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GADGET

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Inside the 555

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like the pros do!

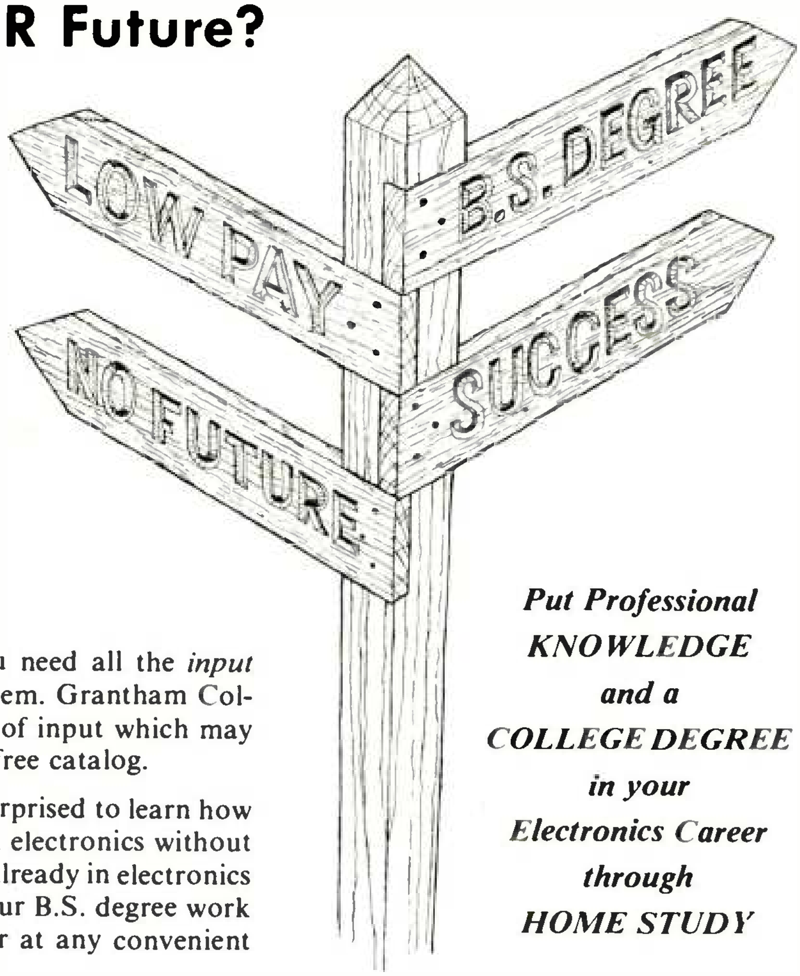
3 New
FactCards
This Issue

Fiber Optics

Learn and build practical gadgets
from an enlightening design kit!

A
GERNSBACK
PUBLICATION

Which Way To YOUR Future?



Are you at a crossroads in your career? Have you really thought about it? Are you *planning* for your future, or perhaps refusing to face the subject? Which way will you go — down the same old road? Or are you ready for something else?

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INCLUDING 12-PAGE GADGET

Hands-on Electronics®

Volume 4, No. 9

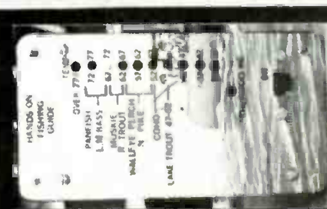
September 1987

CONSTRUCTION

FEATURES

SPECIAL COLUMNS

DEPARTMENTS



Hands-on Fishing Guide—page 24

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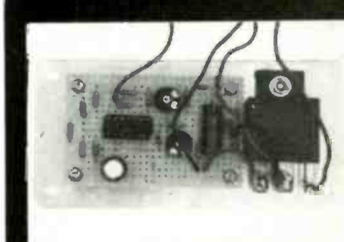

Game Feeder Controller—page 71

Hands-on Electronics®

The Magazine for the Electronics Activist!

What ever happened to "The Great PC-Clone Contest?"

Why, nothing!

Oops, that's a fact, but it gives the wrong impression. The truth is that the contest is still on. I have been quiet on the subject, because I do not want to make a decision until after the December, 1987 issue of **Hands-on Electronics** is on the newsstands. Then watch my smoke!

The rules for the contest are very simple. The author of the best article purchased and published in one of the May through December, 1987 issues of **Hands-on Electronics** will receive a PC-clone computer of our choice as a bonus payment. The decision of the judges are final. There is nothing to purchase, you don't have to be a subscriber, you could read this editorial in a public library, and still enter. We welcome authors, one and all.

Hands-on Electronics devours construction projects at a rate faster than any two other electronics magazines. That is why we need your manuscripts to feed our appetite—it's your appetite, too! And you are best qualified to submit articles. You see, as an experimenter, you put together many gadgets for one reason or another. Some of those projects are valuable ideas for our readers. We want you to share your projects with everyone, and acquire some money while doing it. We purchase your manuscripts and pay for them on acceptance.

Feature and theory articles are also in demand, and they will be considered as entries into the contest. Some of our readers have quite a knack for tackling complex subjects on some aspect of theory, troubleshooting, and design, and drafting articles that are easy to read. You may have that writing knack, and not know it. Also, you may have the inside track to some information or development. Put the facts in a feature article. In the old days we called that a *scoop*.

So stop thinking about writing an article for **Hands-on Electronics**, and do it! Pull out a sharpened-pencil, pen, typewriter, or word processor, and get to work. Remember to include black-and-white photographs, complete parts lists, and detailed sketches and diagrams when necessary.

May the Thesaurus be with you!

Julian Martin

Julian S. Martin, KA2GUN
Editor

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President: Larry Steckler
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NATIONAL ADVERTISING SALES
(For Advertising Inquiries Only)
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714/760-8697

Larry Steckler, Publisher
500-B Bi-County Boulevard
Farmingdale, NY 11735
516-293-3000

Composition by
Mates Graphics

Cover photography by
Bill Peterson
Design Color Labs

Hands-on Electronics, (ISSN 0743-2968) Published monthly by Gernsback Publications, Inc., 500-B Bi-County Boulevard, Farmingdale, NY 11735. Second-Class postage paid at Farmingdale, NY and at additional mailing offices. One-year, twelve issues, subscription rate U.S. and possessions $28.00. Canada $33.00, all other countries $35.50. Subscription orders payable in U.S. funds only. International Postal Money order or check drawn on a U.S. bank. U.S. single copy price $2.50.

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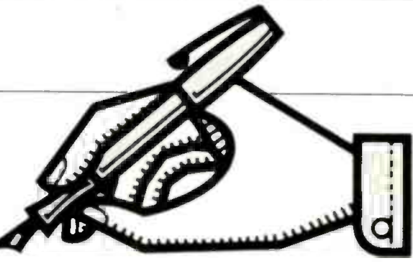
LETTER BOX



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

Chip Change

In reference to my August 1987 article on RAM chips entitled All About Static RAM's, I thought the readers might be interested in knowing I successfully substituted a 7403 quad NAND gate chip for the 7405 LED driver IC. In general, 7403's are easier to come by.

In the revised circuit the two inputs of each gate are tied together and used as the inputs to the inverters used in the original. Thus, pins 1 and 2; 4 and 5; 9 and 10; and 12 and 13 are connected together. The outputs are pins 3, 6, 8, and 11 respectively.
—Louis E. Frenzel, Jr.

Unfortunately, we received that information too late to publish it along with the article. It is presented here for those of you interested in trying this method because we know how annoying (if not impossible) a search for parts can become.

Off Key

I want you to know that I really do enjoy both **Hands-On Electronics** and **Radio Electronics**. I can't think of anything you could do to improve them. I feel that many of the articles are outstanding, and can only ask that you keep up the good work.

In regard to the letter from C.R., Sunnyvale, CA, in the Letter Box of May 1987, he is correct in stating that there are at least three versions of the TI99/4A keyboard, as I have two different TI 99/4A keyboards that are not the same as the one shown in the December 1986 issue. I was able to convert the TI 99/4A keyboards that I obtained from Radio Shack by tearing the old Timex/Sinclair keyboard apart to find the proper hookups, and would be glad to send you the information if you are interested.
—D.J.S., Coos Bay, OR

I'm sure to be receiving another letter from C.R. about that one! Sorry about the mistake, it's just that I keep dreaming that one day I'll come upon an electronic standard *that truly is a standard. So much for idealism in this, the age of the electron.*

Transistors in Transit

In the January 1987 issue on page 111, in Fig. 13; the transistors Q1 and Q2 are drawn as NPN and PNP types, but you give them the same part number. Which is correct, and could you give me a part number for the mislabeled one?
—E.G., Canton, NY

When translating the parts numbers (the originals were European) into ones available in America, a mistake was made. Since I had trouble finding a sister for the 2N2102, I suggest you use a SK3839 (ECG155) as Q1, and SK3198 (ECG131) as Q2. They should do nicely.

Loop Sick

I have a copy of **Hands-On Electronics** from April 1987. I am interested in making the telephone transmitter on page 89. I purchased the parts-except for the L1 tunable broadcast ferrite loopstick. I tried all the electronic stores in Mansfield, including Radio Shack, Sevvix Electronics, etc. and was unable to find one. Where can I purchase, or send for one?
—E.D., Lexington, OH

Any tunable coil selected for the frequency you wish would be fine. Try looking in the Digi-Key catalog; they've got inductors galore.

Chiming In

I was very pleased with your treatment of the article I submitted to you; Hour-Tune came out terrific. I appreciate the fact that you were very accurate in your presentation.

I noticed in the Letter Box section of the June issue that a person wrote in for a recommendation for someone to make him a PC board for one of your articles. Well, I have been making my own circuit boards for many years, and although I do not use production line methods, I have gotten quite proficient in the art.

If you should hear from some person that needs a PC board made etched and drilled for the Hour-Tune project, you may refer them to me. I am equipped to turn out about three per day, they will be accurate and precise, exact duplicates of that shown in your magazine. They would need to allow me six weeks to be on the safe side. My charge would be $30.00 in advance. I would not be interested in furnishing anything but the board.
—Robert Damm, Jackson, MI

The Hour-Tune fans out there will be glad to read that letter! For the uninitiated, circuit board preparation is the most grueling part of building a circuit. Thanks for your kind offer.

Any one interested can write to the author in care of this column.

Selective Reader

I enjoy **Hands-On Electronics** very much, but dislike Gadget. I cannot afford a Jac-Rabbit or the Road Racer or the other things in it. I buy your magazine for the projects and the educational value. Maybe some of the other readers feel the same and will write in about it.

I would like to get in touch with someone who has information on the 1750 meter (160-190) experimenters band.
—B.B., Blackburg, SC

Up until your letter we've received nothing but good reports about Gadget. People like to look at new things, regardless of whether they can afford them. I'm sure you will agree that the amount of educational and construction articles in the magazine have not decreased since Gadget's inclusion.

Anyone interested in helping this gentleman out in his search for knowledge, should write to him in care of this column.

Too Many Bits

I built the ZX-81 Printer Interface featured in November 1986. I am using a Tandy DMP printer. I have a small problem. Running the printer test described on page 80, I am getting an "!" for some of the space characters being printed. Some of the characters are also changed, and seem to be picking up extra bits.

I have also tried a Tandy TRP100 (a slower machine) and it is worse. All con-

LETTER BOX

nections have been verified twice by myself and someone else to make sure I had wired the board according to the circuit diagram. We also made sure all ground connections (pins 19-30) were good. Any idea what the problem might be? The cable between the printer and the interface is about 6 ft. long.
—A.B., Ontario, Canada

You've really got a perplexing problem. I can't figure out what has gone wrong, but I've noticed something interesting in the data output you've sent me. The printer seems to be setting the low bit on characters following "2", "6", "B", and "F." The odd thing is that "2" and "6" have the same high byte, and "B" and "F" have the same high byte. Also, "B" and "2" have the same low byte, and "F" and "6" have the same low byte. One thing they all have in common is a 0 in bit 0, and a 1 in bit 1. So the characters have a rising pulse in the same location (at the beginning of a byte).

To test if that is a useful observation try, printing some of these: "$", "#", "d", and "c", each followed by a space. Those characters are what you get by switching the low and high bytes of the other characters.

Transformer of Mystery

In reference to **Hands-on Electronics** March 1987, on page 75 of the Super Strobe story, could you please tell me the value of T3. That transformer is shown in Fig. 1, but I could not find its value listed anywhere.
—C.H., Minneapolis, MN

A high-voltage trigger transformer (3000-4000 volts) can be used. If you can't salvage one from an old camera flash, then try the Mouser Electronics ME460-1001 pulse transformer. You can call them at 817/483-4422 (in Texas), or 619/449-2222 (in California). Hope the project works OK.

Head Washing

I would like to start cleaning my own VCR. The first thing I did was to purchase the book "Maintaining & Repairing VCR's" by Robert L. Goodman, through TAB books. In his book Mr. Goodman describes a Nortronics VCR-205 head demagnetizer. Also, he states Audio demagnetizers produce a stronger magnetic flux than the video types, and should not be used.

After calling around, I can't find a distributor for Nortronics to get a video demagnetizer. Radio Shack has a nice audio, but no video one. Also, a place I called that services VCR's told me the video heads don't need to be demagnetized. Can you give me some insight into this, and a Nortronics outlet?

I enjoy reading your magazine, and find the series on Electronic Fundamentals great. I've just finished CIE's electronic course 1B, and plan to go for my AA degree. The fundamentals series makes for great review and backup with some different views.
—R.R., Zelienople, PA

Nortronics belongs to the Geneva group of companies and can be reached at 7255 Flying Cloud Dr., Eden Prairie, MN 5334. If they can't tell you where to get their products no one can! As for not demagnetizing video heads—don't believe everything you hear!

Crystal Clear

I enjoy reading your magazine very much. I even found a project that I am interested in building, but there is a problem: I could not find the 3.12MHz crystal anywhere. The magazine to which I'm referring is **Hands-on Electronics**, December, 1987.

I'm wondering if you are making errors, if not can you give me a suggestion where I could find the part?
—D.T., Belton, MO

The crystal can be ordered through Radio Shack. Unfortunately, I don't have a listing of the crystals and their RS numbers, so you will have to get further information from them about ordering.

Slewed

This letter concerns your article about op amps in the June, 1987 issue of **Hands-on Electronics**. On page 75 Fig. 7 shows U2 as a 7815 voltage regulator. That should be a 7915, negative voltage regulator.

Also, under slew rate:

$$SR = 6.28(V \times F)10^{-6}$$
$$= 6.28(3)(1.414)(20{,}000)10^{-6}$$
$$= 1.59\ V/\mu S$$

In performing the calculations I obtain 0.5327952 V/μS. That is considerably less than the value given in the article. We may finagle the equation:

$$SR = 6.28(3)(1.414)(20{,}000)3^{-6}$$
$$SR = 1.598\ V/\mu S$$

But that manipulation is finagling and not a valid procedure.

I have learned quite a lot from you. Please write more articles.
—T.S.P., Groton, CN

Needless to say, you are right! Sorry about the math error, all those calculator keys can get to us sometimes (I wonder where I put my abacus?) ■

NEW PRODUCTS

Current Clamp

You'll never wire your ammeter into a circuit again with the Fluke 801-1010 Current Probe. It's an accessory for digital multimeters that accurately measures AC current to 700 amps, and AC current up to 1000 amps. The probe clamps around a conductor and senses the magnetic field produced by current flow, allowing safe, accurate measurements, without breaking the circuit.

A unique feature of the Fluke 801-1010 Current Probe is a thumbwheel ZERO control. That allows the user to compensate for residual core magnetism in the clamp, and improve the accuracy of dc measurements down to 1 ampere.

The probe uses dual Hall-effect sensors to sense the magnetic field produced by the current being measured. An amplifier circuit generates an output signal of 1 mV per amp; that automatically gives the correct decimal placement when using the DMM's mV range. The dual sensor configuration provides excellent immunity to stray magnetic fields, and minimizes reading variations due to changes of conductor positioning within the jaws.

The large jaw size of the 801-1010 accommodates one 750 MCM THN conductor (1.18 in.) or two 500 MCM THN conductors (0.98 in. ea.). That permits the sum of two currents to be read directly when the probe is clamped over two conductors.

The 801-1010 has a frequency range from dc to 440 Hz, with typical frequency response to 6 kHz. Basic accuracy is (±2% of reading + 1A) from 1A to 100A, DC or AC (48 to 62 Hz). Typical battery life is 200 hours. The 801-1010 is equipped with shrouded right-angle banana plugs, and is packaged with bat-

CIRCLE 86 ON FREE INFORMATION CARD

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teries, operator card, and detailed instruction sheet.

The Fluke 801-1010 DC/AC Current Probe has a suggested list price of $229. It is available from over 500 distributor locations in the United States, and worldwide through the Fluke sales network. For more information on the Fluke 801-1010 write John Fluke Mfg. Co. Inc., PO Box C9090, Everett, WA; Tel. 800/426-0361.

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Believe it or not, the Model SPS450VR Standby Power Supply/Voltage Regulator, rated at 450-watts continuous duty, is housed in a unit one-half the size of a standard 450-watt power supply.

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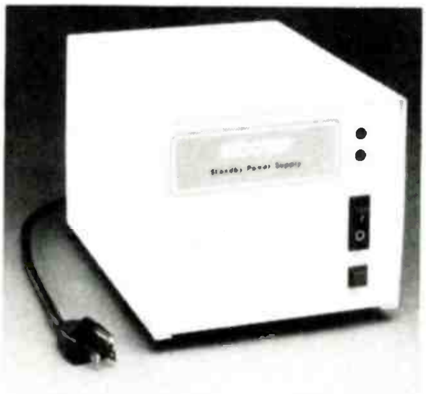

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Scooter combined two products into one compact electronic unit measuring 5-½ × 6-¾ × 9-½-in., and weighing only 18 pounds.

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Other features include an internal audible alarm reporting system "primary power loss" and "low battery," regulated automatic recharging, automatic shutdown to protect battery after discharge, alarm silencing button, status indicator LED's, and master on/off switch.

Suggested retail price for the Model SPS45OVR supply is $895.00.

For further information, call or write: Scooter Products, Ohm/Electronics, Inc., 746 Vermont St., Palatine, IL 60067; Tel. 800/323-2727, or 312/359-6040.

Drafting Aids Kit

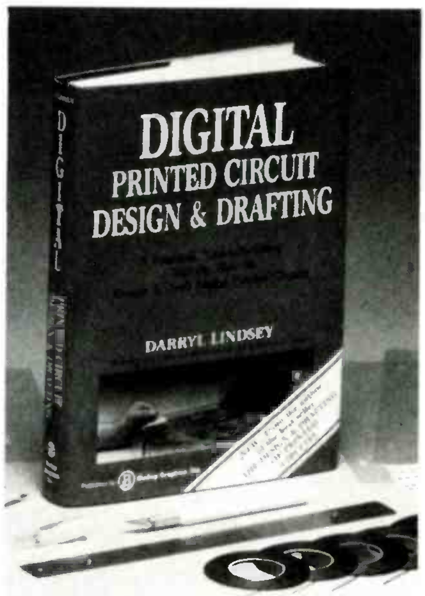
I wish someone had created a "learn by doing" kit when I learned PCB layout. The kit was designed for beginners and professionals seeking to develop or advance their skills in digital printed-circuit board design and drafting.

The combination package consists of a 432-page hardcover text and a companion kit of over 480 professional Bishop Graphics design and drafting aids for doing the actual PCB artwork exercises in the text.

The text and kit are ideal for designers and drafters who want to learn or expand their expertise in digital PCB design on their own, PCB-design and drafting instructors to teach students in the classroom, and PCB drafting supervisors to train new employees in digital design in the workplace.

The text, entitled *Digital Printed Circuit Design & Drafting*, is written by Darryl Lindsey, founder of the Masters Design & Technical Center in California. The book features over 450 photos, charts, and illustrations; how-to drafting techniques; a helpful appendix filled with useful tables, check lists, graphic symbols, terms, and definitions; plus a handy index.

Throughout the book, Lindsey provides readers with numerous how-to exercises and guides them through the creation of artwork for 3-IC digital boards, a 10-IC digital/analog board, a 16/15 IC digital board, and a 10-IC multi-layer board using the companion kit of Bishop PCB



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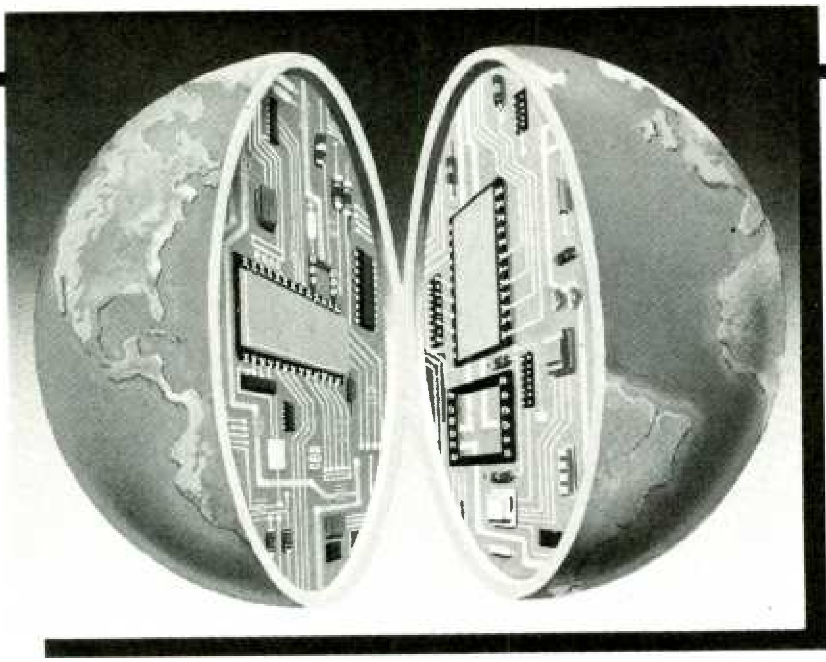

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drafting aids. Mastery of those layouts and artwork will equip the reader for preparation of digital artwork, regardless of size or complexity.

The book also features self-testing quizzes at the end of each chapter with answer keys that refer the reader back to the pages where the pertinent information appears.

The Digital Printed Circuit Design & Drafting kit is available from Bishop Graphics dealers or Bishop Graphics (Order Number 10009C) for $99.90. Both the book (Order No. 10009) at $49.95 and design aids package (Order No. 10009K) at $49.95 also can be ordered separately.

Complete detailed information is included in Bishop Educational Bulletin No. 5011. For a free copy contact the Customer Service Department, Bishop Graphics Inc., 5388 Sterling Center Drive, Westlake Village, CA 91359; Tel. 800/222-5808, in California, Alaska, and Hawaii: 818/991-2600.

B&B Catalog

B&B Electronics has just made available their Catalog #9. The catalog is a must for any RS-232 user who seeks a comprehensive guide to RS-232 converters, break-out boxes, adapters, data splitters, and any other RS-232 accessories. The catalog features a host of new RS-232 products as well, including: RS-232C line booster; RS-422A current loop converter; economy data generator; smart cable; powered current loop converter; programmable communications translator; and 1987 editions of the latest RS-232 books.

CIRCLE 70 ON FREE INFORMATION CARD

Sixteen illustrated pages, complete with technical specifications, photographs, and an index, make the B & B Electronics catalog an ideal reference source. Catalog #9 may be obtained by writing or calling B & B Electronics Manufacturing Company, 1500P Boyce Memorial Drive, PO Box 1008, Ottawa, IL 61350; Tel. 815/434-0846.

Compatible Lan Card

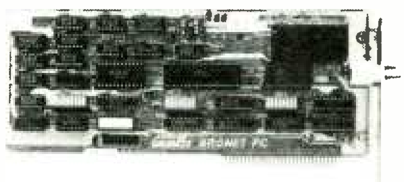
CompuPro has begun shipments of their Arcnet PC Board for Novell and other networks using the industry standard Arcnet interface. The $550 card works in all PC, XT and AT compatible computers including 386 models.

The board is completely compatible with Novell's Advanced Netware 86 and Advanced Netware 286. It also works with any other network operating system that supports the Arcnet interface. It also supports DR-NET, Digital Research Inc.'s network extension to Concurrent DOS, for a cost effective mix of networked multi-user machines.

The CompuPro Arcnet PC also features enhanced transceiver circuitry, compared to other Arcnet cards.

The board is 100% manufactured, burned in and tested in the USA and is not subject to wide swings in quality. It carries a suggested retail price of $550.

For more information contact Com-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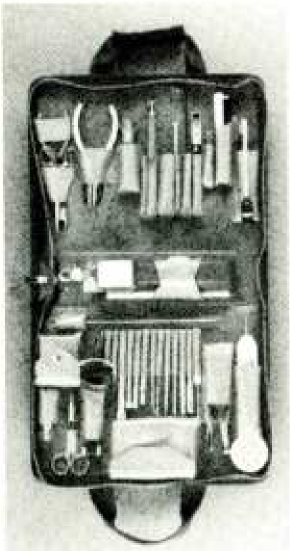
puPro. Viasyn Corporation. 26538 Danti Court. Hayward. CA; Tel. 415/786-0909.

Communications Tool Kit

The JTK-62 Data Com Kit from Jensen features tools and materials needed to install. test. and modify most equipment in a typical data communications system.

The kit contains a custom selection of screwdrivers. nutdrivers. pliers. cutters. hex keys. optical aids. a solder removal tool, and parts retrievers. as well as such specialty items as a cable tie tool. DIP/IC extractor. modular adaptor. Pozidrive blade. and more.



CIRCLE 54 ON FREE INFORMATION CARD

Tools are contained securely in a zipper case with a variety of inner pouches. three large outside pockets (to hold manual. test equipment. or spare parts). and webstrap handles.

The kit is available with additional options for wiring and cable installation (rotary/tone line test set. tone test set. punchdown tool. RS-232/RS-449 crimping tool) and modifying or troubleshooting PCB'S (IC Insertion/Extraction kit. ESD workstation. and digital probe meter).

The kit without options sells for $228.

For more information. write or call Jensen Tools Inc.. 7815 S. 46th Street. Phoenix. AZ 85044; Tel. 602/968-6241.

Powered Breadboard

Looking for a *powerful* breadboard? The PROTO-PAK 300 combines a triple power supply with a large. solderless breadboarding area. providing easier. faster circuit design and testing.

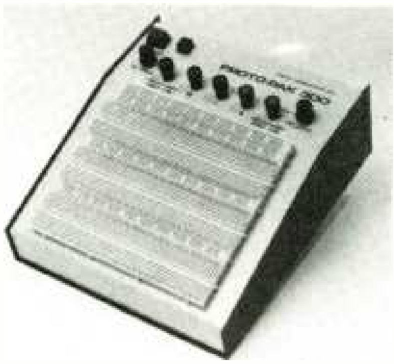
A dual. variable. fully regulated supply provides adjustable panel outputs from +5 to +15 VDC and -5 to -15 VDC at 350 mA each. In addition. an independent. fixed +5 VDC 1.5 A supply allows separation of digital and analog grounds.

NEW PRODUCT SHOWCASE

a feature that is found only on the PROTO-PAK 300.

The PROTO-PAK is available in three models, with either 27, 18, or 9 14-pin DIP capacity, and features labelled, high-grade acetal plastic, solderless breadboards. All models are available as kits, or fully assembled.

Standard features on the PROTO-PAK 300 include a metal case, primary fuse



CIRCLE 57 ON FREE INFORMATION CARD

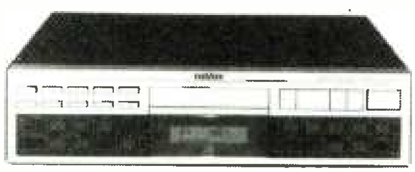
protection, power-on indicator, and a three-conductor line cord. Kit models start at $94.95 and assembled models are priced at $114.95.

For more information and a catalog of other hobbyist products please write or call: Tera Electronics Inc., 1232 Hwy. 74, Unit A, Evergreen, CO 80439; Tel. 303/674-3120.

Compact Disc Player

Revox is introducing a new remote-controlled Compact-Disc player that is so advanced the company expects it to become the industry's new reference standard. In addition to European-system, 16-bit, quadruple oversampling, the Revox B226 Compact Disc Player offers a host of convenience and programming features as well as digital audio-signal outputs for future applications.

The B226 is designed for ease of operation, with remote-control multi-room operation via the B205 remote-control module, coupled with an optional B206



CIRCLE 91 ON FREE INFORMATION CARD

Infrared Transceiver. The B206 remote-control unit operates the CD player as well as all Revox 200 Series components.

User friendliness is carried through to the B226 CD player's LCD information display that includes a multi-function time readout, selectable for time remaining as well as elapsed time for both the disc and individual tracks. In track mode, an additional proportional bar-graph shows the relative position within the track.

The B226's comprehensive information display also indicates the program number, the number of selections remaining, programming steps, and the status of PAUSE, AUTOSTOP, and LOOP functions.

The B226 can be random-access programmed with up to 19 selections for playback in any desired sequence. Sections of a specific musical selection can be played at will, with fast access and search time from any desired starting point. Start up from Pause is just 0.6 seconds.

The Revox B226 Compact Disc player is available from authorized Revox retailers. Suggested list price is $1150. A Revox full-system B205 infrared remote control unit will be included with each B226 for a limited time.

For additional information contact Revox Division, Studer Revox America Inc., 1425 Elm Hill Pike, Nashville, TN 37210.

Fax/Copier

The Group 3 compatible UX-80 offers reduction and enlargement, and is equipped with a built-in telephone handset. Transmission speed in the fax mode is 40 seconds, the UX-80 also has a 30-second per copy speed. Copy size ranges from 8-½ × 11-in. to 8-½ × 5-½-in.

CIRCLE 76 ON FREE INFORMATION CARD

The UX-80 measures approximately 13 × 6 × 16-in., and weighs 22 pounds.

For more information on the UX-80, contact Sharp Electronics Corporation, Sharp Plaza, Mehwah, NJ 07430; Tel. 201/529-9518.

Board-Based Logic Analyzers

If you never thought you'd own an on-board analyzer, think again. The logic 20/8 and the Logic 10/8, are analyzers now available from Bitwise Designs, for around $500.

The 20/8 and 10/8 are designed for digital prototyping and random logic-design projects. Capable of sampling synchronously or asynchronously on 8 channels to up to 10 or 20 Mhz, the logic analyzers are the least expensive of their kind on the market. Various features of the software allow the user to build hardware applications on the same PC that is running the logic analyzer. Moreover, the boards are two-thirds the standard length of comparable eight-bit boards, and are therefore able to operate on a wider variety of personal computers.

The instruments are capable of a 2-nanosecond set-up time. The Logic 20 family of testers are among the industry's

CIRCLE 82 ON FREE INFORMATION CARD

most accurate 20MHz logic analyzers—PC based or otherwise—because of that extremely fast set-up time. That allows accurate measurement of high-performance device applications, where the devices are not stable until until the last few nanoseconds of the clock cycle.

They also incorporate unique synchronous pods that perform all sampling operations internally. That shortens the set-up time and limits the channel-to-channel skew as compared to sampling data on the logic analyzer board itself. That strategy of sampling in the pod, rather than on the board, limits the length of the leads to eight inches. By contrast, in traditional logic analyzers, the critical data must be transmitted over several feet of cable, where it is vulnerable to induced interference.

The software for all three products features menu-driven operating instructions. That includes built-in help functions for technicians without previous experience with logic analysis techniques. It allows specification of trace type and labeling of data points, and the collected data can be displayed in timing-diagram or state-table form.

Another key feature is the ability to interact with the host PC's disk drives to store valuable information from analysis, including permanent storage of test data, and testing parameters such as clock rate, trigger information, and channel labels. It also allows data from known good boards to be saved and used for later signature analysis.

The standard external sampling pod provided with both the Logic 10/8 and 20/8 can sample 8 data points at up to 10 or 20 MHz respectively, with less than one nanosecond of channel-to-channel skew. An onboard comparator allows a trace to begin, end, or be centered on any fully or partially specified 8-bit trigger word. Also, specific selected states can be collected.

With a minimum period of 50 nanoseconds; the trace size

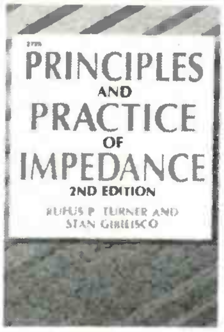
(Continued on page 102)

BOOKSHELF

Principles and Practice of Impedance
By Rufus P. Turner and Stan Gibilisco

Is your mind resistant to understanding impedance? This book may help you see the light. Unlike other electronics guides that merely skim the surface of many electronics topics, *Principles and Practice of Impedance* is devoted exclusively to the comprehensive coverage of one subject—impedance. Its presentation is concentrated and thorough, allowing you to gain a complete understanding of this most elusive aspect of electronics with the least possible investment of effort!

Starting out with the simple fundamentals of impedance and progressing toward more complex, sophisticated, and specific aspects of



CIRCLE 63 ON FREE INFORMATION CARD

the subject, this easy-reading guide explains what impedance is, how to use it in electronics calculations, and how to turn it into a tool when faced with specific design problems involving the transfer of energy from one circuit stage to another. Featuring 25% all-new materials, this up-to-the-minute guide contains important information on the j operator, forward and reflected power, plus an expanded appendix featuring trigonometric and logarithmic function tables, as well as more precise phase-angle data.

Just some of the specific areas you'll be brought thoroughly up-to-date on include: alternating current; the difference between impedance and pure resistance; impedance matching; methods of determining impedance by experimental means; estimating impedance by theoretical means; inductive and capacitive characteristics of various electronic components and circuits; imaginary-number and complex-number theory; complex representation of impedance; effects of reactance on power; and the effects of impedance in radio-frequency transmission lines and other topics.

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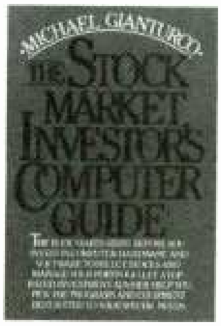
CIRCLE 9 ON FREE INFORMATION CARD

The book retails for $14.95, contains 216 pages, and is available from Tab Books, Inc., Blue Ridge Summit, PA 17214; Tel. 717/794-2191.

The Stock Market Investor's Computer Guide By Michael Gianturco



CIRCLE 89 ON FREE INFORMATION CARD

Want to make investments with a computer edge on other investors? Now there is a book to help you do just that. Filled with solid advice and concrete guidelines for both individual investors and professionals in the field, *The Stock Market Investor's Computer Guide* examines in detail the pros and cons of a wide range of computer hardware and software available to today's investors.

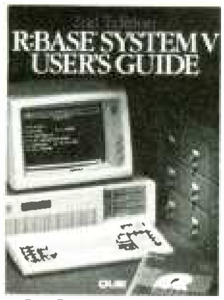
The guide shows how to set up and operate an investment computer system. Even more important, it offers specific rankings, judgments, and purchase recommendations of computer products.

Focusing on products for investors that deliver practical results, speed, logic, and convenience, the author tells which software and hardware to buy and which products to avoid. He emphasizes the combinations of hardware and software that work best for particular investing approaches and recommends the programs and equipment that are successful and practical while requiring the smallest outlay of time, effort, and money.

The book presents the detailed information needed for selecting the products that will enable the user to tap the full potential of computerized investing. It describes ways to use technical-analysis programs for timing buy/sell decisions, names the $50 program that no investor should be without, explores ways to avoid the big pitfall of the $6,000 down-load, shows how to set up a private stock-market database, and explains how to computer-check a portfolio to make sure that presently owned stocks are still earning their keep—at sensible risk.

The book contains 362 pages, and costs $29.95. It is available from McGraw-Hill, 2600 Tenth St., Berkeley CA, 94710; Tel. 415/548-2805.

R:Base System V User's Guide —2nd Edition By Allen Taylor



CIRCLE 67 ON FREE INFORMATION CARD

If you're looking for a data base with both menu and command-level capability, but you don't want to be a master programmer, you may want to read this book on the R:Base software package before you buy. It shows business and professional users how to use Microrim's full-featured program to create business applications without programming. Progressing logically from simple to advanced concepts, the book covers many ways to use R:Base System V, including how to combine several key features into a single application.

With *R:Base System V User's Guide—2nd Edition*, users will learn how to create complex databases, forms, reports, and applications with R:Base System V's Express modules, including definition express, forms express, reports express, and application express; use filegateway to convert incompatible data files to R:Base System V format, and vice versa; use command mode to develop highly complex and sophisticated business applications; use R:Base System V's application express and prompt by example mode to enter and modify data; set up an R:Base System V network. *(Continued on page 102)*

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By Herb Friedman

FRIEDMAN ON COMPUTERS

To store more data, simply use a smaller disk

IN PERSONAL COMPUTING, JUST ABOUT every new development, no matter how insignificant, is hailed as "a quantum leap" in technology. And if not a quantum leap, at the very least, it's "the leading edge" or "the cutting edge" of something: anything, so long as enough people will believe it's the proper thing to purchase *right now*.

Because 5.25-inch disk drives are now flooding the marketplace at better than flea-market prices, it's not unusual to find the 3.5-inch floppy disk being described as the new leading edge in floppy-disk storage: a breakthrough in high-density, floppy-disk technology.

The difference in size between the 5.25 and 3.5 inch disks is obvious; the features aren't. For example, note that the 5.25's magnetic media is always exposed through a window in the sleeve; not so for the 3.5-inch type.

Really Only Two Breakthroughs

In actual fact, there were only two significant floppy-disk breakthroughs. The first was the 8-inch floppy disk system, which was never intended for data storage by the user. In the era of magnetic tape—hard disk-pack and magnetic-core storage—it was simply an easy way for IBM to have on-board diagnostics in their early mainframe computers. There is no record of anyone claiming the floppy disk was sufficiently dependable to be used for storage of the user's data. It was the service technicians using the floppies for diagnostics who realized that floppies were, in fact, a dependable and convenient storage media.

The hand is not quicker than the eye. When a 3.5-inch diskette is out of its drive, a spring-loaded door automatically protects the internal magnetic media. The cutout in the door will expose the window for the heads when the diskette is mounted in a drive.

The second breakthrough was not the 5.25-inch disk, because that was a logical mechanical development and miniaturization of the 8-inch disk mechanism. Rather, the second breakthrough was the realization that floppies weren't as fragile as first believed; that they didn't disintegrate and lose data over relatively short time intervals; and more important, that their magnetic coating was capable of at least twice the magnetic density then believed possible. For example, a floppy being used to store approximately 80K of data could just as easily and dependably store up to 200K. (The so-called "double-density" floppy disk was a very successful marketing ploy. Many users saved big bucks just by buying certified single-density disks for their double-density disk systems.)

In particular, notice that the floppy-disk breakthroughs were not the mechanical mechanisms, but the recording media. The same is true of the 3.5-inch disk, which is fast becoming the standard storage system for many, if not most, of the new computers introduced by the major manufacturers.

Although the 3.5-inch disk is touted as having twice the data storage capacity and greater reliability (two subjects we'll get to later) than the 5.25-inch disk, the primary reasons for changing to the 3.5-inch size is that it's less expensive to manufacture, and requires less mounting space and operating power; the latter two features having particular significance for the new breed of battery-powered, high-performance laptop computers.

Great Packaging

From the average (non-laptop) point of view, the 3.5-inch drive's major advantage—call it a breakthrough if you want—is the diskette's packaging. Unlike the conventional floppy disk, which consists of a magnetic media rather flimsily protected by a sleeve, the 3.5's media is protected by a rigid plastic housing having sliding doors that seal the window—the opening in the sleeve through which the mechanism's heads contact the magnetic coating. As shown in the photos, a metal door normally covers the access window on each side. When the disk is inserted in the drive, an internal mechanism loads the disk by sliding the doors to the side, thereby exposing the disk access windows, which allows the heads to contact the disk. When the disk is removed from the mechanism, the doors automatically slide over the windows to protect the magnetic media from possible damage.

If the now-you-see-it-now-you-don't trick sounds familiar, it's because the same general idea is used for VCR recording tape. If you recall, VCR tape is protected until the cassette is installed in the VCR mechanism, which then opens a door in the cassette, so that the heads can access the tape. It's the same thing with the 3.5-inch disk.

Solid as a Rock

Another basic difference between the 3.5-inch diskette and the conventional floppy is that the 3.5's recording media is encased in a rigid-plastic housing. Between the rigid housing and the automatic doors, the 3.5 is really a cassette, which is considerably more resistant to damage than a conventional floppy.

In fact, you have most-likely seen some of the advertisements that show a 3.5-inch cassette being tucked into a shirt pocket, and maybe you have given some thought as to how the pressure from pencils or pens carried in the pocket would damage the disk. Not so! The 3.5-inch cassette is very rugged, at least until the manufacturers start whittling away the quality in order to reduce the selling price. (Many of you who got into personal computing only recently have never seen the original 5.25-inch floppies; their sleeves were so rugged it took considerable force or pressure to cause damage. Their worst problem was the ever-open window that exposed the magnetic media.)

The 3.5-inch diskette system used by IBM, which we must assume will become the *defacto* standard for all IBM-compatible and clone equipment, has a 720K capacity. While that is touted as one of the things that makes 3.5's superior to conventional 5.25 floppies, bear in mind that conventional quad-density 5.25-inch floppies can easily store 1.6 megabytes of data. Manufacturers of 3.5's have simply used high-density techniques on a smaller size disk. (There is no such thing as a free lunch, or free extra disk storage).

Is 3.5 for You?

Before we get into the pluses and minuses of 3.5 (as far as you're concerned), bear in mind that your operating system must be able to I/O the new size, and it must be able to format 3.5-inch disks. The new computers that use 3.5's are, of course, provided with the necessary software. But if you're going to use a 3.5 with an older computer, say an IBM PC, XT, or AT, or a clone, you will need either PC/MS-DOS 3.2, or your 3.5-inch disk upgrade or retrofit kit must include the necessary software interface.

By *upgrade* we mean one of the kits that adds a 3.5-inch drive to your computer's present configuration. By *retrofit* we mean one of the kits specifically intended to replace an existing 5.25-inch drive with a 3.5-inch type. Several sources of 3.5-inch upgrade and retrofit kits include the necessary software, others do not; just be certain that you get it. Having a retrofit 3.5-inch drive that relies on your ability to write the necessary software is worthless, if you're not the hacker type. (Of course, you can always purchase PC-DOS 3.2.)

Emulating the disk-drive mechanism, the hand pulls the door to the side, so that you can now see how the door's cutout aligns with the cassette's window to expose the internal disk.

As to whether you should upgrade to 3.5; as a general rule, no. If your present software is adequate, if you have no problems with disk damage due to rough handling, 3.5 probably won't improve your computer's data storage. But if you plan on swapping data between your present 5.25-inch equipment and the newer computers, which use 3.5-inch diskettes, then you must consider a 3.5 upgrade or retrofit kit, because unless you can actually read and write to 3.5, the only way you'll be able to swap data between the 5.25 and 3.5 machines will be through a relatively slow telephone modem connection, or a slightly faster null-modem connection; but a null-modem requires that both computers be in the same room; something that might prove impossible if the 3.5 is your office or school computer and the 5.25 is in your home. (Some organizations don't take kindly to people "borrowing" a \$2000 to \$3000 computer overnight so that they can copy data between different disk formats.)

Modernize at Breakdown

One way to get on the leading edge of disk technology is to retrofit to 3.5-inch when one of your 5.25-inch floppies dies. It almost never pays to repair a floppy since new mechanisms often cost less than a repair, and installing a drive is a rather simple task (as we have shown in earlier columns). Because a complete retrofit kit isn't all that expensive—at present they sell for about \$150—the death of a 5.25-inch drive might be the opportune time to upgrade your system to 3.5. Knowing how computer hardware prices plummet almost weekly, 3.5-inch retrofit kits will shortly sell for just a few dollars more than a replacement 5.25-inch drive. ■

Build the ...
Hands-On Fishing Guide

Hands-on Electronics
SEPTEMBER 1987

By Tom Fox

Nothing fishy about this project, it tells you the water temperature that the fish like

☐Are you the type of fisherman who only gets to eat fish at the Red Lobster Restaurant or Long John Silver's Seafood Shoppe? Do you have that haunting feeling that the only fishing device that is at all effective was invented by Al Nobel, and is commonly called dynamite? If so you may be interested in building a Hands-On Fishing Guide. While it won't catch fish, it will help "guide" you to where those tasty morsels with fins are likely to swim.

Once you decide upon which water to fish, the next problem is to locate the fish. That not only means where to park your boat, but at what depth to fish. To help solve the dilemma, the industry has deluged the market with fish finders of all types. Many are so sophisticated and expensive that one might think they were originally designed for the Stealth fighter! While the Hands-On Fishing Guide doesn't "find" fish, it does help one's gray matter figure out where the fish likely are—and it can be built for less than the cost of many non-resident fishing licenses!

What's It Do?

What the fishing guide does is measure the water temperature and locate that almost magical region called the *thermocline*. (Finding fish ain't the whole answer to fishin'—at times it seems you can dangle your hook in front of a zillion fish and never get a nibble. Lure, bait, weather, technique, timing etc., are also important.)

It has been found, for many types of fish, that the most productive depth to fish is in the thermocline region. To better understand the thermocline look at Fig. 1 which shows a cutaway view of a typical lake. During the summer (when most people fish) the warmest water is normally near the surface and the coldest water (near 39.2°F in deep lakes over 70 feet) is near the bottom. The warm top layer is known as the epilmnion. The temperature in that warm layer drops quite slowly with depth. Directly below that warm layer is a fairly narrow region called the thermocline. Here the temperature drops very rapidly (over 1°C per meter, 1.8°F per 3.2 feet). The thermocline is our target area, since most fish prefer that region. Below the thermocline is a cold region called the hypolimnion. There again, the temperature drops slowly. In some lakes there are little or no fish in the bottom of the hypolimnion because there is little dissolved oxygen. The Hands-On Fishing Guide, which is described here, is a simple instrument that not only locates the thermocline region, but measures the water temperature and provides a mechanical means of determining the depth of the layers of water.

The LM335 Sensor

It was just over 10 years ago when the author first designed and built a thermocline indicator. The author's original instrument used matched thermistors since temperature sensor IC's were not widely available. The primary problem with matched thermistors is the amount of green stuff needed to get them. Now, with the availability of cheap temperature sensors, such as the LM335, the primary cost of the project described here is the cable that connects the sensor assembly to the circuit! (The author doesn't want to imply here that IC temperature sensors can take the place of thermistors in all applications. Generally, thermistors are more sensitive than the new sensors and some types are more rugged and less expensive.)

Basically, the LM335 functions as a zener diode whose zener voltage is linearly related to its temperature. Each .01-Volt corresponds to 1° Kelvin. Thus at 273°K (which is about 0°C or 32°F) the nominal output voltage of the sensor is 2.73 volts. Note that Kelvin degrees are the same "size" as Celsius degrees and that °K — °C + 273.16. Thus at 25°C the nominal output voltage of the sensor is a shade over 2.98 volts.

Unlike thermistors, two different LM335 sensors from two different manufacturer's batches have nearly identical

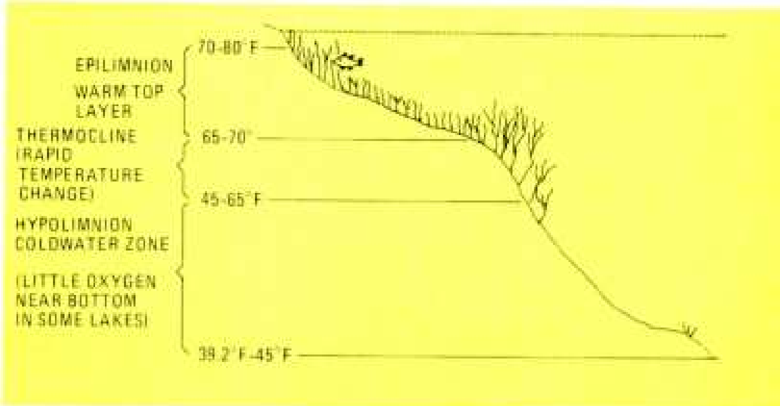
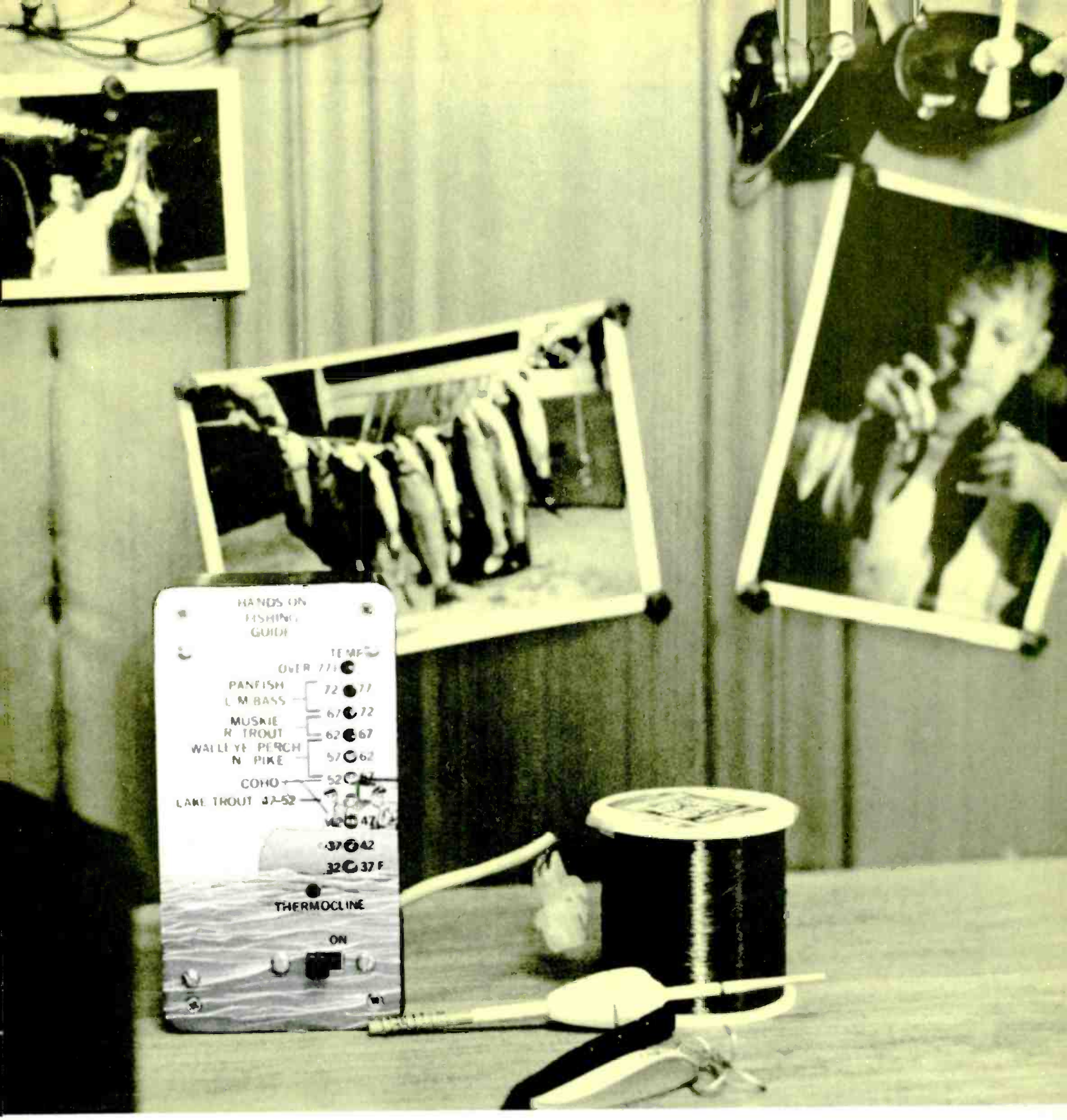


Fig. 1—Since fish get their oxygen from underwater plants, the often congregate around the layer of water that most of the plants grow in. That layer is the thermocline.



characteristics. The primary difference between one LM335 sensor and another is a small uncalibrated offset error. Once calibrated (with a simple pot) the sensors are, for all practical purposes, electrically identical. That feature is important in a thermocline indicator since it must detect small (1°K—1°C—1.8°F) differences in temperature.

Temperature Sensing

Referring to the schematic in Fig. 2, keep in mind that U4 is located 1 meter (3.28 feet) from U5. Under normal usage, U5 is cooler than U4 because it is in deeper water.

During initial calibration, U4 and U5 are at the same temperature, and R1 is set so the voltage at TP1 equals the voltage at TP2. U1a and its associated resistors form a differential amplifier. That differential amplifier subtracts U5's voltage from U4's and then multiplies that difference by 100. That output voltage then goes to the noninverting input of U1b, which is connected as a voltage comparator. U1b's inverting input is connected to a circuit network consisting of the 2.5-volt precision reference U3 (LM336-2.5) and a voltage divider. Resistor R2 is adjusted so 1 volt appears on U1b's inverting input. The output of the voltage comparator drives voltage-follower buffers U1c and U1d, which provide driving current for LED11 and BZ1, respectively.

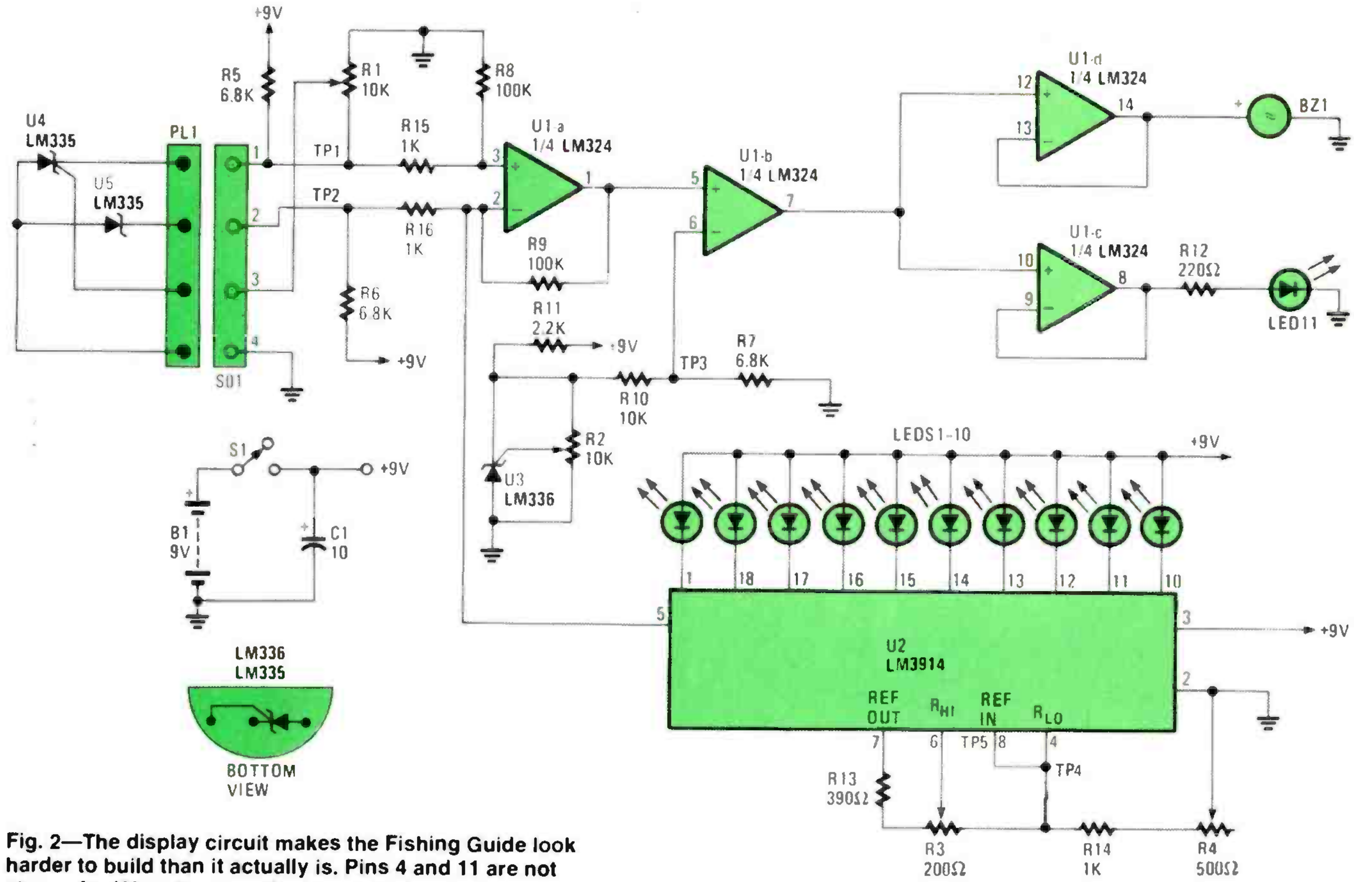


Fig. 2—The display circuit makes the Fishing Guide look harder to build than it actually is. Pins 4 and 11 are not shown for U1 as they are the power leads.

As you can see, when the probe first encounters a thermocline (greater than a 1°K difference between U4 and U5), the output of U1a rises above 1 volt (100 × .01). Since U1b's noninverting input voltage is now greater than the 1 volt at its inverting input, it switches on, lighting LED11 and sounding the alarm.

The Display

Now, we will describe how the temperature-measuring circuit provides its output. As can be seen from the schematic, we make use of the LM3914 dot/bar display driver (U2). That IC not only simplifies things tremendously, but it allowed us to design a surprisingly inexpensive instrument.

Simply put, the input signal from U5 is connected to pin 5. The lowest voltage which turns on the first LED (connected to pin 1) is applied to R_{lo} at pin 4. The highest reference voltage (at which level the 10th LED turns on at pin 10) is connected to R_{hi} at pin 6. The other LED's turn on at signal levels between R_{hi} and R_{lo}.

The LM3914 has a built-in *floating* 1.25-volt reference source. Since it is floating (not internally connected to ground) that internal reference can be used to be an effective 1.2- to 12-volt reference. (That fact is not intuitive, but it does come out in the math and in practice, trust me. Of course the reference source can only produce a 12-volt reference voltage with a supply voltage over 12 volts.)

Resistor R3, in Fig. 2, effectively acts as a "temperature-range" control, and is set for a voltage difference of .27 volts between TP4 and TP5. Resistor R4 is set so that LED1 just comes on when U5 is in a mixture of ice and water. (Or alternately, R4 is set for a voltage of 2.71 volts at TP4.) Remember, LED1 turns on in the 32-37°F range of temperatures. When R4 is set properly, the voltage at R_{lo} is approximately 2.71 volts, which of course means the voltage at R_{hi} is 2.98 volts (2.71 + .27), which corresponds to a temperature of 77°F.

One Step Further

The following may be of interest for those readers who enjoy learning the intricacies of a circuit. Note that with most sensors, R4 will be set for a reference voltage at pin 4 of 2.71 volts. By referring to the simplified schematic in Fig. 3, notice that there is a 1.25-volt potential between pins 7 and 8 (pins 4 and 8 are connected together). To simplify things assume that I_{adj} is zero—in practice it is extremely small, so that assumption is a good one. Referring to Fig. 3 and using I—V/R, it should be clear that the current flowing through R3 is:

$$1.25 \div 590 — 2.118644 \text{ mA}$$

Since we assume I_{adj}—0, that current through R3 also flows through R4 and produces a voltage of 2.71 volts. In order for this to take place, since R—V/I, R4 must be:

$$2.71/.002118644 — 1279 \text{ ohms}$$

which we can see in Fig. 2, is the resistance of the series combination of R14 and R4, with R4 set to near its midpoint.

Construction

While the simplicity of this project does permit point-to-point wiring, a printed circuit board simplifies construction. All parts, except the switch and sensors, can be mounted on this board. The foil pattern for this project is given in Fig. 4 and the component layout is shown in Fig. 5. Note that NO circuit board jumpers are used—a definite indication of circuit simplicity. Use a 14-pin, DIP IC socket for

PARTS LIST FOR THE HANDS-ON FISHING GUIDE

SEMICONDUCTORS
LED1-LED10—Clear, high-efficiency, light-emitting diode
LED11—Green, high-efficiency light-emitting diode
U1—LM324N, quad operational amplifier IC
U2—LM3914, dot/bar display driver IC
U3—LM336Z-2.5 2.5-volt reference diode
U4, U5—LM335 Precision temperature sensor

RESISTORS
(All resistors are 1/4-watt, 5% units except where otherwise indicated.) R1,R2—10,000-ohm, vertical-mount, trimmer potentiometer
R3—200-ohm, 15-turn, trimmer potentiometer
R4—500-ohm, vertical-mount, trimmer potentiometer
R5,R6—6800-ohm
R7—6800-ohm, 1% precision
R8,R9—100,000-ohm, 1% precision
R10—10,000-ohm, 1% precision
R11—2200-ohm
R12—220-ohm
R13—390-ohm
R14—1000-ohm
R15,R16—1000-ohm, 1% precision

ADDITIONAL PARTS AND MATERIALS
B1—9-volt, alkaline battery
BZ1—9 to 12-volt, solid-state buzzer
C1—10µF, 25 WVDC, tantalum or electrolytic capacitor
PL1—4-conductor plug, Digi-key part #A1430, with pins ¢A1422
S1—SPST slide switch
SO1—4-conductor socket, Digi-key part #A1431, with sections #A1423

Circuit board, 4-conductor cable, heat-shrink tubing, heat-shrink capsules, case, press-on vinyl decorative sheet, dry transfer lettering, IC sockets, silicone rubber, hardware, solder, etc.

U1 and an 18-pin, DIP IC socket for U2. (If 18-pin, IC sockets aren't available, you can cut two pins off a 20 pin IC socket or solder U2 directly to the board.) The points marked TP1, TP2, etc. are test-points, and a short piece of bare wire (or a piece of clipped excess component lead) should be inserted in these holes for easy testing.

The wires marked 1, 2, 3, and 4 should be connected to their respective socket connections at the end of the 8-10-inch long, 4-conductor cable. The other end of the short cable is connected to the board. The author used a 4-conductor, Amp mate-n-lok, free hanging connector. The wiring of SO1's mate, PL1, will be described in the next section.

While the author used clear orange LED's for LED1 through LED10 and a green LED for LED11, the reader should feel free to choose other colors. Nonetheless, clear, high efficiency (bright) LED's should be used to provide maximum visibility in sunlight. The author mounted the LED's to the foil side of the board. That allowed the author to mount the circuit board closer to the front panel. Though a piezoelectric buzzer is recommended for BZ1, any low-current 9 to 12-volt buzzer can be used. Battery B1 should be a 9-volt alkaline battery (NEDA 1604A or equivalent).

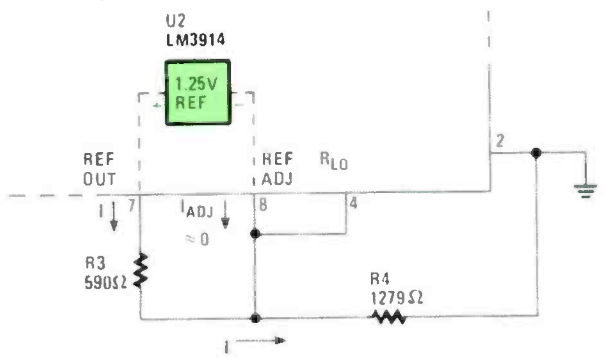


Fig. 3—This simplified schematic for the range-adjustment circuit of U2 should make clear the reasons for choosing the parts used in the real circuit. However, note that R3 and R4 do not correspond to the values of those resistors in the real circuit. They are presented only for illustration.

Sensor Assembly

Refer to Fig. 5, which shows the details of sensor assembly. Note that a 4-conductor cable is required and that the two sensors are separated by 1 meter (3′, 3′-3/8″). The length of this cable depends upon the depth of the water you'll be using the project in—normally from 20 to 100 feet.

Since this assembly is used in water, *it must be waterproofed.* Unless you have previously successfully waterproofed sensors, follow the directions in Fig. 6 carefully.

If you have difficulty in locating heat-shrinkable sensor capsules, you can make your own. Figure 7 displays how

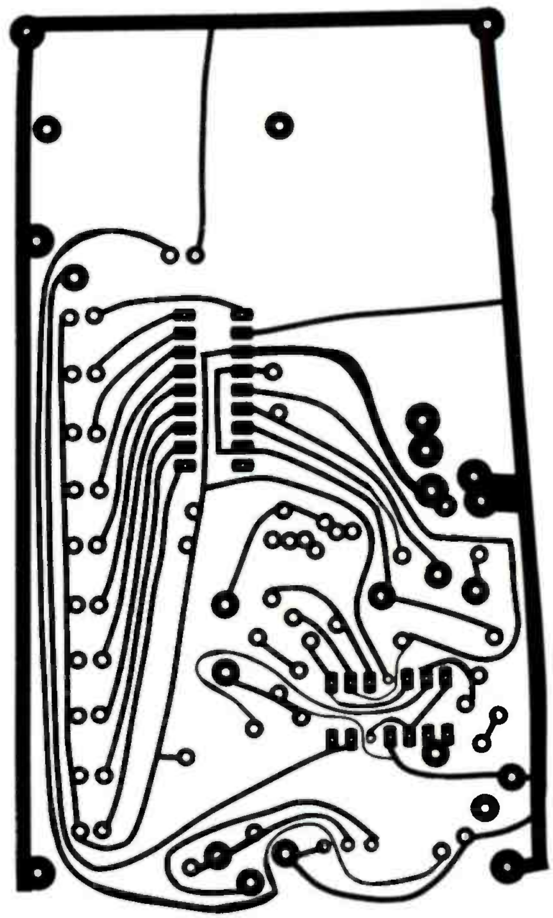


Fig. 4—Use this page and a photo-resist method to prepare your board. Take care to clean up any sloppy traces, as some of them are very close together.

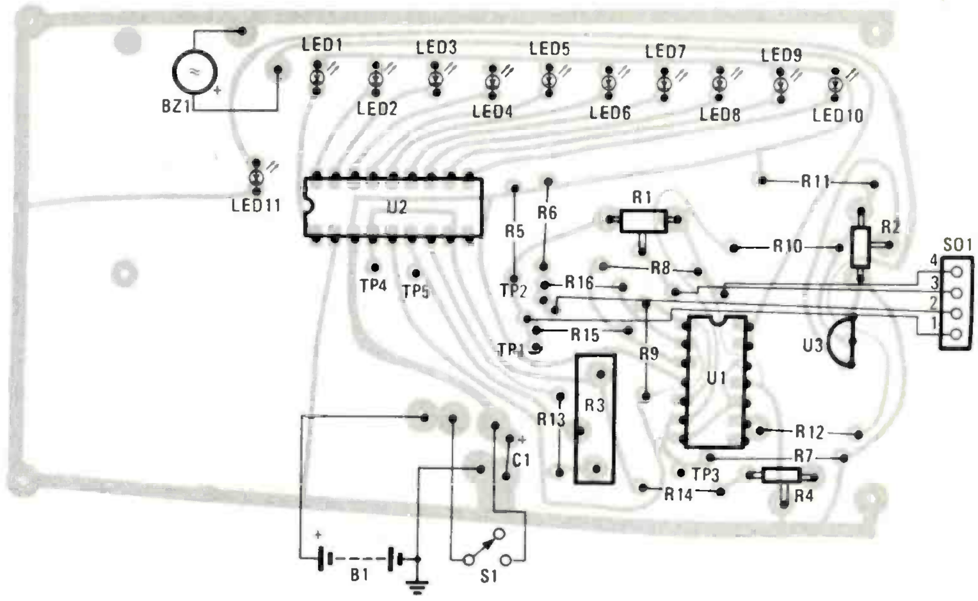
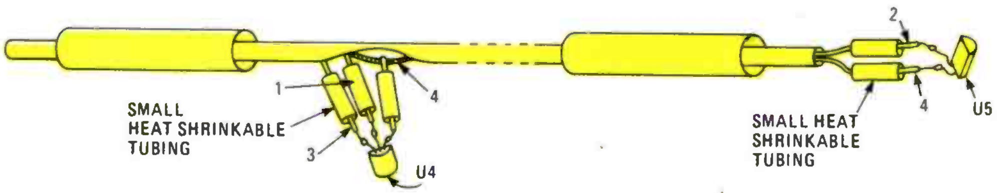


Fig. 5—The LED's are positioned for direct mounting onto the board. That means the case you put the project in must accommodate the board close to its face.



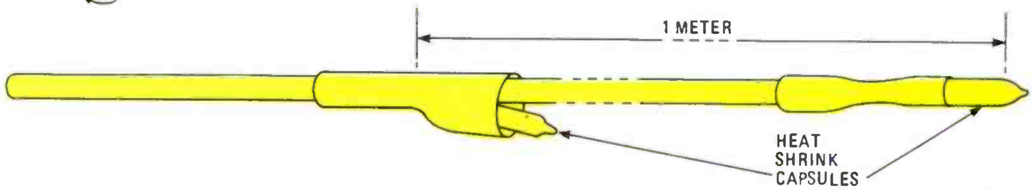


Fig. 6—Be careful not to heat the IC's too much while shrinking the tubing to water-proof them. Also be sure to use heat shrinkable tubing of a small enough size to tighten securely around the components.

to make home-made sensor capsules. When silicone rubber is called for in Fig. 5 and 6 use "Dow's Gaskets in a Tube Black" or equivalent.

In order to know how deep the sensor is, you will need to mark the cable every foot. With a permanent marker, make a mark on the cable every foot. Make the first mark 2-1/2feet from the bottom sensor. To determine the depth, simply count the marks when dropping or pulling up the sensor.

The unconnected end of this cable must be wired to a connector in SO1 that mates correctly with PL1. The author connected the cable's wires to the pins that fit in a 4-conductor pin housing.

Cabinet and Panel Assembly

For the cabinet, the author used a 6 × 3-3/16 × 1-7/8" plastic case that is available from any electronic parts distributor. Use a 3/16" drill for the LED holes. Make sure you use very little pressure when drilling the holes in the plastic. If available, use a drill press. The foil pattern (or bare PC board) can serve as a drilling guide for those holes. Also provide a mounting space on the front panel for the switch.

The front panel can be made more attractive by applying a weatherproof vinyl "Sport-Stik," a type of waterless decal with an adhesive backing. After all drilling was complete, the author cut out a portion of model 12-R (COHO) Sport-Stik and applied it to the plastic front panel. (Sport-Stik's are available at many hardware and variety stores, or write The Meyercord Co., Dept. PHC, 365 E. North Ave., Carol Stream, IL 60187. Include 25 cents in coin for a color booklet. For the professional look, use black dry transfer lettering that is available in office supply stores as well as through electronic parts dealers.

The circuit board can be mounted directly to the front panel with 3 or 4, 1", 6-32 machine screws, nuts, and lockwashers. At least one 5/8" spacer (or washers) is required

(Continued on page 101)

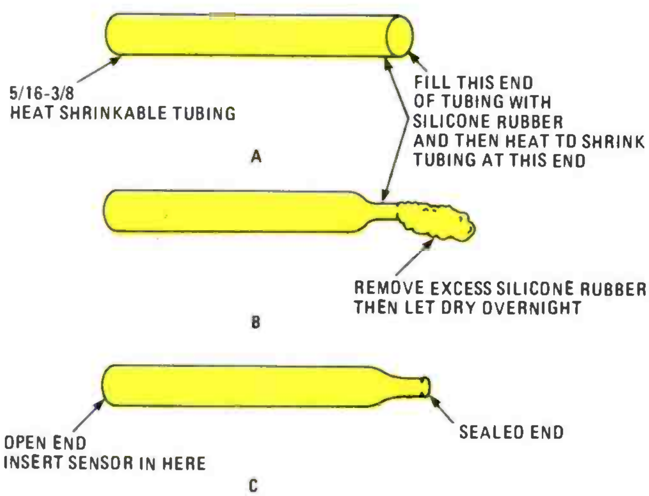


Fig. 7—If you can't find heat shrinkable capsules, you can make you're own with some heat shrinkable tubing and silicon in a tube. Be sure you don't use enough heat to harm the silicon while shrinking the tubing.


Heathkit
A completely mobile, programmable, electromechanical robot, HERO® 2000 is capable of interacting with its environment free of external control.
Hams! Get the latest in amateur radio technology including high-speed Packet Radio Communication.
Build from our full line of precision test instruments and see how they can increase your troubleshooting effectiveness.
Powerful new IBM-PC compatible Heathkit computers are yours to build easily and save with, or to buy assembled.
New Digital Rain Gauge records rainfall accurately and reads out inside your home in 100ths of an inch.

Build the Digital Theremin

It's a common misconception that electronic music did not exist until Robert Moog introduced his synthesizer in the mid-1960's. Actually, experiments with electronics and music go back to pioneering efforts at the turn of the century. While much of the early work has faded from the pages of history, a few have managed to live on to this day.

One of the earliest efforts was the theremin. Named after its inventor, the theremin was developed in the Soviet Union in the early 1920's. It consisted of a box fitted with a pair of antennas. There was no keyboard to play, no strings to strum or bow. Instead, the theremin used the body capacitance of the performer to control the pitch and volume of the output signal. All the user had to do was wave his or her arms near the antennas to produce sound!

The biggest use of the theremin has been in untold numbers of grade-B horror pictures. The eerie gliding sounds that can be heard during the action came from the theremin. It has also been use in pop and rock music as well—Jimmy Page of Led Zepplin used one in concerts for many years. While the the original theremin used two antennas and a slew of tubes and tuned circuits, the use of integrated circuits makes the job considerably easier.

In this article, we'll describe the construction of a simple theremin with under $20 worth of parts. Experimenters with a junkbox will be able to do the job for even less money. The theremin is easily assembled and used, even by those without a musical background. Best of all, the theremin is lots of fun, especially at Halloween parties!

The Inside Track

In our design, the tubes and tuned circuits have been replaced by a pair of inexpensive and easy to find IC's, to produce the Digital Theremin. A block diagram of the circuit is shown in Fig. 1. The Theremin uses a pair of high-frequency oscillators for operation. While one oscillates at a fixed frequency, the second can be varied by the body capacitance of the user. The output of the two oscillators are mixed by a special circuit known as a balanced modulator.

The balanced modulator suppresses the original inputs and produces a complex signal that consists of the sum and difference frequencies of the two inputs. If one oscillator is operating at 100 kHz and the other is operating at 101 kHz, the output will be two frequencies at 201 kHz and 1 kHz. Since the upper range of human hearing is limited to 20 kHz or so at best, only the 1 kHz difference frequency would be audible when the balanced modulator is connected to an audio amplifier.

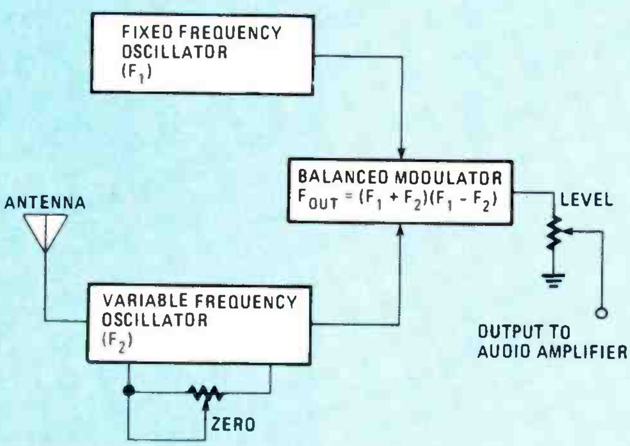


Fig. 1—The block diagram of the Digital Theremin shows a pair of high-frequency oscillators—one oscillating at a fixed frequency, and the other variable via body capacitance. The outputs of the oscillators are mixed by a balanced-modulator circuit, which suppresses the original inputs to produce a complex derivative, consisting of the sum and difference frequencies.

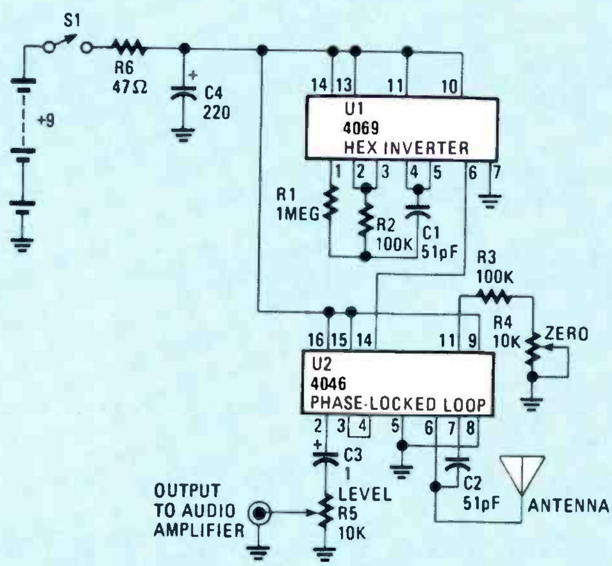
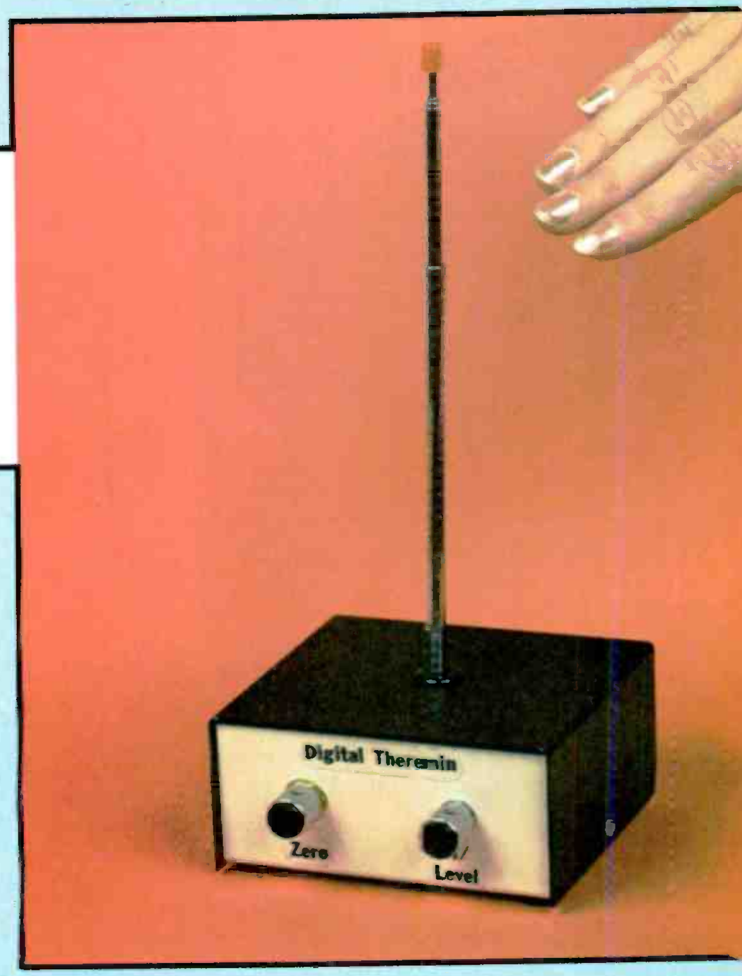


Fig. 2—The schematic diagram of the Digital Theremin shows U1—a 4069 hex inverter/buffer—used as a fixed-frequency oscillator, while U2 (CD4046, a phase-locked loop) serves as a variable-frequency oscillator.



Now you can produce those eerie sounds that lend a chilling effect to horror movies!

By C.R. Fischer

Straight to the Heart

The schematic diagram for our Digital Theremin is shown in Fig. 2. U1—which can be either a CD4069 or 74C04 hex inverter—is used as a fixed-frequency oscillator centered around 100 kHz. U2 contains the variable frequency oscillator and balanced modulator to complete the rest of the circuit. The CD4046 is a phase-locked loop and was originally designed for applications like frequency multipliers, but its hardware fills our needs perfectly. R3, R4, and C2 determine the center frequency of the on-chip oscillator.

The antenna forms a parallel capacitance with C2, which allows the frequency to be shifted several kilohertz by bringing a hand near the antenna. R4, the ZERO control, allows the variable oscillator to be set to the same frequency as the fixed oscillator. When the difference frequency is below 15 Hz, it is below the lower frequency limit of the ear. By setting both oscillators to the same frequency, the Theremin remains silent until the performer brings his or her hand near the antenna.

The oscillators are mixed by an exclusive OR gate inside the 4046. That gate acts as a digital balanced modulator, which produces the sum and difference frequencies as explained earlier. The output of the gate is then AC coupled by C3 to LEVEL control R5 and an output jack for connection to an audio amplifier or stereo receiver.

A 9-volt transistor-radio battery is used for power, controlled by an on/off switch on the back of R5. Since the 4046 contains a 7.5 V Zener reference diode, it is used for voltage regulation along with R6 for current limiting and bypass capacitor C4.

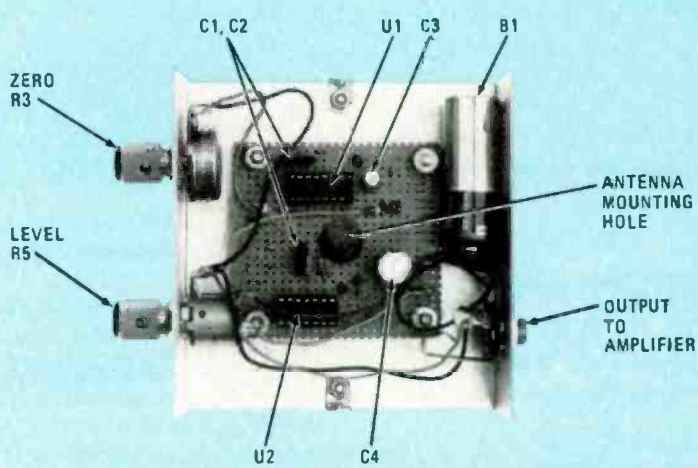
PARTS LIST FOR THE DIGITAL THEREMIN

C1, C2—51-pF, silver mica capacitor
C3—1-μF, 25-WVDC electrolytic capacitor
C4—220-μF, 25-WVDC electrolytic capacitor
R1—1-Megohm, ¼-watt, 5% resistor
R2, R3—100,000-ohm, ¼-watt, 5% resistor
R4—10,000-ohm, linear-taper potentiometer
R5—10,000-ohm, audio-taper potentiometer
R6—47-ohm, ¼-watt, 5% resistor
U1—4069 or 74C04 CMOS hex inverter/buffer, integrated circuit
U2—4046 phase-locked loop, integrated circuit

ADDITIONAL PARTS AND MATERIALS
Printed-circuit or perfboard materials, general-purpose replacement antenna (Radio Shack No. 270-1401), aluminum case (Radio Shack No. 270-271), IC sockets, 9-volt transistor-radio battery, 9-volt-battery clip, wire, solder, hardware, etching solution (if needed), etc.

Putting It Together

The circuit itself is simple, and can be built on a 2 × 2-in. printed-circuit or perf board. A template for the Digital Theremin's printed-circuit board is shown in Fig. 3, and the



Although a printed-circuit template is provided to make the assembly of the Digital Theremin simple, the author's prototype is shown here mounted on perfboard. You'll note that the layout shown here is similar to the layout that's shown in Fig. 4.

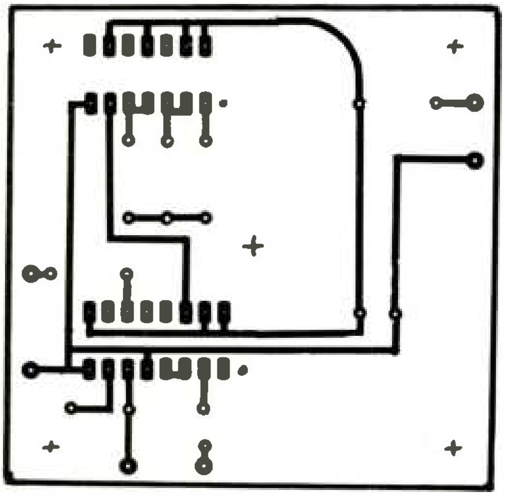


Fig. 3—The full-scale template can be copied or lifted from the page and used to etch your own 2 × 2-inch printed-circuit board. The layout for a printed-circuit board is not critical.

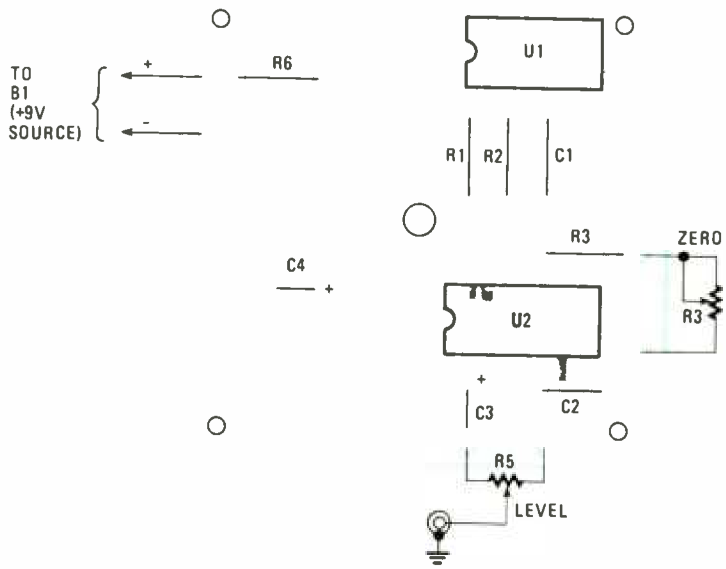


Fig. 4—If you've opted to go the printed-circuit route, this parts placement diagram will make assembly go a lot smoother.

parts layout diagram is shown in Fig. 4. One important detail is that the Theremin should only be built into a metal case, because the metal forms a shield that greatly reduces any tendency for the oscillators to drift in frequency. Using the metal case makes calibration of the theremin much easier.

The author's prototypes were built into an aluminum case sold by Radio Shack (part number 270-271). For best results, C1 and C2 should both be silver mica capacitors, preferably with a tolerance of ± 5%. And since both chips are CMOS, the use of IC sockets or Molex Soldercons are strongly recommended. Aside from that, the layout and assembly of the board is not critical.

After the board is done, we have to deal with mounting the antenna and connecting it to the board. Since the antenna is covered with a thin layer of chrome, it isn't possible to solder a wire directly to the antenna itself. Included with the antenna used in the project (RS No 270-1401) is a pair of copper washers. Simply solder a short length of wire to one of the washers and secure it to the antenna with a 2-56 machine screw and nut (see Fig. 5).

Mounting the antenna to the board and the case is straightforward if you use several rubber grommets. A grommet with an inside diameter of ¼-inch will hold the antenna shaft firmly to the board. In the author's prototype, a hole was drilled in the top half of the case so that the top could be removed without disturbing the antenna. By using a slightly larger grommet for the lid, the case was protected from accidental shorts to the antenna, while still being able to be removed easily. A strip of electrical tape or insulating material should be mounted under the board to prevent the antenna from touching the bottom of the case. The printed-circuit board is held by four machine screws to the bottom half of the box, where the controls and the output jack are mounted.

(Continued on page 103)

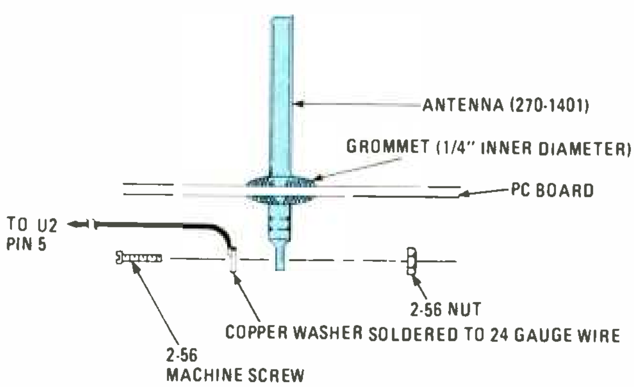
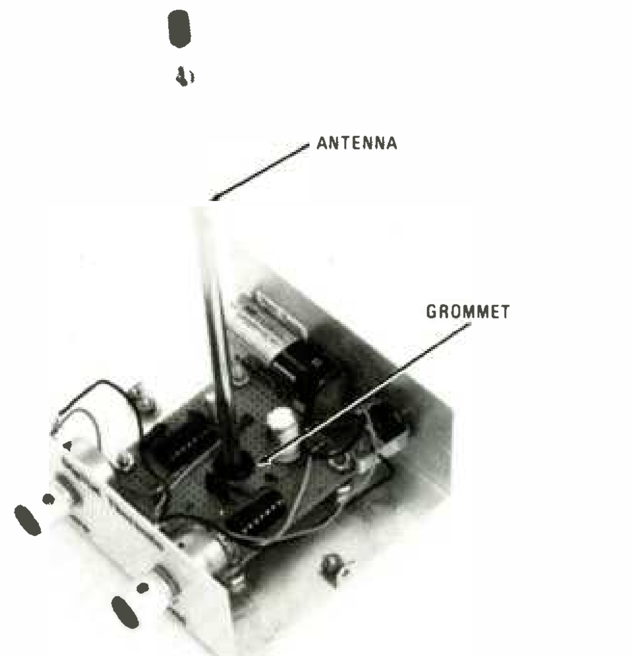


Fig. 5—Because the replacement antenna comes coated with a thin layer of chrome, soldering a wire lead to it won't work. It is therefore necessary to solder the lead to a washer and then use a screw and nut to attach the antenna to the wire. The other end of the wire lead is connected to pin 5 of U2.



The antenna, mounted through a hole in the board outfitted with a grommet for a tight and secure fit, is not connected directly to the circuit board. A strip of electrical tape or insulating material mounted under the board prevents the antenna from touching the bottom of the case.

dB UNDERSTANDING DECIBELS

By Steve Rickman

Here's a quick explanation of what the different kinds of deciBels are and how they are used, that won't make your ears ring

BEFORE WE GET STARTED HERE'S A QUICK QUIZ: HOW MANY OF the following statements would leave you puzzled if you encountered them in a technical article: "Amplifier gain is 20 dB;" "Insertion loss is 1 dB;" "Bandwidth (-3 fdB) is 1 MHz;" "Dynamic range is 60 dB;" "Antenna forward gain is 10 d B;" "Sensitivity is 1 microvolt for a 10 dB signal-to noise ratio;" "Ambient noise level is 50 dB;" "Microphone sensitivity is -60 dB;" "Speaker efficiency is 90 dB;" "Output-audio level is -6 dB."

If any of those statements has you scratching your head, read on. We're going to try to dispel some of the mystery surrounding the deciBel.

Hearing the DeciBel

The origin of the deciBel can be traced to the work of a 19th-century German physiologist named Ernst Heinrich Weber. Weber discovered that the human senses are rather poor at determining absolute levels of stimuli, but are good at detecting fractional differences between levels.

That characteristic is most pronounced for the sense of hearing. Suppose you are listening to a steady tone from an audio-signal generator. The tone will seem just so loud to you. Now increase the generator power in small increments until you just notice an increase in loudness. If you are like most people you will notice a difference when the power has increased by about 26%. It could be a larger or smaller percentage, but that is a fairly typical value.

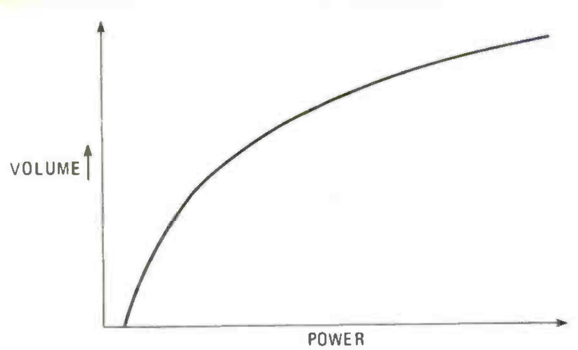


Fig. 1—Perceived loudness of sound is logarithmically related to sound power. On a logarithmic curve, such as this, equal *percentage* increments on the power axis result in equal *absolute* increments on the volume axis.

What is remarkable about that effect is that it is largely independent of the initial generator power. If the initial power was 1 mW, the increase will be to 1.26 mW. If the initial power was 10 mW, the increase will be to 12.6 mW. The absolute power differences are very different—0.26 mW in the first case, and 2.6 mW in the second case. Only the *percentage* difference is constant at 26%.

Enter: the DeciBel

Given that characteristic of human hearing, how do you relate sound power to "loudness?" In the late 19th century that was a question of interest not only to physiologists, but to researchers in the emerging technology of telephone communications. The answer lies in a simple mathematical relationship.

Suppose you drew a graph to map the ear's response to sound power, letting the horizontal axis represent sound power and the vertical axis represent units of volume. For each 25% increase on the horizontal axis, you would go up one unit on the vertical axis and place a point. If you then filled in the gaps between points with a smooth curve, you would have a graph resembling Fig. 1.

Figure 1 is what is known in mathematics as a *logarithmic curve*. It is characteristic, not just of the human senses, but of many natural effects. It can be represented as an equation and, once a base value is supplied, can be calculated to any degree of precision.

Taking advantage of that correlation, researchers created a new logarithmic unit of measurement to relate sound power to perceived loudness. The new unit was called the *bel*, in honor of Alexander Graham Bell, inventor of the telephone and a pioneer in the science of acoustics. It soon became apparent that the bel was too large a unit for practical work, so a fractional unit was created and christened the *deciBel* (abbreviated dB), which is literally one-tenth of a bel.

Power DeciBels

The basic deciBel formula is:

$$dB = 10 \text{ Log } (P_1/P_2)$$

In that formula "P_1/P_2" is a ratio, expressed as a fraction, of two powers. The "Log" denotes the common logarithm or logarithm base-10 of the power ratio. The formula says, divide out the power ratio you are interested in, then find the common logarithm of the quotient. You can look up the logarithm in a mathematical table, but since you were born in the 20th century you'll probably punch it up on your scientific calculator using the "LOG X" key. Finally, multiply the result by 10, and that gives you the dB equivalent of the power ratio.

To see how the formula works, let's try applying it to the tone experiment. If the initial power was 1 mW and the increase was to 1.26 mW, the dB equivalent had to be:

$$dB = 10 \text{ Log } (1.26) = 1$$

A nice round number. If the initial power was 10 mW and the increase was to 12.6 mW, the dB equivalent was:

$$dB = 10 \text{ Log } (12.6) = 1$$

Again the dB equivalent is 1. As a matter of fact, we would calculate 1 dB for each "louder" step, because the percentage difference is constant at 26%, and it is the percentage difference that the deciBel represents.

Incidentally, the fact that one step comes out as 1 dB is one reason the deciBel became more popular than did the coarser bel.

Working Backward

On occasion, it's useful to calculate back from deciBels to a power ratio. That's also easy to do with a scientific calculator. The formula is:

$$P_1/P_2 = 10^{dB/10}$$

In other words, take the given dB value and divide it by 10. Then find the antilog of that number (raise 10 to the power of the number). The result is the quotient P_1/P_2. Note that you cannot get back to the original P_1 or P_2 separately. That information is lost in the dB calculation.

The basic deciBel formula works with power ratios. In electronics, however, power is not easy to measure directly. Except in microwave work, it's more common to measure voltages in a circuit.

Fortunately, a slight modification to the power deciBel formula allows dB's to be calculated directly from voltage measurements. If the voltages are measured across *the same or equal resistances*, then power deciBels may readily be calculated by:

$$dB = 20 \text{ Log } (V_1/V_2)$$

The only difference between that formula and the power formula is that the Log of the ratio is multiplied by 20 instead of 10 (see Table 1). The reason for that difference is that power is proportional to the *square* of the voltage, and the Log of a number squared is equal to twice the Log of the number.

Taking the example circuit in Fig. 2:

$$dB = 20 \text{ Log } (10/1) = 20 \text{ dB}$$

Which is the same as the power decibel result because the calculation of input power and output power yield:

$$P_2 = 1^2/50 = .02 \text{ W}$$
$$P_1 = 10^2/50 = 2 \text{ W}$$

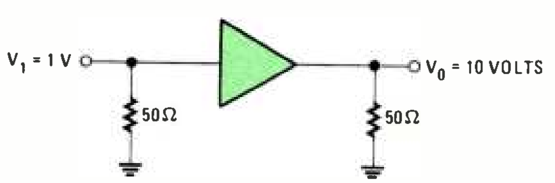


Fig. 2—The standard power deciBel can be calculated from either power or voltage measurements. However, the voltage formula will give true power deciBels only if the voltages are measured across the same or equal resistances.

TABLE 1—COMMON dB VALUES

dB	Power Ratio	Voltage Ratio
+100	10,000,000,000	100,000
+80	100,000,000	10,000
+60	1,000,000	1,000
+40	10,000	100
+20	100	10
+10	10	3.16
+6	3.98	1.99
+3	1.99	1.41
+1	1.26	1.12
+0.1	1.02	1.01
0	1	1
−0.1	.98	.99
−1	.79	.89
−3	.50	.71
−6	.25	.50
−10	.10	.32
−20	.01	.10
−40	.0001	.01
−60	.000001	.001
−80	.00000001	.0001
−100	.0000000001	.00001

$$dB = 10 \text{ Log } (2/.02) = 20 \text{ dB}$$

To calculate back to the voltage ratio, use:

$$V_1/V_2 = 10^{dB/20}$$

Bear in mind that that is just another way of calculating deciBel power ratios. The results of the calculation will be power deciBels so long as the voltages V_1 and V_2 are measured across the same or equal resistances. For unequal resistances we can calculate the voltage dB's (see Fig. 3), but keep in mind that they are not equivalentto power dB's. Thus, the circuit shown will yield a 20-dB voltage gain and an unequal power gain.

It is possible to use the formula with a correction factor for unequal resistance, but then the simplicity disappears—you might as well calculate the two power values and use the basic formula.

The voltage formula may be used with current measurements as well. The V_1/V_2 term is replaced with I_1/I_2 and the same rules apply concerning resistances. However, deciBels are rarely calculated from current ratios because current is generally more difficult to measure than voltage. For that reason, we won't complicate the discussion with currents.

Voltage DeciBels

Now here's a curve ball: In many areas of electronics we don't care all that much about power. Often it is just voltage that we are interested in. In a radio receiver, for example, most of the design effort goes into increasing the voltage amplitude of the desired signal, while excluding noise and unwanted signals. Power is important only in the front end and the final power amplifier.

That fact has led to a practice in some applications of calculating deciBels based solely on voltages and simply ignoring the resistances involved. The deciBel values obtained indicate voltage relationships, not true power relationships. Thus we have "voltage deciBels."

On rare occasions, the symbol dBV is used to distinguish voltage deciBels from power deciBels (see box). More often,

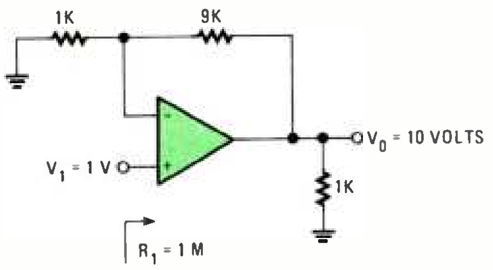


Fig. 3—In some applications, power deciBels are impractical or irrelevant. In this op-amp amplifier circuit the input resistance is very large, but only approximately known, making it difficult to calculate power. Also, in an op-amp circuit we aare usuaally only ainterested in the voltage gain. It can be expressed using the voltage deciBel formula, but remember for unequal resistances *voltage* deciBels are not equivalent to *power* deciBels.

voltage deciBels are quoted in just plain "dB's." So how do you know whether voltage deciBels or power deciBels are intended? Well, you're not going to like it, but it is usually assumed that you know from the context in which the dB reference appears.

The dB's are power deciBels in applications where power is important, such as microwave circuits, antennas, and speaker drive electronics. DeciBels are usually voltage deciBels in low-frequency (less than 10 MHz) signal-processing circuits.

But isn't using the voltage deciBel a kind of cheating? Yes, it is, sort of. But it does make life easier, and that is the whole purpose of the deciBel.

Why Use dB?

There are two primary advantages to using deciBels. One is that the deciBel simplifies computation. The other is that many measurements are much more meaningful when they reported in dB's.

Let's look at the computational advantages first. Long before the deciBel was invented, and longer still before the electronic calculator appeared, logarithms were used to simplify large-number arithmetics. A highly useful property of logarithms is that if you add the logarithms of two numbers, A and B, and then take the antilog of the result, you have the *product* A × B. Furthermore, if you subtract the logarithm of B from the logarithm of A and take the antilog of the result you have the quotient A/B. Logarithms also simplify the task of finding powers and roots of numbers.

Since deciBels are basically logarithms of power or voltage ratios, the same principles apply. Figure 4 illustrates a hypothetical amplifier cascade. The question is, what is the overall gain of the circuit if the gains of amps 1, 2, and 3 are 12 (21.6 dB), 14 (22.9 dB), and 23 (27.2 dB) respectively? One way of finding the answer is to multiply out the ordinary gains:

$$12 \times 14 \times 23 = 3864$$

Even for a circuit as simple as that one, most people can't figure the result without the aid of a calculator or paper and pencil. But now suppose the gains as expressed in deciBels are used. To find the overall gain, all you have to do is to *add* the gains:

$$21.6 + 22.9 + 27.2 = 71.7$$

Notice that the overall gain in deciBels will be a more compact number than the ordinary overall gain. That feature of the deciBel is helpful when you have to work with very large or very small power or voltage ratios. A case in point is the path loss from a geostationary satellite to a receiving antenna on Earth. A typical path loss is about 200 dB, which is an easy number to handle. But suppose you had to work with the equivalent power ratio:

.00000000000000000001

That's 1×10^{-20} if you like scientific notation. But 200 dB is much easier to comprehend, which brings us to the second advantage of deciBels.

Accuracy

To appreciate how measurements quoted in deciBels can be more meaningful, consider the overall ordinary gain for the circuit of Fig. 4. The number 3864 implies a gain accuracy of about .25%. No ordinary amplifier will be that accurate. Even with trimming it is difficult to build amplifiers with a verifiable gain accuracy of better than about 1%, due simply to limitations of the measuring instruments. Then there are the inevitable fluctuations of gain with signal frequency, power supply variations, temperature changes, and component aging.

A more realistic evaluation of the circuit gain would be about 3,900. But how helpful is that number? Suppose you built the circuit, measured the gain under specified conditions, and discovered it was actually about 4,300. Is that a serious error? To find out, you might calculate the percentage error to be about 12%. You then could determine whether a 12% gain error was acceptable in the application.

But if you express the gain of the circuit in dB, all these numeric manipulations are unnecessary. The overall gain is just 71.7 dB. Reporting dB gain to one decimal place implies an accuracy of about 1.16%, which is very close to what can be measured easily. The erroneous gain of 4,300 transforms to 72.7 dB (assuming voltage gain is measured). The gain error is therefore only 1 dB, which is quite acceptable in many amplifier applications.

Now, armed with a basic understanding of the deciBel, let's examine the meanings of the statements presented at the beginning of this article.

"Amplifier Gain is ...."

The ordinary gain of an amplifier is the ratio of the output power to the input power, or of the output voltage to the input voltage. The deciBel gain is just the deciBel equivalent of that ratio. If the gain is a power ratio, a factor of 10 is used in the deciBel conversion. If the gain is a voltage ratio, a factor of 20 is used.

$$\text{Power gain: dB} = 10 \text{ Log } P_o/P_i$$
$$\text{Voltage gain: dB} = 20 \text{ Log } V_o/V_i$$

A 20-dB power gain corresponds to 100 output watts per input watt. A 20-dB voltage gain corresponds to 10 output volts per input volt. For dB voltage gain, the actual power gain depends on the input and load resistances.

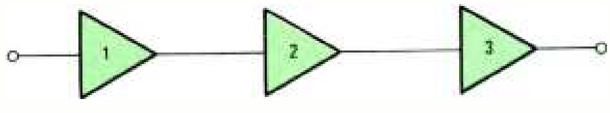


Fig. 4—When amplifiers are cascaded, the total ordinary gain is the product of the stage gains. However, if the gains are in deciBels, the total deciBel gain can be calculated as the *sum* of the deciBel stage gains.

Special dB Abbreviations

One of the biggest problems in understanding deciBels is figuring out what the 0-dB reference is. Sometimes an additional character is tacked onto the dB abbreviation to give you a hint. Here's a glossary of the more common "special" deciBels.

dBa—DeciBels adjusted: Used mostly in telephone work to quantify system noise. The reference level is -90 dBm (see below) into 600 ohms, and the measurement is weighted to approximate the ear's frequency-dependent response to noise.

dBc—DeciBels referred to carrier: Used in measurements of modulation and distortion, where new frequencies are produced. These deciBels represent the ratio of the new frequency amplitude to the base or carrier frequency amplitude.

dBf—DeciBels referred to 1 femtowatt: Decibel ratio of signal power to 1 femtowatt (10^{-15} W). Used in radio work, particularly with broadcast-band FM receivers, to quantify signal strength in sensitivity specifications.

dBi—Decibel gain over isotropic: Used in specifications for directional antennas to quantify the power gain in the favored direction compared to a theoretical isotropic antenna, which radiates power equally in all directions.

dBm—DeciBels referred to 1 milliwatt: Decibel ratio of power to 1 milliwatt. Used extensively in telephone, audio, and microwave work.

dBV—Voltage deciBels: 1) DeciBels calculated solely on the basis of voltage aplitude, without regard to power relations. 2) DeciBels referred to standard level of 1 volt, without regard to power relations.

dBW—DeciBels referred to 1 watt: Decibel ratio of power to 1 watt.

"Insertion Loss is ...."

Insertion loss is the loss in power or voltage due to some device—such as a transformer or passive filter—being "inserted" in the signal path. The ordinary loss is the percentage reduction in power or voltage. The deciBel equivalent of the loss is calculated as in the case of amplifier gain, and it is a negative number. Usually, however, the minus sign is dropped if the term "loss" is used. An insertion loss of 1 dB means a loss of 26% in power, or of 12% in voltage.

"Bandwidth (-3 dB) is ...."

Most electronic devices have frequency-dependent characteristics. An amplifier, for example, will have relatively constant gain over a certain frequency range, but the gain will drop, or "roll off," outside that range. A bandwidth specification indicates how wide the operating frequency range is. By tradition, the upper and lower band edges are considered to be the frequencies at which the gain of the device has dropped by 3 dB. A drop of 3 dB means power has fallen to 50% of its mid-band value, or voltage has fallen to 70.7% of its mid-band value.

"Dynamic Range is ...."

Dynamic range refers to the ratio of the largest signal that can be handled without excessive distortion to the smallest signal that can be detected. The smallest signal that can be detected is usually determined by the inherent system noise. If an amplifier with a gain of 40 dB (voltage gain of 100) produces 1 mV of noise with its input terminated to ground, then its inherent noise referred to the input is .01 mV. If the same amplifier generates excessive distortion when the output reaches 1 volt, then the largest input signal that can be handled is 0.01 volt. The dynamic range ratio is therefore:

.01 volt/.01 millivolt = 1000

The voltage deciBel equivalent is 60 dB.

"Antenna Forward Gain is....."

Antenna gain is the ratio of the power radiated or received in a favored direction to the power radiated or received in that direction by an isotropic antenna. An isotropic antenna is a purely theoretical antenna that radiates power equally in all directions. An antenna with gain does not increase the total radiated power; it only focuses it some direction. DeciBel antenna gain is always a power ratio. An antenna with 10 dB of gain radiates or receives 10 times more power in the favored direction than an isotropic antenna would.

"Sensitivity is...."

Sensitivity is the ability of a receiver to detect and amplify weak signals in the presence of electronic noise. The statement means that with 1 microvolt of signal applied to the input of the receiver, the signal at the output or at some key stage of the receiver is 10 dB greater than the noise generated within the receiver itself. The signal-to-noise ratio may be a power or voltage ratio. If voltage is used, it is root-mean-square (rms) voltage, which is the DC voltage that would produce the same power in a given load over time. Noise must be measured in rms volts because the instantaneous noise voltage varies unpredictably.

"Ambient Noise Level is...."

The scale on which audible sound is measured is Sound Pressure Level (denoted Lp). It is calibrated in dB, and the reference level is the nominal threshold of hearing. In other words, a sound with an Lp of 0 dB can just barely be heard by the average person (in theory, at least). Table 2 gives the Lp for various familiar sounds through the threshold of pain, at which a sound is so loud hearing may be damaged.

The physical quantity measured for Lp is the sound pressure amplitude. The units of pressure amplitude (P) are dynes per square centimeter (dynes/cm^2) or microbar, which are numerically equivalent units. By definition:

(Continued on page 98)

TABLE 2—SOUND MAGNITUDE

SOUND SOURCE	dB
Large rocket engine nearby	180
Jet takeoff nearby	150
Heavy machine gun[1]	120
N.Y. subway train in station	100
Heavy truck, 50 ft; Niagara Falls[2]	90
Noisy office; Average factory	80
Busy traffic on city street	70
Normal conversation	60
Quiet office	50
Public library	40
Whisper at 15 ft	30
Normal breathing[3]	10
Hearing threshold	0

Notes:
[1] Pain threshold
[2] Constant exposure can cause hearing loss
[3] Barely audible

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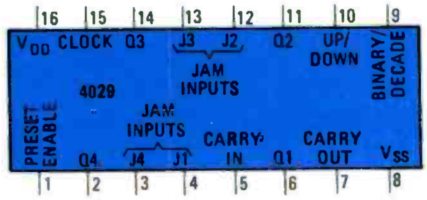
46 Hands-on Electronics FactCard — 4029: Presettable Binary Decade Counter



Features

● Wide supply voltage range	3V to 15V
● High noise immunity	$0.45V_{DD}$ (typ.)
● Low power TTL compatibility	fan out of 2 driving 74L or 1 driving 74LS
● Parallel jam inputs	
● Binary or BCD decade up/down counting	

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

General Description

The CD4029BM/CD4029BC is a presettable up/down counter which counts in either binary or decade mode depending on the voltage level applied at binary/decade input. When binary/decade is at logical "1," the counter counts in binary, otherwise it counts in decade. Similarly, the counter counts up when the up/down input is at logical "1" and vice versa.

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

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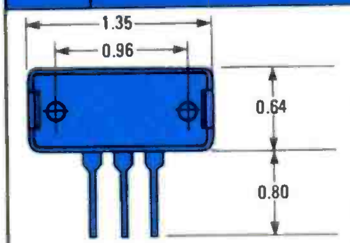
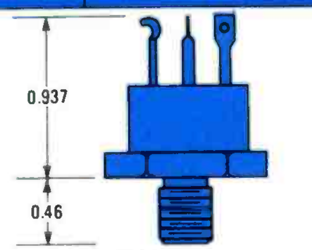
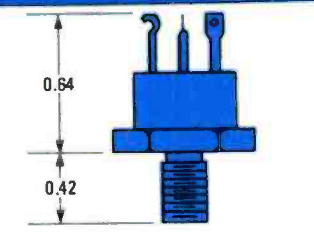
47 Hands-on Electronics FactCard — Transistor Package Outlines (All Dimensions in Inches)



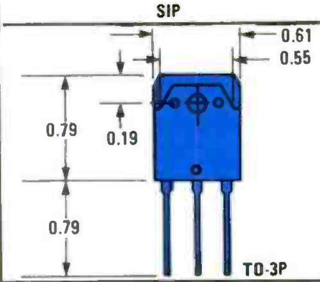
SIP



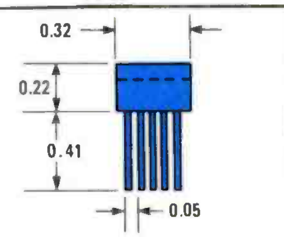
TO-63



TO-61



TO-3P



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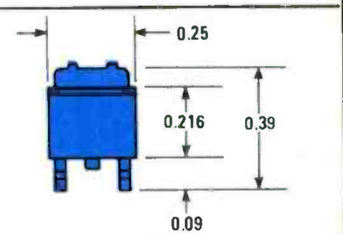

DPAK

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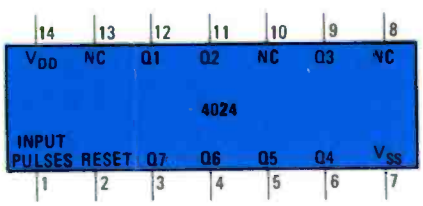
48 Hands-on Electronics FactCard — 4024: 7-Stage Ripple-Carry Binary Counter



Features

● Wide supply voltage range	3.0V to 15V
● High noise immunity	$0.45V_{DD}$ (typ.)
● Low power TTL compatibility	fan out of 2 driving 74L or 1 driving 74LS
● High speed	12 MHz (typ.) input pulse rate $V_{DD} - V_{SS} = 10V$
● Fully static operation	

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

General Description

The CD4024BM/C-4024BC is a 7-stage ripple-carry binary counter. Buffered outputs are externally available from stages 1 through 7. The counter is reset to its logical "0" stage by a logical "1" on the reset input. The counter is advanced one count on the negative transition of each clock pulse.

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

46 Hands-on Electronics FactCard — 4029: Presettable Binary Decade Counter

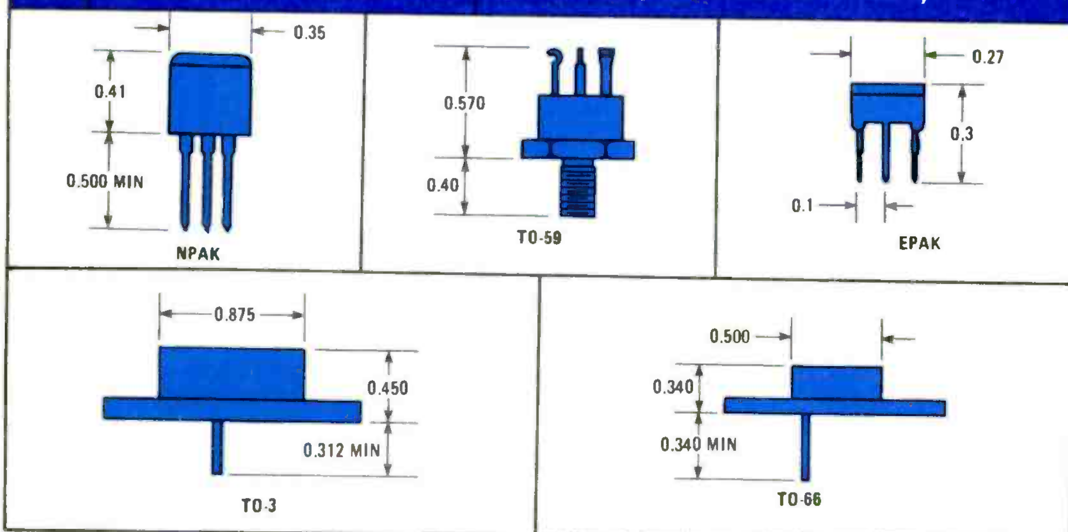
STATIC ELECTRICAL CHARACTERISTICS

CHARACTERISTIC	CONDITIONS V_O (V)	V_{IN} (V)	V_{DD} (V)	LIMIT at 25°C (TYP)	UNITS
Quiescent Device Current, I_{DD} Max	—	0,5	5	0.04	µA
	—	0,10	10	0.04	
	—	0,15	15	0.04	
Output Low (Sink) Current I_{OL} Min.	0.4	0,5	5	1	mA
	0.5	0,10	10	2.6	
	1.5	0,15	15	6.8	
Output High (Source) Current I_{OH} Min.	4.6	0,5	5	−1	
	2.5	0,5	5	−3.2	
	9.5	0,10	10	−2.6	
	13.5	0,15	15	−6.8	
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 Low-Level V_{OL} Max.	—	0,5	5	0	V
	—	0,10	10	0	
	—	0,15	15	0	
Output Voltage High-Level, V_{OH} Min.	—	0,5	5	5	
	—	0,10	10	10	
	—	0,15	15	15	
Input Low Voltage, V_{IL} Max.	0.5,4.5	—	5	—	V
	1,9	—	10	—	
	1.5,13.5	—	15	—	
Input High Voltage V_{IH} Min.	0.5,4.5	—	5	—	
	1,9	—	10	—	
	1.5,13.5	—	15	—	

47 Hands-on Electronics FactCard — Transistor Package Outlines

(All Dimensions in Inches)



48 Hands-on Electronics FactCard — 4024: 7-Stage Ripple-Carry Binary Counter

STATIC ELECTRICAL CHARACTERISTICS

CHARACTERISTIC	CONDITIONS V_O (V)	V_{IN} (V)	V_{DD} (V)	LIMIT at 25°C (TYP)	UNITS
Quiescent Device Current, I_{DD} Max	—	0,5	5	0.04	µA
	—	0,10	10	0.04	
	—	0,15	15	0.04	
Output Low (Sink) Current I_{OL} Min.	0.4	0,5	5	1	mA
	0.5	0,10	10	2.6	
	1.5	0,15	15	6.8	
Output High (Source) Current I_{OH} Min.	4.6	0,5	5	−1	
	2.5	0,5	5	−3.2	
	9.5	0,10	10	−2.6	
	13.5	0,15	15	−6.8	
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 Low-Level V_{OL} Max.	—	0,5	5	0	V
	—	0,10	10	0	
	—	0,15	15	0	
Output Voltage High-Level, V_{OH} Min.	—	0,5	5	5	
	—	0,10	10	10	
	—	0,15	15	15	
Input Low Voltage, V_{IL} Max.	0.5,4.5	—	5	—	V
	1,9	—	10	—	
	1.5,13.5	—	15	—	
Input High Voltage V_{IH} Min.	0.5,4.5	—	5	—	
	1,9	—	10	—	
	1.5,13.5	—	15	—	

A BEGINNERS GUIDE TO

FIBER OPTICS

By Fernando Garcia Viesca

Fiber optics is not a new technology, but how many hobbyists get a chance to mess with it? Well, here's your chance

FIBER OPTICS PROVIDES SUCH A DRAMATIC IMPROVEMENT FOR DATA transmission, that in the information-hungry society of the 21st century, it will become a vital data expressway over which men and computers will communicate. Fiber optics, however, is far from being new and at the cutting edge of technology. For over a decade, it has been extensively used by the military, telephone companies, and in high-speed computer links. But fiber optics has been slow to trickle to the hands of an average electronics hobbyist. But why? Keep on reading....

Today's Fiber

Take for example a dual, fiber-optic cable manufactured by Jetronic Lightwave Corp. It has a very rugged design which permits the cable to be pulled through ducts and conduits with little or no damage. Its cost was prohibitive, but recent developments in low-cost plastic fibers have brought down the cost to the equivalent of a good coax cable.

Difficultly in splicing was another reason why fiber optics have trickled so slowly to the hobbyist level. High-performance glass fibers required extremely elaborate procedures with exquisite attention to detail to splice fiber ends: and even more to couple them to opto transmitters and receivers. But recent strides in both fibers and connectors, have resulted in a technique known as DNP (*D*ry, *N*on *P*olish) splices for medium-to low-performance fibers.

Unavailability and high cost of optoelectric components was the last major reason. But with more semiconductor companies jumping on the optoelectronics bandwagon, price has decreased and availability increased. Now several mail-order electronics retailers offer evaluation kits. With one of those kits and this article, you'll learn some practical aspects of fiber optics. For a glossary of optical fiber terminology, see the box.

Fiber Superiority

There are six main improvements of fiber over traditional wiring. First, light weight and size (a single, small fiber can replace a large bundle of copper cable). That means the savings over copper approaches a 1000:1 ratio.

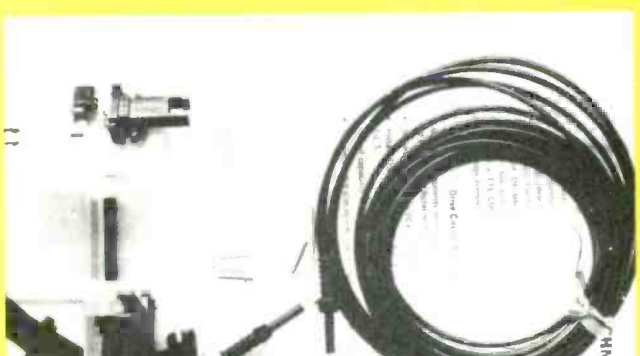
Also, theoretically speaking, the bandwidth of light is almost four orders of magnitude greater than that of radio waves. Practically, that has not yet been achieved; opto electronics is now at the same level as radio communication was in the early 1900's. We have not even scratched the surface of the media's capabilities; its information-carrying capacity may increase one hundred fold over the following decades. Anyway, the information-carrying capacity is enormous even by today's standards.

Further, all long-distance communication networks are prone to disruption from man-made or natural interference. That fact appealed almost immediately to the military, who have to have very reliable data links between sophisticated pieces of equipment that should not be knocked out easily by nuclear detonation—the radiation of a blast emits EMI (*E*lectro-*M*agnetic *I*nterference). But even in more mundane areas, an interference-free communication channel is an asset.

There's More

What's more, one of the worst enemies of any electronic installation from audio to computers, is the lack of electrical isolation between pieces of equipment. Groundloops, voltage transients, and noise result, and electrical failure at one place may cause failure in another.

With fiber optics, only the required data is coupled. Shielding is needless, and therefore, the receiving and transmitting



The transmitter board, receiver IC, 5 meters of optical fiber, and an assortment of connectors are included in the fiber optic kit from the supplier in the parts list.

ends may have a voltage difference of several thousand volts without harm. Also, flooded transmission lines pose no crosstalk or electrical corrosion problems.

Yet another feature makes an optical cable desirable: data security. Any attempt to tap the light within an optical fiber will result in substantially reduced power at the receiving end, and that power reduction is readily detectable. Also light inside the fiber does not radiate energy or otherwise induce detectable changes to the exterior. Those two characteristics make optical fiber communications intrinsically more secure than normal electrical communications.

Another feature is low propagation loss. Premium, telecommunications-grade fibers have lower attenuation than copper wiring. That reduces the amount of repeaters needed for long distance links. Low-cost fibers, however, exhibit larger attenuation than copper and are suitable only for short-distance runs.

On the Downside

Optical fibers do have a couple of disadvantages: The first is that optical communications are intrinsically serial in nature. That means that extensive parallel to serial and serial to parallel hardware has to be implemented to convert the universal parallel-bus conventions.

The second problem is the lack of standards that prevent engineers from designing or correctly applying the fibers. Both problems may be attributed to the fiber's infant-age status. Development of single serial-parallel, parallel-serial converter IC's is well under way, and as engineers gain confidence with the new technology, fibers will start to enjoy widespread use.

Fiber Interconnection

There is a large database of optical-fiber theory, but I've found little about more mundane aspects of fiber utilization; namely, about interconnection splicing.

Premium-grade glass fibers are difficult to splice together, and special tools are required for the job. But, for low-performance fibers where bandwidth and transmission distance are limited, plastic fibers that use DNP connectors are available. Even here information is scarce, so we'll first discuss fiber splicing and connection.

Fiber interconnections are similar to copper interconnections in two aspects; losses occur in the splices and in the transmission media. But how those losses occur in the fibers is a different story. Transmission losses are analogous to the ohmic resistance of a copper wire; i.e., once you have chosen the conductor type, there is nothing you can do to increase its signal-handling capacity.

But the analogy ends there, because with fibers it is possible to decrease the capacity. Bending, crushing, or any other mechanical stress, dramatically increases the loss. Treat the fibers with care; any bending radius should not be sharp, avoid pulling or exerting force on the fiber, and protect it from people stepping on it. We shall see in the experiments several amazing ways to actually decrease a fiber's performance.

Splicing Difficulty

With copper wire you need only be careful about cleaning and tightening the splice to obtain good electrical contact; in fibers there are several parameters you should take into account to have a good optical contact, namely: fiber separation (see Fig. 1A), lateral misalignment (see Fig. 1B),

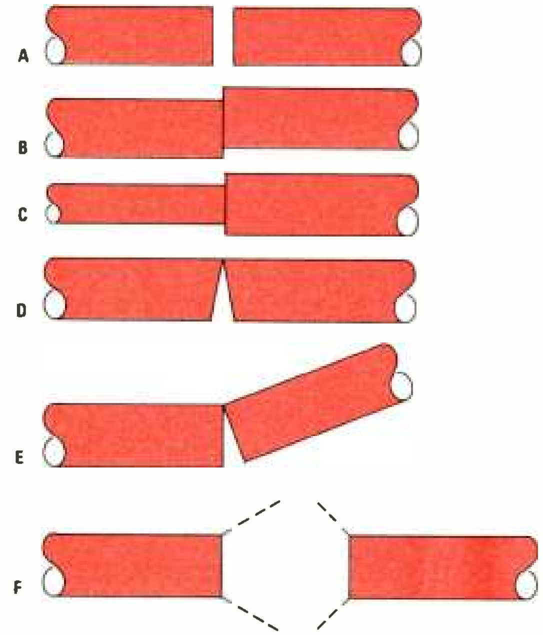


Fig. 1—These are the defects that occur within fiber couplings. Taking them in order, they are fiber separation (Fig. 1A), lateral misalignment (Fig. 1B), diameter variation (Fig. 1C), tilting (Fig. 1D), angular misalignment (Fig. 1E), and NA variation (Fig. 1F).

diameter variation between fibers in the splice (see Fig. 1C), tilting angle (see Fig. 1D), angular misalignment (see Fig. 1E), and NA (*N*umerical *A*parture) variation between fibers in the splice (see Fig. 1F). We'll show in the experiments how fiber performance is degraded by those splicing defects.

Hands-on Fiber Optics

We'll be emphasizing the practical aspects of fibers in this article, and though you can learn a lot just by reading it, the thrill of the hands-on experience is worth the bucks you'll spend in the evaluation kit offered by the mail-order house listed in the Parts List. And, with a couple of practical circuits, we'll show you how fiber links actually work. When you get the kit, it will have the following items:

The optical transmitters, despite their fancy name, are only LED's, but their emitting characteristics have been optimized for optical-fiber use. Sophisticated systems use a semiconductor laser here. The kit also includes the driving circuit and PC board.

The connectors are from the AMP Corporation optimate series of connectors. Those are specifically designed to be used with plastic fibers in DNP (dry, non-polish) applications. There are three types of connectors included: a plug assembly (male), a device mount (female), and a bulkhead receptacle (female-female). A barbed retention clip inside the connectors will hold a fiber securely in place.

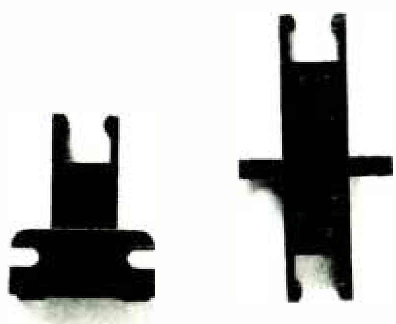
The optical receiver, in the early days, was a photodiode, whose tiny output had to be carefully amplified and conditioned. Except for very high-speed links, that has been superseded by an integrated-circuit detector, that delivers clean digital pulses. A schematic of a typical detector such as the one provided is shown in Fig. 2. For optimum performance, the spectral response of the transmitter and receiver should be matched.

The optical fiber we'll be using is the OE1040 plastic fiber, It is fairly easy to spice, though it is useful for short links only. More complete kits also include cutting fixtures and stripping tools, but they are expensive. We'll do it the poor man's way.

Splice of Life

Before you start cutting your fiber, lock away your faithful copper-wire tools, you won't need them. However, you'll need a very sharp knife, a magnifying glass, and a very fine-grain sandpaper.

We'll start by stripping the fiber. What could be done in copper wire with a knife, scissors, or even your teeth, in optical fibers is a delicate operation where you have to remove only the protective jacket without damaging the fiber's cladding. But after a few practice trys you'll get the feel of it. With your sharp blade, score along the fiber's exterior jacket. Push your blade firmly until you feel a change in the fiber's hardness. That means you have reached the core so do not cut deeper. After the jacket perimeter is cut all the way around, pull it with your fingers to expose the inner core, the optical fiber itself.



The optical connectors, from left to right, are the female-device mount, the female-female bulkhead receptacle, and the male plug assembly. all these come with the kit.

Look at the core right where you've made the cut with your magnifying glass; is it nicked? Perhaps damaged by the knife? If it is, cut everything and repeat the procedure. If that sounds tedious, just remember your first your first run-in with coaxial cable.

The Connection

After you've mastered the stripping method, strip 3/8 in. off the outer jacket. With a magnifying glass look at the fiber's end. Chances are that it will have the defect shown in Fig. 1D. With your knife, cut the fiber at right angles. and look again with the magnifying glass. Repeat the procedure until you've mastered it. Note that in case you make a mistake, do not cut everything (jacket and core) again, just back up about 1/16 of an inch from the fiber's end and cut again. The Optimate connectors need only about 1/8 of an inch of naked fiber to work properly.

After you have obtained a resonable cut, chances are that it will still have a small defect. Though the fibers may work that way and need no polishing. I've found that performance may be increased somewhat with a small polishing procedure.

With a wet, fine-grain sandpaper, rub out the minor imperfections in the fiber's end. Do not try to polish everything, as the sandpaper binding materials may deposit on the fiber's surface impairing performance.

The final result should be a reasonably flat, shiny fiber

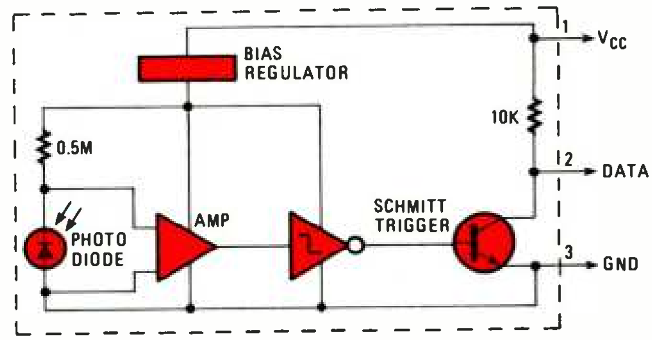


Fig. 2—In the integrated-receiver chip, amplifying and conditioning low-level photo-diode signals are done on-chip.

end. Now take the male plug assembly, and push the fiber until the end of it just barely protrudes from the plug.

Transmitter Installation

Take the female-device mount and introduce the transmitter LED fully into it. Check that the device is properly seated. Afterwards, it is a sound idea to put a couple of drops of epoxy on the leaded side of the device mount to prevent the LED from coming loose. *Do not* contaminate the light-emitting side of the LED. Repeat the procedure for the integrated receiver and another female-device mount. By the way, in the kit sent to me the transmitter and receiver were not identified. They are packaged in identical TO5 housings with a clear top. Being afraid to damage the devices with an improper connection, I looked through the top, and found that one device had a larger chip inside. I assumed that that was the receiver—an assumption that proved to be correct.

Examine the connectors' ends, and wipe out any debris. They are now ready to be plugged together.

Experimenting With the Link

Figure 3A shows the transmitter-board schematic. It is an evaluation board made by Honeywell. (The transmitter

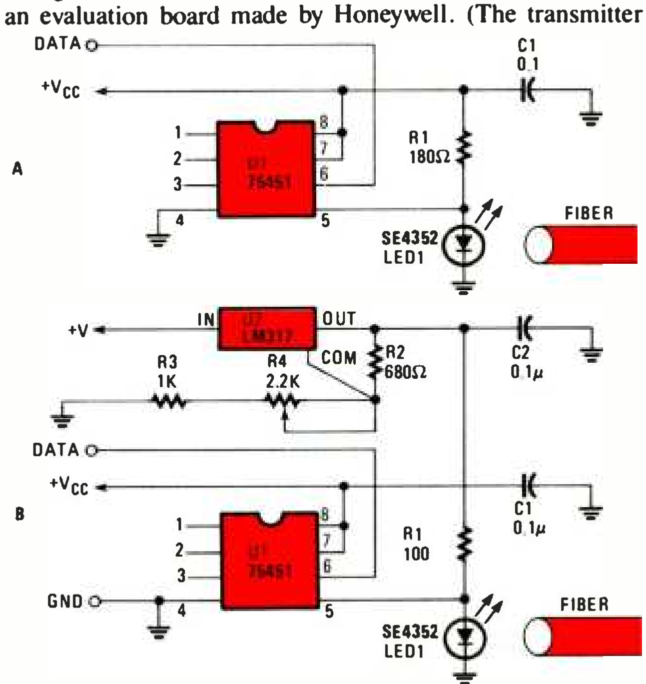


Fig. 3—The transmitter PC board comes with the schematic depicted in Fig. 5A, but we'll modify it as shown in Fig. 5B.

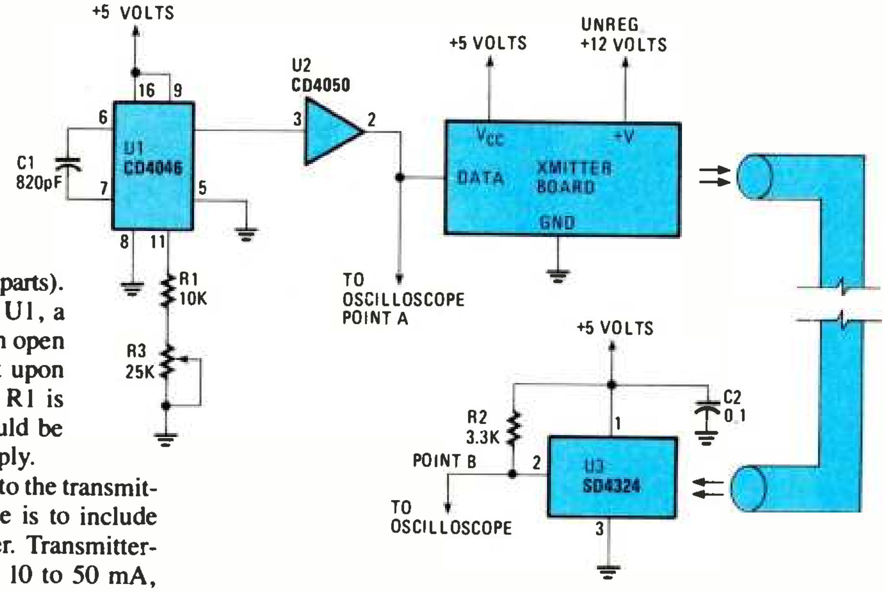


Fig. 4—With this test oscillator circuit, several fiber parameters such as bandwidth and rise time can be tested.

LED and the integrated receiver are Honeywell parts). The data to be transmitted is fed to pin 6 of U1, a dual, peripheral driver. Its output, pin 5, is an open collector that steals the LED's drive current upon turn on. Upon turn off, the current through R1 is available to drive the LED. The circuit should be fed with a well regulated +5-volt power supply.

Figure 3B shows some modifications done to the transmitter to increase its versatility. What I've done is to include the capability to adjust the transmitted power. Transmitter-LED current may be adjusted from roughly 10 to 50 mA, by means of a variable voltage supplied by an adjustable voltage regulator U2, and associated components. You have to provide an extra +12-volt DC power supply. It need not be regulated, but it should be well filtered.

Transmitted Power

With the circuit built thus far you can learn about several fiber parameters before attempting anything further.

Perhaps the most important optical-fiber parameter in the application is the received power. Though a power meter has to be purchased for any serious work in fiber optics, that device would be gross overkill here.

Fortunately enough, there are simpler means to achieve the desired result. Assemble the circuit shown in Fig. 4. Since it will be used for learning purposes only, I recommend building it on a Protoboard. The circuit is basically a 50% duty-cycle oscillator, built around a voltage-controlled oscillator, with a ballpark frequency of 50kHz. Integrated circuit U2 interfaces the CMOS output of the CD4046 with the TTL input of the 75451 used on the transmitter board. Apply power to the circuit, and with a scope, monitor point A first and then point B. You may see that though you are transmitting at a 50% duty cycle at point A, the receiver's output at point B does not have a 50% duty cycle! Be prepared for another surprise; if you adjust the transmitter's potentiometer, the duty cycle is modified.

The Explanation

The reason is that the receiver IC has an optoschmitt section included, and depending on the received power, pulse-width stretching occurs.

Note the differences in the received pulse width as shown in the photos. They were fed with identical squarewaves, but at different optical powers.

Adjust now for a 50% duty cycle at point B. If you can't live with the rounded wave edges, include the optional pull-up resistor R2. Note that if you can't get a 50% duty cycle, and all your electronic components are working properly, then there's a faulty optical connection; so get back to practicing splicing!

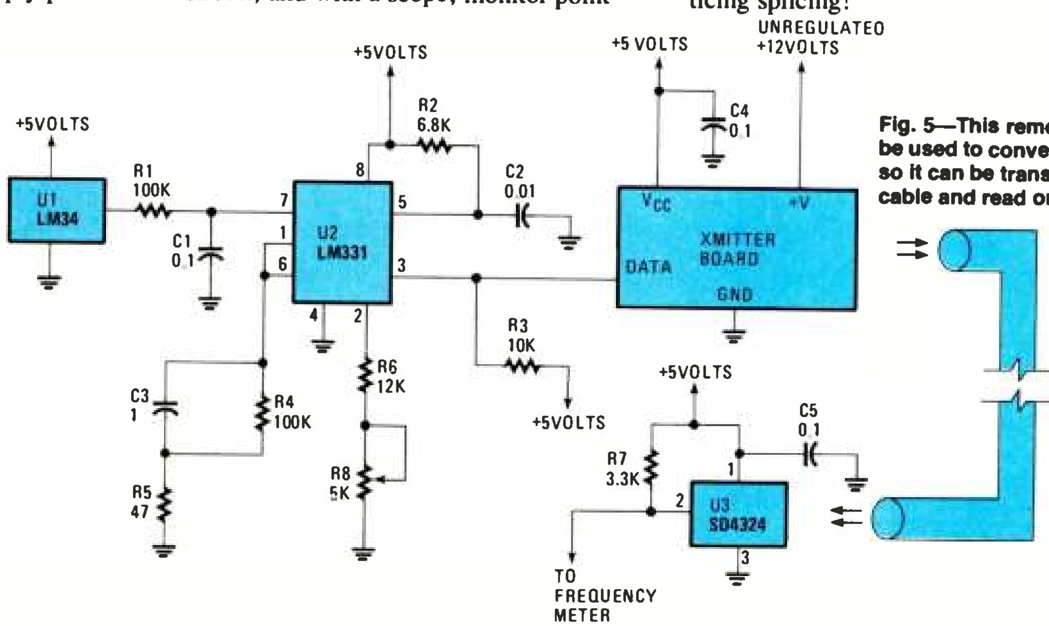
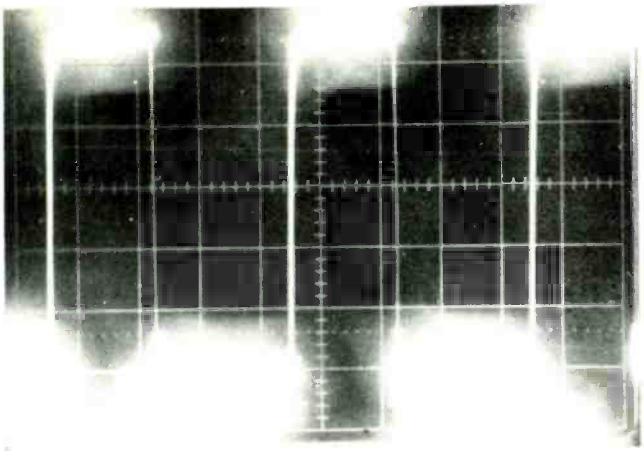
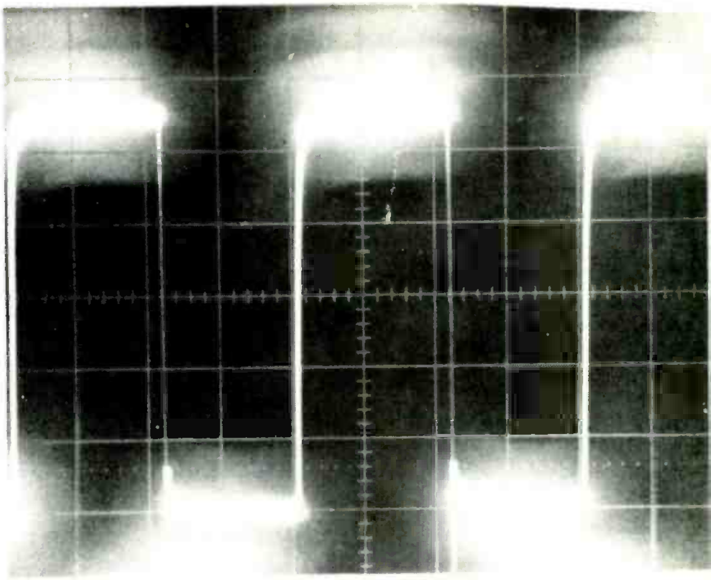


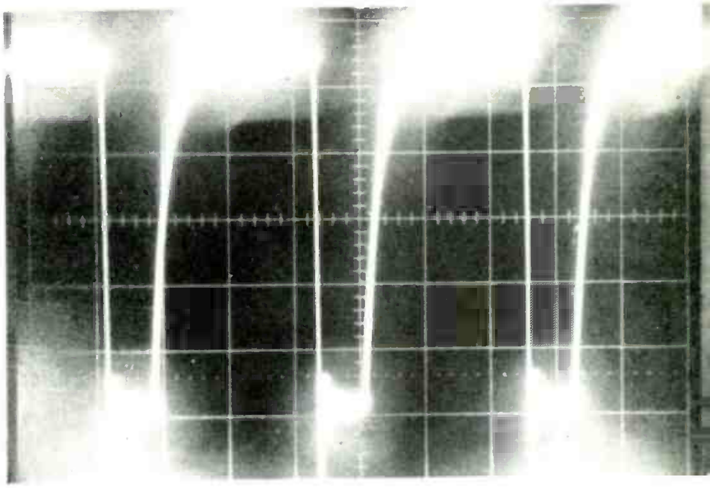
Fig. 5—This remote temperature sensor can be used to convert temperature to frequency so it can be transmitted over an optical-fiber cable and read on a frequency meter.



Note that the "on" time is shorter than the "off" time. That is a low-power transmission effect. To reduce that effect, higher output or optical repeaters are necessary.



Note how the "on" time has been increased. That is a high-power transmission effect. Except for the transmitter power, all other parameters are equal to those in the previous photo, yet the results are opposite.



If the frequency is increased, pulse identity begins to suffer until it disappears. That is due to bandwidth limitation. The frequency used here is more than six times that of the two preceding photos.

Transmission Losses

Now torture the fiber. Bend it, cut it slowly, crush it. You may see in your scope how losses in a link are generated. (Warning: do that only very near the connector, extreme torture will produce irreversible damage. Though you can cut the damaged segment, the shorter the damaged section, the better). You may even want to redo your connector splic-cing to get a feel for the effects of a poor connection.

Before leaving the experiment, again make a neat splice and adjust the power for a 50% duty cycle at 50kHz.

Bandwidth

After you havez cooncz1uzded the above experiment, you may wish to try a more startling one dealing with the fiber's bandwidth. Change the frequency-determining capacitor C1 in Fig. 4 to 100 Picofarads. You will obtain a much-higher frequency and perhaps nothing at point B. Don't panic, just lower the frequency all the way down with R4. Bring it up slowly. There will be a point where you should see a slow rise time (see photo). That happened to me at 310 kHz, but it can happen at another frequency. If the frequency is in-creased further, the signal just disappears because we have reached the upper limit of the optical-link's bandwidth.

If a frequency of 350 kHz sounds like too little available bandwidth, remember this is a low-cost link. Premium-grade links have bandwidths on the order of tens of Megahertz, but they still have a limit. That comes from the intrinsic limitations of electronic components, but it mostly comes from a fiber characteristic known as pulse dispersion.

Practical Use

Experimentation is nice for the novice user, but there comes a time when a practical use for the fiber is desired. When pursuing an actual use for the fibers, two facts must be kept in mind: First, fiber-optic links are basically optimized for digital-data transmission. You can send analog signals, but in our particular case that mode is forbidden because of the optoschmitt section of the receiver. Second, fiber optics handle digital information in serial form only. Of course you could set up an arrangement of several fibers in parallel to send parallel information, but the cost would be prohibitive.

Fortunately, there are several easy ways to get around those drawbacks, and we'll give you a couple of text-book circuits you can start with to build your confidence and open your mind to new applications. The circuits have been tested, but are by no means optimized, since they are only here to show the optical fiber's capabilities.

Temperature Transducer

A widely used and inexpensive way to perform serial analog-to-digital conversion, is a technique known as frequency-to-voltage conversion (sometimes denoted F/V). An analog volt-age is fed to a VCO (*V*oltage *C*ontrolled *O*scillator), and its output frequency transmitted over a serial data link. The data in the receiving end may be either fed to a frequency counter for a direct digital readout; reconverted to an analog voltage by a PLL or similar frequency-to-voltage conversion and measured; or, if you are skilled enough with assembly language programming, connected to your computer's serial port for processing and control.

Figure 5 shows the actual circuit. In the circuit an IC temperature sensor, U1, is used to supply a control voltage

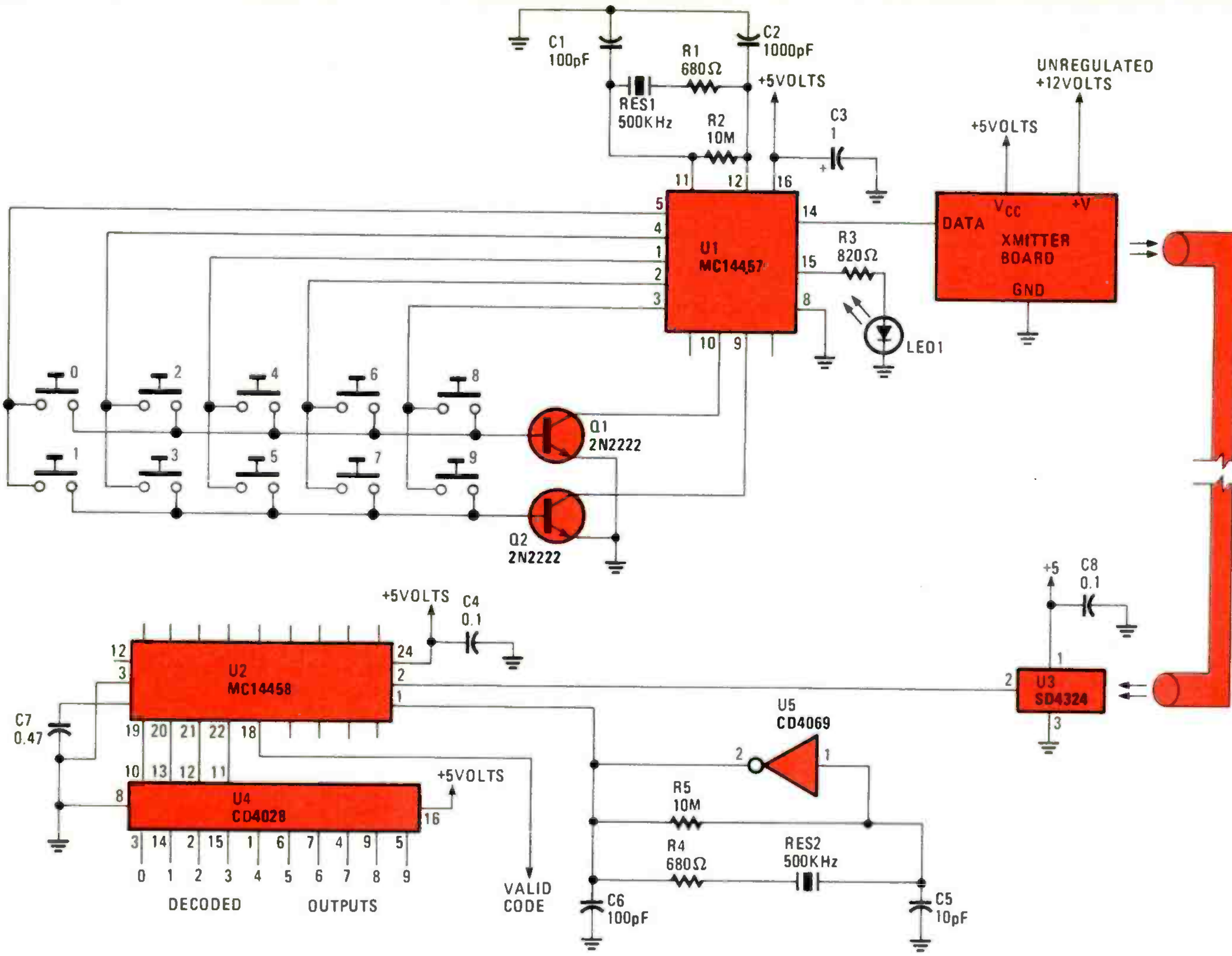


Fig. 6—With the use of common remote control circuits, commands may be transmitted optically between locations.

to U2, a voltage-controlled oscillator. Integrated circuit U1 may be either an LM34 or LM35, depending on whether you desire farenheit- or centigrade-scale sensing. Since those IC's provide an accurate voltage without any trimming, we need only adjust the VCO for the frequency output desired.

Suppose that an LM34 is used and that a temperature range of 32°F to 212°F is desired. Then the control voltage will vary between .32 to 2.12 volts. The VCO may be easily adjusted for any frequency range within its 10 kHz. capability, so a sensible and straightforward solution would be to choose a 10Hz per degree ratio for an output of 320 to 2120 Hz.

Frequency is a function of R2, R4, R6, R4, C2, and, of course, the control voltage. With R4 we can adjust for a full scale frequency output of 2320Hz., when the sensor is at 232°F. Accurate frequency-determining components are vital, so use metal-film resistors and polystyrene or NPO ceramic capacitors. The frequency output is coupled to our modified transmitter board, that in turn drives the transmitter LED. Note: Only U1 should be subjected to those temperature extremes.

The receiver U3 converts the light pulses into TTL-compatible pulses, that may be fed to a frequency meter for direct readout. Optional pull-up resistor R7 should be included when either a very fast risetime is needed or a heavy load is driven.

Remote Controller

You should be familiar with the handheld infrared controllers for VCR's and TV's. Thanks to those familiar gadgets, there are several inexpensive LSI transmitter/receiver IC pairs that encode a command, transmit it with a suitable modulation technique, receive, and decode it.

Though primarily intended for TV-like sets, those IC's coupled with suitable peripheral circuitry can be used for virtually any remote-control function. If we replace the conventional infrared LED's and phototransistors with fiber-ready optical components, and put an optical fiber in between, then we have a nice, optical-fiber link for any remote-control use.

The circuit shown in Fig. 6 works as follows: commands from any of the keys are encoded by U1. The transistors Q1 and Q2 work as column drivers. The keyboard position is encoded into frequency-modulated, biphase data, something similar to FSK (*F*requency-*S*hift *K*eying).

The ceramic resonator X1 accurately times the internal-clock oscillator, much like a crystal. Resistor R1 prevents overdriving X1. The IC, U1, has a powerful enough output to directly supply current to a pilot LED without any additional devices, but the transmitter LED should be driven by our modified transmitter board. The IC enters in the standby mode after the transmission of the last bit, and stays there until a button is again pushed.

PARTS LIST FOR THE TRANSMITTER BOARD

SEMICONDUCTORS

LED1—SE4352 Transmitter LED
U1—75451, Dual, peripheral driver
U2—LM317, Positive, adjustable, voltage regulator

RESISTORS

(All resistors are 1/4-watt, 5% units unless otherwise noted)
R1—100-ohm
R2—680-ohm
R3—1000-ohm
R4—2200-ohm, potentiometer

ADDITIONAL PARTS AND MATERIALS

C1, C2—0.1-µF, 50-WVDC ceramic disc capacitor

Digi-Key Corp., PO Box 677, Thief River Falls, MN 56701; Tel. 218/681-6674, are suppliers of the DNP lab kit, part A1755-ND. Also the following separate parts: plug assembly, part A1703; female-device mount, part A1705; female bulkhead receptacle, A1707; fiber-optic cable, part A1700; and "Designer's guide to fiber optics," part A1799.

PARTS LIST FOR THE TEST OSCILLATOR

SEMICONDUCTORS

U1—CD4046, Voltage-controled oscillator
U2—CD4050, Op-amp buffer
U3—SD4324 Integrated optical receiver

RESISTORS

(All resistors are 1/4-watt, 5% units unless otherwise noted)
R1—10000-ohm
R2—3300-ohm
R3—25000-ohm

ADDITIONAL PARTS AND MATERIALS

C1—820-pF, ceramic disc capacitor (changed to 100 pF; see text)
C2—0.1-µF, 50-WVDC ceramic disc capacitor
Modified transmitter board, plastic Fiber, male plug assembly, female device mount.

PARTS LIST FOR THE REMOTE TEMPERATURE SENSOR

SEMICONDUCTORS

U1—LM34, Farenheit-temperature transducer
U2—LM331, Precision, voltage-controlled oscillator
U3—SD4324, Integrated optical receiver

CAPACITORS

C1, C4, C5—0.1-µF, ceramic disc
C2—0.01-µF, polypropylene
C3—1-µF, mylar

RESISTORS

(All resistors are 1/4-watt, 5% units unless otherwise noted)
R1, R4—100,000-ohm
R2—6800-ohm
R3—10,000-ohm
R5—47,000-ohm
R6—12,000-ohm
R7—3300-ohm
R8—5000-ohm, potentiometer.

ADDITIONAL PARTS AND MATERIALS

Modified transmitter board with components, plastic Fiber male plug assembly, female-device mount.

PARTS LIST FOR THE REMOTE CONTROL TRANSMITTER

SEMICONDUCTORS

LED1—Miniature, red, light-emitting diode
Q1, Q2—2N2222, NPN, general-purpose transistor
U1—MC14457, Remote-control encoder
U2—MC14458, Remote-control decoder
U3—SD4324, Integrated, optical receiver
U4—CD4028, BCD-to-decimal decoder
U5—CD4069, CMOS inverter

CAPACITORS

C1, C6—100-pF. ceramic disc
C2—1000-pF ceramic disc
C3—1-µF, electrolytic
C4, C8—0.1-µF, ceramic disc
C5—10-pF, ceramic disc
C7—0.47-µF, Mylar

RESISTORS

(All resistors are 1/4-watt, 5% units unless otherwise noted)
R1—680-ohm
R2—10-Megohm
R3—820-ohm
R4—680-ohm
R5—10-Megohm

ADDITIONAL PARTS AND MATERIALS

X1, X2—500kHz ceramic resonator
A modified transmitter board with components, plastic fiber, male plug assembly. and a female-device mount.

Circuit Specialists, PO Box 3047, Scottsdale, AZ 85257, can supply: the MC14457 and MC14458 integrated circuits, and Mallory CU455 ceramic resonators.

PARTS LIST FOR THE OPTICAL REPEATER

U1—SD4324, Integrated optical receiver
C1—0.1-µF capacitor
A modified transmitter board with components, plastic fiber, male plug assembly, and a female-device mount.

The demodulating IC, U2, hasn't enough gain to be driven by the tiny output from a phototransistor, so in the MC14457 literature you'll find preamplifier circuits associated with it, but here we've provided gain with the integrated receiver detector U3 used in fiber optics.

After U2 has demodulated the signals, a decoder IC, U4, is used to interface the commands. The output of the decoder can be used, in conjunction with the valid command signal, to drive a buffer, that may energize a relay, a lamp, or whatever.

However, that extremely versatile IC has absolutely no room for an integrated oscillator. That function must be performed externally with U5, X2, and associated components. Note that loading capacitors C6 and C7, differ in value from C1 and C2.

Optical Repeater

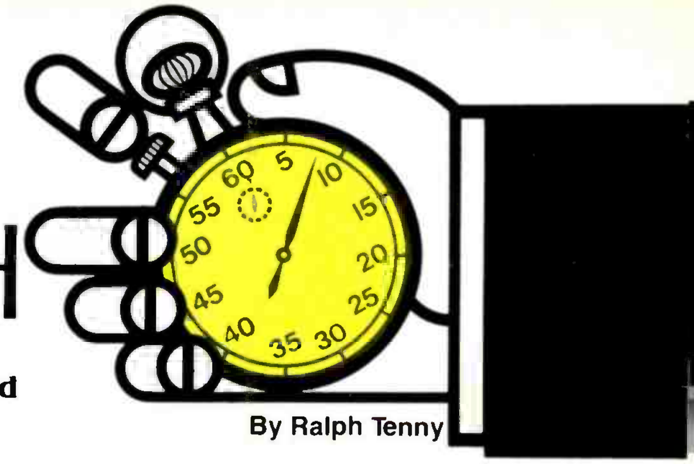
There will be instances when the available transmitter power won't be enough to properly drive a long fiber, and data errors may result. In those cases, a repeater should certainly be used.

With conventional electronic signals, repeater operation is somewhat tricky because induction, ground loops, and noise coupling are always present. Not so in the optical repeater shown in Fig. 7. As you can see, the AC supply lines may be run parallel to the data-carrying fiber without coupling problems.

Operation is straightforward; we have only the transmitter board and the receiver U1. Adjustment procedures are the same as described before.

(Continued on page 98)

The PRINTING STOPWATCH



Keep tabs of your time at the keyboard especially when time is money!

By Ralph Tenny

☐AS A CONTRACT WRITER AND CONSULTANT, I MAY HAVE TWO OR three projects going at one time. These projects are usually billed at an hourly rate. A printed time log makes a handy record and a good billing document. I use a program for the Radio Shack Model 100 called TYMKPR (listing 1) to generate and print these time logs. TYMKPR uses the ON KEY GOSUB interrupt command to generate three functions. Function 1, called by key F1, opens a data file and writes the current DATE$ and TIME$, then closes the file. The second function records the current TIME$ and DATE$. In other words, F1 and F2 behave like the start and stop buttons on a stopwatch. The two time entries in the files are a record of a time interval in a file like this:

B11/02/86
T13:05:23
T15:58:12
E11/02/86

The third button, F3, causes a summary of the time log data to be printed. At the same time, the time interval covered by each record is computed and printed. Finally, the total time is printed, producing a record which looks like this:

B11/02/86
T13:05:23
T15:58:12
E11/02/85
173 MINUTES
B11/02/86
T19:02:44
T21:45:11
E11/02/86
163 MINUTES
336 MINUTES TOTAL

(Continued on page 103)

LISTING 1—TYMKPR

```
10   CLEAR5ØØ,5ØØØØ:DIMJ$(9Ø)
15   KEY ON:DA$="B":DE$="E":TI$="T"
2Ø   INPUT"FILE NAME"; NM$:RA$="RAM"+":"+NM$
25   GOTO1ØØØ
3Ø   OPEN RA$ FOR APPEND AS 1
35   RETURN
4Ø   CLOSE 1:RETURN
45   J$(Y)=I$:Y=Y+1
5Ø   RETURN
55   K$=MID$(K$,2,5,):K$(V)=K$
56   RETURN
6Ø   L$=LEFT$(K$,2):L=VAL(L$)
65   M$=RIGHT$(K$,2):M=VAL(M$)
7Ø   RETURN
75   LPRINT TAB(1Ø); TM;"MINUTES"
8Ø   RETURN
1ØØ  A$=DA# + DATE$:B$=TI$+TIME$
1Ø5  GOSUB 3Ø
11Ø  PRINT#1,A$:PRINTCHR$ (1Ø)CHR$(13)"A",
115  PRINT#1,B$
12Ø  GOSUB4Ø:RETURN
2ØØ  B$=TI$+TIME$:A$=DE$+DATE$
2Ø5  GOSUB3Ø
21Ø  PRINT#1,B$:PRINTCHR$(1Ø)CHR$(13)"B",
215  PRINT#1,A$
22Ø  GOSUB4Ø:RETURN
3ØØ  INPUT"HEADER";E$
3Ø5  LPRINTE$,CHR$(13)
31Ø  CLS:OPEN RA$ FOR INPUT AS 1
315  Y=Ø
32Ø  I$=INPUT$ (11,1)
325  IF EOF (1) = -1 THEN34Ø
33Ø  GOSUB45
335  GOTO32Ø
34Ø  CLOSE 1:GOSUB45:Z=Ø:V=1:Y=Y-1
345  K$=J$ (Z):LPRINTK$;
35Ø  IFLEFT$(K$,1)="T" THEN38Ø
355  IFLEFT$(K$,1)="B" THEN375
36Ø  IF Z=>Y THEN FL=1
365  GOSUB75
37Ø  V=1:IF FL=1THEN43Ø
375  Z=Z+1:GOTO345
38Ø  IF Z=>Y THEN FL=1
385  IF V=2THEN4Ø5
39Ø  GOSUB55:GOSUB6Ø:Z=Z+1
395  L1=L*6Ø    :V=V1
4ØØ  GOTO345
4Ø5  GOSUB55:GOSUB6Ø:Z=Z+1
41Ø  L2=L*6Ø
415  TM=L2-L1
42Ø  TL=TL+TM
425  IF FL=Ø THEN345
43Ø  LPRINT TAB (9);TL;"MINUTES TOTAL"
435  MENU
1ØØØ X=Ø:ON KEY GOSUB 1ØØ,2ØØ,3ØØ
1ØØ1 REM ON ERROR GOTO1Ø3Ø
1ØØ5 E$=TIME$:D$=c$
1Ø1Ø C$=MID$(E$,4,2)
1Ø15 IFC$=D$THEN1ØØ5
1Ø2Ø X=X+1:PRINTX;
1Ø25 GOTO1ØØ5
1Ø3Ø STOP
```

NUMBER 139

GADGET

SEPTEMBER 1987 THE NEWSLETTER FOR GROWN-UP KIDS VOLUME XII/NUMBER VII

What's Inside . . .

Nolo Nintendo

NINTENDO ENTERTAINMENT SYSTEM: DELUXE SET. Manufactured by: Nintendo of America, Inc., 4820-150th Avenue N.E., P.O. Box 957, Redmond, WA 98052. Price: $179.95.

Video games are back, and looking to capitalize on their resurgence is a company that was there at the beginning, *Nintendo*. The original maker of Donkey Kong is frantically issuing updates, peripherals and new games, all in an effort to hold the flagging interest of notoriously fickle consumers.

Nintendo's *Deluxe Set* represents its top-of-the-line offering: four games, a control deck, two controllers, an "interactive video robot," a "futuristic light-sensing video gun," plus connectors and jacks to patch the whole system into your television. These are video games that are a generation beyond the original joystick models—video games for the '80's and beyond.

That, at least, is *Nintendo*'s intent. Still recovering from the video game bust of the mid-'70's—a sort of corporate Armageddon which swallowed up *Nintendo*'s chief adversary, Atari—the company is perhaps understandably nervous as it seeks to avoid the mistakes of the past. Its strategy? *Nintendo* wants to dress up video games, even though you can't take them out. Peripherals are where it's at, electronic geegaws, the fancier, the better—anything to distract the foreshortened attention span of the American adolescent and convince him he's ringmaster of a technological circus.

Chief features of *Nintendo*'s new package are its robot and its gun, both of which interact with the video screen through light sensors. The robot is named Rob, for Robotic Operating Buddy. An active (though immobile) nine-inch unit of encased plastic, Rob is given instructions through the screen to accomplish several tasks: pick up top-like gyros, spin them, and place them on targets. Success in these tasks allows the video game player to proceed with his game.

Our short GADGET test revealed that Rob was by far the most disappointing element in the system. The

(Continued on page 8)

Letters

Dear GADGET:

Apropos that camera which prints dates on the pictures [*Canon Sure Shot Tele Quartz Date Camera*, May, p. 7], what a wondrous thing is progress! In the 1920's, I can recall my mother owning a folding camera, made by Mr. Eastman's elves, with a small door in the back.

Opening it, one could write dates or whatever directly on the film backing. In due course, the date would appear in the finished print. At the time I was too young to care much about just how this was accomplished. Perhaps some other reader will remember.

Parke S. Barnard
New Haven, CT

Dear GADGET:

Thank you for your recent coverage of the *Balans Craftseat* [June, p. 9]. We have received a number of inquiries concerning this product from readers of your publication. However, the article ended with a product cost quote of $30.

We wish to point out the suggested list price of a pair of *Craftseats* is $69.95, $39.95 for a single unit. We are aware that a number of national catalog dealers are selling the *Craftseat* at less than the suggested list, $59.95 per pair, $34.95 per single.

David Russell, General Manager
Amcraft, Inc.

[GADGET regrets the error; thank you for bringing it to our attention.—Ed.]

Titanium Tonsorial

PANASONIC CORD/CORDLESS SHAVER (ES-343). Manufactured by: Matsushita Appliance Co., 1 Panasonic Way, Secaucus, NJ 07094. Price: $69.95.

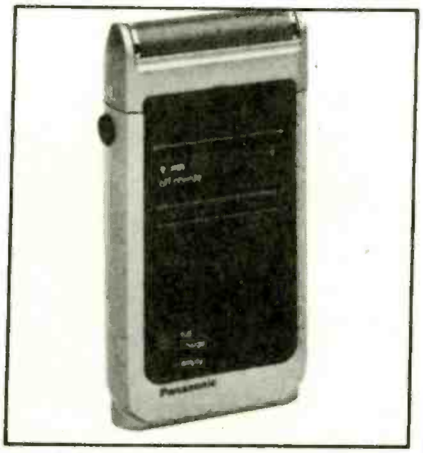
What makes for a good electric "dry" shave? Closeness, comfort, post-shave smoothness and all those other features inevitably trumpeted in TV spots for electric and other razors.

High on our own list would be razor dependability. An assurance that a few years after its purchase, the electric shaver (with proper care) would still be doing a good job.

Panasonic's limited one-year warranty doesn't say much for (or about) the life expectancy of the *ES-343 Cordless Shaver*. But after a couple of weeks of using this model, part of the company's "Titanium Series," we do think it would be worth finding out about. If it works as well after a few years as it does new, the *ES-343* would be well worth owning.

This cord/cordless shaver does away with the slightly bulky AC adapter-charger, instead using an ordinary appearing cord. Requiring a one-hour charge, power status is shown by two indicator lamps ("full" and "empty") on the shaver body.

The instructions don't make clear how many shaves can be powered by a single charging session. Although it is recom-



mended that "when the battery will no longer provide two or three shaves after a full one-hour charge, have the battery replaced." In normal use, a weekly charging is suggested.

Well-balanced in the hand and lightweight (5.6 oz.), we liked the shaver's sturdy, cast-metal cover for the blades, a part sometimes fabricated of plastic. The razor features the nearly standard built-in beard and sideburn trimmer, activated much like the trimmer on the Braun 1-2-3 (GADGET, July, p. 3).

But what makes this *Panasonic* noteworthy is its "titanium coated foil." Hard and durable, titanium is also extremely flexible. As a result, *Panasonic* says this shaver's foil (the blade cover) is a mere "47 microns" thick.

In our tests, the shaver did seem to have an edge in closeness over other electric "dry" razors. The *Panasonic ES-343* produces a noticeably close, even shave.

Having produced a superior razor, why didn't *Panasonic* go the extra micron and provide a first-rate case? The *ES-343* comes in a nifty, slim-line box, but there's no mirror in the lid of this otherwise fully portable shaving kit.

Still, even without a mirror, or Madison Avenue torture tests, this *Panasonic* "proved its metal" (titanium in this case) and brought us, or at least our skin, closer to a dry electric razor than we've ever been before.—G.A.

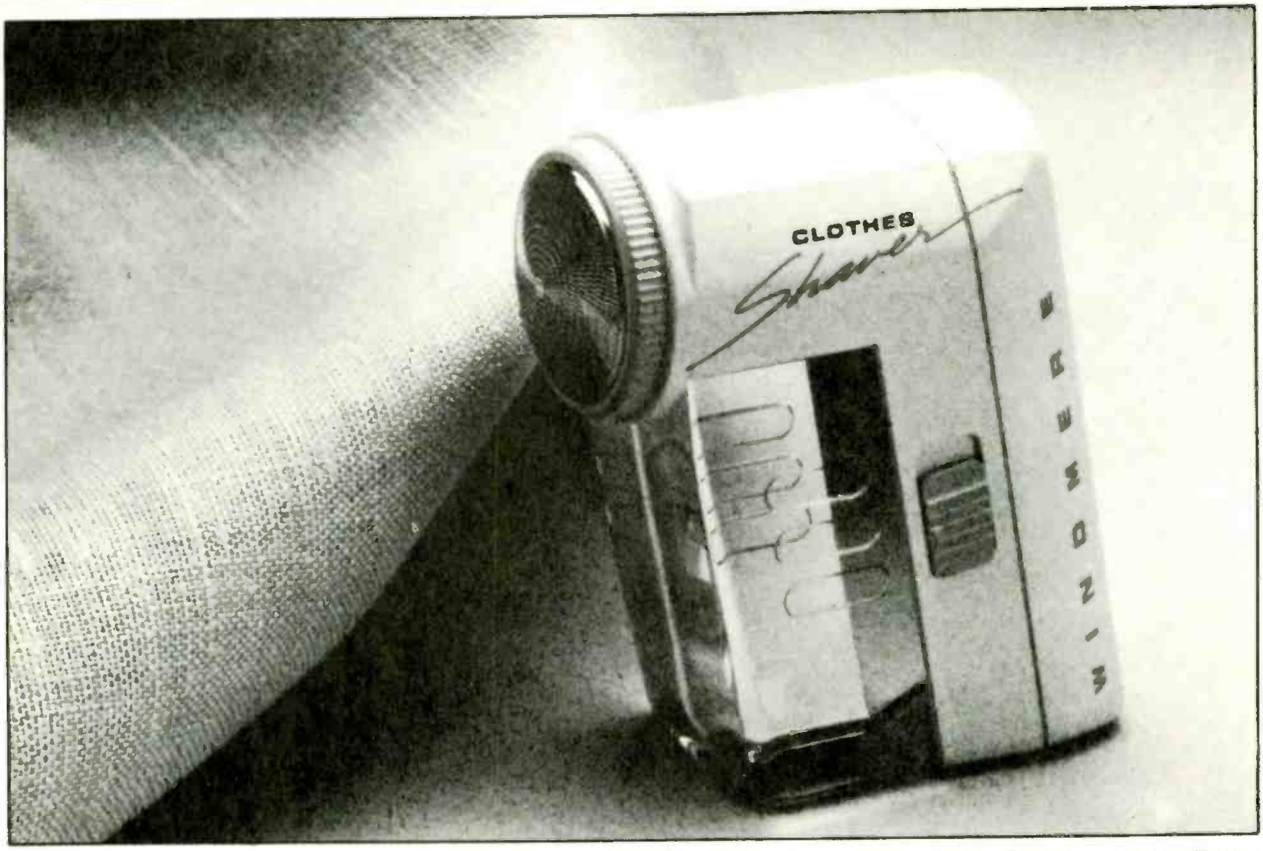
UPDATES

XEC Products has announced new, lower prices for the *Psion Organiser II* and its Datapaks (July, p. 1). The *Organiser II CM* model now retails for $159.95, while the *XP* model is $229.95. *Psion* has also discontinued the 8K Datapak and reduced prices on the 32, 64 and 128K Datapaks.

The *Sega Master System* reported on in the July GADGET (p. 2) has developed problems with its control pads. According to the company, heavy use of the control pads' "mini joystick" accessories places serious strain on the control unit. *Sega* says that if owners experience this malfunction, they can return the control pad to the firm's customer service department, and a new unit will be provided at no cost.

Publisher: Al Goldstein **Editor:** George Arthur **Senior Editor:** Gil Reavill **New Products Editor:** Christine Stevens **Copy Editor:** Danny Jones **Art Director:** Kevin Hein **Associate Art Directors:** D. Devins, C. Giordano, Rob Weisberg **Production:** Bill Mudie **Administration:** Bonnie Keystone **Reader Service:** Kathryn Hartman **Technical Consultants:** Ken Schaffer, Bob Bishop **Contributing Editors:** Philip Eisenberg, Alan Freedman, Jordan Ari Goldstein, Steve Gruberg, John Kois, John Swenson, Ken Swisher, Aaron C. Zimmerman.

GADGET is published by A.G. Consultants, Inc., 116 W. 14th Street, New York, NY 10011, (212) 989-8001. GADGET is a registered trademark of A.G. Consultants, Inc. GADGET is published 12 times a year and appears as an insert in Hands-On Electronics, published by Gernsback Publications, Inc., Farmingdale, NY 11735. For information on subscriptions to Hands-On Electronics, please see the magazine's editorial page. Letters intended for GADGET's editorial staff should be sent to the newsletter's address as shown here.



Clothes Shave

CLOTHES SHAVER. Manufactured by: Windmere Corp., 4920 N.W. 15th St., Hialeah, FL 33014. Price: $14.99.

It's not the answer to world hunger. And it certainly doesn't rank up there with genetic engineering or organ transplants as a startling scientific breakthrough. Still, the *Windmere Corps.' Clothes Shaver* is apparently the solution to a problem which has bedeviled many.

That's our reaction, anyway, after witnessing our co-workers' response to the appearance of this "as-seen-on-TV" product in the GADGET office. People who wouldn't walk across the room to examine a $25,000 home audio-video system suddenly appeared in our doorway asking about the *Clothes Shaver*. Apparently what *Windmere* says is "the largest promotional plan" in its history, including "spot taggable television" and "high impact television commercials," has worked wonders.

A sporty, white-and-pink gadget, the *Clothes Shaver* removes "pills and fuzz that develop on sweaters around the arms and other wear areas. . .coats, jackets, slacks, virtually all of the clothes in a wardrobe that appear worn because of play."

Powered by a single "C" battery, the *Clothes Shaver* incorporates a simple electric motor which spins four small razor-sharp blades, safely shielded behind a plastic guard. Plyed back and forth across the surface of a garment, the blades cut and lift fuzz, knotted threads and the like, smoothing the material's surface.

The removed material, reduced to a lint-like substance, is deposited in a built-in, see-through bin. The transparency of the container is a nice touch. Thanks to the visibility, users see the removed fuzz piling up.

When not in use, the blades and shield are further protected beneath a screw-off plastic cap. "Fuzz" and "pills," by the way, are defined by the *Windmere Corp.* as "nubby fabric clusters caused by friction."

In our tests, we found that the *Clothes Shaver* worked well enough. However to do a really thorough job on a large area is a time-consuming task. Numerous passes across the fabric seem to have little effect, despite the ever-growing cluster of lint in the instrument's container. One staffer said it was the perfect "house husband" tool in that it required zero skill to operate. It does, however, require some patience.

We used it exclusively on sweaters, a heavy, badly fuzzed one as well as a light, less-worn garment. Improvement was visible on both garments after application of the clothes shaver. Unfortunately, the gadget doesn't pick up pet hair or ordinary lint of the sort removed with various adhesive brushes and the like.

Staffers did come up with a few suggested improvements, however. Nearly everyone felt *Windmere* should market an industrial-strength model, larger, with longer blades to cut down on the tedium of shaving an entire garment.

Someone thought that with a slightly bigger motor it would work as a combination clothes shaver-body massager, improving the appearance of your wardrobe as it brings a tingle to your muscles. The suggestion was made that it should include a built-in vacuum, so all kinds of lint would be removed by use of the shaver. And nearly everyone felt that clothes shaving was an exercise in tedium.

Although heavily publicized, the *Windmere Clothes Shaver* is apparently not the only gadget of this sort on the market, so comparison shopping for clothes shavers might be in order. As a handy appliance in some student or bachelor's sewing kit, the *Clothes Shaver* will likely be around long after the last of *Windmere*'s "high impact television commercials" have faded from memory.—G.A.

Porta-Vid

CITIZEN PORTABLE VIDEO CASSETTE PLAYER WITH COLOR MONITOR (VCR-5MU). Manufactured by: CBM America Corp., 2999 Overland Ave., Suite 203, Los Angeles, CA 90064. Price: $599.95.

DUKANE VIDEO PRO 7 VHS VIDEO PLAYER/MONITOR (28A300). Manufactured by: Dukane Corp., Audio-Visual Division, 2900 Dukane Dr., St. Charles, IL 60174. Price: $1,099.

Dukane Video Pro 7 Player/Monitor

If, as sales figures suggest, the VCR market is leveling off a trifle, manufacturers can be expected to prime the pump with variations on the video player/recorder theme. We've already noted an increase in the array of home video accessories and add-ons currently on the market. GADGET's March issue reviewed the Lloyd's Electronics TV/VCR combo (p. 6). Since then, at least one other company, Gold Star, has introduced a TV/VCR unit to the consumer market, and one possible new consumer video product may eventually be a player with built-in monitor. Currently these are manufactured primarily for the commercial, sales, education and corporate markets.

The sales representative of the past was identifiable by his bulky, awkward sample case. Today's salesman (or woman) apparently has discarded that trademark for a portable video player. Nearly as awkward and bulky as the sample case of yore, the video player at least has the advantage of absolutely standardizing a sales pitch, nowadays delivered via videocassette. Standardization remains one of the corporate world's primary commandments, even when it comes to making a spiel.

We took a look at two of these commercial-market products with an eye to imagining their value for ordinary consumers. As features of the video lifestyle, we think these products will come to the consumer market in the not-too-distant future. For example, so-called personal televisions were once a high-priced novelty product, yet today, all kinds of people have discovered the pleasures of owning one.

The *Citizen Portable Video Cassette Player with Color Monitor*, from *Citizen*'s business products division, is the more versatile of the two units examined. Besides ordinary AC power via an outlet, this device can be powered via a rechargeable battery pack with separate charger (BPC-30U and BCG-1U, respectively). *Citizen* also offers an optional "car cord" (CBC-3U) for use with a vehicle cigarette lighter. (*Consumer Reports*, by the way, noted a full-page *Citizen Business Products* magazine ad which offered this trio of accessories "absolutely free," with a $599.95 purchase of the player, or buyers could pass up the "free" accessories and pay $100 less.)

In any event, the *Citizen*'s versatility was offset by another feature, the small size of its monitor screen. A mere 4¾", measured diagonally, watching it was akin to the experience of trying to view a mini-screen personal LCD TV. While this video player/monitor might be fine for individual, desktop viewing, its small screen would make group watching something of a trial. The monitor picture was clear, but its size is just too small for comfortable viewing.

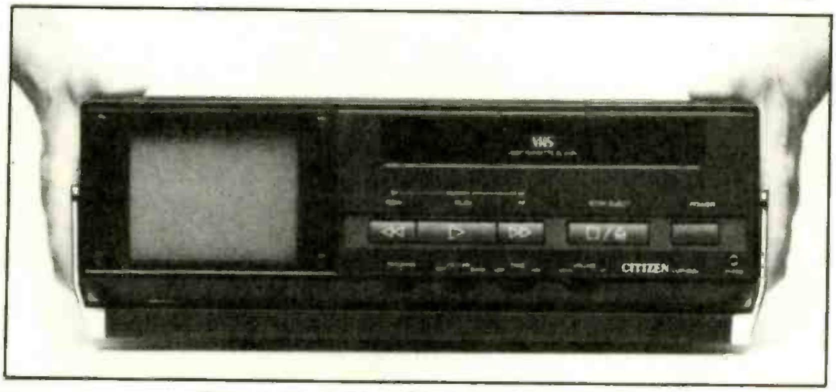
A portability feature of both the *Citizen* and *Dukane* units is a handy carrying bar which swings underneath the units to double as a viewing stand. Controls are similar to those found on any VCR, with the exception, of course, of the record functions. Both devices also provide a protective plastic screen which fits over the monitor.

Perhaps surprisingly, "pause" provided a picture no more clear than on many consumer video players—odd in that for sales, a still-frame image might be an important part of the pitch. *Citizen* also offers stereo audio connection, in contrast to the *Dukane*'s mono jack, for use with separate speakers. There's also a jack for private listening via headphones.

The more expensive *Dukane Video Pro 7* justifies its higher tag with its 7" screen. Weighing 22 lbs., the *Video Pro 7* is slightly larger than the *Citizen* unit. Designed exclusively for plug-in use (via a three-prong connector), the only accessories offered by the company are a dust cover, padded shoulder bag and shipping case.

Perhaps it's a function of its screen size, but the *Dukane* seemed to noticeably brighten the image on home-recorded videotapes. One of those we watched had been recorded from a TV broadcast using a seven-year-old RCA VCR. When the tape was played on the *Dukane*, its colors and hues weren't as faded as when viewed via the old RCA unit. One playback refinement of the *Video Pro 7* is an "automatic program repeat" control which allows the machine to be set to show the same video program repeatedly.

(Continued on page 8)



Citizen Portable Video Player/Monitor

Eight Is Enough

CANOVISION 8 VIDEO SYSTEM (model VM-E2). Manufactured by: Canon, U.S.A., Inc., One Canon Plaza, Lake Success, NY 11042. Price: $1,699.

In the ferocious arena of technological innovation, the hapless consumer at times gets tossed to the lions. He or she buys an expensive, complex, state-of-the-art gadget, only to find that next year's model is so New! so Improved! that the old one is outmoded. In fact, much consumer trepidation at entering a market can be attributed to fear of a technological "shake-out" looming just ahead.

GADGET thought it might be instructive to compare "this year's model"—*Canon*'s *VM-E2 Video 8mm System*—with last year's, the VM-E1 (GADGET, February, p. 2). The results indicate that while there are several improvements packed into the newer model, those who own the VM-E1 aren't left in the silicon dust. Not only is their machine fully compatible with the new unit, but both measure up well when compared to the other entries in the field.

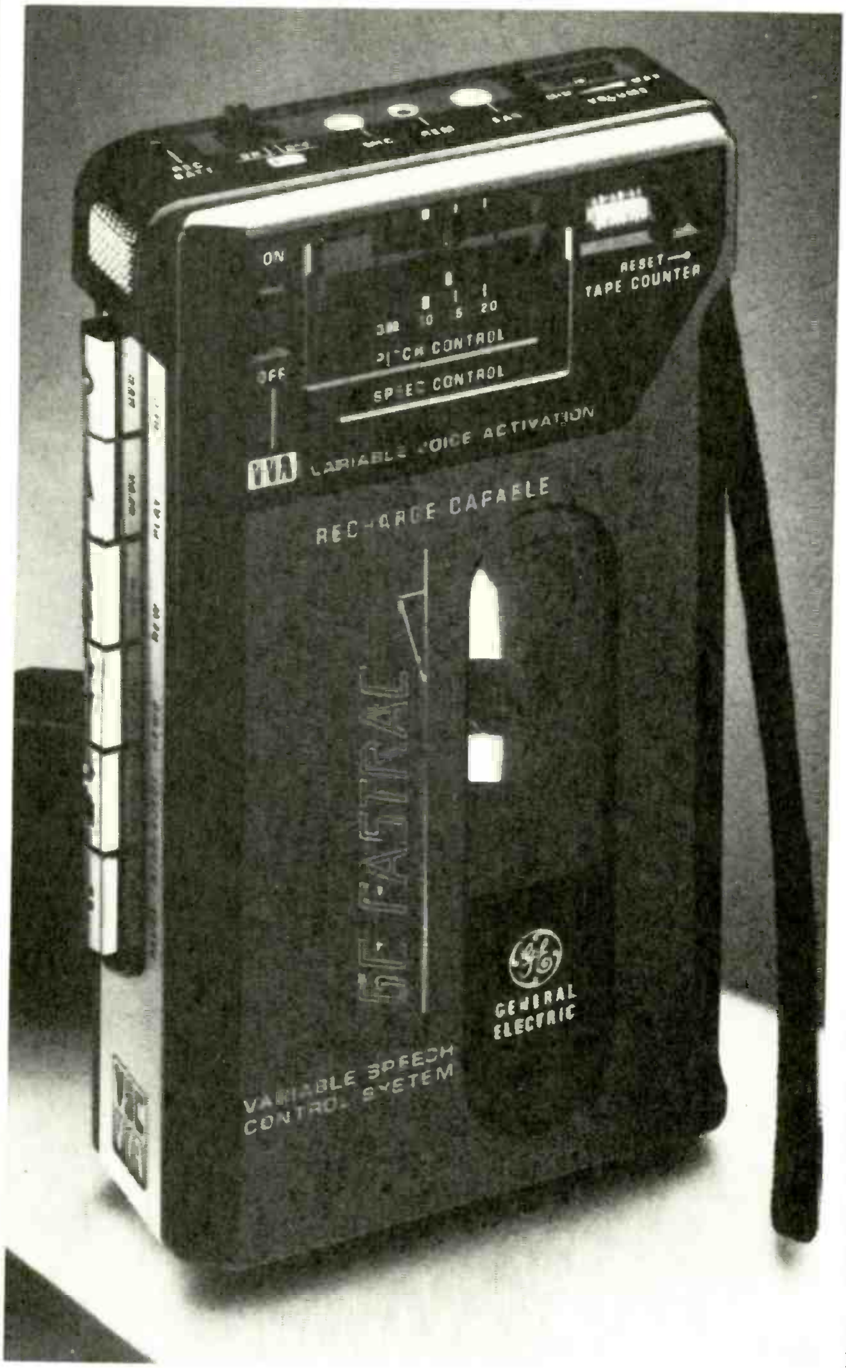
Chief among the *VM-E2*'s improvements is its smaller size: down to 3.5 lbs. from the 4.4 of its predecessor. Of course, in the world of consumer electronics, smaller is almost always better, if for nothing else than to demonstrate the ingenuity of engineers. But here there is ample reason to miniaturize, for the *Canon* system is aimed at those folks who want to bring their home moviemaking into the 20th century by making home videos instead. The lost extra pound can make a real difference when trying to steady the camera on difficult terrain, while walking, or while enduring other rigorous *in situ* conditions.

The miniaturization of the new model was accomplished with no apparent loss of capabilities, but rather through the development of a new image sensor computer chip which is at the unit's heart. The chip allows the *VM-E2* to deliver a truly superior image for a device its size, without distortion, "ghosts" or burn-in. Both the present *Canon* model and the company's previous one compare favorably with the other two entries into the 8mm video field, Sony and Kodak.

As a playback device, the *VM-E2* hooks directly into your television with a supplied RF adapter. Again, this system struck us as superior to the elaborate "piggy-back" arrangement developed by Kodak, which necessitates additional peripherals before the consumer can see the image recorded. With the jacks supplied with the *VM-E2*, its 8mm image can be fed directly into the television (or "home entertainment system," as the case may be), and edited, added to from images supplied by a VCR, or manipulated in other ways.

Canon's design team has assured that the operator of the camera is under the classically simple dual imperatives of "point and shoot," and under no others. There is a knack to handling the "record" and "pause" functions, but these are easily mastered. And, as in all good designs, the automatic functions may be overridden at the behest of the user under unusual conditions, such as backlighting (for the automatic iris) or variegated backgrounds (for the automatic focusing).

All in all, GADGET found that the new, smaller *Canon* performs as well as its predecessor, but that it in no way makes the VM-E1 outmoded or obsolete. For anyone considering the considerable investment a home video system requires, *Canon*'s *VM-E2* more than warrants investigation.—G.R.



Fast Talking

GE FASTRAC TAPE RECORDER/ PLAYER (model 3-5324). Manufactured by: General Electric Consumer Electronics, Portsmouth, VA 23705. Price: $109.95.

Giant *General Electric*, busy in recent years with projects like acquiring RCA and the NBC television network, hasn't forgotten that the small things count, too. Unwilling to entirely cede the tape recorder market to foreign brand names, *GE* last January introduced the *Fastrac Tape Recorder/ Player*.

As a recording and playback device for business or education-related recording, the *Fastrac* is a no-nonsense unit, not flashy but eminently practical. The recorder/player's most interesting feature is its "variable speed control" for playback. Engaged via a switch, it allows recorded material to be speeded up for playback.

Pitch and playback speed controls allow the user to fine tune the playback. As tape speed increases, the pitch can be lowered to keep the high velocity words from becoming unintelligible.

The *Fastrac* also features voice activation. With this feature engaged (via a switch on the top of the unit), if any sound is detected, the machine turns on. If nothing is heard for a period of two to six seconds, it automatically shuts off.

Controls and inputs (for a separate microphone, earphone and remote control) are sensibly grouped on the top of the unit, with the usual tape recorder controls on the side of the machine. The *Fastrac* includes the standard 10-position volume control and three-digit tape counter.

In the "play" mode, and with the "pause" control engaged, the *Fastrac* will still rewind, allowing the listener to back up a recording without going through the hassle of stopping the playback, rewinding and then re-engaging the "play" mode. Compared to other tape players/recorders in its price class, we found that the *Fastrac*'s tape stop allowed only minimal slippage, a feature especially appreciated in the typical stop-and-go involved in trying to get spoken words down on paper.

Power comes from one of three sources. The *Fastrac* uses four "AA" batteries for completely portable recording and is sold with an AC power converter for ordinary plug-in use. *GE* also offers an optional car cigarette lighter adapter (No. 5-1077) and a rechargeable nickel cadmium battery pack (No. 5-1853).

In our tests, we recorded a telephone interview (using a non-*GE* microphone) and used the *Fastrac*'s built-in microphone for recording in-person conversations. In both instances, the recorder produced clear, intelligible recordings, even with considerable background noise audible. Transcription of spoken words went smoothly as well.

Our only caveat regarding the *GE Fastrac* is in regard to its case. The plastic used for its construction seems both brittle and lightweight. *GE*'s design makes no attempt to put the *Fastrac* at the cutting edge in terms of either appearance or compactness.

This unit resembles portable tape recorders on the market five or six years ago. But, given its uses, neither clunky appearance nor size (roughly, 6¼" tall 4" wide and 1½" thick) represents any important drawback. Sold with a carry case and a one-year warranty, the *GE Fastrac Tape Recorder/ Player* is an ideal, workday machine for students, journalists or anyone else who needs clear recording of spoken words.—G.A.

Yogi He's Not

DANNY THE OUTBACK BEAR. Manufactured by: Phonetica One, Inc., P.O. Box 1069, Bailey, CO 80421. Prices: $180-$200.

Consumer applications of voice-recognition technology are still in an early stage of development, so it shouldn't be surprising that pioneer voice-command products in the toy field, animated plush animals from *Phonetica One*, are relatively simple devices. Babies crawl before they walk and the field of voice-command toys is definitely an infant one. That said, *Phonetica One* deserves recognition for its pioneering effort.

The company's two walking, "talking," sitting and guarding toy animals —*Danny the Outback Bear*, modeled on a Koala bear, and *Fred the Ameri-Mutt*—may not perform spectacular feats at the sound of their master's voice, but that they perform at all is something of a small miracle. Even a few years ago, voice-activated devices were more closely associated with the highest of tech than with the simple pleasures of a toy, stuffed animal.

The *Phonetica* bear has been programmed to respond to three commands in English—come here, turn around and stop-stop. As the instruction manual advises, commands should be delivered in "a firm voice" at a distance of two to six feet from the toy. The words should also be run together, that is, "it may be helpful to pronounce the words 'come here' as one word, kumeer."

Standing about 17" tall, on its chest, the bear sports a white plastic control panel and speaker. There are three buttons, each of which puts the animal into a particular mode. In "voice command," it responds to verbal orders, namely come here, turn around and stop. In "entertainment," the bear electronically "hums" a tune and dances, and, after a pause, it will emit another tune and do a different set of movements. In this mode, the animal will also "talk" with someone, mimicking the sounds of any words spoken. A pet on the head will cause the bear to "purr." A flashing red light on the control panel indicates the bear is detecting motion, important for its third mode of activity, security.

As a guard, the bear's mechanism detects motion within 10 to 15 feet of its location. After pressing the security button, the owner has one minute in which to leave the room before the animated toy becomes sensitive to motion. Activity causes the bear to send forth an alarm, a loud, pulsating tone which will be repeated seven times as a warning. It then resets itself.

Turning the bear on requires a firm push on the rump, although it will turn itself off after "two minutes of inactivity," or in the voice command mode the words "stop-stop" will deactivate the electronic critter. Any time the switch located in the bear's head is pressed for six to 12 seconds, "your toy will purr and turn itself off."

Power for the above is supplied by six "D" batteries, and *Phonetica One* warns that only Alkaline or Nicad rechargeable batteries should be used. "Do not use carbon type batteries... this will void your warranty." The warranty covers the mechanics and/or electronics for a period of 90 days. Finally, these animated, voice-recognizing bears are suggested for children six years old and up.

We certainly had no problem putting *Danny the Outback Bear* through its pre-programmed paces but after only a short time, we had to wonder what it does for an encore. We don't imagine that most kids would be enchanted for long by this simple device. After only a few short sessions of "come here," "turn around" and stop-stop," boredom would likely set in.

As for its security applications, possibly a herd of these might scare a yegg away, but as a practical security device it probably rates with fake burglar alarm tape on the window and an imitation security service sticker. Children inclined to be afraid of going to bed, as kids can be, would probably derive some peace of mind from being shown that their bear is on guard.

It's likely, however, that the *Phonetica One* animals will have an honored place in the history of American toys. Perhaps in future years, these first applications of voice-recognition to playthings will be sought-after collectors' items—like early teddy bears or first edition Monopoly games. A demonstration videotape supplied by *Phonetica One* indicates that the firm is working on some marvelous advances in this field that they are pioneering. If that's the case, *Danny the Outback Bear* is merely an ursine hint of the shape of things to come.—G.A.

NINTENDO
(Cont. from p. 1)

robot's limited action vocabulary, matched with the incredibly laborious repetitions needed to carry out commands, rendered its use a prescription for boredom. *Nintendo* evidently hasn't learned the first rule of video games: action, fast and furious. All dead time, repetition and extraneousness becomes absolute poison to the devoted player.

We played Rob with "Gyromite," one of the games included with the deluxe pack and one of the two presently on the market for use with the automaton. In the game, gates on the screen were opened or closed depending on whether Rob had been directed to rest the gyros upon the targets. At many points in the program, two gyros were required, necessitating an infuriatingly slow process of spinning, transporting and balancing the tops. Any novelty soon palled with the drudgery of the activity, which resembled the repetitions of an assembly line rather than a game.

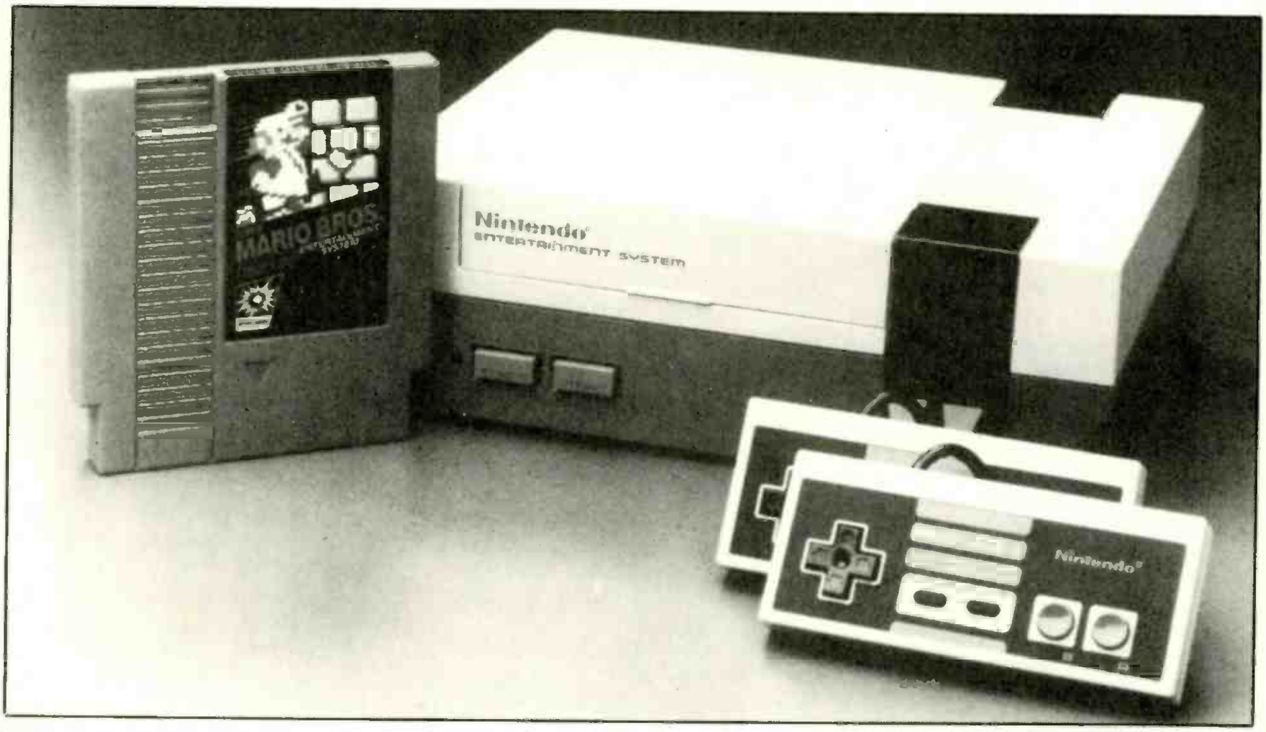
True, the idea of a video-game-playing robot is impressive, and the apparatus itself is cleverly designed enough to satisfy the secret human urge to own an automaton of one's own. But if *Nintendo* is serious about nurturing the video game from a fad into a fixture, it must do more than provide splashy window dressing.

The video gun, also included with the *Deluxe Set*, is a bit more successful, but suffers from the same syndrome—too much of an accessory, not enough an integral enhancement of the game. Of the four light gun game paks available, one is included in the *Deluxe Set*: Duck Hunt, an easily mastered (and soon quite dull) exercise in fowl play.

While the add-ons in the *Nintendo* system are all flash and no substance, the guts remain very sturdy and playable indeed. The game paks boot up instantly, and the control deck is sleek and unobtrusive. The controllers themselves, on the other hand, are not much of an improvement over the "joystick" style; in fact, the thumb blisters on a few of our GADGET staffers show that "user unfriendly" would not be too strong a modifier to apply to them.

The two games which don't require either the robot or the video gun are actually the best of the *Deluxe Set* bunch. "Slalom" is a self-explanatory entry into *Nintendo*'s "sports" series, while "Super Mario Bros." is an instant classic of the "Donkey Kong" mode.

The main conclusion of our GADGET review was an extreme dissatisfaction with *Nintendo*'s Rob, and a lesser level of annoyance with its light gun. No amount of kiddie cajolery should convince parents that either device is necessary to the amusement, health and entertainment well-being of the youthful video game aficionado. Stick to the basics: *Nintendo*'s basic package of games and controls, without the technological "wizardry." In gadgetry, simple is not always better, but in this case that caution holds true.—G.R.



VIDEO MONITOR/PLAYERS
(Cont. from p. 4)

The particular *Dukane* unit we tested seemed to suffer from a mechanical tracking problem. Videotapes, as they unwound, would throw a lot of visual static onto the screen periodically. But the same tape, reloaded, would then play perfectly. Perhaps as a demonstration model, this particular *Video Pro 7* was overdue for some maintenance.

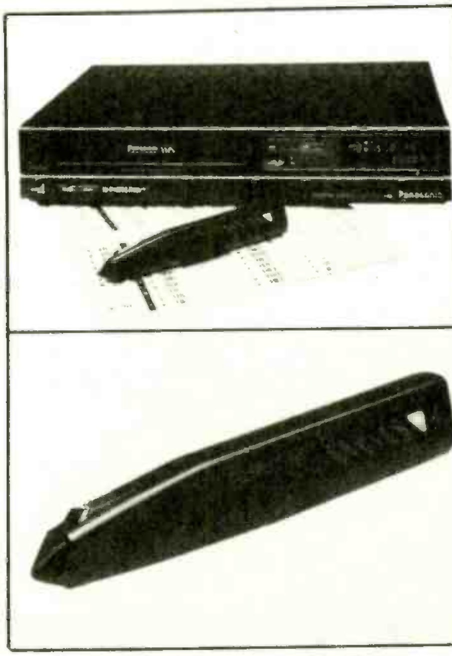
Neither this unit nor the *Citizen* monitor/player offers multiple playback speeds, a shortcoming given the trio of playback and recording speeds available with many home VCRs. Both the *Dukane* and the *Citizen*, we assume, are a bit sturdier and more rugged than similar consumer products. That, after all, is often the point of higher prices for business-market equipment.

As prototypes of eventual consumer-targeted player/monitors, the *Dukane* and *Citizen* are harbingers of what might become a popular video product. Aboard a pleasure boat or while traveling in a motor home, a video player/monitor would bring the comforts of home video (minus recording capability) along for the trip.—G.A.

Bits & Pieces

Bar-code reading, the technology which has given consumers those "universal product codes" found on everything from magazines to cigarette packs, is about to come to home video. The *Panasonic Co. (1 Panasonic Way, Secaucus, NJ 07094)* this summer and fall will introduce two **Bar Code Programmable VCR**s. With this system, the user, with the aid of an electronic light pen, will be able to "program their VCRs directly from a bar code function sheet," eliminating "the need for pushing buttons on the VCR to program the recorder." Speculating about the future, the Panasonic news release on the PV-4722 and PV-4761 suggests, "bar codes could be printed with TV program listings in magazines and newspapers," which would allow owners of these new VCRs to "pass the scanner over their TV schedule guide to set their units to record specific shows." The PV-4722 is scheduled to appear on the market in July, with the PV-4761 slated for a September introduction. Price: to be announced.

For newcomers, visitors, cabbies, messengers and those prone to ambulatory confusion, the **Manhattan City Key** should prove useful. The small calculator device when given the address of a building on any Manhattan avenue will furnish the nearest cross street. Programmed with 35 different avenues (including some we weren't familiar with), the City Key does double duty as an ordinary calculator. Although the avenues are entered using somewhat difficult-to-remember abbreviations, this is a potentially very useful gadget. We just wonder why the manufacturer isn't identified. We first saw this at *Roberts & Co. (182 E. 86th St., New York, NY 10028)*, but it's turned up at numerous specialty shops as well as Manhattan department stores. Price: $19.99.



Bar Code Programmable VCR

"Desktop publishing" has reached the take-off stage in recent months and, as with earlier innovations in graphic design and production, it seems on its way to transforming printing and the publication industry. With these developments in mind, *Canon U.S.A., Inc. (1 Canon Plaza, Lake Success, NY 11042)* has announced its "next-generation" desktop **Laser Beam Printer**, the LBP-8II. Capable of printing eight pages per minute, the unit features 512KB of upgradable memory. Only 9.1" high and weighing about 50 lbs., the LBP-8II also offers expanded font flexibility. Price: $2,500.

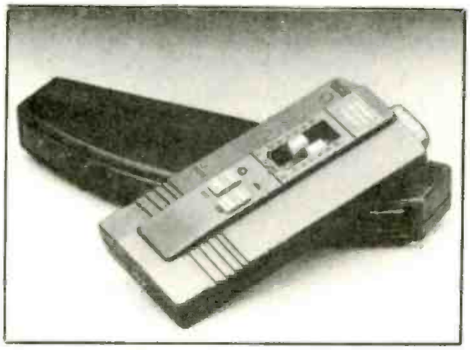
Laser Beam Printer

Here's yet another approach to going musically mobile, the **Sound Sender Mobile Audio Adapter**. The device allows a portable cassette or CD player to be heard via a vehicle's sound system. The Sound Sender plugs into a cigarette lighter and into the player's headphone jack. The user then tunes the car's FM radio to a location between 105 and 107 MHz and, presto, the player is heard via the installed sound system. Or maybe not presto, the GADGET staffer who tried this out found it to be tricky tuning to the right position on the radio dial. Distributed by the *Dynasound Organizer Division of Hartzell Manufacturing, Inc. (2516 Wabash Ave., St. Paul, MN 55114)*, the Sound Sender is available at retail stores and through mail-order firms. Price: $30.

The tendency among modern fitness enthusiasts seems to be to weigh themselves down with equipment during exercise. If that's the case, the *Innovative Time Corp. (6054 Corte del Cedro, Carlsbad, CA 92008)* has just introduced a few ounces any exerciser might want to add. Called the **Sports Master Fitness Computer**, this clip-on unit is "the first to display calorie burn during most types of exercises and count steps while measuring both distance and speed or travel for walkers, joggers and runners." The compact device's other features include a goal alarm (for timing exercise), pacer, stopwatch and time. With a supplied activity level chart, the user programs the device with the "listed exertion level" for the selected exercise and "receives calorie burn information on the spot." The goal alarm can be set to sound when a designated number of calories have been walked or run off or when a selected distance has been reached. Price: $24.95.

Sports Master Fitness Computer

Bits & Pieces

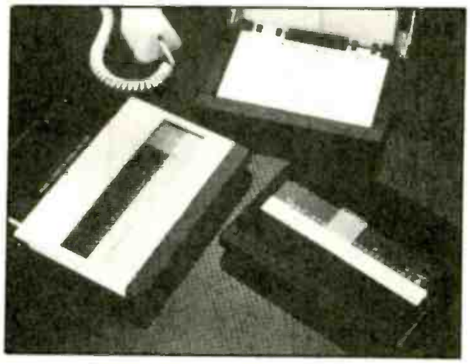

Cordless Stereo Transmitter/Receiver

If you're in the market for a wireless stereo transmitter, there are suddenly plenty of brands to select from. One of the newest is from *Ambico, Inc. (50 Maple St., P.O. Box 427, Norwood, NJ 07648-0427).* The V-0602 **Cordless Stereo Transmitter/Receiver** will send "true stereo sound" from any audio source at a distance of up to 25 ft. The transmitter unit is 7" long, features a 110-degree transmission range, automatic power and its own AC power supply. The receiver weighs 3 oz. and has a 360-degree "sensing area," left and right stereo volume controls, power switch with LED, dynamic and normal settings and a lapel clip and carrying cord. Power comes from three "AAA" batteries. The V-0602 will work with any earphones or headset equipped with a mini-plug. Price: $99.95.

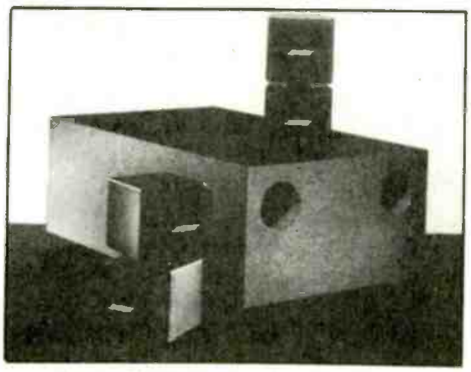

Bodyguard Fitness Mill

Here's a treadmill you'll be proud to call your own. From *J. Oglaend, Inc. (40 Radio Circle, Mt. Kisco, NY 10549-0096),* The T-8100 **Bodyguard Fitness Mill** features a DC-drive motor, control panel and digital read-outs for time, distance and speed. Elevation is adjustable and the Fitness Mill's top speed is 8 mph, with a running or walking area measuring 51" by 14". Flywheel construction, Oglaend says, "makes running or walking smooth, quiet and gives a feeling of exercising outdoors." With this, an electric fan and a tape cassette of bird calls, you'd never have to leave your home to go for a walk. Price: $995.

One of the more interesting timepieces we've seen recently is the Shimoda Electronics Company's **Cosmos Clock** (model BH-121). Called the "Black-Holl" model on its package, the clock is a black, plastic sphere, a little smaller than a soccer ball. The clock face features stylized representations of various heavenly bodies. A rotating sun is the hour indicator while a half moon is the minute hand. A satellite indicates the seconds. The face surface is back-lit, and as the second satellite sweep moves around the dial, it subtly changes hue, yellow, blue, green and purple. According to *Feelings (50 W. 57th St., New York, NY 10019),* the store at which we discovered the clock, the BH-121 is one of a series of similar clocks from Shimoda. Models include a square timepiece, a chrome-plated version and a round one minus the clock face constellation. Price: $109-$159.


Plus 600 Cassette Index

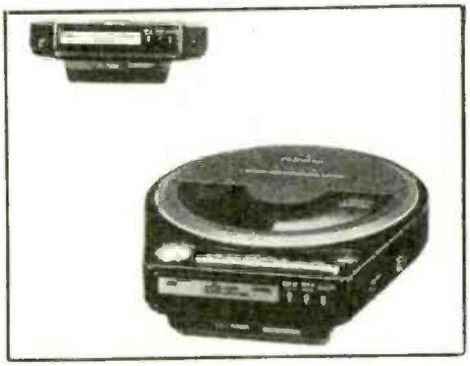
Progressive product manufacturers are applying electronics-related innovations to mechanical devices. The *Plus U.S.A. Corp. (10 Reuten Dr., Closter, NJ 07624)* markets a **Plus 600 Cassette Index,** a desk directory with "1425 spaces for listings." When the gadget's eject control is engaged, the index cassette pops out, converting it into a compact travel directory. The Plus 600 directory is available in black or white matte plastic finish and is sold in department, gift, stationery and office supply stores. Price: $19.95.


Acoustimass Speaker System

Here's a system which actually brings a new approach to loudspeaker design. Perhaps not surprisingly it comes from the *Bose Corp. (The Mountain, Framingham, MA 01701),* a firm which has long maintained an interest in technological development. Called the AM-5 **Acoustimass Speaker System,** the three-piece configuration is said to deliver the "bass power handling, dynamic range and spatial accuracy" of much larger systems. Each of the "two-cube" speakers is smaller than a quart of milk, weighs less than a telephone and is nearly palm-size. the Acoustimass's radical component, however, is its "module," a box weighing about 20 lbs., the size of a small suitcase. Designed to "reproduce all the frequencies below those" from the speakers, the module can be hidden anywhere in a room. Its two driver/two internal chamber system produces low frequency energy and launches it into the room via "the mass of air contained in each chamber's port." It's unusual, but very impressive when heard and seen in a demonstration. Price: $699.

Bits & Pieces

A new wave of portable CD players appears to be breaking upon the consumer shore. Having dazzled buyers with their compact size, portables are now being reconfigured in the interest of both functionality and more eye-catching design. *Toshiba America, Inc. (82 Totowa Rd., Wayne, NJ 07470)* has just introduced a new **Portable CD Player** (XR-9437) which incorporates an AM/FM tuner with digital synthesized tuning and a dozen random preset dial positions. Not much larger "than a standard compact disc," the player has a 16-program random memory with repeat, a quick program selector key, rechargeable battery pack and LCD display for both the CD player and radio. Price: $430.



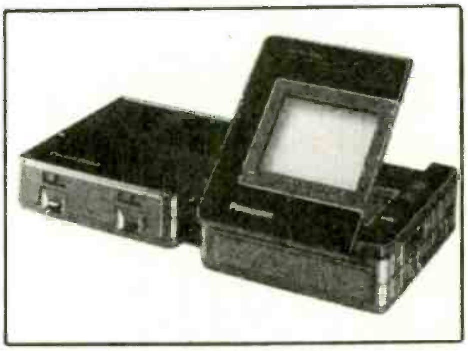
Portable CD Player

A catalog which any gadget fan, or GADGET reader, can spend hours with recently came to our office. Called **Surplus Bits & Pieces**, it's published "more or less six times a year" by *Jerryco, Inc. (601 Linden Pl., Evanston, IL 60202)*. The 50-page spring edition we looked at had hundreds and hundreds of items, alphabetically arranged from "abrasives" and "AC adapter" through "wellnuts, wheels and wires." Written with a fine gadgetical sense of humor, Jerryco says the catalog is aimed at "teachers, labs, tinkerers, small manufacturers, collectors of the bizarre, astronomers, artists, do-it-yourselfers, small retailers, gadgeteers, flea marketeers, the curious." Price: 50¢.

Not only does this have the "rounded corner look of the most stylish European influenced products," but it's a combination device. From *Spartus Corp. (3856 Oakton St., P.O. Box 1200, Skokie, IL 60076)*, a new **Clock Radio** (model 1090) which "has been uniquely mated with a matching free standing lamp." The unit's lamp has its own stand, cord and on-off switch, while the radio is an AM/FM receiver with radio or buzzer alarm, available in bone white finish. Price: $19.95.

Clock Radio

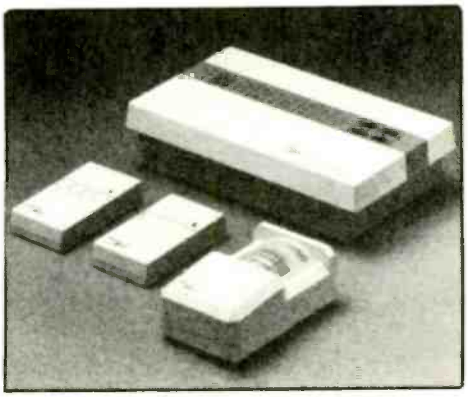
Good news in the "bells and whistles" department from *Technics (1 Panasonic Way, Secaucus, NJ 07094)*. The firm's new CQ-H9600 **Digital Tuner/Cassette Deck** not only offers an electronic graphic equalizer, "but also tri-color illumination," which enables the unit to "display different colors and functions when there is a change from one mode to another." Although Technics fails to reveal what hues the CQ-H9600 produces in its product information, the company is quite clear that three colors appear, signaling the user as to what feature is being used. The unit can also be used in conjunction with a CD changer, such as Technics' CX-DP10 and features Dolby noise reduction. Price: $1,200.



Pocket Watch TV

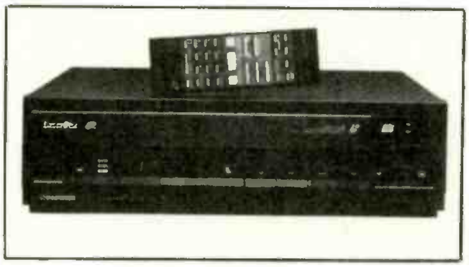
A new personal, portable television from *Panasonic Co. (1 Panasonic Way, Secaucus, NJ 07094)* reportedly represents a significant advance in LCD picture tube technology. The **Pocket Watch Television** (CT-333S) uses what Panasonic describes as a "thin film transistor, active matrix system," featuring 89,280 pixels to "create sharp intermediate colors" and enhance overall picture quality. The Pocket Watch also incorporates an AM/FM radio, features a 3" TV screen and folds up for easy carrying and protection of its components. Power comes from 6 "C" batteries, good for a maximum of 15 hours of viewing. Price: $549.95.

The combination of technological improvement and increased consumer concern has made home security one of the growth markets in the electronics industry. *Heath Co. (St. Joseph, MI 49085)* has a **Wireless Home Security System** (SS-5910) the company says "is ready to use 'out of the box.'" The system uses passive infrared technology to monitor large rooms and features refinements like a tamper alarm that's activated if the unit's back cover is removed, variable shut-off delay and a keylock switch master control. The SS-5910 also has a panic alarm which triggers the system instantly. An optional battery back-up is available for use when regular power goes off. The system can be added to and can interconnect with magnetic contact switches, smoke alarms and additional infrared motion sensors. Price: $399.95.



Wireless Home Security System

Bits & Pieces



LD/CD/CDV Player

It still can't record, but the new CLD-1010 **LD/CD/CDV Player** from *Pioneer Electronics (USA), Inc. (2265 E. 220th St., P.O. Box 1720, Long Beach, CA 90801-1720)* will play four types of "optical discs." That would be CD's, 8" and 12" laser discs and the recently announced 5" CD videodisc, the CDV. This is the so-called "CD single," combining a brief visual segment with a longer audio program. Pioneer, hands-down, is the leader in the laser disc field, so it's not surprising the company has moved aggressively to incorporate this newest optical disc wrinkle into its player capabilities. Pioneer's laser disc combo players made our "Gadgets of the year" list in January, but we have to wonder how popular the heavily touted CDV product will be. Price: $800.

A new patented process will probably be changing the way packaging and labels look in the very near future. Called **Photolabels**, they are "the first color photos with self-adhesive backing," according to the manufacturer, *Photolabels (USA), Inc. (333 Kimberly Drive, Carol Stream, IL 60188)*. Printed in four sizes from photographic negatives, the examples sent to GADGET are bright, colorful and unlike other photo label or color graphic stickers we've seen. Novelty stickers aimed at kids, an enormously popular product, are one of the items which could be transformed by the Photolabel process. When you start seeing these in mass market use, remember you read it here first. Price (per label): 20¢-50¢.

Add-on MTS TV stereo decoders haver been around for some time, but a new one from *Ambico, Inc. (50 Maple St., P.O. Box 427, Norwood, NJ 07648-0427)* is being marketed at a bargain price. The Ambico **MTS Stereo Decoder** (V-0687) features automatic stereo lock-in, two second audio program modes, LED stereo and second audio program indicators and RF and MPX inputs, doing away with the sometimes frustrating audio probes of other stereo decoders. Price: $99.95.

Tune Tote

Headphones can be a danger when operating any sort of vehicle. But try telling that to some music-loving bicyclist racing by deep into decibel-heavy headphone ecstasy. *Novi, Inc. (7920 Silverton, Suite K, San Diego, CA 92126)* has come up with a practical answer to this safety problem. Dubbed **Tune Tote**, it's a lightweight, plastic stereo speaker system that secures most portable radio/cassette players to the handlebars of a bike. Available in two models, one featuring passive speakers with "moderate sound" and the Tune-Tote 2 which features battery-powered amplification, the units weigh 10 and 14 oz. respectively. Sold in department stores, mail-order catalogs and bike supply stores, we'd guess demand will be especially heavy in the 25 states which outlaw cycling while wearing headphones. Price: $25-$35.

Coming in future issues of GADGET newsletter

- **Report From Chicago—The summer Consumer Electronics Show, by most accounts didn't unveil much new technology. But there were products shown worth knowing about. GADGET guides you through the CES high-tech forest.**
- **TV Snapshots—Ads for the Hitachi color video printer promise, "brilliant prints from any TV screen in 80 seconds." GADGET snaps some small-screen candids with this fascinating new device.**
- **Camcorders to the Rescue—VCR sales are slowing, but the all-in-one camcorder is gaining in popularity. We test Minolta's VHS CR-1200 Video Camera/Recorder to discover why consumers aren't balking at these systems' high prices.**
- **Nothing to Hide—For the first time ever, Polaroid is marketing a clear plastic encased version of an instant camera. We take a look at, and through, the stunning Spectra System Onyx.**

Forget the big bucks. You can assemble most of an IBM PC/XT from what other people throw away

By Herb Friedman

BUILD THE POOR MAN'S IBM PC/XT

EVEN IF YOU HAVE ABSOLUTELY NO USE FOR A COMPUTER at this time, your future depends on your having one. Whether it's to prepare a better report for school, to learn word processing because most entry-level office jobs require the skill, to become adept at Lotus because many employers now require a knowledge of spread-sheets, or even if you're simply running a small business from the kitchen table that's outgrowing your shoebox record-storage system. Each day that you are without a personal computer you fall a bit behind of the rest of the crowd.

Now we all know that personal computers, particularly an IBM PC or one of its clones, doesn't come cheap, but you can probably assemble one yourself for just a fraction of a clone's retail price because much of the hardware you'll need might be tucked away at the back of some closet: stuff that you can get for free, or at little cost!

For example, a friend might have an original IBM disc controller left over after upgrading to a multi-function disc controller, while flea markets are a good place to find old style (but new for you) serial and parallel adapters. Maybe your office has converted to the new-style keyboard and the boss has a closet full of older IBM keyboards he'd like to throw out but he's too cheap. And then there are local dealers who might be "stuck" with a batch of monitors with old-fashioned cabinets that can't be easily sold because everyone wants a monitor in a cabinet with high-tech styling. Or maybe you, yourself, upgraded your original IBM for your mail-order business and you've got a drawer full of adapters that can be used to make up a separate computer so the kids can stop using your bit-blaster for their homework. And if you can't get the stuff free or at flea-market prices, there are many mail-order dealers with warehouses full of "surplus" hardware; "surplus" being a euphemism for "no one wants it, so sell it cheap."

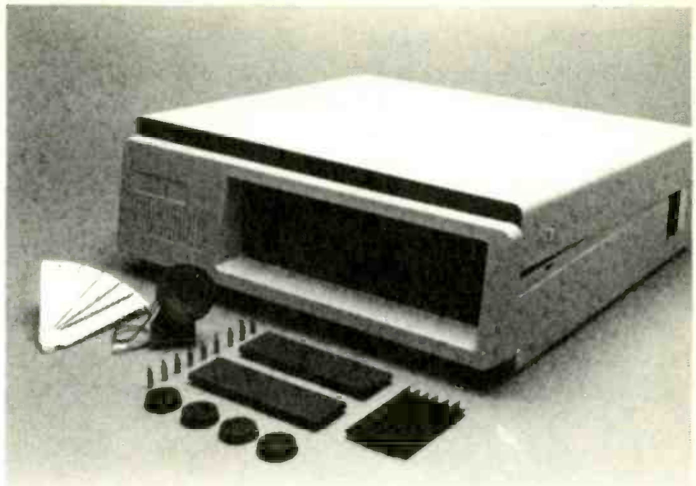
The photo at the top of this article gives you some idea of what's possible. The computer itself has no name because it's built into a $35 IBM-clone cabinet. The keyboard is an original IBM PC that no one wanted because it didn't have a separate numeric keypad or status lights for the CAPS LOCK, NUM LOCK, and SCROLL LOCK keys. The monitor is a razor-sharp NEC that was originally priced near $200. It was purchased for less than $50 from one of America's largest and most famous retailers because people just wouldn't buy such an old-fashioned cabinet. And the two disk drives on the front of the computer were originally used in an upgrade for a Radio Shack Color Computer.

OK, got the picture? We're going to show you the tricks of assembling your own IBM-clone.

The Motherboard

There are three things that you must buy, no matter what else you do. They are the cabinet, the motherboard, and a power supply. For those we recommend any reliable mail order dealer such as JDR, or any local dealer—which is preferable—who will meet JDR's price. There are two kinds of IBM-type computer cabinets. One is a copy of the original, having a chassis that slides out of a sleeve: a troublesome design if you're into changing adapters, experimenting, or anything else involving playing with the guts of the machine. The other kind has a flip-up cover; it's the type shown in the photos. That's the one we recommend, and it should cost you no more than $35 to $40.

The motherboard is the computer itself. Most, but not all, IBM-type motherboards sold by mail-order houses are clones of the IBM PC/XT. Some are PC/AT clones, others are some kind of unknown quantity that resemble an IBM PC/XT—but not necessarily. However, do not confuse them with a "turbo" PC/XT clone motherboard. The "turbos" are XT's that can be software or hardware switched to run about 30% faster than a conventional XT. The reason they must be switched is



This computer cabinet with a flip-up cover comes complete with all hardware, including the speaker and mounting brackets for the disk drives. Price is between $35 and $40.

that some software won't run at the higher speed. If you want to keep costs at rock-bottom stick to the straight PC/XT clone. They're now available for about $100 and are the least trouble when it comes to accessories and software. Keep in mind that the true PC/XT clone, such as the JDR shown in the photos, has eight slots, not five or six, for plug-in adapter cards. (You will probably need at least six or seven slots if you're using "freebie" or flea-market hardware.)

You will also need something known as a BIOS: a ROM or an EPROM containing the input/output system for the computer. They simply plug into one of the empty sockets on the motherboard. Normally, they sell for about $20-$30, but some dealers will throw it in for free with the motherboard. (That's how we got ours.)

Then there's the power supply. The way some magazines tell it, no power supply is ever large enough. Nonsense. There's only so much that can fit into the cabinet. A 135-watt supply that usually sells for less than $70 will handle two floppies, one or two hard disk drives, a 3.5-inch drive, and just about anything else you'll put in the computer. An IBM-type supply will have two power connectors for the motherboard and four (yes four) connectors for disk drives. (The original IBM PC power supply had only two disk drive connectors. Make certain yours has four.) Also, make certain it is a true IBM PC/XT type as shown in the photograph, with the power switch on the side and two power connectors arranged horizontally on the rear. That is the configuration for the standard PC/XT-type low-cost cabinet. Everything, from the fan intake opening to the mounting screws will fit together if you get an exact PC/XT-type power supply. Anything else won't fit the cabinet directly.

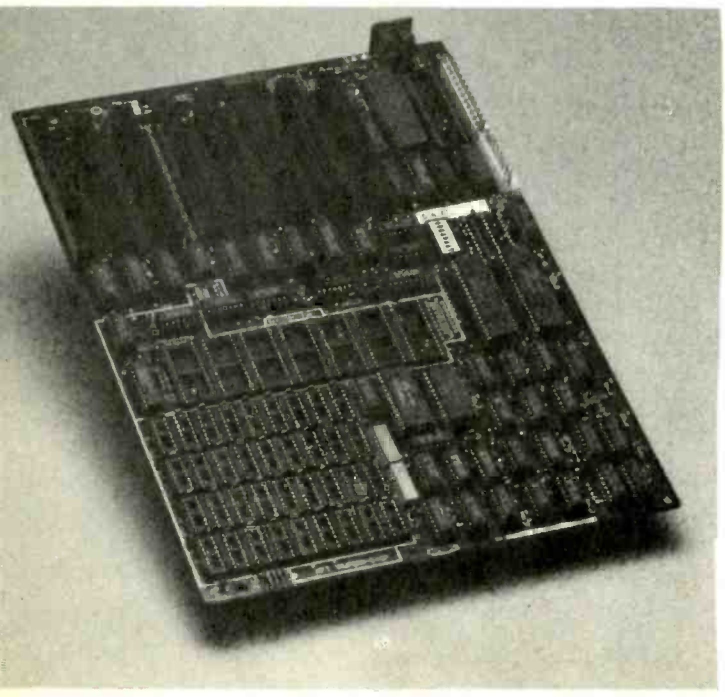
Cabinet Assembly

If you're dealer is at all typical, the cabinet will come with an assortment of parts and not a word about how to put it together. Here are a few tips. There is probably a plastic bracket for the supplied speaker. The speaker's magnet snaps into the bracket and there will be matching mounting holes for the bracket somewhere inside the left front of the cabinet. There will also be an assortment of metal plates for mounting and installing the disk drives. Don't expect to find a use for most of them. And keep in mind that two screws are all that are needed to support a drive.

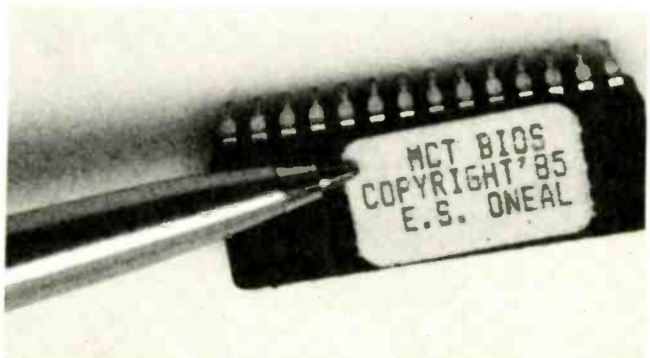
If you have never seen the inside of an IBM computer don't do anything until you see one, and study how everything is arranged. If necessary, make a sketch or take some Polaroid pictures. That is necessary because while the inside of your clone will look like an IBM, much of it is mounted differently. You must know approximately what goes where in order to figure out what hardware to discard. (The clone-type cabinets are made for a variety of "dealer-assembled" hardware configurations, so a lot of extra hardware is supplied.)

Be extremely careful with the screws. They are metric, not ASA (American). Except for the disk driver, do not try to substitute ASA screws. They are a problem we'll get to later because the wrong mounting screw can destroy a disk drive. (No fooling; it's the famed "metric error"—meaning no metric-to-American conversion really works).

The cabinet assembly will be easier if you remove the large bracket that holds the disk drives; it's usually held by only four or six screws. While you're at it, remove the disk drive "dummies"—the four half-height plastic strips that fill the mounting spaces for the disk drives. Don't force them, they



This PC/XT clone motherboard from JDR accepts 640K of RAM and has eight slots. Do not get a board with less than eight slots.



The BIOS is usually, but not always, supplied as an extra-cost option. You simply plug it into the appropriate socket on the motherboard. This one comes free with the JDR motherboard.

should pop free (you might need to use them later to cover unused openings). After the disk-drive bracket is removed, install the speaker and its shield. The shield is usually the bracket for the adapter-card support rails.

Prepare the Motherboard

The first step is to install the BIOS ROM or EPROM in what is usually socket A7. For that step you'll probably get more detailed instructions with the motherboard than you can possibly imagine. Then install the memory IC's. The motherboard has four empty rows of nine sockets each. Each row can accept 64K RAM sets (nine 4164 IC's) for a total of 256K, or two rows of 256K RAM sets (nine 41256's per row) and two rows of 64K. The RAM capacity is programmed by simply moving a plug on the motherboard; instructions for the plug are supplied with the board. Don't try to save a few dollars on RAM. The minimum acceptable memory in terms of new software is 512K, so we suggest you initially install two rows of 256K RAM's for a total of 512K. As shown in the photograph, that will leave two rows unused. You can install two rows of 64K RAM's at a later time, or you can fill up the full 640K now. The extra two rows of memory will cost slightly under $20 additional.

The next step is to install the motherboard in the base of the cabinet. Use all standoffs, spacers, and insulators exactly as described in the documentation supplied with the motherboard. Leave all screws slightly loose until every mounting screw is installed. Then push the board to the front of the cabinet and tighten the hardware. The forward push is important because it provides the very slight clearance needed at the rear so the plug-in adapter mounting brackets will fit without damaging the motherboard.

Next, install the power supply making certain the power switch fits the cutout on the right side of the cabinet, and then reinstall the disk drive mounting bracket. Now for the moment of truth. The disk-drive bracket is meant to hold one or two full-height drives; up to four half-heights; or one or two half-height floppies, and one full or two half-height hard disk drives. If you believe you have no intention of ever using a hard-disk drive use full-height drives. They have a better reliability factor than the half-heights, and more important, no one wants them, so they are usually very inexpensive. Many users replace their two full-height drives with two half-heights so they have an empty compartment for a hard disk. If you can use a full-height drive you can buy one of the "discard" ones new for less than $50, or even pick one up "almost new" for as little as $35.

Mounting the Drives

Any double-sided 5-¼-in. floppy drive advertised as IBM-compatible can be used. That includes drives used by Radio Shack, Zenith, and others. The two half-heights shown in the photos are manufactured by Teac, and were originally used by someone who had upgraded a $100 Radio Shack Color Computer. Normally, however, you will get the lowest price on full-height disk drives. If you use full-heights, simply secure them with two screws passed through the bottom of the cabinet. If you use half- heights, install the bottom one first, using two mounting screws through the left hand bracket. Then attach the right-hand bracket to the drive. Then install the top drive.

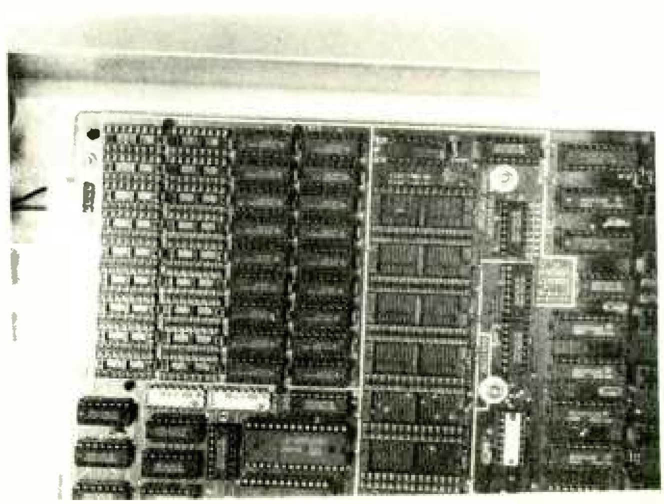
Extra Care

But be extra careful. Although the mounting holes on the bottom of foreign drives might be ASA threaded, the sides often have two sets of holes: one metric, the other ASA. Unfortunately, in many drives the ASA holes are directly opposite the drives' circuit board and the mounting screw simply cracks the edge of the board along with a trace or two. It is an outright stupid design, and you must take extreme care that side-mounting screws do not damage the drive. If you use ASA (type 6-32) screws, make certain they are no longer than ¼-inch. (By the way, you do not have the screw-damage problem with full-height, made-in-the-U.S. drives.)

A Working Computer

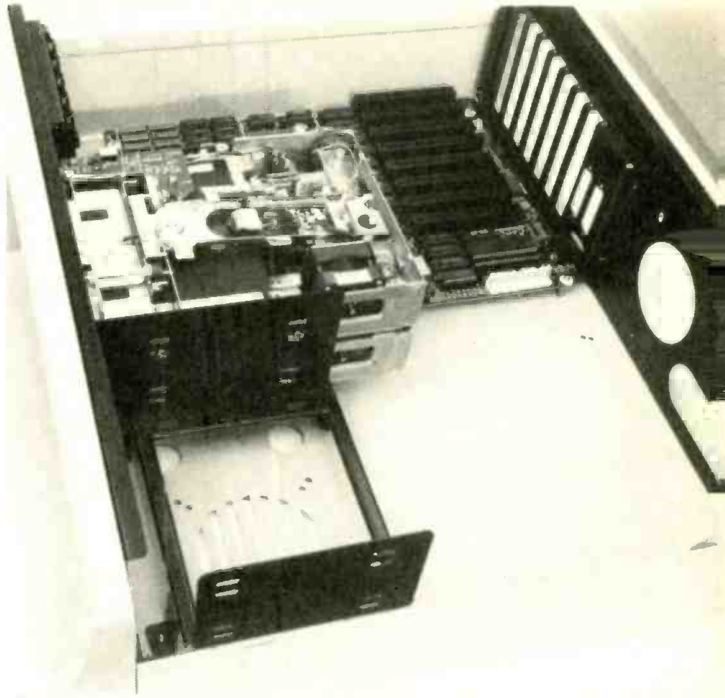
All you need now to get the computer up-and-running is a disk-drive controller and a monitor adapter. You will find that an IBM-type controller can now be purchased new for well under $30 ($10 at flea markets), or you can use a relatively low-cost, multi-function controller that also provides a parallel printer port, one or two serial ports, a game (joy-stick) port, and perhaps a clock. The multi-function board is an outstanding value because you get so much for well under $100. But, and it's a *big* BUT, if you have any intention whatsoever of upgrading the computer in the future, get the cheap IBM-type controller even though the multi-function controller is a much better dollar value. The reason is that the IBM-controller has a connector on the back that was originally intended for two more floppy drives, so it is almost never used. However, the IBM 3.5-inch disk drive's cable plugs directly into that connector, as does one of the least expensive and most convenient tape backup machines (the Irwin). Since 3.5-inch disks will most likely be the standard size by next year, everything will be a lot easier if you have a controller with the external connector.

In addition to the disk controller, you'll need a monitor driver: what IBM calls an "adapter." There are three type of monitors available that work off two basic kinds of adapters. If you're looking to cut costs to rock-bottom, go for a Color/Graphics Adapter and a composite monochrome monitor. The Color/Graphic Adapter, usually called a CGA, allows you to use most word-processing software and all color graphics software. True, the composite monochrome monitor will display everything in shades of green or amber, but that beats not seeing anything at all. You can get an IBM-clone CGA card for about $30 mail order, even less at flea markets;



The two rows of empty sockets on the motherboard are for rows of 64K RAM's. The two rows immediately to the right are filled with 256K RAM's, which provide a total of 512K memory.

No, this is not an IBM power supply, it just looks like one. Notice that it has a total of six power connectors: two for the motherboard and four for disk drives. Do not get a supply with only two disk-drive power connectors.



Assembly will be easier if you install the motherboard and disk drives first. The power supply will fit in the large open space at the right. Notice that one complete disk-drive position is open. It can be used later for one or two hard-disk units.

or maybe there's one stuck away in an office or school closet, or maybe a friend has one he's not using because usually the CGA card becomes obsolete when someone upgrades to extended color graphics. (Again, try to pick up someone's Color/Graphic Adapter cast off.)

The Operating System

Use any version of PC/MS-DOS version 2.0 or higher that's available. If it's IBM's PC-DOS you won't have BASIC because PC- DOS looks for IBM's BASIC in ROM—which your clone won't have. If you have MS-DOS it will have GWBASIC, which emulates IBM's ROM BASIC in RAM. If you never intend to write or run a BASIC program, it won't make any difference whether or not BASIC is available to you. If you have to buy a version of DOS, get MS-DOS 3.1 or 3.2 (3.2 if you think you'll add 3.5-inch disk drives at a later time for added versatility).

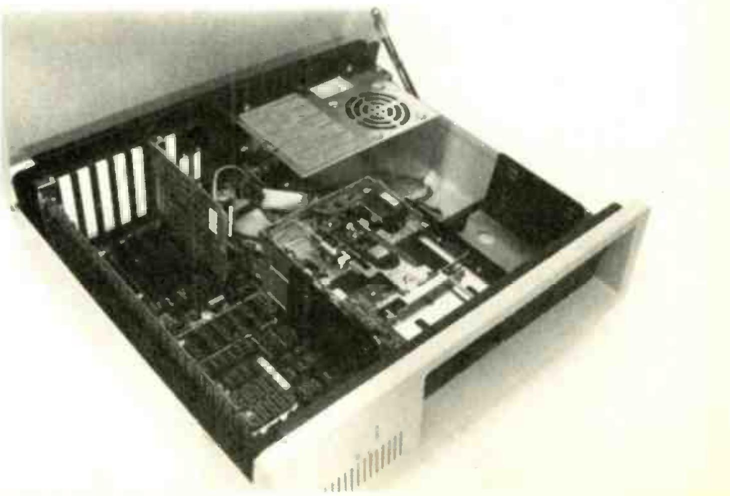
Up and Running

With the cabinet, motherboard, 512K of RAM, two disk drives, a disk controller, and the monitor adapter, you've assembled a complete IBM-clone. If you want to add a printer at a later time, you'll need either a serial or parallel adapter, depending on the the specific printer you use (parallel is always a better buy). Both the serial and parallel printer driver cards are orphans; no one wants them because they take up a full slot. Many have been replaced by multi-function adapters. But your computer has plenty of free slots, so adopt one of the orphans. Last time I looked, an IBM-type parallel adapter was about $15, while the serial adapter went for about $25, not bad is it?

Setting the Switches

Finally, there's a small 8-section DIP switch on the motherboard that must be set to correspond to the amount of RAM in the computer, the type of monitor, the number of disk drives, and whether a math-coprocessor (for extra high-speed math operations) has been installed. There's no reason to waste time going into it because every clone motherboard we've seen comes with notably clear and extensive instructions on how to set the DIP switch.

One last and final word on assembling your own clone. Try to get as much as you can locally, so that if anything is defective you can get a quick exchange. We have had nothing but success with mail-order dealers when it comes to expediting the original order, but getting a replacement for a defective component happens at a snail's pace. Oh, you get the part without any problem. It's just that replacements seem to go at the end of the shipping list. We have waited as long as six weeks to get a defective part replaced. (Remember, even the best shipper, UPS, takes at least six days from coast to coast.) So if you can, use local dealers. ■



Here's the budget-clone ready to go. Note that only two of the slots are used: for the disk controller and adapter.

DIGITAL CAPACITANCE METER

By Dennis C. McClure

This homebrew meter can make short work of identifying unmarked capacitors

□MOST OF US IN HOBBY ELECTRONICS KEEP A WISH LIST (OF equipment that we'd like to have in our shops) tucked way in the back of heads or on a sheet of paper. The essential stuff—for instance, a multimeter or oscilloscope—we always find a way to get. However, the wish list doesn't concern essentials. Instead, it's a list of things that we'd really like to have and should have, if only the need justified the expense: they're just *darned* expensive for the amount of use that they'll see.

If you've been yearning for a capacitance meter (not that they are all that expensive) for as long as I have, then make the *Digital Capacitance Meter* your next project. Easy to build, it's accurate enough for 99% of the uses that you might have in mind. And, best of all, it's cheap. It can be brought in at less than forty bucks.

How It Works

Way back somewhere along the way, you've probably learned that if a discharged capacitor is placed in series with a DC voltage and a resistor, current flows in the circuit, as the capacitor charges to a potential almost equal, but opposite to, the applied voltage. And the charge time (T_c) required to achieve that end is always equal to five times the product of the resistance and the capacitance or 5RC. Thus, it follows that capacity is equal to 5RC/5R or $T_c/5R$. So if you know the value of the resistor and can measure the charging time, a bit of simple algebra yields the capacitance:

$$C = T_c/5R,$$

where C is the capacitance in farads; T is the time in seconds, and R is resistance in ohms. Look at the functional block diagram shown in Fig. 1.

To find a capacitance, we first place a known resistance in series with a voltage source and a couple of test leads for the unknown capacitance, creating a series R/C circuit. If an op-amp is connected across the resistor, it will detect a voltage across the resistor and output a high voltage as long as current flows in the RC circuit.

The op-amp output is fed to one leg of a two-input AND gate, while an oscillator output of known frequency is applied to the other leg. The gate output is the output of the oscillator during the time that (and only as long as) current flows in the R/C circuit. Now, if the output of the gate is fed to a counting circuit—assuming that the resistor for the R/C circuit and the frequency of the oscillator are chosen carefully—the count will be the capacitance of your capacitor. (You won't even have to do any arithmetic.) Display the count and—voila—you have built a capacitance meter.

The Belly of the Beast

Figure 2 shows the schematic diagram of the Digital Capacitance Meter. Let's look first at the series R/C circuit. The unknown capacitor connects to J3 and J4, putting it in series with R6 or R7, depending upon the position of the selector switch, S3. A bounceless switch, consisting of U3a, U3b (2 gates of a 7400 two-input NAND gate connected as inverters), R5 and S2, applies +V to the circuit to initiate a measurement. The bounceless switch is used here because of the tendency of mechanical switches to bounce, which would cause erratic measurements.

With S2 as shown (in its "normal," or up position), pins 1 and 2 of U3 are at ground potential, forcing U3a pin 3 high. That high is fed to U3b at pins 4 and 5, which causes pin 6 of U3b to go low. Any charge on the unknown capacitor is bled off with the switch in the normal position.

If S2 is depressed to its momentary position, pins 4, and 5 of U3b are grounded, forcing the output of U3b at pin 6 high, and the voltage drop across R5 holds the output steady. When pin 6 goes high, +5V is applied through the capacitor and either R6 or R7 (which determine measurement range) to

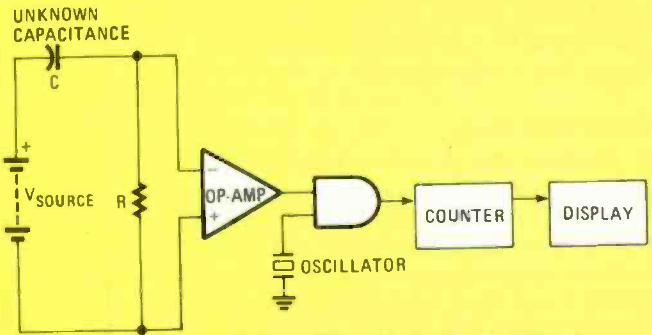


Fig. 1—This functional block diagram shows the flow of operation of the Digital Capacitance Meter. To determine capacitance, an unknown capacitor is placed in series with a known resistance and voltage source, creating a series R/C circuit. The op-amp detects the resistor voltage, feeds that signal to a counting circuit, and displays a value.

The Power Supply

No power source is detailed in the schematic because it seemed desirable to leave you an option. With multiplexing, the meter can be operated from a standard 9-volt transistor battery with a 7505 voltage regulator. But battery life is still not all that long. A surplus +5-volt power-supply connected to the circuit via J1 and J2 is a much better choice.

Capacitor C3 is connected across J1 and J2 to remove any AC ripple that might be riding the DC output of the supply. Any power-supply ripple of more than a quarter volt (peak) will definitely make the meter's operation erratic.

Putting It Together

Figure 3 shows the template for the Digital Capacitance Meter's printed-circuit board (at half size), which measures 6 × 6 inches, giving plenty of room for components. To ensure adequate room for the switches, jacks, etc., an enclosure measuring about 7 × 8.5 inches should be used.

The parts-placement diagram for the Digital Capacitance Meter is shown in Fig. 4, while Fig. 5 shows the positioning of the jumpers connectors. There are a lot of jumpers, but don't let the number put you off. In designing the board, it was necessary to make a choice between double sided—with all the extra expense and difficulty that it would have entailed—and single sided with several jumpers. The latter choice seemed the lesser of two evils.

Begin assembling the board by first installing DIP sockets for the integrated circuits. By installing the sockets first, finding the correct positions for the other parts is made a little easier, and they take much of the pain out of affixing the DIP components to the board. They also make replacement (should it become necessary) a lot simpler, while allowing you to troubleshoot the circuit using the *search and replace* method.

Install and solder the passive components (resistors and capacitors) guided by Fig. 4. Move on, installing the transistors and display modules, which are mounted directly to the board. Careful: too much heat and it's bye-bye silicon. Check your work and, if all seems well, place and solder the jumpers, using Fig. 5 as a guide. Once the jumpers are installed and all work has been checked and rechecked, prepare the project enclosure.

Carefully cut a window in the top of the enclosure—through which the displays will be viewed—and cover it with a clear piece of Plexiglas. The displays are easily read though the window, but kept safely out of harms way. The board, when mounted in the enclosure, is raised (using spacers) so that the display modules are positioned just beneath the top of the enclosure.

Mount four jacks to the top of the enclosure (or in any convenient location), labeling them J1–J4, and connect them to the appropriate points on the circuit, as indicated in Fig. 4. Finally, connect C3 across J1 and J2 (the +V input). After soldering in place fasten the unit to the inside surface of the enclosure with cable ties, a dab of silicon cement, or other adhesive to relieve mechanical strain on the leads.

Troubleshooting Tips

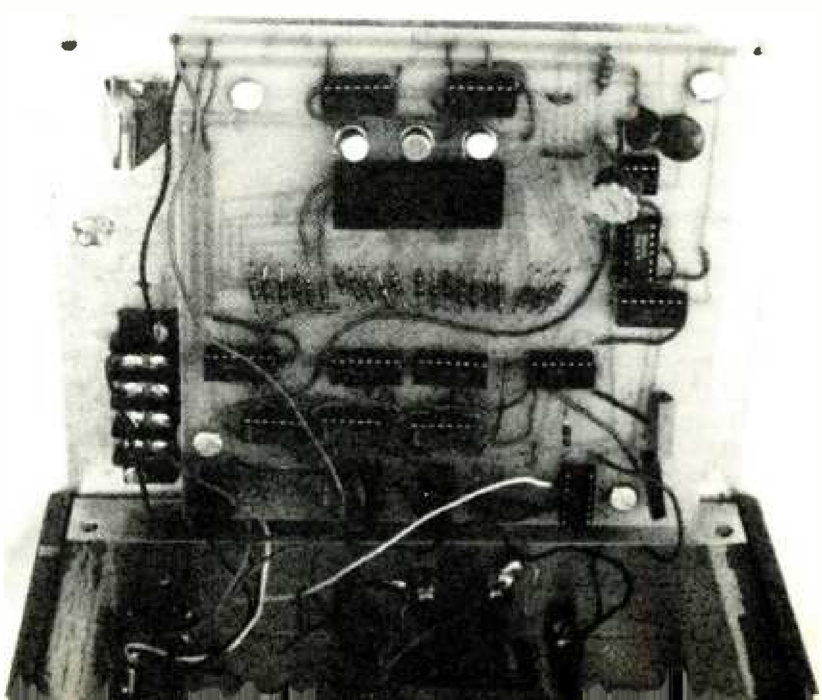
To troubleshoot the circuit, just break it down into components and check them one at a time. Check the power-supply components for a stable voltage. Make sure that +5 V appears at pin 6 of U3 when S2 is depressed, and that it vanishes when S2 is released. Check resistance across R6 and R7 in both selector positions.

Now touch the test leads together, apply power (via S2) and make sure that pin 7 of U4 is at five volts. Release S2 and see that pin 7 goes to zero volts. To check the oscillator simply check pin 3 of U2 for a 10-kHz output, and adjust R2 for the correct frequency. To test the counting circuit, touch the test leads together, apply power by depressing S2 and then check the frequencies at pin 11 on the 7490's: U9 should yield 1kHz; U11, 100Hz and U13, 10Hz. Most of the problems in the display circuit will occur within the multiplexing apparatus. Check the set and reset pulses then check for 3.33kHz at the transistor bases.

Once the circuit is operating, calibration is a snap. Simply set the output of U2 (pin 3) to precisely 10 kHz, and adjust R6 to 20 ohms and R7 to 20 kilohms. Those are only starting points, but they'll be close. Now check each range against a standard and adjust its resistor until it matches. Well, there you have it, a simple-to-build Capacitance Meter that lends itself to homebrew substitution, which could drive construction costs below that of the author's prototype. Have a good time and good luck. ■

A DIGITAL CAPACITANCE METER

This top-side view of the inner workings of the Digital Capacitance Meter reveals that there are actually fewer jumper connections (several of which can be cut-off resistor leads) than you might expect, after viewing the illustration in Fig. 5. You'll note that the author's prototype, in the upper righthand corner near the circuit board, there is a barrier strip. It is really not necessary because all wire connections could just as easily be terminated at the printed circuit board.



Game Feeder Controller

By James H. Bran

With a feeder controller in your hunting gear, the game feeder loads itself

IT'S HUNTING SEASON ONCE AGAIN, AND LIKE A FLASH you grab you favorite hunting outfit and take off for the great outdoors. Crouched behind a clump of bushes, your outfit blending with the surrounding landscape, you wait for the game to arrive. Hours later, off in the distance, you hear scattered gun fire. Surely those hunters are having better luck than you are.

Then like a bolt from the blue, you realize that you've forgotten to set out your bait. Or perhaps some small critter—squirrel, or similar small beast—has been pilfering goodies from your feeder, so there's nothing left to attract the game. What ever! Off you go to your feeder just a few yards away, when just the prey you'd hoped to get in your sights shows on the scene. Startled by your presence, the game takes off for the high country.

And so your hunting excursion goes; each time you check the feeder, its empty and as you attempt to restock it, the game gets a glimpse of you, sending it streaking into the underbrush. You quibble to yourself something to the effect that "I should have gone fishing."

The Game Feeder Controller provides an alternative to paying $80 to $100 for a similar factory-built timer equipped with a light-activated switch. Our device will turn on your feeder twice a day, once in the morning and again in the evening, and can be built for around $20 or less (depending on how well your junkbox is stocked).

About The Circuit

The schematic diagram of the Game Feeder Controller is shown in Fig. 1. The circuit is built around an LM339 quad comparator, U1, which forms the basis of a Schmitt trigger, timer circuit, and a window comparator. One comparator within the LM339 (pins 1, 7, 6), plus LDR1, R4, R5, R6, and R8, is used as a Schmitt trigger. The timer circuit (which receives its input from the Schmitt trigger) consists of R9, R10, R11, R13.

The last two-fourth's of U1 (pins 8, 9, 10, 11, 13, and 14) are wired as a window comparator. The two inputs to the window comparator are derived from the charge on capacitor C1—which is fed to pins 9 and 10 of U1. The other inputs are picked from two points along a voltage-divider network, consisting of R1, R2, and R3. Diode D1 is used as a blocking diode, forcing capacitor C1 to discharge through R10 and R13.

The window comparator looks for any voltage falling between one-third and two-thirds of the supply voltage. When the voltage falls between those two points, the output of the window comparator (pins 13/14) goes high. Transistors Q1, and Q2 are turned on, when the pins 13/14 junction goes high, energizing the relay, K1. The energized relay provides a DC path to ground, activating the motor, M1, which reloads the feeder. The timer circuit also provides immunity from triggering, due to lightning.

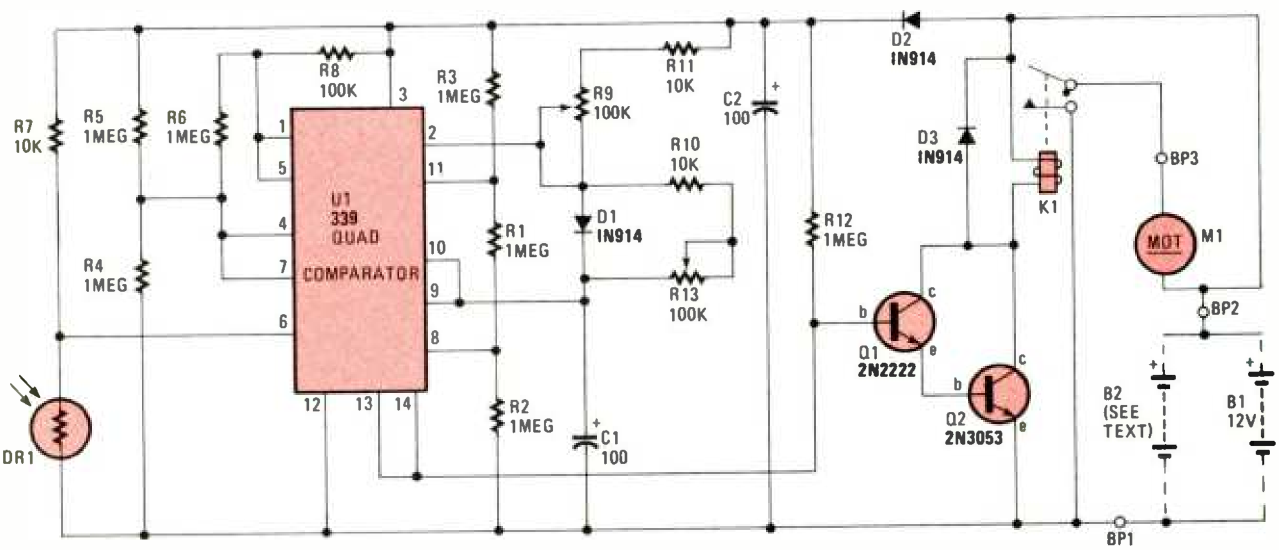
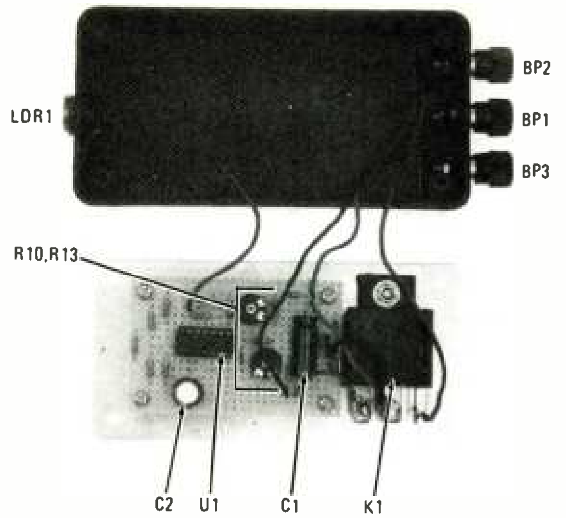


Fig. 1—The Game Feeder Controller circuit is built around an LM339 quad comparator, U1, which looks for any voltage falling between one-third and two-thirds of the supply voltage. When that occurs the output (pins 13/14) goes high, turning on Q1 and Q2, energizing K1, providing a path to ground to actuate the motor.



The author's prototype was built on a 2-¾ by 1-¾ inch piece of perfboard. The circuit-board/relay assembly was mounted to the top of the box. Four holes are drilled into the corners of the board and five into the cover (four for the board and one for the relay) to accommodate mounting hardware.

The on-time of relay K1 is determined by the charge cycle of C1, R11, and R9 or the discharge cycle of C1, R10, and R13. Changing the value of either a resistor or the capacitor, changes the timing cycle.

Construction

There is nothing critical about the circuit layout; therefore any construction technique can be used. If you wish, you can etch and drill your own printed-circuit board, using a layout of your own choosing. Or you might want to build the circuit on perfboard or experimenters board, using the appropriate interconnection technique—wirewrap, point-to point wiring, etc. You might even consider laying out the circuit on a solderless breadboard. But, regardless of the construction method used, it's a good idea to use an IC socket for the comparator chip (U1).

In the author's case, the prototype was built on a 2¾ by 1¾ inch piece of bare (no copper) perfboard, using point-to-point wiring and cutoff resistor leads to accomplish the component interconnections on the underside of the board. If you decide to follow the lead of the author, use the layout in the photos as a guide.

Install an IC socket for U1—making sure that it's properly seated—wiring the socket as you would the chip, making the connections indicated in Fig. 1, and taking care to properly orient electrolytic capacitors C1, C2. When installing transistors Q1 and Q2, make sure that their biasing is correct before soldering their leads to the other wires.

Once the circuit is completely assembled, it can be housed in any plastic or metal enclosure that's large enough to accommodate the circuit-board assembly and power relay K1 (the experimenter box listed in the Parts List, for example). The circuit-board/relay assembly is mounted to the top of the enclosure, on spacers to prevent shorting. Drill holes into the board, and cover to accommodate the mounting hardware.

Next, drill five holes into the enclosure itself—two in the front panel (through which LDR1 is connected to the board) and three in the back panel to accommodate binding posts BP1–BP3 (two going to the power source and the last one serving as one of the motor connections)—for the off-board components. When mounting LDR1, run a thin bead of quick-set epoxy cement or silicone adhesive around the LDR outside the box to anchor it in place.

Using standard No. 18 hookup wire, connect the circuit board to the off-board components. First cut four 4- to 6-inch lengths of wire, stripping away about a quarter of an inch of insulation. Tightly twist the bare ends and tin them to prevent *bird caging*. Connect and solder to the appropriate points.

Calibration and Use

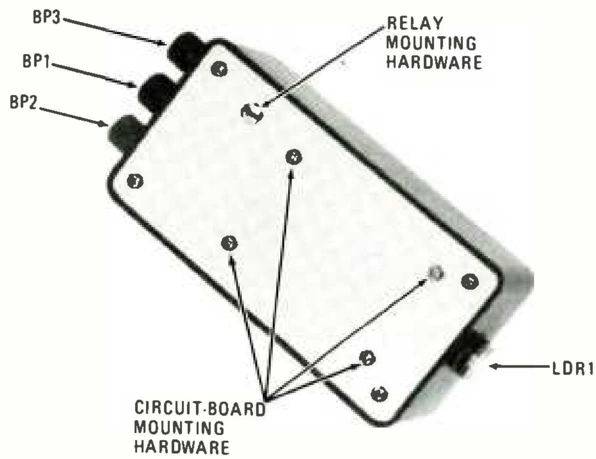
To calibrate the Game Feeder Controller, connect a 12-volt automobile battery to the circuit via BP1 and BP2. Now, connect the motor, M1, to BP3 (which is attached to the K1 contact) and to the positive post of the battery. Adjust R9 and R13 to their mid positions, and hold your hand over LDR1 until the motor starts and stops running. Then, remove your hand and the motor should cycle through another run. Now, this time, put your hand back over LDR1 and measure the amount of time that the motor runs.

On most feeders, the optimum run-time is four seconds. You can make changes in run-time by adjusting potentiometers R9 and R13. Adjust R9 for triggering by decreasing light, and R13, for increasing light. When choosing your battery, be sure it can handle the amount of current required by the motor. If the battery amperage isn't sufficiently large, the relay will drop out.

Well that just about does it, except for connecting it to operate your feeder. Once that's done, you won't have to worry about the game sighting you and we do hope you shoot with a camera. ■

PARTS LIST FOR THE GAME FEEDER CONTROLLER

C1—100-µF, radial-lead, electrolytic capacitor
C2—100-µF, axial-lead, electrolytic capacitor
D1–D3—1N914 (or similar) small-signal diode
K1—Relay, 12-volt DC coil, car-lighting type (RS 275-226)
LDR1—Light-dependent resistor (RS 276-116)
Q1—2N2222 NPN general-purpose, silicon transistor
Q2—2N3053 NPN AF/video amplifier, silicon transistor
R1–R6, R12—1-Megohm, ¼-watt, 5% resistor
R8—100,000-ohm, ¼-watt, 5% resistor
R9, R13—100,000-ohm, potentiometer
R7, R10, R11—10,000-ohm, ¼-watt, 5% resistor
U1—LM339 quad comparator (RS 276-1712)
Printed-circuit board or perfboard materials, IC Socket, PC-board standoffs, binding post, experimenter box, wire solder hardware, etc.



In the base of the project box five holes are drilled—two in one side, through which LDR1 is connected to the board, and three in the other to accommodate the binding posts, BP1–BP3.

MODEM QUESTIONS & ANSWERS

By Jan Exelson

Whether you know a little or a lot about modems, this article will help you get your facts straight.

IT'S NO SURPRISE THAT CONNECTING A COMPUTER AND A TELEPHONE requires a translator. The phone system was designed decades ago for transmitting smoothly changing, low-frequency, voice signals, while computers process the 1's and 0's of digital pulses, usually at high speeds. As you may know, the device that translates between the computer's digital pulses and the telephone's analog signals is called a modem.

To understand what modems are all about, it helps to be familiar with the buzzwords—the words, phrases, and acronyms that describe and help explain modems. Whether you're building, buying, installing, fixing, or just using a modem, chances are you'll come across some of those terms.

What's a Modem?

A modem contains a modulator and a demodulator. A modulator is a device that combines two signals—one containing information and another, called the carrier, that provides a means of transmitting the information. A demodulator does the reverse—it returns the signals to their original form.

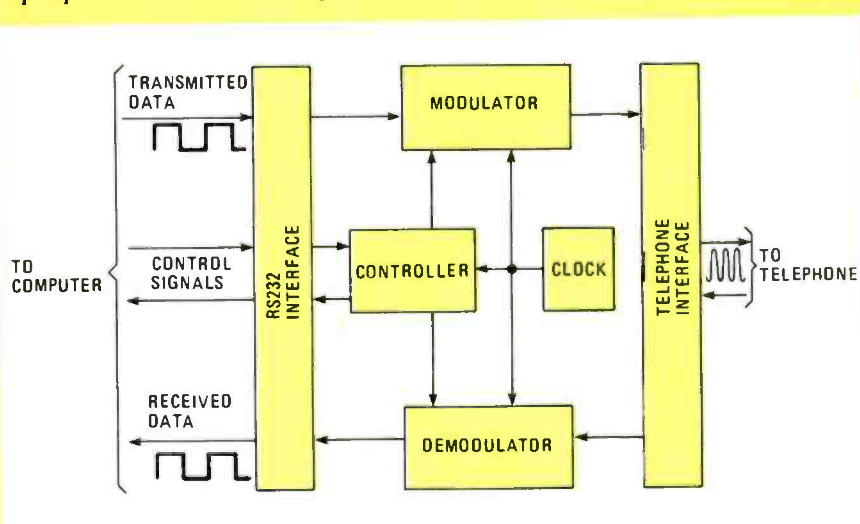


Fig. 1—A modem translates between the analog signals of a telephone and the digital pulses of a computer. It gets its name from the two work horses in this diagram: the *mod*ulator (which outputs to the telephone) and the *dem*odulator (which outputs to the computer). The rest just checks for data.

In the world of personal computers, the word modem usually refers to the entire device that connects a computer to the telephone network. A computer modem such as that, includes a modulator and demodulator, as well as controlling circuits and interfaces to the phone lines and to the computer. Figure 1 is a block diagram of a typical computer modem.

Bell 103, What's That?

A computer hooked to a modem can communicate with other computers that are also linked to modems. But in order to understand each other, the two modems have to agree on what kind of signal to send. To make that decision easier most modems follow one (or more) of several standards.

Bell 103 is one of these standards. It was developed years ago by the Bell Telephone Company and has been popular with home users because it's relatively cheap and easy to implement. The standard defines frequencies for communicating at speeds of up to 300 *bps* (bits per second) using FSK modulation.

What's FSK Modulation?

To understand *F*requency-*S*hift *K*eyed modulation, you need to know a little about the telephone system. Modern telephone networks often use high-speed digital equipment in their central-office switchers and intercity links. But the end item—the standard telephone set and the two wires that connect it to the central office—haven't changed much over the years. A standard telephone line only transmits frequencies from 300 to 3400 Hz, and transmitting digital pulses requires a much wider frequency band than that.

To get around that limitation, frequency-shift keyed modulation uses bursts of tones, or frequencies, to encode the 1's and 0's represented by the digital pulses. Figure 2 shows those tones as defined according to the Bell 103 standard.

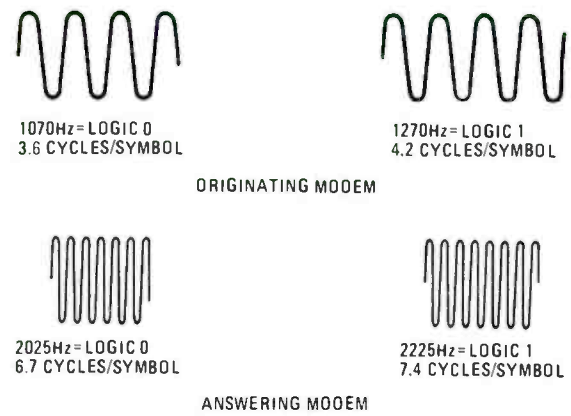


Fig. 2—In FSK modulation, frequencies represent the 0's and 1's of the computer's digital pulses. The symbols shown represent the signals transmitted using the frequencies of the Bell 103 standard. Each burst, lasts 1/300 of a second.

Originate and Answer Modems

Originate and answer modems each transmit in a different frequency band, or channel. That allows modems to transmit and receive at the same time.

The originating modem is usually the one that makes the call, but it doesn't have to be. In fact, two originate or two answer modems can talk to each other, as long as they don't transmit at the same time.

Most modern modems, including all Bell 103 modems, can operate in either originate or answer mode.

Baud Vs. Bit Rate

You'll often find baud rate and bit rate used interchangeably, but they're not the same thing, though they often have the same numerical value. The *bit* rate (bits per second) is the number of unmodulated pulses that the computer or terminal sends to its modem in one second. The *baud* rate refers to how many symbols per second are transmitted over the phone lines.

In Bell 103 FSK modulation the symbols are frequency bursts. Each burst represents one bit and the baud rate equals the bit rate. But in some other modulation methods each symbol represents two or more bits, and the bit rate is faster than the baud rate.

What's PSK modulation?

The *P*hase-*S*hift *K*eyed modulation method encodes data with phase or time shifts instead of frequency shifts. High-speed modems use PSK modulation because it's capable of faster bit rates than FSK modulation using the same bandwidth.

A Bell 212A Modem

Bell 212A is a standard for transmitting at 1200 bps using PSK modulation. In that standard the originating modem transmits a carrier at 1200 Hz, and the answering modem transmits at 2400 Hz.

The standard defines four phase shifts, shown in Fig. 3. Data is encoded by phase-shifting the carrier signal 600 times per second, and the amount of the phase shift represents the code for a pair of data bits. Because each shift represents 2 bits, the bit rate (1200 bps) is twice the baud rate (600 bps).

Bell 212A modems usually cost more than Bell 103 modems, but they might save money in the long run because they're faster and reduce the phone bill. Of course both modems in a link have to be 212A-compatible in order to communicate at 1200 bps, but if need be, a Bell 212A modem can also transmit at a fall-back frequency of 300 bps.

Are There Other Standards?

In a word, yes. The ones you'll hear most about are the high-speed modem standards set forth by the CCITT (*C*onsultative *C*ommittee for *I*nternational *T*elephone and *T*elegraph).

The CCITT standard V.22bis is becoming a popular standard for transmitting at 2400 bps. It describes PSK modulation at 600 baud with 16 different carrier states. And CCITT standard V.32 describes transmission at a speedy 9600 bps,

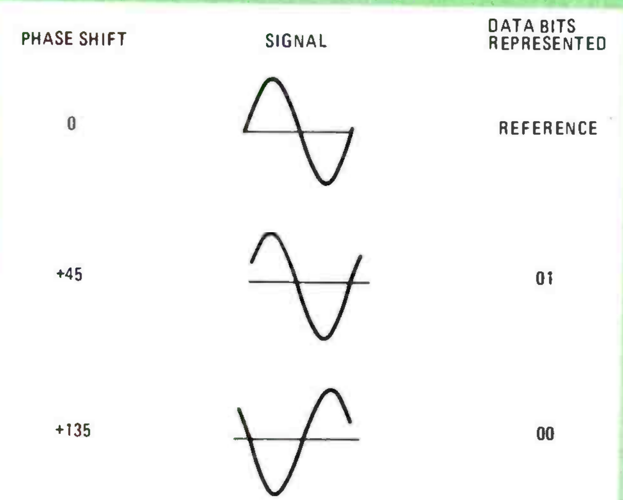


Fig. 3—Phase shifts can also be used to encode data. Notice that each phase shift represents a pair of bits. Those are the phase shifts used in the Bell 212A standard.

transmitting at 2400 baud with 32 different states! That last standard is still difficult and expensive to implement over regular "voice-grade" phone lines.

What's a Terminal Emulator?

To send and receive data via modem, you need a terminal or something that acts like a terminal. A terminal is a device for sending data (a keyboard, for example), one for receiving data (a display), and a means to control them (communications software).

You can mimic a terminal with a computer's keyboard and display and a terminal-emulating program, which makes the computer behave like a terminal. Many of those programs can set parameters, save data, and even remember and dial phone numbers for you.

Parameters

Parameters define how the data will be transmitted. Again, both ends have to agree on how to set them. Some of the parameters in modem communications are baud/bit rate,

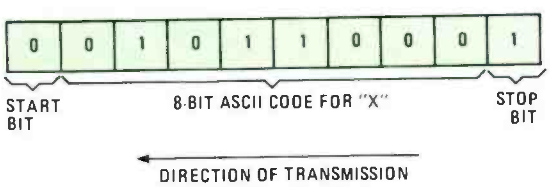


Fig. 4—This is the code for transmitting the letter "X" using 8-bit words, no parity, and 1 stop bit. The leftmost bit (which is the least significant bit) is transmitted first.

number of stop bits, and parity.

You know what baud rate is. Stop bits and parity describe how each character (a letter, number, or other symbol) is transmitted. Figure 4 shows the bits that make up a typical transmitted character.

When there's no data to transmit, the modem sends a string of 1's, so a start bit of 0 announces the beginning of a character. Next come the data bits, usually a 7 or 8-bit ASCII (*A*merican *S*tandard *C*ode for *I*nformation *I*nterchange) code. Finally, there's an optional parity, or error-checking bit, and 1 or 2 stop bits to mark the end of the character.

Usually the communications program allows you to set the parameters from your keyboard. If you're not sure how to set the parameters to match the computer you're calling, you can probably find a working combination by trial and error. A common set of transmission parameters is no parity, 7 bits/word, and 1 stop bit.

Simplex and Duplex Transmission

Simplex is one way only. You can either receive or transmit, but not both. In half-duplex transmission you can send as well as receive, but not simultaneously—the two modems have to take turns, and in full-duplex transmissions both ends can send and receive at the same time. All Bell 103 and 212A modems are capable of full-duplex transmission.

What does X-modem mean?

X-modem is a protocol, or set of rules, for verifying data as it's received. With X-modem the transmitting computer sends files in blocks of 128 data characters. At the end of each block the transmitting end sends a checksum character that represents the sum of all the characters in the file. The receiving end does its own calculation and compares the two numbers. If they agree, the receiver sends an acknowledge signal and waits for the next block. If the checksums are different, the receiver requests the transmitter to try again.

Many communications programs offer the option of transferring data using X-modem protocol. It's a simple though not foolproof way to check for errors in the signal you're receiving.

What are Hayes-Compatible Modems?

The Smartmodem, sold by Hayes Microcomputer Products, Inc., contains its own microprocessor, programmed to obey commands entered at a terminal. The Hayes command set has become an industry standard of sorts, and a modem or software advertised as Hayes-compatible should respond to the basic Hayes commands.

Beyond that there are no guarantees. Additional commands or commands that specifically address the Hayes hardware may or may not work with non-Hayes products.

Direct- Vs. Acoustic-Coupled Modems

An acoustic-coupled modem includes a speaker and a microphone. The handset of the telephone fits into a cradle on the modem, and the modem sends and receives audible tones. By contrast, a direct-coupled modem plugs directly into the phone line. Most direct-coupled modems can dial and answer automatically. Direct-coupled modems have better frequency response and aren't sensitive to room noise, but they cost more, and because they're wired to the phone network, they're more strictly regulated.

What's a DAA?

A *D*ata *A*ccess *A*rrangement is an FCC- (*F*ederal *C*ommunications *C*ommission) registered circuit designed to protect the telephone network. Direct-connected modems are required to connect to the phone lines through a DAA.

What's RS232?

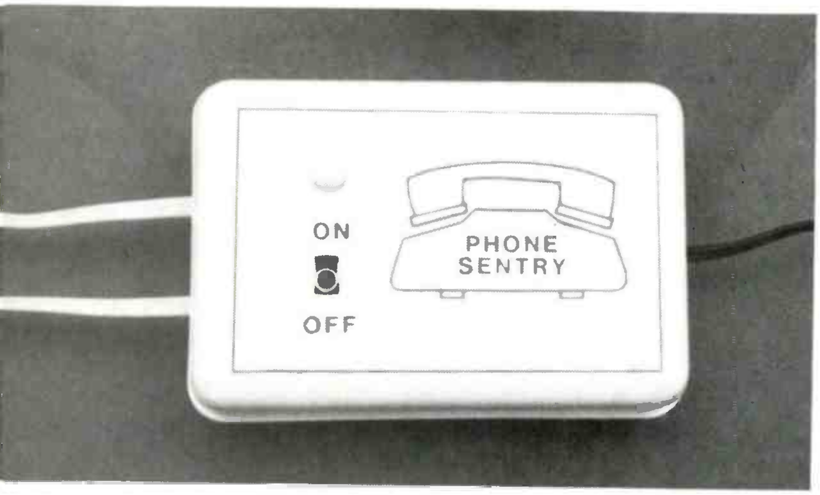
RS232 is a standard of sorts that defines data and control signals between a modem and a terminal. Most external modems connect to the computer via an RS232 interface. Internal modems that plug directly into the computer bus don't require an RS232 interface.

DCE's and DTE's

In the RS232 standard the DCE (*D*ata *C*ommunications *E*quipment) is the modem and the DTE (*D*ata *T*erminal *E*quipment) is the terminal. The standard defines the direction of transmission in relation to those two devices. It also specifies that the DTE port have a male connector and the DCE a female connector.

Because RS232 has become a popular interface for many uses besides modem communication, some computers have DCE ports, usually meant for a printer or other device. You can use a DCE port to connect a modem if you use a special adapter plug that crosses some of the signal lines, and in effect changes the DCE port to a DTE.

That about raps it up for the lingo for modem use. If you wish to go further in your study of modems, there are several good texts from standard electronics publishers on the subject, and with the background material presented here, you should find the information easy to digest. Hope you learn how to reach out and modem someone soon. ■



PHONE SENTRY

By Luther M. Stroud

Daysleepers or professional persons on-call, defend yourself from nuisance calls with this call screener

TELEMARKETING PROFESSIONALS SUBJECT THE UNsuspecting consumer to a barrage of telephone sales pitches. The day-sleeping shift worker has three options: disconnect the phone, use a recording machine, or (most displeasurable of all) answer the phone. The first two options will certainly protect your sleep; but if you are a professional person, who is on-call, you *must* answer the phone. Still, you need not concern yourself with being disturbed by "junk" calls if you build and install the *Phone Sentry*.

The Phone Sentry, with a minimum of cost and complexity, works on the premise that callers of low priority hang up after about six rings or less. Thus, what the Phone Sentry does is allow the user to program the number of rings of an incoming call that must occur before your telephone is allowed to ring. Although Phone Sentry is not a cure-all for disturbing phone calls, it certainly can help protect the sleeping person from wrong numbers, sales pitches, and the most impersonal of them all, telemarketing computers.

How it Works

Figure 1 shows the Phone Sentry's schematic diagram—a rather simple circuit comprised of four integrated-circuit chips and a handful of assorted support components. Placing S1 in the "on" position applies power to the circuit and places R1 in series with one side of the line going to your telephone. That inhibits an incoming ring signal from activating the bell in the phone, but allows the circuitry to sense when the handset is lifted to make an outgoing call.

A fullwave-bridge rectifier is formed by D9–D12, with its positive output being applied to the cathode of D13. The bridge ensures that the voltage applied to D13 is always

PARTS LIST FOR THE PHONE SENTRY

SEMICONDUCTORS
D1–D8—1N914 small signal diode
D9–D12—1N4004 1A, 200-PIV rectifier diode
D13—12-volt ½-watt, Zener diode
LED1—Light-emitting diode (optional, see text)
Q1—2N2222A general-purpose NPN transistor
U1—CD4013B dual, D-type flip-flip, CMOS integrated circuit
U2—CD4538B dual, monostable-multivibrator, CMOS integrated circuit
U3—CD4040B binary counter, CMOS integrated circuit
U4—4N36 or 4N37 optoisolator/coupler, integrated circuit

RESISTORS
(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1—47,000-ohm
R2–R4—10,000-ohm
R5, R6, R9—100,000-ohm
R7—680,000-ohm
R8—330,000-ohm
R10—1000-ohm (optional, see text)

ADDITIONAL PARTS AND MATERIALS
C1—.01-µF ceramic disc
C2, C3—10-µF, 16-WVDC electrolytic
I1—6-volt subminiature incandescent lamp (optional, see text)
K1—Reed relay, (PC-mount) 5-volt coil (RS 275-232)
S1—Double-pole, double-throw (DPDT) miniature PC mount slide switch
Printed-circuit board, suitable enclosure, wire, solder, battery and battery holder or AC adapter, hardware, etc.

The following is available from Pershing Technical Service, PO Box 1951, Ft. Worth, Texas 76101: A kit of parts priced at $30.00, which includes a pre-etched, pre-drilled printed-circuit board; all components; 7-foot modular cable; enclosure, and choice of battery holder or AC adapter. Please specify which power source when ordering. In addition, the following items are available separately: printed-circuit board only at $12.00; component-parts kit with printed-circuit board $24.00; enclosure $3.00; modular telephone cable $4.00; 6-volt AC adapter $4.50. Quoted prices include postage and handling for USA orders. Canadian orders add $2.00. Please allow from 6 to 8 weeks for delivery.

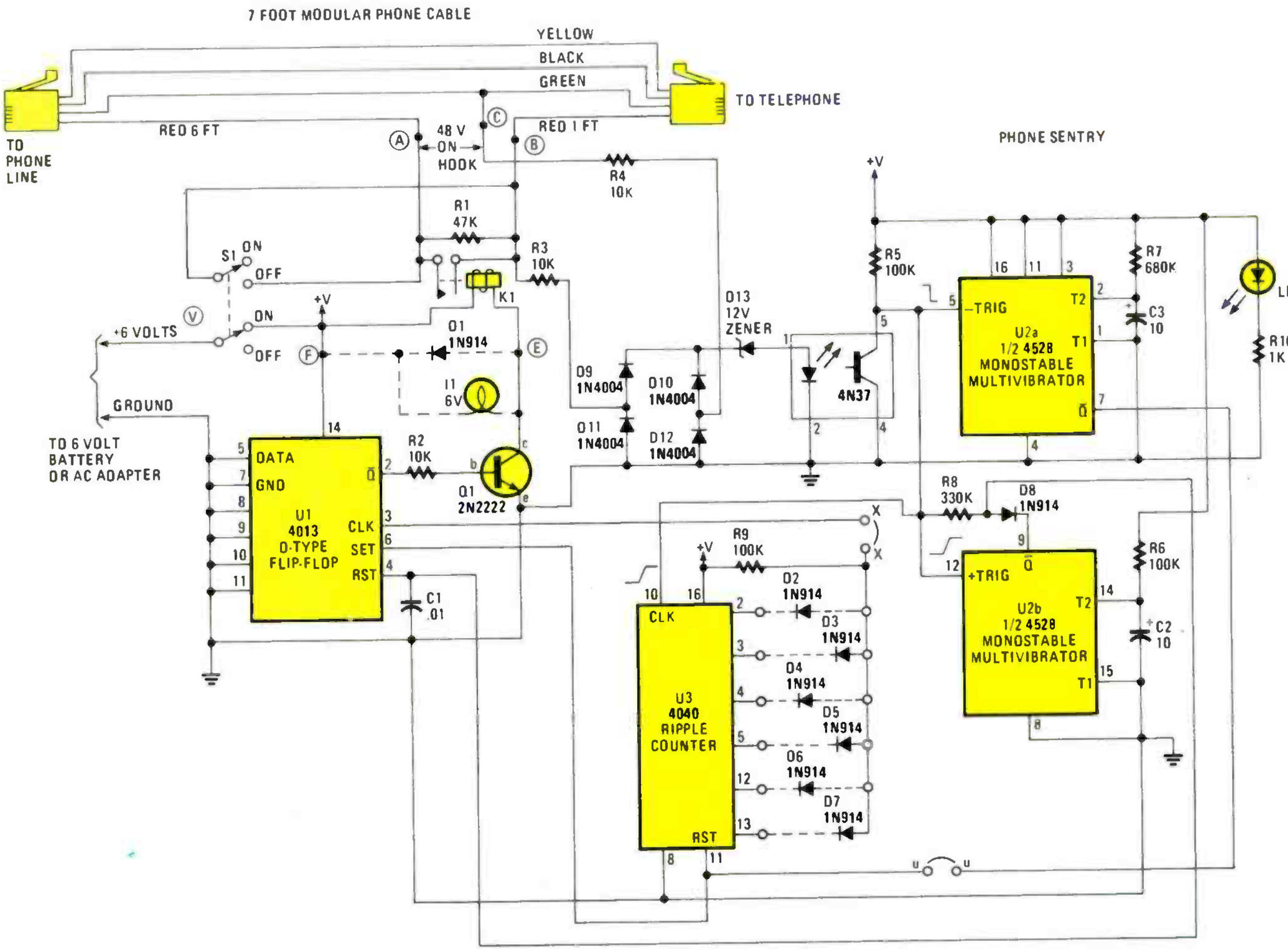


Fig. 1—The Phone Sentry project is a rather simple circuit comprised of four integrated-circuit chips and a handful of assorted support components. A fullwave-bridge rectifier—formed by diodes D9–D12—with the telephone on-hook, applies 10 volts across D13, which enables optocoupler U4, and causes the voltage at pin 5 to drop to near ground potential.

positive, without regard to the telephone-line polarity. Resistors R3 and R4 maintain the balance of the line and limit current through U4, a 4N37 optoisolator/coupler.

With the telephone on hook, 10 volts appears at the cathode of D13, causing current to flow through the LED within U4, enabling it and causing the voltage applied to pin 5 by R5 to be near ground level.

Now let's assume that an outgoing call is to be made. The phone's receiver is lifted, causing a voltage drop across R1. The forward bias is removed from D13 and U4 turns off. Pin 5 of U4 rises to the positive supply rail. That positive-going transition is fed to pin 12 of U2b (half of a 4528 dual monostable multivibrator, set for a timing cycle of 1–2 seconds). Its purpose is to allow relay K1 to close and remain closed when making an outgoing call. The relay closes after U2b completes its timing cycle.

Now let's assume that the outgoing call is completed and the receiver of the telephone is hung up. Pin 5 of U4 returns to a logic "0" level. That negative transition, when sensed at pin 5 of U2a, triggers that multivibrator, starting its 7- to 10-

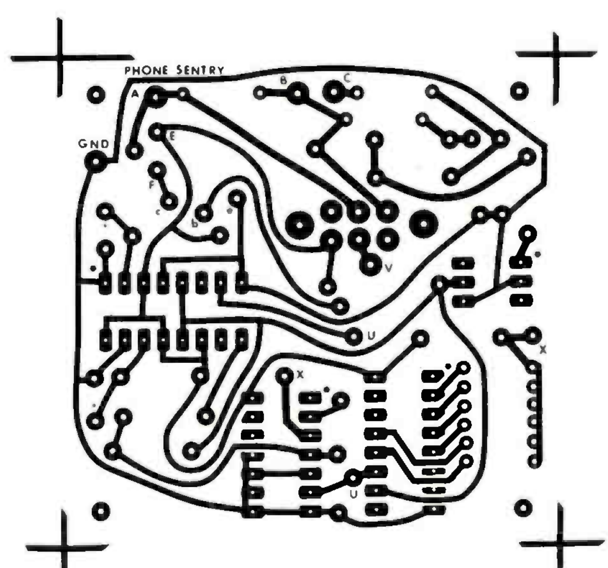


Fig. 2—The assembly of the Phone Sentry on printed-circuit board is, by far, the easiest way of putting the project together. This full-scale template is provided for those who prefer to *roll their own*. For those not inclined to the rigors of etching your own circuit board and chasing down the parts, a kit supplier is given in the Parts List.

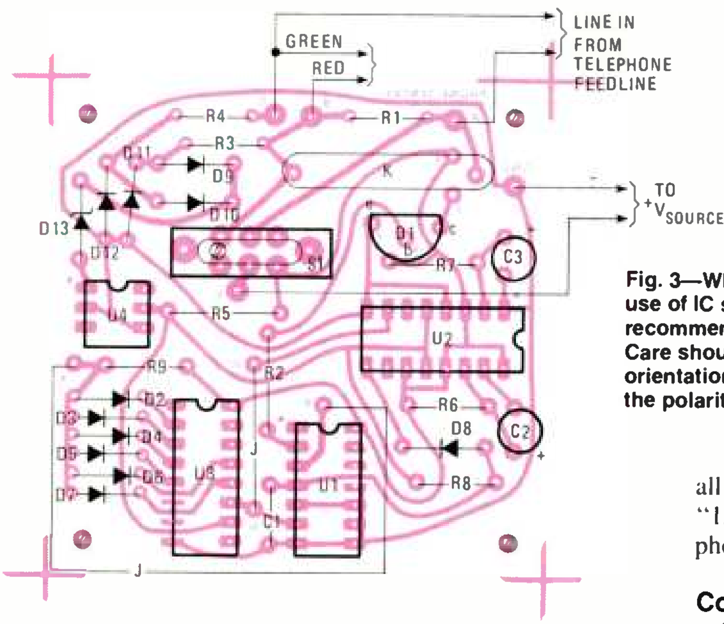


Fig. 3—When assembling the Phone Sentry's circuit board, the use of IC sockets (inserting the actual chip last) is highly recommended to prevent damage to those silicon CMOS wafers. Care should be taken when installing the diodes—note their orientation and avoid overheating during soldering. Also note the polarity of capacitors C2 and C3 during installation.

second timing cycle. That serves a twofold purpose: It holds the relay closed for 7 to 10 seconds after the phone is hung up, and allows U3 to count. U2b does not trigger.

Now let's see what happens when a ring signal is presented on the phone line, indicating an incoming call. The 90-volt, 20-Hz, AC ring signal enters the circuit through the modular plug, travels through the bridge rectifier, which doubles the signal frequency to 40 Hz. That causes both halves of U2 to begin timing. Pins 7 and 9 go to logic level 0, allowing U3 to begin counting ring pulses. U1 is inhibited, so its Q output (at pin 2) is at logic 0, preventing any base-emitter current flow through R2 and Q1.

Under those conditions, Q1 is turned off, the relay (K1) contacts remain open, and the telephone is not allowed to ring. Capacitor C1, connected to pin 4 of U1, prevents the short pulse that occurs between the time U2b is triggered and pin 9 goes low from toggling U1a. All that is needed now is a clock pulse from U3, along with a few associated components, to toggle U1 and close the relay.

Integrated circuit U3 is programmed to count ring pulses by connecting diodes D2–D7 to form a multiple input AND gate that provides a logic "0" output at point X until the desired count is reached. The selected count is reached when all outputs, that have diodes connected to them, are logic "1." This then clocks U2 pin 3 and closes K1's contacts. The phone is now allowed to ring.

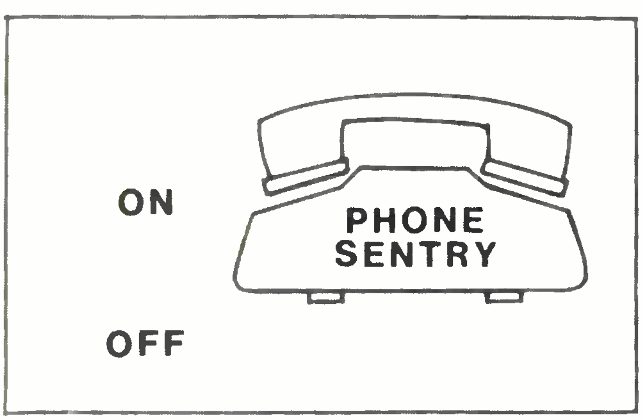


Fig. 4—This logo/label for the authors prototype type of the Phone Sentry may be cut or copied from the page and used to adorn the project's enclosure, giving the Phone Sentry a more professional, rather than a homebrew, look.

Construction

The assembly of the Phone Sentry on a printed-circuit board is by far the easiest way of putting this project together. And to speed you along your merry way, a full-scale template is provided in Fig. 2. For those of you who are not inclined to the rigors of etching your own printed-circuit board and chasing down the parts, a kit supplier is given in the Parts List. The layout is not critical and perfboard construction is fine, but you must work carefully to avoid wiring mistakes.

Figure 3 is the parts-placement diagram for the Phone Sentry's printed-circuit board. The use of IC sockets, inserting the actual chip last, is highly recommended, to prevent damage to those silicon CMOS wafers. Care should be exercised when installing the diodes—note their orientation and avoid overheating during soldering. Also note the polarity of C2 and C3 during installation. Note that in the schematic diagram, incandescent lamp I1 or diode D1 (shown in dotted lines) are optional; you should use one or the other, as in the author's prototype.

The lamp is used as a nightlite, illuminating the telephone, while indicating that an extension phone is in use. If it is not used in your project, a diode should be installed at points marked E and F on PC board foil-side with the banded, or cathode, end of the diode going to F. That prevents an inductive voltage spike from damaging Q1. LED1 and R10 are also optional and are intended to indicate power is supplied from an AC wall adapter.

Power requirements without LED1, R10, and L1 are about 20 mA with the relay energized and a small fraction of 1 mA standby. The author left space in the enclosure for a battery holder and 4 AA batteries. They should last several months, depending on telephone use and if the Phone Sentry is turned off when not needed.

A four-conductor modular phone cable is prepared by carefully cutting away some of the outer insulation (about one foot from one end), without damaging the internal wires. Cut the red and green wires, leaving the other two wires intact. Install both green wires to point C on the printed circuit board. The red wire, going to the long end of the cable, is installed to point A and the other red wire to B. A mistake here will keep your project from working.

Figure 4 shows the logo for the author's prototype type of the Phone Sentry. The logo may be cut or copied from the

(Continued on page 108)

LEARN BY DOING

All About Timer IC's

By Louis E. Frenzel, Jr.

Now that computers are around, time is no longer just a human experience. Computers must perform precisely coordinated functions, so this month we present electronic timers.

☐THIS IS THE SECOND IN OUR SERIES OF ARTICLES DESIGNED to teach you the operation and application of the more popular and widely used electronic circuits. The format of this article is unique in that it is a formal learning experience.

Specific learning objectives are defined, and a tutorial in the fundamental subject matter is given. That is followed by a step-by-step procedure you will use to actually build working circuits using the devices described. The Hands-On experiments with the components and circuits will quickly enhance your understanding of the circuit. The subject of this particular article is integrated circuit timing devices.

Learning Objectives

When you complete this experiment, you will be able to: Explain the operation of the popular 555 timer IC; and build common, useful circuits using the 555 timer including astable and monostable multivibrators.

Background Tutorial

One of the most commonly required electronic functions is timing. Timing refers to the generation of off-on pulses that occur for a specific duration at known intervals. Those timing pulses are used to operate other electronic circuits or to control external devices such as lights, relays, motors, and solenoids. Electronic circuits known as multivibrators are commonly used to produce such timing pulses. Those are easily created with transistors and other discrete electronic components. However, today it is no longer necessary to build special multivibrator circuits. Linear, integrated circuits known as IC timers are available to generate any conceivable type of pulse-timing waveform. When used with external resistor and capacitor networks, IC timers provide a flexible means of creating circuits to perform timing, sequencing, and delay operations. The subject of this experiment is the popular 555 IC timer.

Basic Timing Principles

All IC timers rely upon an external capacitor to determine the off-on time intervals of the output pulses. As you recall from your study of basic electronics, it takes a finite period of time for a capacitor (C) to charge or discharge through a resistor (R). Those times are clearly defined and can be computed mathematically given the values of resistance and capacitance.

The basic RC charging circuit is shown in Fig. 1. Assume that the capacitor is initially discharged. When the switch is closed, the capacitor begins to charge through the resistor. The voltage across the capacitor rises from zero up to the value of the applied DC voltage. The charge curve for the circuit is shown in Fig. 2. The time that it takes for the capacitor to charge to 63.7% of the applied voltage is known as the time constant (t). That time can be computed with the simple expression:

$$t = R \times C$$

Assume a resistor value of 1 Megohm and a capacitor value of 1 µF. The time constant in that case is:

$$t = 1{,}000{,}000 \times .000001 = 1 \text{ second}$$

Assume further that the applied voltage is 6 volts. That means that it will take one time constant for the voltage across the capacitor to reach 63.2% of the applied voltage. Therefore, the capacitor charges to approximately 3.8 volts in one second.

Looking at the curve in Fig. 2 you can see that it takes approximately 5 complete time constants for the capacitor to charge to almost the applied voltage. In the example above, it would take about 5 seconds for the voltage on the capacitor to rise to approximately the full 6 volts.

The curve shown in Fig. 2 can be represented mathematically so you can compute the instantaneous charge voltage at any time.

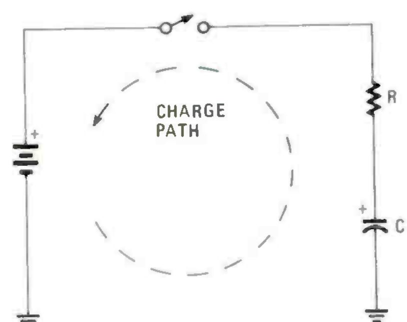


Fig. 1—The charging of a capacitor takes time (lucky for us). We can lengthen the amount of time by adding resistance (R) to the flow of current.

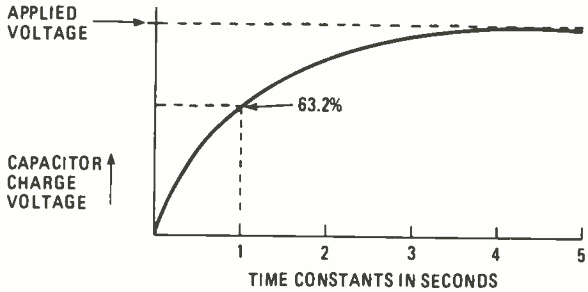


Fig. 2—The capacitor slows down as it charges, and in actual fact never reaches the full supply voltage. That being the case, the maximum charge it receives in the timing circuit (66.6% of the supply voltage) is a little over the charge received after a time constant (63.2%)

It also takes a finite amount of time for a capacitor to discharge through a resistor. Figure 3 shows a circuit used to charge and then discharge a capacitor. With the switch in position A, the capacitor quickly charges to 12 volts. Moving the switch to position B causes the capacitor to be connected to a resistor. The capacitor then discharges through the resistor. Figure 4 shows the discharge curve. It takes one time constant (t = RC) for the capacitor to discharge to 36.8% of the original charge voltage. And, as you can see from Fig. 4, it takes approximately five time constants for the capacitor to discharge close to zero volts. The discharge curve shown in Fig. 4 can also be expressed mathematically.

Simple RC timing circuits like those are used with IC timers to generate desired time intervals, delays, and pulse widths. Since the desired time intervals are determined by resistor and capacitor values, it is essential that their values be precisely known. In non-critical timing circuits, resistors and capacitors with larger tolerances (i.e. 5%) can be used. However, in precision timing circuits, accurate capacitor values and precision resistors (i.e. 1%) are required. Those components must also be stable during temperature changes in order to insure that the timing does not change appreciably over various temperature ranges. In critical circuits, the resistor is usually made adjustable so that a precise time interval can be set.

The secret to using RC charge and discharge networks to produce accurate time intervals is to have some method of accurately detecting specific charge voltages on the capacitor. When a capacitor charges or discharges to a specific voltage level, a circuit is triggered to create either an on or off pulse. IC timers provide built-in comparator circuits that are able to detect those voltage levels and generate fast-switching on and off pulses.

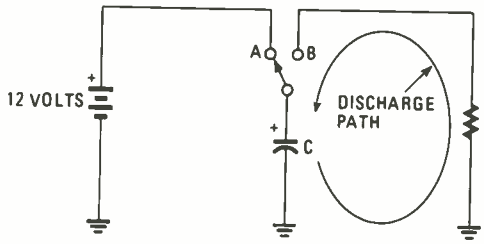


Fig. 3—The discharge of a capacitor also takes time and we can shorten the amount of time by decreasing resistance (R) to the flow of current.

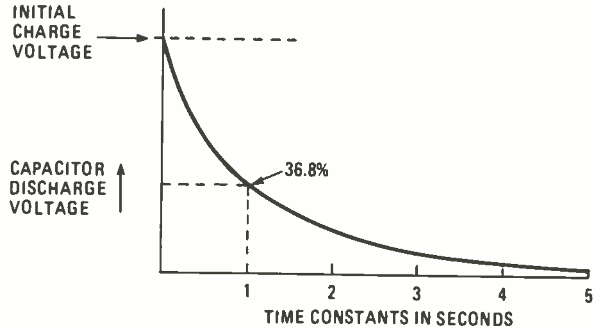


Fig. 4—The capacitor slows down as it discharges, and never quite reaches the ground potential. That means the minimum voltage it operates at must be greater than zero. Timing circuit is 63.2% of the supply voltage.

555 Timer Basics

The 555 timer was introduced in 1972 and was the first commercial timer IC. Despite the age of the device, it is still widely used in electronics. However, there have also been many improvements and variations in the circuit. The 555 is available in a variety of standard IC packages including metal can; 8-pin, mini-DIP; and standard 14-pin, DIP packages. The 556 is a dual version available in a 14-pin DIP. Various manufacturers make similar devices, some of them containing built-in flip flop frequency dividers which provide a wider range of timing.

A basic 555 timer block diagram is shown in Fig. 5. The pin numbers given are for the 8-pin, mini-DIP. It consists of two comparators, a control flip flop, an output stage, and various other components. The comparators are high-gain differential amplifiers. Those differential amplifiers each have two inputs. One input is connected to a reference voltage while the other receives an input signal. When the input signal is equal to the reference voltage, the comparator output will switch from one level to another. The switching of the comparators causes the flip flop to change state.

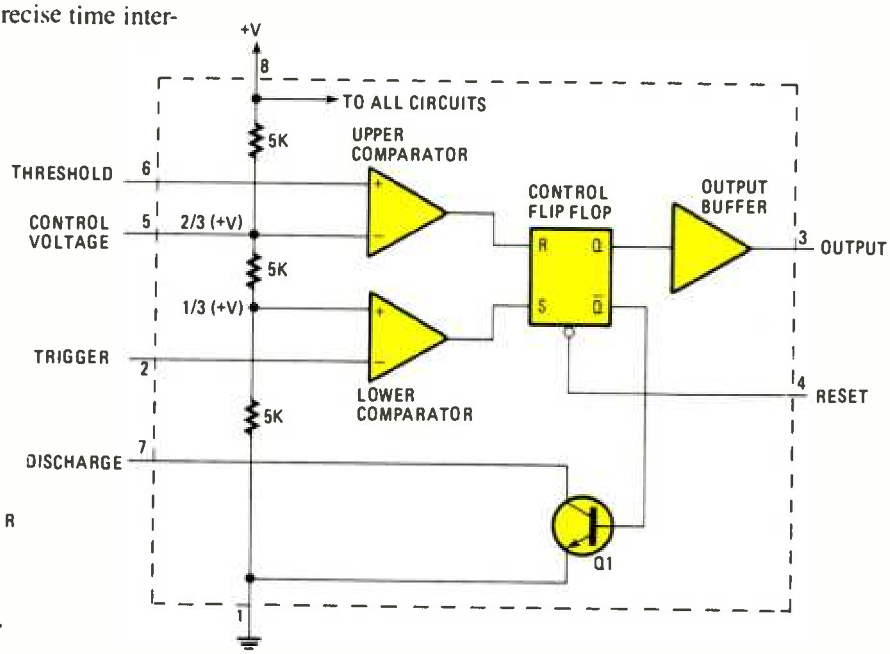


Fig. 5—The three resistors in this block diagram of a 555 divide the output voltage up, and supply the upper comparator with ⅔ +V and the lower comparator with ⅓ +V.

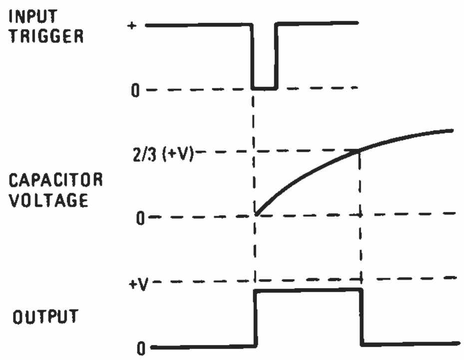


Fig. 6—The monostable circuit requires only one capacitor and one resistor. Note that the input trigger pulse should be negative going (i.e., goes from high to low).

Note in Fig. 5 that the inputs to the comparators are connected to two taps on an internal voltage divider made up of three 5000-ohm resistors. That voltage divider is connected between the power supply voltage (+ V) and ground. The upper tap on the voltage divider has an output equal to ⅔ of the supply voltage. It is used as the reference for the upper comparator. That connection is brought out of the chip and called the control voltage. The second tap from the voltage divider applies ⅓ of the supply voltage to the lower comparator as a reference. The other inputs to the comparators, labeled threshold and trigger respectively, are used to accept external signals, depending upon the application.

The control flip flop is a two-state binary circuit. Its two states are set and reset. The upper comparator causes the flip flop to set while the lower comparator causes the flip flop to reset. It is the flip flop that generates the on-off pulses to be used at the output. The flip flop output is applied to an output buffer stage that greatly increases the driving capacity of the output pulses.

Note in Fig. 5 that the flip flop also drives an open-collector transistor Q1. That transistor connects to the external timing capacitor for the purpose of discharging it. The other transistor accepts an input pulse that causes the flip flop to be reset. The reset signal is used to terminate an output pulse prior to the actual completion of the timing event controlled by the external capacitor.

Operating Modes

The 555 timer has two basic operational modes: one shot and astable. In the one shot mode, the 555 acts like a monostable multivibrator. A monostable is said to have a single stable state—that is the off state. Whenever it is triggered by an input pulse, the monostable switches to its temporary state. It remains in that state for a period of time determined by an RC network. It then returns to its stable state. In other words, the monostable circuit generates a single pulse of a fixed time duration each time it receives an input trigger pulse. Thus the name one-shot. One-shot multivibrators are used for turning some circuit or external component on or off for a specific length of time. It is also used to generate delays. When multiple one-shots are cascaded, a variety of sequential timing pulses can be generated. Those pulses will allow you to time and sequence a number of related operations.

The other basic operational mode of the 555 is as an astable multivibrator. An astable multivibrator is simply an oscillator. The astable circuit generates a continuous stream of rectangular off-on pulses that switch between two voltage levels. The frequency of the pulses and their duty cycle are dependent upon the RC network values.

One-Shot Operation

Figure 6 shows the basic circuit of the 555 connected as a monostable multivibrator. An external RC network is connected between the supply voltage and ground. The junction of the resistor and capacitor is connected to the threshold input which is the input to the upper comparator. The internal discharge transistor is also connected to the junction of the resistor and the capacitor. An input trigger pulse is applied to the trigger input, which is the input to the lower comparator.

With that circuit configuration, the control flip flop is initially reset. Therefore, the output voltage is near zero volts. The signal from the control flip flop causes Q1 to conduct and act as a short circuit across the external capacitor. For that reason, the capacitor cannot charge. During that time, the input to the upper comparator is near zero volts causing the comparator output to keep the control flip flop reset.

The trigger input is initially high (about ⅓ of + V). When a negative-going trigger pulse is applied to the trigger input (see Fig. 7), the threshold on the lower comparator is exceeded. The lower comparator, therefore, sets the flip flop. That causes Q1 to cut off, acting as an open circuit. The setting of the flip flop also causes a positive-going output level which is the beginning of the output timing pulse.

The capacitor now begins to charge through the external resistor. As soon as the charge on the capacitor equals ⅔ of the supply voltage, the upper comparator triggers and resets the control flip flop. That terminates the output pulse which switches back to zero. At this time, Q1 again conducts thereby discharging the capacitor. If a negative-going pulse is applied to the reset input while the output pulse is high, it will be terminated immediately as that pulse will reset the flip flop.

Whenever a trigger pulse is applied to the input, the 555 will generate its single-duration output pulse. Depending upon the values of external resistance and capacitance used, the output timing pulse may be adjusted from approximately one millisecond to as high as one hundred seconds. For time intervals less than approximately 1 millisecond, it is recommended that standard logic one-shots designed for narrow

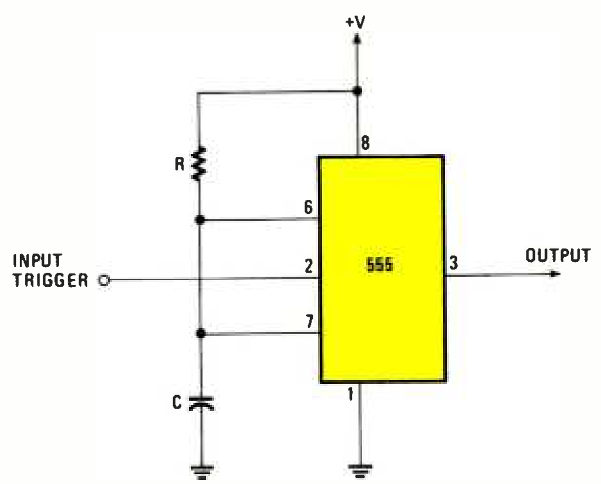


Fig. 7—Notice how the monostable continues to output its pulse regardless of the inputs swing back up. That is because the output is only triggered by the input pulse, the output actually depends on the capacitor charge.

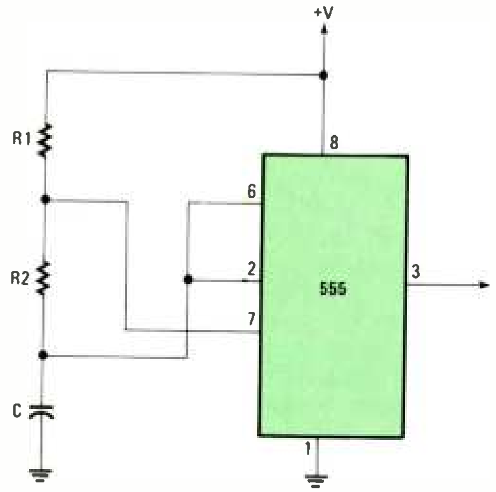


Fig. 8—The astable circuit is a little more involved, having an extra resistor. That is to control the charge and discharge rates of the capacitor (although not independently).

pulses be used instead of a 555 timer. IC timers are normally used where long output pulses are required. In this application, the duration of the output pulse in seconds is approximately equal to:

$$t = 1.1 \times R \times C \text{ (in seconds)}$$

Astable Operation

Figure 8 shows the 555 connected as an astable multivibrator. Both the trigger and threshold inputs (pins 2 and 6) to the two comparators are connected together and to the external capacitor. The capacitor charges toward the supply voltage through the two resistors, R1 and R2. The discharge pin (7) connected to the internal transistor is connected to the junction of those two resistors.

When power is first applied to the circuit, the capacitor will be uncharged, therefore, both the trigger and threshold inputs will be near zero volts (see Fig. 9). The lower comparator sets the control flip flop causing the output to switch high. That also turns off transistor Q1. That allows the capacitor to begin charging through R1 and R2. As soon as the charge on the capacitor reaches ⅔ of the supply voltage, the upper comparator will trigger causing the control flip flop to reset. That causes the output to switch low. Transistor Q1 also conducts. The effect of Q1 conducting causes resistor R2 to be connected across the external capacitor. Resistor R2 is effectively connected to ground through internal transistor Q1. The result of that is that the capacitor now begins to discharge through R2.

As soon as the voltage across the capacitor reaches ⅓ of the supply voltage, the lower comparator is triggered. That again causes the control flip flop to set and the output to go high. Transistor Q1 cuts off and again the capacitor begins to charge. That cycle continues to repeat with the capacitor alternately charging and discharging, as the comparators cause the flip flop to be repeatedly set and reset. The resulting output is a continuous stream of rectangular pulses.

The frequency of operation of the astable circuit is dependent upon the values of R1, R2, and C. The frequency can be computed with the formula:

$$f = 1/(.693 \times C \times (R1 + 2 \times R2))$$

The frequency f is in Hz, R1 and R2 are in ohms, and C is in farads.

The time duration between pulses is known as the period, and is usually designated with a t. The pulse is on for t_1 seconds, then off for t_2 seconds. The total period (t) is $t_1 + t_2$ (see Fig. 9).

That time interval is related to the frequency by the familiar relationship:

$$f = 1/t$$

or

$$t = 1/f$$

The time intervals for the on and off portions of the output depend upon the values of R1 and R2. The ratio of the time duration when the output pulse is high to the total period is known as the duty cycle. The duty cycle can be computed with the formula:

$$D = t_1/t = (R1 + R2)/(R1 + 2R2)$$

You can compute t_1 and t_2 times with the formulas below:

$$t_1 = .693(R1 + R2)C$$
$$t_2 = .693 \times R2 \times C$$

The 555, when connected as shown in Fig. 8, can produce duty cycles in the range of approximately 55 to 95%. A duty cycle of 80% means that the output pulse is on or high for 80% of the total period. The duty cycle can be adjusted by varying the values of R1 and R2.

Applications

There are literally thousands of different ways that the 555 can be used in electronic circuits. In almost every case, however, the basic circuit is either a one-shot or an astable. The application usually requires a specific pulse time duration, operating frequency, and duty cycle. Additional components may have to be connected to the 555 to interface the device to external circuits or devices.

In the remainder of this experiment, you will build both one-shot and astable circuits and learn about some of the different kinds of applications that can be implemented.

Parts Required

In addition to a breadboarding socket and a DC power supply with a voltage in the 5 to 12 volt range, you will need the following components: a 555 timer IC; an LED; a 2-in., 8-ohm speaker; a 150-ohm ¼-watt resistor; two 10K ohm ¼-watt resistors; two 1-Megohm ½-watt resistors; a 10 Megohm ¼-watt resistor; a .1-µF capacitor; a .68-µF capacitor.

Experimental Steps

1 On your breadboarding socket, wire the one-shot circuit shown in Fig. 10.

2 Apply power to the circuit. If you have a standard 5 volt logic supply, use it for convenience. You may use any voltage

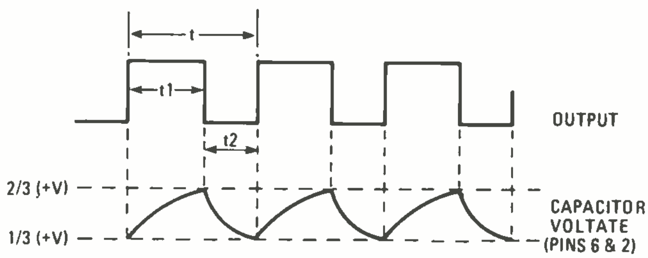


Fig. 9—After the initial charge up (first output high) the voltage of the capacitor swings between ⅓ and ⅔ +V.

between 5 and 15 volts with 555 timer. You can also run the circuit from battery power. A standard 9-volt, transistor-radio battery works nicely.

With the power connected, note the status of the LED. Is it off or on? ______________

3 Connect a short piece of hook-up wire to the trigger input line on pin 2. Momentarily, touch that wire to ground. Remove it quickly. That will create a pulse at the trigger input. Note and record the state of the LED below.

____

4 Continue to observe the LED and note any change in the output state after a period of time. What is that state?

____

5 When you trigger the one-shot, time the duration of the output pulse with a stop watch or the seconds hand on your watch. To do that, the instant that you trigger the one-shot by touching the wire to ground, immediately start your stop watch or make note of the second hand on your watch. Continue to observe the LED until it switches off at which point you may stop the stop watch or again note the position of the second hand on your watch.

Trigger the one-shot and time the output pulse. Write in the approximate value of the pulse duration in the blank below.

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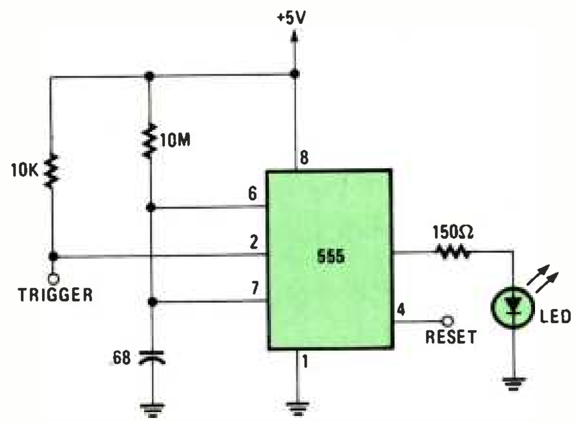

Fig. 10—This circuit is resetable by grounding pin 4, so be sure to have an extra wire at pin 4 to test that feature.

6 Using the values of external resistor and capacitor values in Fig. 10 and the time interval formula for a one-shot, compute the output-pulse duration. Record your value in the space below.

____

7 Compare your computed and timed values of output pulses. Explain any discrepancies between your computed and measured values.

8 Connect a short piece of hook-up wire to pin 4. You will use that as a reset.

9 Trigger the one shot as indicated previously. Then immediately touch the reset wire from pin 4 to ground. Note the result on the LED.

10 With a DC voltmeter, measure the output voltage at pin 3 during the one shot's off and on states. Record your values below.

off ______________ volts on ______________ volts

11 Replace the 10-Megohm resistor with a 1-Megohm resistor and repeat steps 5 and 6. Record your timed and computed values below.

timed: ______________ seconds
computed: ______________ seconds

Review of Steps 1 Through 11

The circuit you built for those steps was a one-shot multivibrator. The circuit is similar to that described in the tutorial. The trigger input is held high with a 10,000 resistor. When you bring pin 2 low by touching the wire to ground, the one shot is fired. The LED installed at the output of the 555 is used to monitor the output pulse. The LED goes on when the one shot is triggered.

The components selected for the circuit are large, so as to generate a long output pulse. That allows you to measure the pulse duration with a stop watch. Once the one-shot is triggered, the output LED stays on until the capacitor charges to ⅔ of the supply voltage. That triggers the upper comparator and causes the internal control flip flop to reset, turning off the pulse and discharging the capacitor. The one-shot will remain in that state until it is triggered again.

Timing the pulse should have produced an output duration of approximately 7.5 seconds. Computing the output time interval using the formula given previously, you should have found the pulse duration to be:

$$t = 1.1 \times .68 \times 10^{-6} \times 10^{7} = 7.48 \text{ seconds}$$

You may have noticed some difference between the computed and actual measured values. The differences probably result from inaccuracies in your timing. Further, component tolerances may be such that the actual values are different from the marked values.

In steps 8 and 9 you demonstrated the reset function. As you saw, you could terminate the output pulse before the timing cycle is completed by touching pin 4 to ground. That instantly resets the flip flop and shuts off the output pulse.

In step 10, you measured the output voltage. When off, the output is only a fraction of a volt. For all practical purposes it is zero. When triggered, the 555 generates a 3.5-volt pulse with a 5-volt supply. If you used another value of supply voltage, you probably discovered that the output during the pulse is about 1.5 volts less than the supply voltage.

In step 11, you lowered the resistor value to 1 Megohm. As you saw, that greatly shortens the output pulse duration. The LED only stayed on for a brief time; so brief in fact that you probably couldn't time it accurately. The computed duration of the output pulse is .748 seconds.

Experimental Steps Continued

12 Next you will experiment with astable circuits. First, rewire the circuit so it appears as shown in Fig. 11.

13 Apply power to the circuit and observe the LED. What happens?

14 Replace the 10 Megohm resistor with a 1 Megohm unit. Again observe the LED. is the frequency higher or lower?

____

15 Using the formula given in the tutorial, compute the oscillation frequency using R1 as 10 Megohm, and again with R1 as 1 Megohm, and again with R1 as 1 Megohm. R2 is 1 Megohm in both cases. Record your frequencies.

(Continued on page 108)

JENSEN ON DX'ING

By Don Jensen

Another SW broadcaster takes to the air

NOBODY LIKES TO ADMIT BEING caught unaware, but yes, I was surprised when a brand new shortwave station, originating from a brand new country, came on the air back in March.

It takes months, sometimes years, to get a new SW operation on the air, so generally the effort gets some advance attention and publicity. But no word leaked to the shortwave-listening fraternity about the plans of the Republic of the Marshall Islands to parallel its medium-wave station, WSZO, with a new 10,000-watt shortwave outlet.

WSZO, also called *Radio Marshalls* or *Radio Majuro*, after the capital of that emerging country in the Pacific, suddenly showed up on 4,940 kHz one morning with surprisingly good signals in North America.

WSZO can be heard best from around 0700 to sign-off, just after 1000 UTC with what SWL's call "island" music—lush melodies reminiscent of Hawaii—and programming mostly in the local Marshallese language. There have been some English announcements heard, and a brief newscast at about 0907 UTC.

What the surprise appearance of WSZO has done is to focus SWL attention on Micronesia, the several thousand specks of land scattered across a Pacific-Island area about the size of the continental US.

The island groups—originally the Marshalls, the Marianas, the Carolines, the Gilberts, and Ellices—had been dominated by western, and later eastern, colonial powers since the 16th Century.

The Gilbert and Ellice Islands gained independence from Great Britain; the Ellice as the nation of Tuvalu in 1978, and the Gilberts as the Republic of Kiribati the following year.

The United States has owned Guam since 1898, and has administered the rest of Micronesia under a UN trusteeship since WWII.

Today, the rest have divided into four units; the Commonwealth of the Northern Mariana Islands, including the island of Saipan (which opted to remain part of the US), plus three newly independent island nations, the Republic of the Marshall Islands, the Federated States of Micronesia, and the Republic of Palau, which will keep certain American links for some years.

Besides the new WSZO operation, other SW signals from Micronesia these days are: **KIRIBATI**—*Radio Kiribati* (pronounced, Kiribas) broadcasts in upper sideband (USB) on 14,802 kHz, from Tarawa. Programs, in English and the local I-Kiribati language, are relayed from the station's medium-wave outlet. It has been heard in the US and Canada at around 1900 to 2000 UTC and again at around 0000 to 0100 UTC. **GUAM**—There are two shortwave stations on that island. The newest (on the air since March) is KSDA, the voice of *Adventist World Radio-Asia*. It began testing on a number of frequencies including 11,700, 11,965, 11,980, and 15,125 kHz at various times with its 100-kilowatt (kW) transmitters. By the time you read this, KSDA should be airing a full scheduled of religious programs in 20 languages to listeners from southern India to northern Siberia.

This attractive tri-color sticker—red, black, and gold—is sent out to listeners by Egypt's *Radio Cairo*.

The second Guamian station also is a religious broadcaster, KTWR, operated by the same *Trans World Radio* organization that has shortwave stations in Monaco, southern Africa and in the West Indies. Its programs are broadcast in English and 10 other languages. A couple of frequencies to try are 9,870 kHz at around 1300 UTC or 11,715 kHz at about 2330 UTC. **SAIPAN**—Another religious broadcaster, the Far East Broadcasting Co., has its 100-kW shortwave station, KFBS on this northern Marianas island. KFBS has been recovering from severe typhoon damage, but you may find it, also in numerous Asian languages, plus some English (on 7,365, 15,270 or 17,745 kHz) among its frequencies.

KYOI was the call of another Saipan-based shortwave operation, which broadcasts US-style commercial pop-music programming, in Japanese to Japan. However, it was bought out by the *Christian Science Monitor*'s Herald Broadcasting network. It probably will return to the air with completely different programming sometime in 1987. Watch these frequencies: 9,665, 9,670, 11,900, 15,190 or 15,405 kHz.

But what of the other two Micronesian nations? So far, there are only medium-wave stations: WSZB, 1584 kHz, at Koror, Republic of Palau; and in the Federated States of Micronesia, WSZD 1449 kHz; Kolonia, Pohnpei State, WSZA, 1494 kHz; Colonia, Yap State, WTFL, 1500 kHz; Lelu, Kosrea State, and WSZC, 1602 kHz, Moen, Truk State.

Maybe, one of these days, though, we'll again be surprised by yet another new Pacific shortwave voice from one of those Micronesian islands.

Monitoring the Ham Nets

Stations broadcasting regular programs are not the only inhabitants of the shortwave frequencies. There are the licensed radio amateurs operating two-way radio communications. While this is a column for listeners, not amateur-radio operators, there are any number of SWL's who get their enjoyment by listening in on the ham QSO's (conversations). Some listeners are aspiring hams themselves; they hope eventually to be licensed to transmit. But others are more than content to just remain SWL's.

Mike Witkowski of Stevens Point, WI, is a ham-band monitor of many years experience. He has edited a club bulletin column on the subject, publishes a newsletter for other ham-bands DX'ers, and

(Continued on page 104)

Give a Friend A "Hands-On" Experience for Christmas. . .

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By Charles D. Rakes

CIRCUIT CIRCUS

If you've been searching for just the right touch switch, look no further....one of these is sure to suit your application

EACH OF THE CIRCUITS OFFERED IN THIS month's Circus are a part of the electronic petting zoo. In other words, each of the circuits have been designed to respond to a warm touch by a human hand. The electronic touch switch is a novel and handy gadget that eliminates many of the problems associated with standard mechanically-operated switches.

If you have ever flipped a toggle switch and had the bat remain in your hand as the innards tinkled to the bottom of the cabinet, you can appreciate the confidence conferred by using a touch-type switch.

Touch On-only Switch

The Touch On-only Switch shown in Fig. 1 can trigger into conduction by electrical means and can only be reset through a mechanical switch, but for some circuit applications, it's ideal. For example, in a simple alarm circuit, the turn-on only switch is just what the doctor ordered, because we want the burglar to trigger the alarm, and under no circumstances be able to turn it off.

When your finger meets the circuit's touch contact, a 60-Hz signal is delivered to the gate of the SCR, turning it on. Since the majority of the single-contact, touch-switch circuits feed on the stray 60-Hz AC field from the surrounding area, they should be powered with an AC-derived, DC power-supply.

A new copper penny makes an excellent low-cost touch contact for the circuit's pick-up terminal, but a 1-inch square piece of circuit-board material does as well. The component values are not critical and can vary some; but for a sensitive switch, SCR1 should be one that's triggered by a very-low gate current.

Touch On/Off Switch

If a Touch On/Off Switch is desired, the circuit in Fig. 2 fills the bill. Two sensitive gate SCR's are interconnected, so that when one of the devices is turned on, the other (if on) is forced off. That toggling effect gives an on/off circuit condition for each of the LED's in the SCR-anode circuits. To turn LED1 on and LED2 off, simply touch the "A" terminal, and to turn LED1 off and LED2 on, the "B" pick-up must be touched. It is possible to simultaneously touch both terminals, causing both SCR's to turn on together. To reset the circuit to the normal one-on/one-off condition, momentarily interrupt the circuit's DC power source.

Additional circuitry can be connected to the anode circuit of either or both SCR's to be controlled by the on/off function of the touch switch.

PARTS LIST FOR THE TOUCH ON-ONLY SWITCH

LED1—Light-emitting diode (any color)
SCR1—2N5062 (or similar) .8 A, 100-PIV silicon-controlled rectifier
R1—470-ohm, ½, 5% resistor
R2—1000-ohm, ½, 5% resistor
R3—1-Megohm, ½, 5% resistor
S1—Normally-closed, pushbutton switch

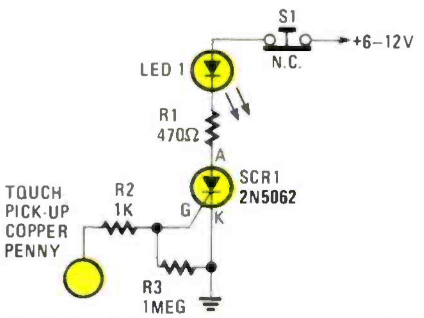


Fig. 1—The Touch On-only Switch can be triggered into conduction by electrical means, and can only be reset by way of a mechanical switch. When the touch terminal is contacted by a finger, the SCR turns on, illuminating LED1.

PARTS LIST FOR THE TOUCH ON/OFF SWITCH

C1—.27-µF/100-volt mylar capacitor
LED1, LED2—Light-emitting diode (any color)
SCR1, SCR2—2N5062 (or similar) .8-A, 100-PIV silicon-controlled rectifier
R1, R2—470-ohm, ½, 5% resistor
R3, R4—1-Megohm, ½, 5% resistor
R5, R6—1000-ohm, ½, 5% resistor

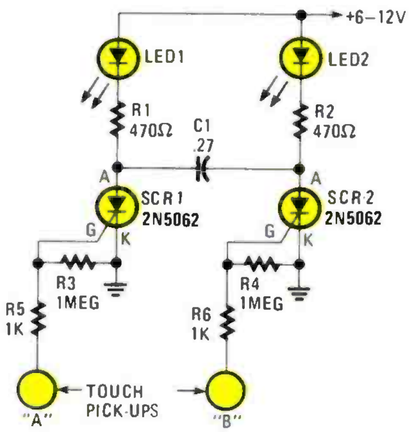


Fig. 2—The Touch On/Off Switch is built around two SCR's that are interconnected, such that when one is turned on, the other (if on) is forced off, either LED1 or LED2, depending on which terminal is touched.

PARTS LIST FOR THE DIGITAL TOUCH SWITCH

LED1, LED2—Light-emitting diode (any color)
R1, R2—470-ohm, ½, 5% resistor
R3, R4—10-Megohm, ½, 5% resistor
U1—4001 quad two-input NOR gate

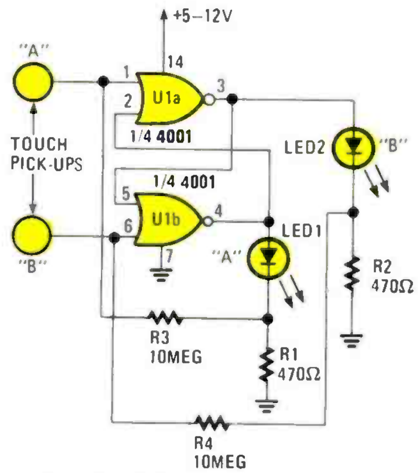


Fig. 3—The Digital Touch On/Off Switch, built around a 4001 CMOS quad two-input NOR gate configured as an anti-bounce latching circuit, allows only one LED to be on at a time.

PARTS LIST FOR THE TIME-ON TOUCH SWITCH

BZ1—Piezoelectric buzzer
C1—10-µF 16-WVDC electrolytic capacitor
LED1—Light-emitting diode (any color)
R1—10-Megohm, ½, 5% resistor
R2—100,000-ohm, ½, 5% resistor
R3—1000-ohm, ½, 5% resistor
U1—555 oscillator/timer, integrated circuit

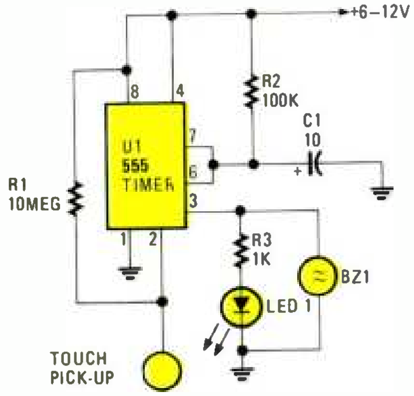


Fig. 4—The Time-on Touch Switch, built around a 555 oscillator/timer (U1), is turned on when a trigger is applied—by touching the touch terminal—to pin 2 of U1. When activated, LED1 and BZ1 (a Piezoelectric buzzer) turn on for the time period set by the value of R2/C1.

PARTS LIST FOR THE TWO-TERMINAL TOUCH SWITCH

C1—680-pF, 600-WVDC ceramic disc capacitor (see text)
LED1—Light-emitting diode (any color)
Q1—2N5089 high-gain NPN silicon transistor
Q2—2N3904 general-purpose NPN silicon transistor
Q3—2N3906 general-purpose PNP silicon transistor
R1—15,000-ohm, ½, 5% resistor
R2—10,000-ohm, ½, 5% resistor
R3— 4700-ohm, ½, 5% resistor
R4—470-ohm, ½, 5% resistor

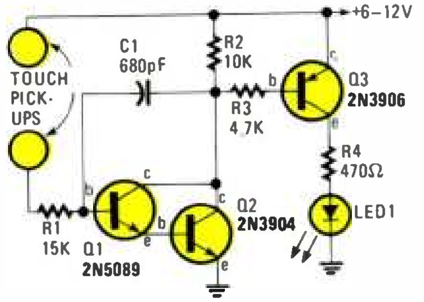


Fig. 5—The Two Terminal Touch Switch requires the bridging of two circuits for activation. Built around a Darlington amplifier, the circuit multiplies the small bridging current to a value of sufficient magnitude to turn on Q3, supplying power to LED1.

PARTS LIST FOR THE TEMPERATURE-DEPENDENT TOUCH SWITCH

D1, D2—1N914 silicon signal diode
LED1—Light-emitting diode (any color)
R1—1000-ohm, ½, 5% resistor
R2, R3—2200-ohm, ½, 5% resistor
R4—470-ohm, ½, 5% resistor
R5—1000-ohm, ½, 5% potentiometer (any taper)
U1—LM324 quad op-amp, integrated circuit

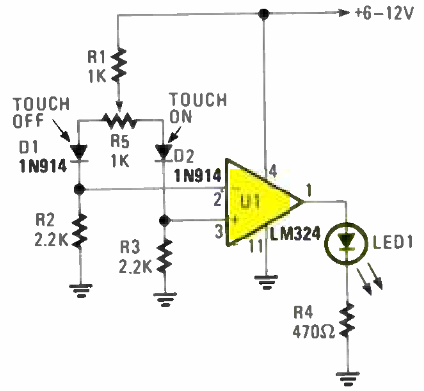


Fig. 6—The Temperature-Dependent Touch Switch, unlike the previous circuits, requires neither a 60 Hz field nor a current flow into or out of the touch pickup to cause the switch to operate.

Digital Touch On/Off Switch

Another on/off Touch Switch circuit, built around a digital IC, is shown in Fig. 3, which offers an advantage in some circuit applications that the previous circuit(s) can not master. Only one LED can be on at a time when the circuit is at rest. Which LED is illuminated is determined by the touch pick-up that last had human contact.

Pickup terminal "A" controls the on condition of LED1, and terminal "B" controls the on condition of LED2. A 4001 quad two-input NOR gate is connected in an anti-bounce latching circuit that is activated by touching a pickup.

Time-on Touch Switch

The Time-on Touch Switch circuit shown in Fig. 4 is built around a 555 oscillator (U1), which is turned on when a trigger is applied—by touching the touch terminal—to pin 2 of U1. When activated, LED1 and BZ1 (a piezoelectric buzzer) turns on for the time period set by the values of R2 and C1. The on-time of the touch circuit can be altered by changing the values of C1 and R2.

The Time-on Touch Switch can be powered from batteries, so that it need not be near a 60-Hz power source for triggering. The extremely small amount of current supplied to the trigger input through the 10-megohm resistor, R1, makes the input circuitry very sensitive to any external loading, and it is easily triggered by touching the pickup.

Two-terminal Touch Switch

The Two-Terminal Touch Switch shown in Fig. 5 requires the bridging of two circuits to activate the electronic switch. That circuit does not require a 60-Hz field to operate and can be battery or AC powered. The two pickup terminals can be made from most any clean metal, and should be about the size of a penny.

The input circuitry of the Two-terminal Touch Switch is a high-gain Darlington amplifier that multiplies the small bridging current to a value of sufficient magnitude to turn on Q3, supplying power to LED1. If a quick on and off switching time is desired, the value of C1 should be very small, but if a long on-timed period is required, the value of C1 can be increased. For a short on-time, the value of C1 should be 680-pF; for a 7-second on-time try a .039-microfarad unit, and to increase the on-time to a full 50-seconds, use to a .27-microfarad capacitor.

Temperature-dependent Touch Switch

Unlike the previous circuits, the one in Fig. 6 requires neither a 60-Hz field or a current flow into or out of the touch pickup to cause the switch to operate. Take a look at the circuit and see if you can figure it out. Give up?

First, notice that U1 (an LM324 quad op-amp) is connected in a comparator circuit that's used to monitor the voltage drop across two resistors (of the same value) in a resistor/diode bridge circuit.

With R5 adjusted to supply a slightly larger current flow through R2, U1 sees a higher voltage at it's non-inverting (–) input terminal (pin 2), causing its output at pin 1 to be at or near ground potential. Thus, the LED will be dark. But if we can somehow cause the voltage at pin 3 of U1 to go more positive than the voltage at pin 2, the output toggles from zero to a + V, lighting LED1. No...Adjusting R5 isn't the answer.

The circuit is turned on by touching diode D2 with a warm finger. If the circuit is adjusted properly, LED1 will turn on. Remove the finger and LED1 goes out. The secret ingredient, as you've probably guessed, is the "warm" digit (finger) that made contact with the temperature sensitive silicon diode, D2.

As the diode is heated slightly by body warmth, the current through it increases, causing the voltage across R3 to rise slightly. That increased current causes a flip-flop within the op-amp to respond by

(Continued on page 107)

By Marc Ellis

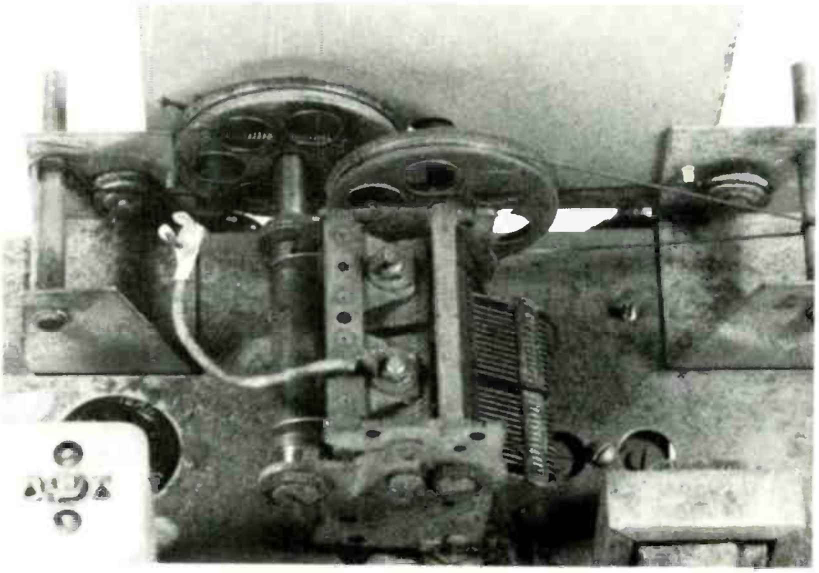
ELLIS ON ANTIQUE RADIO

Restoration of the Echophone EC-1

IN AN EARLIER COLUMN, I INTRODUCED the first *Ellis On Antique Radio* restoration project—the Echophone EC-1—which had just been found at a hamfest. For those of you who haven't seen that column, I'll explain: The EC-1 was a radio that was built for the economy-minded shortwave listener of the early 1940's. Its circuit is basically that of a standard AC/DC broadcast receiver of the era with tuned circuits added to also cover the standard shortwave spectrum (1.8–30 MHz).

The EC1's physical appearance, however, proclaimed beyond a doubt that this was a set for the SWL who meant business. Strictly 1940's high-tech in its design, the radio sports a snappy grey crackle-finished metal case, a 3-band half-moon dial with logging and band-spread scales, and a separate band-spread control. Panel-mounted slide switches are provided to channel the audio to speaker or phones, control the BFO that was included for code reception and disable the receiver for standby.

That sturdily-constructed little set offered good value for its original selling price of about 25 bucks. And it makes a very interesting collector's item today.



Shown here is the area around the main tuning/band-spread capacitor prior to restoration. The unusually heavy accumulation of dust and grime on the chassis made removal of capacitor necessary before cleaning could begin.

The example I'm working with came to me reasonably intact and, except for an exceptional amount of dirt and grime on the chassis, is in good shape cosmetically. As yet, I haven't tried out the radio—preferring to begin the restoration with deep cleaning.

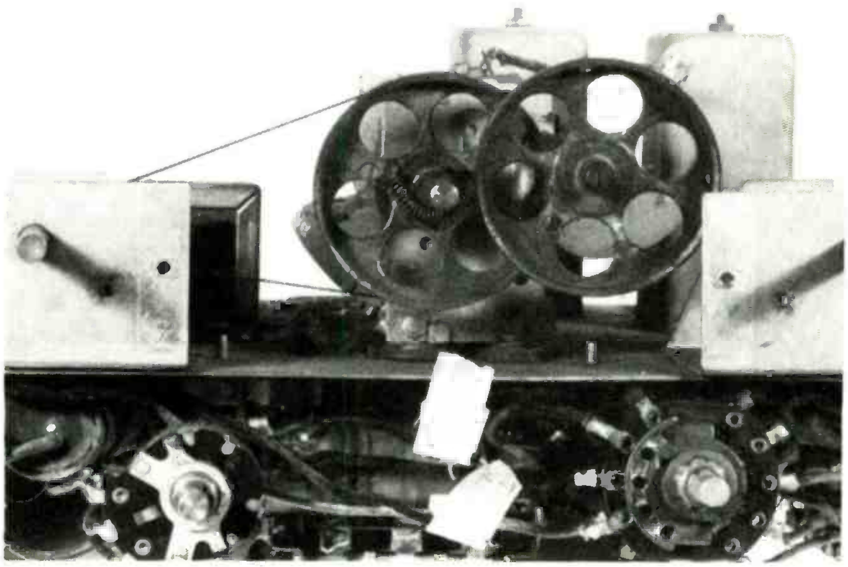
In last month's column, I didn't have enough room to give you much of a report on the EC-1 restoration, so let's pick it up again right now.

Disassemble the Radio

After carefully studying the radio, two stages of disassembly seemed necessary. First, I wanted to remove the chassis from the wrap-around cabinet/front panel to give better access for cleaning. Next, I decided that I would remove the main tuning/band-spread capacitor from the chassis to hasten the removal of the grime trapped in and under the component.

Both of those operations were straightforward enough, though some careful detail work was occasionally required. One problem was caused by the three panel-mounted slide switches—which happen to be permanently riveted in place.

All leads running to the switches had to be removed before the chassis and panel could be separated. I used desoldering braid to absorb most of the solder from each switch terminal so that the leads



This head-on view of the chassis after being separated from the front panel/cabinet assembly shows tagged wires nestled among those removed from slide switches that are riveted to the front panel (not shown).

could be taken off with a minimum of damage.

Removing the main tuning/band-spread capacitor meant that two separate dial-cord systems—both of which had survived intact—would have to be disassembled. That gave me pause, because I hate to restring dial cord. But I finally gave in because I really wanted to get at that encrusted grime and because—too many times—I've had dial cords snap on antique sets as soon as they were put into service again. Better to install new cord now, while the set was apart and easy to work on.

Another problem was caused by the two heavy, braided-cables grounding the tuning capacitor frame to the chassis. The braids were soldered to the chassis, and even my 60-watt *American Beauty* wouldn't release them. I finally used a plumber's propane blowtorch throttled down to minimum flame.

After removing the tuning capacitor, I saw that I'd have to solve another small problem before reassembly could proceed. The capacitor mounting studs pass through rubber grommets mounted in the chassis—evidently for vibration isolation. Those grommets had hardened and deteriorated, and would have to be replaced with ones of similar style.

Results of the Deep Cleaning

The cabinet/front panel is now several shades brighter after removal of about fifty years of grime. Careful scrubbing with hand soap did the trick. (I try not to use detergent or harsh soaps on old paint because of possible damage to the finish.) The hand soap also did a very nice job at cleaning the beautifully enameled dial scale. Scratches and surface discoloration on the celluloid dial window were removed through polishing with Brasso metal polish.

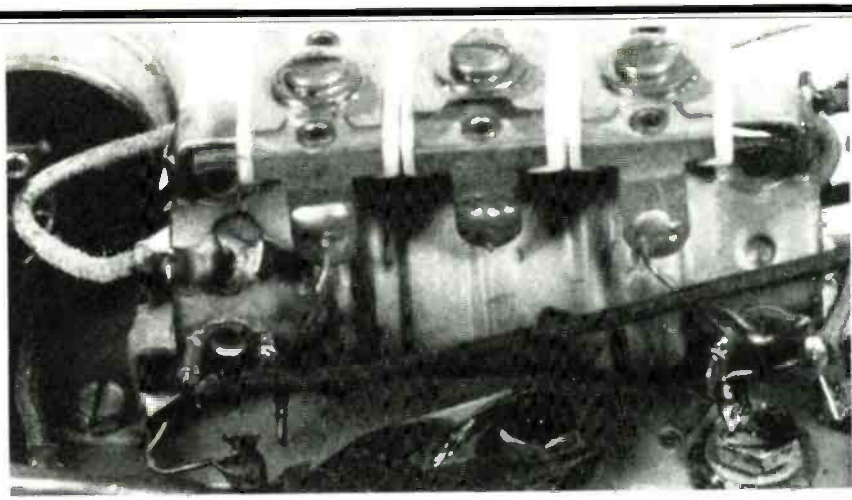
The Brasso also did an amazingly effective job in bringing the cadmium finish on the chassis back to life. The finish had looked very discouraging. Even after the dust and grime was scrubbed off, it remained dull and speckled with corrosion. Applied with a little elbow grease, the Brasso brought up a nice shine. And while it didn't entirely eliminate the corrosion speckles, it certainly did minimize them.

Once the main tuning/band-spread capacitor is cleaned, and I find some suitable replacement mounting grommets, reassembly can begin. And everything is beginning to look so nice, I can hardly wait to start. I'll look forward to writing another progress report very soon!

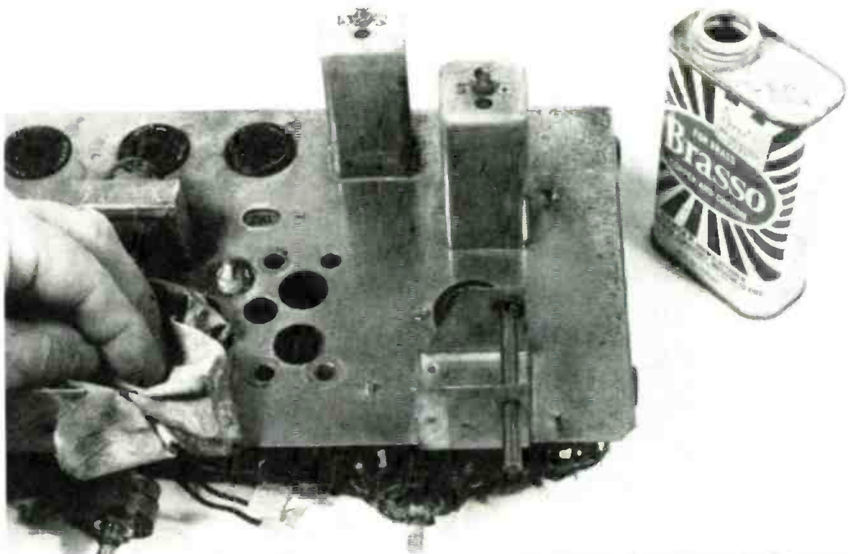
Memories of the Model 42

A few months ago, I received a very interesting letter from Dr. Arthur Fisher of

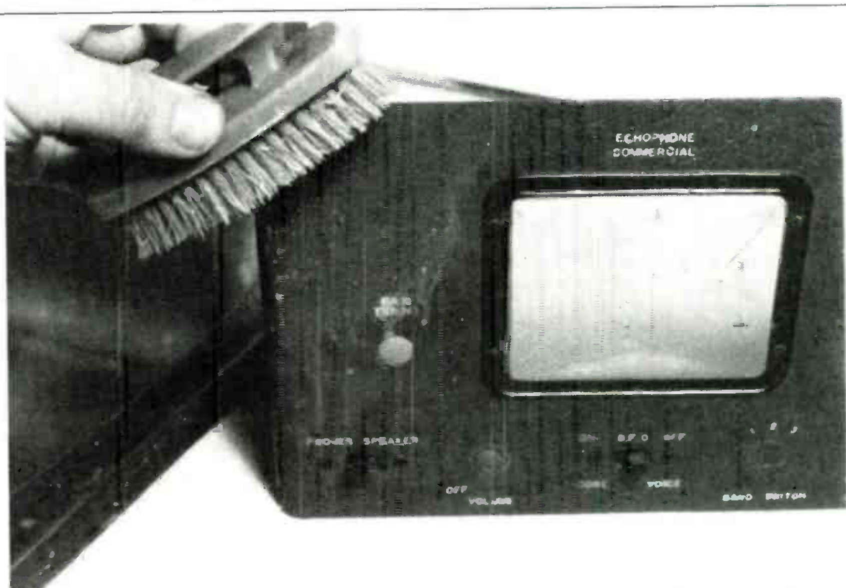
(Continued on page 104)



Removal of two of the tuning capacitor's mounting nuts was a bit tricky because they were located directly under the oscillator coil. I should have used an open-end wrench, but I didn't have one that small on hand!



When applied with a little elbow grease, Brasso metal polish did an amazingly good job of restoring the gleam to the cadmium-plated chassis.



The paint on the front panel/cabinet assembly became several shades lighter after removal of grime with ordinary hand soap and a soft scrub brush.

By Joseph J. Carr, K4IPV

CARR ON HAM RADIO

Using balanced mixers

THE BALANCED MIXER IS A SIMPLE, low-cost circuit that can make certain construction projects a lot easier. They can be used as mixers in receivers, transmitters, frequency converters, and signal-generator projects. They are also used to generate double-sideband suppressed-carrier (DSBSC) signals that can then be filtered to produce single-sideband suppressed-carrier (SSBSC, or simply SSB) signals.

In receivers, they can be used as both main and intermediate mixers (for double and triple conversion designs), or as product detectors. Typical low-cost, commercial balanced-mixers operate over a wide-frequency range. For example, the Mini-Circuits SRA-1 operates with RF and local oscillator (LO) signals from 0.5 to 500-MHz, and allows IF output frequencies of from DC to 500 MHz.

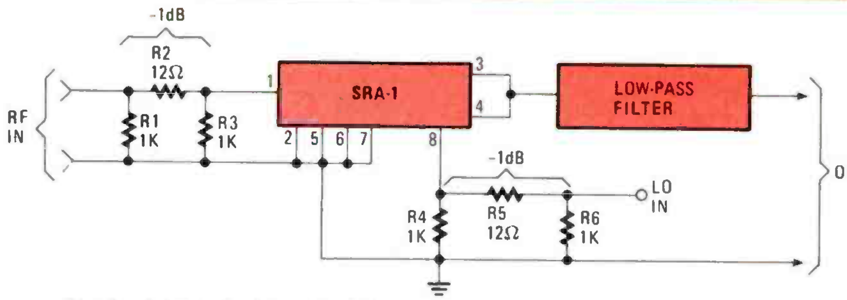


Fig. 2—A typical mixer circuit for applications such as a signal generator, mixer, or others where a low-pass filter is used for the output circuitry. When dealing with very wideband devices, the properties are not always guaranteed unless the source or load impedances remain constant.

Starting From Scratch

This month, we will show you how to make use of those neat little circuits, and recommend a couple of sources that carry the ready-built product. Figure 1 shows the basic circuit for the balanced mixer, consisting of a diode ring-modulator circuit fed by a pair of balanced RF transformers.

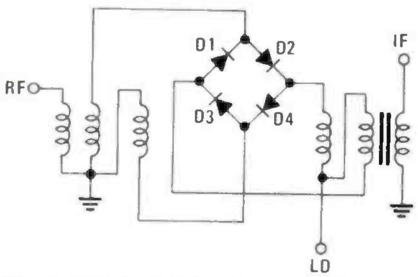


Fig. 1—The basic circuit for the balanced mixer consist of a diode ring-modulator circuit—made from good-quality RF signal diodes that are closely matched—and a pair of RF transformers.

The diodes are used as switches, and must be good-quality RF signal diodes that are closely matched. Readers who want to build their own might want to hand-match the diodes with forward and reverse resistance readings ...or buy matched diodes to begin with.

The recommended diodes are Schottky types. The transformers are tri-filar wound toroids. Most readers would probably prefer to use a commercially available balanced mixer, such as the Mini-Circuits (PO Box 166, Brooklyn, NY, 11235) SRA and SBL devices. Readers can buy those directly from Mini-Circuits, or from Radio Parts (Pelham, NH).

Table 1 gives the pin assignments for the three devices. All three models use pins 2, 5, 6, and 7 as ground (and must all be grounded), and those marked with an asterisk in Table 1 must be externally connected to each other. The SRA-1 operates from 0.5 to 500 MHz (IF + EP DC to 500 MHz), SRA-5 operates 10 to 1500 MHz (IF + EP 10 to 600 MHz), and the SBL-1 operates 1 to 500 MHz (IF + EP DC to 500 MHz).

Figure 2 shows a typical mixer circuit for applications such as a signal generator, mixer, or others where a low-pass filter is used for the output circuitry. Note that 1-dB pads are used at the two inputs and the single output. As I mentioned in an article on MMIC devices earlier this year, when dealing with very wideband devices, the properties are not always guaranteed unless the source or load impedances remain constant (in this case, 50-ohms).

TABLE 1—DEVICE I/O ASSIGNMENT

Device	Signal Designation	Pin
SRA-1	Local Oscillator	8
	RF_{in}	1
	IF_{out}	3, 4*
SRA-5	Local Oscillator	8
	RF_{in}	1
	IF_{out}	3
SBL-1	Local Oscillator	8
	RF_{in}	1
	IF_{out}	3, 4*

* Must be connected together externally

The pads tend to smooth out variations, and as such are highly recommended even if not strictly necessary. The low-pass filter should be selected to attenuate the feedthrough signal of either the LO or RF, whichever is higher. Filter-design tables can be found in any recent edition of the *ARRL Radio Amateur's Handbook*. Always select the 50-ohm versions when dealing with this type of circuit, unless some overriding circuit-design consideration forces you to another impedance.

In some circuits, the low-pass filter will be replaced with an LC resonant tank circuit that selects the IF frequency desired. In such cases, the output waveform is considerably purer because of the filtering effects of a tank circuit.

Going One Better

Figure 3 shows a balanced mixer used as a product-detector circuit. The product detector is used to demodulate SSB signals, and works by heterodyning a stable *B*eat-*F*requency-*O*scillator (BFO) at the frequency of the original suppressed carrier against the sideband. The remaining SSB IF component is removed by filtering in an RC network (R1/C1) and an RF choke (RFC1). Audio from the output of the filter is coupled through capacitor C2 to the following audio amplifier circuits.

The heart of any SSB transmitter is a balanced modulator that suppresses the carrier of the signal. The output of the balanced modulator is a DSBSC AM sig-

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By Byron G. Wels

WELS' THINK TANK

The Tank goes interactive!

THE MAIL RESPONSE TO THIS COLUMN has been wonderful, a fact that I relayed to the boss while lunching yesterday. That prompted him to ask: "Why not give the readers a bigger part in the magazine by letting them submit *their* favorite circuits to share with others?"

That's how it all began. What evolved is even better. We want you to send in your favorite electronic circuits, along with a description of how they work (just as we've been doing on these pages) and we'll publish the circuits—not just with your initials, but your full name! Now I expected that a small honorarium would be paid, but the boss flipped me out when he offered each of you payment in the form of a free copy of *The Collected Works of Mohammed Ulysses Fips*. (A $12.75 value, and some of the *best* reading you're going to come across in the electronics field.)

Here's what we need: Simple, easy-to-build circuits that solve problems. Please keep them down to two transistors, or two IC's, because space is limited. Draw the schematics *clearly* so that our artist can understand what you're getting at. We don't need anything too fancy; we'll redraw them. However, please provide sufficient text to explain the circuit in detail. We'd like to get the text typed, double-spaced, but as long as it's understandable, we'll take it even if it's written in Sanskrit with a crayon on wet blotting paper!

So sharpen up your pencils. There's a copy of the Fips book waiting for you, as well as the pleasure of seeing your name in print. Believe me, the Fips' book is a real hoot, too! So rush your entry to us as soon as possible!

All-Purpose Amplifier

There are very few circuits that you can build that do not require an amplifier. And the one shown in the enclosed illustration is really top-notch. I've used it as an add-on for a code-practice oscillator, an FM or AM tuner, for a small phono—the applications are almost endless. As a result, when I'm running low on them, I make up about a half dozen at a time, etching all the boards at once and buying the parts in bulk. I set up a small assembly line to build them, and then wrap each one in tissue paper to sit on the shelf until one or two are needed.—S. Rubin, Ft. Lauderdale, FL.

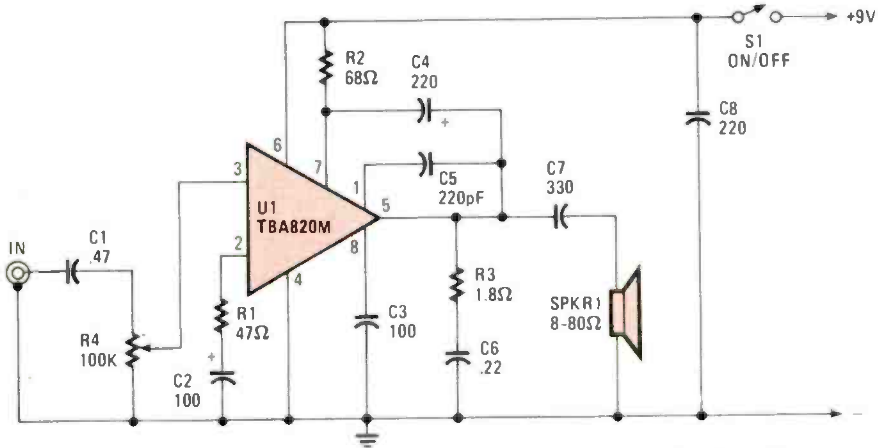


Fig. 1—The input to the All-Purpose Amplifier circuit (which is based on the TBA820M) is DC coupled to volume-control R4, and routed to the non-inverting input of U1 at pin 3, while an internal resistor provides negative feedback to the inverting input (pin 2) of U1.

Thanks, Mr. Rubin. Your copy of the Fips book is now in the mail.

Now, let's turn our attention to Fig. 1. The circuit is based on the TBA820M IC, although a TBA820 (which has a different encapsulation and pinout) could be used. The input signal is coupled through DC blocking capacitor C1 to the volume-control potentiometer, R4, and routed to the non-inverting input of U1 (at pin 3). An internal negative feedback resistor is connected from the output of the U1 to its inverting input (pin 2).

The closed-loop voltage gain of the circuit is determined by resistor R1, which is connected between the inverting input (pin 2) of U1 and the negative supply rail. Resistor R2 and capacitor C4 provide bootstrapping from the input to the collector circuit of the driver stage of U1. That helps to provide a high unclipped voltage swing at the Amplifier's output. Capacitor C7 serves as the output DC blocking capacitor. The specified chip has a class B output stage with quiescent-current consumption of only about 4 mA, which increases appreciably at high volume levels.

The maximum output power depends on speaker impedance, but with an 80-ohm load, it runs about 100 mW rms. And the input impedance is about 100K.

Headphone Amplifier

It all began when I built this code-practice oscillator that was supposed to work off headphones. It did, but was more a peanut-whistle device with absolutely no poop. Then I wired up my amplifier, and was finally able to hear things a lot more easily. My brother, who is hard of hearing, asked me to wire up an amplifier for his little pocket radio. I did, and then wired up *two* of them for a stereo system. The thing works great, provided that you remember that you need a duplicate of this circuit for a stereo system!—Al Fine, Houston, TX.

Thanks, Al. Figure 2 shows a cute Headphone Amplifier and, if you wire up a pair of them, as Al suggests, you can use it in stereo. Voltage gain is provided by Q1, a P-channel JFET in the common-source mode. Resistor R3 is used as the source-bias resistor with C2 serving as a by-pass capacitor. R2 is the drain load for Q1, and gate biasing is provided by R4, R5, and R1. R4, the volume-control potentiometer, along with R5 and R1, serve as a conventional balance control. Capacitor C1 serves for input blocking of the DFC.

Q2 is an emitter-follower output stage that provides a low output impedance, allowing the circuit to work even with 8-ohm headphones. In the schematic di-

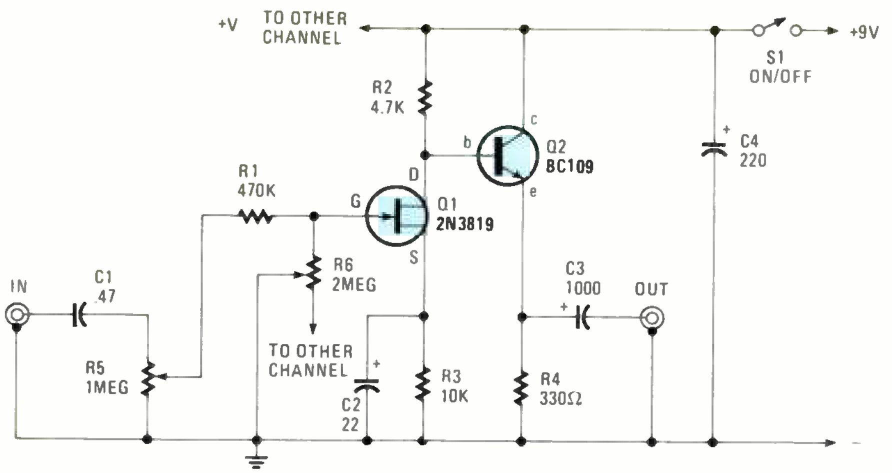


Fig. 2—The Headphone Amplifier, which is built around Q1 (a P-channel JFET in the common-source mode) and Q2 (configured as an emitter-follower output stage) provides a low output impedance, allowing it to drive 8-ohm headphones.

agram. C3 serves as output DC blocking capacitor, while C4 is the power-supply decoupling capacitor. Switch S1 is a standard single-pole single-throw (toggle, rotary, slide, etc.) switch; which, when wired as shown in Fig. 2, serves as the on/off for both the mono and stereo versions.

For stereo, simply parallel two amplifiers across the power supply. If your audio is coming from a mono source, try placing a phase splitter between the signal source and the two amplifier inputs. It's not true stereo—more like dual mono—but then we're not talking *state-of-the-art* at the prices involved here. Current consumption per circuit is about 35mA and we suggest a fairly large battery for this.

Noise Limiter

Anybody who listens to shortwave radio knows how his family feels about all the hash and squitter that comes through. I solved that very problem in my own home by using earphones. It keeps the irritating noise out of the living room, and I tell my family that I'm wearing them so that the TV won't interfere with my listening! But the noise *still* bugged me, until I built the Noise Limiter shown in the schematic. Any of my fellow SWL's are welcome to it. It works!—Frank Lester, Grand Rapids, MN.

Thanks much, Frank! Take a look at Fig. 3. The circuit is fed from the earphone jack of your receiver and goes to limiter control R6 and is then amplified by Q1—a common-emitter stage that has a voltage gain of only about ten because of the negative feedback introduced by R3. You don't need high gain because all the amplifier does is to make sure that a few volts peak-to-peak is available. Since most receivers can easily provide that, little amplification is required.

The output of Q1 is fed to a simple clipping circuit, consisting of diodes D1 through D4. The diodes, connected in pairs, act like Zeners with an avalanche rating of about 1 volt. The two pairs are connected opposite in polarity to each other, so that the audio signal is clipped (limited) at about 1 volt. The signal is then coupled to the output socket through an emitter-follower buffer stage (built around Q2) and an output attenuator control R7. The output can drive low, medium, or even high-impedance earphones. You're going to find that you can listen for much-longer time periods than you could before you installed it.

RF Probe

I think this is one of the handiest devices on my test bench, and I can assure you that when it's needed, its standing changes from handy to essential. If you're into any kind of servicing at all, you'll be happy to have an RF probe!—James Watson, Atlanta, GA.

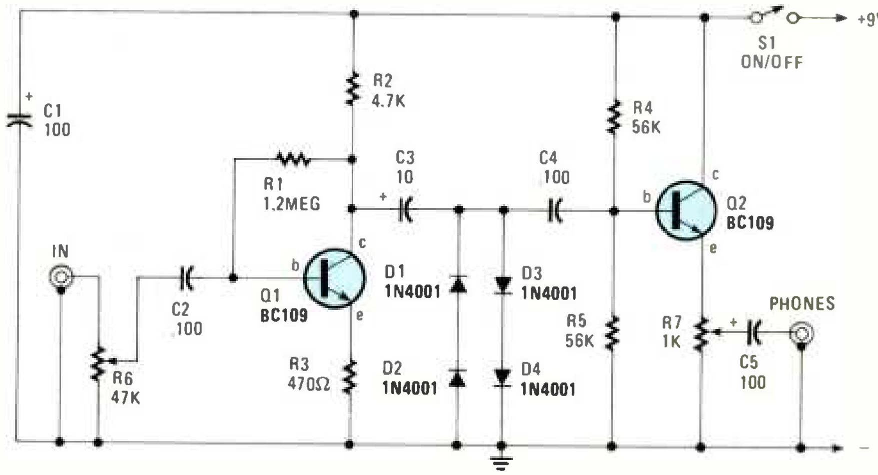


Fig. 3—The input signal to the Noise Limiter (taken from the earphone jack of your receiver) is fed to limiter-control R6 and amplified by Q1—a common-emitter stage that has a voltage gain of about ten due to the negative feedback introduced by R3.

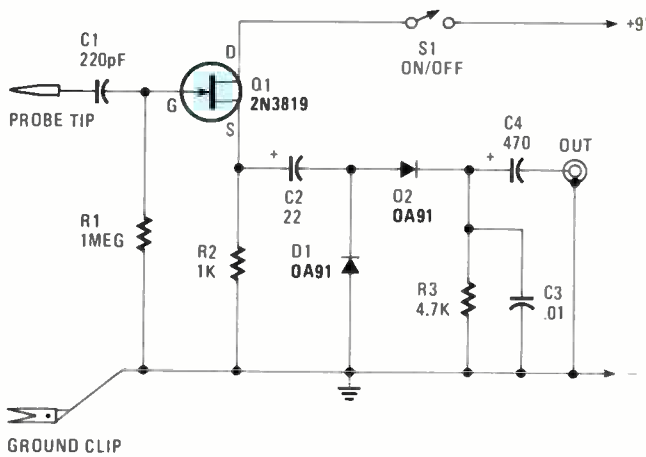


Fig. 4—In the the RF Probe circuit, transistor Q1—configured as a source-follower buffer stage, offering a bit under unity voltage gain—gives the unit a high-impedance input of about 1 megohm, shunted by about 10 pF, which keeps only minimal loading on the equipment being tested.

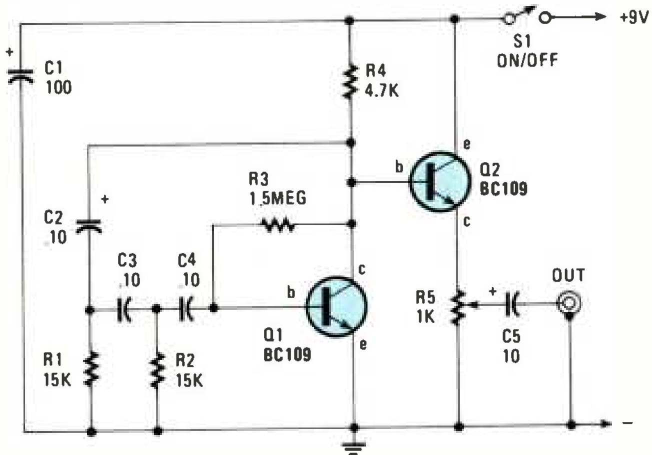


Fig. 5—The Audio Generator circuit produces a sinusoidal output of about 8 volts peak-to-peak (which can be varied down to zero) at about 500 Hz. The signal is generated by a phase-shift oscillator—consisting of Q1 (configured as a high-gain, common-emitter amplifier with feedback provided by a phase-shift circuit).

Thank you Jim; you're quite right about the value of an RF Probe. And yours is about the neatest we've seen. Moving right along, let's turn our attention to the schematic diagram shown in Fig. 4. Transistor Q1—configured as a source-follower buffer stage, offering a bit under unity voltage gain—gives the unit a high-impedance input of about 1 megohm, shunted by about 10 pF, which keeps only minimal loading on the equipment being tested. C1 serves as input DC blocking capacitor. The Q1 output is coupled by C2 to a simple AM detector circuit made up of D1, D2, R3, and C3. Capacitor C4 provides output DC blocking. Total current consumption should be somewhere around 1 mA. The circuit responds to frequencies in the 100-kHz to well over 50-MHz range. A small case for the Probe can easily be put together from clear-plastic tubing—about ½ to ¾ inch in diameter. A short dowel may be used to block the circuit board in the tubing and hold the Probe tip. Make sure that shielded wire is used to connect the output to an amplifier.

Audio Generator

When I heard that you wanted circuits from readers, I looked at my workbench. This small audio injector is probably the most-useful thing I've got!—Jerry Booth, Los Angeles, CA.

OK, Jerry, start watching the mails. Your copy of the Fips book is on the way. Take a look at Fig. 5. The circuit provides a sinusoidal output (more or less) at about 500 Hz. You'll get a peak-to-peak output of about 8 volts, and from a low-impedance source. The output level can be varied down to zero.

The signal is generated by a phase-shift oscillator—consisting of Q1 (configured as a straightforward high-gain, common-emitter amplifier with feedback provided by a three stage, phase-shift circuit). The three stages are formed by C2—R1, C3—R2, and C4, plus the input impedance of Q1. At a given frequency (about 500 kHz here) a 60-degree phase shift occurs through each section of the phase-shift network to provide a total phase shift of 180 degrees. So while the collector and base of Q1 are 180 degrees out-of-phase, the phase-shift network serves to counteract that condition, so that positive feedback is produced. Because the gain of Q1 is greater than the losses through the phase-shift network at that frequency, oscillation results.

Q2 is an emitter-follower buffer stage that reduces the level of loading on Q1. We need that buffering, because a fairly-low load impedance across the output would reduce the gain of Q1 to the point where oscillation would cease. Resistor R5 serves as the emitter load for Q2 and also doubles as the output level control. Capacitor C5 offers DC blocking at the output. That blocks direct current from reaching the circuit that follows; thereby, preventing erratic operation. Total current consumption is in the neighborhood of 5mA. And for a unit as handy as this, that isn't a bad neighborhood at all!

Continuity Checker

I always got a laugh out of people who buy expensive, "super-fancified" digital meters, and then put them to work to check continuity. Talk about over-kill! Man, if they had to pay salaries to those gadgets, they'd *fire 'em*. And just to put things into perspective, here's my submission for a Continuity Checker with no ambitions. It does its job, and that's all!—James MacPherson, Kearny, NJ.

Thanks Jim. Looking at your schematic diagram (see Fig. 6.), I can understand what you're talking about. U1 is an op-amp being used as a comparator. When the test probes are shorted together, resistors R1 and R2 bias the non-inverting input to half the supply voltage. The inverting input is biased by a voltage divider consisting of R3, R7, and R4. Resistor R7 is adjusted so that the voltage to the inverting input is lower than that to the non-inverting input when the probes are shorted together.

With continuity across the probes, U1's output goes high, supplying power to Q1, which is configured as a relaxation oscillator. The output of Q1 is fed to a high-impedance loudspeaker for an audio tone. With the probe is open, the non-inverting input goes to the negative supply rail via R2—forcing U1's output low, resulting in no output from the oscillator.

If there's a low resistance on the probes, a small voltage is dropped across R2, so the voltage to the non-inverting input is a bit lower than when there's zero resistance across the probes. The output of U1 remains low and no audio is produced at the speaker. Adjusted correctly, the circuit

(Continued on page 99)

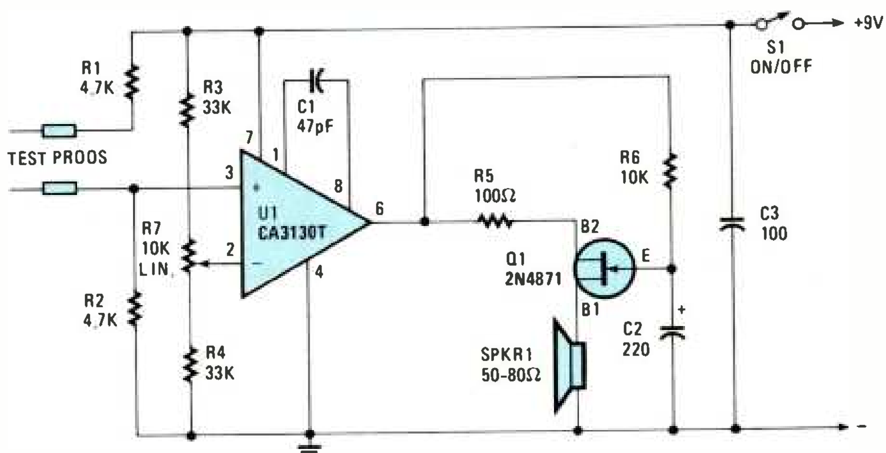


Fig. 6—When the test probes of the Continuity Checker are shorted together, the output of U1 (a CA3130T op-amp, configured as a comparator)—goes high, supplying power to Q1, and producing an audio tone in the loudspeaker.

UNDERSTANDING DECIBELS

(Continued from page 38)

$$0 \text{ dB Lp} = .0002 \text{ dynes/cm}^2 = .0002 \text{ microbar}$$

Sound power is proportional to the square of pressure amplitude, analogous to the way electrical power is proportional to the square of voltage amplitude. Accordingly, Lp is calculated with a factor of 20:

$$\text{Lp (dB)} = 20 \text{ Log P}/.0002 \text{ dynes/cm}^2$$

"Microphone sensitivity is...."

A microphone's sensitivity is specified either as its voltage output or its power output when it is subjected to a standard sound pressure.

In a typical power specification the reference quantity is 1 mW for a sound pressure of 10 microbar. Therefore, the quoted specification of -60 dB implies that the microphone will generate one one-millionth of a mW in its specified load when it is subjected to a sound pressure of 10 microbar. With that information and the specified load resistance you can calculate the equivalent output voltage.

Voltage specifications are gradually becoming more common. A typical specification for the popular electret-microphone uses a reference of 1 V/microbar. The quoted specification of -60 dB in that case implies that the microphone will generate .001 V_{rms} across its specified load resistance when it is subjected to a sound pressure of 1 microbar. Note that 1 microbar translates to an Lp of about 74 dB. That is a typical average sound level in busy traffic or a noisy office.

"Speaker efficiency is...."

Speaker efficiency is sometimes called speaker sensitivity. In general, the efficiency of an energy-conversion device like a speaker is the ratio of useful output power (in that case, sound power) to total input power. However, sound power is hard to measure directly, so speaker manufacturers have settled for a technique which allows speakers to be compared to one another. In one popular technique the speaker is driven by exactly 1 W of *pink noise*. The efficiency is then given as the sound pressure level 1 meter from the face of the speaker. The quoted specification of 90 dB is a typical measurement.

Absolute efficiency for the common dynamic speaker is typically 2% or less, meaning that 98% or more of the electrical power delivered to the speaker is turned into heat. By any standard that is very poor efficiency, but the saving grace is the sensitivity of human hearing. For normal listening levels the speaker needs to generate only a few mW of actual sound power. An Lp of 90 dB is in fact uncomfortably loud for most people.

"Output audio level is...."

The subject here is the audio output from preamplifiers, tape decks, control panels, video cassette recorders, and any other device that produces an audio output meant to be processed by other equipment before being applied to a speaker.

To understand that usage of dB a little history is required. In early audio systems equipment was connected using a matched "line" impedance of 600 ohms at both input and output. That standard was borrowed from telephone engineering, and it made sense in the days of vacuum tube amplifiers and passive switching circuits. The 0 dB reference was an average power of 1 mW in a 600-ohm load resistance. You can calculate that that power corresponds to a voltage of 0.775 V_{rms}.

In modern audio equipment, 600-ohm matching is rarely used. Line inputs are usually high-impedance, and it is voltage that counts, not power. What has survived, however, is the 0 dB reference of 0.775 V_{rms}. A 6-dB reduction in voltage means the 0-dB voltage is divided by 2. So when a manufacturer quotes an output audio level of -6 dB he is saying that the audio signal at the output of his device will be automatically leveled to about 0.388 V_{rms}. In most cases the output is low-impedance and the level will be maintained even if a 600-ohm load is connected.

Speech and music signals vary arbitrarily and must be measured in RMS (time-average DC equivalent) volts. One way of getting an intuitive feel for the size of the signal is to assume that the audio signal is a continuous sinewave. The peak-to-peak voltage of a sine is approximately 2.8 times its RMS voltage. Thus, a device with a specified audio-output level of -6 dB will level a sinewave to a voltage of about 1.09 volts peak-to-peak.

Universal DeciBels

By no means are these examples the only important applications of the deciBel. Although the dB was created to quantify the relation between sound power and loudness, it is now being used in a field as divergent as fiber optics. To understand new or unfamiliar usages, apply basic principles first. In particular, remember that the deciBel always expresses the ratio of two quantities. The main task is to figure out what the quantities are and how they are measured. ■

A BEGINNERS GUIDE TO FIBER OPTICS

(Continued from page 47)

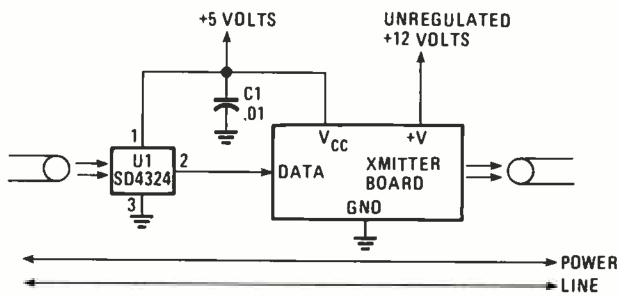


Fig. 7—An extremely simple optical repeater may be built for increased range, or use with poor-grade fibers.

Conclusion

I hope that this very-brief introduction to fiber optics will fuel your imagination, so (hopefully) there'll be more down-to-earth applications and future articles. Since space is at a premium, there was no intention in this article to cover basic optical theory; many books and magazines carry it. I would like to mention, however, an outstanding book for any of you interested in reading further on fiber optics applications and theory. It is the *Designer's Guide to Fiber Optics* published by AMP Corporation.

You are likely to find fiber optics an interesting enough topic to keep you busy for quite some time. Especially since it is a relatively new technology for hobbyists. Keep experimenting and enjoy. ■

WELS' THINK TANK

(Continued from page 97)

responds to a resistance of about three ohms or less over the probes. Maximum current through the probes is about 950 µA. Capacitor C1 is compensation for U1. Simply adjust R7 for the highest tap voltage that doesn't cause the tone to cut off when the probes are shorted.

Treble Boost

Usually, when you think of music amplification, especially with today's rock 'n' roll, you immediately think in terms of added bassiness. The kids listen for that steady, low-frequency booming. But I built this treble booster and what it did for my son's guitar was just a little shy of amazing! There's added brilliance, and he usually cuts it into the circuit when he's about to take a solo.—Frank Lewis, Shreveport, LA.

Thanks Frank. Personally, I haven't heard any good music since Glenn Miller's time! But *cop a gander* at Fig. 7. The circuit is a simple JFET common-source amplifier, configured around Q1. Open switch S1, and there's no bypass capacitor across source-biasing resistor R4. The resulting negative feedback lowers the amplifier's gain to about unity. Close S1, and the Treble Booster comes on. Capacitor C3 bypasses R4, but it's only effective at the higher ranges of audio frequency. That provides a response above 2 kHz and the necessary boost in the treble range.

Since Q1 can only provide a gain of about 18 decibels, no series resistor is needed with C3 to limit the boost that is applied. C4 provides roll-off at the highest audio frequencies so there is no harshness at the output.

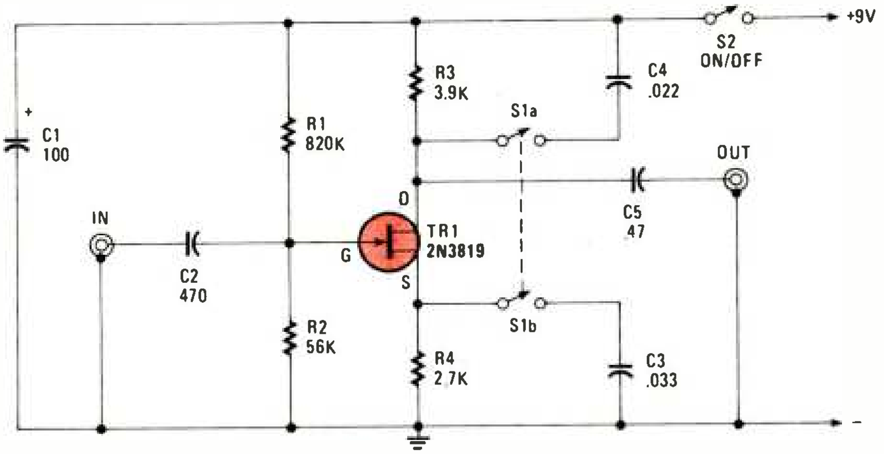


Fig. 7—The Treble Boost circuit is little more than a simple JFET common-source amplifier, built around Q1, which provides a gain of about 18 dB.

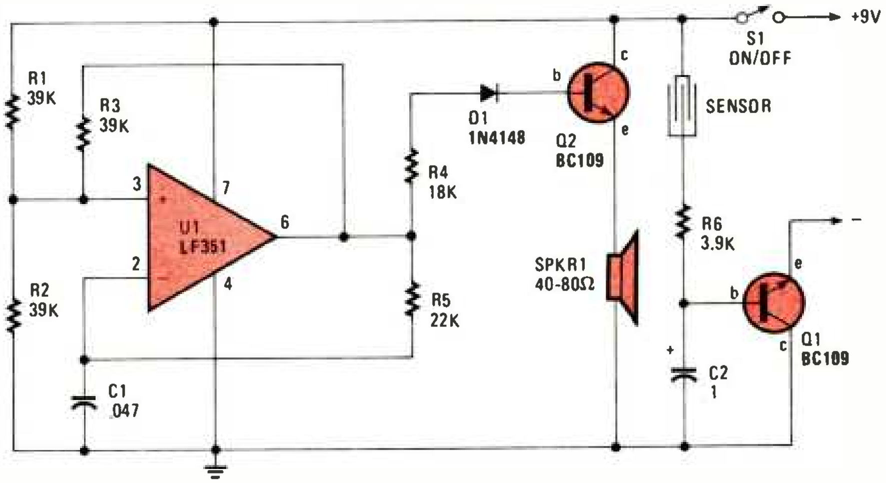


Fig. 8—The sensor in the Water Switch circuit is nothing more than strips of printed-circuit board, interleaved and separated from each other, so there is no current path between them.

Water Switch

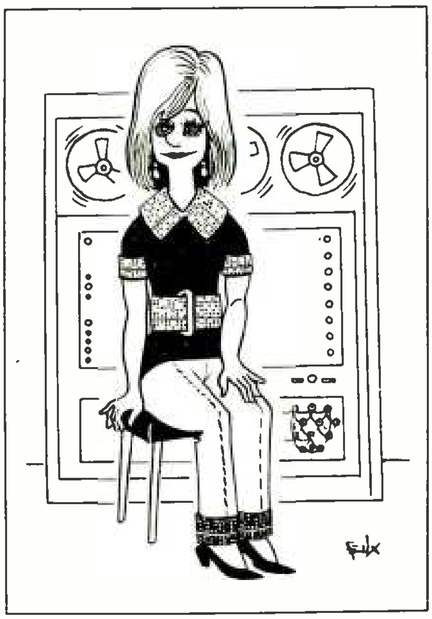
I've used this system for everything from closing the convertible top on my car, to telling me when to shut off the sprinkler on my lawn. As a matter of fact, the only problem that I've run into is that while it raised my convertible top, it wouldn't lock it! And when I get that problem licked, I want still another switch; one that will raise the electric windows in the car when it rains. I'm not lazy, I just don't like getting wet!—Fred Fisher, Dallas, TX.

Thanks for the tip Fred, and as for the rest of you, scan the schematic diagram shown in Fig. 8. There are many forms of sensors, including a handy unit made up on a piece of printed-circuit board. Just interleave the strips several times, and see that they are separated from each other, as shown in Fig. 8. You can also make a suitable detector by placing two conductive rods in a container, making sure that the rods are held slightly apart, so that there's no conductive path between them. As the container fills, the resistance between the plates drops markedly.

U1 (an LF351 op-amp) and Q1 (a BC109 NPN transistor) function as a tone generator. Q2 acts as an electronic switch connected in the ground circuit. Ordinarily, there is a resistance in the sensor that is very high. As a result, Q2 is at cutoff and passes only a small leakage current. Because standby current drain is so low, a small transistor-radio battery can be used to power the circuit. Capacitor C2 filters out any hum or noise,, that might otherwise be fed to the base of Q2, triggering it into conduction. Resistor R6 limits the current to Q2 when water activates the sensor.

When water *does* bridge the sensor, a strong base current flows and into Q2, so that it switches on and sounds the audible alarm through the speaker. Obviously, to make the circuit function with external accessories, the speaker must be replaced by a relay that has a coil impedance of 40-80 ohms.

As usual, we've run out of space for this issue. I've got a collection of the Fips books sitting here on my desk—I just haven't gotten your address yet! Get your schematics and write-ups together, and send them to: By Wels, *Wels' Think Tank*, **Hands-On Electronics** magazine, 500-B Bi-County Blvd., Farmingdale, NY 11735. ■



CARR ON HAM RADIO

(Continued from page 94)

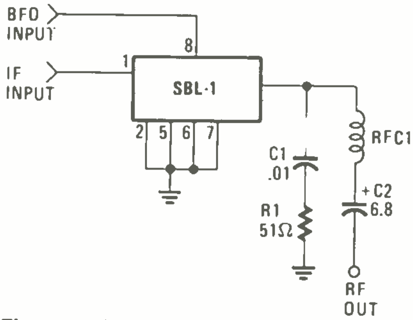


Fig. 3—This balanced mixer (in a product-detector circuit) is used to demodulate SSB signals, and works by heterodyning a stable BFO at the frequency of the original suppressed carrier against the sideband frequency.

nal. When passed through a sharp bandpass filter, one of the two sidebands are removed to become an SSB signal—either upper sideband (USB) or lower sideband (LSB). In Fig. 4, we see a Mini-Circuits SRA-1 used as a balanced modulator in a 9-MHz DSBSC generator. Because filters are expensive, it is the usual design custom to use a single filter, and then switch crystals in the carrier oscillator to select LSB or USB. In the circuit shown in Fig. 4, we would select a frequency of 8.9985 MHz for the upper sideband, or 9.0015 MHz for the lower sideband (assuming a filter with a center frequency of 9.0 MHz). Note in both cases that the carrier frequency is 1.5 kHz from the filter frequency.

The signal levels used in those mixers are +7 dBm for the local oscillator, and up to +1 dBm for the RF. The designation "dBm" refers to power decibels relative to 1-milliwatt (which is the 0-dBm reference level). In order to find the dBm level of any given signal, you must first find the power it represents, by measuring the rms voltage and using the formula:

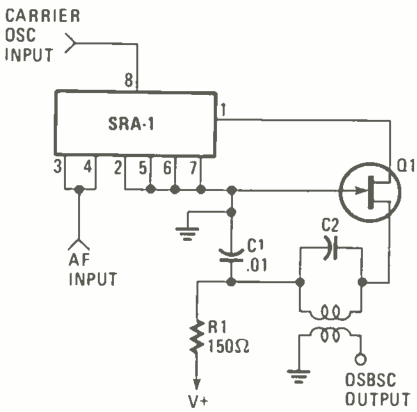


Fig. 4—An SRA-1 is used as a balanced modulator in a 9-MHz DSBSC generator. Because filters are expensive, it's the usual design custom to use a single filter, and switching crystals in the oscillator to select LSB or USB signals.

$$V^2/R,$$

where "R," is 50-ohms.

In most cases, it is easier to measure the peak-to-peak voltage on an oscilloscope, or the peak voltage with a demodulator/detector probe on a DC voltmeter. The rms voltage is close to the peak-to-peak voltage divided by 2.83, or the peak voltage divided by 1.414. For example, in an oscillator that I recently built, the oscilloscope showed an output of 600-mV peak-to-peak (or 0.6 volts) across a 50-ohm resistive load. The rms voltage was: 0.600/2.83, or 0.212 volts, which calculates to a power level of:

$$P = (0.212)^2/50 = 0.045/50,$$

$$P = 0.0009 \text{ watts (or 0.9 mW).}$$

The dBm level is calculated from the standard power dB formula, in which P2 is 1-mW:

$$\text{dBm} = 10 \text{ LOG } P1/P2,$$

$$\text{dBm} = 10 \text{ LOG } 0.9/1,$$

$$\text{dBm} = (10)(-0.046) = -0.46.$$

We can rearrange that formula to find the power required to create a given dBm level:

$$10^{(\text{dBm}/10)} = P$$

Once we know that bit of information, we can work backwards to find the voltage level required. From the voltage-power formula, we can figure out that the RMS voltage is merely the square root of P × R; or in this case, the square root of 50P. If P is expressed in milliwatts, then the voltage will be in millivolts. ■

FISHING GUIDE

(Continued from page 28)

between the board and front panel. Using a small round file, make a small rounded indentation in the top of the case for the cable to come through between the case and front panel.

Calibration

Have available a pail of cool water and install a new 9-volt alkaline battery in the unit. Place both sensors in the pail of water and stir periodically for at least 5 minutes. Connect the negative lead of a digital voltmeter (a good quality analog voltmeter can also be used) to circuit ground. Measure the voltages at TP1 and TP2 and adjust R1 until the two voltages are equal. (An even better way of accomplishing the same thing is to adjust R1 until the voltage difference between TP1 and TP2 is less than 0.000.) With the voltmeter's negative lead still connected to ground, connect the positive lead to TP3. Adjust R2 for a reading of between .99 and 1.000 volt. (With ideal components the voltage of TP3 should be set to exactly 1 volt. However, since three-dimensional, real-life parts are used, it may be necessary to change this setting slightly. (See the next section on preliminary testing and re-calibration.)

Next, connect the negative lead of the voltmeter to TP4 and positive lead to TP5. Adjust R3 for a .270-volt reading. The final calibration can be done with two different methods; the voltmeter or the *icy finger* method (using ice cubes). The voltmeter method is slightly less accurate—typically ±3°F for the voltmeter method versus ±1°F for the "icy finger" method. However, sinnnce few fish are into thermometry, extreme accuracy here isn't really essential. For the voltmeter method, again connect the voltmeter's negative lead to circuit ground. Next connect the positive lead to TP4 and adjust R4 for 2.71 volts.

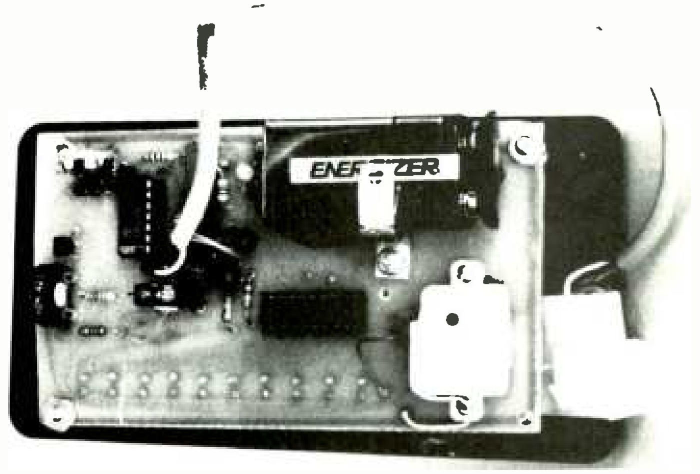
For the icy finger method, place both sensors into a bucket that contains 1/2 ice cubes and 1/2 water. After waiting about 5 minutes, adjust R4 so the LED1 just barely goes on (*make sure LED2 doesn't turn on*).

Preliminary Testing

Before taking your Hands-On Fishing Guide on a fishing trip you probably will want to test it out under simulated conditions. For that test you will need two buckets of water and at least one accurate thermometer—two accurate thermometers are preferred. Half-fill both buckets with water in the 60-70°F range and make a note of the temperature of the water in each bucket. Assuming both temperatures are nearly identical, add enough hot water to one bucket so as to raise its water temperature exactly 2°F above the water in the other bucket. Place U5 (the sensor at the end of the cable) in the cold water and U4 in the warm water. Wait at least three minutes. The thermocline alarm should go on and the LED's should indicate the correct temperature range. If after five minutes the thermocline alarm and thermocline LED do not go on, carefully adjust R2 puntil they do.

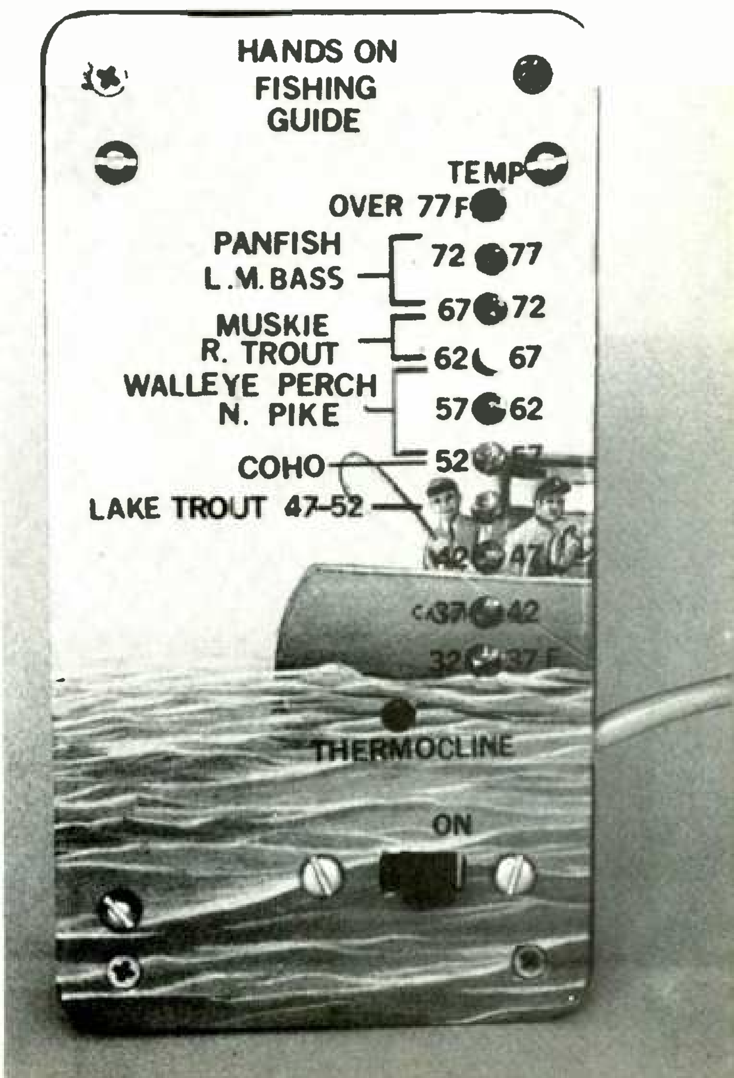
Using the Fishing Guide

When fishing, one should attach what is called a *depth sounder* to the end of the cable. A depth sounder—not to be confused with electronic sonar devices sometimes also



referred to as depth sounders—which are available in most sporting goods stores and bait shops, is simply an alligator clip with a leaded weight. If you wish, you can make one yourself with an alligator clip and molten solder.

When lowering the sensor assembly into the water make sure you do it very slowly or you'll miss weak thermoclines. As the sensor sinks into the water you will notice that different LED's will light, indicating lower and lower temperatures. Assuming it is summer, the buzzer and thermocline LED should go on. When it does, you know the sensors have reached the thermocline. Now make a note of the depth. (You tell the depth of the sensor by counting the number of



Using precut lettering gives the Fishing Guide a professional look. The author included the names of fish next to the temperatures of water they like to inhabit.

marks on the cable that have descended into the water.)

Notice that the Hands-on Fishing Guide is not a fish finder—even lakes completely devoid of fish can have a thermocline and sometimes even ideal temperatures. The project doesn't tell you if there are fish down there, it only tells you where the fish in the lake, if any, have probably congregated.

One worthwhile tip here. Many bodies of water, (especially lakes) have what is known as a *drop-off.* That is, as its name implies, where the water becomes deeper very rapidly. Often the best place to fish is where the thermocline intersects the drop-off. It seldom is productive to fish in the middle of a lake, even in the thermocline region.

Sometimes, however, such as with salmon in the Great Lakes, the water temperature is more important than the thermocline region or drop-off. Other fish, such as lake trout and whitefish, move into the cold depths well below the thermocline. Also, some fish, like catfish, are basically bottom feeders. They pay little attention to thermoclines. Landlocked salmon, brook, brown and rainbow trout seem to prefer the bottom of the thermocline, or even just below it. Panfish, such as bluegills, seem to prefer the upper part of the thermocline. Note that Table 1 lists some popular fish, along with their preferred temperature ranges. Note that in early spring, many fish look for the warmest water available. Everything is relative, thus during April in the north, 50°F

TABLE 1
PLEASANT TEMPERATURES FOR FISH

Type of Fish	Preferred Temperature Range (°F)
Largemouth Bass	67 - 77
Panfish	67 - 77
Smallmouth Bass	62 - 67
Muskellunge	62 - 72
Walleye	52 - 67
Perch	52 - 67
Northern Pike	52 - 67
Brown Trout	52 - 67
Puckerel	57 - 72
Coho Salmon	52 - 57
Brook Trout	52 - 62
Lake Trout	47 - 52

water temperatures might be looked upon as a semi-tropic paradise, to a sunfish.

Note that while the Hands-on Fishing Guide only measures water temperatures in a limited range, 32-77°F, at least one LED should always be on. Liquid water never gets colder than 32°F and LED10 will be lit for temperatures 77°F and above. ■

NEW PRODUCT SHOWCASE

(Continued from page 15)

is 8 bits by 256 words. Samples can be taken synchronously with an external clock for state analysis. The external clock has a five-nanosecond minimum pulse width. The internal clock provides variable rates from 40 Hz to 20 MHz.

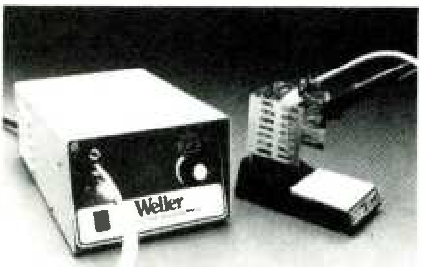
The Logic 20/8 and Logic 10/8 are priced at $695 and $495, respectively, and deliveries are available immediately, with a 15-day trial evaluation for new installations. For more information contact Bitwise Designs, Inc., 1223 Peoples Ave., Troy, NY 12180; Tel. 518/274-0755.

Remote-Pencil Iron

Compact, space-saving convenience is a key feature of the new Weller controlled output soldering station and pencil. The unit, Model WTCPS, allows soldering station operators, who need all the work space they can get, to use the lightweight pencil iron several feet away from the main unit. In addition, the self-feeding water reservoir stand can be attached to the right or the left of the main soldering unit so that both right and left-handed solderers can work more efficiently and in greater comfort. The detachable stand also has storage space for six temperature-sensing tips.

Built to last in the work environment, the closed-loop transformer is protected with impact-resistant plastic. The pencil iron has a flexible end casing that relieves cord strain for increased durability.

The Weller WTCPS carries a suggested



CIRCLE 79 ON FREE INFORMATION CARD

retail price of $119.07.

For more information write: Weller WTCPS, Cooper tools, PO Box 728, Apex, NC 27502.

Temperature Probe for DMM's

How about a measurement accessory that converts any digital multimeter into a thermometer? Well the 80T-150U uses a P-N junction, temperature sensor housed in a low thermal-mass tip to provide fast-response, high-accuracy readings.

The unit is switch-selectable for readouts in °F or °C. The 80T-150U can make temperature measurements of live circuits, with 350-volt peak-ac standoff capability. Small components can be

CIRCLE 98 ON FREE INFORMATION CARD

accurately measured without cooling due to mass of the probe tip.

The probe is suitable for surface, gas, and non-corrosive liquid measurements. That includes most industrial solvents, water lubricants and fuels, as shallow as ½ inch. The 80T-150U has a range of -50°C (-58°F to +302°F). Basic accuracy is ±1°C (1.8°F) from 0° to 100°C, providing more accurate readings than most thermocouple devices. The unit uses a standard 9V battery, with a built-in battery check feature using the external DMM. Average battery life is 1600 hours.

The 80T-150U has a suggested list price of $129. It is available from distributors in the United States, and worldwide through the Fluke sales network.

For more information on this and other Fluke products, write John Fluke Mfg. Co., Inc., PO Box C9090, Everett, WA 98206; Tel. 800/426-0361. ■

BOOKSHELF

(Continued from page 18)

For users who are upgrading to R:Base System V from R:Base 5000, the book explains some of the major differences between the two programs. Nonprogrammers will learn to produce business applications with the menu-driven user interface. Programmers will learn to use R:Base System V's command mode to create business applications.

R:Base System V User's Guide—2nd Edition, is available for $19.95, from Que Corp., 7999 Knue Rd., Indianapolis IN; Tel. 800/428-5331. ■

DIGITAL THEREMIN
(Continued from page 34)

Finally, be sure to scrape the paint out of the insides of the screw holes in the top of the case so that the shielding works on both halves. (An Xacto knife or reamer works well.)

Testing and Calibration

After assembly is complete, carefully inspect the Theremin for wiring errors, poor solder joints, and other potential problems. If everything looks good, hook the Theremin up to a receiver or audio amplifier with a patchcord, attach a battery to the clip, and apply power.

Slowly raise the volume using the LEVEL control. If all is well, a high-pitched squeal should be heard. Waving a hand near the antenna should cause the pitch to raise. Extend the antenna to its full length and adjust the ZERO control knob for a spot where no sound is heard unless your hand comes near the antenna. If the squeal does not *tune out* at any point, shorten the antenna length by a few inches and try again. When set properly, the Theremin will remain silent until the performer moves his or her hands to within several inches of the antenna shaft.

There are many factors that can influence the capacitance of the human body, and all of them can affect the Theremin's operation. Things like the antenna length, air humidity, the size, and dress of the performer, and the thickness of the user's shoe sole (and the color of the socks worn, no doubt) can all interact to necessitate a change in the ZERO control setting. With a little practice, the ZERO control can be correctly set in a few seconds.

Finally, the Theremin should be given a few moments to stabilize due to temperature change after the power is first turned on. If the Theremin is powered up and immediately zeroed, it will be sure to drift and need calibration again (and again). The best cure is to turn the power on with the LEVEL control all the way down and give the Theremin five minutes or so to warm up before calibrating the ZERO control.

This frontal view of the Digital Theremin shows the location of the panel-mounted controls. Also notice that the antenna, beside going through a grommet on the printed-circuit board, protrudes through a second grommet mounted top-center of the enclosure, lending support to the installation.

The Theremin is a natural with audio special effects. A volume pedal can be used to add dynamics and create fadeouts, and almost any of the floor boxes for guitarists or synthesizers will change some aspect of the sound quality. The ethereal sound of the Theremin works very well with echo and delay effects.

Whether the Theremin is used as a special effect for rock bands or theater groups, or to enhance your next Halloween party, you'll find that it will give you plenty of unusual sound for a very modest investment in time or money. Not only is the Theremin interesting and educational, it's fun! ■

THE PRINTING STOPWATCH
(Continued from page 48)

Note that both TIME$ and DATE$ have a prefix tag which aids in coming and printing the time. ("T" flags time entries, while "B" and "E" signify Begin and End.) In operation, the program behaves this way: when started, a "1" is printed in the upper left corner of the screen, followed by a series of numbers which increase in value once a minute. To start timing, press key F1. This causes an "A" to be printed on the next line, followed by the ascending number series on one minute intervals. This screen printing is simply an indication tht the program is running. To stop timing, press key F2. A "B" is printed, followed by the number series. Each pair of keypresses adds another record to the file. The printout is activiated by pressing F3, and can be done anytime as a check of total time expended. After each printout, the program returns to the Model 100 Menu. There you have it—a printing stopwatch!

During program startup, you are prompted for a file name which is used for the timekeeping. This allows you to work on several projects, one at a time. The file name must be unique for each project, with a maximum of six characters in the name. The major limitation is that each time interval must begin and end on the same day. An example will show why: start at 11/3/86, 8 pm. (20:00:00) and stop at 1 am (01:00:00, 11/05/86. TYMKPR will subtract 20:00 from 01:00 and get a negative time, which won't help the income from the contract!

If you aren't familiar with the ON KEY GOSUB routine, see lines 15 and 1000 in Listing 1. KEY ON enables the function interrupt, and ON KEY GOSUB works just like ON...GOSUB. Other program featuers of note are: Lines 320 and 325 read data strings from RAM. Although the data string is only nine characters long, the string terminator (CHR$ (13) CHR$ (10)) must be included for correct end-of-file determination. Each string is saved in the J$ array (line 45), and the RAM file is then closed (line 340). Time computation is performed line-by-line in lines 345-425 and the subroutines at lines 50 and 60. Line 50 truncates the time to HH:MM and lines 60-75 separates HH and MM and gets the VALue of each so lines 395 and 410-420 can compute the minutes per interval and total time. Line 435 provides a no-hassle program termination.

Now you've got The Printing Stopwatch designed for the Radio Shack Model 100. You may want to embelish this program for your computer, or even expand the program into a full time-study instrument. ■

ELLIS ON ANTIQUE RADIO

(Continued from page 93)

Santa Monica, CA. He had just read the March column, which discussed some of the first tubes designed for AC-operated sets. The column included a detailed view of the chassis of one of the first radios—the Atwater Kent Model 42—to use those tubes. The photo reminded Dr. Fisher of some of his boyhood experiences with the set, and he has kindly shared them with us. Here are Dr. Fisher's remarks about the Model 42 exactly as he wrote them. I'm reprinting the picture here, too, so you can look it over as you read.

"Reading your article on old AC-operated vacuum tubes and seeing the picture of the old Atwater Kent Model 42 brought back memories. When I was a boy of about 8, my father bought one of the first "all electric" sets that didn't require battery eliminators—the Atwater Kent Model 42. We had the set for many years, and the insides were almost as familiar to me as the outside, because I had to make the tube substitutions.

I recognized the two speaker terminals in the right rear, where I got many a shock. There was no output transformer—the set used a magnetic speaker. The "power pack" is in the back center in a long rectangular can, and it had a habit of burning out or opening, which was what eventually killed off our set. It cost too much to repair.

The tuning condensers (capacitors) were ganged by metal taps, and worked beautifully. The set was not very sensitive or loud and probably didn't put out a watt—maybe a quarter of a watt. We had to sit close to hear.

We got a "modern" Philco in 1936. We would have replaced the AK 42 in about 1930, except for one thing—the depression was on and there was no extra money to be found. The Model 42 cost about $135.00 in 1928—a vast sum probably equivalent to a thousand dollars today, inasmuch as a loaf of bread was less than a dime then and bacon was 20 cents a pound. The Model 42 was beautifully made and in a well-finished metal case. There are probably some around."

Thanks very much for your reminiscences Dr. Fisher. You've certainly given us a fascinating glimpse of what it was like to operate an early "all electric" set. With regard to your last remark, I'm pretty sure my own Model 42 (the one pictured in the column) is still in working condition. I haven't tried the set in years, but I think it would be fun to fire it up and find out. If the Model 42 is still operable, I'll put it through its paces and include a report in a future issue of this column. Are there any other readers with radio reminiscences to share? We'd all be happy to hear from you!

This is the photograph that sparked Dr. Fisher's memories of the Model 42. You'll want to refer to it as you read his letter!

Reprint of a Classic

Recently, I received a review copy of a very interesting paperback—*Radio's First Two Decades*; a reprint of the first half of a book called *Radio From Start to Finish*, which was originally published by The Crowell Co. in 1942. Reprinted by special arrangement with the publisher, the abridgment traces the evolution of radio from its earliest beginnings through the inception of radio broadcasting in the early 1920's.

The first three chapters of Radio's First Two Decades cover developments prior to the introduction of the vacuum tube. Those chapters cover basic research on radiowaves by Hertz and Maxwell; the development of practical radio communication by Marconi, and the pioneering work in voice transmission done by Fessenden. The final three chapters begin with DeForest's invention of the triode vacuum tube; show how the stage was set for the first radio broadcasts to the general public, and describe the popularization of radio in the early 1920's.

The 64-page book is nicely illustrated with early photographs and drawings, and is a worthwhile addition to the library of any antique-radio enthusiast. Priced at $4.50 (which includes shipping charges), the book can be ordered from Cologne Press, PO Box 682, Cologne NJ 08213.

As this column is being written, I'm getting ready to attend the Dayton Hamvention in Dayton, Ohio. The Hamvention is about the biggest convention of ham-radio operators, computer enthusiasts, and electronic experimenters in the country (maybe the world!).

I'm planning to spend most of my stay during the 3-day event browsing the 1800-table flea market, which—it is said—often contains many items of interest to the antique-radio collector. Barring unforeseen events, I should have some interesting Hamvention experiences to relate in next month's issue. See you then! ■

JENSEN ON DX'ING

(Continued from page 86)

operates a QSL bureau for ham-band listeners to assist them in obtaining verification replies from the amateur stations that they tune.

In a new book, Witkowski details a fascinating aspect of monitoring the amateur-radio frequencies—the *ham nets*. A ham net is a simple concept: A number of amateur operators with some common interest agree to meet on the air on a certain fixed frequency at a regular, predetermined time to talk about some of their favorite subjects.

Ham nets cover a wide range of interests. A network may be made up of amateur operations in a particular state or province. It could comprise a group of missionaries located around the globe. Or, perhaps, retirees. Weather watchers from various locales may fire up on a particular channel to discuss high-pressure ridges and occluded fronts to their hearts' content.

Witkowski, in *The World Ham Net Directory* (Tiare Publications, PO Box 493, Lake Geneva, WI 53147; $9.95, plus $1 shipping), lists more than 300 of those special-interest groups, by name, with the common shortwave frequencies they use and the time and day of the week they meet on the air.

On the *American Foreign Service Net*, for instance, you can hear hams who are part of the US diplomatic corps "ragchewing" around the world. Its schedule is Sunday at 1500 UTC on 14,316 kHz, 1530 UTC on 21,416 kHz, and 1600 UTC on 28,616 kHz. The *Early Bird Net* sets up everyday at 1100 UTC on 3,715 kHz.

(turn page)

ABBREVIATIONS

DX	long distance (over 1000 miles)
DX'er	listener to shortwave broadcasts
DX'ing	listening to shortwave broadcasts
kHz	kiloHertz (1000 Hertz or cycles)
KSDA	Adventist World Radio-Asia
KTWR	Trans World Radio
kw	kilowatt (1000 watts)
NASA	National Aeronautics and Space Administration
QSL	verification reply from broadcaster
QSO's	conversations
SW	shortwave
SWL('s)	shortwave listener('s)
UN	United Nations
US	United States
USB	upper sideband
UTC/GMT	Universal Time Code/ Greenwich Mean Time
WSZO	Radio Marshall or Radio Majuro
UAE	United Arab Emirates

The *Great Circle Shortwave Society* meets on 7.293 kHz at 0300 UTC, Mondays, mostly to swap nostalgia about the radio hobby in the 1950's and 1960's.

There is a ham net for *Pearl Harbor Survivors*; for travelers; for members of the *Quarter-Century Wireless Association*, and for Ontario hams who run a swap shop on the air. And you can't forget the *Northeast Area Barnyard Net*; the *Pacific Gunkholers Net* or the *West Virginia Hillbilly Net* either.

Down the Dial

Join the gang in this little corner of our column each month. It's easy. Tell me what you are hearing, along with the frequency and time. Share your listening tips with the rest of our readers. The address, of course, is *Jensen on DX'ing*, **Hands-on Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735.

Our times are listed in Coordinated Universal Time (UTC) and frequencies are in kilohertz (kHz). **ISRAEL**—5.883, *Kol Israel* can be heard here in English at around 2230 and also at about 0200. **GUATEMALA**—5.980, Adventist World Radio has other stations besides the new one on Guam, which I mentioned earlier. One of them is called *Union Radio/La Voz de Esperanza* and can be heard in Spanish at around 1100. **SOMALIA**—7.200, *Radio Mogadishu* is a nice shortwave catch from the eastern "Horn of Africa." This one is noted coming on the air at 0300 hours with an anthem, Islamic prayer recitations, and talk in the Somali language. **UNITED ARAB EMIRATES**—9.595, *UAE Radio Dubai* can be heard at around 0330 in English. That one is reported to have been heard asking listeners to write to report the reception of their transmissions. **PORTUGAL**—9.705, *Radio Portugal* is not as widely reported as it once was. But try listening for that station, in English, at 0300. **ZANZIBAR**—11.734, *Radio Tanzania Zanzibar* is a nice DX catch for anyone. It has been reported on a number of occasions broadcasting in the Swahili language at about 1730 hours. **SYRIA**—12.085, *Radio Damascus* broadcasts in English at 2000 hours. On that frequency it should not be too tough a logging in much of North America. **GABON**—15.200, Africa No. 1 is a powerful west African shortwave relay station that leases airtime to relay other broadcasters, including *Radio France International*, *Radio Japan*, and *Swiss Radio International*. It also has its own commercial service. Look for it in French and English at around 1500 hours. ■

(CREDITS: Ken Kashiwabara, CA; Lynn Hollerman, AL; Kenneth Hill, MA; Richard D'Angelo, PA; Daniel Sampson, WI; Rufus Jordan, PA; North American SW Association, 45 Wildflower Road, Levittown, PA 19057)

HANDS-ON MARKETPLACE

FOR SALE

LASERS: Surplus parts, and units, "the source for laser surplus!" Free catalog. **MEREDITH INSTRUMENTS**, P.O. Box 1724, Glendale, AZ 85311.

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.

CLASSIFIED AD ORDER FORM

To run your own classified ad, put one word on each of the lines below and send this form along with your check to:

Hands-on-Electronics Classified Ads, 500-B Bi-County Boulevard, Farmingdale, N.Y. 11735

PLEASE INDICATE in which category of classified advertising you wish your ad to appear. For special headings, there is a surcharge of **$10.00.**

( ) Plans/Kits ( ) Business Opportunities ( ) For Sale
( ) 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)
16 ($22.40)	17 ($23.80)	18 ($25.20)	19 ($26.60)	20 ($28.00)
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.):

Card Number ____________ Expiration Date ____________

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.

CLASSIFIED COMMERCIAL RATE: (for firms or individuals offering commercial products or services) $1.40 per word prepaid (no charge for ZIP code)...**MINIMUM 15 WORDS.** **5%** discount for same ad in 6 issues within one year; 10% discount for 12 issues within one year if prepaid. **NON-COMMERCIAL RATE:** (for individuals who want to buy or sell a personal item) $1.15 per word, prepaid....no minimum. **ONLY FIRST WORD AND NAME** set in bold caps at no extra charge. Additional bold face (not available as all caps) **25¢ per word additional (20% premium).** Entire ad in boldface, **add 20% premium** to total price. **TINT SCREEN BEHIND ENTIRE AD: add 25% premium** to total price. **TINT SCREEN BEHIND ENTIRE AD PLUS ALL BOLD FACE AD: add 45% premium** to total price. **EXPANDED TYPE AD: $1.85 per word prepaid.** All other items same as for STANDARD COMMERCIAL RATE. **TINT SCREEN BEHIND ENTIRE EXPANDED TYPE AD: add 25% premium** to total price. **TINT SCREEN BEHIND ENTIRE EXPANDED TYPE AD PLUS ALL BOLD FACE AD: add 45% premium** to total price. **DISPLAY ADS:** 1" × 2¼"—$160.00; 2" × 2¼"—$320.00; 3" × 2¼"—$480.00. **General Information:** Frequency rates and prepayment discounts are available. **ALL COPY SUBJECT TO PUBLISHERS APPROVAL. ADVERTISEMENTS USING P.O. BOX ADDRESS WILL NOT BE ACCEPTED UNTIL ADVERTISER SUPPLIES PUBLISHER WITH PERMANENT ADDRESS AND PHONE NUMBER. Hands-on Electronics** is published monthly, therefore copy to be in our hands for Oct. 87, 6/19; Nov. 87, 7/20, Dec. 87, 8/19.

LINEAR parts—Transistors: MRF454 $15, MRF455 $12, MRF477 $11, MRF492 $16.75, MRF421 $22.50, SRF2072 $13, SRF3662 $25, 3800 $18.75, 2SC2290 $19.75, 2SC2879 $25. **Tubes:** 6KD6 $10.50, 6LQ6 $9.75, 6LF6 $9.75, 8950 $16.75. Best prices on Palomar Road Noise Mics, Ranger AR3300. New 16 page catalog listing radio/amplifier tricks—Channel modification, PLL-Sliders, peaking for range, hard-to-find linear parts—mail $1.00 to: **RFPC**, Box 700, San Marcos, CA 92069. For same day parts shipment, call (619) 744-0728.

CABLE-TV converters. Scientific Atlanta, Jerrold, Oak, Zenith, Hamlin. Many others. **"New" VIDEO Hopper "The copy killer."** VHS wireless remote $239.00. Visa M/C & Amex. accepted. Toll free **1-800-826-7623. B&B INC.**, 10517 Upton Circle, Bloomington, MN 55431.

SURPLUS computers: Multibus, Versabus, S-100, VME, AMIGA, Atari ST—boards, power supplies, test equipment, terminals, disk drives, complete systems. **Free catalog.** Trading IBM-compatibles for unwanted systems; buying unwanted equipment. **HIGH-TECH SURPLUS**, (203) 723-5694, 490 Wooster Street, Naugatuck, CT 06770.

PLANS/KITS

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.

STRANGE stuff. Plans, kits, items. Build satellite dish $69.00. Descramblers, bugs, adult toys. Informational photo package $3.00, refundable. **DIRIJO CORPORATION**, Box 212-H, Lowell, NC 28098.

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.

CATALOG: Hobby circuits, licensed/unlicensed broadcasting, transmitters, antennas, books, scramblers, bugging devices, science projects, more! **PANAXIS**, Box 130-HO9, Paradise, CA. 95967.

DETECTIVE Equipment micro (voice) transmitter. UHF band (highly sensitive and tuneable). Will fit inside an asprin box, including battery, 1 inch antenna. Micro (telephone) transmitter FM/VHF band (tuneable). Powerful, clip-on type. All parts available at local Radio Shack store. Detail plans $10.00 ea. or $15.00 for both when purchased together. Free catalog listing many other devices of this nature with order. Catalog only, $5.00 (refundable). **WILSON**, P.O. Box 5264 Augusta, GA 30906.

VOICE disguisers! FM bugs! SWL active antenna! Receivers! More! Catalog $1.00 (refundable): **XANDI ELECTRONICS**, Box 25647, 32E, Tempe, AZ 85282.

PROJECTION TV...Convert your TV to project 7 foot picture...Results comparable to $2,500 projectors...Total cost less than $30.00...Plans and 8" lens $21.95...Illustrated information **free. MACROCOMA -HA**, Washington Crossing, PA 18977. Creditcard orders 24 Hours. (215) 736-3979.

AMPLIFIER plans—Totally new technology. Quieter, freer from distortion, easier to construct, ideal for home builders. Audio amps, all wattages, $15. **AMPLIFIERS UNLIMITED,** Rt 2, Box 139, Highmore, SD 57345.

CABLE EQUIPMENT

CABLEL-TV Secrets— the outlaw publication the cable companies tried to ban. HBO, Movie Channel, Showtime, descramblers, converters, etc. Suppliers list included, $8.95. **CABLE FACTS**, Box 711-H, Pastaskala, OH 43062.

ADVERTISING INDEX

HANDS-ON ELECTRONICS magazine does not assume any responsibility for errors that may appear in the index below.

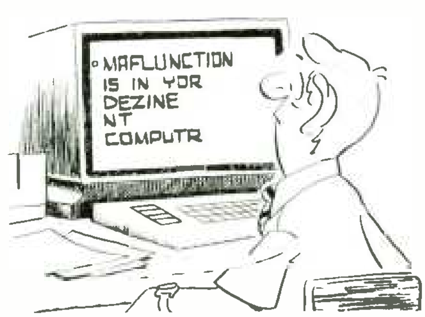
CIRCUIT CIRCUS

(Continued from page 89)

outputting a positive voltage, which then lights LED1. Removing body heat from D2 causes its temperature to decrease to the level of D1, forcing the circuit to revert to its original condition.

Setting up the circuit is easy. Turn R5 until LED1 just goes out. If the ambient temperature surrounding the two diodes (D1 and D2) is below 98.6-degrees (average body temperature), and D2 is touched by a warm live body, its temperature rises, and LED1 should light. If the ambient temperature is above 98.6-degrees, touching diode D2 tends to cool it and LED1 remains off. But by cooling D1 with a touch, the voltage at pin 2 goes below the voltage at pin 3, turning LED1 on.

Reach out and touch an electronic pet today; and until the next time, enjoy the Circus. ■



LEARN ALL ABOUT TIMER IC'S

(Continued from page 85)

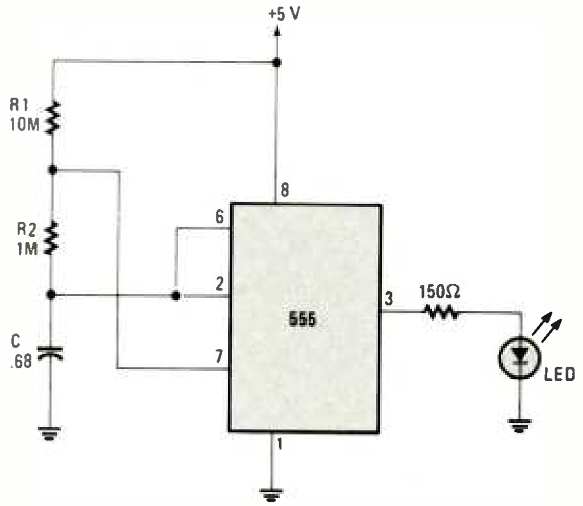


Fig. 11—If you want to get fancy, after you've completed the experiment you may wish to replace the resistors with potentiometers to build a variable function generator.

f = ______________ Hz (R1 = 10Megohm)
f = ______________ Hz (R1 = 1 m)

16 Compute the period, t_1 and t_2, and the duty cycle for each resistor value.

10 Megohm:
t = ______________ t_1 = ______________
t_2 = ______________

1 Megohm:
t = ______________ t_1 = ______________
t_2 = ______________

17 Rewire the circuit making R1 and R2 10,000 ohms and C equal to 0.1 µF. Use the same circuit in Fig. 11. But, replace the LED and its resistor with a speaker and capacitor as shown in Figure 12.

18 Apply power to the circuit and note the result.

19 Compute the frequency of the circuit and record below:

f = ______________ Hz

20 If you have an oscilloscope, monitor the output voltage at pin 3. Disconnect the speaker and note the output. Also, observe the capacitor charge and discharge at pin 6 or 2.

Review of Steps 12-20

The astable circuit is an oscillator whose frequency is dependent upon the R1, R2, and C values. In step 13, you should have found that the LED flashed off and on slowly. The oscillation frequency is .176 Hz. That gives a period of:

$$t = 1/f = 1/.176 = 5.66 \text{ seconds.}$$

Since R1 is larger than R2, the LED will be on for a little over 5 seconds and it will stay off for only about .5 second. Computing the t_1 time, we find it to be 5.18 seconds. That translates to a duty cycle of:

$$D = t_1/t = 5.18/5.66 = .915 \text{ or } 91.5\%$$

In step 14, you replaced the 10-Megohm resistor with a 1-Megohm unit making both R1 and R2 equal. The new frequency is 0.706 Hz, much higher than in step 13. That translates to a period of 1.41 seconds. Computing the t_1 and t_2 times, you see that the LED is on for .942 second and off for .467 second. That represents a duty cycle of:

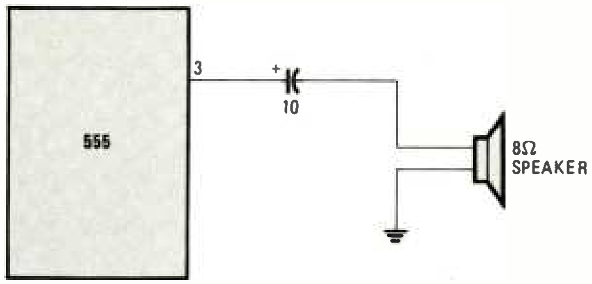


Fig. 12—Monitoring the timer with a speaker can be amusing if you switch capacitors or resistors to make an organ.

$$D = .942/1.41 = .67 \text{ or } 67\%$$

In step 17, you made R1 = R2 = 10,000-ohm and C = .1 µF. That increased the frequency to 480 Hz. The result should have been a loud tone in the speaker.

If you had used an oscilloscope, you saw the output to be a distorted rectangular wave of about 2 volts peak-to-peak. That distortion is caused by the speaker load. Removing it makes the waveform nice and square and the voltage rises to about .5 volts peak-to-peak. The capacitor waveform is a combination of the classical charge and discharge curves given earlier.

The timer is useful in computers, function generators, clocks, music synthesizers, games...and the list goes on. Next month we will discuss another family of integrated circuits known as operational amplifiers. That nice little group can perform truly miraculous functions on waveforms that can help you design very intersting projects. ■

PHONE SENTRY

(Continued from page 80)

page and used to adorn the project's enclosure, giving the Phone Sentry a professional, rather than homebrew, look. You may want to use an ordinary plastic box or aluminum chassis box for the same purpose and keep it out of sight. How you do it is your decision!

Check Out and Use

Remove the existing wire from the back of the telephone and put the short end of the cable from Phone Sentry in its place. The remaining end of the cable goes to the wall plate towards the outside line. Apply power and turn Phone Sentry on, lift the receiver and you should get a dial tone after a short delay. Call a friend and ask him or her to call you back. With D2, D3, D4, and D7 installed, the delay should be between 5–9 rings.

That's best checked by listening and counting the ringing of an extension phone. Your ring and what the caller hears as a ring are not synchronized. You may add or subtract diodes to tailor the ring delay to your specific needs. If you really want privacy, try installing D4, D7, and D6 for a delay of 9 to 13 ring cycles. Also inform the people close to you that you have the Phone Sentry in use, so they'll have to let the phone ring a little longer when calling you. After you explain to them what the Sentry does, they will probably want you to build one for them, too! ■