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THE FUN WAY TO LEARN ELECTRONICS

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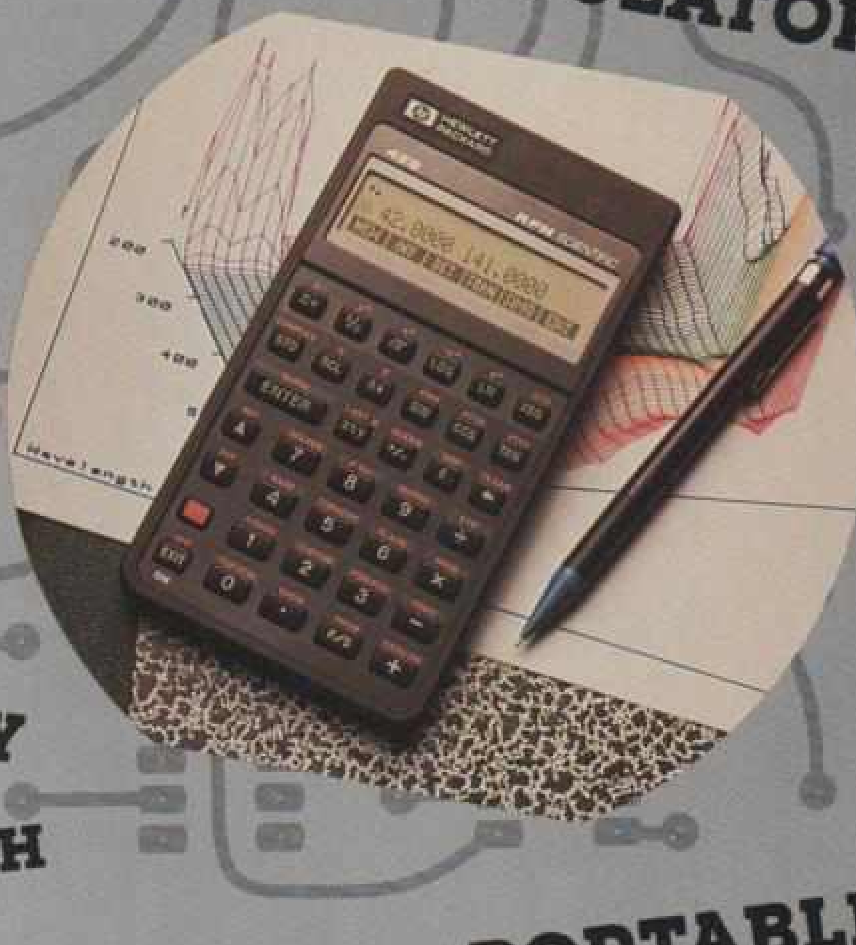

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ELECTRONICS
HANDBOOK
For Yourself

Get switched on

In case you're not all that familiar with us, we're not a publication for electrical engineers and other wizards. No way, ELECTRONICS HANDBOOK is expressly for people who like to build their own projects and gadgets—and maybe get a little knee-deep in tape, solder and wire clippings in the process.

In fact, we have a sneaking suspicion that our readers like us because they think we're just as bug-eyed and downright crazy over great new project ideas as they are. And I guess they're right!

ELECTRONICS HANDBOOK thinks of you who dig electronics as the last of a special breed. It's more than just the "do-it-yourself" angle—it's also the spirit of adventure. In this pre-packaged, deodorized world, building your own stereo system, shortwave receiver, darkroom timer or CB outfit is like constructing a fine-tuned little universe all your own. And when it all works perfectly—it really takes you to another world.

ELECTRONICS HANDBOOK knows the kinds of projects you like—and we bring 'em to you by the truckload!

Ever hanker to build a sharp-looking digital clock radio? Or to hook up an electronic game to your TV? Or an easy-to-build photometer that makes perfect picture enlargements? Or a space-age Lite-Com so you and the family can talk to each other on a light beam? We've got it all to get you started.

Has your sound system gone blooey just when the party's going great? Do you shudder when your friendly neighborhood electrician hands you the bill? ELECTRONICS HANDBOOK can help.

Of course, we can't make you a master electrician overnight. But we can show you the fundamentals of repair plus maintenance tips.

IF YOU'RE NEW TO ELECTRONICS YOU GET A "BASIC COURSE"!

It gives you a complete, ground-floor lowdown on a variety of important electronic subjects. For example—Understanding Transistors...How Radio Receivers Pull in Signals...Cathode Ray Tubes Explained...How Capacitors Work...Using Magnetism in Electronics, and much, much more!

TRY A FEW ISSUES AND EVALUATE OUR...

- HOW-TO-DO-IT HELP Tips and pointers that add up to money saved. For example—tuning up your tape player...all about radios ...whys and hows of turntables...care and feeding of speakers.

- EXCITING DISCOVERIES. Whatever your particular interest in electronics, you'll be entering a world of discovery in the pages of the ELECTRONICS HANDBOOK

ELECTRONICS HANDBOOK

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NEGATIVE TO POSITIVE

Recently, while watching the evening news on television, it ocurred to me that all, or at least most of the news was negative; the Persian Gulf crisis, the national budget deficit, the pending recession/inflation (depending on who you are listening to), the growing AIDS catastrophe, the runaway drug problem, crime in our urban centers and it went on and on, to a point where it became downright depressing. The more I thought about it, the more I realized that this negative approach to the news was not confined to TV. Newspapers and Radio news broadcasts also resorted to a similar technique. They seem to dwell on the negative side of the news. Rarely do we hear any news that will cheer us up. Needless to say, it is refreshing when we do.

For lack of anything better to do and in a subconscious effort to escape this negativism, I wondered into my office and perused some manuscripts that had been submitted by readers of the "Handbook", for possible publication in a future issue. As I casually scanned a couple of these manuscripts that had arrived in the mail that day, I realized that the ELECTRONICS HANDBOOK also deals with "negatives" and "positives" but it confines them to opposite poles in the understanding of electricity.

Each of the manuscripts that we receive in our daily mail is an effort by the author to contribute something "positive" to his fellow hobbyists...something that will, hopefully, teach them something about the electronics hobby and/or help them to solve a problem they may have encountered while building an electronics project. Each manuscript, in its own way, somehow makes life a little easier for the reader and, at the same time, provides the reader with a few hours of enjoyment in a "positive" environment, where he can forget the "negative" aspects of the world around him.

Of course, this is why we like to think of the ELECTRONICS HANDBOOK as "The Fun Way to Learn Electronics"...

Don Gabree,
—Publisher

WANTED: PROJECTS

How would you like to find your own home-brew project in a future issue of the ELECTRONICS HANDBOOK? It could happen. It's up to you! Build your project for yourself...It should have a real purpose. Then, if you think that it is good enough to appear in the ELECTRONICS HANDBOOK, let us know about it...

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

If you would like some "Editorial Guidelines", send us a S.A.S.E. with your request...All correspondence should be addressed to:

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V9

FROM THE EDITOR'S DESK

Ask The Editor, He Knows!

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

The Editor
C&E HOBBY HANDBOOKS INC.
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North Branch, N.J. 08876

CORRECTION

The author has called our attention to a typo in his article "Testing Discrete Circuits" on page 87 of our last issue (Volume #8). The third line should read, "at a current of 18 amps" not "81 amps" as stated...Sorry about that...

—Editor

Substitution Blues

I recently built the Quiz Game Referee featured in the Fall 1988 edition of *Electronics Handbook*. Unfortunately, the circuit does not work, even though I constructed it exactly as specified except for the three SCRs. Here I substituted 3-amp SCRs for the low-current 2N5060s used by the author. According to the clerk at the store where I bought my parts, this is a safe substitution because these SCRs will handle more current than a 2N5060. I'm wondering if maybe there was an error in the schematic or the parts list that accompanied the article. Also, do you check out a project before publishing it?

—Ralph Whitlock, Augusta, ME

Ralph, the First Commandment of successful project building is ***Thou Shalt Not Substitute When The Author Says Not To.*** *Right there on page 64 of the Fall 1988 issue it says "Do not substitute other SCRs for Q1 through Q3. These units were chosen because of their sensitivity." Sure, the SCRs you use will handle more anode current, but they also require more gate current before they will latch, and a higher level of anode current to keep them latched, and that's why they won't operate properly in the Quiz Game Referee circuit. You can buy the correct SCRs, 2N5060s, from the supplier listed in the article, Circuit Specialists, P.O. Box 3047, Scottsdale, Arizona, 85257. The 2N5060s cost 55 cents apiece; include two bucks for postage. Wouldn't it have been easier to buy the correct parts in the first place? As for your final question, Ralph, we do check out every project before it appears in the* ***Handbook.*** *Sometimes an error* ***will*** *creep into an article, and when it does, we do our best to publish a correction in the next issue.*

Wise Guy

I was wondering why we never see pictures of any of your editors. My father says it's because you are a bunch of fat, bearded slobs with bald heads, and that you wear cheap, shiny suits along with bow ties and thick horn-rimmed glasses, and so of course the publisher won't print your pictures. What do you say to that?

—Brian B., Las Vegas, NV

Sounds like your father has us confused with some other electronics magazine, Brian, because none of us has a beard.

Filter Feedback

I wanted to be sure to drop this line to let you know of my satisfaction with the "Selective Audio Filter" (Volume 6, *Electronics Handbook*). I finished the project and put it in service this past weekend. The filter performs extraordinarily well. It appears this filter will enhance my CW work as a Ham Operator.

I had no serious problems to speak of either building the project or procuring materials. As a comment, however, I would recommend that where possible DIP integrated circuits be utilized due to their availability and ease of use with standard sockets. For this project, sockets were extremely difficult to find.

Also, with this writing I am requesting your permission to let other Ham Radio Operators know about *Electronics Handbook* and specifically about this bandpass filter. Thank you for your consideration, and I look forward to future volumes of *Electronics Handbook.*

—Herb Dye, Frostburg, MD

Glad to hear your project was a success, Herb. We asked the author to comment on the above, and he says than when he built the filter, the only CA3140 op amps he could obtain were those in the TO-5 can; DIPs were not available. Today, of course, DIP-packaged versions of the CA3140 are readily available and, as you mention, the DIP versions are certainly preferable if you intend using sockets. As for your request for permission to let other Hams know about ***Electronics Handbook*** *and the "Selective Audio Filter," feel free to let the whole world know, Herb. We love publicity. Incidentally, back issues of Volume 6 are available for readers who missed it and want to try building the "Selective Audio Filter." Send $5.00 and we'll see that you get a copy.*

Shock Therapist

I am interested in building a

high-voltage electronic stun gun. The advertisements that I have seen say such a device can turn a menacing brute into a quivering lump of jelly in a matter of seconds. I know I'm not the only reader who could put one of these to good use, so how about coming up with a stun-gun construction project?

—D.L., Metairie, LA

Look, D.L., even if a majority of our readers ***did*** *want to shock the stuffing out of their fellow man—which I hope isn't true—we still couldn't publish what you want, for the simple reason that whoever you zapped would probably sue us, as well as you, once his limbs stopped twitching. If you really need protection from a bully, do what fellow editor Ivan Rodenko does: eat raw garlic. Since Ivan adopted this healthful but disgusting habit, the boss rarely sets foot in Ivan's office, and Ivan says his blood pressure is now back to normal.*

New-fangled Nomenclature

A friend gave me a copy of an electronics book that had been published in Europe. It was written in English, but all the components in the schematics were identified in a strange way. For instance, a resistor was labeled 3k3, a capacitor was labeled 5u6, and another capacitor was 4n7. What gives here? My friend says that this is the wave of the future. Is he right?

—George Truxton, Billings, MT

George, you've just had your first encounter with the International system of electronic nomenclature. The claimed advantage of the International system over the standard U.S. system is that it minimizes the use of decimal points and zeroes. In case you haven't deciphered things yet, the 3k3 resistor is really 3.3k ohms, the 5u6 capacitor is 5.6 mf.,and the 4n7 capacitor is 4.7 ***nanofarads****, which we would usually write as 4700 pf. or 0.0047 mf. The International system certainly does reduce the use of decimal points and zeroes, but the confusion of switching over hardly seems worth the small advantage that it brings. (Of course, I could be wrong. After all, I was sure that* ***Hz*** *would never replace* ***cps*** *as the unit of frequency.) In any event, there hasn't been a great rush to adopt the International system of nomenclature here in the United States, and you should not expect to see it any time soon in* ***Electronics Handbook.***

Would-be Author

I have just finished building a photoelectric flash meter, a device which determines the proper f/stop and shutter speed to use with a strobe light. The design is completely original; I didn't "borrow" it from any source. Would *Electronics Handbook* be interested in publishing such a project, and if so, do you have any special requirements regarding the manuscript? Also, must an author be an engineer or electronics technician in order to be published? I am neither; in fact, I'm still in college, but I've been building my own circuits for several years now, and I have the skill and experience to turn out a good project.

—Jeff Fournia, Boston, MA

Before saying yes or no to your proposal, Jeff, we'll have to know a little more about the circuit. Send us a concise description of how it works, how much it costs, etc., along with a copy of the schematic diagram and a few black-and-white photographs, 3×5" or larger. If we like the idea, we'll get back to you with a request for a full-fledged article. As far as special requirements go, the only thing we look for are neatness and logical thinking. No, you don't have to be an engineer or technician to get published, although many of our writers do work in those fields. In the past we've published articles by musicians, doctors, high-school students, and members of the Armed Forces. Perhaps you knew that legendary engineer Bill Lear—inventor of the car radio, Lear Jet airplane, and a variety of other devices—never finished high school. So formal education is not one of the criteria we use when selecting an article for publication. We do look for originality and good design. Further information of use to prospective authors will be found in our Authors' Guidelines, which can be obtained by sending us a stamped, self-addressed envelope (business size).

PBC Info

I'm in the process of preparing a term paper on printed-circuit construction for my class in electronic technology. Can you suggest any good references?

—Dave Brinkman, Fresno, CA

As a matter of fact, we'll be running an article on that very topic in the near future. In the meantime, check out the ***Printed Circuits Handbook*** *by Clyde Coombs (McGraw-Hill) and* ***Surface-Mount Technology*** *by James Hollomon (Sams).*

NEW PRODUCTS PARADE

CAD-CYCLER

From **R F TRONICS**, a new product, inspired by the "Radio Control Hobby, which is a very big user of Nickel Cadmium batteries." Almost everyone that uses Nickel Cadmium batteries can benefit from the CAD-CYCLER precision, deep, (down to 1.1 volt per cell) discharge that is accomplished. Deep cycling helps keep a Nickel Cadmium battery at its full amphour capacity.

By not properly discharging a Nickel-Cadmium battery before recharging, the battery will, after several incomplete discharges followed by full recharge cycles, experience a reduced charge acceptance that manifests itself as a reduced amphour capacity. This is commonly known as MEMORY.

R F TRONICS, a company that specializes in custom electronic hobby accessories, has solved the MEMORY problem. They have developed a device called the CAD-CYCLER which helps restore a battery pack to its full amphour capacity by properly discharging the pack to a precise, recommended level.

Full capacity is usually restored in three (3) charge/discharge cycles. Repeated use of the CAD-CYCLER will help prevent MEMORY from ever forming and maximize the life span and number of charge/discharge cycles that your batteries were designed to produce.

The CAD-CYCLER can be used on any battery as long as the number of cells in the pack match the MODEL NUMBER.

There are currently five models developed: CC-4, CC-5, CC-6, CC-7, and CC-8. Models CC-4, 5, and 8 discharge at 500Ma. While models CC-6 and 7 discharge at 600Ma.

FEATURES

1. A small handheld device. All solid state. Needs no external power source. It is powered by the battery being discharged.
2. Red flashing MIN and green MAX L E D load indicators.
3. Reverse polarity protected.
4. Convenient screw terminals on BATTERY and CHARGER end allows the use of any desired connectors.
5. Built in switch allows easy discharge/charge selection.
6. Converts any charger into a quality battery cycler.
7. Stops discharging automatically as battery voltage drops to within .1 volt of designed stop level of 1.1 volt per cell.
8. Beeper signals end of discharge. (less than 5 Ma. drain).
9. Case is impervious to glow fuel.
10. Each model is color coded for easy identification:

4=Green 5=Yellow 6=Blue 7=Silver 8=Red

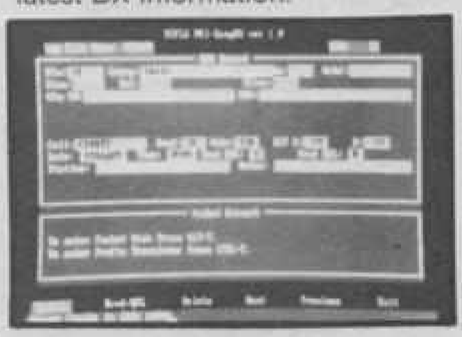
All models carry a full 6 month warranty against defects in material or workmanship.

For further information contact: **R F TRONICS, P.O. Box 718, Agawam, MA 01001-0718.**

DXERS DELIGHT

Here's one for those serious DXers out there, "Easy-DX" from MFJ Enterprises, Inc., an IBM compatible interface for your PC that makes DXing "a piece of cake" and practically assures the DXer a high rating in his DXCC activities.

According to Peter Smith (N4ZR) in the July/Aug. '89 DIGITAL DIGEST, it should be considered "the single indispensable program for any DXer with a computer." The MFJ-1281 Easy-DX program is a unique tool that instantly organizes all your DXCC activity and you also get a packet terminal program and a Packet-Cluster (Pavilion Software) interface so you'll get the very latest DX information.



You can enter any call and it tells you at a glance whether you need that country on the band, the mode or both. It also tells you if you've worked the station before. Plus, it gives you a list of contacts with the country, including bands, modes and QSLs received, so that you can get the station to QSY on the band you prefer.

When you enter a call or prefix, it tells you the country, azimuth to a major city and the sunrise/sunset times at that QTH.

You can import contest logs from the popular CT logging program so that you can easily transfer your contest QSOs into your DXCC log. It even keeps up with your QSL activity.

Packet radio users get a built-in terminal program. MFJ "EASY-DX" will monitor the PacketCluster DX spotting network and send "DX" Morse Code if a country you need on the band, mode or both is reported on the network. You don't even have to be at your computer, as long as you're within listening distance of the speaker.

You get two packet screens. One is a "receive only" screen that can be displayed along with the "EASY-DX" so you can monitor any packet channel while you log your SSB and CW contacts into your MFJ "EASY-DX." The other screen is a "send and receive" packet terminal that is built into the MFJ "EASY-DX."

MFJ "EASY-DX" also prints QSL labels, keeps up with your outstanding QSLs, prints you a summary of DXCC activity by band and mode, prints out daily log sheets, lets you update your log as QSLs are received and more.

There you have it DXers. MFJ-1281 comes on two 5 1/4 floppy disks. It requires a 100% IBM compatible computer with at least 512K of RAM. A hard disk is strongly recommended.

For more information contact any MFJ dealer or **MFJ Enterprises, Inc., P.O. Box 494, Mississippi State, MS 39762, or call (601) 323-5869, Telex: 53 4590 MFJSTKV, FAX: (601) 323-6551, or call toll free (800) 647-1800.**

AUTOMATIC SOLDER FEEDING SYSTEM

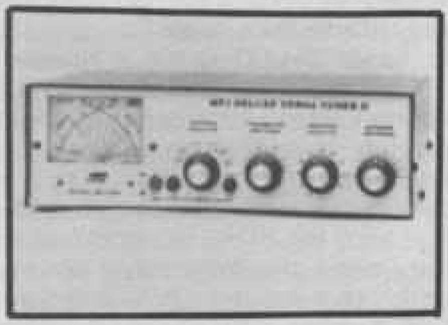
The Swiss made Solbest Model 115 combines a special soldering iron and wire solder dispenser to give the operator an "extra" hand to hold parts. The dispensing module holds a conventional 1-lb.

spool of wire solder and features a precision motor. Utilizing a 24V power system, solder is fed electronically through the soldering pencil itself. Using **one hand only**, the operator simple depresses a microswitch on the handle to advance the wire solder with great precision to the solder joint. The controlled solder feed applies just the right amount of solder allowing a better quality joint with no solder waste. With this unit, higher productivity can be achieved than with standard hand soldering processes. Its low investment cost guarantees fast pay-back even when not used continuously. And the Model 115 is also ideal for soldering SMDs without solder paste. Just hold the SMD with tweezers or a vacuum pick-up tool in one hand and use the Model 115 solder feeder with the other hand; extremely precise dosages of even the smallest wire diameter are possible. For details call or write: **HMC Co. P.O. Box #526, Canton, MA 02021 (617) 821-1870.**

ANTENNA TUNER

MFJ-948 is a 300 watt tuner that tunes out SWR for maximum power transfer to verticals, dipoles, inverted V's, beams, quads, mobile whips fed by coax, balanced lines or single wire—virtually any HF antenna. It covers 1.8 to 30 MHz and is made in the U.S.A.

It features MFJ's lighted peak reading Cross-needle SWR/Wattmeter with an on/off switch for the meter lamp. It also reads average power. This large meter shows you SWR, forward and reflected power at a single glance. It reads power on two scales—20 or 200 watts. Three front panel meter switches let you select peak or average power, hi or low power scales, and meter lamp on or off. Lamp uses 12 VDC or 110 VAC with MFJ-1312, ($12.95).

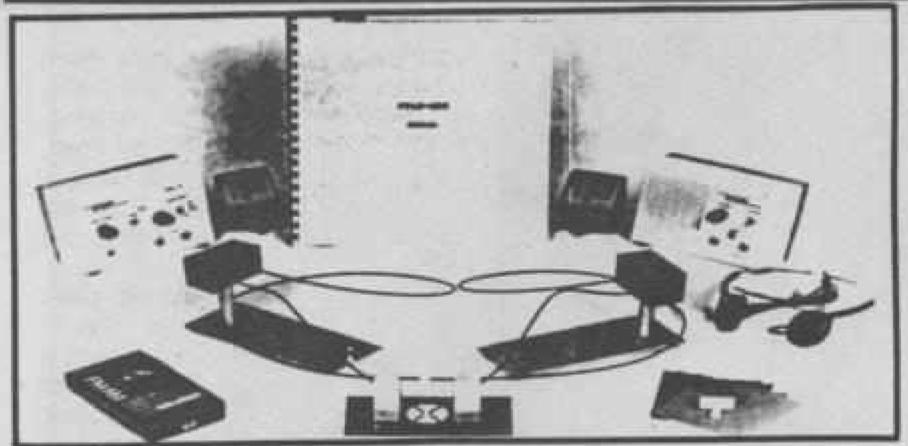


A 6-position antenna switch lets you select two coax lines (direct or through tuner), random wire, balanced line and external dummy load. A 4:1 balun makes it easy to hook up balanced line antennas.

You also get MFJ's full year, No Matter What, (trademark) guarantee. That means MFJ will repair or replace (at their option) your MFJ tuner, no matter what happens to it, for a full year. This Deluxe antenna Tuner has a price tag of $129.95.

For more information or to order, contact any MFJ dealer or **MFJ Enterprises, Inc., P.O. Box 494, Mississippi State, MS 39762, or call (601) 323-5869, FAX: (601) 323-6551, Telex: (601) 323-6551, or order toll free at 800-647-1800.**

NEW PRODUCTS PARADE



FIBER OPTICS

The FOLD-200 is a 2 channel simplex communication system that uses 1000 micron core jacketed plastic fiber optic cable as the transmission medium.

The FOLD-200 is designed to introduce students to fiber optic communication principles. The student can perform hands on experiments in communications, attenuation, coupling and loss. The experiments are basic, easy to setup, and instructive.

The instructor is not tied to a connectorized fiber system making it easy to introduce new demonstrations and to utilize other lab material on hand. The FOLD-200 is open ended.

The transmitter uses visible red LEDs that are auto biased and can be modulated with analog signals in the audio frequency range. The receiver is a PIN photodiode amplifier and can drive a set of headphones (it cannot drive an 8 ohm speaker directly). To drive a speaker for classroom demonstration, use a compatible amplifier or purchase the FOAS-10 amplified speaker. Connection between the transmitter and the receiver are made by simply inserting the fiber optic cable into the tubular aperture of the LED and PIN photodiode. ESE supplies eight fiber optic cables with the FOLD-200.

Electrical connections are made from the input and output device to the transmitter and receiver through audio cables that are supplied with the unit. Power is supplied by two wall mounted type power supplies to allow several meters of separation and to clearly show that communication between transmitter and receiver is only via the fiber optic cables.

The transmitter and receiver modules are ruggedly packaged and mounted on aluminum base plates. The pair is held together by a captive thumbscrew for ease of storage and separation to facilitate use of longer lengths of fiber on the lab bench.

Demonstration may be conducted using an input source such as a Walkman type radio and an output device such as headphones or an amplified speaker. For demonstration, the variations in the audio volume are monitored to indicate the level of coupling between the LEDs and the PIN photo diodes. The FOLD-200 has been designed as a basic demonstrator, however, quantitative measurements can easily be made during instructional labs by using a compatible function generator as the input source and an AC voltmeter or an oscilloscope to measure the signal levels. ESE supplies the model FOSG-40 as a signal generator for lab measurement.

For details and/or more information, contact **ESE Instruments, 1362 Trinity Drive #D-2442, Los Alamos, NM 87544. (505) 622-5225.**

WIRE WRAPPING GUNS

OK Industries introduces two new electric-powered wire wrapping tools that are compact and easy to use. The OK-11 and OK-12 wire wrapping guns both feature rugged ABS housings, RFI noise supression, and lightweight nylon neck harness for added convenience.

The OK-11 Series is a heavy-duty tool ideal for all wire wrapping applications from R & D to production. Used with 22 to 32 AWG wire, its powerful gear-driven motor ensures high quality performance, long life and low maintenance even under the most demanding applications. The "BF" version of the OK-11 features a backforce device designed to prevent overwrapping. This versatile tool is also ideal for cut, strip and wrap applications.

Comfortable and lightweight, OK-12 wraps 24 to 32 AWG wire. Incorporating a timing belt drive mechanism allows long life and reliability. The OK-12 also offers variable indexing ability in increments of 45 degrees. A backforce device, preventing overwrapping, is a feature of the OK-12's "BF" model. Additionally, the OK-12 "U" version has the capacity for unwrapping by using the convenient reversing switch mounted on the tool.

OK Industries manufactures bits and sleeves for all versions of both the OK-11 and OK-12 wire wrapping guns.

OK-11 and OK-12 are sold through authorized OK Industries distributors. List prices range from $187.00 to $247.50 for all the various models.

For more information contact: **OK Industries, Inc., 4 Executive Plaza, Yonkers, NY 10701. Or call: 1-800-523-0667.**

POWER-LINE MONITORING SYSTEM

The new Model MP2120 power-line monitor detects power line disturbances that can cause problems for individuals who work with sensitive electronic equipment or instrumentation. It offers: five fault-detection levels; factory-set trigger points; fast response; compatibility with all power protection equipment; a self-contained, compact design; and ease of installation and use. It's ideal for anyone who suspects equipment problems caused by fluctuations in power provided by a wall outlet or self-contained power supply.

This pocket-sized Model MP2120 detects and classifies five fault conditions: SPIKE, HIGH voltage, LOW voltage, DROPOUT, and PWR FAIL (power failure). When a fault is detected, the appropriate LED locks on, and stays on until reset. Subsequent events of different fault conditions are also registered. If there's a power failure, a LED will flash until the unit is reset. The MP2120 monitor can be used freestanding or with the optional RP2120 recorder. The Model RP2120 is a specially designed event recorder that connects to the MP2120 monitor by means of a modular data cable. Its high resolution thermal printhead continously records six signal tracks plus a timebase track. Five of the signal tracks correspond to the monitor's power fault lights. The sixth track is for future accessory sensors, such as common-mode noise, temperature, humidity, switch closure, etc. Three operator-selectable speeds control time resolution. At slow speed, each roll of readily available 2-¼" thermal paper records power quality for over 65 days. After a power failure, the recorder automatically resets the monitor, and resumes operation unattended. For details, contact: **HMC, P.O. Box 526, Canton, MA 02021 — (617) 821-1870**

WIRE SHELVING

Is your workbench getting crowded? Do you find it more and more difficult to find the part that you need for a project and you end up buying something that you already have? Maybe it's time to reorganize your hobby-shop to provide room for those parts that you just can't throw away, since you know that you will have some use for them one day.

Some new wire shelving from HMC may help you solve the problem. This unique system of modular shelving can be arranged and rearranged to suit ever-changing conditions that you may require and/or desire. From standard components, various shelving units can be assembled quickly and easily.

Chrome-plated wire shelves are designed to allow for greater light penetration and visibility of stored goods compared to a solid shelf. Wire also gives you the benefit of minimal dust and dirt accumulation. Front-to-back shelf ribs and the absence of a "lip" on the edge of shelves allow smooth and easy sliding of items on and off shelves. Shelves can be loaded or unloaded simply, from all sides. No more lifting heavy items up over edges of shelves.

A patented split-sleeve assembly device, snapped onto the post, enables you to space or re-space wire shelves in one-inch increments. The shelf corners slide over these split sleeves, providing a positive lock between shelf and post without the use of any tools...shelving units are assembled in minutes.

Chrome-plated posts are fitted with an adjustable leveling bolt and cap to compensate for uneven surfaces. Stem casters, attached to the bottom of the posts, convert standard in-place wire shelving into mobile material handling units. Large 5" diameter wheels are made of resilient rubber and have 1-¼" wide tracks. Casters come with donut bumpers and are available with or without food-operated brake.

For more information, contact **HMC (Hub Material Company), 33 Springdale Avenue, Canton, MA 02021. Phone (617) 821-1870 FAX (617) 821-4133.**

NEW BOOK REVIEWS

POWER CONTROL WITH SOLID-STATE DEVICES
By Irving M. Gottlieb

Power Control with Solid-State Devices is intended as an introduction to the practical application of solid-state devices (like transistors, triacs, and SCRs) in circuits that control relatively large amounts of power. Because theoretical concepts are explained without resorting to complicated mathematics, this is a book that will be accessible to just about everyone with an interest in electronics.

Chapter One discusses the basic principles of power control. Much of this chapter is devoted to amplifier circuits—the familiar ones (Classes A, B, and C) as well as the more exotic ones (Classes D, F, G, and H).

Chapter Two is a brief introduction to the solid-state physics of transistors, FETs, triacs, SCRs, and diodes. Superb technical illustrations help make this material easy to understand, even for a beginner.

Chapter Three takes the principles developed in Chapter Two and uses them to explain the characteristics and limitations of solid-state devices in practical circuits. Safe operating area, transistor breakdown characteristics, and a host of other essential considerations are discussed.

That does it for theory. The remaining 200 pages of this book contain hundreds of practical, ready-to-build circuits, many of which have been abstracted from manufacturers' application notes. There is no room to list all the circuits, but here are some highlights: motor-speed controls, light dimmers, a 200-watt audio amplifier, a light organ, a battery charger, an electronic siren, a 25-watt amateur 2-meter transmitter, MOSFET power RF amplifiers, and a temperature controller.

In summary, *Power Control with Solid-State Devices* by Irving M. Gottlieb is an excellent 384-page introduction to power-control circuits. It is well-written, beautifully illustrated, and certainly worth the $29.95 price (in hard cover). You can obtain a copy from the **TAB Book Co., Blue Ridge, PA, 17214-9989.** Include $2.50 for postage.

RADIO MANUFACTURERS OF THE 1920s, VOL. 2
By Alan Douglas

Volume 2 of Alan Douglas's trilogy, *Radio Manufacturers of the 1920's*, has just been released by the Vestal Press. (Vol. 1 was reviewed in *Electronics Handbook*, Vol. VII) Manufacturers from Freed-Eisemann to Priess are covered; for each company, the author presents a brief history, followed by photos of representative radio receivers and reproductions of actual advertisements for these sets. Collectors of old radios will, of course, love the book, but you don't have to be a collector to enjoy it. Some of these old-time radios are just marvelous to look at—beautiful cabinet woods, striking design, and "presence" that commands attention in a room. I was also struck with the similarities between the advertising strategies of yesterday and today.

Buzzwords—Today, of course, the favorite buzzword in technical advertising is "microprocessor"; back then, it was "neutrodyne." I guess "superheterodyne" didn't come along until later.

Celebrity Endorsements—On page 62 we see an advertisement showing matinee idol Rudolph Valentino gazing with rapt attention at the innards of a 5-tube Grebe radio receiver that had been custom-made for him. The caption tells us that Mr. Valentino started by making a crystal set and worked his way up to the most complicated hookups.

Pretty Girls—Lots of these. On page 3, a stunning young lady, who looks a lot like Marie Osmond, is shown with her hands on the dials of a Freed-Eisemann receiver. The caption says that she won first prize for physical-culture development (something like physical fitness, I assume) and that she is an experienced housekeeper. Hmmm...all this, and not a day over nineteen.

In summary, I think you're going to enjoy *Radio Manufacturers of the 1920s, Vol. 2*. Order direct from the **Vestal Press, P.O. Box 97, Vestal, NY, 13851-0097.** Price is $24.95 (soft cover) or $39.95 (hard cover). Add $3.00 for shipping.

UNDERSTANDING SECURITY ELECTRONICS

by John E. Cunningham revised by Joseph J. Carr

Crime has been with us since time immemorial, and so has our desire to thwart it. Electrical measures were first put to use in the prevention of crime by Edwin Holmes, who founded the first central-office burglar-alarm system back in 1858. Today's microprocessor-based electronic security systems are far more sophisticated than Mr. Holmes' system was, but the crooks today are smarter, too. It is therefore important that we understand thoroughly the strengths and weaknesses of the security systems we employ. To that end, *Understanding Security Electronics* provides an authoritative overview of the most important features of modern security systems. Although this is not intended as a book of construction plans, the many schematics presented should enable the knowledgeable reader to construct his own system, if he so desires.

The purpose of a security system is not to catch crooks, but to keep them out, if possible. With that in mind, the authors begin the book with a discussion of ways to make a home or business as impregnable as possible, so that the act of breaking in becomes difficult, time-consuming, and attention-getting. This will dissuade the amateurs, but not the pros, so the rest of the book concerns itself with electronic countermeasures capable of stopping the cleverest intruder. The authors discuss electromechanical detectors like window foil and intrusion switches, photoelectric and infrared detectors, ultrasonic motion detectors, microwave intrusion detectors, several kinds of proximity sensors and audio and video surveillance equipment.

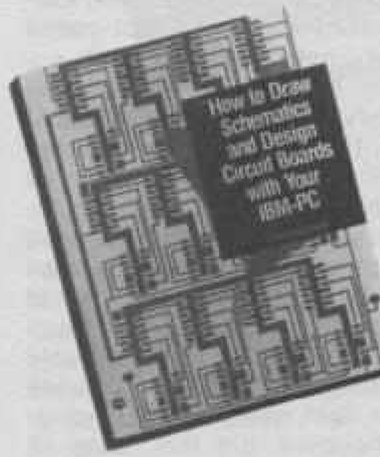
Detection is only one half of the job; we also need to sound an alarm once an intruder has been detected. The authors provide coverage of bells, sirens, lights (both standard and strobe), automatic telephone dialers, and radio transmitters. Special chapters are devoted to the application of manual and electronic locks, the use of computers in security systems, the detection of objects, automobile protection, computer crimes and hacking, electronic eavesdropping and how to thwart it, and practical suggestions for choosing and implementing your own security system.

Understanding Security Electronics by John Cunningham and Joseph Carr is an excellent 282-page guide to system implementation that should be read *before* you buy an electronic alarm system. Check your local bookstore, or send $17.95 plus $2.50 for postage to **Howard W. Sams & Co., P.O. Box 7092, Indianapolis, IN, 46209-9921.**

HOW TO DRAW SCHEMATICS AND DESIGN CIRCUIT BOARDS WITH YOUR IBM-PC

By Steve Sokolowski

Most hobbyists lay out their printed circuits using pre-cut donut pads, IC patterns, and tape. It's a time-honored and effective technique that is even used by many professionals. However, these manual methods are not really efficient where large circuit boards are concerned, and so industrial fabricators have increasingly adopted computer-based systems of PBC layout. These systems allow a designer to input a schematic diagram, and from the information in the schematic, they produce a PBC layout, all with a minimum of assistance from the operator.



Realizing that many electronic hobbyists already own most of the equipment needed for automated circuit design—namely a computer and a dot-matrix printer—author Steve Sokolowski has devised software that allows schematic diagrams and PBC layouts to be produced on an IBM PC computer or any clone running MS-DOS. This very low-cost system is not intended to compete with professional design packages, which often cost several thousand dollars and require either a digital plotter or photoplotter for output. Instead, Mr. Sokolowski's software is targeted at the hobbyist who wants to experiment with computer-assisted design and is prepared to live with the limitations imposed by simplicity.

To use this software, you'll need an IBM PC or clone, 128K or more of memory, a graphics printer, MS-DOS or PC-DOS, and a graphics tablet (optional). The book is not a book in the usual sense, but rather

NEW BOOK REVIEWS

a complete listing of the programs, which are written in BASICA (version 2.11 or later), together with running commentary that explains the code. Also included are complete instructions for running the programs and producing artwork. The book is illustrated with drawings produced using the author's software. These drawings show some of the "chunkiness" associated with low-to-medium resolution dot-matrix output; nevertheless, they are entirely satisfactory, considering the very low cost of the book. Since the program listings are fairly long, many readers may not want to type them in by hand. In that case, a diskette may be ordered from the publisher, and an order blank for that purpose is bound into the book.

In summary, Steve Sokolowski has created a no-frills software system that will give the electronics hobbyist his first taste of automated design methods. Since full source code is provided, the ambitious reader should be able to modify the programs and add extra features, if he desires. *How to Draw Schematics and Design Circuit Boards with Your IBM-PC* costs $13.95 and is available from **TAB Books, Inc., Blue Ridge Summit, PA, 17214-9989.** The companion 5½" diskette is $24.95. Include $2.50 postage.

MODERN DICTIONARY OF ELECTRONICS
By Rudolf F. Graf

Lexicography, of the compiling of dictionaries, has had a long and distinguished history dating all the way back to Samuel Johnson and his *Dictionary of the English Language* (1755). Like most dictionaries since, Johnson's was a general-purpose one designed for use by all kinds of people. Over time, however, science and technology have developed their own argot—specialized words to express ideas that had not even been conceived in the time of Johnson. Rather than put these new words into a general-purpose dictionary, publishers have found it far more practical to bring out special dictionaries for each trade or profession. Rudof F. Graf's *Modern Dictionary of Electronics* is one such example. Now in its sixth edition, this book defines approximately 25,000 electronic terms in its 1152 pages. Concepts that cannot be described adequately with words alone are illustrated with drawings or pictures.

One of the joys of having a dictionary like this to browse through is finding strange new words that will stump your friends. For example, how many of you know what a *ferpic* is? or a *gaston*? Or a *pard*? (No, it's not what one cowpoke calls another.) I found many such stumpers while looking through this dictionary, and soon came to realize just how specialized certain areas of electronics have become. You can spend 30 years designing electronic equipment and still be baffled by terms used outside your own comfortable realm of specialization.

All things considered, the *Modern Dictionary of Electronics* appears to be the kind of book that will appeal to all electronics enthusiasts, from the rank beginner to the seasoned veteran. Definitions are thoughtful and explicit. A no-nonsense kind of guy, Mr. Graf does not take the kind of liberties that Samuel Johnson once did. (Johnson's definition for the word *writer* was "a harmless drudge," which is how he would characterize book reviewers, too, I suppose.) Obviously, a lot of painstaking work has gone into the production of the *Modern Dictionary of Electronics*, and it should be a welcome addition to the bookshelf of anyone interested in electronics. You can find the book in most larger bookstores, or order it from **Howard W. Sams & Co., P.O. Box 7092, Indianapolis, IN, 46209-9921.** The price is $39.95 in hard cover (include $2.50 for postage).

INTRODUCTION TO ROBOTICS
By Arthur J. Critchlow

Robotics draws its inspiration from so many diverse fields that curious newcomers are sometimes discouraged. You need to know mechanics to design a manipulator arm, electronics to design a control system, and computer programming and artificial intelligence to design a robot's brain. Now it's true that most workers in the field specialize; thus, the person who programs a robot often has little to do with the mechanical aspects of the robot's design. Still, it is important that all workers at least understand and appreciate what the other fellow is doing, even if they have no intention of doing it themselves. *Introduction to Robotics* was written to provide the kind of background information needed by anyone contemplating a career in robotics. Although the book was intended for use in an introductory course in robotics at the University of California in Sacramento, it's also an excellent text for self-study. You'll need to have some familiarity with basic mechanics and electronics, but not much.

Chapters One and Two provide a brief overview of the types of robots in use today and some highlights in the history of robotics. Chapter Three deals with the mechanics of robot motion, including motors, power trains, mechanical arms, and end effectors (grippers). Chapter Four covers drive systems in detail, including hydraulic drives, pneumatic drives, and several kinds of electric motors.

Sensors are the topic of Chapter Five. We learn about LVDTs, potentiometers, resolvers, optical shaft encoders, accelerometers, strain gages, optical proximity sensors, ultrasonic echo ranging, tactile sensors, and a variety of others.

Chapter Six provides a brief introduction to electrical control system theory and the kinematics of a robot arm. The treatment here is fairly advanced. If necessary, you could skip this chapter entirely without impairing your understanding of the rest of the book.

Seven covers the software that drives the hardware. All of this is done at a fairly elementary level, and again, most regular readers of this magazine should have no trouble understanding it.

Robot vision is the intriguing topic of Chapter Nine. Since machine vision is a burgeoning field today, and whole books have been written on the subject, you cannot expect one chapter to provide any more than an introduction. If you want more information, there is a long list of references at the end of the chapter (and at the end of every other chapter, too, as a matter of fact). Finally, Chapter Ten discusses present and future applications of robots, primarily in an industrial context.

In summary, *Introduction to Robotics* is an excellent, well-balanced introduction to an exciting field. You can obtain a copy of Arthur J. Critchlow's book from a bookstore that specializes in technical books, or by writing to the **MacMillan Publishing Co., 866 Third Ave., New York, NY, 10022.** Price is $35 in hard cover.

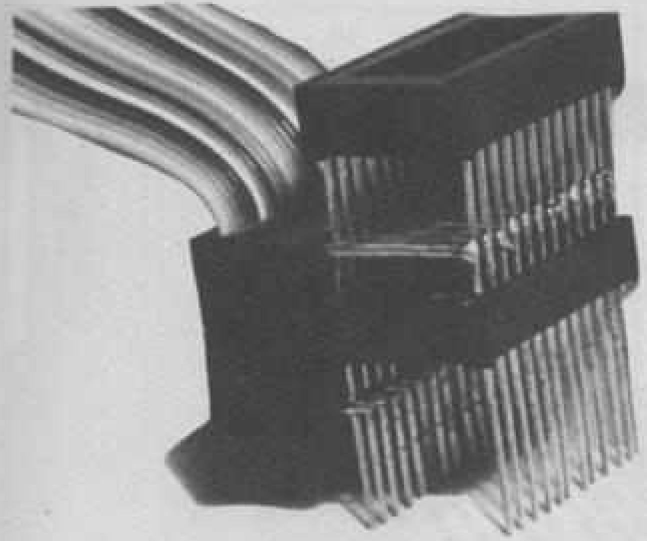
IC OP-AMP COOKBOOK
By Walter G. Jung

It's no exaggeration to say that the operational amplifier has revolutionized the way electronic circuits are designed. The key to the versatility of these high-gain differential amplifiers lies in feedback. With the proper choice of feedback components, an op-amp can be made to perform a wide variety of useful functions. For example, if we use a capacitor to provide negative feedback and feed an input signal to our op-amp's inverting input through a resistor, the circuit acts as an integrator. Now, if we switch these components around, and use the resistor to provide negative feedback while coupling an input signal to the inverting input through a capacitor, we end up with a differentiator. And, of course, we can use positive feedback as well as negative, in which case we'll produce an oscillator.

Walter Jung's *IC Op-Amp Cookbook* provides all the information you need to put the

versatile op-amp to use in your own circuits. The first three chapters of the book consist of a thorough, easy-to-understand explanation of basic op-amp theory. Subsequent chapters concern themselves with practical applications in the following categories: voltage regulators, voltage references, power supplies, signal-processing techniques, logarithmic amps, multipliers, comparators, inverting and non-inverting amplifiers, integrators, differentiators, and signal generators. Well over 200 tried and proven designs are presented. Each circuit configuration is accompanied by an exhaustive explanation of how it performs. Where appropriate, the author even offers advice on the selection of components. Each chapter ends with a list of references for the inquisitive. And the appendix contains complete data sheets for such common op-amps as the 741 and 3140.

This third edition of the *IC Op-Amp Cookbook* by Walter G. Jung gets our highest recommendation. Other op-amp books have come and gone, but this one remains a classic. You can find a copy at your local bookstore, or order it direct from the publisher, **Howard W. Sams & Co., P.O. Box 7092, Indianapolis, IN 46209-9921.** Price is $21.95 (softcover) plus $2.50 postage.



MULTIPLE IC TEST SOCKET

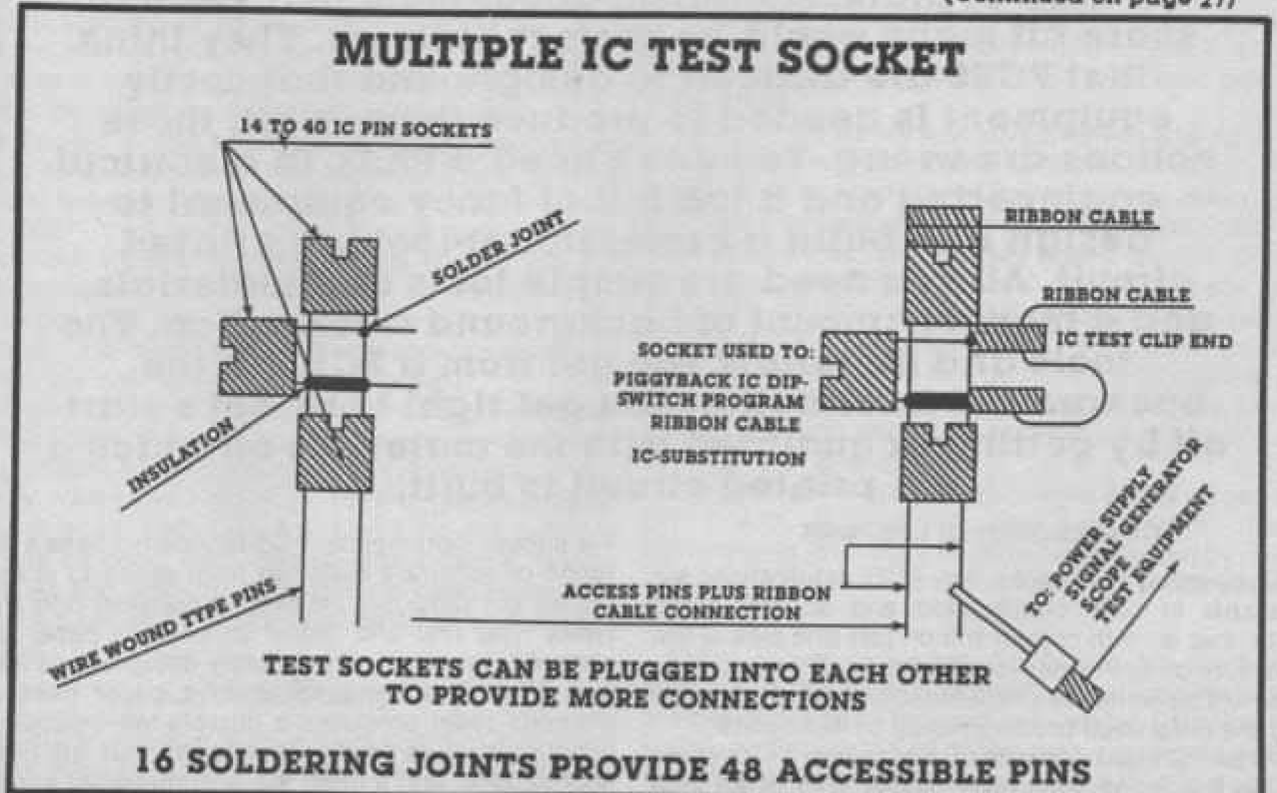
By Gene Barber

Here is a test jig that is sure to get lots of attention and use on the testbench of any electronics technician or hobbyist. It is simple to construct and it has a variety of everyday applications. You can even expand the test socket by plugging one jig into another giving you unlimited access.

The unit consists of three direct inline pin integrated circuit wire wrap type sockets. The sockets are soldered together in a fashion to allow unlimited access to an integrated circuit chip on or off the circuit board.

The unit has two integrated circuit wire wrap type sockets. One is plugged into the other and a third integrated circuit wire wrap socket is soldered in the middle of the pins of the other two sockets. Sixteen soldered pins of the three sockets give the user forty-eight basic connections and an option for more, using small test clips. This is for a sixteen pin socket. The accessible socket can be constructed to accomodate 6, 8, 14, 16, 18, 20, 22, 24, 28 and 40 pin integrated circuit chips. The amount of connections to the sockets will depend on the number of pins on the socket.

(Continued on page 27)



MAKE PRINTED CIRCUITS LIKE A PRO

By Walter Sikonowiz

The most durable and space-conserving way of assembling a circuit is with a printed-circuit board. Projects made with a printed-circuit board often work better than projects assembled by any other means, and they always look better. But printed circuits have an aura of professionalism about them that seem to scare off many would-be project builders. They think that PCBS are difficult to design, and that costly equipment is needed to produce them. Well, those notions are wrong. You don't need a Ph.D. in electrical engineering and a lab full of fancy equipment to design and build a professional-looking printed circuit. All you need are simple tools and materials, and a modest amount of background information. The tools and materials you get from a PCB kit; the background information you get right here. Let's start off by getting acquainted with the materials on which a printed circuit is built.

Characteristics of Laminates

Copperclad laminates for PCB fabrication are available in both single-sided and doubled-sided form, that is, with copper foil on just one side of the board, or on both sides (see Figure 1). Our discussion here will be limited to single-sided boards, since these are the ones used predominantly by hobbyists.

A raw PC blank consists of pure copper foil overlaid on an insulating *substrate*, usually 1/16 of an inch thick, which provides support for the components of the circuit. Commercial PCB fabricators have a wide range of substrate materials from which to choose, but for our purposes we need to consider only three types. The first and oldest of these is paper-base phenolic, known by the industry designations XXXP and FR-2. The combination of a paper base and phenolic resin produces a durable yet inexpensive product that is well-suited to almost all hobby applications, and a great many commercial applications too.

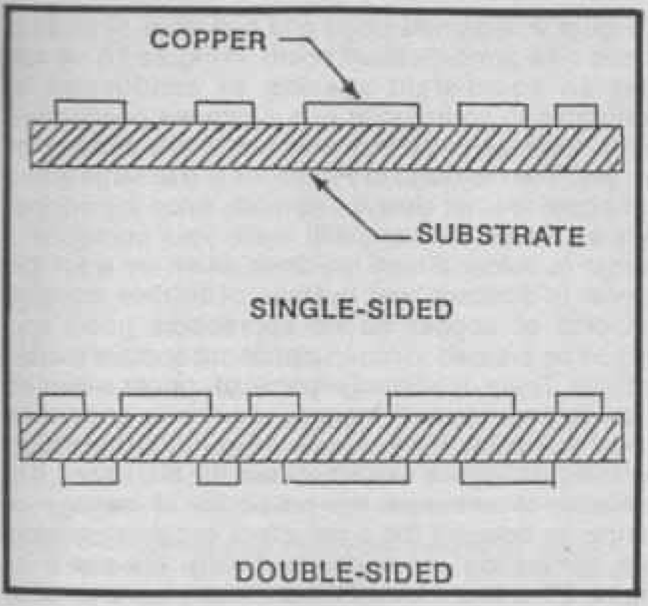


Figure 1. Cross-sectional views of single-sided and double-sided printed-circuit boards.

For critical circuits, the substrate of choice is usually glass-epoxy, which goes by the industry designations G-10 and FR-4. Continuous-filament glass cloth impregnated with epoxy resin yields a premium product with five times the flexural strength of paper-base phenolic and superior insulating qualities. Glass epoxy has less tendency to bend and warp than paper-base phenolic, but it is also more difficult to drill and cut. In addition, glass-epoxy costs about 50% more than paper-base phenolic.

The third type of substrate we will consider is known as CEM-1, an epoxy composite. It consists of cellulose paper sandwiched between sheets of continuous-filament glass cloth and then bonded with epoxy resin. CEM-1 has roughly three times the flexural strength of XXXP paper-base phenolic, and half the strength of G-10 glass epoxy. CEM-1 retains the ease of machining characteristics of XXXP, and its cost is intermediate between G-10 and XXXP.

A printed circuit board's copper foil deserves as much consideration as its substrate. You'll have to choose between 1-oz. foil and 2-oz. foil. Two-ounce foil, .0027" thick and weighing 2 oz/ft^2, was once the norm, but today's fine-line circuits usually call for one-ounce foil (.00135" thick). Use laminates with 2-oz. copper foil only for circuits that will carry high current. One-ounce foil is not only cheaper than two-ounce, it's also easier and faster to etch.

To sum up, most of your printed-circuit needs can be met with XXXP paper-base phenolic laminate and 1-oz. copper foil. If the circuit is a critical one, or you simply want more rigidity, go to G-10 glass epoxy or CEM-1, again with 1-oz. foil. Use 2-oz. foil only for circuits carrying high current—for instance, power supplies and high-power amplifiers—and remember that 2-oz. foil won't render fine line detail as well as 1-oz. foil.

Layout and Design

Layout and design require more skill than any other aspect of the PCB fabrication process. You can't learn to design a PCB just by reading a book or a magazine article; hands-on experience really is essential. Bear that thought in mind as you read the following introduction to the art of printed-circuit design.

The only supplies you'll need to lay out your circuit are a soft pencil, a good eraser, and several sheets of graph paper having ten lines per inch. These tenth-inch graduations are essential because integrated circuits in DIP (dual-inline) packages have leads spaced at 0.1-inch intervals. Professionals lay out their circuits at 2X, 4X, or 10X scale, which allows them to work with less eyestrain and more accuracy. In order to avoid the expense of photoreduction, hobbyists lay out their circuits at 1X scale. This is not a great hardship, and even a 1X scale layout will yield excellent results if it's done carefully.

In most cases, the printed-circuit board will be rectangular, and components will be mounted so that their major axes are parallel to the vertical or horizontal edges of the board. Component mounting pads are identified on the layout by placing small circles at chosen points on the grid of the graph paper. Printed wires, or *traces*, are drawn between pads to establish the electrical connections for the circuit. Traces need not follow the lines on the graph paper, though sometimes they may. A trace should always follow the most direct route between two pads, if possible. Real-world considerations may sometimes force you to abandon this rule and draw a circuitous trace instead, but you should still try to keep your traces as short as possible.

Remember that components are usually mounted on only one side of the board, the non-foil side. Identify the components in your layout by lightly drawing their outlines and letter designations (R1, C2, etc.). You may find it helpful to take the actual ICs and other components that make up your circuit and spread them out on the graph paper, moving them around until you find an arrangement that works. Once you gain some experience, you'll know intuitively how much space to allow for each type of component.

Many of the traces that you draw will later have to be redrawn to make room for other traces. It's no disgrace to remove traces you've already drawn, so don't get discouraged. Draw pads and traces lightly at first, so that they can be easily erased later on. Once the layout is complete, you can darken the pads and traces so that they are easier to see during tape up (which will be described later). Since your graph-paper layout will serve as a guide to the production of circuit artwork, try to be as accurate as possible. Don't worry too much about the accuracy of the widths of your traces, however.

Put heat-generating components at the edges of the board, if possible, and away from other components that might be adversely affected by heat. You may have to allow space for a heat sink, in some cases.

Place ceramic bypass capacitors as close as possible to the V_s and ground pins of digital logic devices. Op amps, too, require careful attention to supply bypassing. Most of the time, placing ceramic bypass capacitors close to the V+ and V− power pins of the op amp will keep the device stable, but some op amps, particularly the high-frequency types, require great care in the way these capacitors are connected. If you work with wideband op amps, you'll find a wealth of helpful information in the application note entitled "An IC Amplifier Users' Guide to Decoupling, Grounding, and Making Things Go Right for a Change." This application note is available free of charge from Analog Devices, One Technology Way, Norwood, MA, 02062-9106.

Large, heavy components like transformers and electrolytic capacitors should not be placed in the middle of a large board without some support underneath. Not only will the board warp; it will probably crack if it is ever dropped. Very large electrolytics should not be supported solely by their leads; they should be strapped securely to the board.

Allow sufficient room for standoff supports around the edge of your board. Large boards should have standoffs spaced 5 or 6 inches apart all around the board's perimeter.

Mount trimpots in such a way that they will be easy to adjust when the board is mounted in its cabinet. The same goes for variable capacitors and inductors.

Use a pad size that is appropriate for the component. A large-diameter component lead requires a large-diameter mounting hole and a large-diameter pad. A general rule of thumb is that pads should be about twice as wide as the traces to which they connect. Traces that are expected to carry high current should be made wider than those that only carry low current.

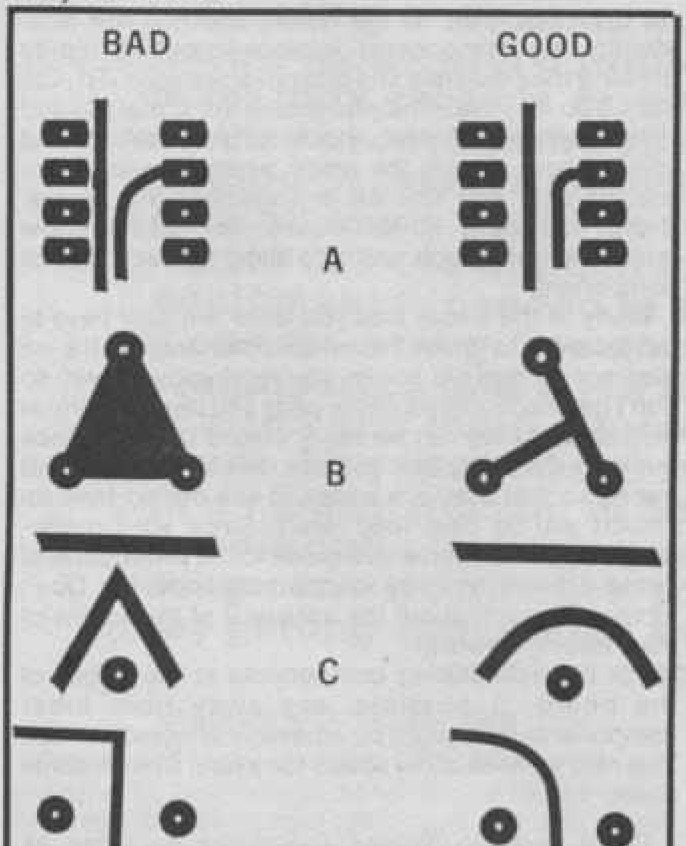


Figure 2. There is a right way and a wrong away to lay down traces. See text for details.

Figure 2 illustrates good and bad ways of routing traces on a printed-circuit board. In Figure 2A we see that an equidistant spacing of conductors is preferable to an irregular one. Cramped conductors invite leakage problems and inefficient etching of copper. The message of Figure 2B is that large areas of copper are not always desirable, since the copper acts as a heat sink and will make your component harder to solder. There are times when we *want* the copper to dissipate heat, but most of the time, massive amounts of copper do no appreciable good and should be avoided. Ground planes are another matter entirely. There, the broad expanse of copper serves as a low-impedance path for ground currents, and not as a heat dissipator. If we assume in Figure 2C that a high potential difference exists between the two traces, it is desirable to minimize the possibility of leakage or arcing by keeping the conductors widely separated and eliminating sharp points. Finally, the moral of Figure 2D is that it is neither necessary nor desirable to emulate the right-angle bends you see in computer-generated artwork. Smooth curves are much easier to produce manually and are preferred.

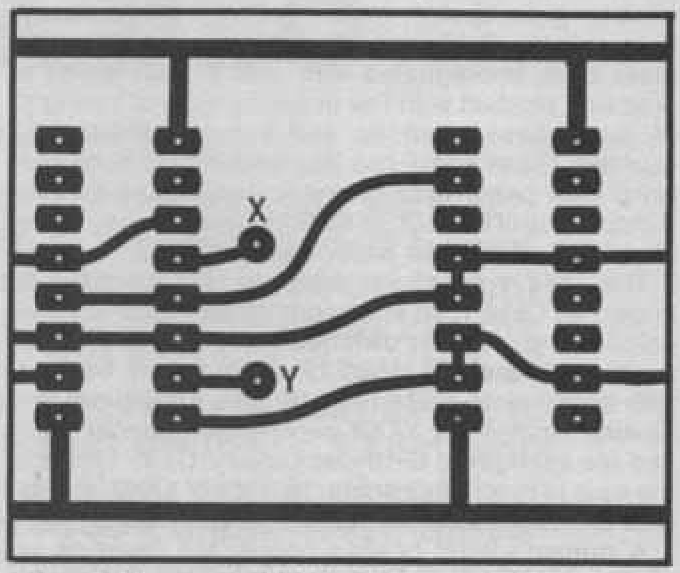


Figure 3. A jumper wire installed between pads X and Y is a practical way to connect two seemingly isolated points.

You've probably heard the joke about the lost tourist who asks a New Englander for directions and is told: "You can't get there from here." It sounds absurd, but in PCB design that kind of situation arises frequently. The only solution on a single-sided board is to use a jumper wire, as shown in Figure 3. A short jumper between pads X and Y will effectively get your signal from one point to the other. Jumpers are usually mounted on the component side of the board, although they can be put on the foil side if they are insulated.

When laying out your PCB, you have to watch out for stages that might interfere with one another. One means by which signals can be inadvertently coupled from one stage to another is through a common ground impedance, as shown in Figure 4. Here, ground current from stage A flows through the ground impedance, represented by R_g and L_g, and produces a noise voltage, e_n. Ground current from

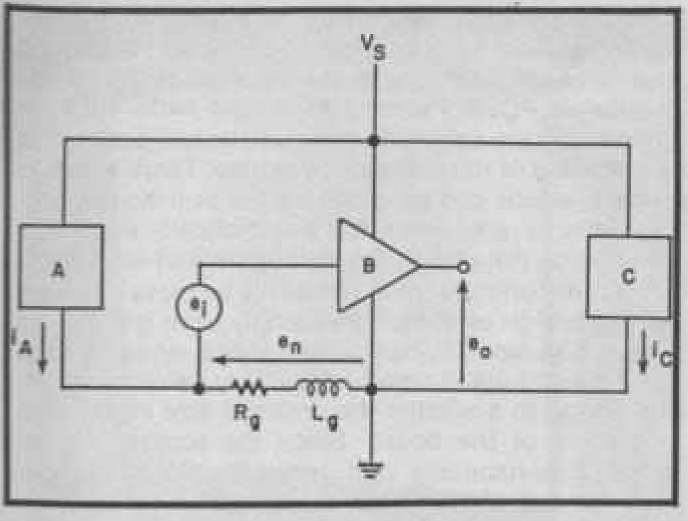


Figure 4. A common ground impedance shared by stages A and B enables noise voltage e_n, generated by stage A, to appear as part of stage B's input signal.

stage C does not contribute to the noise, since it does not flow through R_g and L_g. Stage B is an amplifier that will respond to the potential difference between its input and ground reference, which in this case, is e_i+e_n Thus, $e_o = G(e_i+e_n)$, where G is the gain of stage B. Whether this causes a problem depends on the relative magnitudes of e_i and e_n and the nature of the circuit. If B is a high-gain amplifier, and A is digital logic that produces high-current ground spikes, we're probably in trouble. In that case, it may be necessary to resort to single-point grounding, as shown in Figure 5. With single-point grounding, stages A and B no longer share a common ground impedance, so noise no longer appears in series with e_i.

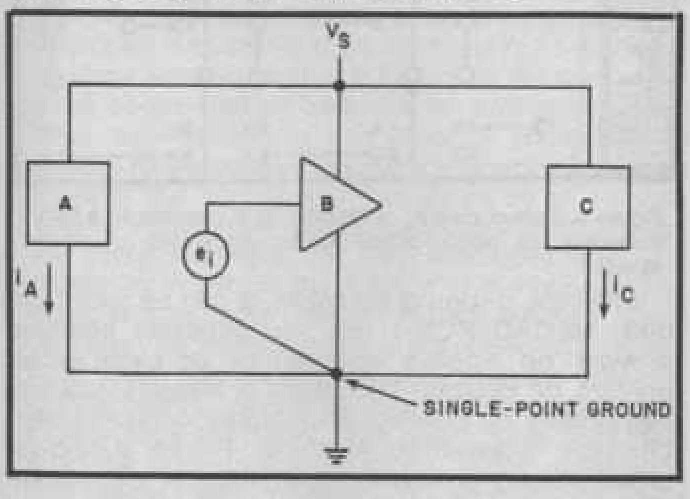


Figure 5. Single-point grounding eliminates the problem of noise coupled through a common ground impedance.

Noise can be coupled from one stage to another through an electromagnetic field, too. Typically, this happens when you're dealing with high-frequency signals, but it can happen at low frequencies, too. The cure here is to use a grounded metallic shield to isolate the noise-generating stage from the stage that's picking it up. The shield could be installed on your PCB, or it might be necessary to divide the circuit and build it on two separate PCBS, each surrounded by a shield. You'll find lots of helpful information about shielding and other noise-reduction techniques in the book by Ott listed in the references at the end of this article.

Some of the information we've just covered will probably seem overwhelming to the beginner, but there is no reason to feel intimidated by it. If you are a beginner, confine your layout and design efforts to simple projects like those found in this magazine. When building a complicated project from some other source, use the layout that the author provides, and study it carefully. There is no better way to learn how to design a PCB than by studying the work of an experienced practitioner.

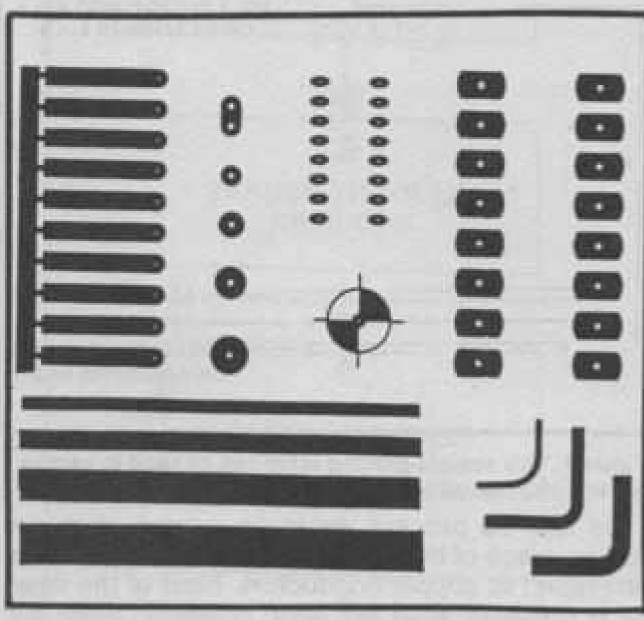


Figure 6. A small selection of pressure-sensitive tapes, donut pads, elbows, and other symbols used in PCB artwork generation.

Artwork Generation

Once the graph-paper layout is complete and has been checked for accuracy, it's time to create a precise representation of the pads and traces of the circuit. This representation, known as *master artwork* or simply *artwork*, will be used to transfer the image of the circuit to a photosensitized PCB blank. To make the artwork, you need a sheet of clear mylar plastic, an X-Acto knife, tweezers, and a set of pressure-sensitive drafting aids like those shown in Figure 6. These drafting aids come in a variety of shapes and sizes. You'll need donut pads ranging in size from 0.031" to 0.2" and 16-pin DIP patterns (1X scale). Patterns for 8-pin and 14-pin ICs can be made by cutting the 16-pin patterns to size with scissors or a knife. Traces will be represented by precision-slit tapes ranging in width from 0.031" to perhaps 0.2". Because the wider tapes don't bend easily, 90° elbows in a variety of widths will also come in handy. Finally, multi-fingered patterns are needed if your board is designed to mate with a standard edge-board connector.

Preparation of the artwork begins by fastening the graphpaper layout to a smooth, flat surface with masking tape. Next, a clear mylar sheet is laid over the graph paper and also fastened with masking tape. With the aid of an X-Acto knife or tweezers, IC patterns are positioned where needed and carefully pressed in place. Once all the DIPs are in place, donut pads are picked up with the tip of the X-Acto knife and placed where indicated in the layout. If you make an error in placement, it's an easy matter to peel off a donut and replace it with a new one. Finally, precision-slit tapes are routed from pad to pad, forming the traces of the circuit. Narrow tapes are supple enough to be bent into smooth curves; wide tapes require elbows wherever a bent is needed.

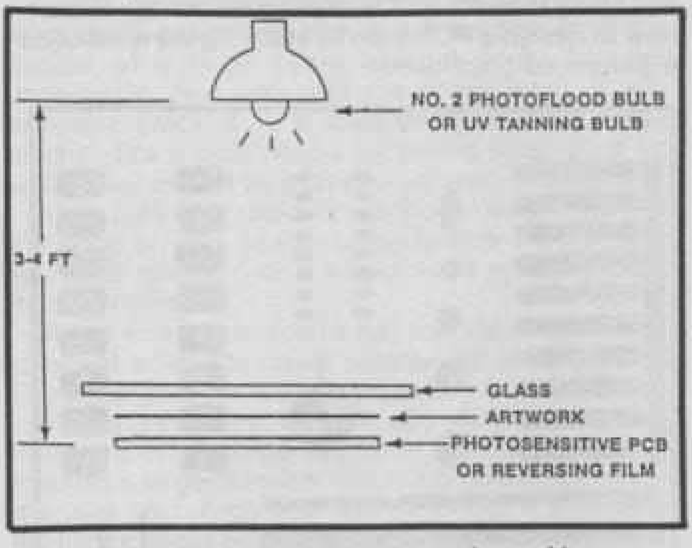


Figure 7. This contact-printing setup can be used to expose either a photosensitive PCB or a sheet of reversing film.

The tape-up process results in artwork that is a positive image of the circuit; that is, the opaque areas correspond to copper conductors. Most of the time, this is precisely what we want. However, there are occasions when you might need a negative image, and this can be obtained by making a contact print of the artwork, as shown in Figure 7. The taped side of the artwork is placed in contact with the emulsion side of a reversing film, then covered with glass and exposed with a No. 2 photoflood lamp. Finally, the film is developed, and a negative is obtained. Kepro Circuit Systems sells a green reversing film intended expressly for PCB work. No darkroom is required, and the film is easily developed in ethyl alcohol. Since the peak light sensitivity of the Kepro film falls in the near ultraviolet region of the spectrum, an ordinary UV tanning lamp can be used instead of a No. 2 photoflood lamp, resulting in reduced exposure times. Complete directions accompany the film, so we won't say any more about it here.

Computer-assisted Design

The manual method of layout and artwork preparation that we've just described is the traditional one that has been used for years by hobbyists and experimenters. Manual methods are economical and produce excellent results; thus, they remain popular with the great majority of experimenters. There is a trend, however, among a small but growing minority of hobbyists, to use computer-based methods of design and artwork generation. This trend is linked to the appearance of relatively inexpensive yet powerful PCB-design software. I recently had the opportunity to check out a program called McCAD PCB-1, which is published by VAMP, Inc. of Los Angeles. This software package, which runs on any Mac computer having at least 512K of RAM, is capable of designing the artwork for single-sided, double-sided, or multilayer PCBs. Patterns for single pads, DIPs, or connectors are selected from a palette and positioned with the aid of the computer's mouse. There is a grid system, which can be made visible or invisible, and the patterns you select will automatically snap into position on the grid, thus ensuring perfect alignment.

Patterns on the screen can easily be moved around as the design evolves, either singly or in groups. As Figure 8 shows, you can expand the on-screen image for a closer look at small details. You can also shrink the image to a smaller-than-normal size in order to see more of the board. Since the screen can be scrolled horizontally and vertically, layouts larger than the size of the screen are possible. Laying down traces is a snap. After choosing the line-drawing function from the palette and specifying a line width, you draw traces from pad to pad using the mouse. The procedure is fast and easy, and best of all, any trace can be singled out and eliminated in an instant. This makes editing a breeze, and allows you to optimize the layout or modify it much faster than you ever could manually using an eraser.

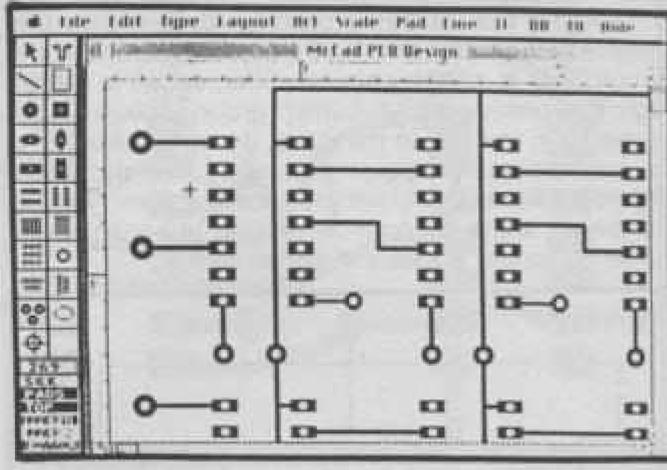


Figure 8. Screen display of McCAD PCB running on a Mac computer. 2X magnification allows observation of small details.

When the design is complete, it can be saved on disk. McCAD PCB-1 lets you generate positive artwork on Apple's Imagewriter or Laserwriter printers, on Houston Instrument or Hewlett-Packard pen plotters, on a Gerber photoplotter, or on an Allied Linotype typesetting machine. Figure 9 shows artwork being produced on a Houston Instrument digital pen plotter. McCAD PCB-1 costs $395.00, and a design-evaluation disk (#PCB-EV1) is available for $15.00, so that you can try it before you buy it. Users of IBM PCs and compatibles need not feel left out; if anything, there is even more PCB-design software available for PCs than for Macs. Manufacturers of some of the better known PCB-design packages are listed at the end of this article. You can find more by checking the ads in the various computer magazines.

Computer-assisted PCB design is fast and a lot of fun, but it's obviously not for everyone. If you are just starting to make printed circuits, perfect your skills using the manual methods described earlier before

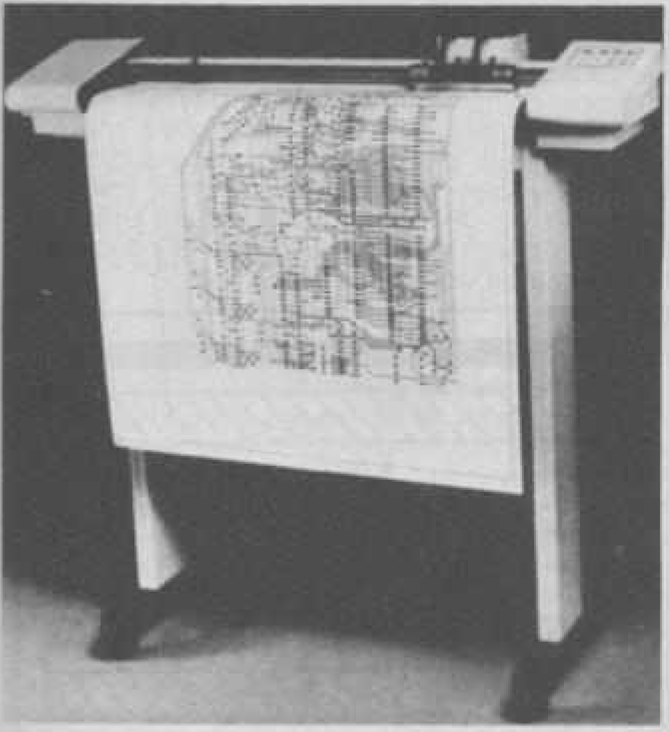


Figure 9. The Houston-Instrument DMP-62 pen plotter can generate PCB artwork as large as 36×48 inches. (Courtesy of Houston Instrument.)

even considering the purchase of PCB-design software. Manual methods do produce excellent artwork; they just don't do it as fast as a computer can.

Print-and-etch Processing

With artwork in hand, we are now ready to consider the chemical and mechanical processes by which a printed-circuit board is produced. The method to be described is known in the industry as *print-and-etch*. Its steps are summarized in Figure 10. We start with a blank copperclad laminate, the foil side of which has been covered with a thin layer of photosensitive *resist*. The purpose of this resist is to protect selected areas of the copper foil from attack by an etchant. This photosensitive resist is exposed to light through the circuit's artwork, and then developed, leaving a pattern of resist on the surface of the copper. The board is then immersed in an etching solution, which eats away all the copper that is not protected by resist. After that, the board is rinsed, and the resist is stripped away, leaving us with the desired pattern of copper pads and traces. That, in a nutshell, is all there is to the print-and-etch process. In the paragraphs that follow, we'll elaborate on each of the steps involved. Refer to Figures 10 and 11 as we go along.

Step 1. We first need to cut out a blank piece of copperclad laminate of the appropriate size. This is most conveniently done with a nibbling tool. A jigsaw or benchtop table saw equipped with a very fine blade would also serve to cut the laminate. File down any jadded edges.

Step 2. Some PCB kits require you to spray a coat of resist over your board's copper foil; others provide you with precoated laminate. Personally, I prefer precoated boards. If you spray the photoresist on by hand, there is always the possibility of ending up with a lumpy, uneven coat if you're not careful. If the coat

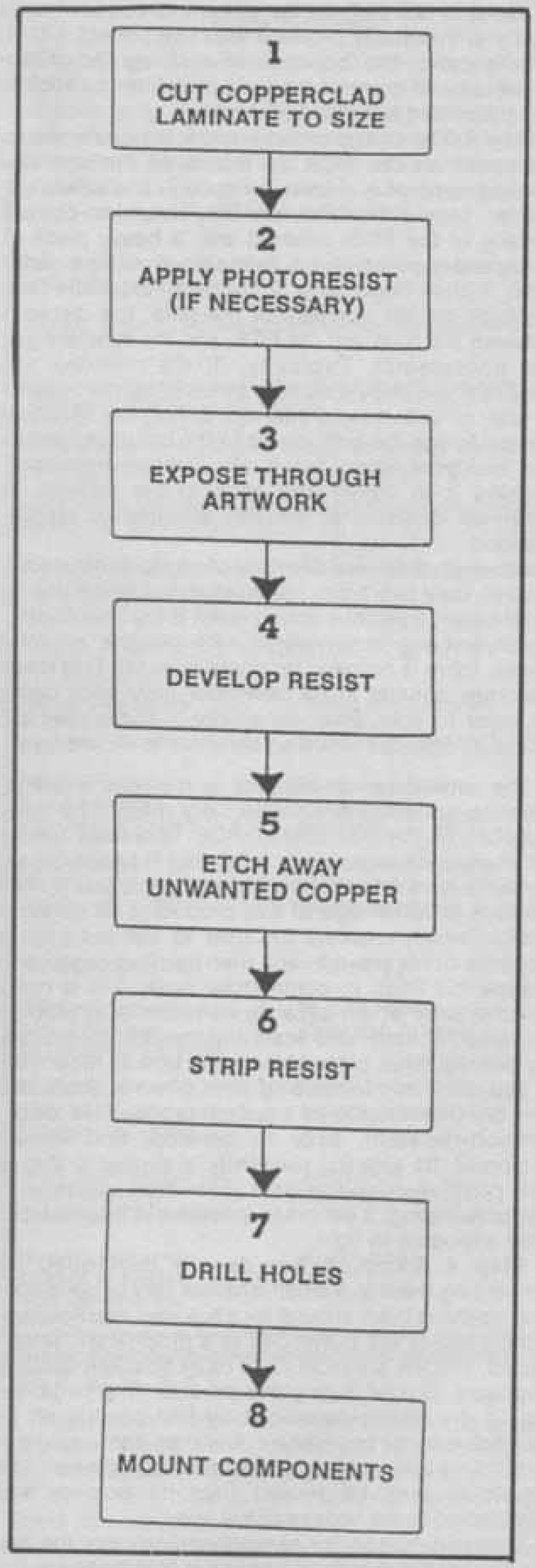


Figure 10. Print-and-etch method of PCB fabrication consists of eight steps.

of resist is not perfect, the pattern of copper traces that you eventually produce won't be perfect, either. What's more, this business of applying the photoresist eats up more of your valuable time, so stick to the precoated boards, if you can.

Step 3. The image of the artwork is transferred to the resist on our PCB by means of the contact-printing apparatus shown in Figure 7. The artwork is placed tape-side-down on the emulsion-coated surface of the PCB, covered with a heavy piece of glass, and exposed for a suitable length of time under a No. 2 photoflood lamp or UV lamp. Exposure time depends on the intensity of the bulb, the distance between the bulb and the PCB, and the sensitivity of the photoresist. Typically, 10-20 minutes are required; you should make a series of test exposures at one- or two-minute intervals to find the optimum value. Moving the bulb closer to the board decreases the exposure time, but it also warms the resist, causing it to soften and stick to the artwork. A minimum distance of 3-4 feet is therefore recommended.

Although there are a variety of photoresists on the market, only two types are suitable for home use. In most cases, a positive-acting resist is the best choice. Positive-acting resist works with positive artwork; hence, there is no need for photo reversal. This resist becomes soluble in its developer only after being exposed to light. Peak sensitivity is in the near UV (200-600 nm), but it is also sensitive to visible light.

The alternative photoresist is a negative-acting, alkaline-aqueous-developed, dry film. The only supplier of dry-film-coated PCB laminates whose products are accessible to hobbyists is Kepro Circuit Systems (to the best of my knowledge, anyway). The obvious disadvantage of this product is its negative action, which requires the user to contact print a negative of his artwork, and then use that negative to expose his PCB. In commercial work, this is not a disadvantage at all, because commercial artwork is produced at expanded scale and then photoreduced, so reversal takes place at the same time as reduction. If you don't mind reversing your artwork, you'll find this dry-film resist to be a superb product. It's tough, scratch-resistant, easy to develop, and almost foolproof. Its spectral sensitivity is similar to that of the positive-acting resists. However, since it is negative-acting, it becomes *insoluble* in its developer after exposure to light.

Step 4. Exposed boards are developed by immersing them in a small, shallow tray of developer and sloshing them around for a few minutes. Positive-acting resists are developed in a proprietary, water-based, alkaline solution. Care must be taken to avoid exposure to light during this process. The negative-acting dry film is developed by first peeling off its protective mylar cover sheet, and then immersing it in a mildly basic solution of sodium carbonate. The developer may be reused until its potency has diminished to an unacceptable level.

My main reason for recommending only the two types of resist mentioned above is that these are the safest and easiest to process. Other resist formulations are processed in such organic solvents as xylene, trichloroethylene, and methylene chloride. These substances are hazardous to your health. Furthermore, it is virtually impossible for the hobbyist to dispose of them in an environmentally safe manner.

After a board has been developed, rinse it thoroughly and give it a careful inspection. Use a magnifying glass, if necessary. Any chips, cracks, or voids that you find in the resist pattern should be touched up with *resist lacquer*, a tar-like liquid that can be applied with a toothpick.

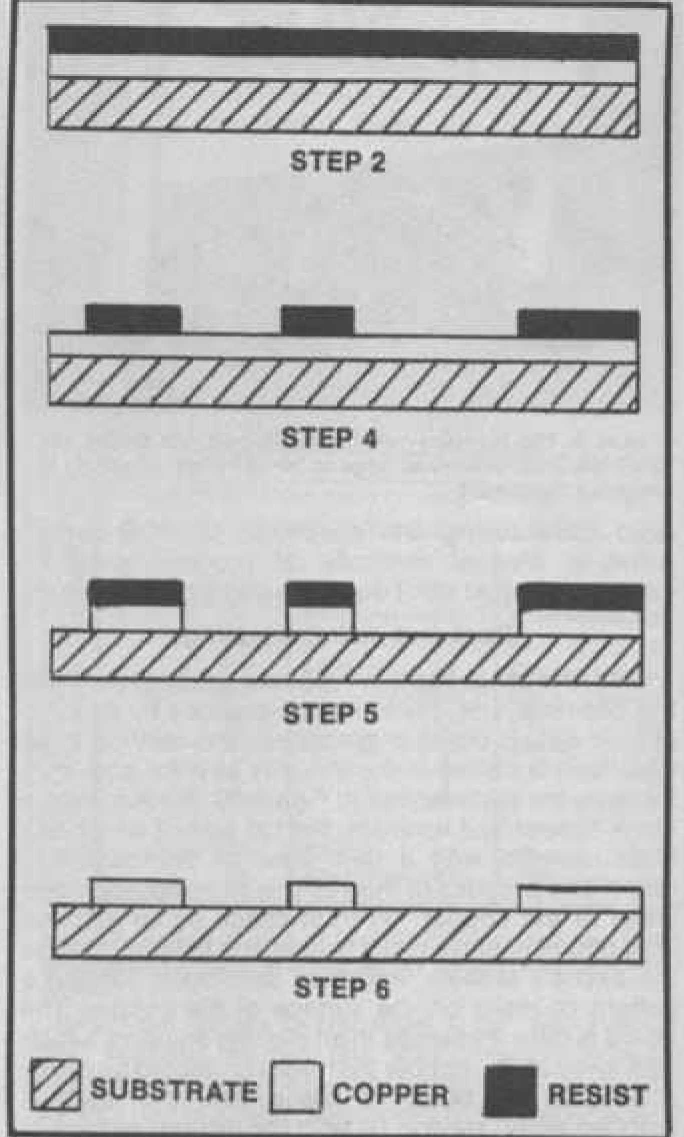


Figure 11. Board profiles after various steps in the print-and-etch process (see Figure 10).

Step 5. To etch a PCB, place it in a shallow plastic pan filled with warm etchant, and rock the pan occasionally. The rocking motion stirs things up and hastens the etching process. Typical etching times for 1-oz. copper are 10 to 20 minutes, depending on such variables as temperature and the strength of the solution. Always wear goggles to avoid serious eye injury.

Two etchants are popular with hobbyists. The first of these is ferric chloride, $FeCl_3$, which is available either as a premixed solution or dry crystals. Ferric chloride works best at a temperature between 100° and 120° F. The solution can be used over and over again, until etching times become inordinately long. Because of ferric chlorides's pungent smell, you may want to do your etching in the garage or outdoors.

Persulphate etchants are the alternative to ferric chloride. Sodium and ammonium persulphate, $Na_2S_2O_8$ and $(NH_4)_2S_2O_8$, are both readily available in dry-crystal form. Sodium persulphate has perhaps a slight advantage over ammonium persulphate, in that the former generates no objectionable ammonia fumes, but in all other respects, the two etchants are identical. The dry crystals will last indefinitely, but once a persulphate solution is mixed, it undergoes spontaneous decomposition. For that reason, persulphate solutions should be mixed just before use for best results. The solution can be reused, but after a couple of weeks, it won't be potent enough to etch anything. Persulphate solutions are often activated by a small amount of phosphoric acid, H_3PO_4, and mercuric chloride, $HgCl_2$. Mercury is poisonous, so be careful. Etching should take place at a temperature of 100°-115° F. Exceeding 115° F. accelerates the natural decomposition of the solution, and should be avoided. Solutions of ferric chloride, in contrast, do not spontaneously decompose, and for that reason alone, many hobbyists prefer $FeCl_3$.

If you leave your board in the etching solution for too long a time, *undercutting* will occur; that is, the etchant will begin to nibble under the resist, reducing the width of your copper traces. Examine the board at regular intervals during the etching process, and as soon as it appears to be cleanly etched, take it out of the solution and rinse it thoroughly.

Step 6. Dry-film resist can be stripped by immersing the board in a 2-4% solution of sodium or potassium hydroxide, NaOH or KOH. These compounds are strong bases capable of burning the skin, so wear rubber gloves and goggles. Although positive-acting resists can be stripped with organic solvents like acetone, the preferred method is simply to re-expose the board to intense light, and drop it into its developing solution.

Step 7. Holes should be drilled in the center of each pad using a suitable drill bit, usually #65. A Dremel Moto-Tool makes a good PCB drill, or you can use a conventional power drill equipped with a chuck adapter that will allow it to accept very small drill bits. If you use a conventional power drill, don't hand-hold it; mount it in a drill-press adapter. This will prevent excessive breakage of delicate drill bits.

Step 8. Stuff the board with components; solder them in place; then go out and amaze your friends with what you've made.

That's All, Folks

That wraps up our introduction to the art of printed-circuit construction. As you've seen, there is nothing extraordinarly difficult about making a PCB. With patience and attention to detail, anyone can do it. So don't just sit there. Get a PCB kit and start etching! ■

FURTHER READING

Clark Raymond H., **Handbook of Printed Circuit Manufacturing**, Van Nostrand Reinhold, New York.

Coombs, Clyde F., **Printed Circuits Handbook**, McGraw-Hill, New York.

Graf, Calvin, **How to Make Printed Circuit Boards, with 17 Projects**, TAB Books, Blue Ridge Summit, Pa.

Hollomon, James K., **Surface-Mount Technology for PC Board Design**, Howard W. Sams & Co., Indianapolis, Ind.

Kasten, Stephen D., **Electronic Prototype Construction**, Howard W. Sams & Co., Indianapolis, Ind.

Ott, Henry, **Noise Reduction Techniques in Electronic Systems**, John Wiley & Sons, New York.

DEALERS WHO SELL PCB KITS

Mouser Electronics
2401 Hwy. 287 North
Mansfield, TX 76063

Circuit Specialists, Inc.
P.O. Box 3047
Scottsdale, AZ 85271

Kelvin Electronics
7 Fairchild Ave.
Plainview, NY 11803

DC Electronics
P.O. Box 3203
Scottsdale, AZ 85271

Parts Express
340 E. First St.
Dayton, OH 45402

Kepro Circuit Systems
630 Axminister Dr.
Fenton, MO 63026

MANUFACTURER	PRODUCT
VAMP, Inc. **6753 Selma Ave.** **Los Angeles, CA 90028**	**McCAD PCB-1** **Macintosh Software**
Wintek Corp. **1801 South St.** **Lafayette, IN 47904**	**HI-Wire** **IBM PC software**
Accel Technologies Inc. **6825 Flanders Dr.** **San Diego, CA 92121**	**Tango-PCB** **IBM PC software**
Houston Instrument **Division of Ametek** **8500 Cameron Rd.** **Austin, TX 78753**	**digital plotters**

MULTIPLE IC TEST SOCKET

The beauty of this jig is that by soldering sixteen joints together, you get forty-eight pin connections. The only thing that you have to watch is the vertical and horizontal pins in the back. The author used an "excello" knife to separate the pins and dash a little shelack between the pins. The limber pins, coming out of the side are covered with wire insulation. He pulled the top off the bottom IC socket to make the pins easier to insert into the other socket.

This design allows IC substitutions, IC piggy-backing, ribbon cable hookups, special circuitry hookups, special programing hookups and all of the test equipment hookups you will ever need or want. These hookups can be done all at the same time, since one socket assembly can be plugged into another socket assembly. There are unlimited connection combinations. ■

CIRCUIT FRAGMENTS

One of the best ways to begin your mastery of electronic circuitry construction is to work with discrete components before diving headlong into integrated circuit construction. After all, integrated circuits are nothing more than these individual components and circuits in a more compact package. The only problem is that they don't come in see-through packages to help you identify the individual working areas.

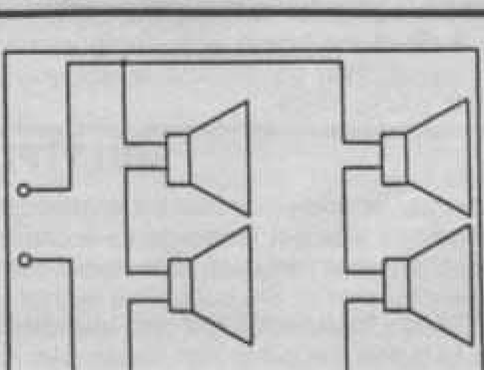
We don't feel that it's of much value to simply "plug in" black boxes without the understanding of what actually goes on inside them. If you can learn what the circuitry of an integrated circuit is supposed to do, then it frees you to come up with your own innovations, and to accurately troubleshoot your creations when you run into the inevitable bugs or "glitches."

This brings up another point. While some ICs are relatively sensitive to miswiring and are easily destroyed, these discrete components, as a rule, are not. It's a lot better to make your mistakes here than on an integrated circuit project, where ruining an IC due to a reversed diode polarity might set you back two or three dollars. So have fun, but learn!

SPEAKER SYSTEM EXPANDER

This neat arrangement lets you connect multiple speakers to your system's speaker terminals without upsetting the impedance match. This series-parallel arrangement of speakers exhibits the same impedance as a single speaker, assuming all speakers are of equal impedance and individually match the rating of the system.

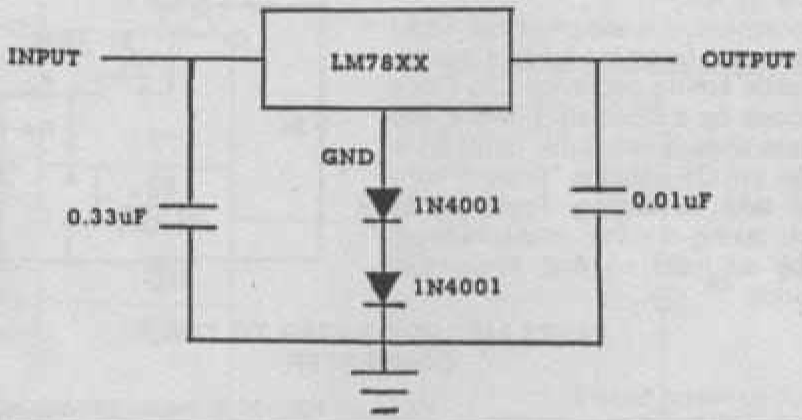
And inasmuch as the response of arrayed speakers is somewhat additive, you will find more bottom to your sound than any one of the speakers could have delivered alone. Of course, it takes more power to drive an array than a single speaker, but most modern music systems have plenty to spare.



INCREASED VOLTAGE OUTPUT FROM A FIXED REGULATOR

Did you ever need a fixed 6 or 9 volt regulated power supply so you could run a battery operated piece of equipment but only had a 5 or 8 volt LM78XX regulator available, which you had purchased in one of those "variety packs"?

There is an easy way to increase the output voltage of these regulators by adding two diodes in series with the ground terminal of the regulator. Each diode will drop approximately .6 of a volt and increase your output approximately 1.2 volts. From a 5 volt regulator you can obtain a 6.2 volt output and an 8 volt regulator can be increased to a 9.2 volt output.

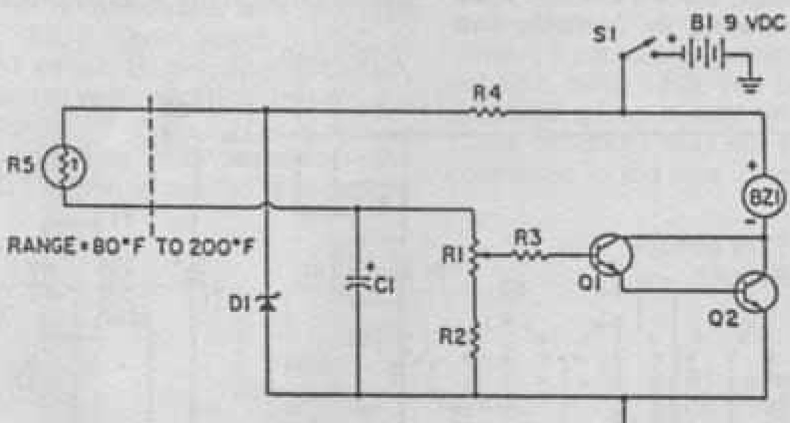


HI-TEMP ALARM

Has a temperature-control problem got you hot under the collar? Well, this little temperature alarm/thermostat may be just the thing to cool you down.

Temperature-sensing is done by thermistor R5, a negative-temperature-coefficient device whose resistance varies between 10K-ohms at 77° F, and about 1000-ohms at 200° F. Potentiometer R1 sets the exact temperature at which the Q1-Q2 Darlington pair gets turned on by the thermistor's signal. Whenever ambient temperature rises above the alarm setting, the transistors conduct current through the buzzer, which then emits an attention-getting shrick.

Note that the thermistor must be located away from the control circuitry—as indicated by the dashed line in the schematic—so that the operation of the control circuit is not adversely affected by temperature extremes. If a 6-volt, 500-ohm relay is substituted for the buzzer, you get a thermostat capable of turning on a fan or turning off a small electric heater.



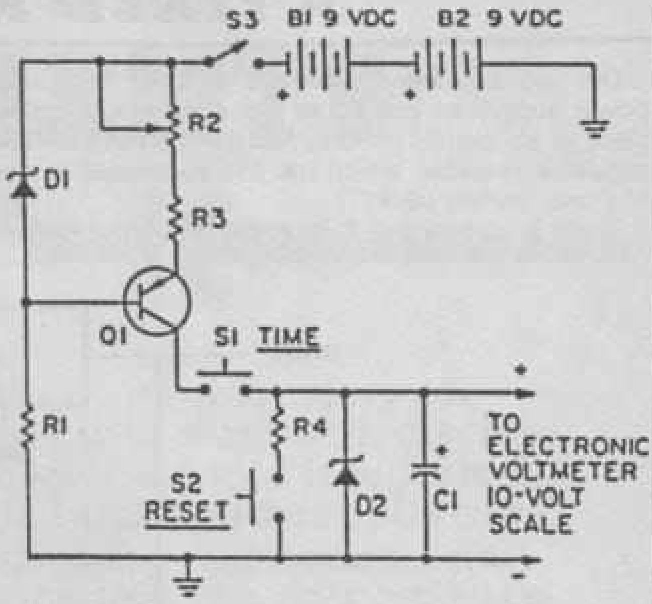
PARTS LIST FOR HI-TEMP ALARM

- **B1**—9-volt transistor battery
- **BZ1**—9-VDC buzzer (Radio Shack #273-052)
- **C1**—220-uF, 10-VDC electrolytic capacitor
- **D1**—1N752A, 5.6-volt, ½-watt zener diode
- **Q1, Q2**—2N3904 NPN transistor
- **R1**—2,000-ohm trimmer potentiometer
- **R2, R3**—1,000-ohm, ½-watt, 5% resistor
- **R4**—820-ohm, ½-watt, 5% resistor
- **R5**—thermistor rated 10,000-ohms @ 25°C (Radio Shack #271-110)
- **S1**—SPST toggle switch

METER TO TIMER CONVERTER

If, like many experimenters, you own an electronic voltmeter—DMM, VTVM, FETVM or whatever—you might like to try this timely circuit. Connected to a high-impedance voltmeter set to read 10-volts DC fullscale, this adapter permits the measurement of time intervals up to 100-seconds long. Either analog or digital readouts are acceptable, although digital meters do have an edge as far as resolution is concerned. To convert voltage to time in seconds, just multiply by ten.

Referring to the schematic, it is apparent that when TIME button S1 is pressed, constant-current source Q1 will begin to charge timing capacitor C1. Since charging is being done by a constant current, the voltage across C1 rises linearly with time. Once S1 is released, the voltage on C1 remains "frozen" long enough for you to take a reading. Press S2 to discharge C1 before taking another measurement. Trimmer R2 can be adjusted so that 10-volts is reached in 100 seconds.

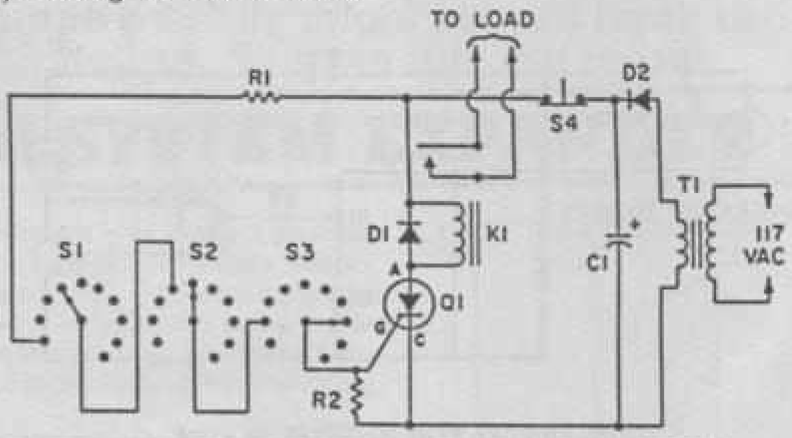


PARTS LIST FOR METER TO TIMER CONVERTER

B1, B2—9-volt transistor battery
C1—10-uF, 20-VDC tantalum capacitor
D1—1N748A 3.9-volt, ½-watt zener diode
D2—1N759A 12-volt, ½-watt zener diode
Q1—2N3906 PNP transistor
R1—2,700-ohm, ½-watt resistor, 5%
R2—10,000-ohm trimmer potentiometer
R3—27,000-ohm, ½-watt resistor, 5%
R4—100-ohm, ½-watt resistor, 5%
S1, S2—normally open SPST pushbutton switch
S3—SPST toggle switch

THREE DIAL COMBINATION LOCK

Here's and effective little combination lock that you can put together in one evening's time. To open the lock, simply dial in the correct combination on the three rotary or thumbwheel switches. With the correct combination entered, current flows through R1 into Q1's gate terminal, causing the SCR to latch in a conductive state. This sends a current through relay K1, which responds by closing its contacts and actuating whatever load is attached. After opening the lock, twirl the dials of S1 through S3 away from the correct combination so that nobody gets a look at it. The lock will remain open and your load will remain on because the SCR is latched on. To lock things up, it's only necessary to interrupt the flow of anode current through the SCR by pressing pushbutton S4.



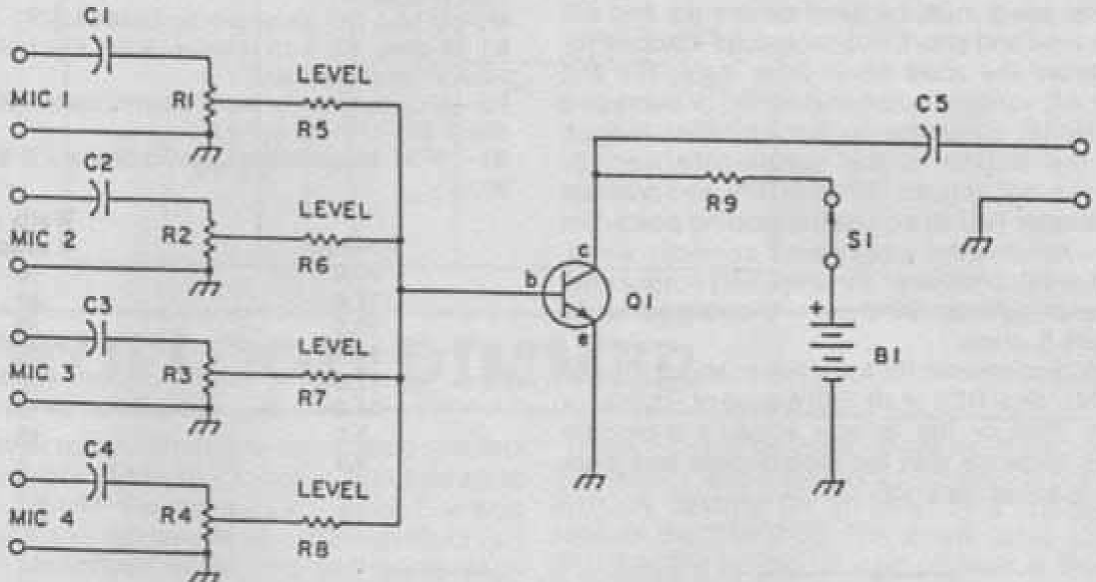
PARTS LIST FOR THREE DIAL COMBINATION LOCK

C1—500-uF, 25 VDC electrolytic capacitor
D1, D2,—1N4002 diode
K1—relay with 6-volt coil rated @ 250-ohms, with SPST contacts
Q1—2N5050 SCR
R1, R2—4,700-ohm, ½-watt resistor, 5%
S1, S2, S3—single pole, 10-position rotary or thumbwheel switches
S4—normally closed SPST pushbutton switch
T1—120-VAC to 6.3-VAC @ 300mA power transformer

LOW IMPEDANCE MIKE MIXER

There's no reason to limit yourself to using just one mike at a time when you have this circuit to help you with your recording—or any other purpose. You can set up a small microphone mixing console. For pizzazz, you could use slide-style controls for R1-4; for miniaturization, you could use tiny trimmer resistors.

Each control adjusts the level of its associated microphone as they are mixed together. This gives you the versatility of making one mike louder or softer without upsetting the level of any of the others. Transistor Q1 provides a bit of amplification to compensate for losses in mixing, and to assure good level at the input.



PARTS LIST FOR LOW IMPEDANCE MIKE MIXER

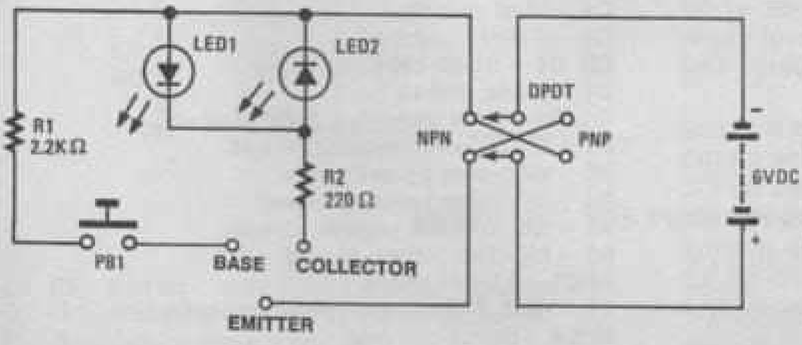
B1—9VDC battery
C1, C2, C3, C4—.1-uF capacitor
C5—10-uF capacitor
Q1—PNP transistor, 2N3904 or equiv.
R1, R2, R3, R4—1-Megohm potentiometer, audio taper
R5, R6, R7, R8—100,000-ohm resistor, ½-watt
R9—15,000-ohm resistor, ½-watt
S1—SPST switch

WORKBENCH TRANSISTOR TESTER

In this circuit, the user places the unknown transistor in the pins indicated and presses pushbutton switch (PB1). Then select "NPN" or "PNP" with the DPDT switch. By pressing PB1 again, the LED will light again to verify an "NPN" (green) or a "PNP" (red) transistor.

For example: If you place an "NPN" transistor in the circuit with the DPDT switch in the "NPN" position, LED1 (green) should light. If you place the DPDT switch in the "PNP" position, neither LED will light.

Note: If you use a transistor in this circuit that does not light either LED, you probably have a defective transistor which should be replaced. Always double check to insure that the pins of the transistor are connected to the pins indicated on the tester.



PARTS LIST FOR WORKBENCH TRANSISTOR TESTER

LED1—Green light-emitting diode
LED2—Red light-emitting diode
PB1—Pushbutton switch (reset)
R1—2.2k ohms resistor
R2—220 ohms resistor
DPDT—Momentary switch

AUDIO POWERMETER

Here's an easy way to measure an amplifier's output power without trying to convert voltage to power measurements. Resistor R1 provides the load for your amplifier and should be rated at least twice the maximum amplifier power output; for example, if your amp puts out 25 watts, R1 should be rated at least 50 watts.

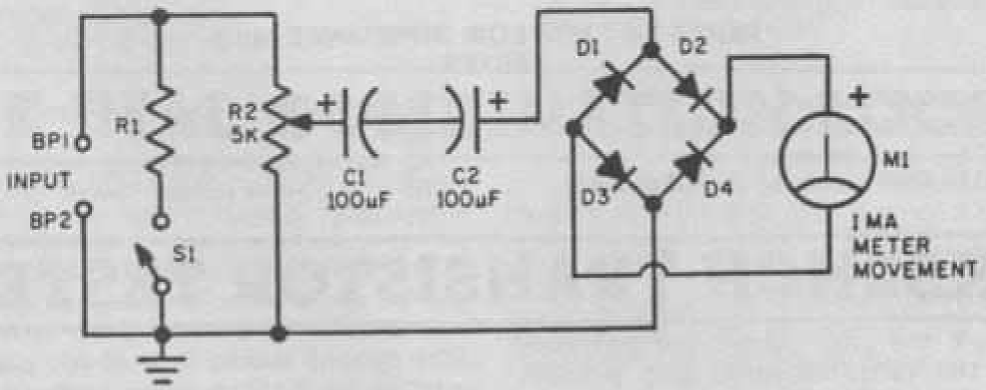
The meter scale must be hand calibrated, and will take some time and effort, but once done it's done for good. Remove the scale cover from meter M1 and borrow an AC variable autotransformer, or connect a 1000 Hz signal generator to the amplifier output. Connect the output of the autotransformer (or amplifier) to binding posts BP1 and BP2, and connect an AC voltmeter (VOM) across the binding posts. Set R2 to *off*—full counter-clockwise if correctly wired. Adjust the autotransformer (or amplifier) output until the AC meter indicates 20 V rms—the voltage for 50 watts across 8 ohms.

Adjust potentiometer R2 for a full scale indication on meter M1. Seal R2's shaft with a drop of Glyptol or nail polish. Reduce the voltage across the binding posts in accordance with the table shown and mark the meter scale accordingly.

PARTS LIST FOR AUDIO POWERMETER

BP1, 2—Insulated binding posts (Radio Shack 274-656 or equiv.)
C1, 2—100uf, 50 VDC capacitors (Radio Shack 272-1016 or equiv.)
D1, 2, 3, 4—1-A 400 PIV diodes (Radio Shack 276-1103 or equiv.)
M1—0-1mA DC meter (Radio Shack 22-052 or equiv.)
R1—8-ohm, 100 watt resistor (Allied Electronics 880-1408 or equiv. see text)
R2—5000-ohm linear taper potentiometer (Radio Shack 271-1714 or equiv.)
S1—SPST toggle switch (Radio Shack 275-602 or equiv.)

Voltage	Watts at 8 ohms
20.0	50
17.9	40
15.5	30
14.1	25
12.6	20
11.0	15
9.0	10
6.3	5
2.8	1
2.0	0.5



CW SIDETONE OSCILLATOR

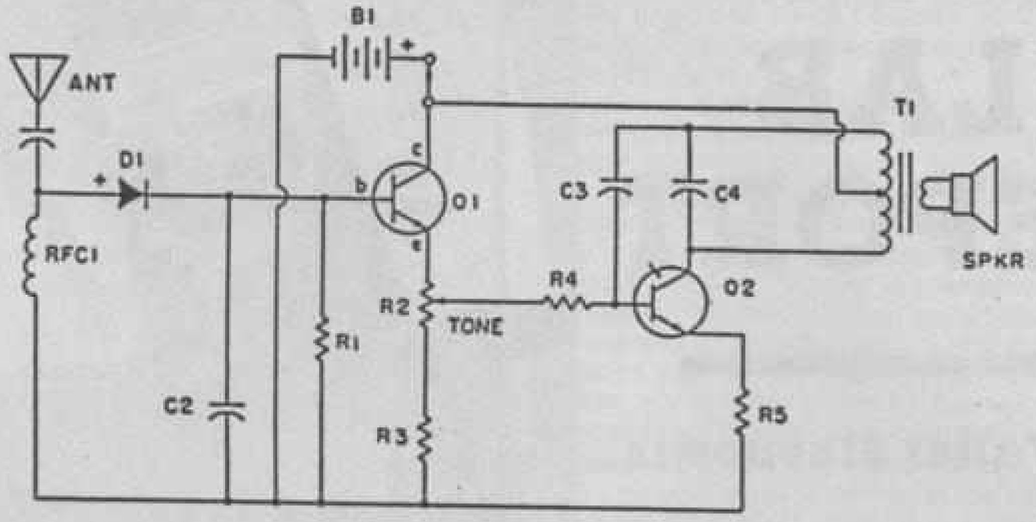
CW (continuous wave, the form of modulation involving a simple turning on and off of the RF carrier) is the simplest way for a beginning ham to transmit to his fellow hams. And the famous Morse Code is how he gets his message across. But Morse is a lot easier to send if you can hear what you're sending. This circuit lets you do just that.

A short length of wire near the transmitter picks up RF as it's transmitted and acts as the antenna for our circuit. This RF is detected by D1, smoothed by C2, and used to turn Q1 on and off, following the transmitted signal exactly. Q1 switches the positive supply through R2 to beep oscillator Q2 through the center tap of T1. The values shown produce a pleasant, easily distinguishable tone.

PARTS LIST FOR SIDETONE OSCILLATOR

B1—9VDC battery
C1—50-pf capacitor
C2—470-pf capacitor
C3, C4—.01-uF capacitor
D1—Diode, 1N914
Q1, Q2—NPN transistor, 2N2222 or equiv.
R1—470,000-ohm resistor, ½-watt
R2—5000-ohm potentiometer
R3—4700-ohm resistor, ½-watt
R4—100,000-ohm resistor, ½-watt
R5—100-ohm resitor, ½-watt
RFC1—2.5-mH choke
T1—1000; 8-ohm transformer, centertapped
SPKR—8-ohm speaker

SIDETONE OSCILLATOR

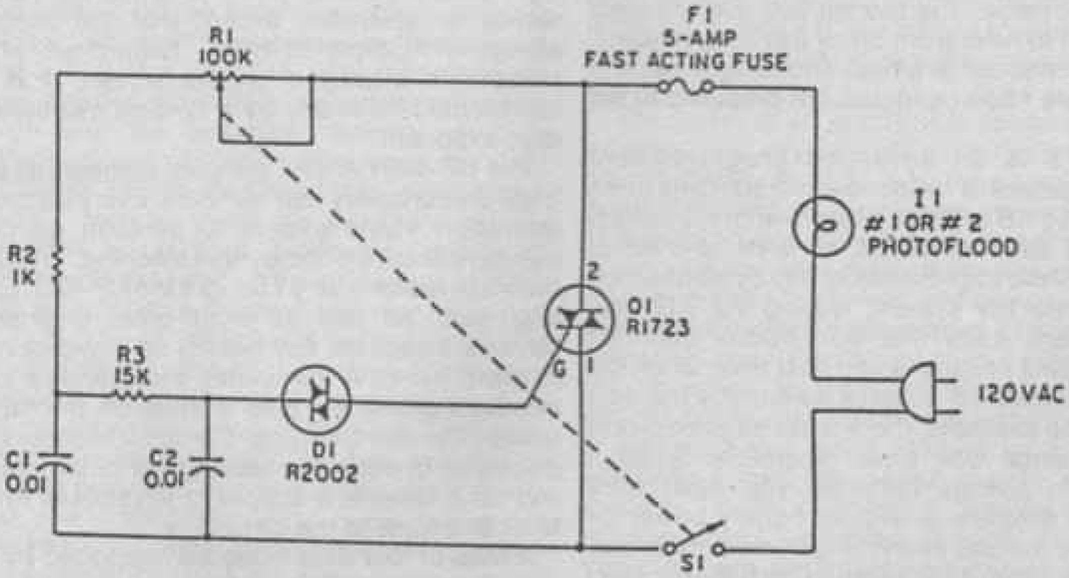


PHOTOFLOOD DIMMER

Professional quality photographic lighting requires complete control of the studio lights, and that's just what you'll get with the pro-type, full-range 500-watt dimmer. Each one can handle one 500-watt #2, or two 100-watt #1 photoflood lamps, and the lighting range can be adjusted from full off to full on.

Triac Q1 must be mounted to a large heat sink, preferably the metal cabinet used to house this dimmer. Make certain you insulate Q1 from the cabinet.

Fuse F1 *must* be used, otherwise, the surge current that occurs when 500-watt photofloods burn out will instantly destroy Q1. F1 must be a fast-acting fuse such as the type 8AG. The slower fuses such as the 3AG and the slo-blo offer no protection. Switch S1 is part of intensity adjustment R1, and R1 should be wired so it represents maximum resistance just before S1 switches off. (While S1 cannot normally handle a 500 watt load, in this circuit, it switches when the lamp is off and has no trouble handling any size photoflood.)



PARTS LIST FOR PHOTOFLOOD DIMMER

C1, C2—0.01-uF, 50-VDC ceramic disc capacitor
D1—HEP-R2002 bi-directional trigger diode
F1—8AG 5-Amp fast-acting fuse
Q1—HEP-R1723 Triac
R1—100,000-ohm, linear taper potentiometer w/SPST switch
R2—1,000-ohm, ½-watt resistor
R3—15,000-ohm, ½-watt resistor
S1—SPST switch, part of R1

LAB REPORT

By Walter Sikonowiz

THE HEWLETT-PACKARD HP-42S CALCULATOR

Last year, Hewlett-Packard introduced a new programmable scientific calculator, the HP-42S, with features so impressive that I said farewell to a perfectly good calculator, and ran out to buy a sleek new HP-42S, complete with printer and enough manuals to choke a horse. More than a year has passed now. I've used the machine virtually every day, at work and at home, and though you might expect the excitement to have worn off by this time, it hasn't. The HP-42S continues to amaze and delight me, and if you can spare fifteen minutes, I'm prepared to tell you why.

The HP-42S is an advanced programmable scientific calculator with over 350 functions embedded in 64 KB of ROM. User memory, in which programs and data are stored, consists of 8 KB of CMOS static RAM, approximately 800 bytes of which are reserved for the system, leaving 7.2 KB free. Hewlett-Packard calls this *continuous memory*, because it retains programs and data even when the calculator is turned off. Internal memory is the only form of storage available; there is no magnetic-card reader or external disk drive. Therefore, when it comes time to change batteries, you must work quickly. If the machine is without battery power for more than one minute, everything in memory is lost. Three 1.35-volt mercury or silver-oxide batteries keep the machine running for about one year, under normal conditions.

Numbers are represented internally as a 12-digit mantissa and 3-digit exponent—that's better than many personal computers. Numbers may range between 1×10^{-449} and $9.99999999999 \times 10^{499}$, which is a big enough range to satisfy even an astronomer. Numbers can be displayed in either fixed-decimal, scientific, or engineering format, as shown below for the number 35000:

FIX = 35,000.00
SCI = 3.50E4
ENG = 35.00E3

You can specify the number of digits appearing to the right of the decimal point. Engineering notation is similar to scientific, except that the exponent is always a multiple of three. Regardless of how a number is displayed on the screen, it is always represented internally by a 12-digit mantissa and 3-digit exponent.

The HP-42S handles complex numbers as easily as it handles ordinary real numbers. Every mathematical operation you'd expect to perform on complex numbers is supported by this machine. That's one of the main reasons why I bought the HP-42S. Electrical engineers, as well as most other engineers and physical scientists, rely heavily on complex numbers in their work. A calculator that handles complex numbers gracefully puts a smile on the face of its owner. I'm still grinning. Complex numbers can be displayed in either the rectangular or the polar form, and all it takes is a couple of keystrokes to convert from one form to the other.

A total of four data types are supported by the HP-42S. In addition to the above-mentioned real and complex numbers, you can work with character strings and matrices. A matrix can consist of either real or complex elements. Matrices are important to anyone who deals with systems of linear equations. The finesse with which the HP-42S handles matrices and solves systems of linear equations was a major factor in my decision to purchase this calculator.

A COMPENDIUM OF HP-42S FUNCTIONS	
CLASS	**EXAMPLES**
Math	SIN, COS, SINH, COSH, SQRT, LOG, ABS
Matrix	DET, EDIT, DOT CROSS, INVRT
String	ALENG, AROT, ASHF, ATOX, XTOA
Statistics	MEAN, WMEAN, SDEV, CORR,FCSTX
Probability	PERM, COMB, N!, RAN, SEED, GAMMA
Logic	AND, NOT, OR, XOR
Storage	STO, RCL, STO+, RCL+, STOEL, RCLEL
Flags	SF, FS?, CF, FC?
Integration	PGMINT, INTEG
Solver	PGMSLV, SOLVE
Menus	MENU, MVAR, VARMENU, KEYG KEYX
Sound	BEEP, TONE
Clearing	CLLCD, CLKEYS, CLMENU
Printing	PRON, PROFF, PRLCD, PRSTK, TRACE
Testing	REAL?, CPX?, X=Y?, X=0?, STR?
Control	GTO, XEQ, STOP, RTN, DSE, ISG

Figure 1. We can't list all of the functions that the HP-42S is capable of performing, but here is a small, representative sample.

You may have heard that Hewlett-Packard calculators use a system of data entry called RPN, or reverse Polish notation, which is somewhat different from the conventional algebraic system used by other calculator manufacturers. Don't be afraid of RPN; it's not at all difficult to master. On a conventional calculator, if you wish to add two numbers, e.g. 2 and 3, you first enter 2, hit "+", enter 3, and then hit "=" to get the answer. On an RPN machine, you first enter 2, then enter 3, and finally hit "+". RPN minimizes the keystrokes needed to obtain an answer, and in conjunction with the automatic memory stack in Hewlett-Packard calculators, it eliminates the need for parentheses in complex algebraic expressions. The HP-42S manual does an excellent job of explaining RPN, and in 15 or 20 minutes, you'll be an expert. Once you get used to the efficiency of RPN, it's hard to go back to a conventional machine.

The LCD display of the HP-42S holds two lines of data, each containing up to 22 characters. The display is 16 pixels high, and 131 wide. Bit-mapped graphics can be displayed as well as text. Display contrast can be adjusted from the keyboard. The two-line display can show two numbers, or one number and a *menu*, as you can see in the photo at the beginning of this article. You select a menu item by pressing the key directly beneath it. The six keys in the top row of the keyboard revert to their usual functions when the menu disappears. Practically everything is controlled by menus. Menus with more than 6 items can be scrolled, and it is possible for a menu key to call up a submenu. You can even incorporate menus in your own programs to make them easier to use.

Applications

The HP-42S incorporates five special applications. These are menu-driven ensembles of frequently used, related functions. I won't discuss all the functional capabilities of these applications, but I will give you some highlights.

The *base* application allows a given number to be converted between number systems. You can enter a number in either binary, octal, decimal, or hexadecimal form, and then convert it to any other representation. For example, the decimal number 1000 is equivalent to the binary number 1111101000, the octal number 1750, and the hexadecimal number 3E8. (Note: the hexadecimal system uses 16 digits, represented by the numbers 0-9 and the letters A-F; the octal system uses the digits 0-7; and the binary system works with 0 and 1.) Converting between number systems is especially important for assembly-language programmers. It also comes in handy when you're programming graphics on the HP-42S.

The *statistics* application lets you rapidly tabulate such things as the sum, mean, weighted mean, and standard deviation of a set of data values. It also allows you to do curve fitting and forecasting. As an example, let's say that you're running an experiment, the object of which is to determine how some quantity Y varies as a function of some variable X. In the old days, before calculators and computers, you would measure Y for various values of X, and then plot the results as a graph of Y versus X. If it appeared that your data points were clustered along a straight line, you'd take out a ruler and draw a line that cleaved through the middle of the cluster, and that line would define the functional relationship between Y and X. The HP-42S does the same thing mathematically, without drawing a graph, and represents its results in the form of the slope (M) and Y-intercept (B) of the best straight line, i.e., the line represented by the equation $Y = MX + B$. In addition to linear curve fitting, you can do logarithmic, exponential, and power curve fitting, too.

The *solver* is an application designed to solve an equation for any one of its variables. Results are usually exact, though in some cases they may be approximations, and only real roots can be found. (There is no general-purpose algorithm capable of finding the complex roots of any equation; a method discovered by Mueller will find complex roots only in the special case of a polynomial.) The solver puts an incredible amount of power at your disposal. It allows you to solve an equation for a specific variable without bothering to rearrange terms so that the form is amenable to a direct solution for that variable. In addition, it has the added benefit of conserving memory. Let's consider a simple example, the equation for Ohm's Law, $E = IR$. There are three variables here, and chances are you'll have occasion to solve for all three. Without the solver, that would mean programming three equations into the calculator,

$$E = IR, I = E/R, R = E/I,$$

which obviously wastes memory. But with the solver, the equation is first put into the form $E - IR = 0$, and then a program is written to calculate the value of the expression to the left of the equals sign. The user can then invoke the solver, specify that he wants to run the program for Ohm's Law, and enter numerical values for any two of the three variables. The solver then calculates the value of the remaining variable. This example using Ohm's Law is relatively trivial. When you're working with an equation having, say, 15 terms and half a dozen variables, that's when the true worth of the solver hits home.

The fourth special application is *integration*, which performs a standard numerical integration of a function of a single variable. A numerical integration is an approximation. You determine the degree of accuracy needed. Higher accuracy requires longer running time, but in general, an answer is obtained in several seconds to a minute. Numerical integration is a lifesaver when you don't know how to evaluate a specific integral exactly, but it's also useful with integrals that do have an exact solution.

Matrix is the fifth and final special application, the purpose of which is to provide a rapid solution to a system of linear equations. All you have to do is enter numerical values in the matrix that defines your system of linear equations, then press a key and sit back while the calculator churns out the answers. Terrific. Systems of linear equations lie at the heart of electric-circuit theory, and anyone doing advanced work in electronics will certainly find good use for the HP-42S's matrix application.

Programming

The HP-42S uses a system of keystroke programming; that is, most commands can be entered with a single keystroke. Program listings at first glance look like assembly language, and like an assembler, the HP-42S programming language gives you control over everything in memory. But the language is much more sophisticated than assembly language; its control constructs are easier to use, and then there is that fat library of special functions, over 350 of them, which can be incorporated into your programs. All the features of the five special applications discussed above can be used in programs. There are actually too many functions to cover here in detail; the table in Figure 1 should give you some idea of what this machine can do, however. Programs written for the HP-41 calculator will run, with little or no modification, on the HP-42S.

Program entry and editing are surprisingly easy. The display scrolls, allowing you to review a listing of your program, and if you own the companion printer, you can print a hard copy of the listing. Debugging features are quite good. For instance, you can single-step through the execution of a program, or use the TRACE facility to print out a running record of each program step as it is executed.

Programs occupy space in RAM, and as you write and save more of them, the amount of free space diminishes. Most programs are quite compact, however, so you should be able to fit a substantial number into 7.2 KB. One way to conserve space is by storing useful subroutines and data structures in RAM, so that they will be accessible to all of your programs, thus avoiding unnecessary duplication of code data. Programs can create their own menus, which simplifies data entry and the selection of options.

Figure 2. The HP-42S calculator has a companion printer, the HP-82240B. Calculator and printer communicate by means of a beam of infrared radiation.

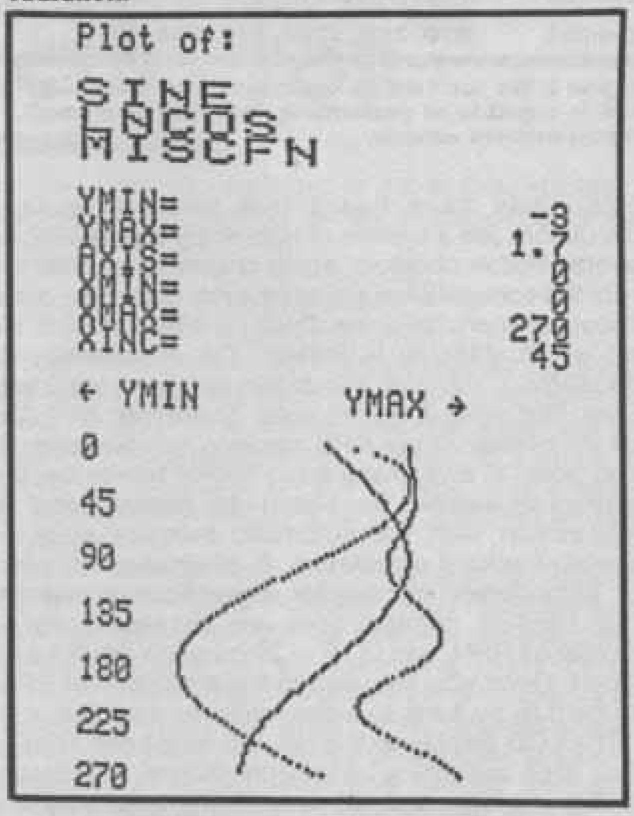


Figure 3. A sample of printer output showing that both graphics and text can be produced.

The Printer

Hewlett-Packard's HP-82240B thermal printer is an ideal companion for the HP-42S, which communicates with the printer by means of a beam of infrared radiation. Communication is one-way; the HP-42S sends, and the printer receives. You can print program listings, the contents of selected areas of memory, the contents of the LCD display, text and graphics generated by a program, and a TRACE as described above.

THE HEWLETT-PACKARD HP-42S CALCULATOR

Some graphics can be plotted in the 16×131-pixel display area. For example, the manual contains a program that graphs a function on the LCD display. Although such a graph is useful, you can print out a much larger graph, with better resolution, if you have a printer. Figure 3 shows a sample of a multi-function plot that was produced on the printer in Figure 2. A suitable graph-plotting program for use with HP's printer is contained in the HP-42S owner's manual.

The printer runs on batteries or AC, and is small enough to stuff into a briefcase. It's quiet, too, because it uses a thermal printing mechanism, so you can calculate and print even in a library without offending anyone.

Further Information

In addition to the owner's manual that comes with the HP-42S, Hewlett-Packard has published three other books to help owners get the most out of their calculators. *HP-42S Programming Examples and Techniques* (#42-90020) contains programming tips as well as some useful programs, and I expect that almost everyone who buys the calculator will want a copy of this. In fact, I think it would make sense to include a copy of this manual with the calculator; after all, is anyone going to buy this machine and not want to program it?

At this time, there are just two application books for the HP-42S. These are *Electrical Engineering for the HP-42S* (#42-90021) and *Mechanical Engineering for the HP-42S* (#42-90022). All three of the books mentioned cost $9.95.

Figure 4. A wide assortment of manuals and application books are available to help the user get the most out of the HP-42S.

The HP-42S itself retails for $120, and the HP-82240B printer will set you back an additional $135. If your budget is tight, you can certainly make do without the printer, or perhaps buy it later on. Incidentally, you'll find that many mailorder retailers offer both the calculator and the printer at substantially discounted prices.

Even at full retail, however, the HP-42S is a good buy. I was initially contemplating the purchase of a well-regarded engineering software package for my computer when the HP-42S was introduced. It didn't take me long to realize that the HP-42S could do everything that the fancy $300 software could do, and what's more, it could be carried in my shirt pocket. Naturally, you can display larger graphs on a computer monitor, but for my needs, the HP-42S is entirely adequate.

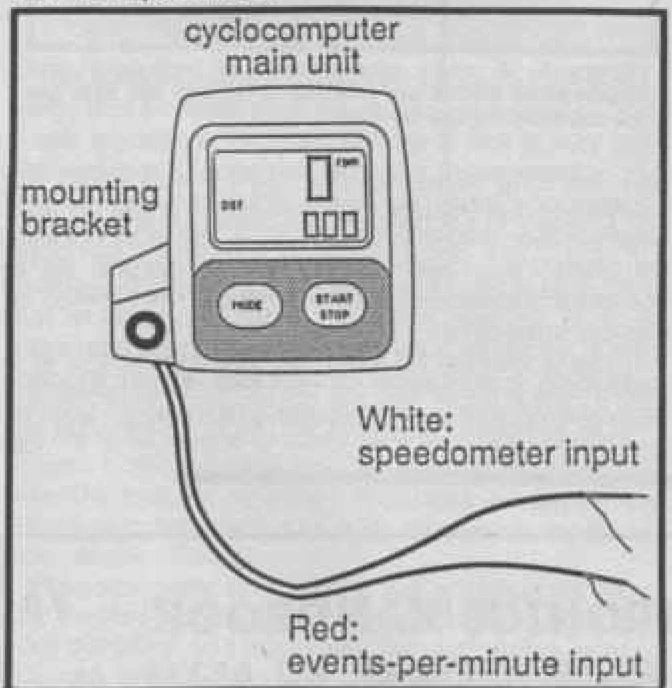
If you're looking for a high-powered calculator at a reasonable price, check out the HP-42S. It's powerful, easy-to-use, and fun to play with when serious work is done. ■

A SIMPLE EVENTS-PER-MINUTE COUNTER

By Joseph O'Connell

A 32 dollar bicycle accessory called the CateyeMicro cyclocomputer can be used as an events-per-minute counter with a range of 0-199 events per minute. With the appropriate sensor, it can monitor heart-rate, revolutions per minute, the cadence of a rowing machine, or any other periodic event that occurs too slowly for a conventional frequency counter. And, unlike a conventional frequency counter, the CateyeMicro is small, lightweight (38 grams), water resistant, and carries its own lithium power supply good for 2-3 years.

In addition to the events-per-minute display (which was originally designed to measure how many rpm's a cyclist is pedalling) the other functions of the cyclocomputer include an elapsed time counter, odometer, trip odometer, speedometer and maximum speed indicator. These functions were intended to monitor a bicyle but can be adapted to other uses, such as a pedometer.



As the illustration indicates, the cyclocomputer has two inputs, each of which were originally magnetic reed switches. These can be replaced by leaf switches or a solid-state switch. Connections are made to the cyclocomputer through wires attached to the mounting bracket into which it snaps. The bracket is sold with several feet of wire terminating in waterproof magnetic reed switches. Additional brackets are available for about 20 dollars, so that you can shuttle the main unit between several sensors. As sold, the bracket will clamp securely to a round bar about an inch in diameter. Part of the bracket can be cut away, however, to allow it to attach to a flat surface.

The cadence input can be used to measure events-per-minute. After just two or three events, the cyclocomputer will calculate and display the rate. It then updates the display with every event. The 0-199 range makes the cyclocomputer suitable for monitoring the heart-rate of a person or the cadence of many exercise machines. For example, a stationary rowing machine can be monitored by placing a leaf switch under one of its resistance cylinders so that the switch is depressed with each stroke. The cyclocomputer will then display strokes-per-minute. With suitable sensors, the cyclocomputer can also be connected to slow-moving shop tools, a potter's wheel, or other exercise equipment. To monitor heart-rate, you could either construct an electronic sensor and interface it to the cyclocomputer, or else use a simple microswitch that you press while taking your own pulse.

The speedometer input to the cyclocomputer can be used with sensors that produce a pulse for every 130 to 229 cm travelled. This corresponds to wheel diameters from 16.3 to 28.7 inches, assuming the sensor generates one pulse per revolution. This obviously makes the cyclocomputer suitable for bicycles, but also lets it work with other wheeled vehicles or with a pedometer attachment. To use as a pedometer, either for walking or jogging, first determine whether your stride is somewhere between 130 and 229 cm. If so, then either a membrane switch in the sole of your shoe or else a slidding magnet and reed switch clipped to your belt. ■

PARTS LIST FOR A SIMPLE EVENTS-PER-MINUTE COUNTER

CateyeMicro cyclocomputer
available in bike stores or from discount mail-order dealers such as the following:

Colorado Cyclist
351 Moraine Ave.
P.O. Box 3074
Estes Park, CO 80517
1-800-525-2906

Bike Nashbar
4111 Simon Road
Youngstown, OH 44512
1-800-NASHBAR

Performance Bicycle Shop
P.O. Box 2741
Chapel Hill, NC 27514
1-800-727-24553

Appropiate sensors:—reed switch and magnet, leaf switch, solid state switch, etc.

PUTTING NEW LIFE INTO OLD TRANSFORMERS

By Ralph Hubscher

Most electronic buffs have a junk-box heavy with old salvaged transformers. Almost all of them are perfectly functional or we would not have saved them. The reason that they have accumulated is probably that their specifications are unknown, and/or they have high-voltage secondaries that nobody needs any more. However, these relics can once again serve a useful purpose.

If a transformer has any leads at all, this is the color code that applies generally in the U.S.:
primary: black
high voltage secondary: red
high voltage center tap: red-yellow
rectifier filament winding (5 VAC): yellow
tube filament winding (6.3 VAC): green

When there are no leads, an ohmeter must be used to check for continuity and resistance. Continuity (any resistance reading other than infinity) will tell you where windings start and end. Jot down their locations and draw a schematic. Enter the resistance values found. Then, study the drawing and see if it makes sense. The diameter of the wires can give further clues. Old tube-type radio transformers have the characteristics shown in Figure 1.

When you think, you have the windings figured out, recheck them with your ohmmeter. Laquer-coated wires will sometimes give erratic readings if the ends are improperly scraped and soldered. However, if it all checks out, choose what you think is the primary and apply a voltage of about 12 VAC across it. Measure the voltages at the other windings. Do they deliver roughly one tenth of what you would expect if the primary were connected across 117 VAC? If this is the case, check for overheating and gradually increase the voltage across the primary while checking the output of the secondaries.

Increasing voltage can best be done with a

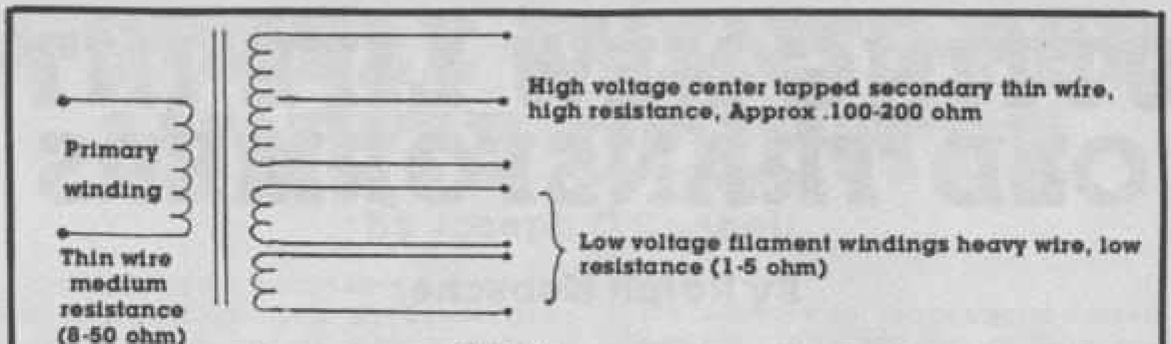


Figure 1

powerstat. However, keep in mind, that one leg of a powerstat can be at 117 VAC (against ground) even though only 12 VAC are being tapped off. So, use alligator clips (or solder the connections) and do not touch the primary of the transformer while measuring.

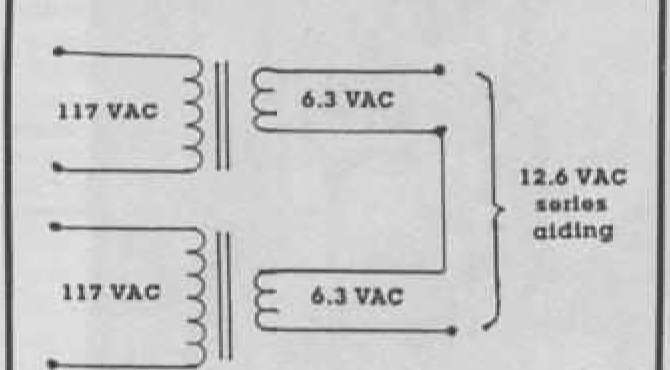


Figure 2

Once the terminals for input and output are found, energize the primary with 117 VAC for about 10 minutes, pull the plug and check for excessive heating. If the transformer feels hot, you may have made a mistake somewhere. If it stays cool, your free-of-charge-transformer can be used as it is or in many possible combinations e.g.:
2 filament transformers 6.3 VAC (or two 6.3 VAC windings on one transformer, other windings taped off) *can supply 12 VAC, a voltage frequently needed. (Fig 2)*

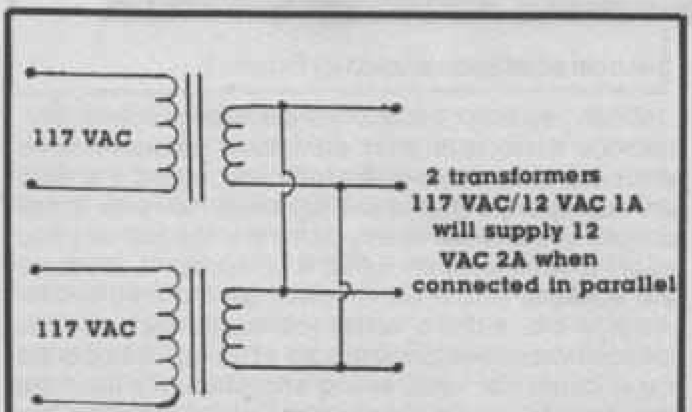


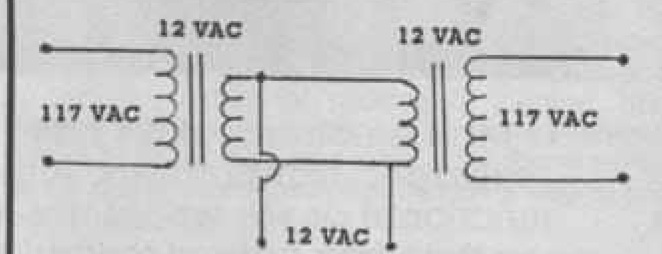
Figure 3

It is a good idea to have a voltmeter already connected to the combined secondaries when you plug in your transformers. If you get no 12 volt reading, you may have one voltage bucking the other and have to reverse polarity on one.

You may not need exactly 12.6 VAC for a particular application. Then you can use the 6.3 VAC and the 5 VAC filament windings series aiding on one transformer.

For more power from a 12 VAC IA transformer connect a second transformer in parallel: (Figure 3)

Whenever secondaries are connected, the possibility of one current bucking the other exists. This must be determined and corrected by reversing polarity, if voltage or current are not what is expected. Overheating may be the result if voltages buck one another.



Line separation can be achieved with 2 117 VAC/12 VAC transformers

Figure 4

Since this is being written in Germany, where line voltage is 220 VAC, using the transformers of the last example we could connect the primaries and run two 117 VAC primaries in series on this 220 VAC.

Line separation can be obtained with 2 transformers 117 VAC and secondaries of the same voltage e.g. 12 VAC. In addition, the common secondary voltage can be tapped off: (Figure 4)

Practically all transformers have the primary wound directly on the core. This facilitates a partial unwrapping of the outside secondary in order to obtain a lower voltage. (Figure 5)

A small power supply can be built by using the stepping-up effect of a 117 VAC/6.3 VAC transformer used in reverse: (Figure 6)

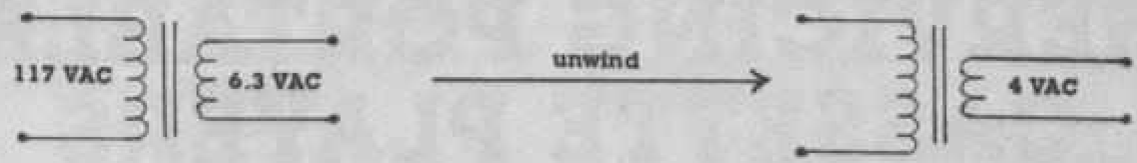
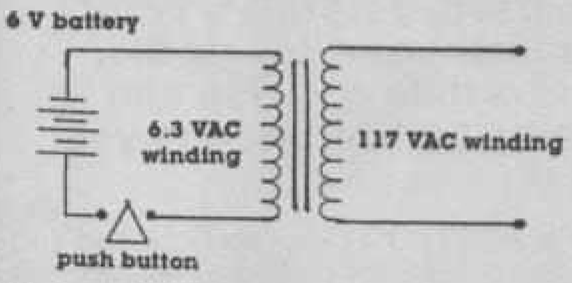


Figure 5

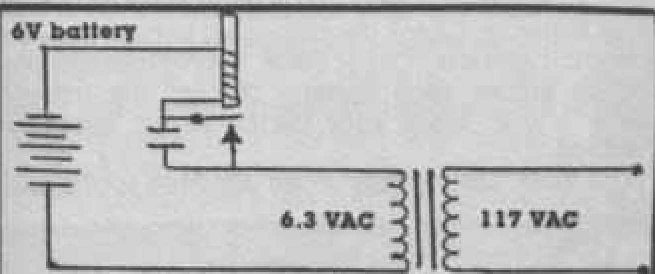
The interrupter in the primary circuit can be a push button for short HV pulses as pictured, or a buzzer as outlined below. When rectified and smoothed-out with electrolytics and a coil, a source of high voltage can be built. (Figure 7)



High voltage pulses can be obtained by using a 117 VAC/6.3 VAC transformer in reverse

Figure 6

High voltage power supplies can also be built by combining the high-voltage windings of radio transformers. They can be used to light up burnt out fluorescent light tubes that still hold gas (add choke). After rectification they can be used as Geiger counter power supplies: (Figure 8)



A more permanent supply of high voltage can be achieved by means of a buzzer or radio vibrator and a filament transformer used in reverse

Figure 7

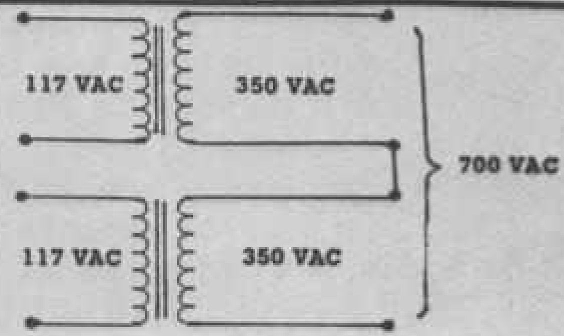
As mentioned before, powerstats can deliver a deadly shock even though they are set to deliver only a few volts. This is because one leg is at line voltage. Line separation can solve this problem: (Figure 9)

Transformers can also be used as chokes to limit current in certain applications or to remove ripple in a DC circuit (Figure 10)

Some audio output transformers can be used as filament transformers by connecting their primaries across 117 VAC and checking the resulting secondary voltage.

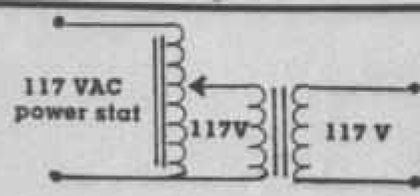
Some transformers will deliver something like 30 VAC, a voltage rarely needed. With an I.C. of the 78 series this voltage can be converted to a constant 24 VDC or 15 VDC or 12 VDC.

This way even odd-voltage transformers may be recycled: (Figure 11) ■



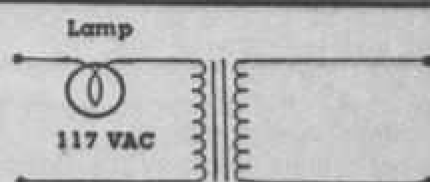
2 plate transformers can supply enough voltage to operate a geiger counter.

Figure 8



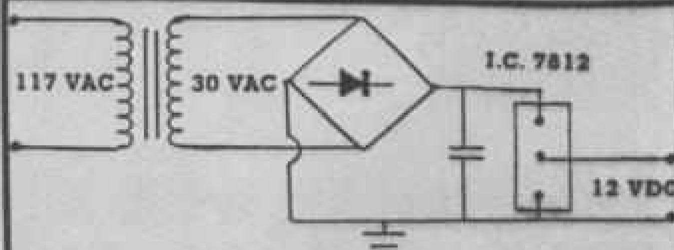
Line separation of a powerstat by means of a 117 VAC/117 VAC transformer is a good idea.

Figure 9



Using a transformer as a choke. (Secondary taped off or used otherwise)

Figure 10



A 30 VAC transformer can be used to deliver 12 VDC by means of a rectifier and IC 7812

Figure 11

SERVICING PORTABLE CASSETTE PLAYERS

By Homer L. Davidson

Most Radio/TV technicians refuse to service the small "tag-along" tape players (Figure 1). Electronic Repair shops hate to see them come in for repair and electrical service firms avoid them like the plague. Don't despair. If you happen to own one of these handy little tape players, you can accomplish the necessary repairs and/or maintenance yourself. Just a few hand tools, a VOM or DMM test instrument and follow the step-by-step instructions in this article and you can have that little cassette player playing like the day you purchased it.

Often portable tape player problems are caused by miss-handling or improper operation. Careless every day operation and listening pleasure frequently adds up to dirty tape heads. Sometimes a good cleanup with alcohol and a cleaning stick solves many problems. The noisy volume control and erratic earphone jack may need a cleanup. While you're at it, why not check out the following symptoms before you put that "tag-along" player back on your belt or shoulder strap.

Do's and Don't's

As much as possible, **do not** expose to moisture, rain, excessive dust or heat.

Do keep the tape head clean.

Do check the batteries when the sound becomes weak or distorted.

Do not operate the player at a voltage other than specified.

Do not leave the player out in the cold, auto or garage. Cold temperatures will reduce the life of the batteries.

Do not store the player for long periods of time with the batteries installed. The batteries may leak or corrode.

Do not be afraid to tackle a few simple repairs included in this article.

Check Those Batteries

The portable cassette player eats up batteries like a chicken pecks up corn. You seem to be replacing them all the time. The player may operate on 1 to 3 small batteries. Check the exhausted battery while in operation with the VOM or DMM. Simply measure the voltage across each battery. Discard the battery below 1 volt. Make sure the battery is correctly installed.

The weak battery may cause distorted sound and

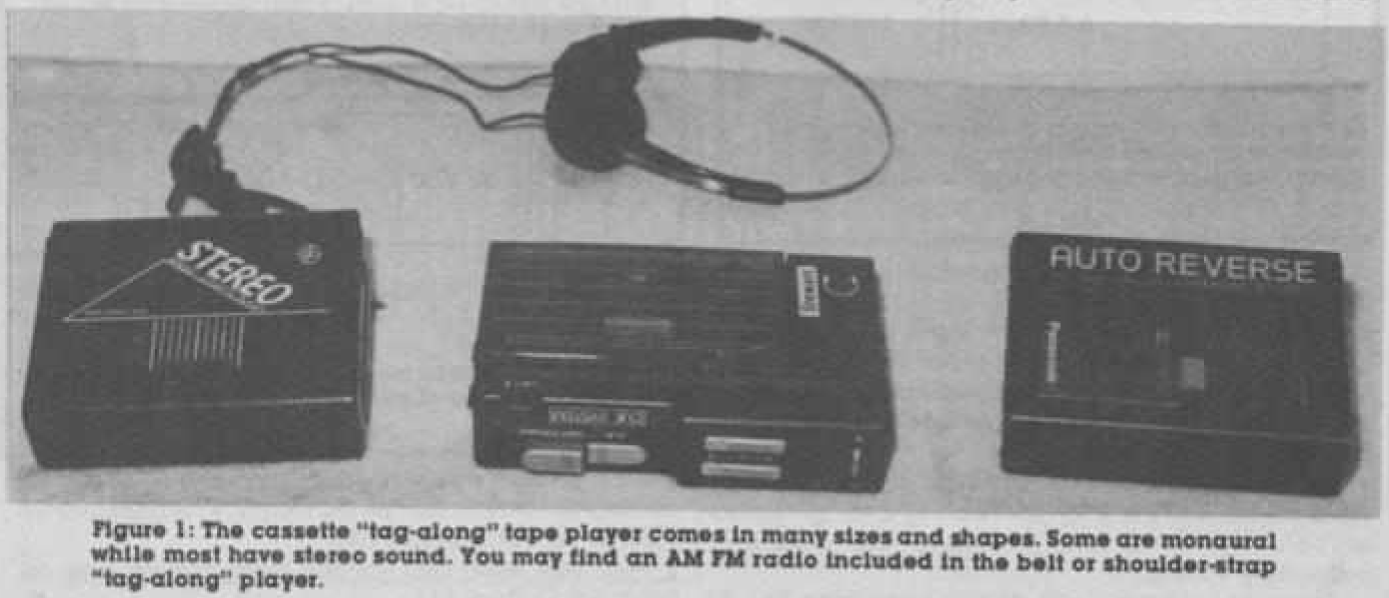


Figure 1: The cassette "tag-along" tape player comes in many sizes and shapes. Some are monaural while most have stereo sound. You may find an AM FM radio included in the belt or shoulder-strap "tag-along" player.

improper speed. Intermittent operation and erratic sound may result from a poor battery connection. Clean off the battery terminals with alcohol and a cleaning stick. Wipe the battery terminals on a rough piece of cloth before installation.

Tape Head Clean Up

A skipping or distorted sound may be caused by a dirty tape head. One channel may be weak or distorted in a stereo player with a packed tape head. These tape head slotted areas are very small and may be clogged with oxide dust. No sound, with a loud rushing noise, may indicate an open or broken tape head connection. Check for a broken wire at the tape head connection.

Figure 2: Cleaning the playback tape head may prevent skipping and distorted sound. Clean-up of the playback head and pitch roller should be normal required maintenance.

Clean up the tape head with Isopropyl alcohol and a cleaning stick (Figure 2). Most small tape player heads can be cleaned from the top or the end without too much difficulty. Press the player button to move the head into a more accessible position. Remove stubborn oxide with a pencil eraser. While you're at it, cleanup the capstan roller and guide assemblies. Sometimes a good clean-up solves both sound and speed problems.

Only A Few Tools Will Do

You probably have most of the tools needed for tape player maintenance right on your workbench. A pair of long-nose pliers, a screwdriver and a soldering iron will just about do it. Let's throw in a small screwdriver set to remove and replace those tiny screws and a VOM or DMM to check voltage and continuity. A cordless soldering iron is ideal, but any iron under 35 watts will do.

Remove Those Covers

Turn back or take off those plastic covers with a small screwdriver set. These screws are very small, so place them in a saucer or plastic cup for safe keeping. First, remove the screws in the bottom cover (Figure 3). Some of these screws are on the side or underneath the bottom cover. Carefully pry off the bottom piece.

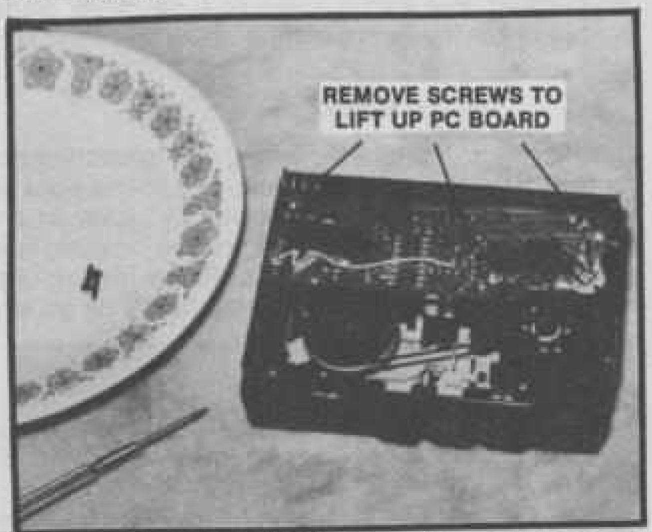


Figure 3: Remove the bottom cover to get at the belt, motor pulley, drive pulley and PC board. Remove 2 screws in bottom or several screws at the back to remove both covers.

Take a peek and see how the PC board and components line up. You may not have to go any further since the defective component may be staring right back at you. Often, removing two or three PC board screws lets the component board free. While in other units, the bottom and top covers have their own circuit board. Work carefully—don't rush it and damage a component.

Tape Head-Aches

A defective tape head can cause many sound problems. A dirty tape head may produce weak and distorted audio. No sound may be caused by an open tape head or broken hookup cable. The missing tape head mounting screw or broken weld may not let the head engage the tape, producing no sound. Intermittent sound may result from a poor internal tape head post or broken wire connection.

Figure 4: Check the continuity of the tape-head winding with the VOM or DMM. The resistance should be between 150 to 1.5 K ohms. Inspect the head wire connections for broken wires.

Check the tape head continuity with the DMM or VOM meter (Figure 4). The resistance should be from

150 to 1.5 K ohms. Inspect the head connections for poor soldering or a broken wire. A loud rush should be heard in the earphones by touching the ungrounded wire with a probe or screwdriver blade. Double check by removing the cable from the tape head.

Noisy Control

After many hours of playing, the small volume control may get noisy and erratic. The sound pops up and down with a gritty or scratchy noise in the earphones. Simply squirt or spray some cleaning fluid inside the volume control area. Rotate the volume control back and forth. The noise should be gone.

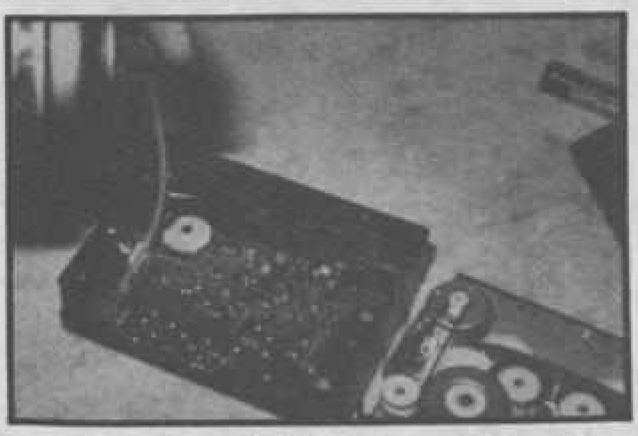


Figure 5: Clean up that noisy or erratic headphone jack with cleaning fluid. The jack is dirty when you rotate the male plug and you hear noise. Do not overlook a dirty male plug or broken earphone cord at the plug end.

Erratic Earphone Jack

Intermittent or erratic earphone reception may be caused from a dirty head phone connection. Spray cleaning fluid down inside the earphone hole. If the problem still exists, remove the cover and spray into the headphone jack (Figure 5). Work the head phone male plug into the jack area to help clean it.

Replace the headphone jack when this clean-up operation does not work. Try another approach. Some of these small jacks have a plastic body that may be broken when dropped. Replace it with an original or if not available, pick one up at your local electronic parts store. You may have to drill or remodel the mounting area to accommodate the new jack.

No Action

Suspect a defective battery, battery connections and/or play-switch when the tape player will not run or produce sound. Inspect the batteries for corroded contacts or the possibility of one being installed backwards. If the tape rotates with no sound, suspect the tape-head, amplifier and/or earphones. When the volume control makes a raspy sound, while rotating and the tape does not run, check the small drive belt. Usually, you can hear the small motor rotate with a broken or loose belt. Sometimes these small belts will slip off the motor or drive-pulley.

Slow - Slow Speed

Check for a weak battery when the sound is garbled and the tape rotates slow. Inspect the belt for oily areas (Figure 6). Draw a rough sketch of how the belt goes around the various pulleys before removing. A loose belt will produce slow speeds. Notice if the motor pulley is rotating inside the belt area. Often, shiny marks are found inside the belt area when it is too large and slipping.

Peek at the capstan roller for excess oxide dust and clean it off. Does the capstan roller spin freely? Check down along side of the pinch roller bearings for excess tape wrapped around the bearing support. If the roller is rounded on the corners, replace it. Do not overlook a defective motor or dry cassette causing slow speeds.

Intermittent Operation

Intermittent rotation of the tape may result from a

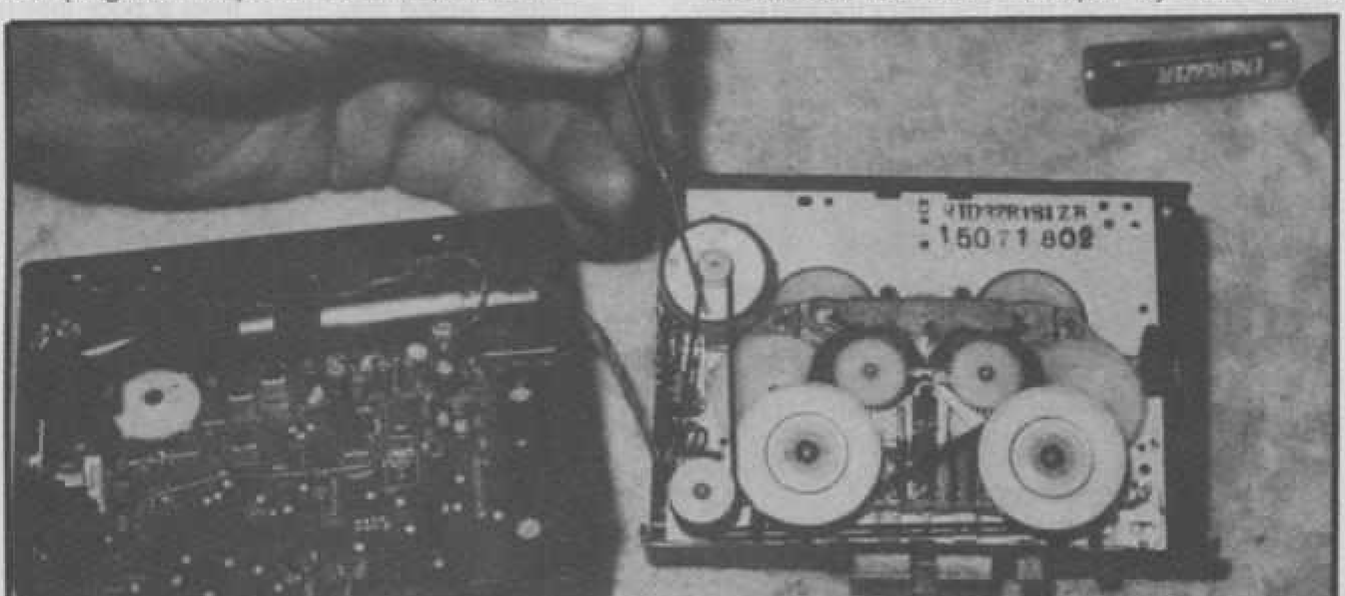
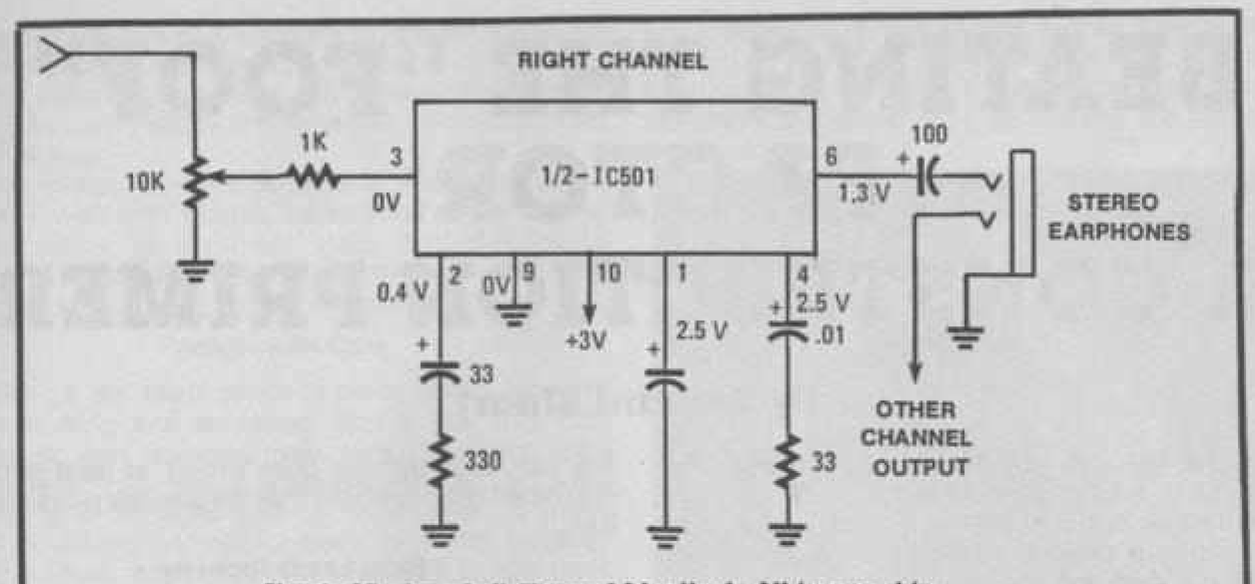


Figure 6: Check the motor drive belt for oily or cracked areas. That loose or oily belt may produce slow speeds.



Simple IC - Amp Left Channel Identical - All in one chip

Figure 7: Check the schematic for possible no sound symptoms. Measure the voltage and resistance on each pin of the IC for a defective component or IC. Compare the IC voltage pins with the normal stereo channel.

defective motor or play-switch. Clean up the switch with cleaning fluid. Often, motor replacement is too expensive. You're better off to simply dump the cassette player with a defective motor. Dry or worn bearings on plastic reels, drive wheel, and/or motor-pulley may cause erratic movement of the tape. Make sure the carriage locks in and engages the tape.

Intermittent sound may be caused from poor tape-head connections. Sometimes pressing up and down of the PC board will reveal intermittent audio. A cracked PC board and/or loose audio components may produce intermittent sound, especially if the tape player has been dropped. Do not overlook intermittent audio transistors or IC components.

Figure 8: You may find only one or two IC's in a portable cassette player. Either one or both channels may be distorted or weak when one IC is used as the output amp.

Tape Spills Out

Nothing is more annoying than interrupted music with tape bunching up and spilling out inside the cassette. Suspect a sluggish or stopped take-up reel assembly. This only occurs in players with a take-up and supply reel. Some of the very small tape players have only a hub and the supply reel rotates on it. Inspect the capstan roller for excess oxide or a sticky substance. Clean up the tape head, reels and capstan roller with a cleaning fluid or Isopropyl alcohol.

No Sound

Rotate the volume control to wide open with a "no sound" symptom. No rushing noise when the volume control is rotated indicates amplifier problems. A loud rushing noise with tape action and no audio indicates a defective tape-head or broken wire connections.

Take critical voltage and resistance measurements. Try to locate a schematic, if possible. Sometimes a real small diagram is found with the operating instructions (Figure 7). Remember, the supply voltage will be very low with 2 or 3 AA batteries. A leaky IC or component will impose an excessive drain on the batteries. Insert a piece of cardboard with tin foil on each side and take a current measurement. These small players will not pull over 20 mills even with an AM-FM radio. After installing new batteries, if the voltage goes down to around 1 volt, suspect a leaky IC.

Figure 9: Make sure the IC is defective before trying to remove it. Check for a new replacement. Run a piece of solder wick and iron point down each row of soldered pins to remove the excess solder. Clean off each PC board wiring before inserting new IC.

(Continued on page 48)

BEATING THE "FOOF" FACTOR: A CONSTRUCTION PRIMER

By Richard Stuart

If you're like me, you like to build things from scratch or a kit rather than buy them. You like the challenge and satisfaction that come from constructing a project, turning on the power, and watching it work the first time.

But what if it doesn't work the first time? What if it just goes "foof!" instead, filling the air with a noxious cloud of smoke? Was there the click of a circuit breaker before your room suddenly went dark? Or did your project perform erratically, blinkling out its own form of an SOS signal? Did it just do nothing at all?

Any of these typical problems can be caused by improper construction techniques when you put your project together. Because you're dealing with an invisible property—the movement of electrons—it's important that you handle, prepare, and solder components into circuit boards with the right tools and techniques. Unless you do, you may unwittingly ruin the parts before you've had a chance to finish your project.

To help you avoid such self-perpetrated damage, I'd like to share some project-saving techniques that I've learned along the way. Following them will greatly increase the chances of success of your own electronic projects and may save you time in trobleshooting a project that refuses to work the first time out.

Sort and Test the Components

Sort the parts by type, using an old cake pan to keep them from rolling off your test bench. Put heavy or sharp parts toward one corner of the pan to prevent their weight or edges from crushing or nicking other components.

Once everything's organized, take the time to test the components to make sure they're within tolerance. You may think this is a waste of time, but a half hour spent checking tolerances can save you hours of troubleshooting if your project doesn't work.

When you test diodes, resistors, transistors, and capacitors, make sure you don't hold their leads with your fingers—your body will act as a parallel circuit, causing an erroneous reading on your test instrument or DMM. Instead, use probe leads with hook-type test clips. These circumvent the possibility of erroneous readings and speed the testing process.

Testing IC chips is another matter. Unless you happen to own or have access to an IC checker, you may just have to trust the silicon gods that your IC chips will function without any problems. Look at it this way: if something goes wrong, at least you've eliminated the possibility that the discrete parts are at fault.

Bend Leads Property

Okay, you've tested your componets and replaced any faulty ones. You're ready to start building, right? Sorry, not yet—you should first bend all the component leads to make the board stuffing go faster and more efficiently.

Some people feel that the easiest way to bend leads is to hold the component between thumb and forefinger and push down on the leads until they're perpendicular with the body. I'm against this form of lead bending for two reasons: 1) the leads may become skewed or bent too close together so they don't line up properly with the board's holes, and 2) you might crack the frail junction between the body and the lead, allowing corrosion to enter the part and introducing unwanted noise into the circuit.

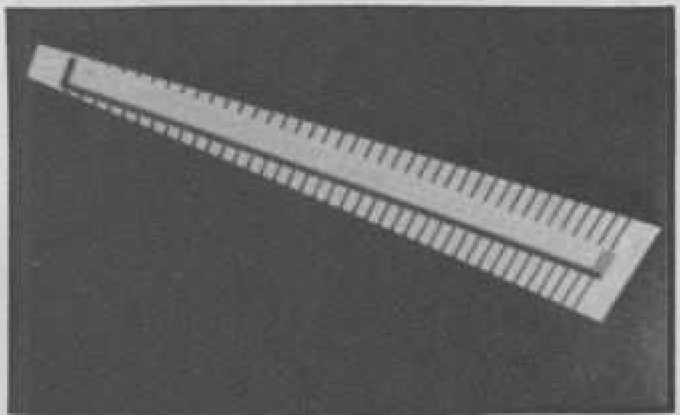


Figure 1: A lead bender helps you align component leads to circuit board holes and bend them properly.

The best way to bend leads is to use a "lead bender," an inexpensive tool available in most large electronics stores (figure 1). You place the bender on your board between two component holes, then slide it until the width of the bender matches the width of the space between the holes. The width will correspond to a slot number on the bender.

Then you simply put the component into the proper slot (printed side up, so you can read its value or part number once it's soldered to the board), hold it in place with your thumb, and push down on the leads at the bender's edges. Looks great, doesn't it? (Usually, kit manufacturers give each set of resistor holes in a board the same spacing, so you may be able to bend all the resistor leads using the same slot number—make a cursory check first to be sure your board is set up that way.)

The beauty of lead benders is that they'll work equally well with diodes, capacitors, and resistors. They come in different sizes and depths to accommodate different body dimensions, so you might want to buy a couple of them.

Solder with Care

With all the leads properly bent, you're ready to start stuffing and soldering. Before you use your soldering iron, however, make sure it has the correct wattage for your needs. Soldering irons and guns are available in wattages from 15 to well over 75 watts. The 75-watters are unfit for electronics work because the high heat they produce can easily lift copper pads and traces from your circuit board, ruining it completely. Use either a grounded iron in the 15-to 25-watt range or one of the new portasol-type butane gas "irons" at a low heat setting.

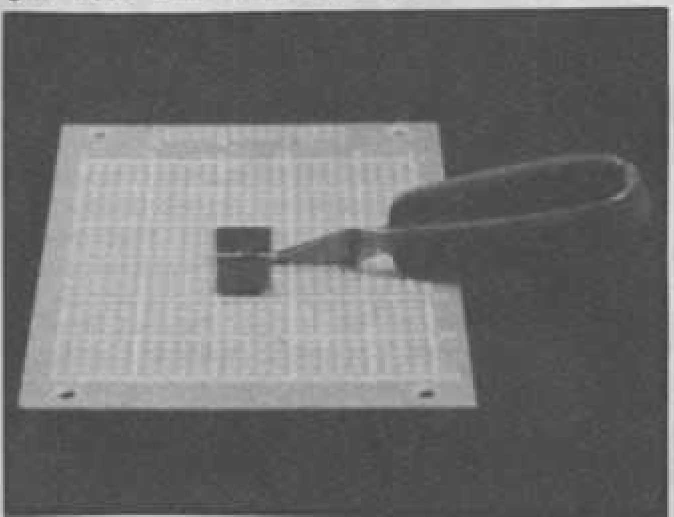


Figure 2: With temporary paper spacers underneath and a heat sink attached, this lead is ready for soldering.

For each component you solder, you should do two things: place a temporary paper spacer between the part and the circuit board, and clip a heat sink to the part (figure 2). The former is done to aid heat dissipation. If a part is mounted flush to the board, hot spots will occur where the part and board make contact. Having air space beneath the part avoids hot spots and helps the component operate a little cooler. Strips of construction paper cut to different widths to fit beneath each component work well for spacers. Remove the paper after soldering.

Using a heat sink is also extremely important. Heat sinks are inexpensive clips or tweezers that you attach to a part's lead on the component side of the board to prevent heat from entering the part. Without heat sinking, a component can be damaged from heat the leads draw up from the iron (component leads are very good at that).

Like diodes and transistors, resistors are susceptible to heat damage. They have a negative temperature coefficient, which means that as they become hotter their resistive value goes down. Without proper heat sinking, you might actually alter your circuit's operation by permanently decreasing the resistors' ohmic values.

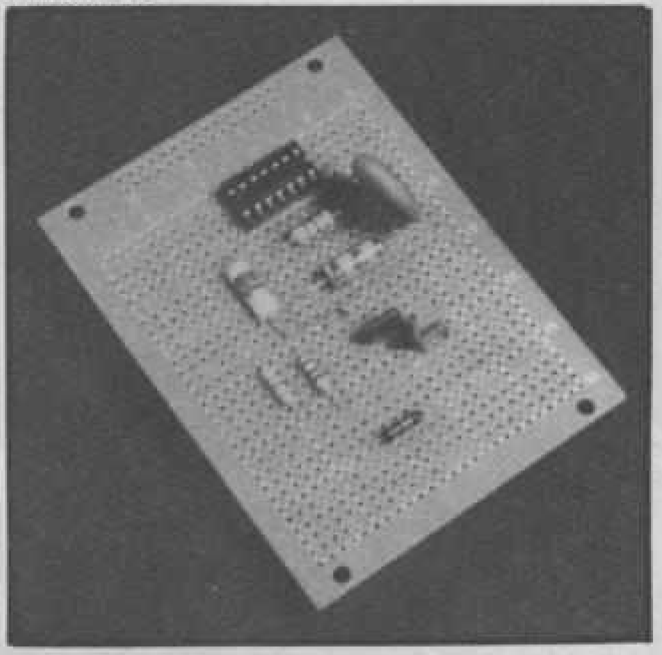


Figure 3: Consistently aligned components make it easy to read values and part numbers.

By the way, a good idea is to solder all of one type of component at the same time, such as all the resistors first, then all the capacitors, and so on. This makes it easier for you to keep track of your work. A handy way to hold each component in place while soldering is to strap it down with a small piece of electrical tape.

When soldering parts on a board, orient them so that, from the "front" of the board, values or part numbers of horizontally aligned components are readable from west to east, and those of vertically aligned components are readable from north to south (figure 3). Such an alignment makes it easier to find or read a particular component on the board if you have to test or replace it later. For you artistic types, it also makes the board look more professional.

The only exception to the west-to-east, north-to-south reading is for polarized parts. These should *always* be inserted according to their polarities—no sense in having a nice looking layout if the parts are in backwards!

Trim the Leads Long

Once you've soldered in a number of components, trim their leads a couple of millimeters beyond the tip of the solder joint with a pair of flush cutters. You don't want to cut the leads flush to the solder joint because if you accidentally soldered the part in backwards and have to remove and turn it around, you won't have enough of a lead to obtain a good solder joint the second time.

Also, when you're trimming the leads, cut them into a paper bag. Snipped leads can travel quite a distance and stray ones might lodge themselves into the carpet and puncture unsuspecting feet. Cutting them into a

BEATING THE "FOOF" FACTOR

bag also keeps them from flying into your eyes.

Clean and Inspect the Board

After you've soldered in all the parts, clean the trace side of the board to remove the rosin flux left by the solder. Use an old toothbrush and either acetone, rubbing alcohol or a commercial de-fluxing agent. Unless it's scrubbed off, flux eventually becomes corrosive and can eat away at the solder joint, causing all kinds of problems. You can use a hair blower to help speed the drying process, but make sure you don't set it at too high a temperature or hold it too close to the board—heat is an enemy of electronic parts.

Next, make a careful inspection of the board. This stage is the most important—you're looking for cold solder joints and bridges, broken traces, and proper component placement. If everything looks good, it's time to insert the IC chips.

Insert IC Chips Last

Before you remove the ICs from their protective tubes or foam holders, eliminate any electrostatic charge you may have built up on yourself by touching a grounded metal object or wire. Once that's done, you'll most likely have to bend the IC pins to fit their sockets (*always* use IC sockets for your projects so you can easily replace faulty chips). You can purchase a plastic pin straightener or straighten them manually by resting one side of the pins on a table and rocking the IC's body (figure 4).

Use both thumbs to firmly press the IC into its socket, then check to see that none of the pins has been tweaked in its hole. If you accidentally bend a pin upon insertion, remove the IC and use a pair of needle-nose pliers to straighten it out.

Figure 4: The proper way to straighten misaligned IC pins is to grasp the body firmly and rock it on a flat surface.

Conclusion

You're finally finished! Your pride and joy should work the first time out. When it does, a wise thing to do is make voltage measurements across each component and from the circuit common(s), then record them on the schematic. This will save you a lot of time later if you ever need to troubleshoot the circuit.

The old addage of "Do it right the first time" is especially true when it comes to building electronic projects, so keep these tips in mind and avoid those "foofs". ■

SERVICING PORTABLE CASSETTE PLAYERS

Distorted Channel

Today, most of these "tag-along" players use one or two IC's for stereo operation (Figure 8). It's possible to have one audio channel distorted and weak while the other is normal. Often, a leaky IC results in both channels being distorted. Critical voltage and resistance measurements on the output IC may solve the problem. Compare the voltage measurements on each IC pin with the normal channel. Take the resistance measurements of each pin to ground to locate a leaky capacitor or cracked resistor. Do not overlook leaky or open small electrolytic capacitors for weak and distorted audio.

Replacing Defective IC

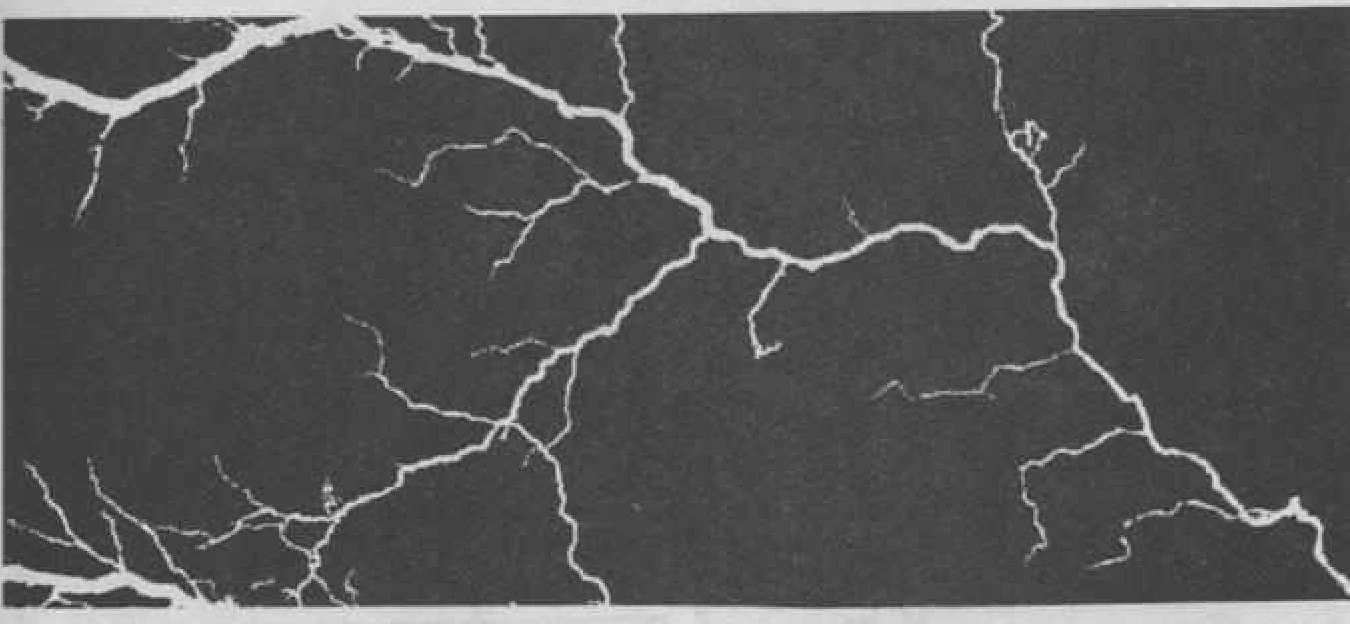
Make sure the IC is defective with voltage, resistance and current measurements and not a connected component. Next, locate the schematic or part number of the suspected IC. Cross reference the part number in the RCA, Sylvania, GE or TAB books transistor guide. Try to pick up the IC locally at radio and TV shops, electronic supply houses or mail order firms. Don't forget to try the tape cassette manufacturer. Remove excess solder with a solder wick and iron. Clean off the PC wiring before installing the new IC.

Play Button Won't Lock Down

Check the tape. The cassette may be at the end of rotation. Rewind the tape. Suspect a loose spring or broken lock assembly when the cassette will not load. On cassette "stop," the tape head should snap back in. Inspect the cassette for a damaged front end or a cracked body.

Conclusion

Repairing your own "tag-along" cassette player can be fun and essential when electronic repair people don't want to bother with these little items. Remember to keep the tape player clean and dry for trouble free operation. Normal maintenance procedures should include cleaning of the playback head and pinch roller occasionally. With some normal preventive maintenance and repairs, when required, you should be able to extend the life of your portable "tag-along" cassette player for many additional hours of listening enjoyment as you take that morning stroll or that evening bike ride. ■



UNDERSTANDING ELECTRICITY

By Ron C. Johnson, C.E.T.

PART I

Are you a newcomer to this fascinating area of electronics? Maybe you are an avid hobbyist with a basic knowledge of the subject but you would like to know more about the theory behind the circuits you are building. Perhaps you have worked around the fringes of electronics and would like to acquire some of the technical background you might be missing.

If so, this series on basic electricity and electronics will serve to fill in some blanks in your knowledge. If you are already familiar with some areas they can be a review to sharpen your skills.

Electronics, like many other areas of applied science, is heavily reliant on mathematics in dealing with the relationships involved. In this series we will attempt to minimize the amount of mathematics and give you a qualitative overview of the subject. Unfortunately, for those of us who do not get a thrill out of number crunching, we will not be able to avoid it altogether. Hopefully, we can "sneak" it in a little at a time in a way that supports the concepts without forcing us to become human calculators.

Those of you who have had high school physics and chemistry can now drag out your old textbooks and blow the dust off them. We are going to enter the sub-atomic world and look around at the nature of charged particles.

Don't worry, it won't hurt a bit.

Why do we call copper, nickel, gold, etc. conductors while other materials are called insulators? What is a semiconductor anyway? What makes current flow in a conductor and what really is current? Why is the sky blue?

Well, except for that last one, we'll try to answer these and a few other questions in this series on "Understanding Electricity."

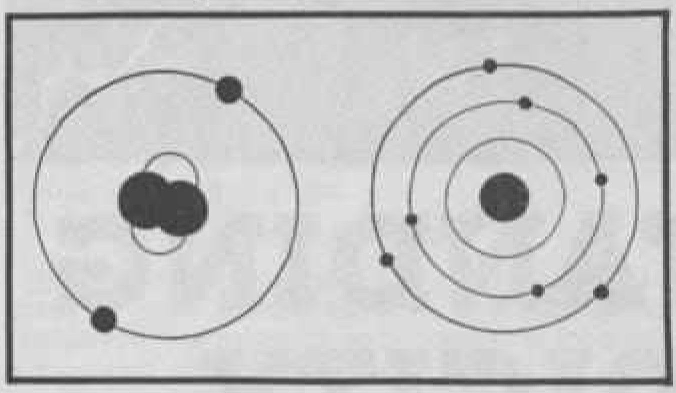


Figure 1. Typical atomic structure with electrons orbiting the nucleus.

If you are at all familiar with the structure of the atom, you know that it is made up of a nucleus with some electrons orbiting around it. (Figure 1) The nucleus of an atom is made up basically of protons and neutrons of which the neutrons have no charge and the protons are positively charged. The electrons, on the other hand, are negatively charged and spin around the nucleus in "shells" or energy levels. They are held in place by a balance of their attraction to the nucleus and their centrifugal force.

All the known elements have different atomic structures with varying numbers of protons and electrons. It so happens, though, that some materials have an incomplete set of electrons in their outermost shell. This makes them easier to remove by adding a little extra energy to that material, (heat or some other force). Add that energy and "presto" we have free electrons floating around in the material. A material that has lots of free electrons is called a conductor because it can easily carry the flow of electrons through it.

An insulator on the other hand is a material in which the atomic structure is very stable. Because the outermost shells in these materials are filled with an absolute correct number of electrons, it would take considerable force to remove any electrons from their orbits. Therefore, current will not flow easily in these materials.

Semiconductors are initially similar to insulators in that they have their outside shells filled. However, by careful addition of the impurities to these materials we can control the presence of some free electrons, and using a voltage or current, control how well they conduct. More about this in later segments.

Now we have materials that will carry free electrons through them and we have materials that will not. What can we do with them?

Let's look further into the matter.

WORK AND ENERGY

In asking, what can we do with them, we are really asking: How can we do some work with these materials?

If you remember your high school physics, you will recall that work is accomplished if you move a force through a distance. You can build up potential energy (stored work) if you put energy into a system. For example, if you lift a pail of water from the floor and place it on a table you have operated a force (against gravity) through a distance (from floor to table). (Figure 2) Once there, it has stored potential energy which can be recovered by lowering the pail back to the floor. Now, you may ask, what has that got to do with electricity?

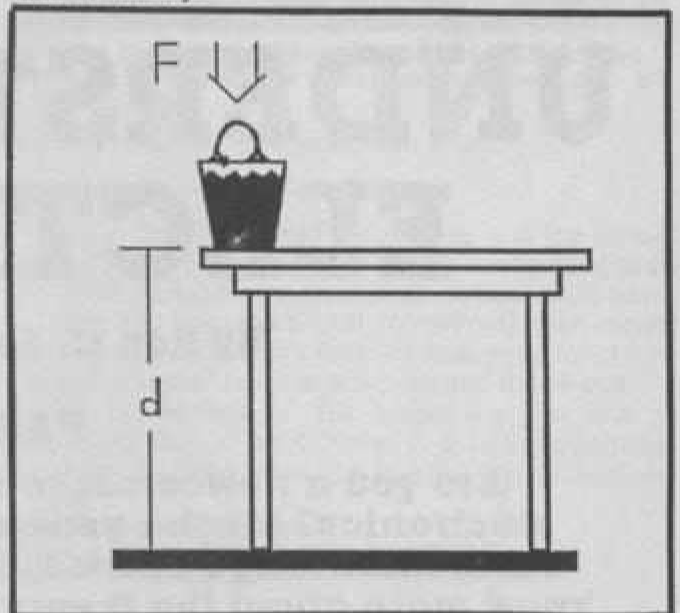


Figure 2. Potential energy is stored by lifting the pail from the floor to the table.

Well, think about the charges in the atoms we talked about earlier. We know that the negative electrons are attracted to the positive protons. That attraction is a force. If we move the electron farther away from the proton it will require a force against the attraction to do so. We will have moved it through a distance and so we have not only accomplished work but we have stored potential energy. This energy could be recovered by allowing the electron to travel back (because of the force of attraction) to the proton.

In a battery that is basically what happens: We use a chemical reaction to separate the negative charges from the positive charges. Energy is put in by the chemical reaction. Energy can be recovered by allowing the charges to move back together. The energy (or potential) stored in the battery is called electromotive force, or VOLTAGE.

Now we connect our conductor, a copper wire, between the two connections on a battery. (Figure 3) The chemical reaction in the battery has produced a potential which causes electrons to flow through the wire to the opposite post of the battery. (The post that has the abundance of negative charges is called the negative post while the post that has the abundance of positive charges is the positive post.) Scary isn't it? You will note that the copper wire becomes very hot and even starts to glow. Why should this be happening?

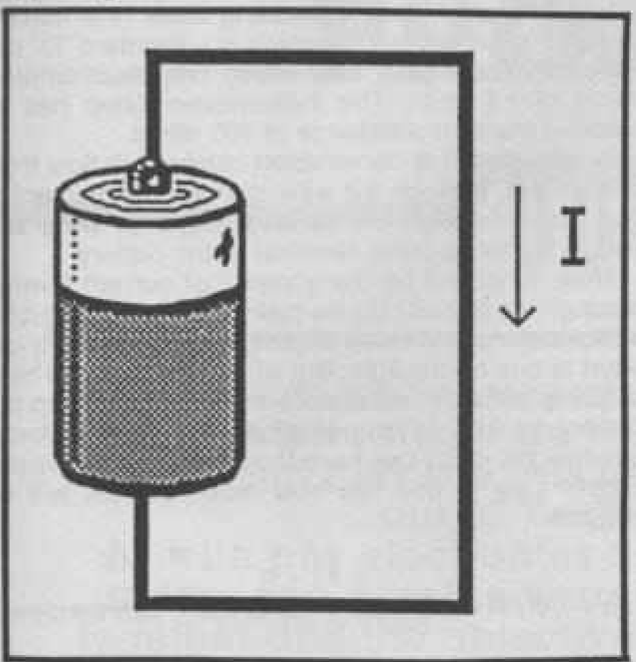


Figure 3. A typical "D" cell with current flowing through the conductor connecting the terminals.

The fact is that even copper, an excellent conductor, is not a perfect conductor. As the electrons are pushed along the wire by the electromotive force they have a tendency to bump into other atoms and other free electrons. As they do, some of the energy used to move them through the wire is converted into heat energy and light energy. The extent to which a conductor opposes the flow of electrons is called its RESISTANCE and is determined by the kind of material, its length and cross-sectional area. The rate of the flow of electrons (charge per second) is called the CURRENT.

Now the confusion: Even though we know that it is the electrons which flow through the wire (because they are the mobile charge and a much lower mass than protons) in electronics it is conventional to think of current as flowing from the positive terminal, of a battery or other power source, to the negative terminal. This is called conventional current flow and is more rooted in history than in physics.

So now we have electromotive force or voltage, current, and resistance. How do these actually relate?

OHM SWEET OHM

Here is where we will sneak in a little math. The relationship between voltage, current and resistance is called Ohm's Law and is expressed as follows:

$$E = I \times R$$

Where E is electromotive force or voltage in volts,
I is current in amperes,
and R is resistance in Ohms.

(Note that when we talk about electromotive force or voltage supplied by a battery or power source the symbol is E whereas when we talk about a voltage drop across a resistance we symbolize voltage with V.)

Ohm's Law is the basic mathematical building block of electricity and as such is something we need to remember to understand what is going on in electrical and electronic circuits. Let's use an analogy to help understand the relationships here.

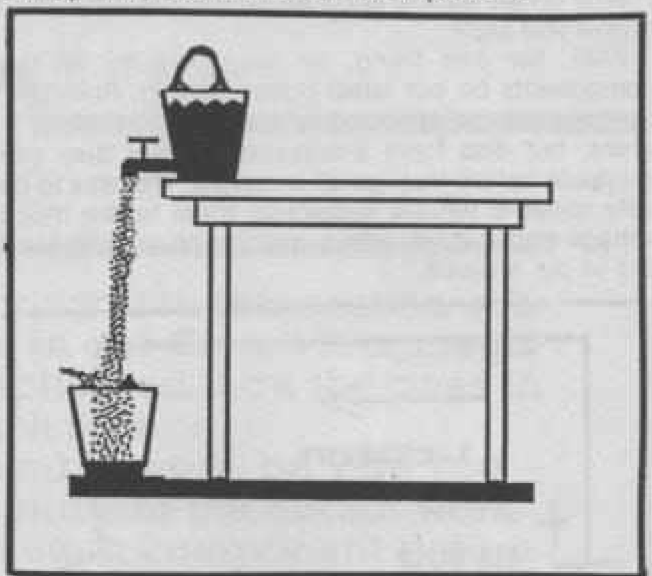


Figure 4. Water pressure (due to potential energy) forces water to flow. The valve restricts the rate of flow.

Remember we talked about lifting the pail of water to the top of a table and in so doing stored energy there. (Figure 4) The potential energy in that pail of water is like voltage. There is a force, created by gravity which is exerted on the water. At this point the water cannot go anywhere. Now let's put a valve into the side of the pail near the bottom and another pail on the floor below it (no need to be sloppy here). When we open the valve part way the water runs out of the top into the bottom pail at a rate determined by how much we have opened the valve. The restriction of the valve is analogous to resistance. The rate of the flow of water is similar to current (which is the rate of flow of charges particles or electrons). We will see in future issues how the pail at the bottom can be compared to a capacitor storing charge.

The difference between the water analogy and electricity is that in electric circuits we have just that—circuits, or circles. Current always flows in complete loops from the positive terminal of the power source, through a resistance or energy converter of some kind, back to the negative terminal of the source. (Remember we are talking about conventional current flow.)

POWER

The other mathematical relationship we should look at in this issue is POWER. We said that in connecting our copper wire from the positive post to the negative post of the battery that current flowed and the wire became hot and glowed. In doing this we have converted electrical energy into thermal energy and radiant energy dissipating power in the process. We can determine the power dissipated by the formula:

$$P = V \times I = I^2 \times R = V^2/R$$

where P is power in watts and V, I and R are the same as before.

The three versions of the formula are derived from the relationships between V, I, and R in Ohm's Law.

Why do we want to know about the mathematics of power you say?

Well, for one thing, so we don't fry all the components on our latest hobby project. Resistors, for instance, are specified by their resistive value, in ohms, but also have a maximum power they can dissipate before they go up in smoke. We have to be able to tell if we are subjecting them to too much voltage and current unless we plan on making toast out of our projects.

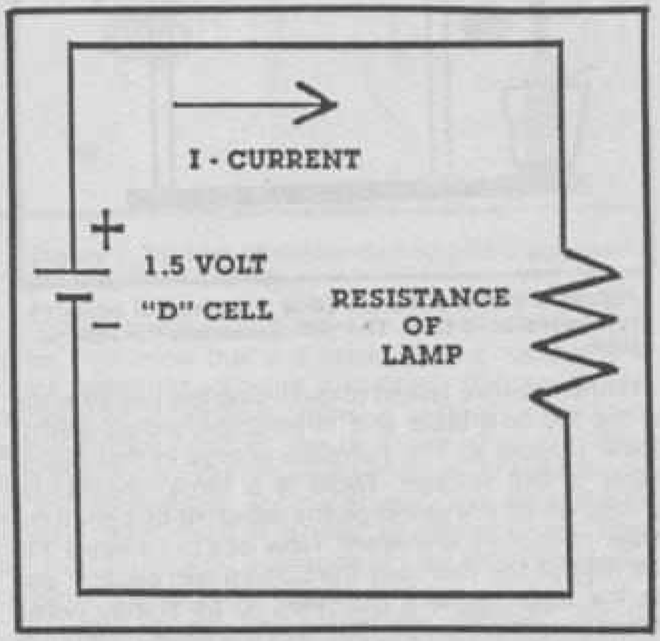


Figure 5. A simple electric circuit.

THE REAL THING

Finally, let's put this altogether in an actual electric circuit and see how it works. In fact, if you want you can set this up and check it out yourself.

In Figure 5 we have a simple electric circuit consisting of a battery (the power source), an incandescent lamp (the resistance or energy converter), and wire connecting them (the current path). The battery we are using is a standard "D" cell (used in flashlights, etc) which has electromotive force of 1.5 volts. The incandescent lamp has an internal filament resistance of 100 ohms.

As the circuit is constructed current will flow from the battery, through the wire, through the filament of the lamp, through the second length of wire, and return to the negative terminal of the battery.

Now, what will be the quantity of current flowing through the circuit? Do we really care how much it is?

We may not care how much current flows if we just want to turn on the light. But what if the lamp we have requires, let's say, at least .01 amperes to light up but cannot handle .03 amperes? We will want to know whether the circuit we have st up is correct. So we use Ohm's Law to find out how much current will be present.

$$V = I \times R$$

$$\text{so } I = V / R = 1.5 \text{ volts} / 100 \text{ ohms} = .015 \text{ amperes}$$

This is within the range specified so the circuit will work properly.

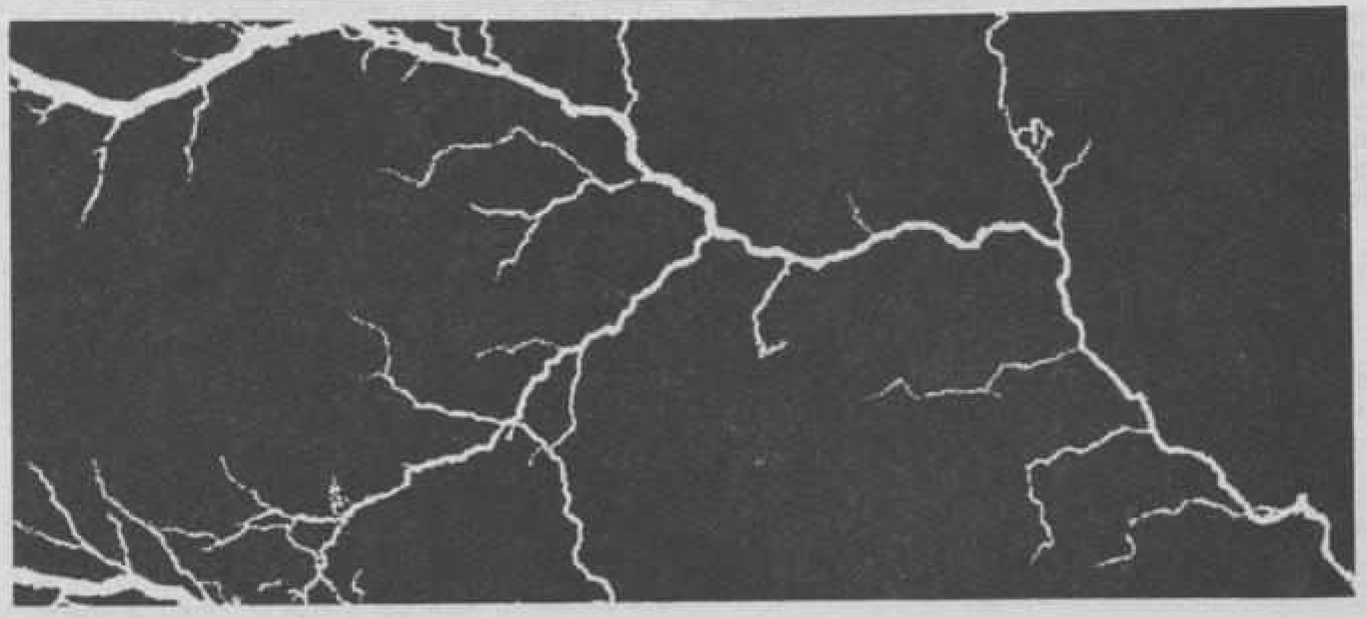
We can also determine how much power the circuit is dissipating by using the power formula:

$$P = V \times I = 1.5 \text{ volts} \times .015 \text{ amperes} = .0225 \text{ watts}$$

These are the basic, but vital aspects of electric circuits. Everything else builds from here. And it gets more practical...and interesting.

In our next issue we will take a look at series and parallel circuits, switches and fuses, power sources, and lots of other interesting things.

Hope you'll get a charge out of it. ■



WORKBENCH PROJECTS

The projects we've prepared for you in this section are more complicated than those in our **Circuit Fragments** section, but they are less complicated than the ones in our **IC Testbench** section.

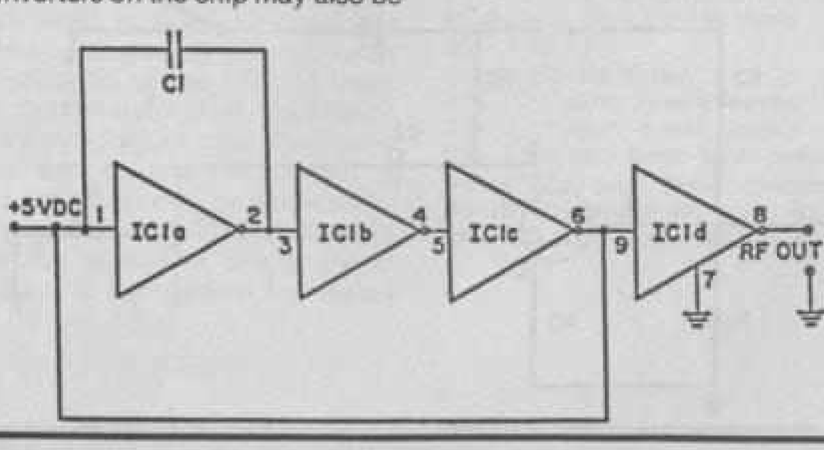
As with any electronics assembly work, be sure you understand how the various parts of the circuit work together and the objective of each component before you start gathering the components together and assembling them. As with any project that uses ICs (integrated circuits) or transistors, be careful to observe precautions regarding overheating their leads. If possible, use sockets instead of soldering directly to their wire leads. If you can't do that, be sure to protect the IC and transistor leads by using long-nose pliers as a heat sink when soldering those leads.

ULTRA SIMPLE RF GENERATOR

A single capacitor can turn a TTL hex-inverter into an RF generator with good solid waveform output. The circuit was checked out on both a 7404 standard TTL chip and the low power Schottky 74LS04 with about equal results, though slight departures in frequencies must be expected. One or more buffer stages from unused inverters on the chip may also be utilized.

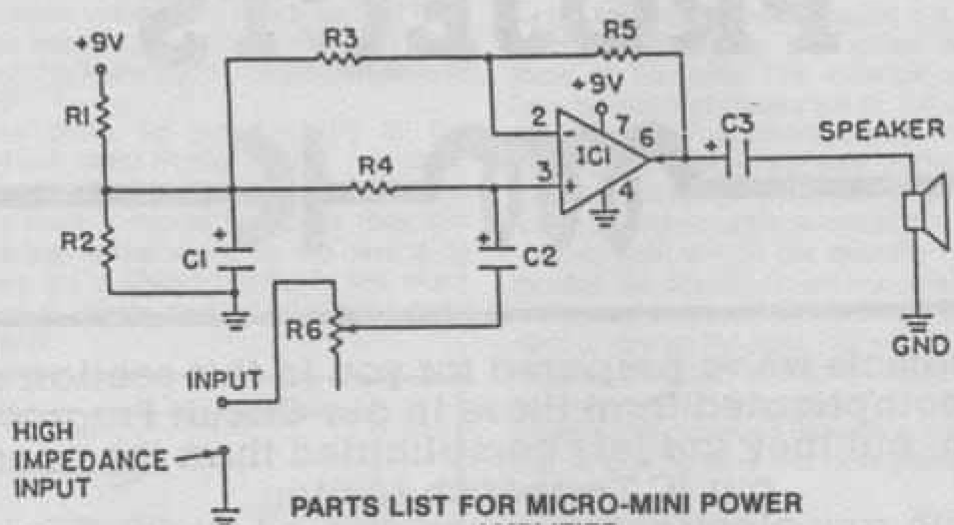
PARTS LIST FOR SIMPLE RF GENERATOR

C1—0.01-uF ceramic disc capacitor, 15 VDC
IC1—7404 hex inverter



MICRO-MINI POWER AMPLIFIER

Designed for *very* private listening, this little amplifier sports a tiny loudspeaker of 1½ to 2 inches diameter. The gain may be varied through the feedback resistor from about 1 to 100. Only a single power supply, which may be a nine volt transistor radio battery, is required.



PARTS LIST FOR MICRO-MINI POWER AMPLIFIER

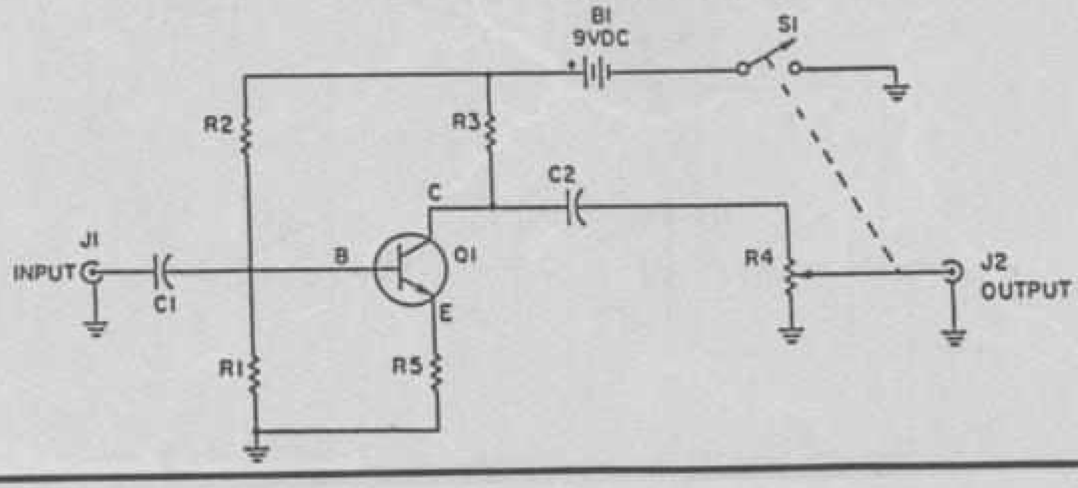
C1—100-uF electrolytic capacitor, 100 VDC
C2—100-uF electrolytic capacitor, 6 VDC
C3—100-uF electrolytic capacitor, 10 VDC
IC1—741 op amp
R1, R2—5,600-ohm ½-watt resistor
R3—1,000-ohm ½-watt resistor
R4—50,000-ohm ½-watt resistor
R5—100,000-ohm ½-watt resistor
R6—100,000-ohm audio taper potentiometer
SPKR—8 ohm, 2-in. PM type

VOCALIST MIKE BOOSTER

Between the lead and rhythm guitars, and the organ or synthesizer, the lead vocalist's mike often gets buried under the instruments if they all use a common amplifier. One way to get the vocalist up and out front is to give the mike some extra sock with a preamp. This one, specifically designed to handle most of the impedances commonly used by rock-group mikes, will give enough extra gain to project the singer's voice out to the last row of the balcony! Build it any way you wish, just as long as it's inside a metal cabinet.

PARTS LIST FOR VOCALIST MIKE BOOSTER

B1—9 volt transistor radio battery
C1—10uF, electrolytic capacitor
C2—0.1uF, 10-VDC mylar capacitor
J1, J2—jacks to match existing cables
Q1—2N2222 NPN transistor
R1—47,000 ohm, ¼ watt resistor
R2—470,000 ohm, ¼ watt resistor
R3—10,000 ohm, ¼ watt resistor
R4—100,000 ohm, audio taper potentiometer w/SPST switch
R5—470 ohm, ¼ watt resistor
S1—SPST switch, part of R4



EASY TOUCH SWITCH

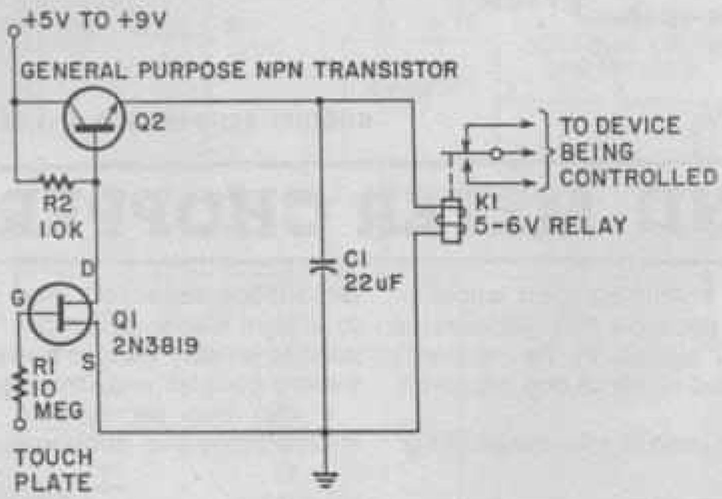
This is a simple two-transistor touch switch that is activated by the 60 Hz AC field which is picked up by your body, anywhere near electrical power in your home.

Field effect transistor Q1 is used as an impedance matching device for Q2, since voltage gain is not required but current gain is necessary. When the touch plate is contacted, a 60 Hz signal is passed from the body through R1 to the gate of Q1. The signal cuts off Q1 causing Q2 to conduct and energize relay K1. Capacitor C1 is used to smooth the pulsating DC signal at the emitter of Q2 and prevent the relay from oscillating.

If the circuit is battery operated, it should be grounded for the best operation, to make the 60 hertz field more effective. If it is used with an AC-power supply, it may be necessary to reverse the plug which is connected to the house current.

PARTS LIST FOR EASY TOUCH SWITCH

C1—22 uF capacitor, 15 volts or more
R1—10 megohms resistor
R2—10,000 ohms resistor
Q1—2N3819 transistor (FET)
Q2—any general-purpose NPN transistor
K1—5 to 6V relay coil to handle current of device being controlled.



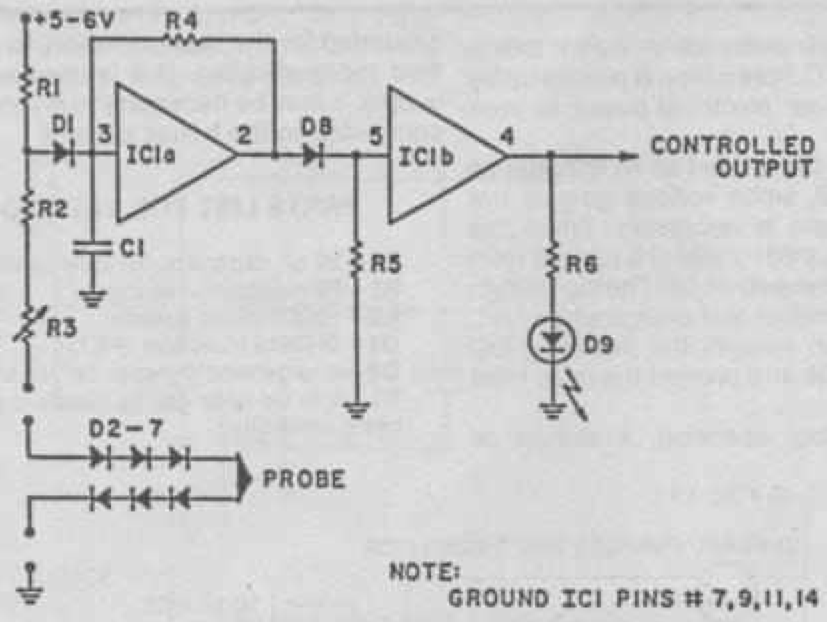
DIODE THERMOSTAT

All semi-conductors are, to varying extents, temperature sensitive. The type 1N914 or 1N4148 silicon diode has a negative temperature coefficient of 2 millivolts per degree Centigrade. While this may seem insignificant, it can be multiplied by adding diodes in series. In the circuit shown here, six 1N4148 diodes were series-wired in a small package, which could then be encapsulated in epoxy (though this slows the response time). The biasing potentiometer is set for an "off" indication of the LED at room temperature. As the temperature rises, resistance decreases, until the Schmitt Trigger trips. Hysteresis (the "dead-band" between on and off actions) is furnished by diode D1. Its action may be modified by replacing, or shunting it, with a 25,000-ohm potentiometer. Since the sensor is practically at ground potential, it may be appreciated by heated aquaria dwellers and owners alike!

PARTS LIST FOR DIODE THERMOSTAT

C1—.05-uF ceramic capacitor, 15 VDC
D1 through D8—1N4148 diode
D9—small LED
IC1—4050 hex buffer
R1—4,700-ohm, ½-watt resistor
R2—1,000-ohm, ½-watt resistor
R3—1,000-ohm linear-taper potentiometer
R4—470,000-ohm, ½-watt resistor
R5—2,200-ohm, ½-watt resistor
R6—270-ohm, ½-watt resistor

DIODE THERMOSTAT

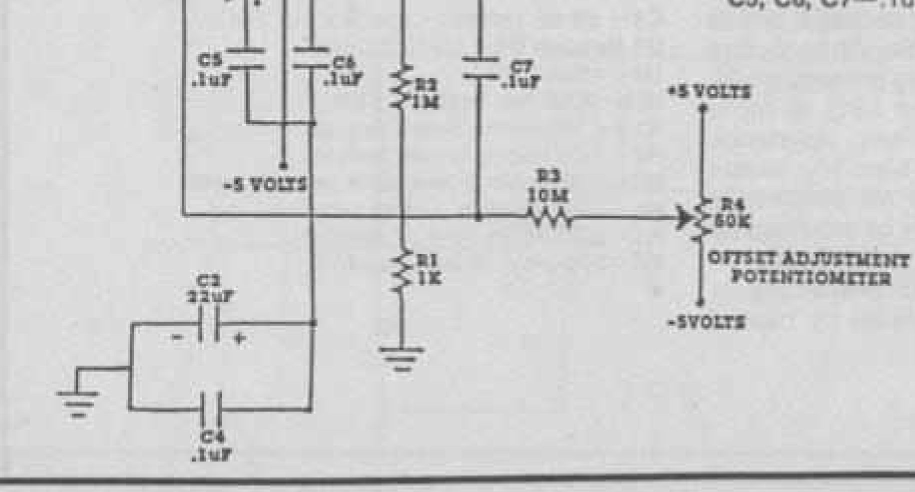


SCOPE AND METER CHOPPER AMP

Here's a simple one-IC instrumentation amplifier. It's called a "chopper" because this differential amplifier can amplify DC signals in the microvolt range and is accurate to plus or minus one microvolt. It has a gain of 1000.

Potentiometer R1 can be used to zero the amplifier. Decoupling capacitors must be used with this circuit to ensure stable operation. This amplifier has been used to amplify various transducer voltages, such as thermo-couples and strain gauges.

It can also be used to amplify the output of microphones and phonograph pickup cartridges.



PARTS LIST FOR SCOPE & METER CHOPPER AMP

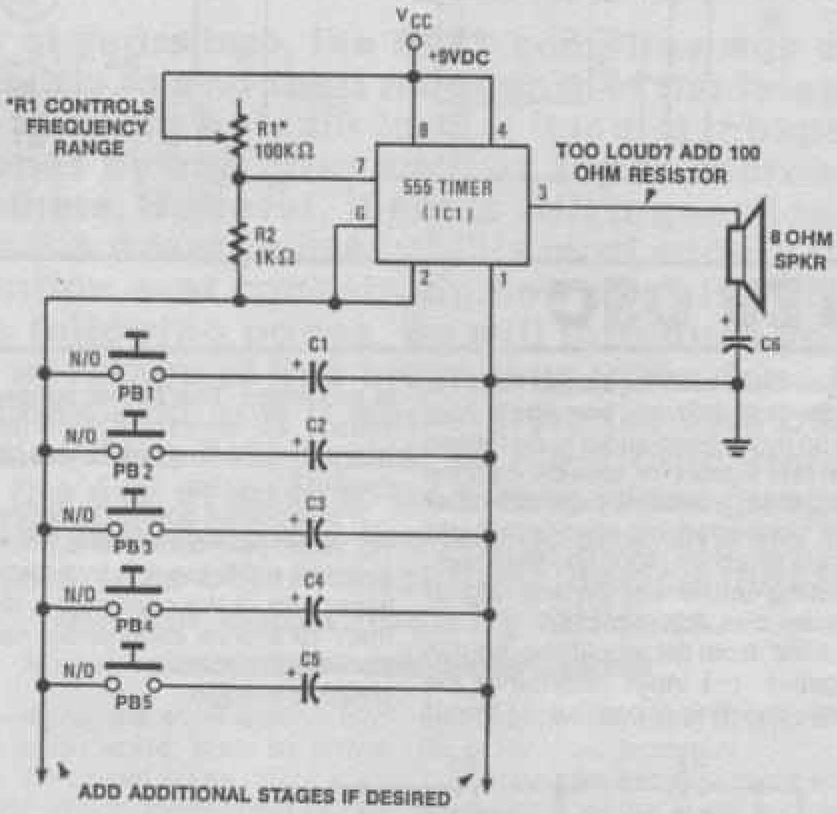
Semiconductors:
IC1—LTC1052CN8 (Linear Technology, Chopper Stabilized Amplifier)
Resistors:
R1—1 Kilohm (¼ watt, 1%)
R2—1 Megohm (¼ watt, 1%)
R3—10 Megohms (¼ watt, 5%)
R4—50 Kilohms (15 turn Pot)
Capacitors:
C1, C2—22uF, 16WVDC, Tantalum
C3, C4—.1uF Ceramic
C5, C6, C7—.1uF Metal Film (Radio Shack #272-1053)

TOY ORGAN

This is a nifty circuit for teaching youngsters the fundamentals of the musical scale. It's a great way for them to learn the different notes used in organs and other musical instruments. The circuit is flexible so that you can vary the values on the capacitors to sharpen or lower the sound. If the sound is too loud, add a 100 ohm resistor between pin #3 on IC1 and the speaker.

PARTS LIST FOR THE TOY ORGAN

C1—.10Mfd disc capacitor
C2—.05Mfd disc capacitor
C3—.01Mfd disc capacitor
C4—.005Mfd disc capacitor
C5—.001Mfd disc capacitor
C6—4.7Mfd disc capacitor
R1—100K ohms resistor (controls frequency range)
R2—1K ohm resistor
IC1—555 IC timer
PB1-PB5—pushbutton switches
Misc.—8 Ohm Speaker



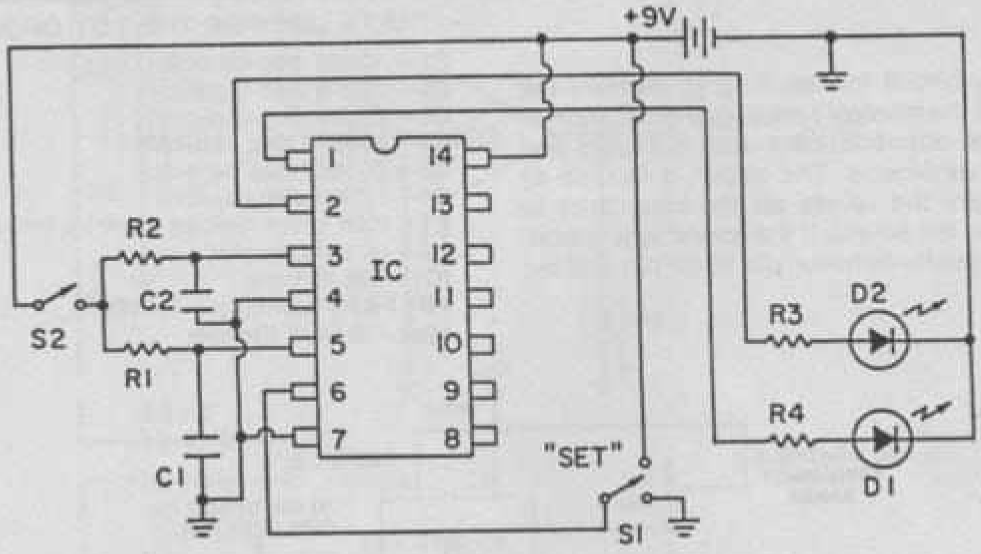
CAPACITOR MATCH MAKER

This useful, but simple circuit will allow you to match two capacitors or to tell if one has greater capacitance than the other. Suppose you have one capacitor of known value, say 1 uF. Put it where C1 is in the circuit. Suppose you have another capacitor of some unknown value. Put it where C2 is in the circuit. Now flip S1 from "set" back to ground. Then press S2. If D1 goes off and D2 goes on, it means C2 is less than C1, like 0.5 uF. If D1 stays on and D2 off, it means C2 is equal or greater than C1. You can use this circuit to help you quickly sort through a pile of old capacitors.

PARTS LIST FOR CAPACITOR MATCH-MAKER

C1, C2—see text
D1, D2—small LEDs
IC1—4013 dual flip-flop
R1, R2—30,000-ohm, ½-watt resistors
R3, R4—1,000-ohm, ½-watt resistors
S1—SPDT slide switch
S2—SPST momentary-contact pushbutton switch

CAPACITOR MATCH-MAKER

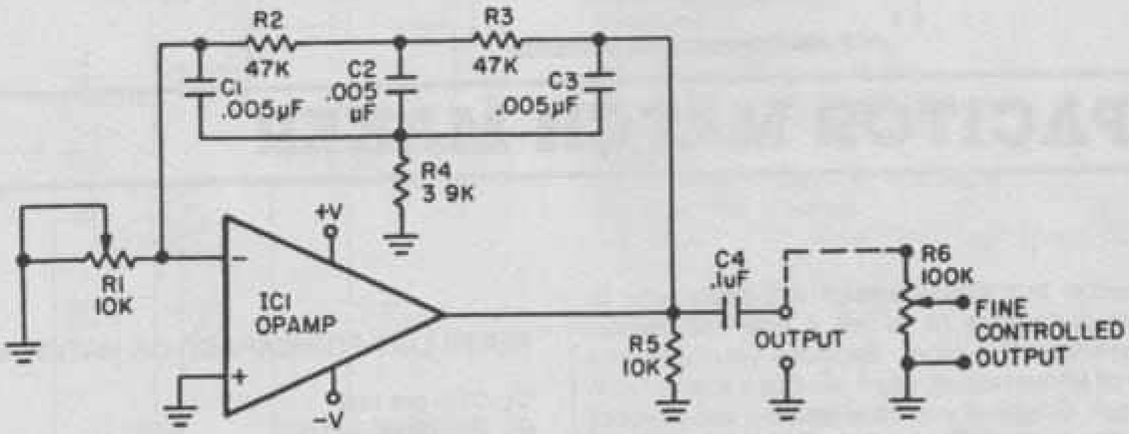


RC FILTER OSC

An experimenter has many uses for a basic 1000-Hz oscillator. If you're an experimenter you know how many and can make up more. Even audio buffs find an increasing interest in test signals for speaker balance and phasing. In this circuit, a resistor/capacitor filter tuned to 1000 Hz is connected between input and output of IC1 to sustain selective (1000 Hz) feedback. It's suitable for testing audio equipment, signal tracing or tape recorder bias adjustments.

The 1-kHz "notch filter" from the amplifier output to the inverting or negative (−) input determines the output frequency. Non-inverting or positive (+) input is grounded. The power supply is bi-polar; use any voltage up to ±15 VDC. While resistor R5 is not needed, in many instances its use insures your project's success.

If fine output control is desired, add potentiometer R6. When your oscillator is connected to a DC circuit, connect a DC blocking capacitor in series with R6's wiper arm. If the oscillator is to drive circuits of less than 10 k-ohm impedance, substitute a 1 uF non-polarized capacitor for C4, rated to the power supply's voltage.



PARTS LIST FOR RC FILTER OSCILLATOR

C1, C2, C3—0.005-uF, 75-VDC (Radio Shack 272-130 or equiv.)
C4—0.1 uF (see text)
IC1—741-type operational amplifier (Radio Shack 276-010 or equiv.)
R1—10,000 ohms pot
R2, R3—47,000-ohms, ½-watt
R4—39,000-ohms, ½-watt
R5—10,000-ohms, ½-watt (see text)
R6—Potentiometer, 100,000-ohms, audio taper (see text)

INSIDE YOUR TELEPHONE

By Steve Sokolowski

A number of years ago, the AT&T company was ordered by the courts to end their monopoly of the telephone lines. This ruling brought forth a flood of inexpensive telephones by countries such as Japan, Korea and many others. However, there is still a question that haunts the average user of this most widely used invention ever conceived...how does it work? Within the following pages, we will introduce you to the inner workings of this marvelous invention...the telephone and how it works, from the TAB book, "Customize Your Telephone: 15 Electronic Projects." Through the use of easy to understand language and informative illustrations, the telephone will no longer be the mysterious communications device that is used but not understood by millions.

The telephone is probably the most widely used electronic instrument in the world, since its arrival over a century ago. In the United States, there is an estimated one hundred million telephones now in use.

It staggers the mind when the thought that any two of these one hundred million telephones can be connected together to allow the human voice or computer data to pass between them, using a pair of copper wires or a beam of light (Fiber Optic Technology). Yet, this huge network access can be accomplished by an unskilled operator...you.

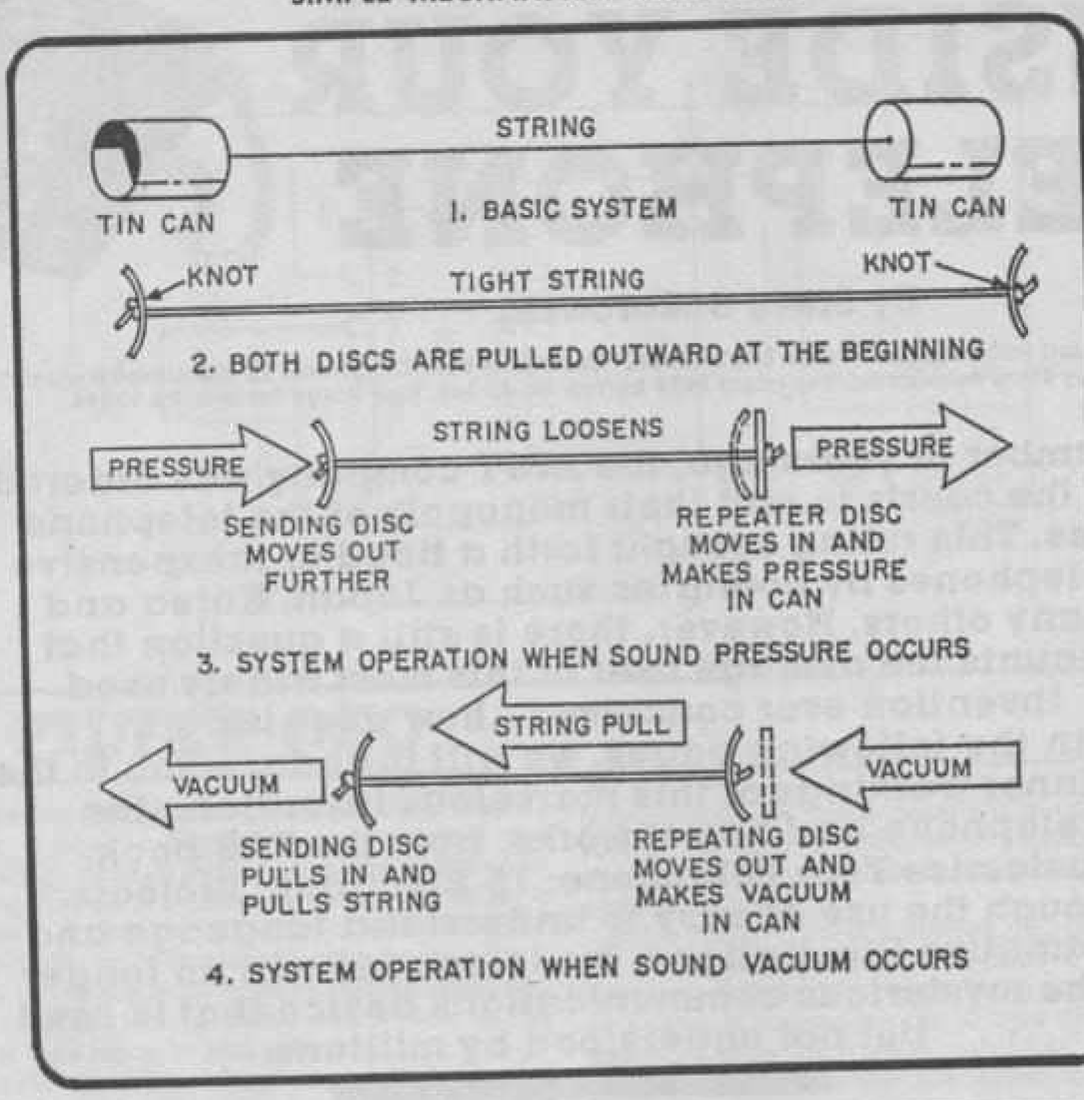
Just by picking up the telephone receiver, a sequence of complicated network events comes alive and it was all made possible in 1876 by Alexander Graham Bell when he spilled acid on his trousers then yelled out the now famous quote "Mr. Watson, come here, I want you."

Over the past few years,the telephone instrument, like the one found in your home, has gone through some monumental changes. Telephones are now highly sophisticated electronic devices using a wide variety of Integrated Circuits as well as computer chips which simulate the human mind.

The shape and style of the telephone may have changed but the basic functions have not. Here is a list of the most important:

1) By lifting the handset, the telephone signals to the local exchange that a call is to be made.
2) It indicates to you that the local exchange is ready to process the call by allowing you to receive a tone. This tone is called the Dial Tone.
3) It sends the number of the telephone you wish to be connected to by having the user press numbered buttons or rotating a plastic dial.
4) It indicates the status of the call in process by receiving a sequence of tones (Ringing—Busy Tone etc.)
5) It indicates that a person is trying to get in touch with you by the ringing of a bell or other type of audible signal.
6) It changes a speech pattern of a calling party to electrical signals that is easily passed through copper wires and converts it back into an intelligible audio pattern at the receiving instrument.
7) It automatically adjusts its internal operation to reflect changes in voltage supplied to it.
8) Finally, it signals to the local exchange that the call is complete when the caller places the handset back on the telephone cradle.

SIMPLE MECHANICAL TELEPHONE



One of the more common telephones used today is the 500 type unit. This is a basic desk model with a rotary dial. This dial produces pulses that correspond to the number of the telephone you wish the network to connect you to.

The counterpart to the 500 type telephone is the 2500. The 2500 type telephone, like the 500, is a standard desk phone but uses a technology that was first introduced to the public at the New York's World Fair back in the 60's.

Instead of pulsing-out the desired telephone number, the 2500 converts this number to a series of specially selected tones, which the local network converts back into the desired dialed number.

Not all telephones manufactured are desk types. Some are produced to be mounted on walls. They are called, as the name implies, wall phones.

A wall-mounted counterpart to the 500 type rotary desk telephone is the 554 model. For the tone dial enthusiast, the 2500 desk phone has two substitutes. They are the 3554 and the more slender and compact 2554 models.

Whichever model telephone you own, the operating functions remain the same.

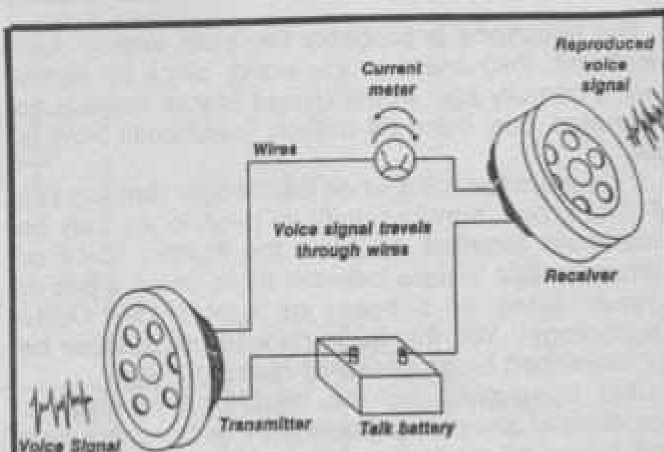


Figure 1. An Audio Signal is converted into electrical pulses then back again.

Telephone Basics

Figure 1 is a schematic illustrating how sound is transformed into electrical signals that are allowed to travel through a pair of wires and be converted back-to sound at the receiving end.

To understand how a telephone operates, one must understand what sound is. Sound, in reality, is a variation in air pressure. It is this air pressure that vibrates the diaphragm of a telephone transmitter. The diaphragm in turn applies this pressure to expand and condense carbon granules which are located within the transmitter. By expanding and condensing these granules, the resistance of the transmitter changes in proportion to the applied air pressure generated by speaking into the telephone handset. When a battery (called the Talk Battery) is connected to the transmitter, the varying resistance of the transmitter allows a varying current to flow. Thus an exact reproduction of the sound created by your voice is converted into an electrical signal.

Sound is reproduced in a telephone by the receiver section of the handset (upper most section). The receiver is a electromagnet with a metal diaphragm attached to it. Variations in the electrical current within the coil of wire that makes up the electromagnet attracts and repels the metal diaphragm in proportion to the applied varying current. When this diaphragm vibrates, varying air pressure is created. This air pressure is then interpreted by your ear as sound.

This can be demonstrated by bringing a telephone handset to your ear and blowing into the transmitter. You will be able to hear this sound in the receiver section. The sound of your own voice in the handset receiver is called Side Tone. Hearing ones own voice in the receiver prevents the user from using an abnormally loud voice when speaking on the telephone. Figure 2 is an exploded view of a typical telephone handset.

If only two telephones were to be connected and they were within a short distance from each other, a telephone instrument could consist of just two handsets connected to a Talk Battery. But this is far from the case. Say you made a call to a friend who lives across the street from you. Your voice signal will be very loud to your friend. He or she may have to hold the receiver away from their ear. Now say, you made a call, using the same telephone, to another friend one hundred miles away. The volume of your voice would be very low.

To eliminate this signal variation between a local and long distance call, designers included a component called a *varistor*. This component is a voltage variable resistor. If the voltage across this varistor is high, the resistance of this component will be low. In reverse, if the voltage is low, the internal resistance of the varistor will be high.

Now, if you made the same call to a friend across the street, the varistor will reduce the amount of signal produced by the transmitter but if you make a long distance call, the volume of your voice on the second call will be the same as the volume received by your neighbor across the street.

Presented in Figure 3 is a schematic of a basic 500 type telephone. RV1, which is a varistor that suppresses dialing clicks that are generated by using the rotary dial. This varistor is soldered directly to the screw terminals of the telephone receiver element that can be found in the handset.

The balancing network, comprised of RV2, C2, C3,

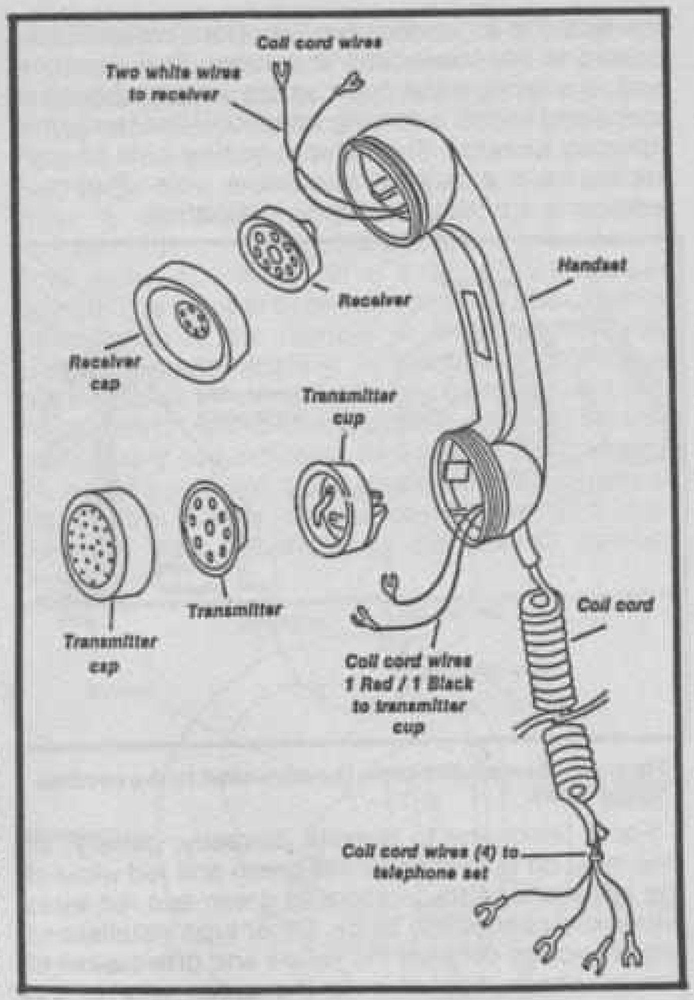


Figure 2. Exploded view of a telephone handset.

R2 and the induction coil, provide simultaneous two-way conversation using a two-wire system.

Capacitor C1 and resistor R1 make up a dial pulse-filter which is used to suppress Radio Interference when dialing a telephone number. Varistors RV2 and RV3 are used to reduce the efficiency of the transmitter on local calls. These varistors maintain satisfactory transmission volume on both local and long distance calls.

Most home-bound telephones have four wires coming out of them. These wires are colored Green (Tip), Red (Ring), Yellow and Black and are contained within a cable called a line cord. This line cord is then

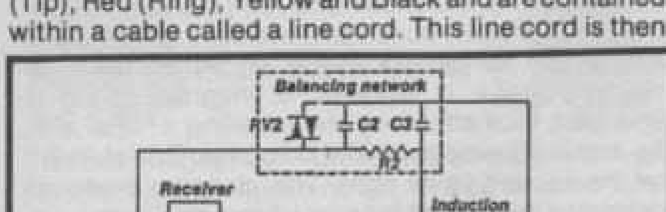


Figure 3. A schematic of a standard telephone.

connected to a "junction box" (or Connection Block) located at the baseboard in a room. This "junction box" is a termination point where your telephone is connected to the incoming telephone line through a lightning arrestor. This telephone line runs to your house from a nearby telephone pole. Figure 4 represents a typical telephone installation.

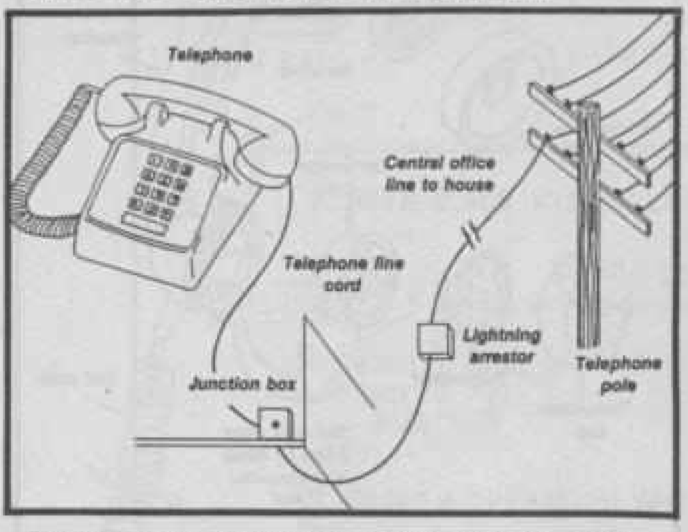
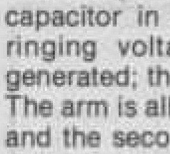
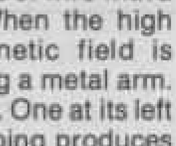


Figure 4. How a telephone is connected to the central office lines.

For a telephone to operate correctly, usually, all one must do is to connect the green and red wires of the telephone to the associated green and red wires within the connection block. Other type installations require you to connect the yellow and green wires of the telephone line cord to the green wire in the connection block. This depends on the physical wiring inside the telephone. Some manufacturers connect these two wires inside the telephone, others require this connection be made outside the telephone at the connection block.



How a Telephone Rings



For a telephone to ring, a voltage between 60 to 90 volts, with a frequency of about 20 Hz. is applied to the internal bell via the green and red (Tip/Ring) wires. This bell (or ringer) consists of two coils of wire with a capacitor in series (C4 in Fig. 3). When the high ringing voltage is present, a magnetic field is generated; thus attracting and repelling a metal arm. The arm is allowed to strike two gongs. One at its left and the second to its right. This clapping produces the ringing sound that is heard when a call is received. On large style telephones (500, 2500, 554 etc.), a two gong type ringer is used (138BA ringer). See Figure 5. This bell produces a very loud ringing sound that can be controlled somewhat by moving one of the gongs closer to the vibrating arm. On a 3554 and 554 wall telephone, this adjustment is in a form of a lever that is located at the bottom of the phone that can be pushed from side-to-side. While on a 500 or 2500 desk telephone, a single adjustment is located on the underside of the instrument.

For smaller telephones, like the 2554, a bell with one

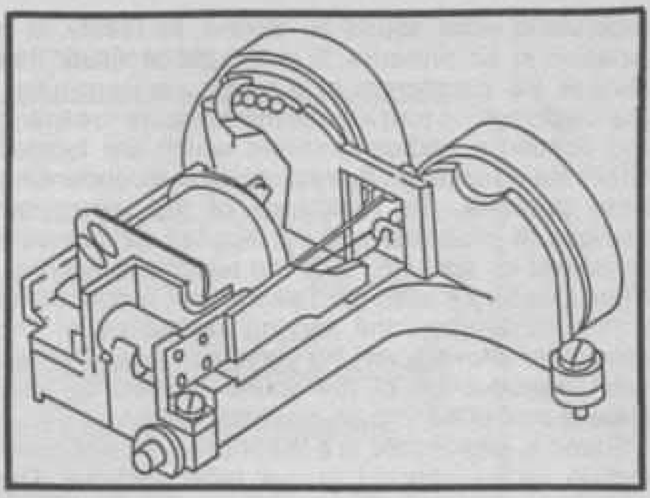


Figure 5. A typical 2-gong telephone ringer (130BA ringer).

gong is used (148BA ringer). See Figure 6. The volume of this type of ringer is considerably lower than the 138BA ringer but loudness is sacrificed for its compact size.

Both the 138 and the 148BA ringers are an industrial standard and can be placed into operation anywhere in the country using a ring frequency of 20 Hz, for which these two bells were designed.

Figure 7 is an electrical diagram of the 138 and 148BA ringers. Note that the 148 ringer has one coil while the 138 has a two coil ringing system.

Let's go back to Figure 3 to see what happens when the handset is lifted and how a telephone can access the sophisticated switching equipment located at your local telephone exchange. When the handset is removed from the cradle, switches S1 and S2 close while S3 opens. These three switches are contained in an assembly known as a Hookswitch (or Switch-hook). Upon the closing of S1 and S2, the telephone is placed across the incoming line. The 48 volts (Talk

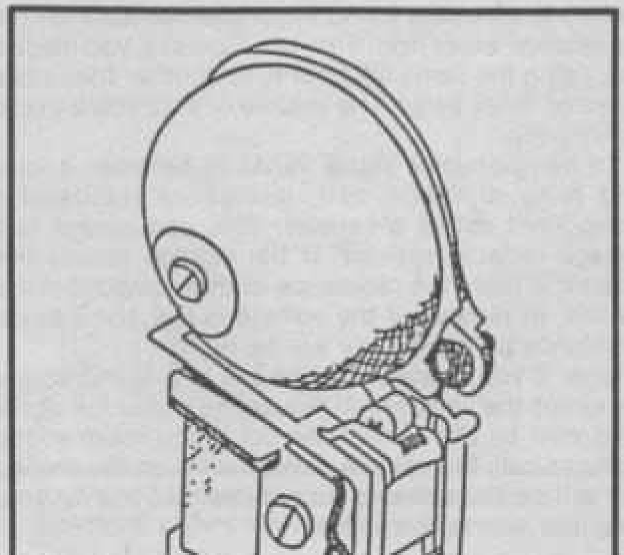


Figure 6. A typical single gong telephone ringer (148BA ringer).

Battery) which is present across the line (Tip/Ring) while on hook, now drops to about 5 volts. At this time a tone is generated by the local exchange indicating that the Central Office (Place where all telephone switching equipment is located) is ready to accept dialing and subsequent connection to the desired location. This tone is called the *Dial Tone*.

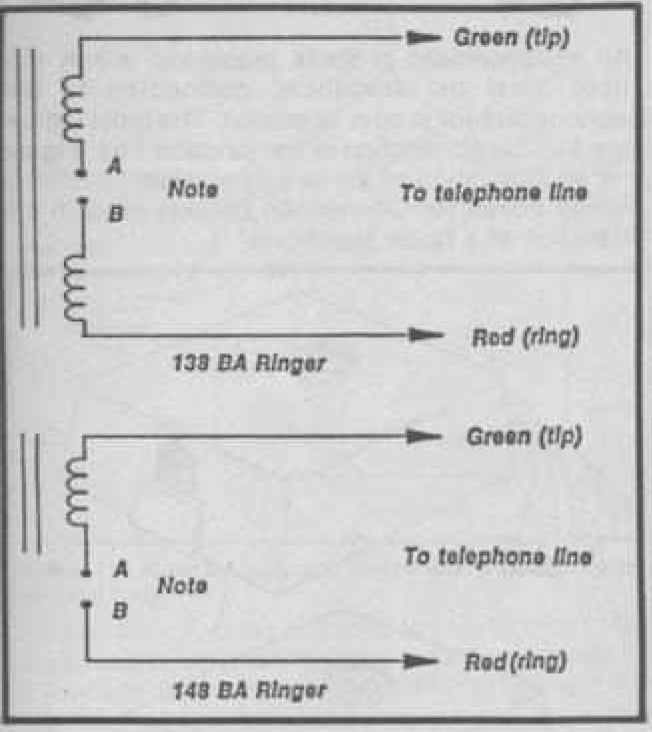


Figure 7. An electronic schematic of both 130 and 148BA ringers.

Rotary Dial

To indicate to the Central Office the telephone number you wish to dial, a means of generating a

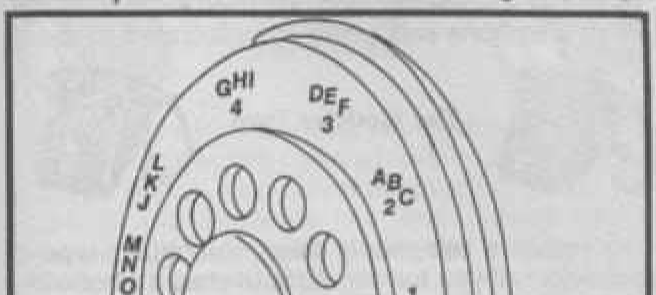


Figure 8. A typical rotary dial.

pulse train (Continuous number of on and off connections that are made within a specific amount of time) was first introduced in 1895. This invention is still in use today. It is called the *Rotary Dial*. See Figure 8. The dial is a device that the user rotates with their finger to a pre-determined position. When the finger is removed, the dial returns to its resting position. While returning, the dial opens and closes a small switch (D1 in Fig. 9) at a rate of 10 times per second. The number of switch openings and closings corresponds to the number or letter the dial was turned to before releasing. An example of this is, say you indicated, by using the Rotary Dial, the number 5. The switch D1 will open and close five times. This also holds true if you indicated the number 9 on the dial. D1 would open and close nine times. Equipment at the Central Office counts each pulse and then connects your telephone to the correct number dialed.

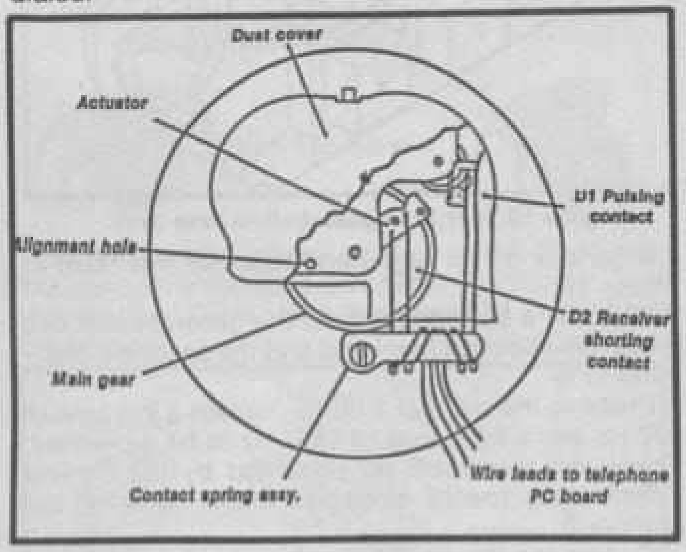


Figure 9. Mechanical switches of a rotary dial.

To prevent loud clicking in the telephone receiver as switch D1 opens and closes, switch D2 (which is wired across the telephone receiver) closes thus shorting the receiver during the dialing interval.

Refer to Figure 9 to see how switches D1 and D2 are interconnected using the Rotary Dial.

Push Button Dialing

Today, more and more telephones sets are manufactured using the newer method of audio tones to send the telephone number to the Central Office. The 2500 model telephone uses this type of dialing.

Instead of a rotary dial, the tone phones have a push-button keypad with 12 keys for the numbers 0 to 9 and the symbols * (asterisk) and # (Octothorpe). Figure 10 is an illustration of a common tone dial, the 32opg type. Pressing one of the keys causes an electronic circuit in the keypad to generate two output tones that represents the number.

To represent telephone numbers, eight frequencies in the 700 to 1700 Hz range comprise a four-by-four code designed for pushbutton dialing. There are four

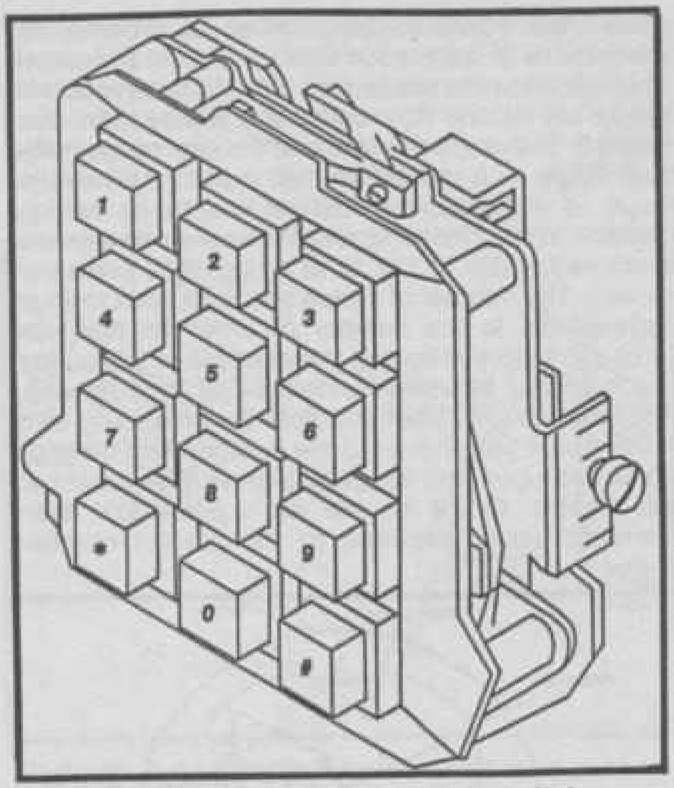


Figure 10. A typical push-button tone dial.

low-band and four high-band tones as illustrated in Figure 11.

Pressing a button results in the generation of two tones. One being a low-band and the second a high-band tone.

Pressing the number 3 button causes a low tone of 697 Hz and a high tone of 1477 Hz to be generated. These two tones will be converted by the Central Office using special electronic filters, as being the number 3.

Generating the frequencies can be accomplished by an Inductor-Capacitor (LC 32opg type) resonant

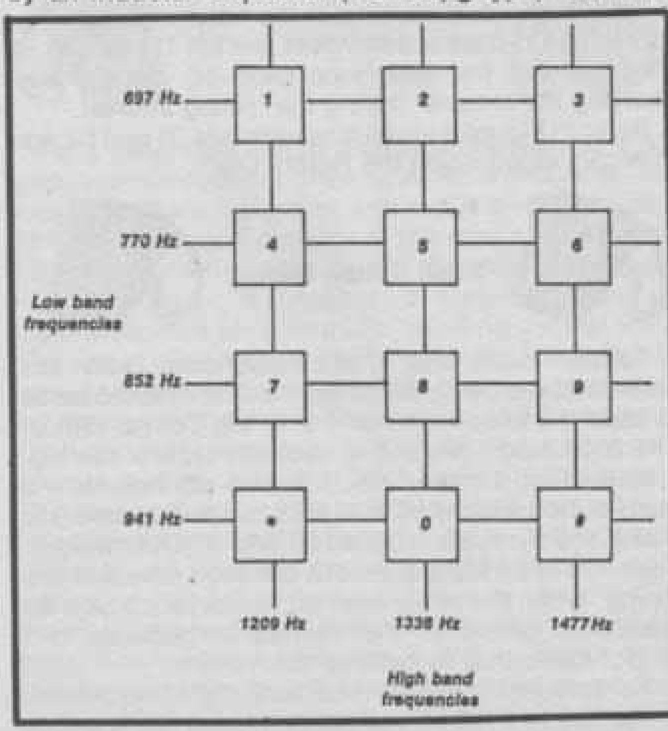


Figure 11. Frequencies generated by a tone dial.

circuit or by a Master clock run by a crystal oscillator which is then divided by a special Integrated Circuit (IC) to the needed push-button tones (42opg type).

Project Installation

All enhancement projects presented within this article must be, somehow, connected to the telephone line for proper operation. The most logical place for this connection is the junction box. Figure 12 is an illustration of the two most widely available junction boxes (or Connection Blocks) used in the installation of a home telephone.

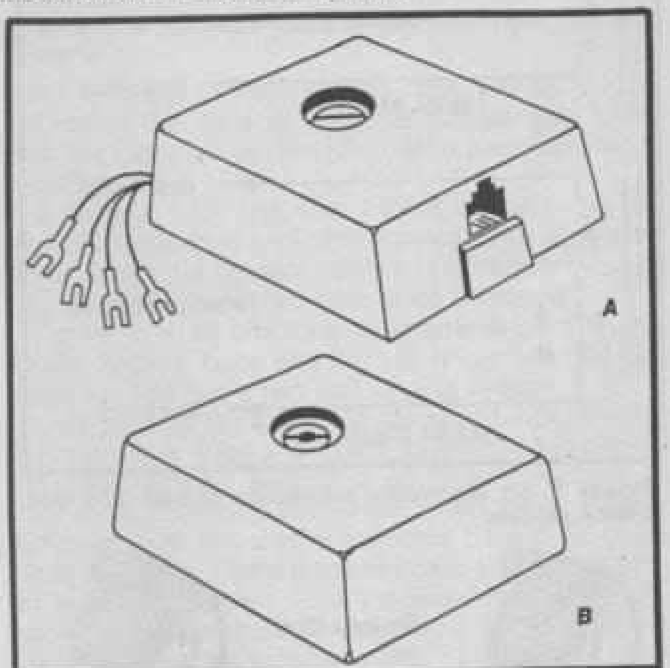


Figure 12. Junction boxes (A) modular box (B) standard box.

Figure 12A is the junction box used with the newer type of telephone sets being manufactured today.

The Modular Type

To install a telephone using a modular type of connector, all you have to do is to snap a plastic line cord terminator into the junction box. Four small piano wire conductors make contact with the plastic terminator thus allowing an electrical current to flow between the two points. At this point, the telephone is connected to the line.

You may have noticed that telephone coil cords also use this type of connection. If your phone makes use of these plastic terminators, your telephone is said to be the Full Modular type.

Presented at Figure 12B, is the older type of junction box. To connect a telephone to this type of installation, one must unscrew the plastic cover which exposes four screws that have the basic line-cord colors fastened to them (Green, Red, Yellow, Black). Figure 13 shows how these wires are fastened to the telephone set.

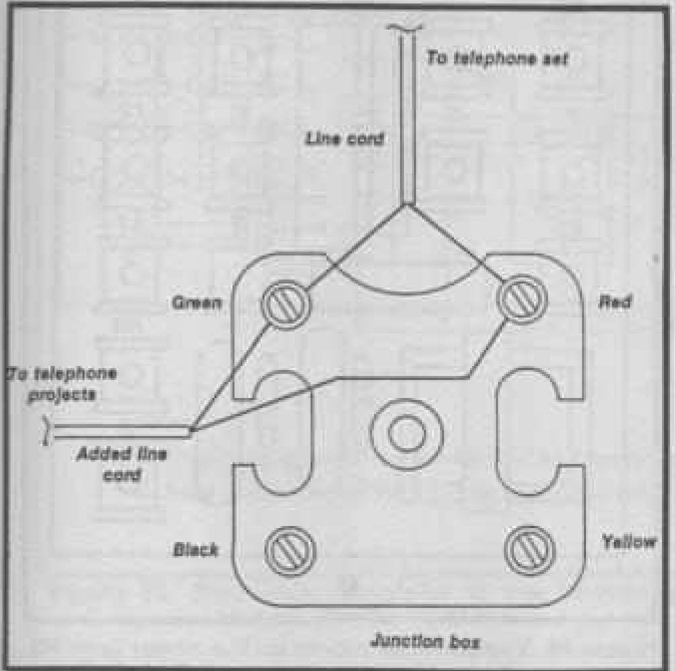


Figure 13. How to connect telephone projects to a junction box.

All you have to do is to match the wire color of the telephone line-cord to the printed wording located on the junction box surface. For example, connect the green wire of the telephone line cord to the screw marked "GN." If your telephone is an older type, remember also to fasten the yellow line-cord wire to the "GN" junction box terminal. Then connect the red line-cord wire to the "RD" terminal.

Having this basic installation concept in mind, you can use this procedure to make a permanent connection to the junction box for any one of the enhancement projects.

Connection to the Modular Junction Box

Before any wiring is made, you must have available, a telephone line-cord using a module plug (purchase this type of line-cord only if the junction box in your home is the same as the one represented in illustration "A" of Figure 12, on one end, while the other is terminated with what are called *spade lugs.* This cord is said to be a ¼ modular line-cord. On the end of the cord with the spade lugs, cut off the yellow and the black wires. These wires are not used and should be removed to prevent accidental shorting. For final installation, just fasten the modular plug into the junction box, making sure the green and red wires on the opposite end of the cord are not shorted.

Connection to a Standard Junction Box

If you have an older type of telephone installation, you can fasten a second line-cord to the box but you must first remove the plastic cover. Do this by loosening the screw located at the center of the box. When it is opened, you will be confronted with the wiring presented in Figure 13.

With a line cord terminated with spade lugs at both ends, cut off the yellow and black wire leads on *both* ends. These two wires will not be used. Now connect the green and the red wires on the line cord to their corresponding screw terminals (GN/RD), making sure the green and red wires at the opposite end are not shorted.

Due to the tremendous growth of the telephone industry, brought about by the FCC ruling, telephone parts, like line-cords, can also be found in hardware and department stores. You may also purchase parts in one of many telephone specialty stores that have popped-up across the country.

The important thing to keep in mind is to shop around for the best possible price. Practically all telephone parts (line and coil-cords) are imported. I find that imported telephone parts are pretty much reliable under normal usage but the pricing from one store to another varies greatly.

Look For Sales

So far, we have introduced you to the basic parts that make up a standard telephone. The Ringer, Tone and Rotary Dials, Handset and the Telephone Electronics.

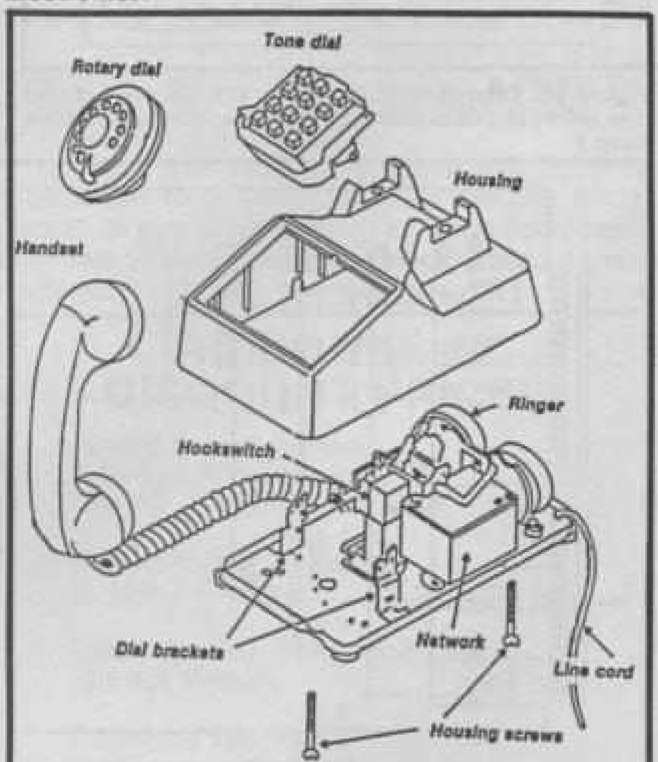


Figure 14. Exploded view of a standard desk-type telephone.

How these various components are connected together to allow the user to access a Central Office, is the topic of this section. The diagram presented in Figure 14 is what is called an *exploded diagram* of a home telephone. From this diagram, you can see how the various components are mounted on the telephone base plate.

The handset and the line-cord are clipped in place, while the Rotary or Tone Dial is screwed to the mounting brackets. The Ringer is screwed to the base while the Hookswitch and the Network are riveted in place.

Let's stop here for a moment. Above, I mentioned a Network (Not to be confused with the Telephone Switching Equipment). The telephone Network is where the Electronics presented in Figure 3 are located. On older models, this network is in the form of a metal box, where the connections to the various points of the electronic circuit are made by screwing down the wire leads of the associated component parts. The network of a telephone is like an engine block to a motor. All components are somehow connected to this one central point.

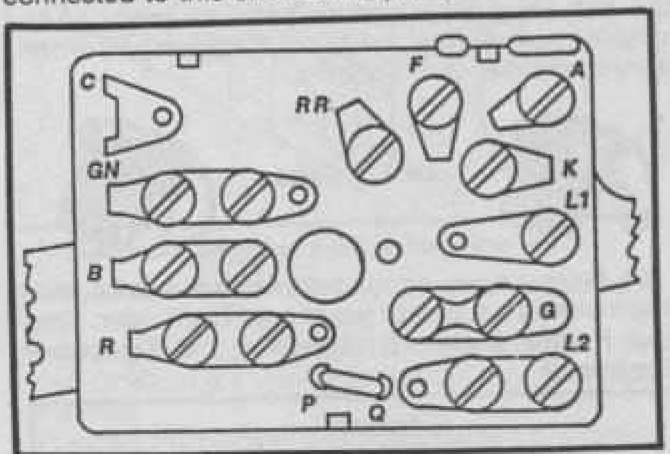


Figure 15. Termination points on the old style metal box network (Courtesy Corinth Telecommunications Corp.)

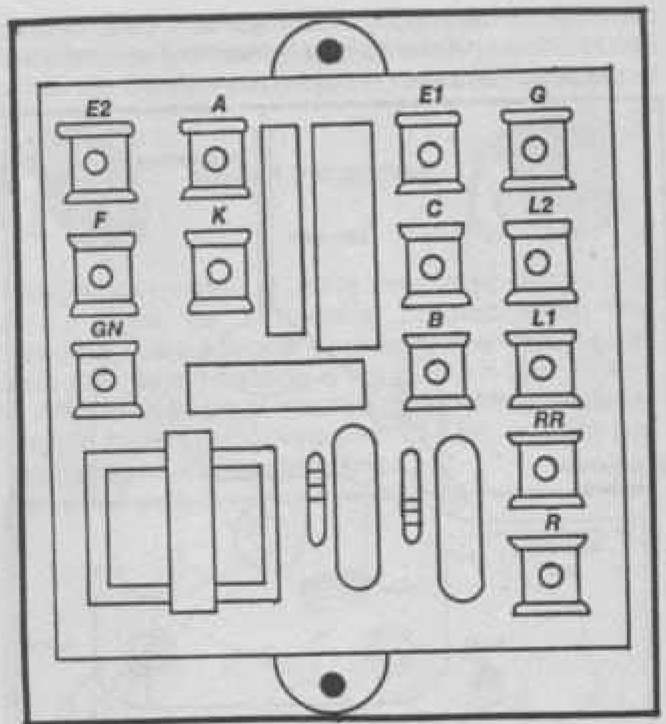
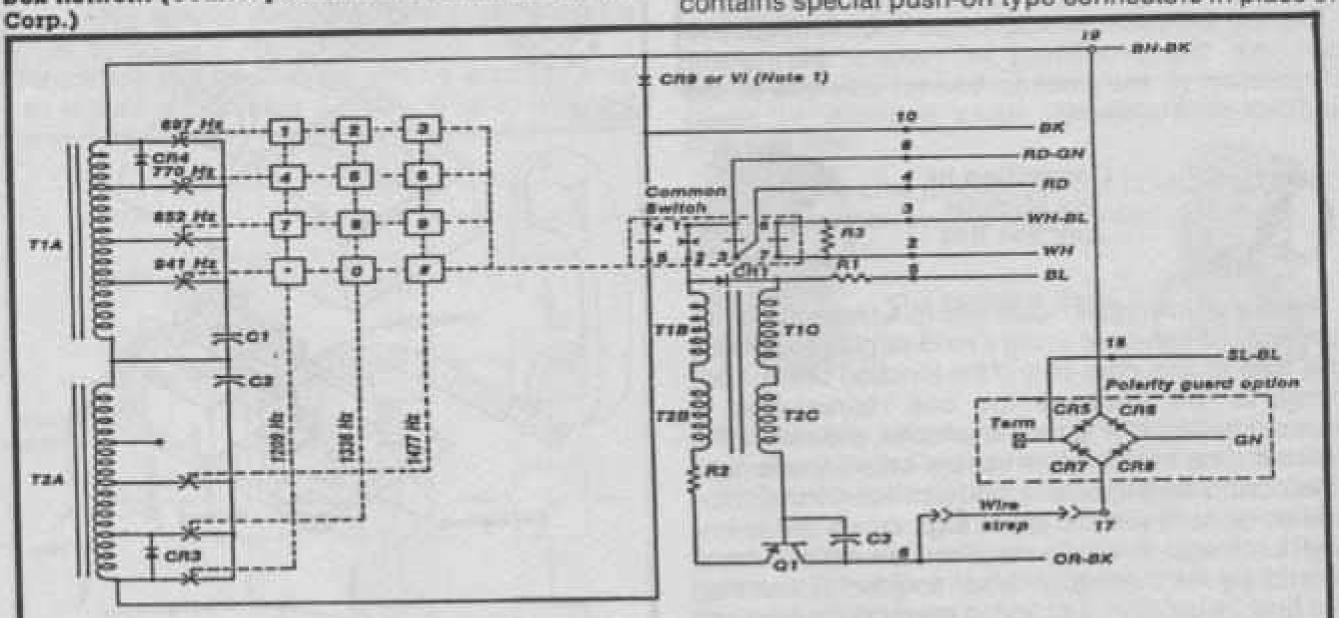


Figure 16. Termination points on the newer type PC board telephone Network (Courtesy Corinth Telecommunications Corp.)

Figure 15 is an illustration of the connector locations of the older box type telephone network. Each connection point is labeled with a letter (Example: R, GN, B, etc). Each letter corresponds to a different location within the electrical circuit of the telephone.

Another widely used network is illustrated in Figure 16. This network uses a Printed Circuit Board that contains special push-on type connectors in place of



T1A, T1B, T1C—Mutually coupled
T2A, T2B, T2C—Mutually coupled

Notes: *1. V1 (varistor) must be used on dials without the polarity guard option.*

2. This is the make-break sequence for the common switch.
The 6-7 springs break first.
Then, the 1-2 springs make.
Then, the 1-3 springs break.
The 4-5 springs break last.

Figure 17.

Electronic schematic on the older type 32G- type tone dial (Courtesy Corinth Telecommunications Corp.)

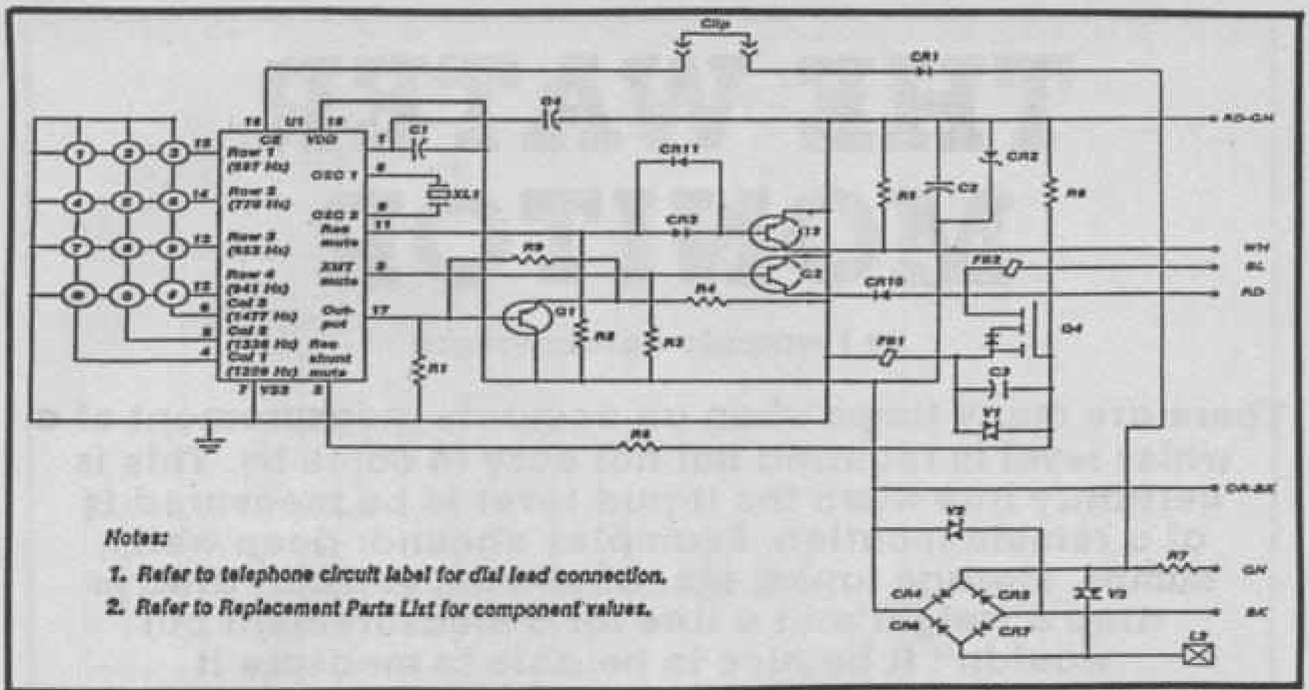


Figure 18. Electronic schematic of the frequency synthesized tone dialer (Courtesy Corinth Telecommunications Corp.)

the screw type terminals that are found on the older box type assemblies.

The termination lettering is identical for both networks except that the PC Board assembly contains an additional two connection points (E1 and E2). These termination points are used as a common termination point and have no connection to any of the telephone electronics.

Due to the construction of the box-type network, this reliable device is used so that no operator contact can be made to the electronic components but it is a different case with the PC board network. It is recommended that while experimenting with your telephone, you exercise extreme caution. The most sensitive component on the board is the induction coil. The fine wires of the coils are exposed and can easily be broken with a careless movement of a screwdriver...Again, exercise caution.

The last component that we will discuss in this article is the Tone Dial. Figure 17 is a schematic diagram of an older 32opg Tone Dial, while Figure 18 is a schematic diagram of the newer 42opg Dial.

Both dials have what is called a *Polarity Guard.* CR5 to CR8 in the 32opg and CR4 to CR7 for the 42opg dial. This bridge rectifier allows the TIP and RING wires of the telephone line-cord to be reversed while still allowing the proper voltage polarity needed by the electronic circuit.

Another point to mention is that the 32opg Tone Dial uses the L-C (Coil/Capacitor—T1 and T2) tuned circuit to drive transistor Q1 into oscillation at the required frequencies needed for tone dialing. While the 42opg uses the newer technology of digital electronics to generate the required tones.

By referring to the schematic of the 42opg dial, U1 is the heart of this type of frequency synthesis. When one of the available twelve buttons is pressed, one Row and one Column pin of the IC (Integrated Circuit) are shorted together, producing the corresponding digital frequency at the output located at pin 17.

By presenting this article, we hope that we have sparked your interest in the operation of the telephone. If so, you might be interested in purchasing a copy of "Customize Your Telephone: 15 Electronics Projects," which contains 15 interesting and easy-to-build telephone projects, including "Tele-Guard," a circuit that detects "bugs" on the line. Also included, are detailed instructions on how to assemble a "Music on Hold" adapter, a device that serenades a caller when you place them on hold. The list of projects goes on and on.

You may purchase an autographed copy of "Customize Your Telephone " by sending $11.00 (plus $1.25 shipping/handling) to: **Steve Sokolowski, P.O. Box 5835, Spring Hill, Florida 34606.** (Florida residents, please include Sales Tax). ■

THE WATER MONITOR

By Fernando Garcia Viesca

There are many times when an accurate measurement of a water level is required but not easy to come by. This is certainly true when the liquid level to be measured is at a remote location. Examples abound: deep wells, sumps, storage tanks, etc. Of course, you can always drop a weight and a line for a measurement but wouldn't it be nice to be able to measure it remotely...better still, to be able to perform a control function remotely? (I.E. turn on an electric pump) Enter the water monitor. The monitor presented here, not only is very simple and inexpensive, it may also be easily tailored to any water depth (try this with a mechanical float). Also, it has an optional high-level, low-level trip point to operate a valve, pump or alarm.

The principle on which this project is based is that 99.99% of all water that you actually encounter is electrically conductive. This statement may be surprising, but water is actually an insulator. But water is also nature's foremost solvent and will always have some substances dissolved that form ions and make it electrically conductive. (The 00.01% that you will find in pure form is distilled water employed mostly for chemical Lab. usage, in this case the project does not work). So for all practical purposes, we may safely assume that you'll be working with electrically conductive water.

The sensor is a resistor that changes value with water level. The easiest way to perform this function is to have a PVC tube, in which fixed resistors have been attached, as in Figure 1. The junction of each resistor pair is attached to a copper "probe" that touches the water. When a probe is submerged, it is short circuited to the deepmost probe, therefore, all resistors below that probe will be effectively out of the circuit, leaving only the "dry" resistors as the total resistance value.

The beauty of this circuit is the fact that even though the water measurement is done in discrete steps, these steps may be as fine as required. In the drawing, for simplicity, only five are shown but the project employs ten discrete steps and may be expanded if desired for increased resolution. As shown in Figure 2, this variable resistor divider R1 thru R9, is fed by constant current source A1 and associated components D1, R11 and R12. Total current is only 33 microamps, that will yield negligible electrolysis, thus negligible corrosion. Including R10, total voltage drop is 5 volts (for a totally dry condition) and 0.5 volts (for a totally saturated condition). The reason for including R10 out of the water tank is both

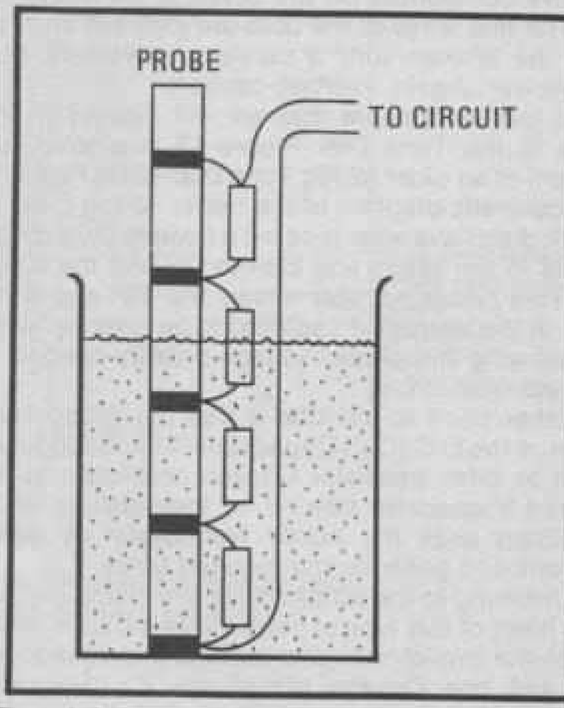


Figure 1. A simple illustration of how the Water-Probe is built.

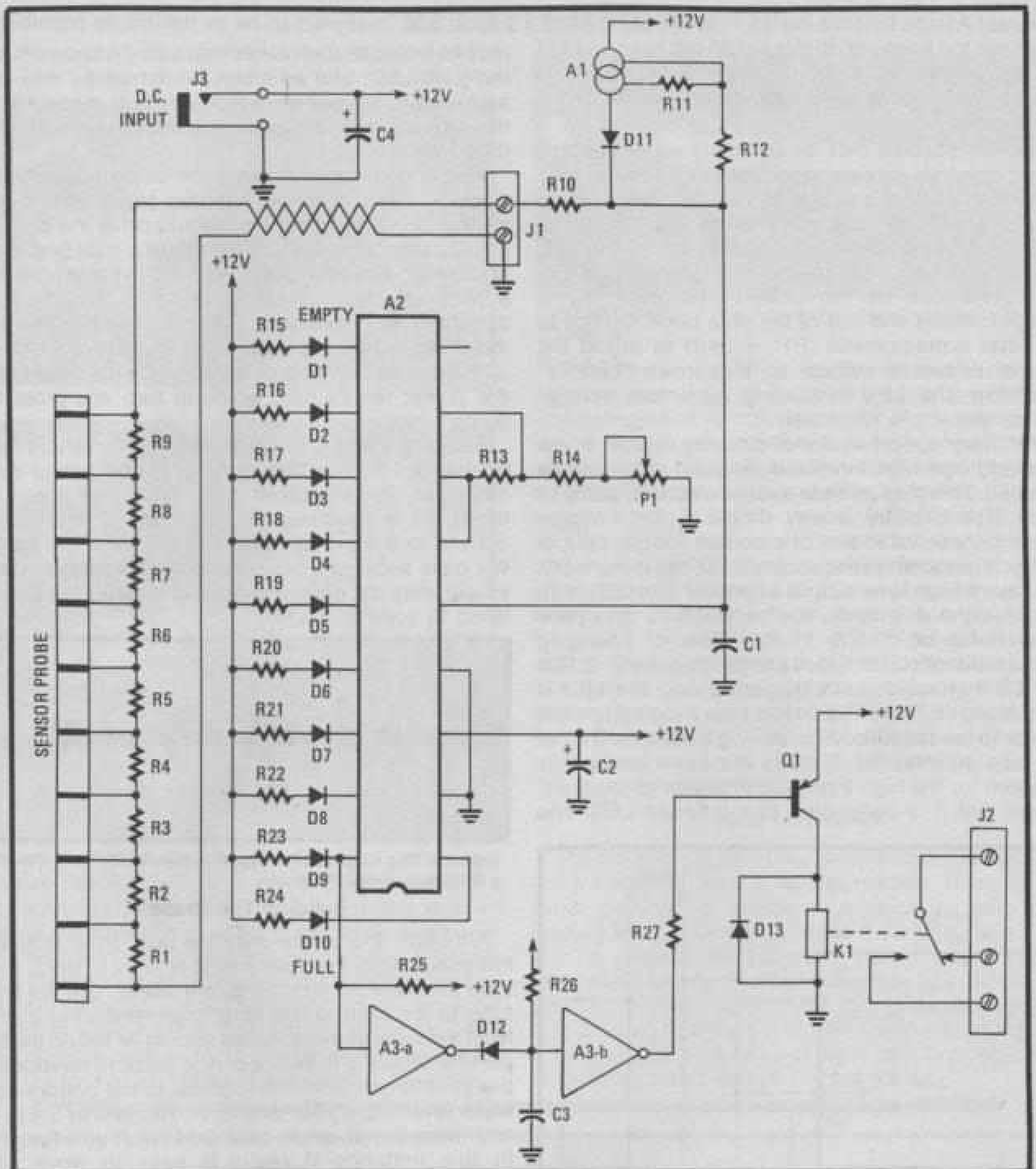


Figure 2. This is a schematic diagram of the Water Monitor.

PARTS LIST FOR THE WATER MONITOR

RESISTORS

R1 Thru R10—15K, 1%
R11—4.3K
R12—43K
R13—1K
R14—2.2K
R15 Thru R24—1K
R25—22K
R26—1M
R27—4.7K

CAPACITORS

C1—.01uF Disc.
C2, C3—1UF, 150V Electrolytic
C4—100 uF, 116V Electrolytic

TRANSISTOR

Q1—2N3906 or Equiv. Gen. Purpose (PNP)

SEMICONDUCTORS

A1—LM334 Current Source
A2—LM3914 Bargraph Driver
A3—CD4584 Schmitt Trigger
D1 Thru D10—Miniature Red LEDs
D11 Thru D13—1N4148 Signal Diode

MISCELLANEOUS

K1—12V coil, SPDT Relay (R.S. 275-241)
P1—4.7K Trimpot
J1—2-screw terminal
J2—3-screw terminal
J3—Power Input Jack
117VAC to 120VOC, 200mA Battery Eliminator (Radio Shack 273-1652 or Equiv.)

to protect A1 and to leave the 0.5 volt residual voltage; otherwise the bargraph meter would not have an LED lit with a sensing voltage of 0 volts, and you could not be sure if the circuit is malfunctioning or you've run out of water!

You will observe that for an empty water tank the circuit develops maximum voltage and, likewise, for a full tank it develops a minimum voltage. This presents no problem for A2, a bargraph driver operated in the dot mode. Upon labeling the display LEDs, the LED that displays Max. voltage would be labeled "EMPTY" (D1). The use of the LM3914 bargraph IC is straightforward and out of the data book. Suffice to say, that potentiometer 'P1" is used to adjust the internal reference voltage so that in an "EMPTY" condition, the LED indicating maximum voltage (connected at pin 10) is well lit.

With very simple optional circuitry, either a low threshold or a high threshold (or both) relay may be included. This may operate a valve, electrical pump or alarm. The circuitry is very simple: Schmitt trigger A3a is connected to any one output; for the sake of clarity, it is shown in the second LED, meaning that it will have a high level output whenever this LED is lit. Since, in the dot mode, the bargraph IC may have some noise or chatter in the midst of changing outputs, the circuit includes a delay made by D12, R26 and C3 that avoids false triggering until the LED is completely lit. Therefore, in this case a logical low will appear in the output of A3b, driving transistor Q1 that will turn on relay K1. Exactly the same circuitry is repeated for the high threshold indicator (if required) except that it is connected to a different LED. The circuit was designed to be as flexible as possible; it may be wired in such a way that a pump turns on, say the third LED, and an alarm on the tenth. You may also wish to delete one of the circuits or, since A3 still has a couple of spare gates, add a third control circuit if you wish.

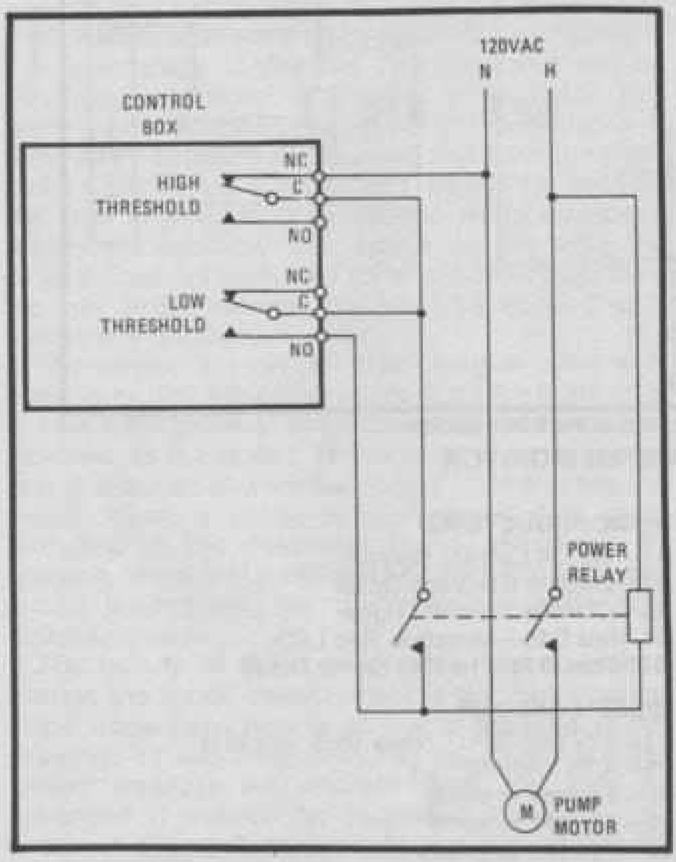


Figure 3. This is a sample of the electrical connections for a fully automatic controller.

Please note that the relays are of low capacity, if a powerful load is to be handled (such as a pump motor); this relay's contact should drive the coil of a power relay or contactor. The actual circuit employed is shown in Figure 3. Suppose that the water level is at a midpoint. AC voltage is available thru the high threshold NC contacts, but is stopped at the low threshold. When the water level drops below the low threshold, its contacts close and AC current is fed to the power relay's coil, which in turn energizes the pump's motor.

The tank starts to fill up and the low threshold relay opens, but an auxiliary contact in the power relay maintains its energized coil. Whenever the high threshold is reached, the relay opens interrupting current to the power relay and the electrical motor. We have avoided a spill and the cycle repeats itself. Power may be obtained from any wall-plug supply rated 12 volts at 200 mA.

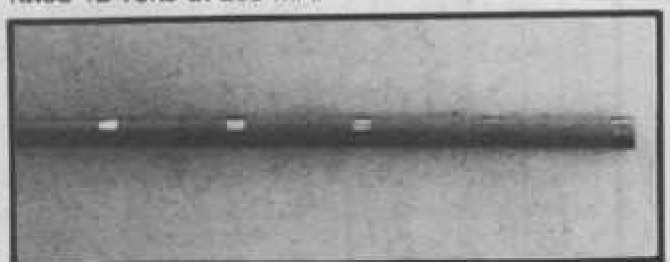


Figure 4. The copper foil wrapped at regular intervals around a PVC pipe makes the probe.

Building The Probe

Although the probe may be built from different materials, what I've found best is ½ inch, rigid, PVC tube available in most hardware stores. Cut the PVC tube to the appropriate length, remembering that at least a couple of extra inches should be left on the top part for securing it. With a pencil, mark 10 divisions in the total length from the topmost to the bottommost water level. I.E. if your tank or well measures 3 ft (91.4 cm) make the divisions each 9.14 cm (You'll find that in this instance it really is easy to work with centimeters; but if you don't feel comfortable with this unit of measurement, inches may be employed. In each division, wrap a turn of adhesive copper tape. This tape, manufactured by 3M and others, is extensively used in radio equipment to cover holes to shield the equipment from interference; it should be available in most electrical stores. See Figure 4. In the event that you can't find the copper tape, a ½ inch ribbon of common household aluminum foil attached to the tube with PVC glue will also do the trick. Next, we prepare (waterproof) the probe's resistors. Solder 24-gauge stranded wire on each end, long enough to reach from one of the copper foils to the next copper foil. Liberally coat the resistor body, leads and soldered junction with silicon caulking glue. Before the glue sets, slice a piece of heat shrinkable tubing over it and apply heat. Some of the "goo" and all the air will be squeezed out, and when the glue sets, you

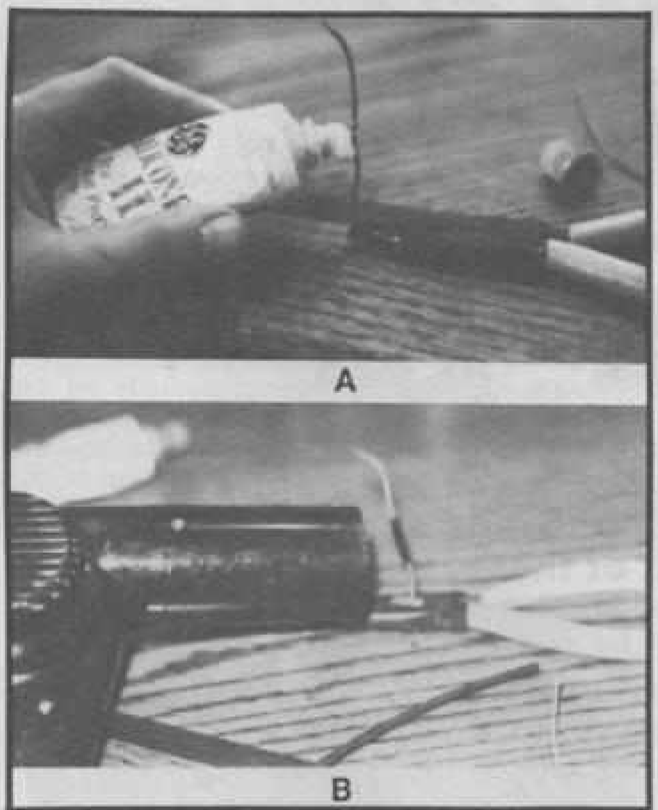


Figure 5. Waterproofing the Resistor. Apply Silicone caulking in the Resistor's body and leads (A), then shrink a heat-shrinkable tubing over the Resistor (B), making a sealed (waterproof) Resistor.

have a fully waterproof resistor. Repeat for the other resistors. See Figure 5. Now, solder each free end to a ring, applying just enough heat to solder without burning the tube. Then apply a plastic tie wrap over everything and your probe is prepared. See Figure 6. If you used aluminum foil, it won't be solderable; therefore, a solid copper wire should be wrapped around as a clamp and soldered. To avoid catching loose objects, be sure to dress your project properly. All wires should be fastened with plastic tie-wraps.

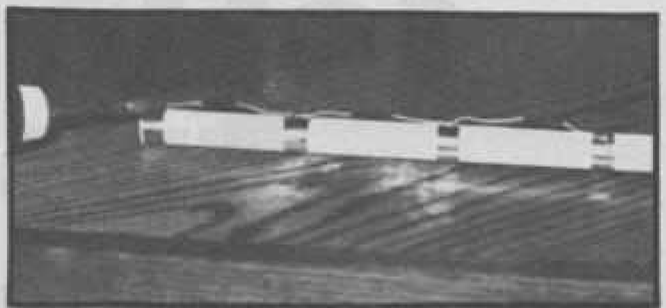


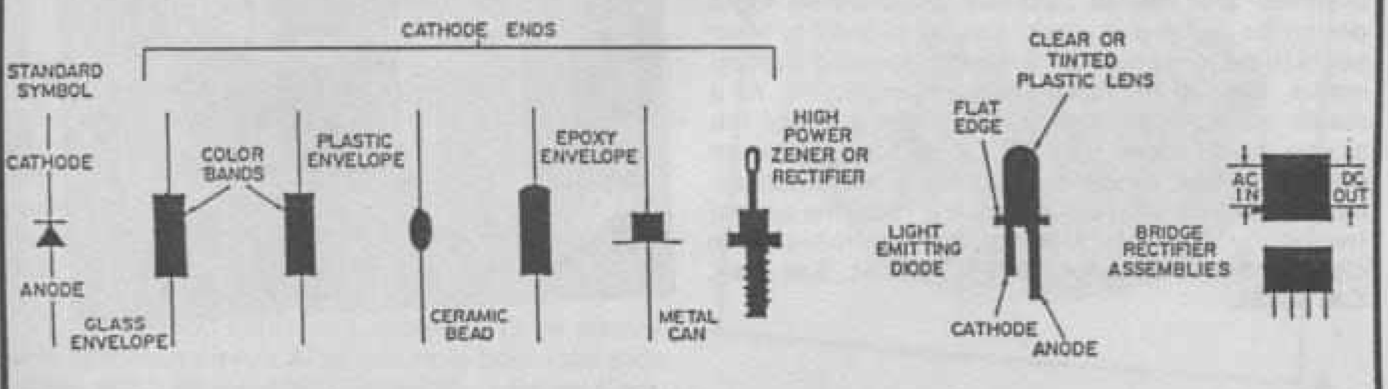
Figure 6. Solder the "waterproofed" Resistor to the copper rings.

Building the circuit is so simple that it may be constructed on an experimenter's perfboard, employing point to point wiring, in which case, bases for the ICs are recommended. Before connecting the sensor, check with a Microammeter across the screw terminal connectors J1 and J2 to be certain that the current supply is 33 microamps +/-5%. If not, recheck your wiring and component placement. If you plan to include the relay options, solder a jumper from the appropriate A2 output to A3's input. Now, connect the assembled probe. Do not immerse in water yet. Adjust P1 so that the LED indicating the highest voltage is well lit. Then, with a length of wire connected to the bottommost copper ring (ground), sequentially short each copper ring and note that the appropriate LED lights up properly. At this same time, check that the relay operates whenever the chosen level is touched. The circuit is now ready.

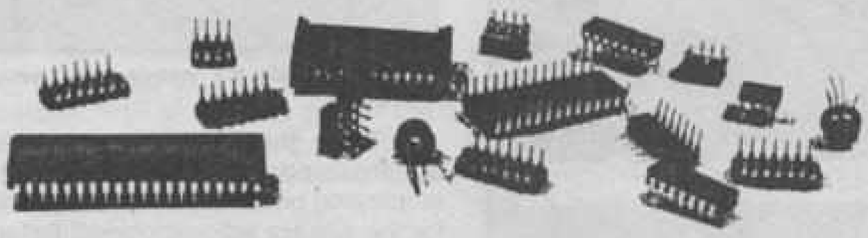
Final Installation

The current-output of the water monitor is certainly more forgiving than a voltage sensor, however, to avoid picking up interference, twist the wire pair leading from the water probe to the control box. This should present no problems up to about 60 ft., otherwise use of a shielded cable may be required. As previously noted, up to three (or none) alarm points may be built into the circuit. If these are handling 120 V AC current, be sure to observe cautions regarding high voltage and always employ a fuse. ■

DIODE DIGEST CHART



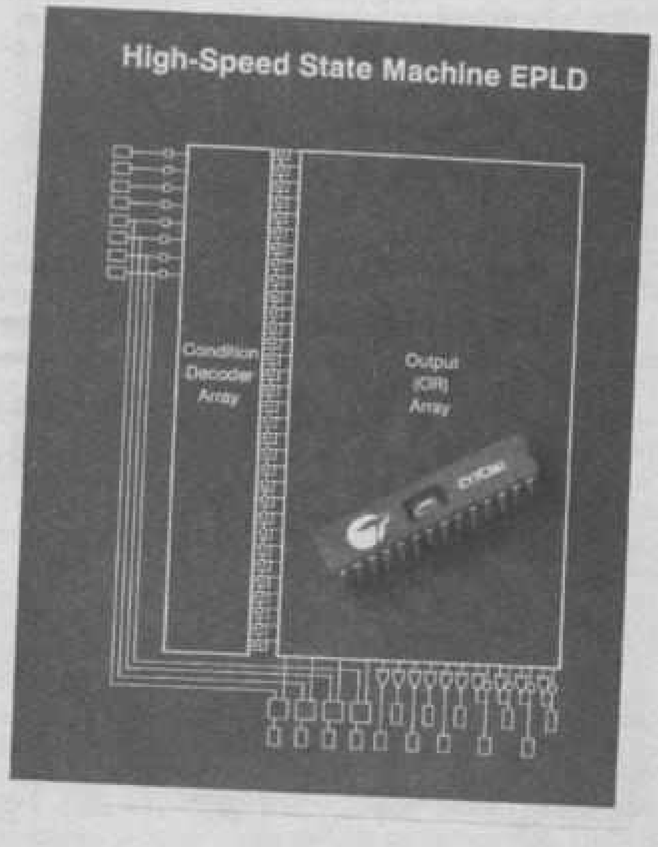
SOLID STATE UPDATE



Each month, the manufacturers of solid state components release literally hundreds of new devices. While we cannot report on all of these, we do intend to feature some of the devices that are most likely to interest our readers. For further information on any of these solid-state components, write directly to the manufacturers. They can provide you with data sheets and application notes at no charge.

CY7C361 125-MHZ STATE MACHINE

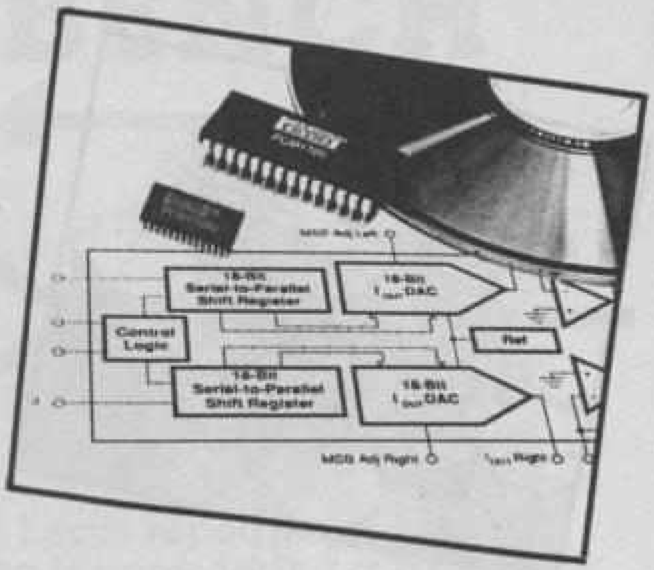
A new high-speed state machine provides the performance needed for design of today's fastest engineering workstations. The CY7C361 125-MHz state machine allows system designers for the first time to implement complex control logic with a highly flexible EPLD (erasable programmable logic device) architecture. The innovative architecture of the CY7C361 allows it to operate at twice the speed of the fastest state machines currently available. The new device reduces design overhead in computer systems, and makes possible EPLD-based logic design for systems at clock rates up to 66 MHz. Most sophisticated computer systems demand system events timed at the clock edge and mid-cycle. As a result, control logic is required to run at twice the system clock speed. The CY7C361 incorporates an on-board clock frequency doubler which automatically creates on-chip clock signals at twice the system frequency. Further information available from **Cypress Semiconductor, 3901 N. First St., San Jose, CA, 95134.**

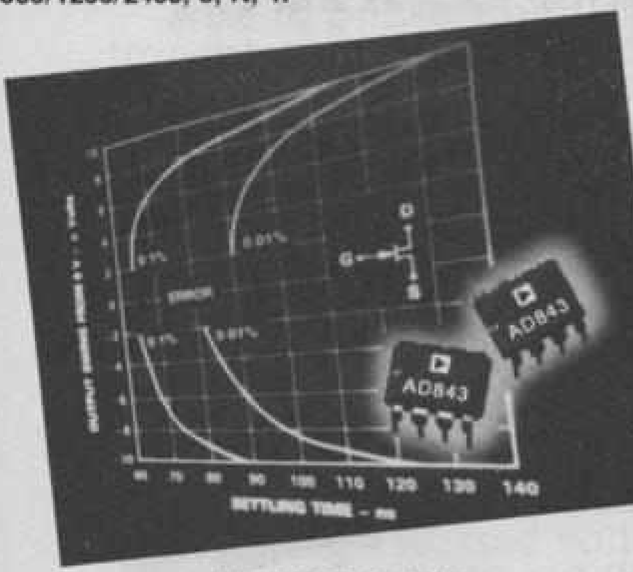


PCM1700P 18-BIT DAC

The industry's first monolithic dual 18-bit audio DAC (digital-to-analog converter) has been announced by Burr-Brown. The PCM1700P has been optimized for digital audio and other dynamic signal-processing applications. Key specifications include -92 dB maximum THD+N (total harmonic distortion plus noise), 107 dB signal-to-noise ratio (20 Hz to 20 KHZ), 3% maximum gain error, 380 mW power dissipation, and settling times of 1.5 microseconds (voltage output) and 300 nanoseconds (current output).

The PCM1700P saves space and lowers costs for stereo and any other application requiring multiple DACs. The device is capable of sampling at up to 768 kHz per channel, permitting up to 16X oversampling of the audio spectrum and giving designers exceptional freedom in output filter selection. You can write to **Burr-Brown Corp., POB 11400, Tucson, AZ, 85734, or access their electronic bulletin board at (602) 741-3978 using the following parameters: 300/1200/2400, 8, N, 1.**





ADS7800 12-BIT A/D CONVERTER

Burr-Brown's new ADS7800 is the fastest complete 12-bit sampling monolithic ADC (analog-to-digital converter) on the market. This new CMOS device acquires a sample in 300 nS max and converts in 2.7 microseconds for a throughput rate of 333 kHz minimum.

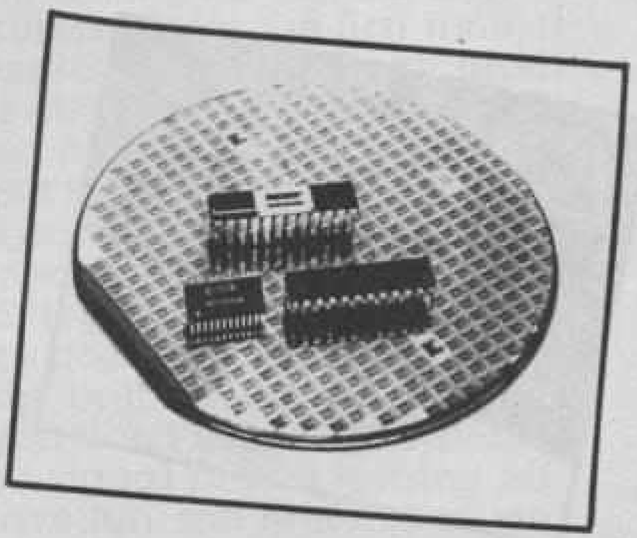
The converter is designed with leading-edge, switched-capacitor array (CDAC) structures which feature the advantages of inherent sampling, reduced space requirements, improved conversion time, and simplified system timing. An innovative input structure developed by Burr-Brown couples this new capacitor-array approach with the company's proven laser-trimmed thin-film resistors to provide users with the industry-standard input ranges of +/- 10 V or +/- 5 V, a first for switched-capacitor ADCs.

The ADS7800 contains a complete 12-bit successive approximation ADC with sample/hold, reference, clock, and 3-state output. Contact **Burr-Brown Corp., P.O. Box 11400, Tucson, AZ, 85734.**

AD843 FET-INPUT OP AMP

Analog Devices' AD843, the industry's fastest FET-input monolithic op amp, needs no external compensation to achieve a 135-nS settling time (to within 0.01%) for 10-volt steps. Compared to other high-speed devices with similar specifications, the internally compensated AD843 costs as much as 45% less ($8.80 in 100s) and dissipates one-third as much power. The maximum quiescent current is 13 mA.

With its 34-MHz gain-bandwidth product, the unity-gain stable AD843 excels in applications that require high precision. In filter and integrator applications, the op amp's guaranteed 1-nA input bias current and 1-mV input offset voltage help keep error to a minimum. Other typical specifications include a 20-pA offset current, 250 V/microsecond slew rate, an open-loop voltage gain of 30,000, and 76 dB common-mode rejection. For more information on the AD843, contact **Analog Devices Inc., 70 Shawmut Road, Canton, MA, 02021.**



PWR40XX DC/DC CONVERTERS

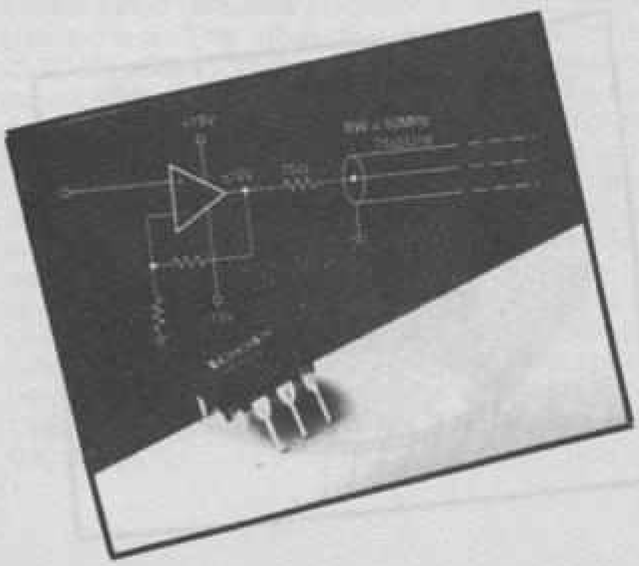
The newly introduced PWR40XX series of unregulated DC/DC converters from Burr-Brown features low noise, high reliability, and low price ($17.00 each in quantities of 1000). The twelve converters in this series accept input voltages of 5, 12, 15, or 24 VDC. The single-output models in this series produce +5 VDC, while the dual-output models produce either +/- 12 VDC or +/- 15 VDC. Other input and output voltages are available upon request, but this applies to large-quantity orders only. Input and output voltages are fully isolated from one another, allowing the designer flexibility in grounding and polarity configurations. Outputs are protected against temporary shorts to ground.

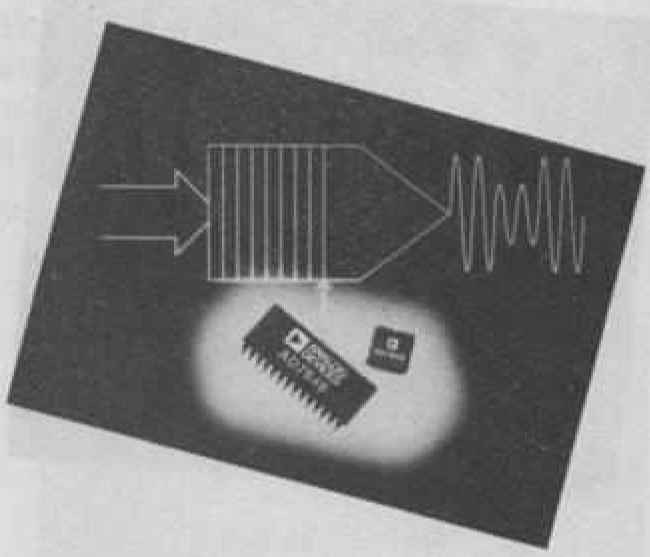
Key features include input and output filtering and a line regulation of $1\%/V_{in}$. All models are specified over a 0-70° C. temperature range and are housed in an industry-standard 1.125" × 1.125" × 0.4" package. Switching frequency is 170 kHz. **Burr-Brown Corp., POB 11400, Tucson, AZ, 85734.**

AD7848 12-BIT DAC

The AD7848 consists of a 12-bit digital-to-analog converter (DAC) together with a first-in, first-out memory (FIFO), an output buffer amplifier, and a voltage reference. The 8-word-deep on-chip FIFO permits output data words to be loaded into the AD7848 in a single data-transfer operation. A 42-nS minimum write-pulse width allows the DAC to be connected directly to most high-speed digital signal processors, thus eliminating the need for external wait-state logic. And a 4-microsecond maximum settling time together with a 250-kHz output rate makes the DAC well-suited for audio-bandwidth, voiceband modem and servo-control applications.

The AD7848 offers +/- one-half LSB (least significant bit) typical relative accuracy, +/- one-half LSB typical differential nonlinearity, and +/- 4 LSB maximum full-scale error. Minimum signal-to-noise ratio is 72 dB; typical total harmonic distortion is -80 dB. Contact **Analog Devices, 70 Shawmut Rd., Canton, MA, 02021.**



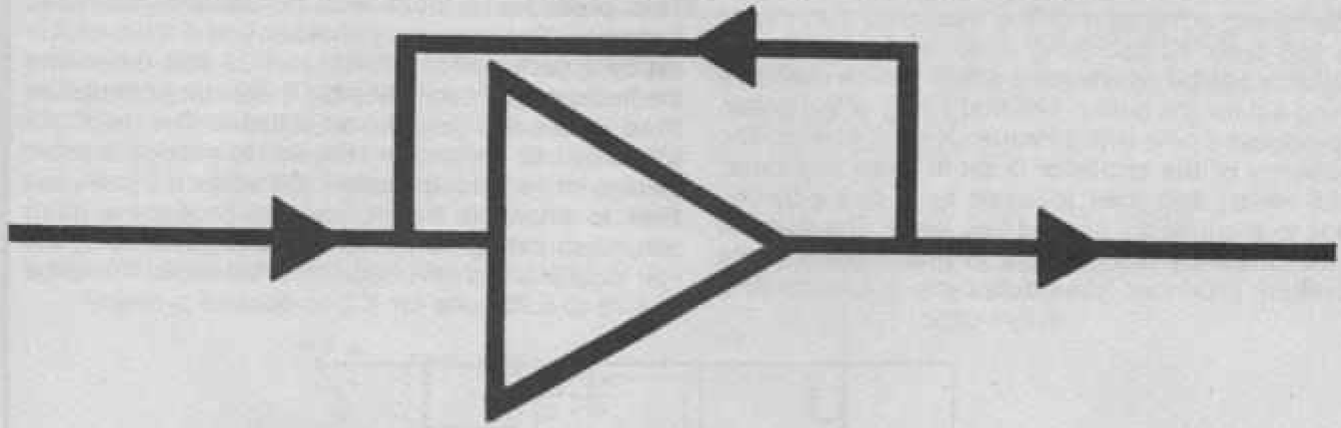


OPA603 OP AMP

The OPA603 from Burr-Brown is a new current-feedback op amp designed for high-frequency applications such as data acquisition, sonar, ultrasound, and video. The device provides a nearly constant 45-MHz bandwidth over a wide range of closed-loop voltage gains. Settling time (to within 0.1%) is 50 nS. The proper choice of feedback resistor values can be determined from simple curves appearing in the detailed data sheet.

Besides having high-speed characteristics, the OPA603 is also capable of producing high output current, which makes it suitable for driving a transmission line or capacitive load. The slew rate with 10V signal levels and a 150-ohm load is 1000 volts per microsecond. Power supply voltages can range from +/- 4.5 V to +/- 18 V. Price of the OPA603 is $4.95 in hundreds, and delivery is from stock to 3 weeks. For further information and a data sheet, write to **Burr-Brown Corp., POB 11400, Tucson, AZ, 85734.**

IC TESTBENCH



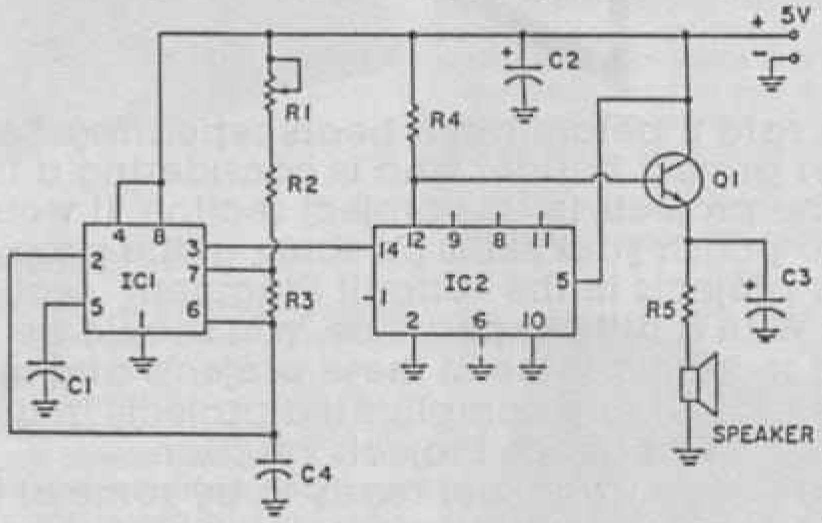
We have said it before but it bears repeating. For the beginner project builder who is considering a try at some of the projects in this project section, it would be wise to polish your skills on some of the simpler transistor projects in the "Circuit Fragment" section of this issue. With a little experience, you should be better prepared to tackle some of these projects and maybe some of the more complicated projects in the "Workbench Projects" section.

For those of you who feel ready to try some of the following projects, we offer some suggestions and precautions. Unless you're using a commercially made breadboard, it would be wise to invest in sockets, whose holes accomodate IC pin spacings for the particular ICs which you're planning to use. Through the use of sockets, solder connections can be made without the danger of damage to the IC, and voltage and input signal tests can be performed without the IC being exposed to their hazards.

When debugging a circuit, or testing for signals and voltages prior to firing your project up for the first time, it is important that you remember to NEVER apply an input signal to a chip unless the circuit is powered up. Damage will certainly occur. Also, in those projects which require a separate input signal, such as a clock source, which is not an integrated part of the circuit you're building, it's a good idea to use a power switch which is capable of controlling the supply to both circuits. This will minimize the possiblity of applying a signal to a non-powered chip, both in turning on the circuit and turning it off. If you don't use this method, remember to remove the input signal before turning off the power to the IC circuit...Have fun, but remember, we warned you!

GUITAR TUNING AID

By taking advantage of the frequency stability of the 555 timer IC operating in an astable mode, an oscillator can be constructed which can be used as a tuning aid for the guitar. The first string of the guitar, E, produces a note with a frequency of 82.4 Hertz. The frequency of the oscillator is set to twice this value, 164.8 Hertz, and then followed by a divide-by-two stage to produce the desired frequency. The purpose of the divide-by-two stage is to guarantee that the waveform produced has a duty cycle of exactly 50%. This produces a note with no second harmonic distortion. The frequency of oscillation of the circuit is set by adjustment of R1. R2, and C2 also determine the frequency of oscillation but these components are fixed values and need no adjustment. The output of IC2 is fed to an emitter follower to provide current gain to drive a loudspeaker. C3 acts as a low-pass filter to attenuate harmonics and produce a more natural sounding note. The circuit is powered by a 5 volt supply, and this voltage *must* fall within the range of 4.75 to 5.25 volts for IC2 to operate properly.



PARTS LIST FOR GUITAR TUNER

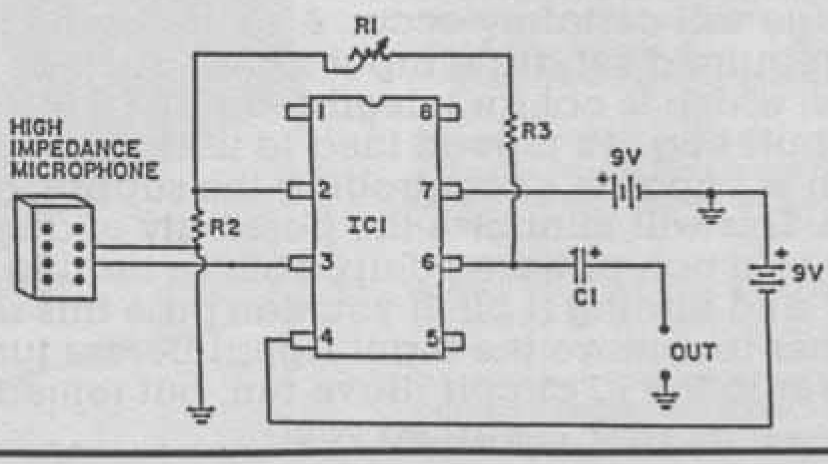
C1-C4—0.1-uF ceramic capacitor, 15 VDC
C2—15-uF electrolytic capacitor, 15 VDC
C3—100-uF electrolytic capacitor, 15 VDC
IC1—555 timer
IC2—7490 decade counter
Q1—2N4401
R1—50,000-ohm linear-taper potentiometer
R2, R4—4,700-ohm, ½-watt resistor
R3—33,000-ohm, ½-watt resistor
R5—33-ohm, ½-watt resistor
SPKR—8-ohm PM type speaker

HI Z MIKE AMP

A high impedance microphone will drive this circuit nicely. The output can drive a 1000 ohm earphone directly, or it can drive a transistor to, in turn, run a speaker. The gain is determined by the ratio of R1 to R2 and, in practice , can get up to about 50 dB.

PARTS LIST FOR HI-IMPEDANCE MIKE AMP

C1—68-uF electrolytic capacitor, 25 VDC
IC1—741 op amp
R1—500,000-ohm linear-taper potentiometer
R2, R3—1,000-ohm, ½-watt resistor

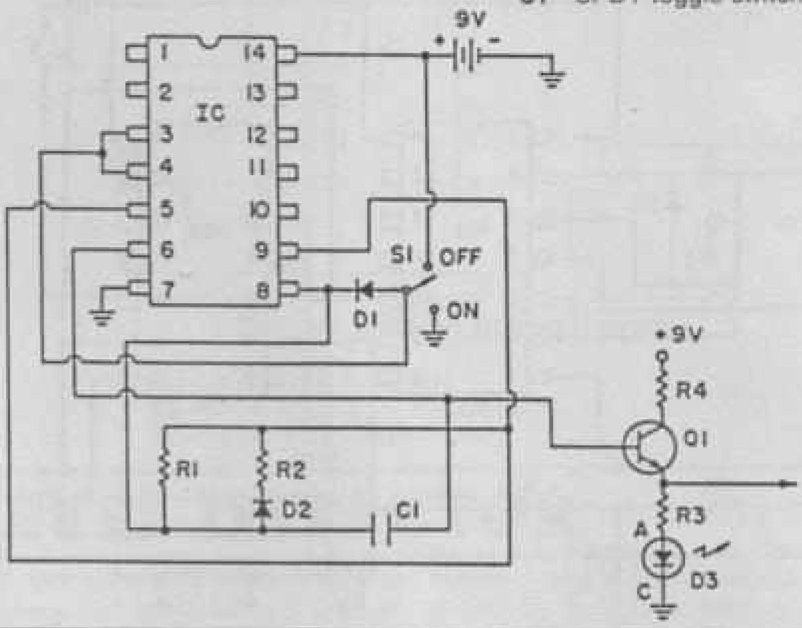


PULSED ALARM

This circuit is great for driving alarms because it pulses the bell or buzzer with a frequency you can select via R1 and R2. The pulsing action not only gets attention faster, but saves battery power as well, because the alarm can run longer. And the beauty of this circuit is its low power consumption. In the off state, before the panic switch S1 is thrown, the circuit uses microwatts of power, so it can sit ready for months. That's one of the beauties of CMOS.

PARTS LIST FOR PULSED ALARM

C1—0.68-uF tantalum capacitor, 15 VDC
D1, D2—1N4001 diode
D3—small LED
IC1—4000 NOR gate
Q1—2N4401
R1—10,000,000-ohm, ½-watt resistor
R2—1,000,000-ohm, ½-watt resistor
R3—1,000-ohm, ½-watt resistor
R4—10-ohm, ½-watt resistor
S1—SPDT toggle switch

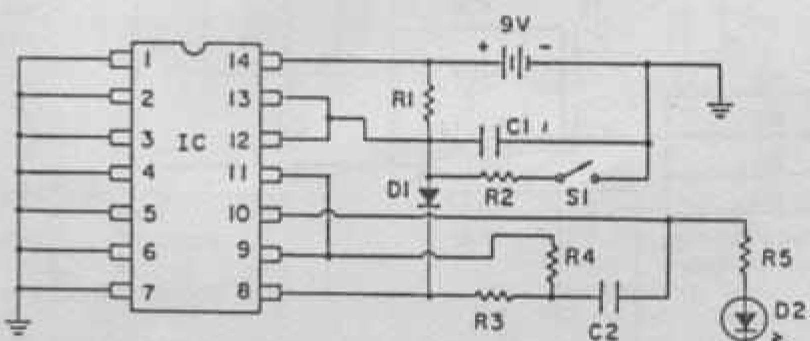


LED BLACKJACK

The object is to see who can get closest to 21 LED flashes without going over. Any number of people can play. Press S1 until D2 starts flashing (1 second on, 1 second off). Then count the number of pulses *after* S1 is released. You may get 5 the first time. That is like being dealt a 5 in Black Jack. Do it again and add the second count to the first, etcetera, until you are as close as you can get to 21 without going over. If you go over, you are out of the game. A fun game and easy to build. The 9 volt battery will last for months.

PARTS LIST FOR LED BLACKJACK

C1—4.7-uF tantalum capacitor, 15 VDC
C2—.01-uF ceramic disc capacitor, 15 VDC
D1—1N4001 diode
D2—small LED
IC1—4000 NOR gate
R1—5,000,000-ohm, ½-watt resistor
R2—30,000-ohm, ½-watt resistor
R3, R4—10,000,000-ohm, ½-watt resistor
R5—1,000-ohm, ½-watt resistor
S1—SPST pushbutton (doorbell) switch

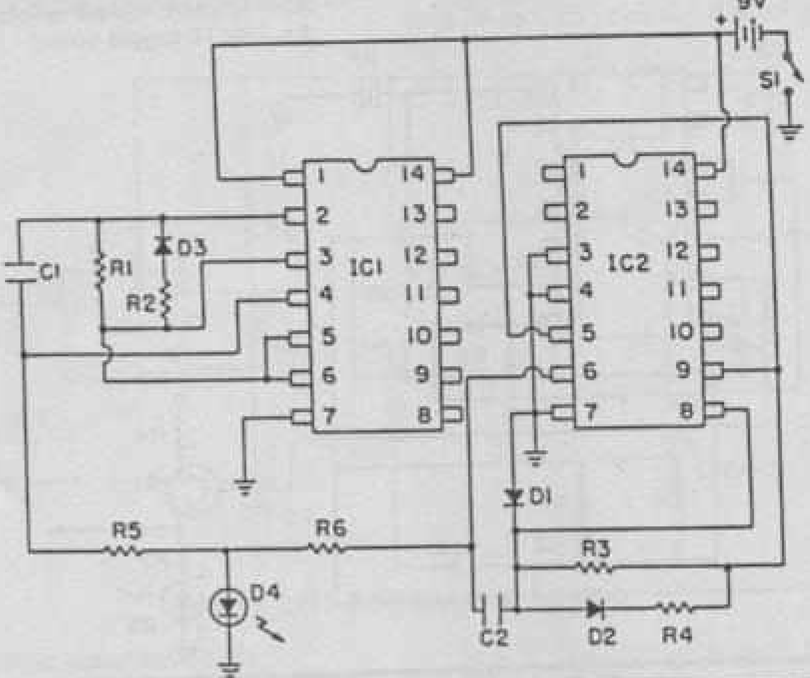


CRAZY FLASHER

This flasher will drive you crazy, especially if you make R1, R2, R3 and R4 variable resistors. LED D4 will flash some wild beats. For a wild party effect, hook up a relay in place of D4 and drive a spot light. Combine with disco music and you have a crazy scene!

PARTS LIST FOR CRAZY FLASHER

C1—0.1-uF ceramic disc capacitor, 15 VDC
C2—0.68-uF tantalum capacitor, 15 VDC
D1, D2, D3—1N4001 diode
IC1—4011 NAND gate
IC2—4000 NOR gate
R1—5,000,000-ohm, ½-watt resistor
R2—100,000-ohm ½-watt resistor
R3—10,000,000-ohm ½-watt resistor
R4—1,000,000-ohm, ½-watt resistor
R5, R6—2,000-ohm, ½-watt resistor
S1—SPST toggle switch

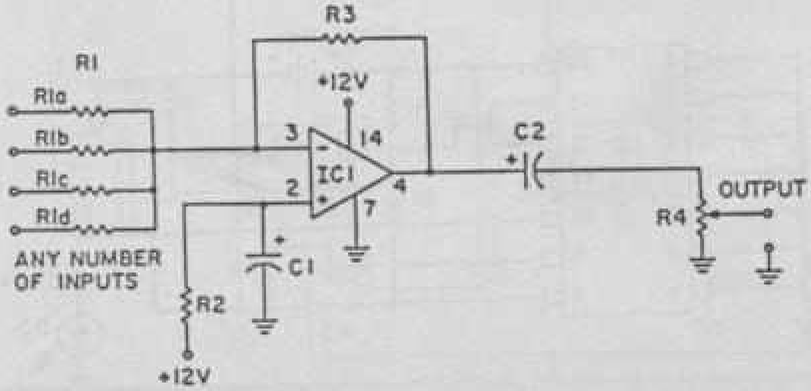


MIXING SIGNALS

When a number of audio signals are to be mixed or blended, isolation should be maintained between the originating sources. Using the almost identical LM 3900 or MC 3401 quad op amps, twelve organ tone generator outputs were combined into one output via one section. In the circuit below, signals of 4 to 5 volts peak amplitude were mixed at unity gain. Resistor R2 is usually twice the value of feedback resistor R3, but it can be varied to shift the output level and avoid or purposely introduce waveform clipping.

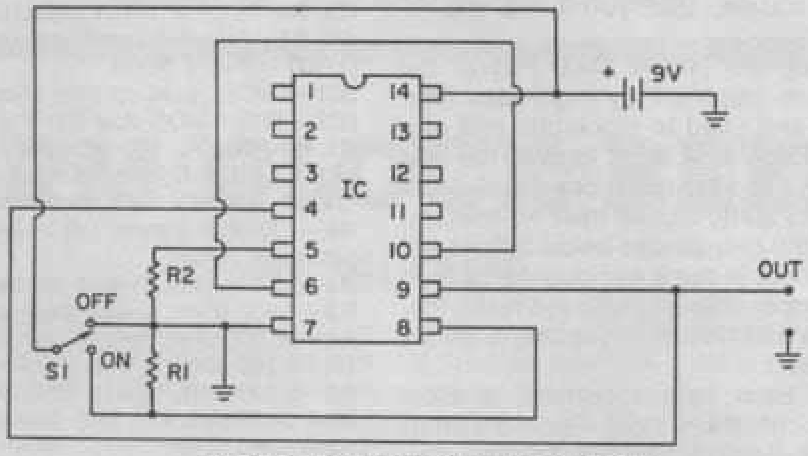
PARTS LIST FOR MIXING THE SIGNALS

C1—7 to 10-uF electrolytic capacitor, 25 VDC
C2—50-uF electrolytic capacitor, 25 VDC
IC1—LM-3900 or MC-3401 quad op amp
R1—100,000-ohm ½-watt resistor (as many as needed)
R2—200,000-ohm ½-watt resistor (see text)
R3—100,000-ohm ½-watt resistor (see text)
R4—25,000-ohm taper potentiometer



CLEAN SWITCH

There is nothing worse in a circuit than a noisy switch. Even the slightest bounce will cause a double "on" and lead to double digits on your calculator display, or extra pulses into a million dollar computer system .So what to do? This circuit shows the basic idea used throughout the computer industry. The CD 4001 NOR gates are hooked up in flip-flop fashion so that once they flip, they stay that way. Double bounces still lead to a single, solid "on" pulse at the output.

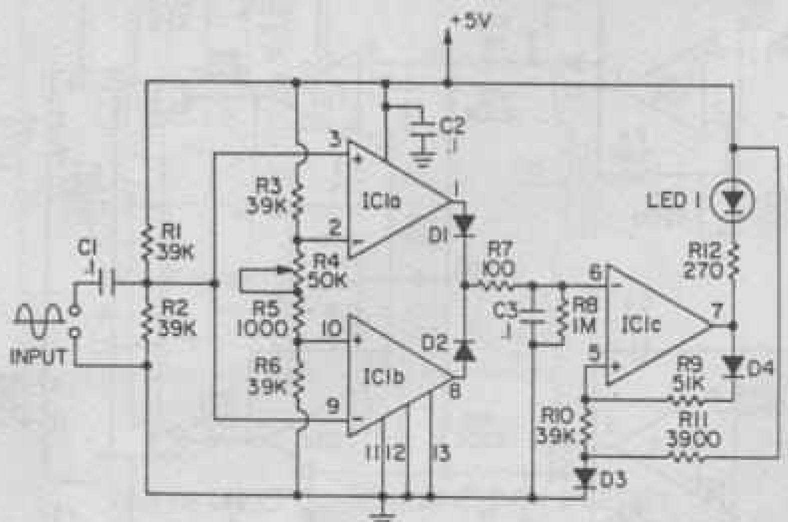


PARTS LIST FOR CLEAN SWITCH

IC1—4001 quad NOR gate
R1, R2—870,000-ohm, ½-watt resistors
S1—SPDT slide switch

PEAK-LEVEL DETECTOR

In many situations, particularly in recording, it is more important to know a signal's peak level than its average level. While VU meters are customarily employed for such purposes, you'll find this circuit's LED output easier to interpret and, as a result, more accurate. IC1a gauges the positive peaks, while IC1b does the same for the negative peaks. Both the positive and negative signal thresholds are determined by pot R4's setting. You can choose any threshold from ±20 mV to ±1 V. Whenever the input exceeds either the positive or negative threshold, LED1 flashes on for approximately one-tenth of a second. That's long enough to attract your attention and warn you to cut back on the volume.



PARTS LIST FOR PEAK-LEVEL DETECTOR

C1, C2, C3—0.1-uF ceramic disc capacitors
D1-D4—1N914 diodes
IC1—LM324 quad op amp integrated circuit
LED1—light emitting diode
R1, R2, R3, R6, R10—39,000-ohm, ½-watt resistors
(all resistors 5%)
R4—50,000-ohm, ¼-watt trim-potentiometer
R5—1,000-ohm, ½-watt resistor
R7—100-ohm, ½-watt resistor
R8—1,000,000-ohm, ½-watt resistor
R9—51,000-ohm, ½-watt resistor
R11—3,900-ohm, ½-watt resistor
R12—270-ohm, ½-watt resistor

CASSETTE-BASED CONTROL SYSTEM

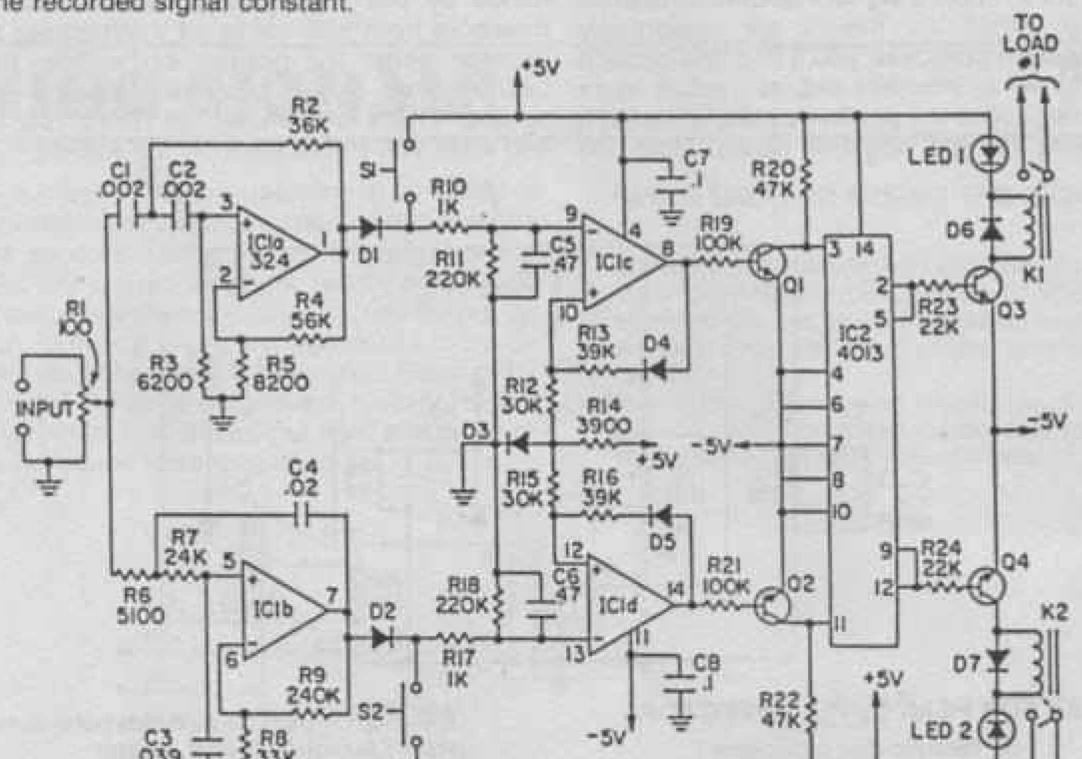
Let's say that you need a programmable control system that can perform a timed sequence of operations. This sounds like a job for a high-priced computer, doesn't it? In many instances, however, just a cheap cassette recorder can do a respectable job—provided, of course, that you build this 2-channel controller.

High-frequency signals (above 5000 Hz) at the controller's input are amplified by high-pass filter U1a, then detected and used to clock one half of a dual flip-flop (U2). Each tone burst toggles the flip-flop, causing relay K1 to alternately open and close. These high-frequency audio signals have no effect on low-pass filter U1b, but frequencies below 500 Hz will produce the same effect in the lower channel as high frequencies in the upper channel, with the result that K2 alternately opens and closes on successve bursts of low frequency audio.

Feed the signal from your recorder's speaker output jack to the controller's input. Record a short sequence of tones—about 300 Hz for the low channel, and 7500 Hz for the high channel. Play back the tape-recorded sequence, and adjust R1 somewhat past the point where toggling of the relays starts. The LED's go on and off with the relays and serve as convenient indicators of channel activity. Push-buttons S1 and S2 can be used to change the status of a channel independently of the audio input. Whistles, tuning forks and electronic oscillators can all be used as tone sources. Whichever you use, strive to keep the level of the recorded signal constant.

PARTS LIST FOR CASSETTE-BASED CONTROL SYSTEM

C1, C2—.002-uF polystyrene capacitor
C3—.039-uF polystyrene capacitor
C4—.02-uF polystyrene capacitor
C5, C6—0.47-uF mylar capacitor
C7, C8—0.1-uF ceramic disc capacitor
D1-D7—1N914 diode
IC1—LM324 quad op amp integrated circuit
IC2—4013 CMOS dual flip-flop integrated circuit
K1, K2—6-VDC, 500-ohm relay
LED1, LED2—light-emitting diode
Q1-Q4—2N3904 NPN transistor
R1—100-ohm trimpot (all resistors 10% unless otherwise noted).
R2—36,000-ohm, ½-watt resistor 5%
R3—6,800-ohm, ½-watt resistor 5%
R4—56,000-ohm, ½-watt resistor 5%
R5—8,200-ohm, ½-watt resistor 5%
R6—5,100-ohm, ½-watt resistor 5%
R7—24,000-ohm, ½-watt resistor 5%
R8—33,000-ohm, ½-watt resistor 5%
R9—240,000-ohm, ½-watt resistor 5%
R10, R17—1,000-ohm, ½-watt resistor
R11, R18—220,000-ohm, ½-watt resistor
R12, R15—30,000-ohm, ½-watt resistor
R13, R16—39,000-ohm, ½-watt resistor
R14—3,900-ohm, ½-watt resistor
R19, R21—100,000-ohm, ½-watt resistor
R20, R22—47,000-ohm, ½-watt resistor
R23, R24—22,000-ohm, ½-watt resistor
S1, S2—pushbutton switch, normally open



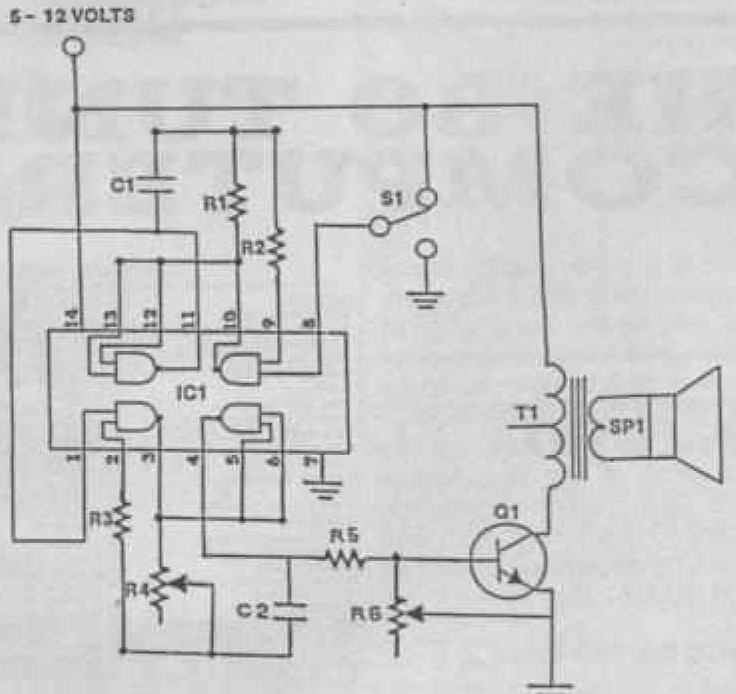
CONSTRUCTION QUICKIE

ALARM CLOCK BEEPER

By Bill Axsen

You may have wondered how your alarm clock or some other appliance around the house makes that beeping sound. With the Alarm Clock Beeper you can learn the principles behind such circuits and tailor them to your own purposes. By removing switch S1 and hooking pin 8 to any TTL of CMOS circuit you can digitally activate the beeper. The beeper can be used in burglar alarms' timing circuits, or any circuit which requires an audible alarm. You will be amazed at how much output you can obtain from such a simple circuit.

The operation of the circuit is quite simple. All four of the 4011 gates are used to make up two oscillators, with the slower oscillator operating at approximately 1 Hertz and the others operating at about 1000 Hertz. The slower oscillator turns off the faster oscillator at one second intervals, producing the beeping sound heard in the speaker. Transistor Q1 amplifies the signal produced at pin 4 of IC1 and drives the speaker. Potentiometer R4 is used to adjust the frequency of oscillation and RG is used as a volume control.



PARTS LIST FOR ALARM CLOCK BEEPER

C1—.22uF Capacitor
C2—.001uf Capacitor
IC1—4011 CMOS Quad 2-input NAND Gate
R1, R2, R3—1,500,000 ohm ¼ Watt Resistor
R4—1,000,000 ohm Potentiometer
R5—10,000 ohm, ¼ Watt Resistor
R6—5000 ohm Audio Taper Potentiometer
Q1—2N3903 NPN Transistor of Equivalent
S1—Toggle Switch SPDT
T1—Audio Output Transformer 1000 ohm center tapped primary 8 ohm secondary Radio Shack #273-1380
SP1—8 ohm ½ watt speaker
Power Supply—5 to 12 volts

ALL ABOUT CRYSTAL SETS. Theory and construction of crystal set radios. $7.95, ppd USA. **Allabout Books, Dept. H., Box 14155, Fremont, CA 94539.**

BUILD YOUR OWN *LASER!*

New manual reveals latest laser break-throughs and gives complete step-by-step instructions for building 6 kinds of real working lasers with easy-to-get parts (sources for all parts are given) - including an infrared laser that you can make quickly for under $30! 30-Day Money-Back Guarantee if not completely satisfied. Send $8.75 plus $2.75 P&H to: Biophysics Inc., 902-H W.36th St., Baltimore, MD 21211

VIDEO MONITOR. 15-inch, high resolution (800 lines), black-and-white, studio-quality monitor in metal cabinet. Used only 100 hours. Perfect condition. Guaranteed. $135 ($330 list). Use for CCTV, Surveillance, etc. For more information, write **Walter Sikonowitz, c/o Electrographics, P.O. Box 537, Auburn, N.Y. 13021.**

ALL ABOUT METERS. A Learn-by-doing history of the development of electrical meters. Build seven simple meters using common hardware. $7.95, ppd USA. **Allabout Books, Dept. H., Box 14155, Fremont, CA 94539.**

THE 80 TUNE COMPUTER

The 80-Tune Computer is a project which is not only easy to build but also fun to use. Its uses are many and are limited only by the imagination of the builder. This is an excellent beginner's project because of its simplicity. A masked microprocessor (special Integrated Circuit, or IC) does all the work.

Any of the 80 songs can be selected by the telephone-style keypad. A push of the *Play* button makes the selection. The *Stop* button resets the microprocessor. The selected tune will start each time the *Play* button is pushed as long as power is on and no *Reset* (or *Stop*) occurs.

Complete plans to build the "80-Tune Computer" $2.95

U1 Custom Microprocessor $9.00

PCB Printed Circuit Board $4.95

Add $2.00 for postage & handling

For each combination of the above items, send check or money order (U.S. funds) to:
C&E Hobby Handbooks, Inc.
P.O. Box #5148, North Branch, N.J. 08876

80 TUNE COMPUTER SONG LIST

0 AMERICA
1 ANCHORS AWEIGH
2 BATTLE HYMN REPUBLIC
3 CAISSONS GO ROLLING
4 CALL TO COLORS
5 CAVALRY CHARGE
6 DIXIE
7 HAIL BRITTANIA
8 YANKEE DOODLE DANDY
9 LA MARSEILLAISE
10 MARINE HYMN
11 REVEILLE
12 STARS & STRIPES
13 TAPS
14 WILD BLUE YONDER
15 ALOUETTE
16 ARIVEDERCHI ROMA
17 CAMPTOWN RACES
18 CANDY MAN
19 CHATTANOOGA CHOO-CHOO
20 CLEMENTINE
21 DALLAS THEME
22 EL PASO
23 THE ENTERTAINER
24 JOLLY GOOD FELLOW
25 FUNERAL MARCH
26 HAVA NAGILAH
27 IN HEAVEN IS NO BEER
28 JIMMY CRACK CORN
29 JINGLE BELLS
30 KING OF ROAD
31 LA CUCARACHA
32 LONE RANGER
33 MODEL T
34 THE OLD GREY MARE
35 POPEYE
36 RAINDROPS
37 SAILORS HORNPIPE
38 SAN ANTONIO ROSE
39 SEE THE USA
40 OUT TO THE BALLGAME
41 TIJUANA TAXI
42 TWO BITS
43 WABASH CANNONBALL
44 SAINTS GO MARCHING
45 WOODY WOODPECKER
46 YELLOW ROSE OF TEXAS
47 ACROSS THE FIELD
48 AGGIE WAR HYMN
49 ARKANSAS FIGHT SONG
50 BE SHARP
51 BOOMER SOONER
52 BOW DOWN WASHINGTON
53 BUCKLE DOWN WINSOCKI
54 CHARGE
55 DEAR OLD NEBRASKA U.
56 THE EYES OF TEXAS
57 ABOVE CAYUGA'S WATERS
58 FIGHT ON USC
59 GO, NORTHWESTERN
60 HAIL PURDUE
61 HEY LOOK ME OVER
62 HOLD THAT TIGER
63 ILLINOIS LOYALTY
64 INDIANA, OUR INDIANA
65 I'M A JAYHAWK
66 IOWA FIGHT SONG
67 LOVE YA BLUE
68 MICHIGAN STATE FIGHT
69 MINNESOTA ROUSER
70 NITTANY LION
71 NOTRE DAME FIGHT
72 OLE MISS
73 ON, BRAVE ARMY TEAM
74 ON WISCONSIN
75 WRECK FROM GA. TECH
76 ROLL ON TULANE
77 THE VICTORS
78 WASHINGTON/LEE SWING
79 YEA ALABAMA

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Record telephone conversations in your office or home. Connects between any cassette or tape recorder and your telephone line. Starts automatically when phone is lifted to make or take a call. Records both sides of the conversation. Stops recorder when phone is hung up. PH009CE

ONLY 19^99 AT OCTE

PH009CE

Please send _____ PH009CE telephone recorder switches. I enclose 19.99 each plus a one time charge of $2.50 for UPS shipment. For a total of_______.

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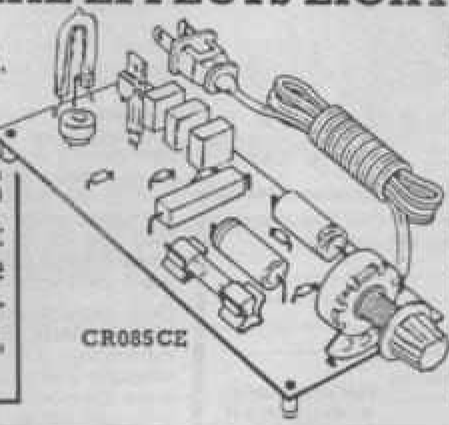
- Includes all parts, PC board, and detailed instruction manual.



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Demonstrates theory of: Voltage Doubling, Time Constant, Neon Oscillation, Pulse Circuitry, Xenon Gas, SCRs.

Please ship _____ CR085CE variable speed strobe units. I enclose 34.95 per kit plus a total of 2.00 for shipping and handling. (Shipped open account with school purchase order).

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- Input 45MV Rms at 1KHz
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- 20 Hz to 20 KHz
- Requires 9 to 14VDC

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This state-of-the-art, complementary symmetry amplifier (a circuit that uses both PNP and NPN transistors in a symmetrical arrangement permitting push-pull operation without an input transformer or other form of phase inverter), uses discreet components, is efficient, has low distortion and high frequency response. Ideal for use in small intercoms, introduction to electronics. This kit is used in schools for the grade 8 & 10 beginning electronics courses. Includes all parts, PC Board, Transistors, Solder, Speaker Wire and instructions. CR093CE

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FLEAMARKET

3 CHANNEL COLOR ORGAN KIT

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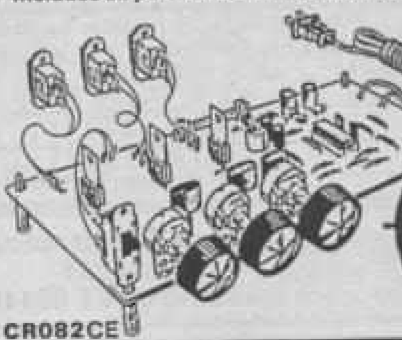
- 300 watts per channel
- Quad Op-Amp state variable filter
- Includes all parts and detailed instructions



ONLY 29.95

CR082CE

YES! PLEASE RUSH THE FOLLOWING ORDER

QUANTITY	PART NUMBER	DESCRIPTION	PRICE EACH	TOTAL
	CR082CE	COLOR ORGAN KIT	29.95	
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		I enclose a total of		

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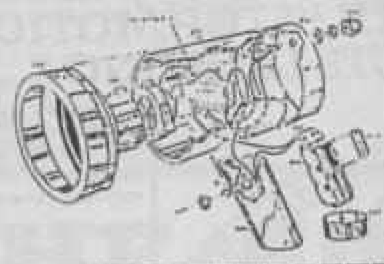

Written by world famous Inventor and Author Robert Iannini

A fascinating state-of-the-art collection of highly unique devices totally unlike those found in run-of-the-mill electronics projects books - includes lasers for a variety of applications, ultrasonic units, scientific experiments, space-age security devices, and more!

This hands-on building guide gives detailed instructions for building a wide variety of high technology devices that are both exciting to put together, and in many cases highly useful. Here's where's readers can become a part of the technology race of the future, learning the fundamentals of modern electronics while actually putting together such devices as a solid-state gas IR laser rifle (for weapons simulation, target designation, or communications) or an invisible sentry property guard alarm system.

Other projects include: a visible-red laser light gun for use in special effects, light shows, holography, optical studies, meteorology; a rodent control device that generates sufficient ultrasonic energy to force pests from an average-sized house; and a 250 thousand volt Tesla coil to produce a variety of eerie and exotic effects. 308 pages, 150 illus. **TA431CE**

Yes...Please rush me _____ copies of "Build-Your-Own". I enclose 16.95 per copy plus a total of 1.50 for postage and handling.

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TA431CE

KEEP YOUR TELEPHONE CALLS PRIVATE . . .

ELIMINATE EXTENSION PHONE EAVESDROPPING!

With an OCTE CR056CE on each phone in the house, the first person to pick up thhe phone is the only one who can use that line until that phone is hung up. No one else can listen in on the other extensions; thus avoiding eavesdropping. Installs easily with a modular plug on one end and a modular jack on the other end. For single line phones only. Order one for each phone in your house or office. CR056CE

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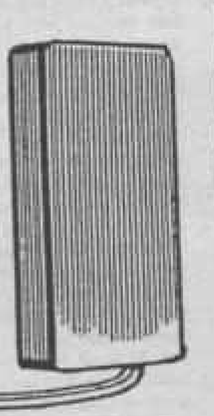

I enclose $_____ Please ship me _____ OCTE CR056 CE telephone privacy adapters. I have included $2.00 for shipping and handling.

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THE CATALOG CORNER

If you live in a relatively remote area that doesn't have ready sources for electronic parts, you can send away to numerous supply houses, who have good catalogs of electronic parts and assemblies...many of them real bargains.

Following are several catalogs that we have recently received in the mail, with brief descriptions and comments. Most of these suppliers send out new catalogs every four to six months, with many of the items repeated and new ones added, plus some new "specials"...usually on the first couple pages and the last few pages of each issue.

TECHNI-TOOL

After looking over several hundred catalogs, you tend to form definitive opinions about what distinguishes a great catalog from the run of the mill. Having said that, we've got to confess that the new catalog from Techni-Tool is one of our favorites. Why? Well, for one thing, it's got a colorful cover, and on the inside, every single item, from a $500 tool kit to a $5 pair of tweezers, is clearly illustrated. What's more, the catalog consists almost entirely of tools used in electronic assembly. If you're looking for sledge hammers or kitchen utensils, you'll have to look elsewhere, but if you want precision electronic tools, the Techni-Tool catalog is the place to look.

They've got soldering irons, solder pots, wire-wrap tools, pliers, diagonal cutters, test instruments, PBC drills, and much more in their 232-page catalog. You can get your own copy of the Techni-Tool catalog at no charge by writing to **Techni-Tool Inc., 5 Apollo Rd., Plymouth Meeting, PA, 19462.**

STOCK DRIVE PRODUCTS

For anyone interested in robotics, the new catalog from Stock Drive Products is a treasure trove of mechanical components. You'll find gears, pulleys, timing belts, and other power-train components in both metric and inch sizes. The majority of these items are commercial grade, but some precision devices are available as well.

In most applications, you'll probably want to use belt or chain drives rather than gears, since these are easier for the beginner to assemble, especially if you don't have precision tools on hand. Whether the job demands a delicate plastic timing belt or a sturdy steel ladder chain, Stock Drive Products can supply the parts you need. Besides drive-train components, their new catalog also features such necessities as AC and DC motors, ball bearings, and precision-ground steel shafts. You can get a free catalog by writing to **Stock Drive Products, 2101 Jericho Turnpike, New Hyde Park, NY, 11040.**

MOTION CONTROL PRODUCTS

Stock Drive Products has a new catalog of motion-control products that will appeal to all the wild-eyed tinkerers out there. The motion-control products represented in this catalog include a variety of small, sophisticated motors and the digital "brains" needed to drive them.

They've got two- and four-phase stepper motors of all kinds, some high-tech linear steppers, brushless DC motors, ironless DC motors by Escap, small DC gearmotors, and reversible synchronous AC motors. Also included are accessories like small gearboxes, tachometers, and optical shaft encoders.

You can design your own control circuits for these motors or use the microcomputer-based controllers that appear in the catalog. Controllers are built on circuit boards that plug into STD-bus slots.

A free copy of the Motion Control Products catalog can be obtained on request from **Stock Drive Products, 2101 Jericho Turnpike, New Hyde Park, NY, 11040.**

DIGI-KEY CORPORATION

For those of you in search of good sources for ICs and other semiconductors, here's another name to add to your list: Digi-Key Corporation. Digi-Key has been in business for a long time, more than ten years by our reckoning, and that suggests a company that knows how to keep its customers happy. Speaking from first-hand experience, we've found their delivery to be fast and their merchandise excellent.

Digi-Key's catalog, which is issued on a bimonthly basis, contains ICs from all of the most important manufacturers, companies like National, Signetics, Texas Instruments, RCA, Intersil, Fairchild, NEC, and Panasonic. They've got TTL and CMOS logic, memory chips, microprocessors, A/D and D/A converters, and linear devices of all kinds. In addition, there's a good lineup of discrete semiconductors like transistors, FETs, diodes, LEDs, triacs, and so on. You can get on Digi-Key's catalog mailing list by writing to **Digi-Key Corp., P.O. Box 677, Thief River Falls, MN, 56701.**

MCM ELECTRONICS

Just when you thought you knew all there was to know about sources of electronic parts, along comes somebody new. Case in point: MCM Electronics, a full-line mail-order electronics retailer that came to our attention in the past year. MCM's new catalog lists over 15,000 parts which are stocked and ready for shipment. They have semiconductors, test equipment, tools, microwave oven parts, resistors, capacitors, electron tubes (!), chemicals, soldering equipment, connectors, CATV equipment, antennas, speakers, VCR parts, public-address systems, and a whole lot more that we don't have room to mention.

They also have courteous and helpful sales personnel, as we learned recently while trying to locate a high-voltage rectifier for a defunct microwave oven. The salesperson we talked with not only tracked down the proper replacement part, but told us where to buy it since MCM didn't stock it. **MCM Electronics, 650 Congress Park Dr., Centerville, OH, 45459-4072.**

AMERICAN DESIGN COMPONENTS

From American Design Components comes a new 32-page catalog featuring both brand-new and surplus electronic components. For those of you unfamiliar with the kind of bargains available on the surplus market, a few words of explanation are perhaps in order. Surplus goods are fully functional, often never-used devices that for one reason or another are no longer of any use to their owners. To recoup some of their investment, these owners sell their unwanted inventory to surplus dealers, who in turn sell the components to you and me at substantially reduced prices.

The surplus items in this catalog include computer printers, monitors, motors, pressure transducers, and transformers. There are plenty of non-surplus devices too—things like semiconductors and PC clones. If this sounds interesting to you, write for a free catalog to **American Design Components, 815 Fairview Ave., P.O. Box 220, Fairview, NJ, 07022.**

UNITED STATES PLASTIC CORP.

If you're like most hobbyists, you probably make most of your projects out of metal or wood, but there is a third alternative, you know—plastic. Sure, there was a time when "plastic" was almost a dirty word, but not any more. Think about it: wood rots, metals corrode, but plastic hardly deteriorates at all if it's properly applied. And today's plastics are remarkably strong too.

The new catalog from United States Plastic Corp. features items made of polyethylene, PVC, polypropylene, polycarbonate, acrylic, nylon, polyester, teflon, and polyurethane. There are tanks, pipes, girders, valves, sheets, jugs, carboys, bottles, faucets, flexible tubing, knobs, and pumps. A chart at the back of the catalog lists the chemical and physical properties of each plastic so that you can choose the right one for the job. You can get a copy of USP's colorful 146-page catalog free for the asking. Write to **United States Plastic Corp., 1390 Neubrecht Rd., Lima, OH, 45801.**

CONSTRUCTION QUICKIE

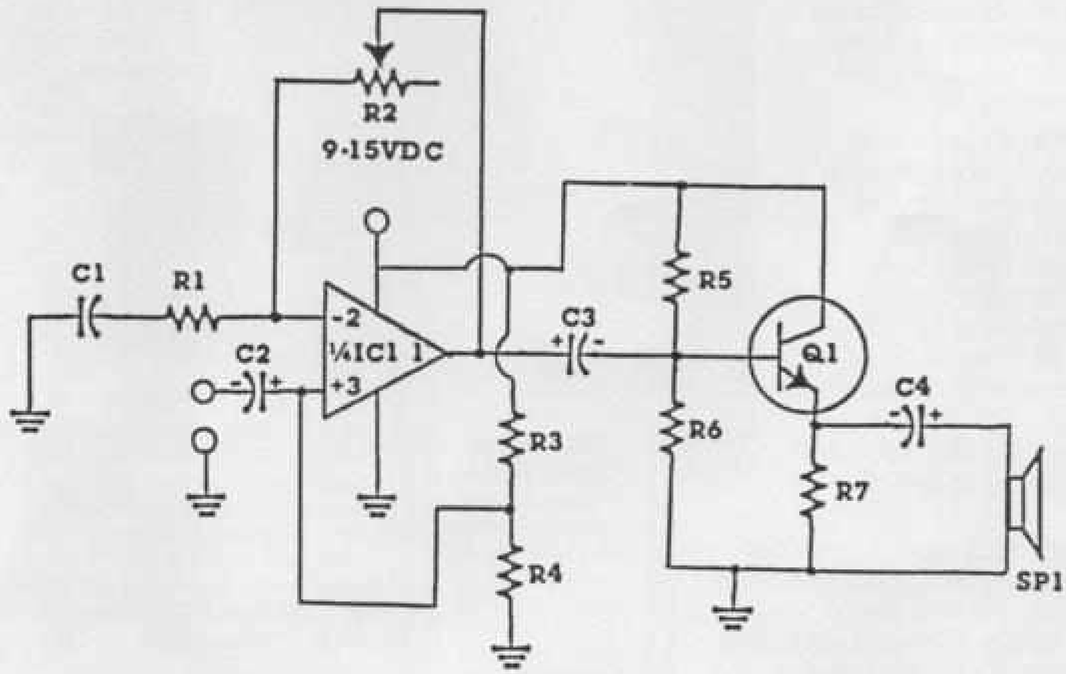
UTILITY AMPLIFIER

By Bill Axsen

This simple, inexpensive utility amplifier can be constructed from commonly available parts and give a big boost to any signal you may wish to amplify. Connect it to your walkman and fill a room full of sound. The amplifier has a gain of a thousand, high input impedance, and operates from 9 to 15 volts.

Operational amplifier IC1 provides the gain for the amplifier, which can be varied from 1 to 1000 by adjusting potentiometer R2. The current gain for the amplifier is obtained from the emitter follower Q1.

The utility amplifier can be constructed using any technique, but Q1 must be heat sinked and R7 must be placed in a position where it will not come in contact with any other component because it will become hot to the touch. If the heat sink used to cool Q1 is large enough R7 may be placed on it. Battery operation is not recommended because the amplifier draws approximately 200 milliamperes, so, when shopping around for a power supply, find one which can supply at least 300 milliamperes.



PARTS LIST FOR UTILITY AMPLIFIER

C1—.1uF ceramic capacitor
C2, C3—10uf electrolytic capacitor 25VDC
C4—220uf electrolytic capacitor 25 VDC
IC1—LM324 low power quad operational Amplifier
Q1—TIP 31 NPN transistor
R1—1000 ohm, ¼ watt resistor
R2—1,000,000 ohm audio taper potentiometer
R3, R4—1,000,000 ohm, ¼ watt resistor
R5—680 ohm, ¼ watt resistor
R6—1,500 ohm, ¼ watt resistor
R7—50 ohm, 10 watt resistor, Radio Shack #271-133 or equivalent
SP1—16 ohm speaker, 2 watts