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HANDBOOK DOUBLE PUZZLE

By Glenn Rawlings

IN THE GROUP OF LETTERS BELOW, FIND THE FOLLOWING WORDS (HORIZONTALLY, VERTICALLY OR DIAGONALLY) AND BOX THEM IN. THEN, WHEN YOU TURN THE PAGES SIDEWAYS, YOU WILL SEE ONE OF GEORGE S. OHMS GREATEST LAWS.

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(SEE PAGE 88 FOR ANSWER)

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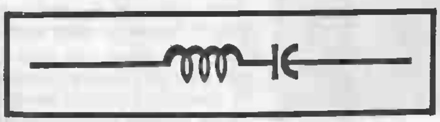

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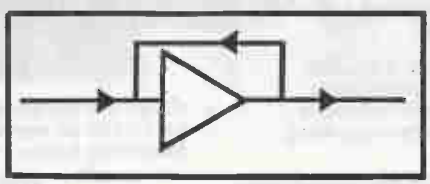

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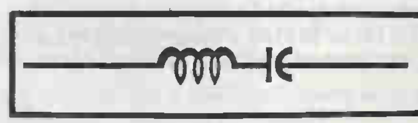

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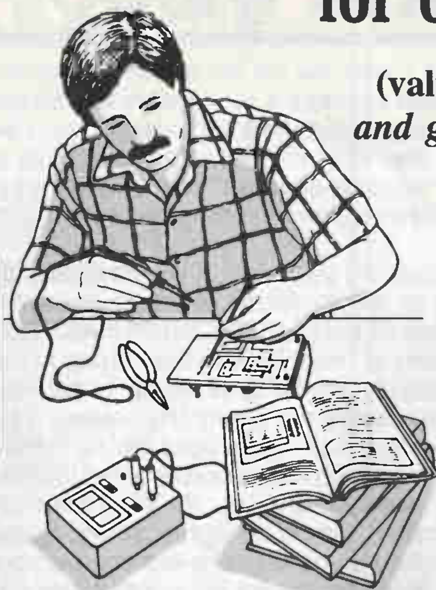

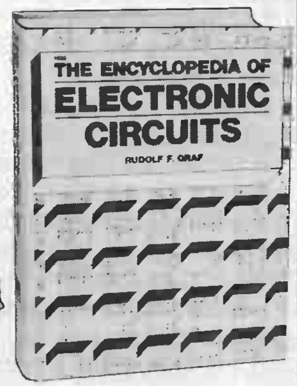

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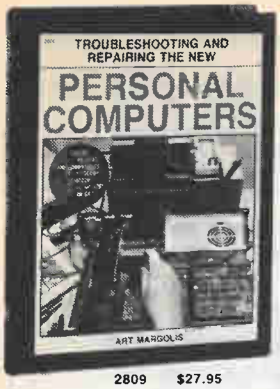

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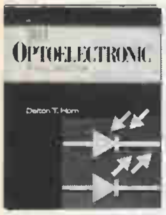

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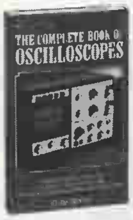

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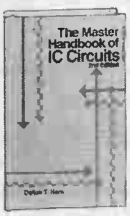

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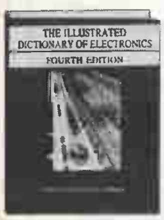

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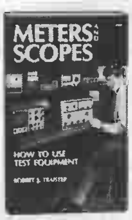

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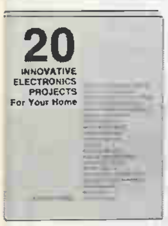

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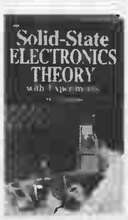

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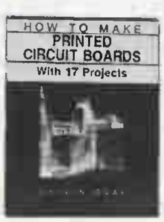

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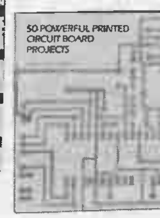

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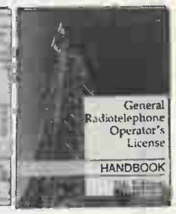

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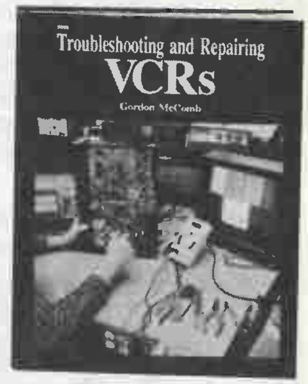

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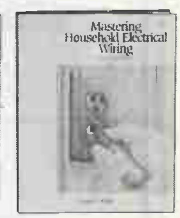

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WHITHER WE GO

Not too long ago, I happened to visit a local new car dealer in our community to have some necessary repairs made on our familimobile to make it serviceable for the coming summer. As I waited for the mechanics to do their thing, I did what I invariably do, I wandered into their showroom and gazed with wide eyes at their new models...truly a sight to behold.

It so happened that there was another "window-shopper" browsing about and I observed that, as he studied the sticker of each car that he examined, he mumbled something that sounded very much like, "Give a guy a break!"

Well, you and I know that if a break is coming your way, it will be mostly due to the effort that you made to make it possible! I reflected on the multitude of letters we have received in the past few years, telling us of savings that readers of the ELECTRONICS HANDBOOK have been able to achieve by assembling projects from one or more circuits they found in the "Handbook". The most popular circuits seem to be the relatively simple ones: audio amplifiers, intercoms, power supplies, etc. It appears to me that these readers are giving themselves a break!

If it were possible to tabulate the cost savings made possible to readers who assembled projects from the "Handbook" to do useful work in place of expensive purchased components, or followed the instructions found in our "service" articles, for the repair and maintenance of valuable equipment that they own, the amount would be significant. In many cases the savings cannot be evaluated since the project developed does not have a comparable component in the marketplace. Think of the service and comfort electronics hobbyists have come to enjoy from the projects they build...and the satisfaction and fun they had building them.

As I was about to depart from the automobile showroom, a salesman approached and asked, "Can I help you?"; to which I replied, "Yes, have you ever written an article on an electronic project?"

To each of you I say, roll up your sleeves, have some fun and save some money with the projects in this issue of the ELECTRONICS HANDBOOK.

Don Gabree

Don Gabree, *—Publisher*

WANTED: WRITERS

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THE SHOCKING TRUTH ABOUT ELECTRICITY

By Dereck Williamson

The following article from our local newspaper (Somerset, N.J. Messenger Gazette) attracted our attention since it involved a subject that was close to home and it appealed to our sense of humor. Since the ELECTRONICS HANDBOOK claims to be "The Fun Way To Learn Electronics", we felt that this article should be shared with our readers. Fortunately, the author agreed to let us reprint it.

Electricity has always been difficult to understand, but now they're making it difficult to use. If that sounds confusing, let me try to explain. (Did you think for a moment that I wasn't going to elaborate, and planned to stop the column right here? Come on, now.)

Electricity is a big mystery. First of all, we can't see it,, and this is a major consumer problem that should have been corrected centuries ago. Although we have a National Electric Code, there is absolutely nothing in it about being able to see electricity; in fact, there aren't even any recommendations about achieving this essential step. Isn't that amazing?

Not being able to see electricity is scary. We can see water leaking, and we can smell gas leaking. In fact, they add something to gas so it can be detected. Why don't they add something to electricity to make it visible? As it stands, we have no idea what the hell our house current is doing from one moment to the next.

A consumer revolt is past due. The next time the Power Company wants to raise rates, we should take this stand: "If we have to pay more for it, we want to see it! After all, how do we know that they're not taking it away during the night, leaving just enough to run the clocks?

Oh sure, they bill us after reading the meter. But sometimes they don't read the meter, and bill us anyway, making an "adjustment" next time they read it. But have you ever read your meter and compared it with their reading? Do you know anybody that did? When we changed the time last month, did they set the kilowatt hours back by one and give us a rebate? The defense rests.

When I was a little kid I thought I had electricity all figured out. I assumed that wires were hollow, like water pipes, and that "lectric" ran through them. Then someone showed me a solid copper wire, and blew my whole theory.

Since electricity is a mystery to us all, it's not surprising that some people develop unconventional notions. A friend's aunt was convinced that electricity leaked from sockets, so she made sure that a lamp or appliance was plugged in every socket in the house. It makes a lot of sense to me.

What doesn't make sense is "alternating current" and "direct current." People who've tried to explain electricity always use these absurd terms. Where does direct current go to? By now, there should be a huge pile of it at its destination. Couldn't this be recycled?

And the idea of alternating current is ridiculous. Think about it. How can current go first one way, then the other? If current really alternated, what would happen when you switched on your vacuum?

Ask an electrical expert about these things and he brings out a piece of paper, draws wavy lines and talks about 60 cycles. You know something's fishy when he quickly shifts the subject to a bike race.

And that brings me to my original point (aren't you glad you waited?) which is that electricity is not only hard to understand, but now they're making it harder to use.

Remember when you just plugged something in, and that was that? No more. Now one of the prongs is wide, and Ohm's Law states: "No matter which way you pick up a plug it won't fit in the socket the first try."

Older sockets won't take a wider plug at all, and the same goes for extension cords. I've got three perfectly good extensions that modern plugs won't fit. And today's three-prong plugs won't fit anything but three-hole sockets. As soon as I have an electrician install the latter they'll probably be superceded by four prong sockets.

It's a frustrating situation, and when I can't fit all the plugs in all the sockets, that could mean expensive electricity is leaking all over the house.

If I could only see it, I'd know for sure. ■

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:

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North Branch, N.J. 08876

MYSTERIOUS CHIRPS

For the past few months, I've been picking up weird transmissions that sound like the chirps of high-speed crickets. On the surface, these sounds are monotonous, but if I listen carefully, I can detect a subtle rhythm to them. Do you suppose I've tapped into the Venusian Top 40, or is this a government experiment in mind control?

—Dexter G., Silver Springs, MD

Well, Dex, if you've been picking up these sounds without the benefit of a radio receiver, professional help is definitely recommended. However, if we assume that your question relates to shortwave radio transmissions, it's a fairly safe bet that these signals did not come from extraterrestrials or Big Brother. What you have been hearing are probably high-speed radioteletype transmissions, which can originate with amateur radio operators or commercial wire services. A good shortwave guide like the ***World Radio TV Handbook*** *(Billboard Publications, One Astor Plaza, New York, N.Y. 10036) or the* ***Top Secret Registry of U.S. Government Radio Frequencies*** *(CRB Research, P.O. Box 56, Commack, NY, 11725) will help you identify other strange signals on the shortwave bands.*

By the way, you are not the first person to be baffled by weird noises in the ether. Back in 1899, before the days of commerical radio transmission, the world-famous inventor Nikola Tesla picked up what he described as "three fairy taps" on his experimental wireless receiver. Tesla postulated that these taps were signals from intelligent life on Mars or Venus, but later came to realize that they may have come from intelligent life in Europe—namely, Guglielmo Marconi who was experimenting with wireless telegraphy at the time.

We're Blushing

First, I would like to congratulate you guys for turning out what is probably the best magazine for people who are beginners in the field of electronics. Your mixture of construction projects and articles on electronic theory is great, and that's not just my opinion, because **Electronics Handbook** often sells out before I have a chance to grab a copy at the newstand. To prevent that from happening again, I've deciced to subscribe. You will find my check for $12.00 enclosed.

My second reason for writing is to request that you publish more articles on photography and R/C modeling, which are two of my favorite hobbies.

—Glenn Halsted, Canoga Park, CA

Thanks for the kind words, Glenn. We try to provide a mixture of projects and articles that will appeal to readers of all kinds, from beginners to experts, but as you have noted, we are especially committed to helping the newcomer. As for your suggestions regarding construction projects, we do publish articles on photographic equipment whenever we get them. R/C modeling, however is a different story. Twenty years ago, electronics magazines regularly published articles on radio-control transmitters and receivers, but today the hobbyist can buy a ready-made, FCC-approved, multi-channel proportional R/C system for less than it would cost to assemble one from scratch. Thus, there is little demand for R/C construction projects. Some companies do offer R/C kits whose critical circuits have been preassembled and tested. You should check out the advertisments in the various model aviation magazines for further details.

Fear of Flying

My job as a salesman requires that I travel extensively by air. I don't mind admitting that the threat of a hijacking or bombing by terrorists worries me greatly. That worry is compounded by the knowledge that the X-ray equipment used to screen passengers and luggage is not 100% effective. Would you happen to know what steps, if any, are being taken to improve the detection of weapons and explosives in our nation's airports?

—Fred Golding Beaverton, OR

Your assertion that the current crop of X-ray machines is not 100% effective rings true, Fred. X-rays are principally used to detect metallic weapons like handguns and assault rifles. They are woefully inadequate where explosives are concerned. Modified X-ray machines capable of detecting explosives have been developed, but it now appears that two new technologies, thermal neutron activation and vapor analysis, will be our first line of defense against the bomb-toting terrorist.

Thermal neutron activation (TNA) will be used only on baggage, not on passengers. Closed luggage is drawn by conveyor belt into the TNA machine, where it is bombarded by neutrons from a 300 - microgram sample of Californium-252. As a result of neutron bombardment, chemical elements emit gamma radiation. The TNA machine looks for a gamma-ray "signature" that is charateristic of the elements, such as nitrogen, which are commonly found in explosives. When that signature is detected, an alarm goes off, and the bag is removed and searched thoroughly by hand. By the time you read this, the first TNA machine in the United States should be in operation at the Pan Am terminal in New York's JFK International Airport.

Vapor analysis can be applied to passengers as well as baggage. A handheld vapor detector will be passed along the seams of a parcel or piece of luggage and will sniff out the tell-tale vapors of compounds commonly found in explosives. Passengers will have to walk through a booth, where air will be swirled around them and analyzed. Not only can vapor-analysis technology be used to check for explosives, it can also be modified to ferret out illicit drugs.

The major drawback to TNA and vapor analysis is the expense involved, which means that it may take years before every airline terminal is equipped with this new technology. In the meantime, the only consolation I can offer is that it is probably safer to fly in an airplane than it is to go for a drive with your teenager at the wheel.

Whither Solar?

Back in the bad old days of the energy crisis, President Carter initiated government-supported research into a wide variety of alternatives to fossil fuels. One of those alternatives was solar energy. Because solar-generated electricity is inherently "clean" energy, a lot of us saw solar power as our best hope for the future, yet now, more than a decade later, we still don't have large-scale power generation using photovoltaic cells. What's happened. Has solar energy been allowed to die a quiet death by the Reagan and Bush administrations?

—Bob Griffin, Tucson, AZ

It's true, Bob, that U.S. government support for solar research has dropped: it was down to $35 million last year, compared to $54 million in Japan and $47 million in West Germany. Still, our solar industry is far from dead. Last year it produced over $400 million worth of photovoltaic cells, which were used to generate electricity for isolated villages in Third World nations, and also to power irrigation pumps, communication and navigation equipment, and consumer products like calculators right here at home.

The big stumbling block to large-scale commercial exploitation of solar power in the United States has been its expense. Right now solar-generated electricity costs about $4-$6 per peak watt (i.e., in the noonday sun). That figure will have to be reduced to $1-$2 per peak watt for solar power to be competitive with electricity generated by hydroelectric, thermoelectric, or nuclear means. Perhaps the brightest hope of achieving that goal is provided by thin-film, amorphous-silicon photovoltaic cells. These are among the cheapest cells to mass produce and have a conversion efficiency of 5-6% at the present time. Through the use of improved photovoltaic materials and a multilayer topology, in which different layers are sensitive to different wavelengths of light, engineers hope to raise the efficiency of amorphous-silicon photovoltaic cells to 15-25%. When that goal is attained—probably within 5 to 10 years—we should begin to see increased exploitation of solar power by utility companies and private individuals.

As a footnote, you may find it interesting to learn that my Uncle Jack was among the first to commercially exploit solar power back in the 1960s. He invented the solar bikini, which looked like any other bikini except that it was covered with hundreds of sparkling solar cells. Using his natural charm, Jack persuaded women sunbathing at resorts all along the French Riviera to slip into his bikinis and plug into the power grid he had established. I guess the French reverence of beautiful women got the better of common sense, because Jack had no trouble selling all the power he could collect. But then came the topless revolution, and overnight Uncle Jack's revenues fell by half. Sensing the winds of change, Jack abandoned the solar-bikini business before the bottom fell out.

Useless Capacitors?

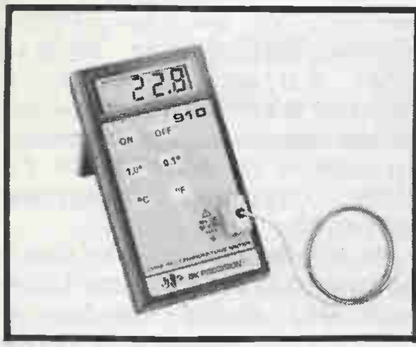
I have noticed that the power supplies of many digital projects have small ceramic capacitors connected between V+ and ground. Since these capacitors are always in parallel with a much larger electrolytic capacitor, I don't understand what good they do.

—Doug Gilfus, Jr., Spokane, WA

Electrolytic capacitors have a relatively large internal inductance, Doug, that effectively prevents them from behaving like capacitors at high frequencies—hence, the need for 0.01 or 0.1 mfd. high-frequency bypass capacitors in the power supply of a digital project.

NEW PRODUCTS PARADE

TEMPERATURE METERS



A series of handheld digital temperature meters has been announced by **B&K-PRECISION.** All models feature 3-½ digit LCD display, standard 9V battery and a high perfomance to price ratio.

The Model 900 Digital Thermometer features selectable internal or external operation. The internal mode selects a self-contained extendable probe with a semiconductor type sensor, which covers the –58° to +302° F range. The unit automatically turns on when the probe is extended and turns off when retracted. In the external mode, a socket accepts an external Type K thermocouple probe for 0° to 1500° F measurements. The mode 1900 is extremely compact and the case includes an integral pocket clip. This unit is intended for HVAC, building maintenance, and general purpose application.

The Model 910 Digital Temperature Meter offers greater precision and versatility for industrial and laboratory applications. This model features Type K thermocouple sensor probe, selectable 1° or 0.1° resolution, and selectable °C or °F measurement. Its measurement range is –50° to +1300° C or –58° to +1999° F.

Manufactured by **Maxtec International Corporation, 6470 Cortland Street, Chicago, IL 60635, (312) 889-1448.**

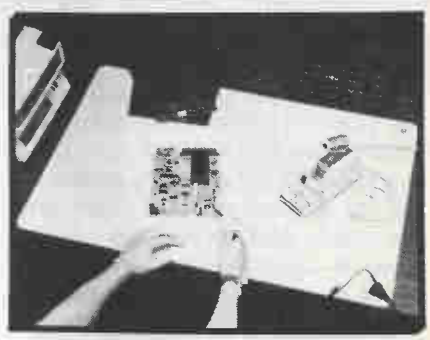
WAVEBOX 100

Teledata Systems announces the WAVEBOX 100 Synthesized Frequency Source. The key feature of this low cost benchtop instrument is 10ppm or 0.001% accuracy and stability over it s 1Hz to 100kHz frequency range. This is typically three orders of magnitude better than most signal sources at this price level. The output frequency is dialed up directly on thumbwheel switches making the instrument exceptionally easy and foolproof in use. Resolution is 1Hz over the entire range. The sine wave output is variable up to 20v p-p with a ±10v offset. Total harmonic and non-harmonic distortion is better than 40dB. An auxiliary TTL/CMOS level square wave output is also provided.

Priced at $325, applications include power, audio, telecommunications and ultrasonic frequency testing, with it s ease of use making it especially suitable for production and educational applications.

For further information, call or write to **Teledata Systems, 68 Reservoir Road, New Milford, CT 06776 (203) 355-8285.**

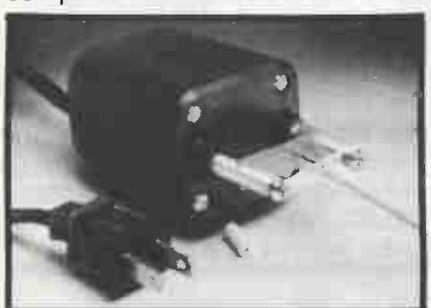
STATIC DISSIPATIVE WORK SURFACE



This rigid, static-dissipative work surface was developed as an alternative to both soft table mats and high pressure laminate work surfaces. This work surface has the conductivity needed for proper drainage of static charges, yet is not conductive enough to serve as a path for dangerous levels of current, or to cause short circuiting of powered-up components. It has rounded corners, smooth, non-cutting edges, and will resist abrasion, staining, scorching from hot solder and flux, and the effects of solvents common to the electronics hobbyists. Work surface is ⅛" thick, comes complete with two installed female snap fasteners compatible with model 3048 common point grounding system (included), and is available in two sizes and three colors. **Contact East, PO Box 786, 335 Willow St. So., North Andover, MA 01845, (508) 682-2000.**

THERMAL WIRE STRIPPERS

From HMC (Hub Material Company), we are informed that they are introducing a new line of thermal wire-strippers that are small, lightweight low-power, AC line-operated tools that will surpass previous devices in safety, versatility and economy. Their patented design incorporates a uniquely shaped nichrome heating element which heats up quickly (less than 5 seconds) to its optimal temperature for efficient wire-stripping. The low mass, guarded element minimizes the risk of burns, eliminates nicks and broken strands of conductors, and reduces lead pull on sensitive components.



These Patco thermal wire-strippers offer many advantages over mechanical-type strippers. The new, very thin heating element consistently produces excellent quality strips while eliminating damage to the conductor.

While the AC line-operated models may be more practical for commercial purposes, rechargeable battery powered models are also available upon request for field service technicians who don't have access to line power. For further information, contact **HMC, Box #526, Canton, MA — (617) 821-1870.**

MINIATURE MICROPHONES

MFJ Enterprises, Inc. announces the release of several new miniature speaker/microphones that fit most handheld radios and are available with regular or "L" connectors and measure just 2" X 1-1/4" X 1/4". You just can't get much smaller than that.

In this tiny package you get a first-rate electret mic element and a wide range speaker that provide superb audio on both transmit and receive.

These feature-packed speaker/mics also give you an earphone jack for private listening, push to talk button, swiveling lapel/pocket clip and a lightweight retractable cord.

MFJ-285 and MFJ-285L (with "L" connector) fit Icom, Yaesu, and Santec HTs; MFJ-287 and MFJ-287L fit Kenwood. All four models come with MFJ's one year guarantee.

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 order toll free at 800-647-1800.**

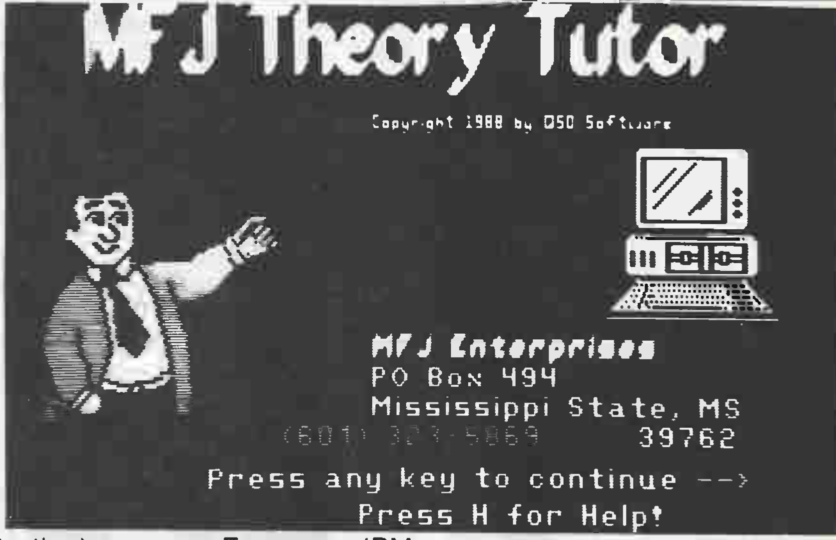
WORK HOLDER/POSITIONER

When you are working with components that are small and delicate and you feel like you have ten thumbs, this PanaVise work holder/positioner may be the answer to your problem. It allows you to position, tilt and rotate your work without removing it from its holding device. Each unit's patented "split ball" joint allows the vise head to be positioned through three planes with just the turn of a knob. It tilts, turns and rotates. One quick turn of the control knob and you can securely position your work exactly where you want it.

This easy-to-use vise has remarkable strength, yet it is gentle enough to firmly hold the most delicate electronic parts and PC boards. Hobbyists should find the PanaVise invaluable. It has a multitude of interchangeable heads, bases, base mounts and accessories which are adaptable to an endless choice of configurations to fit your exact needs. For more details, call or write to **HMC, HUB Material Company, 33 Springdale Avenue, Canton, MA 02021 (617) 821-1870.**

NEW PRODUCTS PARADE

HAM RADIO LICENSE TUTOR



MFJ Enterprises, Inc. announces the release of the new MFJ ham license Theory Tutor for IBM compatible computers.

MFJ'S new Theory Tutor practically guarantees you'll pass the theory part of any FCC license exam.

This versatile and fun new IBM compatible software is the best computer tutor ever tailor-made for ham radio.

You get the FCC question pool. However, what makes this tutor so special is not that it contains the question pool. It is the uniquely effective, fun way it gets you ready for your test!

You can study the entire question pool, concentrate on selected areas or try taking sample tests. There's no better way to make sure you know the material. Each study session is automatically saved and you can return to a previous session at any time. Or print a test (suitable for official testing) on any Epson or IBM compatible printer.

You also get excellent graphics with appropriate questions, complete scoring analysis, color change options, an on-line calculator, explanations of difficult questions plus much more.

The MFJ Theory Tutor is available for each license class. The model numbers are: MFJ - 1610-Novice: MFJ-1611-Technician; MFJ-1612-General; MFJ-1613-Advanced; MFJ-1614-Extra. The retail price is $29.95 per class.

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

PROGRAMMABLE SOLDERING STATION

From **Weller**, a futuristic, microprocessor controlled, soldering station representing a major advancement in soldering technology and efficiency. All relevant thermodynamic properties for its interchangeable irons and tips are programmed into the unit to allow for superior tip temperature accuracy and stability. With the LCD display showing temperature, iron style, and tip style, the user can see selected operating parameters at a glance.

The power unit's interactive menu provides the user with an easy-to-understand method of selecting tip temperature (from 350°F to 850°F), tip style, display mode, (°F or °C) and calibration constants. These operating the set tip temperature, actual tip parameters are stored and retained in memory, even when the station is turned off or power is removed...no reprogramming is required.

The Weller MC5000 is the ultimate in soldering stations and may be a little more than the average electronics hobbyist requires for construction of his projects but as any experimenter knows, good soldering technique and soldering equipment make a world of difference in the final construction of an electronics project.

Two versions of the MC5000 are available: Model MC5000-1 comes with a macro 42-watt iron that uses ET Series tips; Model MC5000-2 comes with a micro 20-watt iron that uses EPH Series tips. For more information contact **HMC (Hub Material Company), P.O. Box 526, Canton, MA 02021 (617) 821-1870.**

FREQUENCY COUNTER

All new hand held frequency counter with low frequency coverage down to 10 Hz and microwave coverage up over 2.2 GHz. This is the hand counter with the widest range of applications because of its wide frequency coverage. Important frequency counter features such as a metal cabinet and precision quartz time base oscillators are included as well as high quality internal Ni-Cad batteries. A full line of accessories include antennas, probes, and carry case.

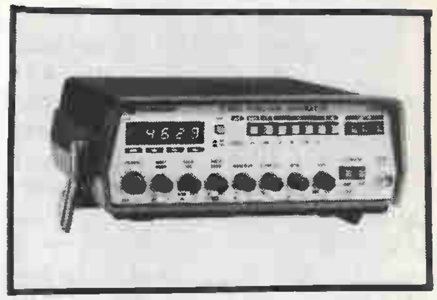
The 2210 features dual crystal oscillator and dual input amplfier design. The low frequency range has a FET input high impedance amplifier circuit. The high frequency range uses microwave miniature integrated circuit amplifiers for excellent sensitivity. Picking up more transmitter frequencies from greater ranges than ever before is now possible.

Input sensitivity is less than 10 mV from 10Hz to 2GHz with 3 mV typical. Accuracy is 1PPM with temperature compensated crystal oscillators. Size is 3.9" H × 3.5" W × 1" D and weight is 9 oz. Resolution is 1Hz below and 100Hz above 12MHz. Two hour battery operation is typical after 16 hour recharge. Operation from AC adapter/charger is possible during recharging.

Manufactured in the United States by **OPTOELECTRONICS INC., 5821 N.E. 14TH AVENUE, FORT LAUDERDALE, FL 33334, (800) 327-5912 OR IN FL (305) 771-2051.** The model 2210 sells for $189 complete with NiCad batteries and charger. Model TA-100S telescoping whip antenna is $12. The vinyl carry case is $10.

SWEEP/FUNCTION GENERATOR

B&K-Precison has announced its new Model 3026 Sweep/Function Generator. This highly versatile 0.5 Hz to 5 MHz signal source includes a built-in frequency counter. The 5-digit LED display indicates the output frequency or may be used to measure external signals to 10 MHz. The external counter mode offers four selectable gating times. Other features include internal or external AM modulating internal or external gated burst operation, and three step attenuators. The sweep generator offers fully variable sweep width and rate and a sweep ramp output. The sine wave, square wave, and triangle wave outputs are given added versatility with normal or inverted polarity selection and variable

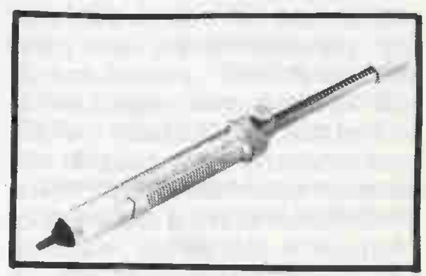


duty cycle control. A separate TTL output provides the correct level without set-up adjustments.

Manufactured by **Maxtec International Corporation, 6470 Cortland Street, Chicago, IL 60635, (312) 889-1448.**

STATIC-FREE DESOLDERING PUMP

Model AS196 is a high-vacuum desoldering pump that is made from special static conductive materials for safe removal of solder around static-sensitive components. Operator simply heats solder joint with conventional soldering iron, and when it melts, just presses the pump trigger button for an instantaneous vacuum through the tip.



Solder is sucked out, leaving the hole clean and ready for easy component removal. The pump has a heavy-duty spring for long-lasting performance, and features easy, one-hand loading. Tip self-cleans each time plunger is depressed. Comes complete with conductive tip. **Contact East, PO Box 786, 335 Willow St. So., North Andover, MA 01845, (508) 682-2000.**

NEW BOOK REVIEWS

IC MASTER

To bring our readers up-to-date, our last issue (Volume #7) reviewed an outdated issue of the IC MASTER The publisher (Hearst Business Communications, Inc.) has graciously provided us with up-to-date information on the IC MASTER, now expanded to 3 separate volumes with a price tag of $145 for the set, with a $10 shipping and handling charge for each purchase.

The new **IC MASTER,** scheduled for release in February 1990 (we can't get any more up-to-date than that) provides the engineer types with extensively updated and all new sections and categories in each of the 3 volumes with the only comprehensive data base in the industry that references, cross-references and organizes product information on 80,000 standard ICs, including 14,000 new ICs.

Volume 1 is a complete functional guide to ICs, grouped by basic category...Digital, Microprocessor, Linear, and Memory. In the Microprocessor section there are new categories on CISC processors, RISC processors, and microcontrollers divided according to processor, data word size and increasing clock frequency. The memory section includes new categories on NVRAMs, EPROMs, video RAMs, multiport devices, and modules sorted by configuration and access time. Three new tables cross-reference MIL-38510, DESC Drawing and Commercial equivalents. The Alternate Source Directory, with over 155,000 listings, includes second source information on obsolete as well as current parts.

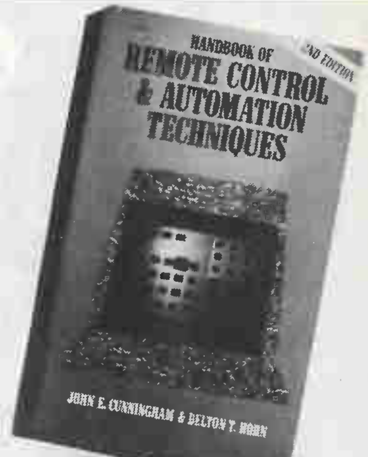
Volume 2 is an entire "stand alone" volume with over 1,000 new and updated manufacturer's data pages. The Product Index cross-references the IC listings in Volume 1 and the data pages in Volume 2 on all products. The Application Note Directory is a library to all available application literature issued by the manufacturers. The addresses and telephone numbers of every manufacturer in the IC industry are listed in the Manufacturers and Distributors Directory.

Volume 3 is a complete Systems Level Volume. This guide to Custom/Semicustom ICs includes gate array and cell-based ASICs. A complete new section is devoted entirely to Programmable Logic Devices sorted parametrically according to function and performance. The Design Automation Section features the industry's most extensive listings of CAE and CAD design tools and includes a complete guide to Microprocessor Development Systems organized by supported CPUs. The newly revised section on Microcomputer Boards lists boards by the bus or system supported.

To order or get further details, contact **Marie Botta, Book Sales Manager, Hearst Business Communications, 645 Stewart Avenue, Garden City, N.Y. 11530 (516)227-1300, FAX (516) 227-1901.**

HANDBOOK OF REMOTE CONTROL & AUTOMATION TECHNIQUES

By John E. Cunningham and Delton T. Horn

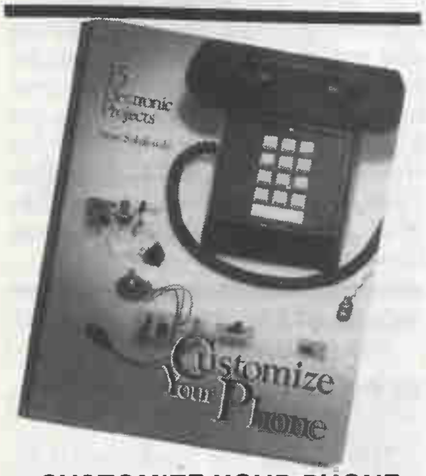


Ordinarily we think of automation as being of use in an industrial setting, and, indeed, *industrial* automation is the prime concern of most academic textbooks. But the *Handbook of Remote Control & Automation Techniques* is different because it focuses on applications of automation and remote control in the home. The book evolved from Mr. Cunningham's efforts to make life easier for a wheelchair-bound girl by providing electronic control of doors, windows, and other features of her home environment.

Hands-on practicality is the watchword here; you don't need an extensive mathematical background to understand this book. The authors begin with a discussion of sensors and indicators, and then proceed to give a quick, painless introduction to the laws of mechanics. Next comes an excellent discussion of hydraulic actuators, electric motors, and solenoids—the "muscles" of an electronic control system.

Remote control requires the encoding and transmission of data, which can be done in a variety of ways. The authors deal mainly with tone encoding/decoding, and light-beam, ultrasonic, audio, and carrier-current transmission. Their treatment of radio control is limited to a discussion of how commercial equipment can be adapted for use in the home—a sensible approach, given that most hobbysts are ill-equipped to satisfy the stringent demands of the FCC regarding radio emissions. Two chapters are devoted to the use of computers in a control system, and there are numerous examples throughtout the book of practical home automation systems.

Readers interested in applying the principles of automation will find the *Handbook of Remote Control & Automation Techniques* by John Cunningham and Delton Horn to be an excellent introduction to the subject. Check your bookstore or send $18.95 plus $2.50 for shipping to **TAB Books Inc., Blue Ridge Summit, PA, 17214-9989.**



CUSTOMIZE YOUR PHONE

by Steve Sokolowski

When asked to identify the home appliance they understand the least, a great many hobbyists would reply: the telephone. Ma Bell was never one to divulge phone secrets or encourage tinkering, and even after the historic Supreme Court decision that gave customers the right to own and install their own telephone equipment, electronics magazines devoted precious little space to telephone-related matters. Now, Steve Sokolowski's new book, *Customize Your Phone,* lifts the veil of secrecy surrounding the telephone and allows the reader to configure his home phone system to suit his own needs. No, you will not find "blue boxes" or any device that even remotely smacks of illegality in this book. What you will find are 15 interesting, easy-to-build circuits that will improve the performance of your phone system at little cost.

Among the projects featured are a phone "bug" detector, a melody ringer, a tone ringer, an automatic telephone recorder (careful with this; remember Richard Nixon), a call indicator, a ring detector, a conference caller, a telephone lock, a telephone intercom, a phone-line tester, a phone amplifier, a speaker phone, an appliance controller, and an animated stuffed-animal telephone ringer. In addition, there is an introductory chapter on the internal circuitry of telephones, as well as chapters on electronic components, reading schematics, making PCBs, and soldering for the benefit of beginners.

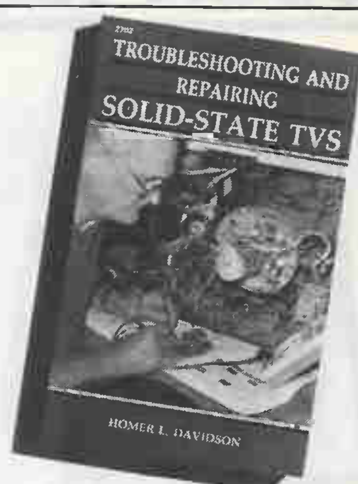
Customize Your Phone by Steve Sokolowski is 160 pages of information and project-building fun. It can be obtained for $12.95 plus $2.50 for postage from **TAB Books Inc., Blue Ridge Summit, PA, 17214-9989,** and also from most bookstores.

TROUBLESHOOTING AND REPAIRING SOLID-STATE TVs

by Homer L. Davidson

For anyone involved in the repair and maintenance of electronic equipment, the latest book by veteran author Homer Davidson is must reading. Mr. Davidson has written a 450-page distillation of the experience gained from nearly 40 years in the TV repair business, and he has done so in a way that is easy to read and understand.

From the start, the book assumes that the reader is familiar with the basic theory of television operation and with the subsystems that make up a modern TV, i.e., the horizontal oscillator, the tuner, and so forth. Each of the book's



fifteen chapters then addresses itself to one of these subsystems and the ailments that can afflict it. An abundance of schematic diagrams and clear photographs makes the discussion easy to follow. At the close of each chapter, the author supplies a selection of actual case histories that illustrate how theory relates to practice. Special attention is given throughout to the "tough dogs," those difficult-to-diagnose problems that cause a serviceman to lose money as well as his temper.

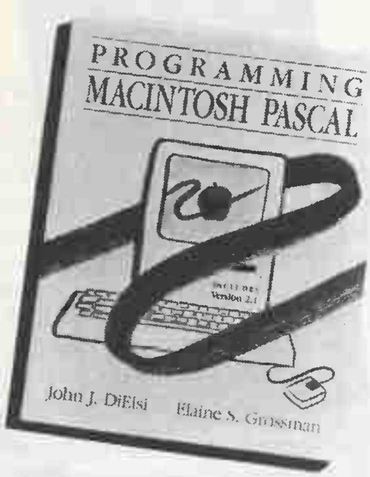
An excellent book for self-study or classroom use, *Troubleshooting and Repairing Solid-state TVs* by Homer L. Davidson is available for $17.95 (softcover) at your local bookstore or direct from the publisher, **TAB Books Inc., Blue Ridge Summit, PA, 17214-9989.** Add $2.50 for postage and handling.

PROGRAMMING MACINTOSH PASCAL

by John J. DiElsi and Elaine S. Grossman

Programming Macintosh Pascal was written to serve the needs of an introductory high school or college course in Pascal programming. It assumes that the reader has little or no experience with Pascal, and only a modest familiarity with the Macintosh. Since this is a book for beginners, no attempt is made to teach the tricky business of programming

NEW BOOK REVIEWS



the Macintosh Toolbox. Structured programming concepts are introduced early on, and reinforced through the use of IPO (input/process/output) and Nassi-Schneiderman charts.

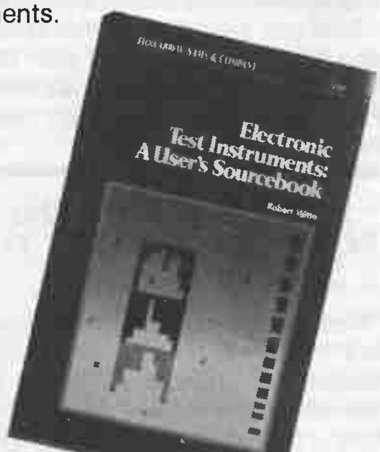
The standard programming issues such as date structures, flow of control, I/O, functions, procedures, graphics, modularity, and data files are covered thoroughly and illustrated by means of numerous programming examples. Program listings are highlighted in blue and well-commented, making them easy to follow. Advanced concepts like enumerated data types, pointers, linked lists, and recursion are introduced near the end of the book; sets and set operations, however, are not covered. Each chapter ends with a set of exercises and solutions appear in an appendix.

In summary, this excellent introduction to Macintosh Pascal reinforces my conviction that the best programming books are written by authors with teaching experience. *Programming Macintosh Pascal* by John DiElsi and Elaine Grossman is lucid and well-organized, an ideal book for the newcomer to Mac Pascal or its descendant, Lightspeed Pascal. To get a copy, see your local bookseller, or contact the **MacMillan Publishing Co., 866 Third Ave., New York,NY, 10022.**

ELECTRONIC TEST INSTRUMENTS: A USER'S SOURCEBOOK

by Robert Witte

Most of us acquire a knowledge of test instrumentation in a haphazard way, usually by reading magazine articles or the manuals that accompany test gear. A more thorough, and perhaps more accurate, grounding in the basics of test instrumentation can be gained by reading *Electronic Test Instruments: A User's Sourcebook.* In the space of 250 pages, author Robert Witte covers the theory and application of just about every type of electronic instrument the average reader is likely to encounter. He begins with a discussion of the theory of DC and AC measurements, explains the significance of average, rms, and peak-to-peak readings, shows how complex waveforms can be treated as the sum of harmonically related sine waves, and provides a clear, concise explanation of the errors that plague all measurements.



The remainder of the book is devoted to detailed discussions of how specific test instruments operate. The king of test instruments, the oscilloscope, gets a two-chapter treatment that includes excellent examples of the kinds of measurement problems a scope is most often called upon to solve. Other less complicated kinds of test gear get treatments that are briefer but no less thorough. The list of instruments covered includes ammeters, voltmeters, ohmmeters, sine-wave signal generators, function generators, pulse generators, arbitrary waveform generators and synthesizers, frequency counters, logic probes, power supplies, bridges, attenuators, filters, spectrum analyzers, wavemeters, gain/phase meters, network analyzers, and distortion analyzers. The only important instrument not covered here is the logic analyzer, which is understandable, since a thorough treatment of that particular instrument would require a book in itself.

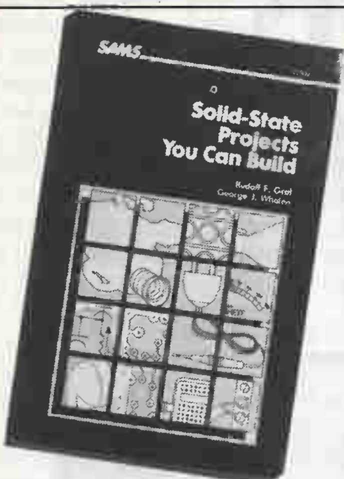
In summary, anyone seeking a first-rate introduction to the theory and application of test gear will be well-served by Robert Witte's new book. You can obtain a copy for $14.95 plus $2.50 for postage from **Howard W. Sams & Co., P.O. Box 7092, Indianapolis, IN, 46209-9921,** or look for it at your local bookstore.

SOLID STATE PROJECTS YOU CAN BUILD

by Rudolf F. Graf and George J. Whalen

The title of this book says it all. We have here a collection of 26 electronic projects that will appeal to everyone from the beginner to the expert. Each project is accompanied by a thorough description of how it works, construction details, a parts list, and, where necessary, tips on where to buy components. Voltage and resistance charts accompany the schematics and enable the builder to test his circuit before applying power to it, thus avoiding the anguish of a project that goes up in smoke.

Projects featured in this book include sequential turn-signals for autos, a wireless video-camera link, a metal detector, an automobile burglar alarm, a proximity



sensor, a signal injector/tracer, a mobile CB converter, a shortwave RF preselector, an automotive safety flasher, a music box, a television remote-sound system, a programmable automotive speed-minder, a brakelight safety pulser, the Rally-mate timepiece, electronic dice, a sing-along light controller, an electronic stethoscope, a time-delay light switch, an emergency light source, a telephone call-timer, a computing thermometer, a liquid-level detector, a delayed-action turn-signal minder, an indoor/outdoor thermometer, an explosion-proof fluid monitor, and a variable-rate horn-blower for boats.

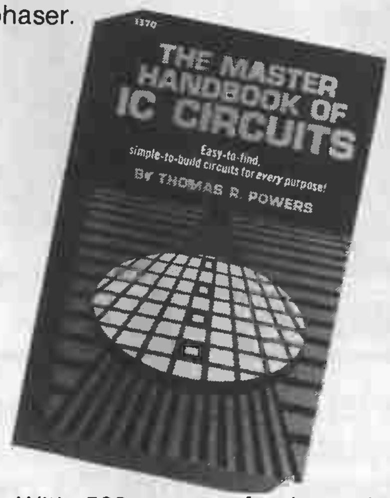
Solid-State Projects You Can Build by Rudolf F. Graf and George J. Whalen is 172 pages of project-building adventure. It can be purchased for $10.95 plus $2.50 for postage from **Howard W. Sams and Co., P.O. Box 7092, Indianapolis, IN, 46209-9921,** or from your local bookseller.

THE MASTER HANDBOOK OF IC CIRCUITS
by Thomas R. Powers

The Master Handbook of IC Circuits is a huge, six-part compilation of circuits that perform a variety of different functions. About the only thing that any of these circuits have in common is that they all consist of one, two, or three ICs.

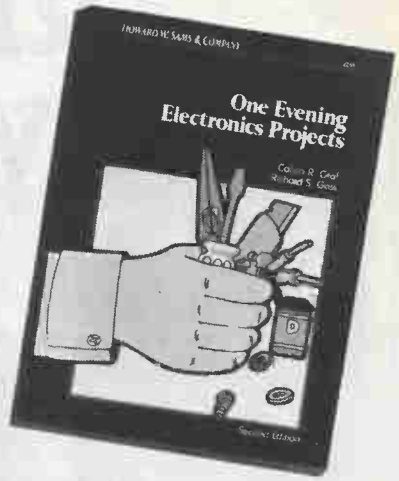
Part I, the biggest section of the book, is devoted to linear circuits. It contains such useful items as precision rectifiers, differential amplifiers, oscillators, and filters, Part II is all about voltage regulators—some with fixed outputs, the rest adjustable. Part III is a brief collection of circuits built around CMOS logic ICs, while Part IV is much the same but features TTL logic instead. The logic circuits featured here do such useful things as debounce a switch, generate clock pulses, or divide the frequency of a square wave.

Radio and television circuits make up Part V, where we find such items as crystal oscillators, simple radios, and video amplifiers. Finally, Part VI consists of circuits built around special-function ICs, which may convert temperature to frequency, generate pink noise, or simulate the sound of a Star Trek phaser.



With 532 pages of schematics, *The Master Handbook of IC Circuits* by Thomas R. Powers certainly delivers the goods. Unfortunately, no explanations accompany the schematics, which means that beginners may have a tough time figuring out what some of the circuits do. You can buy this book for $18.95 (softcover) in bookstores or direct from the **TAB Book Co., Blue Ridge Summit, PA, 17214-9989.** Include $2.50 for postage.

ONE-EVENING ELECTRONICS PROJECTS
by Calvin R. Graf and Richard S. Goss



This is a book of projects that are inexpensive, easy-to-build and simple-to-understand. As such, the book will appeal most strongly to the beginner just starting out in electronics. Sixteen projects are featured here; authors Graf and Goss provide thorough, careful descriptions of how each one operates and how to construct it. They then proceed to suggest novel ways in which the circuit might be adapted to perform other tasks. For example, they suggest using their Sonalight project, an audio oscillator whose frequency varies with the intensity of incident light, for such thought-provoking applicaticns as intrusion detection, observing distant lightning, "listening" to the image on a TV screen, taking one's pulse, and sensing the level of a liquid. The same spirit of fun and curiosity pervades the whole book and makes it an excellent choice for youngsters in particular, since they frequenctly have an abundance of imagination but little cash to spend on equipment.

One-Evening Electronics Projects by Calvin R. Graf and Richard S. Goss contains 174 pages and is an excellent book of projects for the beginner. It can be obtained from **Howard W. Sams & Co., P.O. Box 7092, Indianapolis, IN, 46209-9921,** for $8.95 plus $2.50 for postage, or check your local bookseller.

A TRIPLE-OUTPUT REGULATED POWER SUPPLY

By Walter Sikonowiz

Batteries are all right for beginners, but the experienced hobbyist knows there is no substitute for a good regulated power supply. To be useful, a power supply should consist of three independent sections, two of them continuously variable and providing positive and negative outputs of 0-15 VDC, and the third having a fixed output of +5 VDC for digital logic. Regulated DC power supplies of this kind are available commercially, but by building your own using the plans presented here, you can save money and have fun at the same time. The circuit is a simple one that can be constructed without the aid of expensive test equipment. Furthermore, by choosing from among a variety of circuit options, you can build a supply that suits your needs and makes use of components you have on hand.

You will find that many of the components called for can be purchased at tremendous discounts on the surplus market. Suggestions on how to do this are provided for those of you unfamiliar with surplus buying. Please note that surplus components need not be *used* components, although used items do make up a small percentage of the surplus market. For the most part, surplus consists of new items that someone manufactured or bought and then decided to sell at a sacrifice, perhaps because of a change in design or marketing strategy, or because of a bankruptcy liquidation. Whether you take advantage of surplus bargains or stick exclusively with standard retail parts is entirely up to you. Either way, you will end up with a high-quality power supply that will see you through years of experimenting.

Theory of Operation

To see how the circuit works, let's first look at the schematic in Fig. 2. Transformer T1 converts 115 VAC to 36 VAC center-tapped. Bridge rectifier BR1 changes AC to pulsating DC, which is then filtered to nearly pure DC by electrolytic capacitors C3 and C6. This kind of power-supply configuration is known as a *dual complementary* rectifier circuit or, equivalently, as a *center-tapped bridge*. You'll note that it produces positive and negative voltages simultaneously. The positive potential appears across C3, the negative across C6.

Our positive adjustable supply is built around IC2, an LM317K voltage regulator. C4 and C5 are solid tantalum electrolytic capacitors which stabilize the IC and improve regulation. Diodes D3 and D4 are there to protect IC2. Output voltage is set by means of potentiometer R4, which will be mounted on the front panel of the supply. Trimmer R3 is used to set the maximum output voltage of the supply to +15 volts.

Figure 1. Author's regulated power supply has a single meter for voltage and current, but you can easily build the circuit with dual meters for added convenience.

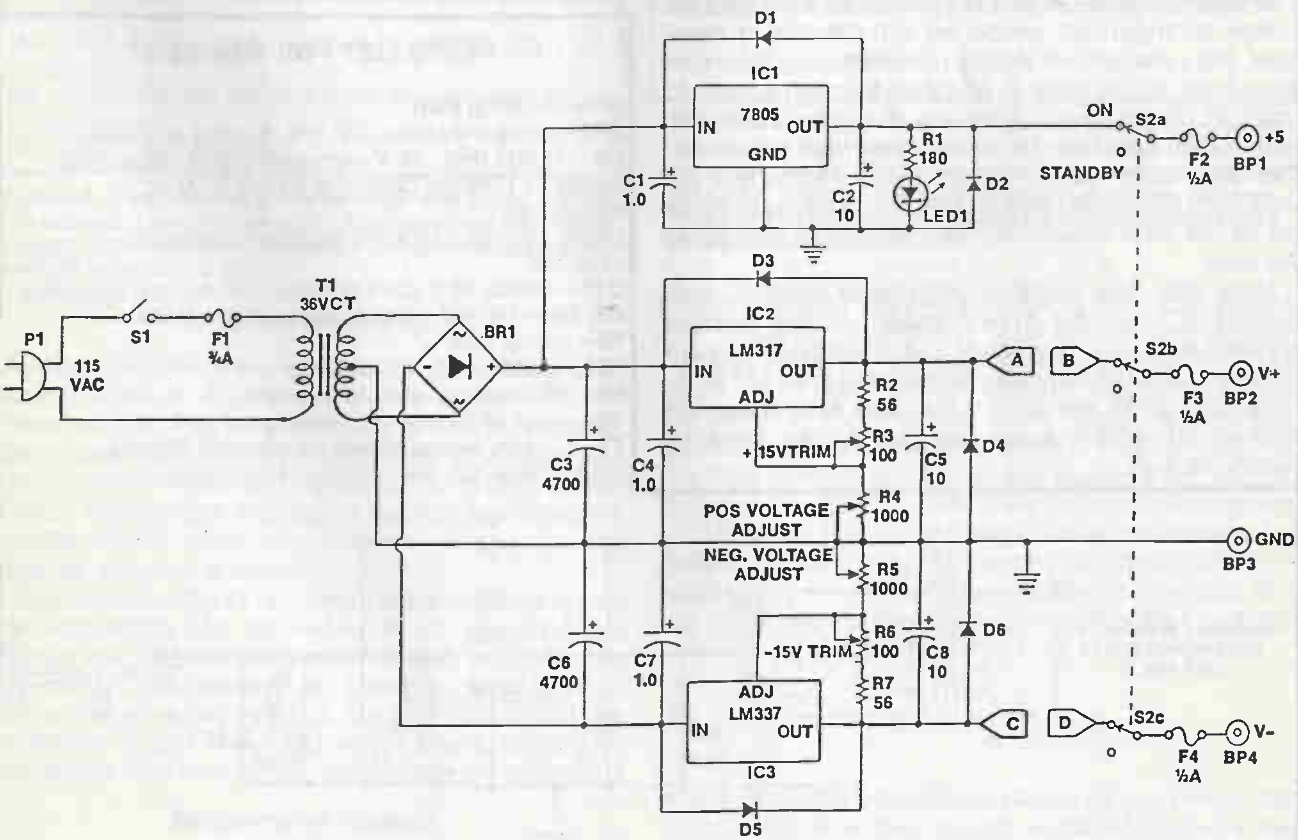


FIGURE 2 POWER SUPPLY SCHEMATIC

Figure 2. Schematic of triple-output regulated DC supply. If you need more than half an amp at +5 volts, omit the 5-volt section (IC1, etc.) shown here and substitute the high-current version in Fig. 3. Points A, B, C, and D connect to meters (see Figs. 4 and 5).

PARTS LIST FOR FIGURE 2

BP1-BP4—binding posts (four different colors)
BR1—bridge rectifier, 200 PIV, 3 amps or greater
C1, C4, C7—1.0 mfd, 50 V solid tantalum electrolytic capacitor
C2, C5, C8—10 mfd., 35 V solid tantalum electrolytic capacitor
C3, C6—4700 mfd., 50 V computer-grade electrolytic capacitor (Mepco/Centralab Series 3120 or equivalent)
D1-D6—1N4003 1-amp 200 PIV rectifier diode
F1—¾ amp slow-blow fuse (increase to 1½-amp if optional 3A/5V section is used)
F2-F4—½-amp fuse
IC1—7805K +5-volt regulator
IC2—LM317K adjustable positive voltage regulator
IC3—LM337K adjustable negative voltage regulator
LED1—light-emitting diode
P1—AC line plug and cord
R1—180-ohm, ½-watt, 10% resistor
R2, R7—56-ohm, ½-watt, 5% resistor
R3, R6—100-ohm trim pot
R4, R5—1000-ohm linear-taper potentiometer
S1—SPST toggle switch
S2—3PST toggle switch
T1—36-volt center-tapped 1.5-amp power transformer (Signal Transformer Co. #241-7-36 or equivalent)
Misc.—heat sinks, hookup wire, fuse holders, knobs, decals, cabinet, mica insulating wafers, and terminal strips.

The points labeled A and B connect to a meter-and-switch arrangement which we will discuss in detail later. For now, we will simply note that output current flows from IC2 to point A, and then through a meter to point B. From there it travels through STANDBY switch S2b and fuse F3 to whatever load we attach. The STANDBY switch allows us to disconnect the load from the supply so that the output voltage can be set to the level desired without danger of damaging the load.

Note that the negative adjustable supply, built around IC3, is the mirror image of the positive adjustable supply. Capacitor and diode polarities are reversed, and the regulator in this case is an LM337K. Other than that, everything that was said about the positive adjustable supply applies to the negative supply as well.

A fixed, regulated potential of +5 volts is provided by IC1, a 7805K voltage regulator. The circuit configuration here is similar to what we have seen before, except that there is no provision for voltage adjustment. LED1 functions as a pilot light. The 7805K regulator can safely supply a maximum of half an amp in this circuit. (In theory, the 7805K could supply up to 1.5 amps, but the input voltage on C3 would have to be lowered, and that would compromise the operation of IC2.) For most experimenters, half an amp at +5 volts will be sufficient. However, if you are a diehard digital enthusiast, you may need a heftier +5-volt supply. In that case, just eliminate IC1 and all its associated components (C1, C2, D1, D2, R1, LED1, F2, BP1) and build instead the alternate +5-volt supply shown in Fig. 3.

The alternative +5-volt supply has its own 10 VAC transformer, T2. Connect the primary side of T2 in parallel with the primary side of T1 (see Fig. 2) so that it sees 115 VAC. The secondary of T2 feeds a bridge rectifier (BR2) and a filter capacitor (C9). Regulation is provided by IC4, and LM323K, which can supply up to 3 amps when adequate heat sinking is provided. Switch S2a is one section of the STANDBY switch shown in Fig. 2. If you build the alternate +5-volt supply, boost the rating of AC-line fuse F1 in Fig. 2 from ¾ amp to 1.5 amps. The heavy-duty supply of Fig. 3 will add about $25 to the cost of this project if new components are used, or about $15 if you find a suitable transformer in surplus.

PARTS LIST FOR FIGURE 3

BP5—binding post
BR2—bridge rectifier, 200 PIV, 6 amps or greater
C9—18,000 mfd., 25 V computer-grade electrolytic capacitor (Mepco/Centralab Series 3120 or equivalent)
C10—1.0 mfd. 25V solid tantalum electrolytic capacitor
C11—10mfd 10 V solid tantalum electrolytic capacitor
D7, D8—1N5402 rectifier diode, 200 PIV, 3A
F5—3-amp fuse
IC4—LM323K +5-volt regulator
R8—180-ohm, ½-watt, 10% resistor
S2a—part of S2 from schematic in Fig. 2
T1—10-volt, 5-amp power transformer (Signal Transformer Co. #241-7-10 or equivalent)

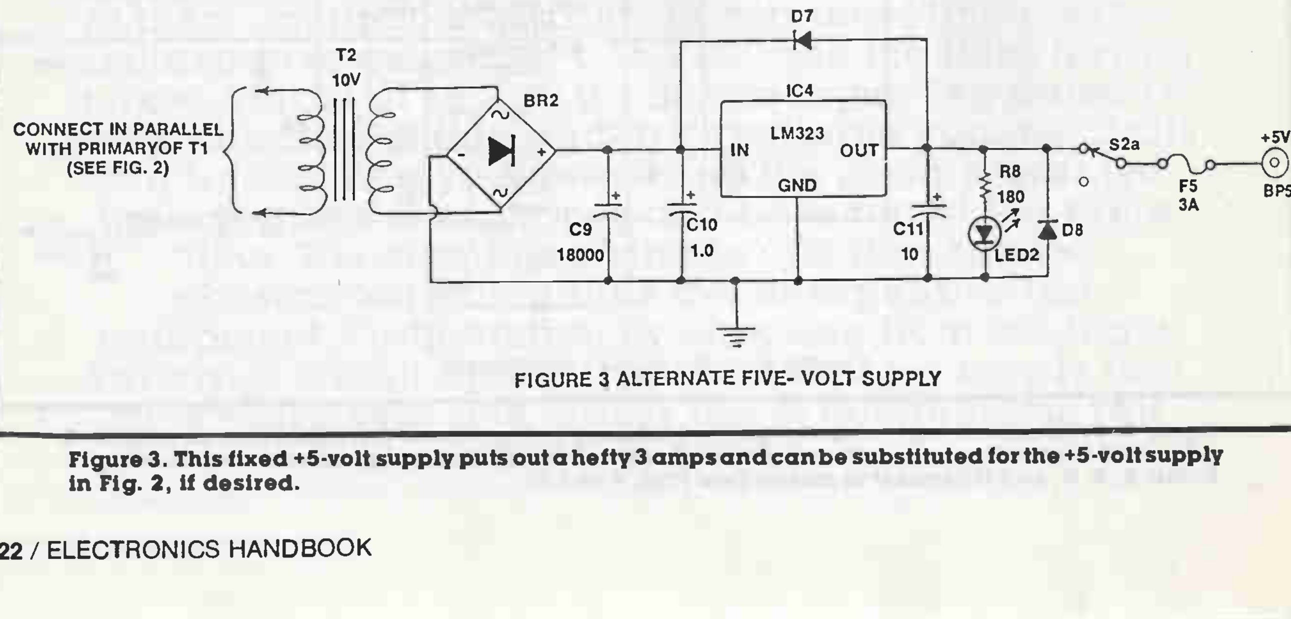


FIGURE 3 ALTERNATE FIVE- VOLT SUPPLY

Figure 3. This fixed +5-volt supply puts out a hefty 3 amps and can be substituted for the +5-volt supply in Fig. 2, if desired.

priced at about $13 each. If you check the surplus outlets, you will find similar meters selling for less than five dollars. Meter M1 should read 0-15 VDC, while M2 can be either 0-500 mA or 0-1 amp DC. The latter may be easier to find on the surplus market.

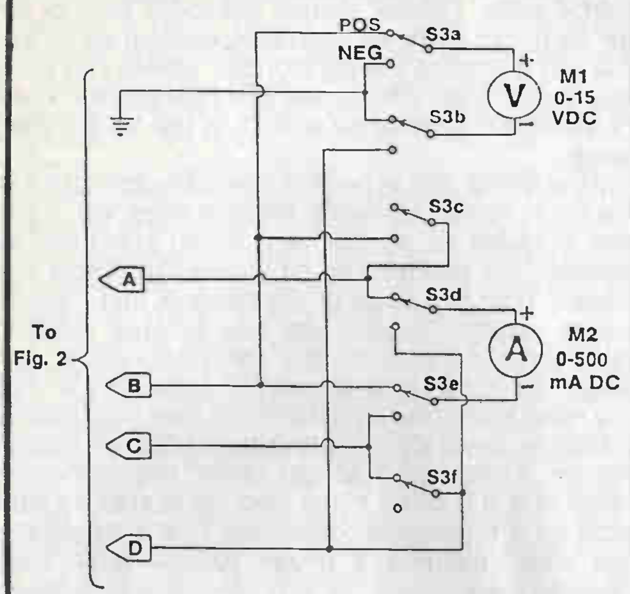


FIGURE 4 DUAL-METER HOOKUP

PARTS LIST FOR FIGURE 4

M1—0-15 volt DC meter (Circuit Specialists #20-1120 or equiv.)
M2—0-500 mA DC meter (Circuit Specialists #20-1116 or equiv.)
S3—6PDT rotary switch

Figure 4. Dual meters allow voltage and current to be measured simultaneously. The positive variable supply is monitored when S3 is up, the negative supply when S3 is down.

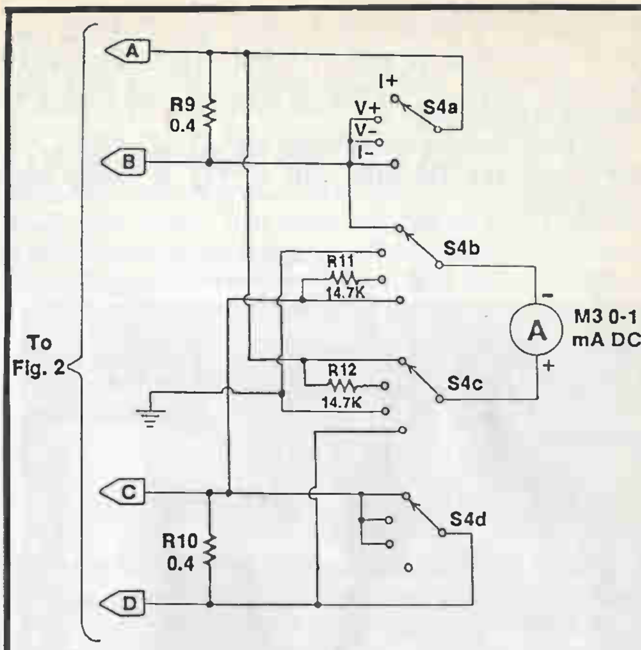


FIGURE 5 SINGLE-METER HOOKUP

PARTS LIST FOR FIGURE 5

M3—0-1 mA DC meter (Circuit Specialists #20-1112 or equiv.)
R9, R10—0.4-ohm (two 0.2-ohm 1% 1-watt wirewound resistors in series; see text for details)
R11, R12—14.7K 1% ½-watt metal-film resistor (see text)
S4—4P4T rotary switch

Figure 5. This alternative to the metering scheme in Fig. 4 uses just one meter but may actually be harder to build. As S4 is rotated counterclockwise from the position shown, positive current, positive voltage, negative voltage, and negative current are measured in succession.

Dual-meter Hookup

We need some means of measuring the voltage and current provided by the adjustable sections of our power supply. Fig 4. shows the preferred method, which uses dual meters that measure voltage and current simultaneously. With switch S3 in the position shown, the positive adjustable supply is monitored; flipping S3 the other way allows us to monitor the negative adjustable supply.

Dual meters may at first seem extravagant, but you will appreciate the convenience of simultaneous voltage and current measurements. In addition, the dual-meter arrangement is easier to build than a single-meter arrangement, and it need not be expensive if you shop for meters carefully. Circuit Specialists Co. has 2-inch panel meters reasonably

Single-meter Hookup

Fig. 5 shows an alternative arrangement that uses just one meter. You will not save any money by using a single meter, and construction will actually be more difficult. The only advantage of a single meter is that it takes up less space. Note that S4 is a four-position switch because the single meter is used to measure four separate quantities: positive voltage, positive current, negative voltage, and negative current. The meter you use for M3 should have a full-scale deflection of 1 mA or less and a voltage drop at full-scale deflection of approximately 0.1 volt or less. For example, Circuit Specialists Co. carries a 0-1 mA DC meter (stock #20-1112) that has an internal resistance of 200 ohms. The voltage drop across this meter at full deflection is 0.2 volt (0.001 amp × 200 ohms), which is satisfactory for our purposes. We must now calculate the value of voltage-dropping resistors R11 and R12 (see Fig. 5) using the formula

$$R = \frac{15V}{I_m} - R_m$$

where Rm is the internal resistance for our meter (200 ohms) and I_m is the current required for full-scale deflection (1 mA). Carrying out the calculation, we obtain

$$R = \frac{15}{0.001} - 200 = 15000 - 200 = 14800$$

The nearest 1% value is 14.7K ohms, and so this is the value we will use for both R11 and R12. Incidentally, Digi-Key Corp. is a good source for low-cost 1% metal-film resistors.

Our final chore is to calculate the values of current-shunt resistors R9 and R10 in Fig. 5 using the relationship

$$R = \frac{I_m \times R_m}{I_{max} - I_m}$$

where I_m and R_m are defined as before and I_{max} is the maximum current we wish to draw from the supply (500 mA, in this case). Carrying out the calculation, we obtain

$$R = \frac{0.001 \times 200}{0.5 - 0.001} = \frac{0.2}{0.499} = 0.4 \text{ ohm}$$

This is the nominal resistance to be used for both R9 and R10. Unfortunately, this is not a standard value of resistance. We can either use a 0.5-ohm 1% wirewound resistor, in which case our full-scale sensitivity will become 400 mA, or we can use two 0.2-ohm wirewound resistors in series to obtain 0.4 ohm. The latter is probably the better course of action. Digi-Key Corp. is a good source for low-resistance 1% wirewound resistors. You may very well want to use a surplus meter for M3. In that case, you will have to redo the calculations outlined above using the characteristics (I_m, R_m) of the meter you have chosen.

We are not through yet. There is still the problem of applying two scales (0-15V and 0-500 mA) to the face of the meter. Let us save the details of that tedious task for later.

Shopping for Components

Right now is a good time to say a few words about where to buy components. As noted at the beginning of this article, many of the components are readily available at reduced prices on the surplus market. You will find that switches of all kinds abound in surplus. Note that the meter-range switches (S3 and S4) specified in this project are described as rotary units in the parts lists. This is because rotary switches are common and cheap. In the prototype, however, I used an interlocking pushbutton-style switch for this purpose. Ordinarily, a pushbutton switch of this kind would be too expensive to consider, but I picked one up cheap as surplus. When shopping for S2, the STANDBY switch, make sure the unit you choose can handle 3 amps DC if you build the heavy-duty +5 - volt supply shown in Fig. 3. If only an AC-current rating is given for a particular switch, divide that figure in half for a conservative estimate of the switch's DC-current capability.

Transformers T1 and T2 are available from the Signal Transformer Co. Their cost was about $16 each at the time this article was written. Be sure to obtain a copy of the Signal catalog and price list before ordering, as prices may change. Even though the Signal transformers specified are well made and reasonably priced, you can probably strike a better deal in surplus. For T1, you can use any transformer with a secondary rating of 32-36 VCT at 1.5 amps or greater. Transformers rated at 34 VCT are quite common as surplus and should work well here. For T2, a transformer with a secondary rated at 10-12 volts AC will work fine. Do not go higher than 12 volts, however. The current capability of T2 should be at least 4 amps. Greater current capability will not do any harm, but as the current rating goes up, so do the size and weight of the transformer. Unless you want your power supply to double as a boat anchor, keep T2 in the 4-6 amp range and T1 in the 1.5-2.5 amp range.

Many of the less expensive components—like AC line cords, knobs, hardware, terminal strips, etc.—are also available as surplus, and if you buy them in quantity, the savings can be substantial. There are actually only two kinds of components that I would advise against buying on the surplus market: electrolytic capacitors and semiconductors. My reason for not buying electrolytic capacitors is that you never know how long they have been languishing in storage. Since electrolytics have a relatively limited lifetime, especially if stored under less-than-ideal conditions, it is better in the long run to spend a little extra for a brand-new component.That is especially true when building a power supply, since filter capacitors are usually the first components to break down. Buy good computer-grade electrolytic capacitors for C3, C6, and C9. Capacitors of this kind usually have screw terminals, as can be seen in Fig. 7.

As noted above, I am also reluctant to buy semiconductors on the surplus market. There is a nagging suspicion I have—probably unfounded in many cases—that surplus ICs are "seconds" that have failed a crucial test and been dumped. Call me a cynic if you like, but the peace of mind that comes form using prime-grade semiconductors in a project is something I am willing to pay extra for.

On other hand, I have no qualms at all about buying meters on the surplus market. You will find the surplus catalogs jammed with analog meters at ridiculously low prices. Take advantage of the savings. A list of surplus dealers appears at the end of this article, along with a list of some reliable standard retail dealers.

Construction

Before beginning construction, you must decide whether to use the heavy-duty +5-volt supply in Fig. 3 or the standard +5-volt supply in Fig. 2. You must also decide whether you want two meters or just one. Having made those decisions and purchased the necessary parts, you are ready to begin construction. Note that a printed-circuit board was not used in the construction of the prototype, since most of the components were not PC-mountable. Terminal strips were used where necessary to hold components that were not self-supporting. You could as easily use perfboard for that purpose.

The prototype is housed in a 6×8×5-inch "N" series cabinet manufactured by LMB. Its cost is roughly $20. If you build the optional 3-amp +5-volt supply or use two meters, a larger cabinet will be needed. A less elegant cabinet will save money without affecting the performance of the circuit.

Potentiometers R4 and R5 mount on the front panel. Be sure to use linear-taper devices, and wire them so that maximum resistance is obtained when they are rotated fully clockwise. R3 and R6 can be small trimpots mounted on perfboard or large-size potentiometers with slotted shafts that accomodate a screwdriver rather than a knob. If you do use large-size pots for R3 and R6, mount them on the rear panel of the supply. Put R2 and R3 relatively close to IC2, and R6 and R7 close to IC3. The stabilizing capacitors—C1, C2, C4, C5, C7, C8, C10, C11—should also mount close to their respective IC regulators (right on the pins, if possible). LED1 can be mounted wherever convenient on the front panel.

Computer-grade electrolytic capacitors require special mounting clamps, which do not come with the capacitors; you must buy them separately.

The current ratings of BR1 and BR2 in the parts list are the minimum acceptable values. Rectifiers of the size specified generally are intended for PC mounting and come with wire leads. If you do not use a PCB or perfboard, you may find it advantageous, though a bit more costly, to use 200-PIV 25-amp bridge rectifiers. These high-current devices come with heavy solder-lug terminals and mount directly on the chassis with a single bolt. They will be easier to work with in the absence of a PCB, and, of course, the more generous current rating does no harm.

Use 16-gauge stranded-copper hookup wire for any lead that may be expected to carry high current. This includes the leads between the transformers and the bridge rectifiers, and between the bridge rectifiers and the filter capacitors. It also includes leads connected to the inputs and outputs of the IC regulators, and the ground-return lead connected to BP3.

All of the voltage regulators used in this supply are specified with a "K" suffix, which means they are packaged in a standard TO-3 case. Regulators with a "T" suffix are less expensive but should not be used because their packages (TO-220) possess too much thermal resistance. In other words, regulators with a "T" suffix will not dissipate heat as effecively as those with a "K" suffix. Furthermore, "T" suffix regulators are intended for PCB mounting and would be awkward to work with here. Fig. 6 shows the pinouts for each of the IC regulators. Note that only the LM323K and 7805K have cases that are at ground potential, which allows us to mount them directly on their heat sinks. The other regulators (LM317K and LM337K) have cases that are "hot". They require mica insulating wafers between them and their heat sinks.

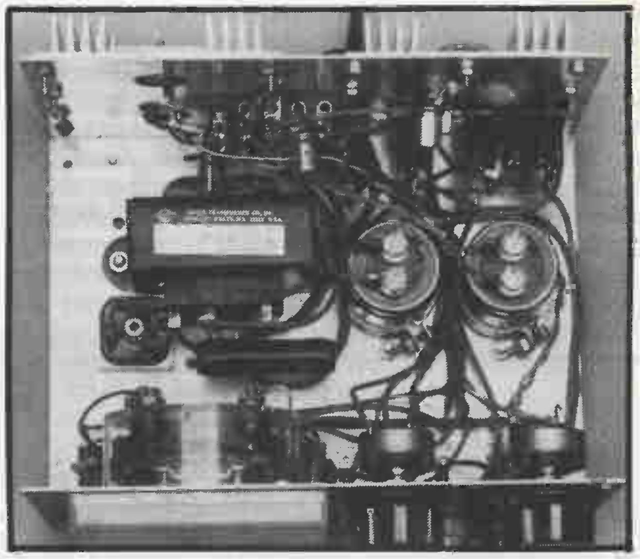


Figure 7. Internal view of the power supply. Note the heat sinks mounted on the back panel and the large computer-grade electrolytic capacitors.

The IC regulators and their heat sinks should be mounted on the rear panel of the power supply (see Fig. 7). The fins of the heat sinks are oriented vertically so that cooling air can flow upward between them. Fig. 8 illustrates the appearance of a typical extruded aluminum heat sink. The chart in Fig. 8 shows the part numbers and physical characteristics of some Wakefield Engineering heat sinks capable of cooling the IC regulators in this project. (Wakefield Engineering products are sold by Newark Electronics

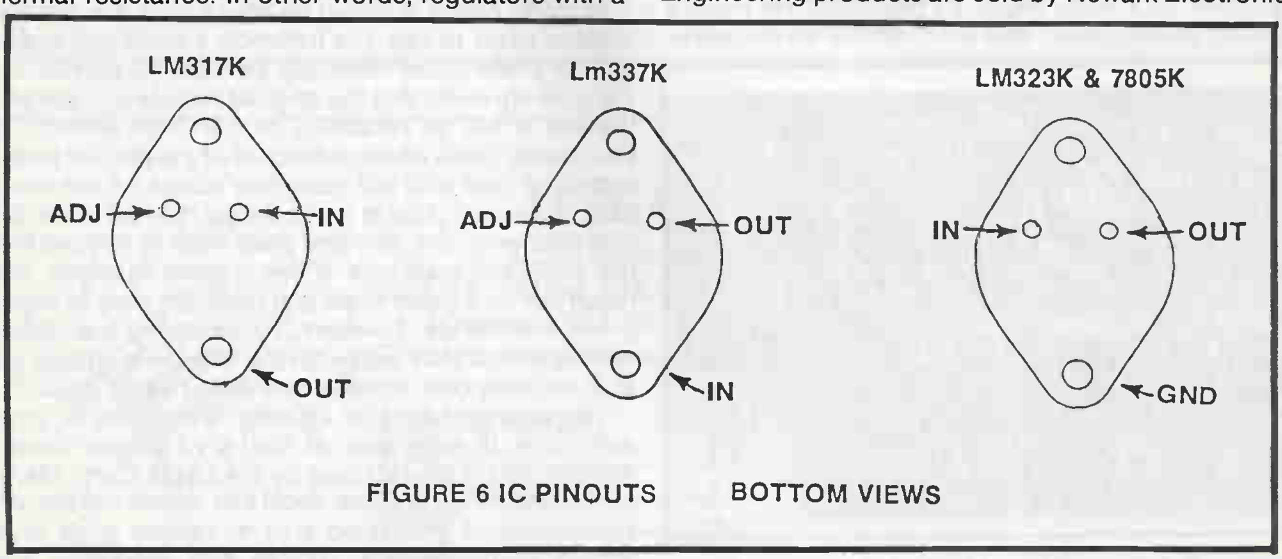


Figure 6. Pinouts of IC regulators. Note that the LM317K and LM337K have metal cases that are not at ground potential, so mica wafers must be used to insulate these ICs from their heat sinks.

and other Distributors.) You can use this chart in one of two ways. The first approach is simply to buy one of the Wakefield Engineering heat sinks specified. Two sinks are listed for each regulator. The smaller one should be entirely adequate; the larger one provides a bit more cooling capability but costs more. If you cannot obtain Wakefield Engineering heat sinks, get a sink whose thermal resistance or physical dimensions come close to what is listed in the chart. You should be able to find a variety of extruded aluminum heat sinks on the surplus market.

In order to improve the transfer of heat, be sure to use silicone grease when mounting each IC regulator on its heat sink. Spread a *thin* film of white grease on the base of the regulator, then bolt the IC to the heat sink. If you use too much silicone grease, it will ooze out and make a mess, so resist the urge to be generous. When mounting the LM317K and LM337K, spread silicone grease on both sides of the mica wafer that insulates the IC regulator from its heat sink. You can buy these mica wafers separately or as part of a standard TO-3 device-mounting kit.

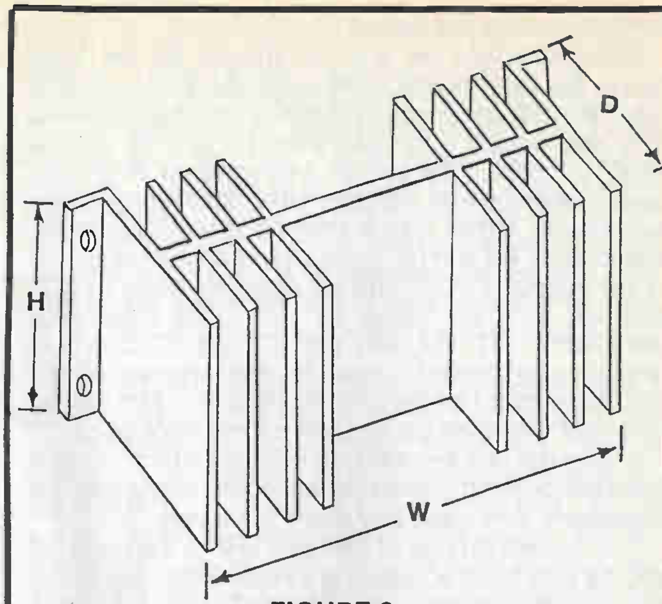


FIGURE 8

HEAT SINK SELECTION GUIDE

Voltage Regulator	Heatsink*	Thermal Res.	H	W	D
317K,337K or 7805K	401	1.95 °C/W	1.5	4.75	1.25
	403	1.3 °C/W	3.0	4.75	1.25
323K	413	.95 °C/W	3.0	4.75	1.88
	423	.67 °C/W	5.5	4.75	2.63

*Wakefield Engeneering type numbers
All dimensions in Inches

Figure 8. Physical specifications of some aluminum heat sinks suitable for cooling the IC voltage regulators used in this project.

If you are building the single-meter version of this power supply, you must put two concentric scales on the face of your meter, One scale will read 0-500 mA, the other 0-15 volts. Begin by removing the meter's glass or plastic bezel, and then remove its dial plate.

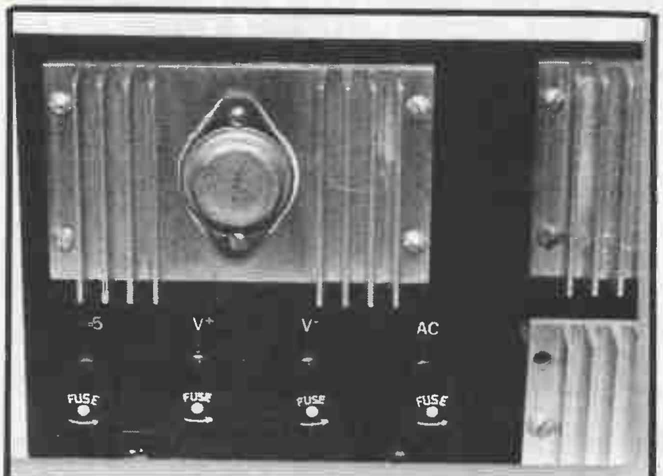


Figure 9. Detail on back of panel showing an IC regulator mounted on its heat sink with four fuseholders below it.

Usually, one or two small screws must be unfastened to free the dial plate. Be careful not to bend the meter needle in the process.

In many cases, you will be able to put the meter's original scale to use. For instance, a scale that reads 0-50 or 0-500 could obviously be used for current. In the unlikely event that the original scale is completely useless, it will be necessary to start from scratch. If your meter has a white cardboard or plastic dial plate, just flip it over and put your new scales on the back side. If the dial plate is metal that is painted white on one side only, use very fine steel wool to remove the old scale and markings. If this is done carefully, the result will be a clean white dial plate. It is easy to make a mess of things, however, by removing too much white paint. If that happens, the dial plate should be sprayed with one or two coats of flat white paint.

The easiest means of affixing new scales to your dial plate is with one of the dry-transfer meter-marking kits manufactured by the Datak Corp. Many parts jobbers carry these decal kits, which contain an assortment of graduated arcs in various sizes plus letters and numbers. Scales and markings are transferred to the dial plate by rubbing gently. The process is fairly tedious, but with care you can produce good-looking results. Be sure to select scales which are the same size as the one that was originally on the meter. Once the scales are in place, the dial plate is remounted in the meter, and the bezel is replaced. One final comment: the meter you see in the prototype (Fig. 1) came from an old power supply and had all the necessary scales already in place. I would not have had the patience to create the meter scales myself.

Calibration

Once construction is complete, two simple adjustments must be made before the power supply can be put to use. First, rotate both R4 and R5 fully clockwise. If these pots have been wired correctly, their resistances will now be at a maximum. Next, adjust R3 and R6 so that their resistances, too, are maximized. Depending on the version of the supply that you have built, set meter-range switch S3 or S4 so that positive voltage can be measured. Now, turn on the supply and adjust R3 until the reading on your meter is exactly 15 volts. Next, set S3 or S4 so that negative voltage can be measured, and adjust R6 until your meter again reads 15 volts. Your power supply is now ready for use.

One final comment: The metering arrangements have no provision for monitoring the +5-volt supply because the act of switching a meter into and out of the circuit would introduce a transient voltage that might disrupt the operation of a digital circuit connected to the +5-volt supply. If you want to monitor the current drawn from the +5-volt supply, mount an ammeter permanently in series with the output. A small edge-reading meter won't take up much panel space and should cost just a few dollars in surplus.. There is, of course, little point in monitoring the voltage put out by the +5-volt supply since it is constant as long as the supply is not overloaded. ■

STANDARD NEW-PARTS DEALERS MENTIONED IN THE TEXT:

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

Digi-Key Corp.
P.O. Box 677
Thief River Falls, MN 56701-0677

Newark Electronics
4801 N. Ravenswood Ave.
Chicago, IL 60640-4496

Signal Transformer Co.
500 Bayview Ave.
Inwood, NY 11696

Jameco Electronics
1355 Shoreway Rd.
Belmont, CA 94002

DEALERS WHO SELL SURPLUS COMPONENTS:

All Electronics Corp.
P.O. Box 567
Van Nuys, CA 91408

Star-Tronics
P.O. Box 683
McMinnville, OR 97128

Jerryco, Inc.
601 Linden Place
Evanston, IL 60202

American Design Components
815 Fairview Ave.
Fairview, NJ 07022

H&R Corporation
401 E. Erie Ave.
Philadelphia, PA 19134

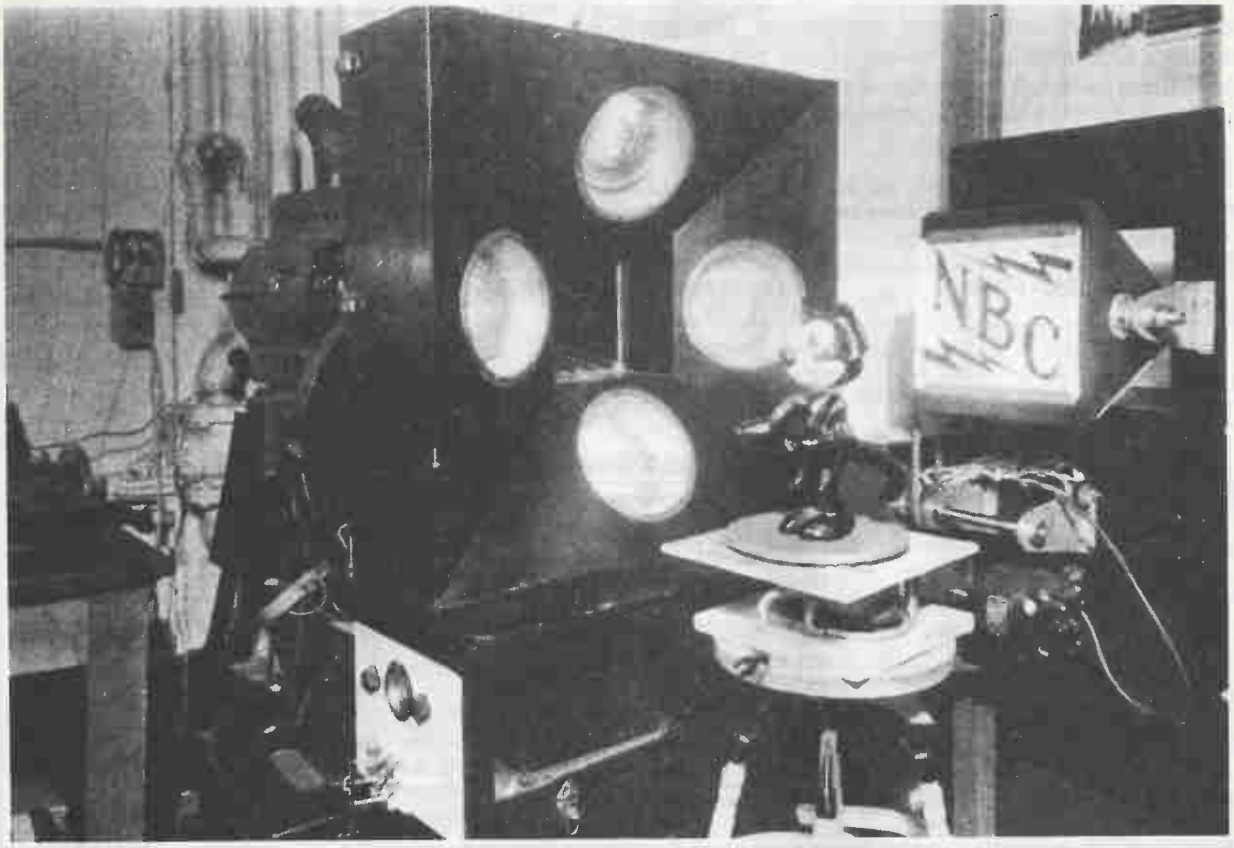
Marlin P. Jones & Associates
P.O. Box 12685
Lake Park, FL 33403

C&H Sales Co.
2176 E. Colorado Blvd.
Pasadena, CA 91107

Surplus Traders
P.O. Box 276
Winters Lane
Alburg, VT 05440

CHANNEL ONE THAT WASN'T

By Glenn M. Rawlings



A rare view of Felix the Cat inside of RCA's transmission facility in 1928.

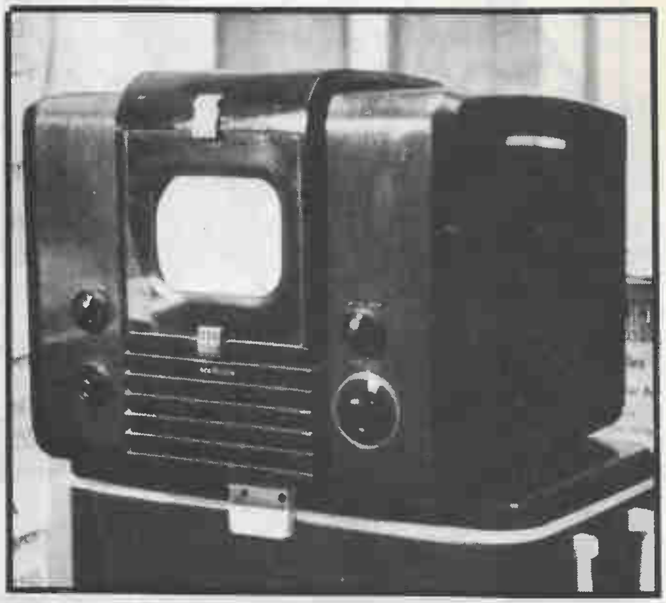
At some point in your experience of watching Television, it must have occurred to you that there is no channel "1" on the tuning dial. Why would this be? Well, it is a fact that channel "1" hasn't been on any TV set since 1946 and a very few year-later production runs. Today, some of the more recent sets have "expanded" cable tuning capability, with letters like "A", "B", "C" etc., but the basic channels are still channels 2 through 13.

In order to understand why we don't have channel one, it is necessary to review some Broadcasting history. Electronics has come a long way from the discovery of static electricity, to the complex marvel of today's TV set. In 1928, there were only a half dozen TV sets in existence, and most of these in New York City. They were custom assembled by engineers, to "pick" an experimental signal out of the air. These TV sets had no resemblance to what we now consider a piece of our living room furniture. Should the erratic and mysterious signal of pictures appear in the air, the 1928 TV Set didn't need a "tunable" portion in its circuitry. The receiver was calculated to be the same as the experimental transmitter, and that was that! No choice of channels! Satellite and cable give us over 200 choices today.

The very first form of communication through the "air", was literally an on-off blast of transmitted static. These static blasts were "coded" with a pattern of short and long durations, known as the "Morse Code", after the man who invented it. At any rate, these blasts are what we consider "interference" today, and would disrupt most forms of modern communication/broadcasting. (Morse Code is still used, but it is confined to a very specific frequency. Frequency is the term used to describe the number of electromagnetic waves that occur in one second of time.) The static blasts were created by using something called a "Spark Gap Transmitter", which was, as the name implies, a transmitter of sparking (or arcing) high voltage electricity. It is the same type signal that is generated when your refrigerator interferes with your radio, or the ignition in your car interferes with your stereo. A "wide band" signal that is not confined to a specific frequency. Many people give credit for the invention of AM Radio to the Marconi brothers, but in fact, they just formed the Marconi Telegraph Company of England in 1897, which transmitted Morse Code messages. The first AM Radio "program" was actually made by a fiddle playing orator named Aubrey Fessenden from Massachusetts. He played the violin, recited verses from the Bible, and in general transmitted messages that were of human recognition to ships and other receivers which had originally been only designed to receive the "static" of the spark gap transmitter. Mr. Fessenden was not only a musician, but a brilliant engineer as well. In many ways, he was the inventor of Radio as we know it. Mr. Fessenden put his first program on the air in 1906. (Bear with me. The story of our missing channel one on TV is related to what is unfolding in our discussion of early radio.)

With more and more transmissions of "entertainment" like Mr. Fessenden's it soon became apparent that the new technology could be used for a better purpose. David Sarnoff of RCA (Radio Corporation of America) was the first to recognize that the concept of selling little "radio music boxes" to the public was a very viable business prospect. Just imagine the time frame we are discussing. To mention that "invisible" signals of an "electromagnetic" nature could relay human intelligence "through the air" must have been mind boggling. The general public must have thought Sarnoff and Fessenden and the likes were close to insanity! At any rate, these early transmissions were amplitude modulated waves of electronic energy, better known as AM Radio. After the Spark Gap transmissions, AM radio was the ONLY form of communication using the "air" waves.

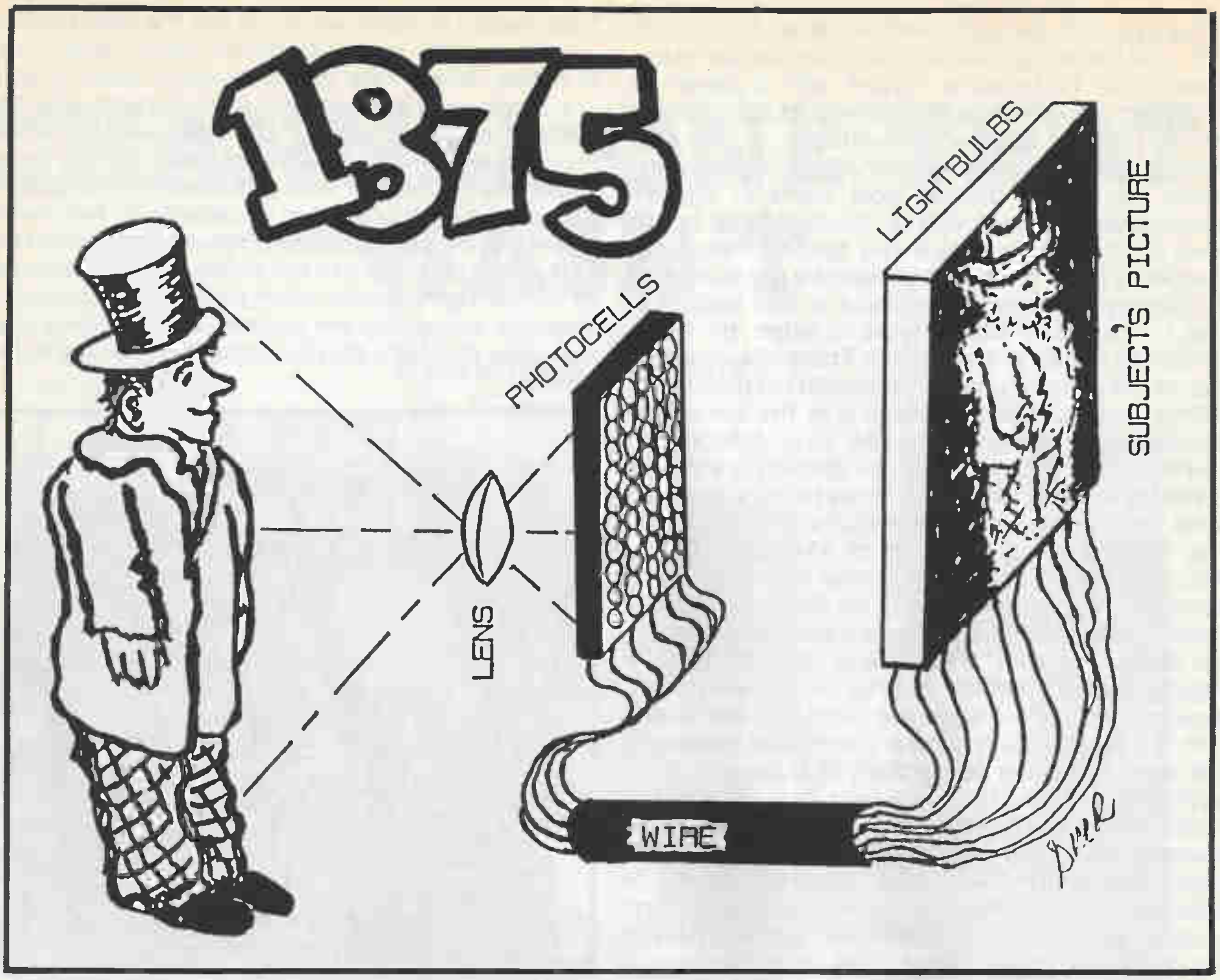
FM Radio (frequency modulation) was invented by Captain Edwin Howard Armstrong about 55 years ago, as an attempt to eliminate static and other "amplitude" modulated interference that was an occasional problem with AM Radio. (Actually AM Radio is capable of high fidelity at great distances beyond FM, but that is another story. It is possible today for everyone to have 200 plus channels of TV available anywhere in the country, using a 2′ dish antenna. But, in the author's opinion this will never happen, due to politics and private interests. What we have today, in other words, is not the best that we could have if the technical decisions were not political in nature. At any rate, FM Radio didn't catch on with the public or manufacturers of equipment until the 1960's. Captain Armstrong was a genius of sorts, and he invented several radio circuits which are still in use today. He eventually was promoted to the rank of Major, and had a number of patents to his credit. There was only one problem. From the time of his very first patent disclosure to the public, he spent the rest of his life fighting with other people who wanted to steal his inventions! He became so depressed over this state of affairs, that he committed suicide in the 1950's.



A photo of the author's 1946 RCA Victor TV set, considered a rarity in its day.

The following is amazing! Television was invented (or at least conceived) before Radio! G.R. Carey of Boston had a "brainstorm" in 1875. He believed that an image could be somehow transported by wire (or air) from one point to another. He believed that an image could be "captured" on a bank of light sensitive material. (It may have been selenium that he had in mind.) The captured image would then be carried through a group of matching wires, to another bank of "light emitting" units. There was one very large problem with Mr. Carey's idea. The technology to do what he had in mind, just didn't exist in 1875! (He may have proposed his invention as a scam, since it was just four years previous that P.T. Barnum made his famous statement; "There's a sucker born every minute." Indeed, this concept of somehow creating a picture at a distant location must have seemed pretty ridiculous at the time. Even more so than the "audio in the air" of AM Radio.)

The first actual television experiments were performed in the early 1920's by a U.S. immigrant from Russia, Vladimir K. Zworykin, as well as by Philo T. Farnsworth, a native American. In addition, John Logie Baird from Scotland, was said to have "relayed" some light and dark images of a dummy head through a concoction of wires, piano strings, cardboard and



THE ONLY TRUE CHANNEL "1" MAY HAVE OCCURRED IN 1875.

batteries. The details are, unfortunately, not very well documented in some of these cases, so it is difficult to give the invention of TV completely to any one person. Regardless, the concept and possibility of a televised picture had forever been loosed from the technical confines of Pandora's Box!

Mr. Guy and Mr. Smith were engineers who worked for the Radio Corporation of America (RCA) in early 1928. They were making history for the company by transmitting actual pictures through the air from 411 Fifth Avenue in New York City. These pictures for the most part, were "Felix the Cat", rotating on a slowly revolving platform. Felix was illuminated with a strong carbon arc light source (actually a 35mm movie lamp housing, used in motion picture projection.) A synchronized aluminum disc was between Felix and the light source. The disc had "spiralled" holes drilled in it, which caused the light source to trace across the subject from left to right, and from top to bottom in a somewhat orderly fashion. The "lined" and "synchronized" image was then transmitted into the air at approximately 42 MHz, (million cycles per second) and at a power of 500 watts (equivalent to the power consumed by an electric toaster in the kitchen.) The station was called W2XBX, and proved to be instrumental in the engineering success of RCA, who subsequently formed NBC, (the National Broadcasting Company.) The technologies of communications were moving faster now, and as we shall soon discover, perhaps a little too fast!

In May of 1928, WGY of Schenectady N.Y. had begun to transmit a somewhat "scheduled" television program. (Three times a week for an hour or so.) Meanwhile W2XBX was busy replacing their mechanical scanning disc transmitter with one of a more electronic nature. (Transistors hadn't been invented yet, so we are talking about vacuum tubes.) You may recall that Major Armstrong had invented the concept of FM Radio. He needed somewhere to continue his FM experiments, so he made arrangements with RCA to share their facilities on top of the Empire State Building. And so, not only were experimental TV pictures being transmitted, but also a new experimental sound as well.

The political structure of the country at the time, just didn't understand what was happening in all this exciting "airwave activity". Electromagnetic waves floating through the air indeed! But it was happening, and various interests in the technology were trying to get into the "action". It was becoming more and more apparent that some type of "co-ordination" of signal frequencies being transmitted into the air would be necessary. And so, in 1934, Congress formed the Federal Communication Commission (FCC). The purpose of this Commission was to "regulate the airwaves for the public's interest." One of the first acts (1935) was to assign television two bands of frequency. (42 to 56 and 60 to 80 MHz.) Notice that this would allow W2XBX to continue operation as usual.

This is a photograph taken from the screen of the author's TV set manufactured in 1946. The picture is of Jerry Lester with his side-kick, Dagmar. The show was called "Broadway Open House", the forerunner of the "Tonight Show".

Felix the Cat was a wonderful way to begin the era of television! There were only 6 or 7 TV sets in existence at the time, but anyone lucky enough to have seen a flickering image, knew that something magical was in the works. From there, the flickering images were beginning to gradually improve, and Major Armstrong's FM Radio was improving with experimentation. Television was assigned the frequency range of 42 to 56 MHz by the FCC in 1935, and then in 1940 the Commission went a step further and agreed that the transmissions of W2XBX (being in the lowest frequency range) could be considered as television's channel "1". But with only a few hundred TV sets in existence at this time, TV was still considered a novelty, and had absolutely no political influence in Washington. With this in mind, you might find it easier to understand why the FCC, just a short while later, decided to assign the frequency range of 42 to 50 MHz to the FM Radio people. Potential chaos was "beginning to crystallize" in the communications world. Radio would be transmitting right smack in the middle of television! And especially note, right in the middle of channel "1". All of this is even more amazing when you consider that neither TV nor FM Radio are using this frequency range today! The FCC didn't envision that TV or FM would become the giants that they are today.

Partly in answer to the above problem, the government decided to form another "committee". This one would be called the "National Television Standards Committee", or better known as the NTSC. The purpose of this committee was to develop TV engineering standards. With an engineering staff, they decided that a TV picture would have 525 horizontal lines, each channel would be exactly 6 MHz wide, and the sound would consist of Major Armstrong's FM Radio invention. They decided that each major city would have 1 TV station, but provided that allocations for "every other channel" would be possible if the technology caught on. The NTSC was formed in 1941. The Japanese bombed Pearl Harbor in December of that year, and the World War II began, which put a hold on TV and Broadcast technology until 1945.

Here is a close-up picture of the tuner from a 1946 TV set, which clearly shows channel "1" on the dial.

Before the war began, however, TV's channel "1" was assigned the same frequency as the FM Radio band. Many FM radios had been made at the time and it is estimated that over a half million became obsolete overnight by this 1940's boondoggle. Since TV was a much more complex subject, the losses from obsolete sets were much less. There were only three TV stations in existence when the war began. They were all in the US, and approximately 9,000 TV sets had been made. As the war proceeded, the Defense Board limited all TV activity to the war effort, with a maximum of four hours per day. (During the 2nd World War, food, gasoline, rubber, nylon stockings, television and FM radio were all rationed. AM Radio was the great communicator during these war years.)

(Continued on page 88)

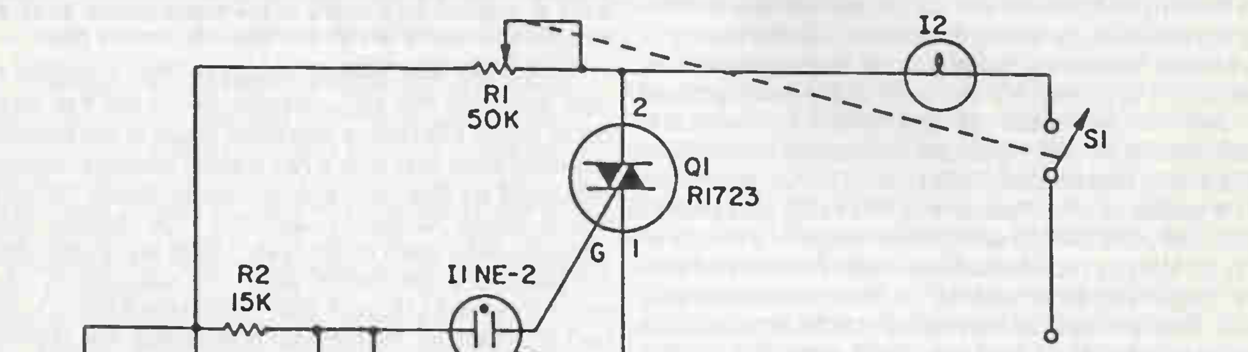
CIRCUIT FRAGMENTS

Reading about electronics can be fun and instructive, but the only way to become a knowledgeable technician is to get hands-on experience, by actually connecting resistors and capacitors together in circuits that do something. These circuits can be as simple as turning a light on or off, or making some kind of alarm sound. As long as we have a power source and a load connected together by wires, we have a functioning circuit.

Another way to think about circuits is to consider one part the **input**, and another part the **output**. This is notably true of amplifiers. The circuits in the following Circuit Fragments section are like this; they all **Do** something.

These projects are comparatively simple—and each uses fewer parts than those in our **Workbench Projects** and **IC Testbench** sections. If you study them and put several together you will increase your understanding of how all electronic components and circuits work.

INEXPENSIVE LAMP DIMMER



INEXPENSIVE LAMP DIMMER

Using almost all "junk box" parts, or those easily found at local parts distributors, this budget-priced lamp dimmer can be assembled directly inside a lamp socket, lamp base, or electrical outlet box (replacing a wall switch).

Triac Q1 can handle up to 75-watts without a heat sink. Over 75 watts, sink Q1 to the metal enclosure, or a small heat sink insulated from the socket (if you build the dimmer into a socket). If you mount Q1 on the enclosure, make certain none of the Triac's leads "short" to the enclosure. Use silicon heat sink grease between Q1 and the sink.

I1 is an ordinary NE-2 neon lamp. If it will somehow be exposed to light, paint the lamps black, or some other opaque color. (I1's "trigger" voltage threshold is affected by light.)

Because the neon lamp has a firing threshold above zero volts, the lamp cannot be turned fully off with the control. Rather, switch S1 snaps the lamp on to a very subdued brilliance which can be faded up to almost maximum lamp brilliance. Make certain R1 is wired so it is a maximum resistance just before S1 switches from on to off.

PARTS LIST FOR INEXPENSIVE LAMP DIMMER

C1, C3—.02-uF, 50-VDC ceramic disc capacitors
C2, C4—0.05-uF 50-VDC ceramic disc capacitors
I1—NE-2 neon lamp
I2—75-watt or smaller standard lighting fixture
Q1—HEP-R1723 Triac or equivalent
R1—50,000-ohm, linear taper potentiometer
R2—15,000-ohm, ½-watt resistor
S1—SPST switch (part of R1)

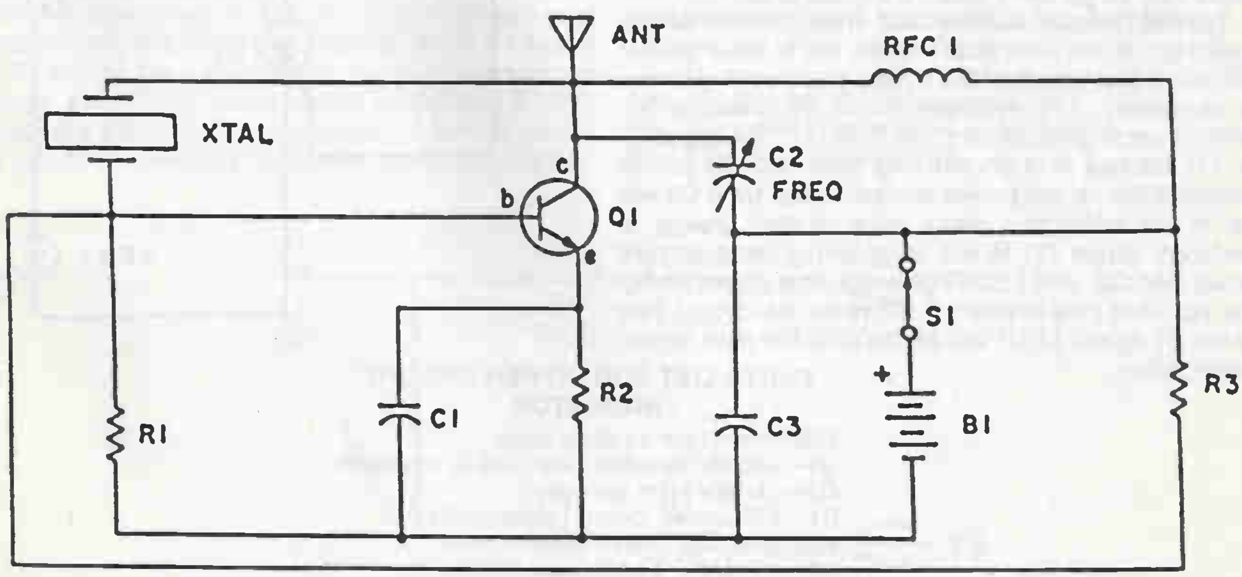
FOX HUNT TRANSMITTER

Ever been to a radio foxhunt? Everyone brings a portable radio and a very directional antenna and tries to find where a small transmitter has been hidden. First one to find it wins. And here's just the transmitter to bring this old ham radio game to the rest of us. Transistor Q1 acts as a crystal oscillator in the new 49 MHZ walkie-talkie band. The output of this oscillator is very low, and no license is required if you keep your antenna down to just a few inches in length.

Trimmer capacitor C2 lets you tweak the frequency of this transmitter right into the middle of the channel. Use a walkie talkie and listen for carrier; when you hear it best you're on frequency. This same circuit can be used as a wireless mike. Connect a carbon microphone, like an old telephone handset mike, in series with R2 and ground.

PARTS LIST FOR FOX HUNT TRANSMITTER

B1—9 VDC battery
C1, C3—.001-uF capacitor
C2—90-pF variable capacitor
Q1—NPN transistor, 2N2222 or equiv.
R1—10,000-ohm resistor, ½-watt
R2—470-ohm resistor, ½-watt
R3—47,000-ohm resistor, ½-watt
RFC1—2.5 mH radio frequency choke
S1—SPST switch
XTAL—crystal cut for the 49 MHz band

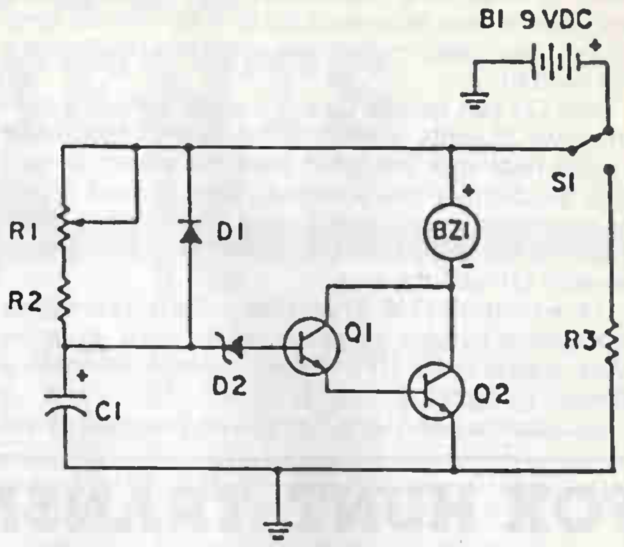


MINIATURE TIMER

We've found a timer circuit that wins everyone's approval. It's small, both in size and in cost.

With S1 in contact with +9VDC, capacitor C1 gradually charges through R1 and R2. When the potential across C1 reaches 5.5 volts, base drive flows into the Q1-Q2 Darlington pair through zener diode D2. This causes the transistors to conduct collector current and activate buzzer BZ1, a miniature device that emits a pleasant, shrill tone to signal the end of the timed interval. To reset the timer, flip S1 so that it contacts R3, which functions to discharge timing capacitor C1 through didode D1.

Using trimmer R1, you can adjust the timed interval to any value between 30 and 120 seconds. We use this timer to control the development of Polaroid instant films, but you can probably find dozens of other uses too.



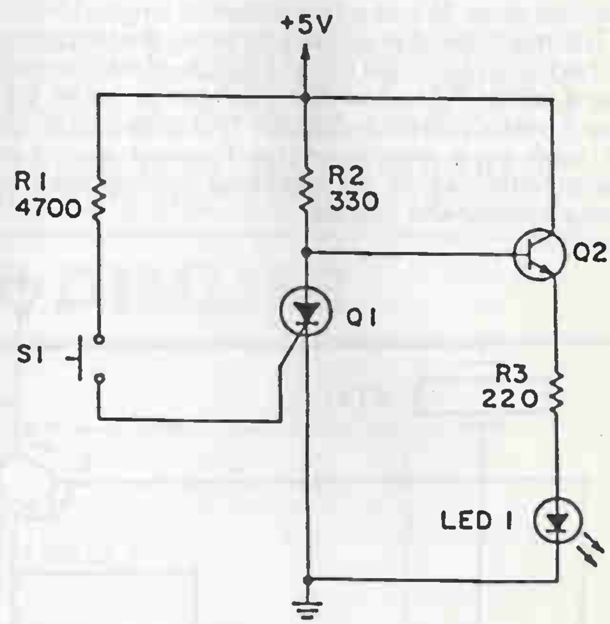
PARTS LIST FOR THE MINIATURE TIMER

B1—9-volt transistor battery
BZ1—9-VDC buzzer (Radio Shack #273-052)
C1—470-uF, 25-VDC electrolytic capacitor
D1—1N4002 diode
D2—1N748A, 3.9-volt, ½-watt zener diode
Q1, Q2—2N3904 NPN transistor
R1—200,000-ohm trimmer potentiometer
R2—62,000-ohm, ½-watt, 5% resistor
R3—330-ohm, ½-watt, 5% resistor
S1—SPDT slide switch

POWER FAILURE INDICATOR

The purpose of this little device may seem a little obscure. After all, when the lights go out, there must have been a power failure, so who needs a special circuit to detect the obvious? It just so happens, however, that many failures are either momentary or incomplete, so we are never aware of them. To certain types of electronic circuits, unfortunately, even a brief power outage can be disastrous. Control systems, computer systems, even your AC-powered digital clock can all go awry when the juice is cut off.

To the rescue comes our little power-failure indicator. It will alert you to even the briefest power failure so that you can take whatever corrective action is necessary. The indicator is set by pressing S1, which injects gate current into SCR Q1. Consequently, Q1 latches in a conducting state with its anode potential low. If the power is interrupted. then Q1 will be in an unlatched state once normal power is restored. Since Q1 is not conducting, base current flows into Q2, and LED1 lights up. This alerts you to the fact that power was off. To reset the circuit, just press S1 again. LED1 will be off until the next power interruption.



PARTS LIST FOR POWER FAILURE INDICATOR

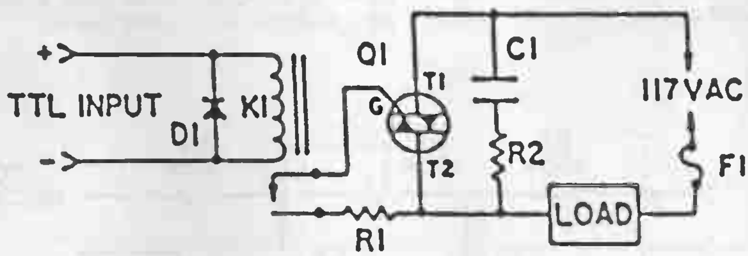
LED1—red light-emitting diode
Q1—2N5060 sensitive-gate SCR or equivalent
Q2—2N3904 NPN transistor
R1—4,700-ohm, ½-watt resistor, 10%
R2—330-ohm, ½-watt resistor, 10%
R3—220-ohm, ½-watt resistor, 10%
S1—normally open pushbutton switch

MICROCOMPUTER/ AC INTERFACE

Here's one of the simplest and best ways to harness your microcomputer for the purpose of appliance control. Let an output line drive relay K1, a small, 5-volt device designed expressly for TTL. The relays contacts supply gate drive to Triac Q1 which, in turn, does the hard job of controlling the relatively large load current. Besides controlling the Triac, relay K1 also isolates the logic circuitry from the AC line. C1 and R2 prevent false turn on of the Triac with inductive loads and F1 protects the Triac should the load short out. Of course, this circuit can be used to interface any type of logic circuit-not just a microcomputer-to the AC line.

PARTS LIST FOR MICROCOMPUTER/AC INTERFACE

C1—0.1uF, 50 VDC ceramic capacitor
D1—1N4002 diode
F1—3AG 10-amp fuse (fast acting type only)
K1—Reed Relay 5VDC, 20ma, 250-ohm (Radio Shack #275-1067 or Equiv.)
Q1—Triac 6-amp, 200 volts, (Radio Shack #275-1067 or equiv.)
R1—1,000-ohm, 1 watt, 5% resistor
R2—10-ohm, 1 watt, 5% resistor



DISGUISED CB ANTENNA MATCHER

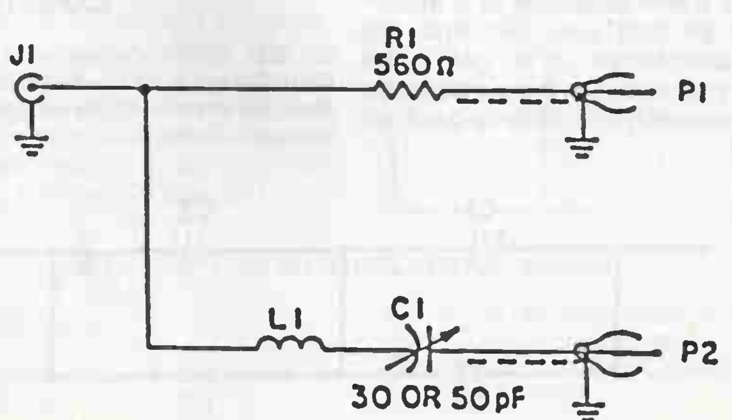
If you're tired of your CB antenna acting like a beacon to every creep and hoodlum in your neighborhood (or wherever you travel) simply install a disguised CB cowl mount antenna in place of your car's existing auto antenna, and then use this matcher to connect the antenna to both your auto radio and CB, without need for any switching system between the two radios. The matcher automatically connects the antenna to the proper radio.

When transmitting on CB, the C1/L1 series-tuned circuit passed the RF to the antenna, while R1 keeps the RF out of the radio, When receiving broadcast stations, the C1/L1 combination represents a high impedance, keeping the signals out of the CB where they would be "shorted" by the receiver's "front end." The broadcast signals pass through R1 to the auto radio.

Build the matcher in a metal enclosure. Jack J1 and plugs PL1 and PL2 should match your existing equipment. The matcher must be adjusted to your antenna system for maximum CB performance. Connect an SWR meter between the CB rig and the matcher (PL2), adjust C1 for minimum SWR.

PARTS LIST FOR DISGUISED CB ANTENNA MATCHER

C1—30-pF or 50-pF trimmer capacitor
L1—RF choke (Ohmite Z-144 or equivalent)
R1—560-ohm, ½-watt resistor



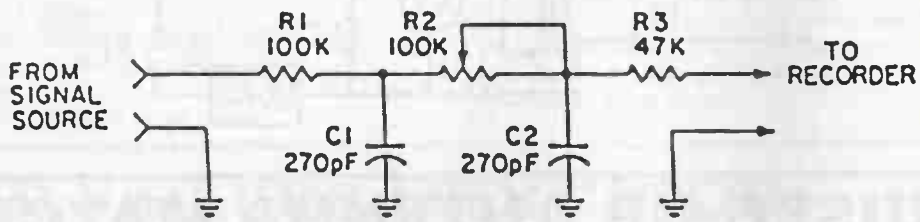
NOISE FILTER

Next time you're dubbing some "oldies but goodies" to tape, there's no need to put up with the scratches and noise that have accumulated over a good number of years of usage. Just pass the signals from the records through this scratch filter, and you'll get rid of much of the noise without too much loss of music frequencies.

The filter connects between the signal source, such as a record player or an amplifier's tape output, and the line input of a tape recorder. It's cut-off frequency is slightly higher than 5000 Hz, with attenuation increasing as the frequency goes up. Potentiometer R2 permits you to vary the "corner" frequency slightly to attain more or less high frequency attenuation as required by the individual record. (Or, you can just set the control to the approximate center and forget about it.) For proper operation, the input impedance of the recorder should not be less than 40,000 ohms—a common minimum value for most better quality recorders. Do not eliminate R3 in an attempt to increase the output level of the filter, because it provides part of the filter's output impedance matching in conjunction with the recorder's input impedance. A metal enclosure is suggested with RCA-type phono jack connectors.

PARTS LIST FOR NOISE FILTER

C1, C2—260-pF silver mica capacitor, 5% or better tolerance
R1—100,000-ohm, ½-watt resistor
R2—100,000-ohm, linear taper potentiometer
R3—47,000-ohm, ½-watt resistor



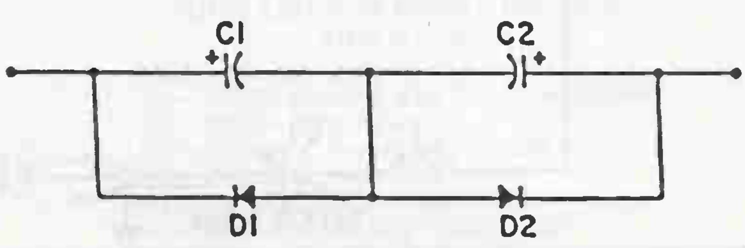
HOME MADE NPO CAPACITOR

From time to time, all of us encounter circuits that require large, *non-polarized* capacitors. Unfortunately, these are scarcer than the proverbial hen's teeth. Looking through some catalogs, you'll soon discover that capacitors larger than 10-uF are usually electrolytics, which are polarized devices. Electrolytic capacitors cannot be used in AC circuits, where the voltage undergoes periodic reversals in polarity. Such reversals destroy the insulating layer between the plates of an electrolytic capacitor, and the device soon fails.

So what can be done when you need a non-polarized capacitor for a hi-fi crossover or a motor-starting circuit, and all that you can find are electrolytics? One alternative is to get some aluminum foil and roll your own, but there's an easier way. Just hook two electrolytics back-to-back as we've diagrammed here, then add two current-steering diodes. These diodes ensure that each capacitor sees only voltage of the correct polarity. C1 and C2 should be identical, and each one should have a capacitance equal to the value needed for proper circuit operation. Make sure that the capacitors have working voltages equal to about three times the RMS value of the AC voltage in the circuit. Also, choose diodes having a PIV rating greater than or equal to the capacitor rating.

PARTS LIST FOR HOME MADE NPO CAPACITOR

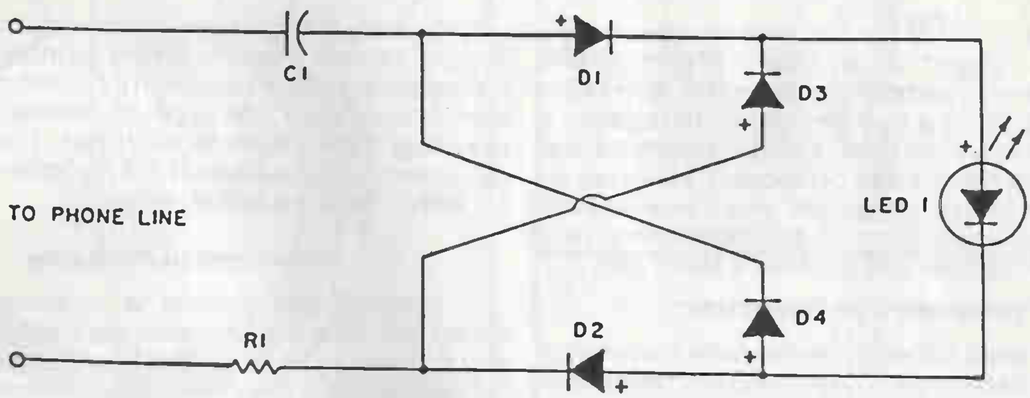
C1, C2—identical electrolytic capacitors
D1, D2—identical silicon rectifiers
Note: Be sure to match voltage ratings of rectifiers and capacitors.



LED TELEPHONE RING INDICATOR

Know what makes your phone ring? A 20 Hertz AC signal at anywhere from 60 to 120 Volts, depending on your phone company. That same bell-ringing signal can be used to light an LED with the circuit shown here, without significantly loading the telephone line. C1 provides DC isolation to help foolproof this project. The .1 value shown works, but you may want to increase it to .5 microfarads. Use a mylar capacitor (like the Sprague "Orange Drop" series) rated at 250-450 working volts or more

Why so high? The telephone company keeps its lines clear of ice and trouble by daily sweeping a pulse high voltage throughout the system. Too low a working voltage could mean trouble for them, and that is absolutely the last thing you want to cause. We might even suggest connecting to the telephone lines only temporarily to verify circuit operation. This will help avoid accidents and trouble. D1 through D4 act as a full wave bridge to deliver the AC ringing voltage as DC to LED1. R1 limits the current through the circuit.



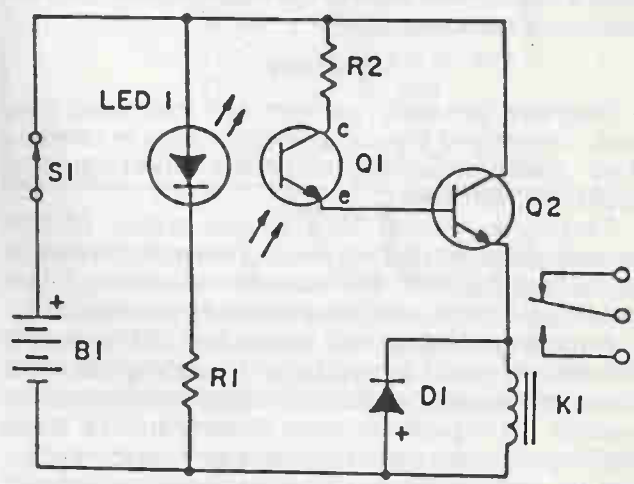
PARTS LIST FOR LED TELEPHONE RING INDICATOR

C1—.1-uF capacitor
D1, D2, D3, D4—Diode 1N914 or equiv.
LED1—Light emitting diode
R1—82,000-ohm resistor, ½-watt

PHOTOELECTRIC SIGNAL

How would you like to know whether or not the mailman brought you any mail? Or how about a circuit to start something going whenever you put a card in a slot? That's what this little photo-relay is all about. Whenever the phototransistor sees the LED, it pulls up the base of relay driver Q2 and pulls in the relay. Stick something between the LED and Q1 and the relay releases. D1 shunts out the relay's inductive kickback.

If you point the LED and Q1 in the same direction, they will act together as a reflective sensor. Then if anything comes close enough to them the relay will pull in. The circuit can also be used without R1 and LED1 as a light-or no-light-operated alarm. Bounce the light from the LED back into Q1 (assuming both are kept in the dark—any light will trigger Q1).



PARTS LIST FOR PHOTOELECTRIC SIGNAL

B1—12VDC battery
D1—Diode, 1N914 or Equiv.
K1—SPDT relay, 12VDC
LED1, Q1—IR Pair, Infrared LED and phototransistor pack (Radio Shack #276-142)
Q2—NPN transistor, 2N2222 or Equiv.
R1—150-ohm relay ½ watt
R2—2700-ohm resistor, ½ watt
S1—SPST switch

TESTING DISCRETE COMPONENTS

Richard Stuart (WF7A)

We are all aware that just because something's new doesn't mean that it's perfect and electronic parts are no exception. Blind faith in the infallibility of a new part can be devastating if your electronic project doesn't work correctly the first time out because of a bad component. However, by testing parts before using them, you'll save yourself the possible aggravation of troubleshooting your project later because you installed a faulty part.

Necessary Test Equipment

You don't need elaborate or expensive instruments to test most discrete components. All you need are an analog or digital multimeter with a set of hook-type probes, a pocket calculator, a battery, and a few appropriate resistors for testing LEDs and transistors.

The hook-type probes are particularly important if you want meaningful and accurate test results. By using them instead of your fingers to hold components during testing, you'll keep your body from acting as a parallel resistance path, which will produce false readings. Hook-type probes also leave your hands free to make meter adjustments and record results.

Here's how to test each of the most popular discrete electronic components.

Resistors

Resistors generally perform two functions: they limit current and they drop voltage. They're rated by their ohmic value (Ω) and their power-handling capability (wattage).

Testing a resistor is a simple matter of first choosing the ohm setting on your meter that's closest to, but greater than, the value of the resistor. Then attach a probe to each lead and read the result.

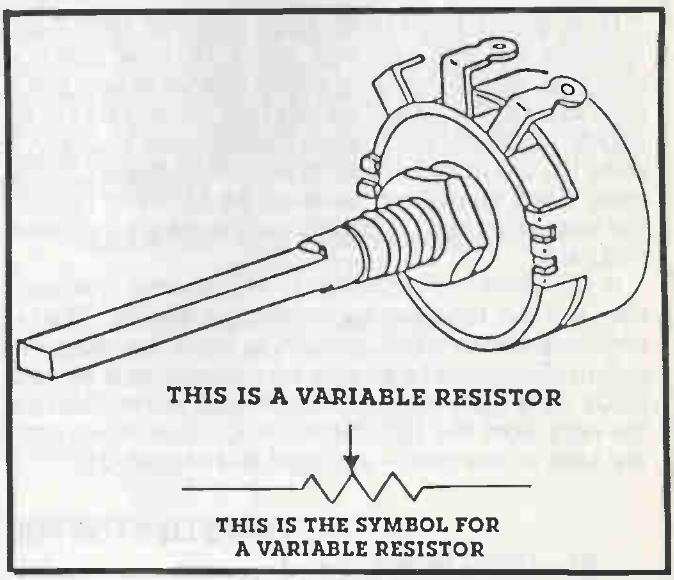
A reading of 0Ω or ∞Ω means that the resistor is shorted or open, respectively. A reading above or below the resistor's tolerance range means that the resistor is flawed. If you receive any of these readings, discard the part. Although a faulty resistor can be substituted for a higher-tolerance resistor of the same value, making such a replacement is not recommended. The color bands of the substitute resistor can be easily misinterpreted by someone unfamiliar with the substitution, especially if you forget to note the alteration on your device's schematics.

Since there are usually many resistors in electronic circuits, you can make the testing go more quickly by first recording all their values in a column, calculating each of their lower and upper resistance limits, then recording these values for each part. That way, you can quickly note whether or not the measured values fall within their respective ranges.

Potentiometers/Rheostats

A potentiometer/rheostat is a component that serves two different functions, depending upon how you connect it into a circuit. When it controls voltage, it's considered a potentiometer (commonly called a "pot"); when it controls current, it is a rheostat. This dual-function component is rated like a resistor—by its ohmic value and its power-handling capability.

Pots/rheostats have three terminals and an adjustable internal wiper arm that rides a hemispherical coil of wire. The central terminal is connected directly to the wiper arm, and the terminals on either side of it are each connected to one end of the coil of wire (Figure 1). By rotating the shaft or thumbwheel of the wiper arm, you adjust how much resistance the device will provide.



Usually the resistance of a variable resistor can be varied from 0 ohms to the value marked on the resistor case. The actual resistance depends on the position of the movable arm and the terminals being used.

To test the part, connect one probe to the central terminal and the other probe to either one of the outer terminals. Rotate the part's thumbwheel or shaft to one stop, then to the other stop, and note both readings. If you ever obtain an ∞Ω value, or two 0Ω values, the coil is either open or it has a short, and the pot/rheostat can't be used.

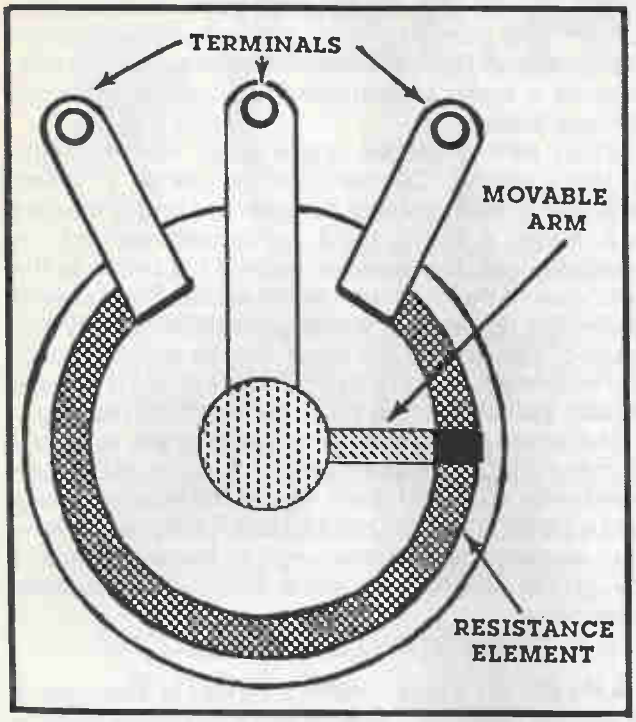


Figure 1

Inductors

Inductors—also called "coils" or "chokes"—provide AC resistance (or more properly, reactance) and oppose any change of current in a circuit. They're rated by magnetic units (Henries), their DC internal resistance, and their maximum current-handling capacity.

Usually, you would need an RLC (Resistance, Inductance, Capacitance) bridge tester to accurately determine an inductor's value. If you don't have one of these, you can perform a "quick-and-dirty" test by using your VOM or DMM at its lowest ohm setting and attaching a probe to each lead of the part. If your meter reads ∞Ω the coil is open; if it shows an ohm value below the inductor's stated DC resistance, the coil most likely has a short. Either reading means that the inductor is flawed and should be thrown away. If in doubt about the coil's DC resistance value, call your dealer or manufacturer for the part's specifications.

Transformers

A transformer is essentially a series of two or more inductors wound on top of one another. It's used mainly to step AC voltages up or down, or to match different circuit impedances together.

You test a transformer the same way you test an inductor, except that you must take multiple measurements: one for every winding and one from each winding to another. In a basic transformer, for example, you'd test the primary winding, the secondary winding, and from the primary to secondary winding (Figure 2).

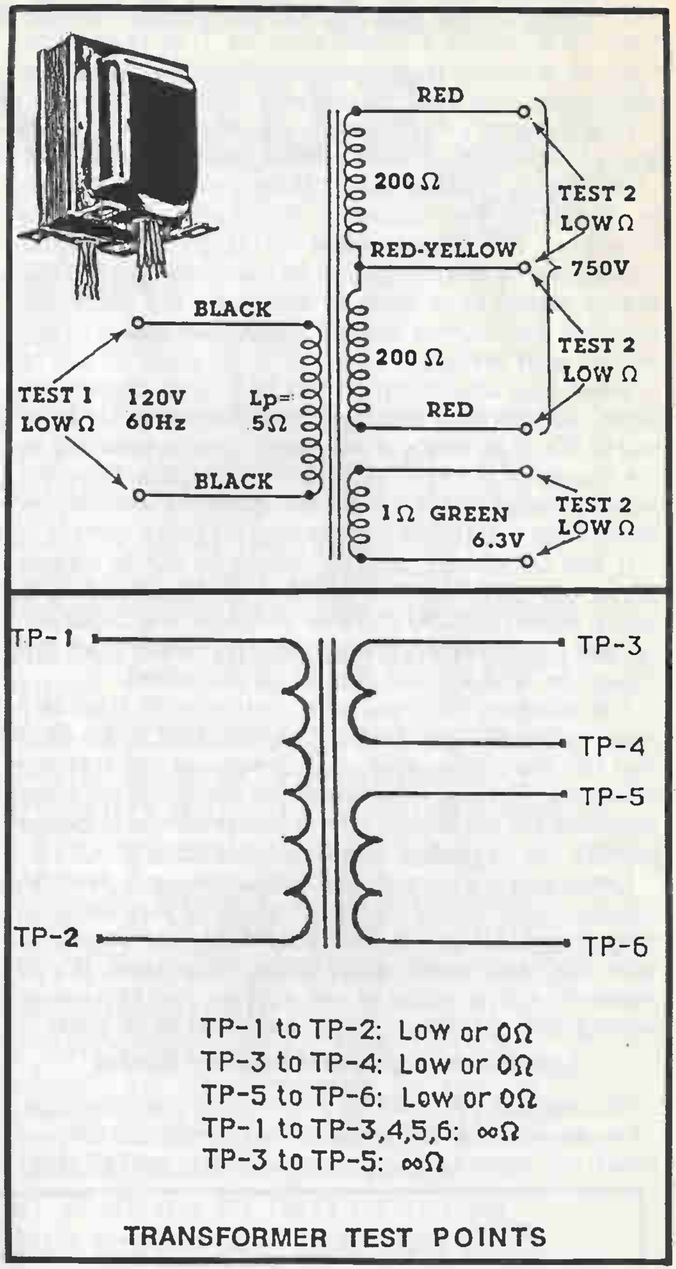


Figure 2

As with inductors, a 0Ω reading on a transformer usually indicates a short, and an ∞Ω reading at any of these test sites means the coil is open. If you get any other ohmic value, you'll just have to trust it: since most transformer manufacturers don't provide DC resistance information, it will be unlikely that you'll know if the reading is acceptable or not.

If your transformer is center-tapped or has multiple secondaries, just watch for an ∞Ω reading on any winding or between any pair of windings. A very low or 0Ω reading may not be a sign of a short, but may instead indicate that the lengths of the wire used in the secondaries aren't long enough to give a detectable ohmic measurement. The winding itself could still be perfectly good.

Capacitors

Capacitors come in a variety of shapes and sizes and perform many functions. They're often used, for example, to couple stages between amplifiers and to filter out AC ripple in power supplies. They're rated by their capacitance (expressed in either microfarads or picofarads) and their maximum DC voltage.

Like inductors, capacitors are generally tested with an RLC bridge. You can, however, perform a test with your VOM or DMM at its R×1MΩ setting. First, be sure to discharge the capacitor by touching its leads together, or, in the case of large electrolytic capacitors by shorting their terminals with a 50Ω/5-Watt resistor. (You have to discharge the capacitor because any stored charge inside can easily "zap" you or your meter.)

When you attach the probes to a large capacitor's leads, your VOM's needle should move quickly from ∞Ω to 0Ω, then swing slowly back to stop near ∞Ω as the capacitor accepts and stores the charge from the meter's battery. With DMMs the numbers will jump in steps from ∞Ω to 0Ω and back.

If the ohmmeter initially moves to 0Ω but stays there, the capacitor is shorted; if the final reading is below 500MΩ (500KΩ for electrolytics), the capacitor is leaky. Either of these results mean that the capacitor is faulty and should be discarded.

For electrolytic capacitors, you should take two readings—one with each probe attached to the lead that has the corresponding polarity, and one with the polarities reversed. (Disharge the capacitor between readings.) If the higher of the two readings is below 500KΩ, the capacitor is leaky and unusable.

Unfortunately, the above test won't work well on smaller capacitance values of 100pF or less because they charge so quickly that your meter can't keep up with the rapid changes in value. In general, if you measure a final value of ∞Ω with an R×1MΩ meter setting, the capacitor can be assumed to be good.

Low-Power Signal and Rectifier Diodes

Diodes allow current to flow in only one direction. They are made of either silicon or germanium and are rated by their forward maximum current-handling capability and their peak inverse voltage (PIV).

Before testing diodes, make sure your meter's ohmmeter circuitry can provide the necessary voltage to forward bias the diode (.7 for silicon diodes, .3 for germanium diodes). If it can't, you'll obtain a reading that indicates the diode is bad. Also be aware of your meter's operational characteristics—some ohmmeters reverse their polarities on some or all ranges.

Don't test current—or voltage—sensitive diodes like those used in high-frequency detection circuits, because a meter's ohmmeter circuitry can possibly damage these.

When testing diodes, place your meter on the R×100Ω setting, Diodes have an anode (+) and cathode(−) lead (usually the cathode end is marked with either a black band, schematic symbol, or beveled edge). Connect the meter's (−) probe to the cathode and the (+) probe to the anode. This forward biases the diode, and you should obtain a very low reading. Disconnect the leads, flip the diode around, and reconnect the probes so that the diode is reverse biased. You should get an extremely high reading.

The exact ohmic values you obtain are relatively unimportant. Just make sure that the ratio of the low-resistance value to the high-resistance value is greater than 1:1000. If your two tests give you two low-ohm readings, two ∞Ω readings, or low resistance in the reverse direction, the diode is faulty and should be tossed out.

LEDs

An LED, or Light Emitting Diode, is basically a diode that lights up. Determining if an LED is good or not is rather straightforward—if it doesn't light, it doesn't work.

You don't need a meter to test an LED. Instead, you use a battery source and an appropriate resistor in series with the LED. You *must* use the resistor: if you don't you'll toast your LED because it'll conduct too much current at the moment it tries to light up. Use this formula to determine what value of resistor to use:

$$R = \frac{V_{SOURCE} - V_{LED}}{I_{LED}}$$

(Continued on page 87)

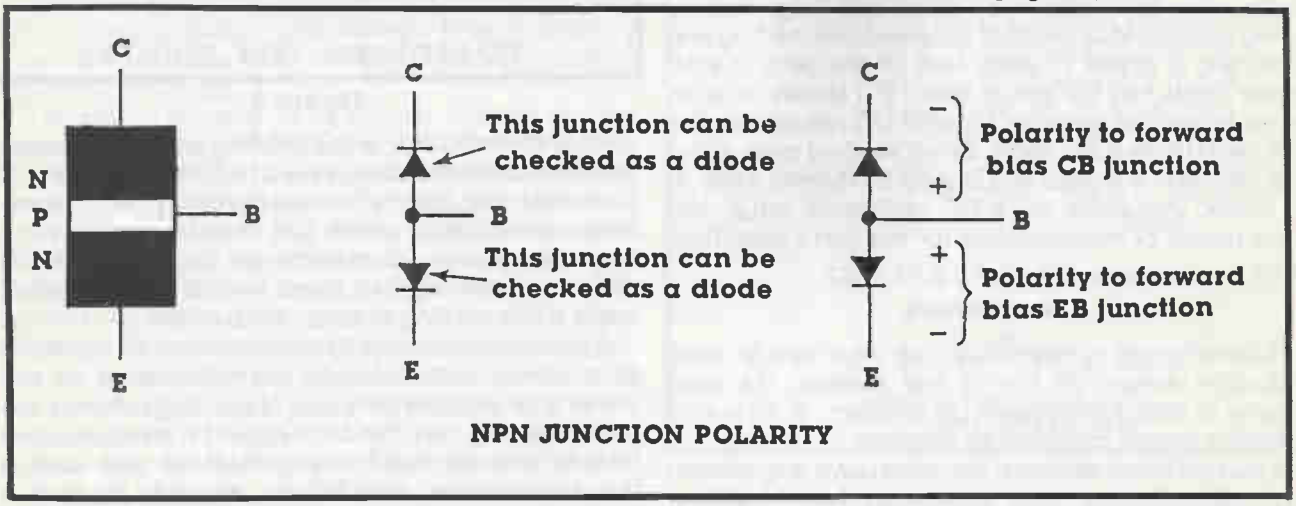
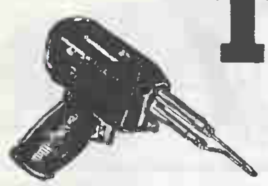
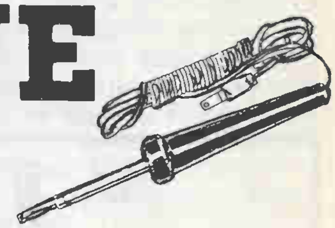


Figure 3

THE SOLDERING TECHNIQUE





By Steve Sokolowski

So the electronic "Bug" finally bit you. You have taken the plunge and purchased one of those electronic kits you see advertised in magazines. Sitting there poised and ready to begin, you realize that the assembly instructions tell you that a resistor goes here and a capacitor goes there, but where are the directions guiding you through the seemingly complex activity of soldering?

Sitting there perplexed and in a quandary, you begin to wonder, how and where to start? Should I purchase a soldering gun or a 25 watt soldering pencil? Should I use Rosin or Acid Core solder? The questions just keep coming but wihtout any answers to satisfy your curiosity. To fill the void left by the neglect of writers and authors alike, and with the permission of Tab Books Inc., we will introduce to you, in these few pages, one of the many interesting and informative chapters from the book titled: "Customize Your Telephone: 15 Electronic Projects." We will illustrate through the use of easy to understand language and informative pictures, the procedures necessary for the the proper joining of two or more electrical components; Better known as the "Art of Soldering."

Whether you purchase an electronic kit or decide to dive into the "unknown" mysteries of "home-made" projects, you will, without a doubt, make use of either a Printed Circuit Board (PCB) or the ever popular Perforated Board (also know as "perf" board) as your building medium.

Whichever technique is employed, whether it is a PC, Perf Board or even an aluminum chassis, good soldering practices are essential for reliable construction of any project. If you are an electronics novice or an experienced technician, please read the following carefully and practice soldering scrap wire together before attempting to join any components to a PC or "Perf" Board.

If you don't own a soldering iron, you should purchase a "Soldering Pencil" (See Fig. 1) with a maximum wattage from 25 to 40 watts. Even a 15 watt soldering pencil would be a good investment. DO NOT purchase a Soldering Gun (See Fig.2). The high wattage associated with a gun can destroy delicate integrated circuits and over heat sensitive components with its high heating level. Besides, it's very awkward to maneuver a gun when soldering components within the confining area of most electronic kits and home brewed projects.

Another important consideration that must be mentioned here is that the tip of the Soldering Pencil, when first, used, must be TINNED with standard electrical solder. Figure 3 illustrates this procedure quite well and it should be followed religiously. The word TINNING is a term used by technicians which means that when the iron is first used, a small amount of solder is dabbed on the tip when the normal operating temperature is reached. Then after a few seconds, using a damp cloth, wipe off the excess solder. After repeating this procedure a few times, you will notice that the irons' tip will become shiny. The bright, polished appearance of the tip indicates that the iron is ready for soldering.

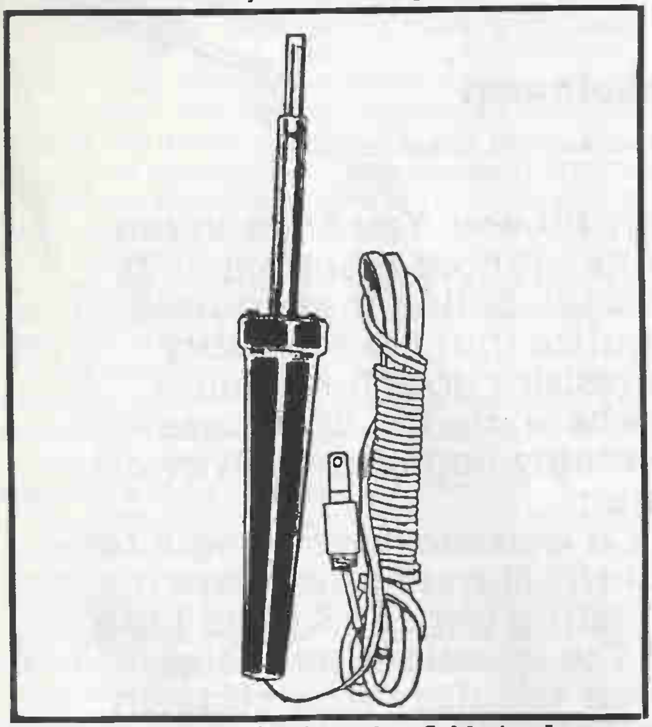


Figure 1. For all electronic work, a Soldering Iron or Pencil with a wattage of about 25 to 45 W should be purchased. Even with these low heat generating devices. Heat Sinks should still be used on ICs, Transistors and other components that can be destroyed by excessive heat.

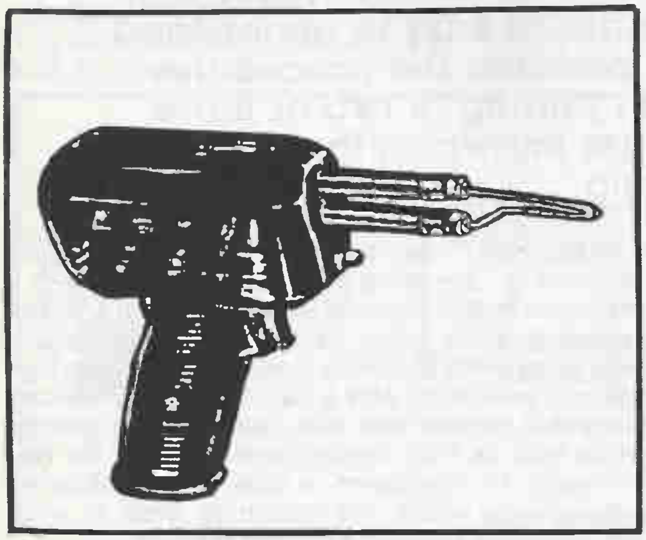


Figure 2. Due to the large amount of heat generated by a Soldering Gun, they are a poor choice if you plan to do excessive soldering of ICs, Diodes and other heat sensitive components.

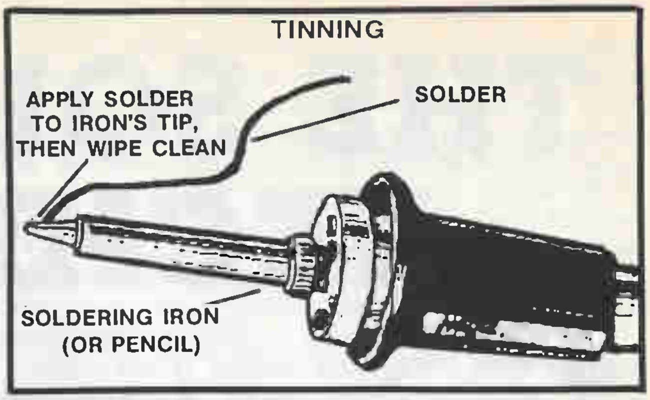


Figure 3. When using an Iron or Pencil for the first time, you should "Tin" the iron's tip by first letting the device reach its normal operating temperature, then "dab" a small amount of solder on the tip. After a few seconds, wipe off the excess solder. The Iron's tip will become shiny and ready for operation.

If tinning is not used, a filmy material or oxidation will be formed on the tip if not removed periodically. If this oxidation is not eliminated before soldering, joining any component will be impossible because the solder will only bead-up on the tip and there will be no transfer of heat from the iron to the device. When this happens, a COLD SOLDER JOINT will be made or you may run the risk of burning-out the component.

For a moment, let's turn our attention to the solder itself. There are many different types of solder on the market today. They come with different alloys and core material. ACID CORE SOLDER, which you will never find in a Radio Shack store, should NEVER be used for soldering any electronic components since this is a corrosive (Acid withing the core) material and will only damage electronic parts. A high quality ROSIN CORE solder (See Fig. 4) should be used. Rosin core will be a type of solder found in your local Radio Shack or any other electronic mail-order house.

Figure 4. Next to purchasing the right Soldering Iron or Pencil, buying the right Solder for the job at hand is also important. You should purchase high quality Rosin Core solder for all electrical work. Acid Core should never be used on an electronic project.

Cleanliness is the next subject to be covered. So it should be mentioned then before soldering any component, the device (or the joint itself) MUST be clean to ensure a permanent bond between solder and the wire lead of the component. This means that any grease, oil, paint or any other foreign matter that might be covering the lead must be removed before soldering. To help in the removal of this undesirable material, you can use a steel wool pad. Not the kind that is used to scrub kitchen pots and pans but a pad that is made less any soapy additives. These items can be purchased in any neighborhood supermarket. And it costs about 75¢.

For now, let's discuss an elementary concept of soldering that is by no means the proper way to solder any components and it is a major pitfall for virtually all budding electronic hobbyists. That is the activity of melting the rosin core solder with the irons' tip then allowing this molten solder to flow over the component. This practice should NEVER be employed or even considered when it comes to an electronic asembly. It will only cause you headaches when it comes time to troubleshoot a project that just refuses to operate. Not because of component failure or improperly wiring a perf board, but due to intermittent operation caused by COLD SOLDER JOINTS. Figure 5 depicts what a Cold Solder Joint looks like when compared side-by-side with a properly soldered connection. Study this illustration and become familiar with its appearance. If you find a joint looking as if were a Colder Solder Joint, don't despair. Just place the tip of the soldering iron (or pencil) on the connection again. And allow the solder to remelt over the components lead. After a second or two, remove the iron and let the connection cool off. This time, the joint will appear to be smooth and shiny. The appearance of the connection is a sure sign of a properly soldered joint.

The customary way to solder a component is to bring the tip of the iron in contact with the wire lead of the part and printed circuit board pad (or perf board wiring), then when heated by the iron, dab a small amount of solder on the component's copper pad or interconnecting wire.

Remove the solder but leave the iron in place for an additional second or two. This additional heat will allow the solder to flow over the connection point thus preventing a COLD SOLDER JOINT. The proper soldering procedure can be seen in Figures 6A and 6B.

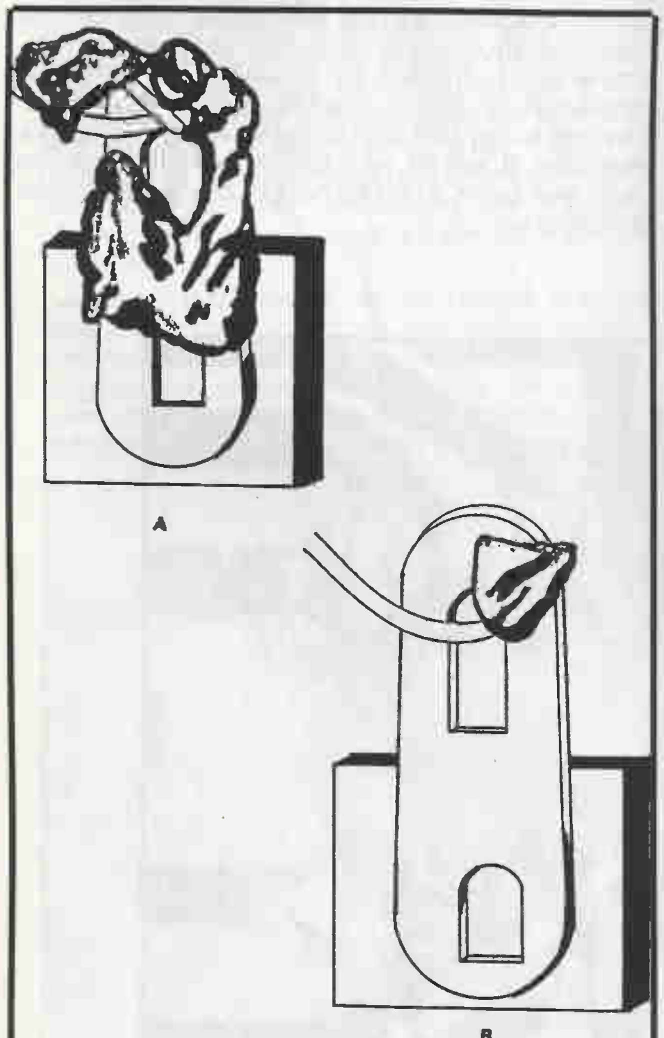


Figure 5. When you have completed soldering a connection, inspect the joints. (A) illustrates a "cold solder" joint. Note that it is rough and dull. (B) illustrates a correctly soldered join. It is smooth and shiny.

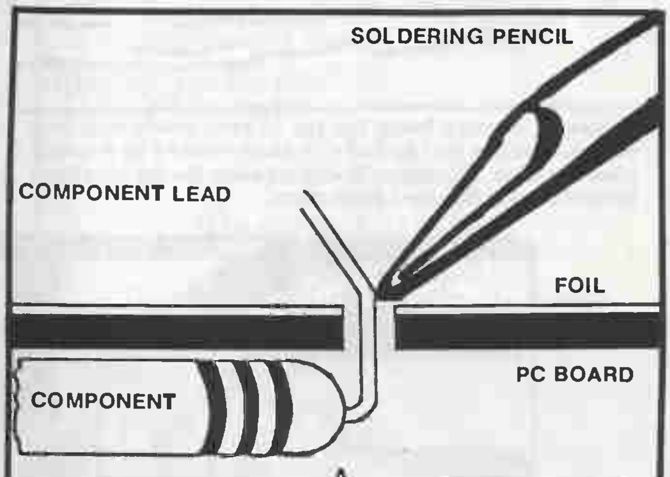


Figure 6A. The correct way to solder a component. Heat the component with the soldering iron then . . .

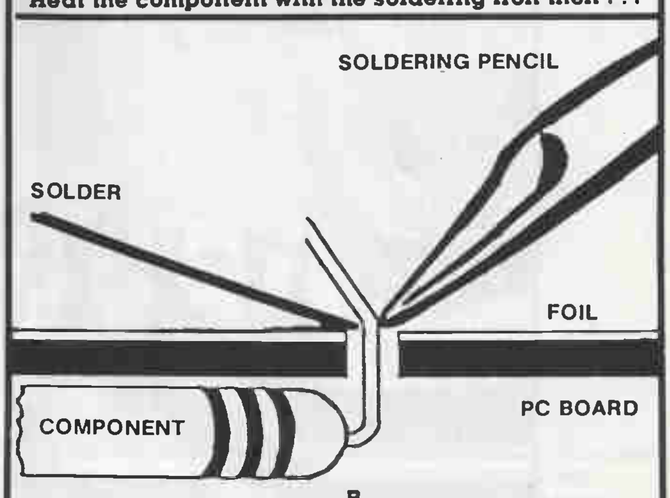


Figure 6B. Have the component's lead and PC Board pad melt the solder over the joint.

After soldering—the connection should appear smooth and shiny, while a poor connection will be dull and rough.

When you have completed soldering a number of connections, the tip of the iron should be cleaned with a damp sponge or cloth to remove excess solder. The damp sponge will also remove the unwanted oxidation that can form on the tip, thus preventing the maximum heat transfer from the iron to the connection. Figure 7 illustrates the recommended procedure for cleaning the tip. It also shows that using a metal dish to hold the wet sponge, while cleaning, will prevent burnt fingers.

The soldering iron's tip should always be clean and free of any foreign material. If not, the additional solder splashes and solder bridges (Solder Bridges—when two or more adjacent connections are shorted together by the use of excessive solder).

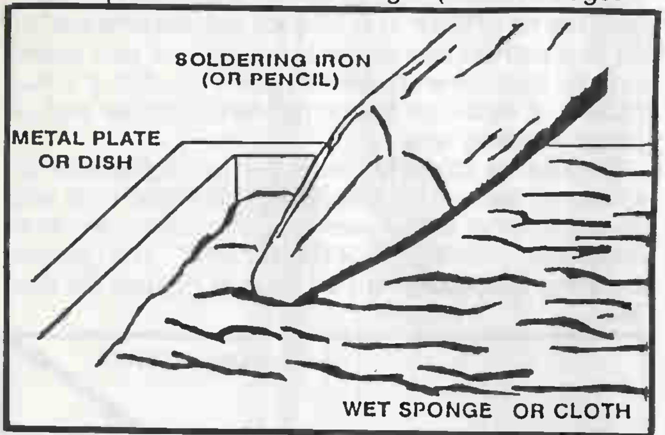


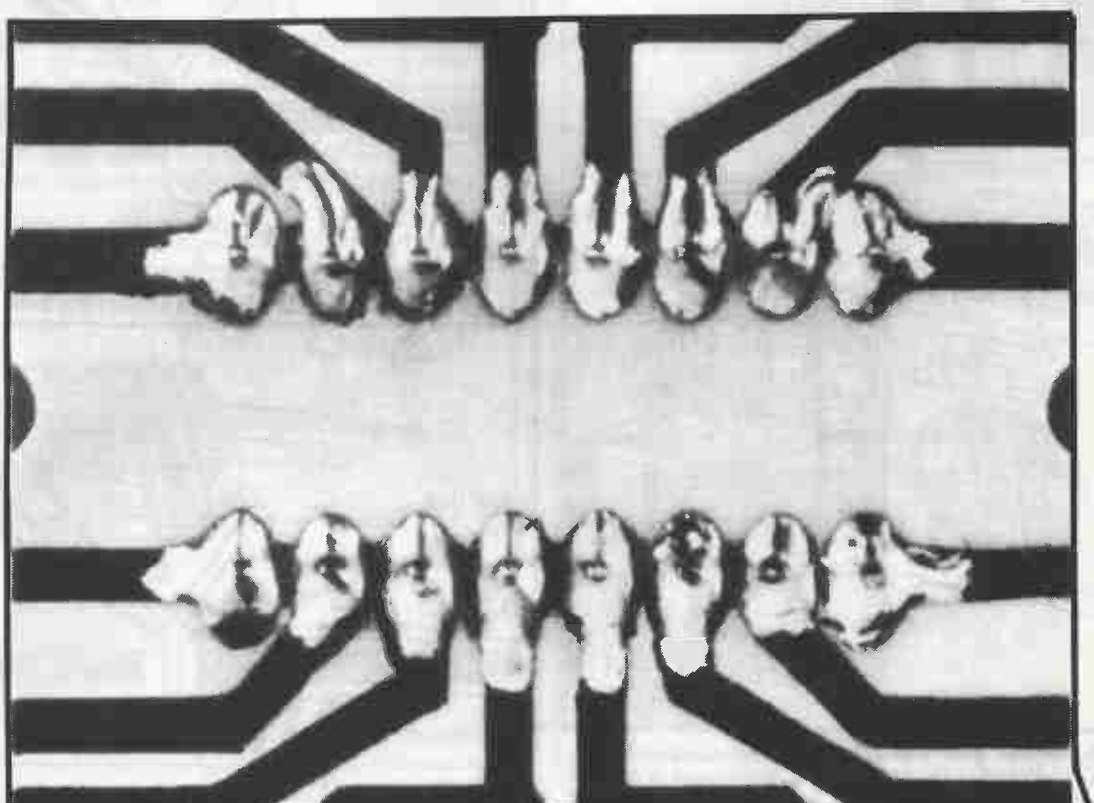
Figure 7. Always keep the tip of your soldering iron clean, using a wet sponge or cloth seated in a metal plate or dish. Cleaning the iron keeps the tip free from excessive solder and oxidation.

Soldering Heat Sensitive Components

Integrated Circuits are very sensitive to heat. For this reason, you should solder the leads of an IC fast but accurately to avoid an excessive rise in temperature that can and, in most cases, will destroy the component, not to mention the destruction of the bonding that holds the copper pads to the PC Board material. This lifting of copper will make the board useless. The use of a HEAT SINK is recommended for soldering all heat sensitive components. Not just ICs.

A HEAT SINK is a device that is clamped to a component lead to conduct the heat away from the delicate internal circuitry of the part. Heat sinks should also be used when soldering Diodes and Transistors since these devices are also sensitive to the destructive power of high heat.

The illustration presented in Figure 8 shows how a common Alligator Clip can be used as a HEAT SINK. Note how the Alligator Clip is placed between the component and the soldering iron. By attaching the clip at this location, the destructive heat can be absorbed thus preventing the abnormally high temperature created by soldering, from being transferred to the component by its wire leads. Needless to say that after using an Alligator Clip as a Heat Sink, it will be very hot to the touch and can cause skin burns if you do not exercise caution upon its removal.



ICs have their terminals very close to each other, hence great care must be taken not to let the solder from one leak over to another. It takes a bit of practice to solder such closely-spaced terminals.

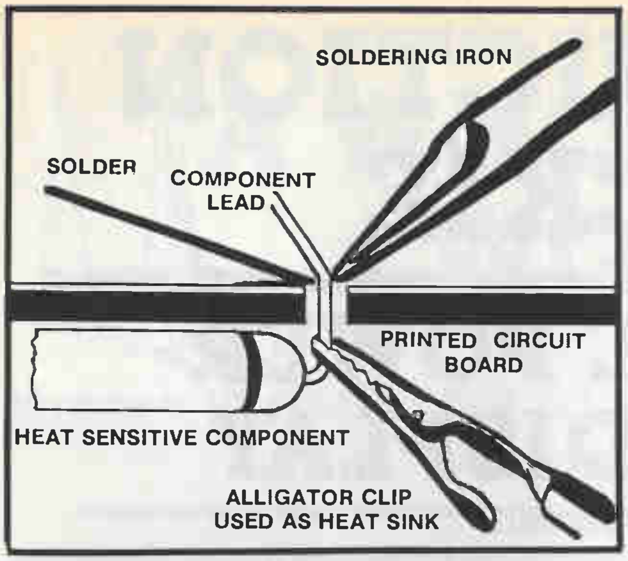


Figure 8. The correct method of using a common Alligator Clip as a Heat Sink. Heat Sinks should be used on ALL Heat sensitive components (Diodes,* Transistors, ICs etc.)

Soldering components and wire together to make an electronic project operate proficiently and have that professional appearance requires skill, patience and experience. These traits can only be acquired after many practice sessions using the iron, solder and a number of experimental scrap wires. If you follow these relatively few suggestions and take the time to thoroughly understand the procedures outlined here, you will become a master in the"Art of Soldering."

By reading this article, we have hopefully sparked your interest in soldering and the assembly of electronics devices. If your interest extends to projects that magically transforms the common, every day telephone into super electronic wonders, you might be interested in purchasing a copy of "Customize Your Telephone." This book includes 15 fun and useful projects that includes an Automatic Telephone Recorder, Animated Telephone Ringer and 13 other easy-to-build projects that anyone can put together. You will also be introduced to the basic operation of Telephones: How to make PC Boards and many other informative chapters.

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.** ■

This photo a poorly soldered joint. It can break almost any time, whenever the wire is moved or flexed.

This picture shows a good soldered joint. It has enough solder to hold securely and make a good electrical connection. It has not too much solder, not too little.

CONSTRUCTION QUICKIE

COLORFUL POWER-OUTPUT DISPLAY

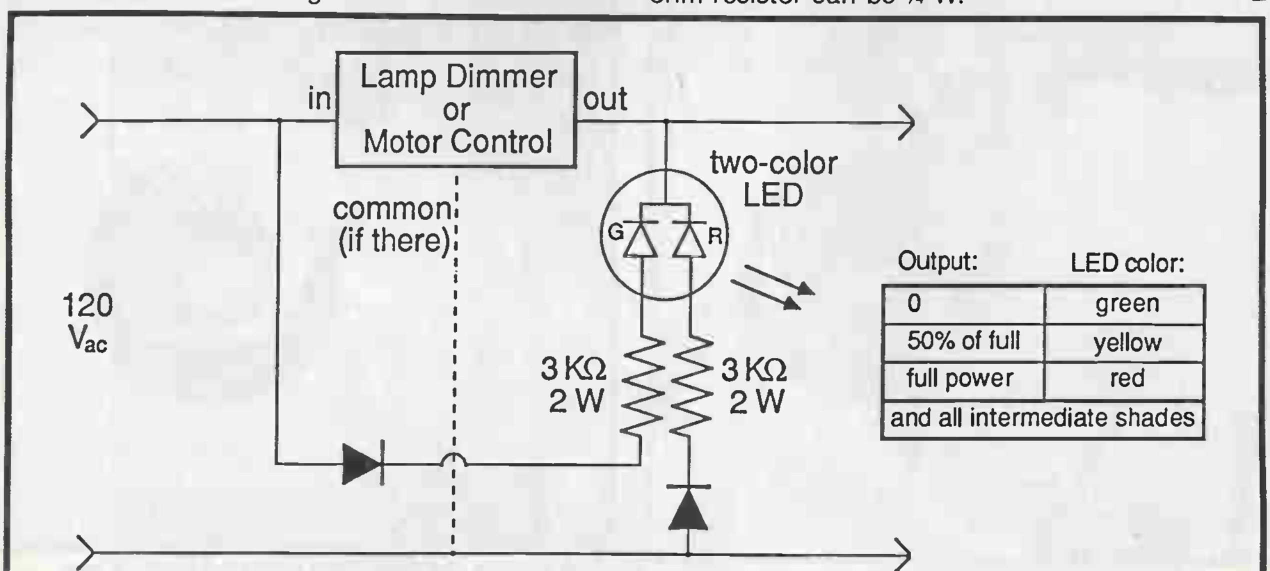
By Joe O'Connell

Remember that motor speed control you built as one of your first projects? With this simple circuit you can add to it an indicator that changes its color to match the control setting. The visual feedback provided by the indicator makes setting the control easier and adds a distinctive touch to your project.

Just about any phase control circuit, autotransformer, or other circuit that controls AC power and has a load connected to its output can be monitored using a two-color LED and this circuit. As the control is turned up, the LED will change gradually from green to yellow to red, giving an indication of the power output as the accompanying chart shows. When the load is open or disconnected, the LED lights up red only.

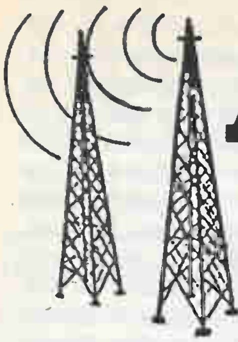
The power that a lamp dimmer, motor control, or autotransformer supplies to its load is always a fraction of full power. The indicator LED in this circuit indicates this fraction by its color. It is a commonly available two-color LED that has both a red and green element encapsulated together. The package has three leads: the red and green anodes and a common cathode. The red element goes across the load. The more power the load receives, the more power the red element receives through its diode and dropping resistor and the brighter it glows. The green element, on the other hand, is connected across the control circuit to measure the voltage drop it produces. The greater the voltage drop across the control, the less power the load receives, but the more power the green element receives. Variations in the amount of power the red and green elements receive will produce all shades of color between green and red.

With only five components, the circuit should be easy to build into motor controls, lamp dimmers, or other circuits. A good place for the indicator LED is the index position of the control knob. The diodes should be rated for at least 100 PIV and 1 A. Mount the dropping resistors where they can dissipate a little heat. Their value is specified as 3k-ohm, which is not a common value. However, 33k-ohm and 3.3k-ohm are common values, and these resistors have an effective resistance of 3k-ohm when placed in parallel. The 3.3k-ohm resistor should be rated about 2 W to allow a comfortable safety margin but the 33k-ohm resistor can be ¼ W. ■

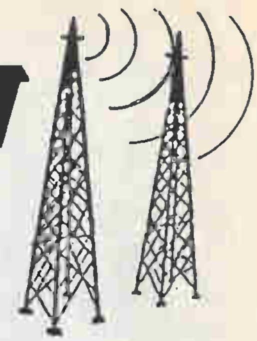


Output:	LED color:
0	green
50% of full	yellow
full power	red
and all intermediate shades	

COLORFUL POWER-OUTPUT DISPLAY



A WHOLE NEW WORLD



EUROPE BROADCASTS TO NORTH AMERICA IN ENGLISH

By Ed Noll (W3FQJ)

Shortwave listening has changed and "program listening" has become more appropriate than "shortwave DXing." Of course many listeners continue to DX and QSL, and others will remain interested in the technical facets of shortwave radio. However, there are probably many more world band receivers owned by people who spend their time in search of strong reliable signals and good program content, rather than DXing a faraway signal to add to their list of stations identified. Signals are strong and program quality has improved to the point that world band programming is considerably superior to local AM/FM "hurry-up" and "commercials" and you gain a new perspective on international news.

Over the last decade many foreign stations have increased their power output and improved their antennas. World band receivers have been made more sensitive and selective and digital displays have made it easier to tune to a specific frequency. Programs are often re-transmitted by relay transmitters located nearer to the target area to which the program has been directed. All of these things improve reception reliability and benefit the program listener.

There is now program competitiveness with each station vying for faithful and new listeners. Just like prime time TV in USA, international broadcast stations know they can reach the maximum number of North American listeners during the evening hours 7 to 11 PM across the continent. Often programs are repeated to match the time difference between the EST and PST time zones. For example, the one-hour English-language program from Spain is transmitted three times, 0000-0100, 0100-0200 and 0500-0600.

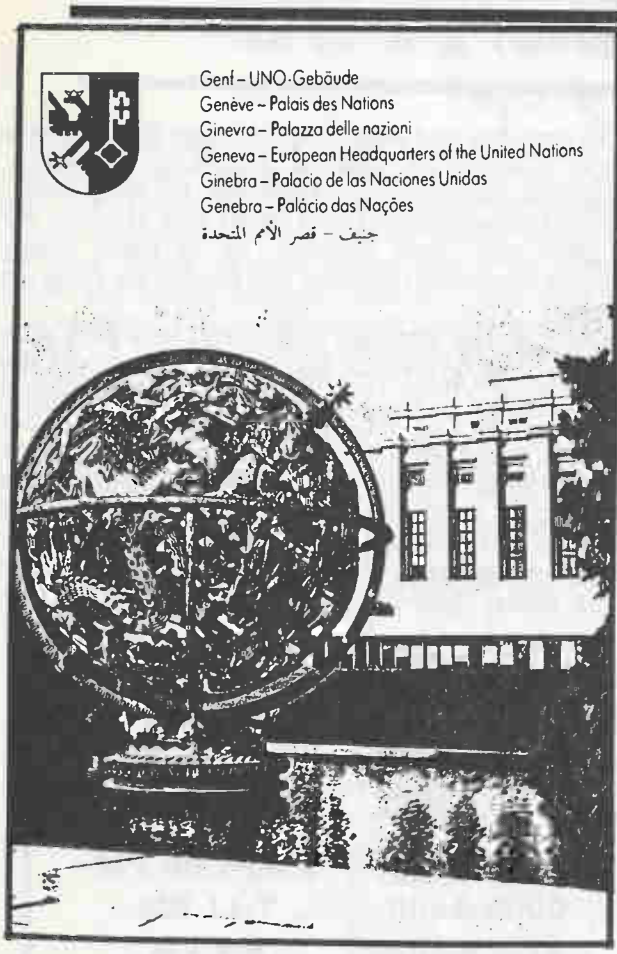
A SAMPLE OF EUROPEAN BROADCASTS TO NORTH AMERICA

COUNTRY	FREQUENCY	UTC (GMT)	EST
AUSTRIA	9875 13730	0130-2000	8:30-9:00 PM
BBC	9915 6175	0000-0400	7-11 PM
CZECHOSLOVAKIA	7345 5930	0100-0200	8-9 PM
ALBANIA	9760	0230-0300	9:30-10 PM
FRANCE	9800 7135	0315-0345	10:15-10:45 PM
GERMANY	9565 6145	0100-0150	8-8:50 PM
GREECE	9420 11645	0130-0200	8:30-9 PM
HOLLAND	620 15315	0030-0125	7:30-8:25 PM
HUNGARY	11910 9835	0030-0100	7:30-8:00 PM
ROMANIA	9570 5990	0200-0250	9-9:50 PM
SPAIN	9630 11880	0000-0200	7:00-9:00 PM
SWEDEN	9695 11705	0230-3000	9:30-10:00 PM
SWITZERLAND	9885 6135	0200-0230	9-9:30 PM
USSR	9720 6045	000-0400	7-11 PM

The transmission of these programs from Spain occur during a time slot between midnight and dawn and match the 7 to 11 PM prime time period in the USA. Much of Europe, and other parts of the world, are aiming their English-language programs toward us during the evening hours.

Foreign broadcast stations like to hear from you. They want to know how well you receive their signals. Of equal importance to foreign management, producers and participants are your opinions about their programs. If you hear a program you like, write a constructive letter to the station. It will be most welcome. This courtesy to world broadcast stations helps them plan better programs for you.

In the same envelope you can include a report of signal quality and other basic information if you would like to receive a QSL card. Send along a report of signal strength and presence or absence of interference or noise. Let them know your opinion of the overall merit of the reception and program. Give the frequency, date and time of reception in UTC or your local time. You might also send a brief list of items you heard in sequence on the program. Choose those items which permit the station to verify and recognize that you have heard their station at the particular date and time. If you want, request that you be placed on their mailing list to receive future time/frequency and program schedules periodically.



Above are recent QSL cards received by the author from Swiss Radio International and Radio Exterior de Espana

QSLing

Following is a sample signal report form. Its arrangement gives you plenty of space for various comments in addition to the specific items needed to obtain a verification QSL card from a particular station. You can type out the form on a sheet of letterhead (8½ by 11) and run as many copies as you like. Don't forget to include your own address and station set-up.

I frequently use this type of request form. Much of the QSL required information can be written in as you listen to the station. You can fill in your comments later.

Received signals can be given an SIO rating of (S) signal strength, (I) interference, and (O) overall merit. 555 would be a perfect signal. Ratings are 1 to 5 as shown. Though not necessary, you can expand on any of these if you like with notes about severe fading, type of interference and other information.

	S	I	O
5	Excellent	None	Excellent
4	Good	Slight	Good
3	Fair	Moderate	Fair
2	Poor	Severe	Poor
1	Very Poor	Extreme	Unusable

A new QSL card from Spain is shown. The Spanish "Exterior Broadcast Service" plans a series of QSL cards to emphasize the fact that the 1992 Olympics will be held in Barcelona, plus two other 1992 events which are a Universal Exhibition in Sevilla and a Madrid Capital Culture Celebration. No doubt many other related affairs will be broadcast on Radio Exterior de España.

Your Address

Name ______________________

Street ______________________

Box ____________ **or Apt.** ________

City ________ **State** _____ **Country** ______

Reception of Radio Station ____________

on Frequency ________________

UTC Time ________ **Date** ________

with SIO of ________________

Comments on Signal ________________

____

Picked up on a ____________ **Receiver**

and a ________________ **antenna**

Identification Information

____

____

____

________ **Please QSL THANK YOU**

Program Report and Comments

____

____

____

____

We have selected 14 European stations you can pick up nightly in the previous table. There are many other stations to copy as well but you can make your start with these stations that usually deliver strong readable signals. Some of the other stations do as well and you can add the same material about them to your table. Addresses are also given for mailing your letters and reports to the stations listed.

You can pick up the majority of these strong stations in any time zone of the USA and you should have little if any trouble receiving them in the east. Even in the west the results should be acceptable. Furthermore, some stations rebroadcast their programs later for western North American listeners. Write for individual schedules. Spain, for example, repeats its nightly English-language program 0500-0600 UTC which corresponds to 9-10 PM PST. In international broadcasting there are frequent changes in schedules and frequencies, therefore, you must keep up to date, especially if a station carries some program that you particularly like.

Program Scheduling

Except for the BBC and the USSR, who transmit in English over the entire 7-11 PM period as well as before and after these prime time hours, most of the stations listed transmit in English for one hour or thirty minutes. Thus, in one evening you can listen to the complete program of a number of the stations. Most programs begin with the news. After the news the programs differ each evening. Sometimes programs will have the same title but different content. Other times a broadcast will have a different title but one that is more appropriate to its special content on a given evening. It is advisable to keep your own program schedule for each station so that you have a record of the programs you enjoy and what night they come on the air so you won't miss them. You can begin to understand why some sort of record system works much better than just tuning haphazardly over each band when program listening is important. You can just tune around for other stations and new programs during empty spots in your listening schedule.

The second column of the table lists one or two frequencies that serve me best at my geographic location with an indoor antenna installation. Some stations broadcast on other frequencies as well and also at different times. You may be able to improve your results with a given station by obtaining a schedule from that station or looking over the schedules printed in the periodicals such as Monitoring Times and Popular Communications.

A multitude of subjects are covered in detail on these shortwave broadcasts that you won't find on your domestic radio stations or prime time TV. If you are already a shortwave listener, try not to miss some of the fine world band radio programs and enjoy. ■

ADDRESSES

Elliniki Radophono Greece
Tileorassi S.A.
P.O. Box 6000019
10 Aghia Paraskevi
Athens Greece

Radio Nederland
P.O. Box 222
1200 JG
Hilversum Nederland

Radio Budapest
P.O. Box #1
H-1800
Budapest Hungary

Radio Romania
Str. Nuferilor 60-62
79756 Bucuresti
Romania

Radio Exterior de Espana
Apartado 156.202
28080 Madrid Spain

Radio Sweden S-105
10 Stockholm
Sweden

Swiss Radio International
3000 Bern 14
Switzerland

Austria International
A-1136 Vienna
Austria

BBC World Service
Bush House
London, England
WC2B 4PH

R Czechoslovakia
12099 Praha 2
Vinohradska 12
Czechoslovakia

Radio Tirana
External Services
Tirana, Albania

Radio France RFI
B.P. 75762 Paris
Cedex 16 France

Deutsche Welle
Raderberggurtel 50
P.O. Box 100444
D5000 Koln 1
Germany

Radio Moscow
Koroleva 19
Moscow USSR

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.

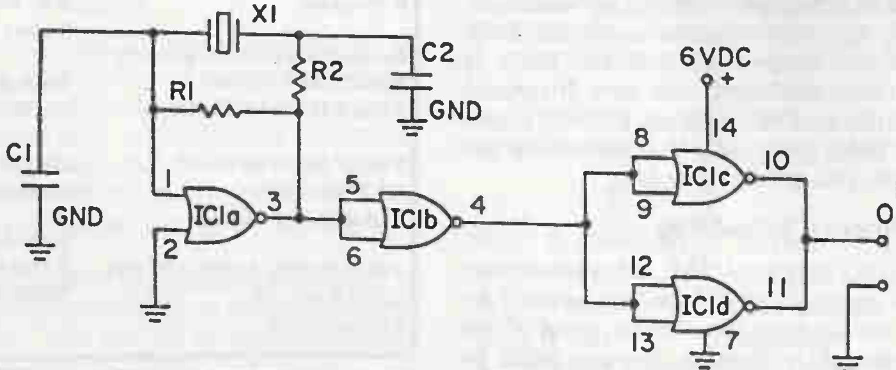
As with any electronics assembly work, be sure you understand how the various parts of the circuit work together and the objective of each component before you start gathering the components together and assembling them. As with any project that uses ICs (integrated circuits) or transistors, be careful 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.

CRYSTAL CONTROLLED CMOS

An inexpensive crystal is the color-control TV crystal, operating at approximately 3.58 MHz. With the circuit shown below, a handy signal, suitable for dividing down to many other frequencies, including a 60 Hz reference for portable clocks, is easily obtained. Unused gates from the 4001 quad-NOR chip are used as buffers.

PARTS LIST FOR CYRSTAL CONTROLLED CMOS

C1—33-pF mica capacitor, 15 VDC
C2—27-pF mica capacitor, 15 VDC
IC1—4001AE quad NOR gate
R1—1,000,000-ohm, ½-watt resistor
R2—10,000-ohm, ½-watt resistor
X1—3.58 MHz crystal (TV color carrier type)

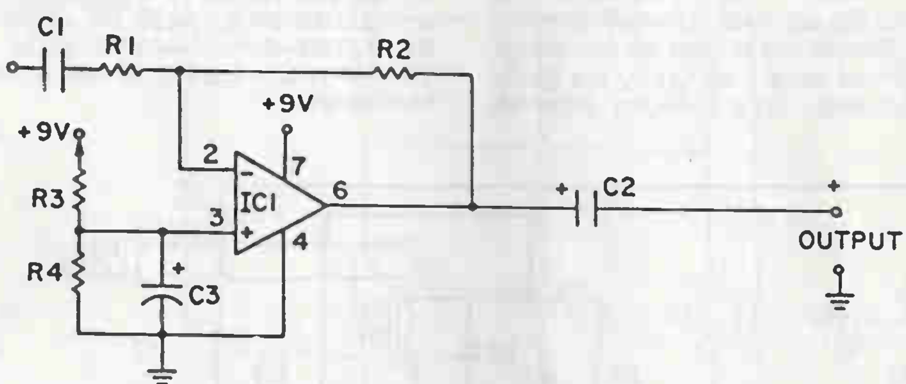


SINGLE POWER AMPLIFIER

Op amps, like the popular 741, are usually operated with matching plus and minus power supplies. However, for simple signal amplification applications, the single positive supply shown here has been found to work quite nicely. Resistors R3 and R4 may be fixed at about 5000 ohms each, or replaced with a 5K or 10K potentiometer, if it is desired to adjust the no-signal output level so that high-amplitude signals will not be clipped. Sometimes, intentional clipping is desired, so this feature may be retained for general experimental applications. Note: If a potentiometer is used for R3, R4, connect center terminals of pots to pin #3 of IC1.

PARTS LIST FOR SINGLE POWER OPERATIONAL AMPLIFIER

C1—0.01-uF ceramic capacitor, 15 VDC (gain = 10)
—0.10-uF ceramic capacitor, 15 VDC (gain = 100)
C2—1 to 100-uF electrolytic capacitor, 15 VDC (increase value with frequency)
C3—100-uF electrolytic capacitor, 15 VDC
IC1—741 op amp
R1—10,000-ohm, ½ watt resistor
R2—100,000-ohm, ½ watt resistor (gain = 10)
—1,000,0000-ohm, ½ watt resistor (gain = 100)
R3, R4—5,000-ohm, ½ watt resistor or 5,000-10,000 ohm linear taper potentiometer

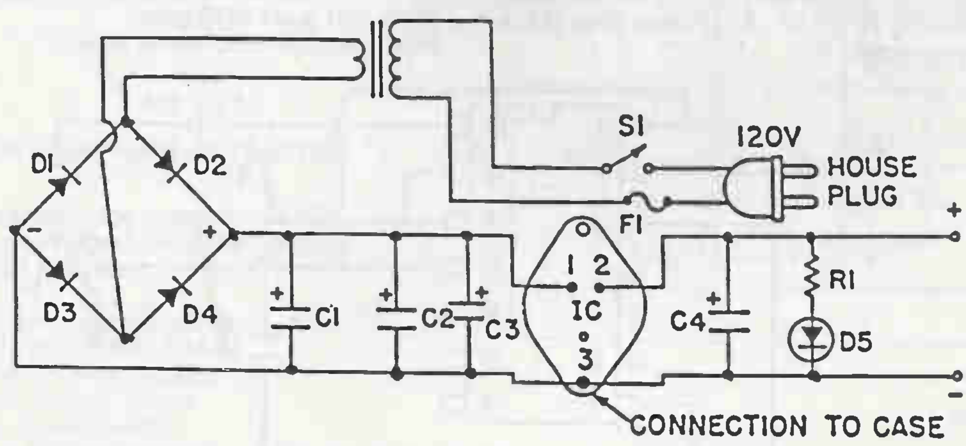


TTL POWER SUPPLY

This IC project will provide you with a flat, ripple-free, and locked-on 5 volts for any use around the house or on your work bench. It will prove to be very handy for the TTL projects using any IC that starts with the two numbers 74. The LM309 is a remarkable IC containing over a dozen transistors and several diodes. It can handle up to about 1 amp without a heat sink. If you mount it on a heat sink. A 4 by 4 inch piece of aluminum will do. It can supply up to 4 amps without dropping its 5 volt output.

PARTS LIST FOR TTL POWER SUPPLY

C1, C2,—1,000-uF electrolytic capacitor, 25 VDC
C3, C4—1uF solid tantalum
D1, D2, D3, D4—1N4003 diode
D5—large LED
F1—120 VAC ½ amp fuse, fast acting type
IC1—LM309
R1—500-ohm, 2-watt resistor
S1—SPST toggle switch rated at 120 VAC, 15 amps
T1—120 VAC to 12.6 VAC transformer



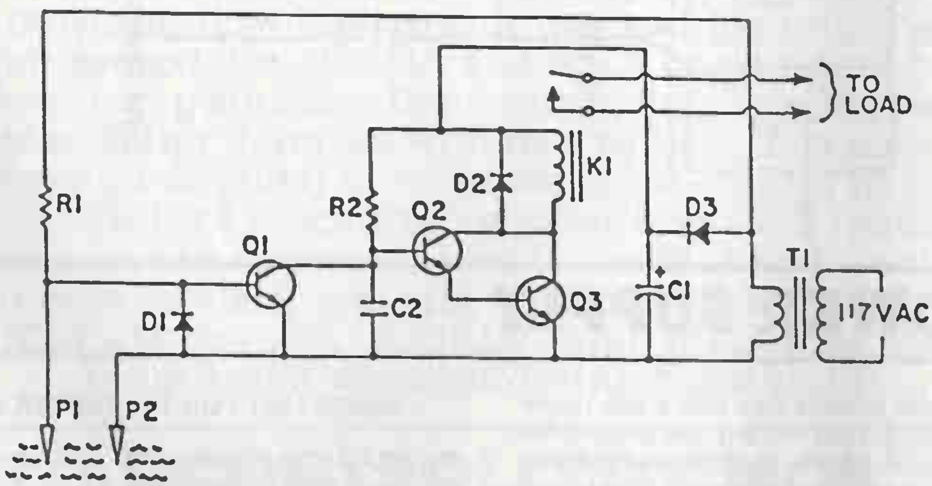
FLUID DETECTOR

For those of you anticipating the melting of the polar ice caps, we present a handy device to warn you of the deluge. Many other useful, though less dramatic, applications should be obvious as well. Basically, this a circuit capable of detecting the presence of any ionic fluid, that is, any fluid that can conduct an electrical current. Ultra-pure water will not be detected because so few ions exist that scarcely any current can flow. However, the water that seeps into your cellar, the water that overflows from your washing machine and most aqueous solutions are all readily detectable.

With no fluid between the probes, AC current flows through R1 into Q1's base, turning the transistor on at 60 Hz rate. C2 filters the signal at Q1's collector to a low DC potential. Should the probes be immersed, base current is shunted away from Q1 by the fluid's resistance. Consequently, Q1's collector potential rises, thereby turning on the Q2-Q3 Darlington pair. This causes K1 to pull in and turn on a pump or whatever load you attach. Because only a small AC voltage exists between the probes, no troublesome plating occurs.

PARTS LIST FOR FLUID DETECTOR

C1—500-uF, 25-VDC electrolytic capacitor
C2—0.5-uF, 25-VDC mylar capacitor
D1, D2, D3—1N4002 diode
K1—relay with coil rated 6-VDC @ 250 to 500-ohms, with SPST contacts
P1, P2—stainless steel or aluminum probes
Q1, Q2, Q3—2N3904 NPN transistor
R1—300,000-ohms, ½-watt, 5% resistor
R2—470,000-ohms, ½-watt 5% resistor
T1—120-VAC to 6.3-VAC @ 300mA power transformer

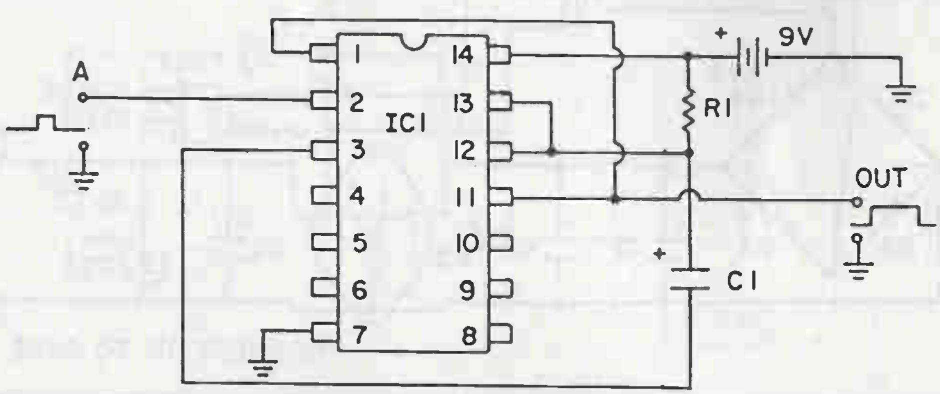


PULSE STRETCHER

Ever need to stretch a pulse? Maybe you can't quite pull up a self-latching relay, or maybe your bike-blinker is on too little and off too much. It can be made longer by increasing R1 or C1. All unused pins of the IC should be grounded.

PARTS LIST FOR PULSE STRECHER

C1—1-uF electrolytic capacitor, 15 VDC
IC1—4001 quad NOR gate
R1—1,000,000-ohm, ½-watt resistor



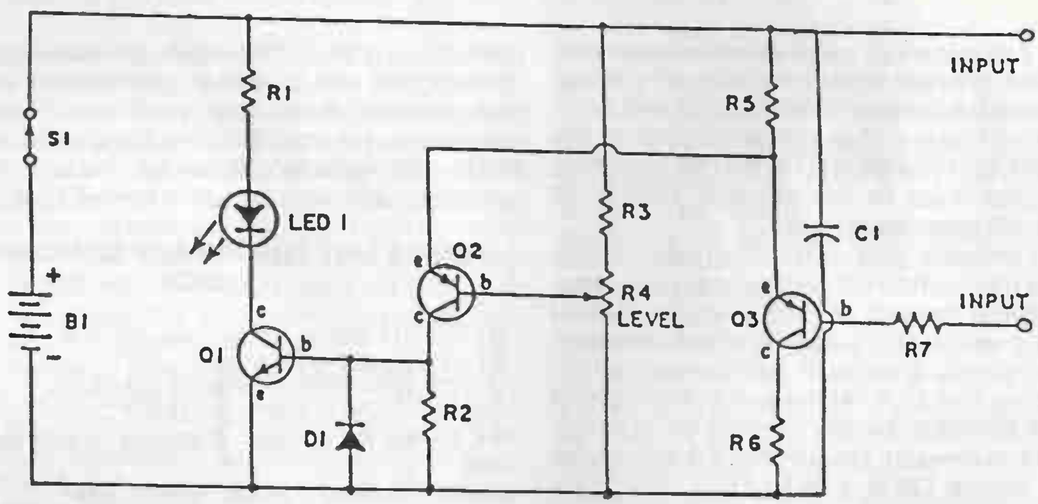
VOLTAGE LEVEL DETECTOR

There are times when voltages are allowed to vary widely in a given system, so long as they do not exceed some preset limit. This might happen in speed or temperature controls, for example, or even simple R-C timers.

This circuit is based upon a two-transistor comparator. An input voltage (which must not exceed B1 in either positive or negative value) at Q3 is compared to a preset divider R3-R4 at Q2. When the input voltage equals or exceeds the preset voltage, Q1 is biased off, turning LED 1 off.

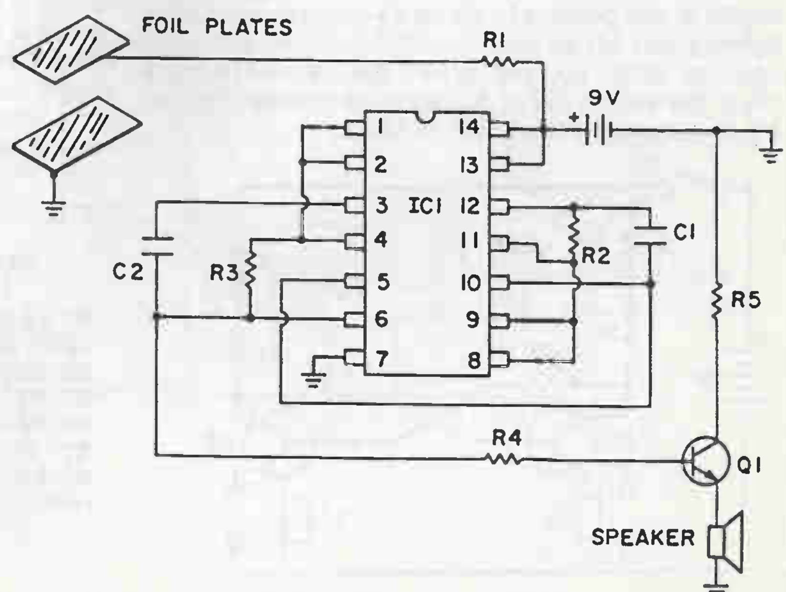
PARTS LIST FOR VOLTAGE LEVEL DETECTOR

B1—9VDC Battery
C1—.1uF capacitor
D1—diode 1N914 or equiv.
LED1—light emitting diode
Q1—NPN transistor 2N2222 or equiv.
Q2, Q3—PNP transistor, 2N3906 or equiv.
R1, R6, R7—1000-ohm resistor ¼ watt
R2—4700-ohm resistor ¼ watt
R3—100,000-ohm resistor ¼ watt
R4—1-Megohm resistor ¼ watt
R5—3300-ohm resistor ¼ watt
S1—SPST switch



RAIN DETECTIVE

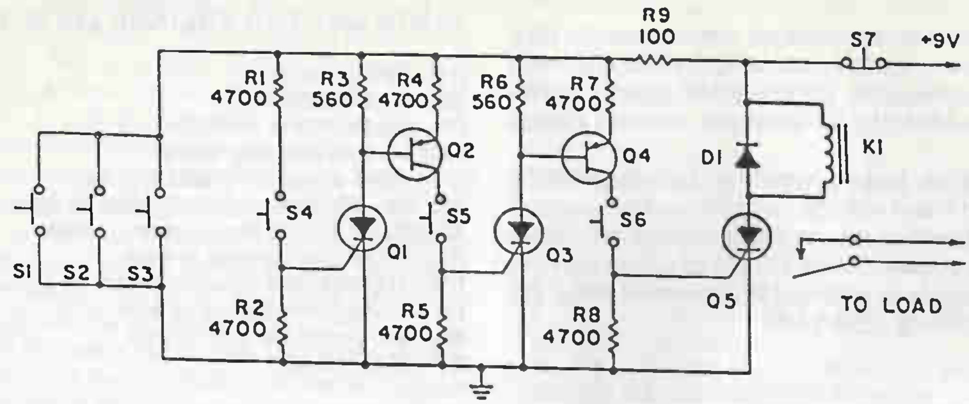
Have some problem with water now and then? Trying to keep rain from ruining your top-down convertible? This circuit will sound an alarm when rain gets between the aluminum foil strips to keep you high and dry.



PARTS LIST FOR RAIN DETECTIVE

C1—0.47-uF ceramic disc capacitor, 15 VDC
C2—0.01-uF ceramic disc capacitor, 15 VDC
IC1—4001 quad NOR gate
Q1—2N4401
R1—5,000,000-ohm, ½-watt resistor
R2—1,500,000-ohm, ½-watt resistor
R3—100,000-ohm, ½-watt resistor
R4—2,000-ohm, ½-watt resistor
R5—100-ohm, ½-watt resistor
SPKR.—8-ohm PM type speaker

SNEAKY COMBINATION LOCK



Now you can lock up your valuable electronic equipment and prevent tampering, with this handy electronic combination lock. Press S4, S5 and S6 in sequential order (the switches can be mounted in any physical order), and you latch K1 in the ON state, thus turning on your load in the process. Hitting S7 momentarily will reset the circuit.

When S4 is pressed, gate current is supplied to Q1, which causes this SCR to latch in a conducting state. This pulls current through R3 and turns on current source Q2. Consequently, when S5 is later pressed, Q2 is able to supply a pulse of gate current to Q3, thereby latching this SCR. At the same time, current source Q4 is activated by the latching of SCR Q3. Thus, when S6 is pressed, Q4 supplies a pulse of gate current that latches Q5 in a conducting state. As a result, relay K1 pulls in.

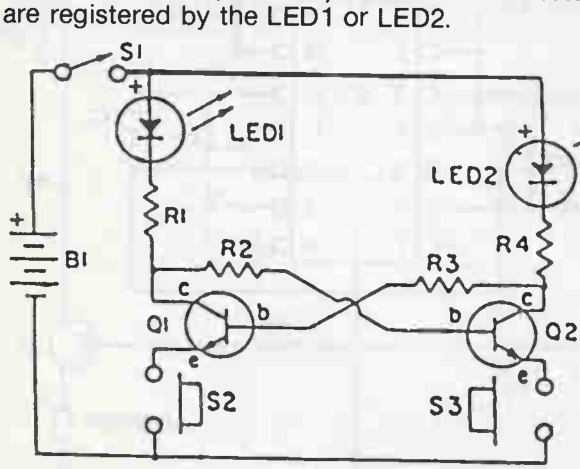
Whenever one of the dummy stwiches—S1, S2, S3—is pressed, Q1 and Q3 are reset to their non-conducting states. Therefore, whenever a potential intruder hits one of these dummies, he defeats his own attempt at picking your lock. Pressing S7 removes power from the circuit and unlatches all the SCRs—Q5 included. Relay K1, therefore, gets de-energized, and your circuit is locked up tight.

PARTS LIST FOR SNEAKY COMBINATION LOCK

D1—1N914 silicon diode
K1—6-volt, 500-ohm relay
Q1, Q3, Q5—2N5060 sensitive gate SCR
Q2, Q4—2N3906 PNP transistor
R1, R2, R4, R5, R7, R8—4700-ohm, ½-watt resistor, 10%
R3, R6—560-ohm, ½-watt resistor, 10%
R9—100-ohm, ½-watt resistor, 10%
S1 thru S6—normally open pushbutton switch
S7—normally closed pushbutton switch

QUICK DRAW McGRAW

"Quick Draw McGraw" is a game of agility. The object of the game is to prevent your opponent from lighting the LED on your side of the circuit before you light his. When you yell "draw", the first one to press his or her switch (S2 or S3) wins the contest. Results are registered by the LED1 or LED2.



To make the game even more exciting, you can try rolling a steel ballbearing down a channel with the contacts at the bottom, replacing switch (S1). When the ballbearing completes the circuit, go for your trigger switch. Or you can leave S1 closed and hold both "triggers" closed (S2 and S3). The first one to release his switch will win the game.

PARTS LIST FOR QUICK DRAW GAME

B1—6.15 VDC battery
LED1, LED2—Light emitting diodes
Q1, Q2—NPN transistors (2N2222 or similar)
R1, R4—150-390-ohms resistor, ½-watt
R2, R3—22,00-56,000-ohm resistors ½-watt
S1—SPST switch (see text)
S2, S3—Normally open momentary, or micro, switches

SHAPED OUTPUT CODE OSCILLATOR

Most code-practice oscillators are keyed by switching the oscillator transistor's supply voltage on and off or by driving the transistor into and out of saturation. This has the advantage of being simple, and it provides tolerable results if a speaker is to be driven.

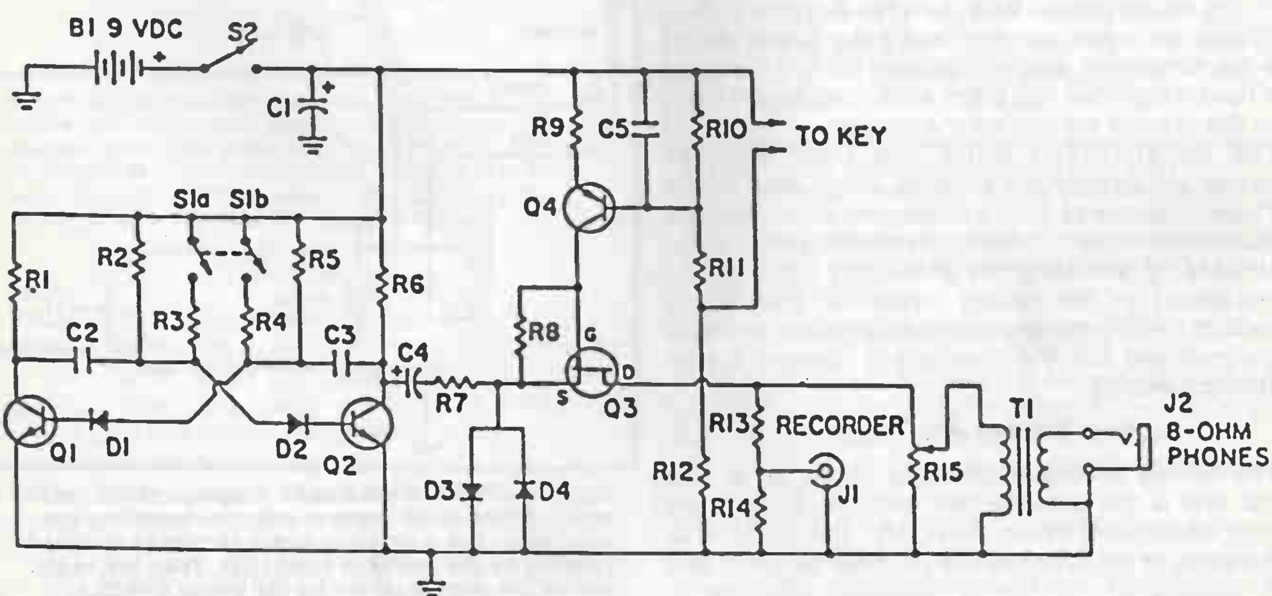
However, the sound of a CPO is like Chinese water torture to the uninitiated, so public opinion usually dictates that you practice with headphones. What you hear then is the "kerchunk" that occurs each time the key is opened or closed. If you want a nice, pure tone signal devoid of "kerchunks," you have to shape the rise and decay of the tone. Here's a circuit that does just that.

The basic tone is generated by a multivibrator (Q1 & Q2) at a pitch determined by S1; low pitch with S1 open, high with S1 closed. This tone is fed through C4 to a clipper (D1, D2) and FET Q3, which functions as a signal attenuator. How much of a signal passes through the FET is determined by its gate potential, controlled by current source Q4 together with capacitor C5, the associated resistors, and your key. With the key down, the signal from Q3's drain is availabe for recording (J1) and for headphone listening (J2). R15 controls the volume.

Smaller values of C5 will yield a more abrupt attack and decay, while larger values can be used to produce mellower results. If you cannot find a 2N3994 FET for Q3, substitute a 2N5461. The great majority of these will work fine, but if you still hear a tone with the key up, try a different 2N5461.

PARTS LIST FOR CODE OSCILLATOR

B1—9-volt transistor battery
C1—220-uF 25.VDC electrolytic
C2, C3—0.22-uF, 25-VDC mylar capacitor
C4—2.2-uF, 10-VDC tantalum capacitor
C5—0.22-uF, 25-VDC mylar capacitor
D1, D2, D3, D4—1N914 diode
J1—RCA-type phono jack
J2—standard 2-conductor phone jack
Q1, Q2, Q4—2N3904 NPN transistor
Q3—2N3994 or 2N5461 p-channel JFET (junction field-effect transistor)
Note: All resistors rated ½-watt, 5% tolerance unless otherwise noted.
R1, R6—1,000-ohms
R2, R3, R4, R5, R8, R10—56,000 ohms
R7—4.700-ohms
R9—22,000-ohms
R11—33,000-ohms
R12—82,000-ohms
R13—51,000-ohms
R14—22-ohms
R15—1,000-ohm audio-taper potentiometer
S1—DPST slide switch
S2—SPST toggle switch
T1—1,000-ohms to 8-ohm audio transformer



BEGINNER'S

FIRST RADIO

Courtesy of RADIO SHACK (A division of Tandy Corporation)

Learn how radio works with this five-dollar kit. Beginner's crystal set goes together in minutes, receives local stations with a piece of wire, or distant broadcasts using an outside antenna.

You can assemble this basic AM radio receiver by putting together the four components (including the earphone) with the wires and spring clips provided, on a pre-punched mounting board which has the schematic symbols printed on it. When you put the kit together you place each component right over the printed symbol on the layout.

The principles on which this basic receiver operates are exactly the same as those used in the cat's whisker sets of the Twenties—as well as the AM radios in use today: (1) Tuning (selecting) the station you want by adjusting the amount of capacity (or inductance) in the tuning (antenna) circuit, (2) detecting (rectifying) the audio information which is superimposed on the alternating current (radio frequency waves).

How Stations Are Tuned

The tuning (antenna) circuit is made up of two parts; one is the antenna coil, and the other is the tuning capacitor (station selector). The amount of inductance in the antenna coil (number of turns) and the capacity of the tuning capacitor combine to determine the resonant frequency of the circuit at any time. This frequency can be changed by turning the tuning knob. This changes the amount of capacitance of the capacitor, which changes the frequency of the tuning circuit.

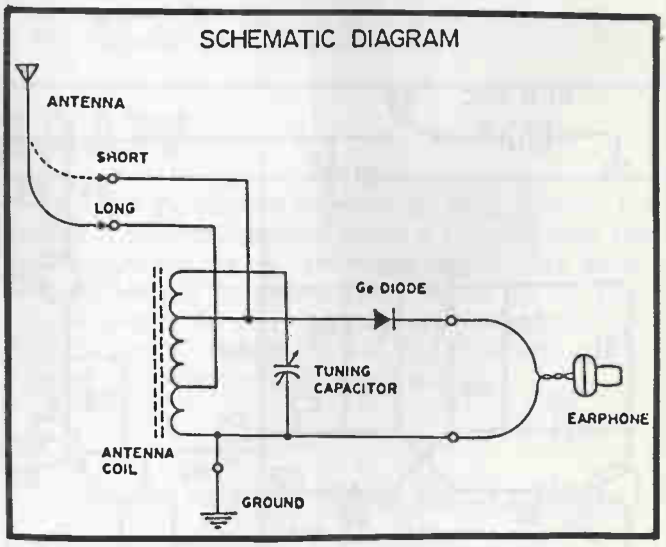


Figure 1. This is a schematic diagram of the crystal radio. It has three components, not counting the earphone. The particular radio station is selected (tuned) by the variable capacitor. Then the radio waves are demodulated by the diode (rectifier). These audio (sound) waves are then sent to the earphone.

The tuning capacitor for all AM radio sets was chosen many years ago to be 365 microfarads. That is, 365 ufd when it is completely closed—the plates are completely meshed. This capacity is varied all the way down to about 20 ufd, when the plates of the capacitor are completely open.

Easy to Assemble

Assembling this kit and using it, is an excellent way for a beginner to get started in radio/electronics. You put it together in a few minutes (15 to 20, at most) and it works right away, pulling in local stations with the 10-foot wire which is included as an antenna. Want to pull in more distant stations? Just add an outside antenna, 30 or more feet long, and placed as high up as you can get it. This way you'll be able to pull in stations much farther away, particularly at night.

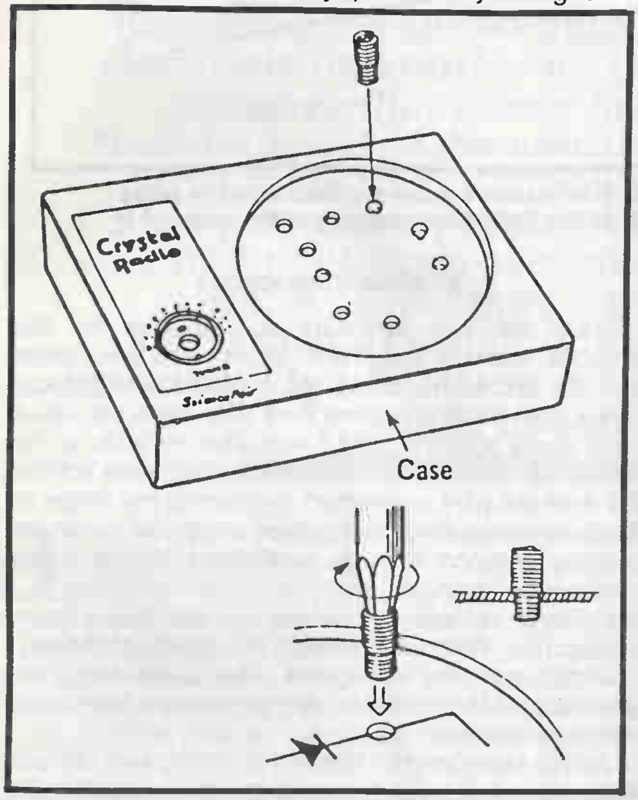


Figure 2. Connections between the components are made with nine small springs. The springs are pressed into their mounting holes by placing each on the tip of a lead pencil and twisting into each hole. Springs are then bent slightly to take the wires, or wire leads of the components.

How It Works

Looking at the Schematic Diagram (Figure 1) you'll see the *Antenna*, the *Antenna Coil*, and the *Ground* at the left. These three components and the tuning capacitor "trap" the radio waves. The longer the antenna and the higher up in the air it is positioned, the stronger will be the radio signals it traps.

Radio waves sent out by AM broadcast stations, operate at frequencies between 550 Kilohertz and 1600 KHz. That means they are AC (alternating current waves) which change direction many thousands of times per second. The audio (sound) signals, music and voice in the radio station studio, are superimposed on the basic radio frequency (RF) and they *vary* (modulate) the strength of the radio waves according to the audio desired.

Each radio station uses a different radio frequency to send out its signals. These frequencies are between 550,000 and 1,600,000 Hertz (cycles-per-second). The particular frequency of each station has been set by the FCC (Federal Communications Commission) so as not to interfere with other stations in its area.

Demodulating the Audio

After your receiver is tuned to a particular radio frequency, according to the combination of the antenna coil and its tuning capacitor, the radio waves go to the germanium diode, shown in Figure 1 between the headphones and the antenna coil. This diode *rectifies* the AC radio waves, turning them into audio currents. These audio currents are the same as the audio signals created at the radio station by the voice and music at the station's microphones.

The process of imposing audio (sound) waves on top of the radio frequency waves is called *modulation* (another word for *changing*). To change the strength of the radio waves according to the audio is *modulating* the RF.

After the radio waves have been *selected* (by the tuning capacitor and the antenna coil) they are *demodulated* by the diode.

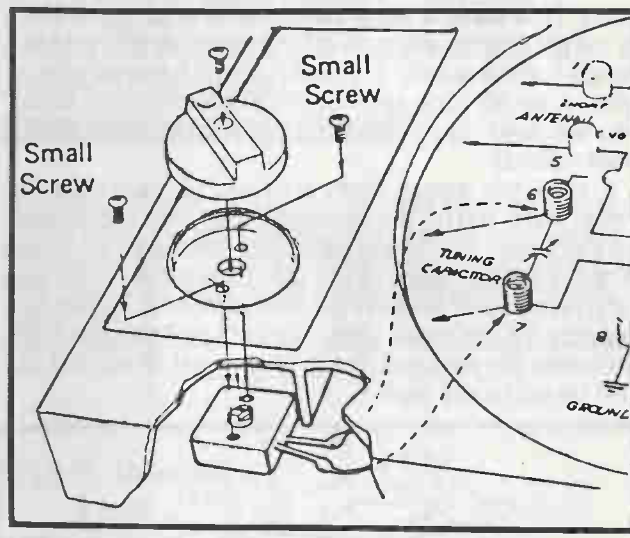


Figure 3. The tuning capacitor (lower left) is mounted under the punchboard with two small screws. The tuning knob is then mounted on top with one screw. The two dotted lines show wires connecting antenna coil (under the board) to the tuning capacitor.

Putting it Together

This radio kit is probably the easiest kit you'll ever put together. All the parts are supplied, but you'll need a few simple tools. The things you'll need are:

(1) a small Philips screwdriver (for the small screws with a cross instead of a slot),

(2) a pair of wire cutters (or scissors),

(3) an ordinary lead pencil,

(4) a pair of long-nose pliers (these are not essential).

Following the manual supplied with the kit, I punched out the nine small holes on the punchboard. These are labeled, and each one makes a small hole in the board where I then inserted a connection spring.

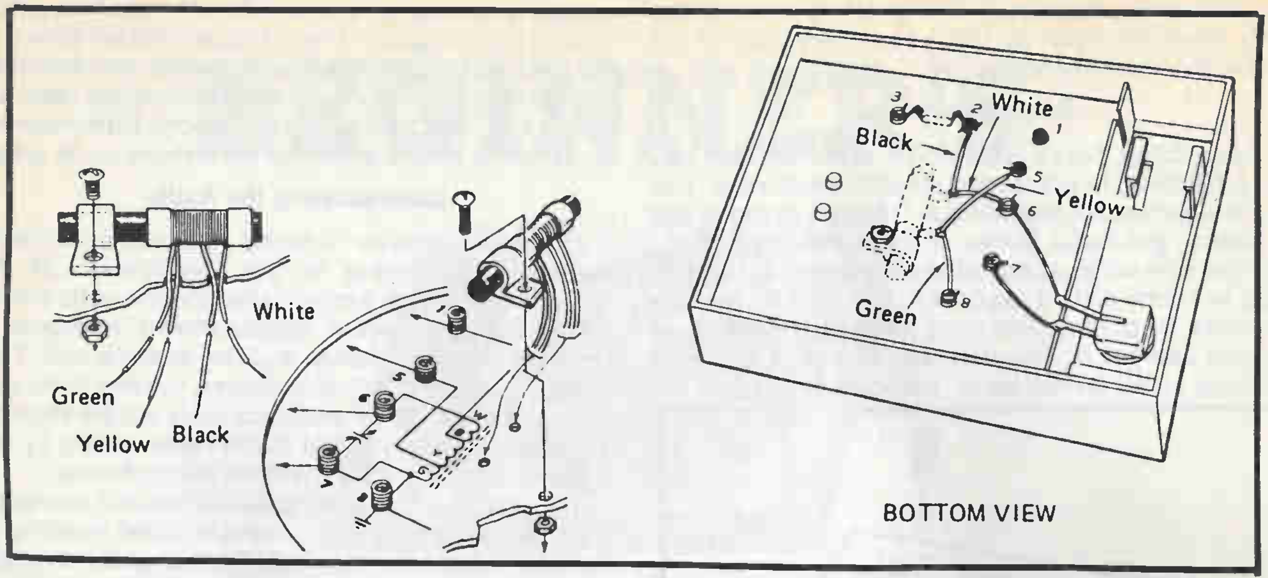


Figure 4. Above (left) are details of the antenna coil. Four colored wires are connected to parts indicated on the punchboard, which is also labeled. At the right the underside of the receiver is shown. The tuning capacitor is at the lower right.

Next the little springs were pressed into the nine little holes (each with a number between one and nine). This takes a bit of dexterity as each spring has to be placed on the end of the lead pencil, and the pencil turned slowly to press the coil halfway into its hole. After all nine springs are placed in their holes, you are ready to mount and connect the *components* (radio parts).

It took me about eight minutes to assemble the three main parts; the antenna coil, which has four connections, the tuning capacitor (two) and the diode rectifier (two). I also had to cut the supplied wire into two pieces. One was the *ground* wire, which goes to a radiator (or the metal plate of a light switch); the other becomes the antenna itself. This is just stretched out and taped to the wall.

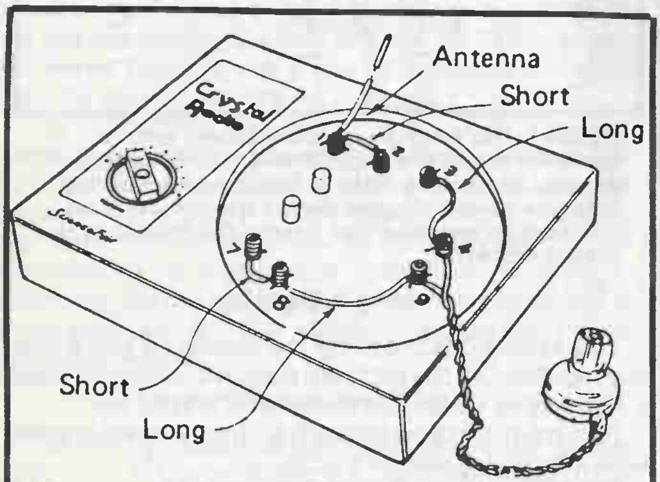


Figure 5. Here the set is complete, except for the antenna coil. Only four connecting wires are used, not counting the antenna and ground wires, two short and two long. All wires are supplied ready to use.

Antenna Connections

There are two alternate connections for the antenna, marked "long" and "short". The one I chose was the short one, using the supplied wire indoors. Since I am located in New York City there are lots of local radio stations, and I was able to pick up the strongest one (WOR—710 on the dial) even without the antenna wire connected, by placing my finger on the antenna spring. For better reception, a longer, outside antenna can be connected to the "long" connecting spring.

I found it was important to use the ground connection. Without it, even in the middle of the city I couldn't get any reception. But connecting the ground wire to a radiator (or light switch plate) made all the difference.

Just to experiment, I hooked up a long wire (40 feet) antenna outside our house in the country, 50 miles north of NYC. This brought in lots more stations (at night) than our one local broadcast station.

My no-power earphone radio works perfectly. I recommend it to anyone who has never assembled an electronics kit before. It'll make you want to go on to more complicated and more interesting projects. ■

"With these kits he can start with the basic crystal receiver and gradually progress up to his very own 10,000 watt radio station!"

SERVICING YOUR STEREO AMPLIFIER

By: Homer L. Davidson

Servicing the stereo amplifier section of your favorite electronic entertainment unit is not as difficult as it may appear, after removing the top or bottom covers. Practically all of the consumer electronic audio products have some sort of amplifying system. The small solid-state portable or table model radio may have only two or three stages of audio. While the big-boom box cassette player may have four or five audio output transistors or two IC components. Of course, the high powered deluxe stereo amplifier may have several audio stages in each stereo channel.

By isolating the various audio stages, you may quickly locate the defective component. A defective stereo channel may be located by taking voltage and resistance measurements and comparing these measurements with the good channel. A dead, weak, distorted or noisy stage may be isolated with signal tracing methods. A separate audio amplifier may be used to signal trace the audio circuits.

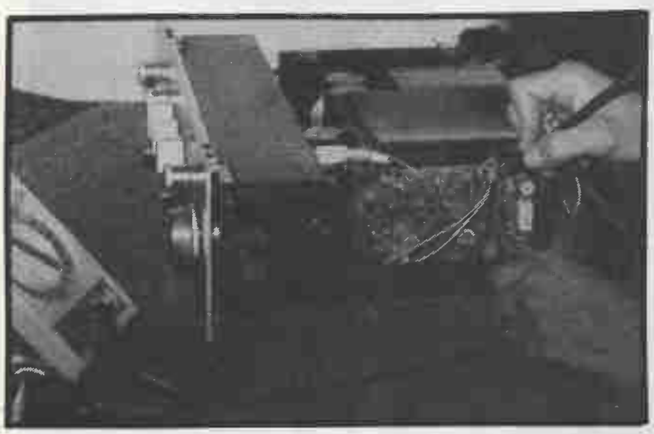


Figure 1: Here a technician tests the ac line fuse in a Yamaha CA600 model stereo amp with a DMM.

A lot of the defective audio components may be found with only a couple of simple test instruments. If you have a pocket VOM or DMM around the house or on your workbench, you may quickly locate the various sound problems. The digital multimeter (DMM) is the ideal test instrument for this kind of analysis. They are fairly inexpensive, starting at about $39.95 and up. Besides critical voltage and resistance measurements required in solid-state servicing, the DMM can also check out those defective diodes and transistors.

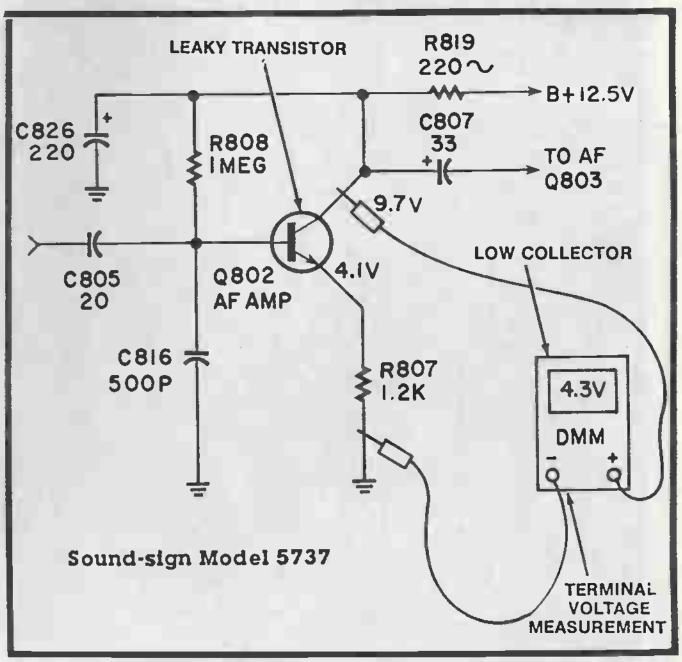


Figure 2: Accurate voltage measurements at the transistor terminals may reveal if the transistor is open or leaky. Suspect a leaky AF or driver transistor when the collector voltage is considerably lower than specified on the schematic.

Voltage Measurements

A defective transistor or IC part may be located with accurate voltage and resistance measurements. Real low collector voltage of the AF or driver audio transistor may indicate a leaky transistor (Fig. 2). Suspect an open transistor when the collector voltage is almost the same as the supply voltage. An open emitter resistor may cause the same type of voltage reading. Check the transistor for leakage when the same lower than normal voltage is found on the base, collector and emitter terminals.

Critical voltage measurements on the IC may indicate a leaky or open component. First, measure the supply voltage tied to one of the IC terminals. This voltage is always the highest measured voltage. Suspect a leaky IC if the voltage is real low at the supply terminal (Fig. 3). You may find all other voltages are not the same with low voltage at the supply terminal.

Remove the supply terminal from the pc board with a low voltage measurement. Use a soldering gun with solder mesh material to remove solder from the terminal. Make sure all excess solder is not connected to the terminal and previous pc wiring. Now take another voltage measurement. If the voltage is now high at the pc wiring terminal area, suspect a leaky Ic component.

Resistance Checks

Rotate the DMM to 2K ohm function and measure the resistance between the unsoldered IC terminal to common chassis ground. A real low ohm measurement under 1500 ohms may indicate the IC is leaky. Infinite measurement may indicate the IC is okay.

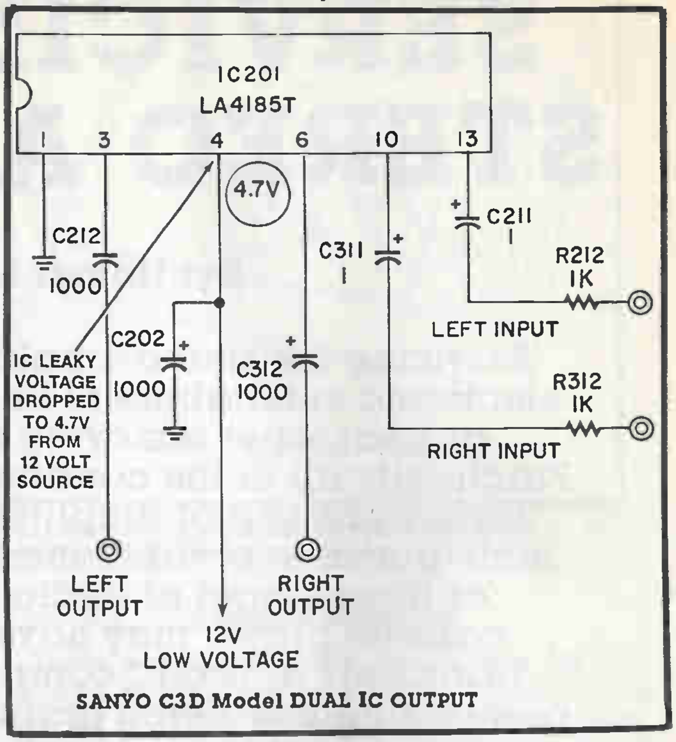


Figure 3: Either the low voltage source is low or the IC audio output IC is leaky when real low voltage is found at the supply terminal. Remove the pin terminal of the IC and take another voltage measurement.

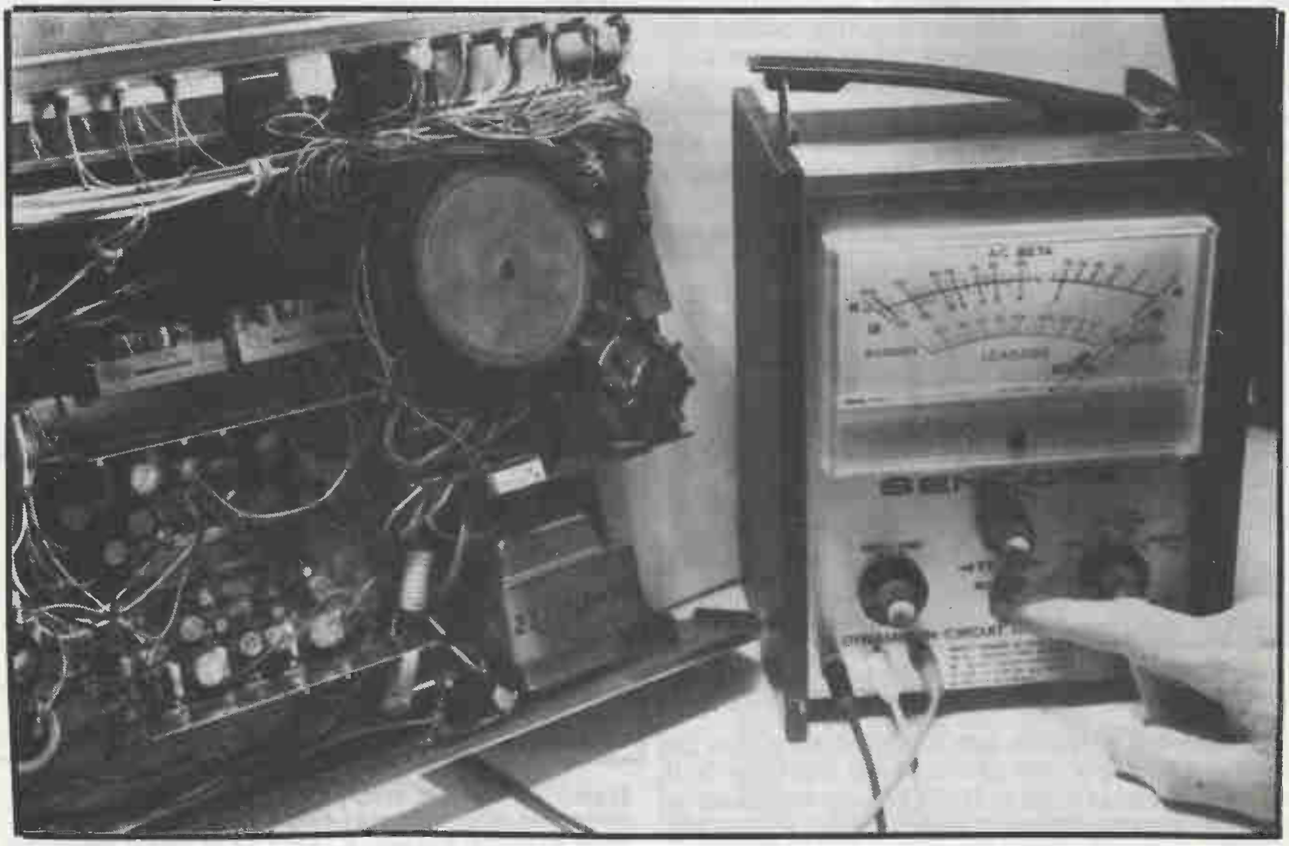


Figure 4: You can use a commercial transistor tester to check the suspected transistor in or out of the circuit. This tester checks for open, BETA and leakage tests.

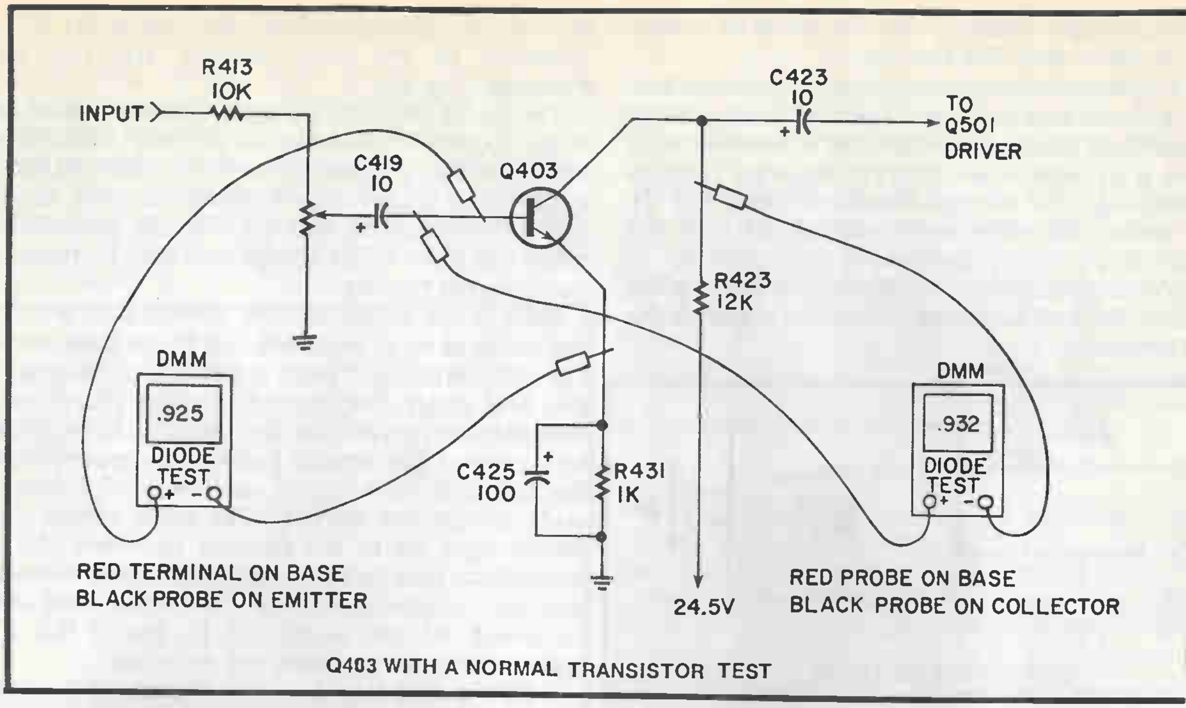


Figure 5: Rotate the DMM function switch to diode or transistor test and check the suspected transistor. The base terminal is always common to the collector and emitter terminals with open or leakage tests.

The defective transistor may be located with low ohm resistance measurements between collect and ground. A low resistance below 1K ohms from base terminal to ground may indicate a leaky transistor. Real low ohm measurement between any two terminals in both directions may indicate a leaky transitor. The low ohm scale of the DMM is real handy in locating burned or open emitter resistors in the audio output circuits since they may be under 1 ohm.

Transistor And IC Tests

A defective transistor may be checked in or out of the circuit with a commercial transitor tester (Fig. 4). Connect the three colored leads to the suspected transistor and read for open or leakage tests. Sometimes if a diode or directly driven transistor is in the base circuit of the suspected transistor, the transistor may have to be removed for accurate leakage tests. No measurement indicates the transistor is open.

You may check the supected transitor in or out of the circuit with the diode and transistor test of the DMM. Since a transistor is two diodes back to back, the elements may be tested with the diode test function. A leaky or open diode may be located with the same test.

Since the base terminal is common with both collector and emitter terminals, the red probe is connected to the base terminal of the NPN transistor (Fig. 5). Connect the black probe to the base terminal of the PNP transistor for leakage or open tests. Practically all transistors found in the present day audio amps are the NPN types.

Place the red probe at the base terminal and the black probe at the collector terminal. You should get a low ohm reading in this direction. No measurement indicates the transistor is open. Now place the black probe at the emitter terminal with a comparable ohm measurement at the collector terminal. If the two comparable measurements are normal with infinite measurement and reverse test leads, the transistor is okay.

A leaky transistor will have a low ohm resistance measurement between any two elements in both directions (Fig. 6). It's possible to find a transistor leaky between all three terminals. Most leaky audio transistors have leakage between collector and emitter terminals. Remove the base terminal from the pc board with solder wick and take another leakage test. All transistors with open and leakage tests can be made in seconds with the DMM. In fact, all transistors

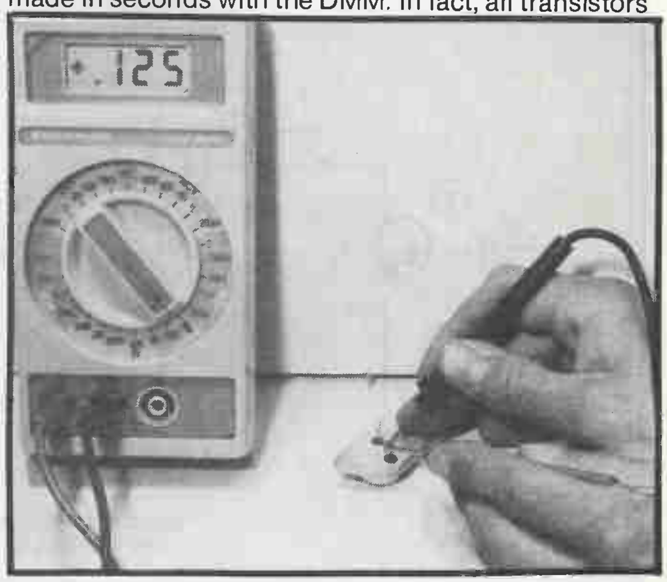


Figure 6: Here the audio output transistor has a 125 ohm leakage between emitter and collector terminal (body). Replace the transistor with the leakage measurement in both directions.

within the audio circuits can be checked within several minutes with this method.

The suspected IC component may be located with audio signal in and out tests. Take accurate voltage and resistance measurements at the IC terminals. It's possible a bypass or electrolytic capacitor may be leaky causing low voltage measurements (Fig. 7). Signal trace the incoming audio signal with the external audio amp. Suspect a defective IC or corresponding parts when the signal is present at the input terminal and no signal or a weak signal at the output terminal.

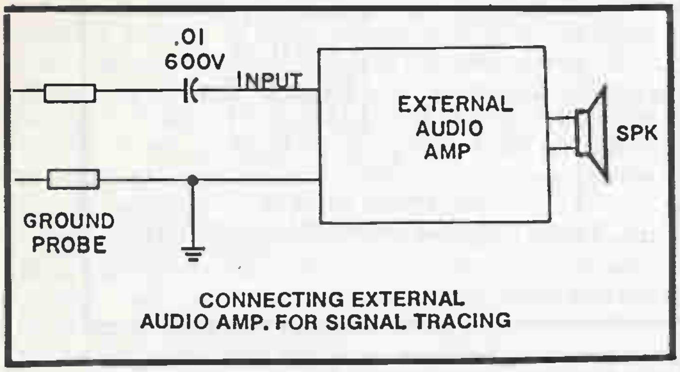


Figure 7: The external audio amp may be used to signal trace the stereo channels for dead, weak or distorted audio. Connect a .01 600 V capacitor with a test probe to the input terminal.

Signal Tracing The Audio Stages

Audio signal tracing may be done with an outside audio amplifier. The audio amp may even be a home built project of two or three stages. There are many transistorized amplifiers in kit or modular form at many mail order electronic stores. You may want to build your own, purchase one in a kit or find a surplus audio amp for only a few dollars. Just connect a speaker to the output terminals and a .01 600 volt capacitor to the input terminal and you are in business (Fig. 7).

The audio amp may be used to locate a weak audio stage. Excessive distortion in the output circuits may locate the leaky transistor or IC component with the audio amp tester. The intermittent poor soldered connection may be located with the audio amp. A noisy transistor or IC component may be found with audio signal tracing.

Start at the center volume control lead and check the audio at both channels. Go to the base and then collector terminal of each audio output transitor until you find where the signal is missing. Of course, the radio or tape player must be operating to produce the audio signal. You should find an increase in volume at the collector terminal of each transistor when the audio stages are working. The audio signal may be traced right up to the speaker terminals. An open headphone jack terminal may be checked in the same manner. Likewise, check the input and output terminals of the audio IC to see if the IC or surrounding components are defective.

If no signal is heard on one channel at the volume control, signal trace the circuits with back up tests. Check the signal at the next transistor or IC component (Fig. 8). Keep going towards the front of the audio amp circuits. Actually, the audio signal in a tape deck may be signal traced from the tape head winding to the speaker output terminals.

The audio amplifier circuits may be signal traced with an audio signal (1KHz) from the audio signal generator applied at the input of the amplifier. Correct balance and small distortion may then be checked with the oscilloscope. The scope may be used to check the waveform signal of each stage to locate the distorted signal. These critical tests should be done by a qualified electronic technician.

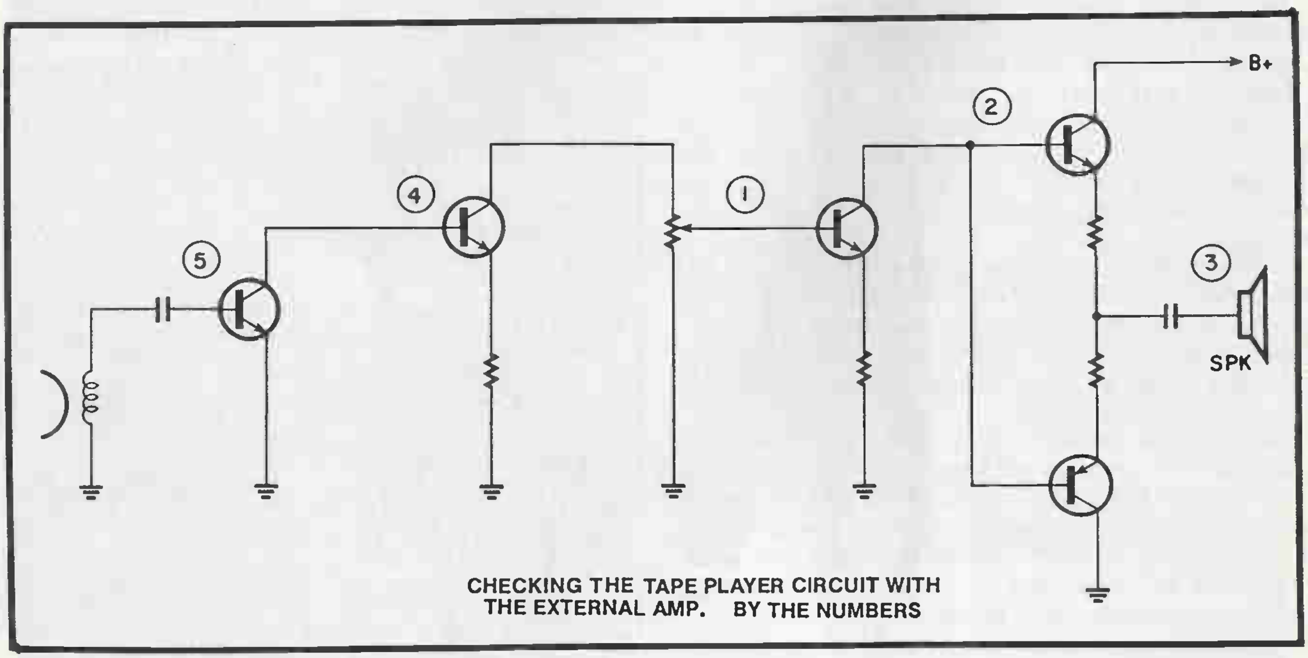
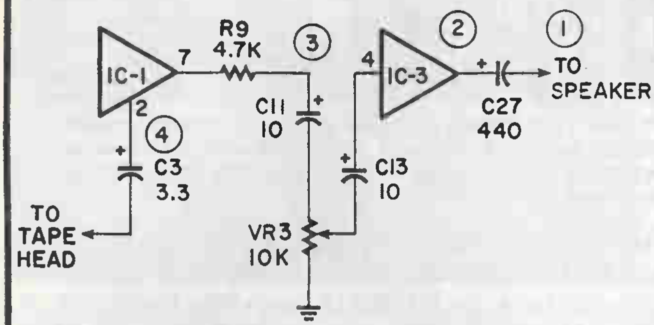


Figure 8: Start at the volume control and work towards the speaker when adulo is heard at the control. Work towards the front end with no audio at the middle terminal of the volume control to signal trace the audio circuits.

Checking The Stereo Circuits

There are two identical audio sound channels in a stereo amplifier. Usually, only one channel contains the defective component. If both channels are distorted or defective, suspect an improper voltage source or low voltage power supply. It's possible to have one channel weak and the other distorted with both stereo channels using one large IC as the audio output component.



TEST POINTS FOR SIGNAL TRACING BY THE NUMBERS

Figure 9: IC components may be signal traced with the external amp connected by the numbers.

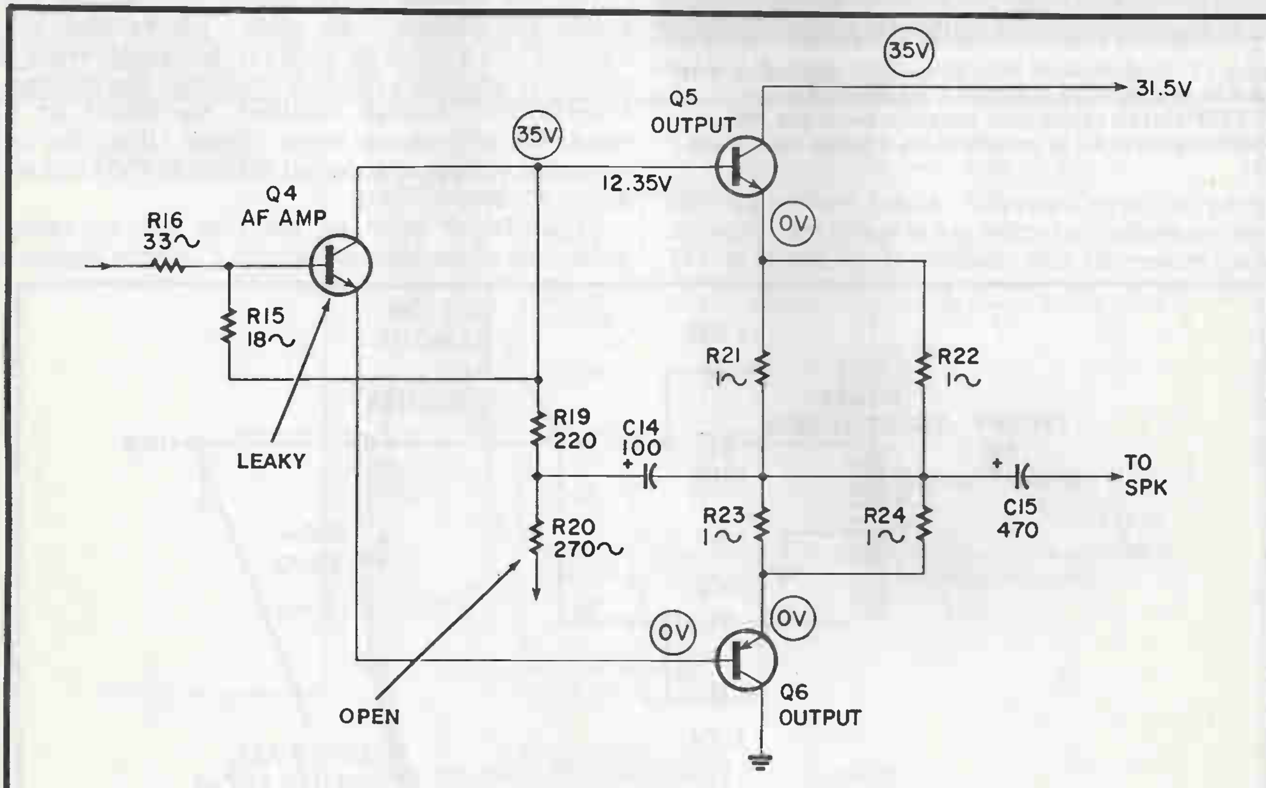
The normal channel may be used to take comparison tests with the defective channel. First, locate which channel has the defect by checking the audio at the output speakers. Next, take the external audio amp and locate the speaker coupling capacitor of the defective channel. Signal trace back through the IC output terminal to determine where the audio is missing or distorted (Fig. 9). Compare the audio signal of the normal channel at the same point in the circuit.

Work towards the volume control and front end with the audio test amp. When the audio signal appears you are close to the defective IC component. Now take voltage measurements at the IC terminals. Check all components tied to the IC terminal for leakage or open conditions. Small electrolytic coupling capacitors have a tendency to become leaky or go open. A burned resistor may indicate a leaky IC or bypass capacitor in the audio circuits.

No Right Channel

A dead channel in the stereo amplifier might be caused by an open or leaky output transistor. Burned bias resistors with a leaky output transistor may cause a dead channel. A leaky AF or driver transistor may cause a dead right channel (Fig. 10). The open speaker electrolytic coupling capacitor may cause the speaker to be dead. Leaky decoupling capacitors in the driver or ouput stages may cause a dead audio circuit.

The right or left channel may be dead with a leaky power output IC. When no sound is evident in both channels, suspect a large power output IC for both channels. Check the speaker and B+ fuse. Some large audio amps have each speaker output fused. Check for improper voltage at the power IC. Low voltage supplied to the IC may cause a dead, weak and/or



NOTICE CIRCLED VOLTAGE WITH LEAKY Q4 AND OPEN R20

Figure 10: A leaky AF amp (Q4) with open resistor R20 (270) produced a dead channel. Notice how the voltage changed on each transistor with voltages circled.

distorted channel.

The dead channel may be caused by a bad pc board connection. Burned isolation resistors may prevent adequate supply voltage at the collector terminals. An open or center grounded terminal of the volume control may cause a dead channel. Don't overlook a possible poor contact inside the earphone jack producing a dead sepaker.

Distorted Left Channel

Most audio distortion is produced in the audio output stage. Interchange the speaker cables to determine if the speaker system is distorted or it is in the amplifier circuits. Suspect a leaky dual IC when both channels are distorted. Suspect an open or broken lead of a large filter capacitor in the low voltage source producing distortion in both channels. The distorted stage may be found with the external audio amplifier.

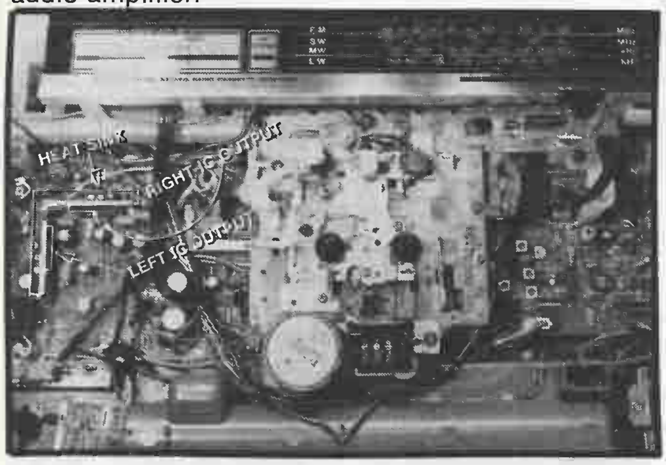


Figure 11: Weak sound with excessive distortion was found in the right channel of a portable Sanyo M9975LV stereo radio and cassette recorder. The defective power IC is mounted on a large bent heat sink.

Leaky or open push-pull output transistors may cause excessive distortion in the speakers. Likewise, a leaky power IC may produce distortion (Fig. 11).

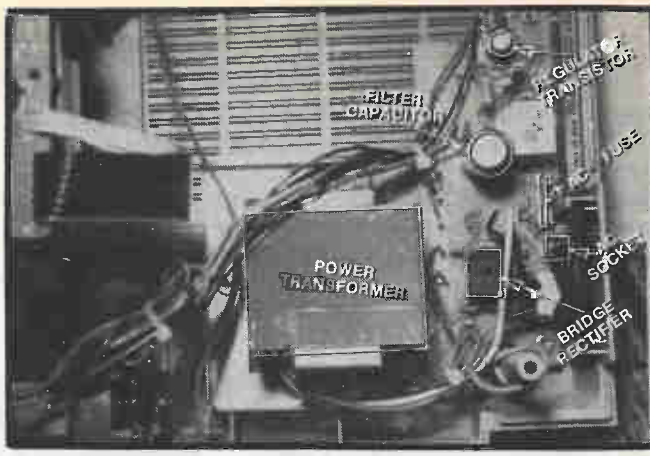


Figure 12: A leaky bridge rectifier or diode may blow the ac fuse in the power supply. Check the primary winding of the power transformer with the low ohm scale of the VOM or DMM.

Remove the suspected transistor from the circuit and test for leakage. Now while the transistor is out of the circuit, check for burned or open bias resistance. A leaky bias diode may cause distortion in the base element. You may find a leaky driver and directly coupled output transistor causing audio distortion.

Real weak and distorted sound may be caused with a leaky and open output transistor. The leaky power IC may cause a weak sound with excessive distortion. Low voltage at the collector output terminals may cause a weak and distorted sound in the speakers.

The Power Source

The low voltage power supply may consist of a power transformer, two silicon diodes and filter capacitor in a small radio or phono player. While in the larger amplifiers you may encounter a large power transformer, bridge rectifier, transistor or IC regulation and several zener diodes. Often, the low regulated voltage is supplied to the AM-FM-MPX and audio pre-amp circuits.

Check for an open AC line fuse with no voltage measured at the output transistor or filter capacitor

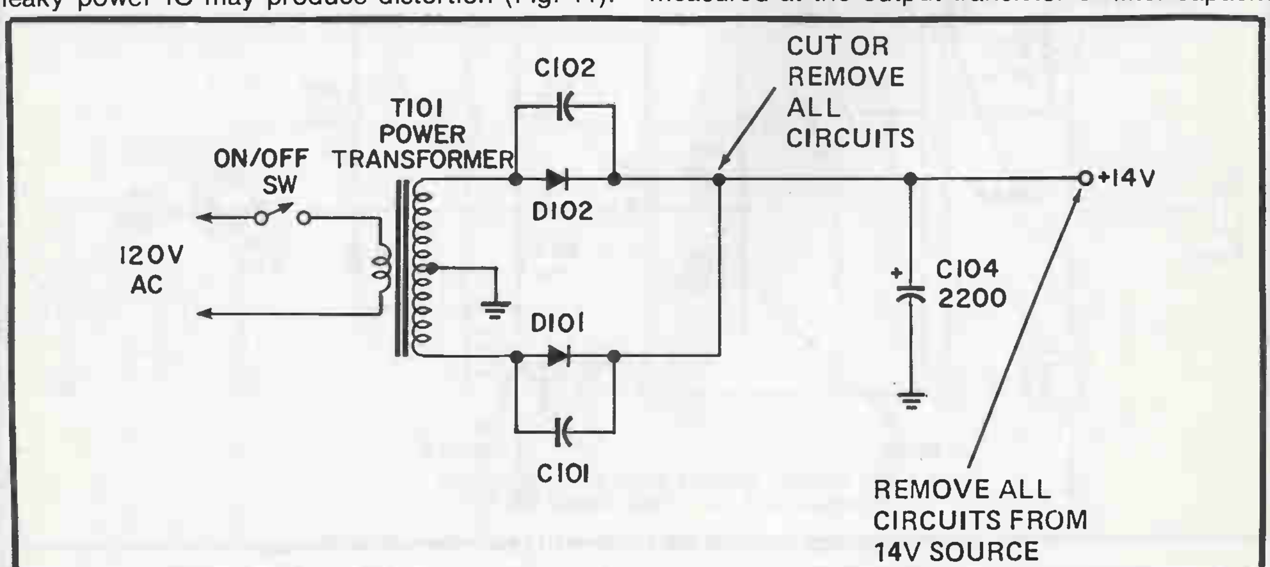


Figure 13: Remove all circuits from the low voltage power source if overloading of a circuit is suspected with low voltage. Check for leaky output transistor or IC components.

terminals. You may not find any fuses in the small radios and player amplifiers. Measure the resistance of the AC male plug of the unit for continuity. This measurement will tell you if the power transformer winding, switch and power cord are okay (Fig. 12).

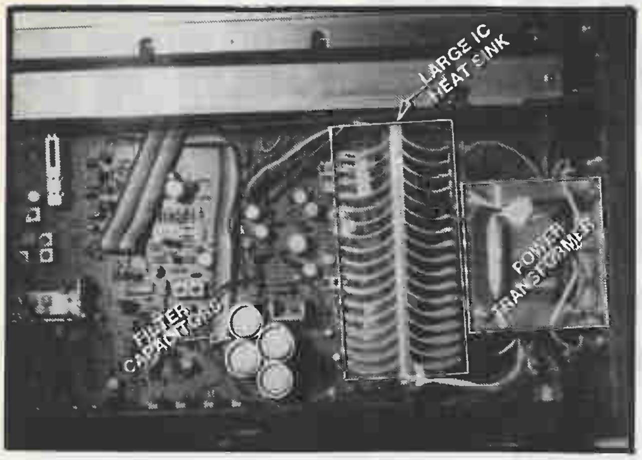


Figure 14: A large IC component may be connected to a large heat sink for both stereo channels. Replace the entire component when one channel is dead, weak or distorted.

suspected filter capacitor from the circuit and test for leakage when suspected of a shorted or leaky condition.

Defective Power IC's And Transistors

The dead amplifier may be caused by a leaky power output transistor or IC components. Suspect a defective power supply or output circuit when the fuse will not hold. If both audio channels are dead or distorted, suspect the output component or power supply. Go directly to the dual audio power IC when both output circuits are fed from one IC component (Fig. 14). Replacing the defective IC solves most sound output problems.

Rotate the DMM to the diode test and check the bridge rectifier or silicon diodes for leakage or open conditions. It's best to remove one terminal of the diode for accurate leakage tests since a feedback measurement may occur through the transformer secondary winding. Most defective diodes will show a direct short or heavy leakage.

Low voltage at the output of the low voltage power supply may indicate overloading in other circuits. Often, shorted or leaky output transistors destroy diodes and cause the fuse to blow (Fig. 13). Remove all circuits connected to the voltage source at the

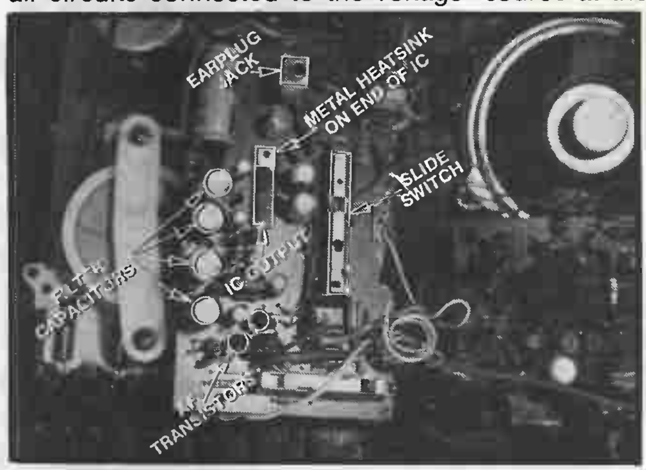


Figure 15: Here in a portable AM-FM-MPX radio and tape player one small IC component provides stereo output for both channels. AF and driver audio transistors are used to drive the IC output.

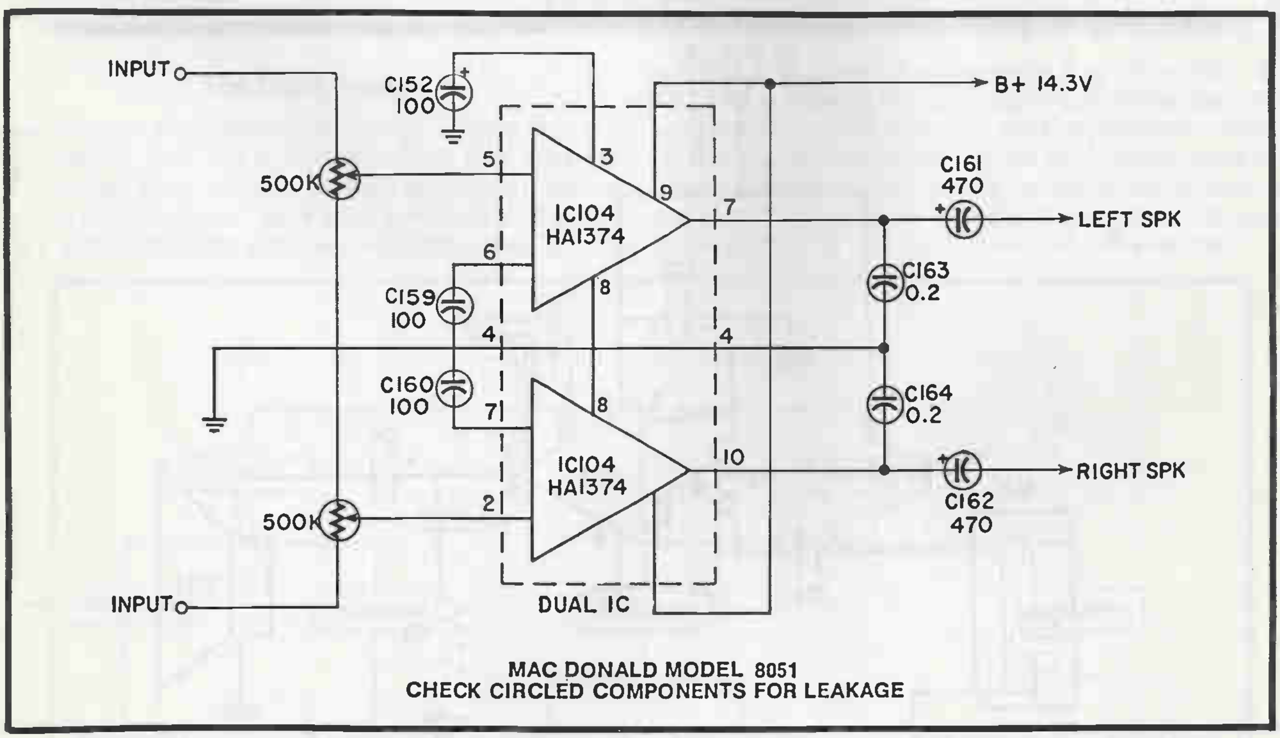


Figure 16: After locating low voltage at the IC terminals, take a resistance measurement to common ground. Resistance measurements below 350 ohms at one terminal may indicate a leaky IC or corresponding part.

(Continued on page 88)

CONSTRUCTION QUICKIE

MICROPHONE AMPLIFIER

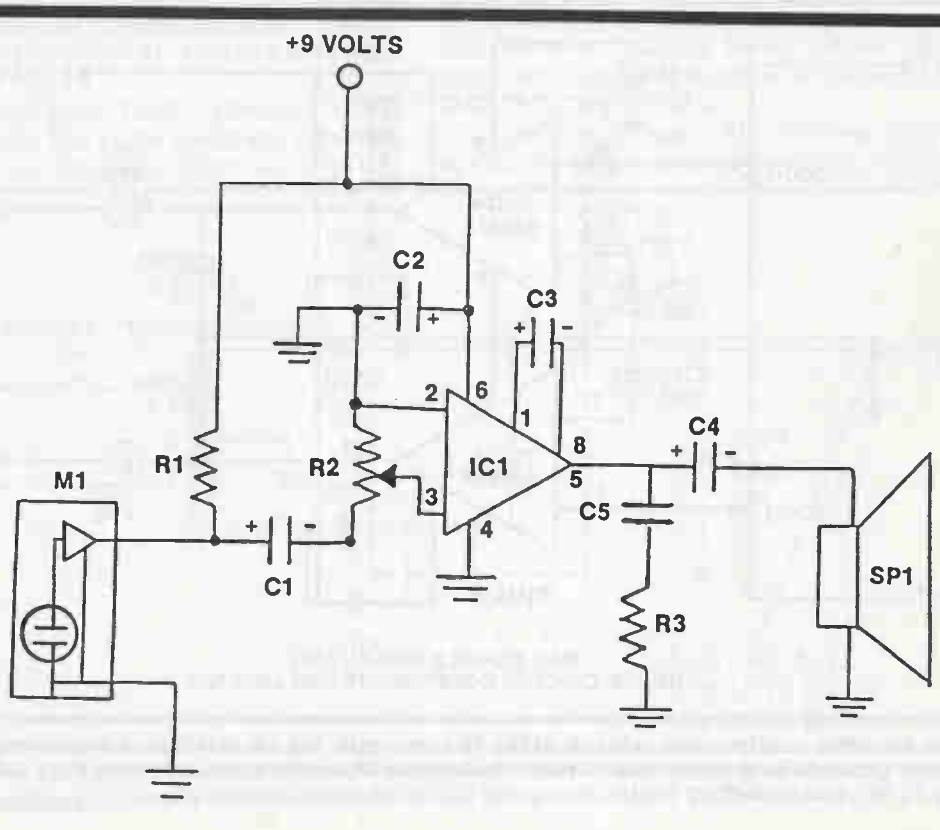
By Bill Axsen

This Microphone Amplifier can be used as a microphone preamplifier, low power megaphone, or in a two station intercom if two units are built. The amplifier uses an inexpensive electret microphone and the popular 386 Low Voltage Audio Power Amplifier. You should be able to build this circuit in an hour or less.

The signal from the electret microphone is amplified by IC1 which is set for a gain of 200. Capacitor C2 is used as a decoupling capacitor. If C2 is removed from the circuit the output will be distorted. ■

PARTS LIST FOR MICROPHONE AMPLIFIER

C1,C3—10uf capacitor 15 VDC
C2—470uf capacitor 15VDC
C4—220uf capacitor 15VDC
C5—.05uf capacitor 15VDC
IC1—LM386 Low Voltage Audio Power Amplifier
M1—4700 ohm, ¼ watt resistor
R2—10,000 ohm, ¼ watt resistor
R3—10 ohm, ¼ watt resistor
SP1—8 ohm speaker ½ watt



UNDERSTANDING SEMICONDUCTORS

PART 3

FIELD EFFECT TRANSISTORS

By William R. Hoffman

For the final part of our series on semiconductors, we are going to meet the most sophisticated of all amplifying devices— the FET (Field Effect Transistor). Actually, the FET is divided into two types, the JFET (Junction FET) and the MOSFET (Metal Oxide Semiconductor FET), along with two subtypes of each with two basic modes of operation. See Fig. 1 for the FET "family tree". Notice that both types come in P and N channel construction, but only the MOSFET has the two different modes of operation: enhancement and depletion. We will be learning more about these as we read on.

The Basic Device

To begin with, the basic FET is a three terminal device, just like a transistor, but with different names for the input, control, and output points. Just as the transistor has a base connection, the FET has a gate; as the transitor has a collector, the FET has a drain; and where the transistor has an emitter, the FET has a source. Fig. 2 shows these in the standard schematic symbol form, for each of the basic types. Notice that the source and drain are just two ends to a channel through the device, which is controlled by the gate. If the channel is of the N type, then it is an N-channel FET, if a P type, then it is a P-channel.

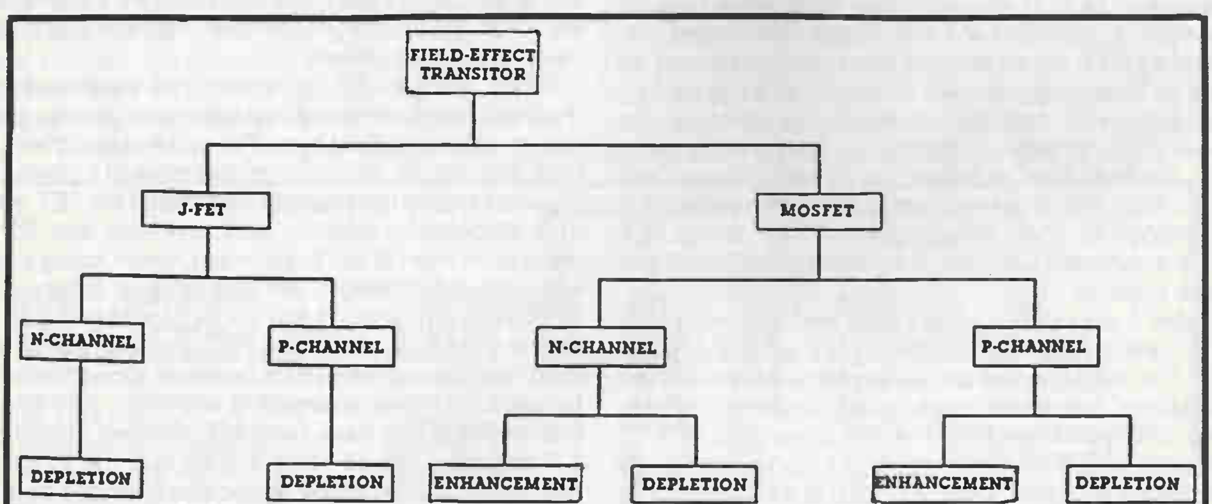


Figure 1. The FET's "Family Tree"

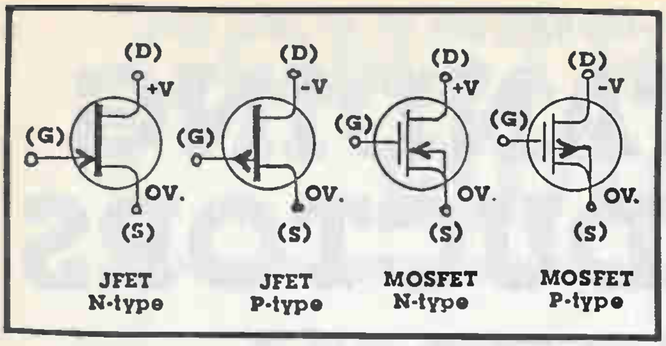


Figure 2. Schematic symbols for both JFET and MOSFET devices with both "P" and "N" types of channels.

The FET is different from the bipolar transistor in one important way. In the transistor a small base *current* controls a large collector current, while in the FET a small gate *voltage* controls a large drain current. The key here is that the transistor is current controlled, while the FET is voltage-controlled. Therefore, they are used a little differently in a circuit. In addition, one variation is the MOSFET with dual gates. The symbol for this is shown in Fig. 3.

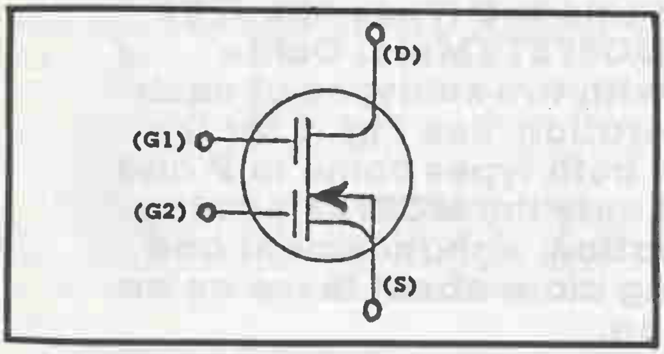


Figure 3. Schematic for a typical dual-gate MOSFET G1 & G2 = Gates

FET Specifications

The FET has several standard specifications,just like a bipolar transitor; its maximum drain *current*, drain-to-source *voltage*, and *gain*, and *power dissipation*. In fact the only real difference here, is how gain is specified. As previously mentioned, the gate of an FET, for all pratical purposes consumes no current. Therefore, our old measure of *Beta*, as in a transistor, will not do. Instead, we specify the relationship between a change in gate voltage and drain current. This is called transconductance, and comes from the older vacuum tube terminology. It is abbreviated as "gm" or sometimes "Yfs". Since FET gain is a complex function, it cannot be specified as a simple number.

Figure 4 shows the case styles and common lead identification (where applicable) for the most popular FETs. For readers who are laying out a PC board, the dimensions for these were given in part-2 of this series. In Figure 5, we have the only other popular FET case style which is not common to the transistor. Its dimensions are given here. Figure 6 is a table of some very common FETs from which a project builder can make a selection for a device to fit a particular project.

Using The Fet

Figure 7 illustrates three typical operating characteristic curves for various FETs, and are analogous to the one given for transistors in part-2 of this series. At A, we see that the current in the drain circuit of a JFET is controlled by a negative gate voltage, the lower the voltage, the greater the current. This is for an N-channel type. For a P-channel type, everything works the same except the gate voltage has the opposite polarity. It is positive, while the drain voltage is negative. See Figure 2.

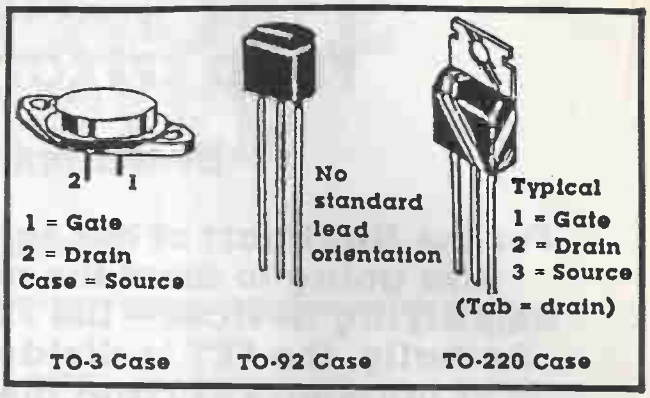
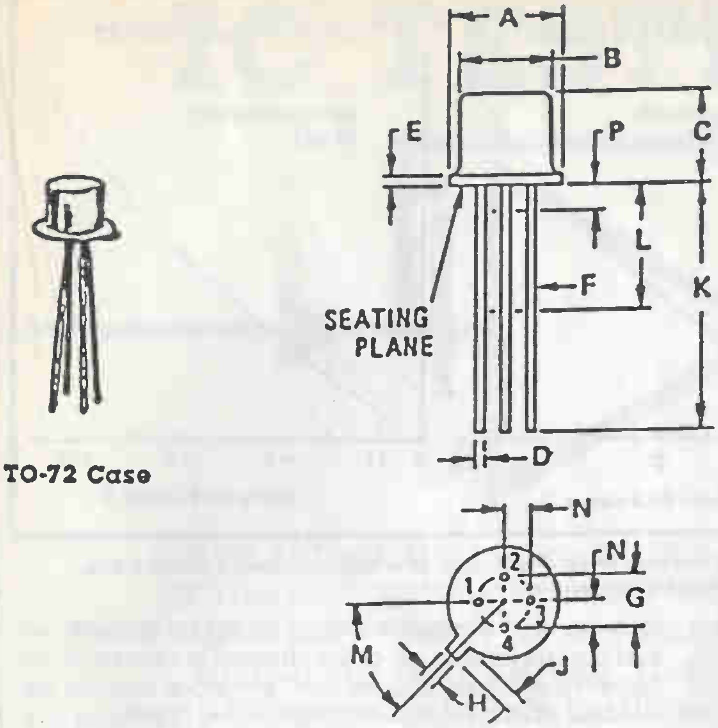


Figure 4. Popular FET case styles with some typical lead orientations. Since standarization is limited, always check the data sheet or catalog to be sure.

At B, we have the MOSFET. When it is a depletion mode type, like the JFET at A, its gate voltage, relative to the source, varies from negative to positive, with increasing drain current. And again, like the JFET, when we go to the opposite channel type, from N to P, the gate and drain voltages are also reversed for the same operation. Again, see Figure 2.

Finally, at C we have the enhancement-mode MOSFET, and it operates somewhat like the depletion-mode type. As the gate voltage becomes more positive, the drain current increases. The only difference is that it does not start at some negative value, but rather just above zero. Actually it starts at about 0.5 to 0.7 volts, not very different from a bipolar transistor. And again, like the other FET types, when we change to the P-channel, the gate and drain polarities are reversed.

When using an FET of either type we must be sure that we always keep within its operating limits, spelled out in the specifications. To understand them, and how they apply, let us use an example of a power FET. Figure 8 shows us a typical example. This FET is rated at 3 amperes maximum drain current, and 35 volts maximum from drain to source. Constructing a graph with this information, we can draw a diagonal line from the 3 amperes on the current scale to the 35 volts on the voltage scale. In the FETs normal operation, as long as its current and voltage conditions stay beneath this line, everything will work just fine. For our example, we have plotted a working condition of 1.7 amperes and 15 volts. Notice that the junction of the two arrows from the two scales meet at a point just below the diagonal line, therefore we are within a safe operating limit.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

Figure 5. This all metal case is popular for some small FET's. The fourth lead is for grounding the case against electrical noise. There is no standard lead orientation.

One final thing to remember. All FETs, like bipolar transistors, when handling a lot of current, may get very hot. Therefore, heatsinking, with its usual insulating precautions, must be observed.

FET Numbering

Like the bipolar transistor, there are standard numbering systems used by both the American and Japanese manufacturers. For the American types, the common FET numbers begin with a "2N-" just like a transistor, although some may use a "3N-" number. Like a transistor, this JEDEC (Joint Electron Device Engineering Council) number specifies the exact voltage, current, and gain values regardless of who the manufacturer is. For the Japanese, we have numbers that begin with "2SJ-" for P-channel devices, and "2SK-" for N-channel. Again, the standard number denotes that the characteristics of the FET are fixed for all manufacturers of the part.

Now that you have gained some insight into the types and operation of FETs, you should feel more comfortable when building some of the "Handbook" projects, or replacing one in a circuit that has failed.

How An FET Works

Despite the complexity of an FET, its actual operating principle is quite simple: the charge on a gate controls the current in a channel through the device.

To begin with, let's look at a JFET, shown in Figure A,1. A bar of silicon material, which is normally a very good insulator is heated and some atoms of another material like phosphorus, are allowed to diffuse into it. In this case, the atoms add some extra electrons to the material, giving it a negative potential, and making it an N-channel device. Also, along the side of the channel, some of the silicon material is exposed only to a material that adds some positive charges to it, like boron, making it a P region. If the bar has a battery connected to it (B1 in the illustration) that is connected between its ends (called the source and drain), then by the principle that like charges repel,

POPULAR F.E.T. TYPES (JFET AND MOSFET), WITH SPECIFICATIONS

TYPE	POLARITY	CONSTRUCTION	POWER	MAX. DRAIN VOLTS	CASE	USE
2SK134	N-Channel Comp.	MOS type	100W.	140V.	TO-3	Power, high.
2SJ49	P-Channel Comp.	MOS type	100W.	140V.	TO-3	Power, high.
2SK176	N-Channel Comp.	MOS type	125W.	200V.	TO-3	Power, high.
2SJ56	P-Channel Comp.	MOS type	125W.	200V.	TO-3	Power, high.
2N3819	N-Channel	JFET type	0.36W.	20V.	TO-92	General Purpose
MPF-102	N-Channel	JFET type	0.31W.	25V.	TO-92	RF/IF Stages
IRF-511	N-Channel	MOS type	20W.	60V.	TO-220	Power

Figure 6. Some popular FET types...with specifications

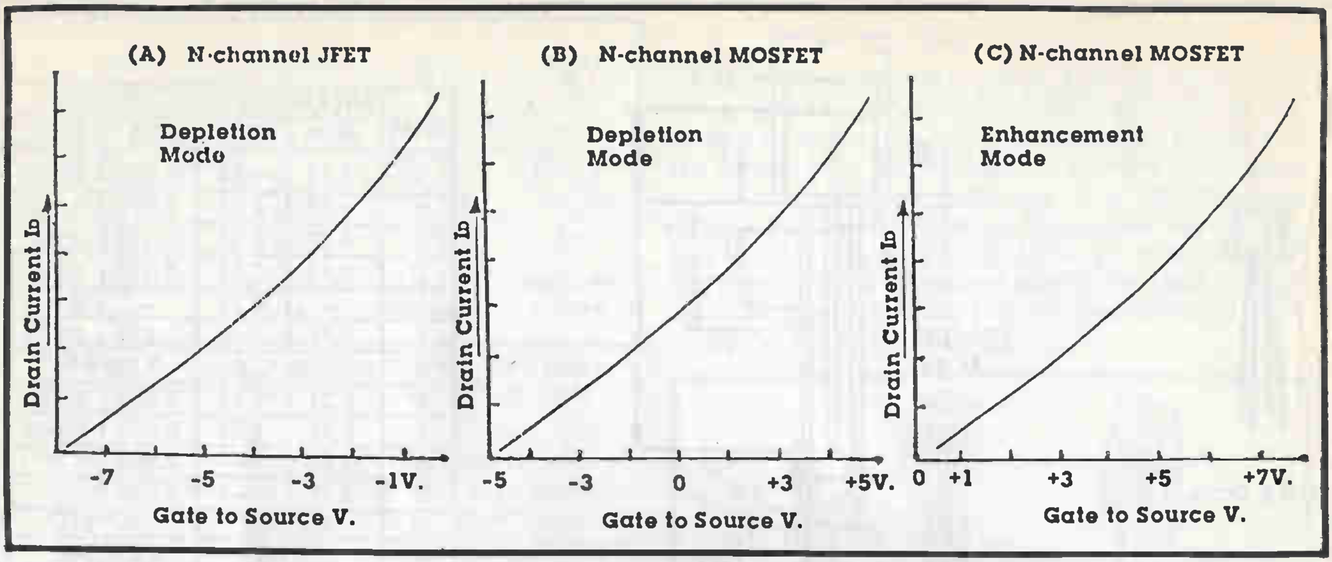


Figure 7. Typical JFET/MOSFET operating curves. Both depletion and enhancement modes are shown. The JFET will operate only in the depletion mode.

and opposite charges attract, the negative end of the battery would force the negative charges in the channel away, while the positive end of the battery would attract them, causing uncontrolled conduction through the channel. This, obviously, is of little use to us.

However, if we add another battery (B2) between the gate and lower end of the channel (the source), and reverse its polarity, compared with the first battery, we will find that the positive charges in the gate are attracted to the negative end of the battery, and the negative charges in the lower channel are attracted to the positive end of the battery, which creates a field or area around the P gate that is now cleared of negative charges. This makes the channel around the gate return to being just a piece of silicon, and acting like an insulator again. Now, depending on how much of a negative charge we put on the gate, we can control how much of the channel is cleared of the negative charges, and we can, therefore, control the amount of conduction. Figure 7, at "A" illustrates this: the more negative the gate, the less the current flows in the channel to the drain. Since what we are doing here is depleting the negative charges in the channel, we call this depetion-mode operation.

In Figure A, at 2, we have another N-Channel fet, in this case, a MOSFET. The difference between the two FET types is shown here: the gate which lies on the side of the channel, is now insulated by a thin layer of metal oxide. This is where the "MOS-" designation comes from. The source and drain connections are exactly the same as the JFET. Also, like the JFET,

(Continued on page 87)

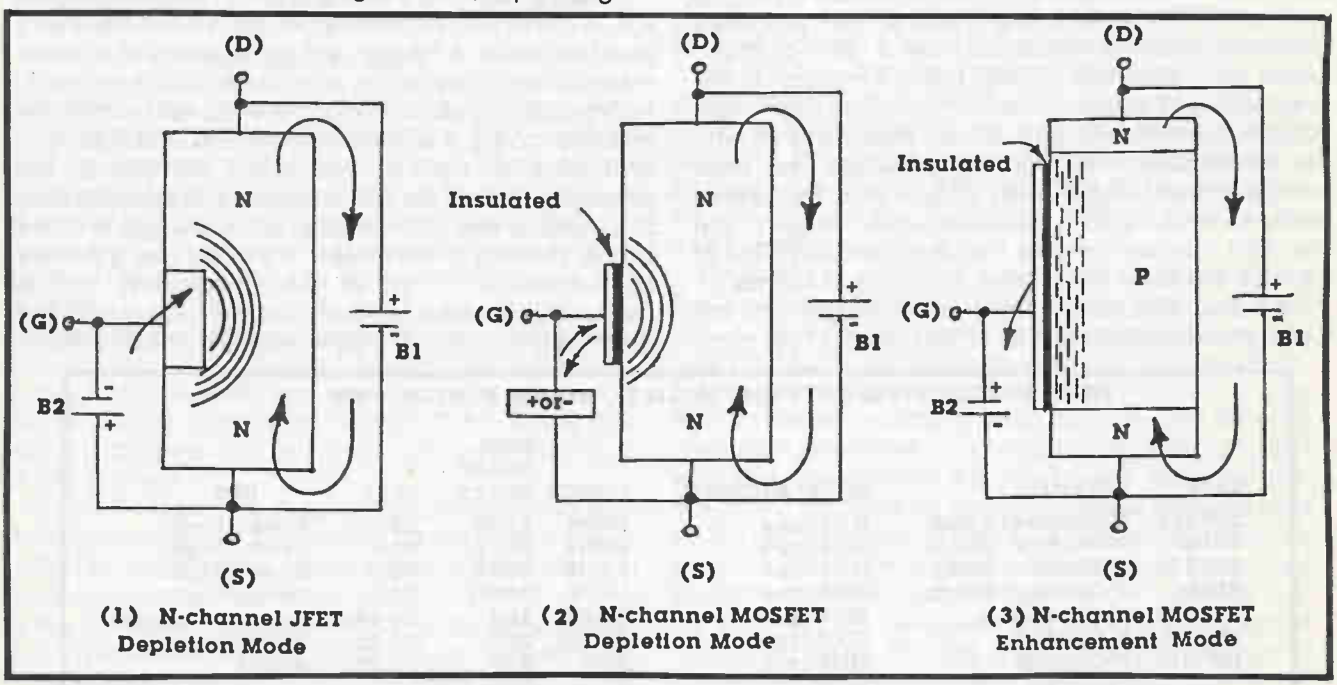
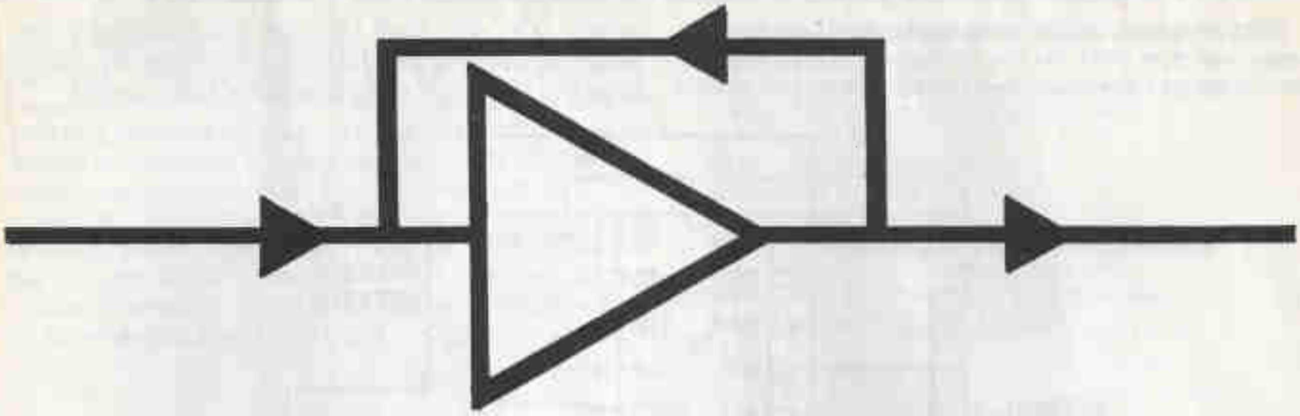


Figure A. Operation of both JFET and MOSFET transistor types, in both depletion and enhancement modes. G = Gate, S = Source and D = Drain

IC TESTBENCH



While integrated circuits are basically composed of groups of transistors and other common electronic components, many, if not most, of them require special handling techniques, therefore, it behooves the inexperienced project builder to try some of the simpler transistor projects in the "Circuit Fragment" section of this issue to become familiar with the components involved before attempting these more complicated projects.

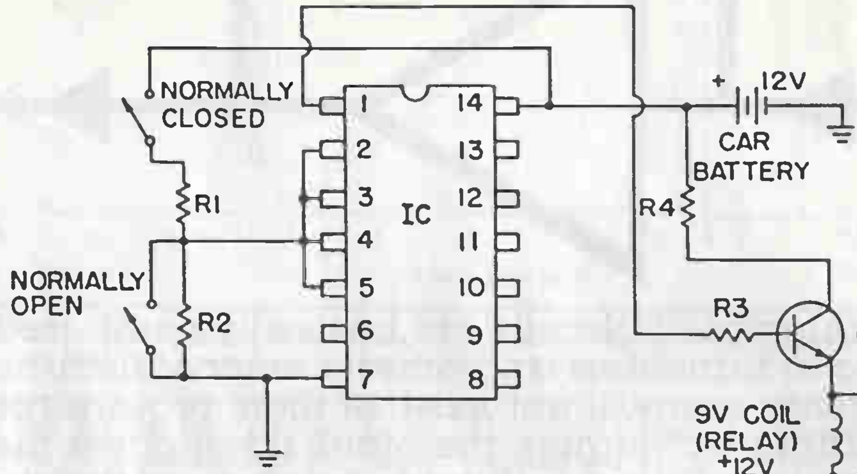
Some types of integrated circuits, especially CMOS, are susceptible to damage in some very strange ways. To protect your investment in these components, we offer some important suggestions and precautions for the handling of the ICs used in the following projects. We strongly suggest that you become acquainted with these precautions before you even take a trip to your local parts supply store to make a purchase.

Even though almost all devices are now designed with resistor/diode protection circuits on the input leads, it is possible for the static electrical charge built up in your body to cause damage to parts of the IC and you'll never know it happened until it is too late. It might be a good idea to invest in a pair of non-conductive tweezers, or a standard IC puller/installer made expressly for the purpose.

If you solder the IC leads directly into the circuit, which we don't recommend, be sure to use a heat sink on the lead between the chip and the tip of the soldering iron. Use a low power iron, and apply heat for the shortest period possible. Always ground the tip of the iron before applying it to an IC. Stray AC in the tip of the iron can also damage a chip severely, and again, you'll never know until it's too late.

OPEN-SESAME AUTO ALARM

This simple auto alarm lets you use either normally open switches (like on the ignition or a door button) or normally closed switches (like on a hood or a radio switch). Or, both may be used simultaneously. The relay coil will operate and the contacts can be used to blow the car horn, or to operate a siren circuit.



PARTS LIST FOR OPEN-SESAME AUTO ALARM

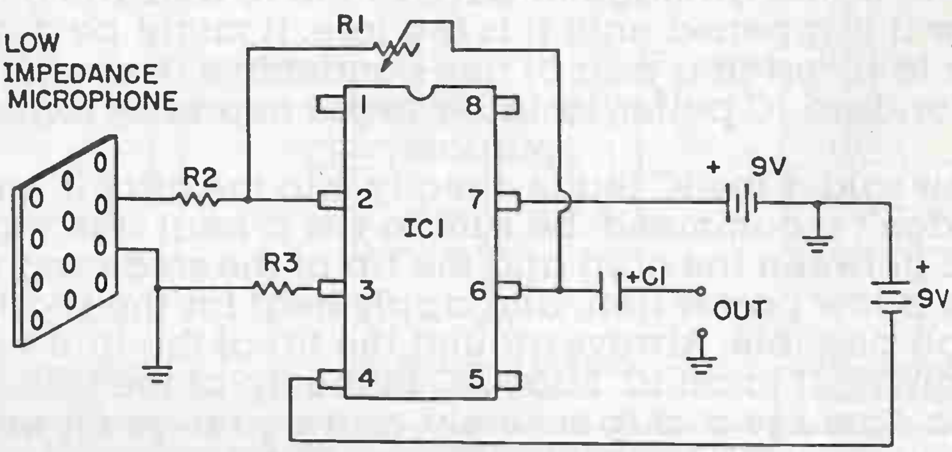
C1—0.1-uF ceramic disc capacitor, 15 VDC
IC1—4002 dual NOR gate
Q1—2N4401
R1—2,000-ohm, ½-watt resistor
R2—100,000-ohm, ½-watt resistor
R3—5,000-ohm, ½-watt resistor
R4—100-ohm, ½-watt resistor
RELAY—9 VDC coil with SPST contacts rated at 15 VDC/15 amps

LOW Z MIKE BOOSTER

A low-impedance microphone has the property of being able to pass sufficient current to be directly in the feedback path of this 741 amplifier. The gain is controlled by changing R1. This circuit can feed into your hi-fi unit to give greater power output.

PARTS LIST FOR LOW Z MIKE BOOSTER 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 resistors

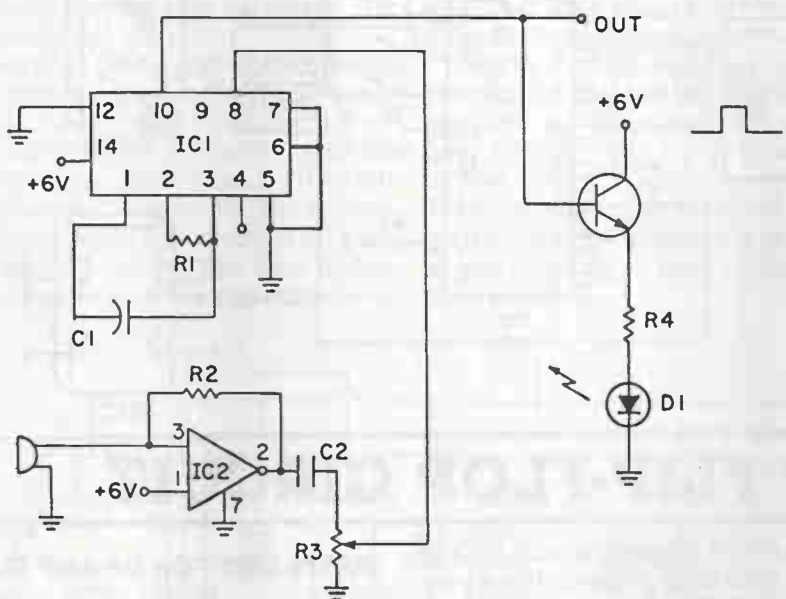


THE ROBOT EAR—CMOS

The CMOS chip type 4047 provides a convenient monostable and astable multivibrator circuit in one package, with provisions for either positive or negative-going outputs. A high impedance microphone is boosted via one (or more) stage of gain from a 4009 or 4049 hex inverter section. External R and C components determine the on-time. For R1 = 1 megohm and C1 = 1-uF, the delay interval is 3 seconds. A sensitivity control can be incorporated at the trigger input. The Robot Ear can act as an intrusion detector, voice-operated transmitter switch, or as an automated baby sitter.

PARTS LIST FOR THE ROBOT EAR, CMOS

C1—1uF electrolytic capacitor, 25 VDC (see text)
C2—.01-uF ceramic capacitor, 15 VDC
D1—small LED
IC1—4047 multivibrator
IC2—4009 or 4049 hex buffer
Q1—2N4401
R1—1,000,000-ohm, ½-watt resistor (see text)
R2—1,000,000-ohm, ½-watt resistor
R3—1,000,000 linear-taper potentiometer
R4—1,000-ohm, ½-watt resistor

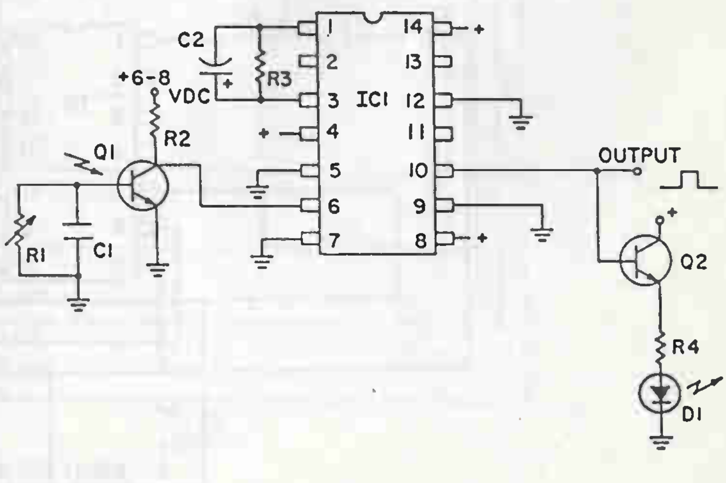


THE ROBOT EYE—CMOS

The Robot Ear described elsewhere can be given visual capability through a type FPT-100 phototransistor. In this application, use is made of the negtive trigger input. Sensitivity control can be a 100K or 250K potentiometer to the base connection. Bypass the base connection to avoid false triggering by pick-up of electrical noise. With the components shown, a delay interval of about 4 seconds was obtained. The Robot Eye is always alert to unexpected light sources and never falls asleep, as may a watchdog or watch-person.

PARTS LIST FOR THE ROBOT EYE, CMOS

C1—0.1-uF ceramic capacitor, 15 VDC
C2—4.7-uF electrolytic capacitor, 25 VDC
D1—LED
IC1—4047 multivibrator
Q1—TIL414 NPN IR phototransistor
(Radio Shack #276-145 or equivalent)
Q2—2N4401
R1—250,000-ohm linear-taper potentiometer
R2—47,000-ohm, ½-watt resistor
R3—220,000-ohm, ½-watt resistor
R4—1,000-ohm, ½-watt resistor

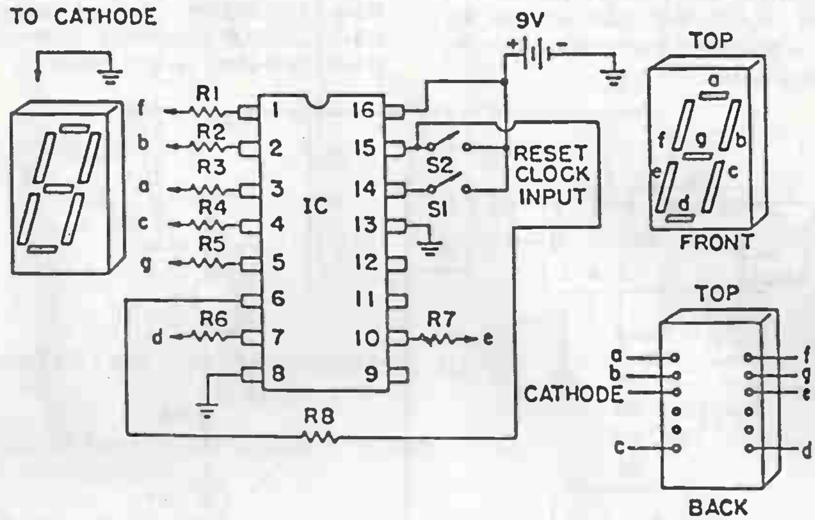


QUICKER THAN THE EYE

The faster you can repeatedly press S1, the faster the segments of the digit "8" will fly around the LED display. The fun of this quicker than the eye game is to see if you can make the 8 look like a solid number. We have here the basic multiplex principle used in calculator displays. In calculators only one segment of a digit is on at a time, but the rapid change makes it appear that all are on. Pin 6 is used to reset to zero.

PARTS LIST FOR QUICKER THAN THE EYE

IC1—4017 decade counter
LED1—7 Segment Display, common cathode (Radio Shack #276-077 or equivalent)
R1 through R7—680-ohm, ½-watt resistor
R8—1,200-ohm, ½-watt resistor
S1, S2—SPST momentary-contact pushbutton switch

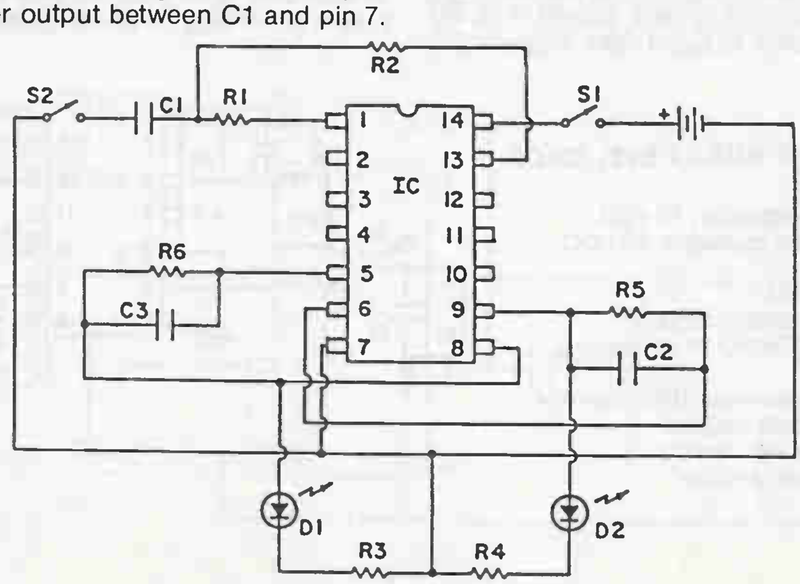


OP AMP FLIP-FLOP CIRCUIT

This op amp flip-flop circuit causes the two LED's to alternate winking each time S2 is pressed. It is a very fast response circuit. If S2 is bounced even the slighest amount, the LEDs will flip, when you think you are pressing S2 only once, therefore, you may see D1 and D2 flip more than once. That is switch bounce in S2, a common problem in the computer world. It is possible to connect an oscillator in place of S2 which will cause D1 and D2 to become dual flashers. Either replace S2 with a relay, driven by the oscillator, or connect the oscillator output between C1 and pin 7.

PARTS LIST FOR OP AMP FLIP-FLOP CIRCUIT

C1, C2, C3—1,000-pF mica capacitor, 15 VDC
D1, D2—small LED
IC1—LM3900 quad op amp
R1, R2—1,000,000-ohm, ½-watt resistors
R3, R4—510-ohm, ½-watt resistors
R5, R6—1,000,000-ohm, ½-watt resistors
S1—SPST slide switch
S2—SPST momentary contact pusbutton switch



COMPUTER-CONTROLLED NOTE GENERATOR

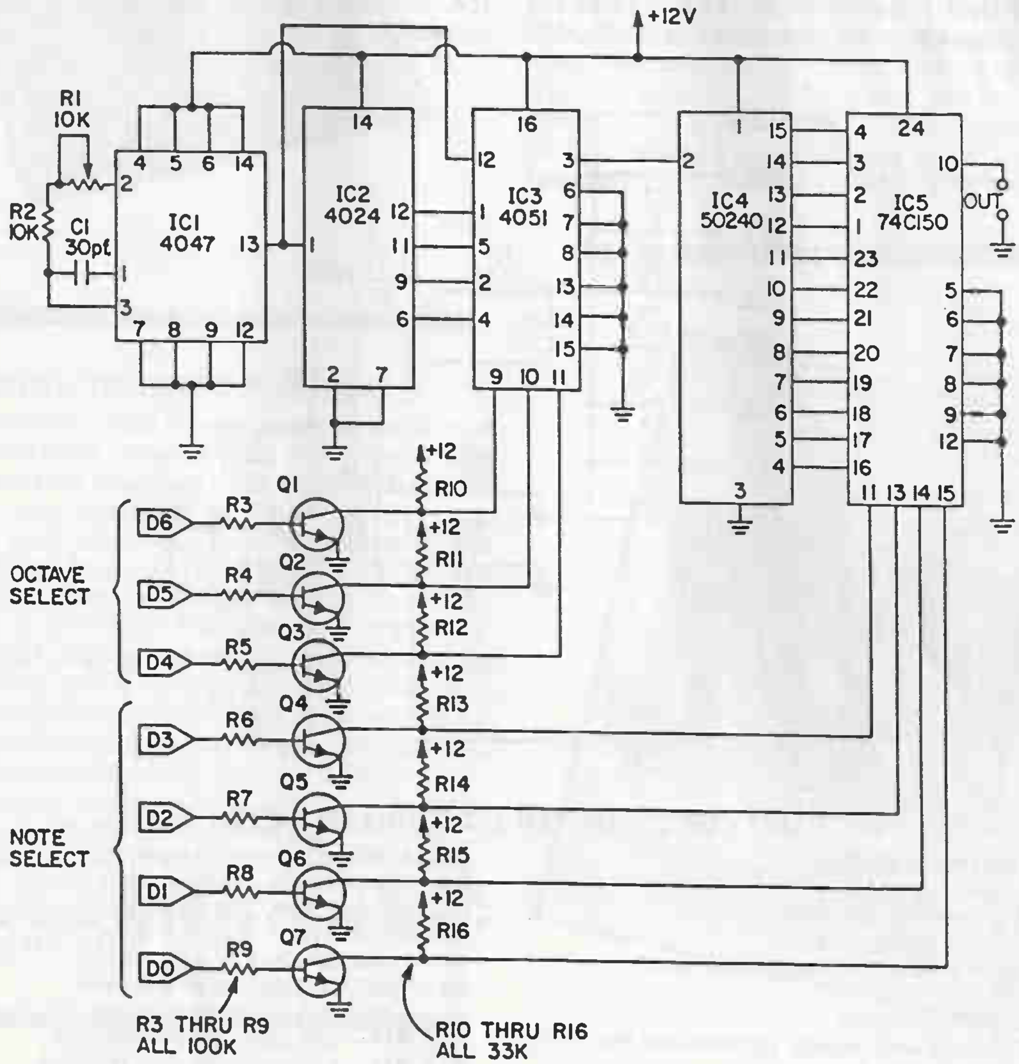
Computer music can be created in many different ways. One method is to specify all of a note's parameters—frequency, harmonic structure, amplitude, and attack/sustain/decay times—as well as special effects by means of software. Naturally, this gobbles up a lot of memory, thus making such an approach impossible for the owner of a very small computer. All is not lost, however. By augmenting your system with some inexpensive hardware, the software burden is dimished.

This computer-controlled note generator produces 5 octaves of the equally tempered chromatic scale under the control of one of your computer's 8-bit parallel ports (only 7 bits of which are used). Lines D6 through D4 select the octave, while lines D3 through D0 select one of the twelve notes within that octave.

The lowest octave is selected by a binary 0 on lines D6 through D4. A binary 1 selects the next higher octave, and so on until you reach the highest octave, coded by a binary 4 (100). (Note: D6 is the most significant bit; D4 is the least significant.) Codes higher than 4 yield no output.

The note-selection lines behave similarly, except that 12 codes are used. (Here D3 is the most significant bit, and D0 is the least significant.) Binary 0 gives you a C#. D is produced by a binary 1, and binary 2 yileds D#. This continues on up the scale until you reach binary 11, which gives the twelfth note, C. Codes above binary 11 give no output.

Tuning can be accomplished by adjusting R1 to produce a 1,000,120 Hz signal at pin 13 of IC1, or you can tune by ear against some pitch reference. The output at pin 12 of IC5 is a square wave that can be filtered and/or shaped (see the computer-controlled keyer circuit). The software we'll leave to you. In general, your programming burden has been reduced to the generation of a rhythmic sequence of 7-bit binary codes.



PARTS LIST FOR COMPUTER-CONTROLLED NOTE GENERATOR

C1—30pF polustyrene capacitor
IC1—4047 CMOS multivibrator integrated circuit
IC2—4024 CMOS binary divider integrated circuit
IC3—4051 CMOS 8:1 multiplexer integrated circuit
IC4—50240 Mostek top-octave generator integrated circuit
IC5—74C150 16:1 CMOS multiplezer integrated circuit (National)
Q1-Q7—2N3904 NPN transistors
R1—10,000-ohm trim potentiometer (all resistors 10% unless otherwise noted.)
R2—10,000-ohm, ½-watt resistor
R3-R9—100,000-ohm, ½-watt resistors
R10-R16—33,000-ohm, ½-watt resistors

COMPUTER-CONTROLLED KEYER

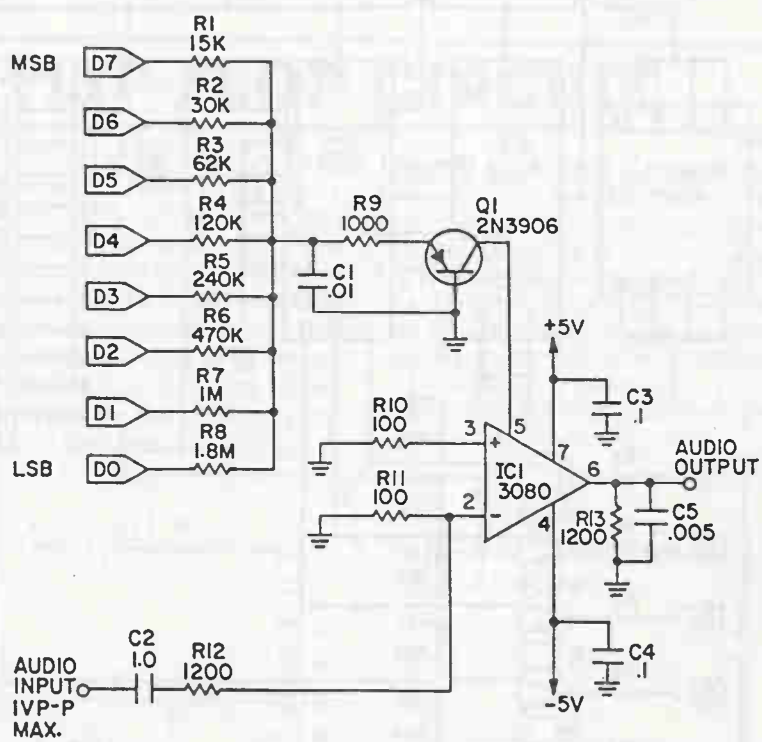
This is a good companion to the computer-controlled note generator. Your computer should have available an 8-bit parallel port with which to control the keyer's gain. Feed the desired audio tone to the keyer's input, and hook an amplifier to its output.

A binary zero on the 8 lines from your computer yields zero output, while a binary 255 (11111111) provides maximum output. (D7 is the most-significant bit, and D0 is the least significant.) During a note's attack interval, count upwards from 0 to 255. Conversely, count down from 255 to 0 to make the note decay. Take tiny steps for best results. Large steps generate thumping sounds in the output.

Let's say we want a fast attack time of 10 milliseconds. Using all available codes, it will take 255 steps to climb from zero to full output. For simplicity's sake, we'll let the note's amplitude rise linearly during attack, which means that the code will be incremented at regular, fixed time intervals. Since we wish to take 255 steps in 10 milliseconds (10,000 microseconds), it will be necessary to increment the code by 1 every 40 microseconds or so.

Linear attacks and decays are easy to figure, but not very realistic—especially for decay. The notes from most musical instruments attack and decay exponentially. This circuit gives you unlimited potential in the specification of a note's envelope, and it lets you change the envelope from note to note.

The audio input should be in the neighborhood of 1 volt peak-to-peak. When using the 12-volt signal from the computer-controlled note generator, raise R12 to 15K ohms to accomodate the increased input amplitude.



PARTS LIST FOR COMPUTER-CONTROLLED KEYER

C1—.01-uF ceramic disc capacitor
C2—1.0-uF mylar capacitor
C3, C4—0.1-uF ceramic disc capacitor
C5—.005-uf mylar capacitor
IC1—3080 transconductance integrated circuit amplifier (RCA)
Q1—2N3906 PNP transistor
R1—15,000-ohm, ½-watt resistor (all resistors 5%)
R2—30,000-ohm, ½-watt resistor
R3—62,000-ohm, ½-watt resistor
R4—120,000-ohm, ½-watt resistor
R5—240,000-ohm, ½-watt resistor
R6—470,000-ohm, ½-watt resistor
R7—1,000,000-ohm, ½-watt resistor
R8—1,800,000-ohm, ½-watt resistor
R9—1,000-ohm, ½-watt resistor
R10, R11—100-ohm, ½-watt resistors
R12, R13—1,200-ohm, ½-watt resistors

THE CATALOG CORNER

CIRCUIT SPECIALISTS

To those of you who've been involved in electronics for a while, the name Circuit Specialists probably needs no introduction. For the sake of the rest of you, let me state that Circuit Specialists is one of the more reliable sources for hard-to-find integrated circuits and discrete semiconductors. I have been doing business with this company for more than a decade, and in all that time I've never had reason to complain about their service or their merchandise.

The 1989 version of the Circuit Specialists catalog is, as usual, chock full of integrated and discrete semiconductors. They've got CMOS, TTL, linear, and special function ICs from such manufacturers as RCA, National, Motorola, Exar, Sprague, and Intersil. Their discrete lineup consists of small-signal and power transistors, FETs, triacs, diodes, SCRs, and power MOSFETs. Getting a copy of this essential catalog is easily accomplished by writing to **Circuit Specialists Inc., P.O. Box 3047, Scottsdale, AZ, 85271.**

SIGNAL TRANSFORMER CO.

Most mail order supply houses stock a selection of power transformers, usually the most commonly used sizes, such as 12 and 24 volts. But where do you turn when you need an oddball voltage or a transformer with ultra low leakage or perhaps a miniature device that mounts directly on a printed circuit board? One excellent source for such transformers is the Signal Transformer Company.

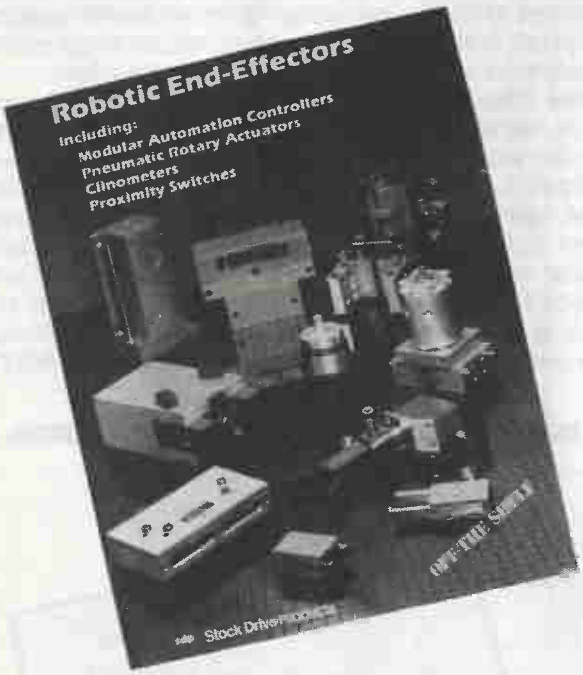
Signal's latest catalog features an astounding array of common and exotic transformer types, including tiny PC-mount devices, high-current transformers for heavy duty power supplies, isolation transformers, step-down autotransformers, and the popular "241" line of economical dual-secondary devices. For those of you with no experience in power supply design, a special section of the catalog is devoted to design tips. A free copy of this catalog can be obtained by writing to the **Signal Transformer Co., 500 Bayview Ave., Inwood, NY, 11696.**

SENCORE

Sencore is a name that is familiar to most service technicians. The company makes a wide range of test gear that's used in the servicing and maintenance of electronic equipment. They've been at it for a long time, too, so we can only surmise that they must be doing something right.

In Sencore's latest catalog you'll find all the usual test gear like oscilloscopes and multimeters, but it's the exotic stuff that sets Sencore apart. For example, there is the VA62 video analyzer which is used to check out VCRs and televisions, the NT64 NTSC video pattern generator, the ST66 stereo TV analyzer, the LC75 digital impedance meter, the SCR250 triac and SCR tester, the well-known "Channelizer" series of television RF signal analyzers, and the CG25 portable digital color bar generator.

Anyone interested in electronic service and repair can get a copy of the Sencore catalog by writing to **Sencore, 3200 Sencore Dr., Sioux Falls, SD, 57107.**



ROBOTIC END EFFECTORS (GRIPPERS)

There's a little bit of Dr. Frankenstein in many experimenters, though they'd never admit it. These guys want to create something immortal from junk parts, but pale at the thought of exhumation, and so turn to robotics instead. Although robotics doesn't carry the stigma of the good doctor's hobby, it's still hard to obtain the healthy component parts you need. If that's been your experience, the new catalog of robotic end effectors from Stock Drive Products is a handy reference that's sure to hold your interest.

Let's be serious for a moment. Robotics is a growing industry, one that will pay handsome rewards to the person who understands it and is ready to seize the opportunities that are now opening up. Those of you who are interested in this fascinating application of electronic technology will find a variety of gripping mechanisms in the catalog of robotic end effectors from **Stock Drive Products, 2101 Jericho Turnpike, New Hyde Park, NY, 11040.**

HERBACH AND RADEMAN

This Month is the curious name of a catalog that is published by H&R Corporation. I say curious because the catalog actually comes out six or seven times a year rather than once a month. All such nitpicking aside, however, this is a catalog that every true-blue experimenter will want for his collection.

H&R (Herbach & Rademan) sells a mixture of surplus and new equipment, all of it reasonably priced. It's the surplus stuff that appeals to me most; you never know what kind of unusual gadget will turn up in the H&R catalog. Parabolic reflectors, lenses, motors of all sorts, solenoids, relays, reconditioned test gear, computer keyboards, video monitors, telephones, and aircraft cameras are just a few examples of the kind of surplus gear you'll find here.

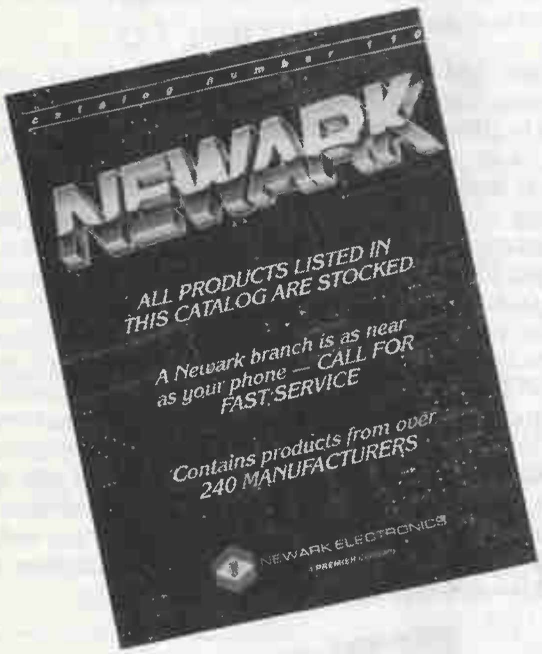
H&R is also an authorized distributor of new items from a variety of manufacturers. You can get a year's subscription to their catalog simply by writing to **H&R Corp., 401 E. Erie Ave., Philadelphia, PA, 19134.**

ELEK-TEK

Elek-Tek is a new firm specializing in computers, calculators, and data-processing supplies. They've got the full line of Hewlett-Packard, Sharp, and Texas Instruments calculators and accessories, all at prices well below suggested retail. Their computer lineup includes machines from Epson, AT&T, Toshiba, and "Capital E," which is their own brand of IBM PC clone.

Also featured is a full line of the accessories that make a computer system complete, things like hard disk drives, modems, printers, add-on cards, and the like. For those of you who like to keep on the cutting edge of technology, they've even got FAX (facsimile) machines at substantially discounted prices.

Rounding things out, they have such essentials as computer paper, printer ribbons, and floppy disks. You can get a copy of the latest Elek-Tek catalog (Vol. 17) by writing to **Elek-Tek Inc., 6557 N. Lincoln Avenue, Chicago, Illinois, 60645-3986.** Their toll-free number is **1-800-621-1269.**



NEWARK ELECTRONICS

What company is the largest supplier of electronic components in the United States? Well, to tell the truth, I don't know, but judging by the size of the new catalog from Newark Electronics, I'd guess Newark to be one of the top contenders. Their current catalog, Number 110, has over 1000 pages containing virtually every component and instrument that an electronic engineer or technician might need.

They can supply the complete line of semiconductors from General Instrument, Sprague, TRW, RCA, GE, PMI, International Rectifier, Texas Instruments, Powerex, and Motorola. They've also got resistors, capacitors, pots, switches, relays, connectors, cabinets, tools, and test instruments. Since Newark prefers selling to industrial users, a minimum billing of $25 per order is enforced. You can obtain a free copy of Newark's catalog by writing to **Newark Electronics, Catalog Dept., 4801 N. Ravenswood Ave., Chicago, IL, 60640.** Type your request; don't scribble it on a postcard!

EIL INSTRUMENTS

You'll find test instruments in the catalogs of most mail order electronics dealers, but the selection is usually somewhat limited because test gear must vie for space with a whole lot of other merchandise. If you can't seem to find the kind of test instruments you've been looking for, your best bet is to consult an instrument specialist like EIL Instruments.

EIL's Test & Measurement Handbook & Buyer's Guide for 1989 features a wide array of common and not so common test instruments. They've got scopes from Tektronix, B&K, and Leader; multimeters from Fluke, Beckman, and Mercer; and frequency counters from B&K, Systron Donner, and Fluke. For those whose needs are more esoteric, EIL carries pressure test devices, electronic thermometers and humidity indicators, reactance bridges, data loggers, board level testers, megohmmeters, and chart recorders. To get your copy of their 290-page catalog, write to **EIL Instruments, 10 Loveton Circle, Sparks, MD, 21152.**

JENSEN TOOLS

Having trouble finding the tools you need at the local hardware store? Well, don't despair, because the new catalog from Jensen Tools probably has just what you have been looking for. For example, there are all sorts of screwdrivers, nutdrivers, wrenches, files, pliers, and diagonal cutters. Both inch and metric styles are available, Businesses and individuals looking for tool kits will also be pleased with the wide selection that Jensen offers.

For electronic assembly, Jensen sells a variety of wire wrapping tools, wire strippers, and, of course, soldering irons. Also available are such necessary accessories as IC insertion and extraction tools, plus antistatic mats and wrist straps (the latter to keep static electricity from zapping your MOS and CMOS integrated circuits during assembly).

Get your free copy of the 1989 Jensen catalog by writing to **Jensen Tools Inc., 7815 South 46th St., Phoenix, AZ, 85044-5399.**

HUB MATERIAL CO.

Tools and test instruments are the featured items in the new catalog from HUB Material Co. The focus here is primarily on electronics; thus, in addition to all the usual general-purpose tools like screwdrivers, pliers, diagonal cutters, wrenches, etc., you'll find a variety of esoteric items that we practitioners of the electronic arts need but often can't seem to find. I'm talking about such things as printed-circuit drilling and cutting equipment, solderless breadboards, large solder pots (a must for rapid assembly of circuits), displacement-soldering equipment (for even faster circuit production), automatic wire-cutting machines, manual and electric wire-wrapping tools, automatic lead-cutting and -forming machinery, and electronic workbenches. Plus, they have all sorts of test gear from Fluke, Triplett, Beckman, Soar, and others.

To get your copy of this free catalog, simply write to **HUB Material Co., 33 Sprindgale Ave., Canton. MA, 02021—and tell 'em you saw it here!**

ELENCO PRECISION

Elenco Precision's 1989 catalog of electronics test instrumentation is available now, and it contains an excellent assortment of good-looking, reasonably priced equipment. I was not familiar with the Elenco name before seeing this catalog, so I assume that the firm is a new one. Whatever the case, their product line looks impressive.

There are several different scope models available. The S-3000 single-trace unit with 10-MHz bandwidth costs less than $285 and would probably be an ideal scope for the beginner. For the more advanced user, the model MO-1252 dual-trace, 35-MHz scope looks like a good buy at $521.

In addition to scopes, Elenco offers multimeters, frequency counters, a digital LCR meter, and several function generators. They even have a line of kits for the hobbyist. A copy of the Elenco catalog can be had by writing to **C&S Sales Inc., 150 W. Carpenter Ave., Wheeling, Illinois, 60090.**

CONSTRUCTION QUICKIE

TAPE RECORDER SIGNAL TRACER

A signal tracer can be easily improvised by using a cassette tape recorder (any tape recorder will do), a capacitor, and an earphone (or loudspeaker), connected as shown in the diagrams. Use the "monitor" switch to hear the output, or connect a loudspeaker or earphones, as shown. Connect the input to the auxiliary jack, if tracing high level signals, and to the microphone jack if tracing low level signals.

Switch the recorder to the *record* mode to trace signals. It may be necessary to defeat the "erase protect" sensing lever in cassette recorders by pressing on it before pushing down on the *record* button. Otherwise, operate the recorder with a cassette in place.

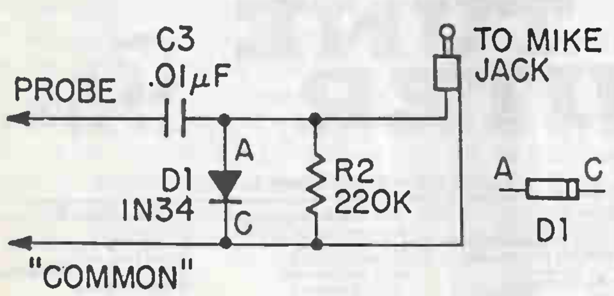


Figure 1.

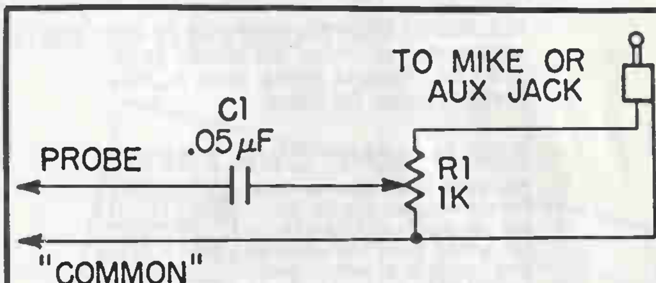


Figure 2.

How It's Done.

Probing with the capacitor lead at the collector and base of each transistor in a circuit, in turn, allows the signal to be traced through the circuit; and faults, such as a dead stage, can be found in a few minutes.

If the amplitude of the input signal is too high, simply connect an attenuator (Fig. 2) across the input terminals to the tracer, as shown, and adjust the potentiometer for correct volume.

While the circuit is useful for tracing the audio sections of an amplifier or receiver, you may also want to trace the radio frequency (RF) sections. This may be done by replacing the capacitor with a simple diode demodulator probe, a sketch of which is shown in Fig. 3.

Safety First.

One good guide by which you should govern yourself when puttering about an apparently defective TV set, is not to perform any adjustment, poking, prying, snooping, cleaning, etc., that you would not permit a six-year-old child to do. After all, why is a child's life dearer than yours when TV service technicians are available to do the task efficiently and safely ■

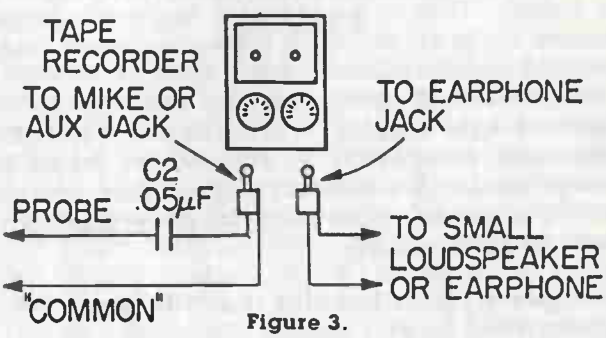
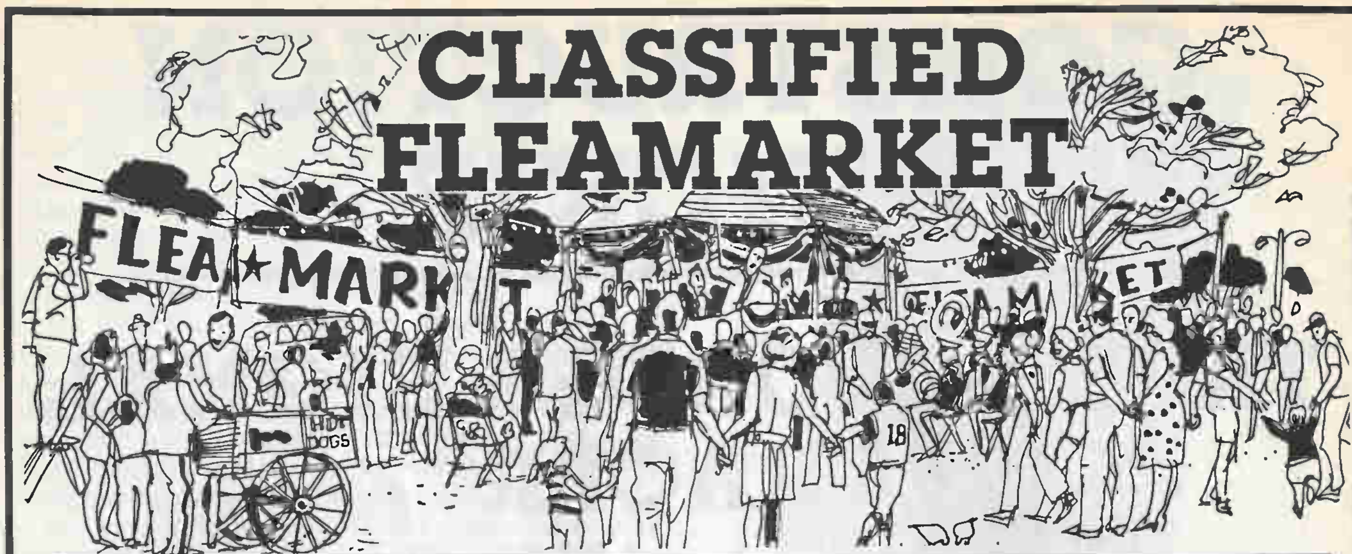


Figure 3.

PARTS LIST FOR A SIGNAL TRACER

C1, C2—0.05-uF disc capacitor
C3—0.01-uF disc capacitor
D1—1N34, gneral purpose germanium diode
R1—1000-ohm potentiometer, any available type
R2—220,000-ohm,½-watt resistor

CLASSIFIED FLEAMARKET



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 breakthroughs 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: Biophysica 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 ARRIVEDERCHI 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 MARÉ
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 WOOPECKER
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 INDINA
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
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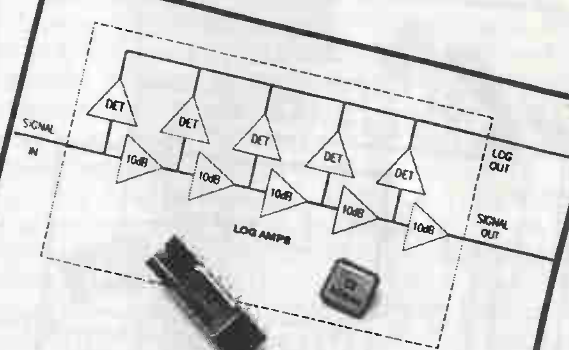
SOLID STATE UPDATE

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.

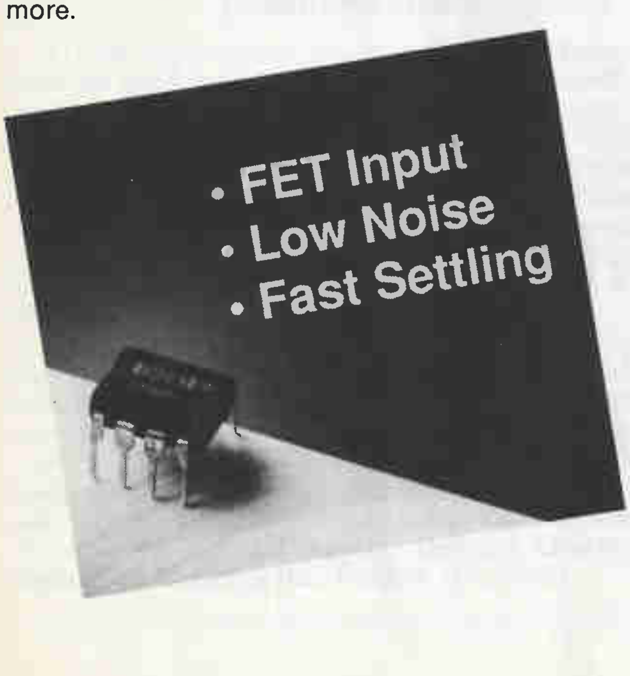
AD640 LOGARITHMIC AMP

Analog Devices' monolithic AD640 logarithmic amplifier provides 50 dB of dynamic range for signals from DC to 120 MHz. Five cascaded 10-dB stages, using successive detection and paralleled outputs, produce an output current proportional to the logarithm of the input voltage. Unlike log amps currently available, this device provides high accuracy without the need of trimming or calibration by the user.

Log amps provide high gain for small signals, and lower gain for larger signals. They are used whenever the input signal is expected to vary in amplitude over a wide range. Typical applications include spectrum analyzers, RF voltmeters, chromatographs, and fiberoptic receivers. A 16-page data sheet which fully explains operating principles, performance, and typical applications is available from **Analog Devices Literature Center, 70 Shawmut Rd., Canton, MA, 02021.** The AD640 costs $63.59 in quantities of 100 or more.



Analog Devices' monolithic op amp, the AD640, features five 10-dB stages with guaranteed specifications and no trimming required over temperature.



OPA627 AND OPA637 OP AMPS

The new OPA627 and OPA637 DIFET monolithic op amps from Burr-Brown deliver high speed, low noise, and high accuracy. They excel in high-source-impedance applications and are a good choice for fast data acquisition, sonar, ultrasound, and other high-performance signal-processing systems. OPA-627 is unconditionally stable, while the OPA637, a faster decompensated model, is stable at gains greater than five.

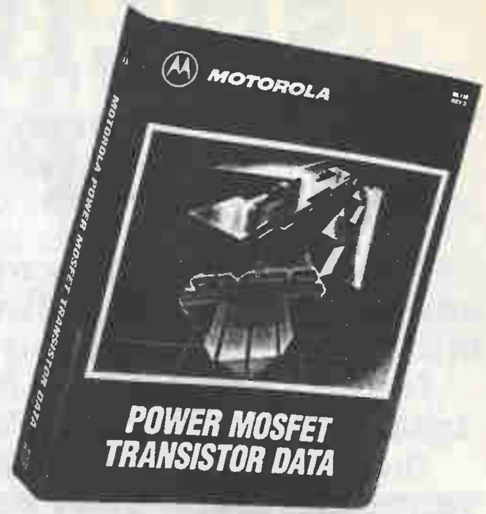
The gain-bandwidth product of the OPA627 is 16 MHz, and the OPA637's is 80 MHz. Noise at 10 kHz is a low 4.5 nV/$\sqrt{\text{Hz}}$. The OPA627 has a settling time (to 0.01%) of 550 nS, while the OPA637 requires 450 nS. Other key features include a 100-microvolt maximum offset, and 5 picoamp maximum bias current. Both devices are capable of supplying up to 45 mA at +/- 10 volts output.

For data sheets or other information, contact **Burr-Brown Corp., P.O. Box 11400, Tucson, AZ, 85734.**

POWER MOSFET DATA BOOK

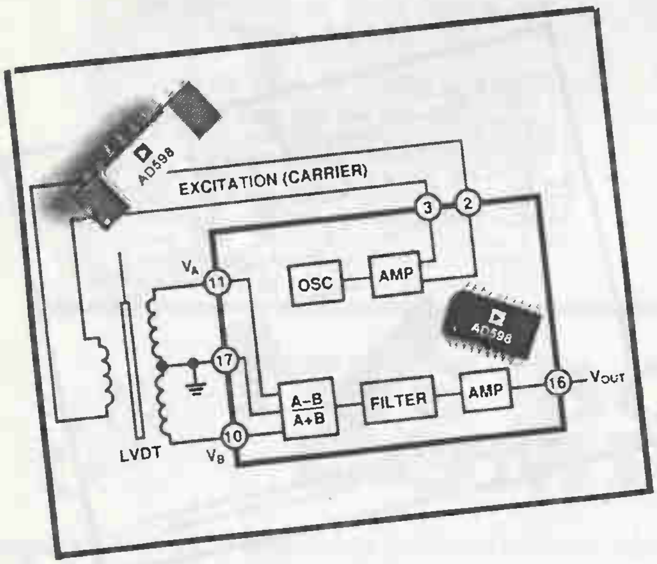
Traditionally, field-effect transistors have been high-input-impedance, low-power solid-state devices. Their versatility was such that they could be used as amplifiers, oscillators, mixers, and so forth, but because of their low power-handling ability, they were never much of a threat to conventional bipolar transistors in high-power applications—for example, audio amplifiers, motor controls, and power supplies. All that changed a few years ago with the advent of the first high-power MOSFET transistors. Today there are a slew of power MOSFET devices to choose from.

The newly revised TMOS Power MOSFET Data Book (DL135/D) from Motorola contains data sheets for more than 380 standard devices, as well as reliability data, applications and basic design information, and a selector guide and cross reference. You can obtain a copy of this information-filled book for $3.45 from **Motorola Literature Distribution Center, P.O. Box 20924, Phoenix, AZ, 85063.**



AD598 LVDT CONDITIONER

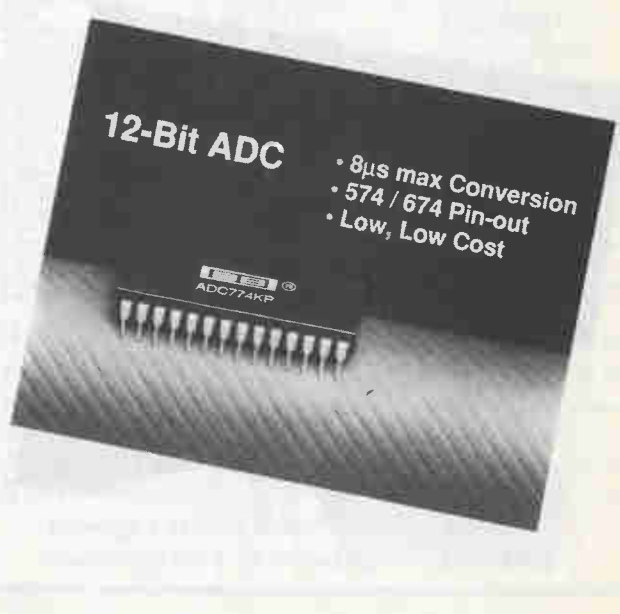
An LVDT, or linear variable differential transformer, is a cylinder-shaped transformer having one primary winding and two secondaries. The core of the transformer is free to move back and forth along the axis of the cylinder. With the primary driven by an AC voltage, the amplitude of the voltage at the output of the LVDT is directly proportional to the displacement of the core from its central position, while the phase of the output relative to the input indicates whether the core has been moved right or left of center. An LVDT is thus useful as a position sensor in automation and robotics. One of the drawbacks of the LVDT, however, is the considerable amount of support circuitry it requires, but all that has changed with the introduction of the Analog Devices AD598. This single chip performs excitation, filtering, and amplification, and its ratiometric demodulation architecture is insensitive to common sources of error. For more information, write to **Analog Devices, 70 Shawmut Rd., Canton, MA, 02021.**



ADC774 A/D CONVERTER

Burr-Brown's ADC774P is a complete 12-bit microprocessor-compatible analog-to-digital converter with an internal clock, +10V reference, 8-, 12-, or 16-bit interface circuitry, and three-state outputs. Its advanced CMOS and laser-trimmed bipolar die ensure freedom from latch-up and optimum performance. The ADC774P has the same pinout as earlier '574 and '674 ADC's, and is a lower cost replacement for other '744 models.

This new device converts 12 bits in 8 microseconds maximum, 8 bits in 5 microseconds. Its linearity error is +/– one-half LSB (least significant bit) maximum, and bus-access time is 150 nS. Output data is available in parallel format from the TTL-compatible three-state output buffers. Coding is straight binary for unipolar inputs, bipolar offset binary for bipolar inputs. The ADC774P operates with +5V and +/– 12V or +/– 15V supplies. Price is $38.60 in hundreds. For further info, contact **Burr-Brown Corp., POB 11400, Tucson, AZ, 85734.**

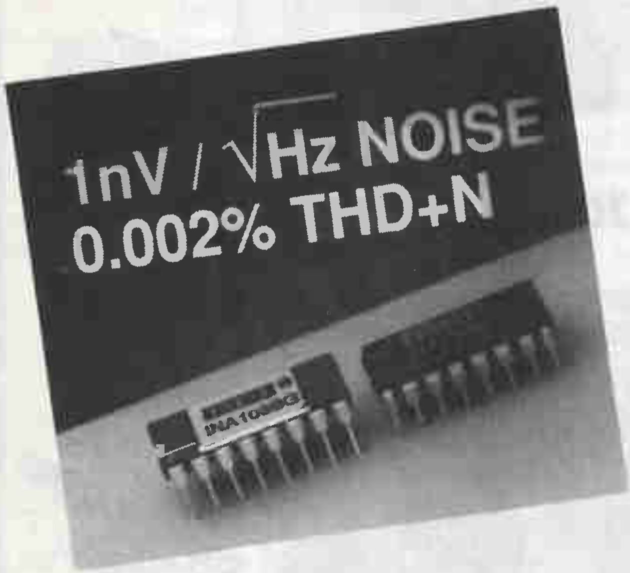


CY7C433 FIFO MEMORY

First-in, first-out memories (FIFOs) are used wherever a system contains two processors that run at different speeds. The FIFO serves to hold data until the slower processor gets around to working on it. Typical areas of application include telecommunications data multiplexers, wide-area networks and disk- and laser-printer controllers.

Cypress Semiconductor's CY7C433 FIFO offers 25-nS access times and comes in a package half the width of any competing 4Kx9 FIFO. Read and write operations may be asynchronous at either port, thus allowing designers to use separate clocks for each processor in the system, if they wish. The CY7C433's 300-mil plastic or ceramic DIP and molded SOJ packages will help designers to create first-in, first-out memory systems with roughly twice as much capacity as other chips in the same board space. Further data is available from **Cypress Semiconductor, 3901 N. First St., San Jose, CA, 95134-1599.**

CYPRESS 25ns 4K by 9 FIFO



AD790 HIGH-SPEED COMPARATOR

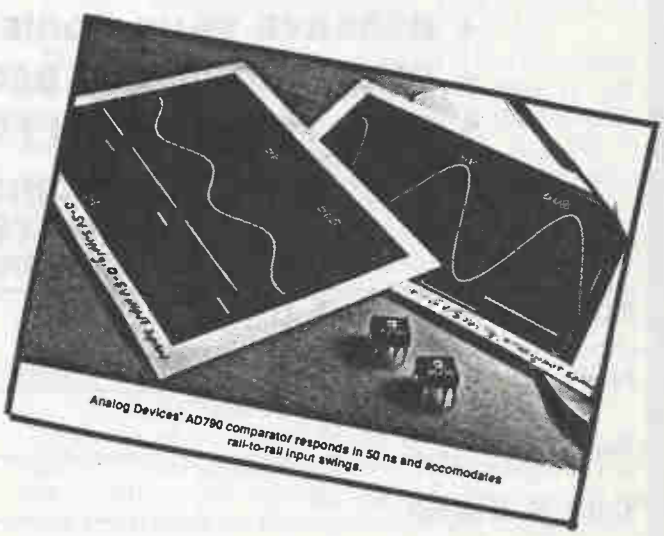
A new high-speed comparator from Analog Devices consumes less than one-third the power of competitive units while combining a variety of features to simplify analog circuit design. The AD790 has a maximum 50 nS propagation delay when operated with a single +5V or dual +/- 15V supplies. Other useful features include the ability to handle ground-referenced signals, wide input-signal ranges, on-board latch, TTL and CMOS logic output, and 500-microvolt input hysteresis voltage.

The AD790 is the first comparator to be manufactured in Analog Devices' high-speed complementary bipolar (CB) process. This comparator can accommodate rail-to-rail input signals and deliver symmetrical output swings. Built-in hysteresis eliminates undesirable oscillations when handling fast pulses or slow, low-level signals. For more information, contact **Analog Devices Literature Center, 70 Shawmut Rd., Canton, MA, 02021.**

INA103 INSTRUMENTATION AMP

An instrumentation amplifier is a special type of amp having high-impedance differential inputs, high gain, and high accuracy. As its name implies, this kind of amplifier is most commonly employed in electronic instrumentation, where it may be called upon to amplify very small input signals in the presence of relatively large amounts of noise.

The new INA103 from Burr-Brown is a monolithic, low-noise instrumentation amplifier with a unique distortion cancelling network in the input stage that reduces total harmonic distortion to extremely low levels. THD+N (total harmonic distortion plus noise) is less than 0.001% at a gain of 100 and frequency of 1 kHz. Designed for use primarily with low source impedance transducers, the INA103 is well-suited to use in pre-amplifiers and other professional audio circuits, due to its small size and low cost ($4.85 in 1000s). Gains of 1 to 1000 are possible. Data sheets available from **Burr-Brown Corp., POB 11400, Tucson, AZ, 85734.**


Analog Devices' AD790 comparator responds in 50 ns and accomodates rail-to-rail input swings.

UNDERSTANDING SEMICONDUCTORS

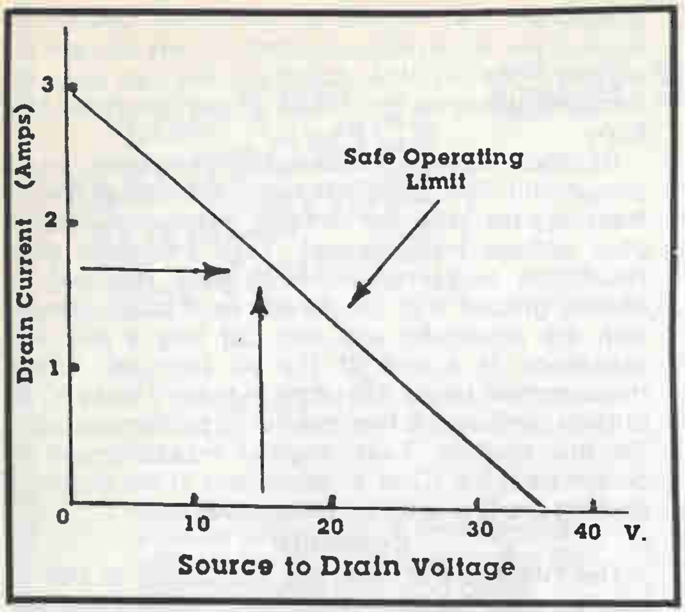


Figure 8. Operating limits of power FET (typical)

when we make the gate negative, it depletes the negative charges in the channel, and reduces conduction. But now the MOSFET has one additional capability because of the insulated gate: we can also make the gate *positive*. Again, because of the rule that like charges repel and opposite charges attract, we see that this will *add* negative charges to the channel, enhancing its conductivity even more. The result here is both a depletion and enhancement kind of operation depending on the polarity of the gate voltage. Figure 7 (B) shows this graphically.

And now finally, at Figure A (3) we have a MOSFET that operates only by enhancement. Notice now, that we no longer have a homogeneous channel (all negative), but instead most of it is filled with positive charges (P-type material). As we learned from the bipolar transistor, when the negative charges move into the positive area, they are attracted and held there, creating a negatively-charged barrier and blocking the channel. However, like the bipolar transistor, if the gate is made positive, and, because like charges repel, clears away the positive charges from the channel to begin with, then a narrow corridor alongside the gate can become negative, and current is allowed to flow. Since we are enhancing the conductivity of the channel, this is obviously called enhancement-mode operation, and is illustrated in Figure 7 (C).

CAUTION

All FETs are very sensitive to static electricity, which can destroy them internally. Be careful when handling them or installing them in a circuit. Always use a grounded soldering iron, and never touch their leads with your hands or clothing. ■

TESTING DISCRETE COMPONENTS

Let's suppose, for example, that you want to use a 9-volt battery as V_{SOURCE} to test an LED that operates at 3 volts (V_{LED}) at a current of .081 amps (I_{LED}). After cranking these values through the above formula, you'll see that you'll need a 330Ω resistor.

To perform the test, first clip one resistor lead to the LED's cathode—the lead extending from the flat or notched side of the LED's lip. Then connect the resistor's free lead to the battery's (−) terminal, and the LED's free lead to the battery's (+) terminal. If the LED lights, it works; if it doesn't , you have a DED (Dark Emitting Diode), which you should toss out.

Bipolar Transistors

The transistor is the workhorse of the electronic age. It can act as a high-speed electronic switch or take a signal and amplify it hundreds of times. Bipolar transistors come in two basic types: NPN and PNP.

Before you make this test with an analog meter, make sure it has an input impedance greater than 20,000 Ω/V. Otherwise the test won't work. (This isn't a problem with DMM's because all DMMs have an input impedance in the mega-ohm region.)

For testing purposes, a transistor can be thought of as two diodes glued end-to-end (Figure 3). For an NPN transistor, set your ohmmeter to R×100Ω and make the following five tests. You should come up with the indicated readings:

1. (−) probe on emitter lead; (+) probe on base lead = low Ω
2. (+) probe on emitter lead; (−) probe on base lead = ∞Ω
3. (+) probe on base lead; (−) probe on collector lead = low Ω
4. (−) probe on base lead; (+) probe on collector lead = ∞Ω
5. (−) probe on emitter lead; (+) probe on collector lead = >2MΩ

For PNP transistors, reverse the probe polarities in the list and perform the test in the same manner.

If your readings differ from those listed, the transistor is either open or shorted.

The above test will only tell you if the transistor's internal junctions are intact. To test whether or not it has amplification ability, or gain, you'll need a 100KΩ resistor. Set your ohmmeter to R×100, and clip the resistor between the transistor's base and collector leads. If your transistor is an NPN, connect the (−) probe to the emitter and the (+) probe to the collector. If your transistor is a PNP, swith the probe leads around so that the (−) probe is clipped to the collector and the (+) probe to the emitter. Either type of transistor should give you a reading much less than 100KΩ.

Now That You've Finished Testing

With all of your testing done, you can have the peace of mind of knowing that the discrete parts you'll use in your project will operate correctly. Now all you have to do is install them properly. We'll save that for another issue. ■

CHANNEL ONE THAT WASN'T

When the war ended in 1945, the FCC had a lot of decisions to make. They were under pressure to allow the natural post-war development of television, FM Radio, Mobil Communications and AM Radio. The FCC made a decision to move FM Radio to the 88 to 108 MHz range of frequencies. (Which is where they are today, right between the TV channels of 6 and 7.) The TV people saw this as a sign that channel "1" would once more exist. They began manufacturing TV sets with channels "1 through 13" on the tuning dial. (The author owns an RCA set from 1946, which proudly shows channel "1" on the tuner.) But alas...the FCC decided to give the frequency once assigned to FM Radio...and previously assigned to television, to the two-way radio mobil services. This was mostly used by the Taxi services right after World War II. Consequently, thousands of TV receivers were made obsolete related to their channel "1" tuning capability. The TV channels were not re-numbered on later sets, as this would have only added to the confusion. Perhaps no one could have envisioned in those days that TV and FM would be the giants they are today. On the other hand, it is possible that channel "1" is the channel we have all been looking for these many years. We salute you Felix the Cat, our Mona Lisa of the air waves. At first a smile, and then a frown, much like some of modern television. You were the best, but search as we may, you are but a flickering memory of days past. If it is any consolation, for some of us, you will always be number "1". It is rumored that cats have nine lives, and perhaps you haven't lived them all out yet. Perhaps you are somehow "related" to the 200 potential channel choices that we have today. ■

SERVICING YOUR STEREO AMPLIFIER

filter capacitor. This is easily done with the point of a pocket knife to piece the pc wiring. If the voltage returns to normal or higher, check the cut off circuit for a leaky transistor or capacitor.

Voltage Regulation Problems

Suspect a leaky or open regulator transistor when a certain voltage source is dead or has low voltage. Notice if the regulator is warm or overheating. Zener diode regulators have the same tendency to overheat and become leaky. Replace the defective zener diode with the same voltage rating.

Defective filter capacitors in the low voltage source may dry up, open or become leaky. An open or leaky filter capacitor may lower the voltage source. Often, you hear hum in the sound with an open or dried up filter capacitor. Shunt another filter capacitor across the suspected one with a loud hum in the sound. Tack it in the circuit with the power off. Remove the

Critical voltage measurements on the suspected IC or transitors may solve the dead or distorted problem. You may find one transitor leaky and the other open in a push-pull transitor output circuit. Remove each output transistor for accurate open or leaky tests. Check the bias resistors and diodes for burned or leakage marks. Always, check the AF or driver transistors for leakage when the output transistors are damaged.

In the small tape player, one IC component may serve both channels. (Fig. 15). You may find small AF or driver transistors ahead of the power IC or the IC component may include all solid-state circuits. In large power IC circuits a separate IC may be used for each channel. In other amplifiers one real large IC component has all the power output circuits in one body.

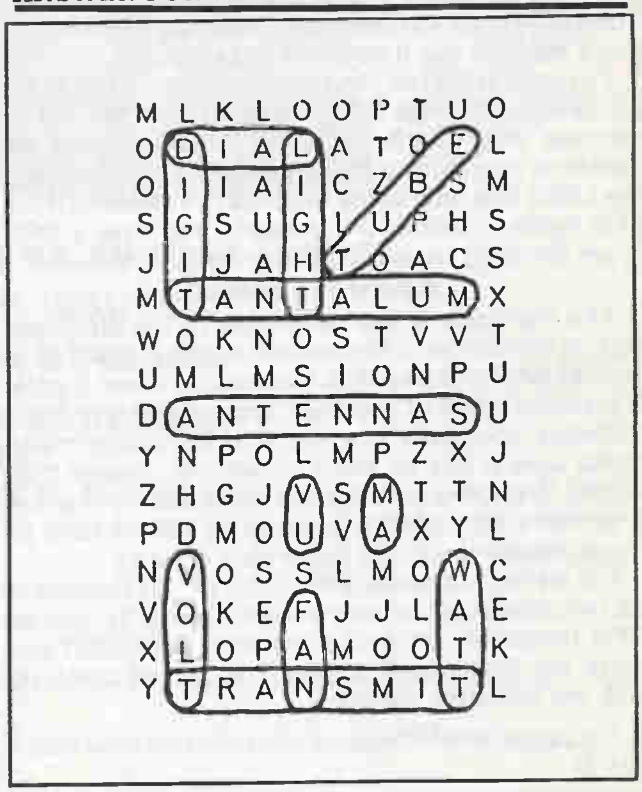
Besides voltage measurements, check each component tied to the IC terminals. Sometimes a leaky bypass capacitor or open resistor may cause poor voltage measurement. Take a low 2K ohm resistance measurement from each terminal to chassis ground (Fig. 16). Check each measurement with the schematic and find out why a real low resistance is found at the IC terminal. Often measurement under 350 ohms indicate a leaky IC or outside component. Remove the IC pin terminal with the low reading. Take another measurement to determine if the IC or a component in the circuit is causing the low resistance measurement.

Conclusion

The DMM is the ideal test instrument to use in locating defective transistors, critical voltage and real low resistance measurements. The external audio amp may locate the weak, distorted or dead audio stage. Simple service procedures may help to locate the trouble in your favorite radio or tape player now languishing on the shelf.

Remember to replace the mica insulation between all power transistors, IC's and heat sink. Place a coat of silicone grease on both transistors and heat sink. Mount the replacement on the heat sink before firing up the unit. Recheck all soldered connections. Clean up between soldered transistor and IC terminals with a pocket knife blade or small wire brush. ■

ANSWER FOR HANDBOOK DOUBLE PUZZLE



Lab Test
ELECTRONICS
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For Yourself

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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.

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