

Radio - SURFACE-MOUNT TECHNOLOGY

SMT SPECIAL 32-PAGE SECTION

\$2.25 NOV. 1987 IN CANADA \$2.75

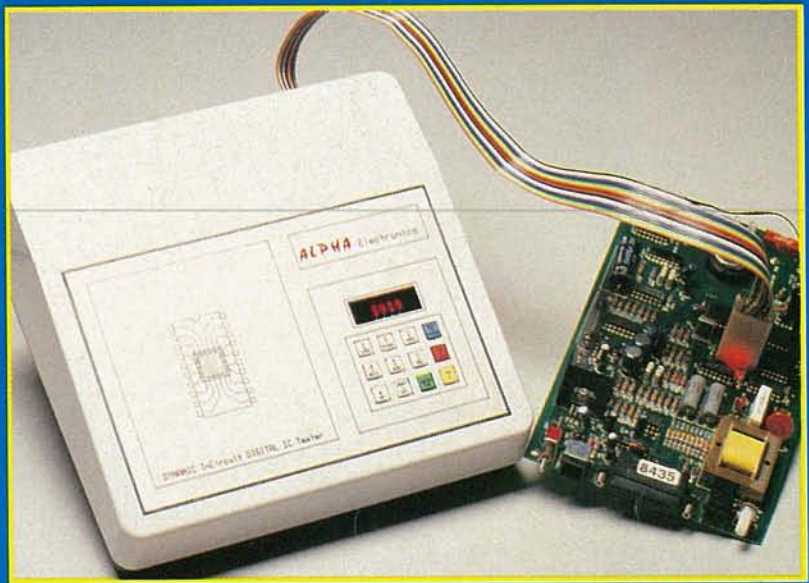
# Electronics

TECHNOLOGY - VIDEO - STEREO - COMPUTERS - SERVICE

## BUILD THIS COMPUTERIZED IC TESTER



Troubleshoot IC's in or out of circuit



## THE TRUTH BEHIND THE BLUE BOX

And how Ma Bell crushed them

## RF TRANSISTORS

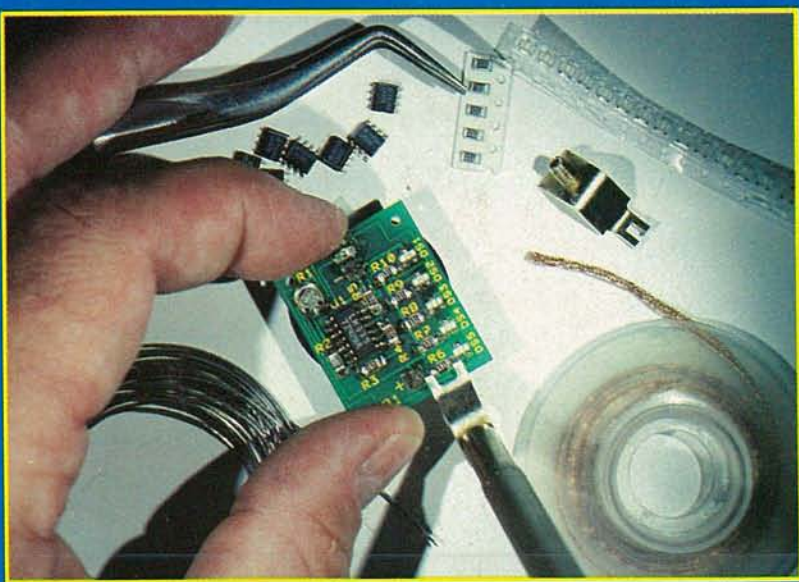
Understanding the data sheets



## SURFACE-MOUNT TECHNOLOGY



Forrest Mims brings you the technology and 4 projects you can build



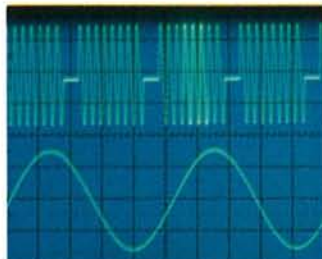
## COMPUTER DIGEST

Turbocharging your PC

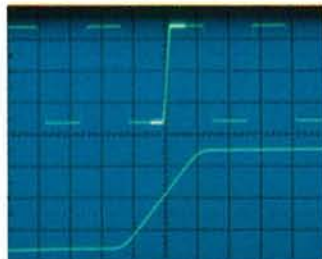
- PLUS:**
- ★ BUILD AN ELECTRONIC LOCK
  - ★ POOR MAN'S STORAGE SCOPE
  - ★ SEMICONDUCTOR TESTING



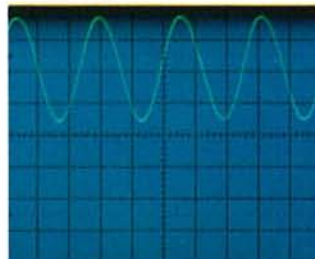
# NOW GET SCOPE, COUNTER AND DMM INPUT ALL AT ONCE THROUGH ONE PROBE!



**Gated frequency measurement.** B sweep triggering during the intensified portion of the A sweep. Intensified portion frequency is measured with the counter/timer/DMM.



**Delay time measurement.** Delay time from the start of A sweep to the start of the B sweep is measured with crystal accuracy.



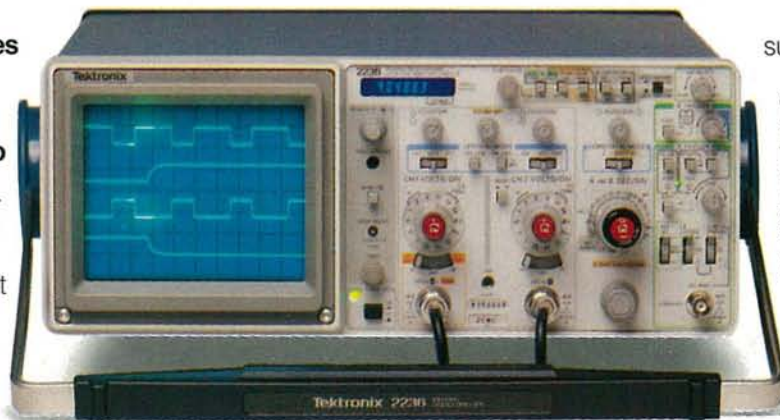
**Channel 1 dc volts measurement.** The average dc component of a waveform is measured directly through channel 1 with direct digital fluorescent readout.

The Tek 2236 combines 100 MHz, dual timebase scope capability with counter/timer/DMM functions integrated into its vertical, horizontal and trigger systems. For the same effort it takes to display a waveform you can obtain digital readout of frequency, period, width, totalized events, delay time and  $\Delta$ -time to accuracies of 0.001%.

The same probe is used to provide input for the CRT display and the digital measurement system, resulting in easy set-up, greater measurement confidence and reduced circuit loading. Probe tip volts can also be measured through the Ch 1 input.

### Precision measurements at the touch of a button.

Auto-ranging frequency, period, width and gated measurements are push-button-simple. And the 2236 offers an independent floating 5000 count, auto-ranging multimeter with side inputs for DC voltage mea-



Bandwidth	100 MHz
No of Channels	2 + Trig. View
Max. Sweep Speed	5 ns/div
Digital Readout Features	Direct Ch 1 Voltage Meas. 0.5% DC; 2.0% AC RMS Resistance: .01 $\Omega$ to 200 Meg $\Omega$ Continuity/Temp: Audible/C $^{\circ}$ or F $^{\circ}$ Totalizing Counter: — 1 counts to 8,000,000 Direct Freq. Meas: 100 MHz to 0.001% acc. Period, Width Meas: 10 ns with 10 ps max. resolution
Timing Meas. Accuracy	.001% (delay and $\Delta$ -time with readout)
Trigger Modes	P-P Auto, Norm, TV Field, TV Line, Single Sweep
Weight	7.3 kg (16.2 lb)
Price	\$2650
Warranty	3-year including CRT (plus optional service plans to 5 years)

surements to 0.1%.

A built-in, auto-ranging ohmmeter provides resistance measurements from 0.01  $\Omega$  to 2G $\Omega$ —as well as audible continuity. Automatic diode/junction detection and operator prompts serve to simplify set-up and enhance confidence in your measurements.

**The 2236: scope, counter, timer, DMM plus a 3-year warranty —all for just \$2,650.**

Contact your nearest distributor or call Tek toll-free. Technical personnel on our direct-line will answer your questions and expedite delivery. Orders include probes, 30-day free trial and service worldwide.

**Call Tek direct:**  
**1-800-433-2323** for video tape or literature,  
**1-800-426-2200** for application assistance or ordering information.

In Oregon, call collect:  
**1-627-2200**

**Tektronix**  
COMMITTED TO EXCELLENCE

# November 1987 **Radio Electronics**

Vol. 58 No. 11

## BUILD THIS

- 43 IN-CIRCUIT DIGITAL-IC TESTER**  
A computerized tester for TTL IC's  
**Bill Green**
- 107 ELECTRONIC COMBINATION LOCK**  
An electronic lock that's opened with an electronic key.  
**Paul Renton**

## TECHNOLOGY

- 49 THE BLUE BOX AND MA BELL**  
Pirates on the telephone lines.  
**Herb Friedman**, Communications Editor
- 57 SPECIAL SECTION: SURFACE MOUNT TECHNOLOGY**  
An introduction to the packaging revolution  
**Forrest Mims, III**
- 113 POOR MAN'S STORAGE SCOPE**  
Give your standard scope the power of more complex instruments.  
**Duke Bernard**

## CIRCUITS AND COMPONENTS

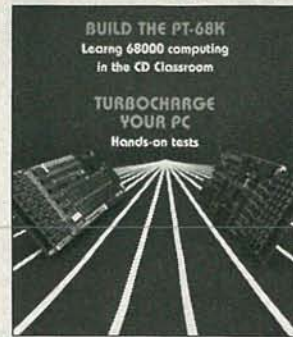
- 109 UNDERSTANDING DATA SHEETS OF RF POWER TRANSISTORS**  
What data sheet parameters mean, and how they're derived.  
**Norman E. Dye**, Motorola Semiconductor Products
- 115 TESTING SEMICONDUCTORS**  
Op-amp AC parameters.  
**TJ Byers**

## DEPARTMENTS

- |  |  |
|--|--|
| <p><b>6 VIDEO NEWS</b><br/>What's new in this fast-changing field.<br/><b>David Lachenbruch</b></p> <p><b>14 EQUIPMENT REPORTS</b><br/>NCM Model 871 Pattern Generator.</p> <p><b>31 NEW IDEA</b><br/>Multi-tone generator.</p> <p><b>32 SERVICE LOG</b><br/>Surface-mount components.</p> | <p><b>33 AUDIO UPDATE</b><br/>Stereo imaging.<br/><b>Larry Klein</b></p> <p><b>39 ANTIQUE RADIOS</b><br/>Restoring a classic, part 2.<br/><b>Richard D. Fitch</b></p> <p><b>41 DESIGNER'S NOTEBOOK</b><br/>An under-voltage monitor<br/><b>Robert Grossblatt</b></p> <p><b>124 STATE OF SOLID STATE</b><br/>A bang-bang IC.<br/><b>Robert F. Scott</b></p> |
|--|--|

## COMPUTER DIGEST

A NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS



PAGE 91



PAGE 57

## AND MORE

- 152 Advertising and Sales Offices**
- 152 Advertising Index**
- 153 Free Information Card**
- 122 Kit Report**
- 8 Letters**
- 131 Market Center**
- 22 New Products**
- 127 PC Service**
- 4 What's News**

## ON THE COVER



Troubleshooting a complex piece of electronics equipment is seldom easy. But when the circuit contains a number of IC's, all soldered securely to a PC board, it can become a nightmare. This month we'll present a digital IC tester that can assess the condition of an IC, in circuit or out. What's more, it can be built at a very reasonable cost. The story begins on page 43.

Also this month, our special section on Surface Mount Technology focuses on one of the most important advances in component packaging. Written by noted author Forrest Mims, III, the special section begins on page 57.

## COMING NEXT MONTH

### THE DECEMBER ISSUE IS ON SALE NOVEMBER 3

#### BUILD THE MACRO-SCRUBBER

Stabilize *Macrovision*-encoded videotapes for best viewing.

#### BUILD A DIGITAL IC TESTER

Part 2 shows you how to program and use the tester.

#### ALL ABOUT STRAIN GAGES

What they are and how they are used.

#### COMPUTERDIGEST

All about disk storage.

As a service to readers, RADIO-ELECTRONICS publishes available plans or information relating to newsworthy products, techniques and scientific and technological developments. Because of possible variances in the quality and condition of materials and workmanship used by readers, RADIO-ELECTRONICS disclaims any responsibility for the safe and proper functioning of reader-built projects based upon or from plans or information published in this magazine.

Since some of the equipment and circuitry described in RADIO-ELECTRONICS may relate to or be covered by U.S. patents, RADIO-ELECTRONICS disclaims any liability for the infringement of such patents by the making, using, or selling of any such equipment or circuitry, and suggests that anyone interested in such projects consult a patent attorney.

**RADIO-ELECTRONICS, (ISSN 0033-7862) November 1987.** Published monthly by Gernsback Publications, Inc., 500-B Bi-County Boulevard, Farmingdale, NY 11735 Second-Class Postage paid at Farmingdale, NY and additional mailing offices. Second-Class mail registration No. 9242 authorized at Toronto, Canada. One-year subscription rate U.S.A. and possessions \$16.97, Canada \$22.97, all other countries \$25.97. All subscription orders payable in U.S.A. funds only, via international postal money order or check drawn on a U.S.A. bank. Single copies \$2.25. © 1987 by Gernsback Publications, Inc. All rights reserved. Printed in U.S.A.

**POSTMASTER:** Please send address changes to RADIO-ELECTRONICS, Subscription Dept., Box 55115, Boulder, CO 80321-5115.

A stamped self-addressed envelope must accompany all submitted manuscripts and/or artwork or photographs if their return is desired should they be rejected. We disclaim any responsibility for the loss or damage of manuscripts and/or artwork or photographs while in our possession or otherwise.

## Radio-Electronics®

Hugo Gernsback (1884-1967) founder

M. Harvey Gernsback,  
editor-in-chief, emeritus

Larry Steckler, EHF, CET,  
editor-in-chief and publisher

#### EDITORIAL DEPARTMENT

Art Kleiman, editorial director  
Brian C. Fenton, managing editor  
Carl Laron, WB2SLR, associate editor  
Jeffrey K. Holtzman,  
assistant technical editor  
Marc Spiwak, associate editor  
Robert A. Young, assistant editor  
Julian S. Martin, editorial associate  
Byron G. Wels, editorial associate  
M. Harvey Gernsback,  
contributing editor  
Jack Darr, CET, service editor  
Robert F. Scott,  
semiconductor editor  
Herb Friedman,  
communications editor  
Bob Cooper, Jr., satellite-TV editor  
Robert Grossblatt, circuits editor  
Larry Klein, audio editor  
David Lachenbruch,  
contributing editor  
Richard D. Fitch,  
contributing editor  
Teri Scaduto, editorial assistant

#### PRODUCTION DEPARTMENT

Ruby M. Yee, production director  
Robert A. W. Lowndes,  
editorial production  
Andre Duzant, technical illustrator  
Ronald Dee, assistant technical  
illustrator  
Karen Tucker, advertising production  
Marcella Amoroso, production traffic

#### CIRCULATION DEPARTMENT

Jacqueline P. Cheeseboro,  
circulation director  
Wendy Alanko,  
circulation analyst  
Theresa Lombardo,  
circulation assistant

Typography by Mates Graphics  
Cover photos by Nick Koudis and  
Forrest Mims III

Radio-Electronics is indexed in  
*Applied Science & Technology Index*  
and *Readers Guide to Periodical Literature*.

Microfilm & Microfiche editions are  
available. Contact circulation department  
for details.

Advertising Sales Offices listed  
on page 152.



# TEST EQUIPMENT THAT MEASURES UP TO YOUR SPECIFICATIONS



**DMM-300 \$79.95**  
3.5 DIGIT DMM / MULTITESTER

Our best model. A highly accurate, full function DMM loaded with many extra features. Audible continuity, capacitance, transistor, temperature and conductance all in one handheld meter. Temperature probe, test leads and battery included.

- Basic DC accuracy: plus or minus 0.25%
- DC voltage: 200mv — 1000v, 5 ranges
- AC voltage: 200mv — 750v, 5 ranges
- Resistance: 200 ohms — 20M ohms, 6 ranges
- AC/DC current: 200uA — 10A, 6 ranges
- Capacitance: 2000pf — 20uf, 3 ranges
- Transistor tester: hFE test, NPN, PNP
- Temperature tester: 0° — 2000° F
- Conductance: 200ns
- Fully over-load protected
- Input impedance: 10M ohm



**DMM-200 \$49.95**  
3.5 DIGIT FULL FUNCTION DMM

High accuracy, 20 amp current capability and many range settings make this model ideal for serious bench or field work. Tilt stand for hands-free operation. 2000 hour battery life with standard 9v cell. Probes and battery included.

- Basic DC accuracy: plus or minus 0.25%
- DC voltage: 200mv — 1000v, 5 ranges
- AC voltage: 200mv — 750v, 5 ranges
- Resistance: 200 ohms — 20M ohms, 6 ranges
- AC/DC current: 200uA — 20A, 6 ranges
- Fully over-load protected
- Input impedance: 10M ohm
- 180 x 86 x 37mm, weighs 320 grams



**DMM-700 \$49.95**  
3.5 DIGIT AUTORANGING DMM

Autorange convenience or fully manual operation. Selectable LO OHM mode permits accurate in-circuit resistance measurements involving semi-conductor junctions. MEM mode for measurements relative to a specific reading. Probes and battery included.

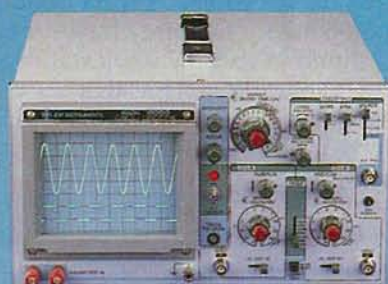
- Basic DC accuracy: plus or minus 0.5%
- DC voltage: 200mv — 1000v, autoranging or 5 manual ranges
- AC voltage: 2v — 750v, autoranging or 4 manual ranges
- Resistance: 200 ohms — 20M ohms, autoranging
- AC/DC current: 20mA — 10A, 2 ranges
- Fully over-load protected
- Audible continuity tester
- Input impedance: 10M ohm
- 150 x 75 x 34mm, weighs 230 grams



**DMM-100 \$29.95**  
3.5 DIGIT POCKET SIZE DMM

Shirt-pocket portability with no compromise in features or accuracy. Large, easy to read .5" LCD display. 2000 hour battery life with standard 9v cell provides over two years of average use. Probes and battery included.

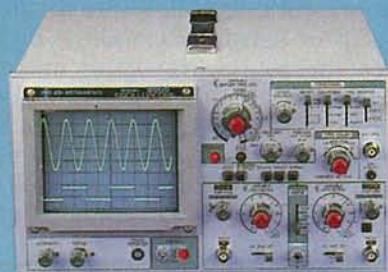
- Basic DC accuracy: plus or minus 0.5%
- DC voltage: 2v — 1000v, 4 ranges
- AC voltage: 200v — 750v, 2 ranges
- Resistance: 2k ohms — 2M ohms, 4 ranges
- DC current: 2mA — 2A, 4 ranges
- Fully over-load protected
- Input impedance: 10M ohm
- 130 x 75 x 28mm, weighs 195 grams



**MODEL 2000 \$349.95**  
20 MHz DUAL TRACE OSCILLOSCOPE

Model 2000 combines useful features and exacting quality. Frequency calculation and phase measurement are quick and easy in the X-Y Mode. Service technicians will appreciate the TV Sync circuitry for viewing TV-V and TV-H as well as accurate synchronization of the Video Signal, Blanking Pedestals, VITS and Verticle/Horizontal sync pulses.

- Lab quality compensated 10X probes included
- Built-in component tester
- 110 / 220 Volt operation
- X-Y operation • Bright 5" CRT • TV Sync filter



**MODEL 3500 \$499.95**  
35 MHz DUAL TRACE OSCILLOSCOPE

Wide bandwidth and exceptional 1mV / DIV sensitivity make the Model 3500 a powerful diagnostic tool for engineers or technicians. Delayed triggering allows any portion of a waveform to be isolated and expanded for closer inspection. Variable Holdoff makes possible the stable viewing of complex waveforms.

- Lab quality compensated 10X probes included
- Delayed and single sweep modes
- Z Axis intensity modulation
- X-Y operation • Bright 5" CRT • TV Sync filter



**DPM-1000 \$54.95**  
3.5 DIGIT PROBE TYPE DMM

Autoranging, pen style design for the ultimate in portability and ease of use. Custom 80 pin LSI chip increases reliability. Audible continuity tester and data hold feature for added convenience. Case, test leads and batteries included.

- Basic DC accuracy: plus or minus 1%
- DC voltage: 2v — 500v, autoranging
- AC voltage: 2v — 500v, autoranging
- Resistance: 2k ohms — 2M ohms, autoranging
- Fully over-load protected
- Input impedance: 11M ohm
- 162 x 28 x 17mm, weighs 75 grams

**2 YEAR WARRANTY ON ALL MODELS**



**JDR INSTRUMENTS**  
110 Knowles Drive, Los Gatos, CA 95030  
(408) 866-6200 • FAX (408) 378-8927 • Telex 171-110

**ORDER TOLL FREE 800-538-5000**

OR VISIT OUR RETAIL STORE  
1256 SOUTH BASCOM AVE.  
SAN JOSE, CA. (408) 947-8881  
CIRCLE 59 ON FREE INFORMATION CARD

# WHAT'S NEWS

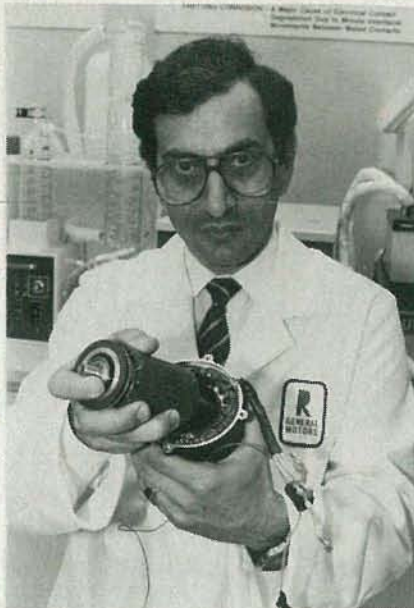
## Solar-powered cars to race across Australia

General Motors is entering a 1,950-mile trans-Australia motor race open only to solar-powered cars. The race, scheduled for November 1, may attract up to 25 entries. It will start from Darwin, on Australia's north coast, and finish at Adelaide, on the south coast, about six days later. The team with each car must be self-sufficient, carrying all its water, food, and supplies, and must camp overnight at the end of each day's driving.

The GM car, named the *GM Sunracer*, runs entirely on storage batteries powered by the car's solar system and uses a new high-efficiency motor from GM's labs that uses low-friction bearings and *Magnaquench* magnets. A *Magnaquench* magnet is a super-strength, rare-earth, iron-based permanent magnet that may revolutionize the field of electronics because it makes possible electric motors having more power, higher energy efficiency, and smaller size and weight than motors made using conventional technology.



THE SOLAR-POWERED CAR's spaceframe and chassis gets its first test drive in California. Dr. Alec Brooks of AeroVironment, Inc., is checking its rigidity, handling and suspension. The lightweight spaceframe, made of aluminum tubing, will become a sleek, high-tech racer when covered by its integral body, canopy and solar panels.



THE MAGNAQUENCH MOTOR to be used in the solar-powered car is unusually small. Dr. Nady Boules, section manager at GMRL's Electrical and Electronics Engineering Dept., is holding the motor's rotor in his right hand, and the motor housing in his left.

A *Magnaquench* technology high-efficiency electric motor has been tested at 92% efficiency. Standard electric motors of comparable size run at only 75–85% efficiency. In practical terms, it means that an 8-pound *Magnaquench* motor can produce two horsepower continuously at 4000 rpm, which is about 30–40% more horsepower than comparable-size presently-available commercial motors.

In designing and racing the *Sunracer*, GM expects to develop and demonstrate expertise in several advanced technologies with practical automotive applications. Those include lightweight structures and materials, low-speed aerodynamics and high-efficiency batteries, electric motors, and solar cells and panels.

## Travelling robot to work in radiation-hardened IC lab

The new Radiation Hardened Integrated Circuit (RHIC) facility nearing completion at Sandia National Laboratories, Albuquerque, NM, will be the first U.S. research lab to use a robot in the entire production process. The new robot will travel RHIC's 300-foot long clean room's center aisle, accessing 22 specialized processing bays (actually small clean rooms) that can be entered from that aisle.

Passing the bays, it will home in on selected work-in-progress stations and pick up the plastic cassettes (small boxes) housed there, moving them to other processing bays. The robot follows a reflective tape track laid on floors through the 12,500-foot clean-room area, and constantly receives routing instructions from the facility's computerized wafer-fabrication operating system.

"Other wafer-fabrication lines have used robots," says a Sandia spokesman, "but they have been confined to specific work stations. The case is the same as that for the highly acclaimed robots that work along modern automobile assembly lines."

Advantages of the new system include reduction of pollution possibilities due to greatly reduced human handling and to more gentle handling due to special force-sensing capabilities built into the robot. The latter makes make sure that the robot is using the right amount of energy in picking up and setting down the cassettes entrusted to it.

The RHIC is the latest major addition to Sandia's Center for Radiation-Hardened Microelectronics. The Center designs and builds microcircuits that continue to operate even after receiving high doses of radiation for use in nuclear-weapon, space, and satellite applications. **R-E**

# TAKE ANY ONE OF THESE HANDBOOKS FOR ONLY \$14.95 VALUES UP TO \$110.00

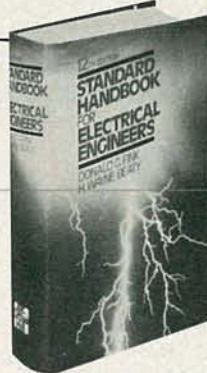
## — when you join the ELECTRONICS AND CONTROL ENGINEERS' BOOK CLUB®

- your one source for engineering books from over 100 different publishers
- the latest and best information in your field
- discounts of up to 40% off publishers' list prices



### STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS, Twelfth Edition

Edited by D.G. Fink and H.W. Beaty  
• 2,248 pages, 1,863 illustrations and tables  
*Publisher's Price \$86.50*



### MODERN ELECTRONIC CIRCUITS REFERENCE MANUAL

By J. T. Markus  
• 1,264 pages, 3,666 circuit diagrams  
*Publisher's Price \$82.50*

### ANTENNA ENGINEERING HANDBOOK, Second Edition

Edited by R. C. Johnson and H. Jasik  
• 1,408 pages, 946 illustrations  
*Publisher's Price \$110.00*



### 4 reasons to join today!

**1. Best and newest books from ALL publishers!** Books are selected from a wide range of publishers by expert editors and consultants to give you continuing access to the best and latest books in your field.

**2. Big savings!** Build your library and save money, too! Savings range up to 40% off publishers' list prices.

**3. Bonus books!** You will immediately begin to participate in our Bonus Book Plan that allows you savings up to 70% off the publishers' prices of many professional and general interest books!

**4. Convenience!** 14-16 times a year (about once every 3-4 weeks) you receive the Club Bulletin FREE. It fully describes the Main Selection and alternate selections. A dated Reply Card is included. If you want the Main Selection, you simply do nothing — it will be shipped automatically. If you want an alternate selection — or no book at all — you simply indicate it on the Reply Card and return it by the date specified. You will have at least 10 days to decide. If, because of late delivery of the Bulletin you receive a Main Selection you do not want, you may return it for credit at the Club's expense.

As a Club member you agree only to the purchase of three additional books during your first year of membership. Membership may be discontinued by either you or the Club at any time after you have purchased the three additional books.

FOR FASTER SERVICE IN ENROLLING CALL TOLL FREE  
1-800-2-MCGRAW

McGraw-Hill Book Clubs  
Electronics and Control Engineers' Book Club®  
P.O. Box 582  
Hightstown, NJ 08520-9959

Please enroll me as a member of the Electronics and Control Engineers' Book Club® and send me the book I have chosen for only \$14.95, plus local tax, postage, and handling. I agree to purchase a minimum of three additional books during my first year as outlined under the Club plan described in this ad. Membership in the club is cancellable by me or McGraw-Hill any time after the three book purchase requirement has been fulfilled. A shipping and handling charge is added to all shipments.

I wish to order the following book:

- STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS (209/758)  
 MODERN ELECTRONIC CIRCUITS REFERENCE MANUAL (404/461)  
 ANTENNA ENGINEERING HANDBOOK (322/910)

Signature \_\_\_\_\_

Name \_\_\_\_\_

Address/Apt. # \_\_\_\_\_

City/State/Zip \_\_\_\_\_

This order subject to acceptance by McGraw-Hill. Offer good only to new members. Foreign member acceptance subject to special conditions.

E 33897

---

---

# VIDEO NEWS



**DAVID LACHENBRUCH,**  
CONTRIBUTING EDITOR

• **SVHS and the Multi-Port.** A new compatibility headache may be in the works for cable, with the introduction of Super VHS recorders. Just when the cable industry thought it had solved its compatibility problems, along comes Super VHS (SVHS) which is at least partly incompatible with the new Multi-Port standard (**Radio-Electronics**, April 1987). Multi-Port was developed over four years by an engineering committee representing receiver manufacturers and cable systems. It involves a 21-conductor connector to be built into future TV sets (a few already have it) that, in effect, will eliminate the need for external cable-tuning and -decoding boxes and make it possible to use a TV set's remote control system to tune all channels, including scrambled ones. The Multi-Port was also designed to accommodate all TV attachments, including VCR's, videodisc players, and home computers. It includes video and RGB inputs—but not Y and C (luminance and color) inputs. Although SVHS recorders have video outputs, a better picture results from using Y/C connectors, and new TV sets designed for use with SVHS recorders have special Y/C inputs. The committee that developed the Multi-Port is now meeting on the subject of SVHS, and one proposal is that the RGB input be made optional and replaceable by Y/C. Disgruntled committee members say that if the Japanese had taken a more active role in the committee's engineering work, the problem would never have occurred.

• **FCC looks at HDTV.** Responding to requests by 58 broadcaster groups, the FCC has opened a "comprehensive inquiry" into advanced television systems, particularly *High-Definition TV* (HDTV). Among issues to be explored are the proposed specifications and characteristics of advanced television systems, timetables, public interest in better television systems, and the effect on existing TV systems. Because many of the proposals for HDTV require using more than the bandwidth of a single present channel, the FCC has frozen new proposed applications for TV channels in 30 of the largest markets. For

example, some proposed compatible HDTV systems would transmit standard 525-line pictures on existing channels, using all or part of a separate channel for additional information to make up a picture with more horizontal lines and a wider aspect ratio.

Meanwhile, Home Box Office has started a campaign to encourage development of HDTV cable service. Because cable has no shortage of channels, HBO feels that cable has an edge over broadcasters in supplying HDTV, because it can assign wideband channels for HDTV while continuing to broadcast standard TV signals over other channels. HBO urged cable interests to avoid "the same kind of incompatibility problems we as an industry experienced with cable-ready TV's, connection of VCR's to the cable drop, and delivery of...stereo."

• **Flickerless 3-D disc.** The Japanese are relentless in their pursuit of 3-D television. JVC and Sharp both demonstrated 3-D videodiscs recently at the American Consumer Electronics Show. That system used electronically controlled LCD eyeglasses connected to the TV set by a wire. The system permitted each eye to see an alternate field of the picture, reducing the number of fields seen by each eye from the normal 60 to 30. The result was that the system suffered from a pronounced "flicker".

Now Sanyo and Japan's NHK (Japan Broadcasting Co.) have come up with a new version of the system that eliminates the flicker. Based on a laser videodisc, the system uses time compression to double the number of fields to 120 per second, letting each eye see 60 cycles, which is above the threshold of flicker. The system maintains full vertical resolution by using 4:1 interlace, letting each eye see a full 525 scanning lines. It also eliminates the wire connection for the eyeglasses by using an infrared wireless system. Of course, all that elaborate engineering is going to cost. The 3-D disc system, including a 30-inch color monitor, will cost almost \$7,000, so the Japanese believe its first uses will be in commercial and industrial applications. **R-E**



# NEW! CB Radios & Scanners

Communications Electronics,<sup>TM</sup> the world's largest distributor of radio scanners, introduces new models of CB & marine radios and scanners.

## NEW! Regency<sup>®</sup> TS2-RA

Allow 30-90 days for delivery after receipt of order due to the high demand for this product.

List price \$499.95/CE price \$339.95

**12-Band, 75 Channel • Crystalline • AC/DC**  
Frequency range: 29-54, 118-175, 406-512, 806-950 MHz. The Regency TS2 scanner lets you monitor Military, Space Satellites, Government, Railroad, Justice Department, State Department, Fish & Game, Immigration, Marine, Police and Fire Departments, Aeronautical AM band, Paramedics, Amateur Radio, plus thousands of other radio frequencies most scanners can't pick up. The Regency TS2 features new 40 channel per second Turbo Scan<sup>™</sup> so you won't miss any of the action. Model TS1-RA is a 35 channel version of this radio without the 800 MHz. band and costs only \$239.95.

## Regency<sup>®</sup> Z60-RA

List price \$299.95/CE price \$148.95/SPECIAL  
**8-Band, 60 Channel • No-crystal scanner**  
Bands: 30-50, 88-108, 118-136, 144-174, 440-512 MHz. The Regency Z60 covers all the public service bands plus aircraft and FM music for a total of eight bands. The Z60 also features an alarm clock and priority control as well as AC/DC operation. Order today.

## Regency<sup>®</sup> Z45-RA

List price \$259.95/CE price \$139.95/SPECIAL  
**7-Band, 45 Channel • No-crystal scanner**  
Bands: 30-50, 118-136, 144-174, 440-512 MHz. The Regency Z45 is very similar to the Z60 model listed above however it does not have the commercial FM broadcast band. The Z45, now at a special price from Communications Electronics.

## Regency<sup>®</sup> RH256B-RA

List price \$799.95/CE price \$329.95/SPECIAL  
**16 Channel • 25 Watt Transceiver • Priority Search • Lockout • Priority • Bank Select Sidelit liquid crystal display • EARMemory Direct Channel Access Feature • Scan Delay**  
Bands: 29-54, 118-136, 144-174, 406-512, 440-512 MHz. The new handheld Regency HX1500 scanner is fully keyboard programmable for the ultimate in versatility. You can scan up to 55 channels at the same time including the AM aircraft band. The LCD display is even sidelit for night use. Includes belt clip, flexible antenna and earphone. Operates on 8 1.2 Volt rechargeable Ni-cad batteries (not included). Be sure to order batteries and battery charger from the accessory list in this ad.

## Bearcat<sup>®</sup> 50XL-RA

List price \$199.95/CE price \$114.95/SPECIAL  
**10-Band, 10 Channel • Handheld scanner**  
Bands: 29-54, 136-174, 406-512 MHz. The Uniden Bearcat 50XL is an economical, handheld scanner with 10 channels covering ten frequency bands. It features a keyboard lock switch to prevent accidental entry and more. Also order the new double-long life rechargeable battery pack part # BP55 for \$29.95, a plug-in wall charger, part # AD100 for \$14.95, a carrying case part # VC001 for \$14.95 and also order optional cigarette lighter cable part # PS001 for \$14.95.

## NEW! Scanner Frequency Listings

The new Fox scanner frequency directories will help you find all the action your scanner can listen to. These new listings include police, fire, ambulances & rescue squads, local government, private police agencies, hospitals, emergency medical channels, news media, forestry radio service, railroads, weather stations, radio common carriers, AT&T mobile telephone, utility companies, general mobile radio service, marine radio service, taxi cab companies, tow truck companies, trucking companies, business repeaters, business radio (simplex) federal government, funeral directors, veterinarians, buses, aircraft, space satellites, amateur radio, broadcasters and more. Fox frequency listings feature call letter cross reference as well as alphabetical listing by licensee name, police codes and signals. All Fox directories are \$14.95 each plus \$3.00 shipping. State of Alaska-RL019-1; Baltimore, MD/Washington, DC-RL024-1; Chicago, IL-RL014-1; Cleveland, OH-RL017-1; Columbus, OH-RL003-2; Dallas/Ft. Worth, TX-RL013-1; Denver/Colorado Springs, CO-RL027-1; Detroit, MI/Windsor, ON-RL008-2; Fort Wayne, IN/Lima, OH-RL001-1; Houston, TX-RL023-1; Indianapolis, IN-RL022-1; Kansas City, MO/KS-RL011-2; Los Angeles, CA-RL016-1; Louisville/Lexington, KY-RL007-1; Milwaukee, WI/Waukegan, IL-RL021-1; Minneapolis/St. Paul, MN-RL010-2; Nevada/E. Central CA-RL028-1; Oklahoma City/Lawton, OK-RL005-2; Pittsburgh, PA/Wheeling, WV-RL029-1; Rochester/Syracuse, NY-RL020-1; Tampa/St. Petersburg, FL-RL004-2; Toledo, OH-RL002-3. A regional directory which covers police, fire ambulance & rescue squads, local government, forestry, marine radio, mobile phone, aircraft and NOAA weather is available for \$19.95 each. RD001-1 covers AL, AR, FL, GA, LA, MS, NC, PR, SC, TN & VI. For an area not shown above call Fox at 800-543-7892 or in Ohio 800-621-2513.

## Regency<sup>®</sup> Informant<sup>™</sup> Scanners

Frequency coverage: 35-54, 136-174 406-512 MHz. The new Regency Informant scanners cover virtually all the standard police, fire, emergency and weather frequencies. These special scanners are preprogrammed by state in the units memory. Just pick a state and a category. The Informant does the rest. All Informant radios have a feature called Turbo Scan<sup>™</sup> to scan up to 40 channels per second. The INF1-RA is ideal for truckers and is only \$249.95. The new INF2-RA is a deluxe model and has ham radio, a weather alert and other exciting features built in for only \$324.95. For base station use, the INF5-RA is only \$199.95 and for those who can afford the best, the INF3-RA at \$249.95, is a state-of-the-art, receiver that spells out what service you're listening to such as Military, Airphone, Paging, State Police, Coast Guard or Press.

## Regency<sup>®</sup> HX1500-RA

List price \$369.95/CE price \$218.95  
**11-Band, 55 Channel • Handheld/Portable Search • Lockout • Priority • Bank Select Sidelit liquid crystal display • EARMemory Direct Channel Access Feature • Scan Delay**  
Bands: 29-54, 118-136, 144-174, 406-512, 440-512 MHz. The new handheld Regency HX1500 scanner is fully keyboard programmable for the ultimate in versatility. You can scan up to 55 channels at the same time including the AM aircraft band. The LCD display is even sidelit for night use. Includes belt clip, flexible antenna and earphone. Operates on 8 1.2 Volt rechargeable Ni-cad batteries (not included). Be sure to order batteries and battery charger from the accessory list in this ad.

## Bearcat<sup>®</sup> 100XL-RA

List price \$349.95/CE price \$178.95/SPECIAL  
**9-Band, 16 Channel • Priority • Scan Delay Search • Limit • Hold • Lockout • AC/DC**  
Frequency range: 30-50, 118-174, 406-512 MHz. Included in our low CE price is a sturdy carrying case, earphone, battery charger/AC adapter, six AA ni-cad batteries and flexible antenna. Order your scanner now.

### ★★★ Uniden CB Radios ★★★

The Uniden line of Citizens Band Radio transceivers is styled to complement other mobile audio equipment. Uniden CB radios are so reliable that they have a two year limited warranty. From the feature packed PRO 540e to the 310e handheld, there is no better Citizens Band radio of the market today.

- PRO310E-RA Uniden 40 Ch. Portable/Mobile CB... \$85.95
- NINJA-RA PRO310E with rechargeable battery pack \$99.95
- B-10-RA 1.2V AA Ni-cad batt. for Ninja (set of 10) ... \$20.95
- PRO520E-RA Uniden 40 channel CB Mobile ... \$59.95
- PRO540E-RA Uniden 40 channel CB Mobile ... \$119.95
- PRO710E-RA Uniden 40 channel CB Base ... \$119.95
- PC22-RA Uniden remote mount CB Mobile ... \$99.95
- PC55-RA Uniden mobile mount CB transceiver ... \$59.95

### ★★★ Uniden Marine Radios ★★★

Now the finest marine electronics are available through CEI. The Unimetrics SH66-RA has 50 transmit and 60 receive frequencies with 25 or 1 watt power output. Only \$169.95. The Unimetrics SH88-RA is a deluxe full function marine radiotelephone featuring 55 transmit and 90 receive channels and scanning capability for only \$259.95. The Unimetrics SH3000-RA is an excellent digital depth sounder, good for 300 feet. It has an LCD continuously backlit with red light display and a 5 ft. or 10 ft. alarm. Only \$189.95. Order today.

## Bearcat<sup>®</sup> 800XL-RA

List price \$499.95/CE price \$289.95/SPECIAL  
**12-Band, 40 Channel • No-crystal scanner Priority control • Search/Scan • AC/DC**  
Bands: 29-54, 118-174, 406-512, 806-912 MHz. The Uniden 800XLT receives 40 channels in two banks. Scans 15 channels per second. Size 9 1/4" x 4 1/2" x 1 1/2"

### OTHER RADIOS AND ACCESSORIES

- Panasonic RF-2600-RA Shortwave receiver ... \$179.95
  - RD55-RA Uniden Visor mount Radar Detector ... \$98.95
  - RD9-RA Uniden "Passport" size Radar Detector ... \$169.95
  - NEW! BC 70XL-RA Bearcat 20 channel scanner ... \$168.95
  - BC 140-RA Bearcat 10 channel scanner ... \$92.95
  - BC 145XL-RA Bearcat 16 channel scanner ... \$98.95
  - BC 175XL-RA Bearcat 16 channel scanner ... \$156.95
  - BC 210XL-RA Bearcat 40 channel scanner ... \$196.95
  - BC-WA-RA Bearcat Weather Alert<sup>™</sup> ... \$35.95
  - R1080-RA Regency 30 channel scanner ... \$118.95
  - R1090-RA Regency 45 channel scanner ... \$148.95
  - UC102-RA Regency VHF 2 ch. 1 Watt transceiver ... \$117.95
  - P1412-RA Regency 12 amp reg. power supply ... \$189.95
  - MA549-RA Drop-in charger for HX1200 & HX1500 ... \$84.95
  - MA518-RA Wall charger for HX1500 scanner ... \$14.95
  - MA553-RA Carrying case for HX1500 scanner ... \$19.95
  - MA257-RA Cigarette lighter cord for HX12/1500 ... \$19.95
  - MA917-RA Ni-Cad battery pack for HX1000/1200 ... \$34.95
  - SMMX7000-RA Svc. man. for MX7000 & MX5000 ... \$19.95
  - B-4-RA 1.2 V AAA Ni-Cad batteries (set of four) ... \$9.95
  - B-8-RA 1.2 V AA Ni-Cad batteries (set of eight) ... \$17.95
  - FB-E-RA Frequency Directory for Eastern U.S.A. ... \$14.95
  - FB-W-RA Frequency Directory for Western U.S.A. ... \$14.95
  - ASD-RA Air Scan Directory ... \$14.95
  - SRF-RA Survival Radio Frequency Directory ... \$14.95
  - TSG-RA "Top Secret" Registry of U.S. Govt. Freq. ... \$14.95
  - TIC-RA Techniques for Intercepting Comm. ... \$14.95
  - RRF-RA Railroad frequency directory ... \$14.95
  - EEC-RA Embassy & Espionage Communications ... \$14.95
  - CIE-RA Covert Intelligence, Elect. Eavesdropping ... \$14.95
  - MFF-RA Midwest Federal Frequency directory ... \$14.95
  - A60-RA Magnet mount mobile scanner antenna ... \$35.95
  - A70-RA Base station scanner antenna ... \$35.95
  - MA548-RA Mirror mount informant antenna ... \$39.95
  - USAMM-RA Mag mount VHF ant. w/ 12' cable ... \$39.95
  - USAK-RA 3/4" hole mount VHF ant. w/ 17' cable ... \$35.95
- Add \$3.00 shipping for all accessories ordered at the same time. Add \$12.00 shipping per shortwave receiver. Add \$7.00 shipping per radio and \$3.00 per antenna.

### BUY WITH CONFIDENCE

To get the fastest delivery from CE of any scanner, send or phone your order directly to our Scanner Distribution Center.<sup>™</sup> Michigan residents please add 4% sales tax or supply your tax I.D. number. Written purchase orders are accepted from approved government agencies and most well rated firms at a 10% surcharge for net 10 billing. All sales are subject to availability, acceptance and verification. All sales on accessories are final. Prices, terms and specifications are subject to change without notice. All prices are in U.S. dollars. Out of stock items will be placed on backorder automatically unless CE is instructed differently. A \$5.00 additional handling fee will be charged for all orders with a merchandise total under \$50.00. Shipments are F.O.B. Ann Arbor, Michigan. No COD's. Most products that we sell have a manufacturer's warranty. Free copies of warranties on these products are available prior to purchase by writing to CE. Non-certified checks require bank clearance. Not responsible for typographical errors.

**Mail orders to:** Communications Electronics,<sup>™</sup> Box 1045, Ann Arbor, Michigan 48106 U.S.A. Add \$7.00 per scanner for R.P.S./U.P.S. ground shipping and handling in the continental U.S.A. For Canada, Puerto Rico, Hawaii, Alaska, or APO/FPO delivery, shipping charges are three times continental U.S. rates. If you have a Discover, Visa or Master Card, you may call and place a credit card order. Order toll-free in the U.S. Dial 800-USA-SCAN. In Canada, order toll-free by calling 800-221-3475. FTCC Telex anytime, dial 825333. If you are outside the U.S. or in Michigan dial 313-973-8888. Order today.

Scanner Distribution Center<sup>™</sup> and CE logos are trademarks of Communications Electronics Inc.  
† Bearcat is a registered trademark of Uniden Corporation.  
‡ Regency and Turbo Scan are registered trademarks of Regency Electronics Inc. AD #080187-RA  
Copyright © 1987 Communications Electronics Inc.

For credit card orders call  
**1-800-USA-SCAN**

**COMMUNICATIONS  
ELECTRONICS INC.**

**Consumer Products Division**  
P.O. Box 1045 □ Ann Arbor, Michigan 48106-1045 U.S.A.  
Call 800-USA-SCAN or outside U.S.A. 313-973-8888



PC 22

# LETTERS



## LASER LISTENER LEGALITIES

The lead paragraph of your October cover story ("Build This Laser Listener") warns that "Breaking and entering to plant a listening device...can earn someone a long jail term." You then suggest that "A better and safer way to bug a room is to use a laser beam to eavesdrop on a window from across the street."

This suggestion is a serious disservice to your readers, for electronic eavesdropping of all kinds, including laser eavesdropping, is

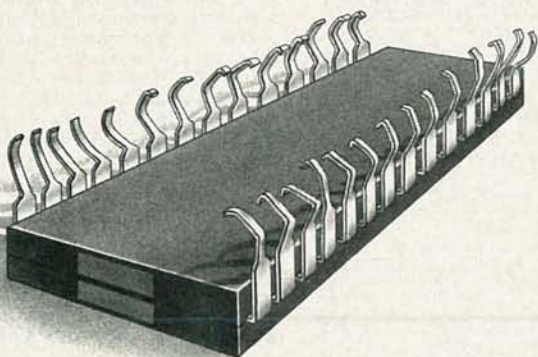
tightly regulated by both federal and state statutes. Severe penalties, including jail terms longer than those for breaking and entering, are specified for violators.

The federal statute prohibits the manufacture, assembly, possession, sale, and transport across state lines of devices whose primary purpose is the unauthorized interception of wire or oral communication (U.S. Code, Title 18, Chap. 119). Willful violators of this statute may be fined up to \$10,000 and imprisoned up to 5 years. Un-

der this statute, the assembly, possession and use of the **Radio-Electronics** laser listening device is clearly illegal, because the device is presented solely as a means "...to listen in to anything, anywhere, any time."

Your article warned of the possibility of "...eye damage if someone in the target area unknowingly stares into the beam..." Yet the cover photo shows a laser pointed very close to the faces of two people behind a window, and the opening paragraph states that

# CATCH BUGS COLD.



## With a Huntron Tracker.

How do you troubleshoot a cold circuit board down to the component level? Without power to the board, finding the bugs can be tough. So when conventional testing is out, call in a Tracker.

## Portable or benchtop.

With our portable, field service Trackers, and now our new bench-top Tracker 5000, you have everything you need for isolating defective analog, digital, and hybrid circuit boards.

## Meet the family:

**Tracker 5000**—A powerful, menu-driven, automated, benchtop troubleshooting system controlled by an IBM PC, or compatible. Now you can develop test procedures for particular boards, store them in a library and call them up whenever you need them. Tracker 5000 speeds up testing of older or less common boards.

**Tracker 1000 & 2000**—The perfect companions to your test equipment arsenal. Both offer in-circuit testing with the power off. In addition, the Tracker 2000 can dynamically test a wider range of devices.

## Find out more.

Call toll free: **1-800-426-9265** or contact Huntron Instruments, Inc. 15720 Mill Creek Blvd., Mill Creek, WA 98012. Phone 206-743-3171. Telex 152951.



# HUNTRON

CIRCLE 219 ON FREE INFORMATION CARD

laser eavesdropping is "better and safer" than conventional electronic bugging.

My personal experience with laser eavesdropping technology, which is neither high-tech nor new, is not unblemished. In "Siliconconnections: Coming of Age in the Electronic Era" (McGraw-Hill, 1986), a memoir about some of my experiences as an electronics writer, I wrote about a 1976 assignment I received from a newspaper to use an infrared laser and receiver to intercept the conversations of Howard Hughes at his hotel in the Bahamas. Fortunately Hughes left for Mexico shortly before I was to leave for the Bahamas. The paper had convinced me Hughes's conversations might reveal possibly illegal conduct. They failed to warn me that laser eavesdropping is in itself illegal.

In 1985 I prepared a report on laser eavesdropping for the Senate Select Committee on Intelligence in which I warned of the vulnerability of government installations to that technology. Since then I have written several articles and papers that discuss the technical, legal, and safety aspects of laser eavesdropping as well as possible countermeasures. None of those articles included construction details. I have also demonstrated laser eavesdropping and discussed some of those same issues in several television interviews and a documentary film.

In short, I believe it is important for private citizens, businesses, and government to be informed about electronic eavesdropping technology. But I believe it was a serious misjudgment for **Radio-Electronics** to have published detailed construction plans for an illegal eavesdropping device and to have encouraged its readers to build and use it.

FORREST M. MIMS, III

### "DREAMS OF RIO"

I think the readers of **Radio-Electronics** will be interested in ZBS Productions' latest audio adventure program, "Dreams of Rio." The 13-week series recreates the magic of old-time radio drama, using state-of-the-art digital recording techniques to capture the sounds of Brazil. The plot takes

Call 1-800-843-3338 today  
to start thoroughly analyzing  
and pinpointing any trouble in any  
TV-RF distribution system,  
automatically to FCC specifications . . .



with the All New  
**FS74 CHANNELIZER SR.™ TV-RF Signal Analyzer**  
Patents Pending \$349

IEEE-488

Does your success in servicing RF distribution systems depend on locating problems quickly and accurately? If so, here's why your all new Sencore FS74 CHANNELIZER SR. will mean success for you . . .

Quickly tune in all TV/FM channels from 5 MHz to 890 MHz. Exclusive all channel, microprocessor-controlled digital tuner checks every standard and cable channel with better than FCC accuracy to fully analyze any system.

Exclusive 5 microvolt sensitivity to bring in even weak signals. Autoranged attenuator automatically selects the best sensitivity for simplifying your VHF, UHF, or FM signal measurements like never before possible.

Automatic hassle-free S/N ratio, A/V ratio, and hum level tests. Exclusive on-channel signal-to-noise ratio test eliminates time-consuming signal comparison and chart reading. Exclusive audio-to-video ratio test measures directly in dB for easy comparison to specifications.

Exclusive checks for ghosts, co-channel interference, line reflections, and other signal quality checks. Portable 4 MHz wideband battery-operated monitor lets you finally check the quality of your cable or MATV system and stop annoying callbacks.

Built-in autoranging AC/DC volt/ohmmeter makes troubleshooting a snap. Exclusive all-weather design holds tighter than FCC specifications from -4°F to +104°F. Truly portable, field-tested tough for dependable ease of use.

Begin successfully locating TV-RF signal problems more quickly and accurately than ever before possible, with the new FS74 CHANNELIZER SR. Call WATS Free 1-800-843-3338 today for a free Product Guide or an industry exclusive "Try before you buy" 15 Day Self Demo.

"CHANNELIZER SR." is a trademark of Sencore, Inc.



WATS Free 1-800-843-3338 In Canada WATS Free 1-800-851-8866

# SENCORE

Means Success In Electronic Servicing

3200 Sencore Drive, Sioux Falls, South Dakota 57107

Call Collect 605-339-0100 In SD 605-339-0100

CIRCLE 177 ON FREE INFORMATION CARD

NOVEMBER 1987

hero Jack Flanders and his anthropologist girlfriend, Frieda, from the night clubs of Rio, through the Brazilian jungles to find the "Lost City." Producer/writer Tom Lopez and composer Tim Clark spent a month on location, recording ambient sounds using Sennheiser 416 and Tram microphones along with Sony's PCM-F1 digital tape recorder. The high-quality recordings bring the characters to life, and make the listeners feel as if *they're* in Brazil.

The half-hour shows will be aired weekly over National Public Radio beginning in September. (Please check local listings, or contact your local NPR station, for exact dates and times.) Some of the major stations that will be airing the shows are: WJCT (Jacksonville, FL), WLRN (Miami, FL), WCBU (Louisville, KY), WVOM (Ann Arbor, MI), WCMU (Mt. Pleasant, MI), WNYC (New York, NY), WOUB (Athens, OH), KCRW (Santa Monica, CA), KOUW (Seattle,

WA), KUER (Salt Lake City, UT), KQED (San Francisco, CA), KBOO (Portland, OR), KCRF (Denver, CO), KUNM (Albuquerque, NM), KMUW (Wichita, KA), KPBS (San Diego, CA), and KUAC (Fairbanks, AK).

I'm sure the series will appeal to fans of old-time radio, as well as anyone interested in the latest in audio technology.

KATHY GRONAU  
ZBS Foundation  
Fort Edward, NY 12828

### SCA ERRORS

I noticed a few errors and discrepancies in the SCA receiver's parts layout ("Build This SCA Receiver, Part 2", September 1987): Diode D5 is shown backwards. No polarity is shown for C59; the upper end is the positive one. Capacitor C29 is shown twice; the one near FL3 is really C24. Also, the correct C29 is shown backwards. The base and collector leads for Q7 are misidentified; swap them and then move the connection from S2 to the unused hole that's approximately 1/4-inch northeast of Q7. Switch S2 shows a wiring error: Remove the connection between pin 1 of the left-hand gang and the line to C59 and add a connection between pin 1 of the center gang and the line to J5.

Going back to Part 1 of the article, there is a missing dot in the schematic at the junction of C25, C26, R33, and pin 3 of IC1.

G.L. McDONALD  
Auburn, WA

### ON TESTING ERRORS

In his letter, "Testing Semiconductors" ("Letters", August 1987) Richard P. Morley is correct in assuming that the voltmeter will have an affect on the indicated leakage current of the diode under test. If we connect a standard 10-megohm voltmeter across that circuit, it will draw 10  $\mu$ A at 100 volts, which is the maximum leakage current specified for a 1N4000-series diode. In that situation, it would be much better to place the current meter on the other side of the voltmeter.

Unfortunately, low-current ammeters tend to have very high internal resistance. Consequently, the voltage indicated by the volt-

## CABLE TV SPECIALS

### CONVERTERS

	JRX-3 DIC—6 Channel Corded Remote . . . .	\$139.95
	JSX-3 DIC—36 Channel Set Top . . . . .	\$129.95
	SB-3 — 'The Real Thing' . . . . .	\$109.95
	SB-M-Refurbished . . . . .	\$89.95
	DRZ-3D1C—68 Channel Wireless with Decoder . . . . .	\$199.95
ZENITH:	Z-TAC Cable Add-On . . . . .	\$199.95
VIEW STAR:	EVSC-2010—60 Channel Wireless— with Parental Lockout . . . . .	\$ 99.95
	EVSC-2010 A-B—Same as above with A-B Switch . . . . .	\$109.95
	View Star 2501—60 Channel Wireless . . . . . with Volume . . . . .	\$119.95
	Unika MR-702—72 Channel Wireless with Parental Lockout . . . . .	\$89.95

### MISCELLANEOUS

OAK:	N-12 Mini-Code . . . . .	\$ 89.95
	N-12 Mini-Code Vari-Sync . . . . .	\$99.95
	N-12 Mini-Code Vari-Sync Plus Auto On-Off . .	\$159.95
JERROLD:	400 & 450 Handheld Transmitters . . . . .	\$ 29.95
HAMLIN:	MLD-1200 . . . . .	\$ 99.95
NEW ITEMS:	Ripco Tape Copy Stabilizer . . . . .	\$109.95
	Scientific Atlanta SA-3 . . . . .	\$139.95
OAK:	E-13 Mini-Code Substitute . . . . .	\$ 79.95
	E-13 Mini-Code W/Vari-Syn . . . . .	\$ 89.95

ALL UNITS GUARANTEED. QUANTITY PRICES AVAILABLE.

## UNITED ELECTRONIC SUPPLY

P.O. BOX 1206 • ELGIN, ILLINOIS 60121 • 312-697-0600

meter in the new configuration is not a true value; that is because the actual voltage across the meter/diode combination adds up to more than the voltage across the diode under test—meaning that the diode is receiving less voltage than indicated.

Should the leakage current be on the order of 1-mA (not uncommon), for example, then the voltage drop across a 2000-ohm milliammeter will be two volts. Two volts may not seem like much, but at 10 volts it is a 20% error. Depending on the voltage and the current values involved, current-meter resistance can (and does) affect the measurement in your alternate configuration to the same extent that a parallel voltmeter may affect measurements in other situations.

The issue of voltmeter loading was discussed at length in Part 1 of the "Testing Semiconductor" series (*Radio-Electronics*, February 1987, page 60), and remedies were recommended. I realize that not all technicians take the time to evaluate the situation properly, and the problem of inaccurate test procedure cannot be over-emphasized. My thanks to Mr. Morley for bringing it to our readers' attention one more time.  
TJ BYERS

### MAKING PC BOARDS

I am writing to share with your other readers a technique that I discovered for using a Xerox copier to make printed-circuit boards. I suspect that there are many hobbyists who would like to etch PC boards but, like me, have no access to a darkroom or the photoresist chemicals, but do have use of a Xerox machine. The technique that I worked out for transferring the layout image onto a copper-clad board is very simple; it is also fast, and it yields near-professional results.

The artwork is prepared as described in your series "Etch Your Own PC Board" (*Radio-Electronics*, December 1982 through February 1983) and then copied onto a Xerox transparency—the type used to make overhead projector slides; the contrast should be set for as dark as possible in order to get the heaviest possible coating of the toner. It is useful to make more

## Analyze defective waveforms faster, more accurately, and more confidently — every time or your money back



with the SC61 Waveform Analyzer  
Patented \$2,995

**If you value your precious time, you will really want to check out what the exclusively patented SC61 Waveform Analyzer can do for you. 10 times faster, 10 times more accurate, with zero chance of error.**

**End frustrating fiddling with confusing controls.** Exclusive ultra solid ECL balanced noise cancelling sync amplifiers, simplified controls, and bright blue dual trace CRT help you measure signals to 100 MHz easier than ever.

**Accurately and confidently measure waveforms from a tiny 5 mV all the way to a whopping 3,000 V without hesitation** with patented 3,000 VPP input protection — eliminates expensive "front end" repairs and costly equipment downtime.

**Make only one circuit connection and push one button for each circuit parameter test:** You can instantly read out DC volts, peak-to-peak volts and frequency 100% automatically with digital speed and accuracy. It's a real troubleshooting confidence builder.

**Confidently analyze complex waveforms fast and easily.** Exclusive Delta measurements let you intensify any waveform portion. Analyze glitches, interference signals, rise or fall times or voltage equivalents between levels; direct in frequency or microseconds.

**Speed your digital logic circuit testing.** Analyzing troublesome divide and multiply stages is quicker and error free — no time-consuming graticule counting or calculations. Simply connect one test lead to any test point, push a button, for test of your choice, for ERROR FREE results.

To see what the SC61 can do for your troubleshooting personal productivity and analyzing confidence, CALL TODAY, WATS FREE, 1-800-843-3338, for a FREE 15 day Self Demo.



Call Today Wats Free 1-800-843-3338

**SENCORE**

3200 Sencore Drive  
Sioux Falls, SD 57107  
605-339-0100 In SD Only

*innovatively designed  
with your time in mind.*

CIRCLE 178 ON FREE INFORMATION CARD

than one transparency in case the first transfer does not come out.

The PC blank is prepared simply by buffing the copper with fine steel wool to remove oxidation and contaminants. The image on the transparency is transferred by heat. When a Xerox copy is made, a black powder called "toner" is deposited on the page and then heated to 300°F to fuse it in place. On paper, the fused toner is absorbed into the porous surface, but on plastic film it just builds up

on top. That image can be remobilized by again heating it to about 300°F. I do that using a household clothes iron.

The iron is secured by clamps in a inverted position, so that its hot sole can be used as a work area. The iron is then brought to temperature for a moderately high setting ("wool"). Then the copper blank is heated from the back, with the transparency secured to the foil with its toner-side against the copper. The transparency is at-

tached along only one edge with tape, so that it can easily be peeled off when done, without damaging the delicate image. While the copper comes up to heat, roll the film against the copper to transfer the image. (I used a 1" wallpaper roller.) As the toner melts, the film adheres to the copper, and after a minute or two, the entire image should be stuck down. Then, while the copper is still hot, carefully peel the transparency off and let the board cool. A mirror image of the layout should be affixed, in complete detail, to the copper.

If the results at that point are not completely satisfactory, there are two options. If there are only a few minor imperfections, they can be touched up with a very fine felt-tip pen. Otherwise, the image can be cleaned off and the copper re-buffed for another attempt with a fresh transparency. It is so quick and easy to transfer an image that it is worth while to make a couple of practice runs in order to get a feel for the process. Once a satisfactory mask is transferred, the board may be etched.

I was amazed at how good the results were: My very first attempt produced a slightly flawed but workable board. After modifying my methods, all subsequent runs have been totally successful.

I have never used the photo-transfer method, so I cannot compare it first-hand to my xerox technique. I suspect that the photographic method is capable of producing slightly sharper detail and higher-density resist. (Minor pitting occurs on some of the traces, but so far that has not interfered with any circuit.)

There are several definite advantages to the Xerox process: Foremost is that almost everyone has access to a Xerox copier, either at work or through commercial copying services. The resist mask is totally visible on the copper blank, so that touch-ups can be made right on the copier, if needed. The process automatically transfers a mirror image. For work with single-sided boards, that is a definite plus. (It is not as useful for double-sided boards, and adjustment must be made for those.) And, finally, it is a great saving in time and expense. An existing layout can be

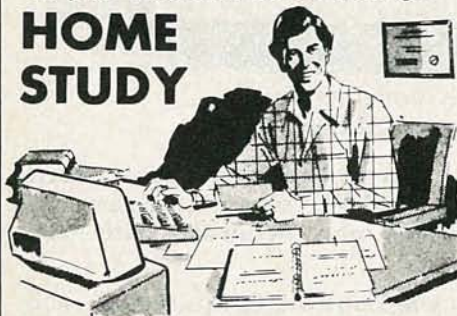
## *Your Career in ELECTRONICS or COMPUTERS*

Put Professional Knowledge and a

### **COLLEGE DEGREE**

in your Technical Career through

### **HOME STUDY**



No commuting to class. Study at your own pace, while you continue on your present job. Learn from easy-to-understand lessons, with help from your instructors when you need it.

Grantham offers two B.S. degree programs — one with major emphasis in ELECTRONICS and the other with major emphasis in COMPUTERS. Either program can be completed by correspondence (also known as "distance education"), NHSC accredited. The sooner you get started, the sooner you can be ready to benefit from greater knowledge and your B.S. degree.

Our free catalog gives full details of both degree programs. For your copy of the free catalog write to the address shown below, or phone (213) 493-4422 (no collect calls); ask for *Catalog 11-87*.

Grantham College of Engineering is a specialized institution catering to mature individuals who are employed in electronics and allied fields such as computers. These fields are so enormous that advancement opportunity is always present. Promotions and natural turn-over make desirable positions available to those who are *prepared to move up!*

Advancement in your career is made easier and more certain by (1) superior knowledge and (2) documentation of that knowledge — both of which are obtainable through Grantham distance education, fully accredited by NHSC.

Grantham's home study (distance education) programs leading to the

### **B. S. DEGREE**

may fill an important need for you. These are comprehensive correspondence programs in which you first review some things you already know, in preparation for the studies that come later. Some previous knowledge in electronics is presumed, but is thoroughly reviewed in depth, so as to give you a thorough foundation for the level of studies you have not previously undertaken. Even though some students hold associate degrees before enrolling, an A. S. Degree *is* awarded along the way toward the B. S. Degree.

*For full information, write for Catalog 11-87.*

**Grantham College of Engineering**

**10570 Humbolt Street**

**P. O. Box 539**

**Los Alamitos, California 90720**

transferred and etched onto a board, ready for drilling, in well under an hour for the cost of only a few Xerox copies.

So far, I have made only single-sided boards; I intend to try double-sided boards in the near future. I expect to etch each side separately, protecting one side with adhesive-backed film while working on the other.

C. BRUCE SNOW  
Lafayette, LA

#### FOLLOW-UP

As a follow-up to "Build This Digital Tachometer for your Car" and "Build This Digital Speedometer for your Car", which were published in the June and July 1987 issues of *Radio-Electronics*, I would like to note a few minor corrections that may help any readers who are building those projects.

First, in the digital-tachometer article, D2 and D4 on the parts-placement diagram should be interchanged, and so should D5 and D6. The 10- $\mu$ F capacitor labeled C14 on the schematic is C4.

In the digital-speedometer article, the schematic reference to IC5 should be labeled 4001 instead of 4011. The pick-up coil input should read P1 not P2. Also on the schematic, C12, a 0.1- $\mu$ F bypass capacitor, was omitted. Getting on to the parts-placement diagram, the set of pads between S1 and IC6 should be labeled C7.

Because of the exceptional response to the digital tachometer and digital speedometer, and a significant number of request for kits, Dakota Digital (R.R. 1, Box 83, Canisota, SD 57012) has expanded its product line as follows:

For the digital tachometer: Display board (#430103), \$6.95; main board (#430104), \$12.95; parts kit (#2002-KIT), \$75.00; Assembled and tested (#3002-UNIT), \$99.95.

For the digital speedometer: display board (#430105), \$6.95; main board (#430106), \$12.95; pick-up coil (#2701278), \$11.95; magnet set (4) (#2701279), \$4.95; parts kit (#2004-KIT), \$75.00; assembled and tested unit (#3004-UNIT), \$99.95.

Add 5% shipping and handling to all orders. South Dakota residents must add 5% sales tax.

ROSS ORTMAN

R-E

## Walk "Tough Dog" Troubles Out Of Any TV & VCR In Half The Time ... Guaranteed!



with the exclusive, patented  
VA62 Universal Video Analyzer™ ... \$3,495

Would you like to ...

**Reduce your analyzing time?** Isolate any problem to one stage in any TV or VCR in minutes, without breaking a circuit connection, using the tried and proven signal substitution method of troubleshooting.

**Cut costly callbacks and increase customer referrals by completely performance testing TVs and VCRs before they leave your shop?** Own the only analyzer that equips you to check all standard and cable channels with digital accuracy. Check complete, RF, IF, video and chroma response of any chassis in minutes without taking the back off the receiver or removing chassis, plus set traps dynamically and easily right on the CRT.

**Reduce costly inventory from stocking yokes, flybacks, and other coils and transformers for substitution only, with the patented Ringing Test?** Run dynamic proof positive test on any yoke, flyback, and integrated high voltage transformer.

**Protect your future by servicing VCRs for your customers before they go to your competition?** Walk out "tough dog" troubles in any VCR chrominance or luminance circuit to isolate problems in minutes. Have proof positive tests of the video record/play heads before you replace the entire mechanism.

**Have one piece of test equipment that doesn't need replacing every time technology changes?** Be able to service Stereo TVs & VCRs profitably, and get in on the ground floor of this growing market with exclusive phase-locked accessories.

**Find out how the VA62 Universal Video analyzer will make servicing easier and more profitable in your shop?** Call WATS Free 1-800-843-3338 and ask your area Sales Engineer for a "Try before you buy" 10 Day Self Demo or a full color brochure and join the many servicers already on the road to more profitable servicing with the VA62.

Universal Video Analyzer is a trademark of Sencore, Inc.



WATS Free 1-800-843-3338 In Canada WATS Free 1-800-851-8866

# SENCORE

**Means Success In Electronic Servicing**

3200 Sencore Drive, Sioux Falls, South Dakota 57107

Call Collect 605-339-0100 In SD & AK

CIRCLE 179 ON FREE INFORMATION CARD

# EQUIPMENT REPORTS

## PATTERN GENERATOR NCM MODEL 871

*A true NTSC audio/video  
pattern generator*



CIRCLE 20 ON FREE INFORMATION CARD

CONTRARY TO WHAT CONSUMER MAGAZINES often claim, in real life you get what you pay for. Buy junk and you get junk, only you don't know it until you get a chance to experience "quality." That holds true when it comes to color-bar generators—test equipment that we

now call "TV pattern generators." The conventional rainbow color-bar generator was just fine as long as the TV's and VCR's themselves were no great shakes at reproducing color. But now that we have digital TV's, HQ VCR's, and computer monitors, all capable of pro-

ducing pictures rivaling photographic prints, the washed-out colors, blended color-bar edges, and the color smear of many rainbow generators makes it almost impossible to determine whether modern TV's, VCR's, and computers are delivering a high-performance picture. That's why we can justify reviewing the NCM Electronics model 871 Video Wonderbox: a TV pattern generator that costs \$519.00.

### Professional quality

The Video Wonderbox is a true NTSC color generator, which means that its output signal is the same one that's used by the TV networks and stations to test and

# A•C•E's You Can Bet On



3M's new expanded line of A P Products® brand A•C•E Board 100 Series solderless breadboards offer durability that can't be beat.

Why gamble with imports when you can have the absolute reliability of an A•C•E (All Circuit Evaluator) Board 100 Series solderless breadboard from 3M? We've made it easier for you to design, prototype and test electronic circuits by providing the most reliable, durable and practical base from which to start.

You can bet we'll stand behind every

A•C•E Board we make. They're consistently reliable time after time, design after design, contact to contact. No import can make this claim.

A•C•E Board 100 series breadboards are now available in five sizes, all with the durability you've come to expect from

Electronic Specialty Products. Why gamble with imports? You just can't lose when you're holding all the A•C•E's.

For more information contact your local authorized Electronic Specialty Products distributor. Call 800-321-9668, or (216) 354-2101 in Ohio to find the name and location of your nearest dealer.

**We Solve Problems.**

Electronic Specialty Products  
3M Associated Electronics Department

9325 Progress Parkway, P.O. Box 540  
Mentor, Ohio 44060

CIRCLE 76 ON FREE INFORMATION CARD

# 3M



**Discover How The World's Only  
100% Automatic, Dynamic, & Portable  
LC Analyzer Gives You Total Confidence  
In Your Cap/Coil Testing . . .  
Call 1-800-843-3338 Today!**

align their recording and broadcasting equipment. Typical of professional gear, the Video Wonderbox features several specialized outputs. First, there's a conventional 75-ohm video output with a switchable peak-to-peak output level of 0.5-, 1.0-, and 1.5-volts. Then there's an NTSC composite (V and H) TTL-level sync output, a conventional 9-pin D-connector RGB TTL-level output for testing computer and "universal" TV monitors, and finally, an RF output having a nominal output level of 5 mV into 75 ohms, with an output attenuator with a range of 0-20 dB.

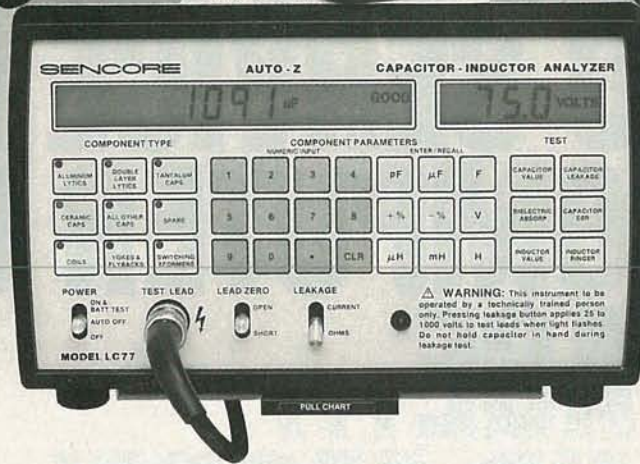
Notice that we didn't refer to a "conventional" RF output. That's because it's anything but conventional. Instead of having an RF output on Channels 3 and 4 (or 2 and 3), the Video Wonderbox's output frequency can be tuned via a front-panel vernier control to any channel in the switch-selected bands of Channels 2-5, 7-13, and 14-40. If you suspect that the reason a TV has deficient color on only one or a few channels might be poor front-end alignment or internally generated *spuri*, you can set the Video Wonderbox right to the troublesome channel. In that way, at the very least you can be certain that you're working with a trouble-free input signal.

Because it's often necessary to make intercarrier checks and adjustments, the RF output has a 4.5-MHz sound intercarrier that can be 100% modulated (25-kHz deviation) at 1000 Hz. The ratio of video and sound carriers is fixed at 10:1.

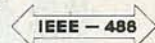
The video, RF, and RGB test signals are switch-selected. They are:

- 8 x 14 B&W video checkerboard
- 19V x 15H B&W crosshatch
- 10V x 8H B&W crosshatch with centered dots
- Line and field squarewave. (Top half of frame B&W; bottom half W&B.)
- White field
- Black field (at blanking level).
- Red field
- 8 Vertical color bars (plus maximum screen brightness for 9 bars).
- 7 Horizontal color bars (no black or maximum brightness).
- Circle (which can be superimposed over any pattern)

**New**



**LC77 AUTO-Z™  
Automatic Capacitor and Inductor Analyzer  
Double Patented \$1,895**



The first cap/coil analyzer guaranteed to reliably test anywhere, without calculations, look-up tables, or error — 100% automatically so you're confident of your accuracy.

Do you want to eliminate doubt from your cap/coil testing? The LC77 AUTO-Z tests all key parameters with results *anyone* can understand. Automatic good/bad results eliminate the guesswork for error-free analysis. Touch-sensitive keypad and one-two-three setup makes your AUTO-Z the easiest and fastest LC analyzer on the market.

Are you frustrated trying to test the new high-tech caps/coils used in modern electronics? Only the LC77 AUTO-Z allows you to test them all. Test capacitors from 1 pf to 20 farads, with leakage tests to 1000 V and ESR to 2000 ohms for locating failures other testers miss. Inductor value from 1 uH to 20 H and a patented ringing test for dependable, error-free coil testing every time.

Do you need the freedom of a battery-operated portable LC meter? The LC77 is 100% battery portable for use in the field or factory. The full power and potential of the LC77 AUTO-Z is packed into a light-weight, portable package. The AUTO-Z puts the complicated electronics on the inside for ease of operation on the outside.

Do you want maximum efficiency with a bus compatible LC testing system? Your LC77 AUTO-Z is IEEE 488 compatible for automated cap/coil analysis for data collection, incoming inspection, and quality assurance tests.

Be satisfied that you can meet all the challenges new technology brings. Call WATS Free 1-800-843-3338 today and tell your Area Sales Engineer you want to "try before you buy" with Sencore's exclusive 10 Day Self Demo.

AUTO-Z is a trademark of Sencore, Inc.



WATS Free 1-800-843-3338 In Canada WATS Free 1-800-851-8866

**SENCORE**

**Means Success In Electronic Servicing**

3200 Sencore Drive, Sioux Falls, South Dakota 57107

Call Collect 605-339-0100 In SD & AK

CIRCLE 180 ON FREE INFORMATION CARD

# *NRI Trains You At Home—As You Build Your Own IBM PC Compatible Computer*

# GET THE KNOW-HOW TO SERVICE EVERY COMPUTER ON THIS PAGE... AND MORE!

## **Learn the Basics the NRI Way— and Earn Good Money Troubleshooting Any Brand of Computer**

The biggest growth in jobs between now and 1995, according to Department of Labor estimates, will occur in the computer service and repair business, where demand for trained technicians will actually double.

You can cash in on this opportunity—either as a full-time corporate technician or an independent service-person—once you've learned all the basics of computers the NRI way. NRI's practical combination of "reason-why" theory and "hands-on" building skills starts you with the fundamentals of electronics, then guides you through advanced electronic circuitry and on into computer electronics. You also learn to program in BASIC and machine language, the essential languages for troubleshooting and repair.

## **Total Computer Systems Training, Only From NRI**

No computer stands alone . . . it's part of a total system. To really service computers, you have to understand computer *systems*. And only NRI includes a powerful computer system as part of your training, centered around the new, fully IBM PC compatible Sanyo 880 Series computer.



IBM is a Registered Trademark of IBM Corporation.  
Epson is a Registered Trademark of Epson America, Inc.  
Apple and the Apple logo are Registered Trademarks of Apple Computer, Inc.  
Compaq is a Registered Trademark of COMPAQ Computer Corporation.  
© 1985 AT&T Technologies, Inc.

**NEW!**

Train with the newest Sanyo 880 Series Computer—it's fully IBM-compatible and runs almost twice as fast as the IBM PC!



You start with the step-by-step assembly of the new, highly-rated, Sanyo computer. You install and troubleshoot the "intelligent" keyboard. Then you assemble the power supply, install the disk drive, and add extra memory to give you a powerful 256K RAM system. The new 880 computer has two operating speeds: standard IBM speed of 4.77 MHz and a remarkable turbo speed of 8 MHz, making it almost twice as fast as the IBM PC. Next, you'll interface the high-resolution monitor and begin to use the valuable software also included with your complete computer system.

It all adds up to confidence-building, real-world experience that includes training in programming, circuit design, and peripheral maintenance. You'll be learning about, working with, servicing, and troubleshooting an entire computer system—monitor, keyboard, computer, disk drive, power

supply—to ensure that you have all the essential skills you need to succeed as a professional computer service technician.

### No Experience Needed, NRI Builds It In

This is the kind of practical, hands-on experience that makes you uniquely prepared, with the skills and confidence you need for success. You learn at your own convenience in your own home. No classroom pressures, no night school, no need to quit your present job until you're ready to make your move. Your training is backed by your personal NRI instructor and the NRI technical staff, ready to answer your questions and help you when you need it. You get it all with NRI at-home training.

### 100-Page Free Catalog Tells More

Send the postage-paid reply card today for NRI's big, 100-page, color catalog on NRI's electronics training, which gives you all the facts about NRI courses in Microcomputers, Robotics, Data Communications, TV/Audio/Video Servicing, and other growing, high-tech career fields. If the reply card is missing, write to the address below.

Your NRI total systems training includes:  
• NRI Discovery Lab® to design and modify circuits • Your four-function, digital multimeter with walk-you-through instructions on audio tape • Digital logic probe for visual examination of keyboard circuits • The newest Sanyo 880 Series Computer with "intelligent" keyboard and 360K double-density, double-sided disk drive • High resolution monochrome monitor • 8K ROM, 256K RAM • Bundled software including GW BASIC, MS-DOS, WordStar, CalcStar • Reference manuals, schematics, and bite-size lessons.



## SEND COUPON TODAY FOR FREE NRI CATALOG!

**NRI** SCHOOLS

McGraw-Hill Continuing Education Center  
3939 Wisconsin Avenue, NW, Washington, DC 20016

We'll give you tomorrow.

### CHECK ONE FREE CATALOG ONLY

- |  |   |
|--|---|
| <input type="checkbox"/> Computer Electronics          | <input type="checkbox"/> Basic Electronics                  |
| <input type="checkbox"/> TV/Audio/Video Servicing      | <input type="checkbox"/> Electricians                       |
| <input type="checkbox"/> Satellite Electronics         | <input type="checkbox"/> Small Engine Repair                |
| <input type="checkbox"/> Robotics & Industrial Control | <input type="checkbox"/> Air Conditioning, Heating, & Ref.  |
| <input type="checkbox"/> Industrial Electronics        | <input type="checkbox"/> Locksmithing & Electronic Security |
| <input type="checkbox"/> Telephone Servicing           | <input type="checkbox"/> Photography                        |
| <input type="checkbox"/> Digital Electronics Servicing | <input type="checkbox"/> Bookkeeping & Accounting           |

For Career courses approved under GI Bill  
 check for details.

Name (Please print) \_\_\_\_\_ Age \_\_\_\_\_

Street \_\_\_\_\_

City/State/Zip \_\_\_\_\_ Accredited by the National Home Study Council 3-117

NOVEMBER 1987

# Radio-Electronics mini-ADS

- Greyscale staircase
- Color burst disabled

The various crosshatch and checkerboard patterns are primarily used for indicating linearity and color-convergence at the sides and corners of the CRT. (When the corner squares start to resemble diamonds you know its the monitor that's stretching the picture, not your eyes.) The pure white and black screens are great for optimizing the adjustment of the CRT's min/max brightness range (blacks really look black—not gray), while the all-red screen is used to test for color purity.

If the picture has smear at brightness-level transitions, pulls, reflections, or other evidence of low-frequency misbehavior, the line and field squarewave will guide you right to the trouble-spot.

As far as the color bars are concerned, they are razor sharp at the color-bar transitions. Anything less than razor-sharp separation generally means that there's a problem with the monitor's frequency response. However, expect considerable separation smearing from a color TV because it simply doesn't have the overall frequency response necessary for sharp transitions.

The circle provides an excellent astigmatism test. Proper astigmatism adjustment can be extremely critical for the correct display of computer graphics. Although an astigmatism adjustment usually is provided only on the finest oscilloscopes, it can be partially simulated by a TV's H and V linearity controls. Since there is no easy way to use the circle part of a TV test pattern for a computer monitor alignment, and since few TV-station test patterns are transmitted during normal working hours, the circle overlay is one of the best tools for making critical astigmatism adjustments to high-performance TV and computer monitors. Essentially, the circle overlaid on the 19V × 15H crosshatch makes a good substitute for a TV test pattern.

The instruction manual claims that various color patterns can be attained by simultaneously depressing two pattern switches, *continued on page 30*

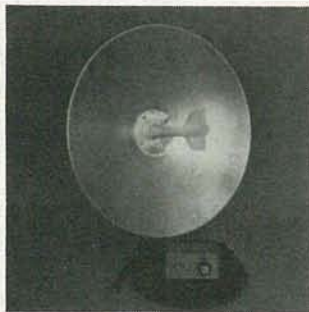


**RADAR SPEED UNIT.** Used professional model. Moving and stationary use, dual display, SPECIAL \$199. Other models from \$275. For clocking speeds in skiing, racing, bowling, baseball, etc. NEW IBM-COMPATIBLE COMPUTER system. Fully expandable, includes monitor, graphics/printer card, 362K floppy drive, game/serial ports, 256K memory, AT-style keyboard, free programs. Monochrome, \$895; color, \$1095. AIS SATELLITE, INC., P.O. Box 1226-D, Dublin, PA 18917. 215-249-9411.

CIRCLE 214 ON FREE INFORMATION CARD

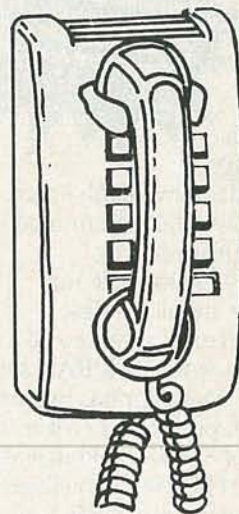


**HUGE SHORTWAVE COMMUNICATIONS CATALOG.** Over 70 pages of the latest in radio monitoring equipment. Includes communications receivers, portable shortwave radios, radioteletype and facsimile equipment, books, antennas, headphones and accessories. Explore the world from your living room with shortwave radio! Catalog available for \$1 (refundable). UNIVERSAL SHORTWAVE RADIO 1280 Aida Drive Dept. RE7, Reynoldsburg, OH 43068



**SUPER HOLIDAY SPECIALS** on our Multi-Channel Microwave T.V. receivers-1.9 to 2.7 GHz-40+ dB Gain. 1 Complete System ONLY \$84.95 (shipping included). Buy 5 at \$75.00 each and get 1 FREE. \$2.00 Credit on phone orders - CALL 602 230-0640 or send your order to K & S ELECTRONICS, P.O. BOX 34522, PHOENIX, AZ. 85067. We accept VISA/MASTERCARD/AMEX/COD. Prices good thru December 31, 1987.

CIRCLE 194 ON FREE INFORMATION CARD



## CALL NOW AND RESERVE YOUR SPACE

- 6 × rate \$800.00 per each insertion.
- Reaches 245,824 readers.
- Fast reader service cycle.
- Short lead time for the placement of ads.

Call 516-293-3000 to reserve space. Ask for Arline Fishman. Limited number of pages available. Mail materials to: Computer Admart, RADIO-ELECTRONICS, 500-B Bi-County Blvd., Farmingdale, NY 11735.



**MEET THE WORLDS SMALLEST MULTI-FEATURED AUTO DIALER.** Dials any of 100 Stored numbers, accesses computer services and long distance networks. Features LCD display, electronic code for private numbers, prefix encoding, redial and pause. Use as a calculator, stop watch, timer, alarm and a clock. Easily fits in shirt pocket. (2½ × 3). Includes full instructions and carrying case. \$49.95 + \$3.74 for shipping. Order toll free 1-800-624-1150. For a free catalog call (402) 554-0383. UNITED IMPORTS & MFG., 6846 Pacific St. Omaha, NE. 68106

CIRCLE 218 ON FREE INFORMATION CARD



### \$75 DMM MEASURES CAPACITANCE, TRANSISTOR HFE, MORE...

B&K-PRECISION'S new 2905 is a more-than-full-feature 3½ digit DMM, at a surprisingly low price. Features include 0.5% VDC accuracy; 100 µV, 0.1 µA resolution. Measures capacitance to 20mF with up to 1pF resolution. Audible continuity and diode junction tests are built in. For field survivability, it features a drop resistant case, reverse polarity and overload protection and high-energy fusing. Contact: B&K-PRECISION, 6460 W. Cortland Street, Chicago, IL 60635 (312) 889-9087.

B&K-PRECISION'S new 2905 is a more-than-full-feature 3½ digit DMM, at a surprisingly low price. Features include 0.5% VDC accuracy; 100 µV, 0.1 µA, 0.1 Ω, resolution. Measures capacitance to 20mF with up to 1pF resolution. Audible continuity and diode junction tests are built in. For field survivability, it features a drop resistant case, reverse polarity and overload protection and high-energy fusing. Contact: B&K-PRECISION, 6460 W. Cortland Street, Chicago, IL 60635 (312) 889-9087.

*RT  
Check out  
these features  
& prices. wow!  
FL*

### 4½ DIGIT TRMS DMM READS FREQUENCY AND TEMPERATURE

The new 2945 is well suited for both the analog and digital worlds. DCV accuracy is 0.05%, with 10µV, 10nA, 0.01Ω resolution. Data hold freezes voltage and current readings. °C and °F temperature readings are from -20° to +1000°C; frequency from 20 Hz to 200kHz. AC voltage and current are read in true RMS. Also checks continuity and diodes. \$250.00 Contact: B&K-PRECISION, 6460 W. Cortland Street, Chicago, IL 60635 (312) 889-9087.



### FREQUENCY COUNTER AND DATA HOLD HIGHLIGHT NEW 4½ DIGIT DMM

For engineers in need of a high-accuracy 4½ digit DMM and a low range frequency counter the 2940 is made to order. DC voltage accuracy is 0.05%. Resolution is 10µV, 10nA, and 0.01Ω. Frequency measurements span from 20Hz to 200kHz with up to 1Hz resolution. The 2940 features a drop resistant case with full internal circuitry protection. \$155.00 Contact: B&K-PRECISION, 6460 W. Cortland Street, Chicago, IL 60635 (312) 889-9087.



### HAND-HELD TEST BENCH READS VOLTAGE, RESISTANCE, CURRENT, HFE TEMPERATURE AND LOGIC.

The new 2906 3½ digit DMM from B&K-PRECISION is virtually a hand-held test bench, with a remarkable range of functions. °C and °F temperature measurements cover from -20C to 1000°C. The logic capability is ready for TTL and CMOS circuits. Other features include drop resistant case, reverse polarity and overload protection; plus high-energy fusing. DC accuracy, 0.25% VDC. \$95.00 Contact: B & K -PRECISION, 6460 W. Cortland Street, Chicago, IL 60635 (312) 889-9087.



### TRUE RMS DMM OFFERS PEAK HOLD, CAPACITANCE, AND LOGIC

3½ digit true RMS handheld DMM featuring 0.1% DC accuracy. Housed in an ergonomic, drop-resistant case, the 2907 offers many functions and a low price. Resolution is 100µV, 0.1µA and 0.1Ω. Capacitance to 20µF with 1pF resolution. Peak hold feature freezes transient readings. Fully protected. Also checks logic, continuity and diodes. \$190. Contact: B&K-PRECISION, 6460 W. Cortland Street, Chicago, IL 60635 (312) 889-9087.



# THE BEST DMM BUY? NOW IT'S B&K-PRECISION

- ✓ Better specs
- ✓ Lower prices
- ✓ More features
- ✓ More capabilities
- ✓ More circuit and safety protection
- ✓ Ruggedized case with safety test leads

Five all-new models step ahead of the competition with better specs and higher performance per dollar. We've also packed more features than ever into every model.

All five instruments measure voltage, current and resistance, check continuity and diodes, and feature a new ergonomic case with angled LCD readout. Depending on model, additional capabilities include logic level, capacitance measurement, transistor gain, true RMS, frequency measurement, high-current measurement, data hold, peak hold and even temperature.

Like all B&K-PRECISION instruments, these new meters are made for the real world. They offer a drop-resistant case and the triple protection of reverse polarity protection, overload protection, and high-energy fusing.

Best of all, the B&K-PRECISION DMM you want is already in stock at your local distributor. Call today for full details.



**BK PRECISION**  
DYNASCAN CORPORATION

6460 West Cortland St. • Chicago, IL 60635 • 312-889-9087

International Sales, 6460 W. Cortland St., Chicago, IL 60635

Canadian Sales, Atlas Electronics, Ontario

South and Central American Sales, Empire Exporters, Plainview, NY 11803

# NEW PRODUCTS



Good  
as  
Gold.

## The 70 Series Multimeter: The Shining Standard By Which Others Are Measured

These multimeters give you solid value for your money. A 3-year warranty keeps you from paying the price over and over for lesser quality meters.

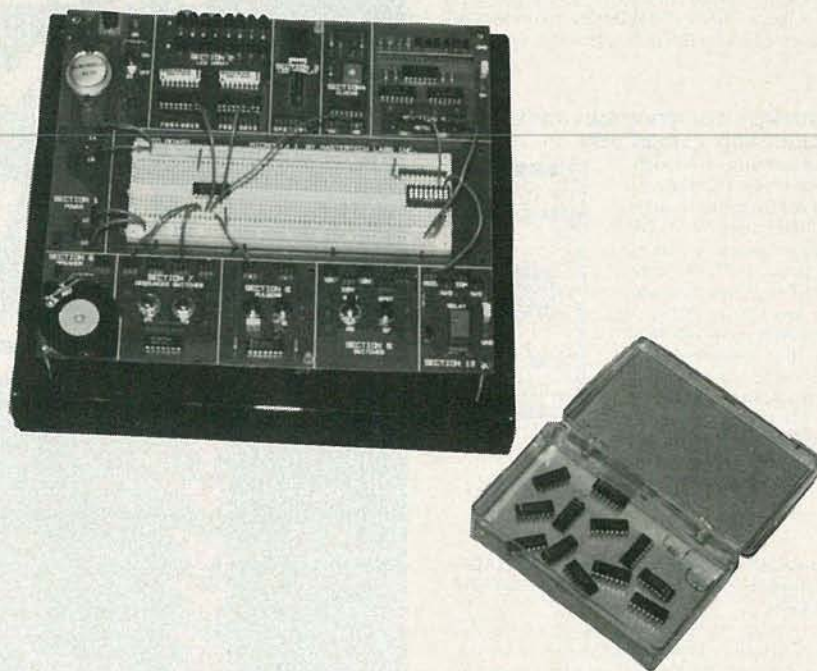
Choose from either the basic 73 or the feature-rich 75 and 77. You'll find the features you need at the price you can afford. Touch Hold™ for holding readings. Audible tones for continuity checks. Autoranging for simple operation.

Uncompromised quality at competitive prices. Get your hands on a 70 Series Multimeter at leading electronics distributors nationwide. Or call toll free 1-800-227-3800, ext. 229 for more information.

FROM THE WORLD LEADER  
IN DIGITAL MULTIMETERS.

### FLUKE 73, 75, 77

\$79, \$109, \$145	3-year warranty
0.7%, 0.5%, and 0.3% basic dc accuracy	Audible continuity (75 & 77)
Analog/digital display	Range hold (75 & 77)
Volts, ohms, 10A, diode test	Multipurpose holster (77)
Autorange	Touch Hold function (77)
2000+ hour battery life	



CIRCLE 10 ON FREE INFORMATION CARD

**DIGITAL CIRCUITS COURSE.** The *Microlab 1*, is intended to introduce students with little or no background to the world of digital electronics. The course includes a training board, two manuals, and all components required to conduct the course's experiments.

At the heart of the training board is a solderless breadboard that allows experimental circuits to be quickly assembled and taken apart. Surrounding the breadboard are support circuits for the experiments, including a bargraph meter, a seven-segment LED display with driver, switches, a relay, a speaker, and more.

Of the two manuals, one contains 40 experiments that lead the user through the fundamentals of digital circuitry. The other contains support information such as manufacturer's data sheets for IC's used in the course; information about the training board, including schematics and parts lists; an index, and answers to the questions posed in each experiment.

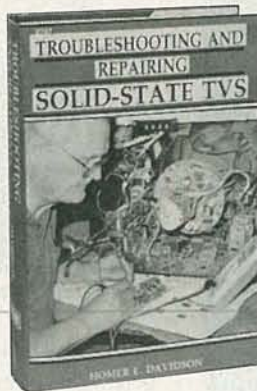
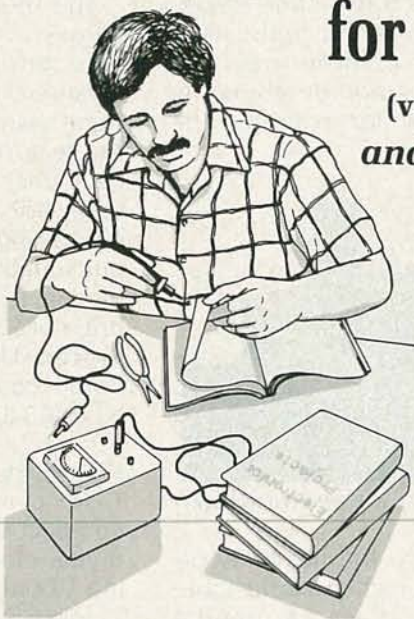
The *Microlab* is priced at \$220.00, plus \$15.00 for shipping and handling (U.S. funds).—**Mastertech Laboratories, Inc.**, 302 Royal Trust Building, 612 View Street, Victoria, British Columbia, Canada V8W 1J5.

**LOUDSPEAKER SYSTEM.** The model AM-5, is a compact, three-piece loudspeaker configuration

that delivers the bass, power handling, dynamic range, and spatial accuracy of a much larger system.

# SELECT 5 BOOKS for only \$3.95

(values to \$123.70)  
and get a Free Gift!



2707 \$24.95

Electronics projects . . . ideas . . . the latest technology  
all at up to 50% off publishers' prices

**Membership Benefits • Big Savings.** In addition to this introductory offer, you keep saving substantially with members' prices of up to 50% off the publishers' prices. • **Bonus Books.** Starting immediately, you will be eligible for our Bonus Book Plan, with savings of up to 80% off publishers' prices. • **Club News Bulletins.** 14 times per year you will receive the Book Club News, describing all the current selections—mains, alternates, extras—plus bonus offers and special sales, with hundreds of titles to choose from. • **Automatic Order.** If you want the Main Selection, do nothing and it will be sent to you automatically. If you prefer another selection, or no books at all, simply indicate your choice on the reply form provided. As a member, you agree to purchase at least 3 books within the next 12 months and may resign at any time thereafter. • **Ironclad No-Risk Guarantee.** If not satisfied with your books, return them within 10 days without obligation! • **Exceptional Quality.** All books are quality publishers' editions especially selected by our Editorial Board.

## FREE when you join!

### Reference Guide to Electronics Manufacturers' Publications

A time- and money-saving list  
of product literature from all  
the major electronics suppliers.

(a \$6.95 value)



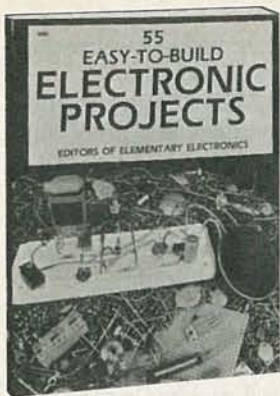
2785 \$34.95  
Counts as 2

**ELECTRONICS BOOK CLUB®**  
P.O. Box 10, Blue Ridge Summit, PA 17214

Please accept my membership in the Electronics Book Club® and send the 5 volumes listed below, plus my FREE copy of *Reference Guide to Electronics Manufacturers' Publications* (2683P), billing me \$3.95 plus shipping and handling charges. If not satisfied, I may return the books within ten days without obligation and have my membership canceled. I agree to purchase at least 3 books at regular Club prices (plus shipping/handling) during the next 12 months, and may resign any time thereafter.


Name \_\_\_\_\_  
Address \_\_\_\_\_  
City \_\_\_\_\_  
State/Zip \_\_\_\_\_ Phone \_\_\_\_\_

Valid for new members only. Foreign applicants will receive special ordering instructions. Canada must remit in U.S. currency. This order subject to acceptance by the Electronics Book Club®.  
RE-1187



1999P \$14.95



2645 \$16.95



1825P \$9.95



2706P \$9.95



1599P \$16.95



2715 \$16.95



1977P \$18.95



2722P \$14.95



1300P \$24.95



1964P \$10.95



1625P \$14.95



1529P \$14.95



2609P \$16.95



1897P \$13.95



1199P \$16.95



2800 \$23.95



1503P \$15.95



1992 \$14.95



1553 \$15.95



2753P \$16.95



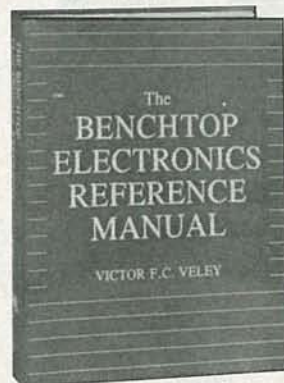
2665 \$17.95



1532P \$14.95



2802 \$39.95  
Counts as 2



2785 \$34.95  
Counts as 2



1909P \$14.95



1663P \$17.95



2839 \$15.95



2625 \$23.95



1604P \$15.95



1536P \$8.95

(Publishers' Prices Shown)

All books are hardcover unless otherwise indicated.

# Sterling™

## precision drills

variable or constant speed . . . from the Maxi to the Mini!



Crafted in West Germany, the high-speed, low-voltage, hand-held drills are extremely quiet, lightweight and cool running with a very low vibration level. Speeds range from 0-21,000 RPM with a universal chuck to accommodate accessories up to .125 in size.

### Accessories for any application!

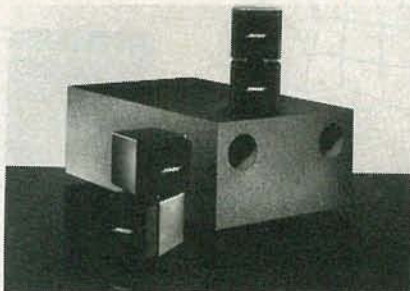
Adapt your drill to all your exacting needs with over 100 high quality drill bits, grinding stones and wheels, saws, cutting wheels, sanders, brushes, polishers and other accessories. Available in "kits" or as separate items.

Your exacting standards demand Sterling quality.

WAHL CLIPPER CORPORATION  
2900 Locust Street, Sterling, IL 61081  
(815) 625-6525

CIRCLE 176 ON FREE INFORMATION CARD

Smaller than a quart container of milk and the weight of a standard telephone, each two-cube speaker array can literally fit in the palm of a hand. Two of those arrays and an *Acoustimass* module (about the size of a typewriter) comprise the system.



CIRCLE 11 ON FREE INFORMATION CARD

In addition to the flexibility offered by the small and adjustable cube-speaker arrays, the model AM-5 is available with several mounting brackets and accessories that allow it to be placed or suspended anywhere. The wide-range driver in each cube speaker is also magnetically shielded for use with a video monitor or TV set.

The model AM-5 is priced at \$699.00.—**Bose Corporation**, The Mountain, Framingham, MA 01701.

**TABLE-TOP RADIOS.** The model 100 (shown) and the model 200B, are compact clock radios with the controls and the sound of a high-fidelity system.

The model 100 is monaural, and features frequency-synthesis tuning with three memory presets, high-density pressboard cabinet, separate bass and treble controls, dual independent alarms (buzzer at one time, music at another), ramp-up (increasing-loudness) alarm, continuously variable "sleep" timer, and dimmer control. Time, station, and status are indicated on a liquid-crystal front-

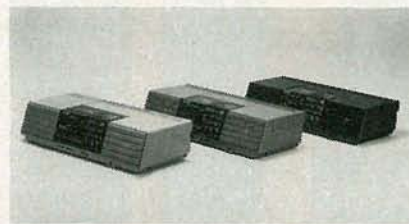


CIRCLE 12 ON FREE INFORMATION CARD

panel display. It has a suggested retail price of \$159.00.

The model 200B is stereo, and comes in two pieces. One contains the radio and left-channel speaker; the other contains the right-channel speaker. It has all of the features of the model 100 except dual alarms. Besides stereo reception and reproduction, the model 200B offers an auxiliary input suitable for a tape deck or CD player. It has a suggested retail price of \$275.00.—**KLH Division of Kyocera Electronics, Inc.**, 100 Randolph Road, CN 6700, Somerset, NJ 08873-1284.

**CD MUSIC SYSTEM.** The model CR-CD10, combines an AM/FM-stereo compact disc player and a built-in digital clock timer. The top-loading CD player features Automatic Programmable Music Selector and Automatic Program Search System functions. Twin 3 1/8" speakers deliver full-bodied sound. The LCD clock section features a convenient wake-up timer and a sleep function.



CIRCLE 13 ON FREE INFORMATION CARD

The model CR-CD10 has a suggested list price of \$319.95.—**Sharp Electronics Corporation**, Sharp Plaza, Mahwah, NJ 07430.

**CTCSS ENCODER.** The model SS-32SMP, is designed for use in handheld radios and other size-restricted applications. It measures .53 x 1.00 x .16-inch, and offers full tone versatility and a high audio level.

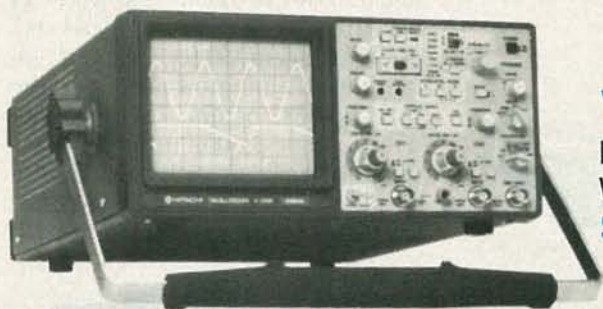
Any 32 tone frequencies between .01-255 Hz may be selected for storage into a 32-bit EEPROM memory. The tone frequencies can be standard or non-standard, and may be changed at a later date if desired. The required tone frequency is selected by soldering binary-coded jumpers on the tone board. The model SS-32SMP may also be ordered to work as a six-tone encoder (no switching di-





# COMPACT SERIES SCOPES

- 6" CRT with Internal Graticule
- Dual Channel X-Y Display
- Sweep Time Autoranging
- Delayed Sweep
- Single Sweep
- Trigger Lock
- CRT Readout
- ±3% Accuracy
- Bandwidth Limiter
- 400V High Input Voltage Protection
- TV Sync Trigger Circuit



**V-1065**  
DC to 100MHz  
With Cursor Readout  
**\$1595.**  
Save **\$200!**

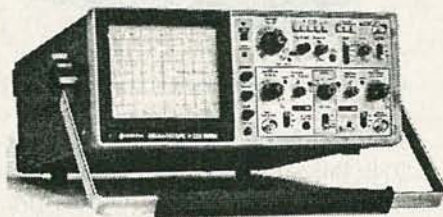
**V-1060** DC to 100MHz  
**\$1345. Save \$150!**

**V-665** DC to 60MHz  
With Cursor readout.  
**\$1145. Save \$150!**

**V-660** DC to 60MHz  
**\$970. Save \$125!**

**PROBES INCLUDED WITH ALL HITACHI SCOPES AT NO EXTRA CHARGE!**

**V-223 \$695. Save \$100!**

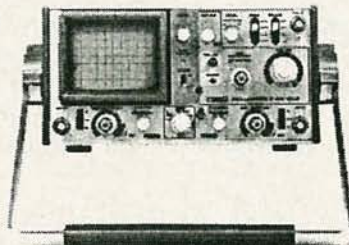


**DC to 20MHz, Dual Channels, Delayed Sweep**

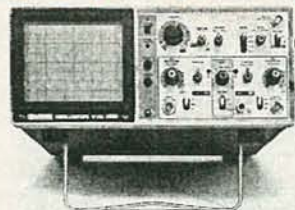
- CRT: 6" rectangular with 2k V Potential
- Vertical Deflection: Ver. Modes: CH1, CH2, ALT, CHOP, ADD (DIFF). Bandwidth: DC to 20MHz(-3dB). Sensitivity: 5mV/div to 5V/div. Max Sensitivity: 1mV/div at X5 Mag. Extends.
- X-Y Operation (CH1:X, CH2:Y): 3° or less from DC to 50kHz
- Weight: 7kg (15.5 lb)

**V-209 DC to 20MHz, Dual Channels**

- CRT: 6" rectangular with 1.5k V Potential
- Vertical Deflection: Ver. Modes: CH1, CH2, ALT, CHOP, ADD (DIFF) Bandwidth: DC to 20MHz(-3dB). Sensitivity: 5mV/div to 5V/div. Max Sensitivity: 1mV/div at X5 Mag. Extends.
- X-Y Operation (CH1:X, CH2:Y): 3° or less from DC to 100kHz
- Weight: 5kg (11 lb)



**V-212 \$440. Save \$175!**



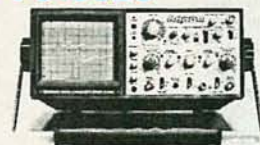
**DC to 20MHz, Dual Channels**

- CRT: 6" rectangular with 2k V
- Vertical Deflection: Ver. Modes: CH1, CH2, ALT, CHOP, ADD (DIFF). Bandwidth: DC to 20MHz(-3dB). Sensitivity: 5mV/div to 5V/div. Max Sensitivity: 1mV/div at X5 Mag. Extends.
- X-Y Operation (CH1:X, CH2:Y): 3° or less from DC to 50kHz
- Weight: 6kg (13.3 lb)

**V-222** • Same as above, but with CH1 output and DC offset voltage monitor outlet available for external counter or DVM.  
**\$515. Save \$200!**

**\$822. Save \$175!**

**VC-6020**



**\$1750.**  
Save **\$200!**  
**1MHz Sampling, Dual Channels**

- Usable as both a conventional oscilloscope and a digital storage scope. • 2kV Potential 6" CRT • DC to 20MHz(-3dB). Sensitivity: 5mV/div to 5V/div. GPIB, IEEE 488 Resolution: 8 bit. Max. Storage Freq: 100k Hz(-3dB). Memory Capacity: 1k words/ch. Hor. Res.: 100 point/div. Sweep Time: 0.1m/div to 1s/div. Data output: Analog.

**POLAROID®**  
**DS-34 CAMERA**



Save **\$135!** **\$290.**

- Instant Hard Copy From Oscilloscopes
- 5", 6" and 7" Hoods (Available separately @ \$51 ea. Please Specify size)
- Pistol Grip For Ease of Operation
- Works on Any Make of Oscilloscope
- Three Full Year Warranty

**V-1100A** DC to 100MHz, Quad Channels, Delayed Sweep  
**\$2240. Save \$250!**

**V-680** DC to 60MHz, Triple Channels, Delayed Sweep **\$1340. Save \$150!**

**V-423** DC to 40MHz, Dual Channels, Single Time Base Delayed Sweep  
**\$745. Save \$250!**

**V-1050F** DC to 100MHz, Quad Channels, Delayed Sweep  
**\$1445. Save \$150!**

**V-650F** DC to 60MHz, Triple Channels, Delayed Sweep **\$1070. Save \$125!**

**V-422** DC to 40MHz, Dual Channels  
**\$795. Save \$130!**

**V-509** DC to 50MHz, Dual Channels, Delayed Sweep **\$1195. Save \$250!**

**V-058G** DC to 5MHz, Dual Channels  
**\$838. Save \$100!**

**V-134** DC to 10MHz, Dual Channels  
**\$1420. Save \$200!**

**V-425** DC to 40MHz, Dual Channels  
**\$845. Save \$150!**



**WM. B. ALLEN**  
SUPPLY COMPANY

ALLEN SQUARE  
300 Block North Rampart Street  
New Orleans Louisiana 70112

TOLL FREE 800 535-9593 • LA 800 462-9520  
NEW ORLEANS (504) 525-8222 • FAX (504) 525-6361

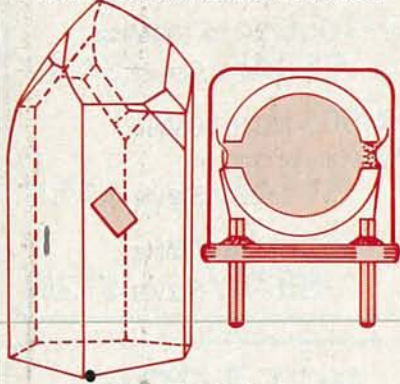
• American Express • Visa • MasterCard •  
928 pg CATALOG free with your order

CIRCLE 103 ON FREE INFORMATION CARD

# CRYSTEK

The pulse of dependable communications

Reliability & Quality  
From Start To Finished Product



## QUARTZ CRYSTALS/OSCILLATORS FOR ELECTRONIC — INDUSTRIAL

- Micro-Processor Control
- Computers/Modems
- Test/Measurement
- Medical

### COMMUNICATIONS—REPLACEMENT

- Mobile/2-way/Channel Elements
  - Pagers
  - Marine
  - Aircraft
  - Telemetry
  - Monitors/Scanners
- AMATEURS**

- CB
- Hobbist
- Experimenter

- COST EFFECTIVE
- MODERATE PRICING
- FAST DELIVERY



NEW

## The Pulse of Dependable Communications

Crystek Crystals offers their new 16 page **FREE** catalog of crystals and oscillators. Offering state-of-the-art crystal components manufactured by the latest automated technology. Custom designed or "off the shelf," Crystek meets the need, worldwide. Write or call today!

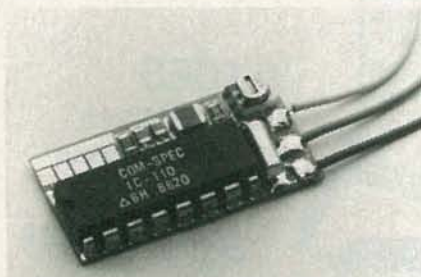
### CRYSTEK CRYSTALS

2351/2371 Crystal Dr. • Ft. Myers, FL 33907  
P.O. Box 06135 • Ft. Myers, FL 33906-6135

**TOLL FREE 1-800-237-3061**  
(813) 936-2109 - TWX 510-951-7448

CIRCLE 205 ON FREE INFORMATION CARD

odes are necessary) at no extra charge. Multiple-tone switching over six tones can be done with switching-diode networks or a binary switch. Tone frequencies above 255 Hz can be ordered for a slight additional charge.



CIRCLE 14 ON FREE INFORMATION CARD

The model *SS32SMP* features a low-impedance, low-distortion, adjustable sinewave output that can provide sufficient deviation for most handheld radios. It operates on 6–15 volts DC so that voltage-dropping resistors should never be required. It is priced at \$27.95.—**Communications Specialists, Inc.**, 426 West Taft Avenue, Orange, CA 92665-4296.

### TOTAL ELECTRONICS CLEANER.

*TEC* is an improved formula containing a cleaning product that has been used by professional technicians for years. It is a non-con-



CIRCLE 15 ON FREE INFORMATION CARD

ductive, non-toxic, residue-free, anti-static, rapid-drying electronics-grade solvent that removes dust, dirt, oil, and oxides. It is completely safe for use on computer, video, audio, telephone, and business equipment. *TEC* is available in an eight-ounce spray

can for \$8.00.—**Lab Products**, 29501 Greenfield Road, Suite #109, Southfield, MI 48076.

**LINEAR AMPLIFIER.** The model *SB-1000*, provides a full 1000-watt PEP SSB output, or an 850-watt CW output. It provides full HF coverage from 160 to 15 meters, including 80% of rated output on the three WARC bands. The amplifier uses a single 3-500Z tube in a high-efficiency circuit, and has a hyper-sil steel E-I core transformer for high-performance operation. It



CIRCLE 16 ON FREE INFORMATION CARD

also features a quiet computer-style fan, a full-wave power supply with computer grade capacitors, adjustable ALC, and vernier-tuned plate and load controls.

The model *SB-1000* is priced at \$739.95—**Heathkit**, P.O. Box 1288, Benton Harbor, MI 49022.

**RELAY SERVICE KIT.** The model *JTK-64*, contains a comprehensive tool selection for relay maintenance. Furnished in a compact 12½ × 10 × 2¼-inch padded zipper case, the tool selection includes

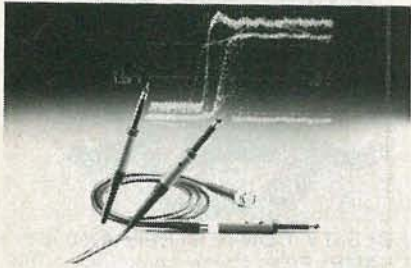


CIRCLE 17 ON FREE INFORMATION CARD

over 40 items, including brushes, burnishers, files, gauges, lamp extractor, mirror and magnifier, ignition wrench, pliers, circuit tester, soldering iron, wire stripper, and more.

The model *JTK-64* is recommended for professional service and repair of magnetic relays and solenoids in telephone/communication systems, process controls, and other plant equipment. It is priced at \$289.—**Jensen Tools**, 7815 S. 46th Street, Phoenix, AZ 85044.

**MODULAR OSCILLOSCOPE PROBES.** The *SP300 Series*, range in bandwidth from 10 MHz to 100 MHz and adapt to all oscilloscopes. They feature replaceable tips, probe cables, probe heads, and ground leads. Designed to be used in a wide number of applications, each probe is equipped with its own accessory kit having two insulating tips, a quick-connect BNC adapter, a spring hook, and a trimmer.



CIRCLE 18 ON FREE INFORMATION CARD

A highly-flexible silicone-insulated probe cable is offered in one, two, and three-meter lengths. A read-out actuator option for use with all  $\times 10$  probe cables is also available.

Prices for the *SP300 Series* start at \$27.00.—**OK Industries, Inc.**, 3455 Conner Street, Bronx, NY 10475.

**COAXIAL SWITCH.** The model *DSK*, measures only 3.1"  $\times$  1.9"  $\times$  1" overall. It functions as an SPDT

A-B switch, and is supplied with three BNC connectors. The large actuator provides a positive switching action. That design incorporates an unusually high isolation between unused lines.

The switch is easily mounted on the side of a desk, or on a wall, by use of two-sided adhesive tape (included). It is equally useful in offices or labs where there is a need for switching coaxial lines that terminate with BNC connectors. The model *DSK* is priced at \$22.00.—**L-**

**Com Data Products**, 1755 Osgood Street, North Andover, MA 01845.

**REMOTE POWER SWITCH.** The model *R119*, is a single-outlet device that can be used for remote control of multiple-outlet strips, surge suppressors, computers, or peripherals. It features a Velcro mounting pad, so that it can be placed conveniently under a desk or work table to control an entire workstation.

The model *R119* converts a sur-

**Immediate Delivery**

# DMM's at SALE PRICES!

**3 1/2 DIGIT 3200 COUNT ANALOG/DIGITAL MULTIMETERS**

**Model 73**  
Value Leader-World's Most Popular DMM-Autoranging  
**\$69** reg. \$79

**Model 75**  
Autoranging + Range Hold Audible Continuity Function  
**\$95** reg. \$109

**Model 77**  
Touch-Hold Feature + Features of Model 75  
**\$125** reg. \$145

**Model 37**  
Bench/Portable, 0.1 VDC Accuracy 10 A, Range 2 yr. Warranty  
**\$199** reg. \$229

**40th Year Anniversary Sale**

Model 77      Model 80218

**3 YEAR WARRANTY**

**3 1/2 DIGIT HIGH-ACCURACY HAND HELD**

**Model 80218**  
0.25% DC Accuracy, Audible Continuity Function  
**\$149** reg. \$169

**Model 80208**  
0.1% DC Accuracy, Audible Continuity & Conductance Function  
**\$219** reg. \$249

**Model 80248**  
0.1% DC Accuracy, 11 Functions Peak Hold, Temperature  
**\$219** reg. \$249

**Model 80268**  
0.1% DC Accuracy True RMS AC Volts & Current  
**\$195** reg. \$219

**4 1/2 DIGIT TRUE RMS HAND HELD**

**Model 8060A**  
Measures True RMS AC Volts & Amps, dB + Frequency From 12 Hz to 200 kHz, Resistance to 300 M  
**\$315** reg. \$359

**Model 8062A**  
Same as 8060A, but Less Frequency & dB  
**\$265** reg. \$295

**TRUE RMS BENCH DMMs**

**Model 8010A**  
3 1/2 Digit 10 AMP Range  
**\$255** reg. \$289

**Model 8010A-01**  
With Rechargeable Battery  
**\$295** reg. \$329

**Model 8012A**  
3 1/2 Digit Two Low Ranges  
**\$319** reg. \$359

Model 8060A  
1 YEAR WARRANTY

**1 YEAR WARRANTY**

**Model 8012A-01**  
With Rechargeable Battery  
**\$355** reg. \$399

**Model 8050A**  
4 1/2 Digit Relative Ref. Function 0.03% DC Accuracy  
**\$355** reg. \$399

**Model 8050A-01**  
With Rechargeable Battery  
**\$389** reg. \$439

\*Conductance Function Checks High Resistance

**FREE SHIPPING!**  
FREE SHIPPING ON FLUKE TO UPS SHIPPABLE DESTINATION.



CIRCLE 19 ON FREE INFORMATION CARD

Send for FREE 480 page "Industrial Products Catalog". Understand it is FREE with any order or if requested on company letterhead. (Otherwise, \$4.95 to cover catalog and shipping costs.)

**ORDER TOLL FREE**  
**1-800-323-5925**  
IN ILLINOIS  
**312-297-4200**  
SINCE 1947

**JOSEPH ELECTRONICS, INC.**  
8830 N. Milwaukee Ave. Dept. R  
Niles, IL 60648

Rush merchandise per attached order. I understand rated accounts are shipped open account; otherwise send per credit card.  
 Visa    Master Card    Discover  
 Check    Money Order    Rush Catalog

Card No. \_\_\_\_\_ Exp. Date \_\_\_\_\_

Name \_\_\_\_\_  
Company \_\_\_\_\_  
Street Address \_\_\_\_\_  
City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_

**Joseph Electronics**  
IL Res. 7% Tax

NOVEMBER 1987

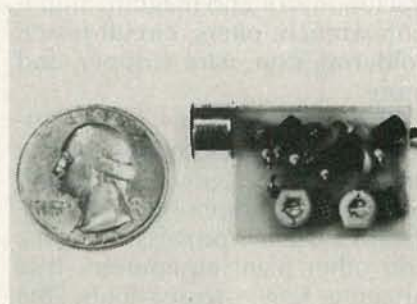
# Radio-Electronics mini-ADS



**APPLIANCE REPAIR HANDBOOKS**—13 volumes by service experts; easy-to-understand diagrams, illustrations. For major appliances (air conditioners, refrigerators, washers, dryers, microwaves, etc.), elec. housewares, personal-care appliances. Basics of solid state, setting up shop, test instruments. **\$2.65 to \$5.90 each.** Free brochure. **APPLIANCE SERVICE, P.O. Box 789, Lombard, IL 60148. (312) 932-9550.**  
CIRCLE 84 ON FREE INFORMATION CARD



**DECODE NEARLY ANY SINGLE LEVEL GATED PULSE SIGNAL.** New circuit works with Hamlin, Jerrold, Sylvania, and Eagle systems. Decodes In-band, Out-band, AM or FM reference. Complete educational kit including P.C. board, parts, case, and 40 page gated pulse theory booklet is only **\$47.00** plus **\$3.00** shipping. Order no. 1PFD-1K. **ELEPHANT ELECTRONICS INC. P.O. Box 41865-R, Phoenix, AZ 85080. (602) 581-1973**  
CIRCLE 120 ON FREE INFORMATION CARD



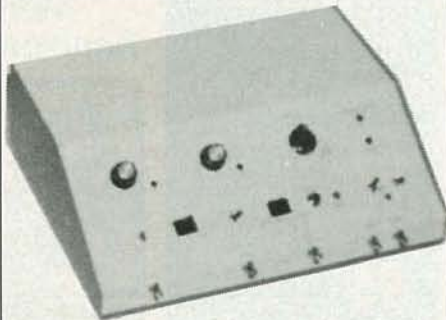
**SIMPLY SNAP THE WAT-50 MINIATURE FM TRANSMITTER** on top of a 9v battery and hear every sound in an entire house up to 1 mile away! Adjustable from 70-130 MHz. Use with any FM radio. Complete kit **\$29.95 + \$1.50 S+H.** Free shipping on 2 or more! COD add \$4. Call or send VISA, MC, MO. **DECO INDUSTRIES, Box 607, Bedford Hills, NY 10507. (914) 232-3878.**

CIRCLE 127 ON FREE INFORMATION CARD



**TRI-MODE DESCRAMBLER PARTS** Original parts as called up in Radio Electronics Feb 1987 article on tri-mode descrambling. Includes pc board, ac adaptor, resistors, capacitors, diodes, pots, transistors, IC's, LED's, toko coil and Plessoy SAW filler. Article included. **\$59** plus **\$2.50** shipping. **ELECTRONIC PARTS, Box 276, Alburg, VT 05440 (514) 739-9328.**

CIRCLE 206 ON FREE INFORMATION CARD



**SIGNAL STORAGE AND DRIVER-AN OSCOPE ACCESSORY.** Dual channel. Input and output sensitivity:  $\pm 50\text{mV}$  to  $15\text{V}$ .  $10\text{M}\Omega$  input,  $10\text{mA}$  output. Automatic internal sync. Stores 4 cycles minimum. Frequency switch with ideal ranges of .5Hz to 100kHz with a maximum dependent on the 8MHz sample rate. Intermittent problem mode for isolating your system transient faults. **\$830.** **BIDAN ASSOC. P.O. Box 907 Princeton, TX 75077.**

CIRCLE 195 ON FREE INFORMATION CARD



**CABLE TV CONVERTERS AND DE-SCRAMBLERS.** Large selection of top quality merchandise. Low prices. Quantity discounts. We ship COD. Most orders are shipped within 24 hrs. Send **\$2.00** for catalog. **CABLETRONICS UNLIMITED, P.O. Box 266 Dept. R, S. Weymouth, MA 02190 (617) 843-5191**

CIRCLE 212 ON FREE INFORMATION CARD



**NEW-SURFACE MOUNT COMPONENT KITS.** Half the price of most competitors. Each kit contains 300 components, 10 each of 30 different values. Resistors are 5%, 1/8 watt, 10 to 2.2M ohms. Capacitors are 20%, 50 WVDC, 33pf to .1 uf. CMOS & TTL kits available soon. Resistor Kit **\$29.95**, Capacitor Kit **\$39.95**, + **\$3.00 S+H.** COD add **\$4.00** VISA, MC, MO call (714) 987-2414, **VALUE COMPUTER, Box 1151, Alta Loma, Ca. 91701**

CIRCLE 209 ON FREE INFORMATION CARD



**PANASONIC CABLE CONVERTERS,** Wholesale and Retail. Scientific Atlanta and Pioneer Cable Converters in stock. Panasonic model 130N 68 channel converter **\$79.95**, Panasonic Amplified Video Control Switch Model VCS-1 **\$59.95**. Scientific Atlanta Brand new Model #8528 550MHZ 80 Channels Converter **\$89.95**. Video Corrector (MACRO, COPYGUARD, DIGITAL) ENHANCER **\$89.95**. We ship to Puerto Rico, Caribbean countries, & So. Amer. Write or call **BLUE STAR IND., 4712 AVE. N, Dept 105, Brooklyn, NY 11234. Phone (718) 258-9495.**

CIRCLE 85 ON FREE INFORMATION CARD



**GUARDIAN STUN GUN:** the most advanced personal protection device of it's kind. Generates a charge of electricity over 50,000 volts to repel an attacker. Non-Lethal effect due to low amperage. Safe and effective. Recommended by many police agencies. Check local laws for restrictions. **\$39.95 + \$3.00** shipping w/30-day return privilege. Call or write: **LIFE PRODUCTS, PO Box 2126, Henderson, NV 85014, (702) 871-1885.**

CIRCLE 208 ON FREE INFORMATION CARD

# Radio-Electronics mini-ADS



**ZENITH SSAVI-1 \$169, LEVEL II \$199.** Original reconditioned UHF input/channel 3 output units with thirty-day limited warranty. SSAVI-1 project handbook \$6.50 ppd. Surplus Sylvania 4040 converter/DIC, Z-tac, N-12, MLD-1200. Quantity discounts. Satellite systems, converters, amplifiers, video accessories. Catalog \$1. **AIS SATELLITE, INC., P.O. Box 1226-RE, Dublin, PA 18917. (215) 249-9411.**

CIRCLE 81 ON FREE INFORMATION CARD



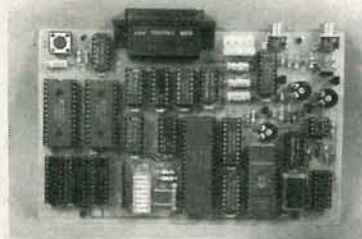
**QUALITY FIELD SERVICE KITS** and test equipment, production aids, telecommunication equipment, maintenance and repair tools, work stations, and static control products can be found in the new **TIME MOTION TOOLS** catalog. All Time Motion Tool products carry out guarantee of complete satisfaction, or your money back within 30 days. For a FREE catalog write: **TIME MOTION TOOLS, 410 S. Douglas Street, El Segundo, CA 90245. (213) 772-8170, Ext. 101.**

CIRCLE 215 ON FREE INFORMATION CARD



**FREE CATALOG OF HARD-TO-FIND TOOLS** is packed with more than 2000 quality items. Your single source for precision tools used by electronic technicians, engineers, instrument mechanics, schools, laboratories and government agencies. Also contains Jensen's line of more than 40 tool kits. Send for your free copy today! **JENSEN TOOLS INC., 7815 46th St., Phoenix, AZ 85044. (602) 968-6231.**

CIRCLE 115 ON FREE INFORMATION CARD



**BUILD STEVE CIARCIA'S NEW VIDEO DIGITIZER.** • True "Frame Grabber", pic takes 1/60th sec • Not bus Dependent - Standalone digitizer • Serial output, transmits 300bps to 57.6Kbps • Resolution: 256 x 244 x 6 w/64 level grayscale • Accepts any NTSC video input, B&W or Color • Optional Rec/Display makes Video Telephone • Images can be stored & displayed on IBM PC. Kits starting at \$89.50. Call for other options and specs. **CCI, 4 Park St., Suite 12, Vernon, CT 06066. (203) 875-2751.**

CIRCLE 216 ON FREE INFORMATION CARD



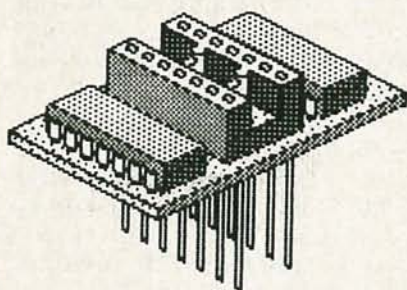
**SURFACE MOUNT COMPONENTS**—Resistors, diodes, transistors (ROHM CORP), ceramic caps (NOVACAP) and tantalum caps (MATSUO). Standard resistor chip values range from 0 ohm to 10 Mohm. Ceramic cap chips range from 1 pf to 1 uf. Tantalum cap chips range from .1 uf to 100 uf. Engineering design kits are available—packaged for convenient lab usage in plastic boxes or steel cabinets. **GARRETT INST. & COMP./IEU INC., 3130 Skyway Dr. #104, Santa Maria, CA 93455. Phone (805) 922-0594, FAX (805) 922-3643.**

CIRCLE 210 ON FREE INFORMATION CARD



**THE MODEL WTT-20 IS ONLY THE SIZE OF A DIME**, yet transmits both sides of a telephone conversation to any FM radio with crystal clarity. Telephone line powered - never needs a battery! Up to 1/4 mile range. Adjustable from 70-130 MHz. Complete kit **\$29.95 + \$1.50 S+H.** Free Shipping on 2 or more! COD add \$4. Call or send VISA, MC, MO. **DECO INDUSTRIES, Box 607, Bedford Hills, NY 10507. (914) 232-3878.**

CIRCLE 127 ON FREE INFORMATION CARD



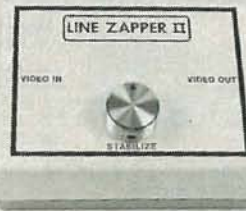
**SCIENTIFIC ATLANTA** cable equipment. Introducing the new **Key Circuits**, made to "test and repair" 8500 (KEY-A) and 8550/8555 (KEY-B) converters. Regular price \$160.00. **Special Introductory Offer \$125.00.** Total channel capability. Complete 8500 or 8550 converters \$225. Hand remotes \$20.00. Free information. Dealers welcome. C.O.D. accepted. **V.I.P. ELECTRONICS, P.O. Box 628, Forestdale, R.I. 02824. (617) 755-9778.**

CIRCLE 213 ON FREE INFORMATION CARD



**FREE 24 PAGE OCTE CATALOG!** Cable TV converters, hand controls, stereo decoders and switching centers. Negative cable TV traps and noise filters. Descrambler books, schematics and parts. SCA books and kits. Nite viewers. Microwave downconverters. Telephone privacy assurance devices and automatic conversation recorders. Bug and tap detectors. Parabolic microphones. Power supplies. Surplus electronics parts. **OCTE ELECTRONICS, Box 276, Alburt, VT 05440. (514) 739-9328.**

CIRCLE 217 ON FREE INFORMATION CARD



**DECODE THE NEW VIDEO TAPE COPY PROTECTION SCHEME.** Bothered by brightness changes, vertical jittering and video noise while watching rented tapes? Stop it with the **LINE ZAPPER II**. New kit removes copy protection that often interferes with normal television operation. Complete KIT only **\$69.95.** Assembled with 1 year warranty **\$124.95.** Add **\$3.00** shipping per unit. Dealer inquiries welcome. **ELEPHANT ELECTRONICS, Box 41865-L, Phoenix, AZ 85080. (602) 581-1973.** Allow 6 weeks for delivery.

CIRCLE 188 ON FREE INFORMATION CARD

## HITACHI SCOPES AT DISCOUNT PRICES!

20MHZ



Model V212 \$475

Model V-212 20MHZ Dual Channel (1mV Sens.) \$475  
 Model V-422 40MHZ Dual Channel (1mV Sens.) \$699  
 Model V-425 40MHZ Dual Channel (with cursor) \$795  
 Model V-660 60MHZ Dual Channel (Delayed Sweep) \$999  
 Model V-1060 100MHZ Dual Channel (Delayed Sweep) \$1,375  
 All above scopes have a 3 year warranty on parts and labor

100MHZ



Model V1060 \$1,340

15-25%  
OFF LIST  
PRICE

## ELENCO PRODUCTS AT DISCOUNT PRICES!



40MHz  
DELAYED  
SWEEP  
MO-1253  
\$550



20MHz DUAL TRACE OSCILLOSCOPE  
\$359 MO-1251

35MHz DUAL TRACE OSCILLOSCOPE  
\$498 MO-1252

Top quality scopes at a very reasonable price. Contains all the desired features. Elenco's 2 year guarantee assures you of continuous service. Two 1x, 10x probes, diagrams and manual included. Write for specs.  
 100 MHz Test Probes, 1X, 10X, Ref. (Complete with 5 accessories) Fits Most Scopes - \$22

MULTIMETER with CAPACITANCE AND TRANSISTOR TESTER  
 Model CM-1500A \$58  
 Reads Volts, Ohms, Current, Capacitors, Transistors & Diodes W/Case

TRUE RMS 4 1/2 DIGIT MULTIMETER  
 Model M-7000 \$135  
 .05% DC Accuracy  
 .1% Resistance with Freq. Counter & Deluxe Case

Auto Ranging plus Manual Ranging  
 3 1/2 Digit Meter  
 28 Functions  
 Fully protected  
 M-1180 .7% Acy \$36.95  
 M-1182 .25% Acy \$39.95  
 M-1181 .1% Acy \$42.95

GF-8016 FUNCTION GENERATOR with Freq. Counter  
 \$239  
 • Sine, Square, Triangle  
 • Pulse, Ramp, .2 to 2MHz  
 • Frequency .1 thru 10MHz  
 GF-8015 without Freq. Meter \$179

10MHz OSCILLOSCOPE  
 \$219  
 Model S-3000  
 • 10MHz DC or AC  
 • Triggered Sweep  
 • Calibrated Vert & Hor  
 • Reads Volts & Freq

BREADBOARD  
 Model 9436 Shown  
 9430 1,100 pins \$15  
 9434 2,170 pins \$25  
 9436 2,860 pins \$35

DIGITAL TRIPLE POWER SUPPLY  
 Model XP-765 \$239  
 0-20V @ 1A  
 0-20V @ 1A  
 5V @ 5A  
 Fully Regulated, Short Circuit Protected with 2 Limit Cont. 3 Separate Supplies  
 XP-660 with Analog Meters \$169.50

DIGITAL LCR METER  
 \$148  
 Model LC-1800  
 Measures: Inductors, Capacitors, Resistors

50MHz LOGIC PROBE  
 20 nsec with memory LP-700  
 \$23  
 Logic Pulsar LP-600 \$23

DIGITAL 3 AMP POWER SUPPLY  
 Model XP-750 \$175  
 0-40V @ 1.5A  
 0-20V @ 3A  
 Fully regulated, short circuit protected current limit control  
 XP-650 with Analog Meters \$129.50

MULTI-FUNCTION COUNTERS  
 F-1000 1.2GH \$259  
 F-100 120MH \$179  
 Frequency, Period, Totalize, Self Check with High-Stabilized Crystal Oven Oscillator, 8 Digit LED Display

C&S SALES INC., 1245 ROSEWOOD DRIVE, DEERFIELD, IL 60015 800-292-7711 (312) 459-9040 ASK FOR CATALOG  
 15 DAY MONEY BACK GUARANTEE  
 2 Year Limited Guarantee! Add 5% for Postage (\$10 max), IL Res., 7% Tax  
 CIRCLE 109 ON FREE INFORMATION CARD



CIRCLE 21 ON FREE INFORMATION CARD

ge-suppressor or outlet strip to instant remote control by simply plugging it in. The switch itself is lighted so that on/off status can be seen easily. The switch is rated for 1,800 watts, 15 amps maximum. The device is UL listed and features a one-year warranty; the price is \$19.95.—Perma Power Electronics, Inc., 5601 Howard Street, Chicago, IL 60648. R-E

## EQUIPMENT REPORTS

continued from page 20

such as the switches for a B&W crosshatch and the vertical color bars. While it's true that pressing two switches creates unusual color patterns, except for the two that create the all-red field, they are useless. It's just something that occurs, and making mention of that fact probably saves the company many complaints that "something is wrong with my unit."

The Video Wonderbox is line-powered and toolbox size: only 8 x 2 x 5 1/2-inches. The carrying handle is detented and also serves as an adjustable tilt-mount. No accessories other than the instruction manual are provided. Optional accessories for the unit include a 75-ohm BNC-to-BNC cable, a 75-ohm BNC-to-IEC cable, and a DB-9-to-DB-9 (IBM-compatible RGB/RS-232) cable.

For additional information write to NCM Electronics, 1500 Wyatt Drive, Santa Clara, CA 95054. R-E

# NEW IDEAS

## Simple multi-tone generator

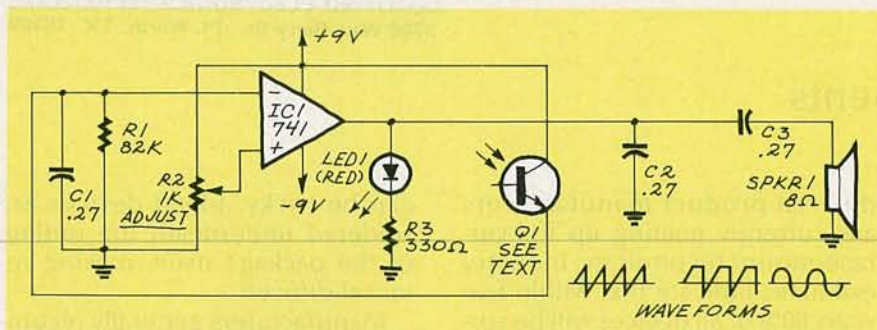


FIG. 1

SOMETIMES YOU NEED A WAVEFORM having a particular shape, frequency, or amplitude that's not provided by your signal generator; or maybe you just don't own a signal generator. If you don't mind spending a bit of time experimenting with parts values, the multi-tone generator circuit described here might give you just the waveform that's needed.

The circuit shown in Fig. 1 can actually be built from parts you probably have lying around on the workbench. A bi-polar power supply is required; two 9-volt batteries wired in series, with their junction used as the "ground" will do.

### How it works

Op-amp IC1 is used as a sensitive voltage comparator, whose trip level—the value at which the output changes state—is determined by potentiometer R2. The resistance of R1 in series with the resistance of phototransistor Q1 provides the feedback divider for IC1's inverting input. Since Q1's "dark" resistance—the resistance when there is no light—is very high. Very little voltage appears across R1; therefore, IC1's output will normally be high.

When power is first turned on, IC1 goes high, causing the LED to glow. However, the instant it glows on Q1, causing a decrease in Q1's collector-emitter resis-

tance, which causes a large voltage drop across R1. The comparator immediately switches to a low output, thereby turning the LED off, which restores Q1's dark resistance. The increase in Q1's resistance causes the cycle to repeat, thereby producing an oscillating output voltage.

Logically, the circuit should "lock up" because the LED and phototransistor would be competing with each other for control of the circuit, and IC1 would get stuck at some equilibrium state. Capacitor C2 prevents that from happening by keeping the LED lit slightly longer than the normal turn-off time. (C1 also helps avoid lock up, but its use isn't critical and it can often be eliminated.)

The output frequency can be changed by varying the values of C1–C3, but keep in mind that making their values too small will defeat their primary purpose, which is avoiding circuit lock-up.

The frequency, amplitude, and the shape of the waveform are determined by R2. Three of the typical waveforms that can be obtained by adjusting R2 are also shown in Fig. 1.

LED1 can be any red light-emitting diode. Q1 can be any phototransistor—try whatever you have lying around or can get cheaply. The only critical part of the assembly is the positioning of

LED1 and Q1. They must be facing and close, and shielded from ambient light—perhaps by placing them inside a small cardboard or opaque plastic tube. Alternately, you could try substituting an optoisolator for LED1 and Q1. However, bear in mind that the spacing between LED1 and Q1 provides some control over the output waveform; an optoisolator would eliminate that degree of control.—Mohd Amjad Khan.

R-E

### NEW IDEAS

This column is devoted to new ideas, circuits, device applications, construction techniques, helpful hints, etc.

All published entries, upon publication, will earn \$25. In addition, for U.S. residents only, Panavise will donate their *model 333*—The Rapid Assembly Circuit Board Holder, having a retail price of \$39.95. It features an eight-position rotating adjustment, indexing at 45-degree increments, and six positive lock positions in the vertical plane, giving you a full ten-inch height adjustment for comfortable working.

I agree to the above terms, and grant **Radio-Electronics** Magazine the right to publish my idea and to subsequently republish my idea in collections or compilations of reprints of similar articles. I declare that the attached idea is my own original material and that its publication does not violate any other copyright. I also declare that this material has not been previously published.

Title of Idea

Signature

Print Name

Date

Street

City

State

Zip

Mail your idea along with this coupon to: **New Ideas Radio-Electronics**, 500-B Bi-County Boulevard Farmingdale, NY 11735

NOVEMBER 1987

# SERVICE LOG

INTERNATIONAL SOCIETY OF  
**ISCET**  
CERTIFIED ELECTRONICS TECHNICIANS  
2708 West Berry St. Ft. Worth, TX 76109

## Surface-mount components

THE BIGGEST CHANGE IN ELECTRONICS since the widespread use of the integrated circuit is now beginning. It will affect virtually all industrial and consumer electronic products and cause some grief for the technicians who must service and maintain those products. In fact, just as in the transistor transition days of the late sixties, some technicians will flatly refuse to work on the new systems. Yet, unlike the development of IC's and the introduction and proliferation of the microprocessor, the coming revolution does not inherently involve the introduction of radically new devices. This revolutionary change is the simple packaging of components in new cases. It is called Surface-Mount Technology, or SMT.

Today, the vast majority of components are attached to printed-circuit boards by passing their leads through holes in the PC boards and soldering them to conductive pads on the other side. This is known as insertion-mount technology and is used to attach virtually all conventional IC's, transistors, resistors, capacitors, and inductors to boards. Surface-mount technology involves the connection of components to the surface of the printed-circuit board by simply laying a component's leads on conductive pads under the component and soldering them. Surface-mount devices are soldered on the side of the board to which they are mounted. Several major consumer and in-

dustrial product manufacturers are currently gearing up for surface-mount technology. Industry estimates indicate that within five years 80% of all devices will be surface-mount types.

### Advantages

Manufacturers are moving to SMT for several reasons. With the development of more complex IC's, the number of pins needed on the package has increased. Because a *Dual In-line Package*, or DIP, is not economical if more than 48 pins are required, new packages had to be developed. Those include the *Plastic Leaded Chip Carrier (PLCC)* and *Leadless Ceramic Chip Carrier (LCCC)*, and were designed to accommodate more pins and to take advantage of SMT. SMT packages for both IC's and passive components are 60% to 80% smaller than insertion-mounted packages. That allows the design of smaller printed circuit boards. It also shortens interconnecting leads and allows the development of faster boards. Because SMT packages are soldered on the side of the PCB to which they are mounted, components can be mounted on both sides of the board. This also lessens the number of layers needed for a typical board.

### Disadvantages

Unfortunately for the technician, this miniaturization is not without disadvantages. Many surface-mounted components are glued to the board before soldering. Removing a glued device without damaging the solder runs

can be tricky. J-lead devices are soldered underneath the outline of the package itself, making removal difficult.

Manufacturers generally recommend special tools for the testing, removal, and replacement of SMT devices. Even with these tools, the job of servicing of SMT devices is tedious. Lead spacing is generally 50 mils, half that used on standard DIP's. Attaching test leads to 50-mil leads that lay beneath a package can be a problem unless a special test clip is used. Alignment of the replacement part and the solder pads—which is essential for SMT devices—is tricky.

Finally, SMT resistors and capacitors are so small that their values or part numbers cannot be printed on them. Good documentation becomes imperative for successful service of equipment that is SMT-based. Look for manufacturers to begin special training on SMT servicing early next year.—*Elmer Poe*  
CET, PhD



"How was I supposed to know you have to plug it in?!"

Reprinted courtesy of ISCET from Technical Reference Log, which is provided to members of ISCET at no charge.



# AUDIO UPDATE

## Stereo Spatial Imaging

IN PAST MONTHS WE'VE DEVOTED SEVERAL columns to those special products and techniques used to enhance spatial perspective and imaging in stereo listening. Dedicated audiophiles, who would never dream of adding "artificial" enhancement devices to their systems, eagerly seek out those components—including special cables—that they believe "naturally" add desirable sonic properties. In that, they resemble the food faddists who insist that vitamin C extracted from rose hips has far greater virtue than vitamin C derived from chemically-produced ascorbic acid. Let's look at some of the electrical, mechanical, acoustic, and psycho-acoustic factors that serve to produce an enhanced stereo sound stage.

### The influencing factors

The most dramatic influence on the perceived depth of the stereo image is usually the type and amount of reverberation in the recording itself. The sound field embodied in a well-miked, simply-mixed recording consists of three sonic components picked up by the microphones: the direct sound, the early reflections, and the reverberation. The direct sound, which is the first heard, is used by the ear to localize the source of the sound. Next, the early room reflections contribute a sense of the size of the acoustic space. When the late-arriving reflections become numerous, they become homogenized and blend into reverberation, which adds a sense of warmth and continuity to the sound.

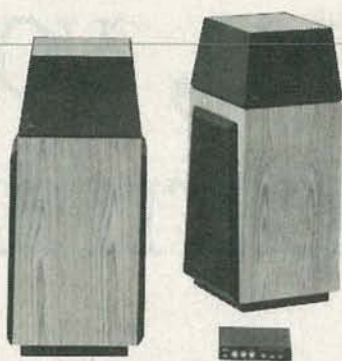


FIG. 1

The factors in a home system that can influence the perceived spatial properties of a stereo signal are: accidental or deliberate phase shift between channels, channel separation, out-of-phase crosstalk between the channels, frequency-response irregularities, and the ratio of directly perceived versus delayed or reflected sound within a room. That last factor is basically determined by the designed-in dispersion of the speakers and their placement in the listening room. And, of course, we can't neglect the speakers' interactions with the acoustic environment they find themselves in. Some of those factors are worth some additional discussion.

### Crosstalk

Out-of-phase crosstalk between channels, whether introduced deliberately or otherwise, will de-emphasize the center-recorded sounds, thus increasing the depth and width of the stereo stage. Because crosstalk in a phono cartridge usually varies to some degree across the audio-frequency



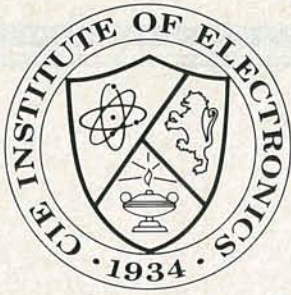
LARRY KLEIN,  
AUDIO EDITOR

range, so can imaging. There was one highly esteemed British phono cartridge whose coils had a matrixed output. If the coils were not properly aligned via a small set-screw adjustment, there would be a high level of out-of-phase crosstalk that provided (for some ears) a wonderfully open, wide-stage quality. Those cartridges that were properly adjusted didn't manifest that effect and were therefore considered defective by many U.S. audiophiles.

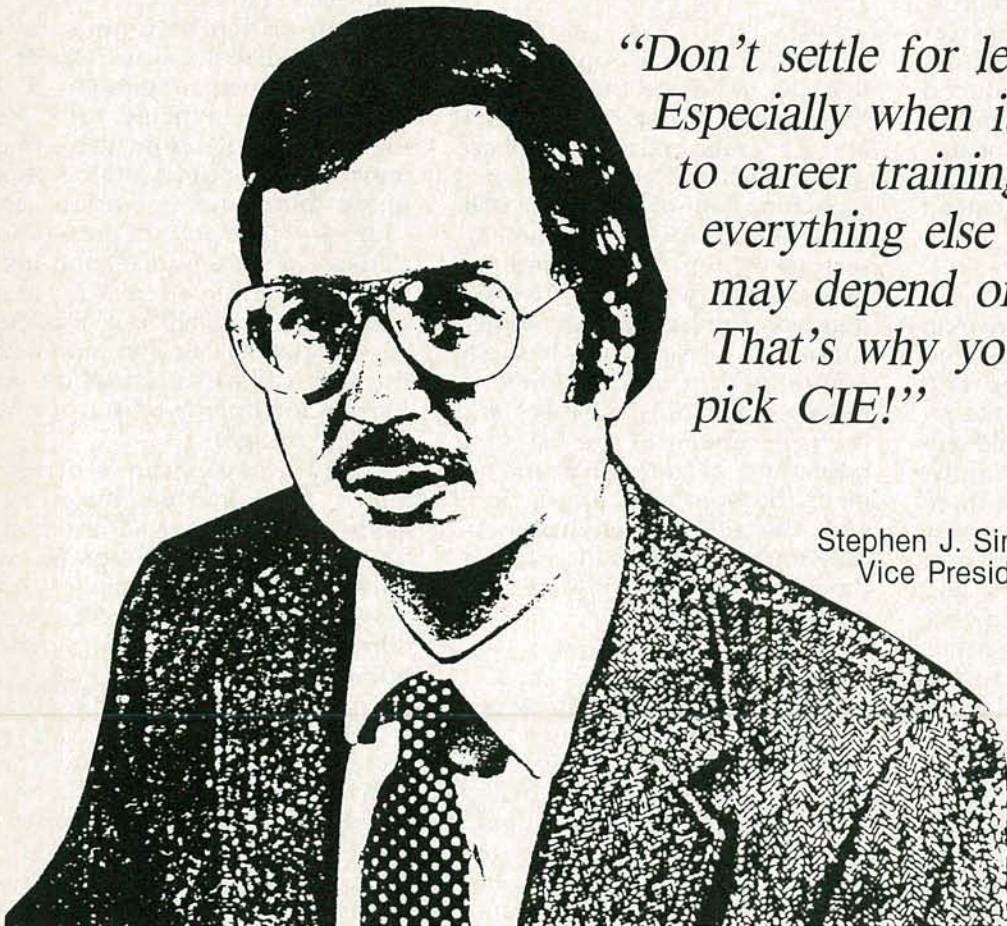
Some critical listeners have complained that music recorded on compact discs frequently lacks depth when compared with LP's that were made from the same masters. It could well be that phase anomalies in phono cartridges—which are not present in CD laser pickups—are responsible for the differences heard. Such enhancing crosstalk can also occur accidentally in a component through capacitive coupling on the circuit board, or purposely through design.

Frequency-response differences, particularly small ones, heard during critical A/B listening tests are frequently interpreted as differences in depth, openness, or "air," rather than as tonal-balance differences. For example, a small bump in frequency response at about 300 Hz (which is where the reverberant energy in a recording is concentrated) may contribute to subjectively-enhanced depth. And many moving-coil cartridges—and some electronic components—have had a rising high-end response that is frequently inter-

*continued on page 38*



“If you’re going to learn electronics, you might as well learn it right!”



*“Don’t settle for less.  
Especially when it comes  
to career training...because  
everything else in your life  
may depend on it.  
That’s why you ought to  
pick CIE!”*

Stephen J. Simcic  
Vice President, Academic Affairs

**Y**ou've probably seen advertisements from other electronic schools. Maybe you think they're all the same. They're not! CIE is the largest independent home study school in the world that specializes exclusively in electronics.

### Meet the Electronics Specialists.

When you pick an electronics school, you're getting ready to invest some time and money. And your whole future depends on the education you get in return.

That's why it makes so much sense to go with number one . . . with the specialists . . . with CIE!

### There's no such thing as bargain education.

If you talk with some of our graduates, chances are you'd find a lot of them shopped around for their training. Not for the lowest priced but for the best. They pretty much knew what was available when they picked CIE as number one.

We don't promise you the moon. We do promise you a proven way to build valuable career skills. The CIE faculty and staff are dedicated to that. When you graduate, your diploma shows employers you know what you're about. Today, it's pretty hard to put a price on that.

### Because we're specialists we have to stay ahead.

At CIE, we've got a position of leadership to maintain. Here are some of the ways we hang onto it . . .

### Programmed Learning

That's exactly what happens with CIE's Auto-Programmed Lessons. Each lesson uses famous "programmed learning" methods to teach you important principles. You explore them, master them completely, before you start to apply them. You thoroughly understand each step before you go on to the next. You learn at your own pace.

And, beyond theory, some courses come fully equipped with electronics gear (the things you see in technical magazines) to actually let you perform hundreds of "hands-on" experiments.

### Experienced specialists work closely with you.

Even though you study at home, you are not alone! Each time you return a completed lesson, you can be sure it will be reviewed, graded, and returned with appropriate instructional help. When you need additional individual help, you get it fast and in writing from the faculty technical specialist best qualified to answer your question in terms you can understand.

### Pick the pace that's right for you.

CIE understands people need to learn at their own pace. There's no pressure to keep up . . . no slow learners hold you back. If you're a beginner, you start with the basics. If you already know some electronics, you move ahead to your own level.

### Enjoy the promptness of CIE's "same day" grading cycle.

When we receive your lesson before noon Monday through Saturday, we grade it and mail it back the same day. You find out quickly how well you're doing!



Microprocessor Trainer

### State-of-the-art Laboratory Equipment

Some courses feature the CIE Microprocessor Training Laboratory. An integral part of computers, microprocessor technology is used in many phases of business, including service and manufacturing industries.

The MTL gives you the opportunity to program it and interface it with LED displays, memory devices, and switches. You'll gain all the practical experience needed to work with state-of-the-art equipment of today and tomorrow.

### CIE offers you an Associate Degree.

One of the best credentials you can have in electronics — or any other career field — is a college degree. That's why CIE gives you the opportunity to earn an Associate in Applied Science in Electronics Engineering Technology. Any CIE career course can offer you credit toward the degree — more than half of the number needed in some cases.

*"Cleveland Institute of Electronics is the only accredited institution of higher learning offering an Associate Degree program with tuition based on actual study time used. The faster you complete your degree assignments, the less your overall tuition."*

Steve Simcic  
Vice-President Academic Affairs

### Which CIE Training fits you?

Beginner? Intermediate? Advanced? CIE home study courses are designed for ambitious people at all entry levels. People who may have:

1. No previous electronics knowledge, but do have an interest in it;
2. Some basic knowledge or experience in electronics;
3. In-depth working experience or prior training in electronics.

You can start where you fit and fit where you start, then go on from there to your Diploma, Associate Degree, and career.

### Today is the day. Send now.

Fill in and return the postage-free card attached. If some ambitious person has removed it, cut out and mail the coupon. You'll get a FREE school catalog plus complete information on independent home study. For your convenience, we'll try to have a CIE representative contact you to answer any questions you may have.

Mail in the coupon below or, if you prefer, call toll-free 1-800-321-2155 (in Ohio, 1-800-523-9109).

ARE-72

# CIE

**Cleveland Institute of Electronics, Inc.**  
1776 East 17th Street, Cleveland, Ohio 44114  
Accredited Member National Home Study Council

YES...I want to learn from the specialists in electronics — CIE. Send me my FREE CIE school catalog...including details about the Associate Degree program... plus my FREE package of home study information.

Print Name \_\_\_\_\_

Address \_\_\_\_\_ Apt. \_\_\_\_\_

City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_

Age \_\_\_\_\_ Area Code/Phone No. \_\_\_\_\_/\_\_\_\_\_

Check box for G.I. Bill bulletin on Educational Benefits:  Veteran  Active Duty

**MAIL TODAY!**

**CIRCLE 60 ON FREE INFORMATION CARD**

Put a  
test lab in  
your tool pouch.



### The Fluke 8060A 4½-digit handheld multimeter.

It's the best tool you could add to your tool pouch, because it lets you troubleshoot more ... with less.

This portable, powerful instrument has a unique combination of features not available in any other handheld DMM.

A simple push of a button on the Fluke 8060A lets you measure frequencies to 200 kHz, make relative offset measurements, convert voltages to direct reading decibels, or conduct audible continuity tests. Plus the 8060A offers wideband True RMS ac measurement capability to 100 kHz.

So say goodbye to your part-time counters, oscilloscopes, continuity testers, calculators and power supplies. And welcome a full-time professional that'll be there when you need it.

You'll find that for troubleshooting everything from motor controls to data communications equipment, the Fluke 8060A is the best multimeter value going.

Find out more by calling our toll-free hotline **1-800-227-3800, ext. 229**, day or night. Outside the U.S. call 1-402-496-1350, ext. 229.

FROM THE WORLD LEADER  
IN DIGITAL MULTIMETERS.



© 1986 Fluke

## AUDIO UPDATE

continued from page 33

interpreted as "airiness" and increased depth.

### Hiss

Also related is the fact that a *small* amount of *stereo noise* (random hiss) added to otherwise-clean program material can add to the subjective appearance of airiness of the stereo image.

I wasn't aware of the hiss-equals-highs phenomena until it was brought to my attention by Bob Carver, many of whose designs have shown an in-depth awareness of psycho-acoustics. When, during a demonstration of a prototype of his "autocorrelator" noise-reduction system many years ago, I complained about a slight loss of highs, he didn't seem to be surprised or upset. He simply used an external white-noise generator to add a touch of hiss to the cleaned up signal—and the "lost" high-frequencies subjectively reappeared!

He then mentioned that there was early resistance to the Dolby professional noise-reduction system because the reduction of tape hiss resulted in a subjective dulling of the program material. It recently occurred to me that some of today's complaints about the "closed-in" quality of CD's might also arise from their inherent lack of background noise.

### Speaker spatiality

As long as I can remember, there have been disagreements, even among equally learned and experienced speaker engineers, about the optimum radiation patterns for a home speaker. In other words, what is the best (most realistic sounding) way for a speaker to deliver its sounds into a room? In my view, the question is so difficult—and provokes so many different answers—because of the essential *artificiality* of the stereo-reproduction process.

When I discussed the matter in earlier columns, I pointed out that nowhere in nature do you find the illusion of a localized *single* sound source generated by the level and phase cues in the sound coming

from *two* widely spaced sound sources (speakers). It is really no wonder then that speaker engineers disagree in their design approaches.

In past columns I've described in detail how phase and level cues are used by the ear/brain mechanism to localize the source of a sound in real life. Stereo reproduction attempts to use those same psycho-acoustic cues to construct a sonic illusion, but the essential artificiality of the process gets in the way. Speaker designers have been manipulating speaker dispersion in a rather hit-or-miss fashion for years in an attempt to achieve greater realism. You will find speakers with drivers facing every which way, including away from the listener, all in an effort to generate the phase, level, and arrival-time cues that the ear/brain uses to construct an acoustic image. The fact that each speaker ultimately must operate in an acoustic environment that is unknown to the speaker designer tremendously complicates the matter.

Audiophiles tend to disagree as to the "best" speakers in respect to their imaging properties. Assuming that none of the speakers argued about are specifically designed for special properties, I think that the disagreements simply reflect an (usually) *accidental* fortuitous match of dispersion characteristics of a particular pair of speakers, their location, and the reflective characteristics of the listening room. Those same speakers in a different room or location might not sound as good.

In the past two or three years two companies (Acoustic Research and dbx) have addressed the speaker-radiation/room-environment problem from a scientifically analyzed psycho-acoustic/acoustic perspective. The result is a substantial enhancement of the spatial realism of several of their systems, one of which, the dbx *SF-10*, is shown in Fig. 1. I think the audio industry is finally getting around to appreciate that creating a realistic stereo illusion in a home environment takes something more than two channels of stereo feeding a pair of conventional forward-facing speakers. **R-E**

# ANTIQUERADIOS



RICHARD D. FITCH

## Restoring a classic, part 2

LAST TIME WE LOOKED IN DETAIL AT THE schematic for one of the most popular radios of its time, the GE A-53. See *Radio-Electronics*, June 1987. As I mentioned, I've had one of those units in my collection for quite a while, but have never attempted to restore it, until now. To show how a typical restoration task might go, we'll restore that radio together now. But first, let's finish up with the circuit.

### Back to the circuit

For space reasons, we were not able to finish up our look at the schematic in the June issue. I'll rectify that problem now. Incidentally, you will likely want to have that figure ("Antique Radios," June 1987, Fig. 1) handy as we proceed, and you will certainly want it when we turn to the restoration itself.

Plate and grid voltages are supplied by a 5Z4 rectifier tube. The output of the tube is fed to L16, the field coil. The field coil serves two purposes: First of all, it is the loudspeaker's electromagnet (permanent magnets were not used in early speakers). Secondly, it works as a choke, filtering the output of the power rectifier. That was a typical design for the period.

Power transformers for the GE Model A-53 (and many other) receivers require some added caution. There were three possible transformers that could have been installed in this chassis, depending on the requirements of the area where the set was sold. Transformer information is usually available on a sticker at the rear of the chassis. In the case of my set, information indicated that it was a universal transformer. The trans-

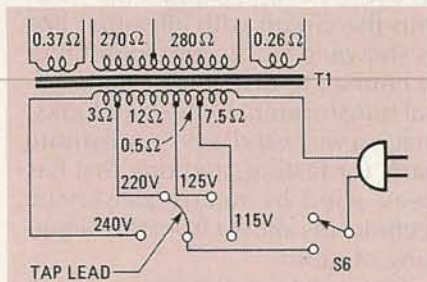


FIG. 1

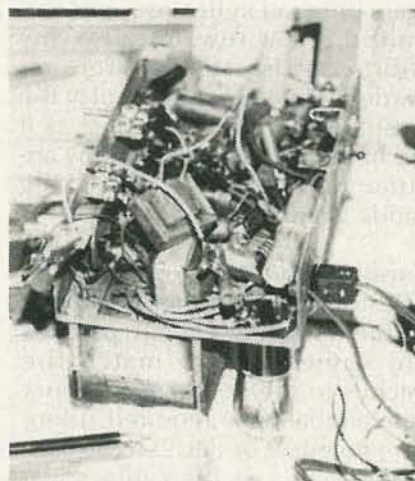


FIG. 2

former is shown schematically in Fig. 1. By properly tapping the unit, output voltages from 115 to 240 volts were available. Again information indicated that my transformer was set up for 115 volts.

### Troubleshooting

Of course you realize that we have been afforded a rare luxury with this set. Often I don't even have the complete tube layout, let alone a schematic and the original factory specifications. That's one reason the set was chosen—it made an ideal "first-time" project.

Now that we are familiar with the

chassis, we can proceed with returning the radio to operating condition. But first we must make sure that restoration is possible and worthwhile. Following the safety rules I outlined last time, the set was plugged in and turned on. All of the glass envelope tubes lit except the rectifier (5Z4). A slight movement of the tube in the socket brought that tube to life. The set was one of the first to use metal-envelope octal tubes. To tell whether or not those tubes were lit required touching each one *carefully*. The touch test told me that they were lit. Despite that, only a slight hum could be heard emanating from the electrodynamic loudspeaker.

I next made a few attempts to inject a signal via the antenna terminals and then the grid caps, but with no luck. Changing the position of the toggle switch that was added at the rear apron produced the same result. The missing band switch was discounted as the cause of the problem because even if the unit had been reduced to a simple phono amp, it should still pass a signal.

My past experience with similar radios told me that a likely place to look for the cause of the trouble is somewhere between the plate of the output tube, here a 6F6, and the speaker coil. I unplugged the unit to make a few continuity tests. The speaker was also unplugged from the chassis. My tests showed that the voice coil and the secondary winding of the output transformer, which on this set is located under the chassis, were both fine.

At this point, we've done about all we can do without pulling the

chassis. That's because several components, including the the first and second IF transformers, as well as the circuit alterations, are located under the chassis. A good sign was that the chassis bolts and the (remaining) front-panel knobs were firmly in place. That indicates to me that this set was operable after the alterations were made, even if just as some kind of amplifier. Human nature, being what it is, no one would bother to tighten the bolts on something that was not working.

Examining the underside of the chassis, after removal, showed that it was clean and neatly done. I didn't even need my handy can of insecticide. In short, there was no obvious reason why the set shouldn't pass a signal. Plugging in the speaker and the line cord, I took a few voltage readings at the output tube. That voltage didn't correspond to what was indicated in the specifications (having those numbers was truly a luxury), so I unplugged the set once again; it was time for some more probing.

Still working in the same area first suspected, one more continuity test located the problem: It was an open in the primary winding of the output transformer.

No, I don't have a new transformer for that set in my stock. Also, all of the suppliers were closed at that late hour. However, I was obsessed with getting the set to play that night so I went searching through my junkbox (I never throw any old parts away). Luckily, I found one that was almost a perfect match.

I laid the substitute in the chassis of the GE, and clipped the wires into the circuit with alligator clips as shown in Fig. 2. (Not forgetting, of course, to disconnect the original transformer.) Crude as it looks, that is a very valid way to substitute parts for testing, and one that has been used by nearly all service technicians almost from the beginning of radio.

After making the proper connections and disconnections, I again plugged in the line cord and waited. In a few minutes my efforts and frustrations were rewarded. The set began to play the music of the big bands, just as it did in the 1930's. (I tune all my antique radios to the local "big bands" station.)

#### Finishing touches

Restoring the cabinet was no big problem. A few veneer patches and some stain to match the patches to the rest of the cabinet were all that were required. There were no inlays or decals to be concerned with, so the cabinet just got a light sanding. The sanding has to be done with extreme care, however. The finish layer of veneer is often no thicker than the paper that this page is printed on. Once you sand through that finish, it's harder to cover up than a hole.

I decided not to bother replacing the missing bandswitch. In its place an almost-matching knob was bolted to the front of the cabinet to maintain at least a look of authenticity.

To finish restoring the chassis, the test output transformer will be bolted in place of the original, or a suitable new one will be used. The tubes will all be tested and all the

tube sockets will be cleaned. The toggle switch and the jack will be removed from the rear of the chassis. That will leave two holes on the rear of the chassis, as well as a dummy bandswitch knob on the front of the cabinet. Just think, 50 years from now some future radio restorer will get his hands on the set and wonder what was in all of those holes, and what kind of modifications were made.

But he won't have to wonder for long. I intend to attach full information on the set to the inside of the cabinet. Included will be details on all alterations and circuit changes that were made by me, and others before me. Leaving information on circuit changes for future servicers is an important habit to get into, and one that has been observed almost from the start. Don't be surprised to find parched, hand-drawn diagrams rolled up inside your antique radio. All early well-trained hobbyists and servicemen followed that procedure.

#### Some closing notes

Tube-socket terminals are one of the prime causes of wiring shorts in antique radios. Wires are dressed along their sharp edges, and over the years that causes breaks in the insulation. If you find that situation, at least bend the wire away from the terminals. Or, even better, you could replace the wire, put a piece of spaghetti tubing over it, or coat it with some liquid high-voltage insulation.

Finally, in the course of our poking around the set we discovered that a wave-trap had been installed between the antenna (blue) and ground (white) leads. That was done in the 1930's and indicated that the owner was located near a powerful telegraph station. Without those traps, the code signals would have overpowered the receiver and would be heard over the entire band. It's fairly common to find such filters on receivers of the period.

Much of the procedure we followed can be applied to any depression-era radio. Of course, things just happen to work out better sometimes than others: I'd say I lucked out on this set. **R-E**

#### Get A Complete Course In

## ELECTRONIC ENGINEERING

8 volumes, over 2000 pages, including all necessary math and physics. 29 examinations to help you gauge your personal progress. A truly great learning experience.

Prepare now to take advantage of the growing demand for people able to work at the engineering level.

Ask for our brochure giving complete details of content. Use your free information card number, or write us directly. **\$99.95**, Postage Included. Satisfaction guaranteed or money refunded.



**Banner  
Technical  
Books, Inc.**

1203 Grant Ave.  
Rockford, IL 61103

CIRCLE 181 ON FREE INFORMATION CARD

# DESIGNER'S NOTEBOOK

## An under-voltage monitor



ROBERT GROSSBLATT,  
CIRCUITS EDITOR

JUDGING BY THE RESPONSE I'VE GOTTEN to October's circuit, there are a lot of you out there who are interested in ways to keep an electronic eye on the state of your batteries. We've already seen how to watch out for excessive voltages, so I guess it's only right to take a look at the other side of the coin—under-voltage indicators.

Just as it is with over-voltage monitors, there are lots of ways to go about designing a circuit to make sure that an input voltage is greater than a particular preset value. As a matter of fact, I've described a few of them in the past. The reason I've decided to talk about it again this month is not only to show you a neat little circuit, but also to demonstrate how a few small changes can let a circuit do two apparently opposite jobs.

The circuit shown in Fig. 1 is really made up of two separate sections. The first is the familiar 7805 regulator and the second is, well, everything else. If you have a copy of October's column handy, you'll find it interesting to compare the circuit there with the one shown here. The basic idea behind the over-voltage indicator was to let the Zener diode look at the voltage and start conducting if it exceeded the Zener voltage. As soon as that happened, the Zener would turn on a transistor, making its collector go low and lighting an LED.

The schematic in Fig. 1 uses the same design approach, but the Zener diode is used in exactly the opposite fashion. As long as the voltage stays above the Zener's

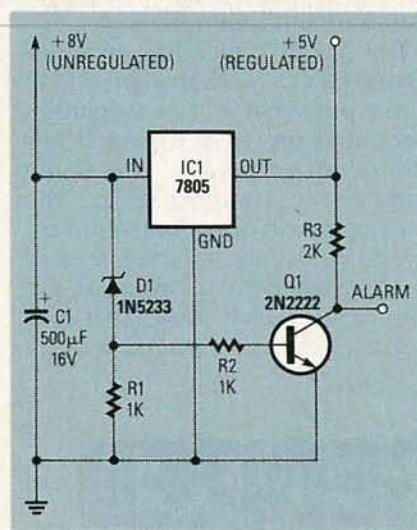


FIG. 1

threshold voltage, the collector of Q1 is kept low. If the unregulated voltage falls below 6.7, the Zener will turn off and Q1's collector will go high. That's 6 volts for the Zener plus the normal 0.7-volt drop across the transistor's emitter-base junction.

I've shown the circuit working in conjunction with a 7805 since it's often very convenient to detect a power drop before it makes itself known in the actual circuit. It is useful to watch the unregulated voltage since there will be a finite time before it gets so low that the regulator turns off. A 7805 will continue to put out 5 volts as long as the input voltage stays above about 7.5 volts. The reason I've set this circuit to trip at 6.7 volts is to guard against any false triggering.

Heavy current demands in other parts of the circuit can cause a

transient drop on the unregulated voltage. Those are handled by C1, a 500- $\mu$ F unit that stores enough energy to supply the 7805 during the transient voltage drop. When the unregulated voltage really starts to fall to zero, C1 will discharge and the voltage at the input of the regulator will start sliding down to zero. Once it gets below 6.7 volts, the Zener will shut down and the alarm output will turn on. The bottom line here is that if the alarm goes off, you can be sure that your circuit is in real trouble. The alarm output can be used to kick in emergency power, do a quick memory write, turn on a siren, etc.

Although you can use the alarm output to trigger anything you want, it's a good idea to stay away from mechanical relays since it won't be too long before you have no power at all. The actual time you will have depends on the circuit you're protecting—how much current it draws, total circuit capacitance, and so on. There will likely be enough time to take electronic action, but most mechanical relays will just be too slow. By the time the relay has closed, you'll be out of juice, and out of luck.

### Product of the month

It's time to award another of our highly coveted Silver Soldering Iron awards. This one goes to Teletype Technology, Inc., of Greenlawn, NY, for their RS-232 Mini Analyzer Kit. See Fig. 2. It consists of a model 43 RS-232 line monitor, a model 51 Mini Patch Box, and a bag of colored jumper wires. Both

# Be an FCC LICENSED ELECTRONIC TECHNICIAN!



No costly school. No commuting to class. The Original Home-Study course prepares you for the "FCC Commercial Radiotelephone License". This valuable license is your "ticket" to thousands of exciting jobs in Communications, Radio-TV, Microwave, Computers, Radar, Avionics and more! You don't need a college degree to qualify, but you do need an FCC License.

**No Need to Quit Your Job or Go To School**  
This proven course is easy, fast and low cost! **GUARANTEED PASS** - You get your FCC License or money refunded. **Send for FREE facts now. MAIL COUPON TODAY!**

## COMMAND PRODUCTIONS

FCC LICENSE TRAINING, Dept. 90  
P.O. Box 2223, San Francisco, CA 94126  
Please rush FREE details immediately!

NAME \_\_\_\_\_  
ADDRESS \_\_\_\_\_  
CITY \_\_\_\_\_ STATE \_\_\_\_\_ ZIP \_\_\_\_\_

units are housed in the same type of plastic hoods that are usually used to make null modems and gender changers. Since they each have a female DB-25 connector on one end and a male on the other, they can easily be inserted into most RS-232 lines.

The line monitor, called the *MicroPeeper*, has both red and green LED's on lines 2-6, 8, and 20. The LED's are high-efficiency types, so they're nice and bright. That is important because RS-232-level changes can be very brief and easily can be missed if the LED's are too dim. That is the problem with the less-expensive units that use tri-color LED's rather than separate red and green ones.

The *MicroPeeper* has an unassigned pair of LED's that are tied to a TEST pin. That is a neat feature, since it allows you to watch any other line you want. The seven lines already monitored are the most common ones, but some applications use the RS-232 standard in less than standard ways. Using the Mini Patch Box and the



FIG. 2

*MicroPeeper* together gives you complete control of the routing and testing of the entire RS-232 line. That is valuable when you're trying to troubleshoot a printer line, modem, or finding out whether your computer's UART is working.

The *MicroPeeper* is priced at \$49, and the Mini Patch Box lists for \$25. If you buy them together as the Mini Analyzer Kit for \$74 (model 301) you'll get a plastic carrying case and the bag of wire jumpers as a bonus. If you shop around there's no doubt you'll be able to find a cheaper RS-232 analyzer kit, but not a better one. **R-E**

# NEW RUGGEDIZED SCOPE PROBES

Just a phone call away.

**\$35** P6103

50 MHz 10x  
Compensation Range  
15 to 35 pF

**\$58** P6109

150 MHz 10x  
Compensation Range  
18 to 22 pF

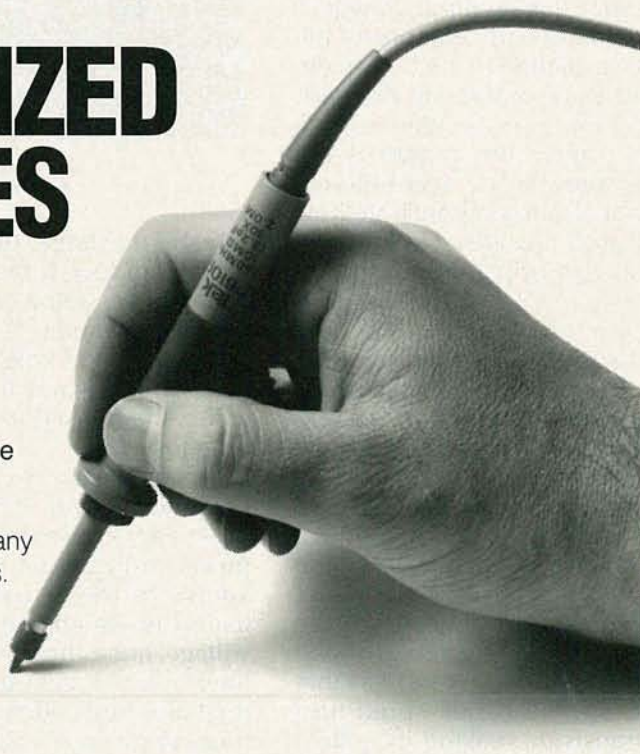
These new passive voltage probes can be used with any oscilloscopes having matching compensation ranges.

Screw in tips mean easy repair, no downtime.

To order call toll free **1-800-426-2200**

In Oregon, call collect (503) 627-9000.

VISA and MasterCharge accepted.

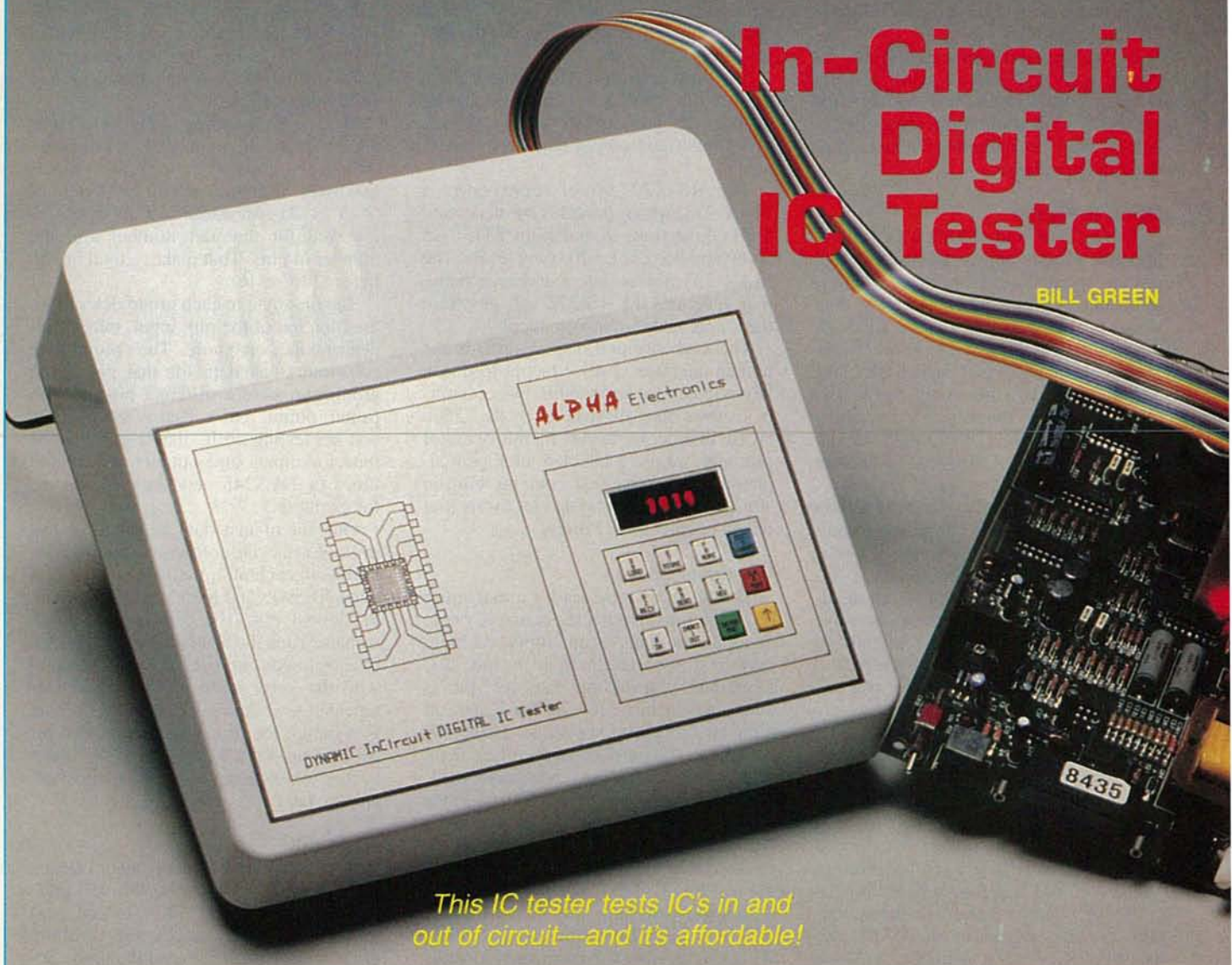


**Tektronix**  
COMMITTED TO EXCELLENCE



## In-Circuit Digital IC Tester

BILL GREEN



*This IC tester tests IC's in and out of circuit—and it's affordable!*

SERVICING DIGITAL ELECTRONIC EQUIPMENT is seldom easy; difficulties arise from several sources. For example, microprocessors, RAM, and ROM IC's are usually socketed, but digital "glue" IC's (gates, flip-flops, etc.) are seldom socketed, because the sockets may cost as much as the IC's themselves.

Not using sockets reduces manufacturing costs, but causes nightmares for the serviceworker. Often, an inexpensive assembly can be discarded and replaced for less than it would cost to repair it. But when a board must be fixed, the headaches begin. For example, how do you locate a bad IC when most or all are soldered to the board?

One way is to remove IC's one by one, replacing each until the board starts functioning again. However, if two or more IC's are bad, the difficulty of locating them increases tremendously. Defect isolation using logic probes, logic analyzers, oscilloscopes, and other equipment can

be performed, but doing so requires a high degree of technical knowledge, which may not always be available. Clearly, a better method is needed.

The in- and out-of-circuit IC tester presented here is such a method. It is a moderately priced device that can test most parts in most TTL families, as well as TTL-compatible MOS and CMOS devices. You use the device by selecting a test routine, clipping a test probe to the *Device Under Test* (DUT), and examining an LED display.

Other IC testers in its price range (\$300 for a complete kit, other configurations available) require a known-good IC of the type to be tested for comparison; ours doesn't. In addition, our tester has enough memory to store 105 different IC test routines, and it has a serial interface to upload and download test routines. Those capabilities allow a field-service technician to load different test set-ups depending on the device he or she will be servicing.

Test routines may be entered by hand on the tester's keyboard or downloaded from any computer with an RS-232 serial port. In addition, routines entered via the tester's keypad may be uploaded and saved for future use. Simple BASIC programs allow you to upload and download test routines. Those programs will appear here, and will be available on the REBBS; the routines run (or can be adapted to run) on many computers, including IBM's and clones, Radio Shack *Models III* and *IV*, the *Color Computer*, Commodore and Apple computers, etc.

### Basic features

The tester has a 12-key keyboard to allow manual entry and editing of test data and commands, and transfer of test data to and from a personal computer. A four-digit sixteen-segment alphanumeric display prompts the user to enter data and displays pin-by-pin test results (both expected and actual data).

External back-up batteries are unnecessary because data and programs are stored in a special non-volatile 32K-byte CMOS RAM IC.

IC's are tested dynamically: inputs are cycled high and low as many as forty times, according to the test routine. That capability allows thorough testing of difficult-to-test parts, including counters, flip-flops, and registers.

### Using the tester

Testing an IC out-of-circuit is straightforward: Simply attach the test clip and run the appropriate test routine, which is selectable by part number. The tester then writes data to the device and reads back the results for comparison. (We'll show you how to generate the test data later.) An out-of-circuit IC is not connected to any other devices, so we needn't worry about input pins of the DUT that might be connected to outputs of the same or another device, or to ground or  $V_{CC}$ .

To test IC's in-circuit, the tester allows for inputs that may be connected to outputs, ground, or  $V_{CC}$  as follows: The tester's output drivers can be floated (i. e., placed in a high-impedance state); in addition, they have enough current drive (both sourcing and sinking) to pull an input high or low (briefly), even if it is connected to an output. Further, you can specify that the test routine ignore any desired pin or pins.

### How it works

All circuitry is contained on two PC boards, which are interconnected by a short length of ribbon cable. One board contains the interface circuitry through which the DUT and the on-board microprocessor communicate. The other contains the microprocessor, the RAM, and the support circuitry, including a 5-volt regulated power supply, an RC reset network, and a 2-MHz crystal-controlled clock. Crystal control is required for precise timing of the serial communications channel. A Z80 microprocessor directs all tester operations.

A major design goal of the tester was the ability to store many test routines, so a large amount of nonvolatile storage is provided by a DS1230 32K byte non-volatile static RAM. The lower 4K of the RAM contains the control program.

The tester's schematic is shown in Fig. 1. It uses several custom CMOS gate arrays for various purposes. Part of IC5 (a 75498) provides the write-enable function. It decodes address lines A12-A14 and disables the processor's write enable signal whenever all three address lines are low, thus preventing corruption of the control program. The remainder of IC5 decodes the input and output strobes for the driver board and the display.

Another custom IC (IC6, a 75500) is the input/output port for the keyboard and

the display. That IC latches the appropriate keyboard row signals and reads the column signals of the keyboard, and it latches the digit address lines for the display.

The third custom IC (IC4, a 75499), is used in the RS-232 I/O channel. The IC decodes the port strobes and latches the serial input and output data and "busy" signals.

The RS-232 driver/receiver is a MAX-233, which provides the necessary level conversions to and from TTL (+5 volts) and RS-232 ( $\pm 10$  volts) levels. The MAX 233 has an internal charge pump that generates the RS-232 voltages from the single-ended five-volt supply.

The keyboard and display provide the human interface. Twelve tactile-feedback keyswitches are arranged in two columns of six rows; they are scanned by the 75500 (IC6). In order to provide legible operator prompts, we use a DL1414 intelligent alphanumeric display. It contains built-in storage, decoders, and drivers for its four red 16-segment LED digits.

### The driver board

The IC tester provides for a maximum of 24 test pins. Each test pin may serve as an input or output; as an output, each pin may be forced either high or low. So, functionally, speaking, each test pin is connected to three IC's in the tester: an input latch, a pull-down driver, and a pull-up driver. The outputs, of course, can be three-stated so that the input can be read.

As shown in Fig. 2, that DUT interface circuit is implemented with nine IC's (IC7-IC15) on the driver board, including three each of the NE590, the NE591, and the 74LS373. The 74LS373's are 8-bit data input latches; the NE590's and NE591's are 8-bit addressable latches with open-collector and open-emitter Darlington output transistors, respectively. The NE590's outputs pull to ground and the NE591's pull to  $V_{CC}$ . Each of the NE590/1 IC's has three address inputs and one data input. The data present at the latter is routed to the internal latch/output circuit decoded by the former when  $\overline{CS}$  and  $\overline{CE}$  are low.

We connect those drivers to the pins of the DUT through P3 by way of a test cable and a DIP header clip. There are 24 test connections, plus power and ground, for a total of 26 pins. You can wire up different test cables for IC's with different sizes and shapes.

An additional ground wire in the test cable is terminated with a miniature clip, which should be connected to ground on the circuit board being tested. The  $V_{CC}$  pin may be terminated in the same manner to supply power to an IC for out-of-circuit testing. The tester's power supply will not supply much current for external circuitry, so the system being tested must have its own power supply.

### Buffer space

Now let's talk about how test data is stored in the tester's non-volatile RAM. First, each test routine takes 256 bytes of memory. In addition to the stored routines, a separate 256-byte buffer is used to store input data.

Next, corresponding to the 24 test pins are 24 "slots" in memory. Each slot consists of five groups; each group contains two bytes. That accounts for 240 bytes ( $24 \times 5 \times 2$ ). An additional 16 bytes are reserved for the part number and the number of pins. That makes a total of 256 bytes ( $240 + 16$ ).

The first byte in each group determines the function of the pin: input, output, indeterminate, or ignore. The second byte constitutes test data for that pin. Each group may have a different pin function (input, output, etc.). That is useful when you are testing an IC that uses the same pins for inputs and outputs at different times (a 74LS245 octal bus transceiver, for example.)

One bit of test data is used per test cycle. Each cycle consists of sending a bit of data to each of eight drivers in each of three NE590's and NE591's, starting with the lowest pin. The drivers latch those signals. Then the level on each pin is read in and stored, one byte at a time, starting with the lower eight pins. The cycle is repeated seven more times, for each byte in a group; the procedure is repeated for each group, for a total of 40 ( $5 \times 8$ ) test cycles. We'll present several practical examples later.

### Assembly

Start assembly by procuring or making the printed-circuit boards. We will present foil patterns in "PC Service next month." Etch the boards and carefully drill the 700 holes. Several hundred connections are made through the board (via plated-through holes), so you will have to make these connections with short pieces of bare wire soldered on both sides.

As shown in Fig. 3, the display may be mounted in one of two positions, depending on whether the boards are mounted in a case or are allowed to "float." If you are using a case, mount it on the foil side of the PC board in the area outlined with dashed lines in the diagram. Otherwise, mount the display on the component side of the board in the area that is outlined with solid lines.

Similarly, if you use a case, the push-buttons must also mount on the foil side of the board. In that case, the key legends must be reversed left to right.

If you use a case, install the keyswitches first. Lay the board on a flat surface, foil side up. Orient each switch so that the flat sides on each is toward the Z80. The keyswitches are colored differently: the 0-8 switches are white; the ENTER switch, green; the SHIFT key ('),

FIG. 1—THE IC TESTER'S MAIN BOARD is built around a Z80 microprocessor running at 2 MHz.

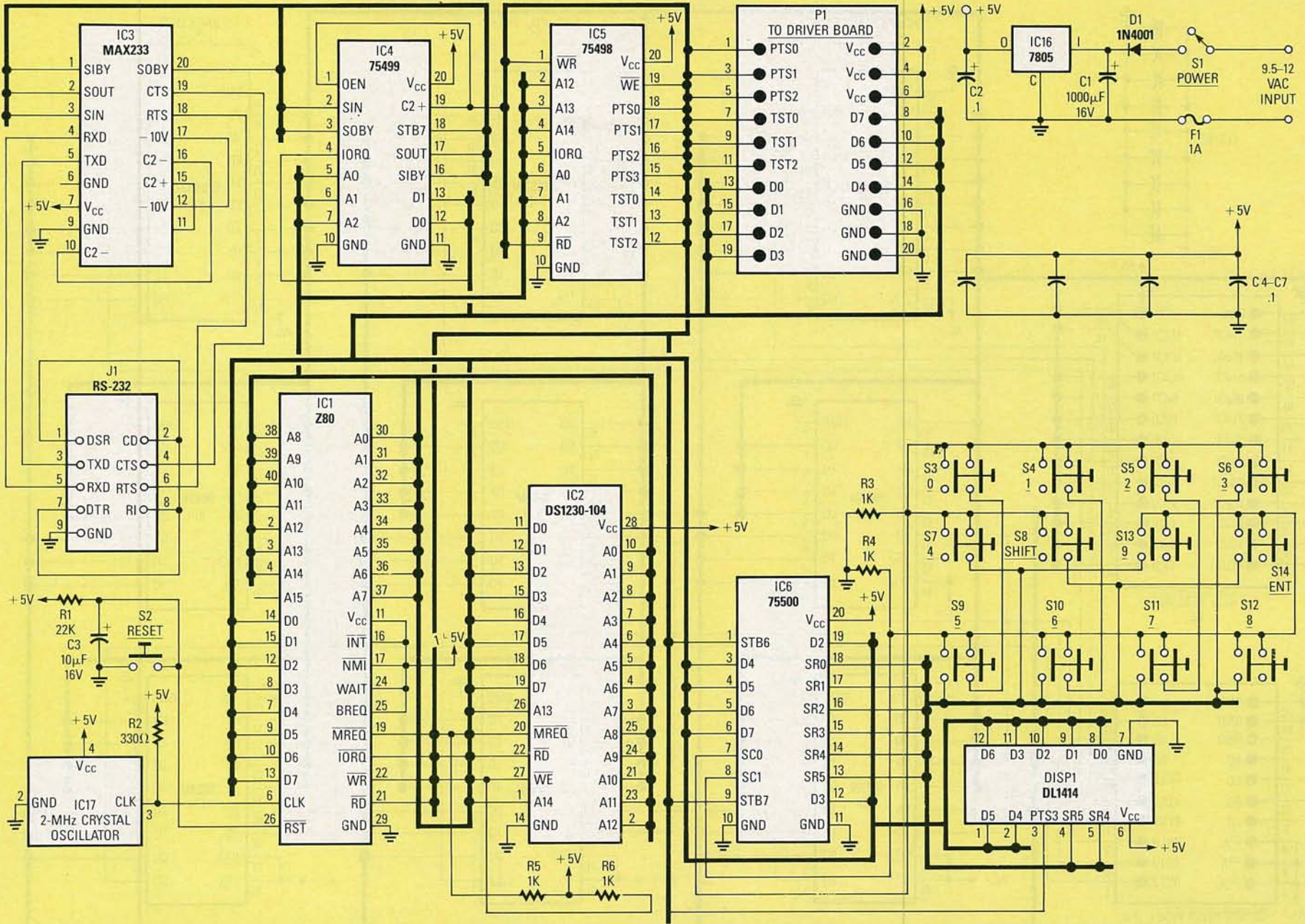
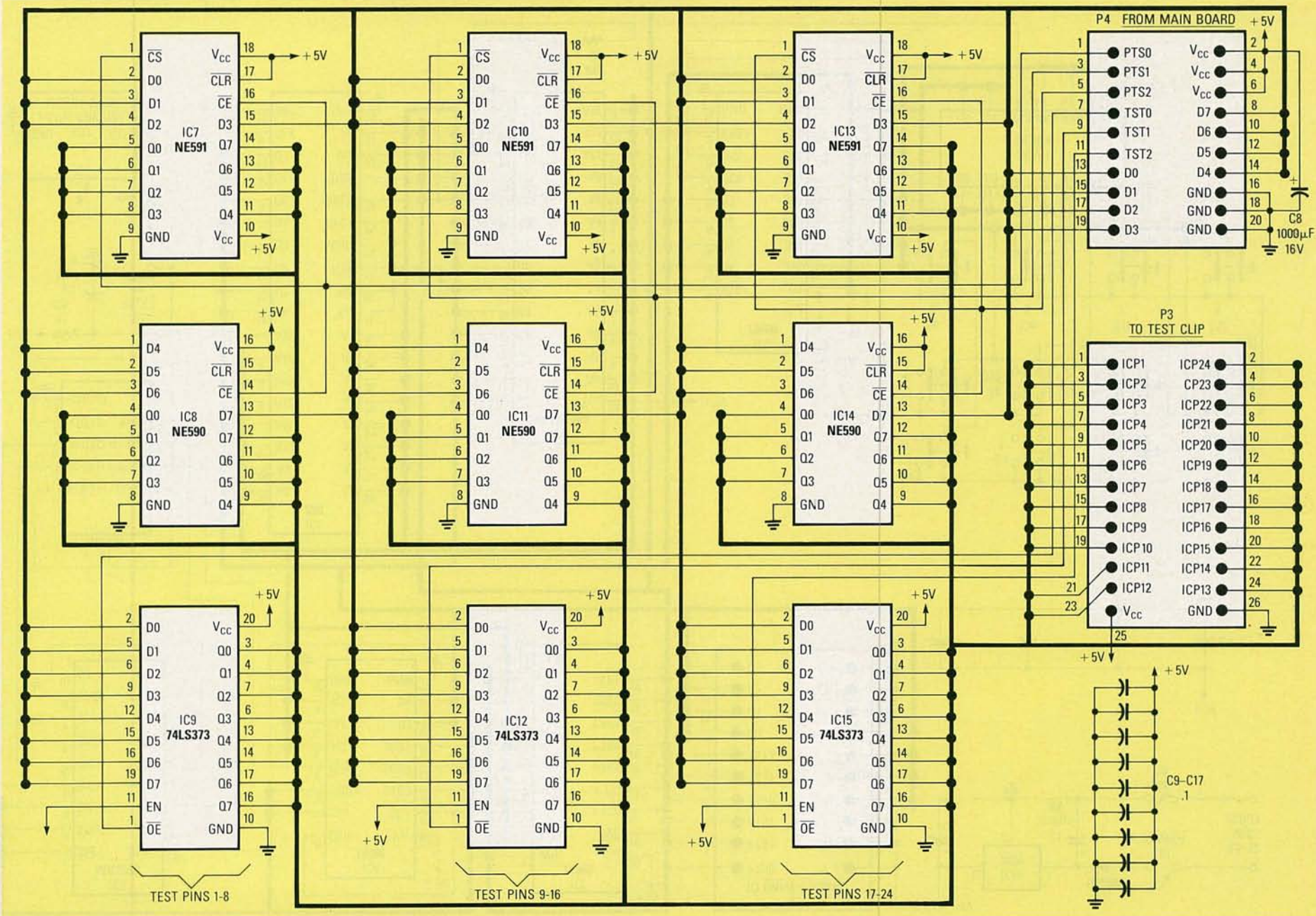
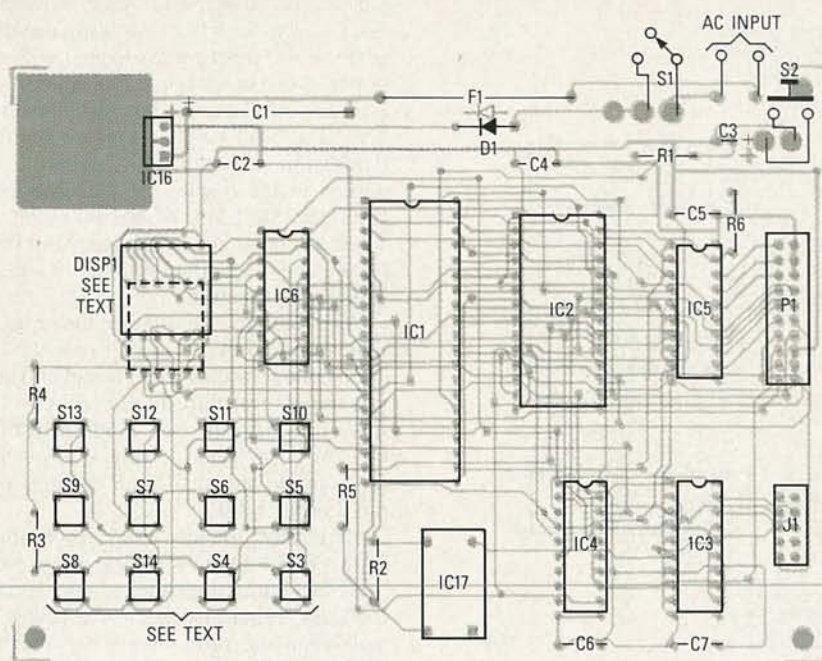


FIG. 2—THE IC TESTER'S DRIVER BOARD provides separate inputs, sourcing outputs, and sinking outputs for each of 24 test pins.





**FIG. 3—STUFF THE MAIN BOARD** as shown here. Mount the display and switches S3–S14 on the foil side if you will install the tester in a case. Note that the display is oriented differently depending on whether or not the tester is installed in a case.

yellow; the 5 key, red, and the 9 key, blue. Select the proper color and install and solder one pin of each switch from the solder side of the board. Then turn the board over and solder the remaining three pins of each switch from the component side. Mounting the keyswitches that way lifts them off the board enough to protrude through the panel of the case. Now install the 12-pin display socket made from a 24-pin IC socket that has been cut in half.

When not using a case, the keyswitches are installed on the component side of the board and are not spaced away from the board. To mount the power and reset switches on the board, you'll have to enlarge the holes indicated in the parts-placement diagram.

The remainder of the instructions apply to both case and case-less installation. Install the IC the sockets on the component side of both boards next, followed by the remaining components, starting with the low-profile devices.

Be sure to orient the electrolytic capacitors, the diode, the clock module and the voltage regulator (IC16) correctly. It is installed so that its metal tab will contact the foil area of the PC board. To provide extra heatsink capacity, you want to slip a clip-on heatsink on the regulator.

Next mount the male header strips on both boards. (See Fig. 4.) Connect the power and reset switches to the board with 10-inch insulated wires (or directly to the board if you're not using a case). Connect the leads of a 9–12-volt AC, 1-amp wall-mount power transformer to the board. **Do not install any IC's yet.** Connect the driver board to the main board with an 8-inch, twenty-conductor ribbon cable ter-

minated on each end with a twenty-pin female header.

**CAUTION!** At this point it is possible to erase the control program in the CMOS RAM. For example, if there is a solder short on the board in the right place, the write-protect function of the 75498 will be defeated. Or the write enable pin on the RAM may be shorted to ground, allowing just about anything to be written to the IC. To prevent that from happening, use an ohmmeter or continuity tester to ensure that there are no connections between the following pins and ground,  $V_{CC}$ , or any nearby traces on the board: IC5, pins 1, 2, 3, 4, and 19; IC2, pins 20, 27, and all of the address lines, and IC1 pins 20, 21, and 22. Fix any shorts before proceeding.

Measure the output of the regulator; it should be +5 volts,  $\pm 0.25$  volt. Assuming it's correct, insert the clock module, and check pin 3 for a 2-Mhz squarewave. Now remove power from the board and allow a minute for the filter capacitors to discharge. Being careful to observe proper procedures to avoid static damage to the MOS (Z80) and CMOS (RAM, MAX233, 75498, 75499 and 75500) IC's, install all IC's in their sockets properly oriented. A square foil pad on the board indicates pin 1 of all IC's. Pin one of the display is marked with a small triangle.

When you're certain that all parts are installed correctly, in the correct place, with no pins bent under any of the IC's, and so on, apply power again. The word *COMMAND?* should scroll across the display repeatedly. If it does, you are ready for final assembly. Turn power off and unplug the transformer.

#### PARTS LIST

All resistors are 1/4-watt, 5% unless otherwise noted.

R1—22,000 ohms  
R2—330 ohms  
R3–R6—1000 ohms

#### Capacitors

C1, C8—1000  $\mu$ F, 16 volts, electrolytic  
C2, C4–C7, C9–C17—0.1  $\mu$ F, 10 volts, ceramic disc  
C3—10  $\mu$ F, 16 volts, electrolytic

#### Semiconductors

IC1—Z80 microprocessor  
IC2—DS1230-104 32K nonvolatile RAM  
IC3—MAX233 RS-232 interface  
IC4—75499 custom decoder  
IC5—75498 custom decoder  
IC6—75500 custom decoder  
IC7, IC10, IC13—NE591 open-emitter octal driver  
IC8, IC11, IC14—NE590 open-collector octal driver  
IC9, IC12, IC15—74LS373 octal latch  
IC16—7805 5-volt regulator  
IC17—2-Mhz crystal oscillator  
D1—1N4001 rectifier  
DISP1—DL1414 16-segment decoder/driver/display

#### Other components

F1—1-amp pigtail fuse  
J1—9-pin D connector  
P1, P2—right-angle double-row 20-pin male header strips  
P3—right-angle double-row 26-pin male header strips  
S1—miniature SPDT toggle switch  
S2—momentary SPST pushbutton  
S3–S14—momentary SPST keyboard switches  
T1—Transformer, 9.5–12-volts, 1-amp, wall-mount

**Miscellaneous:** One 10-pin, two 20-pin and one 26-pin double-row female IDC header connectors. Two 24-pin single-row female IDC header connectors. Flat ribbon cable, 16-pin, 20-pin and 24-pin DIP test clips, others as desired.

**Note: The following are available from:** ALPHA Electronics Corporation, P.O. Box 1005, Merritt Island, Florida 32952-1005, (305) 453-3534: Kit of parts for \$299.00 + \$6.00 P&H. Includes all parts, punched and screened panel, case, and labeled keys. Test cable and clips not included. Completely assembled tester for \$399.00 + \$6.00 P&H. Includes test cable with 16-, 20-, and 24-pin IC test clips. Partial kit, including all IC's, display, and PC boards for \$199.00 + \$5.00 P&H. Three custom IC's (75498, 75499 and 75500) for \$60.00 + \$4.00 P&H. Florida customers please add 5% State sales tax. Canadian customers please add \$3.00 additional postage to all orders. All foreign orders add appropriate postage for Air shipping and insurance.

#### Final assembly

Using the keyboard layout (shown in Fig. 5) as a guide, label the keyswitches. If you plan to use the board without a case, the arrangement of the keys must be reversed from left to right. If you are installing the tester in a case, you will need

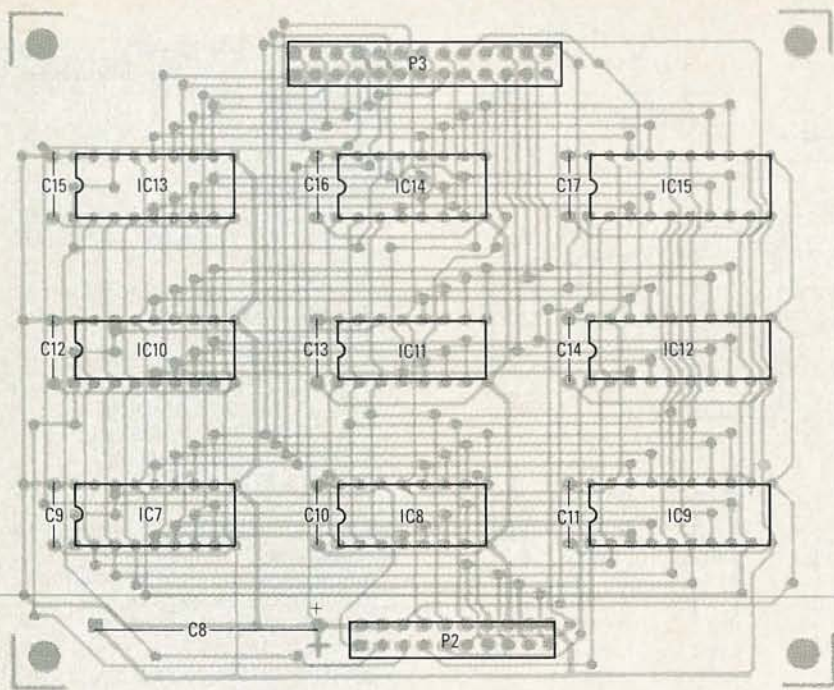


FIG. 4—STUFF THE DRIVER BOARD as shown here. Mount all parts on the component side of the board.

to prepare a front panel for the display and switches; Fig. 6 shows a suitable layout. To protect the display and enhance contrast, install a thin (0.040") plastic bezel inside the panel opening. Then mount the two PC boards to the case.

Using a maximum of three feet of 26-conductor flat ribbon cable, make a test cable. Terminate one end with a 26 pin female header connector. On the other end of the cable separate the 25th and 26th wires. Terminate the 25th wire (+5 volts) with a red test clip, and the 26th wire (ground) with a black test clip. Terminate the remaining 24 wires with two 12-pin single-row female header connectors.

Depending on your needs, you'll want to obtain several IC test clips with different numbers of pins; 16-, 20-, and 24-pin clips will allow you to test 14- and 16-, 18- and 20-, and 24-pin IC's easily. When attaching the test clip to the cable, orient the clip so that pin 1 of the cable connects to pin 1 of the test clip.

If you are going to use the serial port to send and receive files, connect a 10-pin female header connector to one end of a 10-conductor ribbon cable, and a DB9 chassis-mount connector to the other. Mount the DB9 connector on the rear of the case. Also mount the power and reset switches on the back of the case. Wire an interface cable to connect the IC tester's port to that of your computer. RS-232 ports come in many configurations, so you will have to determine which pins are needed for your computer. The tester sends and receives serial data at 1200 baud, no parity, 8 data bits, and 2 stop bits. Pin 4 (CTS) is the transmit busy signal, and pin 6 (RTS) is the receive busy



FIG. 5—LABEL THE KEYS as shown here for installation in a case. Otherwise, reverse labels from left to right.

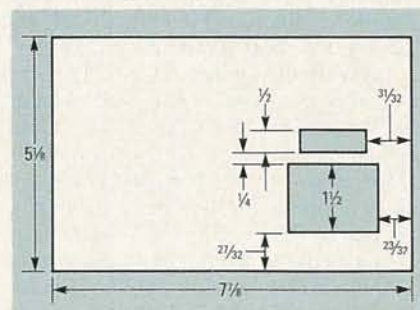


FIG. 6—BASIC DIMENSIONS for the front panel.

signal. The tester requires no other signals to work, but your computer's serial port might. On PC-compatibles, try connecting DSR, CD, DTR and RI together.

Finally, put the case together, plug in the test clip cable and the power transformer, and turn the power switch on.

#### Basic test procedure

The following commands are available when *COMMAND* is scrolling in the dis-

play: Load, Store, Send, Recv, New, Test, and Clr. The Shift key (') is always used to perform the function associated with the upper legend on each key. For example, '6 is a "D," used to enter hexadecimal numbers. The Shift key is a toggle. The first depression causes the shift symbol (') to appear in the display; it will disappear when the Shift key is pressed again, or when any other key is pressed. Shift must be pressed each time you want to use a shifted key function.

As a rule, you should turn the tester on first, followed by the circuit to be tested. Then connect the tester's ground clip, and last the IC test clip. If the test clip has more pins than the IC, "bottom justify" the test clip—when testing a 14-pin IC, for example, connect pin 8 of the clip to pin 7 of the DUT.

Here's how to enter a new test routine. With *COMMAND?* scrolling, press New. The input buffer is cleared of any previous test data. (That also occurs at power up and when the reset button is pressed.) *ENTER PART NO.?* will scroll now. You may enter between one and eight numbers or letters, followed by Enter. *ENTER NO. OF PINS?* appears now. You may enter any even number between 4 and 24 inclusive. Press Enter. *TYPE? PNO1* appears. Enter the function of pin 1 by pressing In, Out, Indet, or Ignore, and then the test byte in two hex digits. (We'll show you how to create the test byte later.) For example, *I55, OAA, X* (no data necessary), or *D98*.

After entering data for all pins (or all pins you want to enter data for) press End. The display will ask *MORE OR END?* Unless you wish to enter data for another test group (remember, there are five possible), press End again to indicate you are finished entering data.

The Edit key allows you to back up one pin if you make an error after entering the three (or one if a pin is set for IGNORE) of the test data characters. Each time you press Edit, you back up one pin. The Clear key works any time the tester is expecting a keyboard entry, and pressing that key is functionally the same as pressing the reset button.

Press the Test key after all data has been entered. The IC will then be tested. If it is good, the display will read *IC TESTS GOOD*. Otherwise, *ERROR PN?? GRP? EXP/RD ?????* will scroll across the display for each pin in error, showing the pin number, the group, and the expected and read data. Each question mark in the preceding message will be replaced by a numeral. For example, *ERROR PNO1 GRP 01 EXP/RD 0100* would indicate a problem with pin 1 in test group 1; a "1" was read where a "0" was expected.

Next time we'll show how to send data to and receive data from an external computer. In addition, we'll give several specific examples of how to generate test data for various kinds of IC's. **R-E**

Discover—Explore—Experience  
Today's Electronics With ...

# McGraw-Hill's Contemporary Electronics Series

Now you can meet the challenges of today's electronics quickly and easily. This professional level learning series is as innovative as the circuitry it explains and as fascinating as the experiments you build and explore! And it's for anyone who has an interest in electronics... from the hobbyist to the professional.

## Thousands Have Already Experienced the Excitement!

Today's high-tech world demands an entirely new and innovative approach to understanding electronics. That's why McGraw-Hill has developed this unique "hands-on" learning method that brings to life the dynamics of the new electronics. It's a unique combination of interactive materials that gets you involved as you build and experiment with today's latest electronic circuitry.

Just how well this innovative learning approach meets the challenge of the new electronics is confirmed by those who have already completed the Series... "You have put me right into the middle of an extraordinary learning experience. With each lab exercise I have gained a new understanding of the intricacies of today's electronics." Or... "For me, the Series was just the answer. I felt confident within my specialty, but my grasp of other areas of electronics was slipping away. Your Series helped me upgrade my knowledge of the latest electronics concepts." Or this from a company director of training... "We manufacture sophisticated electronic products, with a lot of people in sales, assembly and purchasing. McGraw-Hill has answered a real need in helping our employees see the total picture. They now communicate with customers and each other more effectively."

## Your Involvement in the New Electronics Begins Immediately.

You master one subject at a time with 15 McGraw-Hill *Concept Modules*, sent to you one

every 4 to 6 weeks. You waste no time on extraneous materials or outdated history. It's an entertaining, lively, nontraditional approach to the most modern of subject matter.

Your very first module takes you right to the heart of basic circuit concepts and gets you ready to use integrated circuits to build a digital oscillator. Then, you'll verify the operation of different electronic circuits using a light emitting diode (LED).

And each successive module brings you up to speed quickly, clarifying the latest advances in today's electronics... from digital logic and microprocessors to data communications, robotics, lasers, fiber optics, and more.

## Unique Combination of Interactive Instruction Materials Make Learning Easy.

Laboratory experiments, vividly illustrated text and interactive cassette tapes all blend together to give you a clear, simplified understanding of contemporary electronics.

With each module, you receive a McGraw-Hill *Action-Audio Cassette* that brings to life the facts and makes you feel as if you're participating in a lively dialogue with experts.

Your ability to quickly make this knowledge your own is further aided by strikingly *illustrated* texts that use diagrams, explanations, illustrations, and schematics to drive home and rein-

force the meaning of each important point. Carefully indexed binders conveniently house all this material, as well as the instructions that will guide you through your "hands-on" lab experiments.

Throughout your Series, *laboratory experiments* reinforce every significant concept. With this essential "hands-on" experience using actual electronic components, you master principles that apply all the way up to tomorrow's VLSI (Very Large Scale Integrated) circuitry.

## Discover, Explore, Experience for Yourself—15-Day Trial.

In all ways, the Contemporary Electronics Series is an exciting learning experience that offers you the quickest and least expensive method available to master today's electronics... and the only one with "hands-on" experience.

To order your first module for a 15-day

trial examination, simply complete the card and send today! If the card is missing, write to us for ordering information.



McGraw-Hill  
Continuing  
Education Center

3939 Wisconsin Avenue, NW  
Washington, DC 20016

# Cable TV

## DESCRAMBLER ARTICLE PARTS

### February 1984 Issue

We stock the parts, PC Board and AC Adaptor for an article on building a cable TV descrambler appearing in *Radio-Electronics*.

#### #701 Parts Package\* ..... \$29.00

Includes all the original resistors, capacitors, diodes, transistors, integrated circuits, coils, IF transformers (Toko BKAN-K5552AXX).

#### #702 PC Board\* ..... \$8.95

Original etched and drilled silk-screened PC Board used in the article.

#### #704 AC Adaptor ..... \$7.95

Original (14 volts DC @ 285 ma) AC Adaptor used in the article.

**FREE reprint with Purchase Above**

#### #708 Toko Coil Set ..... \$6.95

Includes (2) BKAN-K5552AXX, (1) E520HN-300023, (1) 144LY-120K and BFQ-85 Replacement 2SC2369.

### February 1987 Issue

We stock the parts, PC Board and AC Adaptor for an article on a tri-mode cable TV descrambler appearing in *Radio-Electronics*.

#### #301 Parts Package\* ..... \$39.00

Includes all the original resistors, capacitors, diodes, potentiometers, transistors, integrated circuits, LED's, Toko coil (E520HN-3000023) and Plessey Saw Filter (SY-323).

#### #302 PC Board\* ..... \$8.95

Original 5 x 8.8 etched and drilled silk-screened PC Board used in the article.

#### #304 AC Adaptor ..... \$7.95

Original (14 to 18 volt DC @ 200 ma) AC Adaptor used in article.

**Free Reprint with Purchase Above**

#### #308 Plessey & Toko Set ..... \$6.95

Includes (1) Plessey SY323 Saw Filter plus (1) Toko E520HN-300023 Coil.

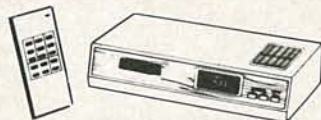
Add \$2.50 Shipping & Handling; \$4.50 Canadian Orders

72-CHANNEL

MC-702 CONVERTER

## CABLE CONVERTER ..... \$79.95

WITH INFRA-RED REMOTE CONTROL



Add \$3.50 Shipping and Handling  
\$4.50 on Canadian Orders

- 72-channel capability
- Wireless, Infra-Red remote control
- Channel output 2 or 3 switchable
- Microprocessor controlled PLL operation
- Skip channel memory eliminates unused channels
- Parental control for all channels
- Last channel recall
- Fine tune memory
- UL listed/FCC approved
- Simple installation with any TV
- Includes battery and 3 foot coax cable

## ORDER TOLL FREE 1-800-227-8529

Inside MA: 617-695-8699

VISA, MASTERCARD OR C.O.D.



\*Not available to Massachusetts residents due to state law.

# J & W ELECTRONICS, INC.

P.O. BOX 800 • MANSFIELD, MA 02048

©copyright 1987 by J&W Electronics, Inc.



# Radio- Electronics



## SURFACE-MOUNT TECHNOLOGY

**AN  
INTRODUCTION  
TO THE  
PACKAGING REVOLUTION**

# SURFACE MOUNT TECHNOLOGY

## 59 INTRODUCTION TO SMT

A new packaging technique, not a new technology, that's forever changing the way that we build electronics circuits.

## 65 INDUSTRIAL SMT ASSEMBLY

How manufacturers are adapting to and using SMT.

## 71 HAND SOLDERING

Soldering SMC's is easy, once you know how!

## 73 SMT PROJECT: LED FLASHER

An attention-grabber that's smaller than a postage stamp.

## 75 SMT PROJECT: LIGHT METER

A bargraph light meter so tiny it can be worn as a charm.

## 77 SMT PROJECT: AN I-R REMOTE ON A KEYCHAIN

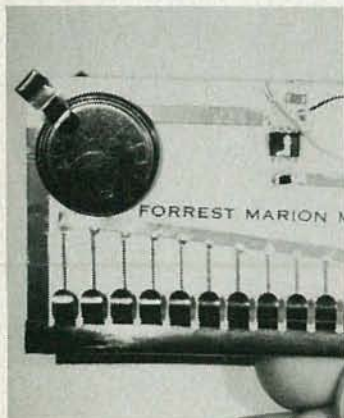
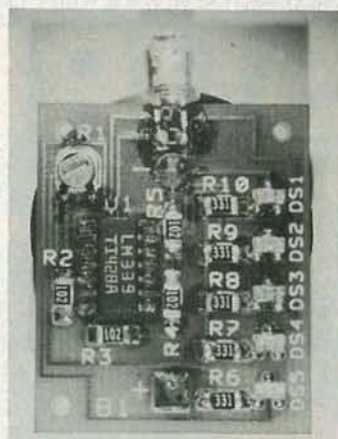
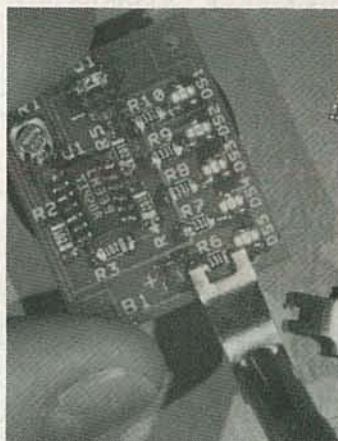
It's so thin, it mounts inside an ID tag!

## 81 CONDUCTIVE INKS AND ADHESIVES

Who needs solder or a PC board?

## 85 SMT PROJECT: A BUSINESS-CARD TONE GENERATOR

Build this circuit on a piece of paper.



# Surface-Mount Technology

*Surface-mount technology is literally changing the shape of electronics manufacturing and packaging.*

## Introduction to SMT

FORREST M. MIMS, III

THE COMPACT SIZE OF MICROCASSETTE RECORDERS, CAM-corders, and credit-card size calculators and radios is not a result of radically new solid-state developments. Rather, those amazingly tiny personal electronic devices are made possible by a clever electronic component packaging and assembly means known as *surface mount technology*.

In *Surface Mount Technology*, or SMT, both components and conductive traces are installed on the same side of a substrate or surface. Many kinds of substrates can be used, including ceramic, paper, plastic, and both rigid and flexible printed-circuit boards.

Though components used for conventional through-hole circuit board assembly can be modified for SMT, the vast majority of SMT components, like those shown in Fig. 1, are considerably smaller than their conventional through-hole counterparts. That means that a circuit assembled with SMT components is much more compact than an identical circuit assembled with conventional components.

Surprising as it may seem, SMT is not a new technology. Its roots can be traced to the development of miniature circuit assemblies in the United States during World War II. Similar techniques were applied to the assembly of circuit boards for

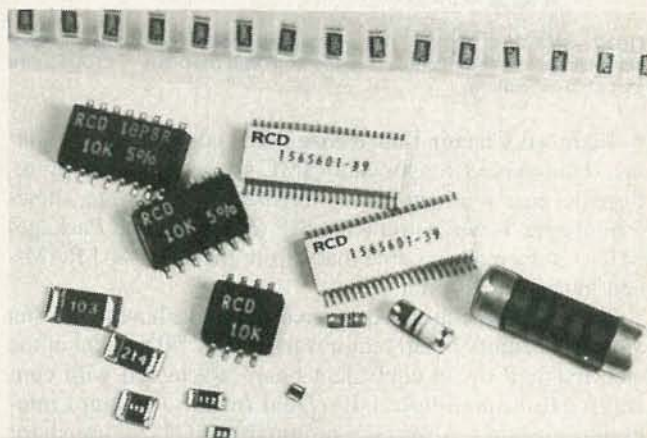


FIG. 1—SURFACE-MOUNTABLE COMPONENTS are supplied in a wide range of miniature package types.

hearing aids. Many of the components and techniques used in the well established field of hybrid microcircuits are used in SMT.

Though SMT has a history at least 30 years long, only in the past decade has it made major inroads in consumer

electronics. In coming years SMT will impact virtually everyone whose career or avocation is electronics. Those who choose not to become familiar with SMT do so at their own peril, for SMT will inevitably replace most conventional circuit assembly methods during the 1990's.

Of course, none of that is news to the electronics technicians who service the personal electronic products mentioned above as well as electronically-controlled 35-mm cameras, pocket and laptop computers, and a host of other products. They have learned, sometimes the hard way, that troubleshooting and repairing SMT circuitry requires different techniques and tools than those used with conventional through-hole circuits.

Engineers, product managers, and entrepreneurs have found that surface-mount technology offers a vitally important means for competing with off-shore electronics manufacturers. Moreover, the economics of SMT are such that circuits can often be produced on-shore using automated production equipment for less money than having them built off-shore.

Finally, SMT provides electronics experimenters and inventors with unprecedented miniaturization capabilities. The proverbial "garage inventor" can now produce functional prototype circuits every bit as tiny as the personal electronic products popularized by the Japanese; and he can produce an SMT circuit in the same time required to produce a conventional circuit.

### Advantages of SMT

The advantages of SMT that we've outlined so far are only some of the reasons the electronics industry is moving so rapidly to SMT. Here is a brief discussion of each of the advantages of SMT:

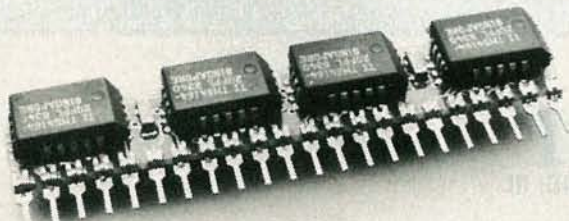


FIG. 2—SMT CAN REDUCE the area of circuit boards. This small Texas Instruments' memory module is made from four SMT 64K × 1 RAM's and four chip capacitors.

• **Reduced Circuit-Board Size**—The compact size of Surface-Mountable Components (SMC's) can substantially reduce the area of circuit boards. Figure 2, for example, shows a miniature Texas Instruments SIP (Single In-line Package) 64K × 4 memory module made from four 64K × 1 RAM's and four chip capacitors.

Texas Instruments and other manufacturers have found that an SMT memory board requires from 30 to 60 percent of the area required by an equivalent board assembled with conventional through-hole DIP (Dual In-line Package) integrated circuits. A surface-mountable SOT-23 transistor occupies only a tenth of the board space of a conventional TO-92 transistor package. A 44-pin surface-mountable PCC (Plastic Chip Carrier) integrated-circuit package occupies only 27.5 percent of the board space required by a standard 40-pin DIP.

A few years ago, TI engineers made an SMT memory board that had been previously assembled with standard

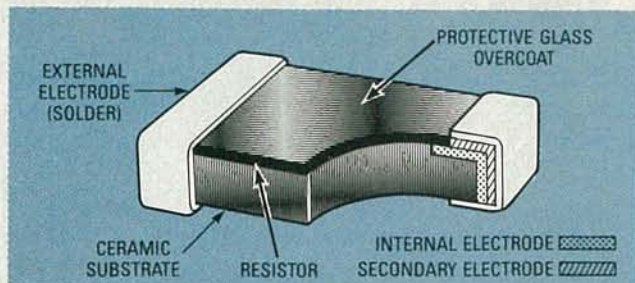


FIG. 3—INSIDE A LEADLESS CHIP RESISTOR. The construction is identical to that of a thick-film resistor deposited directly onto a ceramic substrate.

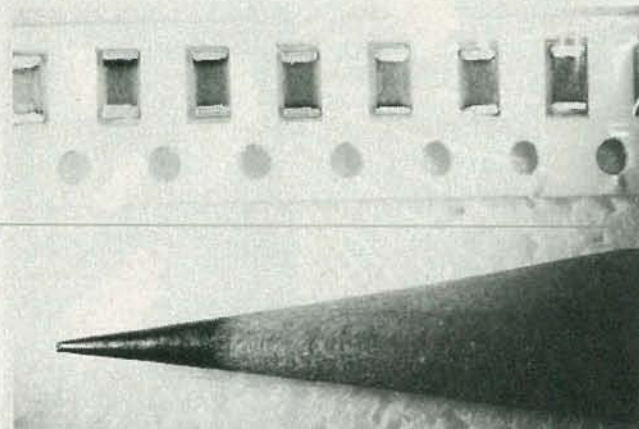


FIG. 4—A STRIP OF CHIP RESISTORS supplied on tape. The pencil point in the photograph is shown for scale.

DIP's. The area of the original board was 152.5 square inches while the area of the SMT version was 62.4 square inches, or only 41 percent of the area of the original board. Ray Prasad, the SMT Program Manager at Intel Corporation, has observed that a 4- × 4-inch board containing half a megabyte of 256K DRAM memory DIP's can contain a full megabyte of surface-mountable DRAM's. If both sides of the board are used, the board can hold 2 megabytes.

SMC's are considerably lighter than their through-hole counterparts. For example, the 8-pin DIP version of National Semiconductor's popular LM308M operational amplifier weighs 600 milligrams. The SO (Small Outline) version of the same IC weighs only 60 milligrams. The low weight of SMC's and the smaller circuit boards they require combine to give typical SMT boards a 5-to-1 weight advantage over conventional boards. Furthermore, the very low profile of SMC's keeps SMT boards very thin and gives them as much as an 8-to-1 volume advantage over conventional boards.

SMT boards are not necessarily used only in highly miniaturized products. Consider, for example, the coming generation of small footprint desktop computers. Those machines will be made possible by 3.5-inch disk drives and SMT. As for add-on peripheral cards, two or more SMT cards will fit in the same space required by a conventional board.

• **Double-Sided Circuit Boards**—Conventional circuits are often installed on boards that have printed or etched wiring on both sides. Plated-through holes provide interconnections between the two sides of the board.

SMT can also make use of double-sided boards but with a new twist. Components can be installed on *both* sides of an SMT board, thereby greatly increasing the savings in space over boards assembled with conventional components. Since many SMC's have a much lower profile than conventional components, an SMT board having components on *both*

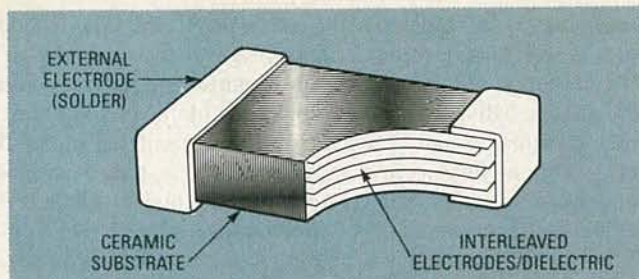


FIG. 5—INSIDE A CERAMIC CHIP CAPACITOR. The device is a sandwich of interleaved metal film and dielectric layers.

#### MONOLITHIC CERAMIC CHIP CAPACITORS

X7R/BX

COG (NPO)

0805 1206 1210 1808 1812 1825

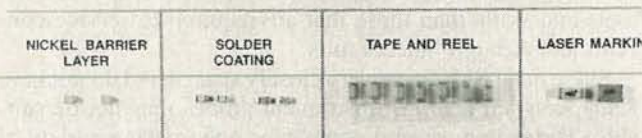


FIG. 6—CHIP CAPACITORS, like these from American Precision Industries, come in a variety of sizes and values.

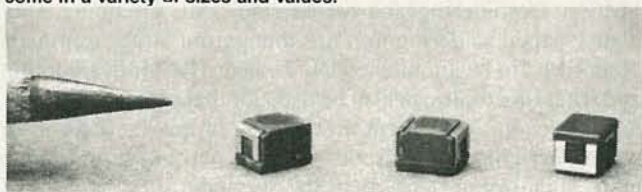


FIG. 7—SMT INDUCTORS are available in values that range from a few tens of nanohenries to one millihenry.

sides can be thinner than a board assembled with conventional components.

- **Subminiature Circuits**—SMT is a spinoff of hybrid microcircuit technology, and some SMT circuits are nearly as tiny as their hybrid cousins. Moreover, subminiature SMT circuits are considerably cheaper than hybrid circuits and prototypes can be assembled in as little as a day using inexpensive assembly tools. Now engineers, technicians, and experimenters can assemble tiny circuits on a low budget and without special facilities.

- **Automated Assembly**—Conventional through-hole components can be installed on circuit boards by means of automated assembly machines. SMT, however, is much more compatible with automated assembly equipment. Unless the board includes plated-through holes, the time-consuming chore of drilling holes in the circuit board is eliminated. SMC's have no wire leads to cut, bend, and insert. For those and other reasons, SMT boards can be automatically assembled much more quickly than conventional boards using through-hole components.

Although automated pick-and-place SMT assembly equipment is expensive, it's also very fast. At the low end are machines that pick and place up to several thousand SMC's per hour. Faster machines can pick and place from 15,000 to 20,000 SMC's per hour. Sophisticated multihead pick-and-place machines can operate at rates exceeding 500,000 SMC's per hour. Automated assembly, the chief driving force behind the rapid acceptance of SMT, will be covered in more detail in the next article.

- **Lower Cost**—The cost of individual SMC's has fallen

rapidly in recent years, but SMC's generally cost more than their through-hole counterparts. Nevertheless, SMT can reduce overall board cost for a variety of reasons. According to National Semiconductor, for instance, a savings of up to 40 percent results from the elimination of drilled holes required for conventional-component leads and pins and the reduction of plated-through holes and conductive trace layers in multi-layer boards.

- **Other Advantages**—Some advantages of SMT are less obvious than those listed above. For instance, the compact size of SMT boards can significantly improve a waveform's rise and fall times, and reduce crosstalk in high-performance logic systems. Those advantages are a result of shorter current paths and reduced pin-to-pin capacitance and mutual inductance. Finally, there is the undeniable advantage that SMT is the wave of the future. Those firms that adopt SMT today will be better prepared to compete tomorrow.

#### Disadvantages of SMT

Since SMT will eventually become the dominant circuit-assembly technology, it's important to fully understand its limitations and drawbacks. They include:

- **The SMT Learning Curve**—Before the advantages of SMT can be realized, the new SMT user, whether a large corporation or a home experimenter, *must* fully understand the many pitfalls that can trap the unwary. Some companies have learned about the pitfalls of SMT the hard way. They committed to manufacturing a new product using SMT *before* fully understanding the potential problems. Whether through overconfidence or ignorance, the end result in several such cases has been a very costly disaster. It's important to keep the principle of the SMT learning curve foremost in mind as you review the rest of the drawbacks.

- **SMC Standardization**—As recently as 1983, only around 300 specific SMC's were available in the United States. According to Bourns, Inc., by the end of 1986 some 15,000 specific SMC's were available. While that increase has helped spur the rapid growth of SMT, it has been accompanied by standardization problems. Supposedly identical components, especially semiconductors, made by different manufacturers may have slightly different dimensions. In view of the close tolerances required for SMT circuit-board design, dimensional compatibility is an essential requirement. Even when identically configured components are available from two or more manufacturers, each company may package its SMC's for different automated assembly formats. The SMT industry recognizes the standardization problem and is working toward solutions. Meanwhile, engineers and parts buyers for companies entering SMT for the first time are often surprised by the lack of standardization that currently exists.

- **SMC Availability**—While some 15,000 components may be available as SMC's, not all of them may be available when needed. The author's experience has been that ordering SMC's from major electronics distributors can be trying. It's particularly frustrating to order an assortment of sub-miniature SO integrated circuits and receive a package of monster DIP's having the same part numbers. It is extremely important that before committing to an SMT product, manufacturers find one or more reliable sources for the components. And care must be taken to be sure that the supplied components will be identically packaged and both functionally and dimensionally equivalent.

- **High Start-Up Expense**—The start-up cost of SMT for

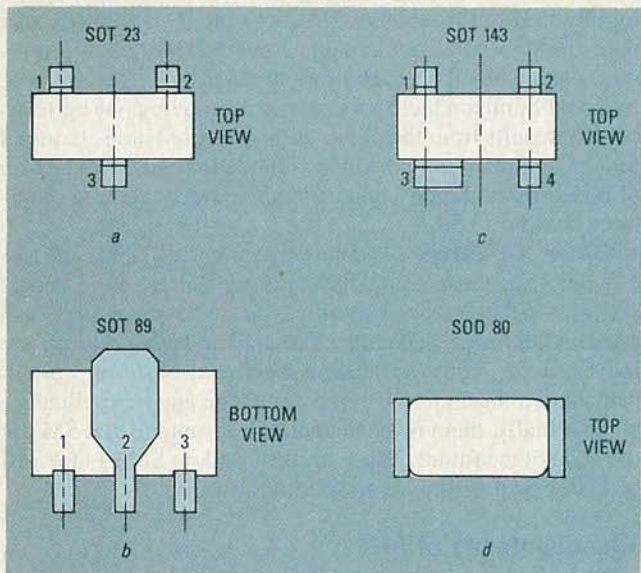


FIG. 8—FOUR MAJOR SO package outlines.

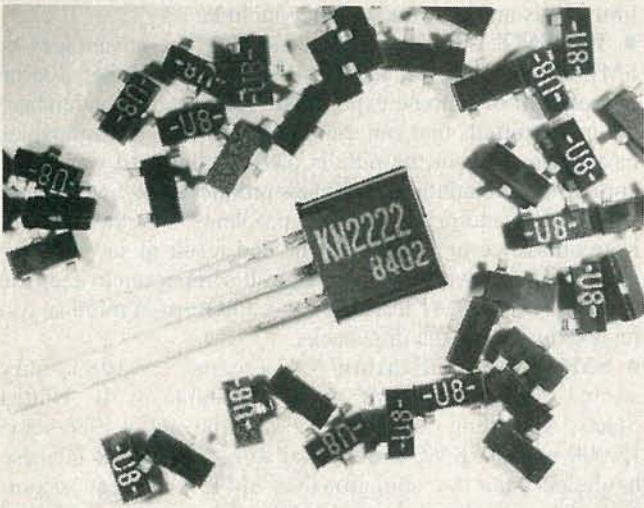


FIG. 9—A TO-92 TRANSISTOR dwarfs its SOT-23 counterparts.

both manufacturers and individual experimenters can be high. For manufacturers, automated production equipment is by far the most expensive investment. Experimenters face the problem of acquiring new assembly tools and a stock of surface-mountable resistors, capacitors, LED's, diodes, transistors, and integrated circuits. While the cost of an individual SMT project may be only slightly higher than the same project assembled with through-hole components, acquiring a sufficient stock of SMT components can easily cost a few hundred dollars or more. That situation will change when retail and mail-order electronics dealers begin offering kits of SMC's.

● **Soldering**—The components of virtually all manufactured through-hole circuit boards are wave soldered. A variety of soldering options, each with various advantages and disadvantages, is available to the SMT user. They include single- and double-wave soldering, and reflow soldering. Wave soldering requires that the SMC's be attached to the circuit board with a droplet of non-conductive adhesive. Reflow soldering involves the use of solder paste or cream. The paste is screened over the SMC footprints or pads, or applied directly to the pads with either an automated or a hand operated syringe. The terminals of the SMC's, which adhere to the

sticky paste, are soldered to the pads when the board is heated in a convection oven, in a vapor-phase chamber, or by infrared lamps. Some SMC's are connected in place with conductive adhesives. SMT soldering methods, including their advantages and drawbacks, will be discussed in detail elsewhere in this section. Suffice it to say that a careful understanding of whichever soldering method is selected is crucial to the production of functioning, reliable SMT circuits. In the final analysis, nothing replaces practical, hands-on experience.

● **Troubleshooting and Repair**—The best way to fully appreciate the differences between conventional and SMT circuitry is to take a peek inside a handheld video camcorder. The optics, focusing motor, gears, and image sensor of the typical camcorder are virtually surrounded by thin circuit boards that are peppered with hundreds of tiny SMC's. The sight of those boards will provide convincing proof that servicing SMT circuits requires a completely different set of tools and skills than those that are required to service conventional through-hole circuits.

Since most SMC's are very closely spaced and do not have leads, conventional test instrument probes may not be suitable. Fortunately several companies now make a variety of probes and clips specifically intended for connection to SMC's. Desoldering and resoldering SMC's requires specially shaped soldering iron tips that permit all the terminals of an SMC to be simultaneously heated. Hot air desoldering and soldering tools can also be used for that purpose if care is taken to avoid inadvertent desoldering of nearby SMC's. In short, servicing SMT circuits requires new skills and much more attention to detail than the servicing of conventional through-hole circuits. The observation about the vital role of practical, hands-on experience given in the discussion of soldering surface-mountable components applies equally well to servicing SMT circuits.

● **Other Drawbacks**—Some of the pitfalls awaiting new SMT designers are less obvious than those discussed so far. Thermal overload is a good example. Since surface-mountable semiconductors are so small, they dissipate less heat than their conventional counterparts. That, and the fact many such devices can be densely packed together on a compact circuit board, can lead to unanticipated thermal-overload problems in your designs.

Another drawback is that SMT boards require tighter dimensional tolerances than conventional through-hole boards. In addition, board designers and draftsmen must become acquainted with the configuration of the many different kinds of SMC's. Computer-aided drafting software may have to be updated or even replaced if it doesn't include an SMT capability.

### Surface-mountable components

Many, but not all, through-hole components have a surface-mountable counterpart. Physical limitations often prevent a conventional component from being manufactured as an SMC. For example, high-capacity capacitors and power transformers are simply too large. And the pinouts and chip dimensions of some IC's don't readily lend themselves to standard surface-mount packages. Nevertheless, most circuits can be assembled using SMT, even if some conventional through-hole components are required.

It's important for SMT circuit designers, draftsmen, and service technicians to be aware of the general physical configurations and operating parameters of the various families of

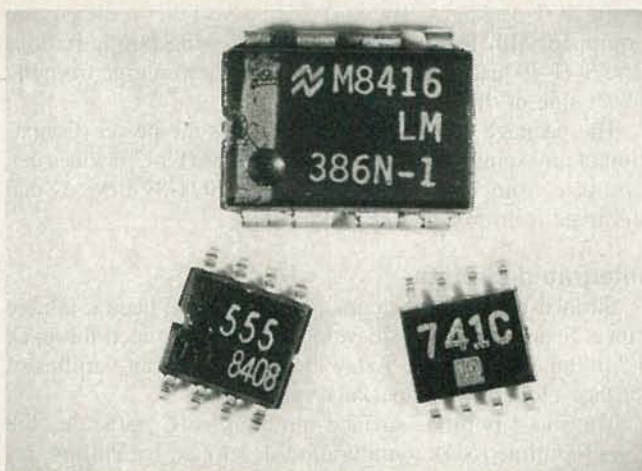


FIG. 10—TWO SO INTEGRATED CIRCUITS and a conventional 8-pin mini-DIP.

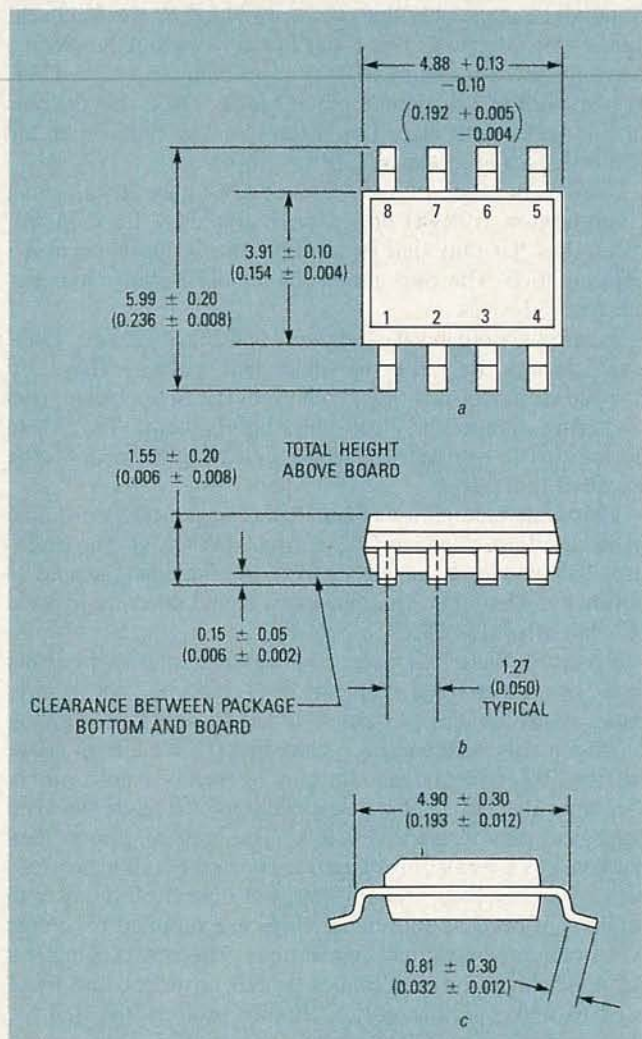


FIG. 11—TOP VIEW (a), side view (b), and front view (c) of a Texas Instruments 8-pin SO integrated circuit.

SMC's. What follows is a quick tour of the most important families of SMC's. All SMC's in those families are available individually or in quantity. SMC's intended for automated assembly are supplied in reels of paper or embossed plastic tape, or in magazines. Some automatic assembly equipment is equipped with vibratory feeders that can be loaded with non-packaged leadless chip components, such as resistors and capacitors.

### Chip resistors

Chip resistors are the most widely produced of all SMC's. Originally developed for use in hybrid microcircuits, chip-resistor technology was well established when SMT was adopted for consumer and industrial products.

Figure 3 shows the cross section of a typical leadless chip resistor. The construction of the device is identical to that of a thick-film resistor deposited directly on the ceramic substrate of a hybrid microcircuit. The nickel barrier between the inner electrode and the solder coating prevents the electrode from leaching during soldering. Without the nickel barrier, leaching may impair the connection between the chip resistor and the external circuit.

Figure 4 shows the very small size of chip resistors. The taped resistors in the photo are classified as 1206, a type designation indicating a physical size of  $1.6 \times 3.2$  millimeters. Other types are the 0805 ( $1.4 \times 2.0$  mm) and 1210 ( $2.6 \times 3.2$  mm). The resistance range of most chip resistors is 10 ohms to 2.2 megohms. Some companies offer values up to 10 megohms and even higher.

### Trimmers and potentiometers

Both single- and multi-turn trimming potentiometers are available in surface-mountable configurations. They are made from ceramic or high-temperature plastics to protect them from the heat of immersion soldering. The smallest single-turn trimmers measure less than  $4 \times 4$  millimeters. Multi-turn trimmers, which closely resemble their through-hole counterparts, measure  $6.35 \times 6.35$  mm (0.25 inch) or  $8.9 \times 8.9$  mm (0.35 inch).

Although surface-mountable trimmers are adjustable, it's important to realize that most of those devices are not designed for repeated adjustments. A typical trimmer, for example, might be rated for no more than 10 adjustment cycles. Another consideration is the adjustment mechanism itself. Most trimmers are designed to be adjusted by means of a miniature screwdriver or special tool. The required slot or slots may not be compatible with all kinds of automated pick-and-place equipment. Also, trimmers that require a special adjustment tool can pose a major problem when only a screwdriver is available.

### Chip capacitors

Like chip resistors, leadless chip capacitors were developed originally for use in hybrid microcircuits. There are three principle categories of surface-mountable chip capacitors: multilayer ceramic, electrolytic, and tantalum. Four out of five chip capacitors are ceramic multilayer devices. As shown in Fig. 5, a ceramic chip capacitor is a sandwich of interleaved layers of metal film and ceramic dielectric. At opposite ends of the chip, every other metal layer is interconnected by an external metal electrode. Often a nickel layer is added to prevent leaching of the internal metal layers.

Ceramic chip capacitors, like the ones in Fig. 6, are rugged, very stable, and highly reliable. Capacitance values ranging from 1 pF to 1  $\mu$ F are available. Package styles identical to those of chip resistors described above (0805 and 1206) are available, as are larger packages. Unlike chip resistors, the size of a chip capacitor is directly related to its value.

For high capacity, electrolytic and tantalum chip capacitors are available. Tantalums are available in values from 0.1 to 100  $\mu$ F. Aluminum electrolytics, which are larger than tantalums, are available in values from around 1.5 to 47  $\mu$ F.

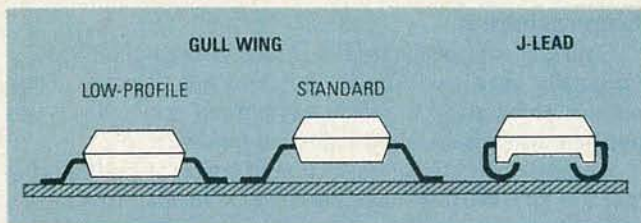


FIG. 12—GULL-WING VS. J-LEAD SMC packages. J-lead packages can be mounted using sockets

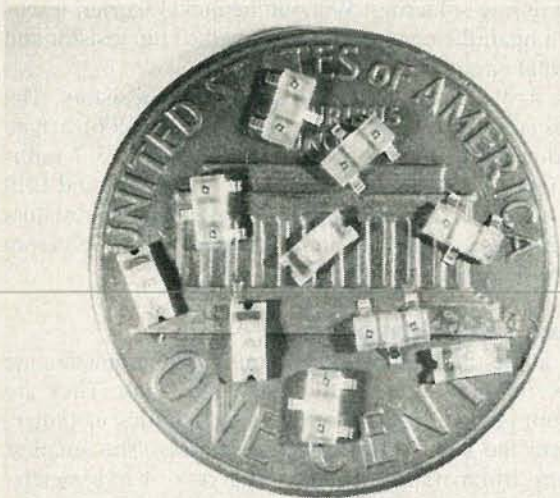


FIG. 13—SOT-23 DUAL-CHIP red LED's and single-chip green LED's are dwarfed by a penny.



FIG. 14—COMPONENTS SUCH AS CRYSTAL FILTERS, relays, switches, and crystals are available as SMC's. An SMC crystal is shown here.

Those capacitance ranges continue to be expanded as new products are added.

### Inductors

Many kinds of surface-mountable leadless and formed-lead inductors, and even toroidal transformers, are available. Inductance values range from a few tens of nanohenries to one millihenry. Figure 7 shows several surface-mountable inductors.

### Discrete semiconductors

Many diodes, transistors, and other discrete semiconductors are available in miniature surface-mountable packages. Figure 8 shows the outlines of the four major package styles SOT-23 (Fig. 8-a), SOT-89 (Fig. 8-b), SOT-143 (Fig. 8-c), and SOD-80 (Fig. 8-d). The SOD (Small Outline Diode) package is a leadless cylinder used for diodes. The SOT (Small Outline Transistor) packages are used for transistors, diodes (1 or 2 chips), and various optoelectronic components. Figure 9 compares the SOT-23 transistor with its conventional through-hole counterpart.

Referring back to Fig. 8, note the configuration of the leads

of the SOT packages. The SOT-23 and SOT-143 packages are equipped with formed leads in a gull-wing configuration. The SOT-89 leads are not formed since they emerge from the lower side of the package.

The package configuration determines the power dissipation of any semiconductor. SOT-23 and SOT-143 devices can dissipate from 200 to 400 milliwatts. SOT-89 devices can dissipate from 500 to 1000 mW.

### Integrated circuits

Surface-mountable integrated circuits have been available since Texas Instruments developed the gold-plated flat pack IC in the early 1960's. Today more than a dozen families of surface-mountable IC packages are in use.

The most popular surface-mountable IC package, the Small-Outline (SO) configuration developed by Philips, resembles a miniature DIP. An SO device occupies around a fourth the board space of an equivalent DIP. Of even more importance is the very low profile provided by the SO package. Figure 10 shows two 8-pin SO devices together with a conventional 8-pin mini-DIP for a size comparison, and Fig. 11 is an outline view of an 8-pin SO device. Note that the pins of SO devices are placed on 50-mil centers rather than the 100-mil spacing found on DIP's.

While the leads of most SO devices have a gull-wing configuration, a newer design popularized by Texas Instruments has flat pins that bend under the IC package in a J configuration. The chips mounted on the SIP shown in Fig. 2 are J-lead devices.

Figure 12 compares the gull wing and J-lead formats. Gull-wing devices are easier to solder and replace. They also provide sufficient flexibility to prevent the SO package from fracturing should the board be slightly bent. The J-lead devices use less space and, unlike gull wing devices, can be installed in sockets.

Chips that require more than 28 pins are generally installed in square Plastic Leaded Chip Carriers (PLCC's). The PLCC uses J-shaped leads and has up to 84 or more leads around its perimeter. Many new microprocessors and other large-scale IC's are offered in PLCC's.

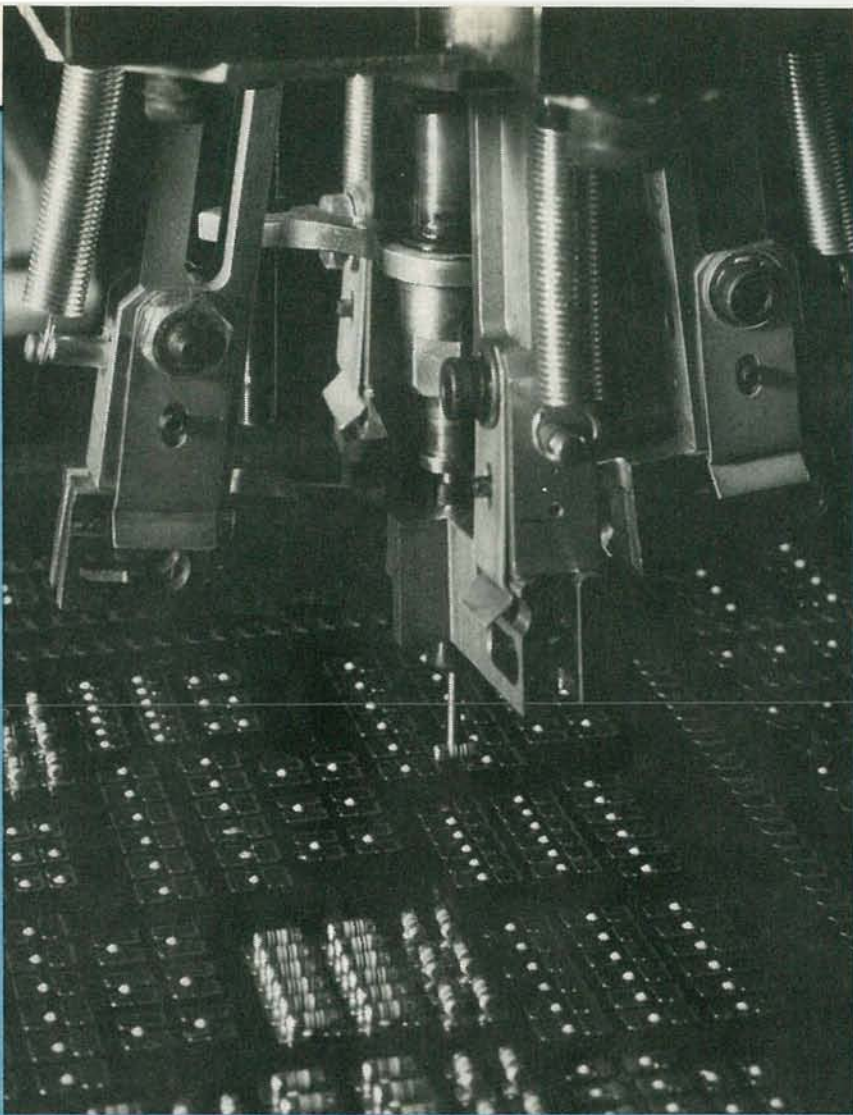
Recently, there has been considerable interest in using tape- or wire-bonded chips in SMT circuits, particularly those in which the pin count is high. The wire-bonding process involves cementing a chip directly to a circuit board and making connections to the chip by means of gold wire in the same manner in which connections are made between chips and pins in packaged IC's. The bonded chip is then protected by a small blob of epoxy. The tape bonding process, also known as TAB (*Tape Automated Bonding*), is easier to implement because individual chips are supplied on a tape with completed electrical connections. The tape is actually a string of connected lead frames similar or identical to those used to make packaged IC's. Epoxy protects the delicate chips and connection leads from damage. TAB chips can be used in automated assembly.

### Other Surface Mountable Components

In addition to the component families discussed above, there are many other surface-mountable devices. For example, many optoelectronic components are available, including phototransistors, optoisolators and many kinds of one- and two-chip infrared and visible LED's (see Fig. 13). Also available are ceramic filters, relays, switches and crystals (see Fig. 14).

R-E





## Surface-Mount Technology

*Now that you know what SMT is all about, here's how to use and repair surface-mount components.*

# Industrial SMT Assembly

SURFACE MOUNT TECHNOLOGY IS FAST BECOMING AS IMPORTANT to modern electronics as microprocessors, programmable logic arrays, and megabit RAM IC's. Microminiature surface-mountable components and the advantages and drawbacks of SMT were previously discussed. Now we'll tackle the assembly and repair of SMT circuits.

### SMT assembly methods

Surface-mountable components, like conventional through-hole components, can be placed on a board and soldered in place either by hand or by machine. Both soldering methods fill important roles in SMT. Hand assembly is used by home experimenters and electronics companies, the latter for the production of prototype SMT circuits. Automated assembly is used to manufacture SMT circuit boards.

### Automated SMT assembly

Automated placement equipment can select and position on a circuit board from 1,000 to 500,000 components per hour. There are three major categories of automatic SMC placement equipment: Mass placement, in-line pick-and-place, and x-y pick and place.

*Mass placement equipment* permits many or all the SMC's in a



FIG. 1—MICROMINIATURE INFRARED LED transmitter assembled by the author.

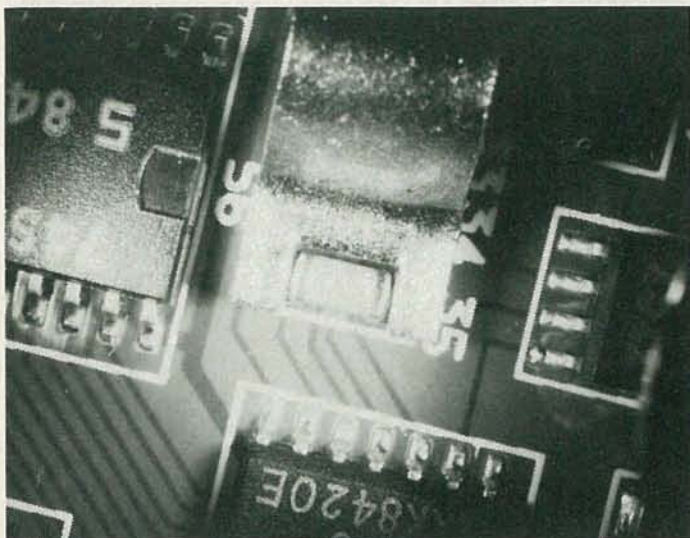


FIG. 2—A U-SHAPED SOLDERING IRON tip can be used for soldering and desoldering chip resistors and capacitors.

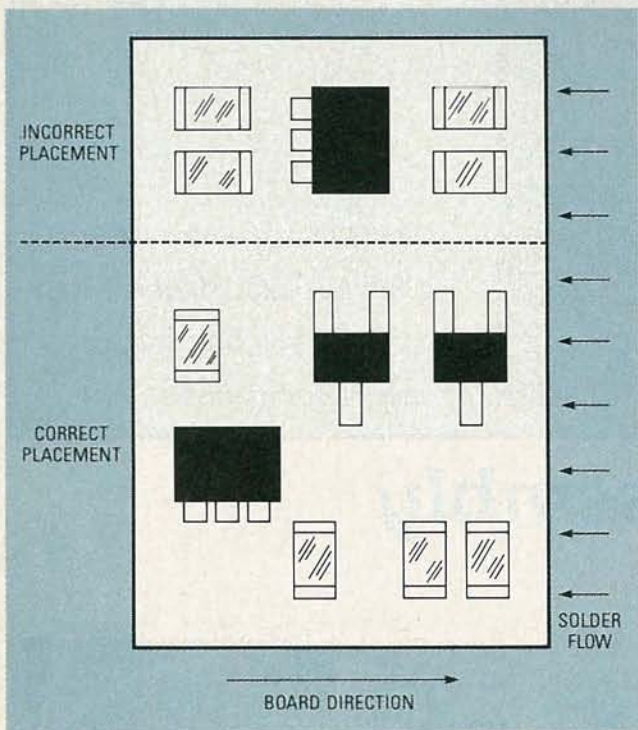


FIG. 3—THE CORRECT ORIENTATION of SMC's for effective wave soldering.

circuit to be simultaneously placed over adhesive dots or solder paste that was previously deposited on a circuit board. Since mass placement equipment provides exceptionally fast board loading, it is well suited for the manufacture of consumer-electronics devices. Its major drawback is that the equipment must be specially configured for specific board designs. Consequently, even minor board design changes can be expensive and time consuming.

In a typical mass-placement system, magazines loaded with SMC's are mounted in the same orientation as the SMC's to be placed on the board. A vacuum head then picks up a complete set of SMC's, transfers them to a board and returns for another set.

*Bench*, or *in-line pick-and-place equipment*, uses a vacuum pickup head to pick an individual SMC from a dispensing tape, magazine, or bin dispenser. The head then places the SMC at the proper position on the circuit board. A single machine may have a series of pick-and-place heads. Boards prescreened with solder

paste or adhesive are placed on a belt that moves under the row of pick-and-place heads. After each head places a single SMC on the board, the board advances to the next head.

In-line equipment, which has long been used to produce hybrid microcircuits, is able to handle many different shapes and sizes of SMC's. And in-line machines can be set up to assemble different circuits much more rapidly than mass placement equipment is capable of.

*X-Y pick-and-place equipment* is the most popular method for the automated assembly of SMT boards. Two basic approaches are used. In one, a moving pick-and-place vacuum head fetches components one at a time and places them on a fixed-position board. In the other, the vacuum head is fixed and the board is attached to a moving x-y table that places the appropriate SMC footprint or pad directly under the head. SMC's are fed to the head by a feeder mechanism.

Understanding the operation of mass placement and pick-and-place SMT assembly equipment is not the only requirement for the effective use of such machines. Automated assembly of an SMT circuit also includes provisions for automated flux application and soldering; procedures that can greatly complicate matters. Soldering of SMC's will be discussed in more detail shortly. For now, it's important to understand that automated soldering requires careful attention to board design and proper component placement.

If the board is to be inverted and wave soldered, then the components must be glued to the board, a process that requires the careful hand or machine application of small dots of adhesive at each component position. Adhesive can be hand-applied with a wire or a probe that picks up a small blob of material when it is dipped into the adhesive, or by a syringe that automatically dispenses a preset amount of adhesive. Adhesive can also be screened onto a board in a single application. In fully automated systems, the adhesive can be applied by a syringe that is mechanically moved to each SMC location, but *automatic pin transfer* is an even faster way to apply the adhesive. An array of pins that exactly matches the SMC locations is dipped in adhesive and then lightly touched to the board. When the pin array is moved away, dots of adhesive are left behind at each SMC location.

All these methods require careful attention to detail. If too little adhesive is applied, the SMC may fall off when the board is

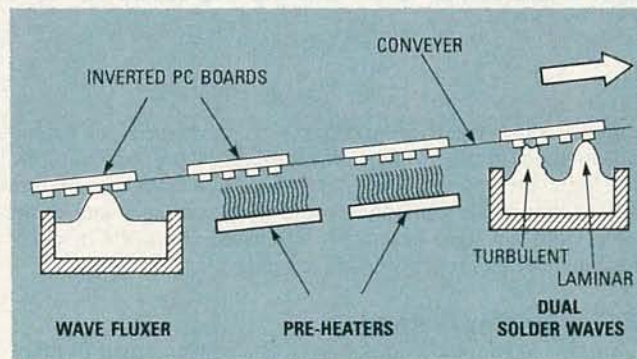


FIG. 4—THE DUAL-WAVE SMT soldering system.

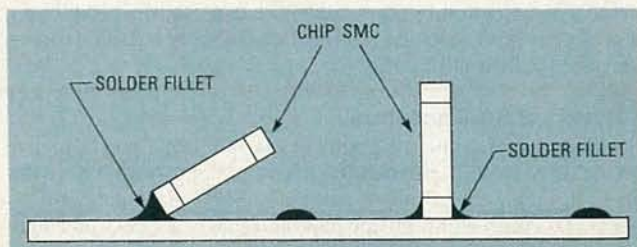


FIG. 5—SOLDERING DEFECTS known as the *drawbridge* and *tombstone effect*.

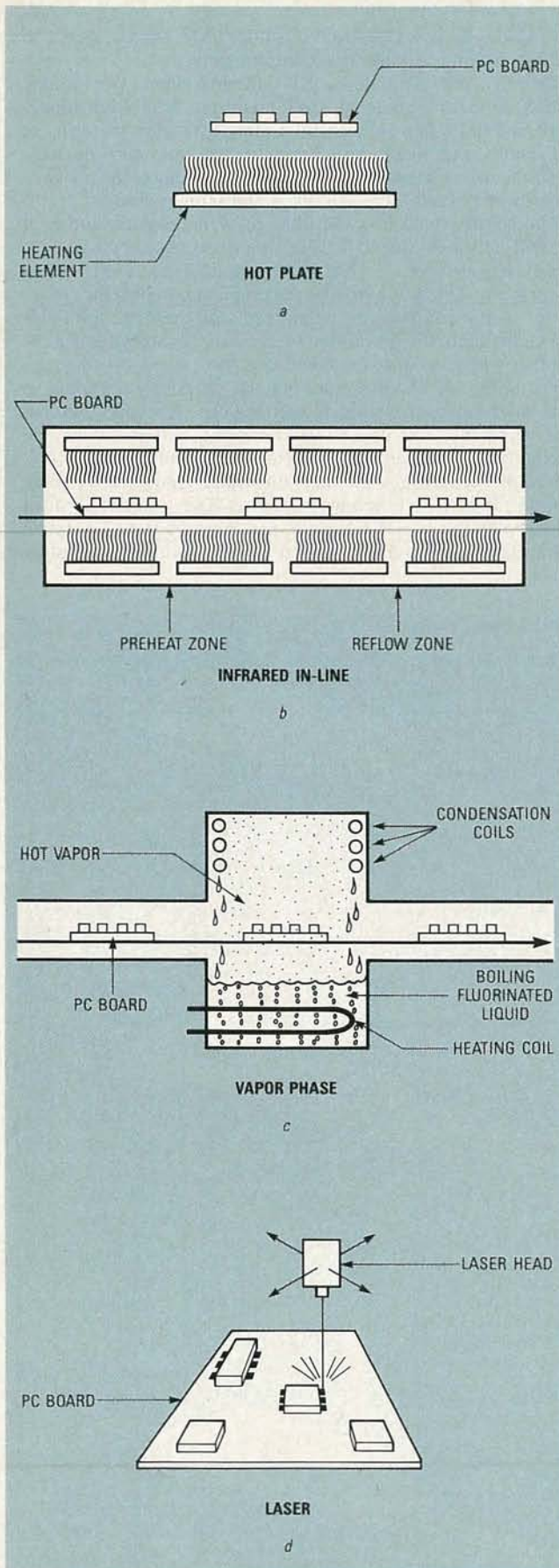


FIG. 6—REFLOW SOLDERING METHODS: Hot plate reflow soldering is shown in *a*, infrared reflow soldering is shown in *b*, vapor-phase reflow soldering is shown in *c*, and laser reflow soldering is shown in *d*. The laser method causes the least component heating. (*d*) causes the least component heating.

soldered. If too much adhesive is applied, one or more of the solder pads may be covered, thereby preventing solder from establishing a conductive bond between the terminals of one or more SMC's and their respective pads.

The delay between the application of the adhesive and the SMC's placement must be carefully controlled—the adhesive must be fresh and any solvents it contains must not attack the board or the SMC's. And, the adhesive must be properly cured before the board is soldered.

Although automated installation of SMC's receives the most attention, hand assembly of SMT circuits is also important since it permits prototypes to be assembled, tested, and evaluated prior to committing a board to machine production. Another important aspect of hand assembly of SMT circuits is that individuals, whether home experimenters or engineers in a large corporation, can quickly and easily build microminiature circuits that rival hybrid microcircuits in size and complexity.

This is a remarkable capability. For example, the circuit shown in Fig. 1 is a miniature pulse generator circuit that drives an on-board LED with high-current pulses. Although the circuit is about the size of a shirt button (0.3 x 0.3 inch) and is so thin it slips easily between two adjacent pins of a conventional DIP, it was assembled from scratch in about an hour using a 15-watt soldering iron.

### Conductive bonding

Though soldering is the chief method for bonding surface-mountable component and socket terminals to circuit board pads, conductive adhesives are also used. Both methods are important, and the prospective SMT circuit designer or service technician should be familiar with each method.

Conventional through-hole circuit boards are soldered either by hand or by passing the bottom side of a component-stuffed board over a wave of molten solder. The same methods and various kinds of *reflow soldering* can be used to solder SMC's onto a board. Reflow soldering is a three-step process in which solder paste or cream is applied to SMC pads on a circuit board, SMC's are placed on the board, and the SMC's are heated simultaneously or one by one. No matter which soldering method is used, the heat sensitivity of the SMC's must be considered because SMC's having a ceramic substrate—such as chip capacitors and chip resistors—can be permanently damaged by the sudden application of the heat necessary for the solder to melt. The problems can be avoided during automated soldering by preheating the SMC's and carefully controlling the time during which the SMC is subjected to the temperature of soldering. Thermal damage during hand soldering can be avoided by keeping the heated tip of a soldering iron from touching the center of the SMC. Instead, only the conductive terminals should be heated.

### Soldering

Manufacturers of SMC's specify the soldering guidelines for their components; be sure to keep them in mind when considering SMT soldering methods. The most important guidelines include:

**1. Hand Soldering**—Although most surface-mount publications and articles relegate hand soldering to the replacement of defective SMC's, as noted earlier, hand soldering can play an important role in the assembly of prototype circuits. To meet that need, some SMC manufacturers provide detailed guidelines for the hand soldering of their components.

Conventional soldering irons, soldering tweezers, and hot air soldering tools are used to hand solder SMC's. Soldering tweezers grip an SMC between two heated tips until soldering is complete. Many different soldering iron tips are available for conventional irons, most of which permit all the terminals of an SMC to be heated simultaneously. For example, a U-shaped slotted spade tip, such as the one shown in Fig. 2, that wraps

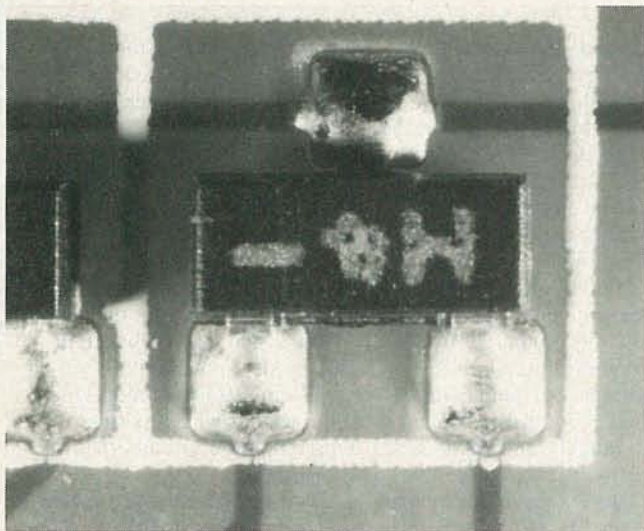


FIG. 8—PERFECT SOLDERING of a leadless diode and a chip capacitor.

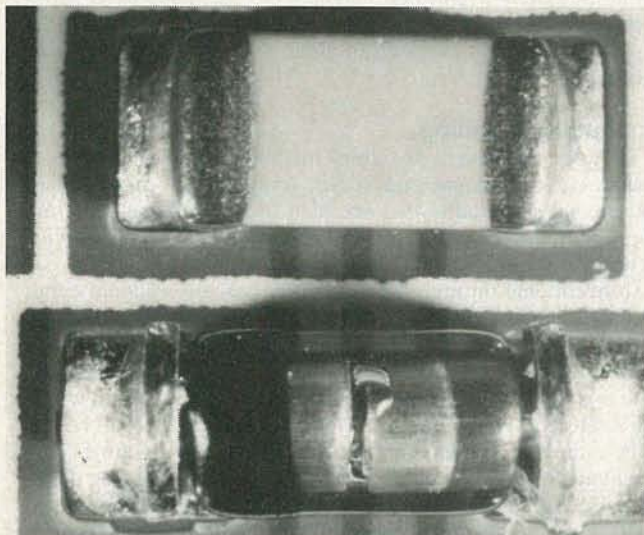


FIG. 7—PERFECT SOLDERING OF AN SOT-23 TRANSISTOR. Note how the solder has flowed completely over the terminals and pads.

itself around the SMC is used to reflow solder and desolder leadless chip resistors and capacitors. Hot-air tools, which are commonly used for desoldering both SMC's and through-lead components, can also be used for hand reflow soldering.

Despite the wide variety of soldering tools designed especially for SMT, an ordinary low-wattage soldering iron having a conical tip and 0.03-inch or smaller rosin core wire solder can be used to solder SMC's. Soldering is fast and reliable if the pads are tinned and if the SMC is held in place with masking tape. Hand soldering is discussed in more detail elsewhere in this special section.

**2. Wave Soldering**—Wave soldering is a well-established means for simultaneously soldering all the leads of through-hole components that protrude through the bottom side of a circuit board. Briefly, boards are machine or hand stuffed with components and placed on a moving carrier. The boards are carried, in turn, over a radiant heater, then a wave, foam or spray of rosin, and finally, a wave of molten solder. The soldered boards are usually cleaned to remove flux residue. Although the residues of rosin-based and other fluxes will cause no electrical problems if left on a board, the residues of some fluxes will cause corrosion if not removed.

When SMT began to become popular several years ago, it was only natural for companies to want to adapt their existing wave-soldering assembly lines for soldering SMT boards. Although

wave soldering is widely used to solder SMT boards, doing so requires solving several important problems.

The most crucial problem is SMC thermal shock, since *all* the SMC's on a wave soldered SMT board are briefly but totally immersed in molten solder. Pre-heating by means of ovens or heat lamps eliminates most danger to ceramic chip devices, while the use of high-temperature plastics protects the package integrity of both discrete and integrated semiconductors.

Another drawback to wave soldering is incomplete wetting of the SMC terminals due to the shadow effect caused by adjacent, closely-spaced SMC's. That can cause cold and even missed solder joints. One way to reduce the problem is to plan the circuit board so chip components are aligned with their end terminals perpendicular to the flow of the solder wave, as shown in Fig. 3. Another way is to pass the board over *two* waves of solder, as shown in Fig. 4. The first wave is made purposely turbulent so that solder can reach even shadowed regions. A second, laminar wave completes the process by removing excess solder and leaving behind a clean solder fillet at every connection point.

**3. Reflow Soldering**—The most important conductive bonding method for SMC's is reflow soldering. The simplest form of reflow soldering occurs when the junction of a tinned terminal and a thickly-tinned pad is heated by a soldering iron or other

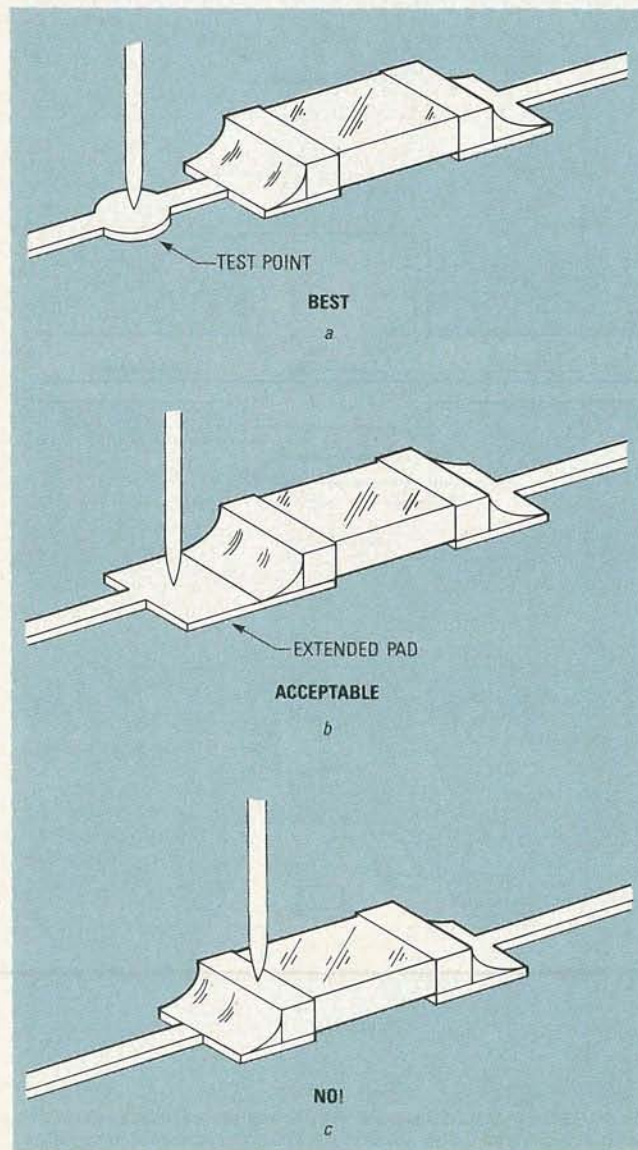


FIG. 9—HOW TO USE A TEST PROBE ON AN SMC. The test probe can touch any part of the board's traces or pads, but not the chip itself.

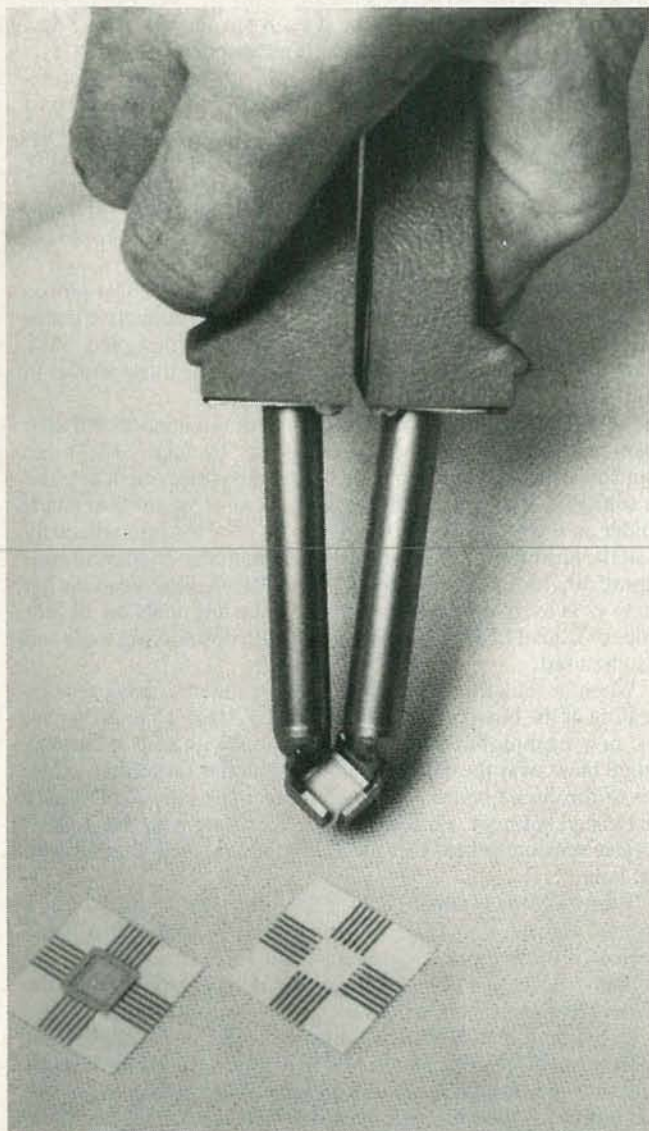


FIG. 10—A PAK-X-TRAC™ DESOLDERING SCISSORS can be used to simultaneously heat the terminals on all four sides of a quad PLCC.

means until the two tinned layers melt and merge together. Reflow soldering can also be accomplished by placing a small, thin square of solder called a *preform* between a terminal and a pad. Preforms are also used to solder semiconductor chips (e.g. laser diodes, LED's, transistors, etc.) to a metal header or substrate.

Solder pastes or creams, which consist of microscopic particles of solder suspended in a flux, are used for SMT reflow soldering. Small dots or squares of solder cream are placed over each SMC pad, the SMC's are placed on the board, and the entire board is heated until the solder melts. No adhesive is required since the SMC's are held in place by the sticky paste or cream.

The cream can be applied to the SMC pads with a handheld wire, a squeeze applicator, a manual syringe, a pneumatic syringe that dispenses a preset quantity of cream, or by stenciling or screening. And solder cream can be applied by means of a pin array using the same principle sometimes used to simultaneously deposit adhesive at each SMC location on a board.

An advantage to using solder cream is that the placement of the SMC's is less critical. When the solder melts, its surface tension tends to pull slightly misplaced SMC's back into position precisely over the solder pads. Even boards having SMC's on both sides can be reflow soldered without adhesive. First, the SMC's on the top side of the board are reflow soldered. The

board is then inverted, SMC's are placed on the second side, and heat is applied. Even though the solder on the lower side of the board may melt, the SMC's will be held securely in place by the surface tension of the molten solder.

Although solder pastes and creams are widely used for reflow soldering of SMC's, they are not without disadvantages. For example, non-uniform heating during soldering or non-uniform deposition of the paste or cream can cause one end of a 2-terminal SMC to lift off the board entirely, as shown in Fig. 5. Sometimes an SMC will actually stand completely on end. That phenomenon, which is commonly called *tombstoning* or *draw-bridging*, is caused by the surface tension of the molten solder at one terminal exceeding that at the other joint.

Although a handheld soldering iron can be used to reflow solder one connection at a time, a better way—and a must for production quantity soldering—is to heat the entire board so that all the solder cream melts at the same time, thereby soldering the entire board in one step.

Figure 6 shows some of the various methods for generating the heat necessary to reflow-solder entire boards in one operation, or one SMC at a time.

*Hot-plate reflow soldering* (Fig. 6-a) is sometimes used to solder hybrid microcircuit components atop a ceramic substrate. The ceramic substrate is placed on a hot plate until the solder melts. A modified version of that process, *convection-oven reflow soldering*, can be used to reflow solder production quantities of SMT boards. Boards are placed on a conveyer belt and moved over a series of hot plates arranged on an oven. One or more hot plates preheat the boards and drive off solvents present in the solder cream, while a single hot plate at a higher temperature melts the solder. The boards are then cooled by a forced-air blower.

*Convection-oven reflow soldering* has many variations, all of which incorporate an oven through which boards loaded with SMC's ride on a moving belt. Ovens may have one or more preheating sections or chambers.

*Infrared reflow soldering* (Fig. 6-b) is claimed by its advocates to provide a higher degree of temperature control than any reflow solder method. That's because the boards to be soldered are heated by a bank of infrared lamps whose power output can be carefully controlled. Moreover, the same lamps that gently preheat a board can also take the board to solder temperatures. The negative side of infrared reflow soldering is that dark-colored SMC's, such as semiconductors and many chip components, absorb heat much more readily than their highly reflective terminals. Also, high profile components may block the radiation intended for other components, thereby resulting in shadow regions containing cold or otherwise imperfect solder joints.

*Vapor-phase reflow soldering* (Fig. 6-c) is a clever procedure, developed by Western Electric, in which a board loaded with SMC's is placed within the hot vapor given off by a boiling fluorinated liquid. The vapor condenses on every exposed surface of the board and its SMC's, thereby heating the entire board more uniformly than any other reflow soldering method. After the solder melts, the board is removed from the vapor. Meanwhile, the condensed vapor is collected, cleaned, and recycled or, in simple systems, falls back into the reservoir of boiling fluorinated liquid.

Vapor-phase soldering provides highly uniform heating of SMC's. Also, the temperature of the condensed vapor remains constant so there is no danger of overheating a component designed to accept vapor-phase temperatures (typically 215-250 degrees Celsius).

On the down side, the near instantaneous heating produced by the vapor-phase process can cause some SMC's to fail. For example, ceramic chip capacitors should be heated at a maximum rate of from 2 to 6 degrees per second; otherwise, the ceramic might develop microcracks that can lead to degradation and eventual failure. Without preheating, a vapor-phase system



FIG. 11—The SMT 2000 TRAINING KIT includes SMC's, conductive adhesive, solder, solder paste, tweezers and practice boards.

can take a chip capacitor from room temperature to 215 degrees in less than a second. There is also some question about the integrity of vapor-phase solder joints.

*Laser reflow soldering* (Fig. 6-d) is among the most gentle soldering method. A pulsed laser beam heats each SMC terminal in sequence. Laser heating results in considerably less heat stress than other solder-reflow methods. However, it is slow and the laser controller requires extensive programming.

### Conductive Adhesive Bonding

Electrically-conductive adhesives have long been used to bond the terminals of components to the conductive traces of hybrid microcircuits. They are relatively easy to use and they eliminate the thermal shock of soldering. Several families of conductive adhesives are available, all of which consist of a conductive powder suspended in a 1- or 2-part base. The most common conductive powders, in order of increasing resistance, include gold, silver, copper, nickel, carbon, and graphite. Adhesive bases include urethane, acrylic, polyester, and 1- and 2-part epoxies.

Conductive adhesives can be applied by hand using a squeezable dispenser, an automatically metered syringe, or a piece of wire. They can also be applied by screening, or by an x-y pick-and-place machine using the same kind of equipment that dispenses dots of non-conductive adhesive on circuit boards.

Thermoplastic conductive adhesives can be reworked using heat from an ordinary soldering iron or a hot air gun; the SMC can be removed after the adhesive softens. A new SMC can then be bonded to the same location by reheating the adhesive.

A significant drawback of conductive adhesives is their relatively high cost, especially for gold- and silver-filled material. Since the conductive particles tend to settle out during shipment and storage, conductive adhesives must be carefully stirred or shaken before use. Most conductive adhesives, like solder pastes and creams, have a limited shelf life of typically 6 to 12 months. Finally, some conductive adhesives may tend to give off hazardous vapors.

### Inspection, testing, and repair

Because of the very small size of the components, a just-completed SMT board requires a more careful inspection than a conventional, through-hole board. In particular, look for solder balls, solder bridges, improperly-soldered joints, missed solder connections, and for SMC's that have moved out of position or "tombstoned" during soldering. Figure 7 is a close-up of a

properly-soldered SOT-23 transistor. Note the smooth, uniform appearance of the solder fillets at each terminal. Figure 8 is a close-up of a soldered diode and chip capacitor.

Some components are especially difficult to inspect. For example, quad PLCC's (IC's having J-profile pins along each of four sides) can trap solder balls and conceal cold solder joints.

Completed SMT boards can be tested by hand or with automated test equipment. A single- or double-sided "bed of nails" test fixture can be used to isolate defective SMC's and cold solder joints. While that permits quick identification of problems, building the test fixture is time consuming.

Whether testing is done by hand or automatically, test probes should be touched to SMC solder pads or their conductive traces and not the terminals of the SMC. Properly designed SMT boards incorporate test point locations, such as those shown in Fig. 9.

Replacing defective SMC's requires more patience and care than replacing through-hole components because SMC's are considerably smaller and have a much higher placement density. A soldering iron fitted with the same kind of tip used to hand-solder an SMC to a circuit board can be used to simultaneously heat the terminals of the same device in preparation for removal. Figure 10, for example, shows how a Pak-X-Trac desoldering scissors is used to simultaneously heat the terminals on all four sides of a quad PLCC. Hot air and vacuum desoldering tools can also be used.

When desoldering, extra care must be taken to prevent overheating of the board and adjacent SMC's. Also, it's important to use non-vacuum hot-air desoldering tools with care since they might blow away the chip being removed and spray molten solder across the circuit board. When the solder melts, the SMC should be twisted before it is lifted from the board to break the solder's surface tension; otherwise, the solder pad might lift away from the board.

The procedure is unnecessary if the solder is *slurped* away by a vacuum desoldering tool. Removal of SMC's that have been cemented to the board is more difficult since it is necessary to twist the device in order to break the adhesive bond after the solder has been vacuumed away.

Installing a new SMC isn't difficult. Indeed, it's sometimes possible to simply place the SMC in position and heat its terminals with an iron or a hot air tool until the solder remaining on the pad reflows around the terminals. For best results, however, the old solder should be removed with desoldering wick or a desoldering tool. The pads should then be retinned and fluxed, or coated with solder cream. Finally, the new SMC is placed over the pads and its terminals reflow-soldered to the board.

### Going further

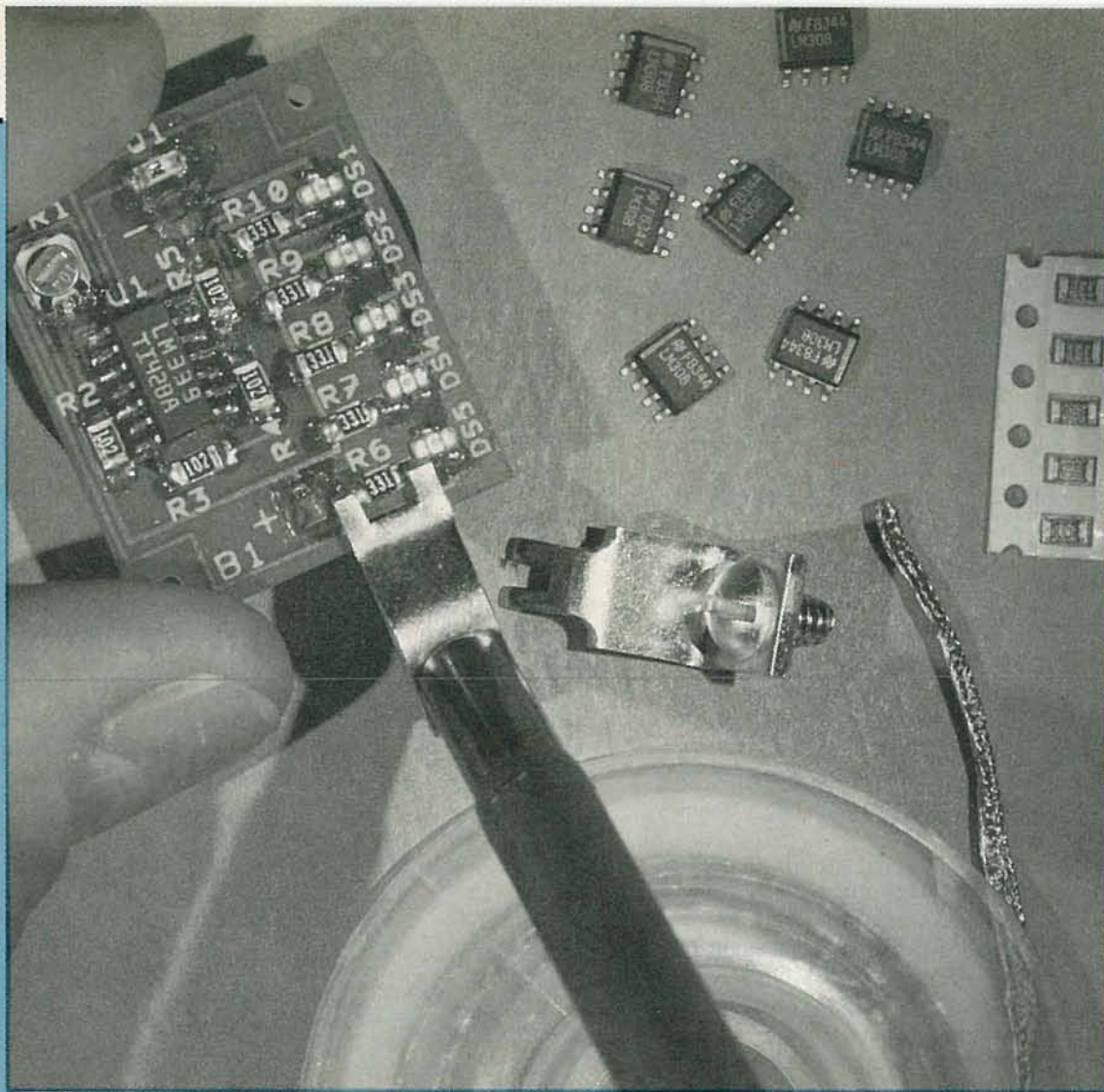
Only the highlights of surface mount technology can be covered in this special section. However, you can learn more and you can gain valuable firsthand experience by assembling the various SMT projects in this issue.

For an even broader hands-on introduction to SMT, consider the Vector Electronic Company's (12460 Gladstone Avenue, Sylmar, CA 91342) *SM2000 Training Kit*, shown in Fig. 11. The kit includes solder, solder paste, conductive adhesive, pre-etched boards, tweezers, desoldering wick, some SOT-23 diodes and transistors, and hundreds of assorted chip capacitors and resistors. The kit sells for \$279.95. Items included in the kit can be purchased separately.

Manufacturers of surface mount components, equipment, and supplies publish brochures, technical reports and specification sheets that provide excellent background information about SMT. Electronics trade magazines often carry both news and technical articles about various aspects of SMT. For those who need up-to-the-minute news about surface-mount technology, contact the Surface Mount Technology Association (Box 1811, Los Gatos, CA 95031).

R-E

# Surface-Mount Technology



## Hand-Soldering SMC's

FORREST M. MIMS, III

THE EASIEST WAY TO HAND-SOLDER SMC'S TO A CIRCUIT board is to use soldering tools and materials, such as soldering tweezers and hot-air soldering/desoldering systems, which are designed specifically for that task. Unfortunately, specialized SMC soldering tools can be expensive and difficult to locate. However, it is safe to assume that such items will become more economical and widely available in coming years. In the meantime, SMC's can be installed using only the common tools shown in Fig. 1. Those tools include an ordinary soldering pencil and a soldering iron equipped with a slotted tips designed for SMC's.

There are two chief differences between hand-soldering conventional through-hole components and SMC's. First, SMC's are installed and soldered on the foil side of a circuit board. Second, the absence of wire leads and pins inserted through holes means that the SMC's must be secured in place during soldering.

In industry, small droplets of adhesive are used to secure SMC's in place for wave soldering. While wave soldering may be impractical for hobbyist applications, the same technique for securing SMC's in place is used when hand-soldering circuits. For reflow soldering, SMC's are held in place by

*Once you master the techniques, soldering SMC's is easy, and fast.*

sticky dabs of solder paste or cream that are placed over each footprint before the SMC's are placed on the board. Reflow soldering can also be used by hobbyists.

Let's now examine some hand- and reflow-soldering techniques.

### Conventional soldering

It's surprisingly easy to solder or "tack" SMC's in place using only a handheld iron and small-diameter wire solder. Solder 25 mils (0.025 inch) in diameter works best, but 30-mil solder, which is more readily available, can also be used. The only special requirement is that the SMC must be held in place until at least one terminal or pin is soldered.

It's possible to use various kinds of adhesives to cement an SMC in place for hand soldering. That, however, can unnecessarily complicate what is essentially a very simple procedure. The adhesive must not be allowed to flow over the SMC's footprints, must be non-corrosive, and must be allowed to set before the SMC's can be soldered. For those reasons, we have experimented with two simpler and faster methods.

One method is to secure one side or corner of an SMC in



FIG. 1—SMC's CAN BE HAND SOLDERED using only the common tools and materials shown here.

place with masking tape as shown in Fig. 2. An exposed terminal or corner pin can then be soldered. The tape is then removed and the remaining terminals or pins can be soldered.

Another method is to place a tiny bead of reusable adhesive between the terminals on the bottom side of the SMC. Suitable reusable adhesives include *Plasti-Tak*, *Fun-Tak*, and *Stikki-Wax*. Those and similar adhesives are widely available at department stores.

Use a toothpick, a sharply pointed probe, or pointed tweezers to apply the adhesive. Then grasp the SMC with pointed tweezers, place it on its footprints, and press it in place. It is important that the SMC be pressed flat against the board. Too much adhesive will keep the SMC suspended slightly above the board and may even cause adhesive to creep between a terminal and its footprint.

After an SMC is attached to the board with tape, cement, or reusable adhesive, carefully touch the tip of a soldering pencil to the junction of a terminal and its footprint. After a

second or so, lightly touch the end of a length of solder to the junction and immediately remove both the iron and the solder. A shiny solder fillet should neatly bond the terminal to the footprint.

Until you gain some hands-on SMC soldering experience, *always* inspect the completed junction with a magnifying lens before moving to the next terminal or SMC. If you use too much solder or form a solder bridge, use desoldering braid to carefully remove the excess solder. Place an unused section of desoldering braid over a footprint and press it in place with a soldering iron tip. Within a second or so, capillary action will wick the excess solder on the footprint into the braid. Remove the iron and braid and go on to the next footprint as needed. Be sure to use a fresh section of braid at each footprint. Clip off used sections of braid as necessary. If necessary, reapply a small amount of solder.

### Reflow soldering

The most straightforward approach to mounting SMC's is reflow soldering. The SMC is held in place with tweezers while a soldering iron presses one end terminal or corner pin against a pretinned footprint. The tinned layer then melts and reflows around the terminal or pin and the footprint. Since no additional solder is used, the tinned layer must include enough solder to provide a good joint.

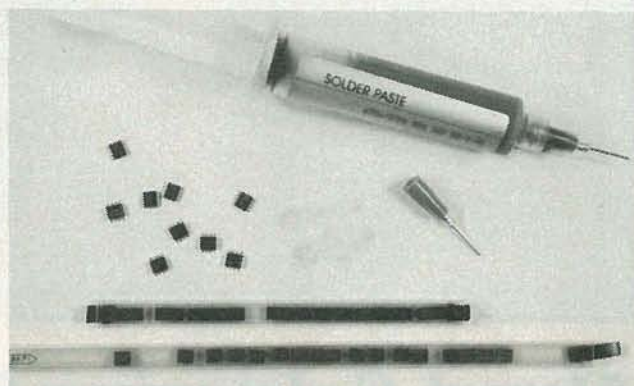


FIG. 3—SOLDER PASTE OR CREAM is available in a syringe. That makes dispensing the paste or cream convenient, once you get the hang of how it's done!

Reflow soldering works best with SMC soldering tools that simultaneously heat all the pins or terminals of the chip being soldered. When a standard soldering iron is used, only one pin or terminal at a time can be heated. That can lead to problems when working with chip SMC's. If the tinned layer is too thick, only the terminal being reflow soldered will be pushed through the molten solder against the footprint; the remaining terminal will remain atop the tinned layer over its footprint. Also, the SMC will be badly tilted when the second terminal is soldered. On the other hand, if the tinned layer is too thin, there will be insufficient solder to form the bond. Therefore, consider other soldering techniques when working with chip components.

Reflow soldering with solder paste or cream is particularly interesting since all the SMC's are soldered in place in a single operation without a soldering iron. Instead, the entire board is heated in a convection oven or on a hot plate. Unfortunately, solder pastes and creams are not always readily available, have a limited shelf life, and have instructions that must be strictly followed. Nevertheless, the method is so efficient that it warrants discussion here.

*continued on page 87*

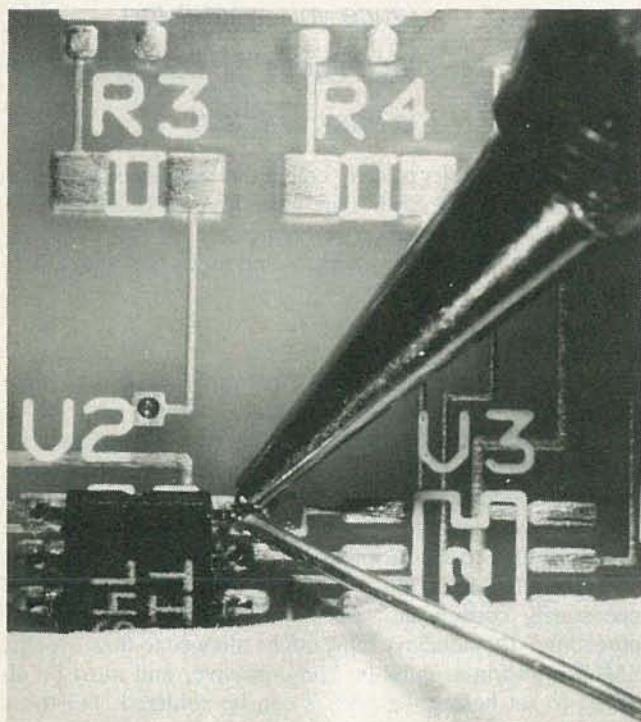
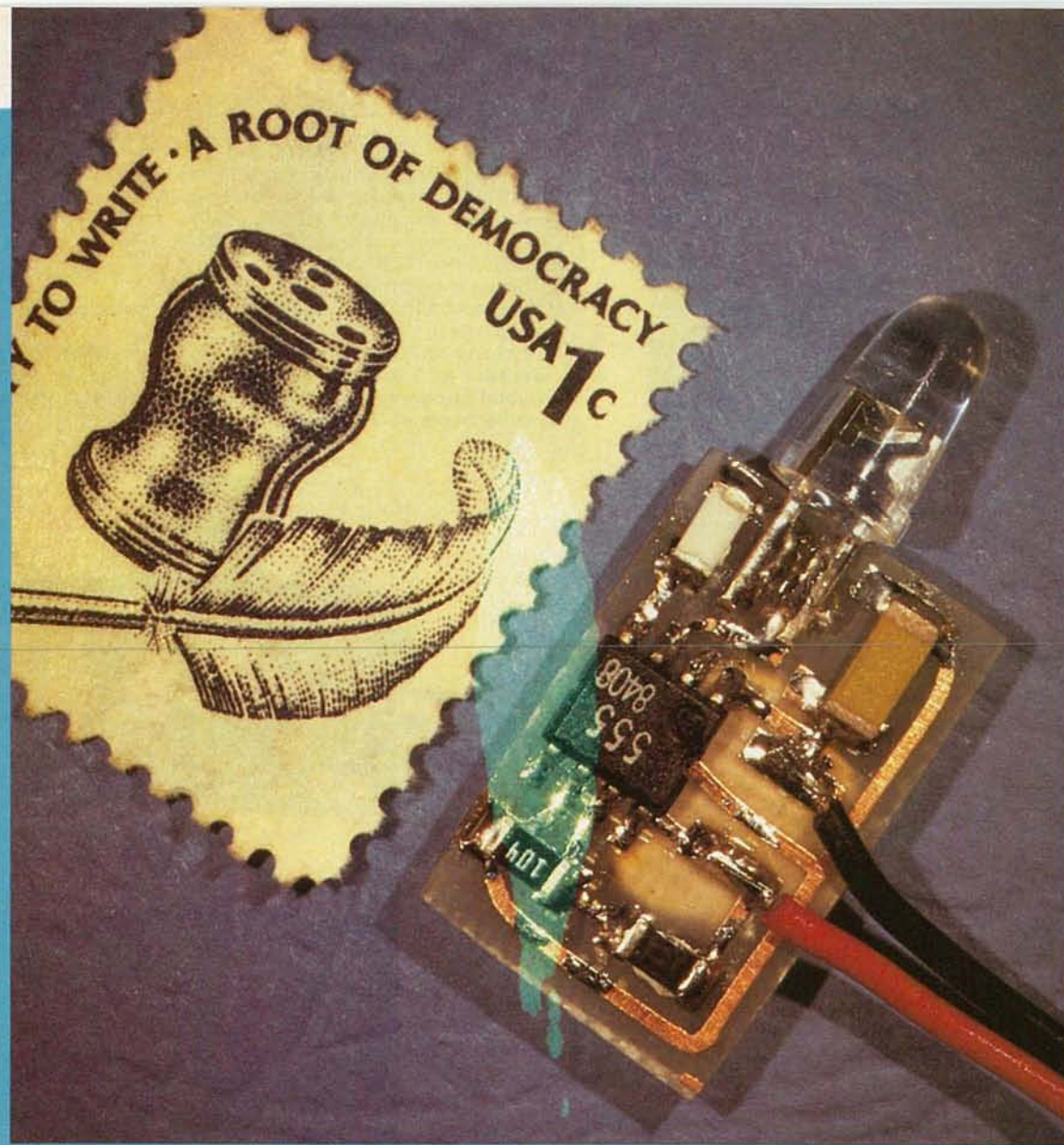


FIG. 2—ONE SIMPLE METHOD of securing an SMC in place is to tape down one side with masking tape.





## Surface-Mount Technology

# SMT PROJECT: LED FLASHER

FORREST M. MIMS, III

*Use surface-mountable components to build this subminiature LED flasher.*

A GOOD WAY TO APPRECIATE THE MINIATURIZATION POTENTIAL of Surface-Mountable Components (SMC's) is to assemble the subminiature LED flasher described in this article. Besides teaching you the basics of how to assemble a simple circuit using SMC's, the flasher has many practical uses. It can, for example, function as a warning flasher, indicator, a tracking beacon for night-launched model rockets or in a number of other applications.

A flasher made with conventional through-hole components can be assembled on a circuit board of about the same size. But while the conventional circuit is more than 0.4-inch thick, the surface-mount version is less than 0.1-inch thin. That means that the surface-mountable circuit can be easily slipped inside a slim slot or a space that might never be used or be usable otherwise.

### How it works

Figure 1 is the circuit for the flasher. In operation, the 555 is connected as an astable multivibrator whose frequency of oscillation is given by  $1.44/(R1 + 2R2)C1$ . With the values shown in Fig. 1, LED1 will flash once each second. The rate can be speeded up by reducing the value of R1 or C1. Resistor R3 is a current limiter.

For best results, the LED should be an AlGaAs super-bright unit. At night the flashes from such an LED can be clearly seen from more than several hundred feet away. Keep in mind that the light level from the LED is directly proportional to the supply voltage. Although Fig. 1 specifies a 9-volt supply, the circuit can be powered by from 3 to 12 volts. Figure 2 shows the relative power output of the LED over that range of supply voltages.

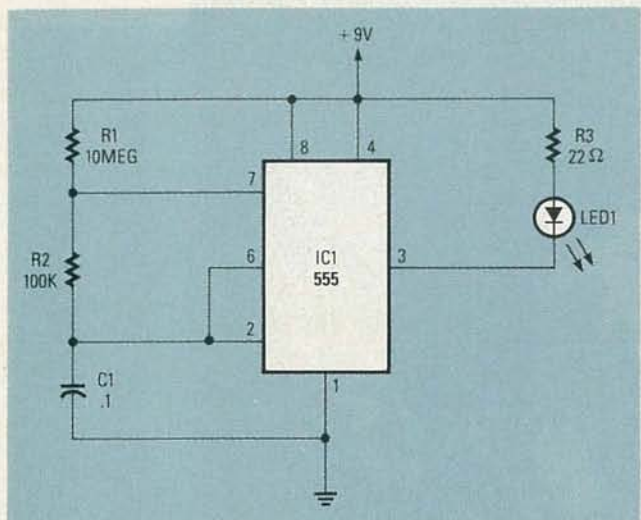


FIG. 1—WHEN THIS LED FLASHER is assembled using SMC's, the assembly is about 0.1-inch thick.

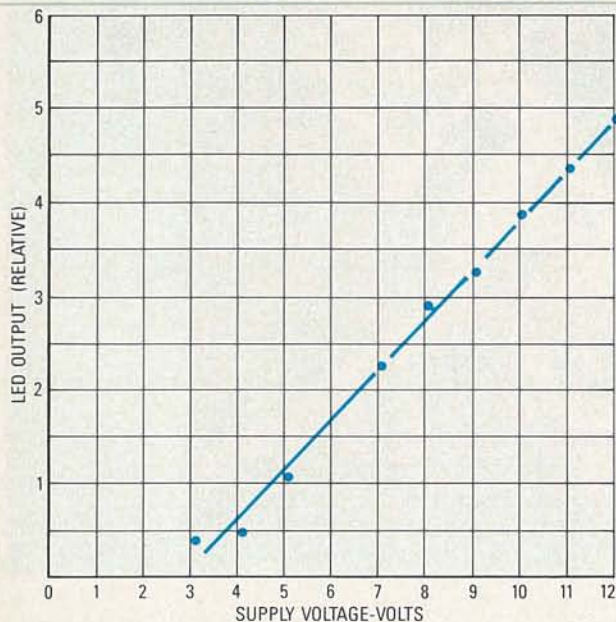


FIG. 2—RELATIVE OUTPUT of a super-bright LED is a function of its supply voltage.

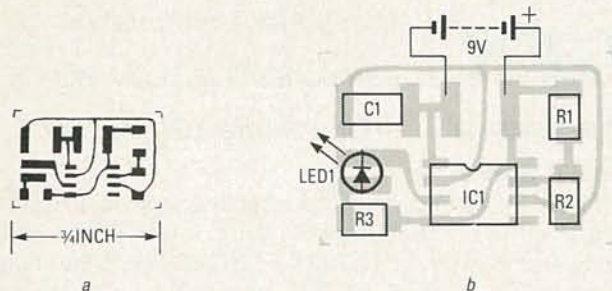


FIG. 3—USE THE PC PATTERN shown in a to etch the board. The parts layout is shown in b.

### Preparing the board

The circuit should be assembled on a thin PC board. A pre-etched board and all necessary components are available from the source given in the Parts List. You can also make your own board using the pattern shown in Fig. 3-a. However or wherever you obtain your board, the component layout is shown in Fig. 3-b.

### PARTS LIST

- R1—10 megohms, chip resistor, 1206 size SMC
- R2—100,000 ohms, chip resistor, 1206 size SMC
- R3—22 ohms, chip resistor, 1206 size SMC
- C1—0.1  $\mu$ F, ceramic chip capacitor, 1206 size SMC
- IC1—555 timer, SO-8 package
- LED1—super-bright red LED, see text

**Miscellaneous:** PC board, 9-volt battery clip, 30-mil solder, reusable adhesive, etc.

An etched circuit board, super-bright LED, and all SMC's are available for \$10.00, including postage and handling, from Gilbert Electronics, P.O. Box 95, Leesville, TX 78122. Texas residents please add appropriate sales tax.

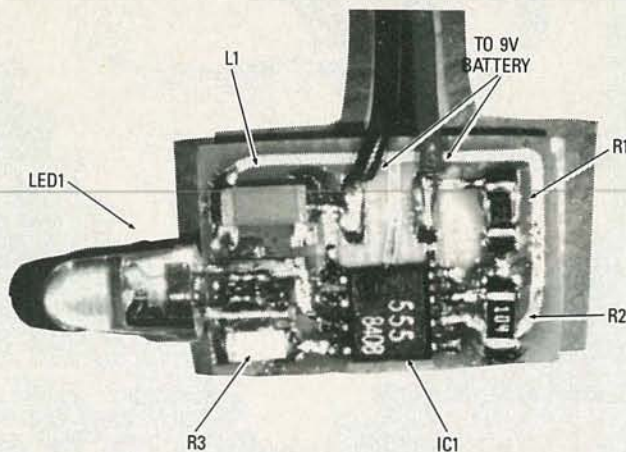


FIG. 4—THE COMPLETED CIRCUIT BOARD. The light from the super-bright LED can be seen for several hundred feet.

The circuit can be assembled in less time than an equivalent conventional circuit since no holes need be drilled in the circuit board. Although an experienced technician can install the components with a 30-watt soldering iron having a wedge tip, for best results use a 15-watt pencil iron having a pointed or conical tip.

Begin assembly by tinning the component footprints on the board. First, use an abrasive cleanser or steel wool to polish the copper traces. Wash and dry the board. Then use masking tape to attach a corner of the board to a flat, movable surface placed on your workbench.

Tinning the board takes just a few minutes. Just touch the soldering iron tip to a footprint for a second or so and then touch the end of a length of 30-mil rosin-core solder to the footprint. When the solder flows over the footprint, immediately remove the iron and solder and proceed to the next footprint. Be sure to rotate the board for best access to each footprint.

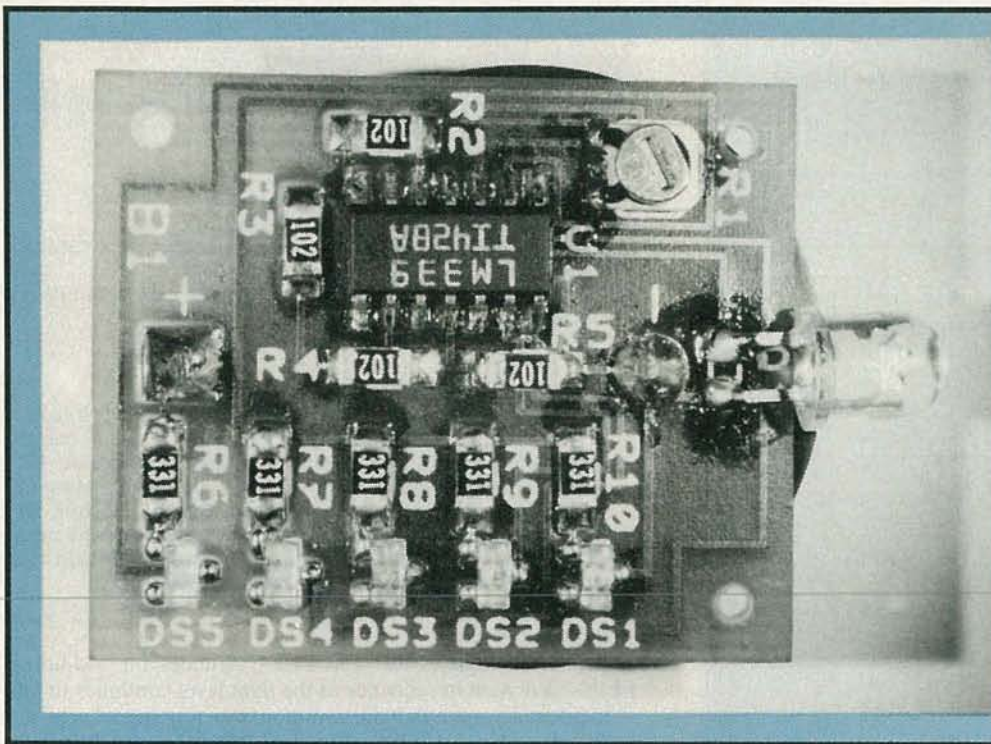
After the footprints on the board are tinned, remove any excess solder from the footprints with desoldering braid. That procedure will also remove any solder bridges.

After the board is tinned and the excess solder is removed, remove any solder balls or splashes from the traces and the substrate. Then use a defluxing agent to remove the flux residue from the board.

### Installing the SMC's

Begin assembly of the LED flasher by first attaching the 555 to the board. Use the methods described in the article on SMC soldering, which can be found elsewhere in this section.

*continued on page 88*



## SMT PROJECT: LIGHT METER

FORREST M. MIMS, III

IN THIS ARTICLE WE WILL SHOW YOU A SIMPLE LIGHT METER with a built-in four-element LED bargraph readout that combines the advantages of analog and digital displays. Since the number of illuminated elements in the bargraph increases as the light reaching a phototransistor decreases, the circuit can be considered a "dark meter." A bonus feature of the circuit is that it can also be used as a four-step timer or as a simple resistance indicator.

The circuit shown in Fig. 1 can be assembled on a tiny circuit board having an area of only about 1.25 square inches, a size made possible by the use of surface-mountable components. Consequently, the circuit is much more compact than an equivalent circuit assembled from conventional through-hole components.

Though the circuit is configured as an inverse light meter or "dark meter," it can be revised so that the number of glowing elements increases with the light level. It can also be used as a timer or resistance indicator by omitting phototransistor Q1. Even if none of the applications for the circuit are of interest, you might want to assemble it anyway since it provides an excellent hands-on introduction to surface-mount technology.

### How it works

There is nothing new about the design of the circuit in Fig. 1, which is often called a parallel or "flash" analog-to-digital converter. To understand how the circuit works, it's necessary to review the operation of the basic inverting comparator shown in Fig. 2. In that circuit, a reference voltage is applied to the non-inverting input of an operational amplifier operated without a

*Here's a simple  
"dark meter" that you can  
build using SMC's.*

feedback resistor. That provides a two-state (off-on) output voltage instead of the linear output that characterizes an op-amp operated with a feedback resistor.

A voltage input is applied to the inverting input of the op-amp. When that input exceeds the reference voltage, the output of the op-amp is low; as far as the LED is concerned, the output is ground. Therefore, the LED switches on. Series resistor R1 limits current to the LED, thereby protecting both the LED and the output-driver stage of the op-amp. When the input voltage is below the reference voltage, the output from the op-amp swings to near the supply voltage (output high). The output LED, which no longer receives sufficient forward bias, then switches off.

The circuit is called a "comparator" since it compares the voltages at its two inputs and switches *on* when one exceeds the other. The circuit shown in Fig. 2 can be changed from an inverting comparator to a non-inverting comparator simply by switching the connections to the inputs. Then the output will swing from low to high when the input voltage exceeds the reference voltage.

Referring back to Fig. 1, IC1 is a quad comparator in a 14-pin SO package. Resistors R1 through R5 form a 4-stage voltage divider with taps connected to the non-inverting inputs of each comparator. The reference voltage delivered to each comparator is determined by the setting of trimmer R1.

Each comparator in Fig. 1 functions exactly like the model comparator in Fig. 2. Therefore, the outputs from the comparators will swing, in sequence, from high to low as the input voltage rises above the reference voltage applied to each comparator. The output LED's will then switch *on* in sequence as the voltage rises.

When the circuit is configured as a light meter, the inverting inputs of the comparators are connected in common to the

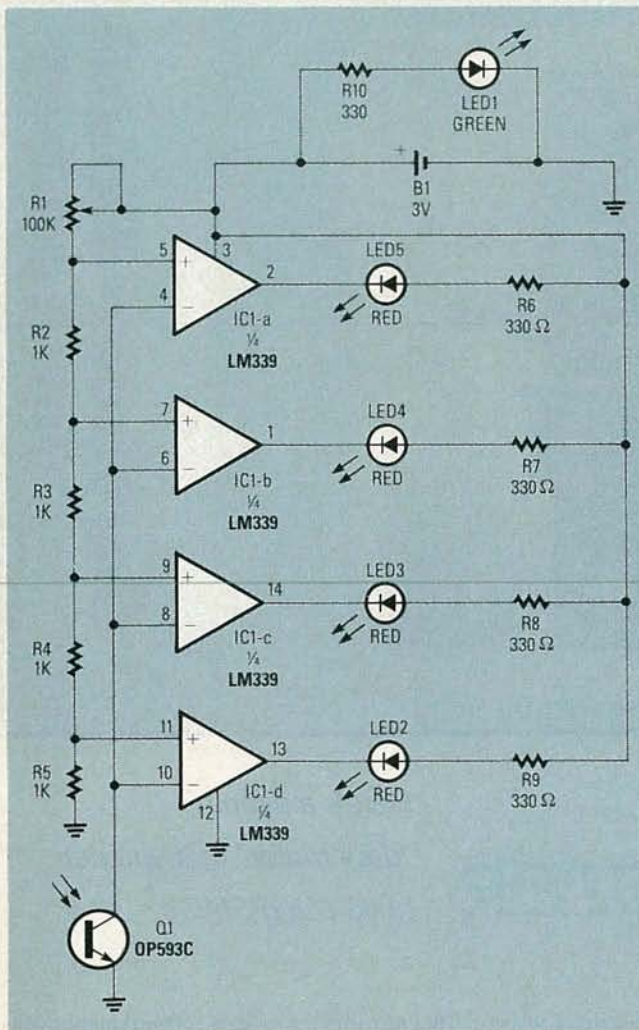


FIG. 1—USING SURFACE-MOUNT COMPONENTS this bargraph "dark meter" can be assembled on a circuit board with an area of just 1.25 inches.

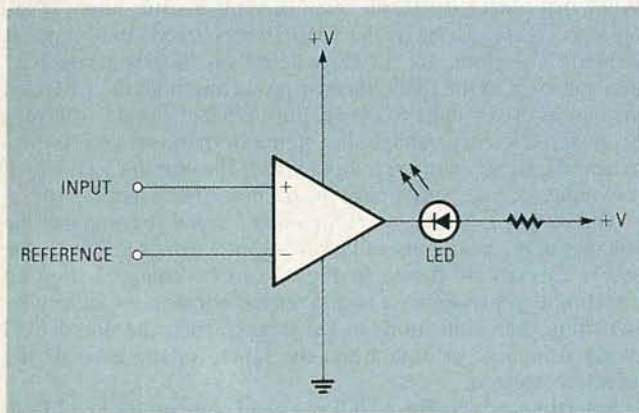


FIG. 2—IN AN INVERTING COMPARATOR, the output is low when the input voltage exceeds the reference voltage; the output is high when the input is lower than the reference voltage.

collector of phototransistor Q1. When Q1 is illuminated, its collector-emitter junction conducts, thereby placing all the inverting inputs within a few millivolts of ground. For most settings of R1, each of the four reference voltages exceeds that value. Therefore, when Q1 is illuminated, the output from each comparator is high and its respective indicator LED is off. As the light level at Q1 is gradually decreased, the voltage at the inverting inputs rises until it exceeds the first comparator's reference voltage (pin 10). The output from that comparator (pin 13) then

#### PARTS LIST

All resistors are 1206 size SMC's unless noted

R1—100,000 ohms, trimmer potentiometer, Micro-Ohm RV43B-CV or equivalent

R2-R5—1000 ohms

R6-R10—330 ohms

#### Semiconductors

IC1—LM339 quad comparator, SO-14 package

LED1—Green LED, SOT-23 package, ROHM SLM-13M or equivalent

LED2-LED5—Red LED, SOT-23 package, ROHM SLM-13V or equivalent

Q1—OP593C NPN phototransistor (TRW), or equivalent

#### Other components

B1—CR2320 or similar 3-volt lithium coin cell

Miscellaneous: Lithium coin cell holder (Keystone P/N 107), PC board, Reusable adhesive or masking tape, 25 or 30 mil solder

A complete kit including a drilled, etched, and plated PC board, Q1, all SMC's, battery, battery holder and solder is available from the Heath Company, Benton Harbor, MI 49022 for \$19.95 plus postage and handling; for credit-card orders, call 800-253-0570. Michigan residents must add appropriate sales tax. Specify catalog number SMD-1.

swings from high to low and LED1 switches on. Additional LED's switch on in sequence as the light level continues to fall.

Incidentally, note that the common inverting inputs appear to be floating when Q1 is fully switched off (dark). Actually, a few tenths of a volt appear between those inputs when Q1 is dark. The inputs can be connected to the positive supply through a pull-up resistor, but leaving them "floating" makes the applications discussed at the end of this article possible.

#### Preparing the circuit board

Figure 3-a shows a suggested layout for the circuit board; the board itself is shown in Fig. 3-b. Also, an etched, silk-screened,

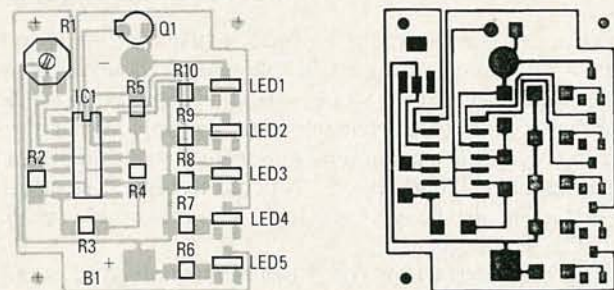


FIG. 3—USE THIS LAYOUT a when building the circuit. The PC board is shown in b.

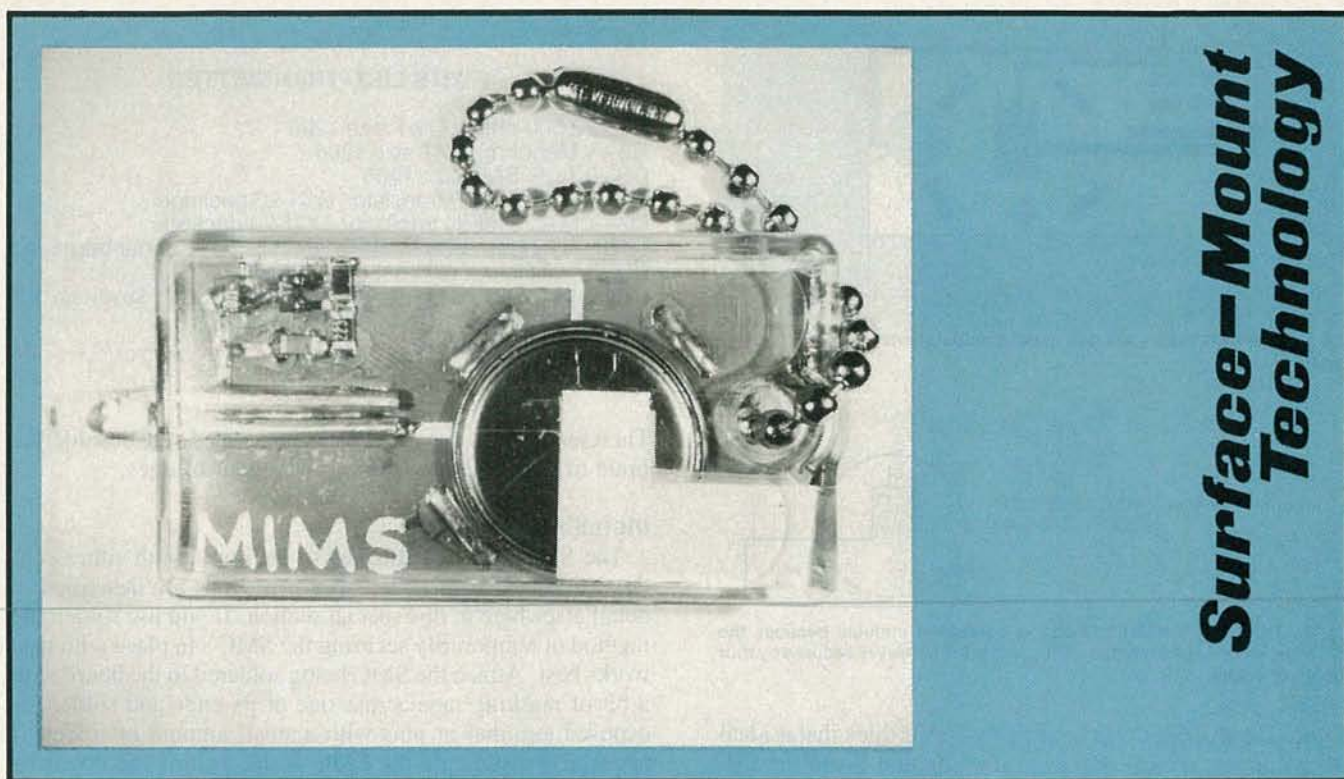
and pre-tinned board is available as part of a kit that includes all necessary components; see the Parts List for more information. Note that the board in the kit also includes a solder-mask coating that both simplifies soldering and greatly reduces solder-bridge problems. The board also includes drilled mounting holes for a Keystone 107, or equivalent, lithium coin-cell holder.

If you build your own board, follow the tinning procedure given in the LED-flasher project described elsewhere in this special section. Also review the SMC soldering procedures given elsewhere in this special section before soldering SMC's to the circuit board.

Begin construction by installing the LM339. Be sure to solder a corner pin first. If the device stays aligned over the remaining pads, then continue soldering.

Next, install the chip resistors one at a time. If you use the tape method to hold the chip resistors in place, you can solder one terminal of each resistor; then you solder the remaining terminals. You can use the same approach when installing the LED's. No matter which method you use, until you become an experi-

*continued on page 88*



## SMT PROJECT: I-R REMOTE ON A KEYCHAIN

FORREST M. MIMS, III

ONE OF THE MAJOR CAPABILITIES OF SURFACE-MOUNT TECHNOLOGY is that experimenters and prototypers can assemble ultraminiature, fully functioning circuits only a few millimeters thin. For example, you can make an optoelectronic remote-control transmitter that is so small that it can be slipped inside a plastic identification-tag holder, yet it's powerful enough to activate a receiver located more than 10 feet away.

The transmitter, shown in Fig. 1, projects a pulse-modulated red or near-infrared beam. Although a 555 timer is often used as an LED driver in this kind of application, the simple two-transistor driver shown is a better choice because it can drive an LED with greater current. Moreover, it can be powered by a supply of less than one volt.

### How it works

Referring to Fig. 1, assume that Q1 and Q2 are initially off when power switch S1 is closed. Capacitor C1 then begins charging through resistors R1 and R2, and LED1. Eventually the charge on C1 becomes high enough to switch Q1 on, which then switches Q2 on.

When Q2 is on, LED1 is connected directly across battery B1 through Q2's emitter-collector junction. Meanwhile, C1 discharges to ground through Q1's base-emitter junction. Eventually the charge on C1 falls below that necessary to keep Q1 on. Transistor Q1 then switches off and, in turn, switches

*Use surface-mount technology to build an infrared transmitter small enough to fit on your keychain.*

Q2 off. The LED is then switched off. The charge/discharge cycle is then repeated at a frequency that is determined by C1's value. The circuit drives the LED with 725 pulses per second using the values given in the Parts List.

### Preparing the circuit board

An ultra-thin circuit board is required if the project is to fit inside the thin label space of a plastic ID-tag holder. A

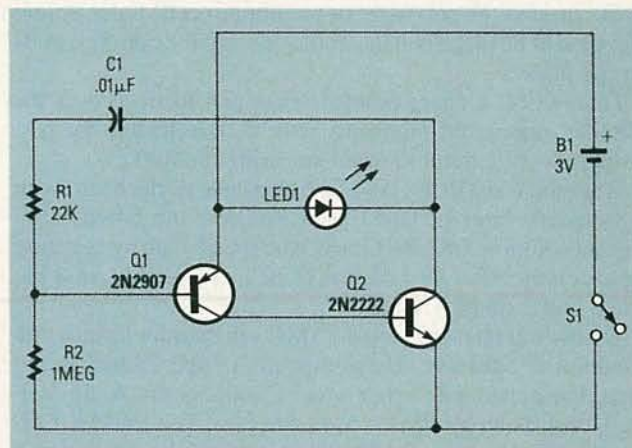


Fig. 1—THE KEY-CHAIN TRANSMITTER uses two transistors to generate a red or near-infrared beam that pulsates at approximately 725 Hz.

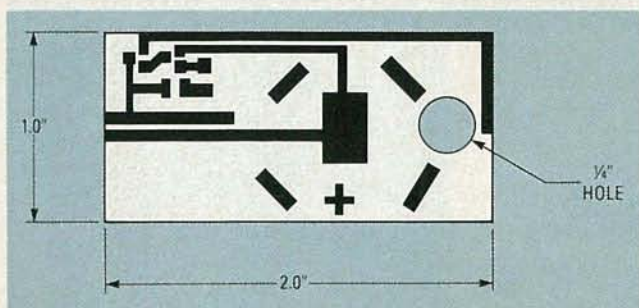


FIG. 2—USE THIS TEMPLATE as a general guide when making the printed-circuit board.

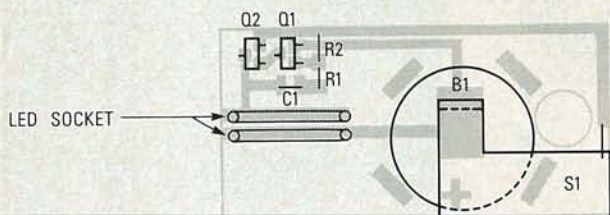


Fig. 3—THE COMPONENT LAYOUT is somewhat unusual because the LED's socket is made from thin tubing, while the battery is secured by four bumps of solder.

double-sided copper-clad board only 7-mils thick that is ideal for the project is available from the Edmund Scientific Co. (101 E. Gloucester Pike, Barrington, NJ 08007). A 12 × 18 inch sheet of the board, catalog number E35,652, sells for only \$2.50.

Although the transmitter is assembled on only one side of the board, keep in mind that SMC's can be mounted on both sides of a double-sided circuit board. The foil pattern for the board is shown in Fig. 2; use it as a general guide and apply the resist by hand using a small brush, which is a somewhat faster way to make a small board compared to using the photo-resist technique.

### Hand-made board

Use a pair of scissors to cut the board to size, then polish the foil with fine steel wool. Use a 1/4-inch hole punch to create the hole for the keychain, then place the various components including B1, a 2016 lithium coin cell, on the board in the approximate locations shown in Fig. 3. Mark their terminal or pin locations on the board with a pencil. Then remove the parts and pencil in the required terminal footprints and interconnection traces. Be sure to include four marks around the perimeter of the lithium cell. Later, solder bumps will be placed on the marks to keep the coin cell in its proper place.

Finally, use a sharp-pointed resist pen to trace over the penciled traces and footprints. Use a straightedge for best results and be careful to avoid smearing the ink.

After the resist dries, cover the back side of the board with a protective layer of tape. Then immerse the board in an etchant solution. Etching time can be speeded up by agitating the solution. After the board is etched, thoroughly rinse the board under running water.

Unless you plan to attach the SMC's to their footprints with conductive adhesive, the footprints of the etched board should be plated with a thin layer of solder or tin. A dip-and-dunk tin-plating solution is available from The DATAK Corporation (Guttenberg, NJ 07093). Alternatively, you can melt a thin layer of standard rosin-core solder over each footprint. For best results, the solder layer should be thin and flat.

### PARTS LIST—TRANSMITTER

- R1—22,000 ohms, SMT size 1206
  - R2—1 Megohm, SMT size 1206
  - C1—0.1  $\mu$ F, SMT size 1206
  - Q1—2N2907, PNP transistor, SOT-23 package
  - Q2—2N2222, NPN transistor, SOT-23 package
  - LED1—Light-emitting diode, near-infrared or super-bright red
  - B1—3-volt lithium coin cell, type 2016
- Miscellaneous:** circuit-board material, plastic keychain ID-tag holder, solder, masking tape, wire, etc.

Therefore, after all the footprints are coated, use desoldering braid to remove excess solder and solder bridges.

### Installing the SMC's

The SMC's can be attached to the board with either conductive adhesive or solder. Both methods are described in detail elsewhere in this special section. If you use solder, the method of temporarily securing the SMC's in place with tape works best. Attach the SMC being soldered to the board with a bit of masking tape across one of its ends and solder the exposed terminal or pins with a small amount of solder. If necessary, make sure the SMC is flat against the board by pressing it down with a pencil eraser while the solder is still molten. Then remove the tape and solder the remaining terminal or pins.

After the SMC's are soldered in place, prepare a socket for the LED by cutting two 0.5- to 0.65-inch lengths of 62.5 mil (1/16 inch) O.D. brass tubing purchased from a hobby shop. Prepare the tubes for soldering by burnishing them with steel wool or fine sandpaper. Insert the wire from a bent paper clip in one end of one tube and melt a line of solder along its entire length. Repeat the procedure for the second tube. Then use the paper clip to hold one of the tubes in place over its footprint and remelt the solder on both the tube and the footprint until the tube is bonded in place. If necessary, apply some additional solder to the side of the tube away from the footprint. Repeat the procedure for the second tube. Be sure to keep solder from entering the open ends of

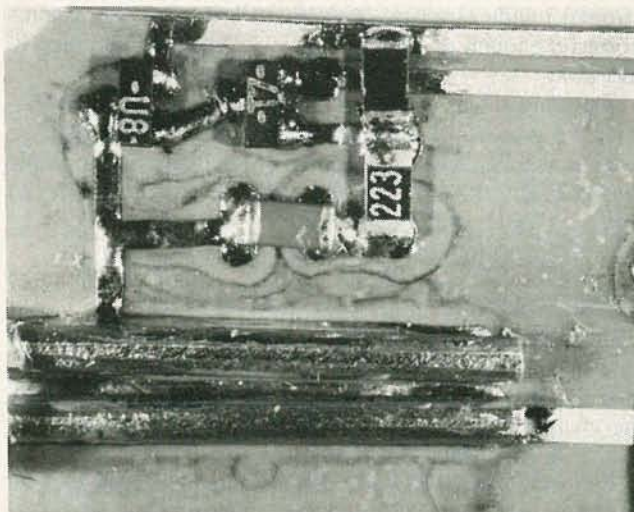


Fig. 4—THIS CLOSE-UP SHOWS how really small the components are. The transistor, labeled U8, is actually smaller than the resistor and capacitor chips. The two "giant" horizontal tubes near the bottom are the LED socket.

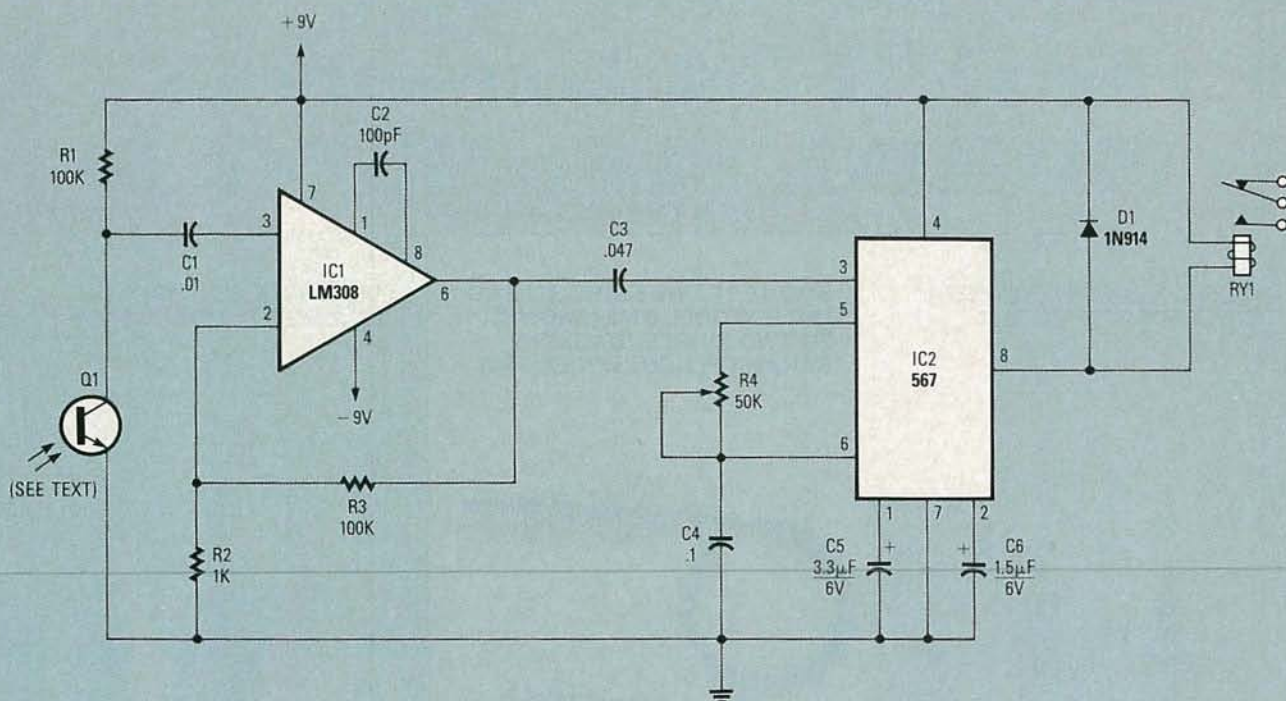


Fig. 5—IF YOU NEED A RED-LIGHT RECEIVER, try building this circuit. Most of what's needed is probably lying somewhere around your shop. Relay RY1 can be any low-current relay rated from 5 to 9-volts DC; such relays are called "sensitive relays."

the tube, especially the end closest to the edge of the circuit board. Fig. 4 shows the tubes, and the Q1/Q2 circuit soldered to the board.

Switch S1 is a *squeeze switch* made from an L-shaped piece of circuit board, as shown in Fig. 3. The exact shape of the switch is unimportant so long as it fits the allowed space. Solder a short length of wire-wrap wire to the lower side of the base of the L. With the exception of a narrow strip of exposed copper along the end of the lower side of the L (the dashed line in Fig. 3), cover both sides of the L with a clear tape. Solder the exposed end of the wrapping wire to the adjacent positive circuit-board foil. Then attach the copper L to the board with a hinge made from a strip of clear tape.

### Testing the circuit

Test the circuit before installing it in an ID-tag holder. First, insert the leads of a red AlGaAs super-bright LED into the LED socket (be sure to observe polarity). Then place B1 on the board (positive side down) and press the squeeze switch. The LED should glow. When the LED is pointed toward a phototransistor or solar cell connected to the input of an audio amplifier, a 725-Hz tone should be heard from the amplifier's speaker.

If the circuit is working properly, remove the LED and slip the circuit inside the ID-tag holder. You might want to first place a self-adhesive label on the back side of the board. You can leave the label blank or record the circuit's operating parameters on it. At least two kinds of plastic keychain ID-tag holders are available from office supply companies. The one used for this project, which has a retail cost of approximately 70 cents, has a 2-mm high slot at one end, opposite the hole for the keychain.

After the circuit is inside the holder, insert the LED into its holder through the 2-mm slot. The slot also simplifies removal of the circuit board: Simply push the board out with a

small screwdriver or a flat implement passed through the slot. Adjusting the squeeze switch can be tricky. If the LED stays on when the board is slipped inside the tag holder, bend the exposed copper end of the L slightly upward. If excessive pressure is required to close the switch, expose additional copper by removing a narrow strip of the tape with a knife.

### Suitable remote-control receivers

The keychain transmitter can be used to trigger various kinds of optoelectronic receivers. The circuit for a suitable receiver is shown in Fig. 5. The circuit uses a 567 tone decoder to help prevent triggering by any unauthorized transmitters.

In operation, pulsed infrared or visible light is received by Q1 and transformed into a pulsed voltage. Any NPN phototransistor can be used for Q1. The signal from Q1 is amplified 1,000 times by IC1, an LM308 high-input impedance operational amplifier, and is passed to IC2, a 567 tone decoder. Resistor R4 and capacitor C4 determine IC3's center frequency. Resistor R4 is a potentiometer rather than a fixed resistor to permit the receiver to be tuned. IC3's output drives RY1, a low-current relay.

The receiver can be assembled on a printed-circuit board using either conventional or surface-mountable components. Both IC1 and IC2 are available in small outline packages.

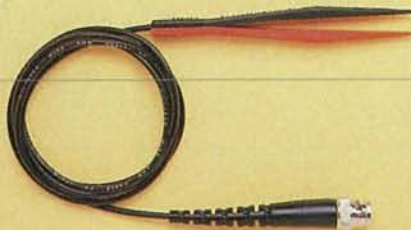
Test the receiver by pointing the transmitter at Q1 while carefully adjusting the receiver's R4. With R4's wiper set near its midpoint, the relay should pull in when Q1 is receiving the transmitter's signal. For best results, bright ambient light must not be allowed to strike Q1; otherwise, Q1 may become saturated and fail to respond fully, or at all, to incoming pulses from the transmitter. If ambient light proves to be a problem, place one or two pieces of developed color film in front of Q1 to serve as a near-infrared filter, and insert a near-infrared LED into the transmitter.

# Your Best Source for SMD Test Accessories is POMONA ELECTRONICS

PATCH CORD; SMD GRABBER™  
BOTH ENDS: MODEL 5301



SMD TEST TWEEZER™ TO BNC  
MALE: MODEL 5142 (SHOWN).  
TO TWO SINGLE STACKING  
BANANA PLUGS: MODEL 5143



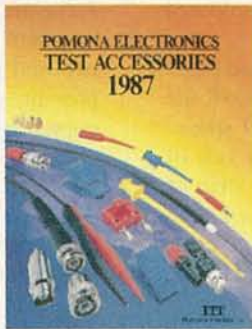
DO-IT-YOURSELF SMD  
GRABBER™: MODEL 5243



SMD MICRO TIP™ TEST  
PROBE TO SINGLE  
STACKING BANANA  
PLUG: MODEL 5144

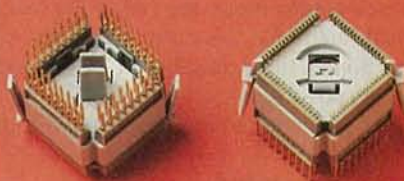


FREE 1987 GENERAL CATALOG



**ITT** Pomona Electronics  
1500 E. Ninth St., Pomona, CA 91766  
Tel: (714) 623-3463

PLCC TEST ADAPTORS  
FIVE MODELS: 20 PIN, 28 PIN,  
44 PIN, 52 PIN, 68 PIN



CABLE ASSEMBLY; SMD  
GRABBER™ TEST CLIPS TO  
BNC MALE: MODEL 5304



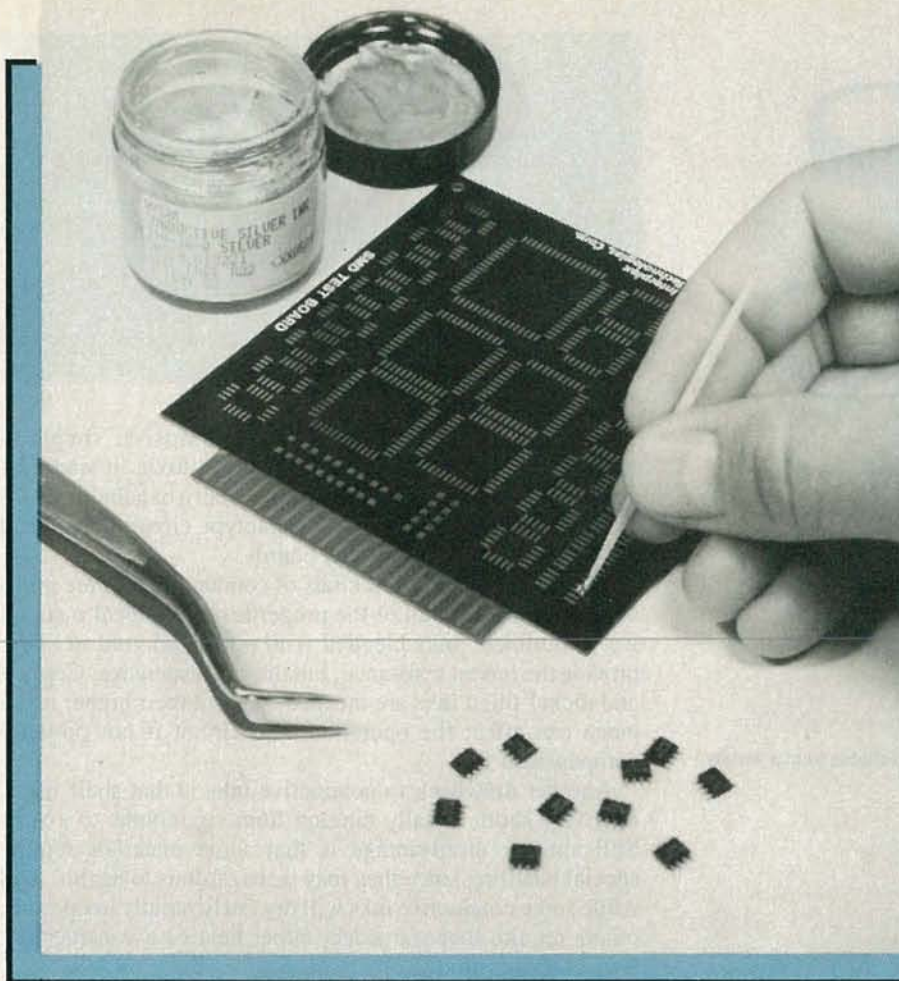
SOIC CLIP™ TEST CLIP: MODEL  
5250 (8 PIN); 5251 (14 PIN); 5252  
(16 PIN) SHOWN; 5253 (20 PIN);  
5254 (24 PIN)



MOLDED BREAKOUT; SMD  
GRABBER™ TEST CLIPS TO  
FEMALE BNC: MODEL 5305







## Surface-Mount Technology

*Who needs copper foil and solder when you can use these conductive inks and adhesives?*

# Conductive Inks and Adhesives

FORREST M. MIMS, III

FOR MANY YEARS, THE HYBRID MICROELECTRONICS INDUSTRY has used electrically-conductive inks and adhesives to interconnect components, and to bond them both mechanically and electrically to a substrate. Those same inks and adhesives can also be used with all sorts of surface-mountable components.

While conductive inks and adhesives are usually used with standard circuit boards or ceramic substrates, they also make possible some very unusual and even novel circuit-assembly methods. For example, they permit surface-mountable components and even complete circuits to be installed on paper, plastic, glass, wood, painted surfaces, and many other substrates. Do-it-yourself examples of such circuits are presented elsewhere in this special section.

Figure 1 shows an assortment of conductive inks and adhesives. Whether or not you decide to experiment with conductive inks and adhesives now, chances are you will encounter those versatile counterparts of copper foil and solder sometime in the future. Therefore, let's take a close look at both conductive inks and adhesives.

### Conductive inks

Electrically conductive liquids and pastes that can be applied to a substrate to form a network of interconnections are collectively known as *conductive inks*. Those materials are usually much more viscous than drawing ink, and often

resemble paints. Indeed, conductive paints and coatings are available that will add RF shielding to enclosures.

Conductive inks are often used to repair broken traces and to form new traces on etched circuit boards. For decades, however, their chief application has been to form conductive traces on hybrid microelectronics substrates. Generally, a conductive-ink pattern is screen or stencil printed on a ceramic substrate that is then fired in an oven. The result is a very tough and permanent conductive network. Additional conductive layers can be added if previously-applied conductive layers are first coated with a dielectric paste.

Figure 2 shows a very simple hybrid microcircuit, a micro-switch Hall-effect sensor assembled on a thin ceramic substrate. The Hall sensor is installed behind the oval protrusion. The three shaded rectangles are thick-film resistors that have been screened onto the substrate. Upon close examination, two of them show the thin slice marks that result from laser trimming, a method used for tuning a low-tolerance thick-film resistor to a precise value. The Hall sensor, the resistors, and the three terminals are interconnected by a solderable conductive ink that has been screened onto the substrate and then fired.

The conductive property of an ink is provided by powdered gold, silver, and other metals. Gold, while expensive, provides very low resistance and long-term stability. Silver is cheaper than gold but has several times its resistance. Further-



FIG. 1—CONDUCTIVE INKS AND ADHESIVES are available from a variety of manufacturers.



1 INCH

FIG. 2—THIS MINIATURE THICK-FILM hybrid microcircuit uses conductive ink for its interconnections.

more, silver may migrate from the fired ink over time. Alloys of platinum and gold or silver are used when it is necessary to solder to the fired ink. Copper and nickel are used as inexpensive substitutes for gold and silver. Both, however, have higher resistance and other less-desirable characteristics.

The resistance of conductive inks is often specified in terms of sheet resistivity. Sheet resistivity, which is given in terms of ohms-per-square centimeter, is the electrical resistance across opposite sides of a square pattern of conductive material. Resistance of conductive inks can also be given in terms of a line of material having specified dimensions. The resistances of several common inks used in the hybrid-microelectronics industry are shown in Table 1.

### Ink properties

The ideal conductive ink would be an inexpensive material having zero sheet resistivity, a short curing time, and an

TABLE 1

Conductor Composition	Sheet Resistivity (ohms/square cm)	Line Resistance (1" × 0.02")
Gold	0.003	0.15 ohm
Silver	0.020	1.00 ohm
Palladium Silver	0.035	1.75 ohms
Platinum Gold	0.100	5.00 ohms

Source: "Designers Handbook on Thick Film Microcircuits," Paine Instruments, Inc.

unlimited shelf life. It would be non-corrosive, simple to apply, odorless, non-flammable, and non-toxic. It would be available in bulk for screen printing, and in a handheld pen for the instant preparation of SMC-prototype circuit boards and for the repair of conventional boards.

Though many different kinds of conductive inks are available, none possess all of the properties of the ideal material we've outlined. Inks blended with powdered gold or silver provide the lowest resistance, but they are expensive. Copper and nickel-filled inks are inexpensive, but their higher resistance can affect the operation of a circuit if not properly compensated for.

Another drawback to conductive inks is that shelf life is relatively short, usually ranging from six months to a year. Still another disadvantage is that some materials require special handling since they may be hazardous to health. And while some conductive inks will dry fairly rapidly in open air, others require that you select either heat or a considerably longer drying time.

### Applying inks

In an industrial setting, conductive inks are usually applied by screening or stenciling. Those methods require considerable preparation time and often are impractical when only a few boards are needed.

Fortunately there are several ways to apply conductive inks by hand to make relatively simple circuit boards. It's even possible to make multiple-layer boards by interspersing conductive layers with a layer of insulating material.

Before going on, a few caveats are in order. The best conductive inks can be very expensive. Also, the physical properties of various inks, both when liquid and after hardening, can be very different. The metal particles in a conductive ink generally do not remain in suspension. Instead, they sink to the bottom of their container under a layer of syrupy carrier fluid. Therefore, for lowest resistance it is essential that the particles be thoroughly mixed with the carrier before the ink is applied. Shaking alone may not be adequate; stirring may be required. Finally, the carriers of most conductive inks are volatile and may be flammable, hazardous to health, or both. Therefore, it is essential to use conductive inks in a well ventilated area and to follow the safety instructions provided with a specific product.

The ideal way to apply conductive ink by hand would be with a drawing pen. However, the author has been unable to find a pen intended for that application. It is possible to load conventional drawing pens with conductive ink. But, the viscous nature of most conductive inks means that they must first be thinned with a suitable solvent or carrier. The drawback to that procedure, aside from it being rather messy, is that thinning increases the resistance of the ink. Furthermore,

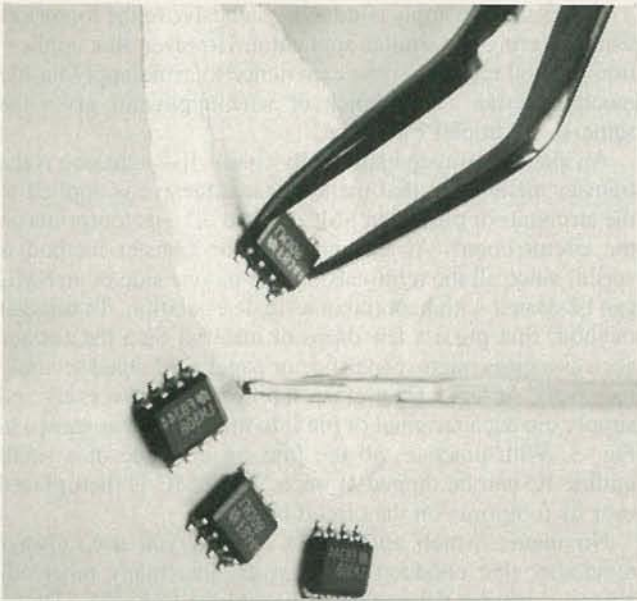


FIG. 3—USING THE TRANSFER METHOD to apply conductive adhesive to the pins of an SO device.

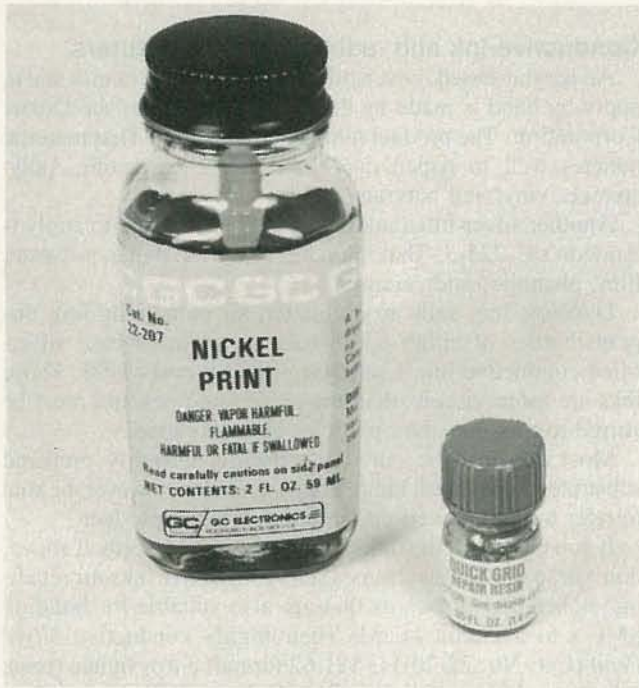


FIG. 4—THESE TWO CONDUCTIVE INKS are low priced, readily available, and suitable for hand application.

considerable experimentation may be needed to arrive at the best combination of pen-orifice size, ink, and thinner.

A simpler method is to apply the ink dot-matrix style; that is, a droplet at a time, by means of a small wire dipped into the material. Generally, dipping the wire into the ink will pick up enough fluid for several dots. The dots should be placed close together so they form a continuous line. That is best done by a quickly tapping the end of the wire against the substrate while moving it in the desired direction. With practice, you can form closely-spaced component footprints and both curved and straight lines. While that low-tech method is both slow and tedious, it works quite well with simple circuits. In fact, a complete interconnection pattern for a circuit consisting of an IC and half a dozen outboard components can be produced in 10 minutes or so.

Another method is to use a hand-held automatic dispensing syringe to form lines consisting of precisely metered dots of material. The necessary equipment, however, is expensive. A conventional syringe with a hand-depressed plunger can be used but only after some experience has been gained to avoid dispensing too much material.

It's best to experiment before selecting a method for hand applying a conductive ink. Then, before beginning work, plan each step carefully. For best results, use a pencil to draw the outline of the circuit on the substrate. If you use a transparent substrate such as Mylar, you can draw the circuit outline on a sheet of white paper that is then placed under the substrate, allowing you to trace several circuits from a single pattern.

### Using inks as adhesives

The composition of some conductive inks and adhesives is very similar. And there are some inks that can provide a relatively strong bond to an SMC terminal or pin. Therefore, it follows that some conductive inks can double as conductive adhesives.

The surface-mount circuit builder can exploit the adhesive property of some conductive inks to speed up the assembly of simple prototypes. For example, the author has assembled a number of miniature circuits using only a lacquer-based conductive ink. First, the footprints for a component are formed with the material. The SMC is then placed on the footprint. Additional component footprints are made and their SMC's are positioned in place. Interconnections between the footprints are made as the circuit is assembled. Any remaining interconnections are formed after all the SMC's are in place. Though the lacquer-based ink hasn't the strength of a conductive adhesive, circuits assembled in that fashion have survived being dropped on the floor from a distance of as much as a few feet.

### Conductive adhesives

Heretofore, the principle application of adhesives in surface-mounting technology has been to use non-conductive materials to bond SMC's to a circuit board in preparation for wave soldering. Although considerable literature and many application notes on the use of non-conductive adhesives for that purpose have been published, comparatively few publications about surface-mount technology even discuss conductive adhesives. That is surprising, particularly since conductive adhesives provide a fast and reliable method of attaching SMC's to a circuit board without using solder. Moreover, conductive adhesives are well suited for use with heat-sensitive components, and they can be used to make quick circuit repairs and modifications when soldering equipment is either unavailable or impractical.

The ideal conductive adhesive would be an inexpensive, single-part material having zero electrical resistance, a short curing time, and an infinite shelf life. It would be non-corrosive, simple to apply, provide a strong bond, and be easily reworked. Finally, it would be odorless, non-flammable, and non-toxic.

While the perfect conductive adhesive has yet to be formulated, a surprising number of products possess many of those properties. Adhesives blended with powdered gold or silver provide the lowest resistance, but they are expensive. Copper and nickel-filled adhesives provide reasonably low resistance for less cost.

Some conductive adhesives have novel properties. For

instance, some can actually be soldered-to using conventional tin-lead solder. And some conductive adhesives are thermoplastics that can be reworked merely by reheating the existing adhesive. In other words, a connection can be heated until the adhesive softens enough for the SMC to be removed. A replacement SMC can then be bonded in place with fresh adhesive or, with some materials, by heating the joint once again.

Unfortunately, the typical shelf-life of conductive adhesives ranges from two months to a year, with six months being fairly typical. Another drawback is that some materials require special handling since they may be hazardous to health. While those drawbacks are certainly undesirable, they are not unique to conductive adhesives. Indeed, most adhesives, conductive or otherwise, have limited shelf lives and some require special handling.

### Conductive-adhesive types

Regardless of their conductive filler, conductive adhesives can be divided into several major classes. The two most important are:

- **Thermosetting adhesives.**—Those adhesives have proven their reliability during many years of use in the electronics industry. Thermosetting adhesives provide a very strong, inflexible bond. They are cured by means of a chemical reaction that is initiated by a chemical catalyst, heat, or ultraviolet radiation. The resulting bond is permanent, and cannot be reworked unless the adhesive is first shattered or dissolved with a solvent. Examples of thermosetting adhesives include 1- and 2-part epoxies, acrylics, and also, the polyesters.

- **Thermoplastic adhesives.**—Those adhesives do not undergo a chemical change when a bond is formed. Therefore, they can be reworked simply by applying heat until the material softens enough to remove the bonded component. A second application of heat permits a replacement component to be attached. Though thermoplastic adhesives provide a weaker bond than thermosetting adhesives, the fact they can be reworked makes them well-suited for many applications in which they will be subjected to only mild mechanical stresses. Examples of thermoplastic adhesives include nylon, polyimide siloxane, and various proprietary materials. Very flexible thermoplastic adhesives can be formulated by mixing synthetic or natural polymers (e.g. neoprene or rubber) in a solvent or other suitable carrier.

### Applying conductive adhesives

In an industrial setting, dots of conductive adhesive are applied to each SMC footprint by screening, an array of pins, or an automatic syringe dispenser. The SMC's are then placed over the footprints and the adhesive or ink is allowed to cure or dry.

There are several ways to apply conductive adhesives by hand. A hand-held automatic dispensing syringe will place a precisely metered quantity of material over each footprint. The necessary equipment, however, is expensive. Fortunately, there are some very simple alternatives.

The simplest method is to dip a toothpick or wire into the adhesive to pick up a small droplet of material. The droplet is then touched to the desired footprint. If the material is slow drying, the conductive material can be applied to all the footprints before the SMC's are installed. If the material is fast drying, only the material required for an individual SMC should be applied.

It's possible to apply conductive adhesive to the footprints using a syringe or similar applicator. However, that application method requires some experience to avoid applying too much material. A toothpick or wire applicator gives the same-sized droplet each time.

An alternate way to hand-apply conductive adhesive is the transfer method. In that method, the adhesive is applied to the terminals or pins of an SMC instead of to its footprints on the circuit board. An advantage of the transfer method is speed, since all the terminals or pins on one side of an SMC can be coated with material in a single operation. To use that method, first place a few drops of material on a flat surface such as a glass microscope slide or paper card taped securely to a work surface. Then grasp the SMC with tweezers and simply dip each terminal or pin into the material as shown in Fig. 3. With practice, all the pins on one side of a small outline IC can be dipped at once. The SMC is then placed over its footprints on the circuit board.

No matter which application method you use, always remember that conductive adhesives, like many other adhesives, may be flammable or hazardous to health. Therefore, always work in a well-ventilated area and be sure to follow the safety precautions provided with the product.

### Conductive-ink and -adhesive manufacturers

An acrylic-based, silver-filled ink that is easy to mix and to apply by hand is made by the Hysol Division of the Dexter Corporation. The product number is *140-18-Q*. That material adheres well to paper, cardboard, wood, phenolic, polystyrene, vinyl and butyrate.

Another silver-filled ink that is easy to mix and to apply is Amicon's *C-225-3*. That ink adheres well to paper, polyester film, phenolic, and ceramic.

Dynaloy, Inc. sells an evaluation kit containing four 50-gram bottles of either epoxy-base or polyester-base silver-filled conductive ink. Each 200-gram kit costs \$100. Those inks are more viscous than the preceding ones and must be stirred to mix the silver particles and the carrier.

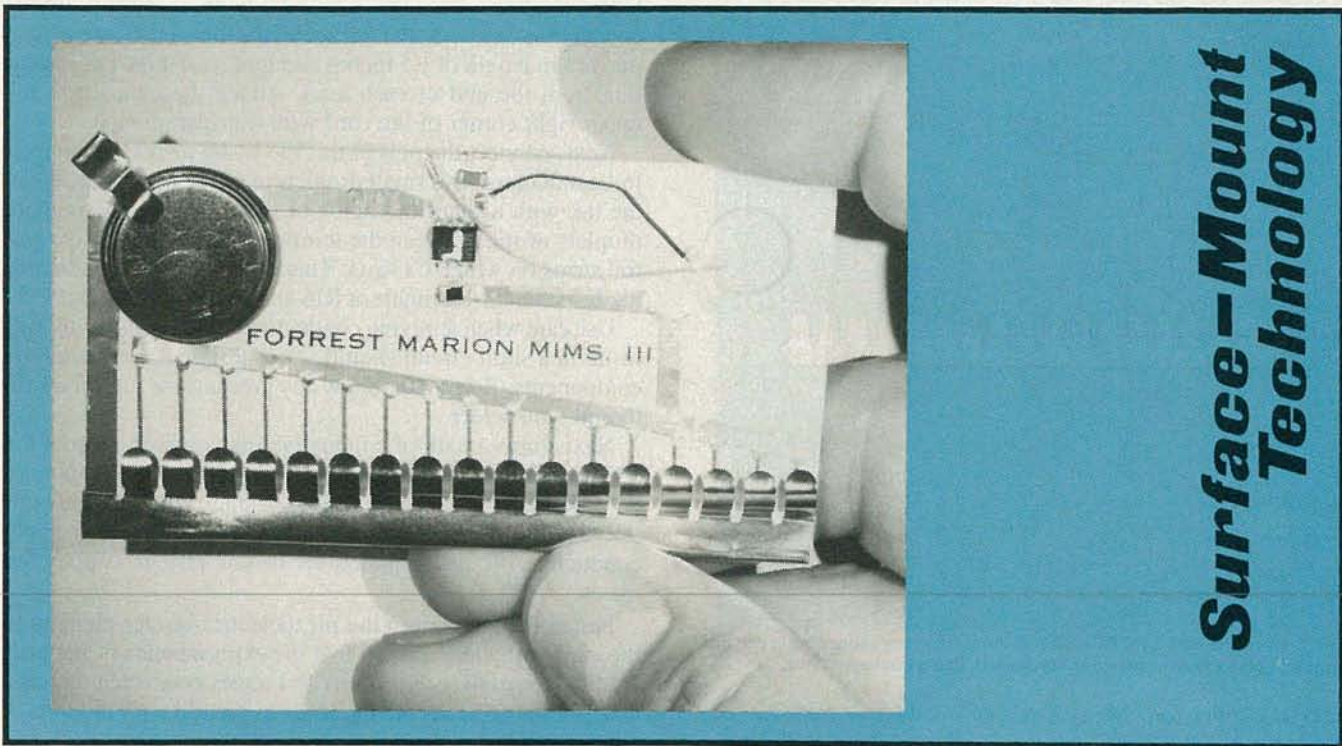
Most inks can be cured by placing a freshly prepared substrate under a desk lamp. For best results, however, be sure to refer to the instructions supplied with the product.

If you can't find the industrial-grade inks described above, don't despair. GC Electronics sells conductive inks for repairing etched circuit boards that are also suitable for bonding SMC's to a circuit board. Their highly conductive *Silver Print* (Cat. No. 22-201) is \$21.62 for half a troy ounce (price subject to change with the price of silver). GC's *Nickel Print* (Cat. No. 22-207), has a higher resistance than *Silver Print*, but the two-ounce bottle shown in Fig. 4 costs only \$3.83. Both of those products can be ordered from GC Electronics or purchased at many electronics dealers.

If those GC products aren't readily available, you can obtain satisfactory results with a silver-filled conductive lacquer available from some automotive parts stores that sell NAPA parts. The product, which is dyed to resemble copper, is Loctite Quick Grid Window-Defogger Repair Kit. The kit, which sells for around \$7.25, includes a small bottle containing 0.05 fluid ounces of silver-filled lacquer. It is also shown in Fig. 4.

Dynaloy, Inc. sells various one-part conductive-epoxy pastes that are well-suited for conductive bonds. An evaluation kit containing 50 grams each of one pure-silver and two silver-alloy adhesives costs \$100. Conductive adhesives are also available from Amicon.

R-E



## SMT PROJECT: A BUSINESS-CARD TONE GENERATOR

FORREST M. MIMS, III

SURFACE MOUNT TECHNOLOGY OFFERS CIRCUIT BUILDERS entirely new methods of assembling solid-state circuits. For example, the circuit shown in Fig. 1 can be installed without solder on an ordinary paper business card. The prototype version of the circuit was built in around 90 minutes.

The primary value of this particular circuit-on-paper is that it vividly illustrates some of the unique capabilities provided by surface-mount technology. Among the more interesting techniques it will show you is how to form resistors simply by drawing them in place with a graphite pencil.

### How it works

Referring to Fig. 1, the circuit for the tone generator consists of a 555 timer connected as an astable oscillator. The circuit's frequency of oscillation is controlled by resistors R1-R17 and C1. The output from the 555 drives a piezoelectric-buzzer element. Note that Fig. 1 specifies a power supply voltage of 6. Keep in mind that selected 555's and low power 555's can be powered by 3 volts.

### Circuit assembly

Figure 2 shows both the conductor traces and the component layout for the assembled circuit. For the circuit to fit on a business card, two specialized components are required. The piezoelectric-buzzer element is a miniature 0.7-inch diameter unit made by Murata Erie North America, Inc. (2200 Lake Park Drive, Smyrna, GA 30080). The keyboard is a

section of clip-on cylindrical-radius contacts made by Tech-Etch, Inc. (45 Aldrin Road, Plymouth, MA 02360). One finger from a contact section is used for the battery clip. An 18-finger section, which we'll call the switch strip, is used for the keyboard.

The circuit also requires conductive ink and adhesive-

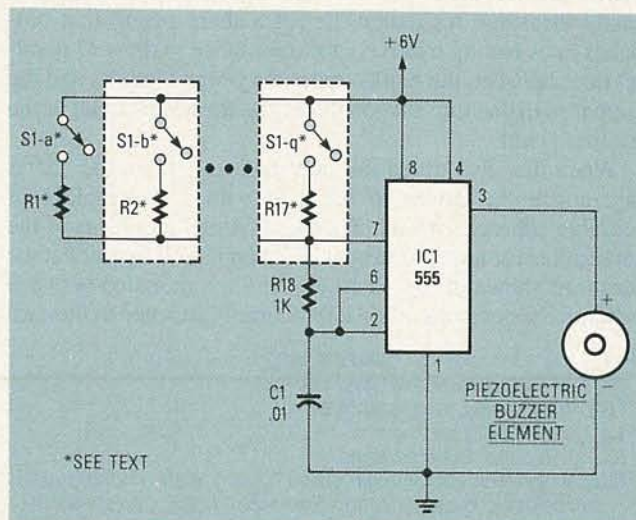
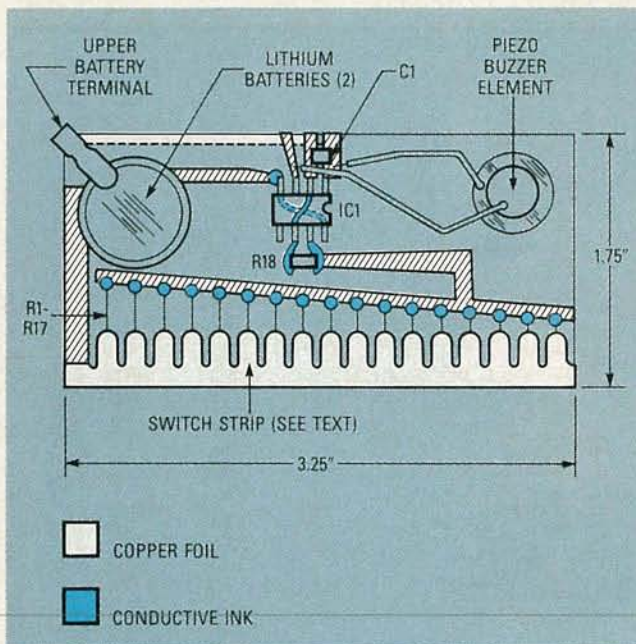


FIG. 1—A SIMPLE TONE-GENERATOR. Resistors R1-R17 consist of nothing more than lines drawn with a graphite pencil.



**FIG. 2—WHO NEEDS A PC BOARD?** As show here, the entire circuit can be mounted on a piece of paper or cardboard, like a business card.

backed copper foil. Many kinds of conductive inks can be used. Silver-filled inks, however, will work best. Adhesive-backed copper foil is available from The Datak Corporation (3117 Patterson Plank Road, North Bergen, NJ 07047).

Begin assembly of the circuit by using conductive ink and a suitable applicator (a wire or a sharp toothpick) to interconnect pins 4 and 8 on the back side of the 555. Set the 555 aside to allow the ink to dry.

Next, follow the layout in Fig. 2 and apply adhesive-backed copper strips to a business card. Note that a single strip is placed along the upper left side of the back of the card.

Cut an 18-finger section from a length of the cylindrical-radius contacts to form the switch strip. Clip off the left-most flexible finger from the switch strip and slip the strip over the lower side of the card. Use a pencil to make a small mark directly below each contact finger, and then remove the switch strip.

Use a multimeter to measure the resistance of lines drawn on paper with various kinds of pencils. While some pencils produce non-conductive lines, others produce lines having an easily measured resistance. Select a sharp pencil that produces lines having relatively low resistance to draw 17 parallel lines between the marks under the contact fingers and the copper strip that runs diagonally across the lower center of the business card.

When the silver-filled ink on the lower side of the 555 is dry, attach the device to the card with a small piece of reusable adhesive or wax. Then use very small pieces of the same adhesive material to attach C1 and R18 to the card at the locations shown in Fig. 2. Note that C1 is mounted between two thin copper strips while R18 is simply attached to the card

#### PARTS LIST

- R1-R17—graphite pencil lines, see text
- R18—1000 ohms, 1206 package
- C1—.01  $\mu$ F, 1206 package
- IC1—555 timer, SO-8 package

**Miscellaneous:** Lithium coin cells (2 each, 2016 or 2020 type), piezoelectric buzzer (Murata-Erie MSJ-70383, or equivalent), switch strip (see text), battery terminal (see text), adhesive-backed copper foil, conductive ink, graphite pencil, business card, etc.

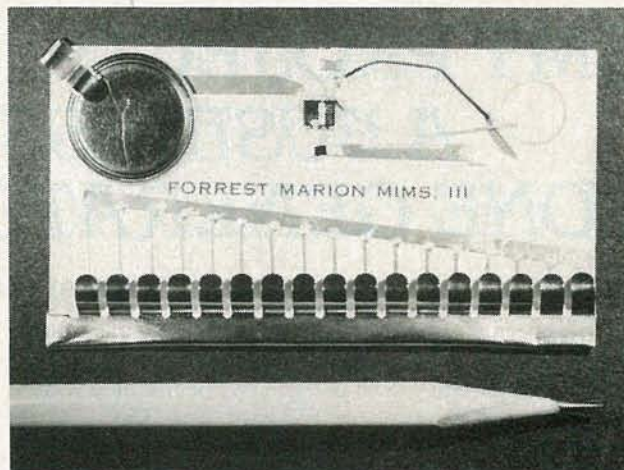
below the 555. After the three SMC's are in place, clip the connection leads of the piezoelectric-buzzer element to a maximum length of 1.5 inches and remove 0.1 inch of insulation from the end of each lead. Attach the element to the upper right corner of the card with transparent tape.

Next, connect the pins of the 555 to the respective copper-foil conductors with small droplets of silver-filled ink. Apply the ink with a sharp toothpick or piece of wire. Also apply droplets of ink between the terminals of C1 and the copper-foil strips on which C1 rests. Then form traces of conductive ink between the terminals of R18 and pins 6 and 7 of the 555.

Use care when applying conductive ink. Too much ink will result in a short circuit should some of the ink run under the components. Be sure to follow any precautions supplied with the ink you select.

Next, form a path of conductive ink across the top of the 555 to interconnect pins 2 and 6. Then apply small droplets of conductive ink at the junction of each graphite resistor (R1-R17) and the diagonal copper conductor. Also apply conductive ink at the junctions of the various copper foil traces.

Fasten the leads from the piezoelectric-buzzer element to the card with clear tape so that the exposed ends of its leads are positioned over the copper foil traces connected to pins 1 and 3 of the 555. Secure the leads to the foil with droplets of conductive ink.



**FIG. 3—THE AUTHOR'S PROTOTYPE.** Pressing different contacts will cause different pitched tones to be produced.

After the conductive ink has dried, slip the switch strip over the bottom side of the card as shown in Fig. 2. Crimp the ends of the strip slightly to secure the switch strip in place. Crimping will also insure that the switch strip makes good electrical contact with the copper trace applied to the left border of the card.

Cut a single finger from a length of cylindrical-radius contacts to form the upper battery terminal. Place a layer of tape under all but the end of the flexible-finger portion of the terminal. The tape is necessary to prevent a possible short should the edge of one or both coin cells make contact with the terminal. Crimp the clip-on portion of that terminal to the upper-left corner of the card as shown in Fig. 2.

Figure 3 is a photograph of the completed circuit. Figure 4 is a highly magnified view of a droplet of conductive ink over the junction of one of the graphite resistors and the diagonal copper strip. Figure 5 is a highly magnified view of C1. Note that Fig. 5 also shows a droplet of conductive ink bonding one

*continued on page 87*

## BUSINESS-CARD TONE GENERATOR

*continued from previous page*

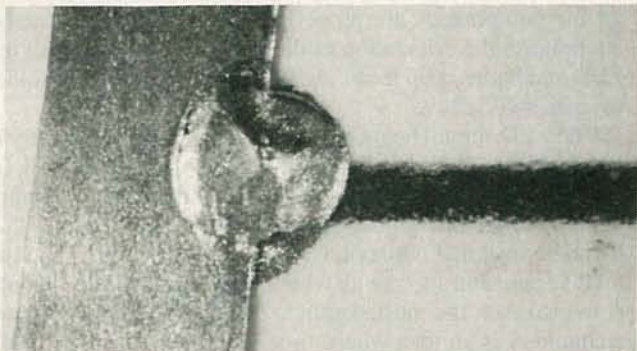


FIG. 4—A DROPLET OF CONDUCTIVE INK connects a graphite resistor to the copper strip.

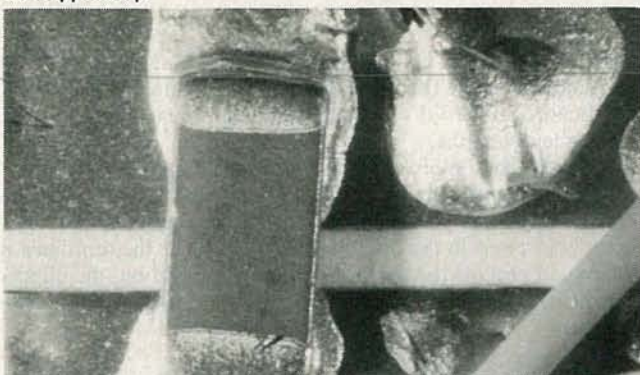


FIG. 5—A CLOSE-UP OF C1. To its right, a droplet of conductive ink bonds one lead from the buzzer to a foil strip.

## HAND-SOLDERING SMC's

*continued from page 72*

Solder paste or cream is offered in convenient syringe applicators by Alpha Metals and Multicore Solders. Figure 3 shows a syringe of solder paste that contains 1.5 ounces of 63%-tin/37%-lead solder paste. Note that when a paste or cream is supplied in that manner, it's generally necessary to mix the material before use by rolling the barrel of the syringe against a hard surface. After the needle is attached and the plunger is installed, a small quantity of material can be applied directly to each SMC footprint as shown in the opening of this article.

It's best to practice applying the paste on a piece of paper first. That will allow you to learn how to cope with unforeseen situations such as how to deal with paste that continues to emerge from the needle after you have coated a footprint. (Hint: Keep some paper towels handy.)

If the syringe method proves too tricky, you can apply the solder paste or cream directly to the terminals and pins of the SMC's themselves using what is called the transfer method. First, place some paste or cream on a clean, flat surface; a glass microscope slide works well. Next, use tweezers to pick up an SMC and then dip its terminals or pins into the paste. When all the terminals or pins are coated with a thin layer of the material, place the SMC on its footprints on the circuit board. The sticky flux will hold the SMC in place while you repeat that procedure for any remaining devices.

of the wires from the piezoelectric-buzzer element to its respective copper strip.

### Testing the circuit

Carefully inspect the circuit to make sure no errors have been made. Then insert a stack of two lithium coin cells under the upper battery terminal (positive sides down). A tone should be heard when one of the switch-strip fingers (keys) is pressed against its respective graphite line on the surface of the card.

**Caution:** Use care to avoid shorting the terminals of one or both coin cells. Lithium cells may explode when shorted.

When the circuit works properly, try pressing each of the keys in turn. That test will illustrate the difficulty of drawing graphite lines having uniform resistance per unit length. The prototype circuit yielded a rather irregular sequence of tones as each key was pressed in ascending order.

The circuit has no power switch. When the circuit is not being used, insert a slip of paper between the lithium coin cells and the upper battery terminal or remove the coin cells.

### Going further

Whether or not you choose to build this circuit, I hope the construction details presented here have given you some new ideas about the unique possibilities offered by combining surface-mountable components and conductive inks. While you might not wish to build miniature circuits on paper business cards, you can build such circuits on glass, plastic, wood, painted metal and many other substrates. In short, a circuit can be built on virtually any available surface. For example, the author has used silver-filled ink and SMC's to build LED transmitter circuits directly on the battery holders that power the circuits.

R-E

After all the components are in place, inspect the board to make sure each SMC terminal or pin is properly positioned. You must then cure the board by preheating it long enough to drive off the volatile solvents from the paste or cream. The curing procedure is very important because it precludes the formation of unwanted solder balls and reduces the thermal shock that the board and its SMC's are subjected to during reflow soldering.

**IMPORTANT:** Various solder pastes and creams may require different curing times and temperatures. They may also require different reflow soldering times and temperatures. Therefore, it is essential to refer to the manufacturer's literature about a specific product to avoid unreliable solder connections.

With that *caveat* in mind, a typical curing procedure is to heat the board in a convection oven for from 10 to 30 minutes at 85°C. After the paste is cured, the board is removed and the oven temperature is increased to the melting temperature of the solder. The board is then placed back in the oven until the solder melts and then quickly removed. Alternatively, if the board can withstand the temperature, it can be reflow soldered by placing it on a hot plate. Another alternative is to use a desktop vapor-phase system such as Multicore Solders' *Vaporette*.

Once again, it is essential to carefully follow the instructions for a particular solder paste or cream. Also, it's very important to avoid overheating the SMC's. Most, but not all, SMC's can withstand the temperature of molten solder for 10 seconds.

R-E

## LED FLASHER

*continued from page 74*

tion. Refer to the component placement diagram in Fig. 3 to make sure the 555 is oriented properly. Then solder each terminal in place.

Continue assembly by installing the resistors and C1 one at a time and soldering them in place as we've described. The value of the resistors is given by a code in which the last digit indicates the number of zeros. Thus the code 104 indicates a resistance of 10 followed by 4 zeros or 100,000 ohms.

Install the LED next. For the utmost in miniaturization, you can use a chip LED. For high-brightness applications, use a leaded device. Cut the leads 0.2 inch from the LED, place them over their respective footprints (be sure to observe polarity), and secure the LED in place with tape. Then solder

the leads in place. Repeat that procedure for the leads from a 9-volt battery clip. Figure 4 shows the completed board.

## Testing the Circuit

Carefully inspect the completed circuit to make sure that all the components are properly positioned. Pay particular attention to the orientation of the 555 and the polarity of the LED and battery clip leads. And be sure to remove any solder bridges and balls.

The LED should begin to flash as soon as a 9-volt battery is connected to the circuit. Operation of the circuit will be identical to that of a flasher made with through-hole components. The thinness of the SMC flasher, however, means that it can be installed in previously unusable locations. And the relative ease and speed with which it can be assembled should convince even the most skeptical builder that surface-mount technology is an idea whose time has come. **R-E**

## LIGHT METER

*continued from page 76*

enced hand-solderer of SMC's, it is essential to carefully inspect each and every junction with a magnifying lens.

Next, solder trimmer R1 to the board. Since cementing R1 to the board might interfere with its rotor if you are not careful, it's best to use a bit of masking tape to secure R1 in place for soldering.

If you want to use the circuit as a light meter, solder Q1 in place next. However, if you want to use the circuit for one of the specialized applications that we'll describe later on in this article, you should omit Q1 and, instead, solder a pair of stranded, insulated hookup wires to its two mounting holes.

Note that Q1 is a conventional through-hole component. The prototype used a tiny surface-mount phototransistor (Stettner Electronics CR10TE1). However, that meant that the phototransistor was aligned in the same direction as the readout. The result was that someone viewing the readout could cast a shadow over Q1, affecting accuracy.

To overcome that, the surface-mountable version of Q1 was replaced with a leaded phototransistor that can be installed facing away from the person viewing the readout.

The leads of the phototransistor are installed in two holes drilled in the circuit board adjacent to the negative battery holder terminal. The emitter of Q1, which is indicated by a small protruding tab (see Fig. 4-a), must be installed in the hole connected to the negative battery-holder terminal. Therefore, bend Q1's leads as shown in Fig. 4-b and insert both leads through the bottom side of the circuit board so that Q1 points away from the circuit board as shown in Fig. 4-c. When the

circuit is complete, Q1's leads will emerge from the board under the battery-holder. Therefore, be sure to keep those leads close to the board. Solder Q1's leads to their footprints and clip off the excess lead lengths.

Complete assembly of the board by installing the lithium coin-cell holder on the underside of the board. Be sure to orient the holder so that its positive terminal (the uppermost battery contact) is inserted in the hole marked +. Solder the terminals in place and clip off the protruding pins. Use caution; the clipped terminals may fly away from your clippers with considerable force.

## Testing the circuit

If you have installed Q1, the circuit will function as a light meter when lithium cell B1 is installed in its holder. LED1 will glow to indicate the power is on. Use a jeweler's screwdriver to adjust trimmer R1 for the desired sensitivity. For best results, perform the adjustment with the circuit in subdued light. Generally, LED2-LED5 will switch off when Q1 is brightly illuminated. Those LED's will then glow in sequence as the light reaching Q1 is progressively reduced.

You can switch the circuit off by removing B1. Or, you can slip a small piece of paper or thin plastic under, or a short length of heat-shrinkable tubing over, the uppermost battery-holder electrode.

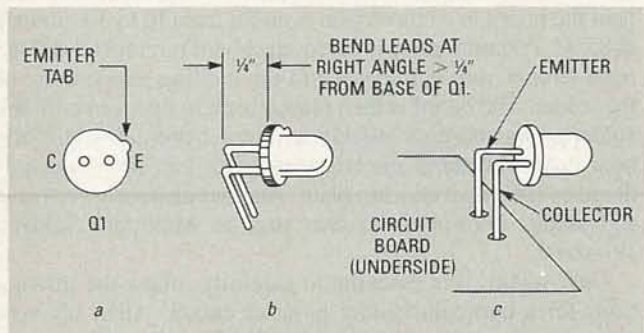
## Going further

As noted previously, when Q1 is omitted the circuit can be used for other applications. For example, when a discharged capacitor is connected in the circuit in place of Q1, LED2-LED5 will glow in sequence as the capacitor is charged by the small voltage appearing at the common non-inverting inputs. One application for that configuration is as a timer whose period is determined both by the size of the capacitor and the setting of resistor R1.

The timing intervals can be increased by increasing the value of the capacitor. A new timing cycle can be started at any time by momentarily shorting the capacitor.

Another interesting application is to use the circuit to indicate resistance. When the input leads are open, all the LED's will glow. If a variable resistance is connected to the circuit in place of Q1, LED2-LED5 will glow in sequence as the resistance is lowered. We're sure that you have often wished for a visual continuity checker.

Finally, keep in mind that the circuit as presented here functions as a parallel array of inverting comparators. It can be revised to function as a parallel array of non-inverting comparators simply by reversing the connections to the inputs of the four comparators. **R-E**



**FIG. 4—THE PHOTOTRANSISTOR'S EMITTER** is indicated by the tab (a). When installing the device, bend the leads (b) and mount it so that it is pointing away from the circuit board (c).



# SMT Resource Directory

THE QUANTITY AND VARIETY OF SURFACE mount components, supplies, literature, and services has grown rapidly during the past few years. Here's a listing of sources and vendors for some of what is now available. Many of these companies are represented by local electronics distributors. For additional information contact the Surface Mount Technology Association (Box 1811, Los Gatos, CA 95031).

## SURFACE MOUNTABLE COMPONENTS

**Amperex Electronic Corporation**  
George Washington Highway  
Smithfield, RI 02917

**Bourns, Inc.**  
1200 Columbia Avenue  
Riverside, CA 92507

**Exar Corporation**  
750 Palomar Avenue  
Sunnyvale, CA 94086

**Mepco/Centralab, Inc.**  
2001 West Blue Heron Blvd.  
Riviera Beach, FL 33404

**Motorola Semiconductor Products, Inc.**  
P.O. Box 20912  
Phoenix, AZ 85036

**muRata Erie North America, Inc.**  
2200 Lake Park Drive  
Smyrna, GA 30080

**National Semiconductor Corporation**  
P.O. Box 58090  
Santa Clara, CA 95052

**NIC Components Corporation**  
6000 New Horizons Blvd.  
No. Amityville, NY 11701

**Signetics Corporation**  
P.O. Box 3409  
Sunnyvale, CA 94088

**SMD Technology Service Center**  
5855 North Glen Park Road  
Milwaukee, WI 53209

**Sprague Electric Company**  
P.O. Box 9102  
Mansfield, MA 02048

**Stettner Electronics Inc.**  
3344 Schierhorn Court  
Franklin Park, IL 60131

**Texas Instruments**  
P.O. Box 809066  
Dallas, TX 75380

## CONDUCTIVE INKS AND ADHESIVES

**Amicon, A Grace Company**  
25 Hartwell Avenue  
Lexington, MA 02173

**Dynaloy, Inc.**  
7 Great Meadow Lane  
Hanover, NJ 07936

**GC Electronics**  
400 South Wyman Street  
Rockford, IL 61101

**Hysol Division, The Dexter Corporation**  
P.O. Box 1282  
Industry, CA 91749  
**Loctite, Electronics Division**  
705 North Mountain Road  
Newington, CT 06111

## SOLDER PASTES AND CREAMS

**Alpha Metals, Inc.**  
600 Route 440  
Jersey City, NJ 07304

**Multicore Solders, Inc.**  
Cantiague Rock Road  
Westbury, NY 11590

## SURFACE MOUNT SOLDERING EQUIPMENT

**Edsyn Inc.**  
15958 Arminta Street  
Van Nuys, CA 91406

**Hexacon Electric Company**  
P.O. Box 36  
Roselle Park, NJ 07204

**PACE, Inc.**  
9893 Brewers Court  
Laurel, MD 20707

## TOOLS

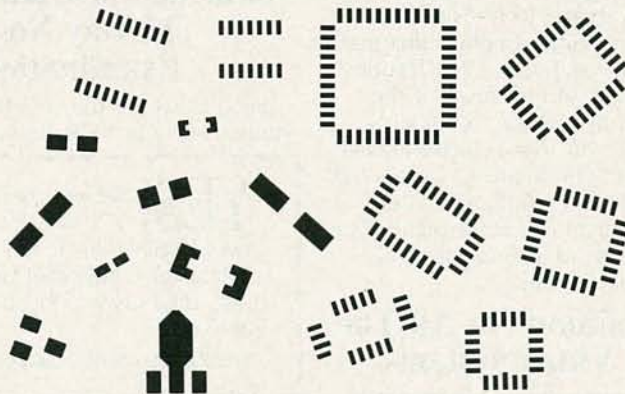
**Edmund Scientific Co.**  
101 E. Gloucester Pike  
Barrington, NJ 08007  
**Jensen Tools, Inc.**  
7815 S. 46th Street  
Phoenix, AZ 85044

**Pomona Electronics**  
1500 E. Ninth St.  
Pomona, CA 91766

## CUSTOM CIRCUIT BOARD DESIGN

**Analytic Design, Inc.**  
3200 Scott Blvd.  
Santa Clara, CA 95054

## Surface MOUNT Artwork Patterns



JotDraft™ rub-down PC drafting patterns now include a complete range of 4X, 2X and 1X SMD patterns conforming to the latest industry practice and to IPC-SM-782. These rugged transfers include over 700 styles of donuts, connectors, DIPs, letters, numbers and fabrication symbols.

The complete **DATAK** catalog describes these and hundreds of other unique printed circuit products, dry transfer electronic titles, drafting symbols, wiremarkers, and protective coatings. **Write for it today!**

**DATAK Corp.** □ 3117 Paterson Plank Rd. □ N. Bergen, NJ 07047

CIRCLE 190 ON FREE INFORMATION CARD

Now electronics technicians can get into VCR Servicing quickly and easily

# Learn professional VCR servicing at home or in your shop with exclusive videotaped demonstrations

Today, there are more than 10 million VCRs in use, with people standing in line to have them serviced. You can bring this profitable business into your shop with NRI professional training in VCR servicing. This top-level training supports the industry's claim that the best technicians today are those who service VCRs.

## Integrated Three-Way Self-Teaching Program

In one integrated program, NRI gives you a study guide, 9 instructional units, 2 hours of video training tapes accompanied by a 32-page workbook that pulls it all together. At home or in your shop, you'll cover all the basic concepts of video recording, mechanical and electronic systems analyses, and the latest troubleshooting techniques. Your workbook and instructional units also contain an abundance of diagrams, data, and supplementary material that makes them valuable additions to your servicing library.

## The "How-To" Videotape

Your NRI Action Videocassette uses every modern communications technique to make learning fast and easy. You'll enjoy expert lectures and see animation and video graphics that make every point crystal-clear. You'll follow the camera eye into the heart of the VCR as step-by-step servicing techniques are shown. Both electronic and mechanical troubleshooting are covered . . . including everything from complete replacement and adjustment of the recording heads to diagnosing micro-processor control faults.

## Plus Training On All The New Video Systems

Although your course concentrates on VCRs covering Beta, VHS, and 3/4" U-Matic commercial VCRs, NRI also brings you up to speed in other key areas. You'll get training in capacitance and optical video disc players, projection TV, and video cameras. All are included to make you the complete video technician. There's even an optional final examination for NRI's VCR Professional Certificate.



Covers Beta and VHS systems with actual instruction on videotape.

## The Best Professional Training

This exclusive self-study course has been developed by the professionals at NRI. NRI has trained more television technicians than any other electronics school! In fact, NRI has consistently led the way in developing troubleshooting techniques for servicing virtually every piece of home entertainment equipment as it appears in the marketplace.

## Satisfaction Guaranteed . . . 15-Day No-Risk Examination

Send today for the new NRI Self-Study Course in VCR Servicing for

Professionals. Examine it for 15 full days, look over the lessons, sample the videotape. If you're not fully satisfied that this is the kind of training you and your people need to get into the profitable VCR servicing business, return it for a prompt and full refund, including postage. Act now, and start adding new business to your business.

## Special Introductory Offer

This complete VCR training course with two hour videotape is being offered for a limited time only, on orders received from this ad, at our low introductory price of \$179.95. Save \$20 by acting now!

NRI Training For Professionals  
McGraw-Hill Continuing Education Center  
3939 Wisconsin Avenue Washington, DC 20016

**YES!** Get me started in profitable VCR servicing. Rush me my NRI self-study course in VCR Servicing for Professionals. I understand I may return it for a full refund within 15 days if not completely satisfied.

PLEASE SPECIFY TAPE FORMAT DESIRED  VHS  BETA

Name (please print) \_\_\_\_\_

Company \_\_\_\_\_

Street \_\_\_\_\_

City/State/Zip \_\_\_\_\_

Enclosed is my  check  money order for \$179.95 (D.C. residents add 6% tax) Make check payable to NRI

Charge to  VISA  MasterCard \_\_\_\_\_

Interbank Number \_\_\_\_\_

Card Number \_\_\_\_\_ Expiration Date \_\_\_\_\_

Signature \_\_\_\_\_

(required for credit card sales)



NRI Training For Professionals  
McGraw-Hill Continuing  
Education Center  
3939 Wisconsin Avenue  
Washington, DC 20016

# COMPUTER DIGEST

VOL. 4 NO. 11 NOV. 1987

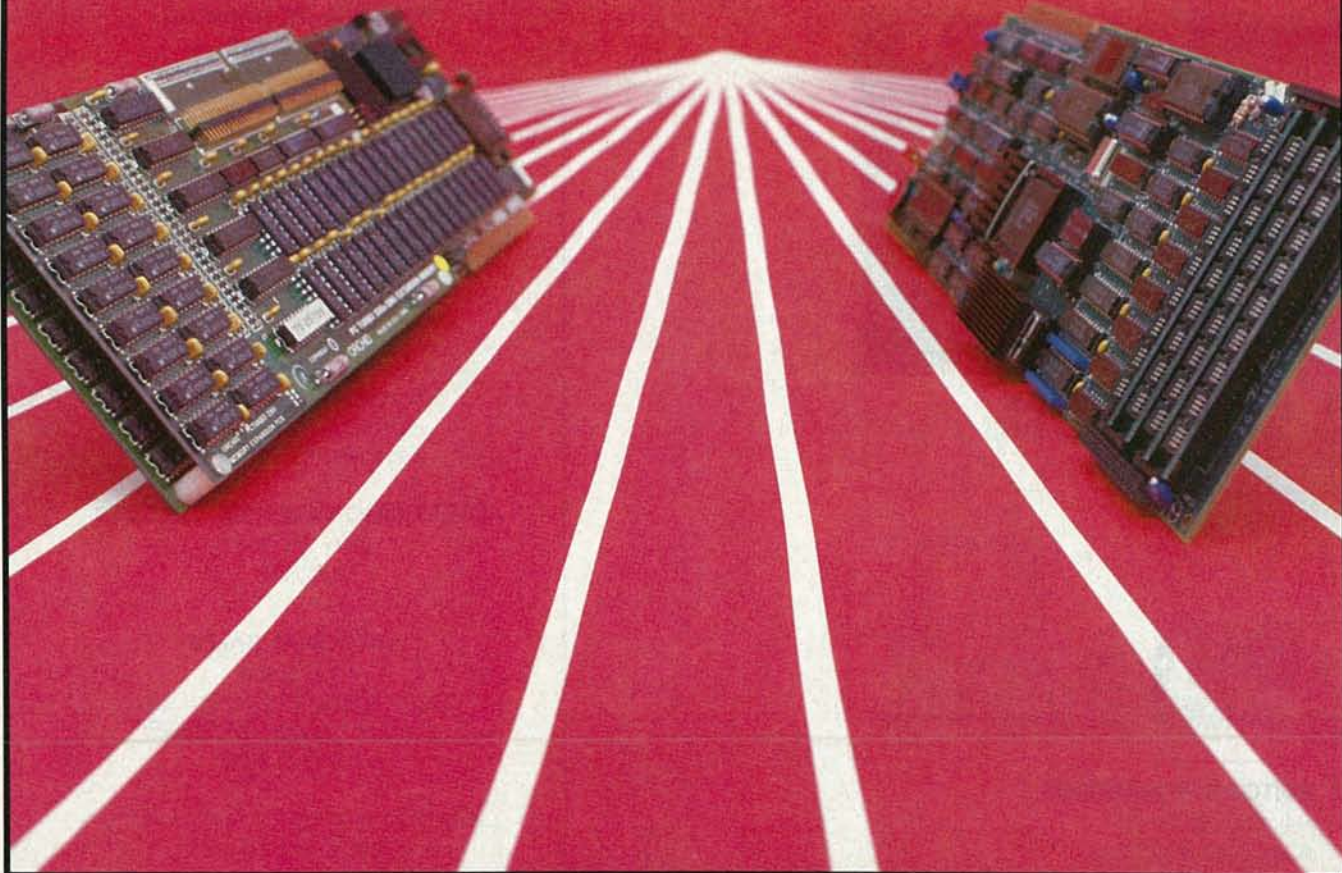
A NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS

## BUILD THE PT-68K

Learn 68000 computing  
in the CD Classroom

## TURBOCHARGE YOUR PC

Hands-on tests

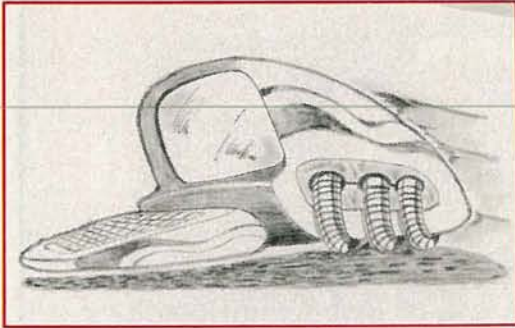


# CONTENTS

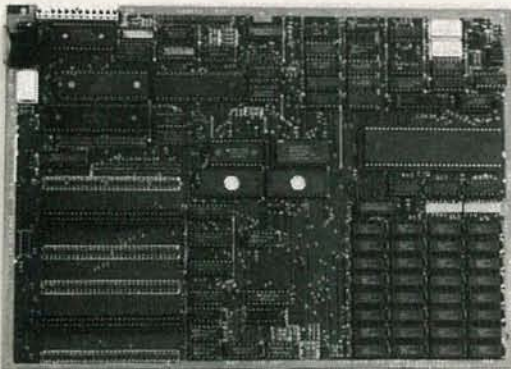
# NOVEMBER

# 1987

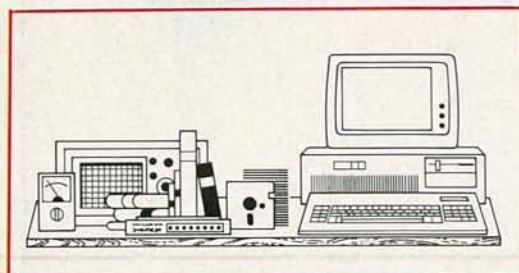
Vol. 4 No. 11



**95 TURBOCHARGE YOUR PC**  
How to and how much



**101 CD CLASSROOM, PART 2**  
Start construction this month



**93 EDITOR'S WORKBENCH**  
Fall reading list  
PC-601 Bus extender  
A86/D86 Assembler/debugger  
MIX C—Integrated development environment

## COMPUTER DIGEST

**Larry Steckler,**  
EHF, CET: publisher & editor in chief

**Art Kleiman,**  
editorial director  
**Brian C. Fenton,**  
managing editor  
**Jeff Holtzman**  
technical editor  
**Byron G. Wels,**  
associate editor  
**Carl Laron,**  
associate editor  
**Robert A. Young,**  
assistant editor  
**Teri Scaduto**  
editorial assistant  
**Ruby M. Yee,**  
production director  
**Karen Tucker,**  
production advertising  
**Robert A. W. Lowndes,**  
production associate  
**Marcella Amoroso**  
production assistant  
**Andre Duzant,**  
technical illustrator  
**Jacqueline P. Cheeseboro**  
circulation director  
**Arline R. Fishman,**  
advertising director

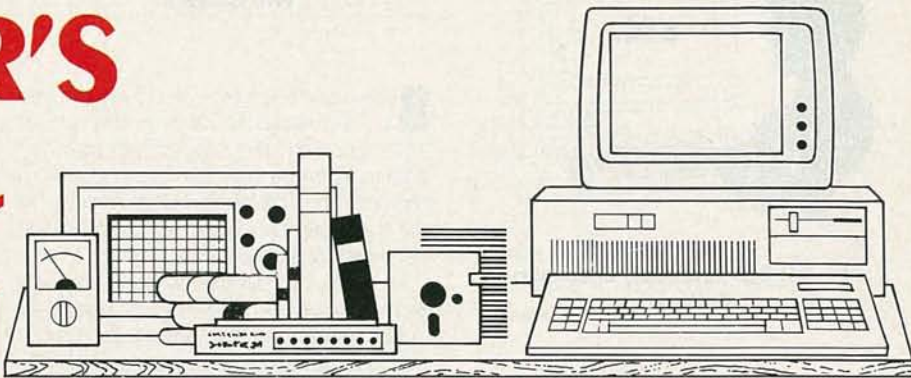
ComputerDigest  
Gernsback Publications, Inc.  
500-B Bi-County Blvd.  
Farmingdale, NY 11735

**ADVERTISING SALES 516-293-3000**  
Larry Steckler  
Publisher

**NATIONAL SALES**  
Joe Shere  
1507 Bonnie Doone Terrace  
Corona Del Mar, CA 92625  
714-760-8697

Cover Photography by Herb Friedman  
and André Duzant

# EDITOR'S WORK- BENCH



## Portable Correction

Our article on portable MS-DOS machines (in the September issue) contained several errors regarding the DataVue 25. First, the machine is not AC-only; an external battery pack is available that will run the machine for about two hours. Second, the DataVue 25's backlighting is not electroluminescent, but fluorescent. Last, the machine's hard disk has a capacity of 20 megabytes, not 10 megabytes, as reported. In addition, contrary to what was stated in the article, it is possible to boot from the hard disk. We apologize for the errors and thank Peter Baron, a DataVue press agent, for pointing them out.

## Back-To-School Booklist

Whatever your interest—80xxx, 680xx, or 65xxx systems, you'll find one of the books listed here useful. First we'll discuss several assembly-language primers for various systems, followed by several tomes specific to the IBM PC.

### For hackers only

Leo Scanlon's *The 68000: Principles and Programming* (c. 1981, Blacksburg Continuing Education Series, Howard W. Sams & Co., Inc., 4300 West 62nd Street, Indianapolis, IN 46268) provides a good, brief introduction to the 68000. One highlight is chapter 6, which includes hardware infor-

mation that's hard to come by elsewhere.

More comprehensive is *68000 Assembly Language Programming* by Lance A. Leventhal, Doug Hawkins, Gerry Kane, and William D. Cramer (c. 1986, Osborne McGraw-Hill, 2600 Tenth Street, Berkeley, CA 94710). The book contains in-depth treatment of the 68010 and 68020, and much advanced information on topics like interrupts, debugging, and program design. An appendix lists all microprocessor instructions in an easily referenced format showing the assembly-language syntax, each instruction's bit-field format, flags affected, textual description, and version-specific variations (68020, for example).

6502, 65802, and 65816 fans will want to check out *65816/65802 Assembly Language Programming* by Michael Fischer (c. 1986, also published by Osborne McGraw-Hill, address above). A brief introduction summarizes microprocessor evolution since the early 1970's; the book then goes on to discuss the 65xxx family architecture, and then focuses on the advanced members of the family. There are many example programs, and appendices include hardware data sheets for most major members of the 65xxx family.

For Intel fans, *80386/80286 Assembly Language Programming* by William H. Murray III, and Chris H. Pappas (c. 1986, Osborne McGraw Hill, address above) will be indispensable reading. The book begins with several chapters of introductory material; chapter three gets into the 286/386 architecture, and is full of comparisons with the 8088/86. It then goes on to examine the 80287/80387 math co-processors, various assemblers, and other topics. Instruction sets of each processor and co-processor are listed, and an appendix provides information on how to maintain a library of often-used routines.

### IBM PC

One of the most useful books I've seen on the internal workings of the IBM PC is *Compute's Mapping the IBM PC*, by Russ Davies (c. 1986, Computer! Publications,

Inc., Greensboro, NC). The irony is that *Compute!* magazine is a traditional 6502 stronghold—but don't let that bother you; the book is chock full of charts, tables, and example programs showing you how to get at your machine's capabilities from both BASIC and assembly language. It's not for beginners, but you needn't be an advanced systems designer either. Highly recommended.

Beginners will, however, find *Understanding MS-DOS* by Kate O'Day (c. 1987 by The Waite Group, Howard W. Sams & Co., Inc., 4300 West 62nd Street, Indianapolis, IN 46268) useful. The book uses color, typeface, and illustration well to bring out important points. Topics include basic DOS commands, subdirectories, hard-disk management, batch processing, etc.; each chapter includes a quiz to help re-inforce your knowledge.

Users at all levels will find *IBM PC & PC XT User's Reference Manual* by Gilbert Held (c. 1987, Hayden Books, Howard W. Sams & Co., Inc., 4300 West 62nd Street, Indianapolis, IN 46268) valuable. Topics include system set-up, DOS operations, elementary and advanced BASIC, graphics, batch files, etc. When I forget the syntax of a command, I often find myself reaching for this book before the appropriate Microsoft or IBM manual.

### Apple and IBM clone boards

NuScope Associates (P.O. Box 790, Lewiston, NY 14092) publishes several manuals with information on building Apple II and IBM PC and AT motherboards, peripheral cards, etc. We examined the IBM book. It's divided into two parts, the first of which contains basic construction information, resistor color-code tables, etc. The second part is divided into eight sections that focus on building several models of each of the following types of boards: motherboard, disk controller, memory, video, multifunction, serial/parallel, miscellaneous, and prototype. Information on each board includes parts layout, parts list, and a few notes. It's definitely not for beginners. ▶◀



**PC-601 Bus Extender, Chenesko Products**

Circuit development for the IBM PC bus is hindered by a myriad of merely physical problems, including getting at bus signals for examination with a scope or logic analyzer, wiring (and modifying) circuits on expansion cards, etc. The PC-601 (shown in Fig. 1) solves the problem by bringing the bus out to a solderless breadboard station with more than 3000 tie points. A half-length card with several buffers is inserted in your PC; a two-foot length of ribbon cable connects it to the breadboard box, which contains built-in  $\pm 5$  and  $\pm 12$  volt power, a scope multiplexer that allows a single-channel scope to display as many as four signals simultaneously, buffered address, data, and control lines, and provi-



FIG. 1

sions for daisy chaining additional PC-601's. Construction quality of the internal PC boards is excellent; the molded plastic case should stand up to rugged shop use. Wiring up I/O or address-decoding circuitry is easy because the address, data, and control lines are brought out to pin sockets. A 16-page manual provides clear installation and usage instructions; schematics for the switching power supply, scope multiplexer, and buffer circuitry are also included.

The PC-601 lists for \$369.95; contact Chenesko Products, Inc., 21 Maple Street, Centereach, NY 11720, (516) 736-7977 for more information.

CIRCLE 22 ON FREE INFORMATION CARD

**Shareware Assembler/Debugger, Eric Isaacson**

8088 assemblers are notoriously difficult to use because of the amount of "housekeeping" the programmer must do even to assemble a simple program. Beginners are turned off because learning how to use the assembler may be more difficult than learning the assembly language!

Eric Isaacson took that problem seriously and wrote a fast, easy-to-use assembler (A86) and an accompanying full-screen symbolic debugger (D86), shown in Fig. 2. The package has gone through several incarnations; early versions could not assemble Microsoft assembler source files, but versions of the assembler greater than 3.00 are

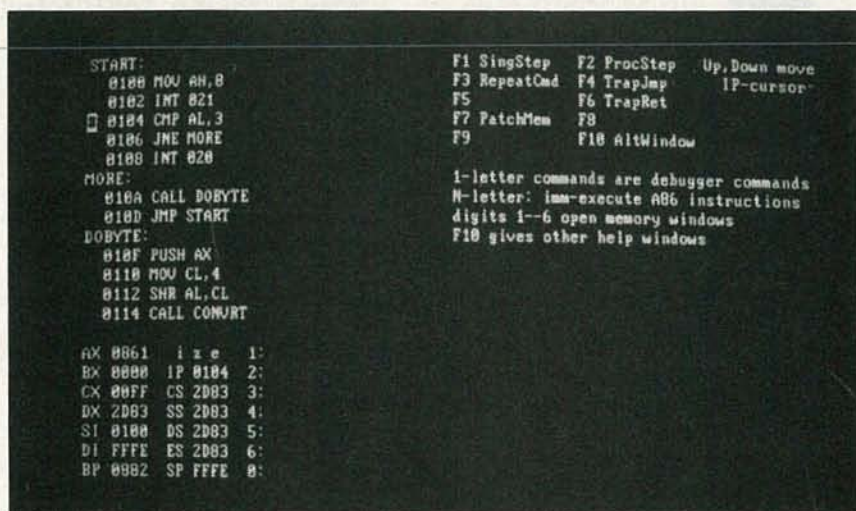


FIG. 2

now mostly Microsoft compatible. (We are still waiting for version 3.00 of the debugger.) Documentation has also improved considerably since the early versions. All programs and documentation fit in several ARC files on a single floppy disk. Many BBS's (including ours, (516) 293-2283, 300/1200,8,N,1) carry the ARC files; you can also order them directly from the author at 416 E. University St., Bloomington, IN 47401, (812) 339-1811. Evaluation copies are free; registration costs \$40 for either A86 or D86, or \$70 combined.

D86 can be used on any .COM file, but to do symbolic debugging, the file must have been assembled with A86. One nice feature of A86 is that it generates code for the 8088, 8086, 80286, 8087, 80287, and several NEC V-series microprocessors. 80386 code is not included in the present version.

In D86, you press F1 to execute a single instruction, or F2 to execute a subroutine. In addition, you can enter assembly-language code, referencing your program's symbols, if desired. An extensive set of memory display commands allow you to set up as many as six multi-format views into any desired area of memory. The microprocessor's registers, flags, and the top of the stack are

shown at all times.

Now that A86 is Microsoft compatible, and the documentation has been cleaned up, our main complaint with the package is that you can't load or save files from within D86 (as you can with DEBUG); you must specify the file name on the invoking command line. But we expect that file problems will be fixed when D86 is upgraded.

CIRCLE 23 ON FREE INFORMATION CARD

**MIX C Compiler, Editor, Debugger**

Compilers that operate in an integrated environment have been around for some time, but one that has been evolving for several years is marketed by Mix Soft-

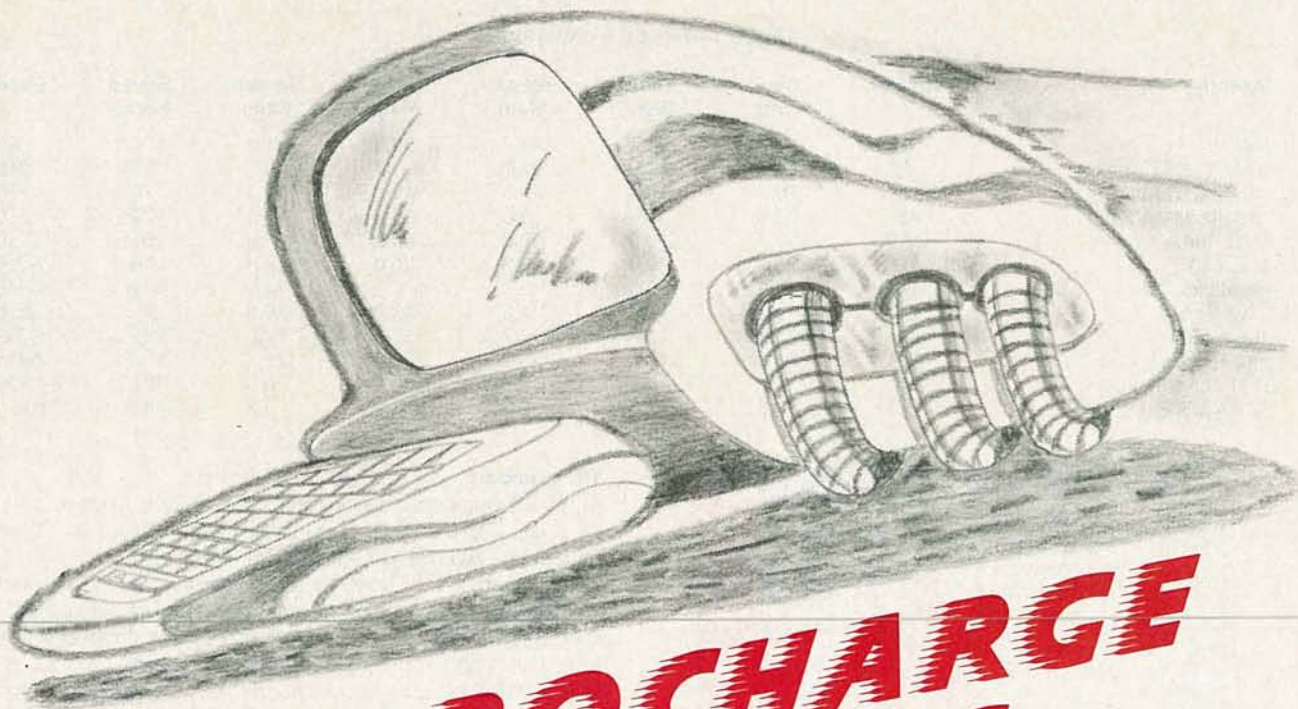
ware (1132 Commerce Drive, Richardson, TX (800) 523-9520). It combines a split-screen WordStar-like editor, a quality C compiler, and a windowed Trace utility, which allows source-level debugging. Each program is available separately; the three can be purchased together discounted. CP/M and MS-DOS versions are available.

The editor is highly configurable, allowing you to define keyboard controls and macros. In splitscreen mode, you can edit two files simultaneously, transferring text between them.

The compiler itself is highly compatible with the Kernighan and Ritchie standard; Mix includes special utilities to either compress or speed up programs created with the compiler. The manual contains a tutorial that should help intermediate programmers get up to speed quickly.

The real gem of the package is the Trace utility, which includes a faster (and larger) version of the compiler. Trace allows single-stepping, tracing, and fullspeed tracing. It also allows you to set up as many as four windows to display source code, program output, and variable values simultaneously. Mix C is hard to beat.

CIRCLE 24 ON FREE INFORMATION CARD



# TURBOCHARGE YOUR PC

JEFF HOLTZMAN,  
TECHNICAL EDITOR

**S**peed—you can never get enough. At last count there were about eight million PC's, XT's, and clones out there, and we'd be willing to bet that most of the people using those machines would jump at the chance to get them running faster. Programs for CAD, circuit design and analysis, desktop publishing—they all work better when the computer thinks as fast as you do.

But how do you increase the speed of a PC, XT, or clone? When you look into it, you quickly find that there is a bewildering variety of choices available, ranging in price from about \$10 to about \$1500—more than a full-blown PC or XT!

Does a \$10 upgrade provide any significant advantage? At the other end of the price spectrum, is a high-speed 386-based motherboard worth as much as—or even more than—the original purchase price of a piece of equipment?

The answer depends on what your needs are and on your previous equipment investment. But before we try to provide the answer, let's talk about each of the upgrade solutions and examine some hard data. Later we'll show how the numbers don't tell the whole story. The hardware we tested is summarized in the sidebar on page 100 alphabetically by manufacturer.

## Accelerator basics

Basically, there are three types of accelerators: clock-speed enhancers, replacement processors, and co-processors. The usual clock-speed enhancer is what we call an *octopus board*, a small PC board that does not require an expansion slot, but rather dangles over the motherboard and somehow injects a faster clock signal into it. Octopus boards have one or more "tentacles" that must connect to various points on the motherboard, both to pick up signals and to insert them.

A replacement processor is a full- or half-length card that requires an expansion slot. You must remove the host computer's 8088 microprocessor from its socket and connect the vacant socket to the accelerator card via a 40-conductor ribbon cable. In some cases the host computer's 8088 microprocessor is installed on the

accelerator card to provide a compatibility mode; in other cases compatibility is achieved by running the accelerator's microprocessor at a slower speed. Replacement processors usually are built around 80286 IC's, but some are built around 8086's. Most early replacement processors ran at 8 MHz; many now run at 10 or even 12 MHz.

A co-processing accelerator adds what amounts to a second, fully independent, computer to your PC. Some co-processing accelerators can actually function at the same time as the host's microprocessor, allowing you to work on completely independent tasks simultaneously.

There exists a fourth and increasingly popular way of speeding up your PC: replacing your motherboard. Replacing it can provide most of the advantages of the previous methods, with few of their disadvantages. We'll examine at least one of each type of accelerator option in what follows.

## Test strategy

To test compatibility, we attempted to run the following software on all hardware: WordStar 4.0, AutoCad 2.6, AutoSketch, VP Planner, Microsoft Windows 1.03, PageMaker 1.0a, and Direc-Link. All tests were performed under PC-DOS 3.30. Each piece of hardware ran each program without problems, although in some cases firmware (EPROM's, PLD's, etc.) upgrades were necessary.

We ran the **Computer Digest** interpreted-BASIC benchmarks on each piece of hardware, except Hauppauge Computer Works' 386 motherboard, so it is not included in the quantitative results. The benchmark consists of five tests, including sequential disk read and write, integer math, floating-point math, and screen write. Except for the replacement motherboards, all tests were run on a standard IBM PC XT. Except for boards with built-in display adapters, all boards were tested with a Hercules monochrome card; those with built-in adapters were tested in Hercules emulation mode. Those boards were also tested in EGA mode for comparison. Last, the disk-speed tests were all run on the same hard-disk drive.

TABLE 1—SPEED COMPARISON

Machine	Abbrev	Disk Write	Disk Read	Integer Math	Float Math	Screen Write	Speed Factor	Price
IBM PC XT	XT	42.3	28.7	32.0	33.3	31.0	100%	\$0
IBM PC XT (V20)	V2	40.3	29.0	30.0	31.7	28.3	105%	\$12
NickelX (7M,V20)	N7	26.7	18.0	17.3	19.0	17.3	170%	\$70
NickelX (8M,V20)	N8	27.0	16.0	16.0	18.0	17.0	178%	\$70
MCT Turbo	MC	29.7	18.0	18.3	20.3	20.0	157%	\$130
Mach 10	M1	29.7	20.0	16.3	20.0	19.3	159%	\$399
Breakthru 286	B2	14.3	9.0	5.3	7.7	10.0	361%	\$595
Tiny Turbo	TT	19.0	13.7	11.0	12.0	20.0	221%	\$595
TurboEGA	TE	21.3	13.7	11.7	11.0	14.0	233%	\$749
286 Rainbow Plus	RB	25.3	16.0	25.7	28.0	20.7	145%	\$945
PCTurbo 286e-8	PT	11.3	9.3	7.0	8.0	6.0	402%	\$1,195
SOTA MB 5.0	SO	10.0	7.0	6.0	6.3	9.3	433%	\$1,295

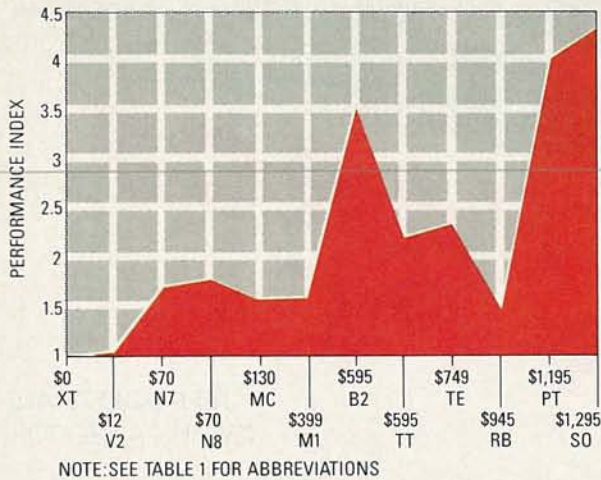


FIG. 1—Performance Comparison Chart

The numbers

The raw numbers obtained are shown in Table 1, which is sorted by price. The first entry is our base test machine, an XT with a Miniscribe hard disk (100-ms average seek time).

Figure 1 shows the speed-test data graphically. (Refer to Table 1 for the meanings of the abbreviations on the horizontal axis.) The shorter the overall height of each bar, the faster the overall speed. From that graph you can see that SOTA's MotherCard 5.0 is the fastest, followed closely by Orchid's Pcturbo 286e, and then by PCSG's Breakthru 286.

Figure 2 plots speed factor (from Table 1) vs. cost. In general, as you would expect, greater speed costs more. However, there are several exceptions, the most significant of which is the PCSG board (labeled B2), which provides about 85% of the performance of the fastest boards, at about 50% of the cost.

What follows are our comments derived from installing each piece of hardware, running the quantifying benchmarks and the compatibility-test software, and overall impressions. The comments are presented in alphabetical order by manufacturer or distributor.

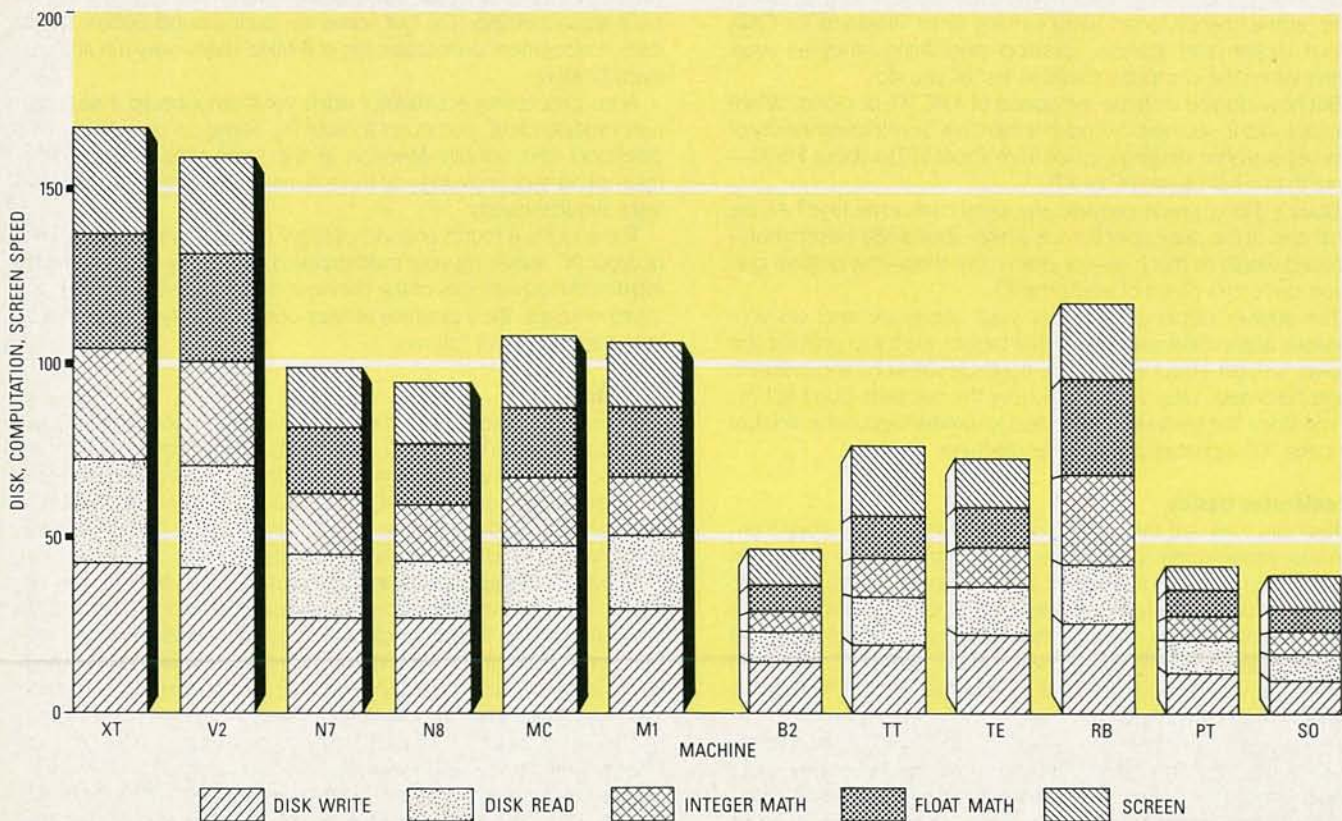


FIG. 2—Price/performance Comparison Chart



### 386 Motherboard

Hauppauge Computer Works got its start selling math co-processor speed-up kits; the 386 Motherboard (shown in Fig. 3) is designed as a replacement for a standard PC or XT motherboard. After dismantling your PC, you install the new motherboard, reinsert your old expansion cards, and you're off into the world of truly high-speed computing. Due to a shortage of boards, we were unable to perform an actual installation and run our benchmarks, but the company was kind enough to allow us to run our compatibility software on a test board in their engineering laboratory. We also installed and successfully ran several pieces of expansion hardware, including our favorite digitizing tablet, Pencept's Penpad 320, which uses a 68000 co-processor.

Subjectively, the 386 Motherboard ran all software frighteningly fast. AutoCad and PageMaker screen redraws happened nearly instantaneously. In fact, with a 387 math co-processor installed, AutoCAD was able to redraw a test screen in twelve seconds; the same redraw on an un-enhanced PC takes over four minutes!

### Nickel Express and Turbo Motherboard

JDR Microdevices markets a number of IBM-type expansion and enhancement products, including the Nickel Express (shown in Fig. 4) and the MCT-Turbo, an 8-MHz XT motherboard (shown in Fig. 5). Like the 386 motherboard, the MCT-Turbo is a direct plug-compatible replacement for a standard XT motherboard; it may also be used as the brains of a build-it-yourself clone. It includes an 8088-2 microprocessor that you can run at either 4.77- or 8.0-MHz. Speed is selectable by means of a shorting jumper plug located near the keyboard connector at the rear of the board. The board's documentation claims that speed is also keyboard selectable, but the keystrokes mentioned had no effect on speed.

The MCT-Turbo accepts 36 4164 RAM IC's, for a total of 256K of memory, or by moving a jumper, two banks can be filled with 41256 IC's for a total of 640K. In addition, seven sockets are provided for EPROM's, one of which is occupied by the MCT BIOS EPROM.

The MCT-Turbo comes with a thin User's Manual that contains a brief theory of operation, complete schematics, switch settings, and troubleshooting hints. An additional loose-leaf page discusses installation.

After setting up the board, we installed our XT's hard disk and controller in it, and then ran our compatibility and benchmark tests. We also tested several pieces of expansion hardware; the only problem we experienced was with a CGA card that had trouble running at the faster speed, and caused our monitor screen to display snow in some, but not all, circumstances.

The Nickel Express is an octopus board. To install it you must remove the 8284 clock IC from your motherboard and then insert a short 16-conductor ribbon cable into the vacant socket. The other end of the cable plugs into a socket on the small (approximately 2" x 3") circuit board, which contains two clock IC's, a PLD, three crystals (corresponding to the board's three speeds: 6.66-, 7.37-, and 8.0-MHz), and several jumpers and discrete components. In addition, speed-selection and reset switches are provided. The board and switches are mounted on a sheet-metal housing that clips on the outside of the rear panel of your PC, thereby providing a reasonably stable mounting scheme. An additional wire may be attached to an IC on the motherboard to allow software speed selection. In that respect the Nickel Express is "cleaner" than most octopus boards.

To use the Nickel Express you have to find the maximum speed at which your motherboard will run. Unfortunately, trial and error is the only way to do so. To run the board at maximum speed, you must run a small program that becomes memory-resident and thereafter slows down the clock whenever the floppy disk is accessed.

The test results shown in Table 1, Fig. 1, and Fig. 2 are with the Nickel Express running at the two highest speeds with an 8-MHz NEC V20, which is included in the purchase price.

The board comes with a slim installation manual that provides detailed installation instructions and some theory of how the board works. It's not fancy, but it gets the required information across.

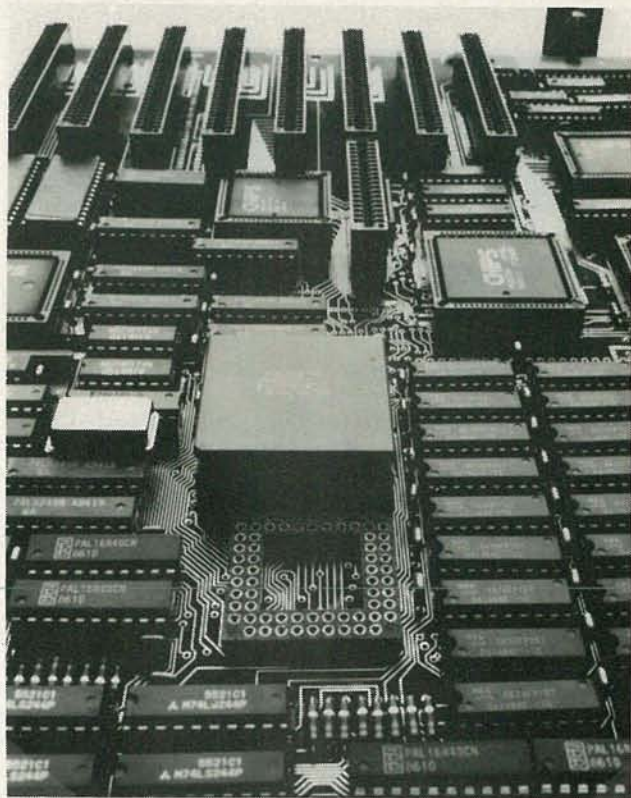


FIG. 3—Hauppauge's 386 Motherboard

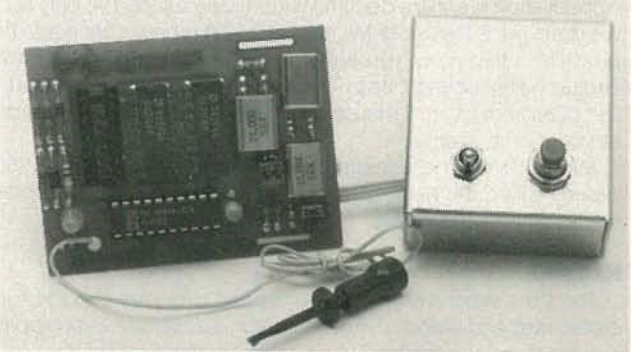


FIG. 4—JDR's Nickel Express

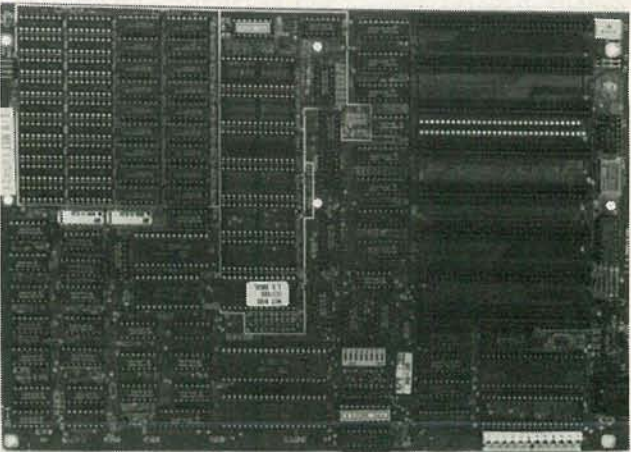


FIG. 5—JDR's MCT-Turbo

### Mach 10

Microsoft sells the Mach 10 (shown in Fig. 6), a replacement processor, in two configurations: the board alone, or bundled with a mouse and Microsoft Windows. In either case, the accelerator

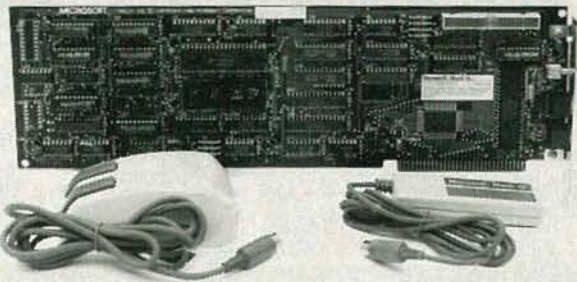


FIG. 6—Microsoft's Mach 10

board runs an 8086 at 9.54 MHz, twice normal speed.

To install the Mach 10, you set some jumpers, remove the CPU from your motherboard, connect a ribbon cable from the CPU socket to the Mach 10 board, and insert the board into an unused full-length expansion slot. The jumpers determine the mouse's interrupt, caching of BIOS and BASIC, (some programs may not run when the BIOS or BASIC is cached) and 8087 presence. The rear-panel mounting bracket has a socket for the mouse, a toggle switch for changing speed, and a socket for an optional speed-select switch that lights up when in turbo mode. The optional switch is nicer than most speed-select switches because it is mounted at the end of a cable, so you don't have to reach behind your PC to change speeds. It's also nicer than most switches (and more convenient than some software speed switches) because you can change speed at any time (after booting) without causing a re-boot.

Installation is a snap; documentation is excellent. The only thing we don't like is the use of Microsoft's Inport mouse connector. The problem is that when you outgrow the Mach 10, the mouse may end up being useless, because few third-party vendors support it. Use of a standard serial mouse would have provided more options as your needs change.

Microsoft will be releasing another accelerator board (286-based) called the Mach 20; however, we were unable to obtain one in time for this article.

#### NEC V20

The least expensive accelerator option provides a modest increase in speed—about 5%. Installation is as simple as swapping IC's; there are no jumpers, DIP switches, or memory-resident software programs to contend with. Compatibility is high, but not perfect; we've seen a number of programs that won't run on a V20, including a version of GW-BASIC, a compiled Turbo Pascal CAE program, and several games and educational programs. Considering the price, however, it can't hurt to try a V20, especially if you're on an austere budget.

#### Tiny Turbo, TurboEGA, and Pcturbo 286e

Orchid Technology has been in the accelerator-board business longer than anyone else, and the quality of their boards, some of which have been reviewed here before, reflects that longevity. We've had minor complaints with their documentation and technical support, but we have since found that in those regards, Orchid is at least as good as the competition, and in many cases better.

The least expensive board is the Tiny Turbo, shown in Fig. 7. It is a half-length replacement processor that contains an 80286 processor running at 7.16 MHz, and an 80287 math co-processor socket. To install the board, several jumpers must be set; the jumpers indicate co-processor speed, amount of system memory, and cache enable/disable. The host's 8088 is inserted on a small daughterboard to which the 40-conductor ribbon cable attaches. A toggle switch that protrudes through the board's mounting bracket selects fast (80286) or slow (8088) mode, and also functions as a reset switch. Changing speeds forces a complete system

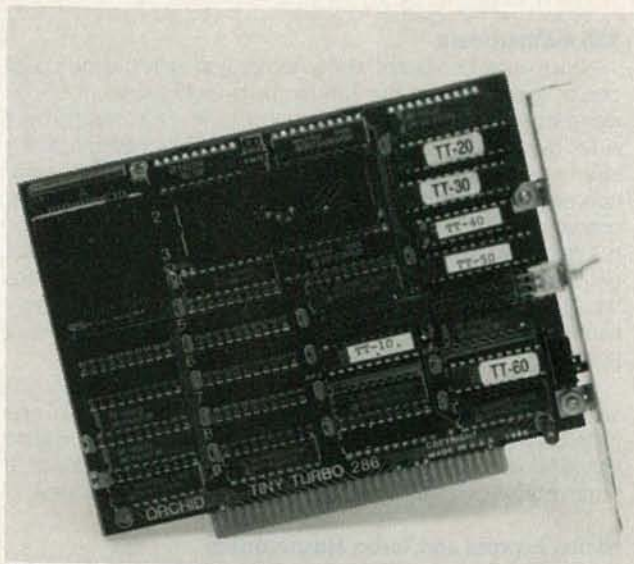


FIG. 7—Orchid's Tiny Turbo

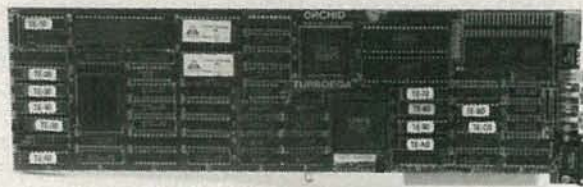


FIG. 8—Orchid's TurboEGA

reboot. Documentation is contained in a clearly written 12-page booklet.

The next model up, the TurboEGA (shown in Fig. 8), combines the performance increase of the Tiny Turbo with a built-in multi-mode EGA adapter. The TurboEGA is a full-length card with an 80286, an 80287 socket, a reset/speed-select switch, and the EGA adapter, which also has modes that emulate CGA and Hercules monochrome text and graphics. The figures presented in Table 1, Fig. 1, and Fig. 2 are with the board running in Hercules emulation mode; in EGA text mode, screen output speed is about 15% faster, due to Orchid's optimized EGA BIOS.

Installation amounts to setting jumpers and DIP switches for monitor type (color, monochrome, or EGA) and number (the TurboEGA can co-exist with either a CGA or a monochrome adapter), co-processor speed, memory size, and cache enable/disable. The host 8088 is inserted into a socket on the TurboEGA's board, which is then connected to the vacant motherboard socket via a 40-conductor ribbon cable.

The mounting bracket has a speed-select/reset switch, a nine-pin D connector (for the monitor), access to the monitor-select DIP switch, and RCA jacks for the EGA's auxiliary outputs.

Documentation consists of a small spiral-bound manual; the manual is well written and well produced. A diskette is included that contains programs to turn monochrome and CGA emulation on and off, a program to display the BIOS ROM's date (the TurboEGA will not work on IBM PC's with ROM's dated before 10/27/82; the ROM can be upgraded), and a screen saver.

Unlike some multi-mode display adapters, Hercules and CGA emulation work fine on the TurboEGA.

Orchid's Pcturbo 286e (shown in Fig. 9) is available in 8- and 10-MHz versions; we tested the 8-MHz version, which is faster than most 10- and 12-MHz accelerator cards. The 286e is a co-processor card that plugs into the expansion bus and has no electrical connections with the host 8088. The 286e really consists of a complete computer on a card, with its own, separate 16-bit 1-megabyte address space. An additional megabyte of RAM can be added via an optional daughterboard; that RAM can be configured as ex-

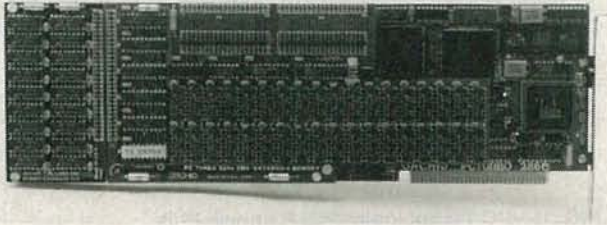


FIG. 9—Orchid's Pcturbo 286e-8

panded or extended memory. The board also has a socket for an 80287 co-processor.

Until recently, the 286e was simply the fastest accelerator card you could buy. A good deal of the card's speed is due to the fact that it copies the host's BIOS and BASIC ROM's into its own 16-bit address space.

In turbo mode, programs are executed on the 286e's 80286 microprocessor; in standard mode, programs are executed on the host's 8088 microprocessor. In addition, it is possible to configure the system so that the 8088 and the 80286 execute programs simultaneously. In fact, you can add as many as four 286e cards to a single PC and operate each one independent of the others.

Installation consists of setting I/O port-select jumpers, interrupt line, 80287 interrupt and speed, and on-board memory. Then you must run a special installation program that configures the software that switches between turbo and normal modes. At that point a new AUTOEXEC.BAT file is created, and two new boot batch files. One contains the contents of your old AUTOEXEC.BAT; the other, any additional commands to be executed solely by the 286e. Any commands in the (new) AUTOEXEC.BAT file are then executed by both the 8088 and the 80286; commands in the other boot files are executed only by the appropriate processor. That allows you, for example, to set date and time only once, say in the 8088's file. A separate TURBO.SYS file is also created; it performs the same function as CONFIG.SYS does for the host.

Several useful utility programs are included: a RAM disk, a disk cache, and a print spooler. Typically you'll spend most of your time (and run your programs) in turbo mode, and use the 8088's address space for the RAM disk, cache, and spooler. All three programs are extremely useful and reliable, and greatly contribute to overall speed and convenience.

The 286e's manual is in Orchid's standard spiral-bound form. It contains a fair amount of information about how the 286e works in

#### Compatibility Software

- PageMaker, Aldus Corp., 411 First Avenue South, Seattle, WA 98104, (206) 622-5500.

CIRCLE 38 ON FREE INFORMATION CARD

- AutoCad 2.6 and AutoSketch, Autodesk, Inc., 2320 Marinship Way, Sausalito, CA 94965, (800) 445-5415.

CIRCLE 39 ON FREE INFORMATION CARD

- WordStar 4.0, MicroPro International, P.O. Box 7079, San Rafael, CA 94901-0079, (800) 227-5609, (800) 343-3000 ext. 655.

CIRCLE 40 ON FREE INFORMATION CARD

- Windows, Microsoft Corp., Redmond, WA 98073, (800) 426-9400, (206) 882-8088 (WA).

CIRCLE 41 ON FREE INFORMATION CARD

- Direc-Link, Micro-Z Company, 4 Santa Bella Road, Rolling Hills Estates, CA 90274, (213) 377-1640.

CIRCLE 42 ON FREE INFORMATION CARD

- VP Planner, Paperback Software, 2830 Ninth Street, Berkeley, CA 94710, (415) 644-2116.

CIRCLE 43 ON FREE INFORMATION CARD

conjunction with the host PC, various kinds of memory (EMS, protected, DOS), installation instructions, memory maps, jumper settings, and information on using the utility software.

For all its power, the 286e is not without problems. For example, it is incompatible with third-party EGA cards, although a special EGA adapter is available from Orchid that is compatible. In graphics mode on a Hercules card, random "garbage" is often left on the screen; the garbage disappears, however, merely by moving the pointing device (mouse or digitizing tablet) in the affected area. And the way the manual intersperses technical with installation and operational information is confusing.

On the plus side, we used the board for a long period of time as the basis of a high-performance AutoCAD system. The 286e co-existed peacefully with a multi-function/EMS board made by Aparat (the Limbo II, reviewed in the March 1987 issue). In a different configuration, it also functioned with a 68000 co-processor board that controls Pencept's Penpad 320 digitizing tablet. Not counting the video controller, that made a total of three microprocessors running simultaneously inside a standard IBM PC XT! All in all, there's a great deal to like about the Pcturbo 286e.

#### Breakthru 286

The Personal Computer Support Group has been around a long time supplying enhancement products for Radio Shack's portable computers, particularly the Model 100 and the Tandy 102. A few years ago, the company got into the PC business with an excellent disk cache program called Lightning; their first hardware entry is the Breakthru 286, which comes in 8- and 12-MHz versions; we reviewed the latter, which is shown in Fig. 10. Every board comes with a copy of Lightning; the program is also available separately for \$89.95.

Like Orchid's Tiny Turbo, the Breakthru 286 is a half-size replacement processor. Unlike the Tiny Turbo, however, you remove and store your PC's 8088 (and 8087, if present); the 8088 does not mount on the Breakthru's board. In addition, a special plug must be inserted in the 8087 socket on your PC's motherboard. The Breakthru has a socket for an 80287. Installation continues by setting a switch on your motherboard and configuring several jumpers on the Breakthru. In addition, you may add a device driver to your CONFIG.SYS file; the driver allows you to change speed from the keyboard, and to set the hot-key combination that accomplishes speed switching. Alternatively, you can use Lightning to accomplish speed switching and to set the hot key. You can switch speed at any time without causing a reboot; a special Lightning command will force clock speed to be reduced whenever a floppy disk drive is accessed.

Separate manuals are provided for Lightning and the Breakthru. The Breakthru's manual is somewhat confusing, due to inconsistent use of the term *cache*. For example, to place the Breakthru in turbo mode, at the DOS prompt you type `A>L CACHE ON`. But to set up a 64K disk cache for drive C, the command is `A>L 64 C`. After overcoming the terminology, however, everything works well. In addition, lightning automatically senses the presence of EMS memory, and can use as much as 1.5 megabytes of it.

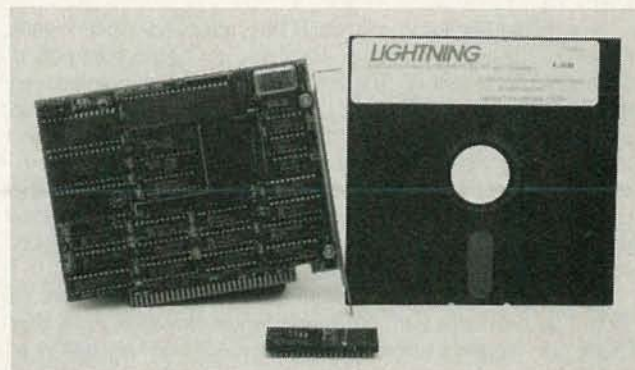


FIG. 10—PCSG's Breakthru 286

## Hardware Manufacturers and Distributors

- 386 Motherboard, Hauppauge Computer Works, Inc., 358 Veterans Memorial Highway, Commack, NY 11725, (800) 443-6284, (516) 360-3827 (NY).

**CIRCLE 27 ON FREE INFORMATION CARD**

- MCT-Turbo and Nickel Express, JDR Microdevices, 110 Knowles Drive, Los Gatos, CA 95030, (800) 538-5000, (408) 866-6200 (CA).

**CIRCLE 28 ON FREE INFORMATION CARD**

- Mach 10, Microsoft Corp., Redmond, WA 98073, (800) 426-9400, (206) 882-8088 (WA).

**CIRCLE 29 ON FREE INFORMATION CARD**

- NEC V20, NEC Electronics, Inc., 401 Ellis Street, P.O. Box 7241, Mountain View, CA 94039, (800) 632-3531, (800) 632-3532 (CA).

**CIRCLE 30 ON FREE INFORMATION CARD**

- Tiny Turbo, TurboEGA, and Pcturbo 286e, Orchid Technology, 45365 Northport Loop West, Fremont, CA 94538, (415) 683-0300.

**CIRCLE 31 ON FREE INFORMATION CARD**

- Breakthru 286, Personal Computer Support Group, 11035 Harry Hines Blvd., Suite 206, Dallas, TX 75229, (214) 351-0564.

**CIRCLE 32 ON FREE INFORMATION CARD**

- 286 Rainbow Plus, PC Technologies, Inc., 704 Airport Blvd., P.O. Box 2090, Ann Arbor, MI, 48106, (313) 996-9690.

**CIRCLE 33 ON FREE INFORMATION CARD**

- MotherCard 5.0, State of the Art Technology, Inc., 657 N. Pastoria Ave., Sunnyvale, CA 94086, (800) 237-1713, (408) 245-3366 (CA).

**CIRCLE 34 ON FREE INFORMATION CARD**

- MultiSync monitor (used for EGA compatibility testing), NEC Home Electronics, Computer Products Division, 1255 Michael Drive, Wood Dale, IL 60191, (800) NEC-SOFT.

**CIRCLE 35 ON FREE INFORMATION CARD**

- Pencept Penpad 320, Pencept, Inc., 39 Green Street, Waltham, MA 02154, (617) 893-6390.

**CIRCLE 36 ON FREE INFORMATION CARD**

- Limbo II, Apparat, Inc., 6801 South Dayton, Englewood, CO 80112, (303) 799-0818.

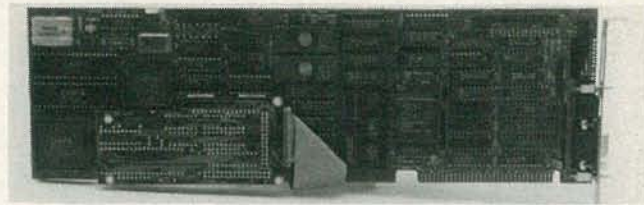
**CIRCLE 37 ON FREE INFORMATION CARD**

### 286 Rainbow Plus

PC Technologies markets a number of accelerator boards with various options. The Rainbow Plus (shown in Fig. 11) includes a 10-MHz 80286, a clock/calendar, a multi-mode EGA adapter, and an 80287 socket. In addition, an optional daughtercard provides a parallel interface and a Microsoft Inport mouse interface (like the Mach 10).

As with the Tiny Turbo, the host 8088 is removed and re-installed on a small daughterboard. A 40-conductor cable connects the assembly to the host PC. The rear connector provides speed- and monitor-select toggle switches, a 9-pin monitor connector, and access to the configuration DIP switch. The DIP switch selects monitor type, and allows you to set up for a dual-monitor system. It also enables the CGA and Hercules emulations (which are turned on and off via software). Others switches control cache state at power up and indicate host memory size. Toggling the speed-selection switch causes a reboot.

The board provides a moderate speed increase, and we detected no problems with the EGA adapter. However, in Hercules mode, the graphics screen (under AutoCAD 2.6) was simply unwatchable due to vertical rolling. With the optional parallel and mouse ports, the board could be useful in a situation where slot



**FIG. 11—PC Technologies' 286 Rainbow Plus**

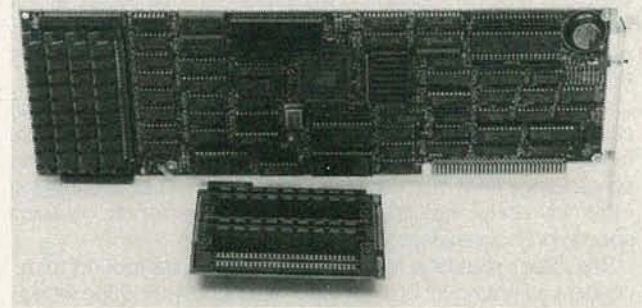
usage was critical.

### MotherCard 5.0

The flat-out winner in terms of overall speed, State Of The Art Technology's 12.5-MHz MotherCard 5.0 (shown in Fig. 12) basically packs an AT onto a single expansion card. Like the Pcturbo 286e, it is a co-processor, but unlike that card, the MotherCard requires the 8088 to be mounted on it, and a ribbon cable to connect to the host. 8- and 10-MHz versions of the card are also available.

The board features a "re-configurable" BIOS, actually a battery-backed CMOS RAM that may be used to patch BIOS updates. The company claims that IBM's forthcoming OS/2 will run on the board, but was unable to verify that by press time. (The 5.0 in the name refers to one of the many names OS/2 was called before it was officially released.)

The basic MotherCard contains a battery-backed clock/calendar, an 80287 socket, and one megabyte of memory; on optional daughterboard will accept as much as four megabytes, built on special modules. However, if you use the daughtercard, you won't be able to install a full-length card in the adjacent slot. The rear mounting bracket has a reset switch; changing from 8088 to 80286 mode is done via software programs and causes a reboot. Reboot-



**FIG. 12—SOTA's MotherCard 5.0**

ing normally forces operation in 286 mode, but pressing F10 will initiate 8088 mode. Utility software is included.

The MotherCard is extremely fast—with a 12-MHz 80287, the board approaches 386 speed in CAD applications. In addition, unlike many boards, the MotherCard is compatible with EGA, LAN programs, and other "problematic" applications.

### Recommendations

We examined a number of octopus boards; the Nickel Express is the only one that worked and the only one whose documentation was comprehensible. However, we don't like the idea of loose wires hanging off a PC board, so in the under-\$150 price range, we'd really recommend upgrading to a turbo motherboard—unless you're working with an IBM PC (not a clone) and wish to retain use of the BIOS and BASIC ROM's.

In the \$400-\$800 price range, the choice becomes much tougher, especially because many products are often heavily discounted, so comparing list prices may not be appropriate. For example, we recently saw both the Tiny Turbo and the Mach 10 (bundled with mouse and Windows) being sold for about \$350. The Tiny Turbo has the performance advantage, and it's a half-length card, but buying a mouse and a copy of Windows could easily cost you more

*continued on page 106*

# BUILD THE PT-68K

*This month we build test, reset, and clock circuits.*

**PETER STARK,**  
STARK SOFTWARE SYSTEMS CORPORATION

Last month we described the PT-68K computer's hardware and software in general terms, covered the data and address buses, and discussed how to get started. We are now ready to begin construction.

Although this month's installment presents the parts layout diagram for the entire printed circuit board, please don't blindly start stuffing parts in a big rush to get things finished. Instead, follow the sequence presented here. We are going to build the PT-68K in sections, providing detailed explanations of what each section does and why. In the process, we will also test each section by performing one or more simple experiments. There are two reasons for following that procedure: First, it gives us the chance to learn how the system really works. But, equally important, it will give us a chance to test each section and isolate small errors before they become big problems.

## Some theory

Digital circuits represent the binary digits 0 and 1 by means of voltages; in most microcomputers, the two voltages are often called *low* (which is a voltage between zero and roughly 0.8 volts) and *high* (which is a voltage between about two and five volts). There are exceptions, of course—such as in an RS-232 circuit, which might connect a computer and a printer together, where larger positive (and negative) voltages are used. However, the specified ranges are the most common. In any case, the range between 0.8 volts and 2.0 volts is a "no-man's land;" if a digital signal is in that range it usually indicates a problem.

Many people think that a low voltage is a 0, and a high voltage is a 1, but that is not always true—in fact it could be the other way around. So talking about ones and zeroes can be ambiguous, but talking about lows and highs is always specific. Note that we don't really care about the exact value of a signal's voltage, so long as it falls into one of the specified ranges.

However, there's yet another way to talk about digital signals. We can say that a particular signal is *on* or *off*. Another way of expressing that is to say that a signal is *asserted* (on) or *negated* (off).

The problem is that some circuits use a high to assert a signal, and other circuits use a low to assert a signal. So that gives us two types of circuits: *active-high* and *active-low*. An active-high circuit is high when it is asserted and low when it is negated; an active-low circuit

is low when it is asserted and high when it is negated. (Some books call that negative logic.) In a typical computer, both kinds of circuits may be used, and often are. In fact, an active-high circuit may be located a tenth of an inch from an active-low circuit.

In text and in schematics, active-low signals are marked with a bar over the signal name:  $\overline{\text{HALT}}$ , for example. By contrast, a signal without the bar, such as  $\text{KCO}$  or  $\text{A16}$ , is active high.

## Step 1: get ready

As shown in Fig. 2 last time, start by mounting the PC board and the power supply on a wooden board that measures about 12" x 24". Then hammer two brads through the appropriate board holes, as shown in that photo. Use the holes mentioned to avoid short circuiting the power supply.

Note, in Fig. 1, how the board is oriented: The power connector is right next to the power supply, and the six expansion connectors are in the left rear corner. We will use the words left, right, front, and back to describe the board when it is positioned like that; it will fit into a "baby" PC AT clone cabinet in the same orientation.

Note also that the side with all of the white lettering, called the *silk-screen layer*, is called the top, and the other side of the board is called the bottom. All soldering will be done on the bottom side; there are no solder joints whatsoever on the top or silk-screen side.

## Step 2: learn to solder

If you already have experience soldering components to a delicate printed-circuit board, you may skip to step 3; otherwise get some advice from a professional on proper soldering technique.

Note that both sides of the board seem to be covered with a thin layer of green paint; that layer is called a *solder mask*. The entire surface area of each side of the board is masked except for the area surrounding each hole; the purpose of the solder mask is to keep the solder on a pad from spreading to adjacent pads or traces.

You can see the copper traces through the solder mask, and you can see that the traces on top of the board go mostly left-right, whereas the ones on the bottom go front-back. If a



© 1987 Peter A. Stark

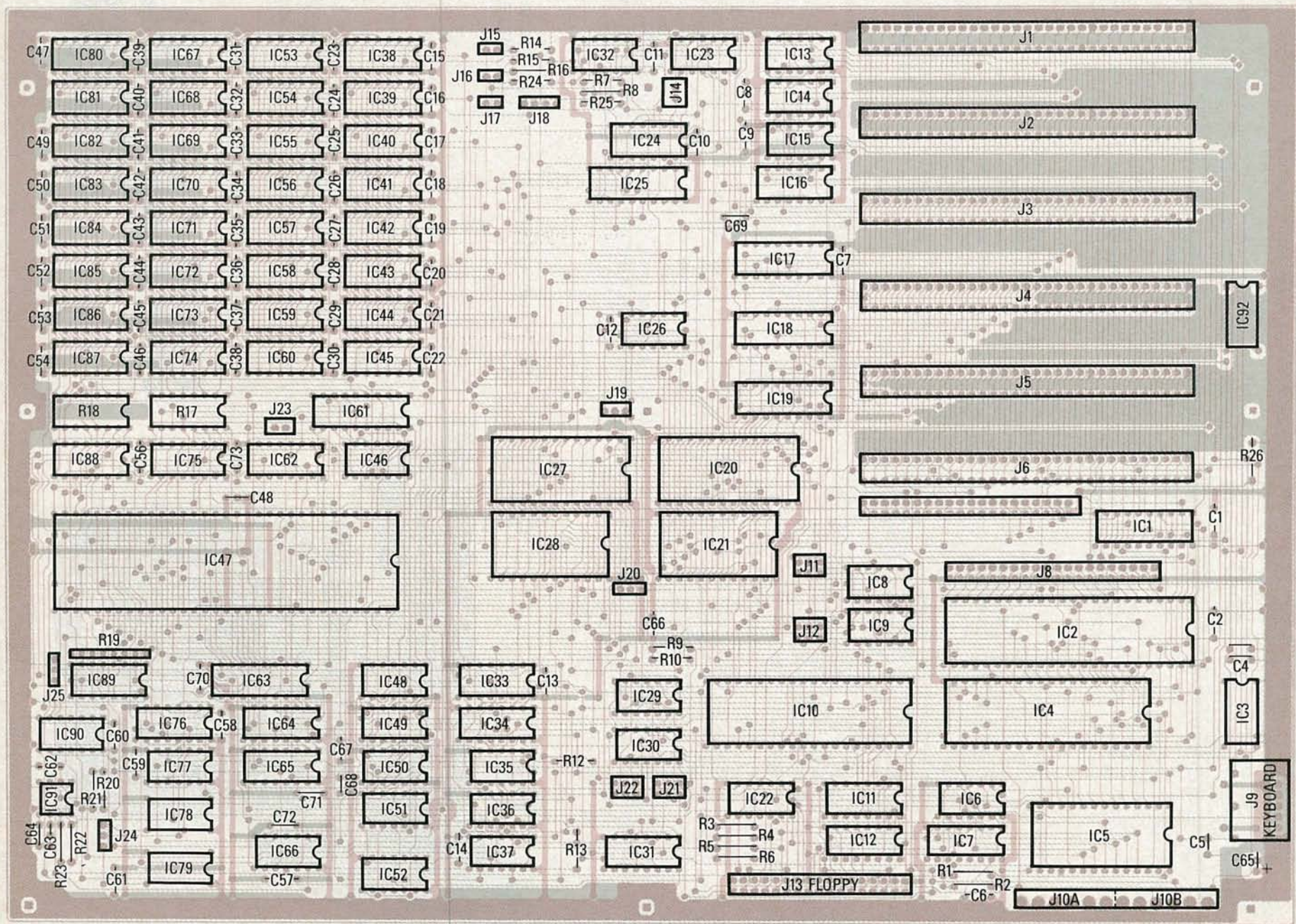


FIG. 1—PARTS PLACEMENT DIAGRAM shows where all board-mounted components are located. We'll use this diagram throughout the series of articles, so keep a copy handy.

connection has to go from one corner of the board to a diagonally opposite corner, it may travel in one direction on the top, then go through a hole to the bottom, and continue at a right angle there. In some cases, a particular connection may go back and forth, top to bottom, several times before it arrives at its destination.

The hole that connects a trace on the top to a trace on the bottom is called a *via* or a *feedthrough*, and it is plated with copper internally; hence it does not need to be soldered on both sides of the board. Solder only those joints into which you insert a lead. And don't wash the board prior to soldering.

### Step 3: the power connectors

The power connector actually consists of two six-pin connectors, J10-a and J10-b, in the right rear corner of the board. They are shown in Fig. 2, where J10-a is on the left, and J10-b is on the right. **Read the following paragraphs before you do anything.**

The power connectors are a potential source of big problems. Note that the two board-mounted connectors are identical, and the two power-supply plugs are probably identical as well. In other words, it is extremely easy to make a mistake and plug the wrong power supply plug into the wrong connector on the board and burn up the works. We must make sure that never happens.

First, look at the two board-mounted power-supply connectors. One has six pins, the other, only five—the next-to-the-last pin is missing. To help remind you of which goes where, cut off the next-to-the-last board-mounted pin on J10-b, as shown in Fig. 2.

Next, compare the shells of those connectors with the connectors supplied in your kit. In the plastic, behind each of the metal pins, is a small rectangular opening with a tiny plastic "bridge" above it.

Now look at the two matching plugs from the power supply; six small plastic tabs protrude from the long side of each. When the plugs and sockets are brand new, the tabs on the plugs prevent them from being inserted into the sockets because the long tabs hit the bridges. The object is to cut just the right combination of tabs and bridges so that the six-wire plug only fits J10-a, and the five-wire plug only fits J10-b. If you look closely at Fig. 2, you will see how we accomplished it.

Now that you know what must be done, solder the two connectors to the board, and then match up the bridges and the tabs so that the power supply plugs in only one way. Make sure that the connectors are oriented correctly.

While working on this section of the board, also install C65 (10  $\mu$ F, tantalum). Make sure it is oriented correctly, because tantalum capacitors have a nasty habit of exploding if connected backward! Then install C3, C4, and C5, three 47-pF disc ceramic capacitors. They look much like the many 0.1  $\mu$ F capacitors; mounting them now avoids possible confusion later. Also mount C6 (0.1  $\mu$ F) now.

Besides C63 (1  $\mu$ F) all the remaining capacitors are 0.1  $\mu$ F disc ceramics. Digital circuits are notoriously "noisy," and computer designers have learned the hard way that it is necessary to install small bypass capacitors between the +5-volt line and ground at many points on a PC board to keep that noise off the power lines. A general rule of thumb is that one such capacitor should be installed for every two or three digital IC's.

NOTE: Some IBM-type power supplies can be damaged if operated without a load, so never do so.

### Step 4: LED indicators

Most "baby" AT cabinets have two or three status-indicator LED's on the front panel. Eventually we'll connect those LED's to J15, J16, and J17 on the board to indicate power on, hard-disk activity, and microprocessor halt status, according to the circuits shown in Fig. 3 (which also shows speaker wiring.) In each case, a resistor in series with the LED (or speaker) limits current

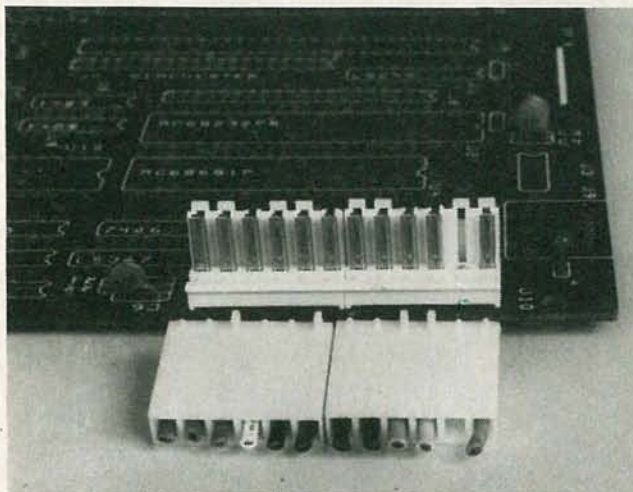


FIG. 2—POWER CONNECTOR J10A (left) and J10B (right). Also shown are the matching plugs from the power supply. Notice how the tabs on the plugs match the bridges that have been removed from the board-mounted connectors.

flowing through the device, which is controlled by one section of IC32, a 7406 open-collector hex inverter.

Note that IC32-b, IC32-c, IC32-d, and IC32-f are all part of one integrated circuit, IC32. It has six inverters; the other two are used elsewhere. For now ignore the fact that IC32-f has a small circle, called a *bubble*, on its input, instead of its output; that notation will be explained next time.

Before connecting them in their final form, we want to use the LED's for experimenting and debugging, so we'll solder the LED's directly to the PC board for the time being. Referring to Fig. 1, install R14 and R15 (330 ohms), R16 (220 ohms), R24 (2200 ohms), C11 (0.1  $\mu$ F), and the 14-pin socket for IC32. While you're at it, also install R25 (33 ohms), and J18, the 4-pin header strip for the speaker. Do not install IC32 in its socket yet, and don't bother connecting the speaker to J18.

Then install the three LED's at J15, J16, and J17. The cathode lead of each LED, usually marked by a flat edge on one side, should go toward the resistors. If at all possible, check each LED first, because sometimes LED's are made with the flat on the wrong side, but rather than destroy those LED's, manufacturers sell them at low prices on the surplus market.

Install each LED so that it stands up straight, about 1/2 inch above the board. Later, when we're ready to mount the board in the cabinet, we'll cut each LED lead just below the LED itself and use the stubs as connectors for the panel-mounted LED's.

Now connect the power supply cables to J10-a and J10-b and power up the board. The power indicated LED (at J15) should light, though it may immediately go off again. If so, don't be alarmed—most PC-type power supplies shut themselves off if there is insufficient load, and a single LED is a very small load indeed. If that's the case, turn off the supply and temporarily connect a 150- or 330-ohm resistor between pins 7 and 14 of the IC32 socket. **Don't force the leads all the way into the socket; rather, hold them gently against the appropriate pins.** Then try again.

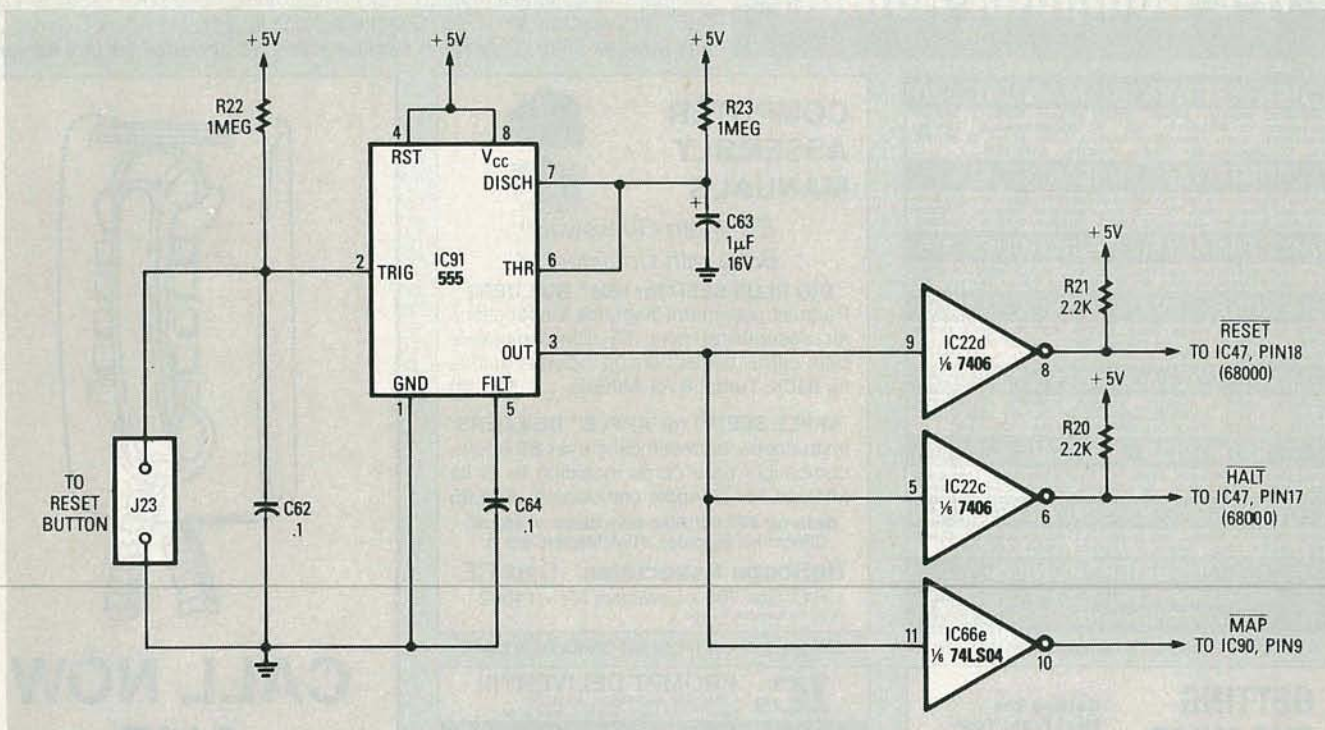
If the LED does not light at all, even for an instant, then most likely either the LED is in backward, R14 is the wrong value, or the power supply is defective or not properly connected to J10-a and J10-b. Correct the problem before continuing.

### Important note

During construction, often we will solder some connections, turn on the power, try the new configuration, turn off the power, make more connections, and so on. **It is absolutely essential that you turn off the power before doing any more wiring, soldering, or inserting IC's into sockets.** Better yet, turn off the supply and also unplug it. If you forget to turn off the power,







**FIG. 4—RESET CIRCUIT.** The 555 generates a high-going one-second pulse each time the terminals of J23 are shorted. The inverters (IC22-c, IC22-d, and IC66-e) drive the appropriate lines low.

runs. That signal is known as  $MPUCLK$ . In the position shown, IC77-b divides the 16-MHz signal by two, to provide an 8-MHz clock. However, by adding optional oscillator module IC79, a different frequency may be chosen by moving the jumper to the other position. For example, to run the computer at 10 MHz, you would install a 20-MHz oscillator module at IC79 and place J24 in the alternate position.  $CLK8$  would still be 8 MHz, but  $MPUCLK$  would now be 10 MHz.

Two modules are necessary because  $CLK8$  is used elsewhere in the computer and must stay at 8 MHz even if the 68000 itself runs faster. However, do not try to increase clock frequency at this time; depending on the frequency chosen, some components may have to be altered. We'll discuss the details in a future installment.

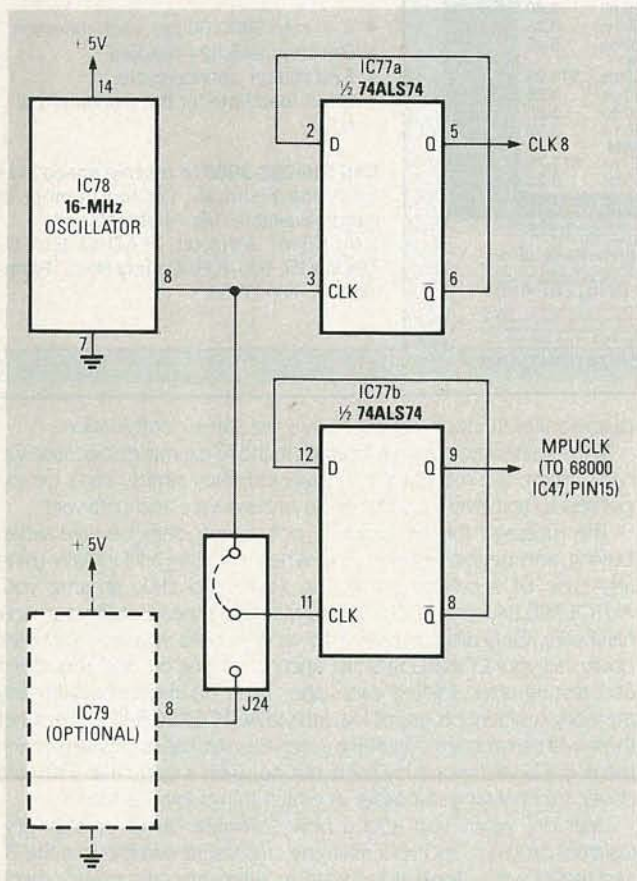
Now mount the 16-MHz oscillator module (IC78) by soldering it directly to the board, without a socket. Note that three corners are rounded; the pointed corner identifies pin 1, which should be closest to IC65. Then install a socket for IC77, a 3-pin header at J24, and three 0.1  $\mu F$  capacitors (C58, C59, and C60). Then insert a 74ALS74 (note: ALS, not LS) into the IC77 socket, and a shorting jumper from the center pin to pin 1 of J24.

Next, power up the computer. If you have an oscilloscope or a logic probe that can detect pulses, examine  $CLK8$  and  $MPUCLK$  for the 8-MHz clock signals. (An inexpensive oscilloscope may have trouble displaying the clock signal, or may show it as a very distorted sine wave.)

To use the built-in LED probe, first note how bright the LED is when the probe wire is not connected to anything. Then connect it to  $CLK8$ . The LED is flashing on and off so fast you cannot see it, so it should be dim, indicating that the signal is high part of the time and low part of the time.

Next, connect the LED probe to  $MPUCLK$  and note its brightness. Then slip the shorting jumper from J24 and note whether the LED gets brighter or darker. Each time you remove the jumper, you stop IC77-b from counting. Sometimes it will stop in the set state, in which case the LED will be getting a full high voltage and become brighter; other times it will stop in the reset state, in which case the LED will go off. Try removing and installing the jumper several times; if you see the LED in both states, the clock circuit is most likely fully functional.

That's all we have time for now; next time we'll install the microprocessor itself and start learning about how it works.  $\blacktriangleright$



**FIG. 5—CLOCK CIRCUIT.** IC78 generates a 16-MHz signal that IC77-a divides by two to provide the main clock signal. IC77-b generates a separate clock signal for the microprocessor, thereby allowing it to run at another (faster) rate.

# R-E Computer Admart

Rates: Ads are 2 1/4" x 2 7/8". One insertion \$825. Six insertions \$800 each. Twelve insertions \$775. each. Closing date same as regular rate card. Send order with remittance to **Computer Admart**, Radio Electronics Magazine, 500-B Bi-County Blvd., Farmingdale, NY 11735. Direct telephone inquiries to Arline Fishman, area code-516-293-3000. **Only 100% Computer ads are accepted for this Admart.**

**DISK SERVICE MANUAL \$20**  
Maintain, Repair, Adjust, Align Drives Without Special Equipment or Software. 5.25", 8", Microfloppies. IBM-PC/Compatible, Apple, Commodore, Kaypro, Tandy, Atari, TI, HP, DEC, etc. 12 chapters, 100+ Photos, Figures. **SAVE \$\$\$!**

**COMPUTER PHREAKING \$15**  
Dozens Computer Crime Methods and Countermeasures. How Systems are Penetrated. BBS Advice; Password Defeats; TEMPEST, Van Eck Methods; Crosstalk Amps. 200 Phreak-Term GLOSSARY.

**CRYPTANALYSIS TECHNIQUES \$15**  
Five Cryptanalysis Programs (COM, BAS, Source Code) for MSDOS Systems. N-Gram, Kasiski, MR, IC Analyses. Disk + Manual = \$25.

**PHONE COLOR BOXES \$15**  
PHONE RED, BLUE, BLACK, GRAY, SILVER, YELLOW, GREEN, BROWN, PURPLE, WHITE, BEIGE, S&M, CLEAR, CHEESE and MUTE BOX Plans. Plus CALL-FORWARDING - Much More! Use not recommended.

**HIGH VOLTAGE DEVICES \$15**  
STUNNER, ZAPPER, BLASTER, JAMMER, FLASHER, STIMULATOR, JACOB'S LADDER, OZONE/PLASMA/VAN DE GRAAFF GENERATORS, GEIGER COUNTER, FENCE CHARGER, etc. Plans. Shocking!

**RADIONICS MANUAL \$20**  
Comprehensive Manual, Plans on ElectroMagnetic Therapies, Diagnoses, Preventions. 30+ figures. Includes FDA-approved.

**ELECTROMAGNETIC BRAINBLASTER \$20**  
Comprehensive Manual and Plans on ElectroMagnetic Weapons and Lab. Devices. Dozens of figures. Mind Boggling!

**CONSUMERTRONICS**  
2011 CRESCENT DR. P.O. DRAWER 537  
ALAMOGORDO, NM 88310

CIRCLE 200 ON FREE INFORMATION CARD

## COMPUTER ASSEMBLY MANUALS



Eliminate Guesswork!  
Build with Confidence!

**BIG BLUE SEED for IBM™ BUILDERS**  
Parts list, placement diagrams & instructions for assembling over 75 IBM-compatible bare cards. Latest version includes guides for 640K, Turbo, & AT MthBds. .... \$17.95

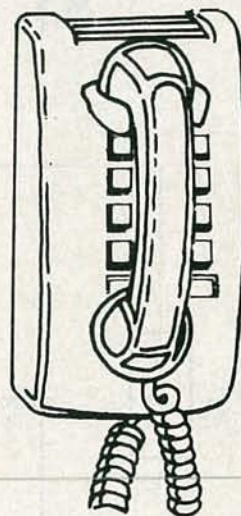
**APPLE SEED II for APPLE™ BUILDERS**  
Instructions for assembling over 85 Apple-compatible bare cards including II+ & IIe MthBds. For all Apple enthusiasts .. \$14.95

Both for \$30.00! Also bare cards in stock!  
Check/money-order, VISA/MasterCard to:

**NuScope Associates\***, Dept RE  
P.O. Box 790 • Lewiston, NY • 14092

\*A Division of Kosmic MicroTech Inc.

CIRCLE 202 ON FREE INFORMATION CARD



## CALL NOW AND RESERVE YOUR SPACE

- 6 x rate \$800.00 per each insertion.
- Reaches 245,824 readers.
- Fast reader service cycle.
- Short lead time for the placement of ads.

Call 516-293-3000 to reserve space. Ask for Arline Fishman. Limited number of pages available. Mail materials to: **Computer Admart, RADIO-ELECTRONICS, 500-B Bi-County Blvd., Farmingdale, NY 11735.**

## GETTING THE MOST FROM YOUR PRINTER

Getting The Most From Your Printer

J.P. HANCOCK



**BP181**—It is probable that 80% of dot-matrix printer users only ever use 20% of the features offered by their printers. This book will help you unlock the special features and capabilities that you probably don't even know exist. To order your copy send **\$6.95 plus \$1.50 for shipping** in the U.S. to **Electronic Technology Today Inc., P.O. Box 240, Massapequa Park, NY 11762-0240.**

## ICs PROMPT DELIVERY!!!

SAME DAY SHIPPING (USUALLY)  
QUANTITY ONE PRICES SHOWN for AUG. 30, 1987

OUTSIDE OKLAHOMA: NO SALES TAX

DYNAMIC RAM		
1Mbit	1000Kx1	100 ns \$26.50
1Mbit	256Kx4	120 ns 32.00
51258	*256Kx1	80 ns 6.95
4464	64Kx4	150 ns 3.50
41256	256Kx1	80 ns 4.95
41256	256Kx1	100 ns 4.40
41256	256Kx1	120 ns 3.40
41256	256Kx1	150 ns 3.25
41264	2-PORT	120 ns 5.25
EPROM		
27C512	64Kx8	200 ns \$11.25
27C256	32Kx8	250 ns 6.65
27256	32Kx8	250 ns 5.50
27128	16Kx8	250 ns 5.35
STATIC RAM		
43256L-12	32Kx8	120 ns \$11.75
6264LP-15	8Kx8	150 ns 3.25

OPEN 6 1/2 DAYS, 7:30 AM-10 PM. SHIP VIA FED-EX ON SAT.

SUNDAYS & HOLIDAYS: SHIPMENT OR DELIVERY VIA U.S. EXPRESS MAIL

SAT DELIVERY INCLUDED ON FED-EX ORDERS RECEIVED BY: Th: 5:00 Ar: 5:00 P: 1:00 P: 1:00  
MasterCard/VISA or UPS CASH COD  
**Factory New, Prime Parts** MICROPROCESSORS UNLIMITED, INC. 24,000 S. Peoria Ave., BEGGS, OK 74421 (918) 267-4961  
No minimum order. Please note that prices are subject to change. Shipping & insurance extra. & up to \$1 for packing materials. Orders received by 9 PM CST can usually be delivered the next morning, via Federal Express Standard Air at \$4.00, or guaranteed next day Priority One at \$10.00. All parts guaranteed.

CIRCLE 61 ON FREE INFORMATION CARD

## TURBOCHARGE YOUR PC

continued from page 100

than \$200, even at discounted prices. And the Mach 10's method of speed switching is more convenient. The overall price/performance leader is PCSG's Breakthru 286.

Above \$800, Orchid's PCTurbo 286e is hard to beat. The 8-MHz model we examined is faster than the 12-MHz Breakthru 286; the 10-MHz model should be a real screamer. However, the 286e won't run a third-party EGA, so SOTA's MotherCard is a strong contender, especially if it turns out that the board can run OS/2.

### Conclusions

All of the accelerator boards we tested for this article enhance performance. At the same time, every single one exhibited some problem with compatibility or performance. For example, one board simply wouldn't run AutoCAD 2.6. Replacing a PLD allowed the program to run, but prevented use of EMS memory. A complete board re-design was necessary to solve the problem. Another board crashed under some combinations of resident and non-resident programs—but then so does a plain-vanilla XT. However, a

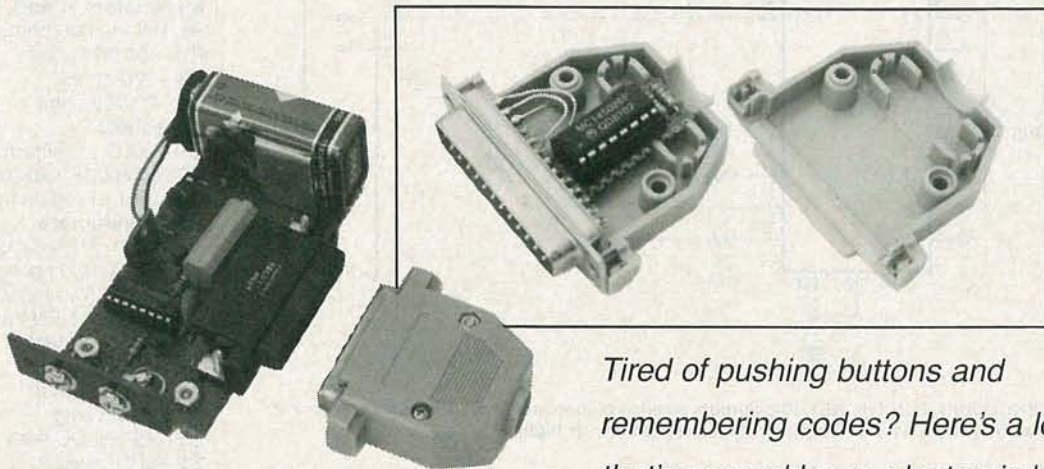
plain-vanilla XT does not crash with the same combination.

We refrained from naming names in those examples because we can't blame the manufacturers involved; they simply can't be expected to test every combination of hardware and software.

The message for the buyer is not a new one: beware when buying, and be extremely careful when installing and initially using any type of accelerator. Back up your hard disk, rename your AUTOEXEC.BAT and CONFIG.SYS files, and then install your new hardware. Only after getting it to work should you add software drivers to your CONFIG.SYS file, and do so one by one, rebooting and testing after adding each one. Then do the same with any memory-resident programs loaded via AUTOEXEC.BAT. Expect that there will be problems and take a step-by-step approach to solving them. If a board works by itself, but not with a particular software driver, try changing the order in which things are loaded.

Later on, when you add a new software driver or memory-resident program, and your machine crashes, remember that the PC and the XT were designed to work in a very specific environment, and that you have drastically altered that environment in a way in which the original designers could not possibly have foreseen—so don't curse them. If you really need the speed, go out and buy a faster machine. **▶▶▶**

# BUILD THIS



*Tired of pushing buttons and remembering codes? Here's a lock that's opened by an electronic key.*

## Electronic Combination Lock

PAUL RENTON

ELECTRONIC-LOCK CIRCUITS HAVE BEEN around, in various forms, for many years. Most have a keypad on which the user enters a combination of numbers. If the combination matches the one that's programmed into the lock, the lock opens. Unfortunately, it takes a relatively large amount of digital circuitry to decode and match keypad entries against the programmed combination.

On the other hand, the electronic-lock system shown in Figs. 1 and 2 uses only three integrated circuits: IC1, an MC145028 that is part of the lock itself (Fig. 1), IC2, an MC145026 that functions as an electronic key (Fig. 2), and IC3, a 5-volt regulator. That all-electronic approach allows the electronic lock to occupy only a couple of square inches of space, while the key is small enough to be carried in a pocket. Although anyone with access to the key can unlock the lock, which is not true for a keypad lock, the low cost and simplicity of the keyed electronic lock makes it somewhat more convenient to build.

The MC145026 is usually used to encode commands for radio-frequency, ultrasonic, and infrared remote-controllers. It has nine address pins. When instructed to send a command, the IC reads the pins, encodes them into a series of bits, and then sends the information out serially. The receiver, an MC145028, receives the serial transmission and checks the received address data against the programming of its own nine address pins. If the programming is an exact match then pin 11, the VT (Valid Transmission) line, goes high.

### Many combinations

When encoding data, IC2 can read one of three states on each of its address pins: 1) open with no connection; 2) low—connected to ground; 3) high—connected to the positive supply voltage. Since the IC reads each as a distinctly different state, the encoder operates on a "trinary" (three value) system. As there are nine address pins, the encoder can encode  $3^9$  (19,683)

possible codes. But while the MC145028 decoder can read three states on address pins A1–8, it can only read a high or a low signal on its A9 pin, thereby allowing only  $2 \times 3^8$  (13,122) possible addresses, a range that is still larger than that provided by a 4-digit keypad code. It gives reasonable assurance that if someone did build an electronic key, they would have a difficult time unlocking the

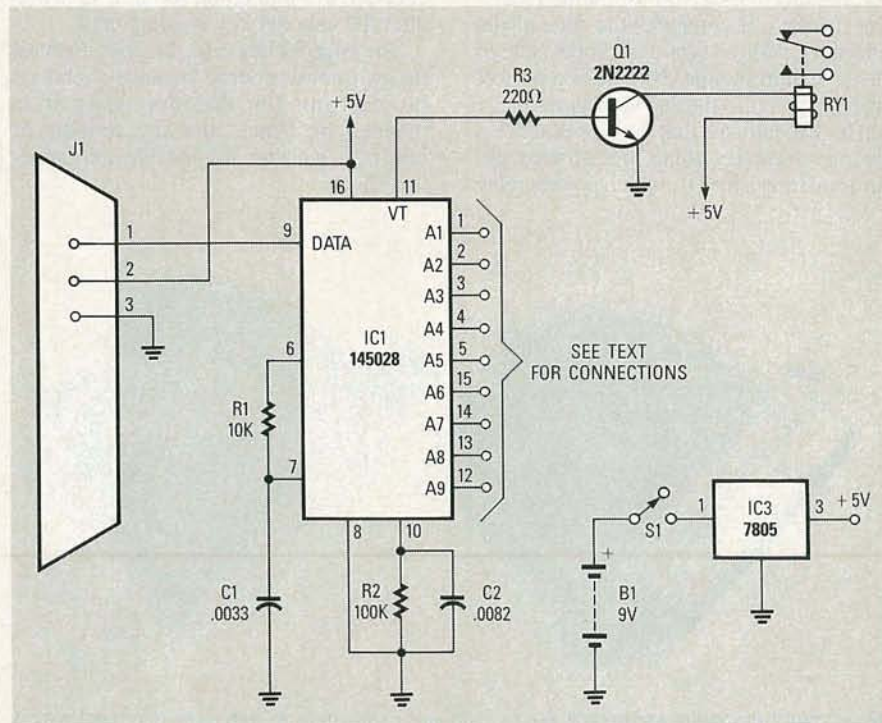


FIG. 1—THE ELECTRONIC LOCK is actually a decoder (IC2) that compares the wiring of its address pins with that of the key.

NOVEMBER 1987

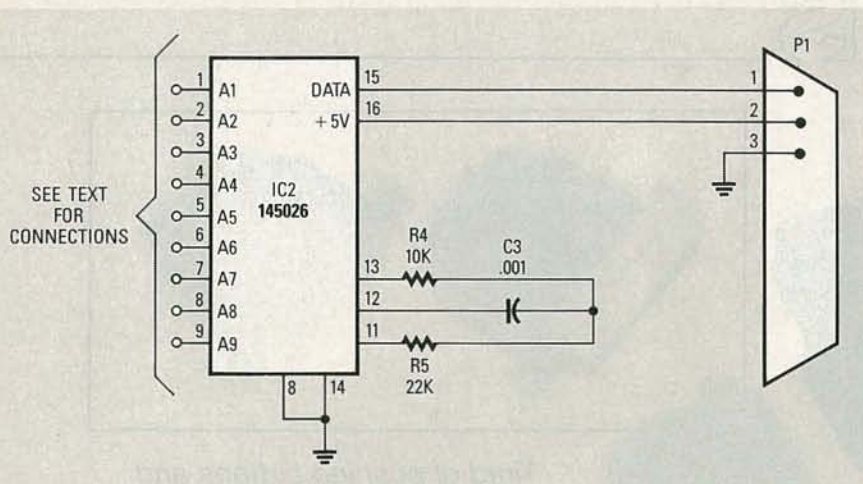


FIG. 2—THE ENCODING IC IN THE KEY, IC2, outputs a series of long and short pulses that represent the wiring of address pins A1–A9. The pins can be brought low, or high, or left open.

electronic lock without knowing the proper combination.

The encoded data sent from IC2 consists of a series of long, short, or a combination of long and short pulses that represent the state of the address pins. A low signal on an address pin is encoded as a sequence of two consecutive short pulses, a high signal is encoded as two consecutive long pulses. An open pin is encoded as a sequence of a long pulse followed by a short pulse. After the encoder sends out its sequence of encoding pulses it immediately re-transmits the sequence for added reliability. (The procedure is called *redundant transmission*. It is commonly used to insure the received integrity of transmitted data.)

Decoder IC1 uses the pulses it receives from the encoder to determine the state of the encoder's address pins. While receiving the data, it compares the state of the encoder's address pins against the state of its own address pins. If there is a perfect match on all pins the decoder brings its  $\nu T$  pin high to indicate that the proper address was received. By going high, the  $\nu T$  pin turns on transistor Q1, which powers relay

RY1. The  $\nu T$  pin remains high, and the relay thereby remains powered until the decoder no longer receives a properly encoded sequence of pulses.

### Construction

The timing of the pulses is not so critical that only high tolerance parts must be used; 5% resistors are acceptable for both the encoder and decoder, which contributes to the low cost of the electronic lock.

The decoder (Fig. 1) is powered by a 9-volt transistor-radio type battery and can be built on a small piece of perforated wiring or construction board. Nothing is critical and any layout can be used. To simplify connections to external equipment, such as an electric door release, relay RY1's contacts should be brought out to a dual screw-type terminal strip. The decoder's combination should be wired after the encoder key is completed.

The encoder key (Fig. 2), does not have its own power source because it obtains power from the decoder when it is plugged in; hence, the key consists of only IC2, resistors R4 and R5, and capacitor C3.

### PARTS LIST

All resistors ¼ watt, 5%.

- R1, R4—10,000 ohms
- R2—100,000 ohms
- R3—220 ohms
- R5—22,000 ohms

### Capacitors

- C1—.0033  $\mu$ F, ceramic disc
- C2—.0082  $\mu$ F, ceramic disc
- C3—.001  $\mu$ F, ceramic disc

### Semiconductors

- IC1—MC145028 decoder (Motorola)
- IC2—MC14026 encoder (Motorola)
- IC3—7805 5-volt regulator
- Q1—2N2222 NPN transistor

### Other components

- B1—9-volt battery
- J1—DB-25 socket
- P1—DB-25 plug
- RY1—5-volt DC relay
- S1—SPST switch

**Miscellaneous:** Perforated wiring or construction board, terminal strip, battery clip, wire, solder, etc.

To set the combination, the encoder's address pins are connected to ground, the 5-volt power supply (pin 16), or left open. One way to program the address pins would be to use a set of switches to place each pin at to one of the three states. However, to keep the key pocket size, the pins are soldered directly to ground, to 5 volts, or simply left with no connection. Soldered pins allow the key to be made small enough to fit inside a conventional DB-25-type connector, although the soldered-pin programming cannot be easily changed to a new code.

If you only expect to set the combination once, then it would be appropriate to simply wire two or more address pins of the encoder and decoder to the positive supply and/or ground to generate the system's combination. If you anticipate having to change the combination, then you might want to consider putting switches on the address pins of the lock and key so that the addresses could be easily changed. But as stated earlier, doing so would mean the key would be larger. A compromise is to use switches on the decoder's address pins and take the time to rewire the key if you change the combination.

To make the electronic key, locate a connector that will hold IC2 along with the two resistors and the capacitor. Fortunately, the commonly-available DB-25-type connector shell has just enough space for those components, but feel free to use whatever case or connector meets your needs. Regardless of the kind of connector used as the key, it must have at least three terminals available for connection to the lock: one for power, one for data, and

*continued on page 129*

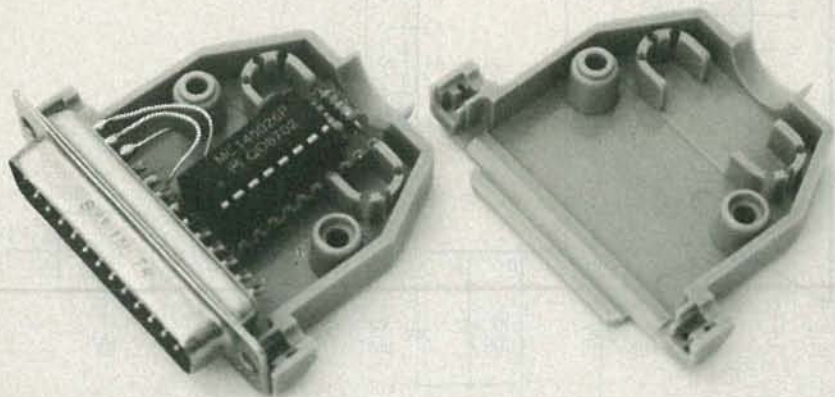


FIG. 3—THE ENCODING ASSEMBLY can be built small enough to fit within the hood of a DB-25 connector. Alternately, you can use any kind of connector large enough to house the circuit.

## Understanding Data Sheets of RF Power Transistors

Data sheet parameters are what tell you whether an RF power transistor can do the job.

**NORMAN E. DYE,**  
Motorola Semiconductor Products

DATA SHEETS OFTEN ARE THE SOLE source of information about the capabilities and characteristics of a product. That is particularly true of RF power transistors that are used throughout the world, so it's important that the user and the manufacturer of a product speak a common language; i.e., what the semiconductor manufacturer says about a transistor is understood fully by the circuit designer.

In this article we will review RF-power-transistor parameters from maximum ratings to functional characteristics. We'll cover critical specifications, and how values are determined and what they signify. Finally, we'll cover possible tradeoffs in device specifications and their importance to the circuit-design engineer.

But before we get into the subject, let's take time out for a brief explanation of the terms die, bond pads, and top metal, because, although those terms are used when describing RF-power-transistor parameters, they may be unfamiliar to many of you.

Although we consider an RF power transistor to be a "unit" device that visually resembles a transistor, it is, in fact, an integrated circuit that consists of several hundred to more than a thousand individual parallel-connected transistors on a single silicon chip. In this instance, the chip, with all its integral transistors, is called a *die*. The *bond pads* are the connections for the both the main emitter, base, and collector leads, and the individual transistors. The term *top metal* refers to the deposited metal wires that interconnect the individual bond pads. We'll cover dies and top metal in greater detail later.

### DC specifications

Basically, RF transistors are characterized by two types of specifications: *DC*

and *functional*. By definition, the DC specifications consist of breakdown voltages, leakage currents,  $h_{FE}$ , or beta (DC gain), and inter-element capacitances. The functional specifications cover AC parameters: gain, ruggedness, noise figure, and input and output impedance. Thermal characteristics do not fall cleanly into either category since thermal resistance and power dissipation can be either DC or AC, so we will treat thermal resistance as a special specification and give it its own heading of thermal characteristics. Figure 1 shows how DC and functional specifications are arranged on a typical data sheet.

*Breakdown voltages* are largely determined by material resistivity and junction depths. Each junction voltage—collector/base and emitter/base—is generally specified at a current level that is well within the safe-operating limits of a reverse-bi-

ased junction. The specifications are conventional and are generally standard throughout the semiconductor industry.

*Leakage currents* (defined as reverse-biased junction currents that occur prior to avalanche breakdown) are likely to be more varied in their specification and also more informative. Leakage currents are a result of material defects: mask imperfections and/or undesired impurities that enter during wafer processing. Some sources of leakage currents are potential reliability problems, most are not. Leakage currents that are material related, such as stacking faults and dislocations, or pipes, created by mask defects and/or processing inadequacies, result in leakage currents that are constant with time and, if initially acceptable for a particular application, will remain so. (Since they do not pose long-term reliability problems.) Some manufacturers do not list leakage



**MRF646**

### The RF Line

#### NPN SILICON RF POWER TRANSISTOR

designed for 12.5 Volt UHF large signal amplifier applications in industrial and commercial FM equipment operating to 512 MHz.

- Specified 12.5 Volt, 470 MHz Characteristics —  
Output Power = 45 Watts  
Minimum Gain = 4.8 dB  
Efficiency = 55%
- Characterized with Series Equivalent Large Signal Impedance Parameters
- Built In Matching Network for Broadband Operation
- 100% Tested for Load Mismatch Stress at all Phase Angles with 20:1 VSWR @ 16 Volt High Line and 50% Overdrive.

45 W — 470 MHz  
CONTROLLED Q  
RF POWER  
TRANSISTOR  
NPN SILICON

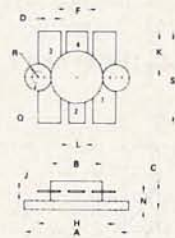


#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V <sub>CEO</sub>	16	Vdc
Collector-Base Voltage	V <sub>CBO</sub>	36	Vdc
Emitter-Base Voltage	V <sub>EBO</sub>	4.0	Vdc
Collector Current — Continuous	I <sub>C</sub>	8.0	Adc
— Peak (10 seconds max)		10	
Total Device Dissipation @ T <sub>C</sub> = 25°C	P <sub>D</sub>	175	Watts
Derate Above 25°C		1.0	W/°C
Storage Temperature Range	T <sub>stg</sub>	-65 to +200	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Value	Unit
Thermal Resistance, Junction to Case	R <sub>θJC</sub>	1.0	°C/W



STYLE 1  
PIN 1 EMITTER  
2 COLLECTOR  
3 BASE  
4 BASE  
FLANGE ISOLATED

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	24.28	25.15	0.956	0.990
B	12.45	12.95	0.490	0.510
C	5.87	7.62	0.231	0.300
D	5.48	7.15	0.215	0.281
E	5.08	5.33	0.200	0.210
F	18.28	18.54	0.719	0.730
G	5.10	5.75	0.200	0.228
H	10.47	10.93	0.412	0.430
I	3.81	4.06	0.150	0.160
J	2.81	3.25	0.110	0.128
K	2.92	3.30	0.115	0.130
L	3.05	3.30	0.120	0.130
T	21.34	21.84	0.840	0.860

CASE 278 06

DS5662 M1

ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
<b>OFF CHARACTERISTICS</b>					
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 20 mA dc, I <sub>B</sub> = 0)	BV <sub>CEO</sub>	16	—	—	Vdc
Collector-Emitter Breakdown Voltage (I <sub>C</sub> = 20 mA dc, V <sub>BE</sub> = 0)	BV <sub>CES</sub>	36	—	—	Vdc
Emitter-Base Breakdown Voltage (I <sub>E</sub> = 5.0 mA dc, I <sub>C</sub> = 0)	BV <sub>EBO</sub>	4.0	—	—	Vdc
Collector Cutoff Current (V <sub>CE</sub> = 15 Vdc, V <sub>BE</sub> = 0, T <sub>C</sub> = 25°C)	I <sub>CES</sub>	—	—	5.0	mA dc
<b>ON CHARACTERISTICS</b>					
DC Current Gain (I <sub>C</sub> = 4.0 A dc, V <sub>CE</sub> = 5.0 Vdc)	h <sub>FE</sub>	40	70	100	
<b>DYNAMIC CHARACTERISTICS</b>					
Output Capacitance (V <sub>CB</sub> = 12.5 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)	C <sub>ob</sub>	—	90	125	pF
<b>FUNCTIONAL TESTS</b>					
Common Emitter Amplifier Power Gain (V <sub>CC</sub> = 12.5 Vdc, P <sub>out</sub> = 45 W, I <sub>C</sub> (Max) = 5.8 A dc, f = 470 MHz)	G <sub>pe</sub>	4.8	5.4	—	dB
Input Power (V <sub>CC</sub> = 12.5 Vdc, P <sub>out</sub> = 45 W, f = 470 MHz)	P <sub>in</sub>	—	13	15	Watts
Collector Efficiency (V <sub>CC</sub> = 12.5 Vdc, P <sub>out</sub> = 45 W, I <sub>C</sub> (Max) = 5.8 A dc, f = 470 MHz)	η	55	60	—	%
Load Mismatch Stress (V <sub>CC</sub> = 16 Vdc, P <sub>in</sub> = Note 1, f = 470 MHz, VSWR = 20:1, All Phase Angles)	ψ*	No Degradation in Output Power			
Series Equivalent Input Impedance (V <sub>CC</sub> = 12.5 Vdc, P <sub>out</sub> = 45 W, f = 470 MHz)	Z <sub>in</sub>	1.4 + j4.0		—	Ohms
Series Equivalent Output Impedance (V <sub>CC</sub> = 12.5 Vdc, P <sub>out</sub> = 45 W, f = 470 MHz)	Z <sub>OL</sub> **	1.2 + j2.8		—	Ohms

## Notes:

1. P<sub>in</sub> = 150% of Drive Requirement for 45 W output @ 12.5 V.

\* ψ = Mismatch stress factor—the electrical criterion established to verify the device resistance to load mismatch failure. The mismatch stress test is accomplished in the standard test fixture (Figure 1) terminated in a 20:1 minimum load mismatch at all phase angles.

\*\* Z<sub>OL</sub> = Conjugate of the load impedance into which the device output operates at a given output power, η<sub>T</sub>, and frequency.

FIG. 1—THIS IS JUST A SMALL SAMPLE of the kind of data you'll find in a data sheet.

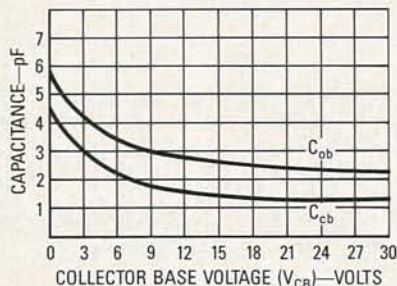


FIG. 2—THE OUTPUT AND INPUT JUNCTION CAPACITANCES can be read directly from curves provided in the data sheet.

current specifications to allow more wafers/dies to pass quality inspection.

On the other hand, leakage current caused by channels created by mobile impurities in the oxide (primarily sodium) tend to change with time and can lead to a progressive increase in leakage current. That can render the device useless for a specific application. Distinguishing between sources of leakage current can be difficult; that is one reason why devices designed for military use require HTRB (High Temperature Reverse Bias) and burn-in testing. Even for commercial applications a leakage-current limit should be included in any complete device specification.

DC parameters such as h<sub>FE</sub> and C<sub>ob</sub> (output capacitance) need little comment. (Typically, for RF devices h<sub>FE</sub>. Instead, AC gain at the desired operating frequency is specified). Keep in mind, however, that DC beta (h<sub>FE</sub>) is related to AC beta (functional gain). AC beta will usually track DC beta, particularly at the lower RF frequencies. Generally, RF device manufacturers do not like to have tight

limits placed on h<sub>FE</sub>. That's because:

- The specification is unrelated to performance
- Difficulty in control in wafer processing
- Other manufacturing constraints, dictated by the device's AC specifications, preclude specific limits for h<sub>FE</sub>.

A good rule of thumb for h<sub>FE</sub> is to set a maximum to minimum ratio of not less than 3, with the minimum h<sub>FE</sub> value selected to assure you of an adequate AC gain margin.

Output capacitance is an excellent indicator of relative device size (base area), provided that the major portion of the output capacitance is created by the base-collector junction and not parasitic capacitance arising from bond pads and other top metal of the die. Keep in mind that junction capacitance will vary with voltage (Fig. 2), while parasitic capacitance is unaffected by voltage variations. Also, in comparing devices, it's important to note the voltage at which a given capacitance is specified. No industry standard exists. The preferred voltage at Motorola, for instance, is the transistor's V<sub>CC</sub> rating; i.e., 12.5 volts for 12.5-volt transistors, 28 volts for 28-volt transistors, etc.

### Maximum ratings

Maximum ratings, such as those shown in Fig. 3 for a typical RF power transistor, tend to be the most frequently misunderstood group of device specifications. Ratings for *maximum junction voltages* are straightforward and simply reflect the minimum values set forth in the DC specifications for breakdown voltages. If the device in question meets the specified minimum breakdown voltages, then volt-

ages less than the minimum will not cause junctions to reach reverse-bias breakdown, with the potentially destructive current levels that can result.

On the other hand, a maximum rating for power dissipation (P<sub>d</sub>) is closely entwined with thermal resistance (θ<sub>jc</sub>). In reality, maximum P<sub>d</sub> is a fictitious number—a kind of figure of merit—because it is based on the assumption that the case temperature is maintained at 25°C. However, providing that everyone arrives at the value in a similar manner, the maximum P<sub>d</sub> rating is a useful tool for comparing devices.

### Thermal resistance

The rating begins with a determination of the thermal resistance of the die to its case. Knowing θ<sub>jc</sub>, and assuming a maximum die temperature, one can easily determine maximum P<sub>d</sub> (based on the previously stated case temperature of 25°C). Measuring θ<sub>jc</sub> is normally done by monitoring the case temperature (T<sub>c</sub>) of the device while it operates at or near rated output power (P<sub>o</sub>) in an RF circuit. Simultaneously, the die temperature (T<sub>j</sub>) is measured by an infrared microscope (see Fig. 4) that has a spot-size resolution as small as 1-mil. Normally, several readings are taken over the surface of the die and an average value is used to specify T<sub>j</sub>.

It is true that temperatures across a die will typically vary over the range of 10–20°C. Normally, the die uses ballasting to insure that the heat is dispersed more or less evenly across the die's surface. Without ballasting the heat would be concentrated near the middle of the die. Ballasting is a technique that reduces the emitter current to the transistors in the middle of the die below the emitter current of the transistors located at the edges of the die. In that way the middle transistors dissipate less heat than those at the edges, and the heat dissipation is spread more or less evenly across the die. A poorly designed die—one with improper ballasting—could result in worst-case hot-spot temperatures that vary between 40–50°C. Likewise, poor die bonds (see Fig. 5) can result in hot spots.

By measuring the DC and RF T<sub>c</sub> and T<sub>j</sub>, along with P<sub>o</sub> and P<sub>in</sub>, it's possible to calculate θ<sub>jc</sub> from the formula:

$$\theta_{jc} = \frac{T_j - T_c}{P_{IN} - P_O}$$

Typical values for an RF power transistor might be T<sub>j</sub> = 130°C; T<sub>c</sub> = 50°C; V<sub>CC</sub> = 12.5 Volts; I<sub>C</sub> = 12 amperes; P<sub>in</sub> (RF) = 10 watts; P<sub>o</sub> (RF) = 80 watts. Thus:

$$\theta_{jc} = \frac{130 - 50}{10 + (12.5 \times 12) - 80} = \frac{80}{80} = 1^\circ\text{C/W}$$

Several reasons dictate a conservative value be placed on θ<sub>jc</sub>. First, thermal resistance increases with temperature

(and we realize  $T_c = 25^\circ\text{C}$  is *not* realistic). Second,  $T_j$  is not a worst-case number. And third, by using a conservative value of  $\theta_{jc}$  a realistic value is determined for  $P_{d(\text{max})}$ . Generally, Motorola's practice is to publish  $\theta_{jc}$  numbers approximately 25% higher than that determined by the measurements previously described, or for the case illustrated, a value of  $\theta_{jc} = 1.25^\circ\text{C/W}$ .

Now a few words about die temperature: Reliability considerations dictate a safe value for an all Au (gold) system (die top metal and wire) to be  $200^\circ\text{C}$ . Once  $T_{j(\text{max})}$  is determined along with a value for  $\theta_{jc}$ , maximum  $P_d$  is:

$$P_{D(\text{MAX})} = \frac{T_{j(\text{max})} - 25^\circ\text{C}}{\theta_{jc}}$$

Specifying maximum  $P_d$  for  $T_c = 25^\circ\text{C}$  makes it necessary to derate maximum  $P_d$  for any value of  $T_c$  above  $25^\circ\text{C}$ . The derating factor is simply the reciprocal of  $\theta_{jc}$ .

### Maximum collector current

Maximum collector current ( $I_c$ ) is probably the most subjective maximum rating on RF-transistor data sheets. It can, and is, determined in a number of ways—each leading to different maximum values. Actually, three possible current limitations can exist in RF transistors. One is package-related, one is wire-related, and a third is die-related. Collector current in most older, lower-frequency transistors is wire-and/or package-limited, which is why those parts generally have  $I_{c(\text{max})}$  determined by collector voltage (or by  $BV_{CEO}$  for added safety). Higher-voltage parts (such as 28 and 50 volts) tend to be wire-limited; when operated at lower voltage those components can safely handle sizable amounts of current. Lower voltage parts (such as 7.5 and 12.5 volts), however, tend to be package-limited; those should have  $I_{c(\text{max})}$  determined by power-dissipation considerations.

Most modern, high-frequency transistors

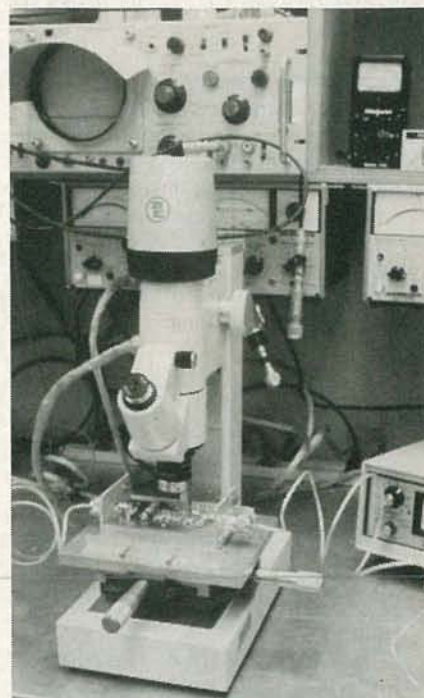


FIG. 4—AN INFRARED MICROSCOPE is used to measure the temperature of various spots on the die.

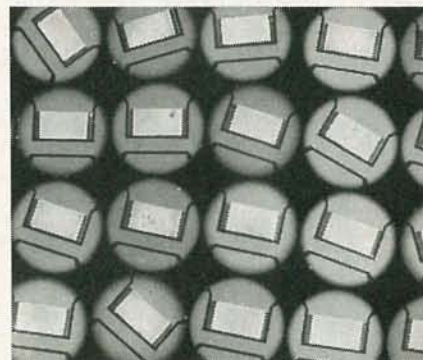


FIG. 5—AN X-RAY PHOTO SHOWS some transistor-cells that are poorly bonded to the die, which will result in hot-spots.

are die-limited because of high current densities that result from their very small current-carrying conductors; those densities can lead to metal migration and premature failure. For those type of transistors,  $I_{c(\text{max})}$  is determined by using Black's equation for metal migration. That equation calculates a mean-time-between-failures (MTBF) based on current density, temperature, and the type of metal. At Motorola, MTBF is generally set at greater than 7 years, and maximum die temperature is set at  $200^\circ\text{C}$ . For plastic-packaged transistors, maximum  $T_j$  is set at  $150^\circ\text{C}$  and  $I_{c(\text{max})}$  is calculated using the resulting current density along with a knowledge of the die geometry and top-metal thickness.

It is up to the transistor manufacturer to specify an  $I_{c(\text{max})}$  that is based on the appropriate limitation (die, wire, package). Note, however, that the limitation depends to some extent on the application. Circuit designers should consult the manufacturer for addi-



### The RF Line

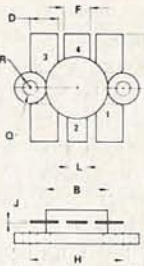
#### NPN SILICON RF POWER TRANSISTOR

designed for 12.5 Volt UHF large-signal amplifier applications in industrial and commercial FM equipment operating to 512 MHz.

- Specified 12.5 Volt, 470 MHz Characteristics — Output Power = 45 Watts Minimum Gain = 4.8 dB Efficiency = 55%
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Built-In Matching Network for Broadband Operation
- 100% Tested for Load Mismatch Stress, at all Phase Angles with 20:1 VSWR @ 16-Volt High Line and 50% Overdrive.

### MRF646

45 W — 470 MHz  
CONTROLLED Q  
RF POWER TRANSISTOR  
NPN SILICON



STYLE 1  
PIN 1: EMITTER  
2: COLLECTOR  
3: EMITTER  
4: BASE  
FLANGE ISOLATED

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	24.38	25.15	0.960	0.990
B	12.45	12.95	0.490	0.510
C	5.97	7.62	0.235	0.300
D	5.48	TYP	0.215	TYP
F	5.08	5.33	0.200	0.210
H	18.29	18.54	0.720	0.730
J	0.10	0.15	0.004	0.006
K	10.67	10.92	0.420	0.430
L	3.81	4.06	0.150	0.160
N	3.81	4.32	0.150	0.170
Q	2.92	3.30	0.115	0.130
R	3.05	3.30	0.120	0.130
S	21.34	21.84	0.840	0.860

CASE 278 06

DS5662 R1

#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	$V_{CEO}$	16	Vdc
Collector-Base Voltage	$V_{CBO}$	36	Vdc
Emitter-Base Voltage	$V_{EBO}$	4.0	Vdc
Collector Current — Continuous	$I_c$	8.0	Adc
— Peak (10 seconds max)		10	
Total Device Dissipation @ $T_c = 25^\circ\text{C}$	$P_D$	175	Watts
Derate Above $25^\circ\text{C}$		1.0	$W/^\circ\text{C}$
Storage Temperature Range	$T_{stg}$	-65 to +200	$^\circ\text{C}$

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Value	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0	$^\circ\text{C/W}$

FIG. 3—MAXIMUM RATINGS AND THERMAL CHARACTERISTICS are also provided by the data sheet.

tional information if  $I_{c(max)}$  for a specific application.

### Storage temperature

Storage temperature is another maximum rating that is frequently not given the attention it deserves. A  $-55^{\circ}\text{C}$  to  $200^{\circ}\text{C}$  range has more or less become the industry standard. For single, metal, hermetic-packaged devices, an upper limit of  $200^{\circ}\text{C}$  creates no reliability problems. However, plastic encapsulated or epoxy-sealed devices should not be subjected to temperatures above  $150^{\circ}\text{C}$ .

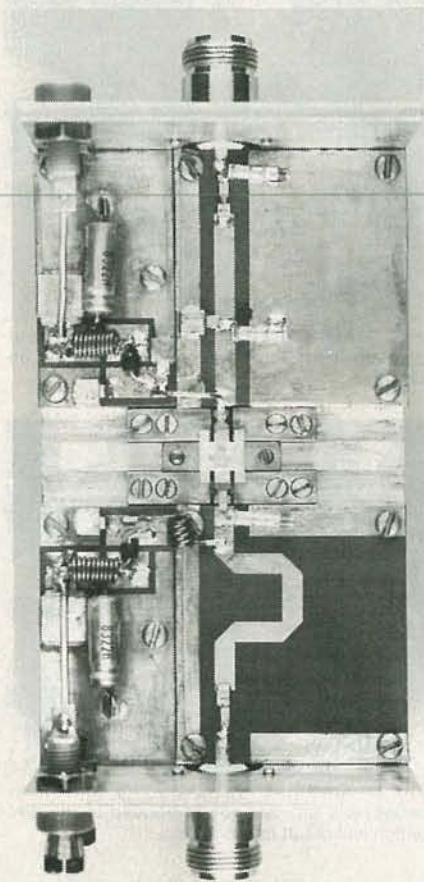


FIG. 6—AN ACTUAL WORKING TEST CIRCUIT is used to determine the parameters of an RF power transistor.

### Functional characteristics

The functional characteristics of an RF transistor are by necessity tied to a specific test circuit, such as the one shown in Fig. 6, because without specifying a circuit, parameters like gain, reflected power, efficiency—even ruggedness—are meaningless. Furthermore, most test circuits that are used by RF-transistor manufacturers today (even those used to characterize devices) are designed to allow for easy insertion and removal of the device under test. For mechanical reasons, that sometimes limits device performance, which explains why the performance attained by users frequently exceeds that indicated in data-sheet

curves. On the other hand, a circuit used to characterize a device is usually narrow-band and tunable, which results in higher gain than attainable in a broadband circuit. Unless otherwise stated, it can be assumed that curves such as  $P_o$  vs. frequency are generated on a point-by-point basis by tuning a narrow-band circuit across a band of frequencies and, thus, represents what can be achieved at a specific frequency of interest with proper impedance matching.

Broadband, fixed-tuned test circuits are best for testing the functional performance of an RF transistor. Fixed-tuning is particularly important in assuring the manufacturer, and the user of product consistency; i.e., that the devices made tomorrow will be identical to the devices made today.

Tunable, narrow-band circuits have led to the requirement that users and manufacturers use "correlation units" to assure product consistency over a period of time. Fixed-tuned circuits minimize (if not eliminate) the need for correlation, and that compensates for the increased constraints they place on the manufacturer of the device. On the other hand, manufacturers like tunable test circuits because they allow adjustments that can compensate for variations in die fabrication and/or device assembly. Unfortunately, gain is normally less in a broadband circuit than it is in a narrow-band circuit, so transistor manufacturers often use narrow-band circuits to improve product specifications for competitive reasons (that is called "specsmanship"). A good compromise for transistor manufacturers is to use narrow-band circuits with all tuning adjustments "locked" in place. The moral to all of that is that data-sheet readers should be careful to note the test circuit used when comparing specific parameters.

### Ruggedness

For RF power transistors, the parameter of ruggedness takes on considerable importance. Ruggedness is the transistor's ability to withstand extreme mismatch conditions in operation, which causes large amounts of output power to be "dumped" back into the transistor, without altering its performance or reliability. In many circuits, impedances presented to a device are variable and unpredictable and can abruptly change. In portables, the antenna may be placed against a metal surface; in mobiles, perhaps the antenna is broken off or inadvertently disconnected from the radio. An RF power transistor must be able to survive such load mismatches. A realistic possibility for mobile radio transistors (although not a normal situation) is the condition whereby the RF power device "sees" a worst-case load mismatch (an open circuit, any phase angle), along with maximum  $V_{CC}$ ,

and greater-than-normal input drive—all at the same time. Thus, the ultimate test for ruggedness is to subject a transistor to a test wherein RF  $P_{in}$  is increased up to 50% above that value necessary to create the rated  $P_o$ ;  $V_{CC}$  is increased about 25% (from 12.5 volts to 16 volts for mobile transistors), and then the load-reflection coefficient is set at a unity while its phase angle is varied through all possible values from  $0^{\circ}$  to  $360^{\circ}$ .

### Testing ruggedness

Ruggedness tests come in many forms. Many older devices (and even some newer ones) simply have no ruggedness specification. Others are said to be "capable of" withstanding load mismatches. Still others are guaranteed to withstand load mismatches of 2:1 VSWR to  $\infty$ :1 VSWR at rated output power. A few truly rugged transistors are guaranteed to withstand 30:1 VSWR at all phase angles (for all practical purposes, 30:1 VSWR is the same as  $\infty$ :1 VSWR) with both overvoltage and overdrive. Once again, it is up to the user to match his circuit requirements against device specifications.

Then, as if the whole subject of ruggedness is not confusing enough, manufacturers "muddy the waters" further by stating what constitutes passing the ruggedness test. The words generally say that after the ruggedness test the device under test "shall have no degradation in output power." A better phrase would be "no measurable change in output power." But even that is not the best because, unfortunately, the device under test can be damaged by the ruggedness test and still have "no degradation in output power." As stated earlier, today's RF power transistors consist of up to 1000 or more small transistors connected in parallel. Emitter resistors—ballasts—are placed in series with groups of those transistors in order to better control power sharing throughout the transistor's die. It is well known by semiconductor manufacturers that a high percentage of an RF power transistor's die (say up to 25–30%) can be destroyed and the transistor will still be able to deliver its rated power at its rated gain, at least for some period of time. If a ruggedness test destroys a high percentage of transistor-cells in an RF power transistor, then it is likely that a second ruggedness test (by the manufacturer or by the user while in his circuit) would result in additional damage, leading to premature failure of the device.

A more scientific measurement of "passing" or "failing" a ruggedness test is called  $\Delta V_{re}$ —the change in emitter resistance before and after the ruggedness test.  $V_{re}$  is determined largely by the net value of emitter resistance in the transistor die. Thus if cells are destroyed, emitter resistance will change with a resultant

*continued on page 126*





## POOR MAN'S STORAGE SCOPE

DUKE BERNARD

*With nothing more than an oscilloscope, a video camera, and a VCR, hobbyists can have many of the advantages of fancy logic analyzers and digital storage scopes.*

WHEN A NEWLY DESIGNED PIECE OF ELECTRONICS equipment or an existing piece of equipment that has gone bad is being debugged, it's common practice to trace signal paths by using an oscilloscope. With digital equipment, logic analyzers are often used to check timing and even store the waveforms on floppy disk for future evaluation. Such equipment is very convenient to use, but very expensive.

When professional designers do a thorough job of evaluating a new design, they record the waveforms at each major node in the system. Traditionally, that has been done by taking Polaroid photographs of oscilloscope traces. The process requires fastening the scope probe to a circuit trace on a printed circuit board long enough to take the photograph, developing the print, recording the appropriate oscilloscope scales, and then moving on to the next location to repeat the process. Things proceed in an orderly manner when documenting a new design that is working properly, though it surely helps to have an assistant. However, when either a new design or an existing system is faulty, circuit tracing usually becomes less orderly, with the scope probe stuck here and there looking for suspect signals.

Life gets even more interesting when the system works perfectly 99% of the time, but has a glitch that causes an error every few hours or so. In industry, troubleshooting such a glitch generally calls

for powerful logic analyzers that can be triggered by the fault condition and then recall the signals that preceded the error. Unfortunately, the hobbyist and the small-business electronics professional generally cannot afford the tens of thousands of dollars that such equipment costs.

With a little ingenuity, however, commercially available video equipment can be made to do many of the tasks of much more expensive equipment, and in some cases do it better. Unlike most commercial logic analyzers, which record only one's and zero's, the technique described in this article works well for either digital or analog signals. It was first used by the author to find an intermittent failure in an asynchronous coupled multi-CPU digital system. It has subsequently been used for debugging simpler systems. It can also be used to turn a simple oscilloscope into a storage scope for reviewing transient waveforms.

The concept is simple and rather straightforward. All that is required is a VCR with top-quality special effects; that is, clean, jitter-free stop frame, fast forward and reverse, and slow motion such as that provided by the top-of-the-line four-head units or the new digital VCR's that feature digital frame storage. A video camera and a video monitor complete the list of required equipment.

A word about the video camera: A high-end unit is not required; a simple

black-and-white surveillance camera will do fine. However, if an expensive color camera is used, to prevent burning the image tube care should be taken not to leave the camera pointed at a very bright trace on the scope for long periods of time. That is less of a concern if the camera uses a solid-state imager.

### More savings

In addition to the obvious savings in equipment cost, it's interesting to compare the number of oscilloscope traces that can be recorded on a two hour roll of VCR tape versus the cost of trying to capture the same amount of information on film. Assume that for recording the waveforms of a new system, each point in the system is recorded for 10 seconds. That is generally enough time to record the scope settings and what point in the circuit is being monitored on the voice track. That yields six traces recorded per minute, or 720 in two hours. At about 50 cents a print for instant film, to record as many traces the cost would be \$360. Compare that to the cost of even the highest quality T120 tape. At even faster recording speeds an even greater savings can be realized.

While hard copies are often desired in addition to the tape recordings, the taped waveforms can be reviewed at leisure and the most important ones photographed off the TV monitor, although with some lim-

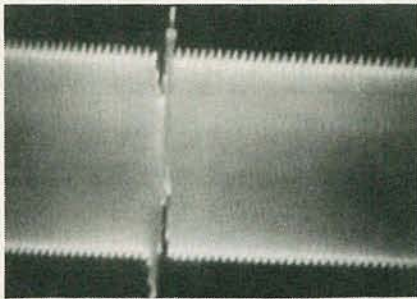


FIG. 1—USING A VCR, this glitch in the system clock waveform was found.

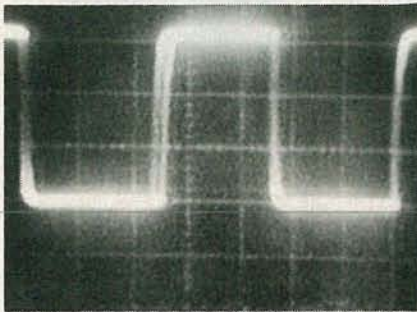


FIG. 2—FURTHER INVESTIGATION found a waveform with a timing shift during alternate leading edges.

itations. Meanwhile, a very extensive set of waveforms have been captured, which can be reviewed later if the system develops a problem.

### A typical application

The problem that initiated the effort to record oscilloscope traces with a VCR was one of those periodic, hard-to-trace glitches that had cropped up during the testing of a new design. In frustration, we decided to record various oscilloscope waveforms with a VCR until one was found that changed appreciably just before the system being tested recorded an error (since the system being tested had a real time clock, it was possible to let it run to give an indication of when an error occurred).

Once an error was noted, the VCR tape was advanced to the approximate time of the error and the waveforms were examined. Finally, a glitch was found on the system's clock waveform; that is shown in Fig. 1. At first, the glitch was thought to be the direct cause of the error, but it wasn't. However, by knowing what to look for, the same conditions that created the glitch in the clock waveform (several high-current devices switching simultaneously) were programmed, and more waveforms were recorded.

The waveform shown in Fig. 2, a sub-clock signal, was found to be the culprit. As shown by the dual-trace leading edge, the signal's timing changed on alternate leading edges during the time that the system clock had the disturbance, causing a synchronization problem. That timing change was further traced to ringing on the waveform, as shown in Fig. 3.

### Budget storage scope

Having found the VCR so useful in recording occasionally occurring waveform disturbances for future review, we looked into using a VCR as a "poor-man's" storage oscilloscope. Events that happen as a transient rather than a repetitive occurrence are hard to capture on an ordinary oscilloscope. One example is speech. With so much interest in speech synthesis and speech recognition, it's often necessary to observe the patterns created by different words and compare their similarities and differences. But since speech waveforms are transient in nature, it's hard to do comparative work using only a standard scope.

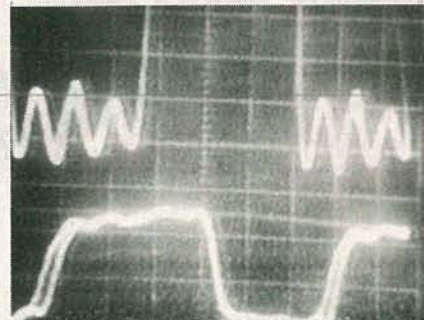


FIG. 3—RINGING ON THE WAVEFORM was finally found to be the cause of the problem.

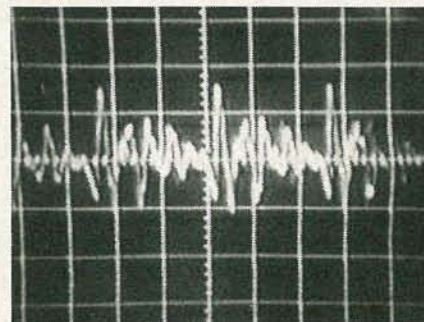


FIG. 4—THE WORD "HELLO" as captured by a video camera and a VCR. The varying intensity of the trace is caused by using a time base longer than a single TV field (about 16 milliseconds).

Recording a waveform on a VCR and then playing it back a frame at a time allows the repetitious patterns in certain speech sounds to be observed. Part of the word "hello" as captured by a VCR is shown in Fig. 4. Note the non-uniform appearance of the trace. That is caused by using a time base that is longer than the TV field rate of 16 milliseconds ( $1/60$  second). Then, the camera can not capture a trace in a single field; instead it does so over two or more fields, causing a stroboscopic effect. The fainter parts of the image are seen only because of image persistence on the CRT screen and/or in the camera pickup. That does not prevent you from examining the waveform, since you can use the frame advance to examine the event one frame at a time, but it does make it difficult to obtain a good hard

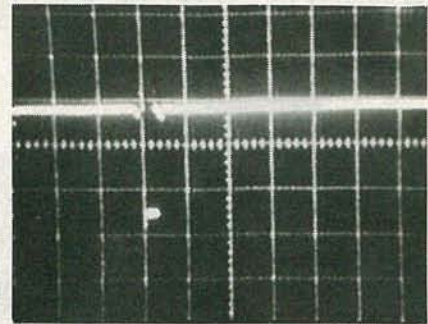


FIG. 5—A CAMERA/VCR SETUP is ideal for viewing short duration transients, such as a voltage interruption caused by a relay's contact bounce.

copy (photograph) from the monitor, as evidenced by Fig. 4.

To get good results when using a VCR's frame-advance feature as a poor-man's storage scope requires some experimenting to obtain the proper trace intensity. Since most video cameras can accommodate fairly low light levels, a trace barely visible when viewed directly may show up quite well when viewed on a TV monitor. To set intensity, then, repeatedly trigger the scope, adjusting the trace intensity until it looks right on the monitor.

Let's close out our discussion by looking at a simple application. One problem that plagues circuit designers is that of contact bounce, a mechanical problem that all mechanical switches and relays are subject to.

Figure 5 shows the output waveform from a relay. When the contacts close, the voltage goes high, triggering the scope. A few milliseconds later, however, the contacts bounce open and closed, creating a momentary voltage interruption.

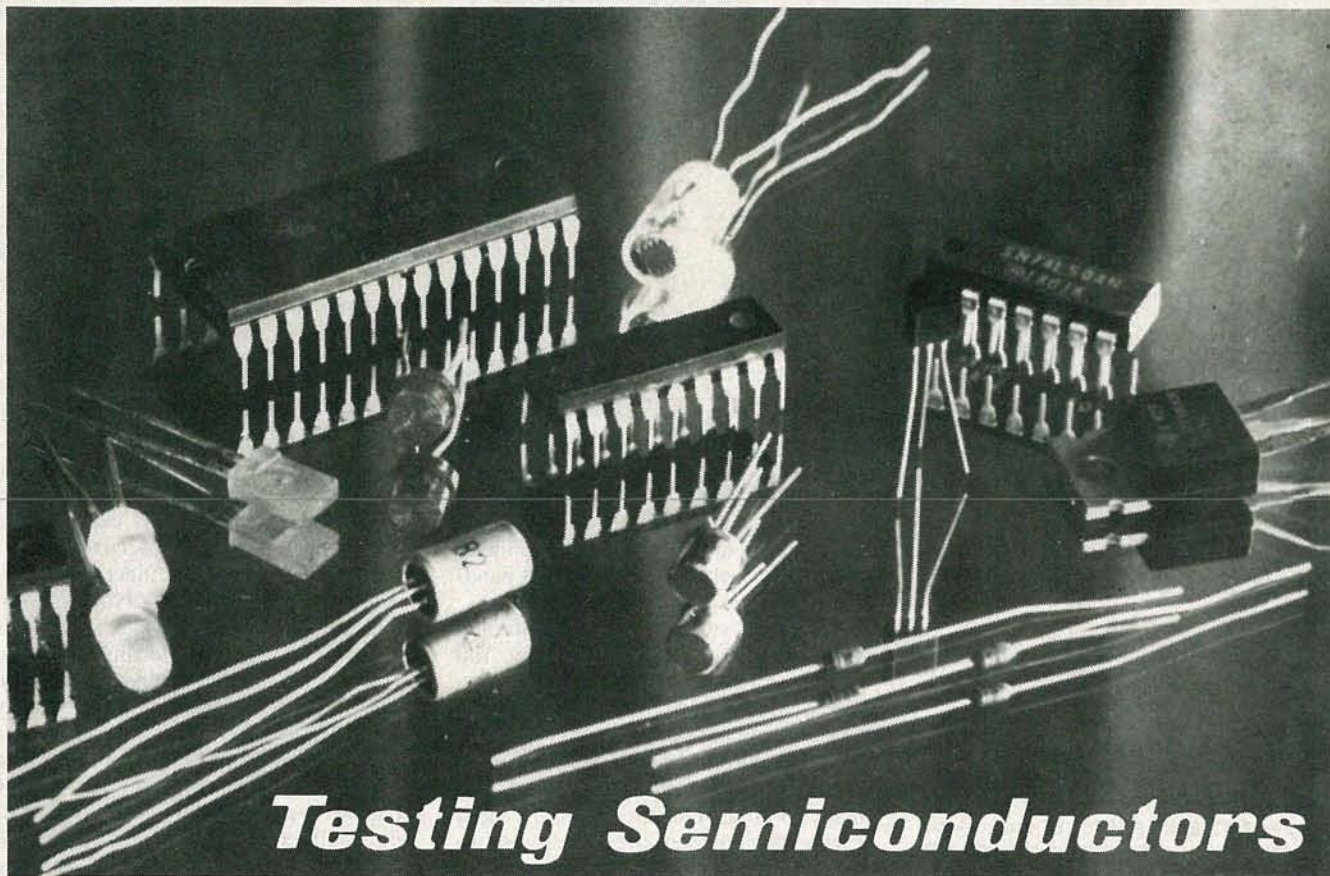
The transient caused by the bounce can disrupt the proper operation of a circuit and is often difficult to eliminate. But by using a VCR to record the scope trace, you can study the waveform at leisure, allowing you to be certain that your fix is working properly.

### Other uses

As you can see, a VCR can make collecting and analyzing data over long periods of time much easier, especially if you can't afford an expensive logic analyzer or a storage scope. And a VCR can be used to record any instrument's readings over time.

For example, the author has used a VCR to record changes in an oscillator's frequency versus temperature. After connecting them to the circuit under investigation, a frequency meter and an electronic thermometer were placed side-by-side and their readings were recorded by a VCR as the circuit was warmed. Fast-forward scanning was later used to find appropriate temperature intervals, allowing the oscillator frequency-versus-temperature data points to be recorded very quickly.

R-E



*This time we examine the AC characteristics of the op-amp.*

TJ BYERS

**Part 7** LET'S BEGIN WITH AN op-amp characteristic that is measured under DC conditions, but that relates directly to AC characteristics: open-loop voltage gain, or  $A_{VOL}$ . Often you see  $A_{VOL}$  referred to as the large-signal voltage gain. Basically, it is the gain of the amplifier with no feedback.

Open-loop voltage gain is defined as the ratio of the change in output voltage to the voltage difference between the differential inputs. It is measured by applying a voltage between the two inputs and noting the change in output voltage.

Open-loop gain is important because it reflects the overall quality of the amplifier. Ideally,  $A_{VOL}$  should be infinite, but when we come to real-world devices, it's not. As open-loop gain decreases, there is a corresponding deterioration in drift, stability, input impedance, output impedance, and bandwidth.

Although op-amp manufacturers specify large-signal gain for a DC input,  $A_{VOL}$  is generally measured with a 5-Hz AC signal. Doing so greatly simplifies the measurement, and the frequency is low enough that the  $A_{VOL}$  obtained by that

method approximates DC  $A_{VOL}$  so closely that any discrepancy is negligible.

Open-loop gain can be measured with the test setup shown in Fig. 1. First, we must cancel the effects of input-offset voltage and current ( $V_{OS}$  and  $I_{OS}$ , respectively) by flipping the function switch to the TEST position and adjusting R7 until the DC voltmeter indicates zero.

Then place S1 in the CAL position and adjust the signal generator until the AC voltmeter reads 10 volts. Return S1 to the TEST position and record the measurement as  $V_{IN}$ . Then calculate  $A_{VOL}$  as follows:

$$A_{VOL} = (1/V_{IN}) \times 10^4$$

The value of  $A_{VOL}$  is likely to exceed 50,000, and that makes it convenient to express it as a ratio between output volts and input millivolts. A value of 50,000, for example, corresponds to 50V/mV.

In fact, you can measure the value expressed by the ratio directly by setting the input voltage to 100 mV (rms) and reading the value on the 10-volt scale of the AC meter (in the CAL position). A reading of 1 volt indicates a ratio of 10V/mV, and a reading of 10 volts represents 100V/mV.

Manufacturers often specify  $A_{VOL}$  in decibels. To convert the amplification factor into decibels, use the following formula:

$$A_{VOL} \text{ (dB)} = 20 \log A_{VOL}$$

The value of  $A_{VOL}$  on the right-hand side of the equation is measured as described above.

Be aware that most data sheets list  $A_{VOL}$  with a specific load attached to the output—which usually is the minimum impedance of the instrument that is used to make the measurement. Typically, you will find the value of  $R_L$  to be 2000 ohms or greater.

### Bandwidth

As the frequency of the input signal increases, open-loop gain decreases. Many reasons are cited for that, but the major cause is reduced performance by the transistors in the op-amp.

What occurs, in essence, is that the output voltage of the operational amplifier remains stable up to a point. After that point, open-loop gain drops off rapidly, as shown in Fig. 2. It is generally agreed that

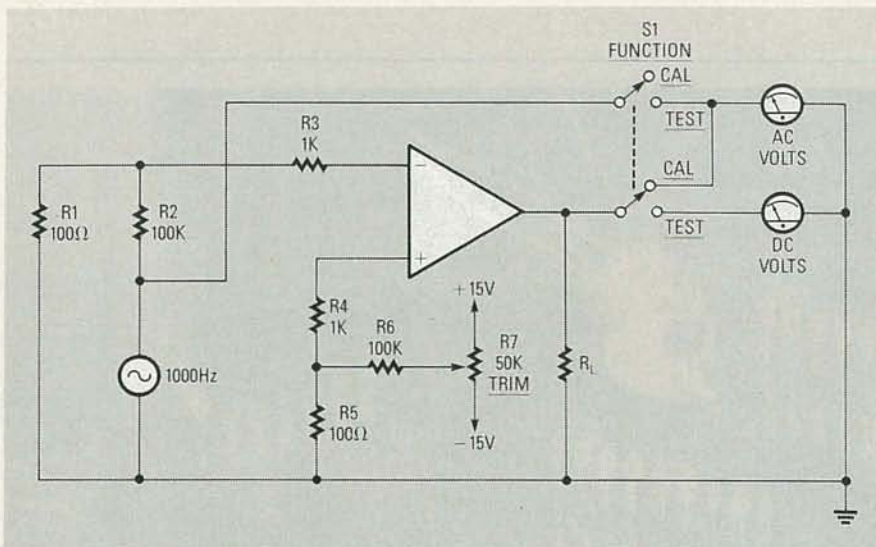


FIG. 1—MEASURE OPEN-LOOP GAIN ( $A_{VOL}$ ) after adjusting R7 for null output.

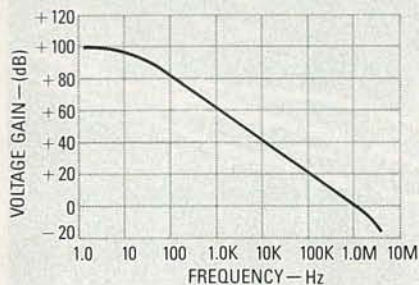


FIG. 2—FREQUENCY RESPONSE of an op-amp is constant up to a point, after which it drops off at a rate of 6 dB per octave. Cutoff frequency ( $f_T$ ) is reached when the amplitude of the output voltage equals that of the input signal.

after the gain decreases by 3 dB (i. e., falls to 70% of its original value), the decline in performance makes it undesirable for many applications. Consequently, the open-loop bandwidth,  $BW_{OL}$ , is specified at the  $-3$ -dB point.

Further increases in input frequency cause further reduction in output voltage at the rate of 6 dB per octave. Eventually a point is reached where the amplifier's gain equals one (unity gain). That is, the amplitude of the output signal equals that of the input signal. Not surprisingly, that is called the unity-gain-bandwidth factor.

Sometimes unity-gain bandwidth is simply listed as BW, implying total bandwidth, rather than the  $-3$ -dB bandwidth. But more often than not, it is described as  $f_T$ . Continuing increases in input frequency beyond that point result in negative amplification, or attenuation.

Both bandwidth parameters can be measured using the circuit shown in Fig. 1. First stabilize the amplifier by compensating for any offset values—you do that using the procedure outlined earlier. It is not necessary for the amplifier's DC output to be at exactly zero volts, but too much of an offset will give a false reading. Next, set the generator to deliver a 5-Hz signal, and adjust the generator's output

so that the meter reads 1 volt. Now increase the input frequency until the meter reads 0.707 volt. That is the  $-3$ -dB bandwidth point, or  $BW_{OL}$ .

Continue sweeping the frequency while keeping your eyes on the meter. You will notice a pronounced decline in output as you do. When the output voltage decreases to about  $1/1000$  of the input (1 millivolt) you have reached the unity-gain bandwidth,  $f_T$ . For an accurate measurement, you must make sure that the input voltage remains constant during the frequency sweep.

### Gain-bandwidth product

Another commonly specified op-amp characteristic is called Gain-BandWidth product, GBW. Essentially, it is the product of the small-signal open-loop gain and the frequency at that gain. It is expressed by the formula:

$$GBW = A_{VOL} \times f$$

There is no standard frequency at which GBW is measured, but most manufacturers arbitrarily specify GBW somewhere around 100 kHz. The actual test frequency may vary and can range from as low as 1 kHz to as high as 10 MHz.

### Slew rate

Whereas bandwidth indicates how the op-amp is able to handle small-signal analog inputs, it provides little information on how the amplifier can handle digital and large-signal inputs.

Digital pulses are unique in that, even though the frequency of the waveform (actually, its repetition rate) may be low, bandwidth requirements are quite high. It is not unusual for digital pulses to have risetimes on the order of five nanoseconds; a five nanosecond risetime corresponds to a frequency of 200 MHz!

The op-amp experiences similar problems when trying to process large output signals. Amplifiers used as high-voltage

drivers are particularly susceptible to being unable to handle large-signal inputs.

The problem lies within the output stage of the op-amp. Because of design requirements, the output transistors experience a high degree of charge retention. In other words, it takes a while for them to change from one phase to the next.

Let's say, for example, that we have a squarewave input that has been adjusted to give us a squarewave output that swings the entire  $\pm$  voltage range. The moment the input signal changes states, the output tries to follow. However, inter-element capacitance (and inductance) prevent it from making the transition instantaneously. Consequently, the output pulse takes longer to reach its plateau than the original input signal did.

The time it takes for the output voltage to correspond to the input voltage is called the slew rate. Slew rate is expressed in volts of change per microsecond.

Slew rate is a linear function. If, for example, the slew rate is 2 volts per microsecond, then it will take 5 microseconds for the output to change 10 volts. No matter how quickly the input signal may rise, the output can not respond any faster.

Slew rate (designated  $S_R$ ) is measured using the circuit shown in Fig. 3. Notice that the op-amp is configured as an inverting amplifier. The input is a low-frequency squarewave of about 100 Hz. The amplitude of the input signal is adjusted

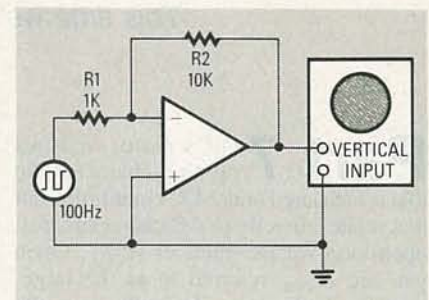


FIG. 3—SLEW RATE is defined as the amount of time it takes for the output voltage to correspond to a change in the input voltage. The slew rate is expressed in volts of change per microsecond.

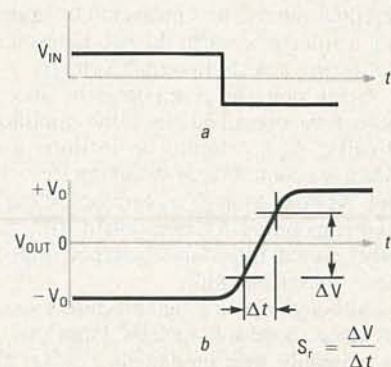


FIG. 4—SLEW RATE is determined by measuring how long a signal takes to rise from 20% to 80% of the total voltage swing.

so that the output swings over the entire  $\pm$  power-supply voltage.  $S_R$  is measured on an oscilloscope by noting the amount of time it takes for the waveform to pass through the 20% and 80% points on the waveform, as shown in Fig. 4.

### Settling time

A closely related parameter is settling

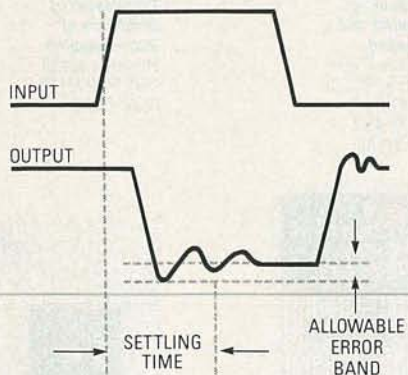


FIG. 5—SETTLING TIME is defined as the amount of time the output signal takes to stabilize at its final value.

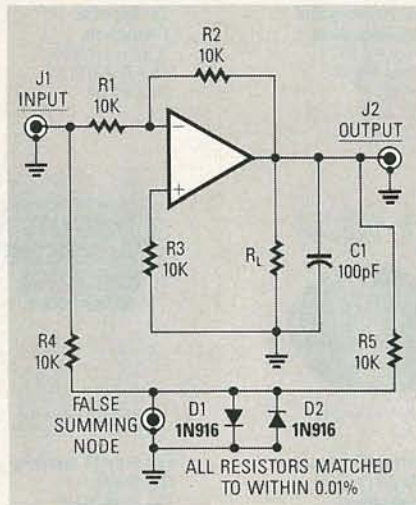


FIG. 6—SETTLING TIME is measured on an oscilloscope using a false summing node.

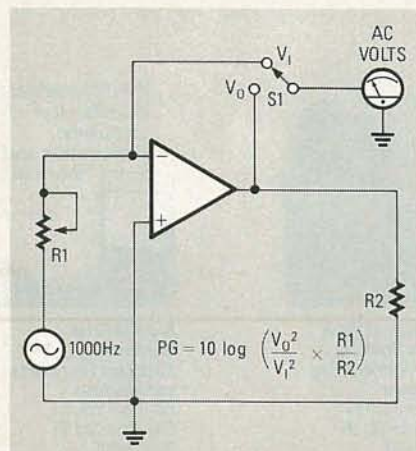


FIG. 7—POWER GAIN is the ratio of the signal power developed at the output to the signal power applied to the input.

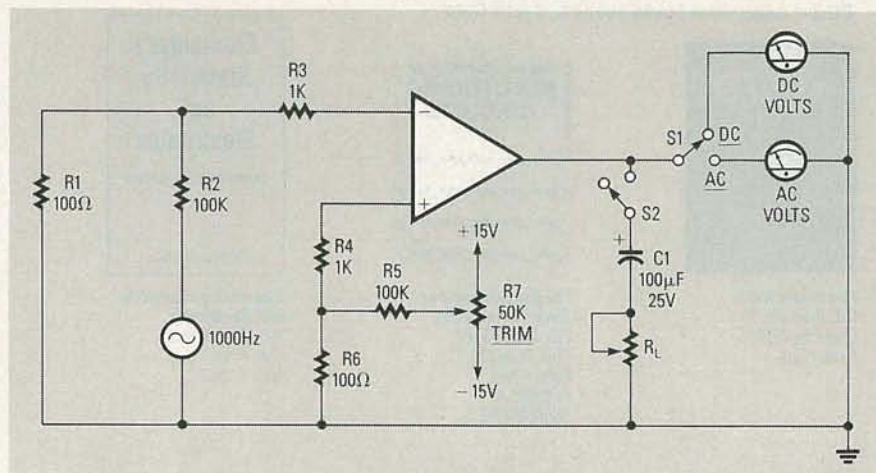


FIG. 8—OUTPUT IMPEDANCE may be determined by first nulling the op-amp for zero offset error and then adjusting  $R_L$  for one-half output. The value of  $R_L$  equals the output impedance.

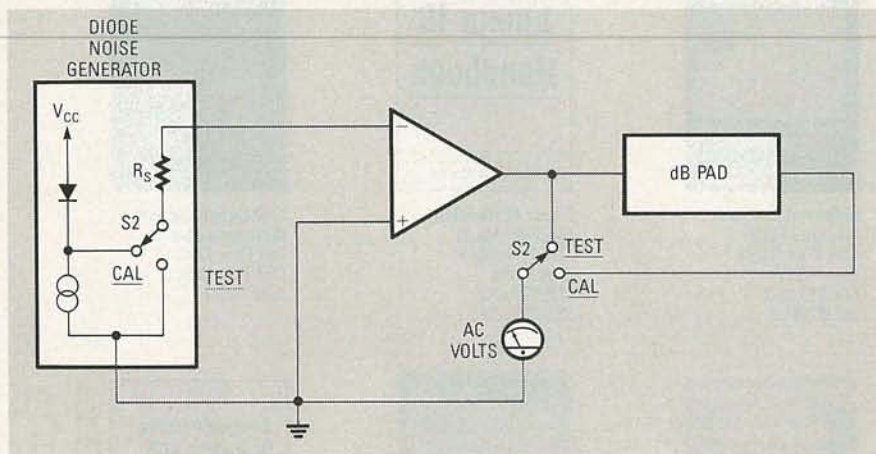


FIG. 9—NOISE FACTOR (NF) is measured with a diode noise source and a 3-dB attenuation pad.

time, which is defined as the time required, after the application of a step voltage (such as squarewave), for the output voltage to settle and remain within a specified error band around the final value.

As you can see in Fig. 5, a normal step function causes the output to swing wider than it should, both overshooting and undershooting the final value, in a gradually reducing series of damped oscillations. Eventually the signal arrives at the proper output voltage. The time it takes to accomplish that feat is called the settling time of the op-amp.

You can measure settling time using the circuit shown in Fig. 6. To measure the settling time of the op-amp accurately, a "false summing node" has been created. Although it might seem that the best place to measure settling time would be at the output of the op-amp, stray capacitance on the test probe makes it impossible to resolve settling time to better than 0.1 percent. The false node eliminates the error by isolating the oscilloscope from the amplifier under test. However, because of the voltage divider composed of R4 and R5, only one-half the actual error voltage appears at the false-summing node—a factor that must be taken into account.

Settling time ( $t_s$ ) which is sometimes listed as step response, is measured according to the tolerance of the overshoot bandwidth. Typically, settling-time responses are measured in steps, beginning with 10 percent. That is, when the ringing (the damped oscillation) has contained itself within 10 percent of the target value, settling time has been reached. In high-precision circuits, tolerances of 0.1 and 0.01 percent are not uncommon.

The lower the loop gain, the faster the settling time. Settling time depends on feedback from output to input, so the higher the loop gain, the longer it takes for the amplifier to overcome external influences within the loop.

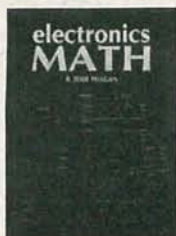
### Power gain

The Power Gain (PG) of an op-amp is expressed in decibels. It is the ratio of the signal power developed at the output to the signal power applied to the input.

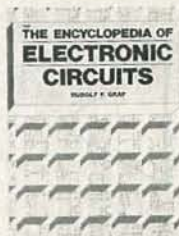
Power gain may be measured using the circuit shown in Fig. 7. The test is made by adjusting the value of R1 so that the input voltage to the amplifier under test is one-half the voltage output of the signal generator. Because R1 is in series with the

*continued on page 130*

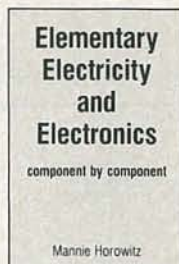
Please note: some books count as 2 selections



**Electronics Math**  
Pub. Price \$22.95  
Club Price \$18.95  
Book #7205



**The Encyclopedia of Electronic Circuits**  
Pub. Price \$50.00  
Club Price \$39.95  
Book #7014  
COUNTS AS 2 SELECTIONS



**Elementary Electricity and Electronics**  
component by component  
Mannie Horowitz  
Pub. Price \$23.95  
Club Price \$19.15  
Book #7285



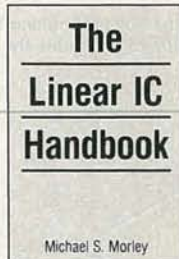
**Handbook of Computers and Computing**  
Pub. Price \$77.50  
Club Price \$62.35  
Book #7072  
COUNTS AS 2 SELECTIONS



**The Illustrated Dictionary of Microcomputers**  
Pub. Price \$24.95  
Club Price \$19.95  
Book #7246



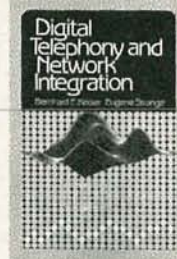
**Industrial Robotics**  
Pub. Price \$43.95  
Club Price \$35.15  
Book #7211  
COUNTS AS 2 SELECTIONS



**The Linear IC Handbook**  
Michael S. Morley  
Pub. Price \$49.95  
Club Price \$39.95  
Book #7214  
COUNTS AS 2 SELECTIONS



**Cost Estimating with Microcomputers**  
Pub. Price \$29.95  
Club Price \$23.95  
Book #7037



**Digital Telephony and Network Integration**  
Pub. Price \$44.50  
Club Price \$35.95  
Book #7204  
COUNTS AS 2 SELECTIONS



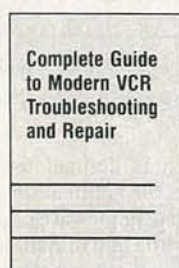
**The Paradox Companion**  
Pub. Price \$24.95  
Club Price \$19.95  
Book #7245



**Semiconductor Power Electronics**  
Pub. Price \$46.95  
Club Price \$37.55  
Book #7267  
COUNTS AS 2 SELECTIONS



**Software Engineering Environments**  
Pub. Price \$38.95  
Club Price \$31.15  
Book #7247



**Complete Guide to Modern VCR Troubleshooting and Repair**  
Pub. Price \$38.33  
Club Price \$31.15  
Book #2126



**Discovering Electronics With Useful Projects and Applications**  
Pub. Price \$29.95  
Club Price \$23.95  
Book #4560



**Complete TV Servicing Handbook**  
Pub. Price \$33.00  
Club Price \$26.35  
Book #7385



**The Complete Compact Disc Player**  
Pub. Price \$33.00  
Club Price \$26.35  
Book #7389



**Troubleshooting Techniques for Microprocessor Controlled Video Equipment**  
Pub. Price \$24.95  
Club Price \$19.95  
Book #7599



**Electronic Connections Home and Car Entertainment Systems**  
Pub. Price \$28.67  
Club Price \$23.15  
Book #2808



**Handbook of Video Camera Servicing and Troubleshooting Techniques**  
Pub. Price \$29.95  
Club Price \$23.95  
Book #4213



**Bob Middleton's Handbook of Electronic Time-savers and Shortcuts**  
Pub. Price \$29.95  
Club Price \$23.95  
Book #4595

# Until you write them yourself, you won't find better books than these...or a better deal!

Take any 3 books for just \$1.00 each.  
Take 1 more at our special Club Price.

*Not only will you save as much as \$120.63 off publishers' list prices on 4 of the most popular — and indispensable — technical books in print today... but also fulfill half the usual 2-book purchase obligation — automatically!*

**Examine your 4 books FREE for 15 days!**

EBS is the professional service designed specifically to keep you on top of everything new in electronic theory and application. Every book is reviewed and approved by our Technical Advisory Board. And every month we bring you the kind of information you want — and need — to know in the field of advanced electronics... access to new thoughts on systems design, op amps, TTL, bit-slice microprocessors, circuits, LSI/VLSI, optoelectronics, satellite communications, LANs, linear control, feedback, instrumentation, A/D crossovers and more. Everything it takes to keep you going *and successful* throughout your career!

## 6 Unbeatable Reasons for Joining Electronics Book Service

**1. Our Introductory Offer** — 3 books for just \$1.00 each... a 4th at our special Club Price — a savings of as much as \$120.63 off publishers' list prices.

**2. Automatic Fulfillment of half the usual 2-book purchase obligation** — Once you have selected and paid for your 4 introductory selections, you *automatically* fulfill half of EBS's usual 2-book purchase obligation. Your remaining obligation is to then purchase only 1 additional book — at Member discounts — during the first year of your Membership. You may cancel any time after that.

**3. Original publishers' editions** — Never cheaply-made reprints.

**4. A complete book store by mail** — Choose from the best, most popular books in your field — by mail and from the comfort and convenience of your home or office. Here's how it works: Every 3-4 weeks (15 times a year) you'll receive the *Bulletin* describing a new Main Selection and several Alternates. If you want the Main Selection, do nothing. It will be shipped automatically. If you prefer an Alternate — or no

book at all — simply indicate your choice on the order card always provided and return it by the date indicated. You'll always have 10 days to decide whether or not you want a Main Selection.

**5. Special Member Discounts** — 20% to 30% — and more — off regular list prices. A small shipping and handling charge is added to all orders.

**6. The Electronics Book Service Guarantee** — You never buy books you don't want. If you ever receive a book that does not live up to your expectations, return it for full credit.



Say YES and  
become an electronics  
know it all!

Send this coupon today!

Electronics Book Service  
A Prentice Hall Book Club  
P.O. Box 10621, Des Moines, IA 50380-0621

**YES!** Please enroll me as a trial Member of Electronic Book Service and send me the 3 books listed below for just \$1.00 each and 1 more book for the special Club Price plus postage and handling and applicable state sales tax. I understand the Membership Plan as described in this ad and that by accepting your offer, I automatically fulfill half the usual 2-book purchase obligation. I agree to then purchase 1 additional book — at Member discounts — during the first year of my Membership. If not completely satisfied with my introductory selections I may return them within 15 days and owe nothing.

Send me these 3 books for  
\$1.00 each:

Book # \_\_\_\_\_

Book # \_\_\_\_\_

Book # \_\_\_\_\_

Name \_\_\_\_\_

Address \_\_\_\_\_

City/State/Zip \_\_\_\_\_

Signature \_\_\_\_\_

(not valid without signature)

Offer good for new Members only in the continental US and Canada.

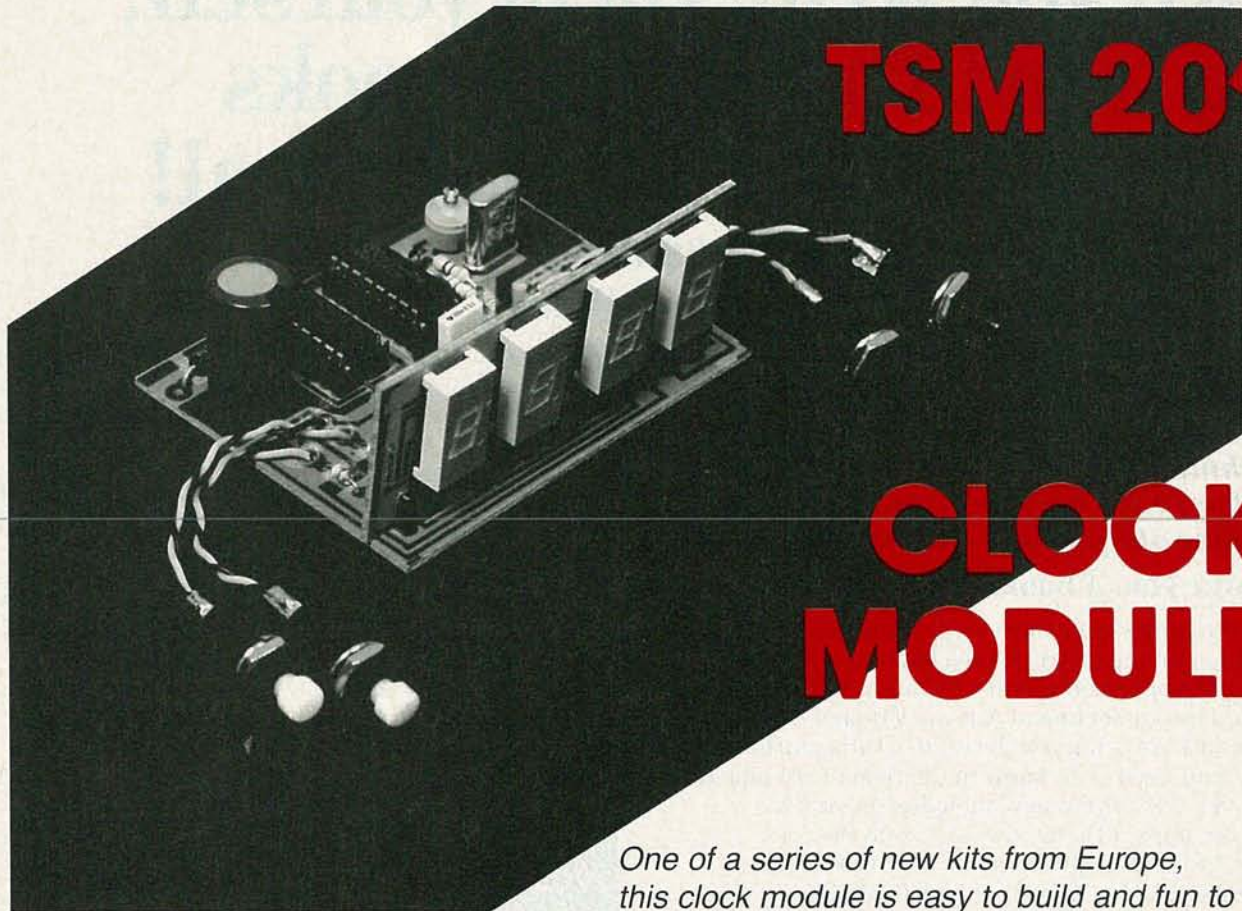
All applications subject to credit approval.

PLUS... Send me this book at  
the special Club Price:

Book # \_\_\_\_\_

(Please note that some books count  
as 2 selections)

87Q51



## TSM 201 CLOCK MODULE

*One of a series of new kits from Europe, this clock module is easy to build and fun to use.*

IN EUROPE, THE NAME TSM IS SYNONYMOUS with educational and useful electronics kits for the hobbyist. Now, some of their products are available in this country. Because the kits fill an important need for hobbyists, especially beginning ones, we'd like to take some time to introduce them to you. In this article, we'll look at one that's typical of the line—an easy-to-build, versatile crystal-controlled clock module.

### Use it anywhere

The TSM 201 clock module is exceptionally adaptable. Powered by AC or DC, it can be installed virtually anywhere—in another piece of equipment; in the dash of a car, truck, or boat; or even in a cabinet by itself. The device features an alarm output that can be used to control another circuit, or to sound the optional TSM 114 buzzer. Time readout is provided by four 8-mm 7-segment LED displays, which can easily be seen from across a room, or on the road at night.

A schematic diagram of the circuit is shown in Fig. 1. The heart of the circuit is IC3, a custom Texas Instruments TMS 3899 clock IC that provides all of the clock and alarm functions, and the display

driver. **Note that the IC is a proprietary device and that it is available in the U.S. only as part of the 201 kit.**

The circuit includes two other IC's: One, IC2, is a CD4060 ripple counter, which is configured as a crystal oscillator. Trimmer C5 allows precise tuning of the oscillator frequency. The other, IC1, a CD4027 dual J-K flip-flop, divides the output from IC2 to provide IC3 with the proper time-base signal.

The clock and alarm functions are controlled by four pushbutton switches. The hour and minute settings are set using S3 and S4; the alarm is set using S2; and the alarm is turned on or off with S1.

A half-wave rectifier made up of D5 and C1 allows the unit to operate from either an AC or a DC power supply. For DC operation, use a 12- to 24-volt power source. For AC operation, use a step-down transformer to provide a 9–12-volt input.

### Building the circuit

All components, except the pushbutton switches, are mounted on two PC boards. The 201 kit, available from the suppliers mentioned in the Parts List, includes two etched and drilled PC boards, with all

component locations clearly indicated. The patterns also are shown in PC Service.

The circuit is extremely easy to build; the most difficult task is making sure all components are oriented correctly. A parts-placement diagram for the main board is in Fig. 2; the parts-placement diagram for the display board is in Fig. 3.

Since most of the components mount on the main board, let's start there. First, mount the five jumpers; note that one runs beneath the socket for IC1. Stuff the board with the remaining parts, starting with the low-profile devices. Be sure to use IC sockets for the IC's. Connect the pushbuttons to the appropriate points on the board using wires.

The four 7-segment displays are located on the display board. Before mounting them, however, be sure to install the two jumpers.

The two boards are normally connected using a right-angle male header. However, just about any scheme can be used.

### Setup and use

Apply power, being careful to observe the proper polarity. A flashing display indicates that the clock is working correctly.



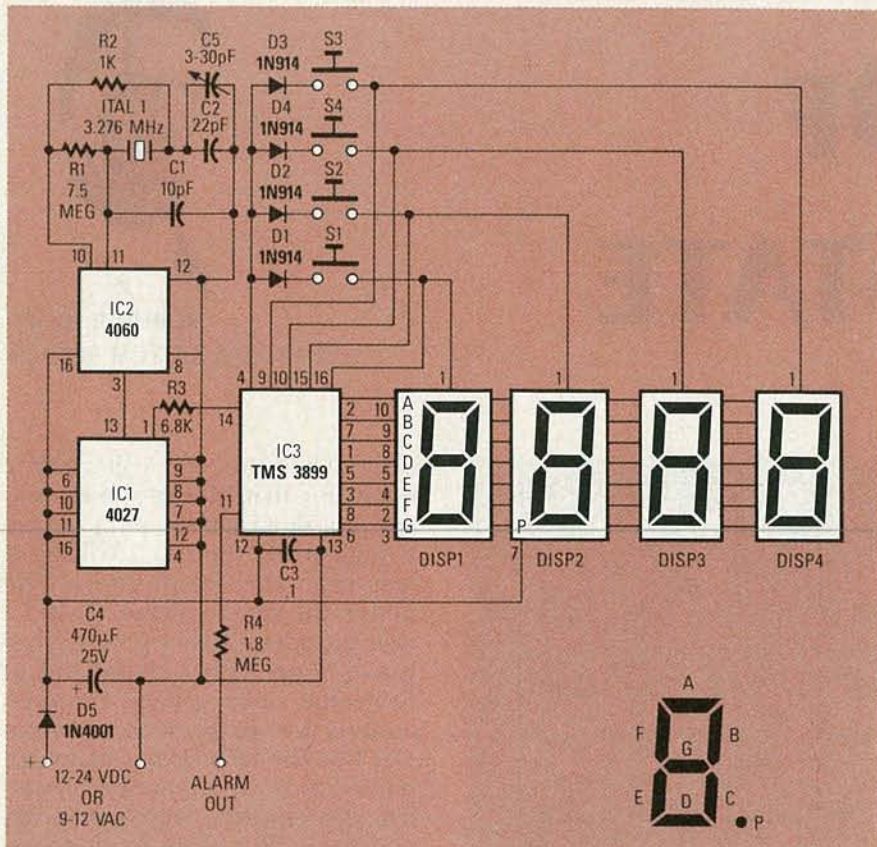


FIG. 1—THE HEART OF THE CLOCK CIRCUIT is IC3, a proprietary clock IC. Note that it can be obtained in the U.S. only as part of the TSM 201 kit.

Set the correct time using S3 and S4. If you have a frequency counter, connect it between pin 11 of IC2 and ground. Then adjust C5 for a frequency of 3.2768 MHz. If you don't have a counter, set C5 to midrange and allow the clock to run for a day or so. Then, compare the time display to the actual time. If the clock is running fast, decrease the capacitance of C5 slightly; if it is slow, increase the capacitance. Allow the clock to run another day, then check again. Repeat until the dis-

played time and the actual time correspond.

The clock is now ready for use. If you wish to take advantage of the alarm function, connect the TSM 114 buzzer circuit, or anything else that you wish to control, between the positive side of the supply and the alarm output.

### Impressions

With a catalog of over 200 kits, TSM is one of Europe's leading suppliers of kits.

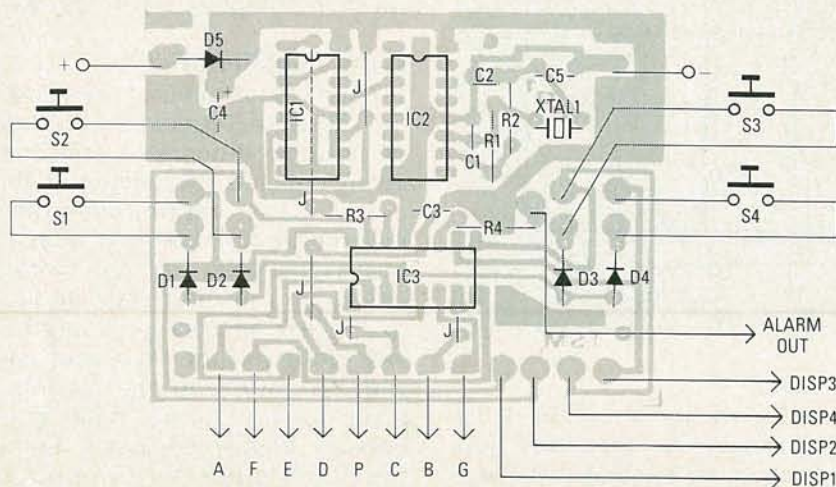


FIG. 2—MOST OF THE COMPONENTS mount on the circuit's main board.

### PARTS LIST

All resistors ¼ watt, 5% unless otherwise noted

- R1—7.5 megohms
- R2—1000 ohms
- R3—6800 ohms
- R4—1.8 megohms

#### Capacitors

- C1—10 pF
- C2—22 pF
- C3—0.1 µF
- C4—470 µF, 25 volts, electrolytic
- C5—3 pF—30 pF, trimmer, PC mount

#### Semiconductors

- IC1—CD4027 dual J-K flip-flop
- IC2—CD4060 14-stage binary ripple counter
- IC3—TMS 3899 clock IC (Texas Instruments)
- D1—D4—1N914 or equivalent
- D5—1N4001 or equivalent
- DISP1—DISP4—7-segment LED display, common cathode

#### Other components

- XTAL1—3.2768-MHz quartz crystal
- S1—S4—pushbutton switch, momentary contact, normally open

Miscellaneous: PC boards, wire, solder, etc.

**NOTE:** The TSM 201 kit is available for \$26.77, plus \$1.50 shipping and handling, from the following suppliers: TSM in America, Inc, 2065 Boston Post Road, Larchmont, NY 10538; Nutron Computer Electronics, 821 E. Roosevelt Road, Lombard, IL 60148; Auto Sound Systems, 1269 East Main St., El Cajon, CA 92021. The optional TSM 114 Buzzer Kit is available for \$7.38, plus shipping and handling, from the same suppliers. Include proper state sales tax, if appropriate. The 201 kit does not include battery, AC power transformer, or case.

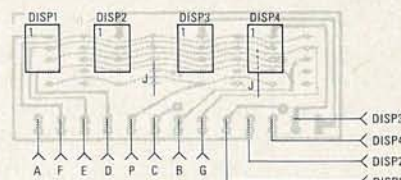


FIG. 3—MOUNT THE FOUR DISPLAYS on the display board. Note that one of the jumpers runs beneath DISP4.

If the 201 is any indication, they should enjoy similar success in this country. Those who purchase the kit will be pleased to note that it is professionally prepared and packaged. Further, its designed to be used with little modification in almost any timekeeping or timing application. The only negative is that the instructions are a little rough around the edges due to translation problems. Despite that, they are easily followed.

R-E

# STATE OF SOLID STATE

## A bang-bang IC



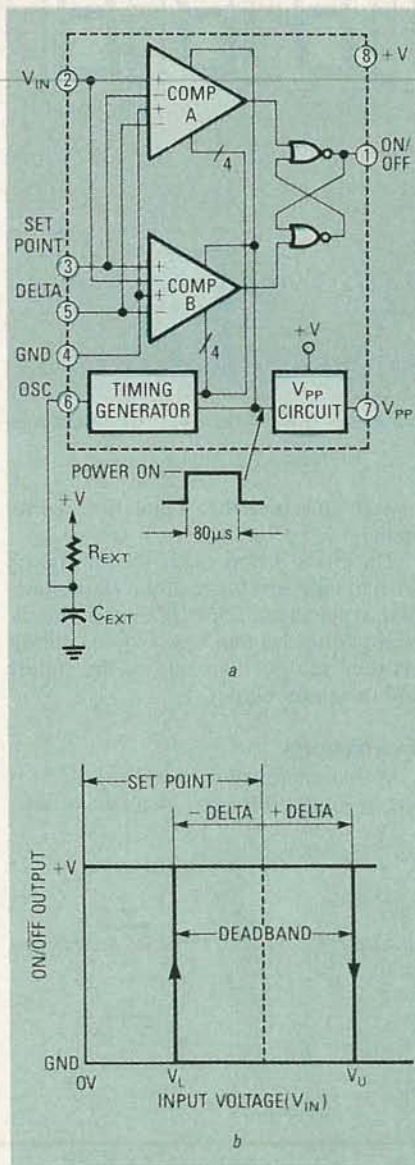
ROBERT F. SCOTT,  
SEMICONDUCTOR EDITOR

A NEW AND INTERESTING MONOLITHIC device for process-control applications is the LTC1041 "bang-bang" controller from Linear Technology Corp. That CMOS component takes its name from its ability to turn a control element either fully ON ("bang") or fully OFF ("bang"), with no middle ground, to regulate the value of the parameter being controlled.

Figure 1-a shows an operational block diagram of the LTC1041 along with the pinout of its 8-pin DIP housing. The SET POINT input determines the average control value and the DELTA input establishes the "deadband". As shown in Fig. 1-b, the deadband is centered on the set-point voltage and is twice the voltage at the DELTA input. An unusual sampling technology allows independent control of the deadband and the set point; there is absolutely no interaction between the two.

A series RC network, connected to pin 6, controls the oscillator frequency and therefore determines the sampling rate. Power is applied to the two on-board comparators for approximately 80  $\mu$ s at the start of each sampling period. During that time, the inputs to the analog section are sampled and compared. Power is removed from the comparators as soon as they have completed their task. The CMOS logic holds the output continuously while consuming virtually no input power.

Each of the two comparators has two differential inputs. When the sum of the voltages on a comparator's inputs is positive, the output is low; a comparator's out-



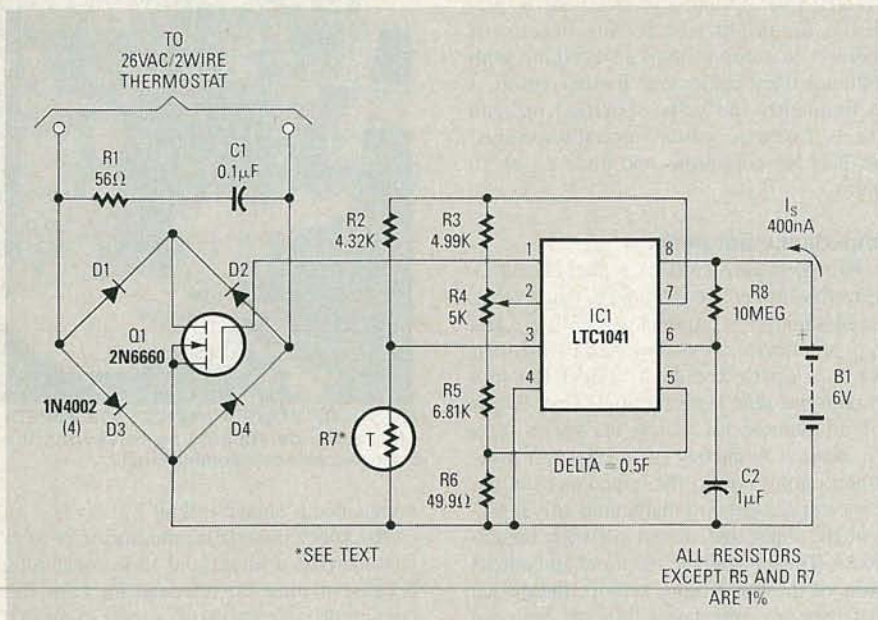
put is high when the sum of its inputs is positive. The inputs are interconnected so that the pin 1 voltage is low (the RS flip-flops are

reset) when the pin 2 voltage ( $V_{in}$ ) is greater than the set-point voltage plus delta and the pin 1 voltage is high when the pin 2 voltage is less than the set-point voltage minus the delta voltage. That action produces a very precise hysteresis loop with a deadband of twice the delta voltage centered around the set point as shown in Fig. 1-b. The LTC1041 has many applications in instrumentation and process control. Figure 2 shows how it can be used in an ultra-low-power (2.4  $\mu$ W) thermostat. The circuit shown is suitable for temperature regulation over a range of +50°F to +100°F.

Complete specifications and additional applications, including a DC-motor control and a battery-charger control can be found in the 1986 LTC Linear Databook. The LTC1041 costs approximately \$5.50 each in small quantities. For additional information on the device and on the data book, write to Linear Technology Corp., 1630 McCarthy Blvd., Milpitas, CA 95035-7487.

### GaAs amplifier brief

Using the Anadigics ADA25001, DC-2.5-GHz Amplifier is the title of an applications technical brief giving detailed information on the use of GaAs (gallium-arsenide) monolithic amplifiers produced by Anadigics, Inc. It begins with a description of the ADA25001 DC-to-2.5-GHz amplifier, a GaAs device designed for high gain and wide bandwidth in high-data-rate fiber-optic systems, radar processors, high-speed pulse amplifiers, and clock-driver applications.



The application discussed in the brief is the layout of a single-stage amplifier using the ADA25001 to provide flat gain response from 100 kHz to 2.5 GHz over a temperature range of  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ . The layout includes a temperature-compensation loop. The brief is available upon request to Mr. Michael P. Gagnon, **Anadigics, Inc.**, 35 Technology Drive, Warren, NJ 07060.

### Computerized FET databook

Designers who use small-signal FET's can now quickly select the best device for a given application by using the *Siliconix Computerized Data Book*, which provides full details on the company's FET product line on a 5¼-inch floppy disk for an IBM PC or PC-compatible computer. The disk also contains an updated version of the *MOSPOWER Computerized Data Book*, originally released in 1986.

The FET section prompts the user to select one of seven major application areas such as amplifiers, analog switches, current regulators, diodes, dual amplifiers, mixers/oscillators, and voltage-controlled resistors. A list of key parameters is then generated on the screen, and the user is instructed to enter a range of acceptable parameter values. In response to those entries, the type numbers of appropriate Siliconix FET's are displayed.

The data book on a floppy is free

to Siliconix customers. Contact *Siliconix Telemarketing* at 800-554-5565 or 2200 Laurelwood Road, Santa Clara, CA 95054.

### New tone ringer

The LS1240A is a recent addition to the SGS Semiconductor family of economical two-tone telephone-ringer devices. The new ringer has a high output-current capability (150-mA maximum), which is sufficient to drive low-cost dynamic transducers having impedances as low as 50 ohms.

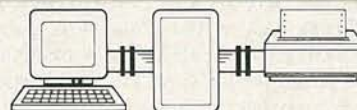
The new ringer, which is pin-compatible with the standard LS1240, generates an alternating two-tone drive signal for the transducer. The tone frequency and the alternation rate are continuously variable and externally adjustable.

The required supply voltage is derived from the AC ring signal and the circuit is designed so that noise on the line or variations in the ringing signal current cannot affect correct operation of the ringer. An external polarity-guard bridge and a protection Zener diode allow direct connection to the telephone line. The IC's low current consumption permits up to four of the devices to be operated in parallel. The LS1240A comes in an 8-pin miniature DIP and requires only six external components. The price is \$0.82 each, in minimum quantities of 1000. **SGS Semiconductor Corp.**, 1000 Bell Road, Phoenix, AZ 85022. R-E

# Test RS232C In A Zip.



Test RS232C data communications interfaces—like computers to printers, computers to modems, and computers to computers—fast and easy in the palm of your hand with Beckman Industrial's low-cost, easy-to-use line of testers. Each is self-contained in a Toughpak case, including five models in a durable zippered pouch, and a 10-year warranty on every model. Prices start as low as \$49.95.



See your nearest Beckman Industrial distributor today, or send for free brochure. We'll send it to you in a zip.

Quick Cable Customizing

Fast RS232C Interfacing and Testing

LED Identification of Cable Configurations

Pocket and Hand-held Compactness

Speeds Up Trouble Shooting

10 Standard, Low-Cost Models



EasyPATCH™ 704

Easy BOB™ 750

In Service  
Instruments,  
We're The One.

**Beckman Industrial™**

Beckman Industrial Corporation Instrumentation Products Division  
A Subsidiary of Emerson Electric Company  
3885 Ruffin Rd., San Diego, California 92123-1898  
(619) 565-4415 • FAX: (619) 268-0172 • TLX: 249031  
© 1987 Beckman Industrial Corporation

NOVEMBER 1987

## POWER TRANSISTORS

continued from page 112

change in  $V_{rc}$ . Changes as small as 1% are readily detectable, with 5% or less normally considered an acceptable limit. Today's most sophisticated device specifications for RF power transistors use that criteria to determine "success" or "failure" in ruggedness testing.

### Other specs

Data sheets for low-power RF transistors show such special characteristics as *noise figure* (NF), *maximum available gain* ( $GU_{max}$ ) and *scattering* (S) parameters. The S parameter is normally taken with the device under test in a standard commercial fixture. Typically, they are given as functions of frequency and  $I_c$ .

NF and GNF likewise use commercial equipment such as the Eaton 4012 gain-noise analyzer, or the HP8970A noise figure meter. A transistor's NF will vary with input impedance match, and as a result is generally measured in a test fixture having input tuning. Usually, data is given with a circuit tuned initially for lowest possible NF, and then for a standard 50-ohm input. Measuring NF at a 50-ohm input impedance ( $Z_{in}$ ) is more repeatable, but normally yields a high-

er NF. The 50-ohm measurement is preferred for production testing because it requires no tuning and can be done with automated test equipment; for that reason, it is frequently the value specified on data sheets. Likewise, gain is normally specified for best NF conditions and for a  $Z_{in}$  of 50 ohms.

### Impedance parameters

RF power transistors are typically characterized by impedance parameters rather than small-signal S+ parameters. Both  $Z_{in}$  and  $Z_{out}$  of a device are determined in a similar way; i.e., place the device under test in a circuit and tune both the input and output circuit elements to achieve maximum  $P_o$  at the desired frequency of interest. At maximum output power, the impedances of the device under test will mathematically represent the input and output network impedances. Thus, terminate the input and output ports of the test circuit, remove the device and measure impedance looking from the device; first, toward the input to obtain the conjugate of  $Z_{in}$  and, second, toward the output to obtain  $Z_{OL}$ , which is normally given as the load required to achieve maximum  $P_o$ .

A network analyzer is used in the actual measurement process to determine the complex reflection coefficient of the circuit. A typical measurement setup for measuring



FIG. 7—RF POWER TRANSISTOR IMPEDANCES are determined by measuring the characteristics of a working circuit.

impedance is shown in Fig. 7.

The entire impedance measuring process is somewhat difficult and time-consuming because it must be repeated for each frequency of interest, using a test circuit that will tune the frequency range. Different circuits must be designed and built for other frequencies, which explains why it is sometimes difficult to get a semiconductor manufacturer to supply impedance data for special conditions of operation, such as different frequencies, different power levels, or different operating voltages.

### Tradeoffs in specifications

Gain and ruggedness are the most obvious device parameters for compromise in RF power specifications. Devices with high gain—high with respect to their figure of merit (emitter periphery/base area)—tend to be fragile; i.e., not rugged. By using materials with higher resistance, with a thicker epitaxial layer, and/or increased values of emitter resistance, ruggedness can be enhanced at the expense of gain. Likewise, to get higher gain, the user may be asked to accept lower collector/base breakdown voltages ( $BV_{CBO}$  or  $BV_{CES}$  and  $BV_{CEO}$ ) in order to reduce collector resistance and thereby increase gain. Transistors designed for operation at high frequencies can be used at lower frequencies to obtain increased gain, but such devices will usually be fragile at the lower frequency.

### Summing up

The RF power transistor is an unusually complex semiconductor device and difficult to fully characterize. Not all information about RF-transistor characteristics have been explained in this article, nor are all usually covered in a data sheet. The circuit-designer should contact the manufacturer for more-detailed information whenever it is appropriate. Most, if not all, manufacturers of RF transistors have extensive applications support for the express purpose of assisting the circuit designer whenever and wherever assistance is needed.

R-E

## NOISE REDUCTION FOR UNDER \$10.

MIXING CONSOLES

SWITCHES

MICROPHONE CONNECTORS

SNAKE CABLES

BATTERY CONTACTS



ALL PLUGS & JACKS  
(XLR, PHONE, PHONO, DIN, MIDI, ETC.)

PATCHBAYS

FADERS, POTS

TERMINAL STRIPS

SPEAKER TERMINALS

### CRAMOLIN®

Even the finest equipment in the world cannot guarantee noise-free operation. One "dirty" connection anywhere in the electrical path can cause unwanted noise or signal loss.

"MORE THAN A CONTACT CLEANER"

CRAMOLIN® is a fast-acting, anti-oxidizing lubricant that cleans and preserves all metal surfaces, including gold.

When applied to metal contacts and connectors, CRAMOLIN® removes resistive oxides as it forms a protective molecular layer that adheres to the metal surfaces and maintains maximum electrical conductivity.

CRAMOLIN® - USED BY THOSE WHO DEMAND THE BEST:

Bell & Howell	Hewlett Packard	MCI(Sony)	Nakamichi
Boeing	John Fluke Mfg.	Motorola	RCA
Capitol Records	McIntosh Labs	NASA	Switchcraft

SINCE 1956

### CAIG LABORATORIES INC.

1175-O Industrial Ave., (P.O. Box J) - Escondido, CA 92025-0051 U.S.A. • (619) 743-7143

CIRCLE 189 ON FREE INFORMATION CARD

### How to live with someone who's living with cancer.

When one person gets cancer, everyone in the family suffers.

Nobody knows better than we do how much help and understanding is needed. That's why our service and rehabilitation programs emphasize the whole family, not just the cancer patient.

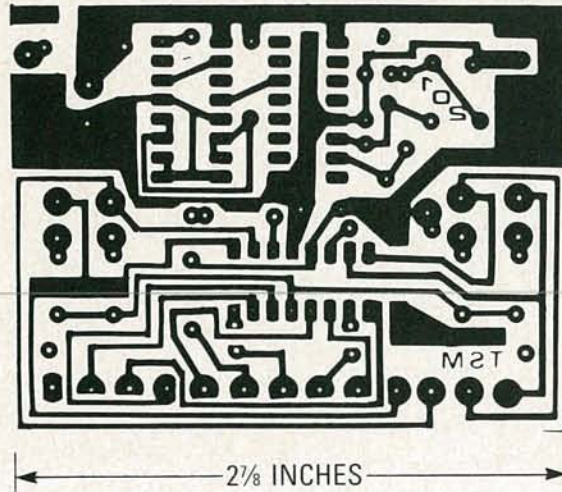
Among our regular services we provide information and guidance to patients and families, transport patients to and from treatment, supply home care items and assist patients in their return to everyday life.

Life is what concerns us. The life of cancer patients. The lives of their families. So you can see we are even more than the research organization we are so well known to be.

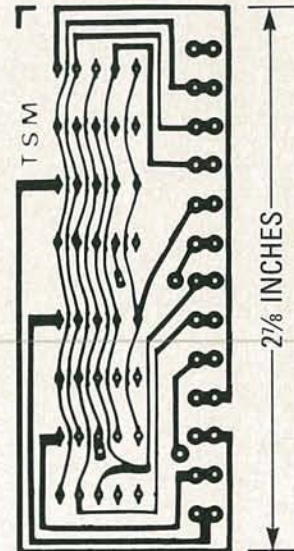
No one faces cancer alone.

AMERICAN CANCER SOCIETY

# PC SERVICE



MOST OF THE COMPONENTS for the TSM 201 clock module are mounted on this board.



THE CLOCK'S FOUR LED DISPLAYS mount on this board.

# PC SERVICE

One of the most difficult tasks in building any construction project featured in **Radio-Electronics** is making the PC board using just the foil pattern provided with the article. Well, we're doing something about it.

We've moved all the foil patterns to this new section where they're printed by themselves, full sized, with nothing on the back side of the page. What that means for you is that the printed page can be used directly to produce PC boards!

**Note:** The patterns provided can be used directly only for *direct positive photoresist methods*.

In order to produce a board directly from the magazine page, remove the page and carefully inspect it under a strong light and/or on a light table. Look for breaks in the traces, bridges between traces, and in general, all the kinds of things you look for in the final etched board. You can clean up the published artwork the same way you clean up your own artwork. Drafting tape and graphic aids can fix incomplete traces and doughnuts, and you can use a hobby knife to get rid of bridges and dirt.

An optional step, once you're satisfied that the artwork is clean, is to take a little bit of mineral oil and carefully wipe it across the back of the artwork. That helps make the paper translucent. Don't get any on the front side of the paper (the side with the pattern) because you'll contaminate the sensitized surface of the copper blank. After the oil has "dried" a bit—patting with a paper towel will help speed up the process—place the pattern front side down on the sensitized copper blank, and make the exposure. You'll probably have to use a longer exposure time than you are used to.

We can't tell you exactly how long an exposure time you will need as it depends on many factors but, as a starting point, figure that there's a 50 percent increase in exposure time over lithographic film. But you'll have to experiment to find the best method for you. And once you find it, stick with it.

Finally, we would like to hear how you make out using our method. Write and tell us of your successes, and failures, and what techniques work best for you. Address your letters to:

**Radio-Electronics**  
Department PCB  
500-B Bi-County Blvd.  
Farmingdale, NY 11735

**Firestik**  
CB ANTENNAS & ACCESSORIES

SINCE 1962

**THE MOST POPULAR  
WIRE-WOUND CB ANTENNAS  
IN THE WORLD**

*Because...they perform!*

#### FACT

"When CB was legalized in England, 'Firestik' antennas were barred from sale because the emitted signal was too strong. Fortunately, no other country, including the U.S., limits antenna efficiency."

**YOU CAN HAVE SECOND  
BEST OR, 'Firestik'!**

Call or Write for **FREE Catalog**

'Firestik' Antenna Company  
2614 East Adams  
Phoenix, Arizona 85034  
(602) 273-7151

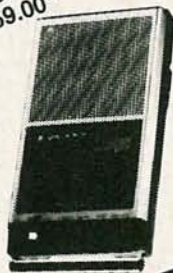
**MILLIONS OF SATISFIED OWNERS**

CIRCLE 100 ON FREE INFORMATION CARD

## SUPER LONG PLAY TAPE RECORDERS

10 Hour Model — \$95.00\*  
14 Hour Model — \$159.00\*

Modified Panasonic Slimline.  
high quality, AC-DC  
Recorders provide 5 or 7  
continuous hours of quality  
recording & playback on  
each side of 10 or 14 hours  
depending on model. Built-in  
features include • Voice  
level control, • Digital  
counter, etc. TDK DC 180  
Cassette Furnished.



### PHONE RECORDING ADAPTER

Records calls automatically. All Solid  
state connects to your telephone  
jack and tape recorder. Starts  
recording when phone is lifted.  
Stops when you hang up. **\$24.50\***



**VOX VOICE ACTIVATED CONTROL SWITCH**  
Solid state. Self contained. Adjust-  
able sensitivity. Voices or other  
sounds automatically activate and  
control recorder. Uses either re-  
corder or remote mike. **\$24.95\***



\*Add for ship & hdlg. Phone Adapter & Vox \$1.50 ea.  
Recorders \$4.00 ea. Cal. Res. add tax. Mail order, VISA,  
M/C, COD's OK. Money Back Guarantee. Qty. disc.  
avail.. Dealer inquiries invited. Free data. ©  
**AMC SALES, Dept. A 9335 Lubec**  
**St., Box 928, Downey, CA**  
**(213) 90241 Phone**  
**869-8519**

CIRCLE 108 ON FREE INFORMATION CARD

# MARKET CENTER

## FOR SALE

IS it true...Jeeps for \$44 through the government? Call for facts! 1 (312) 742-1142, ext. 4673.

DESCRAMBLER catalog. All brands. Special combo Jerrold 400 and SB3 \$165. Descrambler kit \$39.00 (assembles in half hour). Send \$1.00. MJ INDUSTRY, Box 531, Bronx, NY 10461.

OLDTIME radio programs on high quality tapes. Comedy! Adventure! Music! Free catalog. CARL F. FROELICH, Heritage Farm, New Freedom, PA 17349.

TEST equipment, reconditioned. For sale. \$1.25 for catalog. WALTER'S, 2697 Nickel, San Pablo, CA 94806. (415) 724-0587.

LASERS, components and accessories. Free catalog. M.J. NEAL COMPANY, 6672 Mallard Ct., Orient, OH 43146.

TUBES, new, unused. Send self-addressed, stamped envelope for list. FALA ELECTRONICS, Box 1376-2, Milwaukee, WI 53201.

PHOTOFACT folders, under #1400 \$3.00. Others \$5.00. Postpaid. LOEB, 414 Chestnut Lane, East Meadow, NY 11554.

TI-99/4A software/hardware bargains. Hard to find items. Huge selection. Fast service. Free catalog. DYNA, Box 690, Hicksville, NY 11801.

COMMODORE chips, distributor, factory fresh (e.g. 6526-\$9.95 and many others). C64 power supply—\$27.95.... "Commodore Diagnostician", a complete chart for diagnosing faulty IC's \$6.95 + pp. Send for complete chips/parts catalog. Commodore repair, 72 hour service, low prices (eg. C64—\$39.95). KASARA MICROSYS, INC., 33 Murray Hill Drive, Spring Valley, NY 10977. (800) 642-7634 (outside NY) or (914) 356-3131.

APEX<sup>®</sup> screwdriving bits. Any size. Complimentary illustrated list. R. SHOCKEY'S, 5841 Longford, Dayton, OH 45424. (513) 236-2983.

MICROWAVE antennas, multi-channel 1.9-2.7 ghz. DUAL POLARITY Now only \$49.95. Oldest and largest manufacturer. STAR ELECTRONICS CORP., Call 1-800-247-1151 or 1 (602) 939-1151.

FLASHLIGHT that needs no batteries measures 5' x 3' ideal for every situation money back guarantee \$10.—SAMUELS ENTERPRISES, 724 East 231 Street, Bronx, NY 10466.

HACKING, crashing, pirating, and phreaking. Who's doing it, why they're doing it, and how they're doing it. Sample programs, phone numbers, and the tools of the trade. Hacker's Handbook, \$12.95. Computer Underground, \$14.95, \$1 postage to CABLETRONICS, Box 30502R, Bethesda, MD 20814.

## 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:

Radio-Electronics Classified Ads, 500-B Bi-County Boulevard, Farmingdale, NY 11735

PLEASE INDICATE in which category of classified advertising you wish your ad to appear. For special headings, there is a surcharge of \$23.00.

( ) Plans/Kits ( ) Business Opportunities ( ) For Sale  
( ) Education/Instruction ( ) Wanted ( ) Satellite Television

Special Category: \$23.00

### 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 (\$42.75)
16 (\$45.60)	17 (\$48.45)	18 (\$51.30)	19 (\$54.15)	20 (\$57.00)
21 (\$59.85)	22 (\$62.70)	23 (\$65.55)	24 (\$68.40)	25 (\$71.25)
26 (\$74.10)	27 (\$76.95)	28 (\$79.80)	29 (\$82.65)	30 (\$85.50)
31 (\$88.35)	32 (\$91.10)	33 (\$94.05)	34 (\$96.90)	35 (\$99.75)

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

Please 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) \$2.85 per word prepaid (no charge for zip code)...MINIMUM 15 WORDS. 5% discount for same ad in 6 issues; 10% discount for same ad in 12 issues within one year; if prepaid. NON-COMMERCIAL RATE: (for individuals who want to buy or sell a personal item) \$2.30 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) 50¢ 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: \$4.30 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" x 2 1/4"—\$320.00; 2" x 2 1/4"—\$640.00; 3" x 2 1/4"—\$960.00. 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. Copy to be in our hands on the 12th of the third month preceding the date of the issue. (i.e., Sept. issue copy must be received by May 12th). When normal closing date falls on Saturday, Sunday or Holiday, issue closes on preceding working day.

## CB RADIO OWNERS!

We specialize in a wide variety of technical information, parts and services for CB radios. 10M-FM conversions, repairs, books, plans, kits, high-performance accessories. Our 11th year! Catalog \$2.

CBC INTERNATIONAL, P.O. BOX 31500RE, PHOENIX, AZ 85046

RESTRICTED technical information: Electronic surveillance, schematics, locksmithing, covert sciences, hacking, etc. Huge selection. Free brochure MENTOR-Z, 135-53 No. Blvd., Flushing, NY 11354.

TV tunable notch filters, free brochure. D.K. VIDEO, Box 63/6025, Margate, FL 33063. (305) 752-9202.

TUBES "Oldest," "Latest." Parts and schematics. SASE for list. STEINMETZ, 7519 Maplewood Ave., RE Hammond, IN 46324.

SURVEILLANCE-counter, security, 52 products—bulletproof to wireless! Catalog \$2.00: SPYPRO-045ER, POB 45521, Seattle, WA 98145-0521.

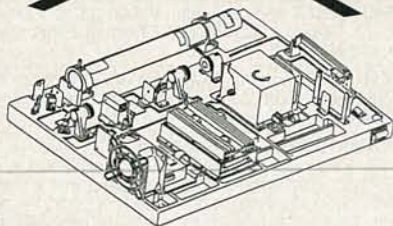
AIDS? Yes we have! Cable aids to help you. Zenith, Jerrold, Scientific Atlanta, Oak, much more. No Michigan sales! HOTRONICS, (313) 283-4299.

CABLE TV equipment. All major brands. Specializing in Scientific Atlanta, Jerrold, and Zenith, add-ons. Our units have worked where others have failed. Send \$2.00 for catalog to K.D. VIDEO, P.O. Box 29538, Minneapolis, MN 55429

# LASER ARRAY

ORIG.  
COST

~~\$5,000.00~~



LIQUIDATION  
PRICE

# \$499

INCLUDES

1. LASER - (10 milliwatt)
2. LASER Power Supply
3. MIRRORS (5)
4. LENSES (3)
5. BEAM SPLITTERS (2)
6. POLYGON MOTOR, LENS & DRIVER
7. A-O MODULATOR  
A-O DRIVER
8. LASER BRACKETS (2)
9. SENSOR (2)

ITEMS MAY BE  
PURCHASED SEPARATELY  
QUANTITIES LIMITED

## CALL FOR FREE INFORMATION ABOUT THIS AMAZING LASER DECK

CONTINENTAL U.S.A.

**(800) 872-8878**

INSIDE CALIFORNIA

**(800) 223-9977**

L.A. AREA & TECH. INFO.

**(213) 217-8912**



1490 W. ARTESIA BLVD.  
GARDENA, CA 90247

CIRCLE 220 ON FREE INFORMATION CARD

**TUBES** 59¢. Year Guarantee. Free catalog. Tube tester \$8.95. **CORNELL**, 4215 University, San Diego, CA 92105.

**SURPLUS auction**, bid kit \$1.00, ends 11/21/87. Reserve your 1988 parts catalog. **LYNBAR INDUSTRIES**, 205 Main, Box 822, St. Joseph, MI 49085-0822.

**CUSTOM** front panel nameplates for your projects. For details: **J & E ENTERPRISES**, 2457 N. Mar-mora, Chicago, IL 60639.

**ASSORTMENT #103**, (February '84 article) printed circuit, toko coils, transistors, IC's, diodes, power supply, \$25.00. Five \$112.50. Shipping \$3.00. **JIM RHODES INC.**, P.O. Box 3421, Bristol, TN 37625.

**CABLE TV converters**. "NEW" Zenith flash. Scientific Atlanta, Jerrold, Oak, Zenith, Hamlin. Many others. "New" video hopper "The Copy Killer". Visa, M/C & Amex 1 (800) 826-7623. **B&B Inc.**, 10517 Upton Circle, Bloomington, MN 55431.

**GIANT shortwave listener's catalog**. Features shortwave receivers, antennas, accessories, radio teletype, facsimile equipment and books. Free! **UNIVERSAL SHORTWAVE RADIO**, 1280 Aida Drive, #RE, Reynoldsburg, OH 43068.

**CAD-Visionics EE01** for PC's \$800.00 or best offer (402) 346-6272. 809 So. 35th Avenue, Omaha, NE 68105.

**MANUFACTURE** electronic equipment in your home for the Army, Navy, Air Force, and NASA. Will supply plan. Inexpensive easy to build equipment. Government pays \$4,000. Cost you \$900. Profit \$3,100. Send \$10 to **SUBCONTRACT R & D**, 136-31 222nd St., Laurelton, NY 11413. Attention: Wilner Nau.

**OAK** 56 channel wireless remote converter/descrambler, original refurbished equipment, exceptional video, \$175.00; legal to own your equipment, however, Federal law prohibits hookup without cable company permission. **PONDEROSA**, (303) 661-1659. (We ship C.O.D.)!

**FREE** remote control converter with any descrambler below: Oak VN12 \$85.00; new Hamlin MLD1200 \$90.00; new SB3 \$89.00; new Trimode/Bistate \$125.00; Starcom-6 system \$125.00; Zenith cable \$175.00; legal to own your equipment, however, Federal law prohibits hookup without cable company permission. **PONDEROSA**, (303) 661-1659. (We ship C.O.D.)!

**TUBES**, \$2.49, TV, audio, Special, 2000 types, SASE brings lists. **DMF**, 6690 7 Mile, S. Lyon, MI 48178.

**RADIO** tubes, parts. Unused. Original cartons. Send \$1.00 (refundable) for lists. **DIERS**, 4276-E2 North 50 Street, Milwaukee, WI 53216-1313.

**SEMICONDUCTOR** and transmitting tube, quotation sent on request. **TSUTOM YOSHIHARA**, C1-105 Deguchicho-34, Suita, Osaka 564, Japan.

**NEW** 30 channel microwave TV antenna—complete \$149.95. Standard 2 channel \$99.95. Lifetime warranty—dealer pricing—C.O.D.—MC—VISA—**HIGH-TECH ELECTRONICS**, 337 Vineyard Ave., Suite 300, Ontario, CA 91764. (714) 391-1655.

**TUBES**, name brands, new, 80% off list. **KIRBY**, 298 West Carmel Drive, Carmel, IN 46032.

**PICTURE** flyer lists quality surplus electronics at low prices. Since 1970. Send for the last 3 issues. **STAR-TRONICS**, Box 683, McMinnville, OR 97128.

**ADD 5 important features** to your home telephone. SASE (805) 583-4272. **B&M ENGINEERING**, Box 823, Simi Valley, CA 93062.

**CABLE TV equipment S.A.**, Jerrold, Zenith, Hamlin, Oak, Eagle, filters, remotes and more. Best prices C.O.D.'s accepted, dealers needed. Ours work where others failed and we guarantee it! **TRANS-WORLD CABLE CO.** (218) 543-6671.

**PLASMA sphere** fascinating lightning display. Build 5" unit for \$50, plans \$10, prefilled sphere parts kits \$50, complete units, catalog \$2. **RIESS**, P.O. Box 54625, Dept. E, Phoenix, AZ 85078.

**SCRAMBLING** news. Monthly. No advertisers to protect, no products to push and no axe to grind. Unique, interesting, informative **SHOJIKI**, 1327R Niagara St., Niagara, NY 14303.

## A SINGER'S DREAM!



### REMOVES VOCALS FROM RECORDS!

Now You can sing with the world's best bands! The Thompson Vocal Eliminator can remove most or virtually all of a lead vocal from a standard stereo record and leave the background!

Write or call for a free brochure and demo record.

**LT Sound**, Dept. R-1, P.O. Box 338, Stone Mountain, GA 30086 (404) 493-1258

## PLANS AND KITS

**HI-FI speaker systems**, kits and speaker components from the world's finest manufacturers. For beginners and audiophiles. Free literature. **A&S SPEAKERS**, Box 7462, Denver, CO 80207. (303) 399-8609.

**VOICE** disguisers! FM bugs! Telephone transmitters! Phone snoops! More! Catalog \$1.00 (Refundable): **XANDI ELECTRONICS**, Box 25647, Dept. 60T, Tempe, AZ 85282.

**STRANGE** stuff. Plans, kits, new items. Build satellite dish \$69.00. Descramblers, bugs, adult toys. Informational photo package \$3.00 refundable. **DI-RIJO CORPORATION**, Box 212, Lowell, NC 28098.



## FINALLY!

An interesting and worthwhile project. This **EASY-TO-BUILD** circuit lets you use any regular TV set as a simple **OSCILLOSCOPE**.

Build for less than \$10. **NO MODIFICATIONS TO TV!** Single or dual trace. Send for **FREE CATALOG** of other plans and kits.

DETAILED PLANS: \$4.95

**TV-SCOPE**

PENN RESEARCH, Box 3543  
Williamsport, PA 17701

**DESCRAMBLING**, New secret manual. Build your own descramblers for **Cable and Subscription TV**. Instructions, schematics for SSAVI, gated sync, sinewave. (HBO, Cinemax, Showtime, etc.) \$8.95 + \$1.00 postage. **CABLETRONICS**, Box 30502R, Bethesda, MD 20814.

**SATELLITE descrambling manual**, Video Cypher II. Schematics, thorough explanation of digital audio encoding, EPROM code, DES. (HBO, Cinemax, Showtime.) \$10.95 + \$1.00 postage. **CABLETRONICS**, Box 30502R, Bethesda, MD 20814.

**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-GC**, Washington Crossing, PA 18977. Creditcard orders 24hrs. (215) 736-3979.

**DESCRAMBLING!** Latest information packed manual! All systems. Schematics, theory, turn-on's, countermeasures, \$14.95. C.O.D.'s **RETTZ**, 4021 Gilbert, Dallas, TX 75219. (214) 528-0309.

**CATALOG**: hobby/broadcasting/1750 meters/ham/CB: transmitters, antennas, scramblers, bugging devices, more! **PANAXIS**, Box 130-F11, Paradise, CA 95967.

**CRYSTAL** radio sets, plans, parts, kits, catalog \$1.00. **MIDCO**, 660 North Dixie Highway, Hollywood, FL 33020.

**DECODING** plans and theory booklets. Video tape copy protection, removes flashing and jitter, 30 pages, \$15.45. Jerrold DI and DIC decoder theory, 12 pages, \$6.95. Gated pulse decoding plus new universal single level suppression decoder, works on Hamlin, Jerrold, Sylvania, Eagle, 39 pages, \$15.00. Video scrambling techniques, the original secret manual, sinewave and Zenith SSAVI, 57 pages, \$14.95. Hidden signals on satellite TV, 178 pages, \$16.95. P.C. board and kits available. **ELEPHANT ELECTRONICS INC.**, P.O. Box 41865-J, Phoenix, AZ 85080. (602) 581-1973.





## REMOTE CONTROL KEYCHAIN



Complete w/mini-transceiver and +3-15Vdc receiver. Fully assembled including plans to build your own auto alarm.

**\$14.95** Check, Visa or M/C 30 days return

VISITECT INC. (415) 872-0128  
PO BOX 5442, SO. SAN FRAN., CA 94080

**FREE** microprocessors, memory chips, etc. Free electronics magazine subscriptions. Free education in computers. For information write **MICROSAT CORPORATION**, 2401 N.E. Cornell, Bldg. 133, Mail Stop 125, Hillsboro, OR 97124.

**VIDEOCIPHER II** manual 119 pages—\$27.45/ Oak "Orion" manual 120 pages—\$22.45/ Macrovision "Stabilizer"—\$99.95/ Plans—kits—descrambling books. Catalog—\$2.00. **MICROTRONICS**, Box 6426, Yuma, AZ 85364-0840.

**PLANS.** Plasma display, H.V. generator, CB modulator, Linear amplifiers, Painfield generators, shock sensor. Plans for all \$20.00 complete. **AET**, Suite 173, 5800-A, North Sharon, Amity Rd., Charlotte, NC 28215.

**NOVELTY** type electronics projects for the gadgeteer. Weird, unusual, fascinating and fun. Free information: **TAYLOR ELECTRONICS**, P.O. Box 1612, Destin, FL 32541.

**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.

**UNIVERSAL** eight voltage regulated power supply. Will power 99% of all discrete transistor and integrated circuit devices. Handiest DC supply around. Every electronic workshop should have one. Kit without case \$179.95. Complete kit \$239.95. Wired \$449.95. F.O.B. **PEPPERKIT**, 527-10th Street, Sparks, NV 89431-0811.

**ELIMINATE** light and dark from copying new video tapes. Completed and tested units \$75.00. Schematic \$5.95 circuit board \$5.00. **BLEDSON**, P.O. Box 3892, Central Point, OR 97502.

**SOFTWARE!!!** Make copies of protected software. Machine costs under \$100. Saves you hundreds, even thousands! Send \$3.00 for complete information. **MIKE MCGLINCHY**, 214 Verano Dr., Los Altos, CA 94022.

**NUTS & VOLTS** MAGAZINE P.O. Box 1111-E Placentia, CA 92670 714-832-7721

**GIVE YOURSELF A BREAK—A PRICE BREAK! NUTS & VOLTS WILL SAVE YOU MONEY ON ELECTRONIC PARTS & EQUIPMENT. PLUS SHOW YOU WHERE TO FIND UNIQUE, UNUSUAL AND HARD-TO-FIND ITEMS.**

**SUBSCRIBE TODAY!**

*A National Publication For The Buying And Selling Of Electronic Equipment*

Subscription Rates	U.S. FUNDS REQUIRED
3rd Class Mail—USA	
One Year	\$10.00
Two Years	\$18.00
Lifetime	\$50.00
1st Class Mail	
One Year USA	\$18.00
Canada/Mexico	\$20.00
Air Mail	
Foreign—1 Yr	\$50.00

**FREE** catalog 99-cent kits—audio, video, TV, computer parts. **ALLKIT**, 434 W. 4th St., West Islip, NY 11795.

**DETECTIVES**, experimenters. Exciting new plans. Hard to find micro and restricted devices. Large catalog \$5.00, refundable on 1st order. **WILSON**, P.O. Box 5264, Augusta, GA 30906.

**VIDEO TAPE COPYGUARD**

Eliminate the latest copyguard problems units from \$59.95 to \$169.95

*Deluxe Electronics (714) 998-6866*

1432 Heim Wy., Orange, Ca. 92665

**Multi-Channel Microwave T.V. Receivers**

1.9-2.7 GHz Parabolic Dish 40+ dB Gain  
**LIFETIME WARRANTY**

Complete System \$89.95 (Shipping Incl.)  
Dealer Rates, Replacement Components & Expert Repairs Available

**K & S ELECTRONICS** Call now for same day shipping!  
P.O. BOX 34522 (602) 230-0640  
PHOENIX, AZ 85067

VISA/MC/COD \$2 credit on phone orders!

## SATELLITE TV

**SATELLITE TV** equipment. Buyers guide, discount prices. \$2.00 N.E.C.S. INC., Box 22808-R4, Little Rock, AR 72221.

**DESCRAMBLER.** Build our low cost satellite TV video only descrambler for all major movies and sports. Uses all Radio Shack parts. Order P.C. board and instructions by sending check, money order, or Visa for \$35.00 U.S. funds to: **VALLEY MICROWAVE ELECTRONICS**, Bear River, Nova Scotia, Canada, BOX-1B0. (902) 467-3577.

## \*\*\*\* SCRAMBLING NEWS \*\*\*\* PAY TV AND SATELLITE DESCRAMBLING

Schematics, theory, bypasses, 13 cable, 7 satellite. New SA turn-on, MLD-1200-3, \$14.95. Experiments With Videocipher Cloning, musketeering, \$14.95. Cable TV Security design, \$12.95. MDS MMS Handbook Microwave hacking \$9.95. Build Satellite Systems Under \$500 \$12.95. Any 3 \$27. Scrambling News. Monthly Feature articles, product reviews, law history, patents. \$24.95-yr. Sample \$5. Winter catalog \$1.

**Shojiki Electronics Corp.** 1327A Niagara St., Niagara Falls, NY 14303. COD's 716-284-2163

**SATELLITE TV** receiver kits! LNA's! Instructions! Schematics! Catalog \$1.00 (refundable): **XANDI ELECTRONICS**, Box 25647, Dept. 21X, Tempe, AZ 85282.

**Parts Express** INTERNATIONAL INC. **HARDWARE AND ELECTRONICS**

 <b>12" POLY WOOFER</b> Clear polypropylene cone. 65 watts RMS, 11 oz. magnet. Ferro fluid cooled 1 1/2" voice coil. Trim ring included. 25-2500 Hz. #290-100 \$15.50 (1-3) \$13.95 (4-UP)	 <b>8" POLY WOOFER</b> Clear ribbed polypropylene cone. 60 watts RMS, 90 watts max. power. 20 oz. magnet. 35-2500 Hz. 4-8 ohm impedance. #290-055 \$20.95 (1-3) \$18.95 (4-UP)	 <b>15" WOOFER</b> 20 oz. magnet. 60 watts RMS, 90 watts max. 8 ohm impedance. 1 1/2" voice coil. 25-2000 Hz. #290-160 \$30.95 (1-3) \$28.40 (4-UP)
 <b>PIEZO TWEETER</b> Mfg #KSN1005A, 3/4" x 3/4". No crossover required. 50 watts maximum input power. #270-010 \$4.95 (1-79) \$3.95 (80-UP)	 <b>HORN TWEETER</b> 3" wide dispersion horn tweeter. 1800-15,000 Hz response. 35 watts RMS, 50 watts max. 8 ohm impedance. #270-050 \$6.50 (1-9) \$5.90 (10-UP)	 <b>5 1/2" CUP MIDRANGE</b> Tuned cup. Paper cone. 1" voice coil. 9.3 oz. magnet. 50 watts RMS, 70 watts max. Response: 320-6000 Hz. 8 ohm impedance. #280-020 \$11.50 (1-9) \$9.95 (10-UP)
 <b>CROSSOVERS</b> 2-Way, 30 watt #260-190 \$3.95 3-Way, 60 watt #260-200 \$7.50 3-Way, 100 watt #260-210 \$12.50	<b>FREE CATALOG</b> Call or write today for your free catalog containing speakers, semi-conductors, CATV products, tools, hardware, TV-VCR parts, and more.	

**CALL TOLL FREE 1-800-255-3525**

In Ohio: 1-800-322-3525  
Local: (513) 222-0173

\* 15 day money back guarantee. \* \$10.00 minimum order. \* COD orders accepted. \* 24 hour shipping. \* Shipping charge = UPS chart rate (\$2.50 minimum charge). Hours 8:30 a.m. - 6 p.m. EST M-F.

**PARTS EXPRESS INT'L INC.**  
340 East First St.  
Dayton, Ohio 45402

VISA  
MasterCard

CALL FOR FREE CATALOG

## TEXT TO SPEECH BOARD!

**PC/XT COMPATIBLE. MAKE YOUR COMPUTER TALK!**  
A VERY POWERFUL AND AMAZING SPEECH CARD. USES THE NEW GENERAL INSTRUMENTS'S SPO256-AL2 SPEECH CHIP AND THE CTS256A-AL2 TEXT TO SPEECH CONVERTER.

THIS BOARD USES ONE SLOT ON THE MOTHERBOARD AND REQUIRES A COM SERIAL PORT. BOARD MAY ALSO BE USED IN A STAND ALONE ENVIRONMENT WITH ALMOST ANY COMPUTER THAT HAS A RS232 SERIAL PORT. FEATURES ON BOARD AUDIO AMP OR MAY BE USED WITH EXTERNAL AMPS.

DEMONSTRATION SOFTWARE AND A LIBRARY BUILDING PROGRAM ARE INCLUDED ON A 5 1/4" INCH PC/XT DISKETTE. FULL DOCUMENTATION AND SCHEMATICS ARE ALSO INCLUDED.



**NEW! PRICE CUT!**  
**\$69.95**  
ASSEMBLED & TESTED

## CANON 80 COLUMN PRINTER - \$39.95

ORIGINALLY MANUFACTURED FOR THE PC JR. BUT WITH OPTIONAL CONNECTOR WILL WORK WITH PC, XT, OR AT. REQUIRES SERIAL I/O. THIS THERMAL PRINTER IS QUIET AND USES EASY TO GET 8 1/2 IN. ROLLS OF PAPER. 50 C.P.S., UPPER AND LOWER CASE, PLUS GRAPHICS. ORIGINAL LIST PRICE \$199.00. ADD \$3.00 FOR PC/XT CONNECTOR. ADD \$5.00 UPS.

## PC/XT EPROM PROGRAMMER \$169



**NEW!**

\* LATEST DESIGN \* PROGRAMS UP TO 4 DEVICES AT ONE TIME \* FEATURES EASY TO USE MENU DRIVEN SOFTWARE THAT RUNS UNDER PC OR MS-DOS. \* USES AN INTELLIGENT PROGRAMMING ALGORITHM FOR SUPER FAST (8X) EPROM BURNING. \* THIS PLUG-IN BOARD ATTACHES TO AN EXTERNAL MINI CHASSIS CONTAINING 4 TEXTOL Z.I.F. SOCKETS. \* NO PERSONALITY MODULES REQUIRED \* AUTOMATIC VPP SELECTION: 12.5V, 21V, OR 25V. \* EPROM DATA CAN ALSO BE LOADED FROM OR SAVED TO A DISKETTE. \* PROGRAMMING SOFTWARE SUPPORTS: 2716, 2732, 2732A, 2764, 2764A, 27128, 27128A, 27256, 27256A, 27512, AND 27512A. \* ASSEMBLED AND TESTED, BURNED. IN WITH MANUAL. \$169 WITH SOFTWARE.

JUST RECEIVED SAME AS ABOVE PROGRAMMER, BUT PROGRAMS 10 UNITS AT ONE TIME - \$299.

## Digital Research Computers

P.O. BOX 381450 • DUNCANVILLE, TX 75138 • (214) 225-2309

TERMS: Add \$3.00 postage. We pay balance. Orders under \$15 add 75¢ handling. No C.O.D. We accept Visa and MasterCard. Texas Res. add 6-1/4% Tax. Foreign orders (except Canada) add 20% P & H. Orders over \$50 add 85¢ for insurance.

ALL SALES SUBJECT TO THE TERMS OF OUR 90 DAY LIMITED WARRANTY. FREE COPY UPON REQUEST.



# FISHER FISHER FISHER

Authorized Parts Distributor  
for Exact Original Parts In

**SANYO  
SYLVANIA  
PHILCO (NAP)  
PANASONIC  
QUASAR (MECO)  
G.E.  
R.C.A.**

Stocking Large Inventories  
Fastest Service

For Orders Only Call

1-800-874-1765

Nat'l

1-800-874-1764

N.Y. Only

For ALL Other Inquiries Call  
516-585-8111

**GMB SALES, INC.**  
2700 Middle Country Rd.  
Centereach, N.Y. 11720

CIRCLE 199 ON FREE INFORMATION CARD

## MACINTOSH NOTEBOOKS PRENTICE HALL BOOKS BY JOHN HEIL BORN

**BUY ALL 3 AND GET 1 FREE**

8 1/2 BY 11" WELL ILLUSTRATED BOOKS  
WITH EASY TO READ TYPE. EACH IS OVER  
200 PAGES AND IS FILLED WITH HINTS, AND  
SHORTCUTS KNOWN ONLY TO PROGRAM DESIGNERS

**MacPaint** I HAVE USED MacPaint FOR TWO  
YEARS AND THIS BOOK TAUGHT ME SOME NEW TRICKS

**MacWrite** THIS BOOK CAN CUT YOUR TIME BY 20%  
WHILE IMPROVING THE APPEARANCE OF YOUR WORK

**MultiPlan** ALL THE HINTS AND SHORTCUTS THE  
OWNER'S MANUAL LET OUT ARE IN THIS BOOK

**MSDOS 3 BOOK SET** 15<sup>99</sup>  
BY MICRO SOFT

■ USERS GUIDE ■ DEBUG UTILITY  
■ PROGRAMMERS REFERENCE  
BUY THIS 3 BOOK SET AND LEARN "DOS" AT HOME.

**FLOPPY DISK CONTROLLER**  
IBM COMPATIBLE WITH PRINTER PORT

CONTROLS 2 DRIVES. THE PRINTER PORT IS  
A DB 25 CENTRONICS AT LPT1. MADE BY  
TANDON PART NUMBER 188400

[MONEY BACK IF IT DOESN'T WORK ON YOUR CLONE]

## ROBOTICS PARTS

**ARM ASSEMBLY** \$299<sup>00</sup>

■ ARM MOVES IN 3 DIRECTIONS  
■ WRIST ROTATES 200 DEGREES  
■ GRIPS ITEMS UP TO 2 INCHES  
■ CENTRONICS INTERFACE

**P.W.M. SERVO AMP.** \$49<sup>00</sup>

■ CONTROLS 6 MOTORS  
■ CENTRONICS INTERFACE

**MOTORIZED PLATFORM** \$99<sup>00</sup>

■ STRONG STEEL CHASSIS  
■ 2 MOTORS AND WHEELS

Call for a copy of 15 day trial agreement. Tax &  
freight extra. Send check or add 1.90 for COD.  
Price may change. Store Price may differ. While  
supplies last. No P.O.s, terms, or credit cards  
\$5 min postage and handling charge.

**Silicon Valley Surplus** OPEN  
415-261-4506 10am-6pm  
4401 OAKPORT OAKLAND CA, 94601 CLOSED  
SUN & MON

**CALL OUR BBS 415-261-4513**

CIRCLE 186 ON FREE INFORMATION CARD

PERSONAL computer owners can earn \$1000 to  
\$5000 monthly selling simple services part time.  
Free list of 100 services. A.I.M.J.K., Box 60369, San  
Diego, CA 92106-8369.

## TELEPHONE VOICE SCRAMBLERS

**SCRAMBLE** your telephone conversations.  
Fully self-contained voice privacy system that pre-  
vents unauthorized interceptions. Highly recom-  
mended for Cellular and I.M.T.S. telephones. Call-  
N.A.S. (213) 631-3552.

## Cable TV Converters

Why Pay A High Monthly Fee?

Jerrold Products include "New Jerrold  
Tri-Mode," SB-3, Hamlin, Oak VN-12,  
M-35-B, Zenith, Magnavox, Scientific  
Atlanta, and more. (Quantity dis-  
counts) 60 day warranty. For fast ser-  
vice C.O.D. orders accepted. Send  
SASE (60 cents postage) or call for info  
(312) 658-5320. **Midwest Electronics,  
Inc.**, **HIGGINS ELECTRONICS**, 5143-R  
W. Diversey, Chicago, IL 60639. MC/  
Visa orders accepted. No Illinois orders  
accepted. Mon.-Fri.-9 A.M.-6 P.M. CST

**MASTERCARD AND VISA** are now accepted  
for payment of your advertising. Simply  
complete the form on the first page of the  
Market Center and we will bill.



## Quality Microwave TV Antennas

Multi-Channel 1.9 to 2.7 GHz 40dB Gain  
12-Channel System complete \$104.95  
2-Channel System complete \$84.95  
Dealerships, Qty. Pricing, Replacement Parts

**Phillips-Tech Electronics**  
P.O. Box 8533 • Scottsdale, AZ 85262  
(602) 947-7700 (\$3.00 Credit all phone orders!)

LIFETIME  
WARRANTY

MasterCard • Visa • COD's

## EDUCATION & INSTRUCTION

**F.C.C. Commercial General Radiotelephone  
license.** Electronics home study. Fast, inexpensive!  
"Free" details. **COMMAND**, D-176, Box 2223, San  
Francisco, CA 94126.

**HAM licenses supereasy.** Cut exam preps 50%.  
All classes. Free catalog. **SASE. BAHR**, 2549-E6  
Temple, Palm Bay, FL 32905.

## Be a TV/VCR Repair Specialist

Now you can train at home in spare time for a money-making  
career as a TV/VCR Repair Specialist. No previous experi-  
ence necessary. No need to quit your job or school. Everything  
is explained in easy-to-understand language with plenty of draw-  
ings, diagrams and photos. We show you how to troubleshoot  
and repair video-cassette recorders and TV sets, how to handle  
house calls and shop repairs for almost any make of television or  
VCR. Tools are included with your course so you can get  
"hands-on" practice as you follow your lessons step by step.  
Send for free facts about the exciting opportunities in TV/VCR  
Repair and find out how you can start making money in this  
great career. **MAIL COUPON TODAY**

**ICS SCHOOL OF TV/VCR REPAIR, Dept. DEOA7**  
SINCE 1951 Scranton, Pennsylvania 18515

Please send me full information and color brochure on how I can  
learn TV/VCR Repair at home in my spare time. I understand  
there is no obligation and no salesman will visit me.

Name \_\_\_\_\_ Age \_\_\_\_\_  
Address \_\_\_\_\_  
City/State/Zip \_\_\_\_\_  
Phone (\_\_\_\_) \_\_\_\_\_



WRITE FOR  
**McGEE'S**

## SPEAKER & ELECTRONICS CATALOG

1001 BARGAINS IN SPEAKERS  
toll free 1-800-346-2433 for ordering only.  
1901 MCGEE STREET KANSAS CITY, MO. 64108

## SCIENTIFIC ATLANTA & SB-3

**SCIENTIFIC Atlanta** models 8500-8550, remote  
included...\$240.00. **SB-3's**...\$74.00. **TRI-  
BI's**...\$95.00. **SBSA-3's**...\$99.00. **Zenith (Z-Tac)**  
descramblers...\$169.00. **N-12 (Vari-sync)**...\$89.00.  
**M-35 B (Vari-sync)**...\$99.00. **Jerrold-450** and **550-  
Meg** converters...\$95.00. **Dealer discount** on (5)  
units. **Brochure** available. Call...N.A.S., (213)  
631-3552.

**THIS IS A BOLDFACE EXPANDED AD.** If you  
like this format, request it. Your cost is  
\$4.30 per word, plus 45% for the boldface  
and tint background.

Copies of articles from this  
publication are now available from  
the UMI Article Clearinghouse.

Mail to: University Microfilms International  
300 North Zeeb Road, Box 91 Ann Arbor, MI 48106

# OPPORTUNITY WITHOUT RISK.

The biggest improvement in  
40 years has made U.S. Savings  
Bonds an ideal investment.

A variable interest rate lets  
you share in rates offered by  
today's securities market. No limit  
on how much you might earn.

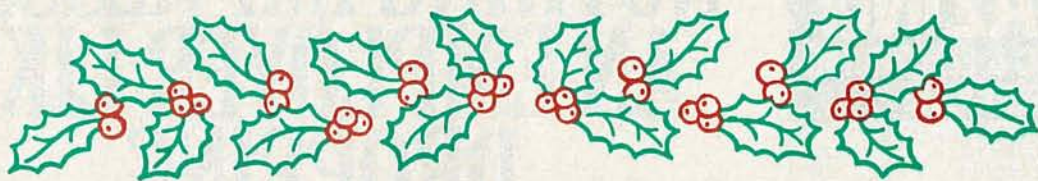
What makes this improved  
Bond ideal is that you're protected  
by a guaranteed minimum. And if  
the Bond is held to maturity, you'll  
double your money.

Take another look at this  
opportunity without risk.

Take  
stock  
in America.



A public service of this publication  
and The Advertising Council.



## Plug a Friend into Radio-Electronics this Christmas ... and Save \$12!

**This Christmas give an electrifying gift ... plug a friend into Radio-Electronics and brighten his whole new year! Whether electronics is his livelihood or his hobby, your gift will sharpen his focus and illuminate the whole spectrum of electronics throughout the coming year.**

Radio-Electronics will keep him informed and up-to-date with new ideas and innovations in all areas of electronic technology ... computers, video, radio, stereo, solid state technology, satellite TV, industrial and medical electronics, communications, robotics, and much, much more.

He'll get complete plans and printed circuit patterns for building valuable test equipment and electronic devices for home and car — practical money-savers like these ... a TV signal descrambler ... a video test generator ... an auto exhaust analyzer ... a clockboard for his PC ... a radio commercial zapper ... a solid state barometer ... a working robot ... and many others!

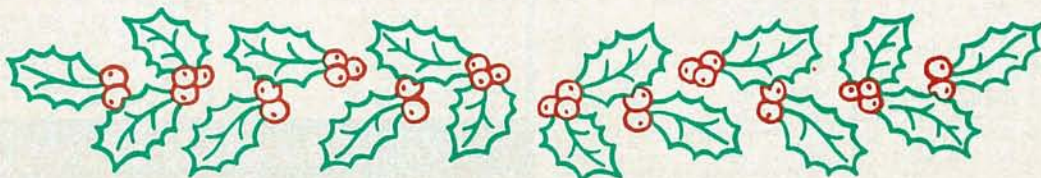
PLUS ... equipment repair and troubleshooting ... circuit design ... new

product news and buyer's guides ... service clinics ... equipment test reports ... a special "Computer Digest" section ... regular columns on video, stereo, radio, circuits, solid state, satellite TV and robotics ... and lots more exciting features and articles.

**SAVE \$12 ... OR EVEN \$24 ... For each gift of Radio-Electronics you give this Christmas, you save a full \$12.00 off the newsstand price. And as an R-E gift donor, you're entitled to start or extend your own subscription at the same Special Holiday Gift Rate — you save an additional \$12.00!**

No need to send money ... if you prefer, we'll hold the bill till January, 1988. But you must rush the attached Gift Certificate to us to allow time to process your order and send a handsome gift announcement card, signed with your name, in time for Christmas.

So do it now ... take just a moment to fill in the names of a friend or two and mail the Gift Certificate to us in its attached, postage-paid reply envelope. That's all it takes to plug your friends into a whole year of exciting projects and new ideas in Radio-Electronics!



# AMAZING SCIENTIFIC & ELECTRONIC PRODUCTS

- PLANS—Build Yourself—All Parts Available In Stock**
- LC7—BURNING CUTTING CO<sub>2</sub> LASER ..... \$ 20.00
  - RUBA—PORTABLE LASER RAY PISTOL ..... 20.00
  - TCC1—3 SEPARATE TESLA COIL
  - PLANS TO 1.5 MEV ..... 20.00
  - IOG1—ION RAY GUN ..... 10.00
  - GRA1—GRAVITY GENERATOR ..... 10.00
  - EML1—ELECTRO MAGNET COIL GUN/LAUNCHER ..... 6.00

- KITS**
- MFT1K—FM VOICE TRANSMITTER 3 MI RANGE ..... 49.50
  - VVPM5K—TELEPHONE TRANSMITTER 3 MI RANGE ..... 39.50
  - BTC3K—250,000 VOLT 10-14" SPARK TESLA COIL ..... 199.50
  - LHC2K—SIMULATED MULTICOLOR LASER ..... 39.50
  - BLS1K—100,000 WATT BLASTER DEFENSE DEVICE ..... 69.50
  - ITM1K—100,000 VOLT 20" AFFECTIVE RANGE INTIMIDATOR ..... 69.50
  - PSP4K—TIME VARIANT SHOCK WAVE PISTOL ..... 59.50
  - PTG1K—SPECTACULAR PLASMA TORNADO GENERATOR ..... 149.50
  - MVPIK SEE IN DARK KIT ..... 169.50

- ASSEMBLED**
- PG70H—MULTICOLORED VARIABLE MODE PLASMA GLOBE "7" ..... 425.00
  - BTC10—50,000 VOLT—WORLD'S SMALLEST TESLA COIL ..... 44.50
  - LGJ40—1MW Hg+ VISIBLE RED LASER GUN ..... 299.50
  - TAT20 AUTO TELEPHONE RECORDING DEVICE ..... 24.50
  - GPV10—SEE IN TOTAL DARKNESS IR VIEWER ..... 299.50
  - LIST10—SNOOPER PHONE INFINITY TRANSMITTER ..... 169.50
  - IPG70—INVISIBLE PAIN FIELD GENERATOR—MULTI MODE ..... 74.50

• CATALOG CONTAINING DESCRIPTIONS OF ABOVE PLUS HUNDREDS MORE AVAILABLE FOR \$1.00 OR INCLUDED FREE WITH ALL ABOVE ORDERS.

PLEASE INCLUDE \$3.00 PH ON ALL KITS AND PRODUCTS. PLANS ARE POSTAGE PAID. SEND CHECK, MO, VISA, MC IN US FUNDS.

**INFORMATION UNLIMITED**  
P.O. BOX 716 DEPT. RE, AMHERST, NH 03031

# NOTHING IMPRESSES AN EMPLOYER LIKE DROPPING OUT OF SCHOOL.

After several years of intense study, a lot of college graduates finally learn something. They're not qualified for the job they want. Fact is, many graduates never find a career in their field of study. All their time spent in study. Not enough time in the field. That's why there's a nationwide program for college students called Co-operative Education. It allows students to alternate studies at the college of their choice with paid, practical work experience in the career of their choice. To participate in Co-op Education you don't have to fit into any particular socio-economic group. You don't have to be a straight "A" student either. All you really need to be, is smart enough to leave school.

## Co-op Education

You earn a future when you earn a degree.

**Ad Council** For a free booklet write: Co-op Education • P.O. Box 999 • Boston, MA 02115  
A Public Service of This Publication • © 1985 National Commission for Cooperative Education

# MICRO MART

508 Central Ave.  
Westfield, N.J. 07090  
(201) 654-6008

TTL SERIES	74367	80	74LS164	45	4013	25	
7400	25	74390	85	74LS165	60	4013	25
7401	25	74393	100	74LS173	45	4015	30
7402	25	75324	20	74LS191	45	4018	25
7403	25	75324	20	74LS191	45	4018	25
7404	25	75454	55	74LS192	60	4022	60
7406	30	N8722	55	74LS195	60	4024	45
7407	25	N8724	50	74LS241	60	4025	20
7408	30	N8726	50	74LS240	60	4025	60
7409	30	N8726	50	74LS241	60	4025	20
7410	25	74LS01	20	74LS242	60	4041	70
7411	25	74LS02	20	74LS244	50	4042	50
7412	25	74LS01	20	74LS245	70	4046	80
7420	25	74LS02	20	74LS247	100	4047	65
7425	25	74LS03	20	74LS251	90	4048	25
7426	30	74LS04	20	74LS252	40	4050	25
7427	25	74LS09	20	74LS257	35	4051	35
7429	25	74LS09	25	74LS258	60	4053	60
7430	25	74LS09	20	74LS259	85	4060	60
7432	25	74LS10	20	74LS260	40	4066	30
7437	25	74LS11	25	74LS262	40	4068	60
7438	25	74LS12	25	74LS268	40	4069	20
7439	25	74LS13	25	74LS273	45	4070	25
7440	30	74LS14	35	74LS290	75	4071	20
7442	25	74LS15	25	74LS293	75	4072	20
7445	50	74LS20	20	74LS295	75	4073	35
7447	75	74LS21	20	74LS298	60	4076	50
7450	60	74LS22	20	74LS299	135	4077	25
7451	25	74LS26	20	74LS336	75	4078	35
7454	30	74LS27	20	74LS365	35	4081	20
7474	30	74LS28	25	74LS366	35	4082	20
7475	45	74LS29	50	74LS367	40	4083	35
7476	45	74LS29	50	74LS368	35	4086	45
7482	85	74LS32	20	74LS373	65	4093	45
7483	50	74LS33	25	74LS374	75	4180	45
7485	50	74LS37	30	74LS391	60	4281	45
7486	40	74LS38	25	74LS377	70	4116	45
7490	45	74LS40	20	74LS378	110	4428	45
7491	85	74LS41	20	74LS383	50	4237	75
7492	45	74LS47	90	74LS620	150	4497	45
7493	35	74LS51	20	74LS670	85	4502	65
7495	50	74LS52	20	74LS671	85	4503	65
7496	50	74LS55	30	74LS672	85	4516	70
7497	35	74LS73	25	74LS737	50	4517	75
74109	40	74LS74	20	74LS738	50	4517	75
74116	100	74LS75	30	74LS739	35	4519	60
74121	35	74LS76	25	74LS737	60	4528	75
74123	40	74LS78	20	74LS739	35	4527	75
74125	45	74LS83	40	74LS737	60	4538	75
74126	40	74LS85	40	74LS737	60	4555	75
74128	55	74LS86	20	74LS737	60	4556	35
74145	45	74LS90	40	74LS244	60	4573	45
74148	100	74LS93	35	74LS273	50	4574	45
74151	60	74LS107	30	74LS290	75	4585	70
74153	50	74LS112	25	74LS290	75	4585	70
74156	70	74LS113	30	74LS290	75	4585	70
74157	60	74LS114	30	74LS290	75	4585	70
74161	60	74LS123	45	74LS240	50	4509	45
74163	60	74LS125	35	74LS240	50	4509	45
74164	80	74LS126	35	74LS240	50	4509	45
74173	70	74LS132	25	74LS273	200	4571	20
74174	50	74LS136	20	74LS273	200	4571	20
74175	50	74LS137	20	74LS273	200	4571	20
74177	60	74LS138	20	74LS273	200	4571	20
74180	60	74LS151	40	74LS273	200	4571	20
74181	180	74LS152	40	74LS273	200	4571	20
74182	180	74LS153	40	74LS273	200	4571	20
74192	70	74LS157	30	74LS273	200	4571	20
74193	65	74LS158	30	74LS273	200	4571	20
74194	65	74LS159	30	74LS273	200	4571	20
74195	75	74LS161	45	74LS273	200	4571	20
74205	35	74LS162	45	74LS273	200	4571	20
74206	60	74LS163	45	74LS273	200	4571	20

LINEAR	NE556	30	TRANSISTORS & DIODES
LM300K	50	UA798	50
LM307H	40	MC1330	50
LM308H	60	MC1350	140
LM311H	50	MC1398	50
LM311H	40	UA458	25
LM317	75	ULN2283	150
LM318H	90	LM2903	50
CA324	35	LM2904	50
LM325A	45	MC7805	45
LM339N	35	MC7806	45
LM339N	75	MC7812	45
LM388A	80	MC7824	45
LM393N	35	MC7905	45
NE555	25	MC7912	45

**DIP IC SOCKETS**  
8 PIN, 09, 14 PIN, 13, 16 PIN, 15, 18 PIN, 17, 20 PIN, 19, 22 PIN, 21, 24 PIN, 23, 28 PIN, 26, 40 PIN, 28 Zero Insertion Test Socket 28 PIN ..... 5.00

**TOKO COILS FOR FEB 1984 TV PROJECT**  
Toko #s BKAN-K5552AXX(2), #E520HN-300023 (07UH) & L-2(12UH) Fixed. 1 Set of 4 pcs \$6.00, 3 Sets \$15.00, 10 Sets \$45.00.  
Opto Isolator H11CX(Transistor Type) ..... 65  
Opto Isolator HXXCX(SCR Type) ..... 85  
Hewlett Packard Clock (No Specs) ..... 2.50  
Line Cord 6 feet UL Listed SPT 2 ..... 60  
Scene Probe Set w/Everything x1x10 ..... 24.95  
Wire Stand Offs ..... 10/\$1  
Zener Ass't — 65 pcs Total — Includes Minimum 3 Different 1W Devices ..... \$1.95  
Resistor Ass't — 1,000 pcs 35 Values Minimum.  
Popular Values (1K, 10K, 100K) Included. Mostly 1/4 & 1/2W. Some 1 & 2W. Lots of Precisions. Carbon Film. Taped and Reeled for Easy Sorting ..... \$9.95  
Jumper Plugs (Cambion) — Male to Male for Breadboard & Connectors ..... 10/\$1.25  
9VDC Wall Transformer, 200ma ..... \$2.95  
9VDC Wall Transformer, 500ma ..... \$3.95  
12VDC Wall Transformer, 400ma ..... \$6.95  
6.3V 1.2A Transformer ..... 10/\$1  
12.6 VCT 1A ..... \$3.50  
7 (Seven) Amp Tapped Transformer — 7 1/2/15VAC or 9V/18VAC ..... \$8.95  
Muffin/Sprite Style Fan #SU2C7 (EG & G Rotron). 3 1/2" Sq. 115V ..... \$5.95  
Jumbo Red LED's ..... 15/\$1.00, 100/\$10.00  
Jumbo Green LED's ..... 10/\$1.30, 100/\$10.00  
Jumbo Yellow LED's ..... 10/\$1.40, 100/\$11.00  
Jumbo Yellow Hi Intensity with RI Angle & Black Case Features ..... 10/\$1.20, 100/\$10.00  
Jumbo Amber LED's ..... 10/\$1.40, 100/\$11.00  
Mini Yellow Hi Intensity with Discreet. Pale Blue Lens/Case Feature 10/1.20, 100/10 LED Clips/Rings for Jumbo ..... 15/\$1, 100/\$6

MAN6910	—	Double Digit 7 Segment Display, Hi Efficiency Red, 56' Comm Ann	1.25
MMS481	—	14 Segment Driver Chip	.75
Hewlett Packard 7 Seg. 4" Red Ann#7651	.....		.95
7 Seg. 3" Bent Lead (Hobby Grade)	.....		4/\$1
7 Seg. 6" Bent Lead (Hobby Grade)	.....		3/\$1
1.5A 50V Bridge (TO-5)	.....		.50
4A 50V Bridge (KBU05)	.....		.75
6A 600V Bridge 5/8" Square	.....		1.00
10A 500V Bridge 5/8" Square	.....		1.15
25A 200 Bridge (Solder Lug Type)	.....		2.00
12VDC SPST Reed Relay PC Mount	.....		.60
SPST PB Switch (Keyboard Type)	.....		3/\$1
Mini Toggle DPDT (Lock Latch Feature)	.....		.75
DPDT "Snap In" Rooker with Bulb Socket	.....		.95
Push-Lighted Switch (No Bulb) Off — Mom — 45	.....		
Pushbutton DPST Off — Mom PC Mount	.....		3/\$1
DPDT Push Button 6A 125V	.....		.65
TPDT "Bat" Handle Toggle (On Off On)	.....		1.65
DPDT RI Angle PC Toggle (On Off On)	.....		.95
11 LED Bar Graph Display, 2-3M", Rectangular LED's (Specify Red, Green, Amber)	.....		2.69
TO-92 NPN 5121	.....		
IN144A	401		
IN4148	401		
IN4001	301		
IN4004	251		
IN4007	151		
IN4021B	51		
50 PIN IDC Ribbon Cable Connector	.....		.50
36 PIN RI Angle "Snap Off" Header	.....		.50
14 PIN Header for Ribbon Cable	.....		.351
7 PIN Male Header	.....		20/\$1
IC Storage "Bug" Box	.....		\$2.45
Heavy Duty Alligator Clips (10 Sets)	.....		\$2.30
Regular Alligator Clips (10 Sets)	.....		\$1.80
Wire Strippers (Spring Loaded, Adjust.)	.....		\$2.50
5" Needle Nose Pliers (Spring Loaded)	.....		\$3.95
4 1/2" Diagonal Cutters (Spring Loaded)	.....		\$3.95
Nut Driver set for 3/16", 1/4", 5/16"	.....		3/\$2
Jeweler's Screwdrivers (4 pcs)	.....		\$2.65
Desoldering Pump (Solder Sucker)	.....		\$4.00
Replacement Tips for Solder Sucker	.....		2/\$3.00
25W Precision Soldering Iron	.....		\$2.95
Safety Goggles	.....		\$2.95
De-Soldering Braid (5 Foot Roll)	.....		.99
Solder Aid Tool Kit (4 pcs)	.....		\$3.00
Model 610B Logic Probe (Pencil Type)	.....		\$18.95
Model 620B Logic Pulser (Pencil Type)	.....		\$18.95
.01uF 100V Mylar Cap	.....		20/\$1
1uF 200V Mylar Cap	.....		15/\$1
?Mystery? Bag #1 The "OHM" Bag	.....		\$1
?Mystery? Bag #2 The "VOLT" Bag	.....		\$1
?Mystery? Bag #3 The "CIRCUIT" Bag	.....		\$1
?Mystery? Bag #4 The "FREQUENCY" Bag	.....		\$1
?Mystery? Bag #5 The "TOLERANCE" Bag	.....		\$1
No Returns or Exchanges with Mystery Bags	.....		
9V Battery Snaps	.....		7/\$1
Self Adhesive Rubber Stripping — Cut to Any Lengths You Choose (3M-Bumper), 3 Feet/\$2, 10 Feet/\$5.00, 50 Feet/\$20.00.	.....		
Hi Reliability TO-3 Socket (August)	.....		.85
Low Fluid Level Detector Kit — Parts, PC Board & Instructions	.....		4.95
Soldering Iron Convenience Stands	.....		5/\$1.00
Voltage Mate Switching Regulator Kit	.....		\$18.95
COMMODORE COMPUTER KEYBOARD & MOTHERBOARD COMBO, INCLUDES ARTICLE FOR COMPATIBILITY (INTERFACE) \$12.95	.....		

OPERATING FEATURES	
DC Voltage	100uV to 1000V
AC Voltage	100uV to 750V
DC Current	0.1uA to 10A
AC Current	0.1uA to 10A
Hi-Lo Resistance	1uΩ to 20MΩ
Capacitance	1pF to 20uF
Diode Test	forward voltage testing
Hz test	transistor testing

**MODEL 705 Digital Multimeter**  
**\$51.95**

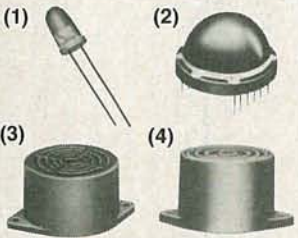
**UHF-TV PREAMP**  
(As featured in Radio Electronics March/May articles, 1982)  
This inexpensive antenna mounted pre-amp can add more than 25 dB of gain to your system. Lots of satisfied customers and repeat orders for this high quality kit, which includes all component parts, PC Board, Case, Power Supply and Balun \$34.50 Assembled Version ..... \$57.50

Terms: MICRO-MART accepts Visa, MC and telephone COD's. Minimum order \$10.00. Shipping — U.S. orders, \$2.50. Canada and other countries, \$3.50. Shipping rate adjusted where applicable. N.J. residents add 6% sales tax.  
**MICRO-MART • 508 CENTRAL AVE., WESTFIELD, NJ 07090 • (201) 654-6008**

# Radio Shack Parts Place™

## ELECTRONIC VALUES AT OUR STORE NEAR YOU

### Jazzy Sight 'n Sound



- (1) Brilliant Red LED. #276-066 ..... 1.19
- (2) Big Red LED. #276-064 ..... 3.49
- (3) Tri-Sound Siren. Extra-loud buzzer outputs. #273-072 ..... 5.95
- (4) Melodic IC Chime. #273-071 ..... 7.95

### Builder Bargains



- (5) High-Torque, Low-Voltage Motor. 1.5-3 VDC, approximately 8300 RPM. #273-223 ..... 79c
- (6) 1:1 Audio Transformer. For phone interconnects. #273-1374 ..... 3.49
- (7) Magnet Wire. Three spool set—22, 26, 30 gauge. #278-1345 ..... 4.49

### Our Finest Benchtop Digital LCD Multimeter



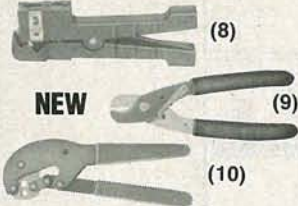
**99<sup>95</sup>**

Low As \$15  
Per Month\*

- Manual or Autoranging
- Min/Max Values Can Be Stored

A champion performer for shop or laboratory. The 31-segment analog bar graph display makes input peaks and trends easier to follow. Transistor checker measures  $h_{FE}$  (gain), diode-check for semiconductor junctions. Memory function and buzzer continuity checker. Measures to 1000 VDC, 750 VAC, AC/DC current to 10 amps, resistance to 30 megohms. Input impedance: 10 megohms on DCV/ACV. Fused, overload protected. #22-195

### Coax Cable Tools



- (8) Cable Stripper. For all popular sizes. #278-240 ..... 11.95
- (9) Coax Cable Cutter. Blades do not flatten cable, preserve impedance. #278-244 ..... 4.95
- (10) Professional Crimp Tool. For all coax connectors. #278-243 ..... 12.95

### Phono Plugs, Jacks



- (11) Solderless 90° Plugs. Two red, two black. #274-383 ..... Set of 4/1.59
- (12) Shielded Plug. #274-339 ..... Set of 2/1.49
- (13) Shielded Jack. #274-338 ..... Set of 2/1.49
- (14) Dual Phono Jacks. Chassis mount. #274-332 ..... Set of 2/1.19

### Solder-Type "D" Submini Connectors

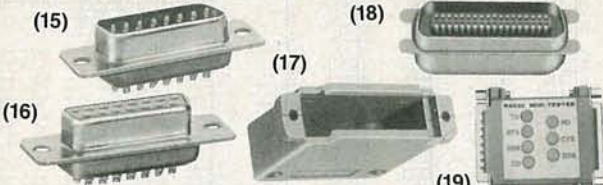
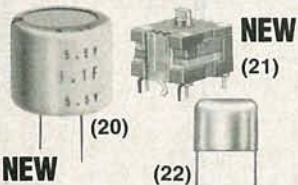


Fig.	Type	Positions	Cat. No.	Ea.
15	Male	9	276-1537	1.49
16	Female	9	276-1538	2.49
17	Hood	9	276-1539	1.99

Type	Positions	Cat. No.	Ea.
Male	25	276-1547	1.99
Female	25	276-1548	2.99
Hood	25	276-1549	1.99

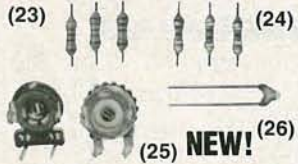
- (18) Printer Connector. Solder type, 36-position. For parallel printers. #276-1534 ..... 4.99
- (19) RS232 Inline Tester. Diagnose interface problems without costly repair calls. #276-1401 ..... 14.95

### Hard-to-Find Parts



- (20) CPU/RAM Backup Capacitor. For CMOS microprocessors. 0.1 farad, 5.5 WVDC. #272-1440 ..... 2.95
- (21) Dual-Ganged 335 pF Pot. PC mount. With knob, pinout. #272-1337 ..... 4.95
- (22) 6-50 pF Trimmers. PC/perfboard mount. #272-1340 ..... Set of 2/1.59

### Irresistables



- (23) 1/4-Watt Carbon Film Resistors. 100 Asstd. #271-311 ..... 1.98
- (24) 1/4-Watt Carbon Film Resistors. 500 Asstd. #271-312 ..... 7.95
- (25) Set of 12 Asstd. Trimmers. #271-1605 ..... 1.98
- (26) Thermistor. - 50 to +110°C. #271-110 ..... 1.99

### Our Newest ICs

**NEW! TDA7000 FM Receiver on a Chip.** Combines RF mixer, IF and demodulator stages in one IC. Just what you need to build a small, inexpensive FM band receiver or public service band monitor. Includes application notes. #276-1304 ..... 5.95

**NEW! TDA1520A 20-Watt High-Power, High-Fidelity Audio Power Amp.** Build your own quality audio amplifier! Nine-pin single inline package. Very low distortion. 20 to 20,000 Hz response. Requires 15 to 50 VDC. With data. #276-1305 ..... 5.99

### Voice Synthesis ICs

**SPO256-AL2 Speech Synthesizer IC.** Give your computer a voice! Built-in program makes it easy to interface with most computers. Requires 3.12 MHz crystal (special order). 28-pin DIP. #276-1784 ..... 12.95

**CTS256-AL2 Text-to-Speech IC.** Preprogrammed 8-bit processor translates ASCII characters into control data for #276-1784 above. With data and schematics. Requires 10 MHz crystal (available from our warehouse via special order "Hotline"). 40-pin DIP. #276-1786 ..... 16.95

### RAM & Data-Xfer ICs

Why gamble with mail order? Factory fresh, warranted popular parts in stock and Radio Shack close.

**4164-64K Dynamic RAM.** Factory fresh, 150 ns access, low-power design. Uses single 5 VDC supply. #276-2506 ..... 3.95

**TMS 4256-256K Dynamic RAM.** 150 ns maximum access time. Low-power design (230 mV typical). Uses single 5 VDC power supply. 16-pin DIP. #276-1252 ..... 6.95

**MC1488 RS232 Quad Line Driver.** Lets you hook up terminals and remote peripherals with a simple "twisted pair" cable. 14-pin DIP with data. #276-2520 ..... 1.29

**MC1489 RS232 Quad Line Receiver.** For use with above line driver. 14-pin DIP with Data. #276-2521 ..... 1.29

### Top-Quality Op Amps

**741.** General-purpose workhorse. Frequency-compensated, 8-pin DIP. #276-007 ..... 79c

**1458 Dual Op Amp.** Internally compensated. Two independent op amps in an 8-pin DIP. Split supply, 5 to 16 VDC. #276-038 ..... 99c

**LM324 Quad Op Amp.** Operates on 3 to 30 VDC or split 1.5 to 15 VDC supply. 14-pin DIP. #276-1711 ..... 1.29

**TL082 Dual BIFET Op Amp.** Low-noise, high-Z inputs. Split 4 to 18 VDC supply. 8-pin DIP. #276-1715 ..... 1.89

**LM339 Quad Comparator.** Four independent voltage comparators in a 14-pin DIP. Single 2 to 32 VDC supply. #276-1712 ..... 99c

**LM567 Tone Detector.** Use for Touch-Tone, remote control and FSK decoding. Requires 4.75 to 9 VDC. 8-pin DIP. #276-1721 ..... 1.99

### Musical Chips

**UMC 3482 12-Tune Melody Synthesizer IC.** Just the thing for musical doorbells, clocks, games and phone music-on-hold. Has an on-chip audio preamp. Some of the tunes are Happy Birthday, Row-Row Your Boat and other all-time "camp" favorites. Operates on 1.5 VDC, 16-pin DIP. With data and circuit examples. #276-1797 ..... 2.99

**AY-3-8910A Programmable Sound Generator.** Produces an astonishing variety and range of sounds! Three independently programmable analog outputs. Single 5 VDC supply, 40-pin DIP. With Data. #276-1787 ..... 9.95

### CMOS and TTL ICs

All include pin-out and specs and are 100% prime.

Description	Type	Cat. No.	Each
Quad 2-Input NOR Gate	4001	276-2401	.99
Quad 2-Input NAND Gate	4011	276-2411	.99
Dual Type-D Flip Flop	4013	276-2413	1.19
Decade Counter/Divider	4017	276-2417	1.49
Inverting Hex Buffer	4049	276-2449	1.19
Quad Bilateral Switch	4066	276-2466	1.19

Description	Type	Cat. No.	Each
Quad 2-Input NAND Gate	7400	276-1801	.89
Hex Inverter	7404	276-1802	.99
Quad 2-Input AND Gate	7408	276-1822	1.29
BCD to 7-Seg. Driver	7447	276-1805	1.69
Div. by 2/5 BCD Counter	7490	276-1808	1.19

Over 1000 items in stock: Binding posts, Books, Breadboards, Buzzers, Capacitors, Chokes, Clips, Coax, Connectors, Fuses, Hardware, ICs, Jacks, Knobs, Lamps, Multitesters, PC Boards, Plugs, Rectifiers, Resistors, Switches, Tools, Transformers, Transistors, Wire, Zeners, more!

# Radio Shack®

A DIVISION OF TANDY CORPORATION

Prices apply at participating Radio Shack stores and dealers

\* Revolving credit from Radio Shack. Actual payment may vary depending on purchases.

**VISA** NATIONAL SEMICONDUCTOR • PANASONIC MACHINE • EWC, INC. • INTERSIL • AD EAC, INC. • W. MILLER • AAVI ENGINEER • E. F. JOHNSON • ATLANTIC SEMICONDUCTOR

**256K (262,144 x 1) DRAM 150NS \$5.70/1; \$39.95/9**

**Factory Firsts**

DIODES • DIAMOND TOOL • UNGAR • ES • CW INDUSTRIES • AMDEK • G.E. IGAR • YAGED • J. W. MILLER • LUXO SC CHEMICALS • ARIES • PLESSEY

### INTEGRATED CIRCUITS

Part No.	Price	7400 TTL
7400	1.80	7400
7401	1.80	7401
7402	1.80	7402
7403	1.80	7403
7404	1.80	7404
7405	1.80	7405
7406	1.80	7406
7407	1.80	7407
7408	1.80	7408
7409	1.80	7409
7410	1.80	7410
7411	1.80	7411
7412	1.80	7412
7413	1.80	7413
7414	1.80	7414
7415	1.80	7415
7416	1.80	7416
7417	1.80	7417
7418	1.80	7418
7419	1.80	7419
7420	1.80	7420
7421	1.80	7421
7422	1.80	7422
7423	1.80	7423
7424	1.80	7424
7425	1.80	7425
7426	1.80	7426
7427	1.80	7427
7428	1.80	7428
7429	1.80	7429
7430	1.80	7430
7431	1.80	7431
7432	1.80	7432
7433	1.80	7433
7434	1.80	7434
7435	1.80	7435
7436	1.80	7436
7437	1.80	7437
7438	1.80	7438
7439	1.80	7439
7440	1.80	7440

### INTEGRATED CIRCUITS

Part No.	Price	4000 CMOS
4000	1.80	4000
4001	1.80	4001
4002	1.80	4002
4003	1.80	4003
4004	1.80	4004
4005	1.80	4005
4006	1.80	4006
4007	1.80	4007
4008	1.80	4008
4009	1.80	4009
4010	1.80	4010
4011	1.80	4011
4012	1.80	4012
4013	1.80	4013
4014	1.80	4014
4015	1.80	4015
4016	1.80	4016
4017	1.80	4017
4018	1.80	4018
4019	1.80	4019
4020	1.80	4020
4021	1.80	4021
4022	1.80	4022
4023	1.80	4023
4024	1.80	4024
4025	1.80	4025
4026	1.80	4026
4027	1.80	4027
4028	1.80	4028
4029	1.80	4029
4030	1.80	4030
4031	1.80	4031
4032	1.80	4032
4033	1.80	4033
4034	1.80	4034
4035	1.80	4035
4036	1.80	4036
4037	1.80	4037
4038	1.80	4038
4039	1.80	4039
4040	1.80	4040

### T.I.C. SOCKETS

Part No.	Description	Price
CS08	8 pin socket, tin	1.15
CS14	14 pin socket, tin	1.45
CS18	18 pin socket, tin	1.70
CS20	20 pin socket, tin	1.90
CS22	22 pin socket, tin	2.10
CS24	24 pin socket, tin	2.30
CS26	26 pin socket, tin	2.50
CS28	28 pin socket, tin	2.70
CS30	30 pin socket, tin	2.90
CS32	32 pin socket, tin	3.10
CS34	34 pin socket, tin	3.30
CS36	36 pin socket, tin	3.50
CS38	38 pin socket, tin	3.70
CS40	40 pin socket, tin	3.90

### 5% Carbon Film Resistors

Part No.	Value	Price
R100	100 Ohm	0.05
R150	150 Ohm	0.05
R200	200 Ohm	0.05
R250	250 Ohm	0.05
R300	300 Ohm	0.05
R350	350 Ohm	0.05
R400	400 Ohm	0.05
R450	450 Ohm	0.05
R500	500 Ohm	0.05
R550	550 Ohm	0.05
R600	600 Ohm	0.05
R650	650 Ohm	0.05
R700	700 Ohm	0.05
R750	750 Ohm	0.05
R800	800 Ohm	0.05
R850	850 Ohm	0.05
R900	900 Ohm	0.05
R950	950 Ohm	0.05

### DISC CAPACITORS

Part No.	Value	Price
DC100	100 pF	0.05
DC150	150 pF	0.05
DC200	200 pF	0.05
DC250	250 pF	0.05
DC300	300 pF	0.05
DC350	350 pF	0.05
DC400	400 pF	0.05
DC450	450 pF	0.05
DC500	500 pF	0.05
DC550	550 pF	0.05
DC600	600 pF	0.05
DC650	650 pF	0.05
DC700	700 pF	0.05
DC750	750 pF	0.05
DC800	800 pF	0.05
DC850	850 pF	0.05
DC900	900 pF	0.05
DC950	950 pF	0.05

### TANTALUM CAPACITORS

Part No.	Value	Price
T100	100 uF	0.10
T150	150 uF	0.10
T200	200 uF	0.10
T250	250 uF	0.10
T300	300 uF	0.10
T350	350 uF	0.10
T400	400 uF	0.10
T450	450 uF	0.10
T500	500 uF	0.10
T550	550 uF	0.10
T600	600 uF	0.10
T650	650 uF	0.10
T700	700 uF	0.10
T750	750 uF	0.10
T800	800 uF	0.10
T850	850 uF	0.10
T900	900 uF	0.10
T950	950 uF	0.10

### 7400 TTL

Part No.	Price
7400	1.80
7401	1.80
7402	1.80
7403	1.80
7404	1.80
7405	1.80
7406	1.80
7407	1.80
7408	1.80
7409	1.80
7410	1.80
7411	1.80
7412	1.80
7413	1.80
7414	1.80
7415	1.80
7416	1.80
7417	1.80
7418	1.80
7419	1.80
7420	1.80
7421	1.80
7422	1.80
7423	1.80
7424	1.80
7425	1.80
7426	1.80
7427	1.80
7428	1.80
7429	1.80
7430	1.80
7431	1.80
7432	1.80
7433	1.80
7434	1.80
7435	1.80
7436	1.80
7437	1.80
7438	1.80
7439	1.80
7440	1.80

### 7400 CMOS

Part No.	Price
4000	1.80
4001	1.80
4002	1.80
4003	1.80
4004	1.80
4005	1.80
4006	1.80
4007	1.80
4008	1.80
4009	1.80
4010	1.80
4011	1.80
4012	1.80
4013	1.80
4014	1.80
4015	1.80
4016	1.80
4017	1.80
4018	1.80
4019	1.80
4020	1.80
4021	1.80
4022	1.80
4023	1.80
4024	1.80
4025	1.80
4026	1.80
4027	1.80
4028	1.80
4029	1.80
4030	1.80
4031	1.80
4032	1.80
4033	1.80
4034	1.80
4035	1.80
4036	1.80
4037	1.80
4038	1.80
4039	1.80
4040	1.80

### WIRE WRAP DIP SOCKETS

Part No.	Description	Price
CS08	8 pin wire wrap, tin	3.00
CS14	14 pin wire wrap, tin	4.00
CS18	18 pin wire wrap, tin	5.00
CS20	20 pin wire wrap, tin	6.00
CS22	22 pin wire wrap, tin	7.00
CS24	24 pin wire wrap, tin	8.00
CS26	26 pin wire wrap, tin	9.00
CS28	28 pin wire wrap, tin	10.00
CS30	30 pin wire wrap, tin	11.00
CS32	32 pin wire wrap, tin	12.00
CS34	34 pin wire wrap, tin	13.00
CS36	36 pin wire wrap, tin	14.00
CS38	38 pin wire wrap, tin	15.00
CS40	40 pin wire wrap, tin	16.00

### 1/4 Watt Carbon Film Resistors

Part No.	Value	Price
R100	100 Ohm	0.05
R150	150 Ohm	0.05
R200	200 Ohm	0.05
R250	250 Ohm	0.05
R300	300 Ohm	0.05
R350	350 Ohm	0.05
R400	400 Ohm	0.05
R450	450 Ohm	0.05
R500	500 Ohm	0.05
R550	550 Ohm	0.05
R600	600 Ohm	0.05
R650	650 Ohm	0.05
R700	700 Ohm	0.05
R750	750 Ohm	0.05
R800	800 Ohm	0.05
R850	850 Ohm	0.05
R900	900 Ohm	0.05
R950	950 Ohm	0.05

### DISC CAPACITORS

Part No.	Value	Price
DC100	100 pF	0.05
DC150	150 pF	0.05
DC200	200 pF	0.05
DC250	250 pF	0.05
DC300	300 pF	0.05
DC350	350 pF	0.05
DC400	400 pF	0.05
DC450	450 pF	0.05
DC500	500 pF	0.05
DC550	550 pF	0.05
DC600	600 pF	0.05
DC650	650 pF	0.05
DC700	700 pF	0.05
DC750	750 pF	0.05
DC800	800 pF	0.05
DC850	850 pF	0.05
DC900	900 pF	0.05
DC950	950 pF	0.05

### TANTALUM CAPACITORS

Part No.	Value	Price
T100	100 uF	0.10
T150	150 uF	0.10
T200	200 uF	0.10
T250	250 uF	0.10
T300	300 uF	0.10
T350	350 uF	0.10
T400	400 uF	0.10
T450	450 uF	0.10
T500	500 uF	0.10
T550	550 uF	0.10
T600	600 uF	0.10
T650	650 uF	0.10
T700	700 uF	0.10
T750	750 uF	0.10
T800	800 uF	0.10
T850	850 uF	0.10
T900	900 uF	0.10
T950	950 uF	0.10

### 7400 TTL

Part No.	Price
7400	1.80
7401	1.80
7402	1.80
7403	1.80
7404	1.80
7405	1.80
7406	1.80
7407	1.80
7408	1.80
7409	1.80
7410	1.80
7411	1.80
7412	1.80
7413	1.80
7414	1.80
7415	1.80
7416	1.80
7417	1.80
7418	1.



# TEST

# EQUIPMENT



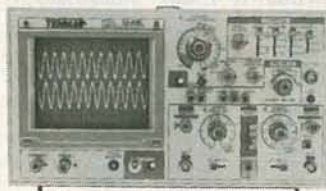
## TENMA 100MHz Multifunction Counter

- Eight digit non-glare LED display
- Selectable gate time
- Frequency, period, totalize and self test functions
- Data hold
- Selectable attenuator and variable trigger level
- Switchable AC and DC coupling systems #72-465



## TENMA 1GHz Multifunction Counter

- Eight digit non-glare LED display
- Selectable gate time
- Frequency, period, totalize and self test functions
- Data hold
- Selectable attenuator
- AC coupling system #72-460



## TENMA Dual Trace 35MHz Oscilloscope

- Two 10:1 probes included
- High brightness CRT with internal graticule
- 6KV accelerating potential
- 5x vertical and horizontal magnifiers
- Delayed triggering sweep
- Front panel electrical trace rotation
- Alternate triggering permits viewing of asynchronous channel A and channel B signals #72-330



## TENMA Sweep Generator

- Produces square, sine, triangle, ramp and pulse waveforms
- Continuously variable sweep width and time
- Variable and fixed output attenuators
- Voltage controlled frequency (VCF) input #72-475



## TENMA Pulse Generator

- TTL or CMOS pulse output
- Built-in logic tester
- Can be used with oscilloscope to provide sweep delay
- Variable pulse width and spacing #72-470

## TENMA AC Millivoltmeter

This is perfect for servicing and designing audio products as well as measuring the outputs of audio and video heads.

- 3 1/2" mirrored scale
- Calibrated in mV RMS and dB
- Amplified output for observing microvolt signals on oscilloscope
- Comes complete with test leads and owners manual #72-450



## TENMA Audio Generator

- Generates sine and square waveforms
- Six step and continuously variable attenuators
- External sync input
- Comes complete with test leads and owners manual #72-455



## Laser Power Meter

- Measures output of laser devices on audio and video disc players
- Two wavelengths and three power ranges give this instrument the versatility to be used in servicing the equipment of many CD and laser disc manufacturers #70-420



For more test equipment, see pages 145-158 of our newest catalog!

For A Wide Variety Of Electronic Parts  
Call Toll Free 1-800-543-4330

In Ohio, 1-800-762-4315 — In Alaska and Hawaii, 1-800-858-1849

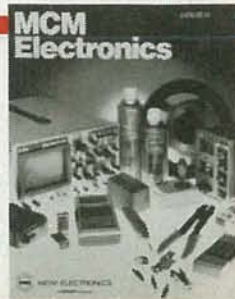
Circle 87 ON FREE INFORMATION CARD

© 1987, MCM ELECTRONICS

SOURCE NO. RE-38



**MCM ELECTRONICS**  
858 E. CONGRESS PARK DR.  
CENTERVILLE, OH 45459  
A PREMIER Company



# 20 MEG HARD DISK DRIVE ON A CARD

# \$349!

## STATIC RAMS / DYNAMIC RAMS

2101	256x4	(450ns)	1.95
2102L-4	1024x1	(450ns)(LowPower)	.99
2112	256x4	(450ns)	2.99
2114	1024x4	(450ns)	.99
2114L-4	1024x4	(450ns)(LP)	1.09
2114L-2	1024x4	(200ns)(LP)	1.49
2114L-15	1024x4	(150ns)(LP)	1.95
TMS4044-4	4096x1	(450ns)	1.95
TMM2016-150	2048x8	(150ns)	1.49
TMM2016-100	2048x8	(100ns)	1.95
HM6116-4	2048x8	(200ns)(CMOS)	1.79
HM6116-3	2048x8	(150ns)(CMOS)	1.85
HM6116LP-4	2048x8	(200ns)(CMOS)(LP)	1.85
HM6116LP-3	2048x8	(150ns)(CMOS)(LP)	1.90
HM6116LP-2	2048x8	(120ns)(CMOS)(LP)	2.45
HM6264P-15	8192x8	(150ns)(CMOS)	3.89
HM6264LP-15	8192x8	(150ns)(CMOS)(LP)	3.95
HM6264LP-12	8192x8	(120ns)(CMOS)(LP)	4.49
HM43256LP-15	32768x8	(150ns)(CMOS)(LP)	12.95
HM43256LP-12	32768x8	(120ns)(CMOS)(LP)	14.95
HM43256LP-10	32768x8	(100ns)(CMOS)(LP)	19.95
4116-250	16384x1	(150ns)	.49
4116-200	16384x1	(200ns)	.89
4116-150	16384x1	(150ns)	.99
4116-120	16384x1	(120ns)	1.49
MK4332	32768x1	(200ns)	6.95
4164-150	65536x1	(150ns)	1.29
4164-120	65536x1	(120ns)	1.55
MCM6665	65536x1	(200ns)	1.95
TMS4164	65536x1	(150ns)	1.95
4164-REFRESH	65536x1	(150ns)(PIN 1 REFRESH)	2.95
TMS4416	16384x4	(150ns)	3.75
41128-150	131072x1	(150ns)	5.95
TMS4464-15	65536x4	(150ns)	4.95
41256-150	262144x1	(150ns)	2.95
41256-120	262144x1	(120ns)	3.95
41256-100	262144x1	(100ns)	4.95
HM51258-100	262144x1	(100ns)(CMOS)	6.95
1 MB-120	1048576x1	(120ns)	19.95
1 MB-100	1048576x1	(100ns)	24.95

## ★★★★ HIGH-TECH ★★★★★

# 80387 \$495.00

- ★ 16 MEGAHERTZ MATH CO-PROCESSOR IN A PIN GRID ARRAY
- ★ FOR INTEL INBOARD AND OTHER 80386 BASED COMPUTERS
- ★ GET ALL THE SPEED AND POWER YOUR MACHINE CAN DELIVER
- ★ GREAT ADDITION FOR CAD, SPREADSHEET AND OTHER POWER PROGRAMS

## ★★★★ SPOTLIGHT ★★★★★

# U.S. AND CANADA ORDER TOLL FREE 800-538-5000



## EPROMS

2708	1024x8	(450ns)	4.95
2716	2048x8	(450ns)(5V)	3.49
2716-1	2048x8	(350ns)(5V)	3.95
TMS2532	4096x8	(450ns)(5V)	5.95
2732	4096x8	(450ns)(5V)	3.95
2732A	4096x8	(250ns)(5V)(21V PGM)	3.95
2732A-2	4096x8	(200ns)(5V)(21V PGM)	4.25
27C64	8192x8	(250ns)(5V)(CMOS)	4.95
2764	8192x8	(450ns)(5V)	3.49
2764-250	8192x8	(250ns)(5V)	3.49
2764-200	8192x8	(200ns)(5V)	4.25
MCM68766	8192x8	(350ns)(5V)(24 PIN)	15.95
27128	16384x8	(250ns)(5V)	4.25
27C256	32768x8	(250ns)(5V)(CMOS)	7.95
27256	32768x8	(250ns)(5V)	5.95
27512	65536x8	(250ns)(5V)	11.95
27C512	65536x8	(250ns)(5V)(CMOS)	12.95

5V-Single 5 Volt Supply 21V PGM-Program at 21 Volts

## SPECTRONICS CORPORATION EPROM ERASERS



Model	Timer	Capacity Chip	Intensity (uW/Cm <sup>2</sup> )	Unit Price
PE-14	NO	9	8,000	\$83.00
PE-14T	YES	9	8,000	\$119.00
PE-24T	YES	12	9,600	\$175.00

## 8000

8035	1.49
8039	1.95
8052AH BASIC	34.95
8080	2.95
8085	2.49
8087-2 5MHz	129.00
8088	169.95
8088-2	6.95
8155	9.95
8748	2.49
8755	7.95
80286	14.95
80287-6MHz	129.95
80287-8MHz	199.95
80287-10MHz	299.95

## V 20 SERIES

V20\* 5 MHz 8.95  
V20\* 8 MHz 10.95  
V30 8 MHz 13.95  
\*Replaces 8088 to speed up your PC by 10 to 40%

## CRT CONTROLLERS

6845	4.95
68B45	8.95
6847	11.95
HD46505SP	6.95
MC1372	2.95
8275	26.95
7220	19.95
CRT5027	12.95
CRT5037	9.95
TMS9918A	19.95

## 8200

8205	3.29
8212	1.49
8216	1.49
8224	2.25
8237	4.95
8237-5	5.49
8250	6.95
8251	1.69
8251A	1.89
8253	1.89
8253-5	1.95
8255	1.69
8255-5	1.89
8259	1.95
8259-5	2.29
8272	4.95
8279	2.49
8279-5	2.95
8282	3.95
8284	2.95
8286	3.95
8288	4.95

## DISK CONTROLLERS

1771	4.95
1791	9.95
1793	9.95
1795	12.95
1797	12.95
2791	19.95
2793	19.95
2797	29.95
8272	4.95
UPD765	4.95
MB8876	12.95
MB8877	12.95
1691	6.95
2143	6.95
9216	7.95

## Z-80

Z80-CPU 2.5 MHz	1.69
4.0 MHz	
Z80A-CPU	1.79
Z80A-CTC	1.89
Z80A-DART	5.95
Z80A-DMA	5.95
Z80A-PIO	1.89
Z80A-SIO-0	1.95
Z80A-SIO-1	5.95
Z80A-SIO-2	5.95

## BIT RATE GENERATORS

MC14411	9.95
BR1941	4.95
4702	9.95
COM8116	8.95

## UARTS

AY5-1013	3.95
AY3-1015	4.95
TR1602	3.95
2651	4.95
IM6402	6.95
IM6403	9.95
INS8250	9.95
NS16450	15.95

## CLOCK CIRCUITS

MMS369	1.95
MMS369-EST	1.95
MMS167	12.95
MMS174	11.95
MMS5832	2.95

## 6500

1.0 MHz	
6502	2.69
65C02 (CMOS)	12.95
6507	9.95
6520	1.95
6522	4.95
6526	26.95
6532	6.95
6545	6.95
6551	5.95
6551	19.95
6581	34.95

## 2.0 MHz

6502A	2.95
6520A	2.95
6522A	5.95
6532A	11.95
6545A	7.95
6551A	5.95

## 3.0 MHz

6502B	6.95
-------	------

## CRYSTALS

32.768 KHz	.95
1.0 MHz	2.95
1.8432	2.95
2.0	1.95
2.097152	1.95
2.4576	1.95
3.2768	1.95
3.579545	1.95
4.0	1.95
4.032	1.95
5.0	1.95
5.0688	1.95
6.0	1.95
6.144	1.95
6.5536	1.95
8.0	1.95
10.0	1.95
10.738635	1.95
12.0	1.95
14.31818	1.95
15.0	1.95
16.0	1.95
17.430	1.95
18.0	1.95
18.432	1.95
20.0	1.95
22.1184	1.95
24.0	1.95
32.0	1.95

## CRYSTAL OSCILLATORS

1.0MHz	5.95
1.8432	5.95
2.0	5.95
2.4576	5.95
2.5	4.95
4.0	4.95
5.0688	4.95
6.0	4.95
6.144	4.95
8.0	4.95
10.0	4.95
12.0	4.95
14.31818	4.95
15.0	4.95
16.0	4.95
17.430	4.95
18.0	4.95
18.432	4.95
20.0	4.95
22.1184	4.95
24.0	4.95
32.0	4.95

## MISC.

MAX232	7.95
TMS99532	19.95
UL14003	7.95
3242	7.95
3341	4.95
MC3470	1.95
MC3480	8.95
MC3487	2.95
11C90	19.95
2513-001 UP	6.95
AY5-2376	11.95
AY5-3600 PRO	11.95

## 74LS00

74LS00	.16	74LS165	.65
74LS01	.18	74LS166	.95
74LS02	.17	74LS169	.95
74LS03	.18	74LS173	.49
74LS04	.16	74LS174	.39
74LS05	.18	74LS175	.39
74LS08	.18	74LS191	.49
74LS09	.18	74LS192	.65
74LS10	.16	74LS193	.69
74LS11	.22	74LS194	.69
74LS12	.22	74LS195	.69
74LS13	.26	74LS196	.59
74LS14	.39	74LS197	.59
74LS15	.26	74LS221	.59
74LS16	.17	74LS240	.69
74LS21	.22	74LS241	.69
74LS22	.22	74LS242	.69
74LS27	.23	74LS243	.69
74LS28	.26	74LS244	.69
74LS30	.17	74LS245	.79
74LS32	.18	74LS251	.49
74LS33	.28	74LS253	.49
74LS34	.26	74LS256	1.79
74LS38	.26	74LS257	.39
74LS42	.39	74LS258	.49
74LS47	.75	74LS259	1.29
74LS48	.85	74LS260	.49
74LS51	.17	74LS266	.39
74LS73	.29	74LS273	.79
74LS74	.28	74LS279	.39
74LS75	.29	74LS280	1.98
74LS76	.29	74LS283	.59
74LS83	.49	74LS290	.89
74LS85	.49	74LS293	.89
74LS86	.22	74LS299	1.49
74LS90	.39	74LS322	3.95
74LS92	.49	74LS323	2.49
74LS93	.39	74LS364	1.95
74LS95	.49	74LS365	.39
74LS107	.34	74LS367	.39
74LS109	.36	74LS368	.39
74LS112	.29	74LS373	.79
74LS122	.45	74LS374	.79
74LS123	.28	74LS375	.95
74LS124	2.75	74LS377	.79
74LS125	.39	74LS378	1.18
74LS126	.39	74LS390	1.19
74LS132	.39	74LS393	.79
74LS133	.49	74LS541	1.49
74LS136	.39	74LS624	1.95
74LS138	.39	74LS640	.99
74LS139	.39	74LS645	.99
74LS145	.99	74LS669	1.29
74LS147	.99	74LS670	.89
74LS148	.99	74LS682	3.20
74LS151	.39	74LS683	3.20
74LS153	.39	74LS684	3.20
74LS154	1.49	74LS688	2.40
74LS155	.59	74LS783	22.95
74LS156	.49	81LS95	1.49
74LS157	.35	81LS96	1.49
74LS158	.29	81LS97	1.49
74LS160	.29	81LS98	1.49
74LS161	.39	25LS2521	2.80
74LS162	.49	26LS2569	2.80
74LS163	.39	74F32	.69
74LS164	.49	26LS32	1.95

## HIGH SPEED CMOS

A new family of high speed CMOS logic featuring the speed of low power Schottky (8ns typical gate propagation delay), combined with the advantages of CMOS: very low power consumption, superior noise immunity, and improved output drive.

## 74HC00

74HC: Operate at CMOS logic levels and are ideal for new, all-CMOS designs

# EGA CARD AND MONITOR NOW \$499!

## MONITOR STANDS

- MODEL MS-100 \$12.95**  
 • TILTS AND SWIVELS  
 • STURDY ABS PLASTIC CONSTRUCTION
- MODEL MS-200 \$39.95**  
 • TILTS AND SWIVELS  
 • BUILT-IN POWER STATION  
 INDEPENDENTLY CONTROLS UP TO 5  
 120 VOLT AC OUTLETS  
 • BUILT-IN SURGE SUPPRESSOR  
 • UL APPROVED



## CRT MONITORS FOR ALL APPLICATIONS



- CASPER EGA MONITOR**  
 • EGA & CGA COMPATIBLE  
 • SCANNING FREQUENCIES:  
 15.75 / 21.85 KHz  
 • RES: 640 x 200 / 350  
 • .31mm DOT PITCH, 25 MHz  
 • 16 COLORS OUT OF 64  
 • 14" BLACK MATRIX SCREEN
- CASPER RGB MONITOR**  
 • COLOR GREEN, AMBER  
 SWITCH ON REAR  
 • DIGITAL RGB-IBM COMPATIBLE  
 • 14" NON-GLARE SCREEN  
 • RESOLUTION: 640H x 240V  
 • .39mm DOT PITCH  
 • CABLE FOR IBM PC INCLUDED
- FORTRONICS MONOCHROME**  
 • IBM COMPATIBLE TTL INPUT  
 • 12" NON-GLARE SCREEN  
 • VERY HIGH RESOLUTION,  
 1100 LINES (CENTER)  
 • 25 MHz BANDWIDTH  
 • CABLE FOR IBM PC INCLUDED  
 AMBER OR GREEN AVAILABLE

**\$399.95      \$279.95      \$99.95**

## SOLDER STATION

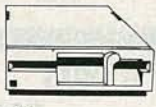
- JDR PART #: 168-2C  
 • FULLY ADJUSTABLE HEAT  
 SETTING WITH TIP TEMP.  
 ERATURE READOUT  
 • QUICK HEATING AND  
 RECOVERY  
 • VARIETY OF REPLACEMENT  
 TIPS ARE AVAILABLE  
 • RANGE: 200°-900°F  
 • UL APPROVED

**\$49.95**



## DISK DRIVES FOR APPLE COMPUTERS

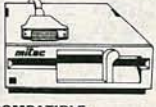
- AP-150 \$99.95**  
 • 1/2 HT, DIRECT DRIVE  
 • 100% APPLE COMPATIBLE  
 • SIX MONTH WARRANTY



- AP-135 \$129.95**  
 • FULL HT SHUGART MECHANISM  
 • DIRECT REPLACEMENT FOR APPLE  
 DISK II  
 • SIX MONTH WARRANTY



- AD-3C \$139.95**  
 • 100% APPLE IIc COMPATIBLE,  
 READY TO PLUG IN, W/ SHIELDED  
 CABLE & MOLDED 19 PIN  
 CONNECTOR  
 • FAST, RELIABLE SLIMLINE DIRECT  
 DRIVE  
 • SIX MONTH WARRANTY



- DISK DRIVE ACCESSORIES**  
 FDD CONTROLLER CARD \$49.95  
 IIc ADAPTOR CABLE \$19.95  
 ADAPTS STANDARD APPLE DRIVES  
 FOR USE WITH APPLE IIc

## APPLE COMPATIBLE INTERFACE CARDS



- EPROM PROGRAMMER**  
 • DUPLICATE OR BURN ANY  
 27xx SERIES EPROM  
 (2716 TO 27128)  
 • MENU-DRIVEN SOFTWARE  
 • HIGH SPEED WRITE ALGO-  
 RITHM  
**RP-525 \$59.95**
- 16K RAMCARD**  
 • FULL 2 YEAR WARRANTY  
 • EXPAND YOUR 48K MACHINE  
 TO A FULL 64K OF MEMORY  
 • CAN BE USED IN PLACE OF  
 THE APPLE LANGUAGE CARD  
**RAM-CARD \$39.95**
- IC TEST CARD**  
 • QUICKLY TESTS MANY  
 COMMON ICs  
 • DISPLAYS PASS OR FAIL  
 • TEST 4000 & 74HC SERIES  
 CMOS, 7400, 74LS, 74L,  
 74H & 74S  
**IC-TESTER \$129.95**

## MOLDED INTERFACE CABLES

- 6 FOOT, 100% SHIELDED, MEETS FCC
- IBM PARALLEL PRINTER CABLE** 9.95  
**CENTRONICS (MALE TO FEMALE)** 15.95  
**CENTRONICS (MALE TO MALE)** 14.95  
**MODEM CABLE (FOR IBM)** 7.95  
**RS232 SERIAL (MALE TO FEMALE)** 9.95  
**RS232 SERIAL (MALE TO MALE)** 9.95  
**KEYBOARD EXTENDER (COILED)** 7.95  
**APPLE II JOYSTICK EXTENDER** 4.95



## C. ITOH RITEMAN II PRINTER



- 160 CPS DRAFT, 32 CPS NLQ  
 • 9 x 9 DOT MATRIX  
 • SUPPORTS EPSON/IBM GRAPHICS  
 • FRICTION AND PIN FEEDS  
 • VARIABLE LINE SPACING AND PITCH
- \$219.95**  
 IBM PRINTER CABLE \$8.95  
 REPLACEMENT RIBBON CARTRIDGE \$7.95

## SWITCH BOXES

- ALL LINES SWITCHED, GOLD PLATED  
 CONNECTORS, QUALITY SWITCHES
- 2 WAY \$39.95**  
 • CONNECTS 2 PRINTERS TO 1  
 COMPUTER OR VICE VERSA
- AB-P (CENTRONICS PARALLEL)**  
**AB-S (RS232 SERIAL)**
- 3 WAY \$99.95**  
 • CONNECTS 3 PRINTERS TO 1  
 COMPUTER OR VICE VERSA
- SWITCH-3P (CENTRONICS PARALLEL)**  
**SWITCH-3S (RS232 SERIAL)**



## NASHUA DISKETTES

- NASHUA DISKETTES WERE JUDGED TO HAVE  
 THE HIGHEST POLISH AND RECORDED  
 AMPLITUDE OF ANY DISKETTES TESTED  
 (COMPARING FLOPPY DISKS, BYTE 9/84)
- N-MD2D DS/DD 5 1/4" SOFT \$9.90**  
**N-MD2F DS/QUAD 5 1/4" SOFT \$19.95**  
**N-MD2H DS/HD 5 1/4" FOR AT \$24.95**  
**N-FD1 SS/DD 8" SOFT \$27.95**  
**N-FD2D DS/DD 8" SOFT \$34.95**

## BULK DISKETTE SALE

- 5 1/4" SOFT SECTOR, DS/DD  
 W/TYVEC SLEEVES & HUB RINGS
- \$9.90** BOX OF 10    **69¢ea** BULK QTY 50    **59¢ea** BULK QTY 250

## DISKETTE FILES

- 5 1/4" DISKFILE HOLDS 70 \$8.95**  
**3 1/2" DISKFILE HOLDS 40 \$9.95**



## 20 MEGABYTE HARD DISK CARD



- SAVES SPACE AND REDUCES POWER  
 CONSUMPTION  
 • IDEAL FOR PCs WITH FULL HEIGHT  
 FLOPPIES  
 • LEAVES ROOM FOR A HALF LENGTH  
 CARD IN ADJACENT SLOT
- NOW \$349**

## Seagate 5 1/4" HARD DISK DRIVES

- ST-225 HALF HT 20MB 65ms \$275  
 ST-238 HALF HT 30MB 65ms (RL) \$299  
 ST-251 HALF HT 40MB 40ms \$469  
 ST-277 HALF HT 60MB 40ms (RL) \$649  
 ST-4038 FULL HT 30MB 40ms \$559  
 ST-4096 FULL HT 80MB 28ms \$1195

## 1/2" HEIGHT FLOPPY DISK DRIVES

- 5 1/4" TEAC FD-55B DS/DD \$109.95  
 5 1/4" TEAC FD-55F DS/QUAD \$124.95  
 5 1/4" TEAC FD-55GFV DS/HD \$154.95  
 5 1/4" MITSUBISHI DS/HD \$119.95  
 3 1/2" FDD KIT DS/DD \$149.95  
 KIT INCLUDES MOUNTING HARDWARE TO  
 FIT 5 1/4" SLOT, AT & XT VERSIONS AVAILABLE

## DISK DRIVE ACCESSORIES

- TEAC SPECIFICATION MANUAL \$5.00  
 TEAC MAINTENANCE MANUAL \$25.00  
 1/2" HT MNTG HARDWARE FOR IBM \$2.95  
 MOUNTING RAILS FOR IBM AT \$4.95  
 "Y" POWER CABLE FOR 5 1/4" FDDs \$2.95  
 5 1/4" FDD POWER CONNECTORS \$1.19

## DISK DRIVE ENCLOSURES WITH POWER SUPPLIES

- CAB-2SV5 DUAL SLIMLINE 5 1/4" \$49.95**  
**CAB-1FH5 FULL HT 5 1/4" \$69.95**  
**CAB-2SV8 DUAL SLIMLINE 8" \$209.95**  
**CAB-2FH8 DUAL FULL HT 8" \$219.95**

## BUILD STEVE GIARCIA'S INTELLIGENT EPROM PROGRAMMER

- AS SEEN IN BYTE, OCT. 86
- STAND-ALONE OR RS-232 SERIAL  
 OPERATION  
 • MENU SELECTABLE EPROM TYPES—  
 NO CONFIGURATION JUMPERS  
 • PROGRAMS ALL 5V 27XXX EPROMS  
 FROM 2716 TO 27512  
 • READ, COPY OR VERIFY EPROM  
 • UPLOAD / DOWNLOAD INTEL HEX FILES  
 • PROGRAMMER DRIVER USER  
 MODIFIABLE
- Kit includes PCB  
 & all components  
 except case &  
 power supply
- \$199**

## KB-1000 \$79.95

- CASE WITH KEYBOARD  
 FOR APPLE TYPE MOTHERBOARD
- USER DEFINED FUNCTION KEYS  
 • NUMERIC KEYPAD W/ CURSOR CONTROL  
 • CAPS LOCK      • AUTO-REPEAT



## JOYSTICK GC-10 \$19.95

- SET X-Y AXIS FOR AUTO CENTER OR  
 FREE MOVEMENT  
 • FIRE BUTTON FOR USE WITH GAME  
 SOFTWARE  
 • ATTRACTIVE, SOLID, PLASTIC CASE  
 • INCLUDES ADAPTOR CABLE FOR IBM,  
 APPLE II, IIc



## POWER STRIP \$9.95

- JDR PART #: POWER-STRIP
- 15 AMP CIRCUIT BREAKER  
 • 6 RECEPTACLES  
 • 6 FOOT POWER CORD  
 • PILOT SWITCH
- WITH SURGE PROTECTION**  
 JDR PART #: MT-660  
**\$12.95**

CALL FOR VOLUME QUOTES      COPYRIGHT 1987 JDR MICRODEVICES

CIRCLE 182 ON FREE INFORMATION CARD

NOVEMBER 1987

# 20 MEG HARD DISK DRIVE ON A CARD

# \$349!

## TOTAL SYSTEM CONTROL FROM A SINGLE SLOT

SAVE THOSE VALUABLE SLOTS FOR SPECIALITY CARDS

### MCT-MGMIO \$119.95

- HERCULES COMPATIBLE MONO-GRAPHICS, 720 x 384 PIXELS
- GAME PORT
- PARALLEL PORT & CLOCK/CALENDAR
- SERIAL PORT INCLUDED, OPTIONAL 2nd SERIAL AVAILABLE
- SUPPORTS BOTH DS/DD & DS/QD USING DOS 3.2 OR HIGHER



## QUALITY IBM COMPATIBLE MOTHERBOARDS

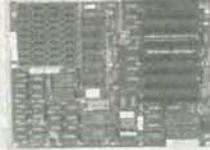
### TURBO 4.77 / 8 MHZ \$109.95

JDR PART #: MCT-TURBO

- 4.77 OR 8 MHZ OPERATION WITH 8088-2 & OPTIONAL 8087-2 CO-PROCESSOR
- DYNAMICALLY ADJUSTS SPEED DURING DISKETTE OPERATION FOR MAXIMUM THROUGHPUT AND RELIABILITY
- CHOICE OF NORMAL / TURBO MODE OR SOFTWARE SELECT PROCESSOR SPEED

### STANDARD MOTHERBOARD \$97.95

JDR PART #: MCT-XTMB



### 80286 6 / 8 MHZ \$379.95

JDR PART #: MCT-ATMB

- 8 SLOT (2 EIGHT BIT, 6 SIXTEEN BIT) AT MOTHERBOARD
- HARDWARE SELECTION OF 6 OR 8 MHZ
- 1 WAIT STATE
- RESET SWITCH, FRONT PANEL LED INDICATOR AND KEYLOCK SUPPORTED
- SOCKETS FOR 1 MB OF RAM AND 80287 ON BOARD
- ON BOARD BATTERY BACKED CLOCK OPERATES WITH PC-DOS OR MS-DOS



## IBM COMPATIBLE 3 1/2" FDD KIT

JDR PART #: FDD-3.5 KIT

- 720K FORMAT, DOS 3.2 COMPATIBLE
- ALLOWS DATA INTERCHANGE WITH NEW IBM MACHINES
- MOUNTING HARDWARE FOR 5 1/4" SLOT
- BOTH AT & XT VERSIONS AVAILABLE

# \$149.95

## IBM COMPATIBLE FLOPPY DISK DRIVE

JDR PART #: FDD-360

- GOOD QUALITY DRIVES BY MAJOR MANUFACTURERS SUCH AS QUME, TANDON & CDC
- 5 1/4" HALF HEIGHT
- 360K STORAGE CAPACITY
- DS/DD
- 48 TPI

# \$69.95

## IBM XT STYLE COMPUTER CASE

AN ATTRACTIVE STEEL CASE WITH A HINGED LID. FITS THE POPULAR PC/XT COMPATIBLE MOTHERBOARDS



- SWITCH CUT-OUT ON SIDE FOR PC/XT STYLE POWER SUPPLY
- CUT-OUT FOR 8 EXPANSION SLOTS
- INCLUDES SPEAKER
- ALL HARDWARE INCLUDED

# \$34.95

- XT STYLE SLIDE TYPE CASE \$39.95
- AT STYLE SLIDE TYPE CASE \$89.95

## NICKEL EXPRESS PC/XT SPEED UP KIT FROM RIM ELECTRONICS

- INCREASE THE SPEED OF YOUR PC / XT OR CLONE BY 67% OR MORE!
- SIMPLE NO-SLOT INSTALLATION
- SOFTWARE OR HARDWARE SPEED SELECTION
- 8 MHZ V20 PROCESSOR & SOFTWARE INCLUDED
- SELECT FOR 3 TURBO FREQUENCIES
- EXTERNAL RESET SWITCH
- OPTIONAL 8088 8 MHZ PROCESSOR AVAILABLE
- KIT INCLUDES CABLING, TEST CLIP AND SWITCHES

# \$69.95

PLEASE NOTE: Certain early PCs may not run at 8 MHz; these machines may be switched to one of the slower speeds: 6.06 MHz-40% 7.37 MHz-55% 8.0 MHz-67%

## IBM COMPATIBLE KEYBOARDS



### MCT-5060 \$59.95

- IBM AT STYLE LAYOUT
- SOFTWARE AUTONSENSE FOR XT OR AT COMPATIBLES
- EXTRA LARGE SHIFT & RETURN KEYS
- LED INDICATORS FOR SCROLL, CAPS & NUMBER LOCK
- AUTO REPEAT FEATURE



### MCT-5339 \$79.95

- IBM ENHANCED STYLE LAYOUT
- SOFTWARE AUTONSENSE FOR XT OR AT COMPATIBLES
- 12 FUNCTION KEYS
- EXTRA LARGE SHIFT & RETURN KEYS
- LED INDICATORS FOR SCROLL, CAPS & NUMBER LOCK
- AUTO REPEAT FEATURE
- SEPARATE CURSOR PAD

### MCT-5150 \$49.95

XT STYLE LAYOUT

### MCT-5151 \$69.95

KB5151- EQUIVALENT

## EASYDATA MODEMS

All models feature auto-dial/answer/redial on busy, Hayes compatible, power up self test, touchtone or pulse dialing, built-in speaker, PC Talk III Communications software, Bell Systems 103 & 212A full or half duplex and more.

### INTERNAL

### EASYDATA-12H \$79.95

1200 BAUD HALF CARD

### EASYDATA-12B \$99.95

1200 BAUD 10" CARD

### EASYDATA-24B \$179.95

2400 BAUD FULL CARD

### EXTERNAL

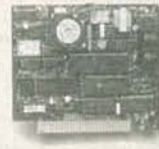
NO SOFTWARE INCLUDED

### EASYDATA-12D \$119.95

1200 BAUD

### EASYDATA-24D \$219.95

2400 BAUD



## MCT DISPLAY CARDS

### MCT-EGA

# \$149.95

100% IBM COMPATIBLE, PASSES IBM EGA DIAGNOSTICS

- COMPATIBLE WITH IBM EGA, COLOR GRAPHICS AND MONOCHROME ADAPTORS
- TRIPLE SCANNING FREQUENCY FOR DISPLAY ON EGA, STANDARD RGB OR HIGH RESOLUTION MONOCHROME MONITOR
- FULL 256K OF VIDEO RAM ALLOWS 640 x 350 PIXELS IN 16 OF 64 COLORS
- LIGHT PEN INTERFACE



### MCT-CG

# \$49.95

COMPATIBLE WITH IBM COLOR GRAPHICS STANDARD

- SHORT SLOT CARD USES VLSI CHIPS TO INSURE RELIABILITY
- SUPPORTS RGB, COMPOSITE MONOCHROME & COLOR AND AN RF MODULATOR OUTPUT
- 320 x 200 COLOR GRAPHICS MODE
- 640 x 200 MONO GRAPHICS MODE
- LIGHT PEN INTERFACE



### MCT-MGP

# \$59.95

COMPATIBLE WITH IBM MONOCHROME AND HERCULES GRAPHICS STANDARDS

- SHORT SLOT CARD USES VLSI CHIPS TO INSURE RELIABILITY
- PARALLEL PRINTER PORT, CONFIGURABLE AS LPT1 OR LPT2
- 720 x 348 GRAPHICS MODE
- LOTUS COMPATIBLE
- CAN RUN WITH COLOR GRAPHICS CARD IN THE SAME SYSTEM



## MCT DEVELOPMENT TOOLS

### MCT-PAL

### PAL PROGRAMMER

# \$269.95

ONE ARRAY LOGIC CHIP CAN REPLACE 4-5 TTL ICs

- PROGRAMS 20 & 24 PIN PALS FROM TI, NSC & MMI
- EASY TO USE MENU-DRIVEN SOFTWARE ALLOWS PROGRAMMING, VERIFICATION READING, MAP BUILDING & BURNING THE SECURITY FUSE
- READ AND SAVE BURN PROFILES IN JEDEC FORMAT ON YOUR DISK



### CUPL STARTER KIT

\$49.95

### MCT-MP

### MICROPROCESSOR PROGRAMMER

# \$199.95

PROGRAMS 8741/218/9 PROCESSOR CHIPS

- EASY TO USE MENU-DRIVEN SOFTWARE SUPPORTS READ, WRITE, BLANK CHECK AND VERIFY OPERATIONS
- PORT ADDRESS SELECTION IS USER CONFIGURABLE
- SAVE AND RESTORE PROGRAM IMAGES ON DISK
- INCLUDES SOFTWARE FOR STANDARD HEX AND INTEL HEX FORMATS



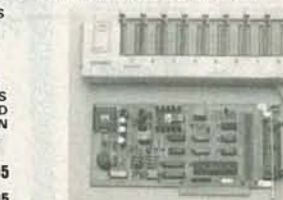
### MCT-EPROM

### EPROM PROGRAMMERS

# \$129.95

PROGRAMS 27xx AND 27xxx SERIES EPROMS UP TO 27512

- SUPPORTS VARIOUS MANUFACTURERS FORMATS WITH 12.5, 21 AND 25 VOLT PROGRAMMING
- MENU-DRIVEN SOFTWARE ALLOWS EASY MANIPULATION OF DATA FILES
- SPLIT OR COMBINE THE CONTENTS OF SEVERAL EPROMS OF DIFFERENT SIZES
- READ, WRITE, COPY, ERASE CHECK AND VERIFY WITH EASY ONE KEY SELECTION
- INCLUDES SOFTWARE FOR STANDARD HEX AND INTEL HEX FORMATS



### 4 GANG PROGRAMMER \$189.95

### 10 GANG PROGRAMMER \$299.95

MCT PRODUCTS CARRY A ONE YEAR WARRANTY

COPYRIGHT 1987 JDR MICRODEVICES

**MODEM 1200 BAUD \$79.95**

**FOR IBM WITH SOFTWARE**

**MODEM 2400 BAUD \$179.95**

**MULTIFUNCTION CARDS**

FROM MODULAR CIRCUIT TECHNOLOGY

**MCT-MF \$79.95**

ALL THE FEATURES OF AST'S SIX PACK PLUS AT HALF THE PRICE!

- 0-348K DYNAMIC RAM USING 4164s
- INCLUDES SERIAL PORT, PARALLEL PRINTER PORT, GAME CONTROLLER PORT AND CLOCK/CALENDAR
- SOFTWARE FOR A RAMDISK, PRINT SPOOLER AND CLOCK/CALENDAR



**MCT-ATMF \$139.95**

ADDS UP TO 3 MB OF 1 BIT RAM TO THE AT

- USER EXPANDABLE TO 1.5 MB OF ON-BOARD MEMORY (NO MEMORY INSTALLED)
- FLEXIBLE ADDRESS CONFIGURATION
- INCLUDES SERIAL PORT AND PARALLEL PORT
- OPTIONAL PIGGYBACK BOARD PERMITS EXPANSION TO 3 MB



**ATMF-SERIAL 2nd SERIAL PORT \$24.95**  
**MCT-ATMF-MC \$29.95**  
PIGGYBACK BOARD (ZERO K INSTALLED)

**MCT-MIO \$79.95**

A PERFECT COMPANION FOR OUR MOTHERBOARD

- 2 DRIVE FLOPPY DISK CONTROLLER
- INCLUDES SERIAL PORT, PARALLEL PORT, GAME PORT AND CLOCK/CALENDAR WITH BATTERY BACK-UP
- SOFTWARE FOR A RAMDISK, PRINT SPOOLER AND CLOCK/CALENDAR



**MIO-SERIAL 2nd SERIAL PORT \$15.95**

**MCT-IO \$59.95**

USE WITH MCT-FH FOR A MINIMUM OF SLOTS USED

- SERIAL PORT ADDRESSABLE AS COM1, COM2, COM3 OR COM4
- PARALLEL PRINTER PORT ADDRESSABLE AS LPT1 OR LPT2 (x378 OR x278)
- CLOCK/CALENDAR WITH A BATTERY BACK-UP



**IO-SERIAL 2nd SERIAL PORT \$15.95**

**MCT-ATIO \$59.95**

USE WITH MCT-ATFH FOR A MINIMUM OF SLOTS USED

- SERIAL PORT ADDRESSABLE AS COM1, COM2, COM3 OR COM4
- PARALLEL PRINTER PORT ADDRESSABLE AS LPTA OR LPTB (x378 OR x278)
- GAME PORT
- USES 16450 SERIAL SUPPORT CHIPS FOR HIGH SPEED OPERATION IN AN AT



**ATIO-SERIAL 2nd SERIAL PORT \$24.95**

**RAM CARDS**

FROM MODULAR CIRCUIT TECHNOLOGY

**MCT-RAM \$59.95**

A CONTIGUOUS MEMORY SOLUTION FOR YOUR SHORT OR REGULAR SLOT

- SHORT SLOT, LOW POWER PC COMPATIBLE DESIGN
- CAN OFFER UP TO 576K OF ADDITIONAL MEMORY
- USER SELECTABLE CONFIGURATION AMOUNTS OF 192, 384, 512, 256 & 576K, USING COMBINATIONS OF 64 & 256K RAM



**MCT-EMS \$129.95**

2MB OF LOTUS/INTEL/MICROSOFT COMPATIBLE MEMORY FOR THE XT

- CONFORMS TO LOTUS/INTEL EMS
- USER EXPANDABLE TO 2 MB
- USES 64K OR 256K DYNAMIC RAM (NO MEMORY INSTALLED)
- USE AS EXPANDED OR CONVENTIONAL MEMORY, RAMDISK OR SPOOLER
- SOFTWARE INCLUDES EMS DEVICE DRIVERS, PRINT SPOOLER AND RAMDISK



**MCT-ATEMS \$139.95**

CAN BE USED FOR CONVENTIONAL, EXPANDED OR EXTENDED MEMORY

- A FINE EXAMPLE OF FLEXIBILITY: OFFERS EXTENDED (AT MEMORY) OR EXPANDED (LIM/EMS) MEMORY AS WELL AS THE ABILITY TO FILL OUT CONVENTIONAL (640K) MEMORY
- 2 MEGABYTE CAPACITY IN A SINGLE SLOT
- RAMDISK, PRINT SPOOLER AND LIM/EMS SOFTWARE INCLUDED
- SPECIAL MEMORY MAP ANALYSIS INCLUDED



**MCT-ATEMS-MC \$34.95**  
PIGGYBACK BOARD (ZERO K INSTALLED)



**HALF HEIGHT HARD DISK DRIVES**

**40 MB**

**60 MB**

Model ST-251 5 1/4" half height  
FAST 40ms access time

Model ST-277 5 1/4" half height  
FAST 40ms access time (RLL)

**\$469**

**\$649**

**HALF HEIGHT HARD DISK SYSTEMS**

**20 MB**

**30 MB**

**\$299**

**\$329**

Systems include half height hard disk drive, hard disk drive controller, cables and instructions. All drives are pre-tested and warranted for one year.

**DISK CONTROLLER CARDS**

FROM MODULAR CIRCUIT TECHNOLOGY

**MCT-FDC \$29.95**

QUALITY DESIGN OFFERS 4 FLOPPY CONTROL IN A SINGLE SLOT

- INTERFACES UP TO 4 FDDs TO AN IBM PC OR COMPATIBLE
- INCLUDES CABLING FOR 2 INTERNAL DRIVES
- USES STANDARD DB37 CONNECTOR FOR EXTERNAL DRIVES
- SUPPORTS BOTH DS/ DD AND DS/ QD WHEN USED W/ DOS 3.2 OR JFORMAT



**MCT-HDC \$79.95**

HARD DISK CONTROL FOR WHAT OTHERS CHARGE FOR FLOPPY CONTROL

- IBM XT COMPATIBLE CONTROLLER SUPPORTS 16 DRIVE SIZES INCLUDING 5, 10, 20, 30 & 40MB
- OPTIONS INCLUDE THE ABILITY TO DIVIDE 1 LARGE DRIVE INTO 2 SMALLER, LOGICAL DRIVES
- INCLUDES CABLING FOR 1 INTERNAL DRIVE



**MCT-RLL \$119.95**

GET UP TO 50% MORE STORAGE SPACE ON YOUR HARD DISK

- INCREASES THE CAPACITY OF PLATED MEDIA DRIVES BY 50%
- RLL 2,7 ENCODING FOR MORE RELIABLE STORAGE
- TRANSFER RATE IS ALSO 50% FASTER; 750K/sec vs 500K/sec
- USE WITH ST-238 DRIVE TO ACHIEVE 30 MB IN A HALF HEIGHT SLOT



**MCT-FH \$139.95**

STARVED FOR SLOTS? SATISFY IT WITH THIS TIMELY DESIGN

- INTERFACES UP TO 2 FDDs & 2 HDDs
- CABLING FOR 2 FDDs & 1 HDD
- FLOPPY INTERFACE SUPPORTS BOTH DS/ DD & DS/ QD WHEN USED WITH DOS 3.2 OR JFORMAT
- ALL POPULAR HDD SIZES ARE SUPPORTED, INCLUDING 5, 10, 20, 30 & 40MB
- CAN DIVIDE 1 LARGE DRIVE INTO 2 SMALLER, LOGICAL DRIVES



**MCT-ATFH \$149.95**

FLOPPY AND HARD DISK CONTROL IN A TRUE AT DESIGN

- AT COMPATIBLE, CONTROL UP TO 2 360K/720K OR 1.2MB FDDs AS WELL AS 2 HDDs USING THE AT STANDARD CONTROL TABLES
- SUPPORTS AT STYLE FRONT PANEL LED TO INDICATE HD ACTIVITY
- 16 BIT BUS PROVIDES RAPID DATA TRANSFERS
- FULLY SUPPORTED BY AT BIOS



**JDR Microdevices**

110 Knowles Drive, Los Gatos, CA 95030  
Toll Free 800-538-5000 • (408) 866-6200 • FAX (408) 378-8927 • Telex 171-110

THE JDR MICRODEVICES LOGO IS A REGISTERED TRADEMARK OF JDR MICRODEVICES. JDR INSTRUMENTS AND JDR MICRODEVICES ARE TRADEMARKS OF JDR MICRODEVICES. IBM IS A TRADEMARK OF INTERNATIONAL BUSINESS MACHINES CORPORATION.

CIRCLE 184 ON FREE INFORMATION CARD

COPYRIGHT 1987 JDR MICRODEVICES

NOVEMBER 1987

**MODEM 1200 BAUD \$79.95**

**FOR IBM WITH SOFTWARE**

**MODEM 2400 BAUD \$179.95**

**BARGAIN HUNTERS CORNER**

**HYUNDAI MONOCHROME MONITOR**

- \* 12" NON-GLARE AMBER SCREEN
- \* IBM COMPATIBLE TTL INPUT
- \* ATTRACTIVE CASE WITH TILT & SWIVEL BASE

**ONLY \$69.95**

**SPECIAL ENDS 10/31/87**

**PAGE WIRE WRAP WIRE PRECUT ASSORTMENT**  
IN ASSORTED COLORS \$27.50

100ea: 5.5", 6.0", 6.5", 7.0"  
250ea: 2.5", 4.5", 5.0"  
500ea: 3.0", 3.5", 4.0"

**SPOOLS**

100 feet \$4.30 250 feet \$7.25  
500 feet \$13.25 1000 feet \$21.95

Please specify color:  
Blue, Black, Yellow or Red

**EXTENDER CARDS**

IBM-PC \$29.95  
IBM-AT \$39.95



**WIRE WRAP PROTOTYPE CARDS**  
FR-4 EPOXY GLASS LAMINATE  
WITH GOLD-PLATED EDGE-CARD FINGERS



**XT**

BOTH CARDS HAVE SILK SCREENED LEGENDS AND INCLUDES MOUNTING BRACKET

IBM-PR1 WITH +5V AND GROUND PLANE . . . . \$27.95  
IBM-PR2 AS ABOVE W/DECODING LAYOUT . . . . \$29.95

**AT**

IBM-PRAT LARGE +5V & GROUND PLANES . . . . \$29.95

**S-100**

P100-1 BARE - NO FOIL PADS . . . . . \$15.15  
P100-2 HORIZONTAL BUS . . . . . \$21.80  
P100-3 VERTICAL BUS . . . . . \$21.80  
P100-4 SINGLE FOIL PADS PER HOLE . . . . \$22.75

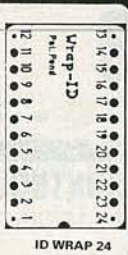
**APPLE**

P500-1 BARE - NO FOIL PADS . . . . . \$15.15  
P500-3 HORIZONTAL BUS . . . . . \$22.75  
P500-4 SINGLE FOIL PADS PER HOLE . . . . \$21.80  
7060-45 FOR APPLE IIe AUX SLOT . . . . . \$30.00

**SOCKET-WRAP I.D.TM**

- \* SLIPS OVER WIRE WRAP PINS
- \* IDENTIFIES PIN NUMBERS ON WRAP SIDE OF BOARD
- \* CAN WRITE ON PLASTIC, SUCH AS IC #

PINS	PART#	PCK. OF	PRICE
8	IDWRAP 08	10	1.95
14	IDWRAP 14	10	1.95
16	IDWRAP 16	10	1.95
18	IDWRAP 18	5	1.95
20	IDWRAP 20	5	1.95
22	IDWRAP 22	5	1.95
24	IDWRAP 24	5	1.95
28	IDWRAP 28	5	1.95
40	IDWRAP 40	5	1.95



PLEASE ORDER BY NUMBER OF PACKAGES (PCK. OF)

**FRAME STYLE TRANSFORMERS**

12.6V AC CT 2 AMP 5.95  
12.6V AC CT 4 AMP 7.95  
12.6V AC CT 8 AMP 10.95  
25.2V AC CT 2 AMP 7.95

**25 PIN D-SUB GENDER CHANGERS \$7.95**



**SWITCHING POWER SUPPLIES**

**PS-IBM \$59.95**

- \* FOR IBM PC-XT COMPATIBLE
- \* 135 WATTS
- \* +5V @ 15A, +12V @ 4.2A
- \* -5V @ .5A, -12V @ .5A
- \* ONE YEAR WARRANTY

PS-IBM/150



**PS-IBM-150 \$69.95**

- \* FOR IBM PC-XT COMPATIBLE
- \* 150 WATTS
- \* +12V @ 5.2A, -5V @ 16A
- \* -12V @ .5A, -5V @ .5A
- \* ONE YEAR WARRANTY



**PS-AT \$89.95**

- \* FOR IBM PC-AT COMPATIBLE
- \* 220 WATTS
- \* +5V @ 22A, +12V @ 8A
- \* -5V @ .5A, -12V @ .5A
- \* 1 YEAR WARRANTY

PS-AT



**PS-A \$49.95**

- \* USE TO POWER APPLE TYPE SYSTEMS, 79.5 WATTS
- \* +5V @ 7A, +12V @ 3A
- \* -5V @ .5A, -12V @ .5A
- \* APPLE POWER CONNECTOR

PS-A



**PS-1558 \$34.95**

- \* 75 WATTS, UL APPROVED
- \* +5V @ 7A, +12V @ 3A
- \* -12V @ 250ma, -5V @ 300ma

PS-1558



**MUFFIN FANS**

3.15" SQ 14.95 3.63" SQ 14.95  
3.18" SQUARE 16.95

**6' LINE CORDS**

2 conductor .39 3 conductor .99  
3 conductor w/female socket 1.49

**EMI FILTER \$4.95**

**CAPACITORS**

**TANTALUM**

1.0µf	15V	.35	.47µf	35V	.45
6.8	15V	.70	1.0	35V	.45
10	15V	.80	2.2	35V	.65
22	15V	1.35	4.7	35V	.85
.22	35V	.40	10	35V	1.00

**DISC**

10µf	50V	.05	680	50V	.05
22	50V	.05	.001µf	50V	.05
27	50V	.05	.0022	50V	.05
33	50V	.05	.0205	50V	.05
47	50V	.05	.01	50V	.07
68	50V	.05	.02	50V	.07
100	50V	.05	.05	50V	.07
220	50V	.05	.1	12V	.10
560	50V	.05	.1	50V	.12

**MONOLITHIC**

.01µf	50V	.14	.1µf	50V	.18
.047µf	50V	.15	.47µf	50V	.25

**ELECTROLYTIC**

RADIAL		AXIAL			
1µf	25V	.14	50V	.14	
2.2	35V	.15	10	50V	.16
4.7	50V	.15	22	16V	.14
10	50V	.15	47	50V	.20
47	35V	.18	100	35V	.25
100	16V	.18	220	25V	.30
220	35V	.20	470	50V	.50
470	25V	.30	1000	16V	.90
2200	16V	.70	2200	50V	.70
4700	25V	1.45	4700	16V	1.25

**DATARASE EPROM ERASER \$34.95**

- \* ERASES 2 IN 10 MINUTES
- \* COMPACT-NO DRAWER
- \* THIN METAL SHUTTER
- \* PREVENTS UV LIGHT FROM ESCAPING



**1/4 WATT RESISTORS**

5% CARBON FILM ALL STANDARD VALUES FROM 1 OHM TO 10 MEG. OHM

10 PCS same value .05 100 PCS same value .02  
50 PCS same value .025 1000 PCS same value .015

**RESISTOR NETWORKS**

SIP	10 PIN	9 RESISTOR	.69
SIP	8 PIN	7 RESISTOR	.59
DIP	16 PIN	8 RESISTOR	1.09
DIP	16 PIN	15 RESISTOR	1.09
DIP	14 PIN	7 RESISTOR	.99
DIP	14 PIN	13 RESISTOR	.99

**SPECIALS ON BYPASS CAPACITORS**

.01 µf CERAMIC DISC 100/\$5.00  
.01 µf MONOLITHIC 100/\$10.00  
.1 µf CERAMIC DISC 100/\$6.50  
.1 µf MONOLITHIC 100/\$12.50

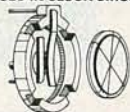
**WISH SOLDERLESS BREADBOARDS**

PART NUMBER	DIMENSIONS	DISTRIBUTION STRIP(S)	TIE POINTS	TERMINAL STRIP(S)	TIE POINTS	BINDING POSTS	PRICE
WBU-D	.38 x 6.50"	1	100	---	---	---	2.95
WBU-T	1.38 x 6.50"	---	---	1	630	---	6.95
WBU-204-3	3.94 x 8.45"	1	100	2	1260	2	17.95
WBU-204	5.13 x 8.45"	4	400	2	1260	3	24.95
WBU-206	6.88 x 9.06"	5	500	3	1890	4	29.95
WBU-208	8.25 x 9.45"	7	700	4	2520	4	39.95



**LITHIUM BATTERY**

AS USED IN CLOCK CIRCUITS



3 VOLT BATTERY \$3.95  
BATTERY HOLDER \$1.49

**2 VOLUME SET**

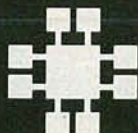
**IC MASTER**

THE INDUSTRY STANDARD

**\$129.95**

**NEW STORE HOURS! M-F: 9-7, SAT: 9-5 & SUN: 12-4**

Visit our retail store located at 1256 S. Bascom Ave. in San Jose, (408) 947-8881



**JDR Microdevices**

110 Knowles Drive, Los Gatos, CA 95030

Toll Free 800-538-5000 • (408) 866-6200

FAX (408) 378-8927 • Telex 171-110

COPYRIGHT 1987 JDR MICRODEVICES

THE JDR MICRODEVICES LOGO IS A REGISTERED TRADEMARK OF JDR MICRODEVICES. JDR INSTRUMENTS AND JDR MICRODEVICES ARE TRADEMARKS OF JDR MICRODEVICES. IBM IS A TRADEMARK OF INTERNATIONAL BUSINESS MACHINES CORPORATION. APPLE IS A TRADEMARK OF APPLE COMPUTER.

TERMS: Minimum order \$10.00. For shipping and handling include \$2.50 for UPS Ground and \$3.50 for UPS Air. Orders over 1 lb. and foreign orders may require additional shipping charges—please contact our sales department for the amount. CA. residents must include applicable sales tax. All merchandise is warranted for 90 days unless otherwise stated. Prices are subject to change without notice. We are not responsible for typographical errors. We reserve the right to limit quantities and to substitute manufacturer. All merchandise subject to prior sale. A full copy of our terms is available upon request. Items pictured may only be representative.

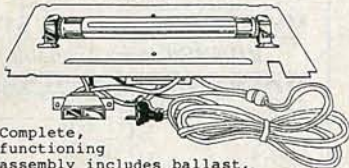
**SEND FOR  
FREE  
1987 CATALOG**  
OUR NEW MAILING  
ADDRESS IS:  
P.O. BOX 567  
VAN NUYS, CA 91408  
800-826-5432

#QUALITY PARTS #DISCOUNT PRICES #FAST SHIPPING!

# ALL ELECTRONICS CORP.

## ALL ELECTRONICS CORP.

### BLACKLIGHT ASSEMBLY



Complete, functioning assembly includes ballast, on-off switch, power cord, sockets and F4T5-BL blacklight. Mounted on a 7 1/8" X 3 1/8" metal plate. Use for special effects lighting or erasing EPROMS.  
CAT# BLTA \$10.00 EACH

### ELECTRET CONDENSER MIKE

Mouser# 25LMO44 Highly sensitive mini microphone. 6" wire leads. 0.39" dia. X 0.27" high. Omni directional. Operates on 2-10 Vdc @ less than 1 mA. 1K impedance. 50 to 8 K Hz range.  
CAT# MKE-1 \$1.00 EACH

### NI-CAD CHARGER / TESTER

DELUXE universal charger and tester for almost every size NI-CAD battery available.  
CAT# UNCC-N \$15.00 each

### RECHARGEABLE NI-CAD BATTERIES

AAA SIZE	\$2.25
AA SIZE	\$2.00
AA with solder tab	\$2.20
C SIZE 1.2V 1200MAH	\$4.25
SUB-C SIZE solder tab	\$4.25
D SIZE 1.2V 1200MAH	\$4.25

### LIGHT ACTIVATED MOTION SENSOR

This device contains a photocell which senses sudden change in ambient light. Could be used as a door annunciator or modified to trigger other devices. 5 1/2" X 4" X 1". Operates on 6 Vdc. Requires 4 AA batteries (not included).  
CAT# LSMD \$5.75 per unit

### LED'S

Standard Jumbo Diffused T 1-3/4 Size  
RED 10 for \$1.50  
CAT# LED-1 100 for \$13.00  
1000 for \$110.00

GREEN 10 for \$2.00  
CAT# LED-2 100 for \$17.00  
1000 for \$150.00

YELLOW 10 for \$2.00  
CAT# LED-3 100 for \$17.00  
1000 for \$150.00

### FLASHING LED

w/ built in flashing circuit operates on 5 Volts...

RED \$1.00 each  
CAT# LED-4 10 for \$9.50

GREEN \$1.00 each  
CAT# LED-4G 10 for \$9.50

### BI - POLAR LED

Lights RED one direction, GREEN the other. Two lead.  
CAT# LED-6 2 for \$1.70

### SWITCHING POWER SUPPLY

Compact, well regulated switching power supply designed to power Texas Instruments computer equipment.  
INPUT: 14-25 vac @ 1 amp  
OUTPUT: +12 vdc @ 350 ma.  
+5 vdc @ 1.2 amp  
-5 vdc @ 200 ma.  
SIZE: 4 3/4" square.  
Includes 18 Vac @ 1 amp wall transformer designed to power this supply.  
CAT# PS-TX \$5.00 / set  
10 for \$45.00

### SLIM LINE FAN

TOYO# TF92115A New 115 Vac cooling fan. 3 5/8" square X 1" deep. Metal housing. 5 blade impeller.  
CAT# SCPE-115 \$8.50 each  
10 for \$75.00

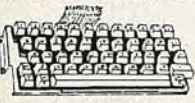
### 1 mA METER

Modutec 0-1 mA signal strength meter with KLM logo. 1/4" X 1 3/4" X 7/8" deep.  
CAT# MET-2 \$2.00 each

### PUSHBUTTON PHONE

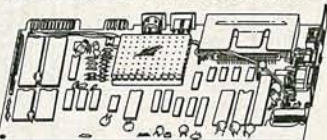
Spectra-phone Model # OP-1 1 piece telephone with rotary (pulse) output. Operates on most rotary or touch tone systems. Features last minute redial and mute button. Includes coil cord with standard modular plug.  
CAT# PHN-1 \$8.50 EACH  
2 FOR \$15.00

### 48 KEY ASSEMBLY



NEW T.I. KEYBOARDS. Originally used on computers, these keyboards contain 48 S.P.S.T. mechanical switches. Terminates to 15 pin connector. Frame 4" X 9"  
CAT# KP-48 \$3.50 each

### VIC 20 MOTHERBOARD



26 IC's including 6502A and 6560. 2 ea. 6522, 2 ea. 8128, 2 ea. 901486, 3 ea. 2114. Not guaranteed but great for replacement parts or experimentation.  
CAT # VIC-20 \$15.00 each

### SOUND EFFECTS BOARD

P.C. board with 2 1/4" speaker, 2 LEDs, IC, battery snap, other components 2 3/8" X 3". When switch is pushed board beeps and leads light. Operates on 9V battery (not included).  
CAT# ST-3 \$1.25 each

### VENTED PROJECT CASE

Bopla #BO 718L Vented top and bottom. Black plastic with removable end panels. 5" X 8 1/2" X 3"  
CAT# MB-718 \$12.50 each

### 2 K 10 TURN

Multiturn pot Spectrol # MOD 534-7161  
CAT# MTP-10-2 \$5.00 each

### 6-12 VDC MOTOR

Mabuchi # RS-550S Permanent magnet motor. 7/16" dia X 2 1/4" long. 2,600 RPM @ 6 Vdc - 200 mA  
5,300 RPM @ 12 Vdc  
CAT# DCM-7 \$3.00 each

### THIRD TAIL LIGHT

Sleek high-tech lamp assembly. Red lens is 2 3/4" X 5 1/2" mounted on a 4" high pedestal with up-down swivel adjustment. Has 12V replaceable bulb.  
CAT# TLB \$3.95 each

### RELAYS

12 VDC-4PDT  
P.C. mount 5 amp contacts 150 ohm coil  
Size: 1 1/4" X 1 3/4" X 7/8"  
CAT# 4PRLY-12PC \$3.50  
10 for \$30.00

### 10 AMP SOLID STATE

Control: 3-32 Vdc Load: 10 AMPS, 120 Vac  
Size: 2 1/2" X 3/4" X 7/8"  
CAT# SSRLY-10A \$9.50  
10 for \$85.00

### COMPUTER GRADE CAPACITORS

1,400 MFD 200 VDC 2" dia. X 3" high  
CAT# CG-1420 \$2.00  
7,500 MFD 200 VDC 3" dia. X 5 7/8" h.  
CAT# CG-75 \$4.00  
22,000 MFD 25 VDC 2" dia. X 4 3/4" h.  
CAT# CG-22 \$2.50  
72,000 MFD 15 VDC 2" dia. X 4 3/8" h.  
CAT# CG-130 \$3.50

### TRANSISTORS

2N2222A 3 for \$1.00  
PN2222A 4 for \$1.00  
2N2904 3 for \$1.00  
2N2905 3 for \$1.00  
2N3055 \$1.00 each  
PN3569 10 for \$1.00

### TRANSFORMER

5.6 Volt - 750 ma  
CAT# TX-56 \$3.00  
12 V.c.t. - 1 amp  
CAT# TX-121 \$4.00  
12 V.c.t. - 2 amp  
CAT# TX-122 \$4.85  
12 V.c.t. - 4 amp  
CAT# TX-124 \$7.00  
18 Volt - 650 ma  
CAT# TX-186 \$2.00  
10 for \$18.00  
24 V.c.t. - 1 amp  
CAT# TX-241 \$4.85  
24 V.c.t. - 2 amp  
CAT# TX-242 \$6.75  
24 V.c.t. - 3 amp  
CAT# TX-243 \$9.50  
24 V.c.t. - 4 amp  
CAT# TX-244 \$11.00

### LED HOLDERS

Two Piece Holder  
CAT# HLED 10 for 65c

### CLIPLIGHT LED HOLDER

Makes L.E.D. look like a fancy indicator.  
CLEAR CAT# HLDCL-C  
RED CAT# HLDCL-R  
GREEN CAT# HLDCL-G  
YELLOW CAT# HLDCL-Y  
4 of one color \$1.00

### SWITCHES

MINIATURE TOGGLE SWITCHES rated 5 Amps  
S.P.D.T. (ON-ON) non-threaded bushing P.C. mount.  
CAT# MTS-40PC 75c each  
10 for \$7.00  
S.P.D.T. (ON-ON) Solder lug terminals.  
CAT# MTS-4 \$1.00 each  
10 for \$9.00  
D.P.D.T. (ON-ON) Solder lug terminals  
CAT# MTS-8 \$2.00 each  
10 for \$19.00  
MINI PUSH BUTTON S.P.S.T. momentary. Push to make. 1/4" bushing. Red button.  
CAT# MPB-1 35c each  
10 for \$3.00

### XENON FLASH TUBE

3/4" long X 1/8" dia.  
CAT# FLT-1 2 for \$1.00

### POLARITY SWITCH

Designed to control an external coaxial relay on a satellite T.V. system. Ideal for parts. Contains a 5 Vdc relay and many other parts on a P.C. board.  
CAT# RDP5 \$1.75 each  
10 for \$15.00

### SOUND AND VIDEO MODULATOR

TI# UML381-1. Designed for use with T.I. computers. Can be used with video cameras, games or other audio/video sources. Built in A/B switch enables user to switch from T.V. antenna without disconnection. Operates on channel 3 or 4. Requires 12 Vdc. Hook up diagram included.  
CAT# AVMOD \$5.00 each

### TELEPHONE COUPLING TRANSFORMER

STANCO # TTPC-8  
600 ohms c.t. to 600 ohms c.t. P.C. board mount. 3/4" X 5/8" X 3/4"  
CAT# TCTXS \$2.50 each

### STORES

LOS ANGELES  
905 S.VERMONT AVE.  
LOS ANGELES, CA 90006  
(213) 380-8000  
VAN NUYS  
6228 SEPULVEDA BLVD.  
VAN NUYS, CA 91411  
(818) 997-1806

### MAIL ORDERS TO:

ALL ELECTRONICS  
P.O. BOX 567  
VAN NUYS, CA 91408  
TELEX  
TWX-101010163  
ALL ELECTRONICS  
Foreign Customers  
Send \$1.50 postage  
for FREE Catalog!!

### TOLL FREE

800-826-5432  
INFO:(818) 904-0524  
FAX:(818) 781-2653  
QUANTITIES LIMITED  
MINIMUM ORDERS \$10.00  
CALIF. ADD SALES TAX  
USA: \$3.00 SHIPPING  
NO C.O.D.  
FOREIGN ORDERS:  
INCLUDE SUFFICIENT  
SHIPPING



## NEC V20 & V30 CHIPS

Replace the 8086 or 8088 in Your IBM-PC and Increase its Speed by up to 40%! Price

Part No.	Price
UPD70108-5 (5MHz) V20 Chip	\$ 8.75
UPD70108-8 (8MHz) V20 Chip	\$10.75
UPD70108-10 (10MHz) V20 Chip	\$29.95
UPD70116-8 (8MHz) V30 Chip	\$13.75
UPD70116-10 (10MHz) V30 Chip	\$29.95

### 7400

Part No.	1-9	10+	Part No.	1-9	10+
7400	29	19	7485	65	55
7402	29	19	7486	45	35
7404	29	19	7489	205	195
7405	35	25	7490	49	39
7406	35	25	7493	45	35
7407	39	29	74121	45	35
7408	35	25	74123	55	45
7410	29	19	74125	55	45
7414	49	39	74126	69	59
7417	39	29	74143	395	385
7417	39	29	74150	135	125
7420	35	25	74154	135	125
7430	35	25	74158	159	149
7432	39	29	74173	85	75
7438	39	29	74174	59	49
7442	55	45	74175	59	49
7445	69	59	74176	99	89
7446	89	79	74181	195	185
7447	89	79	74189	195	185
7448	205	195	74193	79	69
7472	89	79	74198	185	175
7473	39	29	74221	59	49
7474	39	29	74274	195	185
7475	49	39	74365	65	55
7476	45	35	74367	65	55

### 74LS

Part No.	Price	Part No.	Price
74LS00	29	74LS165	75
74LS02	29	74LS166	99
74LS04	35	74LS173	59
74LS05	35	74LS240	49
74LS06	109	74LS175	49
74LS07	109	74LS189	459
74LS08	29	74LS191	59
74LS10	29	74LS193	79
74LS14	49	74LS221	69
74LS27	35	74LS240	59
74LS30	29	74LS243	69
74LS32	35	74LS244	69
74LS42	49	74LS245	89
74LS47	99	74LS259	99
74LS73	39	74LS273	89
74LS74	35	74LS279	49
74LS75	39	74LS322	405
74LS76	55	74LS365	49
74LS85	59	74LS366	49
74LS86	35	74LS367	49
74LS90	49	74LS368	49
74LS93	49	74LS373	79
74LS123	59	74LS374	79
74LS125	49	74LS393	89
74LS138	49	74LS590	605
74LS139	49	74LS624	205
74LS154	109	74LS629	295
74LS157	45	74LS640	109
74LS158	45	74LS645	109
74LS163	59	74LS670	109
74LS164	59	74LS688	239

### 74S/PROMS\*

Part No.	Price	Part No.	Price
74S00	29	74S188*	149
74S04	29	74S189	169
74S08	35	74S196	249
74S10	29	74S240	149
74S32	35	74S244	149
74S74	45	74S253	79
74S85	179	74S287*	149
74S86	49	74S288*	149
74S124	275	74S373	149
74S174	45	74S374	149
74S175	79	74S472*	295

### 74F

Part No.	Price	Part No.	Price
74F00	29	74F139	69
74F04	29	74F157	69
74F08	29	74F193	295
74F10	29	74F240	99
74F32	29	74F244	99
74F74	39	74F253	69
74F86	39	74F373	99
74F138	69	74F374	99

### CD-CMOS

Part No.	Price	Part No.	Price
CD4001	19	CD4076	59
CD4008	69	CD4081	25
CD4011	19	CD4082	35
CD4013	29	CD4093	35
CD4015	29	CD4094	89
CD4017	49	CD40103	249
CD4018	59	CD40107	49
CD4020	59	CD40109	79
CD4024	49	CD4510	69
CD4027	35	CD4511	75
CD4030	29	CD4522	79
CD4040	65	CD4538	79
CD4049	29	CD4541	89
CD4050	29	CD4543	79
CD4051	59	CD4545	495
CD4052	59	CD4555	79
CD4053	59	CD4559	795
CD4063	149	CD4566	249
CD4066	29	CD4583	89
CD4067	129	CD4584	89
CD4069	25	CD4584	89
CD4070	25	MC14411P	895
CD4071	25	MC14490P	449

## MICROPROCESSOR COMPONENTS

MISCELLANEOUS CHIPS	Price	6500/6800/68000 Cont.	Price	8000 SERIES Cont.	Price
D765AC	4.95	6845	3.95	8228	2.95
WD9216	6.95	6850	1.95	8237-5	4.95
Z80, Z80A, Z80B SERIES		6852	1.49	8243	2.25
Z80	1.25	MC68000L8	11.95	8250A	6.49
Z80-CTC	1.79	MC68000L10	13.95	8250B (For IBM)	6.95
Z80-DART	4.95	MC68010L10	49.95	8251A	1.89
Z80-FD	1.79	MC68020RC12B	169.95	8253-5	1.95
Z80A	1.69	MC68881RC12A	149.95	8254	4.95
Z80A-CTC	1.79	8031	3.95	8255A-5	1.89
Z80A-DART	4.95	8031	9.95	8257-5	1.95
Z80A-FD	1.69	8035	1.95	8259-5	2.25
Z80A-SIO/D	5.75	8073	9.95	8272	4.95
Z80B	3.49	8080A	2.95	8279-5	2.95
Z80B-CTC	3.95	8085A	2.49	8748 (25V)	7.95
Z80B-FD	4.29	8086	5.95	8748H (HMOS) (21V)	9.95
8000/6800/68000 SER.		8086-2	6.95	8751	39.95
6502	2.65	8087 (5MHz)	129.95	8755	14.95
65C02 (CMOS)	8.95	8087-2 (8MHz)	169.95	ADC0804LCN	3.19
6520	1.95	8088	6.49	ADC0808CCN	5.95
6522	3.95	8089-2	8.95	ADC0809CCN	3.95
6532	6.49	8116	4.95	ADC0816CCN	11.95
6551	4.49	8155	2.49	ADC1205CC-1	19.95
65C802 (CMOS)	19.95	8155-2	3.49	DAC0808LCN	1.95
6800	1.95	8155	3.95	DAC1008LCN	4.95
6802	3.95	8203	3.95	AY-3-1015D	4.95
6810	1.25	8203	9.95	AY-5-1013A	2.95
6821	1.75	8212	1.49		
6840	3.95	8224	2.25		

## MICROPROCESSOR SALE!

Part No.	Price
MC68000L8	16-Bit MPU (8MHz) \$ 11.95
MC68000L10	16-Bit MPU (10MHz) \$ 13.95
MC68000L12	16-Bit MPU (12MHz) \$ 17.95
MC68008L8	32-Bit MPU (8-Bit Data Bus) \$ 19.95
MC68010L10	16-Bit MPU (10MHz) \$ 49.95
MC68020RC12B	32-Bit MPU (12MHz) \$169.95
MC68701	8-Bit EPROM Microcomputer \$ 14.95
MC68705U3L	8-Bit EPROM Microcomputer \$ 10.95
MC68881RC12A	Floating Point Co-processor \$149.95

### DYNAMIC RAMS

Part No.	Price
4116-15	16,384 x 1 (150ns) .89
4128-20	131,072 x 1 (200ns) (Piggyback) 3.25
4164-120	65,536 x 1 (120ns) .175
4164-150	65,536 x 1 (150ns) .125
4164-200	65,536 x 1 (200ns) .99
TMS4416-12	16,384 x 4 (120ns) 3.49
8118	16,384 x 4 (120ns) .49
41256-120	262,144 x 1 (120ns) 3.95
41256-150	262,144 x 1 (150ns) 3.25
50464-15	65,536 x 4 (150ns) (4464) 4.95
511008P-10	1,048,576 x 1 (100ns) 1 Meg. 24.95
514256P-10	262,144 x 4 (100ns) 1 Meg. 29.95

### STATIC RAMS

Part No.	Price
2016-12	2048 x 8 (120ns) 1.69
2018-45	2048 x 8 (45ns) 6.95
2102-2L	1024 x 1 (250ns) Low Power .195
2114N	1024 x 4 (450ns) .99
2114N-2L	1024 x 4 (200ns) Low Power .149
21C14	1024 x 4 (200ns) CMOS .49
2149	1024 x 4 (45ns) .149
256 x 4	(450ns) CMOS 2.95
6116P-3	2048 x 8 (150ns) CMOS 1.95
6116P-3	2048 x 8 (150ns) LP CMOS 1.95
6264LP-12	8192 x 8 (120ns) LP CMOS 4.25
6264P-15	8192 x 8 (150ns) CMOS 3.49
6264LP-15	8192 x 8 (150ns) LP CMOS 3.75
6514	1024 x 4 (350ns) CMOS 3.49
43256-15L	32,768 x 8 (150ns) Low Power 11.95

### EPROMS

Part No.	Price
TMS2516	2048 x 8 (450ns) 25V 6.95
TMS2532	4096 x 8 (450ns) 25V 6.95
TMS2532A	4096 x 8 (450ns) 21V 5.95
TMS2564	8192 x 8 (450ns) 25V 9.95
TMS2716	1702A 256 x 8 (1µs) 6.95
2708	1024 x 8 (450ns) 4.95
2716	2048 x 8 (450ns) 25V 3.75
2716-1	2048 x 8 (350ns) 25V 4.25
27C16	2048 x 8 (450ns) 25V (CMOS) 5.49
2732	4096 x 8 (450ns) 25V 3.95
2732A-20	4096 x 8 (200ns) 21V 4.25
2732A-25	4096 x 8 (250ns) 21V 3.95
27C32	4096 x 8 (450ns) 25V (CMOS) 5.95
2764-20	8192 x 8 (200ns) 21V 4.25
2764-25	8192 x 8 (250ns) 21V 3.75
2764A-25	8192 x 8 (250ns) 12.5V 3.95
2764-45	8192 x 8 (450ns) 21V 2.95
27C64-15	8192 x 8 (150ns) 21V (CMOS) 6.49
27128-20	16,384 x 8 (200ns) 21V 5.95
27128-25	16,384 x 8 (250ns) 21V 5.25
27C128-25	16,384 x 8 (250ns) 21V (CMOS) 6.95
27256-20	32,768 x 8 (200ns) 12.5V 6.95
27256-25	32,768 x 8 (250ns) 12.5V 6.49
27C256-25	32,768 x 8 (250ns) 12.5V (CMOS) 8.95
27512-20	65,536 x 8 (200ns) 12.5V 13.49
27512-25	65,536 x 8 (250ns) 12.5V 11.95
68764	8192 x 8 (450ns) 25V 13.95

### EEPROMS

Part No.	Price
2816A	2048 x 8 (350ns) 5V Read/Write 5.95
2817A	2048 x 8 (350ns) 5V Read/Write 7.95
2865A	8192 x 8 (250ns) 5V Read/Write 9.95
52B13 (21V)	2048 x 8 (350ns) 5V Read Only 1.49

### COMMODORE CHIPS

Part No.	Price
WD1770	11.95
S13052P	2.49
6502	2.65
6504A	1.95
6507	4.39
6510	9.95
6520	1.95
6522	3.95
6525	4.95
6526	14.95
6529	2.95
6532	6.49
6545-1	4.95
6551	4.49
6560	10.95
6567	14.95
6569	24.95
6572	8.95
6581 (12V)	14.95
6582 (9V)	14.95
8360	14.95
8501	10.95
8502	7.95
8563	15.95
8564	9.95
8566	24.95
8701	9.95
*8721	14.95
8722	9.95
*251104-04	10.95
318018-03	10.95
318019-03	10.95
318020-04	10.95
325302-01	10.95
*325572-01	24.95
*82S100PLA**	15.95
901225-01	11.95
901226-01	11.95
901227-03	11.95
901229-05	11.95

\*No specs. available  
 \*\*Note: 82S100PLA = U17 (C-64)

## SATELLITE TV DESCRAMBLER CHIP

The MM5321 is a TV camera sync generator designed to supply the basic sync functions for either color or monochrome 525 line/60Hz interlaced and camera video recorder applications. COLOR BURST GATE & SYNC ALLOW STABLE COLOR OPERATION  
**MM5321N \$11.95**

INTERSL Also Available!

### 74HC HI-SPEED CMOS



# Worldwide • Since 1974

• QUALITY COMPONENTS • COMPETITIVE PRICING  
• PROMPT DELIVERY

Mail Order Electronics • Worldwide  
**Jameco**  
ELECTRONICS

**NEW!** General Purpose Prototype PC Boards

- Wire Wrap
- Component Testing
- Point-to-Point Wiring
- 31/62 Connection

JE417 (Pictured)

JE411 (6½", No Pads, Gen. Purp.) . . . . \$12.95  
JE415 (6½", No Pads, PC/XT) . . . . \$14.95  
JE417 (6½", Plated w/Pads, PC/XT) . . . \$19.95

Extender Boards Designed for Troubleshooting and Testing

JE419 (5¼" Extender, 22/44 Connector) . . \$19.95  
JE421 (4¼" Extender, 31/62 Connector) . . \$19.95

Commodore VIC-20 Motherboard

CV20

May have to troubleshoot or just use for spare parts.  
CV20 Includes: (1) 6560, (2) 6522, (1) 6502, (2) 6116P-4, and much more!

CV20 (VIC-20 Motherboard) . . . . \$ 9.95  
089033 (SAMS VIC-20 Schematics) . . . \$19.95

Additional Accessories for Commodore VIC-20, C-64 & C-128

JE232CM (Pictured)

\*CM1 (300B Modem VIC-20, C-64) . . \$19.95  
\*JE232CM (RS232 Inter. VIC-20, C-64) . \$39.95  
CPS10 (C-64 Power Supply) . . . . \$39.95  
CPS128 (C-128 Power Supply) . . . \$59.95

\*Also compatible with C-128 in 64 mode only.

**ZUCKERBOARD**

TANDY 1000 Expansion Memory Half Card

Expand the memory of your Tandy 1000 (128K Version) to as much as 640K. Also includes DMA controller chip.

TE512 Includes 512K RAM . . . . \$119.95  
TANC Plug-in Clock option chip (only) . . \$39.95

20Meg Hard Disk

T20MB 20MB Hard Disk Drive Board for Tandy 1000 . . . . \$494.95  
SX20MB 20MB Hard Disk Drive Board for Tandy 1000SX . . . . \$499.95

TANDY 1000 Multifunction Board with Clock Calendar

Expand the memory on your Tandy 1000 (128K Version) to as much as 640K. Complete with an RS232 port, clock/calendar, RAM Disk, Printer Spooler and on-board DMA controller chip.

MT512 Includes 512K RAM . . . . \$199.95

**INTRODUCING JAMECO'S NEW COMPUTER KITS!!**

Jameco's IBM™ AT Compatible Kit!  
Mini-286 6/8/10/12 MHz Kit!

EGA Monitor TE5154 \$399.95  
EGA Card JE1055 \$179.95 (not included)

Part No.	Description	Price
JE1043	1.2M/360K Floppy Control	\$ 49.95
JE1015	XT/AT Style Keyboard	\$ 59.95
41256-120	512K RAM (18 Chips)	\$ 71.10
JE1012	Baby AT Flip-Top Case	\$ 69.95
JE1032	200W Power Supply	\$ 89.95
JE1022	5¼" High Density Disk Drive	\$109.95
JE1003	Baby AT Motherboard (Zero-K RAM-incl. Award BIOS ROM)	\$429.95

**Regular List \$880.80**  
**SAVE \$80.85!**

JE1008 IBM™ AT Compatible Kit. . . . . \$799.95

Jameco's IBM PC/XT Compatible Kit

4164-150	128K RAM (18 Chips)	\$22.50
JE1040	Floppy Controller Card	\$34.95
JE1010	Flip-Top Case	\$34.95
JE1015	XT/AT Style Keyboard	\$59.95
JE1030	150 Watt Power Supply	\$69.95
JE1050	Mono/Graph. Crd. w/Port	\$59.95
JE1020	5¼" DSDD Disk Drive	\$89.95
GREEN	12" Mono. Green Monitor	\$99.95
JE1000	XT Motherboard (Zero-K RAM-incl. Award BIOS ROM)	\$99.95

**SAVE \$72.15**

**FREE! QUICKSOFT PC WRITE WORD PROCESSING SOFTWARE INCLUDED!**

**Regular List \$572.10**

JE1004 (IBM™ PC/XT Compatible Kit) . . . . \$499.95

Jameco's 4.77/8MHz Turbo IBM Compatible Kit

Same as JE1004 except comes with 640K RAM, JE1001 (Turbo) 4.77/8MHz motherboard, JE1071 multi I/O with controller and graphics, and AMBER monitor.

**SAVE \$95.70** **Regular List \$695.65**

JE1005 (IBM™ PC/XT Turbo Compatible Kit) . \$599.95

IBM Compatible Motherboards

- 4.77/8MHz operation (Turbo only)
- 8087 Math Co-processor capability
- BIOS ROM included

JE1001 4.77/8MHz . . \$129.95 \$119.95  
JE1000 4.77MHz . . . \$109.95 \$ 99.95

**Additional Add-Ons Available!**

Color Graphics Card for PC/XT/AT

• Text: 40 or 80 x 25 • Graphics: 320 or 640 x 200 • Parallel Printer Port • Manual included

JE1052 . . . . . \$49.95

EGA Card for PC/XT/AT

• Graphics: 720 x 348 • 16 out of 64 colors • Manual included

JE1055 . . . . . \$179.95

I/O Cards for PC/XT/AT

- Printer Port
- RS232 Port
- Game Port
- Manual included

JE1060 (Pictured)

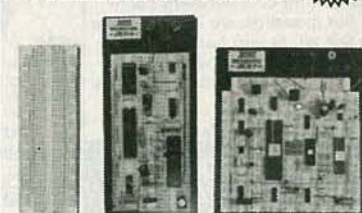
JE1060 I/O for XT . . . \$59.95  
JE1065 I/O for AT . . . \$59.95

Multi I/O w/Controller & Graphics for PC/XT

- Printer port • RS232 port • Floppy controller
- Graphics • Manual included

JE1071 . . . . . \$129.95

**Jameco** Solderless Breadboard Sockets



Part No.	Dim. L' x W'	Contact Points	Binding Posts	Price
JE20	6½ x ¾	200	0	\$ 2.29
JE21	3¼ x 2½	400	0	\$ 4.49
JE22	6½ x 1¾	630	0	\$ 5.95
JE23	6½ x 2½	830	0	\$ 7.49
JE24	6½ x 3½	1,360	2	\$14.95
JE25	6½ x 4¼	1,660	3	\$22.95
JE26	6½ x 5¼	2,390	4	\$27.95
JE27	7¼ x 7½	3,220	4	\$37.95

Extended 80-Column Card for Apple IIe

• 80 Col./64K RAM • Doubles amount of data your Apple IIe can display as well as its memory capacity • Ideal for word processing • Complete with instructions

JE864 \$49.95

ADD12 (Disk Drive II, II+, IIe) \$99.95

Additional Apple Compatible Products Available

**NEW!** Seagate 20, 30 & 40MB Half Height Hard Disk Drives

ST225K (Pictured)

ST225 20MB Drive only (PC/XT/AT) \$269.95  
ST225K 20MB w/Controller (PC/XT) \$329.95  
ST238K 30MB w/Cont. (PC/XT/AT) . . \$369.95  
ST251XT 40MB w/Cont. Card (PC/XT) . \$549.95  
ST251AT 40MB w/Cont. Card (AT) . . . \$589.95

Jameco PC/XT & AT Compatible Disk Drives

JE1020 (360K Drive, PC/XT/AT) . . . \$ 89.95  
JE1022 (1.2MB, AT Compatible) . . . \$109.95

**DATA BOOKS**

30003 National Linear Data Book (82) . . . \$19.95  
30005 Logic Data Book - Vol. II (84) . . . \$19.95  
30009 Intersil Data Book (87) . . . . \$14.95  
21398 CMOS Cookbook (86) . . . . \$14.95  
210830 Intel Memory Handbook (87) . . . \$17.95  
230843 Intel Microsystem Hndbk. Set (87) . . \$24.95

**MUFFIN/SPRITE-STYLE FANS**

TA450S . . . . . \$11.95  
Torin Industries (4.68" sq., 50 cfm)  
SU2A1 . . . . . \$11.95  
EG&G Rotron (3.125" square, 34 cfm)

\$20 Minimum Order — U.S. Funds Only  
Shipping: Add 5% plus \$1.50 Insurance

California Residents: Add 6%, 6½% or 7% Sales Tax  
IBM is a registered trademark of International Business Machines

Data Sheets — 50¢ each  
Prices Subject to Change

Send \$1.00 Postage for a FREE Seasonal Flyer  
FAX 415-592-2503



Mail Order Electronics • Worldwide  
**Jameco**  
ELECTRONICS



Send \$1.00 Postage for a FREE 1988 CATALOG  
Telex: 176043

©1987 Jameco Electronics

11/87  
1355 SHOREWAY RD., BELMONT, CA 94002 • FOR ORDERS ONLY 415-592-8097 • ALL OTHER INQUIRIES 415-592-8121

# What's New at AMERICAN DESIGN COMPONENTS?

We warehouse 60,000 items at American Design Components — expensive, often hard-to-find components for sale at a fraction of their original cost!

You'll find every part you need — either brand new, or removed from equipment (RFE) in excellent condition. But quantities are limited. Order from this ad, or visit our retail showroom and find exactly what you need from the thousands of items on display.

OPEN MON. — Sat., 9-5

## THERE'S NO RISK.

With our full 90-day warranty, any purchase can be returned for any reason for full credit or refund.

### ADAM COMPUTER



(Less printer)

No wiring nec. (just plugs together). Hook-up diagram included. Includes: Keyboard, 1 cassette digital data drive, 2 game controllers, power supply, and one cassette. Capable of running CP/M, has built-in word processor.

Item #7410 Complete — \$99.00

### ADAM

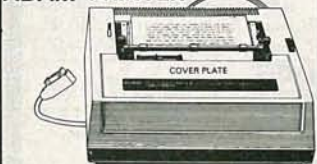
#### 5 1/4" DISK DRIVE



Gives your Adam fast, reliable data storage & retrieval. Can hold up to 160K bytes of information. Uses industry-standard SS/DD disks. Connects directly to your Adam memory console. Comes w/disk drive power supply, Disk Manager disk and owner's manual.

Mfr — Coleco, model 7817  
Item #12830 Like New — \$199.00

### ADAM PRINTER



Complete, less top cover plate. Friction feed. Takes standard paper 8 1/2" x 11". (Customer returns; tested — operational.)

Item #8839 \$69.50

### ADAM Accessories . . .

Data Drive — Item #6641 \$19.95

Printer Power Supply — Item #6642 \$14.95

ASCII Keyboard — Item #6643 \$19.95

Controllers — (Set of 4) Item #7013 \$9.95

Adam Cassettes — (Consisting of Smart Basic, Buck Rogers & blank cassette.) Item #7786

BAKER'S DOZEN — \$19.95

Adam Link Modem — (Software included.) Item #12358 \$29.95

Auto-Dialer

Address Book — Item #12365 \$19.95

Adam Daisy Print Wheel — Item #13305 \$3.95

Adam Ribbon Cartridge — Item #13306 \$3.95

### 5 1/4" 10Mb HARD DISK DRIVE



(IBM® Compat.) Fits standard 5 1/4" spacing. Shock mtd. High speed, low power. Mfr — Seagate/Tandon  
Item #13250 \$159.00 New  
Controller Card for above Item #10150 \$89.00

### 5 1/4" 1/2 HT. DISK DRIVES



48/96 TPI 1.2 Mb. (AT Compat.) DS/single-double density; 80 track. Mfr — Panasonic #JU-475  
Item #10005 \$119.00 New  
96 TPI, DS/Quad Density (DOS 3.2 Compatible) Tandon TM55-4; DS/Quad Item #1904 \$79.00  
2 for \$150.00

### 5 1/4" FULL HT. DISK DRIVES



48 TPI (IBM® Compat.) Double sided/double density, full height drive. 48 T.P.I., 80 tracks. Mfr — Tandon TM100-2  
Item #7928 \$79.00  
2 for \$150.00  
96 TPI, DS/Quad Density Mfr — CDC #9409T Item #1893 \$99.00

### HIGH-RESOLUTION TTL MONITORS



12VDC. Mtd. in metal housing. Schematic supplied.  
12", Green Phosphor Item #6811 \$19.95 New  
9", Amber Item #14332 \$14.95 New

### MAGNIFYING LAMP



Multi position, 30", completely adjustable swing arm w/3-way metal C-clamp. Has 4" diopter magnifying lens, w/ruler. Porcelain lamp socket, & on/off switch; uses up to a 60W bulb. Color: Beige. UL listed.

Item #13136 \$24.95 New

### IBM® PC/XT KEYBOARD



- Illuminated cap and number lock indicators.
- Low profile design.

Item #11041 \$49.95 New

### ADC KITS . . .

IC Socket Kit 100 Ass't. Sockets! Consisting of 100 assorted IC sockets. From 14 to 40 Pin.

Item #5309 \$9.95 New

Components & Parts Kit Hundreds of components! Consisting of Heat Sinks, Capacitor, Trimpots, Resistors, and MORE!

Item #7230 \$15.00 New

Switch Kit 35 Ass't. Switches! Consisting of 35 assorted: Dip, Toggle, Slide, and Sensitive Miniature and Standard Size Switches.

Item #5307 \$9.95 New

### SWITCHING POWER SUPPLY



115 & 230V, 47-440 Hz. Input: 90-135V/180-270V  
Output: 5VDC @ 5.5A  
+12VDC @ .4A  
-12VDC @ .3A  
Perforated metal case enclosure. Dim.: 9 1/2" L x 3 1/2" W x 2" H.  
Mfr — General Instrument  
Item #7983 \$14.95 New

### American's IBM PC/XT-COMPATIBLE COMPUTER . . .

- Contains:
- 256K RAM;
  - XT/AT Style Keyboard;
  - 5 1/4" Full-Height Floppy Disk Drive
  - 10Mb Full-Height Hard Disk Drive
  - Hard Disk & Floppy Disk Controller Cards
  - Color/Monochrome Monitor Card (monitor not included).



Item #14331 \$549.95 New

### COMPUTER GRADE POWER SUPPLY



Other uses—runs CB & car radios. Comes ready to plug in!  
DC Output: -5V @ .5 amp.  
+5V @ 3 amp.  
+12V @ 6 amp.  
Input 115V/60Hz. Dim.: 9 1/4" W x 3 3/4" H. (Rubber ft. incl.)  
Item #9501 \$24.95 New

### — BATTERIES — FANS — BLOWERS

### ADAM PRINTER



Complete, less top cover plate. Friction feed. Takes standard paper 8 1/2" x 11". (Customer returns; tested — operational.)

Item #8839 \$69.50

### COLECOVISION GAME

(Factory returns — tested good!)



Also includes power supply, instruction manual, modulator, and one Donkey Kong cartridge.

Item #7411 \$29.95

### Insides of the COMMODORE COMPUTER



Commodore VIC 20 CPU board & mechanical keyboard. Guaranteed not to work. (For parts only.)  
Item #12144 \$14.95 RFE

### COMMODORE CARTRIDGES

C-64 Consists of 12 asstd. cartridges. Includes: *Number Nabber, Star Post, Financial Advisor, Radar Rat, Jupiter Land, Magic Compos, Viduzzles, Golf, Easy Calc, Simon Basic, Dragon's Den, & ABC Voice.* Item #13573  
Set of 12 — \$49.95 New

C16 & +4 Consists of 9 asstd. cartridges. Includes: *Script + 2, Calc Plus, Script +, Jack Attack, Pirate Adventures, Atomic Miss, Strange Odyssey, Financial Advisor, & Logo.* Item #13572  
Set of 12 — \$29.95 New

### GELL CELL/LEAD ACID BATTERIES . . .

RECHARGEABLE — Used for solar energy storage, alarm systems, remote control boats, robots, etc.



6V @ 7.5AH Dim.: 5 1/4" L x 3 3/4" H x 2" D  
Mfr — EPC #0031  
Item #13324 \$5.95

6V @ 2.6AH Dim.: 5 1/4" L x 2 1/4" H x 1 1/4" D  
Mfr — EPC #0030  
Item #13326 \$3.95

12V @ 4.5AH Dim.: 6" L x 3 3/4" H x 2 1/2" D  
Mfr — EPC #0027  
Item #13325 \$7.95

12V @ 2.6AH Dim.: 5 1/4" L x 3 3/4" H x 2 1/4" D  
Mfr — EPC #0026  
Item #13323 \$5.95

12V @ 1.2AH Dim.: 3 1/4" L x 2" H x 1 1/4" D  
Mfr — EPC #0025  
Item #13327 \$3.95

### COLECOVISION to ADAM Expansion Kit



This expansion module just plugs into your ColecoVision. With printer power supply and data drive (both included), you will have a working Adam Computer. Adam keyboard, one Smart basic cassette and hook-up diagram also included.

Item #9918 \$59.50

### COLECOVISION Accessories . . .

EXPANSION MODULE #2 Play arcade quality driving & racing games on your ColecoVision. Incl. *Turbo* cartridge.  
Item #13146 \$39.95 New

ROLLER CONTROLLER Gives full 360° game control. Hi-speed action of an arcade. Can be used w/the Adam. Incl. *Silther* cart.  
Item #13147 \$39.95 New

SUPER ACTION CONTROLLER SET Gives you indiv. control of 4 + on-screen players. Incl. *Baseball* cart.  
Item #13148 \$39.95 New

### COMMODORE/AMIGA POWER SUPPLY



DC Output: +5V @ 8 amps.  
+12V @ 1 amp.  
-5V @ 250 ma.  
Input: 110VAC/60 Hz., ±20%  
Dim.: 12" L x 3 3/4" H x 5 1/4" D  
Encl. in alum. housing. Fan cooled.  
Mfr — Shindenger Electric #130569SXD  
Item #14707 \$19.95 New



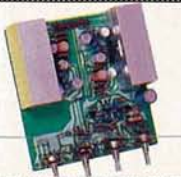


# T S M

2065 BOSTON POST ROAD, LARCHMONT, N.Y. 10538  
TEL 914-937-2447 OR 914-834-7190



**TSM 5A** \$26.30  
AUDIO POWER MODULE 70W PEAK POWER  
35W RMS, INPUT SENSITIVITY 47K/800mV  
OUTPUT 4Ω/8Ω, POWER SUPPLY 39V D.C.  
/ 2.5A



**TSM 9** \$14.00  
AUDIO PREAMPLIFIER FOR GUITAR, INPUT  
SENSITIVITY 47K/5mV, OUTPUT LEVEL  
47K/1.5V, VOLUME CONTROL VARIABLE  
POWER SUPPLY 25V D.C. / 0.1A

**TSM 34** \$9.19  
STEREO RIAA PREAMPLIFIER, INPUT  
SENSITIVITY 47K/3mV, OUTPUT 700mV,  
POWER SUPPLY 12V D.C. / 0.1A

**TSM 35** \$9.19  
MICROPHONE STEREO PREAMPLIFIER,  
INPUT SENSITIVITY 5mV/200Ω OR MORE,  
OUTPUT 700mV, POWER SUPPLY 12V D.C.  
/ 0.1A

**TSM 67** \$39.74  
STEREO AMPLIFIER 2X40W PEAK POWER  
5 SENSITIVITY INPUT 47K/300mV, OUTPUT  
2.5/8Ω, VOLUME, BALANCE, BASS,  
TREBLE, CONTROLS, POWER SUPPLY  
12V D.C. / 3A

**TSM 44** \$18.88  
AUDIO POWER MODULE, 50W PEAK POWER  
25W RMS, INPUT SENSITIVITY 800mV/47K  
OUTPUT IMPEDANCE 4/8Ω POWER SUPPLY  
40V D.C./2A

**TSM 11** \$15.50  
AUDIO AMPLIFIER 30W PEAK POWER, 15W  
RMS, INPUT SENSITIVITY 47K/150mV, 2.5  
TO 8 Ω OUTPUT, COMPLETE WITH VOLUME,  
BASS, TREBLE CONTROL, POWER SUPPLY  
12/16V D.C. / 2A

**TSM 5B** \$33.70  
AUDIO POWER MODULE 90W PEAK POWER  
45W RMS, INPUT SENSITIVITY 47K/800mV  
OUTPUT 4Ω/8Ω, POWER SUPPLY 39V D.C./2A

**TSM 18** \$12.97  
AUDIO AMPLIFIER 15W PEAK POWER, 7.5W  
RMS, INPUT SENSITIVITY 47K/150mV, 2.5  
TO 8 Ω OUTPUT, COMPLETE WITH VOLUME  
BASS, TREBLE CONTROL, POWER SUPPLY  
12/16V D.C. / 1.5A

**TSM 19** \$52.05  
AUDIO 240W PEAK POWER, 120W RMS  
SENSITIVITY 47K/ 0.8 V, OUTPUT 4 Ω,  
THD 0.3%, RESPONSE 15 Hz -100 KHZ,  
POWER SUPPLY 79V MAX. HEAT-  
SINKS NOT INCLUDED WITH THE KIT

**TSM 66** \$16.50  
AUDIO POWER MODULE 40W PEAK POWER  
20W RMS, INPUT SENSITIVITY 47K/300mV  
OUTPUT 2.5/8Ω POWER SUPPLY 12V D.C./2A

**TSM 68** \$22.66  
STEREO AMPLIFIER 2 X 20W,  
INPUT 47K/300mV, OUTPUT 2.5/8Ω SUP-  
PLIED WITH HEATSINK AND BALANCE,  
VOLUME, BASS, TREBLE, POWER SUPPLY  
12V D.C./2.5A

**TSM 155/1** \$46.30  
STEREO AMP, 2 X 50W  
PEAK, INPUT SENSITIVITY 47K/300mV  
OUTPUT 4/8Ω, SUPPLIED WITH HEATSINK  
AND BALANCE, VOLUME, BASS, TREBLE  
CONTROLS, POWER SUPPLY 40V D.C./2A/3A

**TSM 118** \$62.31  
320W PEAK POWER AMPLIFIER MODULE,  
8Ω OUTPUT IMPEDANCE INPUT 47K/800mV  
FREQUENCY RESPONSE 15Hz TO 60KHZ,  
POWER SUPPLY 2 X 40V D.C./6A,  
HEATSINKS NOT INCLUDED IN THE KIT.

**TSM 89** \$30.38  
AUDIO BOOSTER STEREO 2 X 40W FOR  
CAR RADIO, OUTPUT 2.5Ω POWER SUPPLY  
12/16V D.C./4A.

**TSM 102** \$22.50  
18 LED OUTPUT POWER LEVEL, METER,  
POWERED BY THE MODULATION.

**TSM 128** \$20.31  
2 X 6 LED OUTPUT LEVEL-METER, STEREO  
2 X 50W, POWER SUPPLY 15/20V D.C.



**TSM 122** \$13.96  
ALL-BAND FM/VHF/UHF ANTENNA, 20dB  
AMPLIFIER, POWER SUPPLY 8/12V D.C. /  
0.15A

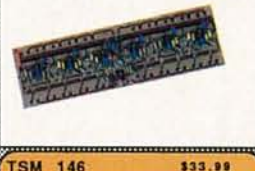
**TSM 31 s** \$14.77  
FM STEREO DECODER, POWER SUPPLY  
12V D.C. / 0.1A

**TSM 62** \$13.00  
CAR ANTENNA PREAMPLIFIER MW/LW/FM,  
POWER SUPPLY 12/16V D.C./0.1A

**TSM 335** \$15.65  
PHYSIOLOGIC TONE CONTROL, STEREO,  
INPUT IMPEDANCE 150mV/160K, OUTPUT  
LEVEL 800mV, POWER SUPPLY 25V D.C.

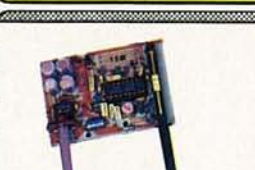
**TSM 146** \$33.99  
STEREO 2X5 BANDS EQUALIZER, SUPPLIED  
WITH 10 POTENTIOMETERS, FREQUENCY  
RESPONSE 50HZ TO 15 KHZ, POWER SUPPLY  
2 X 12V D.C./0.2A

**TSM 147** \$18.88  
MONO 5 BANDS EQUALIZER, SUPPLIED WITH  
5 POTENTIOMETERS FREQUENCY RESPONSE  
50 HZ TO 15KHZ, POWER SUPPLY 2 X 12V  
D.C./0.15A.



**TSM 147** \$18.88  
MONO 5 BANDS EQUALIZER, SUPPLIED WITH  
5 POTENTIOMETERS FREQUENCY RESPONSE  
50 HZ TO 15KHZ, POWER SUPPLY 2 X 12V  
D.C./0.15A.

**TSM 61** \$25.48  
FM RECEIVER, OUTPUT 1 WATT 4/8Ω,  
POWER SUPPLY 12/16V D.C. / 0.2A



**TSM 158** \$27.42  
FM RECEIVER, OUTPUT 20 WATTS/8Ω,  
POWER SUPPLY 12/16V D.C. / 2A.

**TSM 211** \$10.00  
MEDIUM WAVE RECEIVER, 1 W, 0.5 W RMS  
AUDIO POWER, POWER SUPPLY  
9-12V D.C. / 0.1 A

**TSM 205** \$35.40  
FM RECEIVER, HEADPHONE STEREO OUTPUT  
POWER SUPPLY 9/12V D.C./0.1A

## ELECTRONICS KITS

TSM IN AMERICA INC. 2065 BOSTON POST ROAD LARCHMONT, N.Y. 10538



**TSM 201** \$26.77  
DIGITAL CLOCK, 5/16" READ OUT, POWER  
SUPPLY 12V D.C./0.2A WITH HOUR AND  
MINUTE SETTING CONTROLS

**TSM 157** \$40.00  
DIGITAL CLOCK AND UP TO 24 MN  
1/100 S. CHRONOMETER, COUNT-DOWN  
CAPABILITY FOR THE CLOCK,  
POWER SUPPLY 12V D.C. OR A.C.

**TSM 177** \$33.20  
DIGITAL VOLTMETERS 0 V TO 999 V D.C.,  
POWER SUPPLY 12V D.C./0.5A

**TSM 206** \$10.15  
METRONOME, POWER SUPPLY 9 - 12V D.C.

**TSM 210** \$10.50  
FULLY RANDOMISED ELECTRONIC DICE,  
POWER SUPPLY 9 - 12V D.C./0.1A

**TSM 54** \$13.85  
FM TRANSMITTER, POWER SUPPLY 9V  
D.C. / 0.5A

**TSM 150** \$82.50  
HOME PROGRAMMER, 4 DEVICES CONTROL  
20 PROGRAMS, OPERATION WITH RELAYS  
POWER SUPPLY 12V D.C./0.8A.

**TSM 130** \$26.77  
24 TUNE DOOR CHIME, OUTPUT 34 WATTS  
POWER SUPPLY 12V D.C./1A.

**TSM 123** \$46.15  
SOUND CONDITIONER, OUTPUT LEVEL 800mV  
TO BE CONNECTED TO AMPLIFIER AUXILI-  
ARY INPUT, POWER SUPPLY 12V D.C.

**TSM 78** \$33.23  
UNIVERSAL ALARM FOR  
HOME AND CAR, DELAYED EXIT TIME, AD-  
JUSTABLE SOUND ALARM, TAMPER PROOF,  
OPERATION WITH CONTACT SWITCHES,  
POWER SUPPLY 12V D.C./0.15A \$33.23

**TSM 121** \$17.54  
16 LED DISPLAY THERMOMETER, POWER  
SUPPLY 15/18V D.C./0.15A

**TSM 105** \$15.15  
ELECTRONIC ALARM SIREN, 8Ω IMPEDAN-  
CE, 10 WATTS RATING, POWER SUPPLY  
12V D.C., HORN SPEAKER NOT INCLUDED.

**TSM 85** \$22.52  
TIME DELAY SYSTEM FROM 1SEC TO 15  
MINUTES, POWER SUPPLY 12V D.C.

**TSM 69** \$15.93  
TELEPHONE AMPLIFIER WITH INDUCTIVE  
PICK-UP AND SPEAKER, ADJUSTABLE  
VOLUME, POWER SUPPLY 9/12V D.C./0.1A

**TSM 168** \$12.92  
MOSQUITO REPELLER, POWER SOURCE  
9V D.C.

**TSM 86** \$36.50  
ELECTRONIC MONO REVERBERATION SYS-  
TEM, POWER SUPPLY 12V D.C.

**TSM 88** \$38.77  
FUNCTION GENERATOR, FREQUENCY RANGE  
8HZ TO 200KHZ, PROVIDING SINE/Triangle  
/ SQUARE SAW TOOTH WAVE FORMS, PO-  
WER SUPPLY 12V D.C./0.3A

**TSM 58** \$19.94  
TWO-STATION INTERCOM WITH SPEAKER  
VOLUME CONTROL, POWER SOURCE 9/12V  
D.C. / 0.4A

**TSM 160** \$16.62  
STEREO SIMULATOR, POWER SUPPLY 12V  
D.C./0.1A

**TSM 196** \$19.71  
7 INPUT MIXER STEREO PREAMPLIFIER OR  
14 INPUT MONO WITHOUT ATTENUATION,  
INPUT 47K/100 TO 700mV, OUTPUT 47K/  
100 TO 750mV, POWER SUPPLY 24V D.C.  
/ 0.1A



**TSM 212** \$17.50  
LOW OPERATING VOLTAGE  
SPOT TSM 220 AND TSM 221 COMPATIBLE  
CONTROLLED BY A MICROPHONE,  
POWER SUPPLY 12V/ 1A, OUTPUT 0.5A  
MODULATOR, SAFE 3-CHANNEL LIGHT



**TSM 214** \$29.50  
8-CHANNEL CATERPILAR, SAFE LOW  
VOLTAGE OPERATION USING TSM 220  
AND 221 SPOT, 9V D.C./ 0.5 A



**TSM 220** \$25.30  
64 LED'S SPOT FOR SAFE LIGHT MODU-  
LATION, SUPPLIED WITH BOX.

**TSM 213** \$16.20  
SAFE LOW VOLTAGE 2-WAY CATERPILAR  
RANDOMLY FLASHING AND WINKING, TSM  
220 AND TSM 221 SPOT COMPATIBLE,  
POWER SUPPLY 12V/0.5A.

**TSM 221** \$17.20  
25 LED'S SPOT FOR SAFE LIGHT MODU-  
LATION, SUPPLIED WITH BOX.



**TSM 2 V2** \$22.20  
VARIABLE SOLID STATE REGULATED PO-  
WER SUPPLY 8V TO 38V/2A,  
TRANSFORMER IS NOT INCLUDED WITH THE  
KIT.



**TSM 116 V5** \$11.50  
REGULATED POWER SUPPLY 5V D.C.  
POWER TRANSFORMER NOT INCLUDED WITH  
THE KIT.

**TSM 116 V12** \$11.50  
REGULATED POWER SUPPLY 12V D.C.  
POWER TRANSFORMER IS NOT INCLUDED  
WITH THE KIT.

**TSM 163** \$12.92  
POWER SUPPLIES 5, 7.5, 9, 12V/1A,  
POWER TRANSFORMER NOT INCLUDED  
WITH THE KIT.

**TSM 2 V4** \$25.85  
VARIABLE SOLID STATE REGULATED PO-  
WER SUPPLY 3V TO 14V/5A, TRANSFORMER  
NOT INCLUDED IN THE KIT.

### MECANORMA DIRECT ETCHING



P.C.B. SYMBOLS  
— OD 191mm

Transfer sheet \$2.00 each

— OD 254mm

Transfer sheet \$2.00 each

— OD 317mm

Transfer sheet \$2.00 each

— OD 397mm

Transfer sheet \$2.00 each

— OD 500mm

Transfer sheet \$2.00 each

— OD 140mm

— OD 104mm

— A 254mm

Transfer sheet \$2.00 each

— OD 254mm

— I 105mm

— A 508mm

Transfer sheet \$2.00 each

— OD 960mm

— I 094mm

— A 188mm

Transfer sheet \$2.00 each

— A 1270mm

— B 160mm

— C 396mm

Transfer sheet \$2.00 each

— A 1270mm

— B 160mm

— C 396mm

Transfer sheet \$2.00 each

— 1 254mm

— 2 076mm

— 3 762mm

Transfer sheet \$2.00 each

— 1 254mm

— 2 155mm

— 3 762mm

Transfer sheet \$2.00 each

— 080mm

Transfer sheet \$2.00 each

— 100mm

Transfer sheet \$2.00 each

— 127mm

Transfer sheet \$2.00 each

— 178mm

Transfer sheet \$2.00 each

— 203mm

Transfer sheet \$2.00 each

— 254mm

Transfer sheet \$2.00 each

### MECANORMA DIRECT ETCHING



### TRANSFER TAPES

KELVIN ELECTRONICS  
7 FAIRCHILD AVE., PLAINVIEW, NY 11803  
516-349-7620 FAX 516-349-7830

AVAILABLE FROM:  
NUTRON COMPUTER ELECTRONICS  
821 E ROOSEVELT RD LOMBARD IL 60148  
TEL 312-691-89-00

AUTO SOUND SYSTEM  
1269 EAST MAIN STREET EL CAJON  
CA 92021  
TEL 619-442-70-22

**SCOPE 3½ Digital Multimeters**



**Model DVM-634**  
**\$6750**

• 7 function, 32 ranges • Transistor measurement

**Model DVM-638**  
**\$8750**

Test leads included  
• 11 function, 38 ranges • Logic level detector • Audible visual continuity  
• Capacitance and conductance measurement

**SCOPE 3½ Digit Capacitance Meter**



**Model DCM-602**  
**\$5995**

Test leads included  
• 8 ranges with full scale values to 2000 uF  
• LSI circuit • Crystal time base • Frequency range 800 Hz to 8Hz

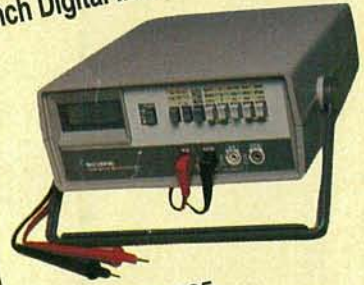
**SCOPE Pocket Sized Audio Signal Generator**



**Model RC-555**  
**\$5995**

Test leads & 9V battery included • Low distortion sine-wave signal • 46 step selected frequency • x1 range 20 Hz to 1.5 KHz/ x100 range 2 KHz to 150 KHz

**SCOPE 4½ Digit LCD Bench Digital Multimeter**



**Model DVM-6005**  
**\$21995**

Test lead set 6, "D" size batteries included  
• 0.4" high characters • Conversion period: 500 milliseconds • Automatic negative polarity

# Mini-Meters with Maxi-Specs

**SCOPE 3½ Digit LCD with 8 Full Functions**

**Model DVM-632**

**\$4495**  
OUR PRICE

Measures only 5 3/8" x 2 13/16" x 1 1/4"

Deluxe test leads included  
• 0.5% accuracy • Transistor gain test • Audible continuity checking & diode test  
• 10 Amp measurement

Zipped Carrying Case CC-30 **\$450**



**SCOPE 3½ Digit LCD**



Measures only 5" x 2 3/4" x 7/8"

**Model DVM-630**  
**\$2995**

OUR PRICE  
Test leads included • 0.5% accuracy • 6 functions, 19 ranges • Automatic zero adjust • Low battery indication

Zipped Carrying Case CC-30 **\$450**

ASK FOR FREE CATALOG.  
Money orders, checks accepted. C.O.D.'s require 25% deposit.



**Fordham**

260 Motor Parkway, Hauppauge, NY 11788

Toll Free **800-645-9518**  
In NY State **800-832-1446**

**Service & Shipping Charge Schedule Continental U.S.A.**

FOR ORDERS	ADD
\$25-\$100	\$4.50
\$101-\$250	\$6.00
\$251-500	\$8.00
\$501-750	\$10.50
\$751-1,000	\$12.50
\$1,001-1,500	\$16.50
\$1,501-2,000	\$20.00
\$2,001 and Up	\$25.00