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Hands-on Electronics®

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THE MAGAZINE FOR THE ELECTRONICS ACTIVIST!

BUILD Hour-Tune—IT'S LCD-TIMED
Take one old digital watch, an opto-coupler, a melody chip, some added circuitry and you'll listen to a different tune each hour!

DX ing WITH ALUMINUM FOIL ANTENNAS
Larger than rabbit ears and smaller than a long-wire antenna—these skyhooks fit inside your home and cost next to nothing!

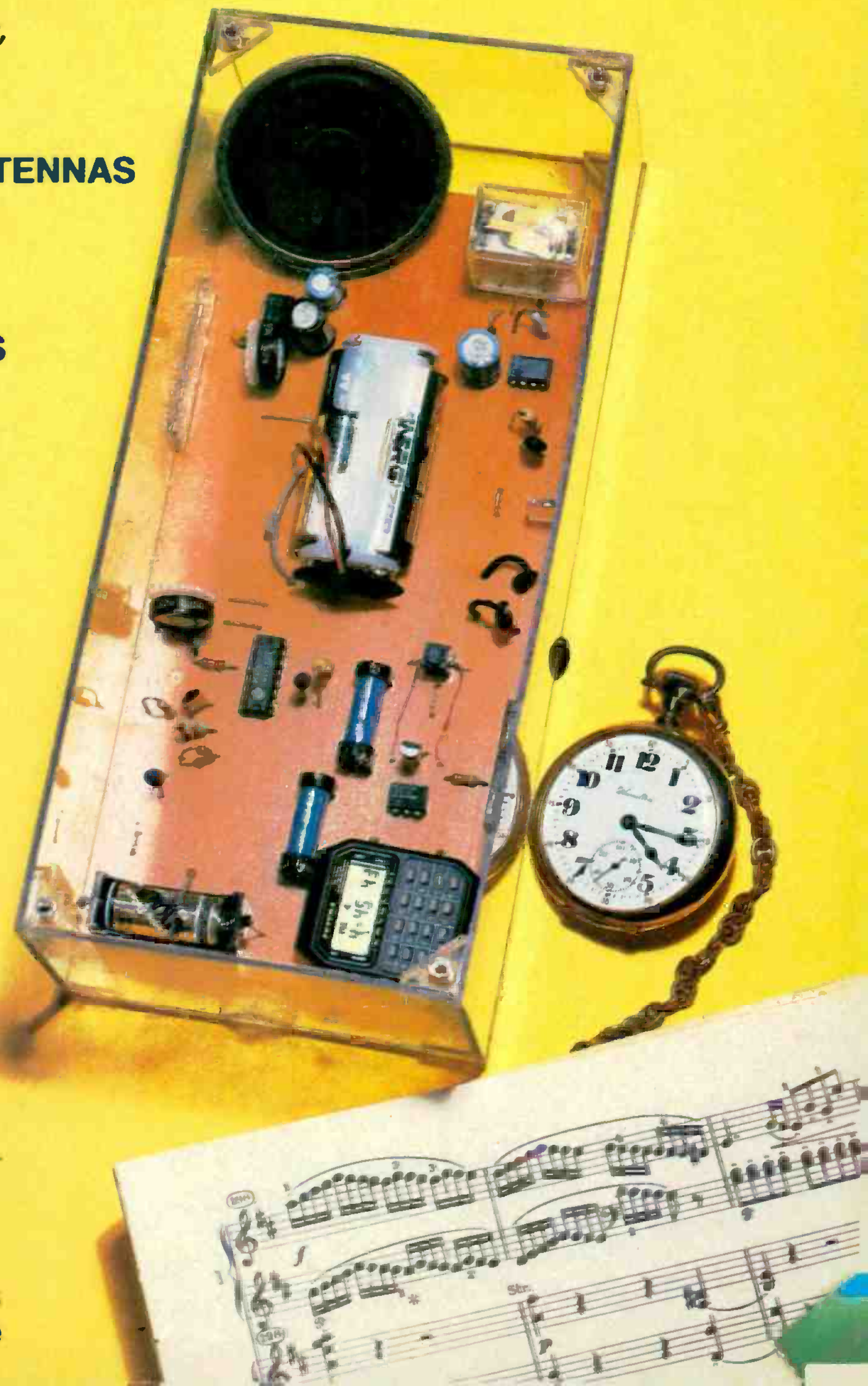
DIGITAL PULSE-TRAIN SWITCHES
Here are some solid-state tips on chips that replace mechanical switches!

CHARGING NiCd BATTERIES
We tell you all the unknown secrets of charging rechargeables and toss in an inexpensive charger circuit.

SOLID-STATE MEMORY DEVICES
A computer is like an elephant, it doesn't forget. But do you know how it remembers?

FET' —WHAT THEY ARE AND HOW TO USE THEM
We use them in circuits, but do you really know how they work?

Plus much, much more!



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3 New FactCards This Issue

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Hands-on Electronics®

Volume 4, No. 6

June 1987

SPECIAL FEATURES

THEORY AND CIRCUITS

CONSTRUCTION

FEATURETTES

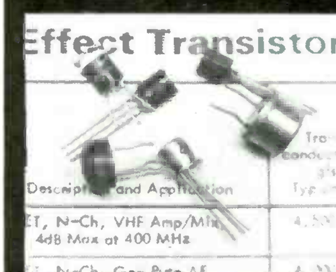
SPECIAL COLUMNS

DEPARTMENTS

Saxon on Scanners—page 31

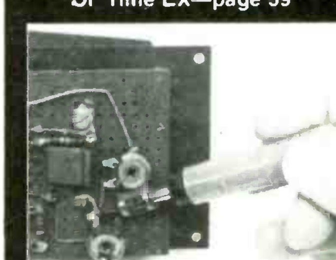
HourTune—page 33

Inside NiCd Batteries—page 39



All About FET's—page 61

Ol' Time DX—page 59



Soldering Iron—page 76

Hands-on Electronics®

The Magazine for the Electronics Activist!

RAM—It's more than a Dodge van!

About ten years ago I assembled my Heathkit H-89 8-bit computer. It featured an 8080 chip and had 16K of RAM (Random Access Memory). Even then, that was too little RAM and I needed more RAM to load an edit/word-processing program and write or edit a typical magazine story.

It was a few months later that I added another 48K of RAM. An out-boarded PC card permitted an additional 8K bringing the total to 64K of RAM—wow! For the next few years the H-89, eventually upgraded to the H-90 for CP/M use, took care of all my needs until I started to work on SuperCalc programs. It wasn't long before my work at home was cut short. The spread sheets that I was using grew and grew until 64K of RAM was not enough.

But, things were really not bad because I had an IBM compatible Zenith in the office good for 256K of RAM. But that was not the solution, so last year I purchased an IBM clone with 640K of RAM and a whole bunch of boards packed into it. Now I was perking on all eight cylinders, or I thought I was.

The history of progress is a list of failures. Playing with a new CAD program I struck out again: "INSUFFICIENT MEMORY." Have I hit the limit? No, it was practical to go up to 1-MEG of RAM with this clone. Imagine the graphics and spread sheets I could manipulate!

Then, a news item crossed my desk. IBM is working on 1-MEG RAM chips that PC's can use. I would be able to get a new motherboard and load up with about 20 1-MEG chips in place of the 40 16K chips I now use. Let your imagination run away with that idea. For example, General Motors could put their entire operation on one spread sheet, and when you buy a set of spark plugs from an Oldsmobile dealer, that information can be added to the spread sheet producing a new-bottom line on the profit and loss statement for the year. Better still, the entire inventory system may be alerted so that some factory somewhere will step up spark plug production the following week. Also, it would be interesting to see the 10-year parts-sales forecast change with each purchase.

I'll go for the extra RAM's for 1-MEG operation, and I'll keep an eye on IBM. I want the first few 1-MEG chips!

Julian Martin

Julian S. Martin, KA2GUN
Editor

P.S. This editorial was hacked out on my old and true Heathkit H-90 machine. You see, 99 out of 100 times 64K of RAM is more than enough!

STAFF

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CIRCLE 19 ON FREE INFORMATION CARD

LETTER BOX

Hands-on Electronics, 500B Bi-County Boulevard, Farmingdale, New York 11735

Free of Charge

I enjoyed your article on the Economy NiCd Battery Charger of March 1987, however, it appears that the U1-d and U1-c designations were reversed, and that the R8 designation in the 1st paragraph under **Detection** should be R9.

I was wondering if you could advise me of anyone who makes the circuit board either drilled or un-drilled.
—T.E.D., San Diego, CA

To make our readers happy is our obligation and pleasure. It is unfortunate that some projects we receive don't have a PC-board source—a problem some find difficult to surmount. But, since we are all in this hobby together, why don't more people send in the trace patterns they've made to help out their fellow hobbyists? If you've got 'em, send 'em! Thank's for the corrections T.D. even if we don't want to see them!

Paying Your Dues

The article you presented in the Nov. 1986 Volume 3, #6 of **Hands-On Electronics** magazine entitled "Build a Musical Doorbell" is wonderful. I've read it over and over again because of the great way is has been presented for even the most amateur do-it-yourselfer to build.

I am in that category, and in five attempts to make my own PC board of the circuit you presented, I've failed. The copper traces just simply disappear every time.

Could you possibly recommend a person or firm, that I could mail your magazine PC layout, and have them make up an etched, drilled, PC board of it for me? At least two boards? Whatever the price is, I would mail for it immediately. I very much want to make the project for my home.
—J.A., Forest Hills, NY

The problem you are experiencing with board development is often due to insuficient agitation of the etchant. If you are not moving the board around in the etchant, the traces will dissolve along with the excess foil. Be sure to constantly move the board around in the solution, and remove it at the first signs of trace deterioration. If the board is not sufficiently etched at that point, then cut away the excess copper with an Xacto knife.

Failing that, while we can't give a recomendation for good work, we can steer you to a company that will at least give you a quote beforehand. Try T.O.R.C.C.C., 1131 Tower, Schaumburg, IL 60195; Tel. 312/490-1374. Good luck, and please let us know how you make out.

A Bridge Too Far

We are electronics students at North-east Area Vo-Tech in Pryor, Oklahoma. We are writing in regard to Volume 4, Number 2 of your **Hands-On Electronics** magazine, dated February, 1987. On page 36, in the article on The A,B,C's of Solid-State Rectifiers, by Joseph J. Carr, we have found a mistake. In Figure 9, D4 is reversed. If the circuit is constructed as per the schematic, D4 will smoke.

We found the article to be very useful even with that mistake. We need some trouble-shooting experience.
—S.M.K., and D.M., Pryor, OK

Well, I've heard that old adage about burning bridges, but never thought I would come across such a graphic example. Even though it's water under the bridge (or smoke on the water), thanks for the correction. We hope that article was educational.

Light Music

I am looking for any schematic information on a particular circuit called the color organ. The circuit was very popular back in the 1960's and 1970's. It used a silicon-controlled rectifier in conjunction with a hi-fi stereo amplifier to turn colored lights on and off in time to the music.
—J.A.H., Ft. Lauderdale, FL

You're in luck because MCM Electronics sells a Color Organ kit, #80-150, for $21.95. It is a three-light organ, and you may wish to purchase one for each stereo channel. For further information and shipping costs, dial 800/543-4330.

Riding the Waves

In regard to Fig. 9 in the ABC's of Solid-State Recitfier Diodes article from Feb. 1987, even if the diodes were all aimed in the correct direction, the circuit would produce two fullwave-rectified wave forms. But don't take my word for it; go whip it up on the bench and see for yourself.
—H.A., Sewanee, TN

A reader who reads captions is a rare and valuable commodity. Have you ever considered editorial work?

Helpful Hints

In reference to the Feb. 1987 issue, the author of "The Antenna That Wasn't," may find that reading *Structures*, by Prof. J.E. Gordon, (Penguin Books) interesting. The alternate title for the book is *Why Things Don't Fall Down.* The topic of stiffness is well covered, with the math relegated to a six page appendix. (Bamboo may be of some interest.

On the variable strobe light, apart from the high-voltage dangers, some individuals exposed to certain flash rates, can be effected by epileptic seizures, with no known previous history of epilepsy.
—F.O., Owen Sound, Ontario

People writing to this column often tend to either ask for information, or give only corrections; few bother to supplement our articles. Frankly, I appreciate the extra information, and look forward to hearing what the readers have to say about this month's topics. Thanks very much for the info. ■

"I'd like to enjoy this, Teri, mind temporarily losing your audio?"

New Products

CIRCLE 93 ON FREE INFORMATION CARD

32-Channel, Logic Analyzer

If you're into high-tech board repair get out a bib, because you'll drool over this item. The 1220 Logic Analyzer offers general purpose logic analysis, state or timing on every channel, simultaneous state and timing acquisition, four 2K memories, and microprocessor analysis. With 32 channels of data acquisition, 8 external clocks, and 4 external qualifiers, the 1220 can accept data from a wide variety of circuits.

The trigger specification menu of the 1220 allows the user to easily acquire basic data (e.g., find a single data word and store 512 samples before the data word, and 1536 samples after). With 12 interactive levels of IF...THEN...ELSE control the user can also track more-sophisticated situations. For example track software flow and trigger if B occurs after A, or if E occurs after D, but restart the process if C occurs.

The 1220 has internal nonvolatile storage for 8 setups, thus allowing the operator to load and use pre-programmed setups for standard tests. Also, the nonvolatile clock/calendar records the data and time the setup is stored. In addition, there is an optional RS-232 communications interface for interaction with a host computer/controller.

A standard feature is the video port, allowing display on large monitors (e.g., for the classroom) or hardcopy via a video printer. An optional printer interface supports text and graphics output on Epson-compatible printers. The 1220 logic analyzer, complete with probes and accessories, sells for $3,995. Included in the price of each analyzer is a small, battery-powered circuit board that is used as a training aid.

For more information write to Logic Analyzer Marketing, Tektronix, Inc., PO Box 12132, Portland, OR 97212; Tel. 800/245-2036. In Oregon Tel. 231-1220.

Pre-programmed Receiver

If you'd like a special mobile receiver that is pre-programmed with key state and local law enforcement frequencies for all 50 states, then read on.

The *Informant* is the world's first public-information radio, a unique concept in public service band receivers. Unlike scanners, the Informant does not need to be programmed by the user so it can be operated by anyone without a prior knowledge of scanning.

Designed for installation in cars, trucks, and RV'S, the receiver eliminates the hassle of having to look up frequencies and program channels as you travel from state to state. The user-friendly receiver is conveniently pre-programmed with the local, state, and national VHF and UHF police frequencies.

In addition to its user-friendly operation, the Informant is also one of the fastest-scanning receivers on the market. Its patented new "TurboScan" technology—a Regency exclusive—allows it to scan police frequencies at a rate of 50 channels per second, or nearly four times faster than competitive models.

Another important feature is the receiver's instant-weather function, which, when activated, automatically causes the radio to search for the closest active frequency from the National Weather Service for the latest, up-to-the-minute weather bulletins.

Other features include a digital display, which shows the state and type of transmission (state police, county police, etc.) being monitored; a highway/city switch, for monitoring either local or statewide police frequencies; a top-mounted speaker; and a hold switch to keep the receiver on a single frequency. The Informant can be installed in minutes in any vehicle—from the biggest 18-wheeler to the tiniest

CIRCLE 63 ON FREE INFORMATION CARD

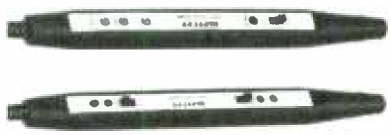
subcompact—and it comes with a multi-position mounting bracket/clip, telescoping antenna, and instruction manual. It can be wired directly to a vehicle's DC system, or used with a DC cigarette-lighter cord. The Model INF-1 has a suggested retail price of $369.95.

Additonal details are available by writing to Regency Electronics, Inc., 7707 Records Street, Indianapolis, IN 46226.

Very-Logical Probes

Two new logic probes for 20 MHz and 50 MHz signals, and a new pulser probe may suit your logical needs.

Models 9604 (20-MHz) and 9605 (50-MHz) logic probes are handy troubleshooting tools for various types of TTL and CMOS logic families. Levels and pulses can be viewed from two front-mounted LED's and even stored by means



CIRCLE 99 ON FREE INFORMATION CARD

of a convenient switch. Two additional LED's in the base of the unit display any improper connection or the possibility of an over-voltage condition.

The Mercer Pulser Model 9606 is a multi-function pulser instrument. In the pulse mode, it can inject 50 µs pulses into a logic circuit without isolating IC's. It also has a sync input to allow the use of an external synchronizing signal. It is ideal for isolating opens, shorts, and malfunctioning IC's in logic circuits.

All three models are available off the shelf at electronic distributors throughout North America. For more information please contact Mercer Electronics, 859 Dundee Avenue, Elgin, IL 60120-3090; Tel. 312/697-2265.

Memory-Chip Phone

Intergrated circuits, like the ones in this phone, are not only putting people out of work, but answering machines as well. Engineers have replaced the outgoing-message (OGM) tape found in answering machines with an OGM memory chip and coupled it with a single microcassette incoming-message (ICM) tape. The OGM chip provides up to 16 seconds for a message that can be updated at any time. Because there's no tape to wear out or jump track, performance and reliability are greatly enhanced.

CIRCLE 77 ON FREE INFORMATION CARD

The KX-T2622 is easier to use due to its Auto Logic control system. When a user wants to listen to messages, he simply presses a single playback/pause button and the answering system automatically switches to the playback mode. It will then rewind the tape, play the message, and then reset to receive additional calls.

The unit also features tone remote control so there's no need to carry a beeper to listen to messages while on the road. It simply uses the tones generated by a pushbutton telephone. The system also has a user-selectable security code for remote use.

Two-way recording is also possible as well as the ability to leave a message on the ICM tape (for family or office workers). Additional features common to both include: automatic quick erase; three-step ringer control; three-step answer pick-up; electronic hold; and on- and off-hook dialing capability.

The KX-T2622 is a sophisticated system with advanced functions like message transfer, which automatically dials a preprogrammed number after an incoming call has been recorded.

The system also has an Answer-Back Speakerphone. Not only can the user conduct a hands-free conversation, but when he's away from home or business, he can activate the speakerphone from any tone telephone. That means that anyone near the unit can answer the call without having to come to the phone—an ideal feature for the disabled.

A one-touch automatic dialer holds up to 16, 30-digit numbers. There's also an automatic redial function to retry a call for up to 15 times. The tone remote system on this unit allows the user to access up to as many as 14 functions and has 100 user-selectable security codes.

The KX-T2622 is now available from most better telephone retailers throughout North America for the suggested retail price of $199.95.

For further information write to Panasonic Consumer Affairs, One Panasonic Way, Secaucus, NJ 07094.

Quackless Gooseneck Microphone

If you record a variety of instruments, you need a flexible mike. Check out the Prologue 2L. It provides a wide-range frequency response with a low-end roll off and high-end presence boost for intelligibility and clarity. Other features include a long-life, easy-access, momentary push-to-talk switch; a tight cardioid polar pattern for effective rejection of feedback and background noise; chrome-plated metal casing; and rugged construction for reliable performance.

The Prologue 2L's microphone base is threaded with a standard ⅝"-27 thread for mounting directly on a gooseneck. A four-conductor cable (two conductors

CIRCLE 86 ON FREE INFORMATION CARD

shielded) is included. The momentary push-to-talk switch is wired with the microphone circuit normally open for use in parallel microphone installations.

Suggested user net price for the Prologue 2L is $40.00. For further information, please contact Shure Brothers Inc., Customer Services Department, 222 Hartrey Avenue, Evanston, IL 60202-3696.

Dot-Matrix Printer Type Selection

If your printer needs a facelift (a typeface facelift, that is), it won't require surgery. The Black Box NLQ Print Buffer will allow any Epson FX or RX printer

CIRCLE 98 ON FREE INFORMATION CARD

with a Centronics interface to produce near letter-quality type in a selection of typefaces—Courier, Prestige, Elan, Italics, or Roman.

Equipped with a 128K buffer that stores the graphic codes and can be used to hold up to 65 pages of text, this device is placed between the personal computer and printer. It receives standard data from the computer software and converts that (via self-contained software) data into a series of graphic instructions. Unlike other print upgraders, the device eliminates waiting and delays associated with software packages sold for that purpose.

Priced at $269, the NLQ Printer Buffer can be made transparent by pushing a button, and it will perform a number of word-processing functions. For more information about this product write to Black Box, PO Box 12800, Pittsburgh, PA 15241; Tel. 412/746-5500.

Communicating CD Player

Compact-disc players are all the rage but can you make a good thing better? Bang & Olufsen thinks it has with its Beogram CD33000.

Like the other Beosystem 330 components, the CD player can be wall mounted. An optional bracketed shelf provides horizontal mounting at any height convenient to its owner. The Beogram CD33000 is operated simply by touching sensi-touch controls embedded in the front panel which use no moving parts that could be subject to malfunction. An illuminated time display can be switched to indicate track and index number, track playing time, or remaining disc playing time. Its microcomputer even displays a question mark when it is given an instruction it cannot carry out. Playing of a CD can be initiated when the CD source is selected via the Beomaster 3300 receiver. Individual tracks are quickly selected by touching the advance or return controls—either directly or remotely. Rapid scanning is carried out by simply touching fast-forward or rewind buttons on the remote control terminal or sensi-touch controls on the CD player.

In addition to communicating with the Beomaster 3300 receiver by Datalink, the Beogram CD3300 player can communicate with the Beocord 3300 cassette deck. When recording a disc onto tape, the CD3300 can be set to automatically pause for 4-second intervals between selections so that the Beocord 3300 cassette deck can carry out its automatic search for music tracks when the cassette is played back. Should tape run out while recording from a CD, the CD3300 will pause until tape recording resumes.

The Beogram CD3300 incorporates the most advanced compact disc playback technology and uses the most sophisticated digital decoding method available today. Four-times oversampling at 176.4 KHz along with digital filtering, allows the original waveform to be more precisely recreated. The 16-bit decoding reliably extracts all the digital information

CIRCLE 56 ON FREE INFORMATION CARD

contained in a compact disc. The result is a reduction in noise to the vanishing point and absolute minimization of the phase errors that can cause strident and grainy music reproduction.

The laser-tracking mechanism is entirely new. It renders the CD3300 extremely resistant to audible interruptions caused by disc damage. A new suspension system isolates the platter and laser assembly from outside physical interference such as acoustic feedback from speakers, vibration, or shock. It's available from authorized Bang & Olufsen retailers throughout North America at a suggested list price of $699.

For more information write to Bang and Olufsen of America, Inc., 1150 Feehanville Dr., Mount Prospect, IL 60056.

Adjustable Crossover

While you're out on the road this active-filter, subwoofer crossover featuring crossover and dynamic equalization controls may spin your wheels. The ALC-10 Electronic Crossover, which is designed to minimize distortion at high listening

CIRCLE 69 ON FREE INFORMATION CARD

levels, is powered from the car battery and can be easily connected to other car audio components as well.

A unique feature of the ALC-10 is an adjustable crossover which enables the user to change the crossover frequencies to accommodate any subwoofer. That allows for maximum performance regardless of the subwoofer used.

A dynamic-equalizer control that assures low distortion at high power levels, is another major feature. At low power levels, bass response is increased; as the level increases, bass response is decreased to assure that maximum cone excursion is not exceeded. That change in bass response is in accord with the Fletcher-Munson curves.

A four-position rotary switch provides for selection of various crossover frequencies. Those are 50 Hz, 80 Hz, 100 Hz, and 150 Hz. All crossover points have a 24 dB/Octave slope.

Another user-adjustable feature is the specially designed dynamic EQ control circuit for loudness compensation. That circuit controls woofer excursion to minimize distortion at high listening levels. Two separate controls are provided to fine-tune the system. One control cuts or boosts the various equalization frequencies chosen by the second control by 9 dB. The equilization frequencies range from 30 Hz to 200 Hz.

Suggested retail price for the unit is $65. For additional information contact Altec Lansing Consumer Products, Milford, PA 18337.

Theft-Proof Car Stereo

For car owners concerned about the security of their car-stereo investment, a Denon cassette receiver is worth a peek at. The new model slides out of the dashboard, leaving only a conspicuous hole for a thief to see!

The new DCR-5320 is Denon's most affordable in-dash Receiver. Its AM/FM tuner boasts the Denon Optimum Recep-

(Continued on page 12)

NEW PRODUCT SHOWCASE

(Continued from page 8)

tion System. The system automatically adjusts the muting, sets the high-cut filter, and continuously varies stereo separation from full stereo (for strong signals) to full mono (for weak ones). The frequency-synthesis tuner also includes 6 FM and 6 AM preset stations. Manual and Seek tuning is provided via Up/Down rocker-type controls on the front panel.

The cassette deck features Dolby B and C noise reduction, metal tape capability, a super-hard permalloy head, and auto reverse. To prevent harm to the tape or the deck, the tape heads automatically disengage from the cassette when the car's ignition is turned off.

The internal amplifier can drive one or two pairs of speakers. Power output is rated at 12 Watts per channel (two channels driven, 1% THD at 1 kHz), or 4.5 Watts per channel (four channels driven, 1% THD at 1 kHz). The preamplifier line-level outputs provide for flexible multi-

CIRCLE 90 ON FREE INFORMATION CARD

amp, multi-speaker systems. A built-in fader balances between the speaker outputs of the internal amplifier and the line-level outputs to an external amplifier.

Human engineering on the DCR-5320 starts with full night illumination on the front panel. Connected to the dashboard light dimmer of the car itself, the panel lights come on only when the dashboard lights are switched on, and vary in intensity as the driver adjusts the dash rheostat. Accessory kits are available to match the color of the DCR-5320's lights to the dashboard's lights. All function switches are fully back-lit for easy visibility at night. The large LCD display indicates station frequency, radio band, noise reduction, and selected preset.

Front panel controls are arranged in a size-priority scheme, with special ridges to help the driver find the right control without taking his eyes off the road.

The unit carries a suggested retail of $375, and is available from better car audio dealers throughout North America. For more information get in touch with Denon America, Inc., 27 Law Dr., Fairfield, NJ 07006.

Handy 40-Channel CB

For you CB'ers, Midland International has added an electronically-tuned, 40-channel, 5-Watt, hand-held CB model to its line of portable, mobile, and base station CB radios and accessories.

CIRCLE 51 ON FREE INFORMATION CARD

The compact, high-performance Model 75-790 offers power and features usually found only on advanced mobile radios. Besides being electronically tuned, the unit is equipped with a sophisticated dual-conversion, superheterodyne receiver and a powerful transmitter with selectable levels of one or five Watts.

The 75-790 also has an adjustable squelch control and an automatic noise-limiter circuit, separate LED's for transmit and receive, and an extra sensitive condenser microphone. An analog meter measures received signal, transmit power, and battery condition. A touch of a button brings in emergency channel 9 instantly.

The radio operates on 12 or 15 VDC. A charger jack for NiCd batteries and a vinyl carrying case are included. The suggested retail price is $149.95. For more information on the new Model 75-790, contact Midland International, Consumer Products Division, 1690 N. Topping, Kansas City, MO 64120.

Analyze Your Interface Off

For you "jail birds" who need to make a "clean break" from your old break-out box, the Model 500 may just get you past the warden. It is a diagnostic tool designed for use at the standard EIA RS-232 or CCITT V.24 data interface of modems, multiplexers, terminals, and computers. It is simply inserted in series between the Data Terminal Equipment (DTE) and the Data Communications Equipment (DCE) to provide access to, and monitoring of, all data, timing, and control signals.

The Model 500 uses LED's to display polarity, activity, and validity of all key interface signals. Miniature rocker switches allow the user to program a make

CIRCLE 79 ON FREE INFORMATION CARD

or break for each signal at the DCE/DTE interface. Mini-patchcords are provided for cross-patching or loopback patching of signals at the front-panel test-point array.

A complete table of EIA/CCITT standard-interface signal descriptions is provided in a reference chart. A rugged carrying case provides secure storage for a folded EIA cable and mini-patchcords. The unit requires no AC or DC power supply. Power is derived from the signals under test. The Model 500 is pocket sized for convenience and constructed in a sturdy aluminum case for durability in field-service use.

The unit sells for $98.00. Address inquires and orders to: Sales Dept., Electro Standards Laboratory, Inc., PO Box 9144, Providence, RI 02940.

Satellite-TV Security Alarm

Satellite-receiving TV equipment is expensive, so how can you protect your investment against the thieving hordes lurking behind every tree in your backyard? Well, the PAL-100 Picolarm acts as a deterrent to theft of a system's valuable outdoor antenna electronics by emitting a high-pitch audio signal when the cable connecting the device to the feed electronics is severed or disconnected.

The Picolarm can be installed on new or existing satellite system installations,

CIRCLE 66 ON FREE INFORMATION CARD

and can be connected to the existing home alarm system. Some insurance companies offer reduced liability rates on satellite systems which have a Picolarm security device installed.

The Picolarm must have continuous electrical power in order to function properly. Newer-model satellite receivers supply electrical power to the antenna's outdoor electronics even when the receiver's main power is off. Older model receivers, which do not power the feed system when the receiver is off, must use Pico's PS-15 power supply for proper Picolarm operation. The PS-15 is easily connected to the Picolarm using a mini-jack. The PAL-100's maximum power-load capability is 750 mA, 18 VDC,

(Continued on page 14)

NEW PRODUCT SHOWCASE

(Continued from page 12)

which can accommodate most types of outside antenna electronics. For more information on the PAL-100 Picolarm, contact Pico Home Satellite, 103 Commerce Blvd., Liverpool, NY 13088 or 12500 Foothill Blvd., Lakeview Terrace, CA 91342; Tel. 800/336-3363.

Hard-to-Find Tools Contact

Contact East is offering a free, one-year subscription to its new Tool and Instrument catalog. With over 5,000 hard-to-find products for assembling, installing, testing, and repairing electronic equipment, the catalogs can be used as buying guides for engineers, technicians, and researchers. With full-size pages, color

CIRCLE 73 ON FREE INFORMATION CARD

photos, and detailed descriptions, the catalog features precision hand tools, tool kits, test instruments, soldering supplies, and static control products, plus many new items never before available. All products come with a 100% guarantee, and are priced for easy ordering by phone or mail. Orders are processed and shipped within 24 hours.

To request your free catalog, write to: Contact East, PO Box 786, N. Andover, MA 01845; Tel. 800/225-5370; in Massachusetts 617/682-2000.

Capacitor-Inductor Analyzer

Sure, you've seen capacitance/inductance-measuring devices before, but have you seen a device that checks *all* their parameters *while* powering them? The new Z Meter reportedly checks all the parameters of a capacitor under dynamic-operating conditions, including capacitor value, leakage, dielectric absorption, and ESR. The LC76 Porta Z has a patented dielectric absorption test, and a patent pending on the ESR test. It also dynamically tests capacitors for leakage at their working voltage.

The LC76 performs a patented inductance value and patented ringing test on inductors. The unit performs all the tests

CIRCLE 82 ON FREE INFORMATION CARD

on both capacitors and inductors at the push of a button. It's similar to the earlier model, the LC75 Z Meter 2. However, there are two very important differences between them. The LC76 is a portable, battery-operated unit, which provides 16 leakage-voltage ranges from 1.5 V to 1000 VDC. The LC75 tests only to 600 VDC.

The Porta Z gives the freedom that is needed when servicing in remote locations and eliminates constraints that AC outlets and extension cords cause. Simply grab the LC76 Porta Z, and test inductors or capacitors to 1000 VDC, plus test transmission lines for opens or shorts, all without the inconvenience of trying to connect to an AC outlet.

The unit dynamically tests capacitors from 1 picofarad to 200,000 microfarads with 1% accuracy, and checks inductor values from 1 microhenry to 10 henrys with 2% accuracy. It can also test SCR's and triacs with the optional SCR250. The SCR250 is connected to the output on the LC76 to receive the voltage to test the SCR's and triacs at their normal operating voltage. You can now test for turn on and turn off as well as any leakage with forward or reverse bias.

The price of the LC76 Porta Z with the PA 251 AC power adapter is $1,295. The SCR250 sells for $148. The BY234 lead-acid battery for portable operation costs $59.95. The CC254 carrying case, which works for the entire Z Meter family, costs $99.00. Anyone seeking further information or wishing to order the LC76 should contact Sencore, Inc., Sioux Falls, SD 57107; Tel. 800/843-3338.

Towering Speaker System

The following review is presented for the people who like to change speaker systems as often as they change socks.

The T830 is a three-way, floor-standing system featuring an 8-in. woofer, 3½-in. midrange, and 1-in. CFT dome tweeter—all new drivers designed and manufactured by Boston Acoustic. Frequency response is 48–24,000Hz ±3dB. Power handling is 100 watts and efficiency is 90 dB/lw/m. Suggested retail price is $500 per pair.

With high efficiency and broad power handling capability, the T830 is not only well matched to moderately powered amplifiers, but it is also able to handle the strong dynamic peaks generated by more powerful amplifiers reproducing digital recordings—a feat many other speakers find difficult to manage.

The tall, slim, space-saving profile of the (32½H × 10W × 9¾D) takes up less than one square foot of floor space. Its height places each driver at an ideal posi-

CIRCLE 58 ON FREE INFORMATION CARD

tion relative to the floor and the listener's ear. High frequency absorption by thick, padded upholstery and deep-pile rugs is virtually eliminated. Also, the need for special shelves or stands is eliminated, as is their cost.

For more information write to: Boston Acoustics, 247 Lynfield St., Peabody, MA 01960.

Oscilloscope With Cursors

If you're fed up with counting lines and calculating RMS values, then this cursored oscilloscope may calm your frayed nerves and rest your eyes.

Designed to greatly increase productivity, the Model SS-6122, 100-MHz oscilloscope offers a unique 4-cursor display feature with 2-speed movement.

(Continued on page 16)

"Okay. I think it's a defective component. Herb thinks it's erronious circuitry. Bobby thinks it's sensor failure. And Dr. Vells, over there, is convinced it's the tube fairy."

NEW PRODUCT SHOWCASE

(Continued from page 14)

The vertical and horizontal cursors automatically track to 10%-90% for easier waveform rise-time/fall-time measurement. The vertical cursors track for rms measurement while the horizontal cursors track for duty-cycle ratio measurement.

In addition, it incorporates a convenient internal, 6-digit, reciprocal counter with an outstanding accuracy of 0.0003%, extending the capability to measure test parameters precisely, conveniently and quickly. Each of the 4 input channels automatically correct the vertical scale factor when standard SS-0012R probes are used.

A few other user benefits include: 80-character on-screen comments allowing measurement set-up, title, and the name of the operator to be displayed making measurement data easily understandable; a convenient date/time notation display on the CRT that is especially useful when waveform data is to be photographed; versatile voltage ratio and phase-difference measurement using reference functions; simultaneous time difference and frequency display; independent A & B trigger; and a low noise design which contributes to the sharpness of the display by eliminating noise that could degrade signals. The 80-character comment and date/time notation features are offered with battery back-up.

CIRCLE 52 ON FREE INFORMATION CARD

The Model SS-6122, 100-MHz scope offers a special jitterless circuit for stable triggering, a one-push free-running ground reference switch, plus an enhance mode which is useful for slow-repetition signals and one-shot phenomena.

Like all Iwatsu scopes, it includes a high brightness CRT display, excellent linearity through advanced analog circuitry, and the use of high reliability components, plus a full 3-year warranty. The model SS-6122 100-MHz scope has a suggested retail price of $2295.00.

For further information, contact Iwatsu Instruments Inc., 430 Commerce Boulevard, Carlstadt, NJ 07072; Tel. 201/935-5220.

ETR Auto-Reverse Cassette Player

If thoughts of theft plague you while you shop for a car stereo, Sparkomatic may be able to put your fears to rest.

The Sparkomatic SR 360 AM/FM Stereo Auto Reverse Cassette receiver is a highly sensitive unit that requires a minimum of signal power (1uV) from the antenna for virtually distortion-free sound. The unit features a programmable-memory tuning system for 5-AM/10-FM station presets, with memory scan for the preset stations; automatic strong-station selection; automatic seek-and-scan tuning; LED digital time/AM/FM frequency readout; and auto reverse for continuous play operation.

Other features that make it easy to operate include full night-lighting, AM/FM and Mono/Stereo selection, soft-touch controls, and a large cassette-eject push-button that drivers can distinguish just by touch. That allows drivers to remove cassettes from the machine without taking their eyes off the road.

CIRCLE 97 ON FREE INFORMATION CARD

The SR 360 offers additional features such as a snap-in/snap-out mounting system so that the unit can easily be removed and stored out of sight when leaving the car. The unit also has built-in DNR (Dynamic Noise Reduction) circuitry, and offers the ultimate convenience of pushbutton tuning.

Specifications for the Sparkomatic SR 360 are: 12 Watts with 10 per cent THD (RMS)/10 Watts with 1 per cent THD (RMS); the frequency response is 80 Hz to 20 kHz; and sensitivity is a solid 2.5 μV for 30 dB S/N.

The suggested retail price is $159.95. For additional information, contact Sparkomatic Corporation, Milford, PA 18337; Tel. 800/233-8831; in Pennsylvania: 800/592-8891.

Audio/Video Receiver

If you want one receiver for both your audio and video entertainment centers, then check out this baby.

In addition to the standard audio choices—Phono (moving magnet or moving coil), CD, Tuner, and Tape 1—the SR-4A accommodates up to three video inputs and has the ability to dub both audio and video from two of these (Video 1 and Video 2) to the third (Tape 2/VCR). As an alternative, the user can connect a

CIRCLE 71 ON FREE INFORMATION CARD

second audio tape deck to the Tape-2 terminals to permit two-way audio dubbing between the decks. It also is possible to transfer the audio portion of a video program to either (or both) audio decks or to copy an audio program source onto a VCR machine connected via cable to the Tape 2/VCR jacks.

A subsonic filter is built into the phono preamp where it serves not only to prevent overload when playing a warped disc, but also prevents tape overload when dubbing the disc. The filter uses a gyrator to create an extremely steep rolloff below 20 Hz with negligible effect on music. Bass and treble controls are provided to alter response as desired, but this circuitry can be bypassed at the touch of a button to ensure absolutely flat response. An external processor loop is also provided so the user can connect outboard equipment without tying up a tape-monitor loop.

The SR-4A volume control is motor driven to provide remote control of sound level without the increased noise and distortion the conventional electronic attenuators introduce. In addition to the volume control, the SR-4A features a continuously-variable loudness control which provides more realistic compensation for the changes in human hearing than is possible with a fixed loudness contour. At maximum setting of the control, frequency response is absolutely flat; as the listening level is reduced with the control, progressively more attenuation is applied in the midrange than in the bass and treble to create the appropriate contour. The SR-4A is rated at 60 watts per channel into 8-ohm loads.

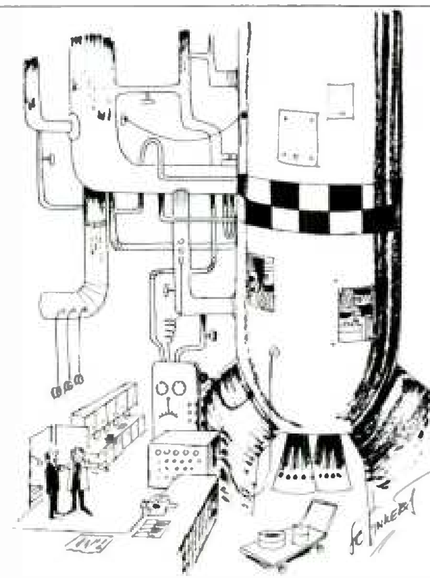
To avoid interaction, the SR-4A power transformer has separate windings, rectifiers, and regulators for the tuner section, video amplifier, display circuitry, and low-level audio stages. A fifth winding, rectifier, and filter circuit supplies power to the output stages.

The supply regulates the positive and negative voltage supplies by passing current between them rather than between each supply and ground. As a result, no current flows in the common-ground system and ground reference purity is perfectly maintained. That, in turn, reduces noise and prevents crosstalk and interstage coupling through the unit's grounding system.

From the front panel, the system provides 10 station presets as well as manual and auto-seek tuning. The RM-4SR Remote Control Unit also can be used to access the presets or to search up and down the AM or FM band. The auto-seek system senses signal strength and noise level to avoid stopping between stations or one channel away from an especially strong station.

The Nakamichi SR-4A STASIS AM/FM-Stereo Receiver carries a suggested retail price of $799.

For further information contact Nakamichi USA Corp., 19701 South Vermont Avenue, Torrance, CA 90502; Tel. 800/421-2313. If you are a little shy (or just plain lazy) circle 71 on the free information card in the back of this issue. ■



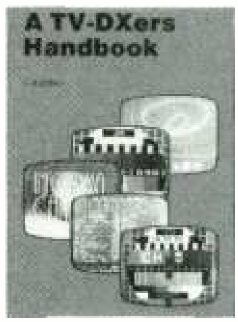
"Herb, you have a lovely hobby-room!"

BOOKSHELF

A TV-DXers Handbook
By R. Bunney

If you're into the two biggest communications mediums (television and radio), and you would like to combine those two interests, then check out this book.

In it the author discusses the possibilities and problems of receiving television signals over long distances, and resolving the picture with a minimum of distortion on the TV screen. That, in essence, is the fascinating hobby of TV-DX'ing. The handbook is an extensively revised, enlarged, and completely updated work. The satellite-TV section has been greatly expanded to encompass further generalized information, since in the coming decade "direct-to-home" transmissions will perhaps herald the most dramatic changes ever in the broadcasting field.



CIRCLE 96 ON FREE INFORMATION CARD

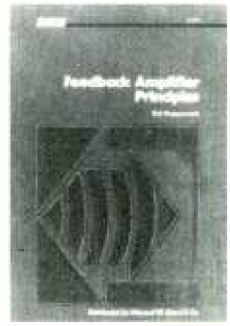
Included are many devices that have been designed by experienced enthusiasts, and often considerable ingenuity and thought have gone into their practical development to overcome problems.

The accumulated information in this book will be a practical guide for the beginner and a source of reference for the established enthusiast.

The book contains 86 pages; retails for $6.95 (plus $1.75 shipping), from Electronics Technology Today, PO Box 240, Massapequa, NY 11762.

Feedback Amplifier Principles
By Dr. Sol Rosenstark

"Everything you ever wanted to know about amplifier calculations but were afraid to ask" would've been a suitable title for this book. Complete with illustrated examples and exercises. It is written and edited for electrical engineers seeking a background in feedback amplifiers, and is suitable for self-study or formal course work.



CIRCLE 75 ON FREE INFORMATION CARD

The amount of circuit analysis required for calculations in the text consists only of the voltage-divider theorem, the current-divider theorem, Thevenin's theorem, and Norton's theorem. Topics include: feedback-amplifier circuit analysis; calculation of loop-gain frequency response; methods for feedback-amplifier stability analysis; common oscillator configurations; feedback amplifier stability based on time and frequency response.

An appendix gives simple methods for performing calculations on bipolar and field-effect transistor circuits, thereby eliminating the need for complex mesh or nodal analysis.

Feedback Amplifier Principles, No. 22545, is 180 pages, retails for $32.95, and comes from publisher Howard W. Sams & Co., 4300 W. 62nd St., Indianapolis, IN 46268; Tel. 800/428-SAMS.

62 Home Remote Control and Automation Projects
By Delton T. Horn

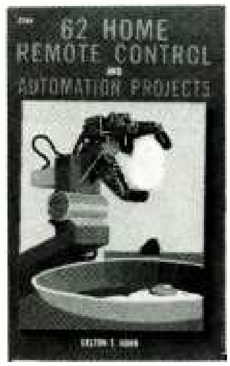
Have you ever wanted a device that automatically dims the lights when you turn on your stereo, an automatic guest greeter, sensors that keep your heat and air-conditioning at ideal levels day in and day out without having to constantly adjust the thermostat, or a

(Continued on page 22)

BOOKSHELF

(Continued from page 18)

liquid probe that alerts you whenever your house plants need watering? Well, you can make them all easily and at amazingly low cost! Or, how about a telephone-activated relay that lets you turn on the outdoor lights if you're getting home late, a remote-controlled "commercial killer" for



CIRCLE 84 ON FREE INFORMATION CARD

your TV, voice-activated transmitters and relays, or an infrared transmitter and receiver to perform a wide variety of control functions, or ways to put your personal computer to work as a home control center? You can have them all with the help of this valuable project guide.

Those are just a few of the highly useful, fun-to-build projects you can put to work in your home no matter what your previous electronics experience! Here's where you'll find a complete selection of door and window controllers, temperature controllers, liquid monitors and controllers, stereo and TV projects, telephone related projects, controller motors, electronic-switching units, timers, wireless controllers, and a computer controller complete with programming information.

The book includes complete instructions, wiring diagrams, and show-how illustrations for each device. And for those who are still a little hazy on how remote-control and automation systems work, there's an excellent introduction to basic functions, as well as advice and guidance on safety precautions, location of needed parts, substitution of components, and customizing techniques.

The book is 268 pages, retails for $12.95, and is available from TAB Books Inc., Blue Ridge Summit, PA 17214; Tel. 717/794-2191.

Understanding Security Electronics
By Joe Carr

If you're looking for a self-instructional book detailing how to

CIRCLE 75 ON FREE INFORMATION CARD

select, install, and maintain a security system, then this book may put an end to your search.

Understanding Security Electronics provides the guidelines to safeguard property on a do-it-yourself basis. Readers will learn the specifics of electronic intrusion alarms, electromechanical detectors, and signaling systems.

Other topics covered include: ultrasonic and microwave intrusion detectors; photoelectric and infrared detectors; audio and visual monitoring; proximity detectors; access control; custom integrated circuits; computers in security systems; computer crime; automobile protection; and holdup and assault alarms.

Understanding Security Electronics, No. 27069, is 304 pages and retails for $16.95, and is available from publisher Howard W. Sams & Co., 4300 W. 62nd St., Indianapolis, IN 46268; Tel. 800/428-SAMS.

How To Develop, Protect, and Market Your Invention
By Robert Park

If you'd like to follow in the footsteps of Edison and Ford, then this book can help you wade through the paper work.

In his foreword to this book, Mr Norris writes: "The Inventor's Handbook not only helps to successfully guide individuals along the complex path of invention, but also encourages them to market their inventions by forming a company for that purpose. As the book accurately notes, the transition from the laboratory to forming a successful

CIRCLE 61 ON FREE INFORMATION CARD

company is not an easy or simple one, as thousands of inventors and would-be-entrepreneurs have learned."

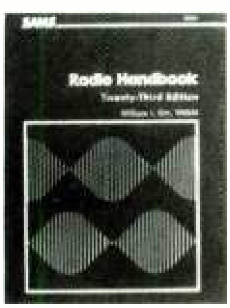
Many of today's "inventors" work for large companies, and their product ideas and development efforts are funded with substantial R&D budgets. In spite of that heavily-funded effort, however, more than 70% of all the patents granted each year are granted to independent inventors. The Inventor's Handbook is for them, and for all others who have similar dreams and abilities, but lack the know-how to take them through the prototype and testing stages to full-scale marketing and manufacturing.

Park covers everything from self-analysis (do you have what it takes to invent?) to the inventing process; all the steps involved from developing a new product (or service) idea, to applying for a patent, to the successful manufacturing and marketing of the patented invention. Valuable performance profit and loss statements, and balance sheets are included.

The 138 page book retails for $8.95, from Betterway Publications, Inc., White Hall, VA 22987; Tel. 804/823-5661.

Radio Handbook—23rd Edition
By William I. Orr

An up-to-date handbook is priceless to a ham, and this new edition has been completely revised and updated, and contains new material reflecting



CIRCLE 75 ON FREE INFORMATION CARD

the latest technology on everything from HF/VHF-amplifier design to interference reduction for VCR's and video disc players.

Readers will have circuit diagrams, photos, construction diagrams, tables, and charts right at their fingertips, for expert guidance and instant reference. Specific topics include: introduction to amateur radio communications; communications-receiver fundamentals; frequency modulation and repeaters; mobile, portable, and marine equipment; radio and television interference; equipment design;

(Continued on page 26)

Bad News For Escort

3RD IN A SERIES

Dear Customer, *From Drew Kaplan*

Escort has ignored DAK's **second**, one-on-one Maxon versus Escort radar challenge. And frankly, I'm fighting mad. I suppose they have a right to ignore me. But after referring to my challenge as only an "advertising gambit" and calling Maxon's radar detector an off-shore, primitive, and bottom-end unit, I'd think they'd be glad to wipe us out in a head to head duel to the death. But, I'm really mad for two other reasons and I think that you may be as fascinated by them as I am.

Mad Reason 1. Road and Track Magazine held an independent general radar detector test in their September 86 issue.

As far as I can see, Maxon beat Passport in Uninterrupted Alert, and Passport beat Maxon in Initial alert. Now to be fair, neither of us seem to have beaten the other by even 2 seconds at 55 miles per hour. So, we didn't win or lose by much.

And, Maxon's 99^{90} detector was tested against the $295 Passport, not the $245 Escort we challenged. What's interesting is that Road and Track had nice things to say about Passport and even about Escort, which **wasn't even included** in the tests any more.

Now, if you've been following DAK's challenge, you know we've only been challenging Escort. If you've read Road and Track's tests, you'll be amazed when you read Boardroom Reports, which I've reprinted for you to the right. What's really interesting is that **it's the exact same person** in both publications.

Actually, Maxon did extremely well. Road and Track only used 'over hill' and 'around curve' tests because on straightaways the differences weren't worth describing. (Imagine that!)

It's just as I've said in my challenge. I don't think there's much difference between Maxon's and Cincinnati's Radar detectors when it comes to sensing radar.

THE CHALLENGE GROWS

In view of the opinions stated in the article in Boardroom Reports about the $245 Escort, DAK hereby adds the $295 Passport to our challenge.

Mad Reason 2. Did you ever hear about the cure for dandruff that was developed in the middle-ages? It was the guillotine. And frankly, I think you should be aware of Cincinnati Microwave's advertising cure for the Rashid VRSS Collision Avoidance System.

The Rashid VRSS system, as described in Popular Science magazine, January 1986, sends out a radar signal on the K band ahead of your car. The good part is that it can help you avoid running into things higher than your front bumper. The bad news is that since it operates on K band, it sets off radar detectors.

Well, hats off to Cincinnati Microwave. I've tested the Passport against the Rashid unit and, as usual, they have done a splendid job. While every other detector I tested, including Maxon's, was driven crazy, theirs didn't utter a peep.

But then, my Maxon hasn't uttered any peeps lately either and let me tell you why. I was on my way to the Far East to visit Maxon, so I asked Tom, a manager at DAK, to purchase and test the Rashid.

Well, did I ever hear from him. First the unit cost $558 plus about $100 to install. Then buying it and finding someone to install it took almost a month.

But the real reason he was unhappy was that the recommended method of installation involved **cutting a 6½" hole** in the front grill of his neat new car.

Well, much to my wife's chagrin, it's now installed in her station wagon.

After installation, it has to be set by an installer. He drives between 15 and 30 miles per hour toward a solid object. When the installer **thinks** he's reached a safe stopping distance, he adjusts the warning alarms to sound. Then in the future, when a similar distance is reached, lights will flash and an alarm will sound.

Of course, if you accelerate too quickly into a lane behind another car the same alarms can go off.

And, I haven't figured out what to do if there's a dog in the road, dirt on the radar sensor, or how to compensate for the different stopping distances encountered on dry, wet, icy or snowy roads.

MOST IMPORTANT PART

Speaking of advertising gambits, in **virtually every magazine I pick up**, I've been seeing Cincinnati's Bad News for Radar Detector ads spelling out the obsolescence of all other detectors.

If it's such an important feature that distinguishes them from us, there had better be some of these devices on the road, or Cincinnati Microwave's credibility may just be on the road as well.

I will add $10,000 to my Escort/Passport challenge if Cincinnati Microwave can prove that there are even 1000 Rashid units on the road **anywhere** in the U.S. Oh heck, I'll add $5000 if they can even find 500. **(And, look at this.)**

NOTE: There are several other potential collision avoidance systems on the drawing boards and each may have a DIFFERENT FINGERPRINT.

So, If you're a current Escort or Passport owner, I suggest that you find out how many Rashid units there are and what Cincinnati Microwave will do about the 'other' units **before** you pay $$$ to have your current detector upgraded.

Besides, with over 3,000,000 square miles in the U.S., even 1,000 units would work out to less than one unit for every 3,000 square miles.

If a major car company successfully sells a collision avoidance system, then Maxon will be ready. But, the car companies currently can't even get consumers to pay $200 for air bags. So, you decide. Is it significant, or an advertising gambit?

Below is the **NEW** version of the challenge. Escort, a reply please!

A $20,000 Challenge To Escort

Let's cut through the Radar Detector Glut. We challenge Escort & Passport to a one on one Distance and Falsing 'duel to the death' on the highway of their choice. If they win, the $20,000 check pictured below is theirs.

By Drew Kaplan

We've put up our $20,000. We challenge Escort to take on Maxon's new Dual Superheterodyne RD-1 99^{90} radar detector on the road of their choice in a one on one conflict.

Even Escort says that everyone compares themselves to Escort, and they're right. They were the first in 1978 to use superheterodyne circuits and they've got a virtual stranglehold on the magazine test reports.

But, the real question today is: 1) How many feet of sensing difference, if any, is there between this top of the line Maxon Detector and Escort's or Passport's? And 2) Which unit is more accurate at interpreting real radar versus false signals?

So Escort, you pick the road (continental U.S. please). You pick the equipment to create the false signals. (Don't forget our $10,000 Rashid challenge). And finally, you pick the radar gun.

Maxon and DAK will come to your

. . .Next Page Please

. . .Challenge Continued

highway with engineers and equipment to verify the results.

And oh yes, we'll have the $20,000 check (pictured) to hand over if you beat us by more than 10 feet in either X or K band detection with the Escort, or by 2 seconds at 55mph with the Passport.

BOB SAYS MAXON IS BETTER

Here's how it started. Maxon is a mammoth electronics prime manufacturer. They actually make all types of sophisticated electronic products for some of the biggest U.S. Electronics Companies. (No, they don't make Escort's).

Bob Thetford, the president of Maxon Systems Inc., and a friend of mine, was explaining their new RD-1 anti-falsing Dual Superheterodyne Radar detector to me. I said "You know Bob, I think Escort really has the market locked up." He said, "Our new design can beat theirs".

So, since I've never been one to be in second place, I said, "Would you bet $20,000 that you can beat Escort?" And, as they say, the rest is history.

By the way, Bob is about 6'9" tall, so if we can't beat Escort, we can sure scare the you know what out of them. But, Bob and his engineers are deadly serious about this 'duel'. And you can bet that our $20,000 is serious.

We ask only the following. 1) The public be invited to watch. 2) Maxon's Engineers as well as Escort's check the radar gun and monitor the test and the results.

3) The same car be used in both tests. 4) We'd like an answer from Escort no later than July 31, 1987 and 60 days notice of the time and place of the conflict. 5) If Escort can prove that there are 1,000, or even 500 Rashid units in operation, we will present them with the appropriate $10,000 or $5,000 check at the beginning of the conflict. And, 6) We'd like them to come with a $20,000 check made out to DAK if we win.

HOW'S THIS FOR FAIR

Cincinnati Microwave will be deemed the winner and given the check if either Escort beats Maxon by 10 feet in both uninterrupted and initial alerts, **OR** if Passport beats Maxon by 2 seconds at 55mph in both uninterrupted and initial alerts. So, DAK wins **only** if we beat both Escort and Passport.

A tie will exist only if both the $295 Passport and $245 Escort fail to beat Maxon's $99^{90} Dual Superheterodyne RD-1 Radar Detector.

SO, WHAT'S DUAL SUPERHETERODYNE?

Ok, so far we've set up the conflict. Now let me tell you about the new dual superheterodyne technology that lets Maxon leap ahead of the pack.

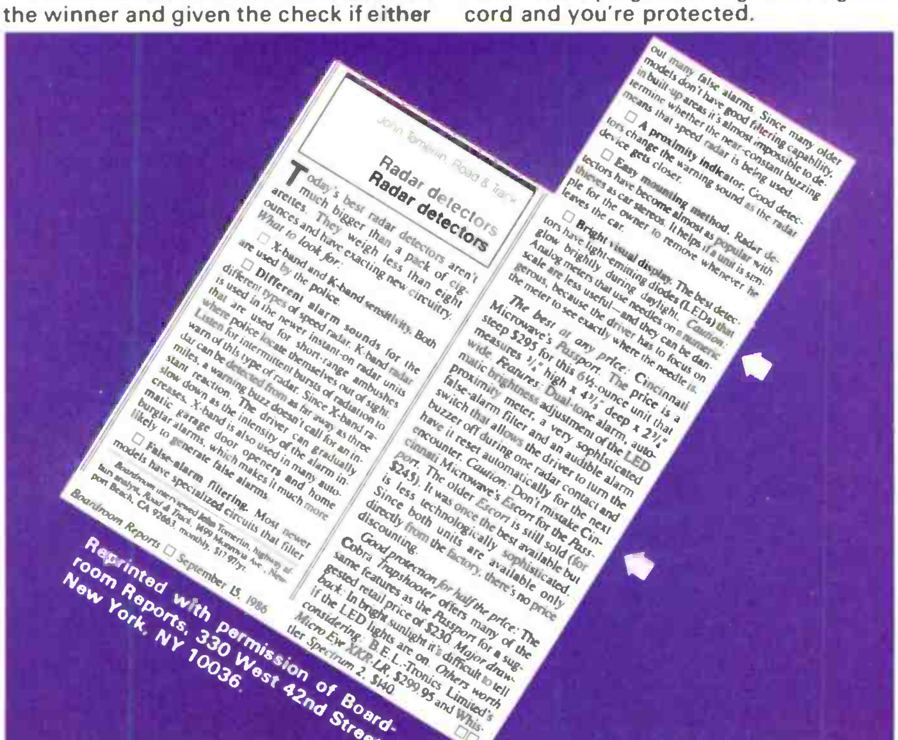
It's a technology that tests each suspected radar signal 4 separate times before it notifies you, and yet it explodes into action in just 1/4 of one second.

Just imagine the sophistication of a device that can test a signal 4 times in less than 1/4 of one second. Maxon's technology is mind boggling.

But, using it isn't. This long range detector has all the bells and whistles. It has **separate** audible sounds for X and K radar signals because you've only got about 1/3 the time to react with K band.

There's a 10 step LED Bar Graph Meter to accurately **show the radar signal's strength**. And, you won't have to look at a needle in a meter. You can see the Bar Graph Meter with your peripheral vision and keep your eyes on the road and put your foot on the brake.

So, just turn on the Power/Volume knob, clip it to your visor or put it on your dash. Then plug in its cigarette lighter cord and you're protected.



John Tomerlin, Road & Track

Radar detectors

Radar detectors

Today's best radar detectors aren't much bigger than a pack of cigarettes. They weigh less than eight ounces and have exacting new circuitry. *What to look for:*

☐ **X-band and K-band sensitivity.** Both are used by the police.

☐ **Different alarm sounds for the different types of speed radar.** K-band radar is used in the newer instant-on radar units that are used for short-range ambushes where police locate themselves out of sight. Listen for intermittent bursts of radiation to warn of this type of radar. Since X-band radar can be detected from as far away as three miles, a warning buzz doesn't call for an instant reaction. The driver can gradually slow down as the intensity of the alarm increases. X-band is also used in many automatic garage door openers and home burglar alarms, which makes it much more likely to generate false alarms.

☐ **False-alarm filtering.** Most newer models have specialized circuits that filter out many false alarms. Since many older models don't have good filtering capability, in built-up areas it's almost impossible to determine whether the near-constant buzzing means that speed radar is being used.

☐ **A proximity indicator.** Good detectors change the warning sound as the radar device gets closer.

☐ **Easy mounting method.** Radar detectors have become almost as popular with thieves as car stereos. It helps if a unit is simple for the owner to remove whenever he leaves the car.

☐ **Bright visual display.** The best detectors have light-emitting diodes (LEDs) that glow brightly during daylight. *Caution:* Analog meters that use needles on a numeric scale are less useful—and they can be dangerous, because the driver has to focus on the meter to see exactly where the needle is.

The best at any price: Cincinnati Microwave's *Passport.* The price is a steep $295 for this 6½-ounce unit that measures ¾" high x 4¾" deep x 2¾" wide. *Features:* Dual-tone alarm, automatic brightness adjustment of the LED proximity meter, a very sophisticated false-alarm filter and an audible alarm switch that allows the driver to turn the buzzer off during one radar contact and have it reset automatically for the next encounter. *Caution:* Don't mistake Cincinnati Microwave's *Escort* for the *Passport.* The older *Escort* is still sold (for $245). It was once the best available but is less technologically sophisticated. Since both units are available only directly from the factory, there's no price discounting.

Good protection for half the price: The Cobra *Trapshooter* offers many of the same features as the *Passport* for a suggested retail price of $230. *Major drawback:* In bright sunlight it's difficult to tell if the LED lights are on. *Others worth considering:* B.E.L.-Tronics Limited's *Micro Eye XKR-LR,* $299.95 and Whistler *Spectrum 2,* $140. ☐☐

Boardroom interviewed **John Tomerlin,** highway affairs analyst, *Road & Track,* 1499 Monrovia Ave., Newport Beach, CA 92663. monthly, $17.97/yr.

Boardroom Reports ☐ *September 15, 1986*

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And you'll have a very high level of protection. Maxon's Dual Conversion Scanning Superheterodyne circuitry combined with its ridge guide wideband horn internal antenna, really ferrets out radar signals.

By the way, Escort, we'll be happy to have our test around a bend in the road or over a hill. Maxon's detector really picks up 'ambush type' radar signals.

And the key word is 'radar', not trash signals. The 4 test check system that operates in 1/4 second gives you extremely high protection from signals from other detectors, intrusion systems and garage door openers.

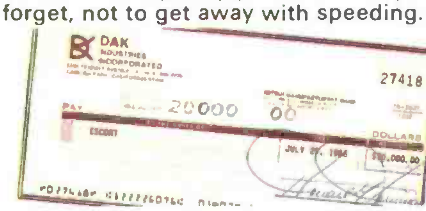
So, when the lights and X or K band sounds explode into action, take care, there's very likely police radar nearby. You'll have full volume control, and a City/Highway button reduces the less important X band reception in the city.

Maxon's long range detector comes complete with a visor clip, hook and loop dash board mounting, and the power cord cigarette adaptor.

It's much smaller than Escort at just 3½" Wide, 4¾" deep and 1½" high. But, it is larger than Passport. It's backed by Maxon's standard limited warranty.

Note from Drew: 1) Use of radar detectors is illegal in some states.

2) Speeding is dangerous. Use this detector to help keep you safe when you forget, not to get away with speeding.



CHECK OUT RADAR YOURSELF RISK FREE

Put this detector on your visor. When it sounds, look around for the police. There's a good chance you'll be saving money in fines and higher insurance rates. And, if you slow down, you may even save lives.

If you aren't 100% satisfied, simply return it in its original box within 30 days for a courteous refund.

To get your Maxon, Dual Superheterodyne, Anti-Falsing Radar Detector risk free with your credit card, call toll free or send your check for just **$99^{90}** ($4 P&H). Order No. 4407. CA res add tax.

Special Note: Now that we're challenging Passport, we've added an optional suction cup windshield mount and extra coiled power cord. (Sorry we can't afford to throw them in for free.) They're just **$5^{90}** ($1 P&H) Or. No. 4800.

OK Escort, it's up to you. We've got $20,000 that says you can't beat Maxon on the road. Your answer, please?

Escort and Passport are registered trademarks of Cincinnati Microwave. Rashid VRSS, and Rashid Radar Safety Brake are registered trademarks of Vehicle Radar Safety Systems, Inc.

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BOOKSHELF

(Continued from page 23)

components, and controls; VHF and UHF antennas; and transmission lines and matching systems.

Radio Handbook, 23rd Edition, No. 22424, is 640 pages, retails for $29.95, and is available from Howard W. Sams & Co., 4300 W. 62nd St., Indianapolis, IN 46268; Tel. 800/428-SAMS.

The Linear IC Handbook
By Michael S. Morley

If instant access to specifications, prices, and other vital data for linear integrated circuits is what you need then check this out.

Far more than a replacement for manufacturers' data books, The Linear IC Handbook bridges the gap between

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data books and the designer's search for the right component. It covers linear IC offerings from all the major manufacturers—complete with specifications, data-sheet parameters, and price information—along with important technological background and details on the internal operations of linear IC's. It contains all the data you need on how linear IC's are fabricated, how they work, what types of IC's are available, and techniques for designing IC circuits. You'll get the background necessary to determine your exact IC requirements for a specific application; evaluate alternative circuit-design approaches; assess the various components available to do the job; and apply those components to your design to assure high yield and reliability.

The book, which contains 611 pages, retails for $49.50 from TAB Books Inc., PO Box 40, Blue ridge Summit, PA 17214; Tel. 717/794-2191.

Understanding MS-DOS
By Kate O'Day and John Angermeyer

If learning to use MS-DOS at the keyboard sounds like a technique you'd like to try, then read on.

Understanding MS-DOS is a step-by-step book designed for those with

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little or no previous experience in computer hardware or software. End-of-chapter study questions, colorful illustrations, and marginal notes enable readers to learn quickly and refer easily to the material presented.

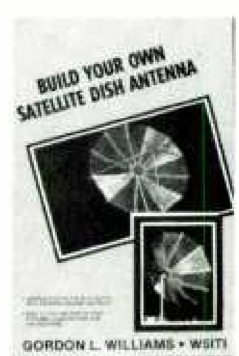
The topics covered include: using commands to manage files; special function keys and key combinations; organizing data-info files; redirecting input and output; using the text editor EDLIN to create and edit files; creating batch files of often repeated commands; creating and using tree-structured directories.

Understanding MS-DOS, No. 27067, is 240 pages and retails for $16.95, from publisher Howard W. Sams & Co. Inc., Dept. R40, 4300 W. 62nd St., Indianapolis, IN 46268; Tel. 800/428-SAMS.

Build Your Own Satellite Dish Antenna
By Gordon L. Williams

With all the interest today in satellite communications, satellite weather information, satellite television, and radio astronomy—all of which require a parabolic-dish antenna—you'll probably be pleased to hear about the publication of this new book.

Build Your Own Satellite Dish Antenna gives easy-to-follow step-by-step instructions, pictures,



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illustrations, and sources for materials. It makes the building of a satellite dish antenna a job anyone can do.

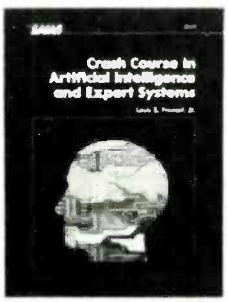
Although the book describes the building of a ten-and-a-half foot dish antenna, pertinent information is given for building nine different parabolic dishes from ten-and-a-half to thirty feet in diameter.

A copy of the 44-page book may be obtained for $12.00 from Power Gain Systems, PO Box 2955, West Monroe, LA 71294.

Crash Course in Artificial Intelligence and Expert Systems
By Louis E. Frenzel, Jr.

If you need a simple, concise approach to learning about artificial intelligence, then Crash Course in Artificial Intelligence and Expert Systems may be the way to go.

This practical, application-oriented course in artificial intelligence takes a broad, complex subject, and explains it concisely so that it is easily understood. The book covers important concepts and techniques that are



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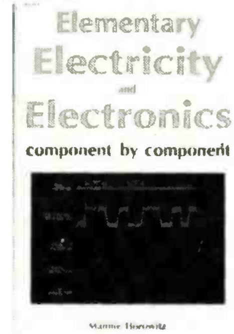
practical rather than theoretical, focusing on subjects that are relevant and useful in the real world.

It includes short programming samples using LISP and Prolog. A general introduction to the entire field is given, with special emphasis on expert systems. Other topics include: natural language and speech processing; computer vision; AI in robotics; AI languages: LISP and Prolog; and the hardware of AI.

Crash Course in Artificial Intelligence and Expert Systems, No. 22443, is 368 pages and retails for $19.95, from publisher Howard W. Sams & Co. Inc., Dept R40, 4300 W. 62nd St., Indianapolis, IN 46268; Tel. 800/428-SAMS.

Elementary Electricity and Electronics Component By Component
By Mannie Horowitz

If you're looking for a single, easy-to-follow introduction to basic electrical and electronics concepts, then this new handbook may do. It's a comprehensive overview of fundamental electronics principles using specific components to illustrate and explain each concept—so you learn component symbols and how to read schematic diagrams as you master



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theoretical concepts.

It starts out with an introduction to electrical and electronic characteristics, and then leads you, step-by-step, through electronic components and their circuit applications, covering resistors, capacitors, inductors, diodes, transistors, power supplies, FET'S, SCRs, and other commonly used analog-circuit components. Digital electronics—so important in today's technology—is also covered, with descriptions of decimal, binary, octal, and hex number systems.

Some of the book's highlights include: descriptions of AC and DC current and how each one behaves in a circuit; explanations of Ohm's law, resistor color codes, kohms,

BOOKSHELF

megohms, mA, µA, mV, and kV; voltage and current dividers; passive components used in AC circuits; the structure of diodes and how they work; how to use diode and capacitor filters in half-wave circuits; the use of full-wave and bridge rectifier circuits; the various configurations of bipolar transistors and their characteristics; a look at the different types of FET'S; a discussion of voltage feedback; a discussion of gates and truth tables; and much more.

Whether you're interested in electronics as a hobby or you're an aspiring electronics technician, this is a book to give you that first, all-important understanding of what the topic is really all about.

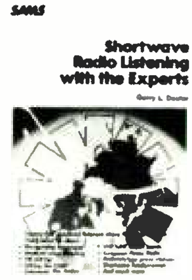
The book contains 349 pages at $16.95, from TAB Books Inc., PO Box 40, Blue ridge Summit, PA 17214; Tel. 717/794-2191.

Shortwave Radio Listening with the Experts
By Gerry L. Dexter

If you're an old ham or a newcomer, this book could help you improve your technique.

The book features 25 contributors who are shortwave listening researchers, pioneers, and specialists wishing to share their experiences and guide beginners as well as veteran radio listeners.

Shortwave Radio Listening with the Experts, is 528 pages and retails for $22.95, from Howard W. Sams & Co. Inc., Dept R40, 4300 W. 62nd St., Indianapolis, IN 46268; Tel. 800/428-SAMS.



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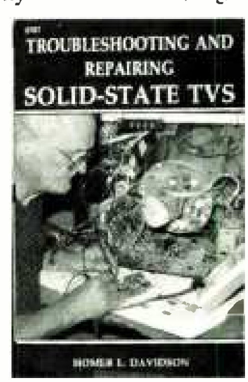
Troubleshooting and Repairing Solid-State TV'S
By Homer L. Davidson

You can zero in on solid-state television problems and repair them quickly and efficiently if you know the methods and techniques revealed in this guide.

With this workbench reference, you will have practical information on troubleshooting and repairing all the most recent solid-state TV circuitry used by the major manufacturers of all brands and models of TV's right at your fingertips. It describes the warning symptoms of solid-state TV problems and gets right to the probable circuits, and individual components causing the malfunction.

You should be able to troubleshoot and repair almost any problem you come across in solid-state TV's, such as a faulty remote control, high- or low-voltage power supply, defective horizontal-sweep circuits, brightness and picture tube problems, defective tuners, etc.



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The 446 page book costs $17.95, from TAB Books Inc., Blue Ridge Summit, PA 17214; Tel. 717/794-2191. ■

By Don Jensen

JENSEN ON DX'ING

How north can you go? Try Nordic DX'ing?

A FEW MONTHS AGO, WE FOCUSED OUR attention on the shortwave stations of Scandinavia—Norway, Sweden, Finland, and Denmark. Now that's north all right, but it isn't *north*! While today there are no shortwave broadcasters transmitting from inside the Arctic Circle, there are a handful of hardy operations working not too far from it on the sunny side of the line.

One is KNLS, the *New Life Station*, a religious SW broadcaster located at Anchor Point, Alaska—nearly 60-degrees north latitude.

Owned and operated by the *World Christian Broadcasting Corporation* of Abilene, Texas, KNLS transmits from a 100-kilowatt shortwave transmitter to Europe and Asia in Chinese, Russian, and of course, in English.

In North America, probably the best time to hear that station is during the evening hours, say 0800 to 1030 or so Coordinated *U*niversal *T*ime (UTC).

Besides its religious and inspirational messages, KNLS has some rather nice musical programming during the English language segment. Big-band music of the 1930's and 1940's is aired at 0800 hours; the World of Country and Western at 0915, and jazz is heard at 1000 UTC. Try 11,850 or 11,960 kHz.

Until last year's summit meeting between the leaders of the United States and the Soviet Union, relatively few people were familiar with the northern capital of Reykjavik. It's the location of Rikisutvarpid, the *Iceland State Broadcasting Service* (ISBC).

ISBC is not one of the world's major shortwave broadcasters, but its 10-kilowatt transmitter can push a decent enough signal into North America. Programming (rebroadcasts of domestic AM mediumwave service) is in the Icelandic language and is intended for Icelanders living abroad and those on-board fishing vessels traveling the high seas. ISBC's shortwave schedule is (at the time of this writing): 1215 to 1245 UTC to Europe on 13,775 kHz; 1300-1330 UTC to North America on 11,855 kHz; 1855 to 1945 UTC to Europe on 9,985 kHz, and 2300 UTC to North America on 11,730 kHz.

An often difficult to log far-north SW service is *Gronlands Radio*, with a mere 7.5-kilowatt station at Nuuk, near the Greenland capital of Godthaab. The best chance to hear this one—which has programs only in the Danish, Greenlandic, and Faroese languages, intended for its small and widely scattered domestic audience in the icy arctic wastes—is to try 3,999 kHz when it signs on for the day at 1000 UTC.

KNLS, the "New Life Station," broadcasts on shortwave across the North Pole to Europe and Asia from this location in Anchor Point, Alaska.

Back to Basics

How do distant shortwave signals reach your radio, half a world away? Last month we began considering radio-wave propagation. When we last saw our *heros*—the shortwave signals—they were outbound from earth in a straight line, but about to encounter ionized layers of gases, which bounce them back to us, thousands of miles downrange from where the transmitter is located.

There are several such ionized layers encircling the globe in the ionosphere. They're known as the D, E, F1, and F2 layers. The D region is closest to the earth, about 50 miles up. Unlike the higher layers, it has a dampening effect on long distance reception. Because of its thickness and low altitude, it tends to soak up, or absorb, rather than reflect radio signals, particularly the longer wavelengths. It is strongly affected by the sun's radiation, so its effects disappear when darkness falls, allowing ionized layers above to bring in distant *skip* signals. You've probably noticed at night that distant stations in the regular 540- to 1600-kHz AM band, which are not audible during the day, can be heard.

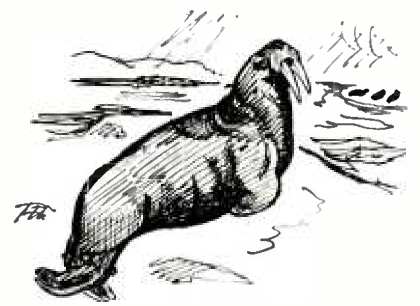
Slightly farther from the Earth is the E layer, which has some effect on the lower shortwave bands, particularly during the day. Between 150 and 250 miles above the Earth lie the F1 and F2 layers. At night, when there is no solar radiation affecting them, they merge into a single F layer. F1 isn't of too much concern to us, but its companion F2 is, perhaps, the single most important layer for propagational phenomenon to the radio listener. That rapidly fluctuating band of gases high above us is responsible for most of our shortwave reception.

When conditions are right, the signal that otherwise would escape forever into space will come skipping back to Earth, far from its starting point. Like Magic Johnson dribbling down the basketball court, the radio wave can bounce back and forth between earth and ionospheric layer, sometimes hopping around the globe.

Getting Wired

One of the most common questions that

JENSEN ON DX'ING



This ink drawing of a walrus is taken from a QSL card formerly sent to shortwave listeners by Gronlands Radio, at Nuuk, near Greenland's capital, Godthaab.

we get deals with shortwave antennas. Typically it's the query: "What's the best antenna?" Unfortunately, there's no simple and universal answer except to say, *it depends*. Ideally, an antenna should be directional and have gain. Thus, it could boost the levels of *wanted* stations while filtering out interfering signals arriving at your aerial from other directions.

Accomplishing that is relatively easy on the VHF and UHF frequencies, but tough for shortwave, where the physical size of an antenna that offers gain and directivity is simply too big and expensive for most of us.

So, usually, SWL's operate with simple, relatively-short wire antennas that fit into the dimensions of their backyard. Fortunately, the results are usually quite decent. But there are alternatives that may fit specific needs—like if you live on the fifth floor of an apartment building; or if there is a noisy source of electrical interference nearby.

Antenna experimentation can be useful—even fun—if the results improve your receiving situation. Some publications that may assist you in that endeavor are: *ARRL Antenna Book* (American Radio Relay League, 225 Main St., Newington, CT 06111); Edward M. Noll's *Twenty-Five Simple Shortwave Broadcast Band Aerials* Electronic Technology Today, P.O. Box 240, Massapequa Park, NY 11762-0240; *How to Build Hidden, Limited-Space Antennas That Work*, by Robert Traister (TAB Books, Blue Ridge Summit, PA 17214); Traister's *The Shortwave Listener's Antenna Handbook (TAB Books), and Antennas For Receiving* by Wilfred Caron available from Grove Enterprises, PO Box 98, Brasstown, NC 28902.

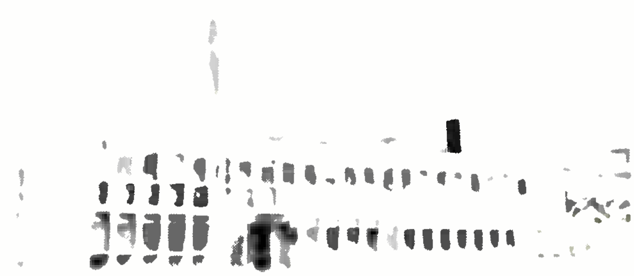
Down The Dial

What are you hearing on the shortwave bands these days? Here are some of the loggings others are making. To join in next month's column, just drop a line with a listing of your more interesting loggings, with times and frequencies, to *Jensen on DX'ing*, **Hands-on Electronics**, 500B Bi-County Blvd., Farmingdale, NY 11735. All times are given in Coordinated Universal Time (UTC, also known as Greenwich Mean Time, GMT). Frequencies are listed in kilohertz (kHz).

BOTSWANA—3,356—*Radio Botswana*, in southern Africa, signs on with English announcements at 0400 hours, and continues in a local language.

BOLIVIA—4,712—This is not the easiest of countries to hear on shortwave. While there are a number of Bolivian shortwave stations, they tend to be low-powered broadcasts in Spanish with somewhat irregular transmissions. One of the better bets is *Radio Abaroa*, which varies in frequency to 4,710 during the early evening hours in North America.

Well, that is about all the room alloted to us for this month. Let us know what stations you've pulled in; include the frequency (kHz) and time (UTC) of your loggings. See you next month. ■



Radio Greenland's shortwave station in Godthaab (as depicted on its verification card) broadcasts daily 8-hour programs, in Greenlandic and Danish. It's a tough catch, even though it has since upgraded its 1-kW transmitter.

By Marc Saxon

SAXON ON SCANNERS

When the marketplace spoke, one scanner manufacturer listened!

□Ace Communications, Inc., has recently introduced their AR-2002 professional-grade scanner. The unit covers from 25 to 550 MHz and from 800 to 1,300 MHz continuously, thus, giving the user an ear in the thick of virtually all VHF/UHF communications. The gap between 550 and 800 MHz is occupied by TV broadcasters, so you aren't going to be missing anything!

The AR-2002 uses the latest microprocessor and circuit technologies to offer a multitude of features. Those features include a 20-channel memory scan, priority scan, band search, multi-mode reception (AM, FM-wide, FM-narrow), conventional dial tuning, selectable frequency increments, bargraph signal-strength indicator, and many more.

The scanner incorporates commercial-type receiver technology, such as a 750-MHz receiver IF; a high-level, double-balanced mixer; a low-noise, wide-band RF amplifier, and a high-stability VCO unit, to obtain maximum performance.

The user price for the AR-2002 is $499.00, and further details can be obtained from Ace Communications, Inc., 22511 Aspan Street, Lake Forest (El Toro), CA 92630-6321.

Advanced scanner enthusiasts will immediately appreciate some of the features on the AR-2002 that were included in response to suggestions from scanner users regarding the things they'd like to see most in a *dream* scanner, including the signal-strength indicator, front-panel headphone jack, and knob-controlled dial-type, continuously-variable tuning. This is a unit that should have high appeal for those who are seeking something rather sophisticated in a scanning receiver. Something more than a little different in all respects. We especially like its ability to tune the 225 to 400 MHz UHF aero band.

Signal Search

More than a few readers have written in to ask for some of our thoughts on the use of the *search/scan* feature of a scanning receiver, inasmuch as equipment manuals never seem to provide anything more than a few brief sentences on the topic.

Actually, it's a great feature in a scanner and it's too bad that it's so little-understood and under-used. You can use it to discover all sorts of unlisted and unknown frequencies that are in use in your area.

First you select a target group of frequencies to explore, let's say 153.00 to 156.00 MHz, popularly used by public-safety agencies. But don't try to search through that much of the spectrum in one fell swoop. Check through it in increments of no more than 500 kHz at a time, starting with 153.00 to 153.50 MHz. By attempting to search through too large a chunk of the spectrum, you diffuse the focus of your intensive search and will probably miss out on some of the transmissions you're trying to discover.

The Ace Communications AR-2002 has a 20-channel memory scan, priority scan, band search, multi-mode reception, conventional dial tuning, selectable frequency increments, and a bargraph signal-strength indicator.

Once you start your search, make certain that (if your scanner offers you a choice of fast or slow channel scanning) you are checking through the frequencies as rapidly as possible. Slow scanning, in general, has few reasons to exist at all since it doesn't seem to serve any practical purpose.

Next, be prepared to spend (at the very minimum) a full day or two concentrating on each of your 500-kHz band segments. Some scanning experts will spend at least a week with each segment, keeping careful records regarding every frequency noticed in use, and whether the stations monitored are known or unknown, local or distant, base or mobile, plus the type of transmissions (police, fire, medical, or whatever), hours of maximum frequency usage, number of transmissions per hour, and so on. At the end of such a search, you should have a fairly complete picture of those communications that can be monitored from your location.

Admittedly, doing that right will take some time. On the other hand, it's your hobby, it's enjoyable, you're likely to come up with all sorts of new frequencies to regularly monitor, and there really isn't anything pressing you to complete the search by a deadline date. Search at your leisure, whenever the mood strikes you; start at 30 MHz and aim towards 512 MHz and beyond! Why not?

Those are the things that the instruction manuals never tell you. We think that knowing such techniques will greatly increase your enjoyment of scanning.

From The Mail Sack

A member of the US Navy stationed at the Norfolk, VA Naval Base writes to say that USN tugs are very active in the harbor area. He says that he's monitored every possible VHF marine (156 MHz) band channel in an effort to latch onto those harbor operations, but he still can't find the frequency used for their communications. He asks if we can possibly locate the mystery frequency.

The tugs are dispatched on 142.05 MHz, and can also be heard operating on 141.95 MHz (Channel 1), on 142.65 MHz (Channel 2), and 142.00 MHz (possibly called Channel 3). Those are military frequencies that lie outside the regular VHF marine-frequency band, that's why you couldn't locate them.

Those who have written to ask where they can get a listing of the police "10 Codes," can obtain one at no cost by requesting the same from CRB Research, PO Box 56-TC, Commack, NY 11725.

We're always looking for questions, photos, and suggestions from our readers. Our address is Marc Saxon, Saxon on Scanners, **Hands-On Electronics** Magazine, 500-B Bi-County Blvd., Farmingdale, NY 11735. ■

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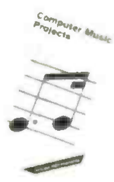

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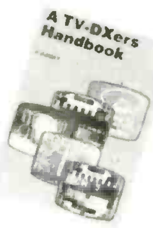

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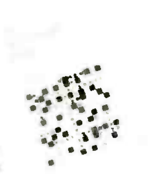

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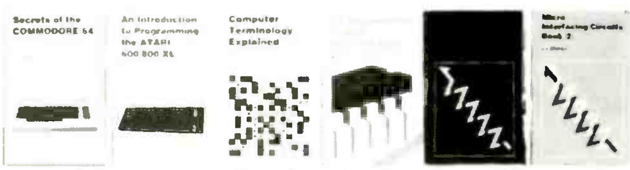

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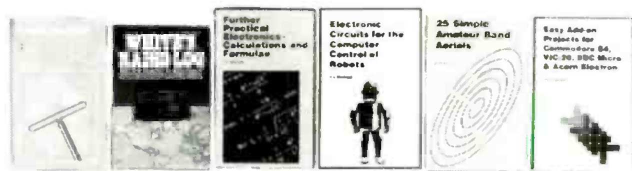

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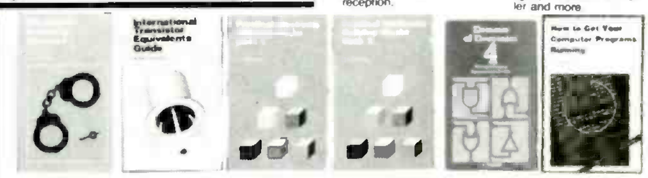

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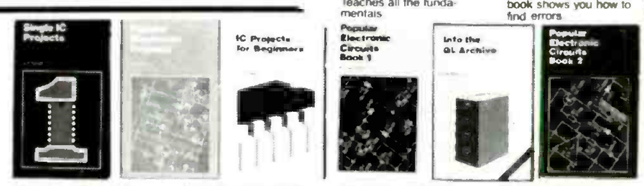

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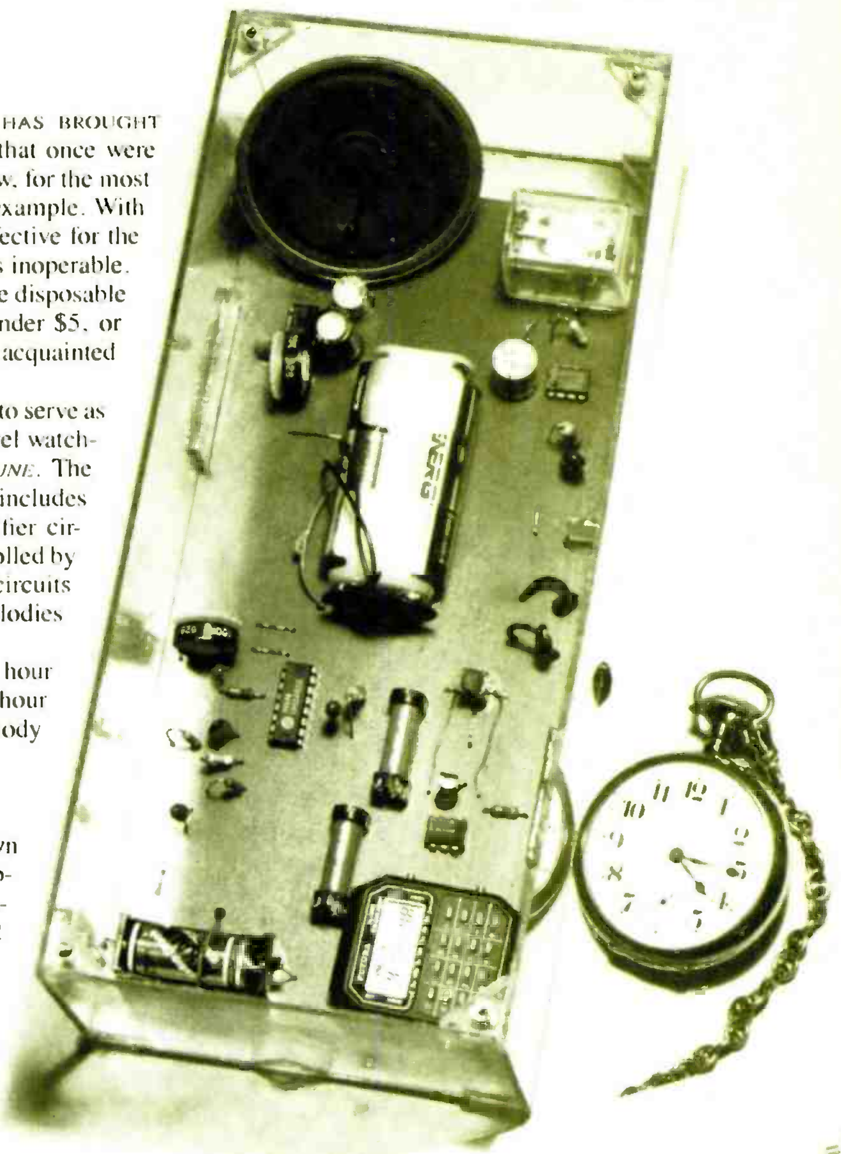
Hands-on Electronics
JUNE 1987

HOURTUNE

Take one LCD watch, add it to this circuit, and you'll be serenaded by a different tune at the stroke of each hour

By Robert E. Damm



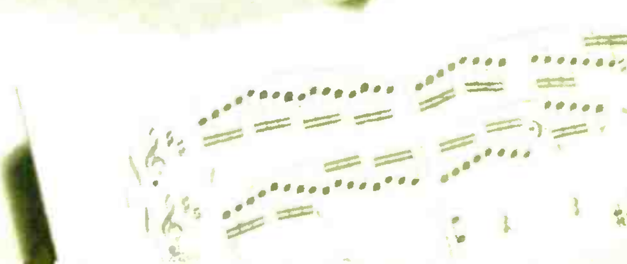
☐THE DEVELOPMENT OF THE INTEGRATED CIRCUIT HAS BROUGHT about many changes in our purchasing habits. Things that once were bought, maintained, and repaired when necessary are now, for the most part, disposable items. Take the black and white TV for example. With many of them selling for $60 or less, it is more cost effective for the consumer to toss it rather than repair it when it becomes inoperable. The digital watch is another item that has fallen prey to the disposable syndrome—with very inexpensive models selling for under $5, or assorted firms giving them away as an incentive to get you acquainted with their product.

Well, if have an old LCD watch whose only purpose is to serve as a dust collector, why not pull it out and use it in this novel watch-controlled melody-generator project. We call it *HOURTUNE*. The project consists of four simple circuits: a trigger (which includes the LCD watch), timer, melody synthesizer, and amplifier circuits. The key circuit is the trigger circuit (which is controlled by the LCD watch). That circuit turns on the other three circuits once each hour, just long enough for one of the twelve melodies contained in the melody synthesizer to be played.

At the end of the tune, the circuit turns itself off for an hour to conserve its power supplies. Then, when the next hour arrives, it turns itself on again and plays a different melody etc. Let's see how HourTune does its thing.

A Look at the Circuit

A schematic diagram of the HOURTUNE circuit is shown in Fig. 1. The trigger circuit is made up of seven components: an LCD watch with a chime function, an optoisolator/coupler (U1), transistor (Q1, a 2N2222 general-purpose), a resistor (R10), two 5-volt reed relays (K1 and K2), and a switch (S1). The trigger circuit is powered by the plug-in wall transformer and the battery contained in the wrist watch.



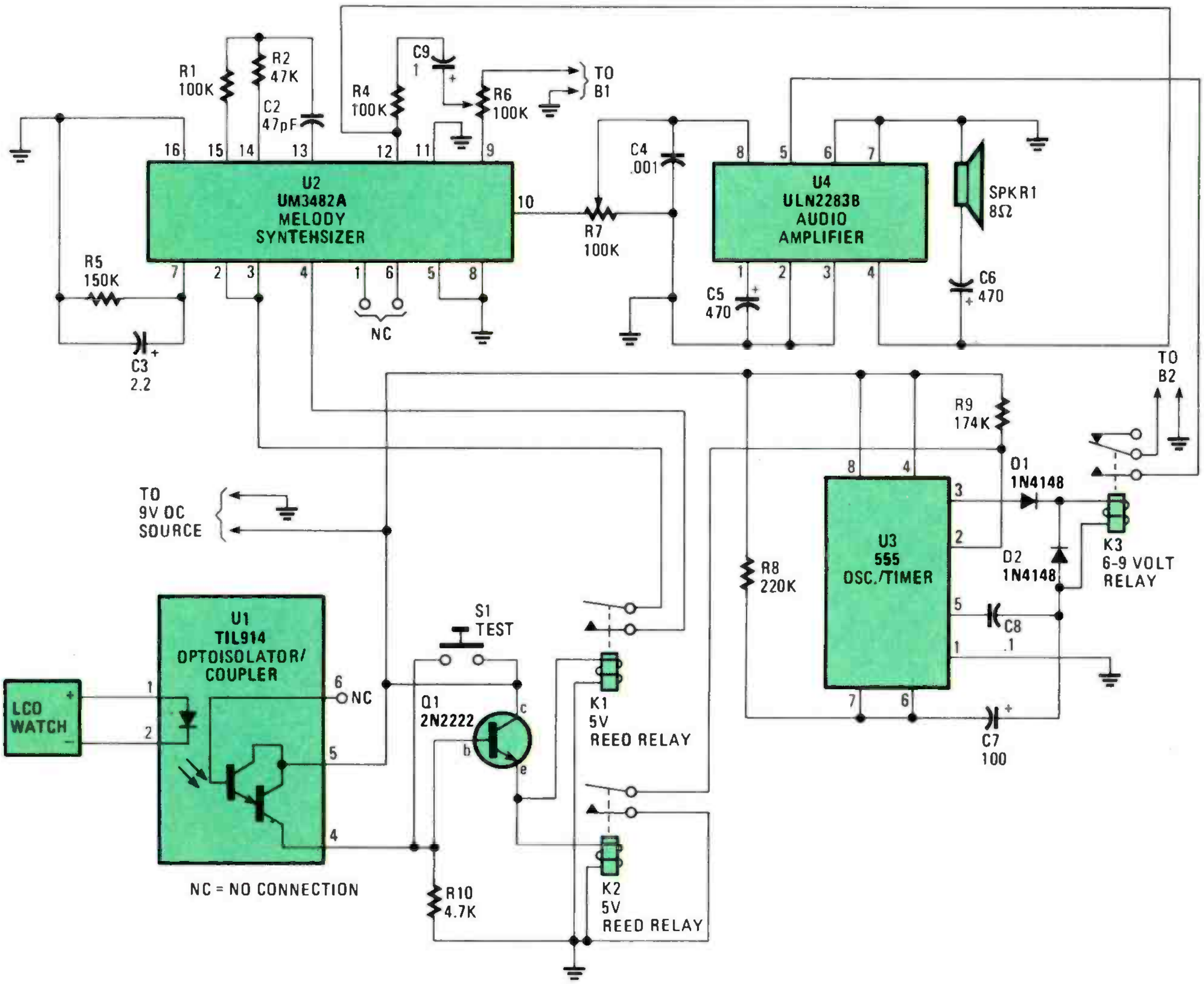


Fig. 1—HourTune, a wristwatch-controlled melody generator, is comprised of four subcircuits; a trigger circuit (which includes the LCD wristwatch), the melody circuit (consisting of U2 and a couple of support components), the timer (built around a 555 oscillator/timer), and the amplifier (a ULN2283B low-power audio amplifier chip).

The LCD watch's chime-triggering circuitry is connected to the input of an optoisolator/coupler (U1) so that the chime-trigger signal turns on U1's internal LED. Light radiation from the LED falling on the light-sensitive area of the U1's Darlington-output element causes it to turn on, thereby closing the contacts of reed relays K1 and K2. Relay K1 has its two contacts connected to U2 pins 2/3 and pin 4, which when closed, enables the chip and causes it to advance to the next tune.

Relay K2 has one contact tied to ground and the other connected to the trigger input (pin 2 of U3) of timer circuit, so that when the LCD watch outputs a chime-trigger signal timing begins. The timer—built around a 555 oscillator/timer—is configured to remain on for 29 seconds after it receives a pulse from the relay. The purpose of the timer circuit is to turn on the amplifier through relay K3.

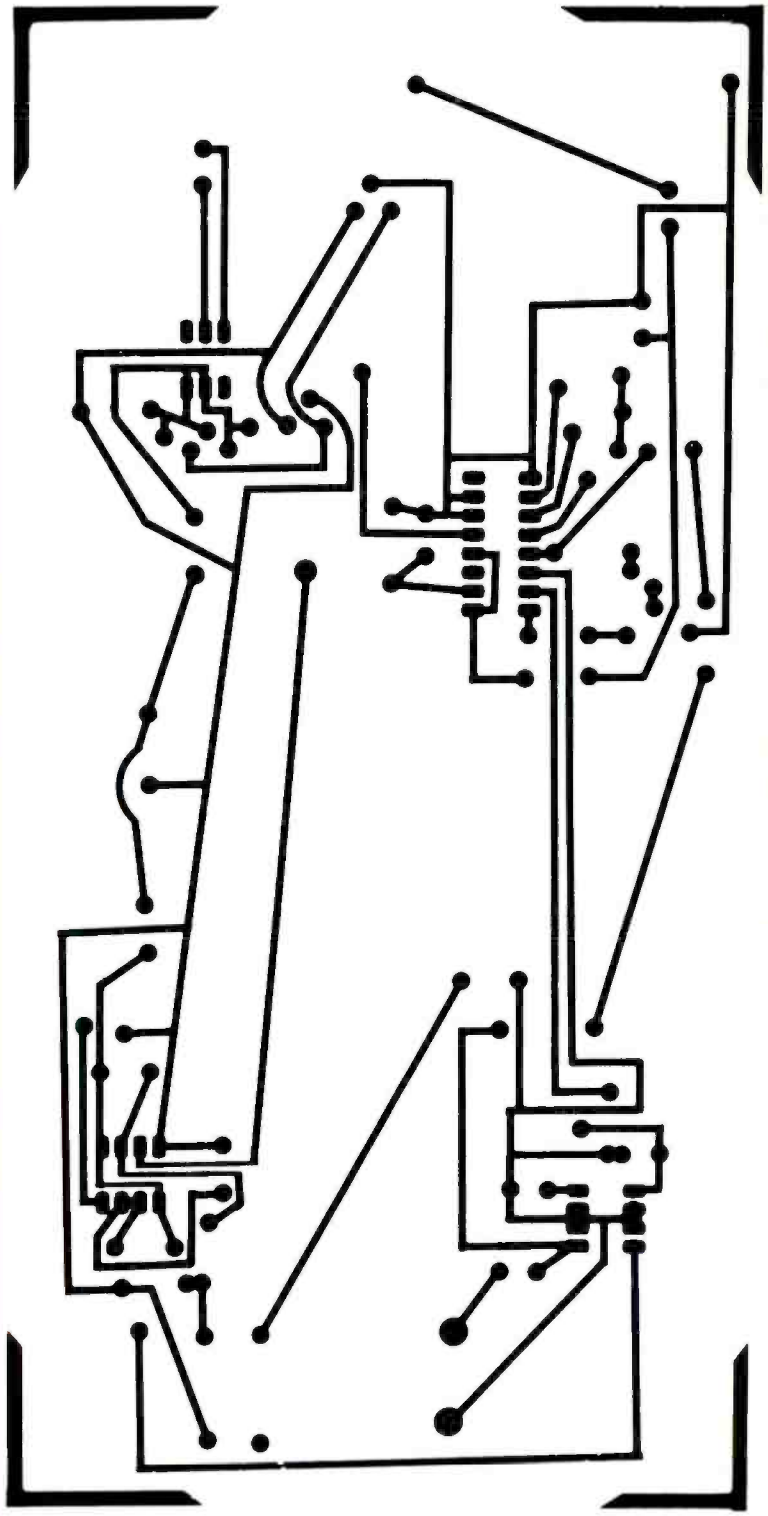
Initally I used a nine-volt battery to power the timer and trigger circuits, but that proved unsuitable because battery life was short; lasting only about a week and a half—and that just ain't good enough. So, I decided in favor of a wall-mounted DC power pack, like the type used for video games, etc. The transformer used in the final version was salvaged from an old in-line amplifier (ARCHER 15-1117 Model PI-001), with a rating of 9-volts DC at 10 mA. I also tried a charging transformer (taken from an old grass-shear) with a rating of 7.5 volts DC at 125 mA, and it worked fine.

The timer controls the amplifier circuit (which is built around U4, a ULN2283B low-power audio amplifier) through relay K3. When K3's contacts close, power is supplied to the +V input of U4, turning it on. The amplifier circuit (which has a low quiescent current drain) is powered by two "AA" penlight batteries.

Now for the final circuit; the Melody Generator UM-3482A (U2), which contains 12 tunes, is turned on by reed relay K1 and it is wired according to the general application which is packaged with the chip, except that pins 2, 3, and 4 are hard wired into a configuration that assures that each hour will change the tune and it will auto stop after one tune. The chip is powered by an N-type battery, B1.

The momentary pushbutton switch, S1, is used to re-cycle the tunes that you will hear and to test the circuits operation. Since the LCD wristwatch gives a double pulse, each time the chime goes off, it causes the generator to play every second tune—in other words, you hear six of them over and over. All you need do is insert a tune when you wish by pressing S1, allowing you to hear the other six.

Fig. 2—If you decide to go the printed-circuit route, this full-scale template made for HourTune can be lifted or copied from the page and used to etch your own printed-circuit board. The simplest method of producing the circuit board is to use Lift-It film to pluck the circuit pattern from the page. Then using the Positive Photo-resist method of printed-circuit preparation, you can etch your own circuit board.



PARTS LIST FOR HourTune

SEMICONDUCTORS
D1–D2—1N4148 small-signal silicon diode
Q1—2N2222 transistor (Radio Shack # 276-2009)
U1—TI914 optoisolator/coupler (Radio Shack # 276-139)
U2—UM3482A melody generator (Radio Shake # 276-1797)
U3—NE555 oscillator/timer (Radio Shack # 276-1728)
U4—ULN2283B low-power audio amplifier (see text)

RESISTORS
(All resistors ¼-watt, 5% fixed units unless otherwise noted.)
R1–R4—100,000-ohm
R2—47,000-ohm
R3—470,000-ohm
R5—150,000 ohm
R6–R7—100,000-ohm, trimmer potentiometer
R8—220,000-ohm
R9—174,000-ohm
R10—4700-ohm

CAPACITORS
C1–C3—2.2-µF, 16-WVDC, Tantalum
C2—47-pF, ceramic disc
C4—0.001-µF ceramic disc
C5–C6—470-µF, 16-WVDC, electrolytic
C7—100-µF, 16-WVDC, electrolytic
C8—0.01-µF, mylar
C9—1-µF, 16-WVDC, Tantalum

ADDITIONAL PARTS AND MATERIALS
B1—N-cell battery and holder
B2—AA-cell battery and holder
K1, K2—Relay, 5-volt reed-type (Radio Shack # 275-232)
K3–K6—Relay, 9-volt coil (Radio Shack # 275-004)
LCD1—LCD wristwatch (see text)
S1—Normally-open, momentary contact pushbutton switch
SPKR1—miniature 8-ohm speaker
T1—9-volt DC plug-in wall transformer (see text)
Printed-circuit board material or prefboard, etching solution, plastic case, wire, solder, hardware, etc.
Note: All parts for HourTune, except for the ULN2283B audio amplifier, are available from local or mail-order parts stores. The amplifier is available—by mail order, priced at $1.40—from Circuit Specialist Co., PO Box 3047, Scottsdale, AZ 85257.

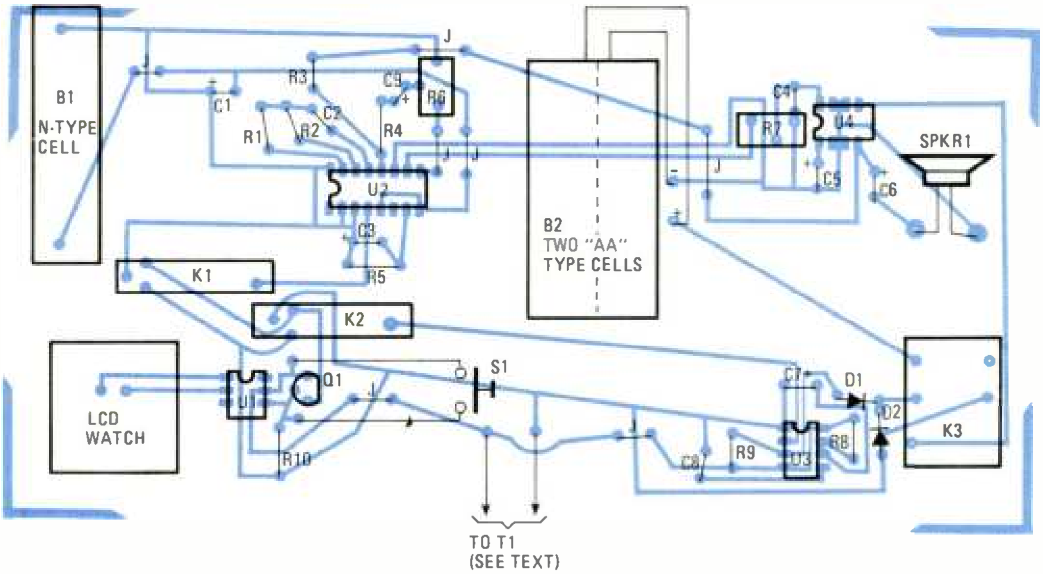
Watch Preparation

The first thing that must be considered before HourTune can be started is the LCD wristwatch. The watch must have an hourly chime function—a feature that's incorporated into many inexpensive watches on the market today. So it should be no problem to find a suitable one. In fact, you probably have one lying around somewhere. The one I used for the project was sent to me by a vitamin company as an incentive when I purchased their product.

I also purchased ten watches from a west coast electronics company for $0.39 each, and every one of them is suitable for the circuit even though they are factory rejects.

In preparing the watch, first remove the back and take out the piezo sounder disk. Carefully solder a length of wirewrap wire to each terminal that had previously made contact with the disk. Drill two small holes in the watch back, thread the wires through the holes, and close the case. Connect an LED

Fig. 3—Once the printed-circuit board has been etched and drilled, stuff the board using this parts-placement diagram as a guide. Start with the passive components—resistors, capacitors, etc—advancing to the semiconductors.



to the wires and activate the chime. The LED should flash regardless of how you hook it up. However, it is recommended that you reverse the leads and try it again, because when the polarity is correct, the flash will be more intense.

A voltmeter can be used to determine the polarity, but by using an LED, you can be more sure that the watch will operate the optoisolator/coupler. When you connect the watch to the board be sure that you connect the positive and negative leads correctly to the optoisolator/coupler. If the watch has a metal back be sure to use a small piece of plastic tape on the inside surface of the back to prevent shorting out now that the piezo disk has been removed.

If the watch has been lying around for a while, replace the battery while you have it apart. Remember also that strange things occur in some LCD watches when the battery gets weak, it might keep perfect time, but other functions go haywire. Replace the battery and everything straightens out again. Lay the watch aside for now and go ahead with confidence that you're home free.

Printed-Circuit Board Construction

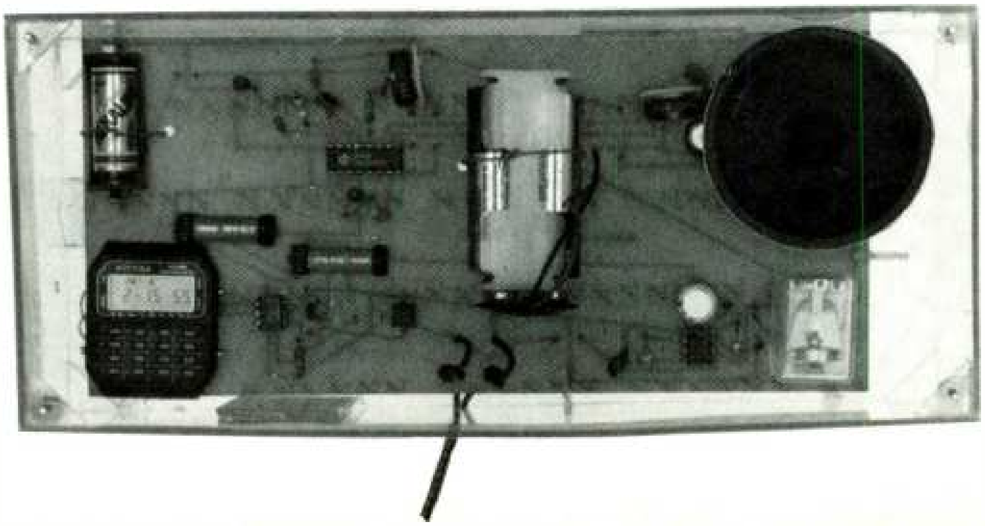
Next prepare the printed-circuit board so that HourTune can be assembled. A template of the printed-circuit board is shown in Fig. 2. The simplest method of producing the circuit board is to use Lift-It film (a clear acrylic film with an adhesive back) to pluck the circuit pattern from the page. Then using the Positive Photo-resist method of printed-circuit preparation, along with the pattern on the Lift-It film, you can etch your own circuit board. (Lift-It film is available at many electronic hobby stores, as well though mail-order suppliers.)

Another method (which you may find to your liking) is to use direct-etch dry transfers, which are available from Radio Shack and by mail order, to lay the circuit out on a copper-clad slug (unetched board) using Fig. 2 as a guide. Or you could layout the components on perfboard, and use point-to-point wiring to complete HourTune according to the schematic diagram (Fig. 1).

If you decide to go the printed-circuit route, stuff the board using Fig. 3 (the parts-placement diagram) as a guide. Start with the passive components; resistors, capacitors, etc. Then move on to the semiconductors. Don't forget to add the jumper connections (labeled J). Once that's done, begin mounting the battery holders (an N-type for B1 and a dual AA-type for B2), wristwatch, and speaker. Use a small piece of double-sided foam tape to attach the watch to the lower left-hand corner of the board and leave about three inches of wire coiled up underneath it, just in case you have to lift it a bit to change the battery or reset it.

Glue SPKR1 to the board in the upper right corner. Glue an N-type battery holder to the board in the upper left corner for B1. The battery holder for B2 can lay in the middle of the board, secured in place by drilling two holes through the board and using a length of wire to tie it down. Finally, cut a couple inches from a plastic drinking cup and place it over the speaker cone and it will greatly increase the volume.

With every thing now in place, power up HourTune and take is for a test run. Press S1; you should hear a click from the relays, followed by a tune from SPKR1. If all seems OK, press S1 again to check that the circuit toggles to the next tune. If that checks out, box the circuit in a housing of your own choosing. Now you can play HourTune. ■



HourTune can be used to provide a melodic doorbell by connecting the doorbell switch in parallel with S2. For greater volume, a more powerful amplifier can be used to drive the speaker.

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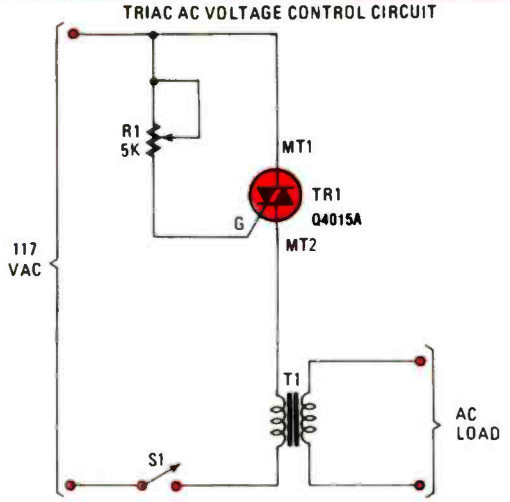
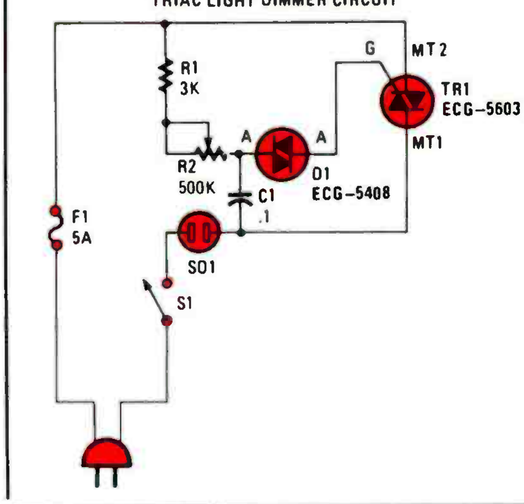
TRIAC AC VOLTAGE CONTROL CIRCUIT



TRIAC LIGHT DIMMER CIRCUIT



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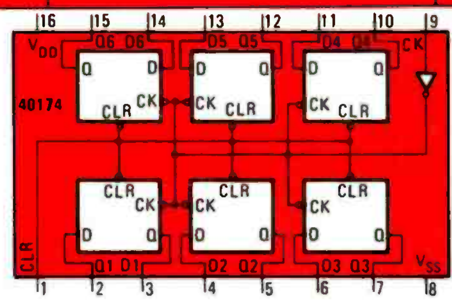

Truth Table

INPUTS			OUTPUTS	
CLEAR	CLOCK	D	Q	$\bar{Q}$
Low	X	X	Low	High
High		High	High	Low
High		Low	Low	High
High	High	X	NC	NC
High	Low	X	NC	NC

Features

- Wide supply voltage range — 3V to 15V
- High noise immunity — 0.45 V_{DD} (typ.)
- Low power TTL compatibility — fan out of 2 driving 74L or 1 driving 74LS

Absolute Maximum Ratings

V_{DD} Supply Voltage	−0.5 to +18V
V_{IN} Input Voltage	−0.5 to V_{DD} +0.5V
T_S Storage Temperature Range	−65°C to +150°C
P_D Package Dissipation	500 mW
T_L Lead Temperature (Soldering, 10 seconds)	260°C

Recommended Operating Conditions

V_{DD} Supply Voltage	3 to 15V
V_{IN} Input Voltage	0 to V_{DD} V
T_A Operating Temperature Range	−55°C to +125°C −40°C to +85°C

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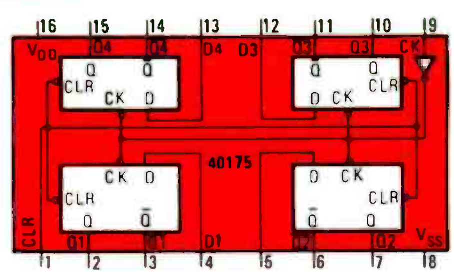
39 Hands-on Electronics FactCard — 40175: Quad D-Type Flip-Flop



Truth Table

INPUTS			OUTPUTS	
CLEAR	CLOCK	D	Q	$\bar{Q}$
Low	X	X	Low	High
High		High	High	Low
High		Low	Low	High
High	High	X	NC	NC
High	Low	X	NC	NC

Features

- Wide supply voltage range — 3V to 15
- High noise immunity — 0.45 V_{DD} (typ.)
- Low power TTL compatibility — fan out of 2 driving 74L or 1 driving 74LS

Absolute Maximum Ratings

V_{DD} Supply Voltage	−0.5 to +18V
V_{IN} Input Voltage	−0.5 to V_{DD} +0.5V
T_S Storage Temperature Range	−65°C to +150°C
P_D Package Dissipation	500 mW
T_L Lead Temperature (Soldering, 10 seconds)	260°C

Recommended Operating Conditions

V_{DD} Supply Voltage	3 to 15V
V_{IN} Input Voltage	0 to V_{DD} V
T_A Operating Temperature Range	−55°C to +125°C −40°C to +85°C

37 Hands-on Electronics FactCard — Triac Circuits/ Replacement Guide

TRIAC REPLACEMENT GUIDE

DEVICE	V_{RRM}	I_T	CASE STYLE	ECG	RCA	NTE/TCG
Q4015L5	500V	4A	TO-126	5606	—	5606
Q6015L5	400V	8A	TO-220	—	—	5608
Q200E3	200V	1A	TO-92	5655	5555	—
Q400E3	400V	1A	TO92	5656	5556	—
Q4003L3	400V	3A	TO-220AB	5638	5538	—
Q2004F41	200V	4A	TO-202AB	5629	—	—
Q4004F41	400V	4A	TO-202AB	5629	—	—
Q4004L4	400V	4A	TO-220AB	5645	5545	—
Q2006L4	200V	6A	TO-220AB	5645	5545	—
Q4006A	600V	15	TO-3	5649	—	—
Q2008H	400V	15A	TO-48	5675	3508	—
Q4008LT	600	10A	TO-220	5646	—	—
Q2010H	200V	15A	TO-48	5673	5173	—
Q4010H	400	15A	TO-48	5675	3508	—
Q2015LT	600V	10A	TO-220	5646	—	—
Q4015A	600V	15A	TO-3	5649	—	—

38 Hands-on Electronics FactCard — 40174: Hex D-Type Flip-Flop

STATIC ELECTRICAL CHARACTERISTICS

CHARACTERISTIC	CONDITIONS V_O (V)	V_{IN} (V)	V_{DD} (V)	LIMIT at 25°C (TYP)	UNITS
Quiescent Device	—	0,5	5	0.02	
Current,	—	0,10	10	0.02	μA
I_{DD} Max	—	0,15	15	0.02	
Output Low	0.4	0,5	4.5	5.2	
(Sink)	0.4	0,5	5	6.4	
Current	0.5	0,10	10	16	
I_{OL} Min.	1.5	0,15	15	48	mA
Output High	4.6	0,5	5	−1.2	
(Source)	2.5	0,5	5	−3.9	
Current	9.5	0,10	10	−3.0	
I_{OH} Min.	13.5	0,15	15	−8.0	
Input Current I_{IN} Max.	—	0,18	18	$\pm 10^{-5}$	μA

CHARACTERISTIC	CONDITIONS V_O (V)	V_{IN} (V)	V_{DD} (V)	LIMIT at 25°C (TYP)	UNITS
Output Voltage	—	0,5	5	0	
Low-Level	—	0,10	10	0	
V_{OL} Max.	—	0,15	15	0	
Output Voltage	—	0,5	5	5	V
High-Level,	—	0,10	10	10	
V_{OH} Min.	—	0,15	15	15	
Input Low	0.5	—	5	—	
Voltage,	1	—	10	—	
V_{IL} Max.	1.5	—	15	—	
Input High	4.5	—	5	—	V
Voltage	9	—	10	—	
V_{IH} Min.	13.5	—	15	—	

39 Hands-on Electronics FactCard — 40175: Quad D-Type Flip-Flop

STATIC ELECTRICAL CHARACTERISTICS

CHARACTERISTIC	CONDITIONS V_O (V)	V_{IN} (V)	V_{DD} (V)	LIMIT at 25°C (TYP)	UNITS
Quiescent Device	—	0,5	5	0.02	
Current,	—	0,10	10	0.02	μA
I_{DD} Max	—	0,15	15	0.02	
Output Low	0.4	0,5	4.5	5.2	
(Sink)	0.4	0,5	5	6.4	
Current	0.5	0,10	10	16	
I_{OL} Min.	1.5	0,15	15	48	mA
Output High	4.6	0.5	5	−1.2	
(Source)	2.5	0,5	5	−3.9	
Current	9.5	0,10	10	−3.0	
I_{OH} Min.	13.5	0,15	15	−8.0	
Input Current I_{IN} Max.	—	0,18	18	$\pm 10^{-5}$	μA

CHARACTERISTIC	CONDITIONS V_O (V)	V_{IN} (V)	V_{DD} (V)	LIMIT at 25°C (TYP)	UNITS
Output Voltage	—	0,5	5	0	
Low-Level	—	0,10	10	0	
V_{OL} Max.	—	0,15	15	0	
Output Voltage	—	0,5	5	5	V
High-Level,	—	0,10	10	10	
V_{OH} Min.	—	0,15	15	15	
Input Low	0.5	—	5	—	
Voltage,	1	—	10	—	
V_{IL} Max.	1.5	—	15	—	
Input High	4.5	—	5	—	V
Voltage	9	—	10	—	
V_{IH} Min.	13.5	—	15	—	

NiCd's

NiCd's are all the rage. Build this simple, penny-sized charger and get in on the savings and the fun

By Robert Grossblatt

THE FIELD OF ELECTRONICS COVERS A LOT OF TERRITORY, but everything in it—from an official Star Wars flashlight to the official Star Wars Defense System—has one thing in common: the need for power. There's a big difference between firing up a nuclear reactor and breaking open a blister pack, but if you want to move electrons around, you need something to push them. The trend in electronics today is to do more with less energy and, as a result, more and more circuits are using batteries. The response of the battery industry has been to develop new chemistries, new cells, and unfortunately, new prices.

Putting in a new set of batteries can be an expensive proposition and if it becomes a major item in your monthly budget, you should get familiar with NiCd's. They may be more expensive to start out with but, if you take care of them properly, they'll wind up being a lot cheaper in the long run. NiCd's aren't "set-them-and-forget-them" batteries. If you don't give them what they want, they won't give you what you want—a reliable source of power. Fortunately, their demands are small and, once you understand how they work, you'll see that it doesn't take much to make them happy.

What's a NiCd?

Figure 1 is a cut-away view of a typical NiCd cell. A strip of absorbent nylon is sandwiched between a strip of nickel and a strip of cadmium hydroxide. All three are then wound together in a tight spiral and put into a nickel-plated steel container. The cadmium-salt electrode is connected to the case as the negative electrode, and the nickel strip is connected to the positive-electrode cap on top of the battery. The insulator and separate nylon seal used between the case and the cap isolate the two electrodes and prevent the alkaline electrolyte in the nylon separator from evaporating.

A NiCd cell has a basic voltage of 1.25 volts and one of the reasons its chemistry is so popular is because that voltage is independent of the discharge rate and is constant through some 90% of the charge life. A disposable alkaline cell starts life at 1.5 volts, but it doesn't stay that way for long. The rate of voltage drop depends on current draw, but whatever it is, not much of the alkaline's life is spent at 1.5 volts. As a result, you can be reasonably certain that if a circuit works with disposables, it will work with NiCd's as well.

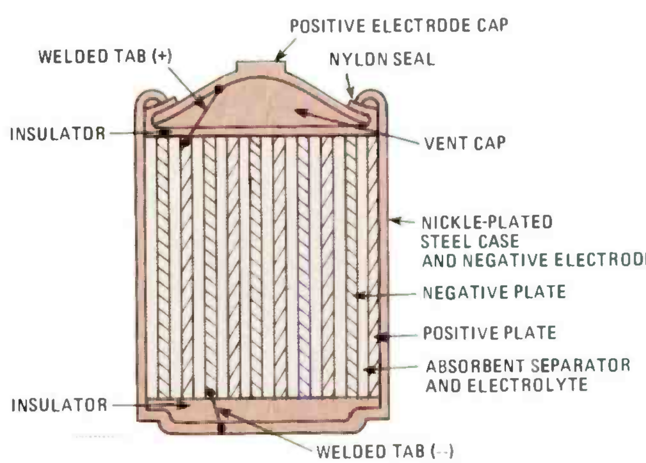
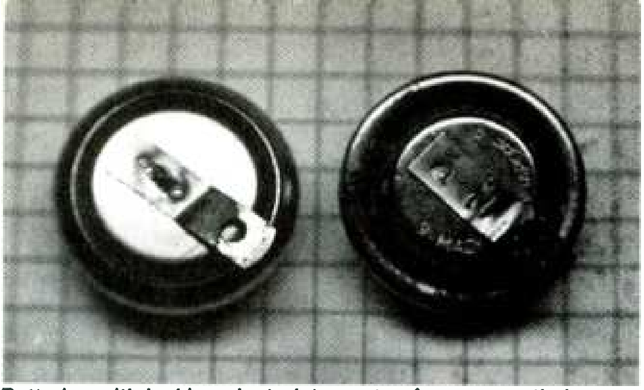


Fig. 1—This cut-away view of a NiCd is misleading since it makes the positive plate, absorbent separator, and negative plate appear to be in pieces. Each actually is a continuous strip or layer wrapped up to fit inside the steel case.



Batteries with leaking electrolyte are too far gone as their seal is no longer effective. Note that the tabs on the batteries indicate that they came from a blister pack.

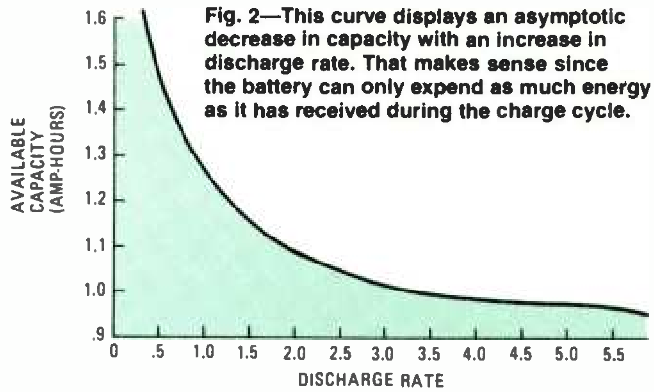


Fig. 2—This curve displays an asymptotic decrease in capacity with an increase in discharge rate. That makes sense since the battery can only expend as much energy as it has received during the charge cycle.

Care and Feeding

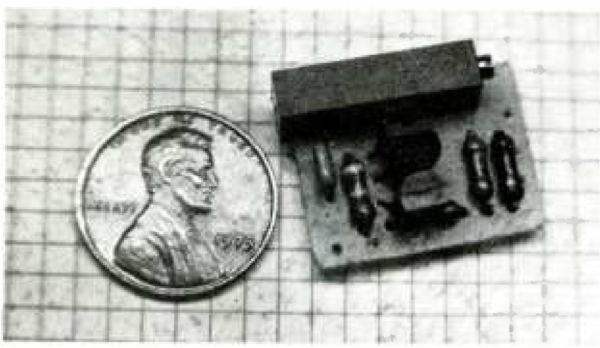
The trickiest part of living with NiCd's is charging them. As a matter of fact, the most common reason for the premature death of a NiCd is undoubtedly incorrect charging parameters. Just about the only thing you can damage by under charging is your patience, but an overcharge can lead to all sorts of problems. The chemical reaction that takes place during the charging cycle generates hydrogen and oxygen as biproducts. The higher the charging current, the more rapidly the gas is produced. Now, if you think about it for a minute, you'll realize that gas build-up is the last thing you want in a sealed container. A straight application of Mr. Boyle's Law will tell you that as the temperature goes up, the pressure goes up, and, at the end, the battery blows up.

In a modern NiCd, hydrogen (which is generated at the negative cadmium cathode) is never produced because the cell is designed so that the electrode never reaches full charge. The anode, however, *will* produce oxygen, but the cell has a mechanism to handle that. As the gas is generated, it permeates through the nylon separator strips and oxidizes the metallic cadmium to cadmium hydroxide, which is then reduced back to metallic cadmium by the electrolyte. The pressure in the cell at equilibrium depends on the rate of charge but is kept between 7 and 15 *PSI*.

Caution

NiCd chemistry is extremely reliable and can forgive just about anything, but if you overcharge a NiCd at an excessive rate, you're sure to damage it. Either you'll rupture the nylon separator or cause the outer seal to blow. If the seal opens up the electrolyte will start to evaporate and that's usually the end of the battery. That is much the same thing as losing acid in a car battery, and it causes the same sort of damage to the electrodes. You can always replenish the acid in a car battery, but there's no way to add electrolyte to a NiCd.

If the separator strips are ruptured, there's a good chance that some of the metallic salts have migrated through the ruptures and formed small conductive bridges connecting the nickel and cadmium electrodes. That will effectively short out some of the electrodes and destroy some of the battery's ability to store electricity. As we'll see later on, if you've lived a clean life, you can *sometimes* repair that kind of damage. The battery won't be as good as it once was, but it won't be totally useless either.



This little charger may be tiny but it can go a long way toward saving you some bucks. It can be configured for any desired charge rate (current) and voltage.

Charging

The amount of energy you can expect from a NiCd is specified in either AH (amp-hours) or mAH (milliamp-hours). Since the voltage of a NiCd is constant over most of the life of its charge, NiCd's are usually thought of as current sources; that's why their rating is a function of a certain amount of current for a certain length of time. The more current you draw from the cell, the shorter the time it can supply it. As you can see from Fig. 2, however, the amount of current draw has an effect on the capacity of the cell. The heavier the draw, the lower the effective AH.

The safe discharge varies from NiCd to NiCd and is expressed by how long it takes a fully-charged cell to drop to a cutoff of 1 volt. If the current draw is such that it takes 10 hours for the cell to get there, it has a C10 discharge rate; if it takes 2 hours, it has a C2 rate, and so forth.

Charging rates are referred to in the same way. A cell with a rated capacity of 1.2 AH being charged with a current of 120 mA, is said to be charging at a C10 rate; the C3 rate would be 400 mA; the C2 rate would be 600 mA, etc.

Words you usually hear when you're talking about NiCd charging are *trickle*, *standard*, and *quick*. If you get into using NiCd's, make yourself a permanent copy of Table 1.

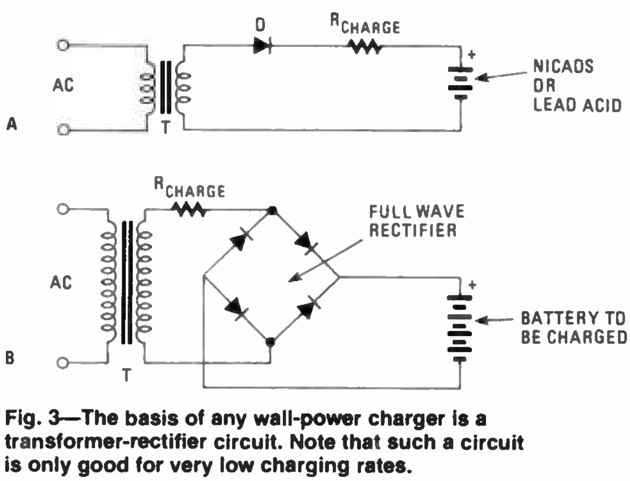


Fig. 3—The basis of any wall-power charger is a transformer-rectifier circuit. Note that such a circuit is only good for very low charging rates.

TABLE 1—CHARGING PARAMETERS FOR NiCd BATTERIES

Charge Type	Current (% of Capacity)	Charge Time (Hours)	Charge Current I_C	Charge Resistor R_C
Rapid*	100%	1-3		
Quick*	20%-50%	12-20		
Standard	10%-20%	10-18		
Trickle	1%-10%	Continuous		

*Not recommended for all cells—check data book

The numbers there relate specific charging rates to the vague terms listed on the blister packs. The last two columns are blank since they relate to specific cells. You should fill them in and keep them near your charger(s).

Don't let all that stuff put you off using NiCd's. Even though there are a lot of theoretical things to keep in mind, the practical side of NiCd's is simple. The circuitry you need to charge them is tinker-toy level, and component values can be calculated with nothing more complicated than Ohm's Law and some third grade arithmetic. So let's roll up our sleeves and get our hands dirty.

Charger Parameters

NiCd charging circuits are a piece of cake. Figure 3 shows two schematics for the world's simplest chargers. Once we know what's going on there, we'll see about adding a couple of bells and whistles. There are some basic rules to follow when you put one of the circuits together: (1) The output of the transformer has to be between two and three times the voltage of the battery. (2) Use a diode with a PIV of twice the transformer output and capable of carrying the charging current. (3) The wattage of the current-limiting resistor has to be large enough to safely handle the transformer output voltage and charging current.

The best way to see how easy it is to figure out the component values is to go through a real example. All you'll have to do for your particular setup is substitute your own numbers for those we'll use. Use the same format, do it in the same order, and you'll have no trouble at all. Let's say we have a 12-volt NiCd pack, rated at 1.2 AH, and want to charge it at the C4 rate (300 mA). Here's the step-by-step run down:

$$\text{Battery Voltage} = V_b = 12 \text{ volts}$$
$$\text{Charging Current} = I_c = 300 \text{ mA}$$

$$\text{Transformer Output} = V_t = 2 \times V_b$$
$$= 24 \text{ volts (minimum)}$$

$$\text{Diode PIV} = 2 \times V_t = 48 \text{ volts (minimum)}$$

$$\text{Resistor Wattage} = V_t \times 300 \text{ mA}$$
$$= 7.2 \text{ watts (minimum)}$$

$$\text{Resistor Value} = R_c = (V_t - V_b)/300 \text{ mA}$$
$$= 40 \text{ ohms (minimum)}$$

And that's all there is to it!

Obviously, the calculated values have to be converted into real-world ones. You may know where to get a 40-ohm, 7.2-watt resistor, but a 47-ohm, 10-watt one is a lot easier to find—even Radio Shack has them!

You'll get a more efficient charging circuit by replacing the diode with a fullwave bridge, but the arithmetic is exactly the same as in our example. Chances are you'll want to use a standard battery eliminator as the charging source. That is fine as long as you get the correct V_t and I_c.

Using charging rates higher than C4 is an iffy business. You'll need something to monitor the battery and cut I_c when the battery is completely charged. That is easier said than done since the value of V_b isn't a good indicator of the state of charge. A dead NiCd gets up to it's nominal voltage early on in the charge cycle. The only factors that reliably indicate overcharge are, as we've already seen, pressure and temperature. Most commercial rapid chargers have temperature sensors that cut the charge rate if the cell temperature reaches a certain point. The risk of cell damage, the complexity of the needed circuitry, and the fact that not all NiCd's can be rapidly charged leads inevitably to the conclusion that rapid charging is a good thing to avoid. If you think that you can't live without it, get a set of data sheets from the NiCd manufacturers.

An Advanced System

Once you have a working charger, it's nice to have some indicators on it to let you know what the circuit is doing. A lot of commercial chargers have a power indicator, but they're really misleading. The light tells you that the charger is powered up, but it doesn't tell you whether the battery is taking a charge. It would also be nice to be told when the batteries need a charge. All that can be done by the circuit shown in Fig. 4. If you use NiCd's, you'll find it's well worth your time to build and keep one at each place where you use NiCd's.

The first part of the circuit is composed of Q1, R1, and R2. The transistor has its base-emitter junction straddling R2. J1 is wired so that when you plug in the charger, the current goes through R2 on its way to the battery. The voltage drop across R2 turns on Q1 and LED1 will light up. But there's more to that than meets the eye. A lit LED not only tells you that current is going to the battery, but if you pick R2 carefully, it can tell you about the battery's state of charge as well. As the battery charges up, less and less current will flow into it and LED1 will get dimmer and dimmer.

You'll have to calculate the value of R2 for your own setup, but let's do it for our earlier example. Just plug in your numbers in place of those for the example.

$$\text{Transistor-on voltage} = V_O = .65 \text{ volts}$$

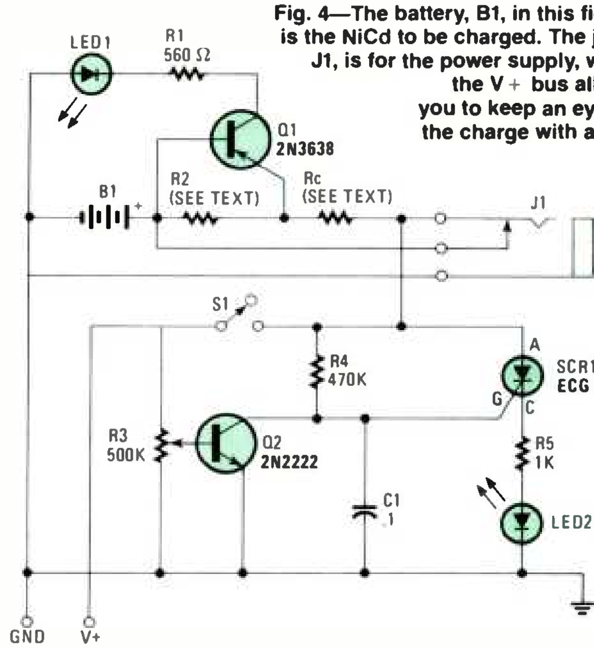


Fig. 4—The battery, B1, in this figure is the NiCd to be charged. The jack, J1, is for the power supply, while the V+ bus allows you to keep an eye on the charge with a VM.

PARTS LIST FOR THE NICD BATTERY CHARGER

SEMICONDUCTORS

LED1—Green light-emitting diode, 20-30 mA rating
LED2—Red light-emitting diode, 20-30 mA rating
Q1—2N3638 PNP silicon transitor
Q2—2N2222 NPN silicon transitor
SCR1—ECG5400 silicon-controled rectifier

RESISTORS

(All resistors are ¼-watt, 10% units unless otherwise specified.)
R1—560-ohm
R2—See text
R3—500,000-ohm
R4—470,000-ohm
R5—1000-ohm
R_c—Resistance and wattage depend on the application (see text.)

ADDITIONAL PARTS AND MATERIALS

C1—.1-µF disc capacitor
J1—Any two-pole jack with internal switching contacts
S1—SPST switch (toggle or otherwise)

A binding post (optional), desired power supply, solder, wire, etc.

Minimum charging current = I_m = 80 mA. (C15 rate)

R2 = V_O / I_m = 8.125 ohms

A close-to-standard value for R2 is 8 ohms. We can use that just as well since it means Q1 will get down to it's cut-off voltage when the charging current is 81 mA. That corresponds to a charging rate of C14.8—that's close enough. The C15 rate is usually used for a standby charge; large enough to keep the battery charged, but small enough to avoid overcharging problems.

The second part of the circuit is a low-battery alarm. By using a 500,000-ohm, multi-turn trimmer potentiometer for R3, the circuit only draws about 20 microamps at 12 volts. As long as enough base current is available to keep Q2 turned on, the collector will be at ground. As soon as V_b falls below the trip point, Q2 will turn off, the collector will be at V_b, and the SCR will fire, lighting LED2. Of course you can substitute anything you want for LED2 (relays, buzzers, etc.).

Construction

The project lends itself nicely to point-to-point soldering, even on a board as small as a penny. The connections to J1 are made so that battery power is only used when the charger is unplugged. If you plug in the charger, you'll be substituting the battery eliminator for the batteries and charging the batteries at the same time. Since the circuit is so small, R_c, the current limiter, isn't mounted on the board shown.

You have to use a variable power supply to set the trip point of the low-battery warning. If your circuit works on 12 volts, use 10 volts as the trip point (1 volt per cell). Set the supply to put out 10 volts and slowly turn R3 until LED2 comes on. It's a good idea to put a drop of nail polish on the set screw once it's been adjusted to keep it in place.

Bad 'Cad

NiCd's, like any other cells, have a usable lifetime. If you're good to a quality NiCd, you can expect it to last through at least 1000 charge cycles. Unfortunately accidents happen and NiCd's get damaged through inadvertent overcharging, hot environments, and so on. Now, a damaged cell isn't necessarily a dead cell and there are things you can try to bring one back to life. How successful you'll be depends on how much damage was done and that's often difficult to tell by just eye-balling the battery. Before you decide a battery is ready for NiCd *Nirvana*, run the following tests.

Take a good look at the battery case. If the metal of the case is puffed out, the cell has been so badly overcharged that the build-up of excess oxygen has undoubtedly killed it. If the seal around the top is still intact, you might be able to keep using the cell, but it's a good idea to get a replacement. If there's evidence of dried electrolyte around the seal, the battery will dry out and should be replaced.

If the case looks okay and but the cell won't take a charge, it's possible there's an internal short. You can sometimes use a circuit like the one in Fig. 5 to blast away the internal shorts—notice that word "sometimes." The capacitor should be at least a 10,000-µF unit, and if you've got a bigger one than that, use it. Hit the button a few times to discharge the capacitor through the cell. Wait a few seconds between hits to let the capacitor charge. Throw the switch to connect the batteries to the charger and watch the voltage. If you were able to blast the small internal shorts, the cell voltage will start to rise as it takes a charge.

You can try that a few times, but if there's no change, the nylon separator is so badly damaged that the battery can't be saved. But even if the voltage does start to rise, you're still not out of the woods. Charge the battery up normally and put it to work. If it's behaving okay, you've saved yourself some money. If it loses power more rapidly than it should, you can try blasting it again, but it's almost certain that the battery is ready to be dumped.

NiCd's work best if you periodically discharge them all the way down to the ground. If you're in the habit of charging them when they're only partially discharged, they'll get used to it and die much earlier in the charge cycle. A cell that's developed a "memory" like that can easily be fixed by completely discharging the battery and then fully charging it again. You may have to do it more than once to restore the cell, but if the battery recovers, it should be fine.

Ever since lithium batteries (which are NOT rechargable) came on the scene, it's become harder and harder to find NiCd's. The mail-order places don't carry the full range of sizes and voltages, and some of the more exotic varieties have virtually disappeared. Radio Shack has a respectable assortment of NiCd's, and if you don't have a lot of experience using them, it might be worth your while to get a few and experiment with them. They'll cost you a bit more to buy, but they can be a lot cheaper in the long run. ■

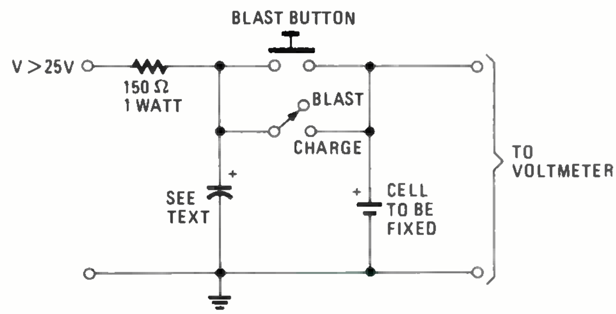


Fig. 5—The bad battery blaster can help to restore NiCd's if they're not too far gone. Be sure not to blow your voltmeter during charging cycles by allowing the voltage reading to move out of the meters set range.

OKIDATA PRINTER UPDATE

The surgery necessary to make the ML92 IBM compatible is quick, neat, and painless

By Jeff Holtzman

☐YOU PROBABLY THINK THAT THE ONLY PLACE YOU'LL SEE A brain transplant is in a grade-B movie. Actually, in the computer world brain transplants are common. You needn't be a surgeon to perform the required "surgery," and the results that you can expect are little short of amazing.

For example, take Okidata's Microline 92 printer. With its die-cast aluminum body, it is a workhorse machine that just refuses to quit. In fact, the only problem with it is one of, well, intelligence. The ML92 is not a dumb machine, you understand. The problem is that it was designed before IBM became king of the PC's. It can handle *generic* printing jobs—those that don't require the use of IBM graphics or the IBM character set—with ease. But if you require strict IBM compatibility, the unenhanced ML92 comes up short.

Setting Things Right

As you've probably guessed by now, there is a solution to that problem: Okidata's *Plug 'n' Play* kit. It does involve a little "micro-surgery" (microcomputer, that is). And you don't need a surgical microscope to do the job. In fact, as you can see in the photos, two screwdrivers—one Philips and one flat-blade—are the only tools you'll need. And don't worry about an anesthetic—the patient will never feel a thing.

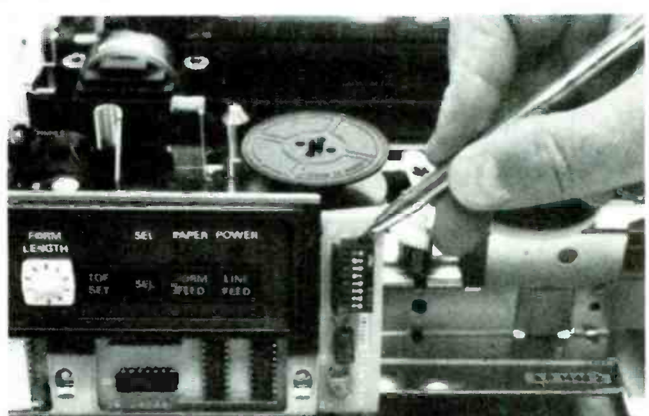
In fact, when the patient wakes up, he'll feel as if he'd taken a new lease on life. Instead of being relegated to the dump heap that is filled with early, but now-incompatible, personal-computer peripherals, your patient will emerge from the operating room with a proud—and IBM-compatible—new attitude toward life.

After Scrubbing-up

The surgical procedure involves opening the case, removing the serial interface card (if present), and then removing the main board. Then, using a flat-blade screwdriver, you

(Continued on page 102)

The Okidata Microline 92 is a workhorse printer that can be quickly, easily, and inexpensively upgraded to be IBM compatible. That allows the printer to be used along with graphics packages such as Print Shop, AutoCad, and Lotus 123.



After removing the cover of the printer, the front-panel configuration switches must be set so that all are off.

By Jeff Holtzman

Solid-State Memory Devices

A computer, like an elephant, doesn't forget. Do you know how it remembers?

SOLID-STATE MEMORIES ARE USED IN MACHINES RANGing from computers to VCR's to automobiles; and the list grows daily. Some types of memory may be set over and over; others may be set just once; still others may be re-used by following special procedures. In this article we'll discuss the basic differences between various types of semiconductor memory devices. Then we'll go on to discuss our experiences with a versatile kit that allows you to program (and to re-program) the resetable type.

Background

Throughout history, philosophers have regarded memory as one of the primary characteristics that distinguish man from beast. However, the ability to store information and recall it later is useful not only to man, but also to one of his grandest inventions, the computer. Computer memory (whether solid state, magnetic, or optical), is often general purpose; the same memory cells may be used over and over to store information and operations. Machine memory is also useful in a wide variety of specialized, dedicated circuits: keyboard encoders (which translate a keypress to an ASCII or other code), character generators (which translate an ASCII or other code to a pattern of dots suitable for display on a CRT), and many, many others.

Solid-state memory devices are available in several forms, but there are basically two types: those that retain their contents when power is removed from a circuit (non-volatile memory), and those that don't (volatile memory). Why are two types necessary? A computer's operating system, for example, is commonly stored in non-volatile memory, so that the computer will know what to do when you turn the power on. On the other hand, the memory in which you load various applications programs (BASIC programs, word processors, etc.) is volatile memory.

The Smart Zap kit comes complete with all components, high-quality PC board, transformer, and comprehensive manual.

There are several types of volatile memory, static and dynamic being the most common; volatile memory is commonly referred to as RAM (Random Access Memory), each location of which may be accessed at random. There are also several types of non-volatile memory; they're generically referred to as ROM (Read Only Memory) because you can't "write" to them (i.e., move data into them).

Actually, the terms RAM and ROM are imprecise, because ROM's, like RAM's, are random-access devices—i.e., it's just as easy to get to any one location as any other. But in common parlance, RAM almost always refers to memory that loses its contents when power is removed, and ROM refers to memory that doesn't.

ROM Types

As you've probably already guessed, there are several types of ROM; their major characteristics are summarized in Table 1. The least expensive type of ROM is the ROM, properly so called. A ROM is created by the semiconductor manufacturer according to a mask supplied by the designer. Designing the mask is expensive, so design mistakes or changes can increase the cost of a product tremendously. After the mask is finalized, however, producing the ROM IC's is very inexpensive. ROM's are best used in thoroughly debugged large-volume applications.

The PROM is next in terms of cost; it is simply a Programmable ROM. The PROM contains a number of internal fuses that can be blown in a purposeful manner. Doing so requires a special piece of equipment called a PROM burner. Like the ROM, the PROM may be programmed only once—once a fuse is burned, it cannot be fixed. PROM's are generally used in applications where small amounts of fast, non-volatile memory are required.

Because of the lead-time and cost problems associated with the ROM, and the cost and size limitations of the PROM, designers clamored for an easier-to-use type of memory. That memory would, ideally, have high density, low cost, and it would be easy to program and to re-program. The last two types of ROM are also programmable, but, in addition, they're erasable, hence the names EPROM (Erasable PROM) and EEPROM (Electrically Erasable PROM).

TABLE 1—NON-VOLATILE MEMORY

Type	User Programmable	User Re-Programmable	Cost	Size
ROM	No	No	Low	Large
PROM	Yes	No	High	Small
EPROM	Yes	Yes	Medium	Large
EEPROM	Yes	Yes	High	Medium

If you've ever seen an IC with a round glass "porthole," then you've seen an EPROM. The porthole allows the EPROM to be erased (all bits set to "1" or high) by applying a low-intensity, ultra-violet (UV) light. EPROM bytes cannot be erased separately; it's all or nothing. The EEPROM, by contrast, has no porthole, because erasure is performed by ap-

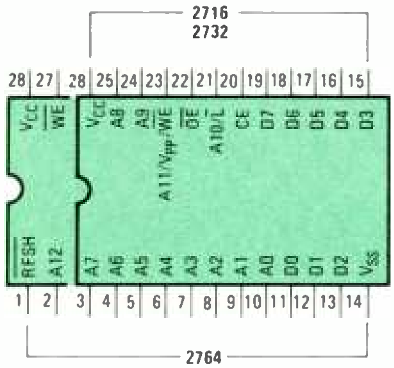


Fig. 1—The 2716 and 2732 EPROM's are 24-pin devices; the 2764 and larger EPROM's are 28-pin devices. An attempt was made to keep pinouts standard for the chips, but the functions of pins 21 and 23 vary from device to device.

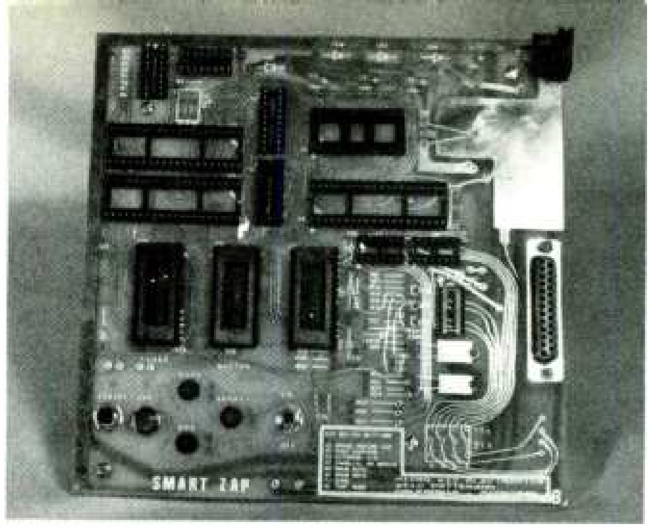
plying special electrical signals. EEPROM bytes can be erased separately. Programming the EPROM or the EEPROM consists of resetting the desired bits to "0" (low).

Due to the wide use of EPROM's, their prices have dropped dramatically in the past few years. For example, the 2716 EPROM, which has 2048 eight-bit bytes, costs under $4.00 now. But shortly after the device was first introduced in the early 1980's, it cost $49.95! The EEPROM is somewhat more expensive (around $10–$15), but requires no UV eraser, and can often be designed to be programmed in circuit, thereby making field upgrades simpler.

The prefix for most EPROM's is 27 (as in 2716, 2732, 2764, etc.); the trailing digits indicate the number of kilobits (not kilobytes) that the IC contains. The 2716, for example, contains 16K bits, actually 16,384 (2E14) bits. To obtain the number of bytes, just divide by eight. So the 2716 has 2048 bytes. Table 2 indicates some popular EPROM's, their capacities, and current low-quantity cost. Those with a "C" in the part number are CMOS (low-power) types; the others are NMOS types.

You might think that EPROM's with larger capacities would cost more, but that's not necessarily true. Because of popularity, the 2764, for example, costs the same as the 2716, and less than the 2732!

As shown in Fig. 1, the pinout of the 2716 is similar to that of the larger devices. That similarity makes it easy to design computer memory systems with a great deal of flexibility. In addition, some RAM IC's share the same pinouts (the 6116 and the 6264, for example), and that increases flexibility even farther.



After mounting all mechanical components (socket, switches, jacks, etc.), the Smart Zap PC board looks like this.

What Are (EP)ROM's Used For?

In digital logic, problems with multiple inputs and outputs can often be resolved economically by using a ROM of some sort, rather than with discrete gates (NAND, NOR, etc.). A classic example: How do you drive standard seven-segment LED displays with hexadecimal input signals and obtain the correct indications (0–9, A–F)? A small EPROM can handle the job with ease.

ASCII keyboards usually have a built-in ROM that converts a keypress to the correct ASCII code. But what if you need different codes? Use a different ROM.

Scrambled TVRO signals are descrambled in the owner's home by the use of codes stored in a ROM. Video pirates create "clones" that duplicate those codes in EPROM's that are changed monthly as the codes change.

Computer users often worry about software backup, but think only of data stored on hard and floppy disks. What about the ROM's containing the operating system, BASIC, etc? Some users copy legitimate ROM's into EPROM's and illegally sell those EPROM's for use with inexpensive (often foreign-made) "clones."

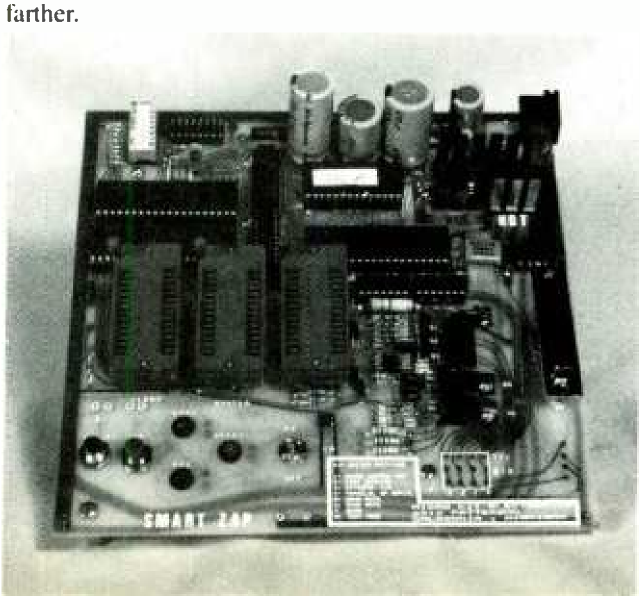
Melody and speech synthesizers are popular projects for electronics hobbyists, who can use an EPROM to store complete songs or short speeches.

When bringing up a new system, computer-system designers go through EPROM's the way most people go through corn flakes.

Programming an EPROM

A typical EPROM is the aforementioned 2716. As shown in Fig. 1, it is a 24-pin device. Eleven pins are for addresses; those eleven lines allow access to 2048 (2E11) bytes. Eight pins are for data, which is arranged as eight-bit bytes, two are for power and ground, and the remaining three are for programming the IC and for synchronizing its operation with other circuitry, if necessary.

A higher-than-usual voltage (25) is used to program locations in a 2716. That voltage is applied to pin 21 (V_{pp}). Then the desired location is addressed and data is applied. Last, pin



The completed PC board looks like this. Assembly takes about an hour, checkout another half hour. The three sockets near the left center of the board allow easy insertion and removal of the devices to be programmed and the personality modules.

Bibliography and Manufacturers

Memory Components Handbook, Intel Corporation, 3065 Bowers Avenue, Santa Clara, CA 95051.

MOS Memory Data Book, and *Supplement to MOS Memory Data Book*, Texas Instruments, P. O. Box 1443, Houston, TX 77001.

MOS Memory Databook, National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, CA 95051.

MOS Memory Products, Toshiba America, Inc., Electronic Components Division, 2692 Dow Avenue, Tustin, CA 92680.

Memory Data, Motorola Semiconductor Products, Inc., 3501 Ed Bluestein Blvd., Austin, TX 78721.

TABLE 2—EPROM TYPES

Type	Capacity (Bytes)	Speed (ns)	Program Voltage	Cost
2716	2048	450	25	$3.50
2716-1	2048	350	25	$4.00
2732	4096	450	21	$4.00
2732A	4096	250	21	$4.00
2732A-2	4096	200	21	$4.25
2764	8192	450	12.5	$3.50
2764-50	8192	250	12.5	$4.00
2764-200	8192	200	12.5	$4.25
27C64	8192	250	12.5	$6.00
27128	16384	250	21	$4.25
27256	32768	250	12.5	$7.50
27C256	32768	250	12.5	$11.00

Note: 1. Check manufacturer's specifications before applying any voltage greater than +5 to any EPROM device!
2. Prices were current in early 1987, but fluctuate often.

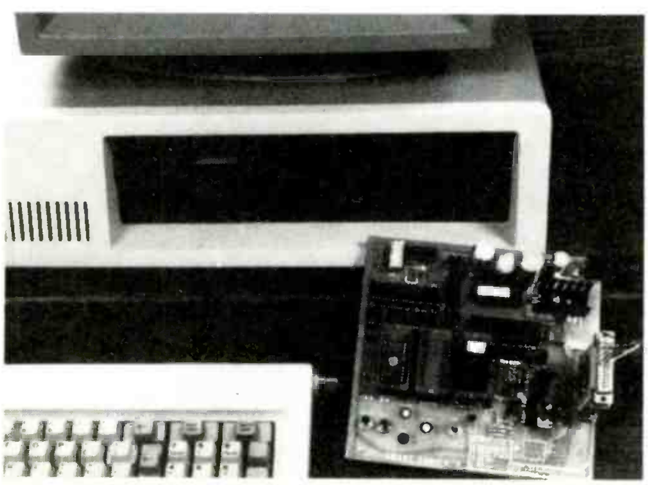
18 is pulsed high for a period of 50 ms. Locations in the device may be programmed in any order.

Other devices use other programming voltages (e.g., 12.5) and pulse times (e.g. 10 ms), and "intelligent" programming algorithms that allow high-density EPROM's (2764 and higher) to be programmed quickly. The time to program a high-density device with a standard 50-ms pulse can be surprising. For example, a 27256 has 256K bits, or 32,768 bytes of storage. At 50 ms per location, it would take almost half an hour (32,768 × 0.050 ÷ 60) to program all locations without using an "intelligent" algorithm.

An EPROM Programmer Kit

It's simple, in theory, to program an EPROM, but, in practice, some "convenience" features are really necessary. You can build a manual programmer with a 4040 CMOS counter, a 555, several gates, and about a dozen toggle switches for setting data and applying the programming pulse. However, setting binary data on toggle switches gets *old* quickly. A better way is to build an intelligent programmer—one that has its own microprocessor to control operation. In fact, several devices of that sort are available commercially. Many cost hundreds or even thousands of dollars, but we've found one that retails for only $99.95, and has nearly all the features of its high-priced cousins. It's called the Smart Zap, and it's sold by Micro Kit (6910 Patterson, Caledonia, MI 49316, 616/791-9333).

The Smart Zap comes with a 60+-page manual, including schematic, parts-placement diagram, and program listings. The manual also contains fairly specific construction details; it does assume that you know the basics of electronics assembly. The kit goes together easily, and Smart Zap's built-in control program provides a comprehensive set of diagnostic routines. Our evaluation unit passed all the self tests, but failed to operate normally. After conferring with Micro Kit, we returned our Smart Zap and received a fully functional unit from them in only two days.



The Smart Zap works well with an IBM-PC (and with a Commodore 64). Menu-driven software allows you to verify erasure, program a device from another EPROM or the IBM's memory or disk, verify programming, and upload the contents of a device to memory and then save it to disk.

The Smart Zap can program all standard EPROM's (including those listed in Table 2). In addition, it can program a number of different EEPROM's. Further, it can program a number of special-purpose microprocessors that have built-in EPROM's.

For each type of EPROM, you must wire up a special "personality module." The module is then inserted in the ZIF (zero insertion force) socket on the right. An erased EPROM is inserted in the left socket. The data to be burned into the "clone" EPROM can come from one of two sources: a master EPROM (which is inserted in the center socket), or a computer attached to the Smart Zap's serial or parallel interface.

Three pushbuttons control operation in the local (non-computer) mode; using those buttons, you can burn an EPROM, verify that an EPROM is erased, and verify its contents against the master. In the remote mode, you can perform both verify operations and burn an EPROM from the contents of the computer's memory or disk.

Micro Kit has written remote-control BASIC programs for the IBM-PC and the Commodore 64. We've posted a copy of each on our Computerized Bulletin Board. Call 516/293-2283 at 300 or 1200 baud, and set your modem for 8 data bits, 1 stop bit, and no parity.

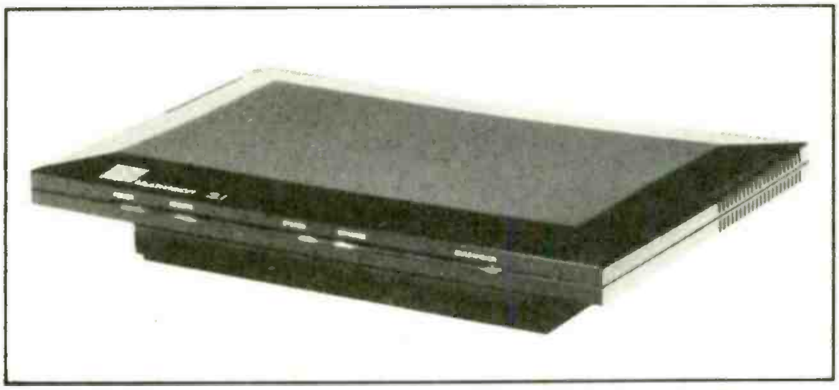
How does Smart Zap perform? In both stand-alone and remote modes, it performed admirably. And, because Micro Kit supplies the source code for both the internal microprocessor (an 8031) and the remote BASIC control program, you can modify either to suit your needs. Due to its versatility and low cost, as well as the excellent support provided by Micro Kit, the Smart Zap is unquestionably the best bargain in EPROM programmers on the market today. For more information on Smart Zap, Circle No. 82 on the Free Information Card in this issue. ■

NUMBER 136

GADGET

JUNE 1987 THE NEWSLETTER FOR GROWN-UP KIDS VOLUME XII/NUMBER IV

What's Inside...



Getting The Picture(s)

MULTIVISION 3.1. Manufactured by: Multivision Products, Inc., 1751 Fox Dr., San Jose, CA 95131-2312. Price: $500.

The redefinition of the TV set, which began a decade ago with the coming of home video, is fairly well advanced today. The world's favorite electronic appliance has become far more than just a box with moving pictures inside it.

Two years ago, American consumers purchased over $11 billion worth of VCRs, camcorders, projection TVs, satellite receivers and an array of other TV-transforming accessories. If our reaction to the *Multivision 3.1* is any gauge, this new product from California's "Silicon Valley" will play a part in boosting that figure even higher. In terms of its capabilities and smooth functioning, this is the most impressive TV add-on GADGET has evaluated in years.

Although the manufacturer is rather coy about classifying the *Multivision 3.1*, it appears to function as a digital transformer. Its "proprietary digital video integrated circuits" add a number of distinctive audio and video capabilities to any television set—regardless of age, make or model—according to *Multivision Products*.

While the idea of testing this accessory with a 1946 RCA 630TS table model set appealed to us, we finally hooked it up to a 1984 Sony KV-1961. Connection took a little more than the suggested "one minute," if time spent studying the *Multivision* manual is taken into account.

The instruction manual devotes a page to each of the various TV configurations and combinations—TV with VCR, cable, cable with scrambler converter, antenna-equipped television, etc. Each variation requires its own set of *Multivision 3.1* connections. Once we knew which combination of inputs to use and figured out that our non-cable-ready, non-remote-controlled set was of the proper wattage ("300 watts or less") to be plugged into the outlet in the back of the device, we were in business. If our set had been equipped with a remote, or been rated at over 300 watts, it would have stayed plugged into the wall.

Multivision 3.1's most spectacular capability is its "picture-in-picture" feature. While the user watches and listens to a main image, an insert box will show programming on another channel or from an additional source like a VCR. The insert box can be positioned in any corner of the TV screen, in any of the four insert-box sizes, at any of four distances from the center of the screen. The *Multivision* remote (which with non-remote-equipped sets

(Continued on page 8)

Letters

Dear GADGET:

In the March issue of your publication, you mention the *Automatic Power Failure Light*, which retails for $16.95 from Sporty's Tool Shop and other sources.

We used to handle this Sanyo item many years ago, and find that it is now somewhat obsolete. The most objectionable feature of this lantern is the poor quality of the flashlight beam.

We are importing, and selling in large quantities, a similar but (we feel) improved power failure light from Hong Kong, the *DL-323*. Enclosed is the Haverhills ad for this lantern and a sample of this model for your evaluation and possible publication in GADGET.

Geraldo Joffe, President
Haverhills
San Francisco, CA

Our evaluation of the DL-323 appears in this issue's "Bits and Pieces" section.—Ed.

Dear GADGET:

Your problem with the *Jac Rabbit Radio-Controlled Racer*'s two-stroke engine is not unique [p. 5, GADGET, February]. Two-stroke engines with nearly symmetrical "port timing" will sometimes run backwards. You should feel fortunate you didn't have the same experience as a friend of mine who restarted his two-stroke motorcross bike at the top of a hill and found himself accelerating nicely back down the way he'd come—backwards!

Obviously, this is an inconvenience, but it doesn't happen often and is a small price to pay for the simplicity, high-power output and smooth running of a two-stroke engine. I suggest that when starting the *Jac Rabbit*, you give it a bit of a forward push, or even push start it (as many two-stroke motorcycle racers do).

Alexandra L. Carter
Honolulu, HI

Run Silent, Run Cheap

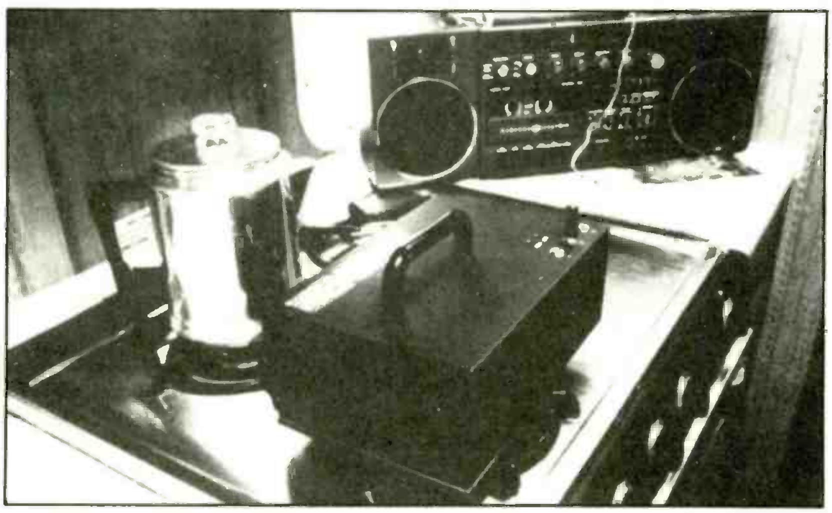
OVONIC COMPACT SILENT GENERATOR. Manufactured by: Energy Conversion Devices, Inc., 1864 Northwood, Troy, MI 48084. Price: $159.95.

Survivalists have spun off useful devices for the mainstream consumer tc about the same extent that the space program has done so. Freeze-dried bananas, collapsible bicycles, the famous "Rambo" knife—these are the types of contributions given to the world by those who are preparing themselves for its end.

The *Ovonic Compact Silent Generator* (*CSG*) may not have sprung full-formed from some survivalist's brain—it is too sophisticated for that—but no doubt the device's marketing mavens are aiming themselves, at least in part, at the doom-and-gloom market. For what we have here is a solid-state, compact unit which turns heat into electrical power. The power is about the equivalent of a D-cell battery pack, but the point is that it's endless, as long as you have an endless source of combustion.

Aside from emergency power for survivalists, civil defense or the military, the other use-group targeted by *Ovonic* is the marine market. The galley stove can be cranked up and united to the generator, and the resulting power can be used for radios, bat-

(Continued on page 7)



CORRECTIONS

The address given in the April issue of GADGET for *Apco*, manufacturer of the *Fear Security System*, was incorrect. The company's address is 478 11th St., Palisades Park, NJ 07650.

In the May issue, the address given for *Sharp Electronics Corp.* with GADGET's review of the WQ-T282 *Stereo Radio Cassette Recorder* was incorrect. The current address of the *Sharp Electronics Corp.* is Sharp Plaza, Mahwah, NJ 07430-2135.

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Auto to the Max

MAXXUM 7000 AUTOFOCUS CAMERA. Manufactured by: Minolta Camera Co., Ltd., 101 Williams Dr. Ramsey, NJ 07446. Price: $623.

Although we have always loved technological advancements, both in the form of useless toys and handy tools, we are also strong advocates of manual cameras. Even such developments as the sonar-system autofocus Polaroid and the shutter-speed-priority auto-aperture features found in most SLRs today don't appeal to us.

Not only do we consider manual adjustment necessary for a good picture, but we feel that people who want good pictures should pay their dues—learning about photography and the equipment, and the adjustments necessary to make it happen. In any event, the *Maxxum 7000* from *Minolta* has changed our thinking. This is a camera that is fully automatic, considerably more automatic, in fact, than some of its competitors. The 110 cameras with auto-wind, built-in flash and similar features only appear to be automatic. Those cameras "automatically" always take the same picture, and have a wide margin for error. In contrast, the *Maxxum 7000* is intelligent.

Its shutter speed, aperture, focus and winding are all truly automatic. Those 35mm cameras a step above the "Instamatic" type featuring automatic exposure usually force the user to choose shutter speed or aperture, and it selects the other variable by means of a built-in light meter. The *Maxxum 7000* can choose both shutter speed and aperture for you, sans any adjustment on your part.

This can be changed to shutter-speed priority, aperture priority or fully manual operation if you want, but the automatic option is always available. Our only complaint regarding either fully or partially manual operation is that it is entirely electronic. Careful and deliberate manipulation of controls is necessary to make these adjustments and is much slower than turning rings around a lens. That complaint is minor, though, because fully automatic operation is far faster than adjusting lens rings.

The *Maxxum*'s auto-winder is a nice function, too. Although the film can be a bit difficult to load at first, it's quite convenient to have the camera automatically advance the film after loading; wind after each shot and rewind the roll when it's completely exposed. The *Maxxum*'s is not a presumptuous auto-winder, it only loads or rewinds the film when "asked" to. It is much more compact than external or add-on rewinding devices, so you needn't worry about bulk. Although noticeably heavier and a bit chunkier than an ordinary 35mm without a winder, it's more compact than others we've seen with winders. We had no problems, despite the weight and bulk, taking pictures while holding the camera in one hand.

Skeptical as we were, we immediately fell in love with the *Maxxum*'s autofocus feature. Like the camera's other automatic functions, it can be turned off for manual focus, but who would want to?

A small rectangle (about ¼ the size of the standard split-field focusing device) in the center of the viewfinder specifies what it is that's being focused on. Touching the shutter-release button engages the electronics of the system and activates a computer to choose a shutter speed and aperture. Pressing gently focuses.

Sometimes heavily contoured subjects (for example, stairs or a close-up of someone's face) confuse the autofocus regarding what surface to focus on. This only happened about two or three times out of each roll of 36 exposures in GADGET's test, so it's a minor problem which can usually be avoided by either focusing manually or adjusting the composition so that a flat surface is in the center.

What's so impressive is that the *Maxxum 7000* actually focuses. It doesn't use infrared or sonar to guess at the object's distance. Rather, its computer checks for a clear image. Depending on where the camera was focused before and what distance it has to change to, it takes between a quarter of a second and one-and-a-half seconds to focus.

As the advertising slogan has it, "only the human eye focuses faster," which is a positive way of saying, "the *Maxxum 7000* focuses slower than the human eye." The autofocus is fast, but *Minolta* is right, the human eye is faster.

Even if the autofocus isn't engaged, the computer is still activated, with an LED display at the bottom of the viewfinder telling the user if it judges the image to be focused or not. When the autofocus knows that it's been beaten, the LED signals that manual focusing is necessary.

We only tested the 50mm lens, but a variety of lenses (including zooms) are available. There's also an optional flash attachment which can be integrated into the camera's automatic systems.

Generally, we were extremely pleased by the *Maxxum 7000*'s ease of operation and the quality of the pictures it produced, to the degree that if not for a minor flaw, we'd give it our strongest recommendation.

In a test run of around a hundred or so difficult exposures, the *Maxxum*'s shutter speed/aperture computer was foiled a considerable number of times. This failure of exposure accuracy is an especially irritating drawback.

Conceptually, the *7000* has the "point and shoot" facility of an "amateur" camera, but with the accuracy and sophistication of professional photography equipment. Certainly, setting the camera on partial automatic overrides the computer's focusing shortcomings, but in that case, why not just focus manually? Or use a less exotic 35mm camera?

Inexperienced photographers may find that the *Maxxum* improves the quality of their pictures somewhat, but non-novice users will probably find themselves often using the manual adjustments, eliminating the *7000*'s most touted feature. Although definitely an impressive stride towards really good automatic cameras, *Minolta* isn't marketing perfection, yet.—A.C.Z.

Triple Play

NATIONAL 3-DECK TRIPLE CASSETTE SYSTEM (RX-F333). Manufactured by: Matsushita Electric Industrial Co., Ltd., Osaka, Japan. Price: Not available.

Products manufactured for domestic consumption often indicate that Japan's consumer electronics industry (or maybe Japan's electronic consumers) suffer from a condition which might be called the "can-you-top-this syndrome." Manufacturers vie in coming up with both outlandish and subtle variations on existing products.

This portable *3-Deck Triple Cassette System*, marketed under Matsushita's *National* brand (Panasonic's Japanese counterpart), is predicated on the notion that if two tape decks in one portable unit are good, three tape decks in one package will be even better. Something called "the law of diminishing returns" seems to have been ignored by *National*'s design and marketing departments.

Purchased by GADGET's publisher on a trip to the Far East, the *RX-F333* came with an instructional booklet in Japanese. But even allowing for not having a guide to its use, we had our doubts about the efficacy of this product.

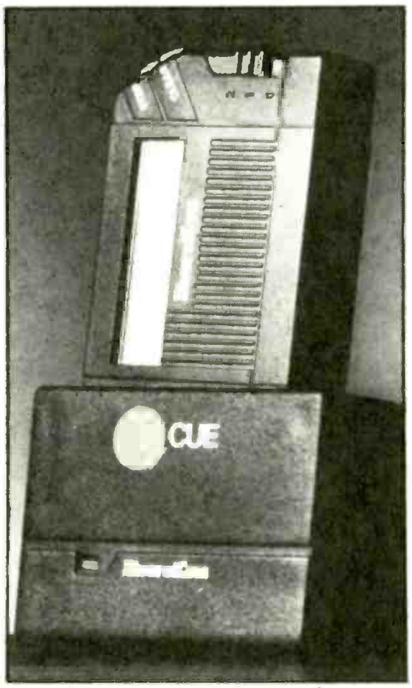
In addition to AM/FM radio reception, the *RX-F333* incorporates TV audio reception, a carrying handle (which handily folds into the back and top of the unit) and the usual telescoping antenna. Power is supplied by a half-dozen "C" batteries loaded into a compartment in the back.

The *3-Deck*'s extra tape deck is limited to "relay play" use. That is, the deck on the left, labeled deck one, won't record from any source or dub from another cassette.

(Continued on page 6)

Taking a Cue

CUE NATIONWIDE PAGING SYSTEM. Distributed by: DiversiCom, 3200 Park Center Dr., Costa Mesa, CA 92626. Price: $350.



Cellular telephones aren't necessarily everyone's solution to the problem of staying in touch while on the go. *DiversiCom*, a unit of the American Diversified Capital Corporation, has taken a page out of a Finnish book for a unique service which may very nicely serve those for whom a cellular telephone would be an over-priced electronic luxury.

It's a tad misleading to compare the *Cue Nationwide Paging System* to other pagers. Although the *Cue* instrument looks like its counterparts, it operates very differently. The instrument and its data delivery system were developed by Mobira, a Finnish telecommunications firm whose cellular phones are also marketed in this country (GADGET, May 1986).

While all paging services and systems use radio transmission to contact subscriber pagers, *Cue*'s transmission method gives it the range necessary to cover an enormous geographical expanse. The *Cue* messaging system operates via standard FM broadcast channels. In each of the cities covered, *DiversiCom* rents "sub-carrier" space on the FM broadcast signal of one or more radio stations. The receiver set includes a scanner which "listens" for the strongest available FM signal and locks in on it. In a manner reminiscent of cellular transmission "switching," as a *Cue* pager wearer moves from a location, "the unit immediately begins to scan for another, stronger signal."

For those locations in which *Cue* transmissions don't come through, the service maintains an 800 number which subscribers can call for messages. In order to reach a subscriber, a *Cue* message center is called via a touch-tone phone. Once connected, a computer-synthesized voice asks first for the subscriber's identification number (which the caller enters via the touch-tone keypad) and then for the message, also entered via the keypad. As many as a dozen digits can be transmitted or stored per message.

The *Cue* system computer routes the message via satellite to participating FM stations nationwide. The message receiver is outfitted with both an audible signal and an LCD panel upon which the 12-digit message appears. The panel also shows the number of messages waiting (up to six can be stored in memory) in the order received. A charger sold or leased along with the receiver allows for up to 72 hours of operation.

Cue's service is not without gaps (again, like cellular telephone service). Besides localities which have not yet come into the system, the crowded ether of various urban centers can block reception.

In GADGET's test, *DiversiCom*'s California office was able to send the test unit a message, but we were unable to reach it using our own office telephone. We wrote that mistransmission off to Manhattan's notorious terrestrial interference, but it did suggest some limitations to *Cue*'s current efficiency.

While ordinary services, according to *DiversiCom*, cost around $28 to $35 a month, *Cue* charges $40 a month for its nationwide service. Users have two options—the equipment can be purchased for $350, with a $40 monthly subscriber fee, or the system and its equipment can be leased, with a monthly cost of $65.

DiversiCom estimates that within two years a full one-half of one percent of the U.S. adult population will be carrying message receivers of one kind or another. With its unique national service, *Cue* aims to garner a substantial portion of that market.—G.A.

To CD or Not to CD?

COMPACT DISC DIGITAL AUDIO PLAYER (DX-620). Manufactured by: Sharp Electronics Corp., Sharp Plaza, Mahwah, NJ 07430-2135. Price: $299.95.

Is the compact disc revolution the future of the recording industry that its proponents insist it is, or is it just another bandwagon fad destined to be quickly outmoded, like 8-track cassette tapes?

Nobody can really answer that question, but there's no denying that the format is the hottest marketing tool in a softening pre-recorded music industry. The CD rage singlehandedly kept the music business from suffering tremendous losses in 1986, as demand for long playing vinyl records has suffered a precipitous drop despite aggressive marketing and reissue programs and several blockbuster albums.

Despite the popularity of the compact disc, the format still has plenty of questions to answer before its future is assured. Many analysts have suggested that the medium is a forerunner of an even more impressive storage and playback system that will make compact discs, for all their advantages, obsolete. The impending war with digital audio tape (DAT) could well decide the future of the CD, because DAT provides everything a compact disc can offer, while also affording consumers the additional advantages of being smaller and offering recording capacity.

The wisest course for compact disc enthusiasts to take, then, is to get a high performance playback system that is reasonably priced. If you buy a top-of-the-line system and compact discs lose their luster, you're left with a white elephant.

Sharp offers a number of discount compact disc players, and their *DX-620*, which is available for under $300, sounds just as good as more expensive makes.

The system, like all compact disc players, is not without its drawbacks. The most alarming is the danger of radiation exposure. Consumers may be familiar with the shock and low-grade radiation warnings associated with taking apart a television set, but compact disc players pose a potentially far more serious health problem.

Page 2 of the operation manual is devoted to a single warning. "Danger," reads the advisory. "Invisible laser radiation when open and interlock failed or defeated. AVOID DIRECT EXPOSURE TO BEAM." Since the beam is invisible, this is a particularly disturbing warning.

As you can imagine, the compact disc player is an extremely delicate machine. This became apparent to us when the first demonstration model we received behaved erratically. At first, the laser was not properly unlocked and the CD skipped like a broken record. Then, while playing a Rolling Stones *Hot Rocks* CD, the sound would suddenly increase in volume without warning, then drop back to a whisper. The company representative explained that the machine must have been jostled or improperly handled. A second model proved much more reliable.

The *DX-620* has a relatively simple locking device for the laser which involves turning a plastic shaft with a screwdriver. The shaft is located on the machine's underside, and when you turn it you have to be very careful because the soft plastic tabs can easily be snapped off by a metal screwdriver head. This is a characteristically annoying feature of budget machines, where a simple part is made of inferior material that would cost almost nothing to improve.

Otherwise, the *DX-620* does most of the things any compact disc player could do. The automatic programmable music selector (APMS) allows you to program up to nine selections in any order you wish. This is useful for skipping tracks on a collection that you don't want to hear.

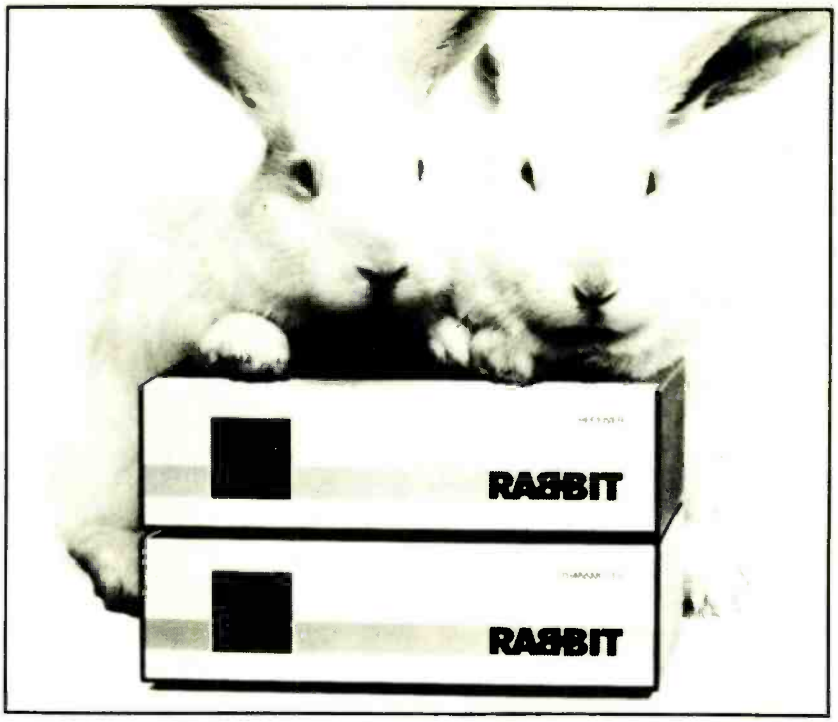
You can do the same thing in the middle of playback if you want by using the auto program search system (APSS), which either ejects the current selection and immediately plays the next, or repeats the current selection from the beginning. There's also a cue and review function if you want to hear a particular section of a track.

All these functions and more are also available on a remote control unit that comes with the set. The remote unit is very convenient, but goes overboard with luxury features. The most ridiculous is the remote control open-close command for the disc table. What good is being able to open the disc table from across the room when you have to walk over to the machine to place or remove the compact disc itself?

In the end, compact discs look like too important a trend to buck. Most record labels have begun to assemble substantial CD catalogs, with particular attention paid to the kind of archive retrieval that has been sadly missing from their LP lists of the last few years. Of course, it's inevitable that CDs will mean fewer new groups and less marginal music will be available to the music-buying public.

It simply isn't cost-effective to put artists or music of limited appeal onto CD. Worthy, but commercially limited material will most likely be confined to the traditional LP medium. Unless vinyl records sustain a level of consumer loyalty in years to come, non-mainstream music and artists may well fall by the wayside.—J.S.

No Dumb Bunny



VCR RABBIT. Manufactured by: Rabbit Systems, Inc., 233 Wilshire Blvd., Santa Monica, CA 90401. Price: $89.95. Additional receiver units: $44.95.

Since its introduction in April of last year, this simple, useful VCR accessory has been sold to over one percent of an estimated 36 million home video owners. For a product which didn't even exist two years ago, that's impressive market penetration.

It helps that the *Rabbit* has a price which puts it at the low end of the VCR accessory market, even though a *Rabbit Systems, Inc.* brochure aimed at retailers boasts, "profit margins that exceed industry standards." Now, that's one set of "industry standards" (are they maximums or minimums?) GADGET would like to know more about.

Also important is the usefulness of the *Rabbit*. Owners of the device can use it to transmit a VCR, cable or other program to any television in their home. As many as five TVs can be linked with a single *Rabbit*.

The complete *Rabbit* consists of a transmitter, connected to the TV which originates the programming, a small receiver unit (an additional receiver is needed for each TV to be *Rabbit*ed), a remote control, and what *Rabbit Systems* optimistically labels "thin, thread-like wire." It is tiny, but in the massive publicity this item has garnered, we've detected a bit of confusion about the *Rabbit*'s use of wire. The GADGET staffer who tested the *Rabbit* in her home felt the wire was unobtrusive—some 300 feet are provided—but admitted to being vaguely unaware that any wire was involved, as, we guess, are most consumers.

As a byproduct of its primary function, the device makes any *Rabbit*ed television into a remote-controlled set. GADGET's tester noted another interesting secondary effect. The set attached to the VCR is the only one in her home with its own antenna. After connecting a second TV, equipped only with a telescoping antenna as the receiver set, she observed that the connection via *Rabbit* actually improved the second set's reception of standard broadcast programming.

The cable industry, although some grumbling was heard at its introduction, appears reluctant to raise the kinds of issues about the *Rabbit* with which it has opposed the spread of satellite dishes. In the case of cable transmission, the *Rabbit* duplicates a signal,

(Continued on page 8)

TRIPLE CASSETTE PLAYER

(Cont. from p. 4)

Instead, in harness with the two other decks, it allows the user to program three cassettes for successive play, each engaging when the previous one ends. With three 90-minute cassettes, that would mean four-and-a-half hours of reasonably uninterrupted programming, which perhaps makes this an ideal portable system for opera buffs.

Decks two and three are for dubbing, at either high or normal speeds. Judging from the English language labels printed on the *RX-F333* case, deck three originates the program to be copied onto another cassette, while deck two will also record from other sources as well as from deck three.

Both deck doors read "dual synchro dubbing, synchro start/one touch rec." But deck three is also labeled "free source monitor/rec." Does this mean deck three can record some other source while the user listens to a cassette in deck one or two? Frankly, even after vigorous manipulation of various combinations of record and play controls, we're not sure. Which is one reason we're cautious about buying electronic goods without English-language instructions.

What the triple-deck configuration (side-by-side-by-side) comes down to, it seems to us, is a lot of fuss for very little advantage, which is where that "law of diminishing returns" previously mentioned comes in.

The consumer ease ensured by having three cassettes' worth of material ready to go at the touch of a finger seems only marginally greater than that offered by the dual-cassette design. If three cassettes are a worthwhile portable system feature, why not four, or five?

The *RX-F333* as a result of its triple decks does have an unusual profile. It's about 22" long and a mere 4" high and 4½" wide. The case also features one of those unusual color combos which are a trademark of Japanese consumer design in the electronics field. In this case, deep red with hot pink and blue highlights and control labeling. The deck doors also use a pastel green. Under its bright colors, the *RX-F333* case seemed a little on the flimsy side, or at least unstable given its unweildy dimensions.

We weren't surprised to learn that Panasonic doesn't market this *National* product under its own name and model number in this country. According to the firm's consumer affairs office, Panasonic doesn't offer any triple-cassette systems to U.S. buyers.

Just as with literature, movies, music and cars, aspects of a country's culture are expressed by its electronic products. While Japan may embrace the triple-cassette concept, the U.S. isn't ready for this slight nuance in portable audio system design. Or is it that the design isn't ready for the U.S.?—G.A.

OVONIC GENERATOR
(Cont. from p. 2)

tery recharging or emergency power. In a home emergency such as a power failure, the device can be used to generate a limited amount of electricity from the gas stove or "canned heat" such as Sterno.

There may be a limited market for such a limited power source, but for what it is, the *CSG* represents a superb execution of an ingenious design. At its heart is a thicket of "Oteg" wafers, power-generating devices which use the Seebeck Effect to convert thermal energy into electricity. This effect relies upon the law of physics which states that a voltage will develop between two materials if there is a large temperature differential between them. Within each wafer in the *CSG*, two such semi-conductors are linked in a positive/negative conjunction.

The major appeal of such wafers—besides the obvious fact that they bypass conventional thermal-mechanical or hydro-mechanical methods of generating electrical power—is that they are solid state. The cold side temperature of each wafer is 30 degrees C, hot side 210 degrees C, while an internal resistance of .4 ohms results in a maximum output of 4 watts. By linking these wafers together, however, the generator can achieve a power output of 5 watts at 12 volts DC, and 6 watts at 9 volts DC. An optional adapter can convert the unit to 6 volts DC, resulting in a 5-watt output.

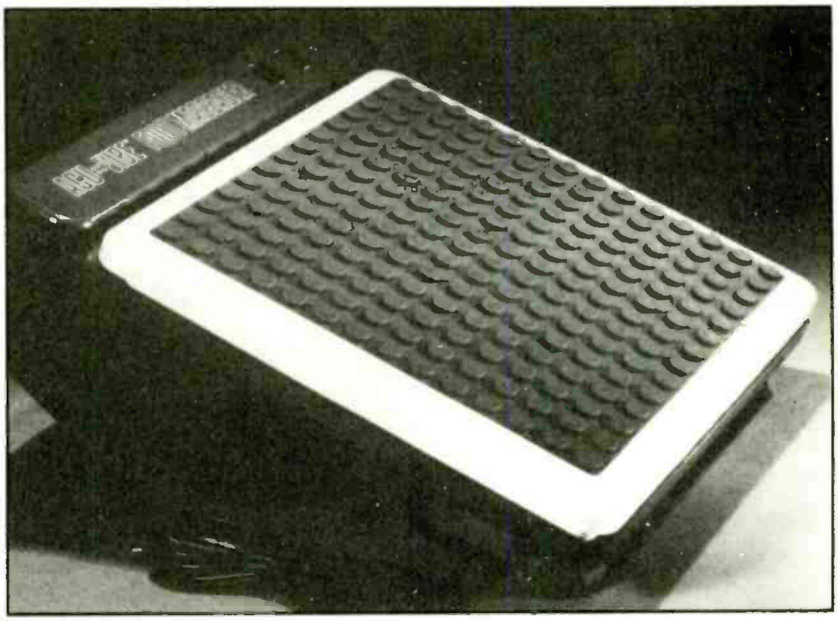
There are three output jacks on the unit's sleek, boxy exterior, designed to allow several different appliances to be used together. Our test showed that power draining devices like televisions and lights could not be hooked up at the same time with much success, but a miniature television alone was powered for an extended period. There is something of a bizarre, displaced effect, too in seeing *Honeymooner* reruns powered by your gas stove.

While fairly fragile—the manufacturer suggests treating the *CSG* as you would a small TV or stereo—the compact, shoebox size and 5-pound weight of the unit make it eminently portable. The "silent" in the *CSG* appellation is more relative than literal—while certainly not as noisy as even the newer, muffled gas generators, the *CSG* nevertheless has a fan that produces a steady, audible "whirr."

The limitations in the output of the *CSG* concomitantly limit its applications. But for anyone interested in a reliable source of low-level electrical power directly from a thermal source, this device is a masterstroke of design.
—G.R.

Heavenly Feats

ACU VIBE FOOT MASSAGER. Purchased from: The Price of His Toys, 9559 Santa Monica Blvd., Beverly Hills, CA 90210. Price: $159.



The art of massage predates electrical science and technology by a few thousand years. Still, at least since the turn of the century, inventors have been trying for some fantastic technological breakthrough by applying electrical science to this ancient relaxation technique. The Japanese-built *Acu Vibe Foot Massager* isn't that breakthrough; in fact, it's fairly simple in design. But don't let that mislead you as to its value; gold ingots are fairly simple in design, too.

The *Acu Vibe* looks like a large footrest, covered by a grid of half-inch circles raised above the surface by about a sixteenth of an inch. The circles and the pad on which they're embossed are made of what appears to be durable rubber. There are power and speed switches mounted on top which, when engaged, operate the massager surface at 2,000 or 2,800 vibrations per minute. In use, we weren't really able to tell the difference between the low and high speed.

The end result of all this high-speed vibration is incredibly relaxing. We found the *Acu Vibe* works acceptably when wearing sneakers, but that its vibrating action doesn't really work through shoes. Experienced barefoot, however, the foot massager is absolutely heavenly.

At first it tickles a bit but after a while it becomes extremely relaxing—so much so that we didn't want the GADGET test to end. However, the unit's noise level in operation kept us from ordering one to go under every desk in the office. It's not exactly loud, but it does require raising your voice a bit to carry on a conversation while being massaged. It's not as noisy as a vacuum cleaner, but is probably as loud as the average hair dryer.

The *Acu Vibe*'s instructions demonstrate "use on calves of legs, use on back" and "use on hands and arms," but we found all of these non-foot uses basically impractical. It calls itself a foot massager and that's what it does. It does that superbly, though, and if you're the kind of person who takes off your shoes immediately upon getting home every day, you'll appreciate the *Acu Vibe*'s virtues.

Maybe the only drawback to this device is that the power and speed switches are too small to be easily manipulated by foot. In order to turn it on and select a speed, it's necessary to bend over the unit. That's a small complaint, but we think that a device designed to relax its user should offer the ultimate in convenience. Nonetheless, a few minutes of *Acu Vibe* massage made us feel like we were walking on air. For anyone concerned with the comfort and relaxation of their "pedal extremities" (to quote Fats Waller's "Your Feet's Too Big"), the *Acu Vibe* massager is highly recommended.—A.C.Z.

RABBIT

(Cont. from p. 6)

allowing the user to escape paying for a second cable connection in order to receive wired transmission programming on another set.

Most likely, the cable TV industry is wise enough to understand that American consumers don't take kindly to being told what to do in the privacy of their homes.

Satellite dishes, the cable industry argument goes, appropriate a privately owned signal from the atmosphere. The *Rabbit* merely processes a signal already received. We'll leave it to the high-priced legal staffs involved to outline how the *Rabbit* conforms to current video industry theorizing and regulation regarding "video piracy."

But, legal mumbo-jumbo aside, the *Rabbit* performs simply, with a minimum of installation fuss and at an extremely attractive price. GADGET also gives *Rabbit Systems, Inc.* high marks for the witty visuals in its promotional campaign. It even took us a while to figure out why this image multiplier is called the *Rabbit.*—G.A.

MULTIVISION

(Cont. from p. 1)

becomes the controller) allows the viewer to automatically scan channels via the insert image, freeze the image on the secondary screen, swap the main with the secondary image and, of course, "disappear" the insert box with the press of a button. The *Multivision* will also display the channel number for each screen in the upper left corner of the main screen.

After the initial printing of the instruction booklet, *Multivision* added a further picture-in-picture capability, which required an insert manual sheet to explain, "Piparama." Using combinations of remote buttons, the insert box can be placed anywhere on the TV screen. Flexibility would seem to be a *Multivision* forte.

The *3.1* also has a number of audio capabilities. The device incorporates an MTS stereo decoder and is equipped with DBX stereo sound, a built-in amplifier and pre-amp outputs for connection to a stereo system. The remote unit allows the user to call up "stereo" sound or something labeled "concert" stereo, apparently a simulated stereophonic sound, or expanded stereo, depending on the audio quality of the programming.

Relying, as we did, on the mundane built-in speakers of our TV, we can testify to only a marginal improvement in audio. Another much appreciated audio feature is the "mute" button on the remote, a wonderful weapon in the war against commercial decibel assault.

The remote also controls most standard picture adjustments (brightness, contrast, etc.) for both the insert and main screen images. *Multivision 3.1* has designed an exceedingly clever, but compact remote. A "shift" button allows the numerical keypad and the function controls to do double duty. A "quick reference" card will help owners remember which controls do what once they've got the hang of the *Multivision* remote.

As with the Rabbit (see review elsewhere in this issue), the *Multivision 3.1* seems to have at least one feature not claimed by the manufacturer. We no-

ticed a sharpening, strengthening and brightening of the routinely muddy and ghost-haunted transmissions received from Manhattan Cable TV, surely among the sloppiest of big-city cable franchises. The *3.1*'s digital processing of the cable transmission seemed to effect a definite improvement in picture quality.

We also discovered, after using the *Multivision 3.1* for a while, why freeze-framing is such an appealing feature. Before our experience, we were inclined to think that only the most video-saturated of viewers would care much about the capability. Besides allowing the user to hold phone numbers on advertisements, weather info or replayed sports highlights in the insert, however, it can add an entirely new dimension to public affairs and news programs.

With both insert and main screen tuned to the same station, we watched the ABC *Nightline* program one evening. A White House official was being interviewed regarding a highly controversial issue. Although the official's presentation, in motion, was smooth and professional, in freeze frame his face mirrored a frightening range of emotions—anger, wariness, fear and hostility to the interviewer. The contrast between his moving image and the frozen counterpart was sometimes astonishing.

We also amused ourselves by creating custom music videos—tuning in two cable music outlets and "swapping" the insert and main picture, moving the insert box around and varying its size and location.

As idle amusement, it certainly beat reruns of *Three's Company.* Considered as mindless fun, it's more intellectually involving than endlessly flipping through the channels. Our only complaint about the *Multivision*'s freeze frame is that it doesn't work for the main image. We also discovered that our set's non-cable-readiness meant that using the remote's "rocker" channel selectors (which allow the viewer to flip through the channel sequence) would only take the *Multivision 3.1*'s built-in, twin tuners through the standard broadcast channels. Any cable signal had to be selected via the numeric keys, admittedly a very slight drawback.

We also wondered if the *Multivision* puts a surge of power through the TV set (not so says the company) and worried if, in the manner of some video games of years ago, it might leave some permanent electronic scoring on the set screen (an unfounded fear according to *Multivision Products*).

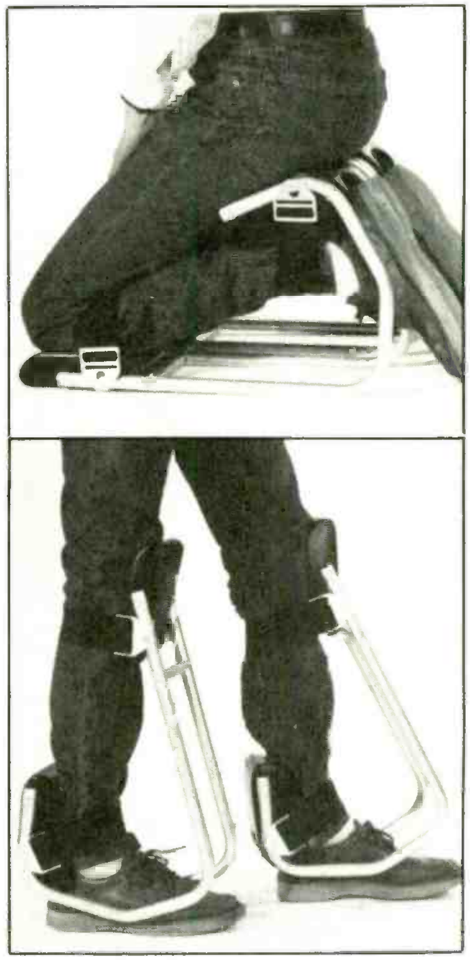
Since launching the *3.1* last Christmas, the company has added two companion models, the Multivisions 2.1 and 1.1. The 1.1 lacks a built-in tuner, an MTS stereo decoder, simulated or enhanced stereo and any RF input. The 2.1 has only a single TV tuner and doesn't offer enhanced or simulated stereo or video switching. Both models lack a built-in audio amp.

Finally, a curious failure. The small plastic slide-in door of the remote's battery compartment (it uses two "AAA" batteries) popped out one evening and no amount of fiddling could make it stay in place again. There was nothing broken off of either the door or the remote control's plastic body. Some kind of materials fatigue?

But that was just about the only negative outcome of GADGET's test. We really enjoyed using the *Multivision 3.1* and for once the term "enhancement" went beyond video marketing jargon. In consumer utopia, this remarkable device would sell for about half its suggested retail price. But a few years ago, these kinds of capabilities weren't available at any price.—G.A.

Bits & Pieces

Something that hasn't changed for thousands of years are the aches and pains associated with working in a kneeling position. Now, *Amcraft, Inc. (P.O. Box 3335, Idaho Springs, CO 80452)* says it's come up with a product which makes stoop labor comfortable. The **Balans Craftseat**, winner of an "outstanding new product" award at the National Hardware Show two years ago and enthusiastically noted by the hard-to-please *Consumer Reports* magazine, straps onto the legs and provides back support, encourages proper circulation and features "soft but durable" pads to protect the knees and bear most of the weight of the body. Once strapped on, the user can also walk around with the Craftseat in place. It's an odd-looking "seat," but something which might reduce "fatigue, stress and the chance of a back injury" could be worth an examination. Price: $30.



Balans Craftseat

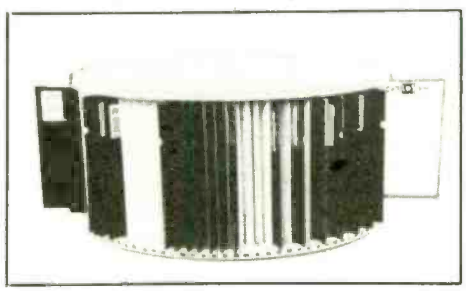
Competition in the contemporary calculator market seems more cutthroat than a TV wrestling grudge match. A leader in the downward trend of consumer electronic prices, calculators would seem a product with a razor-thin profit margin. Regardless, *Olympia USA, Inc. (Box 22, Somerville, NJ 08876-0022)* has introduced two new **Electronic Calculators**, the EC 7000 and EC 8000. Twelve-digit print/display calculators with four-key independent memory and a two-color display that Olympia says "reduces eye fatigue." The EC 8000 prints at a high-speed 4.6 lines per second. A special mark-up key on both machines computes selling prices, while a non-add/date key identifies calculations by date, social security number or other numerical designation. Price: EC 7000—$209; EC 8000—$229.

If your kids (or you) are bored with kites and beach balls, how about the next time you head for the shore taking along the **Solar UFO Hot Air Balloon**? The 10' by 2' diameter "airship" rises gradually when exposed to the sun. Simply tie one end of the balloon and run with the other end until it fills with air. Slowly the balloon's black surface absorbs the sun's rays, heating the air inside and rising majestically at the end of its 60' flying cord. *Free Market Catalog (1001 Connecticut Ave., N.W., Suite 638, Washington, DC 20036)* says it isn't a "toy," but "an experiment in physics." This sounds like it's too leisurely to be anything that edifying. Price (including shipping): $6.35.

Everybody seems to want a piece of today's on-the-go portable music market. *General Electric (Consumer Electronics Division, Portsmouth, VA 23705)* is staking its claim with a **Stereo Cassette CD Music System** (model 3-7030). The unit features AM/FM radio, tape deck and a vertical-loading digital CD player with synchronized CD-to-tape recording function. Line input/output provides the option of connecting the portable unit into a stereo system, or plugging additional components into the music system itself. AC/DC operational, the system is backed by a one-year warranty from GE. Price: $349.99.

GE CD Music System

All you computer disc and video disc users out there, how about something which would eliminate "fumbling through a clumsy box file"? *PAC (Dept. C91, 2507 Ridgemoor Ct., Arlington, TX 76013)* is marketing the **Disk-O-Tel Disc Storage Carousel** (model 108) to do just that. Each disc is stored in a paper envelope in one of 108 separate, numbered slots. The carousel rotates and units can be stacked. Each storage carousel is 6¾" high and 13½" in diameter with a shipping weight of 6½ lbs. Price: $49.



Disc Storage Carousel

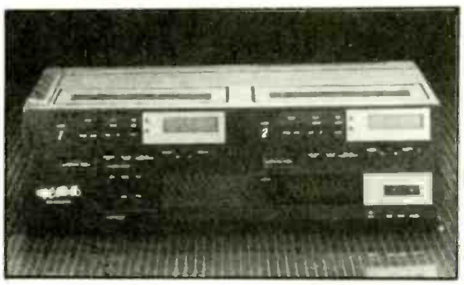
Bits & Pieces

BoosterBox Video Amplifier

Ever been disappointed in the poor quality of a video tape duplicated from another cassette? Without proper amplification, as much as a 10 to 15 percent loss of image quality can result. Our source for that startling statistic is *Sima Products Corp. (4001 W. Devon Ave., Chicago, IL 60646)* which, not coincidentally, is marketing the **BoosterBox Video Amplifier**. Introduced at the Winter Consumer Electronics Show, the BoosterBox boosts "the video signal a whopping 8 db," and, according to Sima, provides "a reproduced tape whose picture quality is so close to the original, the two would appear to be virtually identical." The compact item can be used with either stereo or mono VCRs, and it comes with a "Y" adapter for use when recording from a mono machine to a stereo VCR. BoosterBox power comes from a single 9-volt battery, good for approximately 35 hours of operation. Price: $44.95.

Lunch n' Tunes Lunchbox

Adult lunchroom monitors during our school years would not have welcomed this new product from *Fun Designs (P.O. Box 2837, 30 Tremont St., Duxbury, MA 02332)*. Nonetheless, we're sure the **Lunch n' Tunes Lunchbox** with built-in AM or FM radio will delight many kids, three years old and up. Fabricated of sturdy plastic, it includes earphones and a handy unbreakable thermos with a flip-top spout. An adjustable shoulder strap makes it easy to tote, although whether contemporary schools will greet Lunch n' Tunes with pleasure remains to be seen. Just in case, Fun Designs reminds us it would also be fun "on a picnic, at the beach or around the block." Power is supplied by a single 9-volt battery. Price: AM—$15; FM—$20.



VCR-2 "Conceptual Model"

The return of the dual-deck VCR? Quite possibly, although at this point the market arrival of this announced new product, **VCR-2**, from *Go-Video (4141 N. Scottsdale Rd., Suite 204, Scottsdale, AZ 85251-3940)* is as much as a year away. According to Go-Video, dual-deck VCRs were briefly marketed or planned by Sharp and Samsung, but were withdrawn "under apparent pressure from the movie industry." Now, Go-Video is looking to "license companies for the manufacture and distribution of the VCR-2." The unit will allow consumers "to duplicate video tapes without. . .two separate machines, edit quickly and easily or watch a pre-recorded tape while recording a television program." Further announcements are promised for the near future. Price: $500-$600.

How many marriages could this simple device save? People seem to be divided between those who like to fall into slumber watching TV or listening to the radio and those who insist on silence. Sold by *The Synchronics Catalog (Unique Merchandising Mart, Building 42, Hanover, PA 17333)*, **Wire-Free** is an **Infrared Audio Transmitter** for use with televisions, VCRs or stereo equipment. Hooked up to an audio source, the user plugs headphones into the Wire-Free receiver for private listening while others sleep, study, read, etc. The receiver has both a volume control and an on-off switch. A single transmitter can be used in conjunction with several receiver units. Price: $59 (additional receivers, $29.95).

Finemovie 8mm Camcorder

Despite the commercial questions still unanswered, the 8mm video format doesn't lack for suppliers and equipment manufacturers. *Kyocera International, Inc. (100 Randolph Rd., CN 6700, Somerset, NJ 08873-1284)* has introduced its third generation of 8mm video equipment, the **Finemovie 8mm Camcorder**. Weighing in at 3 lbs., 2 oz. (3 lbs., 12 oz. with battery and cassette), the Finemovie 8 offers infrared autofocus, a 2.5:1 zoom lens, electronic black-and-white viewfinder and in-camera playback. Its solid-state image sensor boasts a quarter-million picture elements (or "pixels") and resists "image lag and streaking and will not 'burn-in' when shooting extremely bright objects." Price: $1,500.

Butane was once the big, new heat on the lighter front. But now, *Colibri (50 Park Lane, Providence, RI 02907)* has introduced an update of the trusty butane lighter which is no less than "the most technologically advanced in the world...the world's first flameless lighter" and "the only truly windproof" fire starter. The **Quantum Lighter** gains its heat from "an electric element deep within," and consumes "as much as 60 percent less butane." The manufacturer also says it's unaffected by altitude and absolutely safe, "because it turns off automatically" with the release of the ignition button. We were impressed by the Quantum's heft and balance, the minor touches which often reveal a quality product. The Quantum is available in black matte, gun metal and brushed gold finishes. Price: $75-$89.50.

If you own a portable CD player, you know how great its sound is. You probably also know how frustrating it is not to be able to connect it to your car stereo or portable sound system. The CD20 **Compact Disc Cassette Adapter**, manufactured by *Recoton Corp. (46-23 Crane St., Long Island City, NY 11101)* is a clever device which allows you to listen to a CD player through a tape player. Basically, it's a bit of electronics inside a cassette housing with a cord that plug into a CD player's headphone input. The CD20 is popped into the tape deck like an ordinary cassette. Of course, if your car tape deck speakers aren't very good, the CD won't sound much better than a tape. Although Recoton offers the CD20 with the cord connected to either the side or bottom of the cassette housing, it can be a tight fit into the deck. Price: $24.95.

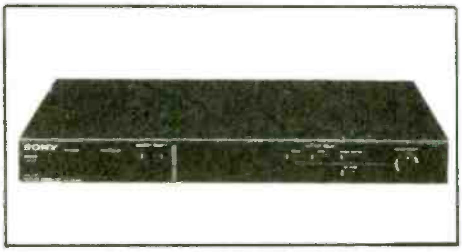
With the video add-on and enhancement market exploding, *Sony Corp. of Amerca (Sony Dr., Parkridge, NJ 07656)* wasn't about to leave the field to a bunch of upstarts and unknowns. The company has introduced three image processors, among them the XV-T600 **Picture Computer**. The "PC" can scan black-and-white, written or printed material, then color or alter it and display the image on a screen. Its purpose is to "help the user create video art" and to make video "more personal." It can also superimpose for light titles on a dark background or vice versa, and is capable of generating 15 background colors. Price: $600.

It's not often a mail-order merchandiser admits that the reason for a low-priced item is to build up a customer mailing list. Nonetheless, that's exactly how *Haverhills (131 Townsend St., San Francisco, CA 94107)* has been promoting the DL-323 **Rechargeable Power Failure Light**. Plugged into any household outlet, the DL-323 recharges away until power goes out, then it comes on, warning of the outage via its heavily reflected 1.5-watt bulb. An LED light below the main lens is touted as a night light, but in GADGET's tests, its illumination was too dim for that purpose. Otherwise, the DL-323 seemed a well-designed, well-constructed device. Even its drum-like shape made for ease of handling. And, of course, you don't have to wait for a power failure to use it as a flashlight. Price: $12.95.

Custom designed for today's hyper-fast lifestyles and work environments, the new *General Electric (Consumer Electronics Division, Portsmouth, VA 23705)* **Fastrac Cassette Tape Recorder/Player** (model 3-5324) can play "standard recordings up to two times faster than normal with minimal distortion of voice quality." Both tape speed and pitch are controlled manually, so as tape speed increases, pitch can be lowered to restore intelligible sound. Regular recordings can be made with the variable speed control off. The Fastrac also features variable voice activation and a built-in microphone for "true hands-free operation." The recorder/player comes with a protective carrying case and operates on four "AA" batteries (not included), as well as via an AC/DC power converter (included) or an optional vehicle adapter. Price: $109.95.

Bits & Pieces

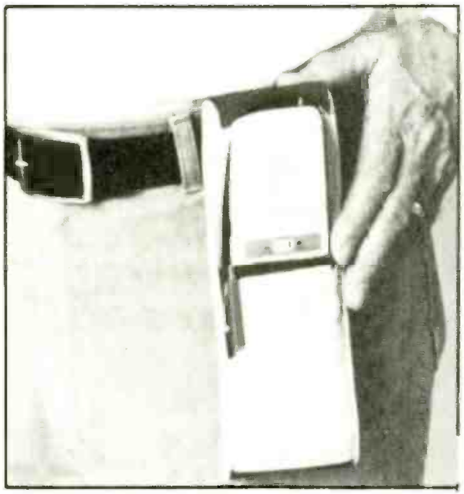
Quantum Lighter



Sony Picture Computer

Fastrac Cassette Recorder

Bits & Pieces



PhonePak Cordless Phone Carrier

Bel-Tronics Radar Detector

Toshiba Magnum TV/Monitor

Convenient is as convenient does and it would seem reasonable that most of the four million cordless phones purchased last year were bought by people looking for it—convenience—that is. So *Sima Products Corp. (4001 W. Devon Ave., Chicago, IL 60646)* thinks it's got a winner in its **PhonePak Cordless Phone Carrier**. Designed to be clipped to a belt or worn over the shoulder, the vinyl PhonePak is "made to accommodate all cordless phones now on the market" and comes in yellow trimmed in blue. It comes equipped with a message pad and space for a pencil. With the PhonePak you'll never have to fear missing a phone call, or not being able to make one, surely among the contemporary world's leading anxieties. Price: $9.95.

It's our impression that radar detector sales have stalled out in recent years which would help explain the new line of "entry level" **Radar Detectors** from *Bel-Tronics Limited (2422 Dunwin Dr., Mississauga, Ontario, Canada L5L 1J9)*. Designated the "Leader Series," the top-of-the-line is filled by the Micro Eye XKR 500. The unit features special "false signal recognition" circuitry capable of tracking the change in a signal and giving an alert if it turns out to be police radar after all. The Leader quartet of radar detectors all share Bel-Tronic's "hybrid half-horn micro strip circuitry and superheterodyne circuitry," but only the Micro Eye XKR 500 has "smart" false signal recognition. Price: $199.95.

You'd think that after a hundred years, communications technology would have come up with a better way to signal an incoming phone call than the often nerve-racking, jangling, "ring" which can make a phone-intensive environment or job an audio nightmare. The **Nobell Ringer Intercepter** doesn't do away with ringing telephones, but it does intercept the signal before it can assault your eardrums. Distributed by *Herrington (10535 Chillicothe Rd., Kirkland, OH 44094)* and other mail-order houses, the Nobell announces calls with the user's choice of signals —a digitalized voice, synthesized music or special-effects sounds. There are some 17 choices programmed into the unit, and Herrington says the voices are "completely human sounding, not computer-like." The Nobell's musical repertoire includes seasonal favorites like "The Twelve Days of Christmas." Handsomely designed for desk display, the Nobell "installs in seconds between any phone and wall socket" and works with any answering machine. Price: $149.95.

Miniaturization isn't the only trend in televisions. Some of them, in fact, are moving in the opposite direction. *Toshiba America, Inc. (82 Totowa Rd., Wayne, NJ 07470)* has introduced a 30" **FST Magnum TV/ Monitor** (CX 3077). "FST" is Toshiba's designation for what it claims are its "flattest, squarest tubes" which, the company says, provide "a picture that is both flatter and squarer than traditional cylindrical and spherical screens." The image is also rated "brighter and sharper" than the picture of "traditional television sets." The CX 3077 incorporates a "high focus 110 degree deflection electronic gun system utilizing seven lens." Toshiba actually calls this behemoth a "table model." Price: $2,499.

Coming in July's GADGET newsletter

• The 84th American International Toy Fair—A report on the toy industry's annual unveiling of what's new, hot and happening for tykes of all ages.
• Sega Game System—After one of the most spectacular disappearing acts of the decade, video games are coming back. We take a look at one of the market recovery leaders.
• The Razors' Edge—There have been lots of shaving developments since the last Burma Shave sign came down. GADGET tests two of the newest, the Freedom Blade and Braun's 1-2-3 System.
• Interplak—It's being called, "the first real advance in home dental care since the toothbrush," and for once a slogan may mean something.

Gimme Dat Ol' Time DX

You can still tune-in yesteryear's shortwave stations!

By Don Jensen

THE BALEFUL GREEN TUNING-EYE WINKED AT ME, THE illuminated "V" on the tube face closing to a mere line as Grandpa peaked the signal right on frequency. Looking back those many years to boyhood, I remember Grandpa's radio, a monstrous Majestic console with the booming *basso-profundo* sound that passed for audio fidelity in those days.

I recall the warm, rich wood of its mahogany cabinet and the little purplish light that hopped the dial when Grandpa switched bands from everyday AM radio to shortwave. I still can see the celluloid circle with the then-incomprehensible frequency numbers. But, most of all, I remember the Majestic's dial plate on which were printed the names of all the faraway places—Hilversum, Quito, Vatican City, Daventry, Berlin, Batavia, and all the rest.

All it took, I supposed then, was to set the dial to the appropriate city and—*Shazam!*—that was it...um-pah-pahs direct from a teutonic beer hall, tangos from Patagonia, kootchie-koos from Pago Pago, all via the wonder of shortwave radio.

It was never that simple then, of course, but with today's shortwave receivers—digital readout's and improved circuits—it's a whole lot easier to tune in the world.

Most of the shortwave stations that Grandpa could hear are only memories. But not all of them! Just for fun, turn on your 1980's shortwave receiver but roll the calendar back to the 1930's, and let's see which SW survivors are still around after a half century or more!

SWB's That Survived

Ecuador—A half century ago, in an era of uncrowded shortwave frequencies, Grandpa was easily able to hear the program of HCJB, the *Voice of the Andes*, broadcasting from the Ecuadorian capital of Quito, despite its *pipsqueak* transmitter equipment.

A young missionary, Clarence W. Jones, had the idea that he could reach widespread audiences with his religious message by using shortwave radio. With a 40-watt transmitter, he began transmitting from a converted sheep shed just 15 miles south of the Equator.

In the beginning, HCJB broadcasted in Spanish and English on the off-beat frequency of 4,107 kHz, with daily programs from 8 to 9 PM, Quito time—which, strangely, was exactly 14 minutes behind Eastern Standard Time (EST).

On April 1, 1934, Jones took a big step forward in broadcasting when he boosted the station's power more than tenfold, to 500 watts. A second frequency was added, 8,948 kHz, for a daily-except-Monday schedule of broadcasts at noon and 6 PM.

At Jones' death, at 85, just two years ago, his Voice of the Andes had grown to a major international broadcaster, with its collection of shortwave transmitters including a 500,000-watt unit, and a staff of nearly 600 persons.

Today you can find HCJB in English from 0200 to 0700 Coordinated Universal Time (UTC) on 6,230 kHz.

England—In years gone by, Daventry meant radio to listeners around the world. Daventry was the location of the *British Broadcasting Corporation*'s (BBC) pioneer broadcasting operations.

In Grandpa's day, the British stations—if they weren't all lumped under the generic location name Daventry—were known by their call letters. There was GSB on 9,510 kHz, GSC on 9,580 kHz, GSD on 11,750 kHz, GSF on 15,140 kHz, GSG on 17,790 kHz, and others.

Predating the popular World Service was the BBC's Empire transmissions, a name that stressed the stations' purpose, to reach English subjects wherever in the world they might be. The sun never set on the empire that Daventry could reach with its radio signals.

It was in September of 1936, when the British government banned all advertising and sponsored programs from radio. The British people, then, as now, paid a radio licensing fee, originally set at 10 shillings.

An American radio-magazine writer felt that his government ought to follow suit. He complained strongly about an experimental U.S. commercial SW outlet, W9XJL on 26,100 kHz, which—figuratively, I hope—endeavored to sell double decker beds to the Eskimos, fur coats to South Sea Islanders, and Tums to the African cannibals.

Note the unique construction of PCJ's rotating shortwave antenna, which could beam programs to any part of the world.

This early HCJB QSL, which at one time was printed on paper, was used for years by that Ecuadorian station.

Times changed. More and more powerful SW transmitters were added at additional British broadcasting sites, places like Crowborough, Skelton, and Rampisham. And then the BBC began installing overseas relay facilities, first in Singapore and then around the world, from the Mid East to the Caribbean, Canada to the South Atlantic to Africa, and beyond.

But some things don't change. Daventry, for instance, remains one of the BBC's broadcasting sites, its original transmitters long ago replaced. Today, Daventry has nine units, five of which are rated at 100 kilowatts, and the four others at 250 kilowatts.

Daventry, today, is not used for broadcasts directed to the United States. The relay facilities on the West Indian island of Antigua are more effective. Still, Daventry can be heard with World Service programming to Europe during the morning hours, from dawn to 1430 UTC, on 17,790 kHz—interestingly, a frequency still used after a half century!

Vatican—Guglielmo Marconi, the father of radio, helped design and install the Vatican broadcasting station, HVJ. He was assisted by the Rev. Guiseppe Gianfranceschi of the Gregorian Academy of Scientists.

Fr. Gianfranceschi stayed on to become, until his premature death in September 1934, director of the new shortwave voice of Roman Catholicism.

The HVJ radio masts were installed in a lovely garden, a hundred meters or so southwest of the Collegio Etiopico, within the Vatican walls. By the standards of its day, HVJ Vatican Radio was a powerhouse, running a 10,000-watt transmitter.

Grandpa and other 1930's shortwave listeners could find the station on 19.84 meters (15,120 kHz) daily in English from 5 to 5:15 AM, EST, and a multi-lingual program, in French, German, Spanish, and Italian, as well as English, from 10 to 10:30 AM, EST. HVJ also was heard on 50.2 meters (5,969 kHz) at 2 to 2:15 PM, every day except Sunday. It was easily identified by the sound of the studio clock, ticking loudly in the background.

The 1980's, SWL will find Vatican Radio beamed to Western-Hemisphere listeners in English at 0100 UTC on 6,015 and 9,605 kHz., and at 0200 UTC on 6,145 kHz.

Netherlands—The N.V. Philips electrical firm at Eindhoven was the private company that put Holland firmly on shortwave in the pioneering days. In later years, though, the early operations of PHI and, especially, PCJ, with transmitters at Huizen and Hilversum, evolved into today's *Radio Nederland*.

As early as 1934, a fellow named Edward Startz, a staff announcer at PCJ, was signing listeners' QSL cards. He was the impresario of the station's popular Happy Station programs until his retirement about 1970. With Tom Meijer as the current host, the Happy Station Sunday show is now into its sixth decade!

PCJ engineers built a revolutionary antenna, including a couple of steel towers mounted on a circular railroad track. The arrangement made it possible to beam the Dutch station's programs to specific target areas of the world.

During WWII, when the Nazis occupied Holland and took over its shortwave facilities. Dutch engineers managed to jam the antenna turntable apparatus, so that the enemy programs were beamed to a sparcely populated arctic area.

Old time shortwave fans could find PCJ on 9,590-kHz and its sister station, PHI, on 11,730 kHz. The 1934 schedule had them broadcasting in Dutch, Malay, German, French, Portuguese, Spanish, and English five mornings a week.

Now Radio Nederland has grown up, with relay stations in the West Indies and on Madagascar, as well as in Holland. While PCJ's old 9,590 kHz channel is still used—and strongly heard in North America—it is via the relay facility on the island of Bonaire in the Netherlands Antilles, much closer to our shores.

But you can hear English shortwave transmissions directly from Holland via Radio Nederland's 500-kilowatt transmitter at Flevoland on 9,895 kHz at 0330 and again at 0500 UTC.

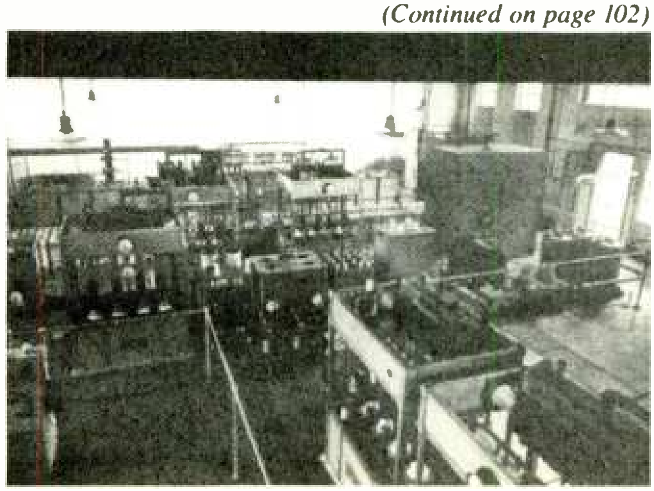
Czechoslovakia—1930's radio fans had been hearing pioneer SW broadcaster OLR at Podebrady for some time, when a new service began in July 1936. So it wasn't too surprising when many of them briefly misidentified a new Czech station.

It wasn't Podebrady they soon found out, but rather a station calling itself *Radio Praha*, anglicized today by the Czech government's foreign service as *Radio Prague*.

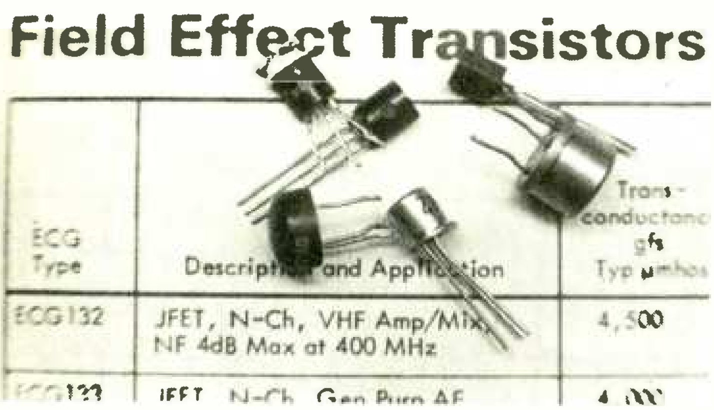
Radio Prague began with daily broadcasts at 11 AM, EST on 49.05 and 19.69 meters, but on Sept. 6, 1936, shifted the latter to 11,760 kHz, where it continued with 6,110 and 15,200 kHz also used.

None of those remain in use today. Still Radio Prague can be heard in English to North America at 0100 and 0300 UTC on 5,930, 7,345, 9,630, 9,740, and 11,990 kHz.

(Continued on page 102)



This is what the BBC's transmitter complex at Daventry looked like back during the 1930's.



FET's

What they are and how to use them!

By Robert Grossblatt

Few know much about the latest member of the semiconductor family even though it's been around a while. Here's a chance to catch up

☐IT MAY SEEM HARD TO BELIEVE, BUT IT'S ONLY BEEN about twenty-five or so years since transistors started replacing tubes in mainstream electronics design. Low power, small size, and just about unlimited lifetime were only a few of the characteristics that made transistor-based designs so popular. But, as we all know, nothing is perfect, and that applies to bipolar transistors as well. Input impedances are low, noise is often a problem, and safeguards have to be taken to design against thermal runaway. Because of those factors, and a few others, tube circuitry didn't totally disappear when transistors hit the market. A classic example was that the VTVM (Vacuum Tube Volt Meter) was still regarded as the instrument of choice even though a transistor-based instrument was currently available.

When the FET (Field-Effect Transistor) was introduced it overcame a lot of the shortcomings of bipolar transistors, and several designs that were traditionally tube-based became transistorized since the FET combined all the standard transistor and vacuum-tube advantages into one package. In order to understand the benefits that came with the FET, let's take a look at a bipolar transistor.

Bipolar Transistors

Figure 1 is a representation of a PNP bipolar transistor. In a nutshell, an N-type material is sandwiched between two pieces of P-type material. The middle layer is the base of the transistor, and the two P layers are the emitter and the collector. If we make the base voltage more positive than the emitter, but not as positive as the collector, the transistor will turn on. Current flow through the base-emitter junction will cause current flow in the collector-emitter junction. NPN transistors are exactly the same except that a piece of P-type material is stuck between two pieces of N-type material and current flow is in the opposite direction.

It doesn't take a deep understanding of transistor physics to see that the two junctions are much the same as two diodes. The input impedance of a bipolar transistor is consequently very much the same as a diode: low. That characteristic was one of the main reasons why the introduction of the transistor didn't completely blow tube design out the window. Since tubes have inherently high impedance, it was simply easier to use them rather than go through all kinds of electronic brain damage trying to phony-baloney high-impedance front ends using bipolar transistors.

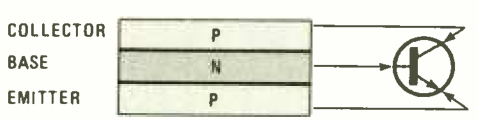


Fig. 1—The typical bipolar transistor is just a semiconductor sandwich. The type shown above is an NPN transistor.

Enter: The FET

While bipolar transistors are basically current amplifiers, FET's are basically voltage amplifiers. The elements of an FET are shown in Fig. 2. The same N- and P-type material we saw in the bipolar transistor is present here as well, but that's where the similarity ends. In the FET shown in the illustration, some N-type material is embedded in a P-type substrate. The substrate is referred to as the *gate*, and the two ends of the embedded material are usually called the source and the drain. The key element in the construction is to actually bury, or channel, the N-type material in the substrate. Of course the situation can be reversed; we can bury P-type silicon in an N-type substrate. That is similar to the NPN and PNP classifications we saw with bipolar transistors.

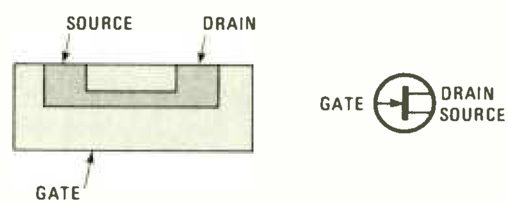


Fig. 2—A JFET is composed of the same kinds of materials as a bipolar transistor, but their arrangement is different. Note that the gate is composed of two P-type regions.

To get an idea how the FET works, take a look at Fig. 3 which shows what happens to the FET if we connect the source to the gate and apply a positive voltage to the drain. The PN junction in the vicinity of the drain is going to be forward-biased and current is going to flow into the substrate. That creates an electron shortage and reduces the amount of current that can flow from the drain to the source. The amount of current that can flow through the channel is directly related to the field created between the gate and the drain—hence the name field-effect transistor. Reverse biasing the gate-source junction increases the depletion layer, decreasing current.

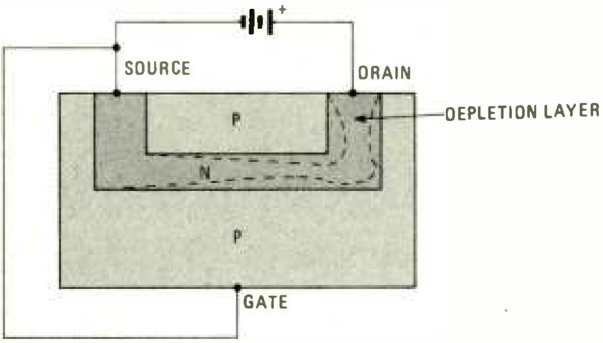


Fig. 3—As current flows through the channel, it becomes depleted of electrons. The region formed by that effect is the depletion layer. It eventually limits the current flow.

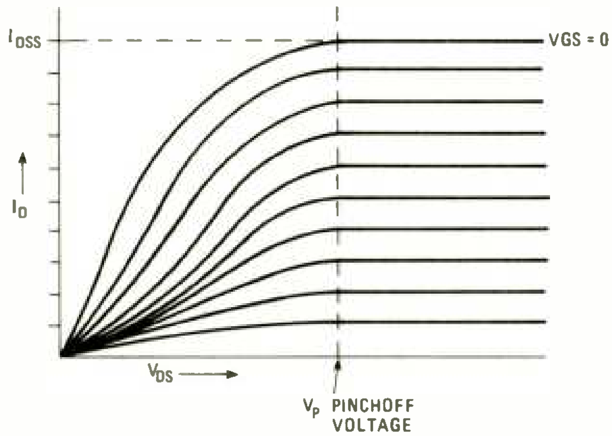


Fig. 4—The family of curves, called characteristic curves, shown above is used to demonstrate the action of a transistor (in this case an N-channel FET) under different operating conditions. Each curve was generated using a different V_{gs}.

FET Characteristics

There are two inter-related factors that control the performance of an FET, (i.e. current flow in the embedded channel). The first is the voltage between the gate and the source (V_{gs}) and the second is the voltage across the drain and the source (V_{ds}). If V_{gs} is at ground, we've already seen that the electron shortage in the channel is going to restrict the amount of current flow in the channel. If we keep V_{gs} locked at ground level, the only way we can increase the current flow is to raise the voltage at the drain (increase V_{ds}).

When V_{ds} reaches a certain level, however, raising it any farther isn't going to increase current flow. After all, you can't have any current flow if you don't have any electrons. The maximum current that can be forced through the channel with the gate shorted to the source is called, obviously, I_{dss} (drain to source current with the gate shorted to the source). I_{dss} is a magic number for an FET and there's even a special name for V_{ds} at that point: the *pinch-off voltage*, or V_p. It was given that somewhat prosaic name because the field generated between the gate and the drain "pinches off" the current flow in the channel.

All that will be a lot clearer when you look at Fig. 4, the curves that are generated by varying both V_{ds} and V_{gs}. Everything to the left of the dashed line is referred to as the *ohmic region* and everything to the right is called the *pinch-off region*. The ohmic region gets its name from the fact that, below V_p, a FET is very-much like a variable resistor. You can see that the curves below the dashed line are very linear—the relationship between the current flow, (I_D), and V_{ds} follows Ohm's law very closely. If you get into the pinch-off region, you'll see that the FET behaves just like a saturated bipolar transistor.

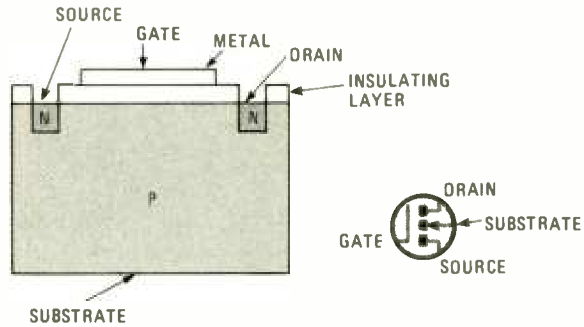


Fig. 5—The insulating layer between the gate and the P-type substrate causes them to act like a capacitor. When the voltage at the gate is positive, electrons gather in the region between the drain and source under the insulator.

The interesting thing to notice from the curves is the effect of the two control voltages on I_D above and below pinch-off. In the ohmic region, both V_{ds} and V_{gs} can be used to control I_D. Once you get past the pinch-off voltage, V_p, only V_{gs} has any effect on the current flow.

The FET we've been describing so far is the JFET, or Junction FET; it also went by the name unipolar transistor. The most distinguishing feature of that family of P- and N-channel FET's is that there's a direct, hard-wired, connection between the gate and the rest of the world. JFET's eliminate a lot of the problems that were found in bipolar transistors; the input impedance is in the multi-megohm range and thermal runaway is much less likely. However much of an improvement they were over bipolars, they were still a far cry from the corresponding characteristics in tubes. And then came the day that someone realized it was possible to have gate control of channel current without actually having a hard-wired connection between the gate and the rest of the world.

The MOSFET

With one exception, the MOSFET, (metal-oxide silicon FET), is the same as the JFET we've just described. The exception, however, is an important one. Instead of having a direct connection between the gate and the substrate, a small

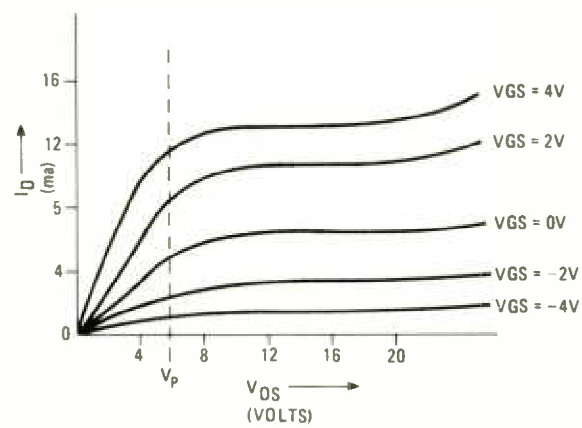


Fig. 6—The family of characteristic curves for a D-MOSFET (this one being an N-channel) are different in that they span both positive and negative gate-source voltages.

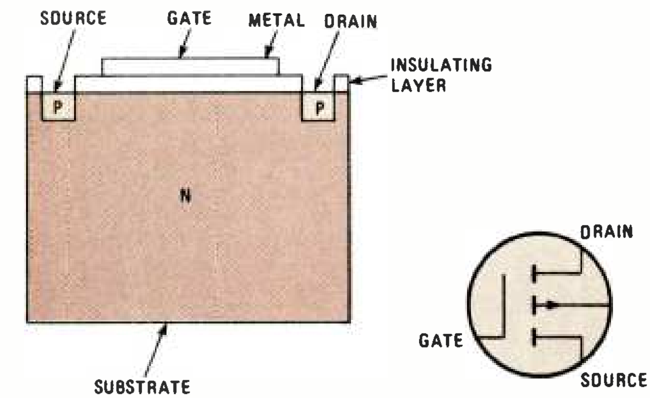


Fig. 7—A P-channel E-MOSFET's operation is similar to that for an N-channel except all biasing conditions are reversed.

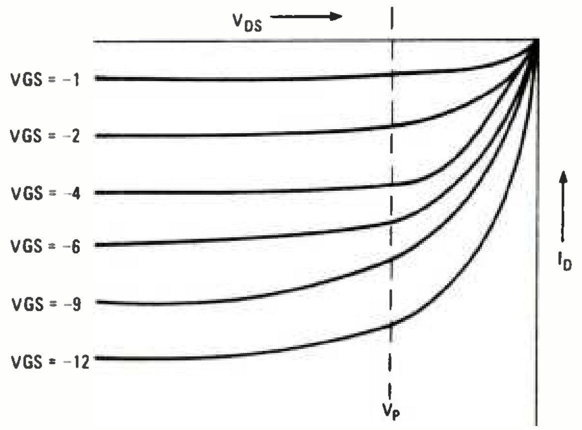


Fig. 8—Unlike the N-channel E-MOSFET, the P-channel can operate in the negative voltage range, with similar characteristic curves. Note that the V_p is negative.

metallic gate is isolated from the channel by a thin insulator, usually a film of silicon dioxide, as shown in Fig. 5. The bottom of the insulator is in physical contact with the substrate material. Applying a positive voltage to the gate causes free electrons to migrate to the bottom of the insulator, forming a channel between the source and drain. Since the gate isn't connected to the substrate, it can be either positive or negative with respect to the source. As a matter of fact, the more negative you make V_{gs}, the fewer free electrons there are in the channel.

That means you actually have to make V_{gs} negative to eliminate current flow in the channel. That type of normally-on MOSFET is referred to as a *Depletion Mode FET* since channel current, I_D, can flow if V_{gs} is zero, all you need is V_{ds} for current to flow. The best way to understand that is to take a look at the curves in Fig. 6. At $V_{gs}=0$, I_D can still be produced by raising V_{ds}.

Enhancement MOSFET

It doesn't take much of a stretch of the imagination to guess that the next step was to develop a normally-off MOSFET. All that was needed to make that a reality was to reverse the polarities of the channel and substrate as shown in Fig. 7. Since the P and N regions are the reverse of the previous example, a conducting path isn't automatically produced between the drain and the source. If V_{gs} is held at at 0, a V_{ds} of either polarity won't induce a P-type channel since either the drain or the source will always be reverse biased.

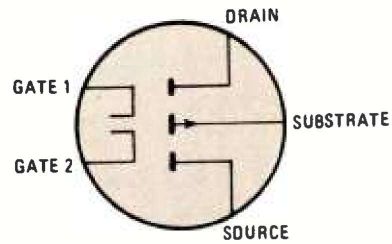


Fig. 9—Dual gate MOSFET's are excellent for mixing signals such as audio from more than one source. This is a P-channel.

The only way to create a P-type drain-source channel is to apply a negative V_{gs} as shown in the output curves of Fig. 8. A MOSFET built like that is normally off since you need both V_{gs} and V_{ds} to have current flow. That MOSFET, the *Enhancement Mode* MOSFET, is the basic element in many IC's, since they have an extremely high input impedance and will stay in the off state until there's an active V_{gs}.

The MOSFET came very close to bridging the gap between the vacuum tube and the semiconductor. Since the gate is completely isolated from the substrate, the input impedance is in the region of hundreds of megohms. That meant that the traditional VTVM, could finally be replaced with the MOSFETVM. But the improved characteristics of the MOSFET found immediate applications in other areas as well. The high input impedance and inherent low noise made it a natural for audio and video signal processing. Those have become such standard uses that MOSFET manufacturers started making P- and N-channel parts with two gates, as shown in Fig. 9, for use as automatic-gain controls and audio mixers. Although either gate can control the device, they're both electrically isolated from each other and the substrate, so inter-gate crosstalk is pretty close to nonexistent.

The Drawbacks

Now that we know all the great things about FET's, you might ask about the down side. Well, they're big and have to be handled very carefully. It takes a lot of silicon to make an FET of any kind and that's why you can't easily find FET's capable of handling lots of current. To put that in perspective, if you wanted to design an FET capable of handling the same amount of current as a bipolar transistor, you'd need more than ten times the silicon for the FET. That is the main reason why you won't find MOSFET-based IC's that can handle a lot of power; it's simply a question of size and space.

Super-high impedance is a terrific design advantage, but it has a down side—sensitivity to electrostatic discharge. MOSFET's are close cousins to the transistors used in CMOS IC's. They both have a very thin layer of insulating material between the gate and the substrate. The high input impedances make MOSFET's very sensitive to static charges. It doesn't take much static build-up to produce a discharge strong enough to puncture the insulating oxide. Once that happens, you can kiss the part goodbye. The moral here is to handle the parts with care. Keep them wrapped in aluminum foil and make sure you've got yourself grounded before you pick them up.

There's a lot more that can be said about FET theory, but we've at least covered the basics. If you really want to learn how to design circuitry around FET's, your next step is to order a few of the data books published by the semiconductor manufacturers. Two really good sources are: National

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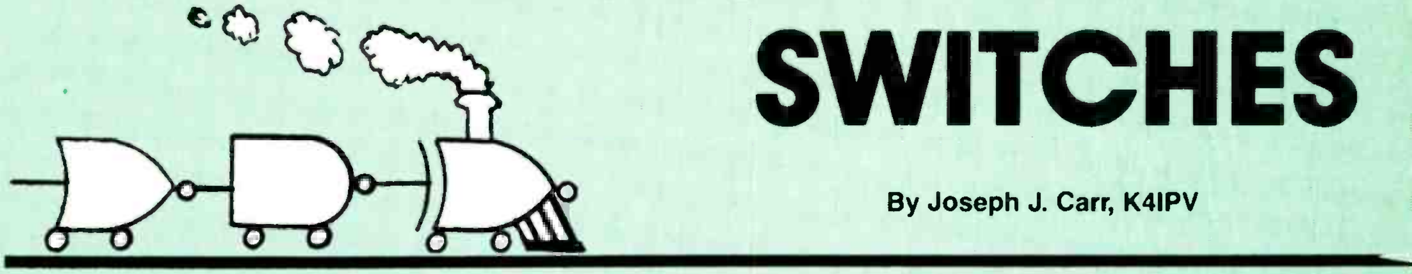
DIGITAL PULSE-TRAIN SWITCHES



By Joseph J. Carr, K4IPV

Mechanical switches are too noisy for many electronic applications, so here's some information on their mute cousins

SOME ELECTRONIC CIRCUITS CALL FOR TURNING PULSE trains on and off. In some cases, the pulses are turned on and off with a manual switch, while in others an electronic timing switch is used. Unfortunately, there are many cases where mechanical switches or relays are not useful for that purpose. In this article we will take a look at several alternative electronic switches that can be used for digital pulse trains.

CMOS Electronic Switches

The first component that comes to mind when thinking about digital switches is the CMOS electronic switch. In the low-cost 4xxx line, we have two examples that are pin-for-pin compatible with each other: the 4016 and the 4066. Those devices contain four independent bilateral switches in the same 14-pin DIP package. The 4016 is now considered obsolete, and the device of choice is the 4066.

Nonetheless, there are still plenty of 4016 devices on the hobbyist market. Figure 1 shows one section of the 4066 device. The switch is bilateral, meaning that signal will flow in either direction between IN/OUT pins. The signal channel acts like a resistor in series with the line. When the control line C is high, the resistor has an extremely large value, so the switch is "off." But when the switch is enabled by making C low, the channel resistance drops to a low value. That value is typically less than 2000 ohms, although some versions have a channel resistance as low as 100 ohms.

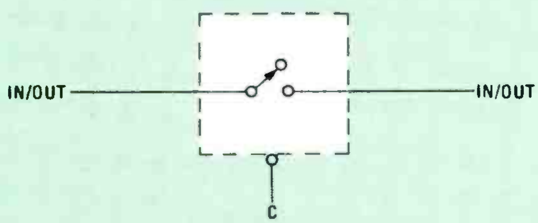


Fig. 1—A bilateral switch can be viewed as a black box containing a single-pole, double-throw switch, which is activated by an "electronic finger" at the control input C.

On the 4066 device, the control input is *active-low*. That means that a low on the control line closes the switch, while a high opens it. When pin 14 is connected to +5 VDC, and pin 7 is grounded, the 4066 device will operate in a TTL compatible mode.

NOR Gate Switches

Ordinary digital gates can be used for switching pulse trains on and off. The charm of using those kinds of devices is that we can often make use of existing sections of chips already in a project. For example, suppose we used a 7402 NOR gate in a project. The 7402 is a quad, two-input, NOR gate, meaning that there are four independent gates in the chip. If we use less than four, the remaining NOR gates are available for electronic switching purposes.

Figure 2 shows the use of the NOR gate for electronic

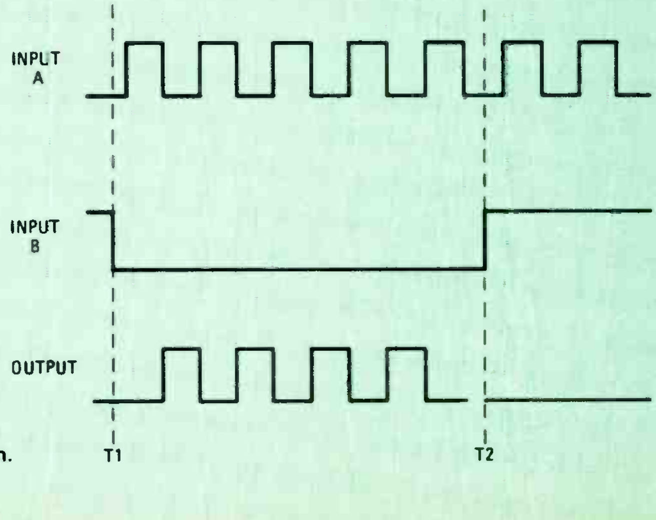


Fig. 2—Spare NOR gates make great switches, but like all gates they can only accept input from one direction.

switching. The NOR gate obeys the following two rules: A high on either input causes the output to be low; and both inputs must be low for the output to be high.

In the circuit we have a two-input NOR gate with one input used to accept the pulse train; the other input is connected to a switch and a pull-up resistor. The resistor keeps input B high whenever the switch is open. But when S1 is closed, the NOR gate input is grounded. When the switch is open, therefore, a high is placed on one input of the NOR gate so its output is low (prior to T1 in Fig. 2B). Closing switch S1 grounds input B, allowing input A to control the circuit operation. Anytime input A is low, the output is high, and anytime input A is high, the output is low. Thus, the circuit in is an inverting digital switch.

NAND-Gate Switches

The 7400 device is a TTL, quad, two-input, NAND gate. Like its 7402 cousin, the 7400 can be used as a digital switch (see Fig. 3). The NAND gate obeys the following pair of rules: If either input is low, then the output is high; and both inputs must be high for the output to be low.

The NAND circuit is similar to the NOR circuit. The signal is applied to input A, while the control circuit is connected to

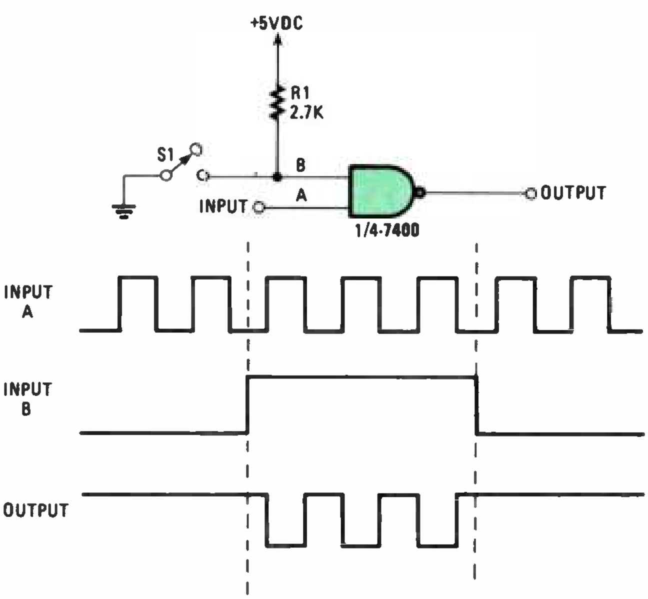


Fig. 3—NAND gates can be used as electronic switches, but like their cousins the NOR gates, they invert the input signal. However an AND will not.

input B. When switch S1 is closed, the NAND-gate input is low, so the output is stuck high. But when S1 is opened, the input is high and the other input controls the output terminal. When input A is high, the output is low, and when A is low, the output is high—the circuit is also an inverting switch.

In considering both the circuits in Figs. 2 and 3, you can probably see that NOR gates and NAND gates can act as inverters. Figure 4 shows the various configurations that will make a NAND or NOR gate act like inverters.

For both types of gate, strapping the two inputs together makes the gate into an inverter (see Figs. 4A and 4B). For the NAND gate, we can also get inverter operation by connecting one input to +5 VDC (see Fig. 4C). The NOR gate is the inverse of the NAND gate, so it becomes an inverter if one input is grounded (see Fig. 4D).

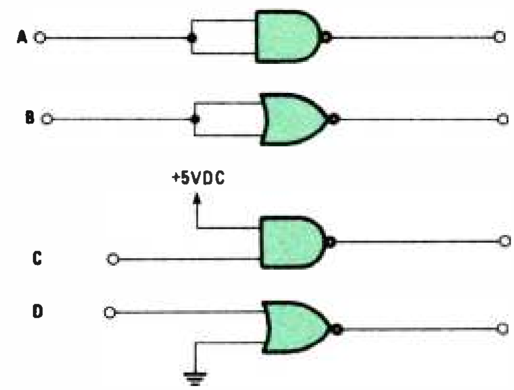


Fig. 4—If you want to re-invert the signal from either a NOR or NAND based switch, you can by using one more gate. The simplest method is to tie the two inputs of the gate together as in 4A and 4B. If that isn't appealing enough tying a NAND input to the supply (4C), or a NOR input to ground (4D) will do.

XOR Gate Polarity Switcher

An exclusive-OR (XOR) gate used as a switch is shown in Fig. 5. The XOR gate operates in a slightly different way than other gates, and obeys two rules: if both inputs are the same, the output is low; if the inputs are different the output is high.

The circuit in Fig. 5 uses input A as the signal input, and input B as the control. As in the previous circuits, a pull-up resistor from the control input to V+ is used to ensure that it remains high when the switch is open. Closing the switch forces input B low.

From the above rules, we can deduce two characteristics about the circuit. First, with S1 open, B is high so a high at the other input forces the output low. A low on the other input forces the output high. Therefore, the circuit acts as an inverter when S1 is open.

Secondly, with S2 closed, B is low so a low on the other input forces the output low, and a high forces the output high. Thus, the circuit operates as a non-inverting buffer when S1 is in the closed position.

Conclusion

Digital electronic switches are useful little circuits that are easily implemented using ordinary gates. This article demonstrates several approaches to the problem, all of which work nicely and quietly. ■

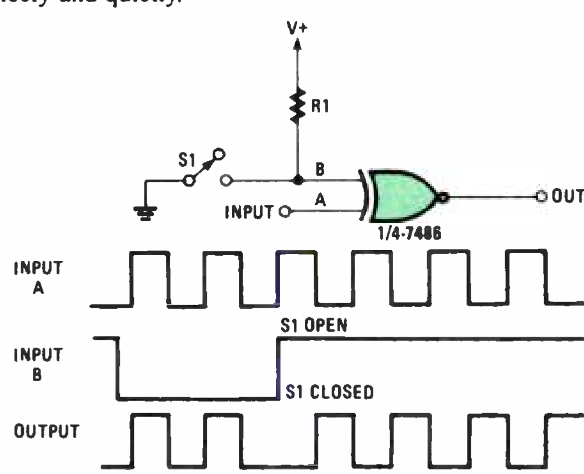


Fig. 5—A switchable inverter/buffer can be created using an XOR gate, allowing you to choose the function it performs: High on B for inversion; low on B for buffering.

Aluminum Foil Antennas

Placing an antenna on your roof is not only dangerous but expensive; here's an alternative

By Ray Ketchledge

GETTING A GOOD ANTENNA FOR YOUR FM TUNER OR TV set is not always easy. Rabbit ears or random lengths of wire tend to work poorly, while beam antennas on a chimney mast are complex and costly. In some places, outside antennas are not even allowed. However, if you have access to your attic, there is an alternative—an *Aluminum Foil Antenna*. It can be simple, inexpensive, and out of sight. Being an indoor antenna, it is out of the weather, out of the wind, and always dry. You can install it and forget it. However, for a neat, professional job, you may want to run the lead-in inside the walls. Even if you have cable-TV service, your own antenna will give you access to stereo TV, which your local cable company may not carry.

Even in an apartment with no attic, the antenna can go in a closet or behind a wall hanging, picture, or piece of furniture. One worked fine in a basement apartment about 20 miles from New York, when mounted on the wall near the ceiling, at ground level! I have personally used aluminum foil antennas for FM, TV, and shortwave radio for over 25 years in 5 houses, plus numerous installations for friends and relatives. In my present home in Florida, I have one TV, two FM, and one shortwave antenna built of aluminum foil. The TV antenna allows me to receive stereo-TV broadcasts, in spite of the limitations of the local cable-TV service, and provides a backup when lightning takes out the cable service.

Why Aluminum Foil?

The bandwidth of an antenna increases with its surface area. Ordinary wire is a small fraction of an inch thick. Aluminum tubing is usually one inch or less. Heavy-duty aluminum foil is available in widths up to 18 inches at any grocery store. Aluminum foil is inexpensive and comes in long lengths.

Consider a center-fed dipole antenna. As the conductors are made broader, the impedance at resonance drops as does the effective "Q." Thus, the impedance at resonance drops even more rapidly. The result is a major broadening of the frequency response, just the ticket for TV, FM, and shortwave. For similar reasons, the antenna's length becomes less critical. Also with broad conductors somewhat less antenna length is required. Thus, it is possible to build dipoles, dipoles with reflectors, dipoles with reflectors and directors, and many other kinds of broadband antennas using aluminum-foil conductors. Construction is easy and the performance will surprise you.

A Simple FM Antenna

You can put an aluminum foil FM antenna in your attic with two pieces of 18-inch wide, heavy-duty foil, each 25 inches long. You will also need enough 300-ohm, twin-lead wire to reach the receiver, and a staple gun with plenty of staples. I used an Arrow T-50 stapler with quarter-inch staples. As shown in Fig. 1, the two pieces of foil are stapled directly to the attic wood with a ½- to ¾-inch gap between adjacent edges. Remember, if you cannot find wood to support your antenna in the place and direction you want, add a board or two to your attic.

These simple tools and materials are all that are required to construct and install any aluminium-foil antenna. You'll find the foil stored in the kitchen.

The next step is to strip about 10 inches of insulation from both conductors at one end of the twin lead. You may find it easier to strip only one inch and solder a 10-inch length of #18 bare copper wire to each conductor. Place the insulated part of the twin lead between the foils and one half to one inch from the top of the foils. Bend the conductors at right angles away from each other, and staple each 10-inch bare wire to one of the foils. Use ten or so staples to insure good contact. I then used a small hammer on each end of each staple to insure it was fully driven. Carefully staple the insulated twin lead to the wooden beams for mechanical support. Drive the staples along the center line of the twin lead being careful not to

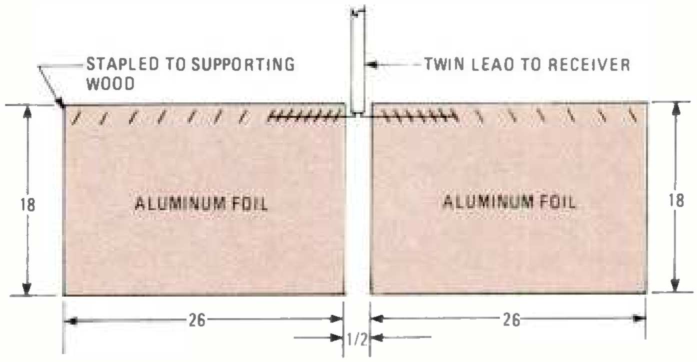
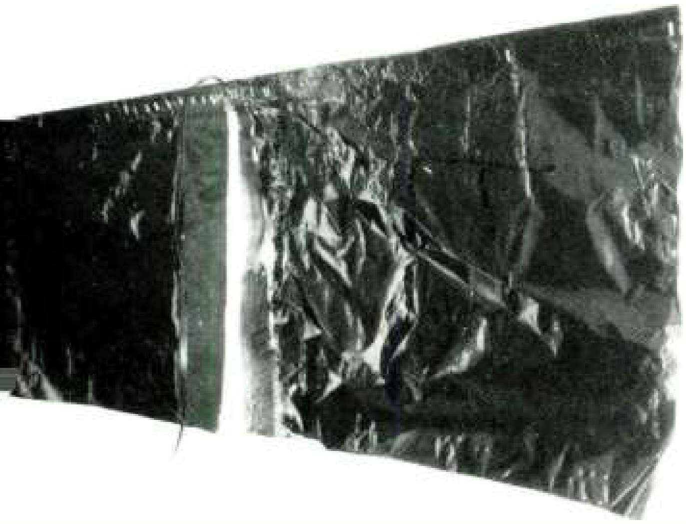
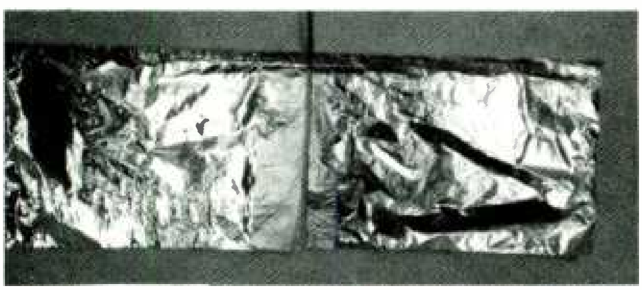


Fig. 1—If you live out in the sticks, or enjoy the programing of a distant radio station, this FM antenna could make your listening habits easier to realize.



damage the conductors. The only remaining task is to run the twin lead to the receiver. Fishing the twin lead through the walls and putting in a wall plate usually takes far longer than building the antenna itself.

Connecting high-frequency conductors directly to bare



This FM antenna is shown mounted on a wall, but it could just as well have been mounted on a single 2 × 4 or light wood stripping for ease of mobility and adjustment.

wood sounds terrible but it works fine. Attic wood is dry wood unless your roof leaks. Think about it; in winter the humidity is low and in summer the temperature is high. In either case you get dry wood, which is a pretty good insulator. I have stapled foil antennas directly to attic beams and roof plywood from New Jersey to Illinois and from Texas to Florida with no problems.

When I moved to South Florida on the Gulf a few years ago, I first chose to play it safe by hanging the foil over a length of 40-pound-test fishing line. One inch of the edge of the foil folds over the line and is secured by use of a paper stapler. However, since my ohmmeter cannot measure any conductivity even on wood stored for several years in my garage, I now just build my antennas on a stick of wood and nail them up in the attic overhead. They work fine, even with inexpensive alligator clips for lead-in connectors.

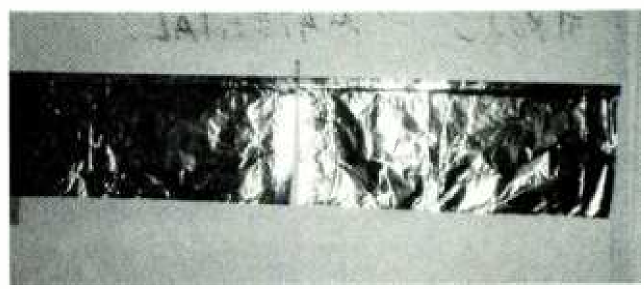
Orientation

Near resonance, dipole antennas receive well off their sides and poorly off their ends, but that is less true at frequencies well above resonance. For FM antennas, 88 to 108 megahertz is not enough to upset the directivity pattern. Consequently one can simply try to keep the stations you prefer more or less broadside to the antenna. TV antennas operated over a wide frequency range are not so simple and some testing is usually required.

A good way to settle the orientation issue for a TV antenna is to make up an antenna on a "stick" so you can carry it around, turn it etc. While you try various channels. Hold the antenna at the center for minimum hand effect. Also remember that however well the antenna works in the living room, it will work better at the higher elevation of the attic.

A Simple TV Antenna

The simple TV antenna shown in Fig. 2, uses two 18-inch wide foils each 42 inches long. The antenna resonates at just over 60 megahertz, (each foil a quarter wavelength). It has a



The 300:75-ohm transformer is not shown in this photo of the TV antenna as it is behind the board the antenna is mounted on. It isn't even necessary if you use 300-ohm cable.

three-quarter wavelength resonance at just over 180 megahertz. In most cases that simple structure will cover the entire 54- to 216-megahertz range, channels 2 through 13 and does fairly well on 470 megahertz (channel 14) and above.

To reduce lead-in pickup of noise, as in our example, use RG 59/U coaxial cable for the lead-in. That will require a 300-ohm to 75-ohm matching transformer (such as Radio Shack part number 15-1253 or 15-1140). The matching transformer converts the unbalanced lead-in into the balanced circuit needed by the antenna. The transformer should be mounted close to the antenna terminals. The same sort of 10-inch bare-wire connection to the foil should be used but running to the 300-ohm terminals of the matching transformer. If your transformer has a twin lead on the 300-ohm

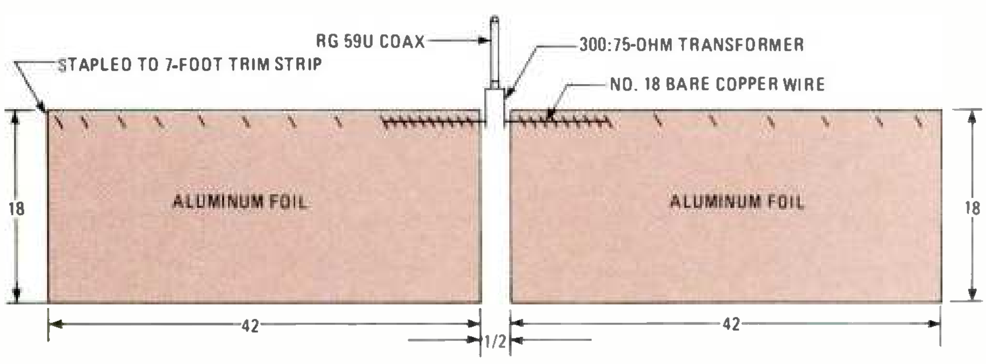


Fig. 2—Any 300:75-ohm transformer can be used to impedance match the TV antenna to the cable. Be sure the 300-ohm side faces the antenna and the 75-ohm side faces the TV.

side, strip back the conductors and solder 10 inches of bare #18 copper wire to each lead. I suggest using #18 gauge bare copper wire for good contact and strength. You can get such wire at most hardware stores if you ask for Handi-wire. Keep leads short and free of stress. Take up the pull of the lead-in with cable clamps. The Radio Shack clamps, part number 20-192, are sized for 59/U cable and are easy to install.

The TV antenna differs from the FM antenna in both the element size and type of lead-in, but otherwise they're quite similar. However, it may be worthwhile to build the TV antenna on a length of wood in the workshop to make testing and orientation adjustment easier. A 7-foot piece of trim, free of knots, ⅜ inch × 1-⅝ inch costs less than a dollar! If you want to be fancy give it a couple of coats of polyurethane beforehand.

Try out the antenna on a stick in the same room as the TV set to determine the approximate orientation. Then try it in the attic to determine final orientation. The last step is to use a few finishing nails to fasten the stick antenna to the attic beams. If you are going to staple the foils directly to the beams, check the orientation of your neighbor's antennas before you start. Use of a compass will improve your accuracy.

Reflectors and Directors

One can add foil reflectors and directors to get greater gain or directivity. That helps prevent ghosts and weak channel reception. However, those structures take up more space and tend to narrow bandwidth. The reflector should be a single length of aluminum foil, slightly longer than the antenna and spaced behind the antenna between a fifth and a half wavelength. One has to compromise due to the wide bandwidth desired.

I suggest starting with a spacing of about three feet and a length of about eight feet. A director should be spaced the same but its length should be shorter than that of the dipole, say 6 feet. It has been my experience that reflectors can be quite helpful when the stations lie mostly in one direction. I have not had such good luck with directors except in improving one channel at the expense of all the others. If you have the attic space, it is an easy thing to try. Good luck!

Ears and Multiple Antennas

When you find one or more UHF channels to be weak, try adding ears to your antenna (see Fig. 3). I usually start with oversize pieces of foil, which I can fold to shorten or narrow them. Also try bending one forward and one backward. Ears change the antenna directivity in the UHF band, channels 14 and up. You can think of ears as a small antenna connected in parallel with the main antenna. I have used ears to get good reception from channel 2 through channels 60 and 66 and all on a single lead-in.

If ears are not good enough, there are still other ways to improve performance. For example, use multiple antennas and combine them onto a single lead-in via splitters. It may be enough simply to use separate VHF and UHF antennas. The UHF antenna can be two 5-inch strips of foil with the 18-inch length being vertical. Try shortening that 18-inch length by folding the aluminum over. If that is no help, unfold it and try something else, perhaps a reflector. Try a 12-inch reflector five inches behind the antenna. One way to build it is on a cardboard box of the right size.

Shortwave Antennas

Substitute aluminum foil for wire in your shortwave antenna and put it in your attic. I have wall cabinets in my lab that do not quite reach the ceiling. Aluminum foil is stapled to their top and a 6-foot wire connects the foil to the receiver. A 50-foot length of aluminum foil stapled to the attic beams would be better and one of these days I will get around to it. If you want an outstanding AM or low-frequency antenna, try aluminum foil running the length of your attic. Changing from wire to 18-inch aluminum foil will make a difference. Just be sure to make good electrical contact between the foil and the lead-in wire. Don't just twist them together. Good contact takes pressure. With screw fastenings there is danger of tearing the foil. The best joint is to fold over the aluminum several times and use several staples to hold the wire tightly against the aluminum. ■

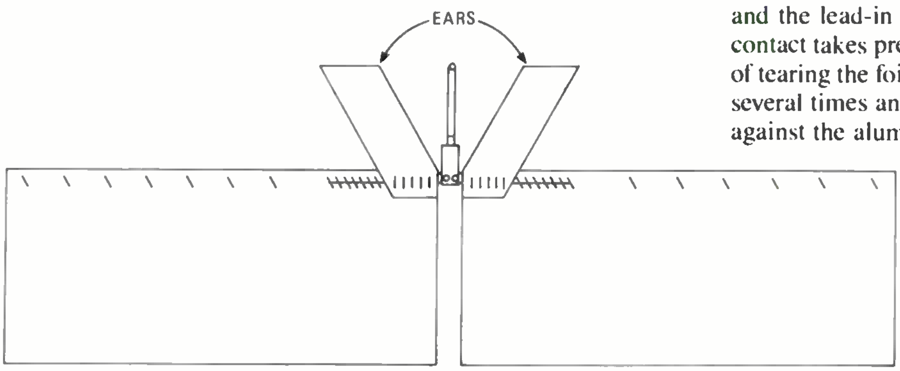


Fig. 3—Ears can be added to the TV antenna to enhance reception, but remember that they will need careful adjustment for proper functioning. To adjust them all, you need do is fold them to the dimensions that give the best reception.

SEVEN GALAXIES FOUND IN REGION THOUGHT TO BE EMPTY SPACE

Astronomers have discovered seven rare galaxies in a portion of the universe previously thought to be a huge void. Discovery of the galaxies, in what had been assumed to be a vast region of empty space will have important repercussions for theories on the formation of galaxies and clusters of galaxies, and on how matter is distributed in the universe.

The galaxies are unusual because they are more active—include more energetic gas—than most large groupings of stars, an indication that they possibly contain regions of star formations. Of 100 "normal" galaxies, only about five percent contain vast amounts of excited gas.

The astronomers did their observing between 1982 and 1986, using a variety of optical telescopes of the National Optical Astronomy Observatory, Steward Observatory and the McGraw-Hill Observatory, all of Kitt Peak in Arizona.

The "empty" region of space where the seven galaxies were found was discovered in 1981 in the direction of the constellation Bootes. The region was reported to be about 300-million light years in diameter, an area so vast that it could contain 2,000 galaxies the size of our very own Milky Way.

The newly discovered galaxies are about the size of the Milky Way or smaller and are spread fairly uniform in the void. The galaxies are described as "round and featureless," meaning they have no spiral arms or jets which characterize some galaxies. The average distance is about 600 million light years from earth. ■

NUTS & BOLTS GUIDE TO OP-AMPS

By Jack Cunkelman

Op-amps are the most useful "black boxes" around if you know their operating parameters

THERE ARE PROBABLY MORE KINDS OF OP-AMPS AVAILable than any other type of linear integrated circuit. Such *gain blocks* have revolutionized the design of linear circuitry. They are predictable and their responses to outside connections follow a set of general rules that anyone can apply.

Such technology has been a blessing to the experimenter. Multiple-stage transistor-amplifier designs, with all the bias calculations needed to make them work, are a thing of the past. Linear amplifiers, using op-amps, can be calculated and constructed with ease and confidence. The op-amp designers have included everything in a chip. We only need to be concerned with the input and output, and how much gain is needed.

We are going to discuss the practical aspects of op-amp usage here—things that "everybody" assumes is common knowledge, but may not be. Also included are some tips that will help your op-amp designs come to life.

Symbols, Schematics, and Circuits

The symbol for an amplifier is a triangle on its side (see Fig. 1). The negative or inverting input is usually on the top, and is indicated by a (–) sign. The positive or noninverting input is indicated by a (+) sign and is usually on the bottom of the triangle symbol. Those two inputs are not interchangeable. The output is shown at the right of the triangle. That is a generalized drawing and specific pin numbers will vary with op-amp and package types. A data sheet should be consulted for the specific pin numbers of the inputs and the output along with the power-supply pins.

There are two basic op-amp amplifier configurations: inverting and noninverting. Every other circuit configuration is a variation or combination of those two.

The inverting-amplifier type (see Fig. 2A) uses the negative (–) input and, as the name indicates, the output is inverted (180° out of phase with the input signal). The input impedance of the circuit is simply the value of R1. The noninverting amplifier configuration in Fig. 2B uses the

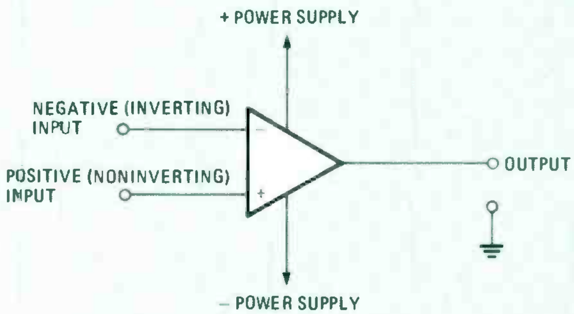


Fig. 1—What is odd about op-amps is that they have two inputs. The output signal is the difference between the inputs times the gain of the circuit containing the op-amp.

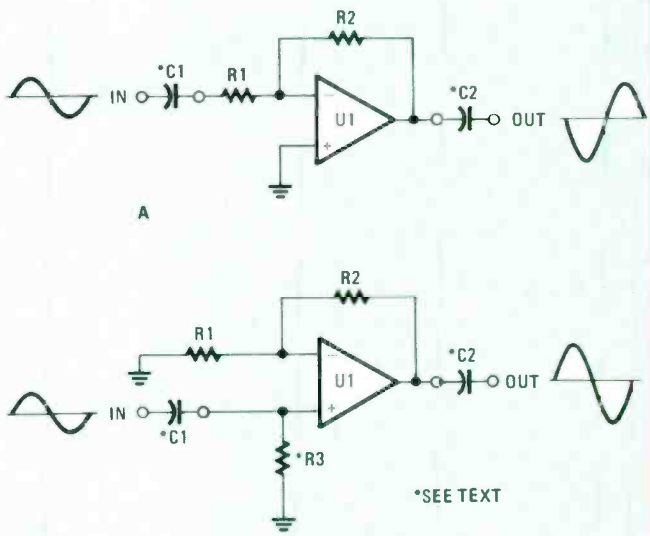


Fig. 2—The two simplest op-amp configurations are the inverting (A) and the non-inverting (B). Resistor R3 is needed only if C1 is used in the non-inverting circuit.

positive (+) noninverting input, and the output signal is in phase with the input signal. The input impedance of the circuit is the input impedance of the op-amp, and is therefore very high.

The ratio of resistors R1 and R2 in Fig. 2 determines the circuit's voltage gain. (That is called closed-loop gain, and it can never be more than the open-loop gain of the op-amp—more on that later). The formulas used to determine the gain are:

$$\text{Inverted } V_G = -R2/R1$$
$$\text{Non-inverted } V_G = 1 + R2/R1$$

Those results will have to be converted to decibels for further analysis.

It is wise, however, to use the lowest value resistors you can for R1 and R2. For example, using the inverting amplifier, if R1 is 100,000 ohms and R2 is 1,000,000 ohms, the gain is 1,000,000/100,000 or 10. However if a 1000-ohm resistor is used for R1 and a 10,000-ohm resistor is used for R2 we still have a gain of 10 (10,000/1000), but the circuit will be more stable and the DC offset error lower (more on that later). Note that the minimum gain possible with the noninverting amplifier is 1 (R2 = 0).

Op-amps were originally designed to amplify and process DC signals in computing circuitry. Over the years op-amp designs have evolved and now include devices that work well into the RF region. Those new designs, however, still retain their ability to amplify DC signals. The internal circuitry in the op-amp is all direct-coupled. If your need is only to amplify the AC (when we talk about AC signals here we are referring to audio signals—20 to 20,000 Hz) portion of the signal, coupling capacitors should be used on the input and output. Figure 2 shows those optional coupling capacitors.

When a coupling capacitor is used on the noninverting input, a DC path to ground must be provided for the noninverting terminal. That is the reason for R3 in Fig. 2B. The capacitor values should be large enough to insure a good response at the low end of the frequency range that you are interested in. The values can be easily calculated from the formula:

$$C = 1/(3.2 \times F \times R)$$

Where F is the frequency in Hz at which the voltage will drop by a factor of .707 across the capacitor; R is the impedance in ohms that the capacitor is coupling into; C is the capacitor value in farads.

Choosing the Right Op-Amp

Now that we have a general idea of what our circuit configuration will look like, we need to select a particular op-amp that will do the job. Since there are so many types of op-amps to choose from, we need to narrow the field a little. Table 1 lists some of the more readily available op-amps and some of their key specifications. Those op-amps are listed in the ads in the back of this and other electronics magazines, so you should have no trouble purchasing them. Availability is the main criteria for the list. We will also discuss how the specifications and parameters affect which op-amp you should choose.

From DC to HF—Almost

As was said before, early op-amps were designed as DC amplifiers. As op-amps became more popular, new types were developed and optimized for specific applications, but

TABLE 1
COMMON OP-AMP'S SPECIFICATIONS

Type	Slew Rate	GBP	Max Supply	Amps/ Package	Comp	Min Load
301	0.5	1	±18	1	Ext	2K
318	50	15	±18	1	Int	2K
324	0.3	1	+32	4	Int	2K
348	0.5	1	±18	4	Int	2K
353	13	4	±18	2	Int	2K
356	12	5	±18	1	Int	2K
357	50	20	±18	1	Int	2K
709	0.3	1	±18	1	Ext	2K
739	1.0	3	±18	2	Ext	2k
741	0.5	1	±18	1	Int	2K
747	0.5	1	±18	2	Int	2K
748	0.5	1	±18	1	Ext	2K
1458	0.8	1	±18	2	Int	2K
34001	13	4	±18	1	Ext	2K
4136	1.0	3	±18	4	Int	2K
4558	0.8	3	±18	2	Int	2K
5532	9	10	±18	2	Int	600
5534	9	10	±18	1	Ext	600
TL074	13	3	±18	4	Int	2K
TL082	13	3	±18	2	Int	2K
TL084	13	3	±18	4	Int	2K

Note: Externally compensated op-amps are rated with unity-gain compensation applied.

most op-amps will make good DC amplifiers. The major error in DC amplifiers is called *offset error*—0 volts in does yeild 0 volts out. The variance is usually measured in millivolts or microvolts and varies with temperature, but nonetheless exists. (If you are using capacitors on the input and output, the offset error can usually be ignored). The offset can be nulled out using an external voltage applied to one of the input pins. Figure 3 shows some typical methods for doing that. Some op-amps have specific pins and methods to perform offset nulling, and are usually shown on the data sheets. Those specific methods are the preferred way of applying null voltages to that op-amp.

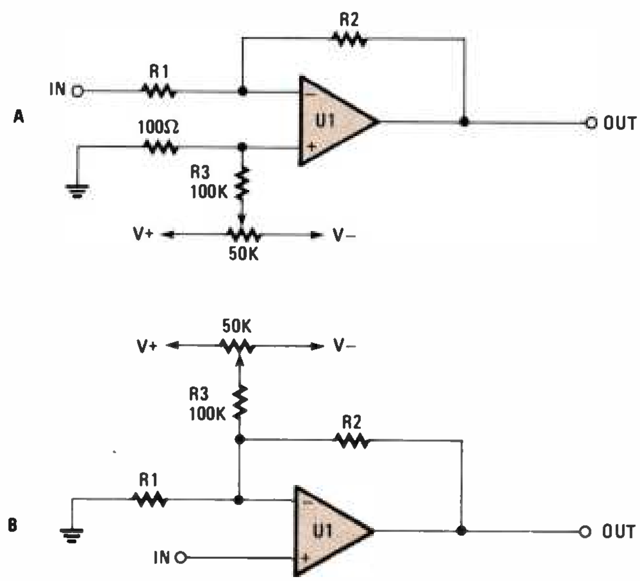


Fig. 3—Offset problems can occur in the best of circuits (and often do) without regard to whether the circuit is inverting (A), or non-inverting (B). Offset-nulling potentiometers are useful in correcting the output to zero, but their effectivness will vary under different conditions.

As the signals we want to amplify become AC and increase in frequency, several new parameters come into play. The first is the *gain-bandwidth product*—a measure of the variation in gain as the frequency increases or decreases. The gain of an op-amp decreases as the frequency it is called upon to amplify increases. We can increase the gain and decrease the frequency or decrease the gain and increase the frequency; but for a given op-amp, a constant gain-bandwidth product exists that we must abide by to ensure we will have flat, linear operation.

The second is the *slew rate*—the maximum frequency or rate that the op-amp can operate at and still provide full-swing, low-distortion output, which is measured in volts per microsecond. The larger that number is, the higher the frequencies the op-amp can handle.

If op-amps were ideal, they would have infinite gain and infinite bandwidth or frequency response—but they aren't. The more gain we take from an op-amp, the narrower the bandwidth of its frequency response. Figure 4 shows the relationship in graph form for op-amps with various gain-bandwidth products.

Those curves are a plot of what is called open-loop gain and shows the response that we would get if we used all of the op-amp's gain to amplify the input signal; thus, no feedback circuit (such as the resistors in Fig. 2) is used. However, feedback is necessary to reduce distortion and ensure amplifier stability, so resistor R2 (see Fig. 2) is used to return some of the output signal back to the input. In amplifier circuits, the feedback is always connected to the inverting (–) input and it consumes some of the amplifier's total or open-loop gain. The voltage divider formed by resistors R1 and R2 sets the op-amp's closed-loop gain as we indicated earlier. The response or gain-bandwidth curves for each type of op-amp are different and need to be considered individually. However, a key point we need to make here is that we need to operate at a closed-loop gain that is 10 to 20 dB below the open-loop gain at the maximum frequency we are interested in passing. That 10 or 20 dB is simply called *loop gain* and it determines how accurately the signal will be amplified. With all that in mind, we can now use the chart in Fig. 4 to select the correct op-amp type.

For example, suppose we are going to construct a 40-dB gain amplifier whose upper frequency limit is 10 kHz. First find the 10-kHz point on the horizontal scale. From that point go vertically until you intersect the 40-dB horizontal gain line. From that point go vertically again and add the amount of reserve loop gain you want in your design (10 to 20 dB). Where that crosses the next gain-bandwidth curve is the required gain-bandwidth of the op-amp type you should choose. In our example, we need an op-amp with a GBW of 10 MHz. The chart in Fig. 4 is an idealized graph and should be used to find a "ballpark" figure of the GBP needed. If more gain is needed at a particular bandwith than one op-amp will provide, consider using two cascaded stages with lower individual gains. (Remember dB-gain figures of individual stages are added.)

Frequency Compensation

The feedback signal that is applied from the output back to the inverting input, is 180 degrees out of phase with the input signal. That relationship always exists between the inverting input and the output. However, stray capacitance within the op-amp and from the external circuitry, can cause additional phase shifting of the feedback signal as the frequency increases. There becomes a frequency at which the feedback

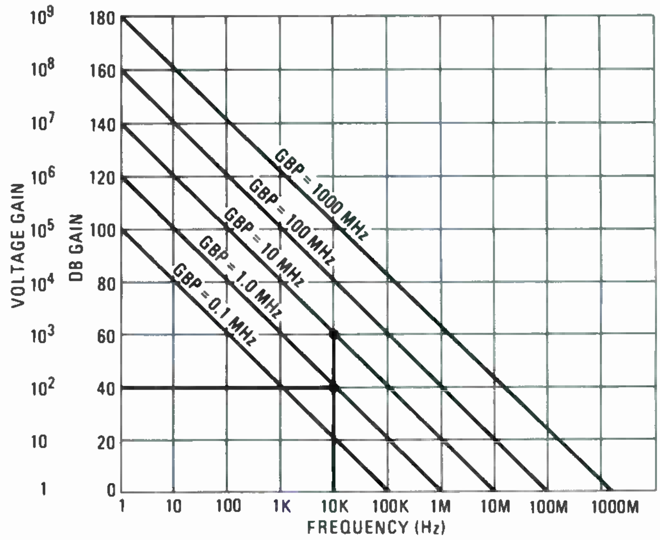


Fig. 4—A commonly graphed, useful charactreristic is the gain-bandwith product (GBP). It is a trade-off between gain (amplification) and effective bandwidth (frequency range).

signal is shifted a full 360 degrees. The feedback now becomes positive and the output signal now adds to the input signal. If the op-amp still has gain at that frequency, we have an oscillator—an undesirable condition for an amplifier. Frequency compensation should be applied to reduce the gain of the op-amp to 0 at some frequency well below that oscillating frequency.

Frequency compensation usually takes the form of a capacitor. If the capacitor is contained on the IC chip itself, the op-amp is said to be internally compensated. Internally-compensated op-amps usually are designed so that they will not oscillate if the closed-loop gain is 3 or more. Some op-amp types provide pins to which the compensating capacitor can be tied. In that case, we have external compensation and the response of the op-amp can be customized. Data sheets should be consulted at this point to ensure correct compensation if you are using an op-amp type that uses external compensation. If no information is available to you on the op-amp that you are experimenting with, capacitor values of 50 pf or less can be tried. The higher the value of the capacitor, the lower the high-frequency response will be. Remember that internally compensated op-amps have that capacitor built in and therefore the compensation is fixed.

Compensation will alter the gain-bandwidth curves and reduce the slew rate. The slew rate is reduced due to the inability of the op-amp to charge that added compensation capacitor at high frequencies. The key is to apply just enough compensation to ensure stability of the circuit at the operating gain conditions. The last item we need to consider in our

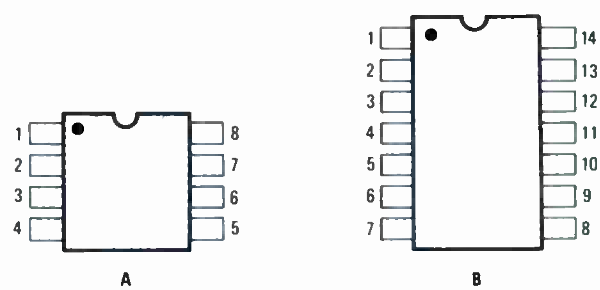


Fig. 5—These top views of DIP IC's represent the two most common op-amp packages. The 8-pin package (A) can contain two amps, and the 14-pin package (B) is a quad.

design is the specification called slew rate. As you will remember the slew rate indicates how well the op-amp can output a maximum level signal. The formula for slew rate is :

$$SR = 6.28 \times V \times F \times 10^{-6}$$

Where V is the peak output voltage ($1.414 \times V_{rms}$); F is the maximum frequency in Hz; and SR is the slew rate in volts per microsecond.

An op-amp with that slew rate is required if we want a clean sinewave output at that frequency or below. For example, if we want an op-amp that can provide a clean 2 volts of output at 20 kHz, it needs to have a slew rate of:

$$SR = 6.28 \times 2 \times 1.414 \times 20{,}000 \times .000001 = .35\ V/\mu s$$

It is interesting to note that when an op-amp is called upon to exceed that limit, the output will go from a sinewave to a triangle wave. A scope on the output will show that very nicely if you get up to the slew rate limit.

If after you have constructed your circuit, you notice heating of the op-amp package for unknown reasons, check for oscillations. You may need to apply more compensation if you are using an externally-compensated op-amp. For example, if your circuit is only designed to pass audio frequencies, the oscillation could be well out of the audio range. Again, an oscilloscope is the best instrument to track that kind of trouble down.

The Packages

The most common package that op-amp's come in is the dual in-line package (DIP). That can be either the 8-pin or 14-pin variety. Single or dual op-amps (two amplifiers in one package) can be housed in an 8-pin package (see Fig. 5A) and as many as 4 op-amps can be housed in a 14 pin package (see Fig. 5B). Figure 5 shows the pinout numbering sequence for those DIP packages. Published schematics that show pinout numbers on the drawing usually refer to the DIP package. Keep in mind that the top view is shown. You have to turn the diagram around when viewing a circuit card or IC from the bottom.

Also available (but not as common) is the TO-5 or round, metal-can package. They come with 8, 10, or 12 leads. The highest number pin is always at the tab, and the leads are numbered in a clockwise direction when viewed from the top as in Fig. 6A. If you want to use a socket for the IC but are stuck with a device in a TO-5 package (TO-5 sockets are not as common and difficult to use), try forming the leads as shown in Fig. 6B and use a DIP socket. Again be sure to check the pinout number vs. function when interchanging package types.

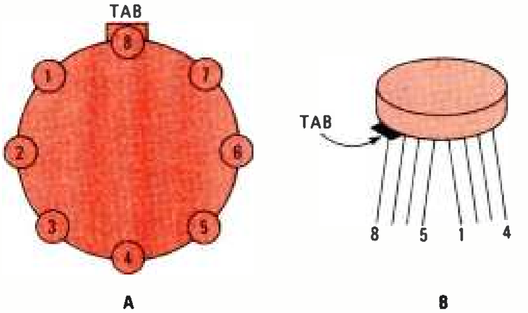


Fig. 6—A TO-5 package is not as popular as its DIP cousins, but can be used to replace a standard DIP circuit by aligning the leads as in B.

Powering an Amp

A power supply is usually the last element to be considered and can make the difference between success and failure of your project.

First, we must supply a low-impedance, well-regulated source of power. Op-amps, in their AC mode of operation, require a bi-polar power supply (+ and – voltages referenced to ground). Those voltages should be as equal as possible to avoid output offset-voltage problems (within a volt or two should be adaquate). The bi-polar supply shown in Fig. 7A should be more than adaquate for most applications. A pair of 9-volt batteries can be pressed into service, and, as Fig. 7B illustrates, will supply ±9 volts.

Bypass capacitors to ground should be inserted as near to the op-amp power-supply pins as possible. Low-inductance, ceramic disc capacitors in the range of .01 to 0.1 µF seem to work best. If the possibility exists that the power-supply leads could be accidentally reversed, a diode should be inserted at the end of each lead. Applying the wrong voltage polarity to the op-amp supply pins will usually destroy the op-amp.

If a bi-polar supply is not available an op-amp can be run from a single supply as shown in Fig. 8. An example of an inverting op-amp is shown in Fig. 8A, while Fig. 8B is a non-inverting configuration. The junction points of the R3's and R4's provide a reference at ½ the supply voltage for the noninverting input. That raises the output of the op-amp to that potential to assure that it will have maximum output voltage swing. In Fig. 8, the C1's bypass any noise on the power supply so it will not be amplified. Those schemes are most useful in AC-amplifier applications where the input and output is AC coupled.

Construction Hints

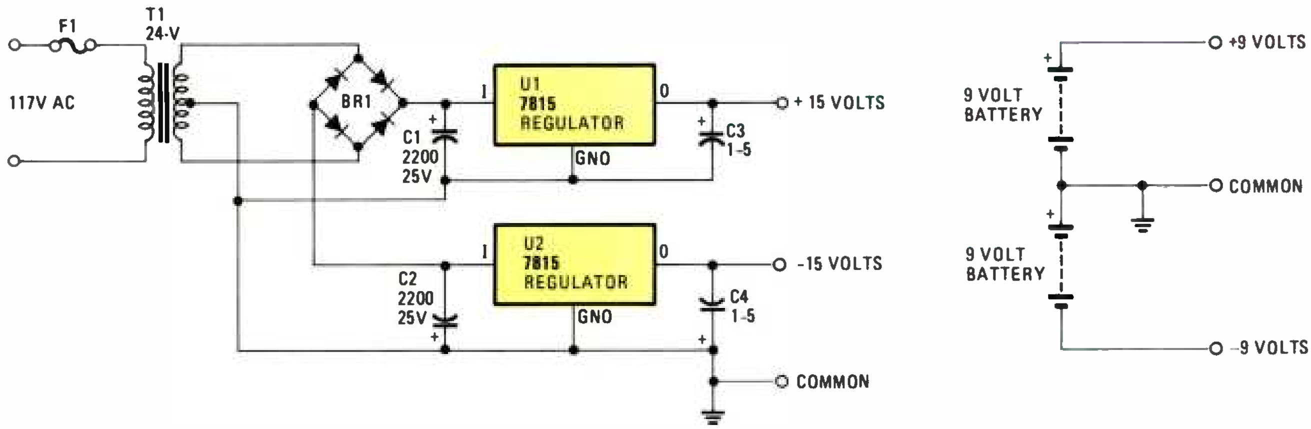
It's a fact that analog-circuit construction is more delicate than most digital-circuit construction. Care must be used in the initial layout to ensure that the input and output components are separated as far as possible while being mindful of unwanted inductance. Stray capacitive coupling can lead to unexplained and unexpected oscillations. Use shielded wire on low-level signals and only ground one end of the shield if possible. Use short leads on all components. Linear circuits are not very forgiving of haywire construction techniques.

Grounding techniques are also important. First, avoid-daisy chain grounds and return all grounds to a master ground point. That point is usually where the power-supply transformer secondary center-tap, filter capacitors, and the chassis ground meet. Secondly, a good ground plane or enclosure should be provided. To that end, mount your circuit board in a metal chassis, not a plastic one.

A 5532 Pre-amp Example

The 5532 series op-amp made by Signetics (now second sourced by several other manufacturers) is an excellent example of the high-quality, audio op-amps available today. We will use it to illustrate the selection process described earlier.

We will define our need as an audio pre-amp with a gain of 40 dB. The response should be flat from 20 to 20,000 Hz and the maximum output we will need will be 3 V_{rms}. Either the inverting or noninverting configuration could be chosen, but for our illustration we will use the inverting circuit. (If a stereo signal is involved, be sure to use the same type of amplifier circuit for both channels. The inverting circuit will invert the phase but that is OK.)



A B

Fig. 7—Be sure never to confuse power-supply leads in either the AC (A) or DC (B) circuits. People commonly mistake the negative lead for the ground lead which places twice the voltage across the op-amp circuit which may blow.

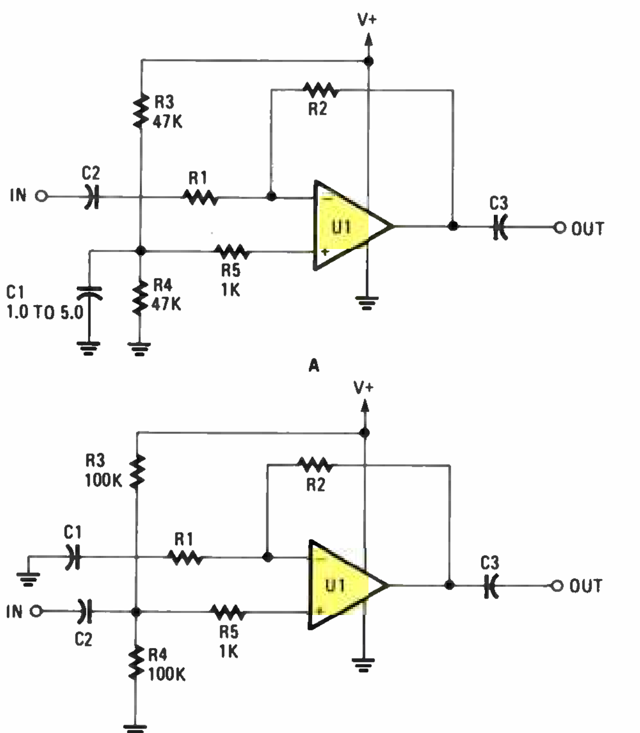


Fig. 8—If you must use a single-polarity power supply for either an inverting (A) or non-inverting (B) configuration, be sure that any DC-coupled inputs have their signals zeroed at half the supply voltage to prevent damaging the op-amp.

For a 40-dB gain amplifier we will need a voltage gain of 100.

$$V_G = R2/R1$$

Lets use 100 ohms for R1. Then:

$$R2 = V_G \times R1 = 100 \times 100 = 10{,}000 \text{ ohms}$$

For truly flat response *at* 20 Hz (not just after) we will only allow our response to be down 70.7% of maximum at 10 Hz so:

$$C1 = 1/(3.2 \times F \times R) = 1/(3.2 \times 10 \times 100)$$
$$= .000312 \text{ Farads} = 312\ \mu F \text{ (use } 300\mu F)$$

Capacitor C2 is coupled into a 10,000-ohm potentiometer, so using the same equation its value will be:

$$C2 = 1/(3.2 \times 10 \times 10{,}000)$$
$$= .0000031 \text{ Farads} = 3.1\ \mu F \text{ (use } 5\mu F)$$

At 20,000 Hz, we need 10 to 20 dB of loop gain to ensure a low distortion signal. Looking at the GBP curve for the 5532 (10 MHz), at 20,000 and 40-dB gain the loop gain is 15 dB, which should be adequate.

To get 3 V_{rms} of clean output we need an op-amp with a slew rate of:

$$SR = 6.28 \times V \times F \times 10^{-6}$$
$$= 6.28 \times (3 \times 1.414) \times 20{,}000 \times 10^{-6}$$
$$= 1.59\ V/\mu s$$

The 9-V/μs slew rate of the 5532 is more than adequate. The final circuit is shown in Fig. 9.

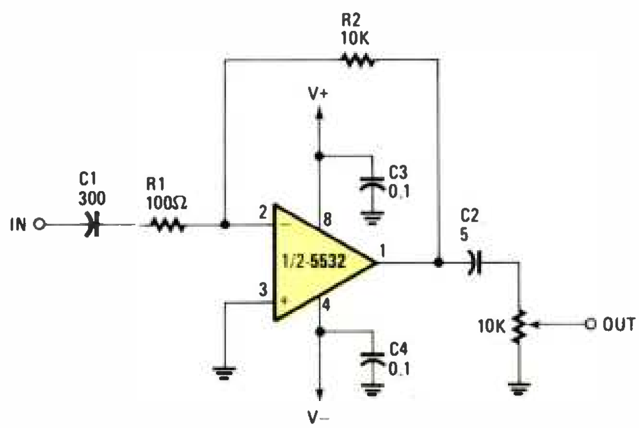


Fig. 9—The example op-amp circuit is AC-coupled, protected from power-lead noise, and even has its own volume control.

The charts and op-amp characteristics you may find useful for experimenting with the IC's, can be found in linear-IC guides available from manufacturers and their publishing companies. Often, applications notes come with an op-amp package at the time of purchase.

Modern op-amp IC's allow all of us to be successful designers and builders. By knowing what your circuit calls for, you can easily use the formulas and specifications presented here to design many useful and fascinating circuits. Jump in and get your feet wet! ■

HANDS-ON REPORT

Portasol Flameless Soldering Iron

A soldering iron you can carry from job to job in your shirt pocket—while it's still hot!

NEXT TIME YOU NEED A SOLDERING iron to make a quick electronic repair, there's no need to search for the correct size iron to do the job. Simply reach into your shirt pocket for a *Portasol Flameless Soldering Iron*, flip the igniter built into its cap, and within seconds you've got the right heat to make a delicate printed-circuit board repair, or to melt a blob of solder on a metal chassis. But best of all, when you're finished, you don't have to search for a safe place to put the iron down while it cools off: Simply put the cap back on and place the Portasol into your shirt pocket or toolbox.

As shown in the photographs, the Portasol is the size of, and closely resembles, a conventional marking pen—right down to the pocket clip. Its overall length is only 7 inches.

On the business end of the "pen" is a user-replaceable, gas-heated, catalytic (flameless) soldering tip that is powered by butane gas, the same kind of fuel used in cigarette lighters, gas-powered candles, and portable cooking devices.

On the barrel, below the tip, is a master gas cut-off valve. Near the bottom is a separate heat control, which is actually a gas-flow adjustment that ranges from full off to maximum gas flow. On the very bottom is a charging valve that mates with the nozzle on conventional butane gas cylinders. To charge the iron you simply press the cylinder against the valve until there is a backspray—the same procedure as used for charging any butane-powered appliance.

The cap, which has an integral pocket clip, is made of heat-resistant plastic. It contains a spark igniter as well as a cutout that automatically forces the cut-off valve closed when the cap is installed on the "pen."

The Portasol is normally supplied with a 2.4-mm, general-purpose tip that is even suitable for working on printed-circuit boards. Tips of 1.2-mm, 3.2-mm, and 4.8-mm are optional accessories. The

Don't search for matches. An igniter is built into the cap. Simply flip your thumb and the sparks the tip lights.

1.2-mm is suitable for very-fine printed-circuit traces, and while the 4.8-mm doesn't sound large, it will melt solder off a metal chassis—it can be made *very hot*. The tips are changed by simply substituting one for another, using only fingertip pressure—no tools. Depending on the adjustment of the gas flow, tip temperatures are equivalent to 10- to 60-watt irons.

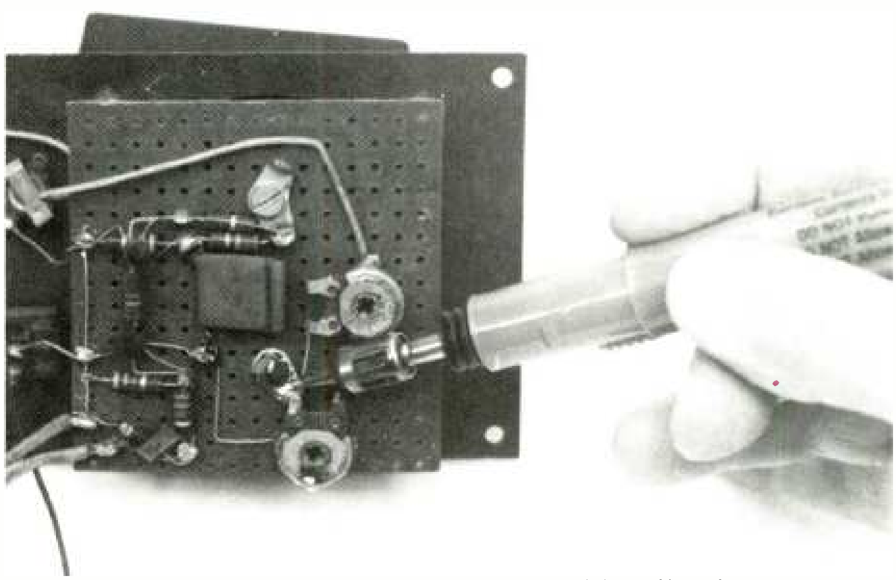
Several Tests

We tested the supplied tip on several kinds of material, ranging from printed-circuit foils to relatively "heavy" solder-lugs and found it performed well over the broad range of applications. The optional tips would be required only for unusual situations, such as unusually fine wires, or unusual heat-absorbing material, such as a metal chassis. The operating time per charge of gas depended on how much heat was needed, and ranged from about 30 to slightly more that 60 minutes in what we considered typical use.

Flip to Light

Lighting up couldn't be easier because the igniter is built into the cap. First, the cut-off valve is opened; then the gas valve is turned to maximum flow (full clockwise); finally, the igniter is placed near the

(Continued on page 106)



Even the standard tip packs a lot of heat when the gas is full on. Here the standard tip shown with the iron, which can safely solder delicate printed-circuit foils, is melting the solder on a screw-supported solder lug.

Electronic Fundamentals

By Louis E. Frenzel, Jr.

You can get more work out of an amplifier if you know how to make the transistors play together

AN AMPLIFIER CAN BE COMPOSED OF MANY AMPLIFICATION stages. Cascaded stages can have clean high-power output by assigning each stage to a particular amplification (powerful stages following weak ones to provide *ommph*). Or, transistors can be bridged so each works on only a portion of the incoming signal. Thus, each transistor will amplify only its portion.

This month we'll show you those two important designs and what they mean in terms of output power and clarity.

Our lesson uses the *programmed instruction format* wherein information is presented to you in chunks called *frames*. Read the information in each frame and then immediately answer a question based on the material by filling in a question blank(s) with appropriate words or figures. The answer to each question is given in parentheses at the beginning of the next frame.

As you progress through the lesson, use a sheet of paper to keep the frame immediately below the one you are reading covered so that you won't accidentally see the correct answer. Slide this sheet downward as you progress.

Staging and Operation

Coupling and Cascading

31. If very high gain is required, several transistor stages may be combined, with one stage connected to another; which is called *cascading*. Figure 11 shows three amplifiers cascaded. The total circuit gain, A_T, is the product of the individual gains (A_1, A_2, A_3).

$$A_T = A_1 \times A_2 \times A_3$$

If $A_1 = 10$, $A_2 = 15$, and $A_3 = 25$, the total gain is:

$$A_T = 10 \times 15 \times 25 = 3750$$

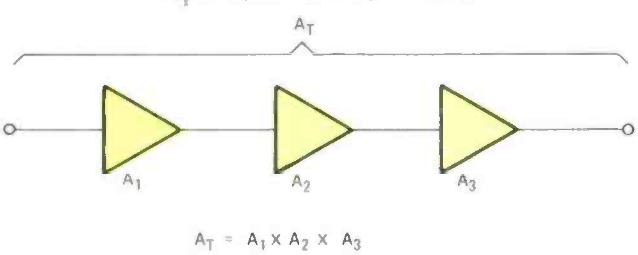


Fig. 11—The total gain of cascaded amplifiers equals the product of their individual gains.

By using multiple stages, gains of many thousands or even millions are possible.

Two amplifiers with gains of 40 and 20 are cascaded. The total gain is ______________. The input voltage is 3 mV. The output voltage is ______________ volts.

32. (800, 2.4) Figure 12 shows how two bipolar stages can be cascaded. A capacitor (C2) feeds the output voltage of Q1 to the input of Q2: a connection called *capacitive coupling*. The DC on the collector of Q1 does not affect the DC bias on the base of Q2 because C2 isolates the two. Additional stages may be cascaded as required.

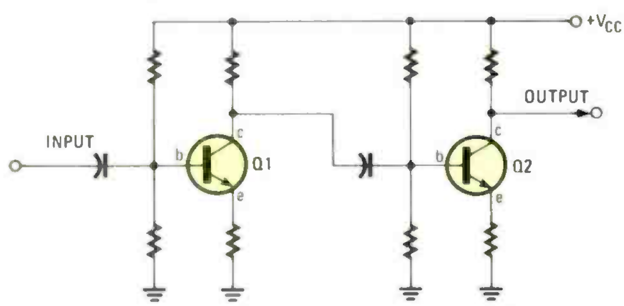


Fig. 12—Capacitor coupling can be used to cascade two bipolar trransistor-amplifier stages.

FET and bipolar stages may also be cascaded.

a. True

b. False

33. (a. True) Usually, the FET is the input stage because of its high input impedance, while the bipolar stage is used to follow it.

Individual amplifier stages may also be connected directly together without a coupling capacitor if care is taken to set the biases correctly. An example of that is shown in Fig. 13, where

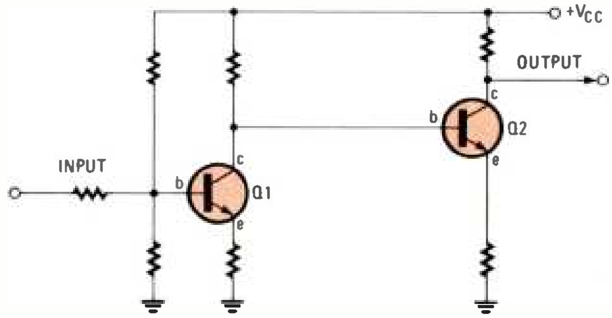


Fig. 13—Cascaded stages can also be direct-coupled.

the collector of Q1 connects directly to the base of Q2. The arrangement is called *direct coupling* and has two important advantages. First, fewer bias resistors are needed; second, the circuit will amplify DC as well as AC. Because capacitors are used to couple the signal from one stage to the next in Fig. 12, only AC signals can be used: the capacitors block DC. In Fig. 13, a small DC variation at the input causes a larger DC variation at the output: the circuit has DC and AC gain.

DC voltages may be amplified if the stages are ______________ ______________

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34. (direct coupled) A popular variation of direct coupling is shown in Fig. 14. An FET is used at the input to give the circuit a

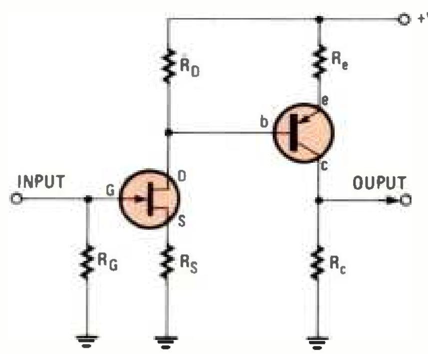

Fig. 14—This is a direct-coupled amplifier with a high input impedance FET stage and a PNP gain stage.

high input impedance. A PNP bipolar stage is direct coupled. The PNP is shown "upside down," but its bias is correct and the output is taken from the collector as it would be in an NPN amplifier.

Connecting capacitors across R_s and R_e will cause the AC gain of the circuit in Fig. 14 to ______________.

---

35. (increase) Capacitors across R_s and R_e will eliminate negative feedback and increase the AC gain.

The amplifiers described here will increase the amplitude of the signals over a very wide frequency range. If direct coupling is used, DC signals will be amplified in addition to AC signals. If capacitive coupling is used, the extent of the lower frequency range will depend on the size of the capacitors. The emitter- or source-resistor bypass capacitors also affect the low frequency range. The larger the coupling and by-pass capacitors, the lower the frequency that can be amplified. Since the audio frequency range of human hearing extends from approximately 20 to 20,000 Hz, most audio amplifiers are designed to pass signals down to about 20 Hz.

The low frequency range of an amplifier is determined by the size of the ______________ *and* ______________ *capacitors.*

---

36. (coupling, bypass) The upper frequency range of an amplifier is determined by the type of transistor used and the extent of any stray or shunt capacitance in the circuit. Most common transistors will readily amplify signals up to many MHz. For higher frequencies, special RF or microwave transistors must be used.

Stray capacitance in a circuit is caused by long component leads, long wires, or the lands of the printed-circuit boards. (They act as one plate of a capacitor, the other plate being ground.) The capacitance has increasingly lower reactance at increasingly higher frequencies. It shunts or loads the circuit, causing the gain to decrease at the upper frequencies.

Shunt capacitance and transistor type affect the ______________ *frequency range of an amplifier.*

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37. (high) The overall range over which an amplifier will provide a constant gain is called the *frequency response*. The frequency response is defined by upper and lower cut-off frequencies, as shown in Fig. 15. The cut-off frequencies are those

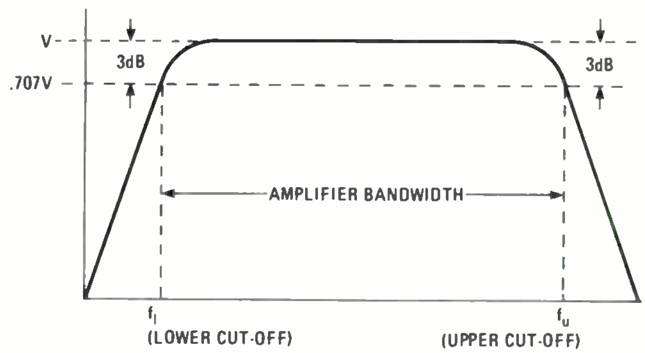

Fig. 15—The 3-dB points (called "3-dB down") determine an amplifier's bandwidth and frequency response.

where the output voltage (V) drops to .707 of the output that occurs over the "flat" mid-range. The output is said to be *3-dB down*. The difference between the upper cut-off frequency (f_u) and the lower cut-off frequency (f_l) is called the *amplifier bandwidth* (BW).

$$BW = f_u - f_l$$

If f_u equals 3 kHz, and f_l equals 300 Hz, BW = ______________ *Hz.*

---

38. (2700) The frequency response of many amplifiers is deliberately controlled to pass signals only in a desired range. Amplifiers can be combined with low pass, high pass, band pass, or notch filters to set the bandwidth. Amplifiers that are used to amplify RF signals usually have built-in tuned circuits to amplify only signals in a narrow range of frequencies. A typical RF amplifier is shown in Fig. 16. The circuit is similar to those discussed previously, except that a parallel LC circuit replaces the collector resistor. Bias is obtained in the usual way. Note that in this circuit coupling between the two stages takes place by transformer action. Varying current in the collector of Q1 causes a varying magnetic field to be set up around L1, inducing a

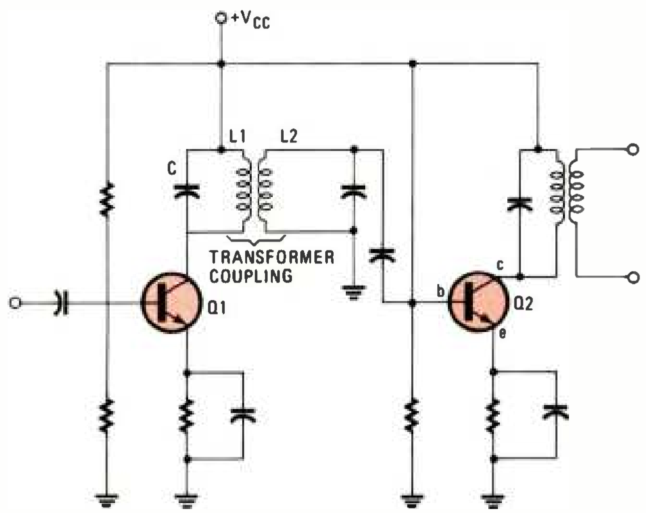

Fig. 16—RF amplifiers use tuned circuits to set the operating frequency and bandwidth. Transformer coupling is used between stages.

voltage in L2 which is applied to Q2. Only AC signals may be coupled in this way.

RF amplifiers use ________ ________ *to set the bandwidth.*

---

39. (tuned circuits) Amplifiers like those in Fig. 16 are used in radio, TV, radar, and other receivers to amplify the RF signals and the intermediate frequency (IF) signals generated within the receiver.

Go to frame 40.

Emitter Followers and Power Amplifiers

40. The amplifiers we have discussed so far are referred to as *common-emitter amplifiers*. The term is derived from the fact that the input and output signals are referenced to the emitter, which is connected to the common ground. (The emitter is connected directly to ground in some cases and through a small resistor in others.) When an emitter resistor is bypassed by a capacitor the low reactance of the capacitor effectively shorts out the emitter resistor as far as AC is concerned, thereby effectively connecting the emitter to ground.

An amplifier whose inputs and outputs are referenced to the emitter are called ________ ________ *amplifiers.*

---

41. (common emitter) Other circuit configurations are possible. In fact, both common-base and common-collector circuits are sometimes used. Common-emitter circuits are by far the most widely used; common-base circuits are rare. Common-collector circuits have special characteristics which make them useful.

A simple common-collector amplifier circuit is shown in Fig. 17. The base bias is derived from R1 and R2 as before, and a resistor R_e is connected between emitter and ground. The output is taken from across this resistor. Note that the collector is connected directly to the supply voltage (V_{cc}); there is no collector resistor. The AC input is applied to the base through a capacitor. Since the power supply's impedance between $+V_{cc}$ and ground is virtually an AC short-circuit, the collector is really at ground as far as AC signals are concerned. The input is applied

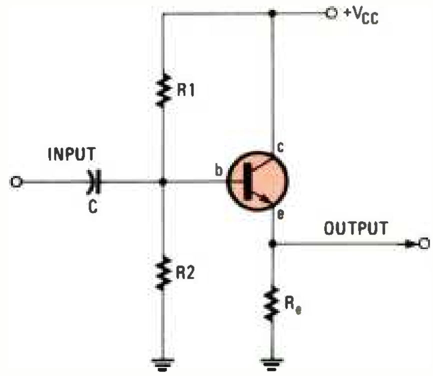

Fig. 17—This is the basic circuit for a common-collector amplifier, also called an emitter-follower amplifier.

between the base and collector, while the output is taken from between the emitter and ground (the collector). The circuit is called a *common collector amplifier*.

The output of the circuit in Fig. 17 is taken from across the ________ ________.

---

42. (emitter resistor) The voltage gain of the circuit in Fig. 17 is approximately one, actually a little less. Since the gain is essentially one, the output voltage equals the input voltage. This is referred to as *unity gain*. Further, the output is in phase with the input. Because the output is virtually the same as the input, the circuit is referred to as an *emitter follower*.

If the AC input to Fig. 17 is 3 Vrms, the output is ________ *volts rms.*

---

43. (3)You are probably wondering what good an emitter follower is if the output is just a copy of the input. The answer lies in the difference between the input and output impedances. An emitter follower has a high Z_i and a low Z_o—both desirable characteristics. The input impedance is higher than that of a common-emitter amplifier because the input is applied across the reverse-biased base-collector junction. In parallel with this is the forward-biased E-B junction in series with a relatively large R_e. The input impedance is roughly the $\beta \times R_e$ in parallel with any other resistive circuits, where β is *Beta*, the h_{FE} or *current gain* of the transistor. The high input impedance minimizes the load on any driving circuit.

If β equals 50, and R_e equals 4700, Z_i is ________ *ohms.*

---

44. (235,000 ohms) 235,000 ohms is much higher than the Z_i of a common-emitter circuit.

The output impedance is very low, approximately $R_e \div \beta$.

Using the figures above, Z_o is ________ *ohms.*

---

45. (94) A resistance of 94 ohms is ver much lower than the Z_o of a common-emitter circuit. Therefc the emitter follower can drive a heavier load.

Now, recall that the power in a circui equal to the voltage squared divided by the resistance, or:

$$P = V^2 \div R, \text{ or } V^2 \div Z$$

If the input and output voltages are the same but the output impedance is very much lower than the input impedance, then the output power is greater than the input power, or:

$$V_o^2 \div Zo > V_i^2 \div Z_i$$

where $V_o = V_i$.

So, while the input and output voltages are the same, the output power is greater than the input power.

The emitter follower is a ______________ amplifier.

---

46. (power) The emitter follower is widely used to increase the power level of a signal. It is also used for impedance matching where a high Z_o must drive a low value of load resistance. Figure 18 shows how an emitter follower is used with a common-emitter stage. The combined circuit provides both voltage and power gain.

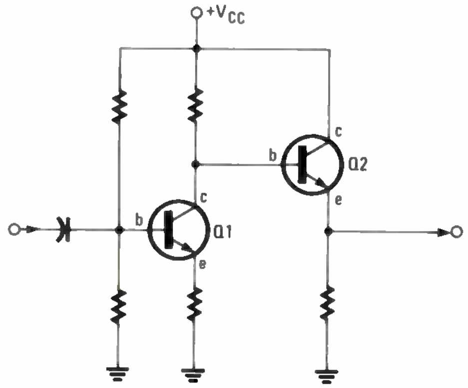

Fig. 18—This circuit combines a direct-coupled amplifier (Q1) with an emitter-follower (Q2) output.

The common-emitter amplifier and emitter follower in Fig. 18 are ______________ coupled.

---

47. (direct) There is often a need to provide high-power AC signals to drive special loads. A speaker is a good example. Most speakers consist of a permanent magnet and a coil connected to the speaker cone. When AC is applied to the coil, a magnetic field is developed, which interacts with the permanent magnet to produce motion of the cone; which in turn produces sound. The speaker coil has very low impedance and requires high driving power. Other devices such as motors also require high power.

The speaker cone is attached to a ______________ that moves when AC is applied.

---

48. (coil) Common-emitter amplifiers provide power gain as well as voltage gain. Heavy-duty transistors capable of withstanding higher voltage and current are used as power amplifiers. Such a circuit is shown in Fig. 19. It is a configuration you are already familiar with. The primary of transformer T1 replaces the collector resistor. The transformer provides impedance matching that steps the high Z_o of the amplifier down to the low speaker impedance, usually 8 to 16 ohms. The amplifier provides the power to operate the speaker.

Impedance matching in Fig. 19 is provided by the ______________.

Amplifier Classes

49. (transformer) All of the amplifiers we have discussed so far are called *class A* or *linear amplifiers*. In a class A amplifier, collector current flows continuously. The circuit is biased so that

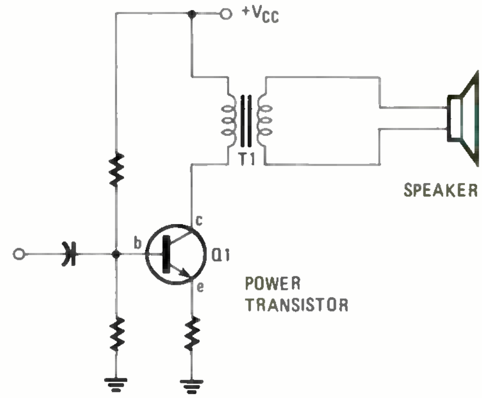

Fig. 19—A common-emitter audio power amplifier. Transformer T1 provides impedance matching to the speaker.

the transistor operates as a variable resistor over its linear (straight line) range. The result is an enlarged reproduction of the input at the amplifier's output. In *class B* and *class C* amplifiers the collector current does not flow continuously; we will talk more about them later.

In a class A amplifier, collector current is ______________ and varies ______________.

---

50. (continuous, linearly) A class A amplifier operates properly as long as it is correctly biased and the amplitude of the input signal is not too great. The biasing network is designed to set the base current to a value that will cause the DC collector voltage to be about one half of the power supply voltage (V_{cc}), a value that is approximately at the center of the linear range. With this condition, if an AC input signal is applied the collector output can vary up to $+V_{cc}$ and down to as low as zero volts (ground) if no emitter resistor is used. (See Fig. 20.) $+V_{cc}$ and zero are the maximum and minimum output voltages for the circuit shown in Fig. 19.

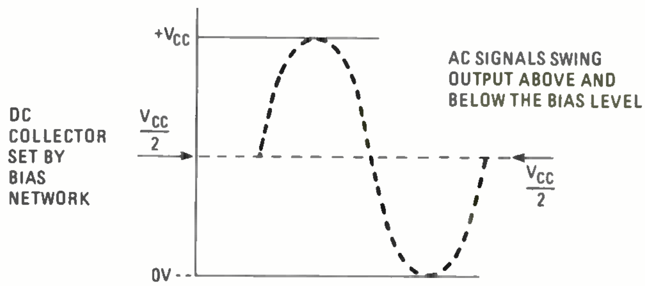

Fig. 20—The output voltage of an amplifier is limited by $+V_{cc}$ and ground.

The collector output voltage in an amplifier with a V_{cc} of 15 volts should be about ______________ volts.

---

51. (7.5) If the bias is set so that the collector voltage is higher or lower than $V_{cc}/2$, then the linear output range will be reduced or limited. The output voltage will "bump up against" $+V_{cc}$ or ground, which causes the peaks of larger signals to be "flattened," or "clipped off." Figure 21 shows an example. The clipping is called *distortion*. With distortion, the output is no longer an enlarged replica of the input.

Distortion can be caused by incorrect ______________.

---

52. (bias) Another cause of distortion is an input signal that is

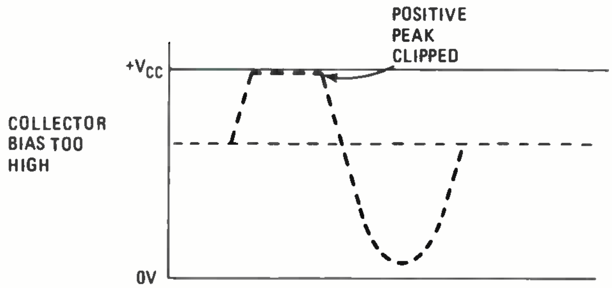

Fig. 21—Incorrect bias can cause distortion by clipping.

too large. Assume an amplifier having a gain of 100, a supply voltage of +12 volts, and a sine wave input voltage of .3 volts peak-to-peak. The amplifier will multiply the input voltage by 100 to get 100 x .3, or 30 volts. But wait. The total output voltage swing is limited to +12 volts and ground or 12 volts peak. The output tries to swing to the desired level but it "bumps up against" its natural limits of $+V_{cc}$ and ground, and the positive and negative peaks are clipped or squared off. The output waveform then is nearly a square wave. (The sine wave peaks are clipped off, and the resulting signal is binary—two state—or digital in nature.) Such distortion causes a whole range of problems.

Distortion is also caused by ______________ input signals.

53. (large or excessive) With a large input signal, the normal DC bias voltages are overwhelmed. When the input voltage swings in a negative direction, the emitter-base bias voltage is cancelled, the transistor cuts off, and no collector current flows. Therefore, the output rises to $+V_{cc}$.

When the large input goes positive, it adds to the bias and causes the transistor to conduct heavily. The resistance between emitter and collector drops to a very low value, almost zero. When that happens, the collector voltage drops below the base-voltage level so that the normally reverse-biased base-collector junction becomes forward-biased. Under this condition the transistor is said to be *saturated*. At saturation, the collector voltage drops to a very low value: zero if the emitter is grounded, or some low DC value if an emitter resistor is used.

A large AC input signal causes the transistor to switch from ______________ to ______________.

54. (cut-off, saturation) Distortion can be corrected by reducing the level of the input signal or decreasing the amplifier's gain. Distortion caused by incorrect bias can only be eliminated by readjusting the bias.

There are some amplifiers that deliberately resort to distortion for their operation. Class B and class C amplifiers are examples. A class B amplifier conducts for only one half-cycle, or 180° of an AC sine wave input. It is cut off the other half-cycle. Therefore, in order for amplification to occur without distortion, two amplifiers must be combined, one for each half-cycle of the signal. Such an amplifier is referred to as a *push-pull* amplifier. A typical circuit is shown in Fig. 22. Q1 conducts on positive half-cycles while Q2 conducts on negative half-cycles of the input.

A class B amplifier conducts for ______________ ______________ ______________ of the input.

55. (one half-)In Fig. 22, transformer T1 couples the input to the bases of Q1 and Q2. R_b provides a small value of bias so that

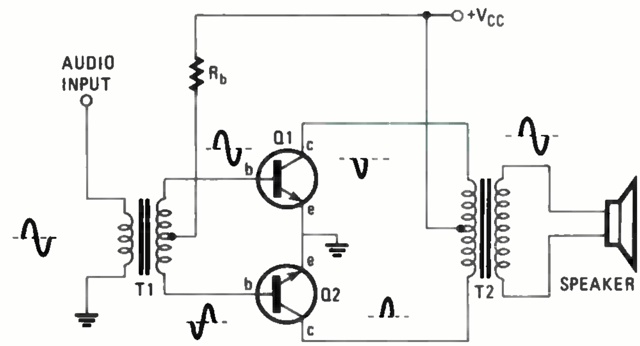

Fig. 22—A class B push-pull audio power amplifier uses each "channel" for one-half the waveform cycle.

the emitter-base junctions are just on the verge of conducting. The center tap on the secondary of T1 is grounded for AC through the power supply. When the input goes positive, the base of Q1 goes positive while the base of Q2 goes negative. Q1 conducts and its collector current increases. Q2 is cut off. The current in the upper half of the primary of transformer T2 produces one half-cycle of variation in the secondary and the speaker.

When the input goes negative, Q1 is cut off and Q2 conducts. The current in the lower half of T2 produces the other half-cycle of AC in the speaker. Thus the signal is amplified; the positive half by Q1 and the negative half by Q2.

The amplifier in Fig. 22 is called a ______________-______________ amplifier.

56. (push-pull)Class B push-pull amplifiers are widely used in audio power applications for driving large speakers. They are also used in RF applications, with the iron core transformers replaced by air core transformers and capacitors which form tuned circuits. Also, high frequency transistors are used to generate high-power radio signals to be fed to antennas.

Push-pull class B amplifiers are used for ______________ amplification.

57. (power) A more widely used transistor class B power amplifier is shown in Fig. 23. It uses no transformers: a major savings in size, weight, and cost. It is made up of both NPN (Q1) and PNP (Q2) transistors connected as emitter followers, with the load (a speaker, motor, etc.) acting as the emitter resistor. Such a circuit is called a *complementary-symmetry amplifier*. (PNP and NPN transistors are said to be complementary devices.) Note that two power supply voltages, $+V_{cc}$ and $-V_{cc}$, are

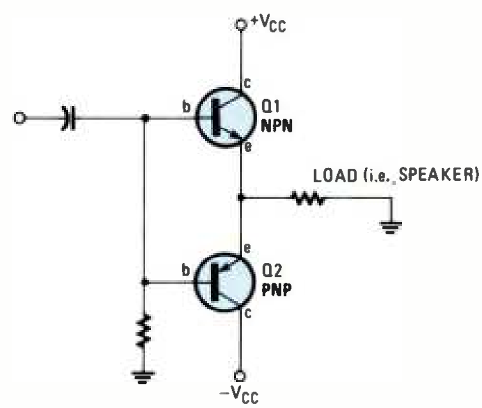

Fig. 23—A complementary-symmetry class B push-pull power amplifier can eliminate the output transformer.

used. The input is applied to both bases simultaneously.

When the input goes positive, Q1 conducts, causing a positive half-cycle of output to be developed across the load. The positive input causes Q2 to be cut off. With a negative input, Q2 conducts and the negative half-cycle of output appears across the load, while Q1 is cut off. Q1 and Q2 are just emitter followers that conduct on alternate positive/negative half-cycles.

A class B push-pull amplifier using no transformers is called a ________ ________ amplifier because it uses both ________ and ________ transistors.

---

58. (complementary symmetry, NPN, PNP)Another type of power amplifier is the class C amplifier. A class C amplifier conducts for only a portion of one half-cycle. Class A amplifiers conduct for 360° (the complete AC cycle). Class B amplifiers conduct for 180° (one half-cycle). Class C amplifiers conduct for 90° to 150°. The base bias is set so that only the high peaks of the input cause the transistor to conduct.

A class C amplifier conducts for ________ to ________ degrees of one sine wave cycle input.

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59. (90 to 150)Figure 24 shows a simple class C amplifier. Note the tuned circuit. Class C amplifiers are used in radio

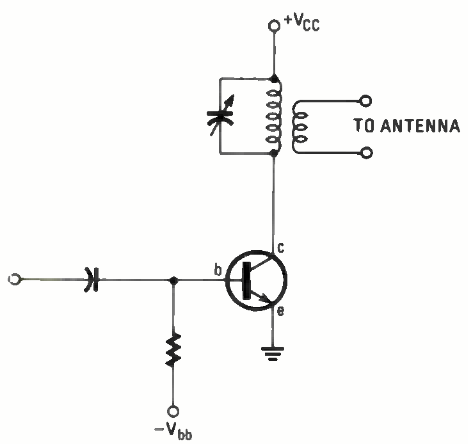


Fig. 24—The class C amplifier is used in radio transmitters.

transmitters to amplify RF signals at the resonant frequency of the tuned circuit. The negative base bias keeps the transistor cut off. (When the input is zero and negative, the transistor is cut off.) As the input goes positive, at some point it overrides the bias, and the emitter-base junction becomes forward-biased, so the transistor conducts. The result is a short pulse of collector current that occurs once per cycle, as shown in Fig. 25.

In a class C amplifier, collector current flows in short ________.

60. (pulses) How does a pulse of current translate into an RF signal? The answer lies in the tuned circuit. Whenever a pulse of current is applied to a parallel-resonant circuit, the capacitor charges. When the pulse stops, the capacitor discharges into the inductor, causing current flow, and thereby a magnetic field to be developed. When the discharge ceases, the magnetic field collapses, inducing a voltage into the coil. The induced voltage charges the capacitor in the opposite direction. The capacitor again discharges into the coil and the process repeats itself over and over again. When a tuned circuit is pulsed, it oscillates or

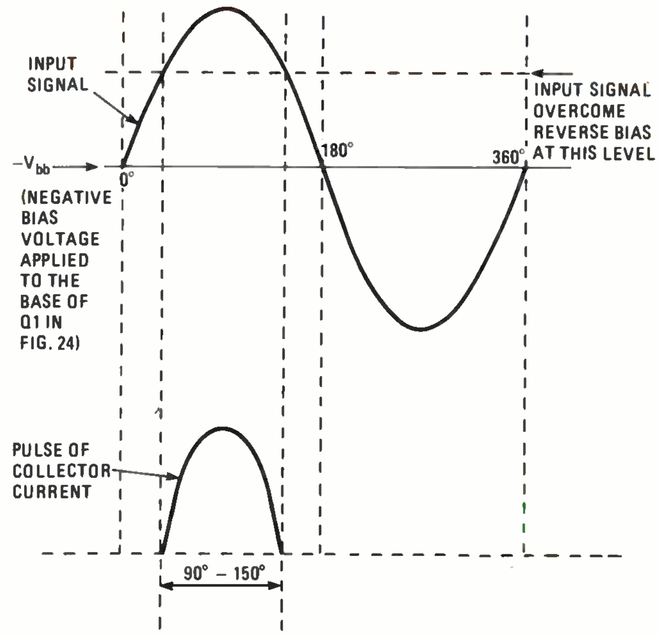


Fig. 25—The ouput signal in a class C amplifier flows for less than 150° of the 360° of the input signal.

rings at its resonant frequency. If it were only pulsed once, it would oscillate in the decaying fashion shown in Fig. 26. The resistance in the coil—which determines the Q of the coil—eventually causes the oscillations to cease. (The higher the Q of the coil, the longer the oscillation.) This kind of oscillation of a tuned circuit is called the *flywheel effect*.

Pulsing a tuned circuit causes it to ________ at its resonant frequency.

---

61. (oscillate or ring)In a class C amplifier, the tuned circuit is pulsed once per cycle, therefore, a continuous sinewave at the resonant frequency is generated, which is coupled to an antenna for transmission. Push-pull class C amplifiers based on the same principle can also be created to develop more power.

The Q and decay time both decrease with increasing resistance. Therefore, the goal of good tuned-circuit design is to decrease internal resistance. ■

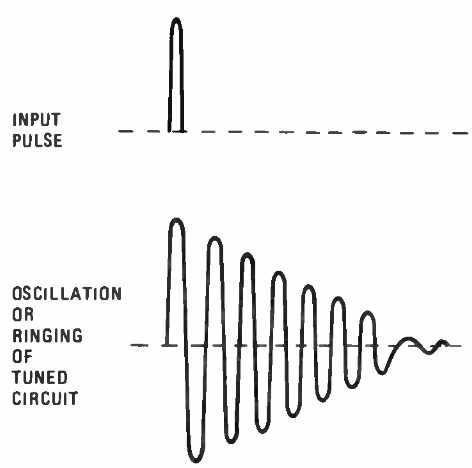


Fig. 26—Pulsing a tuned circuit causes it to oscillate (ring) at its resonant frequency.

HOW MUCH CAPACITANCE SHOULD YOU USE?

By Joseph J. Carr

Everyone has used capacitors for one thing or another, but can't too much of a good thing be bad?

☐CAPACITORS ARE FAMILIAR TO NEARLY ALL ELECTRONICS enthusiasts because they are so widely used in electronic circuits. Even all-digital circuits use capacitors for such jobs as power-supply decoupling, and input coupling on trigger lines, etc. A problem for many, is determining the proper capacitance values for a specific job. In this article we will discuss some of the rules of thumb used to answer the question "How much capacitance do I use?"

Measures of Capacitance

The basic unit of capacitance is the Farad. But for purposes of most circuits, the Farad is far too large a unit. In most electronic applications we use the microfarad (µF), nanofarad (nF) or picofarad (pF). Those units are related to the Farad by the following:

$$1\ \mu F = 10^{-6}\ \text{Farads}$$
$$1\ nF = 10^{-9}\ \text{Farads}$$
$$1\ pF = 10^{-12}\ \text{Farads}$$

(Note: Nanofarads are commonly used in Europe, and are becoming more popular in the USA. Some capacitors are marked in nF, as are most low-cost digital capacitance meters. The picofarad was once called micromicrofarad or mmF.)

Capacitors

Before discussing capacitor applications however, let's first take a look at capacitors themselves. A capacitor is an energy-storage device that consists of two electrical conductors separated by a dielectric (insulating) material. Although capacitance exists between any two conductors separated by an insulator, the standard textbook capacitor is the so-called *parallel plate* type shown in Fig. 1. The capacitance is given approximately by the expression:

$$C_{pF} = 0.2248 \times K \times A/S$$

Where C_{pF} is the capacitance in picofarads; K is the dielectric constant, a property of the insulator; A is the cross sectional area of the plates in square inches; S is the spacing between the plates in inches. From the above expression you can see that the capacitance is directly proportional to the plate area, and the dielectric constant, but inversely proportional to the separation between plates. The dielectric constant (K) is a property of the insulating material between the plates, and directly affects the capacitance of the capacitor. Thus, for any given value of capacitance, the dielectric material used for the insulator determines the physical size of the capacitor. Scientists long ago defined a perfect vacuum as the insulator with a K value of 1, and all other materials are related to the vacuum. Thus, a material with a K of 5, produces five times the capacitance as a vacuum with the same plate area and spacing. Table 1 lists the dielectric constants (K) of certain common insulating materials.

The problem of achieving the desired capacitance looks like a matter of merely choosing a convenient cross-sectional area, and then placing the two plates close enough across the right kind of material. Unfortunately, there are other constraints. One of the most important is the fact that not all

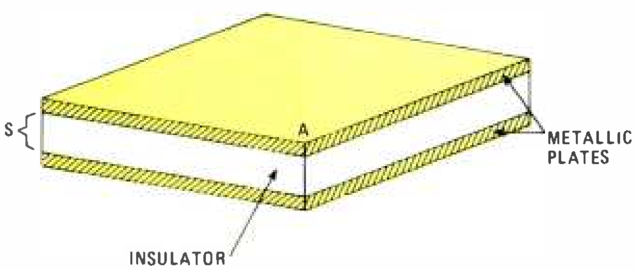
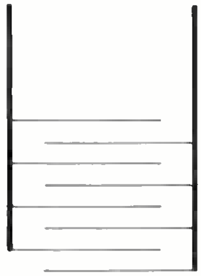


Fig. 1—This cut-away view of a simple parallel plate displays the insulator (dielectric) whose area is equal to the area of the plates (A). If the areas didn't match, the equation for capacitance would be much more complex.

TABLE 1—DIELECTRIC CONSTANTS

Material	K
Vacuum	1.000 (defined)
Dry Air	1.0006
Rubber	2-3
Paper	2-3
Ceramic	3-10
Glass	4-7
Mica	4-7
Barium Titanate	7500

Fig. 2—A capacitor can take up less room if its "plates" are based on a more-complex geometry. This capacitor can make use of a dielectric as the simple parallel-plate capacitor does, but the material used must have electrical properties that are independent of direction.



materials are created equal with respect to the ability to withstand voltage. Table 2 shows the insulating capability of non-conducting materials in terms of breakdown voltage per mil (0.001 in) of thickness.

Figure 2 shows a method for achieving a higher capacitance from smaller plates. We can interleave the plates as shown. The total capacitance will be a function of the total plate area and the respective spacings. Air-dielectric variable capacitors are obviously made that way, but some fixed-value capacitors, with hidden innards, are also built in this manner.

A respected writing colleague of mine, Sam Wilson of CET fame, uses a little *thought experiment* (i.e., an experiment that you don't actually perform) to drive home the fact that energy in a capacitor is stored in the dielectric, not the plates, of a capacitor. Figure 3 shows a capacitor made from three trash cans: two of them are metallic while one is made of cork (an insulator). When the capacitor is assembled, someone presses switch S1 and holds it closed until the voltmeter indicates that the capacitor is fully charged. The switch is then opened, and an instructor very carefully separates the metallic trash cans from the cork can, and touches the two metal cans together. If the charge is stored in the plates, then this action should short it out. But, when the metallic cans are reassembled on the cork can, the voltmeter once again reads 5000 volts DC. This indicates that the charge was stored in the insulator, not in the capacitor plates.

Power-Supply Capacitance

A favorite project for electronic hobbyists is the DC power supply. These circuits consist of a transformer to scale the voltage, a rectifier to convert it to pulsating-DC, and a filter to smooth out the pulsating-DC into almost pure DC. In some cases, a voltage regulator is also used. Several different smoothing filters are used in DC power supplies, but all of them use a capacitor as an energy-storage element. Figure 4 shows three possible cases.

The job of the filter is to reduce the *ripple* at the output of the rectifier. The ripple is a measure of how far the pulsating-DC departs from perfect-DC, and is expressed as the *ripple factor*, denoted by γ (the Greek letter gamma). In general, ripple factors should be as low as possible. But for any given application, the ripple requirement might be less than perfect. For example, a public-address power amplifier can tolerate a higher ripple factor from its DC power supply than can a high-fidelity phono or tape preamplifier.

TABLE 2—DIELECTRIC STRENGTHS

Material	Volts/Mil
Air	80
Vacuum	10,000
Bakelite	500
Glass	250
Mica	2000
Regular Paper	300
Waxed Paper	1000
Rubber	400
Ceramic	80-200
Teflon	1500

Brute Force

The filter circuit in Fig. 4A is the so-called "brute-force" method, and consists of a single large-value capacitor across the output of the rectifier. The value of this capacitor depends upon the ripple factor required. For 60-Hz power systems, the following expressions apply.

For half-wave rectifier power supplies:

$$C_{\mu F} = 1{,}000{,}000/(208 \times R1 \times \gamma)$$

and for fullwave rectified power supplies:

$$C_{\mu F} = 1{,}000{,}000/(416 \times R1 \times \gamma)$$

Where $C_{\$}mv_F$ is the capacitance of C1 in microfarads; R1 is the load resistance in ohms (V_O/I_O); and γ is the ripple factor.

Suppose we want to achieve a ripple factor of 1.5 (a fairly coarse value) for a 12-volt DC power supply that is to deliver 3-amperes from a fullwave rectifier. What value of capacitance is needed for the filter?

$$C_{\mu F} = 1{,}000{,}000/[416 \times R1 \times \gamma]$$
$$C_{\mu F} = 1{,}000{,}000/[(416)(12/3)(1.5)]$$
$$C_{\mu F} = 1{,}000{,}000/[(416)(4)(1.5)]$$
$$C_{\mu F} = 1{,}000{,}000/[2496]$$
$$C_{\mu F} = 400\ \mu F$$

An alternate filter circuit is shown in Fig. 4B. In that case, capacitor C1 forms a brute-force filter for output load R_{L1}, while C1, resistor R1 and capacitor C2 form a pi-section RC filter. Although some power is given up, that type of filter provides a lot more ripple suppression than the brute-force filter. As a result, you could expect the ripple component on voltage output V2 to be much smaller than the ripple component on V1. The expressions to find ripple factor when capacitance and resistance values are known are given below.

For half-wave rectified power supplies:

$$\gamma_{V2} = 1/(C1 \times C2 \times R1 \times R_{L2})$$

and for full-wave rectified power supplies:

$$\gamma_{V2} = 0.0000025/(C1 \times C2 \times R1 \times R_{L2})$$

Where γ_{V2} is the ripple factor for output voltage V2; C1 and C2 are in Farads; and R1 and R_{L2} are in ohms.

A Regulated Power Supply

Our final DC power supply is the regulated supply shown in Fig. 4C. In this circuit, a three-terminal IC voltage regulator such as a 7805, or LM340-12 is used. The noise bypass capacitors, C2 and C3, can have any value between 0.1 μF and 1.0 μF, in most cases. The output capacitor (C4) is used to temporarily supply current to external circuits when a high, instantaneous demand comes along that is too fast for the regulator to adjust for. That capacitor must have a value of approximately 100 μF per ampere of output current. Similarly, the filter capacitor (C1) is specified for a value of 1000 μF per ampere. Thus, for a 1-ampere DC power supply, the filter capacitor is 1000 μF, while the output capacitor is 100 μF. (Although some textbooks claim 2000-μF/ampere is better for C1, which is OK for low- and medium-current supplies, on high-current supplies it only adds to the cost of the circuit).

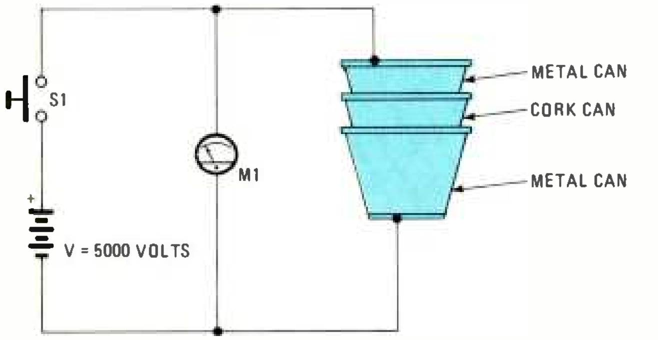


Fig. 3—A capacitor made from two metal cans and one can made of cork, can help to demonstrate that electrical energy is stored in the dielectric, not the plates of a capacitor.

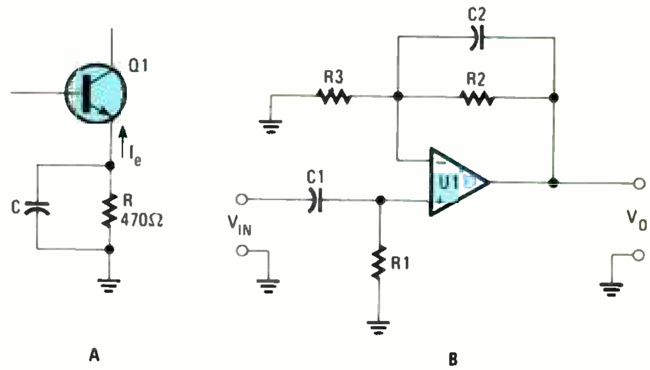


Fig. 5—AC-bypass capacitors are used in simple, single-transistor circuits (A) to eliminate the emitter-signal feedback voltage. The amplifier in B is actually just a bandpass filter if R1 and R2 are equal.

The voltage rating of a capacitor must be higher than the maximum voltage that the circuit will normally see. That does not mean that a 16-WVDC (working voltage DC) capacitor can be used in a 15-VDC circuit. To find the worst-case values, calculate the maximum applied voltage (i.e., when the AC line is at 126 VAC, rather than 110 VAC), add a 15% safety factor, and select a capacitor with a rated capacitance of 120% of that value, or more.

A certain rectifier outputs 17.9-volts peak (pulsating DC) when the AC line voltage is 110 V_{rms}. At 126 V_{rms}, the rectifier output rises to:

$$(126/110) \times 17.9 = 20.5\ V_{rms}$$

Adding a 15% safety factor gives us a worst-case value for the rectifier output voltage:

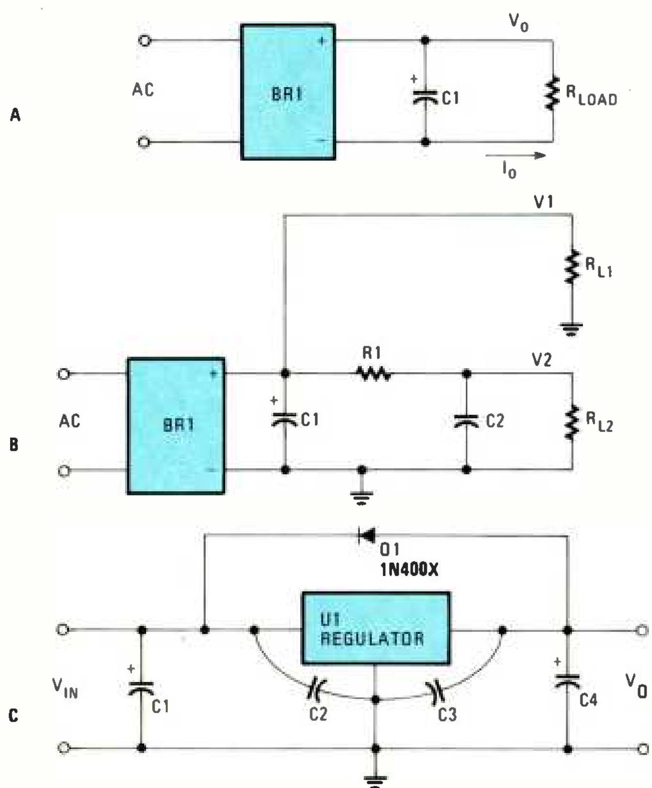


Fig. 4—Even the simple "only rectified" power supply (A) needs to be filtered properly. The power supply can output less ripple if a pi filter is used at the output (B). While regulated supplies don't need as intense a filter, it is wise to place capacitors across the input and output leads close to the regulator to insure against power glitches.

$$1.15 \times 20.5 = 23.6\ V_{rms}$$

We now multiply that value by 1.20 to account for a minus 20% error that is possible in the working voltage rating of electrolytic filter capacitors:

$$23.6 \times 1.2 = 28.32\ VDC$$

Thus, we need a 28.32-WVDC or higher capacitor. Since 35 WVDC is the next highest standard value, the capacitor selected would have that voltage value.

Amplifier-Circuit Capacitance

For most solid-state amplifier projects, the main parameter used for capacitor selection is frequency response. For example, in the common-emitter NPN transistor amplifier shown in Fig. 5A, we have a capacitor bypassing the 470-ohm emitter resistor. The purpose of this capacitor is to set the emitter at ground potential for AC while keeping it at a higher DC potential. The rule of thumb for the capacitive reactance of Capacitor C is:

$$X_c \leq R/10$$

So, for the case shown, we need a capacitor with a reactance of 470 ÷ 10, or 47 ohms. The capacitance is therefore:

$$C_{\mu F} \geq 1{,}000{,}000/(6.28 \times X_c \times F)$$

Where $C_{\mu F}$ is in microfarads; X_c is in ohms; and F is in Hertz, and is usually at the amplifier's -3-dB response point.

Consider the case of a CB transmitter mike preamplifier that requires a low-frequency response down to 300 Hz. For the case above, where a 470-ohm emitter resistor is used, the reactance of C is 47-ohms, so evaluating the above expression tells us our preamplifier will need a capacitor of 11.3 µF (or more).

A more generalized case is shown in Fig. 5B. Here we show any linear amplifier (although an operational amplifier is shown) used to process audio or some other AC signals. The high-end -3-dB point in response (F_2) is determined by capacitor C2, while the low-end -3-dB point (F_1) is set by C1. The following expressions apply:

$$C1 = 1{,}000{,}000/(6.28 \times R1 \times F_1)$$

$$C2 = 1{,}000{,}000/(6.28 \times R2 \times F_2)$$

where C1 and C2 are in microfarads; R1 and R2 are in ohms; and F1 and F2 are in Hertz.

(Continued on page 100)

By Marc Ellis

ELLIS ON ANTIQUE RADIO

The art of replacing defective electrolytic capacitors

☐LAST MONTH'S COLUMN WAS DEVOTED to helping reader Dan Boone with a hum problem that he was having in a 1930's Philco. We diagnosed the problem as most likely being caused by a defective electrolytic capacitor in the power supply. Then we went on to talk a little about power-supply and electrolytic-capacitor theory before suggesting how to locate and replace the defective component. The topic of electrolytic capacitors is important enough to the antique-radio collector and restorer for us to stick with it at least for a while longer before moving on to something else.

The Problem of Aging

As was suggested last time, the electrolytic capacitor is among one of the more short-lived components in a radio receiver. The operation of an electrolytic capacitor is dependent on a layer of chemical paste that separates its two electrodes. Electric current passing through the paste creates a thin oxide (dielectric) coating, which serves to keep the electrodes electrically insulated from each other; and it is that ultra-thin coating that gives the electrolytic capacitor its characteristically large capacitance.

As the capacitor ages, the chemical paste may dry out and become inactive. Also, if the radio is not used for some time, the dielectric coating may break down—rendering the capacitor inoperative, or shorting it out and possibly ruining other components in the set the first time that it's turned on after a long period of disuse.

Finding Replacements

Fresh replacement electrolytic capacitors with the proper ratings are hard to come by. Now that solid-state devices have replaced vacuum tubes in virtually all home electronic equipment, tube-related components (once readily available at any electronic-supply store) are disappearing from the shelves.

For example, you'll find both electrolytic and non-electrolytic units in many capacitance ranges at your local Radio Shack store. But most will be rated at 50 volts or less—nowhere near the 150- to 450-volt ratings needed for vacuum-tube circuits. A visit to a parts store that caters to television-repair technicians may net you the unit you need, but you'll have to travel farther and farther to get results as the number of tube-equipped TV's in use continues to dwindle.

Your best bet in finding a replacement electrolytic capacitor may very well be the surplus route. You can shop by mail with one of the companies dealing in surplus electronics parts. (Check the advertisers in the back this magazine for some good leads.) Or you can visit the next hamfest to be run in your area. Hamfests provide a rich source of used and surplus electronic parts from all eras.

Of course, you have no way of knowing the age of a surplus capacitor—and some may even approach the antiquity of the set that you are trying to repair. So the "new" unit that you purchase *could* be as deteriorated as the component to be replaced. More on how to handle that later.

Implications for the Restorer

All of the above have several implications for the antique-radio restorer. For one thing, get over any guilt that you might be feeling about replacing the original electrolytic capacitor with something that may look very different. Electrolytic capacitors were never intended to be a permanent part of the set anyway; occasional replacement was expected. In fact, an early serviceman might have already substituted a more-recent unit for the one originally in the set. It's also a fair bet that you won't be able to write to Atwater Kent, Grigsby-Grunow, or even Zenith to get an exact replacement. You'll either have to substitute what you can get, or be satisfied with a set that may be all original, but inoperative.

If the electrolytic capacitor you are changing is a can-type, base-mounted unit located on top of the chassis—and you aren't able to find a replacement that is physically or electrically similar—you

When this mid-1930's Aerovox ad appeared, multiple-section electrolytic capacitors—like this unit, which had individual positive and negative leads for each of the two sections—where a new idea.

Pictured here are the common multi-section electrolytic capacitors found in many of the early radios. The upper unit has a clamp for under-chassis mounting, and the unit below is base-mounted above chassis.

can leave the original in place for looks and substitute one or more individual axial-lead capacitors mounted under the chassis. As a matter of fact, replacement with individual axial-lead units may be the only route to go if the can-type unit was a multiple capacitor with several different values. A replacement unit with just the right combination of values could be quite hard to find.

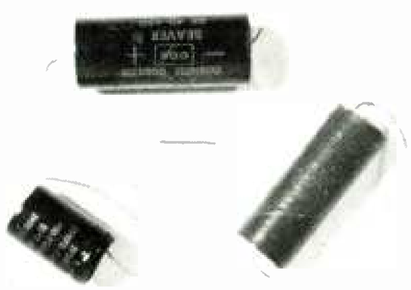
Some purists manage, somehow, to drill out the bottom of the old can, clean it out, and slip the replacement axial-lead units inside, and then remount the can in the set. That is practical because the newer electrolytic capacitors take up much less space for the same capacitance than do the older units. I don't think I'd ever be tempted to do that, however. In fact, I'd argue that the set is more authentic with the (disconnected), original can left in place and intact. A later radio historian who might examine your set will realize immediately what you did and be gratified that the original was still in place.

For the same reason, also try to leave under-chassis electrolytic capacitors in place when you substitute new ones. That isn't practical if the originals are individual units supported only by their own leads. But multiple-unit electrolytic capacitors designed for under-chassis installation were usually fastened with some kind of clamp (often soldered to the chassis). They'll remain secure even with their leads disconnected. If you *must* remove the original electrolytic capacitor, you might want to consider leaving a note for future collectors (possibly stapled to the inside of the cabinet), documenting the repair and describing the removed capacitor as completely as possible (include brand, capacitance, and voltage ratings; physical appearance, etc.).

Working Out a Substitution

As we said last time, your replacement capacitor should have *at least* the same capacitance and voltage rating as the original. It won't hurt if either rating is increased somewhat, but try to stay in the same ballpark. You might replace a 20-µF unit with a 30 (or even a 40, if you had it on hand and it was about the right physical size); but going much higher would violate the design integrity of the set, and might even impair its operation.

You can jury-rig several of the available replacement units of various capacity to produce the proper capacitance value, by paralleling a few of the smaller ones. Remember from your basic electronics course that capacitances in parallel add like resistors in series—in series capacitors divide like resistors in parallel—so you can make a 40-µF unit by paralleling two 20's, a 20 and two 10's, etc. By the same token, you can also create a 40-µF unit by connecting three 120-µF units in series. Just make sure that the voltage rating of each of the paralleled units is at least as great as that of the original. And when you wire the parallel units together,



Replacement capacitors with any desired capacity can be created by connecting several individual units in parallel.

be sure to observe the proper polarity—keeping all positive leads and all negative leads together, or if they're series wired, that the positive lead of one unit connects to the negative lead of the next.

As discussed last month, polarity must also be strictly observed when wiring your replacement unit into the set. Connect the positive and negative leads of your replacement to the same points in the circuit where the positive and negative leads of the original were connected. Capacitors connected with their polarities reversed are quickly destroyed upon the application of power.

If the original is a metal-can unit, study the wiring information on the old part carefully. It will usually be plainly marked—often, the can is the common negative connection for all capacitor sections inside, and is grounded to the set's chassis. But sometimes metal-can capacitors *will* have separate negative leads or connections and the can will be deliberately insulated from ground.

The voltage rating of a replacement capacitor isn't critical as long as it is at least as great as that of the original. Some theorists may argue that, because an electrolytic capacitor's dielectric layer is developed by passage of internal electric current, the electrolytic capacitor can't

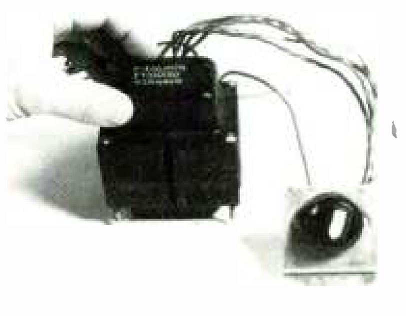
Carefully study the wiring information on the unit to be replaced; it's usually plainly marked. If the chassis does not reflect the capacitor orientation, mark it accordingly before removing the bad component, so that the replacement can be installed in the same way.

develop its full rated capacity unless operated near its rated voltage. I used to respect that principle when electrolytic capacitors were plentiful, but I tend to discount it now. Capacitance "shortfalls" caused by under-voltage operation are probably negligible—and I wouldn't hesitate to replace, say, a 150-volt unit with a 350-volt one that I might happened to have on hand as long as the physical sizes were reasonably compatible.

You can sometimes avoid having to replace an electrolytic capacitor by operating the radio at reduced voltage when you first turn it on. If the dielectric layer has become deteriorated through disuse, a new one—through a process called *reforming*—can be developed by current flow through the unit as long as the electrolytic capacitor paste has not thoroughly dried out. By operating the set at lower voltage, you reduce the risk of shorting out the capacitor before a new dielectric can form.

I'd strongly suggest making it a practice to operate any newly acquired set on a lower line voltage (say, about 60 volts) for several minutes before powering it up to full potential. During that period, if no dielectric voltage is developed across the electrolytic capacitor, disconnect the power immediately and check for shorts.

(Continued on page 103)



An inexpensive way to reduce the AC line voltage is to use an isolation transformer, like this one available from Fair Radio (1016 E. Eureka St., Lima, OH 45802).

By Charles D. Rakes

CIRCUIT CIRCUS

There may be several electronic test instruments lurking in your junkbox

THIS MONTH I'D LIKE TO SHARE A FEW handy-dandy test instruments with you that can be put together for a minimum cash outlay (depending on how well stocked your junkbox is) and, for the most part, can't be purchased ready made.

For you experimenters who know Murphy as well as I know Murphy, the time will come when one of those simple circuits could really save the day. For example, not too long ago I had a very distinguished guest who came especially to observe a special project of some importance to my livelihood. And, as fate would have it, one uninvited guest also showed up.

If I had not had the two simple cable-test sets, Murphy would have had me in a most embarrassing predicament. But, as it ended up, I made a good show out of what could have been a very bad and costly one, by using the two cable-test sets shown in Fig. 1 and Fig. 2.

How many times have you had an interconnecting audio, video, or other electronic cable act up and cause a fit when in use, but as soon as you tried to locate the culprit, Murphy smiled, turning it into a do-right operation until the next time you really need it to work perfectly? Sound a little too familiar? If so, duplicate the two following circuits.

Open-Circuit Detector

The circuit in Fig. 1 is designed to check almost any two-conductor cable for open-circuit conditions that usually only show up when the cable is moved about—most-often referred to as the intermittent open-circuit cable syndrome. The Open-Circuit Detector uses a single active solid-state device, a low-current silicon-controlled rectifier (SCR1) to act as a forget-me-not circuit, that will remember to supply current through the LED as long as the return current path through the cable under test remains complete.

But if the path were to open up for a split second, our circus pachyderm forgets everything and the LED goes out. No matter how many times the connection is re-joined while testing the cable, SCR1 will remain off until the RESET switch is pressed, and if the cable is open at that time it will not reset.

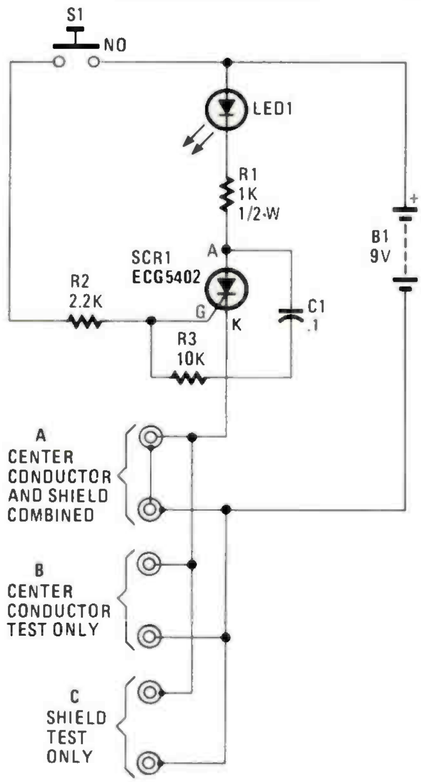


Fig. 1—Open-Circuit Detector

If you build the circuit in a plastic case, you will not need to isolate each of the test sockets—making the construction job a whiz. The test-socket arrangement shown at point "A" in the schematic diagram checks both the shield and center conductor of the same cable simultaneously by routing the two leads in series through the test sockets. If a metal cabinet is used, those two transistor test sockets will need to be isolated from the cabinet to operate properly.

If an open circuit slows up while using the "A" test sockets and you want to determine if the open is in the shield or the center conductor, move on to the "B" test socket and test the cable for an open center conductor. Nothing there? Go on to the "C" sockets, and check out the shield. Even with all of Murphy's laws working overtime, you should be able to locate the cable's defect in short order and make repairs when possible.

PARTS LIST FOR THE OPEN-CIRCUIT DETECTOR

- B1—Battery, 9-volt type
- C1—0.1-µF, ceramic disc capacitor
- LED1—Jumbo red light-emitting diode
- R1—1000-ohm, ½-watt, 5% resistor
- R2—2200-ohm, ½-watt, 5% resistor
- R3—10,000-ohm, ½-watt, 5% resistor
- SCR1—ECG5402 .8-A, 100-PIV, silicon-controlled rectifier
- S1—Normally-open, momentary contact, pushbutton switch
- Printed-circuit or perfboard materials, battery holder and snap-on connector, jack, (RCA, F-type, BNC, etc.), enclosure, wire, solder, hardware, etc.

You can use any number, and combination of connectors for testing audio cables, RF cables, or any other two-conductor cables, and they can be wired in three's for shielded or a single pair will do for non-shielded.

Short-Circuit Detector

If an intermittent-open cable isn't enough for Mr. Murphy, he will introduce you to that infamous *will-o'-the-wisp* short circuit that can come and go at will. Never fear, 'cause we've got Murphy covered on this one too. The ultra-simple circuit in Fig. 2 will ferret out any shorted two-wire cable in a New York minute with

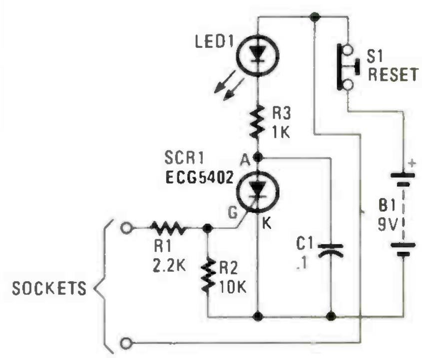


Fig. 2—Short-Circuit Detector

PARTS LIST FOR THE SHORT-CIRCUIT DETECTOR

B1—Battery, 9-volt type
C1—0.1-µF, ceramic disc capacitor
LED1—Jumbo red light-emitting diode
SCR1—ECG5402, .8-A, 100-PIV, silicon-controlled rectifier
R1—2200-ohm, ½-watt, 5% resistor
R2—10,000-ohm, ½-watt, 5% resistor
R3—1000-ohm, ½-watt, 5% resistor
S1—Normally-closed, pushbutton switch
Printed-circuit or perfboard materials, battery holder and snap-on connector, jack, (RCA, F-type, BNC, etc.), enclosure, wire, solder, hardware, etc.

seconds to spare. That feat is accomplished through a single, low-current silicon-controlled rectifier (SCR1) that's set to remember an electrical *sting* that comes from a short in a cable that's connected to its test sockets. In this case, our *elephant* just won't forget the experience until you put his lights out with *reset* switch, S1.

If a very-long shielded cable is connected to the circuit and the LED lights instantly, it might not indicate a short in the cable, but could be caused by the cable's internal capacitance charging up through the gate-cathode junction of the SCR and turning it on. If that proves to be a permanent problem, a .047µF, 100-WVDC mylar capacitor can be connected between the SCR's gate and cathode, but for short cables, that correction should not be needed.

Here again, you can connect as many pairs of RF, audio, etc., types of connectors to the test circuit as needed. But, since they should all be isolated from each other, a housing of plastic would be ideal for this circuit as well.

Low-Power Semiconductor Tester

The circuit in Fig. 3 is a handy tester for checking a large number of semiconductor devices that may have been either scrounged from the bottom of our junkbox or purchased at the bargain counter. Many are *orphaned* parts without a family tree to hang on to. The majority of our two- and three-legged solid-state friends can be checked simply by connect them to the test-circuit terminals, and operating a couple of switches.

The operation of the test circuit goes something like this; a PNP or NPN transistor is connected to the test terminals, while one of the push-button switches (S1-S3) is pressed. If one of the LED's light, look at the polarity reversal switch S4 and see if it's in the PNP or NPN

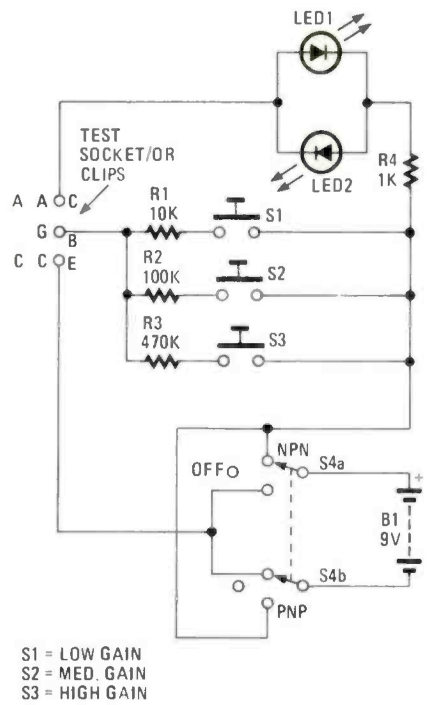


Fig. 3—Semiconductor Tester

position. If both LED's fail to light, reverse the position of R4; if the device is OK, an LED will light. After you have the LED glowing, let up on the push-button switch and the glow should go out. If not, the device is most likely shorted. Naturally all of the three-legged devices must be connected correctly to the test terminals to check out properly, but since the circuit is user friendly and non-destructive, try all combinations to determine the type and condition of the device at the same time.

Low- and medium-current SCR's can be checked with the circuit. Plus, you can get a feel for the gate-current sensitivity

PARTS LIST FOR THE LOW-POWER SEMICONDUCTOR TESTER

B1—Battery, 9-volt type
LED1, LED2—Jumbo red light-emitting diode
R1—10,000-ohm, ¼-watt, 5% resistor
R2—100,000-ohm, ¼-watt, 5% resistor
R3—470,000-ohm, ¼-watt, 5% resistor
R4—1000-ohm, ¼-watt, 5% resistor
S1–S3—Normally-open, momentary contact, pushbutton switch
S4—Double-pole, 3-position (2P3P) rotary switch
Printed-circuit or perfboard materials, 9-volt transistor battery holder and snap-on connector, jack or clip lead, enclosure, wire, solder, hardware, etc.

by pressing S3 first, then S2, followed by S3 if neither of the first two caused an LED to light. If the LED lights on either S3 or S2, you've got an SCR with a hair trigger. Such an SCR could be useful in circuits that require a small trigger current. If SCR's with a holding current of more than 8 or 10 mA are to be tested, the 1000-ohm resistor will need to be lower in value for the required current, but don't go too low in ohmic resistance or the LED's will really light up.

High-Power Semiconductor Tester

Higher-powered transistors, SCR's, and diodes can be put to a more-realistic test with the modified circuit in Fig. 4. With the component values given, a maximum test current of 60 mA can flow through the emitter/collector junction of a power transistor, and a similar amount through the anode/cathode of an SCR. The maximum base or gate current is about 16 mA with S1 on, and a minimum of 1 mA with S3 on. All of the resistor values can be changed to meet the specific current-test requirements, but the values given will let you know if the majority of the devices tested are usable or not.

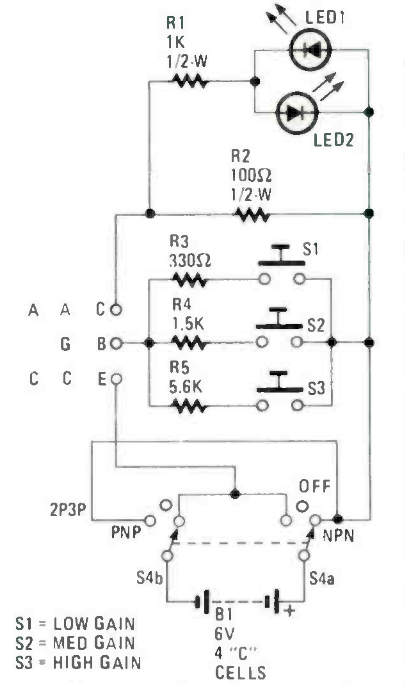


Fig. 4—High-power Semiconductor Tester

VOM Range Extender

If you've ever needed an expanded voltmeter (but couldn't see paying the price), try the ultra-simple and cheap approach shown in Fig. 5. The complete circuit contains only three parts plus your favorite VOM, and even if your junkbox is empty the cost will be less than five bucks.

The circuit can be set up to suppress

(Continued on page 100)

By Herb Friedman

FRIEDMAN ON COMPUTERS

A disk cylinder isn't a phonograph record. Edison wouldn't have done it that way.

☐HANDS-ON ELECTRONICS HAS OFTEN shown you how to inexpensively retrofit or replace both the hard and soft disk drives in your computer. If you recall, the keys to budget-priced disk storage are the surplus and mail-order dealers whose prices for disk drives are often ½ to ¼ of what you'd expect to pay at your local *full-service* computer store. (A misnomer if ever there was one, because the customer often knows more than the help in almost any full-service store.)

Until the past few years, it wasn't difficult to buy the correct drive if your computer was other than an Apple, a Commodore, an Atari, or an *orphan* such as the Osborne. The real biggies of personal computing—IBM (and its clones), Radio Shack, and most Heath/Zenith—all used the same kind of floppy-disk drive: the so-called Shugart SA-200 and SA-400 compatible.

Of course, many other computers, and even some oldies from the early days of personal computing, used the same kind of disk drives: actually, the SA-200 compatible. (We'll soon get to the main difference between the SA-200 and SA-400. Just keep in mind meanwhile that the IBM-type floppy is basically compatible with the SA-400.)

Without going needlessly into the history of how the floppy drive developed, suffice it to say that when the industry scaled-down the highly reliable "standard" 8-inch disk drive, the result was a 5¼-inch disk drive that wrote (recorded) 35 magnetic tracks, which were in turn divided magnetically into sectors. The precise number of sectors was determined by the disk controller selected by computer's manufacturer. The important electrical parameter was 35 tracks, because that was determined by the disk drive, not necessarily the controller. Even if the controller attempted to write to 40 tracks, it could not if the drive's head simply could not physically move beyond track 35.

Double-density

The 35-track format—actually developed from IBM's 8-inch floppy, and used in Shugart's model SA-200 disk drive—was so astoundingly reliable that someone said "Hey, let's try to lay down twice the amount of magnetic data." Surprise, surprise, on many better-quality mechanisms, the disk system still worked reliably, only instead of a disk storing 80 to 100 KB (kilobytes) of data, it could now store nominally 160 to 200 KB.

To distinguish between the two, the older SA-200-compatible type drive was called *single-density*, and the new SA-400 compatible drive was called *double-density*—meaning it could read and write about twice the amount of magnetic information. In actual fact, most of the better-quality, single-density drives such as the SA-200 itself could actually read and write double-density if used with a double-density controller. (Now you also know why and how Shugart got its valuable reputation.)

Then someone tried writing 40 tracks to the disk, and wonder of wonders, the disk

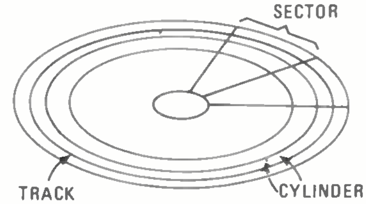
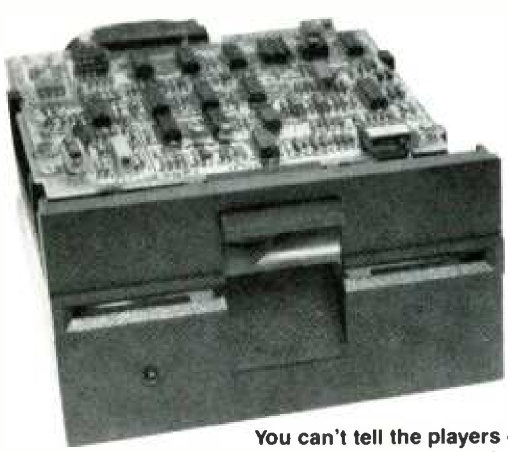
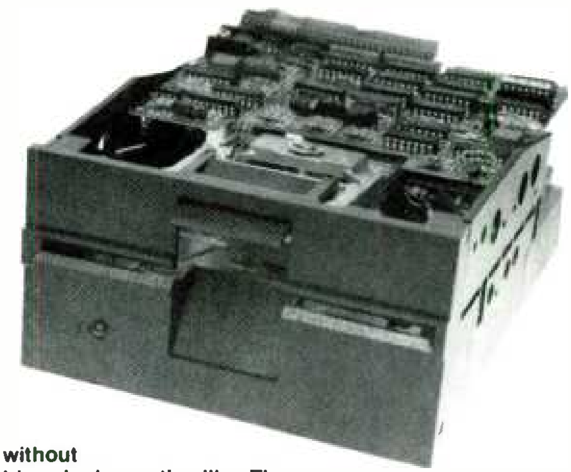


Fig. 1—A 5¼-inch floppy disk closely resembles a 45 rpm record; but instead of grooves, the computer formats magnetic tracks that are magnetically divided into sectors. The tracks can be on one or both sides of the disk, in which case they can be treated as individual disk drives, say Drive A and Drive B, or as a single drive. When both sides are used as a single drive the tracks are considered to be the tops and bottoms of a cylinder. Although there are 40 tracks per side, the computer "sees" not 80 tracks total, but 40 cylinders.





You can't tell the players or a disk drive without a score card. From the front, both disk drives look exactly alike. The one on the left, however, is an SA-200 compatible; 35-tracks, single-sided, single-density. The model on the right is IBM-compatible; double-sided (40 cylinders or 40-tracks per side), double-density.

didn't self-destruct. So most double-density drives were designed to read or write up to 40 tracks. (An IBM-compatible drive can actually accommodate up to 43 tracks.) The Shugart mechanism was the 400L: 40-track drives were Shugart 400-L compatible. (Eventually called by many surplus dealers SA-400 type—which confused just about everyone when what was supposed to be a 40-track drive couldn't read or write beyond 35 or 36.)

The fact of the matter was that the 5¼-inch floppy disk was far more reliable than expected. It had much more capacity and reliability than expected; even when upgraded to 40 tracks/double-density.

But even that did not affect reliability, so manufacturers tried other ways to increase disk storage, and it's some of the resultant upgrades that often mislead the hobbyist and experimenter into purchasing the wrong drive.

Two-headed Monster

Just prior to IBM's introduction of their PC, several manufacturer's figured that it wasn't much more difficult to read and write on both sides of the disk as it was one side. Mechanically, all that was needed was another read/write head on the "opposite," or unused side of the disk. The disk controller and the existing operating systems were something else. Most either treated each side as an independent drive (Drive A *and* Drive B), or counted one side as tracks 1 to 40 (or 0 to 39) and the flip side as tracks 41 to 80 (or 40 to 79). Basically, however, it's the same drive, and it's usually what is now known as an IBM-compatible drive. The independent drive selection is a function of the connecting cable, while the dual 40-track operation is a function of the controller.

But even this could not tax the reliability of the 5¼-in. drive, and some manufacturer's designed their drives for 80 tracks, single-sided (usually misnomered as "quad density"). The 80-track operation was determined by the computer's operating system and/or controller. Unfortunately, most of the early single-sided 80-track drives could not be used for reading and/or writing 40 tracks. (Many of these models are still floating around the marketplace, so be careful.)

But then came the *cylinder concept*, which confused just about all non-technical, personal-computer users until IBM decided to use the same concept for its drives. It is the 40-track/40-cylinder drive that is considered the present IBM-compatible "standard."

It's Still Only Two Sides

The cylinder concept, shown in Fig. 1, really made it possible for a computer's operating system to easily use single- or double-sided drives. Basically, in a very simplified form—so don't quote this anywhere outside this magazine—it works this way. Each side has 40 tracks, which we'll call tracks 1 through 40. (I never really cared for any numbering system that started with a zero.)

Assume each track is divided into 9 sectors. The computer formats all the tracks on one side so the sectors are numbered 1 through 9. The tracks on the flip side are also numbered 1 through 40 but their sectors are numbered 10 through 18. (Remember, this is not the way it's really done, but it helps explain what's happening.) As far as the disk controller is concerned, track 1 has 18 sectors; nine on either side of the disk.

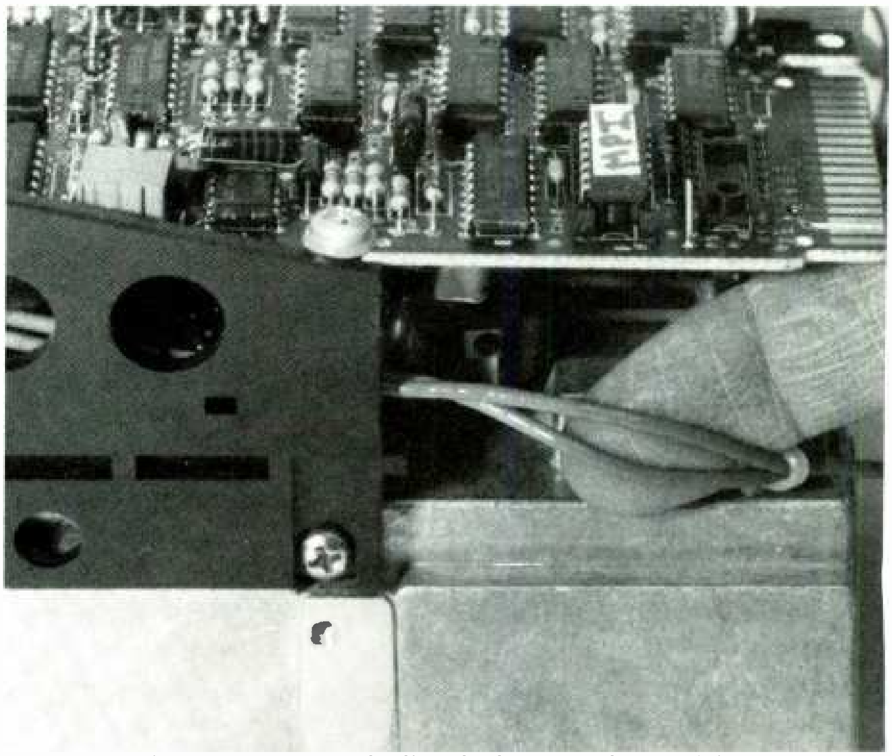
If you examine the track layout in Fig. 1, it appears visually that each track is the top and bottom of a cylinder, so the powers that be (the same kind of folk who decided cycles-per-second will be henceforth known as Hertz) decreed that that kind of track/sector arrangement will be called a *cylinder*. Unlike early controllers, which treated each track independently of the others, cylinders are treated as a single track of 18 sectors: the computer can write to either side. For example, if a BASIC program required two full tracks to store data, the computer could write the data to a single cylinder, actually two tracks: one on each side of the disk. That's the reason why IBM-compatible disk drives are also known as 40-cylinder drives. It means 80 tracks: 40 on each side.

Fortunately, although the cylinder concept is needed by the engineers who design disk controllers, most dealers, buyers, and just about everyone else refers to the 40-cylinder drive as IBM-compatible, which means that it's also compatible with Radio Shack and Heath/Zenith soft-sectored disk drives. (There's no point in getting into hard-sector *vs.* soft-sector drives at this point, because all modern PC's use the soft-sector drive.)

Quad Density

Once again, the reliability of the floppy disk has allowed yet another upgrade, this time to 80 cylinders—quad density: the kind of drive IBM supplies in their AT computer. The 80 cylinder specification means, of course, 80-tracks per side. Quad density means about twice the density of data written to the disk compared to double-density. It's a simple mathematic relationship. Take the 360 KB that can be stored on a typical IBM-compatible drive, double it because of the 80 tracks per side to 720 KB, double it again because of quad-density to 1.4 KB, and you're close to the actual storage value of 1.2 megabytes per disk (quad is not exactly twice double-density, and double-density is not actually twice single-density).

Anyway, if you're totally confused go back and try to understand it all, because it's the only way you'll know for certain that the 40-track disk drive that you've seen advertised for $29.95 (no refunds) will actually work in your computer. ■



If you can't tell otherwise if a drive is double-sided, look for two shielded wires or two unshielded pairs coming from the head assembly. Each head requires its own wire(s).

By Joseph J. Carr, K4IPV

CARR ON HAM RADIO

How to Deal with TVI/BCI

TELEVISION INTERFERENCE, TVI, IS the bane of the amateur-radio community. TVI occurs when emissions from an amateur (or other) transmitter interferes with the normal operation of a television receiver. Except for solo explorers on the north slope of Alaska, and missionaries among the indians of the Amazon basin, all amateurs have a potential TVI problem looming as close as their own TV set...or their neighbors' sets.

Classifying Interference

One way to classify TVI is according to the cause. But before getting into that, first consider that all electronic devices must perform two functions: respond to the desired signals, and reject the unwanted ones. All consumer devices perform—more or less—in accordance with the first requirement, but many fail with respect to the second.

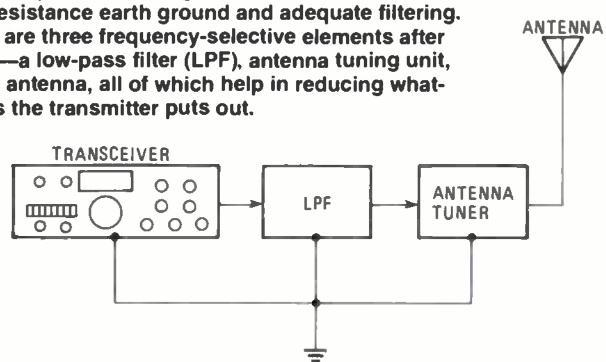
It often happens that your transmitted signal will be received on a neighbor's TV or hi-fi set, in spite of the fact that your own operation is perfectly clean. On some TV sets, the high-intensity signal from your nearby transmitter drives the RF amplifier into non-linearity, creating harmonics where none existed before. In other cases, you may find that audio from your transmission can be heard mixed in with the audio output of a TV set, or seen in the video, as a result of induced signal pickup and rectification inside the set.

Improper shielding can cause signals to be picked up on internal leads and fed to the many circuits throughout the set. I don't have the column space to detail all of the mechanisms that create TVI/BCI, but can refer you to an *American Radio Relay League* (ARRL) publication titled *Radio Frequency Interference: How to Identify It and Cure It* ($3.00) for further information. We can, however, cover some of the most common forms.

By the Book

Remember, there are two rules of thumb: if your emissions are not clean, then getting rid of the TVI/BCI is your responsibility. On the other hand, if your emissions are clean, and the TVI/BCI is caused by poor consumer equipment design, then it's the set-owner's responsibility to fix the problem—not yours. However, you may want to assist him or her where possible.

Fig. 1—The techniques for making the transmitter clean are simple; a low resistance earth ground and adequate filtering. Note that there are three frequency-selective elements after the transmitter—a low-pass filter (LPF), antenna tuning unit, and a resonant antenna, all of which help in reducing whatever harmonics the transmitter puts out.



Amateurs must respond positively to TVI/BCI complaints for several reasons. First, you have a responsibility to keep your emissions clean, and operate your transmitter legally. Second, it makes for good neighborhood relations if you attempt to help them solve the problem. After all, we live in a society where more people seem willing to go running to lawyers than to engineers to solve technical problems. And even though you may win a suit—brought by some lawyer who is either too hungry for his client's money to question the merits of the case or too ignorant to research the matter properly—it can break you financially.

Although some neighbors may not bring suit, they'll, nonetheless, run to local regulatory bodies even though they don't have jurisdiction over the matter. Either way, your enthusiasm for a fight to keep your operating privileges may wane a little bit when you see the legal costs.

Third, it's just good manners to help solve the problem. When dealing with your neighbor, don't ever lose your temper, insult him or her, or pose as an arrogant, haughty high-tech genius who couldn't care less about their problem. Again, good manners go a long way.

Make Sure You're Clean

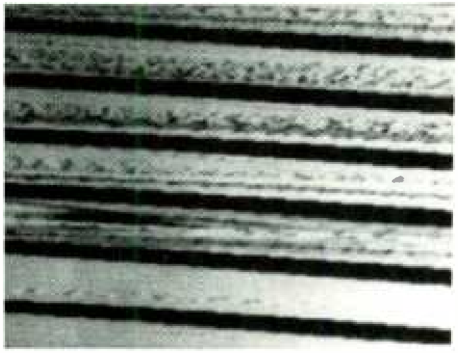
Although it requires a spectrum analyzer to be sure that the harmonics are down 40 dB or more below the carrier, a few simple checks will tell the tale in many cases. An absorption wavemeter is an elderly device that can spot harmonics that are way too high. Also, listening on another receiver from a long distance (say, a mile or more) away will give you some indication if a problem exists. At that distance, if you can hear the 2nd or 3rd harmonic, then you can bet so can your next door neighbor.

Finally, if you own an RF wattmeter, or forward-reading VSWR meter, and a dummy load, then you can make a quicky check by measuring the output power with and without a low-pass filter installed in the line. If the power-level readings vary by appreciably more than the insertion loss of the low-pass filter, then suspect that harmonics are present.

The techniques for making the transmitter clean are simple—a low-resistance earth ground and adequate filtering. In the station shown in Fig. 1, there are three frequency-selective elements after the transmitter: Low-pass filter (LPF), antenna tuning unit, and a resonant antenna. All of those will help in reducing whatever harmonics the transmitter puts out.

Determine that you really have a TVI problem. I was once accused of TVI when I was asleep, and on another occasion when I didn't have a transmitter in the house. Check for TVI both with the transmitter turned on and off. Also, make sure the TV is properly adjusted. Figure 2 shows the difference between misadjusted horizontal hold (Fig. 2A) and TVI from an AM or SSB transmitter (Fig. 2B).

Also make sure that the interference is not coming from another source! Once



A

B

Fig. 2—A misadjusted horizontal hold (A) can be easily distinguished from TVI emitted by an AM or SSB transmitter (B). Less exotic sources of TVI include local broadcast stations, land-mobile radio stations, and all manner of electronic devices. Even some switches can produce *salt and pepper* snow on the TV and/or make 75/80-meters darn-near unusable.

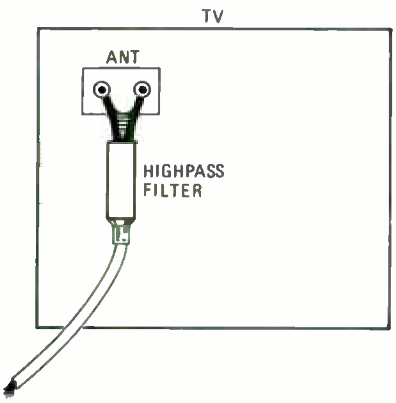


Fig. 3—Try adding a high-pass filter—which will only pass signals with a frequency greater than about 50-MHz, while severely attenuating HF amateur or CB signals—to the TV set. The high-pass filter must be installed as close as possible to the antenna terminals of the TV set. Making the connection wire as short as possible helps to prevent its acting as an antenna in its own right.

your antlers go up, all of your neighbors will assume the worst and blame every flicker of the set on your operations. I once had a little old lady tell me that low-flying airliners that regularly crossed our neighborhood for years never caused any flicker on her set until after I installed my 40-meter dipole. She was a kindly soul, but absolutely adamant that I'd caused airplane flicker to appear on her TV set.

Other, less exotic sources of TVI produce very real interference. Local broadcast stations, land-mobile radio stations, and all manner of electronic devices can generate TVI...it's not just an amateur's problem. In my own house (which we just moved into) I am going to have to change those blankety-blank dimmer switches, which the former owners installed. They produce *salt and pepper* snow on a TV and make 75/80-meters on my receiver darn near unusable.

Try adding a high-pass filter to the TV set. Those filters will only pass signals with a frequency greater than about 50-MHz, and severely attenuate HF amateur or CB signals. As shown in Fig. 3, the high-pass filter must be installed as close as possible to the antenna terminals of the TV set. Make the connection wire as short as possible to prevent it from acting as an antenna in its own right.

You might also want to counsel your neighbor to install an antenna that uses a coaxial-cable transmission line, rather than 300-ohm twin-lead. Although theory tells us that there should be no difference, it is nonetheless true that 75-ohm coax systems are less susceptible to all forms of noise—including TVI. Install a high-pass filter and a 75-to-300 ohm TV-type balun impedance transformer at the TV's antenna terminals.

Many, perhaps most, TV receivers have poor shielding, so signals can bypass the high-pass filter and get picked up on the leads between the TV tuner (inside the set) and the antenna terminals on the rear of the set. That situation makes the high-pass filter almost useless. A solution to that dilemma is to mount the filter directly on the tuner, inside the set, making the lead length essentially zero.

One word of utmost caution, however! Unless you are a sado-masochist, do not—under any circumstances—install the filter on or in your neighbor's set yourself. If you do, then your neighbor will blame you for every repair that the set needs from then on. I once did volunteer work for a TVI Committee that was investigating interference from a CB operator (who was operating completely legally, by the way). The CB'er had personally installed a high-pass filter on a neighbor's TV receiver at the external antenna terminals (he had not even opened the back of the set).

Unfortunately, the vertical/horizontal/sync module went out a few days later. Needless to say, the upset neighbor then complained to just about everyone who would listen to him that this *blankety-blank ham operator* (she didn't know the difference) fouled up her TV set. While some neighbors will blast you for every little problem, others are not so bad...and

(Continued on page 105)

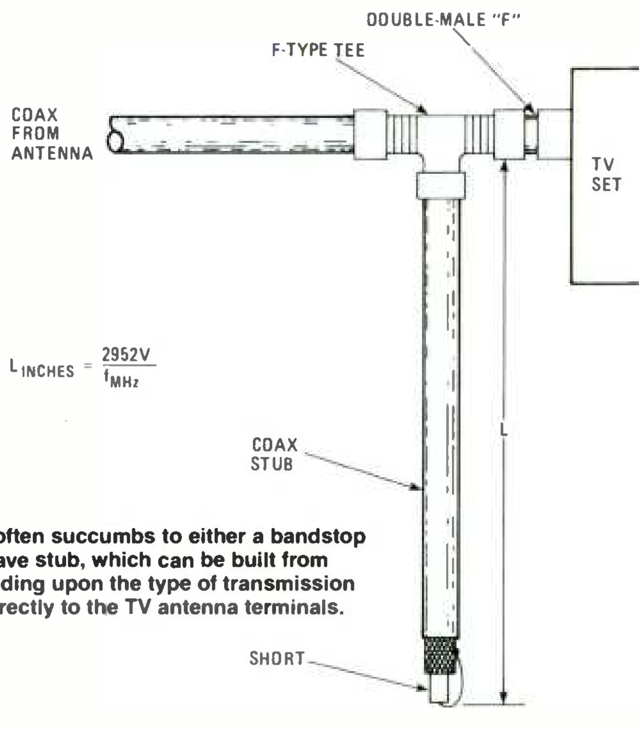


Fig. 4—FM interference often succumbs to either a bandstop filter or a shorted half-wave stub, which can be built from twin-lead or coax, depending upon the type of transmission line, and is connected directly to the TV antenna terminals.

By Byron G. Wels

WELS' THINK TANK

The influx of mail never stops!

It keeps going and going and going! The mail keeps coming in, we keep cranking the column out, and the circle seems to continue with neither beginning nor end. That's good, too! It shows an avid loyalty on the part of our readers, and we respect that; but there are problems. Some of our readers are so well-versed in electronics that if we were to prepare the column for them, it would read like an engineering-level treatise. Interspersed with that level of mail, come questions about "What's an ohm?"

The answer is *not* to seek a middle ground, but rather, to properly assort the material so there's something for everybody. Let's see how we made out.

Telephone Amplifier

I don't care about what the laws say, I just don't want to dig into my telephones. At the same time, I'd like to have one of those telephone amplifiers, so that when Grandma calls, we could all talk. Can you help? —K.G., Lubbock, TX

I think that the schematic diagram shown in Fig. 1 may be just what you're looking for. And guess what—it uses an inductive pickup so you don't have to remove a single screw from the telephone. Audio from the telephone is inductively coupled to the base of Q1, which is used as a preamplifier, providing a gain of about 75, to boost the input signal from about 4 millivolts to about 300 millivolts peak-to-peak. If you use a higher-gain transistor, increase the value of R9 to produce a Q point (measured from minus to the collector of Q1) of one-half the supply voltage.

The Q1 output signal is coupled through C3 to R7 (which serves as a volume or drive-level control) to U1 (a dual, 2-watt amplifier connected in cascade). One side (pins 1 through 7) serves as a driver for the final amplifier (pins 8 through 13). Compensation and balance is accomplished by components R1-R6 and C4, C6, and C7. Pins 3-5, and 10-12 should be tied to the negative supply rail.

Keep all input connections as short as possible to avoid extraneous frequencies. To avoid overdriving the amplifier, adjust R7 for an undistorted signal at the output. Use an inductive pickup with a suction cup as the input.

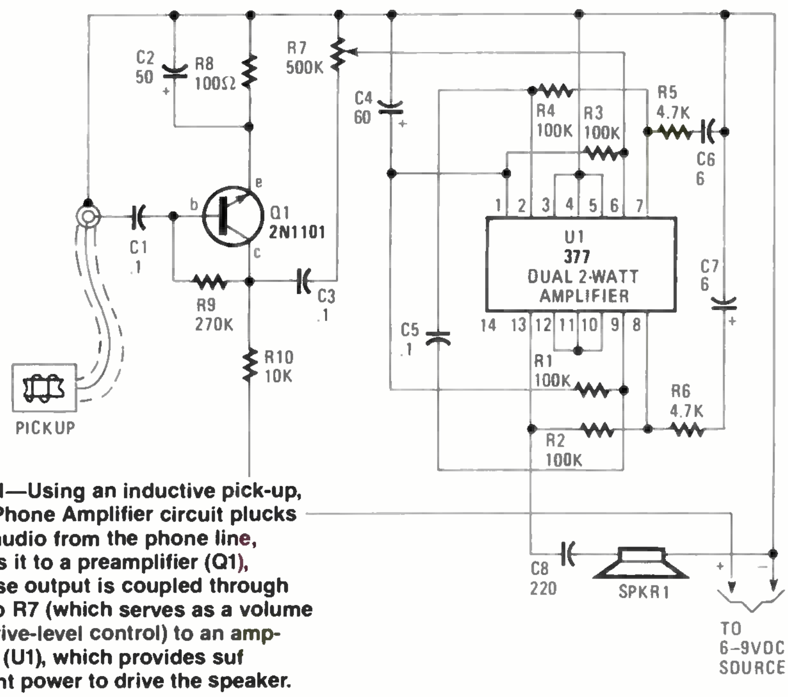


Fig. 1—Using an inductive pick-up, the Phone Amplifier circuit plucks the audio from the phone line, feeds it to a preamplifier (Q1), whose output is coupled through C3 to R7 (which serves as a volume or drive-level control) to an amplifier (U1), which provides sufficient power to drive the speaker.

Tremolo

My friend and I are friends because we share many interests. For instance, we're both electronics hobbyists, and we both play guitar. Now imagine my surprise when we got together last week for a duet session, and he got a beautiful tremolo effect just by pressing a foot switch! Then he showed me that he could even regulate the speed of his tremolo! Well, I wouldn't embarrass myself by asking how he did it, but...how did he do it? —E.D., San Diego, CA

Well, E.D., we all know that tremolo alters the sound of a stringed instrument. That's usually done by rapidly plucking the string up and down, with a plectrum (pick) or in finger style, by rapidly pluck-

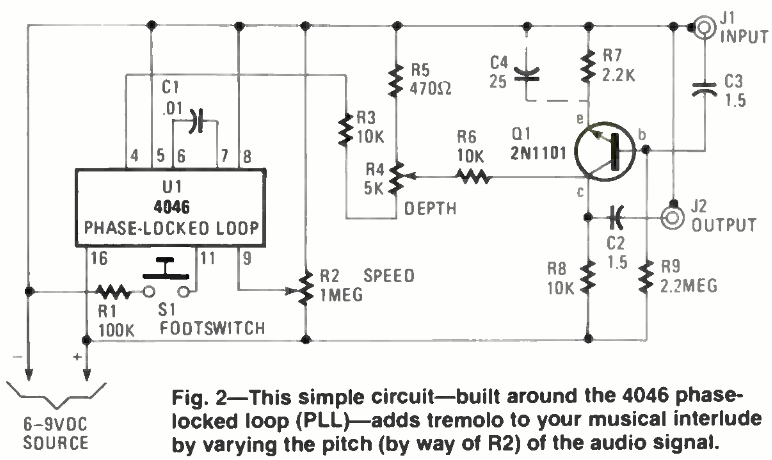


Fig. 2—This simple circuit—built around the 4046 phase-locked loop (PLL)—adds tremolo to your musical interlude by varying the pitch (by way of R2) of the audio signal.

ing consecutively with the three fingers of the right hand. Naturally, we've got a schematic for you. See Fig. 2.

The voltage-controlled oscillator of U1 (a phased-locked loop) produces a low-frequency squarewave signal of from 5 Hz to 2500 Hz, which is controlled by varying the voltage to pin 9 via R2. The frequency threshold is set by R1 and C1. Increasing the value of R1 increases the frequency, while decreasing the value of C1 decreases the threshold frequency.

Transistor Q1 is operated as an amplifier with the Q point at four volts using a transistor with a voltage gain (beta) of 100. The gain without tremolo is about two volts. With bypass capacitor C4 in the circuit, the gain is set at 33. Instrument drive cannot be greater than 30 mV with C4 in the circuit, (no tremolo) to avoid distortion. The drive can be 1.5 volts maximum with no distortion without C4.

U1's output is coupled to the collector of transistor Q1 via depth control R4. The squarewave signal pulls the audio at a frequency determined by R2. The oscillator is activated by foot switch S1.

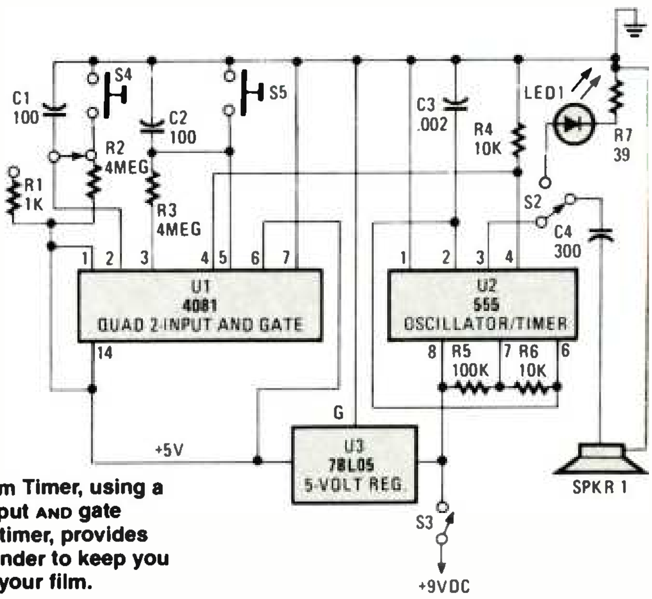


Fig. 3—The Darkroom Timer, using a CD4081 quad two-input AND gate and a 555 oscillator/timer, provides an audio/visual reminder to keep you from over exposing your film.

Darkroom Timer

We photographer-types have problems in the darkroom. First off, instructions for everything are written, and there's just insufficient light in the darkroom for them to be read. I overcame that problem by recording the instructions slowly on my cassette so that I could listen to them rather than read them.

But when it comes to timimg things in the developer, its so easy to get distracted while waiting for the clock to time out that I usually wind up over developing my film. Since you've had so much success at helping others, I thought you might be able to do something for me. —B.S., Provo, UT.

I liked the way that you've solved your darkroom reading problem, B.S., so much so that I'm passing that tip along to your fellow *flashbulb* enthusiasts. Now let's clear up the other sore spot.

The circuit shown in Fig. 3 will call your attention to the timer by sounding a tone before the clock times out.

Two of the gates contained in U1 (a CD4081 quad two-input AND gate) are used as a timer circuit. The truth table of an AND gate shows that when any two inputs go high, the output goes high. The two gates are cascaded so that the timing of gate 1 (when turned on) starts the timing of gate 2 to provide a cumulative time span for you.

Only one side of the CD4081 is used in the timer design. Pin 1 of gate 1 and pin 6 of gate 2 are tied the positive supply rail. Pin 2 of gate 1 is in a time constant circuit (t = 1.1RC) through R2, R1, S1 and C1. If the wiper of S1 is connected to R1, a positive voltage is applied to pin 1 of U1, causing pin 3 (the output of gate 1) to go high immediately. That high is tied to pin 5 (the input of gate 2) with C2/R3 as time constant of gate 2, which, as configured, is about 2 minutes.

If S1's wiper is connected to the junction formed by S4 and R2, pin 2 of U1 goes high (about 2-½ volts with a regulated 5-volt supply). That forces pin 3 to go high, which in turn causes C2 to begin charging through R3. After about seven minutes, the pin 5 input goes high, causing gate 2's output at pin 4 to go high.

Meanwhile, pin 4 (enable) of U2 (a 555 oscillator/timer), is held to ground through R4, disabling the oscillator. But, pin 4 of U2 is also connected to pin 4 (gate 2); so the oscillator is enabled whenever the gate 2 output of U1 goes high. With U2 enabled, the oscillator produces an audio-frequency signal that is the fed to SPKR1 to provide an audible alarm, or to LED1 for a visual indication, depending on switch S2's position. The LED offers a silent reading and could provide an optional darkroom-safe light.

You'll have to play with the values of C1, C2, R2, and R3 to control the time more exactly. The variable tolerances of components can bring some problems in precision timing. For example, we measured 100-µF capacitors at 110 µF. Resistors marked 4 megohms metered in at 4.4 megohms. Wrong, but they are well-within tolerance.

Back-up Beeper

The truck that I drive for a living has a beeper that sounds when the truck is in reverse. I think it's a fantastic idea and would like to add that feature to my car. Is that possible or feasible? —D.S., Morristown, NJ

Yes D.S. It's not only feasible, but if you'll cast your eye over to Fig. 4, we'll show you how it works. When you put the car in reverse, the circuit provides a loud, audible beep at the rate of about 1 per second (1 Hz). Half of U1 (a 556 dual oscillator/timer) is used as a slow-pulse oscillator with a rate of about 1 Hz. Components R2, R1, and C1 form the long time constant. You can calculate on time by $t = .7(R1+R2)C1$ or 1.15 seconds. The off time is shorter than the on time, at .77 seconds.

Enabling pin 4 (reset) is held high to keep the oscillator free-running when voltage is applied to pin 14. The output at pin 5 is coupled to pin 10 of U1 enabling oscillator 2. Oscillator 2 of U1 produces

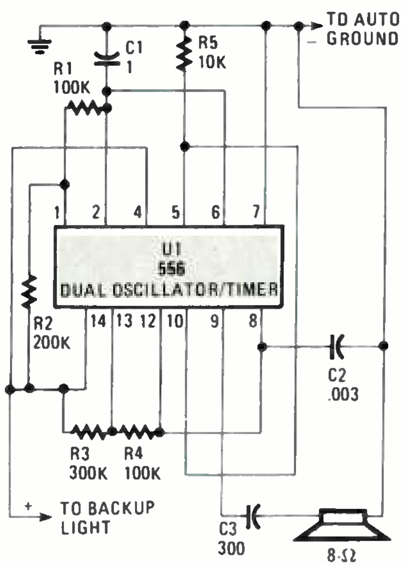


Fig. 4—Built around the 556 dual oscillator/timer—with one oscillator controlling the other—the Backup Beeper sounds off at about 1 Hz.

THINK TANK

(Continued from page XX)

an audio output of about 1 kHz, as determined by C2, R3 and R4. Pin 10 (reset) of oscillator 2 is connected to the pin 5 output of oscillator 1. So when pin 5 goes positive, the oscillator beeps a short pulsed tone of 1 kHz.

Installing the unit is fairly simple—the positive power supply terminal connects to the vehicle's backup light. You can locate the electronics inside the car's trunk and tap off the battery, downstream of the ignition. The speaker can be mounted anywhere that's convenient, preferably in a weatherproof housing.

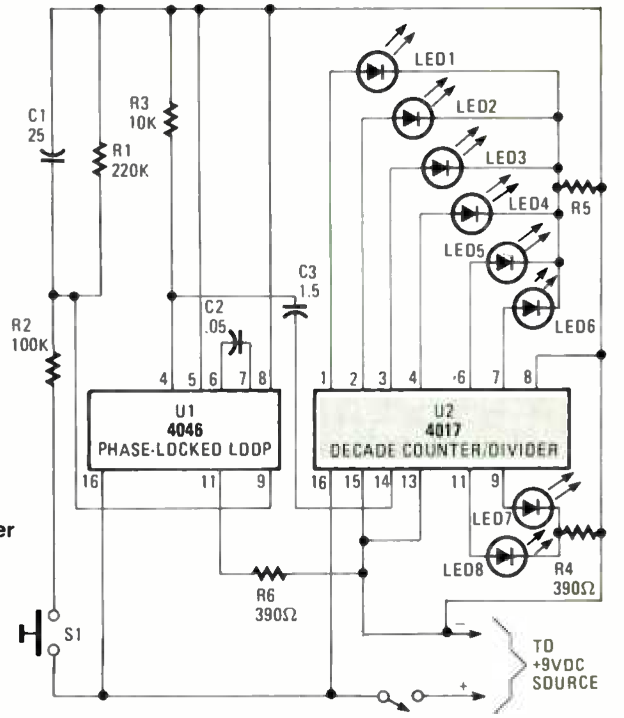


Fig. 6—This two chip Electronic Roulette wheel—built around a 4046 phase-locked loop (PLL) and the 4017 decade counter—sequentially lights eight LED's.

Darkroom In Use

So there I was, in the darkroom, trying to load undeveloped film into the tank, when my wife opened the door! Light flooded the darkroom, ruining some valuable film. Know what I did? I closed my eyes! My wife quickly "sorried" and closed the door again. Unfortunately, it was too late to save the film. Now I want a way to keep that from happening ever again. Please Byron, give me an idea. —A.Q., Phoenix, AZ

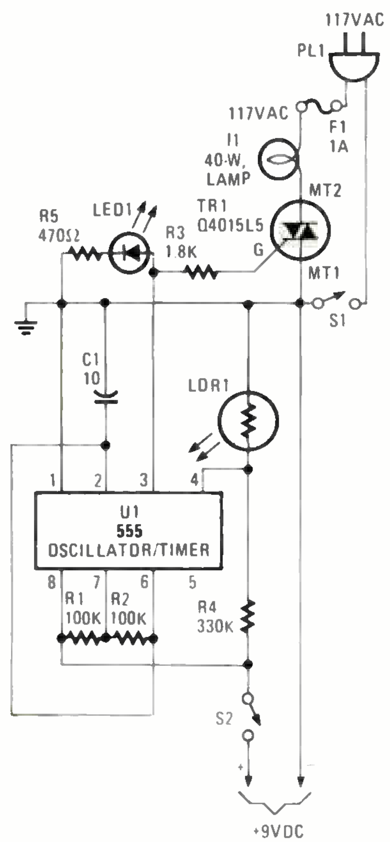


Fig. 5—Using a light-dependent resistor (LDR1) to control a 555 oscillator/timer (U1), this circuit automatically turns on a lamp at about half power and brightness via TR1, indicating that the *darkroom is in use, do not enter.*

OK, I will; just as soon as I stop laughing. It's not that I'm cruel, the same thing has happened to me—many times. I can remember having a red lamp hooked up outside my darkroom that meant, *don't come in*! But as luck would have it, I forgot to turn the lamp on. Need I say more? Anyway, the circuit shown in Fig. 5 will eliminate even that problem.

Built around a 555 oscillator/timer, the circuit is configured to provide a low, pulse rate of 2 Hz that remains positive for about .2 seconds; the frequency of which can be altered by simply changing the value of C1.

U1 is controlled by a voltage-divider network—consisting of LDR1 (a light-dependent resistor with a resistance of about 1 megohm in darkness, dropping to about 100-ohms in strong light)—and R4 (a 330,000-ohm fixed resistor) connected across the DC supply. The ratio of the resistance (and voltage drop) between R4 and the LDR determines the positive or negative state of pin 4. The junction formed by LDR1 and R4 is tied to pin 4 (reset) of U1.

Normal room-level light falling on the sensitive area of LDR1 causes its resistance to drop to about 12,000 ohms. As a result, the voltage applied to pin 4 of U1 is insufficient to enable the oscillator. U1 pin 3 (output) is coupled through R3 to the gate of triac TR1. Because U1 is disabled, no trigger is delivered to the triac gate.

As light falling on the LDR decreases, its resistance increases, thereby increasing the voltage applied to pin 4 of U1. Eventually, the voltage at pin 4 of U1 reaches a level sufficient to enable the chip, which in turn begins oscillating and delivers a trigger voltage to the gate of the triac, turning it on and causing the lamp to flash on and off.

The duration of the positive pulse to TR1's gate is short enough that the triac is not fully gated on. The triac's on time produces about 60 volts across the 40-watt lamp, so the lamp is at half its rated power and brightness. When light again floods the sensitive area of the LDR, its resistance decreases, lessening the voltage delivered to pin 4 of U1. The chip is disabled, pin 3 returns to the low state, and the triac turns off.

The unit is placed outside the darkroom entrance, but the LDR extends back into the darkroom to read the light conditions.

Roulette

I recently saw a cute electronic roulette system that used LED's. The LED's started slowly, came up to speed, then slowed down eventually coming to a stop—just like a real roulette wheel. I'm not just interested in building it, I'd also like to know how it works! —D.W., Ocala, FL.

Well, D.W., turn your attention to Fig. 6. U1 (a 4046 PLL containing a voltage controlled oscillator or VCO, two phase comparators, a source follower, and a Zener diode) are used to produce a low-frequency, pulsed output of about 40 Hz. The VCO's frequency range is determined by R6 and C2, which can be altered by varying the voltage at pin 9.

The rising voltage causes the frequency to rise from zero to threshold and remain at that frequency as long as S1 is closed.

(Continued on page 103)

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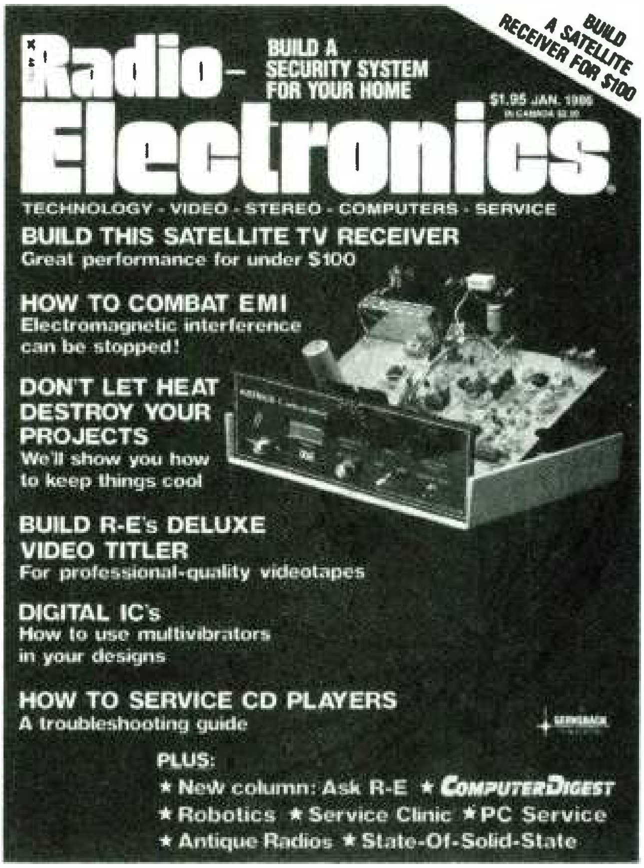

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CIRCUIT CIRCUS

(Continued from page 91)

PARTS LIST FOR THE HIGH- POWER SEMICONDUCTOR TESTER

B1—Battery, 6-volt (see text)
LED1, LED2—Jumbo red light-emitting diode
R1—1000-ohm, ¼-watt, 5% resistor
R2—100-ohm, ¼-watt, 5% resistor
R3—330-ohm, ¼-watt, 5% resistor
R4—1500-ohm, ¼-watt, 5% resistor
R5—5600-ohm, ¼-watt, 5% resistor
S1–S3—Normally-open, momentary contact, pushbutton switch
S4—Double-pole, 3-position (2P3P) rotary switch
Printed-circuit or perfboard materials, C-cell battery holder (four cell type) and snap-on connector, jack or clip lead, enclosure, wire, solder, hardware, etc.

any voltage up to the voltage of the battery used. If, for example, you desired your voltmeter to read 5 to 15-volts full-scale on the 0 to 10-volt scale, you would simply set the 25,000-ohm potentiometer (R1) to insert 5-volts (reverse polarity) in the meter circuit.

A higher- or lower-voltage battery can be used to meet whatever expanded voltmeter scale you might need. There's only one drawback to the circuit, and normally

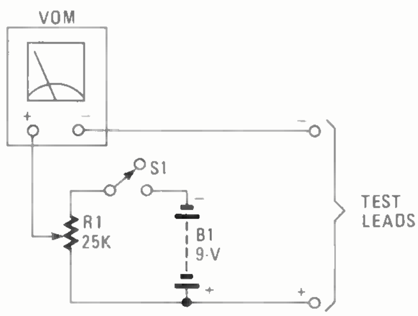


Fig. 5—VOM Range Extender

it won't be a problem in most applications. If the meter is connected to a circuit that's sensitive to a reverse voltage, some damage might occur. But, when making normal predetermined voltage measurements, the circuit performs just fine. If you don't mind introducing a small voltage error, place a diode in series with one of the meter leads.

PARTS LIST FOR THE VOM RANGE EXTENDER

B1—Battery, 9-volt type
R1—25,000-ohm, potentiometer
S1—Single-pole, single-throw (SPST) toggle switch
Perfboard material or barrier strip, 9-volt transistor radio battery holder and snap-on connector, wire, solder, hardware, etc.

It's my hope that at least one of those circuits will be of value to you in a future project, or experiment. So send your comments and circuit requests direct to *Circuit Circus*, **Hands-on Electronics**, 500-B Bi-County Boulevard, Farmingdale, NY 11735. ■

"Just listen to that, Karen, now I know that our line is tapped!"

CAPACITANCE

(Continued from page 85)

The circuit just described is not just an amplifying circuit, but a bandpass filter. It allows only a certain portion of the frequency spectrum to pass through at useful amplitudes.

What About an LC-Tank Circuit?

An LC tank (Fig. 6) is a frequency-selective resonant circuit that is used in radios, antenna circuits, and other applications. Although many of the applications of tank circuits require special equations, we can generalize here by using the parallel tank as shown in Fig. 6.

Resonance occurs in a tank circuit when the inductive reactance is equal to the capacitive reactance, which occurs only at one unique frequency for any given tank circuit. The value of the inductive reactance is normally calculated from

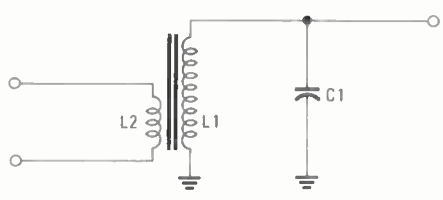


Fig. 6—This tank circuit contains a coupling inductor, L2, which will change the basic equation for inductance, but can be compensated for by using a variable capacitor for C1.

other considerations, such as the reactance required as the load for an amplifier, and the capacitance is selected to resonate that inductance at the operating frequency. Alternatively, you might "wing it" as I did on a third-overtone Miller oscillator. I needed a tank circuit to resonate at 45.5 MHz. The exact reactance was not terribly critical in this application, so I resorted to my own collection of parts, rather than buy a new part. The junkbox contained an RF transformer originally bought from Digi-Key, and it had an inductance of 0.12 µH. Re-arranging the general resonance-frequency formula:

$$F = 1/(6.28\sqrt{L \times C})$$

we can find the capacitance:

$$C1 = 1/(39.5 \times L1 \times F^2)$$

Where C1 is in Farads; L1 is in Henrys; and F is in Hertz. Plugging in all of the values yields a capacitance of 1.02×10^{-10} Farads, which is 102 pF.

When dealing with real RF circuits we find that there is stray capacitance caused by the various conductors in the circuit being near each other. An estimated value of 25 pF for the stray capacitance means that we need to reduce the 102 pF to 77 pF. By using a small variable capacitor, I covered the required range, while also accounting for errors in the real value of the inductor, and errors in my assumed value for the stray capacitance.

Digital Projects

Digital projects only occasionally use capacitors in signal paths, but almost always use them in power-supply decoupling. It is good practice, especially on TTL printed wiring boards, to use either 0.001-µF capacitor at every chip's +5-VDC terminal, or one 0.1-µF capacitor every second or third chip. In addition, long +5-VDC lines, as where a single power-supply bus track serves 10 to 20 chips, should be decoupled with 1-µF tantalum capacitors. The board itself should be bypassed with a tantalum capacitor of 10-µF to 200 µF, depending upon how much current the board normally draws. ■

FET's—WHAT THEY ARE!

(Continued from page 63)

Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051; Tel. 408/737-5000, and Sinconix, POB 4777 Santa Clara, CA 95054; Tel. 408/988-8000. Besides the data sheets, you'll find the books to have a wealth of both theory and practical circuit applications. Quite honestly, it's impossible to do any FET circuit design without a data book for reference.

Touch Switches

What can you do with FET's? Fig. 10 is a good example of how the high impedance of an FET can be used to build a touch switch. A nice feature of the circuit is that it can work with a V_{ds} as small as 3 volts. The 2N3823 is an N-channel JFET with an input impedance of about 15 megohms. The touch plate can be a piece of metal as small as one square inch but it has to be insulated from ground.

The capacitor tied between the gate and ground works as a high frequency by-pass to shunt any incidental RF. The resistor sets V_{gs} so the FET will work in the pinch-off region and produce square waves at the output. When you put your finger on the touch plate, the 60-Hz field from the AC line is amplified by the FET. A 60-Hz square wave that swings between ground and the supply rail appears at the output.

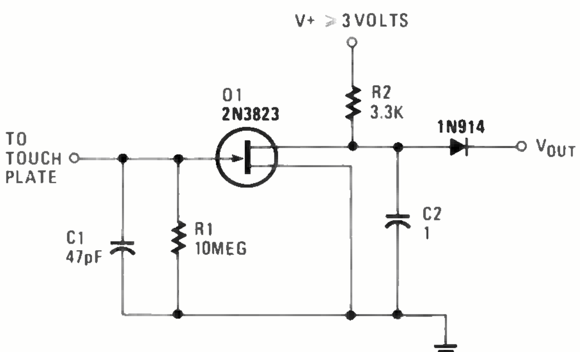


Fig. 10—This simple touch switch is a nice addition to any project since the components use little power or space.

Since the output only lasts as long as you have your finger on the plate, a natural addition to the circuit would be an SCR. By connecting the output of the circuit to the gate of the SCR, the circuit will latch on when the plate is touched. What you control with the circuit is up to you but keep in mind that a doorknob makes a perfect touchplate. It's neat to have the room lights or an alarm go on by touching the doorknob.

Attenuators

FET's operate very much like voltage-controlled resistors. You can build electronic attenuators but the same idea can be taken a step further with the circuit shown in Fig. 11. It's a one-FET attenuator designed to take a mike's high-impedance output and convert it to a low impedance. Running high-impedance mikes more than about 15 feet is a good way to pick up 60-Hz hum. The circuit can work off a 1.5-volt supply and, since it draws next to nothing in current, you can use an alkaline button-cell for power. The whole thing can be mounted in a small box at the mike and you can then run any length of cable you want without picking up 60-Hz hum.

After you've gotten some hands-on experience with FET's, you'll see how much time and energy they can save you when you're working out problems in circuit design. We've really only scratched the surface but you should be able to see from our discussion that the FET, in all its varieties, is an incredibly versatile circuit element whose application is only limited by your imagination. ■

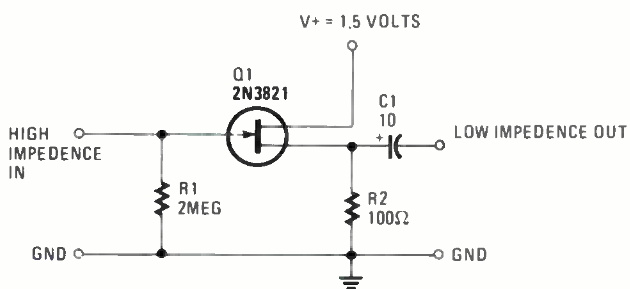


Fig. 11—Many modern high-fidelity mikes have high output impedances, while the inputs to many recording devices are relatively low, which makes impedance matchers necessary.

GIMME DAT OL' TIME DX

(Continued from page 60)

There are a number of other shortwave voices from the past, still operating after a half century.

ICELAND—TFJ in Reykjavik was on 12,235 kHz, Sundays at 1:40 PM, EST in the mid-1930's. Now, better known by its full name, *Iceland State Broadcasting Service*, it broadcasts in Icelandic, at 1300 UTC on 11,855 kHz; at 1855 UTC on 15,395 kHz, and at 2300 UTC on 11,730 kHz.

BOLIVIA—In February 1934, *Compania Radio Boliviana* in LaPaz, announced a new shortwave station—CP5, *Radio Illimani*—would begin broadcasting on a wavelength of 49.3 meters, 6,080 kHz, daily from 6:30 to 8 PM, and 9 to 11:30 PM, EST nightly.

CP5, Radio Illimani is still on the air today, though its frequency now is 6,025 kHz. Its programming is all in Spanish, but it is heard at times on the channel early mornings and evenings.

CANADA—The Montreal shortwave outlet was called VE9DR in June 1933, when listeners noted it strongly relaying medium-wave outlet CFCF on 6,005 kHz, all day long. Its call letters had changed to CFCX by 1937, which remain today. It is harder to hear in the crowded 49-meter band of today, but it's still using the same frequency.

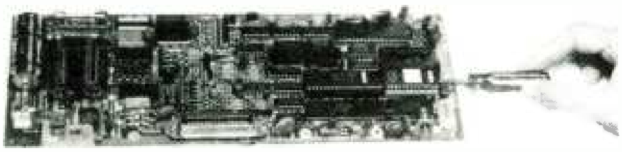
URUGUAY—Brand new in 1937 was CXA4, *Radio Electrica de Montevideo*, which was heard on 6,125 kHz. Over the years, this one has been on-again, off-again, but has been reported active recently, now calling itself SODRE, which for decades stood for *Servicio Official de Diffusion Radio Electrica*. Not long ago the name changed to *Servicio Official de Radiotelevision y Espectaculos*, although the acronym remained the same. Though 6,125 kHz is still registered, it has turned up in Spanish on 9,620 and 15,276 kHz.

AUSTRALIA—The *Australian Broadcasting Commission* (today, Corporation) operated a regular daily shortwave schedule in 1938 from station VLR on 9,500 kHz, with transmitter at Lyndhurst, Victoria.

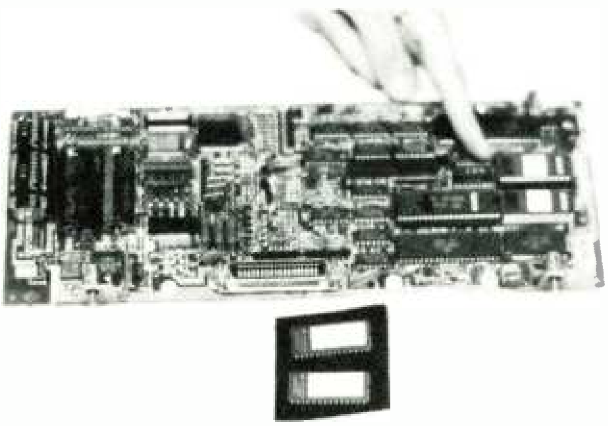
After many years, the Lyndhurst shortwave transmitters were closed down in 1986. However, the domestic SW operations are to be shifted to a new site at Brandon, Queensland next year, according to the ABC. ■

UPGRADING THE OKIDATA ML92 PRINTER

(Continued from page 43)



The main logic board (and the serial interface board, if present) must be removed along with two EPROM's.



After removing the two EPROM's from the main board, the two upgrade EPROM's must be inserted in their places. Then re-insert the board, reassemble the printer, and get to work!

remove an EPROM (or two, depending on when your model was built). In its place (or theirs), you insert two new EPROM's, re-insert the main board, and seal up the case. That's it! You can't use the serial interface now, because your new Frankenstein monster emulates the IBM printer, which is serial only. If you install the EPROM's in a former serial printer, be sure to plug the main board in the rear-most slot, not the one it formerly occupied. Otherwise, the Centronics parallel connector will be inaccessible.

The Pro's and Con's

When the procedure is complete, the Frankenstein monster will walk, talk, and think like an IBM machine. In fact, sad to say, it loses some of the powerful capabilities that once made it so endearing. In particular, you can no longer download your own custom-designed character fonts. Nor can you print in 6 and 12 CPI widths. In addition, but less important, most of the formatting commands are lost: line skip, horizontal tab stops, indenting, left margin, etc.

What you gain, of course, is IBM compatibility. You'll be able to take advantage of all those programs that provide graphic printouts (such as Print Shop, AutoCAD, Lotus 123, etc.). You'll also be able to press the ScreenDump key in graphics mode and obtain a printout of the screen. In addition, you'll be able to print (most of) the IBM graphics characters (those with ASCII values from 128 to 255).

How does it work? Like a charm. In addition to IBM compatibility, now you can choose the text-character set (draft, correspondence, or compressed) at power-up merely by pressing a switch as you turn the machine on. In addition, through software you can choose emphasized and enhanced printing, double-width characters, subscripts and superscripts, etc.

The manual that accompanies the *Plug 'n' Play's* includes instructions for patching several popular software packages (VisiCalc, SuperCalc, WordStar, and SuperWriter) to take advantage of those special features. The manual also contains instructions for beginners on how to program and print APA (All Points Addressable) graphic images.

The only potential problem resides in the *Plug 'n' Play's* character set 2, normally used only for printing special symbols. For an unknown reason, some seldom-used characters were omitted from the EPROM. For example, ASCII characters 3–6 are the heart, diamond, club, and spade symbols. They are not included. Nor are a number of foreign-language characters (ASCII 131–159). All the line-drawing characters are included, however, so there should be no problem for the vast majority of software packages.

All in all, Okidata's *Plug 'n' Play* is an inexpensive way of extending the useful life of an excellent printer. Its cost (under $50) is far less than that of a brand-new IBM printer.

If you're interested in the update, check your local computer dealer to see if he sells Okidata printers. If you strike out, try requesting information from: Okidata, 532 Fellowship Road, Mt. Laurel, NJ 08054; Tel. 609/235-2600. ■

THINK TANK

(Continued from page 98)

When S1 is opened, C1 discharges slowly through R1 to ground and the voltage falls toward zero. That produces a decreasing pulse rate. The output of U1 at pin 4 is connected to the clock input of U2 (a 4017 decade decoder/driver) at pin 14 via C3.

U2 sequentially advances through each of its ten outputs (0 to 9)—pins 1 to 7, and 9 to 11—with each input pulse. As each output goes high, its associated LED is lighted, and extinguished when it returns to the low state. Only eight outputs are used in the circuit, giving two numbers to the spinner or the house.

The circuit can be set up so that the LED's light sequence or you can use some staggered combination; the LED's grouped in a straight line, a circle, or however you like.

That's all the space that they've allocated to us for this month. However, they've promised to let us do it again next month, so hopefully, I'll see you then! ■

*The material for this month's column was taken from "101 Sound, Light, and Power IC Projects, By Charles Shoemaker. The book is priced at $16.95, and was published by TAB Books, Inc., Blue Ridge Summit, PA. 17214; Tel. 717/794-2191.

Ordering Back Issues

For those in need of old issues, we have a reprint bookstore. **Hands-On Electronics** #6 and all 1986 issues cost $3.50 ea.; #1 to #5 are all $4.50 ea., and remaining copies of **Special Projects** are $5.50 ea. Check the order form in the back for postage cost, availablity, and address.

ELLIS ON ANTIQUE RADIO

(Continued from page 87)

The same practice should be applied to a set in which you have just installed replacement electrolytic capacitor of unknown vintage.

An elegant and inexpensive way of reducing the voltage is to use a surplus isolation-transformer offered by Fair Radio Sales, 1016 E. Eureka St., Lima, Ohio 45802. The transformer is listed in their current catalogue (WS-86) as P-126J875 and priced at $7.95, plus shipping. It was originally designed to provide a 120-volt output (approximately) from any of the following five input voltages: 220, 190, 150, 125, or 100., and comes with a rotary switch for input voltage selection.

When operated at a constant 117-volt input, the following output voltage (no load) are available at the respective input voltage tap positions: 69, 78, 100, 122, and 147. As you can see, it's easy to start with a low voltage and increase it in stages simply by turning the switch. But don't use the 147-volt output (from the 100-volt switch position) unless you want to risk damaging your set. The line-voltage output of the transformer is rated at one ampere, which is enough to handle most of the radios that you might encounter. You'll find that the the transformer also has a 6.3-volt, 5-ampere winding.

As an added bonus, the unit is a true isolation transformer. It electrically removes the *set-under-test* from the AC line. That makes working with old sets considerably safer, and is especially helpful when working with transformerless AC/DC sets (which we'll be discussing in a future column). Such sets always have one side of the line grounded to the radio chassis and—without use of an isolation transformer—present a serious shock hazard. I'm testing the Fair Radio transformer now and will report on it soon.

But if you'd like to try a quick and dirty method for capacitor forming, consider wiring a standard lamp socket in series with a standard AC plug and outlet. Insert the plug into a wall outlet and plug the set being restored into the series-connected outlet. Turn on the set and monitor its input voltage as you try light bulbs of decreasing wattage in the socket. You should be able to find a size that provides about 60-volts to the radio. That method, of course, does not give the line isolation obtained by using the transformer.

That about wraps it up for this issue, fellow collectors. So, 'til next we meet, happy antiquing. ■

"You, soldier, with that new MP/Q-33-B mobile computer outfit!"

HANDS-ON MARKETPLACE

PLANS/KITS

CRYSTAL radio sets, plans, parts, kits. Catalog $1.00. **MIDCO**, 660 North Dixie Highway, Hollywood, FL 33020.

BUILD this five-digit panel meter and square wave generator including an ohms, capacitance and frequency meter. Detailed instructions $2.50. **BAGNALL ELECTRONICS**, 179 May, Fairfield, CT 06430.

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To run your own classified ad, put one word on each of the lines below and send this form along with your check to:

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PLEASE INDICATE in which category of classified advertising you wish your ad to appear. For special headings, there is a surcharge of **$10.00**.

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( ) Education/Instruction ( ) Wanted ( ) Satellite Television
( ) ______________________

Special Category: $10.00

PLEASE PRINT EACH WORD SEPARATELY, IN BLOCK LETTERS.

(No refunds or credits for typesetting errors can be made unless you clearly print or type your copy.) Rates indicated are for standard style classified ads only. See below for additional charges for special ads. **Minimum: 15 words.**

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15 ($21.00)
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21 ($29.40)	22 ($20.80)	23 ($32.20)	24 ($33.60)	25 ($35.00)
26 ($36.40)	27 ($37.80)	28 ($39.20)	29 ($40.60)	30 ($42.00)
31 ($43.40)	32 ($44.80)	33 ($46.20)	34 ($47.60)	35 ($49.00)

We accept MasterCard and Visa for payment of orders. If you wish to use your credit card to pay for your ad fill in the following additional information (Sorry, no telephone orders can be accepted.):

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PRINT NAME ______________________ / SIGNATURE ______________________

IF YOU USE A BOX NUMBER YOU MUST INCLUDE YOUR PERMANENT ADDRESS AND PHONE NUMBER FOR OUR FILES. ADS SUBMITTED WITHOUT THIS INFORMATION WILL NOT BE ACCEPTED.

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STRANGE stuff. Plans, kits, items. Build satellite dish $69. Descramblers, bugs, adult toys. Informational photo package $3.00, refundable. **DIRIJO CORPORATION**, Box 212-H, Lowell, NC 28098.

DESCRAMBLE the latest video cassette copy protection scheme. Our simple Line Zapper circuit takes the jitter out of your picture. Complete plans and theory only $9.95 plus $1.50 postage and handling. **ELEPHANT ELECTRONICS INC.**, Box 41865-H, Phoenix, AZ 85080. (602) 581-1973.

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COLOR computer, security devices. Temperature, sound, intrusion alarm. Plugs into cassette and joystick sockets. Plans, programs cost $10.00. **BROWN'S**, 119 Skyline Drive, R.H., Granbury, TX 76048.

KILL commercials. Control your TV. Information $1.00. Plans $4.95. **EASTECH**, Box 3428 Charlottetown, PEI CIA 8C2 CAN.

SATTELITE DISH PACKAGE make your own dish with inexpensive and easily available basic materials. Solid construction, less than 17 hours labor. Templates included. Specify diameter. $9.25 plus $2.00 shipping and handling. Check or money order. **NATIONAL SUPPLY,** Box 370 PortHope Ontario L1A 3Z2 Canada.

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CABLE-TV converters. Scientific Atlanta, Jerrold, Oak, Zenith, Hamlin. Many others. "New" **VIDEO HOPPER** "The copy killer". **Visa, M/C & Amex** accepted. Toll free **1-800-826-7623. B&B INC.**, 10517 Upton Circle, Bloomington, MN 55431.

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TUBES 59 cents. Year guarantee. Free catalog. Tube Tester $8.95. **CORNELL**, 4219 University, San Diego, CA 92105.

OSCILLOSCOPES and test equipment. Tektronix, H.P., Fluke, etc. Free catalog. **CAL-SCOPE**, 1030 W. Maude Ave. #505, Sunnyvale, CA 94086 (408) 730-4573.

INTEL, RCA, National, OKI, SGS, and more. Factory prime and surplus parts catalog. **LYNBAR INDUSTRIES**, 205 Main, Box 822, St. Joseph, MI 49085-0822.

DECODE nearly any Gated Pulse signal with our new super simple circuit. Works on In-band, Out-band, AM or FM pilot tone—use with Hamlin, Jerrold, Sylvania. Complete plans and theory only $13.50 plus $1.50 P&H. **ELEPHANT ELECTRONICS INC.**, Box 41865-H, Phoenix, AZ 85080. (602) 581-1973.

TUBES—over 2000 types, including early and hard-to-find. Parts and literature for antique radio restorations. Send $2.00 for 20 page catalog to **ANTIQUE ELECTRONIC SUPPLY**, 688-C West First Street, Tempe, AZ 85281.

OLD radio tubes. Send $1.00 for lists. Refundable. **DIERS**, 4276 North 50, Milwaukee, WI. 53216.

500 parts $12.00. Mixed resistors, capacitors, diodes, inductors, etc. Good stuff. No junk. 5 free power transistors with each $24.00 order. We pay shipping in U.S.A. Add $2.00 if C.O.D. **BARGAIN CITY**, P.O. Box 121H, Glen Miss. 38846.

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CASH in on Army surplus sales. Buy directly from government. No middlemen. Book $4.50. Shipping and handling included. Check or money order. **NATIONAL SUPPLY**, Box 370, PortHope Ontario L1A3Z2 Canada.

CARR ON HAM RADIO

(Continued from page 95)

may actually respond in a positive manner if you point the way to a TVI/BCI solution even where the local offending station does not happen to be yours.

There is a hill near my home—known locally as *Intermod Hill*—that bristles with the antennae of several broadcasters; AT&T, land-mobile operators, and other powerful RF generators. A common problem for TV viewers in the area is FM interference. That form of TVI produces a herringbone pattern (as opposed to the pattern of Fig. 2B), which characterizes it as FM, not AM/SSB, interference. That form of interference often succumbs to either a bandstop filter or a shorted half-wave stub (see Fig. 4). FM broadcast-band bandstop or *notch* filters are available from most electronics parts distributors, as well as many video stores and TV outlets. Both 75-ohm and 300-ohm forms are available (use the right kind).

The shorted stub of Fig. 4 can be built from either twin-lead or coax—depending upon the type of transmission line used—and connected directly to the TV antenna terminals. It has a length of:

$$L_{(inches)} = \frac{2952\ V}{F_{MHz}}$$

Where L is the length of the shorted stub in inches, F_{MHz} is the offending transmitter frequency in MHz, and V is the velocity factor of the line (use 0.82 for TV-type coax). For example, find the length required for a shorting stub to suppress an FM broadcast signal on 101.1 MHz, assuming a 75-ohm coax transmission line.

$$L = [(2952)\ (V)]/(F_{MHz})$$

$$L = [(2952)\ (0.82)/(101.1)]$$

$$L = 2421/101.1$$

$$L = 23.9 \text{ inchs}$$

Conclusion

Space does not permit complete coverage of TVI problems in a single short column. However in future columns, we'll deal with related RFI topics. But in the meantime, those interested in finding out more about interference problems and their cure can check out any of several publications for further information. Among them are: the ARRL book *Radio Interference: How to Identify and cure it*; and *The TAB Handbook of Radio Communications*, by Don Jensen (TAB Catalog # 1636, $29.50, Tab Books, Blue Ridge Summit, PA, 17214). The Federal Communications Commission is expected to soon release a new TVI consumer booklet. It's free.

If you have any comments or suggestions, address your letters to Joe Carr, K4IPV, PO Box 1099, Falls Church, VA 22041. ■

ADVERTISING INDEX

HANDS-ON ELECTRONICS magazine does not assume any responsibility for errors that may appear in the index below.

FLAMELESS SOLDERING IRON

(Continued from page 76)

catalytic converter—which is behind the slots just aft of the tip—and a flip of the thumb on the igniter produces the spark that lights the torch.

There is a very small start-up flame that lasts but a few seconds until the converter starts to glow, at which point the flame is completely out.

With a little practice and use, it's possible to estimate the relative heat of the tip by the color of the glow. While the response to the adjustment is almost instantaneous as far as the glow is concerned, the actual change in tip temperature takes a few seconds—but not many. For example, from a cold start the Portasol was hot enough to use before an electric soldering iron—that was started at the same time—had barely begun to get warm.

There is no need to let the iron cool down when you're finished. If you're in a hurry, you can simply replace the cap and put the iron in your shirt pocket. The cap might get slightly warm, but it won't get hot and it won't melt. Similarly, you could drop the iron into a toolbox and not have to worry that something will be burned or melted.

About the only complaint we have concerns the procedure for installing a new flint in the igniter. The instructions make it sound easy: remove the top of the cap and replace the flint. It's not that easy. The first time we tried it, a small spring went flying across the room; from which we learned to cover the top when disassembling the cap. It is also not so easy to replace the flint and reassemble the cap because the same spring tends to fly out during reassembly. Eventually it all goes together. Fortunately, the flint will give hundreds of strikes before it needs replacement.

The Portasol Flameless Soldering iron is priced at $24.95. It is available from local hobby and electronic parts distributors. For additional information, write to, The Boardworks, 1077 East Edna Place, Covina, CA 91722, or circle No. 59 on the Free Information Card. ■

The Portasol™ Flameless Soldering Iron resembles an ordinary marking pen. Thanks to space-age plastic, it can be closed and carried in a pocket or tool box while still hot. For additional information circle No. 59 on the Free Information Card.