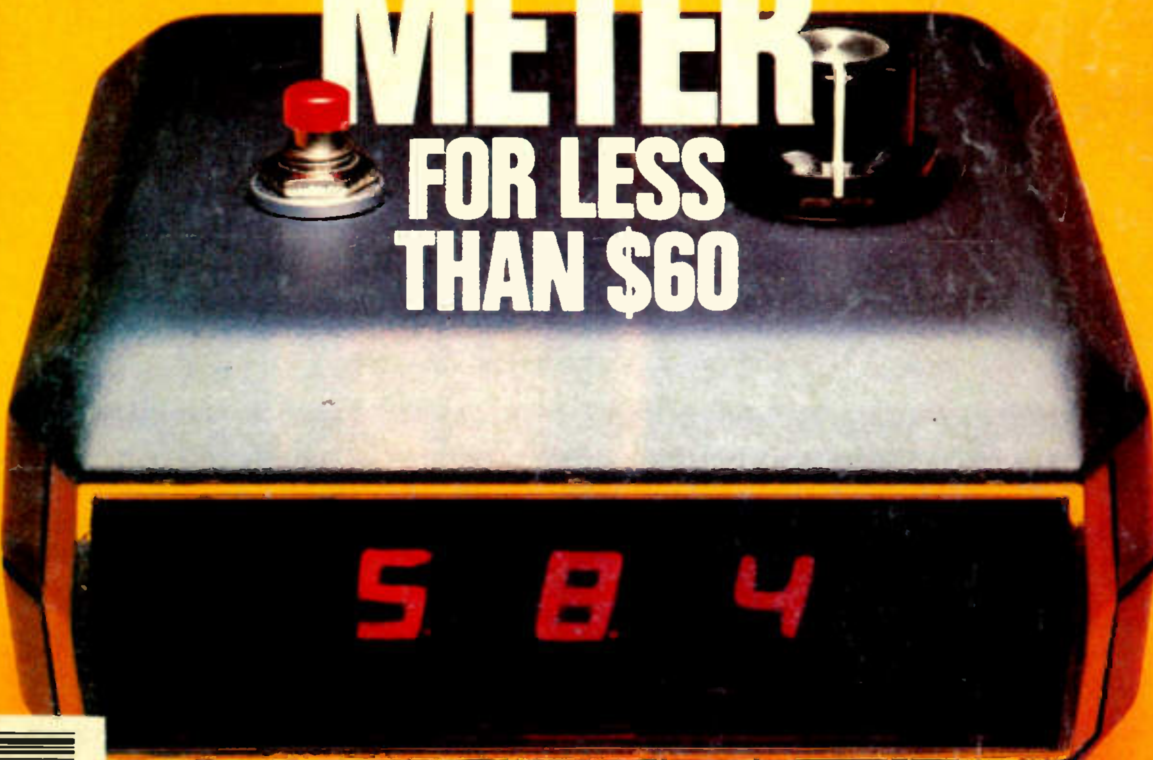
BUDGET Electronics

1982 EDITION $1.95
UK £1.25

BUILD THIS

DIGITAL CAPACITANCE METER



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BUDGET Electronics

Photo by Roy Schneider.

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1982 EDITION

REGULAR DEPARTMENTS

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NEW PRODUCTS PARADE

Saturn Photo

A full-color lithograph of Saturn, as photographed by Voyager 1, is now available in large, 34 x 22-in. size. This magnificent full-view of the ringed planet was beamed to Earth by Voyager 1 spacecraft from almost one billion miles. Reproduced, on high quality stock, vibrant tones of yellow, blue and orange set on a background of night black illustrate the intriguing qualities of one of the most beautiful and unique objects in the solar system. The Full Saturn Lithograph is available by mail from Edmund Scientific, 7082 Edscorp Building, No. 31,234 at $19.95 plus $1.75 packing and guaranteed delivery. For complete information on a full line of astronomy products and over 4,000 intriguing, science-related items, send for the free Edmund catalog at the address above.

CIRCLE 33 ON READER SERVICE COUPON

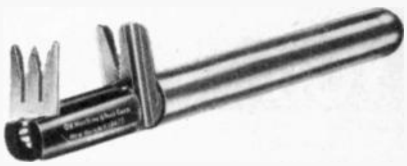
Cordless Digital Wall Clock

A new Cordless Digital Wall Clock, with the timing of accuracy of an expensive quartz watch, is now being introduced by Heath. The new GC-1720 clock features a quartz crystal and a single, complex integrated circuit to keep track of time with ±1 minute per year accuracy. Time is displayed in 12- or 24-hour formats (at builder's option) on an extra large LCD with 1-inch high digits. Priced at $49.95. Besides being accurate and cordless, the GC-1720 is said to feature a revolutionary housing that enables it to be hung almost anywhere and go with almost any decor. It will operate up to two years on one AA alkaline cell. For a free catalog with complete product descriptions for this new digital clock and all the other Heath electronic kits, write to Heath Company, 1480 Dundas Street East, Mississauga, Ontario, Canada L4X 2R7.

CIRCLE 1 ON READER SERVICE COUPON

Wire Wrapping Strip

The OK Machine and Tool ST-100 Wire Cut and Strip Tool uses a new concept for easy and clean stripping of wires for wire-wrapping, electronic and appliance applications. ST-100 strips without nicking and generates the proper strip length for wire-wrapping. Slim design makes it ideal for storing in pocket, belt holder or tool kit. Easy to operate—place wires (up to 4) in stripping slot with ends extended beyond cutter blades, press tool and pull. Wire is cut and stripped to proper wire-wrapping length. The stripping blade is easily replaceable. Available for wire sizes from 20 to 30 AWG (0, 8-0-25mm). Sells for $9.84. OK Machine and Tool Corp., 3455 Conner Street, Bronx, NY 10475.



CIRCLE 35 ON READER SERVICE COUPON

Dual 90 Degree Corner Clamps

The new dual 90 degree corner clamps by Panavise is made of sturdy, lightweight, cast aluminum. Featuring a full ¾-in. capacity, the dual 90 degree assures an accurate 90 degree angle every time whether the pieces

NEW PRODUCTS PARADE

(Continued from previous page)

are cut at 45 or 90 degrees. These handy little clamps have a myriad of uses and combined can be used in all manner of configurations. In fact, the more you use these new clamps, the more ways you will find to use them. They're just right for assembling aluminum frames for mounting or securing large printed circuit and other boards. A set of two sell for $19.95. For more information, contact your dealer or Panavise, 2850 29th Street, Long Beach, CA 90806.

Energy Management

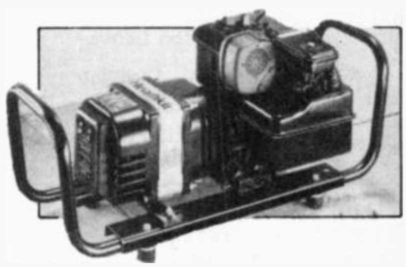
Regency Electronics has introduced a master control system that saves energy and makes life easier at home or in business. The unit simply plugs into a wall outlet and transmits command signals to remote control modules. A pressure sensitive touch pad plus a set of switches allows the user to control any light or appliance in the house from the comfort of their desk, bed, favorite chair, or wherever. A Regulator system can fully pay for itself in less than two years.

CIRCLE 36 ON READER SERVICE COUPON

More than half the energy used in a home is heating and cooling. In a non-electrically heated house, an average 41% of the electricity bill is traceable to electric water heating alone. The Regulator can save wasted energy by turning off the water heater during the night or when the house is unoccupied. The Regulator adds convenience to everyday life. Hot coffee can be ready in the morning. Lamps can be dimmed. TV's or lights left on accidentally at night can be turned off without getting out of bed. Stereos can turn on in the morning. Security is another feature of the Regulator system. While away from home, the Regulator can stand guard by turning lights on and off, even playing the stereo and TV. Weekend commands can be scheduled different from week day command to further confuse potential intruders. The Regulator master control is also available in two models, the 5700 and 1600, $299.95 and $149.95, respectively. While the 1600 lacks the weekend, weekday program cycles and memory retaining battery system of the 5700, it can execute 16 timed preset commands as compared to 57 timed commands for the 5700. For more details, write to Regency Electronics, Inc., 7707 Record St., Indianapolis, IN 46226.

5 Portable Horses

The Heathkit GU-1820 Portable Power System is a lightweight alternator that can produce up to 2200 watts of 120 VAC, 60 Hz power—enough to operate a ham station, an electronic chain saw or a refrigerator-freezer during a blackout. The GU-1820 is designed for ham radio clubs, home owners, civil defense, police and fire departments. It can also provide on-location power for construction and logging crews, campers, hunters, wood cutters



CIRCLE 1 ON READER SERVICE COUPON

and others. Mail order priced at $479.95 (FOB Benton Harbor, MI), the specs are: voltage is regulated to within ±5%, and frequency variation is limited to ±4 Hz, from no load to full load at 3600 revolutions per minute (rpm). Radio frequency interference is eliminated by a resistive spark plug. The 5-horsepower Briggs and Stratton gas engine can run up to 1¾ hours, at half load, on a tankful of gas, unleaded gas or gasohol. Noise is controlled by a low-tone muffler; to reduce sparking to a minimum, the optional GUA-1820-1 Spark-Arresting Muffler ($3.95 mail order; required in California) is available. For more information on the GU-1820 Portable Power System and a full line of over 400 useful electronic kits for home, hobby and car, write for a free catalog to Heath Company, Dept. 350-035, Benton Harbor, MI 49022. In Canada, write to Heath Company, 1480 Dudas Street East, Mississauga, Ontario L4X 2R7.

Descrambler

An advanced consumer voice descrambler by Grove Enterprises, the Code Breaker, contains not only an internal speaker, but a tunable notch filter as well. By simply plugging the Code Breaker into the external speaker jack of a scanner, the listener can restore normal speech to the vast majority of scrambled speech encountered by scanner listeners. Tone masking, frequently used to thwart reception by conventional competitive descramblers is easily eliminated

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by the tunable notch filter. When conventional communications are being monitored, the Code Breaker filter circuit may be used to reject interference from squeals, whines and iritating sound commonly plaguing the busy communications spectrum. The Code Breaker is optimized for voice frequencies, improving intelligibility when used with existing receivers. Only $59.95 plus $1.75 shipping and handling. From Grove Enterprises, Dept. P, Brasstown, NC 28902 or order toll-free calling 1-800/438-8155.

5 dB Gain Mobile Antenna

Avanti Communications has recently modified its 5 dB gain on-glass mobile antenna designed for use in two-way and amateur radio communications. The new ¾-meter 410-512 MHz (AP450.-5G) features a straight 30 inch whip with a small centered posi-

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tioned phasing coil. By popular request the former loop section has been eliminated and replaced by a small, sleek coil measuring only 1½ inches in length and a maximum diameter of ⅜-in. making it the smallest UHF 5 dB gain whip and phasing coil combination on the market. As with each of Avanti's on-glass communications antennas, the new antenna offers improved performance, requires no holes to be drilled, features shorter installation time, and requires no metal ground plane, thus allowing it to be used in many more applications than conventional mobile antennas. Sells for $38.95. For more information, contact Avanti Communications, 340 Stewart Avenue, Addison, IL 60101; or phone 312/628-9350.

Logic Designer

E & L Instruments new LD-1 Pencil Box Logic Designer includes major circuit design needs in a handy portable molded plastic case with integral

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hinged cover. Some of the features are a variable clock, two

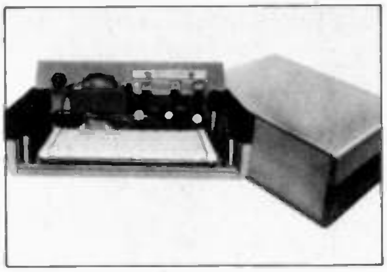
NEW PRODUCTS PARADE

(Continued from previous page)

pulsers, eight LED readouts, eight logic level switches and the E & L SK-10 solderless breadboarding socket. Power is supplied through the use of batteries or an optional AC supply. Available in kit or assembled form. LD-1 Kit, $75.00 (P/N 325-4301). LD-1/Assembled, $99.50 (P/N 325-1301). For more information, write to E & L Instruments, Inc., 61 First St., Derby, CT 06418; phone 203/735-8774.

Hobbyist's Idea Box

The Idea Box from Global combines 3 fully regulated, low-ripple, power supplies, a choice of a solderless breadboard, a pre-etched pre-drilled PCB, or a blank foil PCB; and the best of Global's cases with expanding capabilities. This combination of features allows quick construction of a prototype, or a one-shot device in a practical case which would be an attractive addition to any test or production environment. The Idea Box is priced from just $149.95. The circuit cards are available separately,



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and can be used singly or in any combination. Replacement front panels and printed circuit layout pads are also available. Prices for these accessories range from $4.95 to $44.95. For more information, contact Global Specialties via phone toll-free 1-800-243-6077, or write them at 70 Fulton Terrace, P.O. Box 1942, New Haven, CT 06509.

Catch-A-Pulse

The Triplett Model 205 "Catch-A-Pulse" hand-held logic probe (Model 205-K kit) provides an inexpensive means of analyzing and troubleshooting logic gates and sequential circuits such as flip-flops, counters, registers and microprocessors. Similar in size to a felt-tip marker pen, the 205 provides a visual (LED) display of Hi, Lo, pulsing or open circuit logic states, which are referred to on the probe's truth table. The "Catch-A-Pulse" logic probe au-

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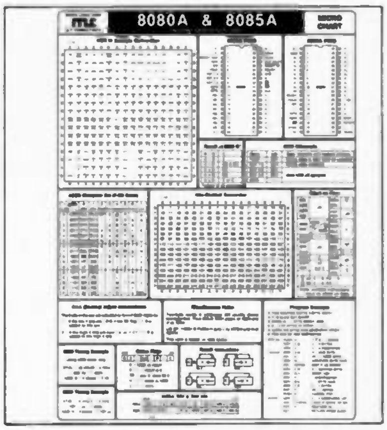
tomatically adjusts to the proper DTL, TTL, MOS, CMOS or microprocessor circuit thresholds when its leads are connected to the IC circuit power supply. Power supply reverse polarity protection is also provided. The input impedance of the probe's tip becomes a slave to the circuit under test, causing it to react to whatever signal or logic condition is present. The probe's memory automatically resets every 50 microseconds to observe and display another pulse. The Model 205 "Catch-A-Pulse" comes complete with one year warranty, detachable 6-foot coiled cord with mini-alligator clips, instruction manual and handy clear plastic carrying case for only $49.50. The Model 205-K kit sells for $59.00 and also includes a high voltage adapter Model 79-465 for 15- to 25-volt circuit applications, and Model 79-466 coiled cord with micro-hooks for direct IC pin attachment. For further information on this useful inexpensive probe and kit, contact Triplett Corporation, One Triplett Drive, Bluffton, OH 45817.

Reference Cards

Micro Chart is a 100 percent plastic 3-color instant microprocessor reference card for programmers, engineers, and students who want to save time and effort. Important hard-to-remember information is extracted from the manuals and displayed in a concise and clear format. Its durable credit card type plastic is 8½ by 11 inches in a one-



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sheet, two-sided, instant format. Much more: "6502 (65XX)" and also "8080A/8085A" are only $4.95 each plus $1.00 postage and handling per order. Write to Micro Logic Corp., Dept. POB 174, Hackensack, NJ 07602. ■

INPUT/OUTPUT

Our Input/Output editor, Hank Scott, will answer any reasonable question about electronic projects and products. Make your questions specific, and remember he is not running a circuit design service. Watch for your answers in print—Hank can't send personal replies. Write to:

Hank Scott
Input/Output Editor
BUDGET ELECTRONICS
380 Lexington Avenue
New York, NY 10017

Where to Buy

I purchased a Panasonic multiband receiver and overnight I became a SWLer. In my town there are no special outlets to assist me in my hobby. Do you know of any?

—A.N., Concord, NC

Even in the big burgs you will have trouble finding an outlet. A local Radio Shack may have some things you need. Check them out. I suggest you write Gilfer Shortwave, Dept. E-1, Box 239, Park Ridge, NJ 07656 and ask for their catalog. They're specialists to the shortwave hobby.

Tubes Never Die

Hank, no one advertises tubes for sale. I'm fixing some 20- and 30-year-old radios and TVs and can use a reliable supplier. Can you help?

—W.A., Albuquerque, NM

I checked around a bit and discovered three. They are:

Cornell
4217-W University
San Diego, CA 92105

McGee
1901 McGee Street
Kansas City, MO 64108

Steinmetz
7519-EE Maplewood
Hammond, IN 46324

When you write for information and prices, send a business sized envelope with postage attached to speed the return mail.

Ribbon Cables

Hank, I'm having trouble with ribbon cables, and their press-on fittings. I tested two brand new cables only to discover that both had at least one open circuit. And, would you believe, I once tested a cable that had six open leads. My question is, since cables must be checked, how can I do it quickly?

—F.N., Melbourne, Australia

If your cable terminates on a printed circuit board, take a double-sided copper-clad board, cut it to size, connect both foil surfaces together and to the common terminal of an ohmmeter. Use the other probe to check out each lead on the other connector (or connectors, if there are more). At each touch of the probe tip to the terminal connector point at each jack and/or plug on the cable, a short circuit, or zero ohm indication, should appear. Should the meter pointer not move indicating an open circuit either at that point or the corresponding point at the other end of the cable, you have an open circuit. Guess which end it is at, open the connector, replace if necessary, and resecure. Recheck your work to be sure you fixed the defective contact(s) and introduced none of your own. Be patient. Ribbon cable assembly testing should not be rushed.

Generation Gap

I purchased an old book that gives tips on constructing old time radios and receivers. The book, published in 1921, gives details on a spark-gap transmitter. I'm going to build one for the CB band. How can I be sure I don't exceed the power input requirement?

—W.E., San Antonio, TX

By not turning it on! Home brew CB band transmitters are taboo! Also, spark-gap transmitters are not suitable for communication because they are broadly tuned and very rich in harmonics. Forget the idea.

Dollar Saver

I find project building very expensive so I use IC sockets whenever I can, so I can strip projects with little loss by damaged parts. I think you should pass this tip on to your readers.

—R.E., Pinellas Park, FL

Good idea, but go a bit farther. Avoid soldering whenever possible. Use solderless breadboard when possible. Also, think about wire-wrapping parts together. There are lots of little gimmicks you can come up with to keep parts like new as you go from project to project. However, should you want to keep a project, think in terms of soldering it together for good mechanical and electrical connection.

Broke a Leg

Hank, how do you solder on a broken contact onto an integrated chip? I blew it on an expensive chip and don't want to go through the expense of buying a new one.

—A.N., Greenville, SC

How? Very carefully. In fact, more carefully than the technique you used to break the leg of the bug. I've tried on several occasions to do just that by using a very low-wattage narrow-tip soldering iron. My results on the "fixables" were 33⅓% successful. I saved one chip and heat destroyed two others. Several chips were beyond saving because not enough of the leg protruded from the insulating body of the chip. If you are salvaging chips from surplus circuit board assemblies as I was, take a tip from one of my readers. His idea for "one of a kind" and very expensive chips, was to cut the board using a table jigsaw all around the chip about ⅛-in. space between the chip and cut. Attach wire leads to the cutout with a low-wattage iron, then wirewrap these leads to a standoff insulator or header that is sized to insert into an IC socket. My big fingers found the job very difficult, but it worked. There must be better ways to do it, so please write and advise me. Finally, no matter if the chip is new or old, cheap or costly, always use care when inserting an IC into a socket. I use a magnifying glass to check that all the legs on the chip are seated in the IC socket before I press down. Also, an IC insertion tool (and IC puller) are invaluable during the hand operations.

Solar Dollars

I truly want to use solar power electricity, but find the initial cost is so very high. I don't see how I can justify an installation of any type.

—H.O., Island Harbor Beach, FL

I agree to a limited degree. Solar power electricity from solar cells requires a large investment to avoid paying all or part of your electric bill. However, there is no reason why you cannot solar power your transistor radio for beach use. Dry cell power is expensive, and solar cells can compete successfully. There must be other ideas you can think of. One reader told me he uses solar cells to trickle-charge his car battery when he leaves his car behind for weeks during business trips. Think, there must be many good ideas we never touched on.

CB Over There

Great Britain has CB. Can I use my rig when I vacation there this fall?

—D.A., Medcensta, TX

I'm not sure, but a safe answer is, "No!" First, you will need a license to operate in the United Kingdom. Second,

INPUT/OUTPUT

(Continued from previous page)

your rig may not meet the frequency, power, etc., requirements. Play it safe and leave your rig home. Now, if you were a ham, something could be worked out. I suggest you write to the ARRL.

Lamp Lighter

Hank, I've gone into business repairing household lamps. Don't laugh! It's a nice part time business and with the profits I bought a new (small) car in two years. My full time occupation is student, and I'm only eighteen years old. Tell your readers what I'm doing so they can get involved also and pick up extra dollars.

—I.B., Brooklyn, NY

Good for you. In fact, many simple appliances can be repaired at home for profit. A small part time business helps support your hobby needs, and improves your lifestyle.

TVX

Don't you think some computer magazine should come up with a conversion plan to modify an old TV set into a video monitor? Also, keyboards are available, why not make it a dumb terminal?

—J.A., Birmingham, MI

Old TV sets are usually "baked" near to death after several years of average home use. Any and most parts are ready to give up the ghost, so give up the idea!

Water, Water, Everywhere

A word of advice to your readers, Hank, should they etch their own printed circuit boards, do not pour the etchant down the drain without flushing the drain with fresh water. It'll save a hundred dollar sink drain job. I know!

—W.E., Charlotte, NC

Better still, since the etchant is usually only several ounces of fluid, soak it up in some sawdust, bag it, and throw it into the trash collection. It's easier on the drain pipes, your sewer system and conserves water. Water is a resource we must begin to conserve. Besides, it costs money!

Current vs Voltage

What is the difference between a transistor and a FET?

—W.N., Mechanicsville, GA

Actually both are transistors where current flows between the collector and emitter which is influenced, or controlled, by an input signal. The transistor, or more accurately the bipolar transistor, controls collector-emitter current flow by a much smaller current flowing between the base and emitter. The Unipolar, or field effect, transistor is controlled by a voltage input at the gate terminal, which is analogous to the base terminal. In the FET, the drain and source terminals are analogous to the collector and emitter terminals. This is an over simplification of the differences, but considering you did not know the differences, you know enough now to investigate transistors and FETs further.

Panic Hood

Hank, when I had my car's burglar alarm system installed, the installer refused to put in a panic button that would turn on the alarm from inside the car. He said the local ordinances prevent him from doing it. Big deal, I could do it, but why such crazy laws, when a life may be at stake?

—D.F., Beckley, WV

Simple, too many people would play police should they be able to control the alarm system from inside the car. In my car, I turn off the alarm after entering the car. I then turn it on again, when I'm parked in an area I feel uncomfortable in. Should anyone approach the car before I can drive away, I simply pull the hood release and the siren sounds. The car is still driveable, and away I go. Should a cop stop me before I have a chance to turn the system off, I'll pay the ticket. However, the chances are he'll let me go after an explanation.

Drip, Drip, Drip . . .

Hank, my CB electric up-down car antenna drips water into my trunk area. What should I do?

—S.H., Watertown, NY

Check the installation. Some units have a drainage fitting which connects via a ¼-in. rubber tubing through the bottom of the trunk area. Be careful where you drill the drain hole for the rubber tubing —the gasoline tank is near by! Do not grease the antenna section(s) that rise up above the rear deck of the car because you may ruin the antenna's conductivity characteristics. I saw one installation where an owner added a soft rubber washer to the top button on the antenna causing a better seal. Also, check the mounting itself. Water may be seeping in between the car surface and the antenna mounting.

Great Idea

Hank, I installed a back-up battery system to power my back-up burglar alarm in my car. I used a small chargeable motorcycle type battery which charges off the car's alternator. A 10-ampere diode permits the back-up battery to charge, but it cannot be discharged into the car's normal wiring system. Sounds crazy? No way, Hank, because the crooks in my neighborhood have a new technique. They poke a sharp slender rod or pike through the gaps in the grille work, through a sheetmetal partition into the car battery. The acid from the punctured cell(s) drains out killing the battery and the burglar alarm system. To date, I lost two batteries, and gained the admiration of my neighbors. My dumb insurance company now wants to put a deductible on my car insurance policy so that I pay for the battery. Save car insurance companies thousands of dollars and they'll find a way to make you add more to their pot!

—P.I., Syracuse, NY

You're quite clever, and I like your idea. It can be used in the home also. All systems should have a back up for power, or even a second complete system.

Pick the Best and Both

Should I use an open wire circuit or closed wire circuit for my home alarm system?

—T.L., Augusta, GA

Mix it up! For example, window foils work on a closed wire circuit. Break the glass and the foil is broken causing the alarm to go off! I prefer window foil the best because it warns the intruder that he is in for trouble. Thieves always look for an easier mark elsewhere. Now, run three-wire cable to all windows and doors. The third wire should be an open wire circuit which, if shorted, will set the alarm off immediately! Thus, should a maintenance person, salesman, or any apparently legitimate visitor to your house short the wires out during the moment you are distracted, he will set the alarm off, and his game is up. As a bonus, the fire or heat detectors can be connected to the open wire circuit giving the dwellers an early warning to an impeding disaster. What about all those fancy "radar" and sonic no-wire system. They're good, too! However, I'd prefer a mix of two systems or more for both inside the dwelling and the surrounding grounds. Make it difficult for the intruder to get in, and have a back-up system should one fail.

Cony Locked

I hear talk about SDS—Special Delivery Software. It seems that SDS disks can't be copied. That's great for the software people, but what about the computer user who needs back-up disks?

—A. F., Oakland, CA

It sounds like a good idea for protecting copyrights and the like to me. However, the software supplier should have some very inexpensive, or free plan, to replace damaged disks. After all, most DOS users make back-up disks, and save the master disk. The idea of copy-locked disks is new. Wait awhile—I'm sure the industry will work it out.

Dolby FM

I haven't heard much talk about Dolby FM in the press lately. Is it dead?

—H.G., Redondo Beach, CA

It's not dead, but not too well either. There are just over 100 Dolby FM sta-

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Portable Radios	Electronic Fire & Burglar Alarm Systems
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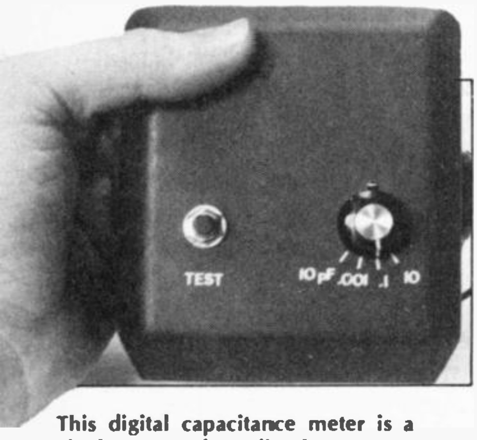
Bargain meter lets you measure those mystery Caps

By Philip M. VanPraag



This digital capacitance meter is a cinch to use; just clip the leads to the capacitor, select the right range and push the TEST button.

With the proliferation of increasingly sophisticated test equipment, it's quite easy to lose sight of one's *real* test needs. An excellent case-in-point is the digital capacitance meter. Many commercially available designs provide for auto-ranging, auto-null, and have eliminated the "push-to-test" requirement. Furthermore, they frequently boast of accuracies up to .1%! These features might be great for professional laboratory or manufacturing requirements. But, really now, when was the last time you needed to verify a capacitance value to .1%?

Enter our Digital Capacitance Meter (DCM). It does *not* have auto-ranging, nor auto-null, nor auto-test, and does *not* approach .1% accuracy, but *does* provide a reliable, easy-to-use, accurate DCM which can be constructed for only about $55 and a couple of evenings' work. It has been deliberately designed with an absolute minimum number of readily available parts, and requires no special calibration or construction skills.

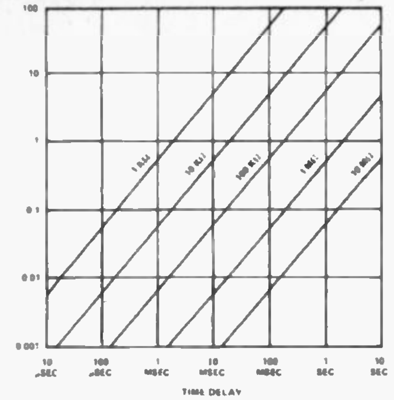
A quick glance at the parts list will reveal that, without exception, all parts are of the "common, garden variety," available from a multitude of sources. For convenience, a printed circuit board set or complete kit of parts is available (see the parts list). A completely wired and tested unit is also available, but construction is straightforward and should be considered for even the "neophyte" project builder. The only tools required for the kit version are a fine-tipped 25-watt soldering iron, small diameter solder (.031 inch), wire cutter/stripper, small screwdriver and long-nosed pliers.

DCM Design. For clarity, DCM circuit operation may be divided into a capacitance measurement task and a display task (see the block diagram).

The capacitance measurement system consists of U1a, U1b and U2a. U2, a 556 timer, contains two independent 555-type timer functions: U1a functions as a monostable oscillator; U1b functions as a 10-kHz astable oscillator. Depressing the TEST switch triggers the monostable. The test capacitor (Cx) is part of the timing circuit, and thus, the duration of the monostable output is dependent upon the value of Cx. One pole of the RANGE switch selects the resistance portion of the monostable timing circuit to match the anticipated range of Cx. See the chart for a 556 monostable time-delay nomograph.

Capacitance measurement is based upon gating, via U2a, the 10 kHz astable output with the monostable output signal. That is, 10 kHz astable pulses will appear at the output of U2a only for the length of time that the monostable output is *high* (triggered state). Thus the number of pulses at the output of U2a is a function of the capacitance being tested.

The display system performs the remaining major task; that is, to convert the gated number of pulses to a recognizable numeric display form. For simplicity, this task is accomplished by a series of TTL decade di-



This is a 556 timer nomograph to be used for determining the delay achieved when a certain capacitor is used with the appropriate calibration resistance.

viders, BCD to 7-segment decoders, and 7-segment LED displays. U3 through U7 are wired as decade dividers, additionally providing BCD outputs for the 7-segment decoders U8 through U10. The DCM Functional Diagram illustrates an example of the timing countdown to the displays. We will use it to facilitate understanding of the counting system.

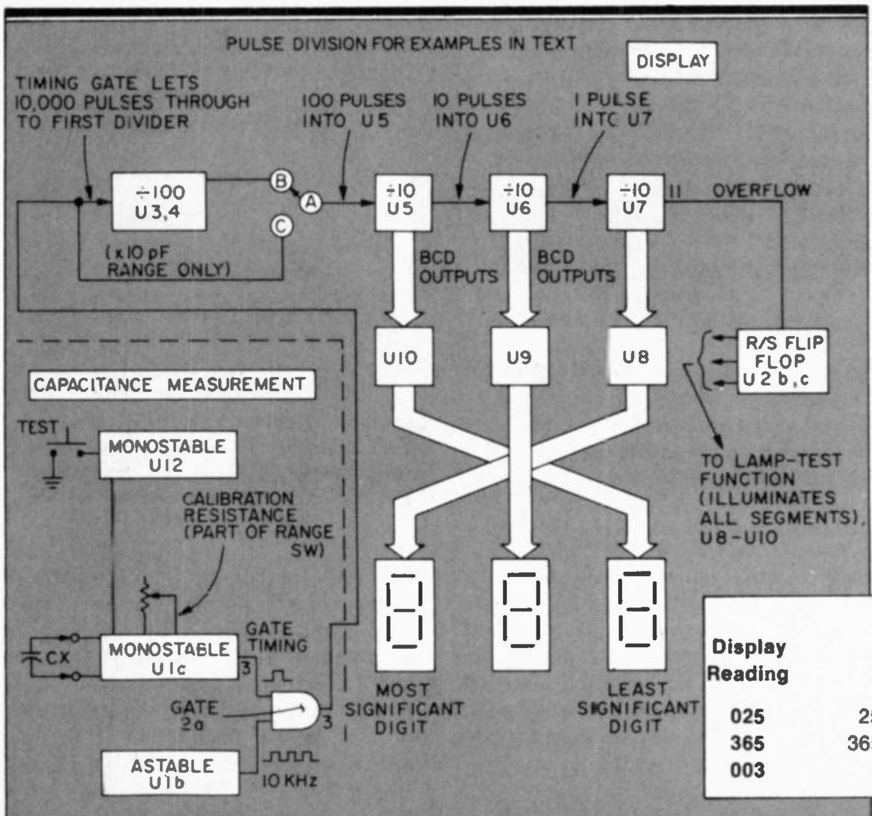
Test Example. In the example, a 10uF capacitor is measured on the X.1uF range. With this test capacitance, and assuming a calibration resistance of 110k-ohms, a one-second monostable output duration will be produced at pin 3 of U1a. (See the 556 nomograph assuming a 110k-ohm calibration resistance.) When the TEST switch is depressed, pin 3 of U2a produces 10,000 "pulses" since we gated the 10kHz astable output for one second. U3 and U4 collectively divide by 100, thus presenting 100 pulses to the next three dividers. U5, U6, and U7 also each divide by 10, and in addition, provide BCD outputs to U8 through U10. In the example, U5 "counts" 100 pulses, U6 counts 10 pulses, and U7 counts 1 pulse. When each divider counts 10 pulses it resets to a zero-count state and outputs a trigger pulse to the next divider stage.

Since U5 counts a number of pulses evenly divisible by 10, its BCD output to U10 is a binary-coded zero (ie: 0000). U6 also counts pulses evenly divisible by 10 and thus outputs a BCD zero to U9. U7 counts one pulse, and outputs a BCD 1 (ie: 0001) to U8. Since U7 does not count up to 10, no output pulse is produced at pin 11. U7 controls the most significant digit of the display, and thus must provide a "flag" to the operator if the maximum display count has been exceeded. This flag exists in the form of an output pulse at pin 11 if count 10 is reached, indicating an overflow condition. This pulse triggers a flip-flop, U2b and U2c, which turns on all segments of all displays via the "lamp test" function of U8, 9 and 10. This alerts the operator to advance the RANGE switch to the next higher position.

U8 through U10 convert BCD information to the 7-segment format used by the displays. In the first example, U10 processes its incoming data (0000) to produce a logic *high* level for segments a,b,c,d,e and f of the least significant digit. This allows those segments to illuminate, forming the number zero. U9 likewise causes a zero to appear on its associated display digit. U8 processes its incoming BCD 1 to illuminate segments b and c, forming the number 1. The result, reading from the most-to-least significant digits, is 100 which, times the X.1uF range position, yields a capacitance reading of 10uF.

The TEST switch actually performs three functions. The function previously discussed (triggering the monostable oscillator) is accomplished by providing a brief logic *low* level at pin 2 of U1a. Before the monostable is actually triggered, however, two "housekeeping" chores must be taken care of. First, all dividers (U3-U7) must be reset to zero. This is accomplished by providing a brief logic *high* level, via U2d, to the "master reset" connections at all divider pins 2 and 3. Second, a brief logic *low* must be provided as a reset to the flip-flop U2b-c to reset the display digits in the event of an overflow during the previous measurement.

Monostable triggering is delayed by the C1, C2 circuitry to allow completion of these tasks. U1a requires a voltage level of one-third or less of the supply voltage in order to trigger. C2 is discharged from 5 volts through R37 via a low potential available for a brief time from C1 and the TEST switch. A second monostable oscillator, U12, is provided as a buffer for



Use this diagram to help you understand the sample capacitance reading described in the text above. A 10 uF capacitor and the .1 range are used for this example. The display will read 100.

SAMPLE METER READINGS

Display Reading	Range Switch Position: 10 pF	.001	.1	10
025	250 pF	.025 uF	2.5 uF	250 uF
365	3650 pF	.365 uF	36.5 uF	3650 uF
003	30 pF	.003 uF	.3 uF	30 uF

The above chart shows sample values when various one, two or three digit numbers appear on LED display panel.

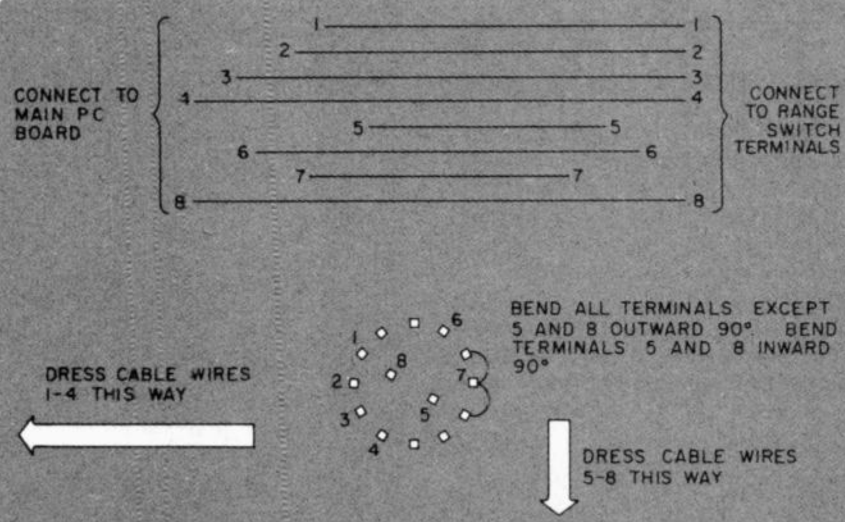
the TEST switch, providing a switch "debounce" function.

Construction. Construction of the DCM is straightforward when using the PC board layout shown. While point-to-point "perf board" construction is feasible, you would probably wish you had opted for the PC method long before you completed the project. Study the parts layout and orientation before starting construction, and decide upon a "method of attack" for inserting the components. Although individual styles differ, the following sequence should work well. The idea here is that by sequencing the parts installation according to the height of the components, several like-components can be inserted on the board before the board is inverted and the parts soldered in place. This should speed things up a bit. As mentioned earlier, use only .031 diameter (or smaller) solder.

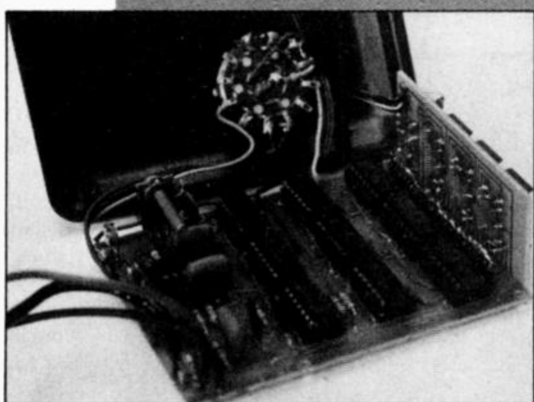
First, install the wire jumpers on the main board as indicated in the parts location diagram. (This is probably the most difficult portion of the construction, so take your time and doublecheck the jumper placement.) Next, install the horizontal-mount fixed resistors, slightly bending the leads after insertion to avoid mispositioning when the board is inverted for soldering. (It is helpful, for subsequent troubleshooting identification, to orient the resistors so that all the first bands point in the same direction. It looks neater, and makes identification a lot easier.)

After soldering them in place, trim the leads flush with the solder "blobs." Next, install the IC sockets on the main board, *making sure* that the notch, or dot, on one end of the socket is positioned as shown. This will facilitate proper orientation of the IC's when they are installed after all soldering is completed. Do not install IC sockets on the display board when using the cabinet described in this article, as there would be insufficient clearance to the front panel.

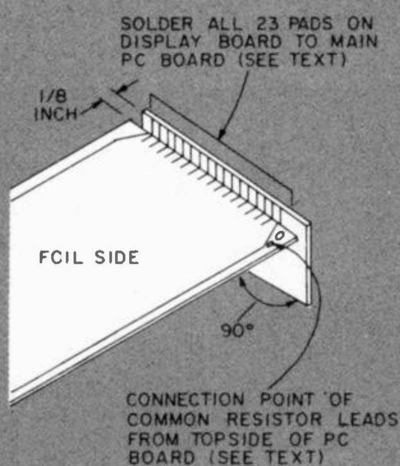
Next, install the capacitors, perhaps beginning with the mylar types (C1 through C7), then C8, C9 and C10. Be careful to observe the polarity of capacitors C8 and C9 before soldering. The trimmer pots should be mounted with the adjustment side facing the center of the board for ease of calibration. Observe the orientation of U11 before installation. U11 does not really require heat-sinking for this circuit, but a 6–32 x 1½ inch screw and nut may be added to more evenly distribute the heat when using a small cabinet. It might be useful to note that the heat-sink tab is at circuit



The top diagram shows the relationships of the wires in each ribbon cable assembly. The lengths of each section are as follows: Section 1–4", Sec. 2–4 1/8", Sec. 3–5 1/4", Sec. 4–5 3/4", Sec. 5–2 5/8", Sec. 6–4 1/2", Sec. 7–3 1/4", Sec. 8–5 1/2". For easier installation dress the wires from switch S1 as indicated. Such efforts are not necessary to the DCM's operation, but they make it look far more professional in appearance. Make neat, clean solder joints.

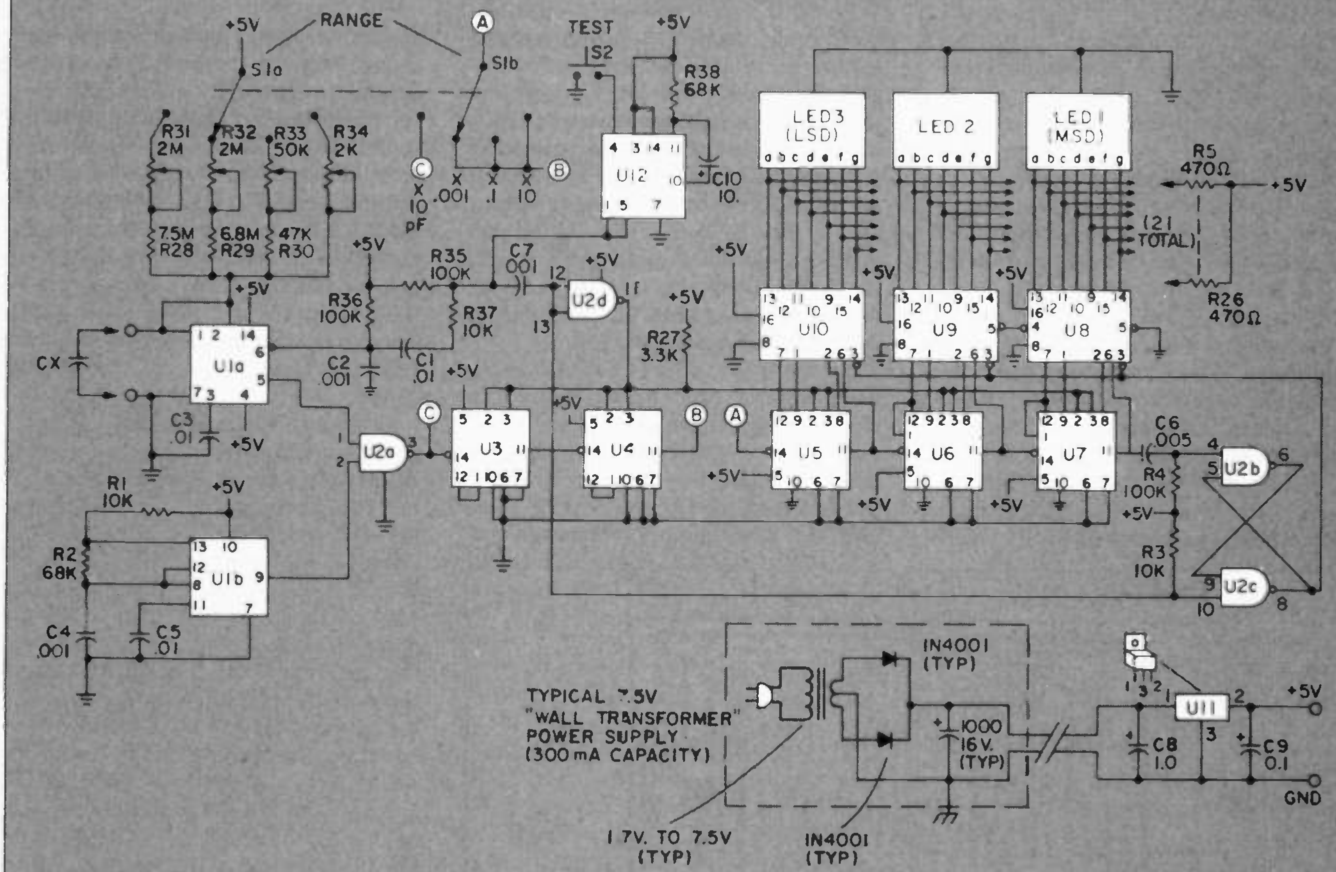


An interior view of a completed DCM. Note the nut and bolt used to dissipate heat from the voltage regulator, the use of IC sockets, and the way the LED current limiting resistors are soldered to the board behind the display panel.



The display board and main board are soldered together in the orientation shown here. Make solid but neat joints.

DIGITAL CAPACITANCE METER SCHEMATIC



PARTS LIST FOR DIGITAL CAPACITANCE METER

C1, C3, C5—.01uF, mylar capacitor
C2, C4, C7—.001uF, mylar capacitor
C6—.005uF, mylar capacitor
C8—1uF, tantalum capacitor
C9—.1uF, ceramic disc capacitor
C10—10uF, electrolytic capacitor
LED1 through LED3—DL704 7-segment LED display, common cathode
R1, R3, R37—10,000-ohm, ¼ watt, 5% resistor
R2, R38—68,000-ohm, ¼ watt, 5% resistor
R4, R35, R36—100,000-ohm, ¼ watt, 5% resistor
R5 through R26—470-ohm, ¼ watt, 5% resistor
R27—3,300-ohm, ¼ watt, 5% resistor
R28—7.5-megohm, ¼ watt, 5% resistor
R29—6.8-megohm, ¼ watt, 5% resistor
R30—47,000-ohm, ¼ watt, 5% resistor
R31, R32—2-megohm, 1-turn trimmer pot, vertical PC mount
R33—50,000-ohm, 1-turn trimmer pot, vertical PC mount
R34—2,000-ohm, 1-turn trimmer pot, vertical PC mount
S1—2-circuit, 4-position rotary switch (GC 35-377 or similar)
S2—SPST momentary contact switch
U1—556 dual timer integrated circuit
U2—74LS00 Quad NAND gate
U3 through U7—74LS90 decade counter
U8 through U10—74LS48 BCD to 7-segment decoder
U11—LM340T-5 5-volt regulator
U12—74121 monostable multivibrator
Misc.—Cabinet 4" x 4½" x 1⅝" minimum, with bezel and red filter (Radio Shack 270-285 or similar), IC sockets, knob, clip leads, PC board, 26 AWG solid hookup wire. AC power supply—7.5 volt, 300 milliamp., wall-plug-in type (Herald BA-46A or equivalent).

Don't use just any "9V AC battery eliminator." It must have sufficient current handling ability; and, to avoid need for an elaborate heat sink, 7.5 V should be used (as available on many "multivoltage" models).

Note—A set of PC boards, complete kit of parts, or wired-and-tested DCM are available as follows:

DCM-PC—etched and drilled PC boards for display and main circuitry: $12.95 postpaid in U.S.A.

DCM-K—complete kit, including all components, IC sockets, PC boards, wall supply, pre-drilled cabinet, etc.: $58.95 postpaid in U.S.A.

DCM-W—completely wired, calibrated, and tested: $89.95 postpaid in U.S.A.

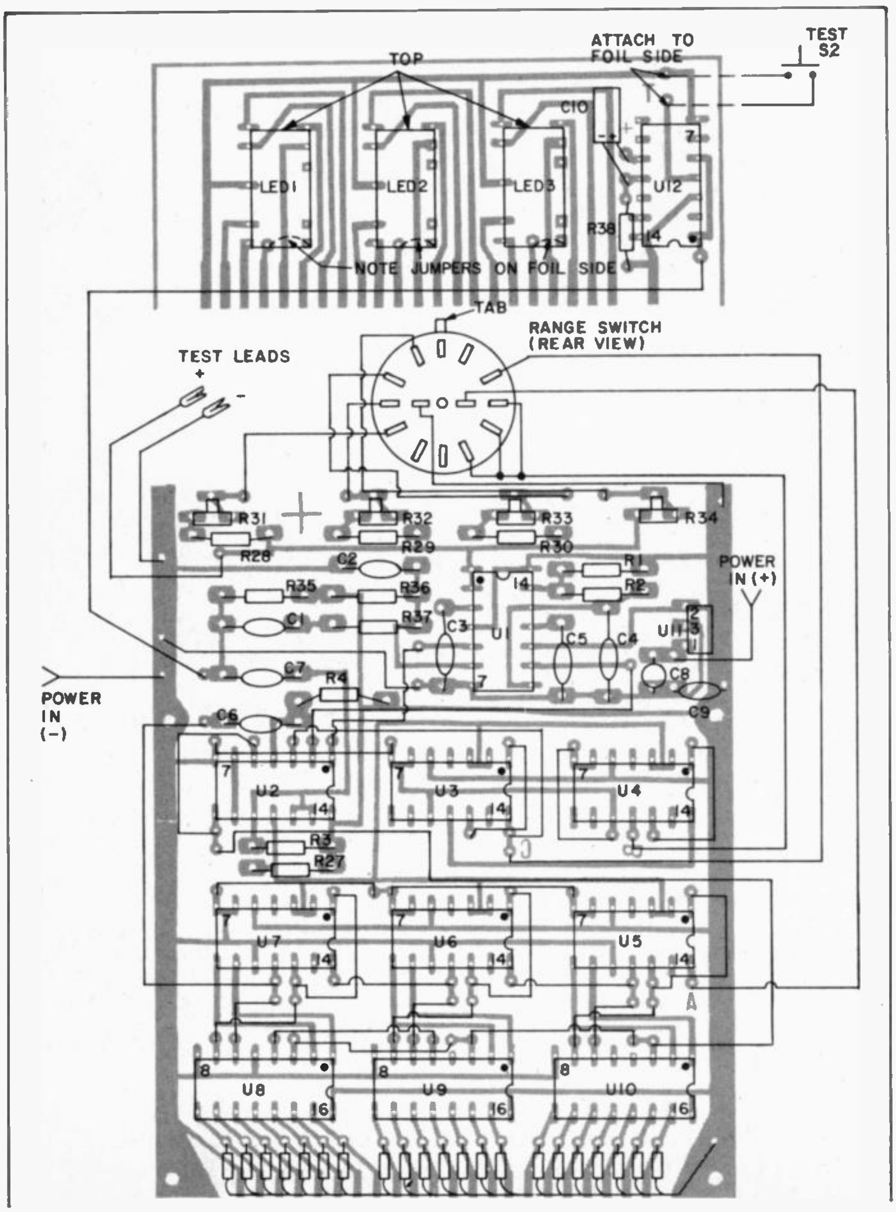
Arizona residents add 4% sales tax. Foreign residents add $5.00 for shipping and handling. No COD's or foreign currency, please. Money orders shipped same day. Order from PVP Industries, Inc., P.O. Box 35667, Tucson, Arizona 85740.

ground potential, and thus makes a handy place to hang a test clip for troubleshooting purposes.

The LED displays and U12 should now be installed on the display board, being careful that the orientation dots face the same direction. The display jumpers shown may be formed either by bending the appropriate LED lead over to the pad, or by using hookup wire. Join the two PC boards by first studying their positioning and the pad orientation. Scotch tape and a book or two may be helpful in obtaining temporary positioning of the two boards, long enough to solder the first few pad-sets. There should be ⅛ inch overlap of the display board over the pattern side of the main board. Apply solder to the pads, allowing the solder to freely flow and form a 1/16" thick bead over the pad surfaces.

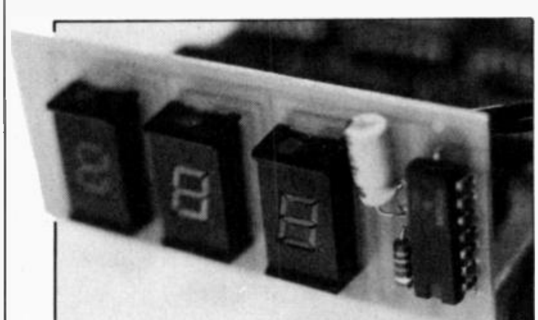
Next, place one end of all 21 470-ohm resistors (R5 through R26) into the proper holes. Apply a long strip of Scotch tape across the upward-facing leads to maintain proper positioning. Invert the board, and solder all 21 leads. Cut off the excess lengths, then turn the board right-side-up. After final straightening of the resistors, solder these 21 leads together (either by bending the lead on appropriately-spaced resistors or using a separate bare hookup-wire). Install a wire from one end of the resistor array through the board to the appropriate solder pad as shown. Stop at this time, take a break, then carefully inspect the work you have done thus far. Recheck for properly oriented components, and make sure that soldering is neat with no solder-bridges.

At this point all PC board components should have been soldered in place. (If you have any left over, install them at this time.) All that remains is connecting the two switches, the test leads, the power supply wires and the wire jumper connected between the display board and the main board. Select a reasonably short path-length for the switch wires, depending on your chosen cabinet design. Either individual leads or flat-ribbon cable may be used. Test leads were chosen for this project in lieu of binding posts since all diverse physical capacitor designs can be accommodated with the test leads. You may, however, prefer binding posts. In either case, keep these lead lengths short to minimize residual capacitance in the X10pF range.

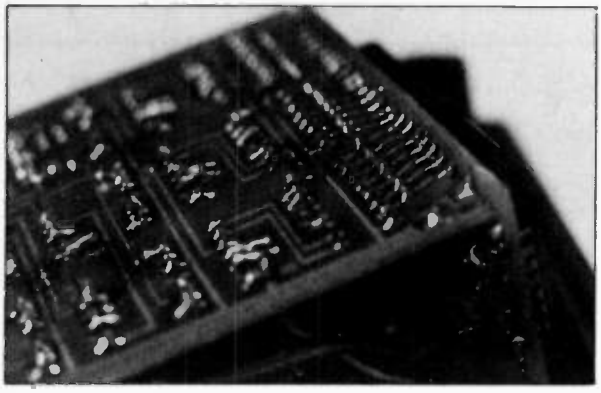


Checkout and calibration. Double-check all connections and component orientation. Do *not* install the IC's into the sockets yet. Instead, plug-in the wall transformer and observe the display. All segments of all displays should be illuminated, forming a display of all 8's. If they are not illuminated, unplug the supply immediately and determine the cause. (If at least *some* of the display segments are on, the power supply and on-board regulator are functioning. If all segments are off, check to see that you installed a wire from the common connection of the 21 vertical resistors through the PC board to a +5 volt pad.) The wall supply case should remain luke-warm after 10 minutes of operation in this mode. (If the supply case becomes hot, chances are you chose an insufficiently-rated AC supply.) If everything appears alright, disconnect the supply and install the IC's, being careful to observe proper orientation in the sockets.

Reconnect the supply. Depress the TEST switch in each of the RANGE switch positions, observing the display each time. (Do not connect a test capacitor yet.) The X10pF range



Orient the LED displays as shown above and in the parts location diagram to the left. Note how C10 is bent over on its side and how U12 is mounted without a socket to allow adequate clearance around the case's red display bezel.



This close-up detail photo shows how the display panel is connected to the main circuit board. This is a complex circuit board, so be careful soldering.

should produce a low single-digit reading corresponding to the residual input circuit capacitance. The other range positions should produce a single-digit zero reading. (This design employs leading zero display suppression to enhance readability.)

Calibration is quite simple, consisting of adjusting the appropriate range trimmer pot for a display reading corresponding to a known test capacitance. Only one capacitor need be used for each range, as the 556's response is extremely linear; but, for accuracy, choose a value for each range that causes all three displays to be lit (eg.: on the X.001uF range, choose a capacitor between .1uF and .999uF). If you have access to an accurate capacitance meter you won't need to obtain premium tolerance caps. Simply measure your selected-value "junkbox" capacitors on this other meter, then calibrate the DCM accordingly. If these means are not available, you will have to use several capacitors of known "nominal" value for each range, and average all of the readings.

Operation. As stated above, accuracy is enhanced by selecting a scale that will produce a two or, preferably, a three digit display. It is best to perform several tests of each capacitor, as an occasional transient pulse (or in some cases, a marginal capacitor) can cause spurious readout counts. Accuracy is also improved by allowing a few seconds "settling time" between measurements; otherwise, the next measurement may produce a slightly lower count. The practical lower limit of measurement on the X10pF scale should be considered 100pF; although with a little experience, and remembering to subtract the residual reading for this scale (ie: TEST switch depressed with no capacitor connected), low capacitance values can be measured with reasonable accuracy. The upper capacitance limit is 9,990uF, obtained on the X10uF range.

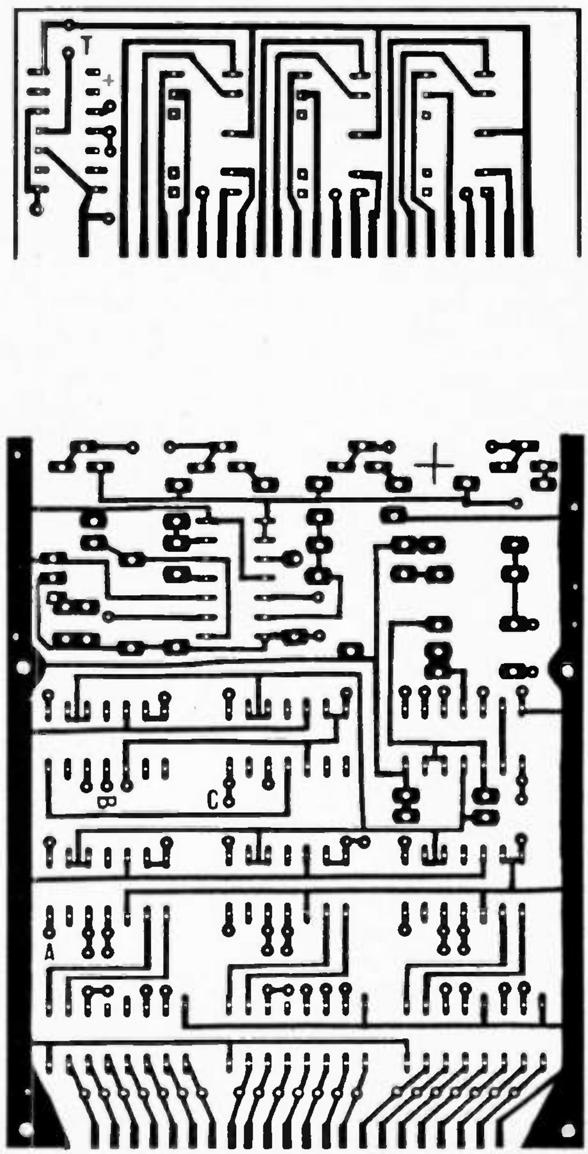
I have found that connecting a wire from the ground lead to the AC outlet cover retaining screw will improve the stability of low capacitance values when measured under high noise conditions.

An overflow condition (steady 888 display) indicates either that the capacitance being measured exceeds the selected RANGE position or may indicate a shorted or excessively leaky capacitor. Leaky capacitors will cause a "suspiciously high" reading. For example, if a 10uF electrolytic (+100, −0 tolerance) reads 100uF, odds are you've got a "leaky-lytic"!

A power switch was deliberately left out of the design. The remaining lit segments when the DCM is not being used serve as a reminder that the wall supply is still plugged in. As with any electronic device employing a wall supply, turning off the power switch, if provided, would still *not* remove power from this supply. Thus, for maximum safety, unplug the supply.

Your efforts in carefully constructing the DCM will be rewarded by many years of dependable service. ■

Full-size photo-etching template.



Digital Debugging

Save a Bundle by Repairing Your Own Digital Circuits

WITH DIGITAL DEVICES becoming so pervasive on today's market, the average do-it-yourselfer may be having a hard time changing over that electron tube and p-n-p transistor troubleshooting ingenuity to integrated circuitry.

However, it requires no mystical incantations to fix a digital radio or clock that goes on the fritz. Debugging digital circuits is no more difficult than troubleshooting analog circuits, just a bit different. Some claim it is even easier.

Problem Proven Probes. Troubleshooting's secret is to use the proper tools. A multitester won't do much good for most digital applications. However, a *logic probe* will.

A logic probe checks the logic state of your test point. The simplest type of logic probe has one LED for an indicator. If the LED lights, the logic state of the tested point is high (or one). If the LED doesn't light, the logic state is low (or zero).

More advanced logic probes have separate LEDs for high and low states, with some having an additional LED indicating that the tested point's logic state is pulsing.

The logic probe sounds like and is a very simple testing device. Yet it's the most important tool you'll need when troubleshooting digital circuits. You can use it to determine the logic states of most MOS CMOS and TTL ICs. It's also handy for checking multivibrator circuit output. To use the probe, just touch the pin or point you're curious about with the probe's tip. Then read the LEDs.

For digital troubleshooting, most service technicians start at the digital circuit's output and work back. The exception is if the circuit is driven by a multivibrator. Then it pays to first check the multivibrator, then go to the output and work your way back into the circuit. A logic probe having a separate LED indicating pulsing states is a real help if you often work with multivibrator circuits.

A bad chip is the first suspect in a malfunctioning digital circuit. But a bad chip is not always the problem. It's easy to misuse TTL and MOS/CMOS integrated circuits.

Stay Grounded. Don't Float! If you're using MOS or CMOS ICs (4000-series devices), one important point often overlooked is that all unused inputs must be connected either to Voltage Common Collector (Vcc) or ground. If you have any floating inputs, you won't damage the IC but its operation will probably be erratic.

Another problem with MOS/CMOS ICs is output overloading. You might be trying to operate too many LEDs from one chip or you could be trying to use the output as the input for too many other ICs. A quick way to check is by touching the plastic case. If it's hot, then you are probably overloading that particular IC.

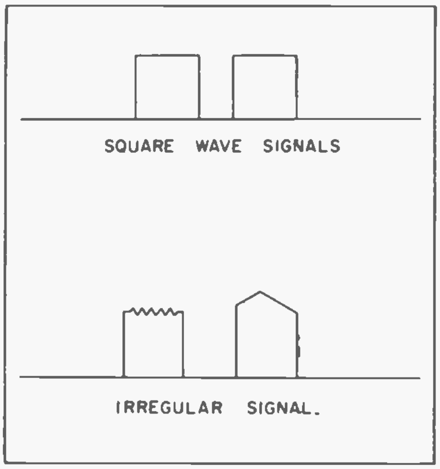


Fig. 1. Irregular signals might impair the operation of an IC. Digital circuits are designed to operate on regular waveforms.

TTL ICs (7400-series devices) also require special attention. If an input should always be high, connect it to Vcc. If the input should always be low, connect it to ground. Many electronics hobbyists believe that unused TTL IC inputs are always high. That's what usually happens, but they can (and unexpectedly) go low and this can mean erratic circuit operation.

You've got to be careful when working with TTL ICs containing OR, AND or NAND gates. If you have an unused input on such a chip, connect it to a used input on the same chip. Otherwise, the chip will probably misbehave. A good rule when working with TTL integrated circuits is all inputs must be connected to something.

Naughty ICs. If you've checked all the IC inputs and found them okay but the circuit still won't work, the problem is a bad IC.

The simplest test for a defective IC (and often the most effective) is to look at and touch the plastic case. Defective ICs often develop a bubble or discoloration in the middle of their package. A bad IC often draws an abnormally high amount of current, so examine IC cases that are hot. (This is the same check used for overloading.)

Another quick way to locate bad ICs is by piggybacking. Piggybacking means placing another IC of the same type on

(Continued on page 98)

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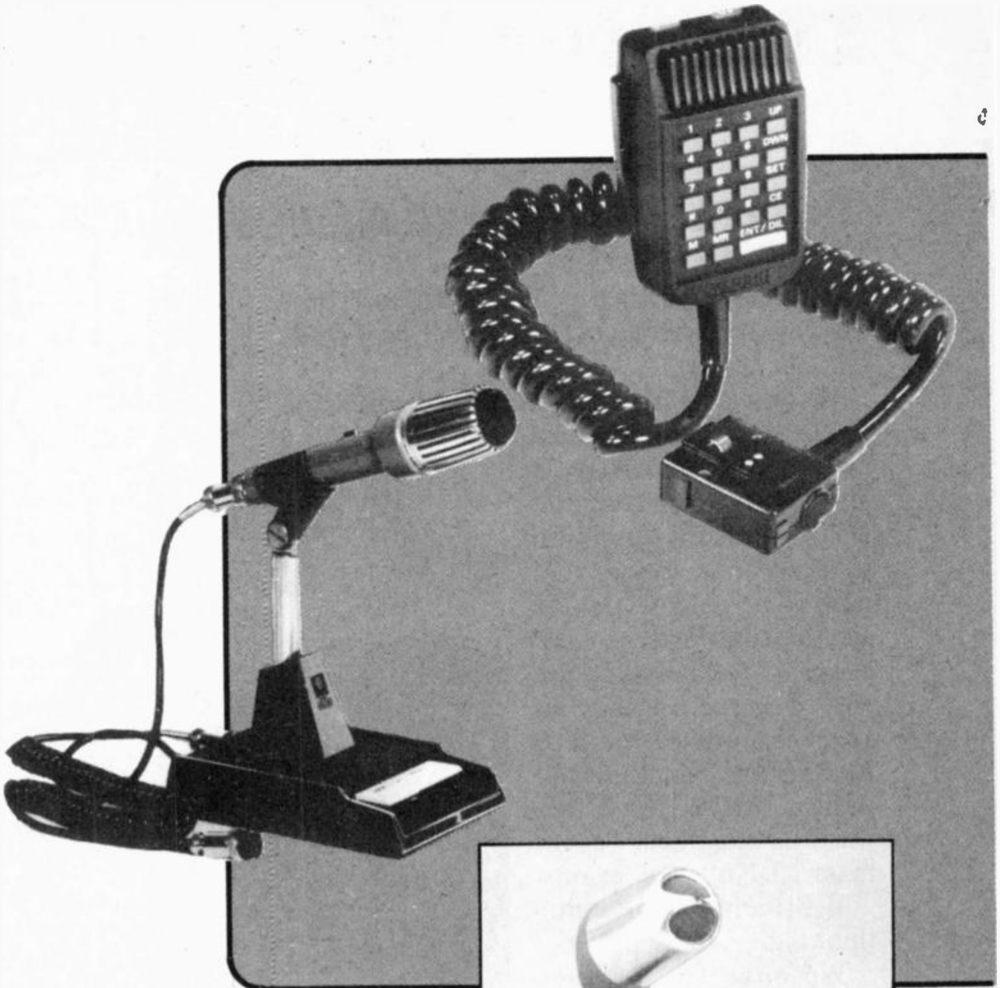


THERE'S A SAYING about computers that we all recognize: garbage in, garbage out. This saying is as true to audio as it is to the world of bits and bytes. Yet, for some reason, most transceivers and transmitters (even expensive high quality models intended for fixed station use) are sold with cheap hand or desk mikes better suited for an inexpensive CB rig.

A considerable investment in a top quality rig can easily be undone by an inferior microphone. One should closely look at the various factors regarding microphone selection.

All Purpose Mikes. There are mikes designed for every imaginable purpose, with prices ranging from $5 to several thousand dollars. The challenge is to get what's best for your needs at a reasonable price. The most basic of mikes are carbon mikes.

Carbon mikes are among the oldest and simplest of microphones. Carbon mikes change the varying pressures of sound waves into electrical pulses by using a diaphragm. It is connected so that the pressure waves alternately compress and decompress loosely-packed carbon particles in a capsule.

Applying a voltage in series with this carbon-granule variable resistor produces a current that varies at an audio rate. About 50 to 100 ma of current is required for operation.

Carbon mikes are rugged and are used where abuse is expected and high output is required. Due to frequency response and audio quality limitations (about 250-4500 HZ), only speech can be transmitted.

There are still some World War II and later era carbon mikes available as surplus, but it makes little sense to use them in most amateur applications. Your audio will sound a bit raspy, somewhat akin to that of the radio operator's in a vintage John Wayne bomber movie. You may also have trouble getting used to the occasional requirement to gently tap the mike's case to break up the carbon granules that tend to pack.

Realistically, crystal, dynamic and related types offer a better choice in microphones for general amateur communications use.

Crystal Clear. Crystal mikes have good communication qualities, with a generally bright sound that's good for piercing through QRM. They contain a piece of quartz used to generate an electrical voltage when subjected to a mechanical stress.

The element is mounted behind a diaphragm and a fixed metal plate. Sound waves striking the diaphragm place a mechanical strain on the element; the voltage produced is taken off between the diaphragm and the fixed plate.

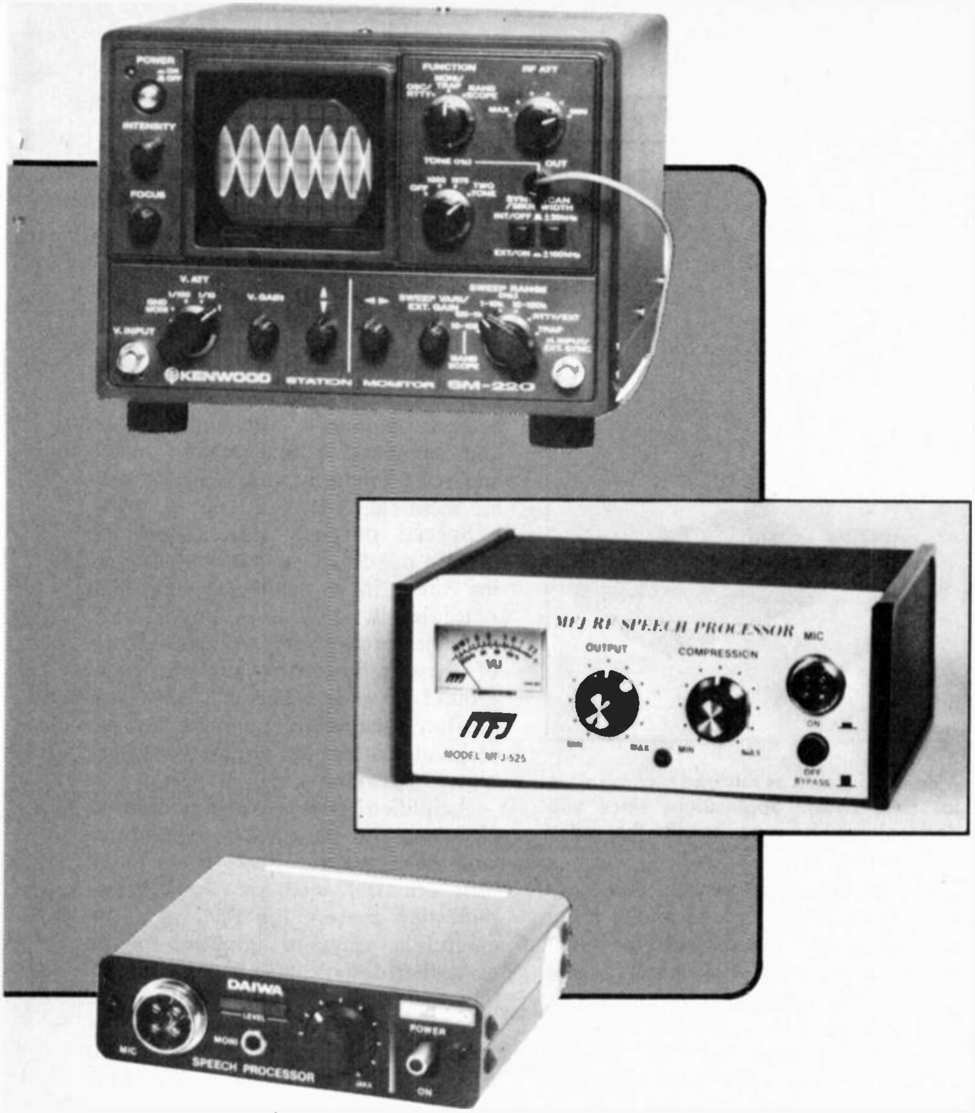
Crystal mikes generally have high output impedances (as high as several megaohms), thereby requiring well-shielded, short-run cables if excessive hum pickup and loss of high-frequency response is to be avoided. Crystal mike output is typically high, though not as high as that of carbon mikes. Quality is good, but the quartz crystals used are sensitive to temperature and humidity variations so crystal mikes are usually unsuitable for mobile applications.

An answer to the limitations of the crystal microphone lies in the ceramic mike. This mike uses a special ceramic wafer to generate the audio signal

The audio is of somewhat better quality, since the ceramic material produces a more uniform frequency response over its entire range. Ceramic mike output is also high impedance, but the output level is slightly lower than that of the crystal mike. The ceramic microphone is well-suited to mobile applications due to the ruggedness of its element.

However, most solid-state transmitting equipment is designed to work best with low-impedance microphones. For this reason, characteristically low-impedance dynamic microphones are gradually nosing-out crystal and ceramic types for both fixed-station and mobile applications.

Very Dynamic! The dynamic microphone and its relatives, such as the controlled-reluctance or controlled-magnetic mike, are taking over the communications field. Such mikes have a uniform frequency response and are very affected by reasonable extremes of temperature and humidity. Some specialized versions can even cancel background noise.



COMMUNICATIONS MICROPHONES

Get Top Value for Your Microphone Buying Dollar.

In some respects, this mike acts as a dynamic loudspeaker in reverse, operating on the principle that when a moving wire cuts a magnetic field, electrical energy is produced. A lightweight coil of wire is attached to the diaphragm and a magnet is placed so that the coil is within its energy field. Sound waves striking the diaphragm make the wire coil vibrate in the magnetic field, resulting in an electrical output that exactly corresponds with the sound waves.

Dynamic mikes are the workhorses of the entire field. Their audio quality is good, though outputs are lower than any type previously described. Output impedance is low, running from about 30-ohms up to several hundred ohms, though some types produce high-impedance outputs, having a very small transformer installed within the microphone case.

The controlled-reluctance microphone, originally developed for the military to combine the desirable characteristics of ceramic and dynamic mikes, is a close cousin.

In it, the coil is stationary and an armature in a magnetic field is moved within the coil by the action of the diaphragm. The wire coil can be wound to match almost any impedance, from high to low.

A Consideration. What are the considerations involved in selecting a microphone? Range and uniformity of frequency response, design-for-application (FM vs. SSB), output impedance, output level (preamplified vs. non-preamplified), ruggedness of element and case, type of stand, push-to-talk (PTT) or grip-to-talk features, pattern, RF and audio shielding and wiring configuration are a few features to look at.

Keep It Flat. Audio response should be uniform throughout the desired band, with no bumps anywhere in the range. Nevertheless, a slight rising characteristic, as in the crystal mike, is often preferred to produce crisp, interference-piercing quality.

As for range, many manufacturers have taken an approach in which microphone response spans from 300 to 5000 Hz. Mikes designed for FM tend slightly to the higher frequency response, SSB mikes toward the lower. The human voice ranges from 300 to 3000 Hz. Very wide range, hi-fi studio mikes are undesirable and may introduce extraneous high-frequency noise into the transmitter's audio circuitry.

Microphone impedance matching is extremely important. For best results, the impedance of the mike should be the same or fairly close to that of the circuit it feeds, up to about 3:1 or 4:1 is acceptable. Beyond these limits, frequency response curves become distorted and mike output suffers.

Most dynamic microphones are low impedance devices in the range 150-600 ohms, so you're usually safe in using them with solid state transceivers. Always look for minimum and recommended load impedances in mike's advertising brochure or spec sheet. And look at the range of minimum and maximum mike impedances your rig will accept, often listed in the set's specs.

If you can't avoid a mismatch, feeding a low-impedance mike into a high-impedance circuit is better than going the other direction. Or buy a dual-impedance mike that will match both high and low impedance mike.

Low dB. Output levels vary and it's hard to get a fix on what minimum output level your rig will accept. Mike outputs are usually stated in dB below 1 volt/microbar. Suffice it to say that the less-negative the figure, the higher the mike's output. Figures of –30 to –75-dB are typical of non-amplified mikes, and much-higher figures with amplified (power) types; as high as –10 to –25-dB.

What about so-called power mikes? The term is one with negative overtones to many hams, one that conjures up grotesquely overmodulated CB signals taking up most of a crowded band, with gain controls on mike and transceiver running full tilt. Obviously, it's wise to avoid cheap CB crowd power mikes for reasons of poor quality. However, a well designed, high-quality (and usually expensive) pre-amplified microphone can be a very worthwhile investment.

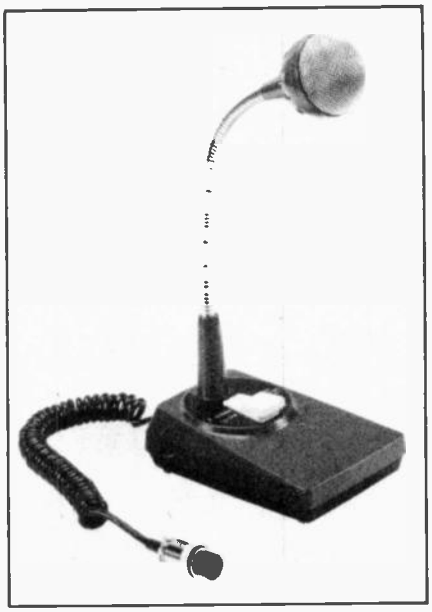
Metal Stands. A heavy, rugged, preferably die-cast metal stand is a must for dependability, and the element should be hum-shielded and insulated against shock. A metal case is a definite plus in keeping hum out and minimizing suspectibility to RF interference, though the metal case can present problems with RF burns if you have station grounding problems.

However, some of the more expensive mikes are going to non-metallic construction using materials that are assertedly more durable than steel, and at the same time claim to be RF tight and hum free.

Virtually all communications mikes are PTT-operated. Some have the PTT switch built into the stand for grip to talk action, while others have it as part of the mike's base plate. Either way, there should be a locking bar to tie down the PTT switch for long-winded transmissions when you want to take your hands off of the mike.

Check Special Connections. Microphone wiring configuration is important. You should know what your rig's mike pin connections are and if there are any special connections the mike circuit must make. Fortunately, most amateur rigs use only two connections plus ground: hot audio and PTT.

Noise cancelling mikes with a pre-amp can be useful if you are using them in a vehicle that has high noise levels.



A desk mike such as this one is convenient for base station applications since you don't always have to handle the mike.

Mobile rigs may have DC voltage brought to the mike connector for powering a Touch-Tone™ pad. In some cases a speaker lead is routed to the connector for positive silencing during transmit or for use of a headset/mike combination.

Depending on the mike's internal wiring, it may or may not work in voice controlled transmit (VOX) operation. You may find that the PTT switch must be depressed to activate the mike's audio, which defeats the VOX operation. Some mikes have a normal/VOX slide switch to facilitate change over.

Mike patterns usually fall into two groups: cardioid or unidirectional and omnidirectional. The cardioid (heart-shaped) types pick up sound mainly from in front, suppressing sounds and extraneous noises from the rear. The cardioid pattern will suppress rear sounds (70% or more) while almost completely eliminating those 120 to 180 degrees off-axis.

The cardioid pattern can be very useful when using VOX, to minimize the possibility of the station speaker or extraneous sounds tripping the VOX; it's especially easy to set up the controls with this kind of mike. Omnidirectional (non-directional) mikes are common and evenly respond to sounds coming from all directions.

Rugged Mikes. Most mobile mikes are dynamic or controlled-reluctance and thus are rugged and relatively insensitive to temperature and humidity extremes. All are designed for high speech intelligibility, most are low impedance, outputs are generally higher than comparable base station mikes and sound patterns are typically omnidirectional.

Special purpose, noise cancelling mobile mikes are useful if you're using them in a vehicle having high noise levels, such as a power boat, airplane, motorcycle, or truck. Some of these mikes can shut out background noise and permit clear transmission even when the noise level is so great that the operator cannot hear himself speaking.

Amplified mikes are also popular in mobiling; the same cautions apply as with base mikes. There seems to be little practical need for a power amplification feature for FM work. Be careful in using an amplified mobile mike that doesn't have a noise-cancelling feature in a noisy vehicle, since the mike will pick up and amplify road noise. This may create a garbled signal that is unpleasant and difficult to understand.

In purchasing a quality mobile mike, one should also look for a high-impact type case (many CB mikes are

(Continued on page 97)

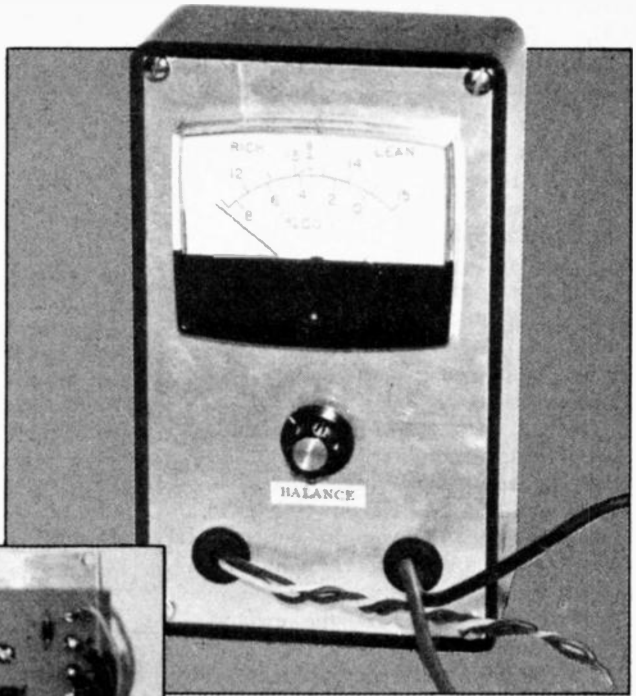
MICROPHONE MANUFACTURERS AND IMPORTERS

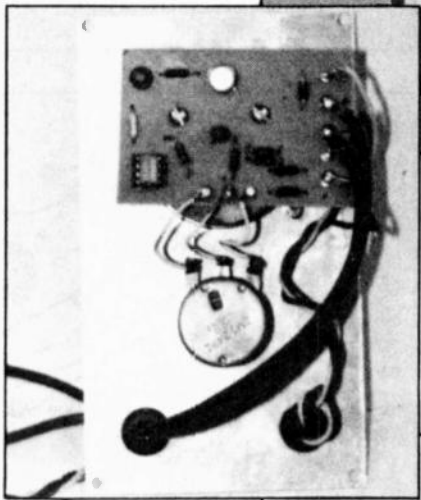
Astatic Corp., Conneaut, OH 44030
Electro-Voice, Buchanan, MI 49107
Midland Electronics Co., P.O. Box 19032, Kansas City, MO 64141
Mura Corp., 177 Cantiague Rock Road, Westbury, NY 11590
Olson Electronics, Inc., 260 S. Forge St., Akron, OH 44308
Radio Shack, 2617 W. Seventh St., Ft. Worth, TX 76107
Shure Brothers, Inc., 222 Hartley Avenue, Evanston, IL 60204
Superex Electronics Corp., 151 Ludlow St., Yonkers, NY 10705
Telex Communications, 8601 Northeast Highway 6, Lincoln, NE 68505

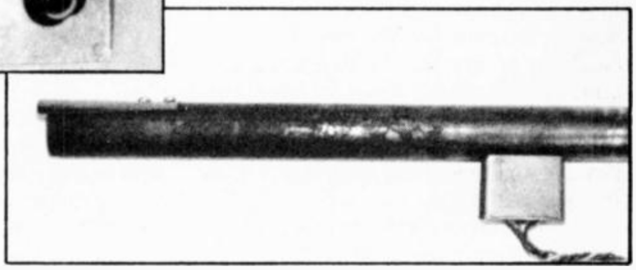
These are a few different manufacturers. Check around before buying a mike to get the one that best suits your needs.

AUTOMOTIVE EXHAUST EMISSIONS ANALYZER

Tune Your Car Properly With This Analyzer







IF THE CAR you drive was manufactured after 1963, it has an emissions control system.As exhaust emission requirements become more strict (some states have annual inspections that include an emissions test) with each passing year, it has become difficult to properly adjust the car engine.

Gone are the days when the idle mixture screws of a carburetor were purposely set to less than optimum condition to assure meeting permitted emission levels. Some tune-up manuals provide a technique for adjusting the carburetor using a tachometer to measure engine RPM.

This method is fine, if all engine systems are operating properly. But what happens if system malfunction causes excessive emissions?

CO Measurement. This is where the Automobile Exhaust Emissions Analyzer comes in. This easy to build instrument provides a visual indication of an exhaust component—carbon monoxide (CO). The level of CO (Fig. 1) in automible exhaust is inversely proportional to the air-fuel ratio and combustion efficiency. The air-fuel ratio is varied when the idle mixture screws of a carburetor are adjusted. (Some carburetors have just one idle mixture adjustment screw; others have two).

The CO level is low when the air-fuel ratio is 14.7. Modern automobile engines are designed to idle with air-fuel mixtures near this theoretically perfect air-fuel ratio.

The Automotive Exhaust Emissions Analyzer contains a sensing element (thermistor) that is exposed to automobile exhaust. A meter readout permits measurement of the air-fuel ratio.

Since one other exhaust pollutant, hydrocarbons, are also controlled by the idle mixture screws, the exhaust analyzer will help to minimize this component even though it is not responsive to it. This is because the optimum setting for minimum CO is close to the optimum setting for hydrocarbon emissions.

Good Mileage. Thus, by adjusting your carburetor with this instrument, you will help reduce air pollution. A properly adjusted carburetor will also help provide better gasoline mileage.

The heart of the instrument is a bridge circuit that contains two 100-ohm resistors (R3 and R4), and two thermisters (T1 & T2). A thermister is a special resistor having a large negative temperature coefficient of resistance. Its resistance value decreases as the resistors temperature increases.

At room temperature the resistance of T1 & T2 is about 2000-ohms. When they are each heated to 150 degrees centigrade by a 10 mA current, the resistance value decreases to 100-ohms. Thus, the four elements comprise a bridge circuit.

A characteristic of CO is that it conducts heat away from a thermistor at a different rate than air. One thermistor, T1, is exposed to the automobile exhaust while the other, T2, is isolated in a pure air environment. The difference in thermal conduction unbalances the bridge.

A voltage difference is caused between points A and C. A differential amplifier, U1, amplifies this difference and drives the meter with sufficient current to read out the percentage of CO and the air-fuel ratio.

A front panel balance control, R5, balances the bridge and calibrates the instrument. Calibration is performed when both thermistors are exposed to the outside air.

Accruate Calibration. To assure accuracy, U1 is used as a current regulator that is adjusted to deliver 20 mA into the bridge. U1 is a voltage regulator designed to maintain 5-VDC between terminals two and three.

Since most of the current fed into the circuit must pass through R1 and R2, the value of this series resistor string will control the output current of the regulator. The current is set by adjusting R2 and will hold its adjusted value over a very wide range of input voltages.

The circuit is powered by the car's battery and generating system. A silicon diode, D1, has been placed in series with the positive power lead to prevent circuit damage in case the power leads are improperly connected to the car battery.

The entire circuit of the exhaust system analyzer, with the exception of the sensing and reference elements, is on a PC board, mounted directly to the rear of the meter. The two large circular pads are designed for the meter studs and are properly spaced for the 0-1 mA meter that is specified in the parts list.

Check the center to center distance of the meter studs and modify the foil layout if you use a different meter. Extra large pads have been provided to accommodate the external wires that connect to the PC board.

Use a socket for all integrated circuits. Once a multipin integrated circuit has been soldered directly into a printed circuit board, it is difficult to remove an IC without destroying it or the printed ciruit.

Follow correct orientation for the integrated circuits, electrolytic capacitor, and diode as illustrated. These parts will not work if they are incorrectly placed. Pin 1 of U2 is identified in the layouts by a small dot. On the IC itself, pin 1 is identified also by a small dot or a semicircle that is molded into the plastic.

Fig. 2 can be used as a meter scale that will fit the meter specified in the parts list. Be sure not to damage the delicate meter needle when you install the new scale.

Construction of the sensing assembly is illustrated in Fig. 3. Use any material for the tubing. Aluminum is ideal because of its light weight and non-rusting quality.

One end of the tubing must be plugged. Epoxy can be used to secure the plug if aluminum is used. Other materials such as steel, brass or copper can be soldered. As shown in Fig. 3, drill and tap the two mounting holes for the sensing unit for 4-40 machine screws. Use 4-40 by ¾-inch screws for mounting. Be sure to orient the sensing element as shown so that the exhaust thermistor will be exposed to the gases in the tube.

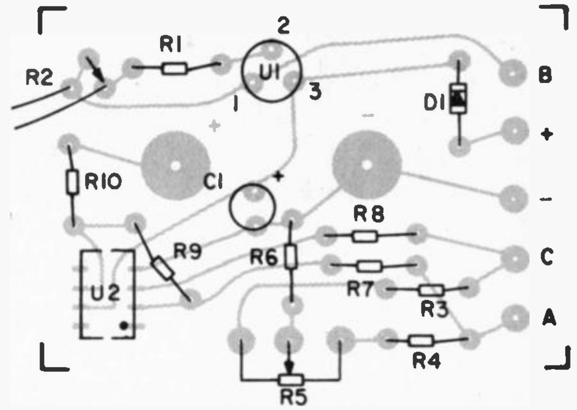
Use a 20 gauge flexible wire for the connections between the sensing assembly and the printed circuit board. Use different colored wire to avoid the possibility of misconnections. Use red and black wires for the battery power connections.

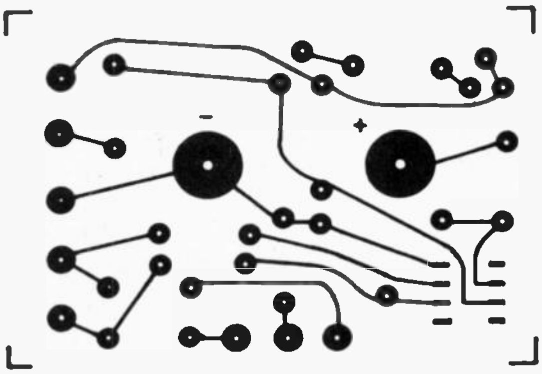
Check The Length. Before making the PC board connections, be sure that the wire between the sensing assembly and unit is long enough. Remember, the unit will be placed somewhere near the engine compartment so that the meter can be monitored during carburetor adjustments.

The bridge current must be adjusted to 20 mA by means of R2. To make this adjustment you need a 12-VDC source and an accurate DC voltmeter. Use a car battery for the power source if you do not have a line operated DC supply.

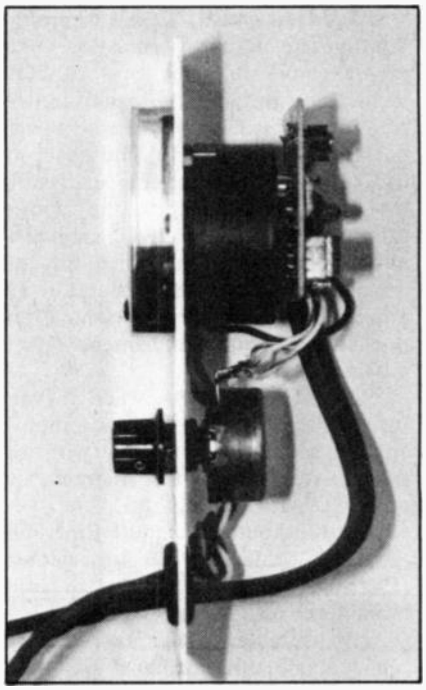
Connect the positive and negative power leads of the analyzer to the power source observing correct polar-

When you install the various components onto the PC board, make sure that you install the ICs properly. Use IC sockets for the two integrated circuits. If you have a bad IC, removal is easier.

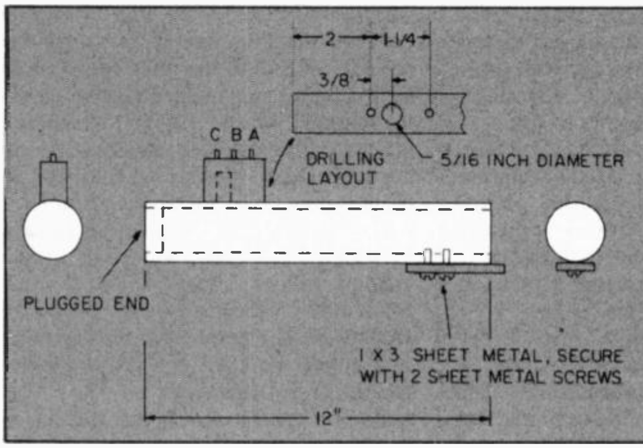




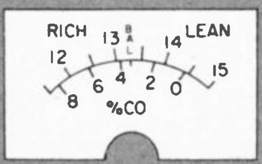
When you construct this PC board, be very careful when you etch the various circuits. Make sure that there are no solder bridges and that all of the connections are good. Use an ohm meter to check out the whole board.



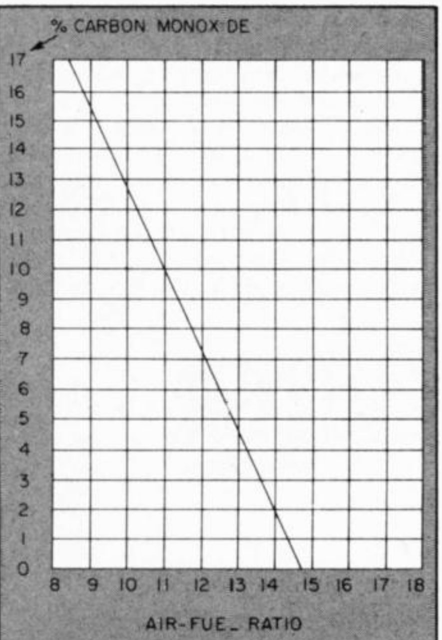
The meter assembly for this project is quick and easy to build. It should be useful for those critical car inspections.



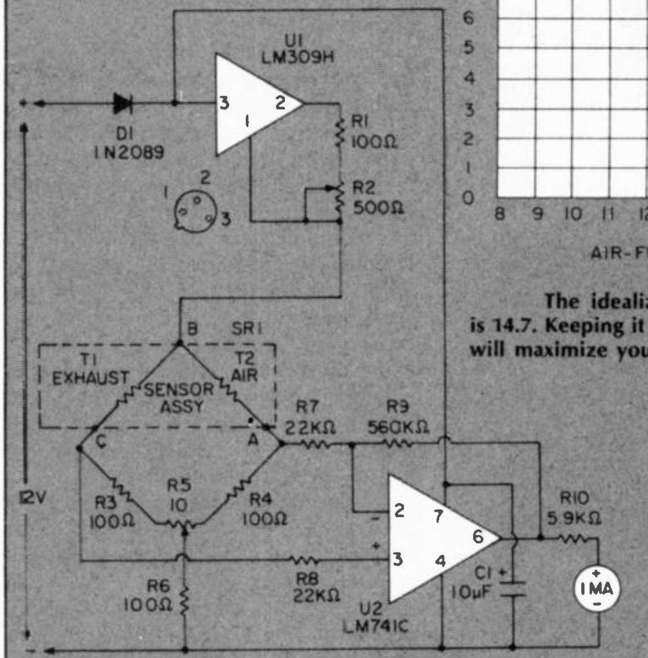
The sensing unit for the Auto Exhaust Emissions Analyzer is constructed as is shown in this drawing. Make sure that one end is plugged when constructing.



This is a scale template to use for your Auto Exhaust Analyzer project.



The idealized air to fuel ratio is 14.7. Keeping it as close to that ratio will maximize your car's performance.



PARTS LIST FOR AUTOMOBILE EXHAUST EMISSIONS ANALYZER

- **C1**—10-uF, 25 volt electrolytic capacitor
- **D1**—Silicon diode, general purpose, 1N2069 or equivalent
- **M1**—0.1 ma ammeter
- **R1, R3, R4, R6**—100-ohm 10% ¼ watt resistor (All resistors are 10%, ¼ watt)
- **R2**—500-ohm potentiometer, PC mount
- **R5**—10-ohm potentiometer, front panel mount
- **R7, R8**—22,000-ohm resistor
- **R9**—570,000-ohm resistor
- **R10**—5,900-ohm resistor
- **SR1**—thermister sensor assembly, part number 100-1648 from Heathkit model CI-1080, Heath Company Benton Harbor, MI, 49022
- **U1**—LM309H 5-volt regulator integrated circuit
- **U2**—LM741TC op amp intergrated circuit
- **Misc.**—PC Board, screws, cabinet, solder, hardware, 10-foot plastic tube, etc.

ity. Set the front panel balance control to midposition. Measure the voltage across R6 and adjust R2 for 2-volts.

Make sure that the control will adjust the meter reading to both sides of center scale. If the unit performs this test, the adjustment procedure is completed. If you are unable to get the proper meter readings, recheck the wiring and the printed circuit board.

The analyzer is designed only for gasoline engines. Do not use it on diesel engines or automobiles with heavy smoke exhaust. To do so may coat the sensing element

For cars that have catalytic converters, the sensing assembly should be exposed to the exhaust gases before they pass through the converter. Some cars have a plug in the exhaust system for this purpose. On other cars, remove the exhaust gas recirculating (EGR) valve and examine the gases through it.

Balance Meter. Before inserting the sensing assembly into the tail pipe, connect the power leads to the car battery and slowly adjust the balance control for a center scale reading of the meter at the point marked Bal. There will be a time lag between adjustment of the control and response of the meter. Be sure the engine is up to normal operating temperature and the choke is fully open.

Place a long flexible tube into the tail pipe and the sensing assembly into the other tube end with the thermistor assembly facing upward. The tube should be long enough to eliminate any temperature difference between the air and CO. Note the reading of the meter.

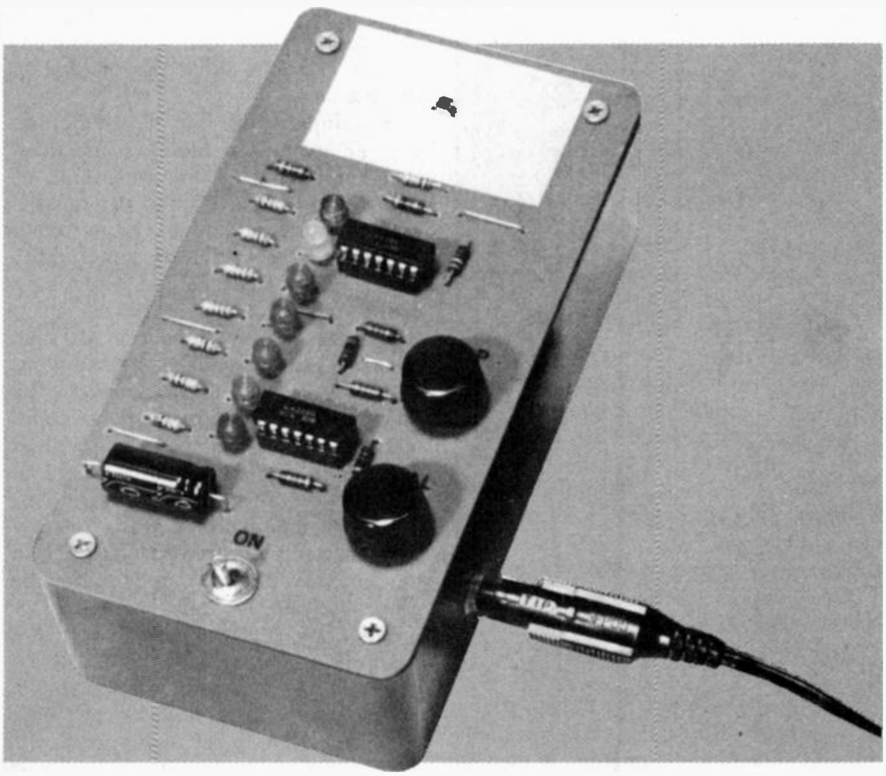
Readings to the left of center indicate an exhaust containing an excessive amount of carbon monoxide by today's standards. Cars with emission control systems should have meter readings to the right of center, indicating a lean mixture and a low concentration of carbon monoxide.

If your car is a recent model and indicates excessive exhaust emissions, you may reduce these emissions by turning the idle mixture screws counterclockwise to lean out the mixture. When this is done, the idle speed of the engine may be reduced. It is best to follow the manufacturer's instructions (usually located on a decal in the engine compartment) as to the proper setting for idle speed.

When you are finished with the test, allow the sensing assembly to purge itself of moisture and exhaust gas before putting it away or using it again. Do not use compressed air to dry out the assembly. ■

PHOTOMETER

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



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.)

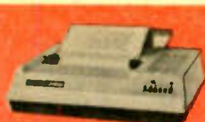
Constant Exposure. The green LED allows setting the aperture for a constant exposure time. Make a good print using your favorite exposure time: 10, 15 or 20 seconds. Without touching the enlarger adjustments, place the photoresistor under maximum light and adjust the EXP (Exposure) control until the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

All-In-One Computer



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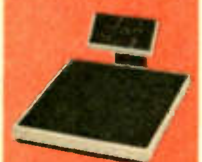
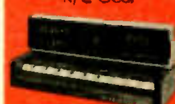


Digital Electronic Scale

R/C Gear

Car Thermometer



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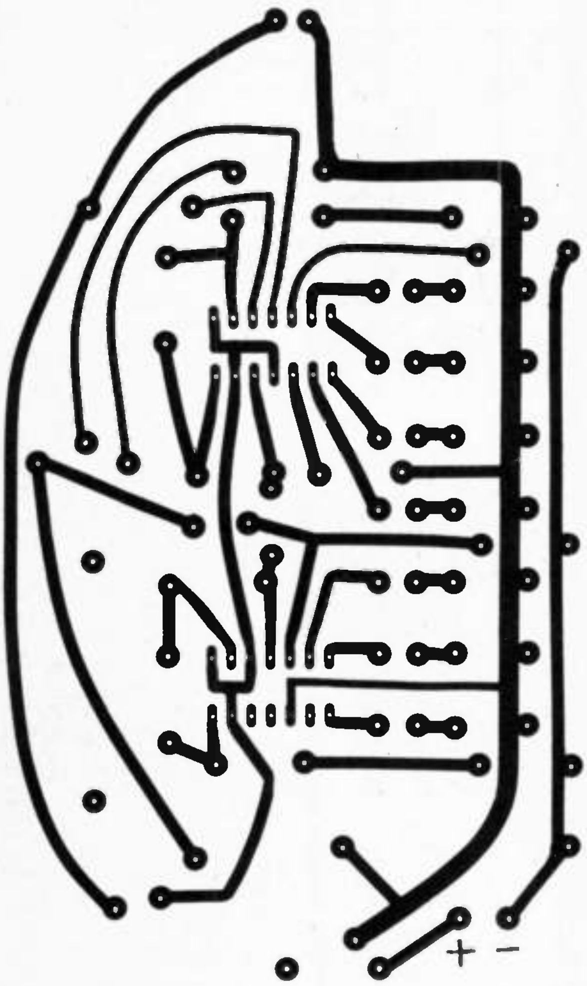
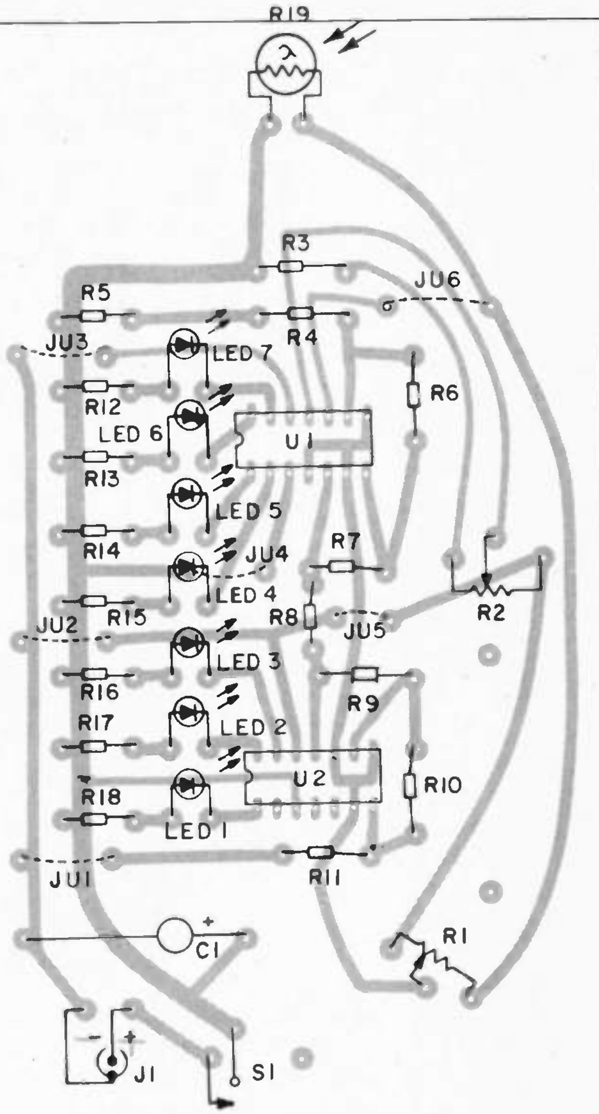
*Units of Veritechnology Electronics Corporation. Some retail prices may be slightly higher.

CIRCLE 5 ON READER SERVICE COUPON



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.

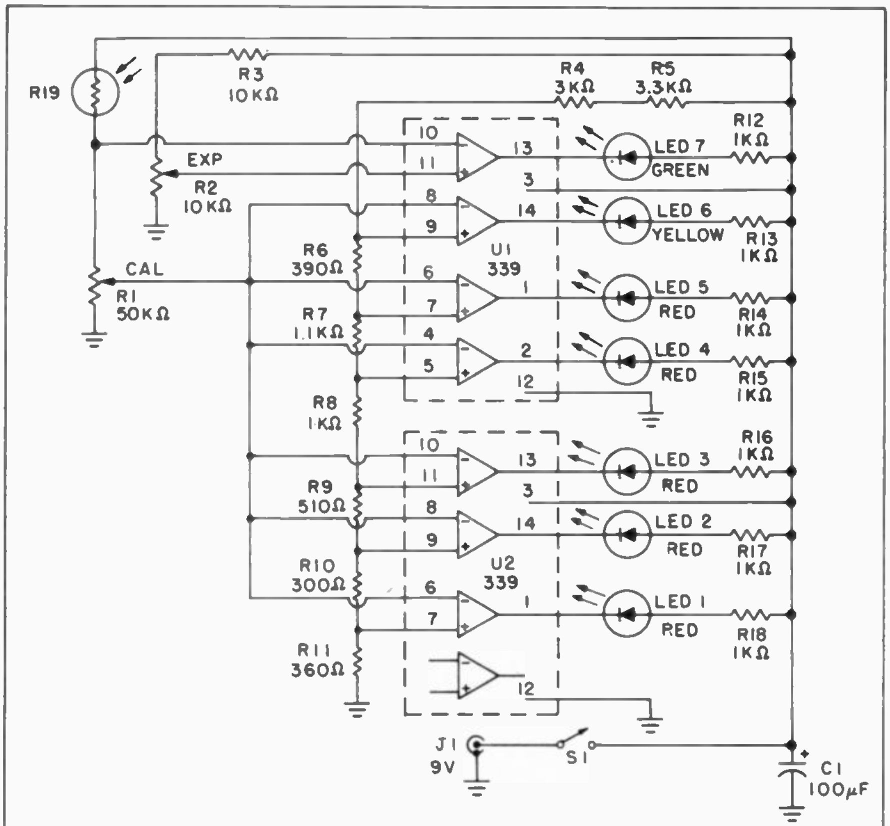
The cabinet *must* be 2¾-3 inches high. No substitute can be used for R19; any other photoresistor will give the user completely erroneous contrast measurements.

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.

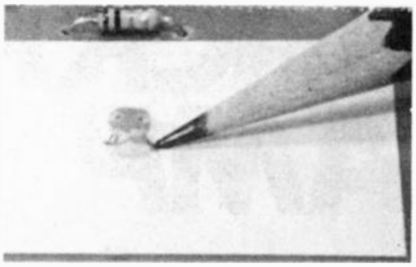
Check It Out. Under normal room lighting, set CAL control R1 fully counter clockwise. Set EXP control R2



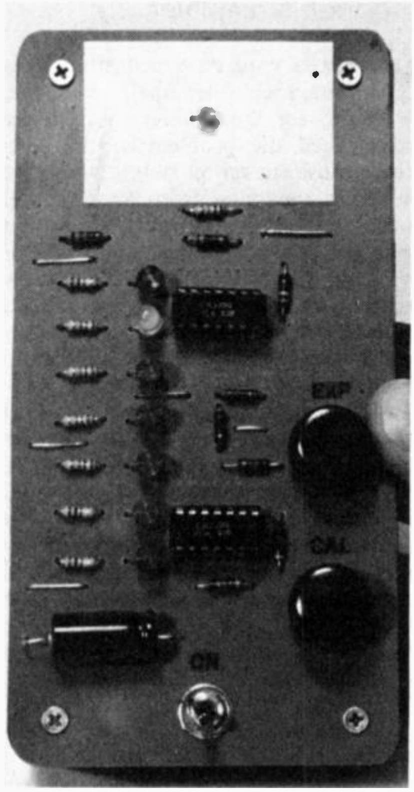
PARTS LIST FOR PHOTOMETER

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

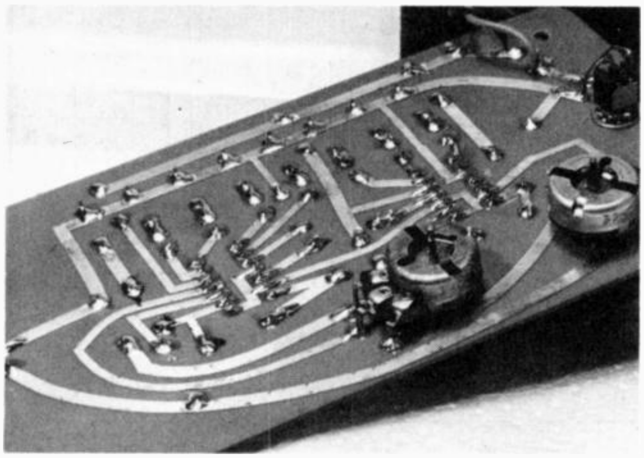
Misc.—Cabinet, 9-volt power adaptor, IC sockets, PC material, solder, wire, hardware, etc. (Photoresistor PRLL9 is available for $5 plus $2 postage and handling per order from Custom Components, Box 153, Malverne, NY 11565. N.Y State residents must add sales tax. No foreign orders except Canada. Canadian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

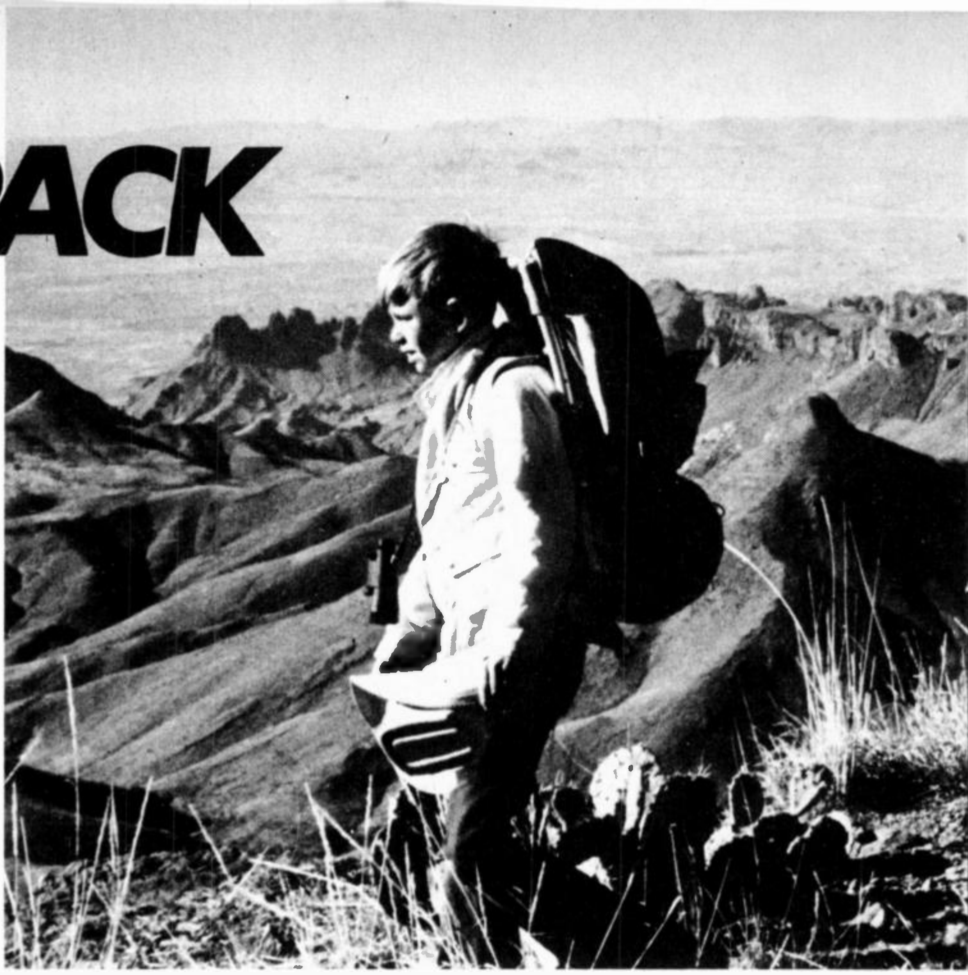
fully clockwise. Turn the Photometer on. Cover R19 with your thumb; all LEDs should be out.

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. ■

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.

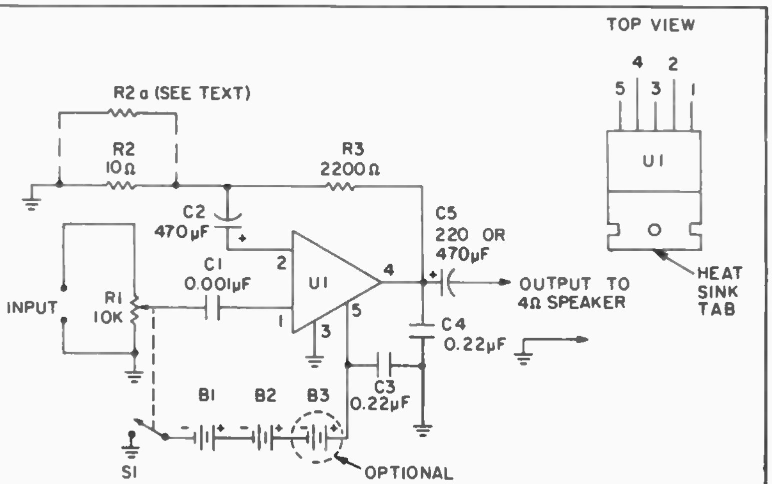
The Circuit. The Backpack Amp is assembled on a printed circuit board measuring 2¾ by 3⅝-inches. All active components which make up the preamplifier and power amplifier are contained in a single LM383T integrated circuit, which is available from Radio Shack. The resistor and capacitor values are considerably 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 7/8 by 1¼-inch. Using the long dimension, bend a 5/8-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.)

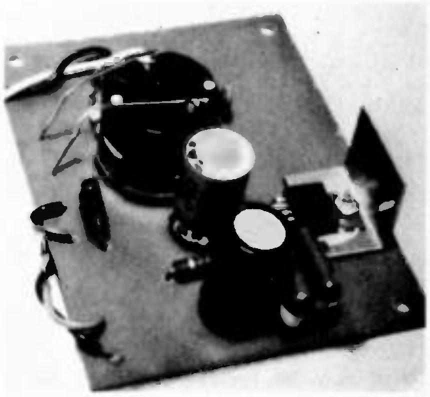
Using long-nose pliers, bend U1's leads to correspond with the holes in the PC board. To avoid shorts, the leads are offset: Nos. 1, 3 and 5 are close to the IC body; Nos. 2 and 4 are bent about ½-inch away from the body.

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.

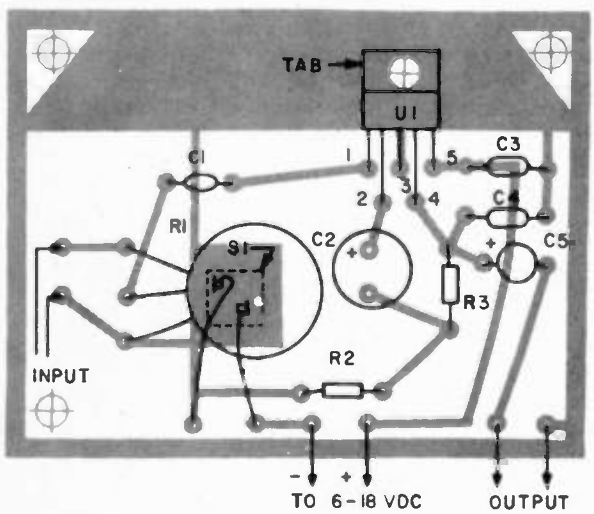
Installation. The Backpack Amp can be installed in any cabinet you prefer. (Note that it has a three-hole mounting.) If you can possibly locate a *potentiometer bushing extender,* which appears and then disappears in the marketplace from time to time, you can mount the amp with a single nut around the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

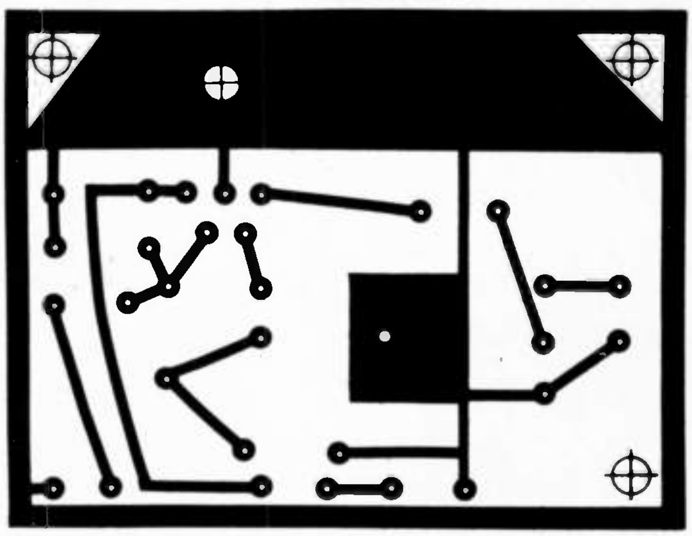
When it's all done, you and your ARP can head for the hills and commune with Mother Nature to your heart's content. ■



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



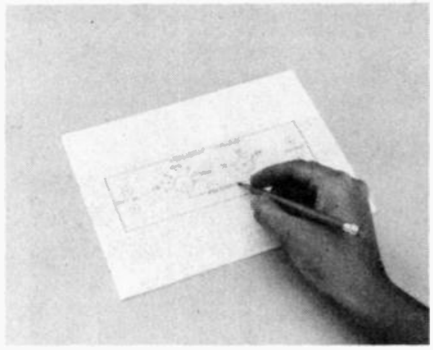
The component placement guide above shows the SPST switch mounted on the back of volume control R1 (dotted line box). External switch can be substituted for R1/S1.



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.

1. Why not build projects you can be proud of, in appearance as well as circuit design? It is neither difficult nor expensive as you'll note when you follow this unit on a step-by-step journey from a blank, machined panel to real artistic beauty.

2. You will need spray and brush-on protective coating, plastic tape, various types of rub-on lettering and designs, and a burnishing tool (the white cylinder) to effect the transfer of the letters from the carrier sheet to a project's front panel.



3. You can't fashion it if you have never seen it before—at least seen it on paper. First, make a sketch and work on the arrangement until you are quite satisfied with it. Using the quadrille paper, as pictured here, makes the job easier.

LOVE THAT

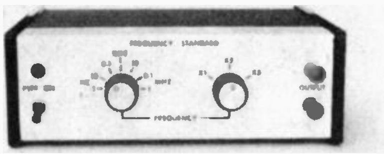
Press-on decals will turn

When you give birth to an electronic project, don't send it into the world illiterate. As shown in this article, it's easy to apply lettering and designs to give your projects a professional appearance, as well as for functional reasons. This is accomplished by using a product called *rub-on lettering* (or *dry-transfer lettering*), which consists of letters, numbers, or designs with an adhesive on their back side so that they can be affixed to a panel or other surface. The letters come attached to the back of a transparent plastic *carrier sheet*, from which they are transferred to the panel by rubbing or *burnishing*. Follow the photos to see how it is done. The process may seem complicated at first, but with a little experience you will find that the steps go quickly.

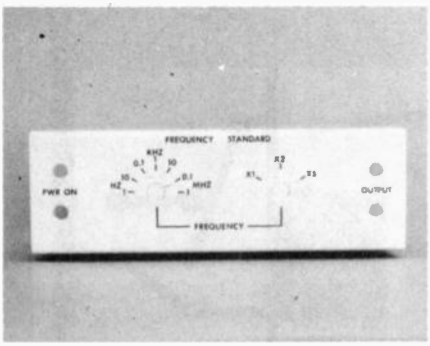
Rub-on lettering is available in various sizes and colors (black and white are the most common). Sets may contain complete words, individual letters or numbers, or a combination of these. Sets consisting of index marks and other designs for rotary switches and dials are also available.

A small set, which should see the average hobbyist through half a dozen projects or more, costs only about two dollars. Your local electronics store probably carries rub-on lettering and related supplies, if not, try the suppliers listed at the end of this article. Rub-on lettering is also available from art, graphic arts, and office supply stores. Although the type they carry is intended primarily for other purposes, it can be used for electronic projects.

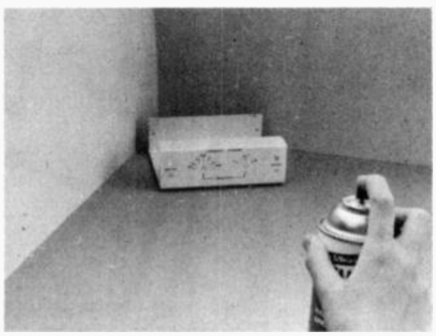
In addition to the lettering and a few household items (cellophane or plastic



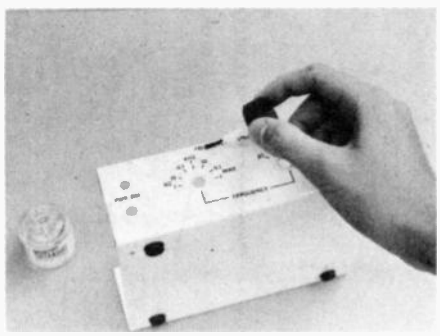
14. And now—the finished project, a delight to the eye! Once you try this method on one of your projects you'll never go back to ugly again. You don't have to be an artist, and it does not add much to the cost. Electronics can be beautiful!



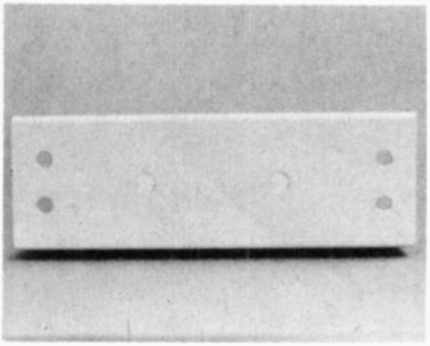
13. Here you see what the panel looks like after the lettering has been completed but before the parts have been mounted. It already has a clean, professional look, more like something out of an assembly-line factory than from your workbench!



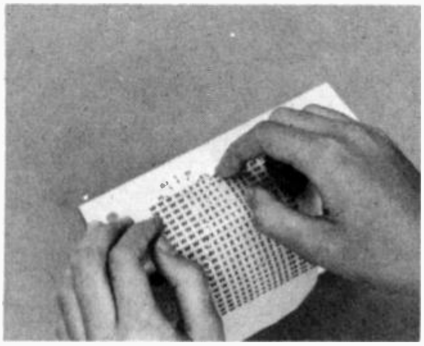
12. You can also buy spray overcoating as pictured here. Spray is more even than the brush-on, but the brush-on can be applied thicker. This method too requires that you carefully check for the compatibility of the overcoat with both letters and panel.



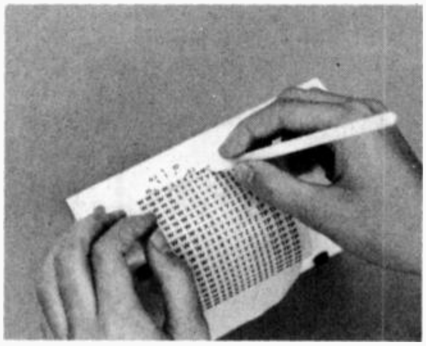
11. You'll want to protect that final panel, and there are two methods you can use. Here we show the brush-on method of overcoating. First, check on a scrap or hidden area for compatibility with both rub-on lettering and the panel finish.



4. Once you know where it is all going to be at, you can begin to machine the panel. Follow your quadrille-paper layout carefully and don't make last minute, poorly planned changes! Then make certain the panel is clean and dry and free of any imperfection.



5. Locate the desired letter (or word, or design) on the carrier sheet, place it in position on the panel and press the sheet against the panel. The back of the sheet is tacky so it will not easily slip. Here we have already applied some of the letters.



6. Transfer the letter to the panel by use of the burnishing tool. Rub over the letter several times, increasing the pressure each time until the transfer is complete. As you do this a slight change in the letter's appearance verifies transfer is working.

LETTERING

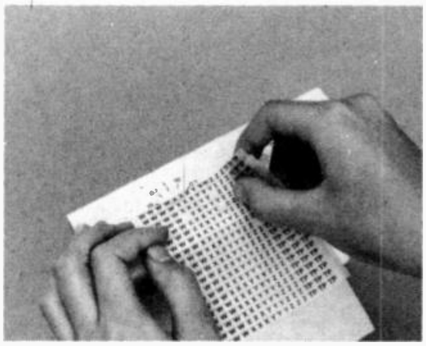
projects into works of art

tape, ruler, paper, etc.), you will need a blunt-pointed tool to burnish the letters into place. Tools for this purpose can be obtained where art supplies are sold, or you may be able to find something around the house that will serve the purpose. However, a pencil or ballpoint pen tends to be too sharp, and may also obscure the lettering. The burnishing tool shown in the photos was made from ¼-inch diameter plastic rod sanded round on one end and tapered and rounded to about ⅛-inch diameter on the other end. It could also have been made from a wood dowel.

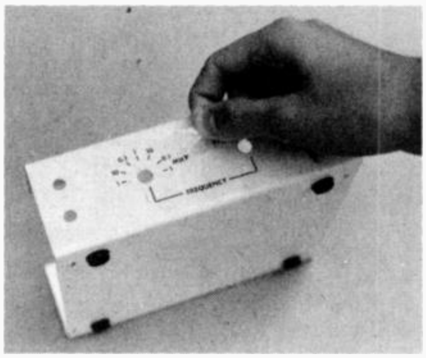
The panel or other surface to which you intend to apply the lettering should be clean and dry. Any oil, grease, dirt, or moisture will hinder adhesion of the lettering. Soap and water can be used for cleaning, except on bare aluminum. Rinse and dry the panel thoroughly; after wiping off excess water, use a heater or warm oven to dry. Solvents can also be used for cleaning; test first for compatibility with the finish. *Do not* use a heater or oven with solvents. To clean bare aluminum, solvents can be used, or chemical preparations for this purpose are available from paint and hardware stores. After cleaning do not touch the areas where you will apply the lettering.

If you use solvents or other chemicals be sure to follow the manufacturer's directions and particularly observe the appropriate safety precautions. Spend a little extra time and effort to be safe and minimize the possibility of injury.

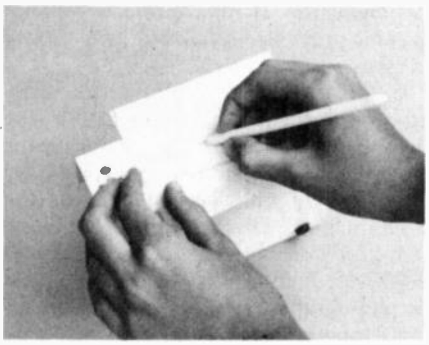
After you have applied the lettering, you will probably want to protect it with a brush-on spray coating. ■



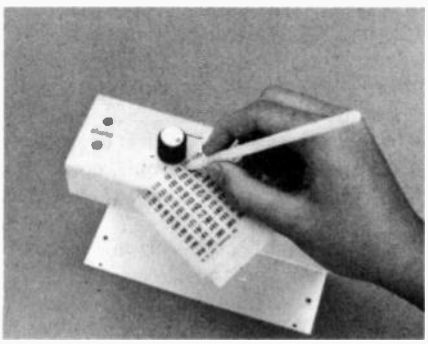
7. Peel the carrier sheet away from the panel, starting from one end and holding the other end in position against the panel. Check that the letter has completely transferred. If it has not, all you have to do is lay the sheet back down and burnish over.



8. Make a mistake? It's no disaster. To remove an error, press ordinary cellophane or plastic tape over the offending letter and then simply lift it off. This may be repeated if needed, until all is clear. An eraser may also be used.



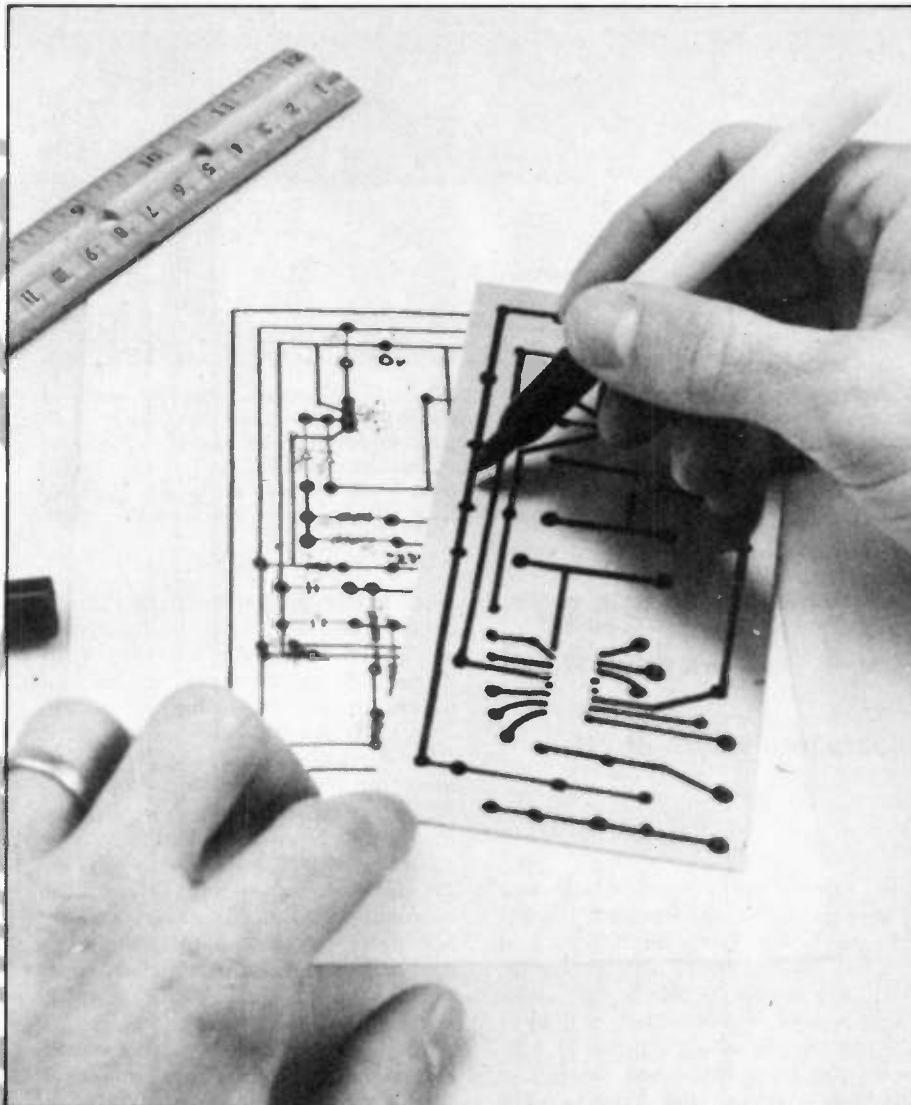
10. Once all lettering is applied, and you are satisfied with it, burnish one more time. Use a backing sheet of slick paper, so the lettering will not stick to the backing sheet, and go over the whole panel. Use the blunt end of the burnishing rod.



9. Positioning index marks is done by temporarily mounting both a switch and its knob. Turn the knob to each position and align the mark with the pointer. As you see here, the number "1" makes a good index mark, certain other letters may be used.

CIRCUIT BOARD ETCHING

A step-by-step guide to making project boards



WHILE PERFORATED PROJECT BOARDS, or perf boards, are relatively cheap and easily obtained, a circuit board etched for its particular usage will provide neater, more professional results. Projects with the circuitry foundation of an etched board will be less prone to vibration damages as well as have greater impact resistance—in all, an etched board provides sturdier construction and greater safeguards.

In addition to the quality of construction, in contrast to perf boards, etching lessens the chances of undesirable oscillations caused by crossed or jumpered output signal wires producing feedback in sensitive component elements. Also, electrical noise interference caused by spurious radiations in the circuit's environment are more easily suppressed as a result of the close proximity of ground and voltage supply leads. Decoupling capacitors can easily span supply and ground distribution lines with correct board layout.

Only the etching process will be discussed in this article. The actual circuit board layout should be considered carefully and fully in advance.

Materials. The materials required for board etching can be found in nearby electronic retail stores, and the supplies, once purchased, should last through a number of etchings. A list of the materials needed includes:

1. Copper Clad Board.
2. Etchant Solution.
3. Resist Pen.
4. Shallow Pan.
5. Heat Source.
6. Template.
7. Drill Bits.

1. Copper-Clad Board. For good results on initial etchings, use boards with copper coating on one side only. A little experience is best before attempting double-sided boards. As for board dimensions, any convenient thickness or size will do depending upon the individual project. Copper-clad boards can easily be cut to fit exact measurements with a fine-toothed saw such as a hacksaw.

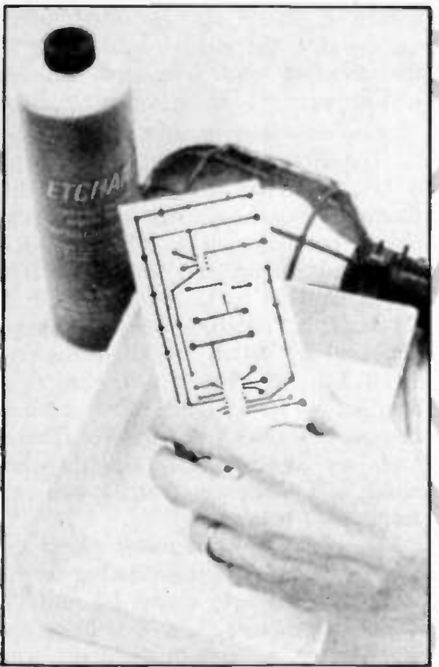
2. Etchant Solution. There is a variety of etchant solutions currently on the market, both in crystal form and already mixed. An inexpensive, pre-mixed solution of ferric chloride is good for a starter; it conveniently provides a uniform end product. Although the solution used during an etching (several boards may be etched at once) cannot be reused, the bottles of solution commercially available contain enough fluid for a number of board projects.

3. Resist Pen. Most electronic retail outlets have on stock pens specially designed for circuit board etching. However, most discount or five-and-dime stores sell the Sanfords Sharpie pen, or one like it, guaranteed to write on metal, plastic, etc. for one-quarter to one-half the price of the special resist pens. Both types give good service.

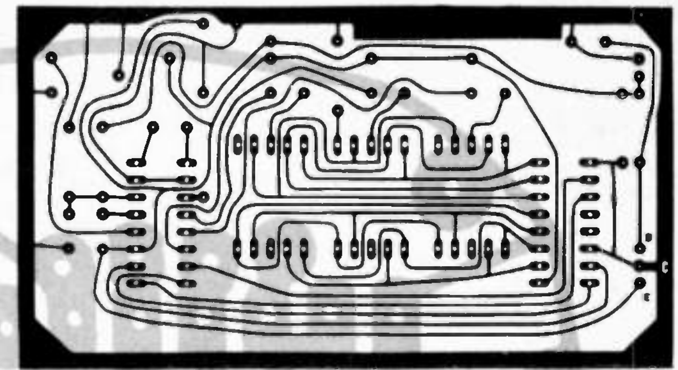
4. Shallow Pan. Do not use metal pans to etch in, because the etchant will act on the pan metal. Instead, use a glass or plastic pan close to board size to conserve the etchant solution. An inexpensive set of plastic photographic developing trays would be a good investment for etching projects. Photographic trays are available in a variety of sizes.

5. Heat Source. A thermostatically controlled heat lamp would be the ideal heat source to be used during the etching process. However, an ordinary 60-watt light bulb suspended near the solution pan will accomplish the same thing for less expense. A droplight with a 60-watt bulb works well. Use a plastic photographic darkroom thermometer for temperature checking. In fact, with warm (60°F or above) air temperature, simply placing the plastic tray in warm water will provide the needed heat during the etching process.

6. Template. A template, or exact board layout, can be hand drawn. Often



This photo shows all of the vital items needed to etch custom-made circuit boards.



Some practice is needed to etch involved circuit boards like this one, but even a board of this complexity is within reach of hobbyist who is willing to learn etching.

it is provided in electronic project plans.

7. Drill Bits. For board projects, get drill bits size 1/16-inch and 1/32-inch. Bits in these sizes can be found in most hardware or hobby stores.

Marking The Board. A board layout, or template, provided with an electronic project may already be drawn in reverse. This is necessary, since circuit designs are drawn from the component side of the board, leaving the copper clad rear of the board an exact reverse.

If the design to be etched onto the circuit board is an original hand drawn layout, though, a reversed drawing can be easily accomplished by placing a carbon ink side up beneath the drawing and retracing the lines of the layout topside. When the carbon is removed, an exact reverse remains on the back of the original drawing. This carbon reverse is the template for etching. Before transferring the template drawing to the copper clad board, *lightly* rub the copper with a steel wool pad, then rinse and dry. Cleaning the board in this way permits the resist ink to adhere better.

Taking the template, punch small holes in the paper at each connection point. Place the template over the copper and use the resist pen to mark each connection point through the holes. Remove the template. If the circuit is simple, draw the rest of the template drawing onto the board. If lines are complicated, use a ruler as straightedge.

To get the most accurate results using the resist pen, store the pen with its tip down for several hours prior to use. When drawing on the copper, use long smooth lines and stop marking only at connecting points, otherwise there will be fine lines in the resist ink that will cause hairline cracks in the finished product. Do not back-up while marking or retrace lines for best results. Wide lines can be drawn by using the side of the pen point. Two lines drawn side by side can produce a wide area, but generally the end product is better using one mark. When mistakes occur, erase with a pencil eraser. Store the resist pen point down to prevent the point from drying between usages.

Etching. The etchant itself is an acid and therefore handle the solution with care. Take the same precautions necessary when handling any acid. Do not store the fluid where it is accessible to children. If during the etching process the solution splashes into the eyes, flush the affected area with water immediately and see a physician. Avoid body contact with the fluid and wash well if the etchant touches skin.

Pour only enough etchant needed to cover the resist marked board to a depth of ⅛-inch or slightly greater into the shallow tray. Use the etchant solution in a well ventilated room, and avoid breathing the fumes. Place the heatlamp or light bulb near the solution to raise the fluid temperature to approximately 100°F—the exact degree of temperature is not critical. Carefully slide the board into the etchant, copper side up. Gently agitate the solution every few minutes. By using the proper temperature of near 100°F, the etching should be completed within 15 minutes or so. Keep a close eye on the board and remove immediately upon completion of the etching. Tilt the pan carefully to one side to determine if all unwanted copper is gone.

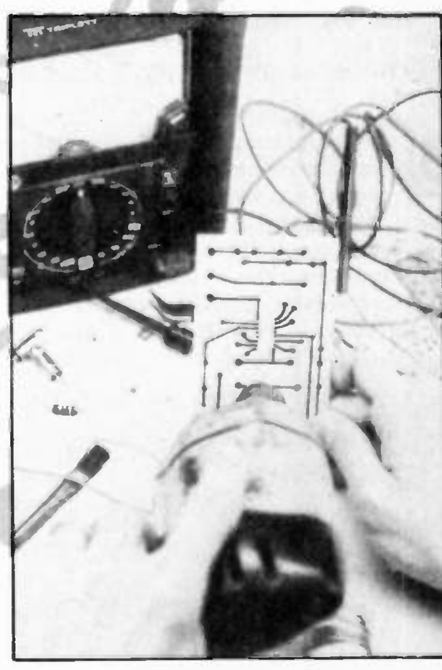
The etching process can be undertaken with success using no heat source if the etchant solution temperature is above 60°F. The process takes approximately one hour with no applied heat, but the results are not as certain.

Finishing The Board. After the etching process has been completed, pour off the solution and rinse the board well under running water. Do not pour the used solution back into the solution bottle with unused etchant—this contaminates the entire contents of the bottle. To remove the resist ink, *gently* rub with a steel wool pad. Rinse, then dry the etched board.

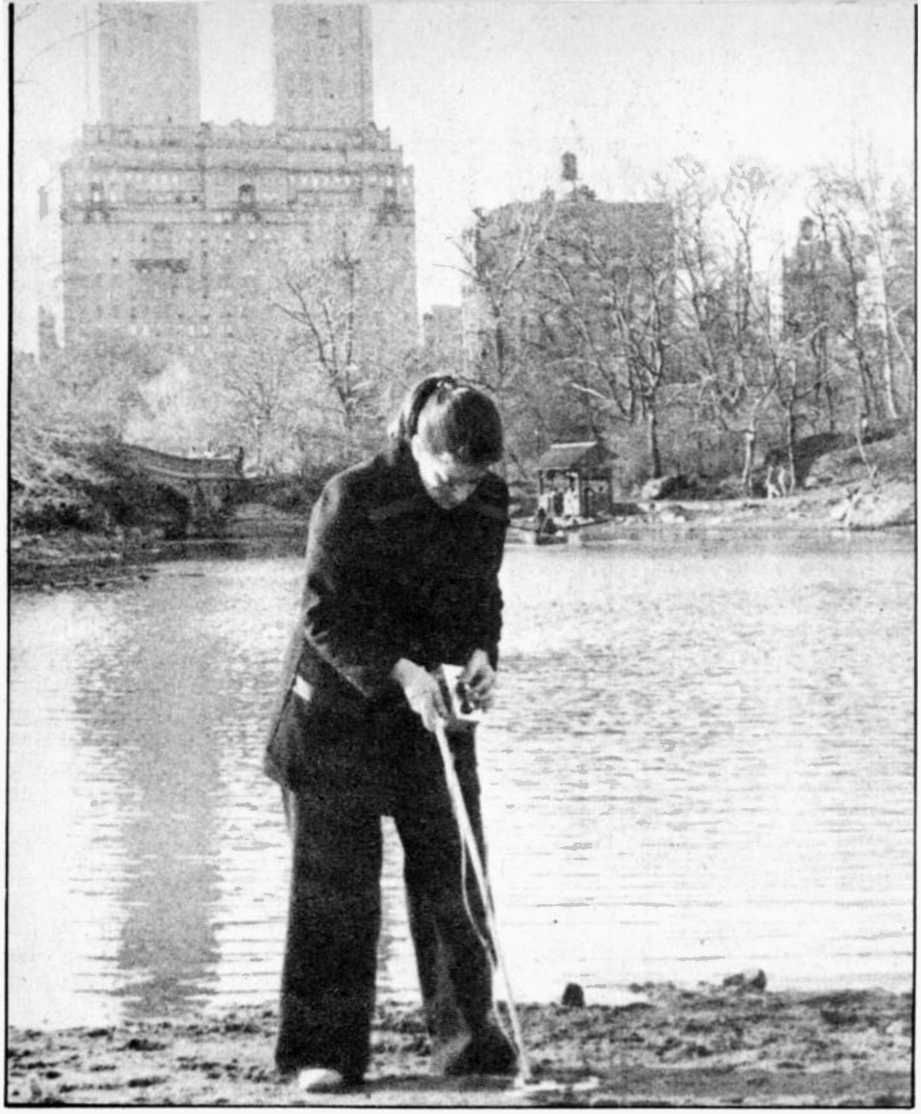
Drill holes for connection wires with a 1/16-inch drill bit. For transistor or other component leads, use a bit size of 1/32-inch. To use these tiny bits in an ordinary hand drill, wrap the bit shank with masking tape before inserting it into the drill.

During etching, hairline cracks may form in critical paths on the board. Repair these cracks with solder before attaching components to the board.

The etched circuit board is now ready for whatever project you have in mind. ■



The final step is drilling holes to mount components. Use a 1/16- or 1/32-inch bit.



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.

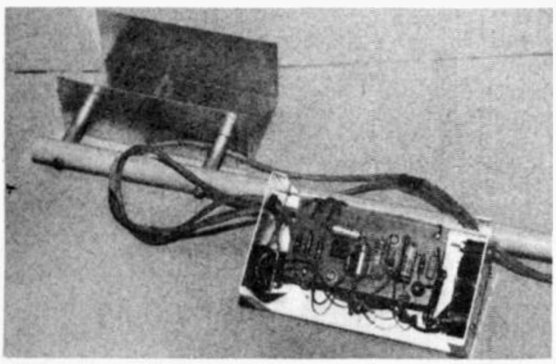
Operational Principle. *Houndog's* "nose" consists of three large inductance coils which, when placed in proximity with a conductive metal will exhibit a change in their total inductance value, the change being read by the circuitry and translated into an audible signal. In short, when *Houndog* "barks,"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

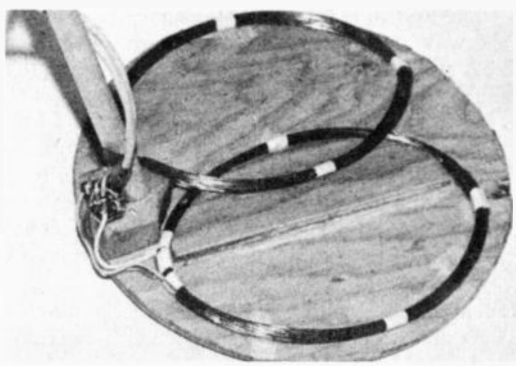
When a conductive metal enters the field, it changes the distribution to the effect that the field across L1 and L2 is no longer zero, and a voltage appears across the amplifier's inputs. The coil connections are such that when this condition exists, the positive input voltage is in phase with that of 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).

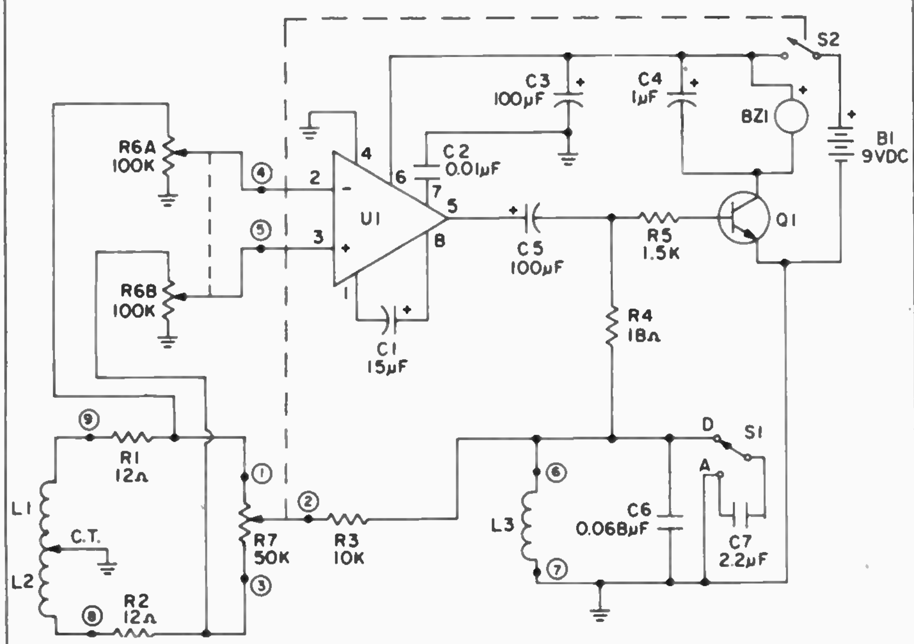
When the coils are completely wound, bind them with tape before removing them from the form. This will help to hold their shape until they are installed on the search head.

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.

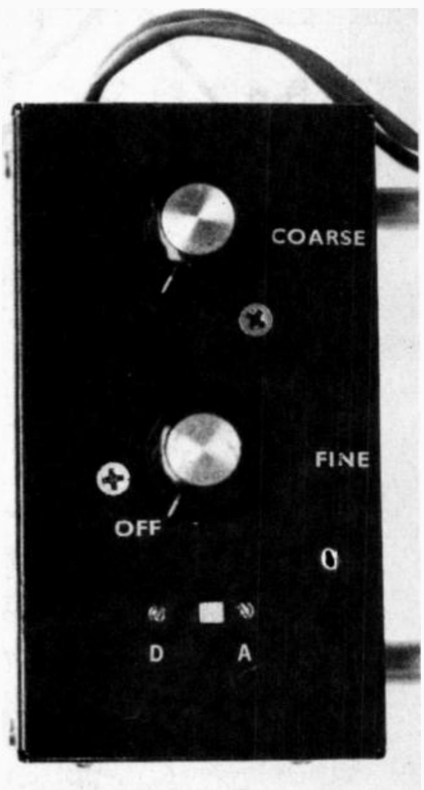
As a final test, return R6A/R6B to the two-thirds position, set R7 just below the point where the buzzer sounds,



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.



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

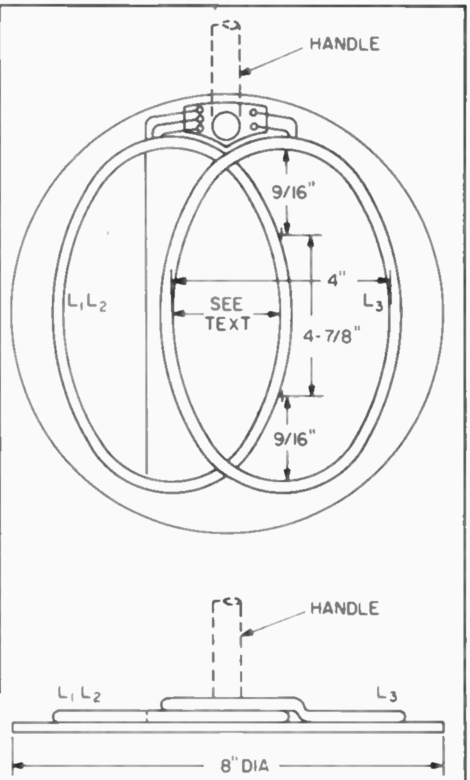
HOUNDOG

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.

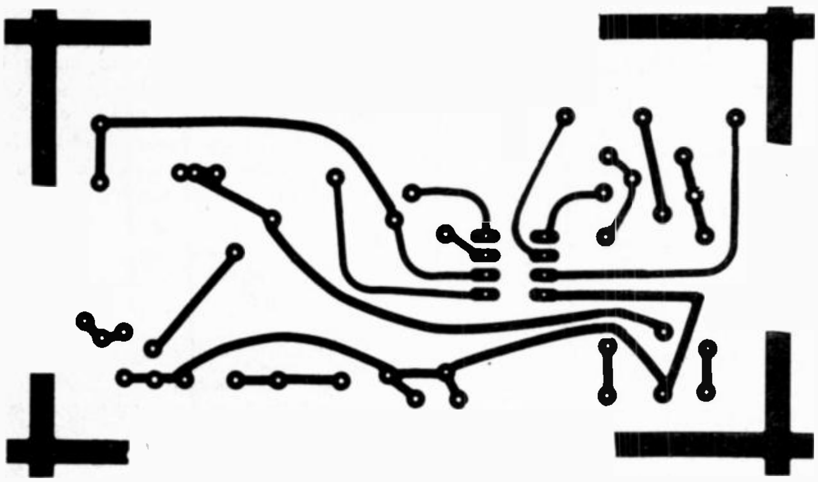
Remember that when conducting these tests, you should be in an area free from the presence of large metallic objects, such as radiators, pipes and ducts, etc. Their presence may cause you to set the sensitivity of R6A/R6B too low, making actual measurements against coins ineffective to the point of believing 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.

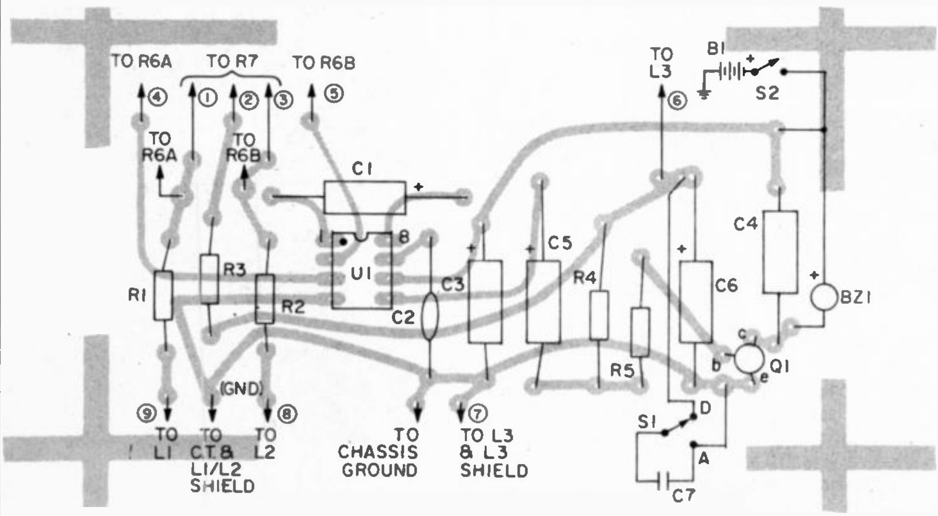
Conclusion. Once you get out of doors with *Houndog*, it might be wise to bury some treasure of your own, and adjust the controls for maximum sensitivity depending upon the type of soil found in your locality. These adjustments will vary from area to area, depending upon soil composition, which is why 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. ■



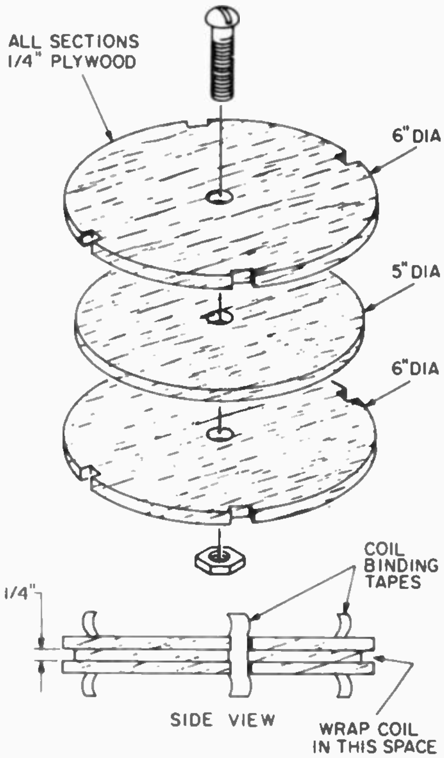
The dimensioning guide for the search head shows you how to bend round coils into the elliptical shape necessary for installation on the search head plywood base.



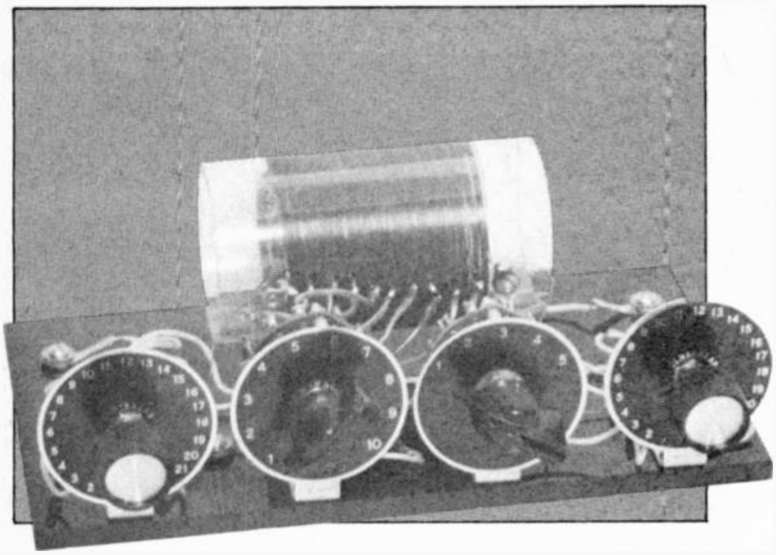
Here is the full scale etching guide for Houndog's PC board.



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.



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.



BCL-SWL ANTENNA TUNER

A perfect match for your antenna

PEAK PERFORMANCE IN a receiver antenna is achieved when it is cut to the proper length for a particular radio band. Since most receivers are used for multiband operation, every antenna is a compromise. However, this compromise is not necessary.

Antenna tuners used with transmitting antennas provide a proper match between the antenna and transmitter for maximum transfer of RF power. A tuner can also be used to match the receiver input to an antenna for efficient operation over the radio bands.

A SWL Tuner. A receiver antenna tuner that may improve your reception is our BCL-SWL Antenna Tuner. The tuner is designed to cover the broadcast band as well as the short waves and it is laid out in breadboard style for easy construction.

The random length single wire antenna, fed to the receiver at one end, has a great range of impedance changes over the radio spectrum. At the low frequency end the impedance is low. At the opposite end it can be several thousand ohms.

Receiver input impedances vary from 50 to 300-ohms. The antenna tuner's basic circuit is a pi-network that can be adjusted to match the antenna's impedance to the receiver's input impedance. This insures maximum reception.

The tuner's antenna input (J1) impedance and output impedance is adjusted by tuning C1 and C6. (Refer to Schematic 1.) Additional capacity (C2-C3-C4-C5) is paralleled across C6 by switch S2 to better match the receiver input impedance (J3). The taps on coil L1 are selected by S1 enabling the circuit to be resonant at the desired frequency band.

The antenna tuner is built on a 8-inch by 4½-inch by ¼-inch section of plastic. (Refer to the base-plate drawing for lay-out dimensions of the tuner components). The tuning capacitors and switches are installed on metal brackets approximately ½-inch wide by 1½-inch high, with a ½-inch foot.

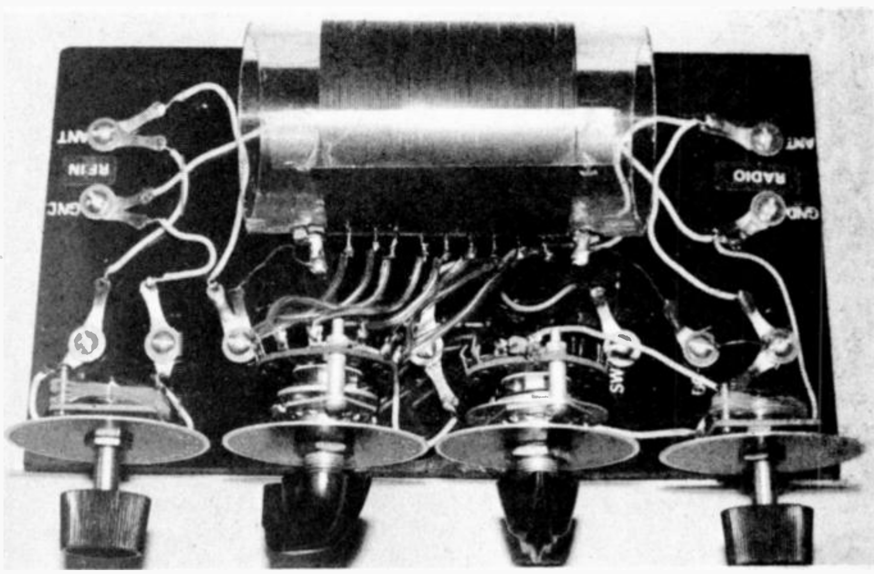
Cut the base-plate to size and mark the component locations. Coil L1 is wound on a 3¾-inch (long) by 2-inch (outside diameter) plastic tube. The thickness of the tube is not critical, but it must be rigid enough for winding the coil. The plastic tube we used has a $\frac{1}{16}$-inch wall.

A Big Lug. A solder lug terminal is mounted ½-inch from the tube's ends. Make a 100 turn coil with number 28 enameled magnetic wire, tapped every 10 turns. Twist the wire together ¼-inch out from the tube, as it is wound, to make the taps.

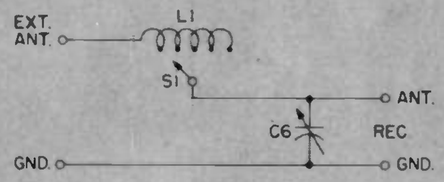
Put a drop of solder on the wire to keep the tap stiff and pointing outward from the tube. Connect the coil ends to the lug terminals. Make sure the enamel on the wire is carefully removed (with sandpaper) before making connections.

Mount L1 on the baseplate with ½-inch spacers. (The taps should face toward the front of the tuner.) Install the remaining components on the baseplate and wire up the tuner as shown in Schematic.

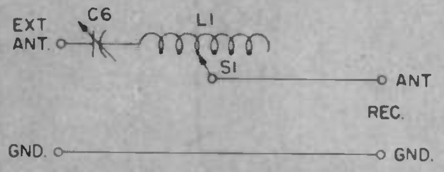
Temporarily connect a clip-lead between the external antenna (J1) and the receiver antenna terminal (J3).



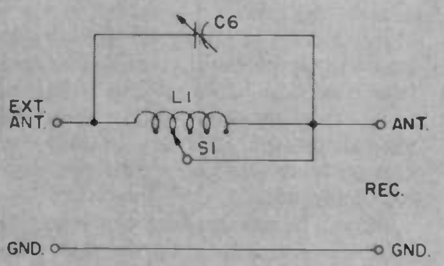
The self wound induction coil, L1, is tapped at nine different points. By doing this, the operator is able to change the inductance of the coil and properly match an antenna to the frequency that a set is receiving. Can be used for SW.



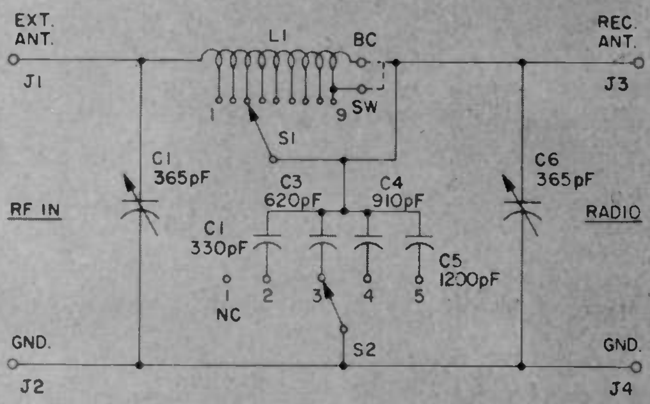
"L" NETWORK



SERIES TUNING



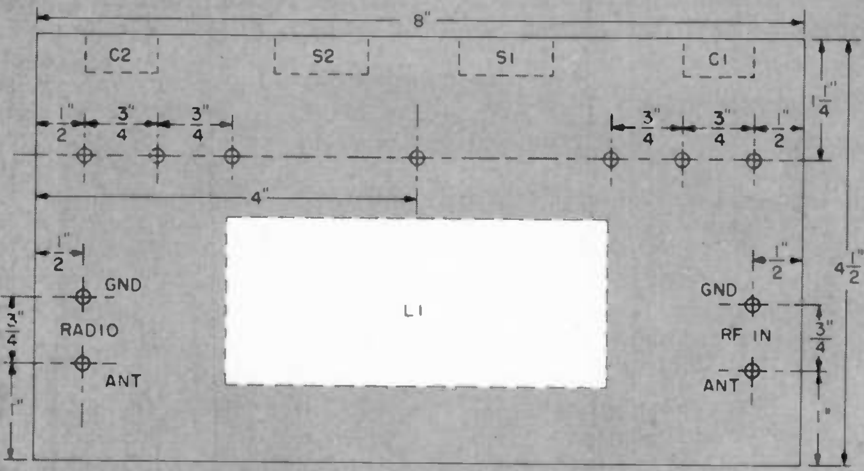
WAVE TRAP



Schematic 1. The upper schematic describes the layout of the antenna tuner. It is comprised entirely of capacitors and inductors. Schematic 2A-C. These three schematics show the hobbyist various things that can be done with the BCL-SWL Antenna Tuner. Try some of the applications yourself.

PARTS LIST FOR BCL-SWL ANTENNA TUNER

C1, C6—365-pF subminiature variable capacitor
C2—330-pF capacitor
C3—620-pF capacitor
C4—910-pF capacitor
C5—1200-pF capacitor
L1—See Text
S1—Single pole, 10 position rotary switch
S2—Single pole, six position rotary switch
Misc.—8-inch by 4½-inch by ¼-inch section of black plastic, 3¾-inch long by 2-inch diameter plastic tube, #28 enameled magnetic wire, 6-32 machine screws, washers, dial plates, hookup wire and solder lugs, metal brackets for mounting switches, hardware, etc.



The base plate drawing that has been given is half scale. When drilling out holes, be sure to carefully observe drilling locations. Any sort of material can be used for the base providing that it is a nonconducting material such as wood or plastic.

Tune the receiver to a radio station and remove the clip-lead. If no stations are heard, tune up on the received background noise. Connect the tuner jumper to either BC or SW position.

Set C1 and C6 to mid-range position. S1 to position 1 (minimum inductance tap) and S2 to position 1 (minimum capacity). Set S1 to each position while listening to the receiver. At each S1 position, switch S2 through the five capacity ranges and tune C1 and C6 as necessary for maximum received signal.

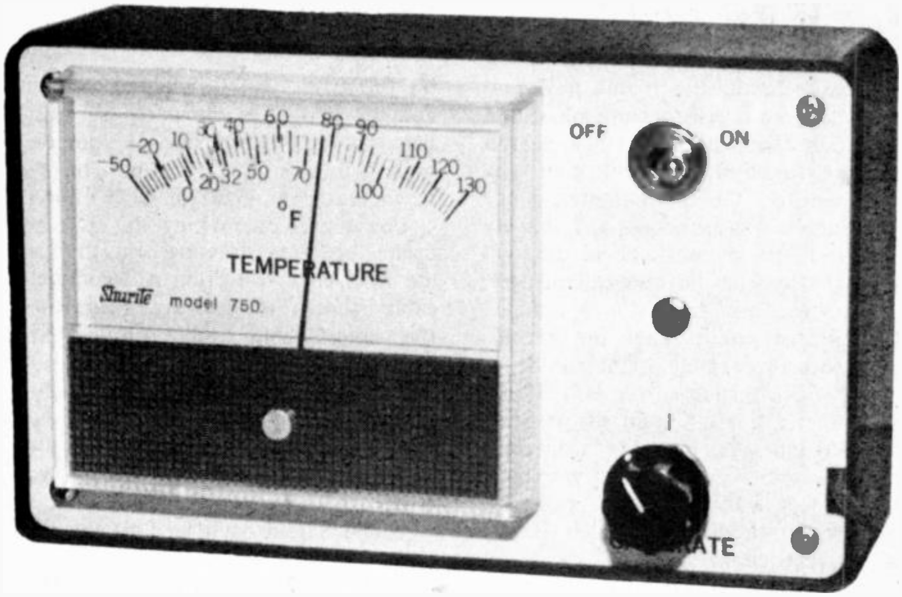
Effective Experiments. You can also use the tuner components for various experiments (refer to Schematics 2A-C and reconnect components):

1) *L Network*—Set S1 through its positions and tune C6.

2) *Series Tuning*—Tune C6 and switch S1 through its positions for maximum signal strength.

3) *Wave Trap*—Tune C6 and switch S1 as necessary to tune out an interfering station.

With this sort of versatility, you can really go far with the BCL-SWL Antenna Tuner. ■



SITRAT

Dig Into Your Junk Box and Build This SIngle TRAnsistor 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!

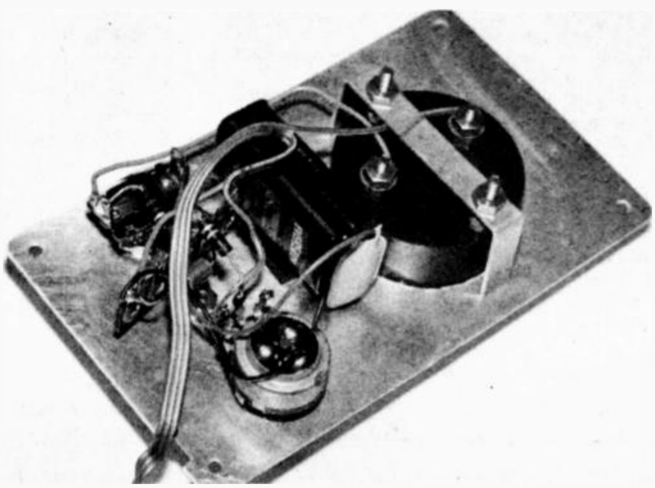
For those who desire a little more insight into this thermometer, notice that the base current flows through R1. Since R1 is a potentiometer we can set the transistor's base current to some specific value by just turning R1's knob. By definition, a transistor's collector current is just its base current 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 × 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 × 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

SITRAT

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.

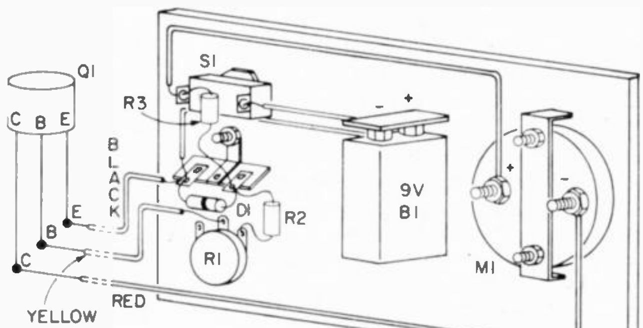
For details on making the transistor probe, see line drawings on this and the next page. First cut a 3-conductor cable, shown in drawing. Strip away the outer cable and push spaghetti sleeving up the three inner leads as shown. Next, using a heat sink such as an alligator clip, solder the cable's wires 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.

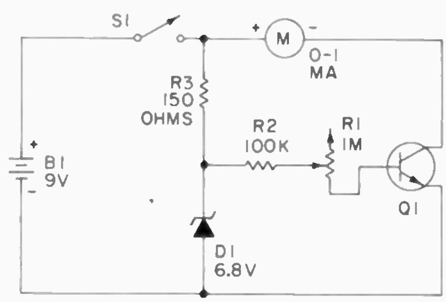
Start out with exactly 120°F water. This can be easily done by first filling the pail with hot water—say 125-135°F —and then waiting until it cools to exactly 120°. Be sure you have the probe in the water for at least a few minutes before you make any adjustments or take any readings. Once you have exactly 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 the middle of the bucket and stir the icy mixture frequently. Wait several minutes 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-

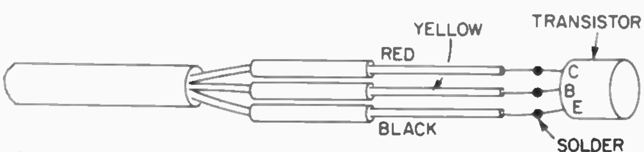
SITRAT line drawing shows simple placement of the few components. Cable to the probe can be almost any length; no electrical problems to worry about. A quick kit!



PARTS LIST FOR SITRAT

B1—9-VDC transistor radio battery
D1—6.8-volt zener diode, ½ watt
M—0 1-mA pane 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.

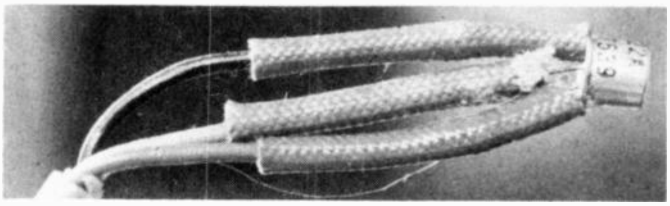


Photo of probe just before encapsulating in putty. Don't forget to use the insulator sleeves, and spray with acrylic, as the text directs you to.

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.

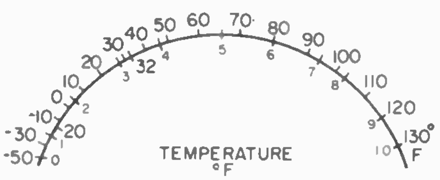
So now you have a beautiful curve. What now? If you are acquainted with curves on graph paper, simply read off the current readings that correspond to every temperature that is divisible by 10 (e.g. 120, 110, 100, 90 etc.) and mark the information down in a table. We assume, that you aren't acquainted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

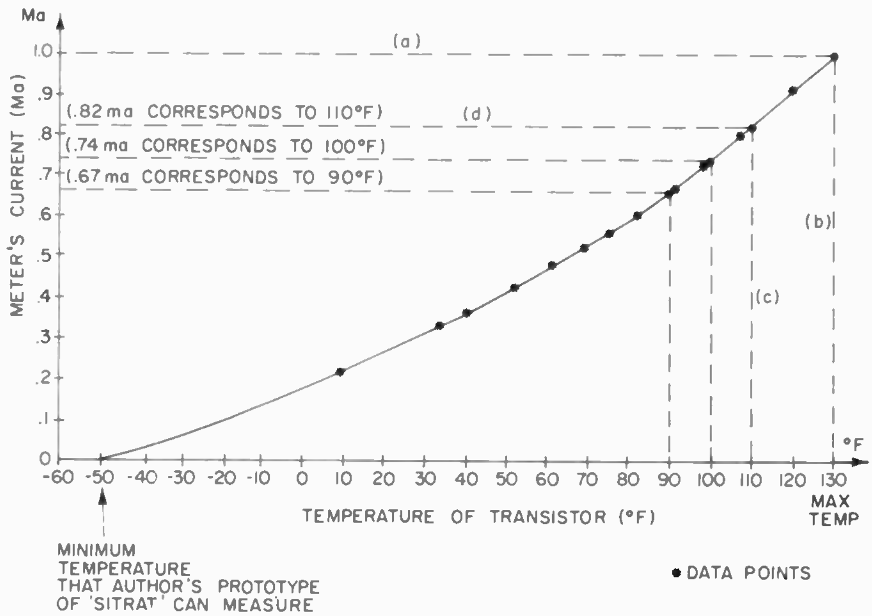
Now to find how low a temperature your SITRAT can measure. Finding the minimum temperature is a bit simpler. First, make sure you have continued extrapolating the smooth curve until it hits the horizontal axis (0 ma point). Mark down the temperature where this extrapolated curve hits the horizontal axis.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

(Continued on page 100)

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.

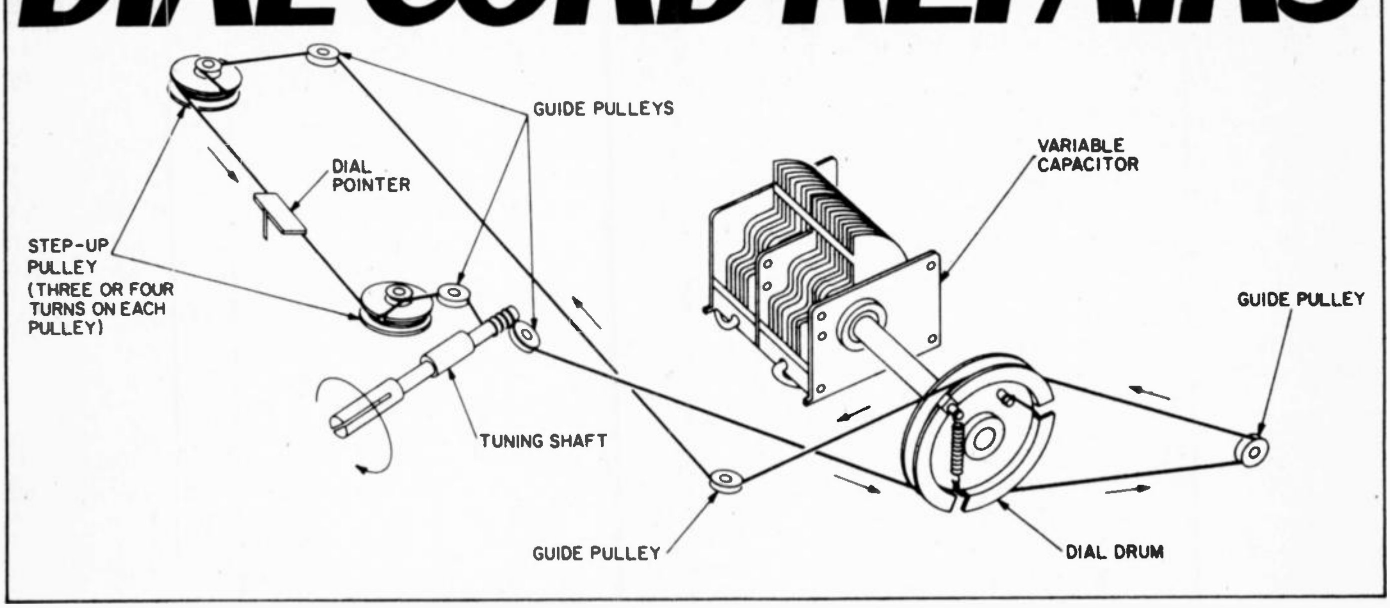


The dial plate of milliammeter, converted to degrees Fahrenheit. Of all the aspects of assembling SITRAT, this is the most time consuming, since you will have to calibrate dial according to your own specific components. Follow text with real care!



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.

DIAL CORD REPAIRS



The old pro shows how to get those radio dials back in line

WHO EVER SAID THAT REPLACING a dial cord was quick and easy? Probably someone who has never had to do it. That simple little repair can quickly turn into a disaster, and if you want to avoid dial-cord disasters then read on. The photos and text should untangle just about any problem.

When you tune in a radio station the dial pointer should end up exactly at the right spot on the dial. To do this the dial pointer is linked to the variable tuning capacitor by a dial cord. When one moves 500 kHz so does the other. It's a simple, straightforward system but once in a while things go wrong.

Slip-Slide, Slipping Dial. Most dial cord slippage occurs at the tuning control knob and shaft (Fig. 1). If the dial cord sticks at one end and won't move or slides erratically across the dial assembly, suspect slippage at the tuning control shaft area. Either the dial cord has slipped off the tuning pulley, become stretched or is almost broken.

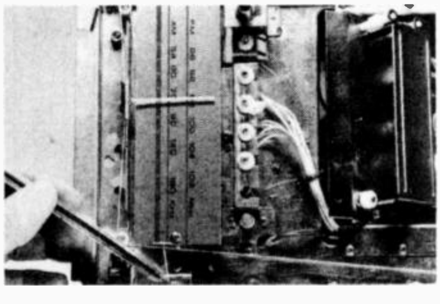


Fig. 1. The base of the tuning shaft is the best place to start looking for a source of slippage in the tuning dial cord assembly.

After removing the receiver chassis from the cabinet inspect the dial cord latch-up. Check the dial cord for broken or worn areas. Thumb the small dial spring for tightness and see if the cord is taut. Now turn the tuning shaft and notice where the cord is slipping or has stopped moving.

If the slippage occurs at the tuning shaft and the cord is only stretched, you may take up the slack by cutting off a turn or two on the dial spring. Replace the spring if necessary and rotate the tuning knob. This will snug up the dial cord. In case the dial cord is still slipping, check for at least three complete turns of cord around the tuning shaft. It's possible someone tried to rewind the dial cord and didn't put enough turns around the shaft. You can stop stubborn shaft slippage with liquid rosin (Fig. 2). In real difficult cases, apply a coat of phono dressing on the tuning shaft and let it dry. The cord may not slip again at this area but be real careful that you don't turn the dial assembly beyond either end or it's possible to snap the dial cord in two.

Repairing the Broken Dial Cord. Locating your favorite station with a broken dial cord is like trying to find a needle in a haystack. Sometimes the tuning capacitor will turn and then snag, but the dial pointer remains in one place. It's best to remove the radio from the cabinet and inspect it.

The dial cord can break almost anywhere (Fig. 3), but most dial cords wear out at the tuning shaft. The dial cord may also break or pull out at the plastic pulley. Sometimes the metal clips on the dial pointer will cut the cord when excessive pressure is applied. But, no matter where the dial cord breaks—replace it; don't waste your time trying to tie a knot.

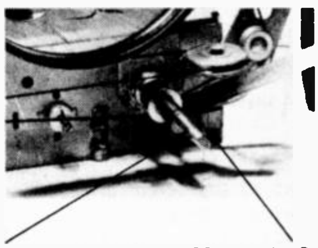


Fig. 2. An application of liquid rosin, usualy found in most TV repair supply shops will help to eradicate the dial cord slippage.

If a dial stringing guide is not handy, try to draw a schematic around and over the pulleys—just the way the dial cord is laying. Take a peek, you may have a dial stringing guide in your service literature. On large, deluxe dials,

Fig. 3. No matter where the dial cord happens to part, don't waste time trying to tie a knot in the cord. Replace cord entirely with a new one.

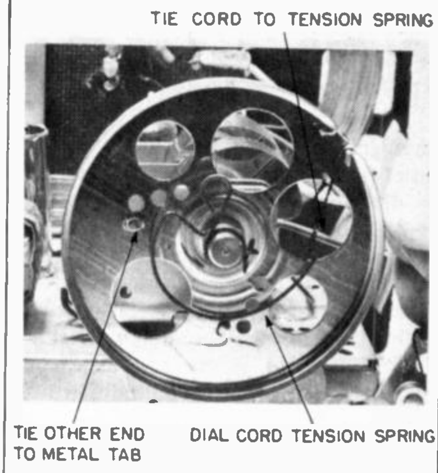


Fig. 5. Start the re-stringing by securing the cord to a tab or hole on the drum. End by securing the cord to the tension spring.

it's best to obtain a stringing guide before attempting the job.

Remember, when the tuning shaft is rotated the dial pointer must move in the same direction. If you start out wrong you may have to rewind the dial drum or reverse the dial procedure at the tuning shaft. Here (Fig. 4) is typical a dial stringing guide. Notice how the arrows and numbers indicate the method of restringing in the correct direction. Dial cord stringing is easy with these simple directions.

From Start to Finish. After a stringing dial guide or a drawing is made, select the correct size of dial cord. Most of the radio dial cords are either a medium or fine grade. They come in handy hanks or on spools. You may buy them at a radio supply store or local TV shop. Remove the broken dial cord pieces and lay them along side the new dial cord. Cut the dial cord about six inches longer than the two broken pieces. This will give you plenty of cord to complete the dial cord stringing procedure.

Start by tying a loop knot in the end of the cord and tying to a plastic hole or metal clip in the dial drum. Some technicians prefer to first tie the dial cord to the spring and keep it taut while stringing the whole dial assembly (Fig. 5). But I find it best to tie it to a solid point on the dial drum and then string the dial cord around the pulley guides.

On large dial drums, the dial cord may go half way around the drum before taking off to a guide pulley or tuning shaft. With a dial stringing guide, follow the numbers and proceed around the guide pulley, tuning shaft and dial drum assembly. If no direction arrows or numbers are shown on the dial schematic, start at the opposite end where the spring connects to the dial drum. Rotate the tuning capacitor to the end of rotation.

Make sure you have at least three turns around the tuning shaft area. If not, the dial cord may slip. Now finish going around the guide pulleys and at least half-way around the dial drum. If you have wound it correctly you should have about five inches of cord left. If not, double check the schematic.

Now, before tying the cord to the dial spring, hold it tight on the drum and slowly turn the drum and notice the direction of the cord movement. A small piece of masking tape placed upon the dial cord at the dial pointer area may help to show the correct direction. Remember the dial pointer will rotate in the same direction as the tuning shaft. Also, notice the dial pointer will go towards the higher dial number as the plates of the capacitor are unmeshed. When a station is found at 540 kHz the tuning capacitor plates are fully meshed.

With the dial cord moving in the right direction, all we have to do is stretch the dial spring and tie a knot or two. If the dial cord is not moving in the right direction, check the dial stringing guide to see if you started correctly at the dial drum and went around the tuning shaft in the right direction. Sometimes by reversing the direction at the tuning shaft you are back in business.

Now insert the end of the dial cord through the dial spring and pull it tight. Wrap about three turns inside the spring loop to prevent the spring from loosening up and tie a knot. Keep the cord and spring taut at all times. Check to see if the dial cord moves freely across the entire band. If so, tie another knot in the dial cord, at the spring loop, and place a dab of glue at both tied ends of the dial cord. Now install the dial pointer assembly.

Dial Pointer Assembly. Dial pointers

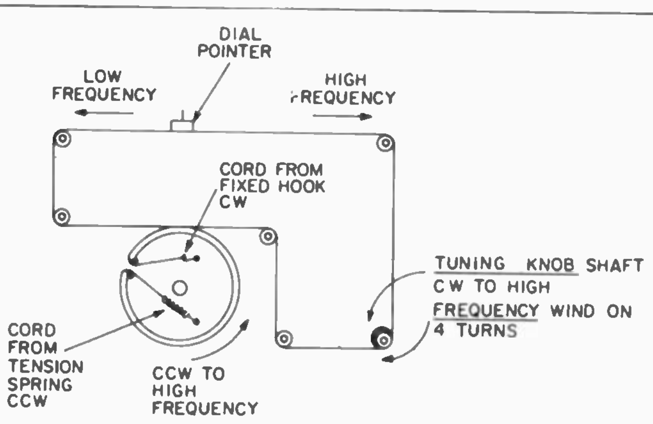


Fig. 4. This is a typical stringing guide. Of course, since almost every maker has its own layouts, this can only serve as a general guide.

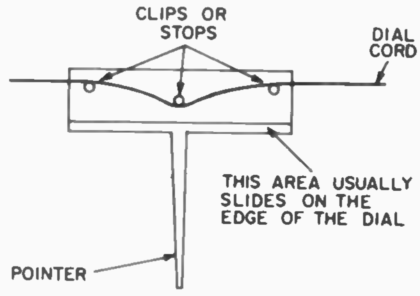


Fig. 6. A drop of plastic cement placed on the stops of the dial pointer will usually prevent the pointer from slipping around.

DIAL CORD

come in all sizes and shapes. Some plastic jobs just slip over the end of the dial shaft, while others connect to the dial cord and slide up and down the dial scale area. You may find the latter are either metal or plastic pointers. Generally, the dial cord is fastened at the back of the dial pointer with clips.

Clean the old grease and dirt from the top track of the dial pointer assembly with alcohol. Install the dial pointer after the dial cord stringing operation is completed. Pull or feed the dial cord around the metal or plastic stops. Then dab on a drop of cement to hold it in place (Fig. 6).

If the plastic dial pointer is broken you can repair it with epoxy cement. On long plastic pointers connect the two broken pieces with a stiff wire such as a single strand of guy cable. A small needle will also do the job by placing the wire or needle at the back of the plastic pointer and pressing it into the plastic pointer area with the tip of a soldering iron. Be careful not to apply a lot of heat or it's possible to damage the plastic pointer.

With long broken metal dial pointers, you can repair them with a stiff piece of number 14 copper wire. To straighten the copper wire, roll it over the work bench under a short piece of 2-by-4. Now scrape off the metal pointer area, apply rosin grease and solder the new pointer to the dial assembly. Smooth down the soldered area with a rat-tail file and touch up the pointer with red enamel spray paint. You may also use a piece of red spaghetti over the new dial pointer.

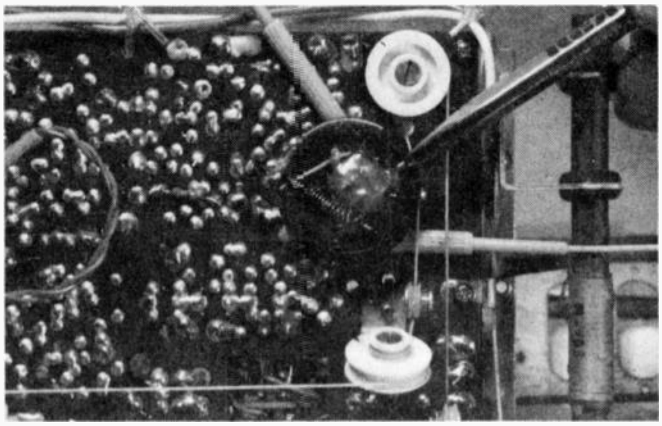


Fig. 8. You can repair a cracked drum without removing the cord by applying epoxy to the drum side facing you, and holding it as it becomes firmly set.

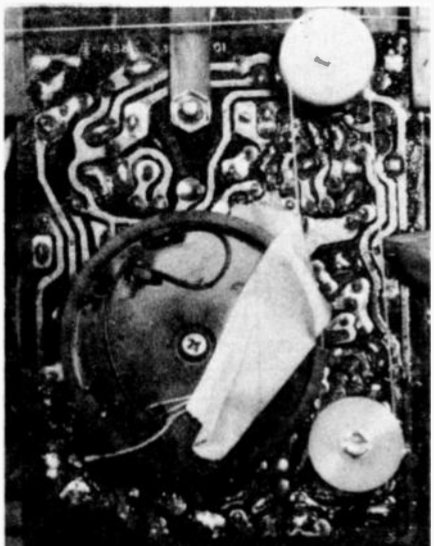


Fig. 7. If the dial drum must be moved during service, lock the cord onto the drum with tape to avoid unwinding the cord.

In case the one or more clips or plastic stops on the back of the dial pointer assembly are broken off, apply a coat of epoxy cement over the dial cord and let set up overnight. Before fastening the dial pointer into position, tune in a local station and clip the dial pointer in place. For instance, if you have a local station at 1400 kHz and another at 540 kHz tune in either station and fasten the dial pointer at the spot. Now, tune to the other station and see if it's right on the nose. You may have to jockey the pointer back and forth a little before cementing into position.

Keeping the Cord on Track. Keep the dial cord on track with masking tape when working upon the dial drum or servicing a component underneath it (Fig. 7). Here in a GE model C4332C radio, the AM oscillator transistor was replaced and the dial drum had to be disconnected to get to the soldered connections. Always apply the tape over the mouth or entrance where the cord enters at the dial drum. The dial cord will remain taut and will not unwind or fly off the guide pulleys.

Take note of the large dial spring. Here a large flat and curved spring keeps the dial cord taut in the dial assembly. Generally, you will find round-coiled springs in most dial cord drums.

(Continued on page 104)

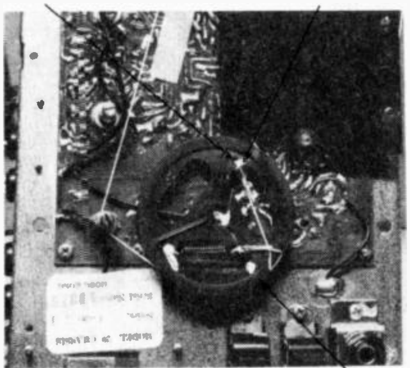


Fig. 9. If the original hole in the drum is broken, simply drill another hole as close as possible to the location of the original.

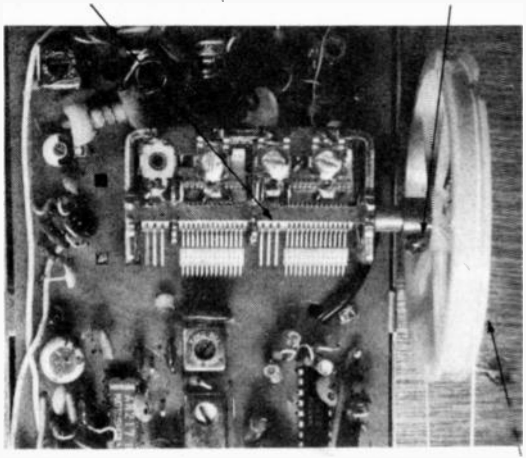
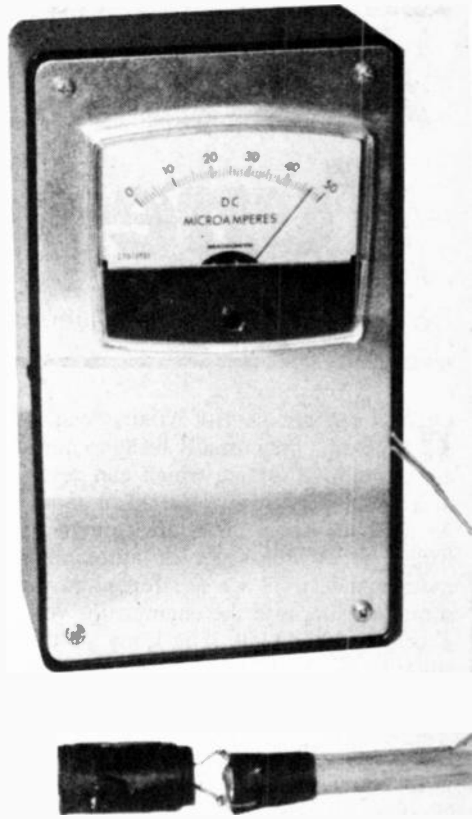


Fig. 10. If the dial pointer seems to hang up at random spots on the dial, suspect a loose set screw on the tuning drum. If the screw continues to work loose, apply a drop of Loctite™ to hold it securely on.



Spark Miss Detector

Check Those Plugs Safely And Easily

YOUR CAR JUST doesn't seem to have it. Passing or accelerating to something of the past. Perhaps one of your spark plugs is missing. But how to check it without getting near high voltage contacts?

With the Spark-Miss Detector, there is no need to get near the ignition cables. A probe will reach into the danger zone while you stand safely behind.

The detector will indicate if the plug is shorted or if the ignition cable is damaged. The meter will indicate if your plugs are dirty and need cleaning.

Let There Be Neon. The circuit is built around a neon bulb used as the sensing element. When a neon bulb is held in the area of a high voltage field, the gas inside the bulb ionizes and glows. The higher the voltage, the brighter the bulb.

The bulb is optically coupled to a photoresistor (R2) whose resistance decreases as the light it receives increases. This neon bulb-photoresistor assembly forms the probe.

The voltage between R1 and R2 (see schematic) depends on the risistance of R2. When the neon bulb is brightly lit, the value of R2 is low and the voltage between R1 and R2 decreases. The change in voltage is amplified by a transistor in the detector.

When the photoresistor senses a spark through the neon bulb, the transistor turns on for an instant and the meter deflects upward. For a six cylinder engine running at 600 rpm, each plug fires 300 times a minute. Therefore, the meter needle deflects five times a second resulting in a bouncing needle that is hard to read.

A capacitor connected across the meter smoothes out these bounces and gives an average reading. If you use a small meter that has little inertia, you might want to increase the value of this capacitor until you are satisfied with the steadiness of the needle. Too large a capacitor will give a slow response.

To use, hold the probe over the spark plug cable. When the plug fires, a voltage is present in the cable. If the plug is fouled or shorted, the voltage in the cable is lower than normal, so the bulb glows dimly and the meter deflection is smaller than normal.

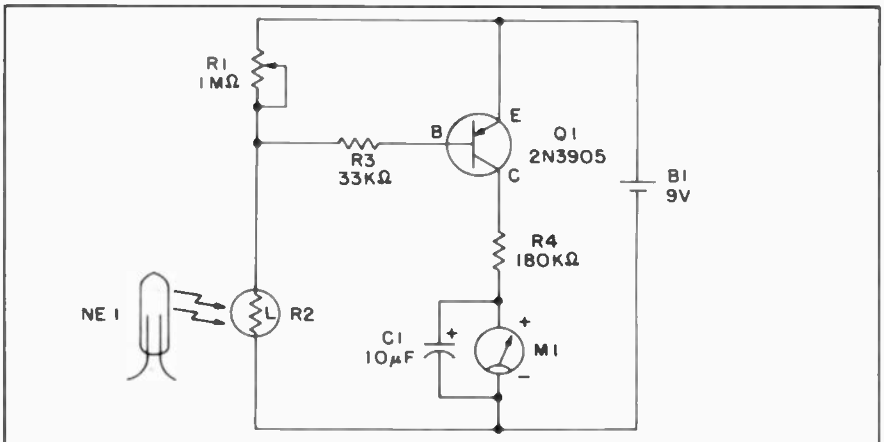
If there is an internal break in the cable, the voltage in the cable (upstream of the break) is high resulting in a larger meter deflection. The location of the break can be determined by moving the probe along the cable.

Pin The Cable. Usually it is best to replace an open cable, but in an emergency it can be repaired. Cut the cable at the break and splice it together using a metal pin.

Component values are not critical so substitutions are possible. Almost any small neon bulb will do, even one without leads. The photoresistor was obtained from a surplus store. These two components are the probe.

To construct the probe, get a hollow 1½-inch plastic or cardboard tube (see Fig. 1) that is closed at one end. The tube must be opaque to block all external light and the inside diameter must be large enough to accommodate the photoresistor. (I used the empty

(Continued on page 98)



PARTS LIST FOR SPARK MISS DETECTOR

B1—9-VDC battery
C1—10-uF, 10-V capacitor
M1—0-50 mA meter
NE—NE-51 neon bulb or similar
Q1—2N3905 PNP transistor or equivalent
R1—1,000,000-ohm potentiometer
R2—Photoresistor, Etco cat. no. 418DR or similar
R3—33,000-ohm, ½-watt resistor, 10%
R4—180,000-ohm, ½-watt resistor, 10%
Misc.—Battery clip, perfboard, hook-up wire, ⅜-in. dowel rod 1-ft. length, plastic tube, suitable enclosure, hardware, etc.

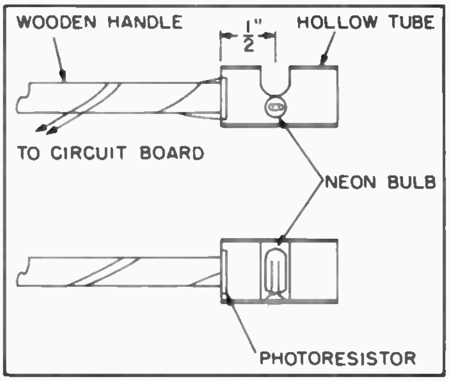


Fig. 1. This is the tip for the Spark Miss Detector. The photocell contained in the end of the stick is the project's key.

A Basic Guide to Using Tune-Up Instruments

Do Your Own Electronic Tune-ups, and Save On Gas and Repairs

WHEN ONE HEARS THE WORDS "engine tune-up," they usually bring to mind an automotive service which can result in a bill approaching $100.00 or more. As a result, many of us are content to forget about this facet of automobile maintenance until we are forced to do something because the engine runs very poorly or not at all. The irony of this situation is that while the engine is in such bad condition, it's costing you money in excessive gasoline consumption. Automobile tune-ups are not complicated, and the investment in parts is so small that there really is no reason why anyone, especially anyone who has a serious interest in electronics, should drive a car that is badly in need of a tune-up. The purpose of this article is to discuss the elements which comprise an engine tune-up, and to discuss some of the various electronic instruments which are being used by both professional and amateur car mechanics alike.

If possible, you should refer to the automobile manufacturer's specifications and tune-up procedures as a supplement to the information provided by this article. At the very least, refer to the tune-up information which is contained on a decal and prominently displayed in the engine compartment of your car. This will give the proper specifications for ignition timing, spark plug gap, and idle speed adjustments.

Tachometer. The basic automobile tune-up instrument is a combination tachometer and dwell meter, which is commonly referred to as a "dwell/tach." This instrument is capable of measuring engine RPM, and in those cars which are not equipped with factory installed electronic ignition, point dwell. (More about dwell later). The more elaborate instruments also include additional functions, such as voltage measurements, resistance measurements, and current measurements. For a small additional cost, some instrument manufacturers have included an alternator test function which determines the condition of the alternator diodes by measuring the level of AC ripple voltage appearing on the alternator output terminal.

The tachometer section of the dwell tach measures engine RPM by responding to the pulses which appear at the distributor side of the ignition coil (negative terminal). This is the point where the sensing lead of the instrument is connected. Referring to Fig. 1, a typical schematic diagram of a conventional (non-electronic) automotive ignition system, note that each time the points open, the collapsing magnetic field of

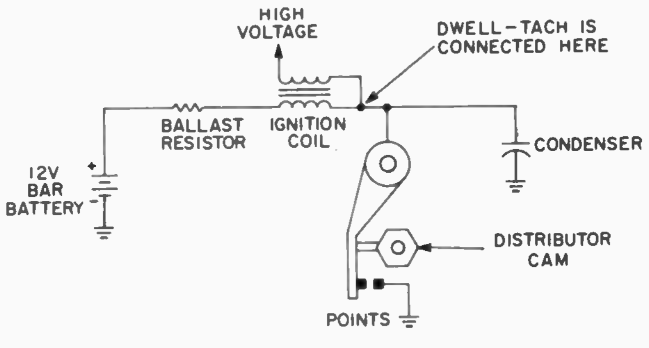


Fig. 1. A simplified schematic of an automotive ignition system using mechanical points (not electronic or "breakerless.")

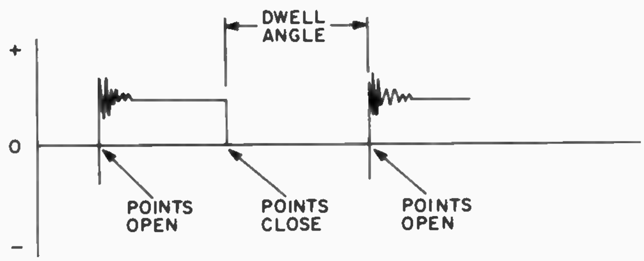


Fig. 2. This is a waveform representation of what occurs as points open and close. Dwell measurement is by averaging.

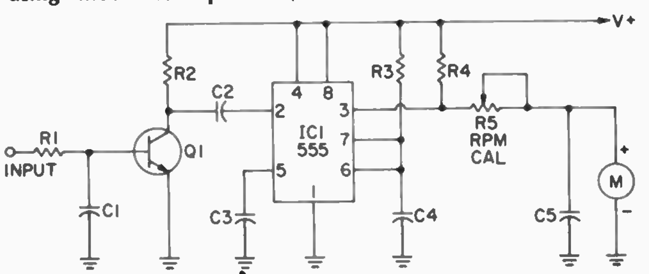


Fig. 3. This is a schematic of a simplified tachometer. It operates by counting pulses which appear at distributor side of coil.

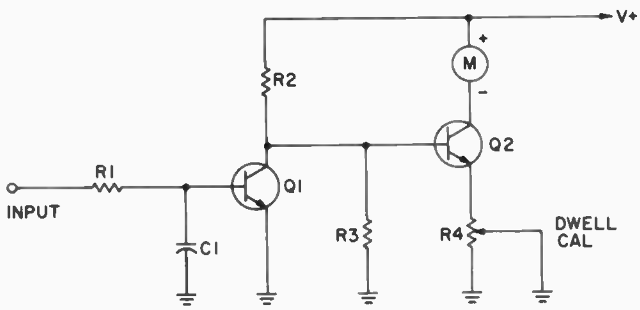


Fig. 4. This simplified dwell meter operates by reading voltage which is inversely proportional to that seen across the points.

the coil produces 20,000-volts or more at the secondary of the coil, and 100-volts or more at the primary. Fig. 2 illustrates the waveform appearing at the primary of the ignition coil, which is the voltage across the points. Since engine RPM is directly related to the number of pulses-per-second at the ignition coil, it can be seen that a simple frequency-to-voltage converter circuit can be used to measure engine RPM.

Fig. 3 is a typical schematic diagram of a tachometer circuit. Each time a pulse appears at the input to the circuit, Q1 conducts current and feeds a negative pulse to the trigger input of a one shot multivibrator, U1. The pulse duration of U1, about 4000 microseconds, is fixed. A resistor capacitor network, R5/C5, acts as a low pass filter to smooth the voltage pulses fed to the meter. The meter responds to the average of the voltage generated by U1, and is calibrated in RPM. Since the number of pulses-per-minute generated by 4, 6, and 8 cylinder engines is not the same, the meter circuit must incorporate a scale factor which automatically provides the correct RPM reading. This is the cylinder select switch which appears on tach's front panel.

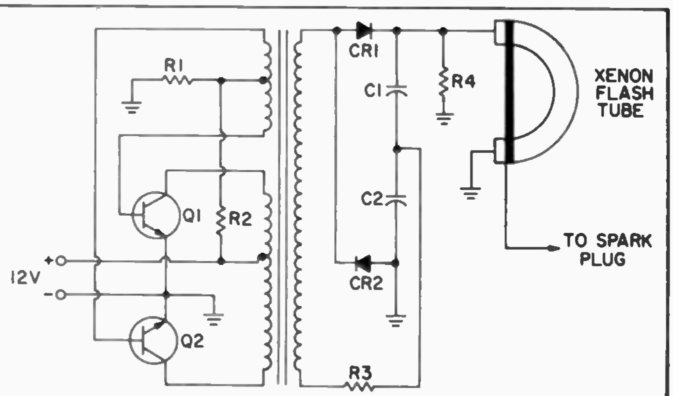
Electronic ignition systems provide a special test point which produces pulses for use with standard automotive tachometers. Refer to the service manual for your car, or ask your dealer for the location of the tachometer connection.

Dwell Meter. Point dwell is a measurement of the number of degrees that the ignition points in non-electronic systems remain closed during the rotation of the rotor in the distributor. This measurement is directly related to the point gap, and is a more accurate methor of properly tuning an engine. This measurement is made at the same test point in the system as used for the tachometer connection. Factory installed electronic ignition systems have no points, and therefore no need for dwell measurement.

The number of degrees of point dwell depends on the number of cylinders in the engine. One full rotation of the distributor rotor is 360 degrees, and this is divided up in equal amounts for each cylinder. Thus, an eight cylinder engine can have a maximum point dwell of 45 degrees. 6 and 4 cylinder engines have maximum point dwell angles of 60 and 90 degrees respectively. Proper point dwell angle for these engines is usually slightly more than half the maximum. Typical dwell angles for 8, 6 and 4 cylinder engines would be 28, 36 and 56 degrees respectively.

The dwell meter measures dwell angle by producing a meter reading which is inversely proportional to the average voltage across the points. One such circuit that does this is shown in Fig. 4. The voltage appearing at the points is fed to the base of Q1, so that it is cut off when the points are closed, and saturated when the points are open. The collector of Q1 controls the base of Q2 which is connected as a constant current generator. Meter current is adjusted to full scale value (45, 60 or 90 degrees) by R4 when the sensing lead at the base of Q1 is shorted to ground, simulating closed points. As the points

Fig. 5. A timing light uses a DC-to-DC converter to obtain the necessary high voltage used to trigger the flash tube. Stroboscopic action freezes flywheel motion to observe camshaft/valve timing.



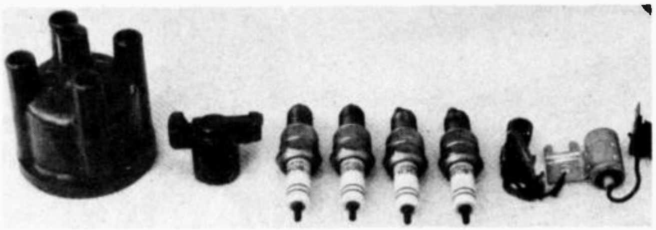
open and close at a rapid rate when the engine is in operation, the meter reading becomes the average of the two conditions and is the actual dwell angle of the points.

Timing Light. One final electronic instrument which is required for engine tune-up is the timing light. Quality timing lights are referred to as "power" timing lights, which means that the energy which fires the xenon flash tube is derived from a built-in power supply. Most units in use today use the car's 12-volt battery as the source of power. Refer to Fig. 5 which is a typical timing light schematic diagram. A DC to DC converter circuit charges two capacitors in a voltage doubler circuit to the high voltage (250 to 450-volts) necessary to fire the flash tube. The spark voltage generated by the car's ignition system provides the trigger which causes the flash tube to conduct. producing a burst of light perhaps 1/1000 second in duration. The car manufacturer has provided a timing mark on the flywheel of the engine, and a timing scale next to the flywheel. When spark plug number one fires, the stroboscopic action of the timing light enables the mechanic to visually determine if the flywheel is in the proper position. This shows engine timing.

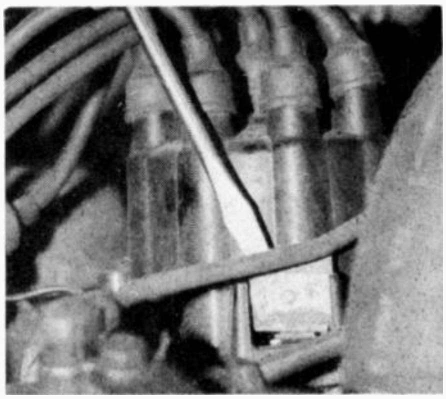
The best timing lights on the market provide inductive coupling to the spark plug wire so that it is not necessary to insert an adapter in series with the distributor wire and number one spark plug. Spark plug wires must never be pierced to make a timing check. To do so will render the wire defective.

The Engine Tune-Up. In addition to making the electrical measurements described above when tuning up an engine, there are certain mechanical procedures which must be performed to do a complete job. These procedures should be performed before making any electrical measurements or adjustments on the engine. It is not the purpose of this article to deal in depth with the mechanical procedures. and they will simply be mentioned briefly.

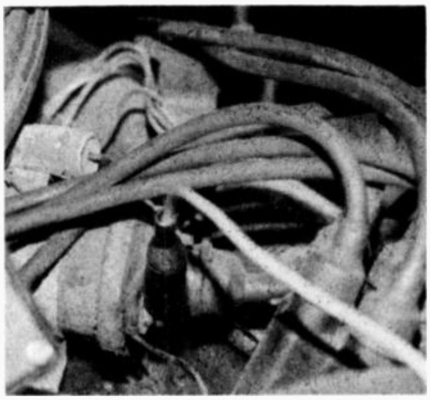
A complete and proper engine tune-up will include replacing spark plugs, ignition points, and condenser (if so equipped). In addition to these items, the distributor cap, rotor, fuel filter, and PCV valve should be either replaced or examined to make certain that they are still in serviceable condition. The air filter and crankcase ventilation filter should also be cleaned or replaced as necessary. The last item on this list are the carburetor and choke linkages, which should be cleaned with a carburetor spray product made for the purpose. Once these procedures have been completed, you are ready to perform the instrument checkout.



This is a typical ignition tune-up kit for a 4-cylinder car. From left to right: distributor cap, rotor, spark plugs, points, and condenser.



Almost all pre-1975 Delco (GM) distributors have a window through which point gap (dwell) can be adjusted while engine is running. This saves the time needed to remove cap and rotor to reset gap.



The input lead to the Dwell/Tachometer is connected to the distributor side of the coil. You can find this terminal by tracing back the wire from the condenser to the coil. Clip on the lead at the coil terminal.

The electrical checkout of the engine is made with the engine running and warm. On those cars which use ignition points, it will be necessary to set the point gap to the proper spacing so that the engine can be started. The only exception to this is on General Motors cars which use external adjustment Delco Remy distributors. Replacement points in these distributors usually are preset to such a gap that will permit the engine to be started without any prior adjustment.

A word of caution before making the instrument checkout of the engine: At no time should you permit your hands to come in contact with the metal portion of the test instrument's clip lead as you are connecting or removing it from the engine, if the engine is running. The test point may have sufficient high voltage to cause electrical shock. This may result in personal injury as you jerk your hand away. If in doubt, make your connections with the engine shut off.

Dwell Angle. The first measurement and adjustment to be made is dwell angle, which is necessary on all cars that have conventional (non-electronic) ignition systems. Attach the meter leads to the distributor side of the ignition coil and chassis, observing correct polarity. On negative ground automobile electrical systems (as in all American made cars), the positive lead of the meter is connected to the ignition coil. Follow the meter manufacturer's instructions for dwell measurement, and refer to the decal in the car engine compartment for the permissible range of dwell. If your measurement falls out of this range, the point gap will have to be decreased (for readings too low) or increased (for readings too high). On most General Motors cars, this is a simple adjustment which can be made with an Allen wrench while the engine is running. On other cars you will have to stop the engine, remove the distributor cap, and reset the point gap making it greater or smaller as necessary. Recheck dwell angle with the instrument after readjustment of the point gap.

Timing. After the proper dwell angle has been attained, the ignition timing can be checked and set if necessary. Ignition timing should always be checked after changing ignition points or point gap since any change in dwell angle will cause a corresponding change in timing. Improper timing will affect gas mileage, engine power, and exhaust emissions levels.

Before starting the engine, you can facilitate the timing measurement by cleaning the engine flywheel and locating the timing mark, which is usually a narrow groove impressed in the flywheel. If possible, apply a small quantity of white paint or chalk to this groove to make it more visible. You must also locate the vacuum advance mechanism which is located at the bottom of the distributor housing, and remove the vacuum advance hose which is connected to the mechanism. Plug the open end of the hose with a pencil. This procedure is necessary if the timing of an engine is to be made with the automatic vacuum advance disabled. Check to see whether or not your car requires this procedure.

Connect the timing light to the number one spark plug according to the directions provided by the timing light manufacturer. Connect the timing light power leads to the car battery, observing correct polarity. Check to make sure that no wires will be caught by the fan or other moving parts. Start the engine and measure the timing. Refer to the tune-up decal in the engine compartment, which should have an illustration of the timing scale for your particular engine. If the timing is out of spec, adjustment is made by loosening a clamp at the bottom of the distributor housing and rotating the unit to the correct spot. Tighten the clamp, and recheck the timing to make sure it did not change. Stop the engine and replace the vacuum hose if it was removed earlier.

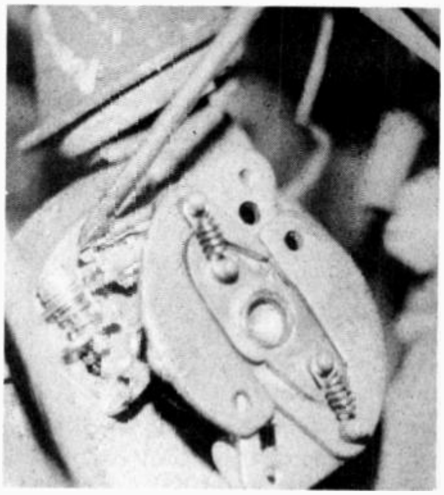
Carburetor Adjustments. All carburetors have some form of adjustment which controls engine idle speed. Single barrel carburetors have one adjustment for idle fuel mixture, and two and four barrel carburetors have two fuel mixture adjustment screws. These adjustments are performed with the aid of the tachometer, since engine RPM will vary as these adjustments are made. Since the order in which these adjustments are performed is important, the best practice would be to follow the vehicle manufacturer's sequence. Some tune-up decals in late model cars contain the proper adjustment sequence. The following procedure should prove satisfactory for most cars. Note: Some cars equipped with extensive emission control equipment have plastic caps covering the idle mixture screws, which limit the adjustment range of these screws. Under no circumstances should these caps be removed to set the mixture screws beyond the normal adjustment range. To do so may upset the engine exhaust emissions and/or affect driveability of the car.

Allow the engine to reach normal operating temperature before adjusting the carburetor. Connect the tachometer to the ignition system according to the manufacturer's instructions so that the meter reads engine RPM. Follow the information provided on the tune-up decal as to whether the transmission should be in neutral or drive, and if the air conditioning or lights should be turned on. (Be sure to set the parking brake securely before placing the transmission in Drive!)

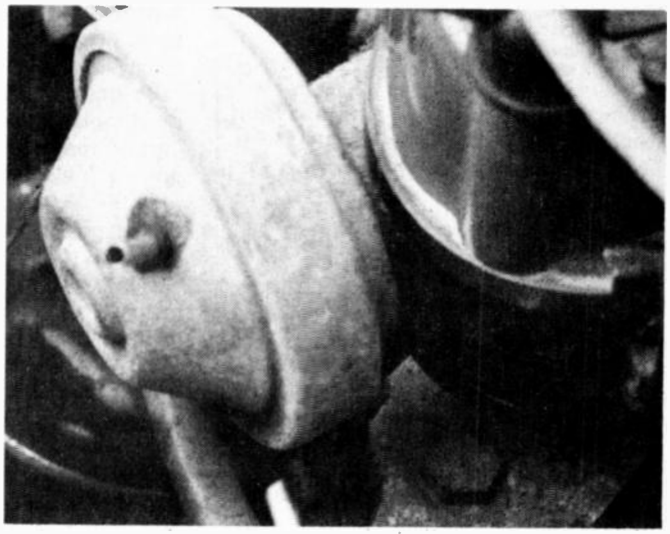
Adjust the idle mixture screw or screws for maximum engine RPM. Do this very carefully since only a small adjustment is usually necessary. Now adjust the engine idle speed adjustment to the engine RPM as specified on the tune-up decal. Very carefully turn the idle mixture screws clockwise to attain a 20 RPM drop in engine idle speed. Reset the idle speed adjustment for the recommended engine RPM.

The method just described is known as the "lean roll" method of setting the idle mixture. With this method, the vehicle exhaust emissions should be within specifications, and it avoids the necessity to use an exhaust gas analyzer for adjustment of the idle mixture.

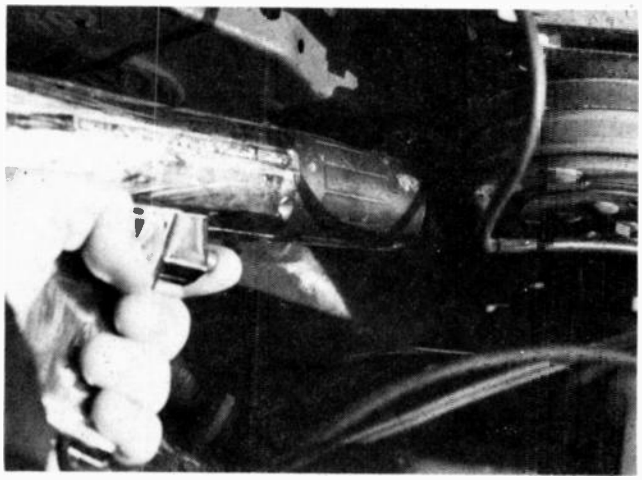
If you have performed the various engine adjustments as specified, you should have an automobile that performs as well as it was designed. Keep a record of the date and speedometer mileage, so that you will be ready to perform the next tune-up when due. ■



With cap and rotor removed on this Delco distributor, the point gap adjusting screw can be seen. Lift the window in the distributor cap and you can turn this screw to perform point gap (dwell) adjustment.



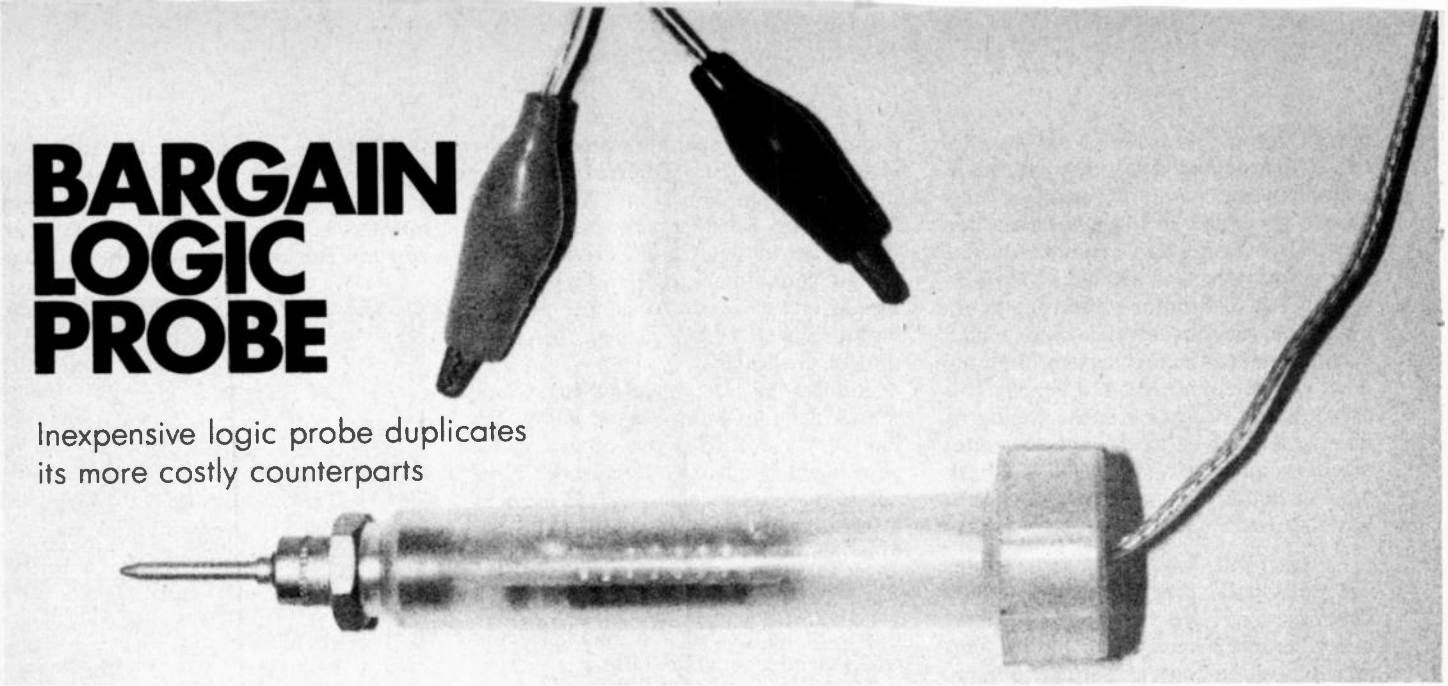
Release the distributor clamp bolt at the base of the distributor to adjust timing. Some engines need to have their timing adjusted with the vacuum advance (round object mounted on the side of the distributor) connected, and some need it disconnected. Check in your owner's manual or with your dealer.



Use of the timing light allows you to freeze the action of the flywheel and read the timing adjustment. A decal under the hood will list number of degrees (either in BTDC or ATDC) to which pointer on the flywheel must point to on scale next to the flywheel. Timing is adjusted by rotating the distributor body.

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.

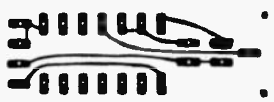
For most of our electronic experiments, we don't need expensive logic probes costing upwards of $40. Here is a cheap unit which can signal high level (1), low level (0), and oscillation. No pulse detection feature was included thus keeping the size small and the price low, around $2. The probe is designed 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.

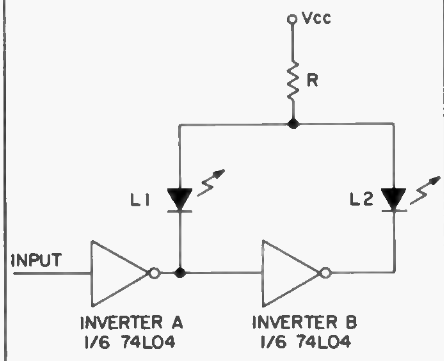
Using a 74L04 is important, the "L" series only requires the driving signal to sink 180 μA max, much below the 7400 series 1.6 mA max or even the 74LS00 series 400 μA requirement.

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. ■

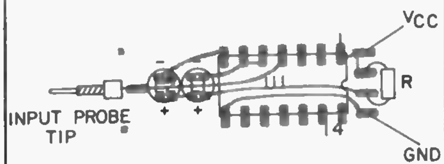


Here's the extra-small printed circuit board template for Bargain Logic Probe.

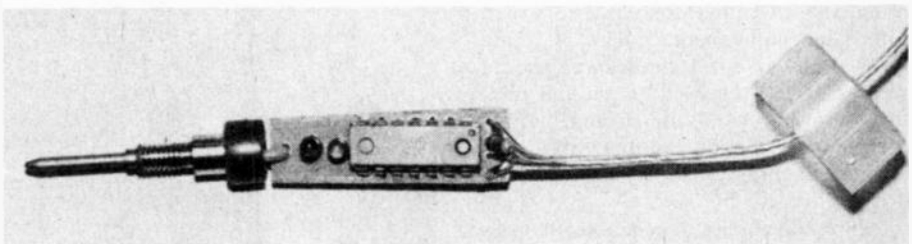


PARTS LIST

- **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, aligator clips, wire.**



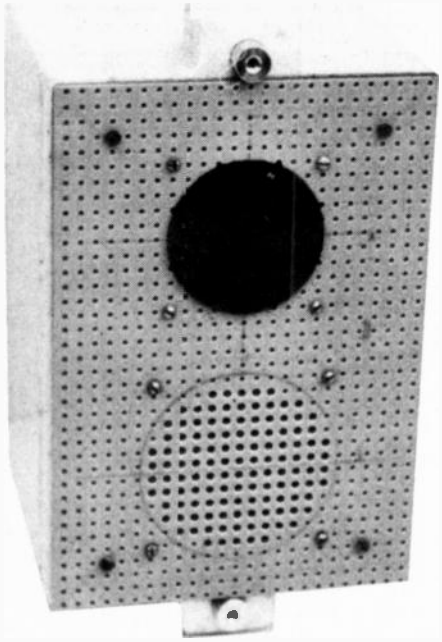
This will give you a good idea of parts layout on PC board. There are few parts.



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.

ICE-BOX HI-FI

This lightweight speaker system is as close as your local hardware store



HERE IS A SPEAKER SYSTEM that is small in size, light in weight, and delivers true high fidelity sound when connected to your audio power source, car radio or tape player.

This unique speaker system consists essentially of two speaker units, a light weight enclosure, a prepunched perf-board, that is modified to become a speaker mounting baffle and grille, hook-up wire and glue. Sounds simple? This do it yourself project consists of an assembly of parts, more than a complex construction job.

The speaker enclosure looks like a small cold chest made of styrofoam Breadboard. Styrofoam is responsible for the minimal weight. This material is acoustically dead. Hence, it can be used to house speaker components, if the enclosure is small enough to minimize acoustic resonance.

Styrofoam will pass low frequency sound like a sieve. This problem is solved by coating all styrofoam surfaces with white glue. Elmer's "Glue-All" or other white glue that is made for bonding styrofoam to itself or to other materials, must be used.

The cold chest box enclosure, listed in the parts list, can be found in stores, labeled as a Bait Box. It is white, speckled with spots of green. A rope handle is provided for ease of handling. The rope is driven through the cover and secured to the box. The outside dimensions are 6⅞ by 9¾-inches. The same width and length of the perf-board speaker baffle. The overall depth is 6½-inches including the cover.

The Assembly. Using a small paint brush, spread a light coating of glue over the inside of the box to seal the panel surfaces. White glue dries clear and fast, and adds strength to the styrofoam. Give it a second coat of glue to insure sound tightness. Do not coat the cover, until an opening is cut to clear the speaker components.

Figure 1 shows the perf-board modifications to convert it to a speaker baffle and grille. Check the length and width of the perf-board when you buy it, they vary somewhat in size. Cut the 2¾-inch diameter tweeter opening with a circle cutter and redrill the holes inside a 3⅝-inch diameter pencil scribed circle, forming a grille for the 4-inch speaker mounting.

The cut-out in the styrofoam cover which clears the speaker units is shown in Fig. 2. Do not glue the cover to the perf-board and mask assembly.

Figure 3 is a section view at the front of the box opening. Note that two wood cleats are glued inside the box for securing the baffle and cover to the box with six, 2-inch long machine screws that are screwed into the cleats. These screws clamp the baffle/mask assembly to the enclosure and provide access should it ever be required. The speaker components are bolted to the perf-board/mask assembly and are tightened with nuts and lockwashers.

The Speaker Components. It is unusual to see two speaker units installed in such a small enclosure as this. True "Hi-Fi" sound cannot be attained without the use of a good tweeter. Radio Shack has added a one-inch dome tweeter to their speaker line, that provides wide dispersion of high frequencies. This unit is almost as good as the

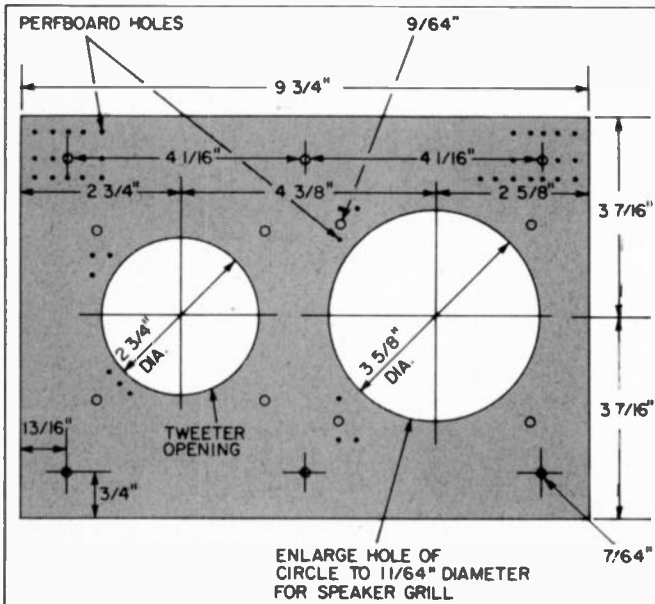


Fig. 1. Perfboard drilling for Ice-Box Hi-Fi. There are a lot of holes to drill, so be careful, because the perfboard can splinter.

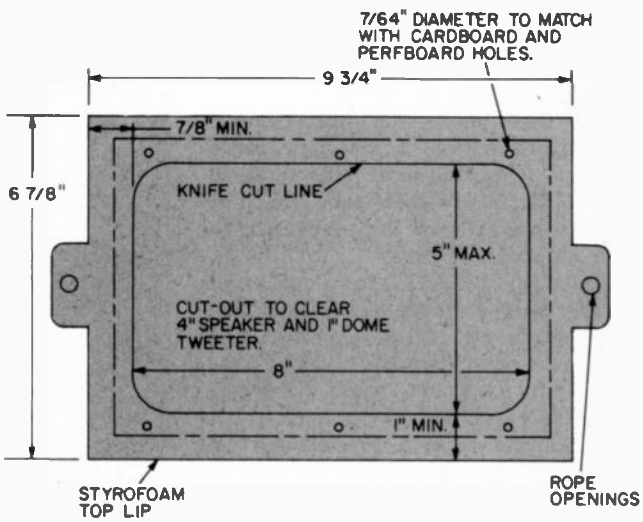
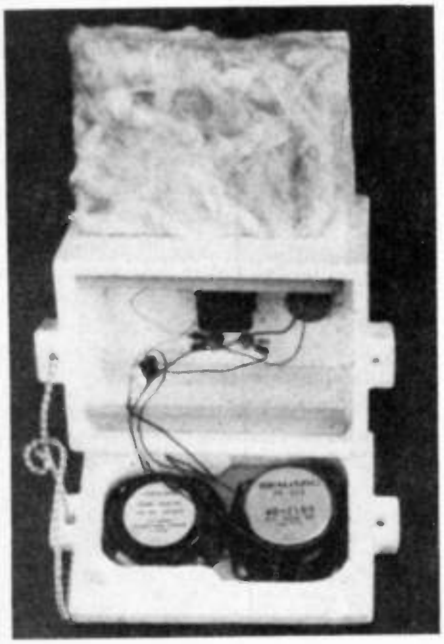


Fig. 2. Cutting and drilling outline for the styrofoam top panel. When coating the styrofoam with glue to make it accoustically opaque, let the glue dry before installing it on the main frame. You do not want to glue the two styrofoam parts together at all.



Inside look at the drivers mounted in our little speaker system. If you use care, everything will fit nicely, and snugly.

Philips Dome Tweeter from Holland that is used in some of the most expensive speaker systems.

A 3.3-uF capacitor is furnished with the tweeter for cross over at 4000 Hz and above. High frequency attenuation is provided by use of an "L" pad. This "L" pad is hooked-up to the outside winding of the pad.

Smooth performance is assured by employing a filter network shown in the wiring diagram. The 20-ohm resistor in the network cancels the effect of the tuned circuit set up by the 2.5 MH inductance and the 4-MF capacitor in the filter.

For wire connection into the enclosure cut a slot in the back for a terminal strip and secure the terminal with 6-32 by ¾-inch long machine screws or use 1-inch long brass screws with nuts and washers.

Upon final assembly, cut a section of 4-inch thick building grade fiberglass to fit inside the enclosure. Try not to compress the fiberglass around the edges. Cut a recess to clear the inductance coil, mounted in the back.

When you have completed the assembly, hook it up to one channel of your home stereo system. You will be amazed by the sound quality from such a small box. You may be tempted to assemble two of this design for stereo use, or perhaps use it as an extension speaker for high quality sound. ■

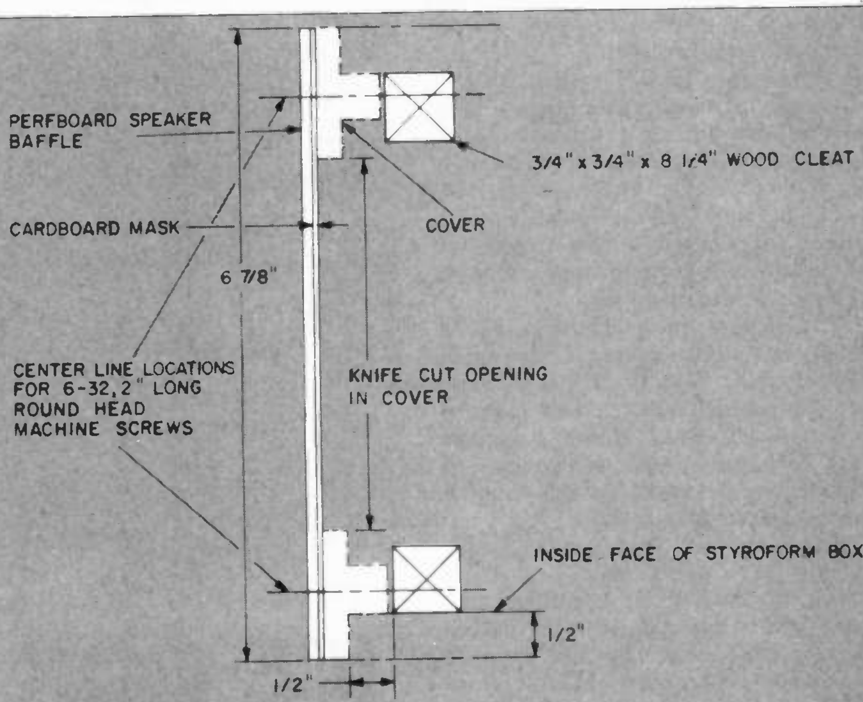
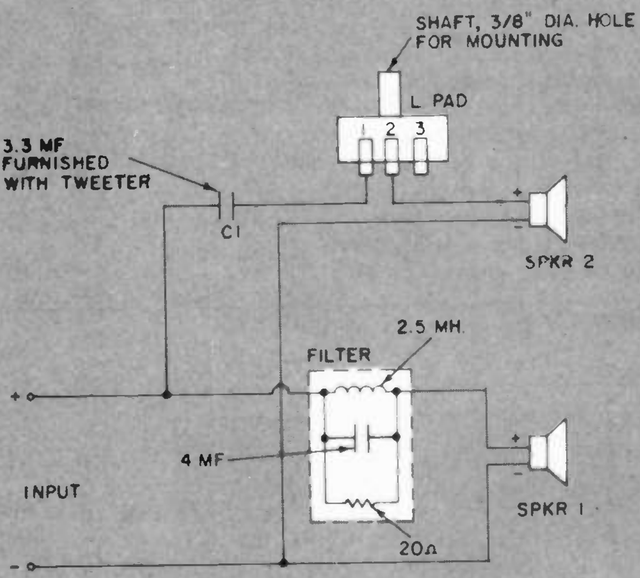


Fig. 3. Cross section of the styrofoam cover of Ice-Box Hi-Fi. The two 8¼-inch long wooden cleats are very important, since they serve to seal up the speaker.

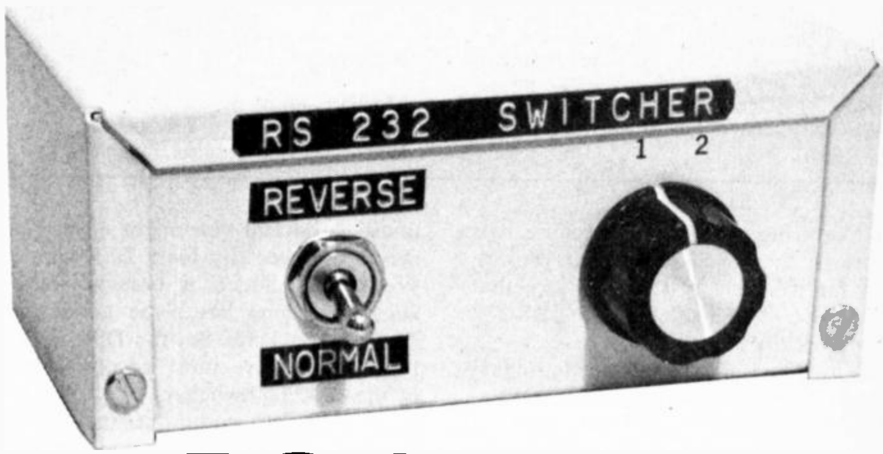


PARTS LIST FOR SPEAKER

C1—3.3-uF capacitor (see Driver No. 2)
Driver No. 1—4-inch cone type speaker (Radio Shack 40-1197 or equiv.)
Driver No. 2—1-inch dome type tweeter (includes C1) (Radio Shack 40-1276 or equiv.)
Filter—audio type filter network (Radio Shack 40-808 or equiv.)
Pad—audio type "L" pad (Radio Shack 40-980, or equiv.)
Misc.—Ice-less cold chest, without inside compartment. Mfg. by Standard Cellulose & Novelty Co., Inc., 90-02 Atlantic Ave., Ozone Park, New York 11416.
8—6/32 round head machine screws, ½-inch long
6—as above, 2-inch long
1—as above, 2½-inch long
2 wood cleats, ¾ x ¾ x 8¼-inch long
Nuts for above cardboard mask 6⅞ x 9¾-inch, see Fig. 2. Pre-punched perf-board 6⅞ x 9¾-inch, see Fig. 1. Building grade, 4-inch fiberglass 5¾ x 8¾-inch. Elmers Glue-All or equal, terminal strip or brass machine screws (see text), hook-up wire, solder, etc.

RS-232 Switcher

Increase available serial ports with this inexpensive, easy-to-build switcher



ONE OF THE PROBLEMS you're likely to encounter as you expand your personal computer system is finding sufficient RS-232 serial outputs. Most small computers provide either no serial outputs, or just one; although there might be relatively expensive add-on serial interfaces available.

For example, the Heathkit H-8 computer is normally supplied with one serial output for a CRT control terminal. If you want to use a serial printing terminal, you must disconnect the CRT and substitute the printing terminal. Either that, or you have to purchase a relatively expensive multi-port serial *card* which permits simultaneous connection of up to four serial devices.

The Radio Shack TRS-80 computer doesn't even have a serial output; it was designed for a parallel printer. With an expansion interface and optional serial I/O, the user winds up with only one serial port left. If both a serial printer and communications modem will be used, it becomes a matter of juggling connections to accomodate each device.

Apple computers accept easy to plug in serial I/O *cards*, but these aren't cheap. If you want to use two or more serial devices, either you purchase an extra card or it's back to rearranging connections.

The least expensive way to equip your computer with two serial connections–assuming they both won't be needed at the same time–is to provide some form of passive electrical switching. While commercial RS-232 switchers can cost almost as much as a serial interface, you can build a serial switcher for personal computers at a rock-bottom cost using switches and parts easily available at most electronic shops.

You can build the Switcher cheaply because, for most applications, only four (or fewer) connections are used. You don't need a device that can switch all 25 terminals of a D-25 microperipheral connector.

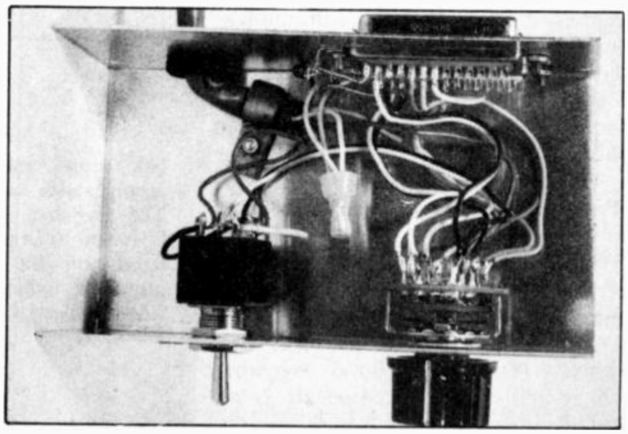
The Standard. RS-232 connections are standardized, and were originally intended to accommodate *communications* via terminal and/or computers through *modems* and telephone lines. For example, one of the RS-232 connections is called a *ring detector*. If the modem detected a ring, it would signal the associated computer to answer the "call" through the modem.

Another RS-232 connection was intended to be controlled by the incoming signal. If the incoming line signal was too noisy, the modem signaled the computer that "garbage" was coming down the line. Yet another connection signaled the associated computer that the modem was still in a dial-out mode, or had not yet established a communications link with the other end of the circuit.

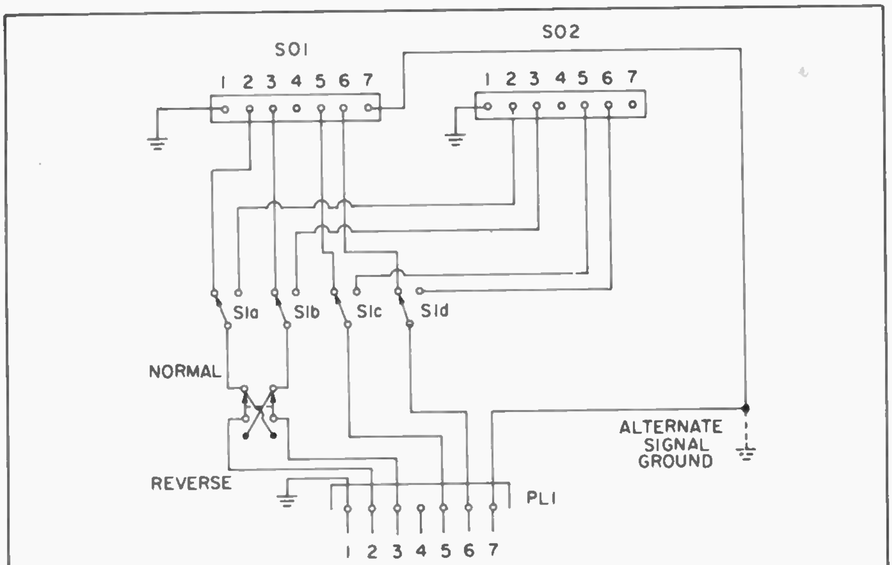
With only a few exceptions, the RS-232 control signals aren't needed or used by personal computers. In fact, if you're using RS-232 for a printer all you might need are the signal in, signal out, and signal common (ground) connections.

Common Connections. In Fig. 1 we show all the RS-232 connections commonly used. The terminal connections are those of a D-25 connector, which is standard for all RS-232 equipment. You should be able to plug any RS-232 connecting cable into any RS-232 socket. The arrows indicate the direction of signal flow; for example, Terminal 2 labeled TRANSMITTED DATA means the signal *from* a computer or *terminal keyboard*. Terminal 3 labeled RECEIVED DATA is signal *into* the computer or printer.

Think about this for a moment: if you were to connect two terminals together, they could not "talk" to each other because both would be transmitting on Terminal 2 and receiving on Terminal 3. The 2 and 3 connections on one terminal would have to be reversed; i.e., they must be connected to receive from Terminal 2 and transmit on 3.



The RS-232 switcher is an easy project to build and use. It has no printed circuit board and very few connections. All you have to do is to connect up a couple of switches to a plug and you are in business. Your TRS-80 will be more useful.



PARTS LIST FOR RS-232 SWITCHER

PL1—Connector, D-25P (plug)
S1—DPDT rotary switch (Radio Shack 275-1384)
S2—DPDT switch
SO1, SO2—Connector, D-25S (socket)
Misc.—Cabinet, wire, solder, fastenings, etc.

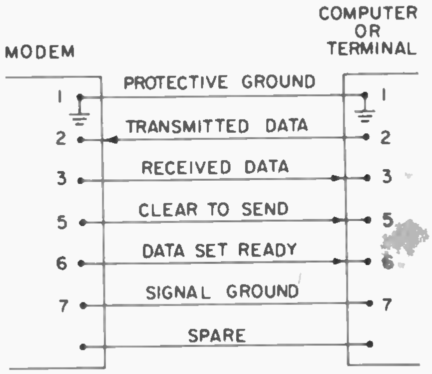


Fig. 1. Connection diagram illustrating how modem is connected to computer or terminal. It's fairly straightforward.

We bring this up now because it is part of the RS-232 Switcher project. So far we have two connections that must be switched between RS-232 serial devices.

The Data Carrier Detector signal from Terminal 8 is one of those signals we mentioned previously used for "communications;" it is almost never needed for personal computing and can be dispensed with.

The Clear To Send, or CTS as it is more often called, flows from Terminal 5 to the computer. This signal is often used by printers and modems to tell the computer that the device is ready to accept data. It is one of the required signals, so it is the third RS-232 signal that we will use.

Terminal To Computer. The Data Set Ready, or DSR, flows from Terminal 6 to the computer. This signal is used to indicate that the communications unit, such as a modem, is not in the test, talk, or dial mode and has completed any special timing functions necessary to establish a call on the phone line.

This signal is not used at all for personal computers that don't have auto-dial modems.

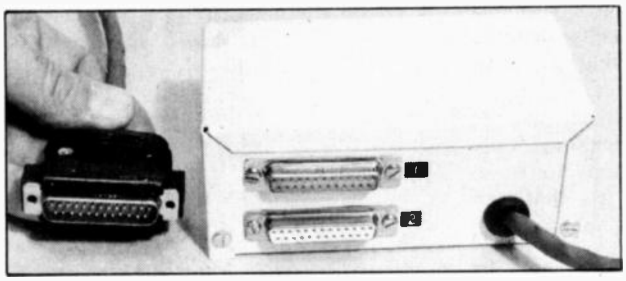
Some equipment rebuilders, however, use this line to signal the computer that the printer is ready to accept data. It works in the same way as the CTS signal as far as signaling the computer is concerned. It is an unusual use and you might never run across the necessity for a DSR signal. We have included it because *somewhere* someone has some peripheral that sends a DSR. So, the DSR is the fourth signal we must accommodate in the RS-232 Switcher.

In personal computing, the Signal Ground is often connected to the protective ground. It's not the best of ways to do things, particularly on long cable runs in areas of relatively high electrical noise. Don't be too surprised to find that some equipment has only one ground wire.

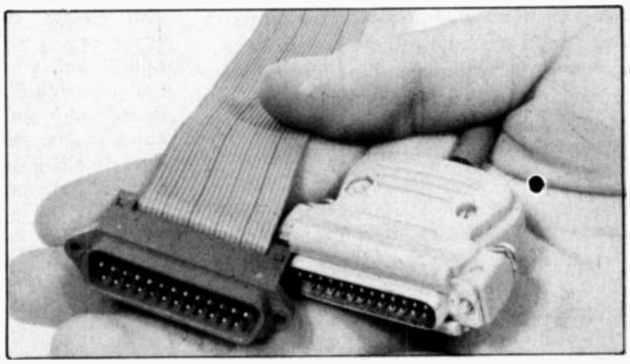
Two signals we don't show (for clarity) are the Data Terminal Ready, or DTR, and the Ring Indicator, or RI. The DTR (Terminal 20 if used) is a signal to the communications device (modem) to connect to the communications channel (phone line). The RI is a signal from the communications device (modem) that the device is receiving a carrier from a remote data set.

A signal sometimes referred to in articles, but rarely used, is the Request To Send (Terminal 4). It is a signal to the data communication equipment that controls the direction of data transmission. It is not used in personal computing gear at all. If you

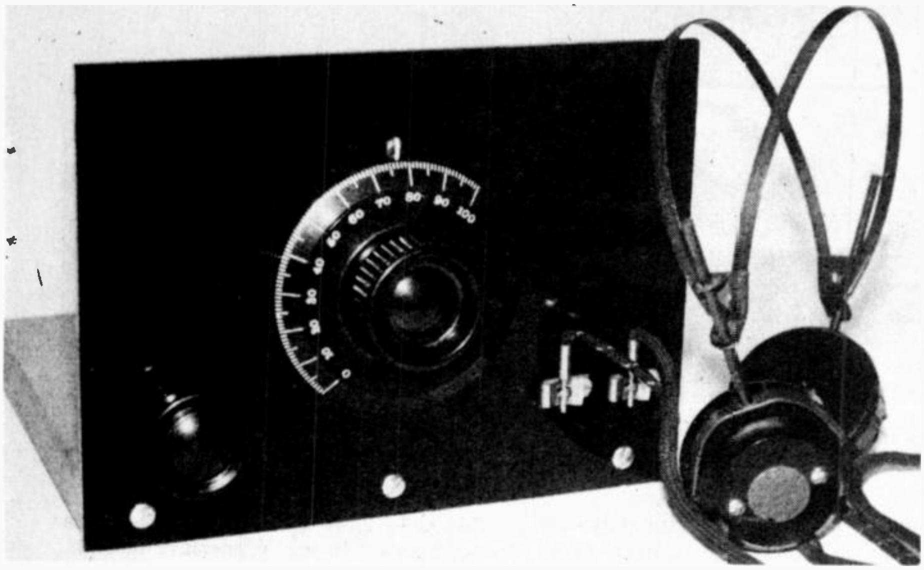
(Continued on page 96)



Two serial ports are available for use with this switcher. Many home computers only offer one or sometimes no serial output. Instead of having to plug and unplug a port, all that needs to be done is to flip a single switch.



No more fumbling around with the RS-232 Switcher. It allows you to keep your hands off the serial ports and on keyboard where they belong.



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.

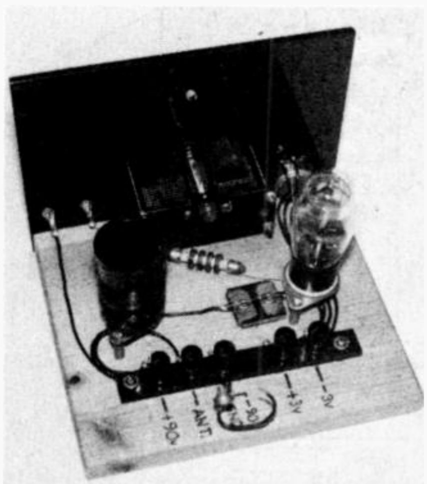
Theory. For those of you who don't remember those two gentlemen, I'm going to give a bit of theory about vacuum tubes and this particular radio. I apologize to those of you who are well versed on these subjects, and beg your indulgence.

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!

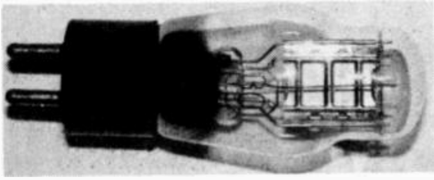
Okay, first diode, then triode, now radio: our simple receiver consists of a tuner, a radio frequency (or RF) amplifier, a detector, and an audio amp.



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 tc the high radio frequencies. Thus an amplified version of the audio that was once impressed on the RF carrier wave appears in the earphones.

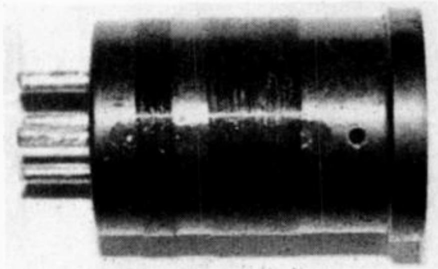
So, what's L3 for? Well, I wasn't telling the whole truth when I said our LC tuner selected only *one* frequency. It tuned in on *mostly* one frequency, but some others sneaked in, too. The width of this tuning curve (see Fig. 5) determines the selectivity, or station selection ability of our radio. 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



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

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.



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

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-

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.

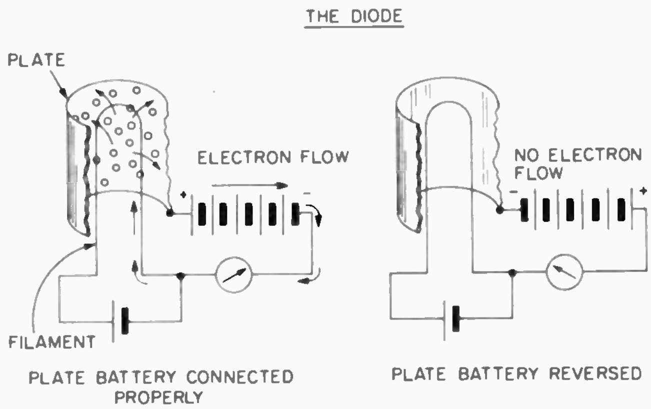


Fig. 1. The diode is the simplest form of vacuum tube. It is made up of a filament wire surrounded by a cylindrical metal tube. Its origins date to before World War I.

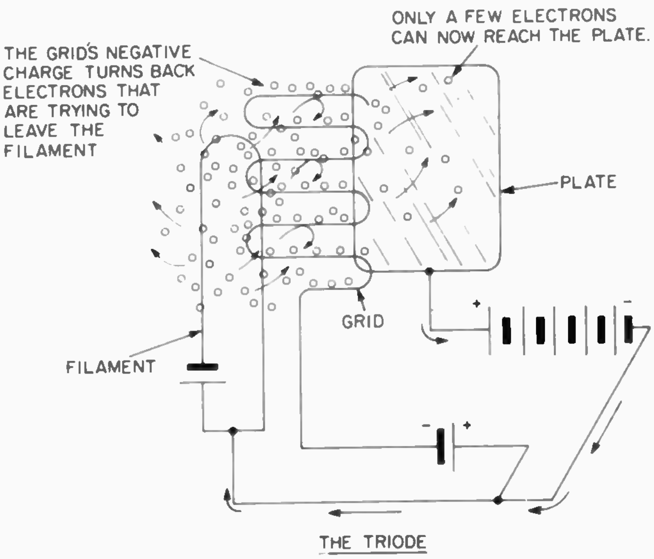


Fig. 2. The triode, a refinement of the diode, has a grid between the plate and filament. This made a rectifying tube into a tube with amplifying capabilities.

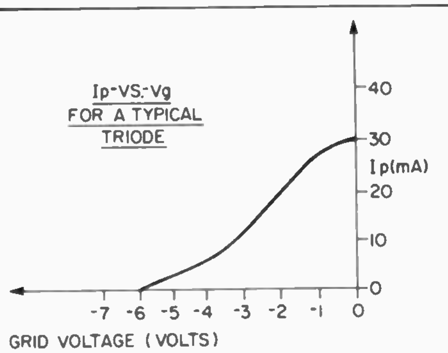


Fig. 3. This graph shows the relationship between the grid voltage and plate current.

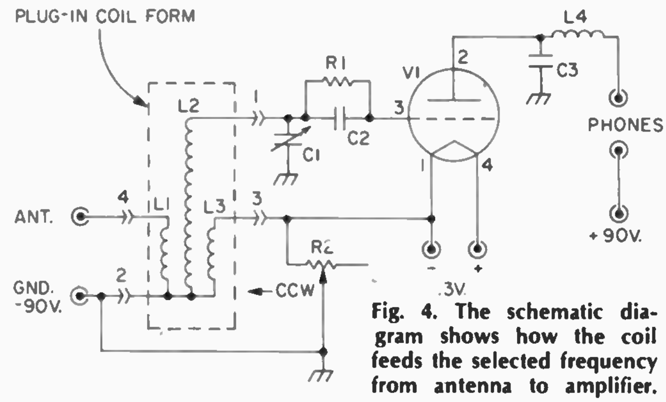


Fig. 4. The schematic diagram shows how the coil feeds the selected frequency from antenna to amplifier.

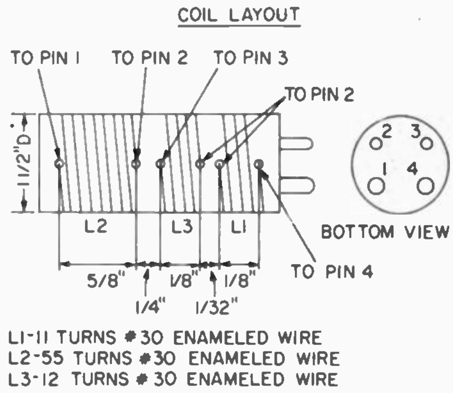


Fig. 7. The coil winding guide shows the wiring configuration of the important coil.

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.

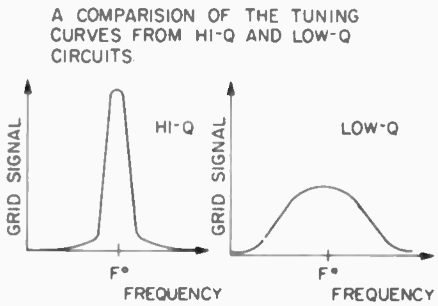


Fig. 5. The width of the tuning curve is the determining factor in set's selectivity.

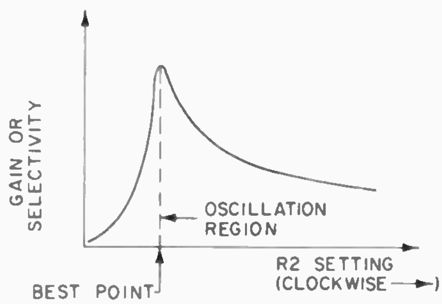


Fig. 6. Too much oscillation is undesirable; R2 must be set to give the minimum.

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 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.

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

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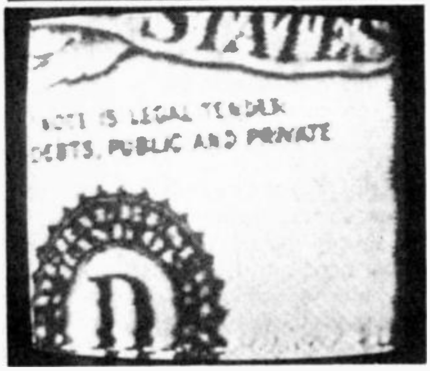


SLOW SCAN TV

Set Up a Bargain Basement TV Broadcast Station

☐ About two dozen years ago, a strange new warble was added to the dah-dih-dahs, buzzes and whistles on the Amateur bands. It was no convolution of a ham's voice, no alphabetic code, no teletypewriter signal; instead, hams were sending and receiving pictures of each other!

In the early days of this new mode, called Slow Scan Television, the picture shows resembled your Aunt Harriet's favorite vacation slides, or call letters pasted on *Playboy* pictorials. For many, a chalkboard or signs hastily crayoned on cardboard were the stars of the show.

But Slow Scan TV (or SSTV) has come a long way since those early days. There have been experiments with color, with 3-D, and with home computer-generated graphics.

Slow Scan Basics. It takes just a tad longer than 8½ seconds for a complete SSTV picture to appear. That's because SSTV is the result of a challenge met and conquered by its ham pioneers: to fit a video signal into the narrow bandwidth of a voice transmission. The bandwidth of an SSTV signal is only about 2500 Hz, which means it can be transmitted over voice channels like telephone lines and the amateur voice bands; compare that to the 4 to 6 *million* Hz of bandwidth required by a standard (fast scan) TV signal, which builds a complete picture thirty times a second—256 times as often.

This difference in *frame rate* was the first major concession these hams had to make in order to meet the narrowband challenge; the second was resolution.

You know that television pictures are made up of lines. A standard television picture (in the U.S.A.) includes a total of 525 lines from top to bottom. By comparison, an SSTV picture has only 128 lines from top to bottom. Also, while a standard TV picture has an *aspect* ratio of 4:3 (meaning it's ¾ as tall as it is wide), an SSTV picture has an aspect ratio of 1:1 (meaning it's square).

Audio to Video. In order to send and receive their pictures with standard ham transmitters and receivers, the SSTV pioneers were faced with the problem of how to *modulate* and *demodulate* the voltages that SSTV pictures are made of. For once, the easy and obvious answer worked! They decided to translate these voltages into tones (audio tones) for transmission, and to translate their received tones back into voltages.

In making this decision, they were also providing themselves with an easy way to record SSTV pictures—standard audio tape. Even the cheapest cassette recorders with reasonable speed stability proved capable performers.

In order to be sure that their signals would be compatible with each other's equipment, a set of standards was developed. The highest frequency, 2300 Hz, was set to represent white. Black was to be at 1500 Hz; and 1200 Hz, a blacker-than-black frequency, used for synchronization.

Sync Or Swim. Synchronization standards for SSTV were also crucial to its development. If a receiver didn't go to the next line exactly when the camera and transmitter did, the result would be a picture that swims—one with undulating edges and bits of one line appearing on the next. At best, the picture looked like it was printed on a balloon being stretched out of shape; at worst, it was indecipherable.

So sync standards were devolped using 60 Hz AC power line frequency as its standard, and provisions were made on SSTV monitors to de-skew slightly off-standard signals.

First, the 60 Hz signal was divided by 4 to come up with a 15 Hz line rate. Once every 1/15th second, a 5 millisecond burst of 1200 Hz sync signal (a total of only 6 cycles) is inserted onto the transmitted signal as a prompt to the receiving monitor to go to the next scan line.

This proud exhibitor at an SSTV hamfest shows off the sophisticated gear used in the pursuit of his hobby. On the right side of the table is the transmitter, to the left an audio amplifier with a cassette deck, and above the amplifier is the monitoring CRT screen. Below is a view of a ham shack with all of the equipment fired up and an SSTV QSL broadcast on the CRT display. As equipment becomes available, Amateur SSTV will grow.

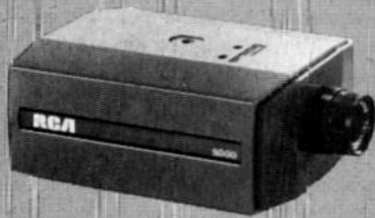
This 15 Hz signal is again divided by 128, and once every 8.5333 seconds a 66 millisecond burst (80 cycles) of 1200 Hz sync tone is transmitted as a signal to start scanning a new picture (*raster*). In this way, exactly 128 lines are counted out for each picture.

SSTV provides a resolution of 128 dots (or *pixels*, short for picture elements) on each scan line. Theoretically, this means that each dot is transmitted during 1/128th of the period between sync pulses, which is 80/86th of 1/15th second. This, according to my pocket calculator, is 1/2064th of a second, meaning that pixels should appear at a 2064 Hz rate. In practice, this is difficult to achieve over a communications channel, but modern equipment has made it possible over closed circuits, and come close to it over the air as well.

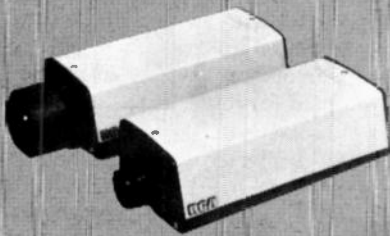
Freezing The Image. Compared to the homebuilt receivers with long-persistence phosphor cathode ray tubes (their dim green glow had to be viewed in near darkness) that were the only way to watch SSTV in its early days, the state of the art has advanced by leaps and bounds. Today scan converters let you watch SSTV pictures on a standard TV monitor.

It works the other way, too. Camera tubes that could be scanned at SSTV rates are rare and expensive, so standard TV cameras are used and their signals sampled at SSTV scan rates. This offers the advantage of being able to see what the camera sees on a standard TV, even while transmitting slow scan.

The Robot keyboard is used to enter ASCII coded characters to the SSTV transmitter for broadcast over the air. This arrangement is used instead of more expensive camera.



Video surveillance cameras, such as this one from RCA, are at the top of SSTVers' wanted lists. Picture quality is excellent.



A less expensive video camera is the RCA 1000 series. Available with a variety of lens configurations, they serve the Amateur SSTVer as well as higher priced units.

The Robot SSTV transmitter has provision for all the varieties of TV transmission possible: plain characters, sound tracks, scan variations. Memory circuit preserves all.

As pictures change, a horizontal line proceeds from the top of the screen to the bottom. As it "wipes" down the screen, it discloses the new picture behind it. The new picture appears above the line, replacing the old picture which still can be seen below the line.

State-of-the-art equipment usually incorporates a good size chunk of data memory, and uses memory to store and

(Continued on page 96)

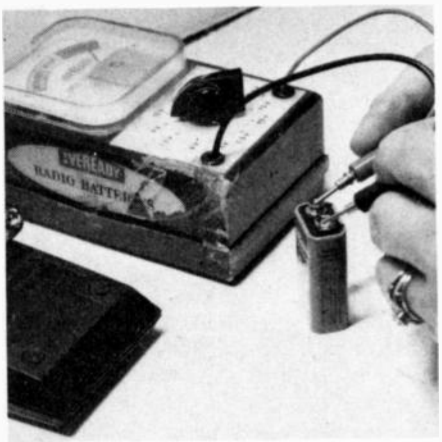
Simple Calculator Repairs

Don't throw that old calculator away!

Save time and money by troubleshooting calculators yourself

CHECKING OUT A MALFUNCTIONING pocket calculator is much easier than tackling a portable radio. There are fewer parts and they are not all squeezed together. Most problems found with the small calculator are quite simple and can be done quickly.

Most calculators are warranted for 90 days. If the calculator breaks down in the warranty period, check the small warranty slip found in the original box, provided you didn't throw it away. A defective calculator may be returned prepaid to the manufacturer's service department. But, when the calculator breaks down after the warranty runs out, you may be able to put it back into operation with a few simple checks. Also, if you picked the pocket calculator up second-hand at a bargain table, you may find the minimum factory repair charge is more than you paid for it.



A simple battery tester like the one shown is a useful basic tool for checking and repairing small battery-operated calculators.

Checking the Batteries. Check for defective batteries since most pocket calculators are operated from only two power sources. You will find very tiny batteries in those thin type calculators. Be very careful when removing them, and always observe the correct polarity. Most battery polarity terminals are marked right on the plastic case. The calculator will not function if the batteries are put in backwards. In fact, you may damage some internal components by reversing battery cells. The suspected battery may be tested in a battery tester or with a VOM. If their quality is suspicious, replace them.

Since the small calculator pulls very little current, the batteries may last to the end of their shelf life. In other words, these small batteries should be replaced every year or so to prevent connection or component damage. When used constantly, they may need replacement three or four times a year. It's best to choose a battery that won't leak after a long period of time. You may find two or more small batteries in the pocket calculator.

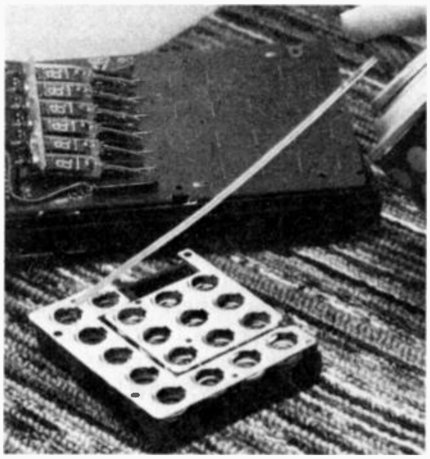
Great care must be used when working on a delicate PC board. Note the fine-tipped soldering iron, perfect for these spots.

Cracked PC Board. You may find a cracked PC board after careless handling or after an accident. When the calculator is accidently dropped or knocked around, check for broken wiring connections or a cracked PC board. In one particular instance, a pocket calculator was accidently dropped upon the cement floor of a garage and the cover accidently run over by a car. The only damage incurred was a broken corner of the calculator case and PC board.

Simply use small, solid hookup wire and join the broken foil ends. In very small pocket calculators, the PC foil is very thin and closely spaced. Scrape the PC foil with a pocket knife to bare any insulated areas (some PC boards are sprayed with a clear plastic liquid) then join the broken area with a piece of bare hookup wire. Be very careful not to overlap the soldered connection onto any adjacent PC foils. If the PC foil is really thin, select one strand of copper wire from stranded hookup cable and use it to join the broken areas back together.

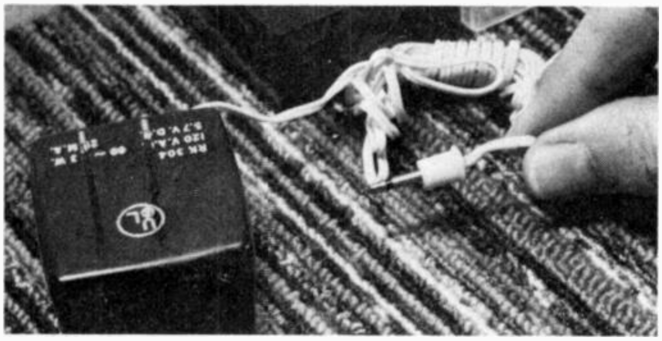
Defective Switch. If the calculator will not light up after new batteries are installed, suspect a defective On/Off switch. Wiggle the switch back and forth while checking for the numbers to come on. A dirty On/Off switch may produce erratic operation. Try spraying tuner or contact cleaner down into the slide switch area. You may be surprised to find that the lights come on and you can now add or subtract once again after this.

When the switch appears broken or doesn't make contact, check for poor switch continuity. Remove the back cover to get at the switch. Notice if all wires connecting to the switch are soldered in place. Now measure the resistance across the switch terminals. Make sure the batteries are disconnected. You should have a dead short across the switch contacts with the switch in the "On" position. If not, pull the switch out and disconnect all wires. Now, repeat the continuity test. Try to clean the switch contacts before ordering a replacement. In some small units, you may have to replace the whole keyboard, since the On/Off switch is sealed inside of it.



Spraying with one of the silicone cleaning and lubricating aerosols in very often a cure for problems with switch contacts.

Bad AC Adapter Jack. When the calculator will function on batteries and not with the AC power supply, suspect a defective power supply or adapter jack. If you had been using the calculator from the power line when it went dead, substitute batteries to determine if the calculator is at fault. You can measure the DC voltage at the output of the AC adapter jack with a VOM.



The most common fault with AC adapter jacks is defective contacts. If spraying with tuner cleaner doesn't help, you may have to replace either the jack or the plug that goes into it. Both of these repairs are easy to do.

If the DC operating voltage is present from the AC adapter, check for a defective female jack. A lot of these female jacks are very tiny and may be easily damaged. Generally, they are the self-shorting type, so when the AC adapter plug is out of the calculator, the batteries are switched into the circuit. First try to clean the jack contacts with tuner or contact spray. Move the male plug in and out to help clean the contacts. The broken or defective jack may often be replaced with a small earphone type jack found at Radio Shack or other Radio-TV outlet stores.

Corroded Battery Terminals. When batteries are left unused for a long period of time, they begin to leak and corrode around the battery terminals. Try to keep fresh batteries in the calculator to prevent corroded terminals. Replacement with leak-proof and long life batteries helps, but after a long time they too may leak all over the battery case, corroding it.

It takes only a very small amount of corrosion to prevent juice from getting to the calculator's circuitry. A light going over with alcohol very often does the trick.

Clean the battery terminals with alcohol or cleaning fluid. If the contacts are very corroded, scrape them with a pocket knife. Try using a small strip of sandpaper on the battery terminals. If the contacts are partially eaten away, you may have to make new metal contact strips. Select a piece of springy brass or copper material for this purpose and solder it on.

Sticky Buttons. After a few years of operation, several of the most used buttons may not want to press downward, or they may want to just stay down. In fact, you would swear someone is pulling down on these small buttons. When plastic buttons work against plastic or metal areas, they have a tendency to stick and become sluggish.

A shot of tuner cleaner or contact lube is usually all it takes to free sticking buttons, unless they are broken or have been heated to the point where they have fused.

You can cure this problem quickly by spraying contact lube or tuner cleaner down around the buton area. A drop or two of light oil will work as well. Work the button up and down until it is free. You might as well clean up all the buttons while you're at it. Wipe off all excess oil or cleaner with a soft cloth. Sticky buttons are a nuisance when trying to figure your income tax, adding today's enormous grocery bills or balancing checkbooks.

Calculator Repairs

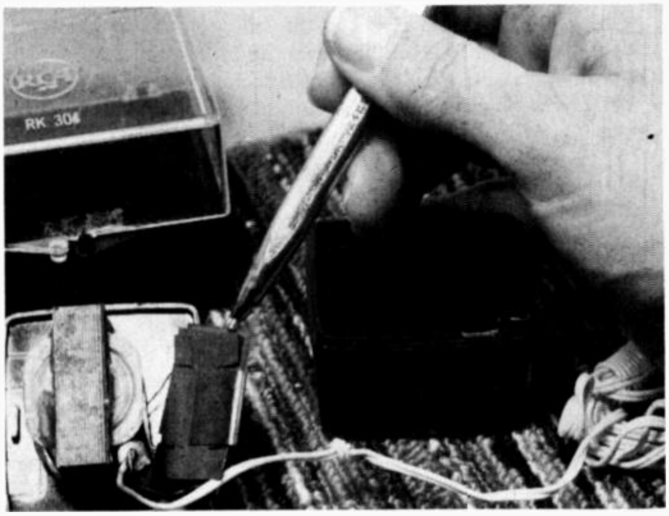
Broken Terminal Wires. After carrying the calculator to school through the rush hour, and dropping the unit several times, you may find a broken terminal wire or two. If the calculator will not function after battery clean-up and replacement, suspect a broken connecting wire. Check the wires going to the battery terminals. Also, check to see if the On/Off switch wires are still connected to the terminals.

Sometimes you may find a broken conncting wire from the pushbutton assembly to the main PC board. You may find a broken terminal connection from the LED display unit to the PC board. Generally, the display unit is tilted at an angle to shield the display from overhead light. Use a very low-power soldering iron when making soldering connections on these delicate calculator boards.

A voltmeter is vital for checking out the electrical continuity, finding shorts and tracing through the circuitry. Pocket calculators very often show signs of abuse.

Defective Power Adapter. The battery eliminator or power converter plugs directly into the AC power outlet with the male plug inserted into the calculator socket. These small AC adapters or gadgets can save you money in the long run. Since leak-proof batteries are quite expensive, you may want to use the AC adapter instead. Check the enclosed literature, and you may find the operating voltage of your calculator. For instance, if the calculator uses three 1.5-volt batteries, the 4.5-VDC voltage adapter plug is used. If the calculator uses four 1.5-volt batteries, use the 6-VDC adapter plug. You may want to select a universal AC adapter with four different voltage sources.

If your battery eliminator or AC adapter is suspected of failure, measure the DC voltage at the male plug. No voltage at this point may be caused by a broken male plug, a broken cable or a dead power pack. Determine if the cord may be broken right at the male plug, or where it enters the AC adapter's case or housing.



It is possible to avoid replacing a defective AC power adapter by making a few simple repairs to the unit. Always measure the DC voltage at the male plug end to determine if the fault lies with the power adapter.

If one wire is broken at the male plug, cut off the cable about one inch up from the plug end. Always unplug the AC adapter while repairing it. Now scrape back the insulation and measure the DC voltage. If voltage is present, locate another male plug. Generally, these male plugs are of the molded type and cannot be used again. You may select a headphone-type plug the same size and install it. Be very careful to obtain the correct DC polariy at the male end to operate the small calculator without damaging it.

A Cracked Case. Rough handling or dropping the calculator may damage or break the plastic case. If the calculator ends up in a dozen little pieces, the plastic case may not be repairable. Some of the cases are made of tough plastic or impact material, and these may wind up with only a crack or two.

You can put the small calculator back into operation by repairing the cabinet with epoxy cement. Simply mix up the epoxy evenly upon a piece of cardboard. Then stick the broken pieces together, and apply a thin coat inside the container and on the outside. A broken corner may be repaired with a layer of thin cardboard held with masking tape on the inside. Then, apply a coat of epoxy over the broken area. Several layers of masking tape will hold the liquid epoxy in line until it sets up overnight. Sand down the rough corners with sandpaper or a coarse file. If the repair is too unsightly, spray paint the area, or the entire cover.

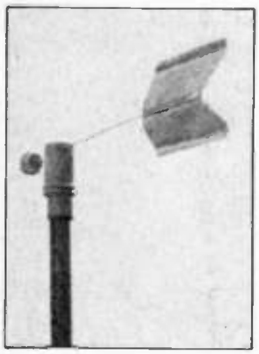
This list of troubleshooting hints should help you cure most of the common pocket calculator problems. And, especially these days, we can all use the savings in repair or replacement costs on these handy devices. ■

Simple cracks or breaks in the plastic of the calculator's housing can be repaired with epoxy cement. After applying epoxy, spray paint the case in its original color.

LED WEATHER VANE

Lets You Know Which Way to Bend With the Breeze

BY T. J. BYERS



The LED weather vane should be mounted high above a roof and clear of any obstructions that might distort the flow of the wind.

WHETHER YOU ARE A PILOT, farmer, sailor, kite flyer or just plain curious about tomorrow's weather so you can go to the beach, this low-cost electronic weather vane will tell you which way the wind blows. All you need are two readily available IC chips, some variable resistors, LEDs, and a handful of junk-box parts to put it together.

By learning how the weather changes with the shifting winds you can learn to predict what is going to happen over your head over the next few hours, rather than trusting that last night's six-o'clock forecast was accurate. We don't have the space to teach you meteorolgy here, but there are plenty of books available on that fascinating subject. Or, you can ask an old-time sailor or farmer to tell you some of the tricks of weather watching.

Wind Direction. Essentially, measuring the direction of the wind is a simple and ancient process. Although there are a couple of methods (the airsock, so familiar at small airports, and the vane), only the vane is suited for our needs.

A vane is fabricated from a flat sheet of material. A pivot point is selected. The material is cut (or fashioned, as in the case of the weathercock rooster) so that one surface about the pivot has considerably more area than the other.

The vane is placed into the wind. Now as the air strikes the surfaces, a force is developed. A greater force is exerted on the larger area. This imbalance of forces causes the vane to twist, seeking an equilibrium; this occurs when the vane is pointing into the oncoming wind. When people talk about wind direction they always refer to the direction the wind is coming from. In other words a northwest wind is blowing out of the northwest towards the southeast. The weather vane would be pointing northwest. To translate this into usable information a transducer is used.

A transducer converts the outside world into a more appropriate form. For us, a potentiometer is the logical choice. By connecting the vane to the control shaft, it will rotate in accordance to wind direction.

When a voltage is applied across it, the wiper becomes a voltage divider with the resultant voltage relative to the shaft position.

The Circuit. But voltage is a very abstract value and in its raw form doesn't lend easily to interpretation of wind direction. So, we incorporate a decoder of sorts. (The two circuits will analyze the voltage as it comes from the sensor; the conversion is merely for our sake.)

The input voltage is converted to a display representative of a compass (the standard used to indicate wind direction). The decoder and display consists of two ladder-type LED driver ICs—the ones so popular with graphic power and tuning displays. U1 and U2 are LM 3914s connected in cascade. They are programmed with a jumper from pins 9 to 11 for dot display.

When a voltage is presented at the input (pin 5), a LED corresponding to that voltage will light. By matching the potentiometer range to that of the display, we represent 16 positions of the shaft, which is the number of compass points associated with wind direction.

Arranging the LEDs in a circle completes the concept, giving us the visual effect of a compass. There are, however, a few not so obvious points about the circuit.

Each IC carries a complement of eight LEDs instead of its capacity of 10. In the case of U1, it was necessary to eliminate the topmost indicator, pin 10. A curious thing occurs with this device when the input voltage exceeds full scale. The last LED will remain constantly lit. We are cascading the two units to increase the number of indicators and unless additional circuitry is incorporated, this situation would prove intolerable. Two indicators at the same time would be confusing. Eliminating this pin circumvents the problem.

In the case of U2, we want the last LED to light. To understand the reasoning behind this we must look at the potentiometer. The resistance element isn't continuous; it has a break in it. When the wiper reaches this position, the output voltage (input as seen by the decoder) goes high.

In this situation, the only lamp to light is the last one LED16. What was a problem for the first series of indicators becomes a solution for the upper set. The remaining LEDs are accordingly distributed.

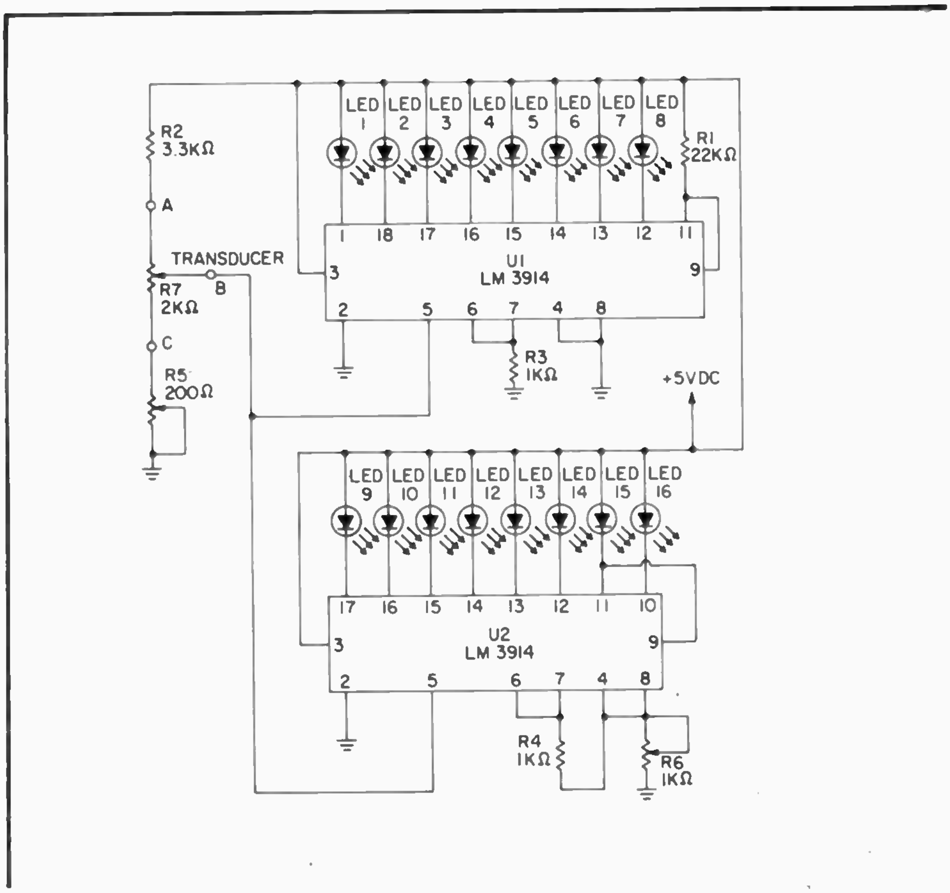
The circuit also has two adjustments to it. R6 controls the input voltage of U2 so LED9 can take over after LED 8 has extinguished. R5 is necessary to overcome the initial voltage required to begin the ladder process.

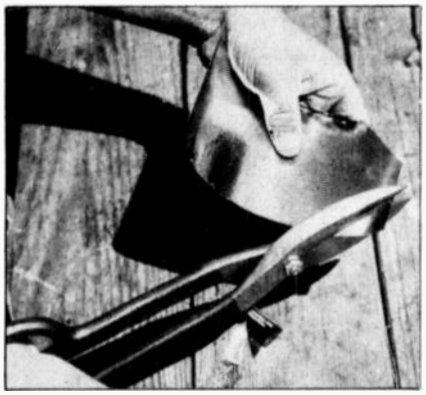
Constructing The Sensor. Since the wind vane will undoubtedly be less familiar than the electronics, let's start there. Begin by obtaining a steel bev-

PARTS LIST FOR WIND DIRECTION INDICATOR

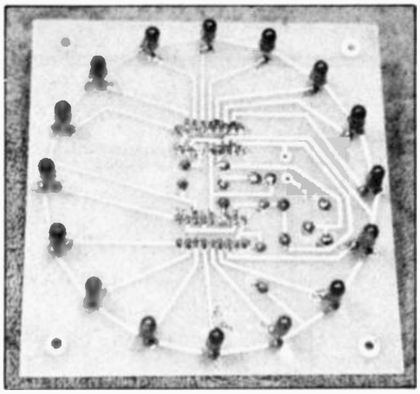
LED1-LED16—Jumbo, red light emitting diodes
R1—22,000-ohm, ½-watt, 10% resistor
R2—3,300-ohm, ½-watt, 10% resistor
R3, R4—1,000-ohm, ½-watt, 10% resistors
R5—200-ohm, trimmer potentiometer
R6—1,000-ohm, trimmer potentiometer
R7—2,000-ohm precision linear potentiometer, 360-degree-free rotation (Bourns model 6538 or 6638 preferred—next choice Bourns 6537 or 6637).
U1, U2—LM 3914 dot/bar display driver integrated circuit
Misc.—cabinet, prescription vial (1½" x 2½"), coat hanger, bezel, beverage can (vane), P.C. board, counterweight, epoxy, hardware, wire, etc.

Note: An etched and drilled printed circuit board is available from Danocinths, Inc., P.O. Box 261, Westland, MI 48185, for $7.93 plus $1.50 shipping and handling. Michigan residents add 4% sales tax. Specify RW-102 when ordering.

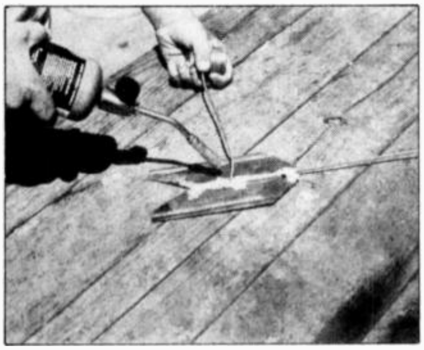




Use tin snips to cut the sheet metal to the appropriate shape (see next page).



LEDs mount on the foil side of the printed circuit board (see text instructions).



Use a blowtorch to solder the vane to the rod. Beware of dangerous fumes released from the tin plating by heat.

erage can. But be wary, most containers nowadays are aluminum and won't work for our application. However, almost all canned teas come in steel, as do some colas. With an opener, remove the top and bottom; next cut down the seam with a pair of tin snips. Don't attempt to flatten the metal.

Remove the outside edge with the snips, then smooth the metal. Shape the vane according to the template. This isn't a necessary step—merely aesthetic. A rectangle will work equally well.

Rigidity is given to the finished piece by bending three grooves into the metal. Lay the vane over a thin metal rod along the designated lines and run a piece of wood over it. A notch in the end of the wood will impart a deeper groove.

Cut out a 10-inch section of coat hanger. Remove the paint and solder it to the center groove of the vane. This must be done in a well ventilated area. The stannous fumes are poisonous!! Avoid inhaling any fumes coming from the tin plating, which will vaporize as soon as you apply heat.

A counterweight is necessary to remove lateral pressure from the potentiometer bearing. It can be fabricated in a number of ways; ours is the decorative end from a curtain rod, along with a short piece of coat hanger filled with solder.

Here's where it all comes together. Obtain a plastic prescription vial, one about 1½ inches in diameter by 2½ inches deep. The plastic bottle will serve to keep rain and dirt out of the sensor pot as well as provide a convenient method of assembly.

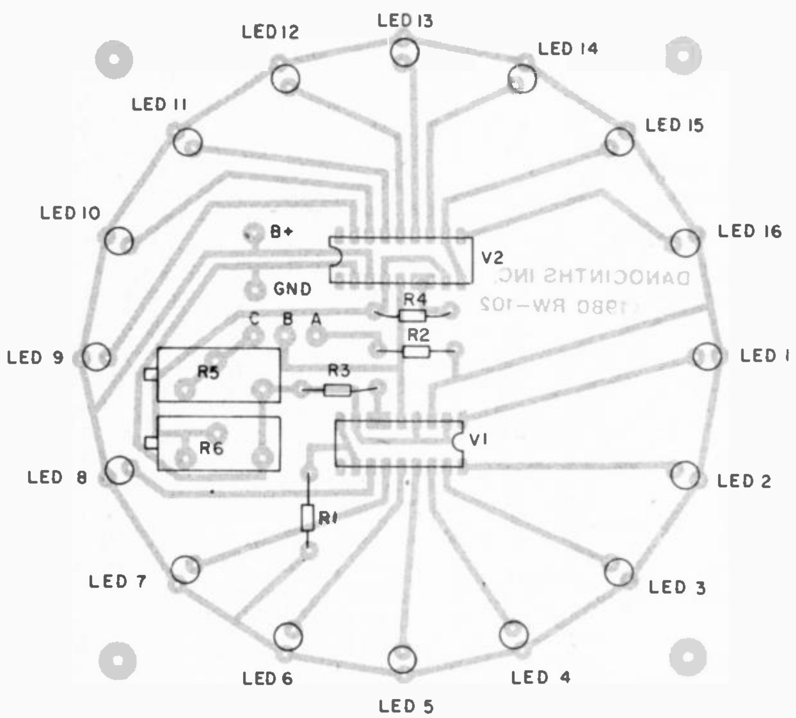
Drill two 7/64-inch holes near the bottom. Locate them so a single piece of wire will pass through the center, barely clearing the bottom. Drill a hole in the center (⅛ inch of the bottom just large enough to accept the potentiometer shaft. It should be a snug fit. Push the support wires from the vane and counterweight into the side holes and adjust the length of the counterweight until the system is in balance.

Epoxy It. Epoxy will hold everything together, but first you must provide the rheostat shaft. Take the drill bit used to make the hole and cover it with a light vegetable oil coating. Place it shank end down into the hole. Line up everything and fill the bottom of the vial with a layer of fast-setting epoxy just thick enough to cover the support wires. Make absolutely sure the drill bit is straight up and down, lest you develop a wobble when the casting is dry.

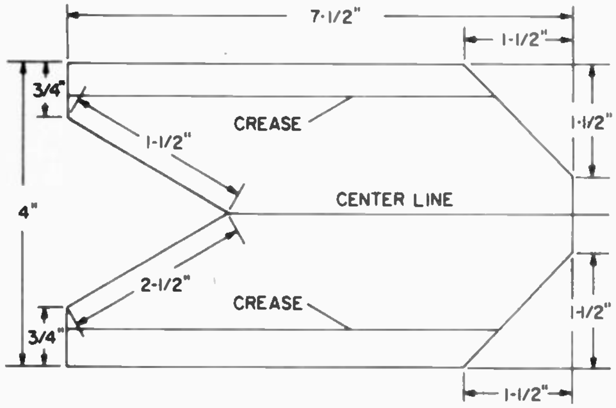
After the epoxy has set remove the drill. Now, set aside to harden overnight.

The transducer pot is mounted inside a ¾ inch plastic coupling. Let's pause for a moment and examine the sensor pot. It's a special precision pot, in that the resistance element has 340-degrees of electrical contact. An ordinary control has only about 260, maybe 290, degrees of resistance path.

Attach three wires to the potentiometer and seat it into the coupling with silicone adhesive. Avoid getting

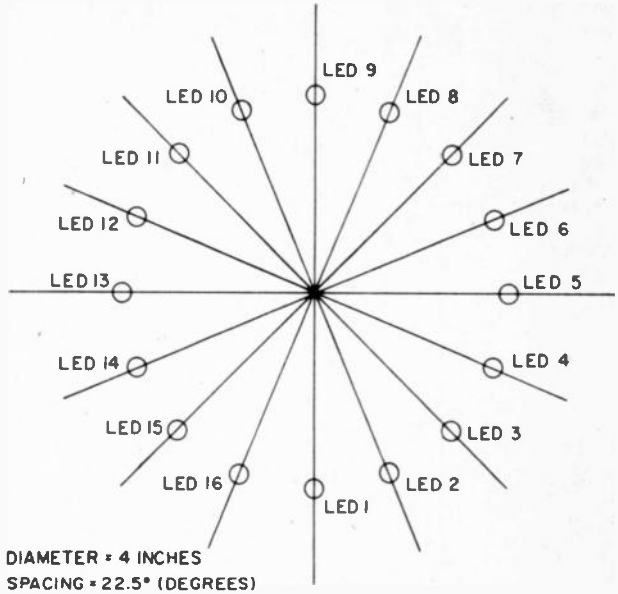


The above diagram shows where the parts are installed on the printed circuit board. Be sure to mount the LEDs on the foil side with cathodes on the outside ring. The flat edges of the LEDs should face the middle of the board.



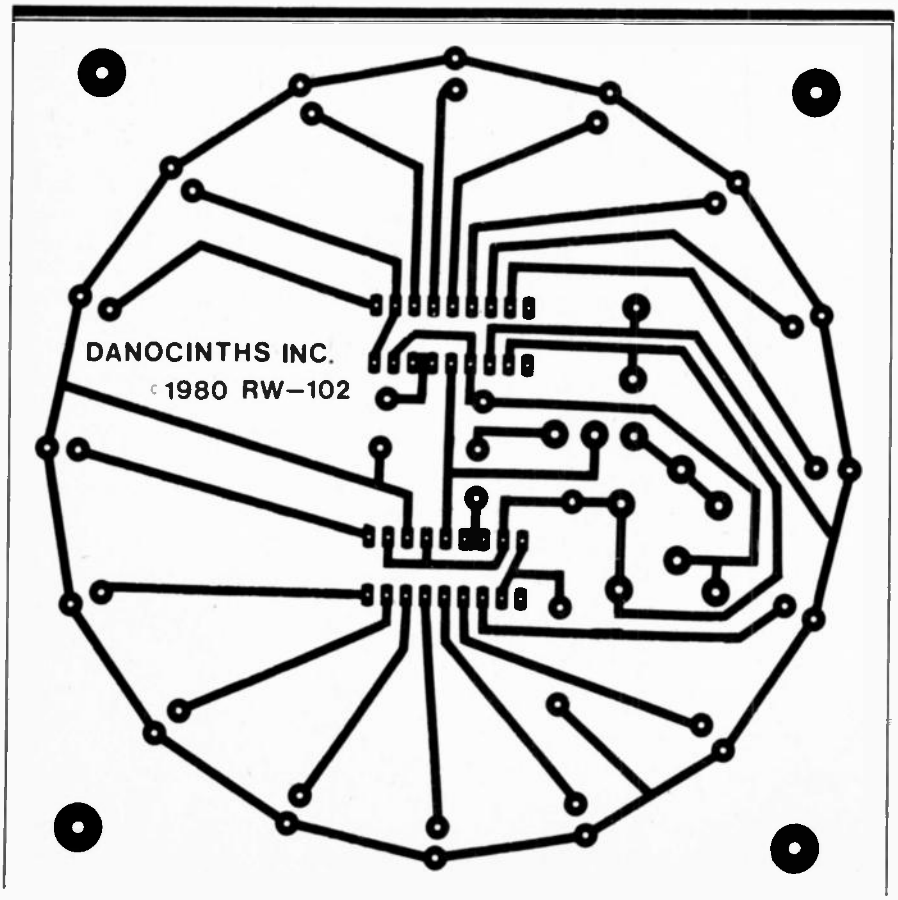
The above pattern is just a sample of a possible weather vane design. This one worked well and has proven itself quite durable. Be sure it points straight at the axis.

The drawing at the right shows the spacing relationships of the LEDs. Be very careful locating the holes and mounting the LEDs on the printed circuit board.



any on the shaft or bearing. The coupling is glued to a section of ¾ inch water pipe, which becomes the support.

Slip the vane assembly over the pot shaft and glue with Crazy Glue or equivalent. (Here's a hint: Slide the vane assembly on the shaft and push down all the way. Apply a drop of glue to the exposed shaft and immediately move the assembly upward about ¼ to ⅜-inch. This eliminates the possibility and frustration of the adhesive running down the shaft and into the bearing.)



Assembling The Display. As previously discussed, we arrange the LEDs in a circle, thus mimicking a compass. We'll start by drilling the required sixteen holes in the cabinet; the reason will become very apparent later when you arrange the indicators.

A full-sized layout of the LED positions is on these pages. Remove (or trace) the template and fasten it to the front panel of the cabinet with tape. With a center punch locate each hole to be drilled. Drill the holes with 13/64-inch bit to accommodate the jumbo LED called for.

Obviously the best way to locate and properly space the LEDs is with a printed circuit board. The LEDs solder to the clad side of the PC board, while the components assume the conventional position. But before soldering in place, read the following.

Since it's highly unlikely you'll be able to eyeball the LEDs into place sufficiently close to match the drilled holes, use this procedure. Begin arranging the LEDs on the board two at a time, LED 1 and LED 9 first (observe polarity). Place the board in the cabinet, adjustments up, and the LEDs into their respective holes. The lamps lead length is adjusted so the base is ¼-inch from the board.

Gently remove the assembly and without disturbing the relative positions of the indicators, solder them in place. Repeat this procedure, two at a time, until all are secured. You'll

(Continued on page 104)

BUDGET Electronics

"Buy one speaker and get the other one free!" "Buy this stereo receiver for one penny!" "Buy this complete stereo system and we'll pay you to take it away!" You've undoubtedly heard hundreds of claims like these, but have you ever wondered how the audio dealer can honor these offers and still stay in business? Have you ever marvelled at those marketing miracles or did you just write a check, load up your car with the advertised goods, and hustle home as quickly as you relinquished your money?

The high fidelity industry is unique. With the exception of a neighborhood tag sale, or a Barcelona open-air produce market, no other business offers the consumer such apparent bargains.

Was your purchase the result of an intelligent decision, or was it merely an impulse brought on by a "last chance" deal that would be offered weeks later at the same store? Although you may be equipped with a thorough knowledge of technical information, specification details, and product familiarity, you may wind up dumping your carload of bargains into the nearest refuse receptacle.

By being aware of a few facts concerning the battle strategies employed by those involved in stereo price warfare, you, the consumer, can avoid the pitfalls that are camouflaged by that lucrative "deal."

History. Prior to 1975, it is unlikely that you would have seen such outrageous advertising claims as you do today. A fossil called "Fair Trade" hovered over the heads of dealers, preventing them from discounting the manufacturer's list price of an item. Thirty-six of the fifty states were bound by the Fair Trade Law. Some dealers were even taken to court for violating it. The law had been instituted some thirty-five years earlier in order to encourage the growth and well-being of post WW II business. Since a turntable at store "A" was the same price as the identical machine in store "B," the consumer's choice was based upon personality, service, and salesmanship. Price competition did not exist.

In 1975, the government decided that repeal of the Fair Trade Law would benefit the consumer. The original intent of the law had long since been realized by the dealer and now should be revised or dissolved to ensure better prices for the buyer. By the beginning of 1976, all participating

FOR YOU I'VE GOT THIS DEAL...

states had repealed the law. Prices dropped. The consumer bought, and bought, and bought. As a result, the audio industry blossomed from a 1.7 billion dollar business in 1975 to an awesome 4 billion dollar enterprise in 1978.

With the former protected profit margins now gone, how does the dealer survive? Was the repeal of the law an actual benefit to the consumer? The staggering growth figures of the audio industry indicate that the consumer has aided the growth. How could you be getting such a great deal and still enable the industry to flourish? Be aware.

"Black Box!" The most notorious method of maintaining a respectable profit margin in the hi-fi industry is the sale of "black box" or "house brand" speakers. These inflated list, low dealer cost items are designed to offset the declining profits realized in receivers, amplifiers, and other electronic components. A "black box" may bear a list price that quadruples the dealer's cost. Thus, a dealer may offer a "sale" that allows him to sell one speaker at regular retail price and give the matching counterpart away free of charge. He can still maintain a healthy 100% profit.

Some of these speakers can be recognized by a series of letters that indicate their "brand." These letters are often the initials of the selling firm. Joe's Bargain Stereo sells JBS speakers. But be aware that many highly reputable hi-fi companies, such as JBL, JVC, KLH and BIC, use their initials on their products. It is this confusion factor that enable dealers to claim high prices for house brands. It seems so obvious when put into print, but many consumers are confounded, or just don't make the association at the point of purchase. The best way to unmask these great pretenders is to familiarize yourself with the names mentioned in **Hi-Fi/Stereo Buyers' Guide** and other quality hi-fi magazines, since the only units mentioned are from recognized manufacturers. If it isn't mentioned, it ought to arouse your curiosity or encourage further research.

Black box" speakers are not fundamentally poor sound reproducers. In fact, some are rather good. They are conceived with a marketing idea in mind rather than the pursuit of sonic excellence. They are often the brainchildren of company executives who supervise the construction of boxes, shipping cartons, and wooden crates. The executives of these companies, observing the potential in the expanding audio industry, direct the construction of boxes, arrange for the provision of raw components from various driver manufacturers, and merchandise the finished product as their own "high fidelity" loudspeaker. Have you ever wondered how you could have purchased that impressive looking six-way tower for the same price as your friend's modest two-way bookshelf speaker? You paid only for the raw materials. The extensive cost of research and development required to manufacture a first-rate piece of audio equipment did not have to be figured into the price. If you think that you got a great deal on the monoliths that dwarf your friend's cufflink containers, try to sell those hulks in five years. Their resale is difficult, and the lifetime warranty that was offered with them at the time of the sale is now void because the manufacturer has changed its name and now only markets funeral caskets.

Try buying one of those high quality receivers for one cent *without* the purchase of the advertised set of speakers. Can you still take advantage of the one penny receiver ad? No. you can't.

Cartridge Deals. Massive profits for the dealer are also concealed within the tiniest stereo component, the phono cartridge. A cartridge listing for as much as sixty dollars may cost the dealer as little as eight bucks. There are many reasons for this seemingly unfair profit enjoyed by the dealer.

Many consumers don't realize that the cost of a cartirdge is *not* included in the cost of a turntable. Therefore, the cartridge manufacturer accommodates the dealer by providing him with a virtual give-away item. If the consumer *is* aware of this separate component, it enables the dealer to offer an apparent substantial discount on the turntable/cartridge combination.

Unfortunately, recognition of these inflated list phono cartridges does not come as easily as the identification of "black box" speakers. Most or all of these items bear familiar brand names. The intricate technology required to manufacture these micro-reproducers eliminates the mass-merchandising furniture or food chains from participating. The cartridge manufacturers recognize the necessity of maintaining the dealer's profit in order to assure their own existence.

Beware of that fifty dollar cartridge that is "thrown in" with the deal on your stereo system. You can benefit by paying a mere ten to twenty dollars additional investment and get a true hi-fi, rather than promotional, phono cartridge.

There are three types of phono cartridges. The first is the promotional freebee that is included with the purchase of any turntable. The second, though it may bear the same "list" price as the former, offers exceptional performance for a small additional cost. The third type are about the same mark-up as other audiophile equipment and should be considered separtely when purchasing a hi-fi system. These are for the avid hi-fi hobbyist. If you are a neophyte in the stereo jungle, avoid the first category. If you are a sound fanatic, go for the third. Phono cartridges in the middle category represent excellent overall consumer value.

Consult reviews in consumer maga-

zines to see if your cartridge has been reviewed. If it hasn't, you may be looking for that proverbial "needle in a haystack." Unless you are familiar with the product, confront the dealer. If you let him know that you are aware of the cartridge marketing facts, he will most likely lead you in the right direction.

Component Hoopla. Electronic components, amps, receivers and tuners, pose a different problem for the consumer. These can be selected on a more objective basis than speakers or phono cartridges. Power, distortion, sensitivity, and selectivity claims are carefully monitored by the Federal Trade Commission. The printed specifications of these components are solid, proven facts. Speakers and phono cartridges, on the other hand, possess those qualities which cannot be written down in black and white. "Uncolored," "open," "sweet," "smooth," and "silky" are intangible, subjective descriptions used to identify a speaker or cartridge. This sonic variation barely exists among receivers. The difference in performance is clearly spelled out in black and white.

What product line should you pursue? Which is the best? The fact is that they are just about all good. You may have to base your decision on features, cosmetics (Although this is an unpopular reason for choosing a component, remember, *you* have to look at it day after day. The salesperson doesn't.), circuit protection, or the feel of the controls. Suddenly an objective decision becomes subjective.

Subjectivity is not an undesirable attitude to maintain when evaluating a stereo system. In fact, an equal balance between subjectivity and objectivity will yield the most satisfaction for your money. Here are a few hints that may help you to realize this satisfaction:

Avoid amp/receiver lines, that are *consistently* "blown out" by dealers. Although the product may be good, *its* value and *your* investment are constantly declining. The low prices are not necessarily an indication of inferior quality, but rather, an indication of the manufacturer's marketing philosophy.

Know Your Dealer. Be cautious of the dealer who says that he does not carry a certain product line because "they all blew up," "they're quality has gone downhill since 1972 B.C.," or "the specs are overrated." The first reason is a lie, (today's electronic components are extremely reliable), (FTC preconditioning tests are rigidly observed since the 1974 court ruling). An audio dealer can't carry every line that is available just as a Ford dealer can't sell a Chevy product. Be wary of the salesperson who tries to sell by berating the product that does not grace his shelves. Listen to the dealer who sells his product on its own merits.

True Value. The best values in the hi-fi market can be found in end-of-year close-outs, demonstration units, and trade-ins.

A manufacturer does not discontinue a particular item due to problems. Models change at the rate of one a year and are no different than the changes in the auto industry. Don't worry about obsolescence. If you buy a 1980 Chrysler in 1980, it will inevitably be superceded by a 1981 model later in the year. The changes are primarily cosmetic, even though the manufacturer may introduce the new version as the embodiment of some major technical breakthrough. Actually, the manufacturer is anxious to get rid of his overstock of "old" models and offers a tremendous savings to the dealer. The dealer is anxious to clear his inventory for the advent of the new, "breakthrough" models and passes an *actual* value onto you.

Many consumers avoid the purchase of demonstration units. *You* shouldn't. Because of rapid model changes, a component rarely remains on the shelf for more than six months. In that six month period, the component receives as much use as an individual would give it in a two week period. Keep in mind that the demo unit you are looking at is only one of many on the dealer's shelves. It is not used exclusively as it would be in your home. Another positive benefit is that you know it works.

Trade-in components represent the "tied-up" profit of the audio dealer. The dealer generally wants to cover his cost when a new component is sold, and wants to turn the trade-in unit as quickly as possible. You pay only for the mark-up that the dealer is trying to retrieve, rather than a price that includes warranty service, advertising costs, and operating overhead. If you choose to buy a trade-in component, make sure that you ask for a warranty of at least thirty days. Most likely, the dealer will agree to this since trade-in gear is generally checked out before his original deal was made. If he refuses, stay clear.

Finally, observe the treatment that you get at various dealerships. The dealer who spends time with you before you have made your final decision is likely to spend the same time if you should have a problem after the purchase. The dealer who points to the price of an item and then shovels it out the door is likely to do the same thing with you if you should encounter any difficulty with the product.

The audio salesperson is, like yourself, a hobbyist and a consumer. He has had the advantage of massive exposure to products that you might not be aware of. He knows . . . or should know all the technical details. Approach him with friendly skepticism, but not outright cynicism. He can become either your ally on the battlefield of stereo warfare or else a ruthless foe. Don't be an antagonist. That can only serve to thwart your potential "good deal." The arrogant question. "What's *my* price?," may not elicit an immediate response, but may manifest itself later in the form of slower service, or reluctant advice. Cooperate.

Rising costs and inflation have created a consumer who is more vigilant than ever. This is a time when you should be thinking about "what you are getting for your money" rather than "how much money you are saving." ■

HIGH-AMP METERS

Keep up with current events by expanding your meter's amp-ability

WITH THE RISING COST of test equipment it is advantageous to be able to perform several operations with one meter. For instance a DC milliammeter can be converted to read higher values of current by adding a shunt to bypass the bulk of the current around the delicate meter. By following a few simple steps a milliammeter can be converted to read 10 to 20 amps or more. The first step is to determine the internal resistance of the meter. From this you can calculate the shunt resistance needed and the type of material to be used.

To find the internal resistance of the meter, construct the test circuit illustrated here. The 4700 ohm resistor is used to limit current and serves no other purpose. Start with the power supply set to zero volts, leaving S2 open and S1 closed. Slowly increase the current flow by varying R3 until the meter needle moves to full-scale deflection. Without touching the setting of R3, close S2 and adjust R2 until the meter reads half of full scale. According to Ohm's Law the resistance of the meter and of R2 are now equal. Open switch S2 and measure the resistance across R2. This value will be equal to the internal resistance of the meter.

Shunt. Precise shunt resistance is important for accurate current readings and must be chosen carefully. With the shunt connected across the meter, most of the current is diverted past the meter. This is the theory behind a small meter being able to read high currents. The shunt can be a wire, steel or copper bar, or almost any material that will offer the proper resistance. To determine the needed shunt resistance we will consider an example. If we want a 0 to 10 milliammeter to be able to read full-scale for a current of 10 amps. Therefore 10 mA will flow through the meter when 9.990 Amps are diverted through the shunt. If the meter resistance was 100 ohms, using Ohm's Law the voltage across this parallel circuit is found by using the following equation:

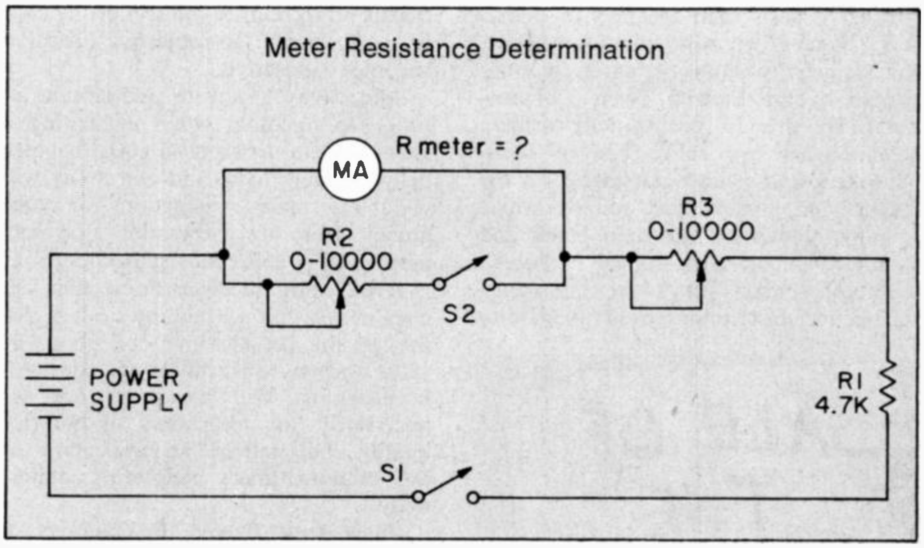
$$E = (\text{Current}) \times (\text{Resistance})$$
$$= (0.01 \text{ amps}) \times (100 \text{ ohms})$$
$$= 1 \text{ volt}$$

Using the calculated voltage and solving Ohm's Law for resistance the proper shunt can be found. This derivation is shown below:

$$\text{Resistance} = \frac{\text{Voltage}}{\text{Current}} = \frac{1 \text{ Volt}}{9.990 \text{ Amps}} = .1001 \text{ Ohms}$$

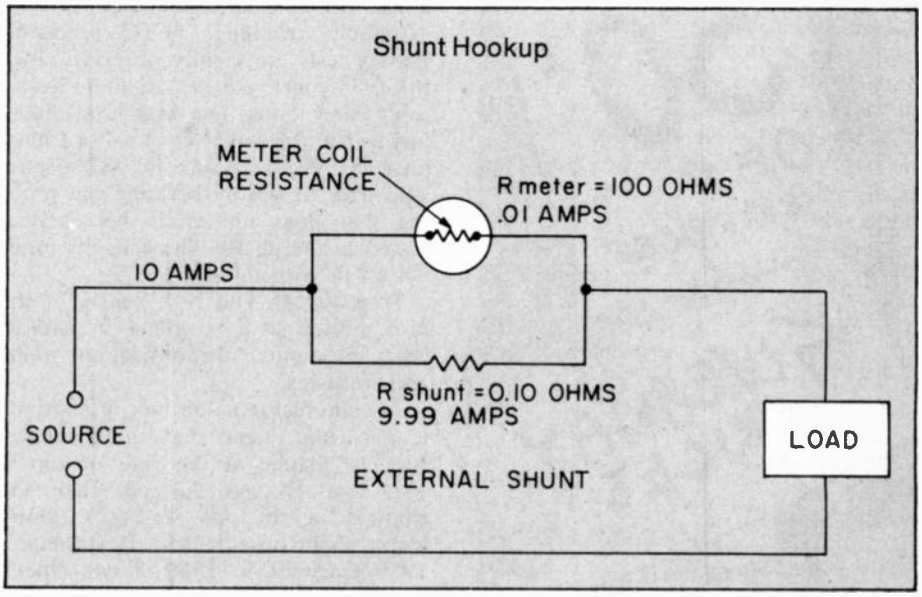
In this case the milliammeter would be capable of giving a readout directly in amperes.

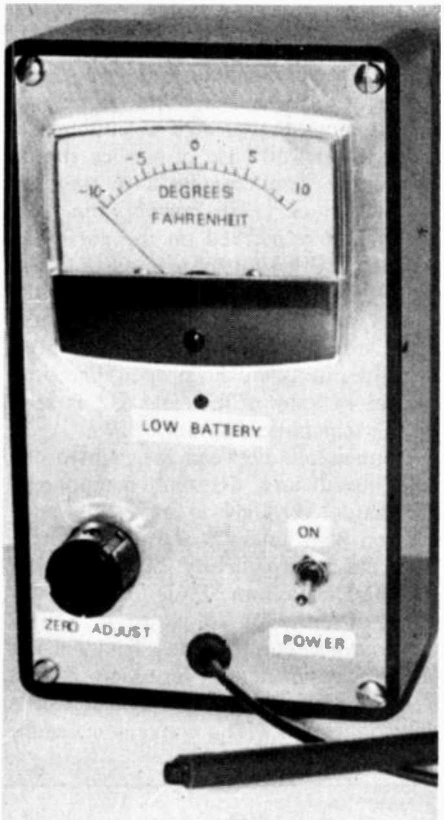
By following these few simple steps you will greatly expand the versatility of your test equipment. It will increase your ability to handle a greater variety of test and trouble shooting situations. ■



To determine the internal resistance of a meter construct a circuit like the one illustrated above. If you don't have the parts in your junk box then check an electronics surplus outlet.

A shunt resistor bypasses the bulk of the current around the meter while allowing a regulated amount to pass through the meter's coil and give an accurate reading. A shunt can be a resistor or a measured length of wire. Make sure it will handle the current.





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.

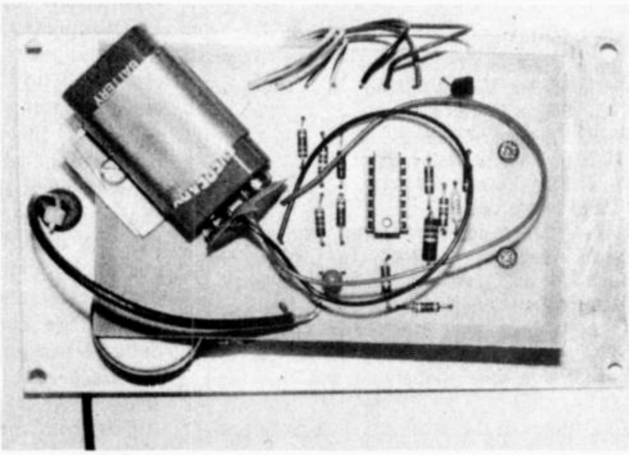
Circuit Theory. Heat Loss Sentry has been made possible by the development of an accurate low cost temperature sensor integrated circuit, LM335. This is a three terminal IC, designed to look like a 3 volt zener diode with an accurate temperature coefficient of 10 millivolts per degree Kelvin. (The Kelvin 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.

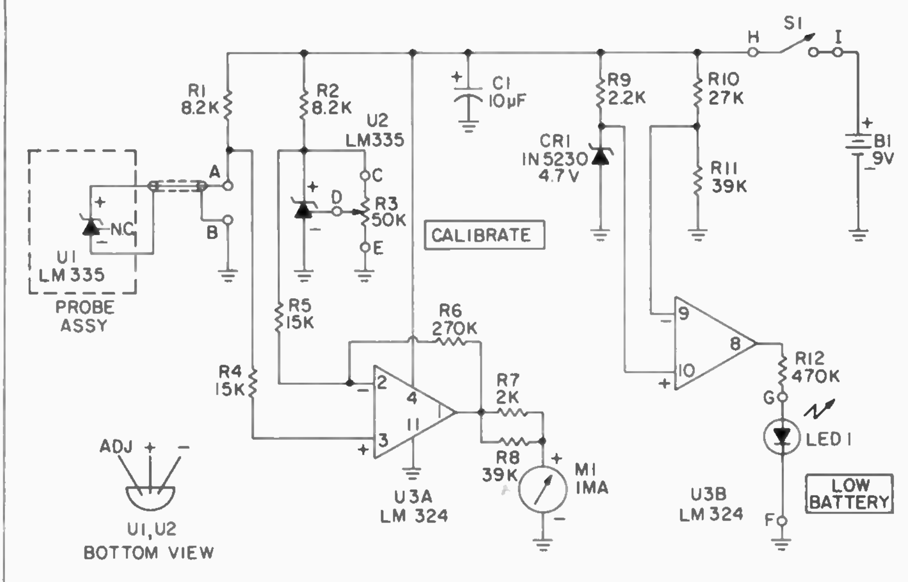
LED 1 is mounted on the front panel of the instrument using a small amount of epoxy. Use a pair of different colored wires to make the connections between the LED and printed circuit, and be careful not to bend the stiff leads of the LED where they enter the plastic body. This might render the LED defective.

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
01–4.7-volt zener diode, 1N5230 or similar
LE01–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.

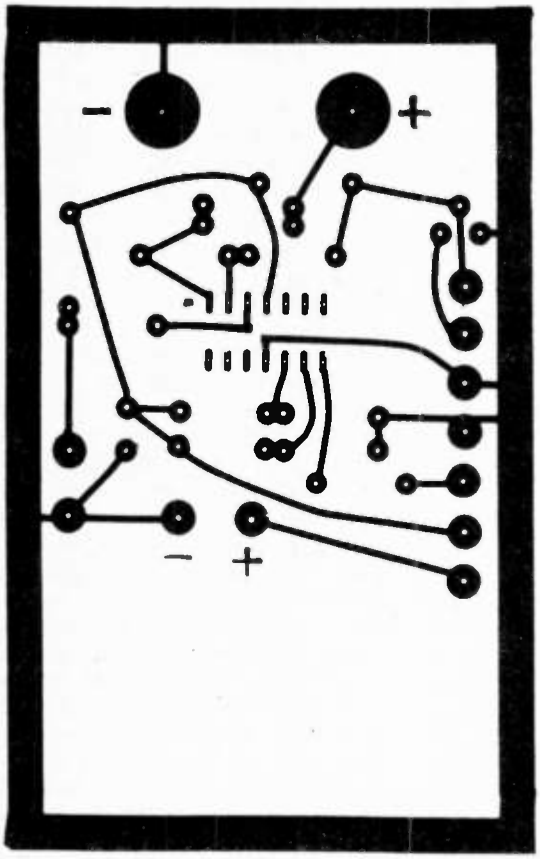
fully wired, check for wiring errors. Then, connect a 9 volt transistor battery to the power input terminals. Activate the power switch and rotate the zero adjust control over its full range. You should be able to adjust the meter reading from zero to full scale, with some extra range left in the potentiometer. 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.

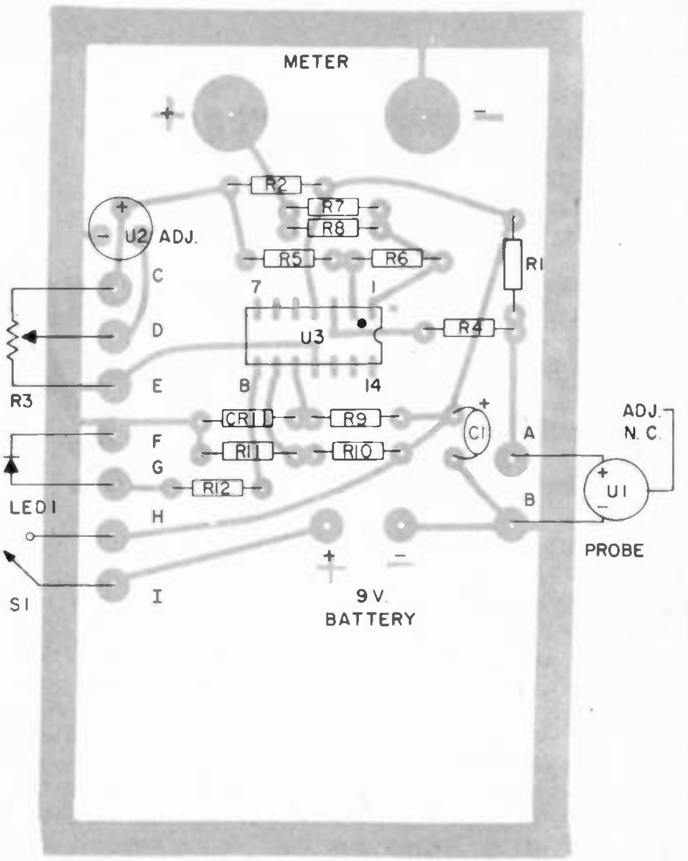
When Heat Loss Sentry is operated, you may notice that the Low Battery indicator blinks as the power is turned on and off. This is a normal reaction, which occurs as the circuit voltage passes from zero to battery voltage then back to zero.

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.

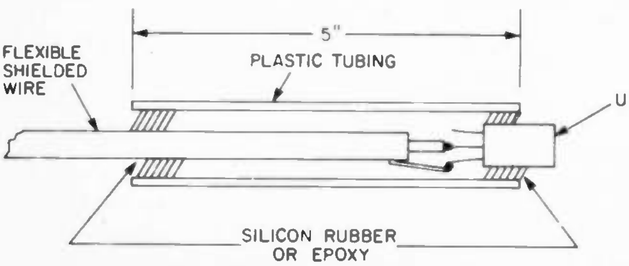
Another interesting use for this device is in troubleshooting defective electronic circuits. When the probe is held close to defective ICs, resistors, etc. a higher than normal temperature will be indicated. ■



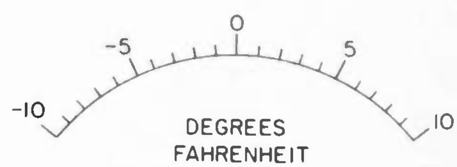
This is the foil side down view of Heat Loss Sentry's PC board. Care must be exercised in etching board.



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 set-up closely, and use the glue! At right is an exact size drawing of the meter face. Cut it out and paste it right on.



Electronic Equipment and your Auto Insurance—A Closer Look

Are you sure that your gear is really insured?

ARE YOU CERTAIN that the electronic equipment that you have in your automobile is insured? Have you called your insurance agent lately and asked? If you haven't, you could be in for a surprise! Far too many CB, ham, eight-track or cassette stereo users, and now owners of "on-board computers," have no idea if their units are insured or not.

Too many of us assume that the "comprehensive" coverage of our insurance policy will automatically cover these items. Chances are, that NONE of the equipment is covered!

Some "old timers" scoff at this statement, but things have changed, fellas, and CB radios might be the cause for these changes. Let's look at this new problem piece by piece.

The Special Policy. As the two meter and CB boom swept our country, so did thefts of this type of equipment. This high theft rate forced the insurance companies to make a move on their own. So, along came the special radio policies. This "special" policy is really an extra policy that is attached to your present automobile comprehensive coverage. Therein lies the nub of a lot of misunderstandings. A point to remember is that if your automobile's comprehensive coverage calls for a fifty or one hundred dollar deductible, then the same deductible applies to the special radio attachment policy, too.

The cost of this "special" radio policy will vary from company to company and is based on the *retail* value of the insured equipment. This rate seems to vary from eight to eighteen dollars and up per year. Another factor that usually comes to the surface only after you have filed a claim, is the *depreciation factor*. Again, this will vary among different insurance companies, but a rule of thumb seems to have been standardized: The figures the companies use for depreciation, usually run at one percent per month after the initial year. This means that if your CB or ham rig was stolen after two years of use, it would have depreciated twenty-four percent.

What's it Worth? With this material in mind, let's look at a couple of examples of just how this would work. John Doe purchased a new single sideband CB radio for $250.00. A year and a half later, his unit is stolen. His comprehensive coverage on his automobile contains a $100.00 deductible. He has also purchased the requisite "special" CB radio policy as an attachment (rider). This rider costs him $10.00 per year. This is how his claim might possibly be computed:

Original purchase price	$250.00
His deductible is	$100.00
1½ years depreciation	$ 45.00
Premiums paid	$ 15.00
Total Reimbursed	$ 90.00

Once again, this will vary with different companies. Also, in this example, we have deducted $15 for premiums paid in. John D. would actually receive a check for $105.00, but try replacing your rig for that! By the same token, how about the CB'er that owns a $39.95 discount special? We're sure you've already seen the light. He gets zilch!

In interviewing insurance agents, we found that about fifty per cent of the insuring companies will replace your stolen unit rather than mailing you a check. This appears the better of the two deals. But it carries what may be an unfair advantage for the insurance companies that follow this practice.

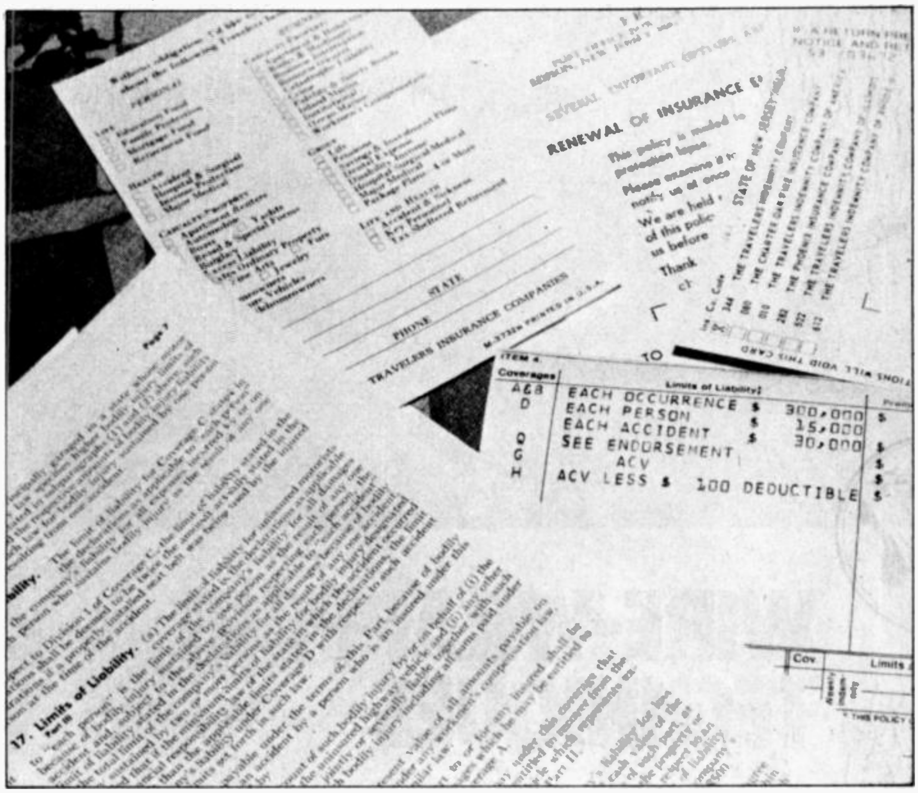
In our previous example of the $250.00 SSB unit, if the company replaces this unit with something comparable, you feel ahead of the game, right? Well, maybe! The insurance company often purchases the replacement from a distributor at, or somewhere near the distributor's cost. In our example, let's say the cost is $150.00. The point here is, why should your "special" CB radio policy have a premium figured from the retail price of $250.00? In reality, the premium should have been figured at the distributor's (or replacement) cost!

Now, with so many of us increasing our deductibles to keep our ever-increasing premiums down, these "special" policies are even more useless. In conversations with practicing insurance agents, it was found that they too feel that these special attachment policies are just not worth the money one must pay for them. The only exception would be the radio enthusiast that has several hundred to thousands of dollars worth of equipment in his mobile.

In defense of the insurance agents, it should be pointed out that they, by selling you this "special attachment policy," do so only to protect themselves from you. If you were to have your radio stolen and called your agent for reimbursement, only to find that your rig isn't covered at all, you would certainly be upset and the agent could lose you as a valued customer. Also, the agent makes only one or two bucks by writing this "special" policy rider, but no more than that. It's easy to see that the agent isn't pushing the policy to make money, but rather to insure his or her integrity as a competent agent.

Cassette and Eight-Track Players. These tape players are generally covered under much the same conditions as the aforementioned radios. We can add in vehicle telephone systems here, too. Of course, while the costs of stereo players and telephone systems are as far apart as one can get, they still provide us with the insight as to what is worth paying an extra premium for, and what is not.

A very elaborate stereo system could have cost you many hundreds of dollars and, of course, merit special insurance. However, what about the $49.95 eight-track and two inexpensive speakers? Don't waste your time and money. Mobile telephones, on the other hand, are very expensive items and should be insured against theft. They can run into the thousands of dollars and most certainly will require your agent's advice on insuring them. A good rule to follow is that almost all sound reproducing equipment will require the special attachment policy or it is not insured!



Don't wait until after you've been ripped off to check your policy's coverage. The best source of information (unless you can decipher your policy's legalese) is your agent.

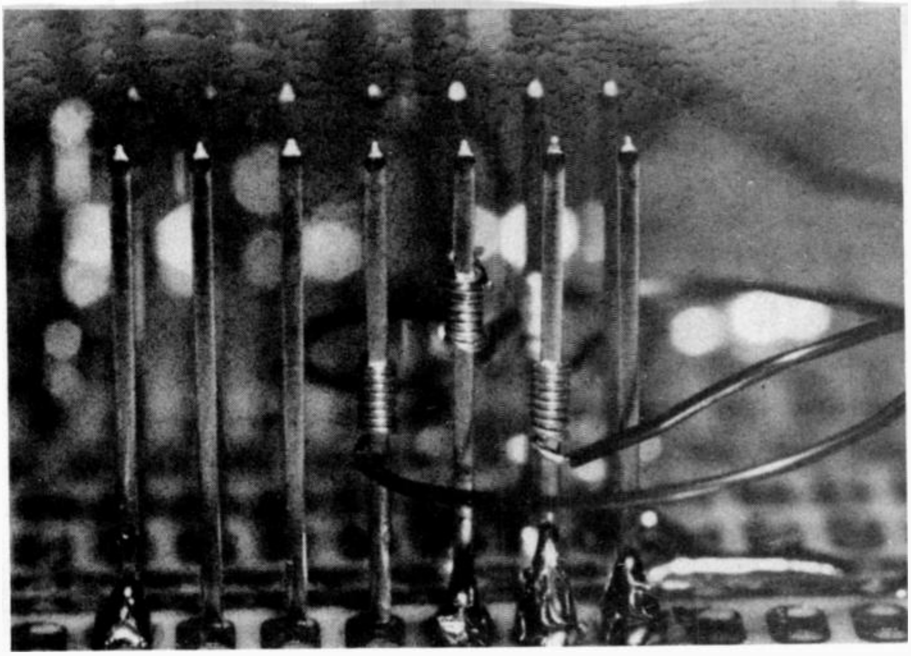
The exceptions to this rule are the CBs, stereo players, etc. that are *factory-installed* in your car. Your comprehensive auto insurance will cover these units as they are "an integral part of the assembled vehicle."

This brings us to the "onboard computer." This calculator-styled unit is appearing in more and more cars as its use becomes known. The onboard computer can tell you everything from the time of day to how many miles you'll be able to travel on the gas remaining in your car's gas tank. Until recently, these units were found only in the luxury cars and were considered "an integral part of the automobile." But now, many companies offer them as "add-on" devices for almost any car.

As of this writing, the majority of companies do not list these computers on their "extra insurance needed" lists. The agents interviewed warned that because they were slowly becoming a popular "add-on," the companies would surely soon insist on special insurance for them, too.

Conclusion. The only safe answer to this insurance dilemma is to contact your agent. Have him explain the deductibles and depreciation variables that are contained in your particular automobile insurance policy. With what is (and what isn't) covered changing almost daily, your agent is the only one that can give you the true figures. Don't wait until you have a claim to file, check it out and add it all up! You may be surprised at what you may learn. And what you learn may just save you some trouble and, more importantly, a lot of money. ■

Question: Which of the car-fi and communications gear seen here would normally be covered by a standard automobile insurance policy? See the text for what may be a surprise answer.



WIRE-WRAPPING TECHNIQUES

Streamline electronic circuit construction with this new method.

WHAT'S THE BEST METHOD for construction of an electronic circuit? There is no easy answer to this question, since the most suitable method varies from project to project (as well as from builder to builder). In this article we are going to take a look at wire-wrap construction; in particular, we'll focus on the OK Machine & Tool's new WK-4B wire-wrap kit.

The OK WK-4B Kit. Each WK-4B comes with one circuit board, a dispenser loaded with AWG No. 30 Kynar wrapping wire, four wrappable IC sockets, a tool for wrapping and unwrapping, an IC insertion tool, an IC extraction tool, and a 22-pin double row edge connector that mates with the kit's circuit board. The clear plastic wire dispenser is an ingenious little device with a built-in wire cutter and wire stripper. It produces cleanly stripped and cut wire in a matter of seconds with a minimum of fuss. Equally ingenious is OK's IC insertion tool. Not only does it do a perfect job of getting an IC into its socket, but it straightens bent IC pins as well.

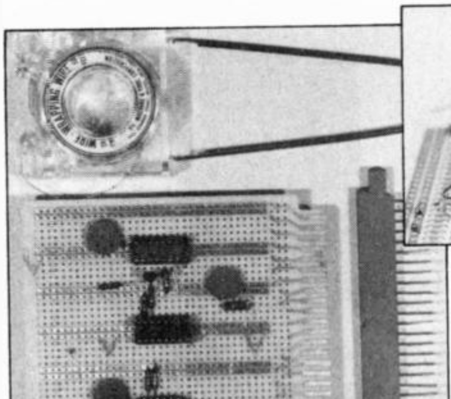
The circuit board is made of heavy duty epoxy composition, which doesn't bend the way paper laminates sometimes do. Each board has etched upon it a pattern of solder-plated copper pads and buses. During construction, which we'll cover later, the builder uses these pads and conductors to satisfy as many of his circuit's connection requirements as possible. Whatever connections that remain are made by wire wrapping. The board's edge has a double-sided pattern of 22 plated fingers that mate with the kit's edgeboard connector. This is handy if the circuit you're building is to be one module of a larger system. Simple projects, however, will not require edgeboard connections, and you can ignore them.

Also included is a double-ended, rod-shaped tool, one end of which does the wrapping. The other end can be used to unwrap an incorrect connection, if necessary. Wrapping is a quick and simple operation that involves threading one end of a stripped wire into the wrapping tool, placing the tool over a wrapping post, and wrapping about ten turns of wire into place. Since the wrapping wire is of light gauge, very little force is required to make an electrically secure connection.

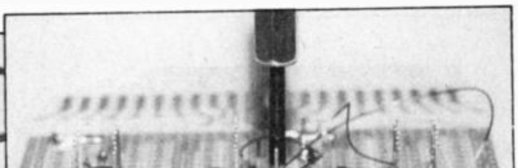
At least part of the credit for a secure wrap must go to the wrapping post. These posts have a square cross section, the corners of which bite into the soft wire as it is wrapped into place. The resulting connection is mechanically tight and of low electrical resistance. Four IC sockets are supplied with the kit, and all of them have wire-wrappable square posts. When you run out, you can buy extra sockets from any electronics dealer. The last kit component, an IC extraction tool, is a U-shaped pincer that lets you pluck an IC from its socket in much the same way as a dentist yanks a tooth.

A Typical Application. Now let's review the construction of a typical project—in this case, the simple pulse burst generator illustrated here. Begin by putting the required IC sockets into convenient positions on the board, and tack-soldering two diagonally opposed pins of each socket to the circuit pads. This serves to anchor the sockets in

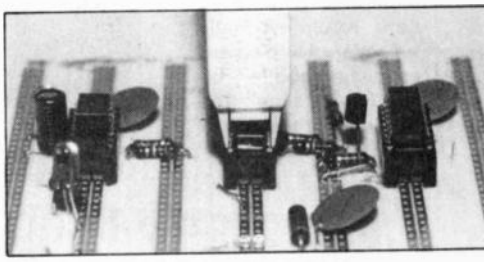
(Continued on page 99)



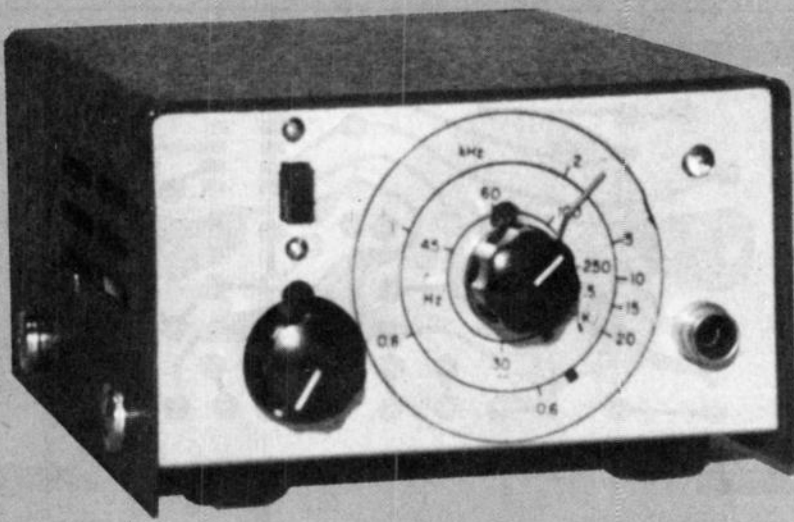
All elements of the OK wire-wrapping kit come conveniently packaged in plastic.



The wire-wrapping tool fits over the posts on the circuit board for fastening on wires.



OK's IC insertion tool aids in assembling projects that use ICs in the circuit design.



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.

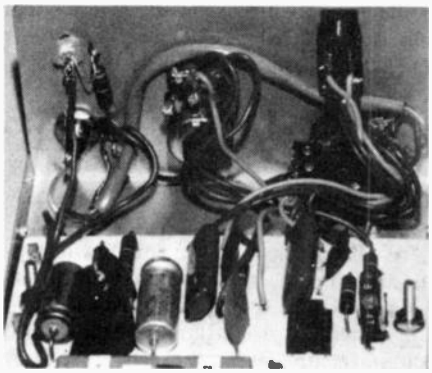
Thus far we have listed the components for a pretty straightforward amplifier circuit. The following components—a photocell (R4), 1.5-volt bulb (L1) and a 100,000-ohm preset linear potentiometer are what make for Oscar's uniqueness.

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.

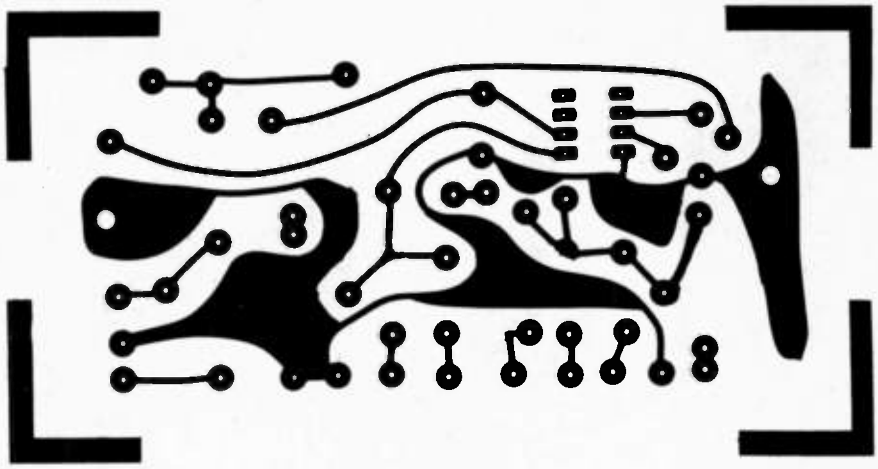
With S1 on the upper frequency range, turn the ganged pots R2a, R2b all the way counterclockwise for maximum resistance in the circuit. A sound—a distorted 600-Hz—should be heard in the headphones.

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.

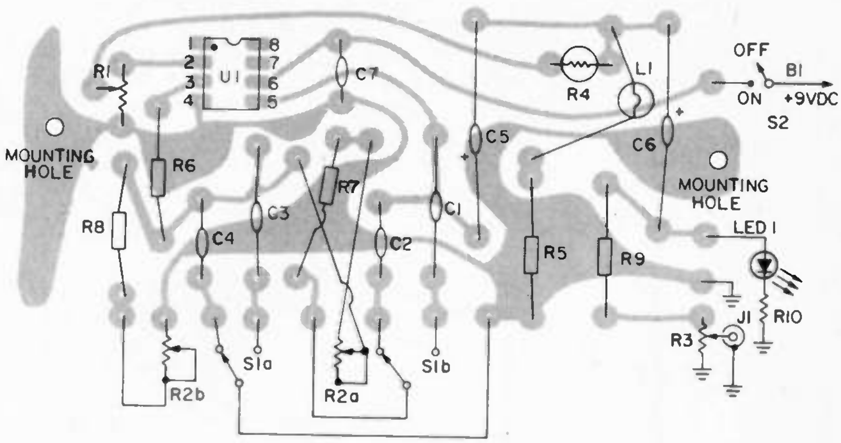
To make life easier for yourself, remember to drill a ¼-inch hole in the oscillator housing opposite the center rotor of R1 to allow a screwdriver blade access for adjustments.

Vary the output frequency by turning the ganged potentiometers R2a, R2b. Turn to the upper end of the frequency range—25-kHz, well beyond your hearing range—and allow a few seconds for the oscillator to stabilize there. Turn back to the audible signal range to make sure that the circuit is still oscillating. If it's not, turn R1 carefully towards ground until the oscillation starts up again.

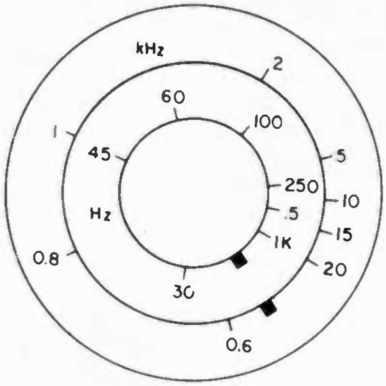
Now that the upper frequency range is adjusted, switch to the lower range.



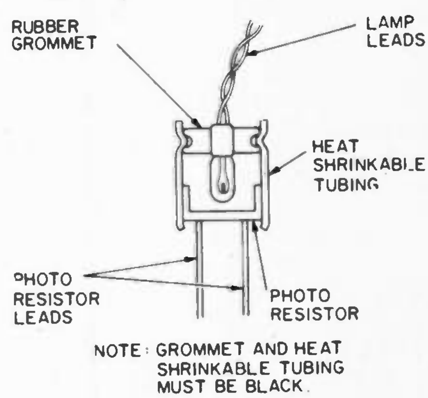
This is the circuit board template, appearing here in its exact size. For those who feel that their skills are not up to board etching, there is a complete kit listed below.



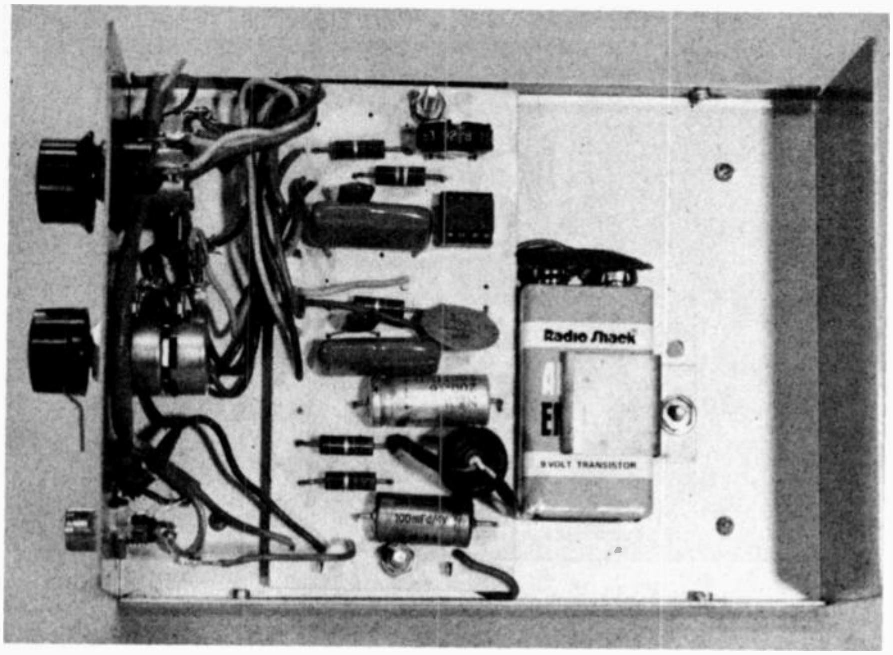
The parts placement is such that nearly any available cabinet which can easily hold the PC board is suitable for OSCAR. This cabinet leaves plenty of room for all components.



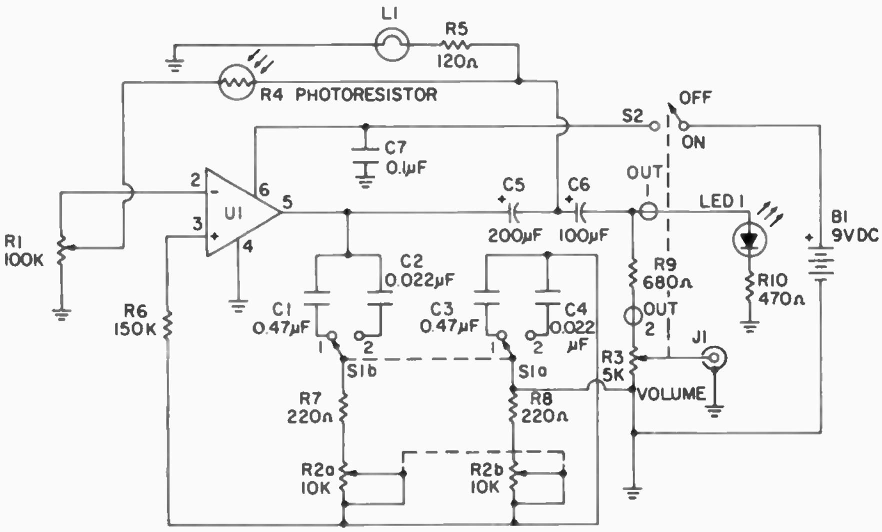
Trace this exact size oscillator range diagram or cut it out and use on the face of the oscillator. It is calibrated exactly for the dual frequency ranges available.



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.

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.

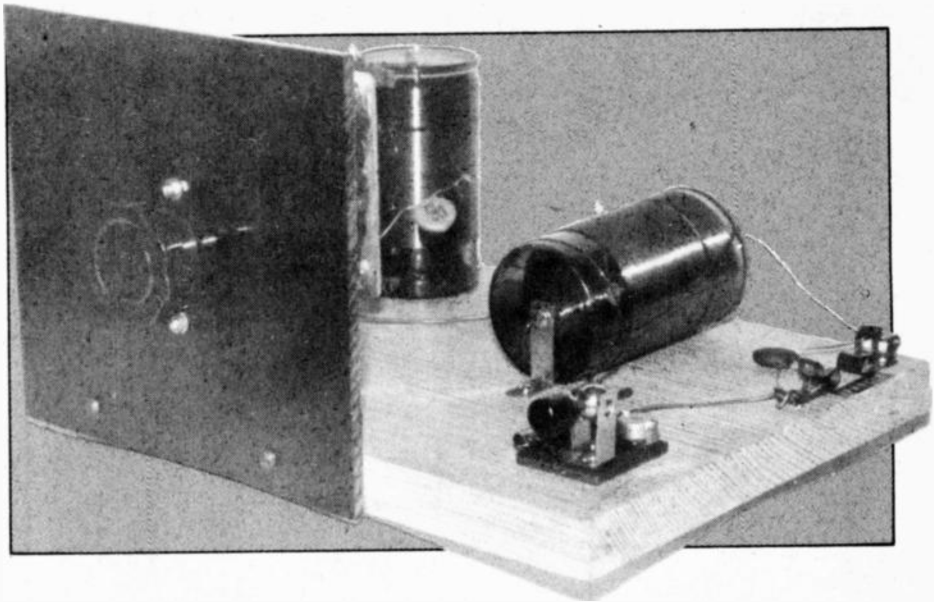
Other possible—and somewhat more farfetched—uses for Oscar are: as an audiometer, offering the bored hobbyist a hearing test at the bench; or, hooked to a high-powered amplifier and speaker, as a device to scare crows off the backyard garden patch.

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

CAT'S WHISKER RECEIVER

Build this update of the classic crystal set

BY JAMES A. FRED



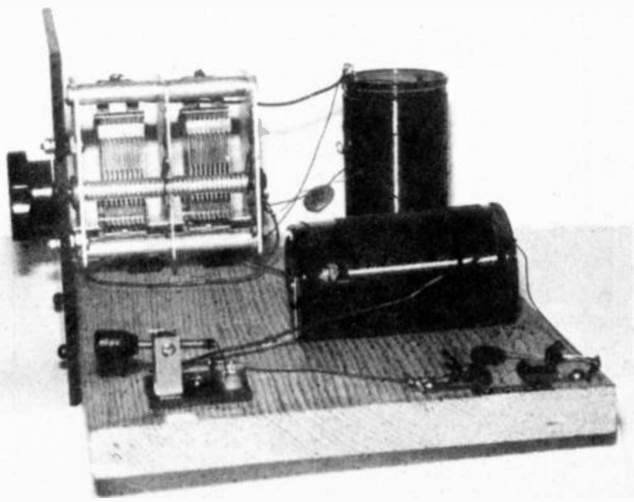
BUILDING A CATSWHISKER crystal set can be lots of fun. The only problem with this type of construction project is the radio's poor selectivity. The weaker stations are usually drowned out by the stronger ones. If you live close to a broadcast station, that station might come in over a good portion of the tuning range. We are faced with this difficulty because a single tuned circuit is limited in its ability to discriminate against unwanted signals. By increasing the Q (qualty factor) of the inductor in the tuned circuit, and adding another, we can improve selectivity sharply. This article will tell you how to build a crystal set that will do a much more efficient job of separating radio stations. This set will have the clarity and tone that is associated with crystal radios.

This selective set will only detect the signals that your antenna picks up. This means that you will need a good antenna of 100 feet in length, at least 25 feet high, plus a good ground system. You will then be able to pick up signals with greater strength from longer distances. You will also need a good set of headphones of at least 2,000-ohms impedance.

Exploring The Circuit. Two tuned circuits are used, each being a combination of inductance and capacitance. The two tuned circuits form a band-pass filter, passing the signal to which it is tuned. This signal reaches the crystal detector. All signals outside the range of the tuned circuit are rejected. This results in the desired selectivity.

Mechanics of Building. To get started building the receiver, look over the parts list, and gather up the parts you will need. To help you find the parts you may not have in your junk box, we have included sources for the parts listed in the Parts List. Start construction with the base board, which is approximately 8-inches x 10-inches by ¾-inch thick. You can stain and varnish the board, and glue small felt or rubber cushions under each corner of the bottom. The panel should be 6-inches x 6-inches, and can be made of 1/16-inch sheet aluminum, ⅛-inch tempered masonite, or formica laminated to tempered masonite. Drill two holes in the lower part of the panel for two screws to hold it upright on the baseboard. In the exact center of the panel, drill a ½-inch hole for the shaft of the tuning capacitor, and also drill the holes to mount the capacitor to the panel. Fasten the panel to the baseboard with two screws. Mount the dual variable tuning capacitor on the panel, and install the tuning pointer or knob.

Winding The Coils. You are now ready to wind the two coils. Both coils are exactly alike and wound in the same way. The coil forms are made from plastic pill bottles from your local drugstore. They are 2-inches in diameter and 3½-inches high. Use care in drilling the coil forms as the plastic is very brittle, and may crack if drilled carelessly. If you like, you may heat a large needle and push it through the plastic to make the holes. To tie the wire ends to the forms, and hold the coils in place, you will need two 1/16-inch holes for each wire end. Make these about ½-inch apart and lace the wire ends thru each hole several times to hold them firmly in place. Drill two holes along the open edge of the form, then move up ¾-inch and drill two more holes, this set of holes is for the ends of L-2. Now move up ⅛-inch and drill two more holes, and then two additional holes at the closed end of the form. This set of holes is for the ends of L-1. Drill both forms alike. An old trick to make the winding easier is to dip both coil forms into melted candle wax. This creates an adhesive surface for the wire. Now carefully wind the coils, keeping the spool of wire under controlled tension

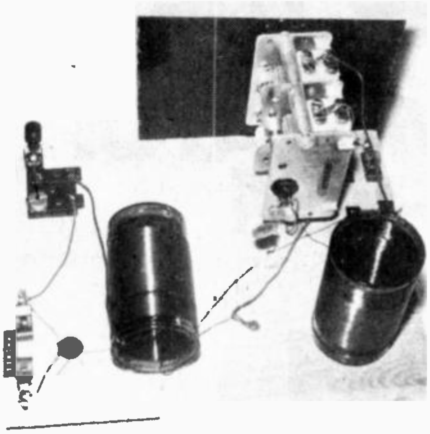


Easy to build, this cat's whisker receiver has two large inductors that must be hand wound. Be very careful when you do this to insure a quality inductor. A wood or other non-conducting base is best for the receiver, so that its components can be isolated.

for a smoothly wound coil. Count your turns carefully. You will need 25 turns on L2 and 90 turns on L1. If you put a ¾-inch wood dowel thru the spool of wire and place a foot on each end of the dowel, you can control the pressure or tension on the wire with your feet (you might even take off your shoes for this exercise). Using your hands to wind the wire by turning the form and laying each turn alongside the last one, you can, with a little practice, make a professional looking coil.

Mount the finished coils on the baseboard, at right angles (90 degrees) from each other. You can drill ⅛-inch diameter holes in the solid bottom of the coil forms. The first coil can be fastened to the baseboard by a small wood screw through this hole. The other coil can be mounted on a small angle and then mounted on the baseboard. You will have one coil with its axis vertical, and the other with ts axis horizontal. This orientation prevents inductive coupling between the coils. The secret behind the sharp selectivity of this radio, is the high Q factor of 2 separate coils. Any coupling between them diminishes Q, and degrades the radio's ability to pick out weak stations.

Setting Up The Rest. Next mount the four binding posts, terminals, or Fahnstock clips in place. Two for the antenna and ground, and two for the headphones. Place your crystal detector stand close to the front of the baseboard, at the end not covered by the panel. This will allow you to adjust the cat's whisker to its most sensitive point. This explains why the panel is shorter than the baseboard. Now, start wiring the parts according to the schematic diagram. Note that the connections to the coil should be made as shown. For example, the top of L2 goes to the antenna terminal, and the bottom of L2 goes to the ground terminal. The top of L1 goes to the single section of the variable capacitor stator, and the bottom of L1 goes to C3. Follow the same game plan on the other coil, as shown in the schematic, and you should have no problems.



Make sure that all solder connections are secure otherwise your receiver may not work.

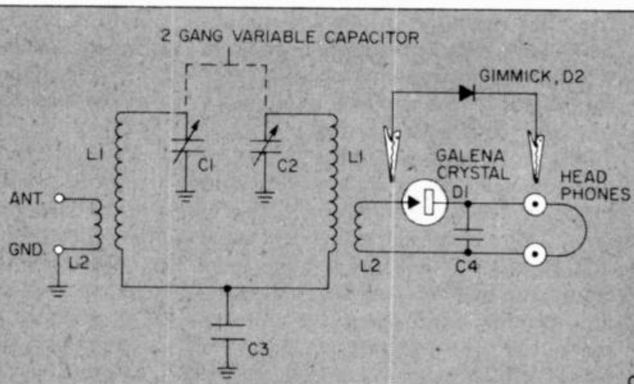
If you purchase a crystal detector stand, it will have two terminals and a cup for the mounted Galena crystal. Put the mounted crystal in the holder or cup and carefully adjust the cat's-whisker to lightly touch the surface of the crystal, not the metal of the mount.

Cheating For Fun. Because it is sometimes difficult to find the most sensitive point on a Galena crystal we can make a Gimmick, as is shown in the drawing. The clips and diode are called out in the parts list. The Gimmick is a sort of cheater, as it merely consists of a Germanium Diode connected to two alligator clips.

Testing. After the set is completely wired, double check to be sure all the suggestions have been followed, and that the wiring is correct. Connect the headphones, the antenna, and ground to the proper points. Clip the Gimmick across the detector stand, and tune the capacitor until you hear one station loud and clear. Now, remove the Gimmick and adjust the cat's whisker until you hear that station again. You are all set to listen to distortion free, pure radio programs.

Many radio experimenters are building crystal radio receivers. There is a desire to go back to the simpler times, before life became so fast paced and hectic. A crystal radio requires no outside power, and is the most energy efficient device you can build. It operates only on the power provided by the broadcasting station. We believe you will derive a great deal of satisfaction from building your radio ■

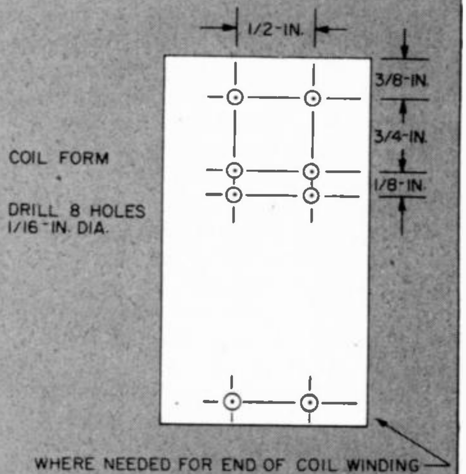
From the schematic, it can be seen that this project is a snap. There are only a few parts that are needed to put this nifty little receiver together.



PARTS LIST FOR SELECTIVE CRYSTAL SET

C1, 2—365-pF, dual section, variable tuning capacitor
C3—.02-uF ceramic capacitor
C4—.002-uF ceramic capacitor
D1—Galena crystal detector, mounted on stand
D2—1N34 or 1N48 germanium diode for Gimmick
L1—90 turns of No. 22 or No. 24 magnet wire on 2-inch diameter x 3½-inch long coil form
L2—25 turns, same construction parameters as L1, separated from L1 by ⅛-inch, wound in same direction as L1.
Misc.—Headphones (over 2000-ohm impedance), baseboard—8 x 10 x ¾-inches, panel—6 x 6-inches (⅛-inch thick tempered masonite, or 1/16-inch thick aluminum), knob or pointer for tuning capacitor, two plastic pill bottle coil forms (2-inch diameter x 3½-inch high), 2 spools of No. 22 or No. 24 magnet wire, 4 binding posts or Fahnstock clips, 2 alligator clips.

Difficult to find parts can be obtained from Modern Radio Labs, P.O. Box 1477, Garden Grove, CA 92642 or Antique Radio Parts, P.O. Box 42, Rossville, IN 46065. Modern Labs requires 50¢ and a large SASE; Antique Radio requires 25¢ plus a large SASE.

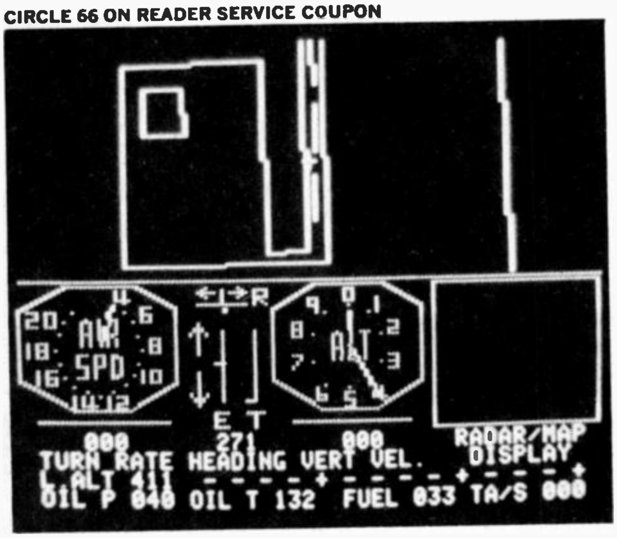


Drill the holes in the base as is shown in this diagram for best performance.

RUNNING THE SUBLOGIC A2FS1 FLIGHT SIMULATOR PROGRAM

Turn Your Home Computer Into a Budget Flight Simulator

CIRCLE 66 ON READER SERVICE COUPON



This program allows a stay-at-home computerist the thrills and excitement of flying a light plane into combat, without any of the attendant risks that the real thing might entail. Not recommended for faint-hearted buffs.

WITHOUT A DOUBT, this is one of the most exciting programs available to the home computerist. It is a relatively full scale, scientifically accurate flight simulator which actually makes your microcomputer into a flight trainer, enabling you to learn the fundamentals, you can go on and learn more. This is a very complete and subtle program, simulating no less than twenty-seven of the basic parameters of flight.

With the FS1 Flight Simulator program you will come as close as possible to the process of learning to fly; something that is normally taught on those multimillion dollar machines owned by the armed forces and major airlines. And all you need is an Apple II or a Radio Shack TRS-80!

You start out with a very complete instruction manual, learning the control configuration set up on the keyboard. Rudder and elevator control are either by a diamond pattern of four keys, or by using the paddles if you have an Apple II.

Since we tested the program on an Apple II, and felt that the paddles were more realistic, we used the paddle option. Throttle up and down are controlled by the left and right arrow keys. There is a brake key (.) for taxiing, and a set of keys to access the data base that contains the "World." But there's also a key which is used to declare "War"; but more about both of these later.

In The Cockpit. Once loaded, the the CRT monitor displays a simplified, but fully operational cockpit, with all the instruments necessary for real flight. There are two altimeters—one for low altitude flight (below 1,000 feet) and a regular altimeter dial to read altitude in hundreds and thousands of feet up to about 19,000 feet. There's an air speed indicator dial (in tens of MPH), relative indicators for throttle position, elevators, and rudder. And there are number readouts for oil pressure, oil temperature, fuel (in gallons), engine RPMs, and a few more things here and there.

All the vital information needed is in front of the "pilot." This display shows a view of mountains and heading, airspeed, available fuel and altitude. All aspects of flight are included in the program.

There's also a radar screen, which shows the positions of enemy fighters, if the War option is used.

Above the dashboard is the really intriguing part. There, the pilot sees the "World." This SubLogic program has a data base which encapsulates a real, if simple, world. The "world" the plane flies over is a 36 square-mile square, with three airfields, a fuel dump and mountain ranges.

When parked on the ground, the pilot looks out of the windscreen, and sees the horizon, pretty much compressed and indecipherable. But once in the air, the data base is switched to a mode reflecting the plane's altitude, and then several features of the world can be distinguished. Of course, more of the world comes into view as the plane climbs.

There's another way to view the world: On command, the data base can be viewed as if looking out of the side window, straight down. In the air, this lets the pilot see the ground as it passes beneath him, with airfields passing below, and with his speed gauged by how fast he passes the one square-mile squares into which the world is divided. Of course, the squares make an excellent pattern to gauge the plane's direction.

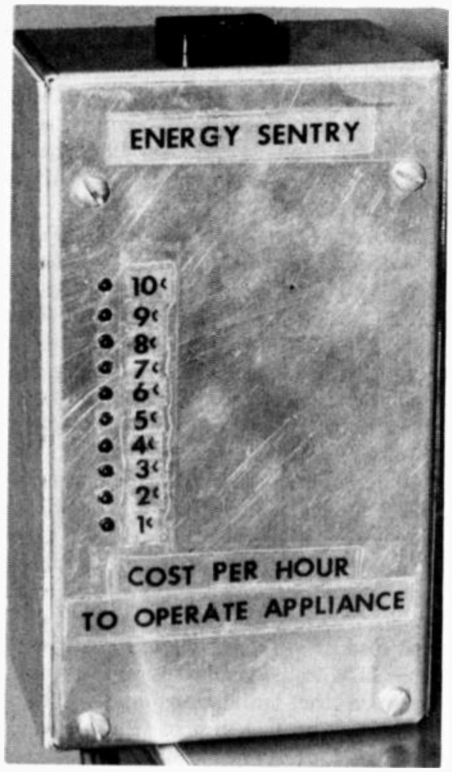
On the ground, the pilot sees an interesting representation of his plane on the airfield, much as seen from slightly above. Thus, the plane taxis from the tarmac to the runway, and in the process the tarmac and the runway actually seem to turn; while the representation of the plane remains stationary. This takes a bit of getting used to, but after a while it becomes entirely natural that the plane you are taxiing for takeoff is actually being seen *beneath* you. Once in the air, that problem takes care of itself.

Clear For Takeoff. Once you have taxied into position for takeoff, the fun really begins. Takeoff is really exciting. You throttle up and watch the airspeed indicator begin to climb.

(Continued on page 97)

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.

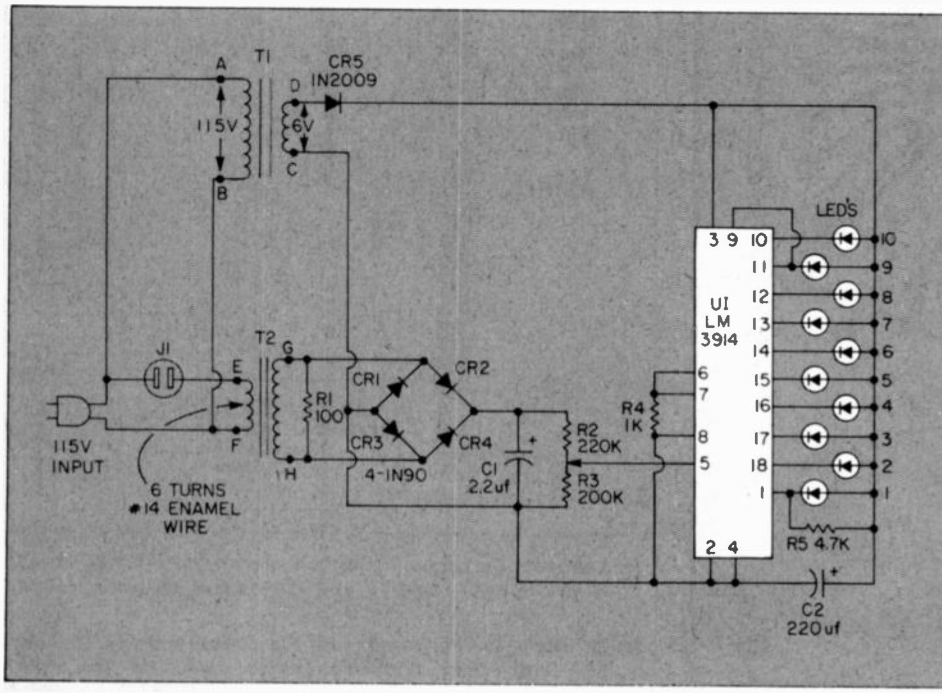
Energy Sentry is an easy to construct circuit; built in a small enclosure, with a built-in receptacle into which the appliance is plugged. Ten separate LED's provides an indication of the power consumption of the appliance. Energy Sentry is calibrated in "cents per hour" over a range of 1 to 10 cents. 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,



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

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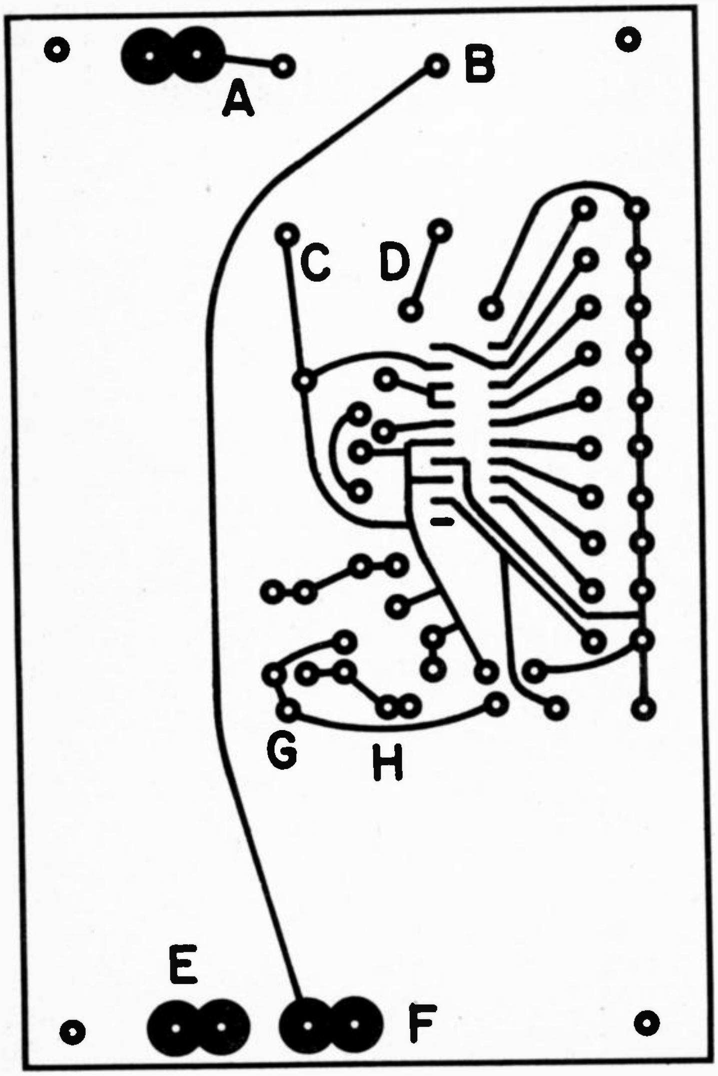

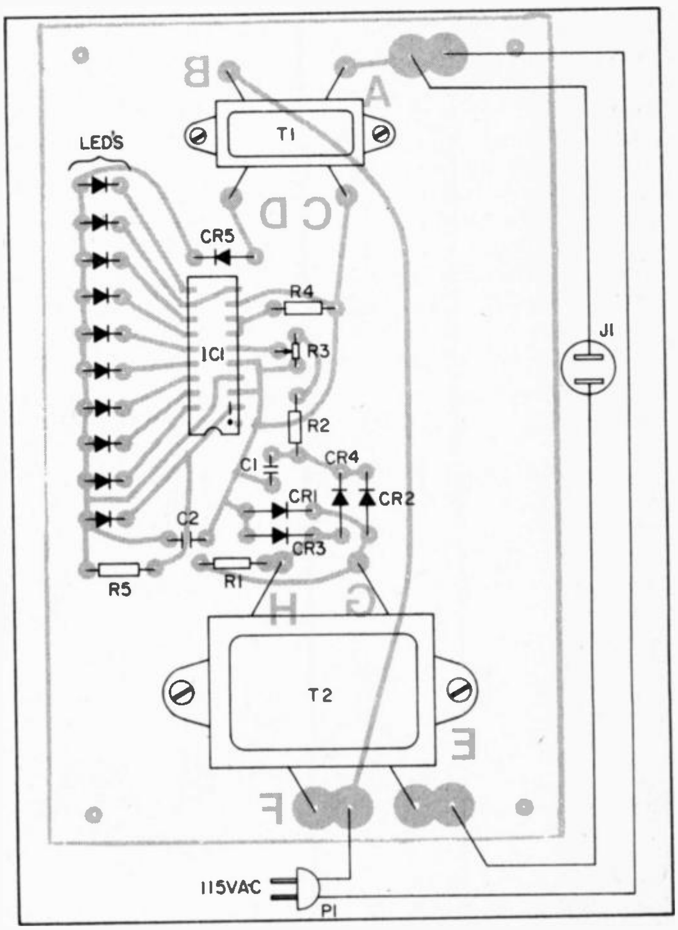

Seen above is the component side of the Energy Sentry PC board. T2 provides power coupling, and T1 provides power for circuit.

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

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 capacitor shown in Fig 3. Tune in an FM broadcast station (it will probably sound distorted now) and touch each coil lightly with your finger. When you touch one of them, the station will be detuned off-frequency; this is the oscillator 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

AM/FM into aircraft scanner

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

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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.

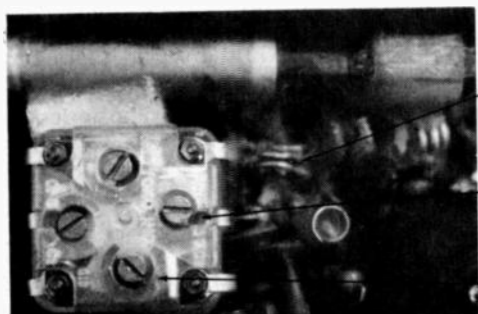


Fig. 3. The two open wound coils located next to the tuning capacitor must have their inductance raised to raise the frequency.

TELECHIRP

Make your home an aviary with this new telephone ringer.

AN EXTRA RINGER in the bedroom or living room is always a good idea but the thought of waking up to a klaxon or having guests jolted out of their seats by a clanging bell is a bit too much for anyone.

However, if you would like a peaceful way to announce that your phone is ringing, use Telechirp. This device produces a low level chirp (or warble) instead of a clang or bong.

Easy To Build. The Telechirp is a simple device requiring few components and is easy to piece together. It is powered by the ringing signal of your telephone.

Electronic buzzer BU1 will produce a high frequency whistle (approximately 5 kHz) when 2-12 volts DC is applied to its wires. Normally, the output of the buzzer is a continuous tone because the applied voltage is continuous (DC). As used in the Telechirp, however, the buzzer chirps in step with the 20 Hz ringing current.

The 20 Hz ringing current passes through capacitor C1 to the diode bridge consisting of D1-D4. Partial filtering of the bridge's output is provided by C2. The resultant pulsating DC is applied to the buzzer, producing a high frequency chirp each time the phone rings.

All components are critical. Any change in values produces improper operation. Make only those changes or substitutions we specify. A silicon rectifier or full-wave bridge rated 200 PIV or higher can be substituted for D1-D4.

While the PIV can be lower, 200 PIV provides a good safety margin. For most applications C1 should be a .1 uF Mylar capacitor rated 500 VDC. (Again, a lower rated capacitor of 100 VDC could be used but 500 VDC provides greater protection.)

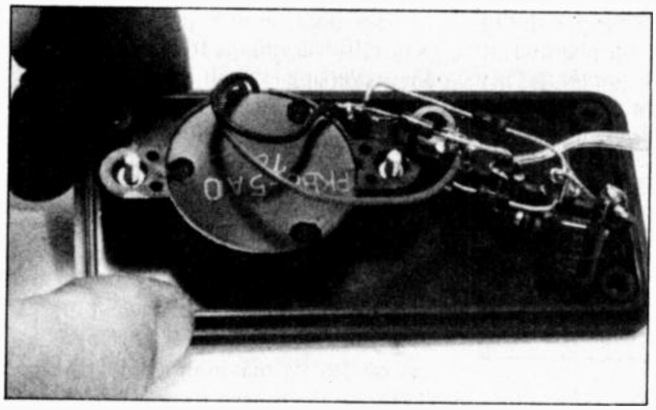
If C1 is made larger, say 0.47 uF, the output of the buzzer will be louder but you will also get kickback, meaning the buzzer will pulse in step with the telephone dial's pulses. If your phone has Touch-Tone® dialing, kickback is not a problem, but line static might cause the buzzer to tick.

Capacitor C2 is also critical. If made larger than 10 μF, it will produce a smooth, non-pulsating, DC and the output of the buzzer will be a continuous high frequency tone, which is not an attention-getter. If C2 is smaller than 10 mF there will be too much AC and the buzzer will tick instead of chirp; a nice sound but not loud enough for general use.

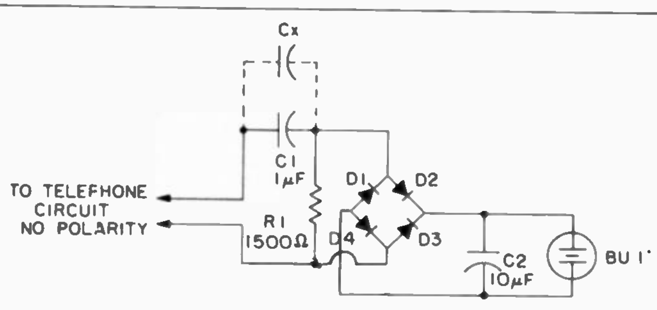
The Telechirp can be connected to your telephone circuit with ordinary zip-cord or speaker wire.

Telephone circuits do vary. Keep in mind that Telechirp is intended for a quiet location, but if the chirp produced by your telephone's ringing signal is too low, connect capacitor Cx, 0.05 uF disc, across C1.

The Telechirp can be used as a quiet warning that someone is dialing out on the phone circuit. If capacitor Cx is raised to 0.1 or 0.2 mF, the device will produce chirps in step with the dial pulsations each time someone dials out. (It works with rotary dial telephones.) The total value of capacitors C1 and Cx should never exceed 0.47 mF, nor should the value of R1 be changed by more than 10%. ■



To make Telechirp, it doesn't take a lot of parts or a PC board. Just hook up the few parts with a terminal strip and Telechirp will sing away. Be very careful when you put together the diode bride. Make sure the diodes are properly polarized.



PARTS LIST FOR TELECHIRP

BU1—solid state buzzer, Radio Shack 273-060
C1—0.1-uF, 500 VDC mylar capacitor
C2—10-uF, 25-VDC electrolytic capacitor
Cx—see text
D1-D4—silicon diodes on small silicon rectifier rated 200 PIV
R1—1500-ohm, ½-watt, 10% resistor
Misc.—cabinet, terminal strip, wire, solder, hardware, etc.

RS-232 Switcher

(Continued from page 60)

run across it in some piece of surplus gear, forget about it. Unless you're experimenting with a rather esoteric data communicator, you will probably never run across an RTS signal.

Building The Switcher. The RS-232 switcher is assembled in an aluminum cabinet, 5¼ by 3 by 2½ inches. As a general rule, the connecting sockets are "female" (D-25S) and the input cable connector is "male" (D-25P).

Do Not get this arrangement confused if you have a Radio Shack TRS-80. For some reason, Radio Shack decided the whole world would use their parallel printer, and the serial interface would only be used with a modem having its own "female" connector. So the output plug provided by Radio Shack is "male," instead of the more common "female."

If you want a universal switching unit, assemble it as shown and make up a "female-to-female" D-25 adaptor cable for your TRS-80 computer. (As a matter of interest, when Radio Shack decided to sell D-25 connectors, they sold only the male, which does not mate with their own computer connection.)

Switch S1 can be any type of DPDT, although to avoid the possibility of damage to some peripherals, it should be *break-before-make*. This means one set of terminals is completely disconnected before the second set is connected. For example, when switching from socket S01 to S02, all connections from S01 will be opened before S02 is connected.

Do Not use a *make-before-break* switch, because it would connect S02 before S01 was disconnected. This would result in the devices connected to S01 and S02 being connected together for a brief instant as the switch was operated. Normally this would not create a problem, but the well-known Murphy's Law clearly states that out there *somewhere* are two peripherals that will be totally wiped out if connected together.

Switch S2 is the signal reversing switch mentioned earlier. In the REVERSE mode it takes the signal from Terminal 2 of S01 and S02, puts in on PL1's Terminal 3, and vice versa. It is used when the computer or terminal can function in two different modes.

For example, the TRS-80 serial interface can be used to communicate with a modem (normal connection), or the TRS-80 itself can be used as a terminal. For the TRS-80 to receive at a terminal, it must "see" an arriving signal on Terminal 2, and send it on Terminal 3. This is not the "normal" arrangement. Radio Shack provides a reversing switch inside the expansion interface on the serial interface board.

Unfortunately, in order to operate the switch, the user must disconnect the display, remove four screws and a trap door, move the switch, and reinstall everything. It's easier to have the reversing switch on the RS-232 Switcher—at the very least you don't have to take anything apart.

Connections to S01 and S02 should be No. 20 or 22 solid wire. Try to avoid the use of stranded wire because a single loose strand too small to be easily seen can short-circuit adjacent terminals. If you must use standard wire, make certain you first twist and tin the ends of the wires. To reduce the possibility of shorts remove no more than ⅛-inch insulation

Wiring Is Critical. Wiring is somewhat tight, and insulation can be damaged by the soldering iron so the following assembly procedure is suggested. First, connect to S01 and S02, starting with the Terminal 7 and keep the soldering iron on the lower terminal side. For example, when connecting to 7 place the soldering iron between 7 and 6. In this way you won't be reheating a completed connection.

Wire the bottom connector (S02) first, then the wires from S2, then those from S01 (top connector), then the PL1 cable.

The protective grounds from Terminal 1 go to a solder lug under the socket's mounting screw(s). In some installations the protective ground—the wire from the chassis of computer or peripheral—is also used as the signal ground. If so, also connect the Signal Ground, Terminal 7, to the solder lug. If you are using separate protective and signal grounds, twist the Terminal 7 wires from S01, S02, and PL1 together, solder, and insulate the connection with plastic tape.

To use the RS-232 Switcher, just connect everything together and set S2 for NORMAL. If your situation requires reversed signal connections, simply set S2 to REVERSE, and that's all there is to using the RS-232 Switcher. ■

Slow Scan TV

(Continued from page 65)

recreate the picture.

Digital Pictures. We've already seen that the SSTV picture is composed of 128 scan lines with 128 pixels per line, giving a total of 16,384 pixels per picture. This fits exactly into 16 Kbytes of microcomputer data memory.

Each of these pixels is characterized by a *gray level*, a value of brightness somewhere on a scale from black (no brightness) to white (full display screen brightness).

Modern SSTV equipment provides for 16 different gray levels; these are represented as a four-bit binary words, or bytes. A binary value of 0000 represents full brightness (white), and the level proceeds through progressively darker values as the byte increases to its maximum binary value, 1111, which is used to represent black.

Cameraless SSTV. There's even a way to get on SSTV with no camera at all. It's the Model 800 Super Terminal from Robot Research, Inc., a veteran manufacturer of Amateur and commercial SSTV equipment. It connects to a transmitter, receiver, teletype loop, TV monitor, CW key or any combination, and communicates in ASCII (computer format code—now authorized on the Amateur radio bands), Baudot (teletype code), Morse code or SSTV. When used on SSTV, it can generate both alphanumerics and graphics. Actually a small computer based on an 8085 microprocessor with 4K of ROM and 2.5K of RAM, this 13-pound marvel is well worth its $845 price.

Robot also manufactures a versatile scan converter, the Model 400, for SSTVers who want to be in pictures. It interfaces with standard TV cameras and monitors to SSTV standards for communications over the air, over phone lines, or recording and playback via audio tape. All solid state and ready to hook up, it's priced at a dirt-cheap $795.

It's not all that hard or expensive for anyone to get involved in SSTV, over the ham bands or in some other form. Once you do, you'll find that the future presents some fascinating pictures. ■

Flight Simulator Program

(Continued from page 90)

When you reach 90 or 100 MPH, easing back a bit on the elevator actually puts you in the air.

At this point a word or two must be said about the sort of plane you're flying. It's a cross between a Piper Cub and a Sopwith Camel World War I fighter—with radar and guns. Its top speed is in the 150 MPH range, it holds 38 gallons of fuel, and it can climb to about 19,000 feet. It is also very maneuverable.

Anyway, back to the controls. Once you climb from the runway, switch to the altitude data base, by pressing the "U" key. If you bank slightly to the right, you will see that you have taken off parallel to a mountain range.

Don't worry—due to one of the few minor flaws in the program, you can fly right through the mountains, and nothing will happen. Try it: it's scary but fun! Under normal flying conditions (no mountain crashes!) you'll probably want to climb at a moderate rate—about 500 feet per minute. There's an altitude and velocity indicator to show you how fast you're going both up or down.

Try banking and turning—the horizon as seen through the windscreen will look exactly as it would through that of a real plane; it tilts one way and then the other. There is also a turn rate indicator to tell you how fast you are turning.

Turn With Care. The instruction manual warns you to be *very* careful in turning. It's not like turning the wheel of a car. First of all, your plane doesn't want to straighten out, as a car would. You have to straighten it out, by turning slightly and momentarily in the other direction, and then coming back to your desired bearing. Also, turning does funny things to your plane. It cuts down on your airspeed, and therefore on your climb, if you're climbing. So it's very easy to misjudge a turn, turn too much, and wind up crashed!

Once you're up a few thousand feet—a process that takes a while due to the plane's limitations—you'll probably want to look around. If you've been climbing in shallow circles, most likely you're still over the "World." You can see it, way below. But if you've been climbing in a straight line, then you're in for a surprise. Because the world has been left way behind you, and all you're looking at through your windscreen is blank air. When you turn around, though, you'll be knocked on your backside, because there will be the "World," looking tiny in the distance, much in the way an aircraft carrier must look to a Navy pilot. You can head back to it—it might take a while—but eventually you can overfly the world and even go on in the other direction.

War Cures Boredom. By this time, however, you might be getting a little bored—assuming that you've fully mastered the facts of flying. Don't worry about boredom, though, because at the touch of a key (the "W" key, of course) enemy fighters will fly up to meet you, and try to shoot you down.

You'll see them as little dots and lines on your radar screen, which will suddenly spring to life. You're armed, as was mentioned before, and can shoot them down if you're lucky. The space bar on the keyboard acts as a machinegun trigger. If they hit you, you go into a spin, and crash. The war game built in to the program makes for a lot of diversion and fun.

Happy Landings? All that's left is landing, but that's the toughest part. With a lot of practice, you can land perfectly. The manual gives some good hints on how to do it—in fact it gives good hints on flying in general. One thing you might want to remember is that, due to memory limitations in the program, although the manual tells you that you have to land on a runway in one of the airports, you really *don't*. You can land on any level piece of ground, of which there are plenty in the "World." So just practice getting down.

We have hardly ever had so much fun with our wife as we had with the SubLogic Flight Simulator program on our Apple computer. Whenever we want to demonstrate our Apple II to a friend, we load up this program, and let the guy crash a few times. For $33.50, the Apple II disk version is a real bargain. SubLogic's address is Box V, Savoy, IL 61874. For more information circle No. 66 on the Reader Service Coupon. ■

Communications Mikes

(Continued from page 24)

notoriously *low*-impact), a shell that is shaped to comfortably fit the contours of the human hand, a long and heavy-duty coiled cord, a positive-acting PTT switch, and wiring circuitry that is compatible with the rig with which it will be used.

Hybrid Mikes. Several hybrid mike designs have emerged in recent years. For VHF/UHF/FM work, you may want to use one of the new Touchtone™ encoder mikes that have a tone pad. This built-in feature makes it convenient to work via autopatch repeaters, especially useful in that many new transceivers do not have a separate accessory pad input.

Some of the latest mikes can control frequency selection and programming as well as transceiver logic circuitry. These mikes also incorporate up/down scanning for autoscan transceivers, remote volume and tone controls and priority-channel activation.

The biggest problem in using these mikes is wiring compatibility. Almost any accessory Touchtone™ mike can be used with any rig if the proper wiring connections are made.

Another popular innovation is the no hands boom headset. This device is a single low-impedance headphone with a dynamic microphone installed on a boom suspended from the earphone assembly. The microphone is usually adjustable on the boom and is of the noise-cancelling, low-impedance dynamic or high-impedance ceramic type and is thus compatible with most mobile transceivers.

A PTT switchbox is usually laid on the seat or mounted on the vehicle's turn signal lever or gear shift, allowing both hands to be free for driving. Most headsets can be worn on either ear and have a response curve tailored for voice reproduction.

Listen In. Dual-headset models are also available though it's probably unwise to wear them with the vehicle in motion, since traffic sounds would be greatly impaired.

It's also possible to convert a standard telephone handset to mobile operation for those instances when some degree of privacy is desired.

We can't all be velvety voiced, network quality announcers in our on the air transmissions, but it's certain that a little effort in microphone selection and employment technique can go a long way in putting our best vocal foot forward. Since the mike represents the heart of voice communications, examine your needs carefully and then get the best you can afford. Your rig will sound as good as your mike and no better. ■

Aircraft Scanner

(Continued from page 94)

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. ■

Spark Detector

(Continued from page 53)

barrel of a large marker pen.)

Do not over enlarge the U-notch of the tube as this will allow external light in. Also make sure there are no obstructions between the photoresistor and bulb. Use a flat disc or black tape to close off the open end. Attach a dowel rod to the tube.

Block That Light! Hold the probe on a spark plug cable so the cable blocks external light from the photoresistor. The voltage in the cable causes the bulb to glow thereby illuminating the photoresistor. The change in its resistance is measured by the meter.

The rest of the circuit is built on a perfboard that attaches to the back of the meter. Check the circuit after completion, then connect a 9V-battery. Turn the 1-megohm trimpot. The meter reading should be adjustable from no deflection to almost full-scale deflection.

Before testing the meter, clean and gap the spark plugs and install good ignition cable. This way you will calibrate your meter under the best conditions. Deterioration from these conditions points out bad plugs or cables.

Lift the hood of your car and start the engine. Hook the probe over a spark plug cable so the neon bulb lies on it. Adjust R1 to get a 40 percent meter deflection. Move the probe to the other cables. The deflections should be similar. Minor variations are possible.

A Foul Plug. If a spark plug is fouled or shorted, the meter reading will be much lower than 40 percent. If the cable is internally broken or removed from the plug, the meter reading will be much higher, almost full scale.

Stop the engine and hold the probe over the cable. You should get a negligible deflection on the meter. This step confirms that there is no external light affecting the meter's operation. If the probe was carefully constructed, external light will not be a problem.

When not in use, keep the probe covered with tape. This will stop current flow through the meter. When the detector is not in use, the circuit draws less than 1-mA. You now have a tool that permits you to inspect the high voltage section of the ignition system safely without soiling your hands.

Now when you try to pass a slower car, you should have no problem since your ignition system will be in top shape. Just push the accelerator down and zip on by. ■

Digital Debugging

(Continued from page 18)

top of the one you suspect is bad. Be sure that the piggyback IC's pins are properly aligned with the pins on the suspicious IC. If the circuit functions normally with the piggybacked IC, you've located the problem.

Some technicians find a spray can of circuit coolant handy in locating a malfunctioning chip. They zap the IC with a shot of Circuit Cooler or Quik-Freeze, instantly chilling it. In many cases, the malfunctioning IC will suddenly start working again.

Contractional Connections. There's nothing magical about this. Many chip problems are caused by poor bonding between the IC pins and the chip inside the plastic case. Because of different pin, case and bonding material contraction rates, the chilling spray causes the IC to start working again since a good electrical connection is restored. But as the chip warms up, the differing expansion rates will cause a broken connection somewhere in the IC.

Digital circuits are designed to work with power sources and inputs that are either on or off like the square waves in Fig. 1. But suppose it has to work with jagged and irregular signals like those in Fig. 2. These signals can cause irregular IC operation.

Integrated circuits have a difficult time deciding when an irregular signal goes high and when it goes low. The chip might respond to each irregularity as if it were a change in the input signal and try to switch states accordingly, resulting in a very confused chip.

Power supply irregularities can also cause problems, particularly if Vcc falls to a level where it could be mistaken for ground and several inputs are connected to ground.

With these problems your VOM can help. A hot ground is a common problem. (Anytime the voltage at ground measures over 0.5 volts, you can be sure you have a problem.) Various integrated circuits specify one voltage as low, such as 0.5 volts, while another voltage, such as 3.5 volts, as high. A good indication of trouble is an intermediate voltage, like 2 volts, at some pin. This is especially true of TTL devices, where any voltage between one and three volts indicates a defect.

Doctoring Those Digitals. These few tips should allow you to feel your way around today's digital circuitry. With a little bit of patience and straight forward deduction. ■

One-Tube Receiver

(Continued from page 63)

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. ■

Wire-Wrapping

(Continued from page 84)

place. Next, wire the power connection pins of each socket to the power buses using conventional wire jumpers and soldering them in.

Now insert the rest of your components, and interconnect them with a hybrid technique: solder those connections which can be made using the board's copper pad pattern. For instance, the junction of two resistors is easily established by inserting the wire leads of the resistors into two adjacent holes in a copper pad, and soldering both leads to the pad.

Wire-Wrap Tight Spots. The great advantage of the wire-wrapping technique is that it allows connections to be made in tight places. There is no danger of shorts from solder bridges, and no nicking of insulation by a hot iron. However, a good wire-wrap joint requires a square post to wrap over. Wrapping on the round lead from a resistor is all right as a temporary technique, but not recommended for more permanent construction.

Digital projects, where the ICs usually outnumber the passive components, will require lots of wrapping. On the other hand, projects containing more passive components than integrated circuits will demand a greater amount of soldering. (Note: Passive components have widely spaced leads; hence they are easy to solder. Integrated circuits, with their tightly spaced pins, are much easier to wire-wrap.)

The Results. How did the WK-4B kit work? Just fine, as you can see from the neat looking pulse burst generator illustrated here. The technique is relatively fast and convenient—much easier than perfboard. While wire-wrap may not be as compact (nor as quick to assemble) as a pre-fab printed circuit, it is much faster to assemble than a homemade PC board. Furthermore, the wire-wrapped connections are every bit as reliable as a solder joint, provided that you make them properly. As testimony to that fact, it should be noted that even commercial equipment is being wire-wrapped today—often by computer-controlled wire-wrapping tools.

So, whether you're building a prototype of your own design, or assembling a project for which no prefab PC board is available, why not give wire-wrapping a try? For more information on the WK-4B Kit, write OK Machine and Tool Corp., 3455 Conner St., Bronx, NY 10475. Circle No. 37 on the Reader Service Coupon. ■

Sitrat

(Continued from page 47)

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.

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.

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.

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 depth indicating that temperature. Then, drop your fishing line to the same depth. While the author hasn't tested SITRAT for cable's longer 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. ■

Energy Sentry

(Continued from page 92)

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 × 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. ■

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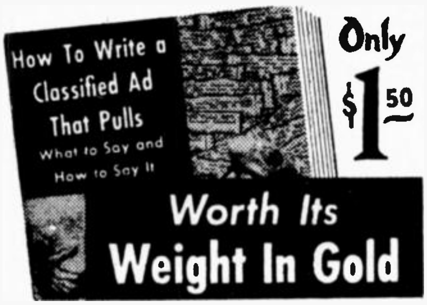

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LED Weather Vane

(Continued from page 74)

notice this gets easier as it goes along!

The power supply is also constructed on a PC board. Transformer T2 mounts on the board. U1 must be provided with a heat sink, since it will supply the current for the readout.

Wire Wrap. Wire wrap posts are soldered to the board to supply the voltages. Although we use only the 5-volt line for this particular board, the finished project will require all the sources (notice all but one are regulated).

Ease the completed display board into the mating panel holes. A dab of silicone glue around a couple of the LEDs will secure it in place. The power transformer (T1) mounts to the bottom of the chassis. Along side the transformer resides the power supply board, which is held in place with plastic circuit board guides fastened to the bottom. Wires interconnecting the voltage sources may be wire wrapped or soldered, as you prefer. A feed through terminal strip attached to the back provides connection to the outside world.

The wind vane is mounted atop a ¾-inch plastic water pipe (schedule 40 or similar) and the wires are channeled through the center. The pipe is then secured with conventional mounting hardware to a convenient location.

The calibration is performed in two steps. With a voltmeter on pin 5 of the IC, rotate the pot so voltage is at a minimum. Now adjust R5 to light LED1. Rotate the control until LED8 just extinguishes. If indicators LED9 through LED16 light during this procedure, ignore them. However, should the vane rotate the opposite direction of the moving display, reverse the outside leads from the sensor pot.

With LED8 off, adjust R6 until LED9 lights. Further rotation of the potentiometer will consecutively light the remaining lamps until the crossover point is reached; the gap in the resistive strip. LED16 should light at this point. If the spacing of the indicators seems uneven, you can juggle the value of R2.

Now point the vane due north and rotate the support pipe so that the north indicating LED is lit. Turn it loose and you're in business! ■

Input/Output

(Continued from page 8)

tions out of a possible 3500 approximately. Most of the Dolbyized stations are PBS or college stations. Considering all the talk that has been going on in the Hi-Fi magazines, Dolby FM laid an egg. Don't invest in any receiving equipment until the picture improves greatly.

Heads Up Only

Hank, I was told that when you properly notch the flip side of a floppy disk, one could reverse its position in the drive, and the flip side of the disk can be used. Is this true?

—W. N., Sykesville, MD

I tried it and it almost works! Yes, it can be done; but before you do it, take a look inside the single-side disk drive. Note that a pad presses one side of the disk against the record/playback head. After a few runs, strange things began to happen to my BASIC program. Then, the entire disk crashed because the boot-up sectors were destroyed. We know that the normal recording side of a single-side floppy has a quality surface; a test sector check always proves this point. But, the flip side has several, and they increase with time due to the effect of a pressure pad pressing against the surface.

Scan

I'd like to join a scanner club because I'm not doing too well with the unit I now own. I know it's me and not the scanner. Any suggestions, Hank?

—R.R., Deerfield, MA

Write to Scanner Association of North America. I read their publication SCAN, and it is packed with interesting tid-bits that'll spice up your hobby experience. Their address is: SCAN, Suite 1212, 111 East Wacker Drive, Chicago, IL 60601.

Lots of Bits

What is the advantage of the 16-bit and 32-bit (wider word) computers that so many people are talking about?

—A. L., Farmington Hills, MI

There are five main reasons, of which the latter seems to be of most value to the home computer user. They are: have greater access to greater volumes of data, can run longer programs, the precision of computations is greater, offloading of mainframes is easier, and they are easier to program. The hobbyist will eventually swing over to 16-bit and 32-bit because the industry will go that way, thus the experimenter will find it cheaper not to go against the mainstream. Actually, most personal computer users will not see an immediate need for the wider word format on their computers. ■

Dial Cords

(Continued from page 50)

Also, two large guide pulleys help keep the dial cord on track.

New Drums. Sometimes it's very difficult to obtain a dial drum replacement for certain models. You may be able to repair these plastic drums if they are not broken or damaged too badly. In this particular AM-FM-MPX model (Fig. 8) the plastic drum was broken around the hub area and would let the drum fall down towards the variable capacitor. You could only tune part of the radio band as the drum would jam against the printed circuit board wiring.

The plastic drum was repaired to its original position and held off the P.C. board by a couple of pencils while it dried. Now, level the plastic drum. Tighten down the screw and top washer. Mix up a dab of epoxy cement and apply over the drum shaft area. Let it set overnight.

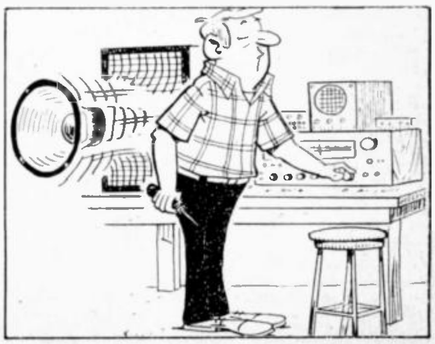
When the dial cord will not move and the dial cord end is pulled clear out of the plastic hole, simply make another hole a little higher upon the drum (Fig. 9). Sometimes the cord will pull out a chunk of plastic from the drum area. You may repair it with epoxy cement.

Erratic Dialing. When the dial will only move in certain areas or stop at a different spot each time, suspect a loose set screw (Fig. 10). Sometimes these small screws will not bite into the tuning capacitor shaft.

Erratic dialing may be caused by slippage at the tuning shaft. First, tighten the dial spring and apply a coat of liquid rosin at the tuning shaft area.

You may encounter a dry or bent dial pointer assembly causing erratic dial operation. Notice if the pilot light wires are snagging on the PC wiring when the dial pointer assembly contains an enclosed dial bulb.

So, the next time you have a dial break or start slipping, sit down and do the work yourself. One thing for sure, you will soon find out if you have ten fingers—or ten thumbs. ■



SEE PAGE 6 FOR EXTRA COUPON