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Now get Wabash Quality at a CE Price

For over 17 years, Wabash has been making high quality and dependable computer products. Wabash diskettes are made to provide error-free performance on your computer system because every diskette has been totally and hypercritically tested. Since you can now buy Wabash computer products directly from CE, the world's largest distributor of magnetic media, you can now get maximum savings on every order. You can even order toll-free.

New Wabash Six Year Warranty

The quality of Wabash diskettes is stressed throughout the entire manufacturing process. After coating, all Wabash diskettes go through a unique burnishing process that gives each diskette a mirror-smooth appearance. Wabash then carefully applies a lubricant that is specially formulated to increase diskette life. Then, to keep out foreign particles, a unique heat seal bonds the jacket and liner together to help prevent contamination. After 100% hypercritical testing and certification, Wabash then packages each diskette, (except bulk pack) in a super strong and tear resistant Tyvek® evelope. The final Wabash product is then shrink-wrapped to insure cleanliness and reduce contamination during shipment. Wabash diskettes are so very reliable that Wabash now offers a six year warranty in case of defects in materials or workmanship on all diskettes purchased directly from Communications Electronics.

New...Wabash Diskette Duplication Services

Communications Electronics has teamed up with Wabash to provide a single-source solution for the diskette duplication requirements of software developers, OEM's and distributors. All service is in-house, to give you fast, dependable service. In most cases, delivery can be completed in five days. Whether you require 100, 1,000, or 10,000 copies per week, call CE first for a no obligation price quote. For additional information, please write us on your letterhead with your requirements.

SAVE ON WABASH DISKETTES Product Description	Part #	CE quant. 100 price per disk ($)
8" SSSD IBM Compatible (128 B/S, 26 Sectors)	F111	1.89
8" SSSD Shugart Compatible, 32 Hard Sector	F31A	1.89
8" SSDD IBM Compatible (128 B/S, 26 Sectors)	F131	2.39
8" DSDD Soft Sector (Unformatted)	F14A	2.99
8" DSDD Soft Sector (256 B/S, 26 Sectors)	F144	2.99
8" DSDD Soft Sector (512 B/S, 15 Sectors)	F145	2.99
8" DSDD Soft Sector (1024 B/S, 8 Sectors)	F147	2.99
5¼" SSSD Soft Sector w/Hub Ring	M11A	1.49
5¼" Same as above, but bulk pack w/o envelope	M11AB	1.29
5¼" SSSD 10 Hard Sector w/Hub Ring	M41A	1.49
5¼" SSSD 16 Hard Sector w/Hub Ring	M51A	1.49
5¼" SSDD Soft Sector w/Hub Ring	M13A	1.79
5¼" Same as above, but bulk pack w/o envelope	M13AB	1.59
5¼" SSDD 10 Hard Sector w/Hub Ring	M43A	1.79
5¼" SSDD 16 Hard Sector w/Hub Ring	M53A	1.79
5¼" DSDD Soft Sector w/Hub Ring	M14A	2.69
5¼" Same as above, but bulk pack w/o envelope	M14AB	2.49
5¼" DSDD 10 Hard Sector w/Hub Ring	M44A	2.69
5¼" DSDD 16 Hard Sector w/Hub Ring	M54A	2.69
5¼" SSQD Soft Sector w/Hub Ring (96 TPI)	M15A	2.59
5¼" DSQD Soft Sector w/Hub Ring (96 TPI)	M16A	3.69
5¼" Tyvek Diskette Envelopes - Price per 100 Pack	TE5	12.00

SSSD = Single Sided Single Density; SSDD = Single Sided Double Density; DSDD = Double Sided Double Density; SSQD = Single Sided Quad Density; DSQD = Double Sided Quad Density; TPI = Tracks per inch.

Quantity Discounts Available
Wabash diskettes are packed 10 disks to a carton and 10 cartons to a case. The economy bulk pack is packaged 100 disks to a case without envelopes or labels. Please order only in increments of 100 units for quantity 100 pricing. With the exception of bulk pack, we are also willing to accommodate your smaller orders. Quantities less than 100 units are available in increments of 10 units at a 20% surcharge above our 100 unit price. **Quantity discounts** are also available. Order 500 or more disks at the same time and deduct 1%; 1,000 or more saves you 2%; 2,000 or more saves 3%; 5,000 or more saves 4%; 10,000 or more saves 5%; 25,000 or more saves 6%; 50,000 or more saves 7%, 100,000 or more saves 8%, 500,000 or more saves 9% and 1,000,000 or more disks earns you a 10% discount off our super low quantity 100 price. Almost all Wabash diskettes are immediately available from CE. Our efficient warehouse facilities are equipped to help us get you the quality product you need, when you need it. If you need further assistance to find the flexible disk that's right for you, call the Wabash compatibility hotline. Dial toll-free 800-323-9868 and ask for your compatibility representative. In Illinois or outside the U.S. dial 312-593-6363 between 9 AM to 4 PM Central time.

Buy Wabash Diskettes with Confidence
To get the fastest delivery from CE of your Wabash computer products, we recommend you phone your order directly to our Computer Products Division and charge it to your credit card. Be sure to calculate your price using the CE prices in this ad. Written purchase orders are accepted from approved government agencies and most well rated firms at a 30% surcharge for net 30 billing. For maximum savings, your order should be prepaid. All sales are subject to availability, acceptance and verification. All sales are final. All prices are in U.S. dollars. Prices, terms and specifications are subject to change without notice. Out of stock items will be be placed on backorder automatically unless CE is instructed differently. Minimum *prepaid* order is $50.00. Minimum *purchase order* $200.00. All shipments are F.O.B. Ann Arbor, Michigan U.S.A. No COD's please. Non-certified and foreign checks require bank clearance.

For **shipping charges** add $8.00 per case or partial case of 100 8-inch flexible disks or $6.00 per case or partial case of 100 5¼-inch mini-diskettes for U.P.S. ground shipping and handling in the continental U.S.A.

Mail orders to: Communications Electronics, Box 1002, Ann Arbor, Michigan 48106 U.S.A. If you have a Visa or Master Card, you may call and place a credit card order. Order toll-free in the U.S. Dial 800-521-4414. In Canada, order toll-free by calling 800-265-4828. If you are outside the U.S. or in Michigan dial 313-994-4444. Telex anytime 810-223-2422. Order your Wabash diskettes today.

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CIRCLE 81 ON FREE INFORMATION CARD

Radio-Electronics

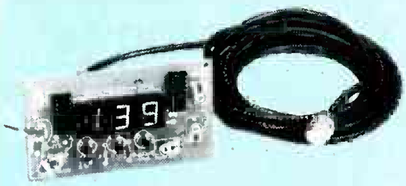
THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

Electronics publishers since 1908

AUGUST 1983 Vol. 54 No. 8

ON THE COVER

One field that has been strongly affected by microelectronics is that of photography. Once-bulky equipment is now built right into pocket-size cameras. And, in the darkroom, microprocessors are making things as easy as 1-2-3. Sony has even unveiled a completely filmless electronic-photography system. All that, and more, is covered in our special section on electronics and photography beginning on page 57.



AS YOUR CAR creeps along in the stop-and-start summertime traffic, its most dangerous enemy is probably the heat. And you have no idea how badly your engine is suffering until the "idiot light" marked "TEMP" comes on...and the radiator blows its top! This digital temperature gauge will let you know at any time exactly how hot the engine is, and allow you to cool things off before it's too late. Construction details start on page 92.

COMING NEXT MONTH

On Sale August 18

- **The Pianomatic.** An attention-getting programmable music maker you can build yourself.
- **ECL.** A tutorial on emitter-coupled logic.
- Plus lots more!

Because of lack of space, the installment of "Analog Design" scheduled to appear this month will appear in next month's issue.

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VIDEO ELECTRONICS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

BETAMOVIE ARRIVES

Loaded with innovations, Sony's *Betamovie* (see **Radio-Electronics,** April 1983) is scheduled to go on sale in the United States in November. The one-piece combination VCR-camera, which weighs less than seven pounds (including cassette and battery), is a unique product in that it's not self-sufficient but is designed to add portable movie-making to the estimated 2 million home Beta decks now in use. It has no playback capability but is merely a simple, easy-to-use recorder.

Betamovie (see lefthand photo) is equipped with a new half-inch Saticon Mixed Field pickup tube, a through-the-lens viewfinder and 6:1 zoom. It uses a standard Beta cassette and will record for three hours and 20 minutes on an L-830 cassette. To accomplish this marvel of compactness, Sony has completely redesigned the Beta tape loading and wrap systems. Abandoning its traditional "U" wrap and still preserving Beta compatibility, Sony has designed a new system using "omega" or "M" wrap similar to that used in VHS recorders. The head drum is reduced from 74.5mm to 44.7mm in diameter and the drum speed has been doubled to 60 revolutions per second. Instead of two heads at opposite sides of the drum, *Betamovie* uses a single head with two gaps, and the tape is wrapped around more than 300 degrees of the drum (versus 180 degrees in a standard Beta recorder). Thus each revolution of the smaller drum is the equivalent of one-half revolution of the conventional Beta drum.

TV WRISTWATCH

Seiko's TV-watch (see righthand photo) will be available in the U.S. in October at $495. It has a 1.2-inch liquid crystal TV display in addition to the usual digital watch functions. The TV chassis and power supply are contained in a pocket unit. The special LCD has a base of silicon, forming an IC which creates a switching transistor for each of 31,920 dots or picture elements.

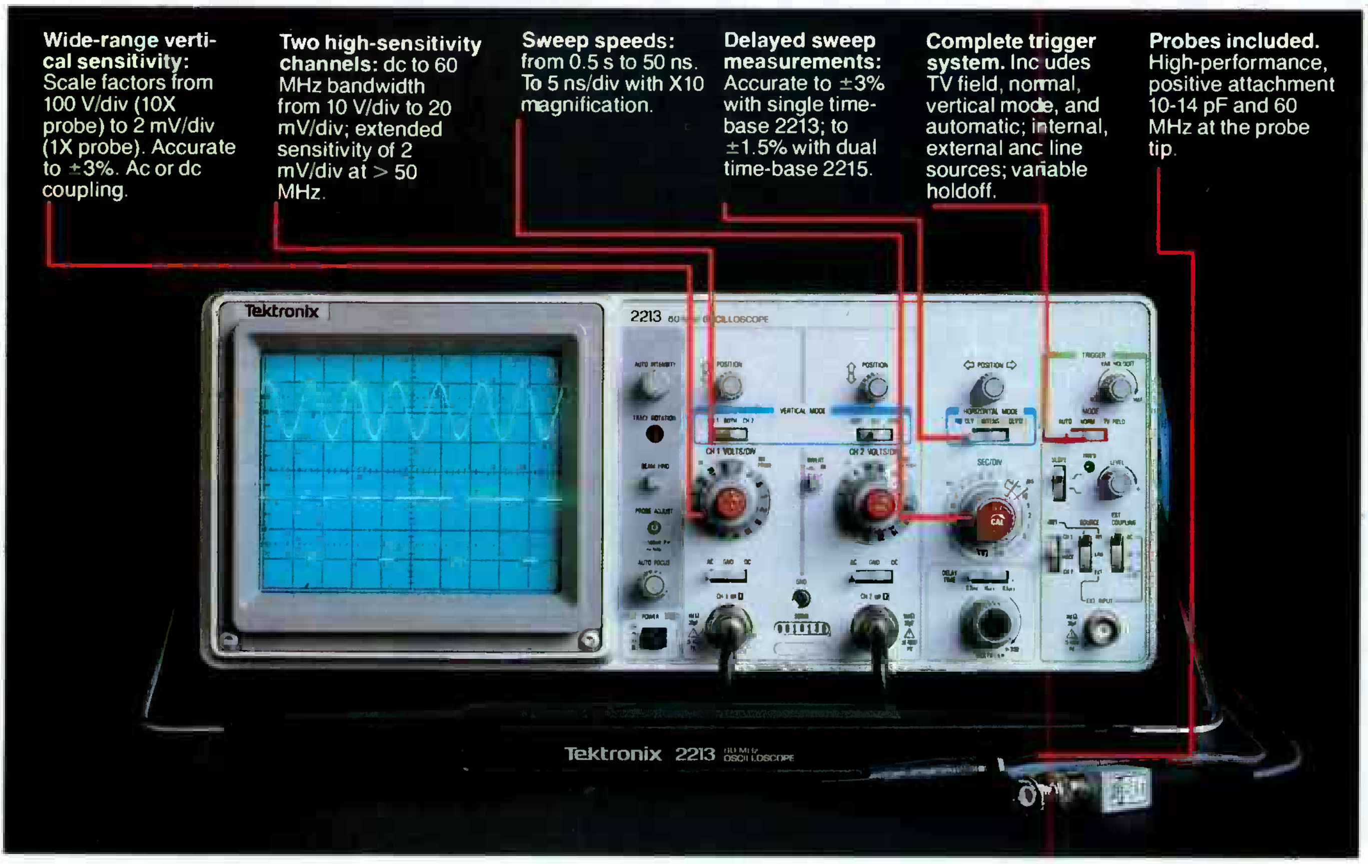
TELETEXT— WHO'S WATCHING?

With the recent inauguration of Teletext as a regular service by the FCC, networks and independent stations are starting to offer the multipage information service in the vertical interval of regular TV broadcasts. The Commission is permitting the service without establishing any standards, and at least two incompatible techniques are being used. As we reported in this column last month, CBS and NBC are using the industry-developed NABTS (*N*orth *A*merican *B*roadcast *T*eletext *S*pecification) standard. That format is a cross between France's Antiope and Canada's Telidon, while some stations are using the British system.

If you want to receive teletext signals this year, you're out of luck unless you're quite rich or are a very intrepid constructor. A check with major receiver manufacturers showed that few, if any, had plans for any popularly priced decoders for 1983. The few professional decoders available are priced at around $2,000. It's possible that some decoders could be available next year in the $300-$500 range. Matsushita, parent of Panasonic and Quasar, is developing a combination home-computer and teletext decoder for the cable-teletext system to be launched by Time Inc. That system will use a full TV channel rather than the vertical interval and will provide access to 5,000 pages of information. Whether the Matsushita decoder will work with the broadcast vertical-interval teletext is among the many undecided aspects of the inauguration of U.S. teletext, as is the price of Matsushita's attachment. (It is hoped that the decoder will sell for $150.) **R-E**

TEK 2200 MULTI-PURPOSE OSCILLOSCOPES — THE PERFORMANCE/ PRICE STANDARD

Now. Tektronix 60 MHz Performance is just a free phone call away!



These easy to order scopes are proof that it's not expensive to have advanced, 60 MHz performance from Tektronix on your bench. It's just practical! Feature for feature, the Tek 2213 and 2215 set a price/performance standard unmatched among portable scopes. And are backed by the industry's first three-year warranty on all labor and parts, including the CRT.

So advanced they cost you less: $1200* for the 2213! $1450* for the dual time base 2215! These low costs are the result of a new design concept that utilizes fewer mechanical parts than any other scope.

Yet there's no scrimping on performance and reliability. You have the bandwidth for digital and analog circuits. The sensitivity for low signal measurements. The sweep speeds for fast logic families. And delayed sweep for fast, accurate timing measurements.

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Order toll free: 1-800-426-2200 Extension 42

In Oregon call collect: (503) 627-9000 Ext. 42

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**Three-year warranty applies to 2000 Family oscilloscopes purchased after 1-1-83.

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CIRCLE 74 ON FREE INFORMATION CARD

There is a word that describes your choices in flexible disks today. That word is "ordinary." The woods seem to be full of offerings of middling quality, neither good nor bad, not necessarily cheap but not overly expensive for the most part, products that are just so-so, just average, just... well, just ordinary.

But now there's a new word in flexible disks. Ultra Magnetics. A word that redefines the state-of-the-art in flexible disk price performance rather than reinforcing the current state-of-the-marketplace. By itself, *Ultra* means "extra ordinary." And by itself is where you'll place the Ultra Magnetics product when you have a chance to compare it to others.

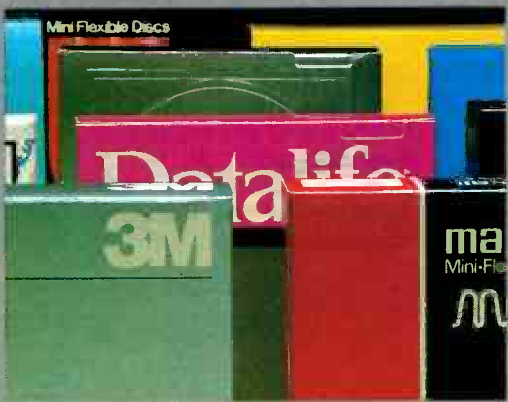
The superb engineering and meticulous manufacturing of each Ultra Magnetics disk clearly shows. A proprietary jacket provides more consistent jacket dimensions and lower torque that result in better auto-loading and longer life. A special lubricant built into each disk surface enhances both disk and head durability. And 100% surface testing of each and every Ultra Magnetics disk ensures the highest data reliability. Our Ultra Magnetics product line currently includes single- and double-sided 5.25-inch disks. Soon, it will feature 8-inch disks as well. For a fact, they are more expensive than some of the garden variety alternatives. But considering the performance and the reliability, Ultra Magnetics is a surprisingly attractive value.

Here's the bottom line. You no longer have to put up with what you may have sadly come to expect from flexible disks. And we encourage you to take the next logical step from the usual to the remarkable—from the ordinary to the extraordinary. Call your local supplies distributor and ask for Ultra Magnetics.

ULTRA MAGNETICS

Ultra Magnetics Technology, Inc.
7 Hangar Way
Watsonville, CA 95076
(408) 728-7777

EXTRA ORDINARY



CIRCLE 24 ON FREE INFORMATION CARD

ULTRA Diskettes

Now...Diskettes you can swear by, not swear at.

Lucky for you, the diskette buyer, there are many diskette brands to choose from. Some brands are good, some not as good, and some you wouldn't think of trusting with even one byte of your valuable data. Sadly, some manufacturers have put their profit motive ahead of creating quality products. This has resulted in an abundance of low quality but rather expensive diskettes in the marketplace.

A NEW COMPANY WAS NEEDED AND STARTED

Fortunately, other people in the diskette industry recognized that making ultra-high quality diskettes required the *best* and newest manufacturing equipment as well as the best people to operate this equipment. Since most manufacturers seemed satisfied to give you only the everyday quality now available, an assemblage of quality conscious individuals decided to start a new company to give you a new and better diskette. They called this product the *Ultra* diskette, and you're going to love them. Now you have a product you can swear by, not swear at.

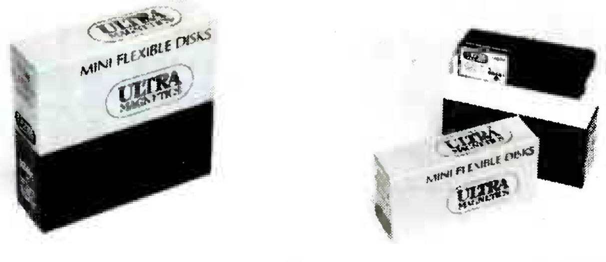
HOW THEY MADE THE BEST DISKETTES EVEN BETTER

The management of *Ultra* Magnetics then hired all the top brains in the diskette industry to make the *Ultra* product. Then these top bananas (sometimes called floppy freaks) created a new standard of diskette quality and reliability. To learn the "manufacturing secrets" of the top diskette makers, they've also hired the remaining "magnetic media moguls" from competitors such as Verbatim, Memorex, Dysan and many more. Then all these top-dollar engineers, physicists, research scientists and production experts (if they've missed you, send in your resume to *Ultra*) were given one directive...to pool all their manufacturing know-how and create a new, better diskette.

HOW ULTRA DISKETTES ARE MANUFACTURED

The *Ultra* Magnetics crew then assembled the newest, totally quality monitored, automated production line in the industry. We know that some of Ultra's competitors are still making magnetic media on equipment that is old enough to vote. Since all manufacturing equipment at *Ultra* is new, it's easy for *Ultra* to consistently make better diskettes. You can always be assured of ultra-tight tolerances and superb dependability when you use *Ultra*. If all this manufacturing mumbo-jumbo doesn't impress you, we're sure that at least one of these other benefits from using *Ultra* diskettes will:

1. **TOTAL SURFACE TESTING** - For maximum reliability, and to lessen the likelihood of disk errors, all diskettes must be totally surface tested. At *Ultra*, each diskette is 100% surface tested. *Ultra* is so picky in their testing, they even test the tracks that are in between the regular tracks.
2. **COMPLETE LINE OF PRODUCTS** - For a diskette to be useful to you and your computer, it must be compatable physically. *Ultra* Magnetics has an entire line of 5¼-inch and 8-inch diskettes.
3. **SPECIALLY LUBRICATED DISK** - *Ultra* uses a special oxide lubricant which is added to the base media in the production of their diskettes. This gives you a better disk drive head to media contact and longer head and disk life.
4. **HIGH TEMPERATURE/LOW-MARRING JACKET** - A unique high temperature and low-marring vinyl jacket allows use of their product where other diskettes won't work. This special jacket is more rigid than other diskettes and helps eliminate dust on the jacket.
5. **REINFORCED HUB RINGS** - Standard on all *Ultra* mini-disks, to strengthen the center hub hole. This increases the life of the disk to save you money and increase overall diskette reliability.
6. **DISK DURABILITY** - *Ultra* disks will beat all industry standards for reliability at well over millions and millions of revolutions. They are compatible with all industry specifications as established by ANSI, ECMA, ISO and JIS.
7. **CUSTOMER ORIENTED PACKAGING** - All *Ultra* disks are packaged 10 disks to a carton and 10 cartons to a case. The economy bulk pack is packaged 100 disks to a case without envelopes or labels.
8. **LIFETIME WARRANTY** - If all else fails, remember, all disks made by *Ultra* Magnetics, (except bulk pack) have a lifetime warranty. If your *Ultra* disks fail to meet factory specifications, *Ultra* Magnetics will replace them under the terms of their warranty.
9. **SUPERB VALUE** - With Ultra's automated production line, high-quality, error-free disks are yours without high cost.



SAVE ON ULTRA DISKETTES Product Description	Part #	CE quant. 100 price per disc ($)
8" SSSD IBM Compatible (128 B/S, 26 Sectors)	81726	1.99
8" SSDD IBM Compatible (128 B/S, 26 Sectors)	81701	2.49
8" DSDD Soft Sector (Unformatted)	82701	3.19
8" DSDD Soft Sector (1024 B/S, 8 Sectors)	82708	3.19
5¼" SSSD Soft Sector w/Hub Ring	50001	1.79
5¼" Same as above, but bulk pack w/o envelope	00153	1.39
5¼" SSSD 10 Hard Sector w/Hub Ring	50010	1.79
5¼" SSSD 16 Hard Sector w/Hub Ring	50016	1.79
5¼" SSDD Soft Sector w/Hub Ring	51401	1.89
5¼" Same as above, but bulk pack w/o envelope	00096	1.49
5¼" SSDD 10 Hard Sector w/Hub Ring	51410	1.89
5¼" SSDD 16 Hard Sector w/Hub Ring	51416	1.89
5¼" DSDD Soft Sector w/Hub Ring	52401	2.79
5¼" Same as above, but bulk pack w/o envelope	00140	2.39
5¼" DSDD 10 Hard Sector w/Hub Ring	52410	2.79
5¼" DSDD 16 Hard Sector w/Hub Ring	52416	2.79
5¼" SSQD Soft Sector w/Hub Ring (96 TPI)	51801	2.49
5¼" DSQD Soft Sector w/Hub Ring (96 TPI)	52801	3.49

SSSD = Single Sided Single Density; SSDD = Single Sided Double Density; DSDD = Double Sided Double Density; SSQD = Single Sided Quad Density; DSQD = Double Sided Quad Density; TPI = Tracks per inch.
For less than 100 diskettes, add 10% to our quantity 100 price.
For additional compatibility info call Ultra Magnetics at 408-728-7777.

The Small Print

To get the fastest delivery from CE of your *Ultra* computer products, send or phone your order directly to our Computer Products Division. Be sure to calculate your price using the CE prices in this ad. 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 30% surcharge for net 30 billing. All sales are subject to availability, acceptance and verification. All sales 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 back order automatically unless CE is instructed differently. Minimum *prepaid* order $50.00. Minimum *purchase order* $200.00. International orders are invited with a $20.00 surcharge for special handling *in addition* to shipping charges. All shipments are F.O.B. Ann Arbor, Michigan. No COD's please. Non-certified and foreign checks require bank clearance.

For **shipping charges** add $8.00 per case or partial-case of 100 8-inch discs or $6.00 per case or partial-case of 100 5¼-inch mini-discs for U.P.S. ground shipping and handling in the continental United States.

Mail orders to: Communications Electronics, Box 1002, Ann Arbor, Michigan 48106 U.S.A. If you have a Master Card or Visa card, you may call and place a credit card order. Order toll-free in the U.S. Dial 800-521-4414. In Canada, order toll-free by calling 800-265-4828. If you are outside the U.S. or in Michigan, dial 313-994-4444. Telex 810-223-2422. Order your *Ultra* diskettes from Communications Electronics today.

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CIRCLE 28 ON FREE INFORMATION CARD

WHAT'S NEWS

Ohio court throws out radar evidence

Judge Anthony M. DeJute, of the Defiance, OH, municipal court, has ruled that a reading taken by a K-55 radar used in the moving mode is "not the subject of judicial notice."

The decision was the result of a test case in which over 600 pages of expert testimony and numerous exhibits were introduced; the case also featured verbal testimony by two recognized experts in the field of police traffic radar. The trial lasted three days.

The court indicated that continued judicial notice would be taken of the K-55's accuracy when used in the stationary mode.

G.E. entering home telephone market

The Audio Electronics Products Department of the General Electric Co. has introduced a line of home telephones, a totally new addition to the company's consumer-product line.

The new Advantage series includes five models, ranging from the standard model *2-9100* desk or wall telephone (with such features as *Versa-dial* pushbutton dialing, one-touch re-dial, and lighted keypad) for a suggested retail price of $43.95, to the model *2-9650*, a maximum-range, cordless telephone system with continuous anti-piracy and clear-channel privacy features, at a suggested price of $199.95. The line also contains two clock-radio telephone combinations.

Reliability, states the company, was the keynote in developing the new line, and all models come with a two-year warranty, except the cordless phone, on which the warranty is one year.

THE NEW GENERAL ELECTRIC ADVANTAGE SERIES. Clockwise from far left: *Wake-Up-Call*, model *7-4700*; *Call-Maker*, model *7-4705*; cordless telephone *Voyager*, model *2-9650* (shown with its recharging cradle); *Hotline*, model*2-9250*, and standard full-feature telephone, model *2-9100*.

Historic call sign revived in England

The call 2MT—initially used to introduce Britain's first regularly scheduled entertainment broadcasts—is being revived after 60 years.

It was first issued in 1920 to the Marconi Co., which was given an experimental license for broadcasting news bulletins. That license was revoked when a musical program was broadcast.

Later, after an appeal from the Wireless Society of London (now the Radio Society of Great Britain) the call was issued again, this time without the "news only" limitation. The first entertainment broadcast in the United Kingdom was transmitted on 700 meters (429 kHz) under that call sign. That transmission took place on Feb. 14, 1922, at Writtle, which is near Chelmsford, England.

The license restricted broadcasting to a half hour each Tuesday. The station was required to cease transmitting three minutes in every ten, in order to check for complaints.

The reissued call (now G2MT) has been granted to the Marconi Radio Society, a new group formed by amateurs employed by Marconi Space and Defense Systems, Ltd.,(MSDS). The Society enjoys the use of the Company's facilities, and its president is Dr. W. Bardo, Technical Director of MSDS.

Funtastic signs with The Games Network

Funtastic, Inc. has leased the cable-television rights for its games to The Games Network, a new cable-delivered videogame programming service. Funtastic's best seller, *Snack Attack,* will be one of the first games offered by the new service.

The new network is viewed as an additional revenue source for videogame manufacturers and designers; it will pay royalties for games offered on the service. It is also expected to provide a test market for new games.

The Games Network will offer a variety of videogames in both educational and entertainment formats. Cable viewers will pay a monthly fee, and will be able to choose from a selection of 20 games, at least five of which will be rotated monthly. The service is expected to start late this year.

Laser disc narrates the life of Van Gogh

A new optical laser videodisc, "Vincent Van Gogh; a Portrait in Two Parts," has been pressed by North American Philips to demonstrate the capabilities of its *LaserVision* system. One side of the disc is a one-man play, "Vincent" starring Leonard Nimoy, television actor and Van Gogh buff; the other: "Van Gogh Revisited," is a study of the artist's life and works.

Narrated by Mr. Nimoy, "Van Gogh Revisited" consists of 16 chapters, plus 677 still frames featuring the works of Van Gogh, as well as those of other artists. The disc takes advantage of the interactive features of the *LaserVision* system by using two separate audio tracks—thus offering two different types of commentary—and by indexing over 200 works of art, which can be accessed at will by the viewer.

"We felt an upscale, state-of-the-art videodisc was needed to show conclusively the vast resources of the *LaserVision* system," stated John Messerschmidt, vice president of North American Philips. To see in person everything offered on this disc, a viewer would have to spend an evening in the theater, travel to 46 art musuems, refer to a variety of art books, and also attend several lectures.

Though Philips is marketing the disc—available at selected video and department stores—it has no intention of entering the videodisc program-production business. Videodiscs are now being produced by 14 companies.

New 3-D viewer

The Bright and Morning Star Co. of Lawndale, CA, has received U.S. patent 4,235,515 for a 3-D viewing system that requires no special glasses, filters, or similar encumbrances commonly associated with stereo viewing in autostereoscopic systems. The viewer, however, must be positioned in front of and at "a comfortable distance" from the viewing unit—between 12 and 24 inches. As the positioning is not critical, a hand-held viewer may be used.

Standard left-right pairs of images are required. A removable external device adapts home, moving picture, X-ray, or TV-cameras to produce such image pairs for display by the system.

The heart of the display system is a sandwich of Fresnel lenses. Since the lines of sight from the viewer's left and right eyes are not parallel, they enter the sandwich at slightly different angles of incidence. One of the lines of sight strikes the sandwich at an angle great enough to undergo total internal reflection from one of the

continued on page 10

affordable precision

Excellence by Design

BBC has been building multimeters and other instrumentation for European engineers and technicians for over 7 decades. And now, twelve advanced technology BBC meters with a complete line of accessories are available in the U.S. Prices range from under $50.00 to $595.00. No other manufacturer offers you comparable price and performance values.

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WHAT'S NEWS

continued from page 8

lenses, and is directed to an area where one of the stereo images is presented to it. The other line of sight, entering the sandwich at an angle not great enough to undergo total reflection, is transmitted through the lenses with only slight refraction, and strikes the other stereo image.

The observer's lines of sight have been separated and directed in two discrete directions, and he sees a right and left image with the corresponding eyes. Thus he sees three-dimensionally.

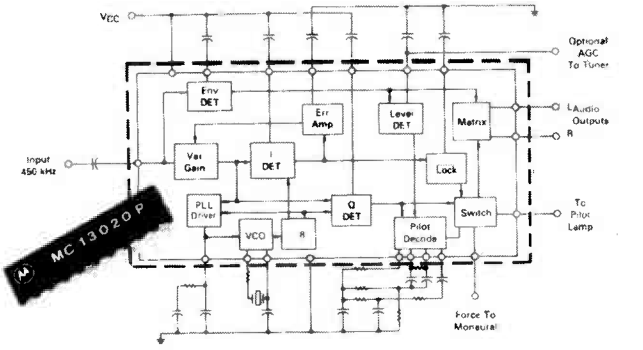
The company suggests that licensees can construct equipment for a wide variety of sizes and uses—ranging from 35-mm photography to videogames—and for a wide range of technical photography, too.

New AM stereo decoder IC introduced by Motorola

Motorola's semiconductor products division has announced the introduction of an IC AM-stereo decoder that's compatible with Motorola's C-QUAM AM-stereo broadcasting system. That system has already been adopted by a number of radio stations; and late last year, the Delco division of General Motors recommended that it be used in future GM car radios.

In the C-QUAM, or *C*ompatible *QU*adrature *A*mplitude *M*odulation system, the L + R and L − R signals are encoded by amplitude-modulating them onto two carrier signals. The signals are at the same frequency, but 90 degrees out of phase. The result is a true L + R carrier envelope. For mono reception, that signal is multiplied by the cosine of the resulting phase angle.

The new IC, designated MC13020P by Motorola, will be the heart of an AM stereo receiver and takes the place of the standard detector in a conventional AM radio. It requires a 200-mV IF signal and produces about 100 to 200 mV of audio. It requires few external components—just a small number of resistors and capacitors as well as an inexpensive ceramic resonator for the phase-locked reference oscillator. The introductory price of the IC, in quantities of 100 to 999, is $2.33 each.



BLOCK DIAGRAM of the new Motorola AM-stereo decoder shows the internal functions of that complex IC.

The Source, Control Data Corporation join forces

An agreement has been reached between Control Data Corporation and The Reader's Digest Association under which Control Data has invested in Source Telecomputing Corporation, Reader's Digest's videotex subsidiary. STC's primary service is The Source, a videotex and information database service.

According to Walter Bruning of Control Data, "The Source is one of the foremost information services in the nation. As such, it offers real potential for us in expanding the channels for computer-based information services to individuals and business enterprises. Control Data's long experience with delivering computer services will complement the strong information orientation of Reader's Digest."

The Source provides information and communications services to over 33,000 subscribers for use with personal computers, terminals, or communicating word processors. Under terms of the agreement, Reader's Digest will retain its controlling interest in STC.

RCA prepares for growing video display business

RCA has set up a Video Component and Display Division as the company's primary business focus for the OEM (*O*riginal *E*quipment *M*anufacturer) sale of video display products for computer and other commercial and industrial applications.

A standard line of video monitors for consumer and industrial use is planned. The majority of those will be designed for color-video displays with improved resolution.

Predicting that the display business is expected to quadruple by 1990, Roy H. Pollack, RCA executive vice president, reported that the company is already heavily involved in video display, and has been particularly successful with TV surveillance equipment and with video monitors sold to the educational market.

Voice recognition/synthesis for videogames

The Milton Bradley Co. of Springfield, MA, one of the world's largest manufacturers of games and educational materials, has contracted with Atari, Inc., Sunnyvale, CA, to manufacture a plug-in peripheral containing voice synthesis and voice recognition for Atari's *2600* and *5200* videogame consoles.

The plug-in will be sold with a headset/microphone that allows the player to voice-control the videogame action. "The addition of voice synthesis and recognition marks the first time that this technology has been applied to home-videogame consoles. It provides the consumer with added excitement and involvement," says an Atari spokesman.

Milton-Bradley will also develop codes for a total of 18 Atari cartridges over a three-year period. Most of them will use voice capabilities. **R-E**

Radio-Electronics

Cover photo by Robert Lewis

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

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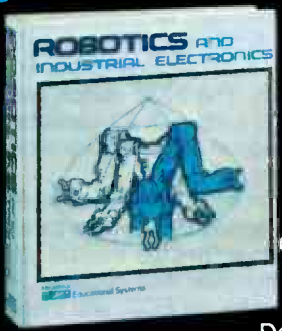
Capable of seven axes of motion, the robot can be programmed to pick up small objects with its arm. It will also speak in complete sentences, using its voice synthesizer.

Remarkable though the robot is, its companion Robotics Education Course is an even more significant "first." It provides a thorough understanding of robot technologies, including robotics programming. Course features self-test unit reviews, experiments and final exam. Designed to be used with HERO 1, this 1200 page course is the most complete introduction to robotics available today.



HERO 1 is a computer on wheels. HERO 1 uses a 6808 microprocessor that controls 13 functions and sense boards. Its on-board processor can take it through complex maneuvers. The programming process is straightforward with provision for step-by-step debugging, enhancement and other corrections.

HERO 1 senses include: sound detection (frequency range 200-5000 Hz); light detection; ultrasonic ranging; ultrasonic motion detection; speech synthesis; and real time, four year calendar clock.

A completely mobile platform robot, HERO 1's motion abilities permit head rotation and arm rotation of 350°, shoulder rotation of 150°, arm extension of 5 inches, wrist pivot of 180° and wrist rotation of 350°. Gripper will open to a maximum of 3½ inches and rotate 90° at extreme extension. Payload capacity of arm is 8 oz. at maximum extension and 16 oz. at normal.

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CIRCLE 16 ON FREE INFORMATION CARD

SATELLITE/TELETEXT NEWS

GARY ARLEN
CONTRIBUTING EDITOR

PRIVATE SATELLITES

Orion Satellite Corp., a new telecommunications firm, wants to launch an ambitious satellite project that would put two birds over the Atlantic, mainly for transmission of *international* video and data between Europe and the U.S. The $230 million plan envisions lofting the two high-power birds in 1986 or early 1987, each with 22 transponders that would be sold or offered on long-term leases to video-program distributors and private companies who would use the circuits for a variety of purposes.

Orion's plan puts the new company in head-to-head competition with Intelsat, the consortium of 108 nations that now has a monopoly on world satellite services. But officials at Orion insist that their satellites will complement the Intelsat offerings, especially by giving heavy video and data users more control over their circuits.

The Orion proposal must be approved by the FCC, and there is already speculation that government officials will try to discourage the effort for fear that other potential international satellite operators may seek to establish similar services if the Orion plan is approved. The Orion management group has strong ties to the cable-TV and telecommunications industries in the U.S.—posing interesting prospects for the new company. Details, including orbital slots for the birds, launch specifications, and transmission systems, are not yet developed.

WEATHER SATELLITES

The Reagan Administration wants to sell the nation's four weather satellites and a low-flying land-survey satellite to private industry as part of a cost-cutting effort; the private operator would then operate the satellites and sell data back to the government's weather service.

Among the first companies to respond to the plan was Comsat, which put together a proposal called "EarthStar." It calls for spending about $300 million to buy the weather-satellite system, and then operate it for about $600 million less during the first five years than it now costs the government. However, Comsat's proposal—and other possible plans—may face legal hurdles from skeptics who don't want the government to give up ownership of those satellites.

NEW SATELLITE PROGRAMMING

More shopping shows are popping up on satellite networks. *The TV Auction,* an hour-long videotape of an auction at the San Jose Flea Market, is carried several times a week on Satellite Programming Network (Westar IV, transponder 11X). Home viewers can phone in orders as the merchanidse is auctioned at the flea market, buying products at the auction-sale price. Another shopping show, *The Sharper Image Living Catalog,* features merchandise from the slick *Sharper Image* mail-order catalog; that one is carried on SPN, Modern Satellite Network, and on selected local-origination cable channels.

There's also more music aloft. Satellite Music Network will use the audio subcarrier of Times Mirror's Spotlight pay TV channel (Satcom III, transponder 4) for a number of new formats, extending the three all-day radio formats which SMN now offers. Mutual Broadcasting and Doubleday media are programming *Rock USA,* a new three-hour weekly album-rock program in stereo. Meanwhile, the popular new national newspaper *USA Today* is heading into satellite radio, developing a series of daily radio features drawn from stories in the newspaper. Three 60-second programs will be beamed daily via Mutual radio's satellite network to stations around the country.

TELETEXT AND VIDEOTEX BITS

J.C. Penney, the giant retail chain, has bought the FirstHand videotext system developed by a Minneapolis banking firm and expects to roll the service out as a national facility for electronic home banking, shopping, and information retrieval. Penney will invite other financial institutions and information companies to join in the FirstHand service, which has been using French videotext (Antiope) technology.

United Video and Weatherscan International have set up the first complete satellite-fed weather information service, Zephyer Weather Transmission. The data will be sent via UV's vertical blanking interval to independent meteorologists, airlines, broadcast stations, and others needing instant weather data.

Atari's mystery-cloaked "Project Falcon" is coming out of the shadows—and it will include some teletext-like features. Ataritel, a package of communications services, including a smart electronic telephone/computer system, is expected later this year. R-E

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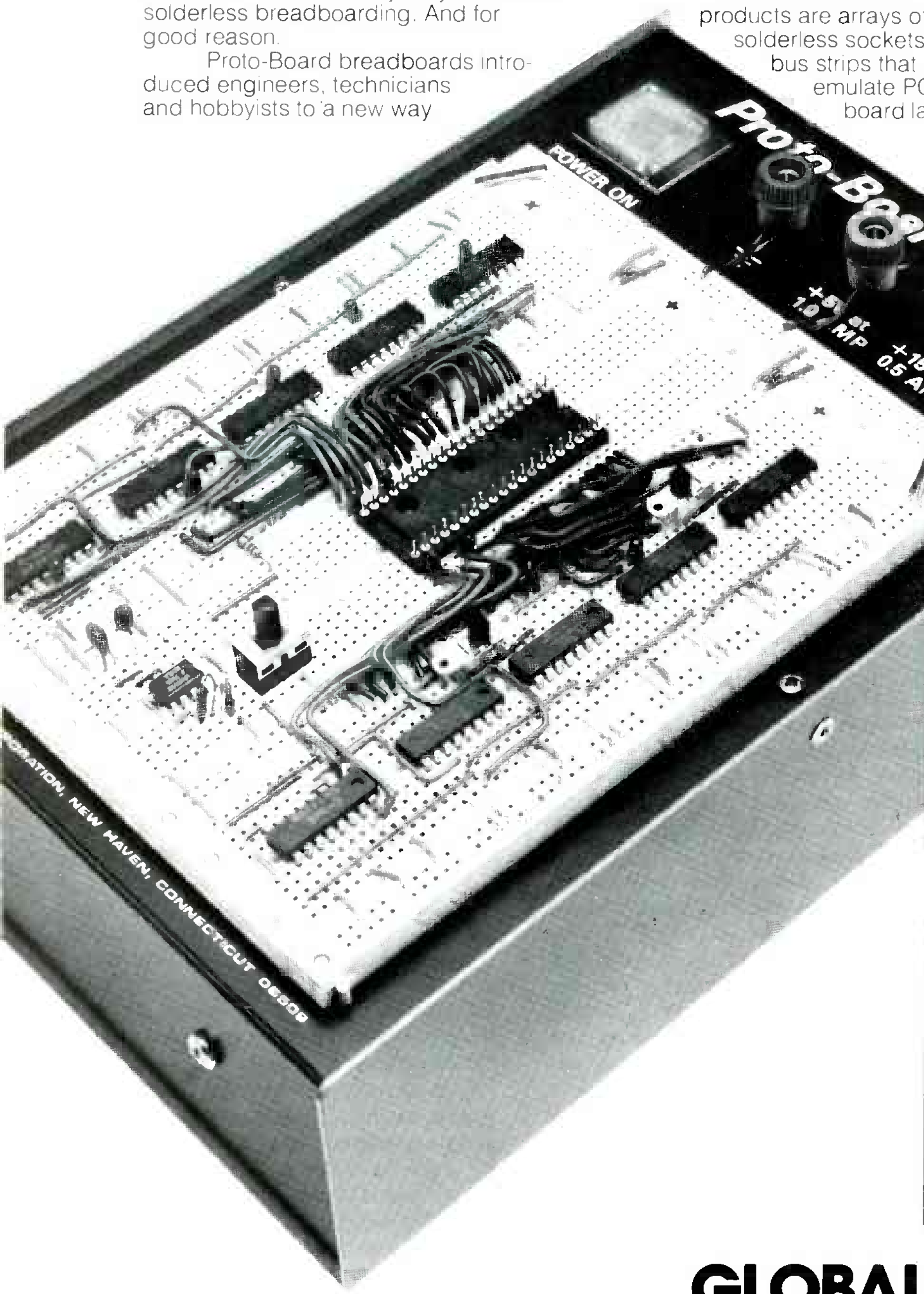

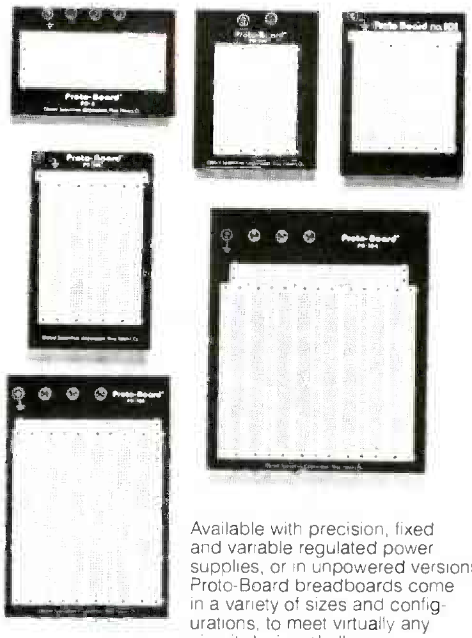

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CIRCLE 31 ON FREE INFORMATION CARD

VIDEOGAMES

Do-it-yourself games

DANNY GOODMAN, CONTRIBUTING EDITOR

THE DO-IT-YOURSELF PHENOMENON HAS affected almost every aspect of life in this country. If there is a task requiring an expensive professional, you can be sure that someone has written a book, or has packaged a set of tools and parts that lets the weekend carpenter, would-be attorney or shade-tree auto mechanic get the job done more cheaply, though not necessarily more quickly. And, of course, there's the satisfaction of doing the work yourself and the pride in showing off the finished product.

But the world of home videogames may seem off-limits to mere "mortals" who must buy professionally designed game cartridges to plug into their consoles. In the meantime, the "David Cranes" of the industry get all the glory for their design work.

There are surely many game players out there—perhaps you are one—who have great game ideas, or would like to try their hand at inventing a better Pac-Man. Well, now you have a way to apply your talents at game design to the Atari *2600* and *5200* videogame systems—a way that doesn't require access to the vast mini- and mainframe-computer development systems the "Big Guys" use.

A company called Frobco (603 Mission Street, Santa Cruz, CA 95060) is offering a game-development system for the two Atari videogame machines. Before you rush out to buy one, though, you should know that the system does require an *Apple II* computer and a healthy knowledge of assembly language programming for the Apple's (and Atari's) 6502 microprocessor. But with that equipment and knowledge, both models, the *FROB-26* and *FROB-52* will allow you to set up a free-lance game design business right from your family's living room.

FIG. 1

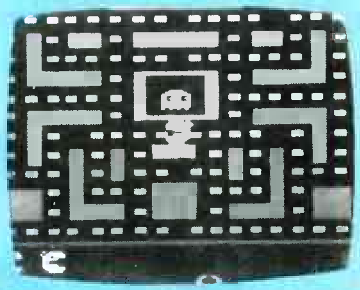
The *FROB-26*, shown in Fig. 1, comes with an accessory card for the *Apple II* computer, a couple of *2600* cartridge adapters, a cable that connects between the cartridge slot and the *Apple II* board, plus software and manuals. The system essentially fools the *2600* into thinking that you have a cartridge plugged into the console. But in reality, your *Apple II* is acting like a dynamic cartridge, complete with the ability to download game programs onto disk for retrieval and editing later. FROB software allows you to experiment inside the *2600* by learning what the various registers control. You can program the unit in real time, that is, the instructions you enter into the various *2600* registers immediately affect what's happening graphically and aurally. And as long as you know machine-language programming, Frobco has an in-depth tutorial, "Inside the VCS," that will fill you in on all the technical details of the console.

As you develop a game, you can save your work-in-progress on a disk. And when you're done (a game, like Rome, won't be built in a day—professional designers take months to perfect their creations) you can transfer the program over to a 2732 EPROM with the aid of the *FROB-Burner*. Then you can let your friends play your game directly on their systems. Or perhaps, if you're more ambitious, you will take the bold step and submit your game to the major videogame cartridge producers.

When you consider the cost of add-on boards and software for the Apple computer, $495 for the basic 4K *FROB-26* system gets you a lot for the money. For Atari *5200* game development, you can simply upgrade the *FROB-26* to the 4K *FROB-52*. That upgrade only costs an additional $195. To design more advanced games, however, a better buy is the 8K *FROB-52* system. It allows you to design 4K games for the *2600* and 8K games for the *5200*; the cost is just $990.

The word "frob," by the way, is a computer enthusiast's term suggesting fine-tuning or adjusting something just for the fun of seeing what will happen. But lest you think the FROB systems are just for mindless computer acrobatics, you should know that serious game designers at Activision, Coleco, and Atari use FROB systems to develop the cartridges you're buying today.

Atari Ms. Pac-Man for Atari 2600



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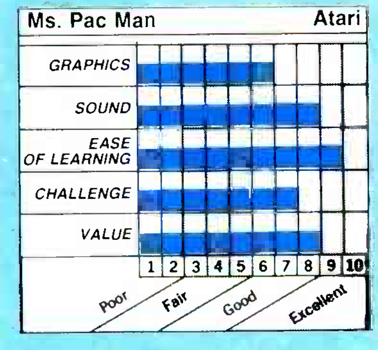

Although few good words have been uttered about the original Atari (1265 Borregas Ave., Sunnyvale, CA 94086) *Pac-Man* cartridge for the *2600*, it was nonetheless a popular one. But the critics will have precious little to quibble about over the Atari's latest home version of a popular arcade gobbler, *Ms. Pac-Man*.

It is apparent that more effort went into recreating the arcade aura of the original *Ms. Pac-Man*. All the characters closely resemble their coin-op counterparts: Ms. Pac-Man herself has a bow in whatever Pac creatures use for hair, the four ghosts appear in their proper colors, and the game features bouncing bonus fruit symbols, not the featureless box of its home predecessor. Mazes change as you progress through the game. About the only holdover from the original *Pac-Man* cartridge is that the dots are more like dashes.

For those who have not played the arcade version, *Ms. Pac-Man* differs from *Pac-Man* primarily in that the maze changes every other time your Ms. Pac-

continued on page 20

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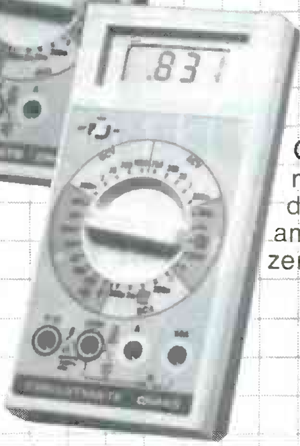

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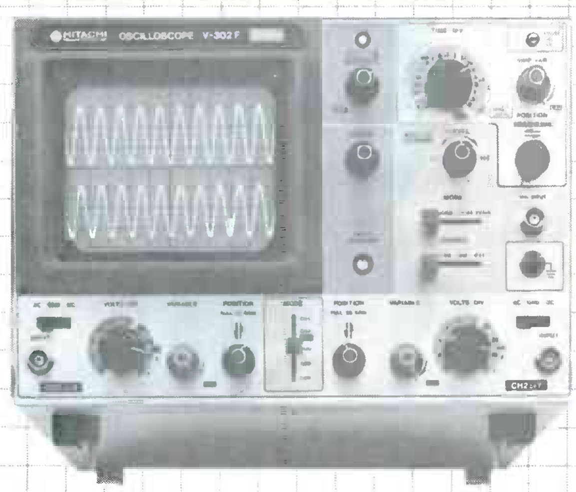

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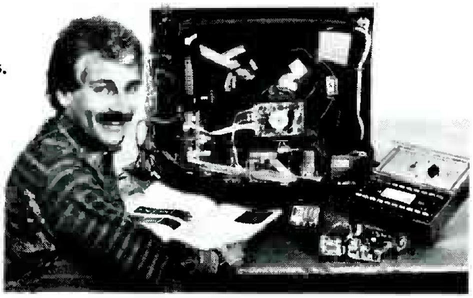

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VIDEOGAMES

continued from page 14

Man character clears the screen of dots. Three of the four different mazes in the cartridge have two escape tunnels off the sides of the screen. The third maze has a single escape tunnel.

The other major difference is that instead of the bonus fruit appearing as stationary objects below the ghost pen, they bounce around the maze in *Ms. Pac-Man*.

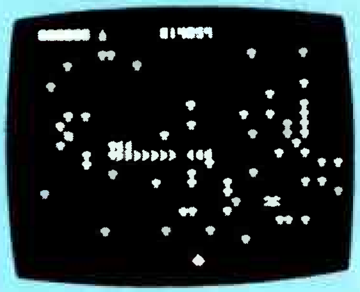
Sound is much improved on this cartridge. When you reset the game from the joystick, the Ms. Pac-Man music theme is played in two voices, a programming feat that, until recently, was considered impossible on the *2600*.

Game play is not exactly child's play. The ghosts are very aggressive, even on the first couple of screens. Nor are they are easily fooled by dodging around corners. According to the instructions, the ghosts' "blue"-time the (length of time that the ghosts are blue after Ms. Pac-Man gobbles an energy pill) is supposed to decrease with every successful clearance of the board. That is definitely true for the first seven or eight screens. But after that, the blue-time, though indeed short, seems to remain constant. A ghost needs to be right on Ms. Pac-Man's tail for her to catch it after she eats a pill.

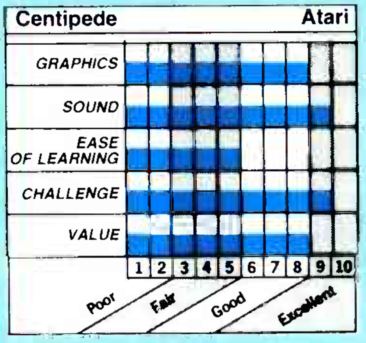
One advantage of a home game over the coin-op version—other than the lack of a coin slot—is that the home version can incorporate variations of the game that help newcomers get used to the action. In *Ms. Pac-Man*, there are a total of four variations. There is "regulation play" with four ghosts, and variations with one, two, and three pursuing ghosts. Those last three are identified on the screen legend with one to three teddy-bear heads—presumably intended for children. But there will be non-game playing adults who will rather begin at the one or two-bear level.

Ms. Pac-Man is a fine example of an arcade translation conceived with ample time and thought. If you held off buying the first *Pac-Man* cartridge, don't hesitate about this one. On the other hand, if you already own the male version of the game, you probably won't see enough difference in the female version to make it worth the investment. Just the same, *Ms. Pac-Man* marks a noticeable improvement in the quality of Atari-produced games cartridges for their *2600* videogame system.

Atari Centipede for Atari 5200



CIRCLE 102 ON FREE INFORMATION CARD



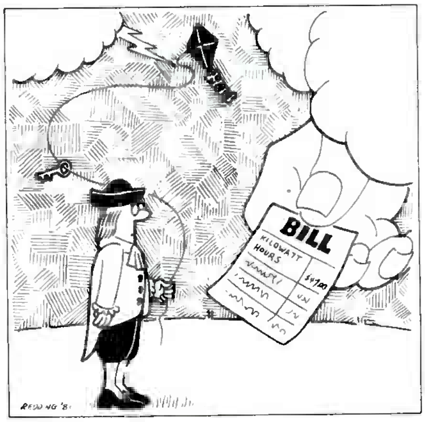
Unlike the endless varieties of maze games, Atari's arcade *Centipede* is not "cute." It is a hard-core gamer's game. So it's not surprising to find an arcade look-alike version for Atari's hard-core gamer's home machine, the *5200*. In fact it is so much like the arcade version, someone might put a quarter up on the console to reserve the next turn.

The story behind the action in that game has little to do with what is happening on the screen, so let's just say that you must defend yourself against a variety of insect creatures: centipedes, spiders, fleas, and scorpions. Each creature has its peculiar characteristics, hazards, and point values. It won't take long to learn what they are—provided you get far enough along in the game to even see some of them—but it will be a long time before you have mastered them.

Centipede is a wave-advancement game in that each centipede, winding its way between mushrooms from the top of the screen, represents a wave. To advance to higher levels you must shoot all the sections of the centipede before you are bitten by any of the creatures (including the centipede if he gets low enough to encounter your on-screen character, which is confined to the bottom quarter of the screen). A pesky spider hovers all around you, trying to bite you, so you've got to keep on the move and not stop too long to take aim at the centipede, the vertically falling flea, or the horizontally roaming scorpion at higher levels. By the way, that scorpion leaves behind poison mushrooms that can send the centipede diving straight down to where your character is. With so much action on the screen, you are not likely to survive long, unless you've had lots of practice.

All is not well, however. This game, like so many others for the *5200*, suffers from the impossible non-self-centering joystick. You just can't control the movement of your character the way you'd like to. Of course, the arcade original was designed with a trak ball on the control panel. I have played the *5200*-version of Centipede with a prototype of Atari's *Trak-Ball* controller accessory, and I must say that it helps immensely. With the *Trak-Ball*, you can take better aim, shoot, and move away to avoid trouble all within a very short instant.

A side note about *Centipede*: Atari also has released a version for the *2600*. While the graphics don't come even close to the *5200's*, the flavor of the game is definitely like the original. It's easier to reach the higher levels of the game, but the action on screen is among the fastest and most enjoyable I've seen from a *2600* cartridge. **R-E**



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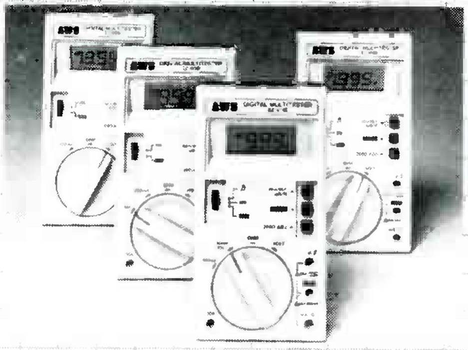

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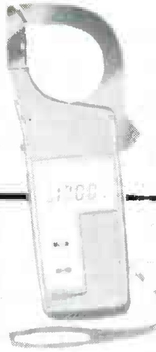

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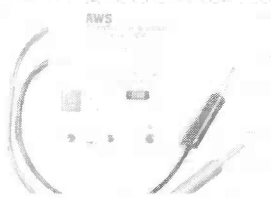

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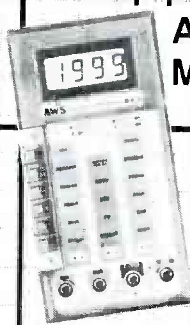

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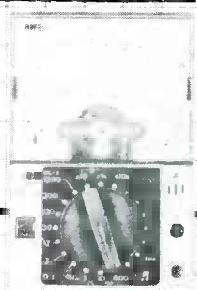

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LETTERS

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NEW USERS GROUP

A National KAYPRO Users Group, open to all KAYPRO users and other people interested in that machine is being formed, with the National Headquarters in New York.

Membership is $8 per year ($6 for the remainder of 1983), and members are entered into a National Database to keep people in touch. They will also receive the quarterly publication, *The Piece of Kayke National Newsletter*, starting with issue #1, dated April 1983. As membership grows, and members submit their own input and applications, it is expected that the newsletter will shift to monthly publication, with corresponding interaction among the local user groups.

The purpose of this Users Group is to unite users, promote interaction, and to supply useful information about the *Kaypro II*—and future matchines in that genre. With approximately 10,000 of the *Kaypro* computers in the field, the pool of *Kaypro* users should double in 1983, with chartered user groups forming in all areas of the country.

Chartered users groups will be recognized when more than six members in close proximity become members.

STEVE BENDER
Users Group #1,
Peoples Computer (of Queens) Kaypro Club,
Box 28360, Queens Village, NY 11428

COMPUTER ARTICLES

I would like to add to the letters that you have been receiving about computer articles or the lack thereof.

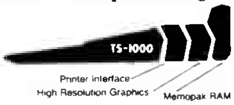
For about eight years, I have been receiving both **Radio-Electronics** and *Popular Electronics*, and during the past year I decided to drop one of the two, because the total of monthly publications was too much to read regularly. But when *Popular Electronics* went over to primarily computer articles, the decision was easy: You won.

Many of us in electronics have to draw the line somewhere. Addding one more hobby or area of specialization each year simply won't work. Considering the cost and vastness of the computer field, several years ago I decided to draw the line there and not try to invest funds and knowledge in computers. Stereo, ham radio, alternate energy, and related experimentation were fully occupying my budget and energy, Photography, computers, and other fascinating fields (even ski-

continued on page 25

TIMEX MAKES THE COMPUTER, BUT WE MAKE IT TICK.

If you own a TS-1000 or ZX-81 computer and want to bring out the power within it, you'll want Memotech. From easier input to high quality output and greater memory, Memotech makes the add-ons you demand. Every Memotech peripheral comes in a black anodized aluminum case and is designed to fit together in "piggy back" fashion enabling you to continue to add on and still keep an integrated system look.



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MEMOTECH KEYBOARD For ease of operation, the Memotech keyboard is a high quality standard typewriter keyboard, with TS-1000 legends. The keyboard is cable connected to a buffered interface which is housed in a standard Memopak case and plugs directly into the back of the TS-1000 or other Memopaks. **MEMOPAK HRG** The Memopak High Resolution Graphics, with up to 192 by 248 pixel resolution, enables display of high resolution "arcade game" style graphics through its resident 2K EPROM, programmed with a full range of graphics subroutines.

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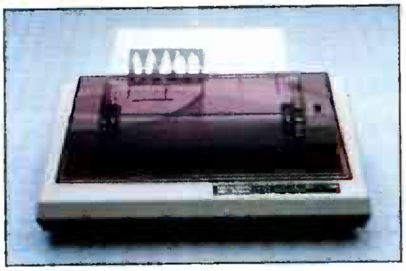
SEIKOSHA GP 100A PRINTER The Seikosha GP 100A uses a 5x7 dot matrix printing format with ASCII standard upper and lower case character set. Printing speed is 30 characters/second with a maximum width of 80 characters. The printer uses standard fanfold paper up to 9-1/2 inches wide. The GP 100A is offered as a package including cable and interface. Other printer packages are also available through Memotech.



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LETTERS

continued from page 22

ing!) had to be passed up, in order for me to succeed with those I had already selected as primary for me.

So, the occasional overview of computer technology and markets in your magazine is welcome as general information, but I would not like to see heavy emphasis on computer circuitry and accessories. The other magazines can serve that need. Finally, we will all have one clear choice in hobby and business electronics reading.

STEPHEN F. WILLEY
Sandpoint, ID

STEREO IMAGE EXPANDER

I am surprised that the two-part article, "Stereo Image Expander," by Joel Cohen (**Radio-Electronics,** June and September 1982) has not generated more comment in your letters department.

I decided to build the image expander, and am I ever glad! Over the years, I have tried to put as little between my ears and the source music as possible, concentrating on obtaining the best speaker systems that I could afford.

Without doubt, next to good speakers, the stereo image expander is the most important component in my system; the improvment in detail and clarity, the general sense of "being there" is just *awesome!* I have used the image expander with Infinity *Monitor IIa's* and with Sander's *Electrostatics*, with excellent results. Naturally, the sonic effect is most realistic with the *Electrostatics*. I can wholeheartedly recommend Mr. Cohen's device to any serious music listener.

One word of caution: In the article, Mr. Cohen explains the importance of carefully determining the optimum speaker placement for best stereo image, even without his device. That very important step must *not* be skipped over if the full potential of the stereo image expander is to be realized.

Thank you for an outstanding construction project and a fine magazine, and don't let the anti-computer people scare you off! I built the Mark 8 successfully in 1974 and enjoy the broad spectrum of your projects.

PAUL FARR
Olivenhain, CA

ACTIVE ANTENNAS

I much appreciate the compact and understandable editing you have done on the VLF Active Antenna articles so far. However, there are some nit-picking problems in labeling and reference to figures in the March 1983 **Radio-Electronics.** Figure 5 on page 67 is not labeled, so the references on page 72 are in error. Figure 5 should be labeled:

5a—450kHz lowpass filter
5b—100kHz series tuned (Loran-C)
5c—60kHz series tuned (WWVB)
5d—180 kHz parallel tuned (high Q)
5e—180 kHz lowpass filter

Perhaps that could be corrected in a future article or note? There is also a minor error in Figure 3. The arrows pointing to the lines should be labeled f1 – f2 and 2f2 – f1. That is because those lines refer to the magnitude of the respective 2nd and 3rd order terms at that point, which, by definition, are the terms f1 – f2 and 2f2 – f1 for that example.

I plan to have some circuit boards and the J310 JFET but no other parts available by about April 1st; if any interest develops, I have had correspondence already from some of my friends in the Longwave Club of America regarding the first article in your February 1983 issue. So, thanks again for the editing and effort of your staff here.

R.W. BURHANS
Athens, OH

R/C SERVOS

I just finished reading the article, "How To Interface R/C Servos" in the February 1983 **Radio-Electronics.** It gave me the idea to build a computer-controlled robot arm that can be programmed to move in a precise fashion pattern.

The application is for a motion-control camera system. My problem is that I need a simple way to program the movement of the servos. The only idea I have is to use the same system that Disney uses on their audio-anamatronics. That is: When they want to move an arm, they set it to one extreme of movement and set that position in memory. Then they move it to the other extreme and set that in memory. When they hit the RUN button, the arm moves smoothly from one extreme to the other.

Another way that I've heard it is done is to move the arm through its pattern manually; and the computer "remembers" the pattern. Do you know how either system works and/or an easy way to program a certain pattern in a servo-controlled arm? I would greatly appreciate your help.

RONALD VEDERAME **R-E**

EQUIPMENT REPORTS

Engineering Specialties Model 770 Serial/Parallel Converter

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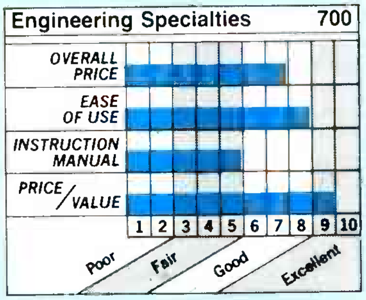

THE MODEL 770 SERIAL/PARALLEL CONverter from Engineering Specialties (1501-B Pine St., Oxnard, CA 93030) is a device that matches a computer's serial-printer output port to a Centronics-type printer.

One of the major problems in upgrading to a better personal-computer system is that of salvaging the peripherals, in particular the printer. For most of us the printer represented a substantial part of the total cost of our original personal-computer system. Considering how rapidly computer prices have fallen, the price of the printer might now be equal to, or greater than, the cost of the new computer itself; yet more often than not the old printer won't work with the new gear. Many of the most popular early computers were set up to use parallel printers because the lowest-cost printers—the Radio Shack and the Centronics models—were parallel input. Similarly, the parallel version of the Epson *MX-80* was priced about $150 less than the serial model. And let us not forget the IBM *Selectric* printers retrofitted for personal computers: the majority of them were also parallel "Centronics compatible."

Unfortunately, most of the very latest personal computer models come with serial outputs for serial printers; a parallel printer port is often an optional accessory at an extra cost, if it's available at all. Considering that printers have virtually no trade-in value and very little resale value (regardless of what anybody tells you), the best thing you can do is convert your parallel-input printer to a serial-input one with a "serial-to-parallel converter" such as the model *770*.

Admittedly, the history of outboard serial-to-parallel converters is not outstanding—many earlier ones worked with only a very few printers. But even more frustrating was the fact that even those converters that worked well with dot-matrix printers could not handle the low effective baud-rate of the inexpensive slow-speed daisy wheel and *Selectric* printers. The result was that those printers would drop every third character or so.

What was happening was that the printer was mechanically incapable of keeping up with flow of data from the computer. What was needed was some type of memory, or buffer, that would store the data until the printer could process it. That need has been answered in this converter; the inclusion of just one byte of memory allows the unit to be used with dot-matrix, slow-speed daisy wheel, and *Selectric* printers.

Description

The model *700* is housed in a plastic cabinet measuring approximately 3¼ × 4¼ × 1½ inches. A standard RS-232 serial input D-connector is mounted on one end. A 12-inch ribbon cable terminated in a parallel Centronics-compatible connector comes out the opposite end of the cabinet. If your printer does not use the standard Centronics-type connector, the converter can be ordered without a connector (you supply your own) for $79.95. With a Centronics connector, it retails for $89.95.

The converter requires a five-volt, 25-mA power source; that is normally provided by the printer through pin 18 of the Centronics connector. However, not all Centronics-compatible printers provide five-volts at the connector; the Smith-Corona *TP-1*, for example, does not provide an operating voltage of any kind for printer accessories. To handle that kind of power situation the converter is wired to allow the supply voltage to be brought in from the computer through the serial input-connector (more on that shortly). If that is not possible the user must provide a regulated five volts from a small external power-supply.

The serial input connections are standard RS-232: pin 1 is the chassis ground, pin 3 is the signal input from the computer, pin 7 is the logic common (signal

continued on page 31

THE POMONA PROMISE

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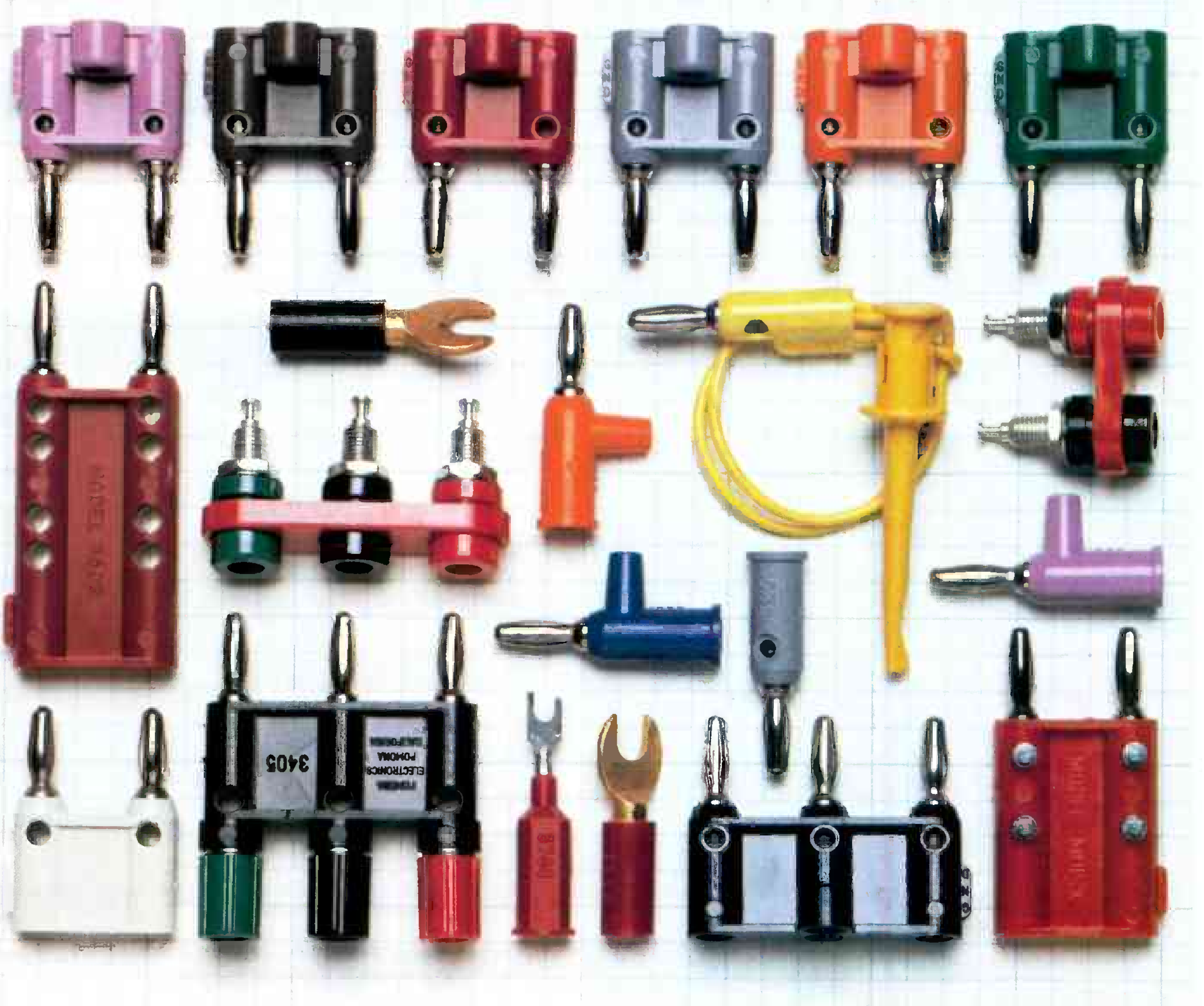

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EQUIPMENT REPORTS

continued from page 28

ground), and pin 20 is the DTR (*D*ata *T*erminal *R*eady) line; it provides a high logic-level to the computer when it is ready to accept data. A wire with a push-in terminal is connected to the internal five-volt supply rail. It can be inserted into the RS-232 connector at whatever pin-location you might select for the input-connector power source.

The only other user-selectable option is selection of the baud rate. Inside the cabinet are pairs of terminal pins that allow you to select rates of 150 to 19.2K baud, in standard steps of ×2. The baud rate that you want is selected simply by installing a push-on jumper across the appropriate pins.

How it works

As we alluded to before, the reason why many serial/parallel converters fail when used with slow-speed printers is that the computer is transmitting the next character before the printer has even returned a "not ready" signal for the first character, or the "not ready" is late on a carriage return or a line feed. The model *770*, however, stores the second character and "not-readies" the computer from its one-byte memory, thereby allowing the printer to complete the previous character and get ready for the next. Surprisingly, that scheme works out very well. Even the *TP-1* printer, whose timing diagram indicates a late "not-ready" signal to begin with, works superbly with that unit. Essentially, it's as if the printer port were serial to begin with. We tried the converter with several unusually slow printers and had absolutely no printing problems to as high as 1200 baud, a more or less standard speed for personal computers. In general, the converter worked well in most cases to as high as 4800 baud, but since it was sometimes a little shaky at that speed, especially when used with a retrofitted *Selectric* we have, such operation can not be totally recommended. But we can state with confidence that reliability is 100% to at least 1200 baud.

If there is any complaint with the converter it's the documentation, which does not spell out clearly and distinctly that parallel inputs can be very fussy, requiring that every single return (common) line be tied to the converter's signal ground at the parallel connector. You can spend hours looking for trouble that doesn't exist if a return line isn't connected. Do not assume they are connected inside the printer—that is rarely the case. If the printer doesn't work, or outputs one character and then appears to lock up, check to see if you have tied all the return lines together at the converter's parallel connector. **R-E**

Phillips Model PM 3207 Oscilloscope

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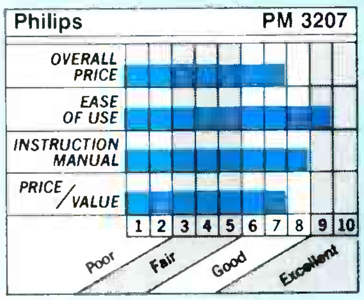

IT'S BEEN SAID THAT THE OSCILLOSCOPE is one of the most useful, and most often used pieces of equipment on a test bench. We've recently seen one dual-trace scope that certainly fits that description and is sure to be a welcome addition to any test bench. The scope is the Philips (85 McKee Dr., Mahwah, NJ 07430) model *PM 3207*.

It boasts a relatively wide 15-MHz bandwidth, making it useful for a wide range of service, educational, and research applications. The unit is lightweight (10.5 pounds) and measures approximately 14.5 × 11.7 × 5 inches excluding the handle and feet. The large bail-type handle also serves as a tilt stand.

Although the unit is certainly portable, there are no provisions for battery operation. The power supply can handle line voltages of 110, 220, or 240 volts AC, plus or minus 10%, at line frequencies between 45 and 66 Hz.

The unit we received came complete with a brief instruction manual, written in seven languages; an extensive service manual, which we will discuss in more depth shortly; and a set of probes including a 1:1 standard probe and a 10:1 attenuator probe. Those probes can handle input voltages of up to 1000 (DC + AC peak).

The capacitance of the 10:1 probe can be varied over a range of 10 to 55 pF by rotating the body. That compensation can be easily done using the PROBE ADJUST terminal on the front of the scope. That terminal provides a pulse train that is synchronized to the timebase. For a correctly compensated probe, this signal is displayed as a straight line. For an uncompensated probe, the leading edge of the trace bends either up or down.

Scope operation

Using the scope was straightforward and provided few surprises. After a reasonable warm-up period, the brilliant blue trace is rock steady. The CRT graticule is marked off in an 8 × 10 cm-per-division grid.

All the controls are laid out in a logical manner and are grouped more-or-less by function. The first group of controls, at the far left-hand side of the control panel, include the POWER switch, the trace FOCUS, and the trace INTENSITY. There is also a PROBE ADJUST terminal previously mentioned.

Vertical amplifiers

Moving from left to right, the second and third groups of controls are for the A- and B-channel vertical amplifiers, respectively. In each group, the order of controls from top to bottom is trace POSITION, VOLTS/DIV, and the AC/DC switch. The AC/DC switch is used to select the

continued on page 38

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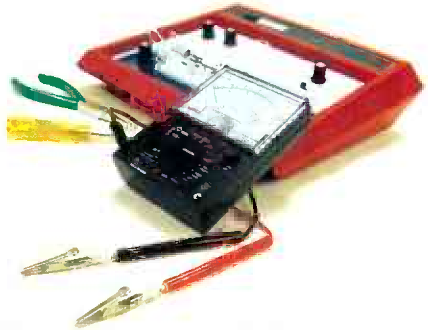

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EQUIPMENT REPORTS

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appropriate input. If AC is selected, a blocking capacitor is inserted in the line; if DC is selected, the signal is direct coupled. The VOLTS/DIV switch is calibrated in the usual 1-2-5 sequence. The minimum vertical deflection setting (AC or DC) is 5 mV-per-division; the maximum is 10 volts-per-division. The accuracy is ± 5%.

There are also two additional switches located between the second and third groups of controls. When the one labeled ± is in the + position, operation is normal. When it is in the − position, an inverted channel-B signal is displayed. The switch labeled A + B/ADD is used to select between displaying either both channels (chopped when the timebase is in the millisecond range; alternated when it is in the microsecond range), or the sum of the channels displayed. If the scope is set to display an inverted channel B as previously discussed, the add mode is especially useful in finding the difference between two signals.

Timebase and trigger controls

The fourth and last group of controls deals with the triggering, timebase, and X-position of the trace. Going again from top to bottom, left to right, those controls are X-POSITION, LEVEL, μS/MS, TIME/DIV, 1X/5X, and four triggering-control slide switches, A/B, ±, INT/EXT, and AC/TV.

The level switch is used to set the point on the input signal at which the trigger signal is derived. The sensitivity for an internally derived signal is 0.75 division at 100 kHz; for an external trigger signal, it is 0.75 volts at 100 kHz.

Looking at the TIME/DIV switch, the time coefficients range from 0.2 seconds-per-division to 0.5 microseconds-per-division. The switch is calibrated in the usual 1-2-5 sequence with an accuracy of ±5%. Using the 5X position on the 1X/5X switch extends the maximum sweep rate to 100 nanoseconds; it also increases the error by ±2%.

One of the positions on the TIME/DIV switch is labeled X VIA A. Instead of a separate external horizontal input, when the switch is set to that position, the horizontal deflection is determined by the input to channel A.

Of the triggering control switches, the one labeled A/B selects which channel's signal is to be used for triggering. The ± switch is used to select between triggering on the positive- or negative-going slope. The INT/EXT switch is used to select between trigger-signal sources. In the INT position, the signal is derived from either channel A or B; in the EXT it is derived from an external signal applied to a BNC connector. The scope is rated to accept external trigger signals of up to 400 volts (DC + AC peak). Finally, the AC/TV switch is used to select between normal triggering and TV-line or -frame synchronization.

Manuals

As mentioned previously, the sample we received came with two manuals. The operating manual was very brief and a bit disappointing. The service manual was quite a different story, however; it contains a wealth of information. Among other things it includes a complete circuit description including block and simplified schematic diagrams. There is, of course, a complete schematic. Also provided is complete testing, calibration, and maintenance information, as well as PC-board layouts and parts lists for the unit. There's even a comprehensive, easy-to-use listing of test points, with an accompanying location chart, for simplified troubleshooting. Rounding out the manual is a listing of Philips sales and service centers world-wide. It would make life so much easier if all pieces of electronics test equipment were so well documented.

The *PM 3207* appears to benefit from a well thought-out, well-executed design. It has a suggested retail price of $725, and all-in-all this scope looks like a real winner. **R-E**

continued on page 40


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Global Specialties Model 3002 Capacitance Meter

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That hand-held instrument is no bigger than a VOM, yet is capable of performing just about any capacitance measurement you might need. It boasts a tremendous range, from 1.0 pF up to 19.99 mF (that's millifarads—one thousand microfarads), and a very high accuracy. (The accuracy is stated to be 0.2% on the lowest range (1 to 199 pF,) and 1.0% on all others.)

The front panel is simplicity itself. It features a nice, large, 3½-digit readout; LED range-indicators are located just to the right of that display. Below the display are the ON/OFF switch and the ZERO-ADJUST control.The jacks for the test leads, and contacts to which a capacitor can be directly connected, are at the bottom.

As simple as that panel is, using the unit is even simpler. There are just two steps: turn on the unit, and connect the capacitor. The meter does the rest; there's no range switch, or anything else, to set.

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Global Specialties 3002	(1–10; Poor / Fair / Good / Excellent)
OVERALL PRICE	6
EASE OF USE	9
INSTRUCTION MANUAL	7
PRICE/VALUE	7

The capacitance is read directly from the LCD display, and the LED range-indicators show the units.

Capacitors can be connected to the device in one of two ways; either through test leads that plug into the front-panel jacks, or directly to the front-panel contacts. Those front-panel contacts can save a great deal of time in situations where large numbers of capacitors must be checked. The only care that must be taken is to be sure to observe the polarity when checking electrolytics. If a polarized capacitor is reversed, the display will read "000.0." If you are unsure of the polarity, which is quite possible when dealing with the small low-voltage types, just hook them up and the readout will tell you whether you are right. Leaky capacitors can be spotted because their readings will be far higher than their rated capacitances. Be aware, however, that the capacitance of electrolytics can vary *at least* ±20% from their rating.

Using the meter

The circuitry that makes all this possible is ingenious; Global uses a dual-slope integrator like those found in many VOM's. A very precise reference voltage is applied to the capacitor, the time needed to charge it is "counted," and that

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count is fed to an A/D converter. The result is displayed on the readout.

For small capacitors, that doesn't take much time. For larger ones, the instrument should be allowed to run through about three count-cycles for greatest accuracy, but even that takes only a few seconds. The ZERO ADJUST control can be used to cancel out stray capacitances in the instrument, as well as in the test set-up, for greater accuracy when checking very small values.

Power is supplied by six "AA" cells, preferably nickel-cadmium, although the alkaline type can be used. The unit can also be powered from the AC line through the use of the *MMA-2* AC adapter/charger, or from your car battery using a cigarette-lighter plug. A selector switch inside the battery compartment sets the circuit for the battery type; you can charge nickel-cadmium cells using the AC adapter, but not alkaline cells. Current consumption is low, about 75 mA, and the batteries will last for 16 hours of continuous use. If the LO BAT annunciator shows up on the display, the voltage is below 5.9 volts, and the batteries should be recharged or replaced.

Lots of tricks can be done with the instrument. You can measure the length of a coax cable if the capacitance per foot is known. That's done by measuring the total capacitance of the cable; divide that by the per-foot rating and you have your length. You can also find an open conductor in a multi-conductor cable; that's one of the toughest jobs around! Just make sure the opposite end of the cable is open and measure the capacitance of each wire. When you find the one that's much lower, you've got it. With its high sensitivity, you can even use the meter to read the capacitance between two conductors on a PC board! That could be invaluable for those who design or make their own.

There is one precaution that should be taken before measuring a capacitor: The capacitor should be discharged first, especially if it's a large-value electrolytic. There is adequate protection in the form of a fuse and clamp diodes, but it's always easier to discharge the capacitor than to replace the fuse.

In general, then, this is quite a handy and accurate little instrument that is very easy to use. It comes with a good instruction manual that covers everything you need to know about the device including applications and theory. The model *3002* sells for $210.00. **R-E**

Heath Semiconductor Devices Course

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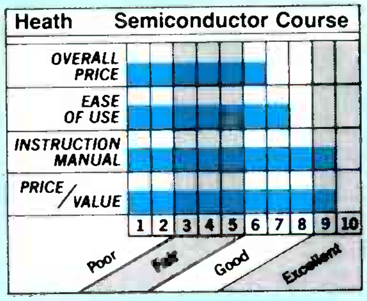

THE HEATH COMPANY, LONG A MANUFACturer of electronics kits of every description, is a name associated with quality. Its products are often used as the standard to which other products, both kit and assembled, are compared.

One factor that has greatly contributed to Heath's (Benton Harbor, MI 49022) success is its highly detailed assembly manuals. The descriptions and illustrations provided are so clear and complete that even a first-time kit builder should have little trouble with most of them. If the manuals have any failings, it is that their theory-of-operation sections tell you *what* is going on in the kits they refer to, but not *why*.

Heath has not ignored those kit builders who want to know "why." They offer an extensive line-up of educational electronics courses that carry on the company's tradition of quality. The courses cover a wide range of topics, including such things as basic and advanced electronics and components, microcomputers, programming, robotics, and amateur radio. We recently investigated one of their offerings, their *Semiconductor Devices Course*, and would like to tell you about it.

Subjects covered

That course, like most from Heath, is a self-contained unit. It is part of a basic electronics series, and uses information taught in the first two parts of that series; it does not, however, require that the earlier parts have been bought. As such, it is suitable for someone with some electronics background who wishes to brush-up on semiconductor fundamentals, or for the complete novice as part of a total educational program.

The course begins with a review of semiconductor-material and atomic fundamentals and then discusses the diode, the simplest semiconductor device. Among the things discussed are how that device works, and how it is used in a circuit. Also covered are special diode-devices, including Zeners, tunnel diodes, and varactors.

In similar fashion, the course deals with a variety of other semiconductor devices including bipolar and FET transistors, thyristors, IC's, and optoelectronic devices. The sections on bipolar transistors include discussions of the characteristics of those devices, as well as how they are used and how they behave in various types of circuits. The look at FET's includes a review of the features of the various types of FET's (JFET, IGFET, and MOSFET).

All of the units in the course cover their topics in sufficient depth to give a novice a thorough, practical understanding of the device in question. Consider the chapter on thyristors, for example. It describes the conditions necessary to turn on or off a silicon controlled rectifier, and explains the forward- and reverse-breakdown voltages of those devices. It then moves on to a discussion of the bidirectional triode-thyristor, and describes the basic operator of a bidirectional trigger-diode. The final part of the unit discusses in detail unijunctional transistors and their characteristics.

The section on integrated circuits discusses when and why they should—and should not—be used. Among the other topics covered are the differences among monolithic, film-type, and hybrid IC's, as well as linear and digital IC's, the types of IC packaging, and small-scale, medium-scale and large-scale integration.

The last part of the course deals with optoelectronic devices. It discusses the characteristics of light and explains the difference between radiometric and photometric measuring systems. Light-sensitive as well as light-emitting devices are described.

From the description of the course, you can see that it is set up in building-block style. One section logically follows the next and provides the user with all the basics needed as he progresses. If one wishes, the learning processes can be greatly aided through the use of an optional audio-visual package and the optional *ET3100B* trainer (we'll have more on that later).

The course comes complete with a softcover, looseleaf binder, which contains the course study material; various components for experiments, including resistors, transistors, diodes of various types, electrolytic capacitors, a small lamp, and a small plastic container to hold those parts, and an optional final exam.

Options

Heath suggests using its *ET3100B* trainer with this course. That unit consists of an experimenter's breadboard, dual variable power-supplies, and a dual-range variable sinewave and squarewave generator. Using that Heath trainer certainly does make performing the experiments easier, and helps you to learn the course material easier. The device should prove valuable later on after you complete the course when you are breadboarding your own designs. The course also requires the use of a good VOM or, at the student's option, an oscilloscope.

All the different parts of the course play a key role in helping the student learn. The loose-leaf binder study guide is written in an easy-to-follow style. Brief quizzes, to help assure the student that he completely understands the material presented, are scattered throughout the text and each unit concludes with a brief exam. The optional audio-visual package (cassette tapes and a picture-book) provides further reinforcement and the trainer provides valuable hands-on experience. With diligent study, this course assures the student mastery of the subject.

The course concludes with a final exam. Taking that exam is optional, but if it is completed and submitted to Heath, and if the score on that exam is at least a 70, the student earns three Continuing Education Units, a nationally recognized measurement of achievement in non-credit secondary education, as well as a certificate of achievement from Heath. It may also be possible to earn college credit for the course at some institutions.

The integration of all the course materials into a very effective instructional program is what makes taking the *Semiconductor Devices Course* such a positive and rewarding experience. The basic course itself sells for \$54.95; when ordered with the *ET-3100B* trainer kit, the package can be purchased for \$134.90, which is a \$10 saving. (The trainer alone costs \$89.95 in kit form; \$159.95 assembled.) Add the \$19.95 audio-visual package, and you have a complete program for under \$155.

When the value and importance of the material is considered, and the cost compared to that of other programs currently available, that is not an unreasonable price to pay. **R-E**

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BP VIDEO GUARD STABILIZER/ RF CONVERTER
MODEL V-1877

OUR PRICE **$69.95** each

Same as above but with a built-in RF Converter that gives the model V-1877 an RF output which can be fed directly to the antenna terminals of a TV set. This enables you to remove the copy guard from a pre-recorded tape and view it on a TV using only a VCR.
Use as an RF Converter only. Used in conjunction with your TV, you can feed direct audio and video signals from any video device such as video camera, computer, portable VCR, etc.

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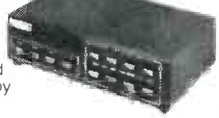
A switcher that can accept 6 inputs and direct them to 3 outputs. Utilizes switch similar to one used on home VCR's. You avoid signal loss incurred by using splitters.



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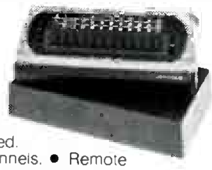

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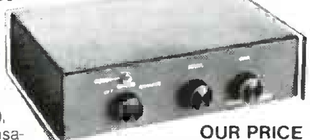

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MODEL V-1885

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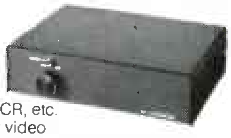
Allows your TV to receive video and audio signals from image enhancer, guard stabilizer, video camera, computer, VCR, etc.



The outputs of many video components cannot be directly hooked up to the VHF antenna terminals on your TV set. This problem is solved by using the Model V-1885 RF Converter. Converts video signal from any video component to adjustable RF signal at antenna terminals. Allows your VCR output to feed two TV sets at the same time, with virtually no signal loss.

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MULTIFUNCTION COUNTER model *1805*, measures frequencies from 5 Hz to 80 MHz. Resolution may be selected from .1 Hz for frequencies below 10 MHz to 1 Hz resolution for frequencies to 80 MHz.

The period mode can be used to measure low frequencies from 5 Hz to 2 MHz accurately. The totalize mode counts individual events from 0 to 99,999,999 plus overflow LED. That mode is helpful in applications where a specific number of cycles occurs, such as gated tone bursts.

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The model *1805* has a suggested price of $290.00.—**BK Precision, Dynascan Corporation,** 6460 West Cortland Ave., Chicago, IL 60635.

CRT TESTER, model *CR70*, is the first CRT tester designed to test all CRT's with only six adaptors. It handles electrical variations with five setup switches, one for each element of the electron gun. Its second exclusive feature is its "CRT-type" switch which makes it the only CRT tester/restorer that works with scope CRT's and projection CRT's as well as with standard video and computer-display CRT's. Setting that switch to the proper position mechanically adjusts the sensitivity of the test circuits and the current supplied during cathode restoring for safe, reliable results.

Other exclusive model *CR70* features include: (1) The industry's only dynamic-emission test, testing the electron gun for true beam current at both the black and white emission levels; (2) a patented color-tracking test that automatically calculates the emission-current ratios to industry standards for a color CRT or for the three CRT's of a projection system; (3) five levels of "progressive restoration", guaranteed to improve the performance of nine out of ten CRT's encountered with shorts or weak emission; (4) the ability to determine setup data directly from a schematic for CRT's not listed in the setup book, and (5) complete protection from shorted CRT's or CRT's with high voltage.

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The model *CR70* is priced at $975.00. To make it truly obsolete-proof, there is an optional universal adaptor to connect to non-standard CRT bases or to newly introduced bases. The adaptor is priced at $30.00.—**Sencore,** 3200 Sencore Drive, Sioux Falls, SD 57107.

ENHANCEMENTS for the Timex Sinclair *1000* computer, are the *Memotech Keyboard* (shown), the *Memocalc*, the *Memotext*, and the *Memopak Assembler*.

The *Memotech Keyboard* with interface is a professional standard (typewriter) keyboard with Sinclair legends. It is housed in an enclosure, and the interface is buffered and housed in a Memopak case, which plugs directly into the back of the Sinclair, and does not inhibit the use of further add-on units. It is priced at $99.95.

The *Memocalc* is a tool to assist you with reports and financial forecasts. This spreadsheet analysis software, on EPROM, enables users to perform complicated number-crunching routines easily. With the 64K RAM, a table of up to 7000 numbers, up to 250 rows or 99 columns can be specified. Quick revisions can be achieved by entering new data to your formula; then, by entering the command CALCULATE, the information is re-evaluated and displayed. The *Memocalc* is priced at $49.95.

The *Memotext* word processor brings com-

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mercial standards of text editing to the TS-*1000* computer. Text is first arranged in 32-character lines for the screen, with comprehensive editing facilities. On output, the user simply chooses the line length for printing, and the system does the rest. The *Memotext* is priced at $49.95.

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The *Memopak Assembler* is for those who want to control the power of their computer precisely. It lets you code and edit a source program in Z80 assembly language, and then assemble in machine code. You can now write flexible and economic programs, tailor-made in every detail to your own needs, and free from the extravagant use of time and space that goes with the BASIC high-level code. The editor mode allows you to code directly in the right format, manipulate individual lines, and control the exact placing of source and machine code. Routines may be merged or listed (even to a commercial printer with Memotech's printer interfaces.) The *Memopak Assembler* is priced at $49.95.—**Memotech Corporation,** 7550 West Yale Avenue, Denver, CO 80227.

CAR AMPLIFIERS, model *HPA-51* and model *HPA-71* (shown) are high-power, low-distortion car-stereo amplifiers, designed to be trouble-free. Both models feature self-protection circuits such as a speaker transient-protection relay, output short-circuit protection, and output thermal-overload protection. Both have provision for low-level or high-level inputs.

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The model *HPA-51* produces 100 watts total (50 watts per channel) at 0.5% THD or less from 20-20,000 Hz into a 4-ohm load. Its suggested retail price is under $200.00.

The model *HPA-71,* designed to appeal to the higher-power performance enthusiast, produces 140 watts total (70 watts per channel) at 0.5% THD or less from 20-20,000 Hz. Its suggested retail price is under $270.00.—**Concord Electronics,** 6025 Yolanda Avenue, Tarzana, CA 91356.

TEMPERATURE PROBE, model *15,* offers fast response time, Fahrenheit or Centigrade temperature measurements with ±2°C nominal accuracy. Portable and plug-in adaptable to any analog or digital multimeter

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with 10 megohms or more input impedance, the battery-operated model *15* is suited for many industrial-, commercial-, or service-oriented temperature-measurement applications.

The fast-responding silicon sensor provides temperature measurements ranging from −58°F to 302°F, −50°C to 150°C with ±2°C accuracy over 0°C to 100°C. Output voltage is 1 millivolt DC per degree, F or C. The model *15* has a life of approximately 3500 hrs when powered by two 1½-volt "AA" alkaline batteries. There is a battery-check function that lets the user know the status of the battery instantaneously. A single switch provides °C, °F, or battery-check/OFF functions. The model *15* is priced at $75.00.—**Triplett Corporation,** Bluffton, OH 45817.

MICROPHONE, the model *SP19,* is designed to provide a high level of performance and is suitable for a wide variety of applications, especially home reel-to-reel and cassette recording. It is also useful for general-purpose use in schools, hospitals, churches and other public-address applications, musical groups, etc.

The model *SP19* also features a pop-resistant, multi-stage steel-mesh grille assembly, an on-off switch, a 15-foot permanently attached cable, and a professional accessory swivel adaptor. It is built to withstand rough treatment.

The model *SP19* is available in two versions: *SP19H-C* (high impedance, with a ¼-inch phone plug at the cable's equipment end) and *SP19L-CN* (low impedance, with a

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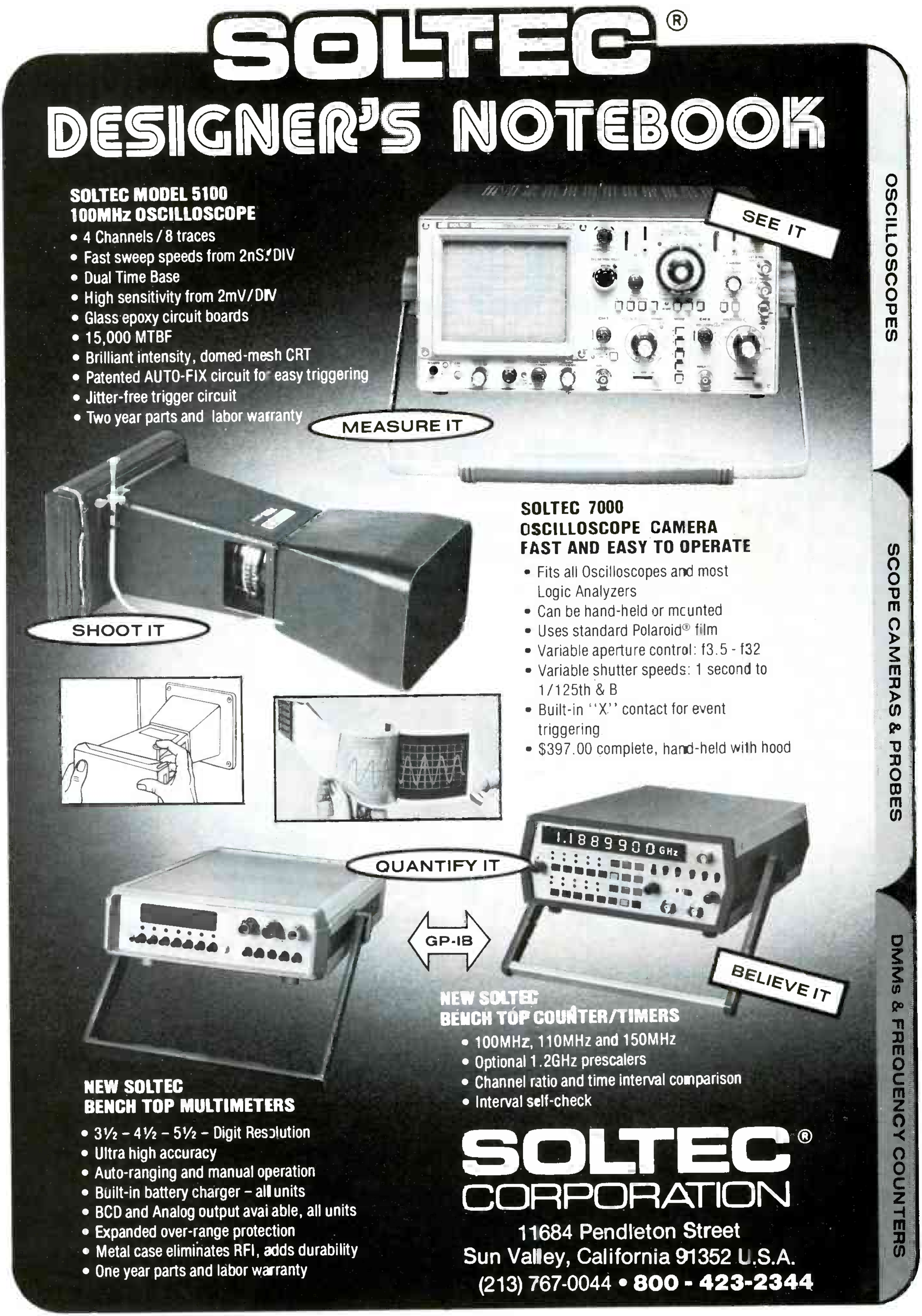
professional 3-pin connector at the cable's equipment end). The suggested retail price is $48.00 for each model.—**Shure Brothers, Inc.,** 222 Hartrey Avenue, Evanston, IL 60204.

R-E



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The Life and Times of

NIKOLA TESLA

Although now largely forgotten, Nikola Tesla was either responsible for, or predicted, much of the technology we now take for granted. Here's a look at the life and achievements of that fascinating man.

E.J. QUINBY

ASK ANY ELECTRICAL ENGINEERING STUDENT today to tell you something about Nikola Tesla, and you are likely to get a blank stare. Or the counter-question: Who was Tesla? It seems preposterous that our educators should have ignored entirely the "father" of our AC age, but such is the fact. Something should be done about our technical education system.

Born July 9, 1856 in the village of Smiljan in what is now Yugoslavia, Tesla rose from relative obscurity to a top position in the scientific world. He became a millionaire at age 32 through his important inventions, but later faded into obscurity and died nearly penniless.

His father was a clergyman. His mother, though she never learned to read and write, was known in the community as an inventor of domestic labor-saving devices, and it is to her that Tesla attributed much of his inventive genius. The young Tesla, opposing his father's urging to study for the ministry, insisted on a career in engineering. His mother encouraged him. He attended the polytechnic school at Graz (now part of Austria), specializing in physics and mathematics, and continued his education at the University of Prague. There he took a course in foreign languages so that he would be able to read foreign technical literature. He became proficient in English, French, and Italian, in addition to German and his native Serbian.

Finishing at Prague in 1880, he took a post-graduate course in Budapest, where he debated the merits of alternating current with his professors. He then went to work for a Paris telephone company, where he acquired considerable experience with DC dynamos and motors.

In those early days, direct current was universally acknowledged to be the only practical medium for generating, transmitting, and using electricity for heat, light, or power. But DC resistance losses were so great that a power plant was needed for every square mile served. Early incandescent lamps, glowing none too brightly on 110 volts even close to the power plant, became pitifully dim on the power that dribbled from the lines less than a mile away. And everyone believed that motors could run only on DC. An alternating-current motor was considered an impossibility.

Reprinted from Communication/Navigation Electronics.

That was the picture when, in 1884, young Tesla stepped off a ship in New York, his head full of ideas, and four cents in his pocket. His experience had convinced him that the commutator in direct-current motors and dynamos was an unnecessary complication, causing endless troubles. He realized that the "DC generator" actually produced AC, which was converted to DC by the commutator. Then, to get that DC to produce rotary motion in a motor, the process had to be reversed. The armature of each electric motor was equipped with a rotating switch (commutator) that changed the polarity of its magnetic poles just at the right instant as it rotated to supply AC to the motor.

To Tesla, that was sheer nonsense. It seemed much more logical to eliminate the commutator at both generator and motor, and use AC through the whole system. But no one had ever built a motor that could operate on alternating current, and Tesla struggled mentally with the problem. Then one day in February, 1882, while strolling with a classmate named Szigetti in a Budapest park, he suddenly blurted out: "I've got it! Now watch me reverse it!" At that moment he had visualized the rotating magnetic field, which would revolutionize the whole electrical industry. He saw the magnetic pull racing around the stationary field (stator) of his motor while the armature (rotor), attracted by the moving field, chased around after it faster and faster until it was revolving at the same rate. He would need no switching to the rotating element—no commutator!

Subsequently he worked the whole alternating-current electrical system out in his mind—including alternators, step-up and step-down transformers for economical transmission and delivery of electric power, and AC motors to supply mechanical power. Impressed by the wealth of available water power going to waste around the world, he visualized the harnessing of that great supply with hydro-electric plants capable of distributing the power to where it was needed. He startled fellow-students in Budapest by announcing: "Some day I will harness Niagara Falls."

The opportunity and fortune Tesla sought in the promised land did not come easily. When he met Edison, then actively engaged in developing a market for his incandescent lamp through his pioneer Pearl Street plant in New York, Tesla launched with youthful enthusiasm ito a description of his alternating-current system. "You are wasting your time on that theory," the great man told him, dismissing the idea promptly and finally.

For a year the tall, gaunt Yugoslav struggled to keep from starving in this strange land. At one point he dug ditches to make a living. But the foreman of the Western Union ditch-digging project on which he was working listened to the visionary descriptions of new electrical systems that Tesla related during lunch hours, and introduced him to a company executive named A.K. Brown. Fascinated by Tesla's vivid plans, Brown and an associate decided to take a flyer. They put up a limited amount of money, with which Tesla set up an experimental laboratory at 33-35 South Fifth Avenue (now West Broadway). There Tesla set up a complete demonstration of his system, including generator, transformers, transmission line, motors, and lights. He worked tirelessly, and without drawings; the plans for every detail were indelibly etched in his mind. He even included two-phase and three-phase systems.

Professor W.A. Anthony of Cornell University examined the new AC system, and promptly announced that Tesla's synchronous motor was equal in efficiency to the best DC motors.

Alternating-current arrives

Tesla attempted to patent his system under a single comprehensive patent covering all its components. The Patent Office would not approve the all-in-one application, insisting on separate applications for each important idea. Tesla's applications, filed in November and December of 1887, resulted in the granting of seven U.S. patents in the next six months. In April 1888, he filed for four more patents, covering his polyphase system. Those too were promptly granted, as were 18 more U.S. patents later in the year. Numerous European patents soon followed. Such an avalanche of patents, so promptly issued, was without precedent. But the ideas were so novel—completely absent was any element of interference or "anticipation"—that the patents were issued without a single challenge.

Meanwhile Tesla staged a spectacular lecture and demonstration of his AC system—single-phase and polyphase—at a meeting of the AIEE (now the IEEE) in New York. The engineers of the world were made aware that the limitations on electric-power transmission by wire had been removed, opening the door to tremendous expansion.

But who would adopt this obviously better system? Certainly not the established Edison-General Electric organization—it would have made their whole investment obsolete. Apparently Tesla was stuck with no market, no customer for what he had to offer.

It was at that moment that George Westinghouse walked into Tesla's laboratory and introduced himself. Tesla was then 32 years old, Westinghouse 42. Both were capable inventors, accomplished engineers, and electrical enthusiasts. Westinghouse listened to Tesla's explanations, watched his demonstration, and quickly made up his mind.

"I will give you one million dollars cash for your alternating current patents, plus royalties," offered Westinghouse.

"Make that royalty one dollar per horsepower, and it's a deal," replied Tesla, without apparent excitement. As simply as that, the two men arranged the historic deal and shook hands on it.

Tesla had arrived. But he was not a man to forget those who had placed their faith in his ideas, and promptly signed over half his million-dollar fee to Brown and his associate, who had financed his laboratory. Although Westinghouse's backers later forced him to get a release from Tesla on the dollar-per-horsepower part of the agreement, such was the friendship that had developed between the two men that an amicable settlement was quickly reached. Tesla relinquished the royalties that would have supported him and his research efforts for the rest of his life.

The phenomenal success of the Westinghouse AC-systems across the nation made it clear to General Electric engineers that they would have to get a license from Westinghouse if they were to keep up with the rapidly expanding electrical industry. The license—negotiated at a handsome fee—was a feather in Tesla's cap; he never forgot Edison's statement that there was no future in alternating current and that experimenting with it would be a waste of time.

A dream realized

In 1890, the International Niagara Commission began its search to find the best way of using the power of Niagara Falls to generate electricity. The scientist Lord Kelvin was appointed chairman of the Commission, and immediately announced that a DC system would obviously be best! It was not easy to challenge that world-famous authority, but Kelvin eventually came to realize that if power were to be transmitted even the 26 miles to Buffalo, AC would be necessary. Thus, it was decided to use Tesla's system and generate AC with massive water turbines. Bids were invited by the newly formed Cataract Construction Co. in 1893. Westinghouse won the contract for the ten 5000-horsepower hydro-electric generators, and General Electric the contract for the transmission system. The whole system including the line and the step-up and step-down transformers followed Tesla's two-phase design. He designed the big alternators with external revolving fields and internal stationary armatures, to minimize the weight of the moving members.

That historic project created a sensation, for nothing of that magnitude had been attempted up to that time. The ten big 2250-volt alternators, revolving at 250 rpm and delivering 1775 amperes each, produced an output of 50,000 horsepower, or 37,000 kilowatts, 25 Hz, two-phase. The rotors were 10 feet in diameter and 14 feet long (actually, 14 feet high in those vertical generators) and weighed 34 tons each. The stationary members weighed 50 tons each. The voltage was stepped up to 22,000 for transmission.

Remote radio control

Tesla's pioneer work in radio ("wireless" as it was then called) went beyond just Morse code communication. In 1898 he staged a spectacular demonstration of remote control without wires at the original Madison Square Garden in New York City. The first annual Electrical Exhibition was then in progress, and in the center of the vast arena where Barnum and Bailey's circus usually performed he had a large tank built and filled with water. Afloat on that small lake he had a 3-foot iron-hulled boat. Inside the hull was a radio receiver and an assortment of electric motors, driven by a storage battery, to perform various ships-functions. The receiver's antenna was mounted on the boat's mast.

From the opposite end of the auditorium, Tesla put the vessel through a variety of maneuvers, including sailing forward, steering left and right, stopping, reversing, and lighting the lights in its rigging in response to audience requests. The impressive demonstration of course "stole the show" and made the front page of the daily newspapers. But how many dreamed that one day, using those same radio-remote-servo-control principles, we would land a man on the moon?

Mathematical wizardry

Tesla's mathematical genius stood him in good stead in the design of the AC equipment for Westinghouse and GE. (In his early student days, he solved complex problems in his head, without pencil and paper. His teachers suspected him of cheating, but young Tesla, it turned out, had memorized whole logarithmic tables!) The now established frequency of 60 Hz stems from Tesla's mental calculations, which convinced him that it was the most practical frequency for commercial use. At higher frequencies, AC motors would become inefficient; at lower frequencies they would require too much iron. Lights would also flicker at low frequencies.

Though the original Niagara Falls plant was designed for 25 Hz to accommodate the limitations of the early Westinghouse turbine generators, subsequent expansion included conversion

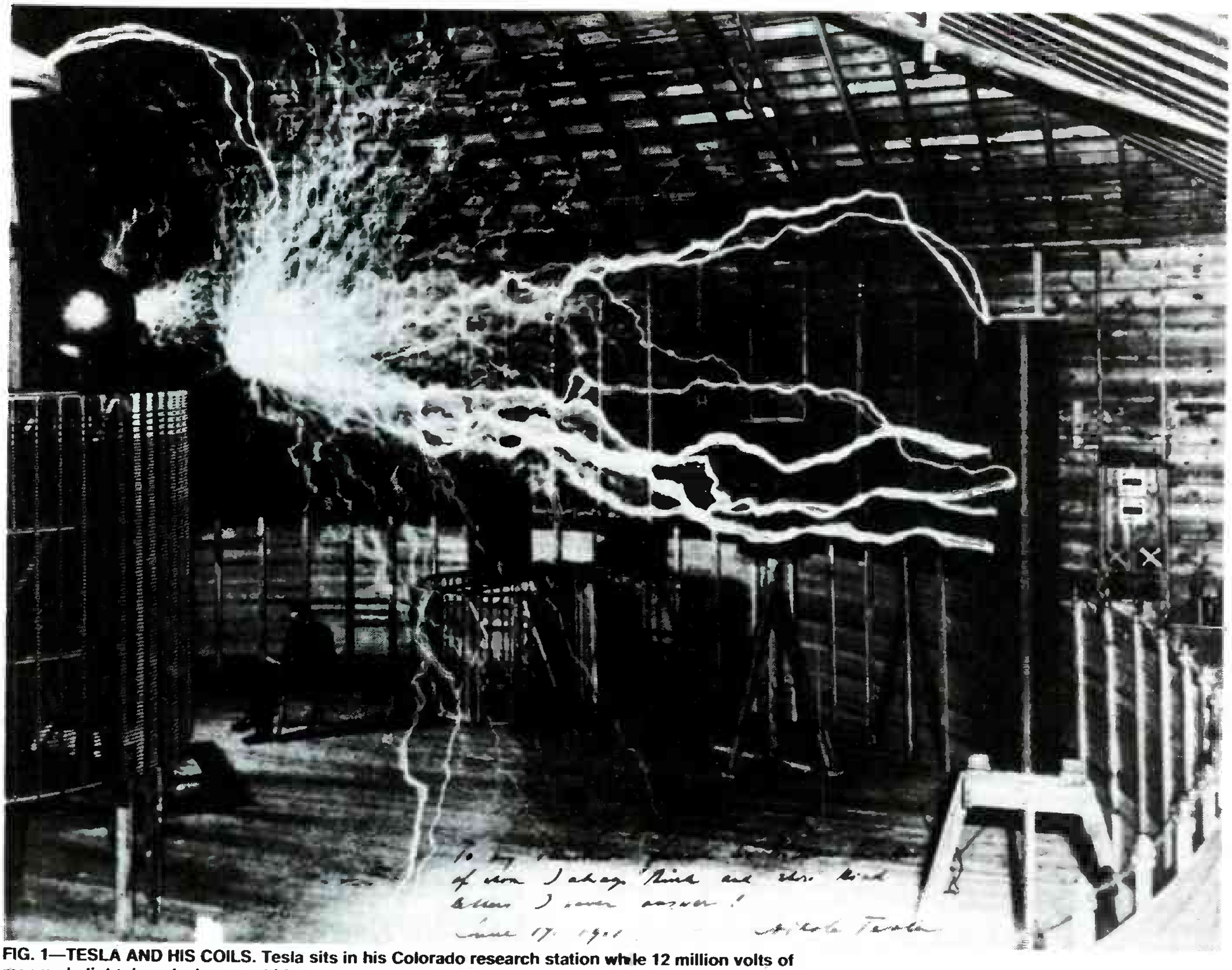


FIG. 1—TESLA AND HIS COILS. Tesla sits in his Colorado research station while 12 million volts of manmade lightning slash around him.

to 60 Hz. Today power from Niagara is transmitted all the way to New York City, 360 miles away, and at times is fed over the Northeast power grid for much greater distances. Remember, when Tesla arrived in New York, the limit for efficient power transmission was less than a mile!

High-frequency pioneering

During his research in high voltage and high frequency, Tesla adopted a most sensible practice. When handling high-voltage apparatus, he always kept one hand in his pocket. He insisted that all his laboratory assistants take that precaution, and to this day that is always done by sensible experimenters when working around potentially dangerous high-voltage equipment.

Tesla's work with high frequencies and in the field of high voltage paved the way for modern electronics, although the word had not yet even been coined. With his unique high-frequency transformers, now called Tesla coils (see Fig. 1), he showed that he could actually pass millions of volts harmlessly through his body to glow-tube lamps held in his bare hands. They would light up to full brilliancy from the high-frequency, high-voltage currents. In those early days he was actually demonstrating neon-tube and fluorescent-tube lighting!

Tesla's experiments with high and low frequencies sometimes had unexpected results. Studying slow mechanical vibrations, he caused a virtual earthquake in the vicinity of his new laboratory on Houston St. in New York City. His mechanical oscillator, operating at close to the natural period of the building itself, threatened to tumble the old structure. Furnishings in a police station over a block away began to dance around mysteriously as Tesla confirmed his mathematical theories of resonance, vibration, and "natural periods."

World's most powerful transmitter

Investigations of high-voltage and high-frequency electrical transmission led Tesla to build and operate the world's most powerful radio transmitter on a mountain near Colorado Springs (see Fig. 2). Around the base of a 200-foot mast, he built a 75-foot diameter air-core transformer. The primary was only a few turns of wire. The secondary within it was 100 turns, 10 feet in diameter. Using power from a generating station several miles away, Tesla created the first man-made lighting. Deafening bolts 100 feet long leaped from the 3-foot copper ball at the top of his mast. He was using voltages of the order of 100 million—a feat not to be equalled for half-a-century.

Tesla burned out the power-plant generator with his first experiment, but repairing it, continued his experiments until he was able to transmit power without wires for a distance of 26 miles. At that distance he was able to light a bank of 200 incandescent lamps—a total of 10 kilowatts. Fritz Lowenstein, later to become famous for his own radio patents, witnessed that spectacular accomplishment, as Tesla's assistant on the project.

By 1899, Tesla had somehow spent the last of the money he got from Westinghouse for his AC patents. Colonel John Jacob Astor came to his financial rescue, and put up the necessary $30,000 for the Colorado Springs experiments. Now that money was also gone, and Tesla returned to New York.

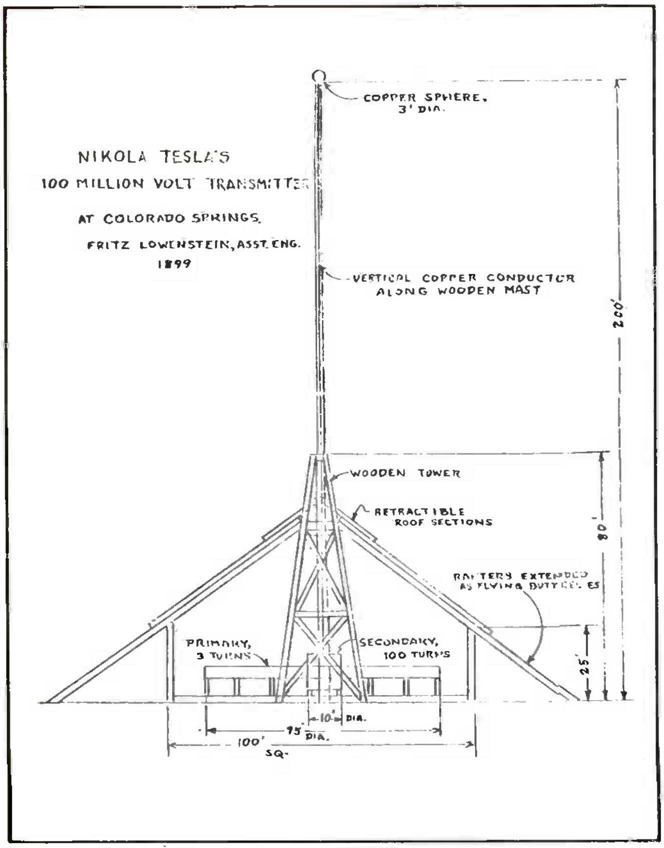


FIG. 2—WORLD'S MOST POWERFUL TRANSMITTER. Using this installation, Tesla generated voltages on the order of 100 million, a level not to be equalled for nearly half a century.

Enter J.P. Morgan

In New York, Tesla was prevailed upon by his friend Robert Underwood Johnson, editor of *Century* magazine, to write a feature story describing his accomplishments at Colorado Springs. But the story Tesla turned out proved to be an involved discourse on the subject of philosophy and "the mechanical process of humanity." Although of the highest literary quality, the treatise said little about the powerful transmitter at Colorado Springs. Johnson had to return the manuscript three times before getting some coverage of the subject he had requested.

In the end, the article was published under the title "The Problem of Increasing Human Energy." It created a sensation when it appeared in print. One of the readers who was deeply impressed was John Pierpont Morgan, who had financed the General Electric Co. in its pioneer DC days, and later in its part in the Niagara Falls project. Morgan was fascinated by the genius of Nikola Tesla, by his spectacular accomplishments, and by his winning personality. Tesla soon became a regular guest at the Morgan home. Impeccably dressed, always the polished gentleman with European manners and cultured speech in several languages, Tesla became a favorite of New York and Newport society. Many prominent matrons regarded him as a "good catch" for their daughters, but Tesla insisted that there was no room in his life for women and romance—they would interfere with his research efforts.

Historians differ on what motivated Morgan to finance Tesla's next big project. Some believe that he was genuinely interested in the wireless transmission of power. Others argue that—in the light of subsequent developments—it seems obvious that Morgan's interest was in getting control of Tesla and his achievements to protect the Morgan investments in the electrical industry.

Finding that Tesla was broke again, Morgan agreed to underwrite Tesla's project of transmitting electric power without wires. In 1904, Tesla acknowledged in *Electrical World and Engineer*: "For a large part of the work I have done so far I am indebted to the noble generosity of Mr. J. Pierpont Morgan."

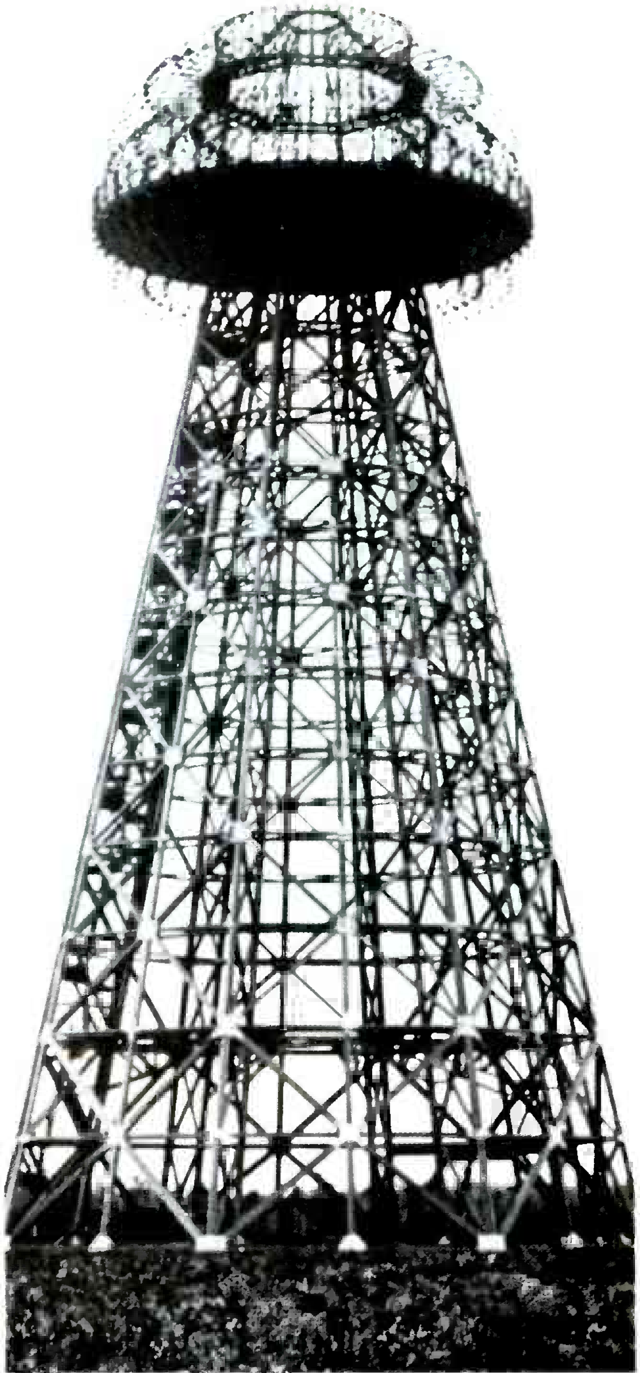


FIG. 3—THE WORLD-WIDE WIRELESS TOWER. Built on Long Island, the mysterious project was never completed.

From that alliance sprouted the fantastic "world-wide-wireless" tower erected on Long Island; that tower is shown in Fig. 3.

World-wide wireless

The strange structure that slowly rose near Wardenclyffe, in the hilly portion of Long Island, mystified all observers. Resembling a huge mushroom, except that it was not solid, it had a lattice-work skeleton, broad at the base and tapering toward its 200-foot top. There it was capped by a 100-foot diameter hemisphere. The structure was made of stout wooden members joined by copper gussets bolted to the wood with sturdy bronze bolts. The hemispherical top was draped over its upper surface with copper mesh. There was no ferrous metal in the entire structure.

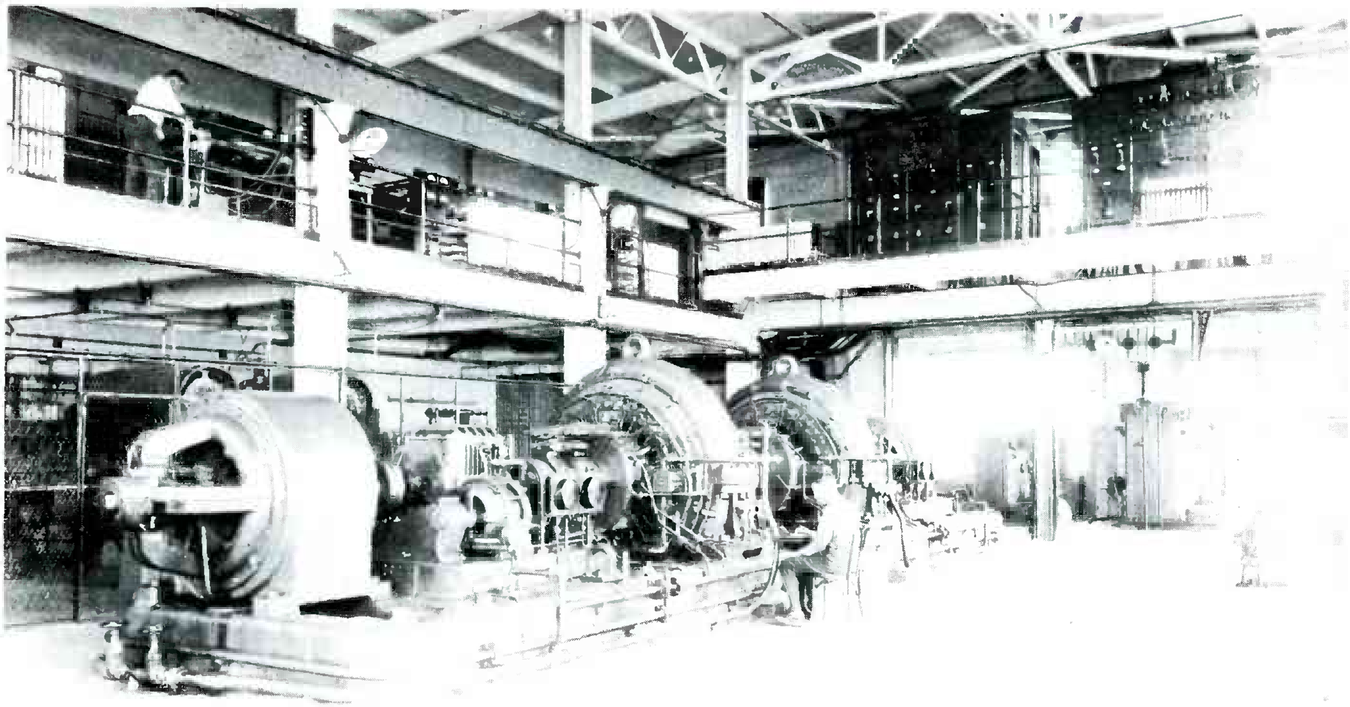


FIG. 4—RF ALTERNATORS, such as this first one installed in New Brunswick, NJ, provided the first reliable transatlantic radio communications.

The famous architect Stanford White became so interested in the project that he did the design work without charge, assigning one of his best designers, W.D. Crow, to the task.

Tesla commuted daily to the construction from his quarters in the old Waldorf-Astoria Hotel on 34th St., riding the streetcars to the East 34th St., ferry, then the paddle-wheel steam ferry to Long Island City and the Long Island Railroad to Shoreham. The railroad's dining service prepared special meals for him so that his supervision of the project would not be interrupted.

When the 100-foot-square brick power plant was completed near the base of the big tower, Tesla began moving his Houston St. laboratory into the structure. Meanwhile, various annoying delays were encountered in the manufacture of the radio-frequency generators. Several glassblowers were busy fashioning special tubes, the design of which remains a mystery to this day.

Tesla's vision

Meanwhile, Tesla issued a descriptive brochure that revealed his far-reaching insight into the future of the great industry that at that time (1904) was limited to dot-and-dash telegraphy. That document has persuaded many that the man was actually clairvoyant. He announced that the world-wide wireless system was being prepared to provide a variety of facilities, most of which we take for granted today. They included the interconnection of the existing telegraph exchanges all over the world; the establishment of a secret and non-interferable and non-interfering government telegraph service; the interconnecion of all telephone exchanges in the world; a worldwide news distribution service in connection with the press; a worldwide private communication service, the interconnection of all stock tickers of the world; inexpensive clocks that required no attention yet were very accurate; the transmission of typed or handwritten characters; the establishment of a marine navigation system, and more. Much of what he described became reality within his lifetime.

Morgan's support ends

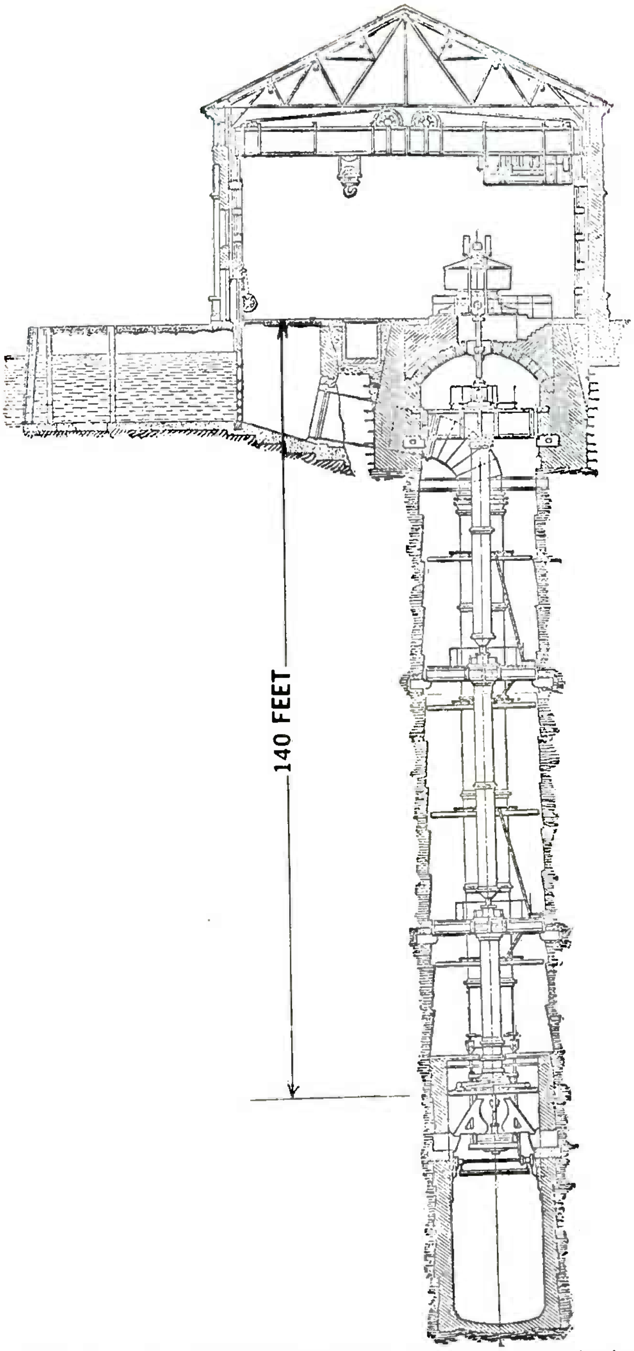
In the *Electrical World and Engineer* of March, 1904, Tesla revealed that the Canadian Niagara Power Co. had offered him inducements to locate his wireless power-transmission project at their plant, and that he proposed to use those facilities to distribute 10,000 horsepower at a potential of 10 million volts.

The Niagara project never materialized, but may have had some influence on the fate of the spectacular Long Island project. For reasons that have never come to light, J.P. Morgan had a change of heart, and Tesla's financial fountain suddenly went dry. At first Tesla refused to believe that Morgan would not arrange for the nearly finished job's completion, but Morgan's withdrawal was abrupt and final. Historians of the industry wonder why. Did Morgan lose patience? Did engineers of high repute convince him that Tesla's visions, so openly revealed in the brochure, were nonsense, and that he was wasting his money on a hopeless dream? Did he suspect that Tesla was diverting time and money to the Niagara project? The facts will probably never be known. Tesla said, however, that Morgan "carried out his generous promise to the letter and it would have been most unreasonable to expect from him anything more." But almost in the same breath, Tesla said, "I am unwilling to accord to small-minded and jealous individuals the satisfaction of having thwarted my efforts. These men are to me nothing more than microbes of a nasty disease. My project was retarded by laws of nature. As for the tower, it was dismantled, although with considerable difficulty, for "security" reasons during World War I.

The radio-frequency alternator

As early as 1890 Tesla built high-frequency AC generators. One, which had 384 poles, produced a 10-kHz output. He later produced frequencies as high as 20 kHz. More than a decade was to pass before Reginald Fessenden developed his RF alternator, which had an output of 50 kilowatts. That machine was scaled up to 200 kilowatts by General Electric, and put on the market as the Alexanderson alternator, named after the man who had supervised the job, and who had built some of Fessenden's earlier alternators.

When it appeared that British interests (already in control of most of the world's cables) were about to acquire the patents for that machine, the Radio Corporation of America was organized at the urgent suggestion of the United States Navy. The new company was formed in 1919, around the Marconi Wireless Telegraph Co. of America, and the powerful but inefficient



NIAGARA FALLS HYDRO-ELECTRIC power plant, the largest of its time. One of the 5000-horsepower Niagara Falls units built by Westinghouse.

Marconi spark transmitters were replaced by the highly successful RF alternators. The first one, shown in Fig. 4, was installed in New Brunswick, N.J. at station WII. It produced a 200 kilowatt, 21.8-kHz signal, and handled commercial business that previously was transmitted over cable. That was the first continuously reliable trans-Atlantic radio service. Those alternators performed so well that a whole battery of them was ordered; they were installed at Radio Central, Rocky Point, Long Island. Ironically, it would have been almost in the shadow of Tesla's tower, if that structure had still been standing.

Thus Nikola Tesla's world-wide wireless dream was fulfilled some three decades after he initiated the project, and right where he started it, using the type of transmitter he devised.

One of the giant radio-frequency alternators has been preserved in the Smithsonian Institute. That one originally served at trans-Atlantic transmitter station WSQ at Marion, Massachusetts.

Radar and turbines

Tesla continued active research in many fields. In 1917 he suggested that distant objects could be detected by sending shortwave impulses to them and picking up the reflected impulses on a fluorescent screen. (If that doesn't describe radar, what does?) He described cosmic rays 20 years before other scientists discovered their existence.

At various times up to 1929, he devoted his attention to a "bucketless" high-speed turbine for steam or gas. Friction between the increasingly irascible Tesla and some of those working with him on tests at the Edison Waterside power plant and in the Allis-Chalmers factory did not help his cause, but many respected engineers today agree that we have not heard the last of the Tesla turbines with their smooth rotor discs.

As the years passed, less and less was heard from him. Occasionally some reporter or feature writer would look him up and manage to get an interview. His prophecies became increasingly strange and involved, leaning toward the abstract and delving into the occult. He never acquired the habit of writing notes, always claiming (and proving) that he was able to retain complete detailed data on all his research and experiments in his mind. He said that he intended to live to 150, and upon reaching age 100, would write his memoirs, which would include a detailed record of all of the data he had compiled. At his death, during World War II, the contents of his safe were impounded by military authorities, and nothing has been heard since as to what records, if any, were there.

One of the peculiar inconsistencies of Tesla's character was revealed when two high honors were offered him, and he rejected the one but accepted the other. In 1912 it was announced that Nikola Tesla and Thomas A. Edison had been chosen to share the Nobel Prize, including the $40,000 honorarium. Tesla could well have used the $20,000 at the time. Nevertheless, he flatly refused to share an honor with Edison. However, when in 1917 the AIEE's Edison Medal—founded by anonymous friends of Edison—was awarded to Tesla, he was persuaded to accept it, after first refusing.

The esteemed eccentric

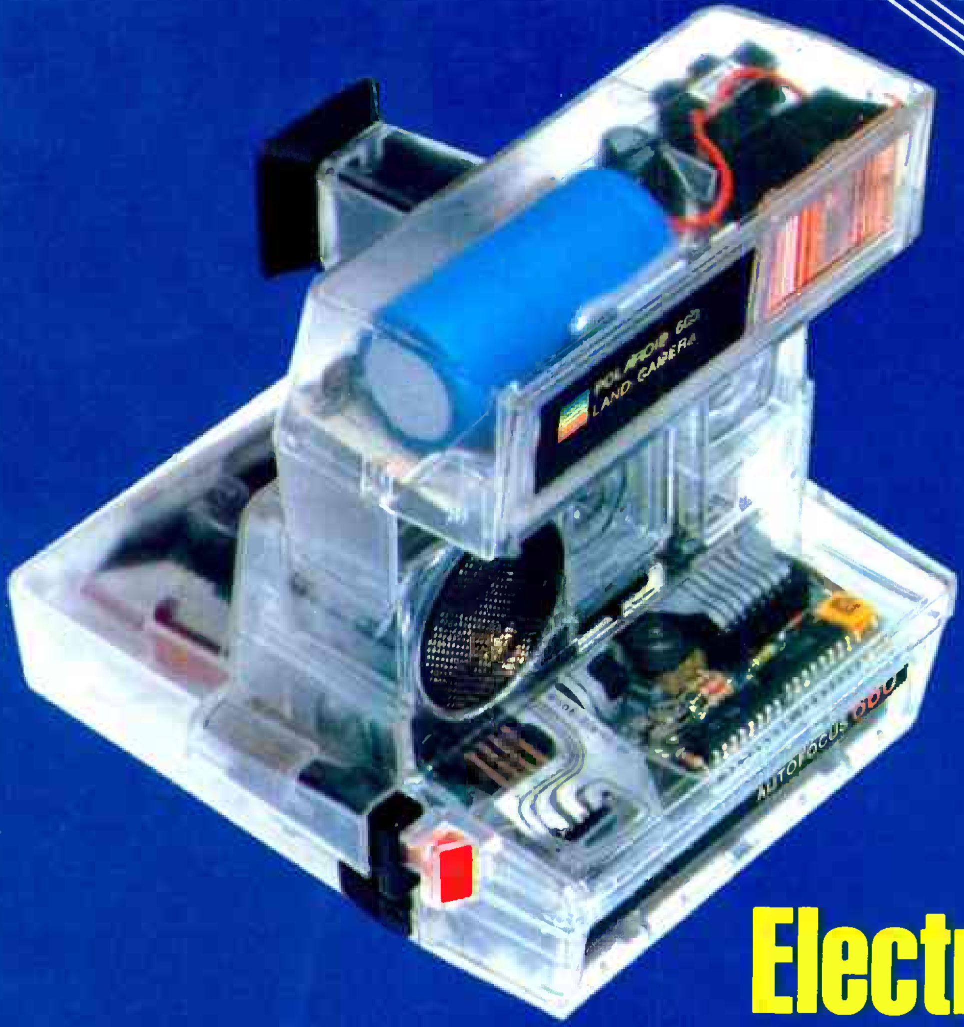
Tesla's natural demeanor was that of the aristocrat. With the passage of time and depletion of his resources, he sank into a condition of genteel poverty. Continuing to live in the best hotels, his credit would become exhausted and he would be forced to seek other quarters. Finally, moving into the newly opened New Yorker, he found his problems solved. Some of the organizations for which he had made millions arranged with the hotel management to take care of the aging genius.

Tesla insisted on carefully wiping each item of silverware, china, and glass before starting a meal, using a fresh napkin for each. In view of that effort to achieve perfect sanitation, it seems inconsistent that the maids reported Tesla's room to be an "unholy mess." It wasn't Tesla's untidiness they complained about—it was the pigeons! When he was not feeding them out in the park, he fed them in his room, where he left the window open so they could come and go.

The gold-plated telephone beside his bed, over which he could speak to anyone anywhere in the world without charge, was the roost of his favorite pigeon, a white one with grey-tipped wings. "When she dies, I will die," predicted Tesla. And so it was that one day in January 1943, that favored bird paid him her last visit. "She was dying," lamented the lonely, unhappy Tesla. "I got her message, through the brilliant beam of light from her eyes."

One of the maids, observing that the "Don't Disturb" sign had been hanging on Tesla doorknob for an unusually long time, used her pass key to investigate. Tesla had passed to his reward, leaving his gaunt 87-year-old frame peacefully in bed. The maid fed the mourning pigeons, gently ushered them out, and closed the window. **R-E**

Author's note: I am indebted to the late Hugo Gernsback, friend and confidant of Nikola Tesla; to *Prodigal Genius*, the biography of Tesla by John J. O'Neill; to the *Proceedings of the AIEE*, and to various publications for their help and information.



Electronics and Photography

MARC STERN

Picture taking—and all areas of photography—have benefited from the introduction of electronics into the equipment used. In this special section we'll examine some recent advances in this area.

WHILE MANY CAMERAS ON THE MARKET TODAY LOOK MUCH the same as cameras some 25 years ago, they are hardly in the same class. Cameras today are "smart." All a photographer has to do is bring the camera up to his eye and press the shutter release. No longer does he have to worry about whether a scene is too bright or too dark. Photosensors take care of reading the brightness of a scene, setting the exposure, and even activating strobe circuits if extra light is needed.

Some cameras on the market even save the photographer from worrying about focusing. Instead, using sonar or one of several infrared rangefinding-techniques, they determine the camera-to-subject distance and cause the lens to be focused for the photographer in a fraction of a second. There are cameras available from Kodak, Polaroid, and other companies that have this feature.

All these cameras allow the photographer what is known as "decision-free" photography, freeing him to be creative. In other words, it's point-and-shoot photography, just as in the days of the box Brownie, but now the cameras are far more sophisticated and the results are much better.

In fact, the whole picture-taking process is far simpler, because "decision-free" photography also extends into the realm of accessories. There are now light meters on the market that do virtually all the thinking for the photographer. He no longer has to spin dials or match needles; instead, a liquid-crystal display gives him all the information he needs.

It's much the same with strobe units, too. Instead of letting the photographer worry about distances, lens openings, and other factors that can affect a flash exposure, dedicated strobe units communicate directly with the camera, presenting exposure information through the accessory "hot shoe." The camera's logic circuitry handles the input from the strobe and sets the correct exposure. If a strobe is not designed to connect directly to the camera, it will present its information on an LCD display so the photographer just has to dial it in.

Further, using photosensors, the strobe will determine when it has delivered enough light, and then shut itself off.

"Decision-free" photography even extends to the darkroom, where the photographer will find microprocessor-driven enlargers that remember correct exposure settings. There are also digital color-analyzers that interface with enlargers and set the correct color-filter combinations. That leaves the photographer free to create. (For the photographer who likes more control of things, there are still manual adjustments that can override the settings determined by the microprocessor.)

How we got here

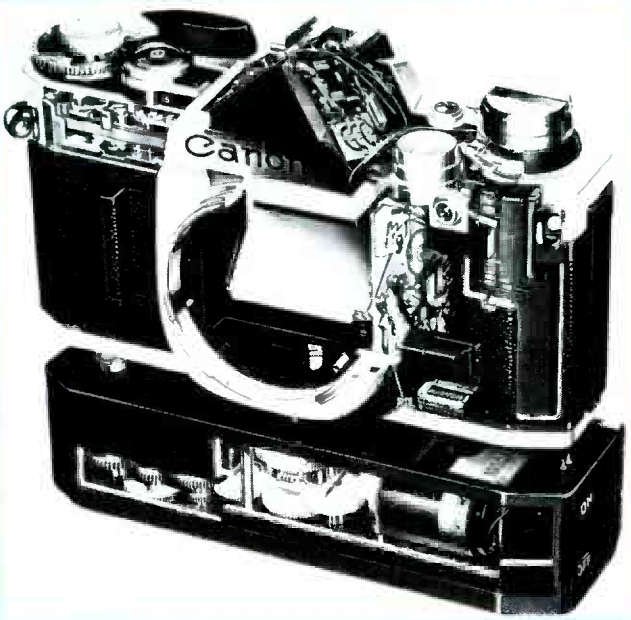
To be fair, some cameras were fairly automated a few years ago, but they still required a great deal of work on the part of the photographer. For example, light meters have been an integral part of cameras for years. However, they have usually required the photographer to handle either setting the aperture or shutter speed, or both, himself. In the late 1960's, an advanced camera might have had a match-needle system that determined the correct exposure. The photographer had to change aperture or shutter speed settings until the needle was centered. The needle was electrically actuated, but mechanically linked to the camera's aperture- and speed-setting mechanisms.

Autofocus, too, was available some years ago, but the apparatus using it was large and clumsy.

What has changed the picture? Integrated circuits. If a camera or accessory manufacturer had tried to make today's type of camera 10 or 15 years ago, it probably would have been as large as the photographer himself. However, as circuit-integration technology headed from small scale through medium- and large-scale and up to very-large-scale, more and more components could be squeezed into a single device. Today, for instance, camera manufacturers are relying on 42-pin and 48-pin flat-pack type integrated circuits to perform the information processing they need. Those circuits accept information about film and lighting conditions and their preprogrammed logic determines what actions to take.

For example, imagine that a photodiode positioned in the camera's viewfinder finds that the light level is too low for available-light photography. It therefore sends a message to the master logic-circuitry that indicates a low-light situation. The logic circuitry, after receiving the message, activates the driver circuitry for the electronic flash, and the strobe fires automatically when the shutter release is pushed. Thus, the photographer never has to think about when to use the strobe because the camera makes the decision for him. That's just one example of what goes on inside the body of a modern camera.

Imagine trying to do that with the discrete componentry of 10 or 15 years ago. The camera would have been enormous! Yet, as a look in any photo store or catalogue will tell you, many automatic cameras—some of them sophisticated 35mm devices—are small enough to fit in a photographer's shirt pocket. If large-scale-integration techniques hadn't been used, that would have been impossible.



Although cameras are getting more and more complex, the electronics they contain make them easier to use than ever.

All-electronic photography

And, while changes have been taking place in camera and photographic accessories, the photographic medium, too, is changing. While recent developments have improved film quality while reducing the amount of silver used in making that material, silver is still expensive, and not getting any less so.

It's possible, though, that in the near future the photographer won't even need silver-halide-based film. Instead, *totally* electronic photography will take its place. The concept has been admirably demonstrated in Sony Corp.'s Mavica photographic system.

Borrowing heavily from video and recording technology—and creating quite a bit of its own—Sony has developed a completely film-free system. Its Mavica camera, a marvel of electronic technology, is very little larger than the standard 35mm film camera with which we are all familiar. But, while it looks normal enough on the outside, things are very different inside. It still uses a lens, but rather than focusing the photographic image on the film plane, the image is focused on a solid-state high resolution charge-coupled device. The resulting electrical signal is then processed and recorded on a miniature floppy disk, a miniature version of the sort used by computers.

The images stored on the disk can be viewed on a TV screen when the disk is inserted into a special player; as is the case with videotape, the pictures can be viewed instantly. Yes, it's true that you can get instant pictures from Polaroid or Kodak cameras, but you have to keep buying film for them; the Mavica's "film" can be reused.

If you decide you want to save a special photo for the family album, the Mavica system includes a printer that can make a color print on ordinary paper in five minutes. You can even send a Mavica picture by telephone; imagine how that could speed up news reporting!

Because the Mavica system is all-electronic, it may be possible in the future to integrate Mavica photos with microcomputer technology and write letters with your word processor that include pictures for Grandma.

These are only a few of the ways that electronics is affecting the world of photography. For a fuller description of what's happening, please turn the page. **R-E**

The all-electronic MAVICA

Sony has developed a photographic system that does away with film completely. To do so, its engineers had to create an entirely new technology.

MARC STERN

FOR NEARLY 160 YEARS, SINCE THE DAY NICEPHORE NIEPCE exposed a piece of silver-bromide-coated glass to the sunlight and ended up with a picture of his yard, we have relied on silver-based materials for photography.

With the shortages of the last few years, we have begun to realize that natural resources are finite and will one day run out. Silver is one of those natural resources, and as it has become increasingly harder to find and process, its price has increased. That has resulted in a corresponding increase in the cost of silver-based products, including those used for photography, and has led photographic researchers to search for new ways of taking snapshots.

One of the avenues into which they have turned is electronics, and the result is in all-electronic still-photo system from Sony Corporation (Sony Drive, Park Ridge, NJ 07656) called the Mavica System.

Mavica stands for *MA*gnetic *VI*deo *CA*mera, and it combines electronics and electromagnetic technology into a non-silver-based photographic system. First introduced two years ago, though not yet marketed, it represents a potential giant step in the history of still photography. Imagine a press photographer in the field hurrying a photo disk, not to a lab, but to a telephone, and almost instantly sending his pictures back to a newspaper or wire service.

Or, how about an amateur photographer taking pictures of a birthday party? Instead of having to send the his film out for photofinishing, he can load the results of his work into a Mavipak viewer for instant viewing on a home television-set, and can then use a Mavigraph printer to produce as many prints as he needs on the spot. In that way, party-goers can have instant souvenirs of their party.

Let's look at the basic Mavica system, beginning with the camera.

The Mavica camera

Figure 1 shows the Mavica camera. About the same size as a conventional 35mm camera, about the only thing the Mavica has in common with one is its optics. Inside, they are as different as day is from night.

Instead of using a roll of film, the Sony camera uses a Mavipak recording disk—constructed much like the floppy disks used by microcomputers—to store pictures. The image produced by the lens is focused onto the face of an integrated circuit called a CCD (*C*harge-*C*oupled *D*evice), which converts it into electrical energy. That energy is converted into a signal that can be recorded on the magnetic disk, which is capable of holding 50 pictures.

The Mavica acts much like a video-recording system. It uses the same general principles but, instead of using a vacuum tube for image conversion, it uses a CCD. Most video terminology can be applied to it.

The CCD is an 11 × 12.1-mm integrated-circuit chip with an image area of 6.6 × 8.8 mm. It is the heart of the Mavica system.

The resolution of the CCD is high—the image formed by it consists of an array of 570 × 488 pixels (a pixel is a picture element). The signal generated on the image area is sent to a storage area on the chip during the vertical blanking-interval. In

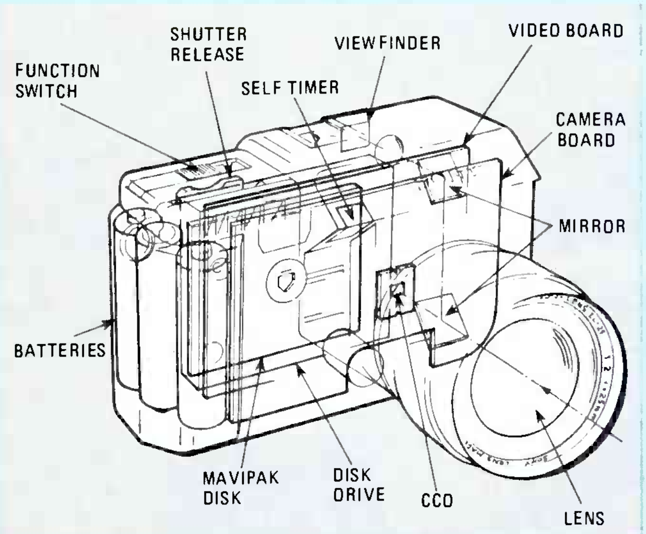


FIG. 1—THE MAVICA CAMERA is about the size of a large 35mm camera but has little in common with it save for its shape and optical system—it is entirely electronic.

response to a clock pulse, the image is then read out of the storage area into a readout register after the vertical blanking-interval. Color filtering is handled by a filter with red, green, and cyan stripes.

The Mavica's CCD was designed to take advantage of the "narrow-channel" effect—when the width of a MOS transistor electrode is narrowed to about 2 micrometers (μm), a change in electric potential can be produced across it if it is excited by light. The small size of the channels means that the CCD can have simple, densely packed, image-sensing cells. The uncomplicated geometry also means that the driving circuitry can be reduced to simple two-phase clocks, and that the power requirements are low.

With the light falling directly on the CCD unit, its spectral response (sensitivity to a wide range of colors) is high. To counteract "blooming" (image degradation caused by excess electrons spilling from one sensor cell to its neighbors), an overflow drain was added to the chip; Sony claims that the drain causes only an insignificant reduction of sensitivity.

The Mavica disk

In the standard photographic process, the storage medium is silver-halide-coated film. The film captures the image, and is later developed to make the latent image visible. However, in the Mavica system, images are recorded on a magnetic-material-coated disk, the Mavipak (see Fig. 2), which is inserted into the camera.

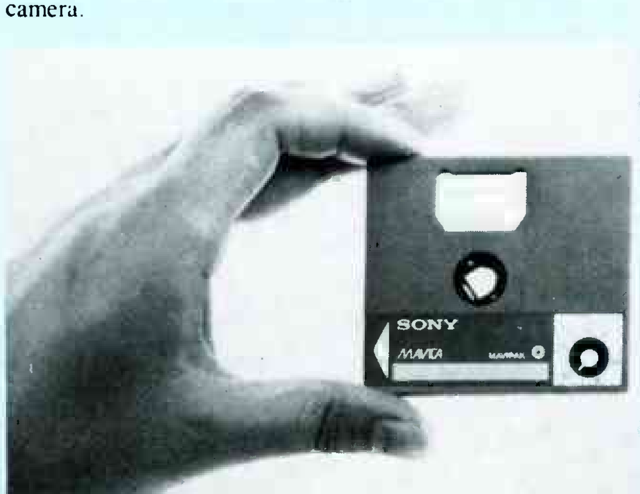


FIG. 2—THE MAVIPAK DISK measures only about two-inches square, yet can store 50 pictures.

The Mavipak is inserted into a disk-drive unit that revolves at a speed of 60 revolutions-per-second. A compact motor that is controlled by servo-circuitry ensures that the speed remains constant.

One would think that due to the high speed of the disk's rotation, there would be some stability problems, but Sony claims otherwise. Because of its small size, the disk is only minimally affected by aerodynamics or centrifugal force. Any tendency for the video disk to move away from the recording head is limited by a guide plate. Instead, because of the position of the guide plate, an air cushion is formed that helps keep the disk-to-recording head relationship constant at 0.07 micrometers as shown in Fig. 3.

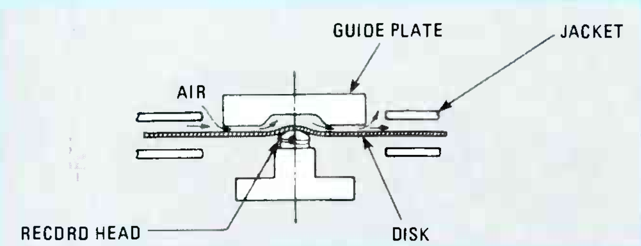


FIG. 3—A SPECIALLY DESIGNED GUIDE PLATE uses air pressure to keep the Mavipak disk in contact with the record head.

Since that arrangement ensures stability, there is no need to have other pressure exerted to bring the head and disk together, and that, in turn, ensures a considerably longer working life for the recording disk.

Head-to-track alignment is also very important, and is a must for quality picture-reproduction. If the head and track being recorded or read are not within ± 10 μm of one another (a lateral measurement), the signal-to-noise ratio becomes too high and quality deteriorates. However, Sony admits in published papers that that figure is hard to achieve (it has been found that temperature variations alone can cause the figure to vary by as much as ± 30 μm) and has been accommodated for by tracking-error-correction circuitry incorporated within the playback unit.

Like a computer's floppy disk, the Mavica's recording medium is a circular sheet of thick plastic film, coated with a magnetic material. It is housed in a plastic jacket measuring about 2⅜ × 2⅛ × ⅛ inches, and the entire assembly weighs only eight grams (a little over ¼ ounce).

Because the magnetic Mavipak disk is erasable, it can be used over and over again.

The first image is recorded on the outermost track of the disk, with subsequent images recorded on tracks closer and closer to its center.

To keep the size of the disk small, Sony engineers had to develop a high-density recording method. To obtain the best possible magnetic characteristics, the development team turned to a ferromagnetic metal alloy—similar to that used in high-quality audio cassettes—rather than using a metal-oxide powder. That coating meant an 8-dB improvement in output level, and permitted the use of a disk half the size of a metal oxide one.

However, that development is only half the picture. To achieve true high-density recording, the surface of the disk must be extremely smooth. Smoothness helps limit modulation noise and the losses resulting from the short wavelengths used for recording. The Mavipak disk is able to boast a 0.05-micrometer peak-to-peak smoothness. The magnetic characteristics of the disk are extremely even—output level along a track varies by no more than ± 1 dB. The result of Sony's efforts is a disk that can record wavelengths of 0.8 μm—equivalent to signals with a frequency of 3.75 MHz.

Signal processing

The concepts embodied in the Mavipak system go a long way toward ensuring that picture quality will be good. But there are other necessities, Sony has found.

To produce high-quality, reproducible images, it is necessary to have luminance and chrominance signals with good resolution and a good signal-to-noise ratio. Accomplishing that is not easy because, due to the limited space available within the Mavica, the circuitry cannot be too complex.

To keep things simple, the Mavica uses a single-track, line-sequential recording system; instead of being recorded simultaneously, the R-G and B-G signals are mixed separately with the luminance-plus-sync signal, and recorded one after the other. That, Sony admits in published technical papers, causes some deterioration in the vertical resolution of the chrominance signal. But, while the amount of deterioration is on the order of 50 percent, it is not noticeable because the horizontal resolution, determined by the one-MHz bandwidth of the chrominance signal, is still less than the vertical resolution. Other single-track recording methods were dismissed because of potential jitter problems that would have led to hue fluctuations.

The recording circuitry is pretty straightforward. When a photographer using a Mavica camera captures a scene, the image of that scene is converted by the CCD into an analog electrical signal. That signal is then broken down into four components—luminance, red, green and cyan—by sample and hold circuits. The green and cyan circuits are used to produce the blue signal and all of them are then fed to processing amplifiers.

The processing amplifiers output the processed luminance, red, green, and blue signals, with the luminance signal then being added to the sync signal and fed to a frequency modulator.

The red, green, and blue signals take a path through a matrix circuit and are then converted to color-difference (R – G and B – G) signals. From that point, the signals are selected line-sequentially and are then fed to a second frequency modulator.

The two signals are passed through low- and high-pass filters to narrow their bandwidth and are then fed to the recording amplifier. It is that final signal that is recorded on the disk.

Those functions are handled by specially developed LSI IC's and hybrid modules.

The Mavica player

The final part of the basic Mavica system is the playback unit, which converts the signals recorded on the disk into a picture that can be viewed on a television receiver. The playback head of the player is analagous to the record head in the Mavica camera. However, while the record head can only move from track to track from the outside toward the center of the disk, the playback head can move from one track to another in either direction; that allows pictures to be accessed at random.

As was mentioned earlier, the tracking error induced in the Mavica camera can be sizeable. The microprocessor-controlled tracking-error-correction circuitry incorporated in the player works by sensing where the RF signal is strongest on the disk and maintaining the playback head in that position.

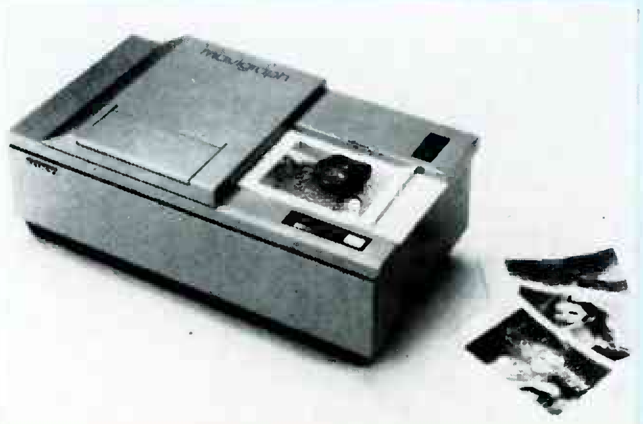


FIG. 4—THE MAVIGRAPH PRINTER can produce a color print from the Mavica or other still-video source in about five minutes.

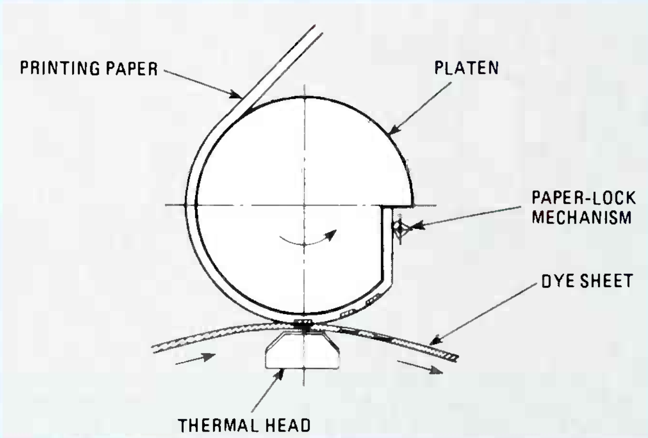


FIG. 5—IN THE PRINTING PROCESS the paper, wrapped around a platen, is brought into contact with a series of dye sheets and the thermal elements that transfer the dye to it.

Each track on a Mavipak disk contains one picture consisting of 262.5 video lines. That's the equivalent of one video *field*: two fields make up a complete video *frame* of 525 lines. Because the Mavica pictures are still pictures, each track is played over and over as the picture is viewed. To generate a standard full-frame NTSC video signal, several sets of delay lines are used in the player. One set takes the line-sequential chrominance information and restores it to NTSC format; one ⅓.3-μs delay line and two 63.5-μs delay lines are used for that purpose.

To generate a 525-line picture, every other field is synthesized from the information contained in the 262.5-line recorded fields.

The horizontal resolution (the resolution in the horizontal direction—*not* the number of horizontal scan-lines) of the Mavica picture is 240 lines; that figure is due primarily to the number of picture cells on the CCD imaging element. The recording capability of the Mavica disk is approximately 350 lines (horizontal resolution), which means that we may see a considerable improvement in picture quality in the future.

The Mavica printer

Although the Mavica system represents a breakthrough in "filmless" photography, it would be of little value if it were limited only to viewing photos on a television receiver or monitor. Recognizing that, Sony has also developed the thermal color video printer shown in Fig. 4.

It is capable of taking the color output-signals from the Mavica—or any other color-video system—and turning those signals into color prints. It can accept either composite-video or RGB (*R*ed-*G*reen-*B*lue) signals.

The Mavigraph, as the printer is called, uses a thermal dye-transfer system. As shown in Fig. 5, a sheet of paper—which can be ordinary writing paper, although a special polyester-coated type gives better results—is wound over a platen. A thermal printing-head is pressed against the platen so the paper and a sheet of material containing dye come into contact with each other. As the platen and the printing paper turn together, the dye sheet is drawn at the same speed over the printing head. The intensity of the heat produced by the print head—which determines how much dye will be evaporated and transfered to the paper—is controlled by the level of the video signal.

Four colors are used in the printing process: yellow, magenta, cyan, and black (these are the same colors used to print the covers and color pages of this magazine); they are the printing equivalents of the video signal's blue, green, red, and black, respectively. Each color is contained on a separate dye-sheet, and the colors are transfered sequentially, in the order indicated above. First, the entire yellow portion of the print is produced. Then the platen carrying the paper returns to its original starting position and the magenta portion of the print is laid down...and

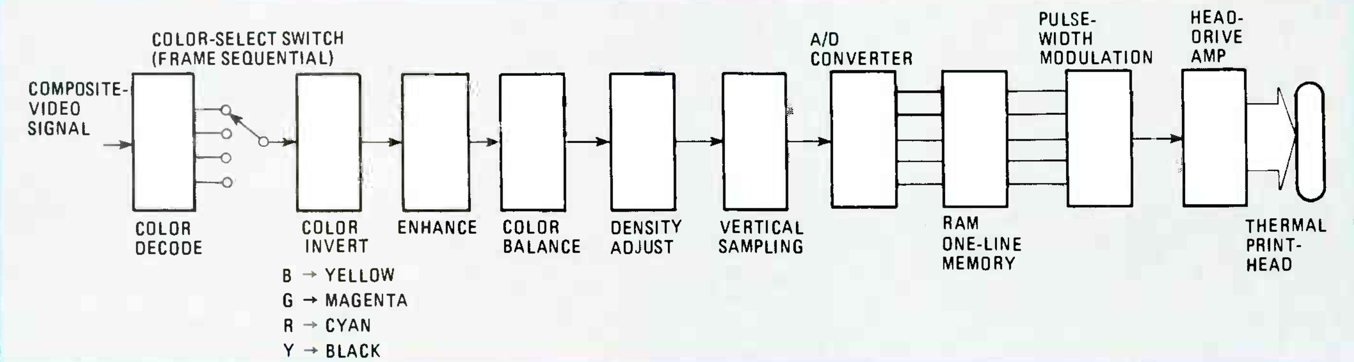


FIG. 6—TO MAKE A MAVIGRAPH PRINT, the video chrominance (blue, green, and red) and luminance signals are inverted to produce their opposites—yellow, magenta, cyan, and black.

so forth. For black-and-white prints, only the black dye-sheet is used. The flow of the printing process is illustrated in Fig. 6. In some versions of the printer, the dyes are contained, one after another, on a single piece of material wound into a roll. The finished print is laminated in plastic both for protection and to enhance the image.

The printer scans the video image vertically—from top to bottom across the scan lines—rather than horizontally (along the scan lines) as you might expect, and the picture is reproduced on paper from left to right. It takes about five minutes for a complete print to be produced.

The thermal print head used in the Mavigraph contains a row of 512 elements—four per millimeter—to produce a picture measuring 4¾ × 6⅓ inches. The compactness of the print head is due to 16 special IC's, each of which contains a 32-bit shift/store register and 32 drivers.

The Mavigraph can be used to produce any number of color prints of a still picture taken by a Mavica or a video camera, or of a single frame or field of an image displayed by any video device, including a television receiver, computer, or VTR.

A home-video camera can be used to convert existing color *film* negatives or positives into video signals suitable for reproduction by the Mavigraph. The fact that the amounts of red, green, and blue in the print can be controlled allows the Mavigraph user to adjust the color balance of his prints to his taste, and to experiment with unusual color-effects. Sony expects to open an entirely new market for the combined use of conventional photography and electronic Mavigraphy.

This printer and the system it supports have been termed a new era in video technology that adds a new dimension to video. For instance, the system can be used to produce hard color-copies from signals received from teletext or videotex systems. It can also be used as an image printer for an x-ray machine, CAT scanner, or other medical equipment. It can even serve as a terminal printer for office computers and as a color facsimile printer.

How will that be done? Sony's engineers have done some thinking about the matter, and have come up with a system they believe will work. It's much like an amateur radio slow-scan television setup, except that it works via telephone.

Photos by phone

Settling on transmission using amplitude modulation, the Sony engineers designed a system (the receiving end of which is illustrated in Fig. 7) that links a transmitting unit and a receiving unit via phone circuits. The system also includes memory storage-devices because of the transmission-time constraints imposed upon it by the phone system.

It takes about 63 μs to display one horizontal line on a TV screen. However, because of the telephone system's limited bandwidth, it takes about 400 ms for the information contained by that same line to be transmitted over a telephone line. That means that some sort of memory buffer must be used to store and transmit each line as the system can handle it. A similar situation holds at the receiving end, except that the entire picture is captured in the receiver's buffer. As each line is received, it is read out, along with the lines that have already preceded it into the buffer, and becomes part of an image displayed on the receiving television set's screen via high-speed video processing circuitry.

Since the system uses voice-grade telephone lines, the analog signal transmitted must be able to fit within the restrictions they impose. The engineering team looked at the various means of modulation—amplitude, frequency, and amplitude-phase—and decided to use double-sideband AM for reliablility.

The engineers also had to keep the system's maximum bandwidth in mind when defining their parameters. Using a maximum range of 300 Hz to 3400 Hz as boundaries, Sony's engineers chose an 800-Hz image frequency and a 1500-Hz carrier frequency for best transmission quality, recognizing not only the limitations imposed by the phone system, but also the potential for fluctuations in level, for line noise, and for system leakage.

The video output of the Mavica is sampled at a rate of about 14 MHz and digitized. The digital information is read into memory and is then read out at a much slower rate—2.2 kHz. After digital-to-analog conversion, a signal suitable for telephone-line transmission is obtained.

One problem with magnetic-reproduction devices (like the Mavica playback unit) is jitter. While it is not apparent on a TV screen, it is something better done without. To eliminate the

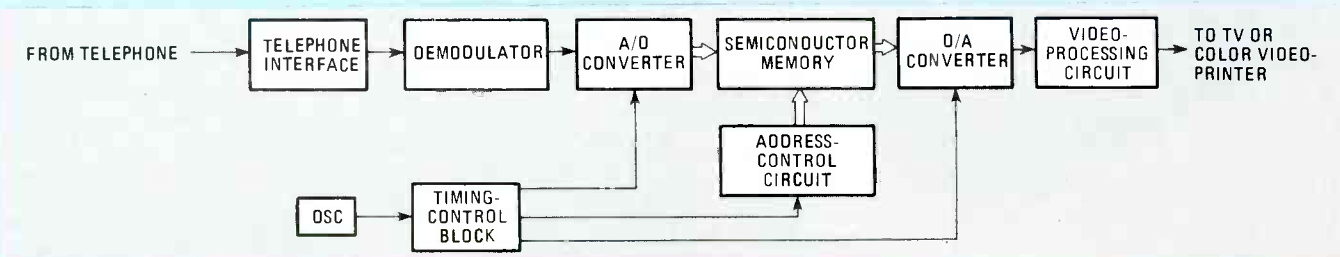


FIG. 7—THE TELEPHONE-LINE RECEIVER converts the slow incoming analog information to digital form so it can be stored, then converts it back to a high-speed analog signal for display.

continued on page 78

The New Disc Cameras

In this article we'll look inside Kodak's new disc camera—a good example of how electronics have made the picture-taking process easier than ever.

MARC STERN

THE EARLY ADVERTISING CLAIM OF EASTMAN KODAK, "YOU push the button; we do the rest!" is now more true than ever. When Kodak was designing their new disc camera, their intention was to develop a decision-free photo system. And thanks to the miniaturization allowed by the continuing advances in microelectronics, that camera maker has been able to produce small but sophisticated snapshot cameras that allow the photographer to simply aim and shoot. While other camera manufacturers have followed Kodak and are producing their own disc cameras, we will discuss only those from Kodak.

What are the features of the disc cameras? There are four models from which to choose: the *3000*, *4000*, *6000*, and *8000*. Essentially the four models are the same, but they differ in some features and, of course, price. (The models' price range is from $56.95 to $142.95.) Let's first look at the features that all models have in common; then we will look at the differences.

Each model has a 4-element, *f*/2.8, 12.5-mm, fixed-focus (four feet to infinity) lens. Each also has two automatic exposure settings. The flash is built in and operates automatically when needed. Without the flash, pictures can be taken every 0.4 seconds. With the flash, that increases to about one second, due to the flash-capacitor charging time. There is no exposure indicator needed and the film advance is automatic. Needless to say, all four models use disc film.

Now that we've seen the similarities, lets look at the differences between the four disc camera models. First, we'll look at "extra" features. Both the *6000* and *8000* have a close-up lens (18 inches to 5 feet) that is simply slid (with a lever) in front of the normal lens. A close-up indicator is seen in the viewfinder when that lens is chosen. All of the models have a metal carrying strap, but the *6000* and *8000* also have a protective handle/cover that covers the entire front of the camera. (It can also be used to stand the camera up.) Only the *3000* is not powered by two 3-volt lithium batteries. Instead it uses a replaceable 9-volt alkaline battery. In the other models, the lithium batteries are considered to be an integral part of the camera and, as such, are covered by the five-year warranty.

The *8000* has three features that none of the other models have: a motor drive that permits rapid firing by holding down the shutter button; a 10-second self timer (with flashing LED and audible beeper), and, located in the cover, a digital alarm clock with its own power supply.

Nothing could be easier

Before we look at the electronics inside of the Kodak disc cameras, let's take a look at how you would operate one of them. The first step, of course, is to load the film. The film-loading

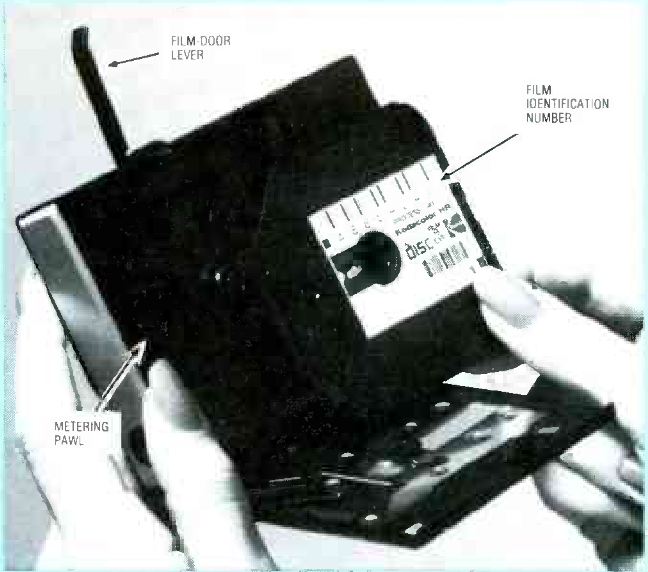


FIG. 1—THE DISC CAMERA might be the easiest-loading camera yet.

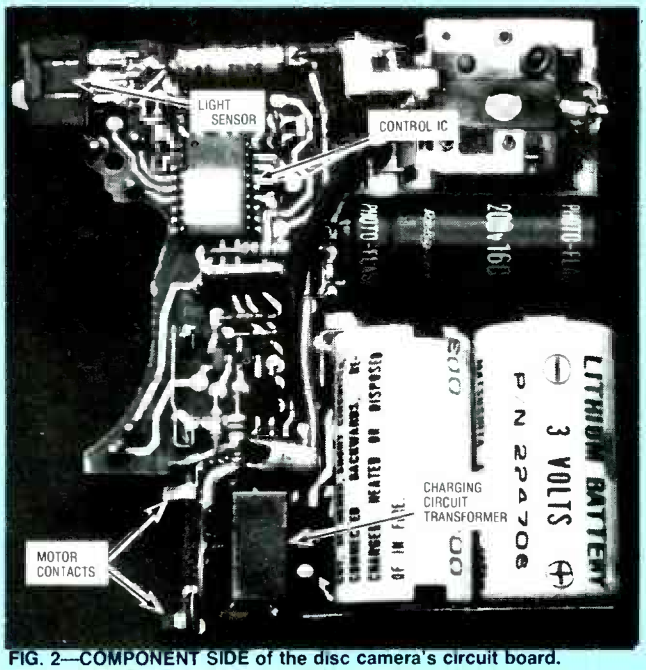


FIG. 2—COMPONENT SIDE of the disc camera's circuit board.

process consists of lifting a lever which locks and unlocks the camera door, then dropping the disc film in place, as shown in Fig. 1, and then closing and locking the film door.

That is a pretty simple method of doing things, and the film can be inserted in only one direction. However, that simple action launches an intricate interplay between camera and film as a complex locking and disc-engagement sequence begins. When the disc is inserted into the camera, teeth on the core of the film disc engage lugs in the camera. Those lugs drive the film and work in conjunction with notches in the film and a *metering pawl* in the camera to automatically position individual negatives for exposure.

Locking the camera door actuates a lever in the camera which rotates the disc's *dark slide*. That slide protects the undeveloped film from light. When the camera is opened, the dark slide is swung back into its protective, locked position.

With the camera ready for action, the photographer opens the lens cover, places the camera to his eye, looks through the viewfinder, and presses the shutter button.

Decision-making electronics

We could say that it is at this point that the electronics developments enter the picture. But that's not really true. Actually, the electronic process is initialized when lens cover or the cover/handle is opened, or when the shutter button is lightly touched. Those actions "wake up" the camera's electronics and start the charging of the flash-capacitor.

The major portion of the disc camera's electronics is contained in two custom IC's—the *light-sensing IC* and the *control IC*. Those IC's and the rest of the camera's circuit board is shown in Fig. 2. We'll look closer at those two IC's in a little while. First, though, let's take a look at what they and the rest of the electronics do.

Figure 3 is a simplified flowchart of the camera operation. Although we would like to show the complete decision-making process, that flowchart is simply too big. Also, the flowchart for the model *8000*, because it contains a rapid-sequence mode and a self timer, is quite complex. Therefore our simplified flowchart does not cover the *8000*. Also, to avoid confusion, we will say here that for the rest of the article, unless we specify otherwise, we will be referring to the model *4000*.

The electronic process begins when the lens or camera cover is opened. When that happens, switch S1 in the camera is closed, and power is applied to the circuit board. (Figure 4 shows some of the camera's switches and their locations and Table 1 lists the functions of those switches.) That starts the "wake-up" routine and initializes the DELAY 8 routine. (That is one of several delay times that are used by the camera in its decision-making process. All of the delay times are listed in Table 2; their function will become clear as we discuss them.) The DELAY 8 routine is the maximum time alowed for a camera cycle to occur. After that time, the camera will automatically go into its battery-conserving "doze" mode. For example, if you push the shutter button with no film in the camera, the motor will run for only 2.4 seconds. As you can see from the flowchart, the 18-pin Kodak-designed control IC is also activated (S1 is closed) whenever the shutter button is lightly touched.

We should take some time here to talk about the shutter switch. The contacts for that switch can be seen in Fig. 4. Unlike

TABLE 1

Swich	Function
S1	Power switch. Actuated by camera cover or lens cover.
S2-a	Soft-touch shutter switch. Starts wake-up.
S2-b	Shutter switch. (Shutter button must be fully pressed.) Starts picture-taking cycle.
S3	Synchronizes flash with opening of shutter.
S4	Tells control IC when film advance should start and stop. This switch is open when the metering pawl is extended (in a film perforation).
S5	Works in conjunction with S4 to tell control IC when the film is finished.

TABLE 2

Delay time	Function	Model 4000 6000	Model 8000
1	Delay for measuring exposure	10 ms	12.8 ms
2	Maximum time to top-off flash charge	716 ms	1 sec
3	Protects against S4 bounce	3.36 ms	3.36 ms
6*	Self-timer: 1-second interval for beeper/flashing LED	—	7.37 sec
7	Total time for self timer	—	9.83 sec
8	Maximum time allowed for picture-taking cycle	2.4 sec	3.2 sec

*Delay-times 4 and 5 are not presently used by Kodak.

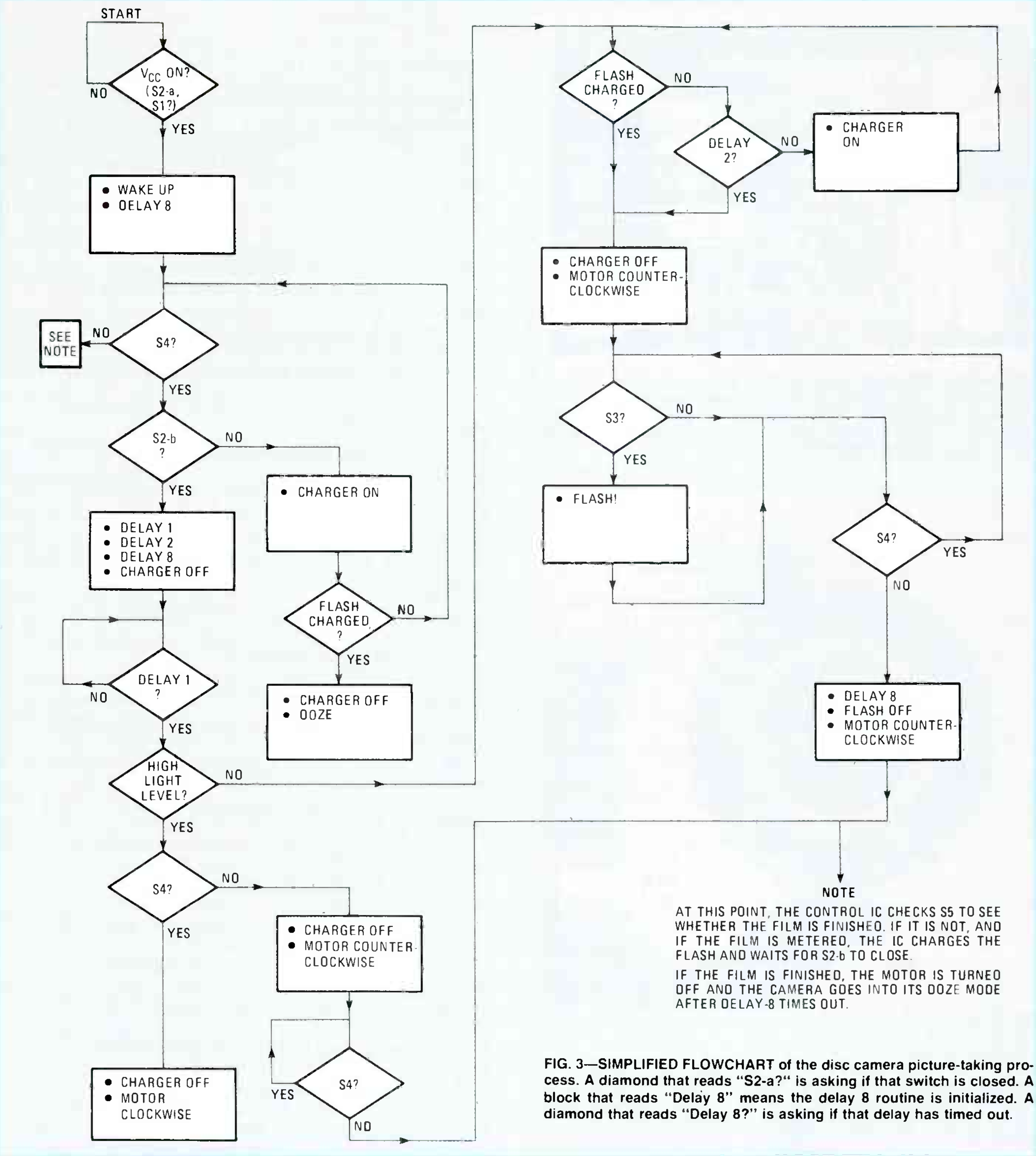


FIG. 3—SIMPLIFIED FLOWCHART of the disc camera picture-taking process. A diamond that reads "S2-a?" is asking if that switch is closed. A block that reads "Delay 8" means the delay 8 routine is initialized. A diamond that reads "Delay 8?" is asking if that delay has timed out.

most cameras, the switch is electronic, not mechanical. Actually it's a bit unfair to say that—the switch was well engineered mechanically. Whenever it is even just lightly touched, S2-a closes and the charging circuit tops off the capacitor charge. Because most people usually rest their finger on the shutter before they actually press it, S2-a is an almost fool-proof method of keeping the flash circuit ready to shoot.

After the camera is in its wake-up mode and the flash capacitor is charged, the next thing the control IC does is to check S4—the switch connected to the metering pawl. That switch lets the control IC know whether or not the pawl is in one of the film's perforations. If the film is metered (if the pawl is in a perforation), then S2-b, the shutter button is checked. If the switch is not closed, the control IC will charge the flash capacitor, if necessary, and will then put the camera into the shutdown or doze mode.

Pushing the button

However, if the shutter button is fully depressed (thus closing S2-b), the camera shifts into its "photo mode." As shown in the flowchart, the control IC first initializes various delay times and the flash charger is turned off. Next, the camera has to decide between a high- and low-light state. During DELAY 1, the control IC checks the output of the photo-sensor IC. That IC measures the ambient light level and acts as a comparator, determining whether or not the light is above 125 fL (footlamberts—a unit of luminance).

If the output of the photo-sensor IC indicates that the light level is above the 125-fL level, the control IC initiates the high-light mode. The charger is turned off; and the motor is turned clockwise. The clockwise motion of the exposure cam, which is driven by the motor, sets the shutter speed to 1/200 second; sets the aperture to *f*/6; cocks the shutter, and then snaps

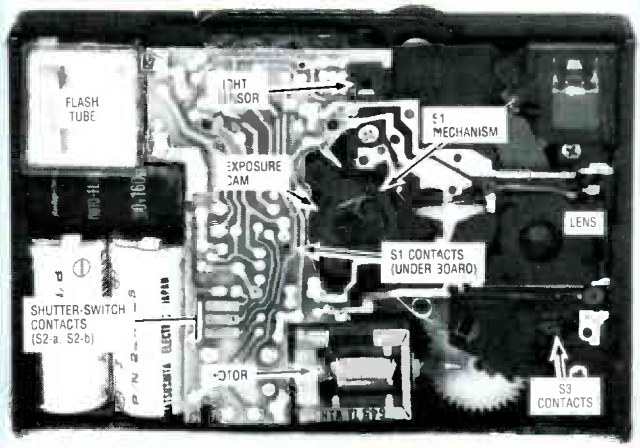


FIG. 4—THE DISC CAMERA consists not only of electronics. Various mechanical sensors are essential for its operation. Don't open your disc camera to look at them, though. First, you will probably damage the camera and void your warranty. Second, you might damage yourself—the flash capacitor is a very real shock hazard.

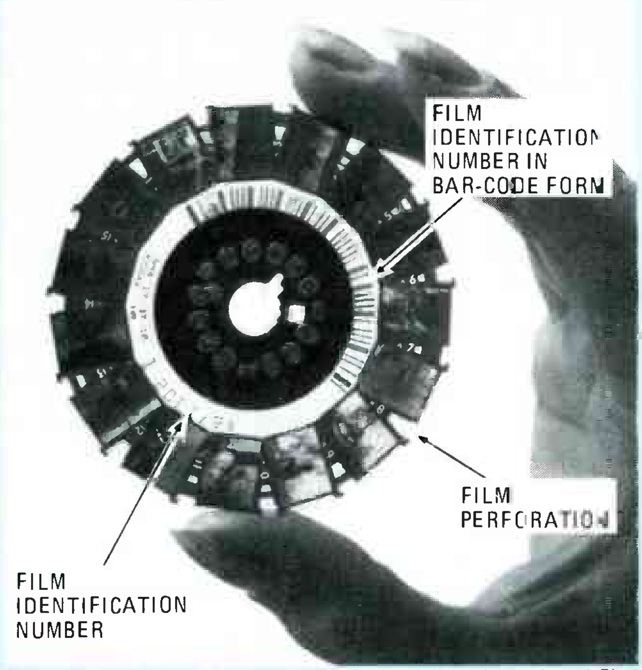


FIG. 5—A DEVELOPED FILM DISC. Note that each frame is numbered. That makes ordering reprints very easy.

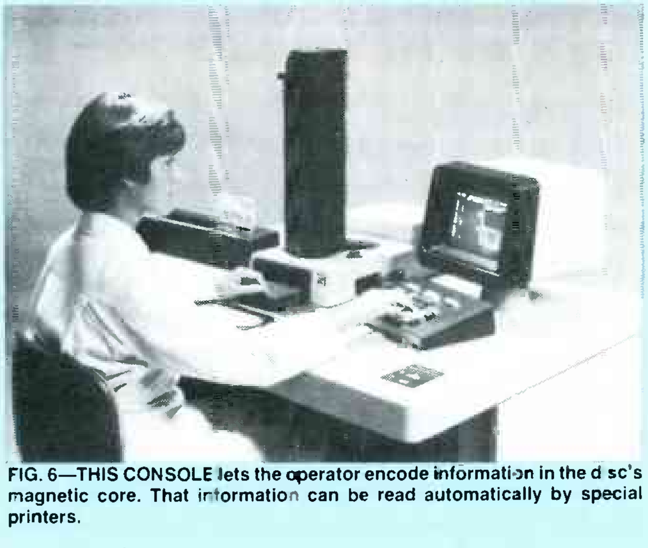


FIG. 6—THIS CONSOLE lets the operator encode information in the disc's magnetic core. That information can be read automatically by special printers.

the shutter. The last thing that the exposure cam does in its cycle is to pull the metering pawl out of the perforation in the film. That is important—as you can see in the flowchart, when the pawl is out of the film perforation, the control IC knows that the picture has been taken. It then orders the motor to turn counterclockwise to advance the film.

If the light level is below 125 footlamberts, then the the light-sensing IC sends that information to the control IC. That initiates another series of actions—the low-light mode. First the charge on the flash capacitor is checked until either the charge is sufficient or until DELAY 2 has timed out. Then the charger is turned off and the motor is turned counterclockwise. This time, however, turning the motor counterclockwise does not advance the film because the metering pawl is still in one of the film perforations. Instead the counterclockwise motion of the exposure cam sets the shutter speed to about 1/100 of a second and opens the aperture of *f*/2.8. Next the control IC looks at S3. That switch is closed whenever the shutter opens and is used to trigger the flash.

After the picture

After commanding the motor to turn, the control IC checks S4. (Remember, the last thing that the exposure cam does in its cycle is to pull the metering pawl out of the film perforation. That closes S4.) When that switch closes, it indicates that the picture has been taken. The control IC then turns off the charger and drives the motor counterclockwise to advance the film.

Two custom IC's

As we mentioned previously, the major portion of the camera electronics is contained in two Kodak-designed custom IC's. Let's look first at the control IC.

The control IC is an LSI integrated-injection logic (I^2L) integrated circuit. That type of logic was used because it allows combining both power and logic control on the same device. (About one half of the chip's area contains power transistors.) When the camera's motor is running, the control IC's output drivers can sink up to two amps and dissipate over 1.5 watts. On the other hand, when the camera is in its doze mode, the IC uses only 90 microwatts. If a more familiar approach, such as CMOS technology, was used, both power control could not have been included on the single IC. Thus, using I^2L helps keep costs, size, and power consumption to a minimum.

The control IC contains an on-chip voltage regulator. That's necessary because during the picture-taking cycle, the battery voltage varies (from 2 to 8 volts) as the motor is used. Also on the chip is a 10 kHz clock. As you can see from our discussion on the delay times, that clock, plays a very important role in the decision-making process of the disc cameras. In the *8000*, it also controls the self-timer. That includes flashing an LED and pulsing a beeper—and doubling the flashing/pulsing frequency about 2.5 seconds before the exposure.

The light-sensing IC measures the ambient light level and sends a one-bit output to the control IC to tell it whether or not the light level is over 125 fL. The photometer and the threshold-detection circuitry are on the same chip. That helps to reduce the chance of electrical noise causing an error.

The clock in the control IC and the detect circuitry in the light-sensing IC are both *wafer calibrated*. That means that the chip is modified while it is still in wafer form. That helps to reduce costs because it eliminates the need for further calibration in the camera. It also helps to achieve better quality control.

Once you've finished taking the pictures, the electronics processes don't stop—they continue during the photofinishing process. On each film label and on the disc itself (see Fig. 5) is a bar code pattern called the film identification number or FID. And the film core is magnetic—styrene impregnated with iron oxide. That means that instructions can be recorded there to be read by special photofinishing equipment. Figure 6 shows a console that prepares disc negatives for reorders. Reprint quantities, frame number, and even color/density corrections can be recorded on the film's magnetic core. **R-E**

Auto exposure and Auto focus Systems

Autofocus and auto-exposure systems have revolutionized modern photography. In this article we'll look at those systems and see how they've made picture taking simpler than ever imagined.

MARC STERN

HAVE YOU EVER STOPPED TO THINK ABOUT HOW PHOTOGRAPHY has changed over the past few years? For one thing, taking a picture, even under adverse conditions, has become simpler than ever. Powerful electronic circuits provide so much control over the various camera functions that essentially all a photographer has to do is focus and shoot. And, with some cameras he doesn't even have to focus; that chore is handled for him by an autofocus system.

All this has been made possible by the microelectronics "revolution" and the resulting development of LSI (*L*arge-*S*cale-*I*ntegration) techniques. Using LSI technology, camera manufacturers have been able to combine many control functions on a single IC. The result is a generation of "cameras that think."

Highly sophisticated electronics can be found in everything from "simple" snapshot cameras to professional photographic equipment. One example of the state of the art in 35mm photography is the Minolta (101 Williams Drive, Ramsey, NJ 07446) *X-700* system. It offers just about every camera feature currently available and consists of the camera itself, an autoflash, a motor drive, a multifunction back, and a wireless remote control. We'll discuss those accessories shortly, but first let's look at what makes this camera so special.

The *X-700*, shown in Fig 1, features a new faster-speed-priority program-mode, plus an aperture-priority auto mode and a metered/full-manual mode. Those modes allow a photographer the choice between automatic and manual picture taking.

In the program mode, the camera automatically selects both aperture and shutter speed for the best exposure. The system logic is designed to maintain the fastest possible shutter speeds as light dims. If the shutter speed will be 1/30 second or slower, the camera will give an audible signal (assuming that feature is switched on) to warn the photographer that blur from subject/camera movement is possible.

In the aperture-priority auto mode, the photographer sets the aperture manually and the camera automatically sets the best shutter speed.

In the metered/manual mode, the photographer can take advantage of the *X-700's* through-the-lens center-weighted averaging meter system, while maintaining full manual control over the exposure setting. When using that mode, both the shutter-speed and the aperture can be varied to achieve any desired effect.

All important information is displayed in the viewfinder. Simply placing your finger on the touch-sensitive shutter release begins metering and activates all of the viewfinder displays; the displays remain active for 15 seconds, or for however long your finger remains on the button.

In the program mode, a green "P" lights in the viewfinder above the shutter-speed scale. Red LED's along the shutter-speed scale indicate which shutter speed is being set by the camera. Because the shutter-speed settings are stepless, if two LED's light, the shutter speed is between the two indicated values. The minimum aperture of the lens you are using appears in the aperture window at the bottom of the viewfinder (that is not necessarily the aperture at which the picture is taken). The lens should be set at its minimum aperture in the program mode. If it is not, or if a non-Minolta MD-type lens is used, the green "P" in the viewfinder will flash. That indicates that the cam-

"I built this 16-bit computer and saved money. Learned a lot, too."

Save now by building the Heathkit H-100 yourself. Save later because your computer investment won't become obsolete for many years to come.

Save by building it yourself. You can save hundreds of dollars over assembled prices when you choose the new H-100 16-Bit/8-Bit Computer Kit – money you can use to buy the peripherals and software of your choice.

H-100 SERIES COMPUTER SPECIFICATIONS:

USER MEMORY:
128K-768K bytes*

MICROPROCESSORS:
16-bit: 8088
8-bit: 8085

DISK STORAGE:
Built-in standard 5.25" disk drive, 320K bytes/disk

KEYBOARD:
Typewriter-style, 95 keys, 13 function keys, 18-key numeric pad

GRAPHICS:
Always in graphics mode, 640h/225v resolution; up to eight colors are available**

COMMUNICATIONS:
Two RS-232C Serial Interface Ports and one parallel port

DIAGNOSTICS:
Memory self-test on power-up

AVAILABLE SOFTWARE:
Z-DOS (MS-DOS)
CP/M-85
Z-BASIC Language
Microsoft BASIC
Multiplan
SuperCalc
WordStar
MailMerge
Data Base Manager
Most standard 8-bit CP/M Software

*128K bytes standard. **Optional.

The H-100 is easy to build – the step-by-step Heathkit manual shows you how. And every step of the way, you have our pledge – "We won't let you fail." Help is as close as your phone, or the nearest Heathkit Electronic Center.

And what better way to learn state-of-the-art computing techniques than to build the world's only 16-bit/8-bit computer kit? To run today's higher-speed, higher-performance 16-bit software, you need an H-100. It makes a significant difference by processing more information at faster speeds.

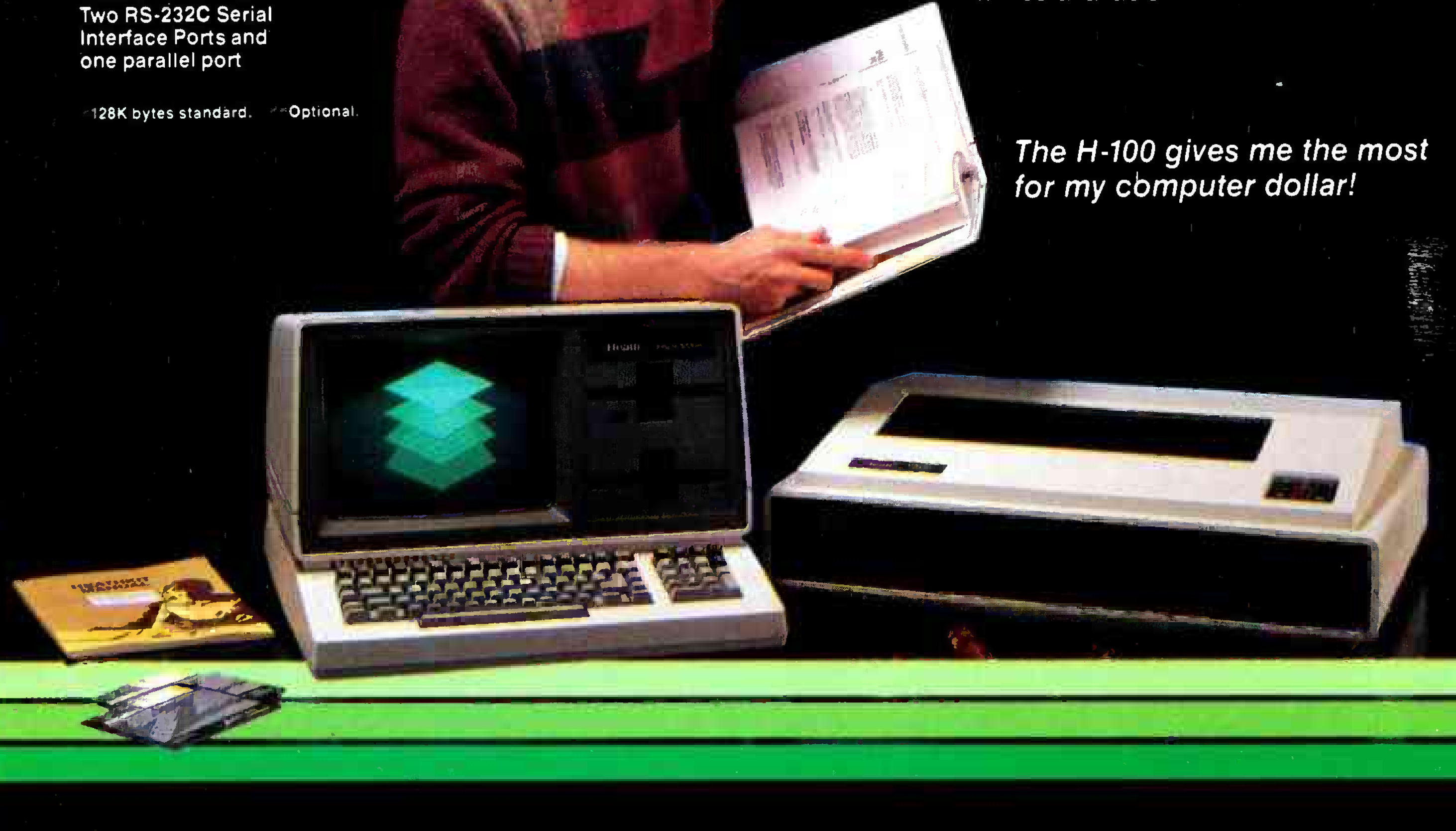
Dual microprocessors for power and compatibility. The H-100 handles both high-performance 16-bit software and most current Heath/Zenith 8-bit software.

Want room to grow? The H-100's standard 128K byte Random Access Memory complement can be expanded to 768K bytes – compared to a 64K standard for many desktop computers.

And the industry-standard S-100 card slots support memory expansion and additional peripheral devices, increasing future upgradability of the H-100.

High-capacity disk storage, too. The H-100's 5.25" floppy disk drive can store 320K bytes on a single disk. The computer also supports an optional second 5.25" and external 8" floppy disk drives. And an optional multi-megabyte internal Winchester disk drive will be available in the near future.

The H-100 gives me the most for my computer dollar!



Critical circuits are pre-assembled, making the H-100 easier and faster to build!

Want beautiful high-resolution graphics? You can create extensive charts, drawings, graphs and symbols to meet your needs – using the H-100's bit-mapped graphics and its 640 x 225 pixel video display.

The H-100 gives you total communications flexibility. Three interface ports let you plug in dot-matrix and letter-quality printers, as well as other peripherals.

Compare the H-100's exceptional capabilities with other desktop computers:

COMPUTER:	Heathkit H-100	IBM Personal Computer	Apple III
MICROPROCESSORS:			
16-bit:	8088	8088	–
8-bit:	8085	–	6502
RANDOM ACCESS MEMORY:			
Minimum:	128KB	16KB	128KB
Maximum:	768KB	576KB	256KB
FLOPPY DISK STORAGE:			
Per Diskette:	320KB	320KB	140KB
Maximum Internal:	640KB***	640KB	140KB
8" Floppy Support:	Standard	–	–
EXPANSION SLOTS:	Five S-100 (four available)	Five (three available)	Eight
I/O PORTS:			
Parallel:	1	Optional	–
Serial:	2	Optional	1
VIDEO DISPLAY:			
Line Columns	25 x 80	25 x 80	24 x 80
Pixels Colors	640 x 225 (8 colors)	640 x 200 (2 colors) 320 x 200 (4 colors)	560 x 192 (16 colors)
OPERATING SYSTEMS:	CP M-85, Z-DOS (MS-DOS)	CP M-86 PC-DOS (MS-DOS) UCSD P-System	Apple SOS

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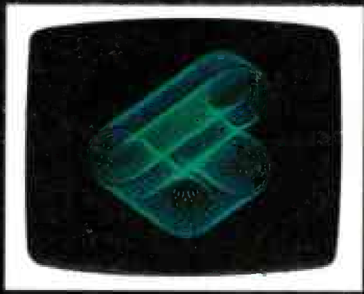

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CIRCLE 7 ON FREE INFORMATION CARD

FIG. 1—THE MINOLTA *X700* represents the ultimate in autoexposure technology and flexibility. If features a program mode in which both the aperture and the shutter speed are determined by the camera, an aperture-priority automatic mode, and a fully metered manual mode.

era's range is reduced, and brighter subjects can not be accomodated. New Minolta MD lenses can be locked at their minimum aperture.

Similarly, a red "A" lights above the shutter-speed scale to indicate when the camera is set in the aperture-priority automatic mode. Once again, LED's light along the scale to show which shutter speed is being set by the camera. The lens aperture that you select is clearly visible in the window at the bottom of the viewfinder.

In the metered manual mode, a red "M" lights in the viewfinder, the aperture setting is shown at the bottom of the viewfinder, and an LED lights next to the shutter speed that will provide proper exposure according to the light metered through the lens. Note that this is not the actual shutter speed; both the aperture and the shutter speed must be set manually, and either setting can be adjusted without affecting the other, affording maximum flexibility.

The camera also has two features that allow for more creative control and better results when using automatic exposure-setting under unusual lighting conditions. The ±2EV exposure adjustment allows you to vary the automatic exposure setting up to more or less two *f*-stops from normal in the program and automatic modes. When that feature is used, a ± LED blinks in the viewfinder. The auto-exposure lock feature is useful when the subject makes up but a small part of the total picture. It is especially useful, for example, if your subject is in the shadows but his background is strongly lighted. Normally, the camera would be "fooled" and set its exposure by the bright light—but not with the auto-exposure lock. When that feature is used, the subject is metered at close range and the AE-lock switch is pressed down. While that switch is held down, all you have to do is move back, recompose the picture, and then release the shutter.

In-the-viewfinder indicators of the status of the autoflash are also displayed when that unit is attached. Among the information available is whether the flash is fully charged, insufficiently charged, or off. In the last two cases, the settings for the ambient light conditions are displayed and, if the shutter is released, those are the settings at which the camera will operate. Once the shutter has been released, another in-viewfinder indication shows if the proper exposure has been made.

What's inside

The Minolta *X-700* uses five integrated circuits. At the heart of the camera is a 32.768-kHz oscillator that provides 1/30,000-second accuracy. The output from that oscillator feeds a 42-pin CMOS IC that controls the timing of most of the camera's functions. Those functions include shutter release, aperture stopdown, and mirror lift. A 42-pin BiMOS IC handles metering, calculations, and controls. Metering is done through two silicon photocells. One of them, on the camera's pentaprism, measures ambient light, while the other, located next to the mirror box, is for direct autoflash metering (see Fig. 2). The output from the photocells is fed to the BiMOS IC, which amplifies and processes the signal. Of the remaining IC's, a 42-pin bipolar device handles mode selection and program-mode operation; a 44-pin I^2L (*I*ntegrated *I*njection *L*ogic) dot-display driver handles the viewfinder displays, and a 12-pin bipolar device handles the electromagnetic shutter release and power control.

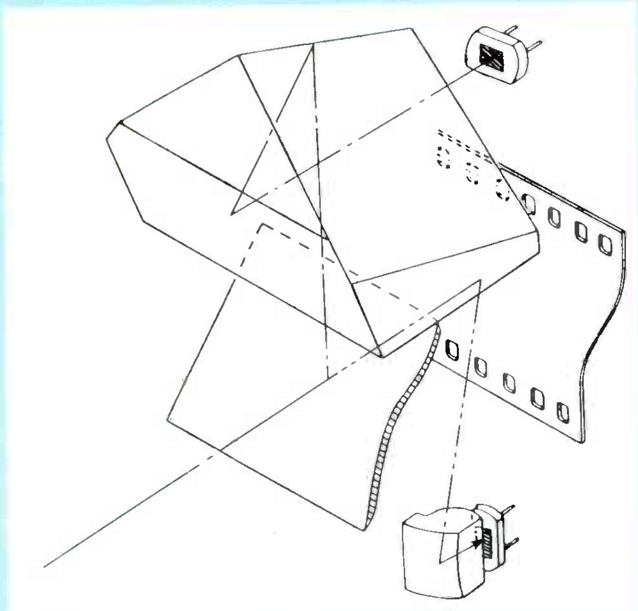

FIG. 2—TWO PHOTOCELLS are used for metering. One, on the camera's pentaprism, measures ambient light. The other, located next to the mirror box, is used for direct autoflash metering.

To better appreciate all of the complex functions that this control system must handle, let's take a closer look at all the steps involved in producing a successful photograph. To keep things as simple as possible, we'll only look at what happens in the program mode.

As we said earlier, in the program mode the camera sets both the aperture and shutter speed, with preference given to using the fastest practical shutter speed. Touching the camera's touch-sensitive operating switch inputs preset camera-setting information and scene brightness into the program-mode circuitry. When the operating button is fully depressed, the camera retrieves a programmed aperture value from the camera's memory based on that information. The aperture is then set, and the light passing through the aperture is re-metered as a final check before shutter operation; sensitive metering and fast reaction time allows the settings to change instantly with changing light conditions. All of that happens in milliseconds.

The camera's electronics also control the flash, when that unit is required. When the flash capacitor is fully charged, a signal is fed from the flash unit to the camera. When the shutter is released, the shutter speed is automatically reset to 1/60 second and the appropriate aperture is determined. After the mirror lifts, the flash emits light simultaneously with full shutter opening so that light reflected from the subject strikes the film surface. The silicon photocell next the the mirror box collects a sample of that reflected light and shuts off the flash at the precise moment for best exposure. A feedback system indicates both in the camera's viewfinder and on the back of the flash whether the exposure was correct.

Accessories

The Minolta *X-700* system includes all of the accessories you would expect to find in such a camera system, and more (see

FIG. 3—ACCESSORIES for the *X-700*. Of particular interest are the dedicated flash, the multifunction back, and the remote-control set.

Fig. 3). Aside from the wide variety of lenses, motor drives, etc., those accessories include an automatic flash, a multifunction back, and a wireless remote control. We'll next look at those three units and see what makes them special.

We've already looked at the *Electroflash 280PX* autoflash unit a bit. It is a clip-on programmed/automatic/manual flash unit with special contacts for both camera control and through-the-lens, off-the-film flash metering. The flash duration varies between 1/50,000 and 1/1,000-second, depending on light conditions. No adjustments or settings are made on the flash unit itself because that unit receives all needed information, including the speed of the film being used, from the camera.

Perhaps the most interesting accessory for the camera is a unique multifunction back. Containing its own dedicated processing unit, that device mounts in place of the *X-700's* regular back. What makes it so interesting is that it offers camera-control modes for time-lapse photographs, timed long-exposures, and multi-frame sequences. In addition, it features six data-imprinting modes to be used for identifying and classifying photographs.

A highly accurate quartz clock and auto calendar that runs from 1981 through 2099 imprint the time in hours, minutes, and seconds, or the date. Once set, the calendar will advance, taking into account leap years and differing month lengths. The calendar will also print the date in any order of year/month/day preferred. Other modes imprint any number from 1 through 999,999 for any coding scheme you like, or will sequencially count the frames.

All of that would make that accessory nice in its own right, but there is much more. For one thing, long, unmanned exposure times of up to several hours are possible. Another feature is unmanned interval-photography. That allows the camera to take photographs automatically at pre-determined intervals of between 1 second and 99 hours, 59 minutes, 59 seconds. Once the interval between photographs is determined, the camera is simply set up and left alone. Interval flash-photography is even possible; the multifunction back turns on the flash unit one minute before the interval expires. That feature requires the use of an autowinder or motor drive.

All the special back's functions are accessed and programmed using six keys and a slide switch that are concealed under a cover on the rear of the camera when not needed. The data imprinting is handled by a series of LED's within the back and the interfacing between the back and the electronics of the camera itself is done through three spring-loaded electrical-contact pins.

The last accessory we'll look at is one that is usually associated with cameras costing far more—a wireless-controller set. The set consists of a small transmitter that resembles a spot lightmeter and a receiver that resembles a small flash unit. The receiver is designed to attach to the camera's accessory shoe, or to a special bracket included in the set.

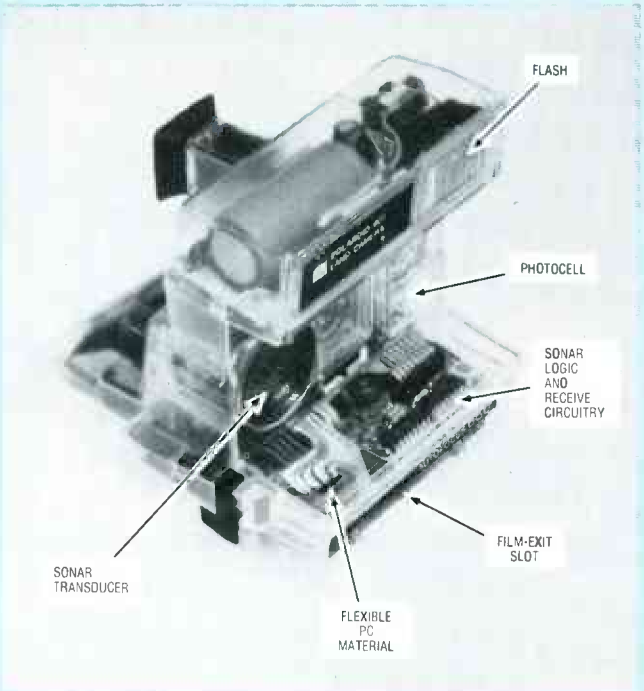

FIG. 4—INSIDE THE POLAROID *660*. This autofocus camera uses an active sonar system.

The wireless control uses near-infrared pulses for communications. That technique avoids problems such as interference and spurious signals so common to radio control. (But the range of the unit can be affected by adverse weather conditions such as direct sunlight or fog and Minolta recommends that operation under actual conditions be checked before any photographs are taken.) Under ideal conditions, communication over distances as great as 200 feet are possible. That communication need not be line-of-sight—the infrared pulses can be bounced around corners or off surfaces. Finally, the unit boasts three independent channels so that up to three cameras, or three groups of any number of cameras, can be controlled independently.

Autofocus

Autoexposure is just one way that electronics has changed the way we take pictures. There are, of course, others. Consider autofocus, for instance. A few years ago, those circuits were bulky, expensive affairs. With the introduction of integrated circuits and large-scale integration, the autofocus circuitry can now be placed on IC's little larger than a postage stamp; what's more important for consumers and manufacturers alike is that the IC's are not costly to manufacture. Autofocus has thus become common on many relatively inexpensive cameras.

Autofocus systems can be grouped into two classifications: active and passive. In an active system, the camera bounces a signal of some type (usually an ultrasonic tone or infrared pulse) off of an object, and uses the reflection to calculate the distance and set the focus. In a passive system no signal is emitted; the camera judges the distance from the subject using optical and electronic means.

Let's first examine active systems. The principles behind a sonar system, such as that used in Polaroid's (549 Technology Square, Cambridge, MA 02139) *660*, should be familiar to most. The camera emits an ultrasonic pulse and measures the time it takes for the echo to return.

Let's take a close look at the *660* (see Fig. 4). When the shutter button on the camera is first pressed, a 50-kHz sound burst is generated by a transducer mounted on the front of the camera. When the sonar echo returns to the camera, it is processed by the sonar logic and receive circuitry, shown in Fig. 5,

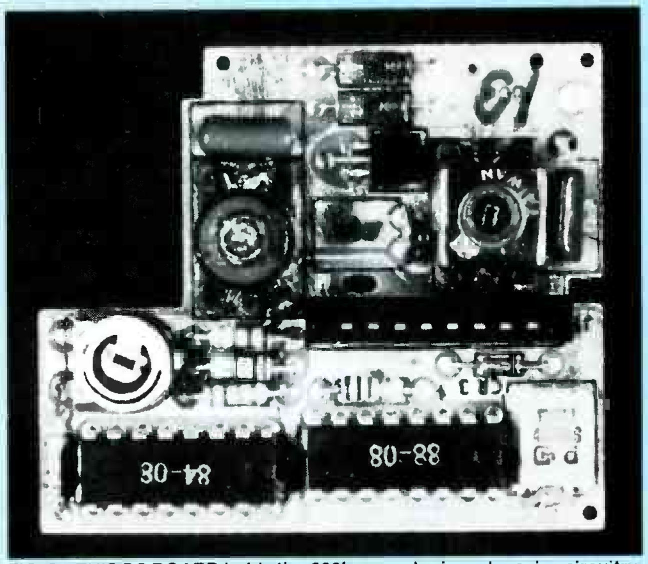

FIG. 5—THIS PC BOARD holds the *600's* sonar logic and receive circuitry.

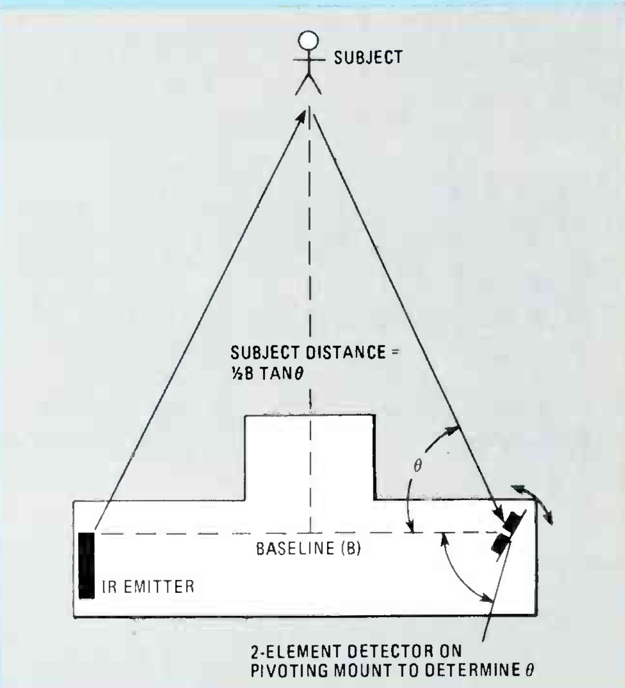

FIG. 6—AN ACTIVE IR autofocus system. This technique, used by Chinon, is based on triangulation.

which computes the elapsed time and stores it. From that information, the camera selects the proper supplementary lens (there are four mounted on an internal disc) and rotates it into position, where it is latched and held. With that lens in position, the camera will be properly focused.

At the moment that the disc is latched, a solenoid releases the shutter blade and a silicon photodiode measures the ambient light level. Information from that photodiode is instantly evaluated by the camera's electronics. If the light is greater than 10 candles-per-square foot, the fill-flash mode is selected; at lower light levels, full flash is selected. The flash will fire for all exposures unless manually overridden. As the shutter blades continue to open, the flash fires at the precise moment and at the correct aperture as selected by the camera's exposure-determining logic circuitry. Those factors are determined by the distance between subject and camera. The measured ambient light level is used to determine the duration of the flash, and the distance and the light are used to determine how long the shutter remains open.

The camera's electronics complement consists of the photodiode, an analog circuit that controls the transmission and reception of sonar signals, a voltage-to-frequency converter, a power IC, and the exposure-mechanism logic network.

The camera, including the flash system, is powered by flat batteries developed especially for the *600* series of cameras. Those batteries are part of each film pack.

An active infrared system, such as that used in Kodak's (Rochester, NY 14650) Kodamatic *980L*, measures the brightness of a reflected pulse. That system can run into difficulty, however, if the object being photographed is more reflective than average. Fortunately, most objects reflect infrared about the same way, and though the system is not totally foolproof, the slight differences that do occur are unimportant considering the camera's small-aperture lens.

A variation on the infrared technique uses triangulation to determine distance. In that system, the baseline runs between the camera's infrared emitter and detector and the peak of the triangle is at the photographic subject. The distance from the camera to the subject is then found by measuring the base angle of the triangle. That measurement can be done either electronically or mechanically. For instance, a camera might use a set of photodiodes in a rotating mount. That mount is tied to a motor that rotates the diodes until the signals at both are equal. When that happens, it means that both are pointed at the area that reflects the most infrared, which is the object to be photographed. The same motor is also tied to the lens in such a way that it is focused on the area that is indicated by the triangulation. The system described is used by Chinon (43 Fadem Rd., Springfield, NJ 07081) and is shown in Fig. 6.

Turning to passive autofocus systems, most use either triangulation or analyze the image produced by the lens to determine focus.

Passive triangulation systems work much like manual rangefinder cameras in that the camera is focused by moving the lens until the two images in the viewfinder correspond. Typical of such systems are Honeywell's (Honeywell Plaza, Minneapolis, MN 55408) *Visitronic* and Canon's (One Canon Plaza, Lake Success, NY 11042) *SST* or *S*olid *S*tate *T*riangulation.

Those systems use arrays of photodiodes to compare the images. Where the systems differ is in how they compare those images. The Honeywell system uses one moving image and one fixed one, much like manual rangefinders. The images are examined by the arrays until they coincide. In the *SST* system, the images are fixed. Two arrays of photodiodes examine the images, and the signals from those devices are analyzed to determine the difference, and hence the distance.

There are two autofocus systems that work by analyzing the image: contrast detectors and focal-plane detectors. Contrast detecting systems, used in cameras such as the Canon *AL-1* and the Pentax (35 Inverness Dr. E., Englewood, CO 80112) *ME-F*, are based on the premise that when the contrast is at a maximum (that is, when the variation in brightness from point-to-point is at a maximum) the image is in focus. Photodetector arrays that are centered around the focal plane, but located at slightly varying distances from the lens, and a microprocessor are used to measure that variation in contrast.

Focal-plane detectors are a bit more complicated, at least in concept. They work on the principle that the light from different points on an out-of-focus subject strikes each point in the film. If those points have contrast (that is if their brightness varies) the aperture will appear to be unevenly illuminated. Conversely, the image will be in focus only if the aperture is evenly illuminated. Thus, to check for focus all that need be done is to use a matched pair of photodetectors to look through opposite halves of the aperture. When both detectors see the same thing, the camera is focused.

From what we've seen so far one thing is clear—that thanks to new advances in microelectronics the nature of photography has changed dramatically. Although it may appear that you're only pushing a button, what's going on inside the camera is making it possible to take pictures under all kinds of conditions with amazing results. **R-E**

SPECIAL SECTION

IF YOU'VE BEEN AN AMATEUR PHOTOgrapher for more than just a few years, you probably remember when the state of the art in photo accessories was a strobe unit that was about the size of a hammer and weighed just about as much. They were the ones that also required an outboard 9- or 12-volt battery pack to drive the flash tube. And after a couple of hours of use they felt as if they weighed several hundred pounds.

Obviously, the scene has changed radically today—many cameras, even inexpensive ones, have built-in strobe units that are powered by a couple of penlight batteries. But the serious amateur photographer has available to him "smart" strobes that can communicate with "intelligent" cameras to produce high-quality photos. These smart strobes boast the same light output as their ancient relatives, but they do more, and are much smaller. In fact, some are so small they can literally fit in your shirt pocket with room to spare.

And strobes aren't the only photo accessories that have seen some radical changes during the last 20 years. Remember the old light meters? They were handheld affairs that offered good accuracy, but using one required spinning dials and matching needles.

Today's advanced light meters, while still about the same size as their counterparts from the 1960's, have lost all of their dials and needles. Now built-in microcomputers and LCD readouts make finding the right exposure setting easier than ever.

Photo Accessories

Camera accessories have not been left out of the "electronic revolution." Microprocessors, memories, and LCD's are among the features that you'll see.

MARC STERN

Strobe units

Before we look at individual strobe models, let's take a look at what a strobe does, how it works, and some features it might contain.

Some strobe units cannot be adjusted—they flash for a given length of time. They usually contain a "computer" dial. To use them, you first dial in the film's ASA number. Then you can dial in the distance from the subject and read off the *f*-stop you need to use a particular aperture you can dial the *f*-stop up on the calculator dial, and it will tell you the distance that you should be from the subject. When the strobe is used, the camera is set to its x position; that sets the shutter speed (usually to about a sixtieth of a second) and causes the camera to close a switch that sets off the flash when the shutter opens.

Dedicated strobes

There is another type of flash unit called the *dedicated strobe*. When the word "dedicated" is applied to strobe units, it means that that unit is tied to being used with one particular camera—or at least one made by a particular manufacturer. If you want a smart unit—a strobe that communicates with the camera to set the shutter speed, select a suitable aperture, activate viewfinder information (such as a flash-charge indicator), and control flash duration—then what you need is a dedicated strobe unit.

What makes one strobe setting different from another is not how *bright* the unit fires. Rather, it is the length of time that it fires. With the non-automatic strobe that time is constant, and to obtain the correct exposure you have control only over the *f*-stop setting and the distance from the subject.

Automatic strobes, on the other hand, use a photo cell to "look" at the amount of light that is reflected by the subject. When it determines that it has received enough light for the proper exposure, it then shuts off. An example of a dedicated electronic flash is the *Speedlight 166A*, from Cannon (One Canon Plaza, Lake Success, NY 11042) shown in Fig. 1. It mounts in the accessory shoe of Canon's *AL-1*. When the flash is fully charged, it automatically sets the camera's shutter speed to 1/60 second, and a light on the flash tells you that it's ready. The flash gives you a choice of two apertures; it displays them in a window on the back of the flash. The settings depend on the speed of the film that you're using. The distance ranges that are available with the selected *f*-stop are shown on a table on the

FIG. 1—A DEDICATED ELECTRONIC FLASH. The *Speedlight 166A* from Canon fires from 1/50,000 to 1/1000 second.

FIG. 2—THE LCD DISPLAY of the *5600* modular flash system from Vivitar makes this unit very easy to use.

back of the flash unit. When you take the picture, the strobe fires for anywhere from 1/50,000 to 1/1000 second—automatically controlled.

If you want a smart—therefore, dedicated—strobe for your camera, you don't have to be limited to buying one from your camera's manufacturer. Thanks to the flexibility afforded by microelectronics, it is now possible for one manufacturer to build a strobe unit that can be dedicated to a number of different cameras. An example of that is Vivitar's *3000* series of dedicated flash systems. It is designed to work with cameras from the Canon, Minolta, Olympus, Nikon, Pentax, Yashica, and Contax lines, as well as just about any of the other popular single-lens reflex (SLR) cameras on the market—provided that you buy the correct Vivitar dedicated module.

Like many other strobes now on the market, the Vivitar (1630 Stewart St., PO Box 2100, Santa Monica, CA 90406) *3500* uses energy-saving circuitry to keep the flash recycling-time down. On units without that circuitry, when the flash has fired long enough for correct exposure, the rest of the charge on the flash capacitor is "dumped." With the energy-saving circuitry, however, the unused charge can be recycled, thus saving the batteries and reducing the flash charging-time. That means that the flash can sometimes be used with an autowind camera, depending on the distance to the subject. (The farther the distance, the longer the flash has to fire, and thus the longer the recycling time.)

Vivitar's *5600*, though, is a better example of an electronically advanced strobe unit. It is shown in Fig. 2. Like the *3000* series, dedicated processor modules are available that let you interface the *5600* to a wide range of popular cameras. Another module is available with a PC cord that allows you to adapt the flash unit to non-dedicated cameras. The feature of this strobe that sets it apart from others is its LCD readout. That readout eliminates confusing calculator dials and mathematical computations—all the information you need to know is displayed in easy-to-read form. Let's take a look at how you would use that strobe, first in its automatic mode. As we discuss the LCD readout, refer to Fig. 3

When you first put the flash unit in its automatic mode, an AUTO indicator is displayed and the the unit beeps three times. (That, and all of the unit's audible indicators, can be switched off if silence is necessary.) Then you tell the *5600* the speed of your film (using either ASA or DIN standards). Next you tell the unit the *f*-stop (eight choices from *f*/1.4 to *f*/16) you want to use. The flash range then appears on the display (in either meters or feet) on a bar graph. Also, the maximum distance is displayed numerically. If you change the *f*-stop, the display recalculates the range. The flash duration range is from 1/30,000 to 1/1000 second.

The flash operates a little differently in its manual mode—the most significant difference being that the flash duration is always 1/1000 second (it does not adjust automatically). When switched into the manual mode, the unit signals with three double-beeps. When you program in the *f*-stop, the display shows the distance for the correct exposure. In the manual mode you have a choice of 12 different *f*-stops (as compared to eight in the auto mode). As you change the *f*-stop, the readout changes the display to show the optimum distance to the subject. (In the manual mode the distance to the subject is more critical than in the automatic mode because of the fixed light-output.)

At the heart of the *5600* is a custom microprocessor that drives the LCD display and accepts inputs from the strobe's photosensor unit. This unit not only accepts user inputs, but also compares those inputs against preprogrammed, proprietary logic and derives the display figures. This unit also controls the flash output in the auto mode and contains all the system driver-circuits.

In the AUTO mode, you can check whether or not the exposure selected will work by firing the flash manually (without snapping a picture). If an acceptable picture will result, the AUTO symbol flashes. (An audible signal can also be enabled.) The AUTO symbol will also flash after you take a picture if the amount of light was sufficient for proper exposure.

The LCD also indicates the angle of coverage for the flash head being used. (There is a variety of heads available for the *5600*, including a zoom head.)

Special voltage-sampling/timing circuitry also enables the microprocessor to flag weak batteries. If the batteries fail to recycle the unit within 35 seconds, the battery-replacement symbol is activated. (The normal recycle time is less than 12 seconds if alkaline batteries are used, and less than 7 seconds if the optional nickel-cadmium battery pack is used. A "starburst" is seen in the display when the flash is fully charged.) The warning symbol indicates that the batteries can still be used, but that they are in a weakened condition and should be replaced soon.

Like the other strobes in this line, it is possible to use this one with any of the popular single-lens reflex cameras by employing special processor modules. These modules contain the necessary electronics for interfacing the strobe head with the electronics inside the new generation of "intelligent" cameras.

Vivitar isn't alone in offering this type of flash, either. The major camera manufacturers, among them Pentax, Minolta, and Canon, also offer dedicated units that interface with, and take advantage of, the electronic circuitry in their equipment.

FIG. 3—A CLOSE UP VIEW of the *5600*'s LCD display shows just how much exposure information it can provide.

FIG. 4—ALTHOUGH COMPLEX INTERNALLY, the *Auto Meter III* from Minolta is a snap to use.

Light meters

Most photographers rely only on their camera's built-in light meter for their exposure measurements. And with the quality of those built-in meters, you might be wondering why anyone would want to use anything else. Serious photographers, however, often *do* want to use an accessory meter. That's because there are many instances when the readings from the built-in meter are too general. And that's why the hand-held light meter is still around. It can help eliminate a lot of the extra exposures and guesswork that often go along with getting just the right shot. But today's light meters are not what they were even a few short years ago.

Before we start discussing how they have changed, let's clarify what we mean by saying that there are situations when should use an accessory light meter. Assume that your subject is standing in the shadows with strong backlighting. Your built in light meter would provide you with an exposure setting based on the overall lighting that it sees, and the resulting picture would be underexposed—the portion you were interested in would be not much more than a silhouette. However, with a hand-held light meter, you could determine the proper exposure setting by measuring the amount of light reflected by or falling on just the subject, and not have to rely on a possibly erroneous overall reading.

This discussion of light meters will not try to be a roundup of manufacturers' products; we just want to give you an idea of what features are available due to advances in electronics. Therefore, we will use one manufacturer's (Minolta's) line as an example.

The first meter we will look at is Minolta's (101 Williams Drive, Ramsey, NJ 07446) *Auto Meter III*, shown in Fig. 4. We find it is built around a custom-built microprocessor, the "brain" of the unit. Its LCD readout makes it easy to use—No longer does a photographer have to twirl dials and match numbers to find correct exposure settings.

A memory in the *Auto Meter III* allows you to store one or two measurements, which can be recalled and compared to the third one being taken. To make the comparison easier, the *f*-stops of all three measurements are displayed on what Minolta calls a "dot-array display." They can be recalled one at a time as desired.

Let's look at how you would use the meter. The first thing that you have to do is to set the film speed and the shutter speed desired. Then, simply pressing the measurement button causes the meter to compute the *f*-stop or EV number (you choose which one you want) that is required for proper exposure. The number is displayed both digitally and by a dot on the dot-array display.

By depressing the memory key, you can then enter that value into the unit's memory. You can then take a second meter reading (at a different shutter speed) and enter that one in memory.

If you need a third measurement, you can take one and it will be instantly displayed. Then, with the RECALL key, you can recall the two previous readings. The *f*-stop (or EV) settings for all three readings are always displayed on the dot array.

That the microprocessor provides versatility is apparent from the fact the photographer can change the film speed set, or the shutter speed, even after the measurements have been taken. When they are changed, the microprocessor automatically adjusts for the changes and indicates the new data in the display.

One of the beauties of an all-electronic meter is its reliability. Since there are few moving parts, mechanical failure or wear is nearly nonexistent.

Spotmeters

A spotmeter, which is a special type of reflected-light meter, is a meter for the more advanced photographer. When such a meter is aimed at the subject it allows him to measure the amount of light from a very small area, so that he can determine the proper exposure setting with great precision. Minolta's *Spotmeter M*, shown in Fig. 5, has a one-degree viewing angle.

That meter uses the same type of microprocessor control and LCD readout as the one we previously discussed, but, being a spotmeter, it allows the photographer to measure the lighting on the exact spot he wants to measure—a highlight or shadow, for example.

Three buttons, labeled S, H, and A (shadow, highlight, and average), are included. When the "shadow" button is pressed the microcomputer recomputes the exposure settings so that the measured spot will be exposed as a shadow. The "highlight" button is pressed for the exposure settings so that the measured spot will be exposed as a highlight, while the "average" key will give the average of the other two readings. That feature is especially useful when taking portrait shots—it allows you to be more creative because it lets you get precisely the effect that you want without a lot of guesswork.

Another type of electronic spotmeter is represented by Minolta's *Auto-Spot II* and *Auto-Spot II Digital*. Like the *Spotmeter M*, they are hand-held spot meters. The interesting feature of the *Auto-Spot II*-line is a "total-information" viewfinder that indicates all necessary information at a glance for proper exposure. With this meter, the scales in the finder move continuously until the trigger is released—then the readings are locked. The key difference between the two meters is that the *Digital* presents a digital readout, while the *Auto-Spot II* presents an analog one (on rotating scales).

Today's light meters are very different from light meters of the past. Their main advantage is that they can be used more accurately. That's not to say that the meters used years ago were

FIG. 5—THE SPOTMETER is a special type of reflected-light meter. Shown is the *Spotmeter M* from Minolta.

not accurate—in many cases they were. But because they were more difficult to use, and because they could be misused easily, the chance of error—usually the fault of the photographer—was high.

With older meters, the light falling on a photocell generates a voltage that then moves a meter needle which is read by the photographer and, based on that reading, dials are turned so that the correct exposure settings can be determined. Today's meters read the light level, take into consideration the user's inputs (such as film speed and shutter speed), and then tell him the correct exposure settings and camera-to-subject distance in an easy-to-read form.

In the 1960's, selenium cells were used primarily, but they were not as accurate as other types of devices and they suffered from several shortcomings. They were replaced in the early 1970's by CdS (cadmium sulfide) photoconductive cells. Those allowed for more precise measurements, but they also had their drawbacks. One of the more troublesome problems was that they could develop "memories." That effect, called the light-history effect, means that the conductance of the photocell is a function of not only the light that it "sees" now, but it is also a function of the cell's previous exposure to light.

The photography industry found the answer to that problem in silicon cells, which can be used as accurately as the cadmium-sulfide cells, but don't suffer from the same problems.

Two other byproducts of electronic technology are flash meters, such as Minolta's *Flash Meter III*, and color meters. Essentially different types of light meters, they, too, use large-scale-integration and LCD technology to assist the photographer. For instance, the flash meter provides precise incident or reflected-light readings of electronic or bulb flash, or continuous illumination, or combinations of them. At the push of a button, a microprocessor turns the results of those readings into a display indicating the correct *f*-stop for a given situation so that the camera can be set correctly. The color meter allows a photographer to determine what filters, if any, are needed to ensure accurate color reproduction.

A relatively new camera accessory that is becoming increasingly popular is the electronic camera-back. Some such backs can imprint the date or time of exposure; the film type and exposure settings, and some can even operate the camera automatically for time-lapse or long-exposure photos. We won't go into more detail at this time; a multifunction back was discussed in a previous article in this section.

As you can see, photographic accessories have come a long way in the last two decades, thanks to the microelectronics revolution. They have given every photographer the chance to produce high-quality photos, something that everyone strives for. **R-E**

THE ALL-ELECTRONIC MAVICA

continued from page 62

affects of jitter on transmission, it is effectively cancelled by extracting the jitter signal from the video and using it to modulate the 14-MHz sampling clock. Since both signals then contain identical amounts of the same jitter component, it is nullified, and the sampled signal is free of that annoyance. The jitter-free digitized video is then stored in the memory of the transmitting unit.

The 800-Hz signal derived from the digital-to-analog conversion process is fed to a lowpass filter to eliminate spurious signals, and its level adjusted to meet the requirements of phone-line transmission.

At the receiving end of the system, further steps are taken to ensure the highest possible image quality. Because phone line signal-levels fluctuate greatly, an automatic-gain-control circuit using a reference signal contained in the system-control signals that start each image transmission is used to adjust the received signal to the proper level. The Sony engineers also realize that the phone system has a rather poor signal-to-noise ratio, and have adjusted the image signal to take that into account. In their system, the extremes of the image signal are the levels representing black and white. The horizontal-sync signal, which is normally "blacker-than-black," is inverted and extended to equal the peak white-level. Because the circuitry may have problems differentiating between a signal that represents pure white and one that represents horizontal sync, a vertical sync signal (also at the 100% level) is transmitted during the interval that contains no image. It, and the fact that the horizontal-sync pulses occur at regular intervals, prevent the sync and image signals from becoming confused. Figure 8 shows a comparison of a standard

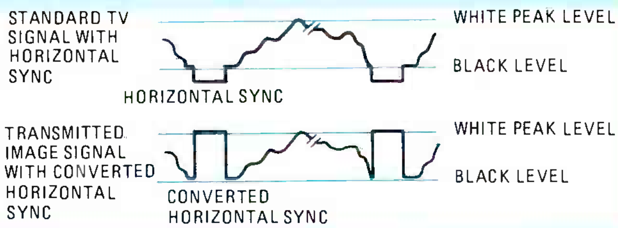

FIG. 8—STANDARD VIDEO SIGNAL (*a*) compared to signal used over telephone lines (*b*). Note how sync is inverted and maintained at white-level (as opposed to blacker-than-black) in the latter.

TV signal (*a*) and the one transmitted over the phone line by the Sony system (*b*).

The received signal is stored in memory and undergoes digital-to-analog conversion (essentially the reverse of what was done at the transmitting end). The image can then be viewed on a TV screen, or printed by the Mavigraph. (You can also record the digital signals on a standard audio cassette, and play them back when you desire.) It takes about four minutes to transmit one picture by this method.

Although this is a somewhat simplified explanation of what goes on, it describes what is perhaps the most important use of filmless electronic photography and demonstrates the ability to combine video with many different forms of media.

Since the Mavica system is based on electronic video signals, it is also compatible with other electronics equipment. It will be possible, then, in the long run, to use and integrate photos and other pictorial matter with computer-generated reports or to access and use pictorial matter in other electronic ways.

The Mavica system has a great deal of potential in many realms, and though we may have to wait a while before we can use it at birthday parties, we are certain to see it widely used commercially. **R-E**

Electronics in The Darkroom

Precise timing and repeatability of results are essential in the darkroom—especially for color processing. The use of electronics in what were previously all-mechanical devices allows a new degree of accuracy to be attained.

MARC STERN

NOT TOO LONG AGO MAKING COLOR PRINTS WAS SO DIFFICULT—especially for the amateur—that many who were proficient in black-and-white darkroom techniques absolutely refused to get involved with color. Processing times and temperatures were critical, filtration and exposures were hard to determine, and the chemicals were a nightmare! It could take an entire evening to make just one satisfactory print. The chemistry end of color processing was simplified about ten years ago, but it wasn't until recently that electronics made color printing really easy. We're going to discuss some of the ways it has done so.

Temperature control

One of the most critical factors in color processing is the temperature of the chemicals used. Color work is much more temperature critical than black-and-white—some of Kodak's processes require the chemicals to be within ± ¼-degree of a certain temperature (usually around 100° F.)

To measure temperatures accurately, an electronic digital thermometer like the Omega *CF-20* can be used. Employing large-scale circuit integration and a solid-state sensor, the thermometer displays almost laboratory-precise readings on a 3½-digit LED readout. The thermometer, which is calibrated to National Bureau of Standards guidelines, has a range of 59° F. to 140° F., and is accurate to ± .25-degree F. Its probe is made of chemical- and heat-resistant plastic, and is designed to hang on tanks and trays without slipping or rolling. The thermometer can be powered by four 1.5-volt "AA" cells or a rechargeable nickel-cadmium battery pack.

Color analyzers

One of the trickiest parts of color printing is color balancing—it's like adjusting the hue control on an old color-TV set for correct flesh-tones, only harder. A number of variables are involved, including the lighting conditions under which a picture was taken and—more critical—the particular emulsion batches used for the film and printing paper. (Each batch of paper or film produced by a manufacturer varies slightly from the ideal specifications for color properties. These have to be compensated for in the printing process through the use of filters.)

Color balancing is simplified by a device called a color analyzer, which measures the color content of the light projected through the negative or slide and, "knowing" the filtration requirements of the particular paper and film being used, de-

FIG. 1—OMEGA's *SCA 300* DIGITAL COLOR ANALYZER can accept user-programmable RAM modules that greatly reduce setup time.

termines the filter values that must be used. It should be mentioned that some filtration is *always* required; the exact amount depends on a number of factors. Because of their cost, color analyzers used to be considered luxury items, but today they almost have become necessities as the costs of paper, chemicals, and other photographic materials have climbed through the roof. Any waste of those items is needless and it is also rather expensive.

A good example of the state of the art in color analyzers is provided by Omega's (Omega Division, Berkey Marketing Companies, 25-20 Brooklyn-Queens Expressway West, Woodside, NY 11377) microprocessor-controlled *SCA 300*. The *SCA 300*, shown in Fig. 1, can accept computer-type RAM (*R*andom *A*ccess *M*emory) programmable memory-modules; each module is programmed by the photographer for a specific film/paper combination. With one of the modules installed, the analyzer allows him to make any number of prints without missing a beat—without his having to retest, reset, or reprogram anything. When a photographer uses a particular combination again, all he has to do is insert the correct module.

The probe contains a set of three silicon cells with matched dichroic and narrow-bandpass filters. In use, it is placed on the printing easel, in place of the paper, and the cyan, magenta, yellow and exposure readings taken in sequence. Each reading is displayed on a 3½-digit variable-intensity LED readout. When all the filter values and the exposure time have been determined and set, the probe is removed, the paper put in place, and the exposure made.

The analyzer, which includes a feature that allows adjustment of the overall color-sensitivity level without affecting stored programs, is capable of selectively displaying the amounts of cyan, magenta, and yellow filtration needed, and the proper exposure time, with the push of a button. It also allows a photographer to recall any previously stored information from memory. The unit has built-in voltage and temperature stabilization and can operate from 117 or 230 VAC, 50/60 Hz.

A device that can be used if you need only to determine exposure times is the *Volomat* light integrator from Karl Heitz (937 Third Avenue, New York, NY 10022), which is a densitometer for black-and-white prints, or for color prints from slides.

The sensor is a cadmium-sulfide cell, whose output, after processing, lights one of a series of LED's. The readings are accurate to one-third of an *f*-stop. The 12 LED's correspond to light values from 0 to 2 lux, and the exposure times that can be read range from 0.7-second to 430 seconds.

Battery powered, the densitometer features a green-LED test light that also indicates when there is too much light on the easel. A chart on the instrument can be used to determine exposure times for seven different paper grades. In normal use, a light

FIG. 2—THE GRALAB *20* DIGITAL DARKROOM TIMER can sound a short tone each second to permit the darkroom worker to carry out time-critical operations like dodging and burning-in without having to watch the time display.

diffuser is placed in front of the lens of the enlarger, but the device can also be used to take spot readings to determine contrast, or from specific parts of a negative.

Timers and color analyzers

With the correct exposure information and timing information in hand thanks to devices like the ones just described, the photographer then can program an all-electronic darkroom timer to turn on the enlarger for the correct length of time. Those devices can either be simple stand-alones, like the Gralab (Dimco-Gray Company, 8200 S. Suburban Rd., Centerville, OH 45459) model *500* or *520* (the latter is shown in Fig. 2), or they can have additional features. We'll see an example of that shortly.

The Gralab *500/520* timers use a quartz crystal timebase to eliminate interference from power lines, and to ensure accuracy regardless of line-frequency variations. They can be pushbutton-programmed for times from 0.1-second to 99 minutes, 59.9 seconds.

The timers provide readouts on four-digit red-LED displays. The intensities of the displays can be set bright for high lighting-levels or low for good readability in total darkness. The timers have grounded outputs for enlarger and safelight control; the enlarger and printer can be switched on or off either manually or by the timer. Both units can repeat the selected time as often as desired, ensuring fast production and identical exposures for large print-runs. They can also generate a metronome signal at one-second intervals (useful if you have to time a process but can't watch the display), and a two-second signal indicating that the timer has reached the end of its count. The model *520* allows the photographer to program two different time settings, each of which can be instantly recalled. The two settings will remain in the unit's memory until cancelled.

The more sophisticated microprocessor-controlled Omega *CT-40* timer/controller (see Fig. 3) allows up to 17 sequential time-intervals to be stored in memory. It can be programmed to stop after each step, or to pause for 10 seconds after each interval and then continue automatically to the next; there is even an independent time-of-day clock. Seven different audible signals can be selected for use with each step. The device is extremely valuable for timing multi-step processes such as making color prints or developing color film, which involve several chemical baths and water rinses.

The *CT-40* uses a membrane keyboard, something of a necessity in the harsh chemical atmosphere of a darkroom where strong processing agents can easily ruin a device. The keyboard has luminous markings, which makes it easy to use under darkroom conditions. A tone is heard each time the microprocessor registers an input.

The 4-digit red-LED display indicates the elapsed time and, when the unit is in the PROGRAM mode, the current sequence-step. That provides visual confirmation of the audible sequence selected.

The clock has an accuracy of ±0.5 percent, and timing

FIG. 3—THE OMEGA *CT-40* DIGITAL TIMER/CONTROLLER allows the user to program up to 17 consecutive time intervals. This feature is extremely useful for complex multi-step color-processing procedures.

functions can be entered in either "minutes:seconds" or "seconds:tenths-of-seconds" form. There are two timing ranges: the first covers a range of 0.1-second to 9 minutes, 99.9 seconds in 0.1-second steps; the other goes from 1 second to 99 minutes, 99 seconds in 1-second steps. The timer can be stopped and restarted at any time without affecting the timing sequence.

An optional expansion-interface allows the use of pre-programmed plug-in process-control cartridges for automatic operation. Those cartridges automatically program the timer for all popular photographic processes, including Cibachrome, Ektaflex, R-14, and others. A single cartridge can contain information for about 60 steps.

The expansion interface also permits the use of additional darkroom accessories: an exposure probe for automatically setting the correct exposure time, a temperature probe (with readouts in both Fahrenheit and Centigrade), a digital PH-indicator probe, and others. It also has a built-in self-test program for the *CT-40* that checks all 17 program steps, all the digits and indicators, and runs through a 10-second timing check—all in just 20 seconds.

An even more sophisticated device is the Omega *SCA 400* automatic digital color analyzer/timer, which combines both color analyzer and timer functions in one microprocessor-controlled unit.

Featuring eight programmable memories, and four-channel simultaneous digital readout of color filtration and exposure time, the analyzer can compute the weighted sum of the yellow, magenta and cyan filter values and automatically set the exposure time. (Of course, if you want, the time can also be set manually.)

The eight memories allow eight different settings for specific paper/film combinations to be stored in nonvolatile RAM; the settings are retained when the unit is turned off. Only two keystrokes are required to access and program the memories. If more—or less—light is required from the enlarger, the unit automatically displays the words "LO" or "HI."

A line of similarly sophisticated solid-state timers and analyzers is also available from Beseler Photo Marketing Co., Inc. (8 Fernwood Rd., Florham Park, NJ 07932).

Enlargers

Enlargers have gotten very smart, too. One example of *how* smart is provided by Omega's *D5500* enlarger system, shown in Fig. 4.

The system starts with an automatic dichroic lamphouse. Repeatability is extremely important in color printing—when you dial in a certain combination of filter values, the color output

FIG. 4—THE *D5500* COLOR ENLARGER SYSTEM is unique in that the color head has no user-operable controls—all adjustments are made either automatically or from a console keyboard.

of the color head (the lamphouse together with its dichroic filters) should always be the same. Over time, though, what you want may not be what you get, due to lamp aging, the darkening of reflecting surfaces, and other factors. A specially designed quartz-halogen lamp from General Electric helps reduce that problem; the *D5500* lamphouse *corrects* for it by constantly monitoring its own color output using a set of three silicon-cell color sensors.

The outputs of those cells are fed to a microprocessor-controlled circuit that "knows" what the normal color-output should be and automatically corrects the filtration as needed. The three dichroic filters, whose positions in the light path determine the color output of the head, are moved to the correct positions by separate DC motors in response to the output of the color-control circuit. Those motors are also used to introduce the amount of filtration selected by the photographer for printing; unlike other color heads, that of the *D5500* has no external color-control knobs—everything is controlled electrically or electronically.

The heart of the *D5500* system is its auto CLS (Closed Loop System) controller, which can also be seen in Fig. 4. It connects to the lamphouse, and allows all timing and filter settings to be made from one console.

The controller has a backlighted membrane keyboard that is used to enter filter and exposure data for the enlarger's color head. Four 3-digit LED displays show the filter values and time selected; the intensity of both the displays and the keyboard lighting is adjustable.

Filtration values can be entered from a numeric pad, or

FIG. 5—BESELER's *DICHRO 45* enlarging system is programmable by means of plastic cards with magnetic stripes.

increased or decreased step-by-step by "up/down" keys. Exposure times can be entered in two ranges: from 0.1 second to 99.9 seconds (in 0.1-second increments) or from 100 seconds to 999 seconds (in 1-second increments). Whenever the controller requires informaton to be input, the appropriate key is illuminated to call the operator's attention to it. This feature is especially useful when several steps have to be entered in a particular sequence—the keys will light up one after the other. That makes it difficult to make a mistake.

Two controller models are available. The first is the *Auto CLS Controller* just described. The second, the *Auto CLS Translator/Controller*, offers several additional features.

In addition to doing everything its smaller cousin can, the translator/controller can be connected to a video color-negative analyzer like those used in high-volume operations, and the color-correction factors determined using that device will be fed directly to the color head of the enlarger. The translator/controller also comes with a density probe for making on-easel exposure measurements.

If desired, the unit can be connected to a color analyzer (like the CA 400 described earlier), and the output of the analyzer converted directly into signals to control the color head. In addition, it has a 25-pin "computer-type" connector, which, Omega says, allows for future interfacing with external memory storage-devices, magnetic-card or paper-tape readers, and various on- and off-easel densitometric devices.

The translator/controller has 19 program memories and includes a number of automatic diagnostic features. Among them are a line-frequency check, a temperature check (for the lamphouse), and a "high-low" light-intensity check (when the density probe is used).

A recently introduced option for the system is a parallel computer-interface, which answers the need for computer control of laboratory processes. The reason Omega chose a parallel interface is because its research showed that most of the computers with which its system would be interconnected used a parallel printer port. The company has solved interface problems associated with interconnecting parallel ports by using a BASIC program and supplying listings that show how to customize the program for particular computers. Among the computers supported are the Apple computers, the *TRS-80, the IBM PC*, and others that use Microsoft BASIC.

Another computer-controlled enlarging system is the Fujimoto *G70*. Although not as automated as the Omega system, its color analyzer—which is built into its base—allows precise determination of filter requirements and repeatability of results. It is marketed by Colourtronic (9650 Topanga Canyon Place, Chatsworth, CA 91311).

The Beseler *Dichro 45* system, shown in Fig. 5, uses a microcomputer-controlled dichroic-head color system similar in some respects to Omega's. It, too, checks the quality of the light it outputs. Instead of automatically changing the position of the filters, however, it changes the figures displayed by the 7-segment LED's that indicate the color makeup of the light inside the head's mixing chamber. A switch allows you to see the actual value of the filter pack, or its effective value. The color head contains a 3870 microprocessor, custom-programmed by the company, that serves as the basic function-controller for the electronics package.

Though only about one-quarter-inch square, the microprocessor chip can collect data, make decisions and calculations, and provide output, commands and control signals. Other electronic components in the color head include a quartz-crystal oscillator and nine integrated circuits (including three MOSFET op-amps and three opto-isolators).

When the photographer turns on the system, three solid-state photodetectors read the actual color of the light within the mixing chamber of the color head. The particular devices used were chosen because they are extremely sensitive and don't have the infrared-response problems associated with silicon photodiodes. They also closely match the spectral sensitivity of color photographic-materials.

The signals from the detectors are fed into three MOSFET operational amplifiers, and from there to a multi-channel analog-to-digital converter. The microcomputer reads and stores the data, processes it, and outputs two simultaneous signals. The first is a BCD (*B*inary-*C*oded *D*ecimal) signal that is sent to a BCD-to-decimal decoder which then provides a signal to select the proper LED display. The second signal supplies the display selected with the appropriate information. The information is updated every tenth of a second, so that any variation in the color of the light is immediately detected and can be corrected for.

The microprocessor also performs a number of other functions, including a self-test diagnostic routine.

Signals to and from the color head can be controlled by what Beseler calls its Data Access Timer Analyzer module, or D.A.T.A. The module is connected to the head by a 24-pin connector.

While the D.A.T.A. module allows you to program the color head manually, it also has a built-in magnetic-card reader that enables it to read data from or write it to a specially designed D.A.T.A. card (which looks much like an ordinary credit card).

The module can store and make use of many types of data, including analyzer programs; color-head-memory offsets; specific information about a particular negative or slide; and information for automatic variable-contrast control and paper/film-emulsion and density control.

With a probe containing three photodetectors, the module can act as a color analyzer. A timer function lets it address the quartz-crystal oscillator built into the color head, providing an enlarging timing capability and exposure repeatability controlled by the on-board microcomputer.

It can also perform as a multiple-memory digital color analyzer with a one-button push-to-program feature. Any number of color-analyzer programs can quickly be stored on D.A.T.A. cards for later use.

As you can see, the nature of the darkroom has changed, thanks to microelectronics. And, since we have progressed this far, can the totally automated, computer-controlled darkroom be far away? Only time will tell. **R-E**

EXPAND Your TIMEX/SINCLAIR Operating System

We told you that you could store system-software modifications in this RAM expansion. When we finish up the construction we'll look at just a few of the possibilities.

PAUL W.W. HUNTER

Part 2 WHEN WE FINISHED UP last month, we had almost completed the construction of the CMOS RAM board. We still have a lot to cover, so let's get started right away.

Look the board over carefully for any loose bits of solder, solder bridges, cold-solder joints, and incorrectly placed components. Connect five volts across the ±VOLTS and GROUND pins on the edge connector (the computer itself is a good source for the five volts) and test for correct voltages at the appropriate socket pins. The CMOS memory IC's are expensive, and it's a good idea to spend a few extra minutes checking the board at this stage before you insert them.

If you're satisfied that all is correct, then you can plug in the integrated circuits. Be careful when you handle the CMOS IC's, though—ground yourself before touching them, and don't touch the pins unnecessarily. You will probably find that the pins are spaced too widely for the sockets. If that is the case, bend the pins slightly inward by pressing one side of the IC at a time against a hard grounded surface. A piece of aluminum foil on a flat surface works fine.

Options

The 8K RAM board offers several options, most of which are selected by positioning jumpers as we will describe in this section.

We'll start our discussion with jumper JU1—the jumper that is used to select the particular 8K block of addresses where the board will reside. On the board, the JU1 area contains five pads, one of which is the "common." A wire should be inserted between the common and one of the other four pads, as shown in Fig. 9.

The memory board can accommodate four 2K 6116P CMOS RAM's, four 2K 2716 EPROM's, or two 4K 2732 EPROM's (in the IC1 and IC2 sockets). As shown in Fig. 10, the signals at pin 21 are different for the three memory devices. Therefore, jumper JU2, as shown in Fig. 11, is used to "program" the board for the type of memory IC used. The Z80 $\overline{\text{WR}}$ control signal is jumper-connected to pin 21 when 6116P CMOS RAM's are used. But for the 2732 EPROM's, pin 21 is connected to A11; and for the 2716 EPROM's, pin 21 is held at five volts.

To control output of the $\overline{\text{RAMCS}}$ and $\overline{\text{ROMCS}}$ signals from the memory board, "jumpers" (some of which are actually 1N4148 diodes) are used.

Jumper JU3 gives the user the option of disabling the *ZX81's* internal RAM when the CMOS board is used as system/user RAM in the 16K–32K region. If you have only 1K installed in your *ZX81*, then a wire jumper JU3 should be inserted to tie $\overline{\text{RAMCS}}$ to five volts, as shown in Fig. 12,

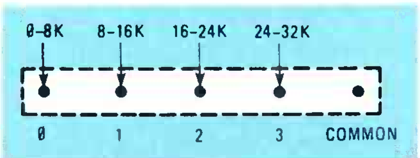

FIG. 9—JUMPER JU1 is used to determine which 8K block of addresses the RAM board will occupy. A jumper wire is inserted between the common pad and one of the other four pads.

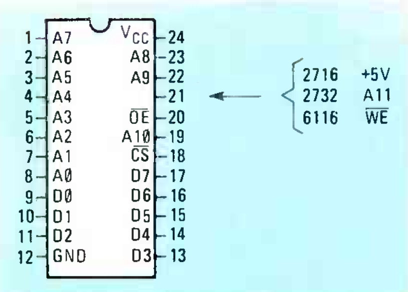

FIG. 10—PINOUTS OF THE MEMORY IC's are shown here. Only the function of pin 21 is different for the three different IC's discussed.

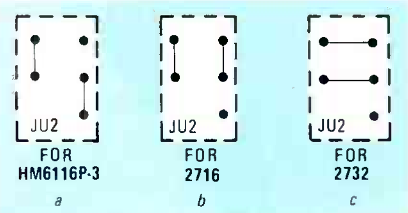

FIG. 11—JUMPER JU2 is used to select the proper pin connections for the different memory IC's.

and the socket for IC1 on the memory board should be used.

However, If you have a Timex/Sinclair *1000*, or if you have upgraded your *ZX81* to 2K by replacing the 2114 IC's with a 6116P memory IC, then position a diode in jumper JU3 as shown in Fig. 12 so that the internal memory will be disabled only when any location other than the first 2K (from 16K to 18K) is addressed. The socket for IC1 should then be left vacant.

If the board is used in the 8K to 16K slot (as system-transparent RAM), then a 1N4148 diode should be inserted for JU4. Then the ROMCS signal output from the CMOS RAM board will disable the system's 8K of ROM when any region other than the first 8K is addressed.

Using 2716 or 2732 EPROM's

If the board is to be fully populated with 2716 EPROM's, then resistors R2–R12, transistors Q1–Q5, diodes D1–D3, and the lithium cell should be omitted. Diode D3 should be replaced with a wire jumper, and wire jumpers should also be inserted to connect the collector and emitter pads of transistors Q2–Q5 together. Jumper JU2 should be positioned as shown in Fig. 11, and JU1 should be in position 1. Make similar modifications if 2732 EPROM's are to be used. The sockets for IC's 2 and 4 are used for the 2732 EPROM's, and jumpers JU2 are positioned as shown in Fig. 11.

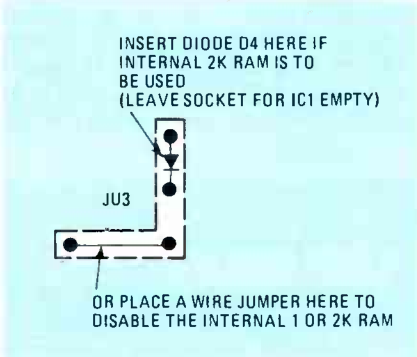

FIG. 12—JUMPER JU3 is used to disable the computer's internal RAM or to use its internal 2K RAM in place of IC1.

To use as system RAM

When the board is used for system/user RAM, the battery backup is unnecessary, and the same modifications described above for 2716 EPROM's can be made. However, if you intend to vary the use of the board, then it's best to follow the instructions for assigning the board to the 8K–16K region. Then, changing over to system RAM is done very simply by changing JU1 to position 2 and adding JU3 as shown in Fig. 12. *Note that if you use the board as system RAM, then you can use 2016 NMOS static RAM's in place of the more expensive CMOS IC's.*

Testing the memory

The completed board should look like the one shown in Figs. 13 and 14. But looks are not enough—now you have to test the board to see whether it works!

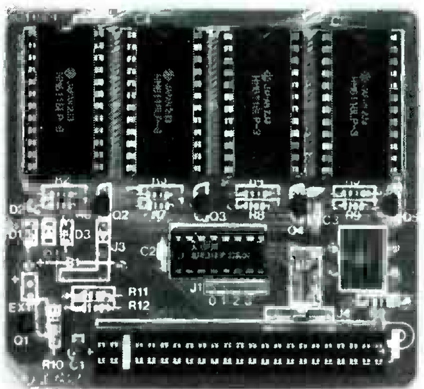

FIG. 13—THE COMPLETED BOARD. Note that jumper positions are labeled "J," not "JU".

If the CMOS RAM board is used in an 8K region between 16K and 24K, then the Timex/Sinclair system software can be used to test the memory. The top of system RAM is a variable, RAMTOP, that is stored in memory locations 16388 and 16389 (decimal). The command "PRINT (PEEK 16388 + 256*PEEK 16389)/1024 – 16; "K" " will print the size of system RAM—in this case 8K (in the absence of any other memory). (We should note here that the beginning and final quotes are ours and should not be typed in. That holds true whenever we mention a command in the text.)

If the CMOS RAM board is used in the 8K region from 8 to 16K, then a different procedure is required to test the memory. That's because the memory in that 8K block is not regarded by the Timex/Sinclair as available system memory—in fact, the system doesn't know that it's there at all! The previous PRINT command (that PEEK's the RAMTOP variable) will produce the same result with or without the CMOS RAM board in the 8K to 16K block.

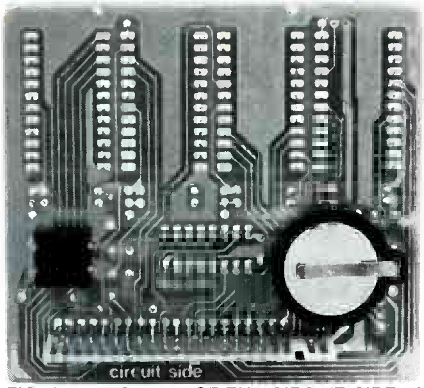

FIG. 14—THIS VIEW OF THE CIRCUIT SIDE of the RAM board shows the only two components mounted there.

Therefore, to test the board in the 8K–16K slot, you will have to use a different program. Before we discuss that program—which is partly written in machine code—we will first discuss a program that you will need to use to enter such a machine-code routine.

That program—the one that will allow you to enter a machine-code routine—is shown in Table 2, and should be entered as written and then RUN. When prompted by the "L" cursor, enter the starting address of the machine-code routine. When prompted the second time, enter the data for that address. The address will be incremented automatically, so at the next "L" prompt, simply enter the data for the next address (without entering the address itself), and so on. To stop, simply enter an "illegal" character (any letter). Check for any errors, and correct them by simply POKE-ing the correct data into the address ("POKE *address,data*").

TABLE 2

```
100  INPUT A
110  INPUT D
120  POKE A, D
130  SCROLL
140  PRINT A, D
150  LET A = A + 1
160  GOTO 110
```

Now we can return to the memory-test program, which is shown in Table 3. First enter the BASIC program shown there, and then enter the machine code using the program in Table 2. Because you want to use that program *before* you use the BASIC program in Table 3, you should *not* type "RUN" after you have entered the two BASIC programs. Instead, to enter the machine-code program, tell the computer to "GOTO 100," and *do not* hit "RUN" until after you have entered the machine code.

At this point, if all is well, the lithium cell can be placed in its holder. Slip it gently under the positive terminal, *positive side up*.

Write-protect switch

It is sometimes useful to be able to prevent writing over your nonvolatile memory—for example when testing a machine-language program for the first time. Jumper JU2, one of the OR gates in a 74LS32, and an external switch can be used as shown in Fig. 15 for write protection. It is also possible to protect and enable individual CMOS IC's in the same way.

Now that we have a working memory extension, it's time to look at some software that can be stored in it.

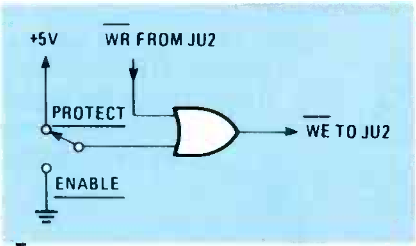

FIG. 15—WRITE PROTECTION can be easily added to the RAM board using the circuit shown here.

A sample display routine

The display file in the Timex/Sinclair *1000* does not occupy a fixed position. Instead, it moves around as the program length changes. If there is more than 3¼K of system/user RAM, then the graphics area of the display file normally consists of 704 characters (22 lines of 32 characters). In addition to those 704 characters, there is a code 118 at the beginning of the file, and a code 118 at the end of each line.

The routine in Table 4 can be used to store all of the characters in the display file in a predetermined memory location—in this example the area between 9000 and 9703 inclusive. The routine in Table 5 loads all of the data back into the display file, and the listing in Table 6 can be used to fill the stored display-file with a defined character that is POKE-d into memory-location 8236.

To experiment with the display routines, enter the machine code in Tables 4 through 6 into the corresponding memory locations. (Again, the BASIC program in Table 2 can be used to enter machine code quite quickly.)

Then enter the BASIC program shown in Table 7. That program fills the screen with a character (in this case the graphics character on the "T" key) and then dumps the display into the transparent region between 9000 and 9703. After you

TABLE 3

```
10 REM 12345678901234567890
20 PRINT "TRANSPARENT CMOS MEMORY";USR 16514/1024;" K"
30 STOP
```

Address	Data	Assembly language (Mnemonic)
16514	33 255 63	LD HL, (top of memory)
	1 0 0	LD BC, 00
16520	62 31	LD A, 31
	54 01	LD (HL), 01
	43	DEC HL
	188	CP H
	32	JNZ
	250	back 5 lines
	35	INC HL
	3	INC BC
16530	53	DEC (HL)
	40	JZ
	251	back 4 lines
	11	DEC BC
16534	201	RET

TABLE 4

Address	Data	Mnemonic
8192	42 12 64	LD HL (start of display file)
8195	17 40 35	LD DE (starting address of storage; 9000 decimal)
8198	62 22	LD A (number of lines in graphics area)
8200	35	INC HL
8201	1 32 0	LD BC (number of characters on a line)
8204	237 176	LDIR
8206	61	DEC A
8207	32	JNZ
8208	247	back 8 lines
8209	201	RETURN

TABLE 5

Address	Data	Mnemonic
8210	237 91 12 64	LD DE (start of display file)
8214	33 40 35	LD HL (storage location starting address; 9000 decimal)
8217	62 22	LD A (number of lines in graphics area)
8219	19	INC DE
8220	1 32 0	LD BC (number of characters on a line)
8223	237 176	LDIR
8225	61	DEC A
8226	32	JNZ
8227	247	back 8 lines
8228	201	RETURN

TABLE 6

Address	Data	Mnemonic
8229	33 40 35	
8232	1 192 2	LD BC (number of characters in display; 704)
8235	54	LD (HL) (code for character to be displayed)
8236	128	(other characters may be poked into this address)
8237	35	INC HL
8238	11	DEC BC
8239	120	LD A,B
8240	177	OR C
8241	32	JNZ
8242	248	back 7 lines
8243	201	RETURN

TABLE 7

```
10 FOR N = 1 TO 704
20 PRINT ▞
30 NEXT N
40 RAND USR 8192
```

TABLE 8

```
10 FOR N= 1 TO 63
20 POKE 8236,N
30 RAND USR 8229
   + USR 8210
40 NEXT N
```

NTS Electronics

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run the program, reset the computer or type "NEW" to clear the system. With the computer cleared and with more than 3¼K of memory, enter "RAND USR 8210." Your original display will reappear. If you don't have a RAM pack (and thus don't have the 3¼K of RAM) you must first expand the display file by filling the screen or by POKE-ing an artificially high value into the location for the variable RAMTOP. For example, without a RAM pack, first enter "POKE 16389,80" and then enter the command "RAND USR 8210."

Now try the program in Table 8. It fills the screen with all of the characters from 1 to 63 in the character set by using the routines in Tables 5 and 6. It will give you an idea of how fast you can change the entire display. One advantage of having a secondary-display file in memory is that it lets you make changes to the file over a period of time and then to display all of the changes simultaneously on the screen.

Saving machine-code routines

Occasionally it is possible to lose the contents of the nonvolatile memory. That can happen due to a fault in a machine-language program under development, if the battery fails, or because of a transient in the power supply—usually during power-up or power-down. (It might be a good idea to hold down the RESET switch on the 8K memory board when switching the computer off—at least until you determine that it's safe not to—because it protects the nonvolatile memory from being overwritten.) In any event, it is advisable to save the contents of the nonvolatile memory on tape as a backup. Re-entering machine code by hand can be extremely tiresome and frustrating.

The SAVE command does not save any programs that are stored in the transparent region, so the contents of the 8K–16K region must be moved up into the system/user RAM and then SAVE-d. The only restriction to the following procedure is to make sure that the machine code contains no code 118 (decimal). That is because the 118 is recognized by the system as the end of a statement. Make note of any 118's and replace them temporarily with zeros.

Next, enter the program in Table 9. Then enter in the REM statement of line 10 the machine code of Table 10. If you use a BASIC program like the one in Table 2 to enter the machine code, remember to delete it. Enter "RUN." When prompted, enter the amount of memory whose contents you want to save (*n*)—usually 2048 (2K) or 8192 (8K). The program takes less than 1 second for 8K. When you now list the program you will see that the REM statement on line 20 contains *n* asterisks.

The next step is to delete lines 10 through 18 and enter a REM statement with 24 characters as line 10. Then enter the machine code in Table 11. Those routines assume that the size of the block to be transferred is 2K. For transfers of 8K, change lines 16522 and 16534 to "32."

You can use a BASIC program to enter the machine code (for example at line 100) but *do not* attempt to delete or insert any line immediately following the REM statement on line 20.

You now have a program consisting of two REM statements. The REM statement on line 10 should now contain the machine code from Table 11. The REM statement on line 20 should contain either 2048 or 8192 asterisks. Save the program on tape for future memory dumps.

To transfer the specified block of system-transparent memory up into the system RAM (so that you can save it), enter "RAND USR 16514." Then SAVE "NAME" on tape. To reload the routines into the 8K–16K region, reload from the tape as normal, enter "RAND USR 16526" and then enter "NEW" to clear the system. *Don't forget* to re-POKE any original 118's that you replaced with zeros.

Merging programs

Merging programs is not impossible with the Timex or *ZX81* system, but it is tedious. It requires reserving memory outside the BASIC system by POKE-ing a new value for the variable RAMTOP, transferring one program into that reserved area, loading the second program from tape, and then transferring the first program back into the computer's BASIC system.

TABLE 9

```
10 REM 123456789012345678
   90123456789012345
12 INPUT N
14 POKE 16516, INT (N/256)
16 POKE 16515, N-256*INT (N/
   256)
18 RAND USR 16514
20 REM
```

TABLE 10

Address	Data	Mnemonic
16514	1 0 0	LD BC (size of REM statement)
16517	3	INC BC
	3	INC BC (add 2 for REM and CODE 118)
16519	42 12 64	LD HL (start of display file)
16522	43	DEC HL
	43	DEC HL
	43	DEC HL
	43	DEC HL (point to size of REM statement)
16526	113	LD (HL), C
	35	INC HL
	112	LD (HL), B (load size of REM statement)
	35	INC HL
16530	35	INC HL (point to address for new character)
	11	DEC BC (decrease BC to number of characters)
	11	DEC BC (to be entered)
	197	PUSH BC
	229	PUSH HL
16535	205 158 9	CALL (move everything up one to make room for a new character)
16538	225	POP HL
16339	193	POP BC
16540	54 23	LD (HL), (character *)
16542	35	INC HL
	11	DEC BC
	120	LD A, B
	177	OR C
	32	JNZ
	248	(back 7 lines)
16548	201	RETURN

TABLE 11

Address	Data	Mnemonic
16514	33 0 32	LD HL (start of transparent RAM; 8192)
16517	17 160 64	LD DE (start of area in REM statement; 16544)
16520	1 0 8	LB BC (size of block to be transferred; 2048)
16523	237 176	LDIR
16525	201	RETURN
16526	33 160 64	LD HL (start of area in REM statement; 16544)
16529	17 0 32	LD DE (start of transparent RAM; 8192)
16532	1 0 8	LB BC (size of block to be transferred; 2048)
16535	237 176	LDIR
16537	201	RETURN

The CMOS RAM board allows you to store and merge programs or data quite easily—using machine-language routines resident in the DMOS memory. (You'll have to enter the two machine-code programs in Tables 12 and 13.)

The routine in Table 12 is used to dump a program from the BASIC system to the CMOS RAM. The contents of all memory (both programs and variables) from the start of user memory (16509) to the start of the display file is dumped. To check the size of the program (to make sure that it will fit in the CMOS RAM) before executing the routine, use the command "PRINT (PEEK 16396+256*PEEK 16397 − 16509)/1024; "K"." The number of bytes is stored by the routine in location 9000 and 9001 and the program and data are stored starting at location 9003 (after a code 118 at location 9002). Those locations can be changed if you wish. You can also modify the routine to dump only a portion of the user memory (for example, just the program or perhaps just the variables). The command "PRINT USR 8244" will execute the dump and respond with a 0 upon completion.

After storing one program in the CMOS RAM, the system can be cleared and a second program loaded from tape. Make all of the line numbers in the second program loaded from tape less than the lowest line number in the first BASIC program. Line numbers from the stored program should not be duplicated—the BASIC program in Table 14 can be used for renumbering. (It is also a good example of a program that might be useful to store in the system-transparent RAM.) Enter the command "IF USR 8269 = 0 THEN STOP." That is necessary to prevent the execution of the program after reloading.

The merge routine can also be used to store a BASIC program in the CMOS RAM. However, you must remember to enter a line like "1 REM" before moving the stored program back up to the system RAM. (You can delete it once it is back in the user memory.)

TABLE 12

Address	Data	Mnemonic
8244	17 125 64	LD DE (start of program area; 16509)
8247	42 12 64	LD HL (start of display file)
8250	183	OR A (clear carry flag)
8251	237 82	SBC HL, DE
8253	68 77	LD B, H and LD C, L
8255	33 40 35	LD HL (start of storage area; 9000)
8258	113	LD (HL), C
8259	35	INC HL
8260	112	LD (HL), B
8261	35	INC HL
8262	54 118	LD (HL), (code 118)
8264	35	INC HL
8265	235	EX DE, HL
8266	237 176	LDIR
8268	201	RETURN

TABLE 13

Address	Data	Mnemonic
8269	237 75 40 35	LD BC (size of progam)
8273	42 12 64	LD HL (start of display file)
8276	43	DEC HL
8277	197 229	PUSH BC; PUSH HL
8279	205 158 9	CALL routine at 2462 decimal
8282	209 193	POP DE; POP BC (note exchange)
8284	33 42 35	LD HL (start of storage area; 9002)
8287	237 176	LDIR
8289	201	RETURN

TABLE 14

```
9900 REM LINE RENUMBER
9905 PRINT "NOTE GOTO AND GOSUB ADDRESSES"
9910 PRINT
9915 PRINT "ENTER NUMBER FIRST LINE WILL BE"
9920 INPUT F
9925 PRINT
9930 PRINT "ENTER LINE INCREMENT"
9935 INPUT I
9940 PRINT
9945 LET N = 16509
9950 POKE N, INT (F/256)
9955 POKE N+1, F − 256*INT (F/256)
9960 REM POINT TO NEXT LINE
9965 LET N = N + PEEK (N+2) + 256*PEEK (N+3) + 4
9970 IF 256*PEEK N + PEEK (N+1) = 9900 THEN GOTO 9990
9975 LET F= F+I
9980 GOTO 9950
9990 PRINT "LAST LINE IS ";F;
```

TABLE 15

Address	Date	Mnemonic	
8297	33 0 0	LD HL, 00	Clear HL
8300	57	ADD HL, SP	Move SP to HL
8301	237 91 28 64	LD DE (Stkend)	
8305	237 82	SBC HL, DE	Carry flag already cleared
8307	68 77	LD B, H and LD C, L	
8309	201	RETURN	

Free space

The amount of free space in memory is the "spare" memory between the top of the calculator stack and the bottom of the machine stack. (See page 128 of your manual.) The top of the calculator stack is stored as the system variable STKEND. The bottom of the machine stack is always pointed to by the Z80 register SP (stack pointer). The routine in Table 15 simply subtracts one from the other. To determine the amount of free memory in your system, enter the machine-code program in Table 15 and then enter the command "PRINT USR 8297." The result that you will see will be the number of free bytes.

As suggested in the introduction, there are many other routines like these that you can devise to expand the versatility of the Sinclair BASIC system. You might consider only partially populating the board with one HM6116P CMOS memory IC initially—even 2K of system-transparent memory is extremely useful. We've discussed several useful programs that can be stored in the nonvolatile RAM. But as you can see, the software does not occupy much of the space that is available.

Before we finish up, a word of caution: If you use this memory expansion along with the 16K RAM pack, be sure to use the programs we discussed earlier to save the contents of the 8K system-transparent region. As you are probably aware, the poor design of the Timex RAM pack connector can be the cause of frequent system crashes. While any crash is annoying, it is even worse in this case. It's bad enough to lose BASIC that is stored in the 16K RAM, but there is nothing more frustrating than having 8K of machine code that you stored in nonvolatile RAM overwritten by garbage. **R-E**

Digital TEMPERATURE GAUGE

FRED L. YOUNG, SR. and
FRED L. YOUNG, JR.

For Your CAR

This is the time of year when automobile engines start to overheat and leave angry motorists stranded by the roadside. This digital temperature gauge for your car will see to it that you're not one of them.

LAST MONTH WE DESCRIBED A DIGITAL voltmeter for your car (or other vehicle) based on the CA3161E and CA3162E IC's. This month we'll use the same IC's to build a digital thermometer that can be used to monitor your car's engine temperature, or in any of many other temperature-measurement applications.

The thermometer's circuit is similar in many respects to that of the voltmeter, and we suggest that you refer to the July 1983 issue of **Radio-Electronics** for a complete description of its operation.

A schematic of the thermometer is shown in Fig. 1. In essence, IC2, a CA3162E dual-slope, dual-rate analog-to-digital converter, translates an incoming analog signal (we'll discuss its source in a moment) into a digital BCD (*B*inary-*C*oded *D*ecimal) number. Then, IC2, a CA3161E, converts that number into signals that cause the segments of DISP1–DISP3 to light up in certain patterns to form numbers. The CA3161E is known as a BCD–7-segment decoder/driver. The power for the entire circuit is derived from IC1, a 340T-5 five-volt regulator.

The temperature probe itself is ridiculously simple—it's just a 1N4002 or 1N914 (1N4148) diode at the end of a piece of coaxial cable. Diodes (and other semiconductor junction-devices) have an unusual—but very useful—characteristic: the forward voltage across them drops as the temperature increases. In the case of diodes, the rate of change is about two millivolts per degree Fahrenheit. The rate of change is linear over a respectable temperature range, and this temperature gauge is accurate from well below zero up to 250°. All we have to do is apply a voltage to the diode and measure the forward voltage, which is then converted by the rest of the circuit into a temperature reading.

(One word of caution, though: If you ever have to change probes, the gauge will have to be recalibrated. While any diode you use will have the same rate of change, each will have a different "base point" from which it is referenced, and recalibration will be necessary to take that into account.)

Construction

Before you start mounting parts on the board, you should prepare the piece of red plastic that will protect the board and display. The plastic should be ⅛-inch thick and just a little larger in area than the circuit board. Place the plastic under the board and, with a sharp point, mark the position of the four mounting holes in the board on the plastic. Then, make a hole at each position for the 4-40 mounting hardware (drill a small pilot hole, and then carefully enlarge it; that way you won't crack the plastic). Temporarily set the plastic aside.

A foil pattern for the digital temperature-gauge circuit board is shown in Fig. 2. If you would rather purchase a ready-to-use board than make your own, see the Parts List for the supplier.

Techniques for PC-board construction were discussed in detail in the article the digital voltmeter, and if this is your first project, you will gain a lot by reading it before you start building.

Figure 3 shows a parts-placement diagram for the board. It's advisable to use sockets for IC2 and IC3; install them first, then the resistors, followed by the capacitors. Do not install IC2 or IC3 until after your initial board-checkout. When you mount the three 7-segment LED's, DISP1–DISP3, solder only two pins at opposite corners at first. That will permit you to adjust their positions fairly easily if you don't put them in straight the first time. Be sure that the ridges at the tops of the LED's face the way shown in the diagram. When you install jack J1, you may have to enlarge the hole in the board so it can fit through. Use a lockwasher on the foil side of board both to keep the jack

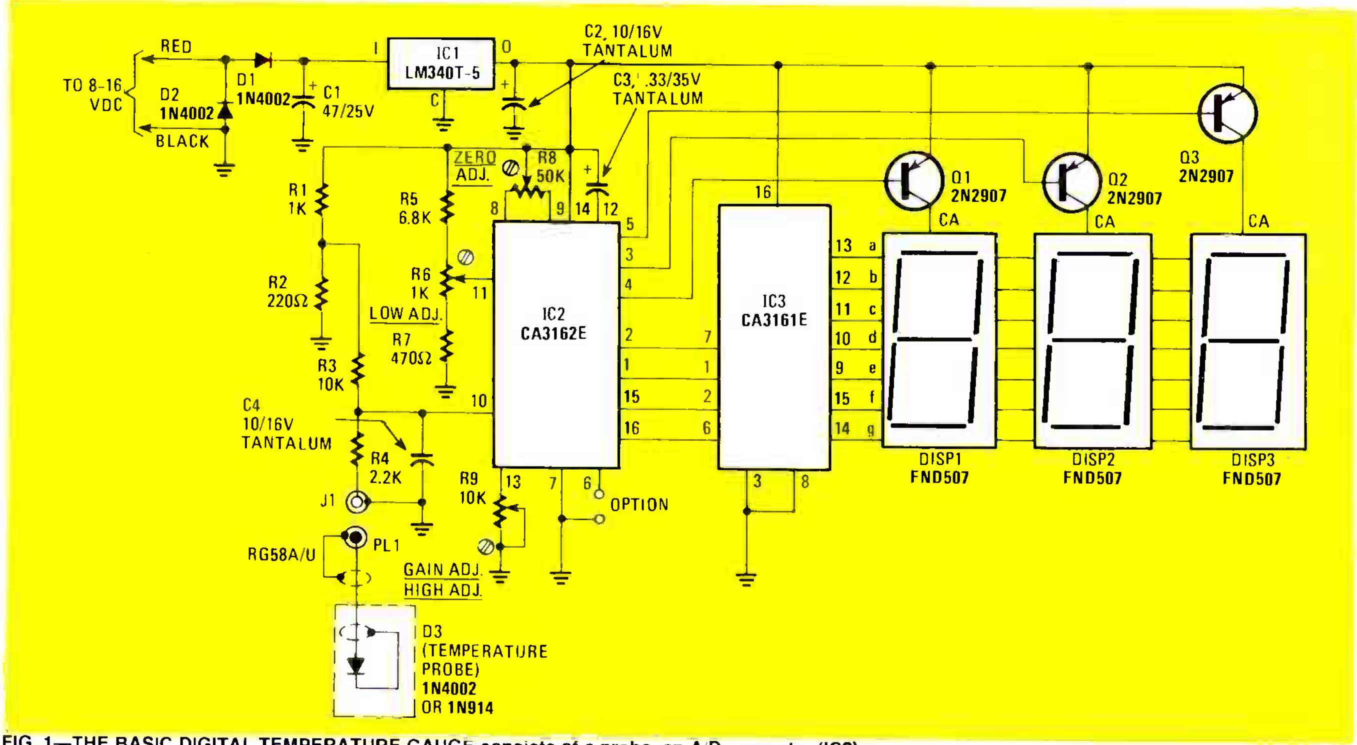

FIG. 1—THE BASIC DIGITAL TEMPERATURE GAUGE consists of a probe, an A/D converter (IC2), a 7-segment LED decoder/driver (IC3) and, of course, the display LED's themselves.

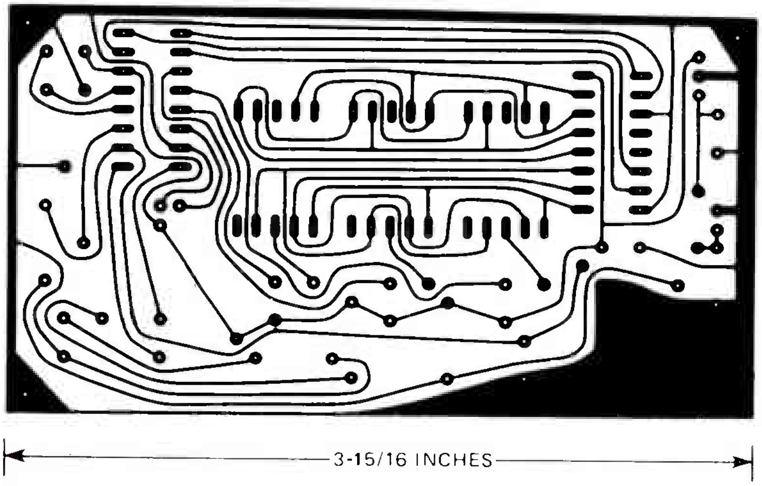

FIG. 2—YOU CAN ETCH this single-sided PC board yourself, or buy it from the source indicated in the Parts List.

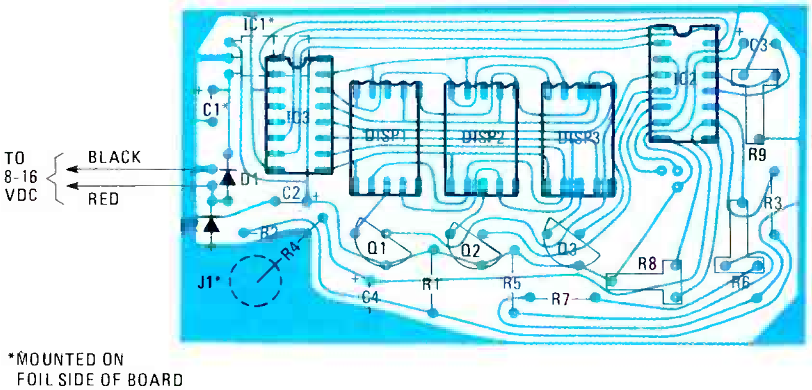

FIG. 3—TWO COMPONENTS (indicated by dashed lines) mount on the foil-side of the board; they are IC1 and C1.

from working loose and to make sure that it makes good electrical contact with the foil. Note that the "business end" of the jack is on the foil side of the board. Connect resistor R4 from the center lug of the jack to the board.

The last two components to be installed (except for the two IC's) are IC1 and C1. They should be mounted on the *foil side* of the board, as shown in Fig. 4. That is done to keep the total height of the component-side of the board down. Make sure that the regulator is arched over backward as shown, but that its case does not contact the board. (A piece of electrical tape on the board beneath the regulator to act as insulation will make sure of that!)

Finally, connect three-foot lengths of

FIG. 4—BEND IC1 OVER BACKWARD on the bottom of the board as shown.

red and black wire to the points on the board indicated in Fig. 3; they will be used to provide power to the circuit.

Before installing IC2 and IC3, apply power (10–14 volts DC) to the board through the red and black wires and measure the voltages at the sockets. You should read five volts at pin 14 of the IC2 socket, and at pin 16 of the IC3 one. Pins 7 and 8, respectively, of those sockets, should be at ground potential. If the voltages are correct, you can disconnect the power and install the two IC's in their sockets. Make sure that they are oriented as shown in Fig. 5.

If everything checks out, you can install the red plastic filter over the face of the board. You can either use ¾-inch spacers or make your own using 1½-inch 4-40 bolts and nuts. If you use the nut-and-bolt method, insert bolts through the

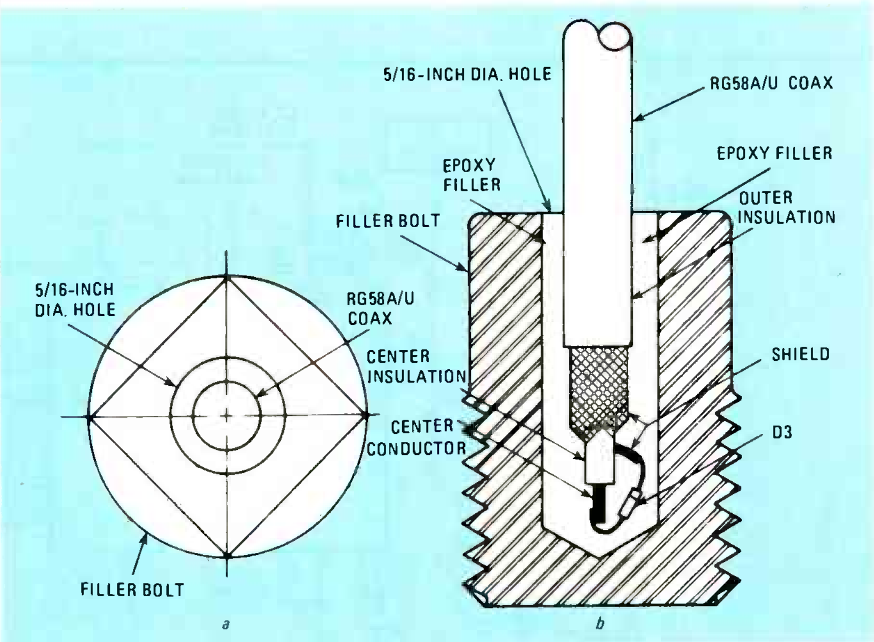

FIG. 6—DIAGRAMS FOR THE DRILLED FILLER-BOLT method. Read the instructions carefully before you start work.

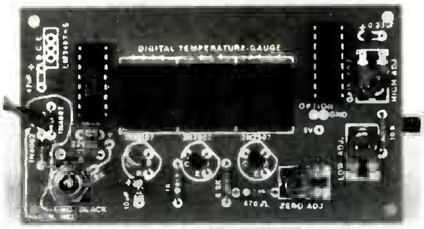

FIG. 5—THE COMPLETED circuit board should look like this. Note the mounting of J1 and how R4 is connected to it.

plastic, and secure them with nuts on the reverse side. Then screw a second nut onto each bolt, allowing ¾ inch of space between it and the first one. Insert the bolted-plastic assembly into the holes in the PC board, and secure it with four more nuts.

With that done, you are ready to build the temperature probe and calibrate unit.

Probe construction

The temperature probe, D3, can be a 1N4002, 1N914, or 1N4148 diode. Keeping the leads short, attach it to one end of a length of RG58A/U coax as shown in Fig. 6. The coax should be long enough to reach from the probe location to the point where the display will be mounted, and should have enough slack to allow it to be routed around areas of the engine compartment that get particularly hot, like the exhaust manifold, and away from the spark-plug wires.

The cathode (banded) end of the diode should be soldered to the shield of the coax, and the anode to the center conductor. Make sure that the shield of the coax does not touch the center conductor (twisting and tinning the end of the braid will help avoid that). The other end of the coax—the end that will be connected to the circuit board—should receive an RCA-type plug, PL1.

To avoid errors and contamination during the calibration, the probe assembly must be insulated. The easiest way to do this is to use epoxy to coat the diode and its leads *and* the end of the coax. That will prevent any current leakage when the probe is immersed in the water baths used for calibration, and will keep water from entering the cable and possibly damaging it. If you're extravagant, you can dip the assembly into a container of epoxy so it is coated as far as about half an inch up the outer insulation of the cable; otherwise smear the cement on liberally, making sure that the end of the coax gets sealed. Allow the epoxy to cure for 24 hours before you go on to the calibration procedure.

Calibration

Before the probe is installed in its permanent location, the meter circuit must be calibrated. *Without the probe connected*, apply 10–14 volts to the circuit board through the red (+) and black (−) wires; 13.8 volts is recommended. Temporarily ground pins 10 and 11 of IC2 and adjust R8 (ZERO ADJUST) until the display reads "000." Then unground the two IC pins.

Next, connect the probe cable to J1, and center the wiper arms on R6 (LOW ADJUST) and R9 (HIGH ADJUST). Immerse the probe (insulated with epoxy as described above) into a plain solution of ice and water—the water should come from ice as it melts so that it is as close to 32° F. as it can be. Wait until the reading on the display stabilizes—that should take about five minutes—and then adjust R6 until it reads "032."

Set the HIGH ADJUST (GAIN ADJUST) potentiometer, R9, by placing the probe in boiling water—again, wait about five minutes until the display stabilizes—and adjusting the control until you read "212."

The adjustments are rather critical, and you should go through the low-high calibration procedures several times to eliminate as much error as you can.

Mounting the probe

The simplest way to measure the engine-block temperature is to measure it at the air-intake manifold. Note that that does not mean that you will be measuring the temperature of the air being fed to the engine—rather, you will be measuring the temperature of the manifold itself, which, because it is attached to it, will be about the same as that of the engine block.

There are three ways that the probe can be attached to the manifold: two involve filler-bolts or filler-bolt holes, and the last uses external connection. The first two give more accurate readings, but involve more work than the third. If you have difficulties with the filler-bolt methods, and are willing to put up with somewhat less accuracy (on the order of several degrees), then the external-connection method can be used. Study all the methods before you make your decision.

Drilled filler-bolt method

A filler bolt is a "dummy" bolt used to plug a hole intended for future or optional use. There may be several in the intake manifold (the part that distributes the air/gas mixture to the engine cylinders) of your car. Before you can install the temperature probe in one of the filler bolts, you first have to remove it; that isn't always easy. Try all the unused filler bolts until you find one that unscrews easily. Be careful—especially if you're using a long-handled socket wrench—not to apply too much force. Doing so can shear the bolt, strip its threads, or it can even crack the manifold.

PARTS LIST

All resistors ¼ watt, 5% unless otherwise indicated
R1—1000 ohms
R2—220 ohms
R3—10,000 ohms
R4—2200 ohms
R5—6800 ohms
R6—1000 ohms, trimmer potentiometer
R7—470 ohms
R8—50,000 ohms, trimmer potentiometer
R9—10,000 ohms, trimmer potentiometer
Capacitors
C1—47 µF, 25 volts, electrolytic
C2, C4—10 µF, 16 volts, tantalum or electrolytic
C3—0.33 µF, 35 volts, tantalum
Semiconductors
IC1—LM340T-5 (7805) positive 5-volt regulator
IC2—CA3162 dual-slope, dual-speed, A/D converter
IC3—CA3161 BCD-7-segment multiplexing decoder/driver
DISP1–DISP3—FND507 (FND510) 0.5-inch 7-segment LED, common anode
D1, D2—1N4002
D3—1N4002 or 1N914 (1N4148)
J1—RCA phono jack
PL1—RCA phono plug
Miscellaneous: PC board, RG58A/U coax, epoxy, etc.

The following are available from Digital World, PO Box 5508, Augusta, GA 30906: temperature gauge PC-board only, $7.50; temperature gauge PC board with schematic & diagrams, $8.50; IC2 and IC3, $12.00; PC board and IC1–IC3, $20.00; kit of all parts including coax (does not include plastic, solder or chassis), $32.50. The first two items (PC board and PC board with schematic & diagrams) are postpaid within the continental U.S.; all other items add $2.00 shipping & handling. APO, FPO, and other U.S. add $3.00. Canadians add $3.00 (please use U.S.-dollar money order). All others write for prices and shipping costs. Please allow 4 to 6 weeks for delivery.

Sometimes, applying some penetrating oil and allowing it to work overnight will allow you to remove a frozen- or rusted-in filler bolt with several light taps and the *gentle* application of force. If none of the bolts can be removed conveniently, you'll have to connect the probe externally, as described below.

With a bolt removed, use a drill press to drill a ⁵⁄₁₆-inch hole in it from the outside to the inside (naturally). Refer again to Fig. 6 (The completed filler-bolt assembly is shown in Fig. 7). The hole should be deep enough to hold the diode and a "dab" of retaining epoxy, but must stop ⅛-inch short of the end of the bolt. If you drill through the end, you'll have to start over with another bolt; it might be a good idea for you to practice on a non-essential

FIG. 7—COMPLETED FILLER-BOLT probe with cable attached.

piece of material similar to the bolt first, to get a "feel" for the procedure.

Mix a batch of quick-setting epoxy and fill the hole half-full with it. You'll have to work fairly quickly—after five or ten minutes the epoxy starts to set and becomes difficult to work with.

Then insert the diode assembly into the epoxy in the hole in the bolt until it makes contact with the bottom of the bolt. Now slowly and gently pull on the coax to lift the diode until it is no longer in contact with the bolt. That's just to make sure that the probe will not short out to the bolt even if there's a defect in the probe's epoxy "insulation." A change in position of about ⅛-inch should be enough. Stop! Hold the probe in that position for at least ten minutes, until the epoxy has set enough to be firm.

When the epoxy has started to set, any excess that may have been forced out of the hole can be removed carefully. Allow the epoxy to cure for 24 hours at a temperature between 60° and 90°F. Finally, after the epoxy has cured, check the cable with an ohmmeter to make certain that the probe has not shorted to the bolt. Reinsert the bolt in the manifold, and proceed to the "Installation" section.

Filler-bolt hole method

If you are unable to remove any of the filler bolts, the probe can be inserted in an unused filler-bolt hole in the intake manifold. The hole should be cleaned thoroughly and any accumulated oil or rust removed—epoxy needs a clean surface to bond to and any foreign matter could prevent a solid adhesion and result in the probe's working loose and coming out.

Make sure the engine is cool—not only could you get burned otherwise, but some epoxies are flammable, and could catch fire if applied to a hot surface. The angle of the hole may present a problem in getting the epoxy in and keeping it in; it may be necessary to build up a shelf of wax around the lower rim of the hole to ensure that enough epoxy is retained to encapsulate the probe and to grip the probe-end of the coax securely.

Mix the epoxy and force an amount into the bottom of the hole by using a wooden dowel of about the same diameter as the hole. The hole should be filled completely to make certain that there's enough cement to hold the probe and cable. The rest of the procedure is essentially the same as that given for the "drilled filler-bolt" method: insert the probe so it's about ⅛ inch from the bottom of the hole and allow the epoxy to set and cure while using an ohmmeter to make sure that the probe doesn't short to the side or bottom of the hole. After the epoxy has cured, proceed to the "Installation" section.

External probe-attachment

If neither of the first two methods will work for you, then the probe can be epoxied to the outside of the intake manifold.

Clean the selected surface well so that the epoxy will bond firmly to it and mix some epoxy (do not mix it all; you'll need more shortly). Apply a coating about ⅛-inch thick to an area about 1½-inches square to form a mounting base. Let the cement harden for 20-30 minutes and then mix a second batch of epoxy. Tape the probe/coax assembly in place and use the second batch of epoxy to encapsulate it. Use your ohmmeter to make sure that the probe is not shorting out to the surface on which it's mounted. After the epoxy has cured, you may proceed to the "Installation" section.

Installation

The temperature gauge can be installed either in the dashboard of your car, or in a separate enclosure. The cable from the probe can be routed through a hole in the firewall; you can later seal the hole around the cable to keep dust, water, and fumes out of the car. Remember to plug the probe cable into the board—otherwise you'll go crazy trying to figure out why the gauge doesn't work.

A good place to obtain power for the gauge is from the same fuse terminal to which your car's radio is connected. The red wire should go there, and the black wire to the car's body (so there is a return to the negative post of the battery).

If you find that the operation of the gauge creates interference on your AM radio, there are several "fixes" you can try to get rid of it.

First, try connecting the gauge to a power source other than the radio's fuse. You can also try locating the gauge a distance away from the radio itself. Finally, if the circuit board is not in an enclosure, add one, made of metal and grounded; this solution is usually quite effective.

A last word of advice: Don't disconnect your present temperature gauge or warning light—it's always a good idea to have a backup!

The use of this gauge is not limited to your car, of course. You can use it to monitor the temperature inside your freezer, for example, or just as an electronic indoor or outdoor thermometer. However you use it, you'll find that its speed, accuracy, and readability make it a valuable instrument to have. **R-E**

NEW IDEAS

Ultrasonic pest repeller

PEST CONTROL HAS BEEN BROUGHT INTO the electronic age by the introduction of the ultrasonic insect repeller. That device is said to repel—not kill—unwanted flying and crawling pests by emitting ultrasonic sound waves that sweep between 65,000 and 25,000 hertz. The sound is apparently rather irritating to them.

I went shopping for one of those "miracle" devices but *I* was repelled—by their prices, which ranged from $49 to $69. Therefore I decided to design and build my own. The circuit I came up with, which should cost about $20 to build, is shown in Fig. 1.

The repeller is designed around a 556 dual timer. One half is operated as an astable multivibrator with an adjustable frequency of 1 to 3 Hz. The second half is also operated as an astable multivibrator but with a fixed free running frequency around 45,000 Hz. The 25–65 kHz sweep is accomplished by coupling the voltage across C2 (the timing capacitor for the first half of the 556) via Q1 to the control voltage terminal (pin 11) of the second half of the 556.

Transistor Q1 serves two purposes: it isolates the timing circuit of the first half of the 556 from pin 11 and it controls an LED indicator. When the first half is operating, timing capacitor C2 continually charges and discharges between ⅓ and ⅔ the supply voltage. Because the base of Q1 is tied to C2, the voltage across C2 will affect the operation of Q1. The voltage at the base of Q1 causes it to conduct, thereby turning on the LED and lowering the control voltage that is applied to pin 11. The lower control voltage causes the output frequency of that half of the timer to increase to around 65 kHz. As C2 is charged toward ⅔ volt, Q1 conducts less and less. That causes the intensity of the LED to decrease and the control voltage applied to pin 11 to increase, because Q1's emitter approaches +V. The increasing control voltage causes the output frequency to decrease from 65 kHz to 25 kHz. That sweep will take from 1 to ⅓ second depending on the setting of R1. Theory has it that periodic adjustment of the sweep rate will prevent the pests from developing an immunity to the sound.

The device that radiates the ultrasonic sound is a piezo tweeter. Radio Shack sells several models ranging in price from $9 to $15.

Because the output of the repeller is above the range of human hearing, it is difficult to determine whether it is operating properly. If S1 is closed, though, the output frequency is lowered so that it can be heard. The output of the piezo tweeter is intense so, if you get tired of the repeller, you can switch C4 permanently into the circuit and turn the repeller into one heck of an alarm.—*David L. Holmes*

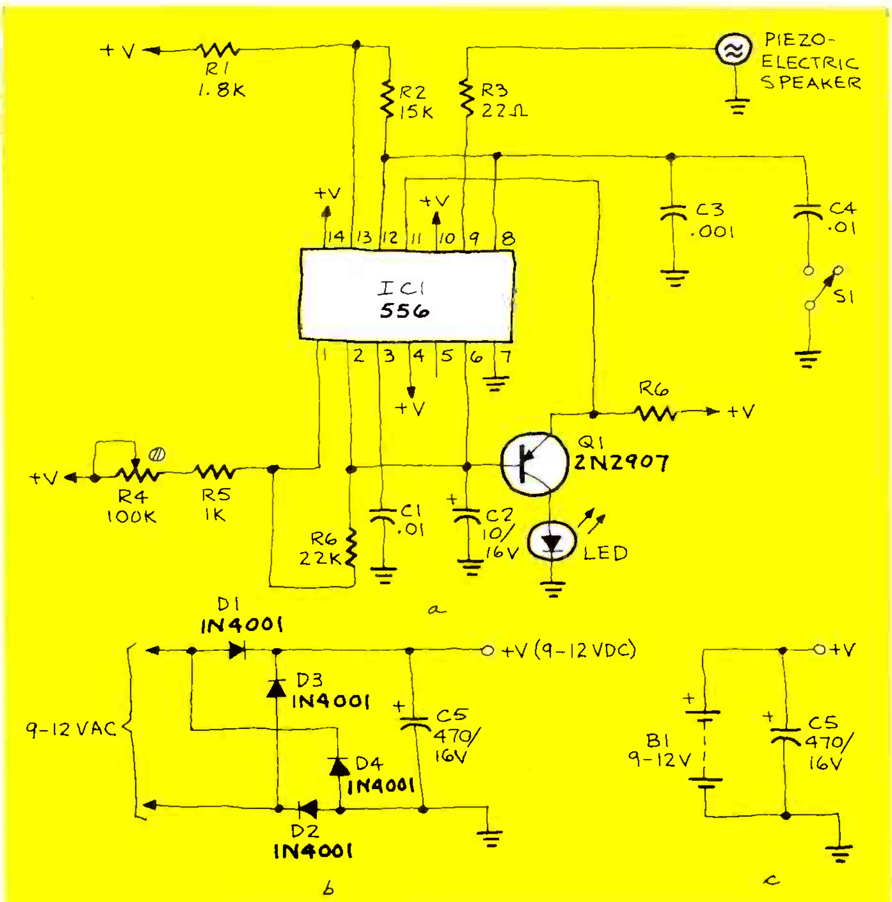

FIG. 1

NEW IDEAS

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

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The Super Fone is less than 1" thick. The base unit has a built-in speaker phone, a fully independent intercom and is 110 volt-220 volt switchable.

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1. The range is limited to 600 to 700 feet.
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The SuperFone 650 uses state-of-the-art electronics to bring you **the ultimate cordless phone.** Sound quality is superb — and it stays superb, 1500 feet or more from the base station. That's **more than twice the distance** of standard cordless phones.

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No other phone can interfere. No other unit can share the signal. No one else can hear or speak on your carrier-wave.

Enormous Range

We say the SuperFone 650 has a range of 1500 feet.

Notice we didn't say "up to" or "as far as" 1500 feet. There's no hedging, because this seems to be the **minimum,** not the maximum range.

Users report 1800 and 2000 feet. That's nearly half a mile. SuperFone 650 is a radiophone, not a toy, and that's why its signal doesn't break up or start hissing or crackling when you get half a block away.

You can tell when you heft it. It's a Little Giant. You can feel the power inside. What a marvel of electronic engineering it is! And it's tough, too. It fits into your shirt pocket, and you can bounce it around all day without damaging it.

Speakerphone, Intercom — Everything!

SuperFone 650 is The Everything Phone. Anything any phone can do, it can do.

First, the base station is a speaker phone. Touch a button and you can have a hands-free conference conversation in the room in which the base station sits.

Next, it's an intercom. You can page the handset from the base unit and have a private conversation. You have a **true wireless intercom,** not just a signal.

Third, you have a privacy button. Push that button and you'll still be able to hear anything the other party says, but he or she won't be able to hear you until you take the button off "hold."

Fourth, you have an automatic redial. Touch the key and the SuperFone will redial the last complete number.

What else? A **security switch** which makes it impossible for anyone to call out on the remote phone, without changing the ability to receive calls. A **volume control** for the speaker on the base unit. A **call button** to page the base from the cordless phone. THIS PHONE HAS EVERYTHING!

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Plug your SuperFone 650 into any wall AC outlet. Push its standard modular terminal into the telephone plug. You're in business.

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The SuperFone 650 is yours for **$249.95** in regular pulse-dial version, **$269.95** in Touch Tone®. If you want the SuperAntenna with it, giving you a range of a mile — or even more — you can have **both** for **$319.95** (rotary pulse) or **$339.95** (Touch Tone). Or you can get the SuperAntenna alone for **$79.95.**

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Use the SuperFone 650 (or any electronic instrument you acquire from us) for up to 30 days. If for any reason you decide not to keep it, return it for a 100% refund.

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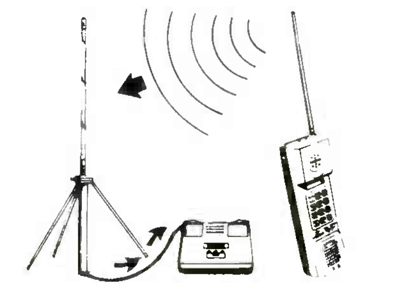

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NEW HORIZONS

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THE DRAWING BOARD

Finishing up about regulators

ROBERT GROSSBLATT

AS YOU'RE PROBABLY AWARE BY NOW, there's a lot more to consider when you're building a power supply than how to get a battery out of a blister pack. Over the last few months we've gone through the design considerations necessary to build a voltage regulator complete with all sorts of bells and whistles. Before we wrap up this project, be aware that we've just barely scratched the surface. There are lots of different sorts of power supplies and we've been looking at only one particular kind. There are design engineers who do nothing else in their professional lives but design power supplies. (That may strike you as being a bit boring but it certainly gives you an idea of the size of the subject.)

Where's the surprise?

Figure 1 is the full schematic of the regulator circuit we've designed. The values for all the components are shown, and if you look closely you'll see that we've added something to the short-circuit protection we discussed last month. We've put in a switch, S1, and broken R_s into two parts. The reason that was done is the surprise I promised.

I told you that there was a way around trying to locate a 0.13 ohm resistor. You probably realized that we would parallel a few resistors to get the value we wanted and that's exactly what I did. When we close S1 we put the two resistors in parallel and arrive at a value of 0.135 ohms—nothing really surprising about that. Opening S1 puts only one of the resistors in the line and lets us change the trip point of Q2 to two amps. We can now switch-select the short circuit trip-point to be either 2.4 amps or 4.8 amps. The real treat comes when we do the arithmetic necessary to calculate the wattage we need for the resistors.

Let's assume that we have the full value for R_s. We saw that it takes a 0.65 volt drop across the emitter-base junction of Q2 to make it conduct. The short circuit trip-point would be: $I = E/R = .65/.135 = 4.82$ amps.

That's pretty close to our original target of 5 amps. Now let's calculate the wattage we need for R_s: $P = I^2R = (4.82)^2(.135) = 3.14$ watts.

In the interest of safety, and with proper respect for Murphy's law, let's call it 4 watts. This makes R_s a pretty hefty resistor, and probably not too easy to find. It is easy however, to find a 0.27-ohm, 2-watt resistor, so we'll put two of those in parallel. Since the wattage adds when resistors are in parallel (do you know why?) we have 0.135 ohms at 4 watts when S1 is closed and 0.27 ohms at 2 watts when S1 is open. If you want to verify the calculations for the circuit with S1 open, follow the format I've just used. It's satisfying to see the numbers work out so neatly.

TABLE 1

R_S	$R_S + R_B$	I_{R_B} at Q1 turn-on	P_{R_B}
0.135Ω	2.135Ω	305 mA	0.185 watts
.27Ω	2.270Ω	286 mA	0.163 watts

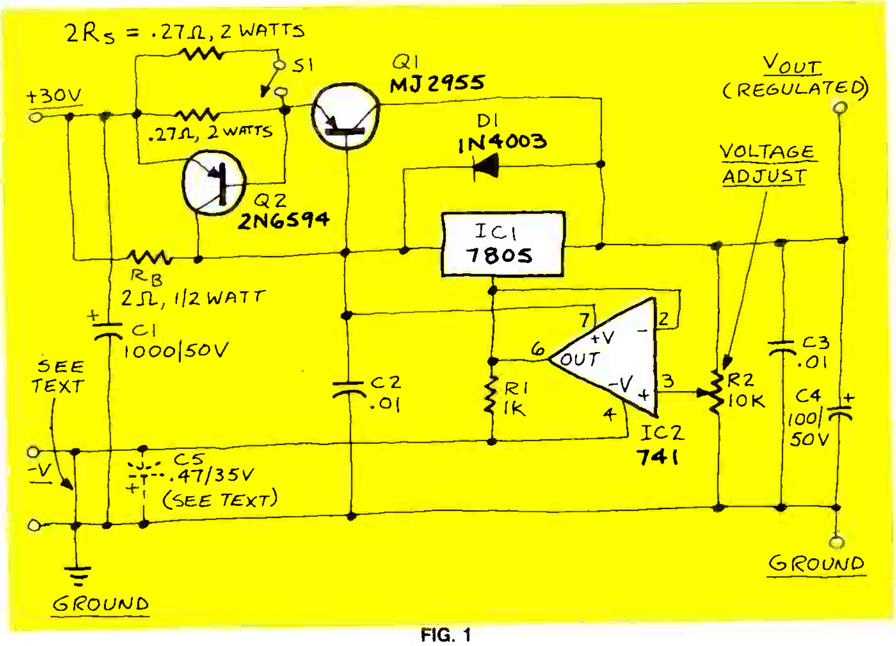


FIG. 1

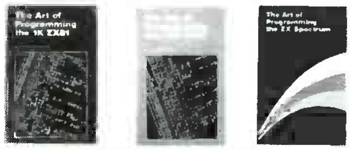
More about component values

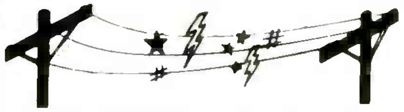
If you remember last month's discussion of R_B, you'll recall that we had to do some math to arrive at a value of 2.47 ohms. A look at Fig. 1 will show you that R_B is now specified to be 2 ohms at half a watt. Changing the value to 2 ohms from 2.47 ohms was done in the interests in reality. The only place you'll be likely to find a 2.47-ohm resistor is the same place you'll find a 0.13-ohm resistor—nowhere. You may be considering the idea of using a trimmer potentiometer in place of a fixed resistor. Don't do it—it's a bad idea.

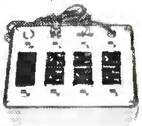
There are two no-no's as far as R_s and R_B are concerned—trimmers are a bad idea, and so are wire-wound resistors. The reasons for avoiding those things have already been discussed and you should realize what they are. Go back through our discussion of regulators so far and figure out the answer. When you get the answer, let me know. The first person to get it right will have the dubious honor of being credited in this column and will receive a prize of four million dollars. The first person to get it wrong will have to come up with the prize money. Only joking, folks—but I will give credit to the first person with the right answer.

The calculation of the wattage I'm going to leave as an exercise for you. To be fair, though, I'll give you the answers. They are shown in Table 1. Make the same assumptions we did last month about the transistor "resistance" and see if you can work out those values.

As you can see, calling for a half watt







for R_B is a bit of overkill, since the calculated value never even reaches one-quarter watt. When we started this exercise in design I told you that one of the cardinal rules of design was always to aim for worst-case operation. By specifying a half-watt resistor we're adding a safety factor of more than two. If you can get your hands on a one-watt resistor of the right value it wouldn't hurt to use that either—you can never have too many watts.

The transistors listed for Q1 and Q2 have the collector-current maximums the circuit calls for. Since they're being used as switches we don't have to worry about any of the parameters we'd have to consider in an analog circuit (frequency compensation, gain, and so on). It's really just a matter of finding some silicon transistors of the right polarity that can handle the calculated current. The MJ2955 can handle 15 amps at its collector, and our circuit only calls for 5 amps—the safety factor again.

As we saw last month, Q2 has to be able to stand the combined short-circuit currents of both the regulator and Q1—that means a collector current of 0.035 + 4.82 = 5.13 amps. A 2N6594 can handle 12 amps. I called for those transistors because they're easy to find. If you want to substitute other transistors, that's okay—just watch the collector ratings, and make sure you use silicon transistors. If you want to use germanium ones, all the calculations we've done will have to be redone. You tell me why.

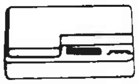
Other components

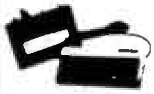
I've called for a 741 as the op-amp to be used for IC2. Actually you can use just about any op-amp there. The 741 seemed to me to be a good choice because it's cheap (always an important design consideration), available, and has internal current-limiting and frequency compensation. If you have some other op-amp lying around, use it. The higher the input impedance the better. Since it's only a buffer, the requirements aren't at all critical.

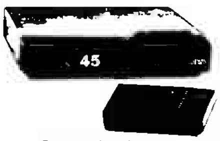
The last thing to look at is C5. It handles the transients from the negative supply, if you use one, to lower the range of the circuit following the guidelines we developed last month. It goes without saying that if you go this route the connection shown in Fig. 1 between the −V input and ground should be ignored—so I won't say it.

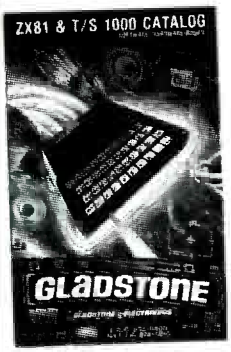
There's nothing sacred about the choice of IC1. If your voltage requirements are going to be consistently higher than five volts use one of the other regulators in the series—the 7812 or 7815 for example. Try giving the the op-amp a bit of gain by putting some resistance on the feedback line from pin 6 to pin 2. The point of these columns is for you to learn—and there are only two ways to do

continued on page 101









HOBBY CORNER

I like birds, but...

EARL "DOC" SAVAGE, K4SDS, HOBBY EDITOR

I AM NOT FASCINATED BY BIRDS, BUT I DO enjoy watching them as they cavort about my yard in the morning and evening. I could identify only a dozen or so species if the need ever arose, so it's apparent that I do not study them beyond casual observation. (But that's enough to have discovered some of their quirks, and to understand that old epithet "bird-brain.")

The reason I'm saying this up front is just to keep you from assuming that I am an enemy of our feathered friends. I do like the little things as long as they stay away from where they don't belong. One of the places they don't belong is in the gutter on my patio roof. When they start carrying nest material in there, they're asking for trouble!

Not wanting to electrocute them or shoot them (and put holes in the patio roof), I despaired of finding a solution other than waving them off from behind the sliding doors. That action, by the way, is effective for about two minutes. Lately, however, they don't care for my gutter. They've learned to steer clear of it because I used my head instead of my arms. In case you have a similar problem, here's one approach you can take to solve it.

Scaring the birds

It's all done with an old doorbell and a timer. The doorbell—minus the bell part—is mounted so that the hammer strikes the gutter (instead of a bell) when it is activated. It both vibrates the gutter and makes a bit of noise—enough of one or the other to send the birds scooting out of there.

At first, I rang the "bell" by pressing a momentary switch when the need arose. Later, my smarts grew, and I put a small clock-type motor in the control box. On the shaft of the motor is a cam that completes the circuit to the bell for a few seconds every five minutes. The setup is shown in Fig. 1. Now, the "scare 'em away" action takes place automatically. After a while, even birds learn that my gutter is not a pleasant place to build a nest.

Of course, the motor can be switched in and out of the circuit. It is not necessary to let the thing sound off every five minutes forever. In fact, the mechanism isn't put in its automatic mode except early in the spring, and a little bit later whenever a new crop of youngsters starts the nest-building ritual.

The wiring diagram in Fig. 1 can also be used in case you need to keep away other animals (cats or whatever) without harming them.

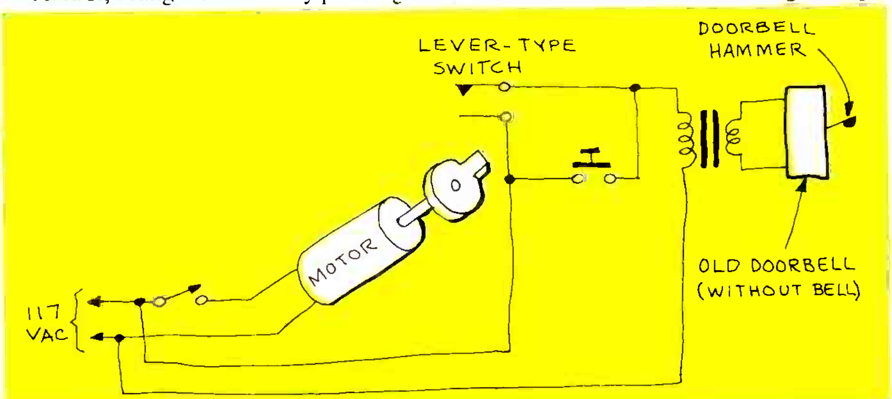


FIG. 1

Computer-tape copying

Both Paul Rittenhouse (PA) and P.J. Donnelly (NY) have written to ask about methods of copying computer programs and data that have been stored on tape. Of course, they can load the data into the computer from one tape and store it on a second one—but that is a time-consuming process. And I don't blame them for trying to find a way around it.

They would like to make copies directly from one tape machine to another but have discovered that this procedure seldom, if ever, produces a usable tape. The reason, of course, is that the signal, which, ideally, is a squarewave, goes through many distorting audio circuits. With two recorders, the signals go through double the normal number of input and output circuits.

What you need, fellows, is a device that will actually reconstruct the signal from one recorder before it goes into the second one. There are commercial devices available, and there were a couple of circuits in the computer magazines several years ago for such a device. Be forewarned, however, that such devices are computer-specific. You know that a tape from one kind of computer cannot be read by another kind—there is no standardization of signals used. Therefore, the "black box" between recorders must be designed to reconstruct the exact type of signal needed. Perhaps you can modify one of the old circuits to match your computer. Sorry I can't be more specific, but I wish you good luck. Let me know if you are successful—I'll spread the word.

BCD readout

Joe Czerniak up in Michigan would like to put a BCD (*B*inary *C*oded *D*ecimal) readout on his digital clock. He figures it will be just as useful with that type of readout and it will be a conversation piece to boot. Well, Joe, the details will vary depending upon the specific clock you have but I can show you enough to get you started.

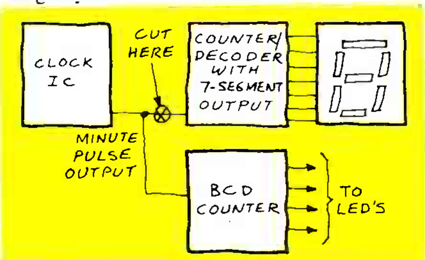


FIG. 2

Clock circuits come in at least three main types. One has the 7-segment readouts driven by multiplexed lines straight from the clock IC. If yours is of this type, the changeover can be quite complex, so I'd advise you to go out and get another one to modify!

A partial diagram of the second type is shown in Fig. 2. In this example, the minute-pulse drives a counter/decoder that has a 7-segment output. Your best bet is to connect a BCD counter to the output of the clock IC in place of the counter/decoder.

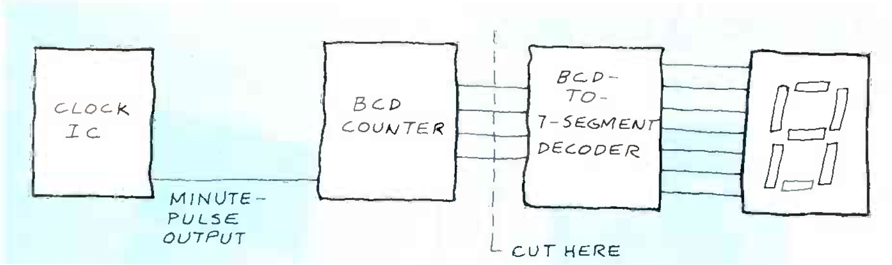


FIG. 3

The BCD counter has "1," "2," "4", and "8" output lines, and all you have to do is to hang an LED on each one. Of course, you will have to replace each of the original digits with a counter (each with four LED's). You could tie the LED's to ±5 volts or to ground (through appropriate resistors), depending on whether you want to read LED's that are on or off. If you use the latter, you'll really have a conversation piece—even with those visitors who recognize the BCD readouts! The tens-of-hours digit can be replaced with a single LED if the clock is the 12-hour type.

The third type of clock has separate counters and decoders instead of the combination counter/decoders of the previous one. You're in luck if you have this type—it's by far the easiest to modify. Now, all you have to do is disconnect the decoders (cut the lines as is shown in Fig. 3) and hang LED's on the lines of the counters that are already there. Could anything be simpler?

That should be enough guidance, Joe, for you to get the job done. Arrange each set of four LED's in a row or column and have some fun by daring the uninitiated to read the time.

Model speed

Rick McQuillan (Wisconsin) is looking for a way to time the runs of slot cars and pinewood derby cars. Rick, look back at "Hobby Corner" in the January and February 1981, and December 1982 issues of **Radio-Electronics** and you will find some information that should solve your problem. If you don't keep your magazines (and I can't understand why you don't), then you'll have to check with your local library. **R-E**

DRAWING BOARD

continued from page 99

that. Read everything you can get your hands on, and get your hands in everything you read. Components are cheap enough so that blowing a few up is still less expensive than going to school...and more instructive as well.

You should have learned enough to design your own negative supply. Try it and let me see what you come up with. Just be careful. You're playing around with circuitry that can deliver a lot of power. If you heat-sink everything—and you should—you're looking at circuitry that can melt the tip of a screwdriver!

We'll end this discussion of voltage regulators with a problem. I told you that there were other ways to create a negative supply besides using a center-tapped transformer. There are some MSI chips developed specially for this, but that's not what I'm talking about. Anyone who has ever needed a few measly milliamps from a negative supply knows how real the problem is.

If you can dream up a way to create a negative supply—a true negative supply—using only a two-terminal transformer, write and tell me about it. I know what I would do—let's see what you would. **R-E**

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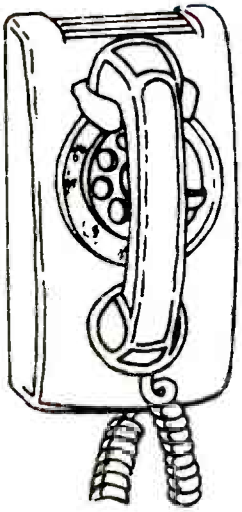

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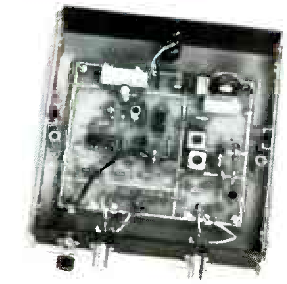

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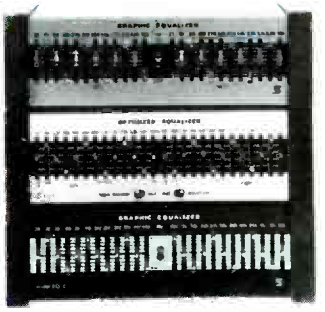

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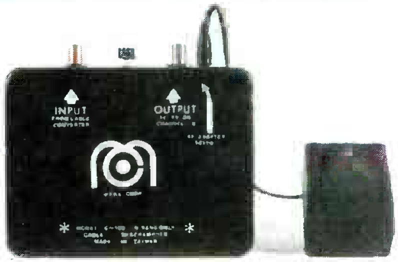

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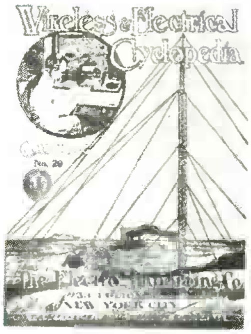

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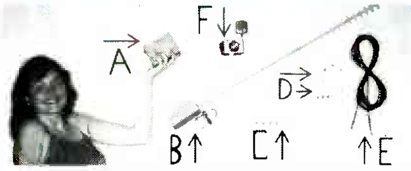

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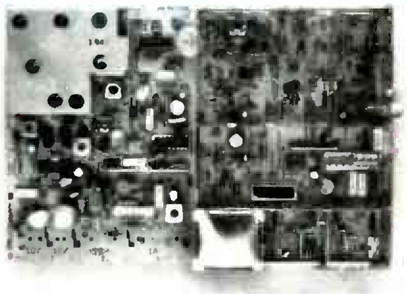

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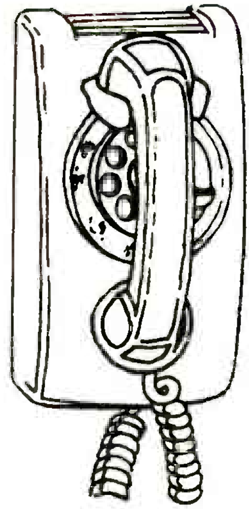

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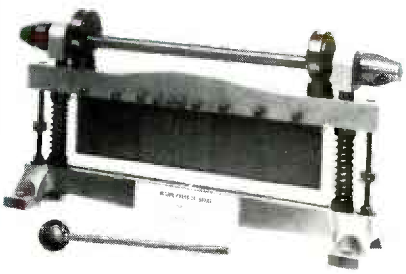

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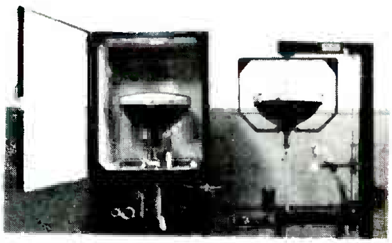

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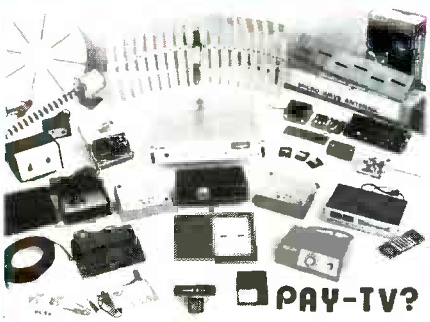

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STATE OF SOLID STATE

Two versatile voltage references

ROBERT F. SCOTT SEMICONDUCTOR EDITOR

VOLTAGE REFERENCES ARE USED TO PROVIDE a constant output-voltage regardless of changes in input voltage, load current, or temperature. The REF-01 and REF-02 are monolithic voltage-reference IC's from PMI (Precision Monolithics Inc., 1500 Space Park Drive, Santa Clara, CA 95050). The REF-01 develops +10 volts and the REF-02 +5 volts. Both devices feature excellent temperature stability, low noise, low power consumption, and high load-driving capability. They are available in three package-types: TO-99, 8-pin hermetic DIP, and 8-pin epoxy mini-DIP. Applications include voltage references in analog/digital converters and digital/analog converters, precision current-sources, use in panel meters, cold-junction thermistor compensation, and calibration standards.

The excellent temperature-stability of the output voltage of these voltage references is due to the application of two theorems in band-gap semiconductor physics. One theorem states that the base-emitter voltage (V_{BE}) of a transistor is dependent on the collector-current and has a negative temperature coefficient. The second theorem states that the difference in the V_{BE} of two transistors operating with different currents has a positive temperature coefficient.

When the difference in the two V_{BE}'s (ΔV_{BE}) is amplified and added to the V_{BE} of one of the transistors, a voltage reference with a zero temperature-coefficient results if the sum of the two terms equals 1.23 volts—the band-gap voltage of a silicon junction at 0°K or −273°C. That 1.23 volts is amplified to produce stable outputs of +5.000 volts in the REF-02 and +10.000 volts in the REF-01.

In addition to the stable +5-volt reference output, the REF-02 provides an additional output voltage that is linearly proportional to the ambient temperature. That voltage, V_{TEMP}, is taken from the junction of R1 and R2. Figure 1 is a simplified schematic of the REF-02. The REF-01 is similar but it does not bring V_{TEMP} out to a terminal pin.

The REF-02 generates a ΔV_{BE} of 72 mV at 25°C. That's done by making the current density (current/area) through Q2 sixteen times greater than that through Q1; while transistor Q2 has four times the emitter current of Q1, Q1 has four times as much emitter area as Q2. A voltage equal to ΔV_{BE} (72 mV) is developed across R1 and is amplified 8.75 times and then added to the V_{BE} of Q2 to become V_Z—1.23 volts with a zero temperature-coefficient. As a proof: V_{BE} of a silicon transistor is 0.6 volts (600 mV) at 20°C and 8.75 × 73 mV = 630 mV, and 600 + 630 = 1230 mV or 1.23 volts.

The −2.1 mV/°C temperature coefficient (TCV_{BE}) is canceled by the +2.1 mV/°C (TCV_{TEMP}) to produce a V_Z of 1.23 volts. That value is amplified by 4.06 to produce a V_{REF} of 5 volts in the REF-02, or amplified by 8.13 to produce a V_{REF} of 10 volts in the REF-01.

In the next column we'll look at how we can use either voltage-reference IC, along with a handful of other parts, to build an electronic thermometer. Direct temperature readings (in either °F or °C) can be displayed on a voltmeter (digital if desired).

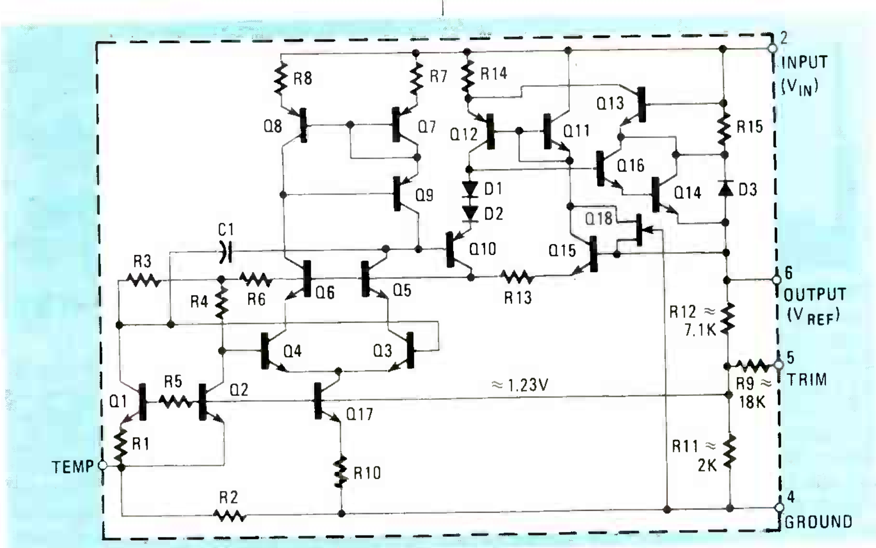

FIG. 1

Programmable quad comparator

The new National Semiconductor LP165/LP365 quad comparators feature low-power operation (10 μW per comparator) over a wide range of supply voltages. The four comparators on each chip can be programmed simultaneously for various supply currents, input currents, response times, and output-current drives. The family operates from a single supply with outputs ranging from 4 to 36 volts, or from split-power supplies delivering ±2 to ±18 volts DC. The comparator outputs are compatible with DTL, TTL, MOS, CMOS, and most other logic families.

Applications include battery power circuits, threshold detectors, zero-crossing detectors, VCO's, multivibrators, and A/D and V/F converters. Sample and production quantities are available at $1.75 each in quantities of 100 and up.—**National Semiconductor,** 2900 Semiconductor Drive, Santa Clara, CA 95051.

High-temperature rectifiers

Four new Schottky rectifiers that have a 175°C junction capability have been added to Motorola's product line. The higher-temperature 65- and 85-ampere, 35- and 45-volt diodes offer a greater temperature-margin in switching-power-supply design than previous 150°C devices.

The devices are the MBR6535/45 and MBR8035/45. The first two digits in the type number indicate the current rating in amperes when T_C is 120°C at the rated V_R (blocking voltage). The second pair of digits shows the voltage rating. For example, the MBR6535 is a 65-amp, 35-volt device. Similarly, the MBR8045 is a 45-volt device rated at 80 amps. These devices are ideally suited for use as rectifiers in low-voltage, high-frequency inverters and for service as free-wheeling diodes and polarity-protection diodes. Prices in quantities of 100 to 499 range from $3.55 to $4.45.—**Motorola Semiconductor Products,** Attention: Cliff Peterson, PO Box 20912, Phoenix, AZ 85036. **R-E**

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SERVICE CLINIC

Bits and pieces

JACK DARR, SERVICE EDITOR

EVERY NOW AND THEN I RUN INTO A situation that I think is interesting, but that is too short for a full column. The solution, of course, is to string several of those together into sort of a bits-and-pieces column. And, as you can see from the title of this column, that's just what we'll do this month.

The first involves a GE 19QB, with no video—just a smooth, dim raster. The video signal could be traced as far as the last stage, and the video amplifiers all tested out as good. The trouble was finally found to be a shorted transistor in the vertical circuit. Stop and think about that for a moment. What transistor in the vertical circuits could affect the video? Remember that the vertical circuit was working; the raster was full. There is only one possibility; the vertical-blanking stage! That transistor feeds pulses from the vertical output into the last video stage. When it shorts, it upsets the bias on the video output and away goes your signal!

Audio trouble

Here's one involving the audio tube in an old set. There was no plate voltage at all; no signal either, of course. The dropping resistor checked out OK, as did the B+. The following test pinpointed the problem: After turning the set off, we hooked a DC voltmeter to the plate of the audio tube. When the set was turned on, the voltage at first came up almost to B+, then dropped off to zero as the tube warmed up.

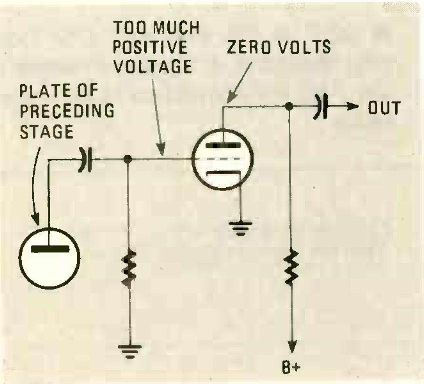

FIG. 1

Have you figured this one out yet? What's happening is that the tube is being biased on so hard that the excess plate current drops the plate voltage to zero.

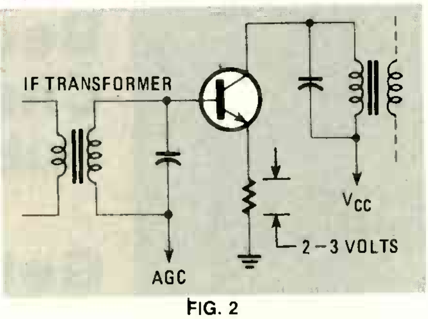

FIG. 2

The cause is usually some leakage in the coupling capacitor between the plate of the preceding stage and the grid (see Fig. 1). That leakage puts too much positive voltage on grid. If that leakage is quite small, the plate voltage may not go all the way to zero but there still will be noticeable distortion.

Troubleshooting the IF

Now to change the topic completely, symptoms of trouble in the IF stage—smooth raster, no picture—are easy to spot; the problems arise when you try to troubleshoot that section. You can't read the collector or base voltages; if you use a voltmeter it will kill the high-frequency signal. Instead, read the emitter voltages. You can read those without upsetting anything because there is no signal on the emitter.

In practically all of those circuits there is a small resistor between the emitter and ground (see Fig. 2). The voltage drop across that resistor is a measure of the collector current. Normally that drop will be small, in the neighborhood of about 2–3 volts, so a digital voltmeter will help. If you find a stage with no emitter voltage, that transistor is open. If there is too much emitter voltage, the transistor is probably leaky. In some cases, you'll just see a very weak signal. What's happening there is that the device is open, but the small capacitances between the elements of the device are coupling the signal through.

Coincidences

Coincidences can sometimes drive you crazy. Consider the problem we had with an RCA CTC-96A. The symptom was a thin horizontal line, which indicated a vertical-sweep problem. The voltages on output stage were all way off, naturally.

When the transistors were checked, however, they all proved to be good. We finally found that R117 was open. When it was replaced the sweep returned, but there was overscanning with glitches at the top. It turned out that R116 was also open. When it was replaced everything worked fine.

Whatever the odds against those two 220K resistors going out at the same time are, it did happen, so never overlook anything; incidentally, those resistors looked brand new—there was no discoloration—which just shows how undependable those kinds of indications are; the only way to be sure, of course, is to use an ohmmeter.

Before we leave this topic, let's look at an interesting aside. In-circuit measurement of resistances can produce some very odd results. That's because there can be several parallel paths in the circuit. We ran into a good example of that some time back. The set in question had very poor horizontal sync. The DC voltages around the sync-separator all seemed pretty close to what they should be. Everything fed through some resistors. Those resistors all seemed OK when checked in circuit, but when the end of one of them, a 1K unit, was lifted, the device proved to be open. Replacing it quickly cleared up the problem.

Catastrophic failures

If you ever run into a situation where several small-signal transistors have blown, look out! Always check the regulated DC power-supplies before turning the set back on. In a Quasar TS929, the 20-volt regulator shorted out; that put over +30 volts on the +20-volt line. Obviously that's no good.

In troubleshooting such a situation a Variac is essential. Plug the set into the Variac, read the regulated B+ voltage, then bring the line voltage up until the meter shows the rated DC voltage; +20 volts in the case above. Now see if the set works. If it does, and you are applying somewhat less than 117-volts AC to the set (say about 75-volts AC), that is proof positive that the voltage regulator is not doing its job.

There you have it. If any of these bits and pieces saves someone out there even just a small bit of time or aggravation, then this column will have fulfilled its purpose. **R-E**

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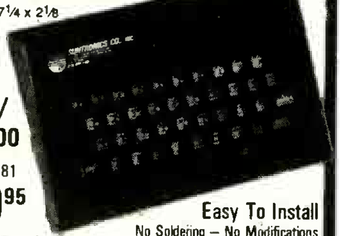

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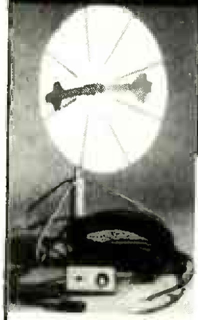

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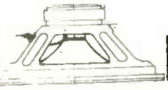

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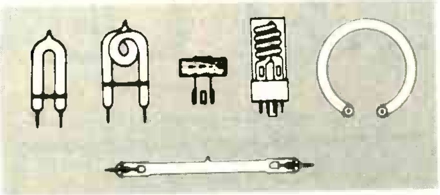

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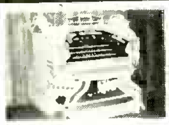

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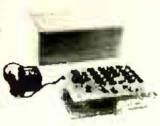

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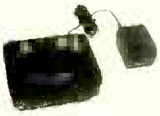

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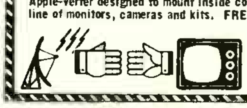

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DP8212	24	8-bit Input/Output (74S412)	2.25
DP8214	24	Priority Interrupt Control	3.95
DP8216	16	Bi-Directional Bus Driver	2.25
DP8224	16	Clock Generator/Driver	2.25
DP8226	16	Bus Driver	2.25
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DP8238	28	System Controller (74S438)	4.49
INS8243	24	I/O Expander for 48 Series	5.95
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INS8246	20	20-Key Keyboard Encoder (74C923)	4.95
INS8247	28	Display Controller (74C911)	8.95
INS8248	28	Display Controller (74C912)	8.95
INS8250N	40	Asyn. Comm. Element	10.95
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DP8253	24	Prog. Interval Timer	6.95
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M-2650	User Manual	5.00
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30003	1982 Nat. Linear Book (1952 pg.)	11.95
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MM5262	22	2048x1	(365ns)	.49 — 8/1.95
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MM5280	22	4096x1	(200ns) 2107	3.95
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MM5290-3	16	16,384x1	(200ns)	1.69 - 8/12.95
MM5290-4	16	16,384x1	(250ns)	1.49 - 8/10.95
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The DT1050 is a standard DIGITALKER kit encoded with 137 separate and useful words, 2 tones, and 5 different silence durations. The words and tones have been assigned discrete addresses, making it possible to output single words or words concatenated into phrases or even sentences. The "voice" output of the DT1050 is a highly intelligible male voice. Female and children's voices can be synthesized. The vocabulary is chosen so that it is applicable to many products and markets.

The DT1050 consists of a Speech Processor Chip, MM54104 (40-pin) and two (2) Speech ROMs MM52164SSR1 and MM52164SSR2 (24-pin) along with a Master Word list and a recommended schematic diagram on the application sheet.

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INTERSIL

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74HC03	14	.75	74HC139	16	1.49	74HC266	14	.99
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74HC08	14	.75	74HC153	16	.99	74HC374	20	3.95
74HC10	14	.75	74HC157	16	1.19	74HC390	16	1.49
74HC11	14	.69	74HC158	16	1.59	74HC393	14	1.49
74HC14	14	.85	74HC160	16	1.79	74HC533	20	3.95
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74HC27	14	.75	74HC164	14	1.79	74HC595		3.75
74HC32	14	.75	74HC165	16	2.39	74HC688		3.19
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74C04	14	.29	74C95	14	1.39	74C244	20	1.95
74C08	14	.35	74C107	14	.89	74C373	20	2.49
74C10	14	.35	74C151	16	2.49	74C374	20	2.49
74C14	14	.59	74C154	24	3.49	74C901	14	.59
74C20	14	.35	74C157	16	2.25	74C903	14	.59
74C30	14	.35	74C160	16	1.19	74C906	14	.59
74C32	14	.39	74C161	16	1.19	74C911	28	8.95
74C42	16	1.39	74C162	16	1.19	74C912	28	8.95
74C48	16	1.95	74C163	16	1.19	74C915	18	1.19
74C73	14	.79	74C164	14	1.49	74C917	28	8.95
74C74	14	.69	74C173	16	.79	74C922	18	4.49
74C85	16	1.95	74C174	16	1.19	74C923	20	4.95
74C86	14	.39	74C175	16	1.19	74C925	16	5.95
74C89	16	5.95	74C192	16	1.49	74C926	18	5.95
74C90	14	1.19	74C193	16	1.69	80C95	16	.39
74C93	14	1.19	74C195	16	1.39	80C97	16	.39

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TL072CP	8	1.39				LM710N	14	.69
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TL082CP	8	1.19	LM340T-15		.79	LM733N	14	1.00
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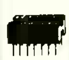
14 pin LP	.17	.15	.14
16 pin LP	.19	.17	.16
18 pin LP	.26	.24	.23
20 pin LP	.30	.27	.25
22 pin LP	.31	.28	.26
24 pin LP	.33	.30	.28
28 pin LP	.40	.37	.35
36 pin LP	.46	.42	.39
40 pin LP	.49	.46	.43


LP


SG

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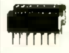
8 pin SG	.30	.27	.25
14 pin SG	.43	.39	.37
16 pin SG	.47	.43	.41
18 pin SG	.53	.49	.47
24 pin SG	.69	.65	.61
28 pin SG	.81	.76	.72
36 pin SG	1.09	1.03	.97
40 pin SG	1.21	1.14	1.08


ST


WW

SOLDERTAIL STANDARD (TIN)

	1-9	10-99	100-up
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16 pin ST	.34	.32	.30
18 pin ST	.38	.36	.34
20 pin ST	.45	.43	.41
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CIRCLE 20 ON FREE INFORMATION CARD

COMPUTER-PERIPHERAL SWITCHERS

Connect any number of peripherals to a single I/O port — use a single printer to support several microcomputers — use two or more printers to support a single microcomputer — access a modem from any of several microcomputers — Ideal for demonstrating or comparing equipment. The Selecto-Switches are designed to eliminate the unnecessary plugging & unplugging of cables which connect printers, terminals, or modems to various computers. By using a Selecto-Switch, you achieve more efficient system operation, better utilization of peripherals & computer ports, eliminate redundant hardware & reduce service calls. 5 yr. limited warranty on all Selecto-Switches. No power required. Size (inches): 10L x 7W x 3H. 2½ lbs.

RS232 SERIAL SELECTO-SWITCH

• Switches all lines of asynchronous data • Easy expansion of serial ports • Connectors are female DB25 type

PART NO.	DESCRIPTION	PRICE
GRS232-AB	2-Way Switch	$139.95
GRS232-ABC	3-Way Switch	$179.95

DB25 PARALLEL SELECTO-SWITCH

• TRS-80, Apple, and IBM compatible • Switches 24 lines (line 1 is ground) • Connectors are female DB25 type

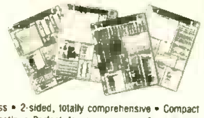
PART NO.	DESCRIPTION	PRICE
GP24-AB	2-Way Switch	$139.95
GP24-ABC	3-Way Switch	$179.95

CENTRONICS-STYLE SELECTO-SWITCH

• Switches all 36 lines • Connectors are female Centronics

PART NO.	DESCRIPTION	PRICE
GCENT-AB	2-Way Switch	$199.95
GCENT-ABC	3-Way Switch	$229.95

Micro-Logic Corp. MICRO-CHARTS



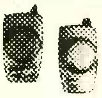
• Fully decoded data • Instant access • 2-sided, totally comprehensive • Compact 8½x11 in. durable credit card plastic • Perfect for programmers & engineers • Clear & concise tables for: full instruction set, disassembly, ASCII, base conversion, effect of flags, compare vs. jump, interrupt structure, pinout, cycle times, diagrams, bug notes, & much more...

PART NO.	REFERENCE	PRICE
ML-Z80	Z80 CPU	$5.95
ML-8080A	8080A/8085A	$5.95
ML-6502	6502 (65XX)	$5.95
ML-8048	8048, Relatives, Algorithms	$5.95
ML-7400	5400/7400 TTL	$5.95

BOOKS

30001	National CMOS Data Book (1981) (640 pages) 74C, CD4000, and A/D Converters	$6.95
30003	National Linear Data Book (1982) (1376 pages) LM, LF, ADC, DAC, LH Series	$11.95
30008	National Memory Data Book (1980) (464 pages) RAMs, ROMs, PROMs, EPROMs Series	$6.95
30009	Intersil Data Book (1983) (1356 pages) Complete line.	$9.95
30010	National Audio/Radio Handbook (1980) (240 pages) Pre-Amps, AM, FM & FM Stereo, Power Amps	$5.95
30011	National Linear Application Handbook (1980) (736 pages) Application Notes, Linear Briefs, etc.	$15.95
30012	National PAL Data Book (1982) (176 pages) Application Notes, Linear Briefs, etc.	$5.95
30013	Zilog Data Book (1983) (641 pages) Microprocessors and Support Chips	$7.95
210830	Intel Memory Components Handbook (1983) (798 pages) Contains all Application Notes, Article Reprints, Data Sheets, and other design information on Intel's RAMs, EPROMs, E²PROMs & Bubble Memories.	$14.95
210844	Intel Microprocessor & Peripheral Handbook (1983) (1027 pages) Contains Data Sheets on all of Intel's Microprocessors and Peripherals.	$14.95

ATARI



ATARI PADDLES

JSP (2) .... $4.95 pair

ATARI DRIVER

JSD (1) .... $2.95 ea.

TV GAME SWITCH

Used on Atari. Cosmetically blemished. 100% functional.

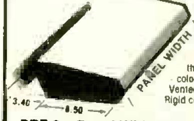
TGS-1 ... $2.95 ea.

Jameco Digital Thermometer Kit

Dual sensors — switch controls for indoor/outdoor or dual monitoring — can be extended to 500 feet. Continuous LED .8" ht. display. Range: -40°F to 199°F, -40°C to 100°C. Accuracy ±1° nominal. Calibrate for Fahrenheit/Celsius. Simulated walnut case. AC wall adapter included. Size: 6⅜"L x 3¼"H x 1¾"D.

JE300 ...... $39.95

Universal Computer Keyboard Enclosures



"DTE" Blank Desk-Top Enclosures are designed for easy modification. High strength epoxy molded end pieces in mocha brown finish. Sliding rear/bottom panel for service/component access. Top/bott. panels .080" thick alum. alodine type 1200 finish (gold tint color) for best paint adhesion after modification. Vented top & bottom panels for cooling efficiency. Rigid construction provides unlimited applications. Assembly instructions included.

DTE-8	Panel Width 7.5"	$24.95
DTE-11	Panel Width 10.13"	$27.95
DTE-14	Panel Width 13.5"	$29.95
DTE-20	Panel Width 19.25"	$34.95

TIMEX sinclair 1000

• Powerful - fully programmable 2K memory • Portable - 6⅞" x 6⅜" x 1⅜" - 12 oz. • Expandable - Optional 16K RAM module • Single-key entry commands • Educational • Unique syntax-check report codes for error identity • Accurate to 9½ decimal places for full range math and scientific functions • Graph drawing and animated display • Advanced 4-chip design combining power, portability and affordable price.

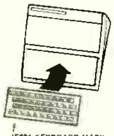
TS1000 .... $54.95

ACCESSORIES FOR TIMEX sinclair 1000 and ZX81

TIMEX sinclair 1016	Expansion from 2K to 16K, size: 3" x 3" x 1.5" (5 oz)	TS1016 $49.95
TIMEX sinclair 2040	32 column thermal printer (4 lbs)	TS2040 $99.95
	Printer paper - 3 rolls (4.3 in. x 82 ft.)	TPP-3 $5.95

Keyboard Mask for Your ZX81/1000* Computer

BRAND NEW!!



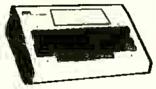
FEATURES:
- Install in seconds. Remove adhesive backing from mask and place over keyboard.
- All characters and symbols reproduced on mask.
- Durable — formed with polycarbonite sheet satin finish

JE681 KEYBOARD MASK

The JE681 Keyboard Mask provides users of the ZX81/1000 series computer the individual feel of each keypad on the keyboard. The mask has a raised outline around each keypad allowing the user to feel and correctly position their fingers onto the keyboard.

JE681 KEYBOARD MASK ..... $9.95 each

Jameco ZX81/1000* Keyboard Conversion Kit



JE682-AK KEYBOARD KIT MOUNTED IN DTE AK ENCLOSURE LIGHT TAN PANELS WITH MOLDED DARK BROWN END PIECES. SIZE: 14⅝"W x 3½"D x 3¾"H

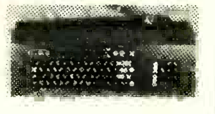
The JE682 Kit provides users of the ZX81/1000 series computers a full-size industrial keyboard hook-up to their computer. The JE682 Kit allows the use of either the full size keyboard or the Sinclair/Timex Keyboard. The Kit also permits the simple disconnection of the Sinclair/Timex Keyboard for portable use. The JE682 Kit consists of a full-size industrial grade keyboard with 62 keys, 2 p.c. boards, 24" ribbon cable, DIP socket and 4 rubber feet. The keyboard conversion kit can easily be mounted into the DTE AK enclosure. This enclosure is large enough to contain the ZX81/1000 computer and the fullsize keyboard together. A handy label representing the ZX81/1000 keyboard layout is placed on the enclosure.

JE682-AK Keyboard Conversion Kit ...... $99.95 ea.
(WITH DTE AK CASE - AS PICTURED)

JE682 Keyboard Conversion Kit .... $59.95 ea.
(WITHOUT DTE AK CASE)

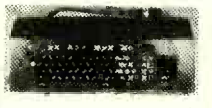
*ZX81/1000 is a trademark of Sinclair/Timex

80-Key Keyboard



CA150C $69.95

95-Key Keyboard



CA154A $79.95

CONTROL DATA KEYBOARDS

Limited Quantities!

- ★ 7-bit Parallel ASCII
- ★ SPST Switching
- ★ FTZ Shielded Base
- ★ N-Key Rollover
- ★ 128 Character ASCII
- ★ Non-Slip, Non-Glare Keycaps
- ★ CDC752 Terminal Keyboards
- ★ Attractive Case

These Control Data Keyboards consist of a base, cover, the keyboard assembly, and an interface cable. Color (case): Harvest gold and black. Color (keycaps): Black, blue, and red. Electrical requirements: +5V @ 600mA, -12V @ 50mA. Size: 21½"W x 9"D x 3½"H. Weight: 6 lbs. All units brand new in original boxes, specifications included.

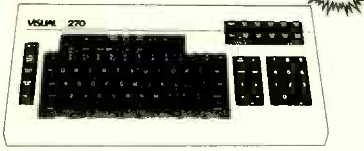
Keytronics 90-Key Soft-Programmable Keyboard

WITH SECURITY KEYLOCK SWITCH

350 Available!

BRAND NEW!!

- RFI shielded
- Cursor controls
- Numeric keyboard
- 8-bit Parallel
- Capacitance keys
- 10 user-programmable keys
- Positive TTL Logic
- Size: 17"L x 8¼"W x 2¾"H

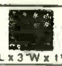


Made for Visual Technology, this keyboard features: a security keylock (includes two keys) to guard against unauthorized use; an 11-key numeric keypad; cursor controls; and 10 user-programmable keys. Electrical requirements: +5VDC. Color (case): White. Color (keycaps): Black. Complete with case, keyboard assembly, 10-inch interface cable, and schematics. Weight: 7 lbs.

Part No. KB270 .... $79.95 each

23"L x 5¼"W x 1-3/8"H

MICRO SWITCH 85-KEY KEYBOARD
Word Processing Keyboard, 26 Pin Edge Card Connection. Supply Voltage +5VDC. Main Keyboard is QWERTY. Additional Key Pads for Cursor and word processing functions.
Part No. 85SD18-1 .... $29.95 each



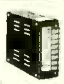
3"L x 3"W x 1½"H

HI-TEK 14-KEY NUMERIC KEYPAD
SPST switching. Charcoal grey keycaps. Mounted on printed circuit board.
Part No. K-14 .... $9.95 each

POWER SUPPLY +5VDC @ 1 AMP REGULATED — *Transaction Tech*
Output +5VDC @ 1A (also +30VDC) reg. Input 115VAC 60Hz. 2-tone (black/beige) self-enclosed case. 6 ft., 3 cond. black power cord. 5⅛"W x 7"D x 2¼"H. Wt. 3 lbs. Data sheet incl.
Part No. PS51194S .... $14.95 each

POWER SUPPLY +5VDC @ 3 AMP REGULATED — *Deltron*
Input: 115VAC, 47-440Hz. Output: 5VDC Adjustable @ 3 amp, 6VDC @ 2.5 amp. Adjustable current limit, Ripple & Noise: 1MV rms, 5MV p-p — 2 mounting surfaces. UL recognized. Size: 4"W x 4½"L x 2-7/16"H - wt. 2 lbs. Data sheet included.
Part No. QPS-1 .... $29.95 each

POWER SUPPLY +5VDC @ 7.5 AMP, 12VDC @ 1.5 AMP SWITCHING
Input: 115VAC, 50-60Hz @ 3 amp/230VAC, 50Hz @ 1.6 amp. Fan volt./power supply select switches (115/230VAC). Output: 5VDC @ 7.5 amp, 12VDC @ 1.6 amp. 8 ft. blk. pow. cord. 11½" W x 13⅛"D x 3¾"H. Wt. 6 lbs.
Part No. PS94VDS .... $39.95 each



POWER SUPPLY 4-Channel Switching - Apple Compatible
FOR USE AS AN EXTERNAL POWER SUPPLY FOR APPLE
Microprocessor, mini-computer, terminal, medical equipment and process control applications. Input: 90-130VAC 47-440Hz. Output: +5VDC @ 5A, -5VDC @ 1A; +12VDC @ 1A, -12VDC @ 1A. Line reg.: ±0.2%. Ripple: 30mV p-p. Load reg.: ±1%. Overcurrent protection. Adj: 5V main output ±10%. 6-3/8"L x 1-7/8"W x 4-15/16"H. Wt. 1⅛ lbs.
Part No. FCS-604A .... $69.95 each

$10.00 Minimum Order — U.S. Funds Only
California Residents Add 6½% Sales Tax
Shipping — Add 5% plus $1.50 Insurance
Send S.A.S.E. for Monthly Sales Flyer!

Spec Sheets — 30¢ each
Send $1.00 Postage for your
FREE 1983 JAMECO CATALOG
Prices Subject to Change

MasterCard — Mail Order Electronics • Worldwide — **Jameco ELECTRONICS** — VISA

1355 SHOREWAY ROAD, BELMONT, CA 94002

8/83 *PHONE ORDERS WELCOME — (415) 592-8097 Telex: 176043*

2708,2716,2732 & 2764 EPROM Programmer

JE664 EPROM PROGRAMMER

8K TO 64K EPROMS — 24 AND 28 PIN PACKAGES

—PROGRAMS 2716's IN 16 SECONDS—

—PROGRAMS 2764's IN 64 SECONDS—

• Programs, validates, and checks for properly erased EPROMs • Emulates PROMs or EPROMs • RS232C Computer interface for editing/program loading • Loads data into RAM by keyboard • Changes data in RAM by keyboard • Loads RAM from an EPROM • Compares EPROMs for content differences • Copies EPROMs • Power input. 115VAC, 60Hz, ◄ 10W power consumption • Enclosure: Color-coordinated, light tan panels w/molded mocha brown end pieces • Size: 15-5/8"L x 8¾"D x 3½"H • Wt.: 5¾ lbs.

JE664-A EPROM Programmer **$995.00**
Assembled & Tested (Includes JM16A Module)

JE665 — RS232C INTERFACE OPTION — The JE665 RS232C Interface Option implements computer access to the JE664's RAM. Sample software written in BASIC provided for TRS-80® Model I, Level II Computer. Baud rate: 9600. Word Lgth: 8 bits - odd parity. Stop bits. 2. Option may be adapted to other computers.

JE664-ARS EPROM Prog. w/JE665 Option **$1195.00**
Assembled and Tested (Includes JM16A Module)

EPROM JUMPER MODULES — The JE664's JUMPER MODULE (Personality Module) is a plug-in Module that pre-sets JE664 for proper programming pulses to the EPROM & configures EPROM socket connections for that particular EPROM.

Part No.	EPROM	EPROM MANUFACTURER	PRICE
JM08A	2708	AMD, Motorola, National, Intel, TI	$14.95
JM16A	2716, TMS2516	Intel, Motorola, National, NEC, TI	$14.95
JM16B	TMS2716	Motorola, TI (+5,-12, +12)	$14.95
JM32A	TMS2532	Motorola, TI	$14.95
JM32B	2732	AMD, Fujitsu, NEC, Hitachi, Intel	$14.95
JM32C	2732A(21V)	Fujitsu, Intel	$14.95
JM64A	MCM68764, MCM68L764	Motorola	$14.95
JM64B	2764	Intel	$14.95
JM64C	TMS2564	TI	$14.95
JM64D	HN482764G-4	Hitachi (21V)	$14.95

iii's Black Hole EPROM Eraser

9 Chips — 8 Minutes

The Black Hole EPROM Eraser will completely and safely erase 9 EPROMs in less than 8 minutes. The Black Hole is a fully automatic cassette loading eraser featuring U-shaped 4000 hr. UV lamps mounted in a special ALZAK (UV reflectivity of .9) parabolic light tunnel. In operation, the user slips in an anti-static Bug Box (3 ea. incl.) containing the EPROMs to be erased into the loading slot on the front panel of Black Hole. The rest is fully automatic. The Black Hole latches the Bug Box into place, turns on the UV lamps and starts its fully solid state (CMOS) UV integration dose timer. The percentage erasure time is monitored and displayed on a front panel LED readout. At the end of the erase cycle, the Black Hole ejects the Bug Box containing the 9 erased EPROMs and turns off power.

PART NO.		PRICE
ULV-008	Replacement Lamp for ERS-008	$29.95
ERS-008	Eraser, Auto Eject & LED Readout	$249.95

IBM MEMORY EXPANSION KIT

SAVE HUNDREDS OF $$$ BY UPGRADING MEMORY BOARDS YOURSELF!

Most of the popular memory boards allow you to add an additional 64K, 128K, 192K, or 256K. The IBM64K Kit will populate these boards in 64K byte increments. The kit is simple to install — just insert the nine 64K RAM chips in the provided sockets and set the two groups of switches. Directions are included.

IBM64K (Nine 200ns 64K RAMs) $59.95

EXPAND YOUR MEMORY

TRS-80 to 16K, 32K, or 48K

**Model 1 =	From 4K to 16K Requires (1) One Kit
Model 3 =	From 4K to 48K Requires (3) Three Kits
Color =	From 4K to 16K Requires (1) One Kit

**Model 1 equipped with Expansion Board up to 48K Two Kits Required
— One Kit Required for each 16K of Expansion —

TRS-16K3 *200ns for Color & Model III $12.95
TRS-16K4 *250ns for Model I $10.95

TRS-80 Color 32K or 64K Conversion Kit

Easy to install kit comes complete with 8 ea. 4164-2 (200ns) 64K dynamic RAMs & conversion documentation. Converts TRS-80 color computers with E circuit boards, & all new color computers to 32K. Minor modifications of 32K memory will allow the use of all the 64K of the dynamic RAM providing you have a FLEX DOS operating system.

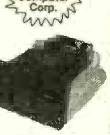
TRS-64K2 .... $54.95

5¼" Mini-Floppy Disk Drive

Pertec Computer Corp.

FOR TRS-80 MODEL I - COLOR COMPUTER

Features single or double density. Recording mode: FM single, MFM double density. Seek time: 25msec. track to track. Power: +12VDC (±0.6V) 1.6A max., +5VDC (±0.25V) 0.8A max. Unit as pic. at right does not incl. case, power supply, cables). 30-pg. data book incl. Wt. 3½ lbs. Size: 5¾"W x 8"D x 3¼"H.



Part No.	*Limited Quantity!*	Price
FD200	Single-sided, 40 tracks, 250K bytes capacity	$179.95
FD250	Double-sided, 35 tracks, 438K bytes capacity	$199.95

8" FLOPPY DISK DRIVE

Siemens

- Shugart 801R compatible
- Single-Sided
- 77 Tracks
- 400/800K Bytes Capacity
- Industry Standard

The FDD100-8 8" Floppy Disk Drive (Industry Standard) features single or double density. Recording mode: FM single, MFM double density. Transfer rate: 250K bits/sec. single density; 500K bits/sec. double density. The FDD100-8 is designed to work with the single-sided soft sectored IBM Diskette 1, or eq. disk cartridge. Power: 115VAC @ 50-60Hz, +24VDC @ 1.7 amps max., +5VDC @ 1.2 amps max. Unit as picture above (does not include case, power supply, or cables). Size: 8.55"W x 14"L x 4.5"H. Weighs 12 lbs. Incl. 96-pg. manual.

Part No. — Price

FDD100-8 .. $169.95 ea.

CIRCLE 20 ON FREE INFORMATION CARD

WE HAVE QUALITY PARTS, DISCOUNT PRICES AND *FAST* SHIPPING!

TRANSFORMERS
120 volt primaries

5.6 VOLTS at 750 MA	$3.00
6 VOLTS at 150 MA	$1.25
16.5 V. at 3 AMPS	$6.50
18 V at 650 MA	$3.50
18 VOLTS at 1 AMP	$4.50
18 V.C.T. at 2 AMP	$5.50
24 VOLTS at 250 MA	$2.50
24 VCT at 1 AMP	$4.50
42 V.C.T. at 1.2 AMP	$4.50

BLACK PLASTIC CASE
PAC-TEC SERIES C

BLACK PLASTIC ENCLOSURE ADJUSTABLE HEIGHT FROM 1.63" TO 2.93"; WIDTH 6.85"; DEPTH 8". BUILT-IN STAND OFFS FOR P.C. BOARDS . . FRONT AND BACK PANELS NOT INCLUDED . .

$5.25 PER CASE

T.V. GAME SWITCH
RCA PLUG or 300 OHM IN

300 ohms OUT

$2.75 EACH

LIGHTS
GRAIN OF WHEAT

T1 SIZE .125" DIA. (3.15mm)

3 to 6 VOLTS 3 for $1.00 Rated: 55ma @ 5 VOLTS

6 to 12 VOLTS 3 for $1.00 Rated: 55ma @ 8 VOLTS

12 to 24 VOLTS 3 for $1.00 Rated: 45ma @ 14 VOLTS

12 VOLT A.C. POWER UNIT
THIS UNIT CONSISTS OF A 12 VOLT 2 AMP TRANSFORMER, 1 AMP CIRCUIT BREAKER, 4 PRONG CINCH JONES SOCKET AND A 3 WIRE A.C. CORD ALL MOUNTED IN AN ATTRACTIVE 4½" x 5½" x 3" CHASSIS BOX. GOOD FOR PARTS OR A NICE START FOR D.C. POWER SUPPLY.

$8.50 PER UNIT

DC WALL TRANSFORMER
ALL ARE 115 VAC PLUG IN

4 VDC at 70 MA	$2.50
9 VDC at 225 MA	$3.00
16.5 VAC at 10 VA	$3.50
17 VAC at 500 MA	$4.00
22 VDC at 60 MA	$2.50

2K 10 TURN
MULTI-TURN POT

SPECTROL #MOD 534-7161

$5.00 EACH

S.C.R.
0.8 AMPS 30 VOLTS 5 for $1.00

4 AMPS 200 VOLTS 65¢ EACH

4 AMPS 500 VOLTS 85¢ EACH

TRIAC
6 AMPS 400 VOLTS 75¢ EACH

T1 SIZE WITH WIRE LEADS
3 to 6 VOLTS 2 for $1.00 Rated: 55ma @ 5 VOLTS

6 to 12 VOLTS 2 for $1.00 Rated: 55ma @ 8 VOLTS

12 to 24 VOLTS 2 for $1.00 Rated: 45ma @ 14 VOLTS

CO-AX SWITCH (A/B SWITCH)
75 ohms IN TWO

75 ohms OUT

$3.50 EACH

LINE CORDS
TWO WIRE

6' 18ga TWO WIRE 3 FOR $1.00

THREE WIRE

18 INCH 18ga THREE WIRE 2 for $1.00

8 FOOT 18ga THREE WIRE $2.00 EACH

MIKE CONNECTOR
5 CONDUCTOR IN-LINE PLUG AND CHASSIS MOUNT JACK. TWIST LOCK STYLE, SAME AS SWITCHCRAFT 12CL5M

$2.50 PER SET

TRANSISTORS

2N706	5 for $1.00
2N2222A	4 for $1.00
PN2222	8 for $1.00
2N2904	4 for $1.00
2N2905	4 for $1.00
2N2907	4 for $1.00
MJ3030	$2.50
2N3055	$1.00
2N3585	$1.00
2N3904	5 for $1.00
2N3906	5 for $1.00
2N4401	5 for $1.00
2N4403	5 for $1.00
2N4898	$1.50
D43C8	2 for $1.00
D44C2	.75
TIP 31	.75
TIP 32	.75
TIP 121	.75
TIP 126	.75

METERS
0 - 20 V.D.C.

0 -20 VDC FULL SCALE FACEPLATE BATTERY TEST SET-UP AS INDICATOR **$5.50 EACH**

1 MA

2 5/16" SQUARE PANEL METER MOUNTS IN 2 1/8" HOLE **$5.50 EACH**

0 - 15 V.D.C.

THIS 2-1/4" SQUARE METER MEASURES 0-15 VDC. **$4.50 EACH**

SWITCHES
MINI-PUSH BUTTON

S.P.S.T. MOMENTARY NORMALLY OPEN 1/4" BUSHING **35¢ EACH** 10 FOR $3.25 100 FOR $30.00

SPECIFY COLOR: RED, BLACK, WHITE, GREEN, YELLOW

T1- 3/4 SIZE WITH WIRE LEADS
.163" DIA. (4.14mm)

3 to 6 VOLTS 2 for $1.00 Rated: 45ma @ 6 VOLTS

6 to 12 VOLTS 2 for $1.00 Rated: 55ma @ 8 VOLTS

12 to 24 VOLTS 2 for $1.00 Rated: 45ma @ 14 VOLTS

VARACTOR DIODE
MV2205 3 FOR $1.00 16 PF 100 FOR $30.00

BB-103 3 for $1.00 33 PF 100 FOR $30.00

CRYSTALS
CASE STYLE HC33/U

2 MHZ **$3.50 EACH**

COLORBURST 3579.545 KC **$1.00 EACH**

KEY SWITCH
S.P.S.T. 4 AMPS @ 125 VAC KEY REMOVES BOTH POSITIONS **$3.50 EA**

NEON W/ RESISTOR
7 for $1.00

DIRECT OPERATION FROM 120 VOLT

2 CHANNEL LIGHT ORGAN
EASILY HOOKS INTO STEREO SPEAKERS AND ALLOWS 110 VAC LIGHTS TO DANCE WITH MUSIC. TWO SEPARATE 110 VAC OUTPUTS FOR HIGH AND LOW FREQUENCY AUDIO SIGNALS. USE TWO ORGANS FOR STEREO . . .

$6.50 PER UNIT

COLOR LIGHT STRING AVAILABLE $1.75 EA

MICROWAVE TRANSISTOR
MRF 901 N.P.N. SILICON REDUCED TO **$2.00 EACH**

120V INDICATOR
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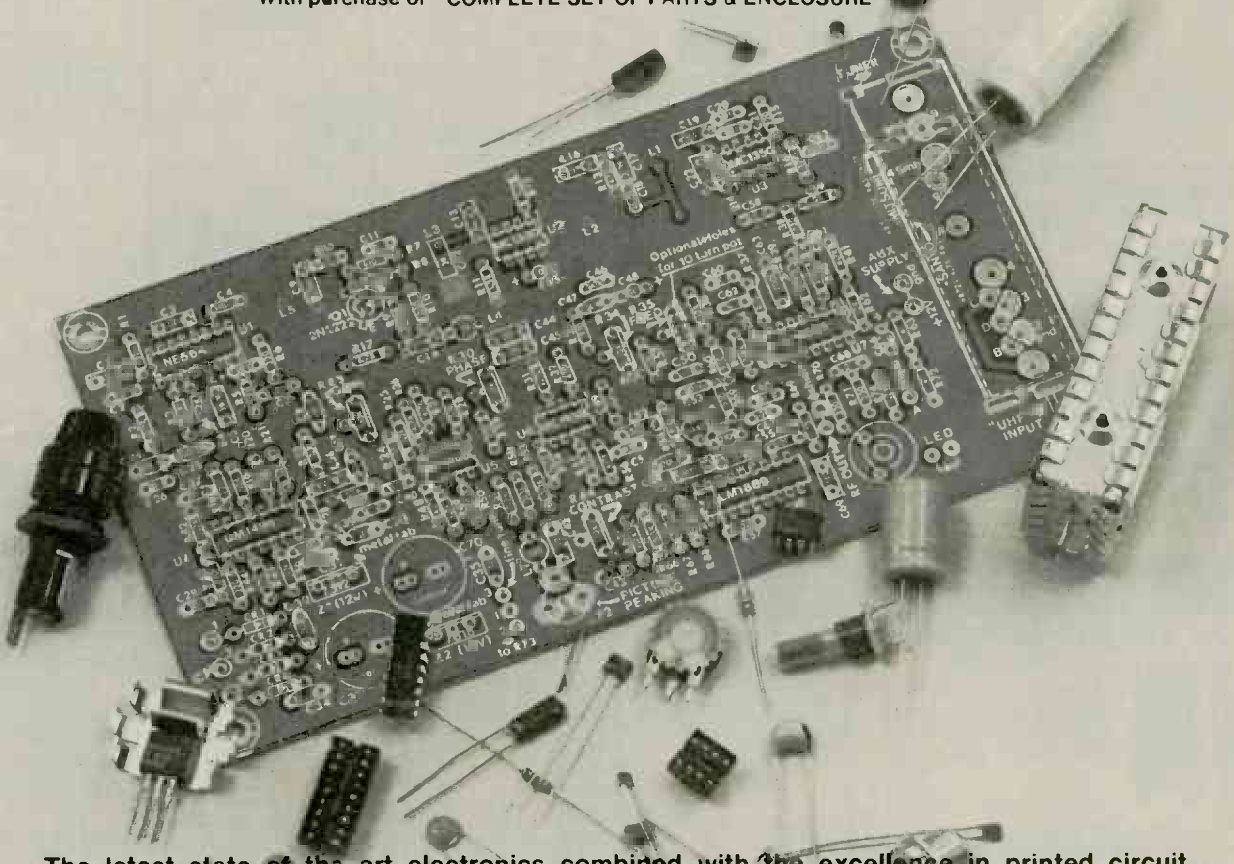

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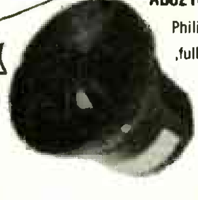

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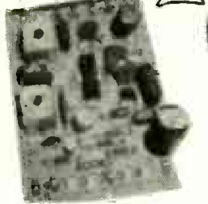

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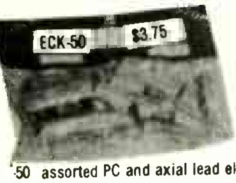

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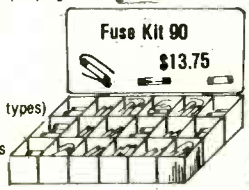

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74LS93	.55	74LS240	1.25	74LS568	3.99
74LS95B	.65	74LS241	1.25	74LS569	3.99
74LS107A	.45	74LS242	1.25	74LS620	2.00
74LS109A	.45	74LS243	1.25	74LS621	2.00
74LS112A	.45	74LS244	1.25	74LS622	2.00
74LS113A	.45	74LS245	1.75	74LS623	2.00
74LS114A	.60	74LS247	1.25	74LS640	2.00
74LS122	.80	74LS248	1.25		

7400

7400	.20	7475	.50
7401	.29	7476	.38
7402	.29	7485	1.10
7403	.29	7486	.35
7404	.31	7489	2.40
7405	.32	7490	.52
7406	.38	7492	.52
7408	.31	7493	.52
7410	.30	7495	.67
7411	.31	7496	.73
7413	.46	74107	.35
7414	.59	74121	.40
7417	.32	74123	.58
7420	.29	74125	.52
7425	.31	74145	.75
7427	.32	74147	1.67
7430	.30	74151	.75
7432	.31	74153	.75
7437	.31	74154	1.17
7438	.31	74157	.75
7440	.29	74164	1.05
7441	1.00	74165	1.05
7442	.60	74174	1.00
7446	.83	74175	.83
7447	.83	74176	.80
7448	.83	74177	.80
7450	.29	74190	1.08
7472	.35	74192	.99
7473	.35	74193	.99
7474	.35	74196	.80

VOLT-REGS

7805	.80	LM317T	1.00
7806	.80	LM317K	3.75
7808	.80	LM323K	6.95
7812	.80	LM350T	3.25
7815	.80	LM350K	5.50
7818	.80	LM338K	7.60
7824	.80	LM337T	1.90
7905	1.30	78L05	.40
7906	1.30	78L12	.40
7908	1.30	78L15	.40
7912	1.30	79L05	.80
7915	1.30	79L12	.80
7918	1.30	79L15	.80
7924	1.30	78H05KC	9.25
		78H12KC	9.25

LINEAR IC'S

LM301AN	.48	LM3900	.75	MC1489P	1.10
LM307N	.56	LM3909	1.00	MC1496P	1.48
LM308N	.71	LM3911	1.50	MC1723P	.62
LM310N	2.40	LF347	2.35	MC1741CP1	.56
LM311N	.69	LF351	.60	MC3301	.90
LM318N	2.50	LF353	.99	MC3302	.80
LM319N	2.40	LF357	1.10	MC3401	.90
LM324N	.71	NE555	.42	MC3403P	1.30
LM325N	3.30	MC1306P	1.10	MC1648P	3.80
LM326N	3.30	MC1310	4.29	MC1658P	4.50
LM556N	.93	MC1330A1P	1.50	MC4024P	4.49
LM339N	.69	MC1349P	1.17	MC4044P	4.49
LM383T	2.30	MC1350P	.98	ICM7208	15.95
LM377N	2.40	MC1351P	1.70	ICM7207A	6.00
LM378N	3.15	MC1357P	1.49	ICM7217A	9.95
LM379N	4.60	MC1358P	1.30	ICM7205	12.95
LM380N	.90	MC1372P	4.42	ICM7045	15.50
LM381N	2.25	MC1373P	3.54	ICL8038	3.40
LM381AN	3.60	MC1403U	2.71	ICM7555	1.20
LM384N	2.00	MC1405L	9.70	MWA110	7.45
LM386N	.99	MC1413P	1.20	MWA120	7.80
LM565N	1.35	MC1374P	2.61	MWA130	8.25
LM566N	2.30	MC1376P	2.08	MWA310	8.25
LM567N	1.35	MC1458CP1	.77	MWA320	8.65
LM1889	3.20	MC1488P	1.10	ZN414	2.00

CMOS

CD4001	.30	CD4046	1.50	MC14000	.40	MC14023	1.22
CD4007	.32	CD4047	1.40	MC14001	.40	MC14024	1.06
CD4010	.55	CD4049	.45	MC14002	.40	MC14024	.40
CD4011	.32	CD4050	.45	MC14006	1.42	MC14027	.72
CD4013	.45	CD4051	1.00	MC14007	.40	MC14028	1.02
CD4016	.50	CD4066	.65	MC14008	1.25	MC14032	1.93
CD4017	1.00	CD4069	.32	MC14012	.40	MC14034	3.50
CD4020	1.17	CD4070	.45	MC14013	.72	MC14035	1.86
CD4023	.32	CD4071	.32	MC14014	1.25	MC14038	2.19
CD4024	.83	CD4081	.32	MC14015	1.47	MC14040	1.47
CD4025	.32	CD4093	.60	MC14016	.72	MC14042	1.06
CD4027	.55	CD4510	1.17	MC14017	1.25	MC14043	.99
CD4029	1.42	CD4511	1.20	MC14018	1.15	MC14044	.99
CD4040	1.17	CD4515	2.80	MC14020	1.47	MC14046	1.57
CD4044	.80	CD4518	1.17	MC14021	1.25	MC14049	.72

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CIRCLE 39 ON FREE INFORMATION CARD

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The Big DIGI-KEY Discount makes a Big Price Difference (SEE BELOW)

ITT SILICON RECTIFIERS ZENER DIODES

3 AMP SILICON RECTIFIER

Part	PIV	Surge (10ms)	VF
3A	50V	100A	1.1V

Part	1	10	100	1000
PR5400	.35	3.00	27.50	250.00

ITT RECTIFIERS

Cat. No.	Description	Pkg.	10	100	1000	10,000
1N4001	1 Amp 50 PIV	DO 41	.80	7.00	60.00	540.00
1N4002	1 Amp 100 PIV	DO 41	.80	7.00	60.00	540.00
1N4003	1 Amp 200 PIV	DO 41	.80	7.50	64.00	576.00
1N4004	1 Amp 400 PIV	DO 41	.80	7.90	68.00	612.00
1N4005	1 Amp 600 PIV	DO 41	1.00	8.00	74.00	666.00
1N4006	1 Amp 800 PIV	DO 41	1.00	9.00	80.00	720.00
1N4007	1 Amp 1000 PIV	DO 41	1.50	12.00	100.00	900.00
1N4148	Ultra Fast Switching Diode (1N914 equiv.)	DO 41	.60	5.00	32.00	276.60

ITT SILICON ZENER DIODES

Catalog Number	Description	Unit Price	10
1N5226B	3.3 V 5% 500mW Zener (1N746A equiv.)	.24	1.80
1N5227B	3.6 V 5% 500mW Zener (1N747A equiv.)	.24	1.80
1N5228B	3.9 V 5% 500mW Zener (1N748A equiv.)	.24	1.80
1N5229B	4.3 V 5% 500mW Zener (1N749A equiv.)	.24	1.80
1N5230B	4.7 V 5% 500mW Zener (1N750A equiv.)	.24	1.80
1N5231B	5.1 V 5% 500mW Zener (1N751A equiv.)	.24	1.80
1N5232B	5.6 V 5% 500mW Zener (1N752A equiv.)	.24	1.80
1N5233B	6.0 V 5% 500mW Zener	.24	1.80
1N5234B	6.2 V 5% 500mW Zener (1N753A equiv.)	.24	1.80
1N5235B	6.8 V 5% 500mW Zener (1N957B equiv.)	.24	1.80
1N5236B	7.5 V 5% 500mW Zener (1N958B equiv.)	.24	1.80
1N5237B	8.2 V 5% 500mW Zener (1N959B equiv.)	.24	1.80
1N5238B	8.7 V 5% 500mW Zener	.24	1.80
1N5239B	9.1 V 5% 500mW Zener (1N960B equiv.)	.24	1.80
1N5240B	10 V 5% 500mW Zener (1N961B equiv.)	.24	1.80
1N5241B	11 V 5% 500mW Zener (1N962B equiv.)	.24	1.80
1N5242B	12 V 5% 500mW Zener (1N963B equiv.)	.24	1.80
1N5243B	13 V 5% 500mW Zener (1N964B equiv.)	.24	1.80
1N5244B	14 V 5% 500mW Zener	.24	1.80
1N5245B	15 V 5% 500mW Zener (1N965B equiv.)	.24	1.80
1N5246B	16 V 5% 500mW Zener (1N966B equiv.)	.24	1.80
1N5247B	17 V 5% 500mW Zener	.24	1.80
1N5248B	18 V 5% 500mW Zener (1N967B equiv.)	.24	1.80
1N5249B	19 V 5% 500mW Zener	.24	1.80
1N5250B	20 V 5% 500mW Zener (1N968B equiv.)	.24	1.80
1N5251B	22 V 5% 500mW Zener (1N969B equiv.)	.24	1.80
1N5252B	24 V 5% 500mW Zener (1N970B equiv.)	.24	1.80
1N5253B	25 V 5% 500mW Zener	.24	1.80
1N5254B	27 V 5% 500mW Zener (1N971B equiv.)	.24	1.80
1N5255B	28 V 5% 500mW Zener	.24	1.80
1N5256B	30 V 5% 500mW Zener (1N972B equiv.)	.24	1.80
1N5257B	33 V 5% 500mW Zener (1N973B equiv.)	.24	1.80

Littlefuse Fuses

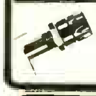
3AG "NORMAL-BLO" FUSES

DIGI-KEY Part No.	Amp Rtg.	5	100	1,000
F100-ND	.010	13.70	206.00	926.00/M
F101-ND	.031	11.00	165.00	741.00/M
F102-ND	.062	4.00	80.00	270.00/M
F103-ND	.100	4.00	60.00	270.00/M
F104-ND	.125	4.00	60.00	270.00/M

3AG "SLO-BLO" FUSES

DIGI-KEY Part No.	Amp Rtg.	5	100	1,000
F338-ND	15	3.54	53.10	239.00/M
F339-ND	20	3.54	53.10	239.00/M
F340-ND	25	3.54	53.10	239.00/M
F341-ND	30	3.54	53.10	239.00/M

3AG PANEL FUSEHOLDER



Black phenolic conforming to MIL M-14, type CFG. Rated at 20 amps for any voltage to 250. Includes neoprene washer, hex nut, and lock washer.

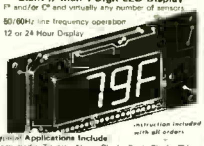
Part No.	1	10	100
F004-ND	1.89	15.00	94.50

National Semiconductor

MA1026 Time-Temp. Clock Module

Giant .7 Inch 4-Digit LED Display

- F° and/or C° and virtually any number of sensors
- 50/60Hz line frequency operation
- 12 or 24 Hour Display



Instruction included with all orders

Typical Applications Include
Clock Radio Timers, Alarm Clock, Desk Clock, TV and Stereo Timer, Instrument Panel Clock, Digital Thermometer and much more

Part No.	Description	Price
MA1026M	MA1026 clock module only	$27.79
MA1026P	Digi Key switch panel kit (P.C. Board, 12 switches, two LM334Z temp sensors, two KOA32 potentiometers, instructional	11.95
MA1026T	110 VAC transformer for MA1026M	3.10
MA1026B	Alarm buzzer for MA1026M	3.36
MA1026K	MA1026M, P, T, B	42.95

For additional sensor units, you will need

LM334Z	Temperature Sensor	1.51
K4A32	300 ohm Potentiometer	.32
502PB	Normally open SPST Switch	.56

"Programmable" Clock Mudules

0.7" or 0.84" Red 4-Digit LED Display

User Programmable For:
- 12 or 24 hour display
- 50/60 Hz line frequency
- Fixed or flashing dot (colon indicator)
- Display, hours and minutes, minute and seconds, alarm time, and sleep time
- Battery back-up in case of power failure
- Typical applications include: clock radio timer, alarm clock, desk clock, instrument panel clock and many more

MA1020 — 0.84 INCH HIGH DIGITS

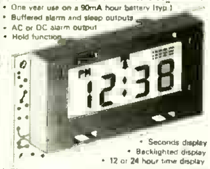
Cat. No.	Description	Price
MA1020M	MA1020 Clock Module only	$17.55
MA1020P	Digi Key switching panel (includes P.C. board, switches, hardware and instructions.)	7.95
MA1020T	110 VAC Transformer for MA1020M	3.10
MA1020B	Buzzer for MA1020M alarm output	3.36
MA1020K	MA1020M, P, B and T	30.95

MA1023 — 0.7 INCH HIGH DIGITS

Cat. No.	Description	Price
MA1023M	MA1023 Clock Module only	$11.70
MA1023P	Digi Key switching panel (includes P.C. board, switches, hardware and instructions.)	6.95
MA1023T	110 VAC Transformer for MA1023M	3.10
MA1023B	Buzzer for MA1023 alarm output	3.36
MA1023K	MA1023M, P, B and T	23.95

.5" 4-Digit LCD Clock

National Semiconductor MA1032 Clock Module
- One year use on a 90mA hour battery (typ.)
- Buffered alarm and sleep outputs
- AC or DC alarm output
- Hold function



- Seconds display
- Backlighted display
- 12 or 24 hour time display

Cat. No.	Description	Price
MA1032M	MA1032 Clock Module only	$17.95
MA1032C	Switches for MA1032	2.85
MA1032R	MA1032M, C, and AA battery holder	21.20

DIGI-CLOCK KIT

Part No. 5001K ONLY $17.95

LED's — Red, Green, Amber, Orange

3 mm, 4 mm, 5 mm, Round, Rectangular Arrow

Panasonic LED Numeric Displays

Red, Green, Amber and Orange Colors — Direct Drive

Comm. Anode	Comm. Cath	Digits	Color	Size In.	1	10	100
P329	P350	8	Orange	.43	2.10	19.32	176.00
P330	P351	8	Red	.57	1.58	14.50	132.00
P331	P352	8	Green	.57	1.90	17.60	159.00
P332	P353	8	Amber	.57	1.93	17.70	162.00
P333	P354	8	Orange	.57	2.25	20.70	188.00
P334	P355	88	Red	.43	2.10	19.30	176.00
P335	P356	88	Green	.43	2.45	22.50	205.00
P336	P357	88	Amber	.43	3.08	28.30	257.00
P337	P358	88	Red	.57	2.10	19.30	176.00
P338	P359	88	Green	.57	2.45	22.50	205.00
P339	P360	88	Amber	.57	3.58	32.90	299.00
P340*	P361*	8888	Red	.28	5.35	49.20	448.00
P341*	P362*	8888	Green	.28	6.16	56.60	516.00

* Multiplexed Display

Silicon Transistors

DIGI-KEY Part No.	1	10	100	1,000
2N3055	1.44	12.00	108.00	960.00
2N3904	.20	1.79	16.25	146.25
2N3906	.20	1.79	16.25	146.25
2N4124	.21	1.93	17.50	157.50
2N4126	.22	2.01	18.25	164.25
2N4401	.21	1.93	17.50	157.50
2N4403	.21	1.93	17.50	157.50
2N4410	.30	2.70	24.38	219.38
2N5087	.24	2.20	20.00	180.00
2N5089	.24	2.20	20.00	180.00
2N5210	.27	2.48	22.50	202.50
2N5457	.54	4.86	43.88	394.88
92PU01A	.38	3.42	30.88	277.88
92PU10	.38	3.42	30.88	277.88
92PU45A	.41	3.69	33.32	299.82
92PU51A	.38	3.42	30.88	277.88
MJ2955	1.47	13.48	122.50	1102.25
MJE172	.74	6.66	60.13	541.13
MJE182	.66	5.56	46.25	416.25
MJE3439	.56	4.80	40.00	360.00
MJE344	.68	6.12	55.25	497.25
MJE370	.89	8.01	72.32	650.82
MJE371	1.10	9.90	89.38	804.38
MJE520	.86	7.74	69.88	628.88
MJE521	.86	7.74	69.88	628.88
MJE703	1.13	10.17	91.82	826.31
MJE712	.74	6.66	60.13	541.13
MJE722	.74	6.66	60.13	541.13
MJE803	1.01	9.09	82.07	738.57
MPF102	.54	4.95	45.00	405.00
MPS2222A	.21	1.93	17.50	157.50
MPS2369A	.24	2.20	20.00	180.00
MPS2907A	.24	2.20	20.00	180.00
MPS3392	.23	2.07	18.75	169.00
MPS3393	.21	1.93	17.50	157.50
MPS3394	.24	2.20	20.00	180.00
MPS3395	.24	2.20	20.00	180.00
MPS3563	.21	1.93	17.50	157.50
MPS3565	.21	1.93	17.50	157.50
MPS3638A	.21	1.93	17.50	157.50
MPS3641	.21	1.93	17.50	157.50
MPS3643	.21	1.93	17.50	157.50
MPS918	.22	1.98	17.88	160.88
MPS930	.21	1.93	17.50	157.50
MPSA13	.27	2.48	22.50	202.50
TIP112	.98	8.40	70.00	630.00
TIP117	1.12	10.08	91.00	819.00
TIP120	1.17	10.73	97.50	877.50
TIP122	1.54	13.20	110.00	990.00
TIP127	1.54	13.20	110.00	990.00
TIP132	2.32	20.88	188.50	1696.50
TIP135	2.32	20.88	188.50	1696.50
TIP29C	.81	6.90	57.50	517.50
TIP30C	.81	6.90	57.50	517.50
TIP31C	.98	8.40	70.00	630.00
TIP32C	1.02	8.70	72.50	652.50
TIP61C	.81	6.90	57.50	517.50
TIP62C	.81	6.90	57.50	517.50

1% Metal Film Resistors

¼ Watt • Temperature Coefficient • 100 ppm/°C
Max. RC WV: 250V Max. Voltage: 500V
Dielectric Withstanding Voltage: 500V

Standard Resistor Values from 10 to 1.00M ohms
STANDARD RESISTOR VALUE TABLE

How To Order: Take any standard resistor value (2.32K) and add an "X" (2.32KX), this is the DIGI-KEY part number. Order by quantity and price listed below.

For large quantities and prices as low as 19.25/M, contact DIGI-KEY.

5% Carbon Film Resistors

Remember a "Q" after the resistance value indicates a ¼ watt, an "H" indicates a ½ watt (i.e., 10KQ or 10KH). Prices are for single values

¼ Watt	5 for 25¢, 200 for $3.40, 1000 for $13.00
½ Watt	5 for 25¢; 200 for $3.60, 1000 for $16.00

In order to receive the pricing below, the resistor part number must be followed by a "ND" (i.e., 10KQ-ND) and ordered in multiples of 1,000 only.

Price /1000	1M	10M	50M	100M	500M	1000M
¼ W	8.10/M	7.20/M	5.80/M	5.40/M	4.60/M	4.00/M
½ W	12.25/M	10.25/M	9.50/M	8.90/M	7.40/M	6.65/M

ROBINSON NUGENT INC

TERMINATION JUMPERS

S = SOCKET CONNECTOR TERMINATION
P = PCB CONNECTOR TERMINATION
K = CARD EDGE CONNECTOR TERMINATION

Number After Dash Is Cable Length In Inches

DIP Jumper Cable Assembly

Standard Assembly Styles

alpha wire cable tubing

Hookup Wire, Stranded, PVC Insulated

Hookup Wire, Solid, PVC Insulated

Multiconductor, Solid, PVC Insulated Cable

Multiconductor, Stranded, PVC Insulated Cable

Twisted Pair, Solid, Comm. and Control Cable

Shrinkable Tubing, Polyolefin, Black

Self-Encapsulating Cross Black

D-Subminiature Connectors

9, 15, 25, 37, and 50 contact solder pot contacts.
Accommodates up to 20 AWG standard wire.
Current Rating of 5 Amps
Contacts: Pin, copper, alloy, gold over nickel plate, Socket, phosphore bronze, gold over nickel plate
Temperature Range -55° to +120°C

The Digi-Key volume discount and handling charges are simple to apply. Most items sold by Digi-Key may be combined for a volume discount. Items that are not discountable are identified by the suffix-ND following the part number. After writing your order, total all of the discountable items and apply the appropriate discount. To this subtotal, add the non-discountable items. Then add the handling charge. We pay all shipping and insurance to addresses in the U.S.A., Canada and Mexico when check or money order accompanies order.

WHEN ORDERING BY PHONE, CALL 1-800-346-5144 (Mn., Ak., Hi., call 218-681-6674) By mail send your order to: DIGI-KEY, Highway 32 South, Thief River Falls, MN 56701

You may pay by check, money order, Master Charge, VISA or C.O.D. ***DIGI-KEY GUARANTEE:*** Any parts or products purchased from Digi-Key that prove to be defective will be replaced or refunded if returned within 90 days from receipt with a copy of your invoice. Prices subject to change without notice.

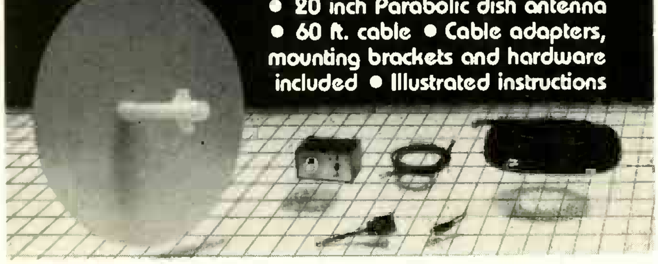
HANDLING CHARGES		VOLUME DISCOUNT	
$ 0.00-$ 9.99	Add $2.00	$ 0.00-$ 99.99	NET
$ 10.00-$25.00	Add $0.75	$ 100.00-$249.99	Less 10%
$ 25.00-$49.99	Add $0.50	$ 250.00-$499.99	Less 15%
$ 50.00-$99.99	Add $0.25	$ 500.00-$999.99	Less 20%
$100.00 & Up	No Charge	$1000.00 & Up	Less 25%

CIRCLE 39 ON FREE INFORMATION CARD

SKYFOX

State-of-the-Art Excellence

SKYFOX DESIGN PERFORMANCE FEATURES:
- Gain 55 db • Frequency 1.9-2.5 GHZ
- Range 55 miles maximum
- Tuning channels 2-6
- 20 inch Parabolic dish antenna
- 60 ft. cable • Cable adapters, mounting brackets and hardware included • Illustrated instructions



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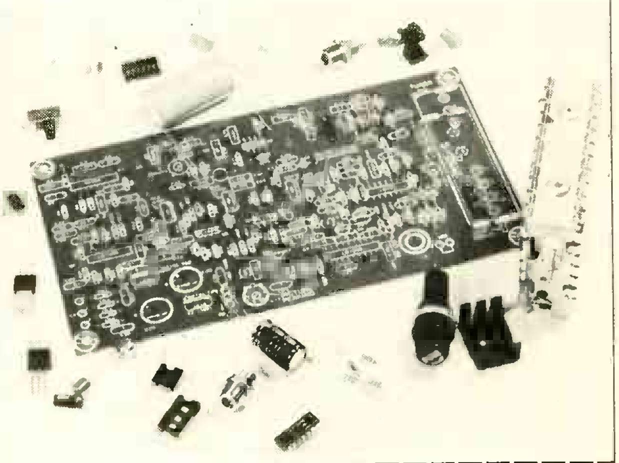

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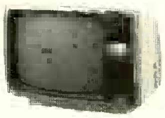

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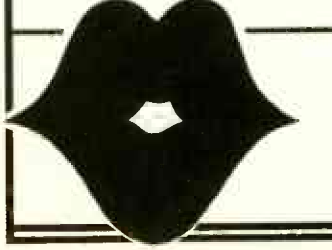

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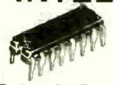

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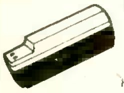

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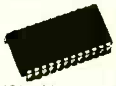

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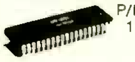

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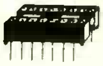

	1-24	25-49	50-100
8 pin LP	.16	.15	.14
14 pin LP	.20	.19	.18
16 pin LP	.22	.21	.20
18 pin LP	.29	.28	.27
20 pin LP	.34	.32	.30
22 pin LP	.29	.27	.24
24 pin LP	.38	.37	.36
28 pin LP	.45	.44	.43
40 pin LP	.60	.59	.58

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10 pin WW (Tin)	.65	.63	.58
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24 pin WW	1.35	1.26	1.14
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LM307CN	.29	LM2111N	1.75
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LM319N/H	1.25	CA3035T	2.75
LM320K-XX*	1.35	CA3039T	1.29
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LM358CN	.98	CA3097N	1.99
LM360N	1.49	CA3130T	1.30
LM372N	1.95	CA3140T	1.19
LM376N	3.75	CA3146N	2.49
LM377N	2.75	CA3160T	1.19
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NE555V	.39	LM3905N	1.19
NE556N	.98	LM3909N	98
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LM748N/H	.39	SN75492N	.89
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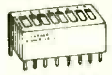

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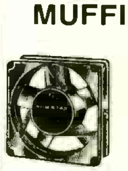

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- 105cfm free air delivery
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7400	$ .19	7475	$ .38	74161	$ .88
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7402	.22	7479	4.60	74163	.87
7403	.22	7480	.49	74164	.87
7404	.22	7482	.95	74165	.87
7405	.23	7483	.55	74166	1.20
7406	.35	7485	.65	74167	1.95
7407	.35	7486	.35	74170	1.69
7408	.26	7489	1.75	74172	4.75
7409	.23	7490	.39	74173	.79
7410	.22	7491	.57	74174	.89
7411	.29	7492	45	74175	.85
7412	.29	7493	.45	74176	.75
7413	.39	7494	.69	74177	.75
7414	.59	7495	.65	74179	1.34
7416	.29	7496	.69	74180	.75
7417	.29	7497	2.90	74181	1.75
7420	.22	74100	2.90	74182	.75
7421	.35	74107	.32	74184	2.25
7422	.29	74109	.37	74185	2.25
7423	.29	74116	1.95	74186	9.95
7425	.29	74121	.29	74188	3.90
7426	.29	74122	.39	74190	1.15
7427	.25	74123	.59	74191	1.15
7429	.45	74125	.39	74192	.85
7430	.23	74126	.44	74193	.85
7432	.29	74128	.59	74194	.85
7437	.25	74132	.69	74195	.68
7438	.29	74136	.75	74196	.85
7439	.29	74139	.95	74197	.85
7440	.19	74141	.79	74198	1.39
7441	.79	74142	2.95	74199	1.39
7442	.57	74143	2.95	74221	1.19
7443	.95	74144	2.95	74251	.95
7444	.95	74145	.62	74273	1.05
7445	.79	74147	1.95	74276	1.89
7446	.79	74148	1.20	74279	.75
7447	.65	74150	1.09	74283	1.40
7448	.79	74151	.67	74284	3.90
7450	.19	74152	.67	74285	3.90
7451	.19	74153	.67	74290	1.25
7453	.19	74154	1.19	74298	.95
7454	.19	74155	.78	74365	68
7459	.25	74156	.78	74366	.68
7460	.23	74157	.69	74367	.68
7470	.29	74158	1.65	74368	.68
7472	.29	74159	2.49	74390	1.45
7473	.34	74160	.88	74393	1.90
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74LS00

74LS00	$ 26	74LS113	$ .43	74LS245	$2.20
74LS01	.28	74LS114	.43	74LS247	1.10
74LS02	28	74LS122	.55	74LS248	1.10
74LS03	.28	74LS123	1.19	74LS249	1.19
74LS04	35	74LS124	1.35	74LS251	1.40
74LS05	.28	74LS125	.89	74LS253	1.40
74LS08	.28	74LS126	.52	74LS257	.85
74LS09	.35	74LS132	.79	74LS258	.98
74LS10	.28	74LS136	.49	74LS259	2.95
74LS11	.39	74LS138	.85	74LS260	.65
74LS12	.33	74LS139	.85	74LS261	2.49
74LS13	.47	74LS145	1.25	74LS266	.59
74LS14	95	74LS148	1.49	74LS273	1.75
74LS15	.33	74LS151	.79	74LS275	4.40
74LS20	.26	74LS153	.79	74LS279	59
74LS21	.33	74LS154	1.70	74LS283	.99
74LS22	.33	74LS155	1.19	74LS290	.99
74LS26	.33	74LS156	.99	74LS293	.99
74LS27	.33	74LS157	.85	74LS295	1.10
74LS28	.33	74LS158	.75	74LS298	1.19
74LS30	.26	74LS160	1.05	74LS324	1.75
74LS32	.33	74LS161	1.15	74LS347	1.95
74LS33	.55	74LS162	1.05	74LS348	1.95
74LS37	.45	74LS163	1.05	74LS352	1.19
74LS38	.39	74LS164	1.19	74LS353	1.19
74LS40	.26	74LS165	.89	74LS363	1.49
74LS42	.79	74LS166	2.48	74LS365	.69
74LS47	.79	74LS168	1.15	74LS366	.69
74LS48	.95	74LS169	1.15	74LS367	.69
74LS51	.26	74LS170	1.99	74LS368	.69
74LS54	.29	74LS173	.89	74LS373	1.89
74LS55	.29	74LS174	.89	74LS374	1.89
74LS73	.45	74LS175	.89	74LS375	.69
74LS74	.42	74LS181	2.20	74LS377	1.95
74LS75	.59	74LS190	1.15	74LS385	1.95
74LS76	.45	74LS191	1.15	74LS386	.65
74LS78	.45	74LS192	.98	74LS390	1.95
74LS83A	.79	74LS193	.98	74LS393	1.95
74LS85	1.19	74LS194	1.15	74LS395	1.70
74LS86	.45	74LS195	.95	74LS399	2.35
74LS90	.57	74LS196	.89	74LS424	2.95
74LS92	.75	74LS197	.89	74LS668	1.75
74LS93	.75	74LS221	1.15	74LS670	2.29
74LS95	.88	74LS240	1.69	81LS95	1.69
74LS96	.98	74LS242	1.69	81LS96	1.69
74LS107	.45	74LS243	1.69	81LS97	1.69
74LS109	.45	74LS244	1.49	81LS98	1.69
74LS112	.43				

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4000	$ .35	4037	$1.95	4089	$2.95
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4002	.35	4041	1.25	4094	2.95
4006	1.05	4042	.95	4098	2.29
4007	.25	4043	.85	4099	2.25
4008	1.39	4044	85	14408	12.95
4009	.45	4046	1.75	14409	12.95
4010	.45	4047	1.25	14410	12.95
4011	.35	4048	.99	14412	12.95
4012	.25	4049	.45	14415	8.95
4013	.45	4050	.69	14419	4.95
4014	1.39	4051	1.10	4501	.39
4015	1.15	4052	1.10	4502	1.65
4016	.59	4053	1.10	4503	.69
4017	1.19	4055	3.95	4505	8.95
4018	.89	4056	2.95	4506	.75
4019	.45	4059	9.25	4507	.95
4020	1.10	4060	1.39	4508	3.75
4021	1.19	4066	.75	4510	1.19
4022	1.15	4069	35	4511	1.19
4023	.29	4070	.49	4512	1.39
4024	.75	4071	.35	4515	2.75
4025	.25	4072	.35	4516	1.45
4027	.65	4073	.35	4518	1.39
4028	85	4075	.35	4520	1.25
4029	1.29	4076	1.29	4555	4.95
4030	.45	4077	.35	4556	.99
4031	3.25	4078	.35	4566	2.25
4032	2.15	4081	.35	80C95	1.50
4034	3.25	4082	.35	80C97	1.25
4035	.95	4085	1.95		

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74LS241	2/1.99	2758 EPROM	2.95	2732	6.95	MM5320	5.99
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LM733CN	3/1.99	6522	6.95	2708 EPROM	8/29.95	10415	4.95
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TMM2016 2KX8 STATIC 200 NS $4.15

STATIC RAMS

2101	256 x 4 (450ns)	1.95
5101	256 x 4 (450ns) (cmos)	3.95
2102-1	1024 x 1 (450ns)	.89
2102L-4	1024 x 1 (450ns) (LP)	.99
2102L-2	1024 x 1 (250ns) (LP)	1.49
2111	256 x 4 (450ns)	2.49
2112	256 x 4 (450ns)	2.99
2114	1024 x 4 (450ns)	8/9.95
2114-25	1024 x 4 (250ns)	8/10.95
2114L-4	1024 x 4 (450ns) (LP)	8/12.95
2114L-3	1024 x 4 (300ns) (LP)	8/13.45
2114L-2	1024 x 4 (200ns) (LP)	8/13.95
2147	4096 x 1 (55ns)	4.95
TMS4044-4	4096 x 1 (450ns)	3.49
TMS4044-3	4096 x 1 (300ns)	3.99
TMS4044-2	4096 x 1 (200ns)	4.49
MK4118	1024 x 8 (250ns)	9.95
TMM2016-200	2048 x 8 (200ns)	4.15
TMM2016-150	2048 x 8 (150ns)	4.95
TMM2016-100	2048 x 8 (100ns)	6.15
HM6116-4	2048 x 8 (200ns) (cmos)	4.75
HM6116-3	2048 x 8 (150ns) (cmos)	4.95
HM6116-2	2048 x 8 (120ns) (cmos)	8.95
HM6116LP-4	2048 x 8 (200ns) (cmos)(LP)	5.95
HM6116LP-3	2048 x 8 (150ns) (cmos)(LP)	6.95
HM6116LP-2	2048 x 8 (120ns) (cmos)(LP)	10.95
Z-6132	4096 x 8 (300ns) (Qstat)	34.95

LP = Low Power   Qstat = Quasi-Static

DYNAMIC RAMS

TMS4027	4096 x 1 (250ns)	1.99
UPD411	4096 x 1 (300ns)	3.00
MM5280	4096 x 1 (300ns)	3.00
MK4108	8192 x 1 (200ns)	1.95
MM5298	8192 x 1 (250ns)	1.85
4116-300	16384 x 1 (300ns)	8/11.75
4116-250	16384 x 1 (250ns)	8/11.95
4116-200	16384 x 1 (200ns)	8/12.95
4116-150	16384 x 1 (150ns)	8/14.95
4116-120	16384 x 1 (120ns)	8/29.95
2118	16384 x 1 (150ns) (5v)	4.95
4164-200	65536 x 1 (200ns) (5v)	5.95
4164-150	65536 x 1 (150ns) (5v)	6.95

5V = single 5 volt supply

EPROMS

1702	256 x 8 (1us)	4.50
2708	1024 x 8 (450ns)	3.95
2758	1024 x 8 (450ns) (5v)	5.95
2716	2048 x 8 (450ns) (5v)	3.95
2716-1	2048 x 8 (350ns) (5v)	5.95
TMS2516	2048 x 8 (450ns) (5v)	5.50
TMS2716	2048 x 8 (450ns)	7.95
TMS2532	4096 x 8 (450ns) (5v)	5.95
2732	4096 x 8 (450ns) (5v)	4.95
2732-250	4096 x 8 (250ns) (5v)	8.95
2732-200	4096 x 8 (200ns) (5v)	11.95
2764	8192 x 8 (450ns) (5v)	9.95
2764-250	8192 x 8 (250ns) (5v)	14.95
2764-200	8192 x 8 (200ns) (5v)	24.95
TMS2564	8192 x 8 (450ns) (5v)	17.95
MC68764	8192 x 8 (450ns) (5v)(24 pin)	39.95
27128	16384x8 Call	Call

5v = Single 5 Volt Supply

EPROM ERASERS

	Timer	Capacity Chip	Intensity (uW/Cm²)	
PE-14		6	5,200	83.00
PE-14T	X	6	5,200	119.00
PE-24T	X	9	6,700	175.00
PL-265T	X	20	6,700	255.00
PR-125T	X	16	15,000	349.00
PR-320	X	32	15,000	595.00

Z-80

2.5 Mhz

Z80-CPU	3.95
Z80-CTC	4.49
Z80-DART	10.95
Z80-DMA	14.95
Z80-PIO	4.49
Z80-SIO/0	16.95
Z80-SIO/1	16.95
Z80-SIO/2	16.95
Z80-SIO/9	16.95

4.0 Mhz

Z80A-CPU	4.95
Z80A-CTC	4.95
Z80A-DART	11.95
Z80A-DMA	16.95
Z80A-PIO	4.95
Z80A-SIO/0	16.95
Z80A-SIO/1	16.95
Z80A-SIO/2	16.95
Z80A-SIO/9	16.95

6.0 Mhz

Z80B-CPU	11.95
Z80B-CTC	13.95
Z80B-PIO	13.95
Z80B-DART	19.95

ZILOG

Z6132	34.95
Z8671	39.95

CRYSTALS

32.768 khz	1.95
1.0 mhz	4.95
1.8432	4.95
2.0	3.95
2.097152	3.95
2.4576	3.95
3.2768	3.95
3.579535	3.95
4.0	3.95
5.0	3.95
5.0688	3.95
5.185	3.95
5.7143	3.95
6.0	3.95
6.144	3.95
6.5536	3.95
8.0	3.95
10.0	3.95
10.738635	3.95
14.31818	3.95
15.0	3.95
16.0	3.95
17.430	3.95
18.0	3.95
18.432	3.95
20.0	3.95
22.1184	3.95
32.0	3.95

CRT CONTROLLERS

6845	14.95
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6847	11.95
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68047	24.95
8275	29.95
7220	99.95
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CRT5037	49.95
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DP8350	49.95

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AY5-3600 PRO	11.95

8000

8035	5.95
8039	6.95
INS-8060	17.95
INS-8073	24.95
8080	3.95
8085	5.95
8085A-2	11.95
8086	29.95
8087	CALL
8088	39.95
8089	89.95
8155	6.95
8155-2	7.95
8156	6.95
8185	29.95
8185-2	39.95
8741	39.95
8748	24.95
8755	24.95

8200

8202	24.95
8203	39.95
8205	3.50
8212	1.80
8214	3.85
8216	1.75
8224	2.25
8226	1.80
8228	3.49
8237	19.95
8237-5	21.95
8238	4.49
8243	4.45
8250	10.95
8251	4.49
8253	6.95
8253-5	7.95
8255	4.49
8255-5	5.25
8257	7.95
8257-5	8.95
8259	6.90
8259-5	7.50
8271	39.95
8272	39.95
8275	29.95
8279	8.95
8279-5	10.00
8282	6.50
8283	6.50
8284	5.50
8286	6.50
8287	6.50
8288	25.00
8289	49.95

DISC CONTROLLERS

1771	16.95
1791	24.95
1793	26.95
1795	49.95
1797	49.95
2791	54.95
2793	54.95
2795	59.95
2797	59.95
6843	34.95
8272	39.95
UPD765	39.95
MB8876	29.95
MB8877	34.95
1691	17.95
2143	18.95

CONNECTORS

RS232 MALE	2.50
RS232 FEMALE	3.25
RS232 HOOD	1.25
S-100 ST	3.95

6800

68000	59.95
6800	3.95
6802	7.95
6808	13.90
6809E	19.95
6809	11.95
6810	2.95
6820	4.35
6821	3.25
6828	14.95
6840	12.95
6843	34.95
6844	25.95
6845	14.95
6847	11.95
6850	3.25
6852	5.75
6860	9.95
6862	11.95
6875	6.95
6880	2.25
6883	22.95
68047	24.95
68488	19.95

6800 = 1MHZ

68B00	10.95
68B02	22.25
68B09E	29.95
68B09	29.95
68B10	6.95
68B21	6.95
68B45	19.95
68B50	5.95

68B00 = 2 MHZ

6500

1 MHZ

6502	4.95
6504	6.95
6505	8.95
6507	9.95
6520	4.35
6522	7.95
6532	9.95
6545	22.50
6551	11.85

2 MHZ

6502A	6.95
6522A	9.95
6532A	11.95
6545A	27.95
6551A	11.95

3 MHZ

6502B	14.95

UARTS

AY3-1014	6.95
AY5-1013	3.95
AY3-1015	6.95
PT1472	9.95
TR1602	3.95
2350	9.95
2651	8.95
TMS6011	5.95
IM6402	7.95
IM6403	8.95
INS8250	10.95

GENERATORS

BIT-RATE

MC14411	11.95
BR1941	11.95
4702	12.95
COM5016	16.95
COM8116	10.95
MM5307	10.95

FUNCTION

MC4024	3.95
LM566	1.49
XR2206	3.75
8038	3.95

74LS00

74LS00	.24	74LS173	.69
74LS01	.25	74LS174	.55
74LS02	.25	74LS175	.55
74LS03	.25	74LS181	2.15
74LS04	.24	74LS189	8.95
74LS05	.25	74LS190	.89
74LS08	.28	74LS191	.89
74LS09	.29	74LS192	.79
74LS10	.25	74LS193	.79
74LS11	.35	74LS194	.69
74LS12	.35	74LS195	.69
74LS13	.45	74LS196	.79
74LS14	.59	74LS197	.79
74LS15	.35	74LS221	.89
74LS20	.25	74LS240	.95
74LS21	.29	74LS241	.99
74LS22	.25	74LS242	.99
74LS26	.29	74LS243	.99
74LS27	.29	74LS244	1.29
74LS28	.35	74LS245	1.49
74LS30	.25	74LS247	.75
74LS32	.29	74LS248	.99
74LS33	.55	74LS249	.99
74LS37	.35	74LS251	.59
74LS38	.35	74LS253	.59
74LS40	.25	74LS257	.59
74LS42	.49	74LS258	.59
74LS47	.75	74LS259	2.75
74LS48	.75	74LS260	.59
74LS49	.75	74LS266	.55
74LS51	.25	74LS273	1.49
74LS54	.29	74LS275	3.35
74LS55	.29	74LS279	.49
74LS63	1.25	74LS280	1.98
74LS73	.39	74LS283	.69
74LS74	.35	74LS290	.89
74LS75	.39	74LS293	.89
74LS76	.39	74LS295	.99
74LS78	.49	74LS298	.89
74LS83	.60	74LS299	1.75
74LS85	.69	74LS323	3,50
74LS86	.39	74LS324	1.75
74LS90	.55	74LS352	1.29
74LS91	.89	74LS353	1.29
74LS92	.55	74LS363	1.35
74LS93	.55	74LS364	1.95
74LS95	.75	74LS365	.49
74LS96	.89	74LS366	.49
74LS107	.39	74LS367	.45
74LS109	.39	74LS368	.45
74LS112	.39	74LS373	1.39
74LS113	.39	74LS374	1.39
74LS114	.39	74LS377	1.39
74LS122	.45	74LS378	1.18
74LS123	.79	74LS379	1.35
74LS124	2.90	74LS385	1.90
74LS125	.49	74LS386	.45
74LS126	.49	74LS390	1.19
74LS132	.59	74LS393	1.19
74LS133	.59	74LS395	1.19
74LS136	.39	74LS399	1.49
74LS137	.99	74LS424	2.95
74LS138	.55	74LS447	.37
74LS139	.55	74LS490	1.95
74LS145	1.20	74LS624	3.99
74LS147	2.49	74LS640	2.20
74LS148	1.35	74LS645	2.20
74LS151	.55	74LS668	1.69
74LS153	.55	74LS669	1.89
74LS154	1.90	74LS670	1.49
74LS155	.69	74LS674	9.65
74LS156	.69	74LS682	3.20
74LS157	.65	74LS683	3.20
74LS158	.59	74LS684	3.20
74LS160	.69	74LS685	3.20
74LS161	.65	74LS688	2.40
74LS162	.69	74LS689	3.20
74LS163	.65	74LS783	24.95
74LS164	.69	81LS95	1.49
74LS165	.95	81LS96	1.49
74LS166	1.95	81LS97	1.49
74LS168	1.75	81LS98	1.49
74LS169	1.75	25LS2521	2.80
74LS170	1.49	25LS2569	4.25

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7400

7400	.19	74132	.45
7401	.19	74136	.50
7402	.19	74141	.65
7403	.19	74142	2.95
7404	.19	74143	2.95
7405	.25	74145	.60
7406	.29	74147	1.75
7407	.29	74148	1.20
7408	.24	74150	1.35
7409	.19	74151	.55
7410	.19	74152	.65
7411	.25	74153	.55
7412	.30	74154	1.25
7413	.35	74155	.75
7414	.49	74156	.65
7416	.25	74157	.55
7417	.25	74159	1.65
7420	.19	74160	.85
7421	.35	74161	.69
7422	.35	74162	.85
7423	.29	74163	.69
7425	.29	74164	.85
7426	.29	74165	.85
7427	.29	74166	1.00
7428	.45	74167	2.95
7430	.19	74170	1.65
7432	.29	74172	5.95
7433	.45	74173	.75
7437	.29	74174	.89
7438	.29	74175	.89
7440	.19	74176	.89
7442	.49	74177	.75
7443	.65	74178	1.15
7444	.69	74179	1.75
7445	.69	74180	.75
7446	.69	74181	2.25
7447	.69	74182	.75
7448	.69	74184	2.00
7450	.19	74185	2.00
7451	.23	74190	1.15
7453	.23	74191	1.15
7454	.23	74192	.79
7460	.23	74193	.79
7470	.35	74194	.85
7472	.29	74195	.85
7473	.34	74196	.79
7474	.33	74197	.75
7475	.45	74198	1.35
7476	.35	74199	1.35
7480	.59	74221	1.35
7481	1.10	74246	1.35
7482	.95	74247	1.25
7483	.50	74248	1.85
7485	.59	74249	1.95
7486	.35	74251	.75
7489	2.15	74259	2.25
7490	.35	74265	1.35
7491	.40	74273	1.95
7492	.50	74276	1.25
7493	.35	74279	.75
7494	.65	74283	2.00
7495	.55	74284	3.75
7496	.70	74285	3.75
7497	2.75	74290	.95
74100	1.75	74293	.75
74107	.30	74298	.85
74109	.45	74351	2.25
74110	.45	74365	.65
74111	.55	74366	.65
74116	1.55	74367	.65
74120	1.20	74368	.65
74121	.29	74376	2.20
74122	.45	74390	1.75
74123	.49	74393	1.35
74125	.45	74425	3.15
74126	.45	74426	.85
74128	.55	74490	2.55

LINEAR

LM301	.34	LM340 (see 7800)		LM566	1.49	LM1800	2.37
LM301H	.79	LM348	.99	LM567	.89	LM1812	8.25
LM307	.45	LM350K	4.95	NE570	3.95	LM1830	3.50
LM308	.69	LM350T	4.60	NE571	2.95	LM1871	5.49
LM308H	1.15	LM358	.69	NE592	2.75	LM1872	5.49
LM309H	1.95	LM359	1.79	LM709	.59	LM1877	3.25
LM309K	1.25	LM376	3.75	LM710	.75	LM1889	1.95
LM310	1.75	LM377	1.95	LM711	.79	LM1896	1.75
LM311	.64	LM378	2.50	LM723	.49	ULN2003	2.49
LM311H	.89	LM379	4.50	LM723H	.55	LM2877	2.05
LM312H	1.75	LM380	.89	LM733	.98	LM2878	2.25
LM317K	3.95	LM380N-8	1.10	LM741	.35	LM2900	.85
LM317T	1.19	LM381	1.60	LM741N-14	.35	LM2901	1.00
LM318	1.49	LM382	1.60	LM741H	.40	LM3900	.59
LM318H	1.59	LM383	1.95	LM747	.69	LM3905	1.25
LM319H	1.90	LM384	1.95	LM748	.59	LM3909	.98
LM319	1.25	LM386	.89	LM1014	1.19	LM3911	2.25
LM320 (see 7900)		LM387	1.40	LM1303	1.95	LM3914	3.95
LM322	1.65	LM389	1.35	LM1310	1.49	LM3915	3.95
LM323K	4.95	LM390	1.95	MC1330	1.69	LM3916	3.95
LM324	.59	LM392	.69	MC1349	1.89	MC4024	3.95
LM329	.65	LM394H	4.60	MC1350	1.19	MC4044	4.50
LM331	3.95	LM399H	5.00	MC1358	1.69	RC4136	1.25
LM334	1.19	NE531	2.95	MC1372	6.95	RC4151	3.95
LM335	1.40	NE555	.34	LM1414	1.59	LM4250	1.75
LM336	1.75	NE556	.65	LM1458	.59	LM4500	3.25
LM337K	3.95	NE558	1.50	LM1488	.69	RC4558	.69
LM337T	1.95	NE561	24.95	LM1489	.69	LM1308	1.29
LM338K	6.95	NE564	2.95	LM1496	.85	LM1360	1.49
LM339	.99	LM565	.99	LM1558H	3.10	LM1370	1.49

H = TO-5 CAN T = TO-220 K = TO-3

RCA

CA 3023	2.75	CA 3082	1.65
CA 3039	1.29	CA 3083	1.55
CA 3046	1.25	CA 3086	.80
CA 3059	2.90	CA 3089	2.99
CA 3060	2.90	CA 3096	3.49
CA 3065	1.75	CA 3130	1.30
CA 3080	1.10	CA 3140	1.15
CA 3081	1.65	CA 3146	1.85
CA 3160	1.19		

TI

TL494	4.20	75365	1.95
TL496	1.65	75450	.59
TL497	3.25	75451	.39
75107	1.49	75452	.39
75110	1.95	75453	.39
75150	1.95	75454	.39
75154	1.95	75491	.79
75188	1.25	75492	.79
75189	1.25	75493	.89
75494	.89		

BI FET

TL071	.79	TL084	2.19
TL072	1.19	LF347	2.19
TL074	2.19	LF351	.60
TL081	.79	LF353	1.00
TL082	1.19	LF355	1.10
TL083	1.19	LF356	1.10
LF357	1.40		

CMOS

4000	.29	4527	1.95
4001	.25	4528	1.19
4002	.25	4531	.95
4006	.89	4532	1.95
4007	.29	4538	1.95
4008	.95	4539	1.95
4009	.39	4541	2.64
4010	.45	4543	1.19
4011	.25	4553	5.79
4012	.25	4555	.95
4013	.38	4556	.95
4014	.79	4581	1.95
4015	.39	4582	1.95
4016	.39	4584	.75
4017	.69	4585	.75
4018	.79	4702	12.95
4019	.39	74C00	.35
4020	.75	74C02	.35
4021	.79	74C04	.35
4022	.79	74C08	.35
4023	.29	74C10	.35
4024	.65	74C14	.59
4025	.29	74C20	.35
4026	1.65	74C30	.35
4027	.45	74C32	.39
4028	.69	74C42	1.29
4029	.79	74C48	1.99
4030	.39	74C73	.65
4034	1.95	74C74	.65
4035	.85	74C76	.80
4040	.75	74C83	1.95
4041	.75	74C85	1.95
4042	.69	74C86	.39
4043	.85	74C89	4.50
4044	.79	74C90	1.19
4046	.85	74C93	1.75
4047	.95	74C95	.99
4049	.35	74C107	.89
4050	.35	74C150	5.75
4051	.79	74C151	2.25
4053	.79	74C154	3.25
4060	.89	74C157	1.75
4066	.39	74C160	1.19
4068	.39	74C161	1.19
4069	.29	74C162	1.19
4070	.35	74C163	1.19
4071	.29	74C164	1.39
4072	.29	74C165	2.00
4073	.29	74C173	.79
4075	.29	74C174	1.19
4076	.79	74C175	1.19
4078	.29	74C192	1.49
4081	.29	74C193	1.49
4082	.29	74C195	1.39
4085	.95	74C200	5.75
4086	.95	74C221	1.75
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4512	.85	74C915	1.19
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4515	1.79	74C920	17.95
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4519	.39	74C923	4.95
4520	.79	74C925	5.95
4522	1.25	74C926	7.95
4526	1.25	74C928	7.95
		74C929	19.95

74S00

74S00	.32	74S163	1.95
74S02	.35	74S168	3.95
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74S04	.35	74S174	.95
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74S11	.35	74S189	6.95
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74S20	.35	74S195	1.49
74S22	.35	74S196	1.49
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74S65	.40	74S253	.95
74S74	.50	74S257	.95
74S85	1.99	74S258	.95
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74S134	.50	74S301	6.95
74S135	.89	74S373	2.45
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		74S571	2.95

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8T98	.89
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7808T	.75	7912T	.85
7812T	.75	7915T	.85
7815T	.75	7924T	.85
7824T	.75		
		7905K	1.49
7805K	1.39	7912K	1.49
7812K	1.39	7915K	1.49
7815K	1.39	7924K	1.49
7824K	1.39		
		79L05	.79
78L05	.69	79L12	.79
78L12	.69	79L15	.79
78L15	.69		
		LM323K	4.95
78H05K	9.95	UA78S40	1.95
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C, T = TO-220 K = TO-3
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RS232 FEMALE RIGHT ANGLE	5.25
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MPS918	.25	2N3903	.25
2N2102	.50	2N3904	.10
2N2218	.50	2N3906	.10
2N2218A	.50	2N4122	.25
2N2219	.50	2N4123	.25
2N2219A	.50	2N4249	.25
2N2222	.25	2N4304	.75
PN2222	.10	2N4401	.25
MPS2369	.25	2N4402	.25
2N2484	.25	2N4403	.25
2N2905	.50	2N4857	1.00
2N2907	.25	PN4916	.25
PN2907	.125	2N5086	.25
2N3055	.79	PN5129	.25
3055T	.69	PN5139	.25
2N3393	.30	2N5209	.25
2N3414	.25	2N6028	.35
2N3563	.40	2N6043	1.75
2N3565	.40	2N6045	1.75
PN3565	.25	MPS-A05	.25
MPS3638	.25	MPS-A06	.25
MPS3640	.25	MPS-A55	.25
PN3643	.25	TIP29	.65
PN3644	.25	TIP31	.75
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DESCRIPTION	SOLDER		RIGHT ANGLE SOLDER		RIBBON CABLE		HOODS	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE	BLACK	GREY
ORDER BY	DBxxP	DBxxS	DBxxPR	DBxxSR	IDBxxP	IDBxxS	HOOD-B	HOOD
CONTACTS 9	2.08	2.66	1.65	2.18	3.37	3.69	—	1.60
15	2.69	3.63	2.20	3.03	4.70	5.13	---	1.60
25	2.50	3.25	3.00	4.42	6.23	6.84	1.25	1.25
37	4.80	7.11	4.83	6.19	9.22	10.08	---	2.95
50	6.06	9.24	---	---	---	---	---	3.50

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IDC CONNECTORS

DESCRIPTION	SOLDER HEADER	RIGHT ANGLE SOLDER HEADER	WW HEADER	RIGHT ANGLE WW HEADER	RIBBON HEADER SOCKET	RIBBON HEADER	RIBBON EDGE CARD
ORDER BY	IDHxxS	IDHxxSR	IDHxxW	IDHxxWR	IDSxx	IDMxx	IDExx
CONTACTS 10	.82	.85	1.86	2.05	1.15	—	2.25
20	1.29	1.35	2.98	3.28	1.86	5.50	2.36
26	1.68	1.76	3.84	4.22	2.43	6.25	2.65
34	2.20	2.31	4.50	4.45	3.15	7.00	3.25
40	2.58	2.72	5.28	4.80	3.73	7.50	3.80
50	3.24	3.39	6.63	7.30	4.65	8.50	4.74

ORDERING INSTRUCTIONS: Insert the number of contacts in the position marked "**xx**" of the "order by" part number listed. **Example:** A 10 pin right angle solder style header would be IDH10SR.

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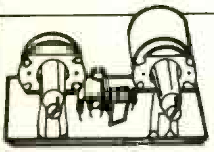

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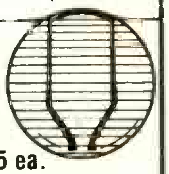

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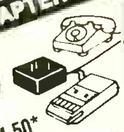

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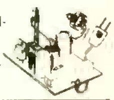

Complete variable rate strobe light kit produces brilliant flashes of light. Operates from standard 120VAC. Reliable design — thousands of these are in use throughout the world. Overall size of completed board: 3"L x 2"W x 3"H.
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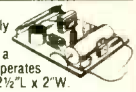

This portable battery operated device continuously emits bursts of intense light at a fixed repetition rate. Can be seen for great distances making it a great safety device. Features xenon flashtube. Operates on 3VDC (two 1.5V Batteries). Size of board: 2½"L x 2"W.
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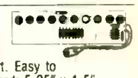

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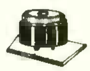

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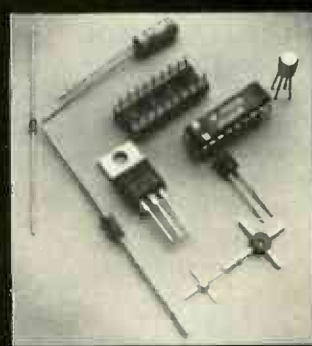

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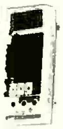

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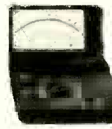

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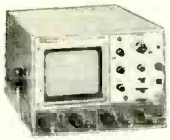

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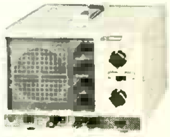

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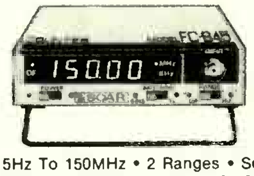

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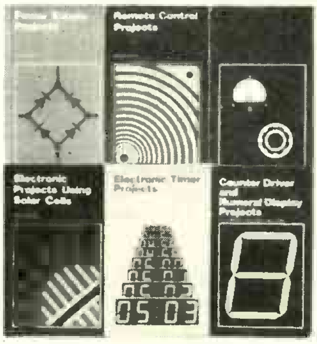

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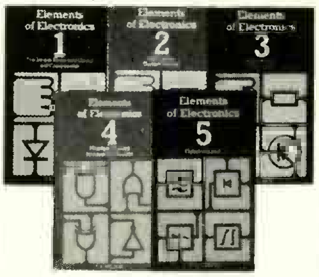

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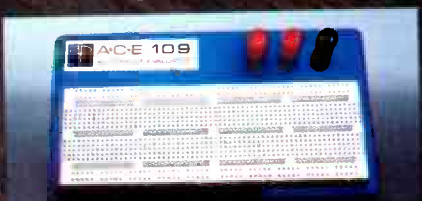

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