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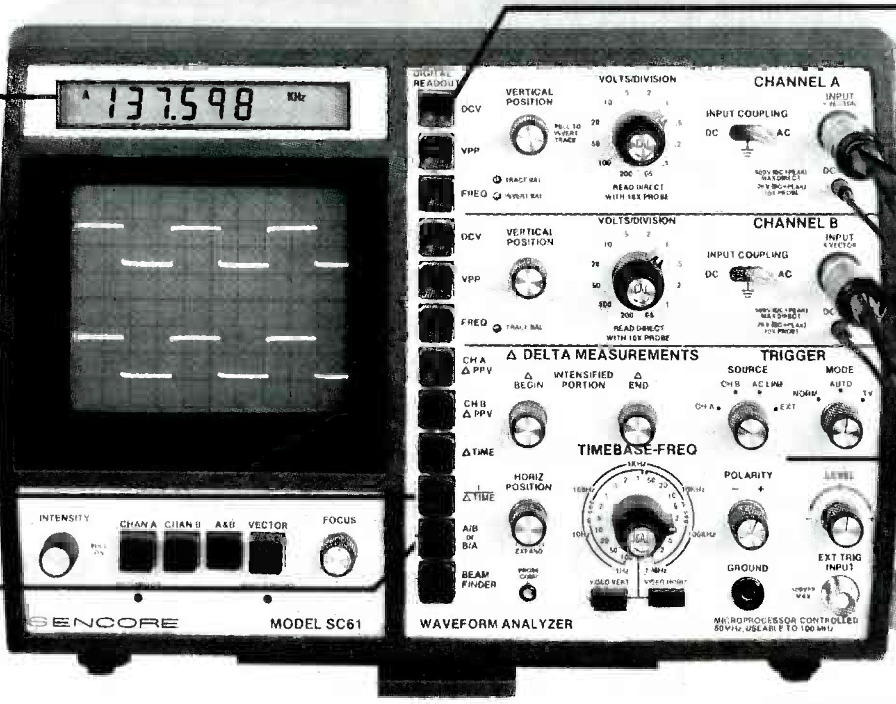

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JULY 1983 Vol. 54 No. 7

ON THE COVER

To most drivers, one of the most exasperating experiences is getting lost in completely unfamiliar territory. But an independent California inventor and a giant Japanese automobile manufacturer are hard at work trying to make that situation a thing of the past. If their efforts are successful, it won't be long until a common automotive accessory will be a navigational computer complete with a video display. This month, we'll preview the future and take a look at both systems. The story begins on page 43.

This upgrade for the Timex/Sinclair 1000 adds 8K of non-volatile RAM. The add-on can be used to increase the system/user memory, or more usefully, for the permanent storage of machine-language routines—thus, in effect, expanding the operating system. Find out more about it starting on page 47.

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A special section devoted to electronics and photography. Among the things we'll look at are:
- **The Sony Mavica system**
- **Autofocus and autoexposure electronics**
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VIDEO ELECTRONICS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

New VCR Standard

A new VCR standard that eventually is expected to replace the three current half-inch home formats (Beta, VHS, and the European Video 2000) has been approved by a Standardization Conference of 122 Japanese, European, and American companies, whose representatives have been meeting in Tokyo for more than a year.

The new "8mm Video" standard was established to avoid the Beta-vs.-VHS problem that has plagued the home-VCR industry since its inception. In order to avoid disrupting the market, member companies, in the past, have insisted that the new standard was designed only for use in portable camera-VCR combinations; but with the issuance of the specifications, many conference members have dropped that pose. Although initially the system is designed to record for only 90 minutes on one cassette (in the NTSC color system), the standard is obviously flexible enough to accommodate much longer recording times.

The recording medium is an 8-mm-wide cassette tape. The cassette itself measures 95 × 62.5 × 15-mm, slightly smaller in length and width than a standard audio cassette and just a touch thicker than the thickest part of such a cassette. The tape can be either the metal-powder or metal-evaporated type, and the system uses helical scan with a head drum 40mm in diameter.

Three separate audio systems are specified in the new 8mm specifications — a standard longitudinal track, an FM-stereo helical system multiplexed with the video signal of the type used in Beta Hi-Fi recorders, and a helical PCM (*P*ulse *C*ode *M*odulation) track. The FM sound system is compulsory, the other two optional. A cue track is also reserved.

The cassette itself is designed for maximum simplicity and low cost, without tape guides and with a wide mouth to accommodate many different loading systems. It has two lids to keep out dust, and recognition holes for automatic detection of tape type and thickness, as well as grips for an auto-changer.

Sources in the Standardization Conference say that an increase in recording time to four hours by means of slower tape speed and thinner tape is easily possible now. Development in the future of new heads and new tape formulations (including the perpendicular or vertical-domain recording system, now in advanced stages of development) will make possible further increases in record/play time.

In Japan, there are widespread forecasts that 8mm VCR's will begin to appear before the year is over, but in any event the American market could see the first portables in 1984. Assuming that longer-playing versions are approved by the Standardization Conference, home decks could show up in about three years, and at that point the new format should begin to take over from Beta and VHS.

The 8mm standard was approved by the conference for both NTSC and PAL color systems, with different parameters — the PAL version has a record/play time of one hour. At the last minute, France's Thomson-CSF proposed that a baseband recording system, "timeplex," be used for any SECAM models. Therefore the conference approved no SECAM standard, but earmarked the French proposal for further study.

The agreement on a new standard format has great implications on the future of the entire video field, laying the groundwork for a new, far more flexible and potentially lower-cost system and eventually ending the standards war.

DIGITAL TV

It can now be definitely reported that color-TV sets using all-digital signal processing will be available, at least in token quantities, in 1984. In the United States, they're expected to be available from General Electric and Zenith, with offerings also possible from Sharp and Sony. All are customers of ITT for its set of seven VLSI digital IC's. The first digital sets may well be in the form of component TV, because they will be designed for add-ons to make possible features not available with analog TV's. One of the first add-ons is expected to be a ghost eliminator. The new digital TV's also are expected to enhance the capabilities of home computers (since they are essentially computers themselves). With the development of low-cost frame-store accessories, the digital TV's will have the potential ability to simulate high-definition television by doubling the number of lines in the picture, inserting "derived" lines between the transmitted ones. Other features could be stop-motion and picture-in-picture (for viewing two channels simultaneously). While digital sets are imminent, those special effects probably won't be along for several years. **R-E**

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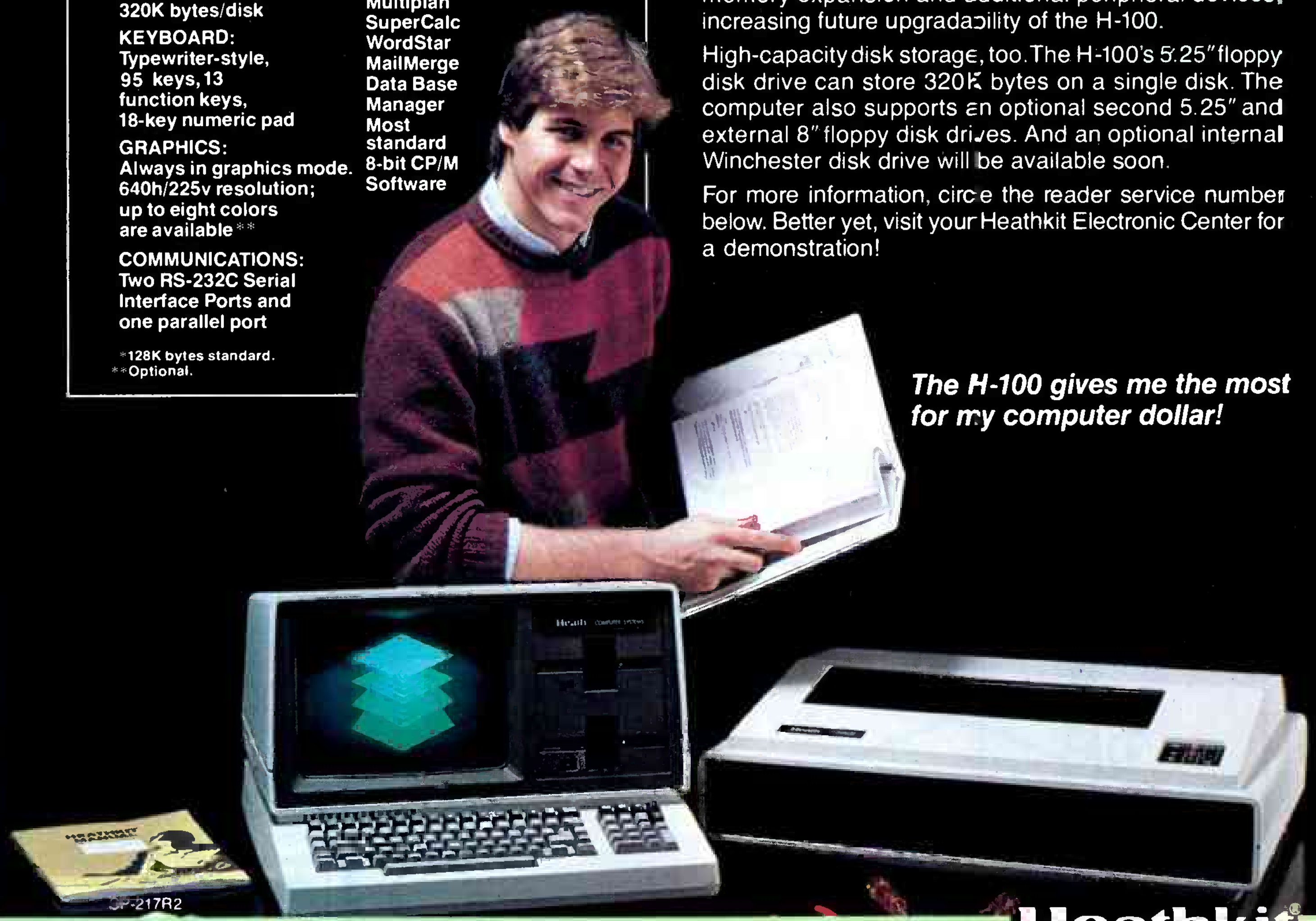

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CIRCLE 16 ON FREE INFORMATION CARD

WHAT'S NEWS

Cellular radio system to begin in U.S.A.

The FCC has allocated 666 channels to a new "cellular" two-way radio service, which, with its greatly more efficient use of the radio spectrum than the current mobile telephony system, will make a car telephone available to anyone almost anywhere in the United States.

In a cellular system, an area such as a city is not covered with a single high-powered transmitter, as is done today. Instead, the area is divided up into sections, or "cells," each with a low-power transmitter whose range is pretty much limited to the area of the cell. Since adjacent cells are on non-interfering frequencies, the same frequency can be "re-used" for several widely separated cells in a large city or metropolitan area, increasing greatly the number of phone calls that may be handled in a given area.

The FCC opened applications for cellular system licenses, and as of March, 1983, had already granted permits to cellular mobile telephone systems in nine U.S. metropolitan areas. Service is expected to start within two years.

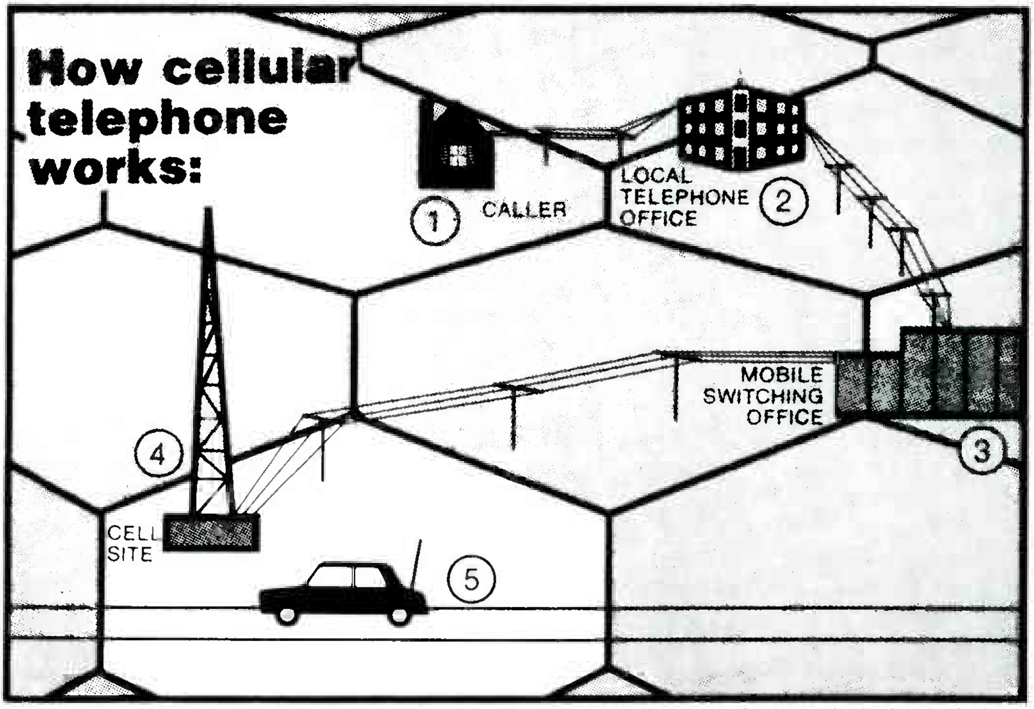
A cellular system is made up of four elements (plus the regular telephone system). Those are the Mobile Telecommunications Switching Office (MTSO); a base station (transmitter/receiver), with its antennas, in each cell; wire or microwave connecting links between base stations and the MTSO, and the mobile radios, which may be vehicle-mounted or hand carried.

When a telephone user wishes to make a call, he simply dials the number of the mobile subscriber, as he would any other call. (He need know nothing of the whereabouts of the car he is calling.) The call then goes to the mobile unit's MTSO, which sends a paging signal over all the base stations in the area. The mobile unit, which monitors a nearby base station continuously, responds automatically to the paging signal and establishes contact with the base station. The MTSO then switches the call to one of the traffic channels of that base station, and the subscriber's phone rings.

If the mobile subscriber travels out of the cell during a call, communications are automatically switched over to the base station of the cell into which he moves.

The subscriber in a mobile vehicle simply dials the number he wants, as he would on his home phone.

The service is expected to cost subscribers anywhere from $75 to $150 per month. That would include an access fee of between $10 and $50 per month, plus charges for actual use. Those might run from 12 cents per minute in off-peak hours to 40 cents per minute in peak periods.



CELLULAR NETWORK OVER PART OF A CITY. The call is routed from the caller's home via the local telephone exchange to the Mobile Telecommunications Switching Office, a complex automatic device that locates the car, makes the connection, and then switches the call from cell to cell as the car moves through the area.

OK Industries forms electronics division

OK Industries, a New York-based manufacturer of production equipment for the electronics and telecommunications industries, has formed an Electronics Division. The new division is putting out a broad range of bench and field test instruments, with the idea of offering "truly superior lab-quality instruments at prices within the reach of even the 'smallest' user."

The first product from the new division is a 1-MHz function generator with both frequency and amplitude modulation; it will sell at $250.

900-MHz personal radio may be on the way

The FCC has issued a Notice of Proposed Rulemaking to implement a new personal radio-communications service (PRCS), proposed by General Electric, in the 900-MHz frequency band. G.E. hopes that the FCC will issue a Final Report and Order within the next few months.

The FCC proposal is for a system that will consist of a base station connected to the telephone network, and one or more units that can be installed in cars. The user in a car will then be able to place calls to any telephone, or be reached in the car from any telephone, provided he is within the system's range.

The FCC notice proposes to set aside 8 MHz in the 900-MHz band for the new service. That reservation would permit 133 channels of 30 kHz each for two-way PRCS communications.

New TV space camera

RCA has developed a new telephone camera tube that can detect objects the size of a soccer ball 22,000 miles away.

Serving as the "eye" of a special camera of the Ground-based Electro-Optical Deep Space Surveillance System (GEODSS), it can see objects 10,000 times dimmer than the faintest ones visible to the naked eye.

The new Silicon-Intensifier Target (SIT) tube, type C21146H, is the largest of its type that RCA has ever made. Its 32mm of usable area is twice that of the targets now used in the surveillance cameras that provide the resolving capability of the GEODSS equipment. The target has four times as many silicon diodes as older types.

The GEODSS system answers the need for advanced tracking

continued on page 8

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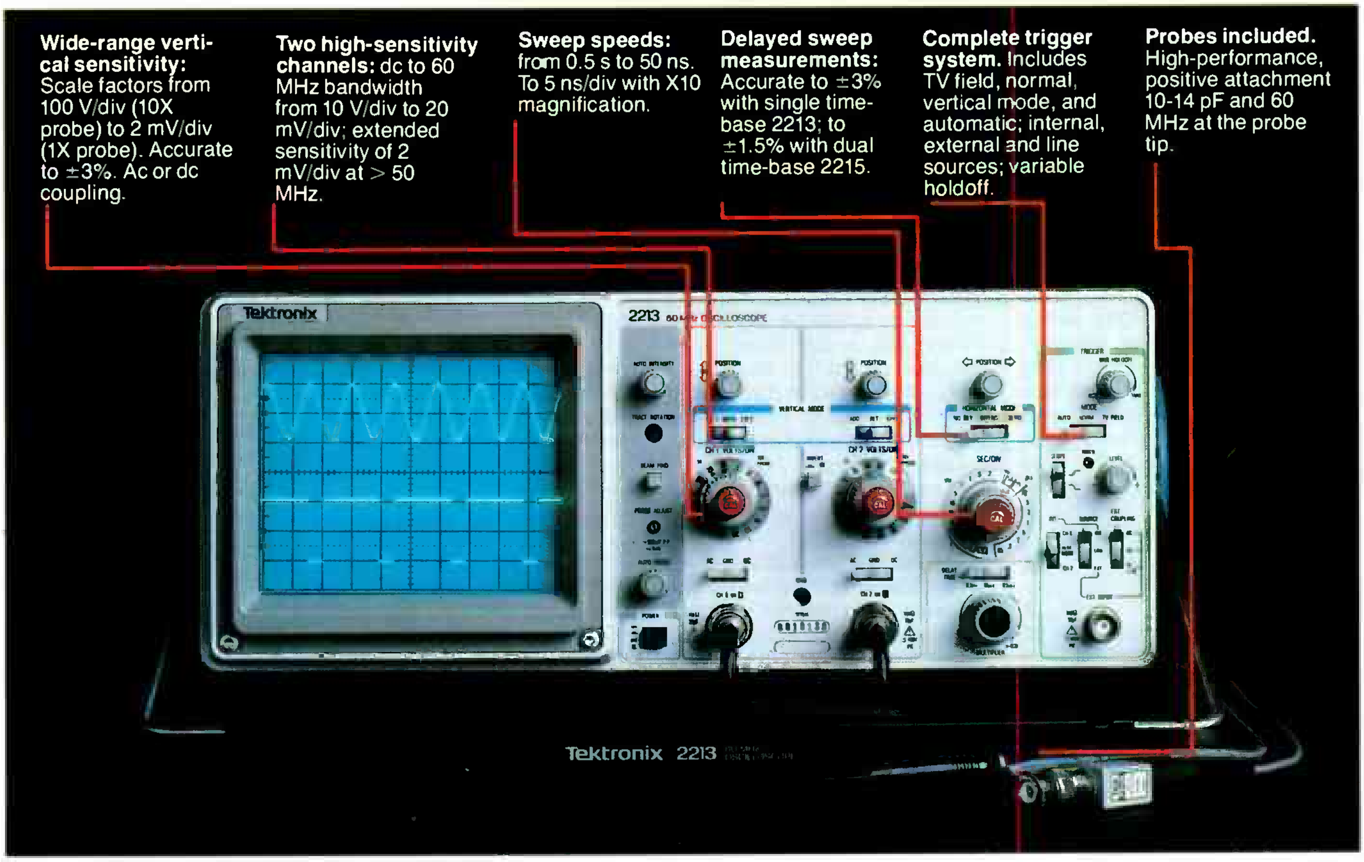

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WHAT'S NEWS

continued from page 6

methods. That need is caused by the ever-increasing number of objects in space. (An estimated 15,000 pieces—satellites and debris—are now drifting in orbit.) It uses two 40-inch telescopes for deep space tracking and a 15-inch instrument for scanning lower altitudes. Each telescope is coupled to a camera containing one of the new low-light-level SIT camera tubes.

Pictures from the TV cameras are converted into digital pulses and fed into a computer, which examines the data to sort out stars from moving objects. The computer software also contains a catalog of known stars and orbiting satellites for identification and location purposes.

Class A power amplifier for car stereo

Visonik of America, Inc., a manufacturer and distributor of automotive-sound products, has introduced the first Class-A power amplifier specifically intended for car-stereo applications. That amplifier, the model *A265*, boasts an output of 65 watts-per-channel with total harmonic distortion claimed to be less than 0.01% from 20 Hz to 20 kHz.

The chief advantage Class-A operation is that it eliminates the distortion introduced by the push-pull action of more conventional Class-B amplifiers. Among the unit's circuit features are full complementary symmetry, just 30 dB of negative feedback, and a wide open-loop bandwidth for a high slew-rate and low TIM distortion. The amplifier also includes an exclusive *Perma-Tect* circuit. That circuit monitors the output current and voltage across the output transistors; and, should those levels become excessive, the circuit limits the power without interfering with the signal. In addition, the amplifier has thermal breakers to prevent overheating. According to a company spokesman, that combination makes the amplifier "virtually unblowable."

The *A265* offers a variable low-level (100-550mV) input for use with almost any program source. A Molex harness is included for easy installation.

THE ALPHASONIK A265 Class-A power amplifier delivers 65 watts-per-channel into a 4-ohm load. It features Visonik's exclusive Perma-Tect protection circuitry.

Sanyo LCD TV

Sanyo has developed 3 and 4-inch liquid crystal TV's, using a newly developed liquid-crystal display (LCD) and amorphous silicon thin-film transistors (aSiTFT) that are designed for switching.

The display on the 4-inch model is 60 × 80 mm (about $2\frac{3}{8} \times 5\frac{3}{32}$ inches) and exterior dimensions are 253 × 30 × 113 mm (approximately 10 × $1\frac{7}{32}$ × $4\frac{15}{32}$ inches)—truly pocket sized.

The new switching transistor is said to provide greater reliability than previous approaches, and the new TN (twisted nematic mode) crystal produces better contrast and a wider view angle. The display boasts are 220 × 240 pixels.

The liquid-crystal displays are being rapidly developed for use in TV sets, office machines, etc., but picture clarity and driving systems remain problems.

"Telephone on an chip"

High reliability and reduced component count are among the features of the new telephone technology introduced by American Telecommunications Corporation, a subsidiary of Comdial. ATC is a supplier of telephones, answering machines, and automatic dialers to the Bell system, as well as to major independent telephone companies and retailers.

Evidence of that new technology can be seen in two ATC products. The *Allegro* is a compact residential phone that features a 10-number memory dialer, automatic redial, and a true hold button. The other new phone, the *Voice Express 41* is designed for business applications. It combines an improved speakerphone, a 41-number automatic dialer, clock, call timer, and security features. Both phones incorporate a new IC that is essentially a complete telephone. That IC is part of ATC's effort to reduce the cost and complexity of manufacturing telephones that meet Bell-system standards.

According to Robert E. Lee, ATC Vice President of Engineering, the company's goal is to totally automate telephone assembly. By using sophisticated robots to assemble the telephones, Comdial hopes to obtain the distinct technology and cost advantage it feels is needed to compete with imported low-cost, and often lower-quality, telephones. **R-E**

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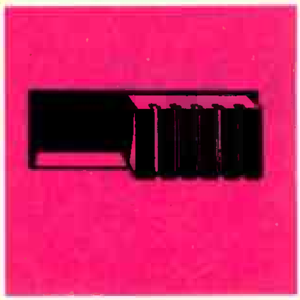

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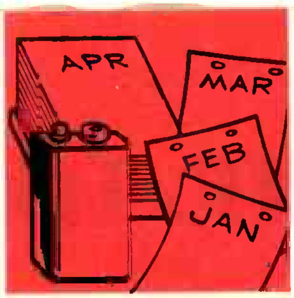

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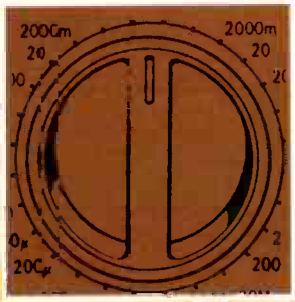

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SATELLITE/TELETEXT NEWS

GARY ARLEN
CONTRIBUTING EDITOR

TELETEXT DECODERS

The CBS Television Network has started a teletext service called Extravision. The service will be broadcast by the almost 200 CBS affiliated stations (90 percent as this is being written), making it the first national broadcast teletext service. Extravision transmits 100 pages of national and local information and advertising as well as closed captioning of some programs. The service uses the North American Broadcast Teletext Standard (NABTS).

Time Inc. and Matsushita Electric Industrial Co. (Panasonic) have signed a "long-term technology agreement" under which the two companies will co-develop hardware for home-information systems. The first such product is a low-cost decoder for Time's teletext service—with the hoped-for $150 device being offered under the Panasonic name. The first test models of the unit will be available late this year, with production runs set to begin in 1984 at Matsushita's automated color-TV factory in Japan.

The teletext decoder will use the "North American Broadcast Teletext Specification," the technical format that Time Inc., CBS, NBC and A.T.&T. have adopted. It will be able to pick up Time's full-channel teletext feed, now being tested, as well as vertical blanking-interval teletext, such as the feeds being planned by the television networks. The decoder will include an extension unit to permit add-ons such as a full alphanumeric keyboard, printer, and floppy disks for data storage. In addition, the terminal can accommodate joysticks for videogames, an audio cassette recorder, and a modem for two-way service.

The decoder will also be able to handle software for the customized information services that Time plans to transmit. The decoder's interactive capability makes faster access possible, and the unit will include provisions that allow it to be used for general-purpose computing. Time's teletext service will be offered to cable TV systems, starting with companies operated by its subsidiary American TV and Communications. In addition to news and other typical information services, Time's teletext project includes a variety of innovative recreational activities that take advantage of the high-quality graphics of the technology. For example, a youth-oriented section of the service includes an electronic version of "Mr. Potatohead," that allows children to compose a face by selecting features they would like to insert and placing them over the face outline on the TV screen.

VCR'S AND TELETEXT

EECO (1601 E. Chestnut Ave., Santa Ana, CA 92701), a California company that produces tape-editing equipment and mini-computer systems, is testing *Pictureware*, a system that will permit home videocassette-recorders to record and transmit videotex or teletext signals. *Pictureware* is an interactive still-frame video technology that uses a VCR and a decoder box to compress images, text, and audio onto videotape; material can then be retransmitted in high-speed bursts. The equivalent of a 100-page teletext magazine with 75 color pages of near video-picture quality can be transmitted in about seven seconds—about the time it takes to cycle such a group of pages through a standard vertical blanking-interval sequence. The system becomes interactive through the use of phone lines or two-way cable. EECO sees the target price for the decoder needed to receive the videotex and teletext signals at about $300. A modified VCR, needed to pick up the digital data, will cost about $100 more than an unmodified one. EECO plans to begin marketing its *Pictureware* system in 1984.

AROUND THE TELETEXT CIRCUIT

In an apparently unprecedented marketing maneuver, Zenith says its will build and sell teletext receivers in a local market if a TV-station owner in that community commits to offering British-format teletext for at least five years. The unusual offer would presumably encourage broadcasters to begin a service knowing that a supply of receivers will be available in their communities. Zenith, which has long favored the "sturdy" British technology, is presumably also willing to deal with broadcasters working in other teletext formats. The company has already been the primary supplier of teletext receivers for other field trials of teletext.

RCA Laboratories has received a patent for a system that will increase the legibility and color contrast of teletext material by modifying the video signal. The system, primarily for use in set-top teletext decoders, is said to improve color definition and clarity. **R-E**

VIDEOGAMES

Future games

DANNY GOODMAN, CONTRIBUTING EDITOR

THE ARRIVAL OF SO-CALLED THIRD-generation home-videogame systems like the Atari *5200* and *Colecovision*, plus Coleco's announcement of a "fourth generation" tape-loading peripheral, leads me to speculate about what kind of home videogames we're likely to be playing in the late 1980's. I'm not talking about science-fiction gadgetry—stuff like holographic projections coming from your R2-D2 robot. I'm talking about the application of technologies that we have today, buried behind locked laboratory doors—technology that needs only a little refinement to be both practical and affordable.

Interactivity between game play and player will be the area where we will see the greatest changes in the years ahead. This interactivity will take many forms.

Late last year, the world was treated to a glimpse of the interactive future when Sega/Gremlin (555 Millrose, Los Angeles, CA 90038) demonstrated an arcade game that superimposed a shoot-'em-up space chase on a videodisc-scene backdrop that looked like outtakes from a low-budget *Star Wars* imitation. If a player successfully hit an alien ship, the disc would jump to a scene of an explosion in space. The game play and background are not particularly well integrated in this early commercial attempt, but the concept is a valid one.

Videodiscs, by themselves, are just now offering interactive adventures such as *Murder, Anyone?* from Vidmax (36 East 4th St., Cincinnati, OH 45202). In that game, the viewer's response to clues causes the story to jump from one character's account of the crime to another's. As a viewer enters a response into a remote control keypad, the microprocessor-controlled videodisc player accesses the proper segment of the disc.

But that's nothing compared to the possibilities of integrating more traditional videogame play-screens with the high-resolution effects of a videodisc scene. With game-console-generated graphics linked to the videodisc frame counter (there are 54,000 individually addressable frames on a disc), we might have the effect of walking down a corridor in an adventure maze-game. Suddenly a game-generated object—how about a treasure chest—appears on the floor in the distance. As we walk toward it, the chest, in

FIG. 1

proper perspective, gets larger. When we're standing directly in front of the chest, we have arms (from the disc) reach down and pick it up. Together, the chest and arms recede out of sight below the screen as though we actually had picked it up. Other game-generated objects could be picked up by the same disc-generated arms later in the game.

Another interactive trend we'll see involves increased use of our other senses. Right now, only our senses of sight and hearing are stimulated by a videogame. For now, we'll have to live with the graphics-resolution limitations of the home color-TV. Better-quality speech synthesis is about all we can expect from the current selection of systems. But stereo sound-effects will be the next step in attempted realism. For example, we'll be able to hear enemy ships approaching from off-screen to the left or right.

Beyond that, the sense of touch opens the way for game development into the late 1980's. Small solenoids will be built into a hand controller to give your palm a little "kick" when you catch a fly ball in a baseball game, or vibration when you're at the control of a race car.

We can even see special environmental videogame-chairs that partially enclose us in a sensory barrage of surround sound and that have motorized or vibrating seats to stimulate the sensations of flying a B-17 through flack or piloting the Millenium Falcon through hyperwarp. Most joystick-type controls would be in the armrests; a steering controller and two foot-pedals would swing in front of us from one side for games requiring that kind of control. The enclosure could adequately contain vapors from scented air and release them in synchronization with changing screens. For example, as you walked through dark, musty caverns of an adventure maze-game, only your keen sense of smell would help you distinguish between several look-alike scenes.

Are these ideas far fetched? Hardly. Coleco has already demonstrated the kicking hand controller, but decided to hold off for a while. And a new company in the add-on business, Amiga, has shown a foot-operated floor controller (the *Joyboard*, shown in Fig. 1) that lets you stand up and recreate the motions of skiing down a mountain in conjunction with a skier's-eye-view of a slalom course. There's even a prototype environmental chamber that spins you around and gives you a real sense of motion as you pilot your craft. Those are but the simple first steps toward future homebound simulations of real-life and imagined adventures.

U.S. Games' Eggomania for Atari 2600

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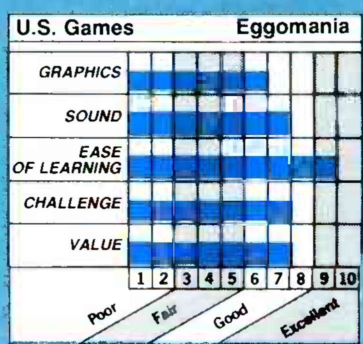

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continued on page 14

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VIDEOGAMES

continued from page 12

ing videogame cartridges for the entire family to enjoy. As a result, they stay away from the heavy artillery shoot-'em-up games and favor those that are easy to grasp by inexperienced game players, young and old. *Eggomania*, for one to four players, is just such a game.

The scenario sets a turkey-like bird scurrying from side to side along the top of the screen. As he moves, he drops green eggs. Each player in turn uses a paddle controller to position a blue bear at the bottom of the screen under each egg and catch it in an upturned hat. Points are scored for each egg caught. If the bear should fail to catch an egg, the floor receives a layer of yellow egg yolk. At the end of each wave of eggs, the tables turn for about 15 seconds and you activate the bear to throw eggs back at the dancing bird. A successful hit is worth points. The game ends when enough eggs have been dropped for the yolk to cover up the bear and his hat.

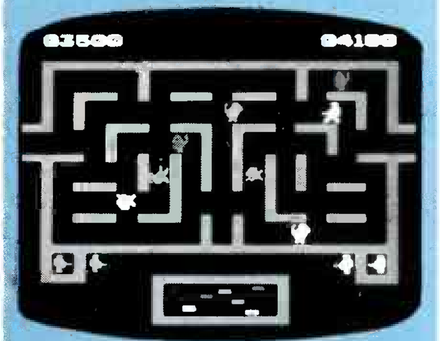
By keeping most of the screen black, the game designer was able to make the Atari *2600* present a graphically well-detailed bird character. The bird is filled with a variety of colors and high resolution crispness that shows up well against the black background. When you hit the bird with an egg, the bird loses its feathers, revealing polka-dot underwear; his top feathers turn into a beanie-like propeller that help his scrawny wings lift him up and out of the screen.

As you can see, the graphics are meant to be entertaining. And the sound, too, is geared toward keeping kids amused. Three different musical tunes, intermixed with cheeps and other bird sounds, spark up the action in places.

One design feature of the game makes *Eggomania* difficult—perhaps frustrating—at the higher levels. You can't just sweep the bear and hat quickly across the screen to catch a horizontal string of eggs. There appears to be just a very small zone around the hat that allows you to catch an egg successfully. There will be many times when you'll think you should have caught an egg for sure, yet wind up knee-deep in yolk.

Eggomania begs comparison with a similar catching game called *Kaboom* from Activision. If you prefer cute music and cartoons, then *Eggomania* is the one to get. But if building game skill is your goal, *Kaboom* is a better choice.

CBS Video Games' Wizard of Wor for Atari 2600



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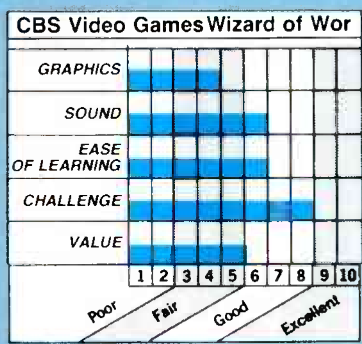

As versatile as the Atari *2600* has proven to be over the years, the machine has limitations in graphics and sound. There is only so much that even the genius game designer will be able to accomplish with a standard cartridge game. *Wizard of Wor* from CBS Video Games (Long Meadow Road, Hagerstown, MD 21740), is one of those games whose ambitions fell prey to the *2600*'s stumbling blocks.

The original *Wizard of Wor* was a modestly successful Midway arcade game of the pre-*Pac-Man* era that put great demands on the player's peripheral vision and coordination. One or two players can each control a "worrior" armed with a laser blaster. Worriors search a dungeon maze for numerous enemies, some completely visible, others visible only at times. All enemies, whether visible or not, are tracked on a radar screen.

Beginning with wave two, after you've cleared the enemies from the dungeon, yet another super-swift enemy, the Worluk, tries to escape the dungeon, and will—unless your worrior can shoot him first. After that (on random waves) the Wizard of Wor appears and hurls lightning bolts at your worrior. Shooting the elusive Wizard before he escapes nets players a dungeon-shaking graphics display—and a ton of points.

The difficulties in putting this game into a *2600* cartridge are many. One of the challenging features of the original was that in advanced waves, the maze walls were partially invisible, leading to a succession of "pits," or large sections of the maze with invisible walls. In CBS's version, there are only two maze-layouts that alternate between waves.

More disturbing during game play on the CBS version is excessive flicker caused by having so many moving objects on the screen at once. As you slowly eliminate enemies, the remaining images become more solid. But until that time, it is very difficult to keep your eye on the dimly lit enemies and the radar screen at the same time.

The only graphics salvation is the display when you hit the Wizard. Instead of a colorful fireworks display, the screen flashes in black and white for a surprisingly eerie effect.

There are many other elements of the original that were left out of the *2600* version, although they were well captured in Astrocade's *Incredible Wizard* version. But even on its own merit, CBS's *Wizard of Wor* does not contribute to the state of the art for the latest *2600* cartridges. **R-E**

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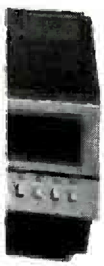

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PRIVACY IN COMMUNICATIONS

Recently, I picked up a copy of **Radio-Electronics** quite by chance, and was so impressed that I subscribed the next day. Keep up the great work.

I would like to comment on the article, "Ensuring Privacy in Communications" in the "Communications Corner" department for January 1983. The writer seems to be conveying a false impression — a misunderstanding that even many amateur radio operators have: that by adding a sub-audible or dual tone signal to your transmission you can ensure privacy from the casual listener.

Tone-squelch systems do not prevent people with scanners from hearing what you say. The tone squelch simply keeps other radios (in a fleet, for example) that have a squelch-muting circuit from being bothered by any except properly encoded signals. A radio without that mute circuitry will pick up everything transmitted over a given frequency, whether or not the transmission has a tone added to it. Since scanners, and the majority of monitoring radios, are not equipped with muting, the tone in no way protects the privacy of the communication. Even radios *with* such muting circuits are usually taken off mute when the microphone is picked up, enabling a listener to hear all the transmissions.

DAN PETERSON
Hemet, CA

ANTIQUE RADIOS

I enjoyed reading Mr. Richard Fitch's recent article about restoring antique radios (**Radio-Electronics,** March 1983). Having repaired many pre-war radios, and some early TV sets, I know the feeling of accomplishment that results from getting one of those treasures playing again.

I'd like to offer a hint that might make troubleshooting an old chassis a bit easier.

When smaller tube-radios became available (and later, when television appeared on the scene), many an old model was retired while still in good working order. But alas, 40 years later, when the old unit is dusted off and plugged in, all that issues from the speaker is a thin, garbled audio strongly overriden by a loud AC hum.

Here's the problem in almost every case that I've come across: The electrolytic capacitor in the power-supply circuit has dried out. Unlike the paper/foil and mica capacitors in the set, the electrolytics *do not* have an unlimited shelf life. The liquid electrolytic can evaporate away, leaving the caps virtually ineffective.

Two things result: First, the filtering of the pulsating DC from the vacuum-tube rectifier becomes very poor. All that's left to provide a modicum of filtering is the field coil on the

electrodynamic speaker (which does double-duty as a choke in most of the old circuits). That isn't enough to prevent a loud hum in the speaker. Second, there's usually an electrolytic capacitor used to bypass the cathode resistor in the audio-output stage. When that goes, the AC gain of the stage is reduced to a fraction of its former level.

Solution? Replace *all* the old electrolytics. The values are almost always marked clearly, and modern equivalents are readily available. Some early electrolytics are rectangular in shape, like a matchbox covered with wax; others are enclosed in metal cans attached to the chassis, so keep that in mind when hunting for them in your old set. When replacing, just be sure to use capacitors of equal or higher voltage, and watch out for polarity. The exact capacitance value is usually not critical, and deviations of 25 or even 50 percent will often work satisfactorily.

So if you have an old set with those symptoms, try my suggestions first; they may save you a lot of time and trouble.
DAVID B. WARD
Madison, NJ

ON NIKOLA TESLA

I would like to thank you for publishing my letter to the Editor in your November 1982 issue of **Radio-Electronics.** I believe that we owed that tribute to Nikola Tesla for his many accomplishments and few rewards. I am also sure that your readers have appreciated it. It is a great credit to your magazine to be so responsive to your readers.

May I now point to a slight discrepancy between my letter and the published version, which, I am afraid, may cause confusion among the experts. My letter said: "Of course, the General Electric Company, which originally followed Edison and the DC approach, abandoned it later and followed Tesla's AC direction to grow into the giant of today." The published version read: "That company had followed Edison and the DC approach, at first; later, it turned to follow Tesla's AC direction."

The substitution of "that company" for "the General Electric Company" unfortunately changes the meaning completely, since from the context, "that company" refers to Westinghouse Electric.

I would appreciate it very much if you will once again spare me some of your valuable space and publish my correction.

Once again, my thanks for publishing the tribute to Nikola Tesla, the inventor *extraordinaire.*
SLOBODAN ĆUK, PH.D.
Assistant Professor of Engineering,
California Institute of Technology

Our apologies for the transcription error through which the proper antecedent to the phrase "that company" was omitted. Editor

VIDEO TRANSMISSION

Just a note on the letter that appeared in the January 1983 **Radio-Electronics** by Mr. Peter K. Onnigan about video transmission via FM radio stations.

By his statements and incomplete reasoning, Mr. Onnigan would have us believe that high-resolution video can't be transmitted over 10-kHz telephone lines or via 3-kHz bandwidth radio-communications links. Well, maybe not *moving* pictures, but ...
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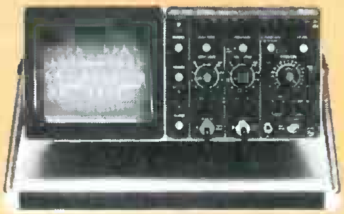

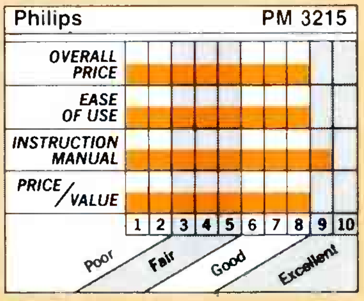

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YOU CANNOT BE INVOLVED WITH electronics—by profession or even as a hobbyist—without eventually needing an oscilloscope. And today's advancing technology often demands an oscilloscope with a wide bandwidth. If you have found that to be true in your experience, and if you are contemplating an oscilloscope purchase, one unit you should not overlook is the *PM 3215* from Philips Test and Measuring Instruments, Inc. (85 McKee Drive, Mahwah, NJ 07430).

General overview

The *PM 3215* is a dual-channel scope with a 50-MHz bandwidth. It is relatively lightweight (less than 18 pounds) and measures 17.5 × 11.8 × 5.4 inches. (Those measurements do not include the front protective cover, the controls, or the handle.) The handle, with its nine locking positions, doubles as a stand for the scope.

The inclusion of a battery input (22–27 volts DC at 1.1 amp maximum) along

continued on page 28

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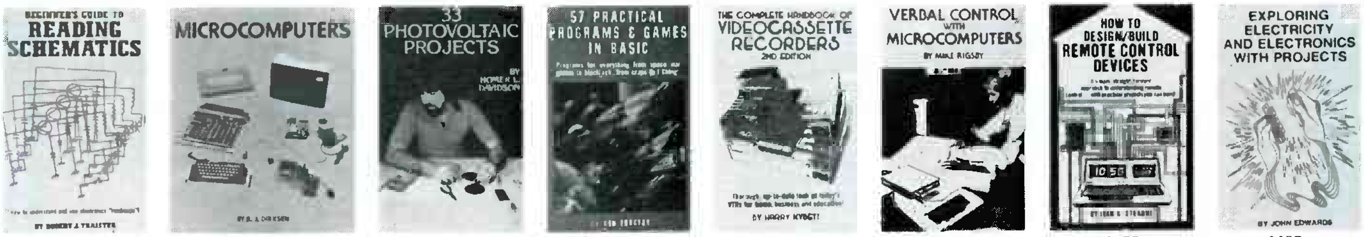

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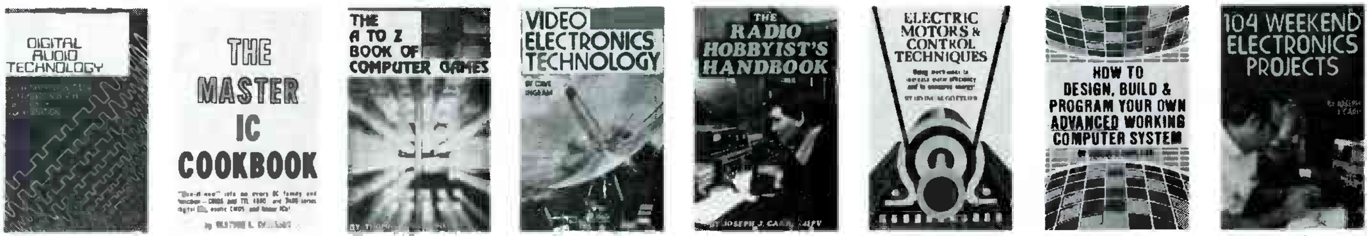

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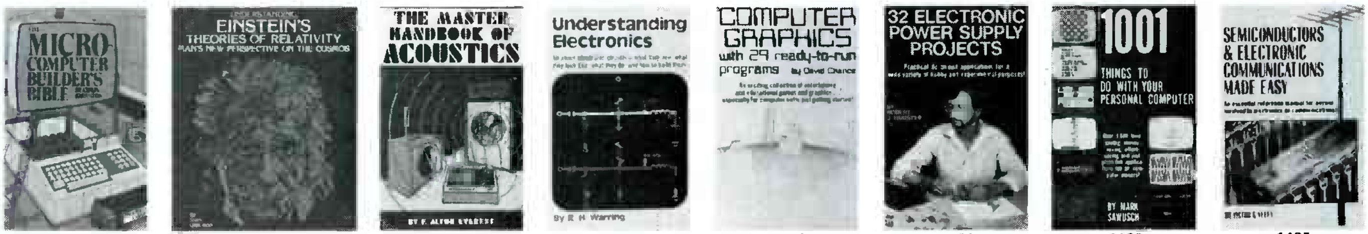

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EQUIPMENT REPORTS

continued from page 24

with its light weight and compactness, protective panel cover, and handle, indicates that Philips wanted the *PM 3215* to be at home either on a laboratory bench or in the field.

The CRT display has an internal graticule (an 8- × 10-cm grid) with continuously variable illumination. Those features reduce parallax error and help to make reading the scope non-fatiguing, especially if you use the scope for long periods of time.

When the scope is first turned on, the blue trace appears within 10 seconds, and the unit is ready for immediate use, although a 30-minute warmup time is suggested in the manual. The trace comes on about 4/10 of a division below where it was when the unit was turned off. However, after the 30-minute warmup period, it has returned to its previous position and there is negligible drift in the trace thereafter.

The unit comes supplied with two passive probes with an attenuation factor of 10 (and a compensation range from 14 to 40 pF—full probe-compensation instructions are included in the manuals). A handy zero- or ground-check button is included on the probe shell. The probes also come with a variety of accessories. They include a spring-loaded test clip, extra probe tips, and special caps for the probe tips that help to make measurements on dual in-line packages or in densely wired circuits easier. An adapter for making measurements of wire-wrapped circuits is also included with the probes.

A look at the controls

The front panel is well organized and laid out in a neat, compact manner with the controls appearing where you would want—and expect—them to be. The controls can be grouped into three main sections. The first section includes the power and CRT controls. The second section contains the vertical-channel controls, and the third contains the triggering and horizontal-channel controls. We'll look at each section in more detail, starting with the first, which is located to the right of the CRT screen.

The ILLUM control acts as the power switch as well as the continuously variable graticule-illumination control. An LED immediately above that control indicates POWER ON. Other controls in this section include those for trace intensity and focus. A screwdriver-adjustable TRACE ROTATION control is included to allow you to align the trace with the horizontal graticule lines. Also included in this section is an output terminal, labeled CAL, which is the source of a 1.2-volt squarewave having a frequency of about 2 kHz. That can be used for vertical-channel calibration or when compensating probes.

The second section includes two columns of controls for the "A" and "B" vertical channels. They include BNC input-jacks, above each of which are two pushbuttons—one grounds the input and the other selects AC or DC input-coupling. Above each set of pushbuttons is a AMPL/DIV which consists of two concentric knobs. The outer knob—with 12 click-stop positions from 2 mV/div to 10 V/div in a 1-2-5 sequence—selects the vertical-channel multiplier. The inner knob has a click-stop CAL position and can be used to continuously vary the vertical-channel scale multiplier. A POSITION control is located above each AMPL/DIV knob allows you to vary the vertical position of the display.

Centered above each of the two columns of controls for the "A" and "B" vertical channels is a 5-position pushbutton switch that is used to select the vertical-display mode. Your choices include looking at signals on channel "A" only or channel "B" only (positions A and B respectively), or looking at both (ALT or CHOP—chosen depending on the sweep rate that is in use). You can also look at the sum of the signals at the "A" and "B" inputs or, by pulling out the channel-B POSITION control, you can in-

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vert the signal on channel-B and can thus look at the difference of the two signals.

The third control-grouping contains a BNC input-jack for the trigger source or for the source of horizontal deflection. The source is selected by a 4-position pushbutton switch (A, B, EXT, or EXT ÷ 10). Above the pushbuttons is the TIME/DIV control, which, like the AMPL/DIV control, consists of two knobs. The outer knob adjusts the sweep rate from 0.1 μs/div to 0.5 sec/div in a 1-2-5 sequence. As before, the center control allows you to continuously vary the sweep rate. The DEFL position of the TIME/DIV control allows you to use the scope in the horizontal-deflection mode. The horizontal deflection can be increased by a factor of ten by pulling out the horizontal channel's POSITION control.

Along the top of the third control-grouping is a 5-position pushbutton switch that selects the trigger mode and the polarity of the trigger. A LEVEL control lets you vary the level of the waveform on which the scope will trigger.

Other features

Located on the back panel is a BNC input for Z-axis (intensity) modulation. That allows you to feed a periodic signal to the control grid of the CRT, which will brighten or dim the trace and give a third, Z, dimension. Periodically brightened spots can be used as markers to time-calibrate the main waveform. A signal that is applied to the external Z-axis input can also be used to cut off the CRT at selected parts of the trace (much like the retrace blanking signal that is fed to the Z amplifier).

The *PM 3215* is very well documented. There are three manuals supplied—an operation manual, a service manual, and a manual for the attenuator probes. All of the manuals are very well written. The operating manual is 87 pages long and is written in three languages (about 25 pages for each). The operating manual includes a brief check-out procedure that is especially useful.

The service manual (written entirely in English) is over 100 pages long. It is comprehensive and includes full schematics, circuit descriptions, corrective-maintenance procedures, printed-circuit board layouts, parts lists, and more. In short, the manuals give you all the information that you need to operate and service the scope. However, if you do not wish to make your own repairs or adjustments, there is also a list of worldwide sales- and service-centers.

All in all, the *PM 3215* is a high-quality 50-MHz dual-trace scope that would be a welcome addition to just about any benchtop. The suggested $1195 list price is just about what you would expect to pay for such a professional piece of test equipment. **R-E**

Vector P184-7 Slit-N-Wrap Tool

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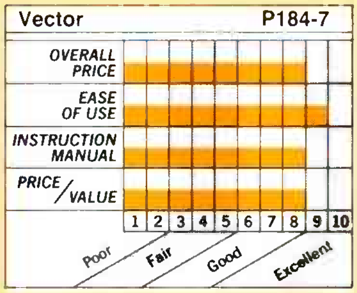

TWO MOTORIZED WIRE-WRAPPING TOOLS, the *P184-7* (shown in photo above) and *P180-7 Slit-N-Wrap* tools from Vector (12460 Gladstone Avenue, P.O. Box 4336, Sylmar, CA 91342) represent a logical extension of their line of convenient and effective wire-wrapping tools. Of course, those two models make the same reliable connections as Vector's

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other *Slit-N-Wrap* tools but they also have some desirable features that can be especially advantageous.

With the *P184-7* and *P180-7*, there will be no more over-wrapped or under-wrapped connections. You simply dial-in the desired number of wraps, and each time the trigger is squeezed, the tool delivers that pre-set number of turns and then stops! Anyone who does more than a minimum amount of wire-wrapping will really appreciate the value of an automatic turns-counter.

Before examining those tools farther, let's distinguish between them. The only different between them is the type of wire that they use. The *P180-7* is set up for use with 28-gauge copper wire coated with polyurethane and nylon insulation. That is the "standard" wrapping wire, which also may be soldered without stripping. The *P184-7* uses 28-gauge silver-plated copper wire with a Tefzel (Kynar and Teflon) insulation. The Tefzel is a bit thicker (.005 inches), but it takes the best features of its component parts, resulting in a tough insulation that helps to reduce crosstalk. Other than using different types of wire, both models are alike.

Certainly, *Slit-N-Wrap* is a well-known wire-wrapping technique. Using that method, it is unnecessary to strip the insulation from the wrapping wire before it is applied to the wire-wrap post. The tool automatically slits the insulation as the wire is wrapped but the insulation remains intact between wraps. Thus, it is possible to wire from post-to-post (daisy-chain style) without cutting the wire and starting fresh at each one or having to worry about wires shorting to each other.

The amount of tension on the wrapping wire is very important. Too little tension will result in a poor electrical and mechanical connection. Too much tension can cause wire breakage and poor mechanical stability. Vector provides explicit and easily-followed instructions for properly setting the two adjustments which determine the tension on the wire as it is fed through the tool. Once those adjustments are made, the tension need be checked only occasionally. During our tests, the tension remained constant after the initial adjustment.

Setting the number of turns to be made is only a matter of setting a small dial on the top of the machine. For 28-gauge wire, 7 turns are recommended. Available settings range from 3 to 9 and R, which is a free-running mode that causes the tool to wrap continuously without counting or stopping—as long as the trigger is held. In addition, there is a small three-position toggle switch that engages or disengages the electronic counting-mechanism or disengages the trigger to prevent accidental turning when you are working on the tool.

Another convenient feature of the tools is that the free end of the first wrap need not be held—it is automatically secured. That provides a further advantage not only in convenience, but in speed as well.

So that you can keep track of the wiring in wire-wrapped circuits—it can get rather unwieldly at times—the insulated wire is available in different colors. At this time, four different wire colors are available with polyurethane-nylon insulation, while six colors are available with Tefzel insulation. The tools are designed to make changing the wire quite painless. Even changing the slitting-wrapping bit is easy, though with an anticipated life of 7,000 seven-turn wraps, the typical operator would not need to do that for some time.

During our testing of the *P184-7*, it was found to be fast and effective. Further, the pistol-like tool was balanced and shaped to reduce fatigue even when used for long periods of time.

The tools are packaged in complete kits. In addition to the wrapping tool, each contains an AC power supply, a large roll of wire, a cutting-format tool, and an adjustment tool. Also included are a weight for adjusting wire tension, a small supply of wrap posts, an Allen wrench and spare set-screws, and even a push pin that may come in handy when threading the wire. Of course, there is a thorough instruction booklet that covers not only the tool itself, but general wire-wrapping techniques.

Altogether, the Vector *P184-7* and *P180-7*, which sell for $175 each, are well-designed, effective and well-package. Using either or both of these tools will provide increased efficiency and maximum assurance that the wraps are mechanically and electrically sound. The *P180-7* and *P184-7* are worthy additions to the *Slit-N-Wrap* line. R-E

System Saver Protection Device for Apple II Computers

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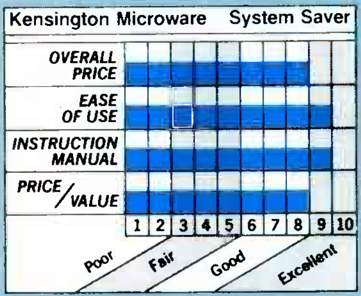


A NUMBER OF TODAY'S SMALL COMPUTers, such as the members of the *Apple II* family, do not use forced-air cooling. Because of their relatively low component count, and the fact that most of the IC's are the low-power Schottky type, they can get by with convection cooling through ventilation slots in the computer case.

The problem with the *Apples*, though, is that their seven or eight expansion slots encourage the addition of additional boards that contain additional heat-producing components. By the time you've added a disk-controller card, extra RAM, an 80-column display board, and I/O capabilities, it starts to get pretty warm inside the case.

Heat, as you are no doubt aware, is the enemy of electronics components. It shortens their lives and can frequently cause IC's to act erratically. (So *that's* why my disks got garbaged last night!)

Kensington Microware Ltd. (300 E. 54th St., New York, NY 10022) has come up with a solution to the "baked *Apple*" problem; it's called the *System Saver*.

The solution

The *System Saver* is really a very simple device. It attaches to the left side of the computer, over the ventilation slots there, and contains a fan that pulls 15-cubic-feet-per-minute of air through the computer, across the area where the accessory boards are located. That flow of air carries away the heat generated by the boards and keeps the computer operating comfortably.

In operation, the fan is quiet enough to become completely unobtrusive after a little while, and the air exhausted is only mildly warm to the hand. What really matters is that the computer runs cool, and can be operated for extended periods without fear of overheating something inside and causing the system to crash.

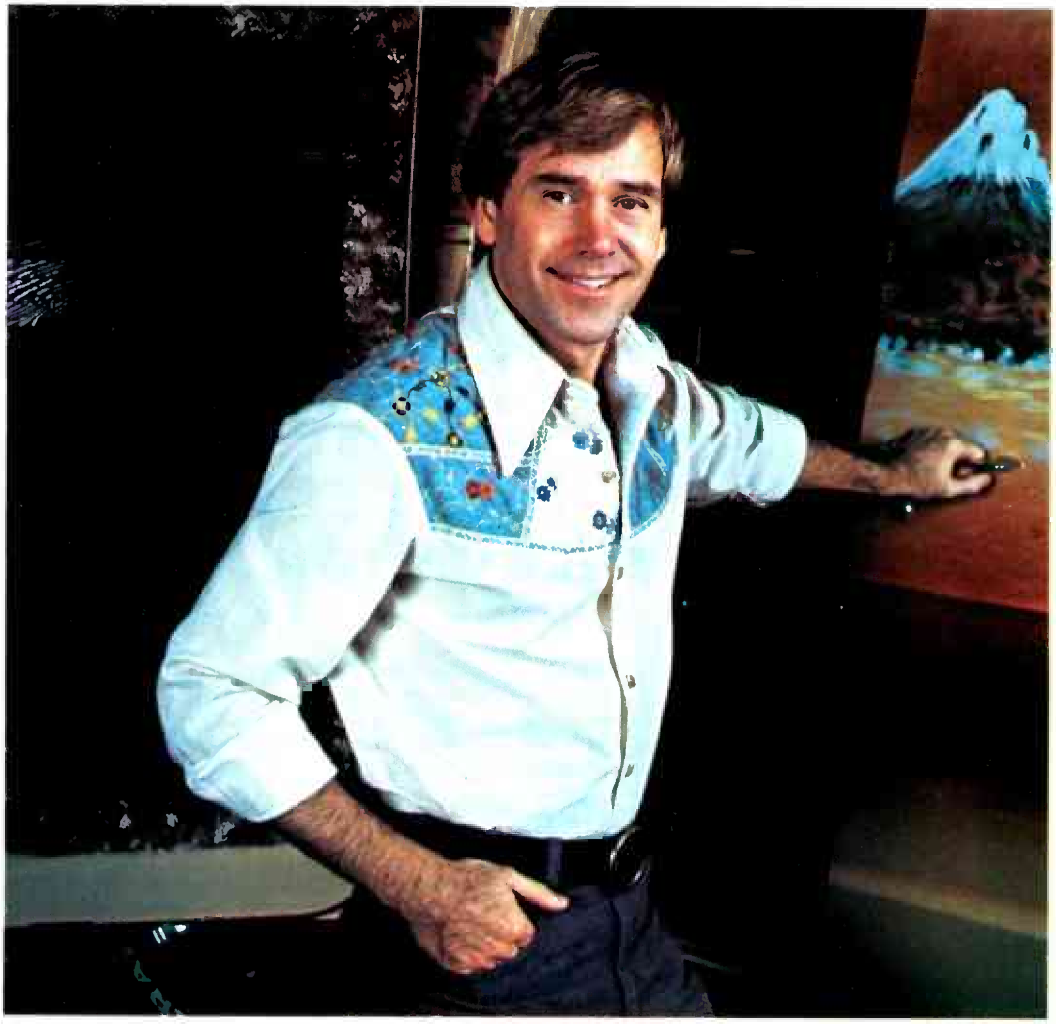
The device offers several convenience features as well. At its rear are two three-prong electrical outlets rated at eight amps (total). They allow you to plug in your monitor and printer and, by throwing the rocker switch—which contains a pilot light, by the way—at the front of the unit, to turn those two pieces of equipment, and the computer, on all at the same time.

The *System Saver* provides another benefit in that it has a surge suppressor built in; voltage spikes that may appear on the power line are clipped off at a level of 130-volts RMS (175-volts DC). That will help keep glitches out of the system. You'll appreciate that, especially if you live in an area where spikes and surges are a way of life.

And, to put the icing on the cake, there is also a "pi"-type RF filter to prevent

continued on page 38

You gotta shop around.



When you do, you'll probably pick CIE. You can't afford to settle for less when it comes to something like electronics training that could affect your whole life.

continued from page 33

electrical noise that may be present on the lines from getting into the computer. The filter is most effective from 600 kHz to 20 MHz, with an attenuation factor varying from 30 dB to 50 dB. Its effect is strongest at 2 MHz, which is close to the fundamental frequency of the computer's crystal clock.

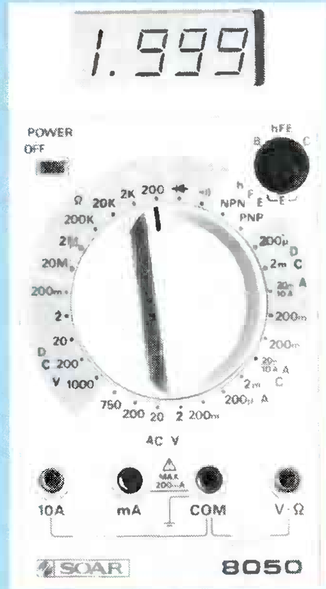
Installation and use

Setting up the *System Saver* is so simple that I'll quote the instructions here in full. My comments appear in parentheses.

1. Attach *System Saver* to your *Apple II* as shown. (A lip on the unit slips over the top of the side of the computer; the unit then just rests there.)
2. Disconnect your *Apple II* power cord. You won't need it any more. (But I'd hold onto it if I were you—you never know when it will come in handy.)
3. Plug the *System Saver*'s short power cord into the back of your *Apple II*. Plug *System Saver*'s long power cord into your wall outlet. IMPORTANT: Leave your *Apple* power switch permanently on. You'll never use it again.
4. Plug your monitor and printer in *System Saver*'s rear outlets.
5. You're all set! *System Saver*'s front-mounted switch now controls your *System Saver*, *Apple II*, monitor, and printer.

That's all there is to it. The *System Saver* is in place and ready to protect your computer from heat, power surges, and line noise and, as far as I can tell, it does a good job of it. The *System Saver* is color matched to the *Apple II*, and can also be used with the *Apple Stand*, if you use one. $89.95 buys a lot of protection. **R-E**

Soar Corporation 8050 Digital Multimeter



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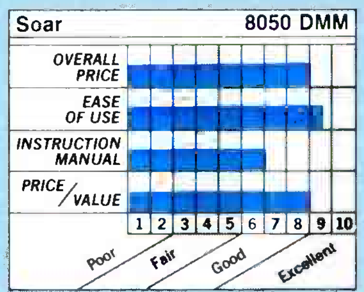

THE NORTH AMERICAN SOAR CORPORAtion (1126 Cornel Avenue, Cherry Hill, NJ 08002) is offering a digital multimeter, their model *8050*, that has just about all the ranges and functions you'll ever need for almost any kind of electronic servicing.

Before we discuss its capabilities, let's look at its external features. The case is made of strong plastic that should be able to withstand some abuse. In the center of the front panel of the case is a single, recessed range-selector switch. The POWER switch is located at the upper left of the case—that's more convenient than having it included on the range selector. (I have more than once left my multimeter

continued on page 98

NEW PRODUCTS

For more details use the free information card inside the back cover

WAVEFORM ANALYZER, model *SC61*, is the first instrument to automate completely every conventional scope measurement for the purpose of obtaining faster, more accurate waveform analysis than is possible with conventional scopes. The unit includes a digital readout on both channels for peak-to-peak

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volts, DC volts, frequency, and time.

The automatic readout eliminates the time-consuming graticule counting and calculating for conventional scope measurements. That total automatic readout is an exclusive. All measurements are made through one probe, available on both channels, eliminating any extra time-consuming lead hookup. Peak-to-peak volts, TIME and 1/TIME are also featured for any waveform section using a variable bar called "DELTA MEASUREMENTS."

For a limited time, the model *SC61* is priced at $2995.00.—**Sencore, Inc.**, 3200 Sencore Dr., Sioux Falls, SD 57107.

MODEM ENHANCER, the *turboMUX*, is designed for owners of 212A modems, and doubles the throughput of a 1200-baud modem. It provides two types of improvements: 2400-baud full-duplex throughput, and the operation of a 2-channel statistical multiplexor.

The *turboMUX* has 2 channels. It attaches via standard *RS-232-C* interfaces, to the

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212A modem on one end, and to the data-terminal equipment on the other. When one channel is used, it accepts data at 2400 bits per second. As a multiplexor, each channel receives data at a minimum of 1200 baud and up to 2400 baud, for a total data throughput of 2400 bits per second. The *turboMUX* unit compacts the data for transmission over dial-up lines.

To double the 212A modem's throughput,

the *turboMUX* unit uses a data-compaction algorithm. For phone-line inconsistencies, the *turboMUX* unit provides error detection and re-transmission facilities.

The *turboMUX* is priced at $995.00. (At $1,275.00, the *turboMUX* unit offers a 20-channel statistical multiplexor that can operate with the 212A modem.)—**Chung Telecommunications, Inc.,** 4046 Ben Lomond Dr., Palo Alto, CA 94306.

TIME-INTERVAL OSCILLOSCOPE, model *1726A*, offers 50-picosecond accuracy and 10-picosecond resolution; it combines counter and oscilloscope technologies and has the viewing and measuring capabilities of a 275-MHz oscilloscope, and the ease of use of a time-interval counter.

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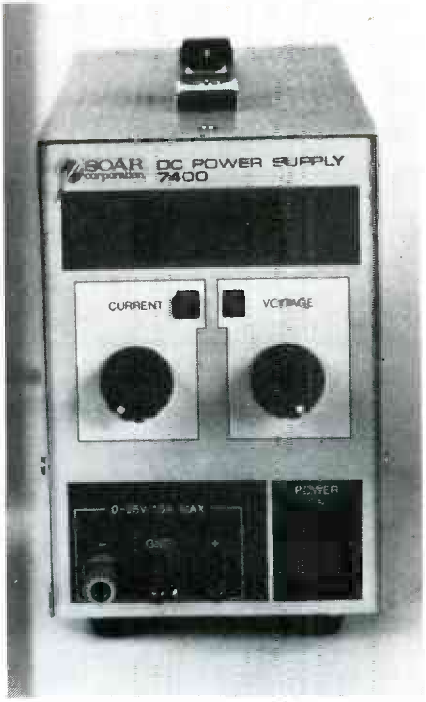
The model *1726A* uses a crystal-reference time base (i.e., the counter measurement technique) in conjunction with a CRT and stable triggering circuits (i.e., the oscilloscope measurement technique). The combination allows the model *1726A* to display the signal being tested as well as measure the designated interval with up to 50-picosecond accuracy. The hybrid technology provides new measurement capabilities (e.g., first-pulse measurements) with a repeatability characteristic (± 30 piocoseconds) not offered by any other time-interval measurement instrument.

The model *1726A* is priced at $7675.00.—**Hewlett-Packard,** PO Box 2197, Colorado Springs, CO 80901.

DC POWER SUPPLIES, model *7400* (shown), model *7401*, model *7402*, and model *7403*, all feature large, bright, 3-digit LED displays that indicate voltage or current. The output of each model is uniform. Ripple is held below 1 mA, line regulation is less than 5mV and 5mA, and load regulation is better than ± 0.3% on voltage and ± 0.5% on current. All models have constant voltage and constant current outputs. If the load current exceeds the established setting, the decimal point in the LED readout blinks and the unit stabilizes, i.e., the output current remains constant while the output voltage changes by whatever amount is necessary to accomplish that.

The model *7400* delivers 0 to 25V to 1.5A, and is priced at $235.00. The model *7401* is 0 to 25V at 0 to 3A, while the model *7402* is 0 to 36V at 0 to 2A; both have the same price: $275.00 each. The model *7403* is 0 to 36V at



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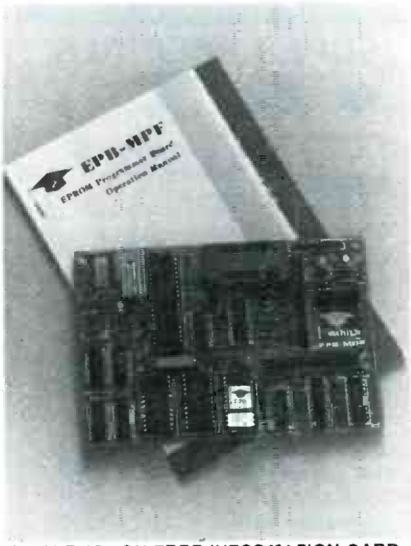
0 to 3A, and is priced at $325.00.—**North American Soar Corp.,** 1126 Cornell Ave., Cherry Hill, NJ 08002.

BOARD, the EPROM Programming Board, model *EPB-MPF* allows the user to program all single-supply (+5-volts) 1K/2K/4K EPROMS. Software stored in 2K bytes of on-board ROM gives the model *EPB-MPF* the capability to read, write, copy, test, and verify desired program code. The software also provides for restart, delete, and insert operations using 4K bytes of on-board static RAM as a buffer memory.



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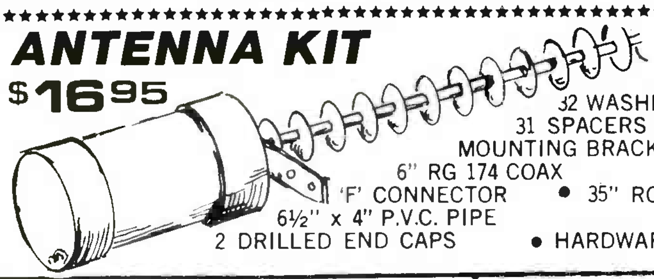
The model *EPB-MPF's* features include: 2K bytes of ROM, 4K bytes of RAM, 24 parallel I/O lines, 24 pin zero-insertion-force socket, 9-volt 400 MA power adaptor, complete accessories to hook up the model *EPB-MPF*, and a detailed operations manual.

The model *EPB-MPF* is priced at $169.00.—**Etronix,** 14803 N.E. 40th Street, Redmond, WA 98052. **R-E**

2300 MHz VARIABLE DOWNCONVERTER

ANTENNA KIT

$16.95



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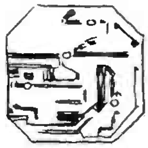

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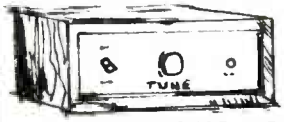

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ALL ABOUT AUTOMOTIVE NAVIGATION SYSTEMS

Computers are finding more and more applications in the car, and soon one will even be able to tell you where you are and where you are going. Here's a look at the automobile navigation-systems of the not-too-distant future.

DANNY GOODMAN

IF YOU WATCH ANY "SCIENCE FICTION," EITHER ON TV or at the movies, you have a pretty good idea of what's Hollywood's concept of the car of the future—a sleek sports model with enough computer screens and controls to make even a Boeing 767 cockpit look like a child's toy.

But researchers are hard at work trying to separate the science from the fiction. A Sunnyvale, California inventor and a major Japanese automobile-manufacturer—in independent efforts—are bringing us closer to the day when you can equip your car with an automotive navigation-computer to guide you

through unfamiliar territory. We are not talking about the Mercedes-Benz system that you might have read about; that system relies on communication between your car and central traffic computers and requires roadbed cables and sensors. The navigation systems we'll be looking at consist of self-contained computers and sophisticated optics systems that will, among other things, eliminate the folded mess of roadmaps in your glove compartment.

Ready applications

If you frequently travel on business, you've probably arrived in a new or unfamiliar city armed with little knowledge about it other than the address of the company you're there to visit. Arriving at the car rental counter, you first ask for an area map that, to your dismay, features only a sketch of the main roads. Asking the agent behind the counter draws a blank as to the location of the company or the small industrial-park street on which it is located.

With a navigation system designed into every car in the agency's fleet, however, the agent could preprogram a small film pack that will display a map on the car's video screen; that map will show both your present location and the location of your appointment. When you're done with the business call, the computer could show you how to get to your next appointment, or perhaps a local restaurant or your hotel.

Preprogramming routes on a map could save time and money for trucking companies and local delivery services. The most efficient routes for each driver could be defined by the company's loading-dock computer based on the listing of deliveries to be made that day. Then each driver could plug his route module into the truck's computer and follow the directions. The same on-board computer could also be used to determine each driver's fuel efficiency and monitor how closely the driver follows the prescribed schedule. A long-haul trucking company could use the same computer-encoded film pack in an office version of the navigation computer to determine the best route for a potential customer, and then quote a price based on actual operating costs that will be incurred over the route.

The system should also prove quite helpful in your family car. Trouble with one-way streets or tricky expressway entrances would be a thing of the past as the computer could help you pinpoint those easily. And cross-country drives would be much more fun since the computer would be able to call up detailed maps of cities and towns for those impromptu side trips. Moreover, you'll never really be "lost" because the computer keeps constant track of where you are and what direction you're going: just check the screen map for your location in relation to some distant landmark.

FIG. 1—A TOUCH-SENSITIVE flat-panel screen displays a full-color area map that shows your location and destination

The Navigator

Perhaps the most sophisticated system is being developed by Michael J. Alton and his company, Omni Devices, Inc. (845 Roble Dr., Sunnyvale, CA 94086) Although the system, called *The Navigator*, looks like something out of the 21st century, it is revolutionary only in the sense that it combines existing technologies—fiber optics and computers—in a new application. The result is a touch-sensitive flat-panel screen that displays a full-color area map indicating your location and destination (see Fig. 1). As you move toward the destination, your position on the map changes, and the screen zooms tighter on the map, producing increased detail over a smaller area.

Figure 2 shows how the *The Navigator* works. The light source consists of multiple bulbs, reflectors (to intensify the light in one direction), and color filters (explained later). Using many small bulbs instead of a single, high-intensity bulb helps disperse heat better. A single bulb would probably require space- and power-consuming forced-air cooling. The multiple light-sources are blended into a single projection beam using the coalescing fibers.

Next, the light passes through a condensing lens, followed by an LCD matrix that is under control of the computer. The matrix is where variable images—your location, destination, alphanumeric readouts,etc.—are added. Just as the electronically activated display-segments in an LCD watch block light from traveling to the reflective silver-gray back plate, images created and positioned by the computer in the LCD matrix of picture elements (pixels) will block light from passing any farther—thus making a shadow appear on the display screen. The prototype system uses a 32 × 32 pixel matrix, but the projected resolution for the production version is 128 × 128 pixels.

The film contained in the film cartridge plays a multiple role in the system. In addition to its obvious purpose of providing the map images that appear on the dashboard screen, the film is also contains the software that tells the computer all about the area you're traveling through.

Map images are about the size of a 35-mm negative, and a single cartridge can hold as many as 400 separate map frames—enough to cover quite a large section of the U.S. for long-distance travel. But some frames contain solid "pages" of computer data (we'll see in a moment how the computer reads the data). The data frames hold not only "raw" data like street names and number ranges or hotel and restaurant locations, but also data the computer needs to follow a given street on the map: where the street starts, what color it is on the map, its direction of travel, length, etc. That data is important because in locating a precise address on a map, the computer essentially "walks up" the street. Text-like data (streets, hotels, etc.) would be converted to LCD matrix characters for display on the dashboard screen. Other coded data including data addresses (that is, where on the film other related data can be found) are implanted on the map's "black areas;" those areas include streets, boundaries, and frame edges. A film cartridge reportedly has space for six gigabytes of information.

To achieve the affect of zooming in on an increasingly smaller area as you approach your destination, the system uses motorized lenses in a sliding bellows-type arrangement. Each map will offer between four and eight different levels of magnification.

After it passes through the lenses, the map image passes through a beam splitter. A small portion of the light is passed straight through, via resolution-intensifying fibers, to film-reading sensors capable of handling a minimum resolution of one thousand lines per inch; those sensors are connected to the computer. The computer correlates what its sensors "see" with the previously obtained computer data to further reposition the zoom lens and variable objects on the LCD matrix. The computer "looks" for color images on the map to help it track exact locations. Instead of using expensive color sensors, the computer controls rapid sequencing of the multiple bulbs at the light source through their respective color filters. Thus, simple sensors in sync with the light-source bulbs can detect which color is being passed at any point on the map.

The majority of the map image light is reflected up through projection fibers in such a way that the screen image is divided into small pieces like a checkerboard. The fiber bundles are attached to a lens plate which in turn projects the segments onto a plastic display screen. The prototype 8-inch-square screen consists of 64 one-inch square segments. That flat-screen projection system is much more space efficient and safer in an accident than the traditional, long-necked cathode-ray tube (CRT) display.

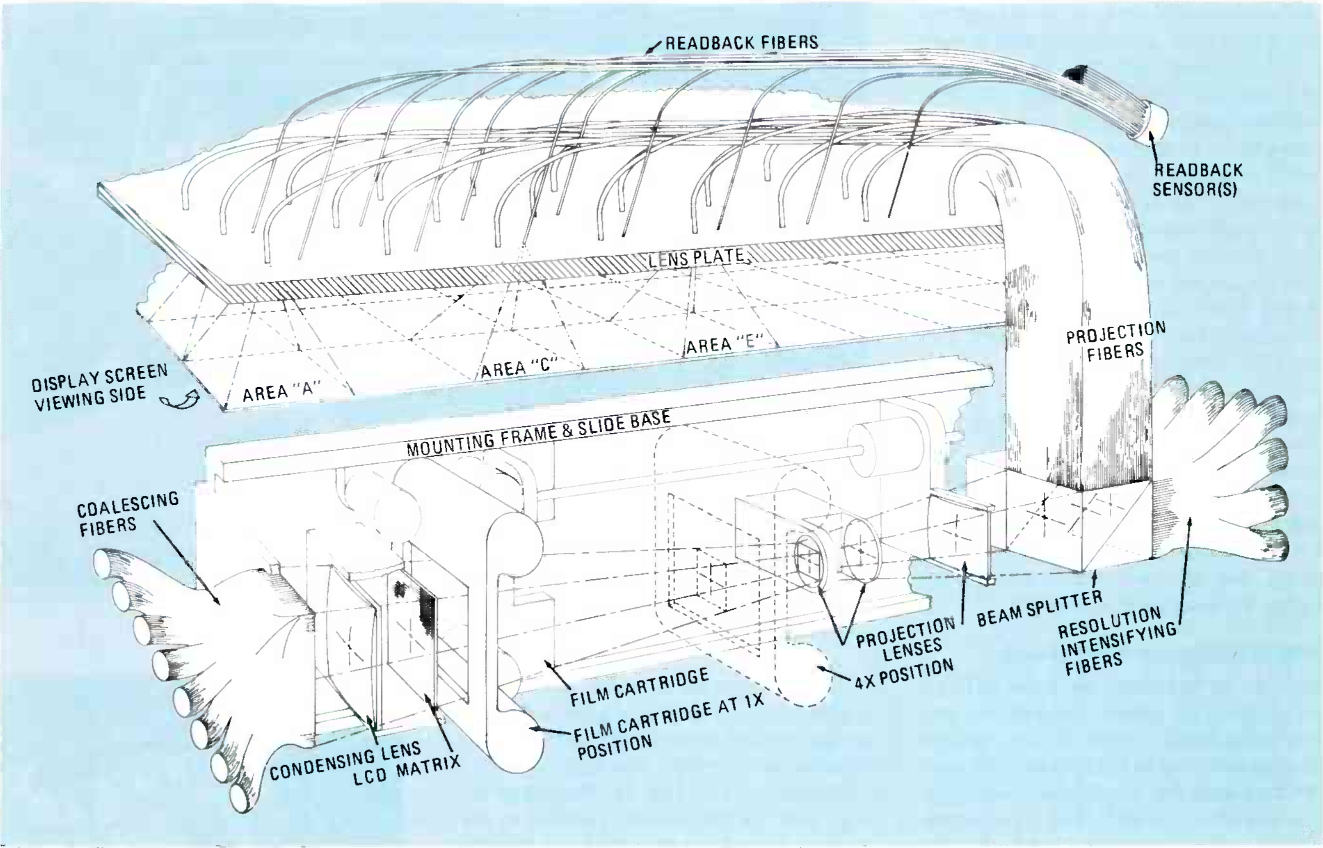


FIG. 2—INNER STRUCTURE of *The Navigator*. In the more recent version, the sliding film-cartridge has been replaced by a sliding bellows-type zoom-lens system.

Another feature of the display assembly is that readback sensors allow the screen to become touch-sensitive. When used in conjunction with screen menus (see Fig. 3), the sensors eliminate the need for a keyboard in an already crowded dashboard.

The prototype computer that controls all of that is currently designed around three Z80 8-bit microprocessors. It is anticipated that before production models become available, the computer will be based on 16-bit microprocessors such as the 8086 or 68000. In any case, multiple microprocessors will be the rule for the sake of redundancy: in case of one's failure, another can step in to keep the system operational.

FIG. 3—WITH *THE NAVIGATOR*, no additional controls need be added to an already crowded dashboard. The touch-sensitive screen allows you to select functions, modes, and more by simply touching the display.

Intelligent software

Most of the inner workings we've discussed will be completely invisible to the operator. Intelligent software is the key to making *The Navigator* easy to use without any computer knowledge—and perhaps without any knowledge of what *The Navigator* is.

As already mentioned, operator input will be done using screen menus. When it comes to trying to fool the computer by asking for an intersection of two streets that don't meet or an address out of the range of the actual street, the computer will pre-check the commands and alert the operator that those entries are not legitimate and perhaps that a slip of the finger has occurred. Of course, while the computer can check map data for whether an address falls within a legitimate range, it won't be able to tell you if the location is a clothing store or an empty lot.

A typical trip

To see how intelligent the software is, let's take a hypothetical trip in a rental car that is equipped with *The Navigator* of the future.

You've just picked up the keys and an area-map cartridge from the rental counter and are ready to leave the parking stall. You start the car, plug in the film pack, and the screen lights up and displays a menu. By placing your finger on the screen, you select the menu item that asks for your destination's address. The screen changes to a scrolling alphabetical list of street names contained on the map. A command line at the bottom of the screen—also touch operated—offers fast, slow, and stop scrolling options. Finding the street name, you stop the scroll and touch the screen beside the street name. Next the screen fills with the numbers zero through nine, which you press to input the address digits. The numbers appear at the bottom command line along with the street name, and stays there throughout the trip.

Since your present location is already preprogrammed, the computer plots the destination on the map and adjusts the amount of lens zoom required to be able to display both the present location and destination. Then the map appears on the screen. Your location is designated by a black arrow pointed in the direction that the car is facing, and the destination appears as a square.

At this point, you'll have a choice of two routing methods. With the aid of the map on the screen, you can determine your route as you would with an ordinary paper map by spotting the major roads or highways to get you across town. Or, with the help of the computer, you can trace a route on the touch-sensitive screen map with your finger. Then, if you deviate from the prescribed route, by taking a wrong turn for example, the computer will alert you to it.

Your estimated time of arrival and the distance to your destination also appear on the command line. As you head out, the computer obtains readings from a magnetic compass and the speedometer; it uses those to update the display every couple of seconds. If you're not sure how to get out of the complex maze of roads that surrounds most major airports, with a touch, you can make the computer zoom in on the airport and show enough detail for you to see where you're going.

Traveling through area roadways, you won't be tempted to watch the display rather than the road because the screen blacks out. Display on/off time will be a function of speed. After all, you shouldn't be studying a video map while racing down a freeway at 60 mph (indeed most states outlaw installing a television in a car so that it can be viewed by the driver). But if you come to a stop, the display automatically reappears.

FIG. 4—IN THE *ELECTRO GYRO-CATOR* from Honda, the maps are on overlays that slip over a display that sits on top of the dashboard.

Programming considerations

As can be imagined, the most difficult part of making a system like *The Navigator* commercially viable is the creation and programming of the film cartridges—it is expected that those will eventually cost consumers roughly $30 for a metropolitan area. Naturally, sophisticated computers will play a large part in getting the job done.

Two techniques could be used to generate the maps. One would be to simply photograph high-detail conventional maps. The other is to generate the maps using computer graphics. The maps could then be drawn by a graphics plotter and photographed as before. New technology, however, may allow the cost-effective use of high-resolution computer-graphics-to-film conversion. Computers will also be needed to generate the data that is to be implanted in the black areas, as well as to bring together all of the map's detailed information for inclusion on the data-only frames.

Software for the on-board computer may be designed to be compatible with CP/M or other popular operating systems. The advantage to that is that a vehicle owner could preprogram a route into a cartridge on a home or portable computer the night before.

The Navigator's developer predicts that it could be offered as optional equipment on U.S. automobiles in about five years, at an estimated cost of about $1000. It is likely that the most interest in such a device will be shown by the commercial transportation companies, which will benefit from routing and other economies offered by system.

Honda's system

In Japan, the Honda Motor Company is already offering a simpler navigation device, called the *Electro Gyro-Cator*, on a limited basis.

In their system, a small control and display unit sits atop the dashboard. Maps in this system come in the form of color translucent overlays that slip in over a video display (see Fig. 4). At the start of a trip, you use the console controls to maneuver a screen cursor (a "+" symbol) to the place on the map that corresponds to your position and the direction you're facing.

Then, as your travel, a trip sensor (a magnetic detection system) measures the frequency of tire rotation. At the same time, a directional sensor (shown in Fig. 5) that contains a self-calibrating gyroscope detects any turns off the original course. A small navigational computer (see Fig. 6) processes the data and generates the video display. The computer traces a video line that highlights the path you've taken on the map overlay. Therefore, you'll have a display of where you are on the map and how you got there. If traffic is at a standstill, you can check the detailed map overlay for an alternate route. As with *The Navigator*, the *Electro Gyro-Cator's* 5- × 6-inch display stays off until the car comes to a stop. A passenger, however, can keep the display on at all times if so desired.

Overlays are produced in varying

FIG. 5—THE DIRECTIONAL SENSOR contains a self-calibrating gyroscope. Its purpose is to advise the computer of any changes in direction.

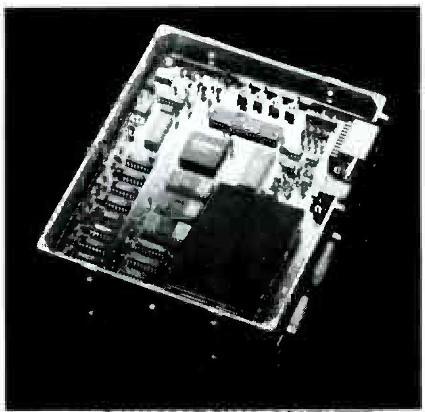
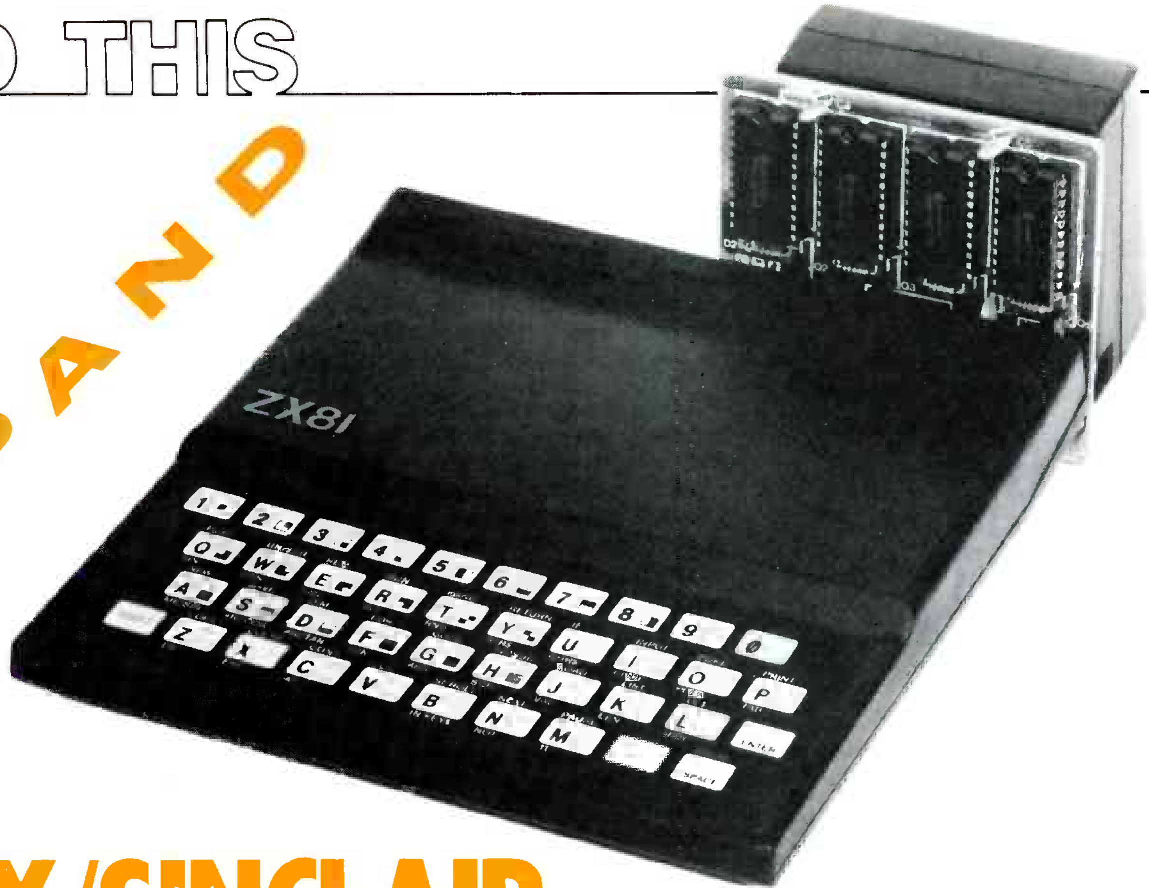


FIG. 6—THE NAVIGATIONAL COMPUTER processes data from the sensors and generates the video display.

scales and are coordinated with adjustable scales on the display screen. You can also map out paths on overlays with a grease pencil to assist in maneuvering through new territory. Cost for the *Electro Gyro-Cator*, including installation by Honda, is around $1100, but the system is presently not available in the United States.

Compared to *The Navigator's* built-in map-generation technique, Honda's overlays seem cumbersome, especially when they may need to be changed in the middle of a trip. But both systems point toward increased use of computers in automobiles of the future, and even if their introduction here is five years or so away, it is an indication of how far and how fast consumer applications of computer technology have come. Concepts that were considered to be too complex for 20th-century development will likely be realized even before the end of the 1980's. Considering that, one must wonder what the next decade, and the next century will bring. It might even leave those in Hollywood breathless. **R-E**

EXPAND Your TIMEX/SINCLAIR Operating System



Build this upgrade for your Timex/Sinclair 1000 and you'll be able to store your own system-software modifications in 8K of nonvolatile RAM.

PAUL W.W. HUNTER

DESPITE ITS LIMITATIONS, THE TIMEX/ Sinclair *1000* microcomputer (previously sold as the Sinclair *ZX81*) is a remarkable machine. It comes complete with an operating system and BASIC interpreter in 8K of ROM; 2K of RAM (the *ZX81* came equipped with only 1K); an RF modulator for black-and-white video output to any TV, and a cassette interface for program and data storage. Perhaps the most remarkable thing about the machine, however, is its $99.95 price, which is often discounted to as low as $70, and may drop even lower in the coming months.

If you own a Timex/Sinclair *1000*, you have probably wondered whether it can be improved. Well, it can. This article describes one upgrade that you can build for your machine—an 8K CMOS RAM board with battery backup. The board can be used simply to expand the computer's system/user memory, or—a more useful application—the board can be used to store machine-language subroutines and, in effect, expand the operating system of the computer.

The 8K RAM board is designed to be used with the Timex/Sinclair *1000* computer and a 16K RAM pack to form a 32K system (8K of ROM, 16K of RAM, and 8K of battery-backed-up nonvolatile memory—see the memory map of Fig 1). In that 32K system, the memory board would occupy the 8K block from 8K to 16K. That area of memory is a very convenient location to store your own system-software modifications and machine-language subroutines because it is transparent to the computer's operating system. That means that the memory is not affected by NEW, LOAD, or other such commands that would normally clear the contents of memory. Even resetting the computer (turning it off and then on) will not affect the memory.

The CMOS RAM board that we will describe requires very little power, so it can use the computer's +5-volt regulated supply. Also, the board requires very little drive, so it is unnecessary to buffer the Z80's data, address, and control lines.

Possible applications

What can you store in an 8K block of memory that is transparent to the computer's operating system? The list is almost endless, but we'll give you some examples.

The Timex/Sinclair BASIC, although

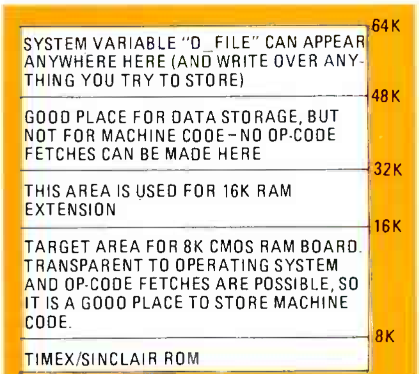


FIG. 1—MEMORY MAP OF the Timex/Sinclair *1000*. The RAM board ignores address line A15, so additional decoding is necessary if you want the CMOS RAM to reside at a block of addresses above 32K.

powerful (especially for its 8K size), does not have READ or DATA commands. However, machine-code routines can be written to simulate those commands, and then those routines can be stored in the nonvolatile memory and called (by a USR statement) when needed. That procedure thereby expands the operating system of the computer.

Other examples of user-defined system-routines that might be stored in the 8K–16K block are: line renumbering, resequencing, copying, and other editing routines; custom mathematical or statistical functions; routines to enter, examine, and edit machine-language programs; a machine-language disassembly program; a checksum routine; decimal/hex/octal conversion routines; other new BASIC commands; Sinclair code/ASCII conversion-tables, etc.

Once you have your software well established, the memory IC's can be replaced by pin-compatible 2716 or 2732 EPROM's. Thus you can even make up your own "game cartridges" that load almost instantly!

The expansion port

Before we discuss the expansion board any farther, we will take a look at the port to which it will be connected. That port, which is located at the back of the computer, provides access to all of the lines from the computer's Z80 microprocessor. The lines that are available are listed in Table 1, and the port's pinout is shown in Fig. 2.

Peripheral modules like the Timex/Sinclair 16K RAM pack—as well as the wide variety of other plug-in units that are available from various manufacturers—plug in at the port, as does the CMOS RAM board. A "piggyback" connector is included, which allows you to plug the memory board into the computer, and then plug other peripherals into the computer via the board.

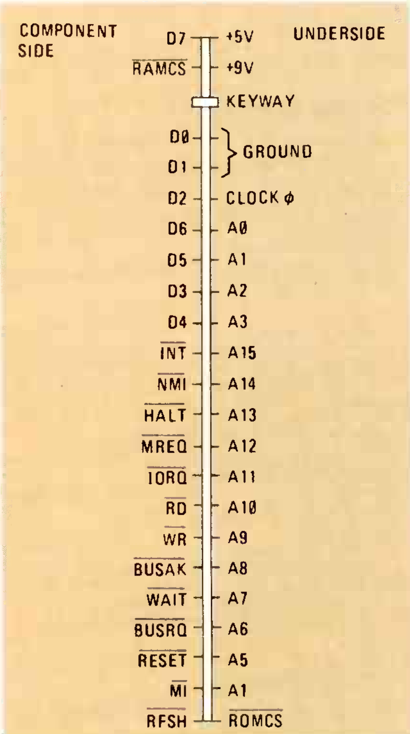


FIG. 2—THE PINOUT of the Timex/Sinclair *1000* card edge that is available at the port at the back of the computer.

TABLE 1

TIMEX/SINCLAIR EXPANSION PORT

Description	Signal	Function
Address bus	A0 - A15	Outputs memory-and I/O-device addresses
Data bus	D0 - D7	Transmits bidirectional data into/out of CPU
	$\overline{\text{MREQ}}$	Identifies any memory-access in progress
	$\overline{\text{IORQ}}$	Identifies any I/O operation in progress
	$\overline{\text{RD}}$	Indicates that the CPU wants to read data
System control	$\overline{\text{WR}}$	Indicates that the CPU wants to output (write) data
	$\overline{\text{MI}}$	Identifies the op-code fetch cycle of instruction Also used with IORQ to acknowledge interrupt
	$\overline{\text{RFSH}}$	Synchronizes dynamic-memory refresh
System clock	φ	3.25 MHz clock (output)
	$\overline{\text{RESET}}$	Resets CPU when pulled low
	$\overline{\text{INT}}$	Interrupt request input
CPU control	$\overline{\text{NMI}}$	Interrupt request input; cannot be disabled
	$\overline{\text{WAIT}}$	Indicates wait state in machine cycle
	$\overline{\text{HALT}}$	Indicates CPU has executed a HALT instruction
Bus control	$\overline{\text{BUSRQ}}$	Request to CPU for control
	$\overline{\text{BUSAK}}$	Acknowledgement of release of control by CPU
RAM/ROM select	$\overline{\text{RAMCS}}$	If pulled high will disable computer's on board RAM
	$\overline{\text{ROMCS}}$	If pulled high will disable computer's ROM
Power	+9V	Unregulated
	+5V	Regulated
	GROUND	

The signals that are available at the expansion port are predominantly the Z80 CPU signals. Two additional signals provided are $\overline{\text{RAMCS}}$ and $\overline{\text{ROMCS}}$—the chip-select signals for the onboard RAM and the system ROM. Having those lines available allows the user to disable the internal memory by tying the appropriate chip-select signal to +5-volts.

Unfortunately, the connector that is required for connection to the port is a non-standard, 46-position (23 per side) card-edge connector with 0.1-inch spacing. However, that really isn't as bad as it sounds because the connector can be fabricated easily enough by cutting the ends off a standard 50-position card-edge connector with 0.1-inch spacing. (The connector for the computer must have open ends.) A key should be inserted in the third position to prevent anything from being inserted backwards.

The CMOS RAM board

As we said earlier, the board is designed to occupy the 8K block of memory from 8K–16K. However, it can be easily "programmed" to occupy other 8K blocks, simply by changing jumper positions. (We'll get to the particulars of that in a little while.) Of course, you would probably not want the memory to occupy the first 8K block (where the computer's operating system is contained), but it could even do that if you wanted it to. The board could equally well, for example, replace half of the 16K RAM pack.

The schematic of the memory expansion is shown in Fig. 3. The Z80 $\overline{\text{MREQ}}$ control signal is used to enable the first half of the 74LS139 dual 1-of-4 decoder (IC5-a), which is used to divide the 32K of memory into four 8K blocks. The particular 8K block that the memory board will occupy is then selected by a jumper (JU1). (We will discuss how to position JU1 as well as all of the other jumpers in a following section.) The second half of that 74LS139 decoder (IC5-b) is used to provide chip-select signals for the 6116P 2K RAM's. The Z80 $\overline{\text{RD}}$ signal is used to enable the outputs of the memory IC's.

The Hitachi MH6116P (standard or 6116LP-3 low-power version) static CMOS RAM can be left in a standby mode when the computer is not in operation. That is done by backing-up the power supply with a lithium battery as shown in Fig 3. With such a back-up, the data stored in the RAM becomes non-volatile. (There is also a provision on the board for an external battery supply other than the lithium cell.) The 6116P data sheet specifies that for low-power standby, the chip-enable pin should be held at a voltage at least equal to V_{cc} – 0.2 volt. Simple NPN-transistor switches (Q2-Q5) allow passage of the $\overline{\text{CS}}$ signal when the power supply is connected, but pull the chip-enable pins to V_{cc} through resistors R2–R5 when the main power supply is not present. Transistor Q1 acts as a voltage-sensitive switch—it switches off when power from the main supply is not present which, in turn, switches off transistors Q2–Q5.

The RAM does not require a full +5-volt supply in standby mode, and a lithium cell (3 volts, 150 mAh) works well. The current drain for a fully populated board is less than one microamp. That means that a single lithium cell

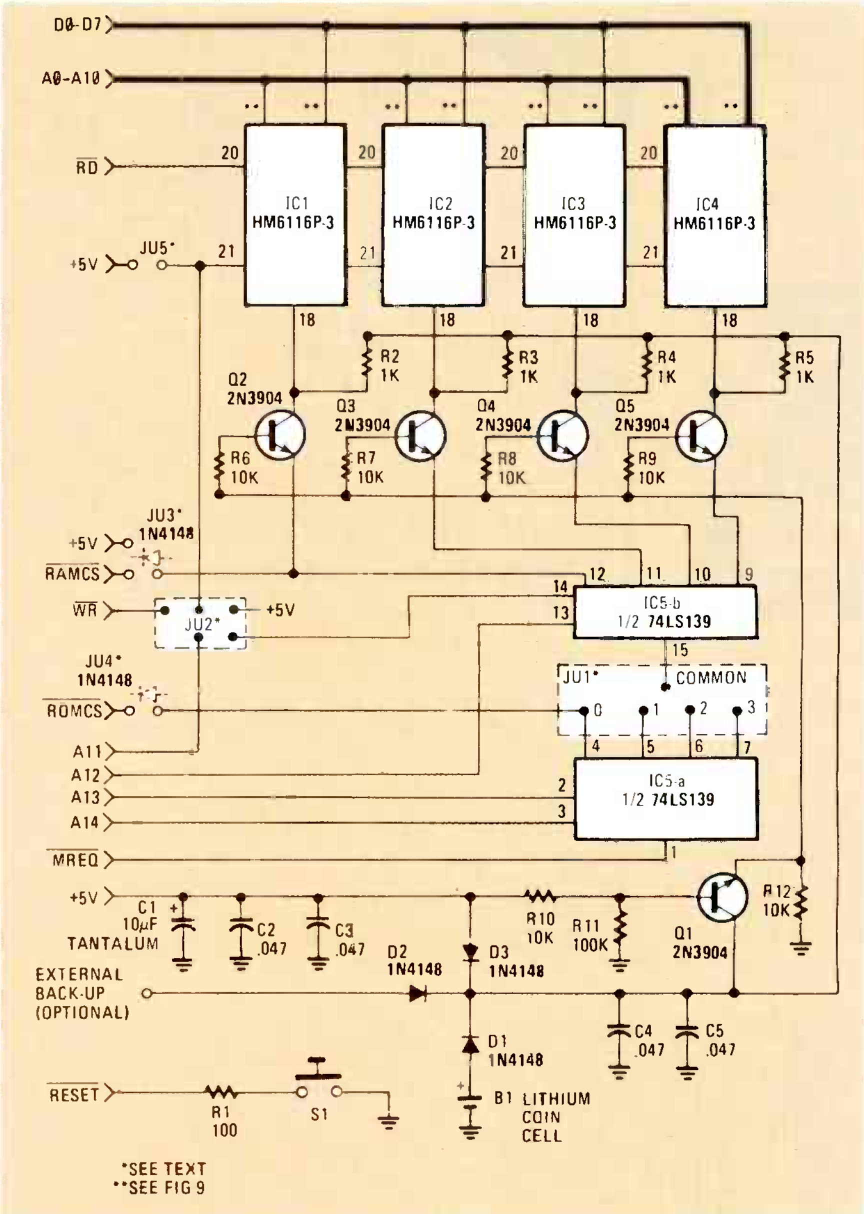


FIG. 3—SCHEMATIC of the 8K CMOS RAM board. Note that the exact pin connections for the data and address busses are not shown here—see Fig. 9.

should last for many years. Be sure to keep the CMOS RAM board plugged into the microcomputer even when you're not using it, and even when the computer is switched off. Doing that prevents the data and address lines from floating high—standby current consumption can increase two orders of magnitude if those lines go high.

A reset switch is located on the board to make it unnecessary to unplug the power supply every time you want to reset the system. It is recommended that you use the switch, because if you reset the computer by pulling the plug and then reinserting it, there is a chance that the filter capacitor in the power supply will not have time to discharge. If that happens, the CPU will not reset when the power is restored, and you may find that it will write over all of your nonvolatile memory.

Construction

We recommend that you use a printed-circuit board for the CMOS 8K RAM extension. (The foil pattern for the piggyback extender board is shown in Fig. 4, and the foil patterns for the double-sided board are shown in Figs. 5 and 6. The parts-placement diagram is shown in Fig. 7). The author, however, did put together a prototype CMOS memory board using wire-wrap techniques, and the circuit worked well. The usual rules apply—keep the connections as short as possible; lay out the circuit in an orderly way in the smallest possible area without unnecessary overcrowding; include decoupling capacitors at the power-supply pins of the IC's; avoid bundling wires together to prevent crosstalk, etc. With a wire-wrap board you will notice slight additional interference on your TV screen. Using prototype boards with a ground plane, and then shielding the boards in a grounded metal case helps a lot. However, interference is usually less of a problem with a printed-circuit board, and such a board will be more reliable in operation and construction.

If you do use a PC board, solder the sockets to the board first—use a fine-tipped low-power (about 27 watts) iron and take care not to cause solder bridges between the traces. Make sure the iron is hot and use a minimum amount of solder—too much solder may run through and form a solder bridge on the component side of the board.

PARTS LIST

All resistors ¼ watt, 5%, unless otherwise specified

R1—100 ohms
R2–R5—1000 ohms
R6–R10, R12—10,000 ohms
R11—100,000 ohms

Capacitors

C1—10 µF, 16 volts, tantalum
C2–C5—0.047 µF, ceramic disc

Semiconductors

IC1–IC4—HM6116LP-3 150-nS low-power 2K × 8 CMOS RAM
IC5—74LS139 dual 1-of-4 decoder
Q1–Q5—2N3904
S1—SPST pushbutton switch (Panasonic EVQ-P1R04K or similar)
B1—3-volt lithium coin-type battery (Panasonic BR-2325 or similar)

Miscellaneous: PC board or wire-wrap board, IC sockets, card-edge connector, battery holder, etc.

The following are available from Paul Hunter, 1630 Forest Hills Drive, Okemos, MI 48864: complete kit, including a drilled, plated, solder-masked, and silkscreened PC board; edge connector; piggyback connector; IC sockets; battery holder; battery; one HM6116LP-3, and all other components, $29.95 plus $1.95 shipping and handling. (Michigan residents add 4% sales tax.) The PC board alone is available for $15.00 postpaid. An additional three HM6116LP-3 CMOS RAM'S may be purchased with the kit for an additional $16.

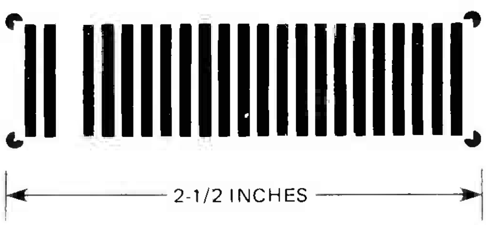


FIG. 4—FOIL PATTERN for the piggyback extender board that lets you use other peripherals with the CMOS RAM extension. Although it is a double-sided board, both sides are the same, so only one pattern is shown. The installation of this board is discussed in the text and is shown in Fig. 8.

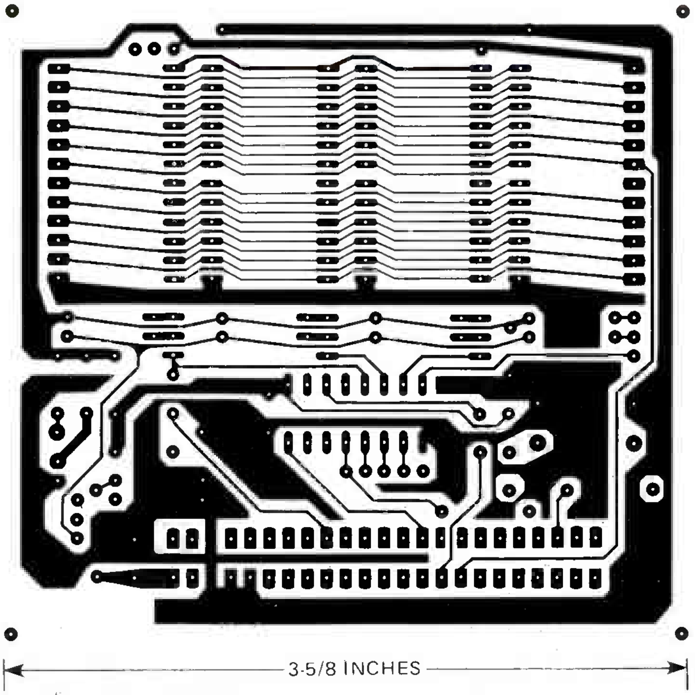


FIG. 5—FOIL PATTERN for the component side of the board. Be careful at the tight spots when you are soldering.

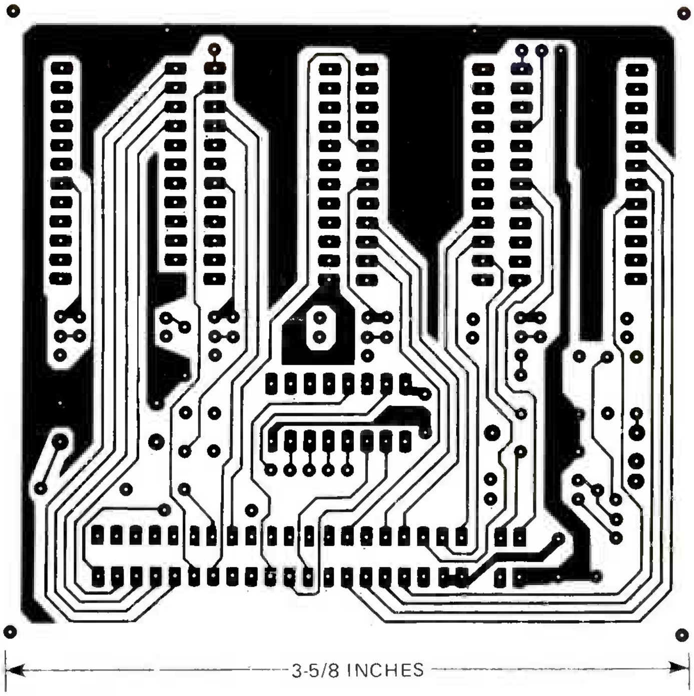


FIG. 6—FOIL PATTERN for the circuit side of the board. There are two components, S1 and the lithium battery B1, that mount on the circuit side.

Solder the card-edge connector in place as follows: Insert the connector in the appropriate holes and adjust the stand-off distance to at least ¼ inch as shown in Fig. 8. Make sure the connector is the same distance off the board at both ends, and at right angles to it; then solder one pin at each end. Check the alignment again, and if you're satisfied, solder the remaining pins. Bend the wrap posts in toward each other as shown. Secure the second extender board (for piggybacking other peripherals) between the pins, and solder the pins to its traces.

Next, solder the resistors, capacitors, diodes, and transistors in place—refer back to Fig. 7. Note especially the polarity of the tantalum capacitor, the diodes, and the transistors. The positive lead of the tantalum capacitor is nearer to the bottom of the board. The curved sides of all the transistors point to the left side of the board. Although we will not discuss the jumpers in great detail at this point, if you plan to vary your use of the board, insert wire-wrap pins at the jumper positions and use wire-wrap wire for the connections.

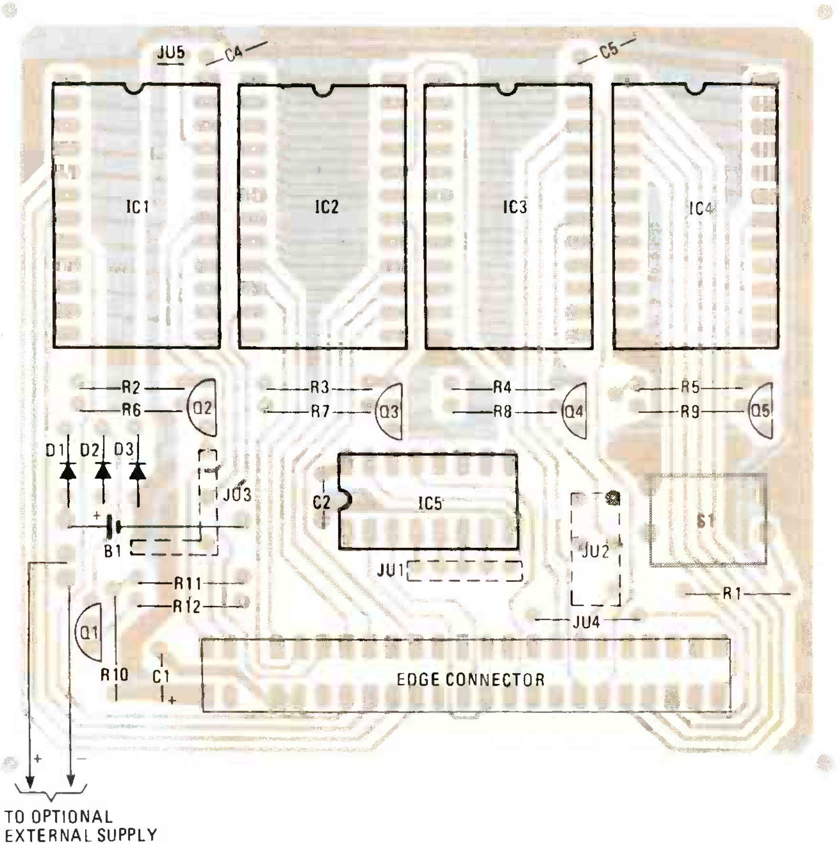


FIG. 7—COMPONENT-PLACEMENT DIAGRAM for the RAM board. Note the extra pads for connecting an external battery (other than the lithium battery) for backing up the RAM.

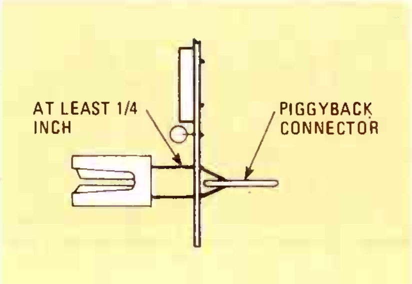


FIG. 8—SIDE VIEW OF THE CARD-EDGE CONNECTOR mounted on the PC board. Note also how the piggyback extender-board is attached.

You should mount the RESET switch on the opposite side (circuit side) of the PC board where there's a little more room for your finger to get at it. Also solder the lithium-cell holder to the that side of the board. Hold the battery-holder firmly against the board when soldering it, and make sure it's oriented correctly.

When we continue we'll finish up the construction, discuss the available options, and look at some software you can store. **R-E**

BUILD THIS

TALKING ALARM CLOCK

When you need to know what time it is, this clock tells you—literally.

LEE GLINSKI

Part 2 WE HAVE ALREADY DIScussed the theory behind how this clock talks. (See the May 1983 issue of **Radio-Electronics**.) Now we'll discuss how to build the clock, and how to operate it.

Hardware description

Please refer to the block diagram (Fig. 2), and the schematic diagram (Fig. 3) of the talking clock as we discuss its internal operation.

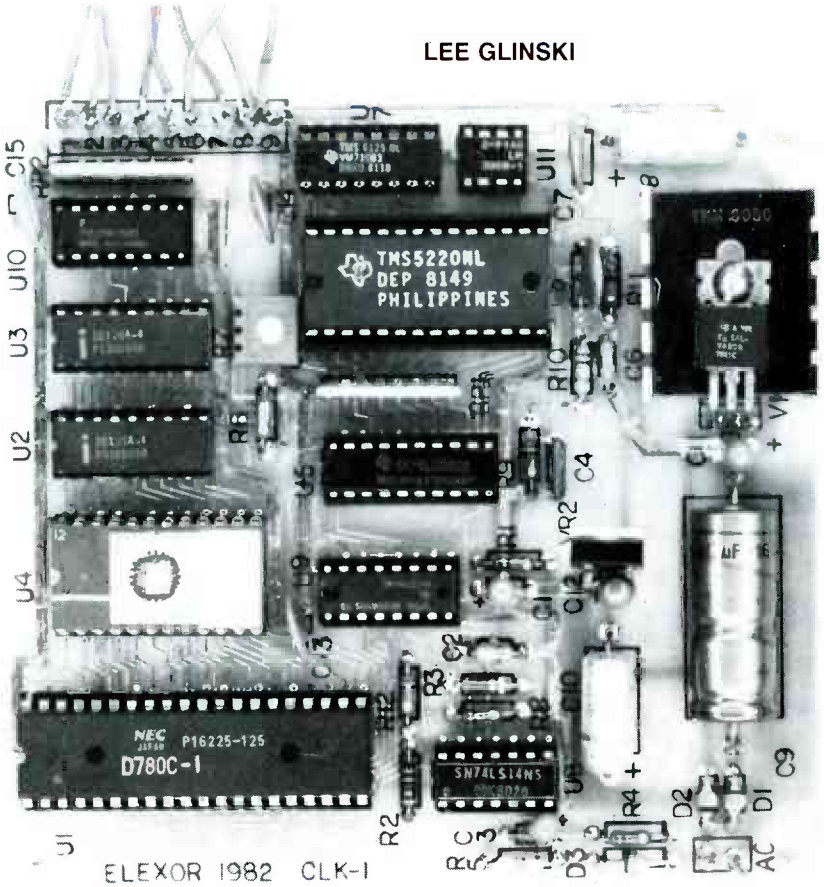
The entire clock is controlled by a Z80 microprocessor, IC1. It keeps track of the time, reads all the switches, and controls the speech synthesizer. The control software for the processor is stored in a 2516 or 2716 EPROM, IC4, with a capacity of 2K bytes. The microprocessor also uses two 1K × 4 2114 RAM's (IC2 and IC3).

The six mode and set switches, S1–S6, are connected to the microprocessor through a Tri-State buffer IC10.

A 74LS139 address decoder, IC9, connected to the microprocessor's address and control lines, generates the various strobe pulses that control reading and writing from and to the memory, speech synthesizer, and the switch buffer.

The voice-synthesis processor is the TMS5220, IC6, which is connected to the microprocessor bus through a 74LS245 bidirectional octal buffer, IC5. The buffer is needed to isolate the TMS5220 from the microprocessor data bus.

In operation, the TMS5220 and the microprocessor operate at different speeds—the TMS5220 is a very slow device. Therefore, the microprocessor has to be slowed down whenever it does a read or write from or to the VSP. That is accomplished by using a special line coming out of the voice synthesizer—the READY line. That line is connected to the microprocessor's WAIT line. When the microprocessor reads or writes from or to the VSP, the READY line indicates when the TMS5220 has finished its data transfer. The VSP will take the microprocessor's WAIT line low to signal the microprocessor to temporarily stop and wait until it (the VSP) has completed its data transfers. As soon as the data transfer is complete, the VSP releases the Z80, and program execution continues.



Speech data for time announcements is contained in ROM IC7, a Texas Instruments VM71003 that is preprogrammed with a clock vocabulary. It is connected to the TMS5220 by means of a dedicated interface bus.

The audio output of the voice processor IC is fed to a simple, passive, low-pass filter consisting of R9–R11, C5, and C6. The filter is needed because the speech waveform coming from the D/A converter contains some digitizing noise and must be smoothed out to produce a clean analog waveform. The filtered waveform is fed to audio amplifier IC11, an LM386 audio amplifier capable of delivering over 100 mW—more than enough for most purposes.

The power supply uses a wall-plug-type transformer, T1. The nine-volts AC from the transformer is rectified by diodes D1 and D2. The rectified voltage is filtered by capacitors C9 and C10 and then goes to two 3-terminal regulators, IC12 and IC13, which regulate it to +5 and −5 volts, respectively. The clock draws under 500 mA from the +5-volt supply, and under 50 mA from the −5-volt supply.

The transformer also supplies the 60-Hz reference frequency used for the timekeeping function. A 60-Hz sinewave is taken from the transformer and rectified by diode D3. The signal is then dropped to TTL levels by a voltage divider made up from R4 and R5. That TTL-level signal is buffered by a Schmitt trigger (IC8-c) and applied to the non-maskable-interrupt (NMI) line of the microproces-

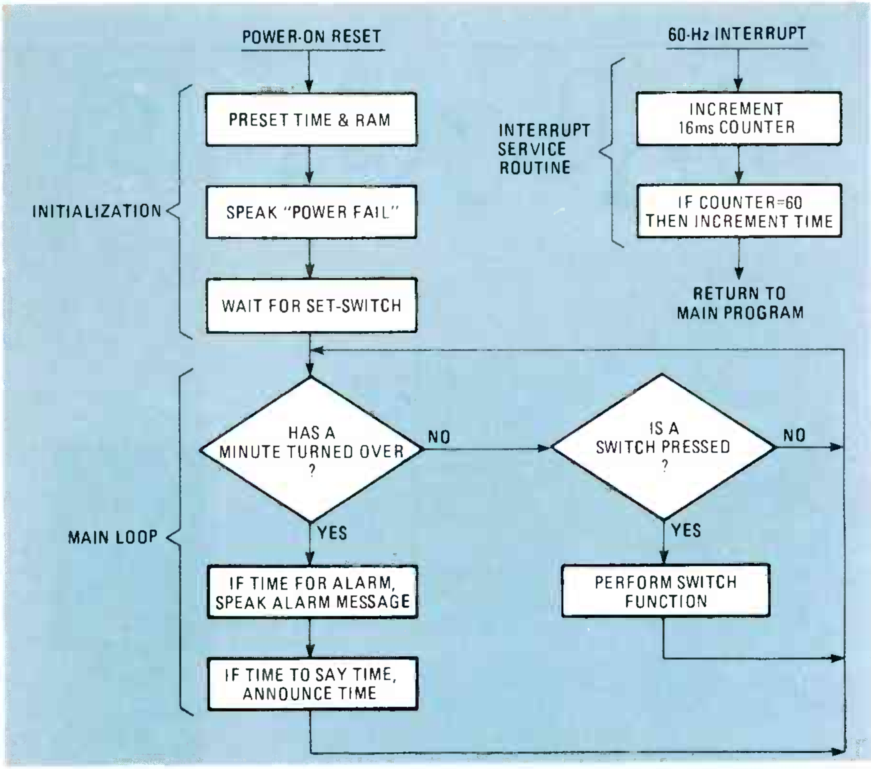


FIG. 4—MAIN LOOP IN LOGIC DIAGRAM handles coordination of timekeeping and speech functions.

(1/60-second), a count of 60 will indicate precisely one second. So, every time the counter reaches 60, the time of day is incremented by one second. The only action performed at the time the interrupt takes place is the incrementing of the time counters; resetting of the clock functions is done in the main loop of the software.

As shown in the flowchart, the primary function of the main loop is to decide when to perform certain operations.

Whenever the minute-point is reached, the software checks to see whether the alarm is on, and whether the time of day matches the alarm time. If the alarm is on and the two times match, then an alarm message is spoken.

The software also checks to see whether it's time to speak the time in the auto-speak mode. Once it decides that the time is to be spoken, it composes a phrase containing the appropriate "hour" and "minute" words. That phrase is then spoken by the voice processor.

Another function of the program's main loop is to continuously check on whether one of the pushbutton switches is pressed. If it finds one of the SET switches pressed, it increments the time, thus allowing the user to set the time of day. If

sor. Capacitor C3 across the input of the buffer filters out high-frequency noise that might give false interrupts.

Software

As mentioned earlier, the entire clock is software-driven. There are routines to keep track of time, check whether switches are pressed, compose phrases for speaking, and control the voice synthesizer to generate speech.

As indicated in the flowchart, Fig. 4, the microprocessor takes care of all timekeeping functions, as well as causing the speech synthesizer to speak words and phrases.

When power is applied to the clock, the microprocessor RESET line is activated, and the microprocessor performs a power-on initialization routine. That routine presets the time and the alarm to 12:00 AM, as well as initializing some internal registers. It then alerts you to set the time by first beeping and then announcing, *"Power fail. Set the time,"* twice. During initialization the normal time-speaking function is inhibited. That's done to prevent false time-indications. When the TALK button is pressed, instead of announcing the time, the clock will tell you to *"set the time."* The normal speaking-function is enabled only after the time has been set.

The 60-Hz line frequency provides the time reference for the clock. The 60-Hz power-line signal is applied to the non-maskable-interrupt line of the microprocessor. Every time the interrupt occurs, the microprocessor increments a counter. Since the interrupts come every 16.67 ms

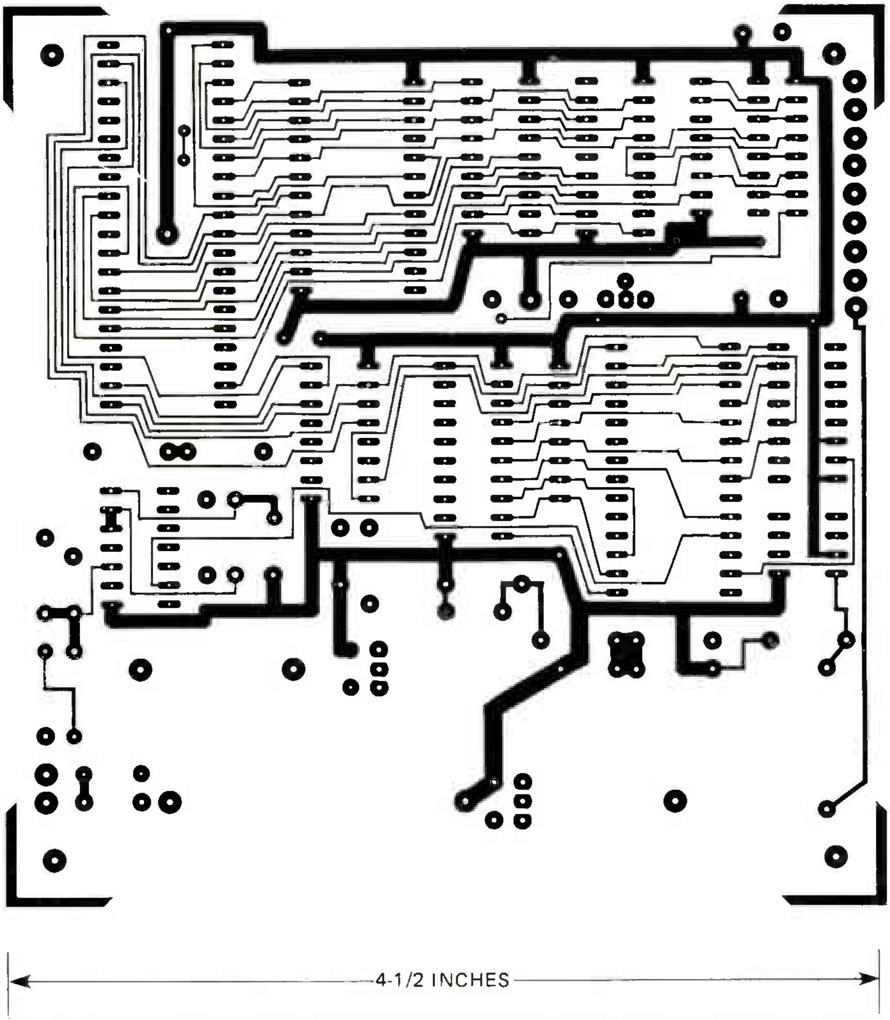


FIG. 5—COMPONENT SIDE of clock board. Large pads at right are for connections to switches and speakers.

the SPEAK TIME switch is found pressed, the software composes a phrase containing the current-time information, and announces it.

Construction

The talking clock should be built using a double-sided printed-circuit board with plated-through holes. A foil pattern for the component side of the board is shown in Fig. 5, and one for the "foil" side in Fig. 6. A professionally made silk-screened board can be obtained from the source shown in the Parts List.

PARTS LIST

All resistors ¼ watt, 5% unless otherwise noted

R1, R11—10,000 ohms
R2—330 ohms
R3—620 ohms
R4, R8, R9, R12—1000 ohms
R5—470 ohms
R5—180,000 ohms
R7—100,000 ohms, PC-mount trimmer potentiometer
R10—100,000 ohms
R13, R14—8 × 1K SIP (*S*ingle *I*n-line *P*ackage) resistor pack

Capacitors

C1—330 µF, 10 volts, electrolytic or tantalum
C2—0.001 µF, ceramic disc
C3, C11, C12—2.2 µF, 10 volts, electrolytic or tantalum
C4—0.05 µF, ceramic disc
C5, C7, C13–C15—0.1 µF, ceramic disc
C6—0.01 µF, ceramic disc
C8, C10—100 µF, 16 volts, electrolytic
C9—680 µF, 16 volts, electrolytic

Semiconductors

IC1—Z80 microprocessor
IC2, IC3—2114 1K × 4 RAM
IC4—2516 or 2716 2K × 8 EPROM, preprogrammed
IC5—74LS245 octal bus transceiver
IC6—TMS5220 voice-synthesis processor
IC7—VM71003 clock-vocabulary ROM
IC8—74LS14 hex inverting Schmitt trigger
IC9—74LS139 dual 2/4 decoder
IC10—74LS367 hex Tri-State bus driver
IC11—LM386 audio amplifier
IC12—7805 5-volt positive regulator
IC13—7905 5-volt negative regulator
D1–D3—1N4001
T1—9 VAC, 600 mA, wall-plug transformer
S1–S3—SPST slide or toggle switch
S4–S6—SPST N.O. pushbutton switch

Miscellaneous: PC board, speaker, IC sockets, heat sink for +5-volt regulator, enclosure, wire, solder, etc.

The following are available from ELEXOR, PO Box 246, Morris Plains, NJ 07950: double-sided plated-through PC board, $12.50; IC4, $7.50; IC6 and IC7, $25.00; kit of all parts (less enclosure) $69.50. Please add $2.50 for postage and handling as well as applicable state and local sales tax(es).

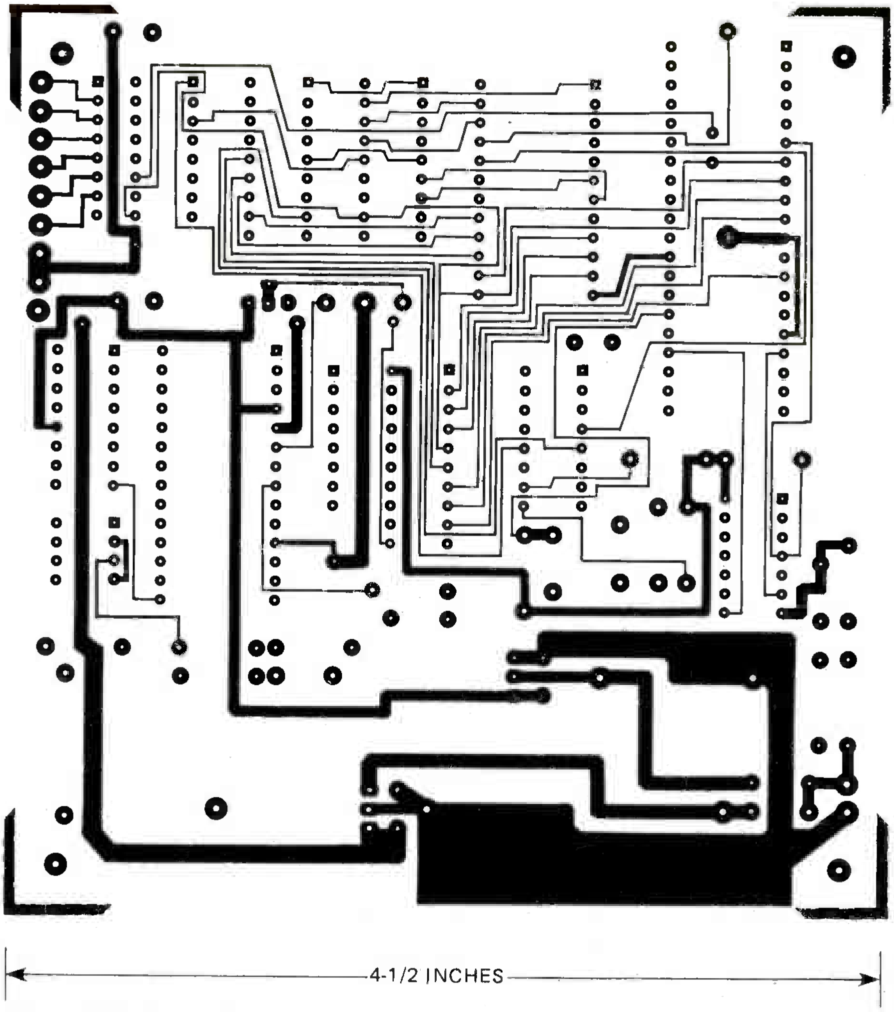


FIG. 6—"FOIL SIDE" of clock board. Double-sided board uses plated-through holes and can be ordered from supplier indicated in Parts List.

Hand-wired breadboard construction can also be used if a great deal of care is taken. The layout should follow the PC-board design. Use heavy wire for the ground and power lines, and make sure the audio section is away from the other IC's to eliminate noise-pickup by the amplifier.

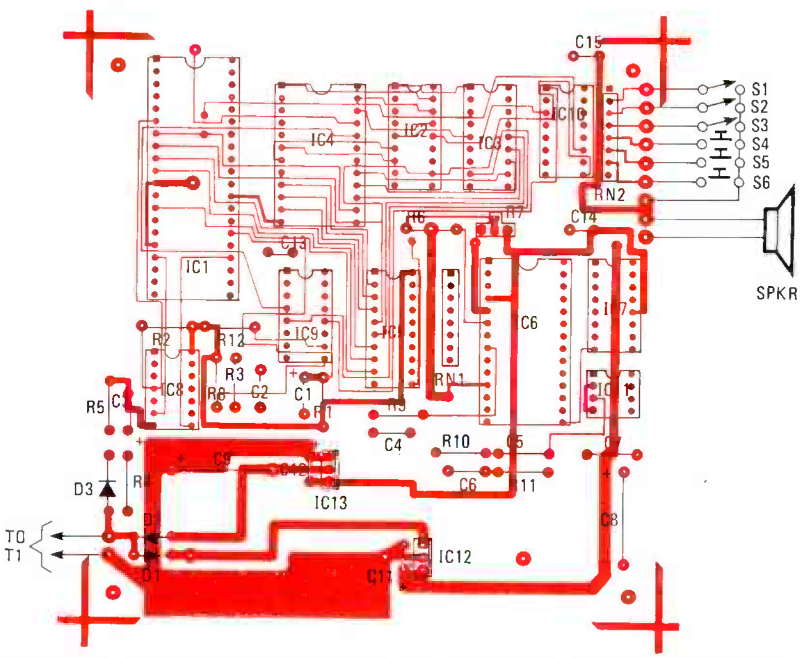


FIG. 7—OFF-THE-BOARD COMPONENTS (with the exception of T1) are mounted on clock case. See Fig. 3 for switch functions.

When assembling the board refer to the parts-placement diagram (Fig. 7). Sockets should be used for all IC's. Install the sockets, but do not insert the IC's (except for the two regulators) until after the initial checkout. When mounting the diodes and capacitors, be sure to observe their polarities. The two SIP (*S*ingle *I*n-line *P*ackage) resistor-networks, R13 and R14, must have their pin-1 ends oriented toward the top of the board as shown. When soldering, use a low-power (about 25 watts) soldering iron and contact the pads on the board for only a few seconds at a time to avoid excessive heat buildup. Excessive heat will lift the pads and thus ruin the board.

When you've finished, check the board to make sure there are no solder bridges between IC pins or adjacent traces. The completed board is shown in Fig. 8.

Final assembly

The assembled circuit board should be housed in some type of an enclosure. The enclosure should be large enough to hold the switches and speaker, as well. The prototype was housed in a toy-clock case (with the insides removed). The "alarm bells" could be mounted on top of such a case and could contain two pushbutton switches (S6) connected in parallel to activate time speaking.

The SPEAK TIME pushbutton switch should be mounted in a visible and easily accessible place like the top or front of the case, since the switch will be used often. If the alarm is also to be used frequently, then the alarm ON-OFF switch should be mounted in an easily accessible place. The MODE and SET switches should be mounted on the rear of the box to keep curious fingers from disturbing the time setting.

The speaker can be any type with an impedance between four and eight ohms. The quality of the speech output is highly dependent on the speaker and its enclosure. Some experimentation can be performed to get the most natural sounding voice. Best performance will be obtained when using a speaker with good low-frequency response. The speaker used in the prototype was 2¾ inches in diameter and, in its plastic enclosure, produced excellent sound.

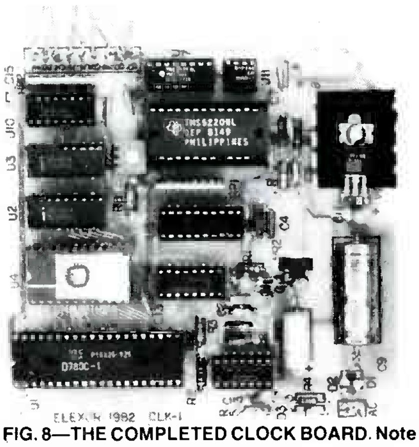


FIG. 8—THE COMPLETED CLOCK BOARD. Note that IC12 requires a heat sink.

After the PC board, speaker, and switches are mounted in the enclosure, connect the switches, speaker, and transformer to the board. Double check all the connections to make sure they go to the right places.

Checkout

For this step, the entire clock should be assembled except for the IC's.

Before turning on the power double-check to make sure all the components are oriented correctly, and check the solder pads again for cold joints and shorts. Also make sure that the off-the-board wiring is correct.

Next, turn on the power and check the power supplies. Measure the +5- and −5-volt supplies to make sure they are operating correctly.

Now turn off the power and (finally!) insert the IC's into their sockets. Make sure they are oriented correctly. Pin 1 of all the IC's should face the top of the board.

With all the IC's in place, turn on the power and listen for sounds coming from the speaker. If everything is working, you should hear a beep followed by the words, *"Power fail. Set the time."* That is the power-fail message and is spoken whenever power is first applied to the clock. If you don't hear anything, something is wrong. The first thing to do is turn off power and re-check the board for cold solder joints and shorts. Make sure that all the IC's are inserted correctly, all the parts are the correct values, and that the power supply is working.

Calibration

Calibration of the clock consists of adjusting the clock frequency of the TMS5220 (it has a built-in oscillator) with R7. It should be 640 kHz (measured at pin 3 of the IC) for the speech to sound natural. The adjustment is not very critical, and can easily be made by listening to the clock's speech output.

Using the clock

Setting the time is performed by using the two SET TIME pushbutton switches. One advances the hours, and the other the minutes. When the SET HOURS switch is depressed, the current hour is announced. (For the SET MINUTES switch it's the current minute.) As the switch is held down, the time will count up, with each increment being announced by the clock. When the desired hour or minute is reached simply release the switch and the time will be set.

If the MINUTE/HOUR SET switch is depressed momentarily, the current MINUTE/HOUR is announced, but is not incremented. At the same time, a counter inside the microprocessor is cleared to zero. That counter is used to count time in seconds, and every time it reaches 60 the time-count will increment by a minute. Thus, momentarily depressing the SET switch will synchronize time to the second.

TABLE 1

S1 Mode 0	S2 Mode 1	Function
OFF	OFF	Speak time every minute
OFF	ON	Speak time on the hour
ON	OFF	Speak time on the quarter hour
ON	ON	Auto-speak disabled

If the clock is just plugged in without the time being set, every time the SPEAK TIME pushbutton is pressed, the clock will say, *"Set the time"* as a reminder that the time has not yet been set.

The position of the ALARM switch determines whether the time or the alarm is to be set. If the switch is off, the time of day will be set. If it's on, the time the alarm goes off will be set. The alarm is set just like the time, except that the ALARM switch must be in the ON position. Remember that whenever the switch is on, the SET switches will set the alarm time and not the time of day. The current alarm setting can be heard by throwing the ALARM ON/OFF switch from the OFF to the ON position. Every time that's done, the clock will announce the alarm setting.

To use the alarm, first set the time you want it to go off, as described above. Then set the ALARM ON-OFF switch to the ON position; that will enable the alarm circuitry. When the alarm time-setting time matches the time of day, you'll hear the following: *"Good morning. The time is seven twenty-six AM. Time to get up."* The time announced is the actual time of day, and the "good morning" changes to "good afternoon" or "good evening," depending on the time of day.

After using the alarm several times I found it much more effective and pleasant than the conventional buzzer. If you are a heavy sleeper and don't wake up to turn off the alarm, it will repeat the alarm message every minute until it is turned off. Once the alarm is tripped, it can be shut off either by pressing the SPEAK switch, or by setting the alarm switch to the OFF position.

Switches S1 and S2 are used to select the auto-speak mode of the clock. In that mode the time will be announced automatically at predetermined intervals. The settings are shown in Table 1.

If you choose not to use the auto-speak mode, you can make the clock tell you the time simply by pressing the TALK button. If the button is held down, the time will be announced continuously. **R-E**

How to Use Transconductance Operational Amplifiers

Often ignored by beginners, operational transconductance amplifiers are useful and easy to work with. This article will give you a good start toward designing and building your own projects using these versatile devices.

THOMAS HENRY

IT SEEMS HARD TO BELIEVE THAT THE first integrated-circuit operational amplifiers (op-amps) were introduced less than twenty years ago. The extremely low price of IC op-amps, and the almost unlimited number of applications for them, have served to make them one of the mainstays of modern electronic-circuit design. Indeed, it is difficult to flip through the pages of any electronics publication without seeing some reference to those useful IC's.

Actually, the term "op-amp" doesn't describe one integrated-circuit, but rather is a generic term for a whole family of linear circuits. There are compensated and uncompensated types, single-supply types, current-differencing types, BiFET types, and so on. But one breed of op-amp, known as the operational transconductance amplifier (OTA) hasn't received the amount of attention that it deserves. This article details both the theoretical and practical aspects of the OTA. By the time you are done reading it, you should feel confident enough to attempt your own design with this interesting type of IC.

One of the earliest OTA's was the 3080. There are now several others available and, while they offer several interesting additional features, they essentially obey the same rules and operate just like their predecessor. Hence, designing with the 3080 is emphasized in this article, but keep in mind that switching over to other OTA's is easy.

Before considering the internal makeup of the 3080, we should consider in general terms just what it is, and what it can do. In many respects, the 3080 is much like a common op-amp. It has differential inputs. The difference between the voltages at those two inputs is multiplied by a certain gain, and the result is available at an output pin. Also, the gain can be altered simply by changing the values of certain resistors. And, finally, the 3080 needs a bipolar power-supply.

What sets it apart from the common op-amp, however, is the inclusion of another pin that allows the user to change the gain (or more properly, the transconductance) of the amplifier. That control pin, pin 5, is a current-type input. The more current, I_{ABC} that flows into the pin, the greater the IC's gain. In other words, that input current varies the transconductance of the device. In the January, 1983 issue of **Radio-Electronics**, in the series on analog-circuit design, the op-amp was modeled as a voltage source in series with an output resistance. (See Fig.3 of that article.) The transconductance amplifier, on the other hand, is modeled as a current source in parallel with an output resistance. So, yet another difference between an OTA and other op-amps is that an OTA features a current output. Speaking very generally, then, the 3080 is a current-controlled amplifier. If you consider the input for I_{ABC} (the control current) to be a programming input, then the 3080 is a programmable OTA.

What can such a device be used for? There are countless applications, but some of the more interesting ones are voltage-controlled amplifiers, voltage-controlled oscillators, sample and hold circuits, analog switches, a trianglewave-to-sinewave converter, and so on. Several of those circuits will be discussed later in this article.

Internal structure

Now that we know basically what a 3080 is and what it can do, we can start to consider its internal makeup. Unlike some other integrated circuits,

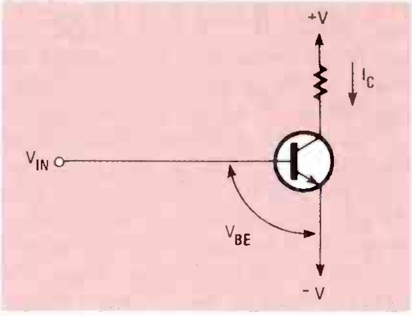


FIG. 1—THE OPERATION of the transistor differential-pair amplifier is based on the relationship of the input voltage to the collector current

where no specific knowledge of the internal circuitry is needed to use them, the unusual nature of the 3080 makes such knowledge very important.

The usual model used to demonstrate the internal structure of the 3080 is the differential-pair amplifier, although there are a few differences between them. Let's take a closer look at such an amplifier.

To understand the operation of the transistor differential-pair amplifier let's first look at the relationship of input voltage to collector current in a single transistor (see Fig. 1). That relationship is exponential and is given by the equation:

$$I_C = I'(e^{qV_{BE}/K_BT} - 1)$$

Several physical constants appear in that equation. The so-called emitter saturation-current, I prime, depends on the particular transistor used. Its value will generally be between 1 and 0.01 picoamperes. Other constants that appear include K_B, the Boltzmann constant, and q, the charge of a single electron. The equation can be considerably simplified by letting $V_T = K_BT/q$, where T is the temperature of the transistor in degrees Kelvin. The value of V_T is then about 26 mV at room temperature. Finally, the -1 term can be ignored if the transistor is forward biased. The revised equation is then:

$$I_C = I'e^{V_{BE}/V_T}$$

That revised equation is considerably easier to work with.

Figure 2 shows a transistor differential-pair amplifier. The input of the amplifier is at the base of Q1, while the base of Q2 is grounded. A control current is drawn from the two tied emitters, and it is that control current that is used to alter the gain of the circuit. The output is taken from the two collectors.

In examining the operation of this amplifier, it is convenient to assume that the beta of the transistors is large. In that case, the emitter currents are approximately equal to the collector current. Hence, $I_O = I1 + I2$. Using the transistor equation we previously discussed, and Ohm's law, the equations for I_1 and I_2 can be derived. They are:

$$I1 = \frac{I_O}{(1 + e^{-V_{IN}/V_T})}$$

$$I2 = \frac{I_O}{(1 + e^{+V_{IN}/V_T})}$$

Note the symmetry of those equations; They must always sum to I_O. That relationship is shown clearly in Fig. 3. The asymptotes of that curve are quite

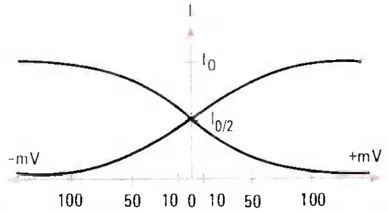


FIG. 3—THIS PLOT of emitter currents I1 and I2 shows that their sum is never greater than I_O. In fact, the sum of I1 and I2 is a constant and is equal to I_O.

important; neither I1 or I2 can be less than zero or greater than I_O. At $V_{IN} = 0$, the currents both equal $I_O/2$.

The curves are, of course, exponential, but for input voltages of less than 10 mV or so, the relationship between I1 and I2, and V_{IN}, is more or less linear. Therefore, to keep distortion to an acceptable level in linear applications, V_{IN} should be held to 10 mV or less. Also, once the input voltage exceeds 100 mV, raising V_{IN} farther has no additional affect. One of the transistors will be cut-off, while the other will be saturated.

A simplified schematic of the 3080 is shown in Fig. 4. The transistor differential-pair is quite apparent, as is the absence of resistors. In their place, current mirrors are used. In a current mirror, the output current "mirrors" the input current, hence the name. Current mirrors CM1 and CM4 are current-sinking types, while CM2 and CM3 are current-sourcing types.

Current mirrors CM3 and CM4 mimic the collector currents of the two transistors of the differential pair. The sum of those currents is thus presented to the output. If the two currents are equal, indicating equal potentials at the inverting and noninverting inputs, the currents balance and there is no current at the output. If, however, CM3 sources more than CM4 can sink, the surplus is made available at the output. Similarly, if CM4 is sinking more than CM3 can provide, the difference must be provided through the output pin.

Figure 4 also shows a pinout of the 3080. The inverting and non-inverting inputs are at pins 2 and 3 respectively; those are voltage inputs. Pin 6 is the current output and may source or sink current depending on the conditions described above. Pin 5 is the input for the amplifier control-current, I_{ABC}. Finally, pin 7 is the positive supply pin and pin 4 is the negative supply pin.

Some practical design-equations

Having described the internal structure

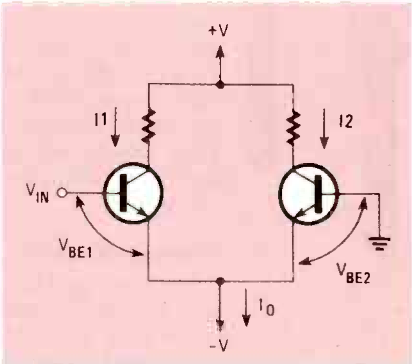


FIG 2—A SIMPLE transistor differential-pair amplifier. In analyzing it, it is convenient to assume that the beta of the transistors is very large.

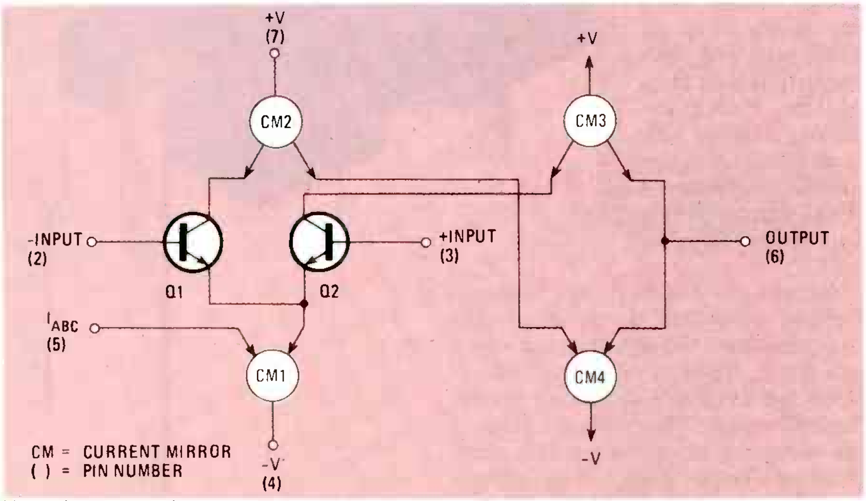


FIG. 4—SIMPLIFIED SCHEMATIC DIAGRAM of the 3080. The pin-out of the device is also shown here.

of the 3080 we can derive some practical design-equations. The most important is the so-called general transconductance equation that relates the output current to the input voltage and control current. It is: $I_{OUT} = 19.2 I_{ABC} V_{IN}$, where I_{OUT} and I_{ABC} are measured in milliamps and V_{IN} is measured in volts.

Eventually, we will want to convert I_{OUT} to a voltage, so that the unit will operate as a voltage amplifier, but for the moment, note that if V_{IN} is some fixed input-signal, we can vary the output amplitude simply by modulating the control current I_{ABC}.

Before the foregoing equation can be put to good use, some practical limits must be specified. In general I_{ABC} should always lie between 0.5 μA and 0.5 mA for best results. While it is possible to increase that upper limit somewhat, it is best not to do so since the 3080 can go into thermal runaway.

The inputs at pins 2 and 3 also have certain limitations that must be respected for good results. As we previously saw, the relationship between the input voltage and the output current is exponential and once the input reaches 100 mV any further increase will have no affect on the output current. Obviously, then, the input must be limited to less than 100 mV (or 200-mV peak-to-peak) for any sort of normal amplifier-response. But for true linear-response, the input voltage must be limited even more—a maximum value of 10 mV (20-mV peak-to-peak) is usually best. There is a trade-off here too, however, as the lower the input voltage, the lower the signal-to-noise ratio. Thus, keeping the inputs at the high end of the linear range—as close to 10 mV as possible—is desirable.

Let's now consider the supply voltage. The 3080 will work well with any power supply between ± 2 volts and ± 18 volts. Those high and low limits are extremes; best results are obtained with voltages that are somewhat between those. In many modern designs, a bipolar 15-volt supply is used, and that seems about right.

Before we move on, let's consider two other points. First of all, pin 5, the control-current input, is usually at a potential that is about one diode drop above the negative supply-voltage. Thus, if a bipolar 15-volt supply is used, the potential at pin 5 is -14.4 volts. When calculating resistor values for that input, be sure to take the negative potential into account.

Secondly, even though the 3080 is an uncompensated-type op-amp, compensation is not usually needed since most applications use an open-loop design. Compensation is only needed when negative feedback is introduced. And simplifying things still farther, the two most common negative-feedback applications for the 3080, the voltage-controlled lowpass filter and the sample-and-hold, already use

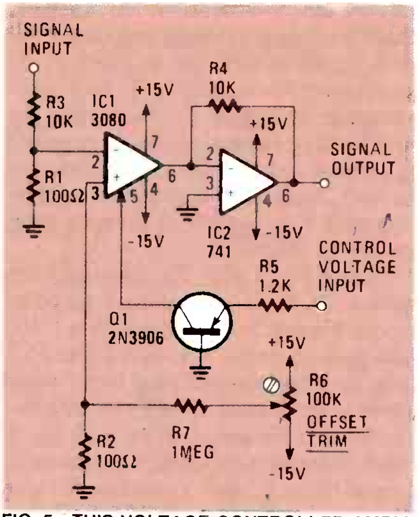


FIG. 5—THIS VOLTAGE-CONTROLLED AMPLIFIER uses just two IC's and a transistor. Though simple, this circuit works surprisingly well.

capacitors in their designs. Thus no additional compensation is needed.

Of course, there is much more to working with the 3080, but that can be picked up with experience. For now, the rules we've presented are all that you need to begin designing. Let's see how to use them in practice.

Some practical circuits

Figure 5 shows a common 3080 application, a voltage-controlled amplifier, (VCA). That circuit is common nowadays, and shows up in everything from noise-reduction units and computerized recording-studio mixing consoles to electronic music-synthesizers. (See the May, 1983 **Radio-Electronics** for a discussion of how VCA's are used in such synthesizers.) We'll examine that circuit first because it involves a very straightforward application of the design formulas and constraints we've discussed.

Suppose that our VCA is going to process a signal with a peak amplitude of ± 1 volt. As we've said, however, the 3080 works best when the input-level is limited to 10 mV. Hence, resistors R1 and R3 are used to drop the voltage to that level. Since R1 is 100 ohms, a similar resistor, R2 is placed at the other input of the 3080. In theory the 3080 should now be properly balanced, and there should be no DC feedthrough. In practice, however, offsets can still occur and when those are modulated by the amplifier severe "thumps" will result. Therefore, trimmer potentiometer R6 is added to the circuit so that any offsets can be nulled out. To adjust that trimmer, modulate the control voltage input rapidly while watching the output on an oscilloscope. Adjust R6 for minimum DC-feedthrough.

It was seen above that I_{ABC}, fed to pin 5, should be no greater than 0.5 mA under most circumstances. Resistor R5 and transistor Q1 provide a linear current that meets that requirement. At the maximum control-voltage of $+15$ volts, Ohm's law shows that R5 will conduct a current of about 0.5 mA. (Remember, pin 5 is at -14.4 volts).

A 741 op-amp, IC2 is configured as a current-to-voltage converter and will provide a low-impedance output as well. To calculate the value for R4, we apply the general transconductance equation. We know that I_{ABC} is a maximum of 0.5 mA, and we know that the input voltage is 10 mV (thanks to the attenuator—R1 and R3). Substituting those numbers into the transconductance equation yields an output current of 96μA. Now using Ohm's law, a value for R4 can be calculated. For unity gain, divide 1 volt (the original peak input-voltage) by 96μA and the result is 10.4K. Pick 10K as the nearest standard value.

That VCA, while very simple, works quite well. Perhaps its main fault is the non-linear response of the control input when the control voltage is small. A better circuit can easily be realized with the addition of a few parts. Such a circuit is shown in Fig. 6.

That circuit is actually a linear voltage-to-current converter. It will produce a current that is linearly dependent on the input voltage. In addition, since the transistor is within the feedback loop, a very precise response is guaranteed whether the control voltage is small or large. The design equation is:

$$I_{ABC} = \frac{V_{IN}\,(R1/R2)}{R2 \| R}$$

where R2||R3 is the parallel combination of R2 and R3.

In designing this circuit, you determine

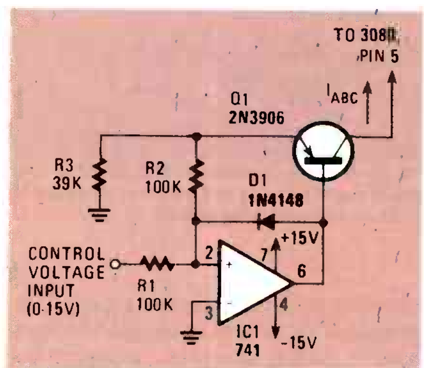


FIG. 6—FOR BEST RESULTS, this high-precision current source can be used with the circuit shown in Fig. 5. Its output is fed to pin 5 of the 3080.

the desired output-current and then select appropriate values for R1 and R2. Those three values are then used in the equation to determine the value of R3. The circuit, using the values shown, is set up to output a maximum current of 0.5 mA for a 15-volt input. That current is fed to pin 5 of the 3080. Diode D1 is included to protect the circuit from large negative input-voltages.

The VCA just described is actually a two-quadrant multiplier. It is a multiplier in the sense that the input signal is multiplied by a certain gain; that gain is determined by the control-voltage input. And it has two-quadrant operation because the signal is allowed to be bipolar; the control voltage, though, can only be positive. For that reason, the graph of the product of the two inputs, which is the output of the circuit, can lie only in one or the other of two quadrants of the four-quadrant Cartesian plane so familiar to most of us from elementary algebra. A four-quadrant multiplier, on the other hand, allows both the control voltage and the signal to be bipolar. Thus the output of that circuit can fall in any of the four quadrants.

Four-quadrant multiplier

Perhaps one of the most interesting circuits to come along in quite a while is a four-quadrant multiplier that uses a single 3080 and a 741 op-amp. Figure 7 shows such a circuit; its simplicity is quite striking. Before describing the circuit in detail, a few things should said about four-quadrant multiplier applications. As mentioned above, either input of the amplifier will accept bipolar signals. The product of those two signals (divided by a suitable scaling factor) is available at the output. But, most important, the polarity of the output will be correct. For example, if two negative signals are multiplied, the output will be positive. That, of course, makes such a circuit quite interesting for, among other things, analog-computer applications. (Actually the circuit given here is inverting; that means that the output will be the opposite of the true product. That can easily be corrected, if needed, by adding an additional inverting-stage).

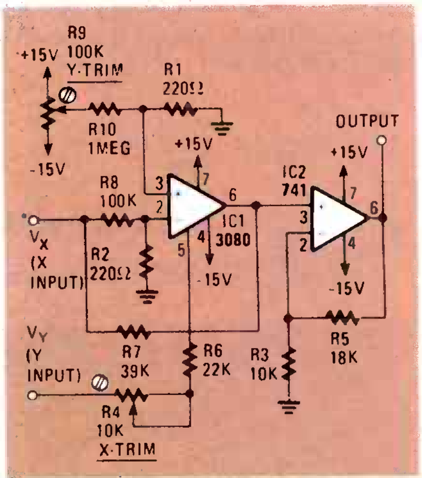


FIG. 7—A FOUR-QUADRANT MULTIPLIER. This circuit could be used in a music synthesizer to create chime and gong effects.

Another place that the circuit is especially useful is in audio applications. That's because it produces sounds that are quite similar to those produced by a ring modulator. For example, if two sinewaves are multiplied by the device, the output will be a complex signal composed of the sum and difference frequencies of the two. Such a signal can be used in electronic music-synthesis to create gong and chime effects.

Refer to Fig. 7 now. The two inputs are labeled "X" and "Y" and are set up to accept bipolar 5-volt signals (i.e., 10-volts peak-to-peak). Resistors R8 and R2 form an attenuator and drop the X-input signal to the desired 10-mV level. Resistors R4 and R6 are in series with the Y input. To balance the multiplier you apply a signal to the X input, ground the Y input (O volts), and then adjust R9 for minimum feedthrough. Then, reverse the procedure—apply a signal to the Y input, ground the X input, and adjust R4 for minimum feedthrough.

The output is converted to a voltage by IC2, a 741 op-amp. For more demanding applications, that IC should changed to a BiFET-type op-amp, such as the LF351. Note that this stage not only buffers, but also scales the output suitably—since the circuit is set up to accept bipolar 5V signals the output is scaled so that it equals $-V_XV_Y/5$. That puts the output in the same range as the inputs.

One drawback of this circuit is that only very-low-impedance input sources can be used. That is easy enough to correct, though, by buffering the two inputs. Additionally, the driving sources must be DC coupled. If those limitations are respected, however, the circuit performs very well and is far cheaper to build than any equivalent.

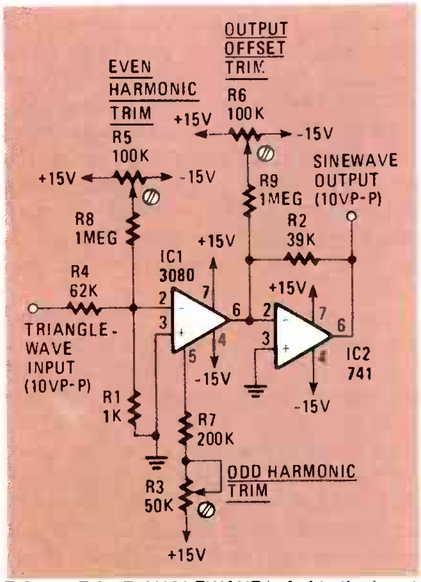


FIG. 8—IF A TRIANGLEWAVE is fed to the input of this circuit, the output will be a sinewave of the same amplitude. The total harmonic distortion will range from 2% to 4%.

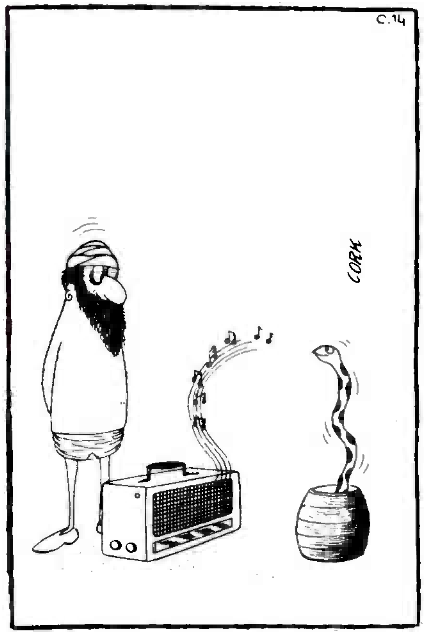
Trianglewave-to-sinewave converter

When we looked at the differential pair, we said that the input signal must always be at or below 10 mV for lowest distortion. A circuit that deliberately violates that rule is shown in Fig. 8.

In that circuit, which is a triangulwave-to-sinewave converter, a triangular wave with a value of 10-volts peak-to-peak is applied to the input at R4. Resistors R4 and R1 drop the voltage to about 160-mV peak-to-peak, which is applied to the 3080. Resistor R5 is used to trim the symmetry, which reduces the even-order harmonics. Resistors R7 and R3 form the current source for the 3080, and adjusting R3 has the effect of rounding or flattening the output; the result is that the odd harmonics are reduced. By adjusting R5 and R3, a very close approximation of a sinewave can be obtained. The total harmonic distortion of the circuit will typically range from 2% to 4%. Resistor R6 is used to adjust the output offset.

The output of this circuit will be a sinewave with the same amplitude as the input triangular wave. An important thing to note about the circuit is that it is non-reactive—it uses no capacitors or inductors. Thus it will work over a wide range of frequencies.

As this article has shown, the 3080 operational transconductance amplifier is not only versatile, but quite easy to work with. The equations we've presented, and Ohm's law, are really all it takes to get circuits using that device up and running. Obviously there are many refinements that can be made—correcting for temperature effects, for instance—but they can be tackled later on when you've had more experience with the device. **R-E**



BUILD THIS

DIGITAL VOLTMETER

For Your Car's Dashboard

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

Keep an eye on the condition of your car's electrical system with this 3-digit digital voltmeter. Even if you're just a beginner in electronics, you can easily assemble it.

MOST CARS THESE DAYS DON'T HAVE gauges or meters on their dashboards—they have "idiot lights" instead. They're great for telling you when something has gone wrong, but they do very little to warn you when something is *about to* go wrong. What's more, even if you are one of the lucky ones and your car does have gauges, their accuracy is not the best. A device with a digital readout would be much more satisfactory in many cases and easier to read as well.

The digital voltmeter described here can be installed in your car (or boat, or truck) to give you constant and accurate (to a tenth of a volt) information about the state of your battery. It is equally useful in electrically powered vehicles like golf carts and electric service-trucks (fork-lifts, baggage carts, etc.). While most of the latter do have meters, this voltmeter will prove to be more accurate.

The meter is very simple to build—it has only three IC's, three capacitors, five resistors, three transistors (and, of course, three LED's)—and for that reason makes an excellent project for the electronics novice who wants to "get his feet wet." Because it may be your first project, we'll go into the details of construction a little more deeply than we usually do in **Radio-Electronics**.

How it works

Figure 1 is a schematic of the entire voltmeter. The LM340T-5 regulator, IC1, has an output of five volts, which is ideal for the other two IC's in the circuit and for the LED displays. The input to the regulator is protected by diodes D1 and D2, and by a 47 μF capacitor, C1. Those components minimize positive- or negative-going voltage spikes that may be caused by switching inductive devices like the windshield wipers, air conditioning, electric windows, etc., on or off. A 10 μF capacitor, C2, at IC1's output damps any noise or transients that may appear on the five-volt output line and makes the regulator a very stable voltage source, which is critical for accurate readings.

The heart of the voltmeter circuit is IC2, a CA3162E dual-slope, dual-speed, A/D (*A*nalog-to-*D*igital) converter that reads the battery voltage and converts it into a BCD (*B*inary-*C*oded *D*ecimal) digital number. That number appears at pins 2, 1, 15, and 16 of the IC and is fed to pins 7, 1, 2, and 6, respectively, of IC3, a CA3161E BCD 7-segment decoder/driver that drives the three FND507 seven-segment LED numeric displays (DISP1–DISP3).

The CA3161E deserves a little further attention. It performs several functions that, in the past, would have required the circuit to contain a number of additional components. For one thing, it limits the current that is drawn by the displays. Without current-limiting, the LED's would tend to overheat and burn out and, in the past, current-limiting resistors would have been required to prevent that from happening; the CA3161E eliminates the need for them. That IC also allows the displays to be multiplexed; that means that only one LED is on at a time—although they're switched on and off so rapidly through driver transistors Q1–Q3 that they all seem to be on simultaneously. Multiplexing the displays saves a lot of power, and the total current needed to operate the voltmeter is 160 mA or less.

The maximum voltage differential allowed between the input pins on IC2—pins 10 and 11—is 999 mV. Therefore, resistors R1 and R2, whose values have the ratio 100:1, are used to form an attenuation network with a factor of 100. If 13.8 volts are applied to the attenuator network, the voltage difference between the pin 10 (which is grounded) and that at pin 11 (the input pin) will be, according to Ohm's law, 136.6 mV. What we want it to be, though, is 138.0 mV. That differ-

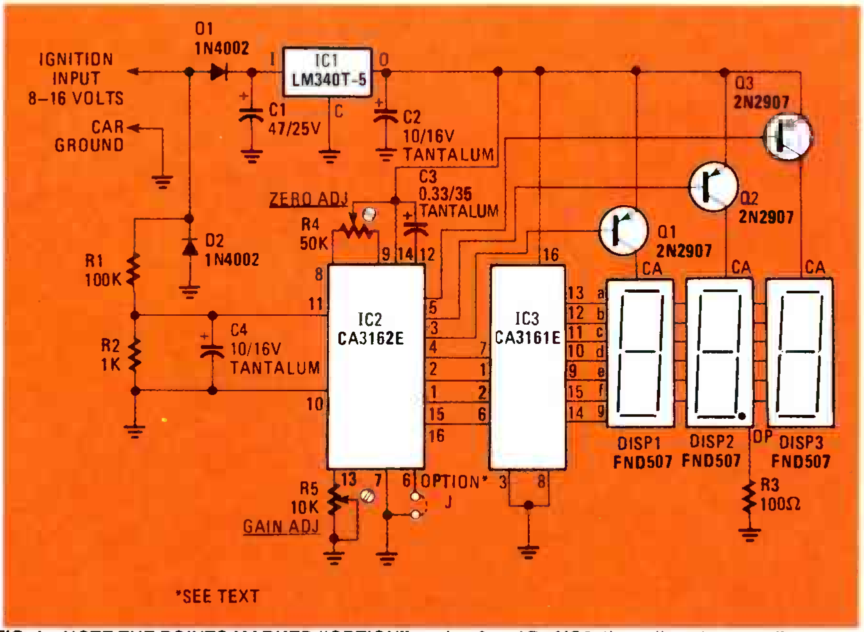


FIG. 1—NOTE THE POINTS MARKED "OPTION" at pins 6 and 7 of IC2; they allow the sampling rate of the converter A/D to be changed. See the text for details.

ence is compensated for by the GAIN ADJUST potentiometer, R5.

The ZERO ADJUST potentiometer, R4, is used—together with a 0.33 μF capacitor, C3—to generate the correct internal ramp-voltage (needed for the dual-slope A/D conversion process) for IC2. We'll discuss the adjustment of both potentiometers later.

Finally, there are two different conversion rates (the rate at which the A/D converter samples the analog input and changes it to digital form) available from IC2. Tying its pin 6 to five volts will produce a conversion rate of 96 (samples) per second. That speed, though, will cause the last digit of the display to become a blur, so we use the other conversion rate—four samples-per-second—by tying pin 6 to ground. The point at which the choice of conversion rates is made is marked "OPTION" in the schematic.

Construction tips

The voltmeter is so easy to build that the process really needs little description. Instead, we'll assume that this is the first circuit you've ever put together, and give you lots of helpful information. Even if you're an experienced constructor, you may find something of interest here, so don't skip this section!

While an etched and drilled circuit board is available from the source indicated in the Parts List, you may decide to go all the way and make your own (the foil pattern is reproduced in Fig. 2). Techniques for making your own PC boards were discussed in detail in the December 1982–February 1983 issues of **Radio-Electronics**. If the board's foil traces are naked copper, there is the possibility that some oxidation may have taken place if the board was not used immediately, and the copper may be difficult to solder to. If that's the case (or even as a preventative measure) use a clean *dry* scouring pad to wipe the copper side of the board gently and bring it to a relatively high polish. *Do not* try to clean it up using a buffing wheel! Then wipe it off with a soft cloth. It should then be as solderable as a board that's just been produced.

The choice of a soldering iron is very important. It should be low power—about 27 watts—and should be used sparingly. Keep it in contact with the points to be soldered only long enough to do the job; if you apply too much heat to a PC board the foil is apt to separate from the board. Use as fine a tip as you can get—that not only keeps heat-buildup down, but lessens the possibility of your creating solder blobs and bridges between adjacent foil points that were meant to be isolated. A fine (thin) rosin-core solder will also help keep your work neat. Use only as much solder as is needed to "wet" the connection; don't make big blobs.

A final word about soldering: keep the tip of the iron clean. A clean tip is a requirement for precision soldering. As your work progresses, solder will usually accumulate on the tip of the iron and it is important that you start soldering with a clean tip, and that you stop the buildup of solder on the tip before it gets started. A damp (not sopping wet) sponge makes a good tip cleaner. Place it out of the way on a plate where you can lightly wipe the tip against it frequently. Wipe the tip whenever you are about to put the iron down after using the it, or at intervals if you are soldering something like a series of IC pins. And, of course, wipe the tip well at the end of your work session.

Many components—like IC's, LED's, diodes, transistors, and tantalum or aluminum electrolytic capacitors—are polarized. That means that they will work properly only if they are installed in the circuit so that the correct pins or leads go to the appropriate points.

The polarities of diodes and capacitors are clearly indicated in schematics and parts-placement diagrams. On diodes, the cathode end is indicated a band; on capacitors, the positive lead may be marked with a dot on the body of the capacitor, or in another fashion. The September 1982 and November 1982 issues of **Radio-Electronics** contained a lot of valuable information on the various types of electronic components; you might want to take a look at them.

Integrated circuits like the ones used in the voltmeter come in DIP (*D*ual *I*n-line *P*in) packages. The pin-1 end of the IC may be marked with a notch, a dot (usually placed next to pin 1), or both. Many IC sockets—which you should use, by the way, in case you have to remove an IC for some reason—also have their pin-1 ends marked, even though the sockets themselves are not polarized. Those markings help you to remember which way the IC is to be installed.

Finally, a word of caution about IC's. Many of them—including the CA3161E

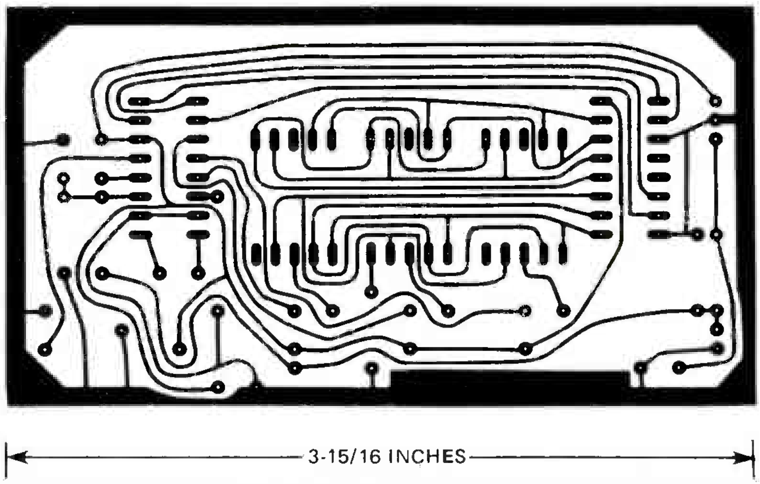


FIG. 2—FOIL PATTERN FOR ETCHING the voltmeter PC-board. A ready-to-use board is available from the supplier indicated in the Parts List.

and CA3162E—can be damaged by static electricity. Do not wear clothing made of synthetic fibers when working with such devices (although, once they've been installed on the PC board, they're relatively safe from harm and you can pretty much wear what you like). If static electricity is a problem for you, handle the IC's under humid conditions. A good solution to the problem is to steam up your bathroom by running the hot water in the shower for a few minutes and then installing the IC's in their sockets in that room while the air is still damp. That trick is especially useful in winter.

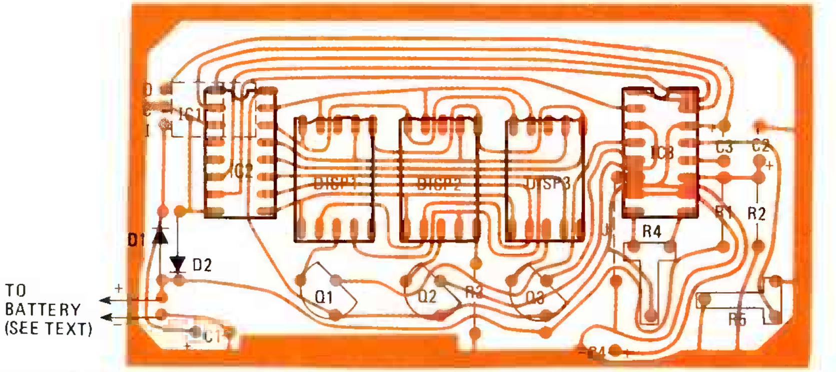


FIG. 3—NOTE THE RIDGES AT THE TOPS of the display LED's. The devices must be installed with the ridges in that position.

Construction

A red plastic filter will make the displays of the voltmeter easier to read under difficult lighting conditions. Use a piece of plastic ⅛-inch thick and a little larger than the PC board. Drill a hole in each corner of the PC board, and drill matching holes in the plastic. To avoid cracking the fragile material, drill small pilot-holes first, and then carefully enlarge them. Be careful not to scratch the plastic. Then set the plastic aside temporarily and, with the advice just given in mind, proceed to "stuff" the PC board.

Use Fig. 3, the parts-placement diagram, to guide you. Install the IC sockets first, and then the resistors, diodes, and capacitors. Don't forget the "OPTION" jumper, which can be a piece of leftover resistor lead. Save the larger parts, like the potentiometers, for last. The 47 μF capacitor, C1, can be mounted on the foil side of the board if you wish to conserve height between the plastic filter and the voltmeter board.

When you install the LED's, which can be soldered directly to the board, be certain that you mount them with the side with the ridges at the top (if you look closely, you'll be able to see the decimal point of the display at the lower right). Solder only two pins, at opposite corners of each device, first. That will allow you to reposition the displays easily if you find that they're in at an angle.

The five-volt regulator, IC1, should be mounted on the foil side of the board as shown in Fig. 4. Bend the leads carefully as shown so they arch backwards. The reason for installing the regulator on the back of the board is, again, to conserve height.

Connect about three feet each of red and black 22-gauge wire to the "IGNITION" and "GROUND" pads of the board, respectively. That will prevent confusion later on in connecting the voltmeter to the vehicle.

Finally, *do not* install IC1 and IC2 in their sockets until you have carefully inspected the board for poor solder-connections, solder bridges, proper component-orientation, and anything else that you might conceivably have done wrong (*anyone*—even you—can make a mistake). Then verify that the supply voltages to the IC sockets are correct. If you temporarily connect the red and black wires to a 12-volt-DC source, you should measure five volts at pin 14 of the socket for IC2 and at pin 16 of the socket for IC3. Pins 7 and 8, respectively,

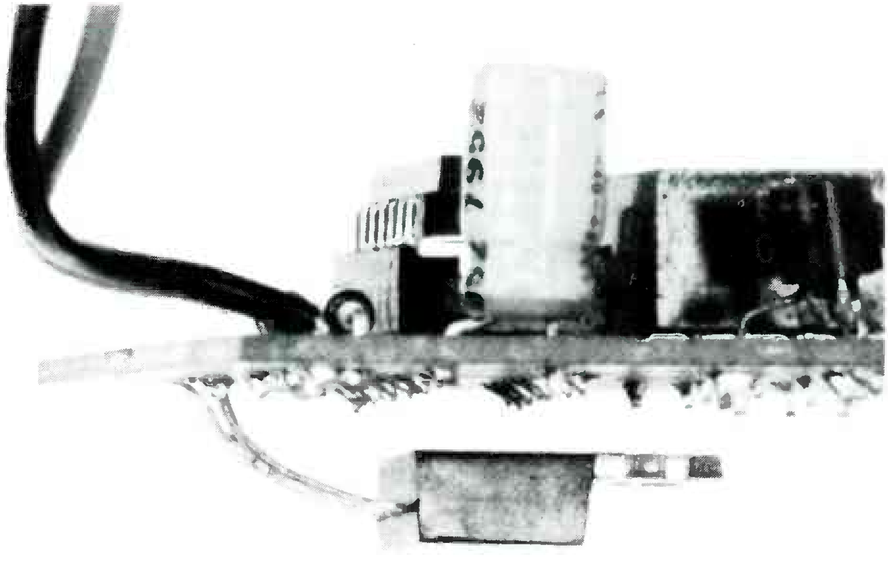


FIG. 4—THE FIVE-VOLT regulator is mounted on the bottom of the PC board, exactly as shown.

PARTS LIST

All resistors 5%, ¼ watt unless otherwise indicated

R1—100,000 ohms
R2—1000 ohms
R3—100 ohms
R4—50,000 ohms, trimmer potentiometer
R5—10,000 ohms, trimmer potentiometer

Capacitors

C1—47 μF, 25 volts, electrolytic (axial leads)
C2, C4—10 μF, 16 volts, tantalum or electrolytic (axial leads)
C3—0.33 μF, 35 volts, tantalum

Semiconductors

IC1—LM340T-5 (7805) five-volt regulator, tab type
IC2—CA3162E dual-speed, dual-slope A/D converter
IC3—CA3161E BCD 7-segment LED decoder/driver
Q1–Q3—2N2907 or similar PNP transistor
DISP1–DISP3—FND507 or FND510 7-segment LED
D1, D2—1N4002

Miscellaneous: PC board, IC sockets, wire, red plastic filter, mounting hardware, etc.

The following are available from Digital World, PO Box 5508, Augusta, GA 30906: PC board only, $7.50; PC board with schematic, $8.50; CA3161E and CA3162E, $12.00; PC board with all three IC's and with IC sockets, $20.00; kit of all parts (no filter, chassis or solder) $30.00. The prices of the *first two items only* include postage and handling costs within the continental U.S. and Canada. For all other items add $2.00 within the continental U.S.; $3.00 all other U.S., APO, and FPO. Canadians please use $U.S. postal money order. Other countries write for prices and shipping costs. Please allow 4–6 weeks for delivery.

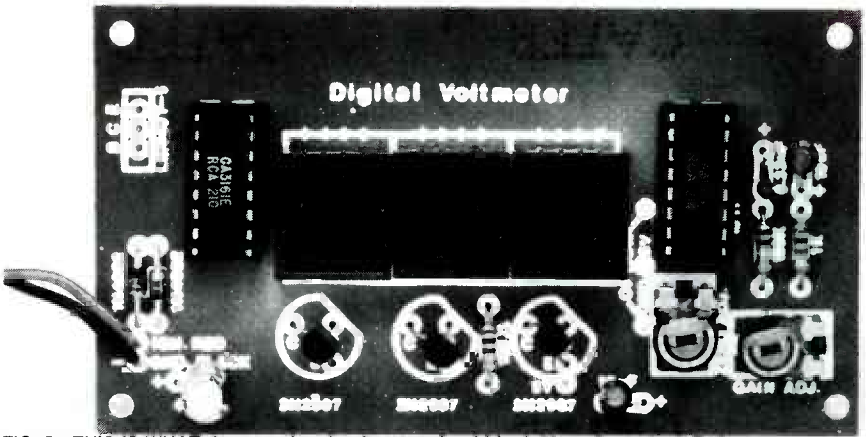


FIG. 5—THIS IS WHAT the completed voltmeter should look like prior to installation.

of those sockets should be at ground potential; you should measure no voltage there.

If your voltage readings are correct, you can disconnect the board from its temporary power supply and install the two remaining IC's. If your measurements differed from those indicated, recheck the board carefully for errors. The completed board should look similar to the one shown in Fig. 5, assuming, of course, that you used the same types of capacitors and other parts.

Calibration

Connect a known, accurate, voltage source to the red and black input wires of the voltmeter. If you already have an accurate meter, connect it in parallel with the one you're calibrating to act as a double check. The calibration voltage should be between 10 and 16 volts; 13.8 volts is recommended. Do not attempt to use a source of less than 10 volts, for it may result in inaccuracies.

To set the ZERO ADJUST trimmer potentiometer, R4, temporarily ground pins 10 and 11 of IC2 to the ground foil of the PC board. Then, very carefully adjust the pot until the display reads "00.0." (You'll need a very fine screwdriver—and some patience—for this.) You can then unground the two IC pins.

Adjust the GAIN ADJUST trimmer potentiometer, R5, until the display indicates the exact value of the calibration voltage being applied. That's all there is to it.

Troubleshooting

If the voltmeter did not light up for the calibration procedure, first make sure that potentiometer R4 is centered. If there is still no response, double check your work once again for solder bridges, unsoldered connections, components installed incorrectly, etc. *Carefully* remove the IC's from their sockets and make sure that none of their pins were bent under.

If the displays are dim, check the emitter and collector leads of transistors Q1–Q3; you might have mistakenly inserted the transistors backwards.

If a digit seems to be trying to display two numbers at the same time, its driver transistor may be defective.

If, after you've installed the meter, it doesn't work, make certain that the red and black wires are properly connected to the "tie in" point and to ground, respectively.

Installation

The first step in installing the meter is to mount the plastic filter in front of it. That can be done using ¾-inch spacers, or by making spacers using 1½-inch bolts and nuts. If you use the latter method, insert a bolt through the plastic and put a nut on the reverse side. Then put a second nut on the bolt, allowing ¾-inch of space between it and the first nut. Do that at all four corners of the plastic. Next, insert the bolts through the holes drilled in the PC board, and secure them with four more nuts. Securing the plastic at all four corners gives the assembly greater strength and minimizes the potential for the plastic's cracking from vibration.

The voltmeter does not require a special cabinet or chassis. It can be mounted in a recess in the dashboard of the vehicle and the edges of the mounting hole covered with a frame, or bezel. For a touch of class, the displays can be mounted on a separate board (a duplicate of the voltmeter board will do quite nicely) and "remoted" from the meter itself. In that case you'll need a 14-conductor ribbon cable to connect the two boards.

The black wire should be securely connected to the vehicle's chassis ground. The red wire should go to a point in the vehicle's electrical system that is active only when the ignition switch is turned on; a good place for that connection is at the same fuse terminal to which the radio is connected.

Now that your voltmeter is installed and working, what voltages should you expect to read? You're probably thinking that the answer is 12 volts. Wrong! Actually, it should be about 12.6 volts. When you're driving, and the battery is being charged, expect to read about 13.8 volts. Any readings above 17 volts or below 11 volts (such as when cranking the starter) indicate trouble!

A possible problem

It is possible that the display-multiplexing circuit will interfere with the operation of an AM radio (especially if the meter and the radio are connected to the same point) by generating some radio-frequency interference that will cause the radio to "whine."

Some radios are more sensitive to that problem than others. There are several solutions to that problem, should it occur.

First, try using a "tie in" point other than the one used by the radio. Just remember that it should be active only when the ignition switch is on.

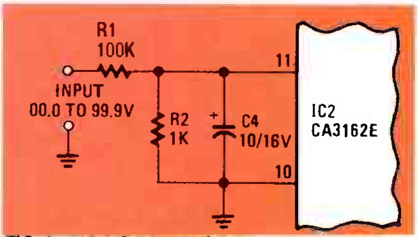


FIG. 6—USING RESISTOR R1 as the input allows you to measure up to 99.9 volts. See the text for precautions.

You can also try moving the meter away from the radio (or vice versa).

Finally, you can try shielding the voltmeter circuit in a metal box. That is usually very effective.

If you decided to "remote" the display from the rest of the meter circuit, wrap the connecting ribbon cable in aluminum foil, and connect the foil to ground. That is almost a "must" in applications where the two units will be separate.

Use with higher voltages

The voltmeter can be used to measure voltages up to 99.9 volts *provided that two conditions are met.*

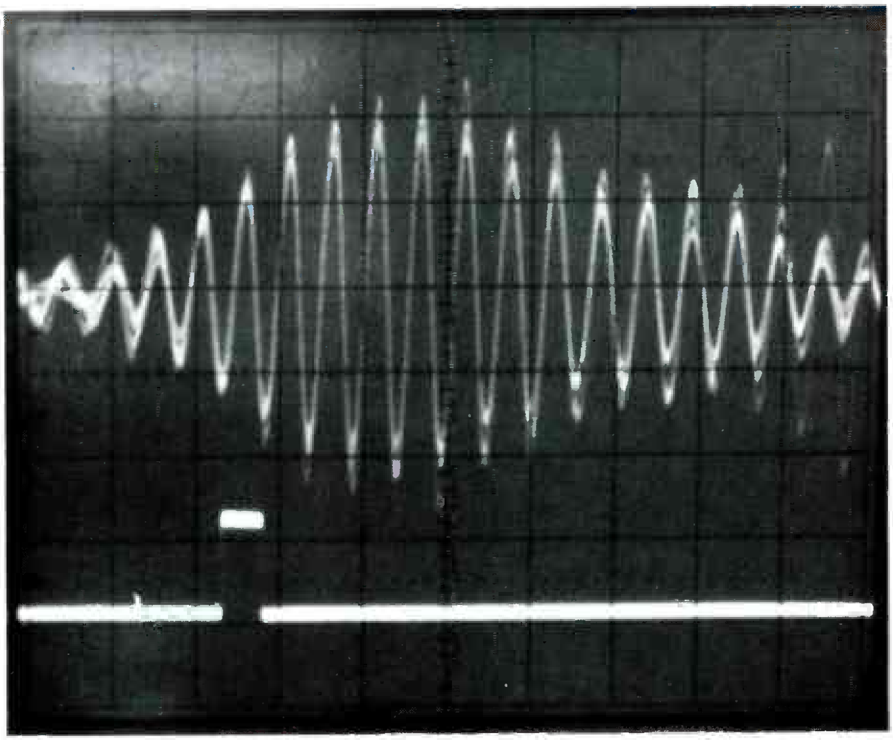
First, the supply voltage to the board must be between 8 and 16 volts. Any lower, and the regulator will not function properly; any higher and it will quickly self-destruct.

Second, the end of the 100K resistor (R1) connected to D2 should be disconnected from that diode, and the voltage being measured applied to the circuit through that resistor. This is shown in Fig. 6.

A last word of advice: Even though your new meter will almost certainly be more accurate than the old indicator you were using, don't get rid of the old one! Keep it in place to monitor the functioning of the meter you built, and to act as a backup just in case something should go wrong.

If you follow the instructions given here, you will not only have learned something about electronics construction-techniques, but you will also have built yourself a very useful measurement instrument. **R-E**

Using LORAN-C for Time and Frequency Calibration



Here's a look at the Loran-C navigation system—what it is and how it works. We will also discover how Loran-C signals can be used as frequency standards for calibrating oscillators.

R.W. BURHANS

THE LORAN NAVIGATION SYSTEM OPERATES on two different frequencies, each with a different set of characteristics. Each frequency has its own Loran designation—Loran-A and Loran-C. Although Loran-C's primary purpose is for long-distance navigation, it has another important use. Because Loran stations have to maintain a high level of precision they can—if used properly—serve as extremely accurate frequency standards. In this article we'll be discussing how we can use Loran-C signals for such applications as calibrating a frequency standard or a frequency-counter timebase.

Before we get into the details of the Loran-C system, let's take a brief look at how Loran-C signals can be used for calibration purposes. The Loran-C signals are observed on an oscilloscope that is externally triggered by a special pulse generator. (The pulse generator is quite simple, and we will provide construction details for it shortly.). The pulse generator is driven by the frequency standard you wish to calibrate. (Details for calibrating a 1-MHz frequency standard will be given, but other frequency-standards can also be calibrated using this technique.) The stability of the frequency standard can be obtained by determining the time it takes the display of the Loran-C signal to drift a given distance across the screen. Using this technique you can calibrate a 1-MHz oscillator to better than 0.001 Hz.

The Loran-C navigation system

Loran-C signals are broadcast on a frequency of 100 kHz with a 20-kHz bandwidth (from 90 to 110 kHz). Because of their low frequency, Loran-C signals tend to be ground waves—they follow the earth's curvature. The signals are usually very stable because they are not affected by the ionosphere. But how are they used for navigation?

Loran signals are sent from a *chain* (usually three to five) of stations. One station in each chain is the *master* and the others are *slaves*. The master station transmits groups of pulses that are received by the slave stations. Each slave station transmits similar groups of pulses, and adds a fixed time-delay between the groups of pulses transmitted by the master and its own pulse groups. A Loran-C receiver receives both pulse groups and calculates the time difference between them. It is that time difference that is used to establish a line of position that is used for navigation.

If (at the receiving end) the time difference between the received signals were to equal the original delay added by the slave station, the receiver would be somewhere along a straight line equidistant from both the slave and the master transmitters. If the time difference were to deviate from that fixed time-delay, the receiver would be somewhere along a particular hyperbola. (A hyperbola is a curve where the *difference* of the distances from any point on the curve to two fixed points is a constant.)

As shown in Fig. 1., a second pair of transmitters (the same master but a different slave) can be used to construct a second hyperbola. The intersection of the two hyperbolas is the receiving point. To be useful for navigation, at least three Loran stations in a chain must be re-

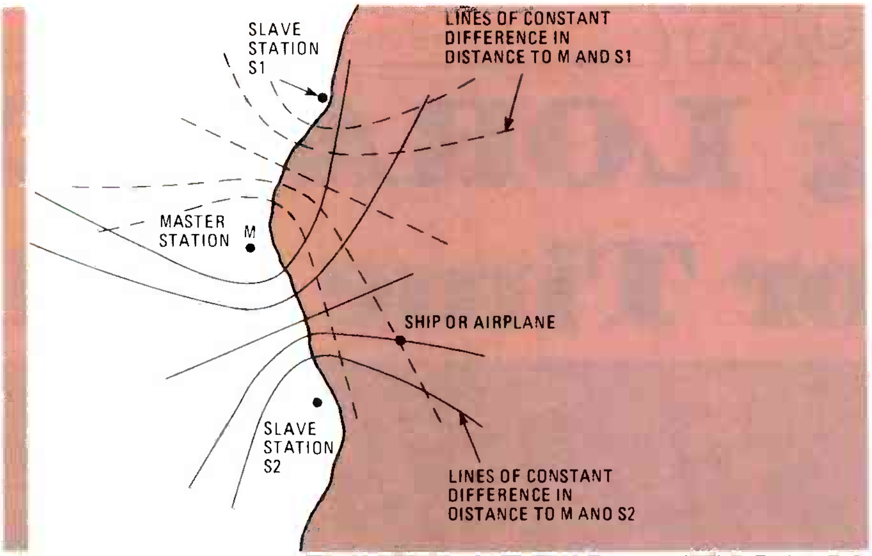


FIG. 1—AT LEAST THREE Loran stations must be received to be useful for navigation. Each master-slave pair is used to establish a particular hyperbola of constant time-differences. The intersection of the hyperbolas gives the receiver location.

ceived. However, for time-and frequency-calibration applications—which is what we are interested in—only one Loran station needs to be received.

One source of more detailed information on the Loran-C navigation system, is the *Loran-C Handbook*. For information on its price and availability, write the Superintendent of Documents, U.S. Government Printing Office, Washington D.C. 20402. The book's stock number is 050-012-00171-5.

Loran-C receivers

The sophistication of modern Loran-C receivers is now very high—some will directly compute your latitude, longitude, range, and bearing. The cost of those receivers is also high, typically \$5000 for marine systems and \$10,000 for airborne receivers. The navigational precision that can be obtained varies with the chain's geometry and distance, but it can be as good as ±50 feet when differential and propagation corrections are taken into account.

A complete Loran-C navigation receiver usually consists of the main components shown in Fig. 2: an active-antenna coupler, an RF sensor, a senor processor, a navigation processor, and finally a data-display device. The last three are microprocessor controlled.

The Loran-C signal

Before we can understand how a Loran-C signal is used by the receivers, and how we can use it for frequency calibration, we have to look at its characteristics. A Loran-C signal consists of pulses. An ideal pulse is shown in Fig. 3. Each Loran-C transmitter transmits a series of 8-pulse groups with the pulses spaced 1 millisecond apart. An extra (ninth) pulse (sent two milliseconds after the 8-pulse sequence) is used to identify the master station. (The master station is the beginning of the chain's sequence.) The sequence is repeated at a certain GRI (*G*roup *R*epetition *I*nterval) that identifies the chain. Figure 4 shows the relative amplitudes of the pulse envelopes as received from one Loran-C chain (Northeast US: the repetition period is 99,600 μs). Each vertical line in the figure represents one pulse. Note that the relative amplitudes as well as the time separations between the groups will vary depending on the receiver location. (Of course if that weren't true, Loran would not be very useful for navigation.)

An additional characteristic that we should point out, although it is not shown in Fig. 4, is that the Loran signals are phase coded. That allows Loran receivers to automatically identify master and secondary stations; to have an automatic search mode, and to reject multi-hop sky waves.

Sky waves

One problem encountered when using Loran-C is that the ground waves are often contaminated by sky waves. (Remember—one of the reasons that Loran can be used for great accuracy is due to the stability of ground waves.) So that the signal at the receiver will not be contaminated by the arrival of sky waves, a signal with a fast risetime is used. That allows the pulse to build up to its maximum value at the receiver before the sky waves arrive. Also, the tail of one pulse should be low in amplitude when compared to the beginning of the next one so that the trailing sky waves will not contaminate the beginning of the next pulse. The limiting constraint on a signal's risetime is its bandwidth. (For example, a squarewave has a very fast risetime, but its bandwidth would be too large to be used by the Loran system.)

The pulse shape shown in Fig. 3 is used to reduce the problem of one pulse affecting the beginning of the next—the tails of the pulses are greatly attenuated (and the 20-kHz bandwidth constraint is still met.) The third cycle of the pulse (that's the one which is tracked by the receiver) will not be contaminated by sky-wave (or reflected) signals.

Because the transmitted signals have a relatively wide (20-kHz) bandwidth, ordinary communications receivers cannot do a good job of detecting Loran-C pulses, although some receivers with a 12-kHz bandwidth can do a reasonable job for long-term frequency calibration (where the local clock is kept running 24 hours a day).

As we mentioned previously, a Loran-C receiver is designed to detect a point on the signal (the third cycle) before the stronger sky waves have a chance to contaminate the envelope. That task is not easy to perform and there is still argument over the best way to detect the earlier, weak ground wave at long range when it has been contaminated with sky waves (which often have a peak level 20 dB greater than the ground wave). Because

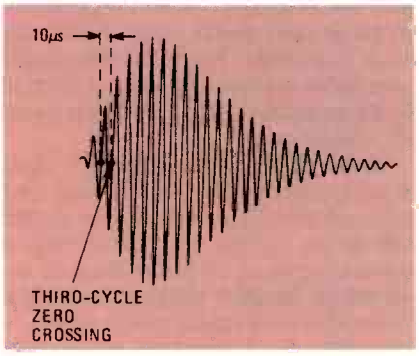


FIG. 3—IDEAL SHAPE of a 100-kHz Loran-C transmitted pulse. Note how the trailing edge is attenuated so that the trailing sky waves will not interfere with the next pulse.

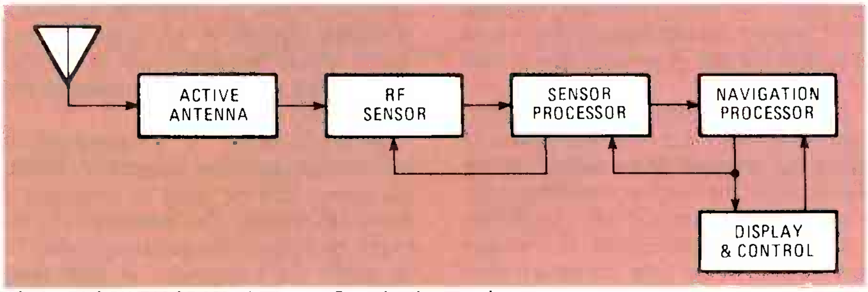


FIG. 2—BLOCK DIAGRAM of a Loran-C navigation receiver.

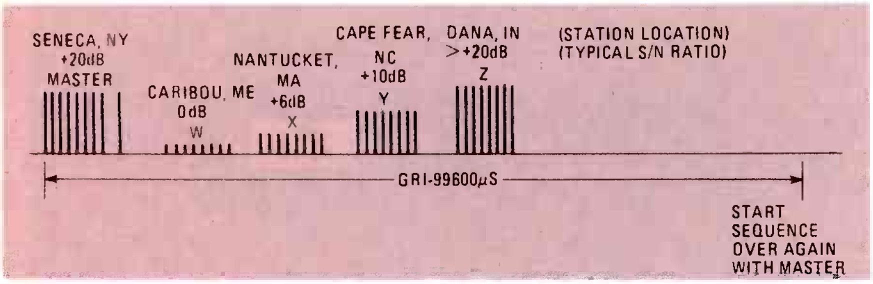


FIG. 4—RELATIVE ENVELOPE AMPLITUDES of a Loran-C chain as received in the midwestern US. Note the "extra" pulse that identifies the master.

the sky-wave signals are not stable—they vary considerably in amplitude and risetime—large errors will be produced if the receiver tracks them.

Another problem with Loran receivers is that any filtering will delay the risetime of the signal so that, with many receivers, a point later than the ideal third cycle is tracked. However, as long as that point is the same for all signals, strong or weak, and is chosen to precede the sky wave's reaching an appreciable amplitude, then the receiver can still operate satisfactorily. Let's look at how the third cycle of the Loran-C pulse is detected.

Third-cycle detection

A theoretical way of detecting a point on the pulse shown in Fig. 3 is to generate the second derivative of the pulse's envelope shape. The resultant envelope has a zero crossing at about 35 μs. The problem in this case is that the envelope generator (with the differentiators) ends up with an extremely wide bandwidth—that adds a lot of noise to the system.

Another way to detect the third cycle is to produce a delay-and-add circuit. Such a circuit delays the signal 5 μs (180°) and then algebraically adds the delayed signal to the original (with a multiplying constant) to produce a phase reversal at about the 30-μs point. A simple implementation of a delay-and-add network—and the effect it has on the Loran-C signal—is shown in Fig. 5.

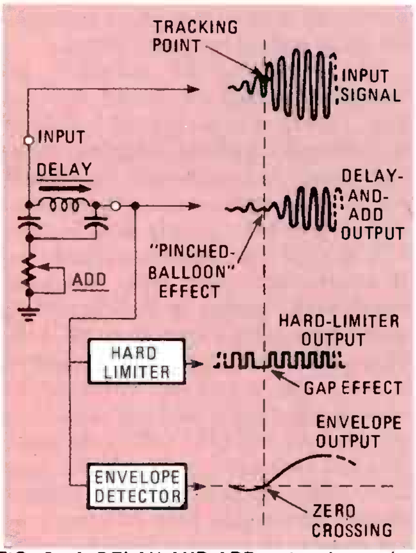


FIG. 5—A DELAY-AND-ADD network can be used to produce a pinched-balloon effect output, which is then used to produce an envelope with a zero crossing at the third cycle.

If the output *pinched-balloon* shape of the delay-and-add network is fed to a *hard limiter*, then the result, as shown in Fig. 5, is a rectangular waveform where the phase-reversal point (the third-cycle point) has a gap. All the receiver designer then has to do is to devise some machine-language software to track that gap for the stations of a given chain. That is, of course, no easy task. But that's what is done in the sensor processor of many Loran-C receivers.

Another problem with Loran reception and third-cycle detection is that the conductivities of the earth and of seawater are different. That can cause the group velocity and the phase velocity of the signal to differ, producing an envelope-to-cycle difference (ECD) error up to several microseconds (depending on the terrain and the distance). (Some very precise Loran-C receivers can use that to an advantage. Precision measurements of the amplitude and phase of Loran-C signals made while flying at low altitudes can yield information on the ground's contours.)

Still another problem associated with Loran-C receivers is the fact that strong interference on frequencies like 88 kHz or 116 kHz can produce errors in the navigation data. Fixed, tuned traps—that are designed for particular coverage areas where there are interferring signals—are often found in Loran-C receivers.

RF filtering

A signal takes a finite time to pass through a filter. That time, called a delay, is a function of the signal's velocity. The signal's velocity is a function of its frequency. (For instance, the signal's velocity is lowest at the lower band-edge.) Thus, a filter can cause EDD (*E*nvelope *D*elay *D*istortion).

The effect that a filter with narrow skirts has on the received signal is shown in Fig. 6. Here we have assumed a worst-case sky wave rising at about 30 μs after the start of the ground wave, and we have assumed that the peak amplitude of the sky wave is 20 dB greater than that of the ground wave.

The filter delays the Loran ground-wave signal (the envelope's zero crossing occurs at a later time), but coincidentally, the strong sky-wave signal is also delayed. Unfortunately, however, the ground wave's third cycle (which we want to detect) is at −60 dB. Fortunately, though, even at the 50-μs point the desired pulse is some 30 dB greater than the sky-wave contamination.

A −30-dB contamination of the tracking point at 50 μs would result in a small error in the data. The data will contain additional error because the results are not as precise when the fifth cycle (50-μs point) is tracked instead of the third cycle. However, as long as the sky-wave contamination is low enough, and the same point is tracked for all signals, then the error can be kept down to perhaps 0.1 μs, even for a weak signal.

The effect of filtering and AGC in conventional communications receivers destroys most of the information in the Loran-C signal. However with a receiver such as the Yaesu *FRG7700* in the WIDE-BAND AM (12-kHz) mode, it is just possible to track the fifth cycle (which will be about the start of the pulse envelope as observed at the receiver's line-level output terminal). Noise blankers in communications receivers also destroy the pulse information because they are inherently timed to blank a pulse of the Loran-C shape and duration.

The envelope detector and simple GRI generator that we will discuss next are useful for experimental observations but are not well suited to precision navigation-receiver applications. The minimal equipment required for Loran-C observation is: a triggered-sweep oscilloscope, a frequency standard, a GRI generator (we'll discuss one), and a reasonably wideband AM receiver. If you do not have a suitable receiver available, you can use the Loran-C front end (or envelope detector) that we'll discuss next.

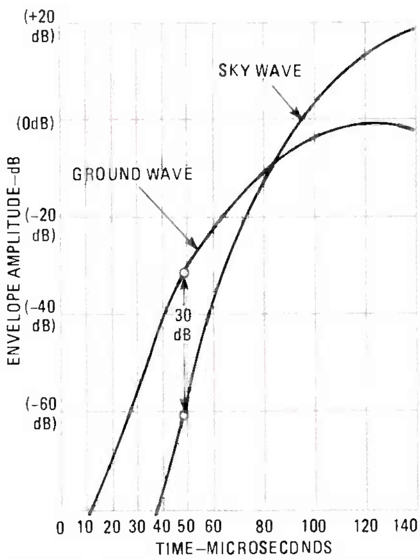


FIG. 6—A FILTER DELAYS both the Loran-C sky-wave and ground-wave signals, resulting in an zero crossing at about the fifth cycle.

RF envelope detector

For the experimenter who wishes only to study Loran-C or to use the signals as a frequency-calibration source, the envelope method (which detects the envelope zero-crossing as shown in Fig. 5) is simple and effective. A schematic of an envelope detector is shown in Fig. 7. The active-antenna preamplifier has been described previously (see the February, March, and April 1983 issues of **Radio-Electronics**). It uses a 1-meter whip with a 150-kHz lowpass filter at the antenna input. The "receiver" coupler is built as part of the Loran-C front end (Fig. 7) and consists of an 80-kHz highpass filter (instead of the 10-kHz filter used with the previous active-antenna circuits). The output of that coupler is fed to a network consisting of a 100-kHz impedance-matching transformer; to series T-notch traps tuned to 88 kHz and 115.3 kHz; and finally to an MC1350 RF amplifier. The sequence of matching and filtering at the input is an impedance step-up to the MC1350 RF stage such that there is a net voltage gain of 10 dB or more between the active antenna and the RF stage, which provides an added 60 dB of gain. The RF stage is operated with a manual control-voltage for the RF gain (or an external AGC system could be devised). The amplifier drives a transformer and a delay-and-add network. The delayed output and the undelayed (RF-amplifier) output are fed to an MC1357 FM detector. There, the hard-limited RF carrier is mixed or multiplied with the delay signal. That results in an envelope with the same amplitude and phase as that from the delay-and-add network. The zero crossing is adjusted for 40 to 50 μs, and the ADD trimmer potentiometer is adjusted for a good null at the zero-crossing point. The actual pinched-balloon effect can be observed on a scope at pin 11 of the MC1357.

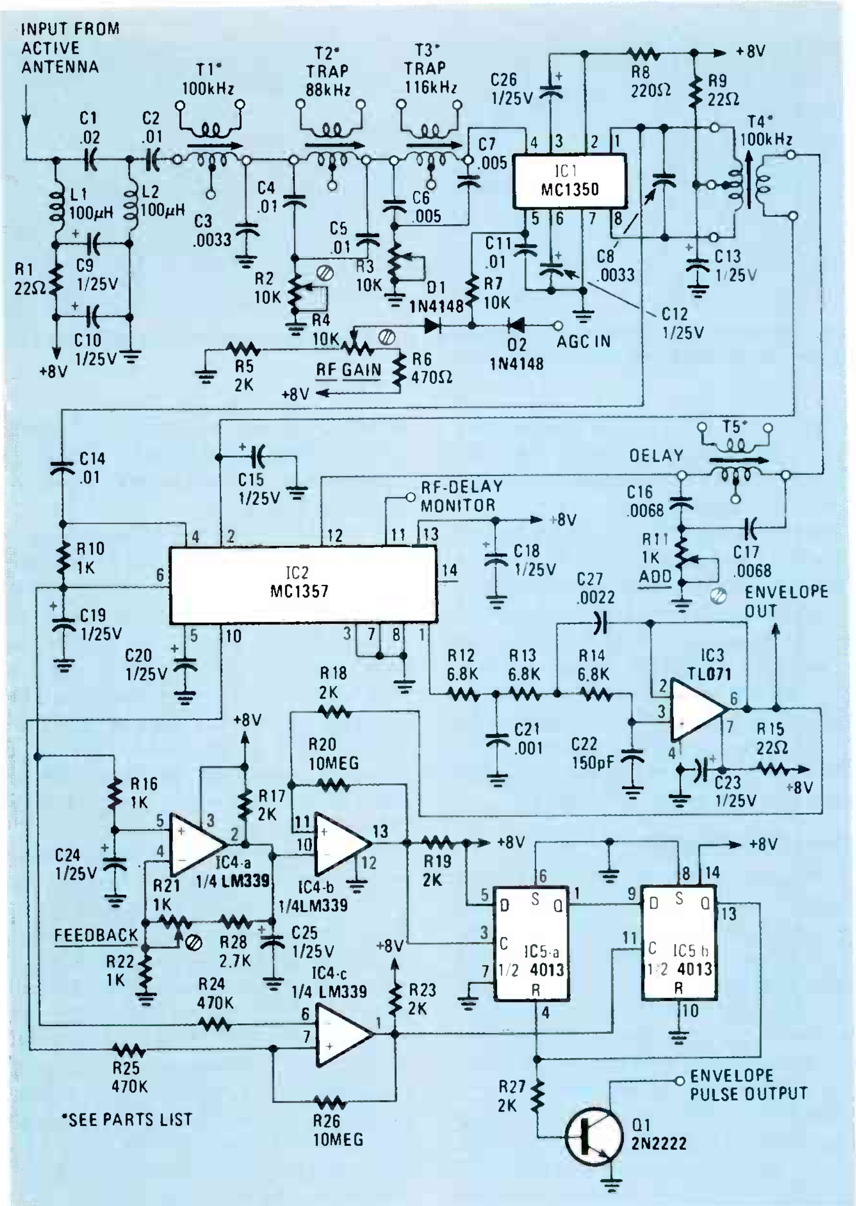


FIG. 7—THE LORAN-C FRONT END can be used to study Loran signals if a receiver with sufficient bandwidth is not available.

To align the RF transformers and traps with the active antenna preamplifier you can use a signal generator along with a 10-pF coupling capacitor to inject a signal at the antenna input. (By doing that you are simulating the response that will be obtained from the active antenna in the presence of an electromagnetic field.) The response at the input (pin 4) of the MC1350 should look something like that shown in Fig. 8, with a peak at about 103 kHz, nulls at 88 kHz and 115.3 kHz, and fairly wide skirts. The MC1350 output transformer is peaked at about 100 kHz and the delay network is adjusted using an on-the-air Loran-C signal.

With this front end, the zero crossing will actually be at about the fourth or fifth cycle of a strong Loran-C signal. But that is quite satisfactory. If a Loran-C signal simulator is available, the network should be adjusted for a pinched-balloon effect (or zero crossing) at about 40 μs.

The output from the limiter/detector drives a 3-pole 33-kHz lowpass filter (IC3 and its associated components) to generate a DC envelope that can be observed on an oscilloscope. The comparators and flip-flop provide a synchronized 10-μs pulse at the envelope's zero-crossing point, but it is fairly noisy compared to observing the envelope at the analog lowpass-filter output. However, this output pulse for each Loran-C envelope is useful for further experimenting with microcomputer tracking-loops (where the bandwidth of the noise can be narrowed with memory-aided numerical techniques in software).

West-coast and foreign experimenters may wish to align the interference traps at some other frequencies. It is a good idea to keep the traps outside the 90 to 110 kHz region because they are not high enough in Q and could attenuate too much of the desired Loran-C signal. A lot of retuning—going back and forth over the adjustments of all of the tuned circuits—pays off in arriving at a reasonably wide bandwidth with a sharp phase-reversal at the delay-and-add network output.

The adjustable RF inductors and transformers used the circuit shown in Fig. 7 are normally 455-kHz IF transformers padded with additional capacitance to tune them to the 100-kHz region. The particular transformers in this experimental circuit are Mouser 421F303's, a type sometimes called a 3rd-IF transformer. Other types will sometimes work, except in the case of the transformer at the output of the MC1350. That's because the tap on the transformer is not a true center tap. However, the loading effect of the 0.01-mF capacitor at pin 4 of the MC1357 makes the output look like a balanced load for the RF stage. Some older transformers, from different manufacturers, may have different winding phases, so you may have to reverse the secondary connections to get everything operating properly. The phase of the smaller output-winding has to be such

PARTS LIST—ENVELOPE DETECTOR

All resistors ¼ watt, 5% unless otherwise specified
R1, R9, R15—22 ohms
R2, R3, R4—10,000 ohms, trimmer potentiometer
R5, R17, R18, R19, R23, R27—2000 ohms
R6—470 ohms
R7—10,000 ohms
R8—220 ohms
R10, R16, R22—1000 ohms
R11, R21—1000 ohms, trimmer potentiometer
R12, R13, R14—6800 ohms
R20, R26—10 megohms
R24, R25—470,000 ohms
R28—2700 ohms
Capacitors
C1—0.02 µF, polystyrene
C2—0.01 µF, polystyrene
C3, C8—0.0033 µF, ceramic disc
C4, C5—0.01 µF polystyrene
C6, C7—0.005 µF, polystyrene
C9, C10, C12, C13, C15, C18, C19, C20, C23–C26—1 µF, 25 volts, tantalum
C11, C14—0.01 µF, ceramic disc
C16, C17—0.0068 µF, polystyrene
C21—0.001 µF, ceramic disc
C22—150 pF, ceramic disc
C27—0.0022 µF
Semiconductors
IC1—MC1350 video-IF amplifier
1C2—MC1357 sound-IF amplifier and quadrature detector
IC3—TL071 JFET-input op-amp
IC4—LM339 quad comparator
IC5—4013 dual D-type flip-flop
D1, D2—1N4148
Q1—2N2222 or similar NPN-type
T1–T5—455-kHz IF transformer, Mouser 421F303 or equivalent
L1, L2—100-µH RF choke

that a positive-going envelope is created at pin 1 of the MC1357 detector IC. The transformers come with a small 150-pF built-in capacitor across the main primary winding, but it can be ignored since it is very small compared to the 3300-pF capacitor required for resonance at 100 kHz.

The LM339 comparator (for the envelope pulse signal) generates a reference voltage from pin 6 of the MC1357. The small FEEDBACK trimmer potentiometer across the LM339 reference source is used to adjust the DC level of the pulse edge that is fed to the flip-flop. The reason for doing that is that the DC level is controlled by the MC1357, so that drift in the lowpass filter DC-level or in the comparator reference DC-level is self-compensating. The envelope 10-µs-pulse output is intended to drive external logic, usually at a five-volt level. The power source for the whole RF front-end should be from an eight-volt regulated source (using a regulator such as an LM7808).

GRI pulse source

Practically every Loran-C experimenter needs a GRI generator that is capable of producing pulse-repetition intervals of 50,000 to 100,000 µs. We'll discuss a simple generator that consists of a 4040 programmable ripple-counter and a dual decade-divider that is driven from a 1-MHz crystal-controlled frequency standard. There are other methods for producing GRI pulses, but the three-IC circuit of Fig. 10 is about as simple as they come. (You could, for example, use only programmable decade-dividers. And you could use something other than a 1-MHz standard to drive the GRI generator and obtain the same results.) The circuit is programmed in hexadecimal notation for the GRI intervals as indicated in Table 1. That table lists the common designation for the GRI in 4-digit numbers (µs/10), as is done on Loran charts and in United States Coast Guard data. The pulse generator that's shown in Fig. 9 produces a 10-µs pulse that is used to synchronize your oscilloscope for observing Loran-C signals.

The programmable GRI-source allows the experimenter to stop the Loran-C signals on the scope trace and examine them in minute detail. That is also the basic

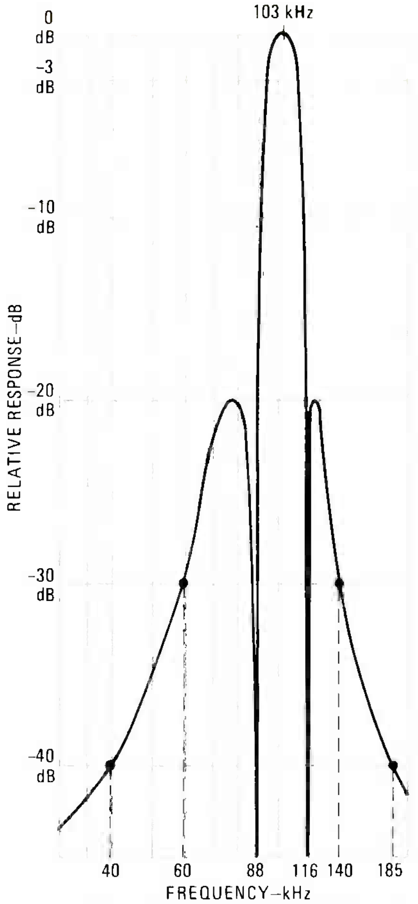


FIG. 8—THE RESPONSE AT THE INPUT to the RF stage (due to the filters) should look like this.

PARTS LIST—GRI PULSE SOURCE

All resistors ¼-watt, 5% unless otherwise specified
R1—47,000 ohms
R2, R3—10,000 ohms
Capacitors
C1, C2—0.001 µF
Semiconductors
IC1—4518 dual decade divider
IC2—12-stage binary ripple counter
IC3—quad 2-input nor gate
D1–D12—1N4148
S1–S3—Hexadecimal thumbwheel switch, 16 position BCD, Unimax SF-54 or equiv.

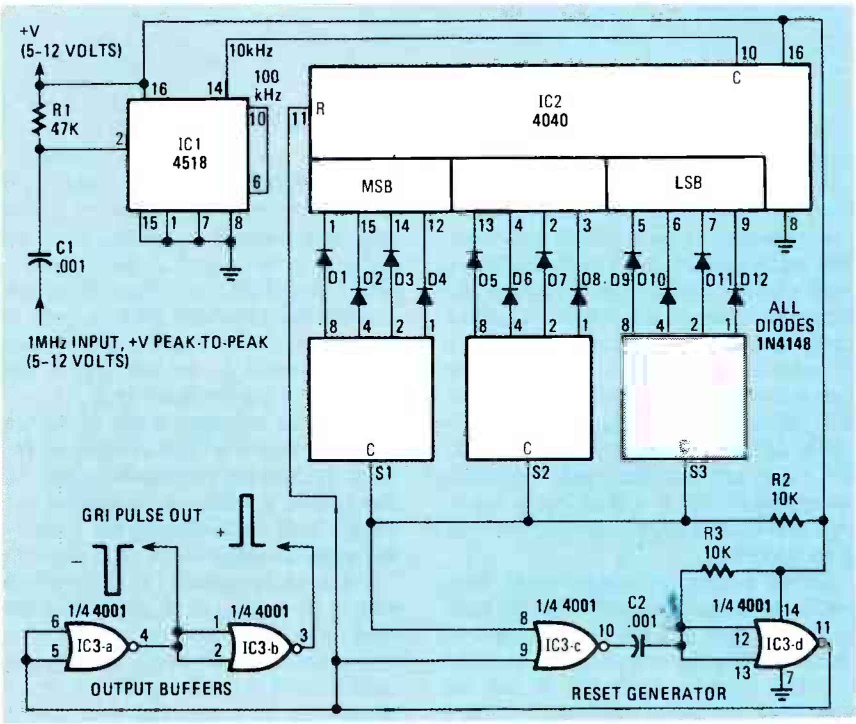


FIG. 9—THE GRI PULSE GENERATOR is used to stop the Loran signals on the scope trace so that they can be examined, and their drift measured. The drift indicates the stability of your frequency standard.

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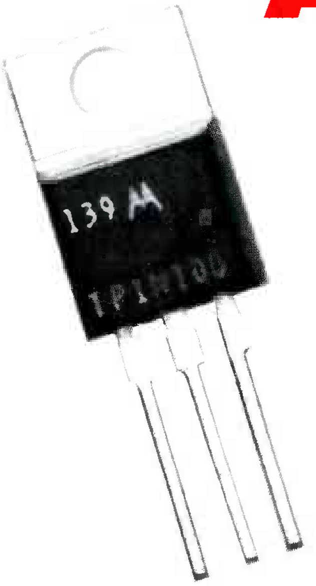
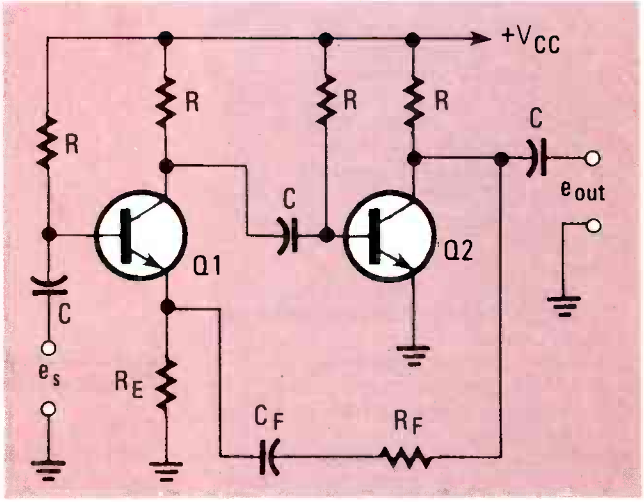
CIRCUITS

How to Design Analog Circuits

How to Use Feedback





MANNY HOROWITZ

This month we turn our attention to an in-depth look at both positive and negative feedback. We will discuss both the advantages and disadvantages of feedback and how to properly design circuits that use feedback.

WE'VE TOUCHED UPON FEEDBACK IN some of our earlier discussions, particularly when we looked at op-amps. In those discussions we saw that feedback was important in establishing many circuit characteristics; this month we'll look more closely at that topic. Among the things we'll see are the different types of feedback, how feedback is established in an audio-amplifier circuit, and how the presence of feedback affects various circuit parameters including gain, bandwidth, and input and output impedances. We'll also see how feedback can cause circuit instability, a characteristic that is undesirable in an audio amplifier but vital in an oscillator.

Before we get too much farther, let's clarify two terms. A signal that is fed back from the output of a circuit to its input in such a way that the overall gain is reduced is called *negative* feedback. If, on the other hand, the signal is fed back in such a way that the overall gain is increased, or so that it causes the circuit to go into oscillation, it is called *positive* feedback.

Feedback characteristics

In any circuit that uses feedback, a portion of the signal at the output is fed back to the input. The ratio e_f/e_{out}, where e_f is the amount of signal that is fed back and e_{out} is the signal at the output, has been called β for many years. So as not to confuse that term with the I_C/I_B ratio of a bipolar transistor, which is also identified by the symbol β, we will use B when referring to the feedback ratio.

With that convention out of the way, let's now look at a basic circuit with feedback, such as the one shown in Fig. 1. In that circuit, a voltage e_s, is applied to the input. With no feedback, the voltage at the input to amplifier A, e_{in}, equals e_s. The gain of the overall circuit would then simply be $e_{out}/e_{in} = e_{out}/e_s$. When feedback is added, however, some of e_{out} appears at the input as e_f. Assuming that the feedback is positive, that is, that the signals are in phase and thus add, the input to the amplifier becomes $e_s + e_f$. When feedback is negative, the signals are 180° out-of-phase and the input to the amplifier equals $e_s - e_f$. Since e_f depends upon e_{out} and B, the gain of the circuit with feedback is:

$$A_F = \frac{A_v}{1 - BA_v} \qquad (1)$$

where A_V is the voltage gain of the amplifier without feedback, or e_{out}/e_{in}, and A_F is the gain of the overall circuit with feedback. The denominator of the equation, $1 - BA_V$, is known as the feedback factor. When negative feedback is used, the expression BA_V is negative; when positive feedback is used, that term is positive.

Assuming that the feedback is negative, and BA_V is much larger than 1, the gain of the amplifier is just about equal to 1/B. Negative feedback makes the gain of an amplifier less sensitive to variations in the circuit's parameters, such as the supply voltage. Positive feedback makes the gain more sensitive to such variations. We will see why that's important when we discuss oscillators.

Because the feedback in this circuit is

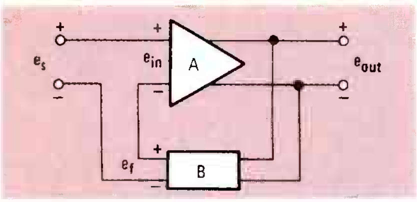


FIG. 1—AN AMPLIFIER with negative voltage feedback is shown in this block diagram.

applied in series with the input signal, the input impedance increases over what it would have been without any feedback; the amount it increases is directly proportional to the feedback factor. The output impedance, on the other hand, is reduced because the feedback signal is taken from across the load; the amount it decreases is indirectly proportional to the feedback factor. We'll see more about how input and output impedances are related to feedback later in this article.

Another effect of negative feedback is that distortion is reduced and the frequency response of an audio amplifier is improved. Distortion with feedback is equal to the distortion without feedback divided by the feedback factor. High-frequency response is extended from f_{OH}, the high-frequency limit without feedback to $f_{OH}(1 - BA_V)$, while the low-frequency response is extended from f_{OL}, the low-frequency limit without feedback, to $f_{OL}/(1 - BA_V)$. Remember here that since the feedback is negative the BA_V terms are negative and $1 - (-BA_V) = 1 + BA_V$.

Designing a circuit

When designing an amplifier with feedback, the first step is to determine the amount of overall gain that will be required. Let us say you need a circuit with a voltage gain of 40 dB, or 100. Assume that in this application about 20 dB of negative feedback is necessary around the circuit to reduce the distortion to about 10% of what it would have been without feedback. Then the gain of the overall circuit must be $100 \times 10 = 1000$ if it is to be adequate after feedback has been applied. The circuit shown in Fig. 2 should

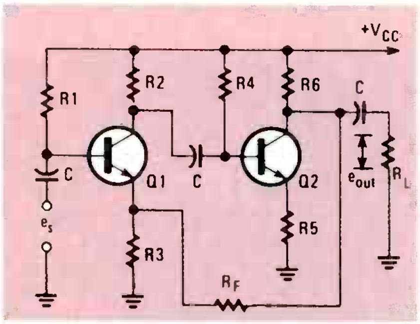


FIG. 2—IF THE FORWARD GAIN of this circuit is to be 100 after 20 dB of negative feedback is applied, the forward gain before the feedback is applied must be 1000. The circuit shown here uses series feedback.

fulfill all the requirements. (That circuit, minus the feedback loop, was first covered in the December 1982 issue of **Radio-Electronics**; please see that issue for a more complete discussion of the circuit). Assume the load, R_L, is 10,000 ohms, $V_{CC} = 9$ volts, and the β of Q1 and Q2 are 100.

Let's start by determining the values needed to get an overall gain of 1000 (before feedback is applied). The signal across the output load should be capable of an output voltage-swing of close to 9 volts, the voltage of the power supply. To accomplish that, the value of R6 should be less than one-fifth of R_L. Resistor R6 is chosen to be 1800 ohms.

The load in the collector circuit is equal to the resistance of R6 in parallel with R_L, or about 1500 ohms. Is is actually somewhat less because R_F is in parallel with the 1500 ohms. In this first step of the design, however, R_F can be ignored. For one thing, we have not yet determined what the value of R_F is. Also, it usually has only a minor effect on the load resistance as that of R_F is very small compared to that of R_L in parallel with R6. So we'll ignore R_F until after the feedback circuit has been designed.

The gain of the overall circuit should be divided between Q1 and Q2. If the overall gain without feedback is 1000, we can let the gain of each stage be about 35 so that the total gain will be 35×35, or 1225, which, of course, is somewhat more than 1000. As the gain around Q2 is just about equal to the ratio of the load in the collector circuit to the load in the emitter circuit (assuming that the load in the emitter circuit is much greater than the AC resistance of the emitter junction itself), by rearranging terms we can see that the value of R5 should equal 1500/35, or about 43 ohms.

The Q2 circuit presents an impedance of $\beta \times 43$ ohms $= 100 \times 43 = 4300$ ohms to the collector of Q1. If a 4300-ohm resistor is used for R2, the impedance in the collector circuit of Q1 is equal to 4300 ohms in parallel with 4300 ohms, or about 2150 ohms. If Q1 is to provide a gain of 35, the value of R3 should equal 2150/35, or about 61.5 ohms; the closest standard value to that is 56 ohms.

Now, let's add feedback to the circuit. Resistor R_F and the 56-ohm emitter resistor, R3, are the components that determine the B term in the feedback factor. If gain is to be reduced by 20 dB and be equal to 10% of the gain without feedback, the gain with feedback, A_F, must be equal to:

$$A_F = 100 = \frac{A_V}{1 - BA_V}$$

$$A_F = \frac{1000}{1 + \left(\frac{56}{56 + R_F}\right) 1000}$$

so that R_F must be about 6200 ohms. Note that since we are again applying negative feedback, the BA_V term here is also negative and $1 - (-BA_V) = 1 + BA_V$.

When R_F is 6200 ohms, it reduces the load in the collector of Q2 to a substantial degree. It was originally calculated to be at about 1500 ohms. With the additional 6200 ohms across it, the collector load becomes about 1200 ohms. With the 43 ohms in the emitter of Q2, its forward gain is now reduced to about 29. To re-establish a gain of 35 for that circuit, R5 must be changed from 43 ohms to 1200/35 = 34 ohms. Use a standard 33-ohm resistor.

In the preceding analysis and example, the circuit discussed used series feedback. The next circuit we'll discuss uses parallel feedback; in it, the fed-back signal is applied in parallel with the input. That circuit is shown in Fig. 3.

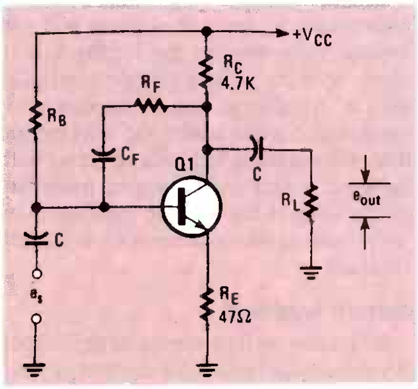


FIG. 3—PARALLEL FEEDBACK is used in this circuit.

Let's assume that we want to use that circuit in an application where the gain must be 10. If the β of the transistor is 100, the impedance at the base of the transistor due to R_E, the 47-ohm emitter resistor, is 4700 ohms. Now assume that all other impedances at the input of the transistor are high when compared to the 4700-ohm input impedance. As for the the output impedance, if R_L were 47,000 ohms, the output impedance would be 47,000 ohms in parallel with R_C, the 4700 ohm collector resistor, or about 4200 ohms.

Ignoring feedback resistor R_F, the voltage gain of the circuit is the output impedance divided by the value of R_E; that is 4200/47, or about 90. In order to get a gain of 10, the feedback factor, $1 + BA_V$, must equal 9. If $A_V = 90$, B is just about equal to 8/90. Because B is equal to the input resistance divided by R_F, 8/90 = 4700/R_F. So R_F must be about 49,000 ohms. Make the impedance of capacitor C_F very small with respect to R_F at the lowest frequency to be reproduced by the circuit so that the capacitor does not affect the feedback.

While the input impedance of a circuit with series feedback is its impedance without feedback multiplied by the feedback factor, in parallel-feedback circuits the input impedance without feedback must be divided by the feedback factor to determine the input impedance. The output impedance is likewise reduced by that same feedback factor, just as it was in the series-feedback circuit. That is because the feedback signal in both instances is taken from across the load at the output.

In all of our discussion thus far, the feedback has been a function of the voltage at the output and hence is called voltage feedback. The feedback could, however, be a function of the current at the output instead. In that case, the signal is not fed back from across the load but from across a resistor or other device connected in series with it. That is referred to as current feedback because the the voltage generated across that device depends upon the current flowing through it as well as the load. When that configuration is used, the output impedance increases with feedback. Input impedance will still depend upon whether the feedback is in series with the input signal or in parallel with it. As always, input impedance increases in circuits where the information from the output is fed back in series with the input signal and decreases when that information is fed back in parallel. Now we'll want to take a closer look at current feedback.

Current feedback

When the current sensed at the output of a circuit determines the amount of voltage fed back to its input, the circuit is called a current-feedback amplifier. Such a circuit is shown in Fig. 4. As was the case with the circuit in Fig. 1, the fed-back voltage is applied in series with the input signal.

In Fig. 4, voltage e_s is amplified and appears at the + and − output terminals of amplifier A. The total output is applied across the two series-connected resistors, R_L and R_S. The output voltage across R_L, as well as the voltage developed across R_S, varies with the current flowing through the two resistors. Because the signal voltage developed across R_S depends upon the amount of current flowing through it, all or a portion of that voltage can be used to supply the required feedback information. Voltage gain of the overall circuit, with feedback, is:

$$A_F = \frac{A_V}{1 - BA_V\left(\frac{R_S}{R_L}\right)} \qquad (2)$$

The values of resistors R_L and R_S can usually be adjusted so that there will be no need to further reduce the signal fed back through use of additional B networks. If that is done, equation 2 can then be simplified by setting B equal to 1.

Although the circuit in Fig. 3 was treated as if it used voltage feedback, it can also be thought of as an amplifier with current feedback (affecting current rather than voltage gain). To see that more clearly, remove R_B and C1 from the circuit and connect R_F directly from the collector of Q1 to the base. The value of R_F must be larger than was found in our original analysis of that circuit so that it can do the dual job of establishing the feedback and setting the DC bias of the amplifier. As collector current divides between R_F and R_C, the portion of the current fed back to the input is $4700/R_F$. If the current gain of the amplifier without feedback is A_I, the current gain with feedback, A_{IF}, becomes:

$$A_{IF} = \frac{A_I}{1 + \left(\frac{4700}{R_F}\right)A_I}$$

Note that while one requirement in establishing a substantial amount of voltage feedback was to make R_F small, its magnitude here has been greatly increased. If R_F is large, voltage gain with feedback is affected slightly by its presence while current gain is reduced considerably.

In practical circuits, current feedback can radically affect voltage gain. Consider the circuit shown in Fig. 5. Here, current in the base circuit due to the input signal voltage is amplified by the transistor. The amplified current flows through both R_C and R_E in the transistor's output circuit. Voltage e_f developed across R_E due to the signal current in the emitter circuit is subtracted from e_s (because the voltages are 180° out-of-phase with each other e_f bucks e_s) and applied to the base-emitter circuit of the transistor. Because $e_s - e_f$ is less than e_s, the gain of the overall circuit is less with feedback than without feedback.

Gain may be reduced further by increasing the size of R_E. Now a larger voltage will be developed across that resistor. That larger voltage is subtracted from e_s so that less voltage is applied to the base-emitter circuit, reducing the gain further. Hence the gain of the overall circuit is inversely related to the value of R_E. That was noted earlier when we indicated that voltage gain of a circuit similar to the one in Fig. 5, is equal to about R_C/R_E. That is true because of the presence of current feedback.

It was pointed out that for this circuit, the fed-back voltage is in series with the input signal voltage. From our discussion of feedback characteristics, we can conclude that the input impedance of that circuit should increase with the amount of voltage fed back. That amount depends upon the value of R_E. When basic amplifiers were discussed, we noted that the input impedance of that type of circuit is βR_E in parallel with R_B. That effect of R_E on the input impedance also holds in circuits were feedback is used.

In order to minimize the affect of R_B on the input impedance, a bootstrapping circuit may be used. An example of that type of circuit is shown in Fig. 6. Capacitor C1 has a large value and it acts as a short circuit to input signal voltage e_s. Without C1, the input impedance seen by e_s is $\beta R_E + R_{IN}$ in parallel with R_B; the combination is in parallel with R_X. (As far as the signal is concerned, V_{CC} and ground are at the same potential.) By adding C1 to the circuit, R_X and R_B are, signal-wise, across R_E while R_{IN} is connected from the base to the emitter of Q1. Now the input impedance of the circuit is equal to the parallel combination of R_B, R_X, and R_E, multiplied by beta. Resistor R_{IN} does not come into the picture for it is directly across the low impedance base-emitter junction; it is negligible when compared to that impedance. Because R_B and R_X have been shifted to be across R_E, the input impedance of the circuit is increased many times over what it would have been if C1 were not present.

Feedback in audio circuits

It was pointed out in a previous article

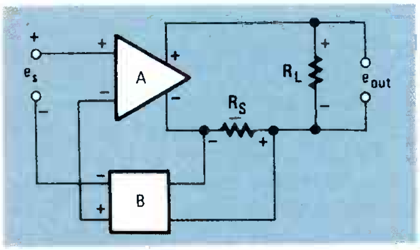


FIG. 4—SINCE FEEDBACK IS GENERATED across a resistor, R_F, that is in series with the load, this amplifier is said to use current feedback. That's because the same current that flows through the load must flow through that resistor

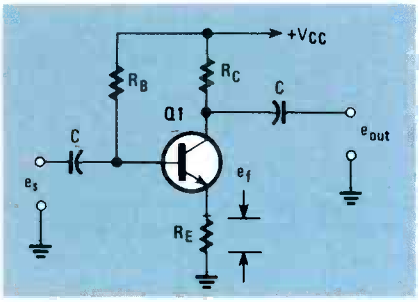


FIG. 5—IN PRACTICAL CIRCUITS such as this one, current feedback can greatly affect the circuit's voltage gain.

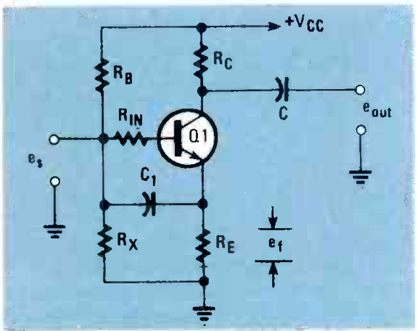


FIG. 6—TO MINIMIZE THE EFFECT of R_B on input impedance, a bootstrap circuit such as this one can be used.

that negative feedback is used around power amplifiers, small-signal audio amplifiers, op-amps, and so on. Its primary function is to reduce distortion, broaden the bandwidth of the amplifier, and reduce the output impedance. If a resistor-capacitor network is included in a feedback loop, the feedback network can also be designed to alter the frequency-response characteristics of the circuit.

Let's take a look at an audio amplifier. An example of an amplifier that can be used to reproduce the output from a tape player is shown in Fig. 7; an approximate curve that shows the desirable frequency characteristics of such an amplifier is shown in Fig. 8. The curve shows that the amplifier's output should remain at a maximum at frequencies below 50 Hz, should drop at the rate of 6-dB-per-octave from 50 Hz to 3000 Hz, and then become level once again at all frequencies above 3000 Hz. To establish that frequency characteristic, only a series resistor-capacitor circuit is required in the feedback loop. That is shown as C_F and R_F in the circuit.

The circuit to accomplish that goal can be designed through use of an R-C impedance equation and equation 1. The impedance of the series circuit consisting of C_F and R_F is $Z_F = (R_F + j/6.28fC_F) = (j + 6.28fC_FR_F)/6.28fC_F$. (For those unfamiliar with the topic, the impedance of a resistor and a capacitor in series is equal to the resistance of the resistor plus the reactance of the capacitor, where the capacitive reactance, X_C, equals $1/2\pi fC$. However, those two quantities can not simply be summed, as the voltages across the components are out of phase. Hence the introduction of the j operator, where $j = \sqrt{-1}$. That of course is an imaginary number and the reactive portion of the impedance is the imaginary component; the resistive part of the impedance is called the real component.) Plugging the impedance equation into equation 1, the voltage gain with feedback is:

$$A_{VF} = \frac{A_v}{1 + BA_v}$$

$$A_{VF} = \frac{A_v}{1 + A_v\left(\frac{R_E}{R_E + Z_F}\right)}$$

The portion of the output voltage that appears across resistor R_E is $R_E/(R_E + Z_F) = B$. That is the B that should be used in the equation. Should R_F be much larger than R_E, B simplifies to being equal to R_E/Z_F. The entire equation may be simplified farther if the voltage gain is very large. When $A_V(R_E/Z_F)$ is much greater than 1, the equation simplifies to:

$$A_{VF} = \frac{Z_F}{R_E} = \frac{j + 2\pi f C_F R_F}{2\pi f C_F R_F}$$

The above equation is the equation of the curve shown in Fig. 8. From the curve, we see that there are two break

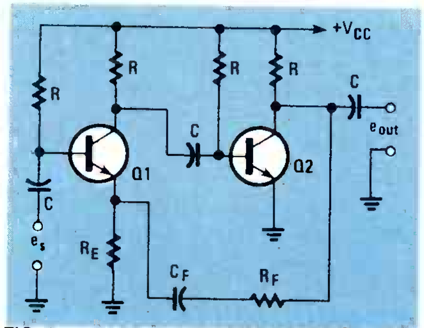


FIG. 7—A TAPE PLAYBACK PREAMPLIFIER is shown here; its simplified frequency-characteristic curve is shown in Fig. 8.

points, or corner frequencies, where rolloff begins and ends. The lower break-point occurs at a frequency such that the denominator of equation 2 is equal to zero. The upper break-point occurs at a frequency such that the numerator of equation 2 is equal to j + 1.

Let's first find the frequency where the denominator is equal to zero. That is, of

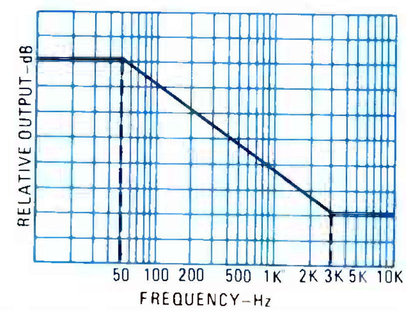


FIG. 8—THE SLOPE between the 50- and 3000-Hz points is 6-dB-per-octave.

course, at $f = 0$. Thus, at $f = 0$ rolloff begins. It will keep rolling off indefinitely unless there is some frequency where gain due to feedback begins to rise to compensate for that initial rolloff. That happens when the numerator in equation 2 is equal to j + 1, or when $f = 1/6.28C_FR_F$. Since the curve calls for a corner frequency of 3000 Hz, choose values of R_F and C_F that satisfy that condition.

Getting back to the frequency where rolloff starts, it was determined from our calculations that for this circuit it begins at 0 Hz. Actually, the curve calls for it to start at 50 Hz. That is taken care of by coupling capacitor C1. In an actual circuit, the value of the capacitor would be selected so that the corner frequency would fall as close to 50 Hz as possible. In a more accurate circuit, a resistor would be placed across C1 so that the corner frequency could be made precisely 50 Hz.

The curve in Fig. 8 is shown with sharp points at the corner frequencies. In the "real world" that never happens—the changes in the curve are never sharp at the corner frequencies and the rolloff and the flat-response sections do not follow the exact contours shown in the drawing. The curve in Fig. 8 is only an approximation of the actual curve required to satisfy the requirements of the circuit, and is used as shown here to simplify the design problem. When designing an actual circuit, most designers follow that procedure.

Stability

Even when only resistors are used in a feedback circuit, the feedback is not uniform over the entire band. It varies with the overall gain of the circuit as well as with the capacitance, inductance, and resistance inherent in the different sections of the circuit.

To check for stability, plot the frequency response of the circuit before feedback is applied. Note the response at the extreme high and low ends of the band. If a circuit is to be stable, the rolloff, when feedback is applied, should be less than 12-dB-per-octave. That can be shown with the help of Fig. 9.

That figure shows the frequency response of a circuit. Two feedback lines have also been plotted—one at −10 dB and one at −20 dB. At the points where the −10-dB feedback line crosses the frequency-response curve, the rolloff is 6-dB-per-octave. At the points where the −20-dB feedback line crosses the frequency-response curve, the rolloff is 12-dB-per-octave. Thus if 10 dB of feedback is added to the amplifier, the circuit is stable, but if 20 dB of feedback is added, the amplifier will be only marginally stable—it may have a tendency to oscillate because the line indicating the −20-dB feedback level crosses the frequency-response curve at a point where the rolloff is 12-dB-per-octave. At that point, feedback has a tendency to turn positive.

If the rolloff should exceed 12-dB-per-octave at the extreme high or low ends of the band, anything more than 20 dB of negative feedback at mid-frequency will turn the circuit into an oscillator.

Oscillators

Getting back to equation 1, if feedback is positive, the BA_V factor is positive. If BA_V is made equal to +1, the denominator of equation 1 becomes zero and the gain with feedback becomes infinite. A circuit with in-phase positive

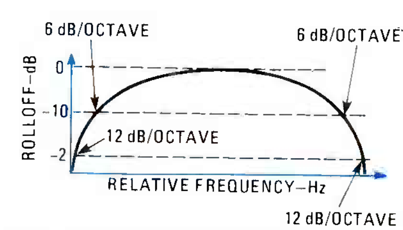


FIG. 9—TO CHECK AN AMPLIFIER FOR STABILITY, first plot its frequency response and then the feedback. At the points where the curves intersect, the rolloff should be less than 12-dB-per-octave to insure stable operation.

feedback and a gain of 1 or more after feedback has been applied will oscillate—there is an output even though no input signal is applied.

A conventional feedback arrangement is shown in Fig. 10. A resonant circuit is formed by L1 and C1. All feedback oscillators are resonant at a frequency of about $1/2\pi\sqrt{LC}$ Hz. Oscillation occurs because of the following sequence of events: When the supply voltage is applied to the oscillator circuit, a pulse reaches the L-C circuit. The L-C circuit turns the pulse into a waveform at its resonant frequency. It is coupled from L1 to L_F and from there to the base-emitter circuit of the transistor. That signal is amplified by the transistor and applied to the resonant circuit. If the signal across L1 and L_F is in the proper relative phase, it keeps on being fed back and amplified until the overall circuit remains in oscillation.

Oscillators have many shapes and forms—three are shown in Fig. 11. The oscillator shown in Fig. 11-a is known as a Colpitts oscillator. When calculating its resonant frequency, use C1C2/(C1 + C2) for the total capacitance of the L-C circuit. Another popular oscillator is the Hartley, shown in Fig. 11-b; its resonant frequency is simply $1/2\pi\sqrt{L1C1}$. A feedback oscillator circuit using only resistors and capacitors is shown in Fig. 11-c. It oscillates because the transistor shifts the phase of the signal 180° from the base to the collector. Each of the R-C networks in the circuit is designed to shift the phase 60° at the frequency of oscillation, for a total of 180°. The appropriate values of R and C for each network is found from $f = 1/(2\sqrt{3}\pi RC)$; that equation allows for the 60° phase shift required by the design.

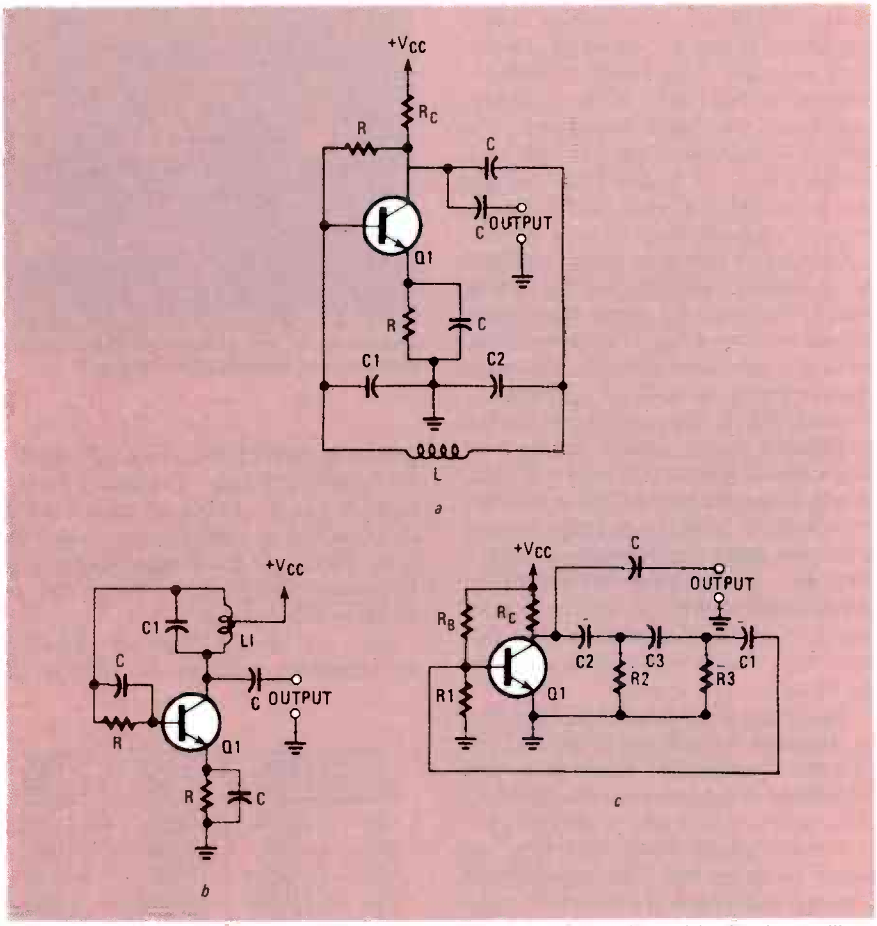


FIG. 11—THERE ARE MANY different kinds of oscillators. A Colpitts oscillator (*a*), a Hartley oscillator (*b*), and a phase-shift oscillator (*c*) are shown here.

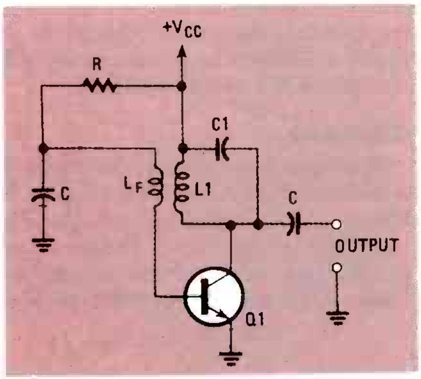


FIG. 10—A CONVENTIONAL FEEDBACK OSCILLATOR. The values of L1 and C1 determines the frequency of oscillation.

Adding the phase shift due to the transistor and the phase shift due to the R-C circuits, the overall phase shift from the input to the output is 360°. Signal from the output is fed back to the base in a positive feedback arrangement (due to the 360° phase shift), to reinforce the signal present at the base. That signal at the base was initiated by a random pulse when power was applied to the circuit, it was amplified, the phase shifted 360°, and fed back. The oscillator frequency will be about:

$$f = \frac{1}{2\pi(C1)}\sqrt{4(R1)R_C + 6(R1)^2}$$

if R_B is considerably larger than R1. Should R1 be omitted from the base circuit, the input resistance of the base circuit, when combined in parallel with R_B, must be chosen so that the combination is equal to R2 or R3 (note that R1, R2, and R3 are all equal).

Oscillators can be built around op-amps. The output of the circuit shown in Fig. 12 is a squarewave; let's see why. Negative feedback is established through R_{F1}, while there is positive feedback through R_{F2}. For that circuit, as well as for circuits described below, assume that the positive saturation voltage at the output of the op-amp is $+V_{CC}$ and that the negative saturation voltage at the output is $-V_{CC}$. The voltage at the non-inverting input depends upon the voltage at the output. It is positive when the saturation voltage is at $+V_{CC}$, and negative when it is at $-V_{CC}$.

Assume the oscillation starts when the output is at $+V_{CC}$. At that time, C1 gets charged to a positive level through R_{F1}. When that voltage exceeds the positive voltage at the non-inverting input, voltage at the output drops to $-V_{CC}$. When that happens, the voltage across C1 begins to drop and become negative because its charging voltage is now being supplied by the negative voltage at the output of the op-amp. Once it drops to below the voltage at the non-inverting input, the voltage at the output returns to $+V_{CC}$. The process keeps repeating itself. Consequently, the output is a squarewave. The frequency of oscillation is $1/2R_{F1}C$, provided that B = 0.462. Since B = $R1/(R1 + R_{F2})$, that condition will hold true if R_{F2} is made equal to 1.16R1.

A sawtooth generator is composed of

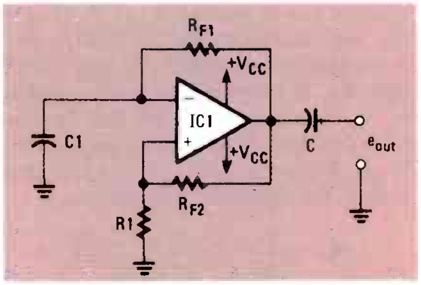


FIG. 12—OP-AMPS are commonly found in oscillator circuits. The output of this circuit is a squarewave.

continued on page 94

NEW IDEAS

Low-distortion audio limiter

SHORTWAVE LISTENING AND DXING IS, without a doubt, an enjoyable hobby. However, it does pose a hazard to your ears—or to your peace of mind—because of the annoying loud-volume pops and blasts you're sure to hear from your communications receiver. Although the AGC (*A*utomatic *G*ain-*C*ontrol) circuits in communications receivers are supposed to take care of those sudden changes in volume, they never seem to do the job well enough. Those of you who wear headphones are especially vulnerable to the annoyance. What's especially annoying then is that you're probably wearing the headphones not for your own benefit, but for the benefit of those around you.

I tried several ways to reduce the problem (for example, using FET's as attenuators) but I was unhappy because I was always trading one problem off for another: distortion. But I finally came up with a design that does what I want—it attenuates the blasts from my communications receiver while causing no noticeable distortion.

The circuit of the audio limiter is shown in Fig. 1. The level at which it comes into action can be set with the LIMIT LEVEL trimmer potentiometer. When that level is exceeded, the output from the LIMITER-DETECTOR half of the op-amp (which is used as a comparator) causes the LED to light. The light from the LED causes the resistance of the photoresistor to decrease rapidly. That in turn causes the gain of the LIMITER half of the op-amp to decrease. When the signal drops below the desired limiting level the LED turns off, the resistance of the photoresistor increases, and the gain of the LIMITER op-amp returns to its normal level—that set by the combination of resistors R1 and R2. A dual-polarity power supply (±12 volts is desirable) is, of course, needed for the op-amp.

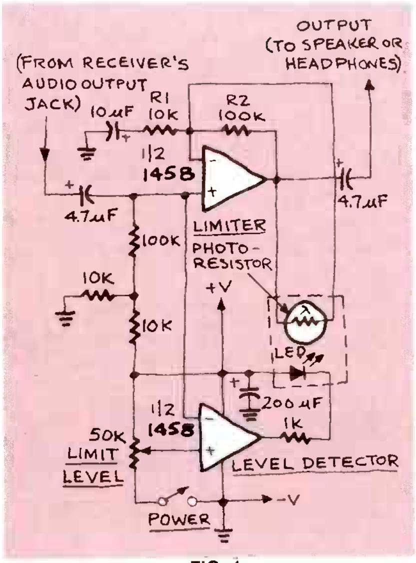
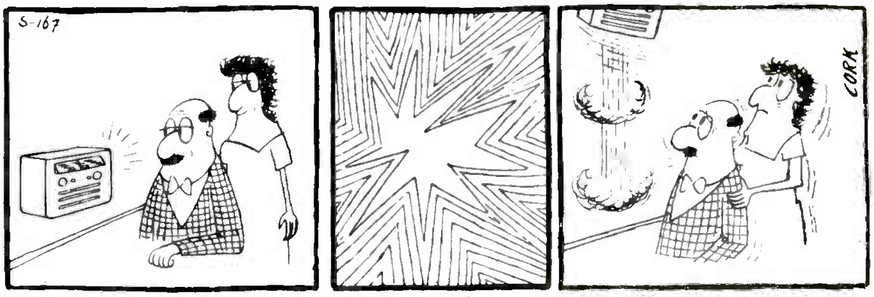


FIG. 1

The circuit is very easy to build, and since the construction method is not critical, use the one you prefer. You might even want to mount the circuit inside your receiver. One important construction note, however, is that the photoresistor and LED should be encased facing each other in a light-tight enclosure.

The parts that you use are not critical either. One note here however is that the (cadmium sulfide, or CdS) photoresistive cell is most sensitive to light with a wavelength of about 5000 angstroms (or, approximately, green light). Therefore, you may want to use a green LED for best response.

Perhaps the best feature of the audio-limiter circuit is that it can be used with any receiver, whether it's a tube-type shortwave receiver or a new solid-state scanner. Your ears will thank you.—*Daniel Ulmer*



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NEW IDEAS

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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.

Until now, cordless phones have given you wonderful convenience. But they've had two problems:

1. The range is limited to 600 to 700 feet.
2. Some of them sound as though you're talking inside a barrel.

As cordless phones have become enormously popular, another problem has arisen: two people, living near each other, can have the same channel. Not only is there line confusion, but someone else can literally make a long distance call on your phone.

No more. Never again.

Range: 1500 Feet OR MORE!

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.

Only SuperFone 650 has a secret code system to prevent interference and false operation of the phone. You choose from 512 possible "code" combinations. Both the base unit and the phone are **locked** onto that code, which you can change when you want to.

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!

30-Second Installation

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

Every component is heavy-duty, from the built-in condenser microphone (with automatic gain control) to the LED indicator lights. This phone is designed for hard use.

The SuperFone 650 is yours for $249.95. If you want the SuperAntenna with it, giving you a range of a mile — or even more — you can have **both** for $319.95. (Or you can get the Super-Antenna alone for $79.95.)

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The SuperAntenna — **$79.95**
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If you have several lines, you can plug them into your SuperFone with this single adapter.

The adapter costs $39.95. Nothing else is required to attach multi-line phones to one SuperFone 650.

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The **SuperAntenna** will give your cordless phone, **regardless of make or model,** three times the range it has now.

If the range is 700 feet, it'll leap to over 2,000. If it's 1500 feet, it could be as far as one mile!

Easy to install. Only $79.95 complete. Add $4.50 for shipping.

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The SuperFone 650, SuperAntenna, and Multi-Line Adapter are more electronic marvels from

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HOBBY CORNER

Reducing battery drain

EARL "DOC" SAVAGE, K4SDS, HOBBY EDITOR

THE FIRST LETTER THAT WE'LL LOOK AT this month is from Ken Alexander in Tennessee. He built and installed a security alarm system in his car. The alarm doesn't draw any current until it is activated. The problem, though, is that the LED indicator light *does* draw current—typically about 40 mA. When the car is not moved for a long period of time, the battery can be affected, particularly in cold weather. Ken wants a way to run the LED with less current drain.

Suppose there were a way to keep the LED turned off most of the time, and on for only short periods. Then, the "heavy" battery drain would occur only in short bursts as the LED was turned on briefly. That would not only solve the main problem but, in my opinion, provide a better indicator—a flashing light usually attracts more attention than a steady one.

Of course, there are many ways to make an LED flash, but one of the simplest is to use a 3909 LED flasher/oscillator IC. The best thing about it (from Ken's viewpoint) is that the operating current is 1 mA—and usually less, depending on the applied voltage (6.4 volts maximum).

The circuit, in spite of the current peaks on flashes, draws only about 1/40 the power used by an LED alone. Add to that the reduced average-current as the flash rate is lowered and you are have an in-

> **AN INVITATION**
>
> To better meet your needs, "Hobby Corner" will undergo a change in direction. It will be changed to a question-and-answer form in the near future. You are invited to send us questions about general electronics and its applications. We'll do what we can to come up with an answer or, at least, suggest where you might find one.
>
> If you need a basic circuit for some purpose, or want to know how or why one works, let us know. We'll print those of greatest interest here in "Hobby Corner." Please keep in mind that we cannot become a circuit-design service for esoteric applications; circuits must be as general and as simple as possible. Please address your correspondence to:
>
> Hobby Corner
> **Radio-Electronics**
> 200 Park Ave. South
> New York, NY 10003

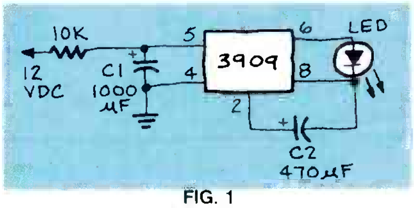


FIG. 1

significant load for a car battery.

Figure 1 shows a schematic of a simple 3909 flasher circuit operated from a 12-volt source. The 10K resistor drops the voltage to the four volts needed to operate the IC. It also restricts the current that flows when the LED does flash. Capacitor C1 is needed to provide that burst of current.

The flashing rate is determined by the value of capacitor C2. I suggest that the rate be made fast enough for the LED to attract attention, but not too fast—the faster it flashes, the more current you'll need. If C2 is 220 µF the rate is about one Hz. For a rate around four Hz, use a 1000 µF capacitor.

If there is a voltage source between 1.5 and 6 volts available, just omit C1 and the 10K resistor. I hope this little circuit meets your needs, Ken.

Battery voltages

Peter Poulos in our nation's capital wonders why all batteries of the same size don't have the same output voltage. (I guess he also is wondering why many batteries of different sizes *do* have the same output voltage.) Well, Pete, it all depends upon the materials of which the batteries are made. Different metals separated by different chemicals (called electrolytes) will produce different voltage potentials.

Let's make a few simple batteries to see how it works. Get a couple of paper cups and put salt water in one and lemon juice in the other. Now find a piece of copper wire, a piece of aluminum wire, and a shiny nail. Clip different pairs of the three metals to the leads of your voltmeter (set on the one- or two-volt scale) and dip them into the two solutions.

You will find that your "batteries" will produce potentials of from 0.15-volt to over a half of a volt. Try some other solutions and other metals (especially an old silver coin if you can find one). What combination can you find to give the highest voltage?

Yes, those really are batteries (actually, wet cells). I wouldn't care to hook them together and carry them around in my flashlight, but they will do real work. Folk who lived out in the country often used similar power sources for early radios. But let's stick with the "dry cells" that we're familiar with. In those batteries, the electrolyte material, which is usually damp, is considered to be "dry."

There you have the basic principles that you need to answer your question, Pete. Of course, sometimes the manufacturers will fool you. They may stack several low-voltage cells together. For example, the common nine-volt "transistor-radio" battery is actually a package of six small 1.5-volt cells. In any event, now you know why all batteries of the same size are not the same voltage. And why some batteries that *are* the same size produce different voltages.

Young entrepreneur

I have a letter from a 12-year-old by the name of Steve Knelly. (I don't know where he lives because I misplaced the envelope.) The rest of us had better watch out because this young man is going somewhere. Steve has a videogame ma-

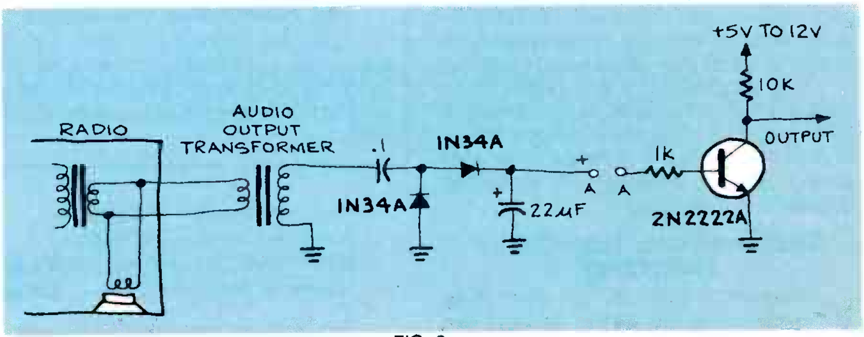


FIG. 2

chine and he is looking for the plans for a coin box similar to the ones used in the arcades. He wants the box to accept dimes, so he must realize he has to beat the competition when he starts out. That boy has a head on his shoulders.

Sorry, Steve, but I can't seem to find plans for a coin box. Perhaps you could figure out a way to use a key-operated switch to turn on a timer that would supply AC to the machine for a preset time-period. Hobby Corner has discussed timer circuits on several occasions in the past. Good luck!

Sound activation

Don Dawson of Ontario, Canada needs help on a circuit to activate some device when sound comes out of his radio. (I'm sure that many of you could use such a circuit to activate something that will wake you up when the clock radio doesn't.) Well, Don, the circuit you wrote me about is on the right track, but I would do it as shown in Fig. 2.

An audio-output transformer is connected "backwards" across the audio output of the radio. This transformer outputs still-higher-level audio, and it goes to the following rectifier. Note that germanium diodes are used instead of silicon ones—the voltage drop across them is lower.

The output at point A is just straight old direct-current created from the audio signal fed into the rectifier. Whenever sound comes from the radio, a positive voltage appears. If that voltage is not great enough for your purposes, an audio amplifier can be added between the transformer and the rectifier.

The DC output (at A) can be used for a variety of purposes. It can turn on a signal light, sound a tone, or do almost anything else. Not knowing what use Don intends for the device, I have shown a 2N2222A transistor switch connected to the output, but almost any NPN transistor can be used. As shown, the switch output varies between ground and the applied voltage. The circuit could as easily activate a relay or other low-voltage device. Of course, if your relay is sensitive enough, it can be operated right from point A without the need for the transistor switch.

Experiment!

Before closing this month's column, I would like to preach a small sermon. Surprisingly often, the mailbag contains a letter that refers to a circuit published here, in another article in **Radio-Electronics**, or even in another magazine. The question usually goes something like this: "Wouldn't it work better if you connected A to C instead of to B?" or "What would happen if you connected a wire from X to Z?"

Well, friends, let me suggest that you get down and dig into the matter for yourselves. Study the circuit as best you can and then try it out. If there are costly components involved, take whatever measures you can to protect them and *experiment*. Even a failed experiment is of value—you'll learn what not to do the next time!

It's easy to try out different things when you use a solderless breadboard. Just build a circuit on it and then start changing component values or connections until you find the combination that makes the circuit perform best. I learn quite a bit by experimenting—you can do the same. **R-E**

"They demand a franchise fee or they'll knock out our satellites."

THE DRAWING BOARD

Increasing current-handling capability of regulators

ROBERT GROSSBLATT

THE TREND IN MODERN LOGIC FAMILIES IS to make them operate with smaller and smaller amounts of power. (I suppose the ultimate goal is the family that can run on potential energy!) Lower power-requirements get rid of the necessity for wrist-thick cables and glass insulators, but there's an even more important benefit. Lower power means smaller, and less complicated, regulator circuits. Some IC's even have the regulator circuitry built onto the chip's substrate. Less current-draw means that the layout of the + V run on printed-circuit boards is much simpler. Remember that when heavy amounts of current are running through a trace on a board, a potentially troublesome voltage drop will be generated because of the resistance (however small) of the copper trace. That can lead to inductive oscillation and other nightmares.

That "low power" side benefit, however, can tend to make you a bit forgetful when you're developing a power supply. LED's, relays, and other things can still gobble up current at an alarming rate. A power supply that can deliver half an amp may seem perfectly adequate for, say, a CMOS circuit—and it is. Unfortunately, when we start asking the circuit to turn something on or light something up, the current draw is going to increase dramatically and our half-amp supply is rapidly going to drop dead.

The voltage-regulator circuit that we've been developing over the past few months can so far safely supply about a half amp over its full range, but it's a smart move to design it so that it can provide a lot more. Since the internal circuitry of the 7805 is limited to less than one amp, it's obvious that we're going to need some other device to provide the additional current.

Adding a pass transistor

In Fig. 1, we've added a transistor and a resistor to take care of the additional current. For simplicity's sake I haven't drawn in the rest of the circuit we've developed so far. All the current that goes into the regulator has to pass through R_B since it's in series with the regulator input. Ohm's law tells us that as the current flow through a resistor increases, so does the voltage developed across it. The base-emitter junction of Q1, a PNP transistor, is in parallel with R_B. As long as the current flowing through the resistor is below a certain level, just about all that's going to happen is that the resistor will get a little warm. At some point, however, the voltage drop across R_B is going to get high enough to turn on the transistor, which will start to pass current through its collector. That current is added to the current supplied by the regulator and allows the draw on our power supply to be increased by the amount that the Q1 can handle without blowing up.

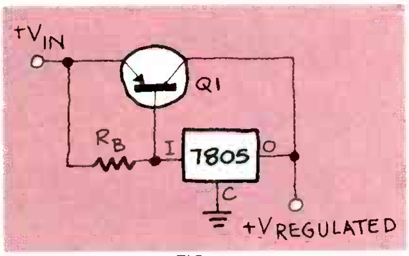


FIG. 1

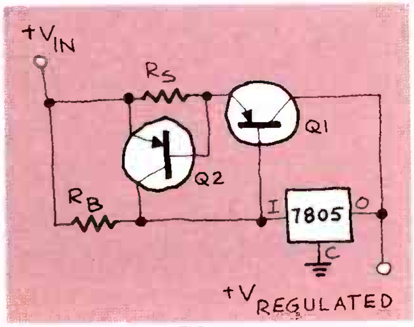


FIG. 2

Transistor Q1, then, is used as a switch that senses when the regulator output is near some limit and turns on to provide the extra current that the regulator can't handle. The turn-on point of Q1 is determined by the value of R_B and the base-emitter voltage of Q1. One other thing to be aware of is that the difference between the input and output voltages is going to change. Since Q1 and R_B are in series with the regulator input, the voltage drop across them has to be added to the inherent 2-volt drop of the regulator. That is important to remember when we're figuring out how much voltage we need at the output of the rectifier.

Short-circuit protection

Before we start doing any arithmetic to calculate the value of R_B we have to add some short-circuit protection to the circuit. I know you're thinking that we took care of that earlier, but we've now added active components to the input. If the output is shorted now, all our earlier protection springs into action—but it only takes care of the regulator. The collector of Q1 is going to be shorted out and the transistor is going to start passing current through the short. It will rapidly exceed its maximum collector-current rating, and all you'll be able to do is administer the last rites.

That is, to say the least, an undesirable state of affairs. In Fig. 2 we've added a safety net for Q1 in the form of Q2 and R_S. Those of you with sharp eyes will recognize that those two new components form a switch in exactly the same manner as R_B and Q1. The same sort of analysis also applies.

All the current that flows through Q1 has to pass through R_S. When a certain point is reached, the emitter-base junction of Q2 is going to conduct and the transistor will turn on. When it does, it will lower the voltage across R_B and turn Q1 off. Since Q2 isn't going to turn on until the power supply is providing really large amounts of current, we need a hefty transistor there. It has to handle pretty close to the sum of the short-circuit currents of both the 7805 and Q1.

Since there are more components connected in the circuit between the base and emitter of Q1, the math needed to calculate the values of the two resistors is going to be more complicated. Rather than going through it however, let's make a few intelligent assumptions and see if we can make life easier.

If we use silicon transistors for Q1 and Q2, we know that the base-emitter voltage is going to be about .65 volts when the transistor is turned on. As long as the voltage is below that, the transistor will be turned off.

Now let's look at Fig. 1 again and assume that Q1 isn't there. The 7805 needs about 8 mA to operate—the rest of the current it passes is available to whatever circuit it's powering. The regulator can handle half an amp without any problem, but let's be on the safe side and arrange for Q1 to turn on when the regulator draw exceeds 250 mA. Since the turn-on voltage for the transistor is 0.65 volts, calculating the value of R_B is a snap: $R_B = E/I = .65/.250 = 2.6$ ohms

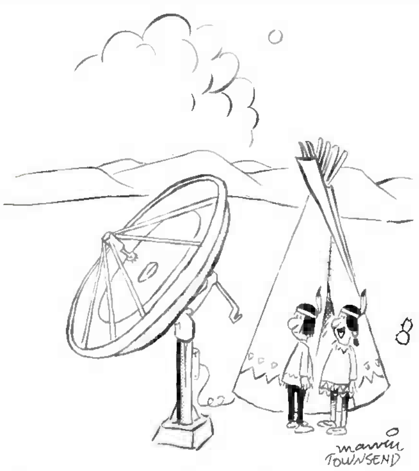
Now, it's true that the emitter-base junction of Q1 is in parallel with R_B so that bunch of arithmetic isn't strictly correct. Remember, though, that the apparent resistance of the junction when the transistor is in cutoff is pretty high. It's not really accurate to talk about the resistance of a transistor (or any semiconductor, for that matter), because they're dynamic devices and we should more properly refer to their "impedance." That's the DC resistance coupled with an AC component. For our "real world" circuit, however, the difference doesn't amount to much and we can ignore it.

If you look at Fig. 2, you'll see that we have to go a little farther in figuring the value of R_B. Since both R_B and R_S are across the emitter-base junction of Q1, both their values have to be taken into account when we figure the trip point of Q1. Once again, the "resistance" of Q2 in cutoff is high enough for us to ignore it and just work with the resistor values.

Since R_S has to pass all the current that flows through Q1, we have to decide what we're going to let the maximum current be. Five amps is a good value for our regulator circuit—more than that will cause design problems we don't want to get involved with. Just as was the case with Q1, Q2 will start conducting when its emitter-base voltage reaches 0.65 volts. If we want that to happen when Q1 is passing 5 amps, R_S has to be on the order of 0.13 ohms. The total resistance we need to turn on Q1 is 2.6 ohms. Since R_S must be .13 ohms, the new value of R_B will be 2.47 ohms.

Now, I'm the first to admit that those are pretty oddball values for resistors. You can't exactly amble down to your local resistor store and buy a 2.47 ohm resistor. There are ways around that, though.

Next month we'll take care of all the unfinished business and complete our regulator. We'll consider choices for Q1, Q2, and the proper wattage for the resistor. Not only all that, but, since we've all been working so hard we'll find ourselves treated to a surprise in the circuit that's not only useful, but that's one we get for free. R-E



"I'm not too thrilled with its aesthetic value, but I sure dig the variety of channels I can get."

STATE OF SOLID STATE

Power MOSFET amplfiers

ROBERT F. SCOTT, CONTRIBUTING EDITOR

SOME OF THE NEWER HI-FI AMPLIFIERS are designed around power FET's in the output stage. That's because they offer low harmonic distortion, extended SOA (*S*afe *O*peration *A*rea), and infinite current gain. The design, construction, and performance of such an amplifier is covered in a recent Intersil applications note. Its schematic diagram is shown in Fig. 1. The amplifier delivers 50 watts into an 8-ohm load. Its frequency response is ±3-dB from 20 Hz to 100 kHz while distortion is less than 0.25% from 20 Hz to 20 kHz.

The amplifier's design is unconventional in several respects: First, there are no rolloff or compensation capacitors. Instead, rolloff is provided by the input capacitance of the power MOSFET's (Q8 and Q9) that are arranged in a quasi-complementary output stage. The driver stage uses bipolar transistors and provides the usual voltage amplification and phase-splitting functions. Finally, the positive power-supply line is bootstrapped to insure that the positive and negative half-cycles of the output signal are equal and maximized.

The input stage is designed around Q3, a U402 dual N-channel JFET in a differential configuration. A pair of J113 JFET's (Q1 and Q2) provide a constant current for the U402. That current controls the bias current of the output stage and is set by R18, a 10-turn 1K trimmer potentiometer. Bipolar transistor pairs Q4-Q6 and Q5-Q7 turn on in proportion to the input signal and provide drive current for output transistors Q9 and Q8, respectively. The drive current flows through R10 and R11 and develops the necessary gate-source voltage for the output transistors. The power gain of the output stage is quite high because of the comparatively high value of the resistors connected between gate and source.

The boot-strapped positive power-supply line, mentioned earlier, is needed because if Q8 is to clip at the level of the positive power-supply line, its gate voltage must be driven beyond that point. Thus, a voltage higher than ⅙ must be supplied to the input and driver stages. Instead of using an external power-supply with an output of more than 35 volts, the designers elected to bootstrap the ⅙-volt supply; that bootstrap circuit consists of D7, C4, D6, C9, and R15.

The closed-loop gain is determined by resistors R16 and R17. Capacitor C3 compensates for any offset in the output. In this design, the open-loop gain is set at 20 kHz by the gate capacitance of the power MOSFET's and the values of the gate resistors, R10 and R11. This frequency can be pushed higher by reducing the value of the gate resistor. However, this will increase the power dissipated in the driver stage—particularly in Q6 and Q7.

Data for this section of the column was taken from a pre-published copy of Application Note A0-40 (A Low-Cost Audio Amplifier Using Power MOSFET's by Bruce Rosenthal and Jim Meador) from Intersil, Inc., 10710 N. Tantau Ave., Cupertino, CA 95014.

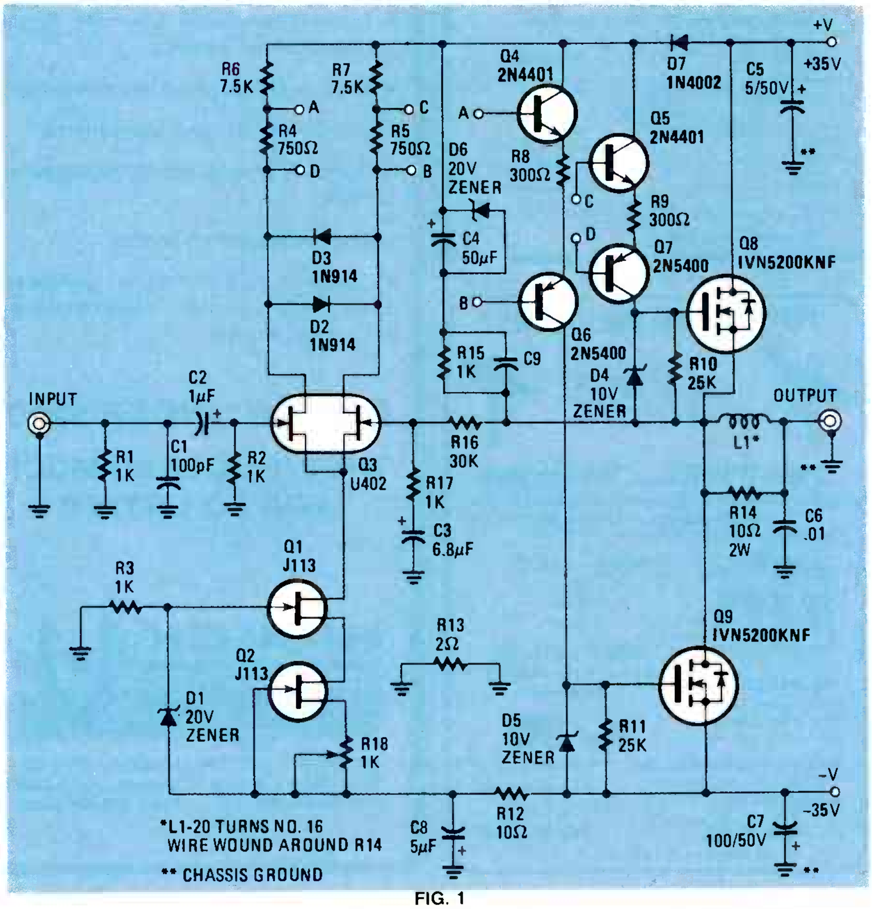


FIG. 1

High-voltage trigger

A series of new semiconductor devices for high-voltage bilateral trigger applications has been introduced by Motorola. Known as SIDAC's, the devices combine the high-voltage bilateral trigger functions of triacs with the simplicity and low cost of two-terminal diac triggers. The devices replace less reliable components such as neon bulbs for applications such as: high-voltage regulators, strobes and flashers, ignitors, line-transient clippers, pulse generators, fluorescent lighting, and high-pressure sodium-vapor lighting

The devices are designed for direct interface with the AC power line. Upon reaching the breakdown voltage in each direction (104 to 135 volts) the SIDAC switches from a blocking state to a low-voltage "on" state. Conduction continues—as in an SCR—until the main terminal current falls below the holding current, typically 100 mA.

The new MK1V series of SIDAC's includes three devices, the MK1V-115, MK1V-125, and MK1V-135; with the last three numbers indicating the maximum repetitive break-over voltage. Figure 2 shows two SIDAC circuits; Fig. 2-*a* shows how electronic equipment can be protected against line-voltage transients and Fig. 2-*b* shows a SIDAC as a two-terminal trigger for a strobe or flasher application.

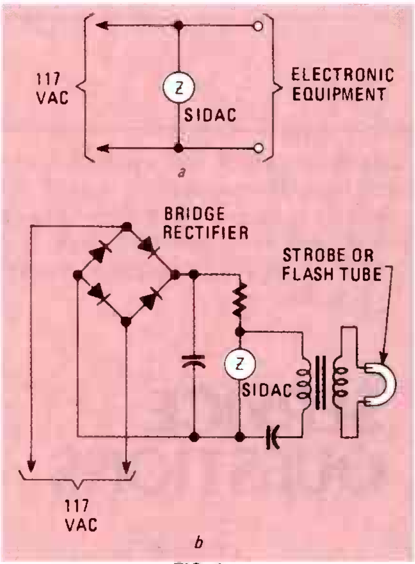


FIG. 2

The minimum breakover (breakdown) voltages are 104, 110, and 120, respectively for the three devices. Off-state repetitive voltage is ±90 volts and repetitive peak off-state current is 10 μA. Instanteneous on current is 1.0 amp RMS for each device. Maximum breakdown current (60-Hz sinewave) is 200 μA. Forward "on" voltage is typically 1.1 while dynamic holding current is 100 mA.

Transistor data book

Field-Effect Transistors—Selector Guide and Cross Reference is a 32-page booklet chock full of valuable information on FET's. It opens with a brief description of all types of field-effect transistors and then comparing FET's to bipolar devices and then JFET's versus MOSFET's. This is followed by many listings of pertinent characteristics of JFET's, single- and dual-gate MOSFET'S, dual-gate DMOS as well as power MOSFET's.

A numerical index lists approximately 70 devices whose characteristics are listed in tables depending on their classification as Switches and Choppers, Power MOS, Low-Frequency Low-Noise Amplifiers, or High-Frequency Amplifiers. A Cross-Reference and Interchangeability Guide matches industry type numbers of approximately 1900 FET's with equivalent types from Motorola. The book concludes with illustrated FET applications that include an ionization-chamber smoke detector and a 500-MHz dual-gate MOSFET amplifier that is suitable for service in the front-end of a communications receiver.—**Motorola Semiconductor Products**, PO Box 20912, Phoenix, AZ 35036.

continued on page 89

SERVICE CLINIC

A dish full of bugs

JACK DARR SERVICE EDITOR

SATELLITE-RECEIVING SYSTEMS HAVE BEcome very popular of late, especially in rural areas where cable TV is pretty certain to remain merely a dream. Such systems, and the large outdoor antennas that they use, have their own peculiar problems, some of which can really "bug" you if you don't recognize the cause. Here are some cases that you may find interesting.

In the first case, the system had been working well, until suddenly the reception started getting worse and worse, and finally went out completely. Checks of the system showed nothing out of order in the electronics—LNA, downconverter, etc. That left only the dish antenna. Nothing was immediately apparent, but close examination finally showed the cause.

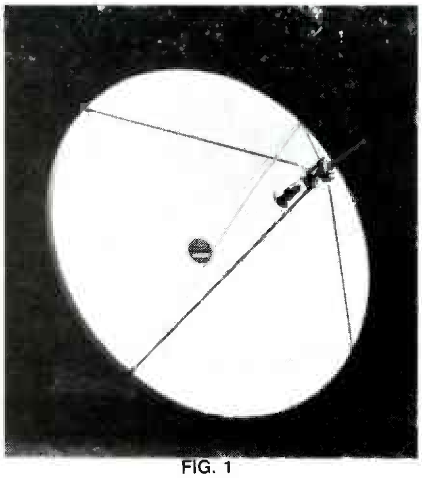


FIG. 1

A parabolic dish reflects the 3–4-GHz satellite signals on to a structure called a feed horn at the focal point of the dish (see Fig. 1). The feed horn directs the signal on to a small pickup device. There are various ways of picking up the signal; some antennas use very tiny dipoles, others use a waveguide, and so on. But one thing is common to all designs—there is a small hole at the end of the feed horn that the signal must pass through. In this case, the hole had been chosen by a female mud-dauber wasp to make her nest in. That busy little bug finds a deposit of wet clay, and carries vast quantities of it, considering her size, to your garage eaves, or anyplace else she can find to build nests, which are long tubes of clay. She loves to use holes in anything she can find—garden hose stored for the winter, a set of socket wrenches in an open toolbox, a paint spray-gun left on the bench; etc. In this case, she had adopted the end of the feed horn—and it's hard to get a signal through a couple of inches of wet clay. Cleaning the aperture out, and guarding against further problems by tying a small piece of plastic wrap over the end, cleared up the problem.

In the second case the system worked nicely during the day, but at dusk the reception gradually got worse until it quit altogether. Once again a wasp eventually proved to be the source of the problem. That one is called the paper-making wasp; their nests, found under eaves, etc., look like a cone made of paper. Those wasps also like to adopt any kind of hole as their own. They were settling in the horn, and getting ready to build their nest there. During the day, they were all out foraging; at dusk, they came back and crawled into the horn. This is a big wasp, and it didn't take many to fill the feed horn completely.

Here's a word of caution. Those red-bodied wasps have a nasty disposition and when they sting you you'll know it. The best way to deal with them is to spray the feed horn with a strong wasp killer while it's "occupied," and come back later to clean it out. Once again, cover the opening with plastic wrap to prevent any future problems.

A different kind of animal

The last case we'll talk about deals with another kind of animal, one that can do far more damage. The animal I am talking about is man, and in particular the type of man that doesn't think.

One such critter was working as an assistant to a dish installer. The installer wrote me asking for help (incidentally, this is the only case of satellite trouble we've ever fixed—by mail, of course). One of his customers had complained that the system got very noisy in rainy weather. I told him to tighten all the coax fittings and then spray them with a clear acrylic coating to weatherproof them. The installer then sent his assistant out to spray the plugs. Spray them he did—with a penetrating oil (the fellow simply did not read the label before doing the job). Of course, the oil not only penetrated the plugs, but went right down to the coax's center conductor, dissolving the insulation as it went. All the coax had to be replaced—which was expensive, to say the least. The moral of the story is: When you give someone instructions to do a job, make sure everyone understands exactly what's to be done. Otherwise, you're inviting disaster. **R-E**

SERVICE QUESTIONS

TWO HINTS

Here are a couple you might be interested in. I had a Wollesak 3M tape recorder that would not run in one direction. It had an odd clutch setup; when the direction was reversed, the idler ran up a spiral groove to engage the other drive. After cleaning the grooves, the idler worked, but the clutch facings were so badly worn that they slipped. The fix turned out to be fairly simple. We got some fairly thin gasket material from an auto supply store, and cut two new clutch facings out of it. Those were cemented to the idler and the whole thing works better than new.

The second hint is for those into restoring old radios. A good place to find information about parts and services is *Hemmings Motor News*, Box 380, Bennington, VT 05201. Their classified section includes ads for various components, as well as for such services as reconing speakers and restoring wood veneer.

Thanks to Rodney K. Schrock of Somerset, PA for these.

BURNING RESISTOR

I repaired a Setchell-Carlson 3C66, including installing a new CRT and so on. I noticed that the 22K resistor between the cathode of the 3A3 and the plate of the 6BK4 had burnt up and replaced it with one of equal value, but rated at 2 watts. The set worked and the customer took it home. A while later I got a call—the set had gone out again. When I got it back into the shop, I found that the same 22K resistor was once more charred beyond recognition. I'm puzzled; is it possible that a common carbon resistor won't work there?—L.P., Osceola, IA

I think your guess is right. I've had some embarrassing experiences trying to use common carbon-types in high-voltage circuits. The best bet here would be to use a glass-film or flameproof type. Carbon resistors, when used in high-voltage circuits, have to handle a lot more power than you might suspect at first glance. As a result, they get hot and burn up.

To tell you the truth, I'm not sure what that resistor is doing there anyhow. The only other time I've seen something like that was in an old Zenith. Incidentally, that resistor, which was a 1K unit, also burned up regularly. We eventually replaced it with a short piece of heavy hook-up wire.

WHICH CAPACITORS?

In the February, 1983 issue of* Radio-Electronics *you had a question about "flag waving" (instability) in older sets when using a VCR. We have a CTC-68 (1973) with that problem. You said to reduce the value of the AFC capacitors; are those the ones that are called out as C2 and C3 in the MAH001A module in that set?—L.K., Newark, CA

I took a look at the Sams *Photofact* (number 1378-2), and I'm pretty sure that they are; try smaller ones there. You might also try reducing the value of the 100K resistors, although I've never heard of anyone having to do that.

POSSIBLE CURE

A recent letter in your column described a problem with a Zenith 16Z7C19Z that was destroying 6HV5's; I may have a solution. In several of those I have found that the tube's screen resistor, a 1K unit, has either increased in value or opened. If that happens, it may produce the symptoms observed. If the 6HV5 has to be replaced, it is a good practice to check that resistor, especially if the tube's glass is cracked; the resistor can be checked from the top of the chassis. Hope that helps—*Robert Cortner Jr., Davison TV, Buffalo, MO*

VERTICAL PROBLEM

I have a Sears 528.41670314 with nothing but a bright horizontal line on the screen. The sound is OK. I checked the vertical circuit and found one problem: There was −50 volts on V6A where there should have been +300. I scoped the boost that fed that plate and found a very high ripple-voltage. Replacing C113C in the +300-volt line cleared up that problem. The moral is that you should always scope the B+ lines.

That bad capacitor was evidently allowing feedback that was upsetting everything. Incidentally, When you see mysterious vertical lines at one side of the picture, and the set uses flyback-derived low-voltage sources, always scope those. You may find, as we did in several sets, that the small filter-capacitor on the low-voltage supply is open and you're getting a ripple voltage at the horizontal frequency!

Thanks to Lesley F. Dahm for this.

REPLACEMENT IC

I need a replacement or substitute for IC-200 in a K-Mart SKC-1940-AM; the part number is 56A49-2 or 56C49-2. I've looked everywhere I can think of.—C.H., Liberty Lake, WN

That set was made by Admiral for the Kresge Co. To my surprise I found a listing for the IC in the Sylvania ECG guide; it's an ECG-854. Incidentally, the letter in most Admiral part numbers doesn't mean much, hence both part numbers you listed are the same. If you need other Admiral parts, and can't get them locally, try their WATS-line number: 1-800-447-8361. Be sure to have the correct *Admiral* part number handy or they can't do much for you.

CLOCK IC

An Imperial clock radio, model CR-102, made for Superscope, was stuck in the calendar mode. The data sheet for the clock IC, an Electronic Arrays 7317, showed that an internal pull-down resistor at pin 24 enables the clock mode unless V_{SS} (20 volts in this case) is applied to the pin. When I measured, I found the

continued on page 99

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COMPUTER CORNER

Recently-introduced microcomputers

LES SPINDLE*

NOT WILLING TO BE LEFT BEHIND WHILE well-established computer companies like IBM and DEC moved aggressively into the personal-computer marketplace, veteran personal-microcomputer manufacturers like Tandy/Radio Shack and Apple Computer recently came back with a vengeance.

After months of media speculation about its not-too-well-kept secret, Apple unveiled its new 32/16-bit *Lisa* computer. Both the Apple *IIe* and the simultaneously-announced Radio Shack *Model 12* were upstaged by the attention-grabbing *Lisa*.

If *Lisa* actually lives up to its pre-release promises, it may well give all competitors a run for their money. Priced just below $10,000, *Lisa* barely fits into the "personal" or "small business" computer categories. Yet, its comprehensive list of features and integrated software may well compensate for its price. And there's plenty of room for expansion as the applications needs grow. But its biggest feature is its user-friendliness. It's aimed at those not well-versed in "computerese." Apple claims that a first-time user can put the *Lisa* to work in less than a half-hour.

The hallmark feature of *Lisa* (*L*ocal *I*ntegrated *S*oftware *A*rchitecture) is the extreme ease of use promised by its "mouse" device. The mouse is a palm-sized box connected to the terminal that allows the user to manipulate a cursor just by moving the mouse across the desk top. Pictorial symbols, such as a file folder, a wastebasket, and stationery, provide the user with an immediately-identifiable range of functions—such as filing a document, discarding old data, or writing a letter. By simply moving the cursor to the desired function, the user can perform functions that ordinarily require a good deal of key-punching, several commands—and occasional swearing by newcomers or those not familiar with the particular system—to accomplish.

Meanwhile, a menu at the top of the screen continuously lists the various functions within each application. By simply moving the mouse to point at one item, another detailed menu is displayed on the screen to guide the user step-by-step through that particular function. The interactive process continues, allowing even a complete computer novice to move quickly from one transaction to another with a minimum of time and effort.

*Managing Editor, *Interface Age* magazine

FIG. 1

The range of software that comes standard with the computer is also impressive, and—another important feature of the machine—data from each package is easily integrated with data from the other packages through the use of the versatile mouse. *LisiCalc* is an spreadsheet program for financial planning. The *LisaWrite* word-processing program integrates several text-editing functions for correspondence, reports, short memos, etc. *LisaGraph* integrates spreadsheet data with various graphs—bar, line, bar/line, scatter graph, or pie charts. That program can work in conjunction with the *LisaDraw* program for creating graphic designs. The *LisaList* program performs comprehensive data-base and filing functions, while *LisaProject* handles various critical-path and project-management functions. And that, too, can be integrated with the other programs.

To make the machine even more versatile, it is compatible with either BASIC, Cobol, or Pascal. Two operating systems—CP/M and Xenix—are supported.

The microprocessor for the *Lisa* is the MC68000, which combines a 32-bit internal architecture with a 16-bit external data path. The computer comes with one megabyte of RAM. Two 5¼-inch floppy-disk drives are standard and a *Profile* hard disk supplies 5 megabytes of storage.

The CRT screen is a 12 inch, black-and-white display. The resolution is 364 × 720 pixels. A typewriter-style keyboard and numeric keypad are standard.

Two serial ports and one parallel port are included and allow for a multitude of additional functions. The *AppleNet* software package (not available as this was written) will enable local-area network communications. Data-base access to The Source, CompuServe, and other such services is possible with the *LisaTerminal* software accessory.

Another new Apple

Somewhat buried under all the hoopla surrounding *Lisa*, the *Apple IIe* (*e* is for "enhanced") is a successor to Apple's most popular computer—the *Apple II*. The system is priced below the similarly-configured *Apple II +*. The 64K unit offers easy expansion to 128K with a plug-in card. A low-cost 80-column card is also available.

The system is fully compatible with all *Apple II* software on the market. Meanwhile, enhancements to existing programs are rapidly being developed by various companies to add new features that are possible on the *Apple IIe*. Among new programs are the *Apple Writer II* word processor and *Quick File II*.

The price for a complete system (with 64K memory, floppy-disk drive with controller card, 12-inch monitor with stand, and the 80-column card) is $1,995.

Not to be outdone

Last, but not least, Tandy/Radio Shack craftily unveiled its latest offering almost the same day as Apple. The TRS-80 *Model 12* (priced at $3,199 with one disk drive, $3,999 with two) is Tandy's low-cost alternative to its popular *Model II*. While running all software designed for the *Model II*, the system looks very much like the 16-bit *Model 16* introduced last year.

The system includes a Z80A 8-bit processor, direct memory access, and vectored interrupts. Standard memory capacity is 80K, with either one or two 1.25-megabyte disk drives.

TRSDOS 4.2 is the unit's resident operating system--an enhancement of the TRSDOS 2.0. Double-density disks are supported, as well as double- or single-sided 8-inch floppy disks.

The display is a 12-inch green-phosphor monitor capable of 80 × 24 or 40 × 24 lines. Upper and lower case characters are supported, as well as 32 graphics characters. A detachable keyboard includes 82 keys, with a numeric keypad and eight special-function keys.

An optional card cage provides six slots for expansion. An upgrade card will convert the system to *Model 16* capability. High-resolution graphics and a 64K VisiCalc are other possible expansions.

Meanwhile, further expansion is available with the newly introduced 12-megabyte hard-disk drive, adaptable to the TRS-80 *Model II*, *16*, or *12* systems. The price is $3,495 for the primary drive and $2,495 for a secondary drive.

While the *Model 12* unveiling may not have been as exciting as Apple's double announcement, Radio Shack reportedly has more tricks up its sleeve, including a portable computer to rival the *Osborne I* and all of its imitators. In any event, it's clear that the pioneer microcomputer companies are determined not to be undone by the flood of competitors entering the market. As the competition heats up, the coming months should offer a number of surprises. **R-E**

STATE OF SOLID STATE

continued from page 81

High-power 900-MHz transistors

Motorola has introduced three new 24-volt DC, 900-MHz power transistors. The line includes the MRF890, a 2-watt, 9.0-dB minimum-gain predriver; the MRF892 14-watt, 8.5-dB driver; and the MRF894 30-watt, 7.0-dB final amplifier. A chain of those three devices is capable of boosting a 100-mW UHF input signal (804 to 960 MHz) to 30 watts output. The new transistors are intended for large-signal, common-base amplifier applications in industrial and commercial cellular-FM radiotelephone equipment. All three devices have guaranteed gain performance at 900 MHz, collector efficiencies of 55% minimum, and will withstand a 30:1 VSWR load mismatch at their rated voltages and power outputs. The MRF390 is packaged in a 305-1 case; the other two devices in the family in 319-04 packages. Prices in quantities of 100-499 are $10.00, $19.55, and $30.60 for the MRF890, -892 and -894, respectively.—**Motorola Semiconductor Products,** Attention: Tom Bishop, PO Box 20912, Phoenix, AZ 20912.

Voltage regulator design data

Linear Voltage Regulators, (Application Note APN-27) is a 16-page booklet that provides detailed design information on a wide variety of voltage-reference circuits and voltage regulators. The material includes schematics, performance data, and descriptions of 18 circuits. Those circuits include band-gap voltage references, Zener-diode references, series and shunt regulators, and positive and negative voltage regulators. The designs include information on such parameters as temperature stability, noise voltages, and line and load regulation.—**Interdesign, Inc.,** 1255 Reamwood Ave., Sunnyvale, CA 94086. **R-E**

COMMUNICATIONS CORNER

Communications for the disabled

HERB FRIEDMAN, COMMUNICATIONS EDITOR

FOR ALMOST ALL MY WORKING LIFE I WAS associated with New York City's High School of the Air for Home Instruction. Using FM radio and sophisticated (for their day) telephone couplers and switching systems, the High School of the Air created real-time classrooms for disabled children who could leave home only infrequently, if at all.

The dial-up telephone system connected the homebound students to the studio console where they were mixed (electronically) with a teacher and his class. We could do straight classroom simulations, or even dramatic programs with music, sound effects, in-studio performers, and dial-up telephone performers. The studio mix was then fed to the transmitter and also out to up to 25 telephone users. (The budget-cutters eliminated the five teachers who serviced 1000 students, and thereby—after 35 successful years—destroyed the program.)

While it was easy for most disabled children to use the service, the blind and deaf had severe communications handicaps, which carried through to adulthood. There is little in the way of low-cost communications equipment for the disabled, and little information on what there is, even from the manufacturers and distributors. (Most of them simply appear concerned with charging as much as the traffic will bear.) Personal computers appeared to be an ideal solution for providing low- or moderate-cost communications for the deaf and blind, but again, there is no centralized information source.

When several of our readers with disabled children inquired about using personal computers for communications, I ran up against the same problem they did—too little information. By chance, I got to talking with some people at The Source about the problem, and it turned out that they were working toward a similar goal of providing a bulletin board and information database for the disabled. In less than two weeks the system was in place.

Users of The Source can go directly from the command mode to a bulletin board and message center for the disabled by typing "POST R DISABILITY" on the terminal. Manufacturers and users can leave general information or specific details concerning special personal-computer equipment specifically intended for the disabled. Also, through the Texas Instruments *Texnet* tie-in with The Source, the UPI news service is prepared for voice output through a personal computer with a speech synthesizer. (Got the idea of what we're looking for? We want everything in communications for the disabled!)

If you have any specific knowledge about personal-computer or communications equipment that would benefit the disabled—such as a moderately priced Braille printer for the Apple computer, or a store-and-forward with voice output for any personal computer—put it up on The Source or pass it along to me here.

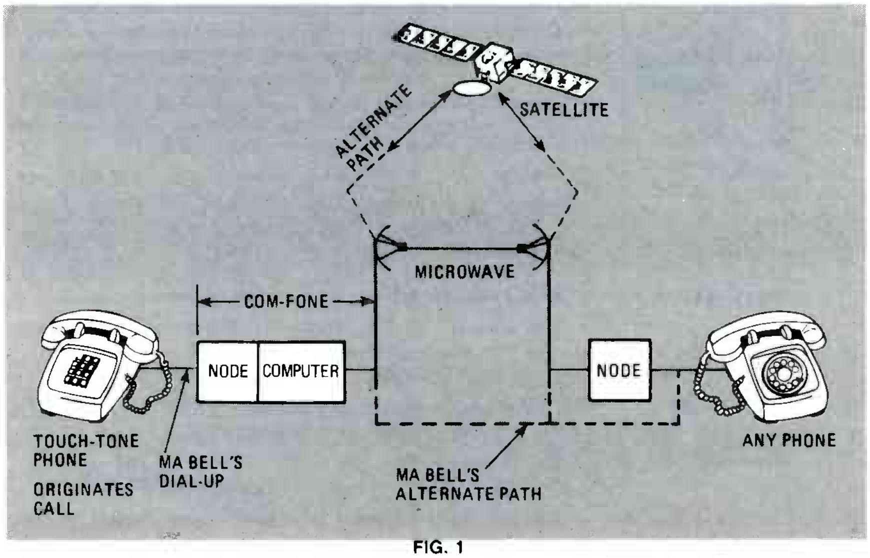

FIG. 1

Saving money by telephone

The way I heard it a few years ago, the telephone was dead. Microprocessors, satellites, and systems that we hadn't even yet conceived were going to make the telephone system as obsolete as the singing telegram. Well, here it is a few years into the computer age and the telephone is livelier than ever thanks to new developments. We're getting more low-cost telephone systems than we could imagine, all thanks to the computer, microwave communications, satellites, and whatever new inventions our engineers will conjure up in the coming years.

Just as soon as I finish typing this column I am going to telephone the editor and explain why it's late. It's a call in the same part of the state, but it will cost a lot less than usual. I will press two keys on the keypad built into the mouthpiece of my phone, and a computer also built into the mouthpiece will dial Sprint. Sprint is one of several communications services that provide short- and long-distance telephone service that is less expensive than the equivalent service from the telephone company (which we'll call Telco). When I hear the Sprint answer-tone, I will press two more keys, and the mouthpiece computer will transmit my identification, travel code (which I can use from coast to coast), and the number that I'm calling. A Sprint computer will recognize who I am and route my call though its facilities to New York City, put it back into the Telco system, and connect my call. I will be billed by Sprint, and pay about 40% less than I would for a telephone call made in the standard way. My only extra charge will be the local one for the connection to Sprint.

As you might guess, the secret to all that is a computer that does the Telco-system interconnects and the monthly billing. There are several ways that such a communications system can be put together, so we'll construct a "basic" model that will help you understand this new wrinkle that's shown up in telephone communications.

First, it's possible to purchase "bulk" telephone service from Ma Bell at lower rates than regular subscribers pay. Then, there are private and public microwave systems through the main business corridors, such as New York to Atlanta, or Los Angeles to Chicago, or Houston to everywhere. Since communications circuits are often kicked upstairs to a satellite (because its easier to get over a mountain that way), it's a safe bet that part of our budget communications will involve satellite transmission (as is often the case with "regular" telephone service).

Figure 1 shows how a hypothetical system we'll call "Com-Fone" might be used to provide you with low-cost telephone communications. Starting at point "A," you use your standard phone with rotary or *Touch-Tone* dialing to get into the nearest Com-Fone node (switching center). Com-Fone's computer answers, and on hearing the answer tone, you transmit your identification code using *Touch-Tone* frequencies. You cannot use the standard telephone dial pulses because the Com-Fone computer "understands" only the DTMF (*D*ual-*T*one *M*ulti-*F*requency) tones used by the *Touch-Tone* system. Still using tones, you dial the area code and number you want. The computer checks your I.D. If it's not valid, the computer does an intercept and a computerized voice informs you that that's the case. If your account is clear, the computer seizes an open communications path that may be part microwave link, part satellite, and part Ma Bell's wiring. At the receiving end, the computer connects back into Ma Bell's system and dials the local telephone number that you are trying to reach.

You pay the telephone charge (to your local telephone company) from your phone to the Com-Fone node. Com-Fone's computer calculates and bills you for the charges for service from the node right up to the party you called. Com-Fone's costs (what Com-Fone must pay Ma Bell) at the receiving end—where your call re-enters Ma Bell's wiring—are calculated and built into your Com-Fone charges. But because Com-Fone purchases bulk telephone-service, your total bill is reduced.

Oh yes! That computer inside the telephone mouthpiece! That's not hypothetical, it's a *Soft-Touch* dialer from Buscom Systems, Inc. (4700 Patrick Henry Drive, Santa Clara, CA 95050) that provides *Touch-Tone* dialing on rotary dial telephones. It substitutes a microphone and miniature keypad for the existing carbon microphone. It has 80 programmable memories that are accessed by pushing two buttons. The memories are maintained by subminiature batteries that last several years. The memories stack automatically, so you can program any series of access numbers and codes; all of them are transmitted by pressing the two buttons representing the initial memory address.

Next month, when we continue, we will look more closely at that *Touch-Tone* autodialer. We'll also be looking at other applications for *Touch-Tones*. **R-E**

USING LORAN-C ETC.

continued from page 67

idea of using Loran-C for frequency-standard checking/calibration. The GRI source, driven from a local frequency standard, is used to trigger the scope externally. The Loran-C signal, either from a suitable receiver or from the RF front end (the circuit shown in Fig. 7) is displayed, and the sweep time is adjusted to observe some part of a particular signal. The Loran-C signal at a given GRI can be momentarily speeded up or slowed down by "bumping" the thumbwheel switches of the GRI generator to place the Loran-C trace at some point on the scope so that a very small part of the leading edge of a pulse can be observed. Then, by determining the length of time it takes the Loran-C signal to move a given distance across the screen of the scope, the fractional frequency-stability of the local 1-MHz standard can be determined.

How is that time measurement used to obtain a measurement of the relative frequency stability? The two measurements can be related by calculus; we will only give the result: $\Delta f/f = -\Delta t/T$.

Here, Δt is the change in time (the drift) read over a measurement time, T. If, for example, the result was 1.5×10^{-6}, it would indicate that the oscillator's actual frequency was its nominal frequency (in this case 1 MHz) multiplied by 1.5×10^{-6}. In this case, the actual frequency of the standard would be 1.0000015 MHz. Typically, with a good (proportional oven controlled) standard, the Loran-C signal will only move to the right or left about 10 μs/hour. That implies an offset of the order of 3×10^{-9}.

The expanded scope-trace (about 10 μs/division) is useful for examining the actual RF-carrier output from the pin-11 test point of the MC1357 detector in Fig. 7. The envelope of that signal at the output of the op-amp-filter can also be observed, and the movement of the inflection point or zero crossing can be recorded at hourly intervals to check the clock-stability.

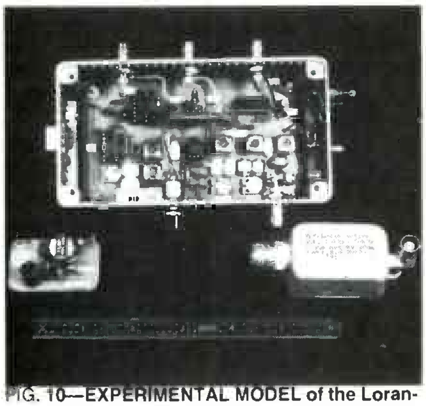

FIG. 10—EXPERIMENTAL MODEL of the Loran-C envelope detector with active antenna preamp and housing.

TABLE 1—GRI RATES

GRI (μs/10)	CHAIN	COUNTER CODE
4990	Suez Canal	1F3
4990	Central Pacific	1F3
5930	Canada East	251
5990	Canada West	257
7930	North Atlantic	319
7960	Gulf of Alaska	31C
7970	Norwegian Sea	31D
7980	US Southeast	31E
7990	Mediterranean Sea	31F
8970	US Great Lakes	381
9940	US Westcoast	3E2
9960	US Northeast	3E4
9970	NW Pacific	3E5
9990	North Pacific	3E7
10000	(HF Radar 0.1s)	3E8
8000	(USSR West)	320
5000	(USSR East)	1F4
1000	(0.01s)	064
100	(0.001s)	00A
10	(0.0001s)	001

When using receivers like the *FRG7700* for Loran-C, the envelope rise-time is smeared out over 150 μs or so. But by observing the change of that signal at daily time intervals, with the clock and GRI source operating continuously, the frequency stability of the clock can be determined without any special Loran-C front-end hardware.

For Loran-C DX hunting on late winter evenings when the noise level is low and DX is coming in from other stations such as Allouis in France on 164 kHz, the GRI rate can be set to try to find some chain not normally observed in the USA. That is done by examining the whole GRI frame in detail (with the oscilloscope in the expanded-sweep mode) and slowly bumping the GRI rate a few tens of milliseconds at a time to find weaker sky-wave pulses standing still. Loran-C signals from the USSR using GRI rates of 8000 and 5000 can sometimes (although rarely) be observed that way. The main problem in looking for weak signals is the cross-rate interference from other chains drifting by the desired small-amplitude signal on the scope trace.

A photograph of an experimental model of a Loran-C RF-envelope detector is shown in Fig. 10. Circuit-board layouts have been prepared for the Loran-C RF detector and the GRI generator. Contact: R. W. Burhans, 161 Grosvenor St., Athens, Ohio 45701. Include a SASE for information on the availability of these boards for experimental use. **R-E**

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DRE

ANALOG CIRCUITS

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complex passive- and active-circuits around an op-amp. A triangular wave can be formed by adding the op-amp integrator shown in Fig. 13 to the output terminals of a squarewave generator like the one shown in Fig. 12.

Among the most popular oscillator circuits is the Wien bridge. A basic transistor circuit using the Wien bridge is shown in Fig. 14. Here, the Wien bridge circuit is placed around a single-ended differential amplifier; it consists of the series and parallel-connected R-C networks. Current is fed back through that filter network from the output to the input. Oscillation occurs if the forward gain of the amplifier is greater than 3 because the output at the junction of the series and parallel R-C circuits is ⅓ of that at the collector of Q2. The frequency of oscillation is $1/2\pi R1C1$, assuming that $R1 = R2$ and $C1 = C2$.

A similar circuit can be built around an op-amp, as shown in Fig. 15. Positive feedback is applied through the R-C Wien bridge to the non-inverting input of the op-amp. Negative feedback is applied through a resistor divider to the inverting input. The frequency of oscillation is found exactly as it was in the previous example. Two Zener diodes are included in the circuit to keep the output voltage, when at a peak, from putting the op-amp circuit into saturation. If it did go into saturation, the circuit would remain in that state and oscillation would no longer take place.

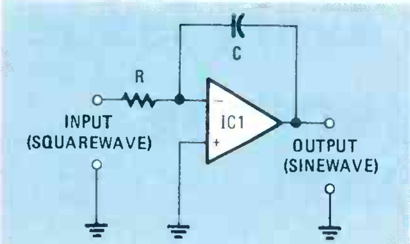

FIG. 13—AN INTEGRATOR, such as the one shown here, can be used to change a squarewave into a triangular wave.

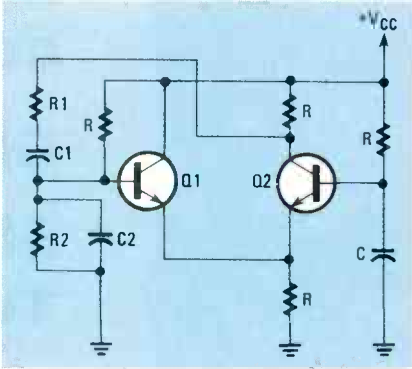

FIG. 14—ONE OF THE MOST POPULAR sinewave generators, the Wien-bridge circuit has been around since the days of vacuum tubes.

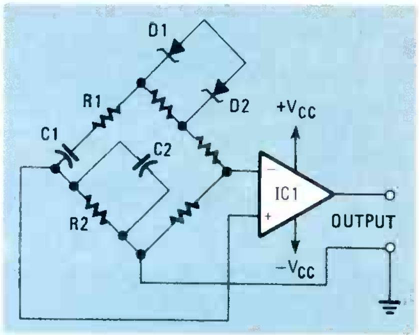

FIG. 15—ANOTHER EXAMPLE of the Wien bridge, this one is built around an op-amp.

High frequency

Unwanted feedback is quite likely to occur in high-frequency circuits. It has many causes: To give just one example, signal at an output can be coupled back to the input through adjacent wiring or through stray capacitances in a circuit. In the next article in this series, we will explore and determine just what its effects are and how to handle them in transistor circuits. **R-E**

NEW BOOKS

For more details use the free information card inside the back cover

MY INVENTIONS, The Autobiography of Nikola Tesla (Introduction by Ben Johnston); Hart Brothers, Publishing, PO Box 205, Williston, VT 05495; 112 pp., illustrated; 5½ × 8½ inches; softcover; $7.95; hardcover $12.95.

This material by the great Yugoslav-American inventor (1856-1943) has been virtually unavailable since 1919 when it was published serially in Hugo Gernsback's *Electrical Experimenter.* The editor's note tells us that Tesla's "idiosyncratic phonetic spellings" have not been changed in this edition, but some of the picture captions have been revised. All the original illustrations are here, and six new ones have been added. There are two excellent wash illustrations by Frank R. Paul, who later became world-famous as the principal illustrator for the Gernsback science fiction magazines.

Tesla was 63 when these articles were published; they reveal his youthful struggle to harness his runaway imagination; after the chapters "My Early Life," and "My First Efforts in Invention", we proceed to the discovery of the rotating magnetic field, the Tesla coil and transformer, the magnifying transmitter, and the art of teleautomatics. Much of what the reader may have seen in various biographics is a mixture of fact and fiction; here the inventor himself sets the record straight.

Although he lived and worked in the United States for nearly 60 years, by the time he died he was virtually forgotten. The present volume is needed to bring Nikola Tesla into proper perspective.

CIRCLE 121 ON FREE INFORMATION CARD

MICROCOMPUTER EXPERIMENTATION WITH THE MOS TECHNOLOGY KIM-1, by Lance A. Leventhal; Prentice-Hall, Inc, Englewood Cliffs, NJ 07632; 467 pp., including appendices and index; 6¾ × 9¼ inches; softcover; $16.95.

This practical easy-to-follow and self-contained guide to MOS Technology KIM-1 experiments represents diverse disciplines and a wide variety of applications. The emphasis throughout is on approaches that are fundamental to the design of controllers for exernal systems; at the same time, it illustrates its points through examples that use nothing more complex than switches, single displays, and the on-board peripherals.

The inexpensive and widely available KIM-1 microcomputer and 6502 microprocessor were selected to provide realistic experience with popular devices for those involved in a wide range of control-operation applications: instrumentation, communications equipment, test equipment, computer peripherals, industrial processes, signal processing, business equipment, consumer products, and many more.

There are two major groupings of experiments. Those in the first group focus on writing and running simple programs, simple input and output, processing of inputs and outputs, forming and processing data arrays, designing and debugging programs, and arithmetical operations. Those in the second group deal with subroutines and the stack, input/output using handshakes, interrupts, timing methods, serial input/output, and microcomputer timing and control.

CIRCLE 122 ON FREE INFORMATION CARD

70 YEARS OF RADIO TUBES AND VALVES, by John W. Stokes; The Vestal Press, Ltd., PO Box 97, Vestal, New York 13850. 256 pp., including glossary and index; 8½ × 11 inches; hardcover; $21.95 through bookstores—add $2.00 shipping when ordering from publisher, and New York residents add 7% sales tax.

Here is the history of the radio tube from its invention in 1904 to its gradual eclipse, beginning in the 1960's when it was replaced by solid-state devices. The emphasis, however, is on developments occurring between 1927 and 1937—the period when the "all electric" receiver evolved to become a familiar part of our daily lives.

All the giants of the industry—Westinghouston, General Electric, Sylvania, RCA, Raytheon, and others their size, as well as many smaller firms now forgotten—are covered in this story of how our technical know-how progressed in the period. It ranges from Edison's discovery that electrons would flow in a vacuum (the "Edison effect") to Lee deForest's invention of the "grid", to RCA's "Nuvistor" that closed the era.

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A MANAGER'S GUIDE TO INDUSTRIAL ROBOTS, by Ken Susnjara; Corinthian Press, publishing division of EDR Corporation, Shaker Heights, OH; 181 pp., including appendices, but no index; 6⅛ × 8¼ inches; hardcover; $24.95.

The robot industry is one of the fastest-growing industries. The capability of those machines, the number of units available, the number of manufacturers, and the number of installations, are all growing at an astounding pace.

This book discusses the new technology in a simple, straightforward manner. It is designed for the non-technical manager who must deal with robots, and assumes no previous knowledge or experience in the area on the reader's part. The author addresses such questions as: "What is an industrial robot?"; "How do industrial robots works?"; "What can they do and what can they *not* do?"; "How much do they cost?"; "How do I find applications in my plant?", and "How do I handle labor and community relations?"

This illustrated, comprehensive guide includes a reference manual covering the details of installing and using an industrial robot. It also provides a glossary of robotic and technical terms explained in simple, non-technical language.

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THE ILLUSTRATED DICTIONARY OF ELECTRONICS (2nd Edition), by Rufus P. Turner; TAB Books, Inc., Blue Ridge Summit, PA 17214; 893 pp.; 5½ × 8¼ inches; softcover; $16.95.

Anyone in any way associated with the electronics field, whether beginning hobbyist, experienced, amateur, or professional will find this book valuable. From "A" to "zymurgy", the more than 25,000 definitions provide needed information to anyone who wants to look up an electronics term in a hurry. The new 2nd edition has not only been completely updated, but contains over 600 new entries, covering electronics, radio, audio, computers, and related studies.

In addition to the alphabetically-arranged definitions, there is a "Tables and Data" appendix that includes the resistor color code, electronics symbols, wire guage, abbreviations, and a variety of conversion tables.

CIRCLE 125 ON FREE INFORMATION CARD

THE BASIC HANDBOOK (2nd edition), Encyclopedia of the BASIC Computer Language, by David A. Lien; Compusoft Publishing, San Diego, CA 92119; 480 pp, 7 × 9 inches; softcover; $19.95.

The BASIC language has changed in many ways since 1978, when the first edition of this book appeared. With each new computer came new words, and with each new word the need to update. Drawing upon his extensive BASIC language library, and with the assistance of many manufacturers, the author has attempted to document and explain virtually every BASIC feature of every type of computer in the world.

Special attention has been given to documenting the diverse BASICs implemented on the many new computers introduced (and about to be introduced) from Europe and Asia. In addition to filling gaps in the 1st edition, a strong effort has been made to continue documenting "disk BASIC", which many users find frustrating. Although there are as yet no standards for "disk BASIC's," only common concepts, the documentation follows those trends that can be identified.

This new second edition introduces 238 additional words, bringing the total of BASIC words to almost 500. Nearly every significant BASIC word, used by virtually every BASIC-speaking computer in the world is explained.

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EQUIPMENT REPORTS

continued from page 38

in the OHMS range and have come back to it only to find a dead battery. Of course my multimeter didn't have a separate power switch.) Across from the POWER switch is a transistor test socket. Four input-jacks (V-Ω, COM, MA, and 10A) are in a row across the bottom, below the range selector. The readout is a "bright," easy-to-read, 3½-digit LCD display that includes a low-battery indicator.

The *8050* has thirty ranges that cover eight functions. It can measure DC voltages to 1000 volts over five ranges (200 mV, 2 volts, 20 volts, 200 volts, and 1000 volts), and AC voltages to 750 volts over similar ranges (except for the upper limit). The input impedance is 10 megohms on all voltage ranges. AC and DC current can be measured to 10 amperes over five ranges: 200 μA, 2 mA, 20 mA, 200 mA, and 10 amperes. (The 10-amp range requires that a separate input jack be used.) Polarity indication is automatic, with a minus sign appearing at the left of the display. And if the battery is low, an arrow appears on the left of the readout.

Resistance measurements (with automatic zeroing) can be made to 20 megohms over six ranges: 200 ohms, 2K, 20K, 200K, 2 megohms, and 20 megohms. Those resistance measurements are accurate to within 1% of the reading on all but the 20-megohm range, where the accuracy 2%.

Other features

A separate position on the range-selector switch, marked with a diode symbol, lets you quickly check diodes. There is also an audible continuity-test position. It sounds rather shrill, but it's very handy for making quick continuity checks.

One unusual feature that is included on the *8050* is a test socket at the upper right of the panel that lets you find a transistor's hFE (Beta) on a 0 to 1000 scale. The NPN-PNP positions on the range switch select the type under test—or they can be used to identify an unknown transistor type. Maximum collector-to-emitter voltage is 2.8 volts under test.

This little instrument is very convenient easy to use. All controls are easy to get at, the readout is visible under all practical conditions, and it is compact enough to fit into the average work-shirt pocket. It's also magnetically shielded; the manufacturer claims that even strong magnetic fields will not affect its accuracy. The test leads that come with it have nice sharply pointed tips that can make some measurements much easier. All in all, the *8050* is a lot of meter for its $89.95 price. **R-E**

SERVICE QUESTIONS

continued from page 83

voltage at the pin to be 18 volts. Installing a 14.2K resistor between pin 24 and pin 29 (ground) pulled that voltage down to 14.5, and restored proper clock operation in all modes. The value of the resistor was found experimentally. Incidently, if you need a new clock IC, they can be bought from SSI Components Ltd., Suite 201, Austin Centre, 21 Austin Ave., Kowloon, Hong Kong. They cost $11.00 each (in U.S. funds) when bought in quantities of 1 to 24.—*V.M., Bronx, NY*

BURNING CAPACITOR

After fixing some other problems in this Zenith 23EC15, I noticed a burning smell, but no smoke, coming from the set during testing. When I investigated I found that fuse F204 had blown, and that capacitor C267 had burned to a crisp. Replacing the fuse and capacitor got the set working, but after an hour the capacitor began getting hot again. What's going on here?—B.M., S. Portsmouth, KY

What you're describing is fairly common in solid-state sets, although this is the first time I've ever heard about it in a tube set. In any event, the cure should be the same. Capacitor C267 is in a circuit with horizontal-frequency pulses; an ordinary capacitor won't work there. You need one of the special "RF" types, one with dielectrics rated to handle the high frequency. Either get an exact Zenith replacement, or one rated for high-frequency service.

UNUSUAL VERTICAL PROBLEM

I had a vertical problem in a Zenith 13A16Z. You made several suggestions including checking the resistance of the vertical-output transformer's primary. After following all of your other hints, and replacing several bad components that I had found, the problem was still there. When I did get around to checking that transformer, the primary's resistance was indeed lower than it should have been. Replacing the transformer solved the problem.—*A.S., Middletown, NJ*

Glad to hear that you found it. Failure in those transformers is really quite rare, but, as you discovered, it can happen.

PEGGING METER

The meter needle on this tube-type VTVM pegs to the right side. I've heard about pegging to the left, but never this. What's going on?—A.M., Darlington, MD

If the meter pegs in either direction, it means that there is a bad unbalance in the circuit. Most often, the cause is a defective VTVM bridge tube, usually a 12AT7 or similar twin triode. Note that you may need to try several tubes, especially in the older models, before you'll find one that will balance the circuit.

Feedback—That was the problem; only needed to try one tube before the trouble cleared up.

COLLAPSING RASTER

I've run into a problem that seems to be common in the Zenith System-3 sets that use the 9-153 high-voltage module. The symptom is an intermittent collapse of the raster and horizontal foldover. The cause is poor solder-connections on two components: the horizontal-output transformer and T3301. It helps to take those components out, scrape the connections clean, and then reinstall them. I've seen that problem in six sets over the past few months, including my own.—*George Yarbrough, West Yellowstone, MT*

CREEPING HIGH VOLTAGE

The high voltage in this Sears 528.41681941 can be varied between 22 and 27 kilovolts when the set is first turned on. After it has been on for a while, however, the high voltage creeps up until it can be varied only between 28 and 30 kilovolts. The B+ voltages are all close to what they should be and stable, but the boost voltage rises from +800 volts at turn-on to +870 volts. Any ideas on this?—J.O., Winthrop, ME

I ran into this some time ago in an RCA that used a 31JS6 output tube. Here's what to do: Check the grid waveform on your 40KD6 tube with an oscilloscope. If it is normal at turn on, but the peaks flatten as the tube warms up, you've got it. The problem is grid emission in the 40KD6. If the peaks flatten enough, it will make a normal waveform look almost like a squarewave. The flattened peaks keep the tube turned on too long, raising the boost, high voltage, etc. The only cure is to replace the tube, and check to make sure the replacement is good; I've gone through 4 or 5 new tubes at times before I've found a good one.

MORE HINTS

Here are a couple more hints from Mike Danish of Aberdeen Proving Ground, MD:

The first involves bad colors and low brightness in an RCA CTC59XD. Resistor RT201 was burnt up. Replacing it, however, did not help. Looking farther, I found that I had no control over the CRT screens. The only thing common to all of the screens was that they got 600 volts from the flyback through a 1K resistor and the boost rectifier. When I looked at the 1K resistor, I found that it, too, had burned up. I tried replacing the resistor, but the replacement also burned out in short order. The problem turned out to be in the boost rectifier. Once it was replaced, and a new 1K resistor was installed, everything returned to normal.

The second one involves a Packard-Bell 1C620WL; that set is actually a GE C2 chassis. The set had no raster but the audio was fine. The trouble was traced to R189 and R191 in the video-output circuit. Those two resistors had burned up. When they were replaced, the set ran fine.

HORIZONTAL FOLDOVER

This Zenith HT2382P came in with intermittent horizontal-foldover in the center of the screen: the left side of the screen was perfect but the raster pulled away from the right side and folded in the center with a vertical white line about ½ inch wide. Replacing the horizontal module had no effect. When I checked the driver transformer I found that the resistance was off—it was 40-45 ohms instead of 96 ohms. A new transformer fixed the problem, for about three weeks. When I got it back in the shop I finally found the true culprit; C227, a 50µF electrolytic was intermittently opening. Replacing that capacitor fixed things permanently.—*Danny Joe Davis, Moundsville, AL*

BAD TRACKING

I asked you about an old RCA AM-FM portable that wouldn't track at the low end of the dial. You suggested spraying contact cleaner on the tuning capacitor, and running the dial back and forth several times. I did that, and it worked. It also cleared up a bad drift problem on FM at the same time. Thanks—*Bill Suhy, Stratford, CT*

Old-radio restorers take note! The cause of that problem is a very poor or corroded contact between the rotor of the capacitor and the frame. As the rotor turns, the resistance varies, which of course changes the capacitance. That used to be quite common in the old sets, but I haven't seen it lately, till now.

OSCILLOSCOPE HINT

We had some Dumont 208 oscilloscopes in our lab with problems in the vertical positioning of the trace. Your column in **Radio-Electronics** about bad contacts rang a bell. We simply pulled the 6V6 vertical amplifier tubes and then put them back in. That fixed everything up. Dumont used the DC plate current of those tubes to provide the positioning voltage for the trace, and the humid summers here had caused some corrosion in the wafer sockets.—*J.R., Ocala, FL*

ION BURN

I saw a question in **Radio-Electronics** some time ago about what seemed to be ion burn in a modern CRT. I ran into a similar problem a while back with a Zenith 14B36Z. After checking several things, I read the high voltage and, lo and behold, it was only 5 kilovolts. The cause of the problem was a bad flyback. Replacing it cleared everything up.—*Bert Balt, Rochester, NY* **R-E**

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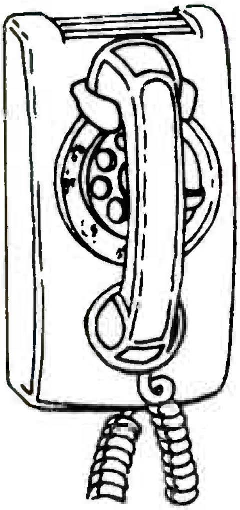

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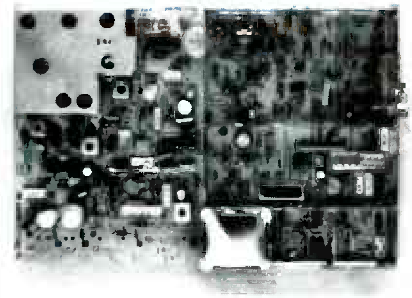

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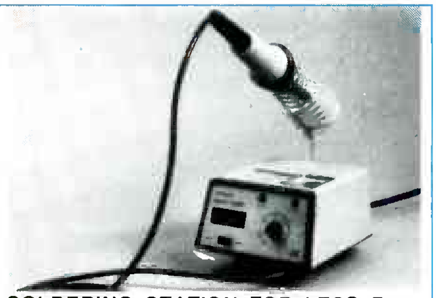

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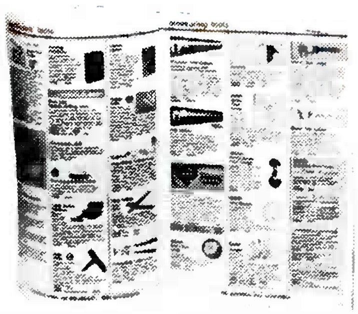

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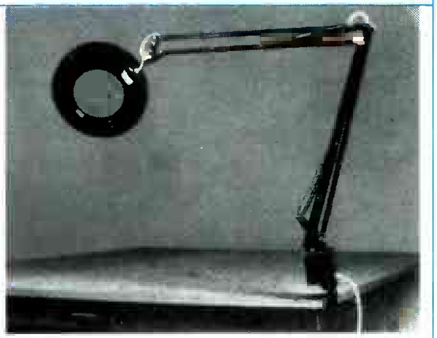

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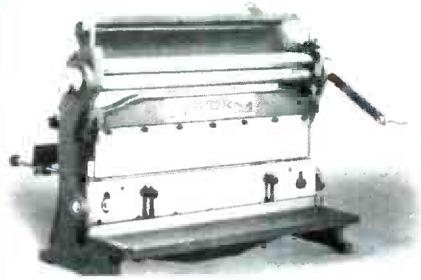

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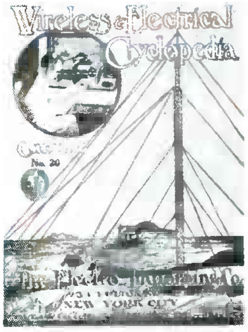

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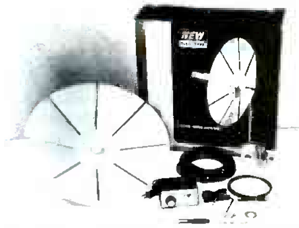

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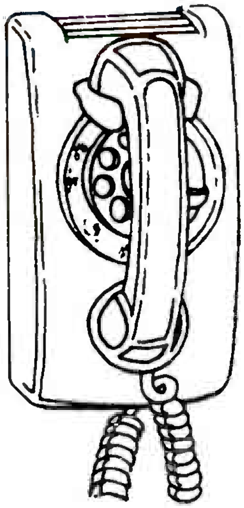

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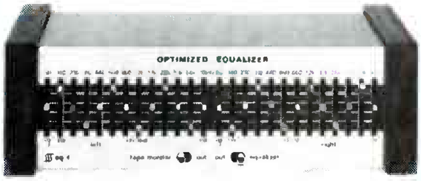

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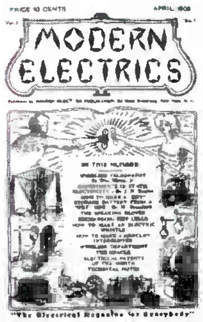

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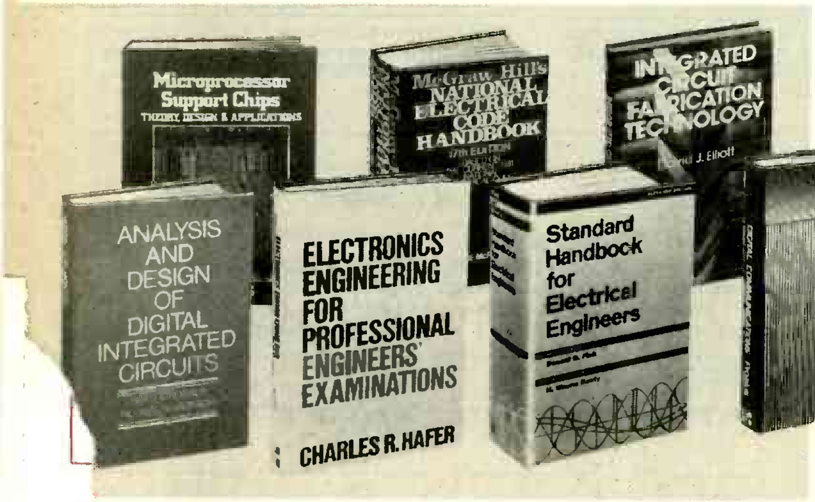

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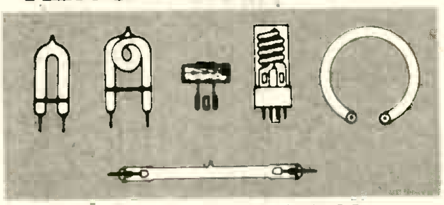

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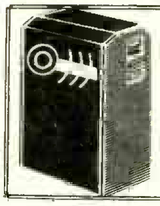

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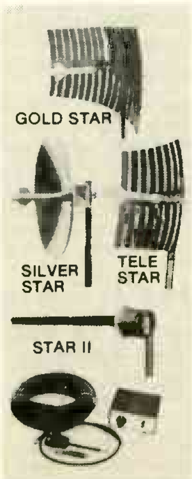

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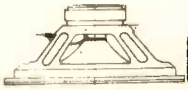

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FP 100 PHOTO TRANS .... $ .50
RED LED's .2" .... 8/$1.00
YEL, GREEN or AMBER LARGE LED's .2" .. 6/$1.00
RED-GREEN BIPOLAR LED .... $ .90
RED-YELLOW BIPOLAR LED .... $ .90
MLED92 IR LED .... $ .40
MRD14B PHOTO DARL. XTOR .... $ .50
MCT2 OPTO ISOLATORS .... $ .40
4N26 OPTO ISOLATOR .... $ .40
1 WATT ZENERS: 3.3, 4.7, 5.1, 5.6, 6.8, 8.2, 9.1, 10, 12, 15, 18, or 22V .... 6/$1.00

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DAQ08EQ — 3.75	LF356 — 1.00	747 — .50
TL062 CP — .95	LM358 — .50	CA758 — 1.75
TL064 CN — 1.50	LM361 — 1.75	LM1310 — 1.60
TL084 — 1.50	LM370 — 1.60	1456 — .80
LM201 — .75	LM377 — 1.60	1458 — .50
LM301/748 — .30	LM380 — .85	LM1808 — 1.75
LM307 — .30	LM383 — 1.90	LM2901 — .95
LM308 — .65	LM386 — .85	CA3018 — 1.95
LM310 — 1.10	LM387 — 1.25	CA3078AT — 1.50
LM311 — .50	LM393 — .75	CA3086 — .75
LM318 — .75	LM555 — .34	AD2700LD — 4.95
LM319 — .95	LM556 — .65	CA3140 — 1.00
LM324 — .55	565 — .95	3900 — .45
LM339 — .65	566 — 1.25	4136 — .85
LM348 — .90	567 — .85	N5596A — 1.50
LF351 — .65	709 — .25	D6303B — 1.75
LF353 — .90	710 — .45	8038CC — 3.90
LF356 — .90	711CH — .40	LM13080 — .95
	741CV — .40	CA3089E — 1.75

FULL WAVE BRIDGE

PRV	2A	6A	25A
100			1.40
200	.80	1.30	2.20
400	1.00	1.65	3.30
600	1.30	1.90	4.40

12V DC RELAYS TTL SIZE

S.P. 1200 ohm coil .75

D.P. 400 ohm coil .95

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PRV	1A	3A	12A	50A	125A	240A
100	.05	.14	.35	.90	4.25	5.00
200	.06	.17	.50	1.30	5.25	9.00
400	.09	.25	.65	1.50	6.50	12.00
600	.11	.30	.80	2.00	8.50	15.00
800	.13	.35	1.00	2.50	10.50	18.00
1000	.20	.45	1.25	3.00	12.50	26.00

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LM317T $1.00
78L05, 78L12 .... $ .40
723 .... $ .50
320T 5, 12, 15 or 24 $ .85
LM 337T $1.95
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LAS1412 + 12V 3A $3.95

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28 gauge
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CTS 206- 4	4 POSITION	.75
CTS 206- 7	7 POSITION	.95
CTS 206- 8	8 POSITION	.95
CTS 206-10	10 POSITION	1.25

DIP SOCKETS

8 PIN	.10	20 PIN	.25
14 PIN	.12	22 PIN	.25
16 PIN	.15	24 PIN	.25
18 PIN	.20	28 PIN	.35
		40 PIN	.40

TANTALUM CAPACITORS

.22UF 35V	5/$1.00	15UF 16V	3/$1.00
.47UF 35V	5/$1.00	30UF 6V	5/$1.00
.68UF 35V	5/$1.00	33UF 15V	$ .50
1UF 20V	5/$1.00	47UF 20V	$ .85
2.2UF 20V	5/$1.00	68UF 16V	$1.00
3.3UF 20V	4/$1.00	120UF 6V	$ .75
4.7UF 35V	4/$1.00	200UF 20V	$1.75
6.8UF 20V	4/$1.00	150UF 16V	$1.30
10UF 20V	— $ .40	330UF 10V	$1.75
22UF 10V	— $ .30		

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16 PIN —	.50
18 PIN —	.65
20 PIN —	.90
24 PIN —	1.10
28 PIN —	1.25
40 PIN —	1.50

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DB9P - $2.00 DB25P - $2.40
DB9S - 3.00 DB25S - 3.20
HOODS- 1.10 HOODS- 1.10

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100 OHM 10K
500 OHM 50K
1000 OHM 500K
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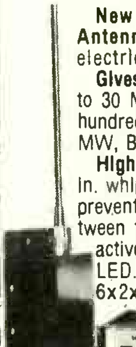

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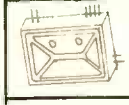

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SN7403N	14	.25	SN7475N	16	.45	SN74161N	16	.69
SN7404N	14	.25	SN7476N	16	.35	SN74162N	16	.69
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SN7408N	14	.29	SN7483N	16	.59	SN74166N	16	.89
SN7409N	14	.25	SN7485N	16	.59	SN74167N	16	2.79
SN7410N	14	.25	SN7486N	14	.35	SN74170N	16	1.29
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SN7416N	14	.25	SN7493N	14	.39	SN74176N	14	.69
SN7417N	14	.25	SN7494N	16	.49	SN74177N	14	.69
SN7420N	14	.19	SN7495N	14	.49	SN74179N	16	1.49
SN7421N	14	.35	SN7496N	16	.49	SN74180N	14	.69
SN7422N	14	.45	SN7497N	16	2.75	SN74181N	24	1.95
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SN7426N	14	.29	SN74105N	14	.89	SN74185N	16	1.95
SN7427N	14	.25	SN74107N	14	.29	SN74190N	16	.69
SN7428N	14	.49	SN74109N	16	.39	SN74191N	16	.69
SN7430N	14	.25	SN74116N	24	1.49	SN74192N	16	.69
SN7432N	14	.29	SN74121N	14	.39	SN74193N	16	.69
SN7437N	14	.25	SN74122N	14	.55	SN74194N	16	.69
SN7438N	14	.29	SN74123N	16	.49	SN74195N	16	.69
SN7439N	14	.59	SN74125N	14	.45	SN74196N	14	.89
SN7440N	14	.19	SN74126N	14	.45	SN74197N	14	.89
SN7441N	16	.89	SN74132N	14	.49	SN74198N	24	1.19
SN7442N	16	.45	SN74136N	14	.69	SN74199N	24	1.19
SN7443N	16	.99	SN74141N	16	.69	SN74221N	16	1.19
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SN7453N	14	.19	SN74151N	16	.59	SN74366N	16	.55
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SN7459A	14	.25	SN74153N	16	.59	SN74368N	16	.55
SN7460N	14	.19	SN74154N	24	1.25	SN74390N	16	1.49
SN7470N	14	.29	SN74155N	16	.59	SN74393N	14	1.49

74LS

74LS00	14	.25	74LS92	14	.55	74LS192	16	.79
74LS01	14	.25	74LS93	14	.55	74LS193	16	.79
74LS02	14	.25	74LS95	14	.79	74LS194	16	.69
74LS03	14	.25	74LS96	16	.89	74LS195	16	.69
74LS04	14	.29	74LS107	14	.39	74LS197	14	.79
74LS05	14	.29	74LS109	16	.39	74LS221	16	.89
74LS08	14	.29	74LS112	16	.39	74LS240	20	1.09
74LS09	14	.29	74LS113	14	.39	74LS241	20	1.09
74LS10	14	.29	74LS114	14	.39	74LS242	14	1.09
74LS11	14	.35	74LS122	14	.49	74LS243	14	1.09
74LS12	14	.35	74LS123	16	.79	74LS244	20	1.09
74LS13	14	.39	74LS125	14	.49	74LS245	20	1.49
74LS14	14	.59	74LS126	14	.49	74LS247	16	1.09
74LS15	14	.35	74LS132	14	.59	74LS248	16	1.09
74LS20	14	.29	74LS133	16	.59	74LS249	16	1.09
74LS21	14	.29	74LS136	14	.39	74LS251	16	.59
74LS22	14	.29	74LS138	16	.39	74LS253	16	.59
74LS26	14	.29	74LS139	16	.39	74LS257	16	.59
74LS27	14	.29	74LS151	16	.39	74LS258	16	.59
74LS28	14	.35	74LS153	16	.59	74LS260	14	.59
74LS30	14	.29	74LS154	24	.99	74LS266	14	.69
74LS32	14	.35	74LS155	16	.69	74LS273	20	1.49
74LS33	14	.55	74LS156	16	.69	74LS279	16	.49
74LS37	14	.35	74LS157	16	.59	74LS283	16	.69
74LS38	14	.35	74LS158	16	.59	74LS290	14	.89
74LS40	14	.29	74LS160	16	.69	74LS293	14	.89
74LS42	16	.55	74LS161	16	.69	74LS298	16	.89
74LS47	16	.75	74LS162	16	.69	74LS352	16	1.29
74LS48	16	.75	74LS163	16	.69	74LS353	16	1.29
74LS49	16	.75	74LS164	14	.69	74LS363	20	1.49
74LS51	14	.25	74LS165	16	1.19	74LS365	16	.49
74LS54	14	.29	74LS168	16	1.19	74LS366	16	.49
74LS55	14	.29	74LS169	16	1.19	74LS367	16	.49
74LS73	14	.39	74LS170	16	1.49	74LS368	16	.49
74LS74	14	.39	74LS173	16	.69	74LS373	20	1.29
74LS75	16	.39	74LS174	16	.59	74LS374	20	1.29
74LS76	16	.39	74LS175	16	.59	74LS375	16	.69
74LS78	14	.39	74LS181	24	2.49	74LS386	14	.45
74LS83	16	.65	74LS190	16	.89	74LS393	14	1.19
74LS85	16	.69	74LS191	16	.89	74LS399	16	1.49
74LS86	14	.39				74LS670	16	1.49
74LS90	14	.55				81LS95	20	1.49
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74S00	14	.35	74S124	16	2.95	74S243	14	2.49
74S02	14	.35	74S133	16	.45	74S244	20	2.49
74S03	14	.35	74S134	16	.55	74S251	16	1.19
74S04	14	.45	74S135	16	.89	74S253	16	1.19
74S05	14	.35	74S136	16	1.39	74S257	16	1.19
74S08	14	.39	74S138	16	.89	74S258	16	1.19
74S09	14	.39	74S139	16	.89	74S260	14	.79
74S10	14	.35	74S140	14	.55	74S280	14	1.95
74S11	14	.35	74S151	16	.99	74S287*	16	1.95
74S15	14	.35	74S153	16	.99	74S288*	16	1.95
74S20	14	.35	74S157	16	.99	74S373	20	2.49
74S22	14	.35	74S158	16	.99	74S374	20	2.49
74S30	14	.35	74S160	16	2.49	74S387*	16	1.95
74S32	14	.45	74S174	16	.99	74S471*	20	5.95
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74S64	14	.39	74S195	16	1.49	74S475*	24	4.95
74S65	14	.39	74S196	14	1.49	74S570*	16	2.95
74S74	14	.55	74S240	20	2.25	74S571*	16	2.95
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74S112	16	.55	74S242	14	2.49	74S573*	16	4.95
74S113	14	.55				74S940	20	2.49
74S114	14	.55				74S941	20	2.49

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CA3039H		1.35	CA3083N	16	1.49	CA3160H		1.95
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CA3059N	14	3.25				CA3600N	14	3.95

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CD4009	16	.39	CD4046	16	.89	CD4511	16	.89
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CD4011	14	.29	CD4048	16	.39	CD4514	24	1.79
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CD4025	14	.23	CD4072	14	.29	CD4723	16	1.19
CD4026	16	2.49	CD4073	14	.29	CD4724	16	1.19
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CD4028	16	.69	CD4076	16	.79	MC14410	16	13.95
CD4029	16	.79	CD4078	14	.49	MC14411	24	11.95
CD4030	14	.39	CD4081	14	.29	MC14412	16	13.95
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MC6802CP	40	MPU w/Clock and RAM	7.95
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Z80-S10/2	40	Serial I/O (Lacks SYNCB)	15.95
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Z8002	40	CPU Non-Segmented	55.95
Z8030	40	Serial Comm. Controller	44.95
Z8036	40	Counter/Timer & Parallel I/O Unit	29.95

6800/68000 SERIES

MC6800	40	MPU	4.95
MC6802CP	40	MPU with clock and RAM	7.95
MC6810APl	24	128x8 Static RAM	3.95
MC6821	40	Peripheral Inter. Adapt (MC6820)	4.95
MC6828	24	Priority Interrupt Controller	15.95
MC6830L8	24	1024x8-bit ROM (MC68A30-8)	10.95
MC6850	24	Asynchronous Comm. Adapter	4.95
MC6852	24	Synchronous Serial Data Adapter	5.75
MC6860	24	0-600bps Digital MODEM	9.95
MC6862	24	2400bps Modulator	12.95
MC6880A	16	Quad 3-state bus. trans. (MC8T26)	2.25
MC68000L8	64	MPU 16-Bit (8MHz)	69.95
MC68488P	40	General Purpose Int. Adapter	8.95
MC68652P2	40	Multi. Protocol Comm. Controller	24.95
MC68661PB	28	Enhanced Prog. Comm. Int.	8.95
SY6522	40	Peripheral Inter. Adapter	7.95

8080A SERIES

INS8080A	40	CPU	3.95
TMS5501	40	Synchronous Data Interface (SIRC)	14.95
INS8154	40	128 Byte RAM 16-Bit I/O	13.95
INS82C06	20	Octal D Flip Flop Tri-State (74C374)	2.49
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
DP8228	28	System Cont./Bus Driver (74S428)	3.49
DP8238	28	System Controller (74S438)	4.49
INS8243	24	I/O Expander for 48 Series	5.95
INS8245	18	16-Key Keyboard Encoder (74C922)	4.49
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
DP8251	28	Prog. Comm. I/O (USART)	4.49
DP8253	24	Prog. Interval Timer	6.95
DP8255	40	Prog. Peripheral I/O (PPI)	4.49
DP8257	40	Prog. DMA Control	7.95
DP8259	28	Prog. Interrupt Control	6.95
DP8275	40	Prog. CRT Controller	29.95
DP8279	40	Prog. Keyboard/Display Interface	8.95
DP8303	20	8-Bit Tri-State Bi-Directional Trans.	3.95
DP8304	20	8-bit Bi-Directional Receiver	2.49
DP8307	20	8-bit Bi-Directional Receiver	2.49
DP8308	20	8-bit Bi-Directional Receiver	2.49
DP8310	20	Octal Latched Peripheral Driver	4.95
DP8311	20	Octal Latched Peripheral Driver	4.95

MICROPROCESSOR MANUALS & DATA BOOKS

M-Z80	User Manual	7.50
M-CDP1802	User Manual	7.50
M-2650	User Manual	5.00
30003	1982 Nat. Linear Book (1952 pg.)	11.95
30008	1980 Nat. Memory Data Book (464 pg.)	6.95
30011	1980 Nat. Linear Applications (736 pg.)	15.95
30013	1983 Zilog Data Book (641 pg.)	7.95

SPECIAL FUNCTION

DS0025CN	8	Dual MOS Clock Driver (5MZ)	2.49
DS0026CN	8	Dual MOS Clock Driver (5MZ)	1.95
INS1771N-1	40	Floppy Disk Controller	16.95
INS2651N	28	Communication Chip	8.95
MM58167N	24	Microprocessor Real Time Clock	8.95
MM58174N	16	Microprocessor Compatible Time Clock	8.95
COP402N	40	Microcontroller w/64-digit RAM and Direct LED Drive	5.95
COP402MN	40	Microprocessor w/64-digit RAM & Direct LED Drive w/N Buss Int.	5.95
COP470N	20	32-seg. VAC Fluor. Drvr. (20-pin pkg.)	3.25
MM5369EST	8	Prog. Oscillator/Divider (100Hz)	1.19

DYNAMIC RAMS

Part No.	**Pins	Function	Price
1103	18	1024x1 (300ns)	.99
4027	16	4096x1 (250ns)	2.49
4116N-2	16	16,384x1 (150ns)	1.89 - 8/14.95
4116N-3	16	16,384x1 (200ns)	1.69 - 8/12.95
4116N-4	16	16,384x1 (250ns)	1.49 - 8/10.95
4164N-150	16	65,536x1 (150ns)	7.95 - 8/59.95
4164N-200	16	65,536x1 (200ns)	7.49 - 8/54.95
MM5261	18	1024x1 (300ns)	.49 - 8/1.95
MM5262	22	2048x1 (385ns)	.49 — 8/1.95
MM5270	18	4096x1 (250ns) MK4096	4.95
MM5280	22	4096x1 (200ns) 2107	3.95
MM5290-2	16	16,384x1 (150ns)	1.89 - 8/14.95
MM5290-3	16	16,384x1 (200ns)	1.69 - 8/12.95
MM5290-4	16	16,384x1 (250ns)	1.49 - 8/10.95
MM5298-3	16	8192x1 (200ns)	1.69

STATIC RAMS

1101	16	256x1 (650ns)	1.49
2101	22	256x4 (450ns) 8101	2.49
2102	16	1024x1 (350ns)	.89
21L02	16	1024x1 (450ns) L.P.	1.49
2111	18	256x4 (450ns) 8111	2.95
2112	16	256x4 (450ns) MOS	2.95
2114	18	1024x4 (450ns)	1.95 - 8/13.95
2114L	18	1024x4 (450ns) L.P.	2.25 - 8/15.95
2114-2	18	1024x4 (200ns)	2.25 - 8/15.95
2114L-2	18	1024x4 (200ns) L.P.	2.49 - 8/17.95
2141-3	18	4096x1 (150ns)	3.95
2147	18	4096x1 (70ns)	4.95
2148	18	1024x4 (70ns)	8.95
TMS4044	18	4096x1 (450ns)	3.95
TMS4045	18	1024x4 (450ns)	3.95
5101	22	256x4 (450ns) CMOS	4.95
MM5257	18	4096x1 (450ns) 4044	4.95
HM6116P-3	24	2048x8 (150ns) CMOS	7.95
HM6116-4	24	2048x8 (200ns) CMOS	6.95
HM6116LP-4	24	2048x8 (200ns) L.P. CMOS	7.95
7489	16	16x4 (50ns)	2.25
74C920	22	256x4 (250ns) CMOS (6551)	3.95
74C921	18	256x4 (250ns) CMOS	3.95
74C929	16	1024x1 (250ns) CMOS (6501)	3.95
74C930	18	1024x1 (250ns) CMOS (6518)	3.95
74S189	16	16x4 (35ns) 93405	1.95
74S200	16	256x1 (80ns) 93410	3.95
74S206	16	256x1 (60ns) 93411	3.95
74S289	16	16x4 (35ns) 3101	2.25
82S10	16	1024x1 (50ns) O.C. (93415)	3.95
82S25	16	16x4 (50ns) O.C. (74S289)	2.25

EPROMS

1702A	24	256x8 (1us)	4.95
2708	24	1024x8 (450ns)	3.95
2708-5	24	1024x8 (550ns) SM00246	2.95
TMS2516	24	2048x8 (450ns) 2716	6.95
TMS2532	24	4096x8 (450ns) NMC2532	9.95
TMS2564	28	8192x8 (450ns)	19.95
TMS2716	24	2048x8 (450ns) 3 voltage	7.95
2716	24	2048x8 (450ns)	4.95
2716-1	24	2048x8 (350ns)	6.95
2732	24	4096x8 (450ns)	9.95
27580	24	1024x8 (450ns) single +5V	2.95
MM2764	28	8192x8 (450ns)	16.95
MM2764-3	28	8192x8 (300ns)	19.95
MCM68764	24	8192x8 (450ns)	39.95
74S188	16	32x8 PROM O.C. (6330-1)	1.49
74S287	16	256x4 PROM T.S. (6301-1)	1.95
74S288	16	32x8 PROM T.S. (6331-1)	1.95
74S387	16	256x4 PROM O.C. (5300-1)	1.95
74S471	20	256x8 PROM T.S. (6309-1)	5.95
74S472	20	512x8 PROM T.S. (6349-1)	4.95
74S473	20	512x8 PROM O.C. (6348)	4.95
74S474	24	512x8 PROM T.S. (DM87S296N)	4.95
74S475	24	512x8 PROM O.C. (6340)	4.95
74S478	24	1024x8 PROM T.S. (TBP28S86)	8.95
74S570	16	512x4 PROM O.C. (6305)	2.95
74S571	16	512x4 PROM T.S. (6306)	2.95
74S572	18	1024x4 PROM O.C. (6352)	4.95
74S573	18	1024x4 PROM T.S. (82S137)	4.95
82S23	16	32x8 PROM O.C. (27S18)	1.95
82S115	24	512x8 PROM T.S. (27S15)	9.95
82S123	16	32x8 PROM T.S. (27S19)	2.95
82S126	16	256x4 PROM O.C. (27S20)	2.95
82S129	16	256x4 PROM T.S. (27S21)	3.95
82S130	16	512x4 PROM O.C. (27S12)	3.95
82S185	18	2048x4 PROM T.S. (TBP24S81)	9.95
DM87S180N	24	1024x8 PROM O.C. (82S180)	9.95
DM87S181N	24	1024x8 PROM T.S. (82S181)	9.95
DM87S184N	18	2048x4 PROM O.C. (82S184)	9.95
DM87S185N	18	2048x4 PROM T.S. (82S185)	9.95
DM87S190N	24	2048x8 PROM O.C. (82S190)	19.95
DM87S191N	24	2048x8 PROM T.S. (82S191)	19.95

DATA ACQUISITION

DC10		Mostek DC/DC Convert. +5V to -9V	2.95
MC3470P	18	Floppy Disk Read AMP System	4.95
MC1408L7	16	7-bit D/A Converter (DAC0807LCN)	2.49
MC1408L8	16	8-bit D/A Converter (DAC0808LCN)	2.95
ADC0804	20	8-bit A/D Converter (1 LSB)	3.49
DAC0806	16	8-bit D/A Converter (0.78% Lin.)	1.95
ADC0809	28	8-bit A/D Converter (8-Ch. Multi.)	4.49
ADC0817	40	8-bit A/D Converter (16-Ch. Multi.)	9.95
DAC100C	24	10-bit D/A Conv. Micro. Comp. (0.05%)	13.95
DAC1008	20	10-bit D/A Conv. Micro. Comp. (0.20%)	7.95
DAC1020	16	10-bit D/A Conv. (0.05% Lin.)	8.49
DAC1022	16	10-bit D/A Conv. (0.20% Lin.)	5.95
DAC1222	18	12-bit D/A Conv. (0.20% Lin.)	6.95
AF100-1CN	16	Universal Active Filter 2.5%	5.95
AF121-1CJ	24	Touch Tone Low Band Filter	19.95
AF122-1CJ	24	Touch Tone High Band Filter	19.95
LM334Z		Constant Current Source	1.19
LM335Z		Temperature Transducer	1.40
LM399H		Temp. Comp. Prec. Ref. (.5ppm/C°)	5.00
AY-5-1013A	40	30K Baud Uart (TR1602)	4.95

Digitalker™

DT1050 — Applications: Teaching aids, appliances, clocks, automotive, telecommunications, language translations, etc.

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 Professor 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.

DT1050 Digitalker™ .... $34.95 ea.

DT1057 — Expands the DT1050 vocabulary from 137 to over 260 words. Incl. 2 ROMs and specs.

DT1057 .... $24.95 ea.

INTERSIL

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Part No.	**Pins	Function	Price
7045IPI	28	CMOS Precision Timer	14.95
7045EV/Kit*	28	Stopwatch Chip, XTL	19.95
7106CPL	40	3½ Digit A/D (LCD Drive)	9.95
FE0203D		3½ Digit LCD Display for 7106 & 7116	19.95
7106EV/Kit*	40	IC, Circuit Board, Display	34.95
7107CPL	40	3½ Digit A/D (LED Drive)	11.95
7107EV/Kit*	40	IC, Circuit Board, Display	29.95
7116CPL	40	3½ Digit A/D LCD Dis. HLD	16.95
7117CPL	40	3½ Digit A/D LED Dis. HLD	15.95
7201IUS		Low Battery Volt Indicator	2.25
7205IPG	24	CMOS LED Stopwatch/Timer	12.95
7205EV/Kit*	24	Stopwatch Chip, XTL	14.95
7206CJPE	16	Tone Generator	4.95
7206CEV/Kit*	16	Tone Generator Chip, XTL	7.95
7207AIPD	14	Oscillator Controller	5.95
7207AEV/Kit*	14	Freq. Counter Chip, XTL	7.95
7208IPI	28	Seven Decade Counter	15.95
7209IPA	8	Clock Generator	3.95
7215IPG	24	4 Func. CMOS Stopwatch CKT	13.95
7215EV/Kit*	24	4 Func. Stopwatch Chip, XTL	14.95
7216AIJI	28	8 Digit Univ. Counter C.A.	29.95
7216CIJI	28	8 Digit Freq. Counter C.A.	24.95
7216DIPI	28	8 Digit Freq. Counter C.C.	19.95
7217IJI	28	4 Digit LED Up/Down Counter C.A.	10.95
7217AIPI	28	4 Digit LED Up/Down Counter C.C.	11.95
7224IPL	40	LCD 4½ Digit Up Counter DRI	10.95
7226AIJL	40	8 Digit Univ. Counter	29.95
7226AEV/Kit*	40	5 Function Counter Chip, XTL	74.95

30009 1983 INTERSIL Data Book (1356p.) $9.95

NEW PRODUCT! 74HC High Speed CMOS

74HC00	14	.75	74HC132	14	.89	74HC257	16	1.19
74HC02	14	.75	74HC138	16	1.49	74HC259	16	1.49
74HC03	14	.75	74HC139	16	1.49	74HC266	14	.99
74HC04	14	.69	74HC147	16	1.19	74HC280	14	4.95
74HCU04	14	.75	74HC151	16	1.19	74HC373	20	3.95
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
74HC20	14	.75	74HC161	16	1.79	74HC534	20	3.95
74HC27	14	.75	74HC164	14	1.79	74HC595		3.75
74HC32	14	.75	74HC165	16	2.39	74HC688		3.19
74HC42	16	1.39	74HC173	16	1.59	74HC4002	14	.79
74HC73	14	.75	74HC174	16	1.39	74HC4020	16	2.19
74HC74	14	.89	74HC175	16	1.39	74HC4024	14	1.59
74HC75	16	.99	74HC192	16	1.39	74HC4040	16	2.19
74HC76	16	.75	74HC193	16	1.39	74HC4060	16	2.19
74HC85	16	2.19	74HC194	16	1.59	74HC4075	14	.75
74HC86	14	.99	74HC195	16	1.49	74HC4078	14	.69
74HC107	14	.75	74HC242	14	2.79	74HC4511	16	3.29
74HC109	16	1.39	74HC243	14	2.79	74HC4514	24	4.79
74HC112	16	.75	74HC251	16	1.19	74HC4538	16	2.95
74HC113	14	.75	74HC253	16	.99	74HC4543	16	4.95

74HCU04 is unbuffered. All others are buffered. Send $.30 for Data Sheet.

Programmable Array Logic (PALS)

Part No.	**Pins	Function	Price
PAL10H8	20	Octal 10-Input AND-OR Gate Array (High Output)	$5.95
PAL12H6	20	Hex 12-Input AND-OR Gate Array (High Output)	5.95
PAL14H4	20	Quad 14-Input AND-OR Gate Array (High Output)	5.95
PAL10L8	20	Octal 10-Input AND-OR-Invert Gate Array (Low Output)	5.95
PAL12L6	20	Hex 12-Input AND-OR-Invert Gate Array (Low Output)	5.95
PAL14L4	20	Quad 14-Input AND-OR-Invert Gate Array (Low Output)	5.95
PAL16L8	20	Octal 16-Input AND-OR-Invert Gate Array (Low Output)	9.95
PAL16R8	20	Octal 16-Input Register AND-OR Gate Array	9.95
PAL16R6	20	Hex 16-Input Register AND-OR Gate Array	9.95
PAL16R4	20	Quad 16-Input Register AND-OR Gate Array	9.95

30012 1982 NATIONAL PAL Data Book (176p.) . . $5.95

74C—C/MOS

74C00	14	.35	74C95	14	1.39	74C221	16	1.95
74C02	14	.35	74C107	14	.89	74C240	20	1.95
74C04	14	.29	74C151	16	2.49	74C244	20	1.95
74C08	14	.35	74C154	24	3.49	74C373	20	2.49
74C10	14	.35	74C157	16	2.25	74C374	20	2.49
74C14	14	.59	74C160	16	1.19	74C901	14	.59
74C20	14	.35	74C161	16	1.19	74C903	14	.59
74C30	14	.35	74C162	16	1.19	74C906	14	.59
74C32	14	.39	74C163	16	1.19	74C911	28	8.95
74C42	16	1.39	74C164	14	1.49	74C912	28	8.95
74C48	16	1.95	74C173	16	.79	74C915	18	1.19
74C73	14	.79	74C174	16	1.19	74C917	28	8.95
74C74	14	.89	74C175	16	1.19	74C922	18	4.49
74C85	16	1.95	74C192	16	1.49	74C923	20	4.95
74C86	14	.39	74C193	16	1.69	74C925	16	5.95
74C89	16	5.95	74C195	16	1.39	74C926	18	5.95
74C90	14	1.19				80C95	16	.39
74C93	14	1.19				80C97	16	.39

LINEAR

TL071CP	8	.79	LM340T-5		.79	LM709N	14	.49
TL072CP	8	1.39	LM340T-12		.79	LM710N	14	.69
TL074CN	14	1.95	LM340T-15		.79	LM711N	14	.79
TL081CP	8	.59	LM348N	14	.99	LM723N	14	.55
TL082CP	8	1.19	LM350K		4.95	LM733N	14	1.00
TL084CN	14	1.95	LF355N	8	1.10	LM739N	14	1.95
LM301CN	8	.35	LF356N	8	1.10	LM741CN	8	.35
LM302H		1.95	LM370N	14	4.49	LM747N	14	.69
LM304H		1.95	LM373N	14	3.95	LM748N	8	.59
LM305H		.99	LM377N	14	1.95	LM1310N	14	1.49
LM307CN	8	.45	LM380N	14	.89	LM1458CN	8	.59
LM308CN	8	.89	LM381N	14	1.79	LM1488N	14	.69
LM309K		1.25	LM382N	14	1.39	LM1489N	14	.69
LM310CN	8	1.75	LM384N	14	1.79	LM1496N	14	1.95
LM311CN	8	.69	LM386N-3	8	.89	LM1800N	16	1.49
LM312H		2.49	TL494CN	16	2.95	LM1889N	18	1.95
LM317T		1.19	TL496CP	8	1.19	LM1896N	14	2.95
LM317K		3.95	NE510A	14	4.95	LM2002T		1.49
LM318CN	8	1.95	NE529A	14	2.95	LM3189N	16	1.59
LM319N	14	1.95	NE531V	8	2.95	LM3900N	14	.59
LM320K-5		1.35	NE536H		8.95	LM3905CN	8	1.19
LM320K-12		1.35	NE540H		4.95	LM3909N	8	.99
LM320K-15		1.35	NE544N	14	2.95	LM3914N	18	3.49
LM320T-5		.89	NE550A	14	1.95	LM3915N	18	3.49
LM320T-12		.89	NE555V	8	.35	LM3916N	18	3.49
LM320T-15		.89	LM556N	14	.69	RC4136N	14	1.25
LM323K		5.95	NE564N	16	2.95	RC4151NB	8	1.95
LM324N	14	.59	LM565N	14	1.19	NE5532	8	2.49
LM337T		1.95	LM566CN	8	1.49	NE5534	8	1.89
LM338K		6.95	LM567V	8	.89	ICL8038B	14	3.95
LM339N	14	.69	NE570N	16	3.95	LM13080N	8	1.19
LM340K-5		1.35	LM703CN	8	1.19	LM13600N	16	1.19
LM340K-12		1.35						
LM340K-15		1.35						

MORE AVAILABLE

30003 1982 Nat. Linear Data Book (1952 pgs.) . $11.95

QUALITY COMPONENTS AT AFFORDABLE PRICES!

LOW PROFILE (TIN) SOCKETS

	1-9	10-99	100-up
8 pin LP	.16	.14	.13
14 pin LP	.17	.15	.14
16 pin LP	.19	.17	.16
18 pin LP	.26	.24	.23
20 pin LP	.30	.27	.26
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

SOLDERTAIL (GOLD) STANDARD

	1-9	10-99	100-up
8 pin SG	.30	.27	.26
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	1.06

SOLDERTAIL STANDARD (TIN)

	1-9	10-99	100-up
14 pin ST	.29	.27	.25
16 pin ST	.34	.32	.30
18 pin ST	.38	.36	.34
20 pin ST	.46	.43	.41
24 pin ST	.49	.46	.43
28 pin ST	.69	.67	.63
40 pin ST	.99	.95	.89

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-9	10-99	100-up
8 pin WW	.49	.45	.42
10 pin WW	.65	.62	.59
14 pin WW	.65	.62	.59
16 pin WW	.69	.65	.61
18 pin WW	.89	.85	.79
20 pin WW	1.09	1.05	.99
22 pin WW	1.25	1.19	1.15
24 pin WW	1.29	1.23	1.18
28 pin WW	1.59	1.50	1.45
36 pin WW	1.85	1.75	1.69
40 pin WW	1.99	1.89	1.79

$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

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VISA

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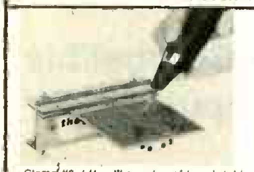
CIRCLE 20 ON FREE INFORMATION CARD

Wall Transformers AC and DC Types

AC250 (Pictured)

Part No.	Input	Output	Price
AC 250 (above)	117V/60Hz	12VAC 250mA	$3.95
AC 500	117V/60Hz	12VAC 500mA	$4.95
AC1000	117V/60Hz	12VAC 1 amp	$5.95
AC9004	117V/60Hz	9.2VAC 2.5 amp	$3.95
DC 800	120V/60Hz	8VDC 400mA	$1.95
DC6912	120V/60Hz	6,9,12VDC 300mA	$8.95
DC5490	117V/60Hz	9.5VDC 275mA	$2.95
DC900	120V/60Hz	9VDC 500mA	$3.95
DC1200	120V/60Hz	9.5VDC 300mA	$2.95
DV9200	117V/60Hz	9VDC 200mA	$3.25



PCB-3 Makes Circuit Assembly A Breeze!

Lets you work with both hands. Sturdy aluminum construction.

Clamp "3rd Hand" on edge of bench table or workboard. Insert circuit board, position components. Notice convenient working angle. Flip circuit board to flat position for soldering and clipping. Reverse procedure for double-sided boards.

PCB-3 .... $13.95

Extension to hold PCB-3 2" from bench and 6" from front edge.
PCB-X $6.95

Mostek DC/DC Converter +5 VOLTS TO -9 VOLTS

Input: +5V. Output: -9V (regulated) @ 30mA. Printed circuit mounting. Specifications incl.
DC10 ...... $2.95 ea. or 2/$4.95

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: 6⅝"L x 3¼"H x 1⅞"D.

JE300 ...... $39.95

RADIO CONTROL CIRCUITS

Ideal to use for:
- Toys, hobby crafts, robots, trains
- Burglar alarms • IR data link
- Remote slide projector control
- Consumer remote data links
- Energy-saving, remotely switched lighting systems

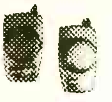
A complete F-channel digital encoder and RF transmitter; low power, at frequency of 27MHz or 49MHz, a field strength of 10,000uV meter at 3 meters. 9V operation on chip RF oscillator/transmitter, on chip 4.6 regulator. Up to 80MHz carrier frequency operation.

LM1871N RC Encoder/Transmitter Chip ... $1.95

A complete RF receiver/decoder, used at either 27MHz, 49MHz or 72MHz. It provides 4 independent channels when used with LM1871 (2 analog, 2 dig.) operates from four 1.5V cells, Crystal controlled.

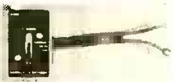
LM1872N RC Receiver/Decoder Chip ... $2.49
SRX1504 49.435MHz Crystal (LM1872N) ... $3.95
SRX1505 49.890MHz Crystal (LM1871N) ... $3.95

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.

BOOKS

NATIONAL SEMICONDUCTOR — INTERSIL — INTEL

30003 National Linear Data Book (1982) $11.95
(1376 pages) LM, LF, ADC, DAC, LH Series

30008 National Memory Data Book (1980) $8.95
(464 pages) RAMs, ROMs, PROMs, EPROMs Series

30009 Intersil Data Book (1983) $9.95
(1356 pages) Complete line.

30010 National Audio/Radio Handbook (1980) $5.95
(240 pages) Pre-Amps, AM, FM & FM Stereo, Power Amps

30011 National Linear Application Handbook (1980) $15.95
(736 pages) Application Notes, Linear Briefs, etc.

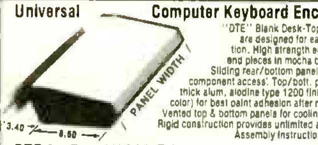
30012 National PAL Data Book (1982) $5.95
(176 pages) Application Notes, Linear Briefs, etc.

30013 Zilog Data Book (1983) $7.95
(641 pages) Microprocessors and Support Chips

210830 Intel Memory Components Handbook (1983) $14.95
(798 pages) Contains all Application Notes, Article Reprints, Data Sheets, and other design information on Intel's RAMs, EPROMs, E²PROMs & Bubble Memories.

210844 Intel Microprocessor & Peripheral Handbook (1983) ... $14.95
(1027 pages) Contains Data Sheets on all of Intel's Microprocessors and Peripherals.

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

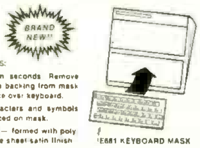
• Powerful - fully programmable 2K memory • Portable - 6⅞" x 6⅝" x 1⅞" - 12 oz. • Expandable - Optional 16K RAM module • Single-key entry commands • Educational • Unique syntax-check report codes for error identity • Accurate to 9½ decimal places for full range math and scientific functions • Graph drawing and animated display • Advanced 4-chip design combining power, portability and affordable price.

TS1000 .... $69.95

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

Keyboard Mask for Your ZX81/1000* Computer



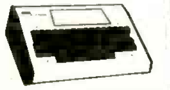
FEATURES:
- Install in seconds. Remove adhesive backing from mask and place over keyboard.
- All characters and symbols reproduced on mask.
- Durable — formed with poly carbonite sheet satin finish.

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: 14¼"W x 3½"D x 3½"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, D.P 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 full-size 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)

80-Key Keyboard

CA150C $69.95

84-Key Keyboard

CA153A $69.95

95-Key Keyboard

CA154A $79.95

CONTROL DATA KEYBOARDS

Limited Quantities!

- ★ 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. 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!!

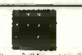
- RFI shielded
- Cursor controls
- Numeric keyboard
- 8-bit Parallel
- Capacitance keys
- 10 user-programmable keys
- Positive TTL Logic
- Size: 17"L x 8¼"W x 2¾"H

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, 40-inch interface cable, and schematics. Weight: 7 lbs.

Part No. KB270 .... $109.95 each

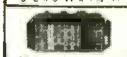
23"L x 5¾"W x 3.8"H

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. 85S018-1 .... $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



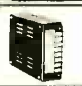
9½"L x 4¼"W x 1¼"H

ALPS 29-KEY CALCULATOR KEYBOARD
Features one 8-position decimal select switch, one 3-position switch, and two 2-position switches, mechanical SPST switching, 22-pin edge card connection. Pin-out included.
Part No. K8297040 (Fits DTE-11 Enclosure) .... $4.95 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 2⅛"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 4⅛"L x 2-7/16"H - wt. 2 lbs. Data sheet included.
Part No. OPS-1 .... $29.95 each

POWER SUPPLY +5VDC @ 7.5 AMP, 12VDC @ 1.5 AMP SWITCHING
Input: 115VAC, 50-60Hz @ 3 amp/230VAC, 50Hz @ 1.5 amp. Fan volt./power supply select switches (115/230VAC) Output: 5VDC @ 7.5 amp, 12VDC @ 1.5 amp. 8 ft. blk. pow. cord. 11⅝"W x 13⅛"D x 3⅞"H. Wt. 8 lbs.
Part No. PS94VDS .... $39.95 each



POWER SUPPLY 4-Channel Switching - Apple Compatible
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. 1½ 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
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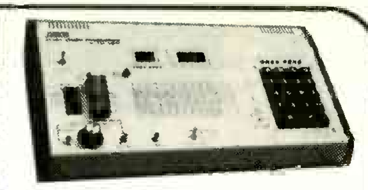


2708, 2716, 2732 & 2764 EPROM Programmer

JE664 EPROM PROGRAMMER

8K TO 64K EPROMS — 24 AND 28 PIN PACKAGES

— PROGRAMS 2716'S IN 16 SECONDS —

• Programs, 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

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

Kit comes complete with 8 each 4164-2 (200ns) 64K dynamic RAMs and conversion documentation. Converts TRS-80 color computers with D and E circuit boards, and all new color computers to 32K. Minor modifications of 32K memory will allow the use of all 64K of the dynamic RAM providing you have a FLEX OOS operating system.

TRS-64K2 .... $54.95

IBM MEMORY EXPANSION KIT

SAVE HUNDREDS OF $$$ BY UPGRADING MEMORY BOARDS YOURSELF!

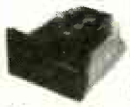
Most of the popular memory boards allow you to add an additional 64K, 128K, 192K, or 256K. The IBM64K Kit will populate these boards in 64K byte increments. The kit is simple to install — just insert the nine 64K RAM chips in the provided sockets and set the two groups of switches. Directions are included.

IBM64K (Nine 200ns 64K RAMs) $59.95

5¼" Mini-Floppy Disk Drive

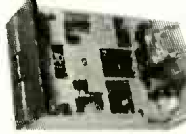
Pertec Computer Corp.

FOR TRS-80 MODEL I (Industry Standard)
Features single or double density. Recording mode: FM single, MFM double density. Power: +12VDC (±0.8V) 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 .... $179.95
Single-sided, 40 tracks, 250K bytes capacity
FD250 .... $199.95
Double-sided, 35 tracks, 438K bytes capacity

8" FLOPPY DISK DRIVE



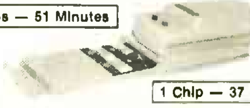
- Shugart 801R compatible
- Single-Sided
- 77 Tracks
- 400/800K Bytes Capacity
- Industry Standard

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 I, or eq. disk cartridge. Power: 115VAC @ 50-60Hz, +24VDC @ 1.7 amps max., +5VDC @ 1.2 amps max. Unit as pictured 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.

UV-EPROM Eraser

8 Chips — 51 Minutes



1 Chip — 37 Minutes

Erases 2708, 2716, 2732, 2764, 2516, 2532, 2564. Erases up to 8 chips within 51 minutes (1 chip in 37 minutes). Maintains constant exposure distance of one inch. Special conductive foam liner eliminates static build-up. Built-in safety lock to prevent UV exposure. Compact — only 9.00" x 3.70" x 2.60". Complete with holding tray for 8 chips.

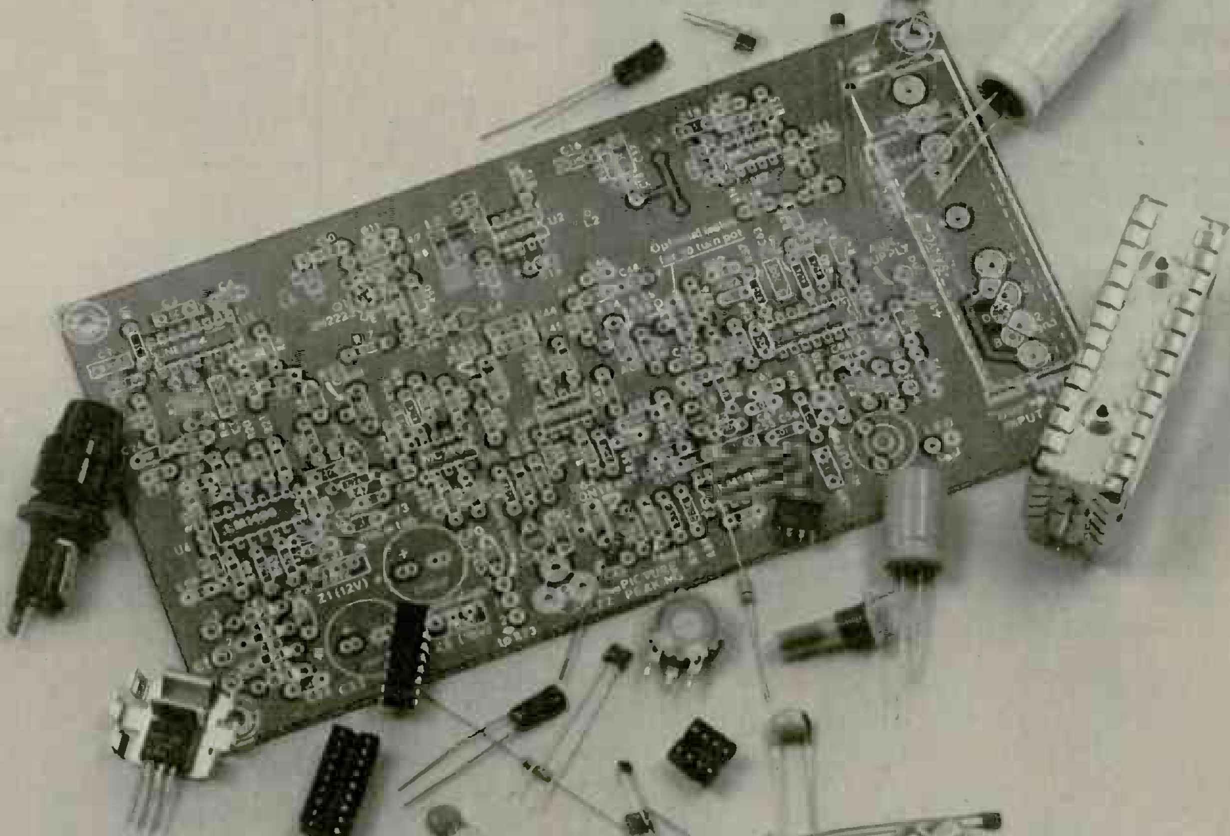
DE-4 UV-EPROM Eraser $79.95
UVS-11EL Replacement Bulb $16.95

"The Deluxe II"

Is The Ultimate In UHF Sine Wave Converter Technology

PC BOARD & PLANS $20.00

With purchase of COMPLETE SET OF PARTS & ENCLOSURE



The latest state of the art electronics combined with the excellence in printed circuit manufacturing creates this high performance UHF Sine Wave Converter kit that outperforms the imitations by a long shot.
Engineered for reliable stability and outstanding reception clarity, uninterrupted modulated audio and fully illustrated instructions with the amateur in mind.

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TOLL FREE **1-800-782-2701**

QTY	DESCRIPTION OF ITEM	COST EACH	SHIPPING EACH	TOTAL
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	PARTS & ENCLOSURE ONLY	$132.99	$4.95	
	PC BOARD & PLANS ONLY	$30.00	$1.50	
			GRAND TOTAL	$

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EPROMS

1702	1ns	2.95
2708	450ns	2.98
2716	450ns	3.25
2716-1	350ns	4.69
2532	450ns	4.69
2732	450ns	4.15
2764	450ns	CALL

DYNAMIC RAMS

TMS 4027	250ns	.79
UPD 411	300ns	2.89
MM 5280	300ns	2.89
MK4108	200ns	1.74
MM 5298	250ns	1.74
4027	250ns	2.00
4116	200ns	CALL
4116	150ns	CALL
4164	200ns	CALL
4164	150ns	CALL

STATIC RAMS

2101	450ns	1.80
2102L-2	250nsLP	1.44
2111	450ns	2.48
2114	450ns	1.74
2114L-4	450nsLP	1.84
2114L-3	300nsLP	1.84
2114L-2	200nsLP	1.94
TMS4044-4	450ns	3.15
TMS4044-3	300ns	3.45
TMS4044-2	200ns	3.89
MK4118	250ns	9.69
TMM2016	200ns	4.15
TMM2016	150ns	4.89
HM6116-4	200ns	CALL
HM6116-3	150ns	CALL
HM6116-2	120ns	CALL
Z6132	300ns	32.95

LP = LOW POWER

8000

8035	4.95	8251	4.39
8039	5.95	8253	6.89
8080A	3.89	8253-5	7.89
8085A	5.89	8255	4.39
8086	24.95	8255-5	5.19
8088	34.95	8257	7.89
8155	7.75	8259	6.85
8156	8.75	8272	39.00
8185	29.00	8275	29.00
8202	27.95	8279	8.89
8205	3.45	8279-5	9.89
8212	1.79	8282	6.49
8214	3.75	8283	6.49
8216	1.69	8284	5.49
8224	2.19	8286	6.49
8226	1.79	8287	6.49
8228	3.34	8288	24.95
8237	19.00	8289	39.00
8238	4.39	8741	34.95
8243	4.39	8748	14.95
8250	10.49	8755	29.95

16K APPLE RAM CARD

Upgrade your 48K Apple II to full 64K

BARE BOARD 14.00
ASSEMBLED & TESTED 42.50

Z80

4.0 MHz

Z80A-CPU	4.90
Z80A-PIO	4.90
Z80A-CTC	4.90

Call for Complete List

MICROPROCESSOR REAL-TIME CLOCK

MSM 5832 6.90

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EPROM ERASERS

HOLDS 15 EPROMS
ERASES IN 20 MINUTES
59.95

CONNECTORS

RS232 Male	3.00
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1.00 Hz	4.50	6.5536	2.69
1.8432	4.50	8.0	2.69
2.0	3.90	10.0	2.69
2.097152	3.90	12.0	2.69
2.4576	2.69	14.31818	2.69
3.2768	2.69	15.0	2.69
3.579545	2.69	16.0	2.69
4.0	2.69	17.430	2.69
5.0	2.69	18.0	2.69
5.0688	2.69	18.432	2.69
5.185	2.69	20.0	2.69
5.7143	2.69	22.1184	2.69
6.0	2.69		

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74LS00	.23	74LS123	.49	74LS253	.58
74LS01	.23	74LS124	1.24	74LS257	.58
74LS02	.23	74LS125	.44	74LS258	.58
74LS03	.23	74LS126	.44	74LS259	1.19
74LS04	.23	74LS132	.54	74LS260	.58
74LS05	.23	74LS136	.54	74LS266	.58
74LS08	.23	74LS137	.89	74LS273	1.48
74LS10	.23	74LS138	.49	74LS275	3.20
74LS11	.25	74LS139	.49	74LS279	.48
74LS12	.25	74LS145	1.19	74LS280	1.79
74LS13	.39	74LS147	2.39	74LS283	.68
74LS14	.39	74LS148	1.29	74LS290	.74
74LS15	.29	74LS151	.39	74LS293	.78
74LS20	.23	74LS153	.39	74LS295	.98
74LS21	.23	74LS154	1.89	74LS298	.88
74LS22	.23	74LS155	.59	74LS324	1.74
74LS26	.29	74LS156	.69	74LS352	1.28
74LS27	.23	74LS157	.44	74LS353	1.28
74LS28	.29	74LS158	.49	74LS363	1.34
74LS30	.23	74LS160	.68	74LS364	1.89
74LS32	.25	74LS161	.64	74LS365	.48
74LS33	.49	74LS162	.68	74LS366	.48
74LS37	.29	74LS163	.64	74LS367	.44
74LS38	.29	74LS164	.68	74LS368	.44
74LS40	.23	74LS165	.79	74LS373	.98
74LS42	.43	74LS166	1.69	74LS374	.98
74LS47	.49	74LS168	1.69	74LS377	1.24
74LS48	.74	74LS169	1.74	74LS378	1.15
74LS49	.74	74LS170	1.45	74LS379	1.34
74LS51	.23	74LS173	.68	74LS385	1.89
74LS54	.23	74LS174	.44	74LS386	.44
74LS55	.28	74LS175	.39	74LS390	1.15
74LS63	1.19	74LS181	1.89	74LS393	1.15
74LS73	.34	74LS189	8.79	74LS395	1.15
74LS74	.34	74LS190	.79	74LS399	1.48
74LS75	.34	74LS191	.79	74LS424	.37
74LS76	.34	74LS192	.64	74LS447	.37
74LS78	.45	74LS193	.64	74LS490	1.94
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74LS85	.65	74LS195	.68	74LS669	1.89
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74LS107	.35	74LS244	.79	74LS689	2.99
74LS109	.35	74LS245	1.48		
74LS112	.35	74LS247	.74	81LS95	1.48
74LS113	.35	74LS248	.89	81LS96	1.48
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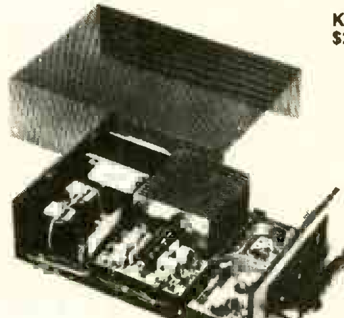

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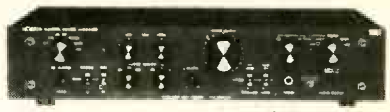

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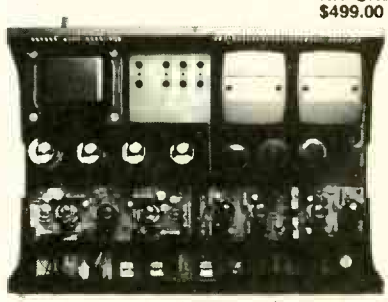

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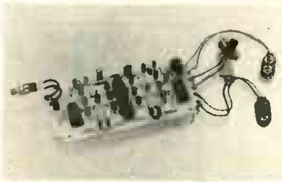

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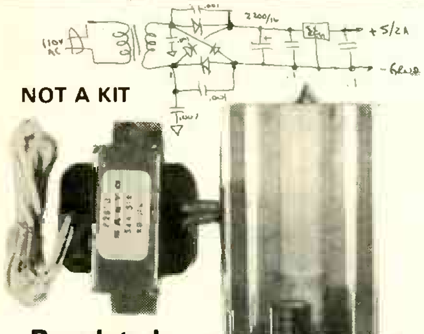

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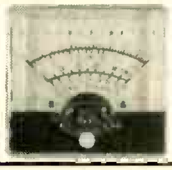

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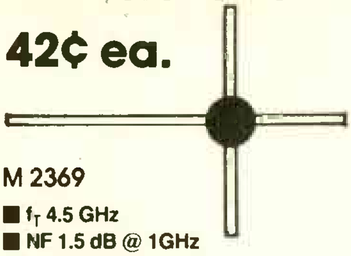

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75 OHM CHASSIS MOUNT CONNECTOR
F-61 Female connector. Rear chassis mount with nut. Mates with male "F" connectors.
While they last! 4 for $1.00

POPULAR MICROWAVE PARTS

MRF-901	$2.75
9-Up	2.19
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MBD-101	.98
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26-Up	.30
2N6603 (formerly MRF 902)	11.95

PROJECT BOXES
Woodgrain
This box is 11¾"W - 4½"H - 6½"D with a removable aluminum U-shaped chassis 11"W - 3½"H - 6"D inside.
$12.50 ea.
4 or more $10.95 ea.
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WINEGARD UHF - VHF - FM SPLITTER
40-900 MHz
Model PM-1030
Low Loss 3.5-4 db, Low VSWR
Waterproof Housing 1-9 $2.49 ea.
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SURPLUS UHF-VHF VARACTOR TUNERS
These tuners receive all channels 2-83, plus midband cable channels and are perfect for home-brew TV circuits etc. Output Freq. 45 MHz. Hookup data included. Name Brand.
Actual unit may differ from that shown.
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ramsey — the first name in Counters !

9 DIGITS 600 MHz $129.95 WIRED

PRICES

CT-90 wired, 1 year warranty	$129.95
CT-90 Kit, 90 day parts warranty	109.95
AC-1 AC adapter	3.95
BP-1 Nicad pack +AC Adapter/Charger	12.95
OV-1, Micro-power Oven time base	49.95
External time base input	14.95

The CT-90 is the most versatile, feature packed counter available for less than $300.00! Advanced design features include; three selectable gate times, nine digits, gate indicator and a unique display hold function which holds the displayed count after the input signal is removed! Also, a 10mHz TCXO time base is used which enables easy zero beat calibration checks against WWV. Optionally; an internal nicad battery pack, external time base input and Micro-power high stability crystal oven time base are available. The CT-90, performance you can count on!

SPECIFICATIONS:

Range:	20 Hz to 600 MHz
Sensitivity:	Less than 10 MV to 150 MHz Less than 50 MV to 500 MHz
Resolution:	0.1 Hz (10 MHz range) 1.0 Hz (60 MHz range) 10.0 Hz (600 MHz range)
Display:	9 digits 0.4" LED
Time base:	Standard-10.000 mHz, 1.0 ppm 20-40°C. Optional Micro-power oven-0.1 ppm 20-40°C
Power:	8-15 VAC @ 250 ma

7 DIGITS 525 MHz $99.95 WIRED

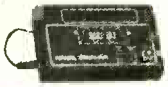
SPECIFICATIONS:

Range:	20 Hz to 525 MHz
Sensitivity:	Less than 50 MV to 150 MHz Less than 150 MV to 500 MHz
Resolution:	1.0 Hz (5 MHz range) 10.0 Hz (50 MHz range) 100.0 Hz (500 MHz range)
Display:	7 digits 0.4" LED
Time base:	1.0 ppm TCXO 20-40°C
Power:	12 VAC @ 250 ma

The CT-70 breaks the price barrier on lab quality frequency counters. Deluxe features such as; three frequency ranges - each with pre-amplification, dual selectable gate times, and gate activity indication make measurements a snap. The wide frequency range enables you to accurately measure signals from audio thru UHF with 1.0 ppm accuracy - that's .0001%! The CT-70 is the answer to all your measurement needs, in the field, lab or ham shack.

PRICES:

CT-70 wired, 1 year warranty	$99.95
CT-70 Kit, 90 day parts warranty	84.95
AC-1 AC adapter	3.95
BP-1 Nicad pack + AC adapter/charger	12.95



7 DIGITS 500 MHz $79.95 WIRED

PRICES:

MINI-100 wired, 1 year warranty	$79.95
AC-Z Ac adapter for MINI-100	3.95
BP-Z Nicad pack and AC adapter/charger	12.95

Here's a handy, general purpose counter that provides most counter functions at an unbelievable price. The MINI-100 doesn't have the full frequency range or input impedance qualities found in higher price units, but for basic RF signal measurements, it can't be beat! Accurate measurements can be made from 1 MHz all the way up to 500 MHz with excellent sensitivity throughout the range, and the two gate times let you select the resolution desired. Add the nicad pack option and the MINI-100 makes an ideal addition to your tool box for "in-the-field" frequency checks and repairs.

SPECIFICATIONS:

Range:	1 MHz to 500 MHz
Sensitivity:	Less than 25 MV
Resolution:	100 Hz (slow gate) 1.0 KHz (fast gate)
Display:	7 digits, 0.4" LED
Time base:	2.0 ppm 20-40°C
Power:	5 VDC @ 200 ma

8 DIGITS 600 MHz $159.95 WIRED

NEW READ RECEIVER FREQUENCY

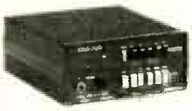
SPECIFICATIONS:

Range:	20 Hz to 600 MHz
Sensitivity:	Less than 25 mv to 150 MHz Less than 150 mv to 600 MHz
Resolution:	1.0 Hz (60 MHz range) 10.0 Hz (600 MHz range)
Display:	8 digits 0.4" LED
Time base:	2.0 ppm 20-40°C
Power:	110 VAC or 12 VDC

The CT-50 is a versatile lab bench counter that will measure up to 600 MHz with 8 digit precision. And, one of its best features is the Receive Frequency Adapter, which turns the CT-50 into a digital readout for any receiver. The adapter is easily programmed for any receiver and a simple connection to the receiver's VFO is all that is required for use. Adding the receiver adapter in no way limits the operation of the CT-50, the adapter can be conveniently switched on or off. The CT-50, a counter that can work double-duty!

PRICES:

CT-50 wired, 1 year warranty	$159.95
CT-50 Kit, 90 day parts warranty	119.95
RA-1, receiver adapter kit	14.95
RA-1 wired and pre-programmed (send copy of receiver schematic)	29.95



DIGITAL MULTIMETER $99.95 WIRED

PRICES:

DM-700 wired, 1 year warranty	$99.95
DM-700 Kit, 90 day parts warranty	79.95
AC-1, AC adaptor	3.95
BP-3, Nicad pack +AC adapter/charger	19.95
MP-1, Probe kit	2.95

The DM-700 offers professional quality performance at a hobbyist price. Features include; 26 different ranges and 5 functions, all arranged in a convenient, easy to use format. Measurements are displayed on a large 3½ digit, ½ inch LED readout with automatic decimal placement, automatic polarity, overrange indication and overload protection up to 1250 volts on all ranges, making it virtually goof-proof! The DM-700 looks great, a handsome, jet black, rugged ABS case with convenient retractable tilt bail makes it an ideal addition to any shop.

SPECIFICATIONS:

DC/AC volts:	100uV to 1 KV, 5 ranges
DC/AC current:	0.1uA to 2.0 Amps, 5 ranges
Resistance:	0.1 ohms to 20 Megohms, 6 ranges
Input impedance:	10 Megohms, DC/AC volts
Accuracy:	0.1% basic DC volts
Power:	4 'C' cells

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For high resolution audio measurements, multiplies UP in frequency.

- Great for PL tones
- Multiplies by 10 or 100
- 0.01 Hz resolution!

$29.95 Kit $39.95 Wired

ACCESSORIES

Telescopic whip antenna - BNC plug	$ 7.95
High impedance probe, light loading	15.95
Low pass probe, for audio measurements	15.95
Direct probe, general purpose usage	12.95
Tilt bail, for CT 70, 90, MINI-100	3.95
Color burst calibration unit, calibrates counter against color TV signal	14.95

COUNTER PREAMP

For measuring extremely weak signals from 10 to 1,000 MHz. Small size, powered by plug transformer-included.

- Flat 25 db gain
- BNC Connectors
- Great for sniffing RF with pick-up loop

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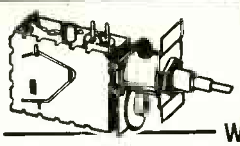
MORE GAIN
Than a Varactor UHF Tuner



$15.00 **SATISFACTION GUARANTEED**

Frequency Range 470-899 MHz Channels 14-83. Output Channel 3. Ch 2 or 4 Avail.

PART #B20 .... $15.00

WHAT'S IN IT?

To make a regular UHF tuner into a **GILCO HIGH GAIN TUNER**, each and every one of the following steps is painstakingly taken by a certified technician:

1. The first thing GILCO does is change the standard diode to a **hot carrier diode**.
2. The tuner's output is then measured on our JERROLD field strength meter and compared to a computer derived chart from which we determine the correct value coil to add across the IF output for ***maximum pre-peaked gain***.
3. The tuner is then fed a standard 10db 300 ohm antenna input and while monitoring the output on our HEWLETT PACKARD spectrum analyzer, the tuner is tuned to the desired channel and its oscillator is offset for the desired output frequency as follows:

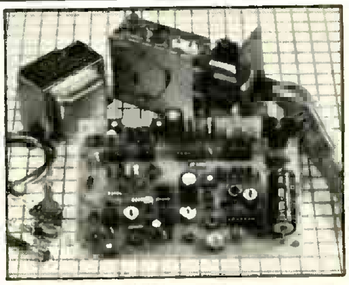
   Channel 2: 58 Mhz, Channel 3: 63 Mhz, Channel 4: 68 Hhz

   We call this step peaking because the tuner's output looks like a peak on our spectrum analyzer and the highest point of that peak is actually adjusted for the desired output.
4. The last step is one more measurement on the field strength meter which is again compared to our performance chart to calculate the correct value of the second coil which is added to the tuners internal connections.

This procedure was developed by GILCO and it is our computer derived performance charts that make our tuner better, that's because ***almost every tuner gets a different value coil*** before it's peaked and again a different value coil after it's peaked. The combinations are endless and ***the way we determine the values is our secret...***

GILCO PARTS KIT & PRINTED CIRCUIT BOARD

- **Use with GILCO High Gain Tuner**
- **Requires NO Modification to Your Television**
- ***Individually Packaged and Labeled Parts Save Guesswork***
- The only tools required for assembly are: screwdriver, soldering iron, voltmeter. No drilling is required to the P/C board.
- This kit was designed to take advantage of the GILCO high gain tuner which means its circuitry is ***simpler and more efficient*** than those circuits that require inferior varactor tuners.



Pre-drilled, pre-screened, plated through the holes P/C board. All hardware, connectors, 22 page illustrated instruction manual, & Gilco Hy-Gain tuner. Kit assembles in just 4 hours.

FREE 22 Page Instruction Book included with each P/C Board or Parts Kit. This instruction book will guide the builder through every step of the assembly. ***Nearly every page is illustrated***. With this Instruction Book, estimated assembly time is 4 hours.

HERE'S WHAT YOU GET FROM GILCO

Part No. B21 Printed Circuit Board $17.00

1. This Printed Circuit Board uses ***only one jumper, others use nine.***
2. ***The component layout is screen printed*** on the component side of the P/C board.
3. The solder side of the P/C board is covered with high temperature solder resist. This prevents solder bridges.
4. ***Newest Addition:*** **the P/C board is plated through the holes**. This allows for easier and more positive soldered contact between the parts and the P/C board.

Part No. B22 Complete Electronic Parts Kit $80.00

All resistors (30), Potentiometers (1-5K, 3-10K), Panel Mount Potentiometer (10K), Electrolytic Capacitors (6), Ceramic and Mylar Disc Capacitors (35), Variable Capacitors (4), All Integrated Circuits (7), Voltage Regulator, Heat Sink, Diodes (4), IC Sockets (4-8 pin, 3-14 pin), Power Transformer (24V, 1A), Coil Kit with No. 26 wire (4), Speaker (4", 3oz.), Standoffs, Coaxial Cable, All Miscellaneous Harware, Etc. All parts are individually packaged and labeled.

All components including the Wire, Hardware, Coaxial Cable and Heat Sinks are included in the parts kit. This means your assembly time from start to finish is just 4 hours.

GILCO ACCESSORIES & AMPLIFIER KITS

#A02 New 2 stage, low noise, 28db gain, RF Amplifier Kit .... Kit $18.00

#A03 New 1 stage, low noise, 14db gain, RF Amplifier Kit .... Kit $10.50

GILCO ORDER FORM

#B20 GILCO Hy-Gain Modified Tuner	$15.00	______
#B21 GILCO Predrilled, Screen Printed, Circuit Board	$17.00	______
#B22 GILCO Parts Kit (Less P/C Board)	$80.00	______
#B20, B21, B22 Complete P/C Board and Parts Kit (all three)	$110.00	______
#A02 Two stage, 28 db gain, Amplifier Kit	$18.50	______
#A03 One stage, 14db gain, Amplifier Kit	$10.50	______

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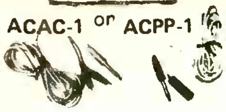
ACAC-1 or ACPP-1



10 ft. audio extension cable. $ 1.50

UVE1-A Mitsumi UHF/VHF combo varactor tuner $9.75

72 PCS. PER KIT

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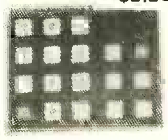

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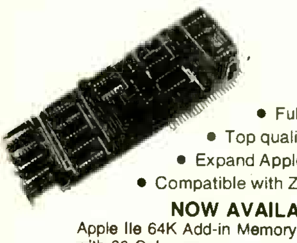

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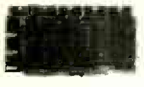

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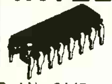

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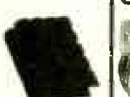

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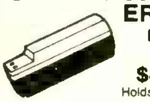

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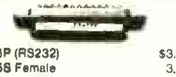

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8255	4.50	6875	5.95	Z80-SIO	24.95
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MOS PROMS

2764 (8Kx8) TS	$69.95	2708 (450nS)	$5.75
2732 (4Kx8) TS	12.95	2708 (650nS)	5.25
2716/2516, 5V		1702A	5.75
(2Kx8) TS	7.95	MM5203AO	14.50
TMS2716, 5V, 12V	17.95	MM5204O	9.95
2758, 5V, (450nS)	3.50		

HI-TECH

2513-001 (5V) Upper	$9.50	DAC08	$9.95
2513-005 (5V) Lower	10.95	DAC100	9.95
2513-ADM3 (5V) Lower	14.95	8038 Function Generator	4.50
MCM66710 ASCII Shifted	12.95	MC4024 VCO	2.95
MCM66740 Math Symbol	13.95	LM566 VCO	1.95
MCM66750 Alpha Control	13.45	XR2206 Function Generator	5.25
1771-01 8" & Minifloppy	24.95	TR1602B (5V, 12V)	3.95
1781 Dual Floppy	29.95	AY51013 (5V, 12V)	4.95
1791-01 Dual Floppy	36.95	AY51014A/1612 (5-14V)	6.95
1791-02 Dual Floppy	44.95	AY51015A/1863 (5V)	6.95
1793 DD, DS Floppy	44.95	IM6402	7.95
1797 DD, DS Floppy	54.95	IM6403	8.95
1691 Data Separator	18.95	2350 USRT	9.95
2143 Clock Generator	18.95	16718 Astros	24.95
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8701 10 bit Binary	22.00	4702	14.95
8703 8 bit TS	13.50	WD1941	9.95
9400 Volt to Freq Conv	7.25	COM5016	16.95
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1408L6 6 bit	3.95	AYS-2376	13.75
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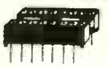
DAC01 D to A	5.95	MM5740AAC	8.95

SOCKETS

LOW PROFILE SOCKETS (TIN)



	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

3L WIREWRAP SOCKETS (GOLD)

	1-24	25-49	50-100
8 pin WW	.55	.54	.49
10 pin WW (Tin)	.65	.63	.58
14 pin WW	.75	.73	.67
16 pin WW	.80	.77	.70
18 pin WW	.95	.90	.81
20 pin WW	1.15	1.08	.99
22 pin WW	1.45	1.35	1.23
24 pin WW	1.35	1.26	1.14
28 pin WW	1.60	1.53	1.38
40 pin WW	2.20	2.09	1.89

LINEAR

78H05K	$5.95	LM1414N	$1.90
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78M G.	1.49	MC1488N	.99
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LM300H	.99	LM1496N	.89
LM301CN	.35	LM1556N	1.50
LM304H	1.98	LM1820N	.95
LM305H	1.89	LM1850N	.95
LM306H	3.25	LM1889N	3.10
LM307CN	.29	LM2111N	1.75
LM308CN	.98	LM2900N	.99
LM309K	1.49	LM2901N	2.50
LM310CN	1.25	LM2917N	2.95
LM311D/CN	.89	CA3013T	2.19
LM312H	1.75	CA3018T	1.99
LM317T	1.70	CA3021T	3.49
LM318CN	1.49	CA3023T	2.99
LM319N/H	1.25	CA3035T	2.75
LM320K-XX*	1.35	CA3039T	1.29
LM320T-XX*	1.39	CA3046N	1.29
LM320H-XX*	1.25	LM3053N	1.49
LM323K	4.95	CA3059N	3.19
LM324N	.95	CA3060N	3.19
LM337K	5.95	CA3062N	4.95
LM338K	6.95	LM3065N	1.49
LM339N	.95	CA3080T	1.29
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LM340T-XX*	1.25	CA3082N	1.69
LM340H-XX*	1.25	CA3083N	1.55
LM344H	1.95	CA3086N	.80
LM348N	1.20	CA3089N	2.99
LM350K	5.60	CA3096N	3.49
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
LM380CN/N	1.25	CA3190N	1.95
LM381N	1.79	CA3410N	.59
LM383T	1.95	MC3423N	1.49
LM386N	1.25	MC3460N	3.95
LM387N	1.40	SG3524N	3.95
LM390N	1.95	CA3600N	3.39
NE531V/T	3.75	LM3900N	.59
NE555V	.39	LM3905N	1.19
NE556N	.98	LM3909N	.98
NE561T	19.95	LM3914N	3.75
NE565N/H	1.25	LM3915N	3.95
NE566H/V	1.75	LM3916N	3.75
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LM711N/H	.39	ULN2001	1.25
LM715N	1.95	ULN2003	1.50
LM723N/H	.65	SN75450N	.59
LM733N/H	.98	SN75451N	.35
LM739N	1.15	SN75452N	.49
LM741CN/H	.33	SN75453N	.49
LM741CN-14	.19	SN75454N	.49
LM747N/H	.75	SN75491N	.89
LM748N/H	.39	SN75492N	.89
LM760CN	2.95	SN75493N	.89
LM1310N	1.90	SN75494N	.89
MC1330	1.95	TL494CN	4.20
MC1350	1.95	TL496CP	1.65
MC1358	1.75		

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74S03	.45	74S134	.66	74S253	1.35
74S04	.52	74S135	1.15	74S257	1.29
74S05	.52	74S136	1.69	74S258	1.29
74S08	.49	74S138	1.29	74S280	.75
74S09	.49	74S139	1.29	74S280	2.79
74S10	.42	74S140	.73	74S287	2.99
74S11	.42	74S151	1.29	74S288	2.55
74S15	.42	74S153	1.29	74S373	3.10
74S20	.42	74S157	1.29	74S374	3.10
74S22	.42	74S158	1.29	74S387	2.75
74S30	.42	74S160	2.79	74S471	7.95
74S32	.49	74S174	1.49	74S472	7.95
74S38	1.19	74S175	1.49	74S473	7.95
74S40	.49	74S188	2.69	74S474	9.95
74S51	.42	74S194	1.89	74S475	9.95
74S64	.46	74S195	1.89	74S570	5.75
74S65	.46	74S196	1.89	74S571	5.75
74S74	.69	74S240	2.75	74S572	8.95
74S86	.72	74S241	2.75	74S573	8.95
74S112	.72	74S242	2.99	74S940	2.90
74S113	.72	74S243	2.99	74S941	2.90
74S114	.72				

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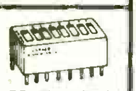
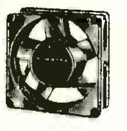


2 Position	$ .99	7 Position	$1.39
4 Position	1.19	8 Position	1.49
5 Position	1.29	9 Position	1.65
6 Position	1.35	10 Position	1.69

MUFFIN® FAN



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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
7474	.34			74490	1.90

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	1.69
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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4008	1.39	4044	.85	14408	12.95
4009	.45	4046	1.75	14409	12.95
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4011	.35	4048	.99	14412	12.95
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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
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2114L-3	1024 x 4 (300ns) (LP)	8/13.45
2114L-2	1024 x 4 (200ns) (LP)	8/13.95
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TMS4044-3	4096 x 1 (300ns)	3.99
TMS4044-2	4096 x 1 (200ns)	4.49
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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

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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
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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

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

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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
68B45	19.95
HD46505SP	15.95
6847	11.95
MC1372	6.95
68047	24.95
8275	29.95
7220	99.95
CRT5027	39.95
CRT5037	49.95
TMS9918A	39.95
DP8350	49.95

KEYBOARD CHIPS

AY5-2376	11.95
AY5-3600	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
8231	call
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
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	.99
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	.99
74LS113	.39	74LS374	.99
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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HOURS: M-W-F, 9-5   T-Th., 9-9   Sat. 11-3

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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	LM13080	1.29
LM338K	6.95	NE564	2.95	LM1496	.85	LM13600	1.49
LM339	.99	LM565	.99	LM1558H	3.10	LM13700	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
4093	.49	74C373	2.45
4098	2.49	74C374	2.45
4099	1.95	74C901	.39
14409	12.95	74C902	.85
14410	12.95	74C903	.85
14411	11.95	74C905	10.95
14412	12.95	74C906	.95
14419	7.95	74C907	1.00
14433	4.18	74C908	2.00
4502	.95	74C909	2.75
4503	.65	74C910	9.95
4508	1.95	74C911	8.95
4510	.85	74C912	8.95
4511	.85	74C914	1.95
4512	.85	74C915	1.19
4514	1.25	74C918	2.75
4515	1.79	74C920	17.95
4516	1.55	74C921	15.95
4518	.89	74C922	4.49
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
74S03	.35	74S169	3.95
74S04	.35	74S174	.95
74S05	.35	74S175	.95
74S08	.35	74S181	3.95
74S09	.40	74S182	2.95
74S10	.35	74S188	1.95
74S11	.35	74S189	6.95
74S15	.35	74S194	1.49
74S20	.35	74S195	1.49
74S22	.35	74S196	1.49
74S30	.35	74S197	1.49
74S32	.40	74S201	6.95
74S37	.88	74S225	7.95
74S38	.85	74S240	2.20
74S40	.35	74S241	2.20
74S51	.35	74S244	2.20
74S64	.40	74S251	.95
74S65	.40	74S253	.95
74S74	.50	74S257	.95
74S85	1.99	74S258	.95
74S86	.50	74S260	.79
74S112	.50	74S274	19.95
74S113	.50	74S275	19.95
74S114	.55	74S280	1.95
74S124	2.75	74S287	1.90
74S132	1.24	74S288	1.90
74S133	.45	74S289	6.89
74S134	.50	74S301	6.95
74S135	.89	74S373	2.45
74S138	.85	74S374	2.45
74S139	.85	74S381	7.95
74S140	.55	74S387	1.95
74S151	.95	74S412	2.98
74S153	.95	74S471	4.95
74S157	.95	74S472	4.95
74S158	.95	74S474	4.95
74S161	1.95	74S482	15.25
74S162	1.95	74S570	2.95
		74S571	2.95

IC SOCKETS

	1-99	100
8 pin ST	.13	.11
14 pin ST	.15	.12
16 pin ST	.17	.08
18 pin ST	.20	.18
20 pin ST	.29	.27
22 pin ST	.30	.27
24 pin ST	.30	.27
28 pin ST	.40	.32
40 pin ST	.49	.39
64 pin ST	4.25	call
ST = SOLDERTAIL		
8 pin WW	.59	.49
14 pin WW	.69	.52
16 pin WW	.49	.49
18 pin WW	.99	.90
20 pin WW	1.09	.98
22 pin WW	1.39	1.28
24 pin WW	1.49	1.35
28 pin WW	1.69	1.49
40 pin WW	1.99	1.80
WW = WIREWRAP		
16 pin ZIF	6.75	call
24 pin ZIF	9.95	call
28 pin ZIF	10.95	call

ZIF = TEXTOOL (Zero Insertion Force)

VOLTAGE REGULATORS

7805T	.75	7905T	.85
7808T	.75	7908T	.85
7812T	.75	7912T	.85
7815T	.75	7915T	.85
7824T	.75	7924T	.85
7805K	1.39	7905K	1.49
7812K	1.39	7912K	1.49
7815K	1.39	7915K	1.49
7824K	1.39	7924K	1.49
78L05	.69	79L05	.79
78L12	.69	79L12	.79
78L15	.69	79L15	.79
78H05K	9.95	LM323K	4.95
78H12K	9.95	UA78S40	1.95

T = TO-220 K = TO-3 L = TO-92

DIP SWITCHES

4 POSITION	.85
5 POSITION	.90
6 POSITION	.90
7 POSITION	.95
8 POSITION	.95

INTERFACE

8T26	1.59
8T28	1.89
8T95	.89
8T96	.89
8T97	.89
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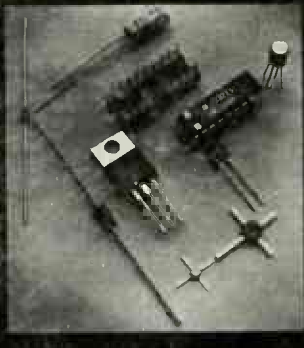

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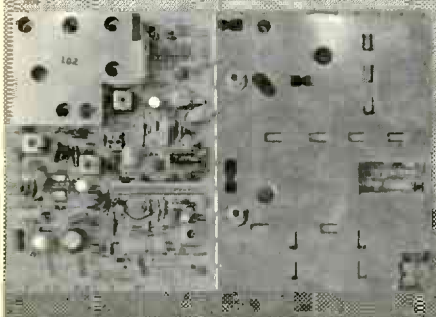

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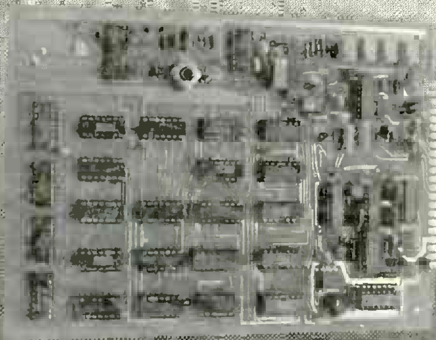

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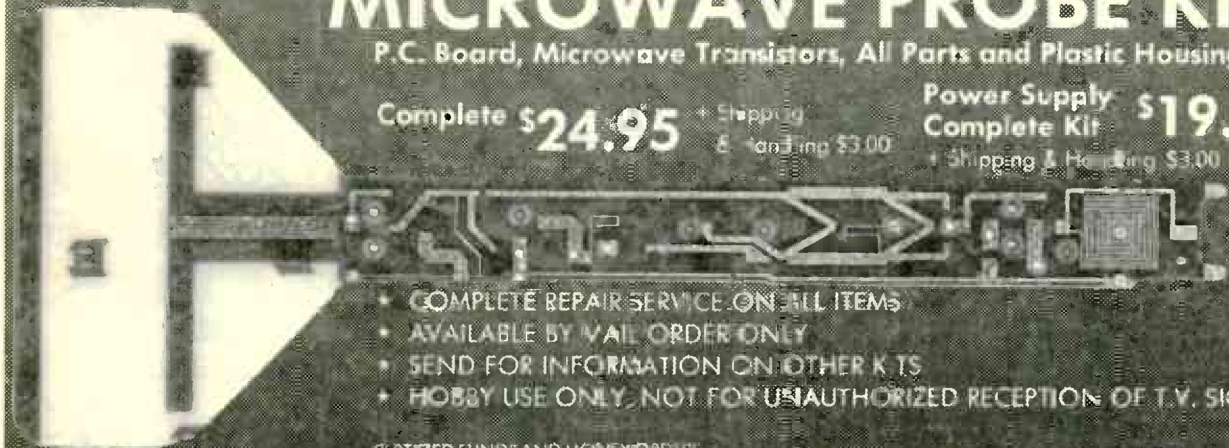

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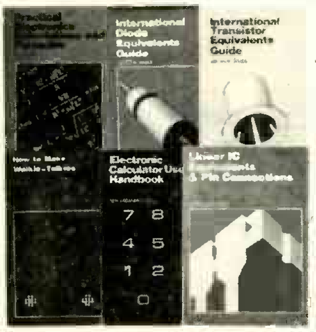

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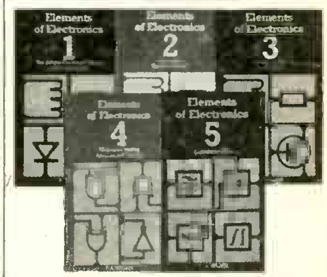

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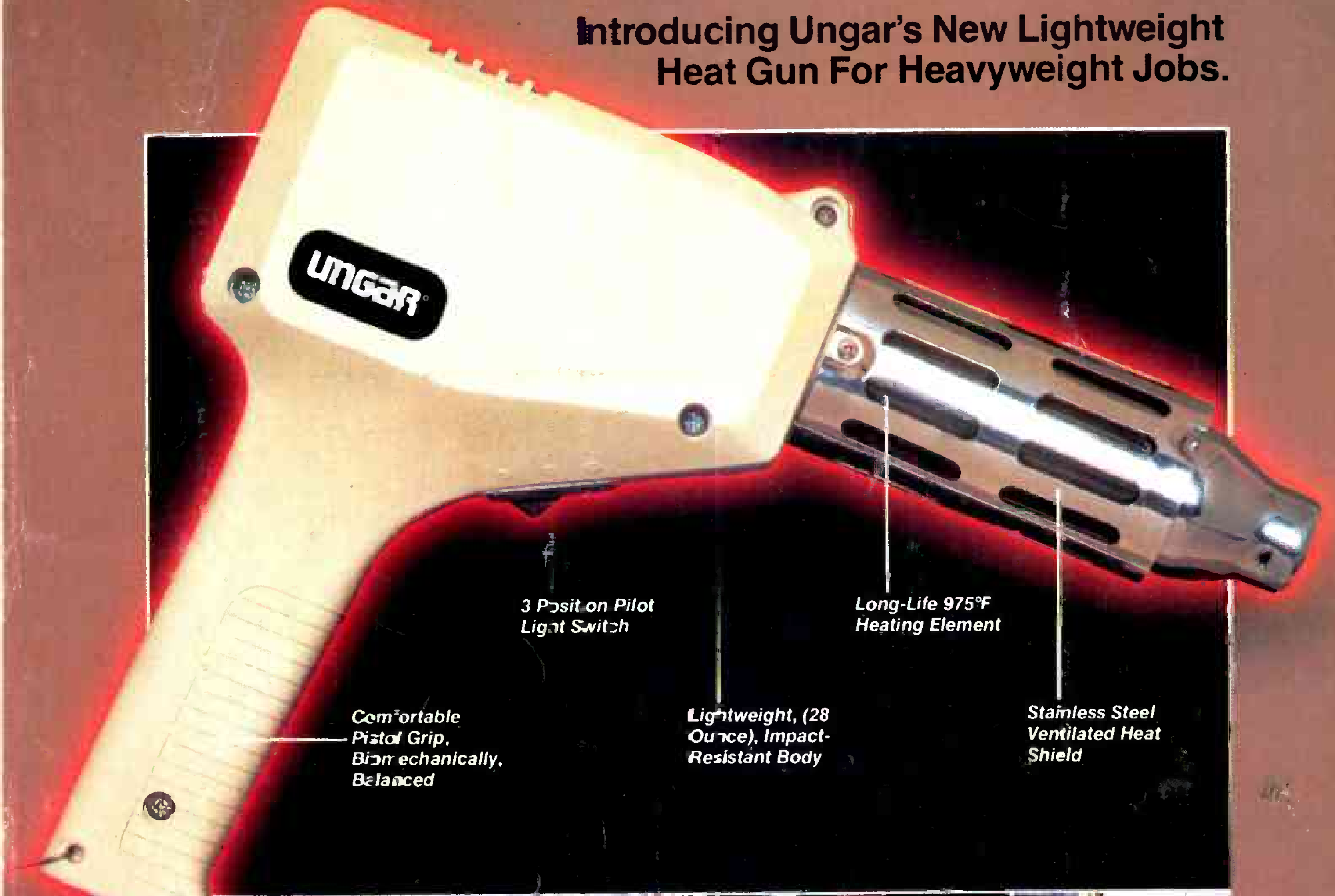

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