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ELECTRONICS HOBBYIST

SUMMER 1984

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PROJECT BUILDERS ONLY

Did you ever get tired of building projects? If you did, the chances are you are not reading this page! Electronics experimenters cannot get enough projects to build. Their first problem is finding the plans for a device, instrument or gadget that they want on their workbench, in their home, or installed in their car. Next comes the time-consuming, parts-acquisition stage for no junkbox is ever complete—if it were, the experimenter owns an electronic parts outlet. Then comes the breadboarding stage. Some like to go the solderless breadboard route, while the hardy types go right into the finished project. Of course, there are countless types between these extremes. Testing tells 'em its finished, and another project bites the dust.

Electronics Hobbyist does its bit by providing the countless plans in each issue. By itself, the magazine is a fantastic buy. However, you can get a lot more by adding the technical love-and-care each project needs—that is the added design input you provide. That's right—copy cats really don't have as much fun as that enjoyed by improvisers and designers. Besides, with inòvation you can add those features you desire and exclude those not needed.

We are proud of this issue of Electronics Hobbyist, and we are equally proud of our readers who add to their knowledge in a fun way. Keep building!

DON GABREE
Publisher

WANTED: PROJECTS

How would you like to find your home-brew project in the next issue of ELECTRONICS HOBBYIST or in one of its sister publications? It's all up to you! Build your project for yourself—it should have a real purpose. Then, if you think it is good enough to appear in one of the Hobby Handbooks, let us know about it.

Write us a short letter describing your project. Tell us what the project does. Provide us with a schematic diagram and a few black-and-white photographs of the project—photos are important. Once we read your letter, we'll let you know, one way or the other, whether we would like to purchase your article describing the project. Send your letter to:

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Got a question or a problem with a project—ask Hank! Please remember that Hank's column is limited to answering specific electronic project questions that you send to him. Personal replies cannot be made. Sorry, he isn't offering a circuit design service. Write to:

Hank Scott, Editor
C & E HOBBY HANDBOOKS INC.
300 West 43rd Street
New York, N.Y. 10036

555-1212

Why are telehone accessories so expensive? Is someone making a killing! Harry R., Portland, OR

Accessories appear to be high in cost; and some are, because they are junk. An accessory made to FCC standards costs more to make and the performance over its lifetime is better than the junk. In fact, the lifetime is much longer, too. The specifications on gold-plated jacks are important for noise-free operation. The junk products use little gold (which is expensive), or no gold at all. Maybe the FCC will get into the act requiring manufacturers to meet minimum specifications and, thereby, making all products nearly equal in performance. Then, the price differences will diminish, and the overall price for telephone accessories will begin to drop in the light of honest competition.

Clean Sweep

Recently, I saw an advertisement for a miniature vacuum cleaner that operates on a 9-volt battery. That product looks like it would be suitable for cleaning the dust that falls between the keys of my computer keyboard. Also, since I am a camera buff, it should provide double-duty for camera cleaning. Tell the readers about this! Adam K., Owing Mills, MD

I saw a few such gadgets that sold anywheres from 20 to 40 dollars. I prefer my Dusterbuster vacuum made by Black and Decker. It has much more vaccum "pull," but it will not cause damage to the computer. Do as I do—dust the keyboard using a soft artist paintbrush after the plate, through which the key board protrudes, is removed. Hold the Dustbuster near the brushed area and watch the gook get sucked up

As for your camera, I suggest you get some camera-shop freon and blow the dust out. Don't buy it elsewhere, because freon used for most commercial applications does have some residual oil in the can that will foul-up the camera. I tell you this because you can use the same can of freon to blow dust out of the disc drives you use.

A word of caution—keep all electric motor decices away from your floppy or hard memory discs. The magnetic field cause by the motor, especially when turning it on and off, will cause bits and bytes to disppear off your discs.

Likes Small Circuits

Hank, I like to build small gadgets and circuits just for the fun of building them. True, I do this to learn all about electronics, which is my hobby, but fun is fun. Where can I find a source of *mucho* small circuits?

—J.K., Brooklyn, MD

First, I did not know there was a Brooklyn in Maryland. So you see how much you can learn by reading this magazine. As for the source you seek, try the magazine you're reading right now (I sent him a copy—Hank), and one other magazine published on an annual schedule—101 Electronic Projects. There are few office copies still unsold which you can pick up for $4.00 (which includes postage and handling) to Worldwide Publications Inc., P.O. Box #5206, North Branch, N.J. 08876.

Computer/Shortwave

Is there a program that I can use with my IBM Jr. to help me with my shortwave listening hobby? I specialize in utility listening although I do tune in the SW broadcast bands. Sid E., Emporia, KS

There must be some available. I suggest you write to the DXing club to which you belong. Also, Bearcat came up with their Bearcat Compu-Scan 2100 scanner radio designed to put the power of a personel computer to work for you. There's lots of interesting info on this device and its yours free by dialing 1-800-S-C-A-N-N-E-R-. Give it a try!

Gets Bigger and Bigger

I believe that the 25-in TV tube is much easier on the eye than the 21-inch job. But, that's not the question. Without resorting to projection TV, is he 25-inch tube the largest picture size I can get? Bob K., Washington Crossing, PA

First, is Washington Crossing near Trenton, New Jersey? (History buffs would like to know that one.) The largest picture tube you can get is the 25-in. job except that the 26-in. and 27-in. TV tubes are about to be released. In fact, it's a sure fact that the new square tubes will be in the stores by late 1984. So, if you want to wait....

Static Kicker

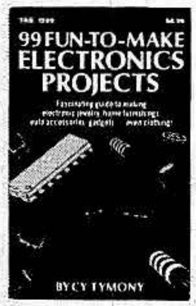
Every winter I build up a static charge as I walk across the living-room rug and get zapped when I want to turn on a light, TV set, or hi-fi. In fact, I once popped a woofer because of the giant static pop produced when I attemped to change a record. What I am thinkirig about is to correct this condition by weaving some fine copper wires in the carpet and connect these wires to a good earth ground. What do you think? Please, don't tell me to get a new rug. My wife is looking for an excuse to replace the livngroom furniture! Jeff C., Williamsville, NY.

I'm surprised that you did not suggest installing copper-foil tiles! But, a more practical approach is to forget about the copper weaving and install static touch-pads at the outlets and electronic equipment. I once ran across some pads of this type on the market that attached to wall plates and provided a resistive path to ground to kill the spark. The resistance reduces the shock to your finger, yet eliminates all of the static. Since I can't tell you where to buy them, I suggest you secure some of the black matting that comes attached to the pins of DIP integrated-circuit chips. These will do the job effectively and cost nothing since [illegible] few pieces must be laying in t[illegible] bottom of your parts box right no[illegible] Loosen the screw(s) that hold t[illegible] wall plate to a switch or outlet an[illegible] slip about 1/4-inch of the pad und[illegible] it—no more than that! Now tighte[illegible] the screws and you have installed a painless, static-removal pad.

BOOKMARK
BY BOOKWORM

99 FUN PROJECTS

Here's a truly unique project-book—*99 Fun-to-Make Electonics Projects*, by Cy Tymony—that highlights the fun side of electronics. The text shows you how to make all kinds of fascinating jewelry, home and auto accessories, gadgets, and even clothes that display the wizardry of electronics via flashing lights and sound effects! Written for the



novice experimenter, but it includes plenty of sophisticated gadgetry to appeal to more experienced hobbyists, too! Best of all, you can put any of these exciting projects together in a single evening using LEDs, batteries, and a few ICs. And, you're sure to be the center of attention when you show off your electronics creations...and probably swamped with requests to make copies for your friends. These gadgets and gizmos make terrific and inexpensive gifts... especially for the disco set!

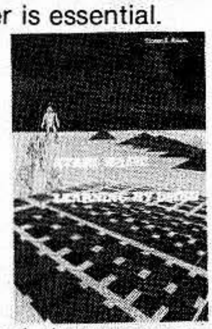
You'll discover a whole new world of wild and way-out electronics applications and lots of practical ones as well. Build an LED space gun with sound effects, a musical door ajar indicator, disco cufflinks, an automatic auto glove box, and much, much more! Each project is unique, can be made with just a few inexpensive parts in just a few easy steps.

To get you in the swing of things, the book starts out with a section on the devices and procedures you'll be using plus all the data you'll need to finish any project given, and do it right the first time! Circuits, switches, lead wires, batteries, resistors, solar cells, LEDs are all thoroughly examined. Plus, there are details on electronics tools like the 555 timer IC and other devices utilizing the newest miniaturized components, then it's on to making lots of electronic things to wear—a multi-color light T-shirt, bracelets, belts, hair clips, eyeglasses...even shoes, pants and jackets! You'll find LED bead curtains and an IC-controlled wall design/light show and other fun things for your home. There are auto accessories, too—a flashing LED hood ornament, a disco dashboard, and more!

Step-by-step instructions and plenty of illustrations, diagrams, and schematics guide you as you make one of the 99 exciting projects in this sure-to-interest project book designed for the NOW generation!—Published by Tab Books Inc., Blue Ridge Summit, Pa 17214; $8.95.

LEARNING ATari BASIC

Atari BASIC—Learning by Using, by Thomas E. Rowley has been written to provide a supplementary resource for learning BASIC programming on the Atari Personal Computer. Short programs and learning exercises are intended to motivate and stimulate learning of Atari BASIC programming. Hands-on interaction with a computer is essential.



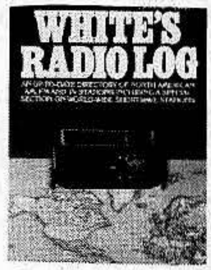
Some of the programs in this book use sophisticated programming techniques while others are written using simple Atari BASIC statements. Many of these programs are appropriate for beginners as well as experienced computer users. It is recommended that the user of this book has an elementary knowledge of BASIC programming and has an Atari Basic Reference Manual available.

Though many of the routines provided will be useful, it is not the intention of the author to provide a book of finished software products. The routines can be adapted as subroutines to other programs or expanded to meet the needs of the programmer. The programs in this book will work properly on either an Atari 800 or an Atari 400 computer. 16K of memory is required for some of the routines.

It is hoped that this book will provide the motivation to grow in the use of BASIC programming on the Atari Personal Computer. Much has been learned in the process of writing it. Distributed by Ing. W. Hofacker GmbH, 53 Redrock Lane, Pomona, CA 91766; $6.95.

BROADCAST LISTENER'S BIBLE

It has been a good many moons since White's Radio Log has been published. And now that it has, pick up your copy soon, for the supply is not large. This all inclusive up-to-date directory of North American AM, FM, and TV stations is the oldest publication of its kind. It started back in 1924



when Charles DeWitt White brought out his first radio log book. Mr. White had it easy in those days. There were only a few stations on the air—about 700 and all were AM types. In the early issues, White listed stations three times, by call sign, frequency and location. This continues till today with the bonus of FM and TV stations making the list. Talking about a bonus, in recent times, world-wide shortwave broadcast station listings were included. Although not complete, the shortwave stations listed were those that could be heard in North America. Thus, in one issue, several hobby groups are provided with a reference work that cannot be purchased anywhere else in one volume so inexpensively. You can obtain your copy by writing to Worldwide Publications, Inc., P.O. Box 5206, North Branch, NJ 08876. The price is $4.95 and include $1.50 for postage and handling.

Hey, look me over

Showcase of New Products

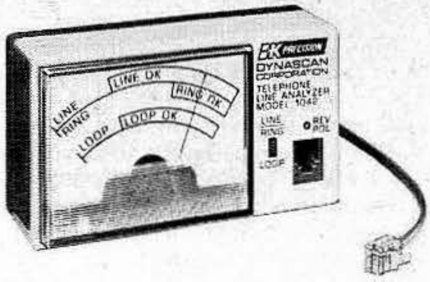
PC CARE PRODUCTS

The Allsop Company has recognized that the storage and printing devices of computers require the same tender loving care as do the delicate components of fine audio and video equipment. To answer the demand for computer maintenance products that meet the same high standards of safety and effectiveness as its fidelity care products, Allsop 3 is putting its label on the top-of-the-line computer maintenance products manufactured by the innovative Computers Products Company.

The Allsop 3 computer accessories line includes head cleaning diskettes in the 5½-inch (Model 10050) and 8-inch (Model 10080) size which can be adapted to either single—or dual-head floppy-disk drives. For computers equipped with Datasette type recording units, Allsop has adapted its highly acclaimed wet system audio cassette cleaner. The Computer Datasette Compatible Cassette Cleaner (Model 10010) is simply loaded into the recording unit and operated like an ordinary cassette tape and features replaceable cleaning felts. Cleaners for daisy-wheel and Selectric type ball printing elements currently complete the line of Allsop 3 Computer maintenance products, although more products, including comprehensive maintenance kits, are planned for the future. For more information write to Jeff Heininger, Allsop, Inc., P.O. Box 23, Bellingham, Washington, 98227.

SAVE COST OF TELEPHONE SERVICE CALL

With the introduction of a low cost Telephone Line Analizer, B&K-Precision has developed an inexpensive alternative to an expensive telephone service call. The B&K-Precision Telephone Line Analyzer, Model 1042, is designed for non-technical users to verify the condition of the telephone line and to isolate a problem to the telephone line or the line. For the customer who is having problems with telephone products, sockets or wiring, the inexpensively priced Model 1042 (suggested retail price: $19.95) could save the cost of a service call—usually more than $30.00



The Model 1042 performs the following functions: Line test—verifies minimum necessary DC voltage on the telephone line; polarity test—determines telephone line polarity; ring test—verifies minimum necessary ring voltage and indicates whether the ring circuit may be defective. Can be used to determine if there are too many phone products on a single line; loop test—verifies condition of the telephone line from central office to user's telephone jack; cord test—tests telephone line cord, from jack to phone imput, for continuity and shorts.

The results of the tests are shown on a large, easy-to-read meter which indicates whether the line, ring, loop or cord are OK without any confusing quantitative measures. Model 1042 requires no external power and no batteries to replace. Complete, easy-to-follow instructions are included with Model 1042.

The Model 1042 and other B&K-Precision test instruments are sold through electronics distributors throughout North America. For more information, write to Martin M. Plude, B&K-Precision, Dynascan Corporation, 6460 West Cortland Street, Chicago, IL 60635.

TIMEX-SINCLAIR COMPATIBLE PRODUCTS

Memotech Corporation has announced four new products for the Timex-Sinclair 1000 and ZX81 computers: A direct connection typewriter quality keyboard, Memocalc, Memotext and Memo Assembler.

Memotech keyboard with interface is a professional, high-quality standard (typewriter) keyboard with Sinclair legends. The keyboard is housed in a well engineered and elegant enclosure. The interface is buffered and housed in a Memopack case, which plugs directly into the back of the Sinclair and does not inhibit the use of further add-on units.

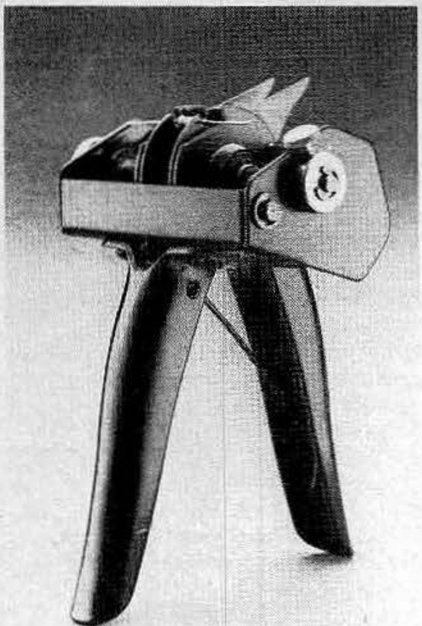
Memocalc is a powerful tool to assist you with reports and financial forecasts. Memocalc, our spreadsheet analysis software, on EPROM, enables TS-100 users to perform complex number crunching routines with ease. With the 64K RAM a table of up to 7000 numbers with up to 250 rows of 99 columns can be specified. Quick revisions can be achieved by entering new data to your formula. Then, by entering the command CALCULATE, the information is reevaluated and displayed. Spreadsheet analysis started as an aid to cash-flow analysis, but this powerful tool has now been generalized and Memocalc with it's special ability to perform interactive calculations is invaluable in the performance of numerical tasks.

Memotext word processor brings commercial standards of text editing to your TS-1000 computer. Text is first arranged in 32 characters lines for the screen with comprehensive editing facilities. On output the user simply chooses the line length for printing and the system does the rest. Used with the Memopack printer interfaces, it makes available output with 80 character lines, upper and lower case, and single and double size characters.

The Memotech keyboard is priced at $99.95, the Memocalc at $49.95, and the Memotext at $49.95 All Memotech products carry a 10-day money back guarantee and a six-month warranty. For additional information on these or other Memotech products, write Memotech Corporation, Customer Services, 7550 West Yale Avenue, Denver, Colorado, 802227.

O.K. INDUSTRIES INTRODUCES NEW LEAD BENDER

The LB-300 from O.K. Industrie Inc. is a useful hand tool for bendin component leads to pre-set dime sions prior to insertion in PC board Pointers on tool accurately set lea distance to match hole-to-ho locations on printed circuit board Setting and bending adjustments are made by simply turning a thumb wheel



to the desired spacing. Lead wires are securely held during forming to prevent lateral stress on component body, and the LB-300 is designed so that components are always positioned centrally, for equal leg length. Featuring rugged all steel construction, the LB-300 will bend 0.016 inch (0,4mm) to 0.055 inch (1,4mm) diameter leads with an easy squeeze of the handle.

The LB-300 is available from stock at local electronics distributors nationwide of directly from O.K. Industries, 3455 Conner Street, Bronx, New York 10475.

H/Z-19 and H/Z-89 GRAPHICS

Health/Zenith H/Z-19 and H/Z-89 users can now have professional quality graphics thanks to the Imaginator Model I-100 from Cleveland Cononics, Inc. Featuring full 504×247 resolution, The Imaginator turns any H/Z-19 terminal or H/Z-89 computer into a powerful graphics display unit without sacrificing any of the standard features which make the H/Z units so popular.

The Imaginator consists of a single, easy-to-install printed-circuit board with its own on-board microcomputer and built-in graphics instruction set. The graphics can be accessed directly from any high level language running in the host, such as PL/1, FORTRAN, BASIC, ETC. Tektronix 4010/4014 emulation is available, featuring a keyboard controlled full screen crosshair graphics cursor for use with GIN mode.

The Imaginator has been engineered to permit easy field installation, and comes complete with extensive documentation. Prices start at only $215.00 for a bare-board and graphics firmware, while the completely assembled and thoroughly tested unit is available for just $445.00. For more information, contact Cleveland Codonics, Inc., P.O.Box 45259, Cleveland, OH 44145; or telephone (216) 327-6405.

300/1200 BAUD AUTO-DIAL MODEM

A new 300/1200 Baud Auto-Dial Modem from U.S. Robotica, Inc. incorporates a significant advance through extraordinary economy in microprocessor design. This simple design achieves a number of sophisticated features while using only about one-sixth the circuitry of other similar modems.

The Auto-Dial 212A automatically dial/answers and transmits at 300 or 1200 baud, operates at full or half duplex (local echo) and contains an audible phone line signal monitoring system. The modem is BE11 103/113/212A compatible and also compatible with Hayes dialing protocol. The Auto Dial's complete self-test system, in conjuction with a system of multiple DIP switches, permits any user to install and adapt the Auto Dial Modem to virtually any computer or terminal without technical experience.

The heart of the Auto Dial is three new microprocessors. These microprocessors compress the entire range of modem functions within just 12 integrated circuits all contained on a single PC board. The radically reduced parts count provides two outstanding benefits for the user. The first is its low cost, the second its exceptional reliability. The suggested list price of the Auto Dial is under $600—as much as $100 less than comparable modems. The reliability and promise of a long, useful life are supported by a two-year limited warranty.

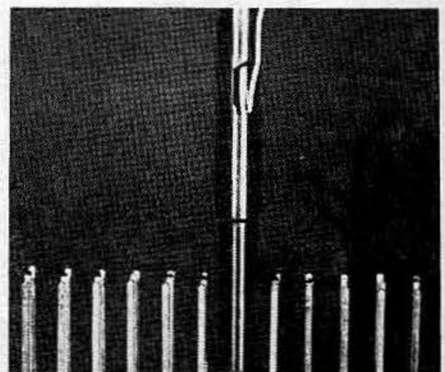
An Auto Link 212A, a companion to the Auto Dial Modem without the automatic dialing system has also been introduced. Both the Auto Link and the Auto Dial are housed in compact, brushed aluminum cases that fit neatly under standard desktop phones. For further information on these new products, or names of local dealers, write or call U.S. Robotics, Inc.,1123 West Washington Boulevard, Chicago, IL 60607; or telephone (312) 733-0497.

NEW ELECTRONIC POWERED WIRE-WRAPPING TOOL

The new OK-10 with its specially designed and reinforced A.B.S. housing is a heavy-duty wire-wrapping tool which is ideal for high volume production applications. Its powerful motor delivers a wrapping speed of 5,000 RPM, high-starting torque and rapid acceleration for optimum performance. Despite its power and rugged construction, the OK-10 is very lightweight (only 14 oz. 400 gm). Available with an optional "back force" device to prevent over-wrapping (designated the OK-10-BF), and a dual speed option for cut, strip and wrap application (designated OK-10-DS).

The OK-10 is compatible with the full line of wire-wrapping bits and sleeves from O.K. Industries and will accommodate wire as large as 18 AWG (1,0 mm) or as small as 32 AWG (0,20 mm).

Very competitively priced and available from local O.K. electronics distributors nationwide. Contact O.K. Industries Inc., 3455 Conner Street, Bronx, New York 10475 for the electronics distributor in your area.



ELECTRONICS HOBBYIST 1984

COMBO AMP

Equalizing levels is a snap with this quick project.

WHEN THE TAPE recorder or public address (P.A.) system is situated away from your microphone, it's inconvenient and a waste of time to go back and forth checking and adjusting volume levels. Unless there's an equipment operator, someone must scramble when the system's level is too high, too low, or if feedback occurs.

But with a Combo-Amp you eliminate all level problems by having a microphone level control and a volume level meter next to you.

If the audience yells for more volume, the gain is easily cranked up. If a P.A. system breaks into howling, the speaker simply turns down the volume.

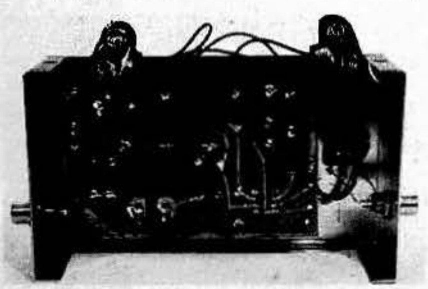
Quite A Combination. The Combo-Amp is a combination microphone preamplifier, line amplifier, and volume level meter. It takes mike level input and provides a line level output of 0.5 volts. An ordinary 0-1 DC mA meter within the feedback loop of the amplifier serves as a volume indicator; a cheaper method than using a VU meter.

A 741 operational amplifier integrated circuit (U1) provides all the gain (approximately 15 dB). U1 is an internally compensated op-amp that's free of self-oscillation. The internal compensation, however, results in a high end that's −3 dB at 12 kHz.

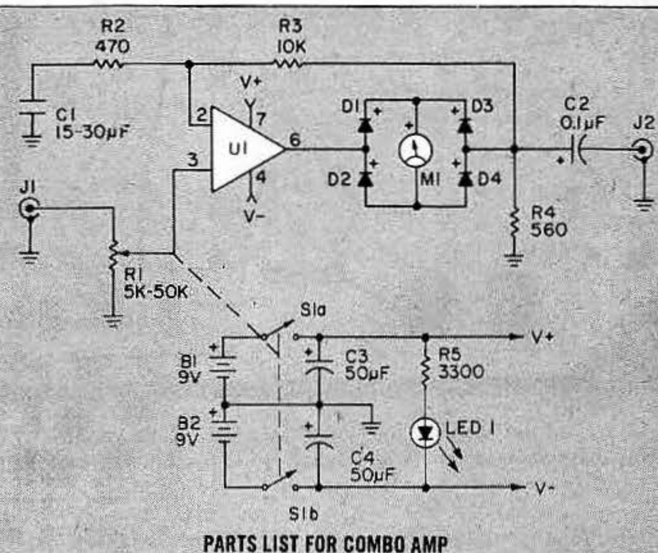
Flat Response. For a flat response to 20 kHz a wideband op-amp requiring compensation is necessary, but they are difficult to find; the 741 is universally available at low cost. The PC board and circuit have been specifically designed for the mini-dip (8-pin) version (available from Radio Shack).

The input impedance is determined by level control R1, which is itself determined by the type of microphone you will be using. For a low impedance (50-600 ohms) mike, a 5000-ohm value is suggested for R1. If you use a high impedance microphone (up to 50,000 ohms), R1 should be a 50,000 ohm resistor.

For a Combo-Amp capable of handling any microphone (other than crystal and/or ceramic), or a line level

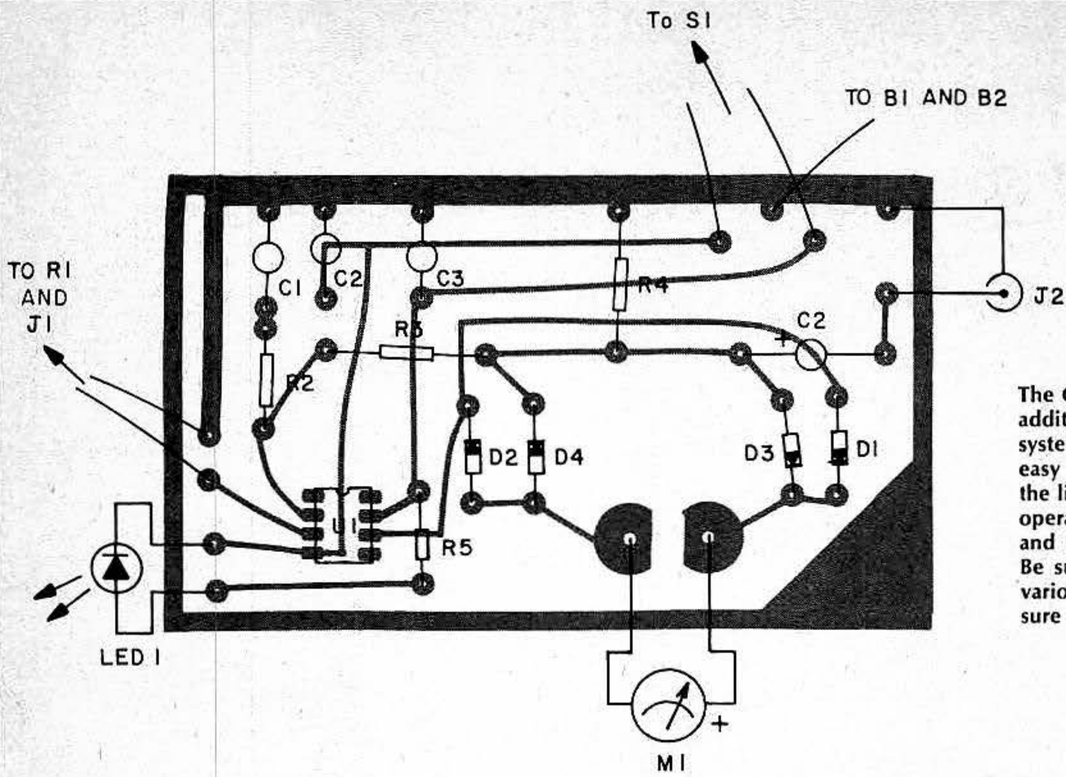


The PC board of the Combo Amp is quite simple. Be careful when soldering. Do not bridge connections with excess solder.

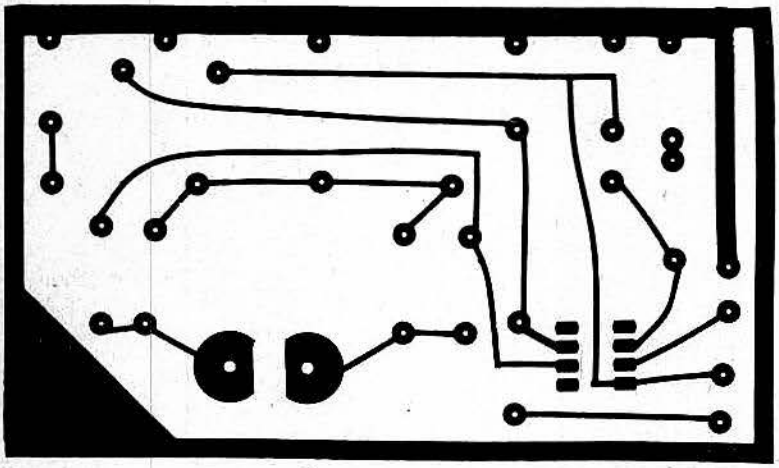


PARTS LIST FOR COMBO AMP

B1, B2—9-volt battery
C1—15 to 30 μF non-polarized capacitor, 10 VDC or higher, see text
C2—0.1 μF Mylar, 10 VDC or higher
C3, C4—100 μF electrolytic capacitor, 15 VDC or higher
D1, D2, D3, D4—Germanium diode, type 1N60
J1, J2—Jacks to match existing equipment
LED1—Light emitting diode
M1—Meter, 0-1 mA
R1—5,000 or 50,000-ohm audio tape potentiometer, see text
(Resistors, ¼ watt, 10% unless otherwise noted)
R2—470-ohm resistor
R3—10,000-ohm resistor
R4—470 or 560-ohm resistor
R5—3300-ohm resistor
S1—Switch, DPST, part of R1
U1—Operational amplifier type 741 integrated circuit
Misc.—Cabinet, battery terminals, wire, solder, hardware, etc.



The Combo Amp is an excellent addition to any recording or PA system. The PC board allows easy soldering. When installing the light emitting diode, the 741 operational amplifier, the meter and the diodes, check polarity. Be sure to cut the leads of the various components short to insure snug fit next to PC board.



If you don't have the tools or the ability to etch out the printed circuit board, you may want to try to wire wrap your project. It's easy to do.

device, use 50,000 ohms for R1. Using a lower value for R1 for low impedance mikes doesn't affect the sound quality all that much but it does reduce the possibility of noise and hum pickup in long microphone lines.

The output level is indicated by a milliammeter. The PC board is designed to fit directly on the terminals of the Radio Shack meter. If your meter has different connections, you must modify the PC template accordingly or use the PC assembly external from the meter. One corner of the PC board has a triangular copper foil that can be drilled to secure a mounting foot.

Diodes Are Critical. The only critical parts of the circuit are diodes D1 through D4. They must be the germanium 1N60 type. Do not substitute silicon diodes as their higher breakover voltage will result in excessive distortion to the output signal.

The PC board is designed to fit an aluminum cabinet approximately 3 x 2⅛ x 5¼ inches. If you want to substitute a different meter or a larger cabinet modify the PC template.

Provision is made on the PC board (R5) for an LED power indicator that draws little battery current (about 6 mA). Eliminate R5 if you don't want a power indicator.

Because the holes for the meter terminals must be 3⁄16 inches large, solder pads are used for the PC connections. Don't hope to use standard component circles and drill-thru with precision; it probably won't work. Make the pads at least ⅜ inch.

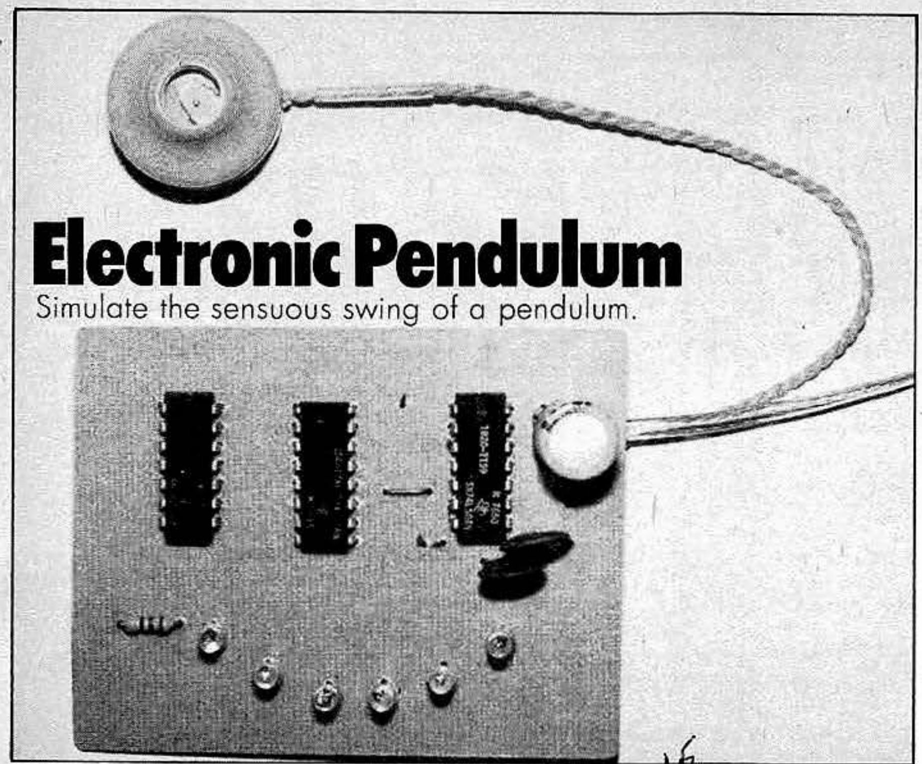
There is a boss on the back of the meter that will prevent the PC board from fitting flat on the back of the meter unless the board is drilled to accommodate the boss.

Keep Them Straight. Install all PC components except the meter connections before plugging in U1. If you use a mini-dip U1, just plug it in. If you get a can (T0-5) type 741 install it in the following manner: Using long nose pliers fold out leads one through four so they form a straight line. Cut the leads about ⅝ inch from the body of U1 so they are straight across the bottom. Do the same for leads four through eight.

(Continued on page 95)

Electronic Pendulum

Simulate the sensuous swing of a pendulum.



3015

EVERYONE LIKES THE GRACEFUL SWING of a grandfather clock's pendulum. The motion and tick-tock sound are pleasing to the senses and reinforce the idea that the clock is working. Here is a quick and easy project which duplicates the motion of a pendulum electronically and if desired, the sound as well. Parts cost should run about $4-5 and if you use the PC layout in this article construction time will be a couple of hours.

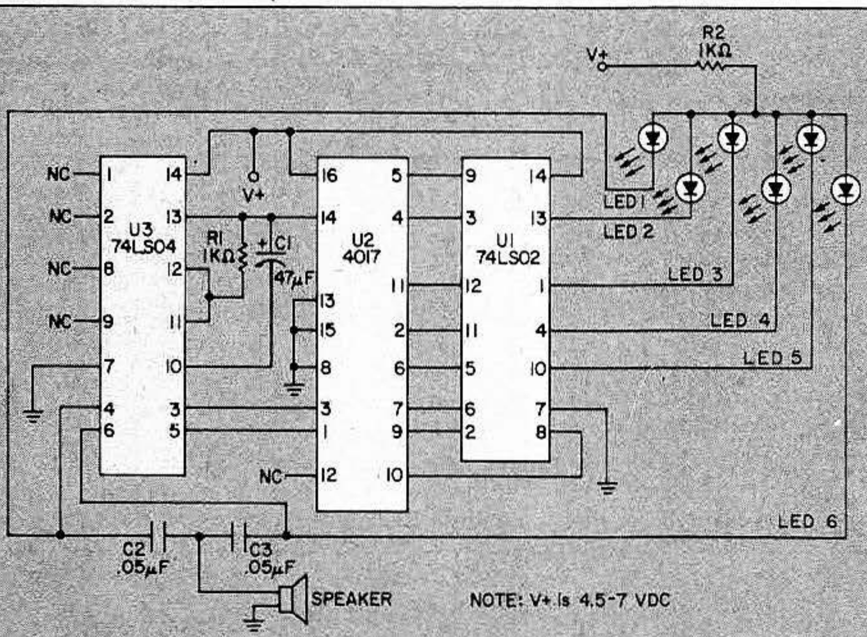
The Circuit. The pendulum operates by having an LSTTL oscillator drive a CMOS 4017 decade counter with decoded outputs. The CMOS chip has ten output lines, 0 through 9, each in turn going "high" after a clock pulse appears on pin 14. Now if you took those outputs and used them directly to light LEDs the result would be a series of bulbs illuminating in sequence 0 to 9 and then going back to 0. But a pendulum doesn't work like that, it swings to the right then to the left. Its electronic counterpart would retrace its path something like 0, 1, 2, 3, 4, 5, then 5, 4, 3, 2, 1, 0, 1, . . . One could use an up-down counter, changing its direction at each end of the count to achieve the above pattern, but there is a simpler way to approximate a pendulum's motion for the hobbyist.

Let's use six bulbs, labelling them A to F. Remember, the counter chip has ten output lines. If we allow some of the lamps to be lit by two outputs instead of just one, we can get oscillatory motion for free, so to speak. Let's see how. Look at Fig. 1. If we let bulb A be turned on by output line 0, bulb B by output 1 or 9, C by 2 or 8, D by 3 or 7, E by 4 or 6, and F by output line 5, the desired result is produced. You can see this easily if you count from 0 to 9 and repeat this modulo ten (base ten) sequence over and over using Fig. 1 for your guide.

Be sure to notice that L1 is inserted in its PC board holes the reverse of the since the LEDs are activated by a "low" or ground signal. Also note that pins 15 and 13 of the 4017 must be at 0 volts for the CMOS chip to count.

Construction: The two boards on the other page show the respective orientation of the parts. C2, C3 and S are optional, depending on an audible click with the pendulum swing. This circuit can also easily b wire-wrapped, beginners may wish do this since the PC layout is somewl tight and could be difficult for you reproduce easily.

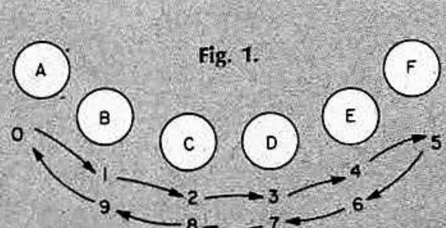
The schematic shows how this is don. Note the use of the circuit's NOR gates other LEDs. Failure to invert it will not harm anything, but it won't light. Sound output for the unit is provided



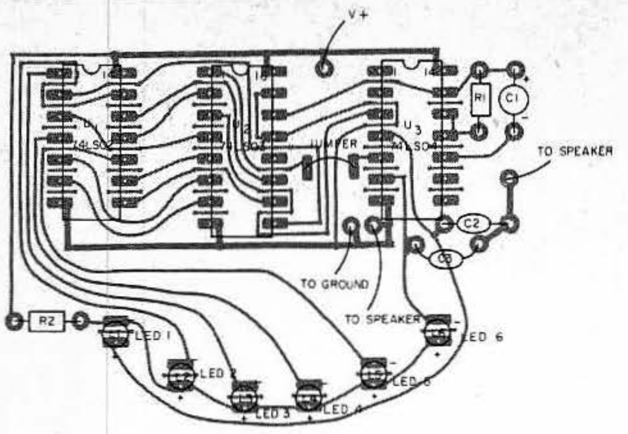
PARTS LIST FOR ELECTRONIC PENDULUM

LED 1–6—light emitting diode, red
R1, 2—resistor, 1,000 ohms, ¼ watt, 10%
S—crystal earphone
U1—74LS02, quad NOR gate
U2—4017, CMOS counter
U3—75LS04, hex inverter
Misc.—jumper wire, PC board, solder

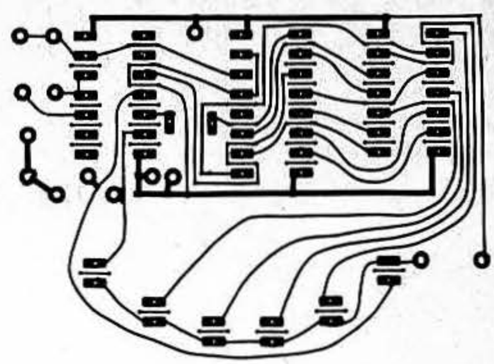
Fig. 1.



As you see, Electronic Pendulum's circuit is simple and straightforward. Just beware of solder bridges. Note the sequence of firing for the six light emitting diodes.



Six LEDs are the center of the Electronic Pendulum. Watch polarity when you install them otherwise you could ruin hours of hard work.



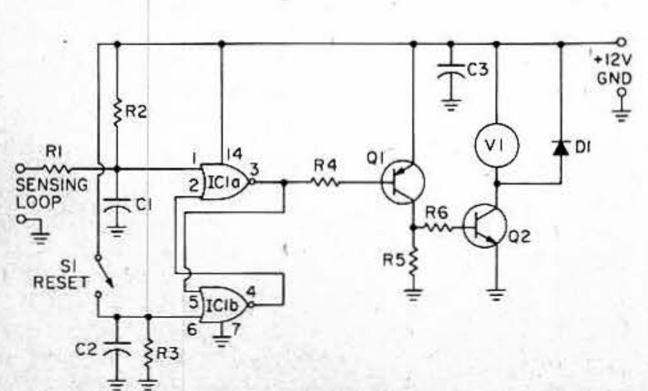
A small printed circuit board, such as the one given for Electronic Pendulum requires good soldering skills. Try to be careful.

by a crystal earphone fed by LED1 and LED6. This arrangement gives plenty of noise in a quiet room, but if desired, more volume can be obtained using an audio amp like the LM386. You will have to experiment with the circuit components to get the proper loudness.

Operation: Simply connect power and ground and Electronic Pendulum should start up. It should be easy to add this project to an existing clock or incorporate it into a new design. Voltage to the board should not exceed 7 V, as the 74LS chips will fail, but V+ can dip to about 4.5 V if you don't mind dim lamps. The circuit draws less than 10 mA so drain from existing supplies will be minimal. Adding a red plastic filter in front of the lamps will improve the illusion of oscillatory pendulum motion. ■

Burglar Alarm

☐ This burglar alarm circuit uses one integrated circuit and operates from a 6 volt battery. It is activated upon the breaking of a circuit. Since the sensing loop operates in a high impedance circuit, there is virtually no limit to the length of wire you can use. You can protect every window and door in your house. Practical operation by using four D cells for power is accomplished through the use of a four-section CMOS integrated circuit which draws only a few microamperes from the battery. Thus, battery life will be equivalent to its shelf life unless the alarm is activated. The heart of the circuit is a pair of NOR gates connected in a bistable configuration called a flip-flop or latch circuit. When the circuit is in standby, pin 1 of IC1 is held to almost zero volts by the continuous loop of sensing wire. This causes pin 3 to assume a voltage of 6 volts, cutting off Q1 and Q2. When the sensing circuit is broken, C1 charges to battery voltage through R2. This causes the latch circuit to change state and pin 3 goes to zero volts. B1 becomes forward-biased through R4 and turns on Q2 which operates the buzzer. The circuit will remain in an activated state once the alarm is set off, even though the broken circuit is restored. A reset switch has been provided to return the latch circuit to its original state and shut off the alarm.



PARTS LIST FOR HOME BURGLAR ALARM

C1—0.1-uF ceramic capacitor, 15 VDC
C2—0.1-uF ceramic capacitor, 15 VDC
C3—0.47-uF ceramic capacitor, 15 VDC
D1—1N4148 diode
IC1—4001 quad NOR gate
Q1—2N4403
Q2—2N4401
R1, R3—100,000-ohm, ½-watt resistor
R2—4,700,000-ohm, ½-watt resistor
R4, R5—10,000-ohm, ½-watt resistor
R6—100-ohm, ½-watt resistor
S1—SPST momentary-contact pushbutton switch
V1—6 VDC buzzer

Convert your AM/FM pocket radio into an aircraft scanner

Monitor the skies with this simple receiver conversion

"DELTA FLIGHT 759 TO KNOXVILLE TOWER . . . what is your local weather? We're experiencing a lot of turbulence."

"Cessna 616 to Miami Center . . . we've spotted what looks like a boat in trouble. Would you notify the Coast Guard?"

The VHF band is filled with intriguing listening. Private aircraft, commercial airliners, military and government flights fill the skies 24 hours a day, seven days a week. Many scanner listeners are discovering the fun and excitement of tuning in on aircraft in flight.

But aircraft scanners are expensive; even pocket aircraft radios command premium prices. There is another way.

Any inexpensive pocket AM/FM portable radio may be converted into an effective aircraft band monitor. The receiver's AM band will remain untouched, so that you will still be able to listen to your favorite local broadcast stations. While the changes to the FM band will allow aircraft band reception, the procedure may be easily reversed to restore the set to FM band reception if desired.

Absolutely any AM/FM portable, even the larger multiband radios, may be converted. Our illustrations happen to use the Radio Shack 12-609. You may wish to check local discount houses for advertised specials on similar radios; flea markets and garage sales are also excellent sources of pocketable AM/FM radios. These are frequently found for $5 to $10.

The Conversion. Before beginning the changeover process, it is a good idea to check the radio completely to determine that it is in good working order. Use a fresh battery and tune it through its FM range to be sure that it is functional, sensitive, and that its audio is loud and clear.

Next, remove the back carefully and locate the IF transformers, as shown in Fig. 1. Some of the IF transformers are used for AM and some for FM. It is virtually impossible to predict accurately which are which without a diagram. Fortunately, only one of them is of interest to us for this conversion project: the FM discriminator transformer; and it is easily located.

If you examine the parts layout of your radio carefully, you will note that one of the IF transformers, probably the one farthest removed from the tuning capacitor, will have two or three glass diodes alongside it (see Fig. 2). That is the discriminator transformer; the diodes are the detectors which extract audio from the IF circuitry. Switch the radio on and adjust it to receive the background hiss between FM stations.

Using an appropriate non-metallic fiber, wood or plastic tool, adjust the slug slightly until the background hiss peaks to a maximum. You have now converted the radio to receive AM! This step was necessary because *all* VHF aircraft transmissions are AM.

The next step is to increase the tuning range to receive the 108-136 MHz aircraft band. Since the receiver already tunes 88-108 MHz, we are nearly there!

Changing Frequency. Inspect the circuit board and locate two open-wound coils each consisting of four or so turns and positioned next to the tuning c pacitor shown in Fig 3. Tune in an F broadcast station (it will proba sound distorted now) and touch ea coil lightly with your finger. When y touch one of them, the station will detuned off-frequency; this is the osci lator coil. The remaining coil is in the RF amplifier circuit. Both coils will be altered to change the receiver's tuning range. To raise the frequency of the circuit we need to decrease the inductance of the associated coils.

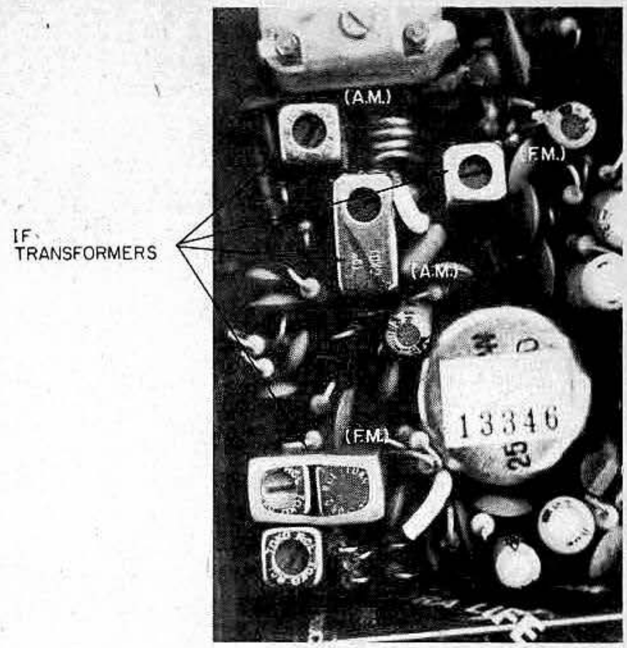
There are several ways to decrease the inductance of a coil: spread the turns father apart; pinch each turn to flatten it slightly; twist the turns at right angles to each other; insert a brass slug inside the windings; remove one or more of the turns; short-circuit two adjacent turns with solder.

The first step in changing the tuning range of your radio will be to spread the turns of the oscillator coil widely apart with a small screwdriver. Be sure to spread them evenly and do not allow the coil to touch any adjacent metal part or wiring. Spread the turns of the RF coil similarly.

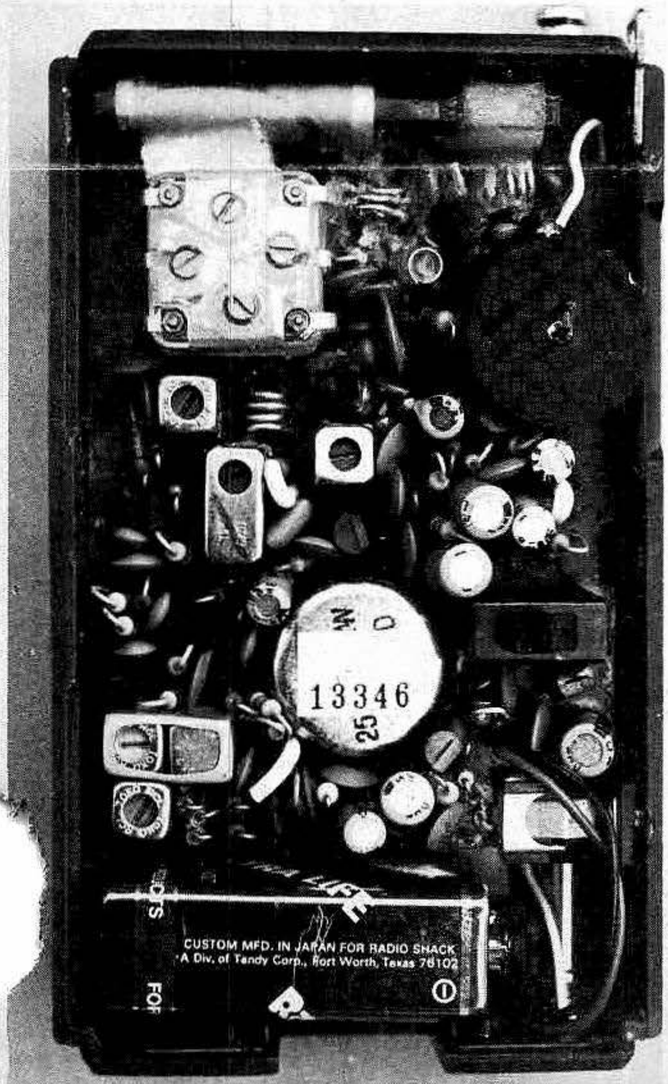
Now attempt to tune through the range of the dial, noting the locations of the FM broadcast signals. Chances are you'll find them cutting off below

(Continued on page 95)

Fig. 1. The IF transformers are shown in this photo. Since it is virtually impossible to tell which are for AM and which are for FM, a process of trial and error will be employed in retuning the frequency.



The open radio gives an idea of the overall parts placement. It is important to work methodically, going from one area of the conversion to the next in the right order. You will find most layouts similar.



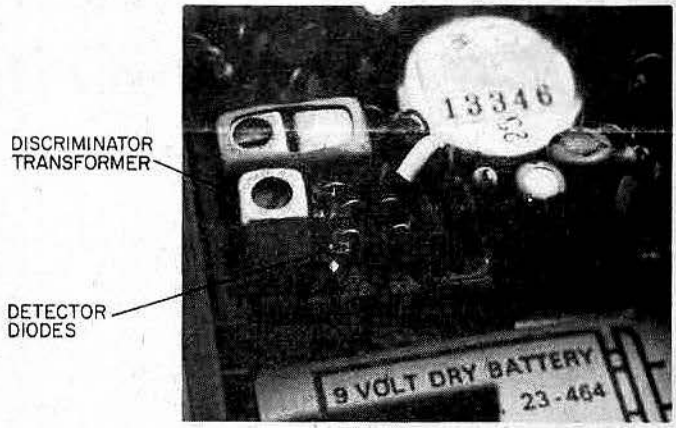


Fig. 2. The discriminator transformer, shown here, has several glass diodes beside it. These take audio from the IF stage.

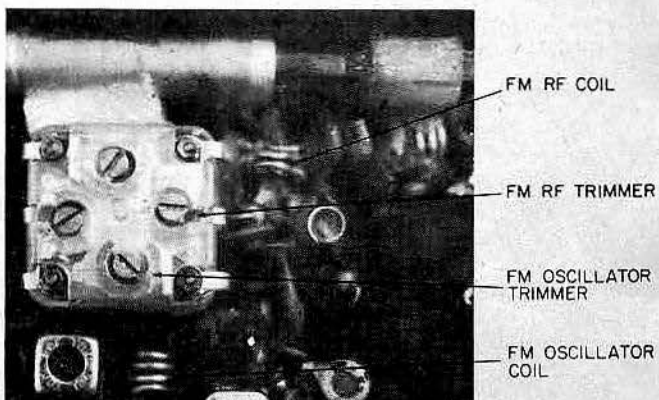
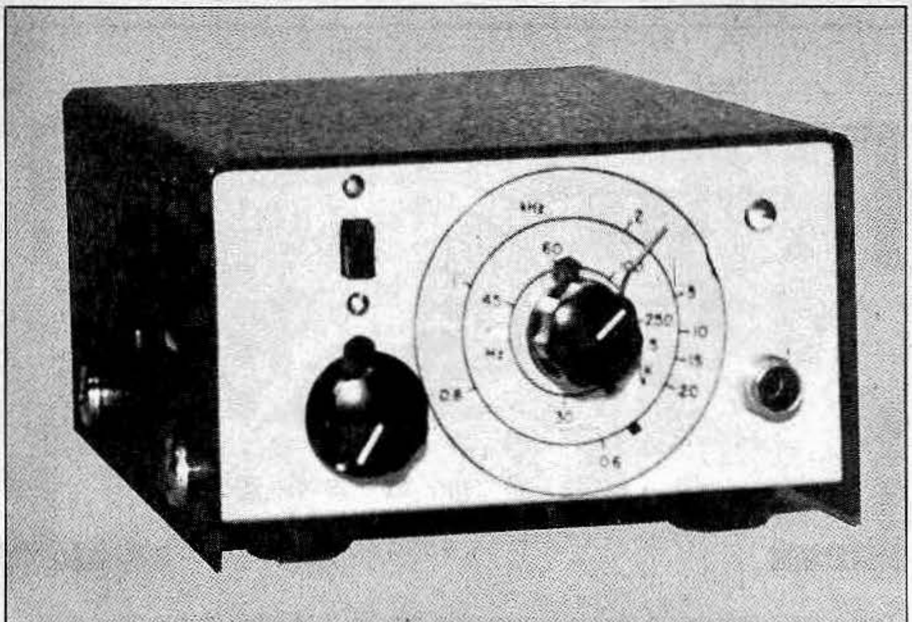


Fig. 3. The two open wound coils located next to the tuning capacitor must have their inductance raised to raise the frequency.



OSCAR, The Audio Freak

A handy audio oscillator for the electronics hobbyist

There's nothing quite as useful as an audio oscillator for testing defective audio or amplifier circuits. An audible signal, or the lack thereof, is proof positive as to whether or not a circuit is behaving as it should. Unfortunately, a good, stable variable oscillator can run into hundreds of dollars—far more than all but the wealthiest hobbyist can afford to spend.

Oscar is an inexpensive, easy-to-build oscillator with a frequency range from 30-Hz all the way up to 25-kHz and an almost flat response over the whole range. It uses a unique circuit: a Wien network with a photocell and 1.5-volt bulb coupled to maintain frequency stability. A compact unit (ours fits easily into a 5¾-inch by 4-inch by 2-inch box) Oscar will drive into a low impedance load, and is powered by a 9-volt transistor radio battery. Those parts that you don't have in your junk box can be found at the local Radio Shack or other well-stocked electronics supply house convenient to you.

Easy Assembly. Assembling Oscar is quite simple. All of the components—except for the variable potentiometers R2a, R2b and R3, the switch, LED and 9-volt battery—are mounted on an etched PC board. Our Oscar is rather fancy, mounted in a two-toned enameled aluminum box with vents and rubber feet, but any Bud or other box of approximately 6-inch by 4-inch by 2-inch dimensions will serve as a housing.

Oscar's heart is a Radio Shack LM386 low-voltage audio amplifier, an IC "bug" giving 20dB of gain without external components. Amplifier output feeds directly into a Wien network which determines the output frequency. From there the signal is fed back into the positive input of the amplifier.

The 150-kohm resistor (R6) is series with the input serves two purposes: it reduces the signal from the Wien network to the amplifier input to a satisfactory level. And, together with the input impedance to the amplifier, it provides an impedance which doesn't affect the audio frequency determined by the Wien network components. The oscillator's frequency is varied by changing the setting of the ganged potentiometers R2a, R2b.

The 5,000-ohm switched variable potentiometer serves as an ON-OFF switch in the circuit and volume adjustment control.

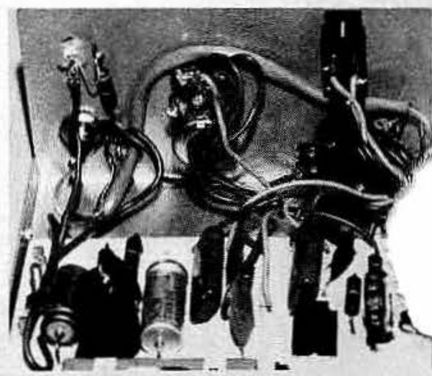
Thus far we have listed the components for a pretty straightforward amplifier circuit. The following components—a photocell (R4), 1.5-volt bulb (L1) and a 100,000-ohm preset linear potentiometer are what make for Oscar's uniqueness.

Circuit Theory. The photocell (R4) is a Radio Shack RS 276-116 or equivalent, with a 5-megohm to 100-ohm resistance range. It will be coupled to a Radio Shack 1.5-volt at 15ma. miniature bulb. The theory behind this circuit is that the light output of a bulb filament varies proportionately to applied voltage. The light output from this bulb is closely coupled to the photocell, the resistance of which varies in proportion to the light shining on it. This circuit ensures that, with proper setting of R1, the output of the oscillator is held constant over its entire frequency range, despite frequency gain variations in either the amplifier or Wien network.

The capacitor C5 blocks DC from getting to the photocell, and C6 blocks DC from the output. The LED lets you know that the oscillator is running.

The thermal time constant of the bulb filament is sufficient to prevent the light output from "following" the waveform output, except at the lowest frequencies. And, if R1 is carefully set, the circuit will be stable even at the lowest frequencies.

Make it Light-Tight. The only tricky spot in assembing Oscar is making the bulb/photocell unit. While the sketch should make this procedure clear, there are several points worth stressing. One—the most important—is that the unit must be absolutely light-tight when assembled. The fit between the bulb base and sealing grommet, and of the heat-shrinkable tubing over the entire assembly, is critical. Also, the tip of the bulb should just clear the surface of the photocell. The whole assembly then mounts on the PC board, supported on the photocell leads.



This photo shows the soldering connections at the rear of OSCAR's front cabinet panel.

OSCAR

While there are very few components on the PC board, it is necessary to pay close attention to the mounting and placement of these. Make sure that the polarities of the electrolytic capacitors are correct and that the amplifier IC "bug" is the right way around.

The PC board itself should be raised ½-inch or so above the bottom of the housing to prevent the soldered joints from shorting. This can be done by drilling two pieces of squared-off plastic to pass the shafts of the bolts attaching the PC board to the housing.

The frequency adjusting potentiometers R2a, R2b should be wired so that rotating the shafts clockwise REDUCES the resistance in the circuit. Reducing the resistance causes the oscillator frequency to rise in accordance with the formula:

$$f = \frac{1}{2\pi RC}$$

where $R = R2 + R3$ and $C = C1$ or $C2$, as selected by the range switch S1.

Turning it on. At this point Oscar is just about ready to be buttoned up and turned on. The final step is turning the center rotor of R1 all the way to ground. Now connect the battery, put the top cover on, attach a pair of 1000-ohm or greater headphones and turn Oscar on.

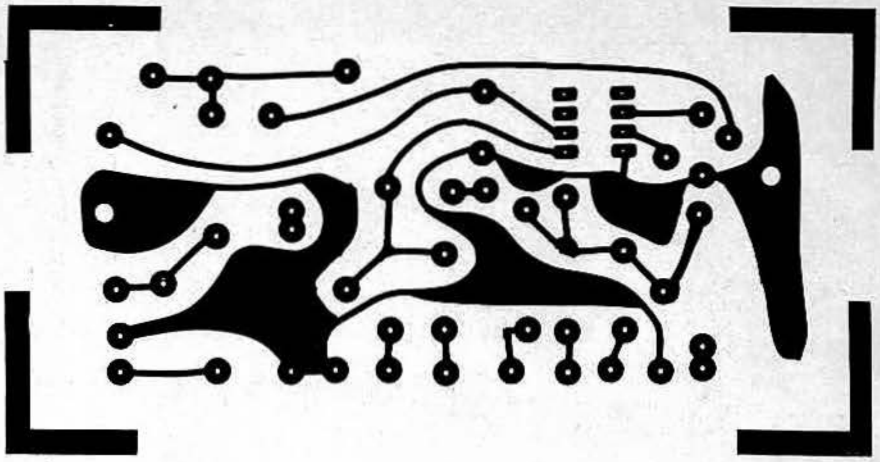
With S1 on the upper frequency range, turn the ganged pots R2a, R2b all the way counterclockwise for maximum resistance in the circuit. A sound—a distorted 600-Hz—should be heard in the headphones.

Let Oscar run for a minute or so to condition the photocell to the light. Now adjust R1 until the distortion just disappears. An oscilloscope makes this easier: adjust R1 for an output waveform that is just short of clipping.

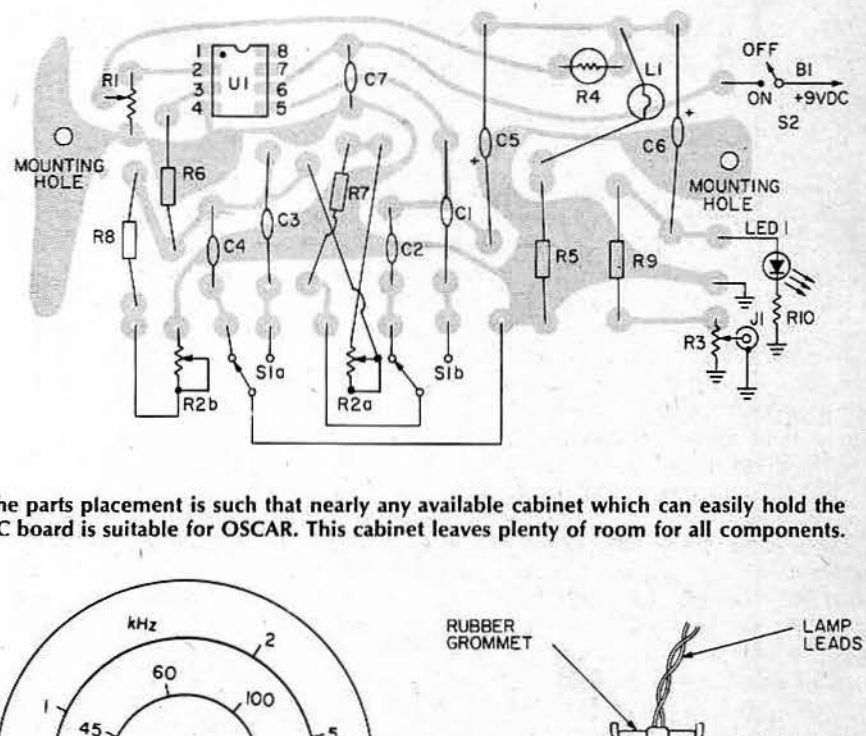
To make life easier for yourself, remember to drill a ¼-inch hole in the oscillator housing opposite the center rotor of R1 to allow a screwdriver blade access for adjustments.

Vary the output frequency by turn-g the ganged potentiometers R2a, . Turn to the upper end of the fre-y range—25-kHz, well beyond hearing range—and allow a few ds for the oscillator to stabilize . Turn back to the audible signal e to make sure that the circuit is ill oscillating. If it's not, turn R1 carefully towards ground until the oscillation starts up again.

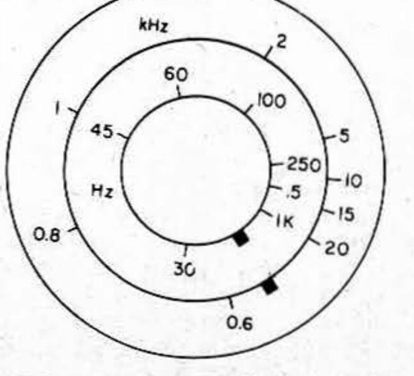
Now that the upper frequency range is adjusted, switch to the lower range.



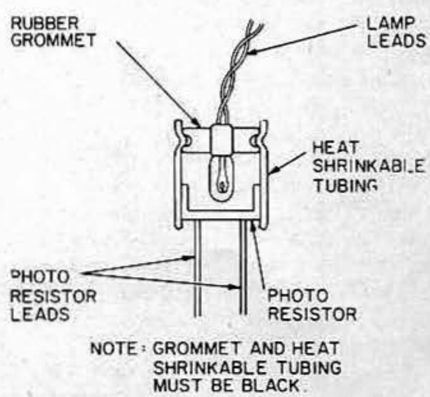
This is the circuit board template, appearing here in its exact size. For those who feel that their skills are not up to board etching, there is a complete kit listed below.



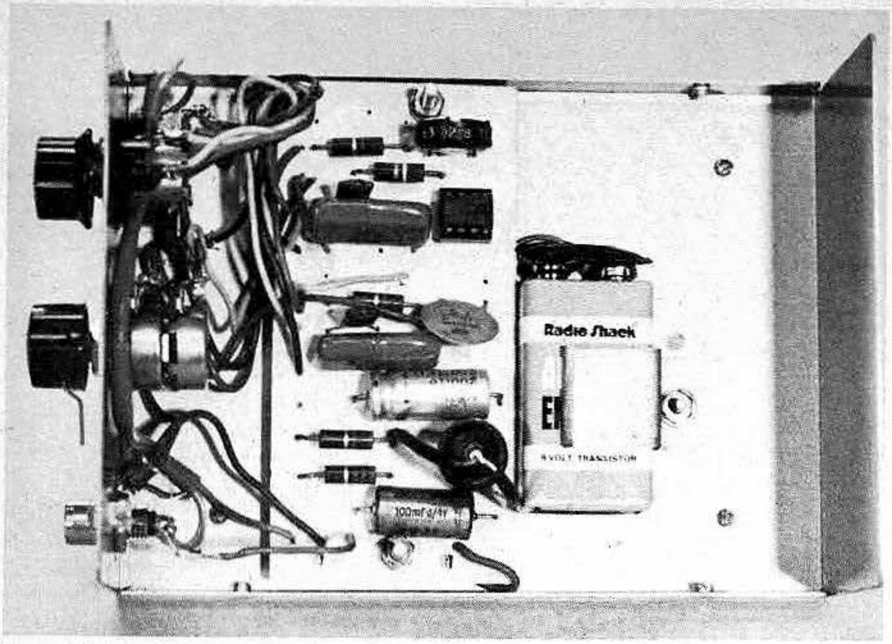
The parts placement is such that nearly any available cabinet which can easily hold the PC board is suitable for OSCAR. This cabinet leaves plenty of room for all components.



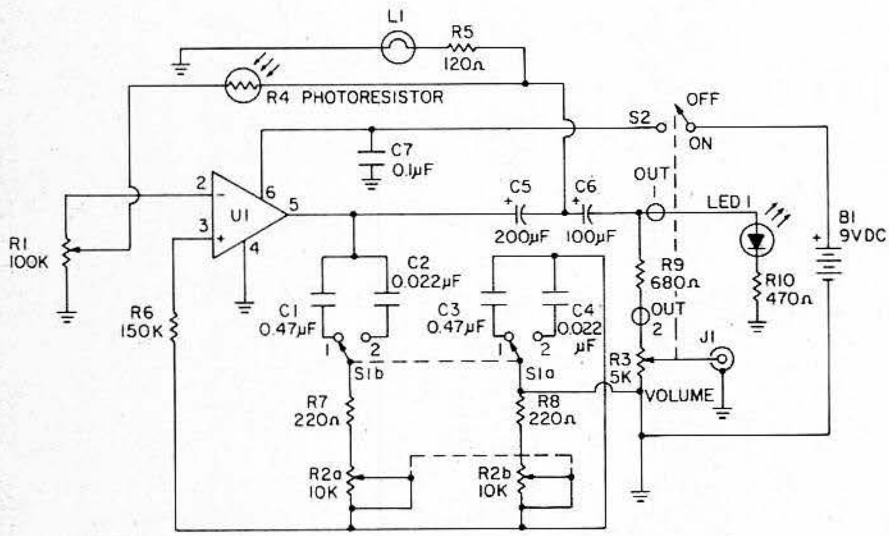
Trace this exact size oscillator range diagram or cut it out and use on the face of the oscillator. It is calibrated exactly for the dual frequency ranges available.



It is very important that the photocell and bulb tandem arrangement be light free.



This foil side down parts overlay shows the exact placement of all the components on the circuit board. Care is required in soldering and placing components with precision.



PARTS LIST FOR OSCAR

B1—9-volt transistor radio battery
C1, C3—0.47-uF, 50-VDC capacitor
C2, C4—0.022-uF, 50-VDC capacitor
C5—200-uF, 16-VDC electrolytic capacitor
C6—100-uF, 4-VDC electrolytic capacitor
C7—0.1-uF ceramic capacitor
J1—Shielded phono jack (Radio Shack 274-346 or equivalent)
L1—Miniature bulb, 1.5-volt 15-mA
LED1—Small red Light Emitting Diode
R1—100,000-ohm linear preset potentiometer for PC board mounting
R2a, R2b—10,000-ohm linear ganged potentiometers
R3/S2—5,000-ohm linear potentiometer with ON-OFF switch
R4—Photoresistor, 5-megohm to 100-ohm range (Radio Shack 276-116 or equiv.)
R5—120-ohm, ¼-watt resistor
R6—150,000-ohm ¼-watt resistor
R7, R8—220-ohm, ¼-watt resistor
R9—680-ohm, ¼-watt resistor
R10—470-ohm, ¼-watt resistor
S1—DPDT slide switch
U1—LM 386 Op amp Integrated Circuit (Radio Shack 276-1731 or equiv.)

MISC.—Box, PC board, 2 1-inch roundhead machine screws with nuts and washers, IC socket (8-pin), 9-volt battery clips, wire, knobs, sheet metal screws and assorted hardware as needed.

For information on the availability of parts and other materials to build OSCAR, send a stamped, self-addressed envelope to Niccum Electronics, Route 3, Box 271B, Stroud, OK 74079.

At the bottom end, about 30-Hz, the frequency amplitude may vary at a very slow rate. If that is the case, give the circuit a little more negative amplitude by turning R1 up slightly from ground. Some experimentation with R1 settings should yield a compromise position giving the best overall performance for both frequency ranges. When this is attained, the oscillator output should be constant within ±1dB over the whole frequency range.

Troubleshooting Oscar. If this output stability cannot be achieved, the ganged potentiometer R2a, R2b is probably at fault. The cheaper varieties track poorly; some may have worse than a 50% difference between the tracks in places. Before throwing out the old one and replacing it, try swapping the R2a and R2b leads around to see if this improves performance.

If the output frequency response is still unsatisfactory, change the 120,000-ohm resistor (R5) in series with the bulb one value up or down. Readjust R1 as before.

While you were making all those adjustments in the lower frequency range the LED should have been winking away at you. This indicates that the oscillator is running and that it has stabilized after a frequency change. You will notice that, in the upper range, the LED stays on steadily. This is because the human eye can't assimilate light oscillations above a certain frequency, so the high-speed flashings appear as a steady light.

Oscar is somewhat sensitive to variations in voltage, especially to low voltage. Serious clipping will result if the voltage drops below eight volts, but the oscillator will operate at up to 14 volts with only an adjustment of R1. If left with the power off for long periods of time, the R1 setting will probably have to be adjusted.

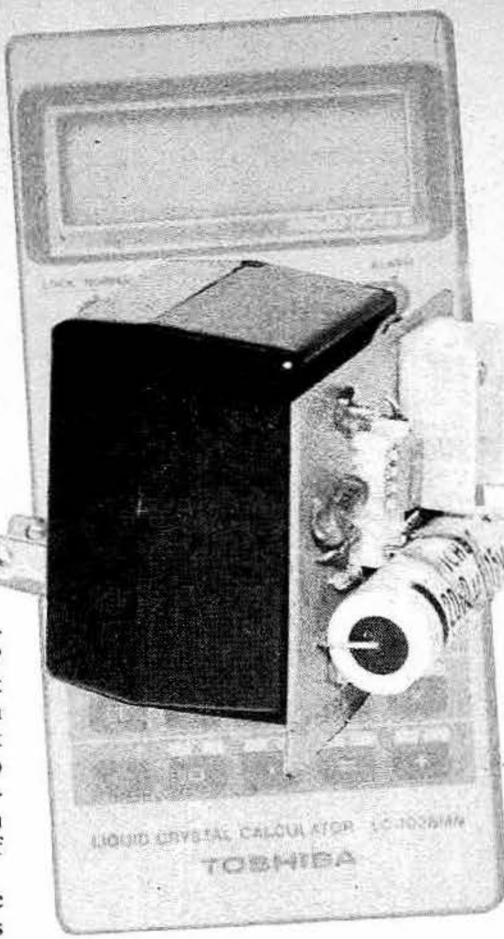
Oscar is a handy piece of test equipment well within the budget and building capabilities of any electronics hobbyist. It's a natural for shooting a signal into misbehaving audio or amplifier circuits: just attach a probe or even two leads to the output jack and you're ready to delve into the innards of recalcitrant circuits.

Other possible—and somewhat more farfetched—uses for Oscar are: as a audiometer, offering the bored hob[illegible] a hearing test at the bench; or, h[illegible] to a high-powered amplifier and s[illegible] er, as a device to scare crows of[illegible] backyard garden patch.

Usefulness, low cost and ease of [illegible]sembly makes Oscar both an interesting project and a welcome addition to any hobbyist's workbench. ■

Calculator Power Supply

Build this handy, multi-voltage power source for your calculator



WHEN WAS THE LAST TIME the batteries in your calculator went dead? Perhaps the night before an important school assignment was due. Or when you were balancing your bank account and found out that you would have to do all of the calculations on paper-again! Such heartbreaking events can be frustrating, and take up much of your valuable time.

Of course, we can do arithmetic manually or in our heads, but it is faster and easier to use a calculator. As one can see, if the batteries are dead and no external power supply is available, the calculator is of no value. This is why the inexpensive power supply described here will be useful.

Batteries are not cheap. It costs roughly one dollar for two AA batteries, or for one 9 volt transistor battery. Supplying approximately 0.3 watts of power, a battery will last for about five hours. This amounts to about one third of a cent per minute to operate. What about cost per year? Here is an example: Say that someone uses his calculator five minutes per day on the average for an entire year. Calculating the battery cost over a year, we discover that we have spent over $6 for batteries. Six dollars could buy another calculator or pay for part (or all) of the power supply. The cost of batteries may seem trivial, but by eliminating the need for batteries, money is saved.

The power supply described in this article, will save money, and it can be used to power other devices. Cost of the power supply will run from five to fifteen dollars depending on cost and availability of parts. In fact, the calculator supply could be made completely from parts found in your junk box!

Ratings. The design of the power supply is flexible. You can change the design to fit your needs more fully; for example, different voltage outputs, current, regulation, etc. The prototype has the following ratings:

1. 3 volt regulated output
2. 9 volt regulated output (via Jumper 1)
3. Maximum current output of 150mA
4. Uses a transformer, from an adaptor, that has this approximate rating: 12 volt @ 200mA

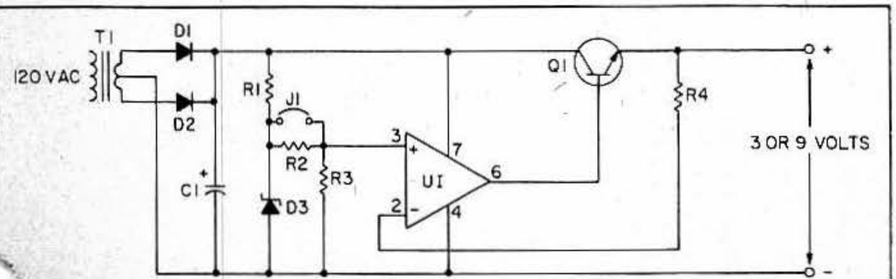
As mentioned before, you can alter these ratings to fit your needs. The phototype will regulate to at least ten percent or better. Its zener diode has a zener break down of about 9 volts.

Before building your power supply, define what it's going to be used for; i.e., the calculators voltage and ampere ratings. Another good question; is the transformer available, at reasonable cost. Once these questions are answered, it is time to proceed to the design and construction of your power supply.

Theory. Basically this power supply is a simple voltage regulator with a filtered and rectified input of about twelve volts. The block diagram in Fig. 1, gives a clear picture of how the circuits interact.

The transformer that will be used, should have a voltage rating of at least three to four volts higher than the regulated output voltage. The voltage output of the transformer is dependent on the load current. If the transformer has a high output current rating, the output voltage will be higher. Remember, ripple may play a part in how you choose your transformer. The current rating of the transformer should be at least fif-

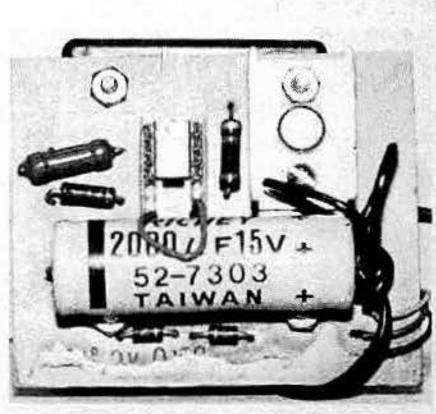
(Continued on page 95)



PARTS LIST FOR CALCULATOR POWER SUPPLY

C1—2,000uF capacitor
D1, D2—1N4001 diode rectifiers
D3—9-volt zener diode
Q1—NPN 2N1893 or similar
R1—200-ohm resistor
R2—43,000-ohm resistor
R3—25,000-ohm resistor
R4—10,000-ohm resistor
T1—12-volt center tapped transformer, 200mA
UI—741 Op Amp IC

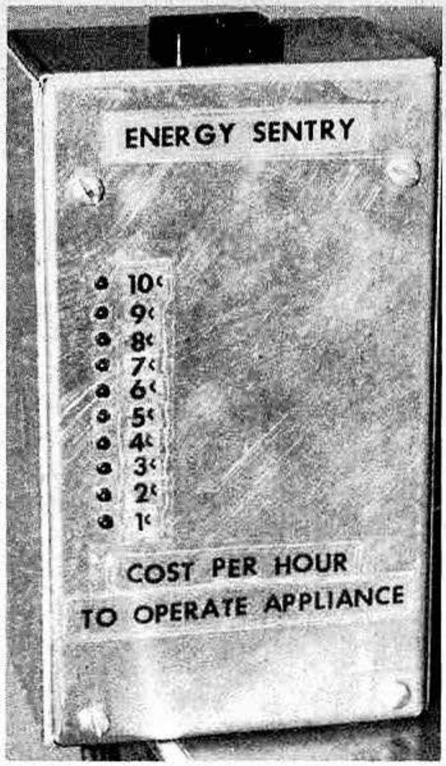
Misc.—22-gauge wire, adaptor case, IC socket, 4-40 machine screws and nuts, heat sink and P.C. board.



The Calculator Power Supply is designed so that the circuitry can be mounted flexibly.

ENERGY SENTRY

Monitor your power consumption to save energy and reduce your electric bill



IF YOU PAY the electric bill, you know only too well what has happened to that bill over the past few years. In addition, you have been bombarded through radio, television, newspapers, and magazines on how important it is to conserve energy, wherever possible. Part of energy conservation includes the electricity used in your home. With the help of Energy Sentry you can determine just how much it is costing you to operate that appliance or T.V. set. This will help you to minimize your electric bill, while saving precious fuel.

Energy Sentry is an easy to construct circuit; built in a small enclosure, with a built-in receptacle into which the appliance is plugged. Ten separate LED's provides an indication of the power consumption of the appliance. Energy Sentry is calibrated in "cents per hour" over a range of 1 to 10 cents. Depending upon your electric rate, this will provide a useable power range of up to 1500 watts. This is near the maximum power which can be delivered by an ordinary 115 volt power receptacle.

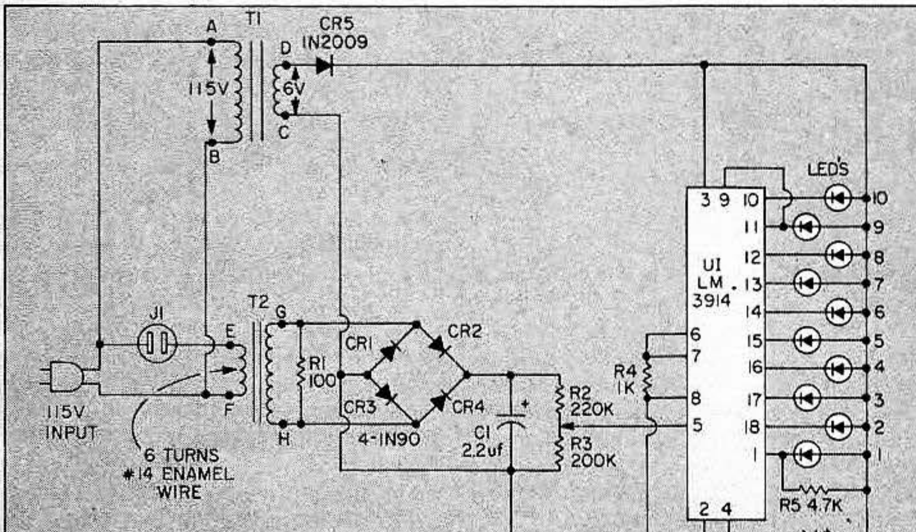
A simple calibration procedure is provided at the end of this article allowing you to compute the average cost of a kilowatt hour of electrical power in your home or office.

About The Circuit. The heart of Energy Sentry is current transformer, T2, which produces an output voltage across its secondary winding corresponding to the magnitude of current flowing in the AC line. A current transformer follows the same turns ratio relationship as does the more common voltage transformer, except that secondary current, not voltage is determined by the number of turns of both primary and secondary. In the case of Energy Sentry, the primary of the current transformer consists of just 6 turns of wire wound by yourself around the core. The secondary is the existing 115 volt winding of the transformer, resulting in a turns ratio of perhaps 100. The existing 12 volt winding of the transformer is not used.

The primary of the transformer is connected in series with the power line and the appliance under test. The current drawn by the appliance induces a proportional current in the secondary. Since a current transformer must operate into a load to provide a path for secondary current, a voltage across R1 is produced which is proportional to the magnitude of the current (and power) drawn by the appliance. This voltage varies linearly with primary current and therefore linearly with power. This is true since the voltage fed to the appliance under test is a fixed power line voltage that is well regulated by the power company.

A bridge rectifier circuit converts the secondary voltage of T2 to pulsating DC which is filtered by C1. The resulting DC voltage is fed to input terminal 5 of U1 through calibrating potentiometer R3. It can be seen that the drive voltage to U1 will be determined by the current drawn by the appliance you are checking out.

U1 is a LED driver chip which has been designed to drive a series of 10 LED's in response to the voltage applied to its input terminal, pin 5. When the voltage applied to the input is zero,



For information on the availability of parts and other materials to build ENERGY SENTRY, send a stamped, self-addressed envelope to Niccum Electronics, Route 3, Box 271B, Stroud, OK 74079.

PARTS LIST FOR ENERGY SENTRY

C1—2.2 ufd 10 volt electrolytic capacitor
C2—220 ufd 10 volt electrolytic capacitor
CR1, CR2, CR3, CR4—Germainium diode 1N90 or similar
CR5—Silicon diode 1N2069 or similar
J1—Power receptacle Radio Shack 270-642 or similar
LED 1 through LED 10—Radio Shack 276-026 or similar
R1—100-ohm, ¼-watt composition resistor 10%
R2—220,000 ohm, ¼-watt composition resistor 10%
R3—200,000 ohm miniature potentiometer, PC mount
R4—1,000 ohm, ¼-watt composition resistor 10%
R5—4,700 ohm, ¼-watt composition resistor 10%
T1—6-volt transformer (Radio Shack 273-1384)
T2—6 or 12-volt transformer (Radio Shack 273-1505 or similar)
U1—National LM3914N Radio Shack 276-1707
Misc.—Cabinet, line cord, plug, wire, solder, etc.

Energy Sentry

no LED will be illuminated. As the voltage is raised each succeeding LED will light, one at a time, until the 10th LED is illuminated. Thus, it can be seen that the circuit will provide a visual indication of the current drawn by the appliance under test.

A fascinating display can be seen when a light bulb load is being observed. As soon as the light bulb is flicked off, LEDs representing full current to no current, will light in rapid succession in an interesting display.

Power to operate the circuit is provided by T1, which feeds a half wave rectifier and capacitive filter composed of CR 5 and C2. The resulting DC voltage, about 8 volts, is sufficient to operate U1. Since U1 has a built-in regulator, the circuit will hold calibration regardless of changes or fluctuations in power line voltage.

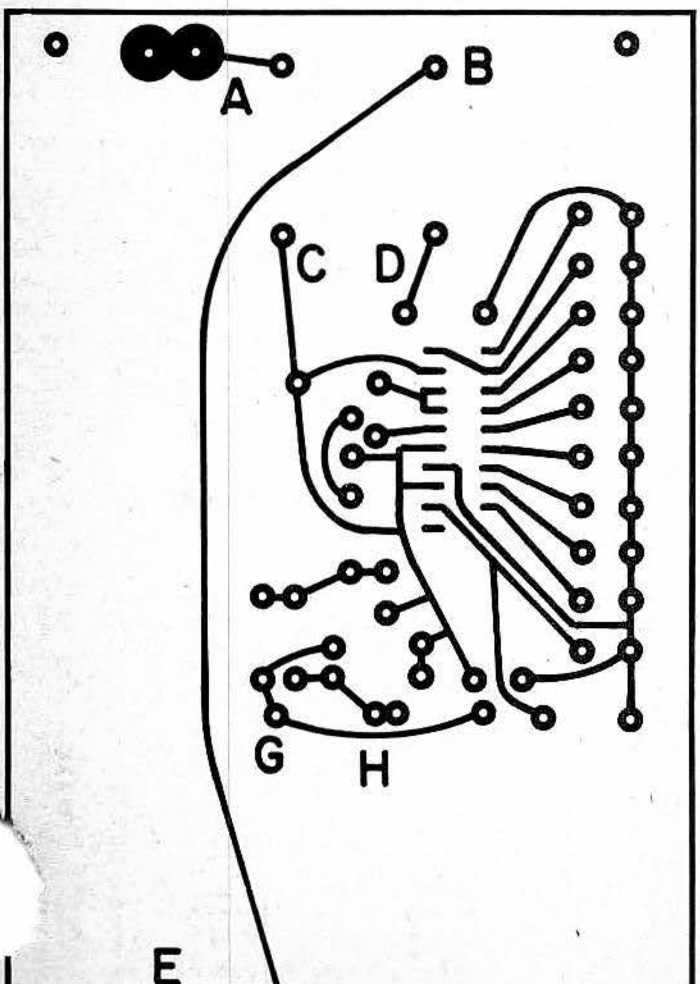
Construction. Most of the circuitry of Energy Sentry is contained on a printed circuit board. At lower left is a full scale layout of the foil layout as seen from the copper side of the board. At right is the parts layout as seen from the component side.

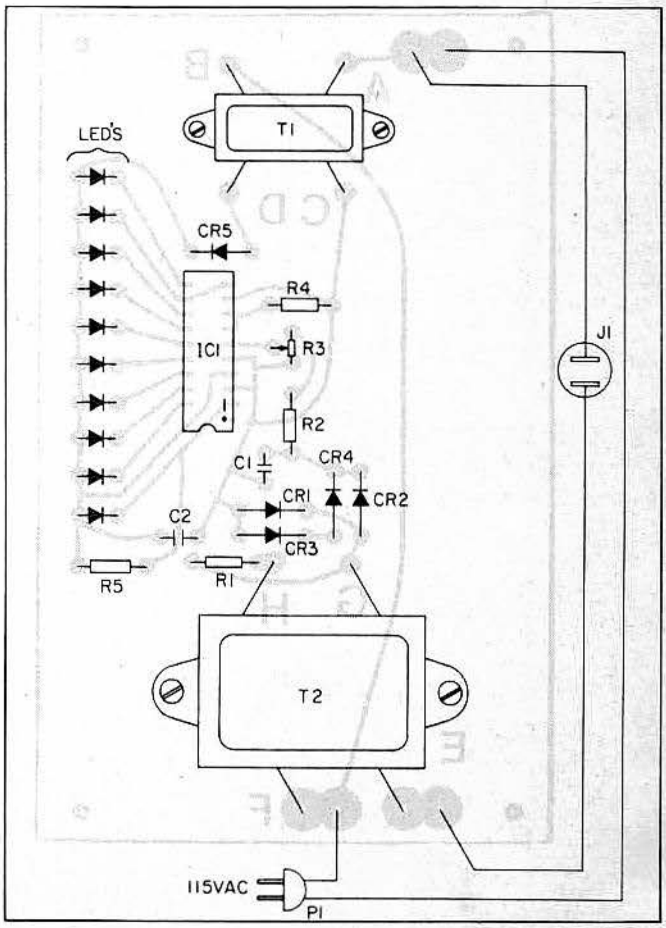
Note that the set of 10 LED's is placed on the copper side of the board. This will permit the printed circuit board to be assembled into a cabinet with the LED's protruding through a set of 10 holes drilled in the cabinet. A drilling template for the cabinet front can easily be obtained by making a photocopy of the printed circuit layout and placing it on the front of the cabinet. The printed circuit board can be mounted in the cabinet with a set of four 3/8" long spaces used for clearance and #6 machine screws.

Transformer T2 has been selected for ease of adding the additional winding. This transformer has ample room between the laminations and winding to easily fit 6 turns of #14 enamel wire. Do not use wire of smaller gauge. *Place sufficient insulating tape around the laminations to prevent a short circuit between the enamel wire and core.* If you substitute another transformer for T2 it may be necessary to remove the existing low voltage winding to provide sufficient room for the new primary. The additional winding placed on the transformer is connected to pads E and F of the printed circuit board. In a similar manner, use pads marked A, E, F, G and H for the 115 volt and transformer connections as shown in the schematic diagram. Except for pads G and H, use #14 gauge wire.

It is recommended to use a socket for U1. This will prevent damage to the IC or printed circuit board in the event U1 has to be removed for service. Double check the polarity of the LED's, diodes, and electrolytic capacitors before soldering them in place. These

(Continued on page 94)

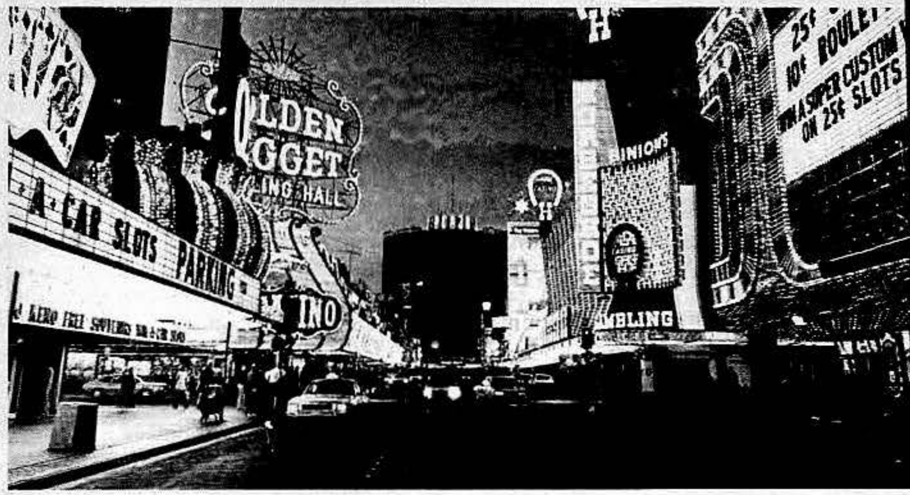


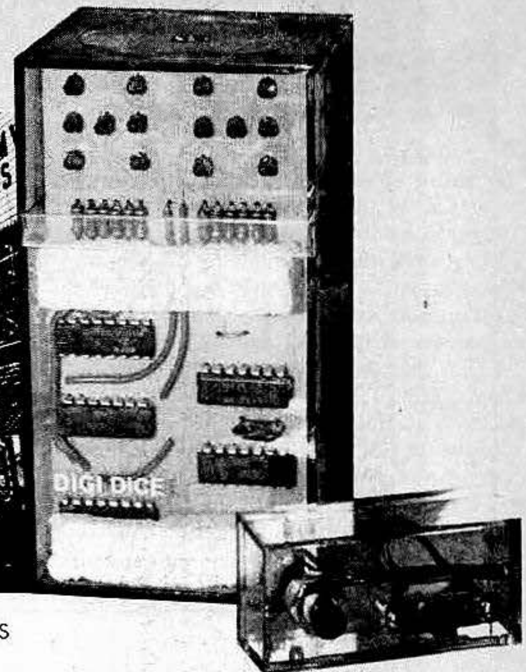


Seen above is the component side of the Energy Sentry PC board. T2 provides power coupling, and T1 provides power for circuit.

To the left is the PC board, with the etched side up. The row of LED connection terminals can be seen on the right.

DIGI DICE





An electronic dice game with infinite possibilities

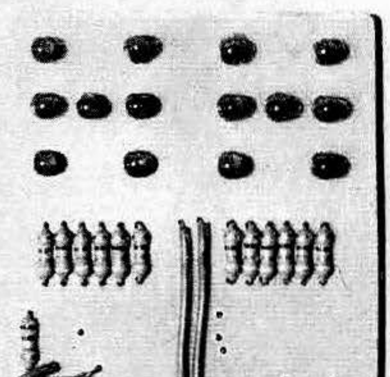
HERE IS A PROJECT for those of you tired of rolling old fashioned mechanical dice. *Digi Dice* can be used anywhere normal dice are used, and has been designed to be cheap, portable, and fun. And, since it is an electronic device, it is probably more random than any regular dice with their inherent mechanical imperfections. Construction time will vary, of course, but we built our dice in an afternoon and by evening were "rolling" in a game of craps. Total cost should run about \$12 to \$15, depending on how much spare junk you have lying about and where you buy the needed parts.

The Circuit. Refering to the block diagram, you can see that *Digi Dice* is composed of three main blocks. Block A, the oscillator, is made of two 74LS inverters connected as an oscillator, using a resistor and capacitor to regulate the frequency. The output of this oscillator is sent to block B, the counter. This consists of two CD 4017 decimal decoded counters, each wired to reset at a count of six, such that its sequence is 0, 1, 2, 3, 4, 5, 0, 1, etc. The first IC (U1) gets its input directly from the block A oscillator, while the second (U2) receives its pulses every time its partner resets itself to zero. Obviously, the second 4017 only counts one sixth as fast as the first.

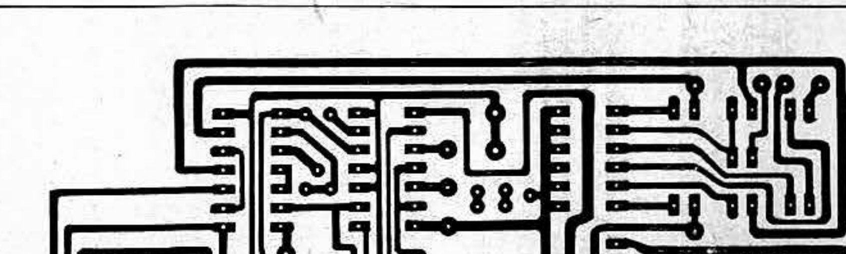
The net result of all this is a two-place base six (modulo six) counter. If we now interrupt the count at some point, each 4017 will contain a value of 0 through 5. If then, and this is the heart of the circuit, we run the counters so fast that we don't know where they are when we halt them, we have devised two independent and "random" six counters. But that is exactly what mechanical dice are, so now all that must be done is to display our results in some suitable way.

Block C, decoding and driving, does this by interpreting the values present in the CD 4017s and displaying them using red LEDs arranged to give the appearance of a pair of dice.

Now, look at the schematic diagram for a more complete idea of how the circuit operates. Switch S1 is power on-off. S2 is a normally closed momentary-contact pushbutton which inhibits



This front view of the PC board shows the arrangement of ICs and the LEDs that read out the score. "Snake eyes" lights up first.



This is the exact size of the PC board for Digi Dice, shown here with foil side up. If you do not care to etch the board yourself, order a pre-etched and labeled Niccum kit.

DIGI DICE

counting in both U1 and U2 by holding pin 14 at ground. Opening (pushing) S2 allows R14 to pull pin 14 to a high level, thereby allowing the counters to run. When this happens, the decoder/drivers will be displaying the contents of the U1 and U2 using the LEDs, but so quickly that the eye cannot follow. Releasing the pushbutton switch (closing S2) will freeze the count in each 4017, which can now be seen displayed by the LEDs.

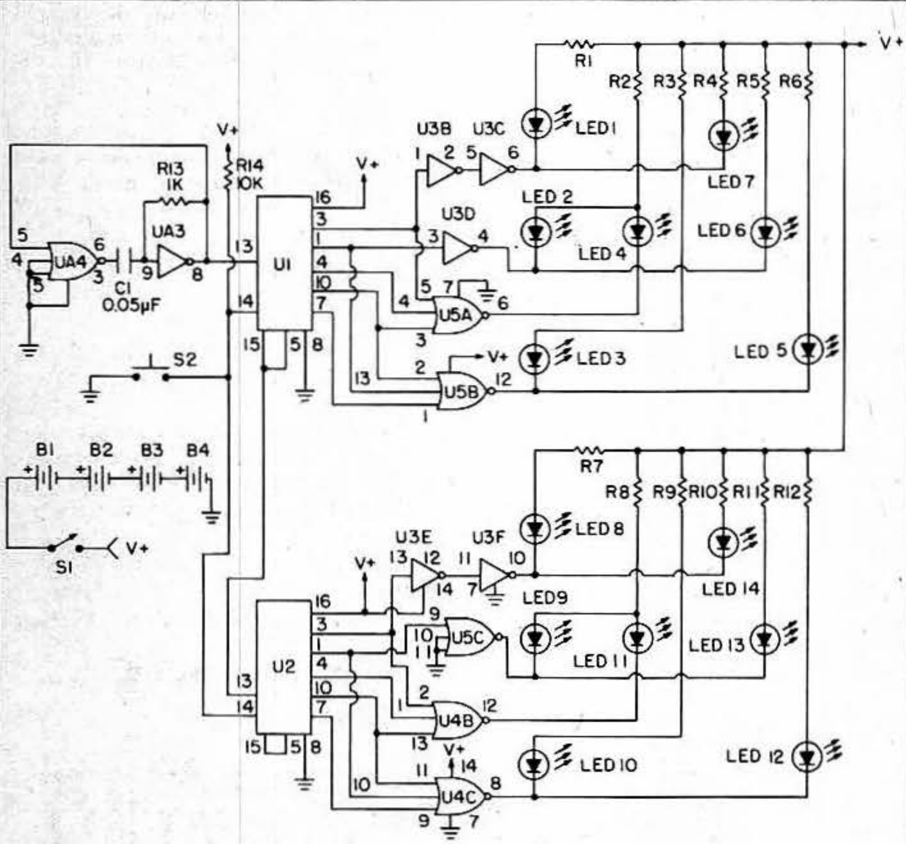
Construction. A full size PC board layout is shown for your use. As the pattern is very tight, we recommend that only advanced hobbyists attempt a reproduction. Wire wrapping is a bit more tedious and time consuming, but easier to correct. Anyway, if you do choose the PC route, carefully check for breaks and shorts in the foil with an ohmmeter, since they are easy to miss by visual inspection.

Follow the parts layout guide when assembling the PC board, and be sure you have the correct orientation of the chips; a small notch is preesnt at pin #1 of each chip. Also, don't arrange the LEDs backwards. The anode lead (+), which is usually longer than the cathode lead is always nearest to the ICs on the board. Reversing this won't hurt the LED but it won't light either.

The entire project fits neatly into a 2¼-inch by 2¼-inch by 4¹⁄₁₆-inch plastic box available in art supply stores. We ran four wires out of the main box to a smaller matching unit in which we mounted switches S1 and S2. Ribbon cable is perfect for this. The battery and circuit board are stabilized by styrofoam strips and blocks cut to the necessary shapes and either glued or press-fit into the large box. When the time comes to change batteries, the holder is easily unclipped and slid out of the case. Incidently, any 5-volt to 6-volt source can be used in place of the dry cells. The absolute maximum voltage the 74LS chips will tolerate is 7 VDC, so be careful.

Operation. Closing switch S1 activates the circuit. Don't be surprised if an unusual combination of lights appears when the unit is first turned on. Now press pushbutton switch S2. All of the LEDs will illuminate, some more brightly than others. Releasing the pushbutton will force *Digi Dice* to display two random values. Repeat the sequence for further play.

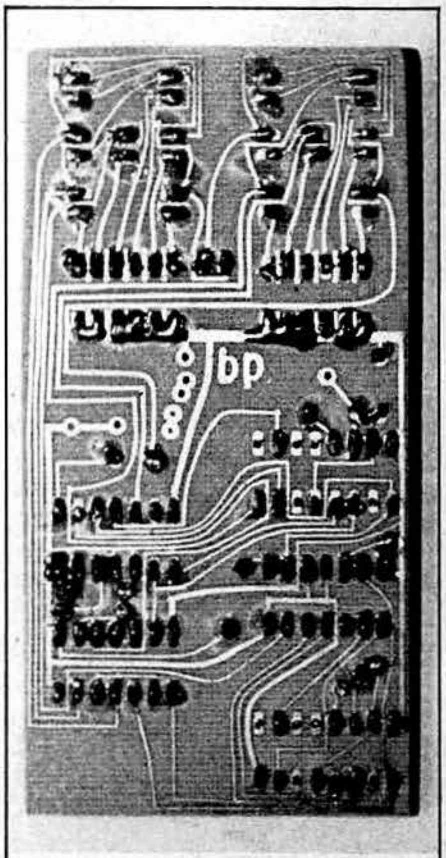
To test the theory of randomness, we "rolled" Digi Dice one hundred times. A summary of the results is shown. Although the tabulation was not checked using statistical analysis, you can see



PARTS LIST FOR DIGI DICE

B1 thru B4—1.5 VDC battery
C1—0.05-uF, 50 VDC ceramic disc capacitor
LED1 thru LED 14—light emitting diode rated 20 mA @ 1.7 VDC
thru R12—470-ohm, ¼-watt resistor, 10%
—1,000-ohm, ¼-watt resistor, 10%
—10,000-ohm, ¼-watt resistor, 10%
—SPST subminiature slide switch
S2—SPST normally closed pushbutton switch
U1, U2—CD4017 decade counter integrated circuit
U3—74LS04 hex inverter integrated circuit
U4, U5—74LS27 three section, triple input NOR gate integrated circuit
Misc.—battery holder/clip, suitable enclosure, IC sockets, hookup wire, solder etc.

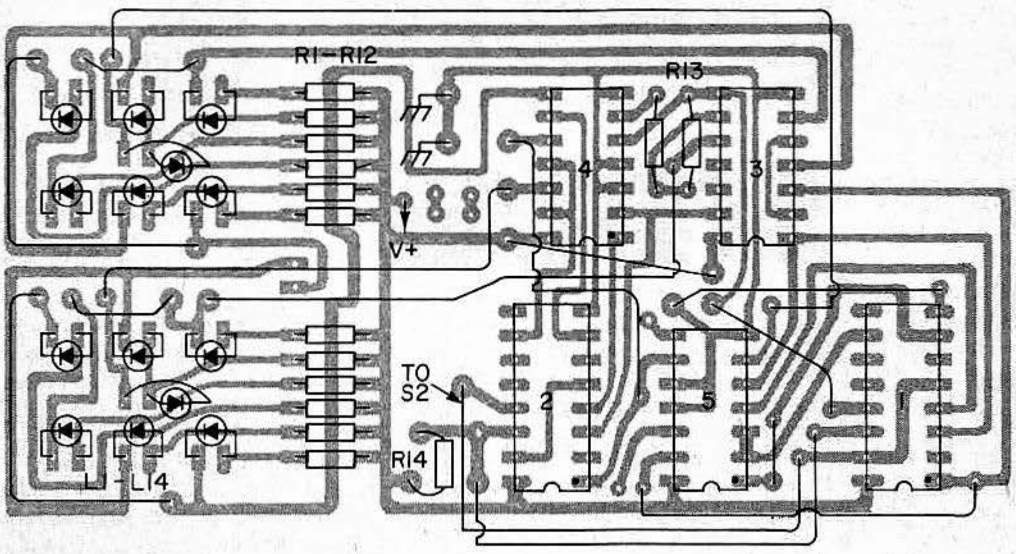
For information on the availability of parts and other materials to build DIGI DICE, send a stamped, self-addressed envelope to Niccum Electronics, Route 3, Box 271B, Stroud OK 74079.



The foil side of the completed PC board is a gem of neat solder connections. The unit fits into a variety of handy plastic cases.

that the theoretical 16⅔ frequency for each level is closely approached—the small variations are just random fluctuations in this relatively few number of trials. *Digi Dice* draws about 20 to 60 mA from the supply, depending on how many LEDs are lit. Alkaline cells are best for long life, but regular carbon-zinc batteries will provide several hours of "rolling." Be sure to try this circuit in a game of backgammon. It runs much more quickly and a third person can get into the game as a dice roller.

Conclusion. We'll add the usual caution at this point about getting involved with "money" games. While *Digi Dice* has been designed to be as "random" as is possible for a project of this nature, we certainly do not wish to become referees in arguments between you and your friends (or your victims). *Digi Dice* is intended for entertainment only, and any other use of this project (either with a modified circuit or not), especially for gambling, is done against our strongest recommendation. If you're all that hot to *really* gamble, the Chamber of Commerce of Atlantic City would no doubt like you to visit the town's casinos instead! ■

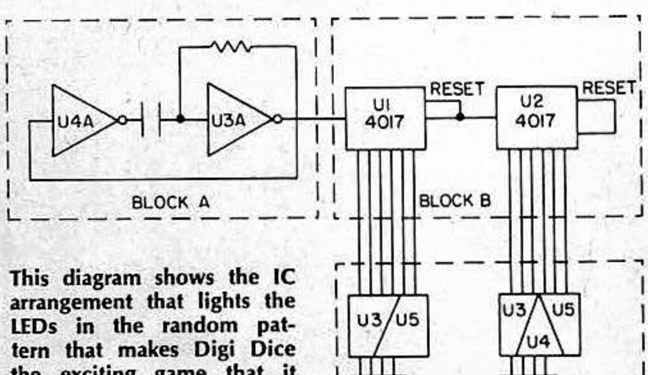


The parts overlay diagram shows the placement of components on the PC board. As in all projects using a number of delicate ICs care must be taken with the pins and with the use of soldering irons too near to the chips. Digi Dice is a project to gladden a gambler.

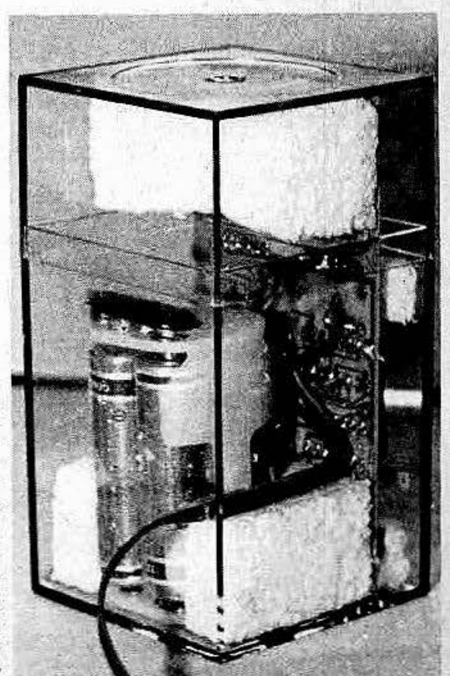
STATISTICAL BREAKDOWN OF 100 ROLLS

Face Value	Die #1/100 Rolls	Die #2/100 Rolls
1	18	16
2	14	18
3	18	14
4	15	17
5	18	16
6	17	19
Total	100	100

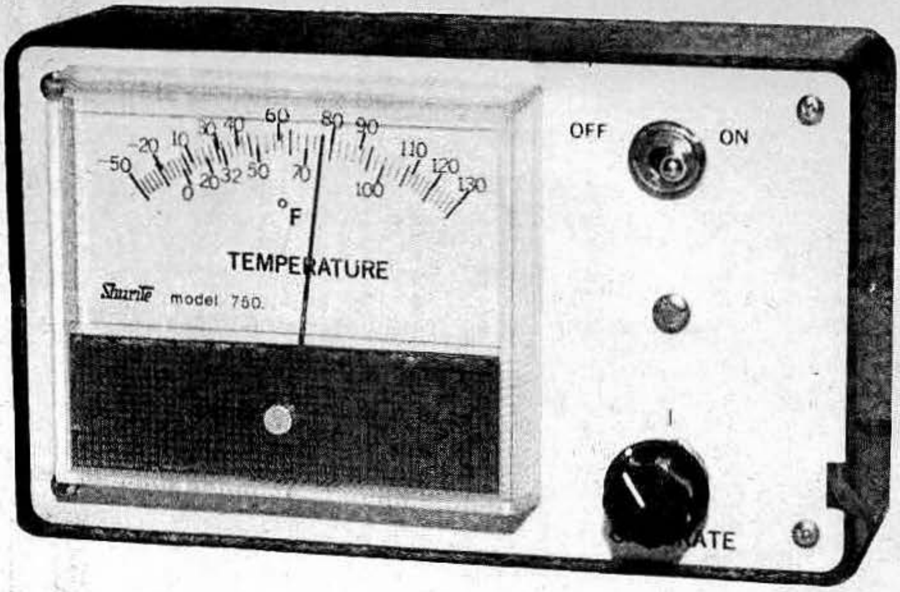
This chart shows how truly random Digi Dice is, much more so than old-fashioned "bones." While it may be possible, we know of no way to rig Digi Dice.



This diagram shows the IC arrangement that lights the LEDs in the random pattern that makes Digi Dice the exciting game that it is. Possibly some devious individual will figure out a way to load Digi Dice.



The battery pack holding the four 1.5 volt cells that power Digi Dice fits neatly into one of the common rectangular plastic boxes which can be found in a variety of shops. Styrofoam or a similar material can be used to take up room in the box, since the PC board and battery pack aren't likely to fill the entire box.



SITRAT

Build this highly accurate electronic thermometer

SITRAT IS AN ELCTRONIC thermometer that requires six components and a battery. The parts are readily available. You may already have them in your junk box. All you need to build the SITRAT is one NPN silicon transistor a potentiometer, 2 resistors, a zener diode, a battery and a 0-1 milliampere panel meter. There's a good chance you can salvage the meter from some previous project. Maybe that neutrino monitor you designed that was to estimate the rate of energy conversion of a Quasar! If you purchase a brand new panel meter it should set you back between five and nine dollars. Other parts combined, if purchased new, should cost less than three bucks.

The author's prototype model of SITRAT is just as accurate with a weak battery as with a brand new one.

The Circuit. In the circuit diagram, the current flowing through the meter is the transistor's collector current. Collector current increases when the transistor's temperature does. This means that the meter's needle goes up when the temperature does. That's basically all the theory you need, to understand how SITRAT works!

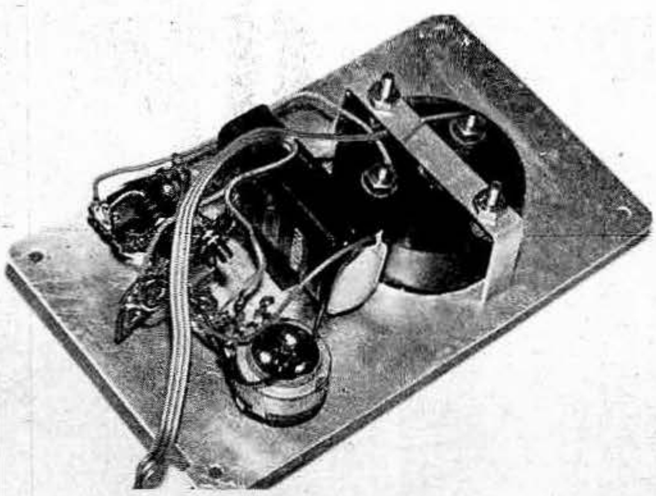
For those who desire a little more insight into this thermometer, notice that the base current flows through R1. Since R1 is a potentiometer we can set the transistor's base current to some specific value by just turning R1's knob. By definition, a transistor's collector current is just its base current times its DC current gain, usually abbreviated β_{DC}. Collector current is equal to the DC current gain times the base current plus I_{CEO}, which is the collector cut off current with the base open. However, I_{CEO} is negligible in silicon transistors so we don't even mention it here. This means, if we squirt a tiny current into the transistor's base, out of the collector comes β_{DC} times the current we squirted into the base.

Let's suppose we have a transistor with a DC current gain, at room temperature of 100. We apply 10 microamperes to its base. We get 10 microamperes $\times$ 100 = 1000 microamperes = 1 milliamperes at the collector. Let's warm the transistor to 100°F. At this temperature, the current gain has risen to 110. Collector current is now 10 microamps $\times$ 110 = 1100 microamps = 1.1 milliamps. These calculations assume base current always remains the same. In real life, base current will increase due to a temperature increase, causing an even greater increase in collector current. The base current increases with temperature because the base-to-emitter voltage, V_{BE}, decreases with increasing temperature. The reason that a decrease in V_{BE} causes an increase in the base current is easy to visualize. R1 see 9 V_{BE}. As V_{BE} decreases, the voltage across R1 increases. As the R1 voltage increases, its current also increases. The current that flows through R1 is the same current that flows through the base. In fact, it is the base current.

A simple voltage regulator circuit consists of R3 and zener diode D1. This voltage regulator provides a constant voltage source for Q1's base bias circuit. Voltage regulation insures that the battery's voltage won't affect I_B and thus the meter's current.

Picking The Transistor. You can use any NPN slicon transistor you find laying around in SITRAT—even that free one that came with that surplus company's "bonus pack." The author has determined the DC current gain at room temperature for 10 different transistors picked at random. The list below includes two unmarked surplus transistors.

You may have noticed that the author chose the transistor with the least DC current gain to use in his prototype.



Inside view of SITRAT. Note component simplicity. There is no need for printed circuit board here! The ball-bearing potentiometer is very classy—but you can use a regular one meg pot in this circuit.

TABLE ONE

Transistor	DC Current Gain
2N5088	710
HEPS002	110
2N5089	625
2N3860	200
2N2222A	153
RS2031	167
2N5129	47
2N2897	55
Surplus "A"	100
Surplus "B"	140

The reason he did this is that he found that when the transistors are placed in the circuit (see schematic), it appeared that the lower the current gain, the more sensitive the thermometer. Since the author was seeking a relatively sensitive thermometer he chose the lowest gain transistor he tested. However, you can use any transistor you have, although the author does not recommend those extremely high gain transistors, say with gains over 500. If the thermometer doesn't seem as sensitive as you would like, just plug a different transistor into the circuit. If you have a data sheet available, choose one with a relatively small β_{DC}, which is the DC current gain.

Construction. Because of its extreme simplicity, the actual construction is a no-sweat job. Use a 2 lug terminal strip to mount R2, R3 and D1 and use point-to-point wiring between them and R1, S1 and M1, which are all mounted on the front panel. See line drawing and the photo. In the parts list, R2 is listed as a 100K resistor. If you use a high gain transistor, R2 may have to be increased to 470K or even 680K.

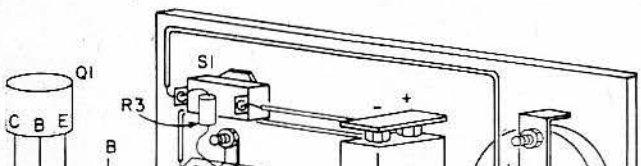
For details on making the transistor probe, see line drawings on this and the next page. First cut a 3-conductor cable, shown in drawing. Strip away the outer cable and push spaghetti sleeving up the three inner leads as shown. Next, using a heat sink such as an alligator clip, solder the cable's wires to the transistor leads, as in detail. Make sure you record on a sheet of paper which wire (usually color coded) is connected to each lead of the transistor (emitter, base, collector)—this is done to avoid any possibility of error when connecting the probe's cable to the rest of the circuit. Next, spray the bare leads, connections and transistor with acrylic plastic. After the acrylic dries, pull up the sleeving over the connections and leads as shown in the drawing. To completely waterproof the probe, take Epoxy Putty or E-POX-E RIBBON and encase the transistor assembly in it. Try to fashion a reasonable looking, pointed probe, by using your fingers. See Figure 8. For that final, semi-professional touch, wet your hands and roll the rough-looking probe between them like dough. You should be able to fashion a smooth, cylindrical probe out of the putty, as in drawing. This completes the actual construction

Data For Meter Dial. The first step here is to 'make like a scientist' and take a number of meter readings when the transistor probe is placed in different temperature water baths.

Obtain a small plastic container. You also will need a fairly accurate thermometer. This thermometer will be kept submerged in the pail. The pail itself will be about half filled with water. For good accuracy, you will have to take at least 10 different readings, each reading at a different temperature.

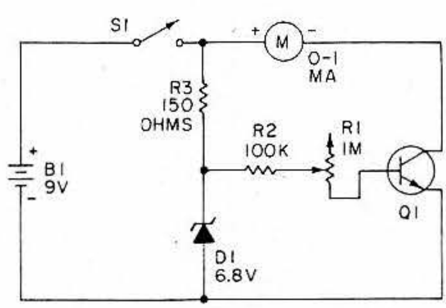
Start out with exactly 120°F water. This can be easily done by first filling the pail with hot water—say 125-135°F —and then waiting until it cools to exactly 120°. Be sure you have the probe in the water for at least a few minutes before you make any adjustments or take any readings. Once you have exactly 120° water, set R1 so that the meter reads exactly .9 milliamperes. If you wish, place a drop of Plastic Rubber or similar glue at the pot's shaft so it can't be turned by mistake or accident. Mark this point down as .9 ma at 120°F. Next, replace the 120° water with some slightly cooler water. Be sure you stir the water. After a minute or two, again take both SITRAT's and the thermometer's readings. Also mark the information down. Similarly, you should take at least six more readings at different temperatures. Make sure each of the six separate temperatures differ by at least 5°F. Another reading should be taken at the freezing point of water. To take this reading, empty the bucket and then half fill it with small ice cubes or compacted snow. Then, pour cold water into the bucket until it is about ⅔ full. Finally, place the probe in th[e] middle of the bucket and stir the i[ce] mixture frequently. Wait several mi[n]utes or until the meter's needle stops moving. Then mark down 32°F and next to it place the meter's reading—for example 32°F @ .3 ma. (Notice that in Table 2, which is the reading the author recorded, 32° corresponds to exactly .32 ma. This is entirely a coin-

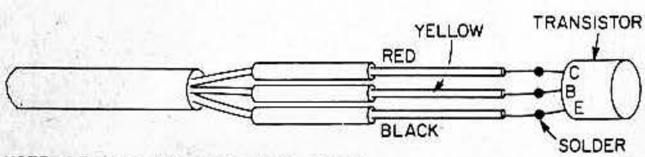
SITRAT line drawing shows simple placement of the few components. Cable to the probe can be almost any length; no electrical problems to worry about. A quick kit!



PARTS LIST FOR SITRAT

- **B1**—9-VDC transistor radio battery
- **D1**—6.8-volt zener diode, ½ watt
- **M**—0 1-mA panel meter
- **Q1**—any type NPN silicon transistor (see text)
- **R1**—1,000,000-ohm potentiometer
- **R2**—100,000-ohm, ¼ watt resistor, 10%
- **R3**—150 ohm, ¼ watt resistor, 10%
- **S1**—SPST switch
- **Misc.**—2 lug terminal strip, an appropriate length of a 3 conductor cable, spaghetti sleeving, acrylic plastic spray, E-POX-E Ribbon or Epoxy Putty, Dry Transfer Lettering, graph paper, suitable case, small plastic pail, good quality thermometer, wire, solder, hardware, etc.





NOTE: BE SURE TO MARK DOWN WHICH WIRE IS CONNECTED TO EACH LEAD OF THE TRANSISTOR. FOR EXAMPLE; RED TO COLLECTOR, YELLOW TO BASE, BLACK TO EMITTER

This is the only tricky part of SITRAT. Follow the directions in the text carefully, and you will not have a single bit of trouble.

cidence!) You should also take at least one reading below freezing. To do this, make a mixture of salt and ice cubes and place both the probe and thermometer in it. Record both the thermometer's and SITRAT's reading and jot it down in the table.

Table 2 lists the readings from the author's prototype. While the general appearance of your table should be similar, your actual readings will differ, except for the .9 ma at 120°F reading which should be identical. (Quickie Quiz: Do you know why this reading is identical to the author's and will always to be the same for all transistors regardless of DC current gain? HINT: Read this section over.)

TABLE 2
MEASUREMENTS TAKEN WITH AUTHOR'S PROTOTYPE OF SITRAT

Temperature of Water Bath (°F)	Current (milliamperes)
120°	.9
108	.8
98	.735
91	.67
85	.63
77	.58
68	.52
61	.48
54	.445
40	.36
32	.32
9	.22

NOTE: This Table is to be used as a guide ONLY. Your readings will differ, perhaps substantially.

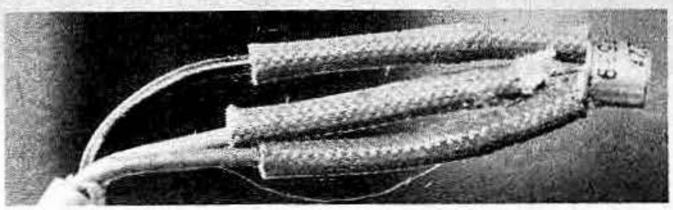


Photo of probe just before encapsulating in putty. Don't forget to use the insulator sleeves, and spray with acrylic, as the text directs you to.

We have the data. Now what? If we tried to label a meter's dial directly from our data we would have a funny looking thermometer indeed. Only the various temperatures measured would appear on the dial.

A far better way is to obtain a sheet of graph paper. Then mark the vertical axis with milliamperes (0, .1, .2 . . . . . 9, 1.0) and the horizontal axis with temperature measured in degrees Fahrenheit. See chart below. Now plot the data points you obtained (as in Table 2) on the graph paper, as in the chart. Then draw a SMOOTH curve through the points. To draw this smooth curve use a 'french curve' or if you are careful, you can draw it free hand. Refer to chart. Notice that this curve has been extended quite a bit above and below the known data points. This procedure enables you to use SITRAT over a greater range of temperatures than you actually measured. This procedure is known as extrapolation.

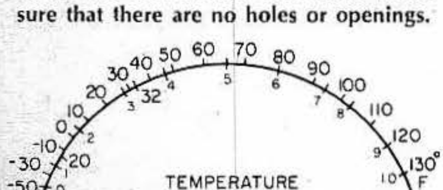
So now you have a beautiful curve. What now? If you are acquainted with curves on graph paper, simply read off the current readings that correspond to every temperature that is divisible by 10 (e.g. 120, 110, 100, 90 etc.) and mark the information down in a table. We assume, that you aren't acquainted with this technique. For this reason, we will describe it.

First you should determine the maximum temperature your SITRAT will measure. To find this 'maximum' temperature draw a horizontal line (this line is marked (a) in the chart) parallel to the temperature axis starting at the 1.0 ma marking on the current axis. Determine the point where this line intersects the curve, then draw a straight line directly down (parallel to the current axis). This line is labeled (b) in the chart. Mark down where this vertical line intersects the temperature axis —this will be the maximum temperature your SITRAT will measure. Note that the author's prototype can measure a maximum temperature of 130°F.

Now to find how low a temperature your SITRAT can measure. Finding the minimum temperature is a bit simpler. First, make sure you have continued extrapolating the smooth curve until it hits the horizontal axis (0 ma point). Mark down the temperature where this extrapolated curve hits the horizontal axis. In the chart, this point is −50°F. This is the lowest temperature your SITRAT can measure and

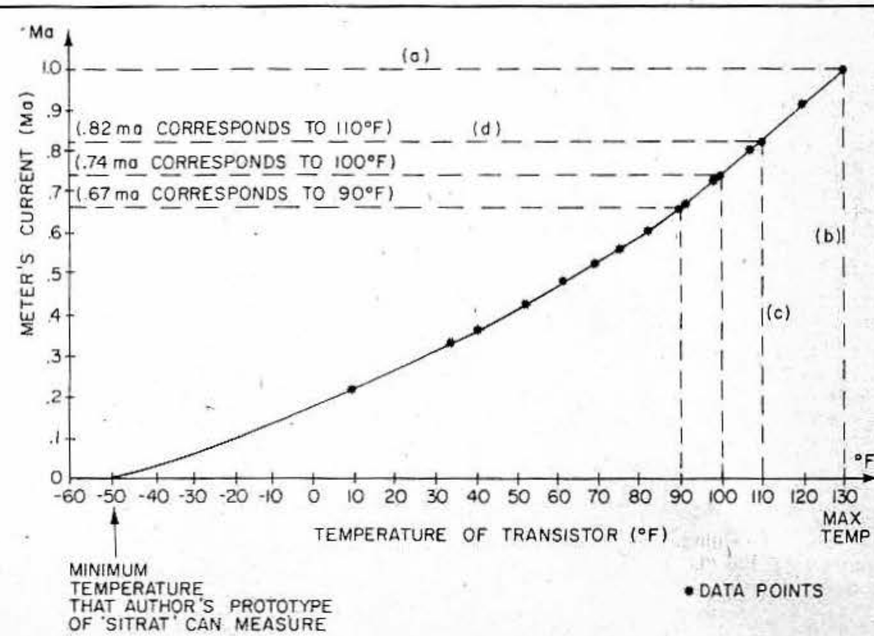
(Continued on page 93)

Drawing of the probe after is has been coated with the epoxy putty. The idea is to mold the putty until it is fairly smooth all around he transistor and leads. Make sure that there are no holes or openings.



NOTE: SMALL NUMBERS ARE MILLIAMPERES

The dial plate of milliammeter, converted to degrees Fahrenheit. Of all the aspects of assembling SITRAT, this is the most time consuming, since you will have to calibrate dial according to your own specific components. Follow text with real care!



This is the graph that you will need to calibrate the temperature reading meter scale. Make a couple of trial runs on graph paper until you get the knack of drawing smoothly.

Heat Loss Sentry

Locate home heating losses and reduce your energy costs

THE MONEY spent on heating and cooling your home represents your largest energy expenditure. As you are well aware, this cost can easily amount to over $1000 a year at today's prices for energy. With the dramatic increase in energy costs, it behooves everyone to do everything possible to reduce his energy consumption. This will help reduce oil imports, while keeping your personal expenses as low as possible.

Many of our utility companies are instituting a program of energy surveys for homeowners to pinpoint the various sources of energy loss in our homes. One way this is done is to pressurize the home under test with an air blower and use smoke generators to detect the passage of air from within the home to the outside. These passageways represent points of heat loss (or gain) in winter and summer.

With the help of Heat Loss Sentry you can perform the same tests for heat loss, using not smoke as the detecting mechanism but temperature change. These tests can be made in winter or summer. All that is required is a temperature difference between the inside and outside of your home.

Heat Loss Sentry is a low cost quality instrument, sensitive enough to detect changes in temperature as low as one degree Fahrenheit. It is self contained in a small cabinet and powered by a readily available 9 volt transistor radio battery which provides many hours of operation. An easy to construct, probe contains a temperature sensing device used to locate sources of air leaks throughout the home. A built-in battery monitor circuit in the instrument alerts the user when the battery is near the end of its useful life. Although Heat Loss Sentry has been designed as a heat loss detector, it is accurate enough for use as a thermometer over its range of 20 degrees Fahrenheit.

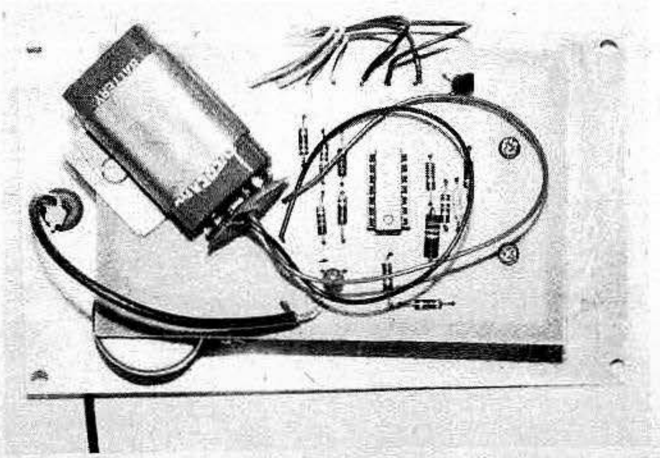
Circuit Theory. Heat Loss Sentry has been made possible by the development of an accurate low cost temperature sensor integrated circuit, LM335. This is a three terminal IC, designed to look like a 3 volt zener diode with an accurate temperature coefficient of 10 millivolts per degree Kelvin. (The Kelvin temperature scale is identical to the more familiar centigrade or Celsius scale with zero degrees Kelvin equal to −273° C, or absolute zero.) The IC can be accurately calibrated to any desired temperature. Typically, the LM335 will provide one degree C accuracy over its entire operating range when it's calibrated at any temperature.

Refer to the scematic diagram. U1 and U2 are each an LM 335 IC, connected in a differential amplifier circuit to detect a temperature difference between these two devices. U1 is mounted in a probe assembly, used to detect temperature changes, and U2 is contained in the instrument cabinet and acts as the reference. The adjustment lead of U2 is connected to a potentiometer (not panel mounted) so the meter reading can be set to center scale.

In energy leak detection, center scale becomes the nominal or average temperature being measured.

When Heat Loss Sentry is calibrated to center scale, the voltage across U2 is adjusted to be sufficiently below the voltage of U1 so that the output voltage of operational amplifier U3A drives the meter to center scale. Since U3A has an accurate gain of 18 determined by the ratio of resistors R6 and R5, the 10 millivolt per degree Kelvin sensitivity of U1 is amplified to 180 millivolts per degree Kelvin. This is equivalent to 100 millivolts per degree Fahrenheit. Resistors R7 and R8 are multiplier resistors which convert the one milliampere meter movement to a voltmeter of 2 volts full scale. This provides a total meter range of 20 degrees Fahrenheit, or a relative scale of ±10 degrees with zero at center scale. Once calibrated to center scale, placing the sensor probe in any environment with a different temperature, will produce an indication. A meter deflection downward occurs for colder temperatures, and an upward deflection occurs for warmer temperatures. If the total temperature change is 10 degrees or less, the actual differential can be read directly from the meter scale.

IC U3B is operated as a voltage comparator to constantly monitor battery voltage when the instrument is operating. This is accomplished by feeding a reference voltage across zener diode D1 to the positive input of U3B. A portion of the battery voltage is fed to the negative input of U3B. Voltage from a new battery is sufficient to develop a higher voltage at pin 9 of U3B than the D1 reference voltage. As a result, the U3B output is at zero potential and LED 1 is extinguished. As bat-



Looking inside a Heat Loss Sentry. There's plenty of room for the nine volt transistor battery, as well as for the components. Note series of wires coming from pads "A" to "I." The wiring is discussed in detail in the text.

Heat Loss Sentry

tery voltage decreases a point is reached when voltage at pin 10 of U3B exceeds pin 9 voltage. This results in U3B output rising to battery potential, and illuminating LED 1. The user is thus alerted that the battery is near the end of its useful life and should be replaced.

Construction. The entire circuit, with the exception of the sensing probe and front panel components, is contained on a printed circuit board. On other page is a full size illustration of the foil layout as seen from the copper side of the board. On page also is the component side, showing the parts layout. The printed circuit board has been designed to mount directly on the back of the meter, using the meter screws for both mechanical and electrical assembly. Before constructing your printed circuit board, take into account the center to center distance of the studs of the meter, if you decide to use a different one milliampere movement than that specified in the parts list.

It is recommended that you use a socket for U3, rather than soldering it directly into the printed circuit board. This will permit ease of service should it ever be required. Be sure that the orientation of U3 is correct. Pin 1 of U3 is clearly marked on the parts layout and foil layout by a small dot. The same precautions hold for U2, the diodes, and electrolytic capacitor. These parts are polarized and must be placed into the circuit in the proper direction. A bottom view of U1 and U2 is seen on the schematic diagram.

Connections between the printed circuit board and external components are made through a series of pads marked with letters A through I. These connections are clearly shown on the schematic diagram. It is best to use wires of different colors to help prevent wrong connections. The sensing probe is connected to terminals A and B of the printed circuit board. Make this connection with a convenient length of flexible shielded wire. Maintain the correct polarity when connecting U1. The shield connection of the cable should be tied to the negative lead of U1, and to terminal B of the printed circuit board. Feed the probe cable through a front panel grommet.

Power to operate the circuit is obtained from a 9 volt transistor radio battery, mounted directly to the printed circuit board. Connect the battery to the circuit with a battery clip made for this purpose. The layout easily provides room on the board for this. The battery can be secured to the board with a homemade clamp constructed from a piece of sheet copper, or by any other means you care to use. The parts list specifies a normally open, spring return, power switch. This was chosen to prevent the unit from being left on when not in use, and depleting the battery.

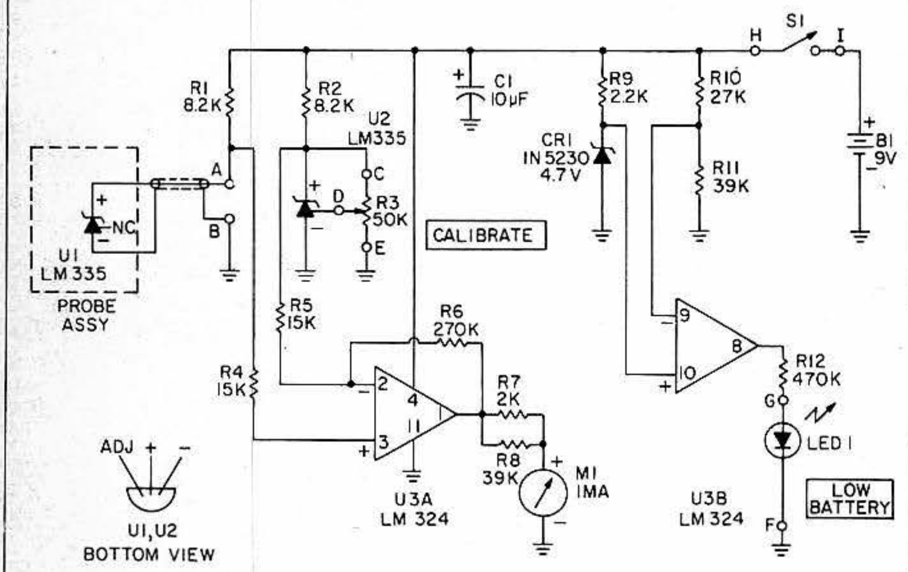
LED 1 is mounted on the front panel of the instrument using a small amount of epoxy. Use a pair of different colored wires to make the connections between the LED and printed circuit, and be careful not to bend the stiff leads of the LED where they enter the plastic body. This might render the LED defective.

Refer to the illustration of a typical probe assembly. If available, you may use a short piece of plastic or synthane tubing for the probe. You can even construct a probe from a piece of wood doweling. It is not recommended to use metal tubing for the probe, since the heat conduction from your hand may affect the temperature sensing performance of the sensor, U1.

Connect the shielded wire to U1, using the + and − terminals of the IC as shown on the schematic diagram. The adjustment terminal of U1 is not used. Insulate the connections carefully, and insert the IC and wire into the probe. Secure the IC and wire inside the probe with epoxy or silicon rubber compound. Allow part of the case of U1 to protrude outside the probe so that it is more sensitive to temperature change. Allow the assembly to harden before placing it in use.

For a professional looking instrument, you can use the meter scale shown which fits the meter specified in the parts list, as well as others. The existing meter scale can easily be removed by prying the plastic cover off the meter and removing two small screws. Be careful not to disturb the delicate needle. Paste the new scale on the back side of the meter scale, and reassemble it into the meter.

Checkout and Use. When the unit is



PARTS LIST FOR HEAT LOSS SENTRY

B1—9-VDC transistor alkaline battery
C1—10-µF, 15-VDC electrolytic capacitor
D1—4.7-volt zener diode, 1N5230 or similar
LED1—red LED
M1—0-1-mA, DC meter
R1—8,200-ohm, ¼-watt resistor (all resistors 10% unless otherwise noted)
R2—8,200-ohm, ¼-watt resistor
R3—50,000-ohm potentiometer, panel mounted
R4—15,000-ohm, ¼-watt resistor
R5—15,000-ohm, ¼-watt resistor
R6—270,000-ohm, ¼-watt resistor
R7—2,000-ohm, ¼-wat resistor, 5%
R8—39,000-ohm, ¼-watt resistor
R9—2,200-ohm, ¼-watt resistor
R10—27,000-ohm, ¼-watt resistor
R11—39,000-ohm, ¼-watt resistor
R12—470-ohm, ¼-watt resistor
S1—SPST toggle switch
U1, 2—LM335 temperature sensor, National Semiconductor or equivalent
U3—LM324 operational amplifier, National Semiconductor or equivalent

Misc.—Cabinet, GC Electronics H4-726 or similar, wire, solder, battery clip, etc.

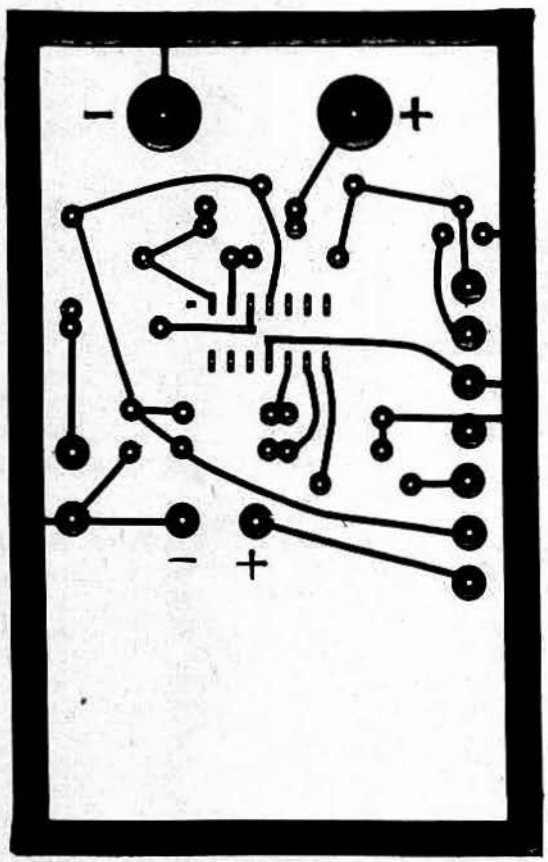
fully wired, check for wiring errors. Then, connect a 9 volt transistor battery to the power input terminals. Activate the power switch and rotate the zero adjust control over its full range. You should be able to adjust the meter reading from zero to full scale, with some extra range left in the potentiometer. Set the control so that the meter reads half scale. While holding the power control on, place your fingers over the sensing tip of the probe. The meter reading should increase to beyond full scale. If the unit performs as specified, it is operating properly.

You may wish to check the Low Battery indicator circuit to determine if it is operating properly. To do this, you must substitute a variable voltage DC supply for the battery. Set the supply to 9 volts and connect it to the power input terminals observing correct polarity. Turn the power switch of Heat Loss Sentry on, and observe the Low Battery indicator as the power supply voltage is reduced. The Low Battery indicator should become illuminated as the power supply voltage approaches approximately 6½ volts. Due to variations in zener diodes, you may wish to change the value of R11, if necessary, so that the LED lights at approximately 6.5 volts battery voltage. Once this is done, the checkout of the instrument is complete. Reconnect the battery to the instrument.

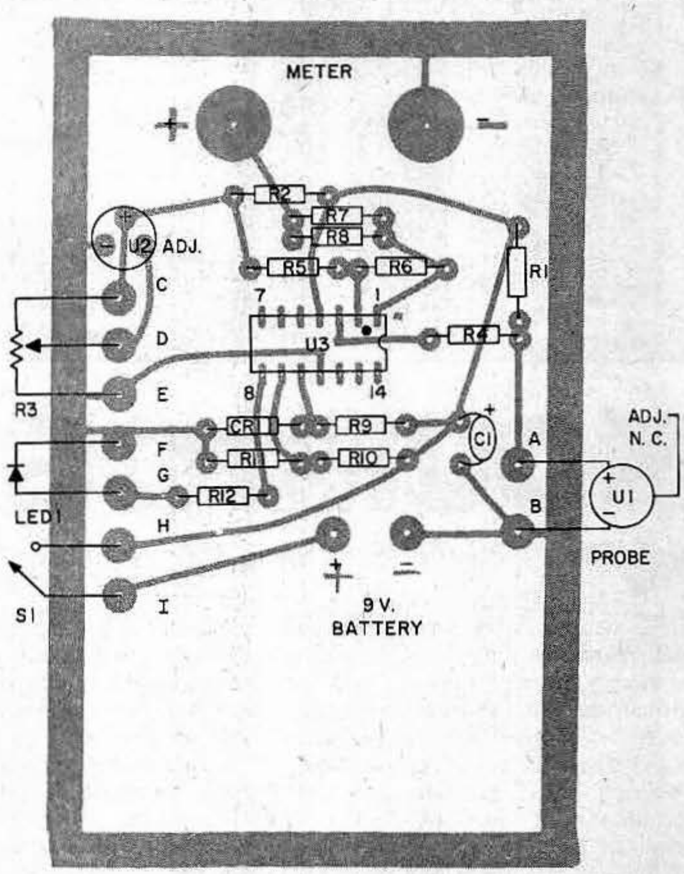
When Heat Loss Sentry is operated, you may notice that the Low Battery indicator blinks as the power is turned on and off. This is a normal reaction, which occurs as the circuit voltage passes from zero to battery voltage then back to zero.

To operate, hold the power switch on and adjust the meter to center scale. Holding the probe, search out any area where you suspect an air leak between inside and outside of your home. The meter will give an immediate indication if there is a change in temperature. In the case of very small leaks, allow sufficient time for the unit to react. This may take several seconds. Once a change of temperature has been detected, it is best to remove the probe from the leak and allow its temperature to stabilize to room temperature before searching out another leak. It takes a few minutes to familiarize yourself with this instrument.

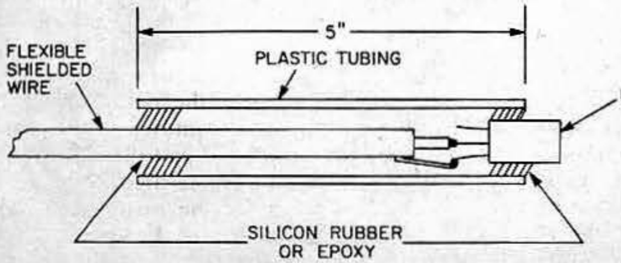
Another interesting use for this device is in troubleshooting defective electronic circuits. When the probe is held close to defective ICs, resistors, etc. a higher than normal temperature will be indicated. ■



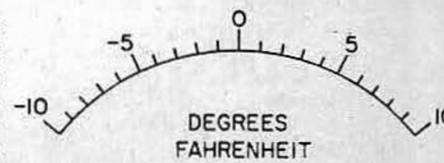
This is the foil side down view of Heat Loss Sentry's PC board. Care must be exercised in etching board.

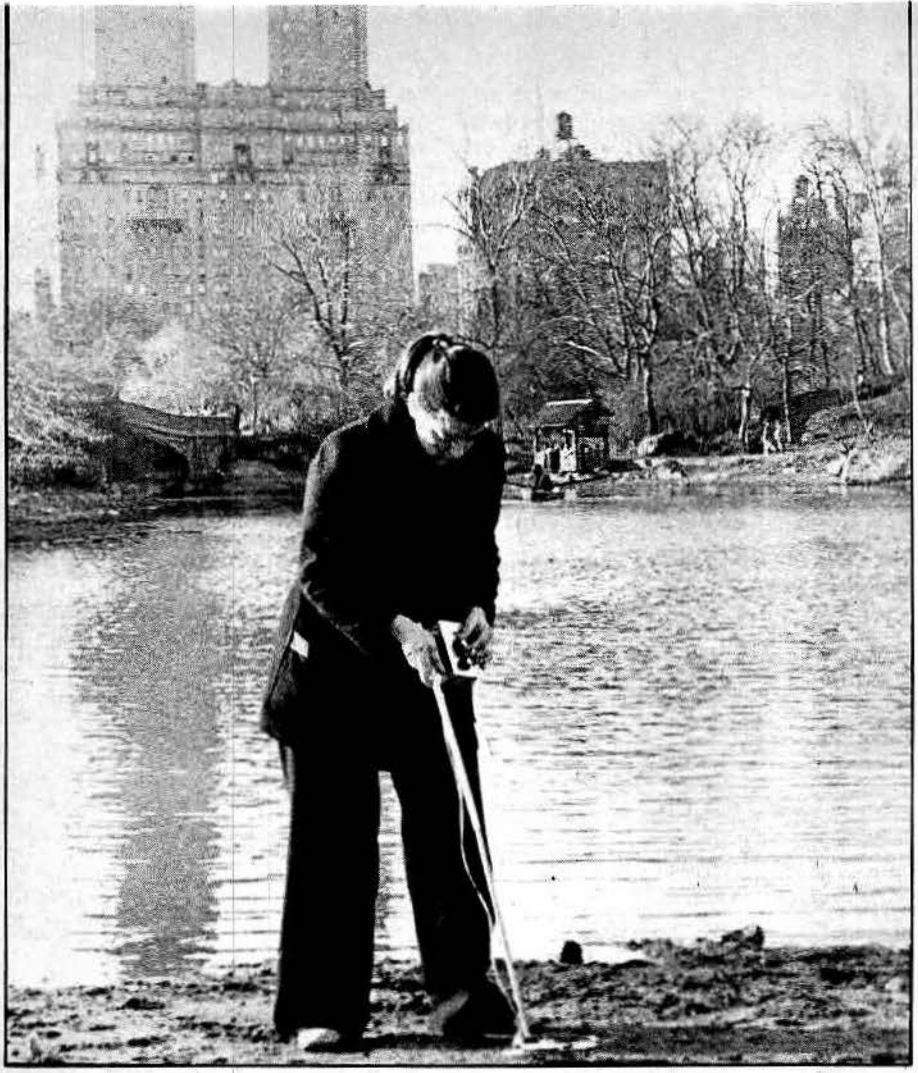


The foil side up diagram illustrates parts placement on the top of the PC board. Heat Loss Sentry requires relatively few components.



To the left is a drawing of the heat sensing probe. Follow the setup closely, and use the glue! At right is an exact size drawing of the meter face. Cut it out and paste it right on.





HOUNDOG

This electronic metal detector is a thoroughbred

ONE OF THE PROBLEMS with the hobby of treasure-hunting is that much more money has been spent on looking for it than the value of what might and has been found gives. One of the best ways to balance the books is to start out as inexpensively as possible, and that opportunity is provided by *Houndog,* a relatively simple and inexpensive metal detection device. *Houndog* can sniff out metal objects as small as a penny buried as deep as 3 to 5-inches, and will operate reliably for up to a year on one 9-volt transistor battery.

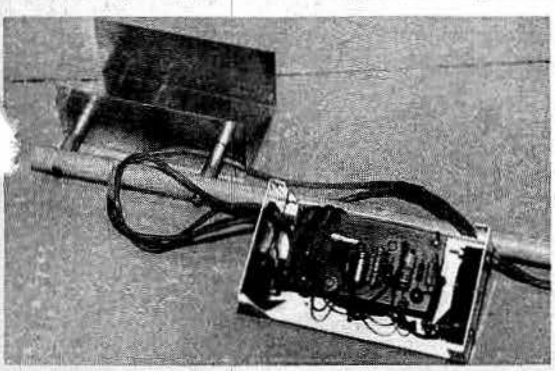
Operational Principle. *Houndog's* "nose" consists of three large inductance coils which, when placed in proximity with a conductive metal will exhibit a change in their total inductance value, the change being read by the circuitry and translated into an audible signal. In short, when *Houndog* "barks," it's time to start digging.

The Circuit. The heart of the circuit is U1, an audio amplifier, whose differential inputs are fed by a bridge circuit consisting of L1, L2, and R7, fed through R6A and R6B. U1's output is coupled to L3 by either C1 or C1 and C2, depending upon the setting of sensitivity switch S1. The placement of L1, L2 and L3 is such that the total field set up in L1 and L2 by current flowing in L3 is effectively zero. Therefore, the inputs to the amplifier are equal and opposite (zero), and it's output will be zero.

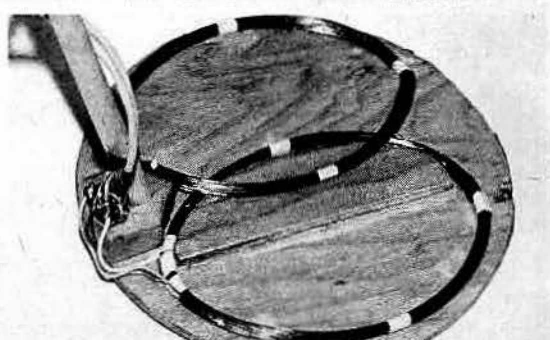
When a conductive metal enters the field, it changes the distribution to the effect that the field across L1 and L2 is no longer zero, and a voltage appears across the amplifier's inputs. The coil connections are such that when this condition exists, the positive input voltage is in phase with that of the output, and the circuit oscillates. The signal is fed to Q1, causing it to turn on, allowing current to flow to buzzer BZ1, creating *Houndog's* "bark."

Because the coils used in *Houndog* are designed to be hand-wound, and also due to the effects of stray capacitance and noise generated internally in the circuit itself, a feedback loop has been included (through R7) which will allow the user to keep *Houndog* from sounding off due to false signals caused by variations from the theoretically perfect zero field.

Construction. There are actually two steps involved in the assembly of the *Houndog;* wiring the PC board for the control circuitry, and the construction of the coils for the search head (which we'll discuss later). With the exception of C7, the potentiometers, the switches and BZ1, all components mount directly on the PC board, as indicated in the PC component layout guide. C7 is soldered directly to the terminals of S1, and the potentiometers and switches and the buzzer are mounted to the



This photo shows the circuit board mounted in the cabinet, and the method used for attaching the cabinet cover to the handle.



Closeup of the search head shows the position of coils L1/L2 and L3, and their respective overlaps as described in the text.

aluminum or plastic chassis. As always, pay careful attention to the polarities of the electrolytic capacitors during installation. Although not completely necessary, use of an IC socket for U1 is recommended.

The circled numbers appearing on the schematic and parts layout guide are for keying up the connections to the off-board components. It is not necessary for you to etch the numbers onto the PC board, so long as you refer to them during the final wiring stages.

To assist you in construction of the coils (L1, L2 and L3), we have provided a diagram of a coil form which may be cut from plywood. This, at the carefully mark the position of the two coils, and prepare to attach them per-very least, will allow you to wind L1/L2 and L3 to the same basic dimension, which is about the only critical factor (outside of getting the number of turns of wire correct) in the construction of the search head.

When winding L1/L2, rather than winding two sets of 30 turns each, we suggest that at turn 30 of L1, you scrape away a bit of the insulation and solder the ground tap in, wrap the solder junction with a small bit of tape, and then begin the next 30 turns for L2. This provides a stronger final assembly, and less of an alignment problem (you now need deal only with aligning two coils instead of three).

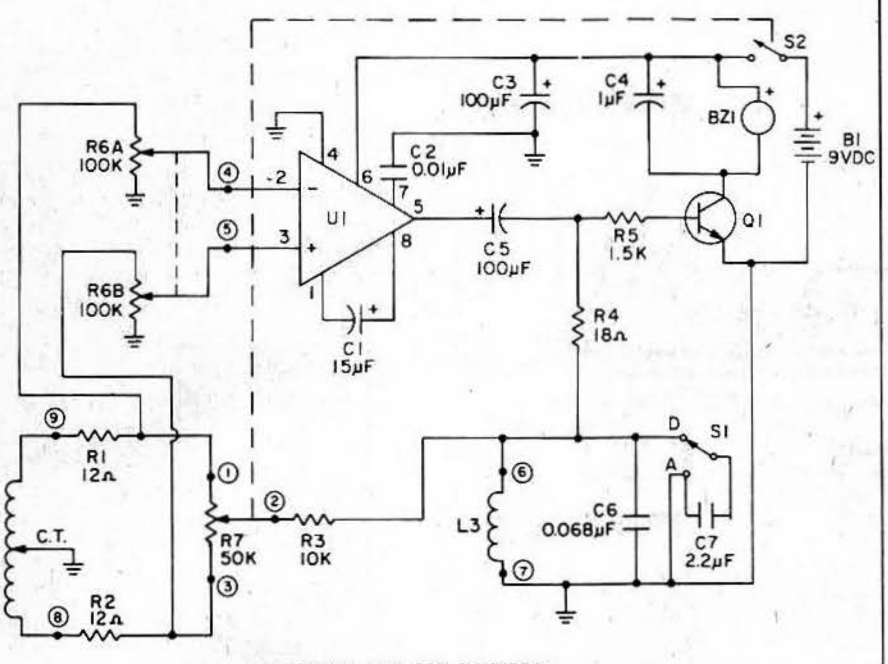
When the coils are completely wound, bind them with tape before removing them from the form. This will help to hold their shape until they are installed on the search head.

Final Assembly/Calibration. Before permanently attaching the coils to the plywood head, it is best to tack them down temporarily with either tape or rubber cement (for obvious reasons, no metal fasteners can be used now or during the final attachment).

Connect L1/L2 to the PC board with 2-conductor shielded wire, attaching the inner conductors to the outside ends of L1 and L2 (points 8 and 9), and using the braided shield for the center tap ground connection. The shield should be grounded to circuit ground on the PC board. Single conductor shielded wire is used for the connection of L3 to the circuit, with the braided shield used for the grounded side of the coil. Solder the braid to circuit ground on the PC board as you did for L1/L2.

Set R6A/R6B to a two-thirds clockwise position, and set R7 to its midpoint. When you throw power switch S2 on, the buzzer should *not* sound. If it does, reverse the L3 connections at the coil end and try again. Slowly reduce the amount of overlap between the two coils until the buzzer sounds. At this point, backing off counter-clockwise on R6A/R6B should cause the buzzer to silence. If this is the case, manently to the search head.

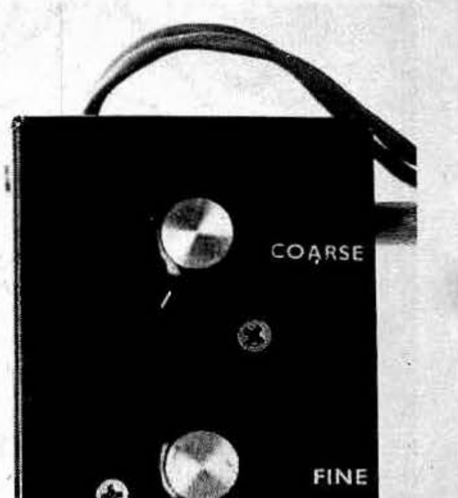
As a final test, return R6A/R6B to the two-thirds position, set R7 just below the point where the buzzer sounds,



PARTS LIST FOR HOUNDOG

- **B1**—9-VDC transistor battery
- **BZ1**—piezoelectric buzzer (Radio Shack #273-060)
- **C1**—15-uF, 15-VDC electrolytic capacitor
- **C2**—0.01-uF, 50-VDC ceramic capacitor
- **C3, C5**—100-uF, 35-VDC electrolytic capacitor
- **C4**—1-uF, 35-VDC electrolytic capacitor
- **C6**—0.068-uF, 25-VDC mylar capacitor
- **C7**—2.2-uF, 35-VDC non-polarized electrolytic capacitor
- **L1, L2**—30 turns of #20 enameled copper wire see text
- **L3**—60 turns of #20 enameled copper wire
- **Q1**—2N5210 NPN low-level transistor
- **R1, R2**—12-ohm, ½-watt resistor, 10%
- **R3**—10,000-ohm, ½-watt resistor, 10%
- **R4**—18-ohm, ½-watt resistor, 10%
- **R5**—1,500-ohm, ½-watt resistor, 10%
- **R6A/R6B**—dual-section 100,000-ohm linear-taper potentiometer
- **R7**—50,000-ohm linear-taper potentiometer with SPST switch (S2)
- **S1**—SPDT slide switch
- **S2**—SPST rotary switch (part of R7)
- **U1**—LM386 audio amp integrated circuit
- **Misc.**—battery clip, aluminum chassis, hookup wire, solder, spacers, knobs, 200-foot roll of #20 enameled copper wire, weatherproofing finisher (varnish, shellac, polyurethane, etc.), non-metallic support rod, 10-feet of 2-conductor shielded wire, 10-feet of 1-conductor shielded wire, ¼-inch plywood stock, etc.

For pricing on parts and pre-etched, printed-circuit board for Houndog write to Niccum Electronics, Rte. 3, Box 271B, Stroud, OK 74079. Be sure to include a stamped, self-addressed envelope.



Houndog's control head is laid out simply; there's an SPDT switch and two adjustments.

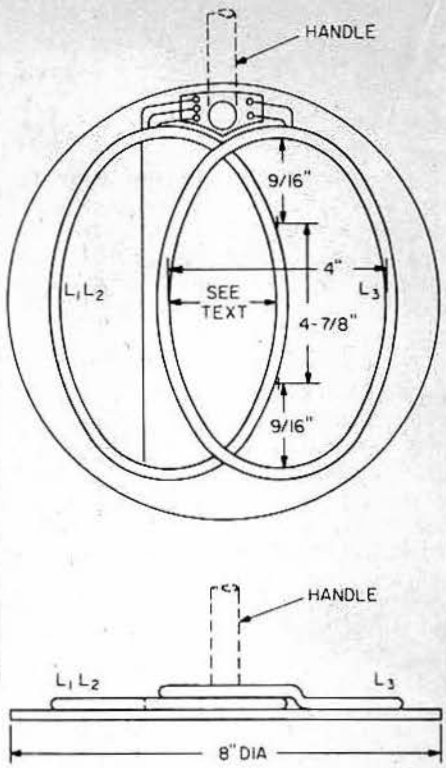
HOUNDOG

and S1 to the "discriminate" position. Bring a penny directly above the coils' overlap, and lower it to a height of about 3-inches above the coils. If the buzzer does not sound, try re-peaking R6A/R6B and R7 for a lower threshold (increase R6A/R6B more clockwise, while backing off more on R7 to stop oscillation) and repeat the procedure. Three inches should be the minimum distance at which *Houndog* detects the presence of the penny.

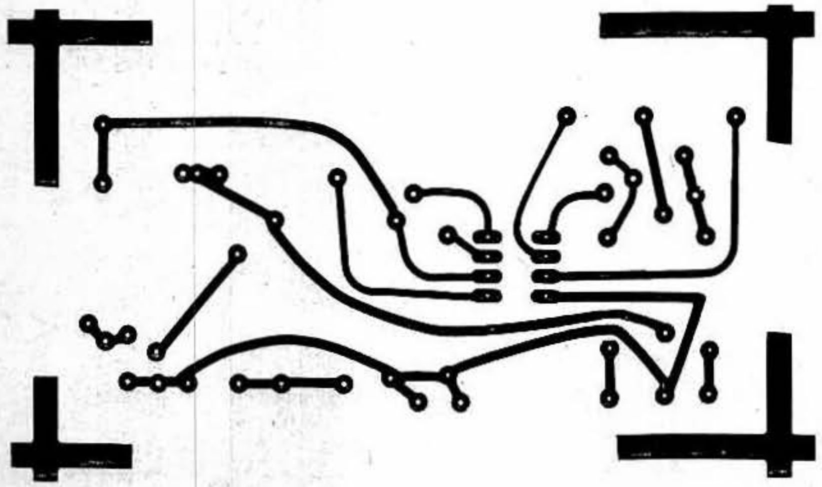
Remember that when conducting these tests, you should be in an area free from the presence of large metallic objects, such as radiators, pipes and ducts, etc. Their presence may cause you to set the sensitivity of R6A/R6B too low, making actual measurements against coins ineffective to the point of believing that the unit is not working.

You may now attach the coils to the head in a permanent manner with epoxy or several coats of polyurethane or shellac, in order to affix the coils firmly.

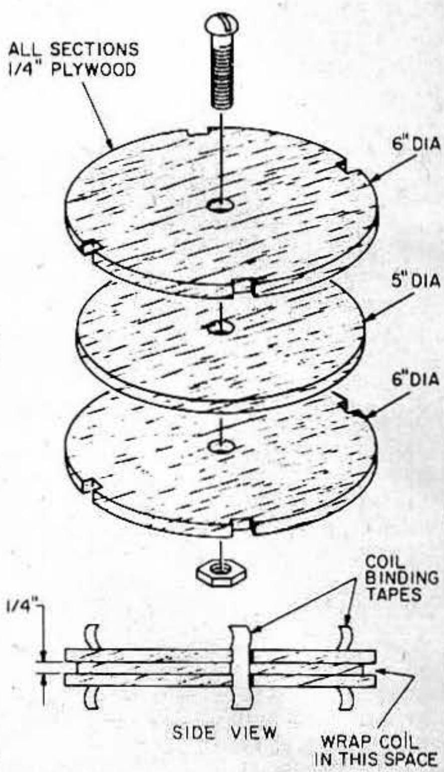
Conclusion. Once you get out of doors with *Houndog*, it might be wise to bury some treasure of your own, and adjust the controls for maximum sensitivity depending upon the type of soil found in your locality. These adjustments will vary from area to area, depending upon soil composition, which is why we haven't used a calibrated dial for the potentiometers. Don't be discouraged if your first few hours of searching with S1 set to the "discriminate" (coins) position don't unearth Captain Kidd's treasure chest. With S1 set in the "all" position, you'll get a lot more "barks," but you might find a lot of tin cans and beer can pull-tops for your efforts. Patience is a virtue in this hobby. ■



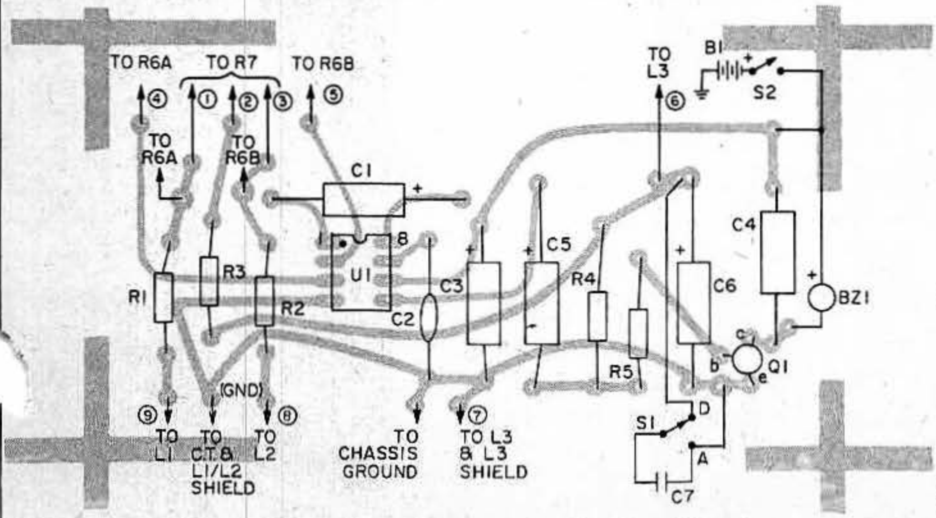
The dimensioning guide for the search head shows you how to bend round coils into the elliptical shape necessary for installation on the search head plywood base.



Here is the full scale etching guide for Houndog's PC board. If you purchase a Niccum PC board, the layout may differ slightly. Follow their assembly instructions for it.

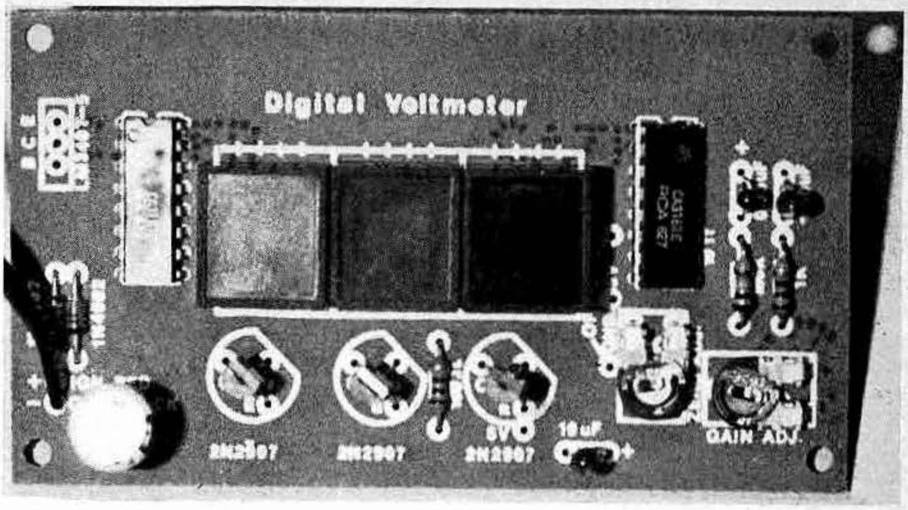


Use this template for winding the coils. The finished coils will be circular, and you will have to bend them into an oval, as seen in the diagram above, to fit them.



The component layout guide gives you the connections for the off-board components. If you use another method of assembly, rest assured that parts layout isn't critical.

Dashboard Digital Voltmeter



Keep an electronic eye on the voltage level of your vehicle's electrical system and save on expensive repair bills later

YOU'RE MAKING TIME down the interstate at three in the morning, and all of a sudden you become aware that the lights on the dash seem kind of dim, and that the headlights don't seem to be reaching out as far ahead to warn you of darkened semis parked on the shoulder. Are your eyes just playing tricks on you, or is there something the matter with your car's electrical system? A quick glance down at the three glowing LED numerals on the dash gives you the instant answer. Either you pull into a rest area and grab a few hours of shuteye, or you pull into a service area and have the battery, alternator and voltage regulator given a good scrutinizing by the mechanic.

In either case, your car's digital voltmeter has given you the information sought about the state of the electrical system, and maybe saved you either a headache, a smashup, or a king-sized repair and towing bill. Maybe all three.

Recent advances in the design and availability of industrial integrated circuits have opened up many doors to the electronics hobbyists. Analog-to-digital devices have become more complex internally, thus making the portions of the circuitry which have to be assembled by the hobbyist that much more simple. The Dashboard Digital Voltmeter takes advantage of these advances, utilizing three ICs and a small handful of discrete components to give you an instrument capable of better than ± 1% accuracy in reading the voltage level delivered by your car's (or boat's) electrical system.

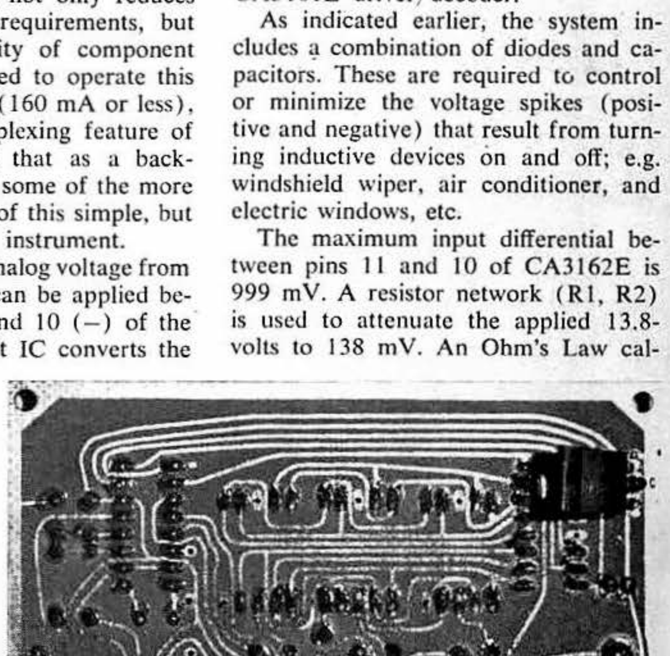
Two New ICs. The system is built about three ICs: the LM340T-5 (a 5-volt regulator now available for several years); a CA3162E; a CA3161E; and a support combination of diodes, resistors, and capacitors. It is the CA3161E and CA3162E that now open the door to new horizons in possible applications not only because of their unique capabilities, but also because they reduce substantially the numbers and types of formerly required support components. The heart of this system is the CA-3162E, a dual-slope, dual-speed, A/D converter industrial chip. Its almost equally important companion, the CA-3161E, is a BCD, 7-segment, decoder/driver chip. It is also unique in that it has a current-limiting feature. This eliminates the necessity of resistors in series with the 7-segment displays that were required in earlier designs.

The above feature not only reduces circuit board space requirements, but reduces the probability of component failure. Power required to operate this voltmeter is minimal (160 mA or less), a result of the multiplexing feature of the CA3162E. With that as a background, let's consider some of the more important operations of this simple, but very accurate digital instrument.

Circuit Function. Analog voltage from 000 mV to 999 mV can be applied between pins 11 (+) and 10 (−) of the CA3162E (U2). That IC converts the voltage into a Binary Coded Decimal (BCD) equivalent. The BCD leaves pins 2, 1, 15, and 16 (the group represents the 1's, 2's, 4's, and 8's) and enters pins 7, 1, 2, and 6 respectively of the CA3161E (U3). The latter IC takes the BCD code, converts the output, then uses it (in conjunction with the 7-segment display) to generate (form) the number that correlates to the BCD input of the CA3161E. The multiplexing driver pins 5, 3, and 4 (5 being the least significant and 4 the most significant) turn on that display by means of the PNP switching transistors. Concurrently, the CA3162E is providing the BCD information to the CA3161E driver/decoder.

As indicated earlier, the system includes a combination of diodes and capacitors. These are required to control or minimize the voltage spikes (positive and negative) that result from turning inductive devices on and off; e.g. windshield wiper, air conditioner, and electric windows, etc.

The maximum input differential between pins 11 and 10 of CA3162E is 999 mV. A resistor network (R1, R2) is used to attenuate the applied 13.8-volts to 138 mV. An Ohm's Law cal-



This view of the assembled PC board shows the voltage regulator, (U1) mounted on the underside of the PC board. This was done in order to accommodate a flush-mount installation in a smaller car. Let your space needs dictate placement of this component.

Digital Voltmeter

culation would give a result of 136.6 mV. The gain-adjust potentiometer compensates for the slight drop. The FND 507s display this as 13.8-volts.

Note the point marked OPTION on the schematic. With Pin 6 of the CA-3162E grounded or disconnected, there are four conversions or comparisons made each second. Tying pin 6 to the 5-volt line will result in 96 conversions or comparisons per second. The 96/second rate moves with excessive rapidity, is not appealing to the eye, and usually results in the least significant digit appearing to be blurred. Of the two rates, the 4/second conversion (4 Hz) is by far the more pleasing to the eye, is easier for the eye to focus on quickly, and is the recommended rate. These rates could vary slightly because of capacitor difference and manufacturer variance from stated values.

Assembling the Voltmeter. The unit may be assembled quickly and relatively easily using a predrilled and etched circuit board. If a Digital World circuit board is being used, the four corner holes will have been drilled. If a blank board is being used, drill the corner holes *before* starting to "stuff" the board. It is easy at this point to scribe the plexiglass panel and mark the corner holes on it for later drilling and perfect alignment. Additionally, examine the recess or place where the completed unit will be mounted. Determine how it will be secured (bolted, clamped, or glued), doing any additional drilling that may be required.

Get the workbench ready for soldering. Use a low wattage, electrically-isolated, fine-tipped soldering tool and fine solder. A blunt-nosed tool could damage or destroy the ICs and create foil bridges between pins. This is both expensive and frustrating. If you have had limited experience in soldering in small areas, it may be wise to practice on something else before you start.

Now, locate all resistors and potentiometers on the circuit board placement diagram and install them in their respective holes. Next, do the same for all capacitors, observing polarity. Install the CA3161E and CA3162E. *Caution!* When inserting the ICs, be careful *not* to fold the pins under or bend them in any way.

IC *orientation* is critical. Be sure these chips (CA3162E and CA3161E) are aligned as shown on the diagram. Note the notch mark on the chips and the corresponding notch mark on the schematic, or the "1" on pin 1 on top of the plastic case. All manufacturers use one or both of these base reference directional indicators.

If you have doubts about your soldering ability or the type of solder tool you have (grounded or not grounded), place two 16-pin sockets in the chip holes. The ICs may then be placed (not soldered) in the sockets. Next, insert the three LEDs, noting the notch marks on the LEDs and the notch marks indicated on the diagram. For the final action on this side of the board, insert both diodes in their respective holes (observing cathode markings).

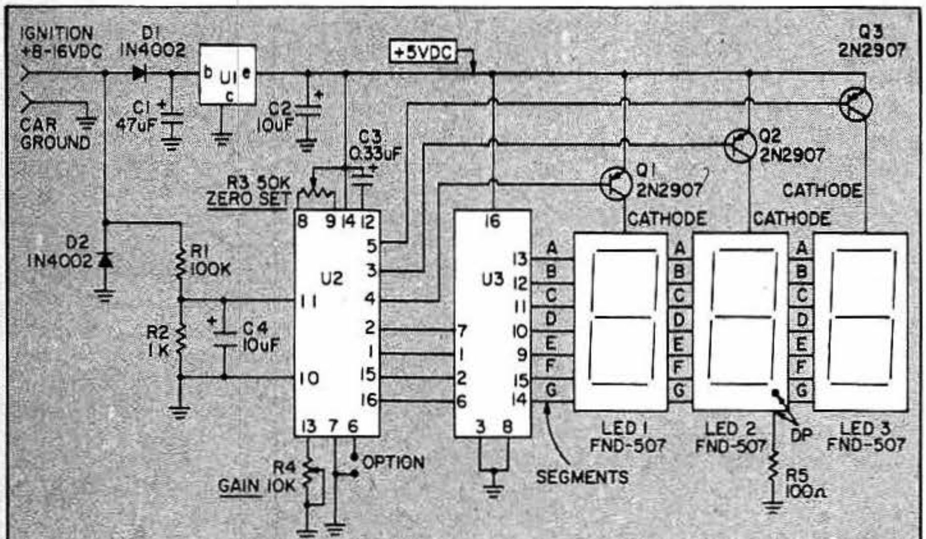
Reverse the circuit board and install the LM340T-5 regulator. *Caution!* This must be correctly placed or it will destroy your unit when power is applied. The *metal side* of the regulator must be facing the FND 507 pins. Recheck it to make sure.

Now, turn the board over again. Use a red wire for the ignition line and a black wire for the chassis ground. Determine the lengths required (usually three-feet is sufficient). Solder the red wire to the point marked IGNITION on the diagram and the black wire to the GROUND.

Calibration Procedure. Correct calibration determines the accuracy of your voltmeter. Follow these steps carefully and sequentially. Apply a *known* voltage source (above 10 and below 16-volts) to the IGNITION point. We recommend a 13.8-volt source. Next, for zero adjustment, ground pins 11 and 10 to the circuit board ground momentarily. Using a small screwdriver, slowly rotate the wiper arm on R3 until there is a reading of 000. Remove the ground from pins 10 and 11. Set the *gain control* (R4) by rotating the wiper arm until the displays are displaying the same voltage as is being applied.

Installation. One final action is necessary before your unit is ready to be mounted in the dash location of your choice. Secure the black wire to the metal chassis ground and the red wire to any accessory line that is active only when the motor is running. Secure and mount the voltmeter in the location of your choice.

A colored plexiglass facing (cover) is required and we recommend red for most display contrast. A location which is not usually exposed to the sunlight will make the displays easier to read during the brighter periods of the day. If the unit is going into an existing recess, the present glass cover may be



PARTS LIST FOR DIGITAL VOLTMETER

C1—47-uF electrolytic capacitor, 25 VDC
C2, C4—10-uF tantalum electrolytic capacitor, 16 VDC
C3—0.33-uF tantalum capacitor, 35 VDC
D1, D2—1N4002 diode
F1—1-amp fuse
LED1, 2, 3—FND-507 7-segment LED display
Q1, 2, 3—2N2907 PNP transistor
R1—100,000-ohm, ¼-watt resistor, 5%
R2—1,000-ohm, ¼-watt resistor, 5%
R3—50,000-ohm PC trimmer potentiometer
R4—10,000-ohm PC trimmer potentiometer
R5—100-ohm, ¼-watt resistor, 5%
U1—LM340T-5 5-volt voltage regulator
U2—CA3162E Analog-to-Digital converter
U3—CA3161E BCD display driver
Misc.—solder, hookup wire, red plexiglass (for display filter), IC sockets, transistor sockets, suitable enclosure, etc.

For information on the availability and prices on parts and printed-circuit board for Digital Voltmeter write to Digital World, P.O. Box 5508, Augusta, GA 30906. Be sure to enclose a business-size, stamped, self-addressed envelope.

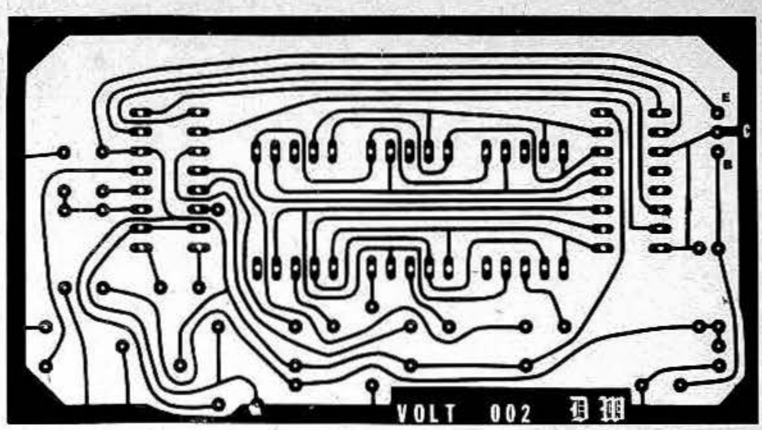
used as a template for the plexiglass cover dimensions. One-eighth or ⅟₁₆-inch thickness plexiglass works well and is relatively easy to cut using a roofer's shingle cutter knife. Place two clamps on a straight line along the template edge, then cut one side at a time. Scribe it deeply with a dozen or more strokes, then break off the excess with a pliers. When drilling screw holes, use a small starter bit first, then the larger bit. This should prevent the larger bit from wandering across the plexiglass.

The plexiglass must be "spaced" away from the board by approximately ⅝-inch, using either spacers or the bolt/nut method. The latter method is to insert a bolt through the plexiglass corner hole and put a nut on the reverse side. Put a second nut on the bolt, allowing a ½-inch inside space between the two nuts. Do this on all corners. Next, insert the bolts into the board corner holes and put on the final nuts. We recommend securing all four corners, rather than just two.

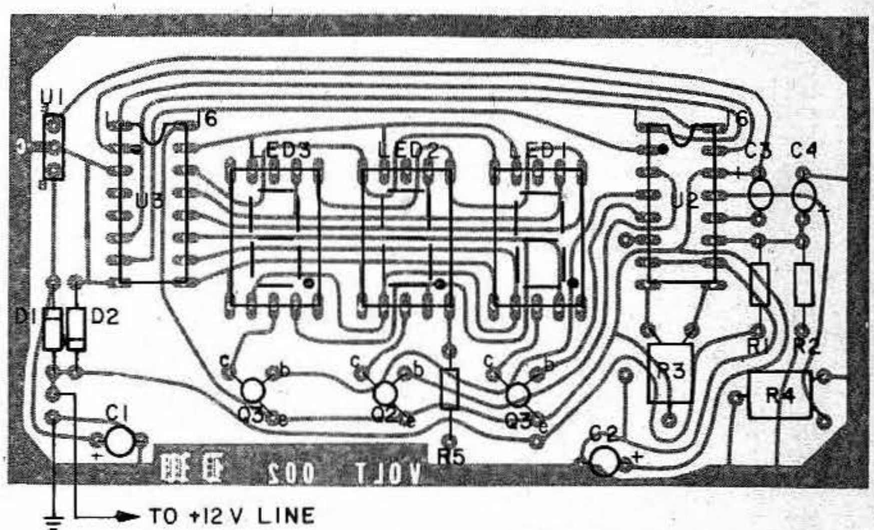
Troubleshooting. If the unit does not light up for the calibration procedure, first check that the wiper of R3 is centered. If it still does not light up, recheck your work. Carefully inspect for possible solder bridges and loose connections. If a solder bridge is discovered, remove it carefully. It is easy to destroy a chip during the removal process. If it still fails to light up, start a systematic test check to isolate possible faulty component(s).

If the unit does not function after installation, recheck for a good electrical connection on the line that supplies power from the car. Did you break or loosen the solder connections of the source wires during installation? If so, this will require removal and resoldering, plus a bit more care during installation the second time.

One Final Note. Some ICs, and quite possibly the ones used in this project, generate high frequency harmonics which might find their way into your car's radio. Try holding your LED readout pocket calculator next to the radio antenna with the radio tuned to a blank spot on the AM dial to see what we mean. If you experience any interference from the voltmeter circuit, try rerouting the antenna coax away from the voltmeter itself. A metal case around the voltmeter's PC board will also aid in the reduction of RFI. We suggest that you avoid using the radio's power lead as the voltage source for your voltmeter. The power lead to the horn (or horn relay) or the hot lead of the windshield wiper switch (find it at the fuse box) is probably the best place to attach the voltmeter. ■



This full-scale etching guide for the voltmeter's PC board is one of the trickiest we've offered. Unless you know your stuff, we suggest you use a Digital World board.



The component placement diagram for the PC board shows all IC and capacitor polarities. Take special care to observe them during assembly phases of project.

Even the best voltmeter in the world won't help you keep your car running if you don't take care of your battery. Check water level often and add only pure, distilled water.

SUPERBASS AMPLIFIER

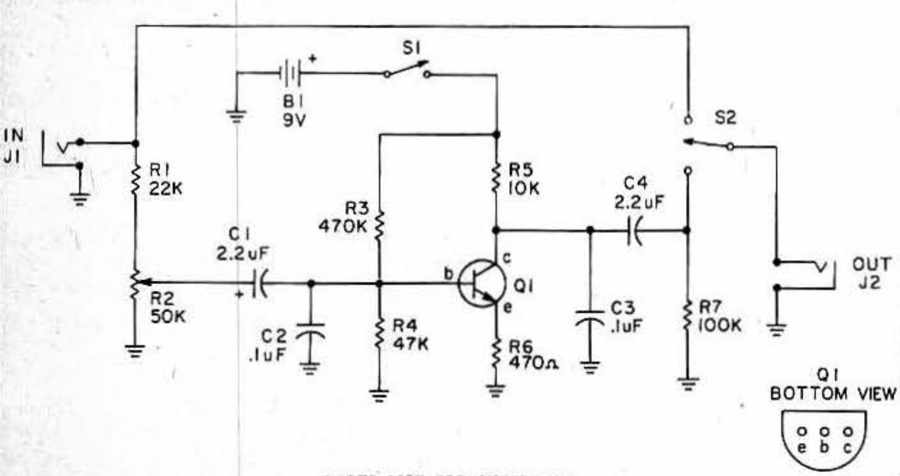
Increase the bass output of your present instrument at modest cost!

Superbass is today's sound . . . whether it's the driving, gut-vibrating pulsations of disco, or the solid bass line of soft, hard, or laid-back rock. One way to get the modern superbass sound without running out and buying an all-new expensive piece of equipment is to use a Superbass amplifier between your guitar, electronic organ or what-have-you, and the instrument amplifier.

A Superbass strips the highs from the instrument's output signal and amplifies low frequencies, feeding on "all-bass" sound to the instrument amplifier. Naturally, the bigger the speakers used with the amp, the more powerful the bass: use 15-inchers with a Superbass and you can rattle the windows.

The Superbass is powered by an ordinary 9-volt transistor radio battery. It is keyed in and out—switching from superbass to standard instrument output—by a foot operated switch. A level control allows you to equalize the superbass sound level with that of the musical instrument, so your volume level remains relatively constant as you key the superbass sound in and out. Of course, if you want the superbass to be louder or softer than the unequalized sound, you can adjust the level control accordingly.

The superbass connects between your instrument and its amplifier through two standard phone jacks—you can use your regular "patch cords"



PARTS LIST FOR SUPERBASS

- **B1**—9-volt battery, Burgess 2U6 or equivalent
- **C1, C4**—2.2-4.7-uF, 10-VDC electrolytic capacitor (see text)
- **C2, C3**—0.1-uF Mylar capacitor, rated 10-VDC or higher
- **J1, J2**—3-conductor, ¼-inch phone jack
- **Q1**—NPN transistor (Radio Shack RS-2010, or equiv.)
- All resistors 1/10 or 1/4-watt, 10%
- **R1**—22,000-ohm resistor
- **R2**—100,000-ohm audio taper potentionmeter (see text)
- **R3**—470,000-ohm resistor
- **R4**—47,000-ohm resistor
- **R5**—10,000-ohm resistor
- **R6**—470-ohm resistor
- **R7**—100,000-ohm resistor
- **S1**—SPST switch (see text)
- **S2**—SPDT push On-push Off switch

Misc.—9-volt battery clip, aluminum cabinet, screws and other hardware.

Construction. Since you're going to stomp down on a footswitch to key the superbass in and out, the project should be assembled in a sturdy metal cabinet. We suggest one of the flat "instrument-type" cabinets which are available from time to time. The project fits nicely into a 1¼-inch x 3-inch x 5½-inch cabinet such as the one shown in the photographs. The "instrument" cabinets are not always available; as a substitute we suggest an aluminum "handy" or "Minibox." Do not use a plastic cabinet with a metal cover because it will probably fall apart after a few stomps.

Plug-in Circuitry. The amplifier itself can be assembled on a small printed circuit board, or on a perf-board using point-to-point wiring. Perhaps the easiest construction is the one used for the model shown: it uses a combination of printed circuit and perf-board. The board is an "Op-Amp IC Experimental Breadboard," available from Radio Shack stores. It has factory-etched copper strips, ground loops and buses that are pre-drilled in a perf-board pattern. You simply plug the parts into the board so the leads stick out on the foil side and solder. When finished, you have a printed circuit without the bother of making the PC board itself. (Use a 1½-inch x 1⅞-inch piece for this project.)

While the overall layout isn't critical, try to follow the layout shown because it keeps cables and the level control away from the footswitch. To conserve space, level control R2 can be any type of miniature audio taper potentiometer.

The battery is held in place by a small L-bracket. To prevent the battery from sliding around, two small strips of cork or rubber are cemented to the bracket. The bracket should be positioned so the battery must be lightly forced into position—in this way the

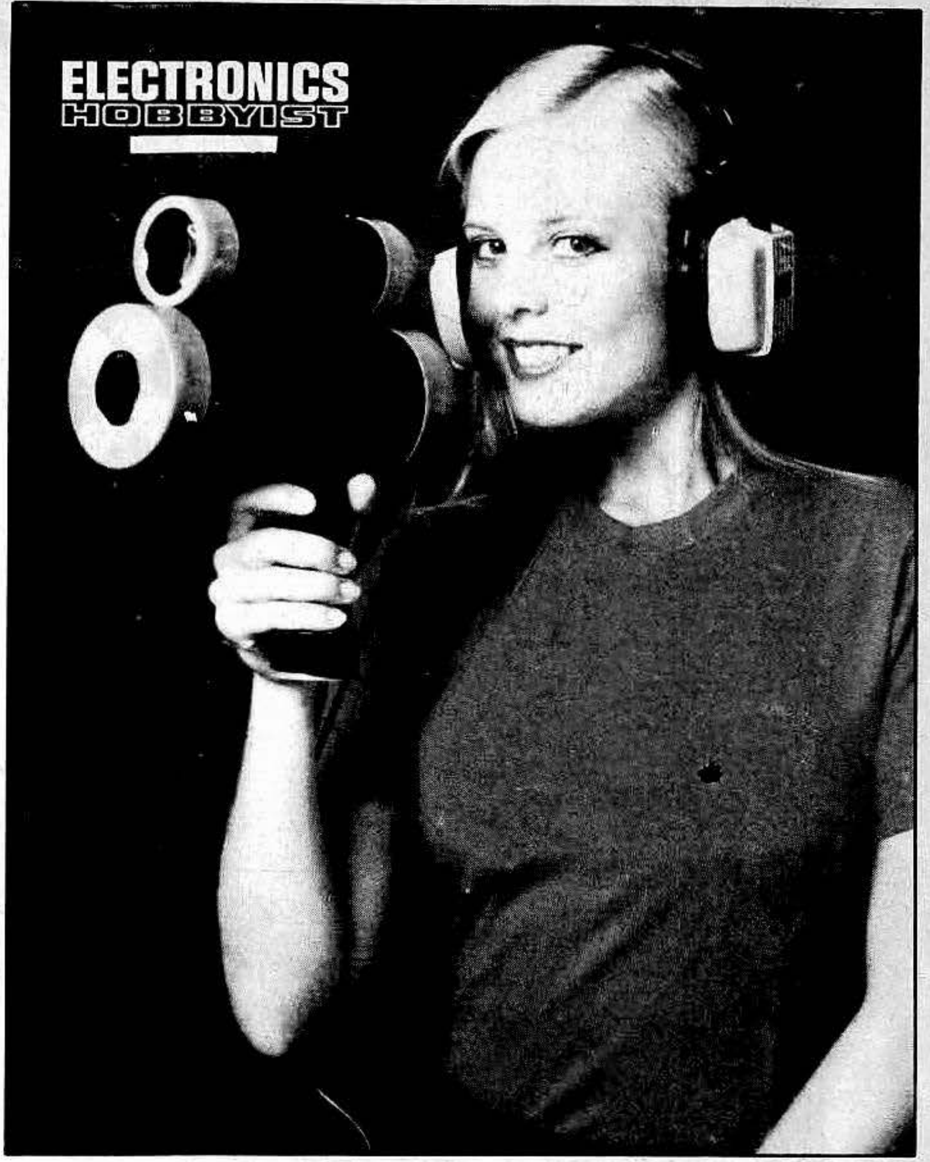
(Continued on page 94)

HAVE YOU EVER TRIED to communicate when skip was coming in over the CB band? Interference from local stations, was only exceeded by interference from long distance stations. The channels were so crowded that stations were as tight as packed sardines. Communication was impossible. There is an intriguing solution to this common problem. Leave the roaring CB crowd behind, and escape up to the light waves.

The Light Beam Communicator described here demonstrates how a light beam can be used for voice transmission. This communicator is also useful to trap intruders at a remote location, and as a top secret communications link between two stations.

The clarity and quality of audio reproduction is crystal clear, with more than enough pick-up sensitivity and modulation power than normally would be needed. Range of the units should be line of sight up to 1000 meters or better. Alignment is easily accomplished by sighting along the barrels of the units. Short range communication (several hundred meters) is easily accomplished by simple sighting to one another's respective units. Long range setups are more conveniently obtained using a camera tripod. Units are built in a pistol-type configuration with all power and optics self-contained. A rear panel contains the necessary controls for operating along with jacks for headsets and a built-in microphone. The device is designed so that it also can be used for actual "listening" to other light sources such as TV pictures, scopes, fluorescents and many other infra-red and invisible radiation sources.

Normally, the units are built using a visible red transmitter for ease and convenience in nighttime alignment. For serious longer range, low noise performance they can be equipped with optional filters for invisible infra-red transmitting capabilities.



Light Beam Communicator

Talk over a beam of light with this transceiver

Looking at The Circuit. The light beam transmitter-receiver consists of a phototransistor receiver which picks up modulated light that is fed through a high gain amplifier and then to headsets or a loud speaker. When in the transmit mode, the amplifier becomes a sensitive mike pre-amp that drives a current amplifier modulating a light emitting diode as the transmitter.

The receiver section consists of a phototransistor (Q4) positioned at the focal point of lens LE2 inside enclosure EN2 (A separate enclosure, lens and phototransistor for transmitting and receiving enhances the flexibility and performance of the device. This, however, adds to the cost. Duplicating these components for both functions could be done, however, overall performance is sacrificed.)

Q4 is mechanically secured to a sliding dowel DO1 that is adjusted to its proper distance from LE2 and secured with a screw. The signal from Q4 is fed into J1 via a shielded cable to keep hum and other electrical pickup to a minimum. Switch S2A now selects J1 in the *receive* mode and feeds the signal to the amplifier via C1. The signal is now matched and amplified via the integrated circuit U1. A gain control R7 controls the sensitivity of the amplifier and also serves as an ON/OFF switch for the receiver section. The output of U1 is now further amplified by Q1 and impedance matched via transformer T1. S2B now connects T1 and J2 for feeding 8-ohm headsets or an external speaker.

The transmitter section consists of a narrow beam visible red or optional infra-red light emitting diode LED1 located at the focal point of lens LE2 inside enclosure EN1. EN1 also contains the electronics and controls for hand grip EN3. A mike M1 is located on the rear panel RP1 and is fed to the amplifier U1 through C1 via mode select switch S2A. The amplifier now becomes a pre-amp for the mike. The output of the preamp is further amplified by Q1 and impedance matched by T1. The output of T1 is fed to Q2 via S2B. Q2 is DC coupled to Q3 whose quiescent state is selected via R15 in determining the DC current through LED1. A modulation signal is AC coupled to Q2 via C8. The hole is covered to minimize random light or noise in the circuit.

Power for the transmitter section Q2, Q3 and LED1 is from battery B3, is controlled by S2C and is used only during transmit mode. This enables the device to be used as a receiver. used as a receiver.

Construction. Begin by making the following parts. The parts list supplies details on how to purchase the items already fabricated. The main enclosure EN1 is an 8-inch long piece of PVC tubing, with a 3½-inch outside diameter. This is sometimes called schedule 40 PVC tubing. PVC tubing is obtained in plumbing supply stores, hardware stores or building supply outlets.

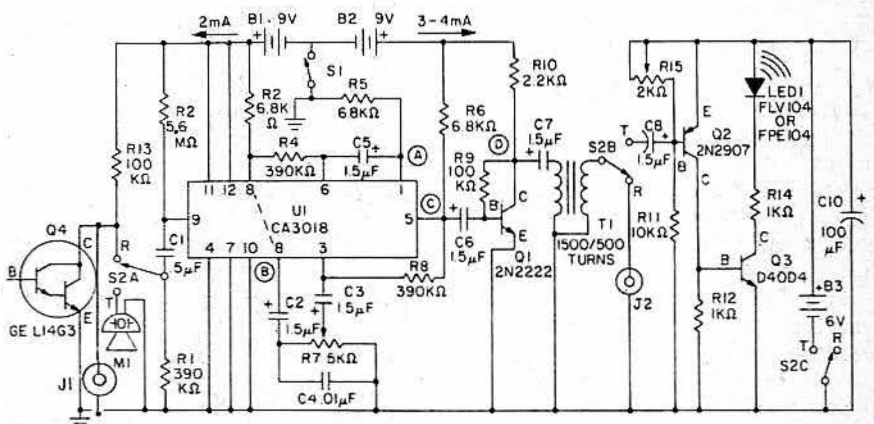
Cut a 2-inch hole for the handle, using a hole saw. As the assembly diagram shows, this hole is located 3 spectively from the rear end. File a ¼-inch slot on each side of the hole that is 2½-inches from the back of EN2. Remember to curve the slot to take into account the pivoting action of EN2's other screw when optical alignment is later attempted. piece of PVC tubing with a 2⅜-inch outside diameter. Next, drill a ¾-inch hole approximately 3 inches from the rear end of the receiver enclosure. This hole is for optical alignment. There are two mating holes to secure the receiver enclosure to EN1. These holes are on top of the piece to allow access with a screwdriver. The bore axis of these two tubes must be parallel. The large ¾-inch hole can be covered with a plug or a piece of tape.

Transformer T1 has a 3:1 turn ratio of 1500 to 500 turns.

The handle and battery enclosure EN3 is a 6-inch long piece of PVC tubing (schedule 40) with a 2-inch outside diameter. Insert the handle after everything has been assembled, and glue it with PVC cement.

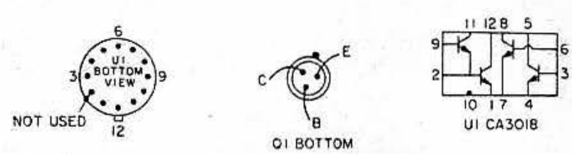
PARTS LIST FOR LIGHT BEAM COMMUNICATOR

C1—0.5-mF, 25-VDC disc capacitor
C2, 3—1.5mF, 35-VDC tantalum capacitors
C4—.01-mF, 25-VDC disc capacitor
C5-8—1.5mF, 35-VDC tantalum capacitors
C9—.01-mF, 25-VDC disc capacitor, across battery, omitted in this model.
C10—100-mF, 25-VDC electrolytic capacitor
J1, 2—RCA jacks
LED1—Small light emitting diode, visible red, FLV104 or infra-red, FPE104
M1—small crystal mike (any type)
Q1—2N2222 NPN transistor
Q2—2N2907 PNP transistor
Q3—D40D4 NPN transistor
Q4—GE L14G3 phototransistor
R1—390,000-ohm ¼-watt, 10% resistor (all resistors 10% unless otherwise noted)
R2—5,600,000-ohm, ¼-watt resistor
R3—6,800-ohm, ¼-watt resistor
R4—390,000-ohm, ¼ watt resistor
R5, 6—6,800-ohm, ¼ watt resistors
R7—5,000-ohm potentiometer with SPST switch (see S1 below)
R8—390,000-ohm, ¼-watt resistor
R9—100,000-ohm ¼-watt resistor
R10—2,200-ohm, ¼-watt resistor
R11—10,000-ohm, ¼-watt resistor
R12—1,000-ohm, ¼ watt resistor
R13—100,000-ohm, ¼ watt resistor
R14—27-ohm, ½-watt resistor
R15—2,000-ohm trimmer potentiometer
S1—SPST switch, part of potentiometer R7 above.
S2—Switch, 3-pole, 2-position rotary
T1—Transformer, 1500 turns primary winding 500 turns secondary winding
U1—CA3018, high gain amplifier
Misc.
BH1—4 AA battery holder snaps
CA1, 2—3½-inch plastic cap
CA3, 4—2⅜-inch plastic cap
CA5—1⅝-inch plastic cap
EN1—8-inch, 3½-inch OD PVC
EN2—6½-inch, 2⅜-inch OD PVC
EN3—6-inch, 2-inch OD PVC



TEST POINTS

TEST POINT	DC	PK-PK
(A)	6-8V	—
(B)	4-5V	—
(C)	3-4V	50MV
(D)	3-4V	2V



BU1—nylon ⅜-inch bushing
CL1, 2, 3—10-inch battery clips, 9-V
WR1—10-inch shielded cable
P1—RCA plug
TA1—3-inch double sided tape, ½-inch
D01—2-inch wood dowel, 1½-inch diameter
RP1—Rear panel, 3¼ x 3¼ inch, 22 gauge
MP1—Mounting plate, 2⅞ x 5½ inch, 22 gauge
SW1—2-each, 6-32 x ¼-inch screws & nuts
SW2—2-each, 6-32 x 1-inch screws & nuts
LE1, 2—Lenses, 54 x 89mm
PC1—Printed circuit board
KN1, 2—small plastic knobs
HS1—8-ohm headsets with matching transformer (not included in kits)
B1, 2—9-volt transistor batteries
B3—Four 1½ volt AA batteries
FTR1—Filter for infra-red light emitting diode
WR2—24-inch piece of #24 blue stranded hook up wire
WR3—24-inch piece of #24 red stranded hook up wire
WR4—6-inch of No. 24 buss wire

The Light Beam Communicator is available in three different kit formats. They are:
Electronic kit for one set (two units) . . $59.50
All the mechanical and optical parts for 1 set (2 units) $39.50
Combination of electronic, mechanical, and optical parts to fully assemble 1 set (2 units) $99.00
Send stamped, self-addressed envelope to Information Unlimited, P.O. Box 716, Amherst, NJ 03031 for parts availability.

The rear plate RP1 can be fabricated from a 3¼ x 3¼-inch square piece of No. 22 galvanized sheet metal or .035 aluminum. Use the RP1 template shown to locate the holes. The mounting plate MP1 is made from a 2⅞ x 5½-inch square piece of galvanized sheet metal (No. 22) or .035 aluminum. This time, use the MP1 template to locate the holes in this piece.

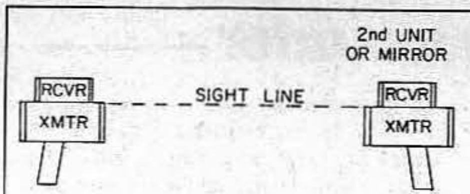
Centering dowel DO1, has a 2-inch length and an outside diameter of 1½-inches. It should fit smoothly in to EN2. The cable, WR1, is fed to the phototransistor, Q4, through a slightly off center feed hole in the dowel. The connection is made by soldering to the exposed leads of Q4. The leads should be as short as possible, and glued with RTV cement. The leads should be only long enough to allow touch up, re-positioning to the true optical axis.

The plastic cap CA1 is 3½ inches, with a 1⅝-inch hole in the center. Use a sharp knife or small snips. If you are not neat in this procedure, the appearance of the device can be ruined. Four small pieces of double sided tape (TA1) are used for securing the lens LE1 to the cap. Be sure that the tape does not contact the ridge of EN1, otherwise it will be difficult to remove for checking. The other plastic cap CA2 is 3½-inch. It has a ¼-inch lip to hold the sub-assembly into EN1.

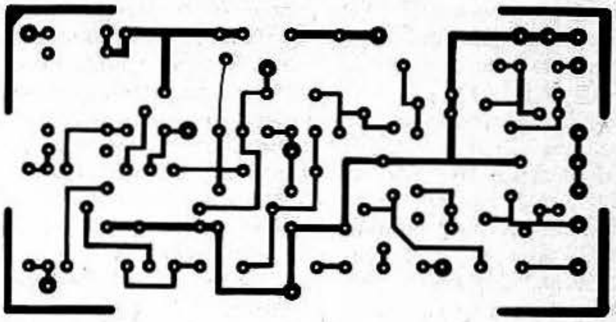
CA3 is the 2⅜-inch plastic cap. Remove the ⅜-inch lip, to retain lens, LE2, and optional filter FTR1. These are fitted against the end of EN2. CA4 is a 2⅜-inch plastic cap. Place a small hole for cable WR1, to create a friction hold and prevent DO1 from sliding once set. After alignment, secure with RTV cement. These plastic caps are available from Information Unlimited (refer to parts list).

It would be preferable to construct all circuits on a board, unless you are very familiar with perf-board assembly. If so, a 3 x 1½-inch perf-board, with a .01-inch grid, may be used. Follow the layout as shown in the printed circuit board layout. As always, use resin-core solder when you build this project. Remember to remove any excess solder from the PC board to prevent shorting.

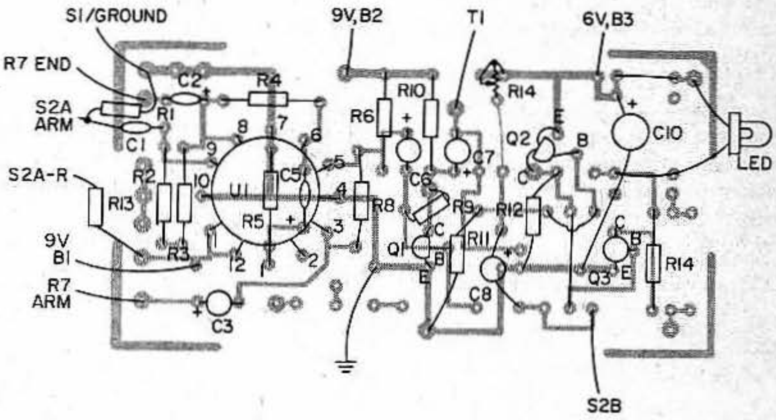
Assemble RP1 as shown in Figure three. Attach R7 to RP1 as illustrated in Figure two; the leads from R7 must be twisted and as short as possible. Connect C4 to S2 and then attach the assembly to RP1. Twist all wires together leading to S2. Route these leads close to metal. Switch leads are all identified in the schematic. Attach microphone M1 using RTC cement. Position and wire as shown. Assemble jacks J1 and J2.



Positioning Light Beam Communicator for two-way communication is line-of-sight. With ideal conditions, it is possible to send and receive up to a mile.



If you are not an expert at etching your own circuit boards, we suggest you buy the kit from Information Unlimited, which includes PC board and parts.



The parts overlay shows components on top of PC board. Note that all of the electronic components fit handily on board, making for easy assembly.

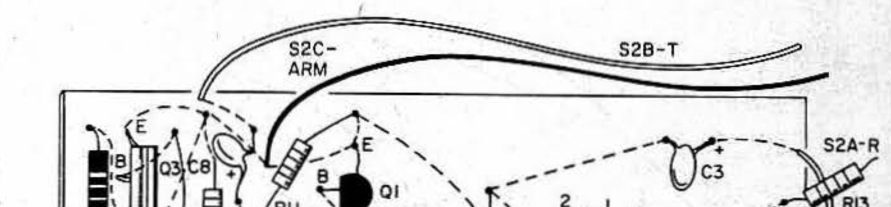


Fig. 1. Actual parts placement on the Light Beam Communicator's board is not critical; however, you must identify all of the leads going to the components to avoid confusion.

Light Beam Communicator

Attach RP1 to MP1 via screws SW1 (6-32 x ¼-inch)

Construct PC1 according to the circuit foil pattern given on the preceeding page. Assemble the board by using the schematic diagram given and Figures one and two. Note polarity of tantalum and electrolytic capacitors and the position of U1, Q1, Q2, Q3 and LED1.

Connect the wires from RP1 assembly to board noting identification of leads shown in sketches. Position as shown in Fig. 2, but do not adhere to tape at this time. Carefully position LED1 into B3 as shown. Attach battery clips CL1, 2 and 3 to respective points, as shown in Fig. four. It is advantageous at first to allow the board freedom to be moved for total access during preliminary trouble shooting and testing. Leads may be further shortened after several minutes of proper operation have been verified.

Next, attach T1 to MP1, bending tabs in the small holes. Solder one lead from primary to secondary and sandwich between core of T1 and plate. This makes the ground contact of the transformer. You may want to solder these wires directly to the plate for a positive contact. Use a heavy iron for this. Note ungrounded 500-ohm lead going to S2B and ungrounded 1.5K ohm (winding marked P) going to C7 on board.

Connect PL1 phone plug to WR1 cable from receiver section.

Testing The Units. It is assumed that the assembled unit, to this point, has been wired correctly, with no shorts, and good solder connections. You will note that the complete working unit is conveniently built on a single removable assembly. This assembly should have the battery clips CL1, 2 and 3 connected to their respective batteries.

Testing The Receiver. Turn S2 and R7 fully counterclockwise.

Connect one terminal of a fresh 9-volt battery to CL1 and connect a 100-mA ammeter between the contact of the battery and the clip. Turn on R7. Current reading should be approxmately 2-mA. Fully connect battery and designate B1.

Repeat above using a second battery connected to CL2. Turn on R7/S1. Current reading should be 3 to 4-mA. Fully connect battery designated B2.

Plug a high impedance set of headphones into J2. HS1 is a standard 8-ohm headset with a spliced in matching transformer that steps up to 1000 ohms. This is suggested, as high impedance headsets are scarce and uncomfortable to wear). Plug PL1 from Q4 (receiving phototransistor) into J1.

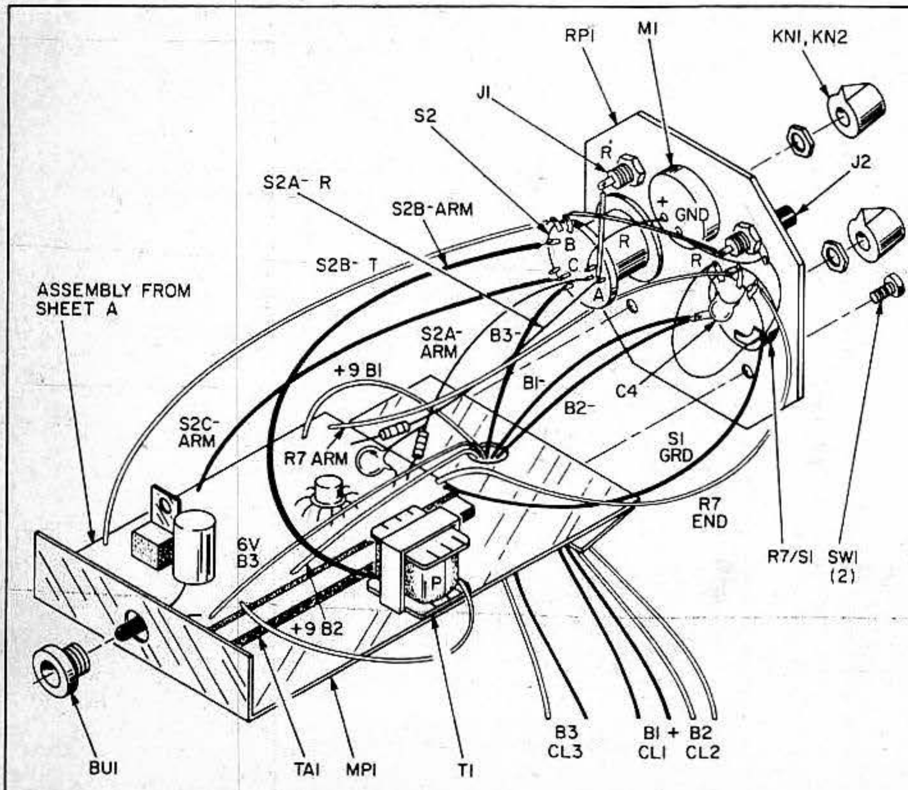
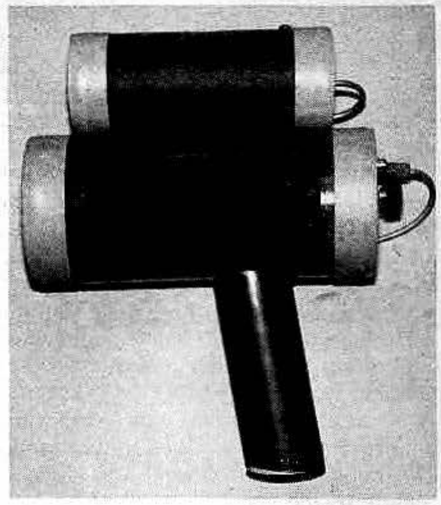


Fig. 2. Leads from the board to the rear plate assembly (RP1) are positioned as shown here. Leave plenty of free play in the leads to allow for adjustments to the device.

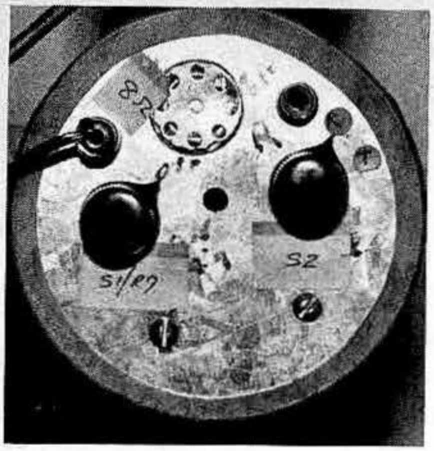


Side view of the Light Beam Communicator

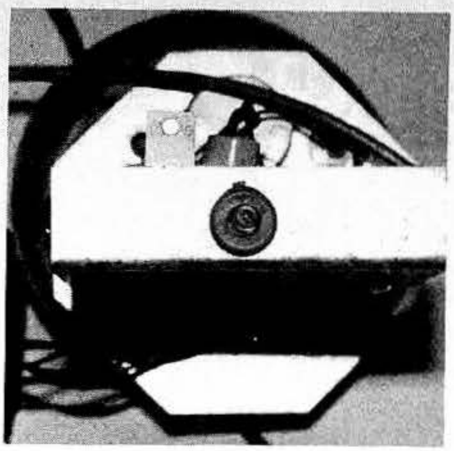
Turn on R7/S1 and slowly turn up gain until a loud 60-cycle hum is heard. This is the normal AC room lighting frequency being picked up by Q4. At normal ambient lighting conditions it will completely block the amplifier. Reduce the gain and attempt to point Q4 at various objects indicating different levels of signal, depending on reflection characteristics of surfaces, etc. You will note that the circuit is relatively prone to power line hum pick up. It is assumed that testing will be done in normay electrical lighting for this step. If not, you may not obtain the 60Hz hum.

If everything above checks out OK, you can proceed to the transmitter section. If not, troubleshoot the faulty circuit. It may be convenient to use the test points shown on the schematics and thoroughly familiarize yourself with the circuit description given in the beginning of the plans.

Testing The Transmitter. With all switches full counterclockwise, connect CL3 to 6-volt B3 as done with B1 and B2. Connect a 100-mA meter in series and turn S2 clockwise to the transmit position. Adjust R15 to read 25-50-mA. LED1 should light to about one-half maximum brilliance. Turn R7/S1 and note LED1 changing brilliance with sounds. Whistle. The current meter should jump to nearly 100mA. *Note:* LED1 increases in brilliance with sound indicating upward modulation. The device seems to work all right with the



This photo of the back end of the transceiver shows mike, mode, volume controls.



The LED, either in normal or infra-red configuration, is the heart of the transmitter.

LED1 downward modulating, but we recommend upward modulating. Certain diodes may require less current than 50-mA for good upward modulation.

You are now ready for final assembly of the unit, and optical alignment. Note that LED1 should automatically center itself inside of EN1.

Optical Alignment. In order to obtain maximum performance from your light beam communicator, it is necessary to properly optically align both transmiter and receiver according to the sight line diagram.

You will note that the receiver tube EN2 is secured to EN1 via screws. The rear hole is slotted to allow a side to side movement of the receiver enclosure in respect to the transmitter enclosure. The up and down position usually self-adjusts simply by the abutting of the two enclosures. Remember that both receiver and transmitter sections must be optically aligned to view the same area for maximum two-way communications.

The method we demonstrate here is not necessarily the only way to align these devices and is only suggested as a possible means. The builder may have his own ideas and methods for accomplishing the above.

The following steps were used at our lab and found to be relatively easy in accomplishing acceptable alignment.

1. Remove transmitter lens and cover and place some thin paper over open end. Adjust LED1's output to the center of paper (this is the bore sight of enclosure). Secure and replace the lens and cover.
2. Secure communicator in vise or other similar holding attachment.
3. Locate a mirror about 20 feet from the device.
4. With transmitter properly aligned and secured, adjust mirror for reflection of output light occuring in receiver lens. This is adjusted by sighting mirror reflection along sight line at surface intersection of the two enclosures (note drawing).

(Continued on page 96)

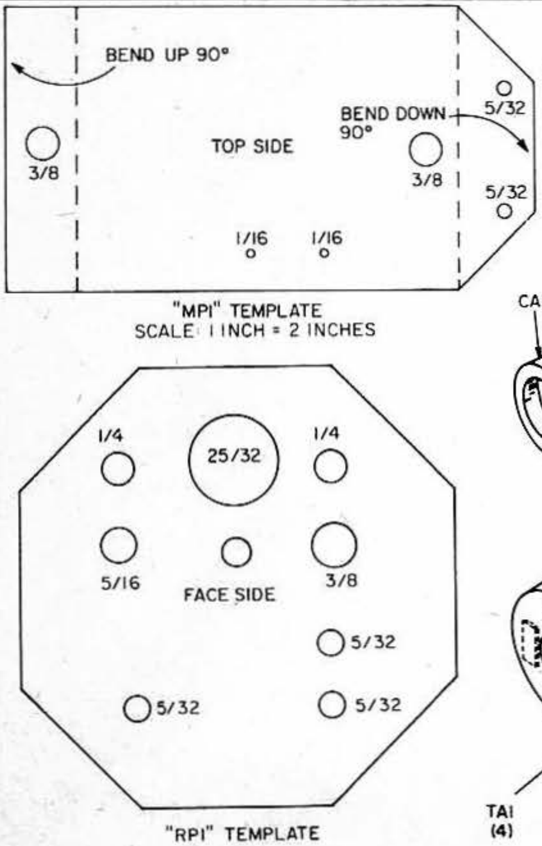


Fig. 3. This diagram shows the dimensions of the board and back plate mountings for Light Beam Communicator unit assembly.

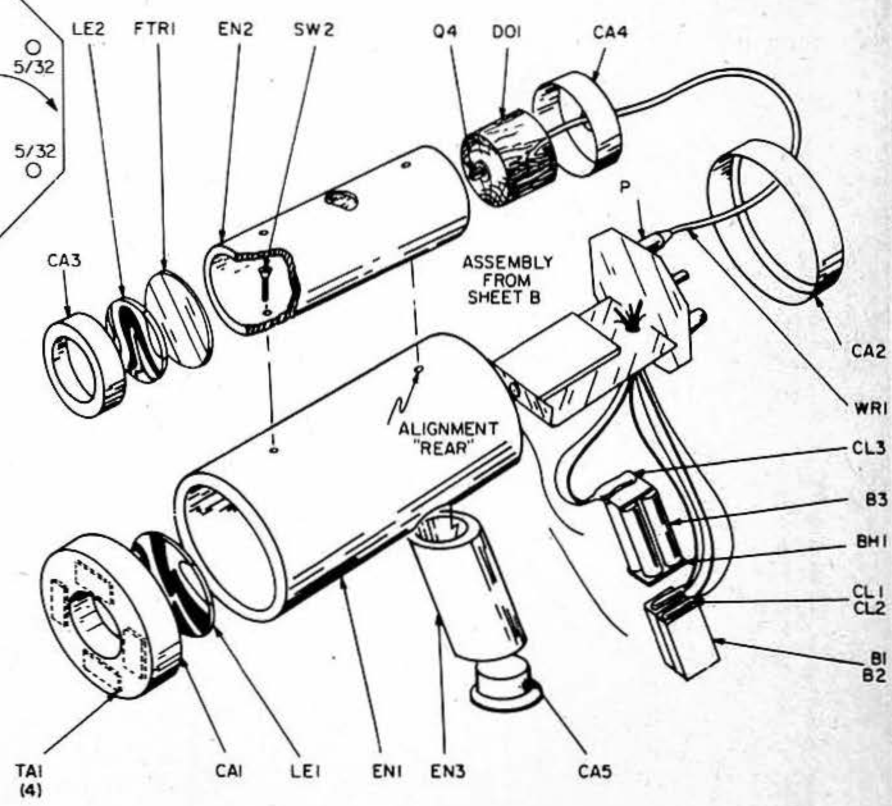
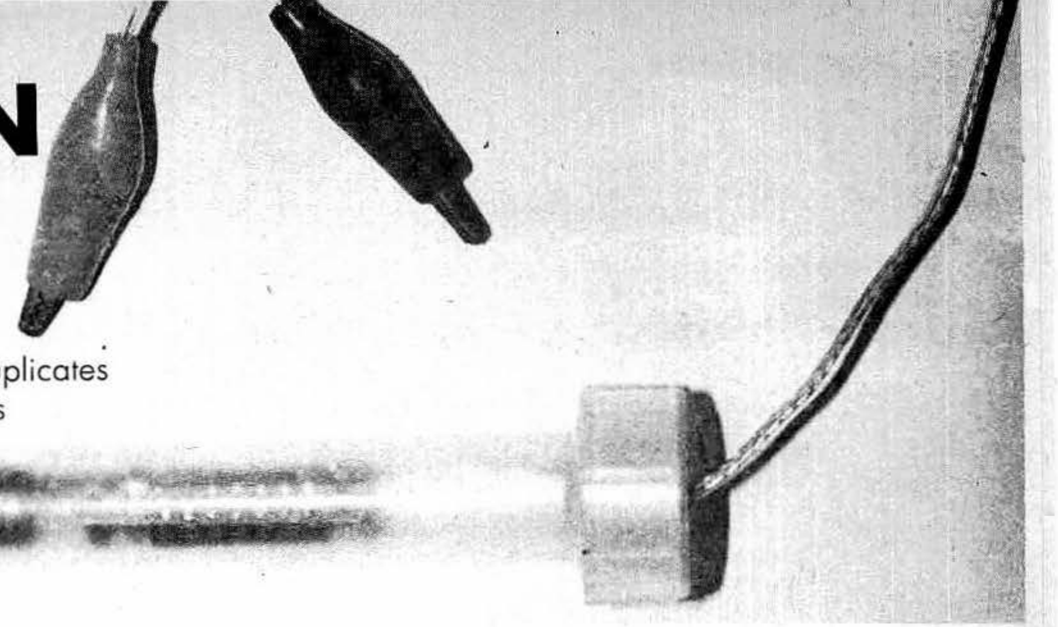


Fig. 4. This exploded view diagram shows the placement of the boards, housing, lenses and other parts necessary for construction and operation of Light Beam Communicator.

BARGAIN LOGIC PROBE

Inexpensive logic probe duplicates its more costly counterparts



WHEN WE ARE DEALING with varying voltages, that is called analog data. In the digital world we do not find a variable signal. It is either on or off, just as a switch would be either on or off. Another way of saying this is high or low, or 1 or 0. Each high or low bit is put together to make up a basic character or Byte. Sometimes these Bytes are called words.

If we have 1001, then we can call that a 4 bit Byte. That is the smallest Byte ever to be encountered in the computer world. It can be used where the data accuracy is not critical and the amount of data is small. To illustrate this, if 1001 were sent and interference generated a pulse at the moment of the third bit, then we have been left with false data of 1011. Its meaning would be completely different. To increase accuracy and handle more data, we could go to 8 bit Bytes. Such as 10101010. A logic probe allows us to look at a particular point in the circuit to determine if a low (0) or high (1) is present.

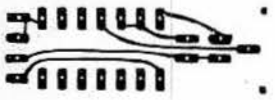
For most of our electronic experiments, we don't need expensive logic probes costing upwards of \$40. Here is a cheap unit which can signal high level (1), low level (0), and oscillation. No pulse detection feature was included thus keeping the size small and the price low, around \$2. The probe is designed for TTL signal levels and can be used for 5 volt CMOS circuits although loading may occur.

Theory of operation: Bargain Logic Probe uses only one IC, a 74L04 hex inverter shown in the schematic. The input to inverter A normally floats high, making its output low so as to light L1. The output of inverter B is high so L2 is off. If you now make the input of inverter A zero volts, L1 will turn off and L2 will illuminate. When oscillation is present at the input, both L1 and L2 will light at some intermediate brightness depending on the duty cycle of the signal being observed.

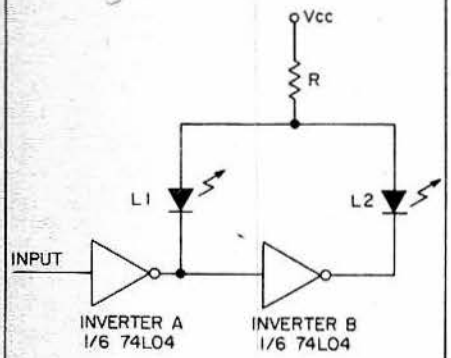
Using a 74L04 is important, the "L" series only requires the driving signal to sink 180 μA max, much below the 7400 series 1.6 mA max or even the 74LS00 series 400 μA requirement.

Construction: A full scale PC board layout is shown in addition to the parts layout on the component side. I slid the entire PC board inside a used syringe cover (available at hospitals for free), and attached a readily available test probe tip. Using different color L.E.D.s to signal high or low will help to quickly distinguish the signal level. Power is supplied by the circuit under test, and runs around 10 mA. Note, voltage requirements for the "L" series are 5 ±.25 V nominal.

So far, Bargain Logic Probe works great. It fits in my pocket and gives me a quick handle on circuit performance. It can also be used to show oscillator output in low power transmitter stages, SW converters & receiver local oscillators. ■

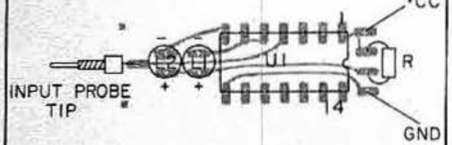


Here's the extra-small printed circuit board template for Bargain Logic Probe.

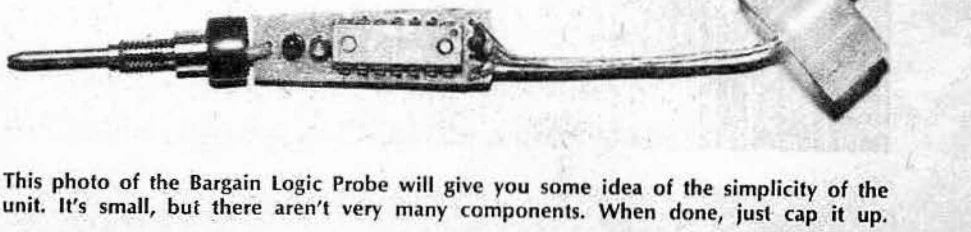


PARTS LIST

L1—light emitting diode, red
L2—light emitting diode, yellow
R—1,000 ohm, ¼-watt resistor, 5%
U1—74L04 hex inverter
Misc.—probe tip, syringe cover, pc board, alligator clips, wire.



This will give you a good idea of parts layout on PC board. There are few parts.



This photo of the Bargain Logic Probe will give you some idea of the simplicity of the unit. It's small, but there aren't very many components. When done, just cap it up.

One-Tube Regenerative Receiver

Build this broadcast receiver from the early days of radio

MANY EXPERIMENTERS NEW to electronics have never worked with tubes. This is unfortunate because while transistors don't require large amounts of power, and ICs can cram huge circuits into dust grains, the vacuum tube has an aestheic advantage over solid state components. In addition, the tube's elements are physically large and the principles involved are simpler and easier to understand. So, here is a one-tube broadcast band regenerative receiver project. The finished radio is much superior to the beginner's crystal set, yet is not much more difficult to build. It only requires a modest antenna (20 feet or so) and a good ground to perform well. Incidentally, the circuit is a real oldtimer. Lee De Forest and E. H. Armstrong simultaneously discovered it around 1912, and were involved in a long patent dispute over it.

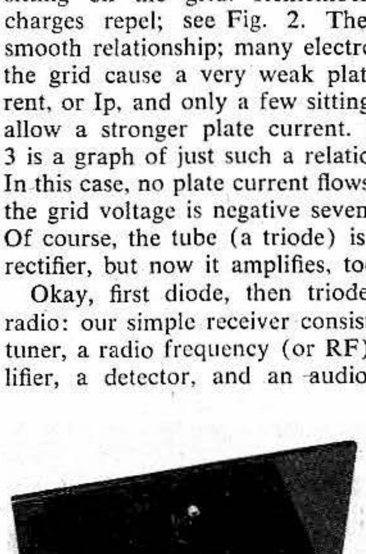
Theory. For those of you who don't remember those two gentlemen, I'm going to give a bit of theory about vacuum tubes and this particular radio. I apologize to those of you who are well versed on these subjects, and beg your indulgence.

The simplest tube is a diode (di- two, ode- element), which is a hairpin of tungsten wire surrounded by a cylindrical metal tube. Both are sealed in a glass bulb from which all the air has been pumped. Connecting a battery across the *filament* wire causes it to glow red hot (much like an ordinary incandescent lamp) and the electrons in the wire are given enough energy to boil off into the vacuum.

If a battery's plus terminal is connected to the metal cylinder (the *plate*) and its minus terminal is connected to the filament, a current of these electrons (electrons have a negative charge) will flow through this plate circuit. *No* current, however, will flow if the plate battery is connected backwards, because electrons cannot leave the plate's surface (see Fig.1). Although this diode will function as a rectifier (one-way valve) or as a rudimentary radio detector, it is good for little else.

Around 1906, Lee De Forest changed this by adding a small twist of wire in between the filament and the plate. This *grid* can be used to control a large power (in the plate circuit) with a small power (in the grid circuit). Here's how: putting a negative voltage on the grid diminishes the plate current, because electrons traveling from filament to plate are repelled by the electrons sitting on the grid. Remember, like charges repel; see Fig. 2. There's a smooth relationship; many electrons on the grid cause a very weak plate current, or Ip, and only a few sitting there allow a stronger plate current. Figure 3 is a graph of just such a relationship. In this case, no plate current flows when the grid voltage is negative seven volts. Of course, the tube (a triode) is still a rectifier, but now it amplifies, too!

Okay, first diode, then triode, now radio: our simple receiver consists of a tuner, a radio frequency (or RF) amplifier, a detector, and an audio amp.

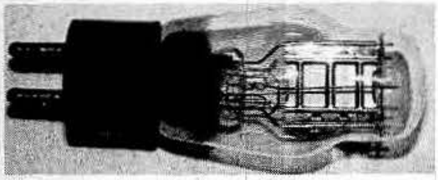


All of the receiver's components are mounted in full view on the spacious rear board.

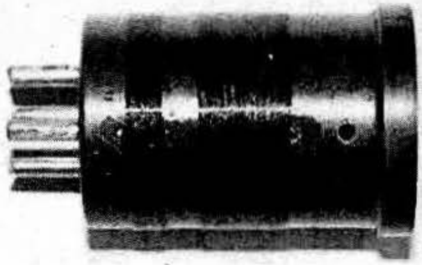
Our versatile tube is both detector and amplifier. The tuner is the parallel combination of L2 and C1. Here's the scheme: many different RF signals exist at the antenna input (see Fig. 4), and are coupled to L2 through the antenna coil, L1. The LC tuner (L2 and C1) looks like a short circuit for all frequencies but one, and this one is sent through C2 and R1 to the grid of V1. They make V1 act like a detector by fixing it so two signals appear: the rapidly varying RF signal (1 MHz or so) and a slowly changing audio signal (200 to 5000 cycles or so). Pretending for a moment that R2 is fully shorting L3, we see electrons flowing from ground, through V1, where they pick up the two signals in an amplified form, and then flow either through C3 to ground or through L4, the earphones. the 90 volt plate battery (which supplies all the electrons' energy) and thence to ground. Note, however, that the RF signal goes through C3 because that capacitor is too small to pass the low audio frequencies, and conversely the audio travels through L4 (an *RF choke*), which presents an open circuit to the high radio frequencies. Thus an amplified version of the audio that was once impressed on the RF carrier wave appears in the earphones.

So, what's L3 for? Well, I wasn't telling the whole truth when I said our LC tuner selected only *one* frequency. It tuned in on *mostly* one frequency, but some others sneaked in, too. The width of this tuning curve (see Fig. 5) determines the selectivity, or station selection ability of our radio. This bandwidth, depends on the Q, or quality factor, of the LC combination. A high-Q circuit has thick wires, no energy losses, and consequently a sharp tuning curve. Unfortunately, the Q of our L2, C1 combination is low, and *that's* why a small amount of RF energy in the plate circuit has to be fed (via L3) back into the grid circuit to account for

One-Tube Receiver



While a Type 30 tube was used in the author's set, any tube in the table is good.



Coil forms such as this one are becoming rare items, so you may have to substitute.

Triode Type Tubes

Remarks	Tube type	Filament Voltage
4 pin	199, 299	3 V
4 pin	201-A, 301-A	5 V
4 pin	30	3 V
5 pin	227, 327	2.5 V AC
8 pin octal	1LH4	1.5 V
8 pin octal	1G4GT	1.5 V
8 pin octal	1H4GT	1.5 V
8 pin octal	6C5	6.3 V AC
8 pin octal	1/2 6SN7	6.3 V AC
8 pin octal	6J5	6.3 V AC

This table gives a list of the tubes that may be used in the regenerative receiver.

energy losses there.

Feeding more and more energy back (turn R2 clockwise) forces the Q sky high, along with the selectivity. The RF amplification increases, too. When we feed more energy into the tuner than is lost, the tube starts oscillating, or producing its own RF signal, at the frequency the tuner is set for. This is undesirable, because it distorts the signals and reduces the set's gain. Obviously, the best setting for R2 is where the tube almost oscillates (see Fig. 6). Now that some of the fundamentals are clear, we discuss next building a real live regenerative receiver.

Finding the Parts. Unfortunately, few electronics shops stock battery tubes (some don't stock any tubes at all!) so here are some hints: a type 30 tube (called for in the parts list) is not necessary. Any of the tubes in the tubetable could be used, but just be sure to use the right filament voltage and the right pin diagrams when you wire. Obviously you will need an appropriate socket, and you may have to up the plate voltage on some tubes to obtain sufficient regeneration. Those tubes marked AC can use alternating current for their filaments because the actual electron emitter is a metal sleeve (called a cathode) insulated from the filament. Without it, hum would be too loud. These types will, of course, use DC as well, but to save the batteries, you would use a transformer to run the filament, and connect the cathode to top of L3 and to R2.

Enough about tubes. Plug in coil forms are hard to find (I don't know if they're still made) but they can be had if you scrounge enough. More on that later. You can salvage the coil wire from an old power transformer by pulling the laminations apart and unwinding the core–number 30 wire is about sewing thread size. The wire, along with the tuning capacitor, earphones, dials and tube sockets, came from my junk box, but any of these items could be purchased commercially (note: don't try to use low impedence hi-fi earphones or the crystal type, either. These won't work). Any wood will do for the base (pine is easy to work with) and the front panel doesn't have to be fancy black plastic: plywood, fiber-

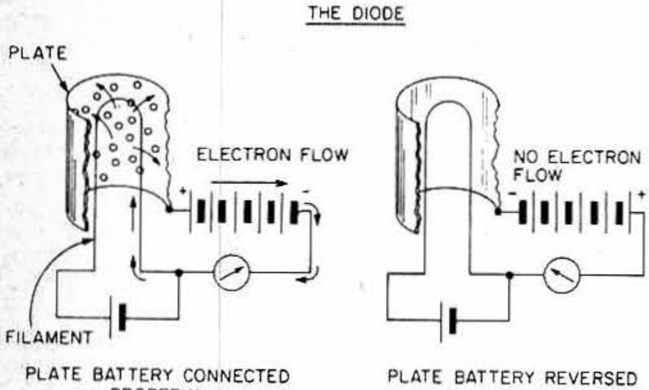


Fig. 1. The diode is the simplest form of vacuum tube. It is made up of a filament wire surrounded by a cylindrical metal tube. Its origins date to before World War I.

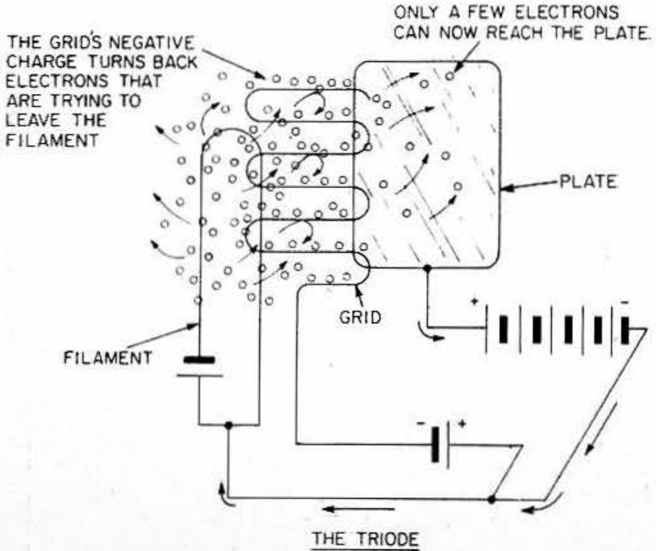


Fig. 2. The triode, a refinement of the diode, has a grid between the plate and filament. This made a rectifying tube into a tube with amplifying capabilities.

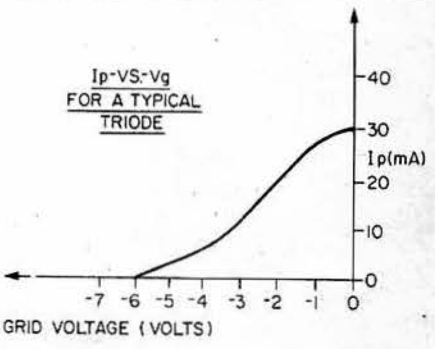


Fig. 3. This graph shows the relationship between the grid voltage and plate current.

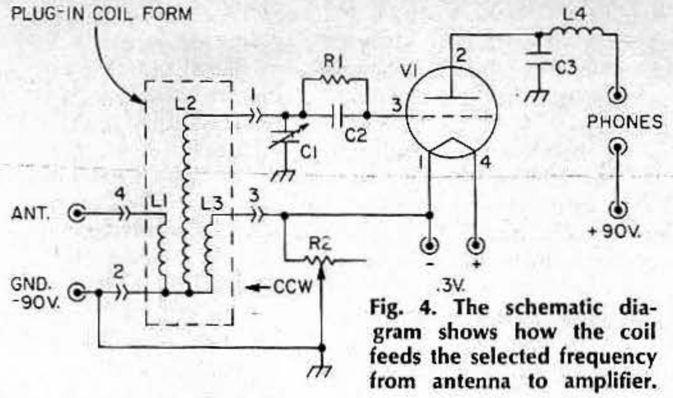


Fig. 4. The schematic diagram shows how the coil feeds the selected frequency from antenna to amplifier.

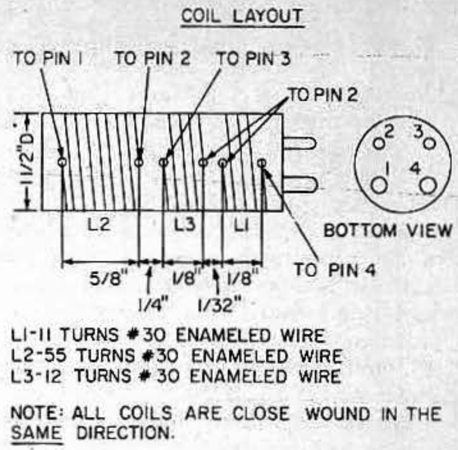


Fig. 7. The coil winding guide shows the wiring configuration of the important coil.

PARTS LIST FOR REGENERATIVE RECEIVER

C1—350 pF, variable capacitor
C2—250 pF, mica capacitor
C3—470 pF, disc ceramic capacitor
L1—11 turns, No. 30 enameled wire, close wound on 1½-inch coil form
L2—55 turns, same construction parameters as L1
L3—12 turns, same construction parameters as L1
L4—2.5 mH RF choke
R1—2,000,000-ohm resistor, ½ watt, 10%
R2—1,000-ohm variable resistor, ½ watt or more
V1—type 30 vacuum tube or similar, see Tube Table
Misc.—Wood base 7-in. x 8-in. x ¾-in., black acrylic front panel 8-in. x 6-in. x ¼-in., 1 large knob, 1 small knob, 7 binding posts, 14 prong plug-in coil form, No. 30 enameled wire, hook-up wire, 2 sockets (4 pin), 4 spacers (¾ inch long), wood screws, machine screws, solder lugs, batteries, earphones (hi-Z type), antenna, ground.

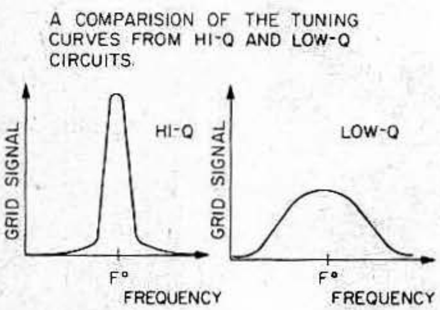


Fig. 5. The width of the tuning curve is the determining factor in set's selectivity.

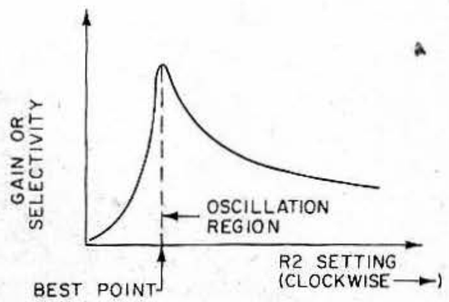


Fig. 6. Too much oscillation is undesirable; R2 must be set to give the minimum.

a strip of plastic, and used the wood screw–spacer technique. Then wire according to the schematic. You probably won't need any tie points, because you can always solder an extra length of wire to a too-short lead, and slip spaghetti over the connection.

Do try to keep the wire between V1's grid and the C2, R1 combination very short. It tends to pick up noise. Finally, mark each binding post with its proper function.

board or metal would all work. My panel, however, was free, courtesy of the local plastic distributor (they even cut it to size!) and it only took a bit of abrasive paper to clean up the edges. The filament, or A battery, can be anything from number six dry cells to storage batteries to flashlight cells soldered together. The B, or plate battery, is a rather esoteric item, and while some stores still stock them, a substitute might be 9 volt transistor (yuch!) radio batteries soldered in series, or a myriad of worn out flashlight cells. Plate current (Ip) is only about 6 mA.

Construction. Now that all the parts are at hand, begin by cutting and finishing the wood base. A quick sanding and a coat of linseed oil or shellac will give it a glossy surface, but avoid paint, as paint often has metallic pigments that could short out connections. Then, mark and drill the front panel to fit your particluar way of mounting R2, C1, and the binding posts for the earphones. Some capacitors have threaded holes on their bottoms, so you may have to fashion an L bracket to hold it to the front panel, or mount it from the base using spacers. Drill three holes ⅜-inch up from the bottom of the panel to fasten it to the base. In all cases, be sure to drill slowly and carefully to avoid splitting the plastic as the bit pops through. Drill pilot holes on the front of the base, and screw the front panel on. After mounting C1, R2, and the earphone connectors, mount the knobs and tube sockets. I mounted my sockets by passing a 1¼-inch long wood screw through each of the socket's holes, and slipping a ¾-inch long spacer over each. Then I screwed the whole thing to the base about halfway between the front and the back, to allow room for wiring. At the back edge of the base, mount the binding posts or clips for the batteries, ground, and antenna. Once again, I mounted all the posts on

Winding the Coil. As I said before, plug-in coil forms are becoming scarce, so if you can't get one (try to, because it makes the coil winding easier), you can substitute many things in its place. Tissue rollers, wood dowels, plastic tubing, or anything non-metallic will work, and it doesn't have to be exactly 1½-inch in diameter if you're willing to experiment some. If the form is too narrow, you'll have to wind more turns than I've indicated, and if it's wider, less wire will be needed. If you're not sure how much to wind onto L2 (L1 and L3 aren't too critical), wind on extra, because it's easier to remove turns than to add them.

Start by marking and drilling the form as I've indicated (see Fig. 7), and proceed by winding the required number of turns. Scrape (using fine sandpaper) the insulation off the end of your wire, run it through the bottommost hole you drilled on the form, and insert and solder it into pin. 4 Hint: if your form is plastic, hold the pin in the middle with a pair of pliers to prevent the heat from softening the plastic. Wind 11 turns, clip the wire (leaving enough to make the other connection) and insert it into pin 2, via the hole in the form's side. Don't solder it, but just cut off the wire, leaving about ¼

(Continued on page 92)

Tuning a guitar is a time consuming and difficult task, especially if you don't have perfect pitch or your ears have been blasted to near deafness by loud music. But here is a project, which is simple to build, that allows you to tune your guitar without listening to it.

Precise Device. Accutune is a precision tuner with an accuracy of ± 1Hz. It allows the guitarist to strum and twang away at a precisely tuned instrument and eliminates the necessity of tuning each string from the tone generated on a previously adjusted lower string. This latter method could result in an improperly tuned guitar.

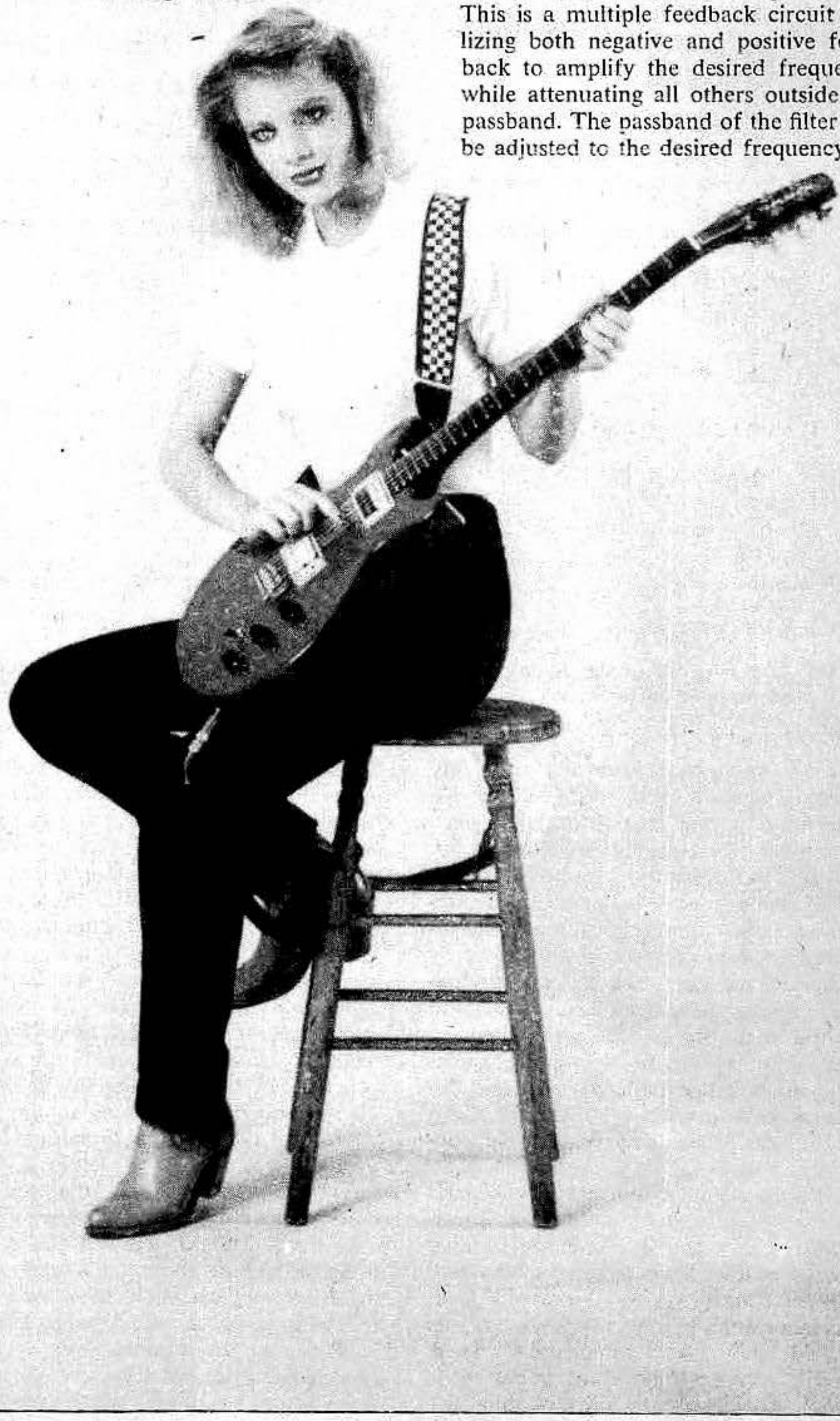
Accutune is self-contained and is powered by a 9-volt transistor battery. A six position rotary switch on the unit selects the desired frequency for each of the instrument's strings.

To operate the unit, plug your guitar's cable into the phono jack of the unit, select the desired string and adjust the guitar for a meter reading of center scale. Accutune also features a battery monitor circuit that checks the battery's terminal voltage.

When the battery has insufficient energy to properly operate the unit, LED1 lights, alerting the user that the battery needs replacement. This feature ensures proper voltage and as a result, proper tuning indications. Although this may sound complex, the theory behind Accutune is very simple.

Harmonics Ignored! All musical instruments, generate tones that are rich in harmonics. To measure the fundamental frequency of an electrical guitar tone, its fundamental frequency must be amplified and harmonic content reduced so that a sinusoidal waveform is generated. This allows the circuit's frequency sensitive section to only respond to the fundamental frequency while ignoring the harmonics.

This is done by sections D and A of U2, which are operational amplifiers connected as an active bandpass filter. This is a multiple feedback circuit utilizing both negative and positive feedback to amplify the desired frequency while attenuating all others outside the passband. The passband of the filter can be adjusted to the desired frequency by



ACCUTUNE

Perfect Pitch Every Time With This Electronic Tuner

selecting the proper resisitve component. The circuit's center frequency selection is determined by a set of six potentiometers and resistors. These parts are labelled R9 through R20. They are chosen by S2A.

U3 is a specialized frequency-to-voltage integrated circuit designed to deliver a DC voltage at its output proportional to the frequency of the input signal. This chip's output voltage level is determined by the resistance value connected between pins three and four to ground and the capacitance connected to pin two.

As with U2D and U2A, the resistance connected to U3 pins three and four is determined by the front panel selector switch and a set of six potentiometers and resistors. These parts are labelled R22 through R33 and S2B.

To provide an expanded meter scale for increased meter sensitivity, U2B is used as an operational amplifier with a gain of three and a DC voltage applied to its negative input. U2B drives a milli-ammeter through R 38 providing a meter scale representing a $\pm 10\%$ center scale frequency range. This sensitivity is sufficient to indicate a change of 1 Hz in the guitar.

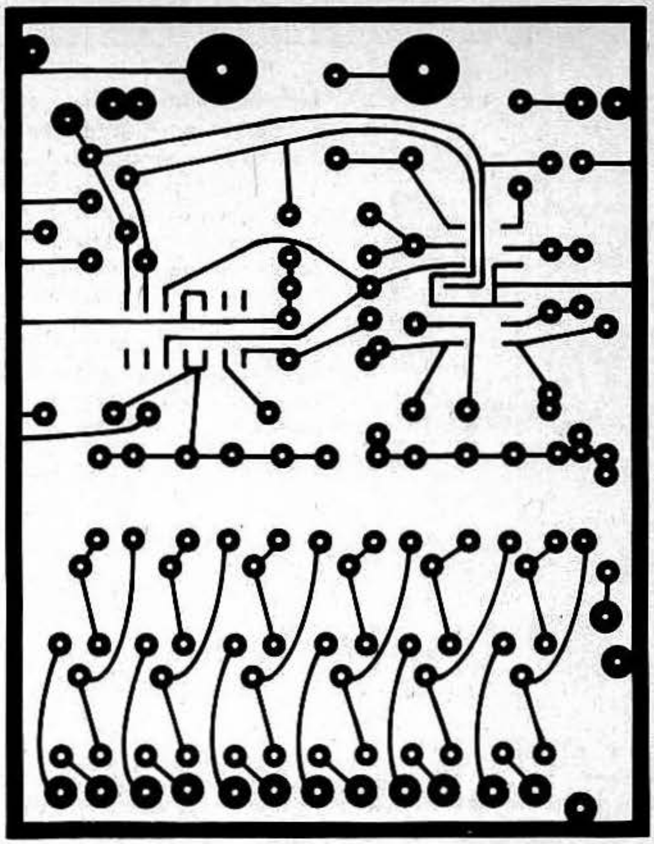
Pins and U2. Section U2C is connected as a voltage comparator to monitor the terminal voltage of the battery. A reference voltage of +5-volts is fed to pin 10 and a portion of the battery voltage is fed to negative input pin nine. When the battery is fresh, its terminal voltage is sufficient to keep pin nine at a higher potential than pin 10.

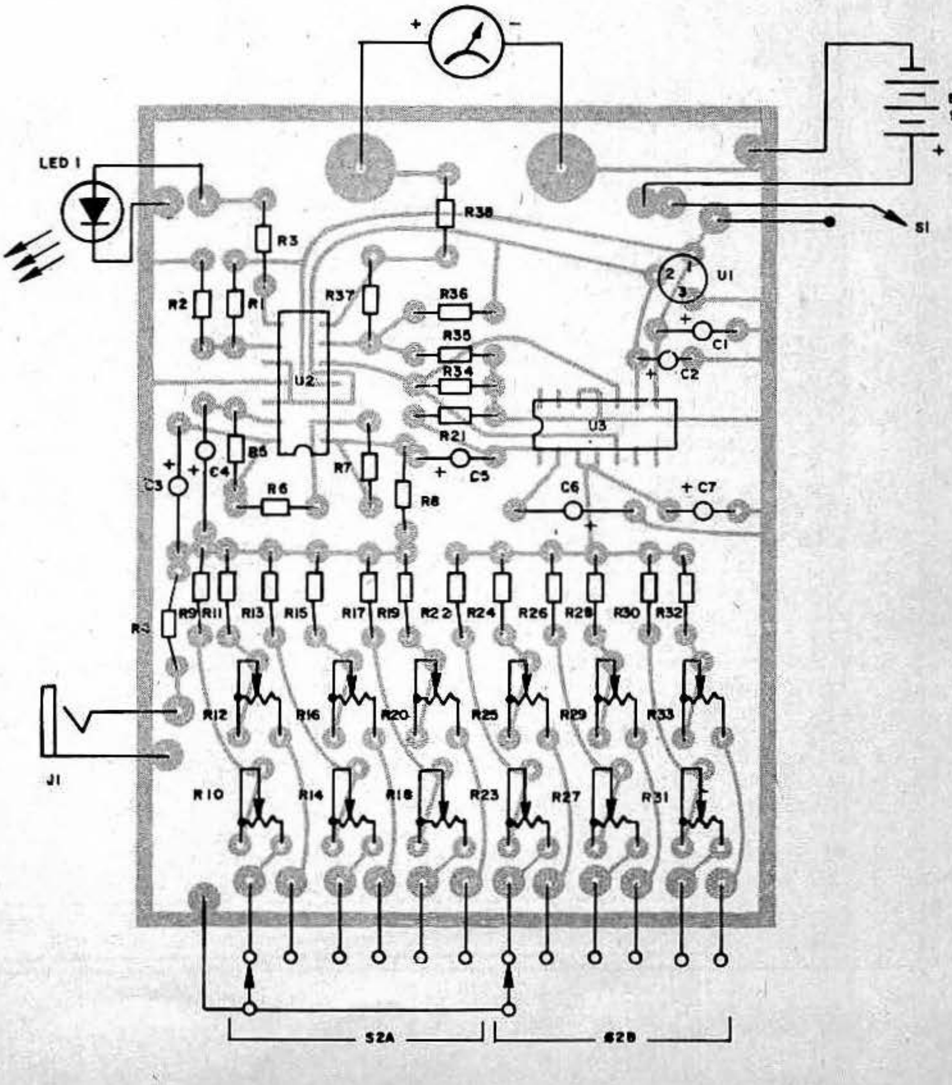
The output U2C is thus zero and LED1 is extinguished. As the battery voltage decreases with use, a point will be reached where the voltage at pin nine is no longer higher than that at pin 10. The output then switches to battery voltage, illuminating LED1.

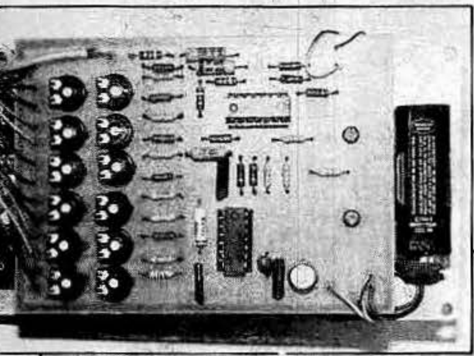
To ensure the continued accuracy of Accutune, 5-volt regulator U1 provides a constant voltage to U3 and U2B. Thus, the circuit will maintain its calibrated accuracy despite the constantly changing terminal voltage of the battery.

M1's Back. The entire circuit of Accutune, except the front panel components, is contained on a printed circuit board mounted on the back of M1. The meter used has a center to center stud distance of 1-inch and this distance is reflected in the foil layout.

The upper illustration shows the foil side of Accutune's PC board. Unless you are an expert at making your own, you should order the kit or a pre etched circuit board from Niccum. The lower illustration is a parts overlay showing completed project. When you install the components, note polarity.







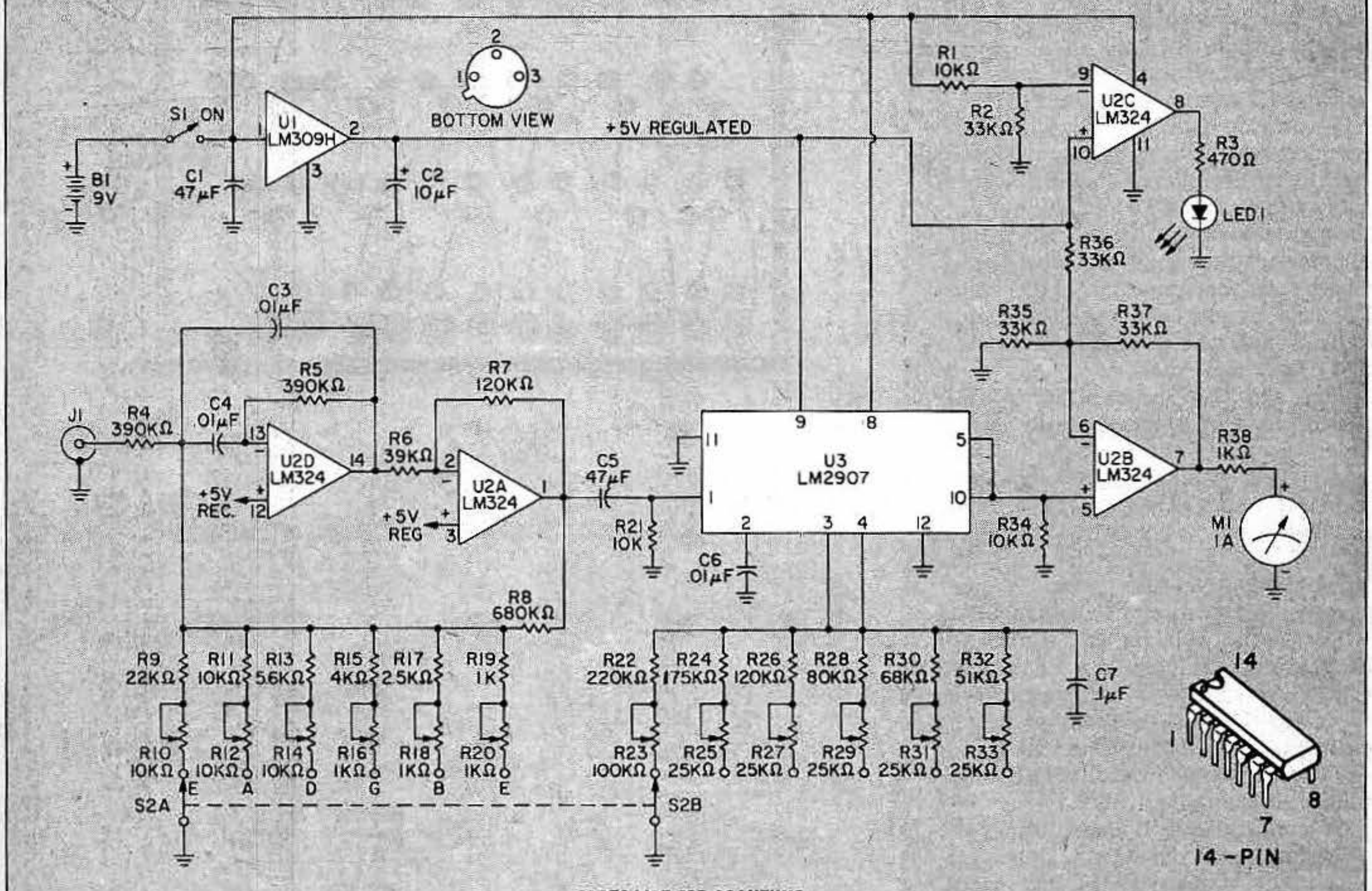
Be sure to measure the center to center distance between the meter studs before making your printed circuit board.

Use sockets for U2 and U3, rather than soldering them to the printed circuit board. It is extremely difficult to remove a multi-pin integrated circuit from a printed circuit board once it has been soldered in place.

No Substitutions! Do not substitute ceramic capacitors for C3, C4, and C6. These parts are used in the frequency sensitive sections of the circuit and should be stable components to preserve the calibrated accuracy of the

(Continued on page 91)

Twelve potentiometers are the heart of Accutune. Each potentiometer must be tuned for a discrete frequency. If there is a problem in getting a center scale reading, then change the value of the resistor that is in series with the problem potentiometer.



PARTS LIST FOR ACCUTUNE

B1—9-volt transistor battery
C1, C5—.47 uF, 50 volt ceramic capacitor
C2—10 uF, 25 volt ceramic capacitor
C3, C4, C6—.01 uF, 100 volt mylar capacitor
C7—.1 uF, 50 volt ceramic capacitor
J1—Phono Jack
LED1—Red light emitting diode, Radio Shack 276-026 or equivalent
M1—1 mA DC Milliammeter
ALL RESISTORS ARE ¼-WATT, 10% UNLESS OTHERWISE NOTED
R1, R11, R21, R34—10,000-ohm resistor
R2—33,000-ohm resistor
R3—470-ohm resistor
R4, R5—390,000-ohm resistor
R6—39,000-ohm resistor
R7—120,000-ohm resistor
R8—680,000-ohm resistor
R9—220,000-ohm resistor
R10, R12, R14—10,000-ohm potentiometer
R13—5,600-ohm resistor
R15—4,000-ohm resistor
R16, R18, R20—10,000-ohm, potentiometer
R17—2,500-ohm resistor
R19—1,000-ohm resistor
R22—220,000-ohm resistor*
R23—100,000-ohm potentiometer
R24—175,000-ohm resistor*
R25, R27, R29, R31, R33—25,000-ohm potentiometer
R26—120,000-ohm resistor*
R28—80,000-ohm resistor*
R30—68,000-ohm resistor*
R32—51,000-ohm resistor*
R35, R36, R37—33,000-ohm resistor*
R38—1,000-ohm resistor*
S1—SPST switch
S2—Two pole six position rotary switch
U1—LM309H voltage regulator integrated circuit
U2—LM324 operational amplifier integrated circuit
U3—LM2907 frequency to voltage integrated circuit
*See text
Misc.—Cabinet with metal face plate, screws, solder, knob, printed circuit board, wires, hardware, etc.

For information on the availability of parts and other materials to build ACCUTUNE, send a stamped, self-addressed envelope to Niccum Electronics, Route 3, Box 271B, Stroud, OK 74079.

DIGITAL CLARINET

Play music by the numbers with your digital clarinet.

TO MAKE A FINE instrument such as a violin or bassoon, a craftsman must meticulously carve, cut, form and finish for hundreds of hours. It takes decades to master the instrument.

The time has now come where you can build a fine instrument and master its musical intricacies in a few hours. Appealing? Then the Digital Clarinet is waiting for you to pick it up and play away to your heart's content.

The Digital Clarinet is a high quality ultra-miniature instrument that's fun to build and play. Its sophisticated digital circuit is as far beyond other similar projects as a Stradivarius eclipses the simple kazoo.

Each note in the unit's three octave range is generated with enormous stability and accuracy; frequency drift, the plague of analog systems, is not a problem. Since this project's output signal is a modulated square wave, the generated frequencies have the range and tonal characteristics of a woodwind instrument–hence the name: Digital Clarinet.

Double Features. The Digital Clarinet provides two keying modes: Sustained and Percussive. After a key is struck in the sustained mode, the sound output rises to maximum and remains there as long as that key is down. Once the key is released, the note gradually decays. Percussive keying yields a note that rises to a set volume and fades to nothing regardless of how long the key is pressed. Also a note's attack and decay times can be controlled with a pair of potentiometers. These controls yield strange effects.

The Circuit. To understand the circuit, let's examine the block diagram (Fig. 1). The unit's master oscillator, integrated circuit U1, operates at a frequency of 250,030 Hz. U1's square wave output signal drives top-octave generator U2. Twelve discrete frequencies (or notes), $C_5^{\sharp}$ (554.3 Hz) to C_6 (1046.5 Hz), are generated by U2. These notes are equally spaced to conform with standard chromatic scale. Since only one note at a time is utilized, the 12 top octave notes are routed to the multiplexer circuitry from U3.

To make our selection, we need a one-octave (12-key) keyboard. Encoder chip U4 provides the necessary logic to interface the keyswitches with the rest of the circuit. U4 debounces all the keyswitches and provides a set of four latched outputs driving the address lines of multiplexer U3.

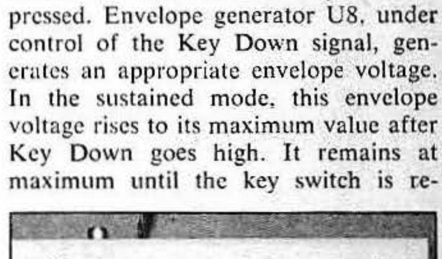
When pressed, each key produces a binary-coded address that selects a unique signal. *Note*: U4's address outputs are latched so the circuit remembers the old note until a new one is selected. Should two keys be depressed at once, U4 responds only to the first one which is pressed.

Multiplexer Times Two. We'll return to encoder U4, but right now let's note that the output of multiplexer U3 is routed to the input of frequency divider U7. Two square wave outputs with frequencies ½ and ¼ as great as the input are generated from U7. Another multiplexer, U6, is used to select between U3's output (the top octave) and U7's outputs (the middle and low octaves). U6's selection is determined by signals from clocked latch U5, which is controlled by two octave-shift keys. If neither octave-shift key is pressed, multiplexer U6 selects f/4 (signals in the lowest octave). Signals in the middle or top octave (f/2 and f respectively) can be selected by pressing the appropriate octave-shift key before striking a switch on the Digital Clarinet's main keyboard. *Note*: Address signals for multiplexer U6 (as with U3) are latched.

Latch circuit U5 memorizes the octave-shift keys that are closed when the Key Down signal at pin 12 of U4 goes high. U5 retains this octave-selection information until the next note is struck, at which time it updates the information. (It should be apparent that ocatve selection must precede note selection.)

The Digital Clarinet's frequency range extends from $C_3^{\sharp}$ (138.59 Hz) to C_6 (1046.5 Hz). This compares favorably to the range of a regular wind-powered clarinet.

The Key Down signal mentioned above goes high for the entire time any switch of the 12-note keyboard is pressed. Envelope generator U8, under control of the Key Down signal, generates an appropriate envelope voltage. In the sustained mode, this envelope voltage rises to its maximum value after Key Down goes high. It remains at maximum until the key switch is re-



Small in size but big in sound, the Digital Clarinet is easy to wire and operate.

DIGITAL CLARINET

leased and Key Down drops low, at which time the envelope decays to zero. Since decay is initiated by release of the key switch, latching is used to preserve the note and octave information that would be lost after key release.

In the percussive mode, the envelope signal rises after Key Down goes high, but decays after reaching its peak even if Key Down is high. Regardless of the keying mode used, the output note's attack and decay times are determined by the envelope voltage's rising and falling speed.

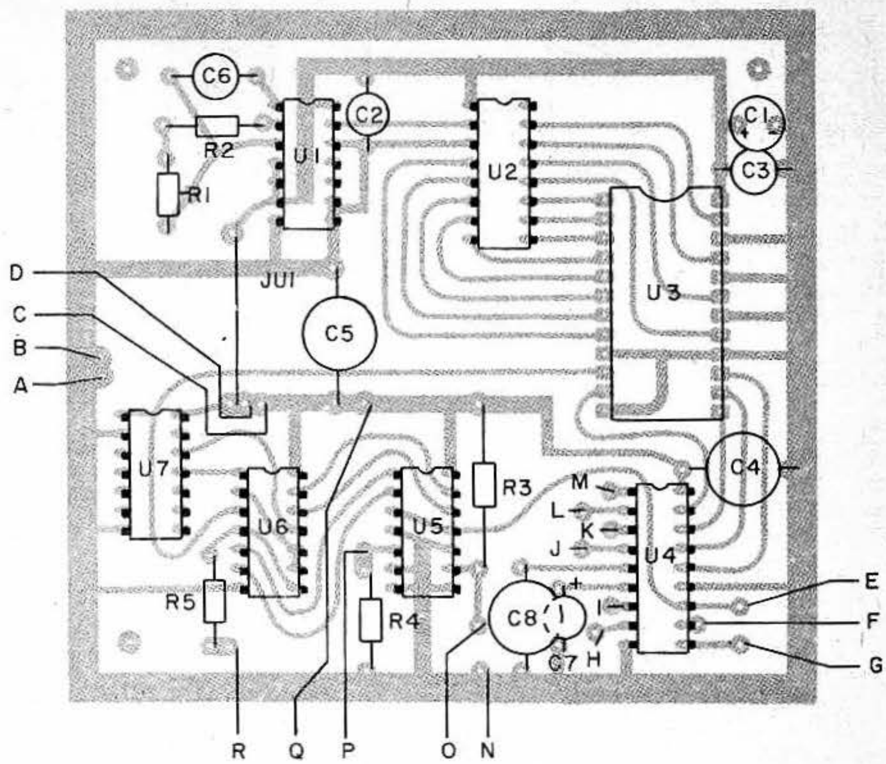
Amplitude modulator U9 multiplies the envelope voltage with multiplexer U6's square wave output to yield a musical note. The note's instantaneous loudness is directly proportional to the envelope voltage.

ICs You See. Circuit power is supplied by eight AA cells arranged to provide a dual supply of +6 and −6 volts. Oscillator U1 is a 4047 CMOS multi-vibrator, which can easily be tuned to proper pitch via trimmer potentiometer R1. The 4047 has excellent stability with changing temperature and voltage. For this reason it was used in lieu of more expensive crystal oscillator circuitry.

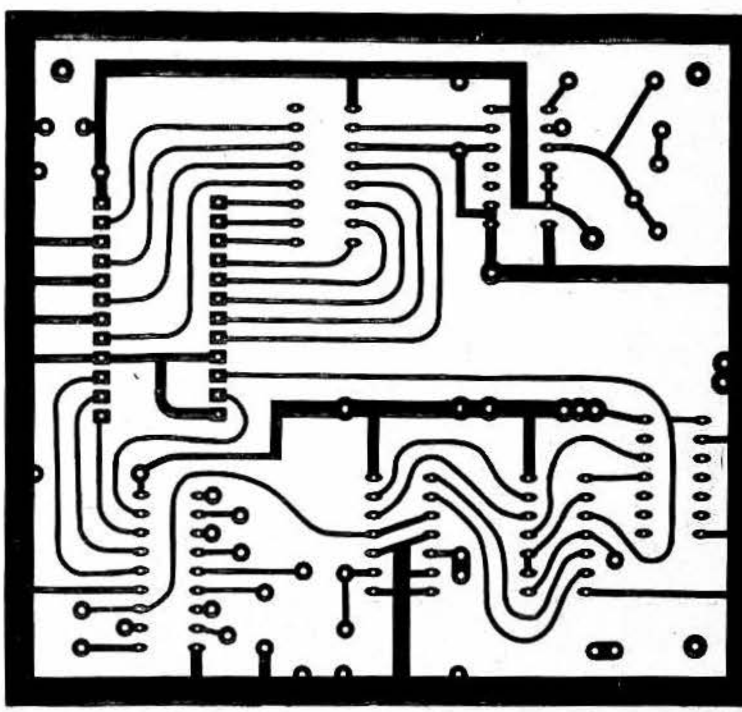
Top-octave generator U2, a Mostek 50240, is fairly expensive. It is recommended that you be especially careful when handling it to avoid damage from static discharge. Note how the keyswitches (S5 through S16) connect to encoder U4 in a matrix arrangement. Each keyswitch connects to one horizontal and one vertical line of the encoder matrix (Fig. 2).

Frequency divider U7 is a common 4024 CMOS binary divider. Mutliplexer U6 (4016) selects the appropriate signals from U3 and U7, routing them to amplitude modulator U9, a 3080 transconductance amplifier. This resembles a standard operational amplifier except its gain is a function of the current injected into pin 5 and its ouput is a high-impedance current source. Trimmer potentiometer R13 is used to null out the offset voltage of U9 and C15 rolls off U9's high-frequency response. Potentiometer R17 is a volume control. The signal at J1 has a maximum amplitude of 500 millivolts and can be fed into the high-level (Tuner, Aux or Line) inputs of any amplifier.

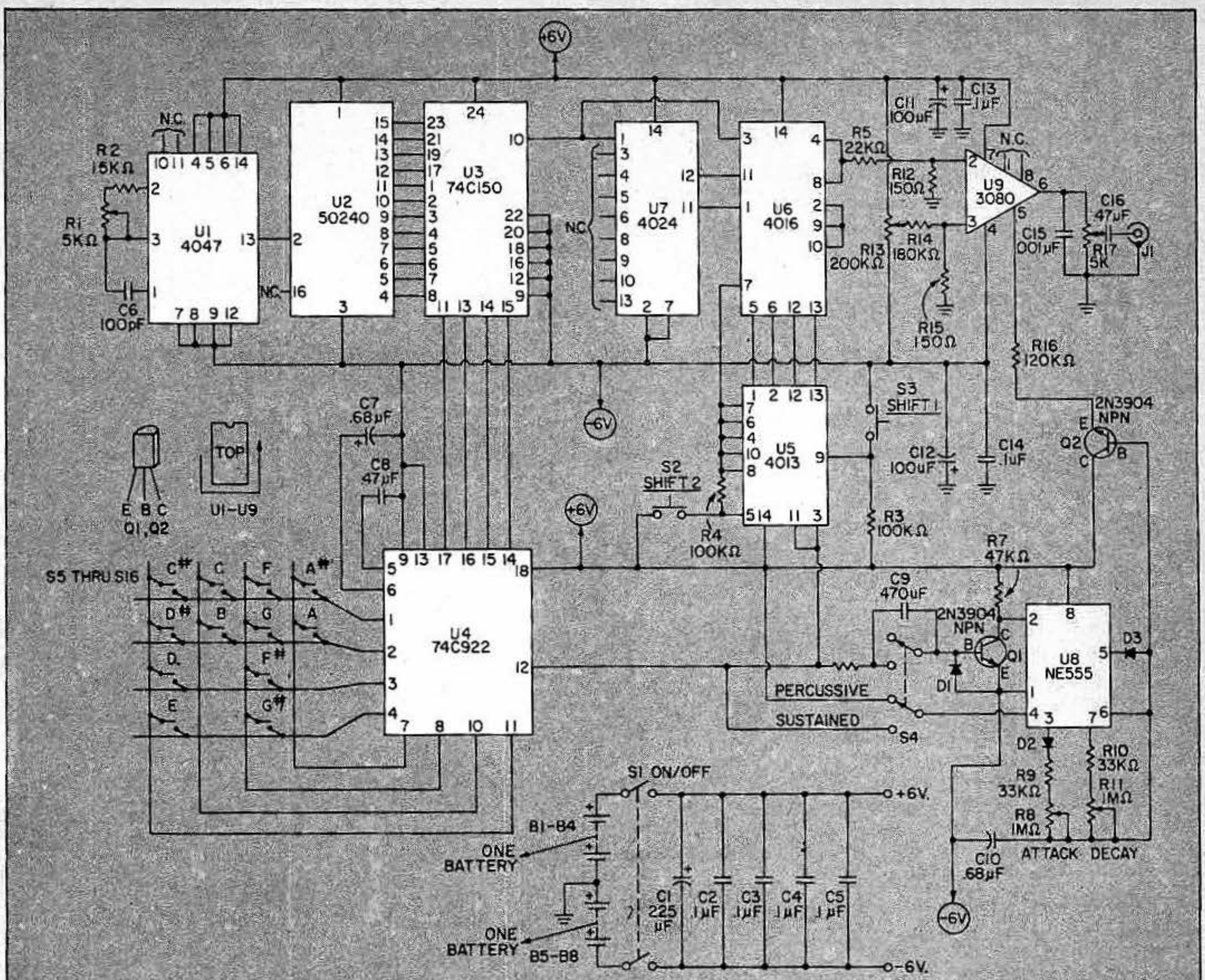
Latch U5 is a type 4013 dual flip-flop. Pressing S3 shifts the scale up one octave; pressing S2 yields a two-octave shift. Pressing both simultaneously gives the same effect as pressing



The parts overlay shows components on top of the printed circuit board. Note that all of the electronic components fit handily on board, making for easy assembly. When soldering integrated circuits, always note the position of the IC on the circuit board.



This is the foil side down of one of the printed circuit boards for the Digital Clarinet. Requiring seven integrated circuits, the project looks complex but is very simple to wire. Other than the integrated circuits, there are relatively few components to wire up.



S2 by itself.

Only Old Friends. Envelope generator U8 is our old friend, the 555 timer. However, use only a Signetics NE555 (note the "NE" prefix) rather than a National device ("LM" prefix). In the majority of circuits, these units are directly interchangeable, but in this circuit proper sustained-mode operation **will be obtained only** with the Signetics NE555 device.

Switch S4 selects either the percussive or sustained modes and transistor Q1 simply inverts the triggering signal applied to U8. Emitter follower Q2 reads the voltage on timing capacitor C10 and injects a proportionate current into pin 5 of U9 (via R16) to control the 3080's gain.

Don't Buzz! Ground. Construction of the Digital Clarinet is not overly complex, but there are a few points that you must strictly adhere to for best

PARTS LIST FOR DIGITAL CLARINET

B1 thru B8—(8) 1.5V AA penlite cells
C1—225 uF, 16V electrolytic capacitor
C2, C3, C4, C5, C13, C14—.1 uF ceramic disc capacitor
C6—100 pF polystyrene capacitor
C7, C10—.68 uF, 20V tantalum capacitor
C8—.047 uF, 100V mylar capacitor
C9—470 pF, polystyrene capacitor
C11, C12—100 uF, 16V electrolytic capacitor
C15—.001 uF, mylar capacitor
C16—.47 uF, 16V mylar capacitor
D1, D2, D3—1N914 silicon diode
J1—RCA jack
JU1—Jumper wire
Q1, Q2—2N3904 NPN transistor
All Resistors 5%, ½-Watt Unless Noted
R1—5,000-ohm, trimmar potentiometer
R2—15,000-ohm resistor
R3, R4, R6—100,000-ohm resistor
R5—22,000-ohm resistor
R7—47,000-ohm resistor
R8, R11—1,000,000-ohm linear-taper potentiometer
R9, R10—33,000-ohm resistor
R12, R15—150-ohm resistor
R13—200,000-ohm trimmer potentiometer
R14—180,000-ohm resistor
R16—120,000-ohm resistor
R17—5,000-ohm audio-taper potentiometer
S1, S4—DPDT switch
S2, S3—normally open pushbutton switch
S5 thru S16—normally open pushbutton switch (computer style)
U1—4047 CMOS multivibrator (RCA)
U2—50240 top-octave generator (Mostek)
U3—74C150 16:1 multiplexer (National)
U4—75C922 keyboard encoder (National)
U5—4013 CMOS D-type flip-flop
U6—4016 CMOS quad analog gate
U7—4024 CMOS binary divider
U8—Signetics NE555 timer (see text)
U9—LA3080 operational transconductance amplifier (RCA)
Misc.—PC 1,2—Printed circuit boards, aluminum box, aluminum minibox, IC sockets, wire, knobs, screws and nuts, solder, etc.

For information on the availability of parts and other materials to build DIGITAL CLARINET, send a stamped, self-addressed envelope to Lectrographic, P.O. Box 537, Auburn, NY 13021.

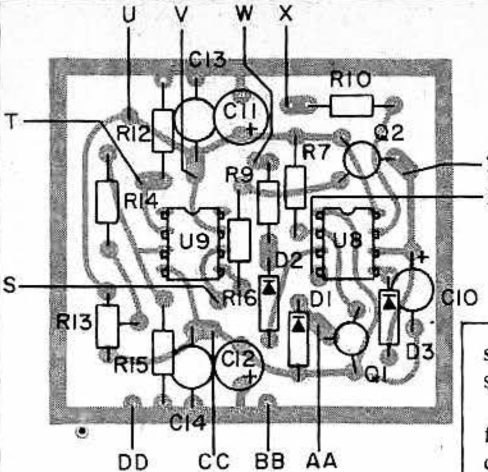
results. First, use an aluminum cabinet and make sure it is connected to system ground. This is easily accomplished at the point where J1 mounts in the chassis wall. A metallic enclosure of this sort is necessary because it minimizes any audio interference (a background buzz) produced by the fast, high-amplitude digital signals in this project.

Printed-circuit construction is highly recommended. Either make your own, if you have the necessary skill or purchase pre-fabricated boards from the manufacturer given in the parts list. The circuit has been segregated into two boards: One to hold the digital circuitry and one for the analog stages. This separation is important because the analog board must be shielded from the digital board to prevent audio interference. Fortunately, shielding is easily accomplished by mounting the analog board together with C15, C16, J1 and volume control R17 inside an aluminum minibox. The minibox ,should be mounted inside the aluminum cabinet housing the Digital Clarinet and the box should be electrically connected to system ground. Wires running to and from the analog PC board can be routed through grommeted holes in the minibox's walls. Using this system, a prototype was constructed; we obtained dead silence between notes and not a trace of digital hash.

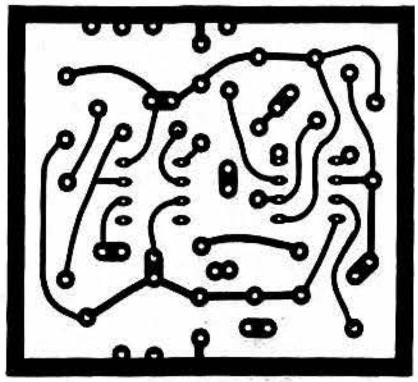
What A Figure. By viewing Fig. 2, it can be seen that certain components do not mount on either board. Specifically, R6 and C9 mount directly on the lugs of S4, while C15 is soldered across the outermost lugs of R17. **Note:** The border around PC1 is at a potential of -6 volts, while PC2's border is at ground potential. Bear this in mind and don't get confused. Be sure to include jumper (JU1) when wiring up the digital board.

When fabricating the keyboard, the use of computer-style keyswitches is recommended. They have a very light, smooth action and are extremely easy to key. We set it up so keyswitches with black tops can signal sharp notes and white topped keys can retrieve non-sharp notes. The notes of the scale in ascending order are: C♯, D, D♯, E, F, F♯, G, G♯, A, A♯, B, C. This is a cyclic pattern, so the 13th note is C♯ (with twice the frequency of the starting note).

In the prototype, keys are arranged in two ranks with the upper row running from C♯ to F♯ and the lower one from G to C. As an alternative to this arrangement, you might consider can-



This parts overlay shows a circuit that is quite a bit crowded. It's bit more so than the other printed that is quite a bit crowded. It's a circuit board. Be careful when you wire up various jumpers and connectors. It's easy to get mixed up.



Unless you are an expert at making PC boards from scratch, we suggest that you order an etched set from Lectrographix Inc.

nibalizing the keyboard from a toy piano. There are many options, but stay away from calculator keyboards. With few exceptions, these are too small for comfortable keying.

You will not find all the ICs required by this project in your local electronics shop or with some of the better known mailorder retailers. The 50240, 74C922 and 3080 are carried by Circuit Specialists (Box 3047, Scottsdale, AZ, 85257). The 74C150 is available from Digi-Key Corp. (Box 677, Thief River Falls, MN, 56701). All remaining ICs are common items; they can be easily purchased.

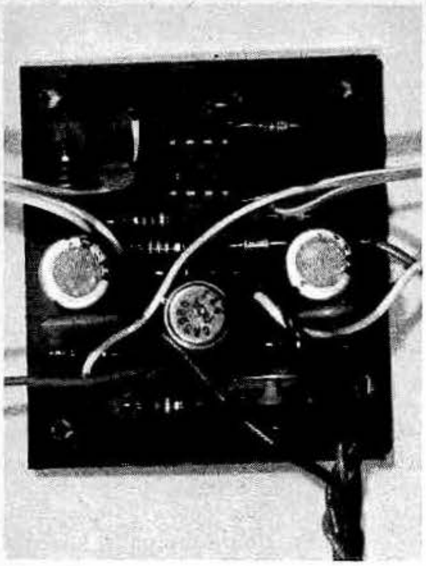
Solder At 25. As always, use resin-core solder and a 25 Watt or less soldering iron when soldering components. Polarized devices must be properly oriented. This applies specifically to all the semiconductors, C1, C7, C10, C11, and C12. Since most of the ICs are MOS devices, therefore **susceptible to damage** from static discharge, IC sockets are strongly recommended. Install the ICs in their sockets only **after** soldering is completed.

Check, Please. Once construction is finished, you're ready to check out the circuit's operation. Feed the output signal from J1 via shielded cable to the high-level input of your amplifier. (CAUTION: low-level amplifier inputs intended for use with magnetic phono cartridges will overload when driven by the Digital Clarinet.) Set S4 to the sustained mode. Adjust R8 for minimum attack time (minimum resistance) and set R11 for a long decay interval (maximum resistance). Trimmer potentiometers R1 and R13 should be set to the midpoints of their adjustment ranges. Turn on the power.

Tap each one of the twelve switches of the keyboard in their chromatic order and verify the presence of an output note, which should decay after key release. Each note should be lower-pitched than its successor and higher-pitched than its predecessor. If not, check for a keyboard wiring error. Next, press S3 and then strike a note on the keyboard. The pitch should be one octave higher. Press S2 and hit the same keyswitch as before. This time the pitch should be shifted two octaves higher. If not, check for wiring errors or faulty components in the circuitry associated with U5 and U6.

Assuming all has gone well to this point, switch S4 to the percussive mode and strike a note on the keyboard. The output note should rise and decay in volume even though your finger continues to press the keyswitch. If not, check the following for wiring errors or faulty components: R6, C9 and S4.

Natural Decay. With these preliminary tests completed, experiment with various settings of the attack and decay potentiometers. Natural musical sounds generally take more time to decay than to attack. On this instrument, however, you can reverse things for a very strange effect. When percussive keying is used, though, keep the attack time short for best results.



Shielded in an aluminum box, a PC board controls mode or sound of musical note.

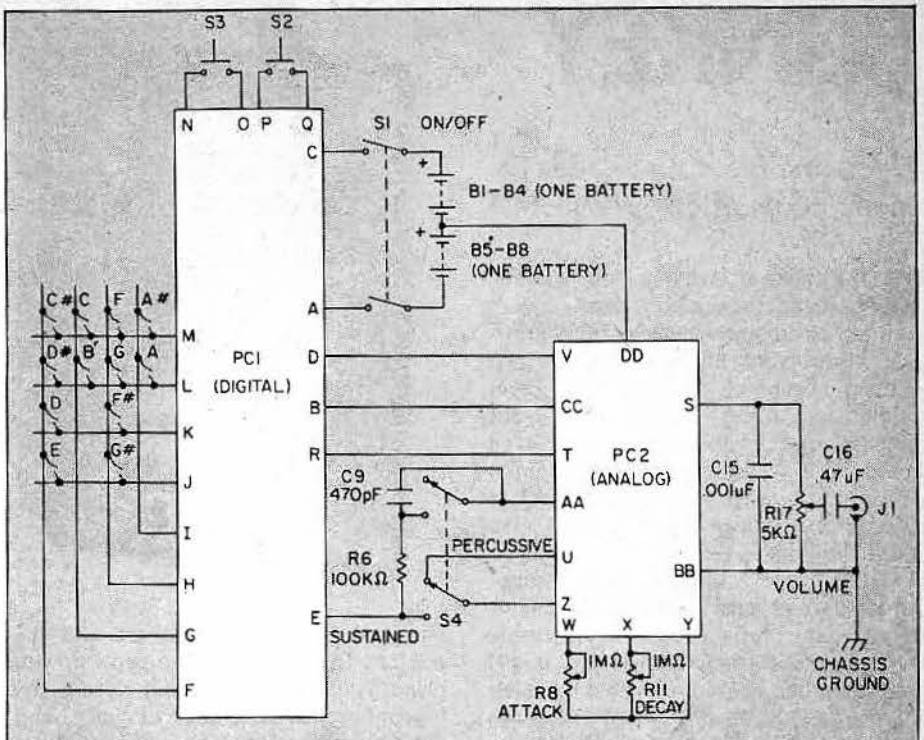


Fig. 2. The various notes that are generated by the Digital Clarinet are created by PC 1. The other controls work out of the analog printed circuit board, PC 2.

Listen carefully to your Digital Clarinet's output note as you key the instrument. If a slight thumping is apparent with very short attack or decay times, it can be cancelled out by adjusting R13.

Those of you who own frequency counters can tune the circuit by adjusting R1 to obtain exactly 250.030 Hz at U1's output (pin 13). Lacking a counter, you can tune the instrument by ear against a pitch reference such as a tuning fork. Remember that this instrument's range extends from 138.59 to 1046.5 Hz and any pitch reference within this three octave interval can be used for tuning purposes. Correct tuning will be found within the mid-portion of R1's range of adjustment.

Although the Digital Clarinet may not be appropriate for Carnegie Hall or your local church, it is great for messing around in your home. Plug it into your stereo and let your fingers fly away at the keys.

So go to it. Although you may not be able to play the clarinet as well as Benny Goodman, there's no reason why you can't swing away to an old Goodman tune with your Digital Clarinet. ■

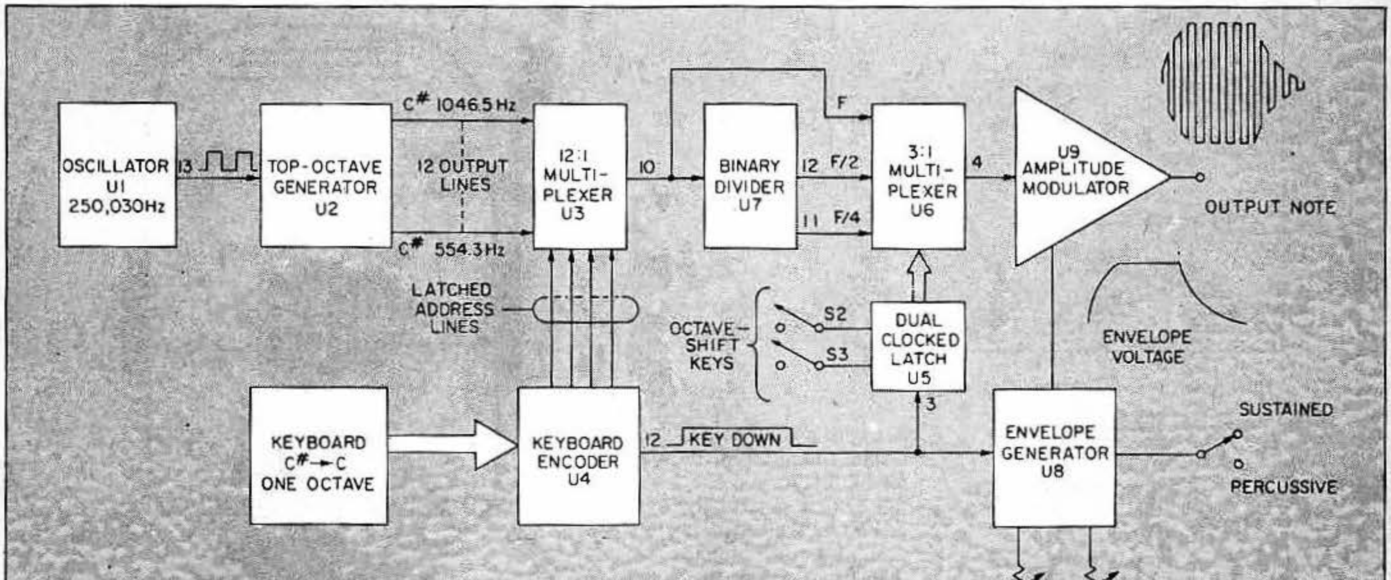
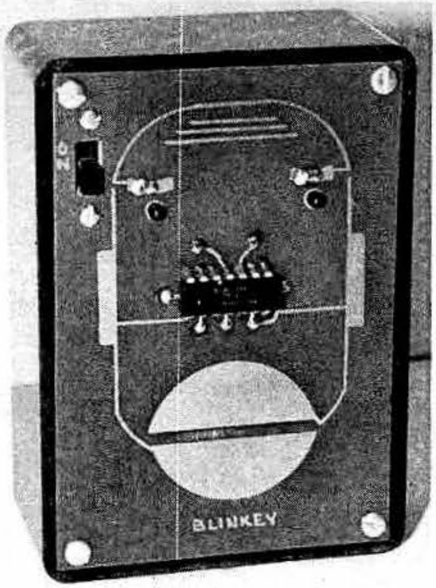


Fig. 1. Starting with a 250,030 Hz oscillator, 12 notes are generated. By using a binary divider and a 3:1 multiplexer, 36 possible frequencies can be retrieved from the Digital Clarinet. Attack, decay, sustained and percussive commands are channeled through the envelope generator to the amplitude modulator. A keyboard encoder sorts out the notes that will be played.

BLINKEY

Electronic friend provides many hours of entertainment



BLINKEY IS AN ELECTRONIC "friend" from another galaxy. He is asleep as long as nobody disturbs him. However, press your finger to his lips and Blinkey becomes agitated. His eyes blink on and off. If you press your fingers more firmly, he becomes even more furious, blinking more rapidly. When you remove your fingers, Blinkey goes back to sleep again and his eyes stop blinking.

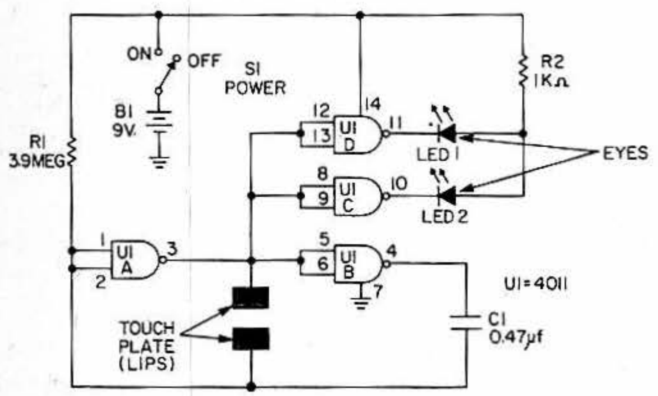
The simple circuit uses one integrated circuit and a few components. If you like, Blinkey can be built inside a doll or constructed on a PC board as the author has done. The remaining copper foil on the PC board resembles a mouth, ears and eye brows. The IC resembles a nose, and the two LEDs are Blinkey's eyes.

How He Blinks. BLINKEY's circuit is shown right below. Consider U1A and U1B alone (without R1 or UIC and D connected). If we replaced the Touch Place (lips) with a resistor, we would have an ordinary oscillator. The frequency of oscillation would be determined by the value of C1 and the resistor. Instead of using a resistor, you place your finger or hand across the touchplate, the resistance of your hand determines the frequency of oscillation. As you press harder, the resistance decreases and the frequency of oscillation increases. Now, if we connect U1C and D to the oscillator, LED (left) and LED (right) will simultaneously blink. U1C and D are buffers which provide enough current for the two LEDs to turn on.

If you removed your hand when the LEDs were on, they would remain on indefinitely. This would drain the battery. Since we often forget to turn off a toy, we provide an automatic shutoff of the LEDs. This automatic shutoff is R1. When your hand is removed from the Touchplates, R1 allows the voltage at pins 1 and 2 of U1A to rise towards 9 volts. Eventually (after a second or two) this will cause the output of UIA to go low, turning off the LEDs. In this state, the current draw by the circuit is very low, insuring a long battery life. R2 limits the current drawn by the LEDs and S1 provides the voltage from the battery for operation.

Construction. Any means of construction is suitable. An easy way of reproducing the circuit is to use the PC Board layout seen below. The overall size of the PC Board should be adjusted to allow it to substitute for the top plate of the box you are using. UIC is mounted on the FOIL side of the PC Board, while all other components are mounted on the reverse side. Mount the two LEDs through the "eye" holes and secure with epoxy. After R1 is installed, solder a short length of wire between it and S1 as shown in the detailed component placement. If a 0.47 uF non-polarized capacitor is not available, five 0.1 uF disk capacitors can be paralleled together and used instead. While R1 is stated as 10 megohms, any value greater than 3.9 meg-

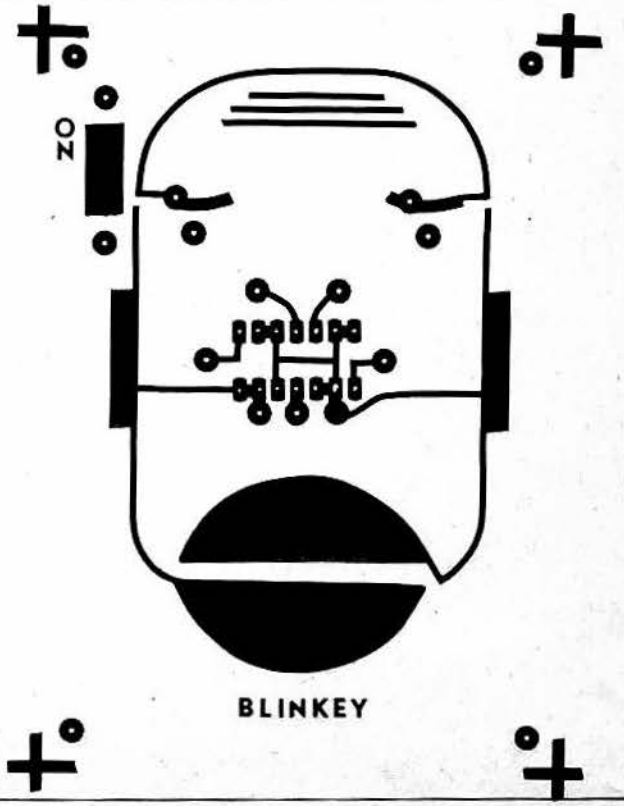
(Continued on page 91)



PARTS LIST FOR BLINKEY

- **B1**—9-VDC transistor battery
- **C1**—0.47-uF, non-polarized electrolytic capacitor
- **LED 1, 2**—light emitting diode, ⅛-inch
- **R1**—10,000,000-ohm, ¼-watt resistor, 10%
- **R2**—1,000-ohm, ¼-watt resistor, 10%
- **S1**—slide switch, SPST
- **U1**—CD 4011 quad, 2 input NAND gate integrated circuit
- **Misc.**—PC board, 9-volt battery clip, suitable case, wire, solder, etc.

At right is the Printed Circuit board template for Blinky. As you see, the switch is actually etched on the board. It uses a bit more copper than usual. Schematic, above, is simple and straightforward. The whole thing should take less than an hour.



Solar Cell Tester

Measure photovoltaic characteristics with this unique meter

PHOTOVOLTAIC SOLAR CELLS may hold the promise for the future, but you can experiment with them today. Before utilizing the units in a project, it's necessary to know their capabilities.

All makers list a maximum output current rating, with some listing of power levels for a given light source (usually 100 mw/cm^2).

So what? You need to know what it will do for you—under your parameters, your light source, and your load! How? With a handy-dandy solar cell tester.

The Rating Game. Silicon cell output varies with the light level, and with the load as well. If a cell is too heavily loaded, the power drops appreciably. Glance at the power graph. Notice it peaks when the voltage across the cell is 460 millivolts.

This is where the manufacturer tests his units, to determine *maximum performance*. He uses variable load, placed across the cell. With no load, the solar generator exhibits an open circuit voltage higher than its working voltage. As the load is increased (more current), the potential across the junction drops.

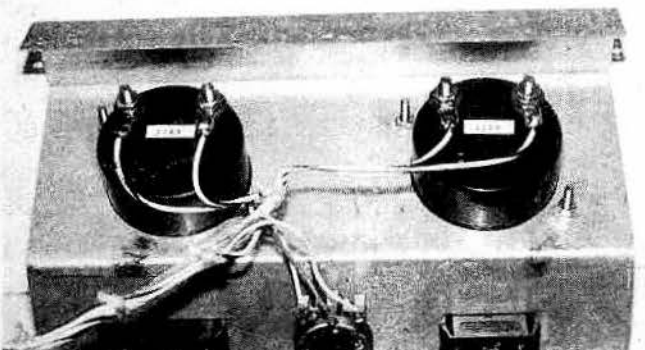
At one point, the current begins to dip along with the voltage—thus further reducing power. The maker sets the resistance so the voltage across the cell under test is optimum.

Figure 1, shows a simple circuit for performing just such a test. One meter monitors current . . . the other voltage. Adjusting the variable resistor to the peak power voltage (460 mv) will net you the device's current! But, the output current differs from cell to cell, necessitating a corresponding change in resistor value. That's fine if you're testing one or two units, but how do you efficiently check 20, or 50, or ??? With a dynamic variable load; one that adjusts itself to the correct voltage.

About The Circuit. The easiest way to achieve a dynamic variable load (DVL) is using a transistor. In figure 2, the solar cell is connected across the emitter and collector. As current is metered through the base, the V_{CE} changes—loading the cell accordingly.

Now, add a feedback loop, an amplifier, a couple of meters, and we have a professional solar cell checker.

The feedback resistor, R_2, determines the amplifier gain, while the non-inverting input monitors the voltage across the cell and compares it to the reference voltage at the inverting input.



Looking down at the Solar Cell Tester. Chassis, meters, switches, and the calibration control can be seen. If you look carefully, you will notice the wire shunt (Rm) across the panel meter on left.

Let's Make One. The tester can easily be duplicated, using any method of construction available to you: perfboard, PC board, point to point, etc. You'll notice, a PNP transistor is used for the load, making the ground positive in respect to the cell's input voltage. That's because the silicon cell has a *positive* backing, with the front contacts *negative* polarity.

The IC amplifier is a 741, but any stable operational amplifier should suffice. Don't forget the external compensation, should your choice require it. The only requirement—output current. As the transistor reaches higher current levels, the H_{FE} (gain) decreases accordingly, requiring more base current through the transistor.

The sink transistor (Q1) may be any silicon PNP capable of passing 1 amp safely and able to dissipate about 1 watt. No heat sink is required.

My test instrument was designed to measure 1 ampere, but you can make it any range you desire by changing R_M. If you use a 0-1 ma meter with an internal resistance of 50 ohms, follow the chart for your selected value. If it is 100 ohms, double that figure—it'll be close enough to be accurate.

Connect R_4 and R_5 to the Vcc power supplies as shown. The power supplies should be tracking—or, at least regulated. Otherwise, the reference voltage at the inverting input will shift, throwing off your calibration setting. (Actually, I've even used two 9 volt batteries and had good results. If the cells are within reasonable tolerance, the shift is negligible. But, for precision, a well regulated power supply is a *must*.)

Using It. Connect the cell under test to the input leads, observing polarity.

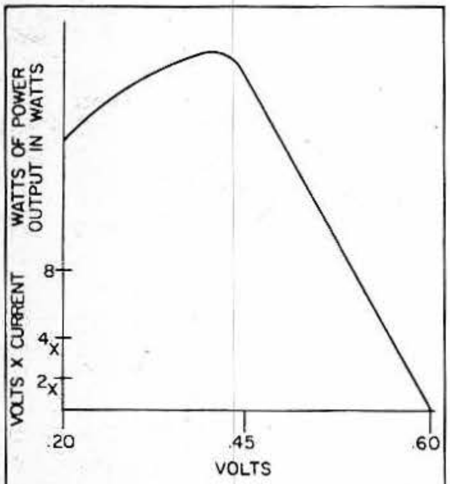
Solar Cell Tester

Illuminate the surface with the light it will be subjected to (sunlight, desk lamp, etc.) and set the CAL control for the voltage—in most cases .46 volts. The current of the cell will be displayed on the other meter—don't forget your multiplication factor!

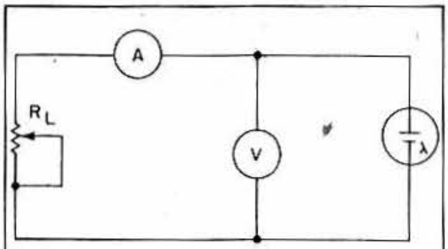
The tester will adjust to any cell automatically, regardless of the output current of the load.

A nice feature about the instrument is you can change the calibration to give you the output voltage at a specific current. Twist the calibration knob to your current value, then read the voltage. Of course, it won't regulate at that current value as it does voltage, but you will know the output voltage under the actual operating conditions.

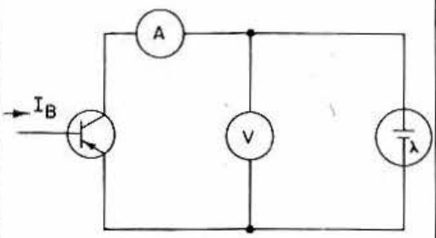
Obtain some solar cells you intend to use for your next solar project. Using your photovoltaic tester, you can now design your load to yield maximum power output. ■



Graph above shows how the solar cell's power output in watts will vary according to voltages above and below rated voltage.



The diagram above shows the basic circuit. The voltmeter shows cell voltage, while Ammeter (A) indicates the load, which can be adjusted by potentiometer, called RL.



In above diagram, the same output voltage can be obtained at different loads. This is accomplished by placing the calibration potentiometer in the transistor's base.

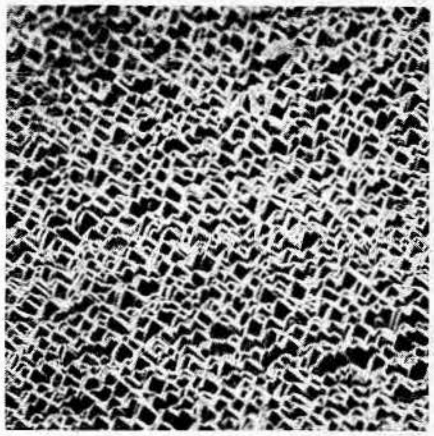
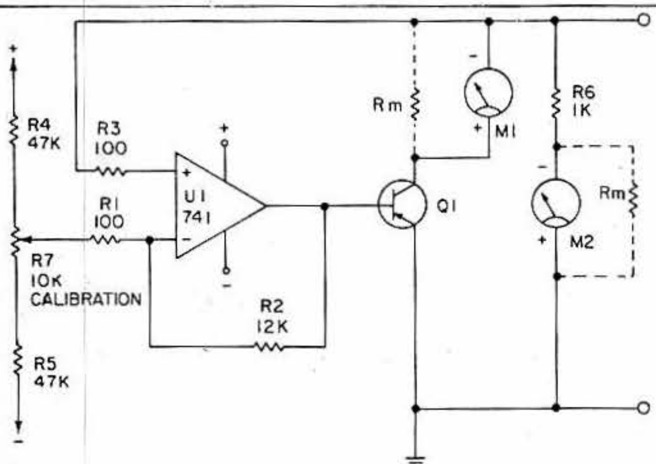


Photo above shows 400 times magnification of a photovoltaic silicon cell surface.

With cell surface magnified 4,000 times, tetrahydrons or peaks stand out sharply.



PARTS LIST FOR PHOTOVOLTAIC TESTER

M1, 2—0-1 ma panel meter (Radio Shack #270-1752)
Q1—transistor, ECG 129, or equivalent
R1—resistor, 100 ohms, ½ watt, 10%
R2—resistor, 12,000 ohms, ½ watt, 10%
R3—resistor, 100 ohms, ½ watt, 10%
R4-5—resistor, 47,000 ohms ½ watt, 10%
R6—resistor, 910 ohms, ½ watt, 1%
R7—(VR1) potentiometer, 10,000 ohms
U1—integrated circuit 741,1458, etc., operational amplifier

Note: The Radio Shack meter listed has 100 ohms internal resistance.

WHAT'S YOUR Rm VALUE ?

X1	0-1	NONE
X10	0-10	5.00 10.00
X100	0-100	.500 1.00
X1000	0-1000	.050 .100
	RANGE (MA)	OHMS

TOP VALUE IS FOR METER WITH 50 OHMS, BOTTOM IS FOR 100 OHMS.

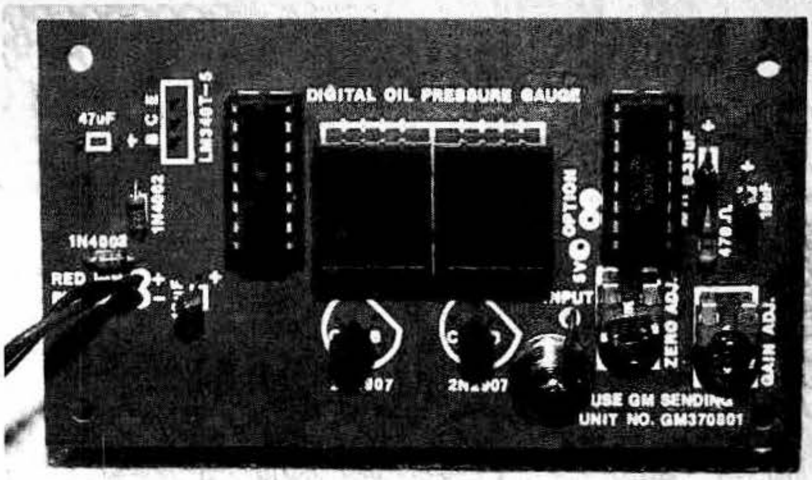
Rm, or meter shunt value is determined by the meter's internal resistance. Using a shunt we can multiply the meter's face value by 10X, 100X, or 1000X. As we increase the multiplied range, the resistance value of the shunt (Rm) goes down.

THERE ARE TWO MAIN CAUSES of "blown" engines, and they both relate to the subject of oil. Either there's not enough to sufficiently lubricate the engine, or it is circulating under too low a pressure to reach all of the areas it is supposed to. In any event, if either condition persists too long, you're likely to be looking for a new mill in very short order, something which can run you anywhere from $300 to $1,000, not to mention the cost of labor involved.

For a few dollars, and with some basic attention to the markings on your dipstick, you can build a highly accurate oil pressure gauge and with it, establish good maintenance habits which can prolong the life of your car or boat engine for thousands of extra miles. Why should you add a gauge if your car already has a dummy light? A dummy light will only signal you when oil pressure has *already* dropped to a dangerously low level. At this point, it's usually too late, and the pistons will seize against the cylinder walls, causing the car to stop as if hit head on by a truck. A gauge, on the other hand, allows you to establish the normal operating pressures for your car, and can take note of the fluctuations caused by worn oil pump gears, jammed oil pump pressure relief pistons, leaking seals and gaskets, and can even tell you, by indicating an increase in pressure, when it's time to change your oil filter. In some cars, a gradual drop in oil pressure can indicate low oil levels, although the only *positive* method for determining the amount of oil left in the oil pan is by checking the dipstick itself.

One of the best features of this gauge is that it is installed so as not to eliminate the function of the dummy light system. In effect, the dummy light serves as a fail-safe against the possibility of gauge or sender malfunction.

The Circuit. Regular readers of this magazine will no doubt recognize the basic design of the oil pressure gauge from those of the voltmeter and temperature gauges. The same three versatile ICs are used again here.



Dashboard Digital Oil Pressure Gauge

An essential instrument to help prolong engine life

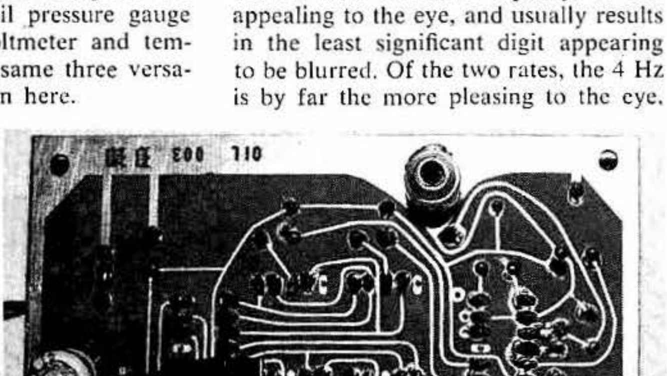
The ignition input (+12 VDC line) should be connected to some point on the car's electrical system that is active only when the ignition switch is on, and the motor is running. At all other times, the ignition line should be off. The most desirable connection would be the same fuse terminal that the horn or windshield wiper is connected to.

Note the point marked OPTION on the schematic. With pin 6 of the CA3162E disconnected, there are four conversions or comparisons made each second. Tying pin 6 to the 5-volt line will result in 96 conversions or comparisons per second. The 96 Hz rate moves with excessive rapidity, is not appealing to the eye, and usually results in the least significant digit appearing to be blurred. Of the two rates, the 4 Hz is by far the more pleasing to the eye, is easier for the eye to focus on quickly, and is the recommended rate. These rates could vary slightly because of capacitor variance from stated values.

The multiplexing digit driver pins (pins 3 and 4) on the CA3162E switch the two transistors that drive their respective 7-segment displays. The CA3162E determines which display is to be on, and sends the BCD (Binary Coded Decimal) information to the display that is on. The BCD information is converted into a 7-segment output by the CA3161E. This, in turn, causes those segments to be lit that correspond to that BCD number.

Note that across pins 8 and 9 of U2 there is a 50K (R2) potentiometer connected. Pin 12 of U2 has a 0.33-μF tantalum integrating capacitor (C4). These components (in conjunction with the CA3162E) generate the necessary waveform for that IC to perform the conversion. The operation of the 50K potentiometer (ZERO ADJUST) will be covered in the calibration procedure.

Sending Unit Operation. The maximum voltage differential that can be read by the CA3162E is 999 mV. With this in mind, examine the circuit configuration. The sending unit specified must be used because of its ¼-inch pipe thread and its electrical characteristics. With the application of pressure, the sending unit's resistance change is virtually linear. At 40 PSI (pounds per



A view of the foil side of the PC board for our Digital Oil Pressure Gauge. Note the clean layout. If you mount the regulator chip on the foil side, carefully bend it parallel to the board, making sure that nothing shorts out.

Oil Gauge

square inch), the resistance is approximately 40-ohms.

Let's now consider what happens when voltage is applied to the sending unit and the digital oil pressure reading which results. By applying a small current through the 470-ohm resistor to the sending unit, the resulting voltage is almost linear in relation to pressure. At 40 PSI there are approximately 400 mV developed across the sending unit. The voltage enters pins 11 and 10 of U2 by means of the coax cable coming from the sending unit to the display board. There the 400 mV is converted to a BCD equivalent. The BCD information enters the CA3161E (U3), a current-limiting, decoder/driver IC. This causes the 7-segment display to display 40 pounds of pressure. An Ohm's Law calculation will show that the voltage is actually slightly less than 400 mV. This requires compensation, which is corrected (or compensated for) by using the GAIN ADJUST.

Assembly. After etching your PC board, (or receiving one from Digital World) check the finished product for foil bridges and other imperfections which might create difficulty during assembly and calibration. Leaving installation of U2 and U3 for later, install all other components on the board, following the component placement guide. Be sure to observe polarity with respect to diodes and capacitors.

We strongly suggest that you make use of IC sockets when installing U2 and U3. These two chips are highly sensitive to static electrical damage caused by handling without insulated tweezers. In addition, stray AC from the tip of your soldering iron (not to mention excessive heat) can also cause irreparable damage to the chips.

With all components installed, make a final check of the board against the component layout diagram as a precaution. If the final check is positive, proceed to wire in the 2 leads for the 12-volt power source. The unit is now ready for calibration.

Calibration. The degree of accuracy ultimately attainable with the gauge will be determined to a great extent by how carefully you adhere to procedures.

Begin the calibration by applying 13.8 VDC to the voltage input lines. While the LM340-T (U1) is a darned good regulator, seeing as how you'll be powering the gauge from 13.8 VDC during operation, why not try to duplicate operating conditions during calibration? At this point, you should get some sort of reading on the LED displays. If not, skip ahead to the Troubleshooting section to clear up the difficulty.

Assuming all is well, momentarily ground pins 10 and 11 of U2 to circuit ground, and adjust R2 until the LEDs read "00." Avoid rapid movement of the wiper on R2, as the range is very short, and you may pass the desired point before realizing it. Remove the ground on pins 10 and 11.

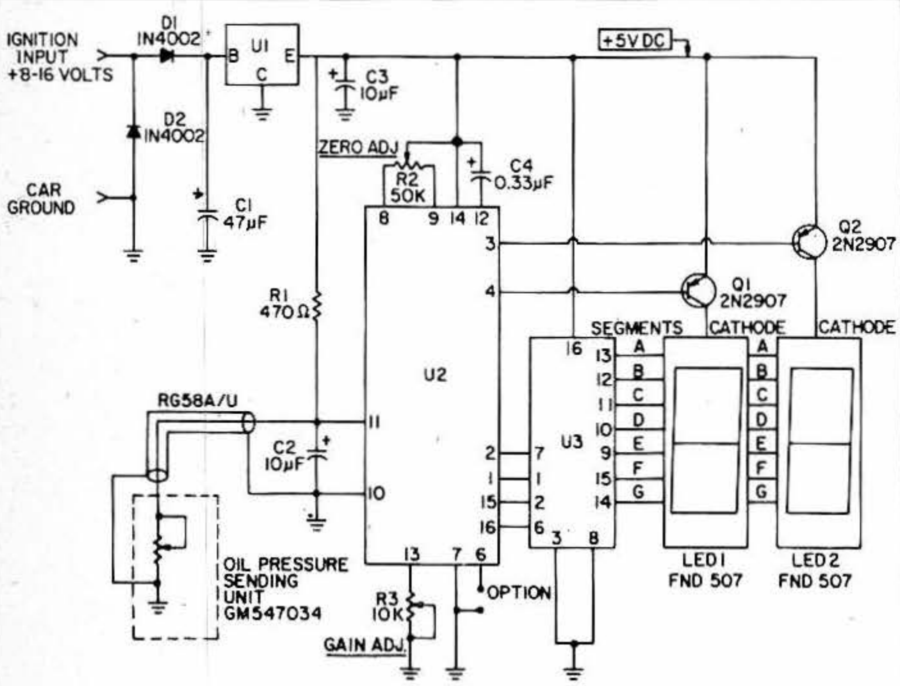
Momentarily disconnect the sending unit's coax plug from the board and insert a 47-ohm resistor across J1. Slowly adjust R3 until the displays read "47." This completes the calibration procedure, and the unit is now ready.

Troubleshooting. If, as mentioned above, the displays do not light when power is applied, recheck to see that you have not created any solder bridges which may be shorting out some components. Check to make sure that all diode polarities are correct, and that the input power line polarity is also correct. Additionally, check to make sure that the wiper of R2 is centered. If the displays light only dimly, check to make sure that Q1 and Q2 have been installed correctly.

Some GM sending units may generate electrical noise during their operation, which may result in rapidly fluctuating readings. If this is the case, you may either replace the unit with another one, or try replacing C2 with a 100-uF, 16-VDC electrolytic capacitor. This may filter out the undesired noise.

Mounting The Unit. Determine where the gauge will be installed and how it will be mounted; i.e., glued, bolted, or clamped. This will, of course, vary from car to car.

The plexiglass panel should be cut and fitted to the circuit board (then re-



PARTS LIST FOR
DIGITAL OIL PRESURE GAUGE

- **C1**—47-uF, 25-VDC electrolytic capacitor
- **C2, C3**—10-uF, 16-VDC tantalum capacitor
- **C4**—0.33-uF, 35-VDC tantalum capacitor
- **D1, D2**—1N4002 diode
- **LED1, LED2**—FND-507 7-segment, common cathode display
- **Q1, Q2**—2N2907 PNP transistor
- **R1**—470-ohm, ¼-watt resistor, 5%
- **R2**—50,000-ohm linear-taper potentiometer
- **R3**—10,000-ohm linear-taper potentiometer
- **U1**—LM340T-5 voltage regulator integrated circuit
- **U2**—CA3162E analog-to-digital converter integrated circuit
- **U3**—CA3161 BCD decoder/driver integrated circuit
- **J1**—RCA-type phono jack
- **P1**—RCA-type phono plug
- **Misc.**—General Motors oil pressure sending unit #547034 (fits 1966-79 Chevy, Buick, Olds), ¼-inch brass pipe tee fititng (available at most auto supply/speed equipment distributors), 1 to 2-inch length of ¼-inch diameter extender pipe, teflon plumber's tape (for sealing pipe threads), 10 to 15-feet RG58A/U coaxial cable, IC sockets, spacers, red plexiglass contrast panel, hookup wire, solder, etc.

For information on the availability of parts and other materials to build DIGITAL OIL PRESSURE GUAGE, send a stamped-self-addressed envelope to Digital World, P.O. Box 5508, Augusta GA 30906.

moved) before the board is assembled.

A plexiglass panel with a metal rim may be purchased from Radio Shack for several dollars. Ask to see the die-cast bezels. We have no information at this time on the availability of multiple display bezels. The single unit bezels look "pro" and are relatively easy to fit, requiring little or no modification.

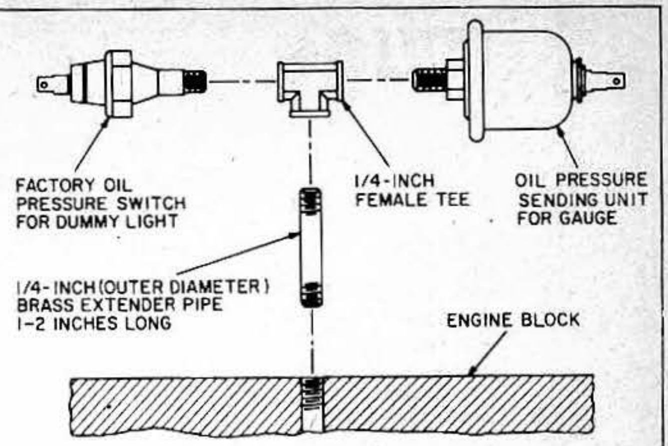
You may wish to use a larger piece of plexiglass for a multiple display panel, attaching several units to it. This requires detailed planning in layout, care in cutting the total panel, and patience in the drilling of the holes for the four retaining bolts (for each gauge) to be mounted behind it.

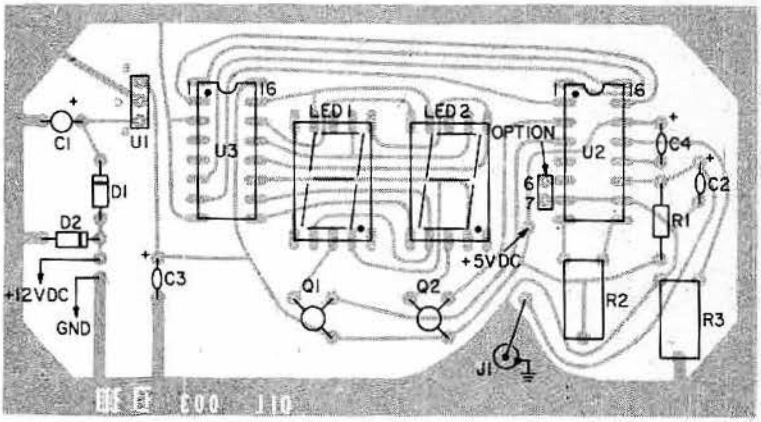
Another idea is to place the LEDs (for a series of gauges) on a "perf-board" behind the single panel, putting the units elsewhere, out of sight but easily accessible for repairs. However, this requires extensive wire hookups between the circuit boards of the several units and the corresponding display LEDs. Such a project is not recommended for the hobbyist just starting to work with digital units.

The Coax Connector. What length should the coax cable be? A simple way is to use a piece of string to measure sufficient coax length. A coax piece too short must be spliced and could be of questionable operational efficiency. Measure distance from the sending unit, routing it about the motor to points where it may be easily and firmly secured and which are well away from the hot manifold and the vicinity of the spark plug wires. Cut a sufficient length of RG58A/U cable (coax) to go from the sending unit to the display board dash location. It is wise to allow at least an extra 18-inches, permitting possible relocation, should a second location be selected later.

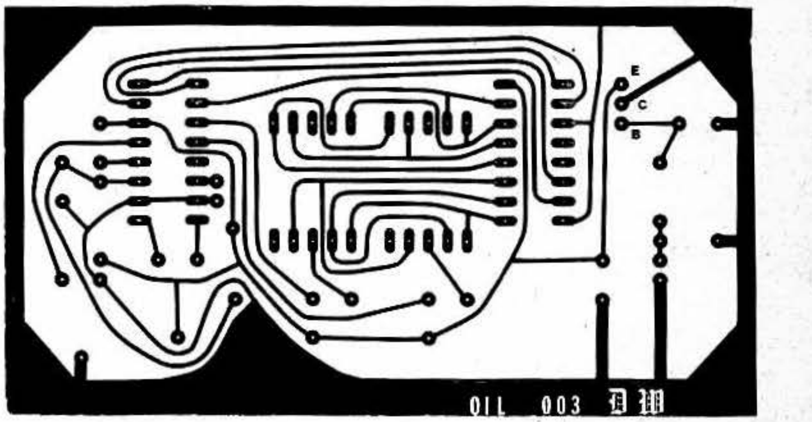
Solder the center conductor wire to the terminal of the sending unit, and the shield to the case of the sending unit. Do not rely on the car chassis ground to complete the path of current flow for the sending unit. The properly installed shield acts as the ground. The coax cable should be further secured and protected by being heavily taped to the sending unit. Failure to do this could result in the cable being broken at the connections because of car vibrations and/or turbulent winds under the car at higher speeds. At the dashboard end of the coax, the center connector is soldered on to the middle pin of P1, and the shield is soldered to the outer skirt. The plug is then ready to be inserted into the female jack on the back of the circuit board. Again, thread and secure the coax away from the hotter parts of the motor and the ignition system wiring.

A drawing of the sending apparatus. This system insures that both the gauge which we're installing and the original oil warning light will keep operating. Thus, there are two warning devices, backing up each other, thereby bringing about real auto safety.





Parts layout for the Digital Oil Pressure gauge. There are relatively few components to worry about, those that there are, are relatively well-spaced. VCR's on other side.



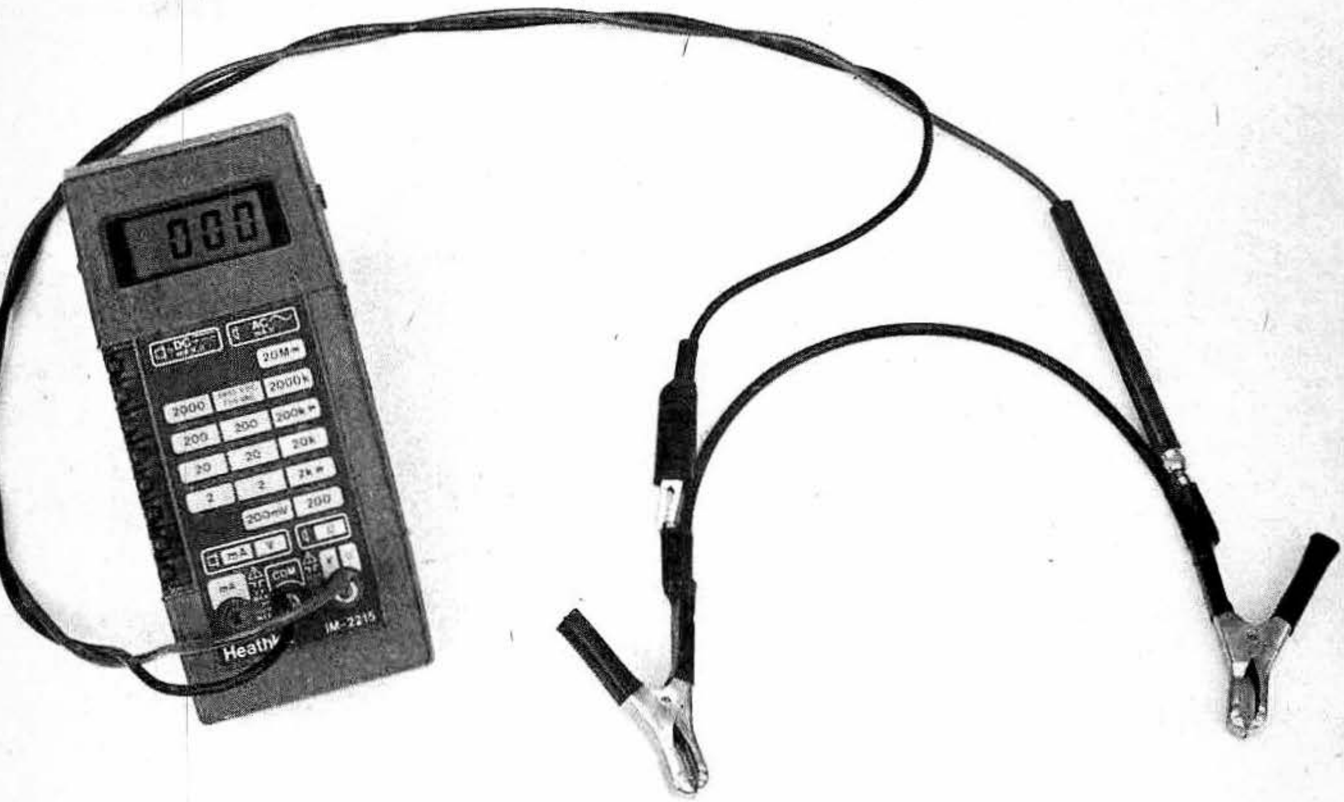
Here's the printed circuit board for the Digital Oil Pressure Gauge, foil side up. This is exactly the way the board you make for the unit should look. Watch for solder bridges!

The Dual System. Examine the dual system connection diagram. To use the dual system, a brass "tee" adaptor is required. Use a ¼-inch, 3-input female adaptor, which should be available at your local plumbing supplier. Purchase, also, a 1-inch or 2-inch piece of standard ¼-inch brass pipe (long enough for the sending unit to clear the engine block and other components). Next, screw the pipe extender into the center of the "tee" adaptor. Now, screw the other end of the extender pipe into the engine block where the factory switch was installed. The two remaining arms of the tee are used to atach the factory warning light switch on one end and the GM sending unit on the other. On foreign cars using the metric standards, it may be necessary to use an adaptor for the ¼-inch extender pipe, or to secure a blank brass pipe and

(Continued on page 96)

TROUBLESHOOTING WITH A DIGITAL MULTIMETER

Check out your ignition system for fun and profit



IF YOU WANT to measure the large current from your car's alternator or starter, here are a few tricks on how to do it with your digital multimeter.

Digital multimeters (DMM) are sensitive and accurate devices. They have a much greater range than common analog multimeters; with a little help, they can measure very large currents. The help is from a low resistance shunt.

A Small Resistance. A one milliohm shunt is a very small resistance, but it still behaves as a resistor and every ampere through it causes a one millivolt drop. Digital voltmeters can read millivolts and most will read and display tenths of millivolts. This extreme voltage sensitivity allows them to work as ammeters when connected across a one milliohm shunt.

A DMM connected across the ground cable thus becomes a high-current ammeter. Similarly, a charging current of 40 amps into the battery produces a voltage drop of .040 volts across the cable.

The key is to calibrate your battery cable. It's easy. Most car low beams, including the running lights, use about 12 amperes. With the headlights on, measure the voltage drop across the ground cable. Suppose this turns out to be .020 volts.

Therefore, a starter draw of .192 volts across the cable means that 12÷20 or .6 of 192 amperes are flowing: about 120 amperes. Approximately .6 of the millivolts read on a DMM are the amperes through it.

If the 12 ampere headlight had caused a .005 volt drop across the cable, 12÷5 or 2.2 times the DMM reading of millivolts across the cable represents the amperes through it.

Needs A Strong Battery. This calibration is best done with a strong battery. Check the cable on the positive terminal, running to the solenoid. It might be more convenient to use.

If you do not like the mental arithmetic involved in converting millivolts into amperes, connect taps to the battery cable to produce a 12 millivolt drop when the low beams are on.

Puncture the cable insulation with a sharp pin. Place the tap in the middle of the region of the cable where the voltmeter reads 12 millivolts.

The taps are combination jacks accepting probe tips, banana plugs, or alligator clips (GC F2-883 or Allied 920-0222). Make the electrical connection with a small sheet metal screw, #4, ¼" long. It will separate the strands of wire in the cable and be held snug to the taps.

Tape it securely. This is a more satisfactory way to measure all currents in the car, even down to tenths of amperes for small lights or electronic systems, provided your DMM reads to tenths of millivolts.

Even a 20% error is acceptable when looking for trouble and will tell the difference between a shorted starter motor and a solenoid that isn't closing.

A third way to read currents in your car with a DMM is to build or buy a one milliohm shunt that can be clamped in between the battery ground cable and the negative terminal.

With this value of shunt the millivolts on the DMM connected to the shunt read accurately as amperes. ■

Build a budget DWELL/TACHOMETER

Saves money on tune-ups!

Outside of a good set of wrenches, the most commonly called for automotive tool is the dwell/tachometer. When tuning up an engine, there's no substitute for the kind of accuracy a dwell/tach can bring to your engine adjustments. A commercial version of this apparatus might run as high as $25.00. With some judicious parts buying, you should be able to do the job for roughly half of that figure. In addition, our dwell/tachometer gives you an additional feature not found on any but the most expensive commercial units: a DC voltmeter, which is highly useful in checking a car's electrical system and, in particular, the ignition.

Most of the parts used in the construction of this instrument will probably be found in the electronics hobbyist junk box. The meter is a common 1 mA DC movement. If desired, other meter movements may be used by simply changing circuit values to accommodate a more or less sensitive meter.

Construction. Most of the circuitry of the instrument is built on a printed circuit board, which mounts all components except the front panel switches and meter. The PC board is mounted to the rear of the meter by means of the two meter studs. This type of construction allows the entire circuit of the instrument to be contained in one module, and allows ease of assembly and service if ever necessary. The components layout as seen from the parts side of the board is shown in Fig. 1, and the printed circuit layout as seen from the copper side of the board is shown full size in Fig. 2. If you are going to use a physically different meter than that specified in the parts list, be sure to take into account the center-to-center stud distance when laying out the printed circuit board.

Fig. 3 is an illustration of a meter scale which can be used for the instrument. This scale has two ranges; 0 to 1500 RPM, and 0 to 60 degrees dwell. To change the 0 to 1 milli-

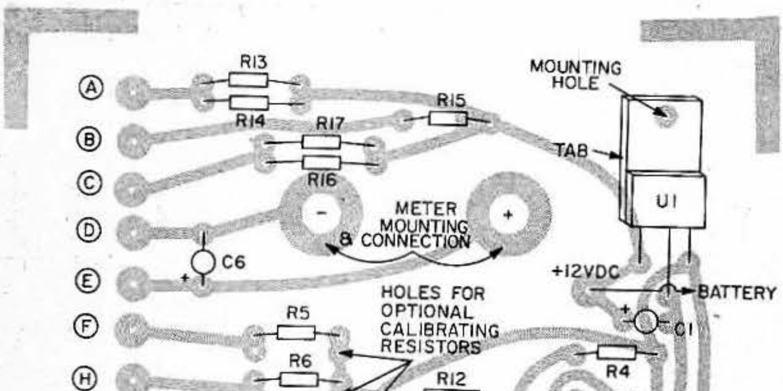
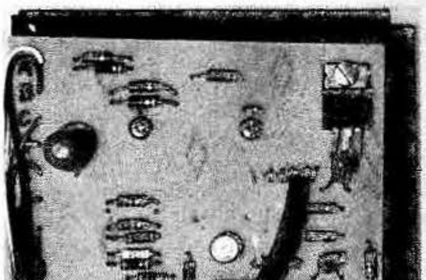


Fig. 1. The component layout diagram will guide you in assembly of board. Take care not to cover holes for calibrating resistors near R5, R6 and R7.



Compare this photo with the component layout guide at left for reference during assembly. In author's prototype, some calibrating resistors have been added. Don't be discouraged if your model needs them.

DWELL/TACH

ampere scale on the meter, remove the plastic front of the meter and carefully remove the two small screws which hold the scale in place. You can then paste the scale of Fig. 3 over the back side of the meter scale and put it into place over the meter movement. Be careful not to disturb the meter needle during this operation, since it is very fragile. Fig. 4 can be used as a front panel label which provides the FUNCTION and CYLINDER lettering.

The instrument is connected to the automobile ignition system with three wires, as shown in Fig. 6. Be sure to use different colors to help prevent misconnections when the instrument is placed in use. Rubber covered test lead wire is ideal for the purpose, and comes in several colors besides red and black. Alligator clips and boots can be placed on the ends of the wires for the connections to the automobile.

Connections between the printed circuit board and front panel switches are indicated on the schematic diagram and printed circuit layout by a group of 14 letters, A through N. Three additional wires are used for the three operating leads of the instrument. These connections are clearly marked on the parts location guide diagram.

After the unit is completely wired, double check to make sure that the transistors, integrated circuits, and electrolytic capacitors are mounted to the printed circuit board in the correct direction. These components are polarized and will be damaged if they are placed into the circuit improperly.

The Circuit. In order to best understand the operation of the dwell/tachometer circuit, it is necessary for the reader to be familiar with the voltage waveform appearing at the primary terminal of the ignition coil. This is shown in Fig. 5. The basic voltage waveform is a rectangular pulse with a considerable amount of ringing on the rising edge of the pulse. This ringing is caused by the sudden cut-off of current in the ignition coil, and results in the high voltage generation which fires the spark plugs. The duty cycle of the rectangular pulse is determined by the dwell angle of the ignition points (or solid state circuit in electronic systems), and must fall within specified limits for

The dwell meter section of the instrument is composed of Q2, Q3, and associated components. Q3 is connected as a constant current generator with eight-volts impressed upon the base and

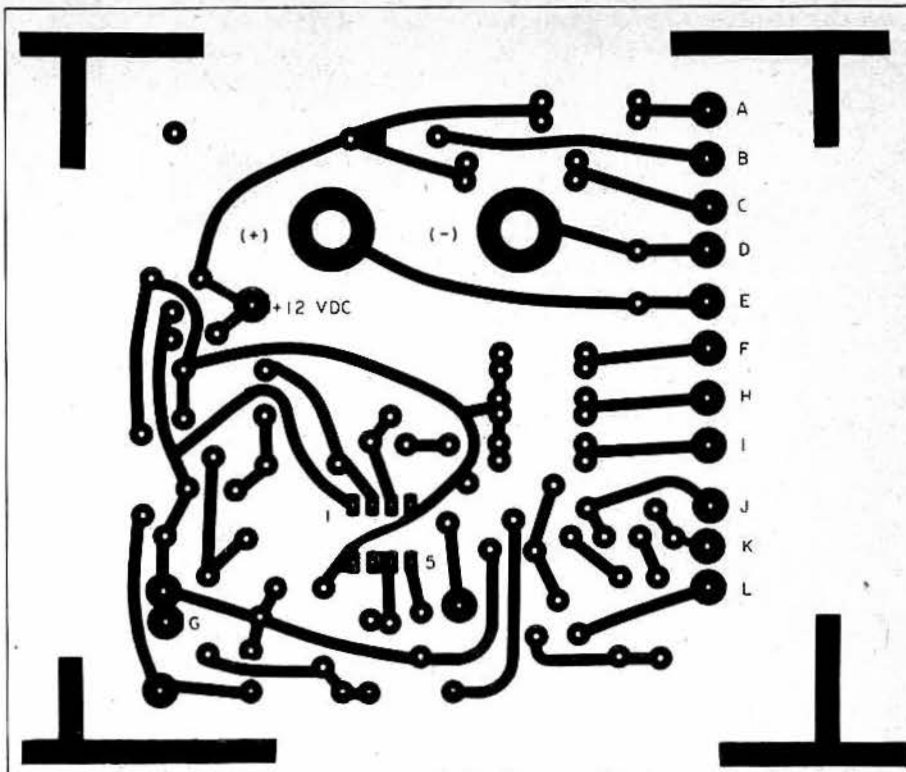
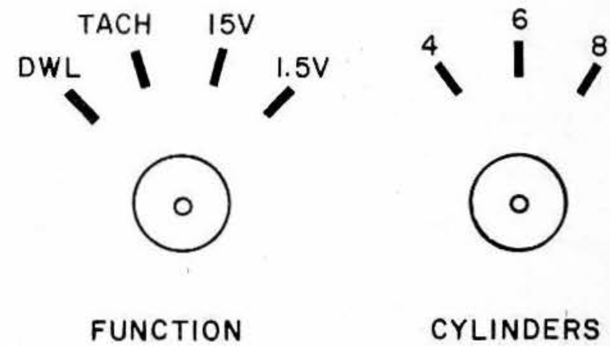


Fig. 2. This is the full-scale etching guide for the Dwell/Tachometer's printed circuit. DO NOT etch the board until you know the center-to-center distance of the studs.

Fig. 3. This is a full-scale template for use on the meter face. It is designed to be used with the GC Electronics movement described in the parts list, but will likely fit other meter faces just as well.

Fig. 4. Function template, also full-scale, can be used on the cabinet front to illustrate the switch positions. If your configuration differs from ours, a good method of illustrating the front panel is to use transfer lettering stencils.



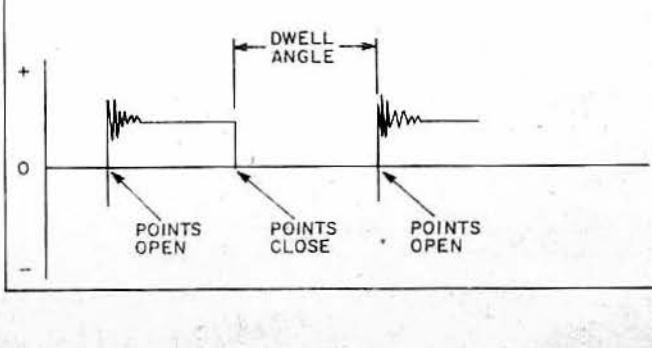
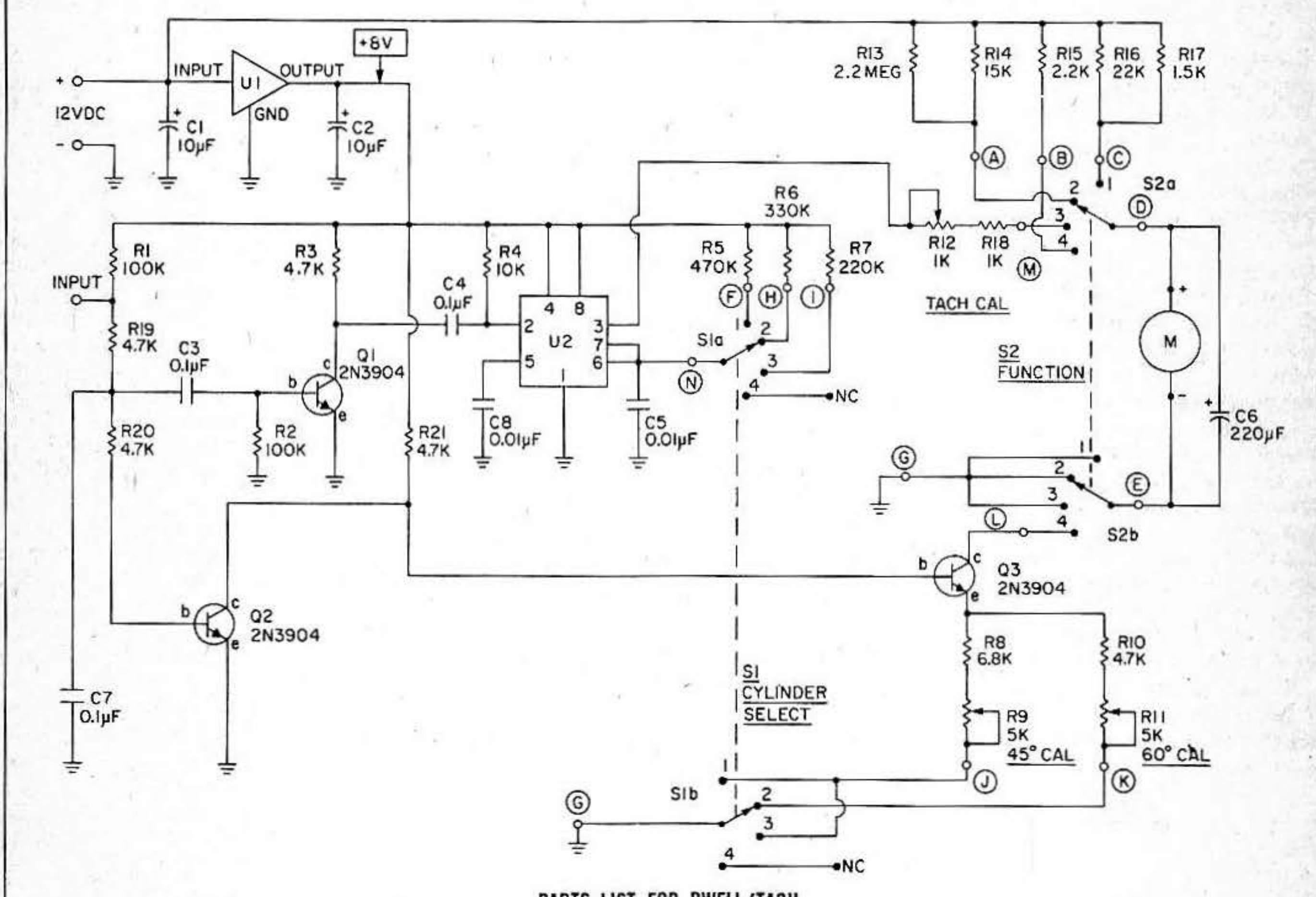


Fig. 5. A waveform diagram of the voltage across the ignition points illustrates exactly what happens during operation, and what it is that you're measuring when you use the instrument.

the meter placed in the collector circuit by the FUNCTION switch. The value of resistance placed in the emitter of Q3 determines the collector current of the transistor, and is adjusted so that the meter reads the full dwell angle (45 or 60 degress) when the sensing lead of the instrument is shorted to ground. Q2 acts as a switch which controls the base of Q3, and causes Q3 to either be on or off, depending upon the state of the ignition points. When the points close, Q2 is cut off and Q3 passes its calibrated constant current through the meter. When the points open, Q2 is forward biased and saturated by the voltage appearing across the points. This cuts off Q3 and the meter current is zero. Since this action takes place much faster than the meter needle can follow, the meter reading is the average of the two conditions, and is the actual dwell angle measurement.

The tachometer section of the instrument makes use of the fact that the meter of spark plug firings per second is directly related to the RPM of the engine. Q1 is used as a buffer transistor between the ignition system and the trigger input of a 555 timer IC which is connected as a one-shot multivibrator. Each time the ignition circuit produces a positive-gain pulse, U2 generates an 8-volt pulse of 2500 to 5000-microseconds duration, depending upon the number of cylinders of the engine under test. The output of U2 is fed to the meter through a calibrating potentiometer. C6 acts as a filter to smooth out the pulses to nearly pure DC, and provides a steady meter reading which is engine RPM.

The voltmeter section of the unit consists of R13, R14, R16 and R17. These components are used as multiplier resistors so that full scale meter current is generated when either 15



PARTS LIST FOR DWELL/TACH

C1, C2—10-uF, 25-VDC electrolytic capacitor
C3, C4, C7—0.1-uF, 25-VDC ceramic capacitor
C5—0.01-uF, 25-VDC tubular capacitor
C6—220-uF, 6-VDC tantalum capacitor
C8—0.01-uF, 50-VDC disc capacitor
Q1, Q2, Q3—2N3904 NPN silicon transistor (or equivalent)
R1, R2—100K, ¼-watt resistor, 10% (all resistors 10% tolerance unless otherwise noted.)
R3, R10, R19, R20, R21—4.7K, ¼-watt resistor
R4—10,000-ohm, ¼ watt resistor
R5—470,000-ohm, ¼-watt resistor
R6—330,000-ohm, ¼-watt resistor
R7—220,000-ohm, ¼-watt resistor
R8—6,800-ohm, ¼-watt resistor
R9, R11—5,000-ohm linear taper potentiometer (PC mount)
R12—1,000-ohm linear taper potentiometer (PC mount)
R13—2,200,000-ohm, ¼-watt resistor
R14—15,000-ohm, ¼-watt resistor
R15—2,200-ohm, ¼-watt resistor
R16—22,000-ohm, ¼-watt resistor
R17—1,500-ohm, ¼-watt resistor
R18—1,000-ohm, ¼-watt resistor
S1, S2—2-pole, 4-position rotary switch, GC Electronics #E2-166, or equivalent
U1—LM340T-8, 8-volt regulator integrated circuit
U2—555 timer integrated circuit
Misc.—0 to 1 mA DC ammeter movement, GC Electronics #D1-912, or equivalent, cabinet, solder, alligator clips, knobs, etc.

For information on the availability of parts and other material to build DWELL/TACH, send a stamped, self-addressed envelope to Niccum Electronics, Route 3, Box 271B, Stroud, OK 74079.

Here the Dwell/Tach's voltmeter function is being utilized to test a battery. If you look closely, you'll see that the meter is reading a nominal 12-volts.

or 1.5-volts is fed to the power leads of the instrument. The function switch of the unit connects the proper resistors into the circuit as necessary for a full scale voltmeter reading of either 15 or 1.5-volts.

U1 is a fixed, 8-volt regulator IC which provides the power to operate the dwell and tachometer sections of the unit. Since the circuit derives its power from the battery and alternator of the automobile under test, the 8-volt regulator ensures that the calibrated accuracy of the instrument is retained regardless of varying voltages being generated by different charging systems.

Checkout and Calibration. To check and calibrate the unit, you will need a variable DC power source of 0 to 15-volts, an accurate DC voltmeter, and an audio oscillator which can deliver at least 15-volts RMS output. A Hewlett/Packard 200CD or equivalent is ideal.

Set the FUNCTION switch to 15-volts and connect the positive and negative leads of the instrument to the power supply. Connect the voltmeter across the output of the supply. Raise the voltage of the supply from zero to 15-volts while watching the instrument, which should agree with the DC voltmeter. If necessary, you can change the value of R14 to provide an accurate indication of 15-volts. Reduce the output of the supply to 1.5-volts and set the function switch to 1.5-volts. If necessary, the value of R17 can be changed to provide an accurate indication of 1.5-volts.

The next check to be made is upon the dwell meter circuit. Set the FUNCTION switch to DWELL, and the power supply to 14-volts. Connect the sensing lead of the instrument to the negative side of the power supply. This should result in some positive meter reading. Set the CYLINDER switch to 8, and adjust R9 for a meter reading of 45 degrees on the 0 to 60 dwell scale. Set the CYLINDER switch to 6 and adjust R11 for a meter reading of 60 degrees. Check the meter reading with the CYLINDER switch set to 4. It should read 45 degrees. (This reading will be doubled during operation of the instrument, and is actually 90 degrees for 4 cylinder engines). Remove the sensing lead from the negative side of the power supply. The meter should read zero for all settings of the CYLINDER switch. This completes the dwell calibration.

To calibrate the tachometer section of the unit, connect the instrument, power supply, and audio oscillator as shown in Fig. 6. Set the power supply to 14-volts output, and the audio oscillator to 30 Hertz at 15-volts output or more. Set the FUNCTION switch of the instrument to TACH and the CYLINDER switch to 8. Adjust R12 for a meter reading of 450 on the 0 to 1500 scale of the meter. Check the reading of the meter with the cylinder switch set to 6 and 4. These readings should be 600 and 900 respectively. If necessary, you can parallel R5, R6 or R7 with resistors as required to attain proper calibration for all positions of the CYLINDER switch. The printed circuit layout has additional pads and holes for any extra resistors that may be necessary.

Operation. The Dwell/Tach is connected to the automobile system as shown in Fig. 7. Note that cars with factory installed electronic ignition systems will have a special terminal for the connection of the sensing lead of the instrument. Refer to the service manual for your car, or ask your dealer where this terminal is located. Once the instrument is connected to the automobile, the function switch can be set to DWELL, TACH, or 15-volts as necessary. Keep in mind that when measuring dwell on 4 cylinder engines, you must double the meter reading. Be very careful not to switch the function to the 1.5-volt scale unless you have first checked the voltage of the circuit under test with the 15-volt scale to be sure that the voltage is less than 1.5 volts. This will avoid possible damage to your meter. ■

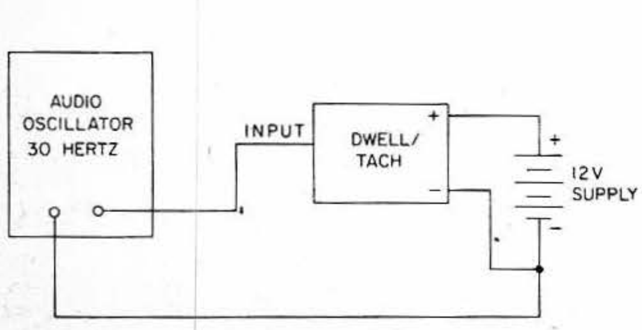


Fig. 6. This is the wiring setup utilized for final calibration. A well-regulated 12-volt power supply is a necessity here. Alternatively, you can use the car's battery if it is fully charged.

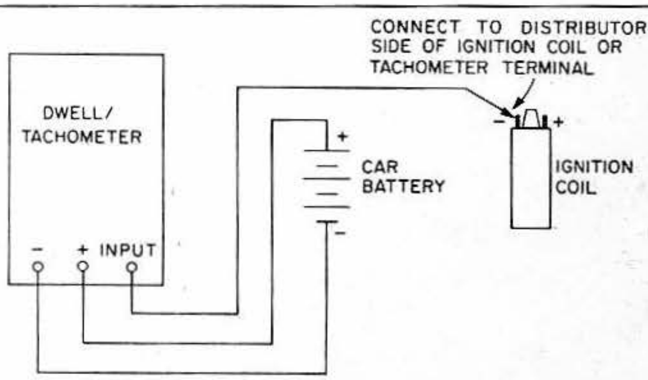
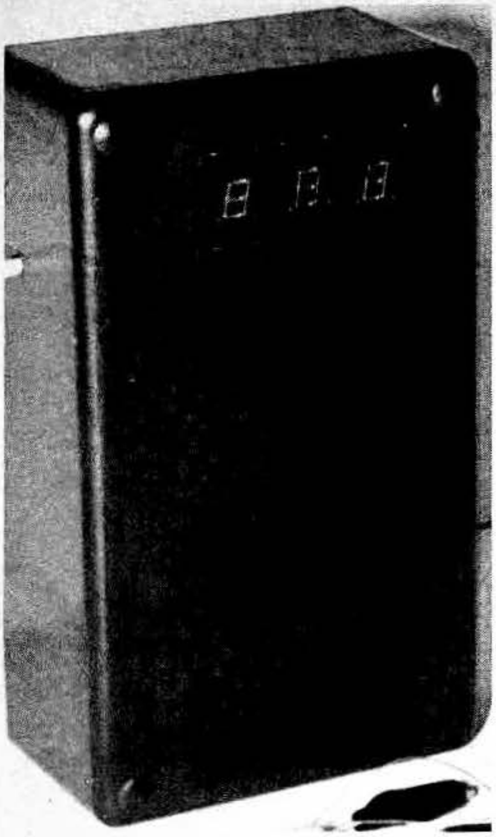


Fig. 7. This is a schematic representation of the manner in which Dwell/Tachometer is connected to car's ignition system. No other connections needed to use all of meter's functions.



BINARY-BCD 7 Segment Converter

Raw binary data is converted for real time LED display

IF YOU'VE done much work with digital IC's, you've undoubtably had occasion to make use of binary counters. These are very useful and versatile components. Unfortunately, they are also the most susceptible to problems with noise, self-annihilating coincidences, too short reset pulses, too slow rise and fall time on input pulses, and related problems.

Some practical means of monitoring counters is needed when troubleshooting digital circuits. Multi-channel logic probes are helpful, but trying to decode a rapidly changing binary count in your head to see if it is skipping any numbers can rapidly lead to mental exhaustion. This is especially true since most binary counters do not have their outputs arranged in an orderly formation for visual monitoring. In addition, multi-channel monitoring instruments can be very expensive.

The best way to monitor binary coded information is with a binary-to-BCD-to-seven-segment converter. The device described in this article accepts binary input and displays it in normal base ten format on (seven segment) LED readouts. The converter has eight inputs 2^0 through 2^7) so it can decode any number from zero up to 255.

The converter can be used in any circuit using binary coded numbers, not only counters. For example, it can be used to determine which address a memory IC is at, so that any address line of a microprocessor can be checked out. In microprocessors using DMA (direct memory access) this technique will solve most troubleshooting problems. In parallel to serial data circuits (multiplexers) such as the 74150, each parallel input line (including the strobe) can be checked using the binary-seven segment converter described in this article. Troubleshooting applications alone make this device very useful. In addition it is worth its weight in gold as a training tool to teach yourself or others how data processing & microcomputer circuits function.

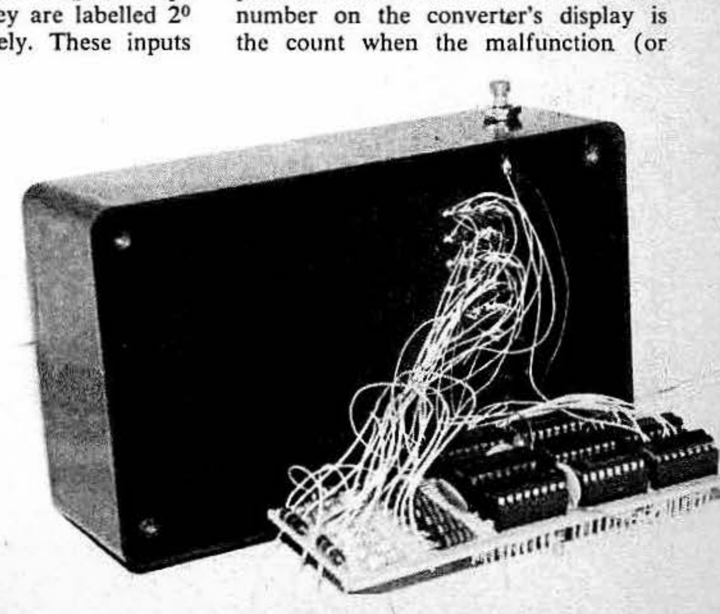
How to Use the Converter. The binary-to-BCD-to-seven-segment converter is extremely simple to use. There is nothing to tune or adjust. It just has ten wires with insulated alligator clips to connect to the part of the circuit you are monitoring.

The first wire has a black insulated alligator clip and should be connected to any ground point on the circuit being monitored. The second wire has a red insulated alligator clip and should be connected to any V+ (5 volts) point on the circuit being monitored. These two connections provide power for the converter. They must be connected before the other eight wires.

The remaining eight alligator clips can be any color. They are labelled 2^0 through 2^7, respectively. These inputs are connected to the corresponding outputs of the counter being monitored. For example, the 2^0 input of the converter goes to the 2^0 (1) or least significant digit output of the counter, the 2^1 input goes to the 2^1 (2) output, the 2^2 input goes to the 2^2 (4) output, the 2^3 input goes to the 2^3(8) output of the counter, etc. If you do not have eight binary outputs, the unused inputs must be connected to ground. If they are not connected to ground, they will read as a high input, resulting in an incorrect display reading.

There is only one button on the converter. This is a momentary contact switch which latches (freezes) the display for as long as the button is held down. This would be used to determine what the count is as a specific event occurs, if the count is changing too rapidly to read.

For example, let's assume that an observable malfunction (such as a sudden heavy power draw) occurs periodically in a circuit. You may wish to determine if the output of a counter in the circuit is the same each time the problem occurs, as a first step in locating the problem. After connecting the converter to the counter, you can watch your instruments for an indication of the malfunction. When it occurs, you press the latch button and hold it. The number on the converter's display is the count when the malfunction (or



Exposed perf-board reveals the 8 ICs, the wire wrap connectors, and 7 resistors for each LED. These 21 resistors, reduce the current driving the LEDs. This model uses 400 ohms. A lower value will produce a brighter display, but more current will be consumed from the power source.

other event) occurred. Note that the latch button does not effect the counter or the circuit being monitored. It merely freezes the display on the converter.

About the Circuit. At the heart of the circuit are three 74185 TTL IC's. These are actually factory programmed ROM's programmed with a binary to BCD conversion table. A single 74185 can convert a six bit binary input to BCD. By cascading the 74185's you can convert as many bits of binary as you like to binary coded decimal (BCD).

Unfortunately, the number of 74185's required goes up exponentially with the number of input bits. A converter that accepts eight input bits requires three 74185's. A converter that accepts 12 input bits requires eight 74185's. To get 16 input bits you need 16 of 74185's. It is unfortunate that a 74185 draws from 40 to 80 mA of current. I have been unable to locate a source of 74LS185's or 74C185's. This means that a converter with 12 inputs would draw about 500 mA just to power the 74185's. Since my prototype draws its power from the circuit being monitored, that is quite a heavy load.

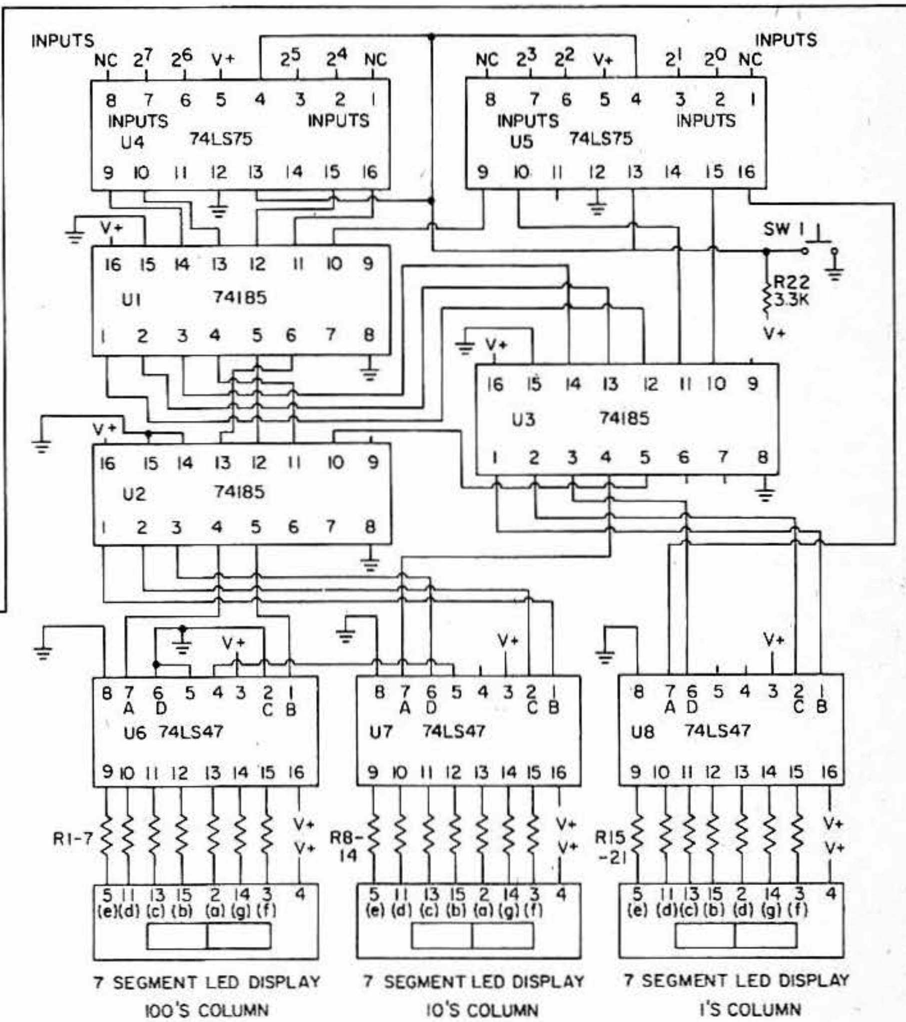
After some debate, I decided to settle for a converter that accepts eight inputs and requires three 74185's. With three 74185's the total converter draws 250 to 350 mA, depending on the binary input. Since eight bits is the output of two cascaded four bit binary counters (such as the 74193), that is quite adequate for most purposes.

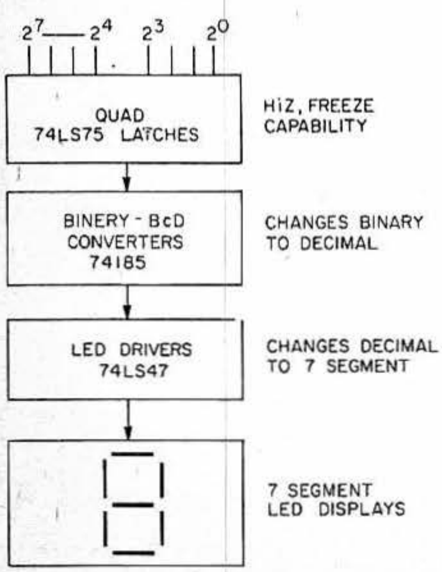
The eight inputs to the converter are actually the inputs to two 74LS75 quad latches. These latches serve two purposes. First, because they are LS IC's they have twice the input impedence of regular IC's. This means that the converter will produce less interference with the circuit being monitored than if the inputs went directly to the 74185's. Secondly, the latches enable you to freeze the display of the converter. When switch 1 (SW 1) is open the enable inputs of the latches are positive and the digital levels at the outputs follow the inputs. When switch 1 is closed the 74LS75's are latched and the outputs are frozen at the values that were at the input at the moment switch 1 was closed.

The outputs of the 74LS75's go to the inputs of the 74185's, where the binary number is converted to BCD. Note that the 2^0 bit bypasses the 74185's and goes directly to a 74LS47. This is because the 2^0 bit is identical in binary and BCD and therefore does not need to be converted.

The outputs of the 74185's go to

(Continued on page 96)



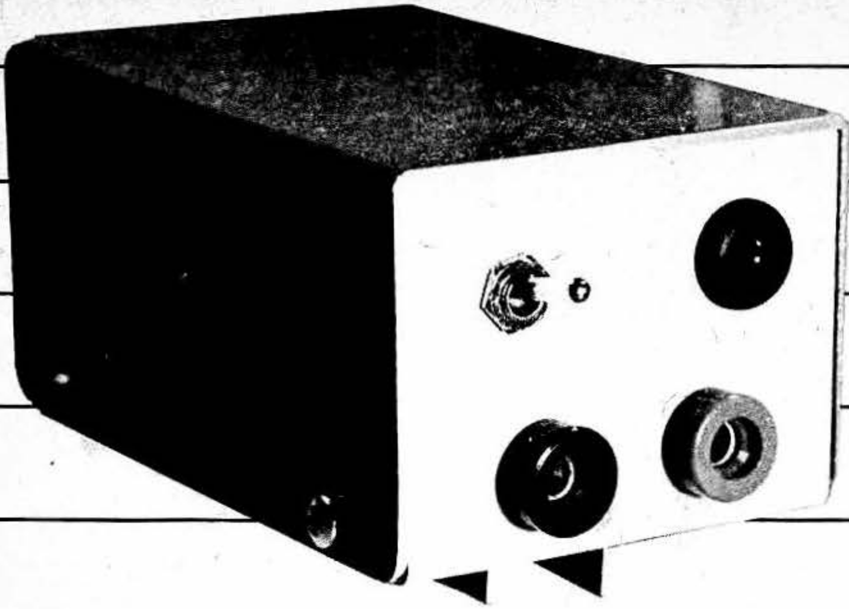


Functional diagram reduces components so that basic theory of the Binary-BCD-7 segment converter is easier to understand.

PARTS LIST FOR BCD CONVERTER

LED 1-LED 3—7-segment common anode display readouts (Radio Shack 276-053 or equivalent)
R1-R21—400-ohm, ½-watt resistor, 10% (see text)
R22—1,000-ohm, ½-watt resistor, 10%
SW1—SPST normally open, momentary conswitch
U1-U3—74185 BCD programmed ROM integrated circuit*
U4, U5—74LS75 quad latch integrated circuit
U6-U8—74LS47 LED driver integrated circuit

Misc. Perfboard, plastic housing, IC sockets if desired, ten insulated alligator clips, wire, solder, etc.
*Available from: Jameco Electronics, 1021 Howard Ave., San Carlos, CA 94070



BUILD A SIMPLE VOLTMETER AND SCOPE CALIBRATOR

Make your test instruments precision measuring devices without breaking the bank

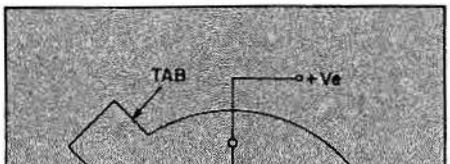
PRECISION VOLTAGE MEASUREMENTS require a calibrated source against which to compare the readings of the voltmeter or oscilloscope. In really high-class measurements, where absolute accuracy is needed, laboratories will use something like a Weston cell and a precision potentiometer. But to the hobbyist, such instruments are both too costly and, in most cases, more accurate than is necessary. In the past, the hobbyist had to be content with zener diode calibrators. Unfortunately, these diodes are not the best and tend to drift. But today, a new breed of regulator is available. Several manufacturers are now offering regulator/reference source ICs using *band gap* zener diodes, and internal amplifiers. These ICs give the hobbyist a low-cost method for building a reference voltage source.

Calculate Your Needs. The circuit in Fig. 1 is sufficient to operate as a hobbyist-grade voltage calibrator. Only a power supply (in this case a battery), a resistor, the regulator IC, and a means for turning it on and off are required.

The value of the series resistor depends upon the reference current selected and the power supply voltage. The reference current may be set at any point in the range of 2 to 120 milliamperes, provided that the overall power dissipation is kept to less than 300 milliwatts. In practice, however, one is advised to select a value in the 2 to 5 mA range. In the example of Fig. 1 we have selected 8.75 mA for a very special, high level, technical reason—we had a 4.2-volt battery and a 200-ohm resistor in the junkbox at the time.

The series resistor's value is computed as:

$$Rl = \frac{Eb - Eo}{Ir}$$



Here is an internal schematic of the band gap zener diode, which serves as the heart of the calibrator. Use the tab on the case as the reference point for making circuit connections. No heatsink is required here.

Where:

Eb is the battery voltage

Eo is the output voltage (1.26 or 2.45-volts)

Ir is the reference current

Rl is the resistance in series with the IC

Example:

In the circuit of Fig. 1, we used a 4.2-volt mercury battery, and selected a reference current of 8.75 mA. Find the value of the resistor needed for *Rl*. A ZN458 (2.45 volts) is used.

$$Rl = \frac{(4.2-2.45)\ volts}{(0.00875)\ Amp}$$

$$Rl = \frac{(1.75)}{(0.00875)} = 200\text{-}ohms$$

The resistor used should be a low temperature coefficient type. We used a wirewound precision resistor for *Rl*, and selected it because it was in the junkbox. Contrary to the example above, we actually selected the reference current based on the resistors on hand. An ordinary carbon composition resistor could be used, but the results are not guaranteed.

Construction. The construction of the calibrator is shown in Fig. 3. The largest part in the project is the battery, so a small LMB aluminum box was selected to house the calibrator. The electronic circuitry was built using the banana jacks as tie points; no wire

SCOPE CALIBRATOR

board is needed. The battery holder is ordinarily used with size "C" batteries, but the Mallory TR233 (4.2-volt mercury cell) fits nicely. The battery holder was fastened to bottom of the box using a small 4-40 machine screw. Small rubber feet can then be glued to the box to offset the "bump" created by the screw head. If you want to avoid this, however, it should be easy to superglue the battery holder flush to the aluminum.

The ZN458 has a 100 *parts per million* (PPM) drift specification, the ZN458A is a 50 ppm device, while the ZN458B is a 30 PPM device. The voltage output is nominally 2.45-volts DC. (measured at 2 mA reference current), but may have an absolute value between 2.42 to 2.49-volts. With no additional circuitry, then, these devices will produce an accuracy of ±40 millivolts, or better. This voltage cannot easily be adjusted without external circuitry, but you can use any of the standard IC operational amplifier voltage regulator circuits to set the output voltage to a standard level. Fig. 2 shows a circuit that is usable for this purpose. The ZN458 is used to set the voltage at the noninverting input of the op amp. The output voltage can then be trimmed to the desired value by potentiometer *R3*. This circuit is an ordinary op amp noninverting follower, so the desired output voltage can be derived in the following equation:

$$Eo = Eb \left(\frac{R3 + R2}{R1} + 1\right)$$

The table shows values for *R2/R3* needed for output voltages of 5 and 10-volts. Note that the resistors used in this circuit must be low temperature coefficient precision (1%) resistors, or drift will result. It is even more important in this circuit, than in the circuit of Fig. 1. The trimmer potentiometer should be a ten-turn, precision type, so that very tight control over the adjustment of the output voltage is possible.

There is, however, a hitch in this variable output circuit. It is not inherently "calibrated" as is the case of Fig. 1. Although this circuit is capable of better accuracy, initially, it must be adjusted. You will have to find a very accurate voltmeter, or precision reference potentiometer to make the initial adjustment. After this adjustment, however, it should remain in calibration for a long time. ■

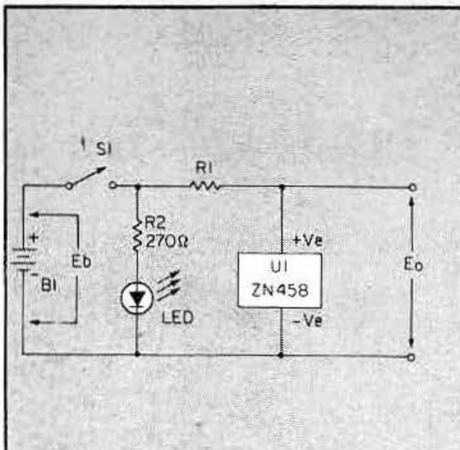


Fig. 1. This is a basic schematic used to demonstrate the calculations necessary to determine the value of the associated components used in the regulator circuit. Refer to the text for a full explanation.

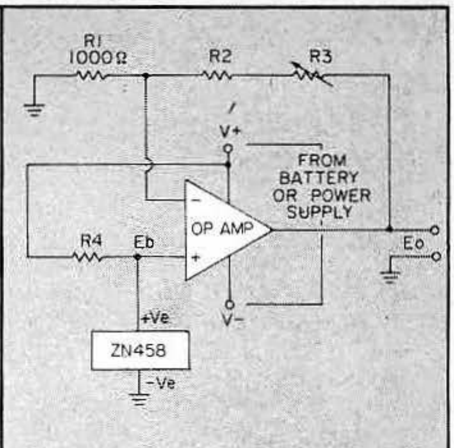


Fig. 2. This schematic depicts a variable regulated power supply, with the source being either a battery or a line-powered DC source. Refer to the table below and text, to determine your own parts needs.

TABLE 1—ZENER SELECTION

Type	Voltage	Drift
ZN423	1.26	—
ZN458	2.45	.00 ppm
ZN458A	2.45	50 ppm
ZN458B	2.45	30 ppm

TABLE 2—R2/R3 SELECTION

Output Voltage	R2	R3
5	1000-ohms	100-ohms
10	2600-ohms	500-ohms

The four most popular low-voltage band gap zener diodes are listed above, with their respective drift figures. Obviously, the smaller the drift figure (in terms of parts per million) the more accurate the calibrator circuit will be. Use the highest tolerance parts available, in order to enhance the accuracy of the circuit. Refer to the text for an explanation of the significance of the values given for R2 and R3 in Table 2 above.

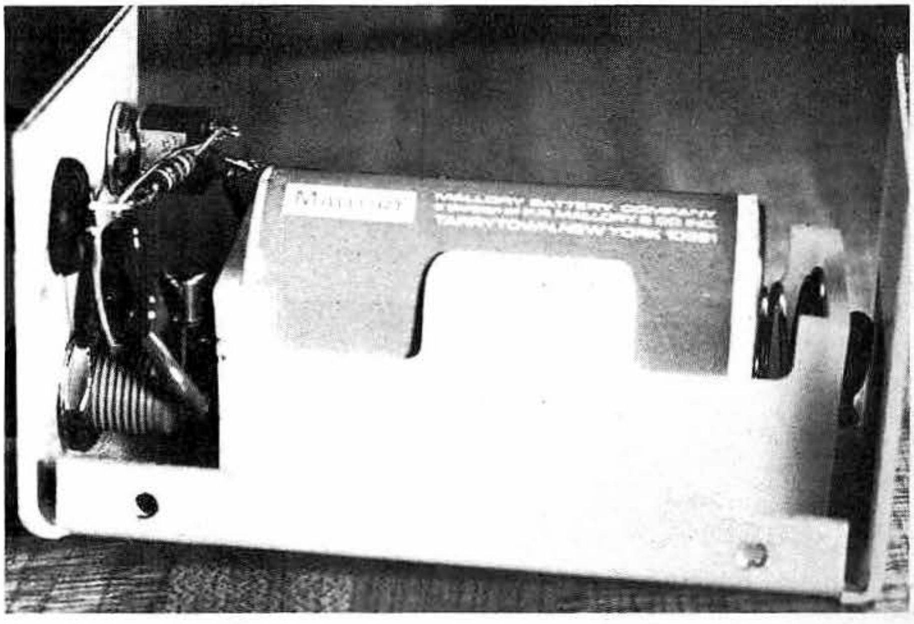
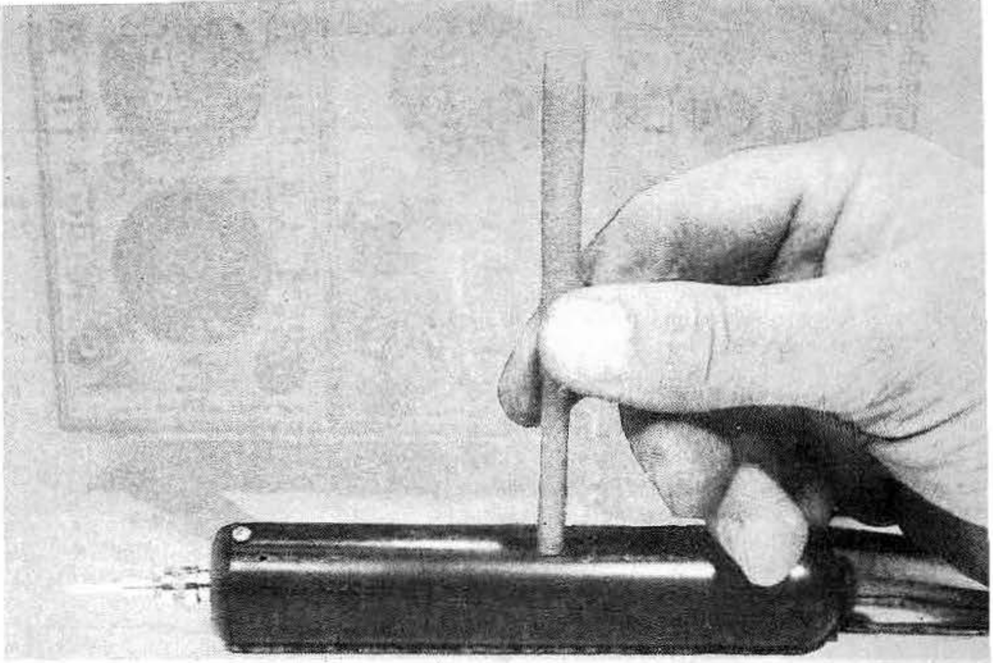


Fig. 3. The compact construction of the calibrator is seen here. We wired all components to the terminals of the banana jacks first, and then bolted in the battery holder to the bottom of the chassis to allow working room for assembly. You may choose to utilize either perfboard or even a printed circuit board for your model. This will allow you to mount it directly inside the cabinet of whatever test instrument you wish to calibrate. With this method you can always have a reliable source of instrument calibration with you, no matter where you might happen to be doing your repair or field operations.

LO CAP PROBE

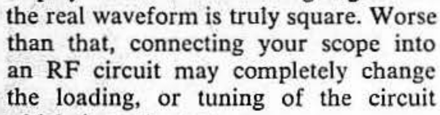
Simple probe helps your oscilloscope perform at high frequencies



"WHAT YOU SEE is what you get" might be A-okay for a television comic, but it's not necessarily true when you use an oscilloscope.

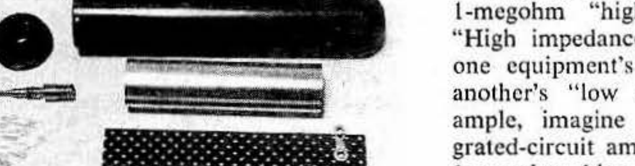
It is unfortunate, but true, that a scope's performance is specified from the input terminals to the scope itself, but does not include the test probe or connecting wires. For this reason a service-grade scope rated out to 4 MHz, or 7 MHz, or even a laboratory scope rated out to 20, 50, or 100 MHz, might poop out on something as mundane as a 60 Hz square wave, delivering a CRT display with rounded leading edge while the real waveform is truly square. Worse than that, connecting your scope into an RF circuit may completely change the loading, or tuning of the circuit which is under test.

Here's Why. Forget for a moment that the scope has a frequency-compensated input. That has no bearing on your measurements, which is affected by the cable between the circuit being tested and the scope input. An ordinary shielded test lead approximately 3 feet long has a capacity of about 100-300 pF, depending on the type of shielding. If a "bare" test lead is connected into a circuit it is effectively loading the circuit with 100-300 pF: just imagine what this will do to an RF circuit, or any high frequency circuit from about 10k Hz up. "What you see *isn't* what you get in this case."

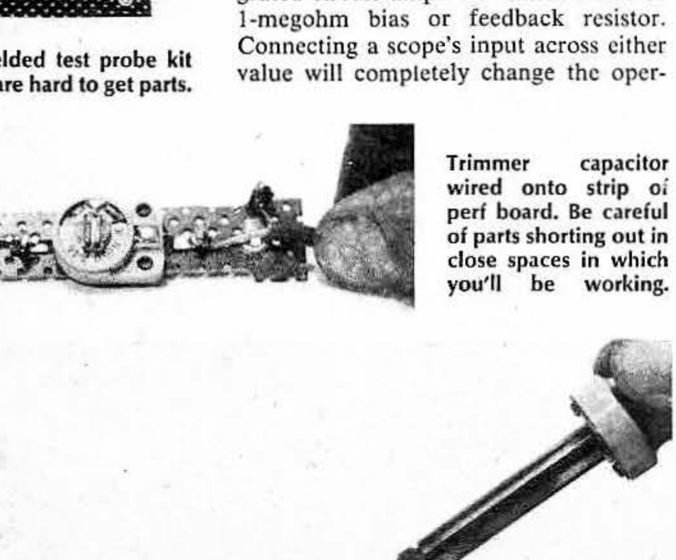


The Keystone 1810 shielded test probe kit before assembly. These are hard to get parts.

Also, consider the average scope's 1-megohm "high impedance" input. "High impedance" is a relative term: one equipment's "high impedance" is another's "low impedance." For example, imagine a transistor or integrated-circuit amplifier with a 500k or 1-megohm bias or feedback resistor. Connecting a scope's input across either value will completely change the operating parameters of the circuit. Or imagine what a 1-megohm "load" across a tuned RF input circuit will do: the "Q" might drop like a rock, not to forget the detuning effect of the test lead capacitance of the lead itself.



Trimmer capacitor wired onto strip of perf board. Be careful of parts shorting out in close spaces in which you'll be working.



As the text discusses, tack solder the test probe shield to the solder lug you've installed on the perf board. Do not fold the lug over the shield.

Follow the Labs. Commercial labs get around both the capacity loading and 1-megohm impedance by using a "10X low-capacity" test probe for the scope input. This device does two things: It makes the input capacity to the scope's test lead appear to be about 5-10 pF; and it raises the input impedance into the test cable—the impedance seen by the circuit being tested—to nominally 10 megohms (a value that won't affect any circuit the hobbyist will use or test).

Easy to Build. A 10X Low Capacity Test Probe circuit is shown in Fig. 1. Basically, it consists of two components: trimmer capacitor C1 and resistor R1. C1 is generally any small trimmer wtih a maximum capacity in the range of 25-50 pF. R1 should be 9 megohms for a precise 10:1 voltage division: ie: the scope will indicate 1 volt P-P if the input to the cable is 10 volts P-P. However, 9 megohms, or anything close, is usually unattainable by the hobbyist. If you substitute a 10 megohm 5% resistor for R1 the accuracy will be sufficient for almost all applications (nominal voltage readout error will be about 10%).

In A Shielded Probe. The 10X probe must be assembled in a shielded test probe; if not shielded, hand capacity will induce "hum" into the signal, and add capacity loading to the circuit.

A shielded probe kit, the Keystone 1810, was used for the 10X probe assembly. The Keystone probe kit contains an insulated probe shell, a shielding sleeve, perforated wiring board (sized to fit inside the shield), probe

LO CAP PROBE

tip, and "flea" clips (soldering terminals). That's all you need.

Temporarily mount C1 to the perf-board and see if you can slide the shield over the assembly without having the shield short the trimmer capacitor. If it touches a metal part of C1, file the edges of the perf-board so it will sit lower in the sleeve and not short C1. When the shield can slide over the assembly secure C1 to the board with flea clips, as shown in the photographs. Install R1 across the C1 flea clips on the opposite side of the board (there isn't room for C1 and R1 on the same side) of the board.

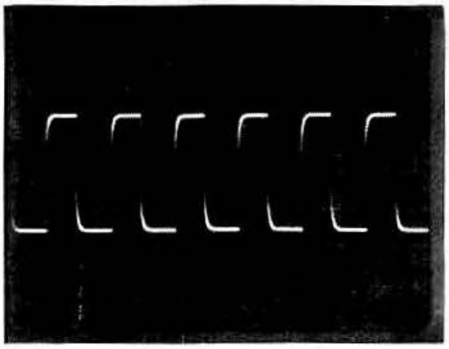
Solder about 3-inches of solid No. 20 or No. 22 wire to the front flea clip, the one on the opposite end from the solder lug which is factory installed on the perf board. This wire will eventually connect to the test probe tip.

Cut a piece of shielded wire to about 3-feet. You can use an ordinary audio patch cable with the phono plugs cut off the ends. Solder the center conductor to the rear flea clip; solder the shield to the solder lug and bend the solder lug at right angle to the perf-board. Make certain when you solder wires to the flea clips that C1 and R1 are also soldered to the clips.

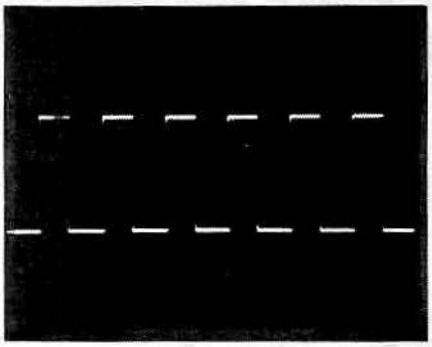
Slide the probe shield over the perf-board from the front until it touches the solder lug. Carefully mark the sleeve directly over the trimmer capacitor's adjusting screw. Remove the sleeve and drill a ¼-inch hole at the mark (careful, the sleeve is very thin). Solder an insulated stranded wire approximately 8-inches long to the solder lug's grommet—where it's secured to the perf-board. (This wire will pass out the hole in the rear of the probe cover and will connect to an alligator ground clip) that you use.

Now slide the shield over the perf-board, press it against the solder lug, and tack solder the shield to the solder lug. Do not fold the lug over the shield as it might prevent the cover from being slipped into place. Screw the probe tip into the probe's front cap, and then thread the solid wire from the perf-board through the probe, pulling on the wire so the perf-board is tight against the cap. Secure the wire to the probe tip. Measure the distance from the cap to the hole in the shield and transfer this measurement to the probe cover. Drill a ¼-inch hole in the cover at the mark. This will be the access hole for the capacitor C1.

Next, assemble the probe and install the required connector (to match your scope's input) at the free end of the shielded cable coming out the back.



Too much capacity shows up in a rounded leading edge, as shown here in Figure 2A.



Here, C1 has been adjusted correctly. Leading edge is perfectly square, here in Fig. 2B.

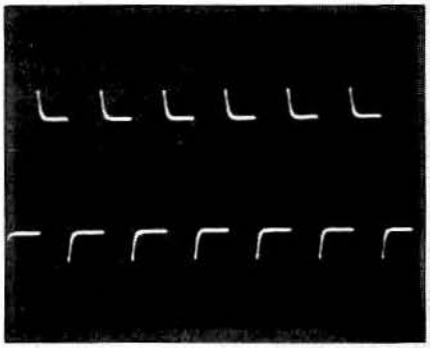
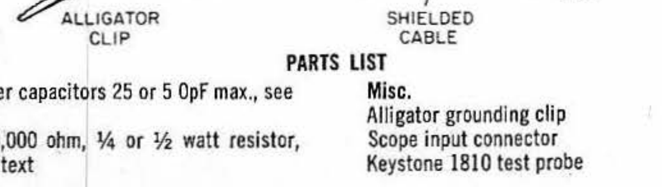


Fig. 2C. Peaked leading edge, shown, results from too little capacity in C1 adjustment.

Alignment. You must align the low capacity probe using some form of square waveform in the range of 60-1000 Hz. This can come either from the calibration voltage built into your scope or the square wave output of a sine-square signal generator. You can even use a broad pulse from a pulse generator if you have such an instrument in your workshop.

Touch the low capacity probe to the square waveform output, adjust your scope for a convenient CRT display, and then using an insulated alignment screwdriver, adjust C1 for a perfectly square *leading edge*, as shown in Fig. 2B. If you have too much capacity the leading edge will be rounded, as in Fig. 2A. If you have too little capacity the leading edge will peak, as shown in Fig. 2C. Perfect adjustment is a *perfectly square leading edge*. Once C1 is adjusted it need never be changed as long as the same scope is used.

Using the probe. Remember to multiply the CRT voltage indication by 10 to obtain the correct voltage at the test probe. For example, if the scope is set for 1 volt per division, and the peak-to-peak waveform is 1.5 divisions, the actual voltage at the test probe is 1.5 volts p-p x 10, or 15 volts p-p. ■



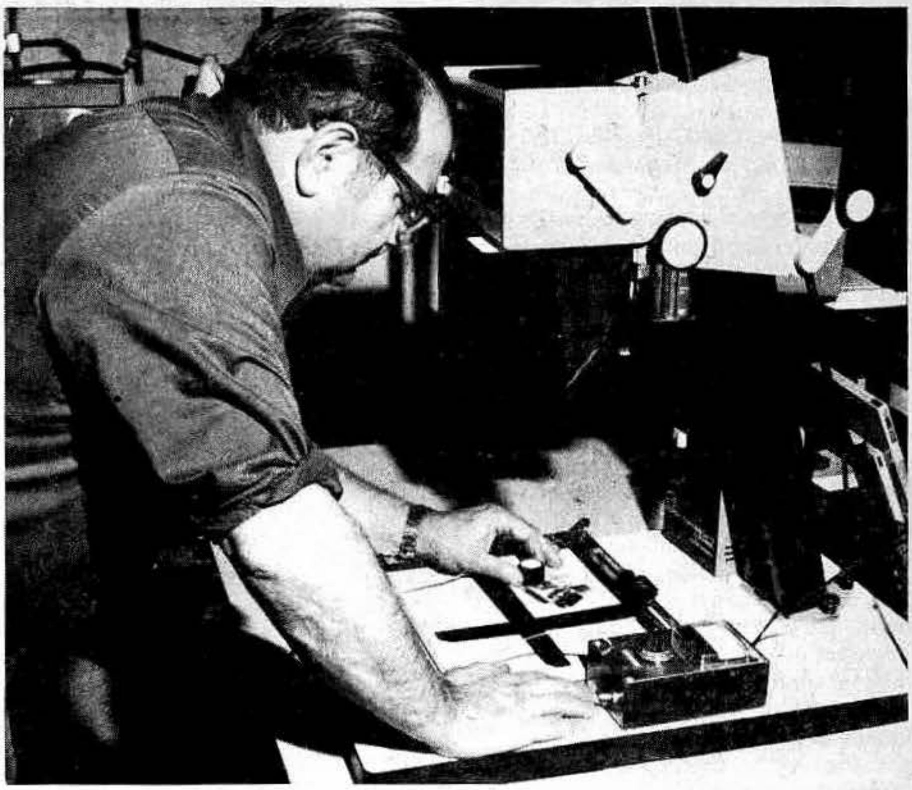
PARTS LIST

C1—Trimmer capacitors 25 or 5 0pF max., see text
R1—10,000,000 ohm, ¼ or ½ watt resistor, 5%, see text

Misc.
Alligator grounding clip
Scope input connector
Keystone 1810 test probe

For information on the availability of parts and other materials to build LO CAP PROBE, send a stamped, self-addressed envelope to Custom Ponents, Box 153, Malverne, NY 11565.

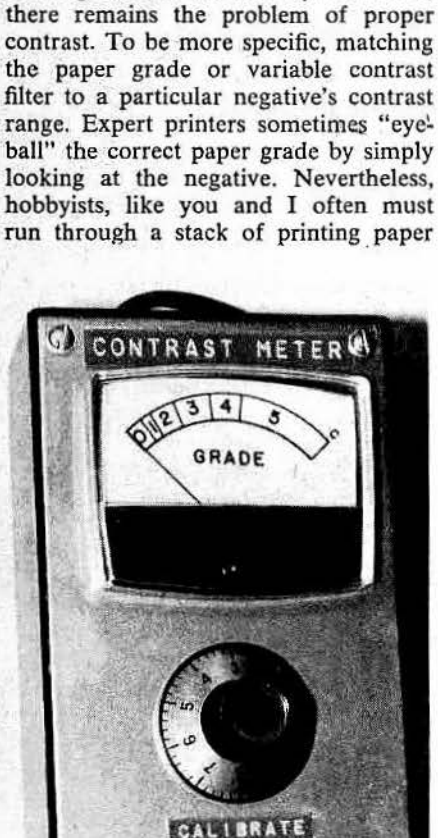
Darkroom Contrast Meter



Make perfect prints every time

WITH THE COST OF SILVER rising faster than the price of oil, every test strip or "washed out" print you throw in the wastebasket represents a considerable amount of money. Money you can spend on film, chemicals, and other photographic gear.

A printing exposure meter saves time and material by almost insuring a perfect exposure at the first try. However, there remains the problem of proper contrast. To be more specific, matching the paper grade or variable contrast filter to a particular negative's contrast range. Expert printers sometimes "eyeball" the correct paper grade by simply looking at the negative. Nevertheless, hobbyists, like you and I often must run through a stack of printing paper to make test prints. This can be an evening's work or more.



Photograph of Contrast Meter shows its meter calibrated for various paper grades.

Using a photographic contrast meter you can eliminate virtually all guesswork and test prints. A contrast meter automatically tells you the *standard* contrast paper grade for an "average" negative. This means a negative containing both highlight and shadow detail.

Every photographer has his or her idea of what constitutes the proper contrast range for a particular black and white print. In actual fact, there are "standard" contrast ranges for each paper grade. However, the grade of a particular paper might not precisely match the accepted standard. As a general rule, if you match the paper grade to the negative's "standard" contrast range you will wind up with a *good* to *excellent* print. Bringing the print up to exhibition quality might take some tweaking of the basic print, but at least you will be starting out with something that's *good*.

The contrast meter shown is self-calibrated to the "standard" contrast grades. It will be accurate if you use the specified components. To start with, focus the enlarger on the easel. Then, position a photoresistor light pickup under the maximum light area (which will be *d-max* or maximum shadow density). Adjust the contrast meter for maximum meter reading. Then, you move the pickup under *d-min*, the minimum light transmission (which is maximum highlight in the print). Now, read the paper grade off the meter scale.

For the sake of discussion, let's assume your meter reading is dead center in the #2 grade. Let's assume you like your prints with a little extra "snap" (contrast). If you use #2 paper or filter you'll end up with a "standard" contrast range. Slightly extending development, process or using #2½ filter or #3 paper, will give the extra snap your looking for. If the meter reads right on the border between grades #2 and #3, you should move to the nearest higher grade paper (#3) for "average" photographic scenes. For portraits, use #2½ or #2 for a "softer" effect.

Construction. The project is self-calibrated; you can use it as soon as the last wire is soldered. However, the calibration is accurate only for the specified photoresistor and meter. The meter scale is cemented on the existing meter scale. The new scale is automatically calibrated to the resistance range, rate of change, and spectrum sensitivity of photoresistor PC1 in the schematic. *The scale is inaccurate for any other photoresistor or meter.* Use a Calectro D1-912, 0-1mA meter. The printed circuit board shown later is designed to fit directly over the meter's terminals. Radio Shack has an 0-1mA meter which appears to be similar to the Calectro. This meter has similar electrical characteristics and can be substituted; its terminals, however, are not the same as the Calectro and the PC board will not fit, nor are the terminals strong enough

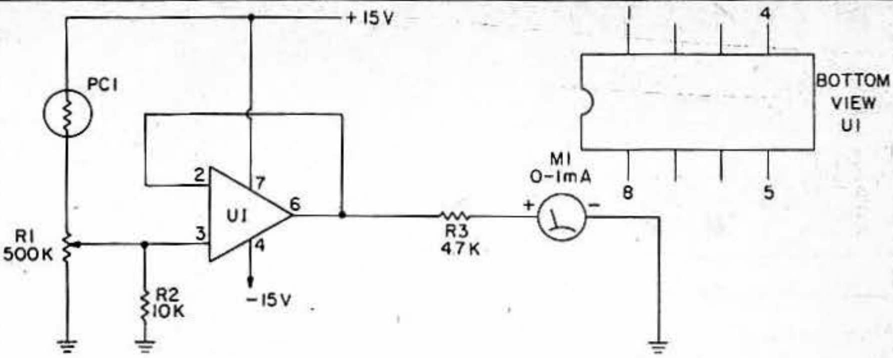
Contrast Meter

to support the PC board because they are simply small solder lugs. If you mount the PC board off the meter, you may substitute the Radio Shack meter.

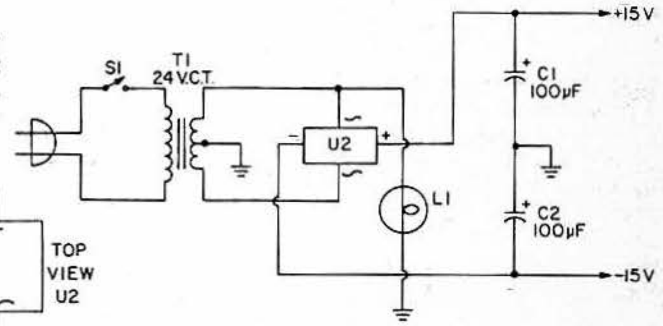
The parts layout is not critical, so you can use the PC template shown left or make your own. The advantage to our layout is that it fits the Calectro meter. Use only the IC2 bridge rectifier specified. It has the new lead arrangement with both the positive and negative terminals on the same side. If you substitute the older "diamond" lead bridge rectifier with positive and negative outputs on opposite sides, change the PC foil layout for IC2 accordingly.

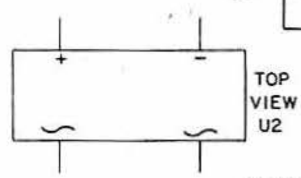
IC1 is any type 741 operational amplifier. We recommend the 8-pin mini-DIP because it matches the PC layout. you may substitute a TO-5 or 14-pin mini-Dip type 741 IC. (It doesn't matter what or how many letters or numerals are added after the "741," as long as the device is a 741, it can be used as the amplifier in this project.

There isn't sufficient clearance between the component side of the PC board and the meter case for capacitors C1 and C2 so they are installed as shown, on the foil side of the board. They are the last PC board components installed; even the two wire jumpers are installed first. Simply pass the leads through the PC board from the foil side, press the capacitors against the board, and then solder the leads to the foil using as little solder as is possible. Snip the excess lead length flush with



On the right, power supply with +15 volt and −15 volt outputs, also pilot indicator.

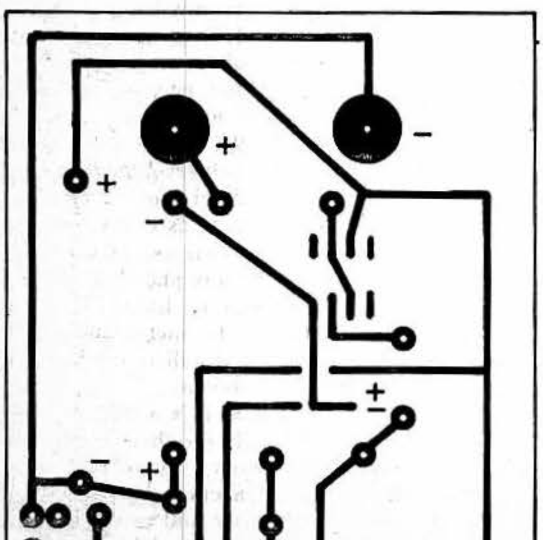




PARTS LIST FOR DARKROOM CONTRAST METER

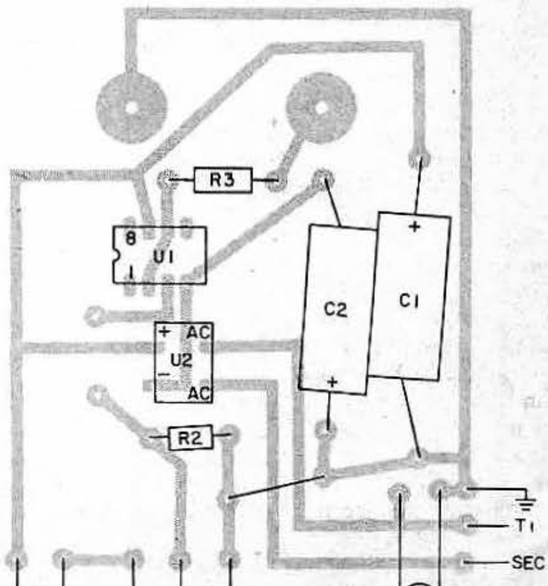
- **C1, C2**—100-mF, 25-VDC capacitor
- **I1**—14-volt replacement lamp, see text (or Radio Shack 272-1141)
- **M1**—0-1 DCmA meter, Calectro D1-912 (see text)
- **PC1**—Photoresistor, National type 4921 (do not substitute)
- **R1**—500,000-ohm linear potentiometer
- **R2**—10,000-ohms ½-watt resistor
- **R3**—4700-ohms, ½-watt resistor
- **S1**—SPST switch
- **T1**—Transformer 120v. 24v. C.T. at 0.1A or higher current
- **UI**—Integrated circuit type 741 (8-pin mini DIP version, see text)
- **U2**—50 PIV Bridge Rectifier, Radio Shack 276-1161 or see text
- **Misc.**—Cabinet, printed circuit materials, etc.

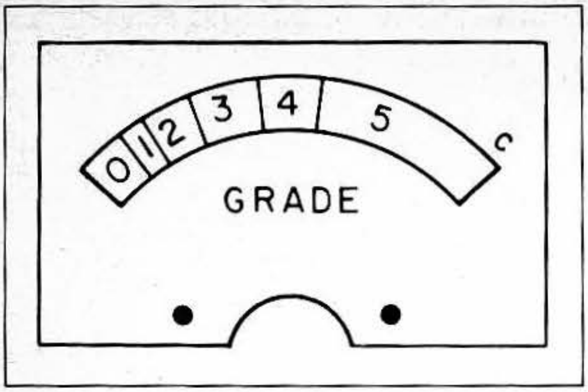
Photoresistor PC1 is available for $5.00 from Custom Components, Box 153, Malverne, NY 11565. Add $2 per order for postage, handling and insurance. Residents of New York State must add sales tax. Canadian orders must include an additional $2.00 for shipping. No foreign orders, please.



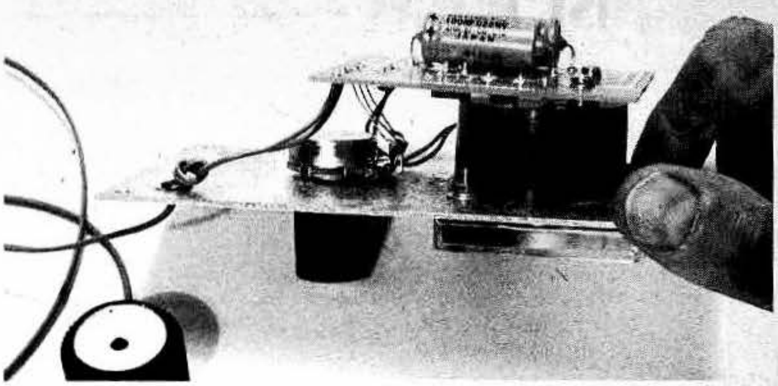
This is the Contrast Meter PC board with the etched side up. Make sure to observe meter polarity markings over the meter.

On the right, can be seen the Contrast Meter looking at the component side of printed circuit board.





Above can be seen the meter with its highly non-linear markings which correspond to various grades of paper.



Notice how the large capacitors are mounted on the etched side of the PC board. The meter connections are used to support the entire PC board.

the board on the component side.

The meter has no pilot lamp and you obviously must have some form of illumination if you don't want to juggle a flashlight each time you take a reading. Illumination is provided by a pilot lamp you must install within the meter.

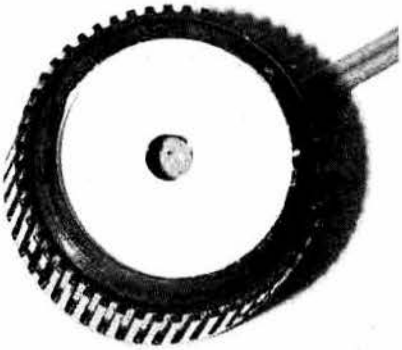
Modifying The Meter. Very carefully remove the plastic meter face; it simply snaps off. If you have difficulty, use a small screwdriver at the notch molded into each side of the back of the face. Now look at the back of the meter. It has two mounting screws and two raised circular "boss' " where two additional mounting screws would go if there were four mounting screws. Locate the "boss" at the bottom of the meter and very carefully, using a slow drill speed, drill a 1/4-inch hole through the center of the boss. Take extreme care not to damage the meter pointer.

One way to sharply reduce the possibility of pointer damage when you drill the hole, is to make the hole in three passes. Start with a small bit of approximately 1/16" move up to approximately 3/16", and finally 1/4".

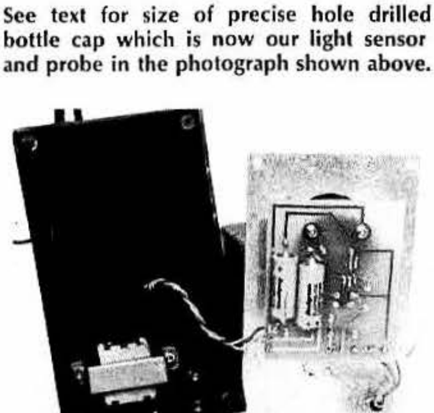
Next, remove the two screws that secure the meter scale and slip the scale *upwards* from under the pointer. Using scizzors, cut out the new meter scale we've provided, staying to the inside of the black outline. Using a paper punch, or any other punch approximately 3/16" to 1/4", punch the holes for the mounting screws using the "dots" as the target centers.

Coat the original meter scale with a thin layer of rubber cement and apply the new scale, taking extra care that it's aligned with the top and side edges of the original scale. Slip it under the pointer—and replace it in the front of the meter again.

The pilot lamp is installed next. I1 is a 14 volt replacement pilot for CB transceivers; it comes with attached wire leads. If you cannot obtain the 14 volt replacement type use the 12 volt type specified in the parts list. (The 14 volter, *in this project*, will have slightly reduced brilliance, which is what's needed in a dark room.) Place a thin ring of contact adhesive (such as Touch-n-Glue) around I1 where the metal base just touches the glass. Insert the lamp into the meter until it touches the front of the case, then push the glue down *very lightly* with a toothpick (don't force the glue into the case).



See text for size of precise hole drilled bottle cap which is now our light sensor and probe in the photograph shown above.



Everything has been assembled and cover has been removed. Cable connecting PC board to power supply should not be tight.

After 24 hours the glue will have shrunk and secured the lamp to the case quite securely.

Next, proceed to assemble the photoresistor pickup component.

Photoresistor PC1 is mounted in a small enclosure; anything from a large knob to a plastic or metal box will work. The only requirement is that the box be reasonably light tight. A clear plastic box cannot be used unless it is painted opaque. The pickup shown in the photographs is an ordinary replacement knob that has been drilled out to fit PC1, which is secured inside with plastic cement. The only critical aspect of the pickup is the hole under which PC1 is mounted: it must be 3/16", or the next immediate larger size, if you use numbered drill bits. *The project will not work accurately if the hole is larger or smaller because the meter scale is calibrated for PC1's characteristics under a 3/16" hole.* (Try to center PC1 under the hole.) The wire from the pickup to the meter can be anything that's convenient; usually, 3' is more than adequate. (Thin, rubber covered "speaker wire" is suggested because it's highly flexible and will not break.)

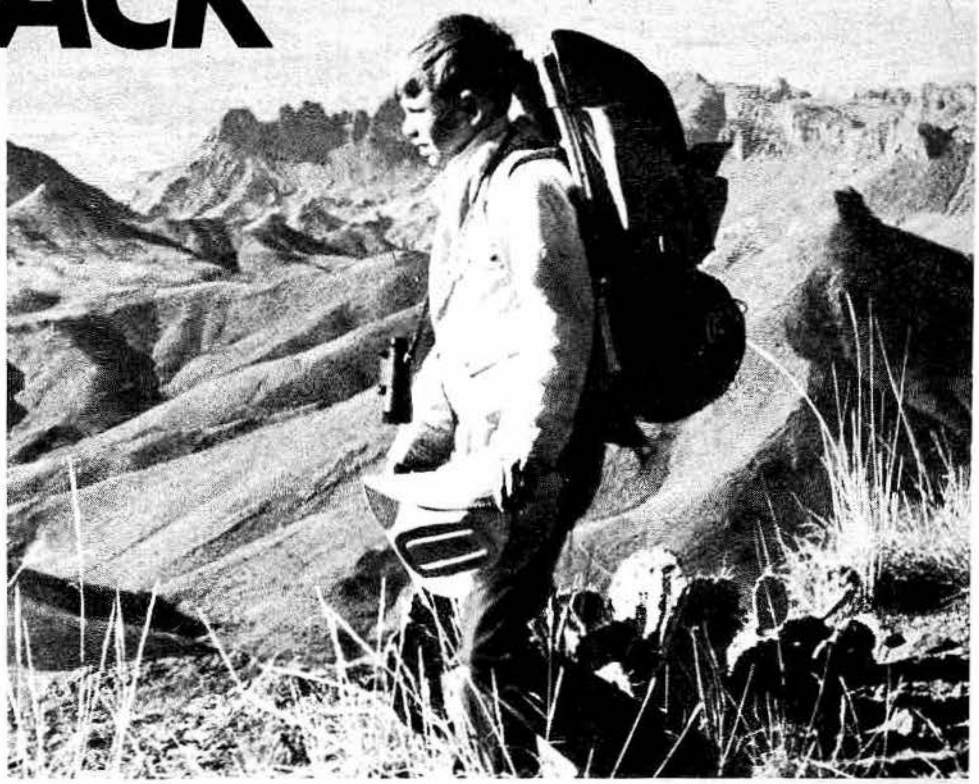
Final Assembly. Transformer T1 can be any 24 volt *center tapped* model as long as it's rated 0.1 ampere or higher. (Note that lamp I1 is connected from one side of T1 to the center tap—which is 12 volts.) Use any plastic utility cabinet large enough to hold T1 without interfering with the meter and the PC board which is installed on the cabinet's panel as shown.

Do as much of T1's wiring as is possible, leaving only the three connections from the secondary to the PC board, for the last connection.

Install the meter and calibration control R1 on the panel and then install the PC board on the meter (if you have used the type of assembly shown in the photos). Connect the wires from I1 to

(Continued on page 92)

BACKPACK AMP



Take your electronic instrument anywhere with this low cost portable amplifier

MUSICIANS WHO PLAY acoustic instruments, such as trumpet, saxophone, or violin, for that matter, have never experienced the problem of the electronic musician on an outing where he or she is separated from an electrical source for an amplifier (assuming that one had even managed the task of bringing one along). It's admittedly pretty hard to entertain your friends with an electric piano which lacks electricity. What then, is the answer to this dilemna?

It's quite simple, actually—build a Backpack Amp. Designed to operate from "C" or "D" cells, or two or three small lantern batteries, the all-in-one-IC Backpack Amp will directly drive a speaker from the output of virtually any electronic instrument without need for additional amplification. Install the Backpack Amp in a small cabinet along with a 6 or 8-inch speaker and you can take your electric guitar, or whatever, with you on holidays.

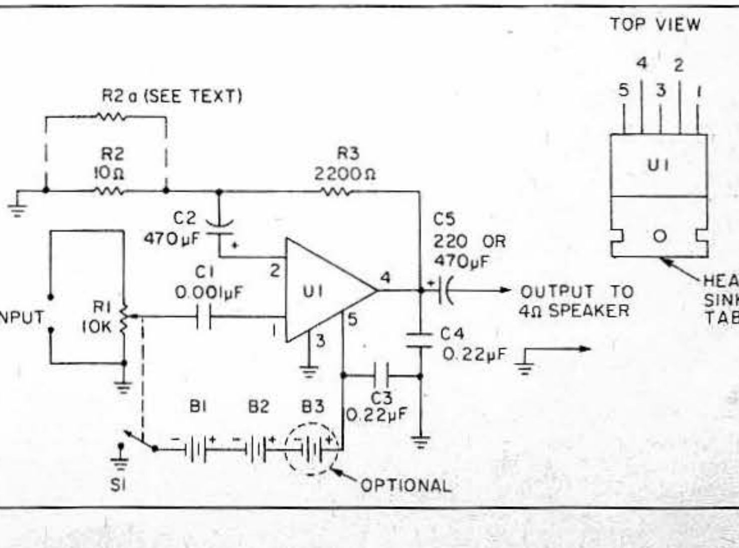
The Circuit. The Backpack Amp is assembled on a printed circuit board measuring 2¾ by 3⅝-inches. All active components which make up the preamplifier and power amplifier are contained in a single LM383T integrated circuit, which is available from Radio Shack. The resistor and capacitor values are considerably different than those given in the IC's data sheet (which is usually supplied with the IC). If you want the lowest distortion level from your electronic instruments use our values.

With a 12 to 18-volt power supply, the Backpack Amp will deliver from 1 to 3-watts into a 4-ohm load. Most replacement-type speakers are 4-ohms, and a 6 or 8-inch speaker is suggested. If all you have around, or can get, are 8-ohm speakers, we suggest you use two, parallel-wired 6-inch, 8-ohm speakers. (The amp will work with one 8-ohm speaker, but 1-watt is about the maximum low-distortion output even with an 18-volt power supply.)

The value used for capacitor C1 is 0.001-μF only if the amp will be used with an electric guitar. It compensates for the relatively higher low frequency output of an electric guitar pickup and prevents low frequency overload of the loudspeaker. If the Backpack Amp will be used with a synthesizer, you will probably be happier with the sound quality if C1 is 0.01-μF. If you use a 0.01-μF unit and find the low frequencies are overloading the speaker, sim-

PARTS LIST FOR BACKPACK AMP

B1, B2, (optional B3)—6-volt lantern battery (see text)
Note: Capacitor voltage rating must be equal to power supply voltage rating.
C1—0.001-uF mylar capacitor (see text)
C2—470-uF electrolytic capacitor
C3, C4—0.22-uF mylar capacitor
C5—220-uF or 470-uF electrolytic capacitor
R1—100,000-ohm audio taper potentiometer with SPST switch attached (S1)
R2—10-ohm, ½-watt 5% resistor
R3—2200-ohm, ½-watt 5% resistor
S1—SPST switch (part of R1)
SPKR—see text
U1—LM383T audio amplifier integrated circuit
Misc.—Cabinet, screws, grille cloth, wire, solder, printed circuit etching materials, suitable input jack and matching plug, etc.



ply replace C1 with a 0.001-μF unit.

The correct value for R2 is usually 10-ohms. If you find your instrument's output is on the low side, and you have all gain controls wide open and still can't overdrive the amp, then tack-solder another 10-ohm resistor (shown as R2a in the schematic) across R2. If you need even more gain, R2 can be lowered to 2.2-ohms, but keep in mind that a 2.2-ohm resistor isn't the easiest of things to locate in this day and age.

Construction. Using any method you prefer, make the PC board using the supplied template. Note carefully the large copper foil area; it is part of U1's heat-sink and must not be eliminated. Don't substitute a thin foil strip as a *ground* connection. The foil rectangle in the middle of the PC board provides the anti-hum grounding for potentiometer (volume control) R1's shaft and frame. Again, don't substitute a thin foil strip because it might not contact R1's case when the potentiometer is installed. Depending on the particular style of potentiometer used, drill the proper size mounting hole where indicated by the dot in the foil rectangle.

Double-check the polarity of C2 and C5 before soldering. In particular, make certain C2's *positive* terminal goes to IC pin # 2. (It might not look correct but it really is.)

The IC must be mounted with a heat sink. From scrap aluminum, cut a section about ⅞ by 1¼-inch. Using the long dimension, bend a ⅝-inch tab. Drill a hole in the tab for a #4 bolt as close as possible to the "L" section (so as much metal as possible will be under the IC when the IC is positioned over the hole; but double-check that the tab does not touch any of the IC leads.)

Using long-nose pliers, bend U1's leads to correspond with the holes in the PC board. To avoid shorts, the leads are offset: Nos. 1, 3 and 5 are close to the IC body; Nos. 2 and 4 are bent about ½-inch away from the body.

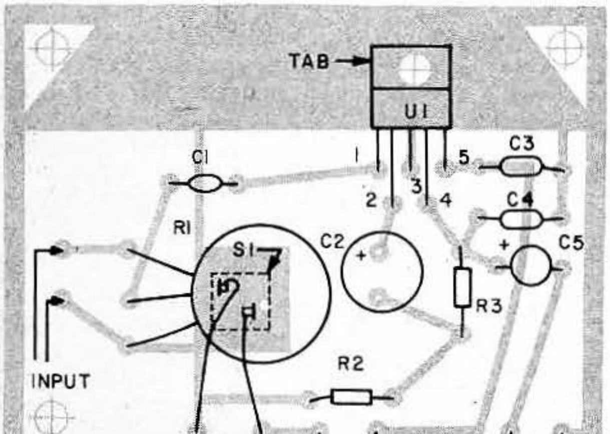
Place a drop of silicon heat sink grease on the underside of IC's mounting tab, position the IC on the sink, and then secure the IC and sink to the PC board with a #4 bolt, lockwasher, and nut. Place the lockwasher between the nut and the heat-sink foil on the PC board, and tighten securely.

Installation. The Backpack Amp can be installed in any cabinet you prefer. (Note that it has a three-hole mounting.) If you can possibly locate a *potentiometer bushing extender*, which appears and then disappears in the marketplace from time to time, you can mount the amp with a single nut around the volume control's shaft.

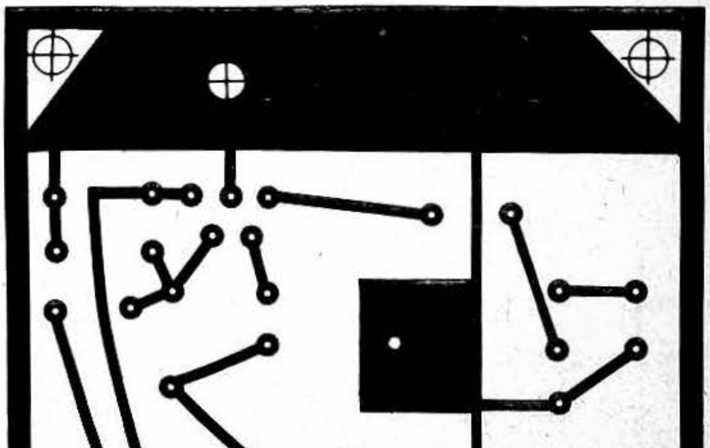
While the power supply can be made up out of flashlight batteries, two or three series-connected small 6-volt lantern batteries make the most convenient and reliable portable power source.

When it's all done, you and your ARP can head for the hills and commune with Mother Nature to your heart's content. ■

The completed PC board, showing U1 mounted with it's homebrew heatsinks.



The component placement guide above shows the SPST switch mounted on the back of volume control R1 (dotted line box). External switch can be substituted for R1/S1.



The full-scale printed circuit template has two areas of solid foil which must be duplicated on your board. The large area at top helps heatsink U1, the other grounds R1 to minimize humming.

WITH A LITTLE BIT OF time and effort, anyone with a well equipped darkroom can turn out good prints. However, problems come up when someone gives you a 36-exposure roll, all with different densities and asks for a full set of wallet-size prints.

Even if you don't mind the cost of test strips and wasted prints, it will take at least an evening to bang out 36 prints to your satisfaction.

But if you use a Photometer to determine exposure and paper grade, you'll cut wasted paper to an absolute minimum and total processing time to an hour for 36-exposures.

If a stabilization machine is used, you'll be able to develop a black and white prints in less than a minute. The Photometer allows a good print to be made with every attempt.

Unless you're making artistic prints suitable for exhibition, good tonal balance is any print with white highlights and jet black coloration. It doesn't matter how black the print is, it can be a spot, but the eye expects to see black. If there is no black, the print appears flat (lacking in contrast).

Dense Negatives. Pure white highlights and jet black detail are determined by various paper grades (#1-#5). The density range of the negative determines which grade to use.

The Photometer, by analyzing a negative that is projected by the enlarger (it is not fooled by condensed or diffused enlarger illumination) indicates the paper grade required by a negative. It can be used to determine lens aperture for an exposure time.

The Photometer has a row of five red light emitting diodes (LEDs), a yellow LED and a green LED. The green LED is used for determining exposure. Centered in a white target area, there is a ⅛-inch diameter photoresistor that is small enough to represent a spot on a final print.

Projecting the negative, adjust the enlarger for the desired print size, focusing on the easel with the lens diaphragm wide open and place the Photometer on the easel with the photo resistor under an area of maximum light transmission (minimum density). Adjust the Photometer's CAL (calibrate) control until just the five red LEDs are clearly lit and glowing.

Move the Photometer so the photoresistor is under the minimum transmitted light (maximum density). Count the number of red LEDs that remain lit; that's the standard paper grade for the negative. If two red LEDs are lit, the negative calls for a #2 paper.

The yellow LED checks the contrast reading. After you make the initial reading, which should take no more than a few seconds, return the photoresistor to the point of maximum light and adjust the CAL control so the yellow LED just lights.

Rock Control. Rock the CAL control a few times to be certain its at the setting that just lights the LED. Move the photoresistor back to the point of minimum light and count the number of lit red LEDs. If the number remains the same the contrast is in the approximate center of standard contrast range.

If the next higher red LED lights during the yellow test, the contrast range is closer to the top of the initial lower range. For example, if the first test lit two red LEDs and the yellow test lights three, #3 paper should be used or #2 with slightly extended development. Almost a #3 is the same as using Polycontrast #2½ or #3 photographic filters.

(Note. Variable contrast filters are not the equivalent of standard paper grades. It all depends on the filter and the particular type of variable contrast paper being used. Crossindex the measured contrast range with the specified range for variable contrast filters from the manufacturer's data sheet.)

Constant Exposure. The green LED allows setting the aperture for a constant exposure time. Make a good print using your favorite exposure time: 10, 15 or 20 seconds. Without touching the enlarger adjustments, place the photoresistor under maximum light and adjust the EXP (Exposure) control until the green LED just snaps on.

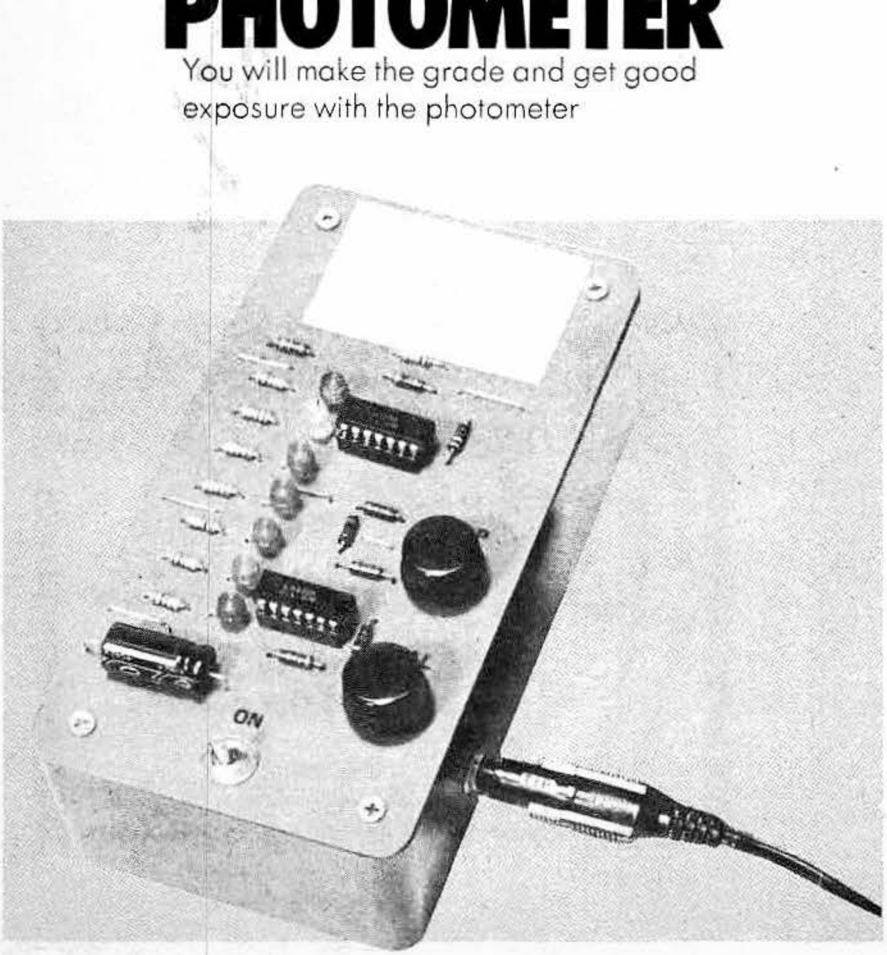
Set the EXP controls so the green LED goes from off to on. The Photometer is now set for what you consider proper exposure.

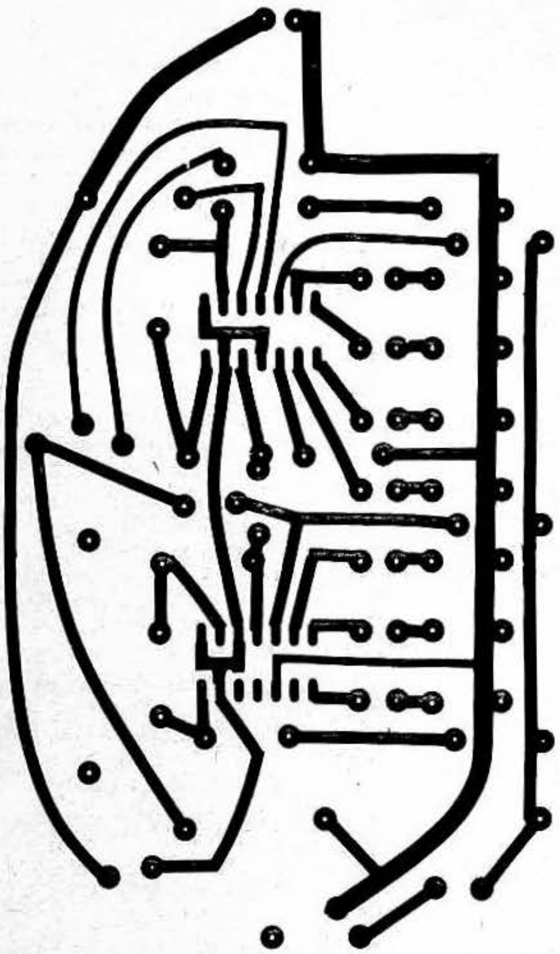
Assume you have used a 10-second exposure. You rack up the next negative, compose, focus, and make the contrast measurement. (Remember, the lens is wide open.) Place the photoresistor under maximum light transmission, the same spot used for the contrast calibration, and slowly step down the lens until the green LED lights.

That's the right amount of light for a 10-second exposure. Because of memory in the photoresistor, you cannot rock the lens's diaphragm for the green LED adjustment. The diaphragm must

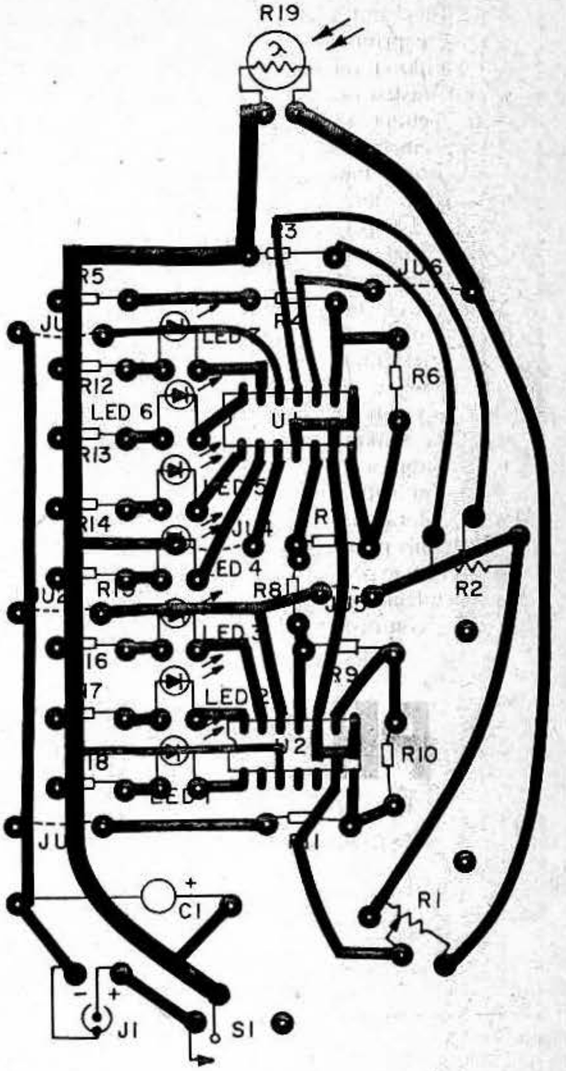
PHOTOMETER

You will make the grade and get good exposure with the photometer





This project is for the complete do-it-yourselfer. The printed circuit board given here is not available through any outfit, so you must etch it yourself. An alternative to etching the board is wire-wrapping your project. By following the PC diagram, you can easily see how to connect the wires to each other in a simple and orderly manner.



When installing the components in your Photometer, observe polarity; otherwise you could fry part of the circuit.

be started from the wide open setting (the same one that is used for the contrast measurement).

If the lens is adjusted beyond the setting where the green LED snaps on go back to maximum light for 3-5 seconds for a precise adjustment.

The entire project, except for the power supply, is built on a printed circuit board that also serves as a cabinet cover. The power supply can be any 9 volt AC adapter. Any current rating greater than 100 mA will work well.

Critical Parts. There are three critical parts in assembling the Photometer: the cabinet, whose height establishes the operating parameters for photoresistor R19; the photoresistor itself, which is a version specifically designed for linearity and EXP control R1, which must be as close as possible to 50,000-ohms.

All other components are common tolerance and substitutions can be made as long as the tolerance, where specified in the parts list, is not reduced.

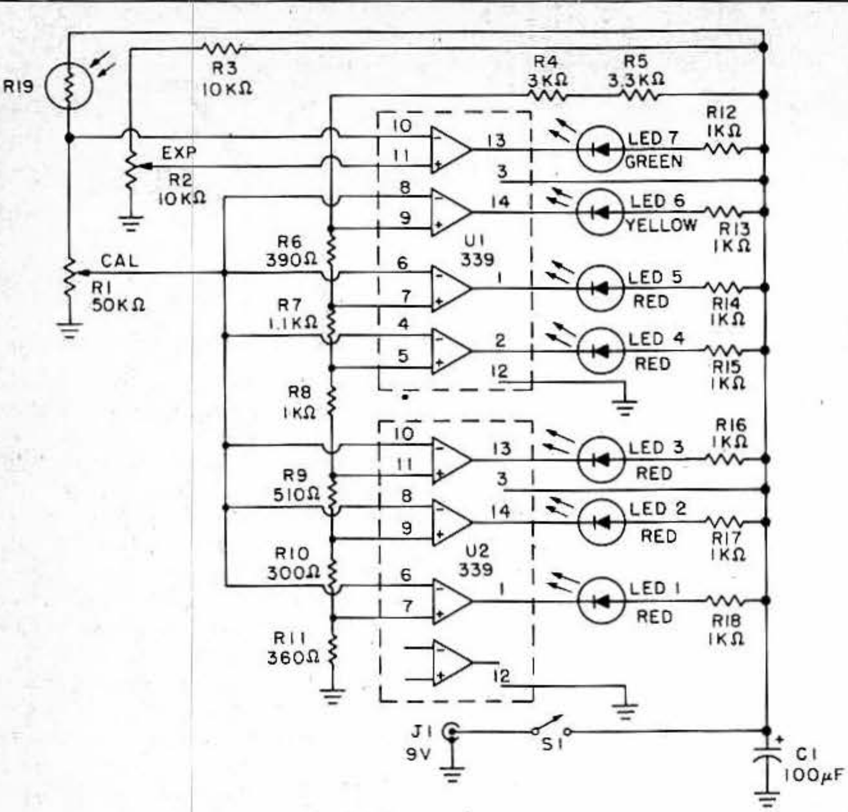
The cabinet *must* be 2¾-3 inches high. No substitute can be used for R19; any other photoresistor will give the user completely erroneous contrast measurements.

Socket To U1. Sockets are suggested for U1 and U2. They prevent butchering of the PC board if you must remove an IC. The ICs are installed with pin #1 facing the LEDs.

Before installing R19, cement a white target approximately 1⅜ by 2-inches to the PC board and punch-through the holes for R19. Then install R19 so its top is ⅛" above the PC board. If you must bend R14's leads, brace them with long-nose pliers directly behind the photo-resistor—the pliers should actually touch PR1. (Careful, R19 tends to be fragile when bending its leads.)

Finally, install J1 and connect it to the PC board. Double-check the polarity of the 9 volt adapter. Some have the plug tip *negative;* if so, be certain you connect J1's tip to the negative foil on the PC board.

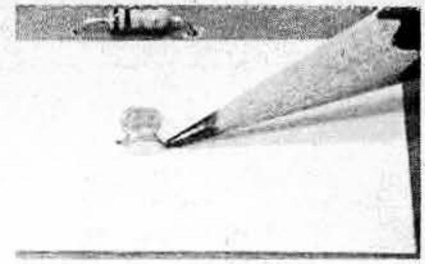
Check It Out. Under normal room lighting, set CAL control R1 fully counter clockwise. Set EXP control R



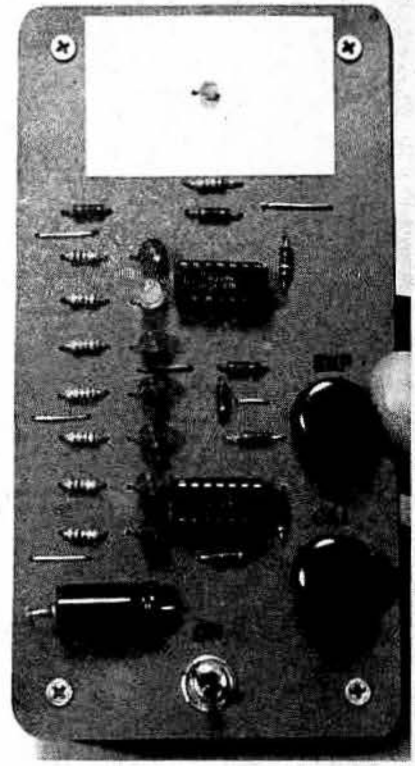
PARTS LIST FOR PHOTOMETER

C1—100-uF, 35-VDC electrolytic capacitor
J1—Jack to match power adaptor
LED1-LED5—Red light emitting diode (LED) fresnel lens
LED6—Yellow LED
LED7—Green LED
R1—50,000-ohm potentiometer, linear taper see text) all resistors are ¼-watt, 5%, except potentiometers)
R2—10,000-ohm potentiometer, linear taper
R3—10,000-ohm resistor
R4—3,000-ohm resistor
R5—3,300-ohm resistor
R6—390-ohm resistor
R7—1,100-ohm resistor
R8—1,000-ohm resistor
R9—510-ohm resistor
R10—300-ohm resistor
R11—360-ohm resistor
R12-R18—1,000-ohm resistor
R19—Photoresistor, Custom Components PRLL9
S1—SPST mini-switch
U1, U2—Quad Comparator LM339 Integrated Circuit

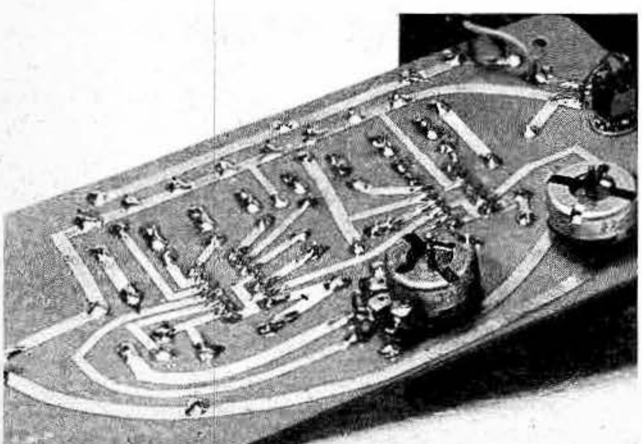
Misc.—Cabinet, 9-volt power adaptor, IC sockets, PC material, solder, wire, hardware, etc. (Photoresistor PRLL9 is available for $5 plus $2 postage and handling per order from Custom Components, Box 153, Malverne, NY 11565. N.Y. State residents must add sales tax. No foreign orders except Canada. Canadian orders must be in $US.)



This photoresistor is the heart of the Photometer. Be sure you get the right one.



The Photometer is compact and easy to use. Photometer's circuit is totally exposed and allows easy removal of circuit parts.



Two potentiometers and an On/Off switch are connected to the back of the PC board. The battery is connected to the case.

fully clockwise. Turn the Photometer on. Cover R19 with your thumb; all LEDs should be out.

Advancing CAL control R1 should cause the red and yellow LEDs to light one at a time. Adjusting EXP control R2 anti-clockwise should cause the green LED to turn on.

If you don't get this response, there is a wiring error or a defective component. (Note: Under full room illumination, with no covering of R19, the green LED can remain lit through R2's range of adjustment: this is normal.)

With your Photometer operating, you can spend less time and money in the dark and more time in the light doing what you want to do: taking pictures. ■

SLOPING DIPOLES

A new *slant* on a popular antenna design.

THE SLOPER DIPOLE HAS BECOME A popular ham radio antenna. In some amateur circles, its performance is even considered sensational. When you rate the antenna on ratio of performance and convenience over cost it is sensational indeed.

The basic sloper is a tilted one-quarter wavelength dipole, (Fig. 1), with one end high and the other end near ground level. Although the radiation from such an antenna is reasonably omni-directional, there are claims for some directivity in the direction of the slope. It may just be that there is considerable radiation at the low vertical angles in this direction which favors DX communications.

In experiments here at W3FQJ, the dipole was extended to a three-quarter wavelength antenna, thereby raising gain and improving directivity off the ends of the wire, particularly in the direction of the slope. Again, the improvement may be the result of good low-angle radiation in that direction.

Some helpful tuning aids can also make it convenient for tuning-up the sloper on a particular band, or as an aid in two-band operation. The capability of ground-level tuning is an experimental convenience. Let's consider some very practical and effective sloper antennas.

The Basic Sloper. A simple set-up (Fig. 1) consists of a telescoping TV mast for the high end of the antenna, and an 8 to 10-foot fence post for the low end. A rope can be used as a halyard for convenience in raising and lowering the antenna if desired. A tree, the side of building, a roof mast, etc. could also be used as the high end of the sloper. A coax-to-dipole connector can be used as an interface between the wire antenna and the coaxial transmission line that connects to the transmitter output.

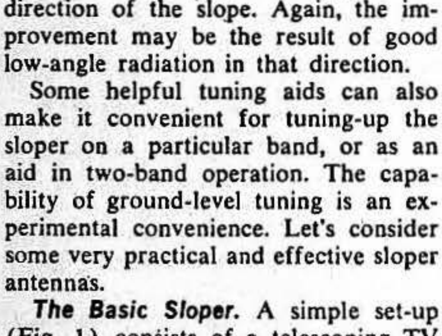


Fig. 1. This is the basic configuration for both the one-quarter and three-quarters wavelength dipole. Slope angle is up to you.

Typical lengths for one-quarter and three-quarter wavelength segments are given in the chart. For example, a 40-meter sloping dipole cut for a mid-band frequency would consist of quarter-wave segments with a length of 32-feet, 9-inches. A sloper cut for the 80-meter phone band would have quarter-wave segments with a length of 60-feet, 4-inches. A three-quarter wavelength sloper cut for 10-meter phone operation would require two segments that are 24-feet, 10-inches long.

TABLE OF DIPOLE DIMENSIONS

Band Segment	Quarter-wave Ft.	In.	¾-wave Ft.	In.
160 METERS				
Low End	126	6	383	9
Mid-Band	123	3	373	8
High End	120	—	364	1
80 METERS				
CW	63	7	192	11
Mid-Band	62	5	189	4
Phone	60	4	183	—
40 METERS				
CW	33	1	100	4
Mid-Band	32	9	99	2
Phone	32	5	98	3
20 METERS				
CW	16	7	50	3
Mid-Band	16	6	50	—
Phone	16	5	49	9
15 METERS				
CW	10	11	33	3
Mid-Band	11	—	33	3
Phone	11	1	33	7
10 METERS				
CW	8	4	25	2
Mid-Band	8	1	24	6
Phone	8	3	24	10

The dimsensions given above are pretty accurate, but make your first cuts longer to allow for capacitative loading effects.

The antenna can be made of regular, stranded copper wire or a similar gauge of insulated wire. The antenna wire we used here was some #16 stranded, insulated wire that was picked up at a flea market. Insulation *does not* interfere with electromagnetic radiation from the antenna. Insulation is an asset if the antenna must be run through trees. Bare the wire for connection to the coax-to-dipole connector. Also, it should be bared at point where such an antenna is to be end-tuned with a clip-on piece of wire. More on this later.

40-Meter Sloper With End Tuning. The arrangement of Fig. 2 shows how a sloper can be constructed, and the bottom section made tunable for operation with minimum SWR at low-end, mid-band or high-end of the 40-meter band. The top segment of the sloper is cut for mid-band, or a length of 32-feet, 9-inches. The low-end segment is cut for operation at the high-frequency phone end of the band. In this case, no additional length of wire need be clipped on to the antenna end. The antenna resonates even though segments are of dissimilar length.

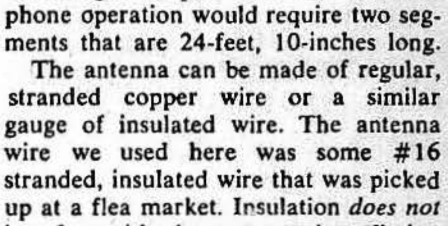


Fig. 2. The end-tuned sloper for 40 meters allows the resonance to be adjusted for mid-band and low end band operations quickly.

When you wish to resonate the antenna to mid-band frequencies, clip an additional length of wire to the end

SLOPING DIPOLES

Fig. 3. This photo shows the low end of the sloper with the end-tuning stub clipped into position. It clips to the guy if not used.

of the low end of the dipole, as seen in Fig. 3. In this case, it would be 1-foot, 5-inches long, making the bottom side equal to an overall length of 32-feet, 9-inches. The segments are now of identical length.

If you wish to resonate the antenna at a low-band CW frequency, add a length of 9-inches to 1-foot. A very low SWR is obtained even though the top section of the sloper has a length of 32-feet, 9-inches. Tuning of the antenna is done at ground level.

To a lesser degree, the same thing can be done on the 80-meter band. The arrangement of Fig. 4 shows how the

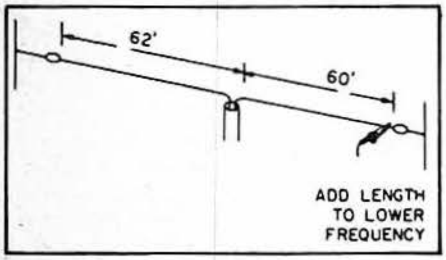


Fig. 4. The end-tuned 80 meter dipole can be tuned to resonance at both 80 and 75 meters by using two different tuning stubs.

SWR can be lowered to a minimum at some specific 80-meter frequency between mid-band and the high-frequency end of the band. To obtain a very low SWR at the low-frequency end of the band, it may also be necessary to increase the length of the top section of the sloper. This would require lowering of the entire antenna using the halyard, and would not be quite as convenient as being able to do the tuning at the ground-level end only.

Two-Band Operation. The antenna of Fig. 5 performed impressively, and per-

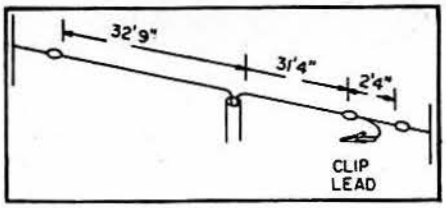


Fig. 5. This sloper is suitable for 40 and 15 meter operation, and adjusts by connecting a jumper to the additional segment.

mitted operation on either 15 or 40-meters. On 40-meters, it operated as a 40-meter sloping dipole, and on 15-meters as a three-quarter wave-length sloper. Instead of clipping on an additional length of antenna wire to the low side of the sloper, an additional insulator was incorporated along with an appropriate clip as shown in Fig. 6.

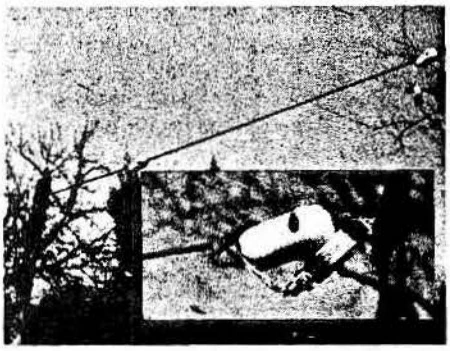


Fig. 6. The photo shows the extra length used for 40 meter operation, and the inset shows the jumper wire in position for 40 meters.

When the clip was disconnected, the antenna tuned to the 40-meter phone band. Connecting the clip tuned the antenna to the CW end of the 40-meter band, and to the sideband spectrum of the 15-meter band.

This antenna was sloped toward Europe, and in a brief three hours of operation, four continents and 16 countries were contacted using only 100-watts PEP. The high end of the sloper was only 30-feet above ground. The antenna can be tuned toward the CW end of the 15-meter band by clipping on an additional length of wire at the second insulator. The 15/40-meter combination works out well because 15-meters is the approximate third harmonic of the 40-meter band—7 MHz times 3, equals 21 MHz.

10/20 Meter Operation. The success of the three-quarter wavelength antenna on 15-meters led us to the construction of a similar antenna for 10-meter operation. Some experimentation with element length was required, and the resulting arrangement of Fig. 7

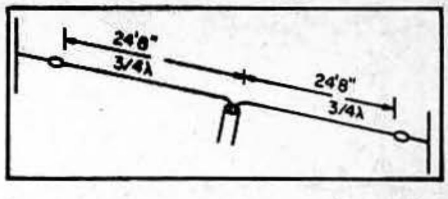


Fig. 7. This is the straight dipole cut for 10 meter operation before being modified for 10 and 20 operation as seen in Fig. 8.

provided resonance at approximately 28.6 MHz. As you have no doubt learned through your antenna experimentation, there are variations in resonance depending upon site, height above ground, and other variables. Hence it is advisable to cut antennas a bit longer than calculated. You can then trim the segments later to obtain resonance at some precise frequency.

An advantage of the sloping dipole not mentioned previously is the fact that it can be oriented rather easily, if you wish to take advantage of its somewhat better directivity, in a given direction. Several fence posts placed strategically at the mounting site will permit you to change that directivity simply by swinging the antenna around to a given fence post. At the same time, the performance in other directions will not deteriorate to the degree that they do with the use of a beam antenna, such as a Yagi or quad.

Somehow the sloper antenna, with its combination of horizontal and vertical polarization, also provides good low-angle vertical directivity. It might be that vertical polarization provides the low angle vertical directivity much as for a vertical ground-plane antenna. At the same time on the low-frequency bands, there seem to be higher angle components for good, close-in contacts on 40 and 80-meters as well as some low angles for DX results.

Finally, the 10-meter three-quarter wavelength antenna was broken at the two points indicated in Fig. 8 to permit operation as a 20-meter sloping dipole

(Continued on page 96)

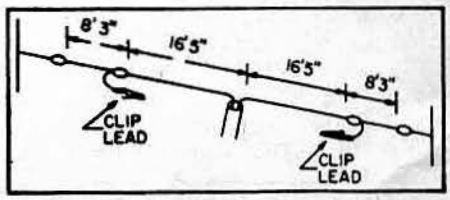


Fig. 8. By breaking up the segments and adding jumpers, the monobander becomes a dual-band dipole for both 10 and 20 meters.

SEMICONDUCTOR SURVEY

The RCA CD40459: Count Down With This Programmable Frequency Divider

THE RCA CD4059 IS A down counter that can be programmed to divide an input frequency by any number from 3 to 15,999. It has applications as either a fixed or programmable frequency divider, digital frequency synthesizer for communications and a timer for consumer equipment applications and industrial controls.

The positive output pulse has a duration corresponding to the period of one clock input cycle. The frequency of this pulse (pulse repetition rate) is the clock frequency divided by the programmed count (N):

$$f_o = \frac{f_c}{N}$$

The functional plan of the chip is given in Fig. 1. The clock input is at the center left. The clock enters the first counting section, the count of which is determined by the mode select inputs at the lower left and the four so-called jam inputs J1, J2, J3 and J4 at the top left.

The output then passes through three cascaded basic divide-by-ten counters. However, each of these counters can be preset between 0 and 15 by their associated jam inputs, J5 through J16. The jam inputs program the counter. Each is programmed by the BCD code .

The output of the intermediate counting section is applied to the last counter, which is also pre-set by the mode control and jam inputs J1 through J4.

A Recognition Gate. The output of the last counting section reaches the output through a recognition gate, a pre-set/enable circuit and the output stage. The fundamental programming of the counter determines how many pulses enter that counter before there is one output pulse.

If the programmable counter is preset to divide by 2563, there will be one positive output pulse for every 2563 input clock pulses.

The first and last counting sections operate together in accordance with the three mode select inputs, K_a, K_b and K_c. The actual mode count is determined by the logic 1 and logic 0 settings at these three inputs according to Fig. 2.

The truth table shows there are five mode pre-sets for the first counting section of 2, 4, 5, 8 and 10. If the mode count is to be 2, all of the K inputs must be set to logic 1. If the input mode division is to be 10, K_a and K_b are set to logic 1, while K_c is set to logic 0.

The actual count of the first section is determined by the jam settings. The maximums of which are indicated by the column labeled, 'can be preset to a max of.' The next column indicates the jam inputs that can be used for programming the first count section.

Interconnecting Modes. You can note from Fig. 1 that the first and last counting sections are interconnected with the mode select inputs and jams J1 through J4. Whatever jam inputs of the four modes are not used by the first counting section can be used by the second counting section.

For example, for a mode of 2 only J1 is used in the first section making available jam inputs J2, J3 and J4 for the last counting section. Note that for an initial mode of 10, all of the J1 through J4 jam inputs are used by the first section and the last counting section has no available jam inputs and cannot be used.

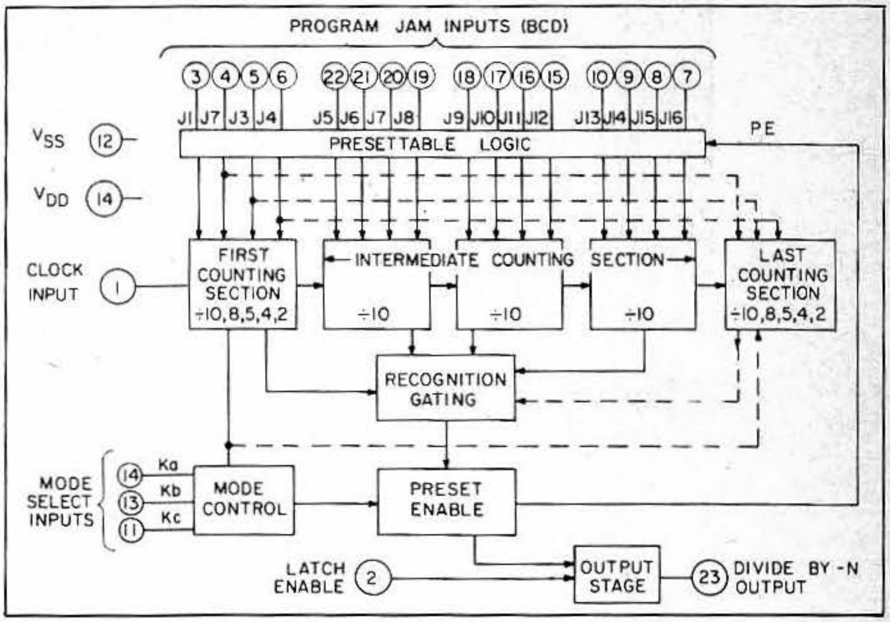


Fig. 1. This line drawing shows the functional plan of the RCA CD4059 down counter. It is a versatile integrated circuit that can be programmed to divide an input frequency.

MODE SELECT INPUT			FIRST COUNTING SECTION			LAST COUNTING SECTION			COUNTER RANGE	
									DESIGN	EXTENDED
Ka	Kb	Kc	MODE DIVIDES BY	CAN BE PRESET TO A MAX OF	JAM* INPUTS USED	MODE DIVIDES BY	CAN BE PRESET TO A MAX OF	JAM* INPUTS USED	MAX	MAX
1	1	1	2	1	J1	8	7	J2,J3,J4	15,999	17,331
0	1	1	4	3	J1,J2	4	3	J3,J4	15,999	18,663
1	0	1	5#	4	J1,J2,J3	2	1	J4	9,999	13,329
0	0	1	8	7	J1,J2,J3	2	1	J4	15,999	21,327
1	1	0	10	9	J1,J2,J3,J4	1	0		9,999	16,659
X	0	0	MASTER PRESET			MASTER PRESET				

X = DON'T CARE

Fig. 2. The mode count for the RCA CD4059 is given. There are five mode pre-sets for the first counting section of 2, 4, 5, 8 and 10. The first and last sections are connected.

SEMICONDUCTOR SURVEY

The functions of these two sections will be better understood when some actual counts are programmed.

When the mode select inputs K_b and K_c are both set to logic 0, the counter presets and the counter remains low. Count down begins again whenever a counting mode other than the master preset mode is selected. As a note in Fig. 2 indicates, the counter should always be put in the mster preset mode before the divider by five mode is selected.

Mode Values. The mode value refers to the logic settings of the K inputs. Decade 1 refers to the setting of the first counting . ction, decade 2 to the first intermediate counting section, decade 3 to the second intermediate counting section, decade 4 to the third intermediate counting section and decade 5 to the last counting section. Refer to Fig. 1.

Figs. 3 and 4 are an aid in programming as they show the K and jam inputs for the various modes along with the decades and the chip pin numbers. Fig. 3 shows the various division modes 2, 4, 5 and 8. Fig. 4 shows the division mode of 10 and, in addition, some specific examples of programming.

Let us work out an example using the divide by four mode to obtain a count (N) of 8479. As shown in Fig. 3, K_a must be set to logic 0, K_b must be set to logic 1 and K_c must be set to logic 1. The BCD jam controls must now be programmed to a pre-set value of N ÷ mode or:

Preset Value =

$$\frac{\text{N (Desired Count)}}{\text{M (Mode)}} = \frac{8479}{4}$$

Preset Value =

8479 ÷ 4 = 2119 + 3

10 | 0001 | 0001 | 1001 | 11

Use Those Jams. Note that the answer is 2119 + 3 left over. These five numerals must be pre-set on the jam inputs using the BCD code. Decade 5 must be set to the numeral 2 using jams J4 and J3 or jam J4 to logic 1 and jam J3 to logic 0. Pin 6 would be connected to logic 1 and pin 5 to logic 0.

The fourth decade would be set to 1 which in terms of the BCD code is 0001; jam J5 would be at logic 1 and the other three jams of the decade at logic 0.

The same 0001 code applies for the third decade which is also the numeral 1. The second decade is set to numeral 9 or, in the BCD code, 1001. The first decade must be set to the numeral 3 using jams J2 and J1. Both would have to be set to logic 1. You can now prove your program by using the basic equation:

$$N = \text{MODE}\ [(1000 \times \text{decade } 5) + (100 \times \text{decade } 4) + (10 \times \text{decade } 3) + (1 \times \text{decade } 2)] + \text{decade } 1$$

$$N = 4\ [(1000 \times 2) + (100 \times 1) + (10 \times 1) + (1 \times 9)] + 3 = 8479$$

Divide By Ten. Fig. 4 shows the relations for the divide by ten mode as well as the programming for divisions (N) of 10, 100, 1000, 1001 and 5200. In the divide by ten mode the four jams, J1 through J4, are active in the first count. In this mode decade 5 is inactive.

To determine the preset value, the desired count must be divided by the mode. If the desired count (N) is 10, the preset value is 1 (10 ÷ 10). Therefore only the X1 or decade 2 jam section is active. In Fig. 4 for the division by ten, all of the decades, except 2, are set 0000 while decade 2 is set to 0001. ■

DECADES	1	2	3	4	5
	FIRST COUNT	X1	X10	X100	LAST COUNT
	MODE ÷2 Ka-1 Kb-1 Kc-1				
PINS	3	19 20 21 22	15 16 17 18	7 8 9 10	6 5 4
JAM	J1	8 7 6 5	12 11 10 9	16 15 14 13	4 3 2
	MODE ÷4 Ka-0 Kb-1 Kc-1				
PINS	4 3	19 20 21 22	15 16 17 18	7 8 9 10	6 5
JAM	J2 J1	8 7 6 5	12 11 10 9	16 15 14 13	4 3
	MODE ÷5 Ka-1 Kb-0 Kc-1				
PINS	4 3	19 20 21 22	15 16 17 18	7 8 9 10	6
JAM	J2 J1	8 7 6 5	12 11 10 9	16 15 14 13	4
	MODE ÷8 Ka-0 Kb-0 Kc-1				
PINS	5 4 3	19 20 21 22	15 16 17 18	7 8 9 10	6
JAM	J3 J2 J1	8 7 6 5	12 11 10 9	16 15 14 13	4

Fig. 3. An aid for programming, this diagram shows the various division modes for the RCA CD4059 IC frequency down counter.

	MODE ÷10 Ka-1 Kb-1 Kc-0				
	DECADE 1	DECADE 2	DECADE 3	DECADE 4	DECADE 5
	FIRST COUNT	X1	X10	X100	LAST COUNT X1000
PINS	6 5 4 3	19 20 21 22	15 16 17 18	7 8 9 10	—
JAM J	4 3 2 1	8 7 6 5	12 11 10 9	16 15 14 13	—
	DIVISION BY 10				
BCD	0000	0001	0000	0000	—
	DIVISION BY 100				
BCD	0000	0000	0001	0000	—
	DIVISION BY 1000				
BCD	0000	0000	0000	0001	—
	DIVISION BY 1001				
BCD	0001	0000	0000	0001	—
	DIVISION BY 5200				
BCD	0000	0000	0010	0101	—

Fig. 4. Specific examples of programming are shown in this diagram and the mode of 10 is given. Examples can be easily worked.

DESIGNING REGULATED POWER SUPPLIES

You don't have to have a degree to design the power supply you need

UP UNTIL A FEW YEARS AGO, the task of designing a regulated power supply was both complicated and time-consuming. As a result, the average experimenter either made do without regulation or copied someone else's circuit. Things have changed a lot since then. Now, even a beginner can design his own regulated supply using one of the integrated-circuit voltage regulators. No fancy oscilloscope is necessary; in fact, you don't even need a calculator. Simply by consulting the tables and graphs in this article, you can custom-design your own regulated supply in a matter of minutes.

The supplies to be covered here range in output from 5 to 18-volts at currents up to one-ampere. Both positive and negative outputs are possible. Let's start by examining the basic positive-regulator circuit shown in Figure 1. Voltage from transformer T1 is full-wave rectified by diodes D1 and D2, and smoothed by filter capacitor C1. Voltage regulator VR+ converts the unregulated DC across C1 into a regulated potential of the desired size at its output, pin 2. Capacitor C2 bypasses this output and thereby stabilizes the circuit and improves transient response. On the primary side of T1, fuse F1 protects the circuit should a malfunction cause excessive current to be drawn from the AC line.

Similar, But Not Equal. The similarity between the positive-supply circuit and the negative-supply circuit (Figure 2) is apparent. Note, however, that D1, D2, C1 and C2 are reversed in the negative circuit. Furthermore, the pin designations of negative regulator VR− are different from those of positive regulator VR+. For the positive regulator, pin 1 is the input, while pin 2 is the output, and pin 3 is ground. On the negative regulator, however, pin 1 is the ground connection. Pin 3 is now the input, and pin 2 remains as the output of the voltage regulator.

Both the positive and negative regulators are available in two case styles, a "T" package and a 'K' package; see the base pin diagram.

Regardless whether a regulator is positive or negative, the same pin-numbering scheme applies. Remember, however, that the numbers have different meanings for positive and negative regulators. For example, on the "T" package, pin 3 is always the middle pin. If the regulator is positive, the middle pin is ground. But if the regulator is negative, then the middle pin is its input.

In the design procedure to follow, the same tables and rules will be used to specify F1, T1, D1, D2, C1 and C2, whether a positive or negative supply is being built. This is certainly reasonable since the two circuits are so similar. However, the positive and negative supplies must use different types of regulator ICs, and these may not be interchanged. With all the preliminaries out of the way, let's get down to the basics of this easy seven-step method for designing the supplies.

Determine the Required Voltage. You have your choice of seven positive voltages and seven negative voltages, as shown in the middle column of Figure 6. Note that +10V has no negative counterpart. Be sure that you know the *maximum* current that your load can draw; it must be no more than one ampere. If you are powering a construction project or a kit, you should find a supply-current specification somewhere in the literature. If you have no idea as to how much current your intended load will draw, you can measure it directly. Connect the device you intend to power to a variable bench supply set to the desired voltage. Measure the current drain with an ammeter in series with one of the power leads.

Select a Transformer. Refer to Figure 6, and locate the desired output voltage in the middle column. For a positive supply, you will find the necessary transformer listed in the hight-hand column, and in the same row as your selected voltage. The proper transformer for a negative supply will be found in this same row, but in the column furthest to the left. The transformers are specified according to the RMS voltage from one end of the secondary to the other. Note that all secondaries must be center-tapped (CT). The transformers listed are standard, although they may not seem so if you are accustomed to the usual 6, 12, and 24-volt transformers that flood the hobby market. Finding a source is not hard; check the catalogs of any of the large electronics retailers. At least one transformer company, Signal, will sell you these transformers by direct mail-order. Before ordering, request a catalog and price list (Signal Transformer Co., 500 Bayview Ave., Inwood, N.Y. 11696).

You do have a little bit of leeway in the selection of a transformer, particularly at the higher voltages. If a 34-VCT transformer is called for, and you have on hand one that measures 32-VCT, go ahead and use it. Also, you could hook up the secondaries of two 12-volt transformers in series (and in the proper phase) to obtain the equivalent of a 24-VCT transformer.

In addition to the voltage, you must also specify your transformer's current rating. A convenient rule-of-thumb is to pick a transformer whose secondary-current rating is about 1.2 times the maximum current that is to be drawn from the supply. If you use a transformer whose current rating is too small, it will overheat. On the other hand, if you choose a transformer that can supply much more current than is necessary, it will be bulkier and more expensive than a transformer of the proper size.

Pick a Regulator. Here again, you should use Figure 6. Positive regulators can be found in the column just to the right of the "Output Voltage" column, and negative regulators are just to the left. As you can see, a positive regulator may be chosen from either of wo IC families: The 7800 series, or the 340 series. Furthermore, each family comes in either the "T" package or the "K" package. Thus, when selecting a 6-volt positive regulator, you can pick from any of the following: 7806K, 7806T, 340K-6 or 340T-6. If you were looking for a negative 6-volt regulator, the 7900 and 320 families would offer the following candidates: 7906K, 7906T, 320K-6 or 320T-6. Actually, there is no significant distinction between the 7800 and 340 families, nor between the 7900 and 320 families. The "K" package, however, can facilitate high power more readily, so it might be preferred at the higher supply-current levels. On the other hand, the "T" package is probably preferrable if you intend to build your supply on a PC board.

At all but the smallest load currents, these voltage regulators will have to be heat-sinked. This will be covered in more detail later. When you buy a regulator, try to get a specification sheet, too. It will provide you with more complete information on your particular IC.

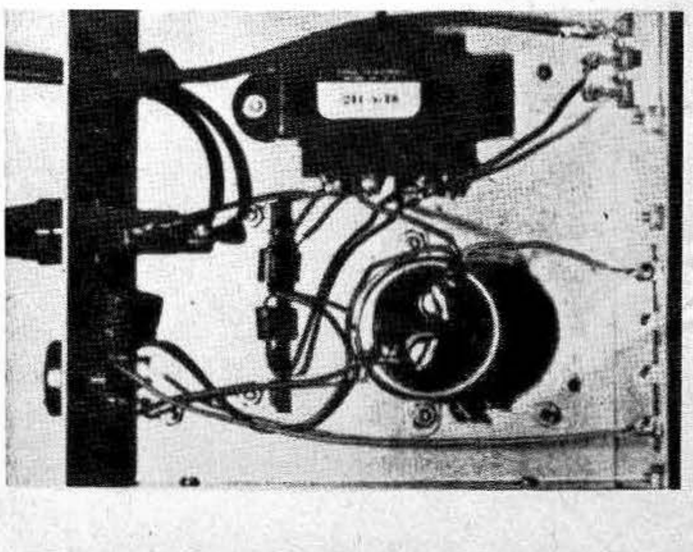
Choose Your Rectifier Diodes. The factors to be considered here are the diodes' voltage rating, average-current rating, and surge-current rating. Since the supply's load current is restricted to a maximum of one ampere, each diode must see an average current of less than half an ampere. Therefore, a rectifier diode with an average-current rating of one-ampere should suffice. A voltage rating of 100-PIV would be adequate, but it is even safer to use diodes with a 200-PIV rating. These will survive most power-line transients. The surge-current rating becomes an important consideration at the instant when the supply is turned on. At that moment, filter capacitor C1 is uncharged. Transformer T1 charges the capacitor with a current through one of the rectifier diodes. Since this current is limited primarily by the small resistance of the transformer's secondary, it is very large. When all of the above factors are taken into account, the 1N4003 emerges as a good rectifier with transformers of 28-VCT or less. Its higher-voltage cousins, the 1N4004 and 1N4005, also will work well. For transformers of 34-VCT to 48-VCT, use a 1N5402 rectifier or a higher-voltage relative (1N5403), etc.). The 1N5402 is a 3-ampere diode that will handle higher surges than the 1N4003. Both rectifier types are readily available from many suppliers, including Radio Shack.

Specifying Capacitor C2. This is easy, since anything greater than 25-µF will be fine. The capacitor's voltage rating should be from 1.5 to 2-times the output voltage of the supply you are building. If a capacitor with too small a working voltage is used, it will not last long. Conversely, using a capacitor with a working voltage greater than twice the supply voltage is wasteful of space and money.

Selecting Filter Capacitor C1. First, determine this component's working-voltage rating from the chart. A range of satisfactory working voltages will be found opposite the transformer voltage that you selected in step 2. Use a filter capacitor with a voltage rating as high as possible within the recommended range of working voltages.

The minimum capacitance of C1, in microfarads, can be found from the graph. Locate your supply's maximum current drain (see step 1) on the x-axis of the graph. Project a line upward to strike the one line (out of the three in the graph) that is appropriate to the transformer voltage being used. The y-value at the point of intersection is the minimum capacitance necessary. Use a standard electrolytic capacitor that is greater than or equal to the value determined from the graph.

In most cases, you can afford to be generous with capacitance. A larger capacitor will have less ripple voltage across it. As a result, it will heat less and last longer. So, when a low-current supply demands only 200-µF, you can



Here's the interior of our "typical" 5-volt power supply. Unless you're the type who likes to dress up all of your projects, these types of power supplies can be assembled in any handy chassis. There's almost never any cause to worry about ventilation, as many of the regulator chips can handle their full-rated loads without even heatsinking!

DESIGNING SUPPLIES

use 500-μF if you like. But when the capacitor must have a high working voltage (50 to 75-volts), extra microfarads come in a bigger package and at a higher price. Therefore, you may not wish to be so generous.

In order to locate a suitable electrolytic capacitor, consult the catalog of a large mail-order supplier, such as Allied or Burstein-Applebee. You will find some electrolytics listed as "computer-grade." These cost a little more, but they last longer in heavy-duty service. Whether or not the extra cost is warranted is a decision that is up to you.

Finding the Right Fuse. The fuse rating table will be of assistance here. Locate the row corresponding to the transformer being used, and the column appropriate to the maximum expected load current. Check the zone in which the row/column intersection lies for the proper fuse rating. Be certain to buy a slow-blow (3AG) fuse, since this type is less prone to blow on the current surge at turn-on.

Now, let's consider a practical design example. Suppose that a 15-volt, 350-milliamp, positive supply is required. The table indicates that a 40-VCT transformer will be needed. Estimate the transformer's current rating: 350 x 1.2 = 420. A look through a transformer catalog reveals the nearest commercially available unit to be 40-VCT @ 500 milliamps.

Referring once more to the table, let's choose a 7815K regulator IC.

Since a 40-VCT transformer is being used, 1N5402 rectifier-diodes are a good choice.

For capacitor C2, let's use a 100-μF unit with a standard working voltage of 35-volts. Because the voltage rating is about twice the supply's output voltage, this is a safe selection.

Figure 4 reveals that filter capacitor C1's working voltage should lie between 40 and 60-volts. Turning to Figure 5, and using line "B," we find the minimum capacitance to be about 750-μF. The nearest commercial unit turns out to be 1000-μF @ 50 volts. You can use more capacitance if desired.

Finally, Figure 3 indicates that a ¼-amp, slow-blow fuse is appropriate for this particular combination of transformer voltage and maximum load current.

Now that you know how to design your supply, let's talk about how to build it. Most manufacturers recommend that a voltage regulator be mounted fairly close to C1. This means 3-inches or less of interconnecting wire. Likewise, C2 should be mounted close by—right on the pins of the regulator, if possible.

Rectifiers D1 and D2 are cooled by heat conduction through the two mounting leads. To assist conduction, mount these rectifiers with short leads. If the rectifier is mounted on a terminal strip, then the lugs of the strip will act to sink some heat. Printed-circuit mounting requires the use of large pads and thick connecting traces to draw heat away from the rectifier's leads.

Be sure that there is adequate air flow around the components of the supply in order to prevent overheating. This applies particularly to the higher-current supplies.

Short, heavy wires should be used for interconnecting components. Again, this is most important for high-current

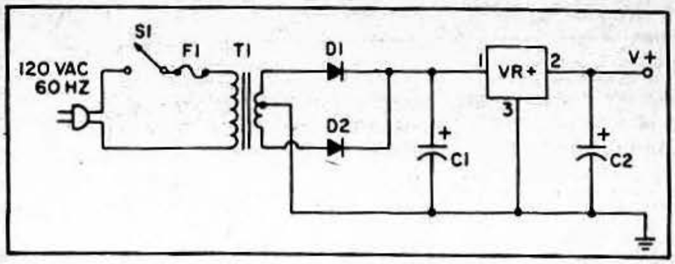


Fig. 1. Here is the schematic for the typical positive - regulated supply. Note the pin connections on the voltage regulator chip.

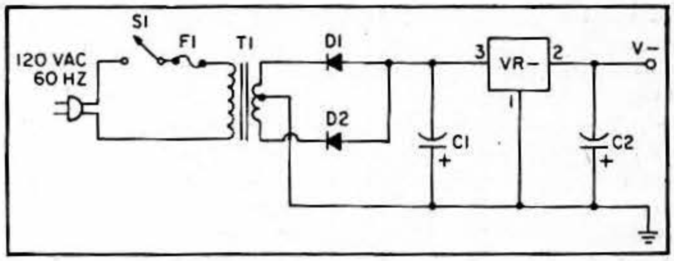


Fig. 2. The negative supply is almost identical to positive, with the exception of the reversals of the diodes and the pinouts of the regulator.

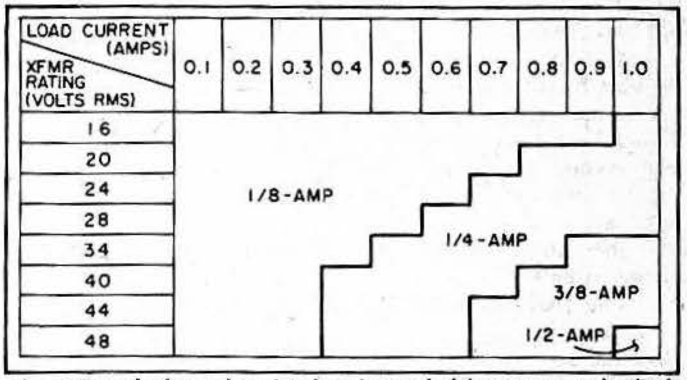
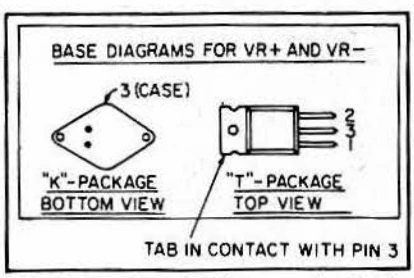


Fig. 3. To calculate what size fuse is needed for your supply, find your transformer's output rating in the vertical column, and your regulator's rating at top. Draw a line out to the center of the chart from each box. Where they meet is the fuse rating in amps.



Above are the pin diagrams for both the "T" and "K" package regulators. Note difference between pos. and neg.

TRANSFORMER RATING (RMS VOLTS)	WORKING VOLTAGE OF C1 (VOLTS DC)
16	16–25
20	25–35
24	25–35
28	30–40
34	35–50
40	40–60
44	50–75
48	50–75

Fig. 4. Simply look across from left to right in order to determine what the working voltage of C1 will need to be.

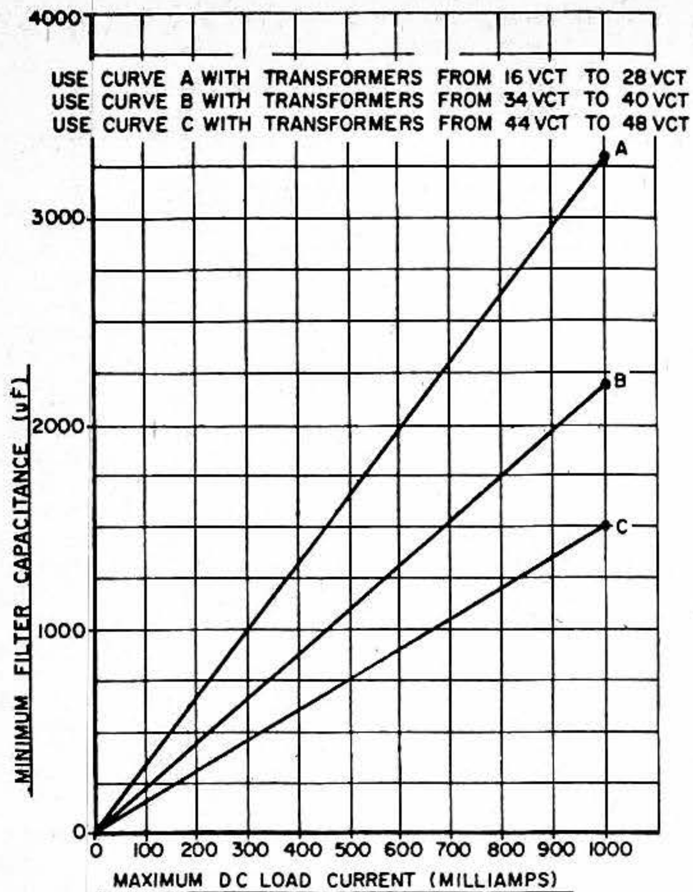


Fig. 5. After consulting fig. 4 for the voltage rating, use this graph to determine the correct capacitance for capacitor C1.

NEGATIVE SUPPLIES			POSITIVE SUPPLIES	
TRANSFORMER (RMS VOLTS)	REGULATOR	OUTPUT VOLTAGE	REGULATOR	TRANSFORMER (RMS VOLTS)
16 ct	7905/320-5	5	7805/340-5	20ct
20 ct	7906/320-6	6	7806/340-6	20 ct
24 ct	7908/320-8	8	7808/340-8	24 ct
24 ct	7909/320-9	9	NOT AVAILABLE	
NOT AVAILABLE		10	7810/340-10	28 ct
34 ct	7912/320-12	12	7812/340-12	34 ct
40ct	7915/320-15	15	7815/340-15	40ct
44ct	7918/320-18	18	7818/340-18	48 ct

Fig. 6. Here's a listing of the most commonly used transformer and regulator combinations for both positive and negative.

supplies, which should be wired with #16 or #18 stranded wire. Those wires connecting the load to the supply should be as short as possible for the best regulation.

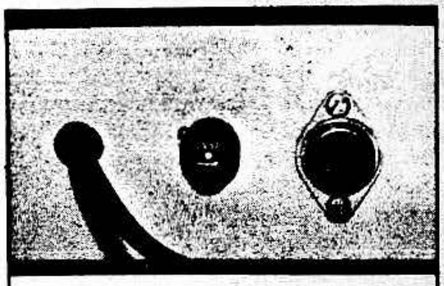
In most instances, voltage-regulator ICs will need to be heat-sinked. There just fine. However, there is an even better, cheaper way to heat-sink a regulator IC: Assuming that the supply will be mounted in an aluminum case, simply attach the regulator to the case. Remove all paint from the area where the IC is to be mounted, and then bolt the regulator to the chassis. Silicone grease between the chassis and the regulator will improve the heat transfer.

If, as is generally the case, the chassis is to be at ground potential, then positive regulators may be mounted directly to the chassis with no difficulty. Negative regulators, however, pose a problem because the mounting flange on both the "T" and "K" packages is connected to the in-

If, as is generally the case, the chassis is to be at ground potential, then positive regulators may be mounted directly to the chassis with no difficulty. Negative regulators, however, pose a problem because the mounting flange on both the "T" and "K" packages is connected to the in-put, not ground. The solution here is to use mica insulating wafers, coated with silicone grease, between the IC and the chassis. Heat will still be effectively transferred, but the mounting flange will be electrically insulated from the chassis.

Once your supply is finished, check it out before permanently wiring it to a load. You will need a dummy resistor to test the supply. Its resistance should be equal to the supply's output voltage divided by the maximum expected output current, in amperes. For the supply that was designed in this article, that amounts to 15/35, or about 43-ohms. The resistance should have a power rating of about two-times the product of output voltage and maximum current. Again, for the supply that was designed here, this comes to 2 x 15 x .35, or about ten-watts. Usually, you can build up such a dummy resistance from series and parallel combinations of lower-wattage resistors.

Connect the dummy resistance across the supply's output terminals, and then connect a voltmeter across the dummy resistance. Turn on the supply. Your



This is a prototype power supply with a "K" package regulator mounted on rear of chassis for heatsinking. Make sure case connection agrees with ground!

meter should indicate the desired output voltage. After a few minutes, *carefully* feel the regulator IC's flange. It should be no hotter than hot tap water. If touching the regulator case is painful, use a larger heat-sink to cool it down.

If, at the end of ten minutes, your supply is still putting out full voltage, and the regulator is not uncomfortably warm, you can turn the supply off. Disconnect the dummy resistance and voltmeter, wire the supply up to its load, and start pumping out those happy amps. ■

THE VERSATILE HORIZONTAL DIPOLE

Get the most antenna for the least amount of money.

THE HORIZONTAL DIPOLE is a simple, effective antenna. Antenna wire and accessories for its construction are inexpensive and readily available. It is of a length that makes for efficient use as a receptor of an incoming radio wave. When used as a transmitting antenna, it radiates efficiently and, at the same time, displays a proper impedance match to the output of the transmitter.

Dipoles are of critical length when used as transmitting antennae because of the need for proper match. Length and match insure ideal characteristics for reception as well. It is true that length and match are less critical if the antenna is to be used for receive only, because of the high sensitivity of modern receivers. For example, an antenna cut to length on one of the lower-frequency short-wave broadcast bands, will also receive well on other international broadcast bands. However, a dipole cut to length and properly oriented may be of considerable help in receiving some favorite, but weak station.

Dipole Length. The physical length of the antenna is related to the wavelength of the signal frequency to be received or transmitted. Frequency in megaHertz, and wavelength in meters are related as follows:

Wavelength in Meters = 300/Frequency in mHz. For example, the wavelength of a 3.75 mHz signal frequency would be: Wavelength

$$= \frac{300}{3.75} = 80 \text{ meters}$$

A dipole is a half-wavelength antenna and, therefore, its theoretical length would be one-half of this value, or 40-meters long. In practice, however, there are capacitive end-effects which cause a dipole that is cut to exactly the so-called "free-space" wavelength to be resonant on a lower frequency than the calculated value. In fact, to make the antenna an exact "electrical" half-wavelength long, it is necessary to shorten the physical length by 5-percent. Hence the dipole length for 3.75 mHz resonance would be:

$$\textbf{Dipole Half-Wavelength} = 0.95 \times 40 = 38 \text{ meters}$$

Since the dipole antenna is fed at the center and separated into two quarter-wavelength segments as shown in Fig. 1, each side of the antenna would be 19 (38/2) meters long.

Physical antenna length for each quarter-wave segment of the dipole can be obtained by multiplying the 19 meters times the meters-to-feet conversion constant of 3.2808, obtaining a value of 62.34 feet.

A conversion from metric to linear length results in a very simple equation that can be used to determine the length of the quarter-wavelength segment of a dipole:

$$\textbf{Length in Feet} = 234/f(\text{mHz})$$

***Table 1*—Here are the dimensions for cutting half-wave dipoles for the various Amateur frequencies below 30 MHz. The number given represents one-half the total antenna length.**

FREQUENCY IN MHz	DIPOLE λ/4 IN FEET
160 METERS	
1.81	129.28
1.83	127.86
1.85	126.49
1.87	125.13
1.89	123.80
1.91	122.51
1.93	121.24
1.95	120.00
1.97	118.78
1.99	117.59
80 METERS	
3.525	66.38
3.550	65.92
3.575	65.45
3.600	65.00
3.625	64.55
3.650	64.11
3.675	63.67
3.700	63.24
3.725	62.82
3.750	62.40
3.775	61.99
3.800	61.58
3.825	61.18
3.850	60.78
3.875	60.39
3.900	60.00
3.925	59.62
3.950	59.24
3.975	58.87
40 METERS	
7.025	33.31
7.050	33.19
7.075	33.07
7.100	32.96
7.125	32.84
7.150	32.73
7.175	32.61
7.200	32.50
7.225	32.39
7.250	32.28
7.275	32.17
20 METERS	
14.025	16.69
14.050	16.66
14.075	16.63
14.100	16.60
14.125	16.57
14.150	16.54
14.175	16.51
14.200	16.48
14.225	16.45
14.250	16.42
14.275	16.39
14.300	16.36
14.325	16.33
15 METERS	
21.05	11.12
21.10	11.09
21.15	11.06
21.20	11.04
21.25	11.01
21.30	11.98
21.35	10.96
21.40	10.94
10 METERS	
28.2	8.30
28.4	8.24
28.6	8.18
28.8	8.13
29.0	8.07
29.2	8.01
29.4	7.96
29.6	7.91

A hand calculator is an aid if you wish to make your own antenna calculations.

Dipole Dimension Charts. Quarter-wave segment lengths for each of the Amateur bands, 10 through 160 Meters, are given in Table 1. For example, each quarter-wave segment of a dipole antenna cut to 14.2 mHz in the 20 Meter band should have a length of 16.48 feet. Table 4 gives dimensions for dipole quarter-wave segments for reception on the various shortwave broadcast bands. Dipole lengths for the various WWV frequencies are given in Table 3.

Lengths are given to a decimal part of one foot in the tables. In addition, Table 2 permits you to make an approximation in inches. In fact, when erecting an antenna for use with a transmitter, there are other variables, such as proximity to ground and metallic surfaces, as well as antenna element diameter, that influence the exact resonant frequency. Therefore, cutting an antenna within an inch or two of indicated value is satisfactory. For example, in cutting the dipole for 14.2 mHz use, a practical value is 16-feet, 6-inches. Note from Table 2 that the six-inch figure is appropriate for a decimal part falling between 0.55 and 0.65.

It has been my experience in cutting antennas, that it is preferable to cut elements somewhat on the long side, permitting you to trim down the antenna to a specific resonant frequency after initial tests have been made. Of course, antennas for receive-only use are not nearly so critical as to their length. Consequently, in Table 4, one dimension is given for operation over the specific shortwave broadcast band.

Of course, it should be stressed that an inch or two of length has a much more decided effect on the resonant frequency on a higher frequency Amateur band as compared to a lower one. Thus, you should be more careful in cutting the dipole for 10 or 15 Meters, as compared to the cut for 80 or 160 Meters. For example, a differential of 3-inches on 10 Meters might result in a frequency change of approximately 1 megaHertz, while a similar differential on 80 Meters corresponds to a frequency shift of only 20-25 kiloHertz.

Dipole Directivity. The horizontal dipole is directional. As a transmitting antenna, it sends out maximum radio energy (radiation) in the two directions broadside (perpendicular) to the antenna wires (Fig. 2). As a receiving antenna, it displays maximum sensitivity to radio signals arriving from the same two directions. Radiation and sensitivity taper off at angles away from the perpendicular, declining to a minimum in the direction along the line (parallel) of the antenna wire. The response pattern of Fig. 2 is a theoretical one. The antenna does radiate energy at other angles and is sensitive to incoming signals as well. The extent of the differential depends upon a number of variables including type of antenna, proximity of ground, nearby metallic structures, propagation conditions, transmission line system, etc. It is a fact though, that maximum radiation and sensitivity occur perpendicular to the antenna wire and minimum in the direction of the antenna wire. The figure-eight pattern is itself rather broad, and it is only at angles near to the angle of the antenna wire that the response is sharply down.

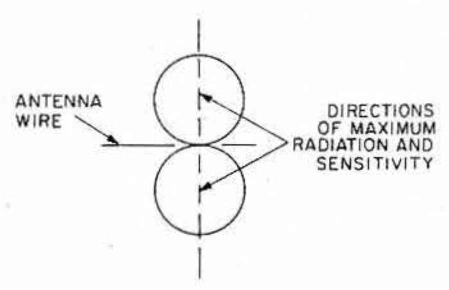


***Figure 2*—If you're interested in working a particular area with your dipole, then be sure to orient it properly. The maximum amount of RF is radiated perpendicular to the line of the antenna wire itself.**

In practice then, it is a good idea, if possible, to erect the dipole antenna with an orientation that places it broadside to the direction toward which you wish to radiate maximum signal or display maximum sensitivity. If your intent is to minimize the pickup of an interfering signal, you should point the dipole antenna wire in that direction.

Dipole Antenna Components. Essential components of the dipole antenna are: antenna wire, dipole center connector, end insulators, support rope, transmission line, and other accessories as needed. The antenna wire can be the popular 7-strand, #22 type, which is common and inexpensive. When it can be found at low cost, our personal preference is for #14 or #16 solid, insulated wire. A good-quality, insulated wire gives you added safety and weather protection. Insulation in no way interferes with the radiation or pick-up of signal

Available end insulators are usually made of porcelain and are 1.75 to 3-inches long. They are oval-shaped or rectangular, some having a ribbed construction. Two holes are provided, one for the antenna wire itself and the other for the support line. Support line can be nylon rope or strong plastic

***Table 2*—Use this table to convert the decimal portion of the feet measurement given in Table 1, to inches. Always cut your antenna a bit longer at first. It's easier to trim it down than to add length later.**

DECIMAL PART OF ONE FOOT	INCHES (APPROXIMATE)
0-.05	0
.05-.10	1
.10-.15	2
.15-.25	3
.25-.35	4
.35-.45	5
.45-.55	6
.55-.65	7
.65-.75	8
.75-.85	9
.85-.90	10
.90-.95	11
.95-1.0	12

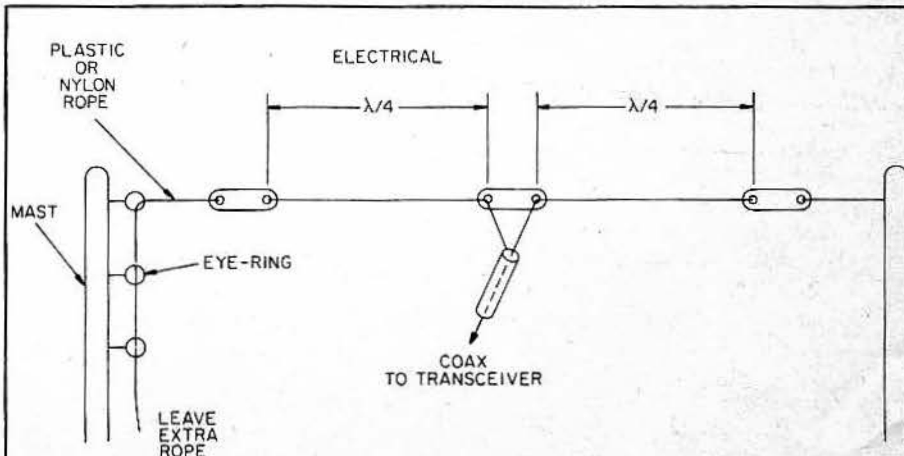


***Figure 1*—Here's the proper way to erect a dipole. Either or both ends may also be attached to the house or garage. Lead the coax away from the antenna at right angles.**

clothes-line with a nonmetallic core. To make it easy to lower the antenna, for cleaning or experimentation, the support line at one end can be fed down through eye-bolts to ground level, as shown in Fig. 1.

A coax-to-dipole connector, Fig. 3, is the ideal method of linking the dipole antenna to the coaxial transmission line. This connector provides a durable and reasonably weather-proofed connection, providing for convenient connection and detachment of transmission line. An alternative plan is to use an end insulator at the center. The two conductors of the transmission line can be attached firmly, soldered and taped to the antenna wire on each side of the center insulator.

There are various support means for horizontal dipole antennas. The variety of TV-antenna hardware such as chimney, side-wall and roof mounts, permit easy attachment to a house or garage. Support itself can be a 5 or 10-foot section of TV mast. Free-standing and guyed masts are available for ground-mounted supports. A telescoping TV mast is versatile because of its ease of erection and let-down. Guying is required. Guy rings are spaced approximately every 10-feet along such a telescoping mast.

Use good quality coaxial line, either 50-ohm or 70-ohm. Preferred types are RG-58A/U (50 ohms) or RG-59A/U (70 ohms) for low power applications. RG-8A/U is recommended for higher-powered applications, and installations where a long feed line, from antenna to transmitter, is necessary.

Erection of Dipole. Plan your installation according to length, height, and directional orientation. You must consider the space required by the antenna, and where the line must be brought into the house.

Safety and performance are important criteria. For safety reasons, keep the antenna clear of power lines. Be certain that if the antenna falls when erected, or while under erection, it cannot fall across electrical wires.

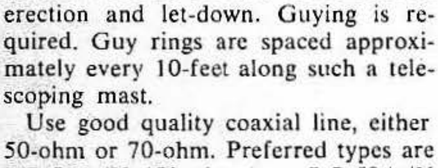


***Figure 3*—The best method for mating the antenna to the transmission line is a coax-to-dipole insulator/connector.**

***Table 3*—For receive-only operation, the dipole is still a very good choice. Here are the optimum lengths for broadband operation. Remember to orient the antenna for the area you wish to listen to specifically.**

BAND METERS	FREQUENCY IN MHz	DIPOLE λ/4 IN FEET
120	2.3-2.495	97.5
90	3.2-3.4	70.9
75	3.8-4.0	60.0
60	4.75-5.06	46.8
49	5.95-6.2	38.36
41	7.1-7.3	32.5
31	9.5-9.775	24.4
25	11.7-11.975	19.8
19	15.1-15.45	15.3
16	17.7-17.9	13.15
13	21.45-21.75	10.8

Make certain that under no circumstances, can mast or wire come in contact with power lines if you lose control of the mast or antenna. Keeping clear of power lines also improves the antenna performance. You will pick up less power line noise on receive. On transmit, you will radiate the least signal into the power lines, minimizing loss and possible interference with home entertainment units such as television receivers and high-fidelity amplifiers.

Orient the antenna to best meet your needs. If you wish to radiate maximum signal east and west, orient the antenna wire north and south. In a built-up area, it is not always possible to find an ideal mounting situation. However, within reason, it is not necessary that the two antenna ends be the same exact height above ground. Neither must the two quarter-wave segments of the dipole be in an exact line. Stay as close as you can to the idealized situation, but don't worry if you must make limited departures. The antenna will still perform well if you are reasonable in the changes you make.

Receive Only. The same general considerations must be made in the erection of a receive-only antenna, with the exception that power handling capability and transmitter matching are no longer factors of concern. Thus the antenna need not be cut as precisely. The two-wire transmission line can be made of lamp cord or, preferably, a good quality 300-ohm TV ribbon line. A combination of dipole antenna and TV line makes a good combination for short-wave listening on the international broadcast and radio amateur bands. A receiving dipole cut for 35-feet on each segment is a reasonable antenna for all-band listening. However, if you want peak performance on some particular band, you can then cut a separate receiving antenna for that particular band. Orient this antenna with its figure-eight reaching out in the favored direction.

Tuning With An SWR Meter. An SWR meter connected between transmitter and transmission line, Fig. 4, can be used to measure the resonant frequency of a dipole. To go a step further, the antenna can now be trimmed or extended if it does not resonate to the desired frequency. The results can be observed by the SWR meter, as the antenna resonant frequency is moved up or down the band. Since it is easier to trim off rather than to add on wire length, cut the initial antenna wire longer than the specified value for the particular frequency, in order to catch up with any variables that might influence resonance. A practical example will demonstrate an acceptable procedure.

Assume an antenna is to be cut for 7150 kHz in the 40 Meter amateur band. Table 1 indicates a dipole length of 32.73 feet. This suggests a dipole length of 32-feet, 9-inches. Cut each dipole element to 33-feet, which would be for a resonant frequency of 7100 kHz. Erect the antenna on a temporary basis.

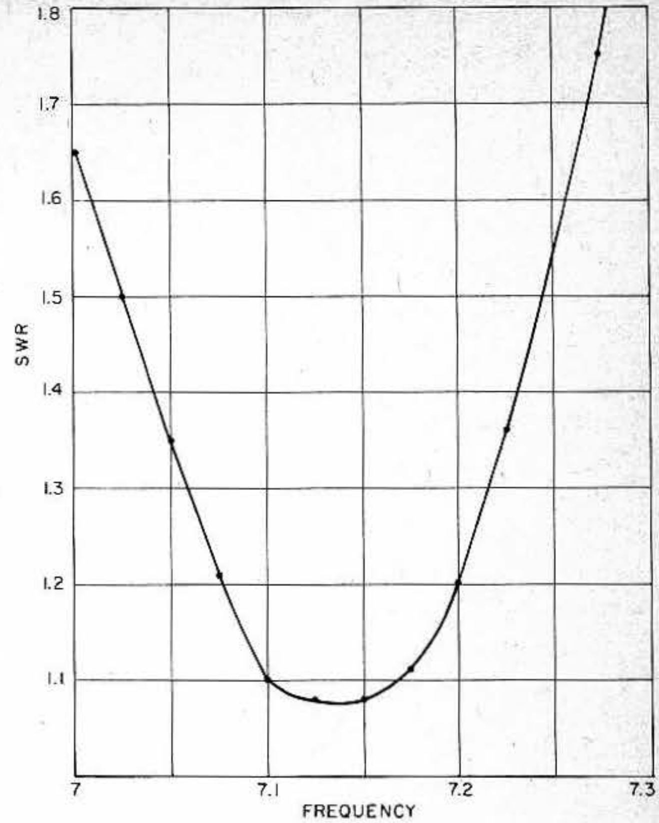
Measure the SWR every 25 kHz between 7025 and 7225. Set the readings down in a table form of frequency vs. SWR. Determine the precise frequency at which the SWR reading is minimum.

FREQUENCY IN MHz	DIPOLE λ/4 IN FEET
2.5	93.6
5	46.8
10	23.4
15	15.6
20	11.7
25	9.36

***Table 4*—Here are the dimensions needed to cut a dipole for WWV time station frequencies. WWV is an excellent source for receiver frequency calibration as well as the correct time. WWV's transmitters can be heard world-wide, 24-hours every day.**

f(mHz)	SWR
7.005	1.65:1
7.025	1.5:1
7.050	1.35:1
7.075	1.21:1
7.100	1.1:1
7.125	1.08:1
7.150	1.08:1
7.175	1.11:1
7.200	1.2:1
7.225	1.36:1
7.250	1.51:1
7.275	1.75:1
7.295	2.2:1

Figure 5—Table 5— **At left is the table made from the SWR plot (right) of our experimental dipole for 40 Meters. Make a similar one for your antenna in order to determine the exact resonant frequency. It is shown at right as the lowest point in the curve. Even though the curve is rather steep, we managed to achieve an SWR under 2.0:1 for just about the entire band. This would normally be acceptable.**



This would be the resonant frequency of the dipole. In our example, it was exactly 7050 kHz.

Inasmuch as the resonant frequency reading is low, you can now trim the antenna to attain the desired resonance. Be careful not to trim off too much. According to Table 1, each trimmed inch corresponds to a frequency change of approximately 20-25 kHz. In our example, we trimmed off six-inches, and increased the resonant frequency to 7141 kHz. If your SWR reading is low, and the resonant indication falls near to 7150, let well enough alone.

The plot of our experimental antenna is shown in Fig. 5. Note that even at the band edges, the SWR reading is reasonable. In the range between 7050 and 7250 kiloHertz, the SWR meter indicated almost ideal performance.

Antenna Tuners at Work. The primary function of an antenna tuner, Fig. 6, is to provide a proper match between your antenna system and transmitter. In so doing, your transmitter sees a proper load and is able to operate at the optimum conditions of its design. The tuner does not alter the performance of the antenna or the SWR on its transmission line. Rather, it makes certain that an improper SWR does not result in unfavorable operation or possible damage to your transmitter. Primarily it is a transmitter protector.

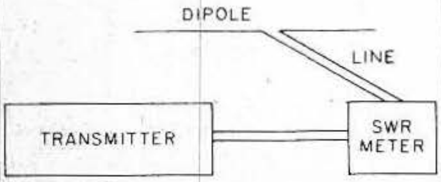


Figure 4—**An SWR meter should be inserted in the transmission line between the transmitter and antenna for accuracy.**

However, a tuner has a number of secondary benefits that enhance antenna system experimentation and permits the use of antenna systems that are not, in themselves, ideal for matching the standardized 50-ohm output of modern ham radio equipment. Again, it must be stressed that the tuner does not influence the performance of an antenna system. Rather, it acts as an interface between an antenna system and transmitter.

An additional secondary benefit is that it reduces harmonic and spurious signal radiation because it blocks the path between any such signals generated by your transmitter, and the radiating antenna. The tuner also rejects incoming signals that are on frequencies removed from the desired operating band. In effect, it reduces the sensitivity of the receiving system to image and other spurious frequency components.

A tuner makes the dimensioning of a horizontal dipole antenna less critical. It extends the frequency range of operation of the antenna that will provide an ideal match to the transmitter. For example, an 80 Meter dipole cut to 3750 kHz, will be made operable over the entire 80 Meter band from 3500-4000 kHz. The electrical performance of the antenna will not differ greatly from an antenna cut precisely to some specific frequency on the band. Even though the SWR on the transmission line might be rather high at the band extremes, the transmitter itself will look into an optimum load.

Conclusion. The horizontal dipole is indeed a versatile antenna, giving good performance at low cost. It should be dimensioned properly, and should be used with an SWR meter to evaluate its performance. A tuner insures proper match between dipole antenna system and transmitter, and also extends the operating bandwidth of the dipole in terms of proper matching to the transmitter. Let the dipole start you off in your first experimental activities with antenna systems. ■

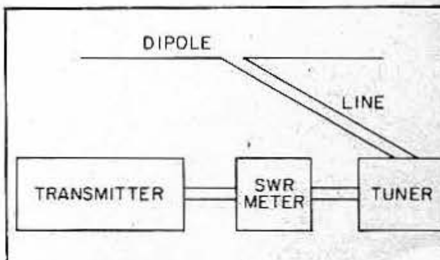


Figure 6—**The antenna tuner allows the transmitter to work into an optimum load even if the dipole itself is not cut for the correct frequency. A tuner won't correct an inefficient antenna installation.**

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Accutune

(Continued from page 46)

unit. As an option for greatest calibration stability, you may substitute metal film resistors for those resistors identified with an asterisk(#)

The LED may be permanently attached to the front panel by using a small amount of epoxy. Avoid bending the leads of the LED and solder two different colored flexible wires to it.

Convenient, Yet Stylish. A convenient place to install the 9-volt battery is above the meter, attached to the front panel. You may wish to fabricate a small battery clip out of sheet metal and fasten it to the panel with screws or epoxy. Secure the battery to the front panel so that it does not dangle.

It is best to calibrate Accutune with an accurate audio frequency generator and an oscilloscope (or VOM). If these instruments are not available to you, go to your local electronics repair shop and have them calibrate it fro you: completes the alignment of the unit's bandpass amplifier.

A Set Back. Set the audio oscillator back to 165 Hz and the rotary switch to lower E. Adjust R23 for a meter reading of exactly center scale. Do the same for the other five notes by adjusting the proper potentiometer and setting the audio oscillator and rotary switch to their appropriate positions.

To calibrate, connect the audio generator's output to Accutune's input jack using a standard phono plug. Set the generator's frequency to 165 Hz and its amplitude to 20 millivolts RMS. If the audio generator's amplitude control does not permit you to set such a coltage, connect a 10,000-ohm and a 470-ohm resistor voltage divider across the audio oscillator's output, set it to 0.5-volts RMS and use the voltage across the 470-ohm resistor to drive Accutune.

Turn on Accutune's power switch, set the rotary switch to lower E and examine the waveform at pin one of U2. Adjust R10 for the maximum amplitude of the 165 Hz signal, which should be about 0.15-volts RMS. In a similar manner set the audio oscillator to each of the remaining frequencies.

GUITAR STRING	FUNDAMENTAL FREQUENCY
E	164.8 HERTZ
A	220.0 HERTZ
D	293.7 HERTZ
G	392.0 HERTZ
B	493.9 HERTZ
E	659.3 HERTZ

Set the rotary switch to a certain note and adjust the proper potentiometer for a maximum amplitude of the waveform at pin 1 of U2.

To operate the unit, plug the guitar cable in to the front panel jack of Accutune and turn on the power switch. Set the guitar's volume controls to maximum output and set the rotary switch to lower E. Pluck the lowest string of the guitar. Adjust the tuning of the guitar until the meter reads exactly center scale. (You may have to pluck the string several times before the adjustment is complete.) Set the rotary switch to each of the remaining positions and adjust each string in a similar manner. Be sure to turn off the power switch when finished tuning.

For those of you who have a fledgling rock band and use an electric organ or piano to tune up, Accutune can be calibrated to the keyboard. First, plug Accutune into the keyboard and set the volume at minimum. Slowly increase the volume until you get a reading.

Hit a low A. Adjust the A potentiometers until you get a dead center reading. Do the same for the other notes. Accutune can pick up the musical hash of other instruments (different harmonics) and be calibrated to the pitch of your choice.

Now that Accutune is completed, you can put it to use. With Accutune in hand, you will never again have to fret about those screechy or klunker notes you may have once plucked. ■

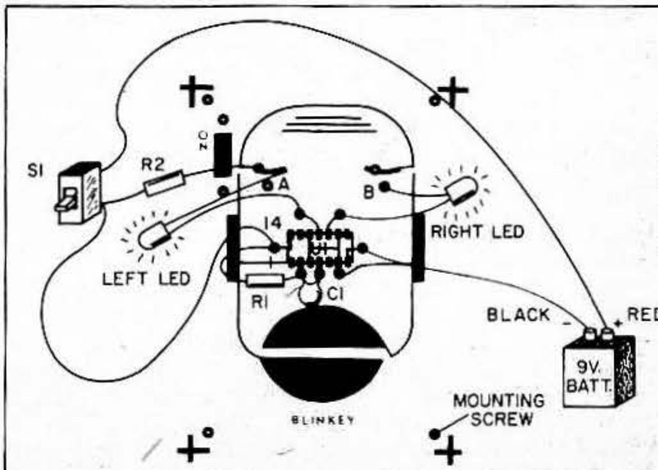
Blinkey

(Continued from page 52)

ohms can be used.

How to Make Him Blink. Place S1 to the ON position. Press your finger(s) across the two semicircular portions of the "mouth" (or place one finger on each hand on each of the two "ears"). You will note that the LEDs blink at same rate By applying less pressure, the LEDs will blink at a slower rate. By pressing harder, the LEDs blink faster until (if you skin resistance is low enough) the two LEDs appear to be on continuously.

Factors such as dryness of the skin effect the skin resistance and, therefore, the blinking rate that can be achieved by an individual. It is interesting to note the rates that can be achieved by different people. Considering this, the basic circuit could be changed slightly to create a "strength" tester similar to those seen in Penny Arcades. All



This is the only tricky part of Blinky. Follow the directions in the text carefully, and you will not have a single bit of trouble.

that is needed is to replace the Touch Plates with a "strength tester." This can be a short (6-inch or so) length of 1-inch dowel. Glue a ⅛-inch strip of aluminum foil down the length of the dowel. Glue an identical strips to the Touch Plate of the circuit and you have your strength tester. Although no true indicatio.., this is very enterta...

One-Tube Receiver
(Continued from page 43)

inch protruding from the pin. Pull that same end back out of the form so you can scrape ½-inch of insulation off, and re-insert it into pin 2, Still don't solder, but just fold that extra wire over the edge of the pin, to keep the coil from unwinding. Repeat this process for the remaining coils and pins, soldering in pins three and one, and folding two more wires over the edge of pin two. Evenutally, you will have three bare wires sitcking out of pin two. That's when you can solder them all in place, at once. Finally, add a bit of coil dope to the whole thing to keep it from loosening up and unwinding (clear nail polish works well). Plug the coil into place, and the tube, too, while you're at it.

For those of you who are using a substitute coil form, just run the ends of the windings out of one end of the coil, and secure the coil to the base using L brackets or spacers.

Operation. Check the wiring against the schematic for errors. If all looks okay, attach only the filament battery. If you can see it, the tube's filament will glow orange red. If not, re-check the wiring. Don't connect the B battery if there's any chance that 90 volts will wind up across the filament–some of these battery tubes like the 99 are very fragile in this respect. Assuming all looks well, connect earphones, an antenna, and a ground. Finally, connect the B battery; doing this should cause a decided click in the earphones.

Turn the regeneration control (R2) clockwise until you hear a pop or click in the phones, and beyond that point will be a soft hissing or squealing. That means the set is oscillating. Back off on the regeneration control until the set pops back out of oscillation, and tune around until you hear a station. Alternately adjust C1 (for loudest volume) and R2 (for most regeneration without allowing oscillation). This is where a steady hand helps. If, for some reason, you can hear stations, but can't seem to get any regeneration, by turning R2 back and forth. If the signals are *loudest* when R2 is counter-clockwise, you may have accidentally reversed the leads to L3, producing negative feedback, instead of positive. Try switching the leads.

Now is the time to see if your coil covers the broadcast band properly. Using a calibrated AM receiver set to the high end (1.6 MHz) of the band, make your regenerative radio oscillate, and tune C1 until its plates are mostly open; at some point you should hear a hiss or a whistle in the calibrated receiver as it is held nearby. Do the same for the low end (.55 MHz or so). The dials should roughly match, and if they don't, you will have to add or subtract wire from L2. Removing wire will shift your radio's range to higher frequencies, and adding wire will shift it downwards.

If you find that stations are too loud (which might be the case if you live nearby several transmitters) you can reduce the overload on the RF amp. by inserting a small (10-75 pF) capacitor in series with the antenna lead, at the receiver. Choose a value that cuts out enough signal: the larger the capacitor, the more signal gets through.

Finally. Always be super-careful when installing antennas. Stay away from power lines and avoid high dives off ladders or out of windows. B batteries can give you a small sting, but 90 volts probably couldn't injure you if you're in good shape. However, that sting could surprise you enough to make you drop your prized audion to the floor.

Warnings aside, this project has many open ends that beg for experimentation: filament current might be varied with a low value (10-20 ohms) rheostat to provide volume control. The antenna coupling could be varied with a 150 pF variable capacitor in series with the antenna lead. Many different triodes are usable, or even tetrodes (double grid tubes) can be used. The coil may be re-wound for other bands, although the value of C1 might have to be lowered. Regeneration can be accomplished by varying C3 and eliminating R2, or even by physically rotating L3 with respect to L2. Try considering what negative feedback does to any amplifier.

A good book to help the experimenter is the ARRL's *The Radio Amateur's Handbook*, which has tips on safety, construction, theory, and it even has a complete index of tube types and pin diagrams for all your junk box tubes. Even if you are somewhat of an advanced hobbyist, you can still delight in an antique technology as you listen to the radio by the glow of your venerable vacuum tube. ■

Darkroom Contrast Meter
(Continued from page 71)

their appropriate PC board "holes." Then connect the wires from R1, T1, and finally, connect to PC1.

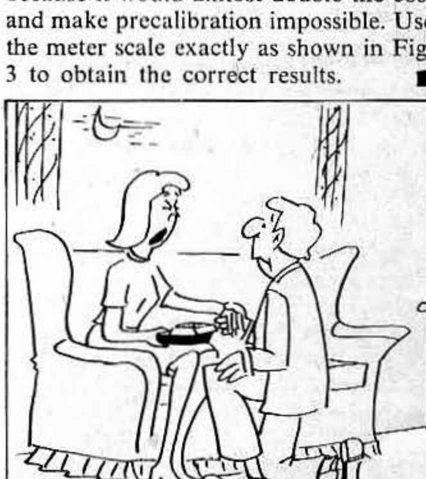
Apply power then measure the voltage from IC's "+" and "–" terminals to T1's centertap connection. You should indicate ±15 to ±17 volts. If you get any other value, turn off the power immediately and check for a wiring error, or improper installation of either IC1 or IC2.

Using The Meter. Compose the projection from your enlarger and focus it on the easel. Leave the lens' diaphragm open and place the meter's pickup under the maximum light area (representing pure *black* in the final print). Adjust R1 until the meter pointer is over the letter "C" at the end of the scale. Without disturbing any of the enlarger or meter controls, move the pickup to a spot under the minimum light area (representing pure "white"–or maximum highlight–in the print). Give the meter a few seconds to settle down, then read the required paper contrast grade directly from the meter scale.

Since the meter indicates projected contrast range, it doesn't matter whether your enlarger is the diffusion, condenser, or mixing-chamber type. The contrast reading will be correct *at the easel of the enlarger*.

Since developing techniques vary, as does personal preference, you might want to apply your own "fudge factor" to the meter readings. For example, you might give a ½-grade increase on all readings.

Note. Do not attempt to linearize the meter scale in Fig. 1, as contrast densities aren't linear. Also, the use of a log amplifier required to linearize the scale has been avoiding in this project because it would almost double the cost and make precalibration impossible. Use the meter scale exactly as shown in Fig. 3 to obtain the correct results. ■



"I don't care if it is already on this cassette tape . . . I want to hear you say it!"

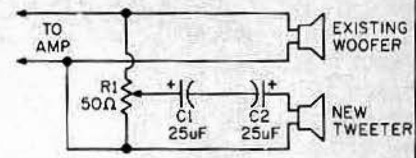
Add-A-Tweeter

☐ Any single-voice coil speaker is hard pressed to handle both low and high frequencies simultaneously—and it's the highs that suffer most. A much cleaner sound can usually be obtained from speakers 6 inches or larger if the highs are pumped through a tweeter. It can be any small speaker rated 4 to 6 ohms of approximately 2 to 3 inches in diameter.

The back-to-back capacitors, C1 and C2, permit only the highs from about 1500 Hz up to pass into the tweeter. By keeping the lows out of the tweeter, the highs come out cleaner, and there's no chance of the greater low frequency power "blowing" the tweeter. Potentiometer R1 is used to match the tweeter's output level to that of the woofer—because small speakers are generally much more efficient than large speakers. If you eliminate R1, the highs will literally scream in your ears. ■

PARTS LIST FOR ADD-A-TWEETER

C1, C2—22-uF electrolytic capacitor, 50 VDC
R1—50-ohm wirebound potentiometer, 1 or 2 watts.



Misc.—Cone type tweeters are suitable for use with this circuit.

Sitrat

(Continued from page 24)

corresponds to 0 ma on your meter. When your SITRAT is complete, you will have labeled the 1.0 ma mark on the meter's dial with the maximum temperature and the 0 ma point with the minimum temperature.

Next, draw a vertical line directly up from the temperature axis at the 110° mark. This line is labeled (c) on the chart. Determine the point on the curve this line meets, then draw a horizontal line (labeled d) to the current axis and make a note of the current reading. The author marked this point as .82 ma at 110°F. He did the same for the following temperatures; 100, 90, 80, 70, 60, 50, 40, 30, 20, 10, 0, −10, −20, −30 and the minimum temperature (−50). All the information is given in Table 3. The reader should construct a table similar to Table 3. However, the exact numbers will differ (except for the 120°F, .9 ma point) from Table 3. This is due to the fact that no two transistors (even two 2N5129) have exactly the same characteristics.

Alternative Method. If graphs and curves aren't your bag, you can still build SITRAT. All you have to do is take measurements at *exactly* 10 degree intervals. While this isn't easy, it can be done. Your table should be similar to Table 3, although it probably won't go much below 10°F because of the difficulty of easily obtaining temperatures below this value.

Drawing The Meter's Dial. After you construct the final table (which should be similar to the author's Table 3), the final step is to label the meter's dial plate. Remove the meter's clear faceplate. For meter's with plastic faceplates, this is done by gently prying it off with your fingers. Better meters have two small screws holding it in place. Use a pencil eraser and remove the *'D.C. MILLIAMPERES'* label as well as all numbers.

TABLE 3

Temperature (°F)	Current (milliamperes)
130°F (Max.)	1.0 ma
120	.9
110	.82
100	.74
90	.67
80	.60
70	.54
60	.475
50	.42
40	.365
32	.32
30	.31
20	.265
10	.22
0	.18
−10	.145
−20	.11
−30	.07
−50 (Min.)	.00

NOTE: Table 3 was derived by the author from measurements taken with his prototype of SITRAT. Your Table will be similar, although it will differ in actual readings as well as the minimum and maximum temperature.

Applications. This thermometer has many applications. Remote-reading outdoor thermometer and freezer thermometer are just a few of the possibilities. To catch lots of fish, find the species water temperature. Drop the probe to the water dept[illegible] that temperature. Then, [illegible] your fishing line [illegible] author [illegible]

than 15 feet, the reader should experience no problem with very long cables.

Final Comments. Your SITRAT is unique. No one has another one exactly like it. The reason for this should be obvious now. The transistor you used is one of a kind. The higher the transistor gain, the less sensitive your SITRAT will be. However, this isn't necessarily bad. The less sensitive your SITRAT the greater the range of temperatures it will measure.

Your SITRAT's accuracy depends upon how carefully you labelled the meter's dial plate. The quality of panel meter you use is also a factor. SITRAT's accuracy is diminished at bitter cold temperatures; below about −20°F.

While SITRAT is about as cheap an electronic thermometer it is possible to build, you actually substitute your time for dollars. There is no such a thing as a free lunch. However, most of the time used in completing SITRAT is fun time. You will soon dream up applications that the author has never even thought of. ■

"You know, by the time you finish this thing, they probably won't make the tubes for it anymore."

Superbass

(Continued from page 34)

cork or rubber will retain the battery. You can use small cork "feet" such as sold in hardware stores for use on the bottom of bric-a-brac to prevent scratching of furniture. The cost is usually well under fifty cents and you can cut the "feet" to the needed size.

Take extra care to get S2's wiring right the first time. Note that S2 is SPDT, switching only the output connection. The input is permanently connected to the amplifier and switch S2.

Nothing about the entire project is really critical other than the values of C2 and C3. Resistors need be no better than 10% tolerance–why spend money for better tolerance when the project won't work any better?–and electrolytic capacitors C1 and C4 can be any value from 2.2-uF to 4.7-uF. Use whatever you can get at lowest cost. The same "lowest cost" rule applies to C2 and C3; they don't have to be precision tolerance as long as their rated value is 0.1-uF.

Using Superbass. Connect your electric guitar or other electronic instrument to input jack J1; connect output jack J2 to your instrument amplifier's normally-used input. With power switch S1 *off*, key S2 so the instrument feeds directly to the instrument amplifier. With R2 set full counter-clockwise (Off), turn power switch S1 on, key S2 once, and advance R2 for the desired superbass sound level. To cut back to natural sound just stomp down on S2 and key the superbass out.

Don't worry about leaving power switch S1 on for the several hours of a gig. The circuit pulls less than 1-mA from the battery, so the battery will last many, many months. ■

Energy Sentry

(Continued from page 18)

components are polarized and the circuit will not work if any of these are placed incorrectely on the board.

Before inserting U1 into its socket, apply power to the circuit and measure the DC voltage across C2 to ensure that the circuit is operating properly. Once this is done, disconnect line power before inserting U1. Be sure the IC is plugged in facing the correct direction. Pin 1 of the IC is indicated by a small dot on the foil layout.

Test And Calibration. For best accuracy, the circuit should be calibrated somewhere near the middle of its range. A set of six 100 watt incandescent lamps, connected in parallel, will provide an excellent 600 watt load to calibrate the unit.

Before the calibration can be performed, determine the actual cost of electricity in your area. The easiest and best way to do this is to obtain a recent electric bill which shows the number of kilowatt hours of electricity used, and the total cost during one billing period. Divide the electrical cost by the number of kilowatt hours. The resulting quotient will be the average cost of one kilowatt hour of electricity.

Once you have determined the cost per KWH, multiply this by the wattage of your test load. In this case it would be 8¢ times .6 KW (600 watts) for six 100 watt lamps connected in parallel. Thus, in our example:

8¢ per KWH $\times$ 0.6 KW = 4.8¢ per hour.

4.8¢ can be rounded off to 5¢ strictly for calibration purposes.

Connect the test load to the receptacle on Energy Sentry. Plug the line cord into a 115 volt receptacle and adjust R3 so that LED #5 (5¢) is illuminated. This completes calibration of your cost saving Energy Sentry.

Use of the Instrument. You may use Energy Sentry on any 115 volt appliance in your home. Although this unit will generally be accurate to within 1¢ per hour, it does not take into account the power factor of the load. In the case of appliances which generate heat, such as toasters, irons, and coffee makers, the power factor of these units is 1 and no correction factor is necessary. Other appliances which use inductive components, such as motors, have power factors of possibly 0.8 or 0.9. In this case Energy Sentry will indicate a cost per hour greater than true cost. A correction can be obtained by multiplying the indicated cost per hour by the power factor of the appliance or load being tested.

Note. Be sure to insulate the transformer case of T2 from the metal case. If not, an AC leakage current to the case will make the case hot, creating a shock hazard. ■

Combo Amp

(Continued from page 8)

Bend the groups of four leads so they correspond to the pin spacing of the socket. Plug U1 into the socket.

Install all the cabinet components, then place the completed PC assembly on the terminals of M1. Locate the position for LED1 on the cabinet directly under the PC board terminal holes and mark the cabinet.

If you want the LED at some other location make the change now, but keep in mind you must connect wires to the LED if its position is relocated.

Remove the PC board and the meter, drill the hole for LED1, replace the meter and the PC board and solder the meter's terminals to the foil pads. Then install LED 1.

The PC board has some give so you can work the wires into the PC board; push the LED against the panel and solder its leads to the PC foils.

Switch Both Leads. The positive and negative battery leads must be switched: S1 must be DPST. Twist the red wire from one battery connector with the black wire of another connector. This is the *common* or *ground* connection and is soldered to the PC board's ground foil. The remaining wires connect to switch S1.

Doublecheck the polarity; if it's reversed U1 gets instantly zapped.

The meter indicates one-half the output voltage. (We provide the information to avoid possible damage through unnecessary experimentation.)

Connect your mike to J1 and the line from your recorder to J2. Speak to the mike and advance level control R1 so meter M1 peaks at any convenient reference value: 0.8 is recommended. Adjust your recorder's control level so the 0-VU or 0-dB record level occurs when the Combo-Amp's meter peaks at the 0.8 reference value.

If you're using the device for a P.A. system, adjust the P.A. gain so the desired volume occurs when the meter indicates 0.8.

As long as the meter peaks at 0.8 you know the recorder or P.A. is getting the correct level. If the meter value rises above or below 0.8 simply adjust R1 for the optimum 0.8 value.

If you want to paint over the meter scale to show a 0-VU reference do so. The only reason we did not use a meter with a VU scale is that they are very expensive and difficult to obtain. Also a VU meter's internal diodes would have to be removed to work in this circuit, a somewhat difficult task. ■

Aircraft Scanner

(Continued from page 12)

the upper setting of the tuning dial. Ideally, you will adjust the oscillator coil so that the highest frequency FM station (near 108 MHz) will now be heard at the lowest dial setting (marked 88 MHz).

If the turns of the oscillator coil are fully spread and yet the tuning range is still not high enough to cover the aircraft band, carefully solder two adjacent turns together at one point. It is a good idea to scrape the wire at that point before soldering. Use a sharp blade or sandpaper cautiously.

Another way to increase the tuning frequency of the receiver slightly is to decrease the trimmer capacitance on the tuning capacitor (see Fig. 3). The four small adjustments are the oscillator and RF trimmers for the AM and FM band. Be sure to select the trimmers next to the FM coils! It would be wise to mark the original settings of all trimmers with a felt tip pen in case the wrong trimmers are turned.

A tiny screwdriver will be used to adjust the trimmer capacitors. Note as you turn the trimmer that there will be one setting where the two metallic surfaces of the trimmer will be fully visible. This is the minimum capacitance (highest frequency) setting.

Fine Tuning. Now for the final adjustment! Tune in a weak station near the low frequency (88MHz) portion of the dial and adjust the turns of the RF coil with a non-metallic tool for maximum signal strength. If your particular receiver has sufficient background hiss, you may use that sound for peaking the coil. Tune the receiver dial near its upper setting (108MHz) and peak the RF trimmer capacitor for maximum background hiss.

By carefully repeating the last two steps (RF coil and RF trimmer capacitor), you will have completed the conversion of your AM/FM receiver into a useful aircraft band monitor. If you live near large airports, the radio will be extremely active. Even if you don't live near an airport, reception over long distances will be heard because of the altitude of the aircraft.

While the radio may not be as good as a receiver designed specifically for the aircraft band, it will give a good accounting of itself. And if you grow tired of aircraft band monitoring, you can always return the radio to its original state as an AM/FM set. ■

Calculator Power

(Continued from page 16)

teen hundredths of an ampere (150-mA), which will be adequate for most calculators. Try to get a transformer that has a higher current rating (in this case 200mA or greater) and at least three volts higher than the regulated output voltage.

One can apply this data to other power supply designs as well. It is very important to pick a transformer that has a current rating beyond what is necessary to supply a particular circuit. It is good practice to use a transformer with a current rating ten percent higher.

The block diagram shows in simple form how the inexpensive power supply works. As they say, a picture is worth a thousand words! The schematic shows how the circuit works in detail.

The pass regulator is an NPN transistor with a high current rating. This component should be able to easily handle the output current. The transistor should have a heat sink.

The 741 operational amplifier (U1), acting as the error detector/amp, has its negative input (pin 2) coming from the emitter of the transistor through a 10,000 ohm resistor. Its positive input (pin 3) comes from the reference voltage; either a 9 volt reference (via Jumper 1) or a 3 volt reference via a 43,000 ohm dropping resistor. The reference voltage originates across the zener diode.

Now, the output voltage regulation, or swing, for a variable load is approximately 10%. This is good enough for most calculators.

Construction. The printed circuit board layout is not included in this article because of design changes and other variations. It is a good project to practice printed circuit board designing, and to get the feel of fabricating PC boards. The prototype was designed so that the board could be piggybacked onto the adaptor's case. Thus, mounting schemes will dictate your PC board layout and design.

The board was mounted using 4-40 machine screws. These screws were placed through four holes that were drilled in the adaptor's plastic case and through the PC board.

The transformer was left inside the plastic case and the secondary wires were sent to the externally mounted PC board. In this way, the 120 VAC is isolated inside the plastic case and thus there is no chance of getting a shock. The rest of the construction is left up to the hobbyist. ■

Light Beam

(Continued from page 39)

5. With the device and mirror aligned as above, carefully adjust the position of the receiver enclosure so that the focused received beam is centralized (bore sighted) inside the tube. This is best accomplished by placing a thin strip of paper through the adjust hole over the phototransistor and adjusting the dowel to the focal length of the lens. This should place the focused received light directly on the lens of the phototransistor. Further touch up can be done by careful positioning of the phototransistor with needle nose pliers. Secure dowel, enclosures, etc., to eliminate movement and improper alignment.

6. Repeat with the other unit. You should now be able to hand-sight units along sight lines for medium range use. Good, reliable long range use should be done with a camera tripod. Nighttime use, with the visible red transmitting diodes is easily accomplished at ranges up to 1,000 meters or so by noting the reflection of the transmitting light in the receiving lens as noted at the transmitter station. Day-time operation is best with filter and IR transmitter. Securing of optical components via permanent means should only be done when optimum optical alignment can be assured.

Operation. For both transmitter and receiver to be in the OFF mode. S2 must be at R position and R7 to the OFF mode.

To use receiver only, plug in headsets to J2 jack and turn on R7 and adjust to desired level (usually no more than ⅛ turn). Point unit at a normal 60Hz lamp, TV or other light source and note hum.

To use in transmit mode, all that is necessary is to place S2 from the R to the T mode. The modulation level is preset by R7 when used in the receiver mode.

One way to test is to look into the transmitter section and note the LED flickering with audio signals. R7 can then be readjusted if necessary by this indication. Note that the LED only has to change ever so slightly for sufficient modulation.

You will see there is a trimpot R15 on PC board. This adjusts the quiescent current through this LED and should be set just where the LED is emitting with no audio signal. This saves batteries and prevents downward modulation. This probably should be reset as batteries weaken. Also, note that the units pick up 60Hz hum from power lines and normal lighting. The visible red LED (supplied in these units) obviously operates best in darkness. For normal daylight operating, the infra-red LED and filter must be used.

In general, reception is possible as long as the transmitter output light can he seen by the naked eye.

Applications. Aside from the line of sight communications possibilities, this communicator is extremely useful for surveillance applications. Install one of the communicators in a location that is vulnerable to trespass by intruders. You can buy an inexpensive sound activated alarm, with its microphone taped to an earphone. The alarm will be activated whenever there is noise.

Another appliation is Morse code practice. Two people up to a mile apart, with a pair of practice code oscillators, can use the Light Beam Communicator to sharpen their code skills. ■

Oil Pressure

(Continued from page 57)

have a machine shop thread an extender pipe to that car's metric specs. Stop the oil leaks before they occur by using a pipe cement or plumber's teflon tape when assembling the fittings. Exercise caution when tightening this fragile piping, especially when tightening it in the motor block. It is frustrating work to remove a sheared piece from the motor block hole.

Conclusion. There you have it, a relatively easy (as promised) method of keeping watch on one of your car's most important systems. Combined with the digital voltmeter and temperature gauge, and those gauges coming up in later issues, this represents one of the most important weapons you can have in your arsenal in the fight against the ever-rising costs of automotive maintenance and repair. In addition, you will possess a set of instruments of fargre¼ter accur¼cy than those analog devices commonly available for aftermarket installation. This is one instance in which you could not possibly buy anything better than what you can put together on your workbench in a few hour's time. ■

Sloping Dipoles

(Continued from page 78)

with the clips disconnected. Since it was easy to raise the antenna up and down with the halyard, there was no great problem in changing over the antenna between 10 and 20-meter operations.

Conclusion. In summary, the sloper antenna advantages are very low cost and good performance. It is easy to erect, and requires only a single high-point support. The other end of the antenna is near ground-level, making it easy for trimming and tuning to some specific frequency or band. It performs well as a receiving antenna.

There is some directivity even though it does well as an omni-directional antenna system. Good DN performance may largely be the result of low angles of radiation, but for whatever reason, it does the job. ■

Binary/BCD Tester

(Continued from page 64)

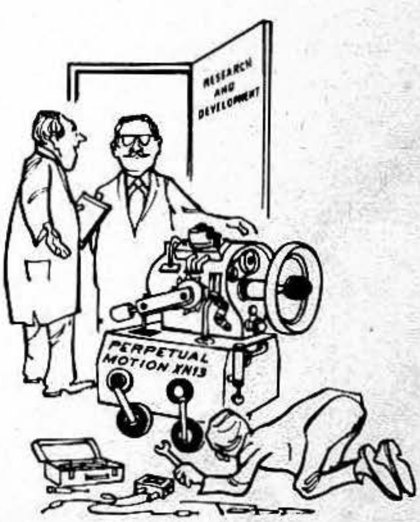
three 74LS47's which convert the BCD to seven segment LED display format. The outputs of the 74LS47's are connected to common anode seven segment LED displays through resistors. The values of the resistors depend on the size of the LED displays, the brightness of the displays that you desire, and the amount of current that you are willing to expend on the displays. Normally the resistors should be between 330 ohms and 470 ohms.

The 74LS47's are programmed to provide leading zero suppression.

Construction. The IC's and resistors can be mounted on any type of board you prefer (PC, wirewraping, etc.).

Connect a long wire (about one foot) to the common V+ on the board, and an equally long wire to the common ground. Solder a red insulated clip (such as Radio Shack catolog number 270-1545) to the other end of the wire to V+, and a black alligator clip to the other end of the wire to ground. These will be your power supply lines for the converter. Connect a 10µf across these two wires.

Connect a one foot long wire to each of the input pins on the two 74LS47's. These are pins 2,3,6 and 7. Solder an insulated clip (any color) to the other end of each of these wires. Label each of these wires near the clip with the notation from 2^0 through 2^7. Figure 1 shows which label goes on the wire to each 74LS75 pin (2^0 for pin 2 of 74LS75 #1, 2^1 for pin 3 of 74LS75 #1, and so on). ■



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At no increase in price, the "Edu-Kit" now includes Printed Circuitry. You build a Printed Circuit Signal Injector, a unique servicing instrument that can detect many Radio and TV troubles. This revolutionary new technique of radio construction is now becoming popular in commercial radio and TV sets.

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