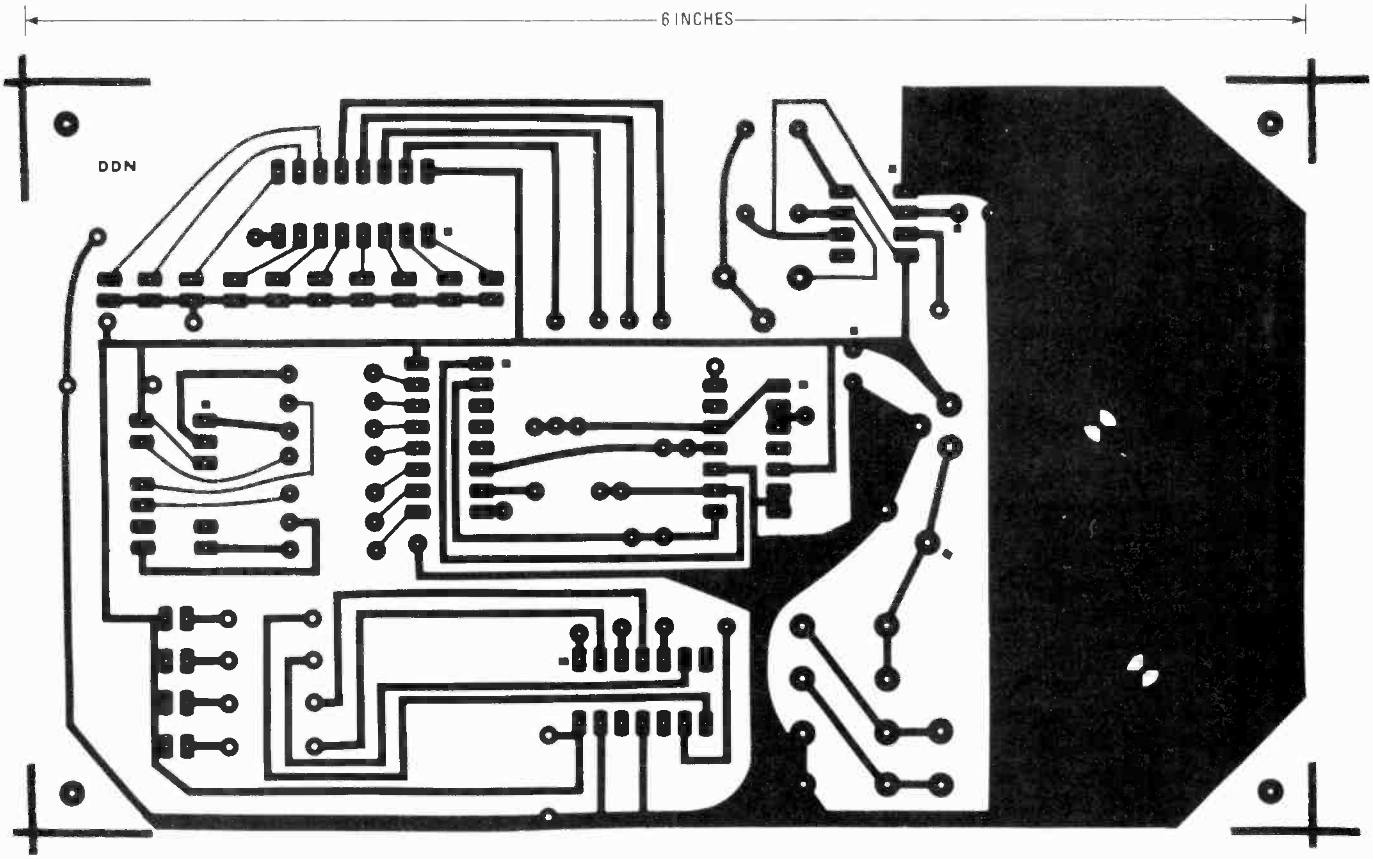


FIG. 2—FOIL PATTERN FOR THE PRINTED-CIRCUIT BOARD is shown full-size. You can copy it photographically or use any one of several transfer methods that can be used to either copy of "lift" the pattern directly from this page.

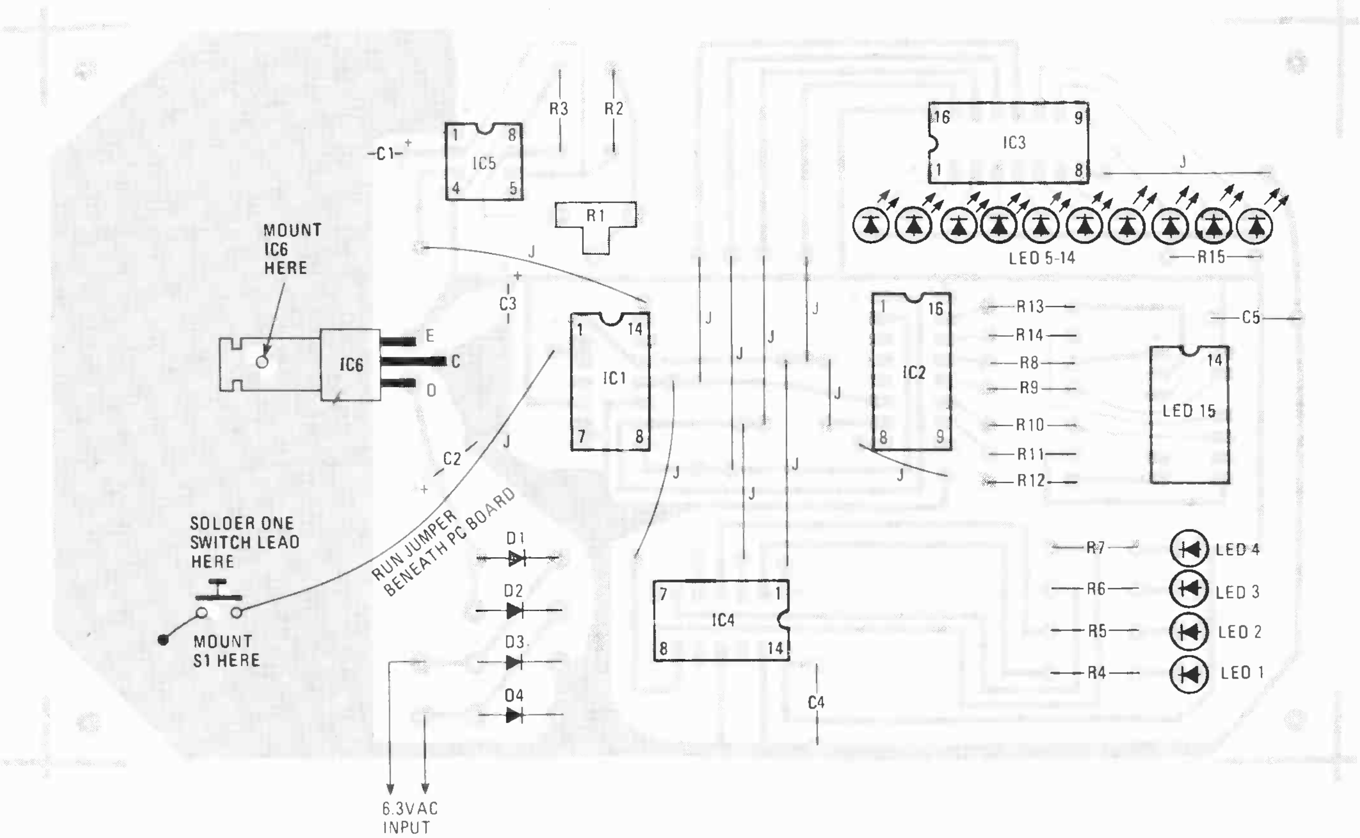


FIG. 3—WHERE PARTS ARE LOCATED on the top or component side of the PC board. Although IC's are wired directly to the foil, we recommend using IC sockets so you can experiment and replace components when necessary. Don't omit the Jumpers.

IC2, a 7447, decodes the BCD input to display the familiar digits 0 through 9 using a seven-segment LED. IC3, a 74145, decodes its inputs to drive one of ten discrete LED's corresponding to the input code. Only one LED will be lit at a time, thus the need for only one current-limiting resistor, R15.

IC4, a 7404, is a hex inverter that is used to turn on LED's 1-4 to display each count in a BCD format. As many as three LED's will be lit at one time (for the digit 7) and they will all be dark for the count of 0. The inputs of the two unused inverters are tied low (grounded) via pins 11 and 13.

Construction procedures

Most projects go to some length to pretty-up the displays and hide all the IC's and internal parts inside a case. The Digital Do-Nothing, however, has a definite appeal by baring it all, so to speak. Except for the power transformer and its attendant dangerous 117 VAC primary voltage, all the parts are visible for examination, explanation and testing.

A PC board (Fig. 2) is recommended due to the numerous connections involved and will result in a better completed unit. Additionally, IC sockets are suggested, particularly if the Digital Do-Nothing will be used for classroom study or built with doubtful quality, surplus parts, which may have to be replaced.

Assemble the PC board while carefully noting the orientation of pin 1 of the IC's and the positive ends of the electrolytics (see Fig. 3). These are identified by a dot on the foil side of the board. Use care when soldering the LED's—they're very sensitive to overheating.

PARTS LIST

RESISTORS: ¼ *W 5% unless noted.*
R1—100,000 ohms, trimmer, vertical mount
R2—10,000 ohms
R3—1000 ohms
R4-R15—150 ohms

CAPACITORS
C1, C3—10 μF, 10 volts, electrolytic
C2—2200 μF, 16 volts, electrolytic
C4, C5—.01 μF, ceramic disk

SEMICONDUCTORS
LED1-LED14—Red LED XC526R or equivalent, .200 in. diameter or smaller
D1-D4—1N4001, 1-amp, 50-volt diode
IC1—7490 decade counter
IC2—7447 BCD-seven-segment decoder/driver
IC3—74145 BCD-decimal decoder/driver
IC4—7404 hex inverter
IC5—NE555V timer
IC6—7805 or LM340-T 5-volt, 1-amp regulator
LED15—0.3-in., common-anode 7-segment display, DL707 or equivalent
T1—6.3-volt, 1-amp transformer, Calectro D1-745 or equivalent
S1—Normally-closed, momentary pushbutton switch

MISCELLANEOUS: Case, line cord, IC sockets, terminal strip, hardware

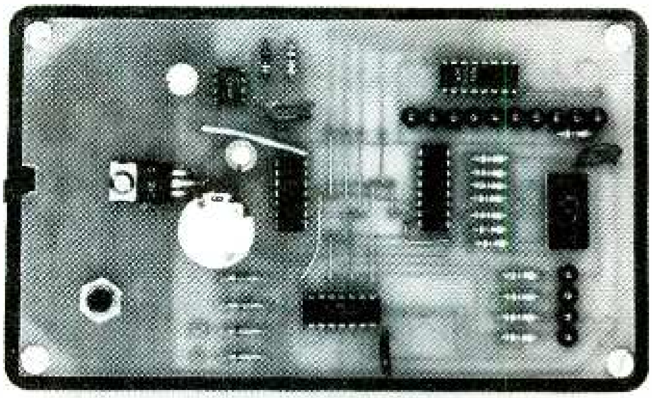


FIG. 4—TOP-VIEW PHOTO shows the locations of all the on-board components. The trimmer resistor (approximately top center) controls the clock speed and, thus, the counting rate.

The negative, or cathode, end of most LED's is identified by a slightly longer lead and/or a notch or flat spot on the plastic near the lead. If any of them will not light during check-out, it's reasonable to assume that the LED, and not the IC, is at fault. After installing the above identify the location of each jumper and install it. If you used IC sockets, insert the IC's as shown in Fig. 3.

Use heatsink compound on IC6 to help conduct heat away from it. Secure the IC to the board as shown in Fig. 4 with a 6 × 32 screw and nut.

Mount the transformer inside the box and use a terminal strip for tie points. Make sure the transformer is small enough to fit within the box without shorting to the PC board. It must be less than 1-5/8 inches tall.

After assembly is complete, carefully recheck all connections and polarities. If you've used IC sockets, leave IC's 1-4 out of the circuit and plug in the AC cord. Check the output of the regulator and make sure that the V_{CC} pin of each IC is receiving five volts. Then unplug the cord and insert the IC's.

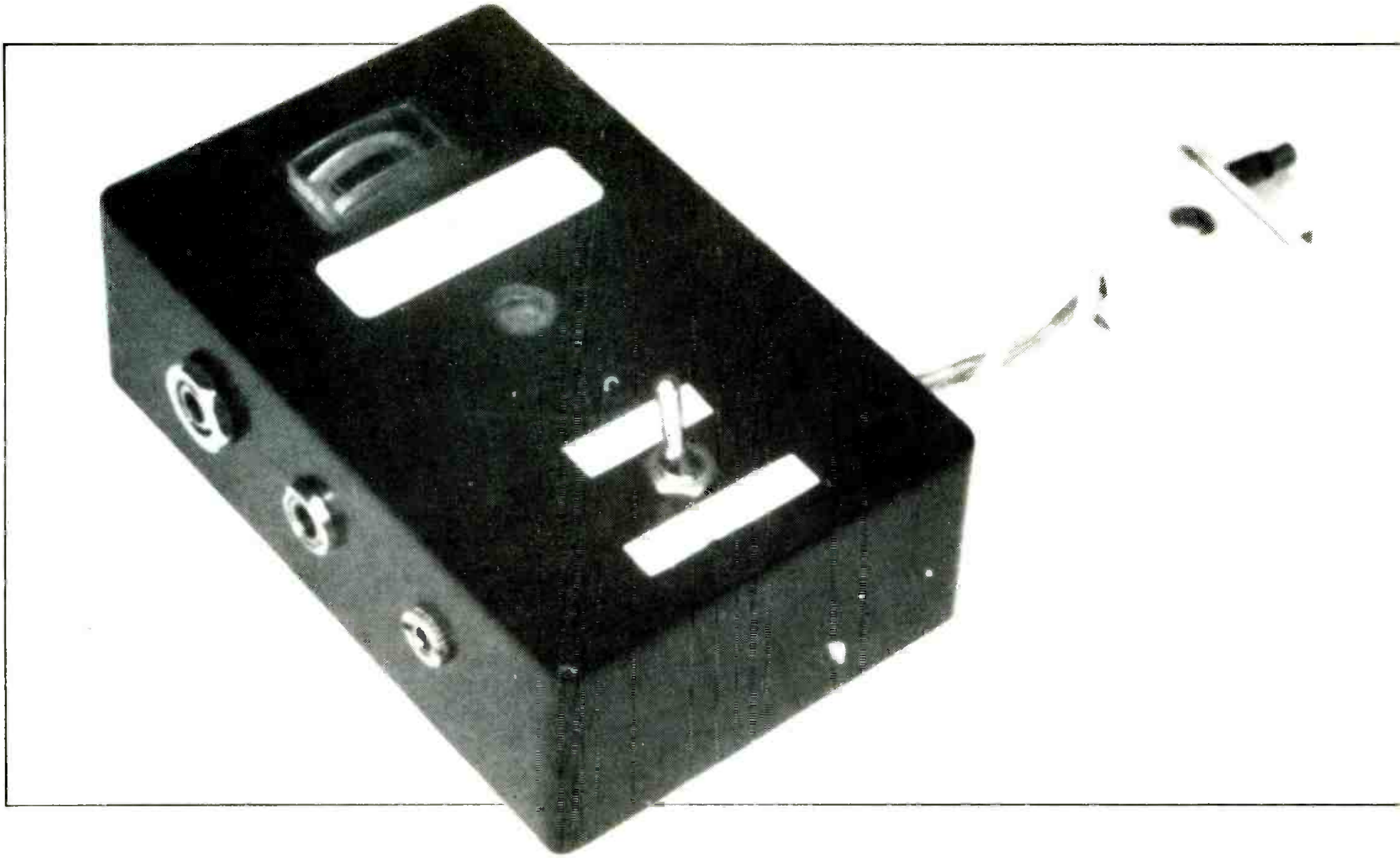
The circuit draws as much as 500 mA, depending upon what number is being displayed. This can result in IC6 becoming warm to the touch. That shouldn't cause any concern since the IC internally limits its current and will automatically shut down if it becomes too hot but it is best to allow plently of free-air circulation around the IC.

Let's put it to work

Plug in the AC cord and adjust trimmer R1 for a comfortable clock rate. The momentary switch, S1, will reset all displays to zero any time it is pressed. No harm will result from pressing the button as often as you like.

There are exposed voltages of 6.3 VAC and 5 VDC, which are not normally dangerous. Nonetheless, care should be exercised in handling the board to prevent injury.

You can use the Digital-Do-Nothing as an attention-getter or teaching device. It also makes a great "first project" for anyone wanting to build his first printed-circuit board or digital project. **SP**



TRS-80 AUDIO-VISUAL

FRED BLECHMAN, K6UGT

ALTHOUGH THE RADIO SHACK TRS-80 MICROCOMPUTER System has many features for a low price, various design compromises were made to keep the price down. The recording and playback of cassettes is clumsy at best, requiring that you pull plugs from the recorder to move the tape when it's not under computer control, or to monitor the signals. Also, the loading signal voltage is critical, especially in Level II.

The *Audio-Visual Control Box* described here does the following:

1. **Eliminates plug handling** by providing a manual switch to control the recorder motor.
2. **Allows you to hear the tape signals** during both record and playback *CSAVE and CLOAD).
3. **Provides a "signal level meter"** for reliably loading programs from tape, especially for Level II machines.
4. **Visually alerts you** when any recorder buttons are depressed and the computer has stopped the recorder motor.

No modification whatever is required to the TRS-80 system, since the *Control Box* is simply inserted between the existing TRS-80 cable plugs and the recorder jacks. Also, the total cost, using all new parts, is under $15!

How it works

The schematic (Fig. 1) shows the basic no-frills design. No batteries or active circuits are involved. To describe how it works, assume that the *Control Box* is installed between the computer plugs and the recorder jacks, and that you're playing a tape into the computer (CLOAD or INPUT#). The tape signal comes out of the recorder earphone jack into P1. The earphone makes the signal audible, and output transformer T1, operating "backwards", steps up the output voltage. Diode D1 rectifies the signal to pulsating DC for indication on meter M1. Potentiometer R1 is a calibration control.

Nothing at all is happening at J2 at this time. Switch S1 would be in the "AUTOMATIC" (open) position, since

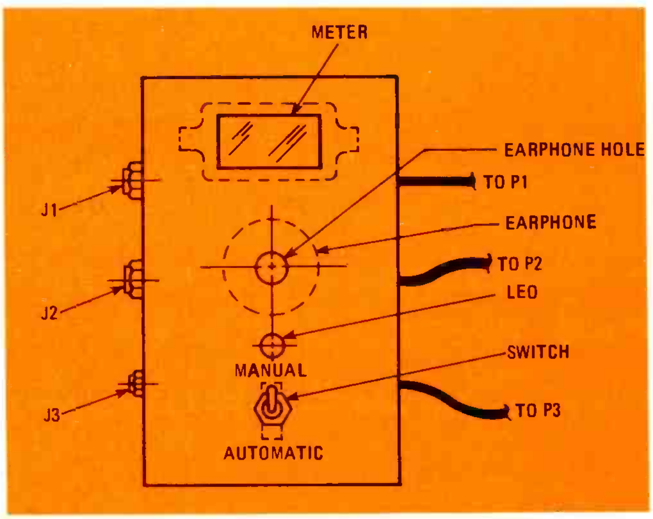
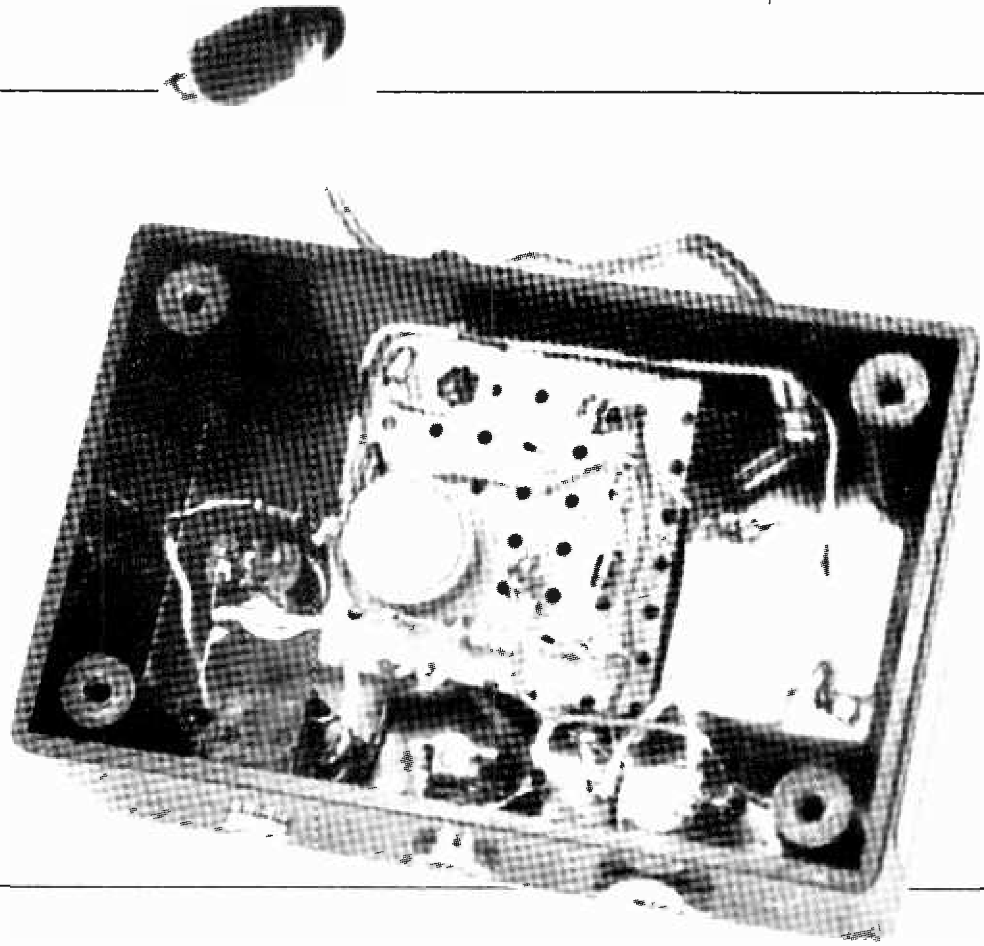


FIG. 1—DRAWING OF THE FRONT PANEL shows the locations of most of the components and how they are mounted on the panel and sides of the case.



CONTROL BOX

you are letting the computer control tape movement. The TRS-80 internal relay is closed, to run the recorder motor, and the relay contacts act as a direct short circuit across J3. No voltage appears across the series combination of resistor R2 and the LED, so the LED is dark.

When the tape reaches the end of its "message" to the computer, the TRS-80 relay contacts open, so J3 is an open circuit. Since the recorder "PLAY" key is depressed, voltage appears across R2-LED and the LED glows. This reminds you to press the recorder's STOP key. Leaving the recorder set for PLAY or RECORD without the motor running is harmful.

Now, suppose you want to rewind the tape. Just place S1 in the MANUAL (closed) position and press the recorder REWIND button. By just putting the switch into the MANUAL position you can exercise full recorder keyboard control, bypassing the computer relay.

How about recording on tape? The signal comes from the computer gray mini-plug through J2 to P2 and into the recorder auxiliary jack. As the signal is being recorded a monitor signal appears at the earphone jack. This is heard from the earphone, and also reads on the meter. In that case volume adjustment is not required since the recorder has automatic volume control, and the meter reading is not critical. The switch should be in the AUTOMATIC position.

Construction techniques

Any small box will do for a cabinet. Cut and file a rectangular hole in the top face of the cabinet and mount the meter into position (see Fig. 1 and the photos for suggested layout). I used glue to hold the meter, but mounting ears on some small meters allow the use of small screws.

Mount the three input jacks (they may be either open-circuit or closed-circuit types) on the left side of the box, with the LED and switch on the top. Also, make a ¼" diameter hole in the top of the box for the earphone to "play" through. Prepare the earphone by cutting off the projecting part that normally goes in your ear, and glue the earphone into the case directly below the earphone hole. That will allow the sound from the earphone to be loud enough to be useful, but not loud enough to be annoying.

The transformer, diode, and potentiometer can be mounted on a piece of perforated board and wired to the meter and J1. Position the potentiometer so it can be set during calibration. Wire according to Fig. 2, being careful to observe polarity for D1, LED and M1—and don't forget the LED dropping-resistor R2.

Assembly is completed by bringing wires through small holes in the right side of the box and soldering the wires to the plugs as shown in Fig. 2, being careful to connect the correct wire to the tip and sleeve of each plut. No shielded wire is required, and J2-P2 are connected with only a single wire to avoid a ground loop.

Calibration and use

If you have a calibrated oscilloscope connect it across the earphone, J1 or P1 and play a known-good

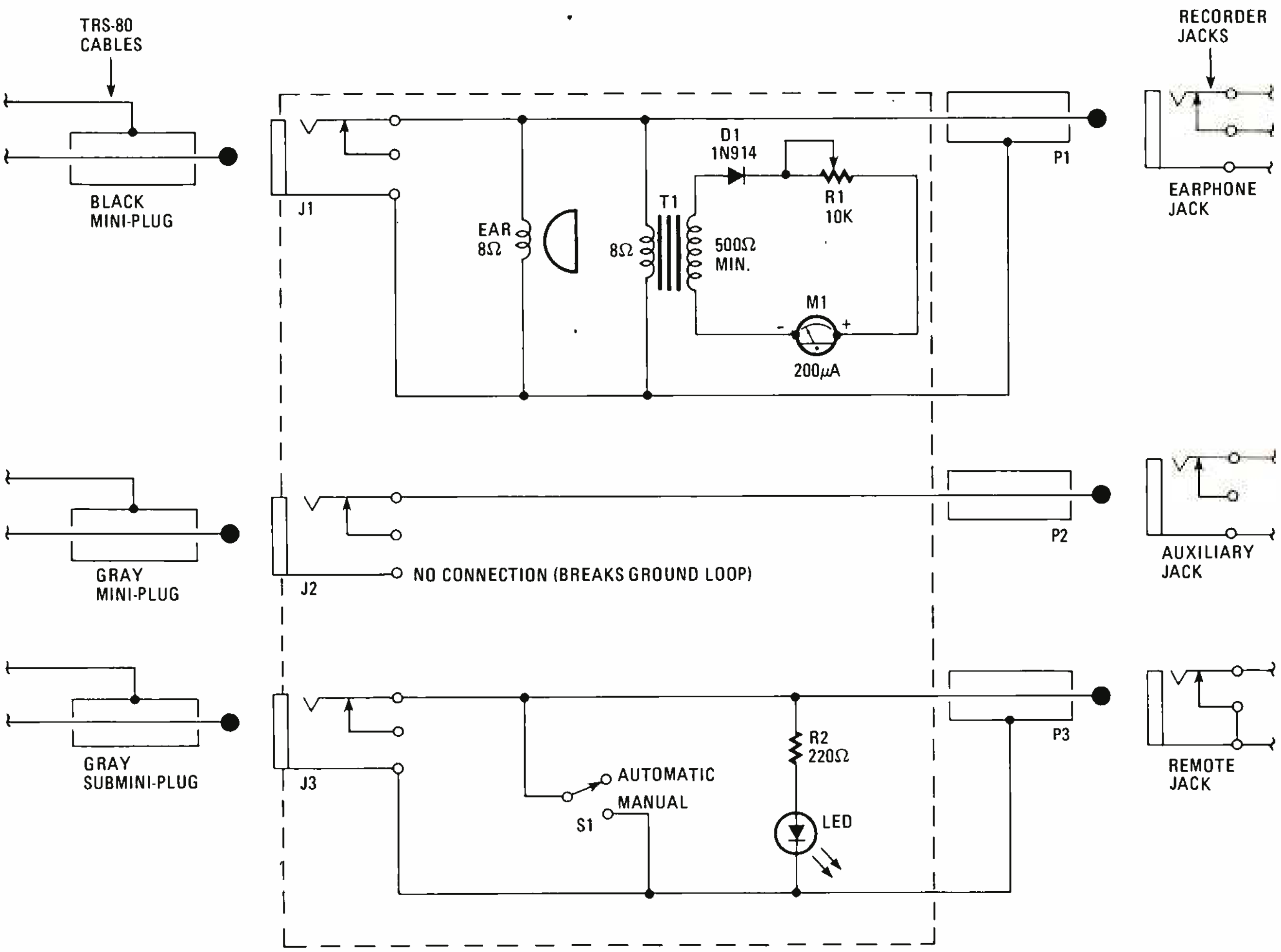


FIG. 2—SCHEMATIC DIAGRAM OF THE AUDIO—VISUAL CONTROL BOX. This device is an interface between the TRS-80 microcomputer and the cassette recorder. It provides instantaneous control of the recorder and lets you hear the signals.

PARTS LIST

	Radio Shack #	Calectro #
Plastic cabinet, approx. 3" × 2" × 1"	270-230	H4-723
EAR—8-ohm dynamic earphone	33-175	Q4-215
T1—subminiature audio output transformer, 8:500 or 8:1000 ohms	273-1380	D1-712
M1—200 uA subminiature meter	—	D1-901
D1—signal diode, 1N914 or similar	276-1122	J4-1610
R1—10,000-ohm subminiature trimmer pot	271-218	B1-644
R2—1/2 watt carbon resistor, 220 ohms	271-000	B1-386
J1, J2—miniature open or closed circuit jacks	274-292	F2-842
J3—subminiature open or closed jack	274-251	F2-845
P1, P2—miniature phone plug	274-286	F2-821
P3—subminiature phone plug	274-289	F2-826
S1—SPST subminiature toggle switch	275-612	E2-116
LED—jumbo red light-emitting diode	276-041	J4-940
—Perforated board, 1¼" × 1¼"	276-1395	J4-601

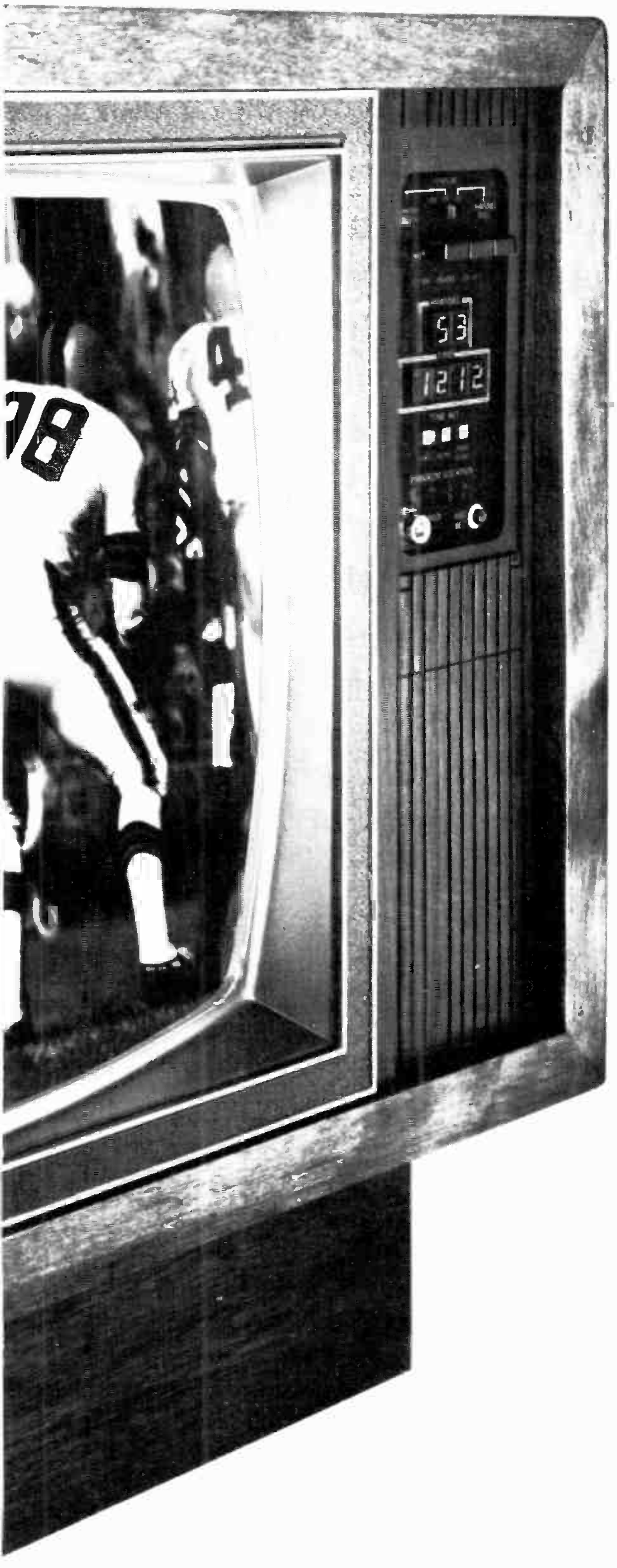
computer tape into the computer. Adjust the recorder volume control for 2 volts peak-to-peak on the oscilloscope, then adjust potentiometer R1 for the meter to read about ¾ scale. Note this meter reading, since that will be your desired recorder-to-computer setting, regardless of whether you're in Level I or Level II.

If you don't have an oscilloscope you simply find the proper loading level by trial and error, and set R1 for the desired meter reading at that signal level. From then on, any good tape fed into the computer at that meter reading should load properly. Since the output level of tapes can vary, all you do is adjust the recorder playback volume until the meter reading is where you know it should be and the computer is receiving the proper signal voltage.

You'll very quickly find that this *Control Box* is worth ten times its cost in eliminating the frustration and unreliability of tape operation, especially in Level II. You'll be able to do other things while you *listen* to the tape playing into the computer during loading—and a bad tape is very obvious from the abnormal sound. The meter will allow you to load with confidence. During CSAVE you'll also hear the computer "talking" to the recorder, putting the signal on tape. No more watching the display for a READY. The switch give you positive recorder control without constantly pulling (and wrecking!) plugs and jacks. **SP**

New from NRI! 25" color TV that tunes by computer, programs an entire evening's entertainment.

DIAGONAL



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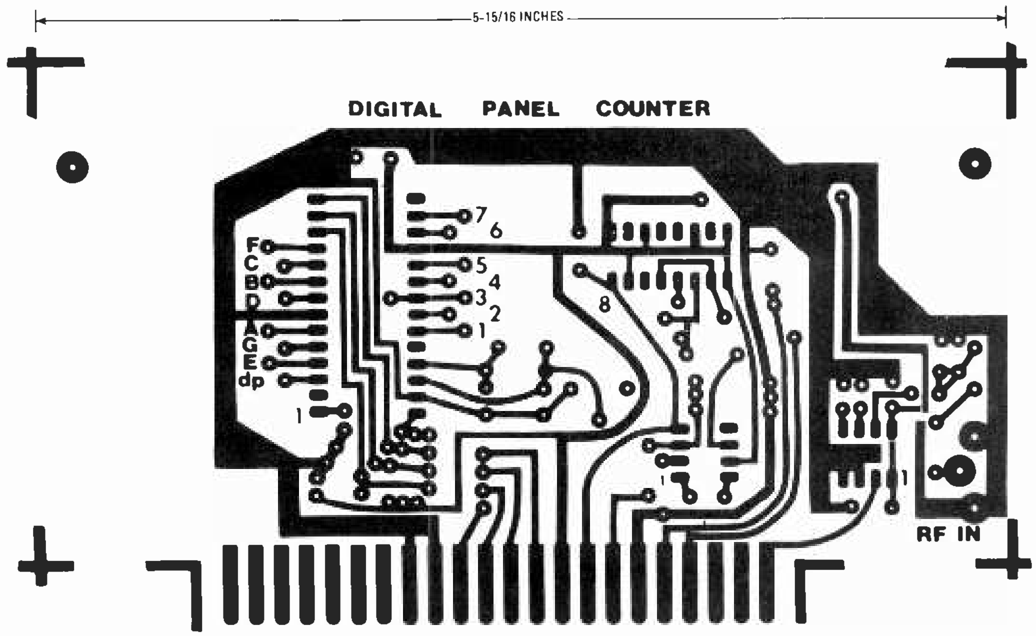


DELUXE PANEL COUNTER

Easy to construct using readily available components, this simple frequency counter will be a valued accessory for small signal generators, function generators and radio transmitters.

GARY McCLELLAN

IN CASE YOU HAVEN'T NOTICED, A QUIET REVOLUTION has taken place in the lowly frequency counter. Until now, counters required rows and rows of TTL IC's, and that meant accuracy-robbing heat, and high complexity. Then there was the cost of assembly and of all those parts. Thanks to a new development from Intersil, all those parts have all been combined into a single IC! At last you can buy all the counter logic-circuitry in a single package—from time-base oscillator to display drivers. That means lower cost and easier construction for a high-quality counter. And, since the chip is CMOS, power drain is slashed, the chip runs cooler, and there is less heat to affect accuracy.

To go with this new IC we are offering a revolutionary idea in frequency counters. We call our project a *D*eluxe *P*anel *C*ounter, or DPC, for short. The counter is unique in that it is small enough to be mounted in many types of existing equipment, such as your signal generator or radio transmitter. And its construction, with separate display and electronics board, makes the installation easy. If you prefer, the project can fit very nicely in its own small box. Add a battery power supply and *voila!*...you have a nice portable frequency counter. You can probably find many other places for this counter; it is just palm-size. And, there is plenty of equipment that can benefit from a "dedicated" frequency counter. Where could you use something like this?

Besides all IC construction and small size, our DPC offers a wide range of delightful extra features.

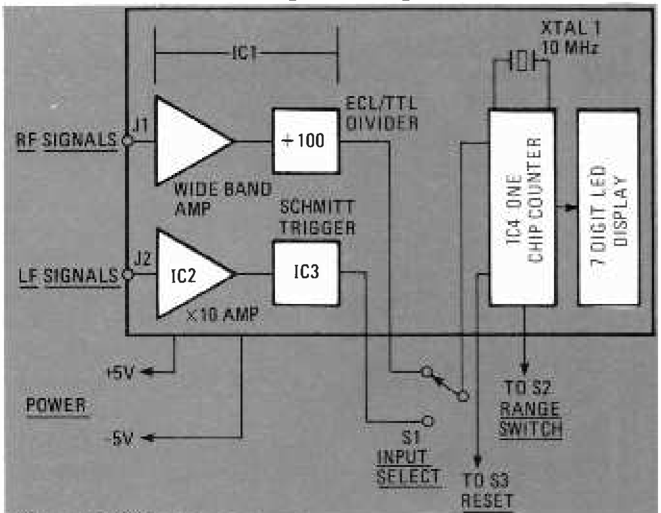


FIG. 1—BLOCK DIAGRAM of the basic frequency counter. There are separate inputs for audio-and radio-frequency signals. Selectable gate speeds set measurement speed and accuracy.

For one thing, you can measure frequency over a very wide range—from DC to over 135 MHZ! The counter features two separate inputs to permit maximum performance over its entire operating range. At the low-frequency end, there's a DC-coupled input with industry standard 1-megohm input impedance. There's an external adjustable trigger-level control for sensitivity control on either positive-or negative-going signals Plus, there's an overvoltage protection circuit to prevent damage in the event of overload. This input cir-

PARTS LIST (DPM)

RESISTORS
All resistors ¼W 5% unless noted
R1—100 ohms
R2, R5, R19, R20—10,000 ohms
R3, R8—1 megohm
R4, R9, R21, R22—1000 ohms
R6—47,000 ohms
R7—100,000 ohms
R10-R17—180 ohms
R18—22 megohms
R23—15,000 ohms, potentiometer, linear taper

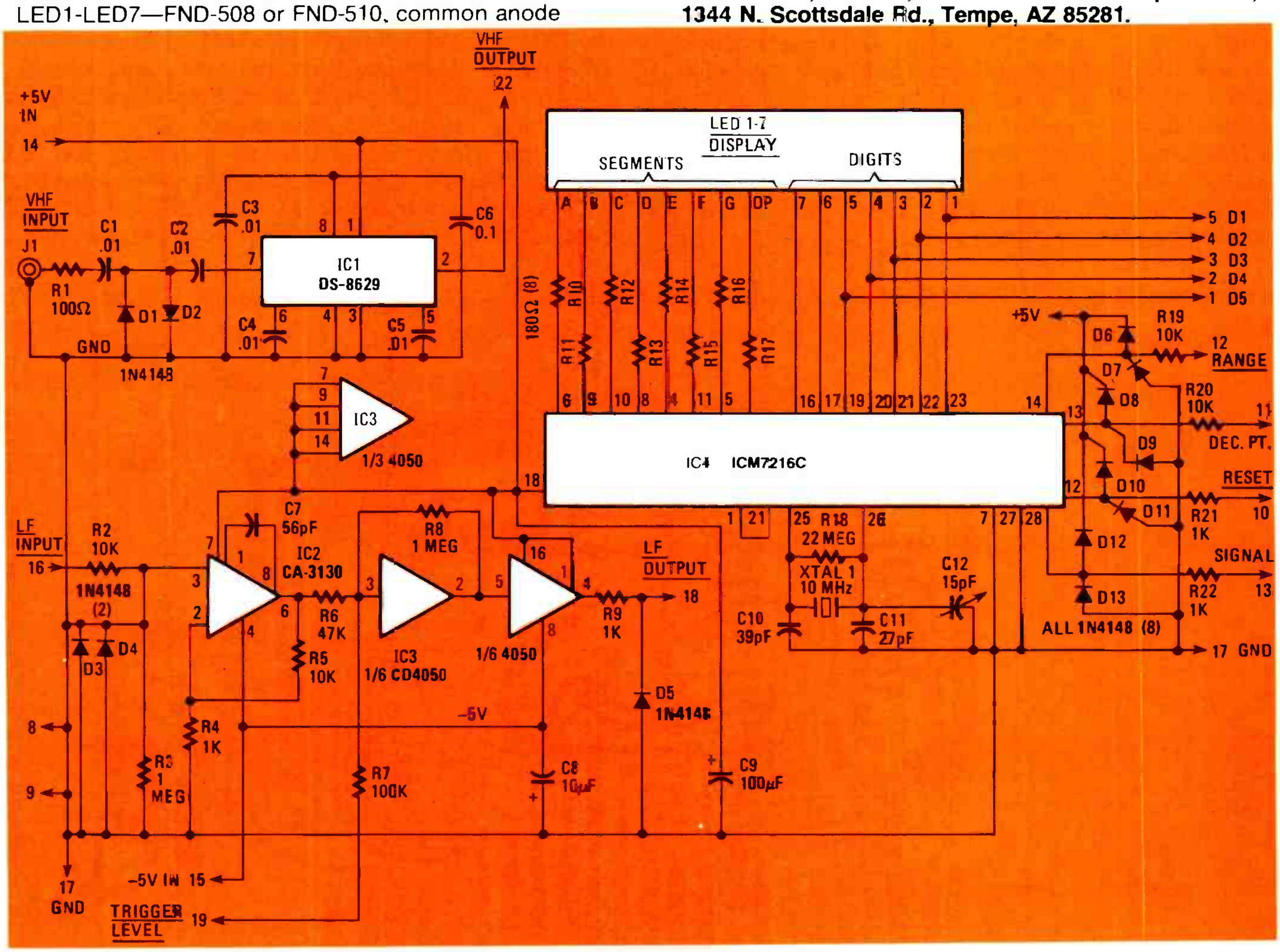
CAPACITORS
C1-C5—.01 μF, 50 volts, ceramic disc
C6—0.1 μF, 25 volts, ceramic disc
C7—56 pF, 1 kV, ceramic disc
C8—10 μF, 16 volts, tantalum
C9—100 μF, 6.3 volts, tantalum
C10—39 pF, 500 volts, mica
C11—27 pF, 500 volts, mica
C12—8-15 pF trimmer (Erie 650-8-15 or equivalent)

SEMICONDUCTORS
D1-D13—1N4148 or 1N914
LED1-LED7—FND-508 or FND-510, common anode
IC1—DS8629N VHF prescaler (National)*
IC2—CA3130AE op amp (RCA)
IC3—CD4050 CMOS hex buffer
IC4—ICM7216C LSI counter (Intersil)
J1—PC-mount RCA jack
S1—DPDT mini-toggle switch
S2—four-position, three-pole rotary switch
S3—SPST N.O. momentary pushbutton switch
XTAL1—10.000 MHz crystal, HC-18/U case, parallel-resonant, 25 pF loading capacitance

MISCELLANEOUS: PC boards, 22-pin edge connector, two 8-pin IC sockets, one 16-pin IC socket, one 28-pin IC socket, aluminum for brackets, wire, solder, etc.

NOTE: A set of industrial-quality, fully-plated and drilled PC boards for the DPC is available from Technico Services, P.O. Box 20 HC, Orangehurst Station, Fullerton, CA 92633 for $12.00 postpaid. CA residents please add 6% tax. No COD's. Foreign orders add $3.00 for special handling and postage.

***IC1 is available from, among others, Tri-Tek, Inc., 7808 N. 27th Ave., Phoenix, AZ 85021 and Circuit Specialists, 1344 N. Scottsdale Rd., Tempe, AZ 85281.**



COMPLETE SCHEMATIC DIAGRAM of the digital counter. This is a handy add-on accessory for signal generators and transmitters. Range-switching, not shown, is a selectable option.

cuit is good to over 1 MHz, and the sensitivity is adjustable from 20 mV and up. Such performance and capability have not been available in any published counter until now! And that is just the beginning!

At about 100 kHz there is another input circuit that takes over. With this input, you can measure signals from 100 kHz to over 135 MHz, with sensitivity to spare—typically 20 mV at 135 MHz and only 5 mV at 27 MHz. This counter works very well with just a short whip near radio transmitters; if that is your area of interest, you'll be pleased. Of course there's input overvoltage protection, and a low input-impedance for maximum performance at VHF frequencies.

The display's something special, too. There is a seven-digit, half-inch LED display for easy reading, for starters, and leading-zero blanking of unused digits, so they are turned off to save battery or line power. A very important bonus is a feature hardly ever found on low-cost counters like this one—a timebase selecter switch. Most counters leave you with a 1-second gate time, which is too short for audio frequencies, and too long for radio frequencies. Our DPC offers a 10-second gate time for audio so you can read frequencies like 60 Hz as "60.0 Hz" for better accuracy. In addition, you get selectable settings of 1 second, 0.1 second, and 0.01 second for optimum speed in measurement with desired accuracy. Why not join the revolution and build our high-performance counter today? If you do, you'll have something to be proud of!

Construction of the DPC is easy and straightforward. In fact, thanks to two PC boards, it is almost kitlike. There are four IC's that make up the bulk of the circuitry, plus a few other parts. To simplify this project even further, careful layout of the PC boards has resulted in only a few jumpers. In fact there are no jumpers directly on the display board! So this project should be easy for you to build.

The DPC was designed specifically to use only readily available components. True, a new-type IC is used, but the parts list gives suppliers' names and addresses for this and several other items that could be hard to find. That makes things a whole lot easier.

A look at the circuitry

As mentioned before, the DPC is based on a single IC that contains the essential electronics for a complete frequency counter. To this, we add three more IC's to give VHF counting and low-frequency counting ability. Other than a few extra diodes, there are no other semiconductors in this counter.

Figure 1 shows a diagram of the basic DPC configuration. As mentioned before, the counter has two separate inputs—one for low frequencies up to 100 kHz, and one for frequencies of 100 kHz to over 135 MHz. The reason for two separate inputs is that it is difficult and expensive to design a single wide-range input circuit. With two inputs, we can optimize each for maximum performance, and, at the same time, reduce the cost. If you wish to measure RF signals from 100 kHz up, you connect them to jack J1. The signal enters IC1, a combination preamp and ECL/TTL prescaler chip. There, the signal is amplified and divided by 100. The result appears at switch S1, which selects VHF or low-frequency input signals.

On the other hand, if you have a signal that lies in the DC to 100 kHz range, you would connect it to the LF input, J2. From this point, the input signal is amplified by op amp IC2, and converted into a logic signal by Schmitt trigger IC3. The output of IC3 appears at switch S1, providing the low frequency source. After the desired signal range is selected by switch S1, the input drives a one-chip counter, IC4. This chip contains the complete frequency-counter circuitry:

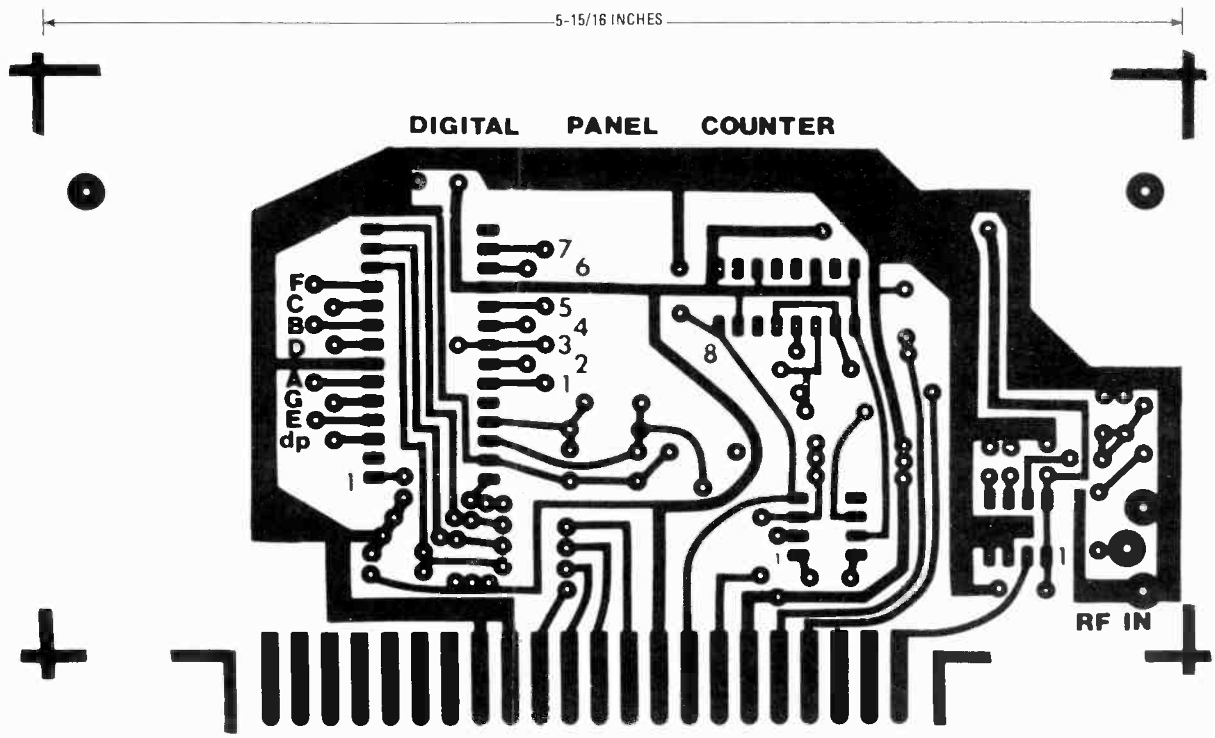


FIG. 2—FOIL PATTERN to be used when etching the circuit lines for the main counter board.

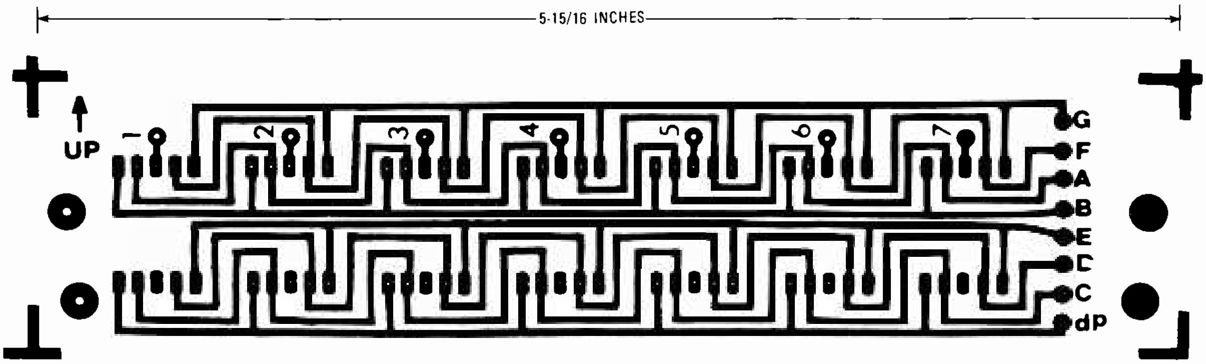


FIG. 3—USE THIS FULL-SIZE PATTERN to etch the display board of the deluxe panel counter.

That includes a crystal oscillator, time-base divider, control logic, 8 decade counter, 8 latches, and display-multiplexing circuitry. Care to build that up with TTL? You would need a boardful of IC's!

The counter accepts the signal from S1 and determines its frequency. That frequency is displayed on a 7-digit LED readout. The internal timing and accuracy of the counter IC are determined by a 10-MHz crystal, XTAL1. The IC also provides several control functions, such as an external reset, decimal, point drive in the display and timebase select. The reset function is controlled by an external switch, S3, and, when activated, resets all counters to zero. This feature is especially valuable when you use the 10-second gate time, where your measurements require ten seconds. Thus, you reset the counter and display to zero after connecting your signal, clearing the counter, and your first reading, in ten seconds, is accurate. There is an input on the chip for the decimal-point drive, and when used in conjunction with the range switch, S2, it properly positions the decimal point on the display. This function eliminates a few extra parts, reducing cost. The timebase function on the chip selects the counter gate-time (how long the counter counts signals before displaying them). This unit provides gate times of 10 seconds, 1 second, 0.1 second and 0.01 second, all selected by range-switch S2. That takes care of the DPC circuitry basics.

Let's dig deeper into the counter circuitry, and look at the schematic and some of its key components. Like all other professional-quality counters, this one has input overload protection. In the DPC, resistor R1, capacitor C1, and diodes D1/D2 protect the prescaler IC from damage. Similarly, resistor R2 and diodes D3/D4 protect the op-amp from overloads. These protection networks work on the principle of *V-I limiting*, meaning that the diodes limit the voltage, while the resistors limit the current. This provides good protection against over-strong signals. Prescaler IC1 is a unique product. It was originally designed for frequency-synthesized FM tuners, but it well-suited to this application. It has an internal preamp and a divide-by-100 prescaler. Thus, 100 MHz in becomes 1 MHz out, allowing the counter to measure VHF frequencies, while using a slower CMOS counter IC. At the low-frequency end, op-amp IC2 serves as an × 10 amplifier. Resistors R4 and R5 set the gain. The frequency bandwidth is determined by capacitor C7, and is optimized for best bandwidth. IC3 is in a circuit you may not have seen before—a CMOS Schmitt trigger. This circuit takes advantage of the fact that a CMOS output will change state when you apply to its input a signal in the range of 45% of the IC's supply voltage. All that is needed are resistors to set the hysteresis level, or trip point, and they are R6, R7 and R8. An external trigger-level control permits changing the hysteresis point to allow for different types of signals.

There are a few external connections to the main IC that you should be aware of. First, a jumper between pins 1 and 21 programs the IC to activate the decimal-point circuitry. Then, a simple crystal oscillator circuit, consisting of C10-C11-C12 plus crystal XTAL1, generates the 10-MHz signal that provides the gate-time signal, display multiplexing, and other internal functions. Resistor R18 provides the required biasing for the CMOS oscillator. The control function inputs are next, with the RANGE function first. This input allows you to select the gate time of your counter. By connecting this pin to different digit lines on the display, you control the length of time the gate is open. The same is true with decimal-point positioning on the DECIMAL POINT input; any decimal point in the display can be selected by connecting this input to the appropriate digit line. The RESET line is simply shorted to ground via a normally-open switch to activate that function. The SIGNAL INPUT requires a logic-level signal. With this IC, you can go as high as 10 MHz.

The rest of the counter-chip input circuitry is a simple V-I limiter consisting of diodes D6 thru D13, and resistors R19 thru R22. These extra parts are desirable, since the CMOS IC is static-sensitive, and can be damaged either by static charge if its pins are left floating or by excessive voltage.

Construction techniques

Thanks to that one LSI IC, this counter will assemble quickly. For best results, you should use PC boards to speed construction. For your convenience, foil patterns have been supplied (Figs. 2 and 3).

Your first step in construction should be to duplicate the two PC boards. After exposure, development, and etching, cut the board to size and drill all holes. Use a No. 64 drill on all holes except the two display-mounting holes, where you can use a ⅛-inch drill. Finish by trimming the board to fit the PC edge connector, and solder-plating the connecting fingers (if you wish).

One of the nice things about this project is that you can customize the DPC to suit your needs. Want only a VHF counter? Leave out the IC2-IC3 circuitry. Need only a low-frequency counter? Leave out the IC1 cir-

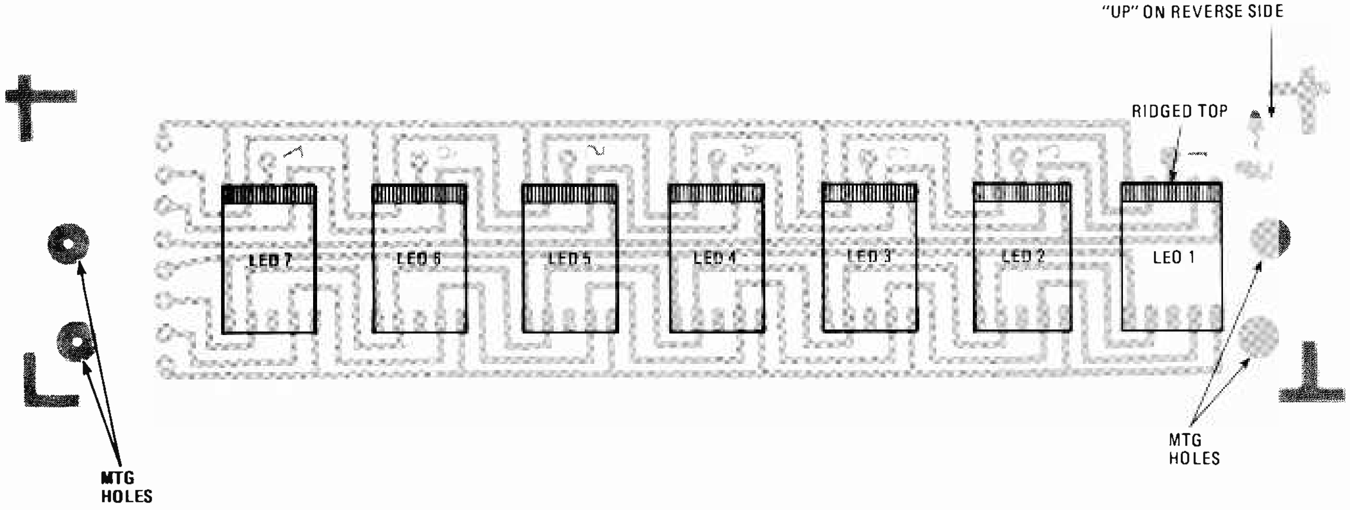


FIG. 4—PARTS PLACEMENT GUIDE for the seven-digit display board. The top edges of the seven-segment display devices are identified by a series of ridges or notches. A bezel and plastic filter improve appearance and readability.

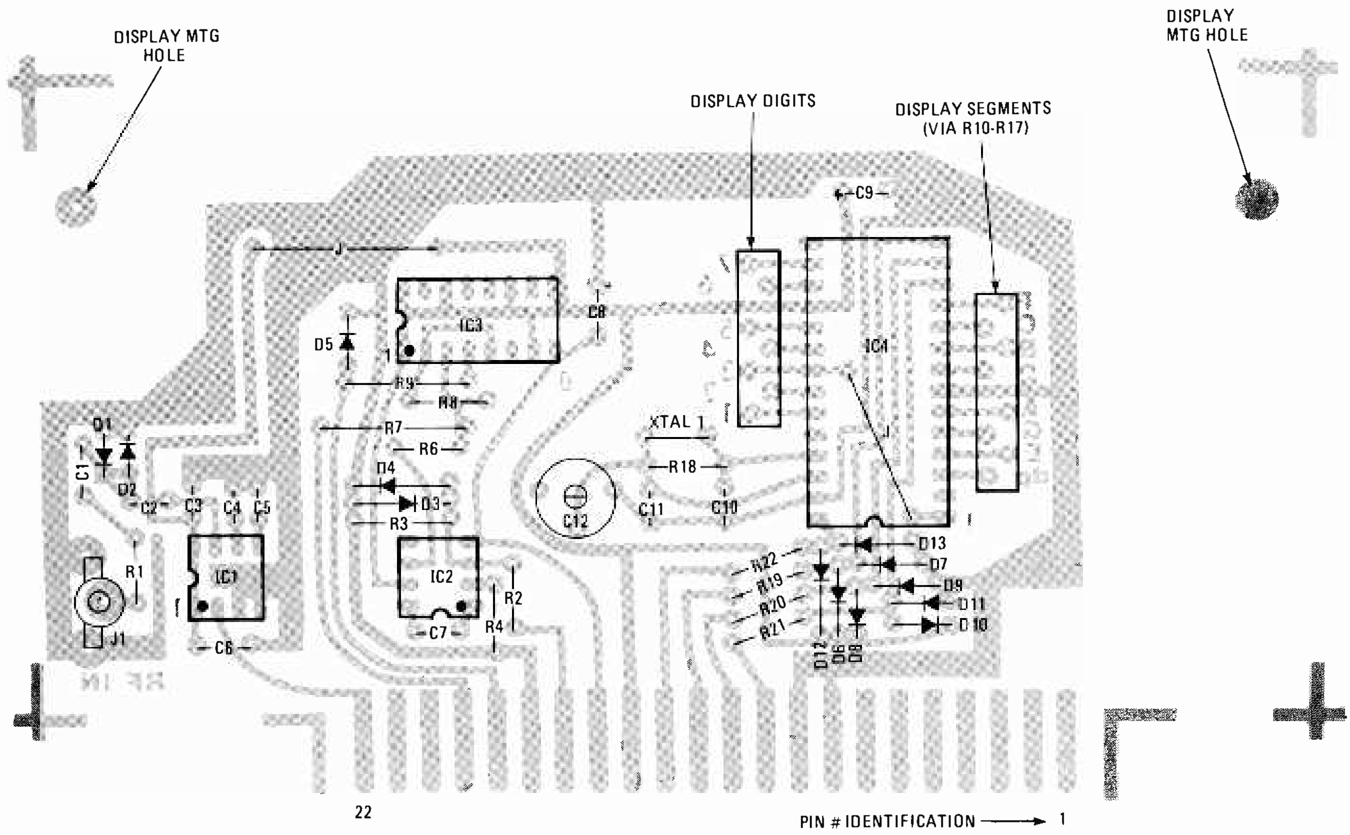


FIG. 5—HOW PARTS ARE POSITIONED on the main counter board. Double-check the polarities of diodes and electrolytic capacitors before soldering. Areas marked "display digits" and "display segments" indicate pads for external connections.

cuitry. And so on. By determining exactly what you need, you can save money; so determine what your requirements are before starting construction. We are going to assume that you want the deluxe version, so just skip over the sections not applicable to you during the construction phase.

Start by wiring the display board. Position this board as in Fig. 4, with the "Up" printed on the foil side to your right, but work from the "component side" of the board at this time. Insert display, LED1, in the farthest right set of holes. Note that the ribbed side of each display is at the top. *This is important!* Solder the display in place. Continue with the six other displays, making sure to keep the ribbed edges pointing up as you install them and that all displays are aligned. When you are done, check over your solder connection and set the board aside.

Next, do the main-board wiring. (Refer to Fig. 5 for details.) Position the board, component side up to match the illustration, and then install the two jumpers as shown. Be sure to install both, as an IC socket mounts over one of them. Install the IC sockets next,

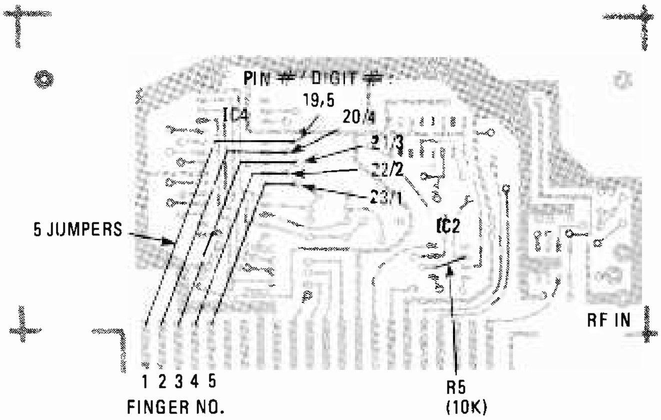


FIG. 6—JUMPERS ARE NEEDED to complete the connections between several points on the foil side of the counter board. Use thin insulated wires for making the jumpers from pins 19–23 on IC4 to fingers 1–5 on the PC board edge.

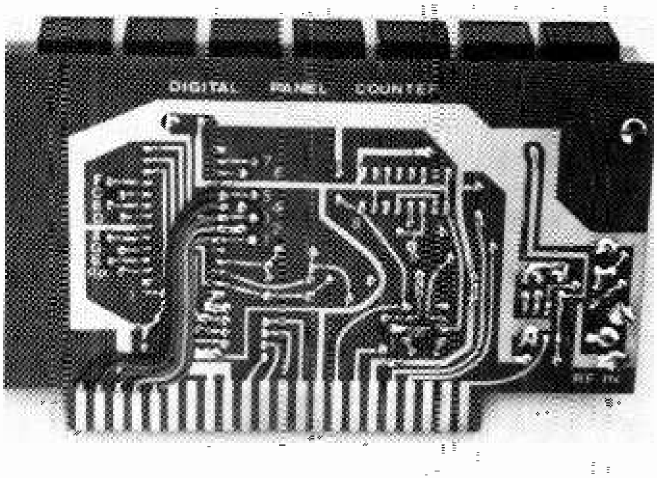


FIG. 7—PHOTO OF THE FOIL SIDE OF THE MAIN CIRCUIT BOARD with the five jumpers and resistor R5 in place.

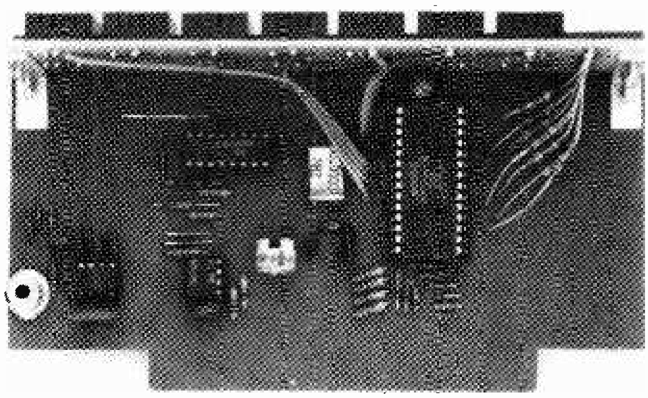


FIG. 8—PHOTO OF TOP OF MAIN BOARD also shows the rear of the display board and the angle brackets used to join the two boards.

starting with the 8-pin units. Mount one at the IC1 location, and then another at the IC2 location. Solder both. Install a 16-pin socket in the IC3 position and solder all pins. Finally, install a 28-pin socket at IC4 and solder. Visually check all connections.

Continue with RCA-type jack, J1. Mount it in the corner of the board, enlarging the mounting holes if necessary. Solder it in place.

The next big step is to install all capacitors. Start in the corner near J1. Mount C1, C2, C3, C4 and C5 first. Solder the leads and then clip them short. Move below the IC sockets and install C6 and C7. Solder and clip the leads. Jump up to the 16-pin IC socket and mount C8. Be sure to note polarity; if you don't you'll have to install another one soon! Then move down slightly and install trimmer C12. Note that quite a few trimmers will fit this space, including many imports, if you weren't able to find the unit specified in the parts list. Move over from the trimmer and install C11 and C10. Solder the leads and clip off the excess. Finish up the capacitors by installing C9. As always with tantalums, watch the polarity before soldering and trimming the leads. When you are through with capacitor installation, check to see that the units are in their proper places and that the polarities are correct on the tantalums. If there are any errors, correct them now and then continue with construction.

Next come the diodes. Note that all units on the board are the same type (1N4148); a bonus in that you won't have to dig up different types to suit the circuitry. Start at jack J1, as you did with the capacitors. Mount diodes D1 and D2 first. Note the position of the cathode bands. They point in opposite directions. Then move over to the IC 2 socket. Mount D3 and D4 as shown. Be sure not to mount D3 in resistor R3's place! When you have the four diodes in place, solder and clip the leads. Continue with D5, which mounts next to the 16-pin IC socket. Solder and clip the excess leads when it is installed. Jump over to the area between the 28-pin IC socket and the bottom of the board and install diodes D12, D6 and D8 with the bands pointing down. Solder and clip the leads. Then move over to the right and install D10 in the bottom set of holes. Note that the banded end of only *this* diode (in this section of the board) points to the right. When this diode is installed, continue with D13, D7, D9 and D11. Note that the bands on these four diodes point toward the *left* of the board. Solder and clip off the excess leads. Finish up by checking the diodes for proper installation and correct any errors.

The resistors come next. Move back to J1 and start with R1. Install it, then clip and solder. Move to the IC2 socket. Install R4, R2, and R3 next to it. Solder and clip off the excess leads. Move up over the two diodes and then install R6, R7, R8 and R9. Preform the leads of R7 and R9 with pliers before installation—they have to stretch over the board during installation. Solder and clip the leads. Move next to trimmer C12 for R18, which is installed next. Then do resistors R22, R19, R20 and R21. Note that R22 and R21 are *1K* units while R19 and R20 are *10K* values. Solder and clip off the excess leads. Finish up by double-checking the resistor placement. The display resistors, R10 thru R17, will be mounted shortly between the two boards you wired, so don't be concerned about them yet.

The last part to mount on the main board is crystal XTAL1. This goes in the space indicated in Fig. 5. Bend the body over so that it is flush with the surface of the board. Then solder the leads and clip off the excess. If desired, secure the crystal to the board with a drop of silicone rubber sealant.

Turn the main board over and refer to Fig. 6. First, mount resistor R5 across pins 2 and 6 on the IC2 socket. Cut the leads to about ¼-inch, and bend them before soldering this resistor in place. Next, five insulated wires must be attached between pins 19 through 23 on the 28-pin IC socket and PC-board fingers 1 through 5.

Ribbon cable is ideal for these interconnections. Refer to Figs. 6 and 7 as you make the connections. Cut each wire short so it lies against the bottom of the board. Then solder a wire end to the inboard end of each finger. Do not use too much solder as you will be putting an edge connector on these fingers later!

Now, the two boards can be mated together. Make two ¼-inch wide "L" brackets out of scrap aluminum to secure the boards. Then fasten them together as shown in Figs. 8 and 9. Complete the wiring by installing the 180-ohm resistors, R10 thru R17. Start with the "F"-segment resistor. Pass one end through the hole marked "F" on the main board. Then pass the other end of this resistor through the "F" terminal on the display board. Leave some slack in the resistor leads, as illustrated in Fig. 9, and solder in both places. Trim the excess leads at both ends. Repeat these steps for the other 7 resistors, working from "E" to "DP" and matching holes each time. The digit leads to the display board are next to be installed. Refer again to Fig. 9. If desired, a piece of ribbon cable can be cut for this job; the result makes for a neat assembly. Start with digit 1. Cut a wire slightly longer than necessary to run between the "1" printed on each board. Strip and tin the ends. Then solder one end at the "1" hole in the main board and then the other end at the "1"

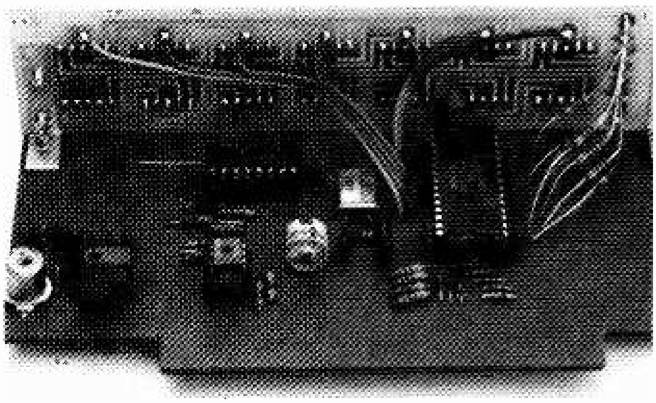


FIG. 9—ANOTHER PHOTO OF THE ASSEMBLED BOARDS. Leads of resistors R10 through R17 are left with some slack to relieve strain and facilitate handling.

hole in the display board. Continue in this manner until all seven wires are in place. Finish up assembly of your DPC by bending the segment resistors so their leads don't touch, and by checking the balance of the circuitry for errors.

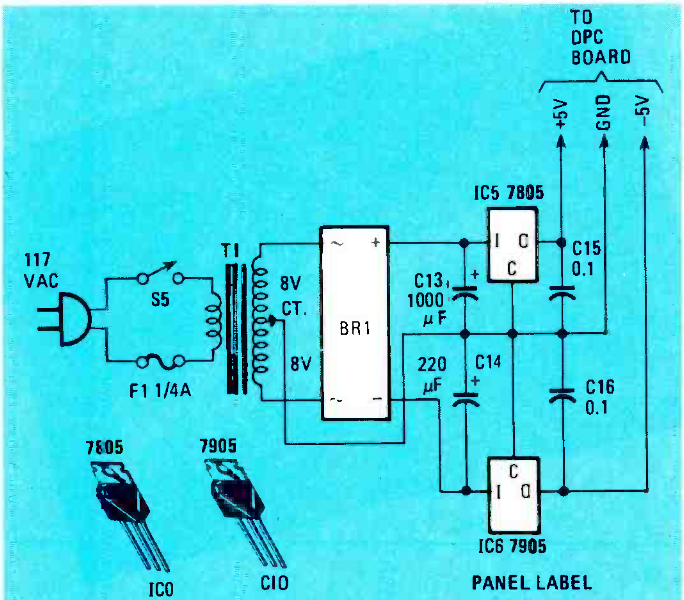
If desired, a power supply may be built for the DPC as shown in Fig. 10. It may be constructed on a 3- by 4-inch piece of perforated board if desired or mounted on the inside of the equipment you are installing the counter in. Component placement is not crucial. Use a heatsink for IC5, as it does dissipate some power. A piece of aluminum 1 inch wide by 4 inches high can be bent into a "U" shape and used for this purpose. The transformer suggested in the parts list has secondary voltages ideal for this power supply, and may be ordered directly from Signal. However, you may substitute a 24-volt, center-tapped, ½-amp-or-greater unit if you wish. If you do, be sure to raise the working voltages of capacitors C13 and C14 to 25 volts each to allow for the higher output of the 24-volt transformer. It might be wise to increase the size of the heatsink on IC5 at the same time. The rest of the power supply circuitry is straightforward and needs no comment.

Checkout steps

Before hooking power up to your DPC, take a moment to study Fig. 11. As mentioned before, this counter has many options for signal inputs. The input you use is determined by the signals you measure. Decide which hookup you want, or if you like, spend a little extra time and hook up the deluxe "everything" circuit shown in the first part of Fig. 11. Later, if you need your counter tailored to a more specific frequency range, you can use jumpers on the edge connector to get what you want without all those switches. In any case, make all the connections, including the decimal-point switching, to switch S2. Some of the early ICM-7216C chips (IC4) wouldn't light the display without decimal-point switching, and that can be disturbing during checkout! Probably by now this feature has been changed; but nevertheless, include all the connections to S2. After wiring the switches, connect the DPC to its power supply.

Before plugging in or turning on the power supply, take a moment to check the supply voltages at the IC sockets. If everything is OK, then you may install the IC's. To refresh your memory, refer back to Fig. 5 for proper location and orientation. Be careful with IC's 3 and 4, as they are CMOS. It might be wise to unplug the board from the edge connector before installing these IC's, as they are static-sensitive. Make double sure that IC4 is positioned correctly; the notch in the case points directly at the fingers at the edge of the board. It's no fun to blow an 18-dollar IC like this one due to misposition! Then reinsert the board into the edge connector.

Continue the checkout by powering-up the counter. The display should show a decimal point followed by a string of zeros to its right. The length of this string will change as switch S2 is rotated. If switch S1 is set to the VHF position, you will probably get a jumpy reading. This is caused by noise triggering IC1. If switch S2 is set to the 10 SEC position, it will take a while to get a reading, so be patient. However, you won't use the 10 SEC position in VHF measurements because the measurement time is too long. The decimal point is not connected to the 10 SEC setting; that blanks the display and tells us not to use this position. Set switch S1 to the VHF mode, and then switch S2 to the 1 SEC position. (All of the proceeding assumes you wired your counter for VHF operation, of course! If you chose not to do so, skip over this section.) Connect a 10-MHz signal to jack J1 and you should get a 10 MHz reading when you apply about 10 mV or so of signal. Note that the decimal point denotes "MHz" on the display. Then flip S1 to the LF position and connect a signal of 10 kHz or so to the input cable coming from the connector. You should get a reading of 10 kHz when you apply about 20 mV or more of signal. Rotating R19, TRIGGER LEVEL, will allow you to adjust the sensitivity, and thus the difference between no reading and a 10-kHz display. Note that the decimal point in this case denotes *Hz*. That takes care of the basic checkout of the DPC. If you have any problems, check your wiring, the power supply voltages, and substitute IC's.



PARTS LIST (Power supply)

CAPACITORS
C13—1000 μF, 16 volts, electrolytic
C14—220 μF, 16 volts, electrolytic
C15, C16—0.1 μF ceramic disc

SEMICONDUCTORS
IC5—7805 five-volt positive voltage regulator
IC6—7905 five-volt negative voltage regulator
BR1—one-amp, 50-volt PIV, silicon bridge rectifier
T1—16-volt CT, 640 mA or greater, power transformer (Signal PC 16-640)
F1—¼-amp, 3AG fuse (with holder)
S5—SPST mini-toggle switch

MISCELLANEOUS:
Perforated construction board, heatsink, wire, solder, etc.

FIG. 10—POWER SUPPLY SCHEMATIC DIAGRAM. Circuit is simple; just a transformer, full-wave bridge rectifier, two voltage regulators and a few filter capacitors.

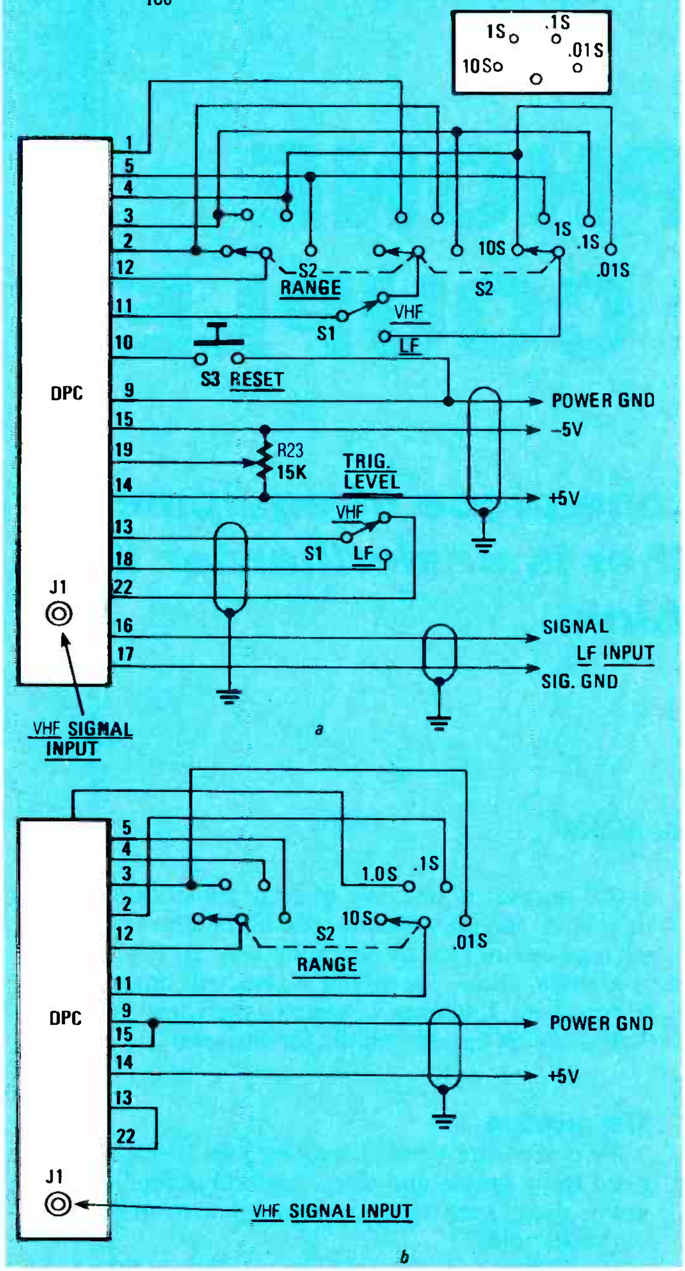


FIG. 11—OPTIONAL CONNECTIONS for handling signal inputs. The circuit at "a" is the more versatile. If you are sure of your needs and a simpler circuit will do, use circuit "b".

Calibration is easy

Calibrating the DPC is a snap if you have a frequency standard available. Ideally, that standard should be better than ± 0.0005% accurate at room temperature to get maximum accuracy out of the DPC. Also, a 10 MHz output would be ideal. A 1-MHz output is fine if just the LF input is used. Set switch S1 to VHF, S2 to the 1 SEC. position. Connect the frequency standard to jack J1, and turn on the counter. For best results you should calibrate at room temperature and allow at least five minutes for the counter to stabilize before starting. You should get a reading very close to 10 MHz. Adjust trimmer C12 for a reading of *exactly* 10 MHz. Disconnect the standard and you are all set. If you don't have a frequency standard, use a counter of known accuracy and a signal generator. Allow the equipment to warm up fully, and connect the generator and counters in parallel. Adjust C12 so the readings match and you are all set.

Put it to work

The counter may be installed in either its own cabinet or together with another piece of equipment. The switches and pot are mounted near the display. You may also customize your counter, possibly by eliminating the external controls. This flexibility is one of the delights of the project.

Using the counter is straightforward and needs little comment. Remember that the decimal point denotes *MHz* in the *VHF* mode and *Hz/KHz* in the *LF* mode. With the switch S2 set at 10 SEC. or 1 SEC., you get readings in Hz, while at the 0.1 SEC and 0.01 SEC. settings you get *kHz* readings. If desired, LED's denoting HZ, kHz, and MHz can be installed next to the display and be operated by switches S1 and S2. The reset switch, S3, is used only to reset or "hurry up" the counter on the 10-second range. **SP**

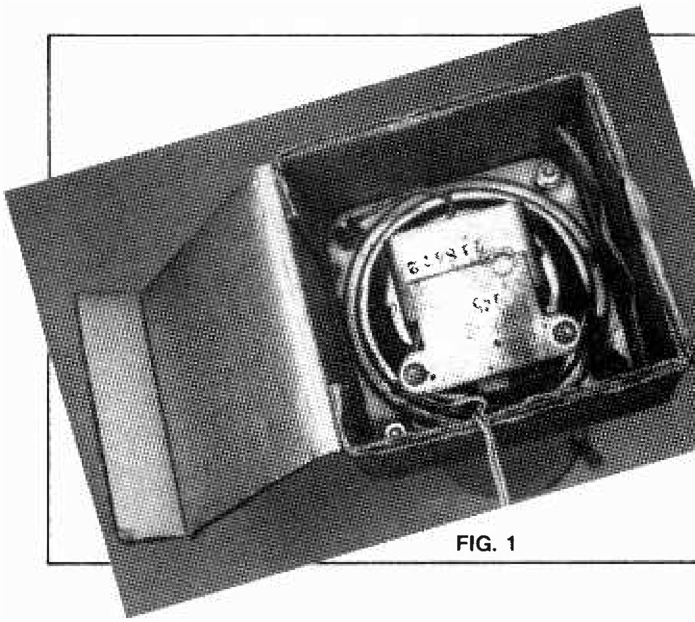


FIG. 1

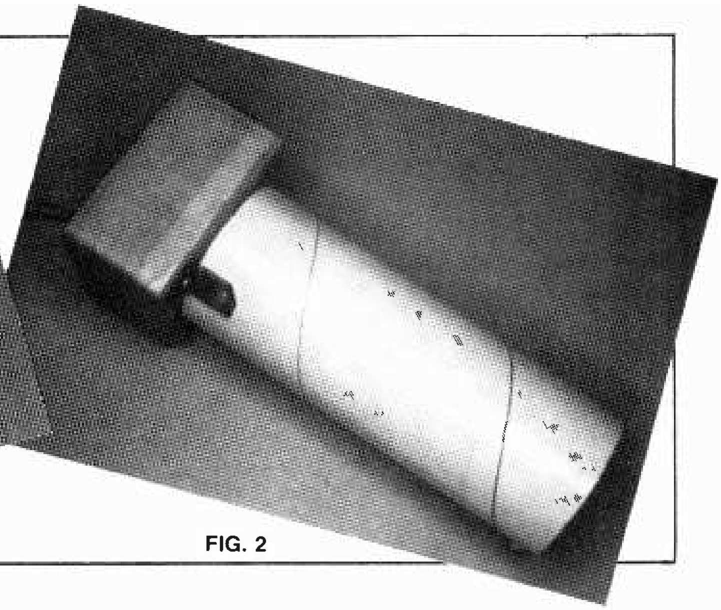


FIG. 2

MICROPHONE ACOUSTIC COUPLER

Coupling the speaker of one piece of equipment to the microphone of another is easier/harder than you think.

ELMER C. CARLSON

GETTING AN AUDIO SIGNAL OF CONSTANT LEVEL INTO a microphone input for a recorder, PA system, or CB transceiver can be a problem. Although whistling, humming, and puffing into the microphone can be used to create an audio input signal lasting, maybe, as long as 15 seconds, that can hardly be considered a sustained—or consistent—signal for making a series of amplifier voltage tests. So you are going to have to find a better way to solve this problem.

While you can disconnect the microphone and make a direct connection to the microphone jack, that won't help diagnose problems that lie within the microphone circuitry.

Connecting a small speaker to the output of an audio generator (through an appropriate matching transformer, of course) and holding the microphone in front of the speaker is one way of getting a sustained audio signal into the microphone. But if you don't center the microphone in exactly the same way, or if you hold it at a slight angle, the sound waves will not strike the microphone diaphram in exactly the same way every time and test results will be inconsistent.

The problem

Two separate troubleshooting jobs brought out the need for a simple and direct method of feeding a constant audio tone into a microphone to make audio-amplifier tests.

In the first case the problem was finally found to be a microphone with a corroded coil pole-piece that prevented coil movement. Signal still got into the amplifier through the microphone because of the inductive coupling between the microphone coil and the speaker voice coil. The input signal was weaker than normal but it still gave the false indication that the microphone was operative. This temporarily sent troubleshooting on a wild goose chase through the amplifier.

The symptons in the second case were even more subtle and misleading. Distortion showed in the scope pattern while checking for low output. Only an unintentional movement of the microphone away from the speaker showed a reduction in distortion in the output signal of the tape recorder being tested—at the same time the signal amplitude was reduced. Keeping the microphone several inches away from the speaker, and increasing the audio output from the speaker did not reintroduce the distortion in the sine wave that occurred at lower audio levels and less separation.

Apparently, in this second case, the induced signal voltage was not in phase with the audio signal generated by the speaker cone and, as a result of phase shift and possibly hysterisis effects in the magnetic circuit, the peaks of the audio sine wave were distorted.

The solution

Since it took only about four inches of separation to reduce the induced audio signal to about zero, it seemed that putting a few more inches between the speaker and microphone could do the job completely.

With a three-inch speaker already mounted in a carboard box baffle (Fig. 1) all that was needed was a non-inductive means of coupling and a way of confining the sound for a distance of four or more inches between the speaker and the microphone.

An 8½-inch, heavy-duty mailing tube (Fig. 2) turned up in the search for parts. Its inside diameter was 3 inches and the wall was about ¼-inch thick. To cut down on sound-path resonances and possible distortion, the inside of the tube was lined with ¼-inch polyurethane foam cut from a discarded mattress pad as seen in Fig. 3.

Next, the mailing tube was attached to the reinforced cardboard-carton speaker baffle using the smallest angle brackets that could be found in a hardware store blister package.

The results

Construction with cardboard made it easy to work out construction details, and design problems were easy to correct. The finished unit is shown in Fig. 4.

During the trial period everything worked out fine—except that it was discovered that pressing the microphone too hard against the coupler tube caused a change in tonal quality from the speaker. That was easy to correct—just don't press the microphone so hard against the acoustic-coupler tube.

Using the microphone acoustic coupler was so convenient that plans were made to contruct a sturdier bench-top unit. But it worked as it was, so it became a very-low-priority project—very, very low priority. In fact, after more than three years the original cardboard acoustic coupler is still working fine, doing the job it had been intended to do for just a trial period.

And, unless someone spills coffee all over it, or knocks it on the floor and steps on it, it might just last another three years.

A simple solution to a difficult problem. **SP**

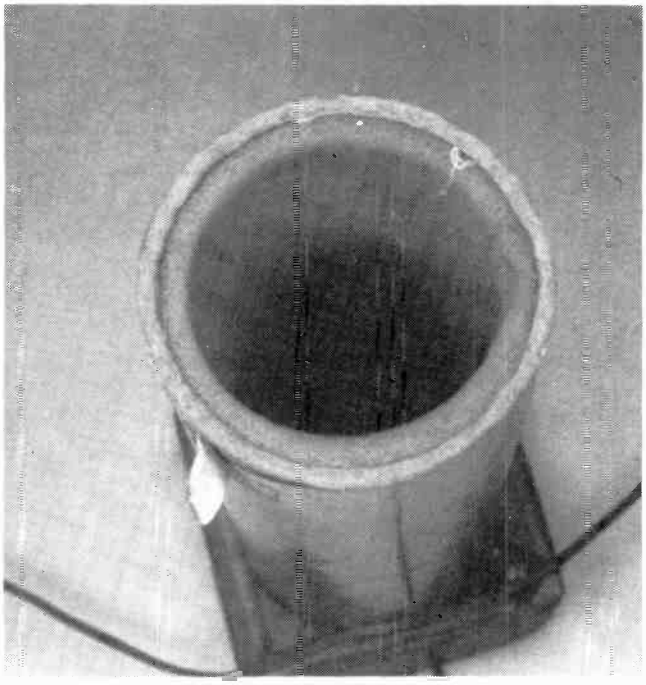


FIG. 3—LINE THE INSIDE OF THE TUBE WITH polyurethane foam. A piece of foam from a discarded mattress or sofa cushion will work just fine.

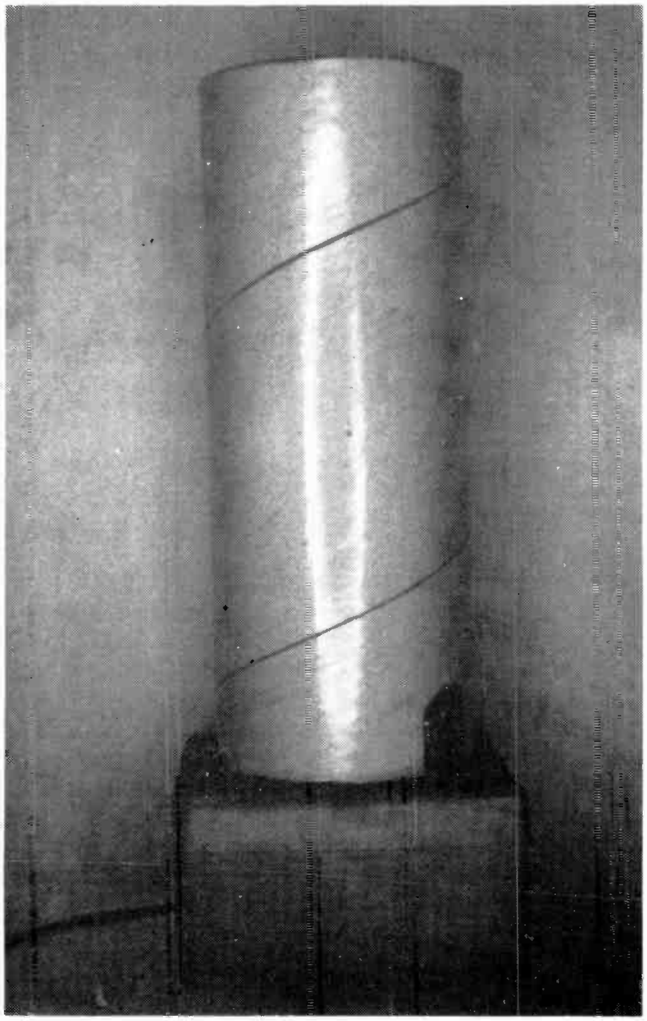
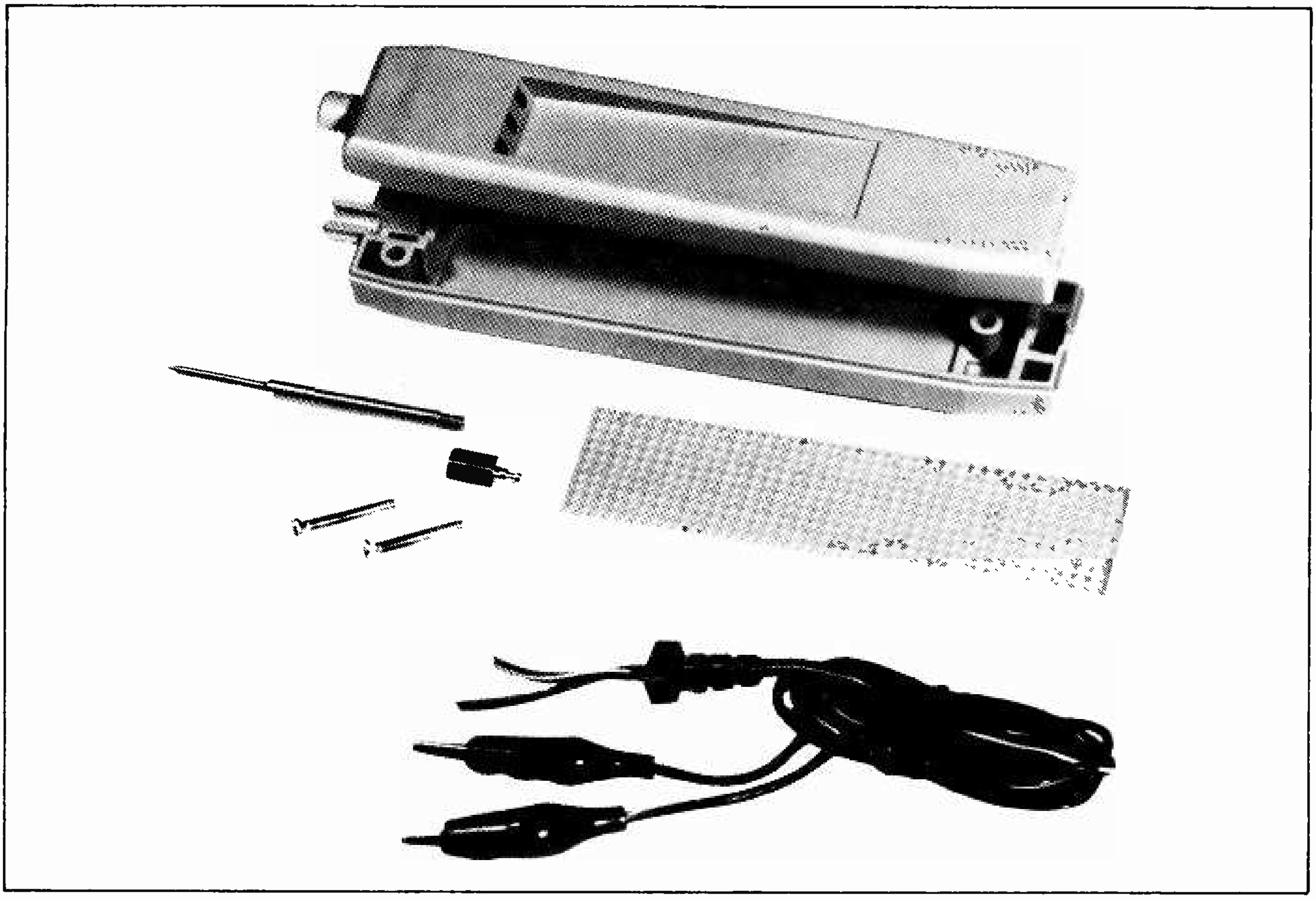


FIG. 4—THE FINISHED COUPLER MAY NOT look very professional, but it will do the job. It's so inexpensive that you won't hesitate to make more than one.



CAR TEST PROBE

Simple instrument for on-the-spot electrical system troubleshooting.

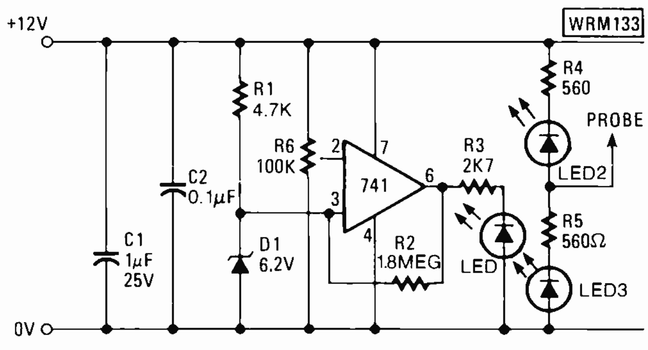
G.J. BEARMAN

THIS USEFUL PROJECT WAS DESIGNED AS A PIECE OF simple test gear to be carried around in the car for on-the-spot electrical system troubleshooting. It can be built in various forms to suit the individual requirements of the user.

The first part of the probe consists of two LED's that indicate the condition at any electrical connection in the car. With the probe unattached, both LED's light, indicating a voltage level that is neither positive nor negative. When the probe is applied to a connection with a definite voltage condition on it, the appropriate LED will light and the other will go out.

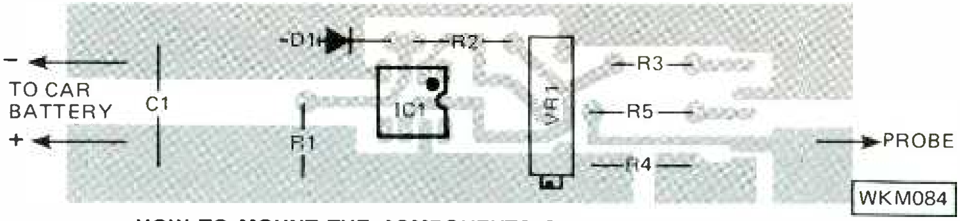
Voltage sensing

The second part of the probe consists of a voltage-sensing circuit, using a 741 operational amplifier to detect when the voltage across the car battery rises above 12.5 volts. This provides a simple way to check that the battery is being charged.

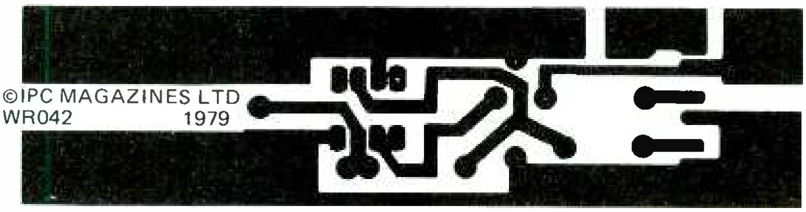


IT TAKES ONLY A FEW INEXPENSIVE components to assemble your probe.

© Practical Wireless, May 1979, Dorset, England



HOW TO MOUNT THE COMPONENTS ON THE printed circuit board. Polarities are indicated where needed.



FULL SIZE FOIL PATTERN. Use it if you want to make a circuit board. You can also use the perf board that comes with the probe case.

It is obvious how LED 2 and LED 3 detect the voltage levels. They are connected in series with R4 and R5 as current-limiting resistors. When the probe is connected to either a positive or a negative voltage one or the other LED is effectively shorted, leaving just the other one on.

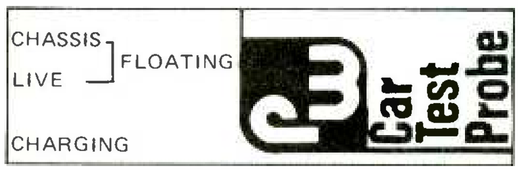
Comparator circuit

In the second part of the circuit, a 741 operational-amplifier IC is used as a comparator. Its output state changes when the voltage on one input rises above the other input. A reference voltage is seen across Zener diode D1, by the input on pin 3, and pot R6 is used to set the required voltage on pin 2. When the battery voltage drops, the voltage on pin 2 will drop below that on pin 3, causing the output to go high and lighting LED 1, marked CHARGING.

Construction steps

The probe is constructed onto a small printed-circuit board that fits into a plastic probe case made by Global Specialties Corporation.

This printed-circuit board houses all the components including the three LED's that fit into holes in the case. During assembly you must be certain that the LED's and the 741 operational amplifier are positioned correctly. The small front panel can be cut out of the magazine or reproduced. Then it is carefully cemented onto the recessed portion of the case to give easy identification of the state being sensed by the probe.



FULL SIZE PATTERN for labelling probe case. A neat final touch.

PARTS LIST

RESISTORS

All ¼W 5% unless noted
- R1—4700 ohms
- R2—1.8 megohms
- R3—2700 ohms
- R4, R5—560 ohms
- R6—100,000 ohms, multiturn Cermet potentiometer

CAPACITORS
- C1—1μF 35V Tantalum
- C2—0.1μF ceramic disc

SEMICONDUCTORS
- D1—6.2V Zener diode
- IC1—741 op amp
- LED1, LED2, LED3—miniature red LED

MISCELLANEOUS
- Printed circuit board (make your own or use perf board)
- Probe case (Global Specialities Corp.)
- Alligator clips (3)
- Wire, 2-conductor lamp cord (3 feet)
- Wire, single-conductor, flexible (3 feet)
- IC socket, 8-pin DIP

PC board description

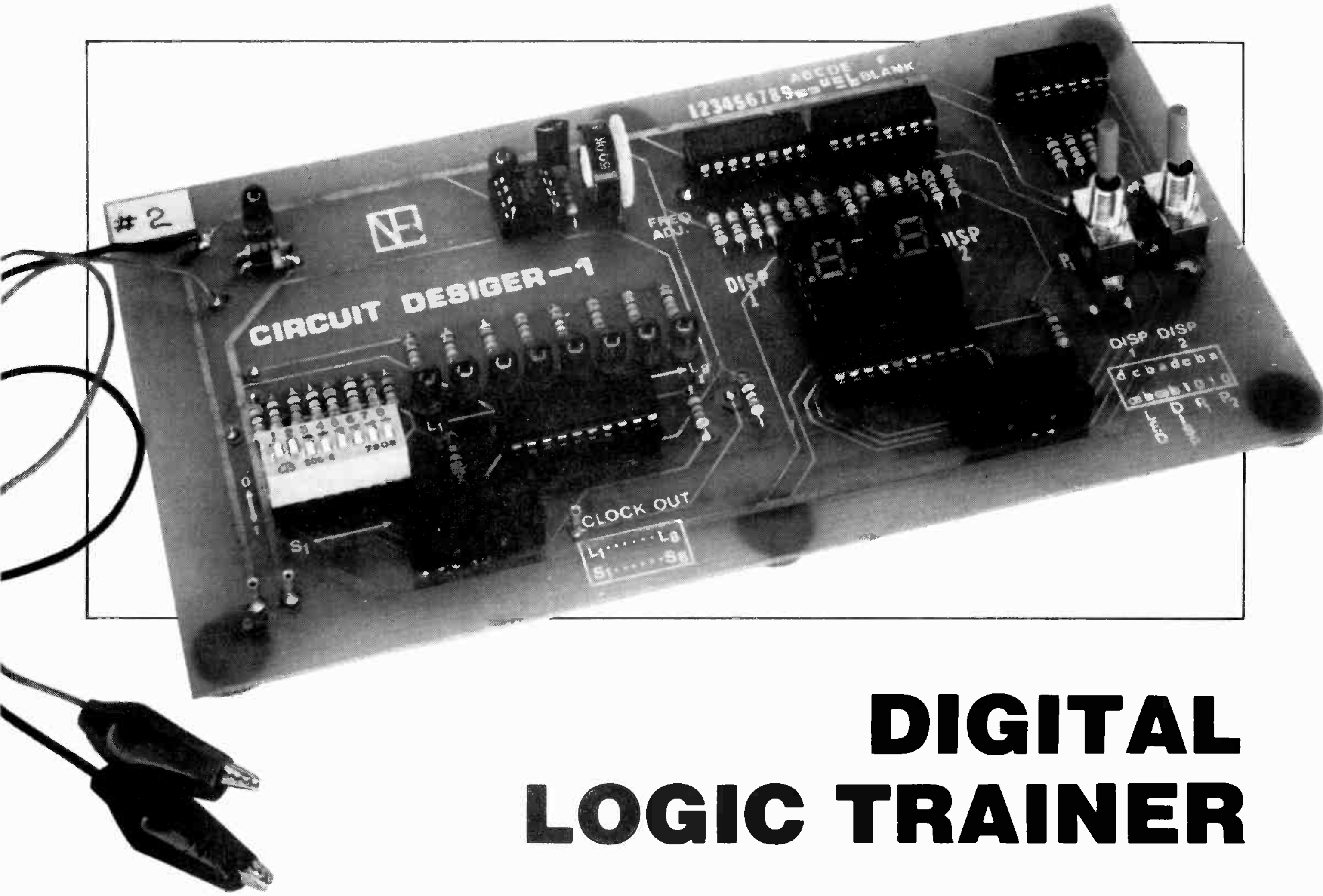
The printed-circuit board foil pattern is reproduced full size as is the component placement drawing. The photograph shows the probe case kit. If you use the circuit board you will not need the perf board. However, you can use the perf board and skip the printed circuit. Make sure that the LED's are correctly oriented. The "bridge" can be glued to the PCB using one of the rapid bonding adhesives. Align it carefully, so that the LED's fit into their holes in the case top.

Testing the unit

After the circuit has been completely assembled it is tested by first setting R6 to the center of its range, and connecting a variable-voltage supply and a voltmeter across C2. Now, with the unit turned on, when you reach a voltage somewhere between 6 and 12 volts LED1 comes on (or goes off). The preset is now adjusted so that the LED just goes out when the supply exceeds 12.5 volts.

Ignition timing

Keep the test probe in your car's glove compartment or trunk. You will always have it ready for use in case of electrical problems. It can also be used to detect the instant at which the contact breakers open, enabling accurate static ignition timing to be carried out. SP



DIGITAL LOGIC TRAINER

Delivers all of the functions you need to explore the theory and operation of digital and microprocessor IC's.

NEIL J. BUNGARD

THERE HAS BEEN AN INCREASING NUMBER OF DIGITAL cookbooks and books related to the training of digital and microprocessor techniques appearing on the market. With this increase in literature it becomes desirable to find an affordable device to supply and monitor the functions necessary to explore the theories and operations of digital and microprocessor IC's. The *Circuit Designer-1* is such a device. It can be used as an aid in training digital and microprocessor techniques but will also double as a prototyping aid in circuit design and IC investigation and testing.

Circuit Designer-1 is configured in two separate PC boards: a digital techniques board and a microprocessor techniques board. They can be used independently or combined to complement one another. Since the two boards can be used as stand-alone units I will explain their functions and their use independently.

Circuit description

In this article I will focus on the digital techniques board that consists of 8 logic-level switches, 8 (input-latchable) logic-level indicators, a variable-frequency square-wave generator, 2 (input-latchable) decoded seven-segment displays, and 2 debounced-pulsers with complementary outputs.

The total circuit is basically 5 separate circuits on a single printed-circuit board. Also provided on the power input is a diode to protect against applying reverse voltage to the board, and a LED to indicate a "power on" condition. The logic-level switches (Fig. 1) consist of a pullup resistor to a logic-1 state. When the switch is closed it grounds the output pin and establishes a logic-0 state. There are 8 such switches on a single DIP.

The logic-level indicators (Fig. 2) consist of an octal tristate latch which has its outputs tied to light-emitting diodes through current-limiting resistors to ground. In the normal condition (that is with no input control signals connected) the output disable pin is tied to V_{cc} through R3, holding the output enabled. The latch-enabled pin is tied to ground through R2, maintaining the latch disabled, which means that the 74LS373 is transparent and the outputs will follow the inputs.

The variable frequency clock is a basic 555 oscillator-circuit (Fig. 3). The oscillator is variable via R_t but since the frequency is dependent upon R_t and C_t (FREQ = 1.44 / (R_tC_t)) the dynamic range can be varied by your choice of C_t. With the values provided on my board the limits you can expect are between 0.5 Hz and 20 Hz.

The decoded seven-segment displays (Fig. 4) consist of an octal tristate latch (each display using half of the

74LS373) whose outputs are tied to a set of BCD-to-seven-segment decoders (7447's). The decoders are tied through current-limiting resistors to common-anode seven-segment displays. The normal condition of the seven-segment octal latch is exactly the same as the logic-indicator octal latch. The inputs are enabled and the latches disabled, which means that the 74LS-373 appears transparent.

The debounced pulsers (Fig. 5) consist of a SPDT momentary switch and the NAND gates for debouncing. the circuit utilizes the fact that a TTL gate has a definite signal propagation time (about 10ns for a NAND gate) to filter out the contact bounces.

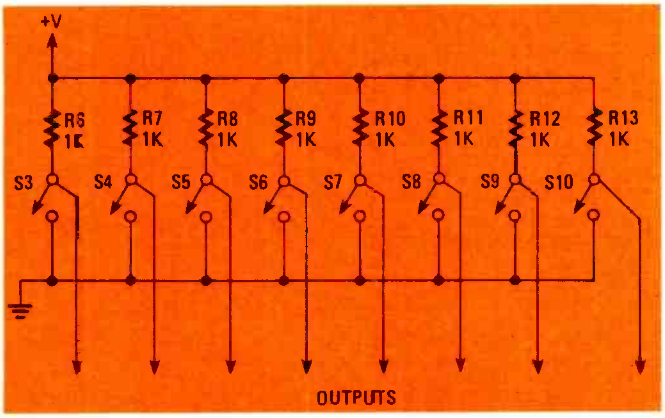


FIG. 1—LOGIC-LEVEL SWITCHES. When any one is closed, it grounds the output pin and establishes a logic 0 state.

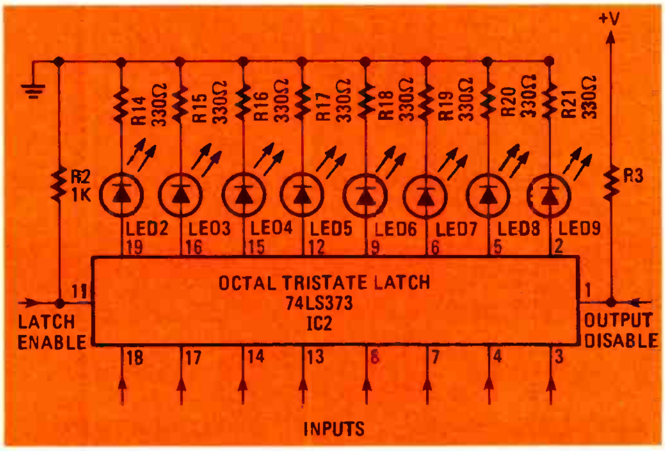


FIG. 2—LOGIC-LEVEL INDICATORS use LED's. They are driven by an octal tristate latch.

Using Circuit Designer-1

On the digital techniques board all the inputs and outputs are obtained via two DIP header sockets (see Fig. 6) on the lower edge of the board (with the exception of the power and oscillator outputs, which are taken from individual wire-insert sockets).

Operation of the state-switches, oscillator, and pulsers are straightforward. Just run the outputs from

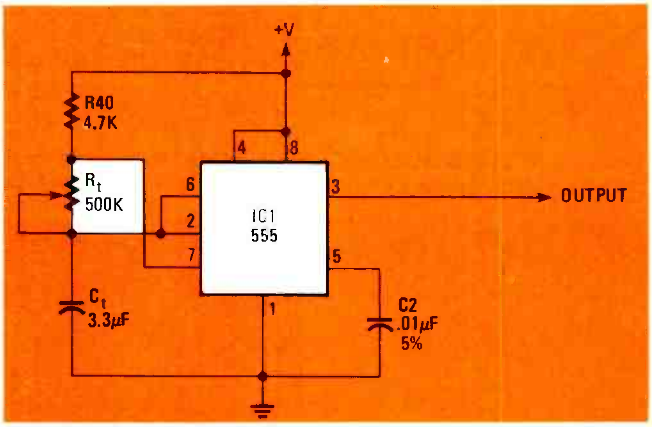


FIG. 3—BASIC 555 OSCILLATOR is used to form the variable-frequency clock. Change the value of C_t to adjust frequency.

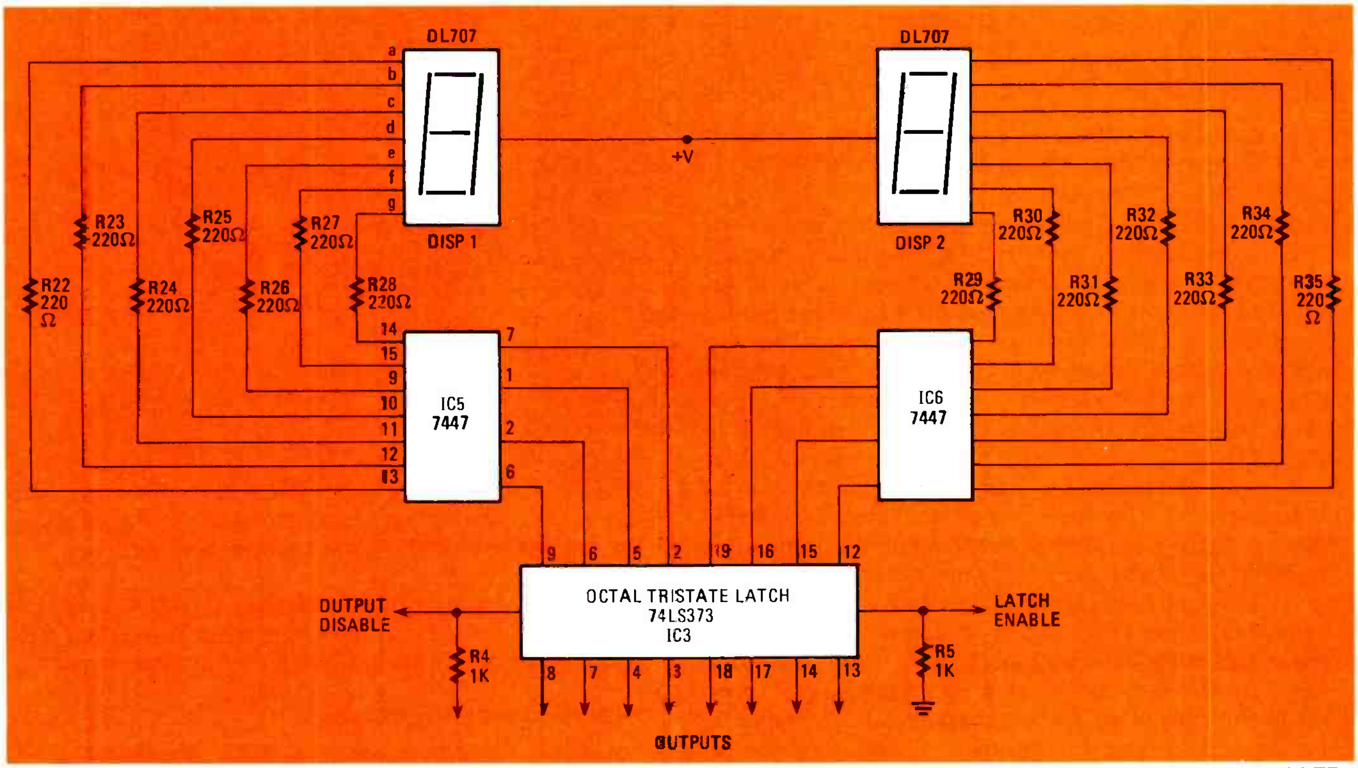
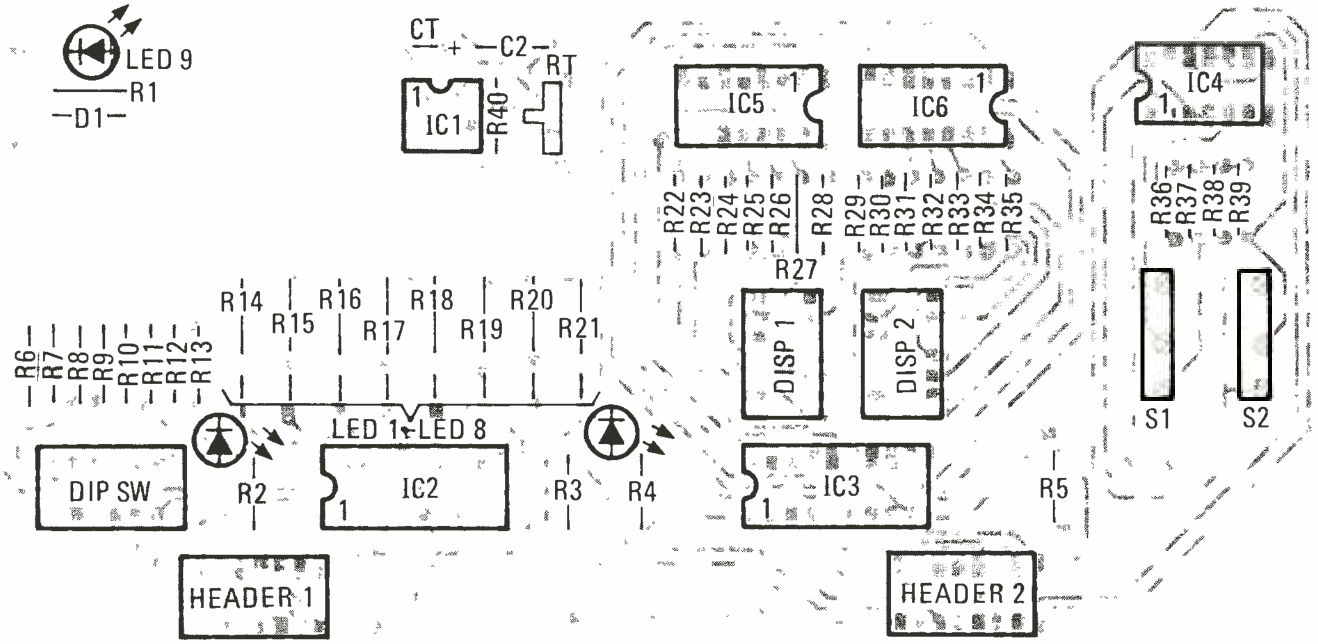


FIG. 4—DECODED 7-SEGMENT DISPLAYS are driven by ½ of an octal tristate latch and are fed by the BCD decoders that sit between the latches and the displays themselves. D1 and LED1 are located in the power input.



PARTS LAYOUT DIAGRAM SHOWS exactly where each component should be located on the two-sided circuit board. Be careful when inserting components that the IC's and LED's are positioned correctly.

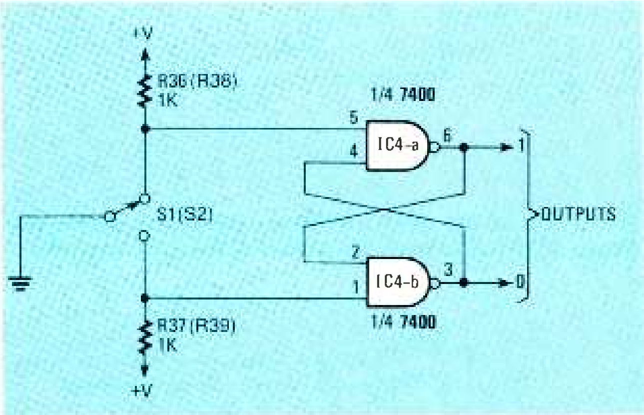


FIG. 5—DEBOUNCED PULSERS consist of a SPDT switch and two NAND gates for debouncing. Circuit is repeated for S2.

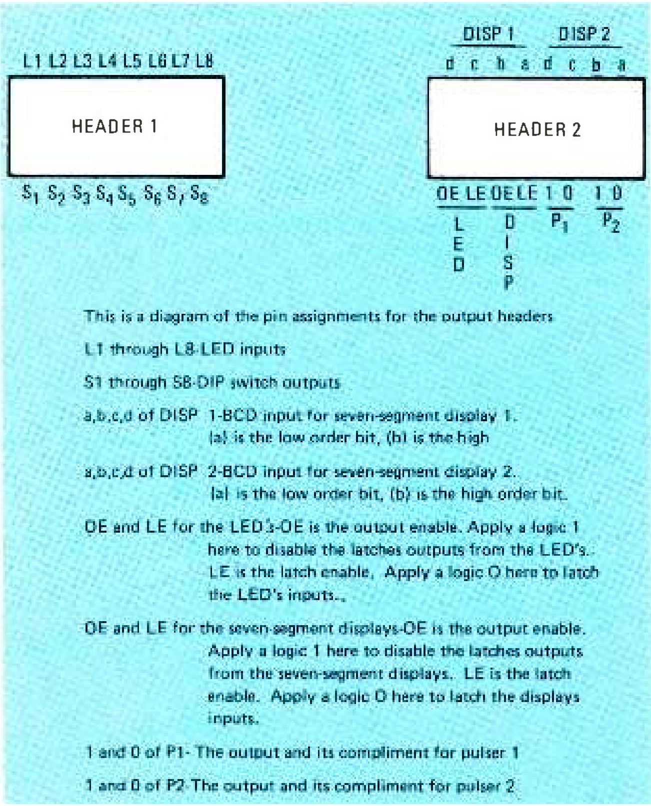


FIG. 6—ALL INPUTS AND OUTPUTS are obtained via the two DIP sockets located at the lower edge of the board.

the *Circuit Designer-1* to wherever they are needed on the breadboard. Switching the DIP switches changes the states at the pins assigned to them. The states related to the switch positions are marked on the board. If you need a clock pulse just run a jumper from the oscillator output pin to your circuit. The frequency is variable via variable resistor on the board.

The pulsers are treated in the same manner. Run jumpers from the pulser outputs to your circuit. When you depress the pulser the pins will change states without bouncing. Using the LED's or seven-segment displays is equally as simple except that the inputs are controllable. There are two input-control signals for the LED's and two identical signals for the displays. These signals are OE and LE, which represent output enable and latch enable respectively.

As I mentioned earlier, with no control signals connected the output of the octal tristate latch buffer is enabled and the latch is disabled. If you want to disconnect the LED's or seven-segment displays from the octal latch's output place a logic 1 on OE. If you want to latch the information on the inputs apply a logic 0 on LE. This is very useful when using the LED's or displays as output ports from a microprocessor.

Miscellaneous information

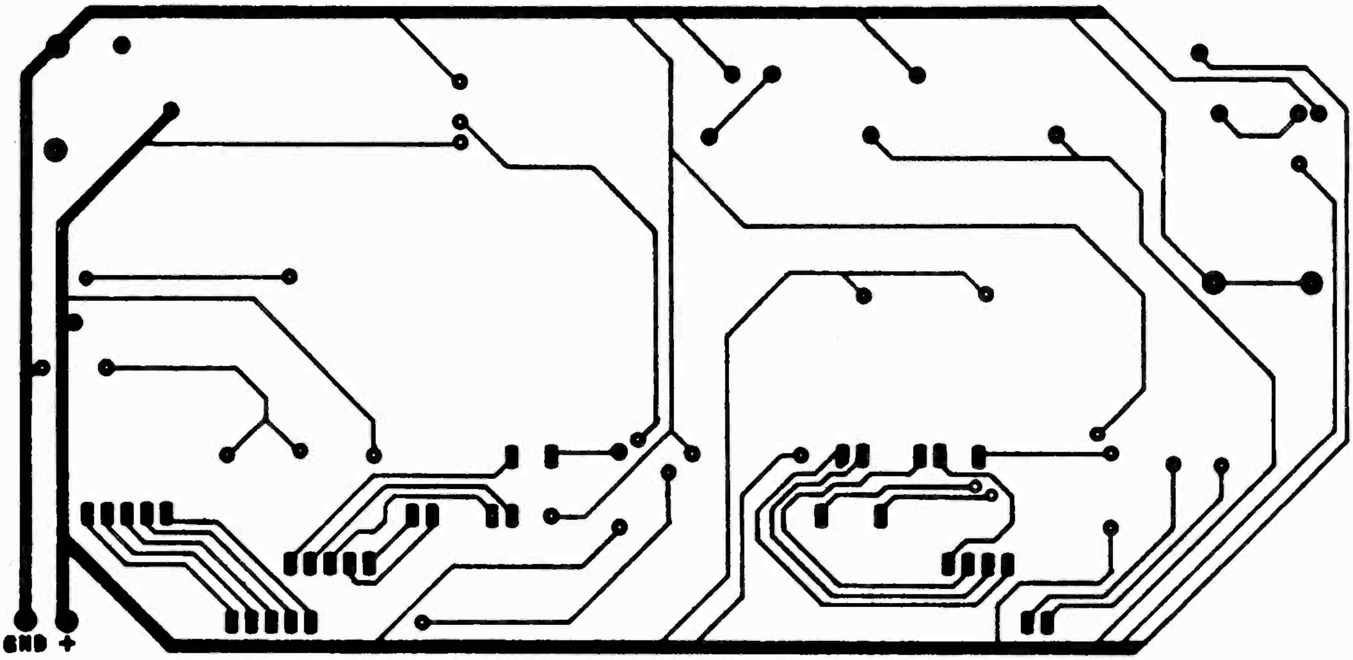
Circuit Designer-1 is best used by running DIP header cables from the board sockets to the breadboard

text continues on page 38

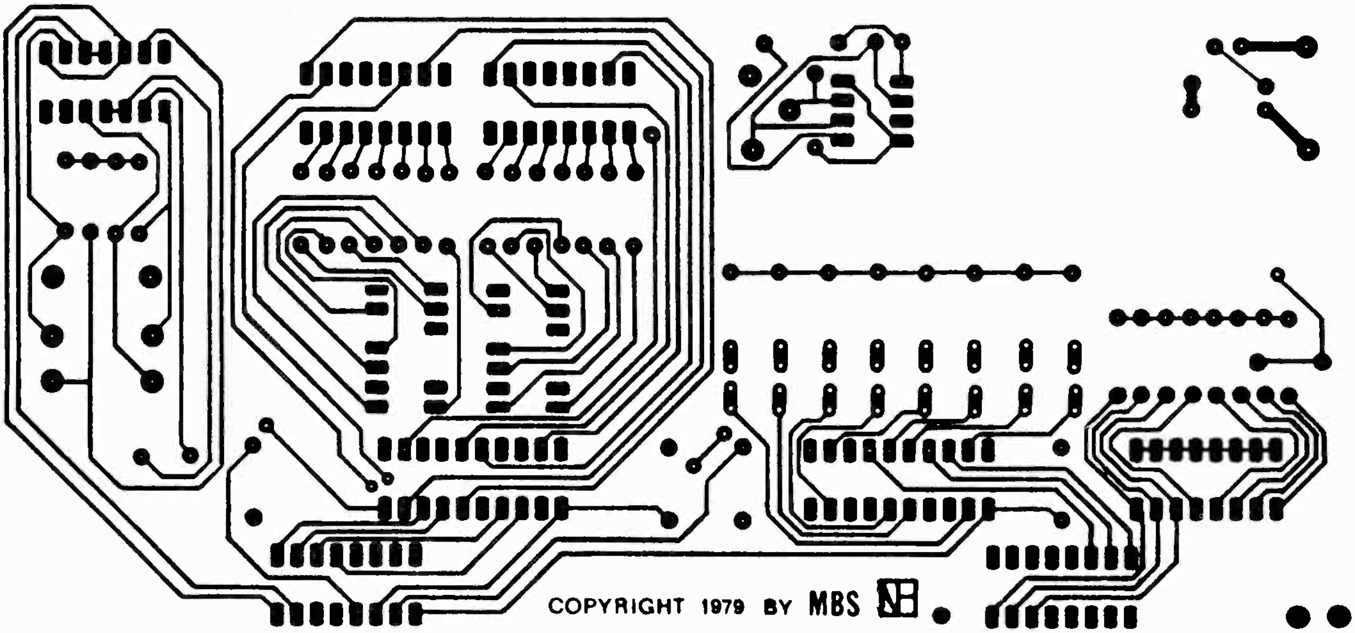
continued from page 34

and running shorter wires from the header on the breadboard to the circuits under examination. The power supplies that I have been using in my classes are 6-volt lantern batteries which deliver months of reliable service. Also the books that I have found that best complement *Circuit Designer-1* as a trainer are the *"Bugbook"* series by *Rony, Larsen, and Titus.*

In a future article I will introduce *Circuit Designer-1's* microprocessor techniques board. This board is also powered by a lantern battery and connects directly to the digital techniques board. With this device we will be able to investigate microprocessor address and data bus concepts, memory allocation, I/O control, interrupts, machine language programming, and other microprocessor-related concepts. **SP**



FULL-SIZE FOIL PATTERN of the reverse side of the double-sided circuit card.



FULL-SIZE FOIL PATTERN OF THE COMPONENT SIDE of the circuit board.

PARTS LIST FOR DIGITAL LOGIC TRAINER

RESISTORS:
R1, R14 though R21—330 ohms
R2 through R13—1,000 ohms
R22 through R35—220 ohms
R36 through R39—1,000 ohms
R40—4,700 ohms
Rt—500,000 ohm PC mount variable resistor

CAPACITORS
Ct—3.3 μF tantalum
C2—0.01—μF 5% polystyrene

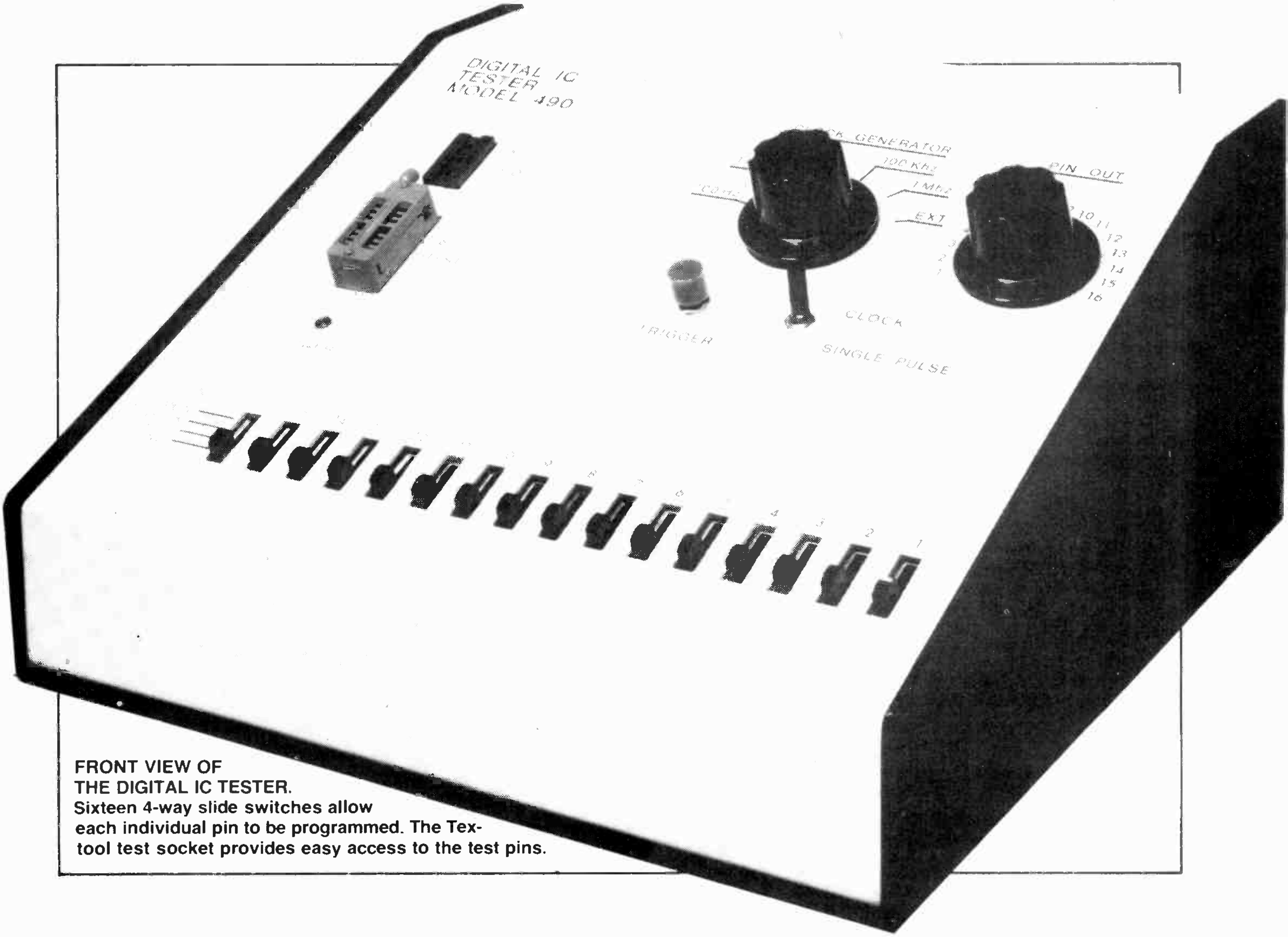
SOLID-STATE DEVICES
D1—1N4000 silicon diode
LED1 through LED9—0.200" diameter diffused red light emitting diodes
DISP1, DISP2—DL707 common anode, seven-segment displays
IC1—555 timer IC
IC2, IC3—74LS373 octal tristate latch
IC4—7400 quad NAND gate
IC5, IC6—7447 BCD to seven-sgement display/driver

SWITCHES
S1, S2—SPDT momentary switch
S3 through S10—16-pin DIP switch

MISCELLANEOUS
(3) 16-pin low-profile IC sockets, (2) 16-pin regular IC sockets, (3) 14-pin low-profile IC sockets, (2) 20-pin low-profile IC sockets, (1) 8-pin low-profile IC socket, printed circuit board, wire, alligator clips, rubber feet, hardware, 6-volt battery, solder, etc.

TO MAGAZINE RETAILERS:

Radio-Electronics Special Projects Magazine is pleased to announce its "Retail Display Allowance Plan" available to retailers interested in earning a display allowance on **Radio-Electronics Special Projects** Magazine. To obtain details and a copy of the formal contract, please write to the Marketing Department, Kable News Company, Inc., 777 Third Avenue, New York, New York 10017, our national distributor, who will act as administrator of our plan. Under our Retail Display Allowance Plan, in consideration for fulfilling conditions of the agreement, you will be entitled to receive a display allowance. This plan will become effective for all issues you receive subsequent to written acceptance on our behalf of your application.



FRONT VIEW OF THE DIGITAL IC TESTER. Sixteen 4-way slide switches allow each individual pin to be programmed. The Textool test socket provides easy access to the test pins.

DIGITAL IC TESTER

This unit tells you if the trouble is in the IC or in your circuit design

JOHN W. RASMUSSEN

IF YOU ARE INVOLVED WITH DESIGNING AND OR BUILDing digital circuit projects, you have undoubtedly, at one time or another, encountered a situation in which the project doesn't work and in which you are left with the task of deciding if it is one of the IC's that doesn't work or if it is a faulty design that is the cause of the failure of the project.

In such situations it would be handy to have a permanent setup, where you can test all kinds of digital IC's without having to spend a lot of time on wiring, etc. Such a setup would also be helpful in checking out IC's bought surplus, but of unknown quality.

The article presented here, describes the construction of a manual digital IC tester, that will fill this need. With this tester you will be able to check the operation of any 14- or 16-pin digital IC with ease and speed. Both CMOS and TTL circuits can be tested with this unit.

The basic principle of the tester is to have an array of 16 slide switches that allow each individual pin on the IC to be tested. The switches connect each pin to either GND, V_{CC}, CLOCK or may be left open. The pins of the test socket are also connected to the corresponding pins on another 16-pin IC socket. This one serves as an output socket. It makes it possible for the user to connect components to the IC under test. This makes it possible to test astable and nonostable multivibrators in operation. It also allows external feedback paths in testing of counters and applying loads to drivers, LED drivers, etc.

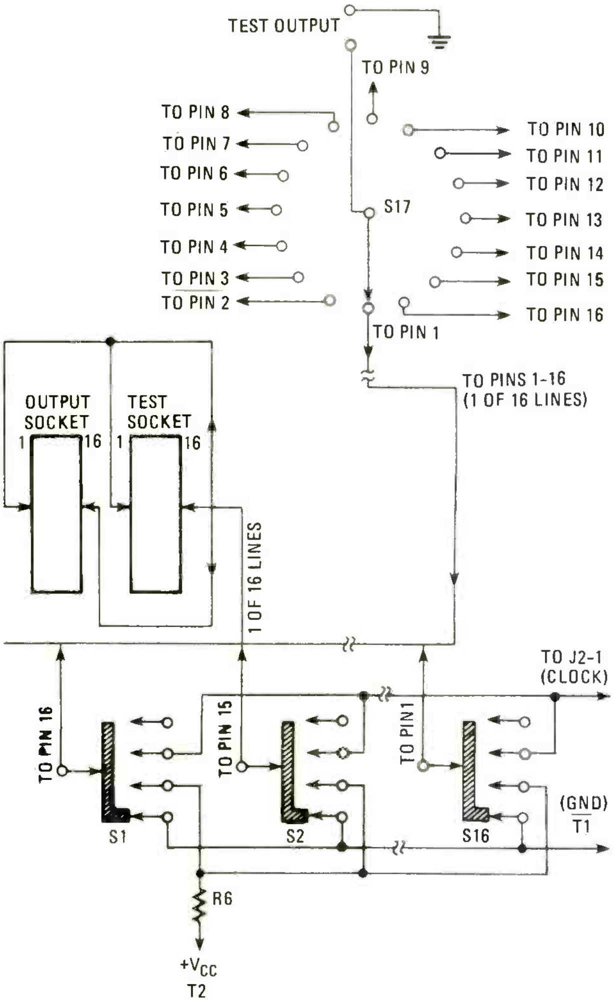


FIG. 1—**CIRCUIT CONNECTIONS OF SLIDE SWITCHES** and output switch are shown in this schematic.

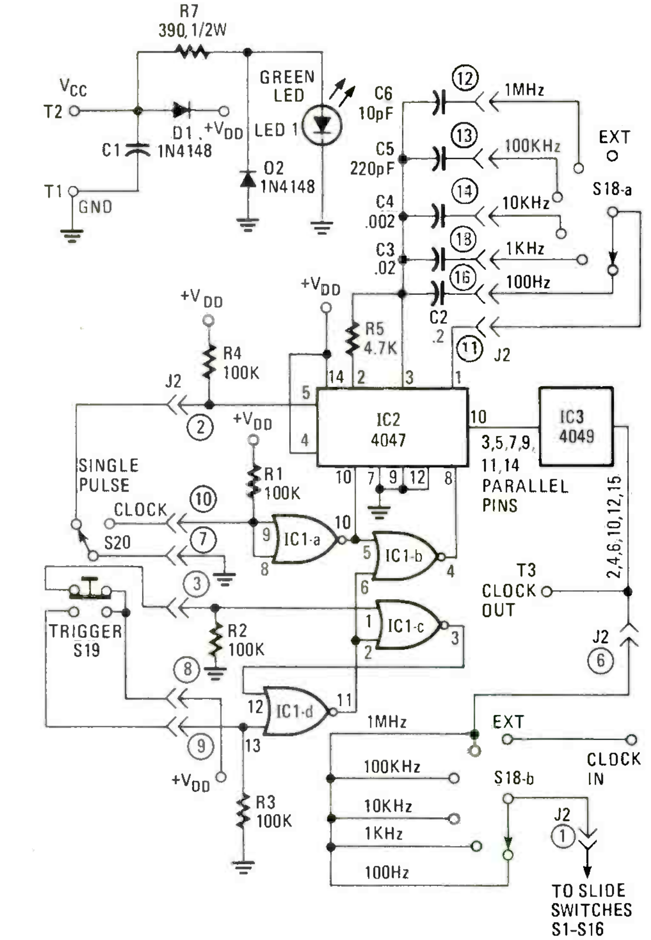


FIG. 2—**CIRCUIT DIAGRAM OF THE INTERNAL CLOCK GENERATOR.** Only three IC's are needed.

PARTS LIST

SEMICONDUCTORS

IC1—CD 4001
IC2—CD 4047
IC3—CD 4049
D1, D2—1N4148
LED1—Green Led

SWITCHES

S1 thru S16—4-position slide
S17—single-pole 23-position rotary
S18—2-pole 6-position rotary
S19—Push button
S20—Single-pole toggle

RESISTORS

All 1/4W 10% unless noted
R1, R2, R3, R4—100,000 ohms
R5—4400 ohms
R6—not used
R7—390 ohms, ½W

CAPACITORS

C1—0.1 μF, disc ceramic
C2—10-pF disc ceramic
C3—220-pF disc ceramic
C4—.0022 μF, 10% mylar ceramic
C5—.022 μF, 10% mylar ceramic
C6—0.22 μF, 10% mylar ceramic

J1, J2—16-pin IC socket
I/O socket—16-pin 3-level wire wrap socket

Test Socket—Textool 216-3340-00-0602 or equal

Receptacle—Textool 216-3593-00-0602 or equal

Binding Posts—(4)
Cabinet—MBK 5-10-10: Intra-Fab, Inc., 425 Queens Lane, San Jose, CA 95112

Knobs

Hex spacers

Circuit description

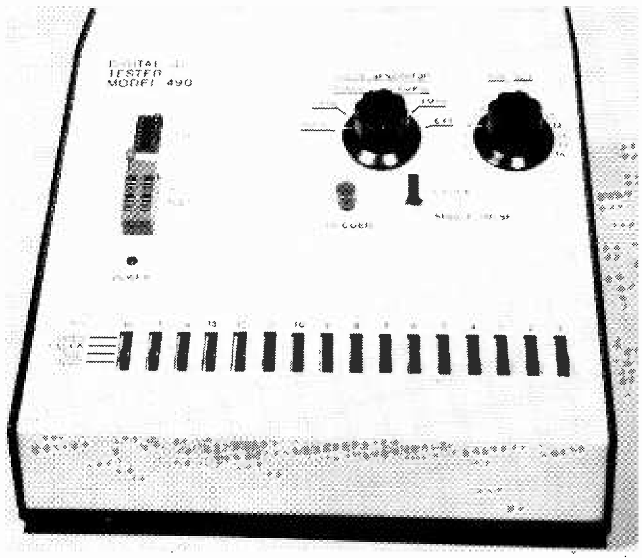
Figure 1 shows how the slide switches are connected to the test socket, as described in the introduction. Switch S17 is a rotary switch that connects the test output terminals to any one of the 16-pins on the test socket. The output test terminals can be connected to a scope, a DVM or other test instrument to check out the operation of the IC under test.

Although only 16 positions are needed on S17, a 23-position switch is used because it allows a smaller angle of rotation, which makes the front panel legend easier to read. Adjustable stops on the switch limit the rotation to 16 positions.

Figure 2 shows the circuit diagram of the internal clock generator. IC2, a 4047, forms the basic oscillator circuit. Its mode of operation is controlled by S20. When S20 is in SINGLE PULSE, pin 5 of IC2 is grounded. This makes IC2 operate in the monostable mode. In this mode IC2 is triggered on the rising edge of a positive pulse on pin 8. Two sections of IC1 form a debouncing circuit for S19, which acts as a manual trigger for IC2.

When S20 is in CLOCK, IC2 operates in the astable mode. In this mode pin 10 of IC2 is held high. This, in turn, inhibits the operation of the trigger input. The clock frequency is controlled by R5 and C2 through C6 and covers the range of 100 Hz to 1 Mhz. At the 1-Mhz setting, however, the operating frequency will to a substantial degree be dependent on operating voltage V_{CC}. At V_{CC} = 5V the operating frequency will be only about 600 Khz, rising to 1 MHz when V_{CC} = 10V. This is due to limitations in the 4047.

IC 3 acts as a buffer, using six paralleled sections of the 4049, yielding a fan-out of 12 TTL loads. Diode D1 protects the clock generator against damage in case of



FRONT PANEL LABELLING can be seen from this photo. Use rub-on lettering as detailed in the text.

polarity reversal of V_{CC}. C1 is a filter capacitor. LED1 is a green LED indicator. It shows correct polarity of V_{CC}. Diode D2 protects LED1 against reverse breakdown damage. It may or may not be required, depending on the specifications of the LED that you use. One

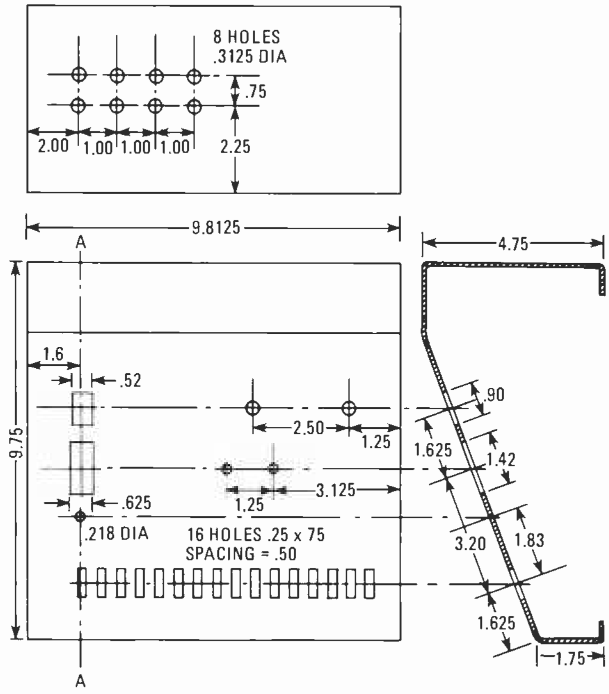


FIG. 5—DRILLING AND CUTTING GUIDE for the top shell of cabinet.

section of S18 switches capacitors C2 through C6. The other section of S18 selects the internal or external clock for clocking the IC under test.

Assembling your tester

The first thing to do is to get all the parts together. You'll find a complete parts list and a list of suppliers in this article. The circuit board you may etch yourself using the layouts in Fig. 3 and Fig. 4. A guide to drilling and cutting the cabinet is in Fig. 5. The printing on the cabinet may be done using dry transfer letters, available in most artist-supply stores. The lines are done with thin adhesive drafting tape.

Before lettering the cabinet, drill and cut all of the holes. Then spray the top shell of the cabinet with an antique white *flat* enamel.

The original paint of the cabinet is semigloss, which is not very receptive to the dry transfer lettering. By spraying first with a flat enamel, any problem with the lettering is virtually eliminated.

After the lettering, spray the top shell of the cabinet with two or more coats of a clear matte finish. These coats should be thin to prevent any possible loosening of the lettering.

The assembled PC board can be seen in the photos. If you etch your own PC board, all of the pads around the feed-through holes will have to be connected by a wire. This is simple. Just take four holes at a time and put a short 22-gage wire through the holes. Then bend the wires on one side of the board, lay the board flat against a table and solder the top pads. Next, turn the board over and solder the bottom pads. Continue until all the feed-through holes are soldered.

Under the slide switches is a feed-through hole. It was located there to avoid having to solder the top pads on these switches. These pads are inaccessible after the switches are mounted on the PC board, so if you etch your own PC board, the feed-through holes

text continues on page 45

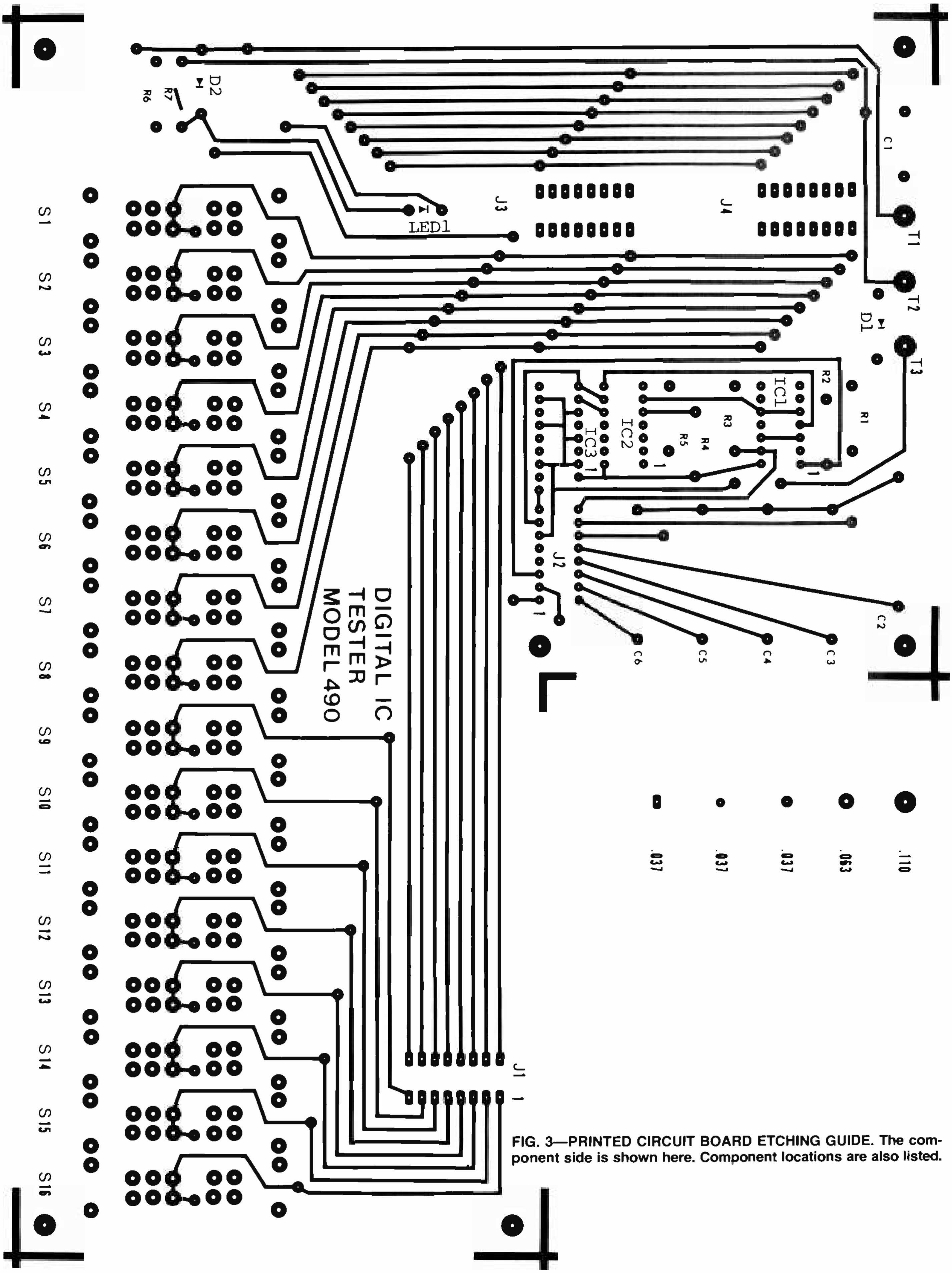


FIG. 3—PRINTED CIRCUIT BOARD ETCHING GUIDE. The component side is shown here. Component locations are also listed.

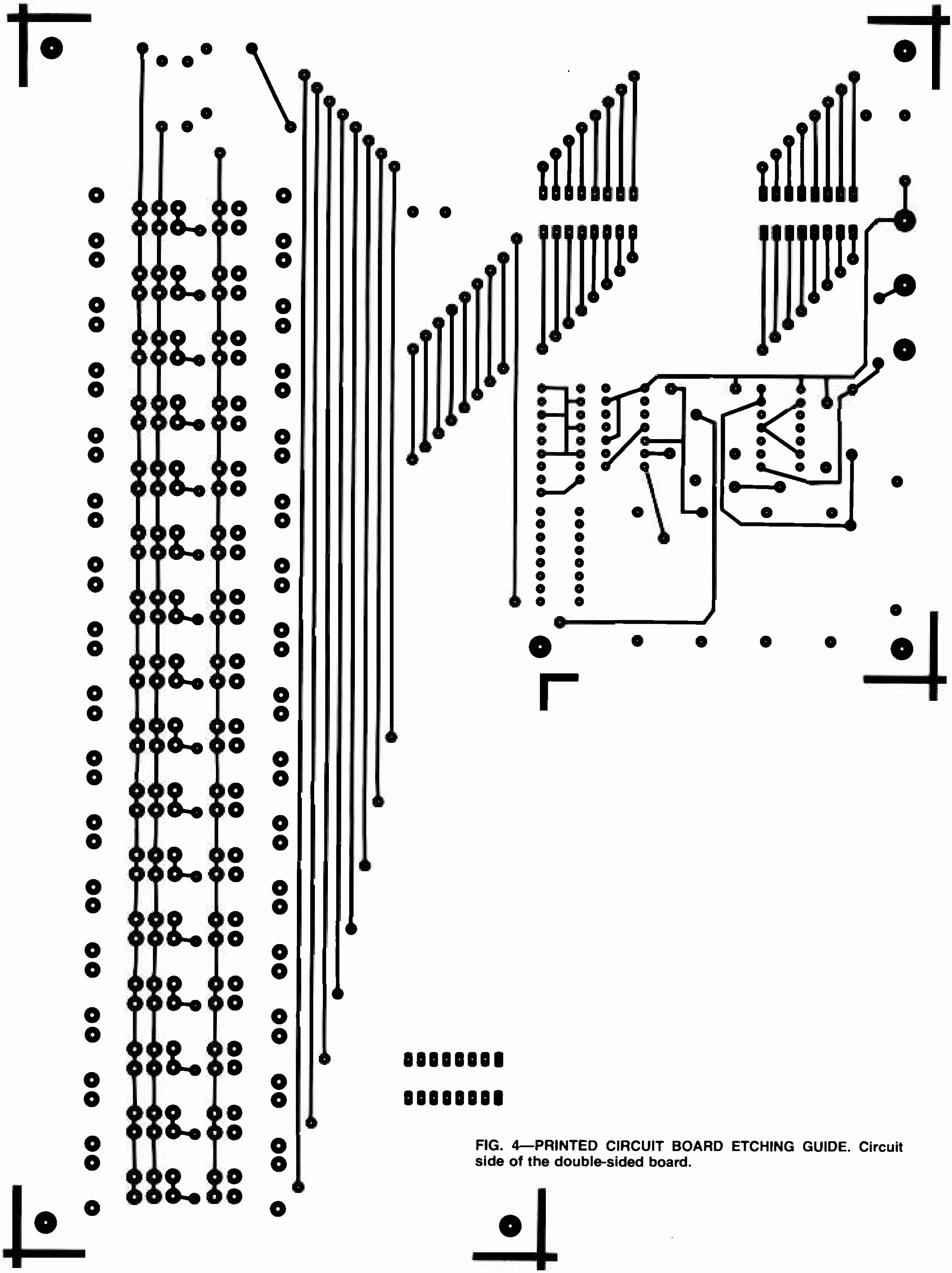
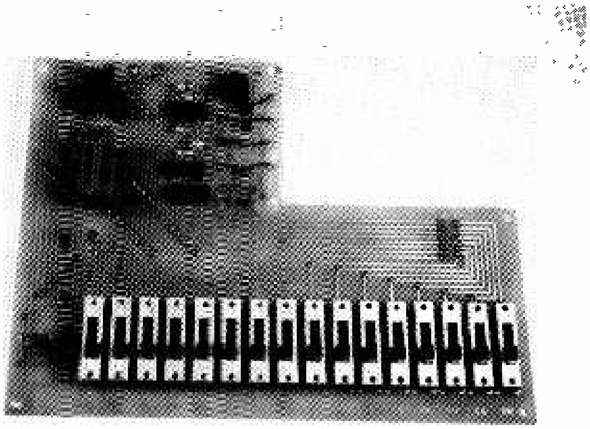
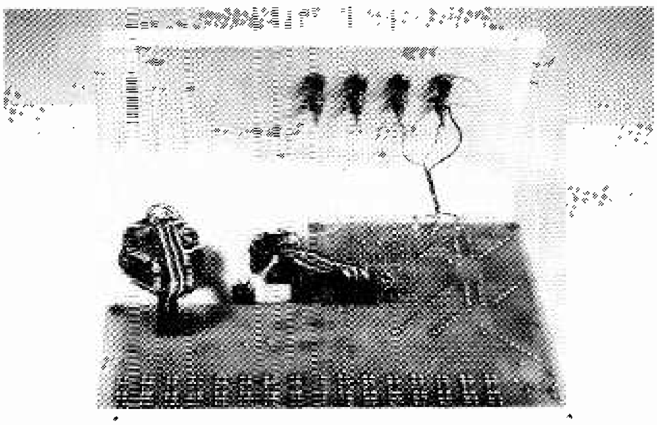


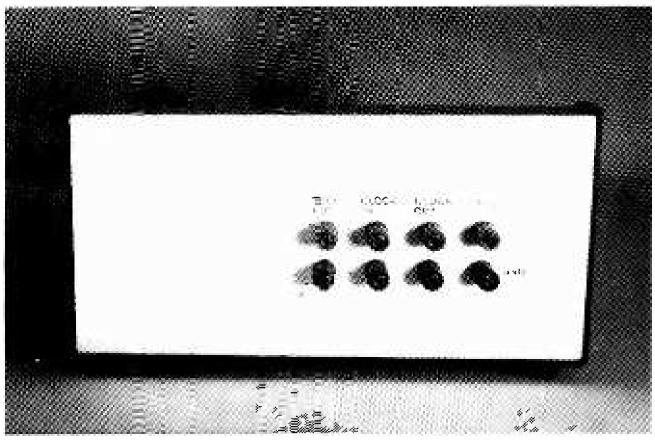
FIG. 4—PRINTED CIRCUIT BOARD ETCHING GUIDE. Circuit side of the double-sided board.



ASSEMBLED PRINTED CIRCUIT BOARD. Note that the test socket and the I/O socket are elevated from the PC board. J1 and J2 are located on the circuit side of the board.



PRINTED CIRCUIT BOARD MOUNTED IN CABINET. Note the flat cable assemblies connecting the switches to the PC board through J1 and J2.



TERMINALS ON REAR OF CABINET are detailed in this photo.

under the switches must be soldered before mounting the switches. J1 and J2 are 16-pin IC sockets mounted on the reverse side of the PC board and provide connections to the rotary switches. Note in the internal view the flat cable assemblies, connecting the switches to the PC boards through J1 and J2.

All of the GND terminals on the rear of the cabinet are tied together and then tied to the cabinet and the T1 terminal on the PC board.

To avoid screw holes in the front panel, the PC board is mounted on stand-offs bonded to the inside of the cabinet with clear Silicone Rubber sealant.

First six 0.5-inch hex spacers are mounted to the PC board with screws. The assembled PC board with the spacers mounted are then held in place with tape, while the positions of the spacers are marked with pencil on the inside of the cabinet.

A portion of the sealant is then placed at the markings of the spacers after first removing the PC board with the spacers. After the sealant has been deposited, the PC board with spacers is again positioned inside the cabinet and temporarily held in place by tape. The sealant is worked in around the body of the spacers to provide maximum support and adhesive. After allowing 12 hours for drying, the tape may be removed.

The test socket and the I/O socket is elevated from the PC board. These sockets are soldered to the PC board after being positioned correctly, with the PC board mounted inside the cabinet.

Put the tester to work

The majority of IC's—gates, counters, decoders and multiplexers—do not require any external components for performance testing. One-shots, line drivers and 7-segment LED drivers do require external components for testing. The I/O socket makes this possible. It gives direct access to all of the pins of the IC.

As an example, if you want to check out a one-shot, you may use a DIP plug-in module to hold the timing components for the one-shot. The trigger can be either CLOCK or a SINGLE PULSE.

Another example would be the check-out of a 7-segment LED driver. In such a case you would need a 7-segment LED, some resistors and possibly a counter to drive the 7-segment LED driver. These components could be mounted on a solderless breadboard and connected to my Digital IC Tester by a DIP cable.

The clock for driving the counter may be taken from the CLOCK OUT terminals on the back of the cabinet. A test sheet could be made, listing the pin connections for various IC's. That would eliminate the need for reference to the data sheets and speed up the testing.

As you can see, this versatile tester will allow you to check out the operation of a wide variety of IC's with minimum efforts. **SP**

"No matter what the project he's working on is supposed to be—it ends up being a light dimmer."

CASSETTE JUNCTION BOX

A handy interface between your microcomputer and its cassette recorder. LED's indicate the states of the signal and control lines.

MILTON D. CHEPKO

WHILE WORKING WITH SEVERAL HOBBY-TYPE MICRO—computer systems during the past two years, I've discovered that they all share one problem—inadequate interfacing with tape storage facilities. This shouldn't come as a surprise, since the cassette recorder wasn't designed for use as a digital data device. Unfortunately, the alternative in bulk storage—floppy disc—is too expensive for most of us, so we use $30-40 cassette recorders in spite of the inconvenience. By using fairly good quality tape, and keeping the heads clean and demagnetized, a reasonable level of performance and reliability is available at an acceptably low cost. The main problems are the cables and plugs that must occasionally be disconnected to regain control of the tape drive; also, level control settings can be critical.

For only a few dollars and a short evening's work, you can build a junction box to eliminate these shortcomings. Below are several suggestions to serve as a starting point for your plans. You may not need all of them, so they are presented separately and can be used in almost any combination. Figure 1 shows a typical junction-box configuration

Motor override switch

This is probably the easiest modification, yet the most essential. Rather than pulling out the REMOTE plug each time you want to rewind a tape, simply wire a switch (pushbutton or toggle) across the control lines. Since the voltage and current are low, any small switch should work.

Ground-loop hum

Most recorders generate hum when connected to microcomputers, presumably because of the multiple grounds that occur. You can prevent this by pulling out the unused plug while making or playing recordings, but it is easier to permanently interrupt the ground connection in one of the lines carrying data to and from the recorder. I've had better luck making this modification in the AUX or MIC line than in the EAR or AUDIO OUT line, although you may want to try both and select the one that works best in your system.

Signal level

Most cassette recorders use ALC (*A*utomatic *L*evel *C*ontrol) during recording, and it's only on playback that the volume control is effective. A glance at the cassette interface specifications for Radio Shack's TRS-80 shows that a two volt of input-signal level is needed for reliable data transfer. Interestingly, LEDs begin to glow at 1.7 volts, and connecting one across the EAR line provides a cheap, easy-to-read, signal-level indicator. In addition, the LED seems to "absorb" some of the excess signal if the volume is set too high, so adjustment becomes less critical.

If you plan to use the junction box with several cassette recorders, use two LED's, with the cathode of one, and the anode of the other, going to ground. This will give good results regardless of the polarity of the output jack.

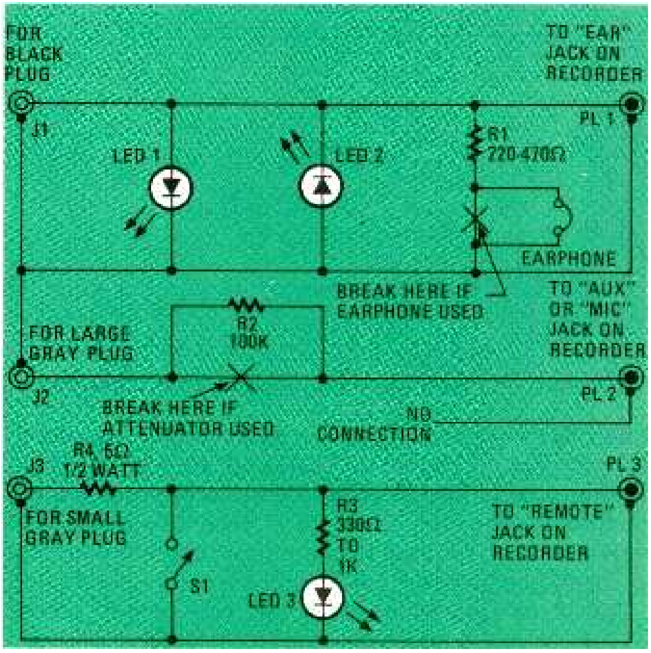


FIG. 1—INTERFACE CIRCUITRY for use between the TRS-80 and cassette recorder. Top circuit feeds recorder output to computer, midele circuit is from computer to recorder and bottom is for control.

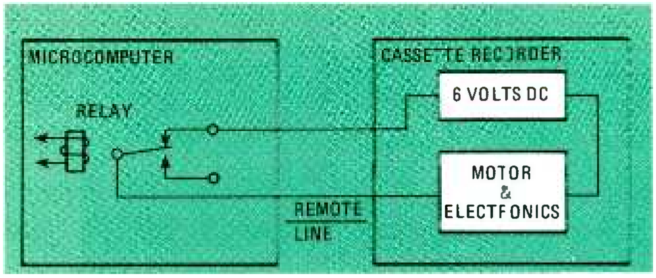


FIG. 2—MICROCOMPUTER CONTROLS RECORDER through a simple relay.

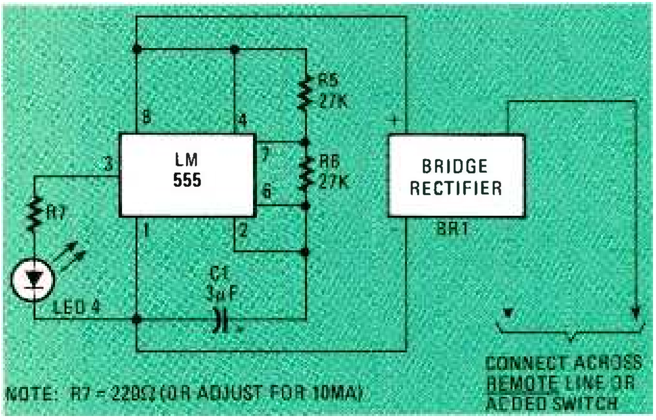


FIG. 3—SIMPLE FLASHER CIRCUIT, using a 555 timer as an oscillator, pulses the LED to signal when computer has finished using the recorder.

Some cassette recorders have only a MIC jack for audio input. The addition of a 100K, ¼-watt, resistor to the "gray line" part of the junction box attenuates the signal from the computer to a level which will not overload this type of circuitry. The resistor does not affect matters if it is left in the line when using recorders with an AUX input—the ALC circuit compensates for the lower signal strength.

Below are three more additions you might find useful in certain applications.

Recorder "ready" signal

Sometimes, in our hurry to get to work on a program we've just loaded in, we forget to hit the recorder's STOP button. Most microcomputers use a small reed-relay to control the recorder drive by interrupting the DC power to the motor, as shown in Fig. 2. At the start of data transfer the relay is actuated by the computer, starting up the recorder. When data transfer is completed, the relay opens, and the recorder stops. Until you hit STOP, there are still 6 volts DC at the recorder's motor-control jack, and that voltage can be detected and used to signal the computer operator. The bottom part of Fig. 1 shows a simple circuit using only a LED and resistor. Again, the polarity of the LED should match the polarity of the REMOTE circuit and the value of the resistor should be chosen to limit the current through the LED to about 10 mA.

Alternatively, a simple flasher circuit (Fig. 3) can be used to catch attention, or the LED can be replaced by a small audio oscillator to provide a "beep" when the computer is finished using the recorder. Just adjust the current to about 10 mA.

Audible data

Sometimes it's reassuring to know that your computer is "hearing" digital data rather than Aunt Martha's latest taped letter from home. You can always pull the EAR plug and listen to the tape, but you may forget to replace the plug later. Instead, wire a small earphone and resistor in series and connect them across the EAR line as shown in Fig. 1, in parallel with the LED level indicator. The low-level audio won't be objectionable, and the resistor prevents loading down the amplifier. I found that a 330-ohm resistor gave acceptable audio and barely dimmed the LED, but you might need anything from 220- to 470-ohms for acceptable operation.

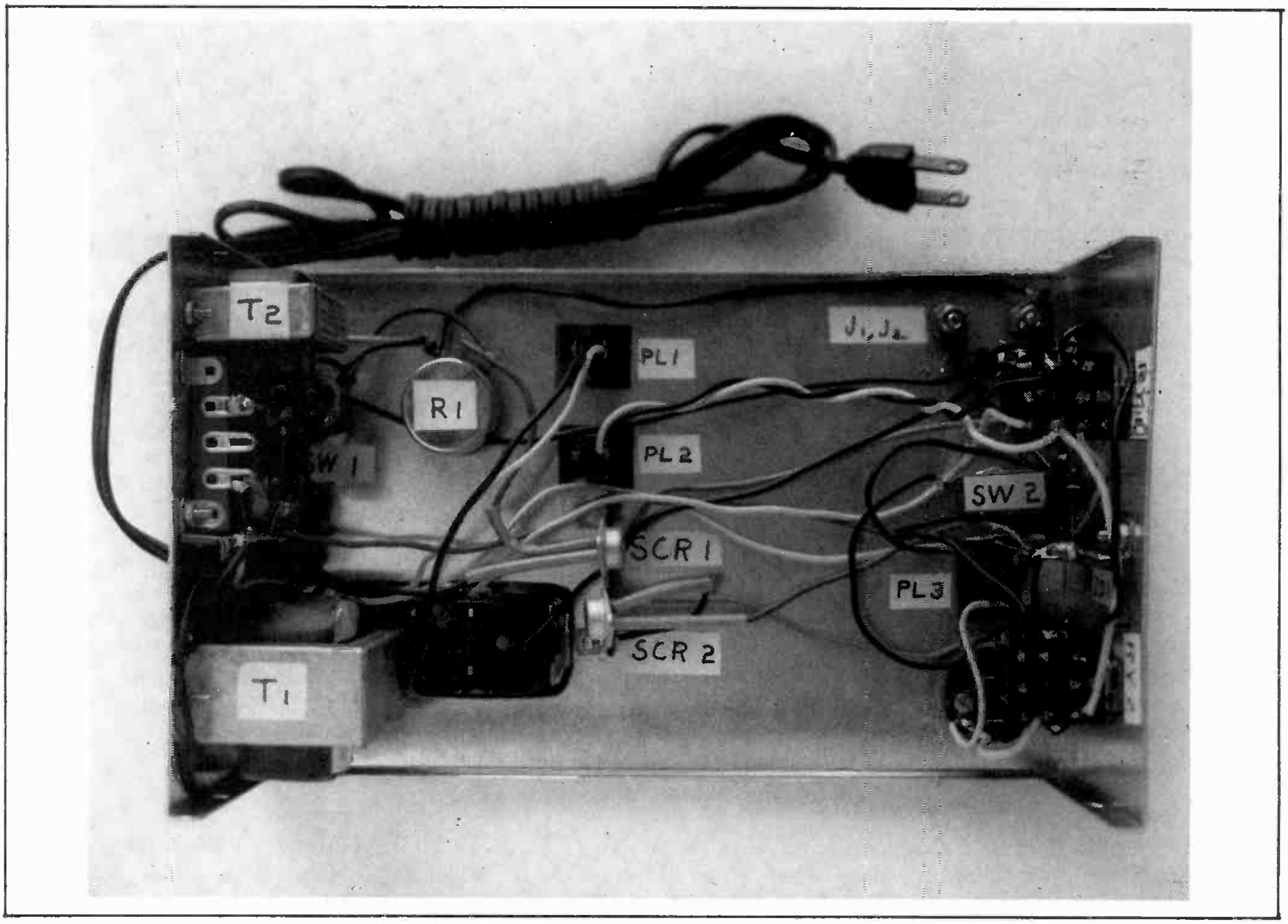
Preserve the control relay

The reed-relay chosen by Radio Shack for use in the TRS-80 appears to have a high failure rate, with the contacts sticking together. The ultimate cure is to replace it with a heavier-duty relay, but this means opening the sealed case and voiding the warranty. By placing a milliammeter in the motor-control line, I found that the relay draws over 250 mA at start-up, dropping to 130 mA while running. With a 5.6 ohm, ½-watt resistor wired in series with the motor-control cable, the peak current is cut to 150 mA but the running current is essentially unchanged. Operation of the recorder seems unaffected, and the life of the reed-relay may be extended.

In summary, I'm sure there are many other modifications that could be made, but few will be as cheap or useful as those described above. Actually, I'm surprised that manufacturers don't add such things as the LED level indicator to their computers, considering that it looks impressive, performs a useful function, and would only cost a few cents! **SP**

PARTS LIST

RESISTORS ***¼ watt, 5% unless otherwise noted***
R1, R2, R7—220 ohms
R2—100,000 ohms
R3—330-1000 ohms (see text)
R4—5 ohms, ½ watt
R5, R6—27,000 ohms
CAPACITORS
C1—3 μF, electrolytic
SEMICONDUCTORS
IC1—LM555 timer
BR1—silicon bridge rectifier, 50-volts or better
LED1-LED4—XC556R or equivalent
S1—SPST switch
J1, J2—miniature phono jack
J3—subminiature phono jack
PL1, PL2—miniature phono plug
PL3—subminiature phono plug
MISCELLANEOUS: Shielded cable, case, earphone, etc.



SAFETY COOKER

In its basic form, it's a ultra-fast circuit-breaker to be used when "cooking" TV sets. Add a few more parts and it's an electronic fire extinguisher

JACK DARR

YOU START OUT TO BUILD A *THING* THAT WILL DO something. Then, when you finish, you find out that it will do something else, and something a lot more useful! That's what I did. I'll tell you what the original idea was, at the end of this article, and you can use it if you want to. Now, let's see what this *More Useful Thing* is.

The heart of the original idea was a very fast, easily adjustable circuit-breaker. So I scrabbled up a circuit, made a lashup and found that it worked, beautifully. In fact, it worked the first time I hooked it up. This wiped me out completely. Nothing I build ever works right the first time—at least I've never had such good fortune before. It turned out to be so sensitive that I could adjust it to hold a given load, and adding only *5 watts* more would trip it!

This was fine, for the original idea. So, I built a prototype. The *More Useful Thing* was discovered by accident! Let's say that you've just finished overhauling a TV set, and you want to cook it for a while, to see if there are any more troubles. (Great call-back-avoider!) But you have to go out of the shop and run some service-calls. You don't like to leave with the set on. So plug it into this fast-acting circuit-breaker, adjust the sensitivity control to just barely hold the normal load-circuit, and get on with your rat-killin'. If anything serious happens to the set, it will be turned off so fast that no further damage will be done! It will cook in perfect safety. (Very useful for those intermittent-short sets, too.)

Design and circuits

I needed a very fast-acting, adjustable circuit breaker. Fuses hold for a short time before they go and conventional circuit breakers have a long time-lag, being thermally operated. What I wanted was something "Fast, *fast* FAST!" as the commercial says. So solid-state. The fastest switch is an SCR; turn-on time less than 1.0 μs. However, that is a "turn-on" reaction, and I needed a turn-off reaction. So I made the SCR close a relay, opening the normally closed (NC) contacts. Total time, at a guess, something like 2 ms.

Also, I needed a latching action, and an SCR won't do that on AC. So I made up a small DC power supply, 12-volt filament transformer (T1), diode, and filter capacitor. By using a big input capacitor, I helped the relay closing-time, too. The capacitor "dumps" its charge through the relay as a surge of current, when the device is tripped.

Now I had to get the SCR to let go, when I wanted it to. This was easy. I added a normally-closed pushbutton switch (S1) to the primary of the filament transformer. That interrupts the DC supply and the SCR resets again.

Now I had to find a way to sense the normal load-current through the device, which would also signal a sudden increase of current to gate the SCR on and close the relay. For this, I connected a stock audio output transformer, 2000 ohms to 3.2-ohm voice coil, with the low-Z secondary winding in series with the AC line going through the unit.

I connected a 5K wirewound pot across the secondary (2K winding) with one end grounded, and the slider going to the gate of the SCR. The AC line goes through the sensor winding, then through the normally-closed contacts of the relay and on to the outlet receptacle.

As long as the relay is "open" (not energized) everything goes along nicely. When an overload occurs, the resulting surge of current through the sensor raises the secondary voltage, above the level needed to fire the SCR. When it fires, the relay closes and breaks the AC circuit to the load.

When I got through with all of that high-powered en-GI-neering, I had the circuit of Fig. 1. That's all there is to it. I made a lashup of this on the bench, connecting everything up with clip-leads. To my utter astonishment, it worked! (You should have seen it; looked like a nest of snakes!) I killed the snakes and built the prototype into a 4×5×6-inch utility box.

Notes on how it does it

I'm feeding raw AC to the SCR gate. You may question this; I did, until I tried it. Later, I added a series diode in the gate circuit, and that made no perceptible difference at all. However, after the *Mark I* was done and checked out, I had doubts. It would work, and trip very rapidly on very small added loads. In fact, I could set it up to hold on loads from 100 to 250 watts, adjust the SENSITIVITY control to the point where it was barely holding, and then plug in only *one* 7-watt Christmas-tree lamp and it would trip!

This was all very well and just what I wanted. However! The added surge current was pretty small. What would happen on a real, dead short? Would the high

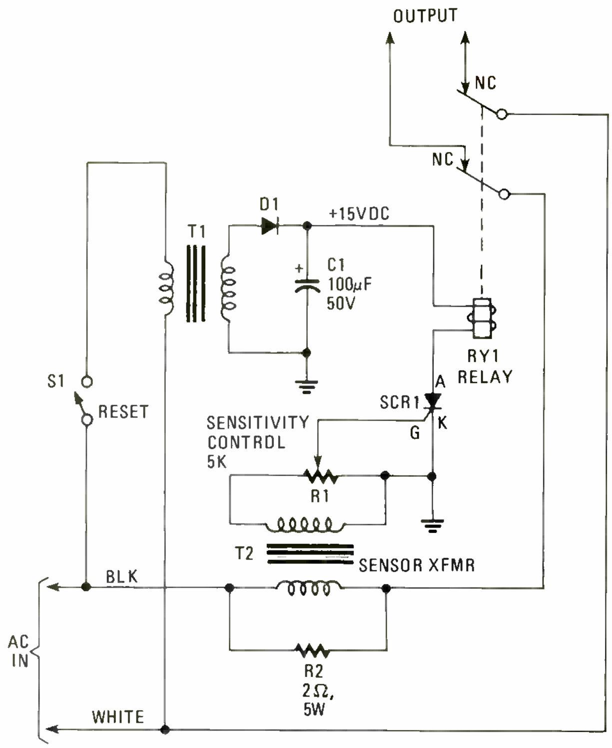


FIG. 1—THE CIRCUIT-BREAKER or Mark I section. It's easy to build your own.

PARTS LIST, MARK I

T1—Filament transformer, 12 V, 2.0A Stancor P-8130 or equal
T2—2000/3.2-ohm audio output trans. Stancor A-3876 or equal 5 W
RY1—12-VDC relay, 120-ohm coil DPDT contacts 5A Potter-Brumfield KA11DY or equal
D1—Silicon rectifier, 200 PIV 1.0 A RCA SK-3030, or equal
SCR1—RCA SK-3042, or equal (See text)
R1—5000 ohms, wirewound
R2—2 ohms, 5 watts
C1—100μF, 50 volts, electrolytic
LM1, LM2, LM3—Pilot lamps, 117V, Industrial devices B3060D1 or equal (red & green)
S1—Pushbutton switch, normally closed Switchcraft 102SW

Standard dual AC outlet, cover plate, pointer knob, terminal strips, asst'd hardware; Bud "Minibox" CU-3010A 4×5×6 inches.

transient blow the gate right out of the SCR? There was only one way to find out; try it.

So I picked up my fool-killer, connected the clip together, crossed my fingers and plugged it in, with the unit running on a 100-watt load and set up. What happened? "Click": that's all. I pulled the fool-killer, opened the clips, reset the SCR and plugged the fool-killer in with clips open. Then I touched them together. "Click!" and the circuit opened so quickly that there wasn't even a spark! (A fool-killer, for those who do not have one, is an AC cord with alligator clips on one end, for hooking up assorted equipment when you don't have the right line-cord. The derivation of the name is obvious.)

Later I connected the scope across the SENSITIVITY control, then shorted the output. From what I could

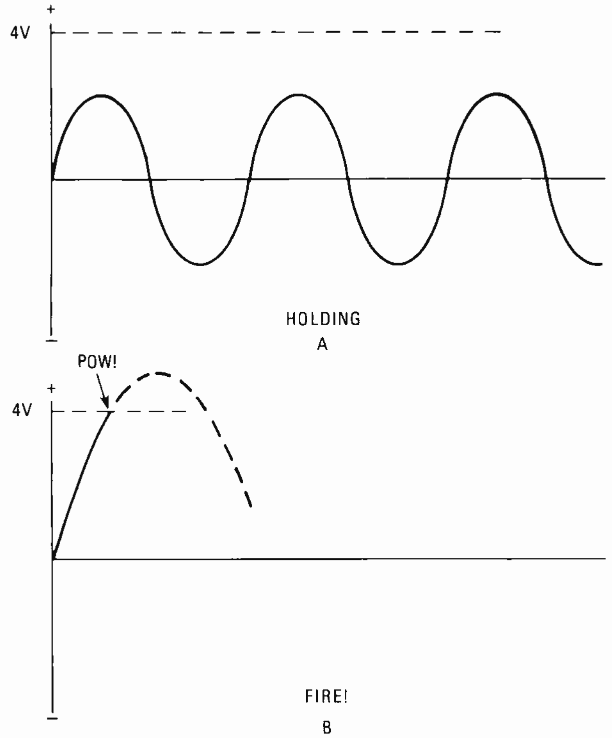


FIG. 2—THE SCR FIRES AS SOON AS PEAK VOLTAGE of first half-cycle reaches gating level of 4.0 volts.

see, the transient is not very large. It looks as if it is about twice the normal "hold" voltage on the SCR gate.

This is about 4 volts. The reason for the fast tripping is that the SCR is firing, as I hoped it would, on the first *half-cycle* of the transient; as soon as the voltage goes above the 4-volt gating level, pow! If the sensitivity control is set just below the trip point, the sensor voltage will run just below 4 volts peak. When a short occurs, the voltage goes up. Figure two shows this.

How to make your own

You can build this thing in any way you want. The photos shows how I did it. (Differences between the photo and text will be explained later! This shows the *Mark II*.) I used terminal strips and point-to-point wiring. Be sure to run all AC wires with at least No. 18 stranded wire with very good insulation.

The SCR(s) are mounted by their ears on a small terminal strip. Gate and cathode leads are tacked on and spaghetti slipped over the pins, just for luck. No heat-sinking will be needed since the SCR is normally *off*. Even when it's left on for long periods of time, it won't even get warm. The 12-volt relay takes only about 100 mA. The negative side of the DC voltage supply is connected to the metal box, but it doesn't have to be. You can run a floating negative as I did, just for luck.

Resistor R2 in Figure one is an addition. It's a 2-ohm, 5-watt wirewound shunted across the primary of the sensor transformer. This carries part of the load current. I added it in the *Mark I* because the audio transformer I had was rather small and got a little warm in operation. The older type (3 to 5 watts) with more iron, won't heat up, and then R2 can be left out.

All parts are stock, and can be found at any radio-

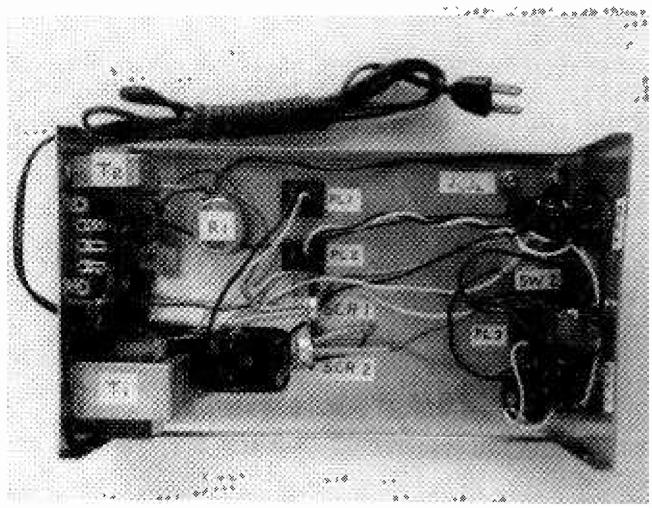


FIG. 3—UNDERSIDE VIEW OF COMPLETE UNIT. This is the MARK II, including the fire-extinguisher trip.

TV supply house. As a matter of fact, you can get a small 12-volt "trickle-charger" from most auto supply stores for less than the cost of the filament transformer and diode! Add a 100-μF 50-volt electrolytic and your DC power supply is done! The junkbox will supply a lot of the parts, saving quite a lot of money.

The circuit could be built on a small panel to get rid of the box. (Before someone asks, the relays shown in Figure 3 are not the Potter-Brumfield type given in the parts list! They're a couple I had lying around; electrically identical though. Any suitable relay can be used, but be sure that the contacts have at least a 5A rating.)

You can vary parts-values if you have to. As long as it works, the heck with it. For example, bargain SCR's could be used, since they have to carry only the 100-mA current of the relays. Most of them gate on at about the same voltage and this makes no difference, since the gating is adjustable.

In normal operation, the device itself takes no current at all. The SCR is turned off, so the relay is not energized. It's ready, but nothing is turned on until there is a short. Only the green READY pilot lamp is taking any current.

Setup and operation

It's very simple to set up. After the wiring is completed and all of the bad solder joints cleaned up, plug it in and check the DC power supply. With the 12-volt filament transformer, you should read about +15 volts DC on the SCR anode and relay coil.

To adjust, turn the sensitvity control full counterclockwise and plug in some kind of test load. A lamp is the best, since you can see it turn on and off. The green pilot light should be on, indicating "Ready, Boss!" Now, turn the SENSITIVITY control slowly clockwise until you hear a click. The lamp will go off and the "Tripped" (red) pilot will turn on.

This shows that it's working. Now, back the SENSITIVITY control off just a little (about 5 to 10 degrees) and push the RESET button. The red light should go out, the green one and the test-lamp come on. If it retrips instantly, turn the SENSITIVITY control back just a bit farther and try again. At this point, you can make the single-Christmas-tree lamp test I mentioned before.

If you have the sensitivity control set right on the threshold, that much extra load will make it trip.

If you plug this unit in, then plug the load into it and turn it on, you may get tripping due to the transient. Turn the SENSITIVITY control full counterclockwise; reset, then turn it up until you find a setting just below the trip threshold.

If you want further verification, plug a TV set into it and set it up. Now, pull the horizontal oscillator tube! It should trip. In fact, that is how I discovered this application. I'd just finished some extensive repairs to a large color set and wanted to run down the street for something. (OK, I wanted a cuppa cawfee!) However, I didn't have too much faith in the set and I started to turn it off. Instead I plugged it into the *Mark I*, set it up, and went happily off. When I came back, the red light was glowing brightly, and the set's horizontal oscillator tube was quite dead! However, my new 6LQ6 and the flyback, were still in *very* good shape!

If you want to, and if you used a DPDT relay as I did, you can add a bell, buzzer, or any other kind of alarm to the thing, to signal when it trips. (However, don't use too big a bell. I tried it, and the thing went off and almost scared the pants off me!)

The original idea

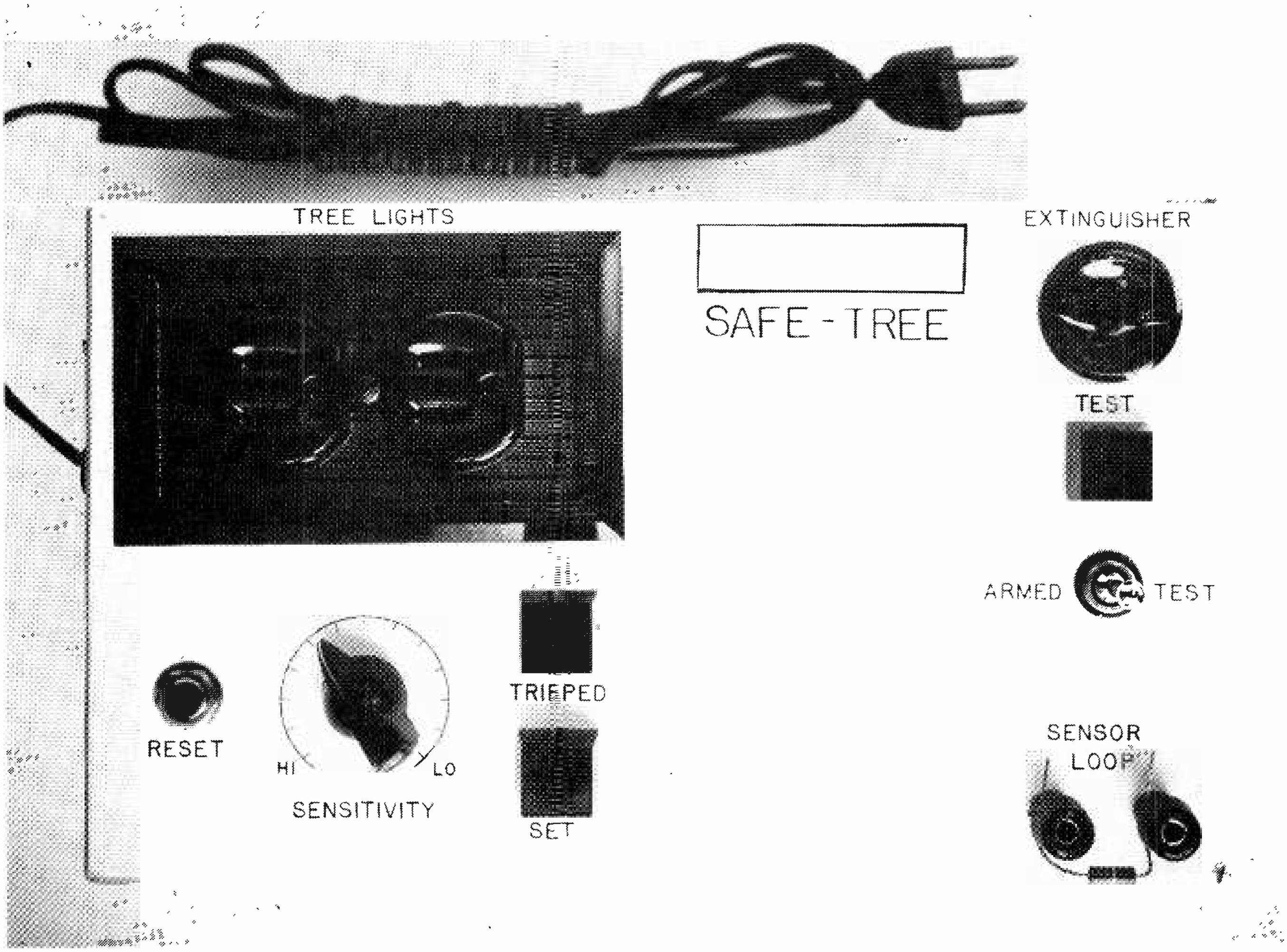
Now comes the part I told you about, and the idea that started the whole thing. At first, this *Thing* was supposed to be a fast-acting combination circuit-breaker and fire-extinguisher for preventing Christmas-tree fires! The other function turned out to be so fascinating, and so much more useful in everyday work, that we turned it around!

If you do want to use it for protecting a Christmas-tree, or anything equally flammable, it's easy. Just build the *Mark I* as in Fig. 1, and then add the few extra parts shown in Figure 4. The relay and SCR are the same types used the the first section. We'll get to the rest in a moment.

The idea is to trigger a fire-extinguisher rigged to spray the tree, but only if there *is* flame. Most Christmas-tree fires are caused by defective lights. So the first thing to do is kill the AC supply to the lights to get rid of the arcing that starts the fire. This is done by the *Mark I* section.

Of course, we *do not* want to soak down the tree and the gifts unless it is absolutely necessary. (Although some of those gift neckties might be improved by a drenching!) So the extra circuit is designed to "arm" the fire-extinguisher actuating solenoid, but to hold it off unless there *is* flame. The normally-open contacts on the first relay close when the device trips. This supplies AC to the contacts of RY2. But RY2 does not close tripping the fire-extinguisher. At least not yet.

Another SCR is used to operate this relay. Its gate is controlled by a voltage divider across the DC voltage supply from the *Mark I*. A Zener diode is connected to the tap. As long as the DC voltage here is *below* the Zener voltage, the Zener won't conduct. This voltage



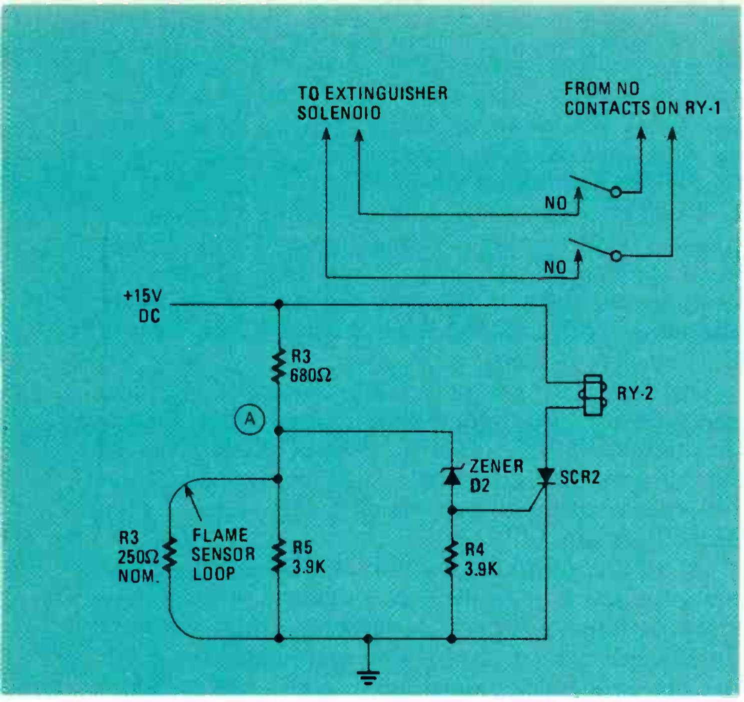


FIG. 4—ADD THIS CIRCUIT TO MARK I and you have the whole thing.

PARTS LIST

Add this circuit to *Mark I* and you have the whole thing!

RY2—Same as RY1.
SCR2—Same as SCR1.
D2—Zener diode 7.5 volts 1 W, RCA SK-3059 or equal
R3—680 ohms, 1 watt
R4, R5—3900 ohms, 1 watt
AC outlet—Amphenol 160-2-N, for fire extinguisher
S2—SPDT toggle switch (test-armed)

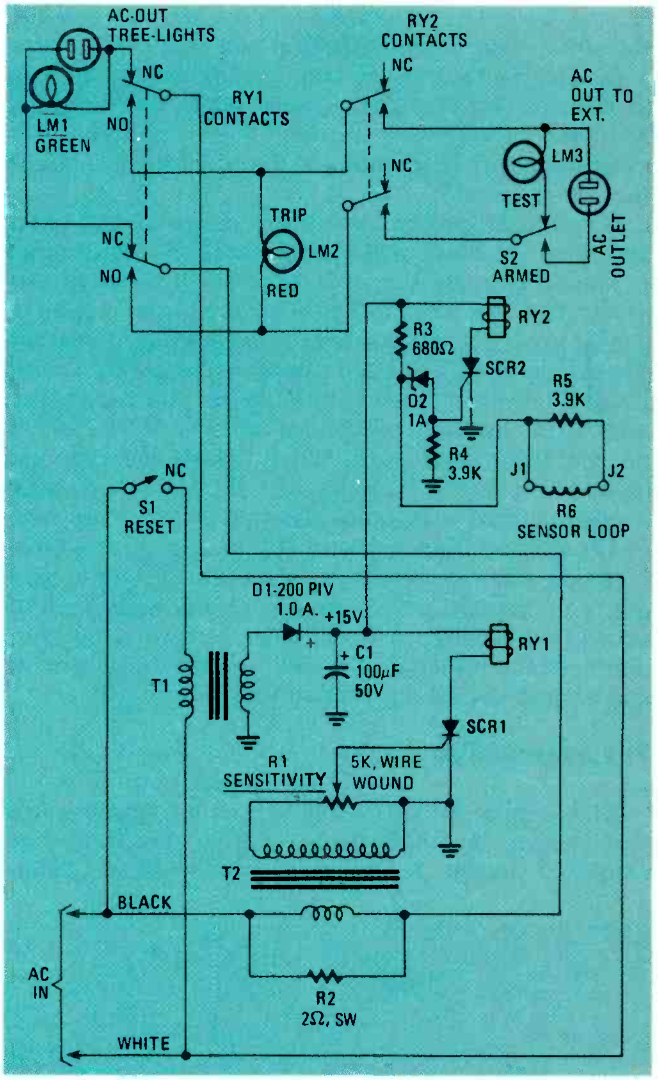


FIG. 5—COMPLETE CIRCUIT of Mark I and Mark II combined.

is held low by a "flame-sensor loop" connected across R5. That loop is made up of some kind of flexible, current-carrying material, that will burn in two if there is flame in the tree.

There are several kinds of ornamental foil ribbon which will do that. Use enough of it to make a loop long enough to be strung throughout the whole tree, so that it will be broken by flame at any point. The resistance of this should be as low as possible; anything from about 250 ohms on down is fine.

For testing the flame-sensor loop, hook a 270-ohm resitor across the terminals and make whatever adjustment is needed. Figure 5 shows the whole circuit, including the flame-sensor, extra SCR, and so on. Remove the 270-ohm resistor when adjustments are completed.

Note that Fig. 5 shows a TEST ARMED switch and pilot light. It is included so that the flame-sensor loop and its continuity can be checked and you can be *sure* that the fire-extinguisher won't go off accidentally. (It will, if the flame-sensor loop is accidentally broken and the breaker is tripped!)

To check that, hook up the flame-sensor loop, set the TEST-ARMED switch (S2) to TEST, and deliberately trip the breaker. If everything is in order, the TRIP light on the breaker will light. The TEST light *should NOT* go on! (For added safety, unplug the cord to the extinguisher solenoid!) Opening the flame-sensor loop by unhooking one terminal *should* make the TEST light go on. Pushing the RESET button resets both SCR's at once since it breaks the DC supply.

If you run into trouble getting a trip on the flame-sensor, check the DC voltage at the Zener. You may not have enough voltage at this point to make it operate. If so, either use a lower-voltage Zener, or change the ratios of R3/R5. I used a 7.5-volt Zener diode, RCA SK-3059, and it worked very well with the resistance values shown.

Any kind of extinguisher can be used that has a 117-volt electrically operated solenoid valve. There are quite a few of these available.

Merry Christmas! **SP**

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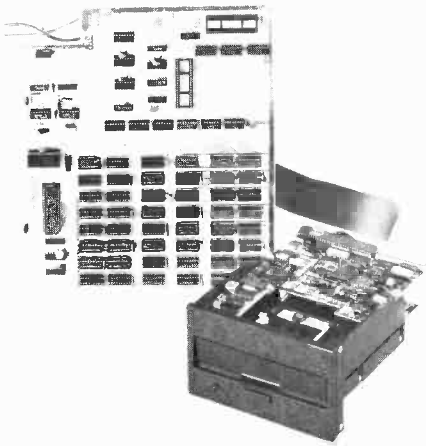

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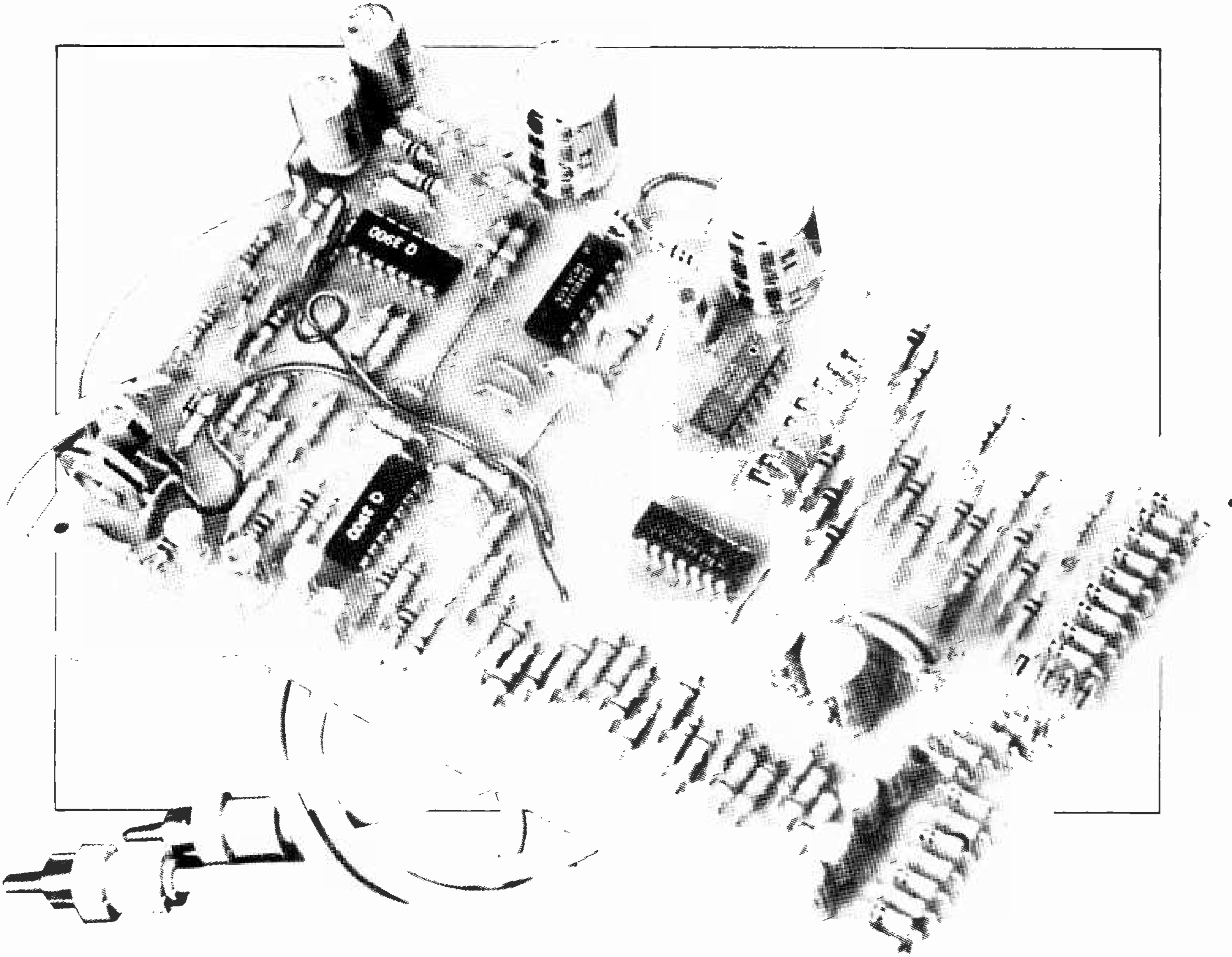


CHORD EGG

That's EGG as in Encephalo-Gratification Generator. Produces one musical chord after another.

**JOHN S. SIMONTON, JR.
and CRAIG ANDERTON**

QUESTION: WHAT DO YOU GET IF YOU COMBINE THE LSI heart of a modern electronic organ using synthesizer-type processing elements with digital logic and randomizing circuits for control, and stereo for spatial effects?

Answer: A mind-boggling piece of technology called the Chord EGG (*E*ncephalo-*G*ratification *G*enerator).

Here's what it does: The Chord EGG randomly selects one of four pre-programmed major triads (C, F, the first inversion of G and the second inversion of C, in the version described) and just as randomly selects and accentuates single notes or intervals from the triad. Simultaneously, other random circuitry is independently sweeping a pair of subtle bandpass filters back and forth over the entire output. Each filter's output drives a stereo channel.

This all sounds incredibly busy, and describing it in words may leave the impression of frenetic electronic and musical activity. In reality, just the reverse is true. The result is an exceptionally pleasing background to conversation, meditation or work, or just nice listening too. It's not organ-like, and it's not the typical synthesizer sound. It's something entirely different.

And when experienced through a set of headphones, the effect is unique to the point of being unearthly and potentially illegal. The tones and chords have body and *exist*, and gently flow and sweep and pan their way through your mind; never repeating, never predictable.

Circuit description

A first glance at the schematic of the Chord EGG (Fig. 1) may be a little intimidating. But, like most complex things, it's only a collection of simple ones. To illustrate this we'll divide the EGG into seven simple parts and analyze each individually. These will be: 1) Tone generator, 2) Chord randomizer, 3) Chord decoder, 4) Note randomizer, 5) Control-voltage summing matrix, 6) Voltage-controlled attenuators and 7) Voltage-controlled filters.

Tone generator: The tone-generator portion of the EGG uses two gates from a CMOS quad NOR package (IC2-a & -b) configured as an astable multivibrator with a frequency of approximately 250 kHz. This clock frequency is applied to the input of IC1, a MK50240

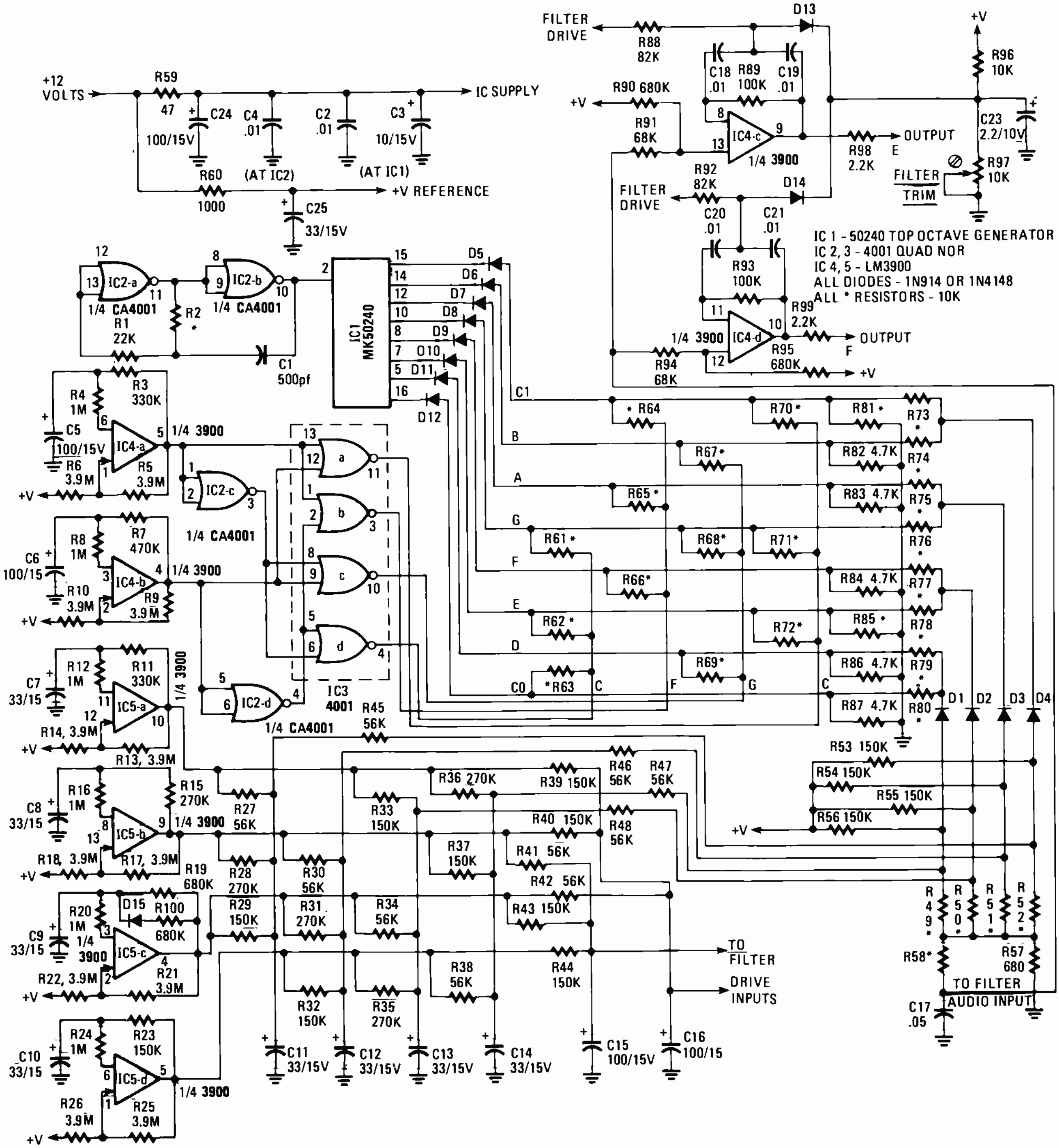


FIG. 1—COMPLETE CIRCUIT OF THE CHORD EGG. It is far from a simple device, but thanks to the circuit board, it is not difficult to assemble. If you look at it as several separate circuits wired together, its operation is easier to understand.

top-octave generator, which in turn produces at its 13 outputs a complete octave (plus one note) of equally tempered musical tones. The frequency of the multivibrator is determined by the R2/C1 time constant, while C4 and C2 provide high-frequency bypassing on the supply lines of IC's 1 and 2. Electrolytic capacitor C3 provides low-frequency bypassing for the power supply to the top-octave generator.

Chord randomizer: Essential to the operation of the chord randomizer is the long-period astable multivibrator, a circuit used extensively in this project. The one built around IC4-a is typical of all of them. Resistor R6 is a biasing resistor, R5 provides positive feedback for hysterisis, R4 converts the voltage appearing across the timing capacitor, C5, to a current that the amplifier can work with and R3 sets the time required for C5 to charge to the threshold voltages established by the rest of the components. Two of these circuits are built around two of the four amplifier stages in a single LM3900 quad current-differencing amplifier package (IC4-a and IC4-b). Their periods are about 15 and 25 seconds respectively, and naturally (since their periods are different), they run asynchronously. We can think of the outputs of these two circuits as representing a two-bit, ever changing binary number which drives the 2-to-4 decoder consisting of the six NOR gates—IC2-c & -d and IC3-a—d.

When the two asynchronous astable multivibrators are combined with the 2-to-4 decoder, we have a circuit that selects one of four lines in a pseudo-random manner and raises that line to a high state while leaving the other three output lines low. All four lines go to the...

Chord decoder, where they select one of four possible chord structures. Each tone from output-line from the top-octave divider is connected to a diode (D5—D12). The diodes are used as switches that allow the notes needed for a particular chord to pass while blocking the unused notes. If, for example, the F chord is selected, diodes D5, D7 and D9 are forward-biased by the voltage applied to resistors R64—R66 and the positive portions of the square waves generated by the top-octave chip on the F, A and C lines can pass. Because the remainder of the resistors in the chord-decoder matrix are grounded (either directly or through the 2-to-4 decoder), they are reverse-biased and block the unwanted outputs of IC1. Resistors R81—R87 are provided to compensate for the fact that, while some lines in the chord decoder have a single selecting resistor attached to them, others have two or three. Without these compensating resistors, lines that connect to a single selecting resistor would carry a signficantly higher signal-level than the rest.

Resistors R73—R80 mix the selected notes onto three of the four audio busses which are in turn connected to the...

Voltage-controlled attenuators. We need a separate line for each tone because we don't want all the notes in a chord to rise and fall in volume simultaneously, but, rather, we want the individual notes that make up the chord to rise and fall independently. The voltage-controlled attenuators work in essentially the same manner as did the switching diodes in the chord decoder with one important exception. Instead of being biased on with a constant voltage and mixed to a single output, they are controlled by a voltage which varies at (pseudo-)random, and whose source we will investigate shortly. As the time-varying control voltages applied to R45—R48 increase, the point at which the diodes clamp also increases, thereby increasing the amplitude of the square wave on that line.

Control voltages for the attentuators begin their existence in the:

Note randomizer, which is in all important aspects identical to the chord randomizer. The differences are that, instead of two astable multivibrators, we have four (all sections of IC5) and these have shorter periods (in the 5-to-10 second range) than the others. The conversion of the binary numbers generated here to a smoothly varying control voltage is handled by the:

Control-voltage summing matrix, resistors R27—R44, and integrating capacitors C11—C16. A total of six control voltages, four for VCA's (Voltage-Controlled *Attenuators*) and two for VCF's (Voltage-Controlled

PARTS LIST

RESISTORS

¼W 5% unless noted

R1—22,000 ohms
R2, R49-R52, R58, R61-R81, R85, R96—10,000 ohms
R3, R11—330,000 ohms
R4, R8, R12, R16, R20, R24—1 megohm
R5, R6, R9, R10, R13, R14, R17, R18, R21, R22, R25, R26—3.9 megohms
R7—470,000 ohms
R15, R28, R31, R35, R36—270,000 ohms
R19, R90, R95, R100—680,000 ohms
R23, R29, R32, R33, R37, R39, R40, R43, R44, R53, R56—150,000 ohms
R27, R30, R34, R38, R41, R42; R45-R48—56,000 ohms
R57—680 ohms
R59—47 ohms
R60—1000 ohms
R82-R84, R86, R87—4700 ohms
R88, R92—82,000 ohms
R89, R93—100,000 ohms
R91, R94—68,000 ohms
R97—10,000 ohms, trimmer, vertical mount
R98, R99—2200 ohms

CAPACITORS

C1—500 pF ceramic disc
C2, C4, C18-C21—.01 μF ceramic disc
C17—.05 μF ceramic disc
C3—10 μF, 15-volt electrolytic
C5, C6, C15, C16, C24—100 μF, 15-volt electrolytic
C7-C14, C25—33 μF, 15-volt electrolytic
C23—2.2 μF, 10-volt electrolytic

SEMICONDUCTORS

D1-D15—1N914 or 1N4148 diode
IC1—MK50240 top-octave generator
IC2, IC3—4001 quad NOR gate
IC4, IC5—3900 quad Norton amp.

MISCELLANEOUS

Hookup wire, shielded audio cable with connectors to fit amplifier used, solder, hardware, PC board, etc.

NOTE: A complete kit of all parts required to build the Chord EGG is available from PAIA Electronics, Inc., P.O. Box 14359, Oklahoma City, OK 73114 for $24.95 plus $2.00 shipping & handling (OK residents add 4% tax). Order No. 3790. Etched & drilled PC board only (No. 3790PC) $9.95 plus $1.00 shipping & handling and tax where applicable.

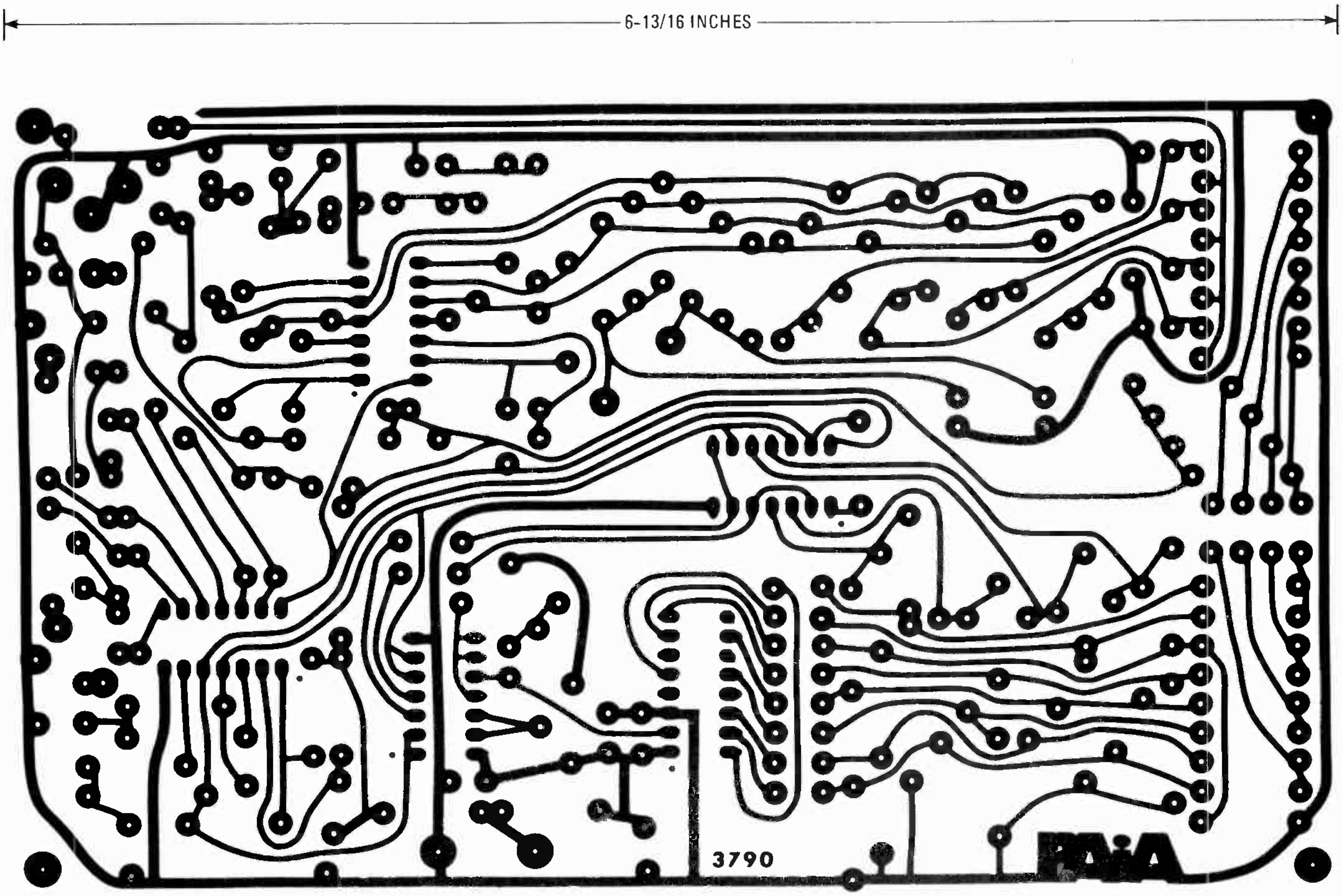


FIG. 2—ACTUAL SIZE DIAGRAM OF THE FOIL PATTERN Chord EGG. Single-sided board makes it an easy one to duplicate.

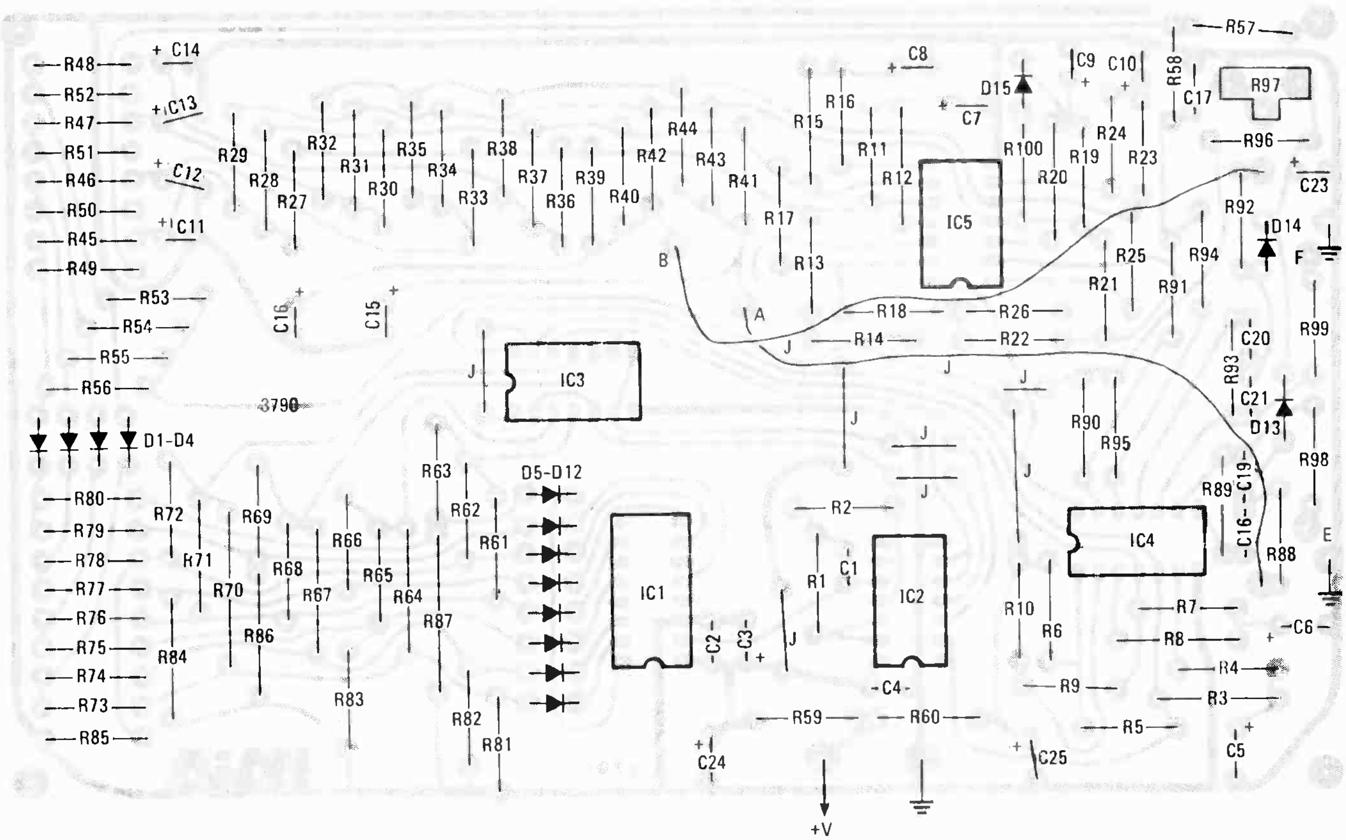


FIG. 3—PARTS PLACEMENT DIAGRAM shows exactly where every component is mounted on the circuit board.

Filters), are produced by this matrix and all six are the result of charging and discharging a capacitor through one of three resistors which may be either at the positive supply-voltage or ground depending on the states of the multivibrators; for example, C11 charges and discharges through resistors R27, R28 and R29. The important thing to note here is that each of the four voltages produced for the VCA's is unique because the outputs of the 4 multivibrators are combined three-at-a-time in the matrix. The two voltages that will be applied to the filter are not unique because of the *combinations* of astable outputs that produce them, but are unique because of the *resistor values* used in the matrix.

R-2R ladders could have been used as the basis of these matrixes but that would have been significantly more complicated and would not have yielded significantly better results.

The circuitry, as described so far, is interesting; chords are randomly produced and individual notes randomly emphasized. But, if we stop here, we have a device with a definite "Gardens of Eternal Peace" quality to it. Morticians would love it, but those of us who are interested in more lively applications would be less than enchanted.

There are still two sections of current-differencing amp left over (IC's 4-c and 4-d) and we can make the transition from dirge to delight by turning them into:

Voltage-controlled filters of the bridged-T, bandpass type. These filters are tuned by putting diodes D13 and D14 into the circuit at positions which would ordinarily be occupied by a frequency-determining resistor. By changing the DC current flow through these diodes we can change their AC impedance and, consequently, the tuning of the filter. Note that these diodes terminate at a point (the junction of R96 and R97) that is above ground potential. The tuning voltage applied to the filters must exceed this voltage level before the tuning will change.

The outputs of these two filters are the stereo outputs of the EGG and the subtle differences in the center frequency and attenuation of the filters provide the apparent motion of the sound in the stereo field. It is interesting to note that, while listening to the EGG, the apparent motion of the sound source is not constrained to the horizontal plane.

Construction procedures

If you are going to build the EGG on a circuit board such as that shown in Fig. 2, construction is a snap. You only have to make sure that the parts are in the proper locations as indicated in the parts-placement diagram (Fig. 3) and that the electrolytic capacitors, diodes and IC's are properly oriented.

If you've worked with it before, perforated prototyping board would be an excellent construction medium (if you haven't, build something simpler first). There are no extremely high frequencies wandering around, so wiring lengths are not critical in that respect, but for the sake of your sanity keep the wire runs *short*—particularly those going to the audio control-voltage inputs of the filters, otherwise the CB'ers will drive you buggy (it's most difficult to meditate with "Breaker, breaker" running through your mind—unless, of course, that's your mantra). If you're going to run the EGG from a power supply other than batteries, make sure that it has *as little ripple as possible*—some of the audio paths are dividers directly across the supply lines and the ripple can really get into them. The EGG, as illustrated here, has a total current drain of about 30 mA so batteries are not out of the question.

Use it well

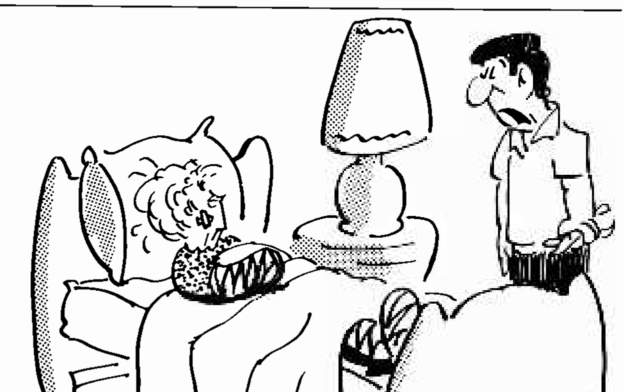
The EGG is easier to use than a radio—you don't have to waste a lot of time deciding what station to listen to. Make the connections between the EGG and your amplifier using shielded cable terminated in plugs that are appropriate for the input of your amplifier. The ubiquitous "auxiliary" amplifier inputs should be your first choice but just about any input will do.

To use the EGG in mono, you can either use just one of the outputs or tie both outputs directly together—whichever is most pleasing to you. You won't really get the full benefit of the EGG, though, until you hear it in stereo—especially through headphones.

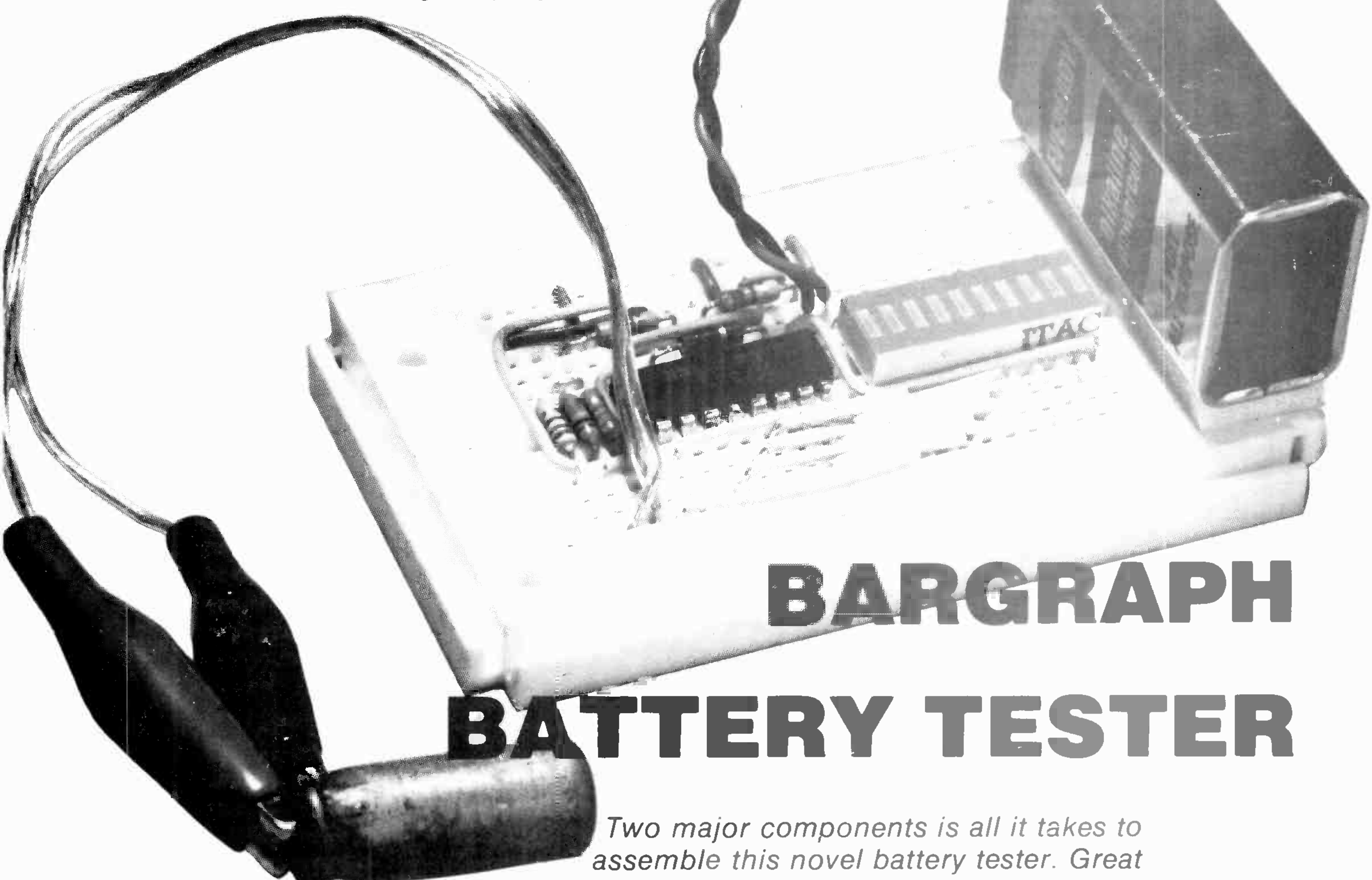
If you wish, there are a number of points at which the EGG may be customized. For instance, you may for some reason want to tune the EGG exactly to the key of C. This is just a matter of changing the frequency of the clock and is most appropriately handled by adjusting the value of R2. (Don't go any lower than about 2200 ohms. For higher frequencies, lower the value of C1.) Resistors R53—R56 determine the "on" time of the notes and chords. By lowering these values slightly (not more than 33%) the EGG will be producing sound a great percentage of the time. Raising the values of these resistors will make the EGG "quiet" a greater percentage of the time.

Changing the value of R97 changes the point at which the voltage-controlled filters come into play. Lowering the value makes the action of the filters more evident and, conversely, increasing it makes the action less noticeable.

You can even change the chord structures if you wish. Just make sure that only one note from a chord terminates on any one audio line at a time or the notes will not be free to change independently. **SP**



"Don't beat around the bush, Agnes. If you don't want to help with my antenna again today, why don't you just come right out and say so?"



WIRED ON A BREADBOARD, the complete unit is easy to assemble. It is shown here checking out a penlight cell.

BARGRAPH BATTERY TESTER

Two major components is all it takes to assemble this novel battery tester. Great for checking out single cells, it gives quick evidence of a battery's condition.

MARTIN BRADLEY WEINSTEIN

BAR GRAPHS AND MOVING-DOT DISPLAYS CAN PROVIDE smarter answers than D'Arsonval meters and multiple-digit readouts in a number of applications. They're immune to static and magnetic fields, unlike plastic-faced magnetic-movement meters. They require only minimal front panel space. They're easily interpreted for trend and magnitude, if not precise value. And now, they're inexpensive.

The schematic diagram demonstrates how easy it is to implement a practical instrument with only a few components. Officially, the bargraph display (which could just as easily have been a moving-dot display), is serving as an expanded scale voltmeter, operating in approximately 1/10th-volt increments from 0.7 to 1.7 VDC. The turn-on values for each segment shown adjacent to the schematic are measured, not calculated, for the particular unit we breadboarded.

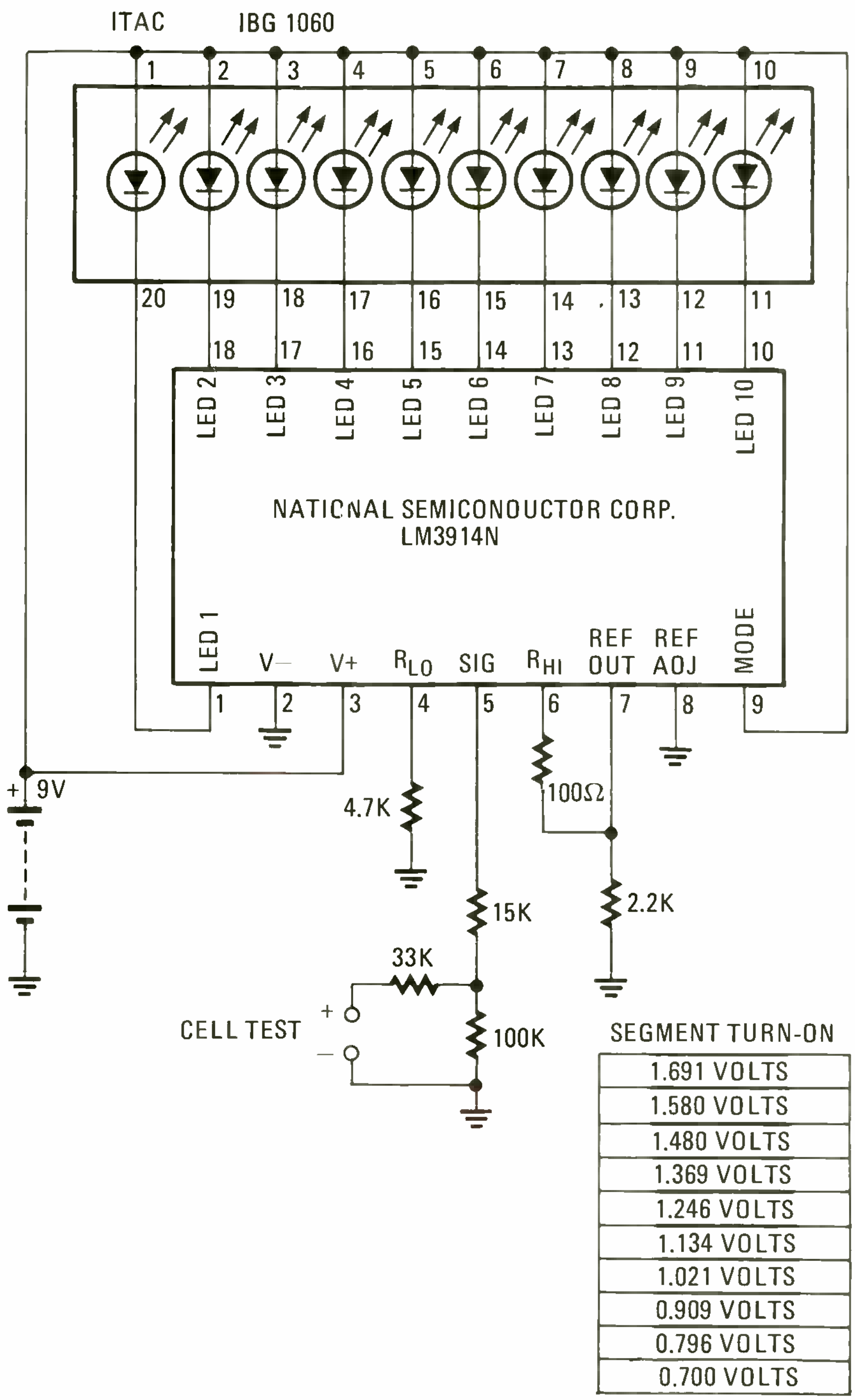
The National Semiconductor LM3914N, in fact, can emulate a 0 to 1.2-VDC meter with just a 3 to 15 VDC supply, 10 LED's and one resistor—in either moving-dot or bargraph mode! If the 10 LED's are those of the ITAC display, the total parts count (less power supply) is three.

The secret of the LM3914's external simplicity is a bit of internal ingenuity. In addition to the resistor/comparator chain that characterizes bargraph-type A-D circuits, there's an input buffer amplifier (high impedance, to minimize loading on the signal under test), an internal voltage reference (1.25-V nominal, but adjustable with an external resistor or two), a mode control, and LED brightness current programming.

National's data sheet/application note offers a more thorough treatment of the full capabilities of the '3914, of course. If you can't get one through National, you'll find the Radio Shack LM3914 has information attached to its skin card. At this writing, the Radio Shack version is priced under three dollars.

ITAC (ITAC Corporation, 2045 Martin Avenue, Santa Clara, CA 95050) introduced their IBG-1000 series of 10-segment LED DIP bargraph displays in July, 1978. This, we believe, makes them the forerunners in this specific field—though many other companies are now making similar displays.

Key to the utility of this display is that its standard dual-inline package (0.3" center spacing, 0.1" lead spacing) packs all 10 segments in a compact, 0.990 x

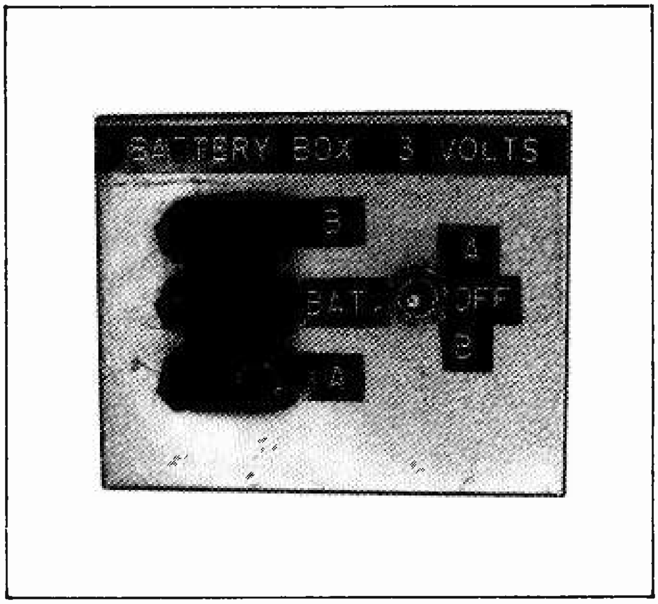


SCHEMATIC DIAGRAM shows just how simple the tester can be. Test AA, C and D cells. When testing, load the cell with 2.4 ohms for heavy-duty or 10 ohms for light-duty applications.

0.360 inch component. All 20 leads are brought out separately, making both leads on each LED individually accessible, permitting anode multiplexing, cathode multiplexing, or discrete element drive.

Each LED in the array is encapsulated with a reflector, greatly enhancing legibility. The orange IBG-1060 used in our breadboard, typically offers 0.6 millicandelas per segment, at a 10-mA forward current.

This display is available in four colors: green (IBG-1050), orange (IBG-1060), red (IBG-1070) and yellow (IBG-1080). These displays are end-stackable for applications where more than 10 segments are needed. In addition, under normal lighting conditions, their low-drive current requirements (typically 5-mA per element) permit direct drive by CMOS circuits. **SP**



BATTERY SWITCHING BOX

Ridiculously simple, this gadget has applications for the experimenter and service technician. Here are a few; you'll think of others.

ELMER C. CARLSON

THIS SIMPLE AND INEXPENSIVE DEVICE HAS FOUND A number of uses. It has been particularly valuable in science fair projects and has also proven its worth in electronics testing and experimentation.

It uses only a few components: a DPDT, center-off switch, three pairs of 3-way binding posts, a battery holder, and an aluminum box. That, together with some solder and wire—and whatever batteries you choose to provide the voltage you need—makes up the entire parts list. The battery/switching box has paid for itself many times over.

Here are just several uses to which it can be put.

Even with the switch in the center-off position, the BAT terminals are still connected to the battery. That allows connection of a voltmeter to monitor the battery voltage or voltage of a charger, if nickel-cadmium cells are used (Fig. 1). In fact, both the meter and charger may be used if one of them is connected to terminals A or B, and the switch thrown to the appropriate position.

Two circuits may be powered from the same DC cells are used (Figure two) by connecting one of terminals A and the other to B, using the switch to select the circuit to which current will be supplied. Voltage can still be monitored at the BAT terminals.

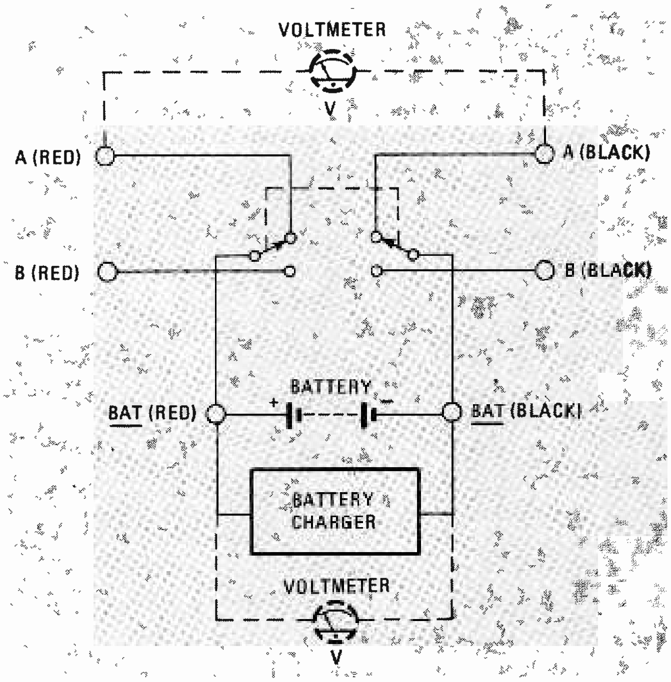


FIG. 1—HANDY BATTERY BOX can be used to power transistor radios while under test on the service bench.

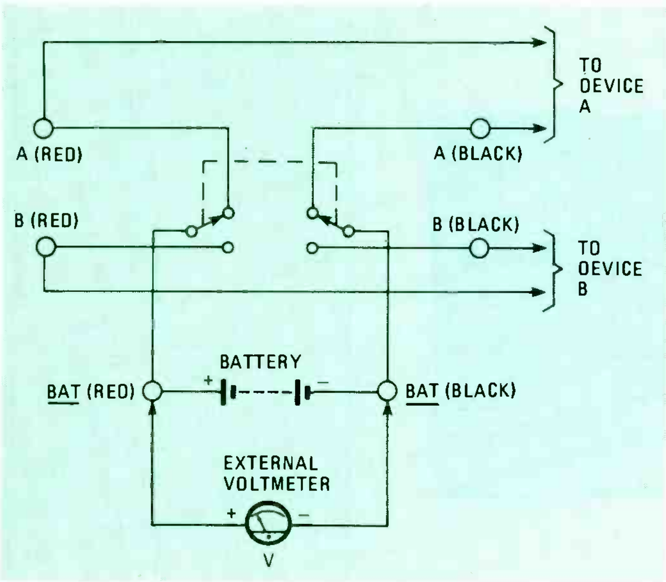


FIG. 2—TWO DEVICES can be powered by the battery box. Simply throw the switch to feed power to the selected device.

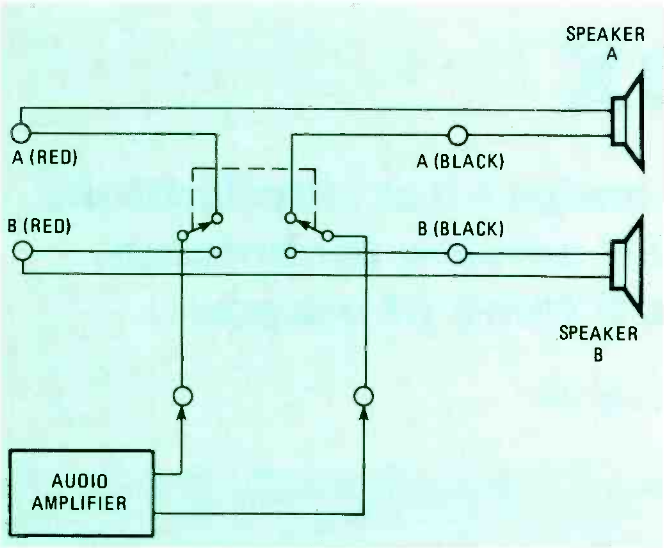


FIG. 3—WITHOUT BATTERIES, use the gadget as a switching box to feed the radio output to either one of two speakers.

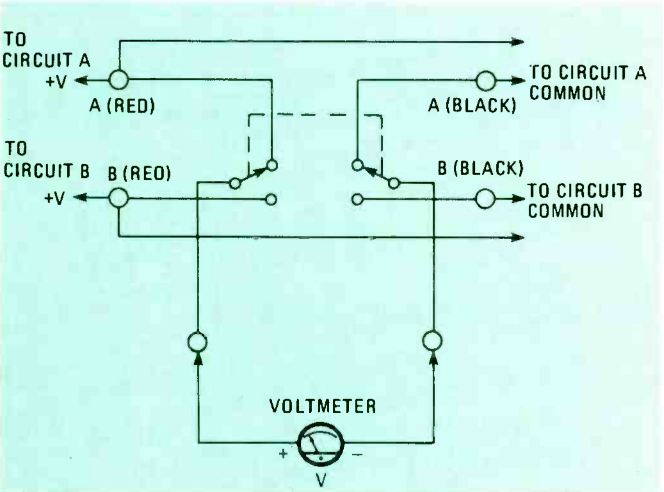


FIG. 4—A SINGLE VOLTMETER can be used to monitor two separate voltage test points withoug moving test leads from one point to the other.

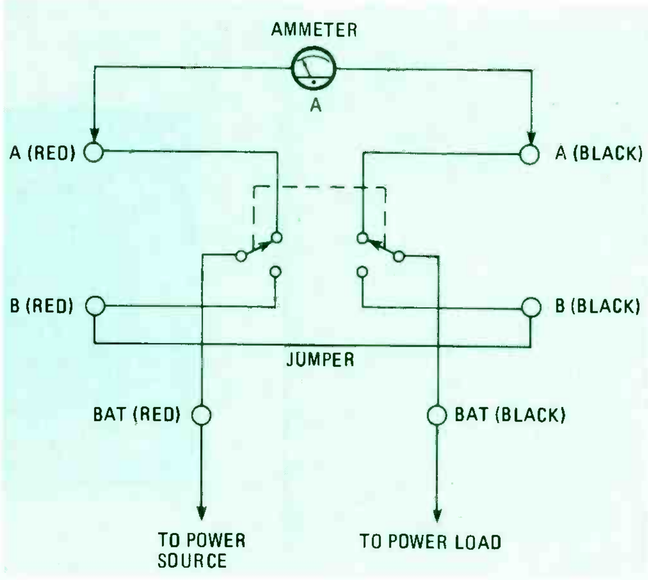


FIG. 5—CHECKING CURRENT DRAIN is simple when the switch box is connected this way.

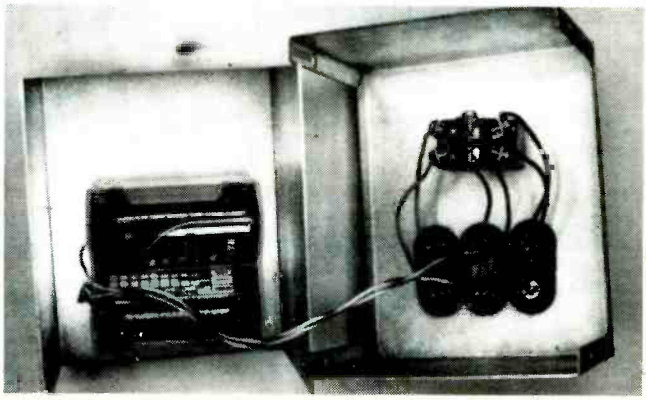


FIG. 6—THE BATTERY BOX. Batteries, as needed, are in one part of the box; switch and terminals in the other.

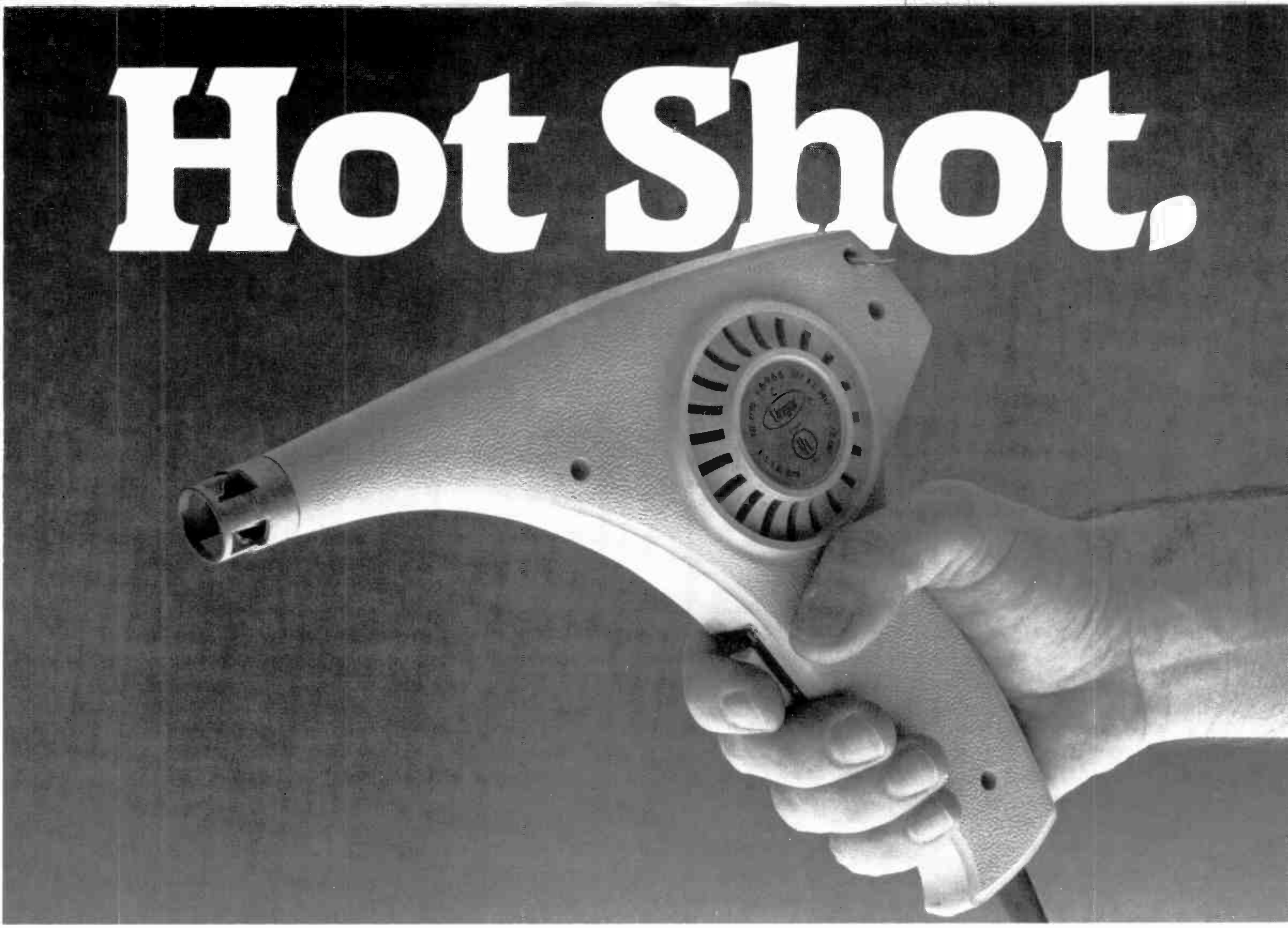
The box can be used without batteries, too. Figure 3 shows an application where two sets of speakers, fed from the same audio source, can be compared at the flip of a switch. Of course, comparisons of other things besides speakers can be made the same way.

Similarly, a single voltmeter—as shown in Figure four—can be used, by means of the switching box, to monitor voltages at two different test points without having to switch leads constantly. The box can also be used as a combination on/off switch and ammeter in/out selector (Figure 5).

The switching box can also be used to insert two or three components (or component networks) into a circuit. It can alleviate the hazards of loose clip-leads and eliminate the frustrations of poor contacts and broken connections.

As is obvious from Fig. 6, there is nothing critical about parts or component placement. It would be advisable, though, to space the 3-way binding posts exactly 3/4 of an inch apart, to accommodate the dual banana-plugs that are often found in laboratory environments.

There is very little to this project in the way of construction, but the applications that have been given here are only a few of the possibilities that will occur to you as you begin to use this simple—but versatile—device. **SP**



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

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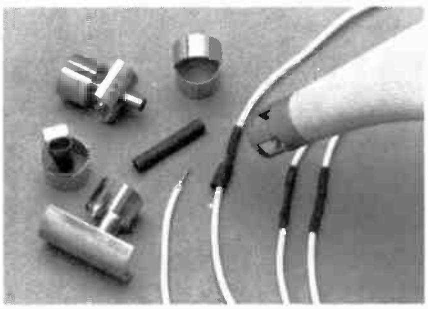

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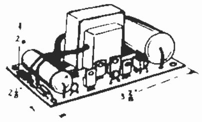

PARTS INCLUDED
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PC board
4 diodes
Capacitor 1000 uf
Capacitor 500 f
3 Capacitors 10 uf

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10-24	13.50ea
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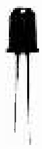

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XAN72(MAN72 equiv)	25/$17.50
common anode	100/$65.00
.3" RED LED DISPLAY	$.79ea
7 segment RHD	10/$6.95
NSN74R common cathode	25/$16.25
	100/$59.00
.6" RED LED DISPLAY	$1.25ea
7 segment LHD	10/$11.50
XAN6940 - common cathode	25/$26.50
	100/$98.00

LINEAR CIRCUITS 1/2 PRICE SALE

	REG.	SALE		REG.	SALE
LM300H	$.59	$.30	LM376CN	$.50	$.25
LM301CN	.32	.16	LM380-8	.89	.45
LM302H	.59	.30	LM565N	1.15	.58
LM307CN	.32	.16	LM709H	.39	.20
LM308H	.79	.40	LM733H	.89	.45
LM308CN	.79	.40	LM739N	.89	.45
LM309H	1.05	.53	LM748CN	.35	.18
LM310CN	1.07	.54	LM1414N	1.25	.63
LM311H	.89	.45	LM1800N	2.40	1.20
LM311CN	.89	.45	75453CN		
LM311N	.89	.45	(351CN)	.35	.18
LM322N	.89	.45	75491N	.75	.38
LM340T-6V			75492N	.89	.45
(7806)	1.19	.60			

CERAMIC CAPACITORS

1pf	22pf	56pf	120pf	270pf	820pf	.0047uf	.030uf
5pf	27pf	68pf	150pf	390pf	.001uf	.01uf	.050uf
7pf	33pf	82pf	180pf	470pf	.0015uf	.015uf	.1uf
10pf	47pf	100pf	220pf	600pf	.003uf	.022uf	

	1pf - .050uf			.1uf		
Total	EA.	PK-10	PK-100	EA.	PK-10	PK-100
1-1000	$.20	.95	6.50	.25	1.25	9.00
1000-	.20	.85	6.00	.25	1.10	8.00

CERAMIC CAPACITOR KIT
CK-c2 5ea. of the above values $11.50
CK-c3 10ea. of the above values 20.50

POLYESTER FILM CAPACITORS - 100V ± 10%

	EA.	PK-10	PK-100		EA.	PK-10	PK-100
.001uf	$.15	.95	6.50	.033uf	$.20	1.00	10.00
.0015uf	.15	.95	7.50	.047uf	.20	1.15	10.50
.0022uf	.15	.95	7.50	.068uf	.25	1.30	12.00
.0033uf	.15	.95	7.50	.1uf	.30	1.75	13.50
.0047uf	.15	.95	7.50	.15uf	.35	2.25	14.00
.0068uf	.15	.95	7.50	.22uf	.40	2.55	20.00
.01uf	.15	.95	7.50	.33uf	.45	2.75	25.00
.015uf	.15	.95	7.50	.47uf	.50	3.50	30.00
.022uf	.15	.95	7.50				

TOTAL QTY. 1000 pcs. -10%, 5000 pcs. -15%

POLYESTER CAPACITOR KIT
5 ea of the above values $14.95

TANTALUM CAPACITORS

solid dipped ± 20%

.1uf/35V	.30	.25	4.7uf/16V	.38	.30	22uf/16V	.50	.40
.22uf/35V	.30	.25	4.7uf/25V	.45	.35	22uf/35V	.60	.55
.33uf/35V	.30	.25	6.8uf/6V	.35	.28	33uf/6V	.55	.45
1uf/20V	.30	.25	6.8uf/16V	.45	.39	33uf/10V	.60	.50
1.5uf/20V	.30	.25	10uf/20V	.42	.35	47uf/6V	.60	.50
2.2uf/20V	.35	.25	15uf/6V	.42	.35	47uf/15V	.65	.55
2.2uf/35V	.38	.28	15uf/20V	.50	.40	56uf/6V	.85	.75
3.3uf/35V	.40	.30						

CAPACITOR KIT ck-t2
tantalum
solid dipped ±20%

.22uf/35V	2.2uf/25V	6.8uf/16V	22uf/16V
.33uf/35V	3.3uf/35V	10uf/20V	33uf/10V
1uf/35V	4.7uf/16V	15uf/20V	47uf/20V

5ea of above values..........$17.75
Supplied in clear styrene utility box..........$21.95

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CARBON FILM RESISTORS 1/4 & 1/2 watt

CARBON FILM ±5%
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.095"dia X .250"long (body)
1/2watt (R.Ohm R50)
146"dia X .354"long (body)

total quantity	ea	pk-10	pk-100	pk-1000
1-999	$.10	.45	2.00	
1000-	.10	.40	1.80	15.00
5000-	.10	.30	1.70	14.50
10000-	.10	.25	1.55	13.00

VALUES STOCKED (ohms)

15	3.9	16	68	300	1.2K	5.1K	22K	91K	390K	1.6M	*6.2M
1.0	4.3	18	75	330	1.3K	5.6K	24K	100K	430K	1.8M	*6.8M
1.1	4.7	20	82	360	1.5K	6.2K	27K	110K	470K	2.0M	*7.5M
1.2	5.1	22	91	390	1.6K	6.8K	30K	120K	510K	2.2M	*8.2M
1.3	5.6	24	100	430	1.8K	7.5K	33K	130K	560K	2.4M	*9.1M
1.5	6.2	27	110	470	2.0K	8.2K	36K	150K	620K	2.7M	*10M
1.6	6.8	30	120	510	2.2K	9.1K	39K	160K	680K	3.0M	*11M
1.8	7.5	33	130	560	2.4K	10K	43K	180K	750K	3.3M	*12M
2.0	8.2	36	150	620	2.7K	11K	47K	200K	820K	3.6M	*13M
2.2	9.1	39	[illegible]	680	3.0K	12K	51K	220K	910K	3.9M	*15M
2.4	10	43	[illegible]	750	3.3K	13K	56K	240K	1.0M	4.3M	(* 1/2w
2.7	11	47	200	820	3.6K	15K	62K	270K	1.1M	4.7M	only)
3.0	12	51	220	910	3.9K	16K	68K	300K	1.2M	5.1M	
3.3	13	56	240	1.0K	4.3K	18K	75K	330K	1.3M	5.6M	
3.6	15	62	270	1.1K	4.7K	20K	82K	360K	1.5M		

METAL FILM RESISTORS 1/4 & 1/8 watt

METAL FILM ±1%
RN60 (R.Ohm CRB60FY) 1/4watt
Low temp coef - 50ppm/°.
.138"dia X .355"long (body)
color banded

total quantity	ea	pk-10	pk-25	pk-100	pk-250
1-999	$.25	1.00	2.00	7.50	17.50
1000-	.20	.90	1.80	7.00	16.25
5000-	.20	.85	1.70	6.50	15.00
10000-	.20	.80	1.55	6.00	13.75

VALUES STOCKED (ohms)
Standard decade values from 10ohm to 475Kohm

10.0	12.1	14.7	17.8	22.6	27.4	33.2	40.2	48.7	59.0	71.5	88.7
10.2	12.4	15.0	18.2	23.2	28.0	34.0	41.2	49.9	60.4	73.2	90.9
10.5	12.7	15.4	18.7	23.7	28.7	34.8	42.2	51.1	61.9	75.0	93.1
10.7	13.0	15.8	19.1	24.3	29.4	35.7	43.2	52.3	63.4	76.8	95.3
11.0	13.3	16.2	19.6	24.9	30.1	36.5	44-2	53.6	64.9	80.6	97.6
11.3	13.7	16.5	20.0	25.5	30.9	37.4	45.3	54.9	66.5	82.5	
11.5	14.0	16.9	20.5	26.1	31.6	38.3	46.4	56.2	68.1	84.5	
11.8	14.3	17.4	22.1	26.7	32.4	39.2	47.5	57.6	69.8	86.6	

and multilples of 10 of the [illegible] values to 475K
i.e. 10.0 100 1.0K 10.0K [illegible]0K etc (total 448)

METAL FILM ±1%
RN55 (R.Ohm CRB14FY) 1/8watt
Low temp coef - 50ppm/°C
.094"dia X .225"long (body)
color banded

total quantity	ea	pk-10	pk-50	pk-100	pk-500
1-999	$.25	1.00	4.00	7.50	35.00
1000-	.20	.90	3.60	7.00	32.50
5000-	.20	.85	3.40	6.50	30.00
10000-	.20	.80	3.10	6.00	27.50

VALUES STOCKED (ohms)

10.0	27.4	75.0	348	1.74K	5.11K	11.0K	20.5K	31.6K	54.9K	140K	324K
10.2	28.7	78.7	402	1.87K	5.36K	11.3K	21.0K	32.4K	57.6K	147K	332K
11.0	30.1	84.5	475	1.96K	5.49K	11.5K	21.5K	33.2K	60.4K	150K	348K
11.5	31.6	90.9	487	2.05K	5.76K	12.1K	22.1K	34.8K	64.9K	158K	374K
12.1	33.2	100	499	2.21K	6.04K	12.4K	22.6K	36.5K	68.1K	165K	402K
13.0	35.7	107	604	2.43K	6.49K	12.7K	23.2K	37.4K	69.8K	174K	432K
14.0	37.4	121	649	2.49K	6.81K	13.0k	23.7K	39.2K	75.0K	182K	453K
14.7	40.2	127	715	2.74K	7.15K	13.3K	24.3K	40.2K	76.8K	191K	464K
15.0	43.2	137	750	2.87K	7.50K	14.0K	24.9K	41.2K	82.5K	200K	475K
16.2	45.3	150	909	3.01K	8.25K	14.7K	25.5K	43.2K	90.9K	205K	1M
17.4	47.5	165	1.00K	3.16K	8.66K	15.0K	26.1K	45.3K	95.3K	210K	
18.2	49.9	191	1.02K	3.32K	9.09K	15.4K	26.7K	46.4K	100K	221K	
19.1	54.9	200	1.10K	3.57K	9.53K	16.2K	27.4K	47.5K	105K	232K	
20.0	57.6	210	1.21K	4.22K	9.76K	16.9K	28.0K	48.7K	110K	249K	
22.1	60.4	232	1.27K	4.53K	10.0K	17.4K	28.7K	49.9K	115K	255K	
23.2	64.9	249	1.30K	4.75K	10.2K	18.2K	29.4K	51.1K	121K	287K	
24.9	68.1	301	1.47K	4.87K	10.5K	19.1K	30.1K	52.3K	130K	294K	
26.1	71.5	316	1.50K	4.99K	10.7K	20.0K	30.9K	53.6K	137K	301K	

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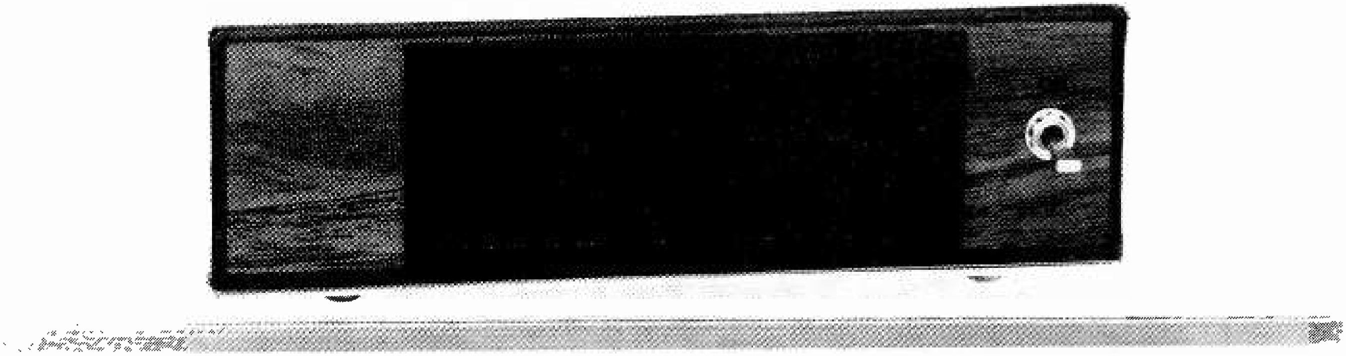
DIGITAL FREQUENCY DISPLAY

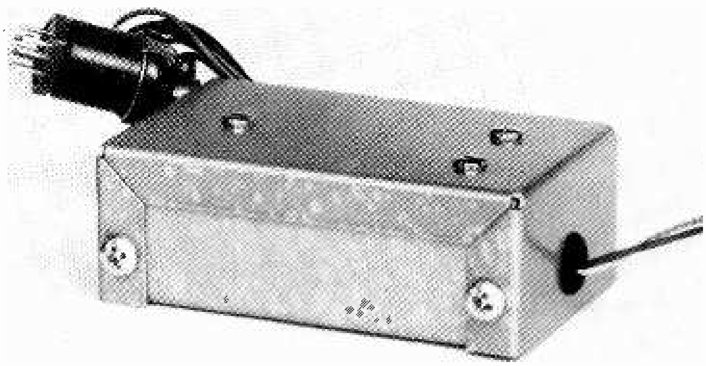
Add-on digital display for your communications receiver

GARY McCLELLAN

IN CASE YOU HAVEN'T NOTICED THERE HAS BEEN A BIG change in the general-coverage shortwave receiver in the past few years. Gone are the hard-to-read analog tuning dials. In their place most receivers sport a digital display of frequency. And thanks to this new feature, the latest shortwave receivers are easier to use than ever, with plenty of owners delighted over the ease of tuning. Another advantage of the digital display is that no crystal calibrator is required, as there's no dial to calibrate! Then too, one of the nicest features of a digital frequency display is the ability to choose a station to listen to, look up the frequency, then dial in this frequency and listen for the station. Still another advantage is that you don't have to squint at a tiny scale packed with numbers, as found on most shortwave receivers; the frequency can be read at arm's length. Needless to say, these features will guarantee that digital displays in shortwave receivers are here to stay!

If you are one of the countless people who own one of those older shortwave receivers you probably wish that





There are three major elements to this display. The display itself, the prescaler and the basic DC power supply.

you had a digital display. Thanks to our project your wish can come true! You build this simple project and connect it to your shortwave receiver. The result is that you get a display of frequency with resolution to the nearest 1kHz! In fact, this project isn't limited to just shortwave receiver, but can be used on standard AM or FM receivers as well! Thus, you may want to build several for other receivers you have. Construction of this project is easy for what it does, and the parts cost is probably lower than you expect. This is due to several low cost LSI IC's in the design. Unlike most frequency displays (even commercial ones) this project has the bulk of the circuitry inside two CMOS LSI IC's. They replace several rows of traditional TTL IC's. At the same time, three PC boards simplify the wiring, and make this project highly adaptable to different receivers.

We've paid special attention to circuit details like jumpers. They have been reduced to the bare minimum. That simplifies an annoying assembly task! Generally, construction time will run about 2 or 3 evenings, including receiver installation. The latter will probably take the most time, but I'll show you how to connect the project to your receiver later, simplifying the job. As far as cost is concerned, this project can be built for about $50 even if your shopping skills are limited. By using state-of-the-art parts selection and design, you can build a digital display very cheaply; to appreciate the difference check the price tags of the latest digital tuning receivers! Also, a set of boards and plans are available to help you start off on the right foot.

If you are concerned about connections to your receiver, they're simple too. Just two wires are connected to the circuitry, and a matchbox sized module is installed inside the receiver. In most cases the job is simple and easy to do. If possible, dig out the schematic to your set for reference later on or buy one. For older receivers try Supreme Publications, Rider manuals, or Howard W. Sams (Photofacts®). Armed with a schematic, the hookups become simpler, so be sure to get a schematic if you can!

Avoid these pitfalls

You should know that this project was designed to work with the single-conversion superhet receiver. This is the all time best seller, so most receivers are likely to meet this requirement. **There are a few sets, however, that should be avoided. Don't try to adapt this project to a double-conversion receiver.** The reason is that double-conversion superhets contain two local oscillators, both of which must be measured to determine the received frequency. This project can measure just one local oscillator, so it wouldn't work. **Also, don't try to adapt this project to receivers with transformerless chassis,** like the Hallicrafters S-38 series. **If you do, the result will be a potential shock hazard. And finally, avoid CB radios.** This is necessary because most modern ones have double-conversion receivers. And remember, this project will only display frequency. Most CB enthusiasts want digital display of channel numbers, which this project won't do.

How it works

This project is basically nothing more than a frequency counter that can be programmed to a preset count. In fact, by disconnecting the preset circuitry,

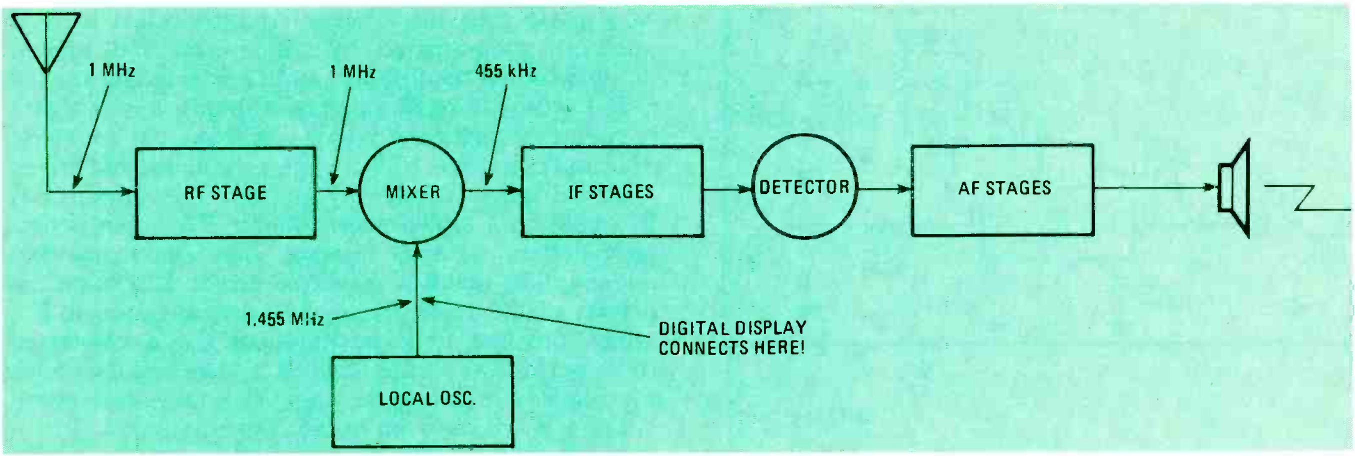


FIG. 1—BASIC SUPERHET GENERAL-COVERAGE RECEIVER. Countless numbers of units with this design have been sold and many are still being made today.

you get an excellent 100-MHz counter that has superior sensitivity. Let's start with the basics of a typical receiver to see why such a fancy frequency counter is necessary.

The general-coverage receivers recommended for use with this unit are basically alike even if made by different manufacturers. Fig. 1 is a block diagram of a typical set. In operation, suppose you want to receive a 1-MHz signal. The tuning dial is set to this frequency. This peaks up the coils in the RF stage, and sets the local oscillator frequency to 1.455 MHz. Why the higher frequency? Let's back up and see. The 1-MHz signal at the antenna is amplified by the RF stage and passed on to the mixer. The mixer combines the 1-MHz signal with the 1.455-MHz output from the local oscillator. As a result, a 455-kHz difference signal is generated. It's amplified by the IF stage, detected, amplified as audio, and passed on to the speaker. In short, this receiver is known as a *simple superhet.*

At this point, let's add the frequency display to our simple superhet. The only place you can measure frequency in a superhet accurately is in the *local oscillator* section, and that's where the digital display is connected. But the moment you connect a counter, you'll discover the local oscillator frequency is always 455-kHz higher than the frequency you are tuned to. So what's necessary is to automatically subtract the IF from the display. By programming the counter to start from a certain value, the IF subtracts out mathematically, leaving the frequency you are tuned to. Thanks to modern LSI circuitry, making such a programmable (or presettable) frequency counter is very easy.

Now let's look at the circuitry of the shortwave frequency display. If you'll turn to Fig. 2 for the block diagram you'll get a quick idea of how it works. To simplify construction, and make the receiver connec-

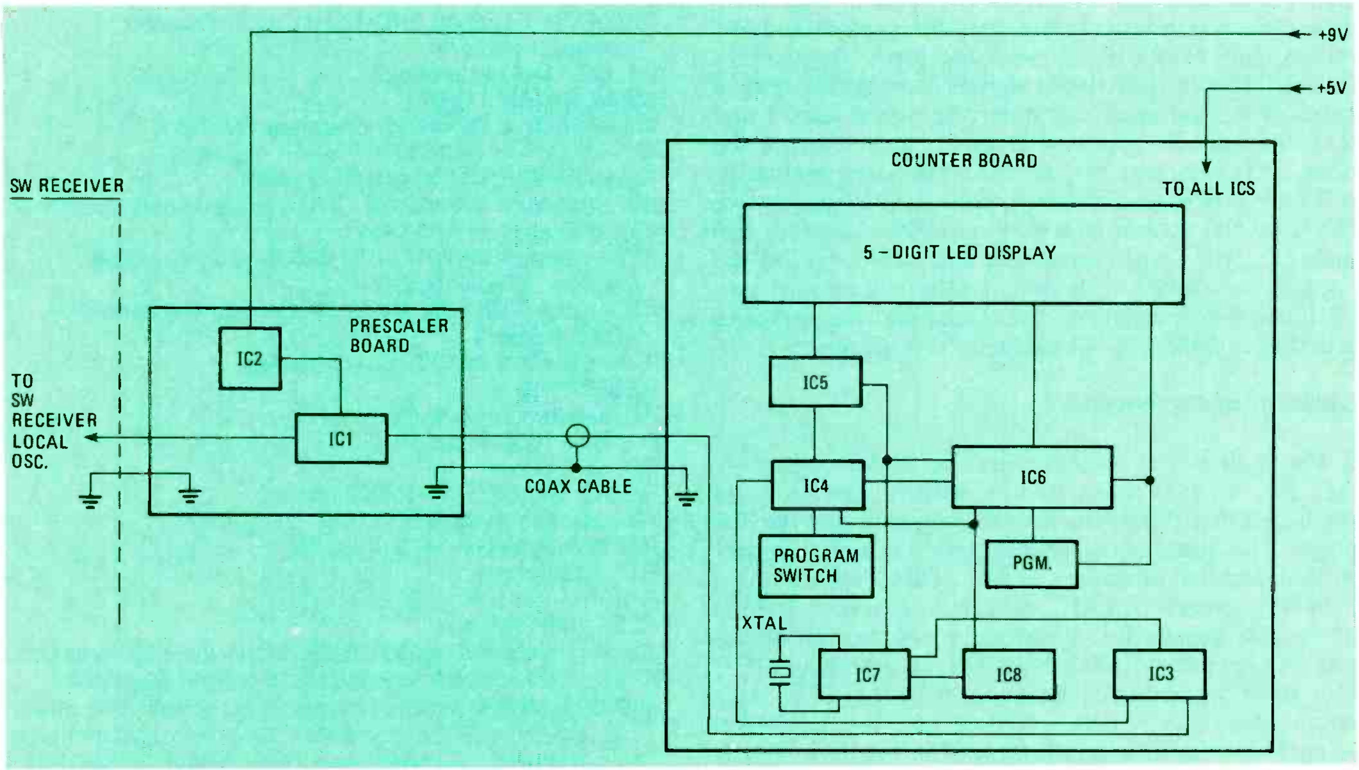


FIG. 2—BLOCK DIAGRAM of the digital frequency display described in this article.

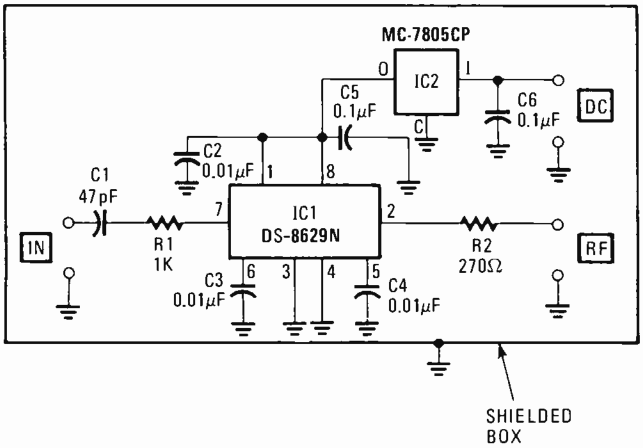


FIG. 3—PRESCALER INPUT CIRCUITRY. Two ICs make it uncomplicated and reasonably easy to build.

tions easier, the project is built in sections. The first section is the *prescaler* assembly. It mounts inside the receiver, near the local oscillator. There's also a voltage regulator on this board for the circuitry, allowing it to run on a wide range of voltages. A short length of coaxial cable links this assembly to the display section which can sit on top of your receiver. The second section, or *counter assembly*, displays the output of the prescaler, after correcting for the IF. This assembly contains a CMOS programmable counter, an oscillator/controller IC, and some miscellaneous logic devices. The counter IC is simply programmed with a plug-in module and a DIP switch. If desired, the project can be used as a frequency counter by unplugging the module and setting the switch to zero.

Now let's dig deeper into the circuitry, starting with the prescaler board. Refer to the schematic in Fig. 3 for details. In operation, IC1 serves as a combination input amp/squaring circuit/divide-by-100. This busy little chip was originally designed for synthesized FM radios, but works nicely with the lower frequencies found in this project. Input signals from the shortwave receiver's local oscillator enter the board via C1 and R1. They act as isolation elements and separate the noisy IC frequency divider from the local oscillator. IC1 then processes the signal, producing a squarewave (TTL levels) output of exactly 1/100th the input frequency. This signal drives the logic circuitry on the counter assembly. The other IC on this board is a standard 5-volt regulator. It insures that the prescaler receives a stable, low-impedance voltage source.

Closeup of the counter

The bulk of the project is on the counter assembly (see Fig. 4). It is really two PC boards. Let's discuss the larger board only, as the other one has just the displays. The heart of the counter board is a crystal-controlled counter-timebase, or IC7. This chip accepts a 5.24-Mhz crystal, XTAL, and generates a complete set of control signals for a frequency counter. In operation, it generates a 100-mS gate signal that drives IC3, plus reset and transfer pulses for the other IC's. As a result, this counter makes 5 readings a second, which is optimum for this application. The last two signals drive flip-flop IC8. It generates a "load preset count" pulse between the times these lines become active. This pulse tells the counter circuitry when to load numbers programmed by the switch and plug-in module so that the display can be corrected for the IF.

IC3 is a quad NOR gate and it simply acts as a gate between the prescaler board signal and the counters. The first counter is IC4. It counts the signal and drives IC5, a display decoder/driver chip. The output from IC4 goes to a four-decade counter. This chip is programmed to a preset number, then counts the frequency. The result is displayed on the LED's on the display board. Note that the four displays going to IC6 are multiplexed, while the fifth is not. Diodes connected to J1 perform the programming by steering the multiplex signals back into the chip. That takes care of the counter board; now on to the construction!

How to build your own

There are several ways you can build this project, but the best way is to build the display section as an external unit. That way it can be connected to other receivers, or used as a frequency counter, if desired. You can simply build low-cost prescaler boards for each receiver, and build only one counter assembly, saving money. Conceivably, this project could take the place of the dial in a typical communications re-

PARTS LIST

CAPACITORS
C1—47-pf mica
C2, C3, C4—0.01-μF 25-V disc
C5, C6, C10, C11—0.1-μF 25-V disc
C7—100-μF 6.3-V electrolytic
C8, C9—22-pF 25-V disc
C12—100-pF 25-V disc
C13—0.001-μF 25-V disc

DISPLAYS
DIS1-DIS5 Fairchild FND-503, ½" LED displays, common cathode
D1, D2—1N4148 diodes

SEMICONDUCTORS
IC1—National DS-8629N prescaler (Tri-Tek)
IC2—Motorola MC-7805CP 5-volt regulator
IC3—CD-4001 CMOS quad NOR gate
IC4—National MM74C192 CMOS programmable counter
IC5—CD-4511 or MC-14511
IC6—Intersil ICM-7217*AIPD* CMOS programmable counter (Circuit Spec)
IC7—Intersil ICM-7207*AIPD* CMOS counter controller (Circuit Spec)
IC8—CD-4013 CMOS dual-D flip flop

RESISTORS
All resistors ¼ watt, 5%
R1, R3—1000 ohms
R2—270 ohms
R4, R5, R6, R7, R9—10,000 ohms
R8—22 megohms
R10 through R16—470 ohms (7)
R17—330 ohms
R18 through R24—180 ohms (7)
R25—100K resistor
S1—4 position DIP switch (Radio Shack 275-1301 or equal)
XTAL—5.24288-MHz crystal, HC18 holder, 30-pF load

MISCELLANEOUS: Set of model-83 PC boards (See offer), "L" brackets (2), ¼" standoffs (3), hardware, your choice of aluminum cabinets, bezel (Radio Shack 270-301), 16-pin IC socket, 16-pin DIP header, wire, solder, etc.

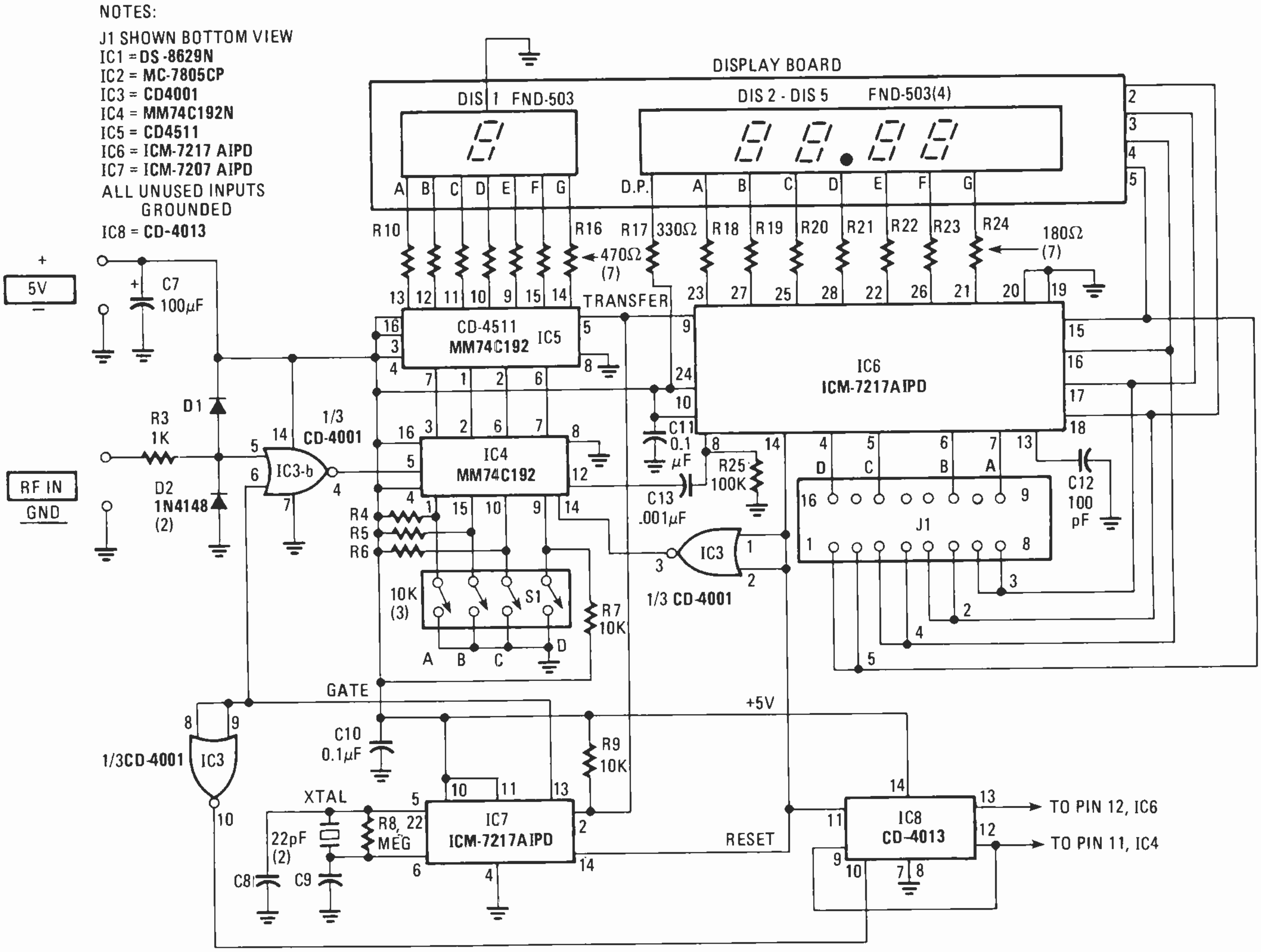


FIG. 4—COMPLETE CIRCUIT OF THE COUNTER BOARD. The display-board circuitry is also shown, but since this board contains only the five displays, it needs no special attention.

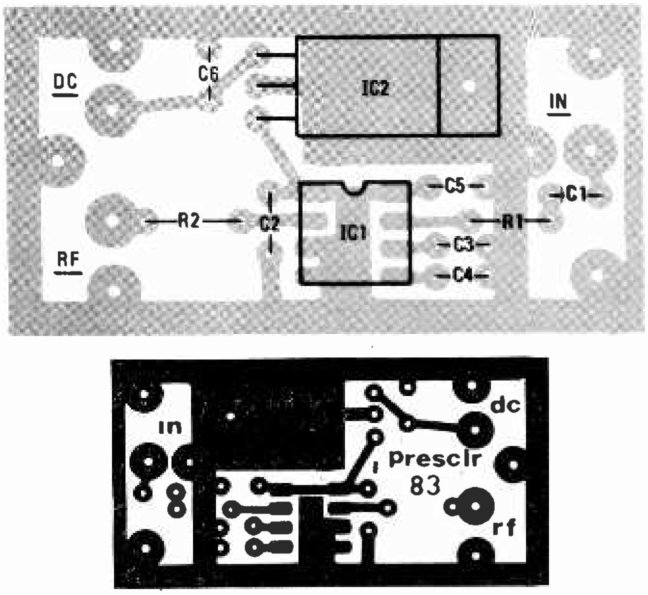


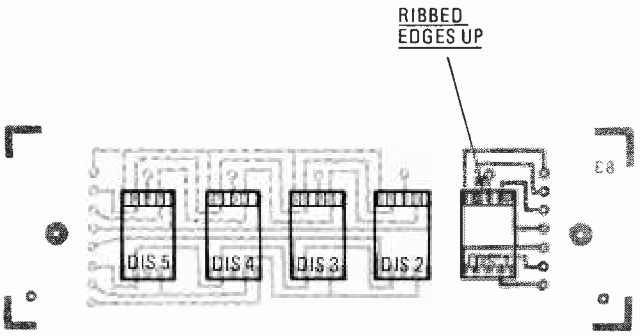
FIG. 5—EXACT-SIZE FOIL PATTERN FOR THE PRESCALER BOARD along with the appropriate parts-replacement diagram.

ceiver, but this would affect the resale value of your set. So don't build the complete project inside of your receiver unless you aren't concerned about its value!

As far as the construction goes, you'll be simply "stuffing" three PC boards with parts. The first step is to obtain the PC boards from the supplier listed, along with illustrated plans, installation, and troubleshooting. Or if you prefer, you can make your own boards from the artwork shown in this article.

Prescaler board

A good place to start is with the prescaler board. First install an 8-pin IC socket at IC1, and then plug a DS-8629 in to it. Refer to Fig. 5 for details. Then install a 7805 on the board at IC2, securing the tab with 4-40 hardware. NOTE: It will be necessary to enlarge the hole to ⅛" on the board for the hardware. Next, refer to the illustration and install the capacitors, starting with C1. Once they are installed, continue with the resistors. After that, check over your wiring for errors, correcting any that you find. Cut two 3-foot lengths of stranded hookup wire (No. 24 is ideal), and one 3-foot length of RG-174 coax cable. Connect the wires to the *DC* connections on the board, and the coax to the *RF* pads. Finish up the wiring by cutting two short lengths of hookup wire and connecting them to the *IN* pads. If desired, this board can be installed in a receiver and tried out at this point. If so, turn to the *Installation* section for details on hookup, and use a conventional frequency counter to display the output. Otherwise,



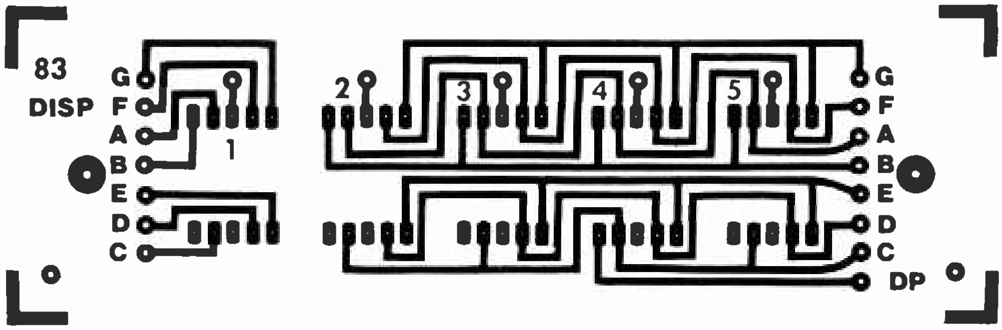


FIG. 6—FOIL PATTERN FOR THE DISPLAY BOARD SHOWN FULL-SIZE along with the appropriate parts-placement diagram.

mount the completed board in the box using short spacers and you're all set.

Display board

The next step is to build the display board. This job will be easy as you know there are only five LEDs on it. Refer to Fig. 6 for details and then start construction. First, position the board so that the "83" is in the upper right hand side as you face the component side. This step positions the board properly so that the LEDs are installed properly. Mount each of the displays on the board with the ribbed edge facing up as shown. After you are done, be sure to check for errors and correct any that you find. Then place the completed board aside for a while.

Counter board

The counter board is the "busiest" board you'll have to stuff, but the job should go quickly. Take your time and do a good job. Start by referring to Fig. 7, and the photograph for details, then begin construction. Install the resistors first, beginning with R3 (1K) in the lower corner. Work across the board, installing the other resistors as you go. Note that resistors R10 through R16 and R17 through R24 are not mounted on the board yet. They will be installed later between the counter and display boards, eliminating wire jumpers.

Continue with diodes D1 and D2 (1N4148), being sure to position the banded ends as shown. After that, install the capacitors, starting with C7 (100 μF). Be sure to watch the polarity on this one! Then continue

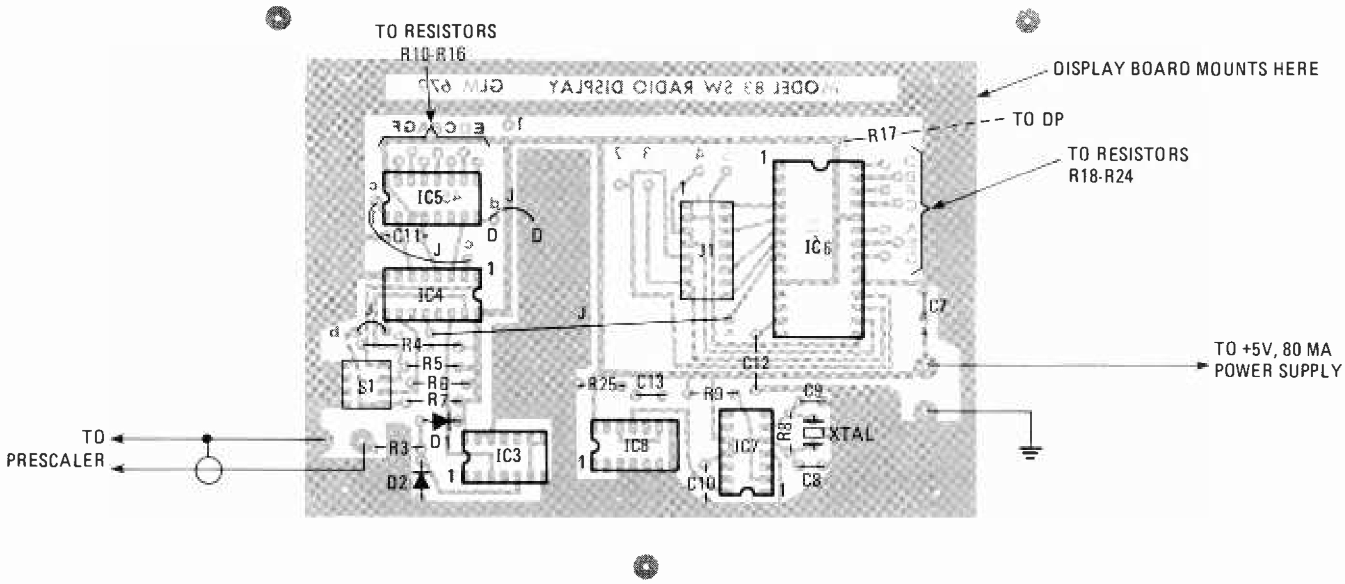
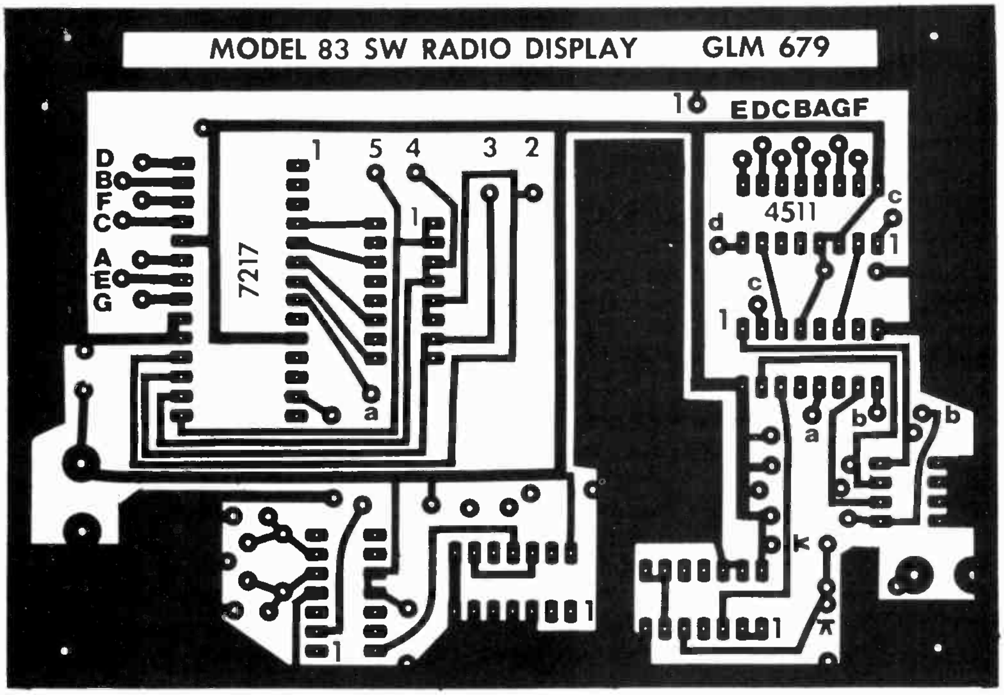


FIG. 7—COUNTER BOARD IS TWO SIDED. Also shown is parts-placement diagram. Don't forget the four wire jumpers—A B C D. Note that it might be easier to mount jumper C on the reverse side of the board. The hole is close to the side of IC5. Only the foils on the reverse side of the board is shown. But remember, this board is a 2-sided circuit board. Full-sized patterns are on the right.

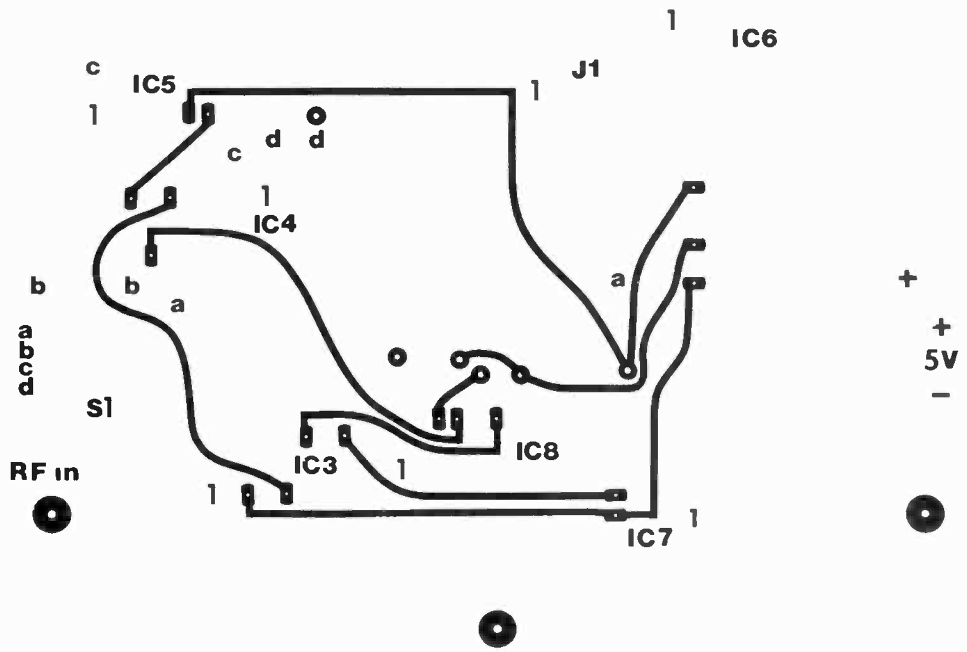
across the board with the other capacitors. Don't forget C12 (100 μF). It goes between IC6 and IC7. You'll have to bend the leads on this one to match the widely separated holes in the board.

Continue by installing the jumpers. There are four of them and insulated wire should be used to prevent shorts with the printed circuit foil. Start with the "A" jumper. This is a long wire that runs between the "A" pad below IC4 and the "A" pad below the 16 pin socket. Cut a piece of insulated wire and install it here. Then turn to the rest of the jumpers as shown on Fig. 7 and install them as shown. You might want to mount jumper "C" on the reverse side of the board because the pad is so close to IC5. Finish up with the jumpers and you can go on with the next step.

Take a breather for a moment and survey your work. Double check to be sure that parts are in the proper places, and that they are of correct value. Then make



COMPONENT SIDE

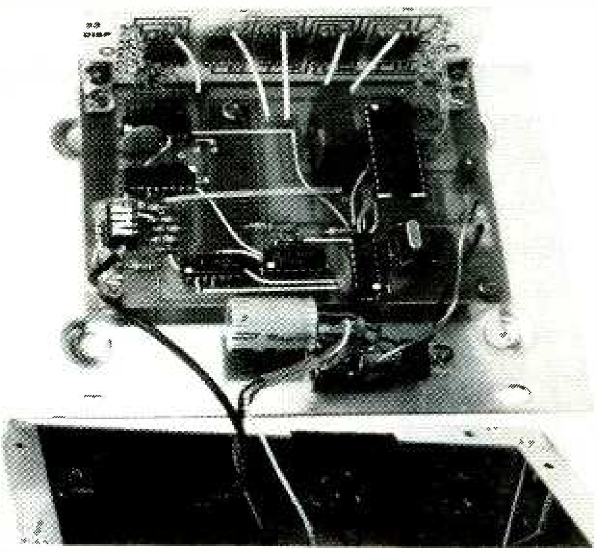


sure all connections are properly soldered. **Since this board doesn't have plated through holes, you must solder on both sides of the board.** But this should be obvious anyhow. Be sure to correct any errors NOW before going further.

Resume construction by installing XTAL (5.24-MHz crystal), and switch S1. After the crystal is installed, it would be a good idea to *quickly* solder a ground wire to the case. That's why a ground pad is provided on the board. Be sure to use heat sparingly on the case when you solder to it. Next, install a 16-pin IC socket in the J1 position. Then finish up with the IC's.

Start the IC installation with IC7 (7207A). Note the pin 1 identification mark on the board. Insert the chip carefully, and doublecheck to be sure it is in the right spot. Then solder all the pins carefully on both sides of the board. Continue with the other ICs in the same manner, installing them as shown in Fig. 7.

Finish up the counter board wiring by cutting two pieces of hookup wire about a foot long, and soldering them to the *5V* input on the board. Now the construction is in the home stretch!



COUNTER AND DISPLAY BOARDS are mounted in a single cabinet. Here's a look inside the display unit showing how they are interconnected.

Now marry the boards

The last phase of the construction is to attach the display board to the counter board, then wire them together. Let's do the attaching part first. As you can see from the illustration and photo, the display board mounts at a right angle to the counter board. It is held in place by aluminum "L" brackets. You can make the two brackets out of scrap metal, or buy them from Calectro or Keystone dealers. Enlarge the holes on the boards to ⅛" for the mounting hardware. Then mount the brackets on the counter board with 4-40 hardware. And finally, secure the display board to the "L" brackets with more 4-40 hardware.

Now for the final wiring. You'll be installing those resistors you left off the board earlier. Install resistors R10 through R16 (470 ohms) first. They connect IC5 (4511) to DIS1. Simply pass the leads of the resistors through the holes in the counter board, soldering them to the pads on the rear of the display board. Connect the "A" pads of both boards via a resistor, then the "B" pads, and so on. The job's easy and no illustration is necessary.

After these resistors have been installed, move to the other end of the display board and install R17 through R24 (180 ohms). Wire them as you did the others, linking the "A" pads between IC6 (7217) and displays, "B" pads, and so on. Be sure to leave some slack in the resistor leads. When you are done with the resistors, move them around so the leads don't touch.

Then turn your attention to wiring the display digits. Use short pieces of hookup wire for this job. Start by connecting a wire between the "1" on the display board to the like numbered pad on the counter board. Then use more pieces of wire to connect the "2", "3", "4" and "5" pads on both boards together. That takes care of the wiring on the counter assembly. Be sure to check it over for mistakes carefully, and correct them before going any farther.

The next part is to machine a case for the counter assembly. You can make a good, inexpensive one from an aluminum chassis, as was done for the prototype. Otherwise, select an aluminum box more suited to your taste. **Be sure to enclose this project in a metal box for shielding. If you don't, the circuitry will radiate noise back into your receiver!** As far as the prototype goes, the construction was simple. The counter assembly mounts to the bottom plate of the chassis using metal spacers. Then a hole was cut in the chassis for the bezel. A Radio Shack bezel was used with excellent results. Then the rear panel of the chassis was drilled for connectors to attach to the prescaler board and the power source. You can follow these construction guidelines if you wish, or try out your own.

Chances are that you will need a source of power for this project. Generally, you'll need 8-12 volts at 100 mA for the prescaler board, and 5V at 50 mA for the counter assembly. The latter voltage should be regu-

POWER SUPPLY PARTS LIST (Fig. 8)

C101, C102—0.01-μF 25-V disc
C103—470-μF 16-V electrolytic
C104—0.1-μF 25-V disc
IC101—National LM 340-5 voltage regulator or equal
RECT101—50-PIV 1-A bridge rectifier
S101—SPST toggle switch
T101—8-V 300-mA transformer-"Charger Plug" type

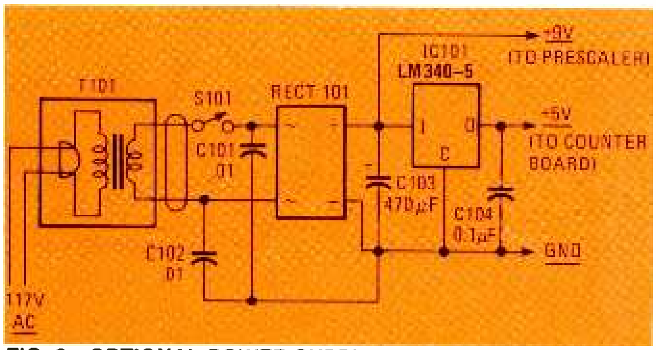


FIG. 8—OPTIONAL POWER SUPPLY may be needed. It delivers both positive voltages needed.

lated, and a simple 7805 voltage regulator will suffice. If you can get these voltages from the receiver, fine. Otherwise, build the circuit shown in Fig. 8. In the prototype, this extra circuitry mounts behind the counter assembly and can be seen in the photograph. That takes care of the construction.

Hook up to your receiver

To install this project in your receiver quickly and with the least amount of strain, you should have the schematic to it. Also, it would be helpful if you could poke around the circuitry inside it to find where to install the prescaler assembly. Remember, this project connects to the local oscillator of your receiver. With that, you are ready to make the installation!

The first thing to do is to locate the local oscillator section of your receiver. Often this will be marked on your receiver schematic. Then compare the circuitry to that of Fig. 9, noting how the prescaler is connected to the local oscillator circuit. Generally, the circuitry shown is similar enough (or identical to) the local oscillators found in most receivers. If you have a receiver that is the exception, you can either write the supplier for assistance, or determine the lowest-impedance signal point in the circuit. Generally, this will be the cathode of a tube, or emitter of a transistor. This is important, because tapping a low-impedance point for the prescaler will reduce circuit loading that can cause errors in dial calibration and frequency drift.

Once you have identified the correct place to connect the prescaler in the receiver, it's time to mount the prescaler assembly and wire it up. Since there are so many different receivers available, and with different mechanical layouts, you'll have to exercise your own ingenuity in finding the best spot for the prescaler. Generally, it should be as close to the local oscillator section as possible to keep the leads short. You can mount the assembly on a nearby coil shield, on top of the chassis, or perhaps on the outside of the receiver.

For example, we mounted one prescaler assembly in a military surplus receiver. There wasn't room to mount the little box inside the RF deck, so it was mounted outside the deck, and the wires were run through a hole in the box and the deck. In another case, the project was installed inside a Panasonic portable radio. In this case, the box was strapped to two bandswitches on the receiver PC board, which straddled the local oscillator. Some further tips to help with the installation include reminders to scrape the paint off the box before mounting it; to mount the box in a strudy spot; and to keep the wires to the local oscillator short. By doing so you'll minimize drift, microphonics, and noise pickup. After the box is installed, run the long wires out of the rear of the receiver, connecting the plugs to them if desired. That takes care of the most challenging phase of this project.

The next job is to connect up the counter assembly. Simply connect the coax cable from the receiver to the wires coming from the RF pads. Use a mating connector if necessary. Then scrounge up a source of power, if you haven't done so yet. After the prescaler power and signal connections are made, you're all set! On to the programming step.

Programming your display unit

If you power the receiver and the counter assembly you should be rewarded with a display of frequency. It won't be exact yet, because the counter hasn't been

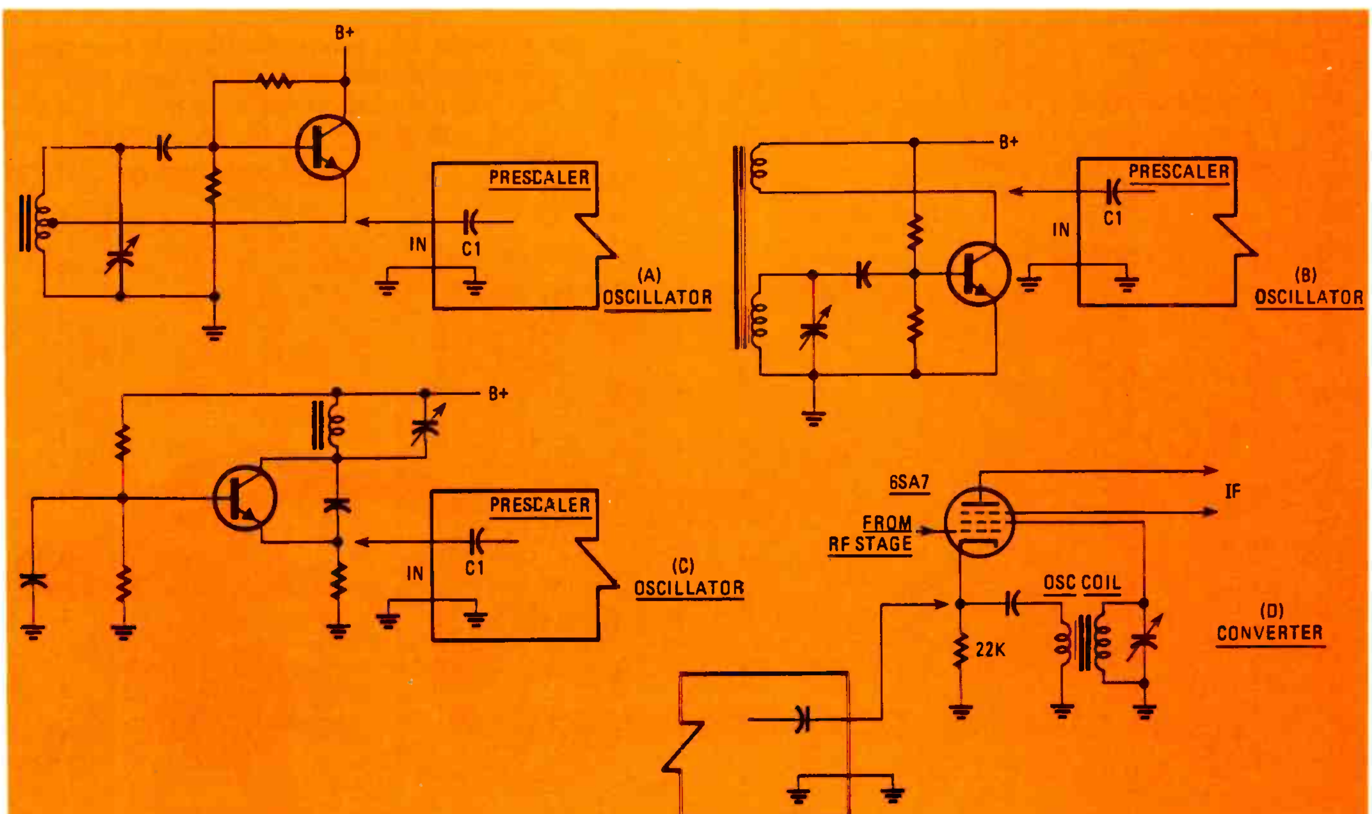
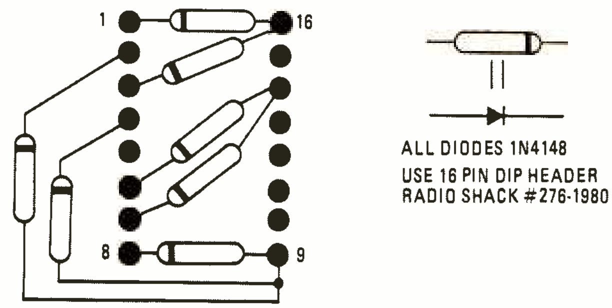


FIG. 9—LOCAL-OSCILLATOR HOOKUPS. Either tube or transistor circuitry can be used here. Be sure to mount the prescaler module as close to the oscillator circuitry as possible to keep wiring short.



SOCKET PINOUTS

DIGIT 5 = PINS 1 & 2

DIGIT 4 = PINS 3 & 4

DIGIT 3 = PINS 5 & 6

DIGIT 2 = PINS 7 & 8

BCD "A" = PIN 9

BCD "B" = PIN 11

BCD "C" = PIN 14

BCD "D" = PIN 16

NO.	A	B	C	D
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1
0	ALL OPEN			

BCD TRUTH TABLE FOR PROGRAMMING.

NOTES:

"1"
OPEN SWITCH ON S1
A DIODE TO DIGIT ON J1

"0"
CLOSED SWITCH ON S1
NO DIODE ON J1

FIG. 10—TOP VIEW OF THE 455-KHZ PROGRAMMING PLUG. Table at right is programming truth table for setting up programming plug for other IFs.

programmed yet. That's your next step. It's easily done by setting S1 and wiring a DIP header that plugs into J1.

Since the most common IF frequency in shortwave receivers is 455 kHz, the programming is shown in Fig. 10. As you can see, this is nothing more than a series of diodes wired in a DIP header available from Radio Shack. In addition, the switch on the board is set for the BCD value of "5". The result is that when the counter assembly is turned on, with the prescaler unplugged, the display is *99545*. When you reconnect the prescaler, you're finished and are all set to enjoy the advantages of digital readout of frequency.

On the other hand, if your receiver has a different IF than that of the example we just gave, you'll have to do your own programming. Generally, you can get the IF from your receiver schematic, but if you aren't sure, or want the best accuracy from this project, measure the IF with a signal generator/frequency counter combination. Then use this simple procedure to program your shortwave display:

1. **Determine the IF.** Use either the schematic value, or better yet, measure it with a signal generator/frequency counter.

2. **Determine the programming number** by subtracting the IF frequency from 100,000 as in these examples:

100 000		100 000
– 455 (IF)	OR	– 1 550 (IF)
99 545		98 450
(Program number)*		(Program number)*

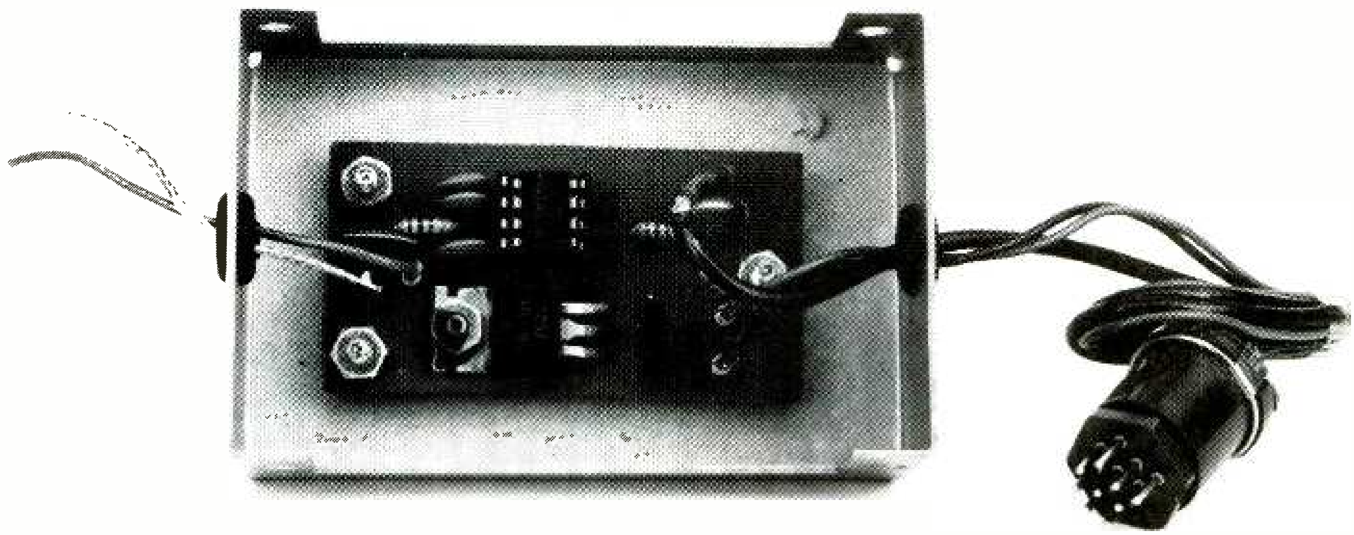
*Note that without the prescaler connected, your counter assembly shows these numbers.

3. **Set the DIP switch (S1),** and wire the DIP header. See Fig. 10 for details.

A. **Enter the farthest righthand digit of the programming number** (e.g.) "5" or "0" as in the examples) into the DIP switch. Use the BCD code of Fig. 10-b to do it. "A" "B" "C" "D" are weightee "1" "2" "4" and "8".

B. **Wire the DIP header for the next four digits in order of increasing significance.** Wire the second right-hand digit from pins 5/6 of the socket to pins 9, 11, 14, 16 as required for

text continues on page 98



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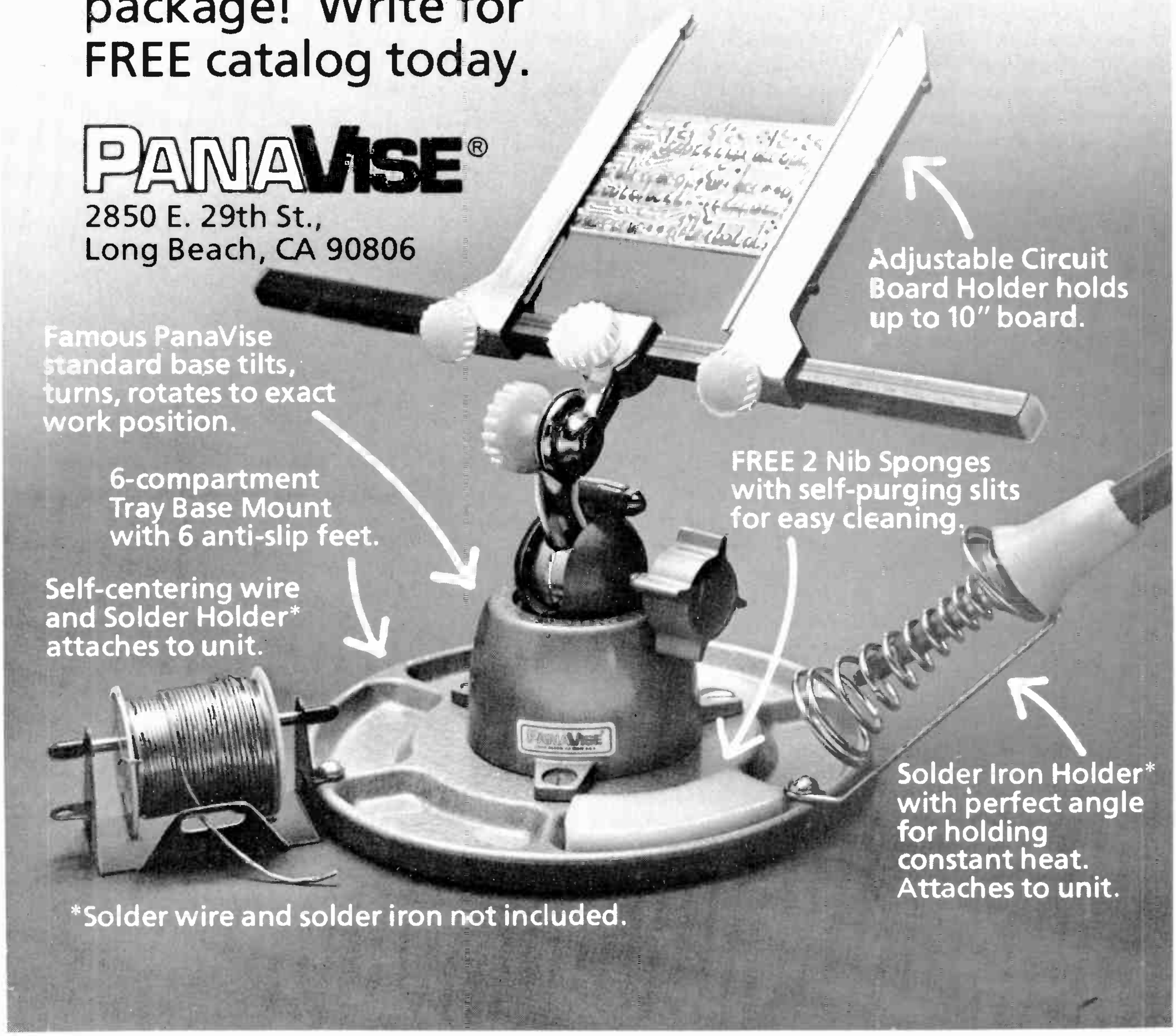


CIRCLE 310 ON FREE INFORMATION CARD

GET BIG SOUNDS FROM REED CHORD ORGANS

With a little mechanical ingenuity and the addition of a few simple electronic circuits, you can convert your reed-type chord organ into an all-electronic model.

FREDERICK W. CHESSON

YOUR TYPICAL SMALL NON-ELECTRONIC CHORD ORGAN can be given a new lease on its musical life with but a few integrated circuits and related components. The result can be as satisfying as the purchase of a complex all-electronic organ and much less costly.

Such expediencies as placing microphones or guitar-type pickups in or around the average chord organ are iffy at best and such add-ons are always prone to picking up the sounds of the blower motor and key actions. The tonal range, in addition, is virtually limited to the original organ sounds, subject to the amplifier's tone control manipulation.

The average home-entertainment-type chord organ has one keyboard with two or three octaves and from six or eight up to two dozen or more chord keys. A typical small Hohner organ has 18 chord buttons and 37 keys in three octaves, extending from F_2 at about 175 Hz to F_5 at nearly 1400 Hz. It is powered by a motor-driven rotary blower, the sound of which is amplified by the instrument case to a point where live tapings are barely feasible. The tones are generated via metal reeds, very much like an accordion or harmonica. Some smaller models are of almost total plastic construction. Clearly, the "big pipe sound" is not available for an aspiring E. Power Biggs of the livingroom. However, electronics—and relatively simple electronics at that—stands ready to "pull out the stops."

The organ chosen for potential conversion need not necessarily be in "full voice," as the keyboard alone is the criterion for possible modifications. Even an old piano has potential for producing sounds undreamed of by artists of the past. Where metal rods or fingers are used to lift the valve covers, a common ground could probably be used, as the electronic tone generator to be described is not too fussy as to switching-circuit impedance. **Make certain that the keying mechanism is totally isolated from any line voltages powering the blower motor.** In the absence of metal elements, contact fingers may be fabricated from wires or spring brass. A quantity of surplus miniature key switches were available to me, and the advantage of their double-throw action is examined later.

Oscillator circuits

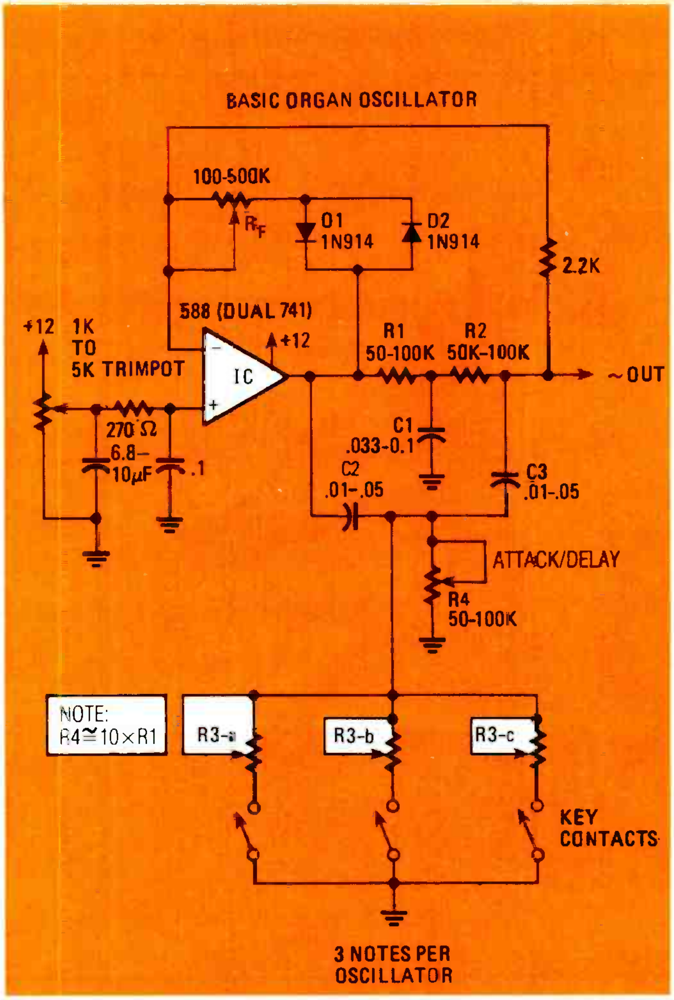
A vast variety of audio-frequency oscillator circuits, utilizing tubes, transistors, and integrated circuits, have been developed over the years. Almost any gate-type or flip-flop IC can be persuaded to produce stable oscillations in the audio range. Their waveforms, however, are largely square waves, not exactly traditional tones for pipe organs, but perhaps suitable for rock groups and others favoring "far-out sounds."

I used a Twin-T oscillator (see schematic) that produces a sinusoidal waveform over a wide audio range and in which decay and attack features can be included with little difficulty. (When, in a Twin-T frequency selective network, R1=R2=2R3 and C2=C3=½C1, frequency equals $1/2\pi C2R1$ or $1/2\pi C1R3$.—Editor)

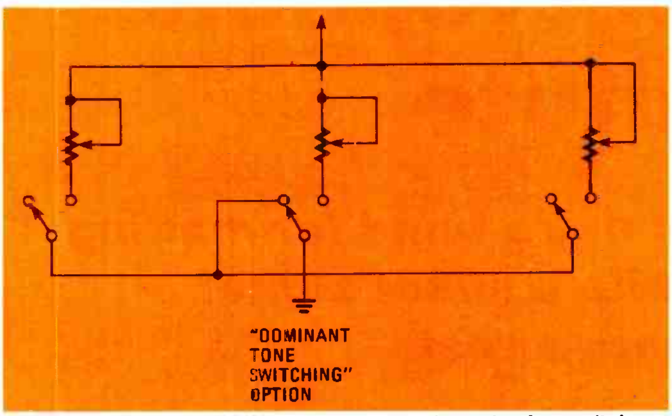
Within the limits of the feedback loop, varying R3 in the stem of the T can produce about an octave frequency shift. Merely connecting a series of individualized tuned resistors and keys would produce an instrument of sorts, but it would be extremely basic and limited. This is because closing two or more keys simultaneously would place two or more frequency-determining resistors in parallel. Hence, A and C together with say 1000 and 750 ohms respectively, would give 430 ohms, producing a much higher tone!

I felt that limiting each oscillator to three adjacent notes, such as B, C, and C#, would effectively prevent this problem, as few conventional compositions would require two of these or all three tones to be produced simultaneously. If double-throw key switches are available, one note of the trio, say C, may be made dominant, locking out the other two.

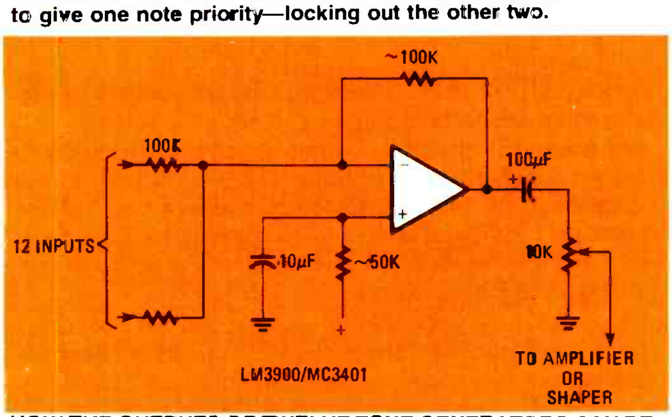
Attack and decay variations were effected by use of the resistance in parallel with the tuning resistors and key switches. This eliminates keying clicks and produces a more realistic pipe-organ sound. Very long decays can simulate a bell-like effect, and this re-



THE BASIC OSCILLATOR CIRCUIT is designed around a Twin-T filter. Oscillator frequency is determined by the values of R1-R2-C1 and C2-C3 and R4.



DOMINANT-NOTE KEYING uses double-throw keying switches to give one note priority—locking out the other two.



HOW THE OUTPUTS OF TWELVE TONE GENERATORS CAN BE COMBINED in an op-amp mixer and fed to a note-shaper or to additional amplifiers.

sistance may be varied from the console.

The outputs of the twelve oscillators used in the Hohner were combined in a mixer circuit using an LM3900 or MC3401 quad op-amp. The additional sections are available for tone-shaping and the driving of multiple outputs for stereo operations. In the way of variation, the nearly sinusoidal tones could be routed through one sound system, while more complex waveforms from the chord keys could be fed through a separately positioned speaker system.

Building your organ

Construction is so much a matter of organ layout and number of keys and chords, that no one definitive plan can be presented outright. However, the following suggestions, based upon my experience, will be useful.

If the electronics board or boards are to be located within or on the bottom of the organ, keep them well removed from the blower motor (if it is to be operated in conjunction with the transistorized sounds) and shielded as well. The power supply should be on a separate chassis and should be designed so it does not generate enough heat to damage the basic organ. Since the oscillators are modest in their power requirements, it is entirely possible that operating voltage could be obtained from the audio amplifier itself.

A 5″ × 10″ perf-board, with 0.1″ holes is probably the best construction medium, though I was able to fit the six 558 IC packages and their associated components on a 3.5″ × 9″ surplus PC plug-in board. I placed the fixed and variable tuning resistors in a corner of the wind-chest, where the organ's reed valves and the added key switches were positioned.

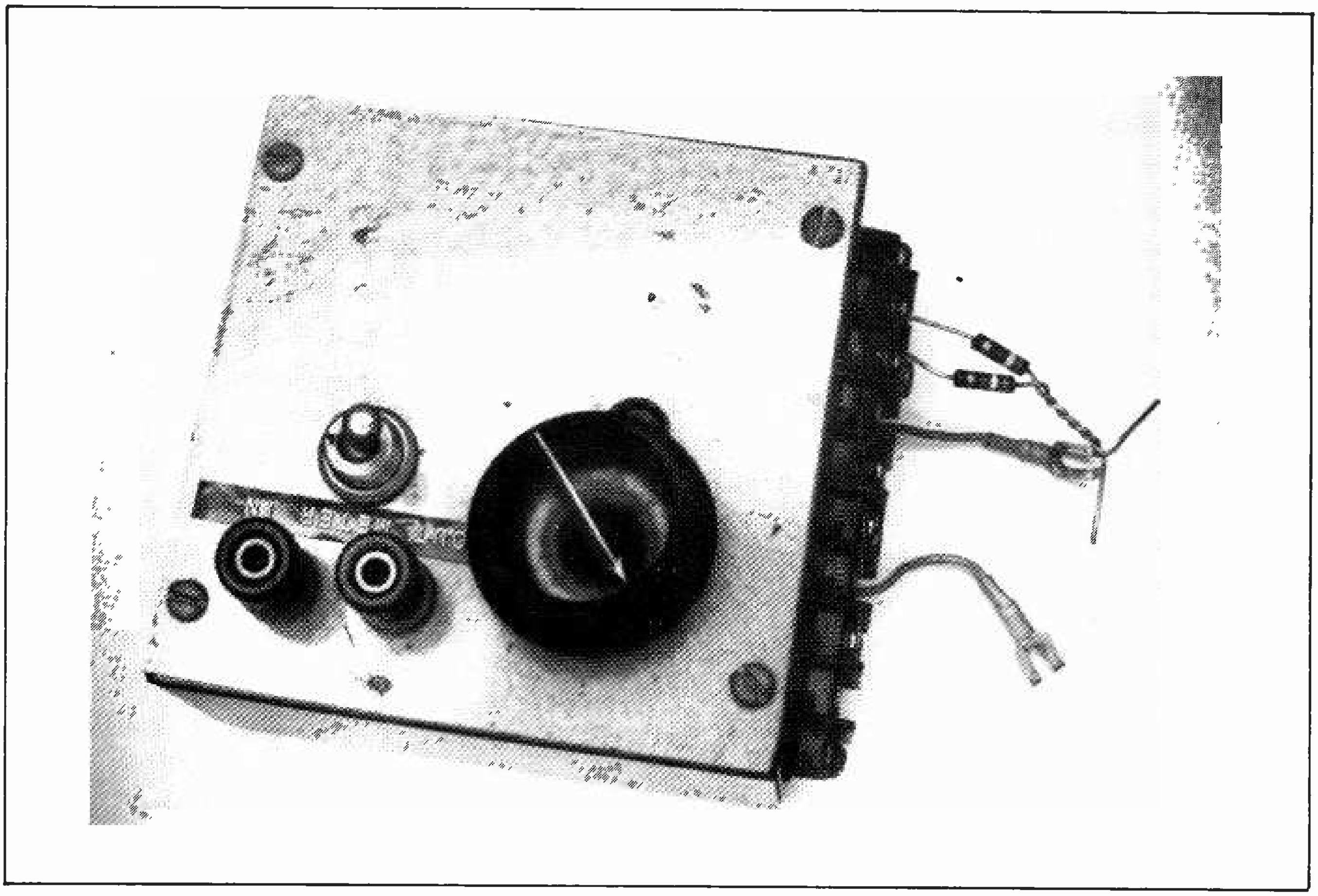
Tuning up

I purposely pitched the electronic tones one octave lower than the existing keyboard reed tones. This sounded more "powerful" when played over the hi-fi system and was very pleasing when played in combination with the normal organ notes.

Tuning was done by simply listening for harmonic beats, though a counter and oscilloscope were also used. If the electronic tones are to match their reed counterparts, quite close adjustment via "zero-beating" may be done. It is best to match the new notes to the reeds, as major adjustment of the mechanical reeds is a tricky process at best, if not a potential for being left "speechless" with a broken reed. Naturally, some drift in both reed and electronic tones must be expected, due to the combined effects of temperature, humidity, and component aging. This is why separation by an octave may be an additional benefit.

Variation on the theme

The constructor will probably find individual variations on the above theme suggesting themselves, especially in the way of waveform modification to create diverse instrument sounds, including *"Square Waves in the Sunset"*. Stereo and quadriphonic sound systems can also be used to bring out both keyboard and chord sounds with striking effect. Let the New Sound begin! **SP**



Black-Box Microphone Substitute

Foot switch gives you an extra hand for making transmitter tests while a silent signal gives your ears a rest.

ELMER C. CARLSON

HOW MANY TIMES HAVE YOU TRIED TO KEY A CB TRANSceiver, modulate the transmitter, flip the pages of a service manual and manipulate a pair of test leads? How did you make out?

Since you can't grow another hand the next best thing is to put one of your feet to work. That was a good idea, but since I couldn't successfully squeeze the microphone between my toes to key the transmitter I decided there had to be a better way. Holding the microphone between my knees wasn't much more successful either. You just can't talk into a microphone that way.

But manipulating the Transmit-Receive switch on the microphone was the easy problem to solve. Obtaining a good, reliable audio signal for transmitter modulation proved to be a bigger problem.

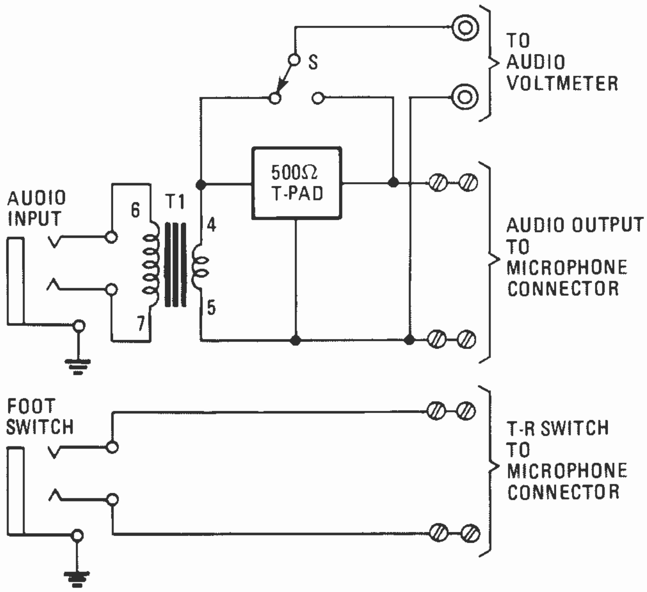
It proved impractical to construct a jig to mechanically actuate the microphone T-R switch with a foot pedal because of the different shapes of microphone cases and styles of T-R switch levers. As time went on it became more and more apparent that the microphone would have to go.

Besides, as technology progressed, it becomes more evident that there would be other benefits eliminating the microphone completely and replacing it and its functions with electronic circuits that would improve upon the microphone as a source of modulation and transmitter control.

Benefits

Besides freeing a hand for holding test prods, the test bench substitute for the microphone has a few other benefits too. For example, modulation for the transceiver is silenced. Also the modulating signal can be easily adjusted in level and accurately set for viewing modulation distortion and for measuring the percentage of modulation on an oscilloscope. With a few other accessories, audio frequency response tests of modulation can be made—easily and much faster.

Also, a substitute for the existing microphone helps to eliminate a good many audio trouble spots—like broken wires, loose connections and defective switches and microphone cartridges.



BLACK-BOX CIRCUIT IS UNCOMPLICATED. Everything plugs into or attaches to terminals so there are no loose leads.

Design problems

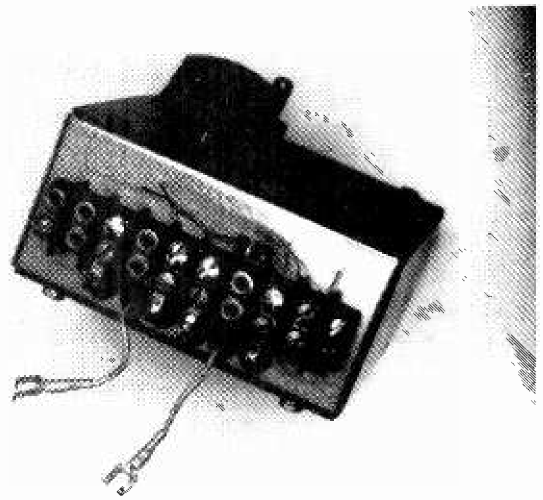
A major problem is the many and varied microphone connectors that have been used by the different manufacturers. Even when the same plug is used by two manufacturers the connections might not be the same—the connections might not be the same for two models by the same manufacturer. That problem means there must be a multitude of plugs to match all the different combinations that have been used. And that can become expensive.

A much less expensive method is to eliminate the body of the plug and just retain the pins that can then be inserted into the receptacle contacts of the microphone connector. The other ends of these interconnecting leads can then be terminated in lugs which are slipped under the screw terminals of a terminal strip. With this method you can substitute low-cost hardware items for the more expensive connector plug.

Audio matching

The other problem is in connecting an audio generator to the black-box microphone substitute. It proved to be a three-fold problem—impedance matching, DC isolation and signal attenuation.

Audio generator impedance matching and DC isolation can be easily taken care of with an audio transformer. And if you don't plan on using the microphone substitute for audio frequency response measurements (even 300 to 5000 Hz) a low-cost audio transformer can be used.



THIS PANEL IS ACTUALLY THE TOP of the microphone substitute. Obviously terminal arrangements can be rearranged to suit individual needs.

For development of the microphone substitute a multi-impedance, good quality audio transformer was used. Once the problems caused by direct coupling the audio generator to the transceiver input were solved the loading problems on the solid-state generator were eliminated. The impedance match did not have to be changed for the many makes and models tested afterward.

Construction considerations

With the transformer and the level control being the major components in the microphone substitute, their size have a lot to do with determining the size of the box needed for the microphone substitute. Very small transformers can be used along with miniature controls, but if the box is too small it won't have enough weight to stay in place on the test bench.

The foot-switch connection and audio input connection were put on the end of the box that would be closest to the audio generator. Wiring to the foot switch runs down the back of the bench to keep it out of the way, reducing the possibility tripping over the wires and pulling everything off the top of the test bench.

While the lead from the audio generator to the microphone substitute does not have to be shielded, the audio lead from the microphone substitute must be shielded to prevent hum pickup at the microphone preamplifier input.

Transceiver control (T-R) leads from the foot switch do not have to be shielded.

During wiring of the box a ground "strap" is threaded through both grommets before the spade lugs are attached. This prevents this short lead from being misplaced when it is disconnected from the terminal strip when testing transceivers that do not have a common ground for the audio input and the control circuit.

Leads between the microphone substitute and the transceiver can be two or three feet long. If necessary, they can be as long as the stretched out microphone cord. But it is best to keep the leads as short as possible. A light weight, very flexible cable is best. Lapel microphone cord can be used for the shielded audio lead and light-weight speaker wire will serve for the control leads. If such a cable is made the leads should be tied, taped or otherwise held together—just for neatness and to prevent tangled wires. Short lengths of heat-shrink tubing can be slipped over the wires before the plug pins or lugs are soldered on. Spaced every three or four inches and shrunk in place, they will make a very neat job.

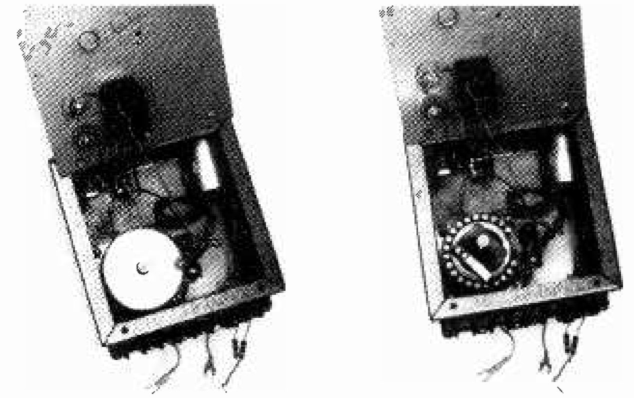
Lengths of tubing added to both the plug pins and the lugs will give strain relief and reduce bead breakage that always occurs—a result of the twisting and bending right at the solder joint.

Input jacks are two-circuit non-shorting phone jacks. This makes it possible to isolate the audio and foot switch leads from each other without insulating the jacks from the metal box. It also makes it possible to shield the from the audio generator, if necessary. No ground loops either.

Combination binding posts and a selector switch make it possible to connect any type of audio voltmeter to the audio signal leads. Audio signal levels at the output of the 500-ohm T-pad attenuator are extremely low and must be measured with an amplifier-type audio voltmeter (vacuum-tube or transistor).

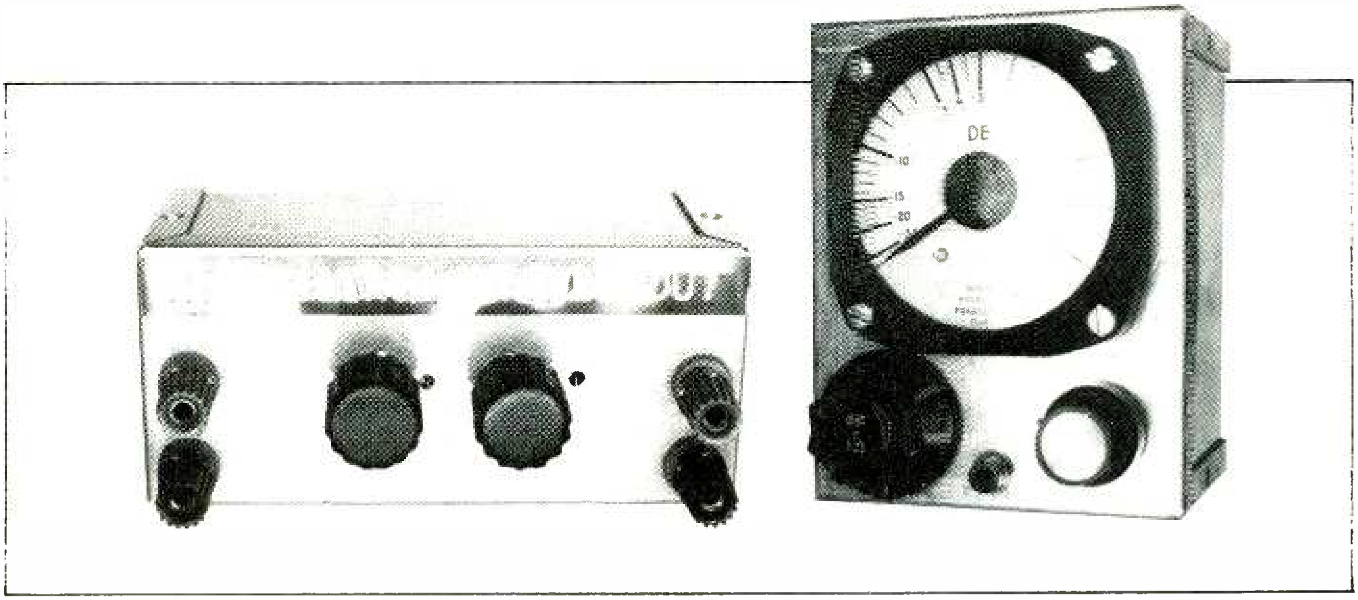
None of the wiring is critical and components may be substituted. Even the transformer isn't critical. In fact an audio output transformer from a tube-type radio or TV set should work just as well—if you are not going to make audio frequency response measurements. Audio input and foot switch jacks can be eliminated if those leads are just soldered to the internal circuitry.

Of course some common sense will have to be used when making substitutions. For example, if an audio output transformer is used then the impedance of the T-pad attenuator will have to be selected to match that of the transformer. Also a larger box may be needed if the transformer is larger and the control size remains about the same.



INTERNAL VIEWS SHOW SIMPLICITY of wiring and parts placement. Cover of audio attenuator is removable for cleaning contacts inside.

Unlike many RF circuits, the microphone substitute does not have critical lead lengths or parts placement—or even critical parts selection. A knowledgeable technician should be able to put one together in a short time from parts that are on hand. **SP**



FUDGE-FACTOR BOX PLUS A BASIC dB METER

Use a variable dB indicator at the output of the amplifier under test to make life easier.

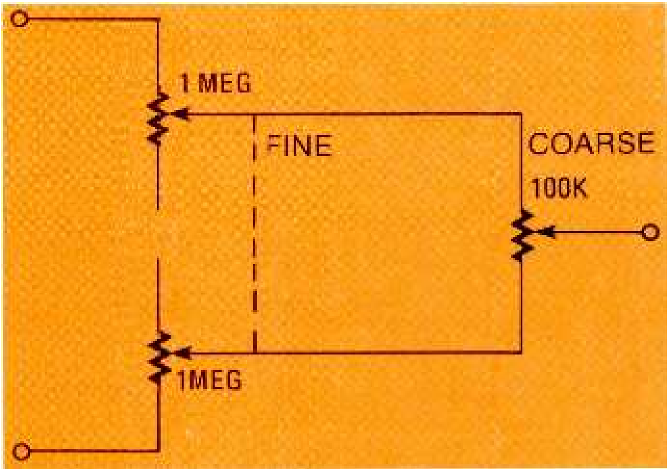
ELMER C. CARLSON

DO YOU GET A COLD CHILL IN THE PIT OF YOUR STOMACH everytime you have to make dB measurements for a frequency response test? Well you can take some of the worry out of making those graphs by using a variable dB indicator at the output of the amplifier under test instead of the conventional fixed range dB meter.

Decibel (dB) measurements for frequency response tests are usually passed over because such measurements require algebraic addition to determine the amount of gain in the signal level. When it happened that there was no way in getting around making dB measurements for frequency response graphs that were required for an extensive series of gain tests it became apparent that there must be a better way—a faster and less complicated way to obtain dB output indications for both frequency response and amplitude distortion tests. A way without juggling all those plus and minus dB calculations that took most of the time.

The first attempt at speeding things up resulted in a Fudge Factor Box wired up from standard parts. It uses a dual section potentiometer and a single potentiometer, two pair of combination binding posts and a suitable aluminum box. If a three-section potentiometer with concentric shafts could have been made up by the local parts supplier a much smaller box would have been used.

The schematic for the Fudge Factor Box shows that it is only a potentiometer circuit with all resistance



FUDGE-FACTOR BOX is a simple potentiometer circuit where all the resistance elements are connected in series.

elements connected in series. When the COARSE adjustment knob is turned one resistance element of the dual potentiometer increases in resistance while the other element decreases in resistance. The FINE resistance element is connected to the wipers (the center terminal) of the dual potentiometers. The main advantage with this setup is that the input impedance (resistance mostly) remains approximately the same at all settings of the potentiometer.

With the input of an audio voltmeter connected to the OUT binding posts of the Fudge Factor Box, leads from the IN binding posts are connected across the audio level under test. The impedance (resistance) of the Fudge Factor Box is high enough that connecting it across a speaker circuit or even a 600-ohm audio line has little effect.

Making dB tests

With a 0-dB signal input level applied to the input of an amplifier and the Fudge Factor Box inserted between the amplifier output and the audio VTVM it is easy to adjust the audio VTVM to indicate 0 dB too.

Once set, this 0-dB setting (accomplished with the Fudge Factor Box) is not changed during the frequency response run—only the input signal level to the amplifier is reset to 0 dB with the audio generator controls.

With a 0-dB input and output indication (set at 1 kHz) any change in the output indication above or below the 0-dB level can be plotted directly on a graph without any manipulation of plus and minus dB indications of the input and output meters.

A complete dB meter

Switching one dB meter between input and output while changing ranges was the remaining bottleneck in the speed up of frequency response measurements.

Since the dB meter is basically a voltmeter, the Fudge Factor control can be included in the dB meter circuitry as a variable multiplier resistor. This is shown in the more complex schematic diagram.

The push-pull switch on the dual potentiometer permits 3 modes of Fudge Factor control operation. A push-pull switch must be used.

With the push-pull switch in its open (in) position the portion of the dual potentiometer controlled by the inner knob and shaft acts like an additional variable multiplier resistor in series with the dB meter movement.

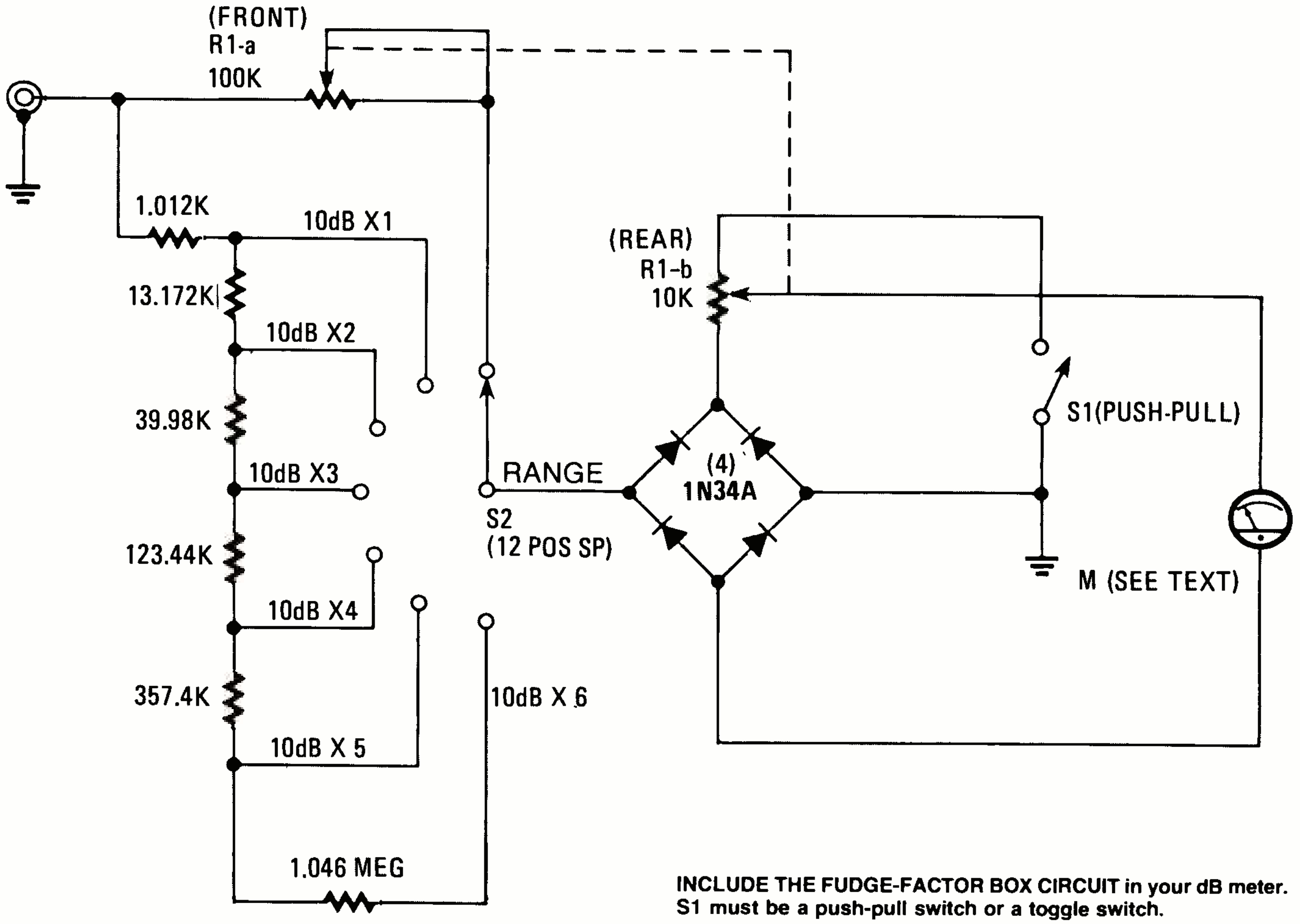
When the knob is pulled out (switch closed) that section of the control becomes a potentiometer or voltage divider—greatly reducing the sensitivity of the meter.

This portion of the Fudge-Factor circuitry is in the circuitr at all times. While it could have been wired so that it was completely in the X-position circuitry, the dB meter would have lost some of it's Fudge-Factor versatility.

When the dB X 10 selector is in the X position only the two sections of the Fudge-Factor control determines the dB meter range. The high-resistance element of the outer control shaft acts like a coarse adjustment while the inner control shaft permits finer adjustment to 0 dB.

dB X 10 switch

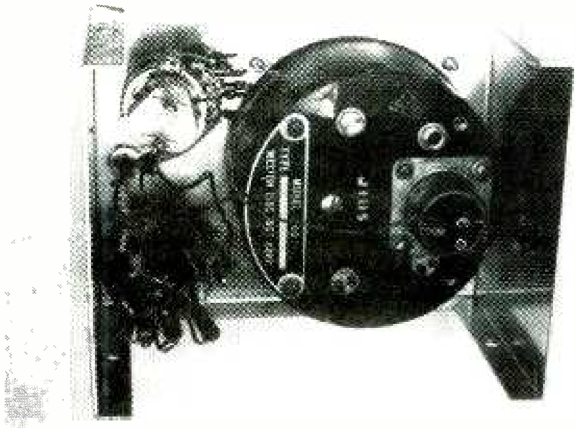
In the other positions of the dB X 10 switch the fixed multiplier resistors give exact dB levels, that can be



INCLUDE THE FUDGE-FACTOR BOX CIRCUIT in your dB meter. S1 must be a push-pull switch or a toggle switch.

used to measure exact output levels, but the Fudge Factor control must be set to the extreme counter-clockwise end of its rotation.

Once 0 dB has been set with the Fudge-Factor control the range can be changed in 10-dB steps if neces-



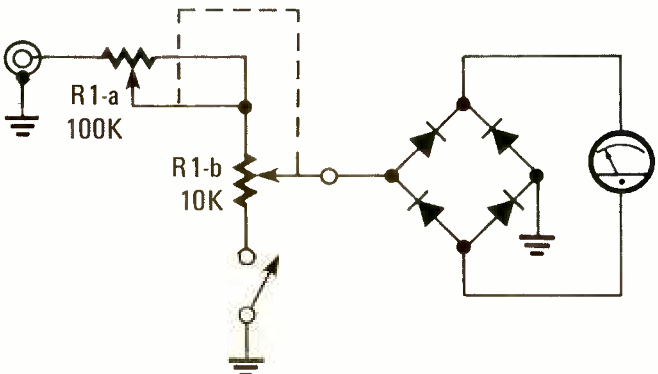
INTERNAL VIEW OF THE dB METER. The original connections were made with a cable having screw-on shell.

sary for frequency response measurements that excede the easily read indications on the meter scale.

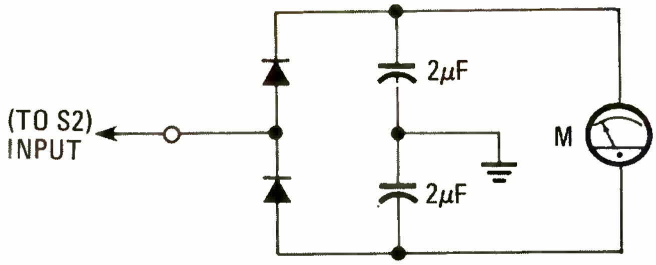
Range selection for the dB meter is limited only by the number of ranges you are capable of calibrating—which is set by the maximum output level of your audio generator, the total number of positions on the range switch and the practical limits for dB level indications. Overall range of the dB meter can be doubled if the selector switch is calibrated in dB X 20, providing, of course, that the −20-dB marking on the meter scale can be read easily—and to an accuracy suitable for the measurement.

It was only luck that made the Weston model 955 meter part of this instrument—it was found in a surplus electronics store that was going out of business. Several other 270° rotation meters were bought at the same time. The length of the scale is about three times that of the usual panel meter which means that three times as many scale calibrations can be accomodated than is possible on the more common panel meter. Any other type of dB (or even VU) meter can be substituted for the 270° type used here.

If a 100-μA full-scale meter movement is used all the resistance values given will remain just about the same (magnets in the meters can weaken with age and rough handling). Meters with other sensitivities, such



SIMPLE CIRCUIT IS A dB LEVEL-CHANGE INDICATOR. It is built into the dB meter shown earlier.



EXTRA SENSITIVITY CIRCUIT can be added to the dB meter if desired. It connects to switch S2.

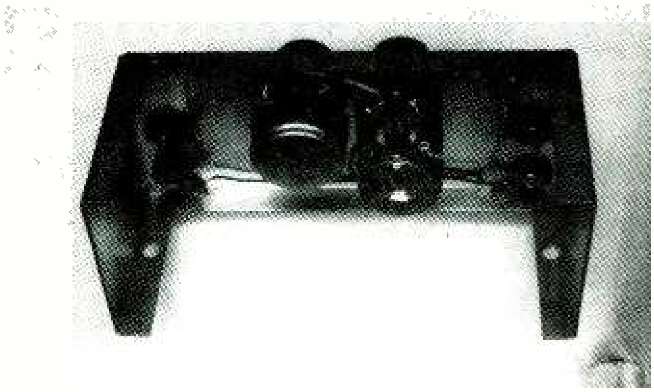
as 50-μA or 200-μA full-scale can be used but the multiplier resistors will be about double the resistance for a 50-μA meter and about half the resistance value for a 200-μA meter.

Calibration

A common way to calibrate the dB meter, or any meter, is to use a variable sinewave source and a second meter that has known accuracy. (A tone or sinewave frequency of about 1 kHz is preferred for audio work but even 60 Hz can be used for calibration.) Of course you will also need a variable resistance and a means of measuring that resistance accurately. A decade resistance box can be a lot of help.

With the meter connected across the audio signal, just add enough total resistance to bring the dB meter pointer to the 0-dB mark. Total up the decade box switch position indications or measure the resistance added with a digital multimeter.

Once the resistance needed to obtain 0 dB when the dB X 10 switch is set to the 1 position has been



LOOKING INSIDE THE FUDGE-FACTOR BOX you can see just how easy it is to build.

determined a fixed resistance of the same amount must be made up—using series, parallel or series-parallel resistor combinations to obtain the exact resistance. That resistance is then wired into the dB X 10 selector switch, and the meter indication is rechecked, to make sure it is accurate.

Now additional resistance is added until a dB meter indication of −10 dB is obtained then the signal level is increased until a 0 dB indication is reached once again. This indication is compared to that of the second meter.

This procedure is repeated for each position of the dB range switch.

Range is limited on the low ranges because of the sensitivity of the meter. Some increase in sensitivity can be obtained if the bridge rectifier is replaced with a voltage-doubler rectifier. **SP**

continued from page 97

make your own, remember that all interconnections between sides must be soldered using a wire through all holes. Also make sure that you solder all components on both sides of the board.

The point that we will begin is by assuming you have a PC card. Any components that are not commonly available—AY-3-8910 and the printed circuit board—can be obtained from Quest-Star Engineering Company, see the parts list.

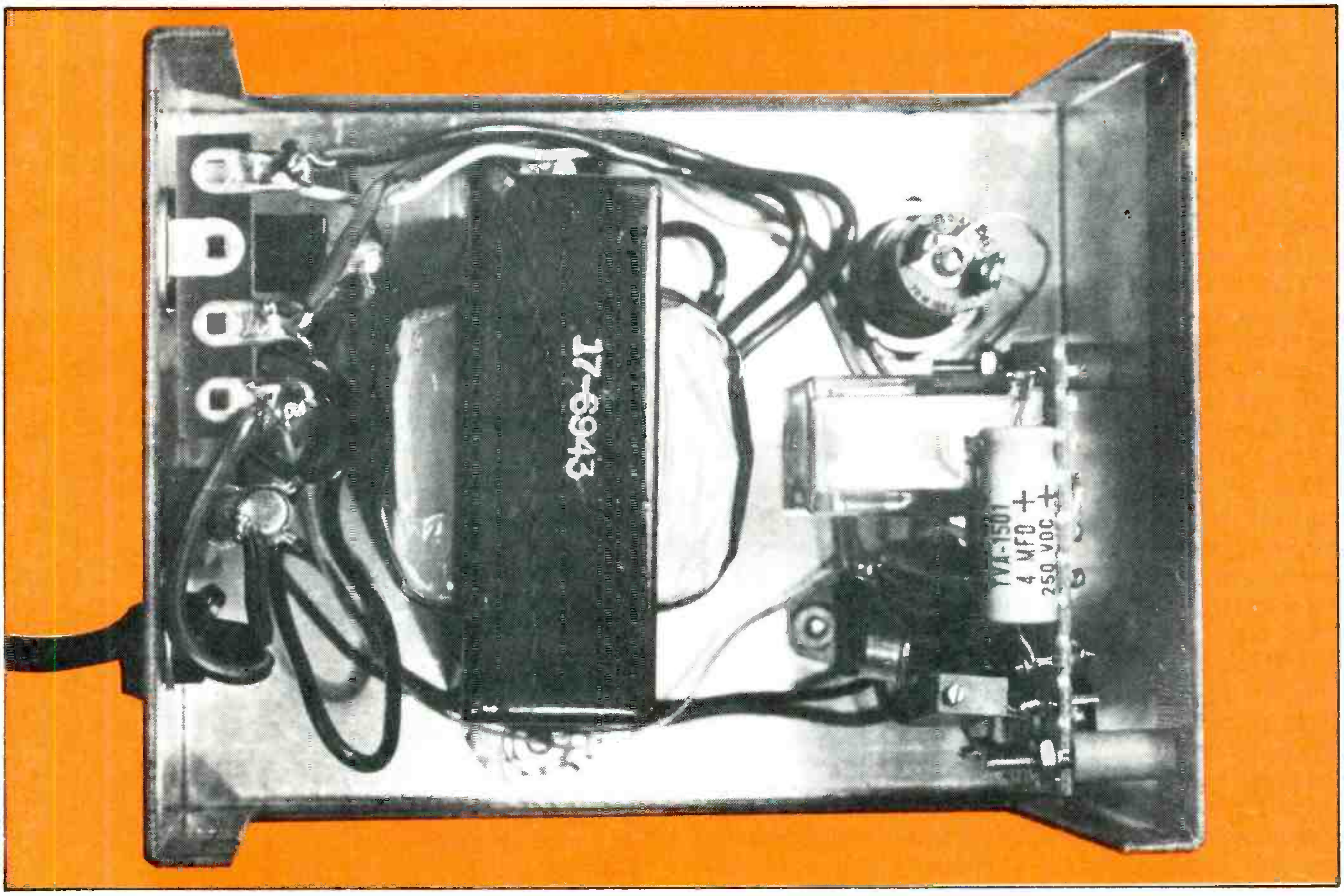
Refer to the parts list to identify all of the components you need for your system. Use all of the components in the top section plus the components listed for just your system. Lay all electronics components out on a workbench, desk, or table. Keep the AY-3-8910 and the 40001/4011 in their protective packaging. Verify that you have all the required components. Install the IC sockets in the locations shown in the parts placement guide, Fig. 3. Make sure that pin 1 of the socket and the PC card pin 1 are at the same corner. Turn the printed circuit board upside down, using a piece of cardboard on top side to keep the sockets in place. Now solder the socket pins.

Install all the resistors and capacitors. Doublecheck the location and orientation before soldering. Install the XTAL and transistor if needed for your system. Solder the 5-volt regulator to the card and install its hardware. Connect power and check output for 5 volts. If the card is not for the S-100 bus, install the connector. Next install all ICs in there proper locations.

For I/O operation, first latch the address of register seven. Next set the direction of the ports by a data transfer. Now latch the address of port register R_{14} or R_{15}. Finally input or output the data. Data enters or exits the card by I/O socket #2. Port B on pins 1 to 8, where pin 1 is bit 7 and pin 8 is bit 0. Pins 9 to 16 are for port A. Starting from pin 9 and progressing to pin 16 the data bits are 0, 4, 3, 2, 1, 5, 6, and 7. If you want a program for an S-100 based Z-80 circle 342 on the Free Information Card.

A second example, one that produces sound, also uses a Z-80 S-100 bus computer. This program will generate the eight octave B (790 Hz) tone we said earlier would require processor attention once every 63 μs. Our program will take 27 bytes of code and require execution only once! First we will assume our Z-80 has a 2-MHz clock. Then we will solve the tone equation for channel A. We find that register 1 should contain a OF_H and register 2 should contain 00_H. Next we need to enable tone channel A, register 7. Then we set a constant amplitude for channel A, register 8. For a copy of this program circle No. 345 on the Free Information Card.

I could proceed forever giving examples, but the best solution is for you to play with the card a bit and develop your own sounds. A manual does exist for the AY-3-8910. It has some sixty-four pages. Quest-Star will acquire some of these and proved them to those who feel they need one. At this time the price of the manual is uncertain (Quest-Star will sell it for General Instruments price plus something for shipping and handling). **SP**



AUTOMATIC STEPPED LINE-VOLTAGE REGULATOR

If fluctuating line voltage is a problem, here's a handy little device that keeps AC line voltage where it belongs.

HERBERT ELKIN

ARE YOU LIVING IN AN AREA WHERE YOU HAVE LOW AC line voltage? Does your line voltage dip in the evening, or vary with weather conditions? Does your television picture shrink on all sides, flutter, or lose brilliance at varied times, or completely cut out especially during a power "brown-out"?

The schematic in Fig. 1 is a completely automatic voltage controller for TV or any other appliance or instrument (not recommended for airconditioners). Simply plug the unit into your wall outlet and your TV set into the unit's AC receptacle. From then on, the unit will automatically boost the AC voltage to your TV set by an additional 6.3 VAC whenever the line voltage drops to 110 VAC (or to another preadjusted switchover level). Therefore, if your TV performs well when the line voltage is at 117 VAC (where it should be), it will still be operating satisfactorily when your line voltage drops to 110 volts as an additional 6.3 VAC will be added to the 110 volts of the line, thus returning the voltage applied to your TV to 116.3 volts.

You can leave your TV (or instrument) permanently plugged into the regulator, as the unit is automatically shut off when your TV is turned off. When your TV is turned off, the regulator consumes only one watt of power. Therefore, you can leave your set connected to the regulator for one year at an additional cost of less than 50¢ for electricity.

How it works

Filament transformer T1 is wired as an autotransformer. When the secondary winding of the transformer is wired with the proper phasing, it adds its output voltage in series with the wall outlet voltage thus increasing the voltage appearing at the unit's outlet receptacle.

When the line voltage exceeds 110 volts (or another set trip point), relay RY1 is activated removing the 6.3-volt boost from the unit's receptacle.

The voltage across capacitor C1 follows the AC 60-Hz waveform but is divided down by the variable voltage divider consisting of R1 and trimpot R2. R2 is set so when the AC line voltage out of your wall receptacle is just above 110 volts (or 108 or 112 volts if you desire, etc.) the voltage on capacitor C1 at the AC waveform's peak is just at the firing point voltage of the NE-51H neon lamp. See Fig. 2 (a through d). When the neon lamp fires, a positive pulse is applied to the gate of the SCR. The SCR conducts for the remaining positive portion of the AC cycle until the AC waveform passes through zero volts. Then the SCR is back-biased and conduction ceases. Therefore, the SCR conducts for only one-quarter of the AC cycle (or 90 degrees). Diode D1 keeps the voltage across C1 low during the negative half of the AC cycle and applying a pulse to the SCR. The SCR additionally performs the function of rectification. When the SCR conducts, relay RY1 is energized but would drop out periodically (chatter) without capacitor C4 across the relay coil. C4 charges when the SCR fires and provides filtering and relay holding current while the SCR is off. At any time thereafter, should the line voltage fall below 110

PARTS LIST

RESISTORS

All resistors ½W 10% unless noted
R1—51,000 ohms
R2—100,000 ohms, multi-turn potentiometer (Bourns trimpot type 3006P-1-104 or equal)
R3, R4—56 ohms
R5—47 ohms

CAPACITORS

C1, C2, C3—0.015µF 20% 400V ceramic
C4—4µF 250V electrolytic

OTHER COMPONENTS

D1—1N2069 or equal (1A 200PIV)
SCR—1R106B1 silicon controlled rectifier (4A 200PIV)
RY1—DPDT 48V 2.5K relay (Sigma type 62R2-48DC-SCO or equal) (4A contacts @ 115VAC)
LM—NE-51H neon lamp
F—Fuse, 3A 125V slo-blow
S1—SPDT slide switch
PL—AC line cord with plug

MISCELLANEOUS

AC socket
5 X 4 X 3-inch chassis box
Fuse holder
Lamp socket with red lens
Perfboard for chassis
Mounting spacers
3-lug terminal trip (non-grounded lugs)
Flea clips for perf board

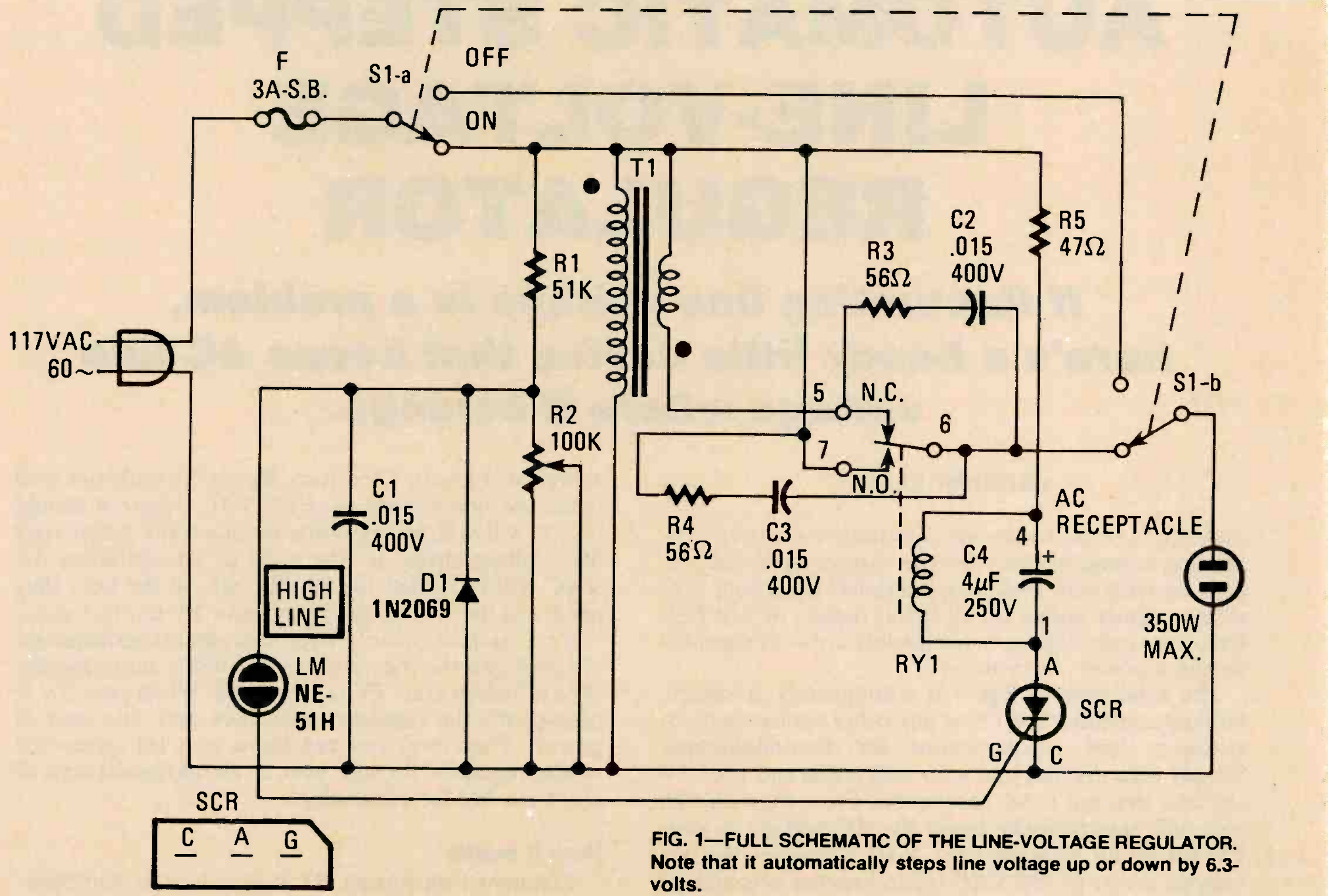


FIG. 1—FULL SCHEMATIC OF THE LINE-VOLTAGE REGULATOR. Note that it automatically steps line voltage up or down by 6.3-volts.

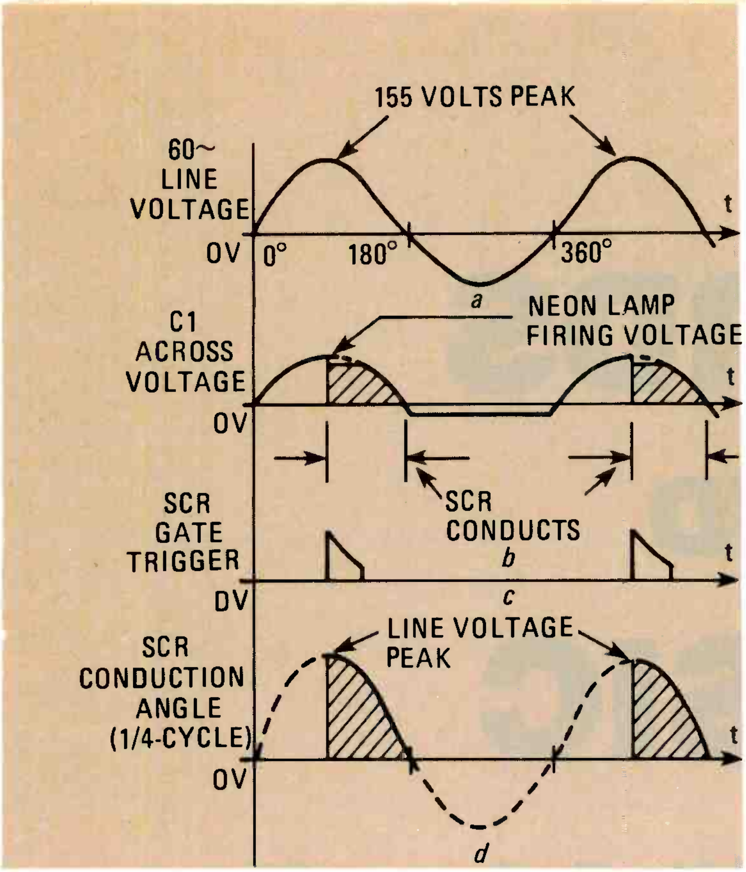


FIG. 2—LOOKING AT THE WAVEFORMS we can see exactly what happens as the automatic regulator does its thing.

volts, the neon lamp will not fire, thereby leaving the SCR in the non-conducting state after the first positive portion of the AC sinewave passes through zero volts. With the SCR in the non-conducting state, RY1 is not energized and the autotransformer voltage is picked up through the normally closed relay contacts 5 and 6.

The NE-51H neon lamp is also used as an indicator light. When the line voltage is high (112-117 volts), the firing neon lamp will glow indicating that the regulator is not boosting the line voltage. When the line boost is not needed or wanted, switch S1 can be placed in the off position to completely turn off and bypass the regulator circuitry. R3 and C2, and R4 and C3 are arc suppression networks added to minimize pitting of the relay contacts thus prolonging the relay's useful life. R5 limits the SCR surge current through C4 to the SCR's maximum current rating. Fuse F1 is a 3 ampere slow-blow type that protects the transformer from exceeding its rating should more than a 350-watt device be plugged into the regulator. A slow-blow fuse is used in order to accommodate turn on surge currents.

Construction is easy

The regulator is housed in a 5x4x3-inch aluminum mini-box which was covered with wood-grain plastic "contact" material in order to make it unobtrusive. The components were mounted on a phenolic perforated board which was fastened to the mini-box using spacer legs to allow for clearance of the bottom mounted components (see the head photo.) **Be sure not to make any electrical contact with the aluminum mini-box or you will have a "hot" regulator in your hands!**

Transformer T1 has a secondary winding (6.3VAC) rated at 3 amperes maximum. Therefore, the regulator can be used to power devices requiring up to 350 watts. Relay RY1 has a 110 VAC contact current rating of 4 amperes. Therefore, you can supply up to 465 watts using the Sigma type 62 relay if you select a 6.3-volt filament transformer rated at 4 amperes. Don't forget to change fuse F1 accordingly if you use a 4 ampere transformer.

To check for the proper transformer wiring connection refer to Fig. 3. First, measure your wall outlet AC voltage. Twist one transformer secondary (6.3 volt) lead to one primary (110 volt) lead. Connect the

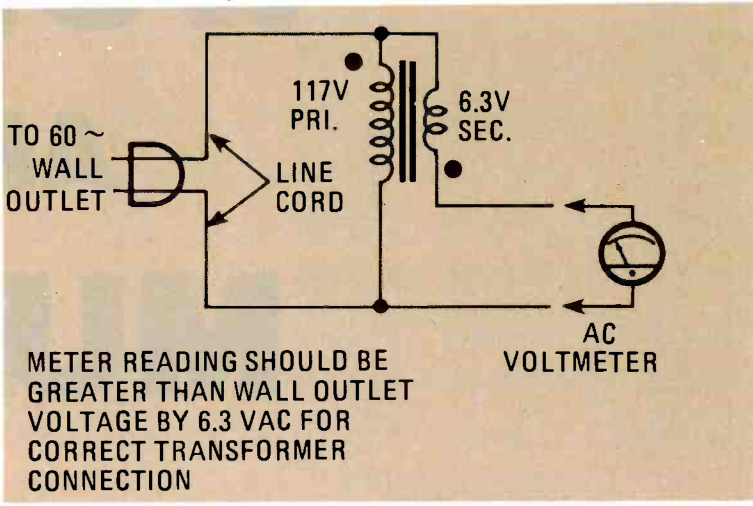


FIG. 3–YOU MUST BE SURE THAT THE TWO WINDINGS are connected properly. Here's the right way to check it out.

open primary lead to a line cord (with plug) lead and the primary and secondary joined leads to the other line cord lead. Cover the exposed wires with electrical tape for safety. Connect an AC voltmeter between the primary lead which is *NOT* connected to the secondary lead and the open secondary wire. Plug the line cord into your wall outlet. If you tied the right secondary lead to the primary, the AC voltmeter will read approximately 6.3 VAC above the reading you took of your wall outlet voltage. If the reading is 6.3 VAC lower, reverse the secondary connection to the primary lead.

Calibration and use

Adjusting the trip point of the regulator is easy if you have a "Variac" (an AC variable voltage control) that can adjust the voltage from 10% below to 10% above your wall outlet line voltage. If you do have a Variac, plug the regulator into the Variac and do not plug a load into the regulator. Adjust the variac output for 110 VAC (or any slightly higher or lower voltage that you want the regulator to trip at). Connect the AC voltmeter to the regulator output. Adjust R2 so that the neon lamp is lit and relay RY1 is activated (voltage *NOT* boosted). The meter will read 110 volts. Then, turn R2 so that the neon lamp just extinguishes and the relay is deenergized (voltage boosted). The voltmeter will read approximately 116.3 volts. Now slowly increase the Variac's output voltage until the neon lamp just lights and the relay is pulled in; the Variac's output voltage should be approximately 112 volts at this point. Note that now whenever your line voltage decreases to 110 volts the regulator will boost its output to 116.3 volts and then when the line voltage increases to 112 volts or above, the regulator will cut

text continues on page 98

WORDS AND MUSIC

COSMOS counters coupled to displays and tone-generating circuits form simple audio-visual devices with a hundred-and-one applications.

FREDERICK W. CHESSON

THIS ARTICLE DESCRIBES AN EDUCATIONAL CONSTRUCTION project involving CMOS counters in conjunction with various displays and tone generating circuits. Applications include programmable doorbells and annunciators, warning and security signalers, advertising and novelty displays, and a variety of instructional options, including teaching aids for children learning to count and spell.

The basic system is shown in Fig. 1, in block diagram form. Included are the clock, common to all sub-units, and counter, display, and audio sub-systems. Figure 2 shows two forms of pulse clock, one using a CMOS chip, the other a type 555 timer. Note that both circuits provide for varying both the frequency and duty-cycle of their outputs, a feature that will be found useful in this and other projects.

The clock pulses are counted by a type 4017 decimal-decoded-output counter, and as each output is sequentially made high, it drives one or more LED segments of a common-cathode display. In the music sub-system, these outputs drive a 555 tone oscillator through selected tuning resistors.

To simplify the demonstration of the words sub-section, letters were selected having common segments, these elements being the a, e, and f LEDS. They comprise such letters as A, B, C, D, E, F, G, O, and P. From this selection, the sequence P-E-A-C-E was chosen.

To demonstrate the versatility of the 4017 chip, I used the CARRY OUTPUT (pin 12), which is high for counts 0, 1, 2, 3, and 4; while low for counts 5, 6, 7, 8, and 9. Thus, with segments a, e, and f constantly illuminated for counts 0 through 4, it is only necessary to decode segments b-g, d-g, b-c-g, d, and d-g to form the PEACE sequence. Note that segment g is common to all but letter C, hence it would be possible to decode by *turning off* this lamp at count 4. The basic circuit is shown in Fig. 3. Note that driver transistors and current-limiting resistors may be necessary for differing supply voltages and display units.

An alternate circuit uses a sequence of readouts that are "dedicated" to a particular letter or number. Each readout is turned on and stays on until the last letter of the sequence (up to 9 for a single 4017 counter) is lighted, whereupon a reset signal turns all off and starts the sequence anew.

Music from a 555

A 555 timer is the heart of the music sub-system. It has enough power capacity on its own to drive a small loudspeaker. Its frequency is determined by both fixed R-C components and the value of the output resistors from the 4017 counter(s). For demonstration purposes, resistors ranging from about 100 to 10,000 ohms were chosen at random, yielding an "outer space" sound.

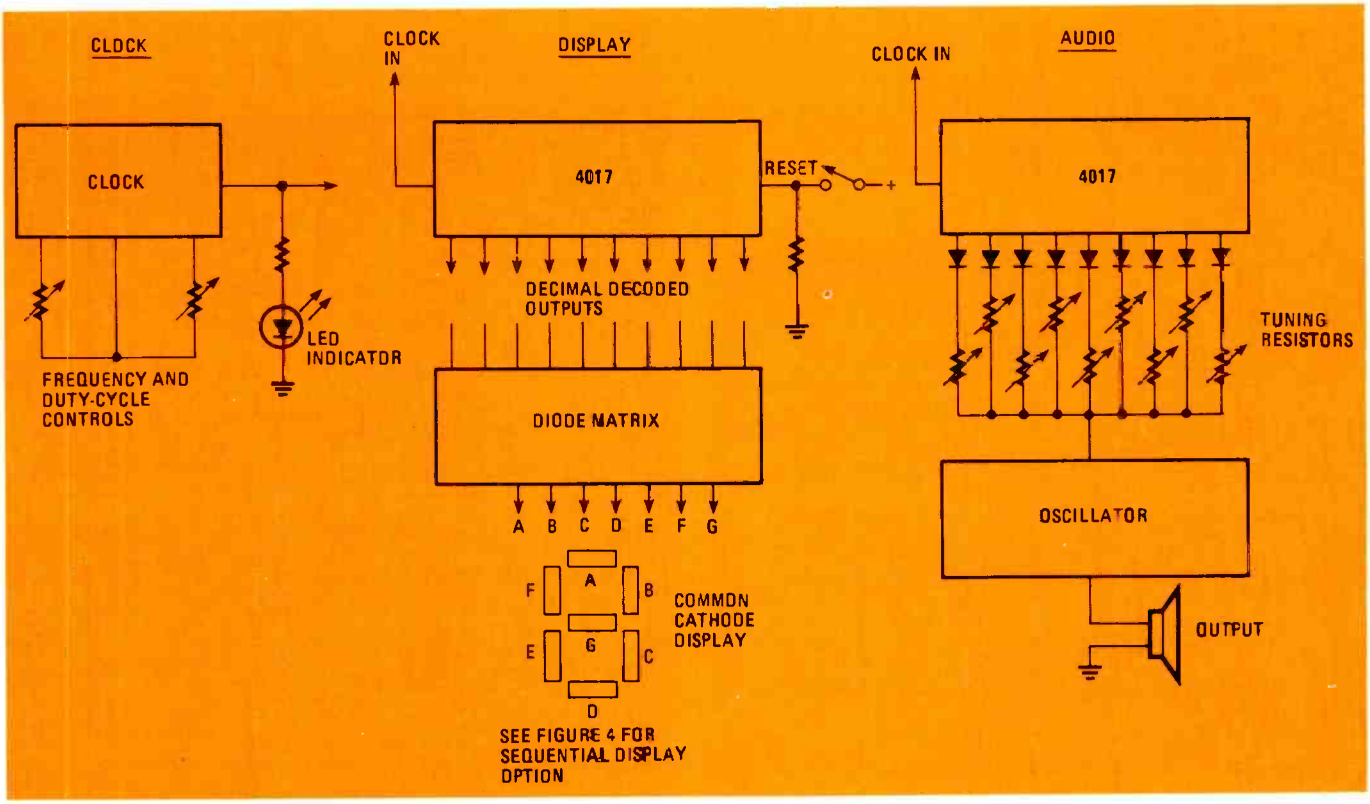


FIG. 1—BASIC SYSTEM IN BLOCK DIAGRAM FORM. Clock, display and audio (tone generator) elements are illustrated.

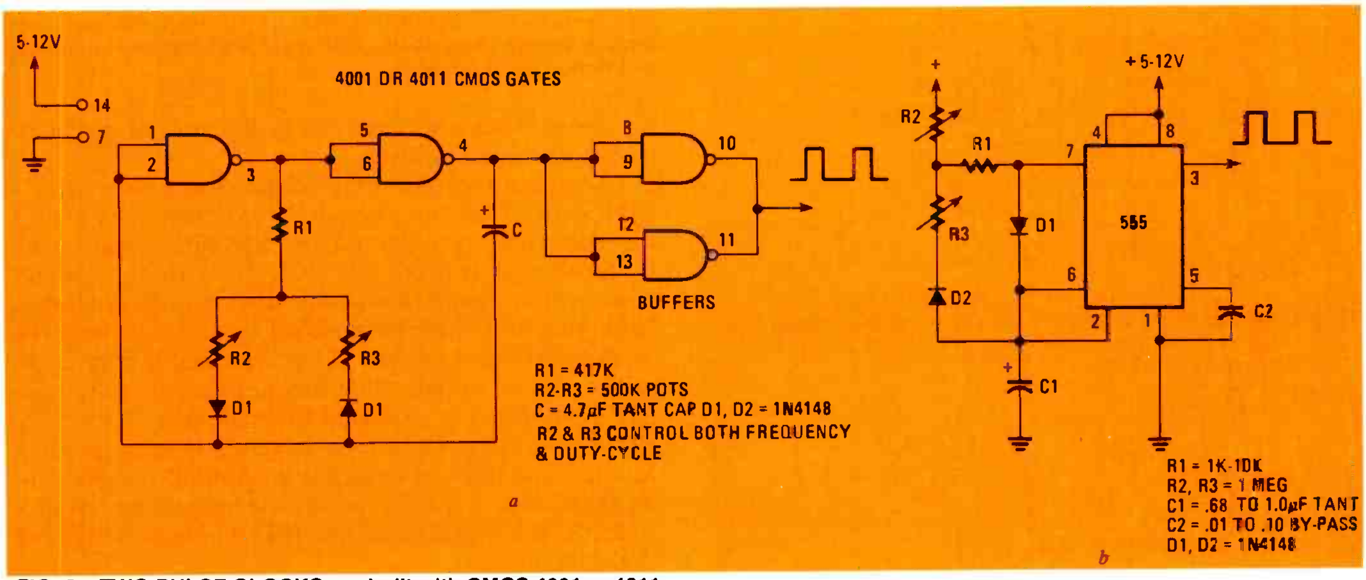


FIG. 2—TWO PULSE CLOCKS. a—built with CMOS 4001 or 4011 gates. b—Built with a 555 timer clock.

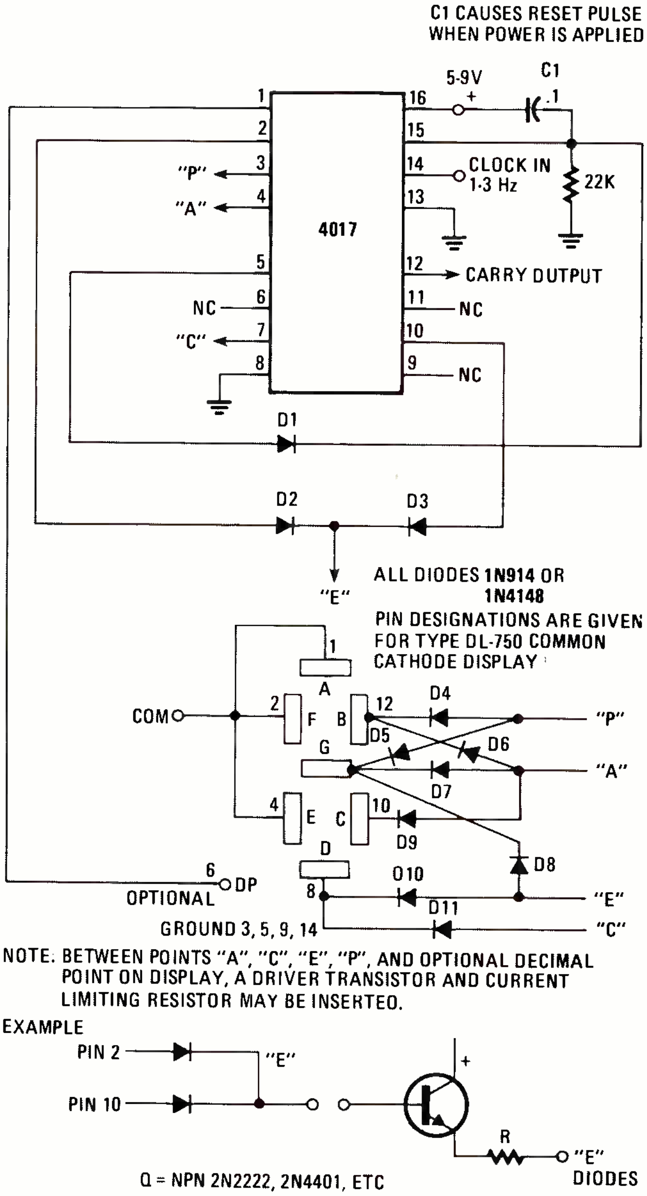


FIG. 3—CIRCUIT FOR AUDIO-VISUAL DEVICE THAT spells out the word PEACE.

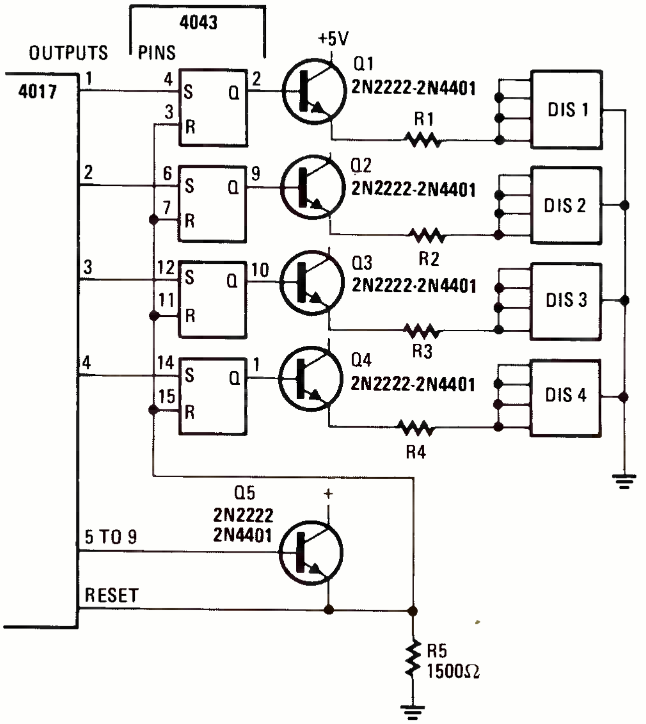


FIG. 4—CIRCUIT FOR SEQUENTIALLY TURNING ON four numbers or letters sequentially, with reset after last one turned on; or interval up to count 9.

For more exact compositions, as assembly of miniature trim-pots would be useful.

To extend the repertoire of the circuit, two 4017's were used. They are alternately switched in by a 4013 flip-flop, that is triggered by alternate pulses from Count-0 signals from the 4017's. With this circuit modification, up to 18 separate tones may be generated. Note that this may be doubled to 36 by driving the modulation input of the 555 via the variable duty-cycle of the clock. By adjusting this, a plucked-string two-part tone effect is produced for each step.

When only a single tone is desired, such as for a Morse Code letter or code group, multiple resistors are unnecessary. A single resistor or potentiometer with suitable isolation diodes from the counter outputs is all that is required.

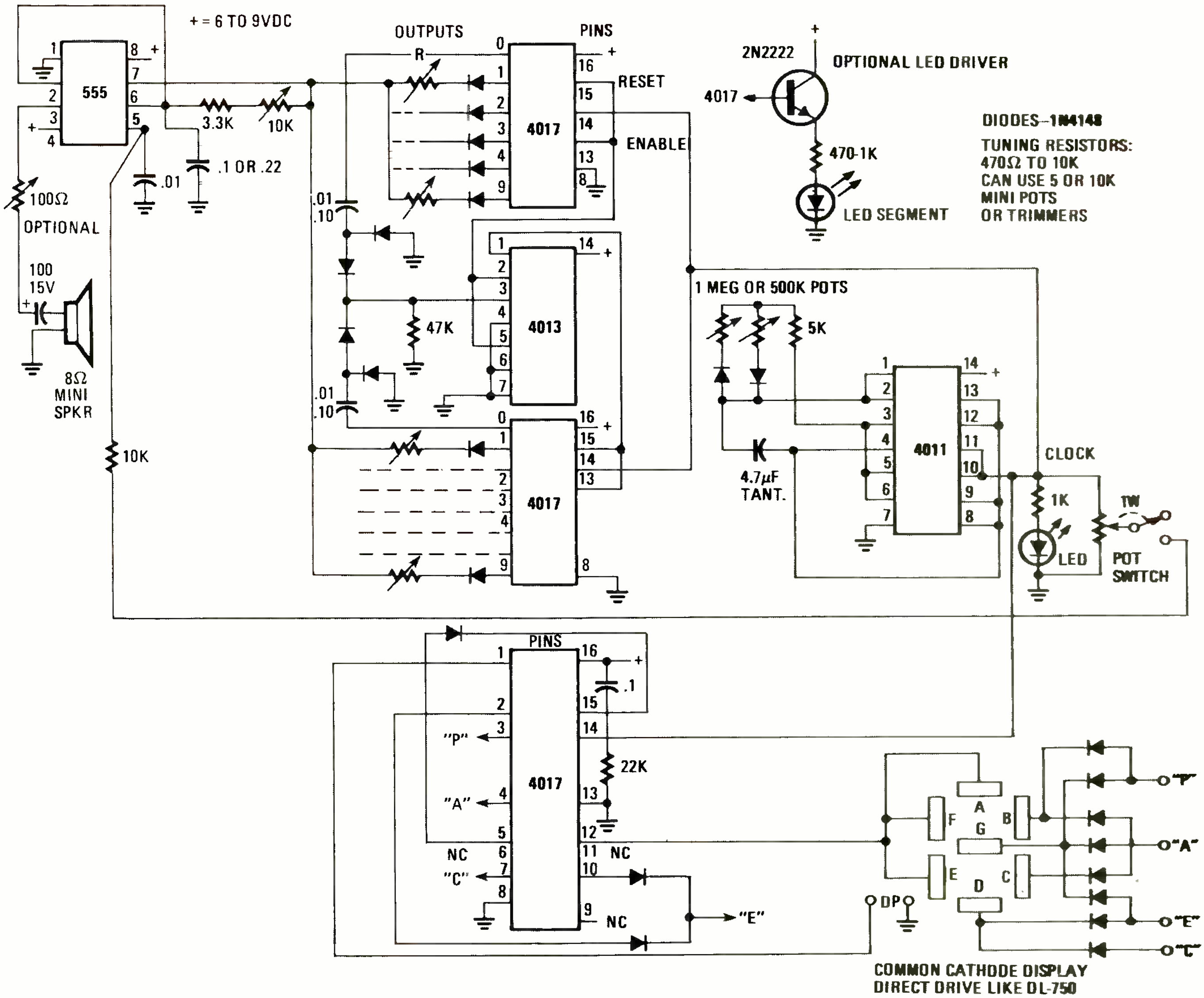


FIG. 5—COMPLETE CIRCUIT FOR WORDS & MUSIC DEVICE.
It's fun to use and the potential applications are a real challenge.

Construction uses plug-in breadboards

For demonstration and experimental purposes, set up the components on one of the several plug-in boards now available. For more permanent installations, perf-board with 0.1-inch hole spacing is very useful. A 9-volt transistor radio battery can be used to make the demonstrator portable, if LED display current can be kept moderate. Otherwise, use a positive power supply from 5 to 12 volts, taking due care with chip and display dissipation. A conservative approach is to use NPN driver transistors with current-limiting resistors to the displays. If numbers alone are to be displayed, note that the 4026 CMOS chip has built-in decoding and can directly drive certain displays, making separate diode matrixes unncessary.

Now put it to work

Both light and sound sub-systems can be combined so that a single tone or tone pair can represent a particular letter or number. This feature would be useful in teaching children to count and spell, or in identifying a product. With a little ingenuity, almost all of the letters of the alphabet can be represented with a seven segment display, although the more expensive MAN-2 5 × 7 dot matrix provides the greatest clarity. For dedicated displays turned on in sequence, M and W, for example, the unit *on its side*.

A handicapped adult or child could easily learn to operate a combined words-music portable display board, calling for H-E-L-P in flashing light and sound. A pet could even be trained to make its wants known by nosing a switch that would initiate an unmistakeable audio-visual request to go O-U-T. And finally, for company calling, there is always the robot butler who responds to a push of the doorbell button by a tuneful and cheerful H-E-L-L-O. **SP**

Programmable Sound Generator

Plug in the right parts and it will work with your choice of a TRS-80, S-100 Bus, or SWTPC 6800.

L. STEVEN CHEAIRS

CURRENTLY THE HOBBYIST HAS A HOST OF MICRO-computer systems to choose from. Though this one has many positive features, it does present some problems. When you build a memory card, I/O board or a peripheral interface it generally means that those cards are only useful for one system. The programmable sound generator presented in this article follows a different course; through careful attention to circuit design and board layout a card was developed that can interface to three major micro-computer systems. These three basis systems are the TRS-80 Radio Shack Z-80, the S-100 bus, and the SWTPC 6800.

A number of microcomputer systems are used in situations where an audio signal is required. For example; video games, keyboard feedback, and music instruments all require audio signals and each one can be computer controlled. Most any microprocessor can generate these sounds with a minimum of external components. If the CPU (central processing unit) had only this task to perform, no problem would exist. In a real computer system the CPU is kept busy with other tasks. For example, to produce an eighth-octave-B (7902 Hz) signal, the processor would be required to provide attention every 63 microseconds. As you can imagine, the software to generate a single eight-octave-B, plus other computer tasks would be complex. other audio signals that are not as predictable as a simple tone would be impossible to produce. Using a new LSI integrated circuit from General Instruments it is now

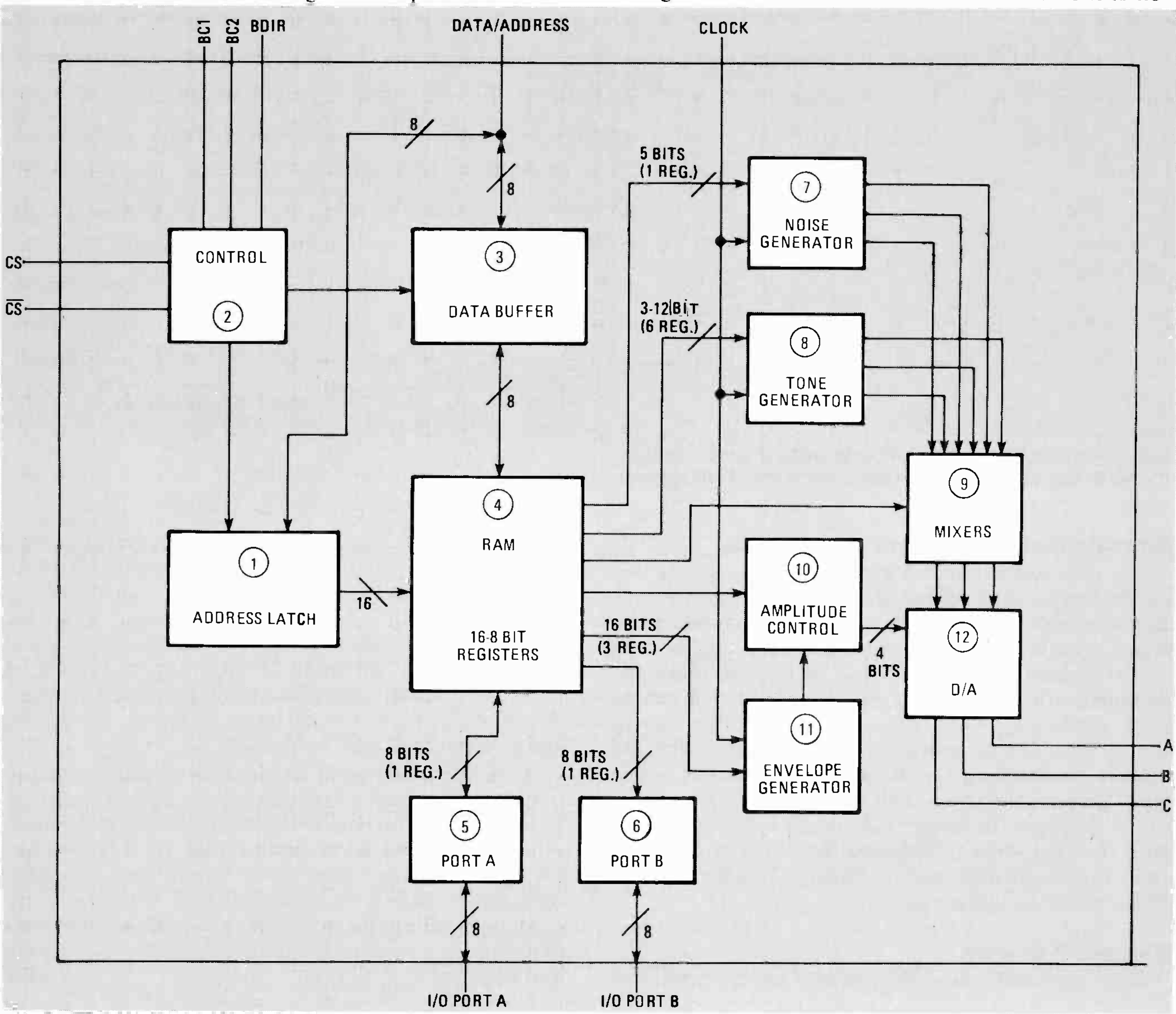


FIG. 1—BLOCK DIAGRAM GIVES YOU A PICTURE of the entire operating system for the programmable sound generator.

possible to softwave produce complex sounds with only infrequent attention of the host processor.

Description of the AY-3-8910

The AY-3-8910 was designed to produce a wide variety of complex sounds under processor control for GI's programmable game series. This Large Scale Integrated Circuit (LSI) is fabricated by GI's N-channel Ion Implant process; it requires a single 5-volt power supply, has a TTL compatible clock, and is easy to interface to a microprocessor.

Since realistic sounds often require more than one audio effect, three independent channels are available. To minimize the amount of interaction between the processor and the PSG, programmable sound generator, the PSG can continue to produce sound after an initial set of commands are given. The IC's internal design makes it useful for applications such as music synthesis, sound effects generation, audible alarms, tone signals, and FSK modems. Each channel has an analog output, 4 bits of logarithmic digital to analog conversion. Since all sounds are created digitally, the PSG can produce a variety of sounds without any external circuit changes. The frequency range covers sub-audible to post-audible frequencies. There are few sounds that are beyond reproduction.

How it works

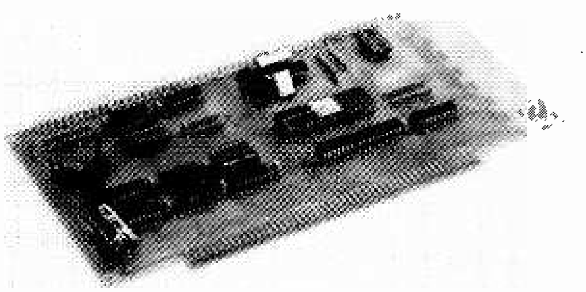
Figure 1 is a functional block diagram of the PSG. Block one is the address latch decoder, its outputs will select one of the 16 resisters. Block two is the control decoder. It determines if a data read or write is desired or if an address is to be latched. Block three includes the bidirectional data buffers required for data transfer. Block four is a 128-bit RAM, it is used to form the 16, 8-bit registers. Blocks five and six are each an 8-bit bi-directional parallel data port. Though these have nothing to do with sound generation, any computer can always stand an extra couple of I/O ports. Block seven is a 5-bit programmable noise generator, used for making sounds such as gunshots or bombs blowing up. Block eight contains three 12-bit tone generators. Block nine contains three mixers. Block ten controls the amplitude of each of the three outputs. The circuits of block eleven create a variety of envelopes for complex sounds. The last one, block twelve, consists three programmable gain D/A converters.

The microprocessor interface

Since the PSG was intended to interface with GI's 8900/8910 microprocessors, it has control characteristics for those processors; the controls are somewhat non-standard. Three control lines are used; BC_1, BC_2, and BDIR. The S-100 bus uses $\overline{WR}$, SOUT, SINP, and DBIN to do the same job. The Radio Shacks' TRS-80 uses $\overline{WR}$, $\overline{SOUT}$, $\overline{SINP}$, and DBIN; while SWTPC's 6800 uses $\overline{VMA}$, and $\emptyset_2$, and R/$\overline{W}$. As you can see, a logic array was needed that could take these three sets of inputs and develop the B_1, B_2, and BDIR signals for the PSG. There are eight possible states for the PSG's three control lines. When all three are low; when BDIR and BC_1 is low and BC_2 is high; or when BDIR and BC_1 is high and BC_2 is low—the PSG's data bus is inactive. If BDIR and BC_2 are low and BC_1 is high; BDIR is high and BC_1 and BC_2 are low; or all controls are high—the register address active on the data bus is latched. A read from the PSG is decoded when BDIR is low and BC_1 and BC_2 are high and B_1 is low.

The S-100 bus and the TRS-80 I/O controls are similar. I/O mapping was chosen since the high address byte does not require busing around the card. For these two configurations the $\overline{WR}$ is inverted and "ANDed" to the SOUT signal, the TRS-80's $\overline{OUT}$ is also inverted to form a $\overline{WRIGHT}$ pulse. DBIN for the S-100 IRD for the TRS-80) is "ANDed" with the SOUT (again for the TRS-80 $\overline{IN}$ is inverted) to form a $\overline{READ}$ pulse. For the SWTPC's 6800; jumpers J_1, J_2, and J_3 are installed to separate the R/$\overline{W}$ control into a $\overline{READ}$ and $\overline{WRITE}$ pulse. For all three computers IC12 is used for this decoding. Board select is combined with the $\overline{READ}$ and $\overline{WRITE}$ pulses to prevent false data transfers.

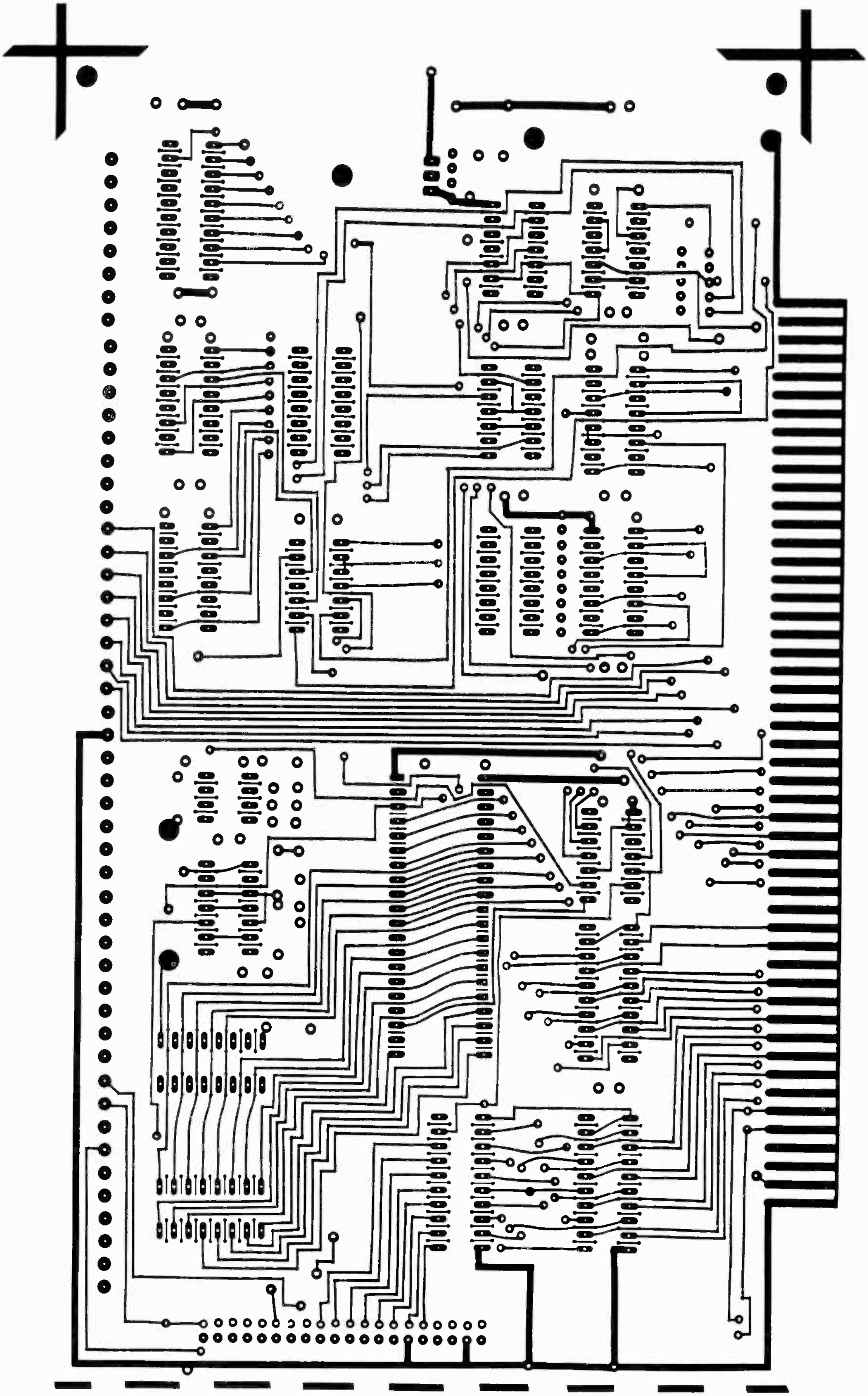
Integrated circuit IC8 used the $\overline{READ}$ and $\overline{WRITE}$ pulse along with address line A_0 to form three signals. These signals are $\overline{READ\ DATA}$, $\overline{WRITE\ DATA}$, and $\overline{LATCH\ ADDRESS}$. When address bit A_0 is a logic zero, then address latch is enabled. Likewise, when address bit A_0 is a logic one, then data transfer is enabled. Note: The above statements are only true if the appropriate $\overline{READ}$ or $\overline{WRITE}$ pulse is present. The last IC in the chain, IC9, uses the three signals formed by IC8 to form the required code for the PSG. A $\overline{LATCH\ ADDRESS}$ command will cause BDIR, B_1, and B_2 to all be logic one levels—as stated earlier this is a latch address command. A $\overline{WRITE\ DATA}$ command will cause BDIR and BC_2 to be a logic one and BC_1 will be a logic zero—this is a write data code. A $\overline{READ\ DATA}$ command will cause BC_1 and BC_2 to be a one, but let BDIR to be a zero; this is a read data code. If none of the three signals are received BDIR, BC_1, and BC_2 are all zero, or inactive.



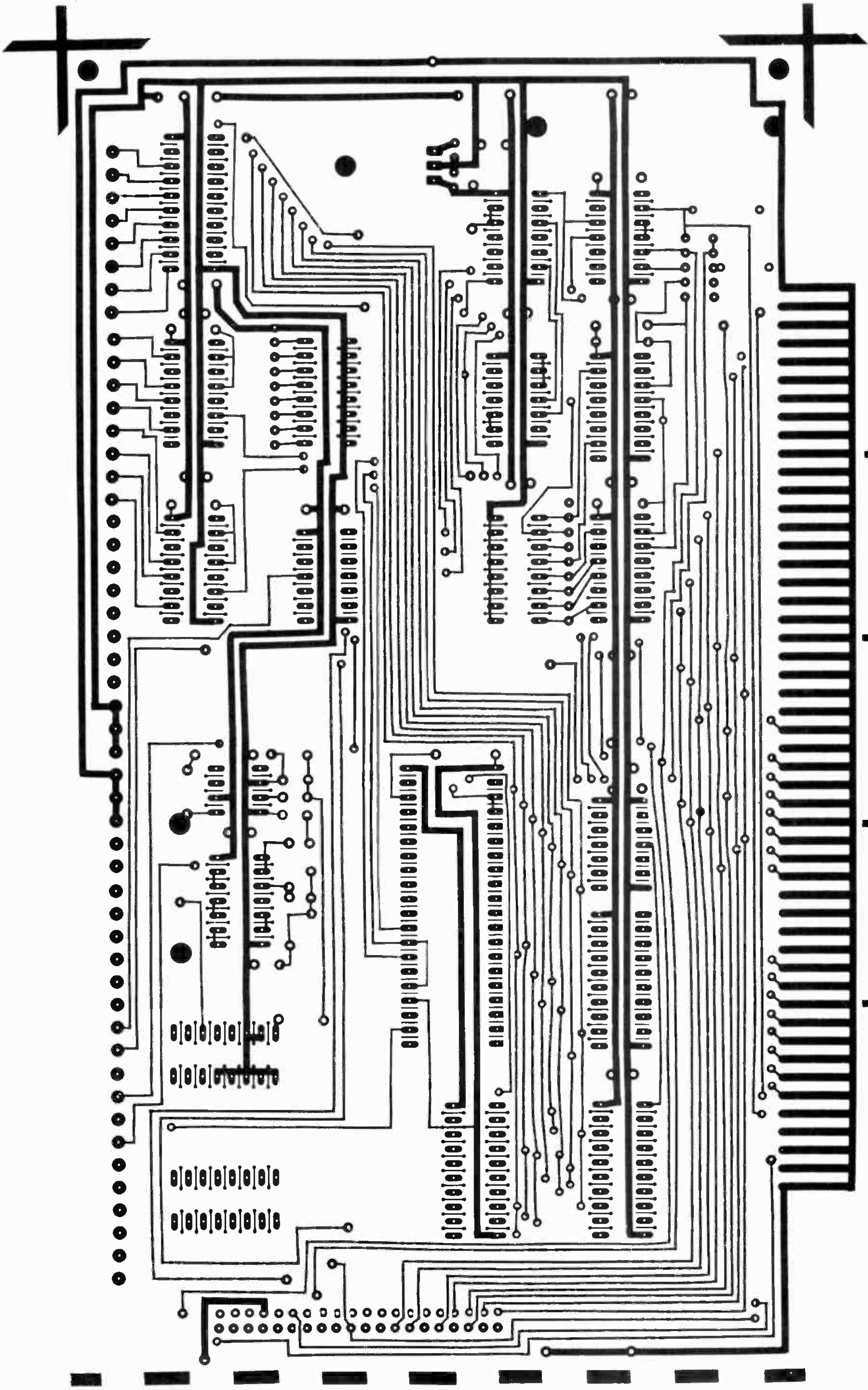
PHOTOGRAPH OF ASSEMBLED BOARD. It contains the complete programmable sound generator.

Audio amplifier IC4 is not actively connected to the PSG. Its input is available on pin 8 of I/O socket #1. The speaker output is available on pin 1 of the same socket. If you wish to use the amplifier then connect the channel out, pin 3 of I/O #1, to pin 8 of I/O #1. Also, if your system may use this amplifier at times or an external amplifier, use a switching audio jack for this connection.

Integrated circuit IC5 acts as a clock buffer, for the TRS-80 is a form oscillator. When interfacing to the S-100 bus or to SWTPC 6800 do not install XTAL, R22, R23, C5 or C6. The reset line is also buffered for all three systems. IC13, 14 and one gate from IC15, along with DIP switch S2 and resistors R1, R2, R3, R5, R6, R7, R8, R17, R18, and R28 form the I/O port decode for the S-100 bus and TRS-80 systems. These components form the low-order address decode for the SWTPC 6800



FULL SIZE FOIL PATTERN for the component side of this two-sided circuit board.



FULL SIZE FOIL PATTERN for the reverse side of the programmable sound generator board.

system. Also common to all systems is the 5-volt regulator and its associated filter capacitors.

For the S-100 bus, in addition to the above circuit elements, you need IC16 and IC17. Integrated circuit IC16 forms the S-100 bus input data buffer; IC17 forms the output buffer. The S-100 bus uses two data buses—one for each directions. The PSG though has a bidirectional bus—IC's IC16 and IC17 develop this interface.

For the Radio Shack TRS-80 IC16 and IC17, of course, are not needed, instead IC11 is used to interface to the TRS-80. The gate, from IC15 is used to make the bi-directional buffer look like the S—100 bus buffers. Also required are two inverters for the RD and OUT controls. For this computer, since Radio Shack did not make the clock available externally, add the XTAL, R22, R23, C5, and C6 to form a 2-MHz oscillator. In the

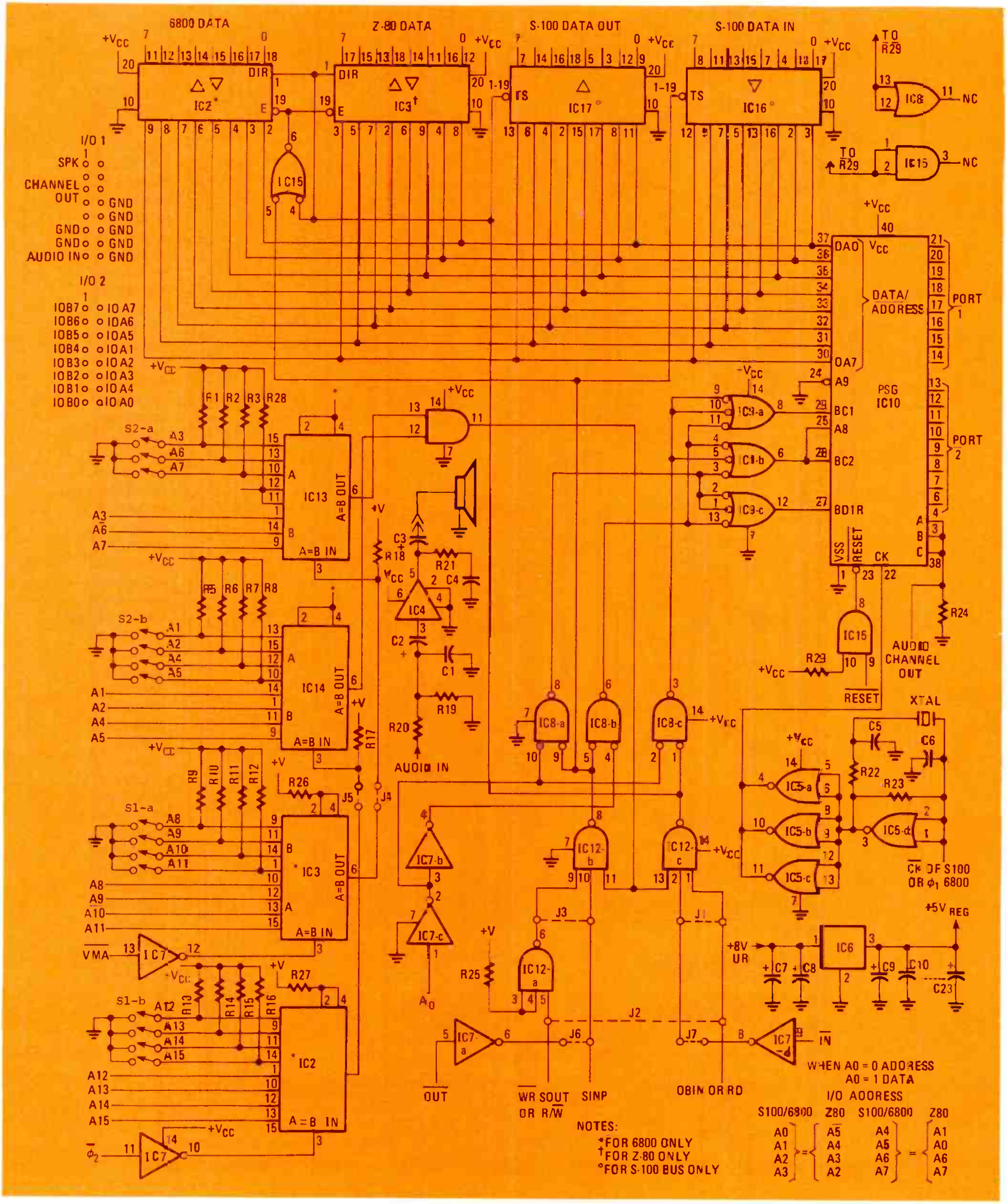


FIG. 2—COMPLETE SCHEMATIC OF THE PSG. You will not need all of the components shown. For clarity, parts valves are not shown here. Refer to the parts list for details.

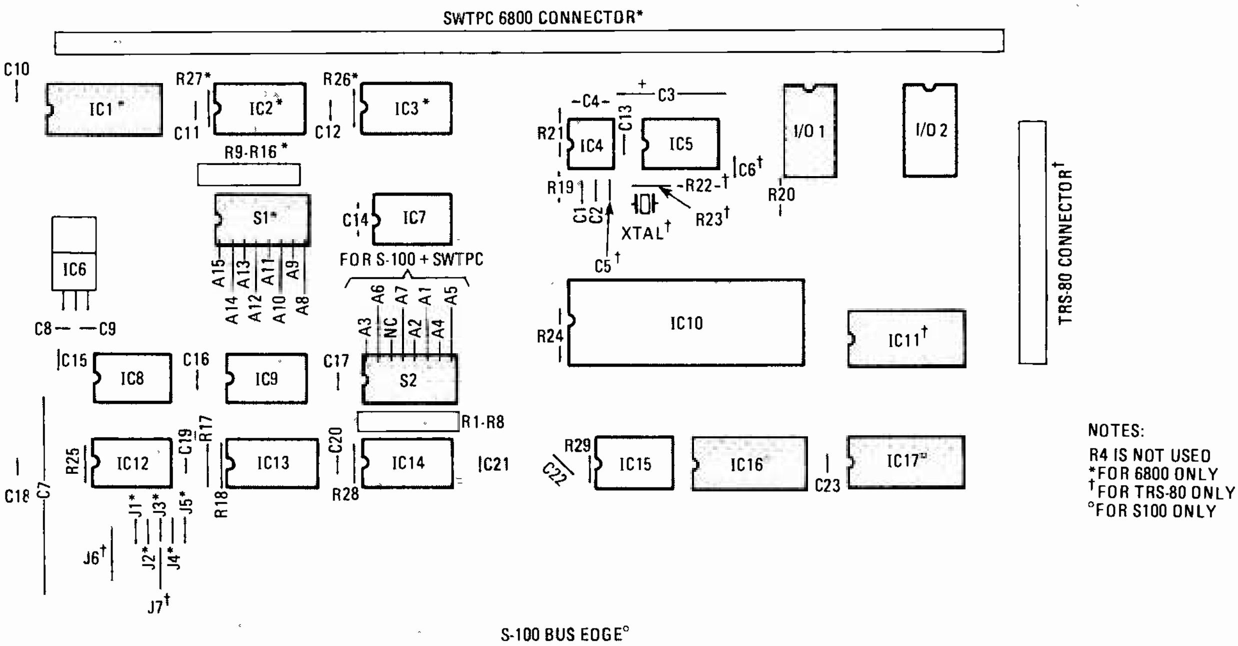


FIG. 3—PARTS LAYOUT DIAGRAM shows where you should position the components on the printed-circuit board.

PARTS LIST
COMPONENTS COMMON TO ALL SYSTEMS

RESISTORS

All resistors ¼-W 5%
R1 through R8, R25, R28, R29—2,200 ohms
R19—510 ohms
R20—5100 ohms
R21—10 ohms
R24—1000 ohms

CAPACITORS

C1—100pF ceramic
C2, C8, C9—2μF Tantalum
C3, C7—250μF electrolytic
C4—0.05μF ceramic
C10 through C23—use a ceramic with values in the 0.01 to 0.1μF range

INTEGRATED CIRCUITS

IC4—LM 386 audio amplifier
IC5—4001 or 4011 CMOS quad gates
IC6—7805 5-volt regulator
IC7—74LS04 hex inverter
IC8—74LS32 quad OR gate
IC9, IC12—74LS10 triple NAND gate
IC10—AY-3-8910 PSG
IC13, IC14—74LS85 4-bit logic comparator
IC15—74LS08 quad AND gate

OTHER COMPONENTS

S2-DIP switch, 8 SPST switches
SK8—8-pin socket (1)
SK14—14-pin sockets (6)
SK16—16-pin sockets (5)
SK40—40-pin socket (1)

SWTPC 6800 ADDITIONAL COMPONENTS

R9 through R1, R26, R27—2200 ohms
IC1—74LS245 octal bus transceivers
IC2, IC3—74LS85 4-bit logic comparator
S1—DIP switch, 8 SPST switches
SK16—16-pin sockets (3)
SK20—20-pin socket (1)
Molex edge connectors

TRS-80 ADDITIONAL COMPONENTS

R22—220 ohms
R23—12 megohms
XTAL—2 MHz
C5, C6—30pF ceramic
IC11—74LS245 octal bus transceivers
SK20—20-pin socket (1)
Four board spacers and hardware
Ribbon Connector (Ansleu 40-pin)

S-100 BUSS ADDITIONAL COMPONENTS

IC16, IC17—74LS244 octal buffers
SK20—20-pin socket

The following are available from Quest-Star Electronics, 5412 Burntwood Way, Las Vegas, NV 89108:
Complete S-100 kit (No. MC2000), $112.00
Complete RS-80 kit (No. MC2001), $125.00
Complete SS-50 kit (No. MC2002), $120.00
PC board only, $35.00
AY-3-8910, $18.95
Nevada residents please add 3½% tax. No credit cards.

schematic diagram of Fig. 2, the address labels for IC13 and IC14 are only valid for the S-100 bus or the SWTPC 6800. For the TRS-80 A_0 should be A_5; A_1 should be A_4; A_2 should be A_3; A_3 should be A_2; A_4 should be A_1; A_5 should be A_0; and A_6 A_7 are as labeled. Jumpers J6 and J7 should be installed.

If the SWTPC 6800 is to be used with this circuit, add IC1, IC2 and IC3. IC1 is the data bus buffer. IC2 and IC3, along with two inverters from IC7 and DIP-switch S1 and resistors R9 through R16 form the high byte of the memory address. Jumpers J1 through J5 need to be installed.

As with most construction projects assembly can proceed by many routes—such as point-to-point wiring, wirewrap, or printed circuit board. By following the schematic, any one of these technologies may be used. In this article only printed-circuit fabrication will be assumed. You can buy the plated-hole circuit board, or make one from the artwork on pages 94 & 95. If you

text continues on page 84

DIGITAL FREQUENCY DISPLAY

continued from page 74

BCD values "A" "B" "C" "D" respectively. Use diodes for "1" values, leave open for zeros.

Repeat the above for the third from the right digit. Diodes go from pins 7/8 of the socket to 9, 11, 14, 16 as before.

Repeat the first step for the fourth digit, with diodes running from pins 3/4 of the socket to pins 9, 11, 14, 16.

Finish up the programming by wiring diodes as required for the fifth digit from pins 1/2 of the socket to pins 9, 11, 14, 16 as before.

NOTE: It is possible that there will be no connections for a particular digit.

C. **Insert the completed header,** connect the counter assembly and check programming. If you get what you set, connect the prescaler, turn on the receiver and enjoy the results!

Troubleshooting procedures

Generally, you should have no real problem programming this project. If you do, study the example we gave for a 455-kHz IF. On the other hand, if you discover the shortwave display is off by twice the IF, the local oscillator is running at a frequency *below* the value you are tuned to. This is a rare situation, but possible. The cure is to simply add the IF to 10 000, as outlined in the *Programming* section and redo the switch and DIP header.

If there is any question about accuracy, dial up station WWV on 10.000 or 15.000 MHz. Slight corrections may be needed in the programming if you didn't use a signal generator/frequency counter to determine the exact IF.

Operation is a snap

Operating this project is a snap; turn it on with your receiver, then simply read the frequency off the display. Now it's possible to look up a station you want to listen to, dial the frequency, and (if receivable) hear it!

If you would like to use this project as a high-performance frequency counter, build another prescaler board for this application. Then whenever you want to measure frequency, unplug the DIP header, set S1 to 0000, and connect the prescaler. Sensitivity runs from 100 mV with a 100-kHz signal to about 20 mV at 100 MHz. Maximum performance is at 27 MHz, where the sensitivity in under 10 mV. **SP**

List of Parts Suppliers

1. LED's, resistors, caps, etc.

Digi-Key, Inc.
PO Box 677
Hiway 32 South
Thief River Falls, MI 56701
Telephone: 1-800-346-5144

2. Intersil IC's, crystal, etc.

Circuit Specialists
1344 N. Scottsdale Rd.
Tempe, AZ 85281
Telephone: 1-800-528-1417

3. National IC's, etc.

Tri-Tek, Inc.
7808 N. 27th Ave.
Phoenix, AZ 85021
Telephone: (602) 995-9352

As a special offer to Radio-Electronics Special Projects readers, Technico Services can provide a set of PC boards, plus assembly plans. The plans include assembly data, troubleshooting info, and how-to-install procedure for most shortwave receivers. The set is $14.00 postpaid in the USA. (Foreign residents add $3.00 for postage & handling). California residents include sales tax. No. CODs.

To order: **1. Ask for Model 83 SW Display set at $14 each.**
2. Send check or money order to:
Technico Services
PO Box 20HC
Orangehurst Station
Fullerton, Ca. 92634

STEPPED VOLTAGE REGULATOR

continued from page 87

out its boost. You can set the trip point to another voltage if you wish so that the range of the output voltage of the regulator is within the range of voltage required by your TV or instrument for satisfactory operation.

If you do not have access to a Variac, wait until you just start to experience low power line voltage troubles with your TV or instrument. Then connect your set to the regulator and adjust R2 so that the neon lamp just extinguishes and relay RY1 is deenergized. Whatever the line voltage was when you experienced difficulties will now be the trip point at which the regulator will boost your low line voltage by 6.3 volts.

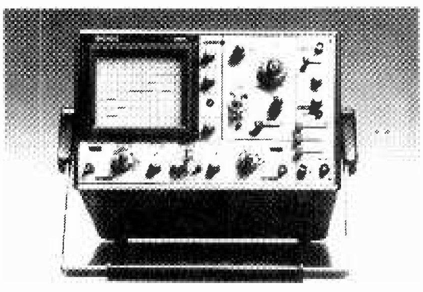
If you do not wish to keep the regulator on when your line voltage is high (possibly during the daytime), switch S1 can be set to off completely bypassing the regulator and automatic operation, except for fuse F1 which will provide added safety protection for the device connected to the regulator. **SP**

ELECTRONIC KITS, *Catalog 849*. Contains descriptions of nearly 400 different electronic kits for home or business in its 104 pages. Included are computers, a projection TV system, energy-saving devices for home and car, test instruments, marine gear, radio-control modeling devices, amateur radio equipment, stereos, color TV's and education self-instruction programs.—**Heath Company,** Benton Harbor, MI 49022. Phone 616-982-3411.

FOR MORE INFO CIRCLE 338 ON FREE INFORMATION CARD

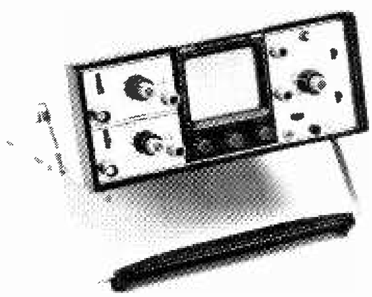
MAXI-GRABBER, *Model 4724*, has a standard 4.22mm (0.166-inch) diameter banana jack built into the plunger. Designed for attaching the grabber directly to the end of a banana plug patch cord. Gold-flashed beryllium copper hook for attachment to the test point. Banana jack is brass, nickel plated, with glass filled nylon insulation. Available in 10 colors. $3.95.—**Pomona Electronics, Division of ITT,** 1500 E. Ninth Street, P.O. Box 2767, Pomona, CA 91766. Phone 714-623-3463.

FOR MORE INFO CIRCLE 333 ON FREE INFORMATION CARD



50MHz OSCILLOSCOPE, *Model V-550B*. Dual-trace delayed-sweep unit has 6-inch square CRT with an internal graticule. Features trigger view, (external and internal triggering signals can be displayed as a third trace); variable trigger hold-off; full TV triggering and single-sweep capability. An additional feature is automatic focus correction that restores correct focus whenever intensity or sweep range-control settings are altered. Vertical sensitivity is 5mV/DIV over the full bandwidth and 1mV/DIV to 10MHz. Display modes are CH1, CH2 (normal or invert) alternate, chopped and added. Time Base A has 22 calibrated sweep positions from 50ns/DIV to 0.5s/DIV. Time Base B has 19 calibrated steps from 50ns/DIV to 50ms/DIV. 10X magnification extends fastest sweep rate of both time bases to 5ns/DIV. Unit weighs 20.5LBS; measures 12.2(W) x 7.7(H) x 16.1(D)-inches. Price $1745 with two probes.—**Hitachi-Denshi Ltd.,** 175 Crossways Park West, Woodbury, NY 11797. Phone 516-921-7200.

FOR MORE INFO CIRCLE 324 ON FREE INFORMATION CARD



DUAL-TRACE MINI SCOPE, *Model 1420*. Portable unit measures 11 x 22 x 30 cm (4.5 x 8.5 x 12 inches). Bandwidth is conservatively rated at 15MHz with 10mV/DIV vertical sensitivity. Usable response extends beyond 20MHz. With optional battery pack (it mounts inside the case) unit can be used away from AC power lines. Scope can also be powered from 117VAC, 234 VAC or 10-16 VDC. Eighteen calibrated sweep ranges cover luS/DIV to 0.5s/DIV with ±5% linearity. 10X magnifier extends sweep range to 100ns/DIV. Automatically selects chopped or alternade mode of display and provides automatic selection of video line and frame sync. $825 with two probes, AC power pack and instruction manual. Options include rechargeable battery, 235VAC power pack, carrying case, DC power cable and demodulator probes.—**B&K Precision,** 6460 W. Cortland St., Chicago, IL 60635. Phone 312-889-9087.

FOR MORE INFO CIRCLE 326 ON FREE INFORMATION CARD

DIGITAL MULTIMETERS, *MX Series; models MX 331 and MX 333.* Both provide 0.1% basic accuracy, 10-megohm input impedance, plus overload protection.

Premium version, *MX 333*, contains built-in audible signal that changes frequency in proportion to digital readings, called VARI-PITCH™: Also features self-contained logic testing capability that combines features of high-performance logic probe and voltmeter in one function. VARI-PITCH™ operates on all voltage, current, resistance and diode test ranges. With practice, operator can troubleshoot by ear without taking his eyes off the probe or waiting for digital readings to settle. Ranges include DC volts to 1000 in 4 scales; AC volts to 1000 in four scales; Resistance to 20 megohms in 7 scales; diode test; AC/DC current to 10A in 5 scales.—**Hickok Electrical Instrument Company,** 10514 Dupont Ave., Cleveland, OH 44108. Phone 216-541-8080.

FOR MORE INFO CIRCLE 323 ON FREE INFORMATION CARD

ADVERTISING INDEX

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INSTRUMENTS CATALOG, *1980/1981.* Oscilloscopes, Function Generators, and professional Video Generators are among the products features in this 40-page full-line catalog. Features, specifications and applications for more than 50 test instruments are included, as is a large selection of probes and other test accessories.—**Leader Instruments Corp.,** 380 Oser Avenue. Hauppauge, LI, NY 11787. Phone 516-231-6900.

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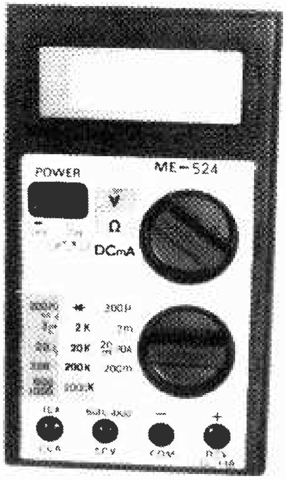

LCD MULTIMETER, *Model ME-524.* A 3-1/2 digit unit that has a built-in buzzer for making continuity checks. Features four function modes (DCV, ACV, DCA, and Ohms). Also offers automatic polarity indications and automatic zero adjustment. All modes appear on the LCD display. Battery-operated unit for use by lab technicians, field service technicians or hobbyist who needs accurate measurement with a maximum indication of 1999 or −1999. Unit measures DCV from 200mV to 600V, ACV from 200 to 1000. DC current from 200μA to 10A and resistance from 2000 ohms to 2 megohms. Price $90.00.—**Soar Electronics Corp.,** 200 13th Ave., Ronkonkoma, NY 11779. Phone 516-981-6444.

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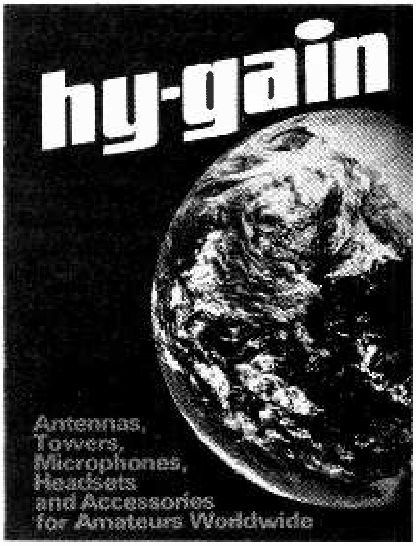

AMATEUR CATALOG, *No. AM2504* includes more than 100 products in this 24 page booklet. More than 100 base and mobile antennas, towers, rotators, microphones, headphones, boom mike headsets and accessories for the amateur radio operator are included. Full line of desk and hand mikes, new antenna rotator and a series of seven crank-up antenna towers are included along with full specifications including SWR curves on all base antennas.—**Hy-Gain, Division of Telex Communications Inc.,** 8601 Northeast Highway Six, Lincoln, NE 68505. Phone 402-467-5321.

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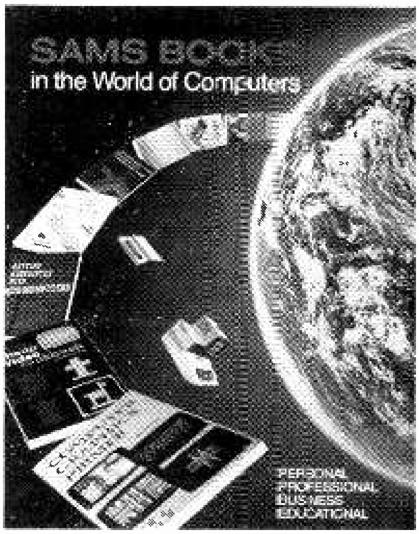

COMPUTER BOOK CATALOG. 16 pages crammed with descriptions of more than 50 books about computers. Includes detaled descriptions of book contents and there is a section that tells you about the authors.—**Howard W. Sams & Co. Inc.,** 4300 West 62 Street, P.O. Box 7092, Indianapolis, IN 46206. Phone 317-298-5400.

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