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MAY/JUNE
1986

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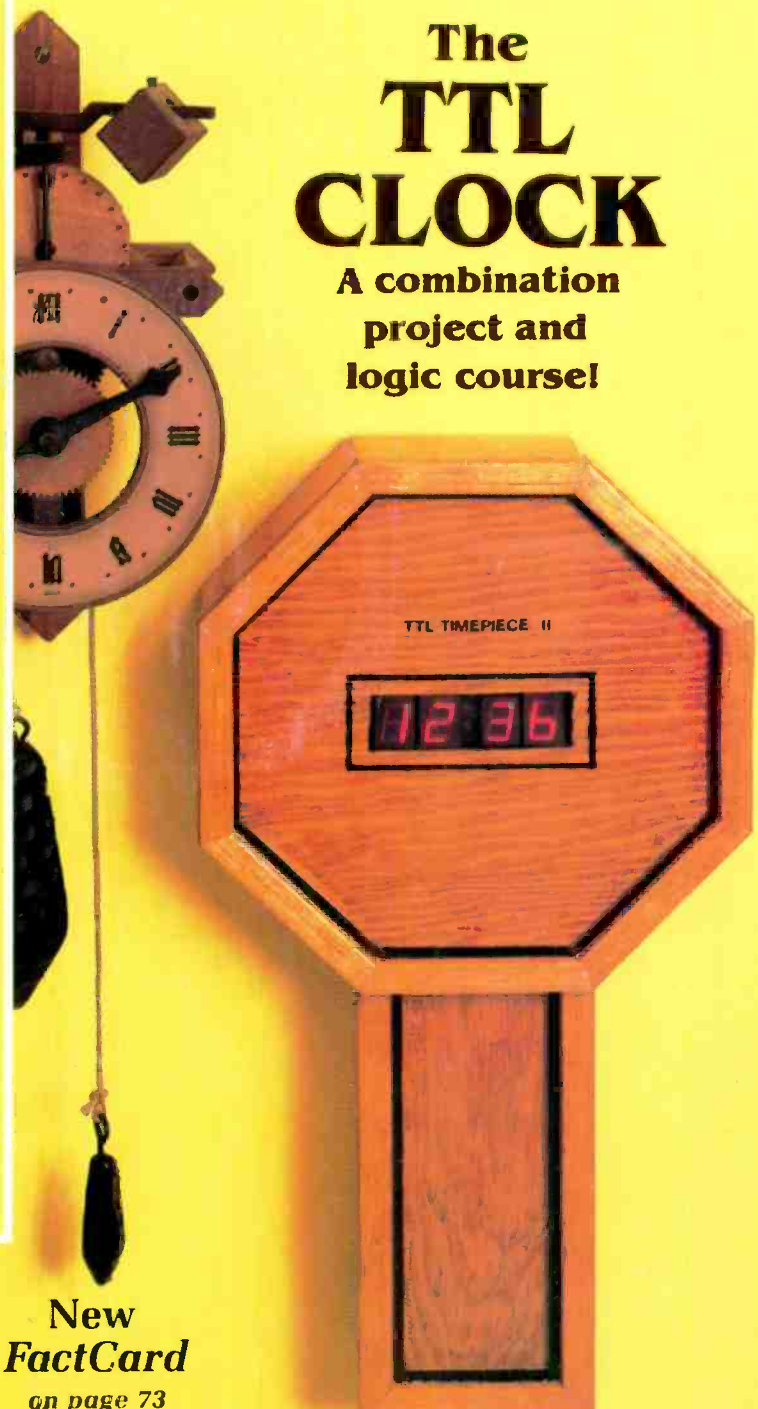

New FactCard on page 73

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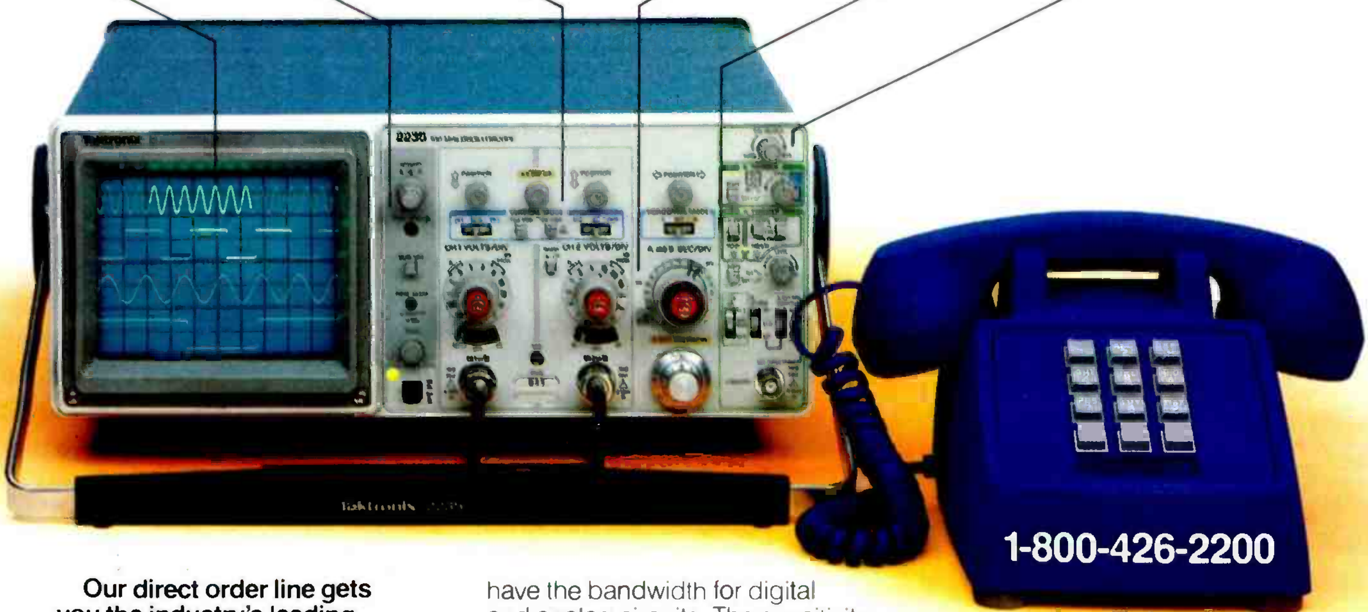

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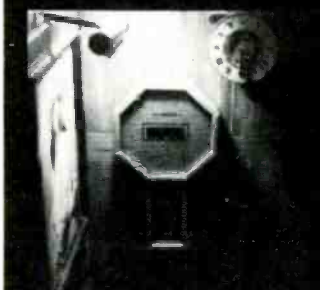

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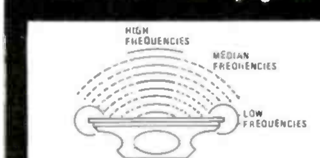

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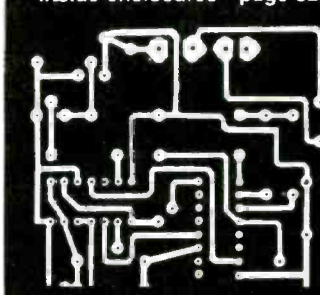

Hands-on Electronics

The Magazine for the Electronics Activist!

EDITORIAL PAGE

Volume 3, No. 3
MAY/JUNE 1986

It happens every other month!

Who would ever believe that I had to readjust my life style so that my bio-rhythm rate would be bi-monthly? Yes, that's what happened, and I seriously doubt that my 24-hour work/rest rate has been unaltered!

Ever since **Hands-on Electronics** had changed its publication frequency from four to six issues per year, the activity at our office has speeded up, and *I like it!* The added activity has invigorated everyone's thinking, and you saw the results in the past three issues. I don't want to beat the drum about all that we did; however, I do look with pride upon our *free* FactCard program that appears in this issue for the second time. What I honestly believed was a reasonable additional service to our readers has been lauded by *your* mail. In fact, if they were QSL's, I could have said the staff earned a "Worked 48 States" certificate. (We're missing two states).

This issue has a nice mix of information and you-build-it articles along with our regular columns. Read the article on radar traffic control systems for airports—you'll begin to fully understand the magnitude of the roll that electronics plays in keeping the skyways safe. Also, we take an earthy look at installing a satellite TVRO system at home—for the budget minded! And our construction projects (I like the Fence Charger) never fails to excite editors and readers alike. In fact, do what I did—read this magazine from cover to cover—maybe your bio-rhythm will change also!

Julian Martin

Julian S. Martin, KA2GUN
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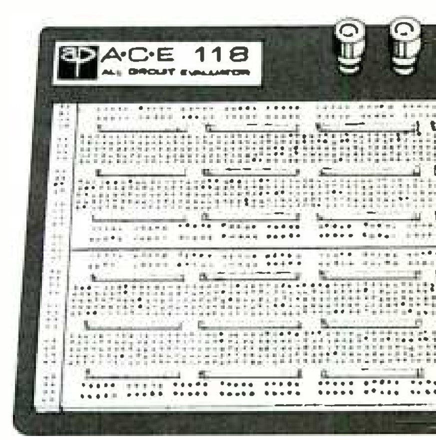

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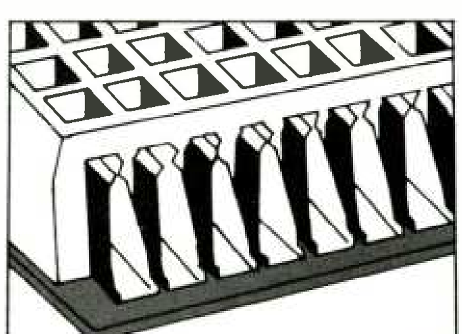

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LETTER BOX

We Blew It!

OK, so how come in your great article on Satellite TV (March/April, page 42) you listed all those great Satellite TV publications and omitted my favorite, *Satellite TV Week*? M.F.—Waco, TX

It's easy to explain. Satellite TV Week *is our favorite publication, too. That's why it was on your editor's coffee table at home instead of being filed with all the others. And because it wasn't in the file, it didn't get written up along with the others. Know what? It's still on my coffee table, and it will stay there until the next issue comes out! If you'd like to be kept up to date on weekly satellite broadcast listings, send a buck for a sample copy. Write them at Satellite TV Week, P. O. Box 308E, Fortuna, CA, 95540. If you're in a hurry, and live in the U.S., call 800/358-9997. In California, call 800/556-8787. All others call 707/725-2476.*

It's All in the Issue

Recently **Hands-On-Electronics** ran an article about six construction projects. They were listed as sold by Dick Smith Electronics. I ordered three of the six. When they arrived, each had a sticker on the package stating that no instructions were included. You have to send and buy *Funway Book Number Two* for seven bucks and pay an extra buck to have it mailed to you. Is that fair?.
J. M., Virden, IL

The projects in question could have been built directly from the descriptions in the magazine—no additional purchase was necessary. Your letter has been sent to Dick Smith Electronics.

Designing Help Needed

I am an instructor in Cardiopulmonary Resuscitation (CPR). I would like to construct a simple device that would *beep* and light-up indicating simulated heart beats of 80 and 60 beats per minute. These are the rates of chest compression taught to CPR trainees. In this way, my students could see and hear the rhythms (this is in addition to the mnemonics suggested by the American Heart Association). I imagine the block diagram to be like Fig. 1 below:
A suggestion: A flashlight bulb is preferred over the LED indicator—it can be seen better in a classroom. Barry I. Kelner, D.D.S. 499 Ernston Road Parlin, NJ 08859

Ok, circuit designers, here is your chance to assist a volunteer who donates his time to those who want to save lives—maybe your own life some day. If you come up with a workable circuit, send it directly to the good Doctor.

RS-232C Troubles

I interconnected two micros via their serial ports using ordinary ribbon cable and a black box. The micros "talk" to each other over short distances; but when the ribbon cable gets longer than 50 feet, strange things begin to happen. Characters are lost, verification takes several tries, and sometimes I never get to transmit the full file—that's during a good day. On bad days I'm sorry that I started the whole business! What is going wrong? W.B.—Amherst, NH

The same problems occurred with the early transatlantic cables—capacitance
(Continued on page 6)

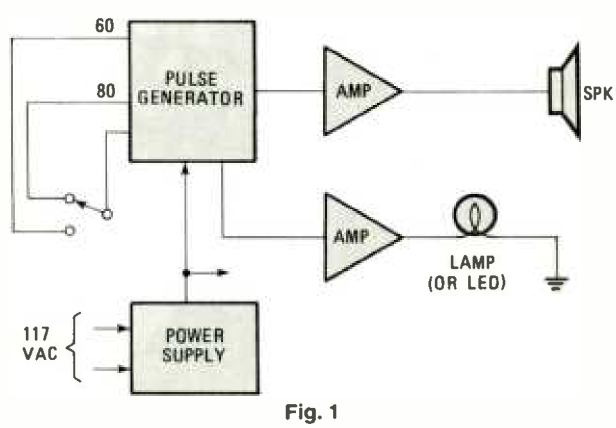

Fig. 1

C.O.M.B. BREAKS THE SATELLITE TV PRICE BARRIER!

KLM 8-ft. SATELLITE TV RECEIVER SYSTEM

HIGH PERFORMANCE! TOP NAME BRAND!

ABOUT THE MANUFACTURER

KLM introduced the FIRST satellite TV receiver system for consumers! They designed the FIRST programmable receiver. KLM is one of the largest in the industry and is a leader in advanced technology. Because they are concentrating efforts on new designs, KLM has allowed us to offer a quantity of these current 8-ft. models to the public at an unusually low price! It's a tremendous value!

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COMPLETE, PERFECTLY MATCHED SYSTEM!

- ***Designed for do-it-yourself installation!***
- ***Fully programmable location of each satellite!***
- ***All motorized!***
- ***Automatic push-button selection of each satellite!***
- ***Includes 120 feet of cable!***
- ***Superior quality throughout!***

REMOTE CONTROL
Operates Aimer IV (shown at right). Push-button access to 64 programmed satellites. 6 pre-sets for your favorite programs.

Does not include metal support pipe.

INCLUDES ALL THIS, TOO!

SKY EYE X BLOCK RECEIVER!

Uncomplicated, easy operation! Fast fingertip selection of channel, polarity, audio tune. Relative signal strength meter lets you hit station right on the button. Separate AFC on/off selector allows precision tuning, even of weak channels.

INCLUDES blockdown converter (an expensive option on competitor's models). This splits signals so 2 TV sets in your home can "tune in" on 2 different channels of same satellite at same time. However, you need another receiver (available from regular KLM dealers) for the second TV set.

HORIZON TO HORIZON MOUNT

This special mount delivers 180° range for maximum degree of "dish" rotation for access to TV satellites in western hemisphere. 120 feet of cable also included.

Fully Programmable AIMER IV REMOTE "DISH" POSITIONER

Microprocessor controlled for pushbutton access to 64 pre-programmed satellite locations. Six pre-sets for favorite satellites. Automatically positions "dish" and channel skew (polarity). Battery backup for three-month memory retention in case of power failure or for unplugging system during vacations. **Parental Lockout** prevents children from viewing restricted channels.

HOW TO SELECT A PROPER SITE

Stand in your yard, look due South and side to side. You should have an unobstructed view of the sky. Tree branches and power lines diminish quality of reception.

It opens up a vast new world of TV entertainment! MORE sports! MORE movies! MORE of everything you like to watch! And it provides superior reception capabilities!

The KLM 8-ft. Satellite TV Receiver system picks up signals from more than a dozen communications satellites in the sky. This opens up over 100 channels of TV viewing, with a multitude of programs. And the KLM system provides outstanding reception capabilities throughout the entire 48 states!

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HUGE VARIETY OF ENTERTAINMENT. Watch popular new films and plenty of classic "oldies" on the movie channels. Keep up with fast-breaking national and international events, any time of day, on all-news networks.

Get important investment "tips" and information from the financial/business channels. View provocative Adults Only programs. Delight in video entertainment of top performers on music channels for rock, pop, country, classical, etc.

PLUS, there are entertaining and educational channels specifically for children. Religious and cultural channels. French and Spanish networks. The list goes on and on! And with each new TV satellite placed in the sky, your exciting world of home entertainment keeps growing LARGER and LARGER!

IDEAL FOR RURAL AREAS! If TV reception is poor or the variety is very limited where you live, you're in for a HUGE DELIGHT! With the KLM system, reception is as good as in a big city. And the variety is huge!

GREAT FOR URBAN AND SUBURBAN AREAS! With the KLM system, you can still pick up all your usual local stations. PLUS, you get greatly expanded selection from all the satellite channels. There's a huge world of viewing pleasure in store for you. Up to 100 or more TV channels are available with the KLM system!

DO-IT-YOURSELF INSTALLATION! You don't have to be an electronics "whiz" to install the KLM system. Components come pre-assembled, except for the 8-ft. "dish." Need: 3½" outside dia. support pipe, bag of cement mix and your own TV. KLM has a Toll-Free number to call just in case you need assistance. The "dish" is designed to withstand high winds.

AN EXCELLENT VALUE! Don't be fooled by someone else's "low" price on a "dish" that is SMALLER than ours...NOT as high-tech...or is INCOMPLETE and requires costly purchases of additional components. With our KLM 8-ft. "dish" you get a complete, superior quality system from a leader in the industry...at a remarkably low closeout price!

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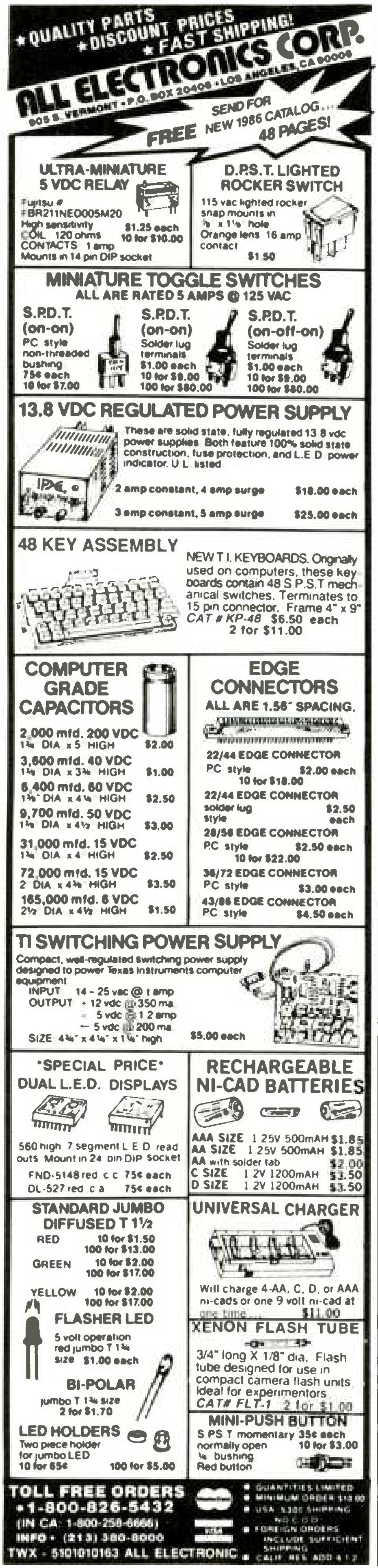

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Letter Box

(Continued from page 4)

per foot accumulated over long lengths so that code pulses were rounded off, blending into each other, causing havoc at the receiving end. When an RS-232C signal changes from one condition to the other, the specification limits the amount of time in the undefined region to 4 percent of a bit period. That requirement determines the maximum amount of stray capacitance allowable in a cable, because the capacitance stretches the rise time of the signal. RS-232C specifies that the capacitance must not exceed 2500 pF. Since the cables generally used for RS-232C have a capacitance of 40- to 50-pF per foot, RS-232C limits cables to 50 feet approximately. That distance is reduced by noise pickup from AC lines.

The capacitance of the ribbon cable increases when the ribbon cable is bunched, folded, or rolled, or placed next to a metal conduit or AC line. What to do? You could reduce the overall length of the cable and be more careful about the path taken by the cable, but I'm sure you have tried that. Try lowering the baud transmission rate. Nice things begin to happen as you reduce the data rate from 9600 bps (bits per second) to 300, or lower. The lower rate reduces the overall effective transmission-line capacity

Also, your signal ground may be poor by not having enough copper in it. Beef it up by adding several unused wires in the ribbon cable in parallel with the existing signal ground wire (pin 7).

Another option is to use current-loop technique for data transmission that is permitted and provided for in many I/O serial boards and defined in RS-232C. Beyond this advice, I propose using modems.

What Is It?

What is the difference between a Zener diode and an avalanche diode? Can they be used interchangeably?
E.N.—Moonachie, NJ

Technically, if a Zener diode breakdown voltage is above 8 volts, it should be called an avalanche diode. Differences are noted in the negative or positive temperature-coefficient characteristics of the PN junction. But who cares 99.99 percent of the time.

Make a 7805 Yourself

Integrated circuits are nice for lazy builders; however, I'd like to build a 5-volt DC regulated circuit where I substitute discrete circuit parts for the circuit that is used in the 7805. What is your opinion?
R.M.—Bothell, WA

My dad said that I should never ask a question that requested an opinion. You know what opinions are worth on the open market! As for your project, I suggest you go the entire route on this one by first going to the beach and picking up some sand from which you can purify rods of silicon, etc. One of the prime advantages of the voltage-regulated IC, in fact any IC, is that it is cheeeeeper to buy and install than the many parts that are packaged within it.

Stick with technology, and develop new and useful applications from existing components!

A Short Question

What is "Noise Floor?"
T.H.—Larchmont, NY

Actually, your question was not that short—I made it short to keep our readers guessing! When you talk about background noise, you often resort to the words "noise threshold." That is the noise that is always present and from which the signal must rise over in order to be detected. Put all of this on the screen of a cathode-ray tube of a spectrum-analyzer, and you will see something that looks like grass at the bottom with some spikes pushing their way upward.

The term grass *defines the noise seen on the scope. Old radar operators referred to the noise as grass because the green phosphor gave it the appearance of a grass lawn. Modern-day technicians call this the "floor" or "noise floor," because any signal that occurs below it cannot be seen—it is lost! The spikes are those signals that are stronger than the noise and poke their outputs above the "noise floor." Gee, I like that kind of talk!*

Notes on Van deGraff Machine

I've played around with a large Van de Graaff machine and I have some ideas to share with anyone messing around with those things.

If you suspend the generator upside-down a few inches above a sheet of tin-foil and place a small foil fragment on the sheet, you can levitate the small fragment. It's attracted by "induction" and then repelled by like charging as it approaches the sphere, the result is that it floats in the air between sphere and plate!

Tape a "tower" of paper to the generator sphere and draw a line of india ink on the paper. When the generator is running, you can touch the ink and charge yourself without getting a zap. The dry ink forms a giga-ohm resistor that limits current without affecting the final voltage. *(Continued on page 107)*

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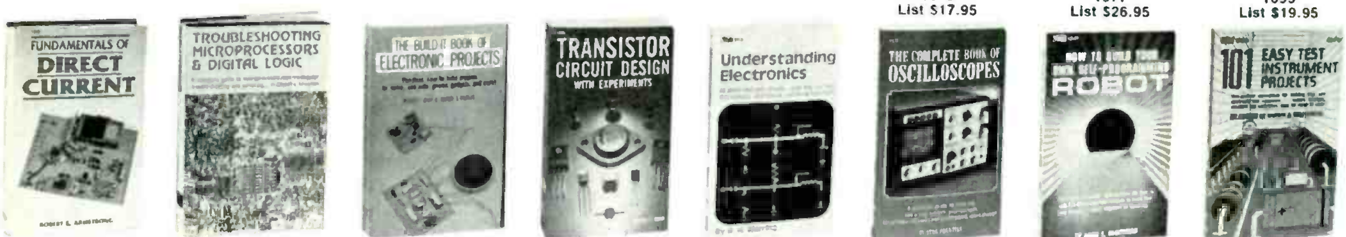

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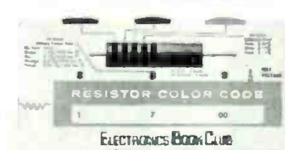

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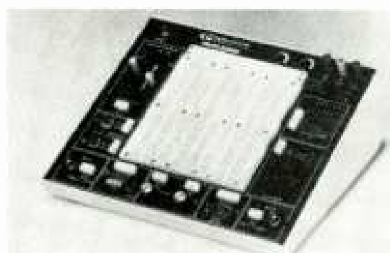
NEW PRODUCTS SHOWCASE

Prototyping Station

Global Specialties' PB-503 Proto-Board is a complete electronics prototyping station. It has a large, 3-socket breadboarding area and such conventional support features as a function generator, a variable-output power supply, and 8 LED logic indicators. Also built into the PB-503 are such frequently used circuit components as debounced pushbuttons, eight-position DIP switch, SPDT switch, 1000-ohm and 10,000-ohm potentiometers, a speaker, and two BNC connectors. Everything is connected to the breadboarding area through a PC board.



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With the PB-503 Proto-Board station, the experimenter can eliminate the tedious building of redundant circuits and connections from the prototyping function, and reduce the number of conventional support instruments required for test and verification.

For further information, write or call Global Specialties, 70 Fulton Terrace, New Haven, CT 06512; or telephone 203/624-3103. The PN-503 suggested retail price is $275, and is available through distributors throughout the North American continent.

Peripheral X-10

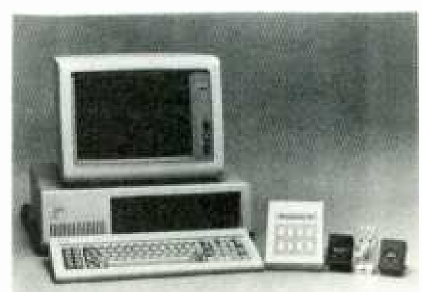
X-10 (USA), Inc. has a peripheral system for IBM-PC computers; it can operate lights, appliances, heating systems, and other electrical devices automatically by remote control. Called the X-10 Powerhouse, it can separately control dozens of devices and can automatically change the daily operating schedule of each device.

Powerhouse works with the System X-10 products, and it is suitable for home, business, and commercial uses. The peripheral is currently available for Apple IIc/IIe and Commodore 64/128 computers.

PC users will find Powerhouse software similar in use to popular spreadsheet software. Setting up the control system is fast and easy, and changes can be made at any time. The software permits 24-hour, 7-day programming, so that day-to-day schedules can be different if desired. (This feature is useful in security, energy-saving, and production applications.) The software tells the user how to select the lights, TV's, stereos, air conditioning and heating systems, and any other electrical devices to be controlled. The brightness of any incandescent light can be set to a selected level.

As the user selects devices and timing schedules, the computer loads the information into Powerhouse's memory, and Powerhouse runs the entire control system according to the stored information. A 9-volt battery protects the controller's electronic memory and powers its self-contained clock, either during a power outage or when someone unplugs the unit to move it to another location.

The Powerhouse controller, which plugs into a typical electrical outlet, works by sending signals over the regular home AC wiring to X-10 remote-control modules anywhere in the home. Like earlier X-10 home-control products, the system requires no additional wiring and can be quickly installed by homeowners or renters. Lamps and appliances, plugged into control modules (which in turn are plugged into wall outlets), are controlled by Powerhouse signals. As an added convenience, the Powerhouse console has rocker switches that provide instant manual ON-OFF control of eight lights or appliances.



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Powerhouse will be available in computer and electronics stores at a suggested list price of $150. The purchase price in-

(Continued on page 12)

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New Product Showcase

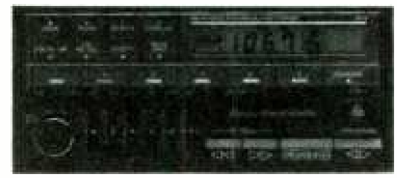
(Continued from page 8)

cludes the programmable interface/controller, software on diskette, and a cable to connect the controller to the computer. The controller is self-powered and, once programmed, can be disconnected from the computer, leaving the PC free for other applications. Further information can be obtained from X-10 (USA), Inc., 185A LeGrand Avenue, Northvale, NJ 07647; or telephone 800/526-0027.

Car Stereo with GM-Chassis

Mitsubishi Electric's Mobile Electronics Group has two high-power, in-dash-cassette receiver systems designed to fit more than 90 percent of recent GM models. Designated the JX-3 and the JX-2, these car-stereo systems provide either 100-watts or 60-watts total power *rms* maximum at four ohms, respectively. The units feature Mitsubishi's three-stage tuner circuitry, which automatically clears FM stereo signals to their optimum reception level and monitors and suppresses interference from signals caused by strong transmissions from nearby stations. Stereo Reception Control (SRC) provides automatic and gradual phasing to monaural broadcasting as FM-stereo signals weaken.

Mitsubishi's JX-2 (above) and JX-3 (below)



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The JX-3 features both AM stereo and FM stereo reception. It has an easy-to-read digital LCD display that shows frequency selections and features switchable display/clock priority. Electronic-programmable 18-station memory provides 12 FM and 6 AM station pre-sets. Additional features include six-position graphic equalizer, auto-loudness, fader/balance controls, OEM wiring harness connector, and Mitsubishi's audible mode acknowledgement that tones when mode selections are made.

The JX-3's cassette player has Dolby B noise reduction, auto-reverse, locking fast-forward and rewind, and tape-direction indicator. The suggested retail price of the JX-3 is $349.95.

The JX-2 with 60-watts maximum *rms* at 4-ohms provides Dolby B noise reduction and separate bass and treble control. Its suggested price is $279.95. Both products are available in most consumer electronics outlets in North America.

Canon Software and Hardware

Canon is making its series of personal computers (mini-floppy disk model, hard-disk model, and a transportable model) even more useful when used with CanoWriter II +, Canon's own word-processing software. CanoWriter I + is an easy-to-use package and provides more power than most word processors.

CanoWriter II + includes standard editing features such as a glossary and 67,000-word dictionary for spelling verification and correction, as well as index, table of contents and word-list generators.

(Continued on page 14)

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New Product Showcase

(Continued from page 12)

A page-layout function eliminates trial printouts by allowing the user to view the document position during the editing process. Several advanced features, such as extended character set generation, and use of key macros to eliminate repetitive data entry, are also available with CanoWriter II +.

With the CanoWriter II + complementing the Personal Computer A-200 Series, Canon is able to meet all printing requirements with its complete line of printers highlighted by the Laser Beam Pringer and including Impact Matrix Printers, Ink-Jet Printer and a Thermal Transfer Printer.

PC Line Tamer

Shape Magnetronics has added 450-VA and 600-VA Personal Computer Line Tamer power conditioners to its line of products designed specifically for desktop computers. Like the original 150-VA and 300-VA Personal Computer Line Tamers, the two new units protect PC's and peripherals from 99.5% of all power-source aberrations for little more than products that do much less.

Personal Computer Line Tamers meet IEEE Std. 587, Cat. A and B for surge suppression while providing complete power conditioning. They remove spikes, transients, common and transverse noise,

CIRCLE 943 ON FREE INFORMATION CARD

provide line isolation, and protect against surge, undervoltages and overvoltages by providing constant-voltage, clean power to the computer.

The 450-VA and 600-VA Personal Computer Line Tamers have 6 rear-panel plug receptacles, a six-foot power cord, and a front-panel power switch. The attractive bone-color case fits into any environment, home or office.

The personal Computer Line Tamer has no moving internal parts or electronic circuitry to cause untimely disruptions of valuable Line Tamer protection. Shape backs up the quality of its new products with a limited one-year warranty.

Personal Computer Line Tamers demand no minimum load, providing complete regulation and noise isolation from no load to full load. Isolation is complete from the power line, and response to changes in the power source is instantaneous.

Constant output with power from the Personal Computer Line Tamer is 120-volts AC. Noise rejection is 120 dB common mode; 60 dB transverse mode. Spike attenuation is 250:1, short circuit protection is approximately 200% of load current, and no damage will occur. The unit also offers EMI protection, and harmonics are rated at approximately 3%.

Suggested resale price for the 450-VA unit is $259; for the 600-VA unit, $299. For complete information on the new Personal Computer Line Tamers, call or write Shape Magnetronics, Inc., 901 DuPage Avenue, Lombard, Illinois 60148; or telephone 312/620-8394.

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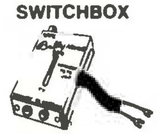

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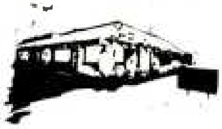

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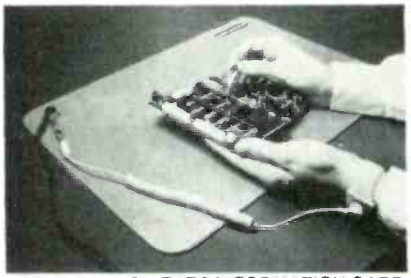

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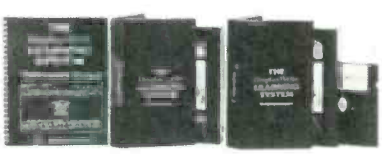
age suppression and dissipate a 5,000-volt static charge to zero in less than 0.05 seconds. Supplied with a pressure-sensitive adhesive on the underside for rapid and secure installation, the pads are cleanroom safe and can be used on existing nonconductive workbenches.

They come in 7 standard colors in two sizes: 24 × 36 and 24 × 48 inches, equipped with a ground cord and dual snap fastener for attaching conductive wrist straps. MicaStat Portable Pads are priced from $42 (list). Literature is available on request from Charleswater Products, Inc., 93 Border St., West Newton, MA 02165; or telephone 617/964-8370.

DisplayWrite Training Tape

MicroVideo Learning Systems has joined forces with Logical Operations, Inc., combining their experience and expertise to create interactive learning systems for specific programs, which are suitable for both individual, corporate, and classroom use. The first product of this joint venture is already available. It is the Displaywrite Learning System, an in-



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depth, 125-minute training package for IBM's leading word-processing software package. Logical Operations' extensive experience in teaching Displaywrite has been adapted, with the help of MicroVideo, to a video format and the result is a top-quality, highly-effective learning system. The package includes two video cassettes; a VideoGuide, which provides point-by-point reference to the videotape as well as detailed explanations of the entire process; and a Data Diskette, which, used in conjuncton with the tape, enhances the hands-on training experience by making it possible to work with the actual program during the course. The Displaywrite Learning System is currently the most in-depth and effective program available, touching on everything from document creation to merge printing

(Continued on page 103)

CABLE-TV

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SB ADD-ON UNIT	109.95	58.00 ea.
BRAND NEW — TRIMODE UNIT FOR JERROLDS	*Call for specifics*	
MINICODE (N-12)	109.95	58.00 ea.
MINICODE (N-12) VARISYNC	119.95	62.00 ea.
MINICODE VARISYNC W/AUTO ON-OFF	179.95	115.00 ea.
M-35 B (CH. 3 OUTPUT ONLY)	139.95	70.00 ea.
M-35 B W/AUTO ON-OFF (CALL FOR AVAILABILITY)	199.95	125.00 ea.
MLD-1200-3 (CALL IF CH. 2 OUTPUT)	109.95	58.00 ea.
INTERFERENCE FILTERS — CH. 3	24.95	14.00 ea.
JERROLD 400 OR 450 REMOTE CONTROLLER	29.95	18.00 ea.
ZENITH SSAVI CABLE READY (DEALER PRICE BASED ON 5 UNITS)	225.00	185.00 ea.
SPECIFY CHANNEL 2 or 3 OUTPUT	***Other products available — Please Call***	

Quantity	Item	Output Channel	Price Each	TOTAL PRICE
			SUBTOTAL	
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			COD & Credit Cards — Add 5%	
			TOTAL	

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Signature ______

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Pacific Cable Company, Inc.

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NEC Memory Chips

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[illegible]

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SOLDER TAIL DIP SOCKETS

- Single beam
- Low profile
- YOUR CHOICE TIN OR GOLD*

TIN PLATED SOLDER TAIL

Part No.	Description	1	10	100
[illegible]	8 pin solder tail, tin	.13	1.15	10.50
C8814	14 pin solder tail, tin	.15	1.45	12.00
C8816	16 pin solder tail, tin	.17	1.60	13.00
C8818	18 pin solder tail, tin	.20	1.90	17.00
[illegible]	20 pin solder tail, tin	.23	2.10	20.00
C8822	22 pin solder tail, tin	.25	2.25	21.00
C8824	24 pin solder tail, tin	.28	2.50	24.00
C8828	28 pin solder tail, tin	.32	2.90	27.00
[illegible]	40 pin solder tail, tin	.46	4.20	39.00

GOLD INLAY SOLDER TAIL

Part No.	Description	1	10	100
[illegible]	8 pin solder tail, gold	.34	3.20	30.00
C9814	14 pin solder tail, gold	.44	4.20	40.00
C9816	16 pin solder tail, gold	.50	4.70	45.00
C9818	18 pin solder tail, gold	.57	5.40	52.00
C9820	20 pin solder tail, gold	.63	5.80	57.00
C9822	22 pin solder tail, gold	.70	6.60	64.00
C9824	24 pin solder tail, gold	.76	7.20	70.00
C9828	28 pin solder tail, gold	.79	7.50	73.00
[illegible]	40 pin solder tail, gold	1.12	9.80	97.00

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Part No.	Description	1	10	100
[illegible]	8 pin wire wrap, tin	.38	3.60	34.00
C8114	14 pin wire wrap, tin	.50	4.50	40.00
C8116	16 pin wire wrap, tin	.57	5.60	56.00
C8118	18 pin wire wrap, tin	.69	6.70	65.00
C8120	20 pin wire wrap, tin	.76	7.50	74.00
C8122	22 pin wire wrap, tin	.83	8.20	81.00
C8124	24 pin wire wrap, tin	.91	8.90	[illegible]
C8128	28 pin wire wrap, tin	1.04	10.30	102.00
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

GOLD INLAY WIRE WRAP

[illegible]

Silicon Transistors

[illegible]

1 AMP SILICON RECTIFIERS

[illegible]

3 AMP SILICON RECTIFIERS

[illegible]

5% Carbon Film Resistors

Available in 1/8, 1/4 & 1/2 Watt

Wattage Rating	1/8W	1/4W	1/2W
Max. Working Voltage	200V	250V	350V
Rated Ambient Temp.		70°C	
Operating Temp. Range		-55°C to +155°C	
Dimension "L"	3.80	6.50	9.50
Dimension "D"	1.50	2.30	3.20
Dimension "d"	0.45	0.60	0.60

5% Carbon Film Resistor Values in Ohms - 1.0 to 4.7M

How To Order: Take any standard resistor value (i.e. 3.2) and add an "E" for 1/8 watt, or a "Q" for 1/4 watt or an "H" for 1/2 watt (i.e. 3.2Q for 3.2Ω 1/4 watt). This is the Digi-Key part number.

Pricing	5	200	1000
1/8 Watt	.25	6.40	25.00
1/4 Watt	.25	3.40	13.00
1/2 Watt	.25	3.50	16.00

1/8 Watt Carbon Film Assortments

RS112 5 each of the 73 standard values in series 1.0, 1.2, 1.5, 1.8, 2.2, etc. through 1.0M (365 total pcs.)

RS212 5 each of the 72 standard values in series 1.1, 1.3, 1.6, 2.0, 2.4, etc. through 910K (360 total pcs.)

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RS125 5 each of the 73 standard values in series 1.0, 1.2, 1.5, 1.8, 2.2, etc. through 1.0M (365 total pcs.)

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1/2 Watt Carbon Film Assortments

RS150 5 each of the standard values in series 1.0, 1.2, 1.5, 1.8, 2.2, etc. through 1.0M (365 total pcs.)

RS250 5 each of the standard values in series 1.1, 1.3, 1.6, 2.0, 2.4, etc. through 910K (360 total pcs.)

1% Metal Film Fixed Resistors

Available in 1/4 Watt

[illegible]

5% Metal Oxide Film Resistors

[illegible]

5% Wirewound Rec. Resistors

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RS406 3 each of values 100Ω to 2.0KΩ (96 total pcs.)

10 Watt Resistor Assortment

R110 2 each of all standard values (168 total pcs.)

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[illegible]

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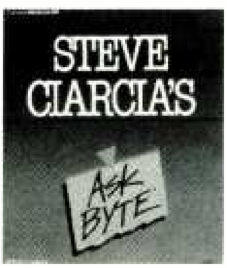
BOOKSHELF

By Barmard de Backus

Steve Ciarcia's Ask *Byte*
Edited by Phillip R. Robinson, *Byte* West Coast Editor, with a foreword by Philip Lemmons, *Byte* editor-in-chief

Osborne/McGraw-Hill published *Steve Ciarcia's Ask Byte*, written by the renowned author of numerous books and two popular columns that appear monthly in *Byte* magazine: *Ciarcia's Circuit Cellar* and *Ask Byte*.

For years fans have regularly written Ciarcia with more questions about hardware and software than he can possibly answer in his columns. This



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new collection in *Steve Ciarcia's Ask Byte* includes many questions and answers that have never been published before.

With Ciarcia's solutions, readers can troubleshoot difficulties that affect their computer peripherals, accessories, and operating systems, as well as their computer hardware and applications software. Ciarcia's ingenious ideas provide readers with a greater understanding and appreciation of computing. As Philip Lemmons writes, "No one is better at explaining the intricacies of all the technologies associated with microcomputers."

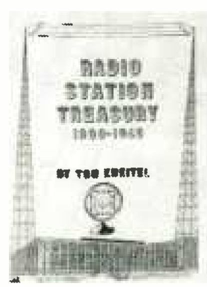
Published by Osborne McGraw-Hill, 2600 Tenth Street, Berkeley, CA 94710 and available at technical bookstores throughout North America. Soft cover, 323 pages, $14.95.

Radio Station Treasury 1900-1968
By Tom Kneitel

The roots of the current communications explosion grow deep into the past—a past that is both fascinating and little known to all but a few intrepid historians who delve into the early days of wireless and radio. Kneitel's new book, using faithfully reproduced rare archives, provides an in-depth view of wireless and radio stations as they evolved from the dawn of spark transmission, through the golden years of radio broadcasting, and right to 1946, the beginnings of the TV era.

Until *Radio Station Treasury*, there has never been a comprehensive directory chronicling these stations. A profusion of tens of thousands of frequencies, call signs, slogans, schedules, licensee data, locations, power, etc. It covers (worldwide) AM and SW broadcasters, "utes," point/point, press, aviation, maritime, police, federal, military, experimental, longwave, early FM/TV, secret WW II propaganda stations, and more!

This large (8-1/2- by 11-in.) reference sourcebook is packed cover-to-cover with a huge array of



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fascinating features and facts about stations in every nation and category, of every size and type.

The book is available at $12.95 per copy (plus $1 postage to USA/Canada/APO/FPO) from CRB Research, P.O. Box 56, Commack, NY 11725. (Canadian customers please submit payment by Postal Money Order made out in U.S. funds.) Softcover, 176 pages.

How to Design Circuits Using Semiconductors
By Mannie Horowitz

At last! An up-to-the-minute sourcebook that gives you all the practical details of today's semiconductor technology without overwhelming you with unwanted theory and superfluous information. It's a handbook designed for realistic workbench use by electronics experimenters and professionals who need to design semiconductor circuits for specific applications.

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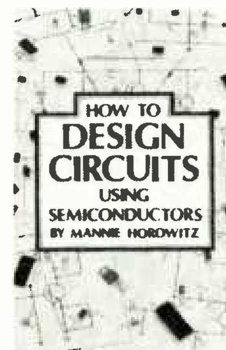
Get all the hands-on guidance you need to understand and use semiconductors in all kinds of devices, ranging from simple temperature-



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sensitive resistors to integrated-circuit units composed of multiple microcircuits! This book covers everything from the basics of semiconductor design right up through the techniques used to construct sophisticated solid-state devices.

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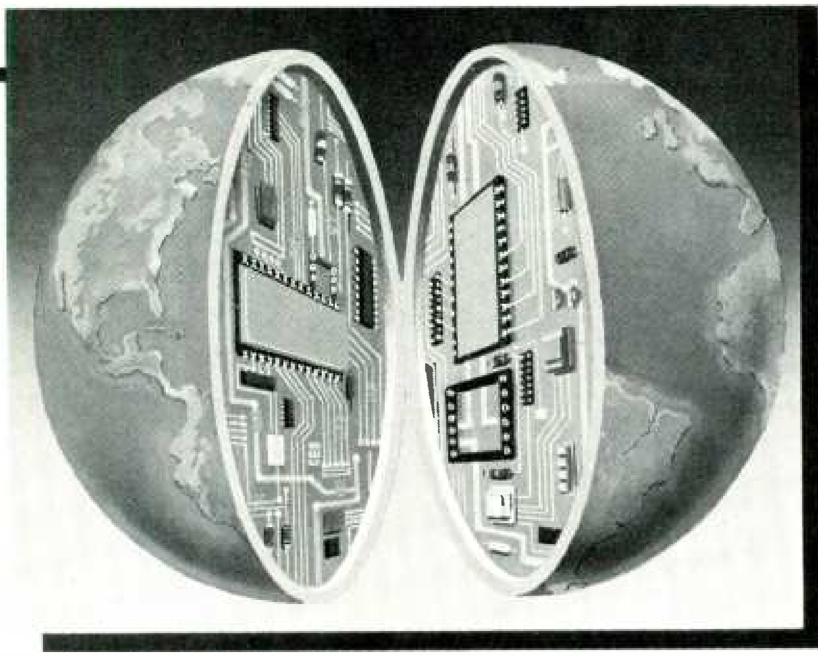
Locate the facts you need to design power supplies, transistor switching circuits, amplifiers, coupled circuits, digital electronic circuits, All the specific semiconductor circuits you need for any experiment, any design application!

For more information write to TAB Books, Inc., Blue Ridge Summit, PA 17214. TAB wil be happy to send their free catalog describing over 750 current titles. The text sells for $11.50, has 341 pages, and is paperback bound.

1986 Programmer's Market
Edited by Brad M. McGehee

Despite the "gloom and doom" reports on the future of the software industry, the good news is that the market is still growing, now at a healthy, instead of an explosive rate.

(Continued on page 22)



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Bookshelf

(Continued from page 18)

And the market for freelance programmers is better than ever. reports Brad McGehee. editor of the annual directory *Programmer's Market: Where & How to Sell Your Software*, which gives programmers current information on who's buying what.

Just published, the 1986 edition of *Programmer's Market* will be especially helpful to freelance programmers in finding publishing opportunities in today's software market now that the software explosion has tapered off. They'll find 700 software publisher listings (200 brand new) in this new edition, with complete details on who to contact—and how to approach them. Each of the listings of software, book, and

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magazine publishers includes contact name/address/-phone, plus the types of computers the company publishes software for and the kinds of programs they concentrate on—with examples of recently published packages.

Freelancers will learn the preferred format for submissions, usual response time, payment terms, and the number of submissions received and published in the last year. Comments and tips from editors give freelancers inside information on how best to get attention.

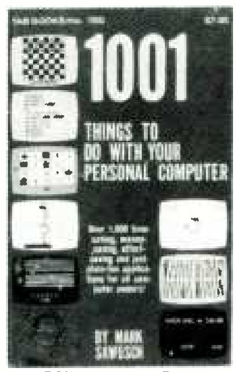
Five separate indexes allow programmers to look up software publishers by name, by the type of software they publish and by the microcomputer manufacturers they publish software for. Two additional indexes list the publishers that offer contract programming and technical writing opportunities.

1986 Programmer's Market (348 pages, softcover) is available at bookstores or from the publisher. To order direct, send $16.95 plus $2.00 postage and handling to Writer's Digest Books, 9933 Alliance Road, Cincinnati, OH 45242. Visa and MasterCard orders may be placed by calling toll-free 1-800-543-4644 (outside Ohio).

1001 Things to Do with Your Personal Computer By Mark Sawusch

If you own a home computer, or if you're involved using one professionally, you'll find this book a gold mine of applications! And, it's more than just an idea book—it contains actual programs, printouts, flowcharts, diagrams and illustrations to help you put these applications right to work.

Twelve Chapters contain programs



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for any and every use, and taste; and applications for literally anyone and everyone: business and financial, mathematical, technical and scentific, educational, statistical, control and peripheral, hobbies, and games, etc. There's also a chapter on artificial intelligence, its development and the future of personal computers.

You'll find it possible to use your home computer to calculate hundreds of complex problems-for example, precise values for camera settings. Plus there's all the information you need to write any program—or derivation from a given program—no mater how complex.

Just take a look at the Table of Contents, and you'll be truly impressed with the wide range of unique applications.

Mark Sawusch is an experienced computer programmer who has written a wide variety of programs in many computer languages. He has had a number of magazine articles published in computer magazines, and is currently employed by Florida State University in designing and writing programs. The book is paperback bound, 335 pages, and sells for $7.95. TAB Books is located at Blue Ridge Summit, PA 17214. Send for the free TAB catalog describing over 750 titles. ■

New Product Showcase

Tool Catalog

The latest catalog from Jensen Tools features the recent additions to the Jensen line of tools, tool kits, and test equipment. Included are the JTK-9 Service Kit, the JTK-33 Executive Tool Kit in compact size for home or auto, new designs in tools

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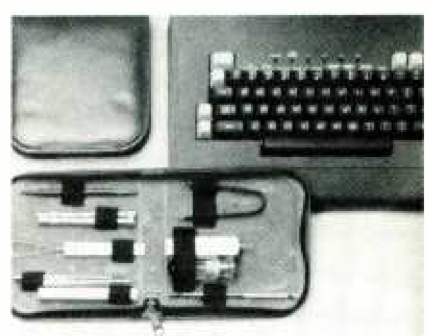
chests and cases, and many unique tools available only from Jensen.

Completely detailed and color illustrated, this free 82-page catalog contains *the right stuff* for every engineer and service technician. For a free copy write to Jensen Tools Inc., 7815 S. 46th Street, Phoenix, AZ 85044; or telephone 602/968-6241

Personal Computer Service Kit

Jensen Tools has designed a tool kit for owners of personal computers and related peripheral equipment. The JTK-9 PC Service Kit enables the non-technical user of most personal computers to remove and install unit covers, circuit boards, memo-



CIRCLE 957 ON FREE INFORMATION CARD

ry chips, cables and connectors, and to perform other routine maintenance tasks with ease.

The tool selection includes a screwdriver handle with four interchangeable blades (⅛-in. slotted, #1 Phillips screwdrivers; 3/16-in. and ¼-in. nutdrivers), CMOS safe IC insertion and extraction

(Continued on page 105)

SAXON ON SCANNERS

By Marc Saxon

Tips on tuning-in the railroads!

OFTEN OVERLOOKED IN THE CLAMOR to tune scanners on police, fire emergency, federal agency, and aeronautical frequencies are those channels used by railroads. Yes, the nation's railroads are heavy users of two-way radio; they've got all sorts of frequencies set aside for their exclusive use!

The frequencies used by the railroads are quite numerous and, for the most part, run between 160.215 and 161.565 MHz. Three additional frequencies (452.90, 452.925, and 452.95 MHz) are available, but seem to be used primarily in the larger terminal and yard areas. Some frequencies (between 452.325 and 452.875 MHz) are shared with truckers and not heavily used.

So-called "offset" frequencies in the UHF band may also be used, but they have not seen much activity thus far. Those frequencies lie between 452.3375 and 452.4875 MHz, also between 452.7625 and 457.9625 MHz. If these "offset" frequencies are in use at all, they are used by low-powered, short-range, hand-held transceivers.

So, for the most part, the place to listen is around 160 MHz; that's where you'll find most of the action. What action? Plenty!

Where to Be!

It helps for you to be within receiving range of railroad operations. That means, your base receiver should be located within at least 25 miles (in any direction) of tracks that are in use. An antenna high on your roof will add a few more miles. Of course, if you're lucky enough to have a hand-held scanner, you can travel to the scene of the action.

It's possible to tune in on the train crews communicating with one another and with various stations, offices, and switching stations. You'll hear dispatchers, yardmasters, freight-loading personnel, repair shops, and the crews who maintain the right-of-way (the tracks).

And, of course, you'll hear the special agents, better known as the railroad police (sometimes called bulls). Special Agents with the larger railroads operate in much the same manner as regular police departments. The fact is that some railroad police have full police powers and can exercise those rights on matters unrelated to railroad operations.

Almost all modern scanners have a scan/search mode; so your best bet is to start at 160.215 MHz and search back and forth between there and 161.565 MHz. There are more than ninety frequencies in

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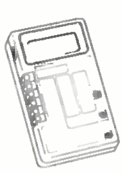

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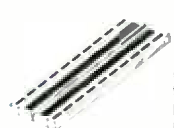

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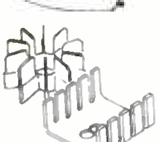

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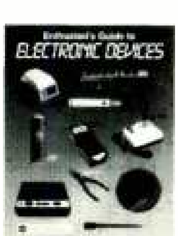

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Saxon on Scanners

(Continued from page 23)

that band and, unless you live in the middle of nowhere, you should be able to spot at least several active channels. Naturally, if you're near a major metropolitan area where several railroads converge, you've got it made, as there may be loads of activity all over the band!

Although major railroads each use numerous frequencies over the full extent of their route, here's some you might wish to check out if you're located near their operations area: Amtrak (N.E. corridor) on 160.245, 160.305 160.365, 160.545, 161.55; Santa Fe Railway: 161.205; Illinois Central: 161.205; Denver & Rio Grande: 161.19; Southern Pacific: 160.86; Southern Railway: 160.245, 160.83; Grand Trunk: 160.775; Conrail: 160.56; CN Rail: 160,545; CP Rail: 159.885; B&O: 160.875, 161295; The Milwaukee Road: 161.235; Union Pacific: 160.74, 160.77; Cotton Belt: 160.41, 160.455; and Norfolk & Western: 160.62, 161.01.

That was only the smallest sampling, just to get you started if you're within range of where those frequencies might be active. There are well over 800 different railroads (large and small) operating in North America, and a list of their communications activities covers about 4,200 frequencies. There are several railroad-frequency directories available to the scanner owner; the one that looks to be the most inclusive and thorough is *Rail-Scan*, $7.95 (plus $1 postage to USA/Canada/APO/FPO) from CRB Research, P.O. Box 56, Commack, NY 11725.

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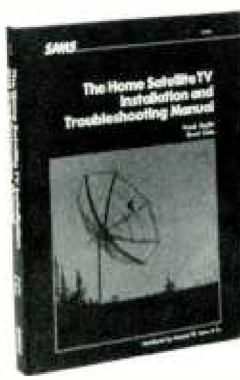

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This complete but elementary guide leads you through the electronics and basic steps of troubleshooting for this popular consumer product. It features a detailed description of the major components of a microwave, how the components operate, and the common problems that can occur. It includes a useful section on preventive maintenance and cleaning. The more experienced technician will appreciate the section on advanced repairs and adjustments. For easy reference, a special appendix listing manufacturers and parts is included. No. 22481, $19.95

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Scanner Report

We came across a nifty scanner that you'd probably like to know about. It's called the Regency Z60.

This unit is especially interesting because it offers numerous features without looking like Master Control at the Goddard Spaceflight Center. If you've been looking around for a full-feature scanner

Looks good enough to listen to—the Regency Z60 is a fully programmable, 60-channel scanner with built-in FM.

that you can put on your living room bookshelf along with the stereo, then the Z60 may be just the ticket for you.

No pantywaist, the Regency Z60 carries within its circuitry a full 60 channels and a built-in alarm clock! In addition to the standard six public-service bands and the VHF aero band, the Z60 also brings in the FM broadcast band (you can pre-program your favorite ten FM broadcast stations into the memory).

Fully programmable on all bands (no crystals—hurray!), the Regency Z60 has search/priority channel features, permanent-memory system, dual-level display with prompting messages, and scan delay. And let's not forget that it's very snazzy and has contemporary-woodgrain cabinet styling. A built-in telescoping antenna does a good job for local reception, and if you're looking to reach out farther than that, there's a connector for an external antenna.

The Z60 "weighs" in at around $380, a reasonable price tag for all of these features. Look for it at your nearest Regency dealer, or check with the company for more details. Regency Electronics, Inc. is located at 7707 Records Street, Indianapolis, IN 46226-9989. ■

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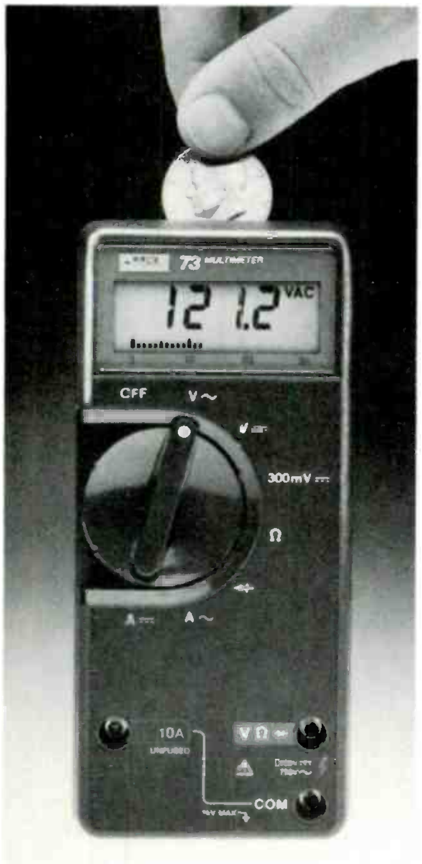

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By Don Jensen

JENSEN ON DX'ING

Tuning North—Canada Way!

☐SHORTWAVE BROADCASTING NORTH OF the border is dominated by *Radio Canada International*, the international voice of the publicly-owned Canadian Broadcasting Corp.

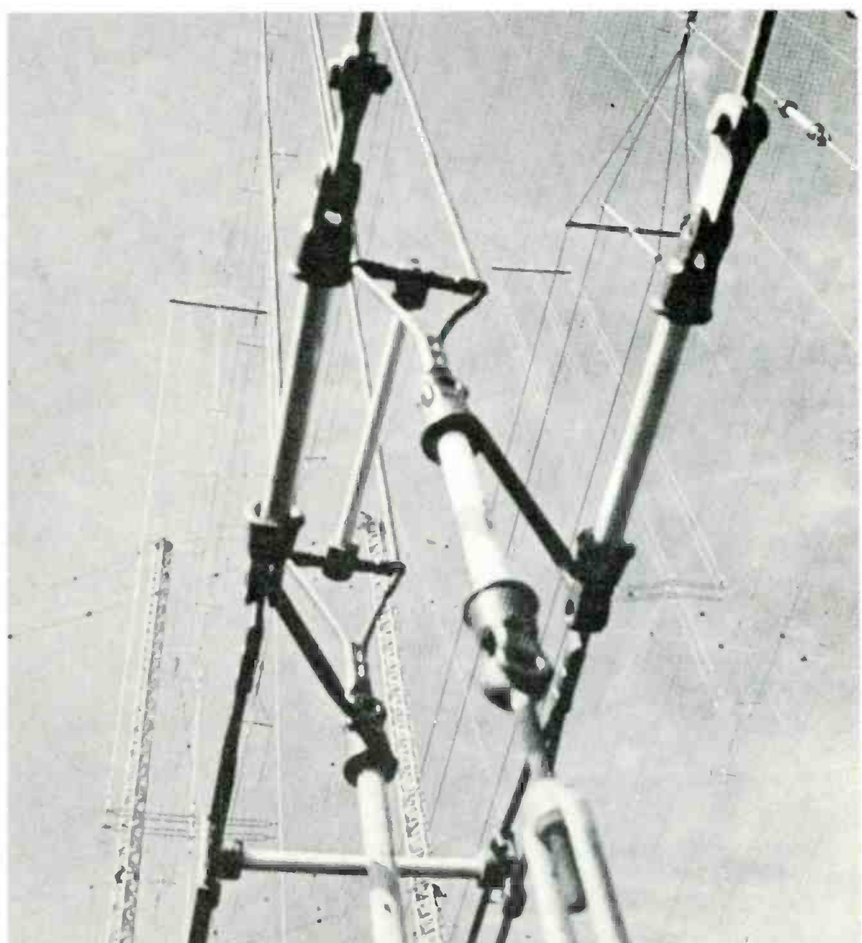
But just as U.S. shortwave is more than only the *Voice of America*, there's more to SW in Canada than RCI. In fact, there are a handful of small, low-powered Canadian shortwavers that offer some interesting listening.

Most shortwave listeners are familiar with the RCI programs. RCI's five 250-kw transmitters at Sackville, New Brunswick, on Canada's Atlantic coast, pump out strong signals on a number of frequencies easily received throughout North America. The station's programs also are relayed by leased facilities in England, Portugal, and Japan, providing worldwide coverage.

If you're not well acquainted with *Radio Canada International*, which has just celebrated its 40th anniversary of broadcasting, you can write for a free program and frequency schedule. RCI's address is P.O. Box 6000, Montreal, Canada, H3C 3A8.

Depending on where you live, Canada's smaller shortwave outlets can be "tough DX," quite difficult to hear regularly.

Perhaps the most challenging catch in much of North America is CKFX, 6,080 kHz, in Vancouver, British Columbia. But amazingly, under the right condi-



Although it looks like a plumber's nightmare, this collection of pipes, connectors, wires, and guys is really part of the curtain array station at Kigali, Rwanda in East Africa.

tions, this station—running only 10 watts of power—can be heard over a range of thousands of miles, from northern Europe to Down Under.

Like Canada's other low-powered private shortwave stations, CKFX operates 24 hours a day and relays the programming of a "big brother" medium-wave AM station. In CKFX's case, the country and western commercial programming originates with CKWX on 1130 kHz.

Originally, soon after World War II, the station "went shortwave" to provide radio coverage to remote areas of British Columbia. Today, though those areas are well served by the 50,000-watt CKWX, and the station management says that it has no intention of shutting down the flea-powered shortwave repeater.

Even though it runs 10 times the power of CKFX, for most North American SWL'S, CFVP is the hardest of the "little Canadians" to log. The "VP" in the call letters originally meant, *Voice of the Prairies*, a reference to the station's location in Calgary, Alberta, in the heart of Canada's flat wheatlands.

CFVP on 6,030 kHz runs a measly 100 watts of power, but its spot on the dial is unfortunately plagued with interference from other stations. Reception of CFVP is so seldom reported that listeners are tempted to conclude, despite reports to the contrary by station personnel, that it is on the air irregularly. But at one time or another the SW outlet has been logged by SWL's thousands of miles away, relaying programming of medium-waver CFCN.

Toronto is home to another of the private SW voices of Canada, CFRX. This station used a 1000-watt transmitter on 6,070 kHz.

The outlet relays the medium-wave programming of AM'er CFRB.

For listeners in the eastern part of North America, CFCX, operating from Montreal, Quebec, may be the best bet among the smaller Canadian shortwave stations.

It carries the programs of its MW counterpart, CFCF, using a 500-watt shortwave transmitter on 6,005 kHz.

And CHNX in Halifax, Nova Scotia, transmitting with 500 watts of power on 6,130 kHz, carries the programming of CHNS, its AM counterpart.

One reason that those Canadian stations tend to be more difficult to hear than RCI, of course, are their lower transmitter powers. But the difficulty is compounded by the fact they all operate in the midst of the crowded 49-meter band. To escape much of the interference, try tuning during the wee hours of the morning, when many of the interfering stations are silent—say between 0800 and 1100 UTC/GMT.

ABBREVIATIONS

AM	amplitude modulation (modulated)
CST	UTC +6 hours
EST	UTC +5 hours
FM	frequency modulation (modulated)
FM'ers	FM broadcasters
kHz	kiloHertz (1000 Hertz or cycles)
kW	kilowatt (1000 watts)
MST	UTC +7 hours
PSC	UTC +8 hours
QSL	verification reply from broadcaster
RDI	Radio Database International
SW	shortwave
VOA	*Voice of America*
UTC	Universal Time Code
VOFC	Voice of Free China
WWII	World War II (1939-1945)

Shuttle Talk

"I read with much interest your article "Tuning in on Shuttle Communications," (**Hands-On Electronics**, Summer 1985), writes Dave Anderson, "and I'd like to pass on some additional information."

Dave, WA3WZX, of Ellicott City, MD, says that at a local hamfest in the Bal-

(Continued on page 28)

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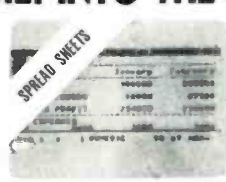

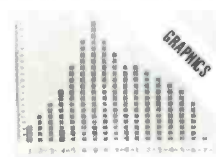

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Jensen on DX'ing

(Continued from page 26)

timore area, he picked up some information about Space-shuttle Communications.

The Goddard Amateur Radio Club at NASA's Goddard Space Flight Center, Greenbelt, MD, retransmits live Space Shuttle communications (during Shuttle flights) through its club ham station, WA3NAN.

During the missions of the four shuttle craft, *Challenger, Discovery, Columbia*, and *Atlantis*—currently on a schedule of about one flight every month or so—SWL's can listen in to the communications via WA3NAN on 3,860, 7,185, or 14,295 kHz. The transmissions are in the single-sideband (SSB) mode.

Listeners in the Baltimore-Washington, DC area can hear the same retransmission by WA3NAN on 2-meter VHF FM, 147.450 MHz. The ham club's Shuttle-communications links do not operate during the astronaut sleep periods nor during Department of Defense classified missions.

For more information about the special WA3NAN transmissions, Dave notes, readers may contact Pat Kilroy, WD8LAQ, public information officer for the Goddard Amateur Radio Club, P.O. Box 86, Greenbelt, MD 20770.

ANARC Updater

The Association of North American Radio Clubs (ANARC) is an umbrella organization linking 17 different shortwave, medium wave, longwave, VHF/UHF, TV and FM listening hobby clubs in North America.

It was founded in 1964 by the author as a non-profit organization to promote closer ties among radio clubs, promote the interchange of ideas and information among member clubs, to work for the common good of the listening hobby and to provide a medium to speak out for clubs and listeners.

ANARC's executive secretary currently is Richard T. Colgan, 8120 Ripplewood Drive, Austin, TX 78758.

A monthly newsletter is published by ANARC. A sample copy is available for 60 cents and a business-sized, addressed, stamped, envelope in the U.S., 75 cents in mint stamps in Canada. *always use commemorative stamps whenever you can. You may run into a stamp collector like the Editor*—Editor)

If you'd like the ANARC Club List, which gives membership details for the 17 affiliated clubs in North America, the cost is 25 cents in the U.S., or 60 cents in mint stamps in Canada.

The address for the sample or club list is ANARC Newsletter, 1500 Bunbury Drive, North Whittier, CA 90601.

For readers with personal computers and modems, ANARC offers a new informational service—a computer bulletin board. The message bases include a mailbox, questions, technical topics, buy and sell equipment, DX news, QSL section and others.

For details, write Bill Krause, 4397 29th St., SE, Rochester, MN 55904. Enclose a SASE for a reply.

Down the Dial

What are our shortwave listening reporters hearing these days? Let's take a look. All frequencies are in kilohertz; times are in UTC (EST + 5 hours; CST + 6 hours; MST + 7 hours or PST + 8 hours):

Japan—3,910, Far East Network serves the members of the U.S. Armed Forces in the Orient with 10-kW shortwave transmitters in Tokyo. The station can be heard on this frequency, and on a parallel channel, 6,155 kHz, around 1100 UTC/GMT. Programming, of course, is in English.

Burkina Faso—4,815, *Radio Burkina* is the government shortwave station at Oaugadougou, capital of the West African country which used to be called Upper Volta. This station signs on about 0600 UTC/GMT. Much of the programming is in French and the African music is great.

Chad—4,904, *Radiodiffusion Nationale Tchadienne* is another West African broadcaster widely heard recently, also with French programming and African "highlife" music. Try this one at 0500 UTC/GMT sign-on.

French Guiana—5,950, the relay station of *Radio France International* at Montsinery, French Guiana, puts through a very strong signal in North America. Want to practice your French? You can hear a French newscast at 0130 UTC/GMT.

Saipan—9,665, KYOI is a commercial station broadcasting pop programming to Japan from the American island of Saipan in the Pacific. You can tune this station around 1700 or 1730 UTC/GMT. Most programming is in Japanese, but some English may be heard.

Credits—Dave Valko, PA; John Wilkins, CO; Bob Hill, MA; Dan Fisher, ME; Robert McDade, MD; Kenneth Sorensen, MN.

Drop me a line in care of **Hands-on Electronics**, Gernsback Publications Inc., 500-B Bi-County Boulevard, Farmingdale, NY 11735. ■

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Baffles, Boffles,

If you're thinking of building your own speaker system, "pour" the foundation before you erect the "building!"

WHILE EXPRESSING APPRECIATION FOR A PREVIOUS article on current hi-fi technology, a reader has entered a strong plea for a plain-language discussion of speakers and enclosures, both old and new. "Surely," he says, "a modern, fully sealed enclosure must *strangle* the speaker? And whatever happened to that very sensible concept, the 'boffle' box?" In his request, he adds: "I guess that my interest owes more to mechanical than to electrical engineering. What I'm trying to sort out is the effect of various type enclosures on the basic pumping action of a speaker." We'll refer to that concept later, but let's start at the beginning.

When an electrical drive signal is applied to a dynamic (moving coil) speaker, the cone moves back and forth in accordance with the instantaneous polarity, frequency, and amplitude of the signal. As the cone moves forward, it creates a layer of compressed air at the front, and rarified air at the back; as it moves backward, the reverse applies. The effect of pressure pulsing on the surrounding air can be compared to what happens when something disturbs the water in a still pond; waves can be observed radiating outward from the source, effectively dispersing and propagating the original energy over a wide area.

Variations in instantaneous pressure produced by a speaker cone in an invisible medium (air) are likewise dispersed and propagated in the form of sound waves.

Directional Effects

The pond analogy applies best to frequencies in the middle of the audio spectrum—from a few hundred to a few thousand hertz. Over that range, sound waves are propagated from an unmounted dynamic speaker substantially through the full 360°. Above about 4–5 kHz, however, as the sonic wavelength diminishes and becomes smaller than the frontal dimensions of the cone, propagation from an ordinary dynamic speaker becomes increasingly directional.

Depending, in part, on the size and shape of the cone, sound propagation to the sides diminishes, while that to the rear is shadowed by the housing and magnet structure. What remains is predominantly a *beam* of high frequencies, typically 20–40° wide, along the frontal axis of the cone.

At frequencies below about 600 Hz, however, the situation is different. With the cone moving in a given direction for a progressively longer period during each half-cycle, air under pressure on the one side of the cone has time to flow around the edge of the housing to relieve the partial vacuum on the other side. Instead of propagating a pattern of low-frequency sound waves into the surrounding atmosphere, much of the system energy is wasted in simply pushing air back and forth around the edge of the housing.

Figure 1 depicts the sound-propagation pattern of a typical (unmounted) full-range dynamic speaker with the highest frequencies projected as a beam, the median frequencies widely dispersed, and the lowest frequencies confined mainly to the immediate vicinity of the speaker cone. Clearly, if the reproduction is to sound reasonably balanced, it's essential to achieve better propagation at the bass end. That's mainly what this article is all about: "Baffles, Boffles, Boxes and Vents," and their influence on low-frequency response.

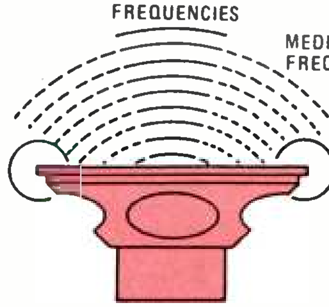


Fig. 1—The sound-propagation pattern for an unmounted full-range loudspeaker. Baffling is necessary to prevent low-frequency energy from being merely pumped back and forth around the edge of the housing.

Bass Roll-off

In their speaker literature, manufacturers of sound equipment describe the direct front-to-back path for bass energy as an *acoustic short-circuit*. It becomes evident at frequencies below that at which the distance from the front to back of the cone approximates one-half wavelength. (For an unmounted driver, I take it upon myself to suggest a mean distance between points at about half the driver radius.)

Below that region, the effective response falls at the nominal rate of 6 dB/octave, down to the system resonance. Below that, the slope steepens to 18 dB/octave, as shown in Fig. 2. It follows that physically large, unmounted speakers with a normally lower cone resonance exhibit better bass response than do their smaller counterparts—something that most listeners have noticed.

In fact, examples exist in commercial hi-fi systems and electronic organ speakers which, for bass response, rely primarily on jumbo size (and sometimes oddly shaped) cones, with only a modest amount of additional cabinet work. But while they may provide an interesting talking

*Original article appeared in Electronics Australia, June, 1985 edition, and reappears here by permission.

Boxes and Vents

By Neville Williams

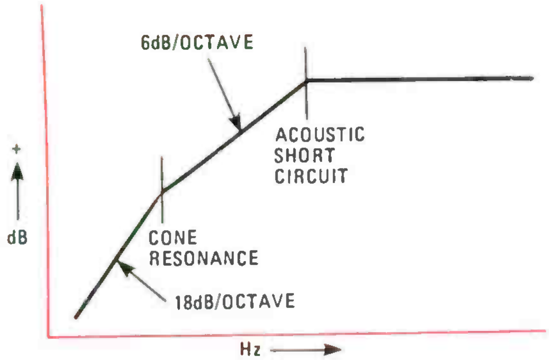
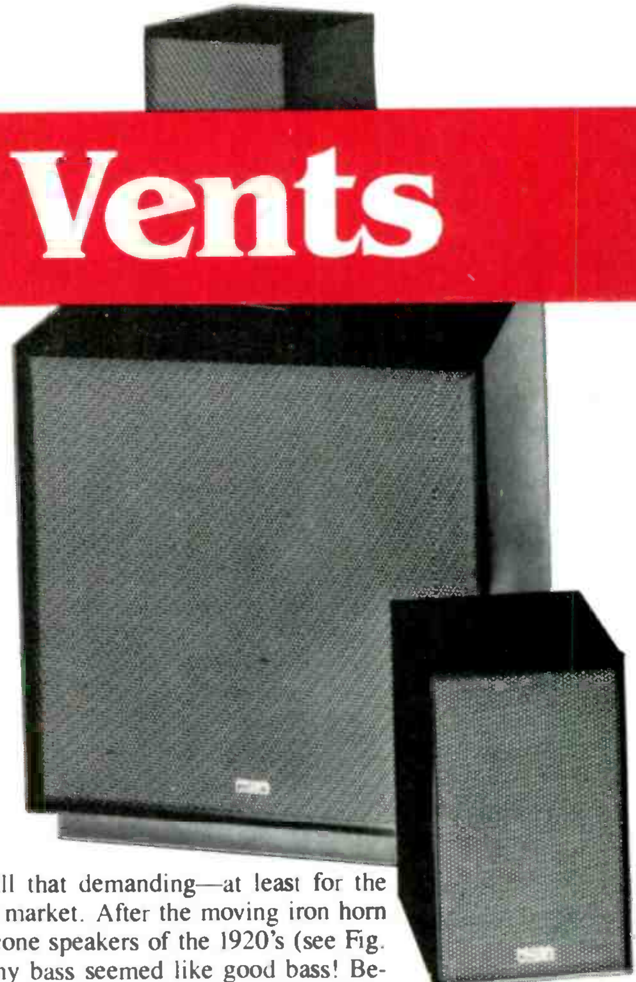


Fig. 2—The low-frequency response of an unmounted loudspeaker diminishes at about 6dB/octave in the region of acoustic short-circuit and by a further 12dB/octave below the cone resonance.



point, they can offer, at best, only a partial solution to the basic problem.

Baffling Essential

In the late 1920's, the potential for improved bass response was a major reason for the rapid adoption of dynamic speakers. It was accepted, however, that the raw-speaker would have to be mounted on a "baffle" of some sort for the advantage to be realized. The baffle might take the form of a rigid panel, possibly resting on the floor and/or mounted across a corner, to increase its effective area. Alternatively, the need might be met by an open-back radio cabinet, preferably as large and substantial as possible.

Either way, the basic purpose was to increase the path length between the front and rear of the cone, thereby, pushing the region of acoustic short circuit and low-frequency roll-off farther down range. However, aspirations at the time were not all that demanding—at least for the mass market. After the moving iron horn and cone speakers of the 1920's (see Fig. 3), any bass seemed like good bass! Besides, other factors had to be considered in a booming, highly competitive market: for example, supply, reliability, and price.

Sensitivity, too, was vital. In keenly priced, mass-produced models, that meant using a lightweight cone and a relatively short voice coil in a narrow magnetic gap. To maintain the voice coil central in the gap, and keep cone excursions within acceptable limits, suspension systems had to be relatively stiff. As a result, the majority of speakers ended up with a prominent (high Q) cone resonance, commonly above 70 Hz for 12-inch models and higher for their smaller counterparts.

When mounted in typical console radio cabinets, it was not unusual for the low-frequency response to meet with the cone resonance, which would then be heard loud and clear, resulting in the infamous "one-note bass" of the early 1930's. (See Fig. 4.) To curb it, designers came to rely on negative feedback in the amplifier to lower the impedance of pentode vacuum-tube output stages and provide a measure of electrical damping on the coil/cone system.

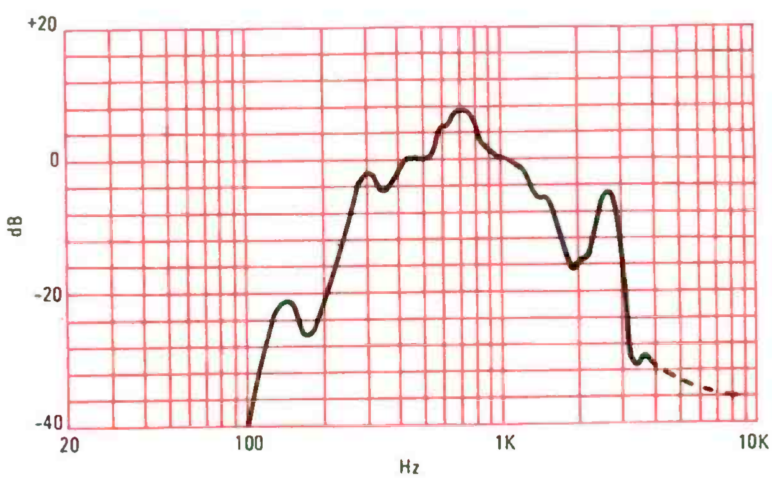
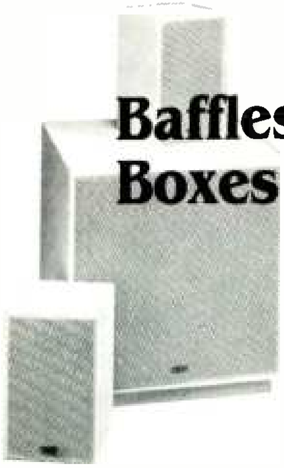


Fig. 3—The frequency-response curve of a typical old-time horn loudspeaker; bad enough, without even considering the distortion! It's of little wonder that dynamic speakers took over so rapidly.



Baffles, Boffles, Boxes and Vents

While budget-priced radio speakers, with suitable circuitry, may provide acceptable sound for general listening, their potential for use in a high-quality sound system is strictly limited, despite claims to the contrary over the years. In any case, what might have been rated as excellent in the days of indifferent signal sources could sound very ordinary in this, the digital era.

Hi-Fi Loudspeakers

With rare exceptions, the starting point for a good speaker system is a high quality driver(s), which have been available since the early 1930's. I still look back with a certain anguish to the big full-range Magnavox and Jensen models that I had to fit to other people's systems, but could not afford myself! Those units were followed by a variety of British and European models, including big-name brands like Goodmans, Wharfedale, Celestion, and Philips.

Best described as *general-purpose* hi-fi speakers, they were generously proportioned (12–15 inches in diameter) with specially molded cones, long-travel voice coils and suspension, and a large magnet structure to ensure high sensitivity and good electrical damping with (commonly) power-triode vacuum-tube output stages. Their bass resonance was down around 45 Hz, but so well damped and so broad that it was usually difficult to find fault with by ear.

They certainly sounded impressive in a deluxe console or, less commonly, on a large suitably styled baffle made from heavy timber or, in the Wharfedale manner, from plywood layers filled with dry sand.

Extended Bass

Still not satisfied, individual enthusiasts and a generation of dedicated English hi-fi manufacturers aspired to a still farther downward extension of the bass response, requiring the means to more effectively contain or control back radiation from the cone.

One logical—but not very practical—answer was to create an *infinite* baffle by mounting the speaker: **1**, in a dividing wall; **2.** in the door of a capacious cupboard; **3.** in the opening of an unused chimney, or **4.** through the ceiling. Apart from the structural implications, however, other matters had to be considered, like noise from the rear of the speaker, unequal air pressure on the respective sides of the cone—and hungry rodents! To quote Gilbert Briggs of Wharfedale: "Moral: don't use the mouse's living room as a speaker enclosure!"

So the tantalizing problem remained: how to devise an enclosure that would be self-contained, of practical dimensions and construction, and able to contain or control low-frequency radiation from the rear of the cone—without

Multi-directional Speakers

Conventional stereo speakers project sound toward the listener and are frequently judged on their ability to create a sharp, stereo image. Multidirectional speakers, on the other hand, are designed to project middle and high frequencies in a variety of directions, often deliberately bouncing the sound off adjacent and rear walls.

The claim is that it's subjectively more natural, pleasant, and relaxing to be surrounded by sound than to have it "squirted" at the listener from two sonically obvious sources. It's largely a matter of individual preference, but one thing is certain: An array of small speakers to disperse middle and high frequencies does not obviate the need for adequate provisions for the bass end. ■

"strangling" the speaker! What should be added is that, for the most part, the effort was concentrated around general-purpose hi-fi speakers, which (as a class) did not lend themselves to being crammed into practical-sized enclosures of any description!

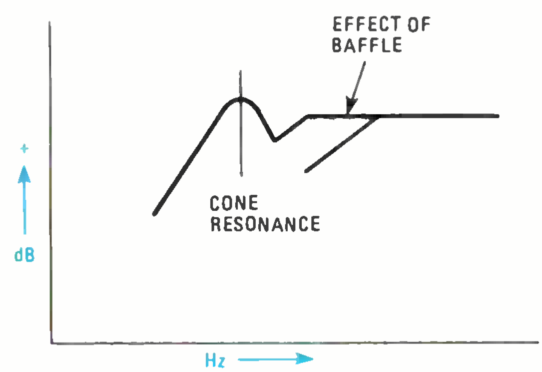


Fig. 4—Fitting a loudspeaker to a baffle pushes the 6dB/-octave roll-off further down in the range. The cone resonance can become very prominent, as a result, if it's not sufficiently damped by the associated amplifier.

The obvious starting point was a rigid, completely sealed box, still misguidedly described by some as an 'infinite" baffle. While it may indeed have contained back radiation from the cone, it was (and still is) anything but infinite in its effect on cone behavior. In particular, the body of air trapped behind the cone, alternatively compressed and rarified by cone movement, acts as a supplementary spring, tending to restore the cone to its median position. It has the effect of raising both the frequency and the "Q" of the cone's resonance—particularly apparent with large speakers in unduly small enclosures.

In the *mono* era (before the introduction of stereo), some enthusiasts nevertheless found it practical to accommodate a general-purpose hi-fi speaker in a single large enclosure—9 cubic feet or more—tolerating a modest 5–10 Hz rise in the bass resonance and restraining the "Q," if necessary, by partially filling or padding the enclosure.

Smaller Boxes?

With the arrival of stereo, 9-cubic foot enclosures were out of the question for most enthusiasts. Neither did they relish the idea of small sealed enclosures, with their potentially traumatic effect on the resonance of typical speakers, padding and filling notwithstanding. The *boffle* box represented one of many attempts to get around the dilemma. I've forgotten the finer details, but as I recall, they were about 18–20-inch cubes that were open at the back. But, behind the 12-inch speakers was a succession of panels and spacers, with a circular hole in each panel, progressively smaller towards the back.

The idea was that the panels would intercept and absorb mid- and high-frequency radiation from the rear of the cone and, thus, minimize standing waves in the box; and they probably did. But at the vital lower frequencies, their contribution would have been something of a gamble. Air partly trapped behind the cone could still affect the speaker's resonant frequency, while the residual direct front/back path would have imposed its own roll-off.

While acknowledging that some boffle boxes might have worked well with some drivers, in other cases, the results would have been very ordinary. Like jumbo-size cones, boffles provided an interesting idea but not a fundamental solution to the basic problem. See Fig. 7.

Among other approaches, popular at the time, was the acoustic labyrinth—an enclosure with internal partitions that formed a convoluted path for back radiation to a separate outlet port. The object was to achieve an approximate half-cycle phase delay through the labyrinth at selected low frequencies, such that the output from the port would reinforce direct radiation from the cone in the normal roll-off region.

Unfortunately, a suitably long acoustic path of sufficient cross-section, to work well with a large speaker, can itself be quite large. If shortened, it will reinforce the wrong frequencies. If narrowed, or filled with fibrous material, it may raise the resonant frequency of the cone and achieve little else. Much the same remarks apply to folded-horn enclosures. If well executed, they can be very good, even if rather large and expensive. But if scaled down in an effort to conserve space and cost, they become eminently forgettable!

Forgettable, too, are many other examples of the enclosure maker's art from the immediate pre- and post-war period, based on earlier work, hunches, observation, enthusiasm—and an imperfect understanding of the principles involved! Prominent in that group is an array of small, highly "doctored" vented systems.

Such creations are the product of an era in which those involved started out with a particular speaker (or system) and, thereafter, attempted (by empirical methods) to produce an enclosure to suit it. The inevitable result has been misinformation and confusion.

The Modern Approach

The present-day approach to hi-fi speaker and enclosure design is reminiscent of the old adage: "If you can't beat 'em, join 'em!" Instead of acquiring independently an ostensibly high-performance speaker (or system) and then trying (possibly against the odds) to devise an enclosure to go with it, the speaker (or bass driver) and enclosure are chosen and/or designed, from the outset, to complement each other.

The concept is not new but, over the past 20-odd years, mathematical analysis and computer programs have emphasized its advantages, transforming what was once a rather tedious and empirical procedure into an exact science. For a given speaker, it is now possible to predict system performance for a range of enclosure dimensions. Or, given certain enclosure specifications, a design can be derived for a complementary driver. Yet, for a certain performance target, the options for both driver and enclosure can be explored to discover the most practical combination—before any hardware is produced.

Computer aided design (CAD) has focused mainly on fully sealed and on reflex (vented) systems, both of which combine relative ease of construction with a wide range of options in terms of size, cost, and performance. Both can be presented as simple, rectangular boxes housing either a single full-range speaker or a complete multi-way system with a dedicated bass driver. Alternatively, they can be constructed in a

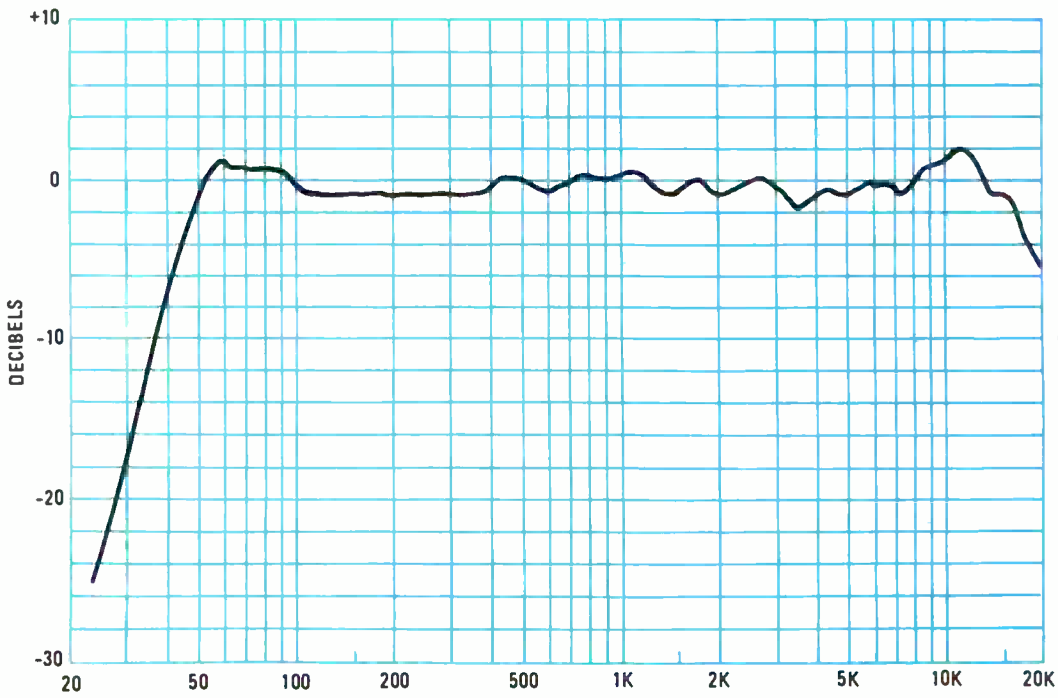
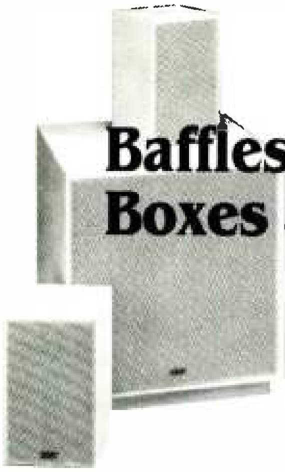


Fig.5—The frequency-response curve of a full-scale domestic loudspeaker system using Philips drivers and a Philips-designed, sealed enclosure. It could readily cope with low-end bass boost.



Baffles, Boffles, Boxes and Vents

variety of shapes, provided the correct volume is retained.

Sealed Systems

In the case of fully-sealed systems, the basic concept is to plan for a speaker (or a bass driver) with a deliberately soft (compliant) suspension and a deliberately low cone-resonance, typically below 30 Hz. Such a driver would be liable to damage by excessive cone excursion if used on a flat baffle, in an open-back cabinet, or an overly large sealed enclosure. But by mounting it in a suitably small enclosure, the stiffness of the entrapped air supplements that of the mechanical suspension, affording greater protection from overdrive and raising the resonance to a still low, but convenient frequency.

Instead of the enclosure strangling the speaker, as was formerly the case, it became an essential part of the suspension—completely containing back radiation and, thereby, solving the basic problem. For example, a typical large, 3-way speaker system marketed for commercial or home construction, includes a 12-inch bass driver with a cone resonance (unmounted) of 20 Hz. Installed in the recommended fully sealed 3.6 cubic-foot enclosure, the bass resonance rises to about 50 Hz, giving full output at that frequency and a useful response extending to below 30 Hz (see Fig. 5). Rated power handling capacity for the system is 100 watts typical.

At a more modest level, commercial sealed enclosures range downward in size to small bookshelf dimensions, often providing surprising performance for their size. They use proportionately smaller drivers, with a long-travel voice coil to permit high output, and rely heavily on the entrapped air to cushion the cone against excessive travel.

However, small, wide-range, fully sealed systems are, by nature, comparatively insensitive and require more drive than their larger counterparts to produce an adequate level of sound in the listening room. Fortunately, that seldom poses a problem with modern solid-state amplifiers.

One other point warrants a little spotlighting at this time: If a sealed enclosure has been optimally designed to complement a particular driver, it is unwise to arbitrarily increase the enclosure's volume with the idea of gaining extra bass response. The resonance of the system may indeed be moved to a lower frequency, but the "Q" of the system could also be lowered (as illustrated in Fig. 6), causing the response curve to drop, with a marginal loss, rather than a gain in useful response.

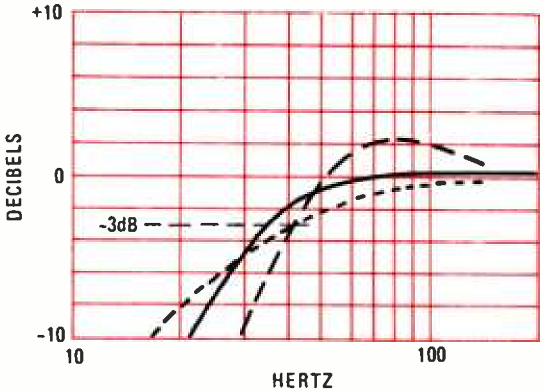


Fig.6—The solid curve shows the bass response of a critically designed, sealed enclosure. A too-small enclosure produces an undesirable peak (dashed), but too large causes the curve to droop (dotted).

Reflex Enclosures

Reflex or vented enclosures are a derivative of the historic Helmholtz resonator, involving an otherwise airtight cabinet, with a vent or tubular port, plus a mounting hole for a speaker. The volume of the enclosure and the dimensions of the vent are normally chosen so that mutual acoustic reso-

(Continued on page 102)

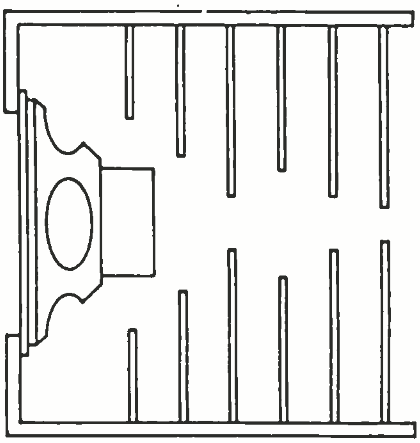


Fig.7—The "boffle" box used a succession of panels and spacers, with a circular hole in each panel, progressively smaller toward the back. The panels were designed to minimize standing waves in the box.

Linear Phase Speakers

In these systems, the treble-, mid- and low-frequency drivers are mounted on the front panel in such a way as to equalize, as far as possible, the distance from each cone to a listener seated in the optimum listening area. The purpose is to maintain the correct phase relationship between the frequency components of the reproduced sound, both to preserve its integrity and to optimize stereo imaging.

Special attention may also be paid to the dividing network in the system, with the same objective in view. The measures can be shown on instruments to have an effect on phase and wave shape, but whether the difference is significant, subjectively, is open to argument.

Either way, linear phase design does not modify the need to pay full attention to basic requirements for proper bass response. ■

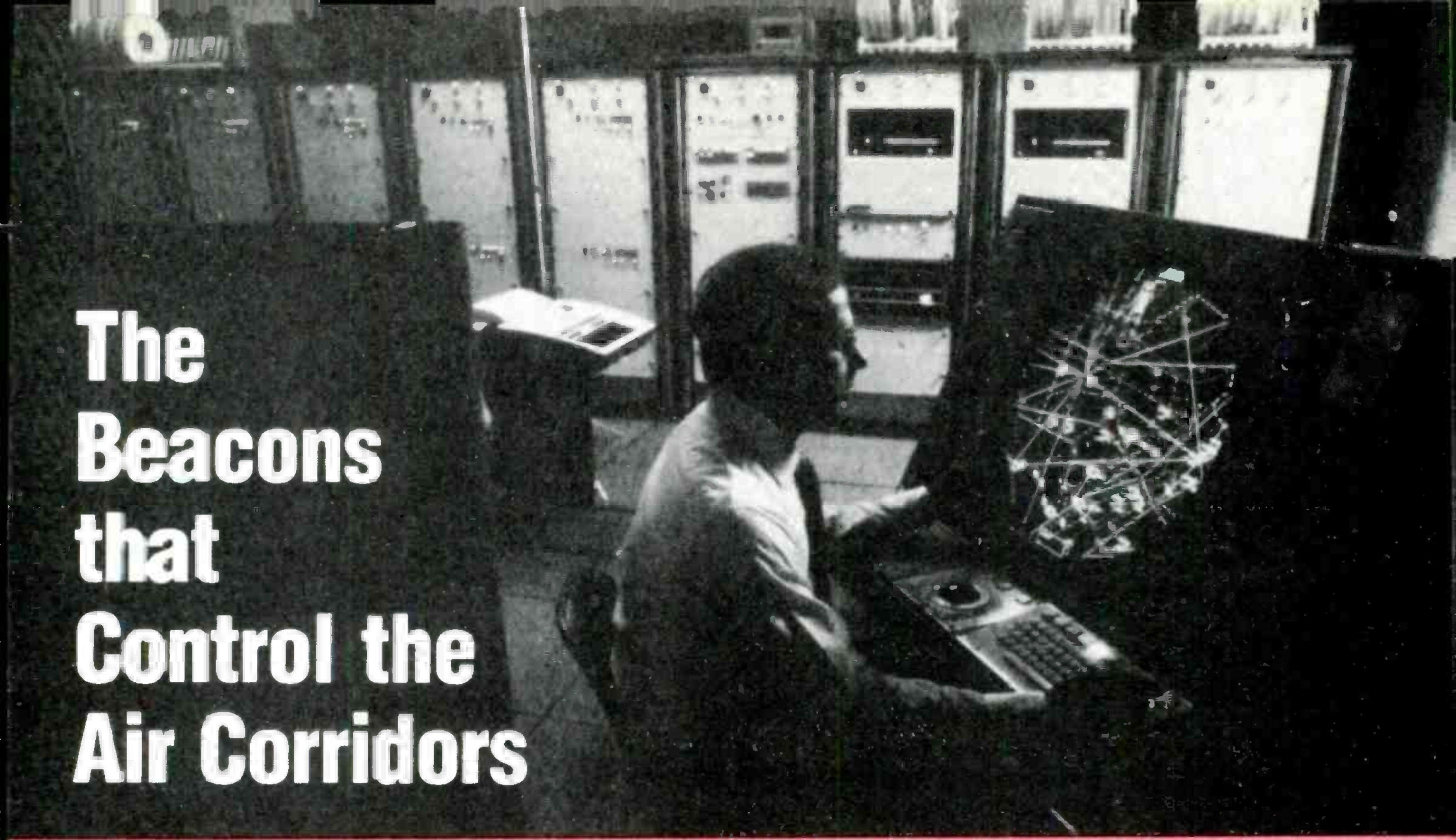


Photo courtesy Raytheon

The Beacons that Control the Air Corridors

Here's how air-traffic control radar systems work, and how they distinguish one aircraft from another.

By Jonathan Alan Gordon

EVER WONDER HOW AIR-TRAFFIC CONTROL SYSTEMS really work? How they identify one aircraft from another and then track each craft separately? Well, we'll explore how that's accomplished. And we'll also point out the differences between primary radar—the type most of us are familiar with—and beacon radar, which is used by air-traffic control installations. We'll follow up with an overview of a typical beacon system, a more detailed analysis of the hardware used to implement the system, and give special attention to the signal-processing capabilities and coding strategies used to make the system work.

Primary vs. Beacon Radar

Radar systems used by air-traffic controllers are specialized to locate and direct, and identify aircraft. Refer to Fig. 1. The *primary radar* system puts out a single pulse of high-energy RF, which is transmitted through a highly directional beam antenna along a specific azimuth (direction). The antenna, rotating 360 degrees at a rate of 6 rpm, emits RF pulses at a specific pulse-repetition frequency (PRF), which can average about 350 PRF. Because of the antenna's directional qualities, as it rotates, it can receive or transmit signals only along defined parameters, called the *boresight*. Only targets within the antenna's boresight will be struck by the radar's transmitted signal and reflect back a portion of that RF energy.

When the transmitted signal strikes the aircraft, energy is scattered in many directions, with some being reflected back to the radar's receiving antenna. The receiver detects the returned energy, called an *echo* signal, amplifies it, and then processes it to display the target's range and azimuth on a *plan position indicator*, or PPI.

The image seen on the PPI cathode-ray tube screen appears as a map of the region as seen by a bird flying high over the transmitter site. A straight line from the center of the display extends out to the edge of the circular display (called the *sweep*), rotating in step with the rotating antenna. When an aircraft 20-miles out is struck by the radar's transmitted signal, the echo reflects back to the antenna, and that echo is seen on the screen as a light blip at a distance from the center of the PPI proportional to the the distance the aircraft is from the radar. In this example, the 20-mile distance could equal 10 inches on the PPI. Unlike your TV screen at home, the phosphors on the PPI remain illuminated for a small fraction of a second so that the *blip* (echo) of the aircraft persists through two or three sweeps.

That's fine for the detection of an airborne craft, say, as an early warning system for the military but how do we identify friend from foe, or for that matter, who belongs and who does not? To combat that problem, a system (which was destined to later become known as IFF Beacon Radar, or Secondary Surveillance Radar) was devised by the military. In fact, the same technique is used in today's Air Traffic Control systems.

Such systems contain an electronic device known as an *interrogator* that transmits a coded signal in the form of three pulses that are spaced at precise intervals. A block diagram of the interrogator—a complex electronic system that codes the

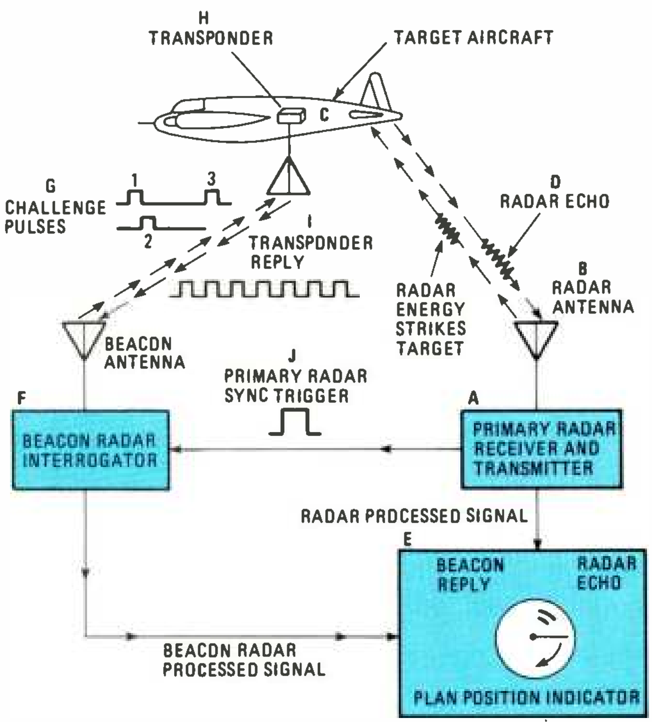


Fig. 1—Examples of primary and beacon radar are compared. Note that in the primary radar system, the transmitted signal is reflected from the target back to the source, and displayed on the PPI as a blip to indicate the target's location; whereas, in beacon radar, a challenge signal from the interrogator is picked up by the target, which then decodes the signal and sends a reply to the interrogator.

challenges, decodes transponder replies, takes care of input signal processing and timing functions, and then outputs target information to the PPI—is shown in Fig. 2. The interrogator outputs a signal called *radar challenge*. The challenge is not reflected back as in primary radar but, instead, is detected and decoded by a device called a transponder located in the aircraft.

The transponder (in the target craft) then transmits its reply in the form of 14 pulses, also spaced at precise intervals, which identifies the target. When the reply is received by the interrogator, it is decoded and displayed on the PPI as an identified target. Because each target can select its own identification code, beacon radar is often prefixed by SIF (Selective Identification Feature). Both primary and SIF beacon radar signals are often displayed simultaneously on the PPI. The primary radar provides a trigger to the beacon radar for just that purpose.

Of course, the beacon and primary radar antennas must rotate at the same speed and in the same direction, which is why they are often piggybacked together on the same pedestal. In short, the ground interrogator issues the challenge (asks the aircraft, "Who are you?"). The aircraft's transponder decodes the challenge and responds with a SIF reply from its own airborne transmitter that identifies itself to the air-traffic controller via the PPI.

Coder Function

Coding circuitry in the beacon-radar interrogator generates three pulses for each challenge mode. Figure 3 gives the various challenge modes and the type of communications for which they are used. Note that mode 3/A is common to both commercial and military. In addition to the modes shown, there is another, mode 4. Mode 4 is used for special military cryptographic coding of secure communications for the identification of friend or foe IFF beacon radar.

Each challenge mode consists of three pulses, P1, P2 and P3. The distance between pulses P1 and P3 determine the challenge mode. For instance, in mode 3/A, the P1 and P3 pulse period is 8 μs (microseconds). Regardless of the mode in use, each pulse has a width of 0.8 μs. The P2 pulse, designated interrogator side-lobe suppression (ISLS), is always 2 μs away from the leading edge of the P1 pulse. (More about the ISLS pulse later.) The P1 and P3 pulses are transmitted through the main beam antenna, while the P2 ISLS pulse is transmitted thru a separate omni-directional antenna. The P2 pulse tells the target craft whether it's in the high-gain boresight beam or one of the low-gain side lobes. The target craft replies only if it's in the boresight beam.

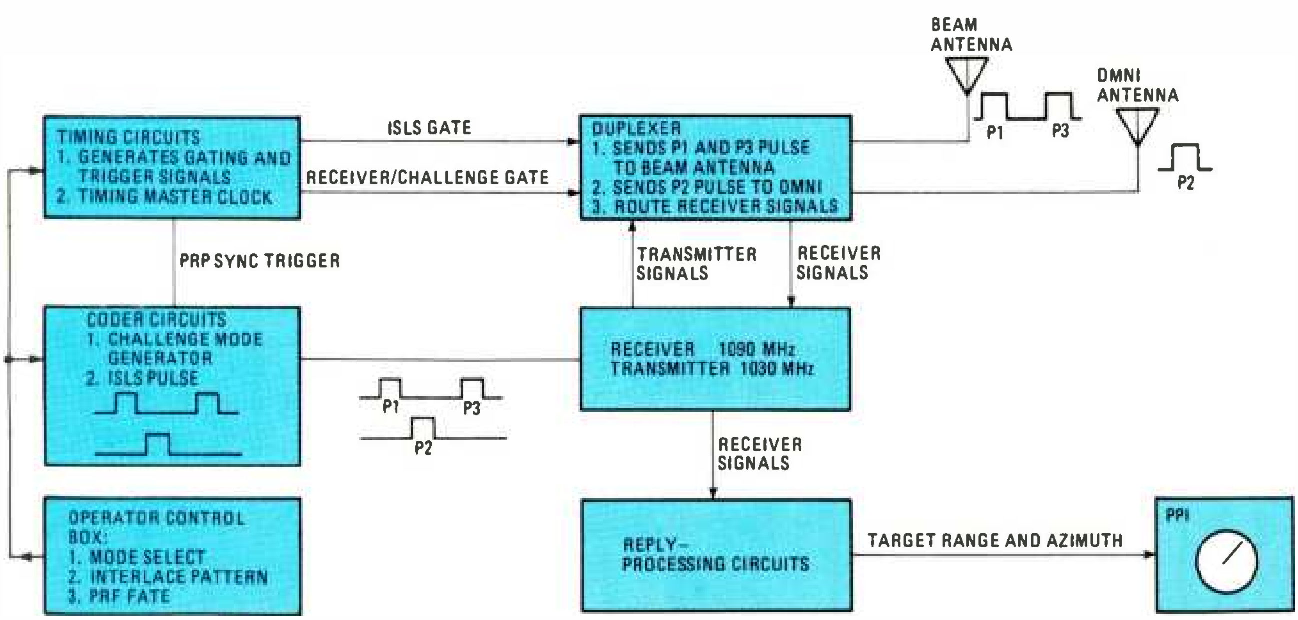


Fig. 2—The interrogator system is a complex conglomeration of several subsystems designed to interact with each other. The subcircuits, in conjunction with two antennas, transmit challenges to and process replies from the target craft.

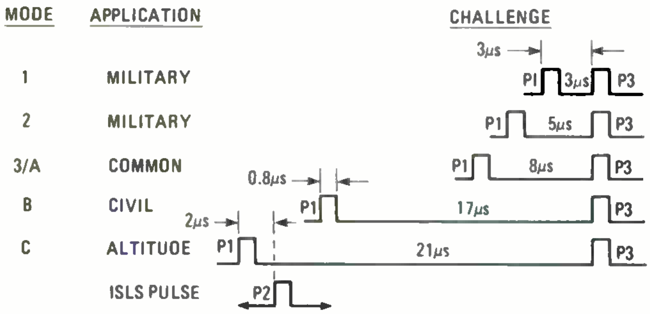


Fig. 3—This diagram gives the challenge modes generated by the coder circuits of the interrogator system, along with the uses for that mode. The mode of the transmission is determined by the time lapse between the leading edges of the P1 and P3 framing pulses. For instance, if the framing pulses are separated by 8 μs, the transmission is mode 3/A, which is common to both civil and military use.

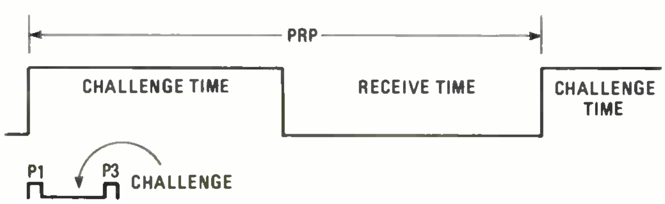


Fig. 4—The pulse repetition period, as shown, is the time between challenges, and extends from the time the challenge is issued to the end of the receiver period—which is actually the time between the leading edges of the P1 pulses in successive challenges.

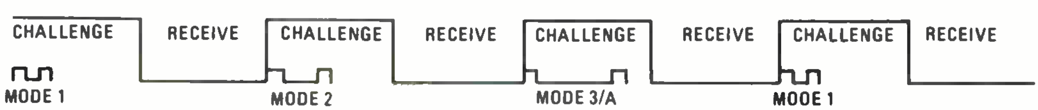


Fig. 5—The interrogator interlaces the challenge modes so that all modes can be transmitted one right after the other, allowing military, civil, and commercial traffic to be displayed on the PPI together.

The challenge time or period (as Fig. 4 shows) is followed by a receiver period, and then the cycle repeats itself. The time between challenges, called the *pulse repetition period*, or *PRP*, is set by the operator, and usually expressed as pulse repetition frequency, where: PRF = 1/PRP.

The frequency varies between 300 and 450 PRF, depending upon the PRF of the primary radar, to which it is synchronized, and other interrogator PRF's in the immediate vicinity. For example, if an interrogator transmits challenges at a rate of 350 PRF (which means that challenges are issued 350 times per second), the PRP equals 1/PRF, about 2850 μs. Since the mode 3/A challenge is only 8 μs long, it's obvious that the receiver time of 2850 μs is much longer than the challenge time, which is necessary for range-determination circuitry to be effective.

The ground operator can select the challenge mode and PRF of the interrogator using a control box on his console. He may also interlace the challenges, as shown in Fig. 5. For example, the first challenge could be in mode 1, the next in mode 2, and another in mode 3/A, then repeating the interlace starting with mode 1 again. Military, civil, and commercial traffic can, thereby, all be challenged at the same time and then evaluated on the PPI together.

Reply Processing

The target craft's reply is characterized by a 12-bit code sandwiched between two framing pulses, F1 and F2, as illustrated in Fig. 6. The 14-bit pulse train is 20.3-μs long from the leading edge of the F1 pulse to the leading edge of the F2 pulse. The SIF allows the pilot to select his identification by dialing up any 4-digit number, which causes selective bits between the framing pulses to either drop-out or pop-up. Thus, if the pilot selects 1367 as his identification number, certain code bits will be present, while others are absent.

Refer to Fig. 7 as we examine the coding bits a little closer. The 12 information bits are each assigned a letter (A through D) and a corresponding numerical subscript (either 1, 2, or 4). The letter indicates the positioning of the number, and the sum of the numbers under each letter designation produces the actual code number. Zero is the absence of any bits within a letter group. For instance, in the code number 1367, A1 equals 1; B2 and B1 equals 3; C4 and C2 equals 6, and D4, D2, and D1 equals 7. The reply code train for 1367 would look like Fig. 8. Under that system, there are 8^4 (binary) or 4,096 discrete codes available, ranging from 0000 to 7777 in mode 3/A.

There are also two special reply-code configurations known as *Emergency* and SPI (*Special Position Identification*). *Emergency* (7700 followed by three sets of framing pulses for mode 3/A) that can be selected by the pilot. The SPI function (which is pilot-selected on request from the ground controller) causes the mode 3/A reply to be followed by a SPI pulse 24.65 μs away from the leading edge of the F1

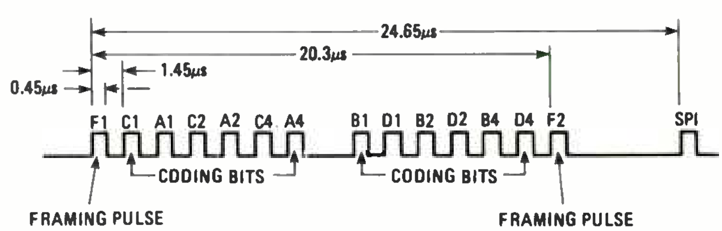


Fig. 6—After the reception of the interrogator's challenge transmission, the target craft's reply is characterized by a 12-bit code sandwiched between two framing pulses, F1 and F2.

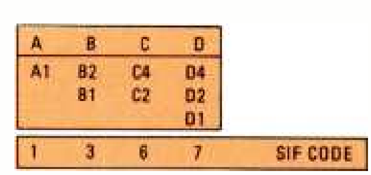


Fig. 7—Within the 14-bit reply transmission, aside from the two framing bits, there are 12 information bits, each assigned a letter (A through D) and a corresponding numerical subscript (1, 2, or 4), which allow the pilot of the target craft to transmit an identification code.

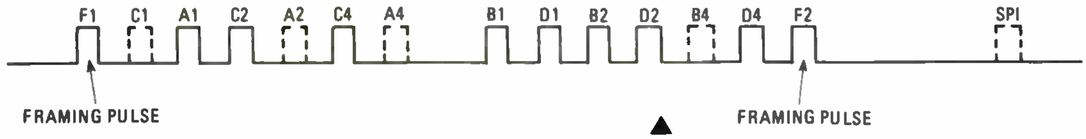
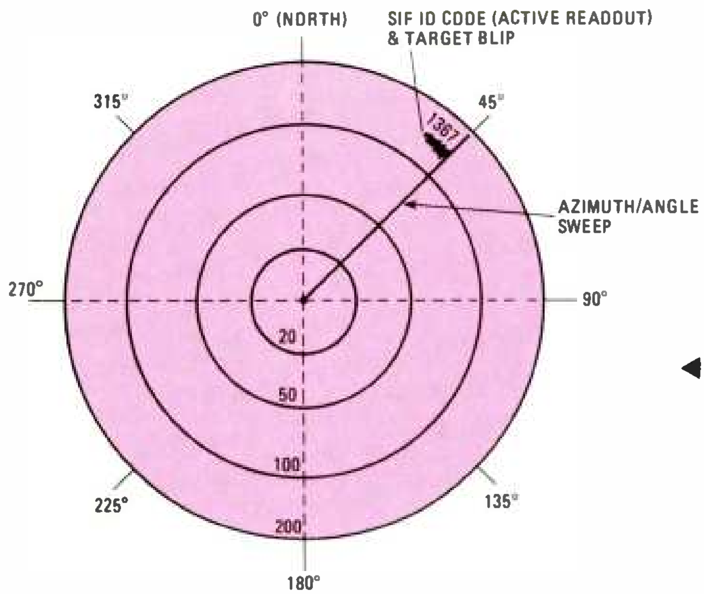
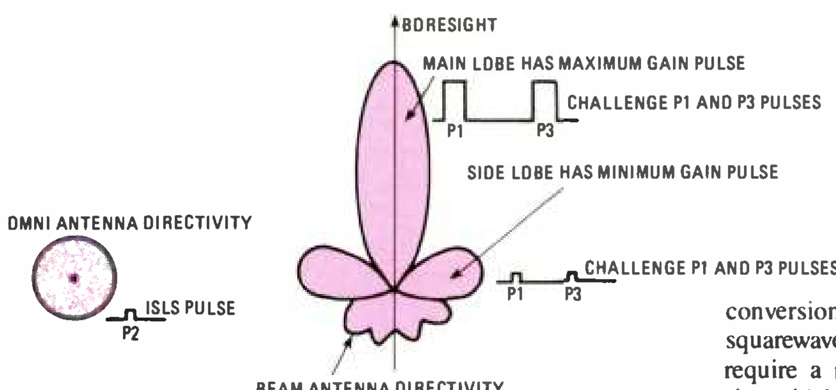


Fig. 8—The reply code transmission from the target craft is similar to the pulse train show here, which is for a 1367 reply code. The coding bits shown in dashed lines are omitted from the transmission.



A



B

Fig. 9—The drawing in A is a representation of the PPI (as seen by the controller), displaying the target-craft's location and ID code. The sketch in B is a comparison of the radiation patterns of the omni-directional and main-beam antennas. Note that the omni-directional antenna radiates energy equal in all directions, while the main antenna's radiated energy is concentrated in one direction (main lobe), with its side lobe containing some lesser degree of energy. The interrogator responds to only aircraft located in the boresight, or high-gain main lobe of the beam antenna. Replies initiated from a side lobe are suppressed by filter circuits within the interrogator.

pulse (see Fig. 6). The SPI function provides a marker for the controller to identify a specific target craft from among many others, usually by making the target's blip on the PPI blink on and off.

The timing circuits link all aspects of the beacon system together by generating the clock signals, timing gates, and synchronizing triggers for all other circuits. The least little change in the timing circuits can cause a complete system failure.

Receiver/Transmitter

The beacon receiver uses a superheterodyne configuration along with a few additional circuits. The input-signal selectivity is, to some extent, determined by front-end microwave resonators used as bandpass filters with sharp leading and trailing edges. The receiver is tuned to only one frequency—1090 MHz—with an 8–10-MHz bandpass. The 1090-MHz receiver frequency is mixed with the local oscillator frequency (1030 MHz), which results in an IF of 60 MHz after single conversion. The 8–10-MHz bandpass is required because squarewave pulses are being received. Pulse-type waveforms require a much wider bandpass than do transmissions of sinusoidal waveforms of the same frequency.

In addition, the RF section's sensitivity is automatically adjusted for varying input-signal strengths. For instance, a much stronger signal is received from an aircraft directly overhead than from one that's 100 miles away. Thus, signal strength may vary as much as 90dB—a difference in field strength of between 1 volt and 10μV. Obviously, without some sort of special gain-control circuitry, a normal receiver, designed to receive very weak signals, would be overloaded by a transponder directly overhead. The answer to that problem was to logarithmically compress large variations in signal strength and then restore it to its equivalent input amplitudes using analog circuits.

In the old days, beacon transmitters used magnetrons and traveling-wave tubes (TWT) to generate microwave oscillations and then amplify them for RF-power output. But today, as with everything else, solid-state drivers have taken over, making several hundred watts of microwave pulsed power possible. Using *surface acoustic-wave* technology for the local oscillator (SAW LO), the 1030-MHz RF carrier is generated, and pulse-code modulated. The P1, P2, and P3 challenge code is delivered to the duplexer through the output driver stages.

Duplexer

Using a common antenna for both receiving and transmitting is the general rule, which saves space and reduces cost. However, such a system also requires that the receiver circuits be protected from the high-energy RF transmitter output. And providing such protection assures that the transmitter does not absorb any energy from the target craft's reply, which might already be weak. The device that allows a transmitter and receiver to share a single antenna is known as a duplexer.

The duplexer contains relatively few parts and can fit in the palm of your hand. Its operation usually depends on specially fabricated PIN diodes and waveguide strips cut to exacting quarter or half wavelengths of receiving and transmitting frequencies. At high frequencies, the PIN diodes act as T/R switches when forward biased. At the same time, the waveguide strips act as tuning stubs, which further attenuate or pass the correct frequencies; 1030 MHz for the transmitter frequency and 1090 MHz for the receiving frequency.

Recall the Challenge/Receiver gate of Fig. 4. That gate forward-biases a selected PIN diode, thus connecting the transmitter or receiver to the antenna. When PIN diodes are used as switching elements for RF frequencies, superior reliability, greater durability, and faster switching speeds are achieved when compared with their electromechanical counterparts.

Plan Position Indicator

The plan-position indicator (PPI) is a cathode-ray tube that displays a chart of the surrounding airport and all targets in the vicinity, which can extend out 200 miles in some cases. PPI's whose range extend to the horizon or about 200 miles are usually military early-warning radars; while those limited to 20 miles or so are used for congested airport locations.

Now let's turn our attention to how the PPI displays a target's range and azimuth, as shown in Fig. 9A. The range sweep (time base) starts at the center of the PPI, zero range, and then travels radially outward. Zero range is considered to start immediately after the challenge is transmitted. The sweep then moves out radially toward the circumference of the PPI at a calibrated rate. When a target replies, the received code is processed and identified on the display as a blip of light at the proper range. For the purpose of calculating range, the transit time of the challenge to the target and then to return reply from the target must be taken into account.

It takes about 6.18 μs for electromagnetic energy to travel one nautical mile—a nautical mile being the accepted unit of distance in radar. Therefore, the time elapsed between challenge and reply, ignoring a few microseconds delay in electric signal processing, is 12.36 μs/radar mile. The range formula is thus:

$$\text{Range} = \Delta t / 12.36\ \mu s \text{ per radar mile.}$$

For example, let's say that the interrogator transmits a challenge, and a reply is received after 61.8 μs of elapsed time. The target range is, therefore, 61.8/12.36 μs or 5 radar miles.

Figure 9B is a comparison of the radiation patterns of the omni-directional and directional-beam antennas. The omni-directional type radiates energy equally in all directions; but, with the directional beam antenna, RF energy is most strong along the antennas main lobe, or boresight. It is through the directional antenna that azimuth measurements are accomplished.

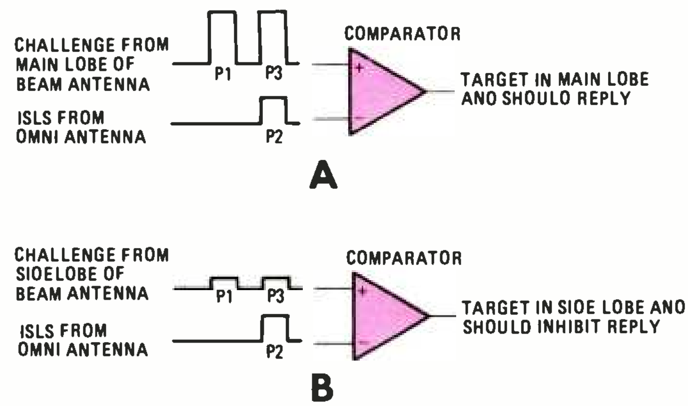


Fig. 10—Within the target craft is an ISLS circuit that uses an op-amp comparator, which determines (by signal strength) if the craft is in main lobe boresight. If the challenge (from the beam antenna) is of greater amplitude (as in A) than the ISLS signal from the omni-directional antenna, the comparator allows the transmission of the reply code. If, on the other hand, the craft is located in a side lobe, the challenge is of lesser magnitude than the ISLS (as in B); thus, the comparator inhibits the transmission of a reply.

The directivity of the antenna is aligned along its main lobe. As the antenna rotates, the target enters the antenna's boresight, producing a blip on the PPI, which is shown as an arc because of the antenna's rotation. The arc, along with its SIF identification code (as shown in Fig. 9A), is displayed only as long as the target is within the antenna's boresight. As the antenna rotates away from the target, the blip disappears. But, how does the interrogator know the direction or antenna azimuth?

The antenna structure contains an optical disk that sends the interrogator a true-north sync pulse, which tells the interrogator the antenna's precise location: zero degrees, or true north. From then on, as the antenna rotates, azimuth-change pulses (ACP's) from the optical disk are continuously relayed to the interrogator. The ACP's are then translated into control signals, which cause the (azimuth/range) sweep of the PPI to revolve clockwise, precisely following the antennas rotation.

The round screen of the PPI is laid out in circular grids, with the center of the pattern being the radar's originating point, as shown in Fig. 9A. Thus, the position of the arc on the screen gives the target's direction in degrees and distance in miles. For instance, Fig. 9A shows that the target is located at 45° north-east (NE) of the radar tower, at a distance of about 150 miles.

Interrogator Side-Lobe Suppression

The beam antenna not only has a main lobe of high gain, but also a side lobe of lesser gain, as Fig. 9B shows. As the antenna rotates, targets within the side lobes may respond to challenges mistakenly thinking they're in the main lobe. Those replies, however, must be filtered out since the beacon system is only interested in targets within the main beam's azimuth boresight. If the target responds from a side-lobe challenge, the azimuth reading on the PPI could be off by as much as 180 degrees.

A ISLS circuit, using an op-amp comparator, prevents the transponder from replying when the target craft is in a side lobe. It matches the gain of the signal in the Pl and P3 pulses from the main lobe to the gain of the signal in the P2 pulse from the omni antenna, which simulates the side lobe.

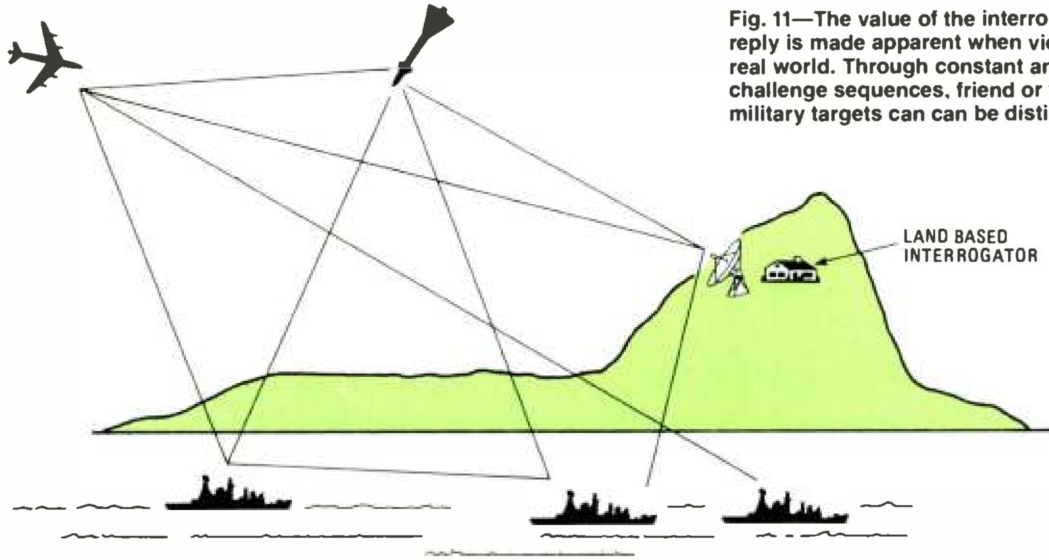


Fig. 11—The value of the interrogator's challenge and reply is made apparent when viewed in the context of the real world. Through constant and repeated reply and challenge sequences, friend or foe, civil, commercial, or military targets can can be distinguished from each other.

If, as Fig. 10A illustrates, the P1 and P3 pulses are indeed greater in amplitude than the P2 pulse, then the target is in the main lobe and should reply. If, on the other hand (as in Fig. 10B), the P1 and P3 pulses are less than the P2 pulse in amplitude, then the target is in the side lobe and should suppress a reply.

Fruit in the Air

If there were only one interrogator and one aircraft, it might be said that a beacon system is unnecessary. But imagine for a moment, the way the real world operates. A good illustration of how the real world works is shown in Fig. 11—ground stations interrogating aircraft and ships at sea; other ships and aircraft interrogating other aircraft. Imagine the sky full of electromagnetic pulses flying every which way: Whose pulses belong to whom? How can we straighten this mess out? To the rescue come special circuits called defruiters, degarblers, gain-time control, not to mention software statistical methods of target validation.

One name given to that electromagnetic nightmare is *fruit*, which are replies that are asynchronous with your challenge's PRF rate. The *defruiter* may, therefore, be considered an asynchronous filter; for without it, the PPI display would have lines, blips, and streaking lights swirling all over the scope. For instance, if two interrogators are operating different PRF's (say one at 300 and the other at 301) each would not interfere with the other if they both have *defruiter* circuitry as part of their input signal processing. There's also a statistical side to *defruiter* circuitry. For example, a target's code may be identified, but the interrogator will not consider it valid unless the same reply codes are received at the same target range, over a number of challenges.

Garbling, another type of reply interference, is an example of what can happen when two aircraft are separated in altitude by a few hundred feet, but have the same range to the airport. Both aircraft receive the same challenge, so their replies may interleave, as in Fig. 12. Since the pulses arrive as serial data, how can the interrogator then discriminate a framing pulse from a coding pulse? The circuitry that degarbles the replies is excessively complex; requiring that numerous serial shift registers be used in delay lines, with output taps sampled for framing-bit and coding-bit coincidence.

Gain Time Control

To allow recognition of valid replies, while rejecting signals from a previous challenge-reply cycle (PRP), GTC (*gain time control*) is provided as illustrated in Fig. 13. The GTC generates a threshold that's high when strong replies are expected from close targets, and low when weak replies are expected from targets far away.

The amplitude of each reply pulse is compared to the threshold and considered valid only if the GTC threshold is exceeded. A transponder reply from a previous challenge would be considered to weak to be declared valid. For example, in Fig. 13, reply 1 is valid since it's a target's reply from

(Continued on page 108)

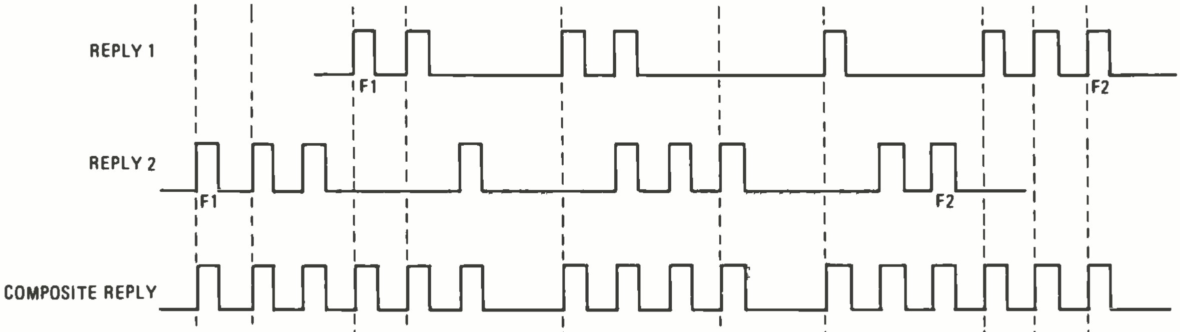
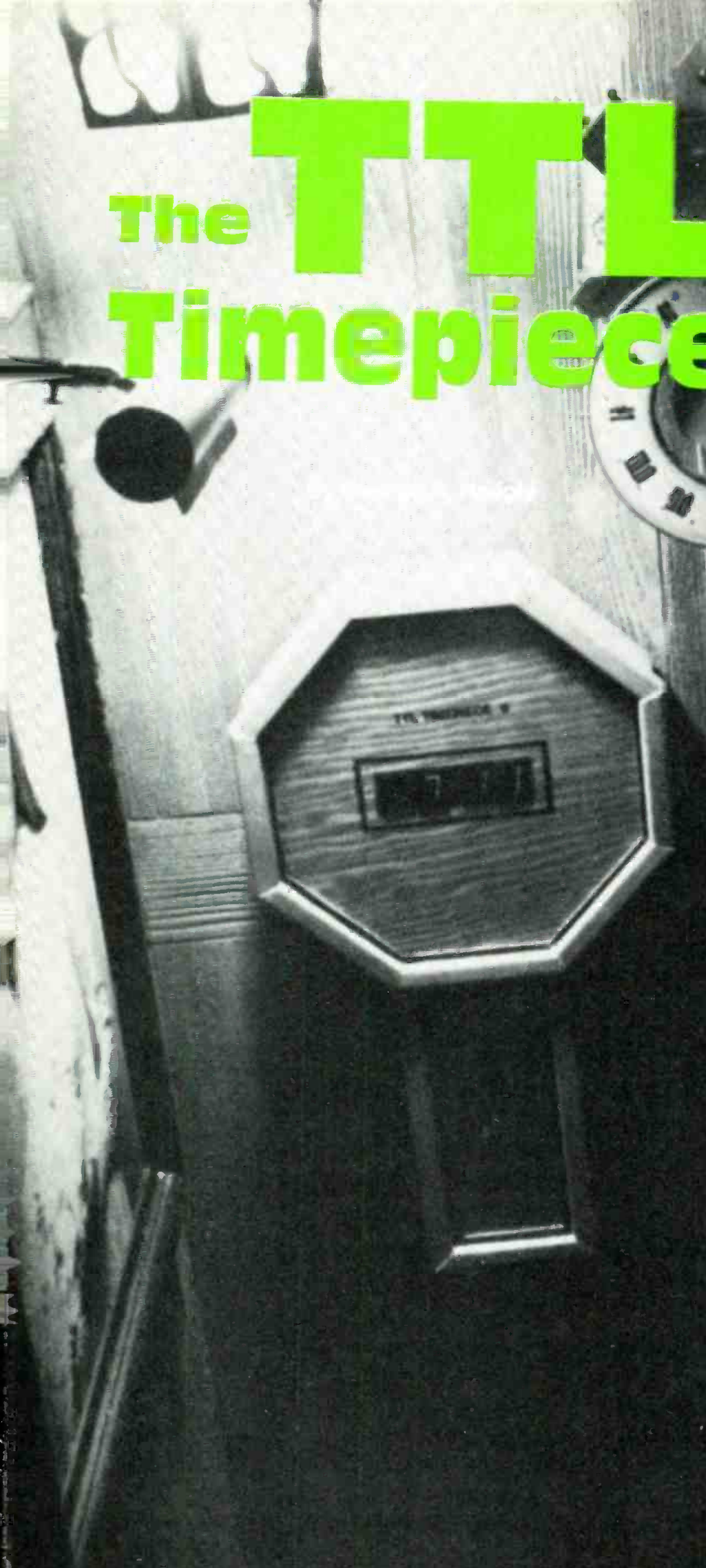


Fig. 12—Garbling is an example of what can happen when two aircraft are separated in altitude by only a few hundred feet, while being equal distances from the airport. The reply signals from the two craft are interlaced, producing a composite of the two replies.



The TTL Timepiece

IN THE BEGINNING, MAN OFTEN WONDERED WHAT time of day he should go hunting or fishing. After all, the degree of success depended on getting to the lake at a time when the fish were biting, or to the water hole when the animals were out for their daily drink. Eventually, the sundial and other primitive methods of tracking the passing of time were discovered. It was later determined that, by using springs and gears, the guesswork could be taken out of telling time. As civilization progressed, so did man's ability to build a more accurate "sundial." Through the years, the format used on those early clocks became a standard for today's timepieces.

Enter The Digital IC

Over the past 20 or so years, we've ushered in the integrated circuit, and with it a whole new era of time keeping. Probably one of the first applications of those tiny wonders was the digital clock. After all, what could be more logical than to use flip-flops and counter circuits to tap the stable frequency of the AC power line from which timing pulses could be derived.

In this article, we'll show you how to build a TTL clock as it might have been done some 15 years ago, before the use of the more advanced single-chip clock circuits that we come to know today. The circuit does not contain any exotic parts; so if your junkbox is well stocked, it's possible to build this clock for under twenty dollars. And if you're short, most (if not all) of the parts are available at your local Radio Shack store or mail-order outlets.

More than just another digital timepiece, this project can teach you some of the principles of timing circuits, counter/divider circuits, and more!

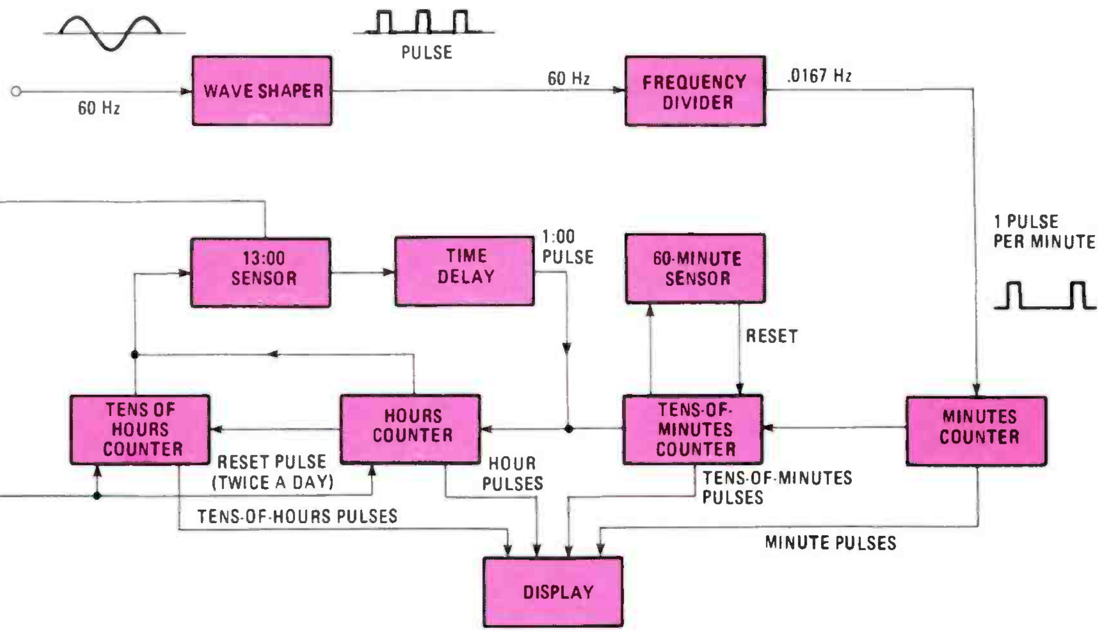
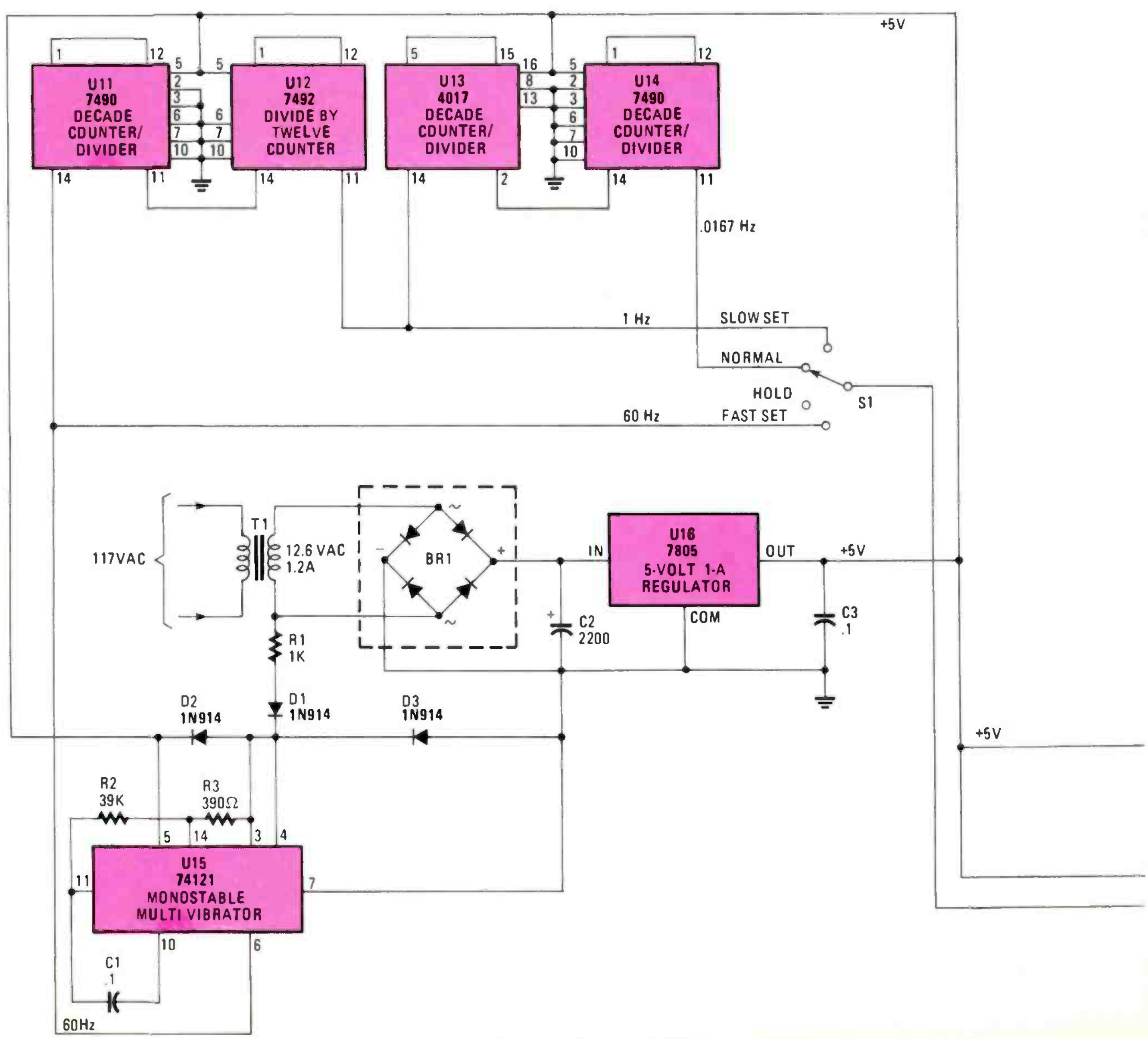


Fig. 1—The block diagram shows the flow of operation of the TTL Clock. Comparing this with the schematic diagram, you can see that the format is the same. That is also true in the foil patterns.



With a little imagination, the applications for this timepiece are endless. If you're a pretty good handyman, you may want to put your timepiece in an old schoolhouse clock-case design (see photos) and perhaps add an electronic pendulum and chimes. Another possibility is to modify the display circuit with transistors and LED's to create a larger display.

An Overview Of The Circuit

The block diagram in Fig. 1 shows the TTL Clock's flow of operation. The 60-Hz line frequency is shaped and buffered prior to being fed to the frequency-divider network, which outputs 1 pulse per minute for the time keeping operation. The signal is then fed to the minutes counter—which counts to nine, as shown on the minutes readout—and then resets to zero. When the minutes counter resets, a single pulse is sent to the tens-of-minutes counter, causing it to display a "1" on its respective readout.

That process continues until the minutes and tens-of-minutes readouts show a count of 59. On the next count, the minutes and tens of minutes counters toggle, returning their respective readouts to zero. At that time, the hours counter receives a pulse, which is then output to its readout. The clock now shows 1 o'clock (1:00). That sequence of events repeats until the readout shows 9:59. On the next count, those three readouts are zeroed, and the tens of hours readout shows a "1." (The time now displayed is 10 o'clock.) The count continues to a maximum of 12:59. On the next count, all readouts are zeroed and the sequence is repeated for the next half day.

How It Works

In Fig. 2, 117-volt, 60-Hz AC is fed to the primary winding of stepdown transformer T1, which outputs 12.6 volts at its secondary winding. At that point, the voltage is applied to two circuits; the wave-shaper circuit (consisting of a 74121 monostable multivibrator, U15, and a handful of additional components) and the +5-volt regulated power supply.

In the pulse-shaper circuit, the AC (see Fig. 3A) voltage is first rectified by diodes D1–D3 (back to Fig. 2), and filtered by capacitor C1. The filtering is required because of the presence of line noise, which causes the counters to count improperly.

The rectified voltage (Fig. 3B) is then applied to U15 at pin 4, which suppresses any noise over the 60-Hz line frequency and then puts out a squarewave signal, see Fig. 3C, suitable for driving the divider circuitry. The value of R3 should be kept at or above 300 ohms, because anything below that value

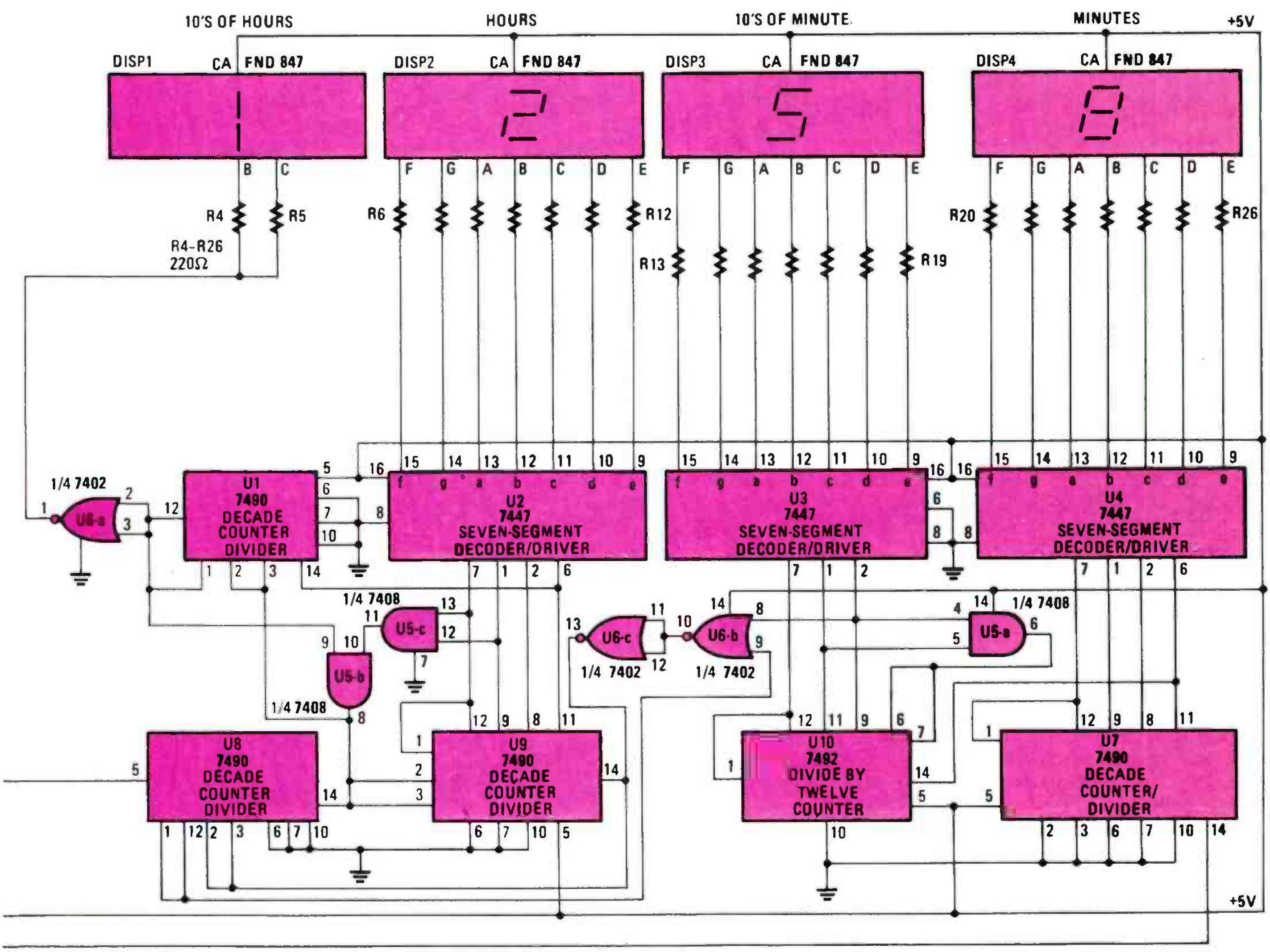


Fig. 2—Schematic diagram of the entire TTL Clock. The circuit consists of three separate sections: The display, the counter/-display driver, and the power supply/frequency divider. The three sections are layed out on individual printed-circuit boards.

PARTS LIST FOR THE TTL CLOCK

RESISTORS
(All resistors are ¼-watt, 5% fixed units)
R1—1000-ohm
R2—39,000-ohm
R3—390-ohm
R4–R26—220-ohm

SEMICONDUCTORS
BR1—Full-wave bridge rectifier 1-A, 50-PIV
D1–D3—1N914 (or 1N4148) small signal, silicon diode
DISP1–DISP4—FND847 common-anode, seven-segment display (Fairchild or similar, see text)
U1, U7–U9, U11, U14—7490 decade counter/divider, integrated circuit
U2–U4—7447 BCD-to-decimal seven-segment display, decoder/driver, integrated circuit
U5—7408 quad, two-input AND gate, integrated circuit
U6—7402 quad, two-input NOR gate, integrated circuit
U10, U12—7492 divide-by-twelve counter, integrated circuit
U13—4017 decade counter/divider, integrated circuit
U15—74121 monostable multivibrator, integrated circuit
U16—7805 5-volt, 1-A regulator, integrated circuit

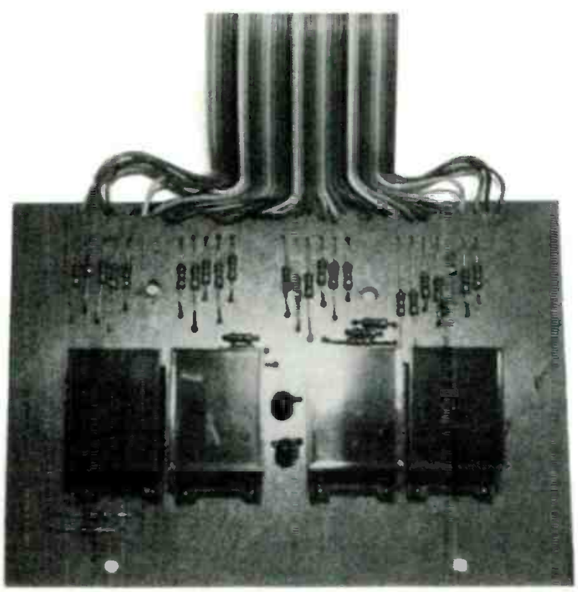
CAPACITORS
C1—0.47-µF, 50-WVDC, metalic film
C2—2200-µF, 35-WVDC, electrolytic
C3—0.1-µF, 50-WVDC, ceramic disc

ADDITIONAL PARTS AND MATERIALS
S1—Single-pole 4-position (SP4T) rotary switch
T1—117-volt AC primary, 12.6-volt AC, 1.2-A secondary stepdown transformer
Printed-circuit material or perfboard, IC sockets, ribbon cable, silicon grease, TO-220 heatsink, wire, solder, case, hardware, glass, wood, glue, nails, etc.

results in the line frequency being filtered. If R3's resistance is too high, the cutoff-filter frequency won't be low enough and some unwanted line noise may pass through and throw off accuracy. In short, try to keep the resistor R3 between 300 and 400 ohms.

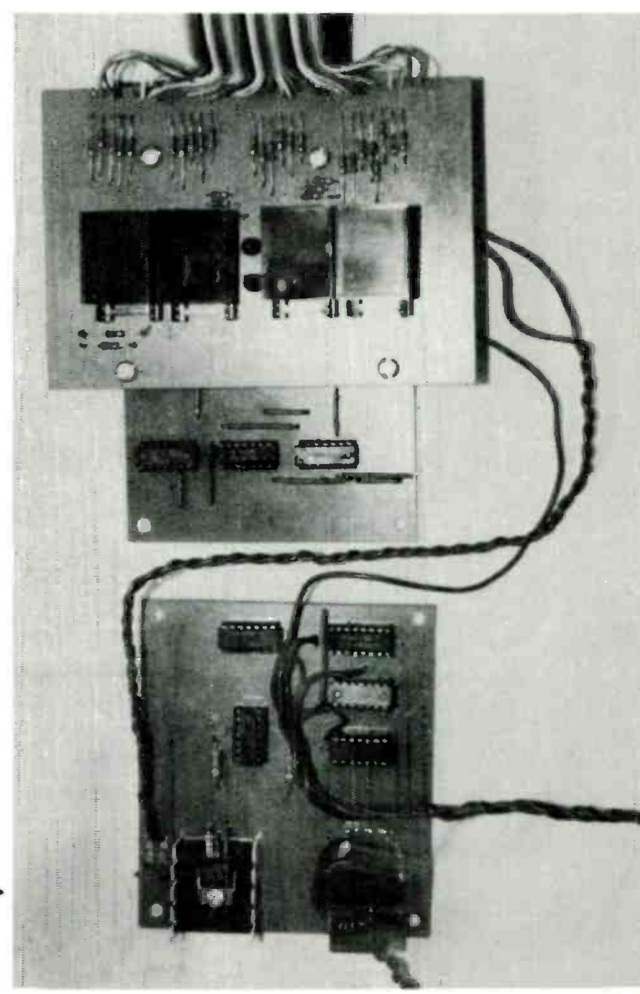
Once the timing signal has been buffered, it is fed to the divider network (consisting of U11–U14, in Fig. 2). Three chips, U11, U12, and U14, are set up as divide-by-ten counters, while U13 is set for divide-by-four operation. Together they reduce the 60-Hz signal to 0.0167 Hz, which is representative of one pulse every minute. That one-pulse-per-minute signal is then counted by U7 and U10 until a count of 59 is reached. Then on the next count, when 60 is sensed, the minute counters reset to zero and the hours counter advances one hour.

The same principle is used in the hour portion of the clock.



▲ A 34-conductor ribbon cable is used to connect the display board to the counter/display driver board. Also, note that the seven-segment display modules are mounted in 28-pin sockets. The bottom socket contacts protruding from beneath the displays are used as test points. If at any point along that line, you are unable to get a 5-volt reading, check to make sure that power is being delivered to the board. Also check the copper traces for breaks.

The display board and the counter/display driver board may be stacked as a space-saving measure. It is not recommended that power supply/frequency divider board be stacked because, in tight quarters, the regulator may generate enough heat to damage the integrated circuits; so give the circuit a wide berth. ▶



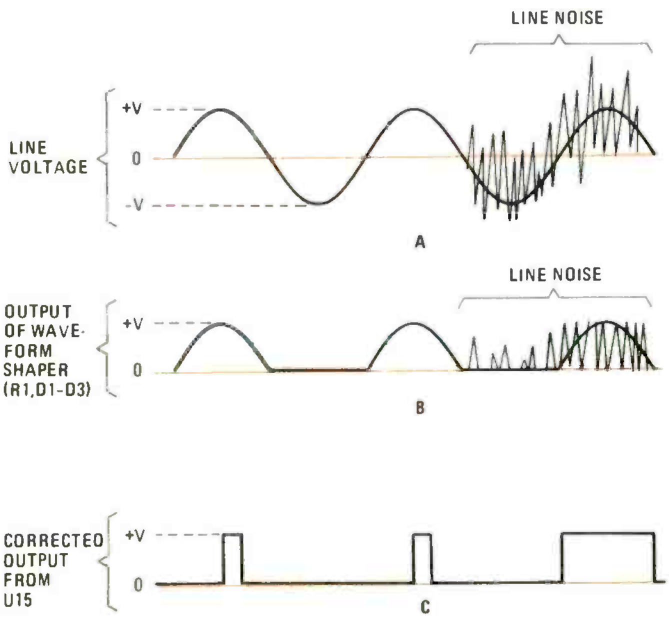
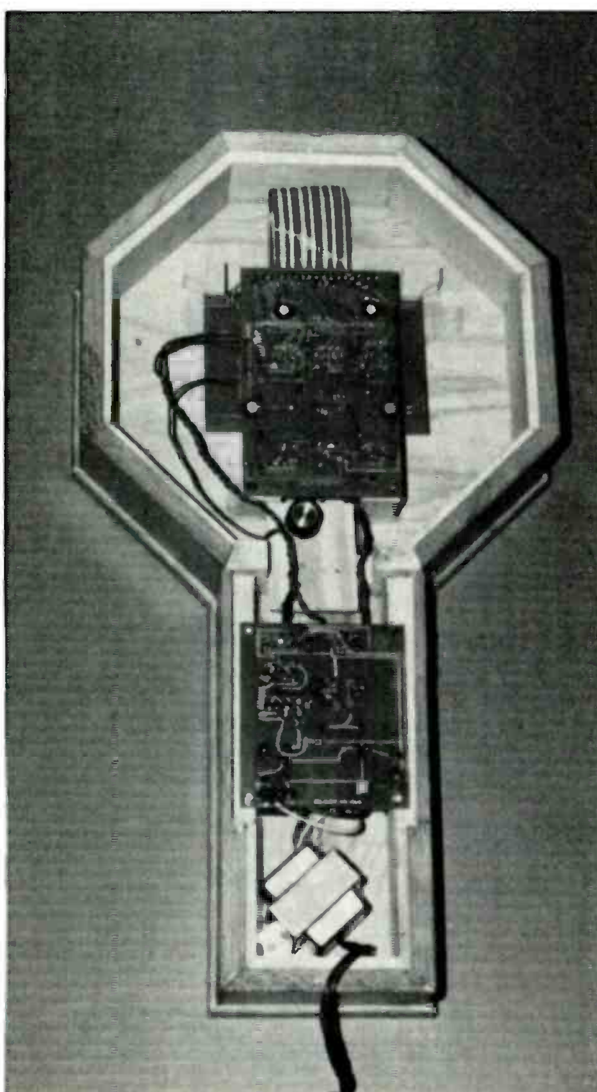


Fig 3—This graph illustrates the sequence of events that must take place in order for the TTL Clock to accurately keep time.

except that when a 13 is sensed on the hours and tens-of-hours counters, all of the counters are reset to zero, and the count begins again for the second half-day. The purpose of U8 is to provide a pulse to advance the hour from zero to one and to allow for sufficient time delay before the pulse is sent. The NOR gates also provide a short time delay, so that the counter can reset to zero before the hour advances to one. The total time delay is around 50 nanoseconds.

Setting the time on the clock is accomplished through switch S1. Frequency taps are made into the frequency dividers for a FAST set and a SLOW set, as well as a tap for NORMAL operation. In the FAST set mode, the time advances one hour per second (60 Hz). In the SLOW set mode, the time is incremented at a rate of one minute per second, which is the equivalent of 1 Hz.

The other circuit connected to the secondary of T1 is the power supply. The 12.6-volt output of T1 is rectified by bridge rectifier BR1, and then filtered by C2 (a 2200-µF capacitor). The voltage is regulated to 5 volts by U16 (the common 7805 chip), and applied across C2, to the +V inputs of the integrated circuits and the common anodes of the seven-segment readouts. The purpose of C2 is to remove from the supply voltage any ripple that may remain after regulation. If desired, the switch debounce circuit shown in Fig. 4 may be




The TTL Clock can be housed in in a schoolhouse clock cabinet (as shown). Note the location of transformer T1. By keeping the heat-producing devices separated in that manner, thermal destruction is less likely to occur.

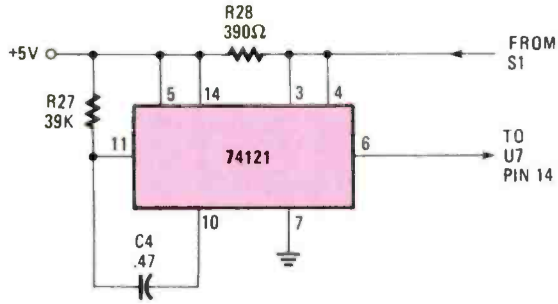


Fig. 4—This circuit, made from an additional 74121 monostable multivibrator and three external components, can be placed between switch S1 and the pin 14 input of U7, to eliminate false counting that may occur because of a noisy (bouncing) switch.

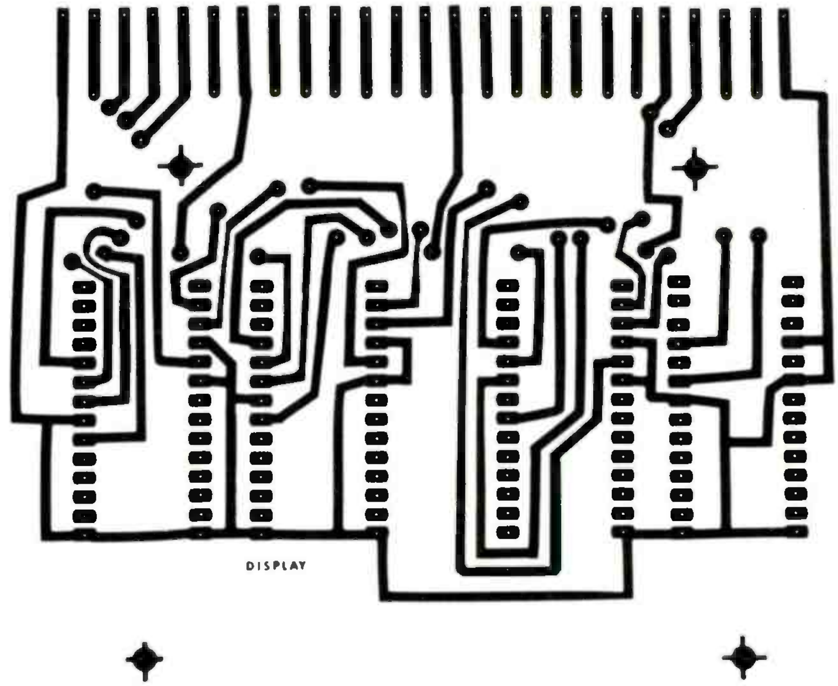


Fig. 5—The foil pattern for display board may be used as is, or modified as you see fit (see text).

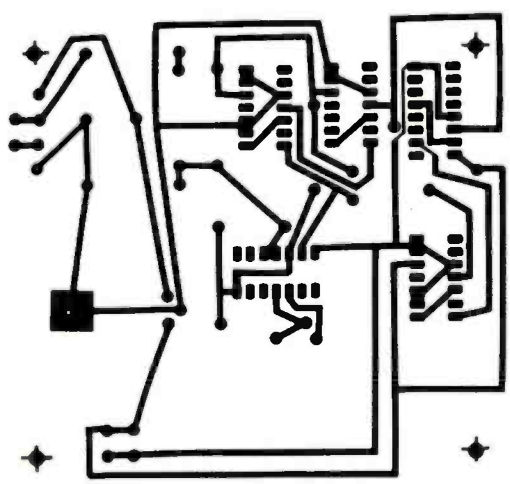


Fig. 6—Foil pattern of the power supply/frequency divider board. When mounting the diodes and electrolytic capacitor, be careful of their orientation.

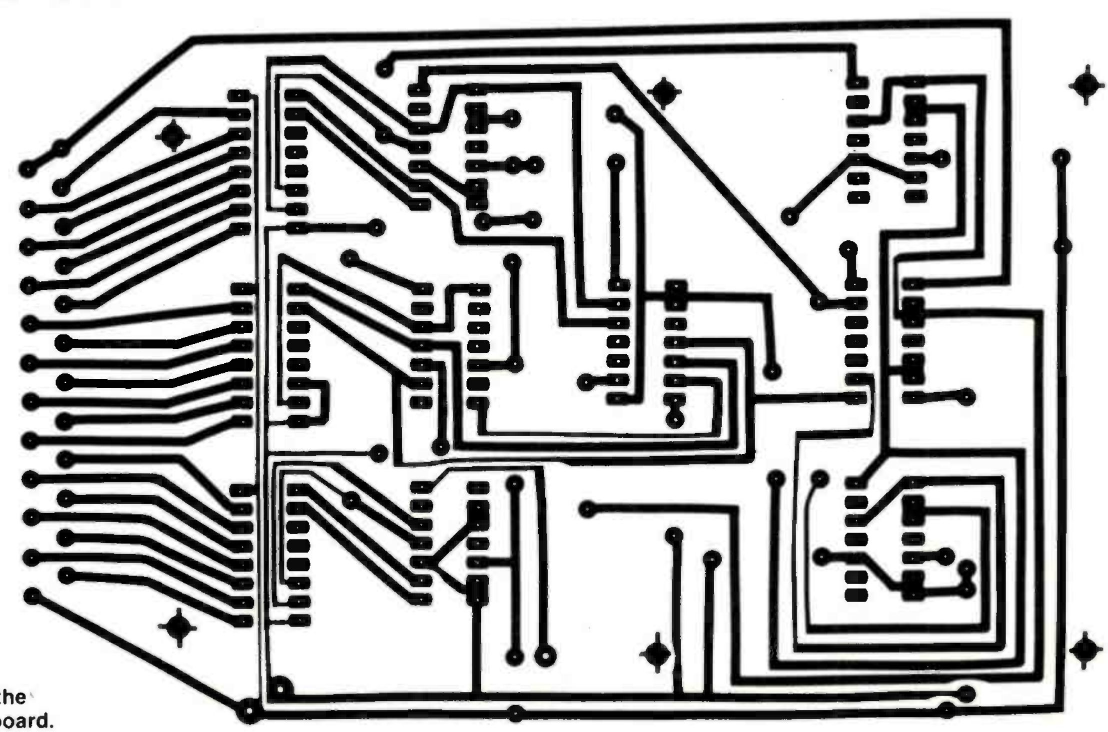


Fig. 7—Foil pattern for the counter/display driver board.

inserted between switch S1, and the input of U7 at pin 14, to eliminate false counting due to noisy switches.

Construction

To make the circuit easier to put together, the author built the TTL Clock on three separate printed-circuit boards: the display board in Fig. 5; the power supply/frequency divider board in Fig. 6; and the counter/display driver board in Fig. 7. Those foil patterns may be lifted from the page with Lift-it film and used to etch your own board using the positive photo-resist method. Although any method of construction can be implemented for this project, the PC board approach is probably the easiest. After the boards have been etched and cleaned, drill holes for the parts and mounting screws. Once done, you are ready to begin mounting the parts.

The use of IC sockets is highly recommended because they simplify construction by serving as markers. And they also help to ensure the safety of the chips. Another valid argument in favor of the use of IC sockets is that substitutions can be made without having to take out the soldering iron. The heat generated during component substitutions can often remove the tiny traces from the board, or destroy nearby components. Also remember that the 4017 is a CMOS integrated circuit and is, therefore, static-sensitive; so handle it with care. It's a good idea to ground yourself and the circuit board before handling the integrated circuits.

If you use IC sockets, mount them first and then install the on-board jumper connections and the wires that will be used to connect the individual boards together, using the parts placement diagrams—Fig. 8 the display board, Fig. 9 the power supply/frequency divider board, and Fig. 10 the counter/display divider Board—as a guide.

Note that on the display board, provisions have been made for 28-pin IC sockets; so make sure that each display module is installed as shown in the layout whether or not sockets are used. A pinout diagram for the FND847 display units is given in Fig. 11. If you are unable to locate that particular part, the pinout should enable you to find a pin-for-pin compatible unit. And if all else fails, you can always modify the display board to accommodate the units that are available. In the author's prototype, a 34-conductor ribbon cable was used to connect the display board to counter/driver board, although only 24 conductors are actually used. The extra wires could come in handy should you decide to modify the board later.

Since most of the TTL Clock is made of integrated circuits, mount all of the passive components (resistors, capaci-

(Continued on page 95)

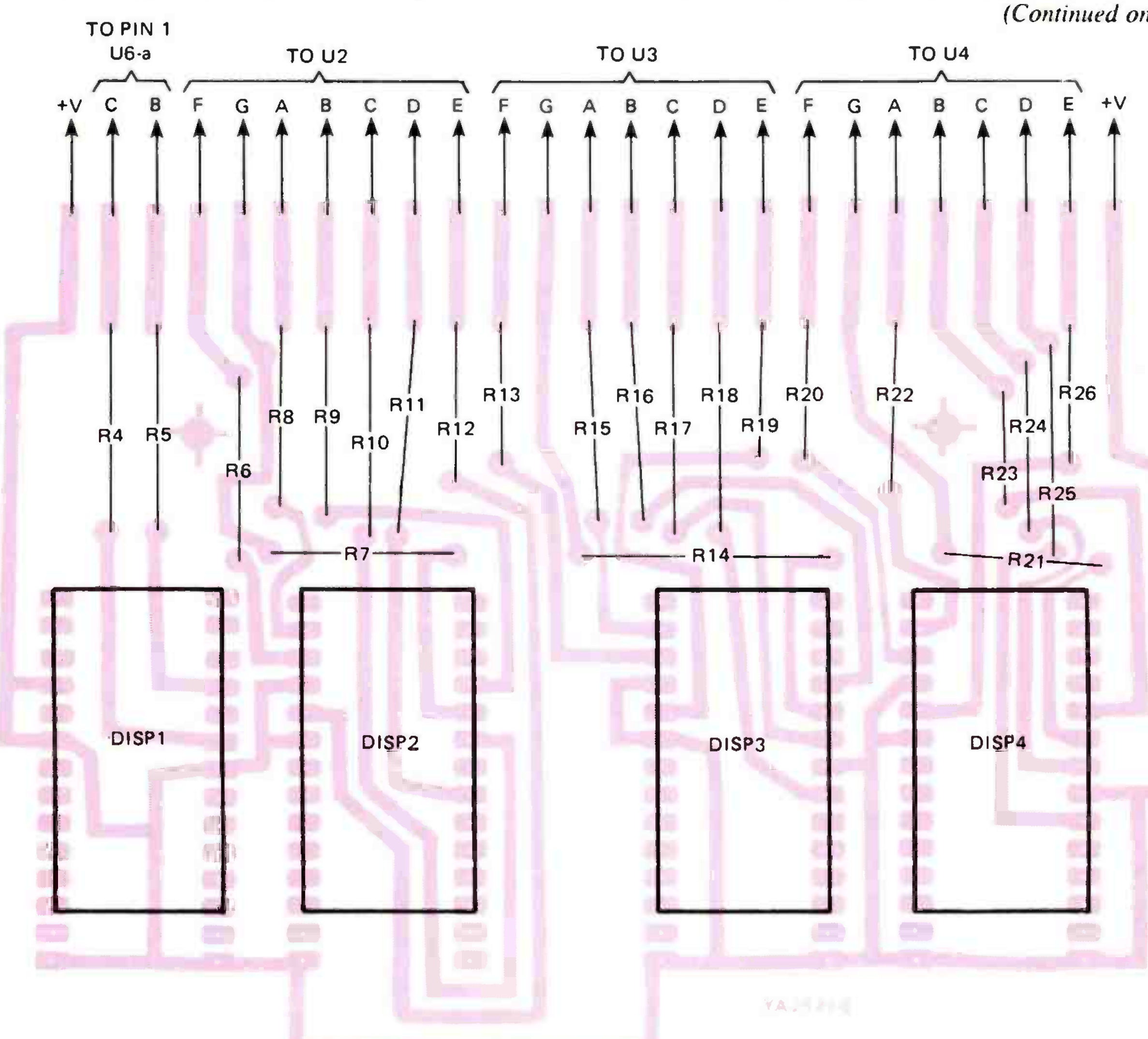


Fig. 8—The parts layout for the display board shows that only the segments used for DISP1 are to be connected. Unused pins of the socket are connected to +5V for use as test points. One of the +V tie-points, which are located on either side of the printed-circuit board, is used for future circuit additions; for instance, chimes might be added.

Battery-Powered FENCE CHARGER

A varmint will get a real shock out of this circuit should he decide to poke about your place!

By T J Byers

ALTHOUGH THE INVENTION OF THE ELECTRIFIED FENCE may seem frivolous to some people, its introduction has changed all of our lives in one way or another. Whether it be used to ward off corral critters or poachers, electric fences are an important part of our daily existence. If you've ever had the need for a fence charger, though, then you know how limited your choices can be. Have you noticed that if it doesn't cost an arm and a leg, then it probably isn't worth taking home? Well, fret no longer. To the rescue comes HOE's Battery-Powered Fence Charger.

Finally, here's a quality fence charger that you can build with all the features of an expensive model, but at a fraction of the cost. The Fence Charger incorporates such features as a variable pulse rate, low-duty cycle, and high reliability. Moreover, it is battery powered and completely transportable.

How it Works

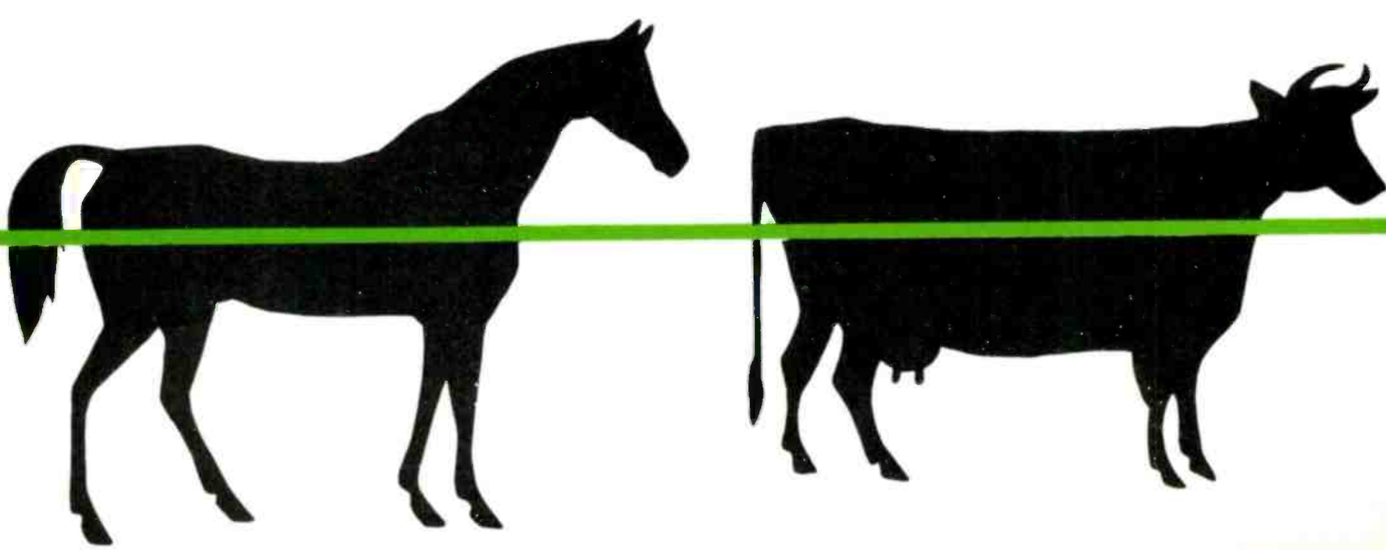
The Fence Charger works on the same principle as electro-shock therapy; that is, the discharging of a mildly irritating high voltage through the body. Electro-shock has been used successfully for many years to modify the behavior of both man and animal. It is completely harmless when used properly, and has recently found application in helping people to quit smoking, and in the treatment of alcohol abuse. If you've ever felt the sting of a live spark-plug wire, then you know how effective this form of behavioral modification can be.

The Fence Charger is a high-voltage spark generator modeled after the now extinct Kennington ignition system, in which breaker points and a coil were used to breathe fire into your engine. It's the kind that costs only ten bucks to bring back to life, not the $350 you're going to shell out when your electronic ignition takes an extended lunch. Well, that simple points/coil combination is the heart of our project.

Basically, the coil supplies the high voltage needed for the circuit, using an electrical phenomenon known as reverse EMF (electro-motive force), which is more commonly called the flyback effect. The way it works is quite simple: First, a large current is sent through the winding of a coil, and that, in turn produces a magnetic field, which is allowed to build up. Then, at some point, the flow of current is abruptly shut off. (In an automobile, the affect is achieved by opening the breaker points.) With no electrical current to support it, the magnetic field rapidly collapses.

As the field collapses, the magnetic flux lines cut across the winding of reverse polarity to the original current. The coil is actually a transformer that has a high ratio of secondary windings to primary windings, something on the order of 100 to 1. That means that whatever the primary winding sees in the way of voltage is multiplied in the secondary by one hundred. Two hundred volts at the primary, for example, translates into 20,000 volts at its secondary.

The result is a short, high-voltage pulse that will deter all but the most determined of *critters*. That voltage is then routed to a fence or control electrode that is used to control



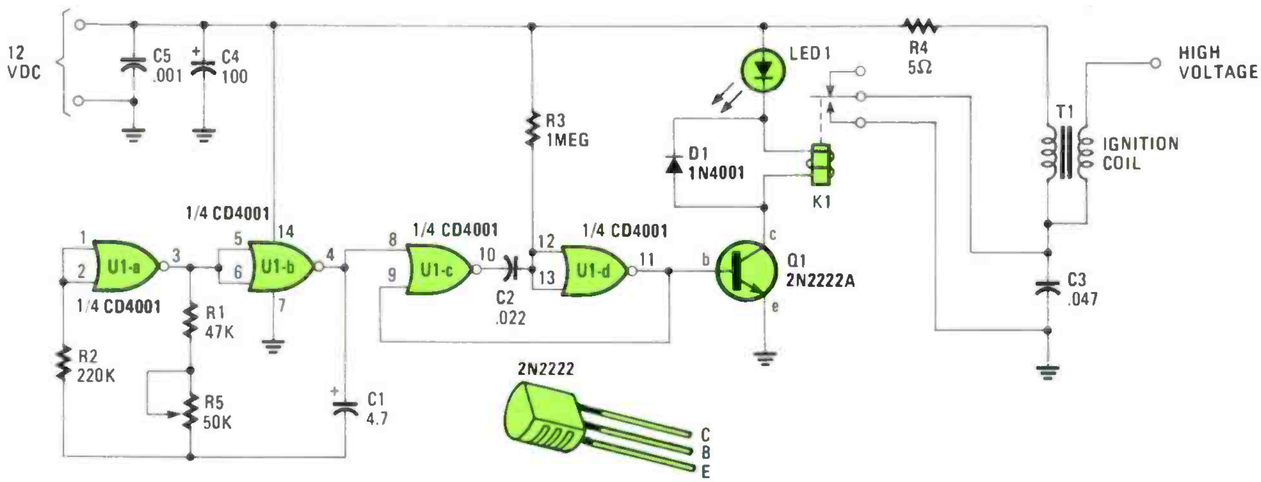


Fig. 1—The Fence Charger, for the most part, consists of a handful of easily obtainable parts. The coil, however, comes from the standard ignition system of 1960-era GMC cars. Capacitor C3 is the original component used in the system.

the animal. In most cases, the control element is a wire strung around a perimeter to confine an animal to a certain area. In no way is the unit connected directly to the animal, or, for that matter, connected to a human being. Now that we have some idea of how it works, let's apply those principals.

About the Circuit

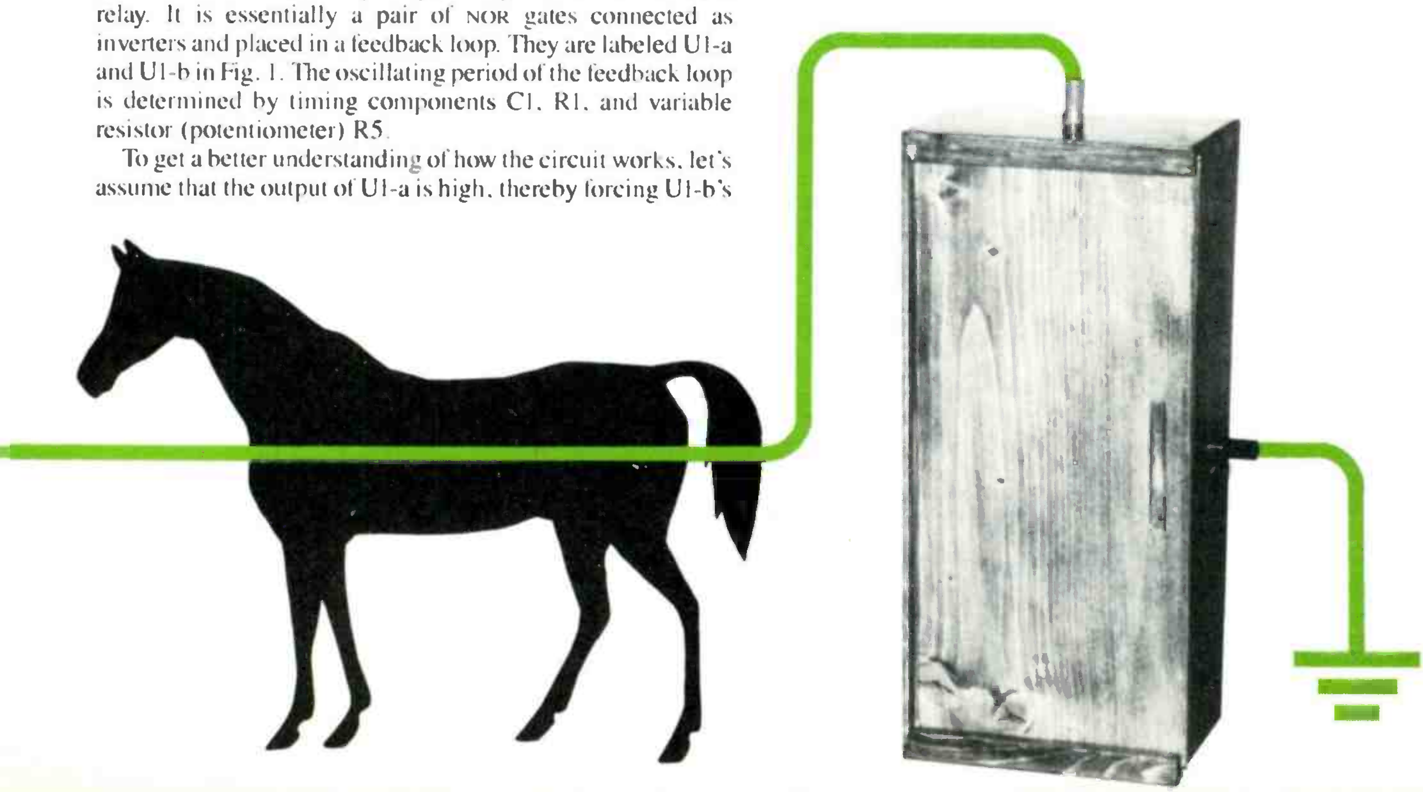
Looking at Fig. 1, the schematic diagram of the Fence Charger, we see that the circuit itself is very straightforward and its secrets yield to logical circuit analysis. In essence, the circuit is nothing more than an auto ignition coil and a set of points—the points in our circuit is a relay, which accomplishes the same thing. A pulsing circuit (oscillator), which is made from a single CMOS NOR integrated circuit (U1), opens and closes the relay contacts to simulate the action of the original breaker points.

The relay pulser is divided into two clocking functions. The first circuit is a free-running squarewave generator that determines the rate or frequency of the pulses that activate the relay. It is essentially a pair of NOR gates connected as inverters and placed in a feedback loop. They are labeled U1-a and U1-b in Fig. 1. The oscillating period of the feedback loop is determined by timing components C1, R1, and variable resistor (potentiometer) R5.

To get a better understanding of how the circuit works, let's assume that the output of U1-a is high, thereby forcing U1-b's output to go low (inverters, remember?). That condition places a voltage across C1 through the R1, R5 resistor combination. Consequently, the capacitor begins to charge. As the voltage across C1 increases, so does the voltage presented to the input of U1-a. At some predetermined point, the input voltage to U1-a exceeds the limits of the logic level and the gate flips to its alternate state (low), forcing the output of U1-b to go high.

The process now reverses itself as capacitor C1 begins discharging through the resistor combination. Once the voltage drops below the sustaining level for a high output, the logic again reverses itself, thus perpetuating the process. Resistor R2 prevents loading of the timing circuit and sets the trip point to a level where the oscillator's output approximates a squarewave. That waveform triggers a monostable multivibrator, consisting of U1-c and U1-d.

Essentially, the monostable circuit is held stable by resistor R3. Notice that the output of U1-d, which is low at rest, is fed



back to one leg (pin 9) of U1-c to form a conditional loop. As long as both logic inputs to U1-c are low, the circuit is stable. However, let the pin 2 trigger input go high, and the output of U1-c changes to a low because the logical input conditions are no longer valid. That, in turn, forces C2 to begin charging through R3 and establishes the output of U1-d high. The circuit is now locked.

Once triggered, no amount of *tugging* or *pulling* at the trigger input can change the state of the output signal: At least not until C2 has charged to the point where U1-d again goes low and the trigger can regain control of the circuit. The output of our monostable multivibrator is used to drive transistor Q1, which in turn, energizes or deenergizes relay K1. The timing components in the monostable have been selected so that the relay is engaged for a very brief period of time—about 15 milliseconds—each time it is pulsed by the square-wave generator. That is roughly equivalent to the amount of time that the points would remain closed in a car engine running at 1000 rpm.

Construction

Building the Fence Charger is relatively simple. Unlike other high-voltage circuits that use exotic flyback transformers, our high-voltage coil is salvaged, as you may suspect, from an old automobile. Before rushing out and securing any old coil, though, here are a couple of helpful hints.

The author recommends Delco coils removed from GMC cars of the 1960's. It is also a good idea, to obtain the original condenser (capacitor). That capacitor, which will be used in the position of C3, forms a resonant circuit with the coil's primary winding to help boost the output voltage and reduce internal losses.

Consequently, its value is fairly critical and original parts always work best. Avoid, if you can, high-performance coils, such as the type used for high-performance engines. The resistance of the primary winding is considerably lower than a conventional coil, and they tend to reduce the life of the relay contacts. Volkswagon coils also draw large amounts of current and should be avoided. And finally, make sure that the coil you use is from a car with a standard ignition: those new electronic "jobs" simply won't work.

PARTS LIST FOR THE BATTERY-POWERED FENCE CHARGER

SEMICONDUCTORS

D1—1N4001 1A, 50-PIV rectifier diode
LED1—Jumbo red light-emitting diode
Q1—2N2222A NPN general-purpose silicon transistor
U1—CD4001 quad two-input NOR gate, integrated circuit

RESISTORS

(All resistors 1/4-watt, 5% units unless otherwise specified)
R1—47,000-ohm
R2—220,000-ohm
R3—1 Megohm
R4—5-ohm
R5—50,000-ohm, linear-taper potentiometer

CAPACITORS

C1—4.7-µF, 35-WVDC, electrolytic
C2—0.022-µF, 50-WVDC, ceramic disc
C3—0.047-µF, 250-WVDC, ceramic disc (see text)
C4—220-µF, 16-WVDC, electrolytic
C5—0.001-µF, 50-WVDC, ceramic disc

ADDITIONAL PARTS AND MATERIALS

K1—6-VDC coil, 117-VAC contacts, SPDT relay
printed-circuit board, suitable enclosure, wire, hardware, solder, etc.

The following is available from Danocinths, Inc., PO box 261, Westland, MI 48185: A complete kit (FC-107) of parts, less the ignition coil, priced $18; printed-circuit board, RW-107, at $10; assembled kit, cabinet included, at $40. Price includes postage and handling; Michigan residents add 4% sales tax. Please allow 6 to 8 weeks for delivery.

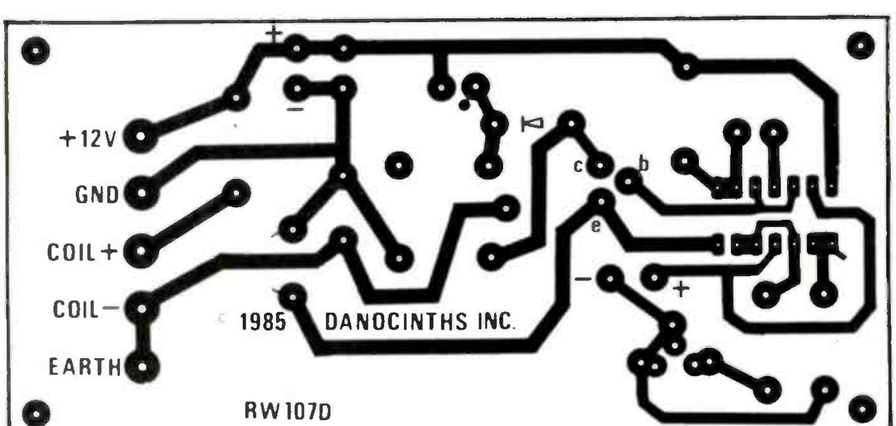


Fig. 2—Printed-circuit foil pattern is shown same size. Although, construction is not critical, using the printed-circuit board illustrated helps to cut down on errors that may damage polarized components.

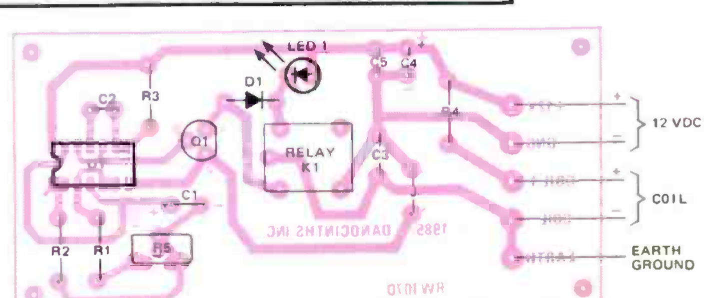
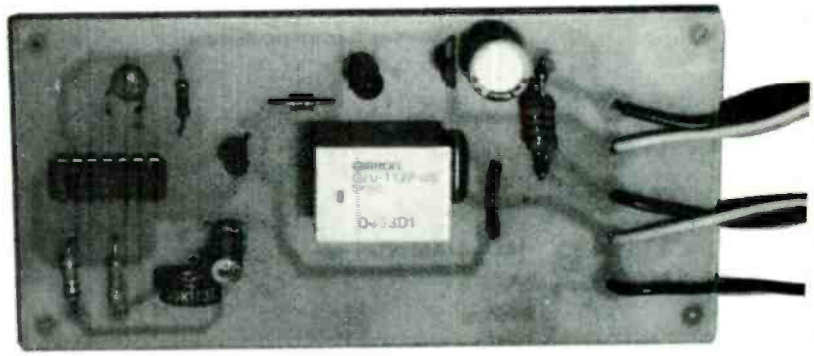
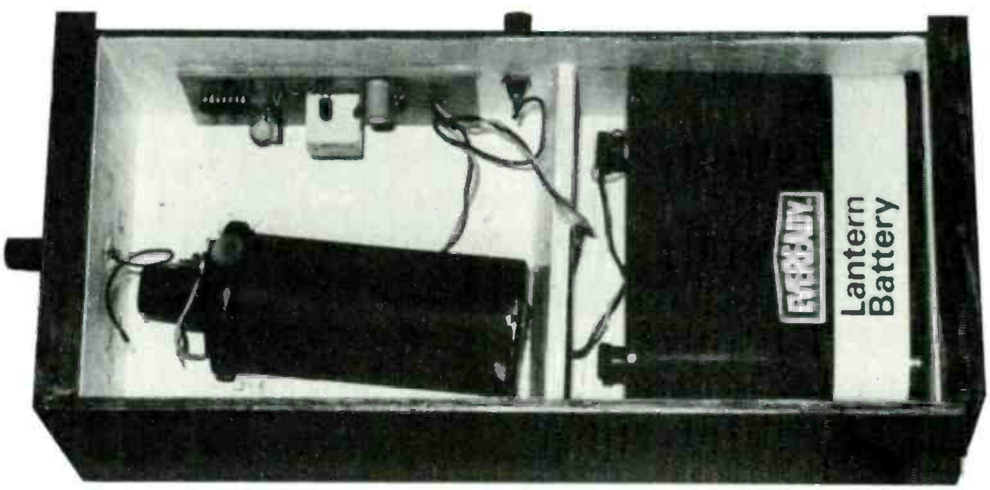


Fig. 3—Here is the parts-placement diagram for the Fence Charger's printed-circuit board. Note that connections are provided for both the earth ground and the power-supply ground—be careful not to confuse the two. Also, make sure that all the polarized semiconductor and capacitor components are in the right position and properly oriented.



The Fence Charger's printed-circuit board (right) is shown with all on-board components installed. Note the five wires (two twisted pairs, and a single conductor) coming off the circuit board; they are used to connect the system power source, the high-voltage source, and the fence (or other metal object) to the circuit. The Fence Charger can be powered from a single 12-volt lantern battery (below), or you can whip up a power supply, which can be housed in the enclosure. The canister sharing a compartment within the enclosure with the printed-circuit board; the canister is the auto ignition coil, which provides high-voltage for the circuit's operation.



The pulser circuit is constructed on a printed-circuit board. Although the method of construction and/or layout is not particularly critical, except the proximity of the coil to the integrated circuit, certain precautions must be observed, because the timing circuitry is made from a CMOS IC. If you've ever dealt with CMOS parts, you are probably aware that they are extremely susceptible to damage caused by static electricity, so careful handling is a *must*. It only takes the static charge that normally builds up on your body to *fry* one of those IC's.

The printed-circuit foil pattern is shown in Fig. 2, should you decide to go that route. As for the parts, you should be able to obtain them from your local electronics supplier or, if you prefer, through mail order. Once you have all the parts and the circuit board, begin stuffing the board according to the layout in Fig. 3.

First install the resistors, capacitors, and the relay, in that order. And then move on to the semiconductors, saving the CMOS integrated circuit for last. When soldering the integrated circuit in place, it's best to use a grounded soldering iron. In that way, any electro-static (static electricity) build-up is channeled away from the unit, preventing possible damage. Grounding a soldering iron is as simple as attaching a clip lead to the tip of an iron and connecting the other end of the lead to a neutral metal surface.

The IC is also very sensitive to stray electric fields after it has been installed on the board. Therefore, the high-voltage coil must be located as far away from the relay board as practical. And never—repeat, *never*—run the high-voltage lead anywhere near the board!

Trash Can Security

Nothing is more annoying than being awakened in the middle of the night by the sound of rattling trash cans. It is often the case that stray dogs and other critters can be found rummaging through your discards looking for a free meal. Not only does it disturb your sleep, but there is always the distasteful task of picking up the spilled litter come morning. That often repeated scenario presents the ideal situation for the installation of a Fence Charger.

By placing a charged wire around your cans, or applying the charge directly to metal cans, you will make your pawed prowler think twice before patronizing your "restaurant" again. Although the jolt is absolutely harmless to the animal, it will only take one or two treatments before even the most ardent diner gives up and looks for easier pickings. A rubber mat or wooden platform under the charged can is all that's necessary to keep the can from shorting to ground.

Keep the dimensions of the insulator close to the diameter of the can, though, so the intruder comes in contact with the ground. Oh, yes; don't forget to turn off the charger on trash day, or you may be in for a shocking surprise. ■

Installation

The Fence Charger is obviously designed to electrify a metal fence. The design of the fence, though, will depend on the security requirements of your application. The simplest design is undoubtedly charged barbed wire wrapped around

(Continued on page 97)

BUILD A DATA-REVERSING RS-232 CABLE

Untangle those I/O mismatch problems with this simple switchable RS-232 connector.

By Herb Friedman

FORMERLY USED PRIMARILY BY COMMUNICATIONS AND computer equipment as a "standardized" input/output connection, the RS-232 serial I/O is now being found on a broad range of modern electronics appliances, providing such things as remote control of tape recorders, user-programming of high-fidelity cassette decks, computer control of digital disk players, and even telephone access of home security systems. The fact is, RS-232 interfacing is becoming so commonplace that ordinary folk who can't tell the difference between a DIN connector and a phono jack can expertly discuss the functions of all 25 pins of the subminiature D-connector—the connector generally used for RS-232 I/O.

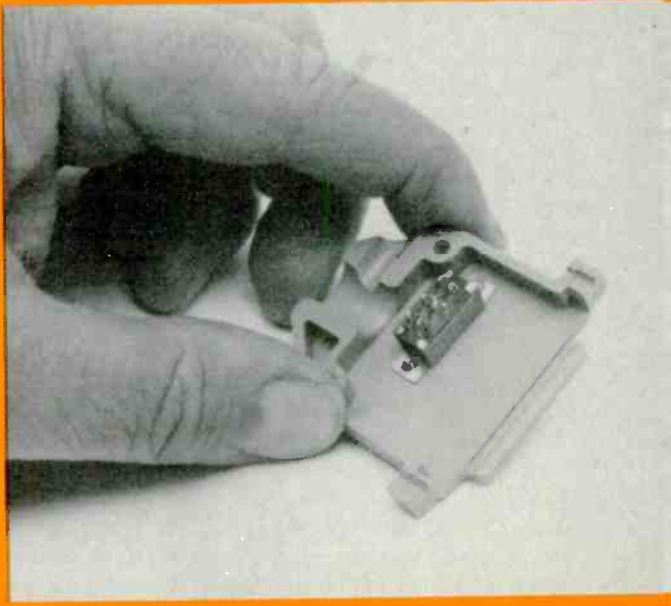
The problem with RS-232, however, is that the data (signal) input and output connections vary from device to device. Although they almost universally use pins 2 and 3 of a D-connector, on some devices pin 2 is the input and pin 3 is the output, while on other devices the connections are reversed. And that often leads to a hunt for some extra connectors to make up an adapter cable.

However, you can easily simplify your RS-232 connections by making a cable using the wire-reversing scheme shown in Fig. 1. With the switch in one position, pin 2 is the input and pin 3 the output. Flip the switch the other way and the connections are reversed; pin 3 is input and pin 2 the output. If you connect two serial devices together and they can't "talk to each other," you simply flip the switch to reverse the signal connections rather than try to scrounge up an adapter cable.

The only special components needed for the reversing cable are a double-pole, double-throw (DPDT) subminiature slide-switch and the plastic hood for a 25-pin D-connector

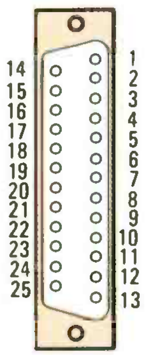
PARTS LIST FOR THE REVERSING RS-232 CABLE

DPDT, miniature, slide switch (Radio Shack 275-407)
Two hoods for 25-pin subminiature D-type connector (Radio Shack 276-1549)
Two 25-pin subminiature D-type connectors (Radio Shack 276-1547, male or 276-1548, female)
Multi-conductor or ribbon cable of required length



Install a subminiature DPDT slide switch on one half of a D-connector's plastic hood. Be sure to allow for cable leads to fit around switch. Refer to the text.

D-SUBMINIATURE CONNECTOR



RS232C Standard Pin-Function Designations

Pin No.	Function
1	Ground
2	Data (Transmit)
3	Data (Receive)
4	Request to Send
5	Clear to Send
6	Data Set Ready
7	Ground
8	Carrier Detector
9	Data Set Test
10	Data Set Test
11	Unassigned
12	Secondary Carrier Detector
13	Secondary Clear to Send
14	Secondary Data (Transmit)
15	Xmit (DCE)
16	Secondary Data (Receive)
17	Rcvr Clock (DCE)
18	Unassigned
19	Secondary Request to Send
20	Data Terminal Ready
21	Signal Quality Detector
22	Ring Indicator
23	Data Signal Rate Selector
24	Xmit Clock (DTE)
25	Unassigned

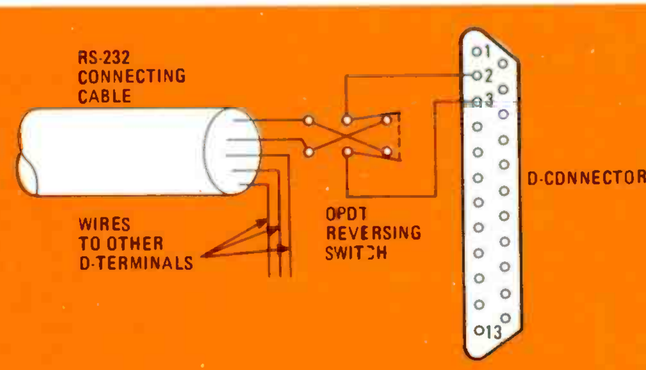


Fig. 1—The wiring scheme for the DPDT switch, which sets up the signal I/O lines for normal and reversed operation.

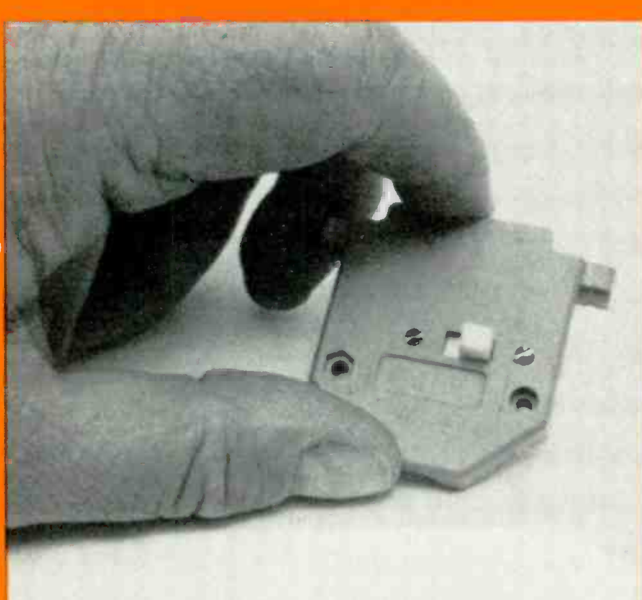
(which is sold by Radio Shack). The Radio Shack hood is specifically recommended because we know for certain that it has sufficient internal space for a miniature slide switch. Other kinds or styles of plastic hoods don't necessarily have the required internal space.

Construction

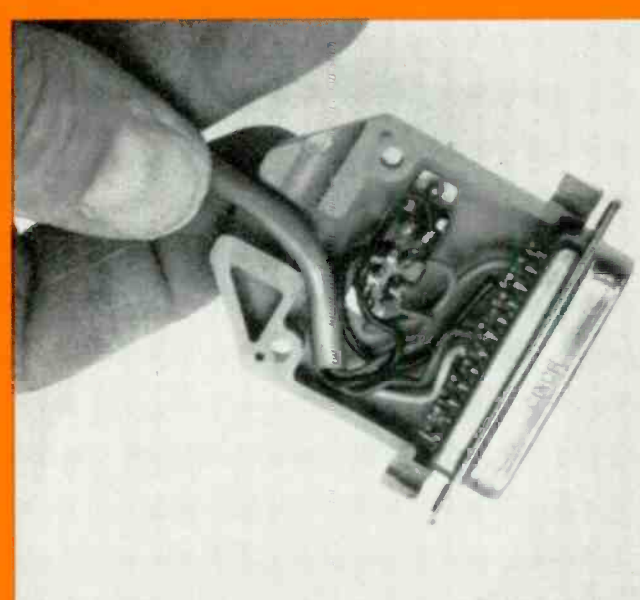
The first step is to install the switch inside the half of the hood you will use as "the top." Pre-connect the switch's jumper wires before installing the switch in the hood. Make certain that you locate the switch as far to the rear of the hood as is possible and as close as possible to one side, so that the switch doesn't block the opening for the main cable. Also, double-check to make sure that the switch's handle can move its full length in both directions.

Install the RS-232 connector on the hood and install all connecting wires except the two signal wires: They will be connected to the switch. Next, connect two wires from the switch to pins 2 and 3 of the D-connector. Route the cable carefully around the switch and assemble the hood. That's the whole bit. Refer to the D-Subminiature Connector illustration to the right of Fig. 1 and its table for all RS-232C pin assignments.

Through trial and error, or if you know by the color coding of the wires, attach a label to the hood showing the normal and reversed switch positions, so that the next time you make connection to a modem, another computer (null-modem), tape recorder, or whatever, you need only flip the switch to get the signal connections straight. ■



Make certain that the switch's handle is free to move to both extreme positions. If it's not, remove the switch and file the opening to accommodate the switch's handle travel.



Wire the cable and switch according to Fig. 1, and carefully route the cable around the switch, so that the cable doesn't get pinched when the other half of the hood is secured.

Your First TVRO System

We take the the first hurdle for you by installing a Black Widow Series I TVRO System, and sharing our experiences with you!

By Hands-on Electronics Staff

IF YOU'RE THINKING OF BUYING A SATELLITE TV SYSTEM, you are not alone. Over a million residents of the US and Canada have already taken the plunge and another million dish-shaped antennas are expected to crop up in yards and on rooftops across the North American continent within the next year.

In the Beginning

The first satellite TV system (TVRO) owners were, for the most part, rural area residents who weren't able to receive all three major networks—many TV viewers were lucky to get one! But, in the past couple of years, they've been joined by a great number of suburbanites seeking access to a weekly diet of news, information and variety shows, 500 sporting events, and 250 movies that can be pulled off the 14 *birds* (satellites) hovering over North America.

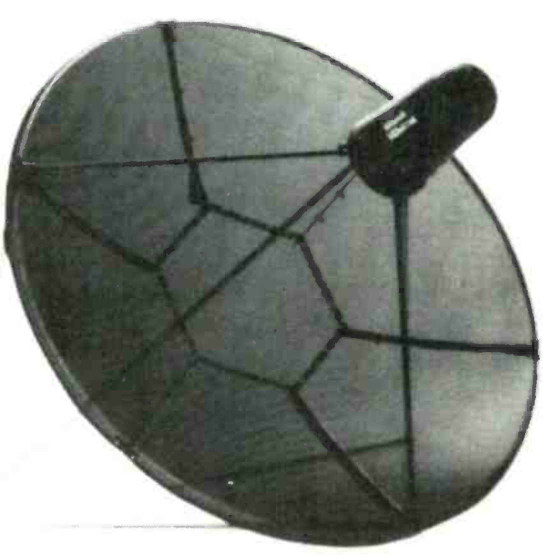
Even though the price of a TVRO system has dropped dramatically since they were first introduced in 1979 (from $36,000 then to under $2000 now), it's still a major purchase, and should not be entered into lightly. If you rush into such a purchase without doing your homework, you are bound to make some costly mistakes. But, by investing a little time and effort in educating yourself on the basics of TVRO's, you'll be rewarded with years of viewing pleasure. We have taken some of the steps for you.

What You Should Know

TVRO equipment falls into two categories; *basic*, which sells for $1300 to $2500, and the *deluxe*, starting at $2500 and ranging up to $5000—don't hold us to the exact price ranges specified. The amount of your purchase depends on your locale. For instance, in the midwest (where satellite signals are the strongest), a dish 5- to 10-feet in diameter is all that's needed. But in the other areas—like Florida and California, and along the upper east coast, where satellite TV signals are weakest—an 8- to 12-foot dish is required. Larger dishes are, obviously, more costly than smaller ones.

In any TVRO installation, the location of the dish is critical. The site chosen must have an unobstructed view of the southern and southwestern skies, since the satellite TV signals originate from about 22,000 miles above the equator. And the dish should be located in reasonably close proximity to the house (preferably within 150 feet) so that cable can easily be run between it and the receiver.

The in-coming satellite transmission along the axis of the dish is bounced off the dish's surface and concentrated on the focal point of the reflector, where the LNA (low-noise amplifier) picks-up and amplifies the weak microwave signal. The amplified output of the LNA is then fed to a downconverter, located near the LNA, which transforms the microwave transmission into conventional TV signals. Like the output of a VCR (video cassette recorder), the signal is then input to a TV set on an unused channel.



The Black Widow Series I is a basic TVRO system consisting of a 6-foot dish with patio mount, low-noise amplifier, and a single-conversion receiver. The system is designed to be up-graded by the user as he/she outgrows the basic package.

Regardless of whether you're interested in a basic or deluxe model, each system consists, essentially, of the same components: the parabolic dish (also called the antenna), LNA, and receiver (see photos). The dish, like any other antenna, is a signal gathering device, which is pointed toward the sky at an angle dependent on the site's location in relationship to the orbiting *birds*.

The LNA—an amplifier that's rated in degrees Kelvin (°K) and specially designed to add a minimum amount of noise to satellite TV transmissions—is charged with the task of amplifying the weak microwave signals gathered by the dish. Although the signal starts out in space with 8.5-watts of power (roughly slightly stronger than the equivalent output of a CB transmitter) by the time it reaches the earth, it is extremely weak. The microwave transmission is susceptible to interference generated by thermal energy from the Sun, for instance. Amplifiers themselves can introduce interference, due to heat generated during operation, into the signal.

The LNA's degrees Kelvin rating (also known as noise temperature) is an indication of its ability to amplify the microwave signal, without introducing additional interference. Therefore, the lower the noise temperature, the better the LNA. For instance, an LNA with a rating of 100°K would out perform one with a 120°K rating.

The receiver, one of the few TVRO components designed for indoor use, is assigned the task of converting microwave signals to conventional TV signals. A portion of the receiver, the downconverter (which is usually mounted at the dish site near the LNA), takes in microwave signals and outputs RF signals, which after additional processing, may be fed to an unused TV channel. The receiver also contains tuning circuits that allow you to choose a particular channel (transponder) for viewing.

The deluxe package, in addition to the components already mentioned (which make up the basic package), might contain extras like a dish positioner, infrared remote-control, stereo-sound circuitry, programmed-memories, etc.

About the Extras

The dish positioner allows you to redirect or correct the aim of the dish. Without such a device, the system owner is forced to go outdoors to reposition the dish in order to pick up programming from another satellite or improve reception. (An extremely unpleasant task during the winter season.) The positioning system includes motor drives, which are located outside the home, and a motor-drive controls located on a console inside the home, which allow dish manipulation from the comfort of your living room.

The infrared remote-control enables you to control all the functions of the TVRO system from your favorite chair; everything from changing the channels to repositioning the dish. For even more *bells* and *whistles*, you can plunk down $4500 to $5000 for a system the comes with a receiver that provides an on-screen display of all functions and para-

Black Widow II, a cut above the basic package, contains the same components as the basic model, but with one slight difference: The patio mount provided for the Black Widow I package is replaced by a polar mount, which allows for easy on-site dish positioning. Also, instead of an LNA, this package contains a block-conversion receiver, consisting of an LNB (low-noise amplifier and block-converter), and receiver.

meters. For instance, the name of the satellite and the transponder (channel) that you are receiving, along with whether you're picking up stereo sound might be flashed on screen.

A piece of equipment that's not required now, but probably will be in the next couple of years, is a signal decoder (descrambler), since HBO and others are planning to encode (scramble) their transmissions. The decoder, which is expected to sell for $400, will be necessary if you intend to continue accessing the available programming. In addition, when scrambling is implemented, dish owners will also be required to pay a $12.95 monthly fee for HBO or Cinemax alone, or $19.95 for both. However, the added expense is offset by the decrease in price of TVRO equipment.

The Black Widow Series I single-conversion receiver is shown here on top of a Panasonic video cassette recorder.

What's Available

Many manufacturers, such as Drake, Dexel/Gould, McCullough and others, produce TVRO components and systems ranging from the most basic do-it-yourself hookups to deluxe convenience-packed systems. For the *do-it-yourselfer*, R.L. Drake Company (P.O. Box 112, Miamisburg, OH 45342; 513/866-2421) has introduced a series of three TVRO's called *Black Widow* that are designed so that those starting out with the most basic package can up-grade their systems to one of the feature-packed versions.

The Series I package, the most basic of the three versions, includes a 6-foot dish with patio mount (which eliminates the need for pouring cement), an LNA, a single-conversion receiver (which down converts a single microwave signal at a time), and 100 feet of connection cable. The basic system carries a suggested retail price of under $1000.

Series II, a step above Series I, consists of a 6-foot dish with polar mount, an automatic dish positioning system, a block-conversion receiver, and 100 feet of cable. The block-conversion receiver, as opposed to the single-conversion unit, down converts several microwave frequencies as a block. Such a system allows the simultaneous viewing of several channels (transponders) at once from the same installation. All that's needed is a receiver (tuner) at each viewer location.

The final system in the trio is the Series III, which also contains a 6-foot dish with polar mount. But, unlike the others, it also includes expansion panels that allow the dish's diameter to be increased to 8 feet. Like Series II, it is supplied with a block-conversion receiver, and 100-feet of hookup cable. Each system in the Black Widow series comes with step-by-step instructions that are geared so that the home owner can handle the installation. If being able to say, "I did it myself" is your bag, then the Black Widow series is worth a look.

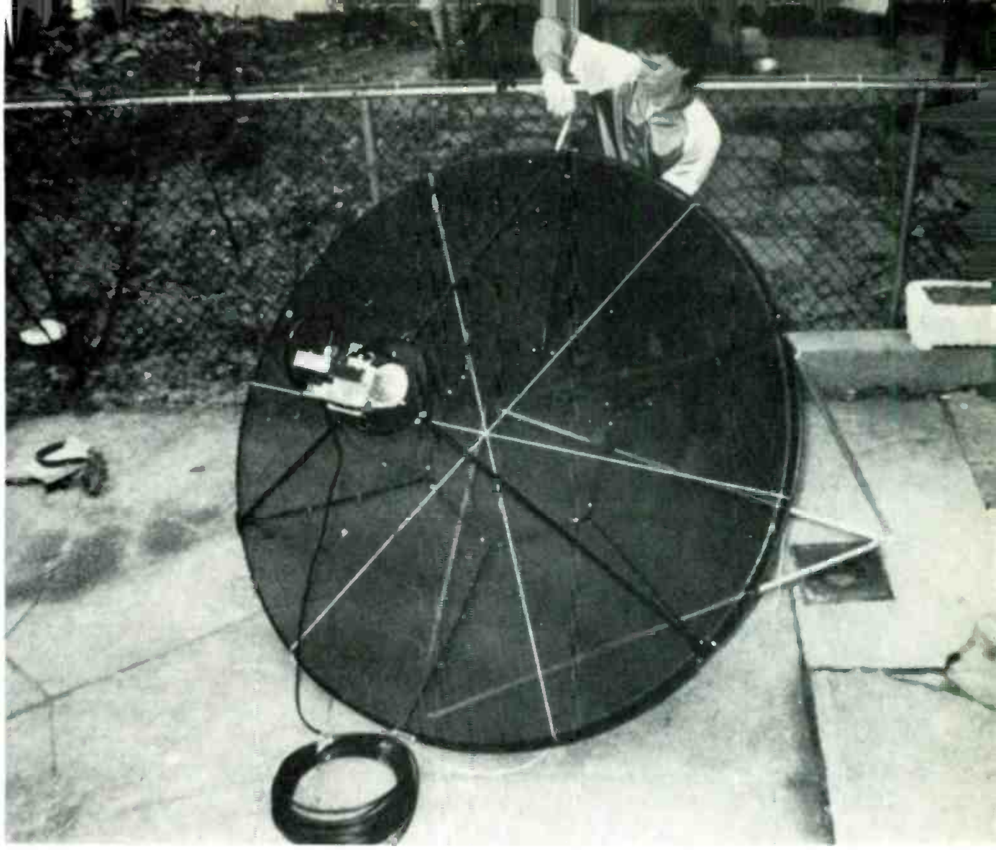
Putting the Black Widow Together

The Black Widow Series I TVRO system was assembled by the editors in the preparation of this article. The system is delivered in three cartons, each is heftable without any real effort by an adult male. Open up the cartons and check that all the parts listed in the enclosed manuals are there.

You can expect to use hand tools to assemble the dish—it is shipped in seven major pieces and other small parts and hardware, plus the patio mount required to mount the dish.

Be sure to include a $7/16$-inch, $1/2$-inch and $9/16$-inch ratchet socket wrenches on your tool list. If you don't have a ratchet set, then open-end or box wrenches will be needed. Try not to use adjustable wrenches, because their jaws may be too large for the job.

The final package in the trio, Black Widow III, features, in addition to the components found in the Black Widow II package, a 6-foot dish that can be extended to 8 feet with its expansion-panel option. The dish, supplied with polar mount, also comes with an automatic dish positioner.



The advantage of setting up the Black Widow Series I system in the backyard was the elimination of all wind stresses while still having a clear shot of a strong, overhead signal from SATCOM F4 satellite. At this time, all of the bolts and nuts were checked for tightness prior to powering up the unit.

You'll need three pieces of seven-foot light string and masking tape. Also, a little bit of hand lotion and old utility or driving leather gloves will be helpful to protect the hands when you are working with the stamped metal dish sections.

All the dish sections and parts were spread out on the floor in an indoor area during our assembly, because the outdoor weather was too cold. The floor work area must be flat for assembly purposes. In warmer weather, the garage floor or outside deck or driveway will do. Keep in mind that the dish must pass through a doorway to be brought outdoors. Although the entire dish assembly was completed indoors, the LNA had to be removed to get the dish outdoors.

All the parts are identified by name, diagram and number in the instructions. We placed all the parts on the floor and used small slips of paper with numbers inscribed thereon that conformed to the step-by-step manual. Assembly was speeded, and the common mistake of using the wrong screw size was avoided. In fact, no mistakes were made at all—a credit to the Drake people.

The printed instructions will require that strings be positioned along three dish diameters during assembly. To properly place the strings, and to do it with a minimum of hassle, mark the outside rim of each of the six dish pie-section panels with masking tape and place a pencil mark on the center rim length before starting assembly. This will save time and trouble later.

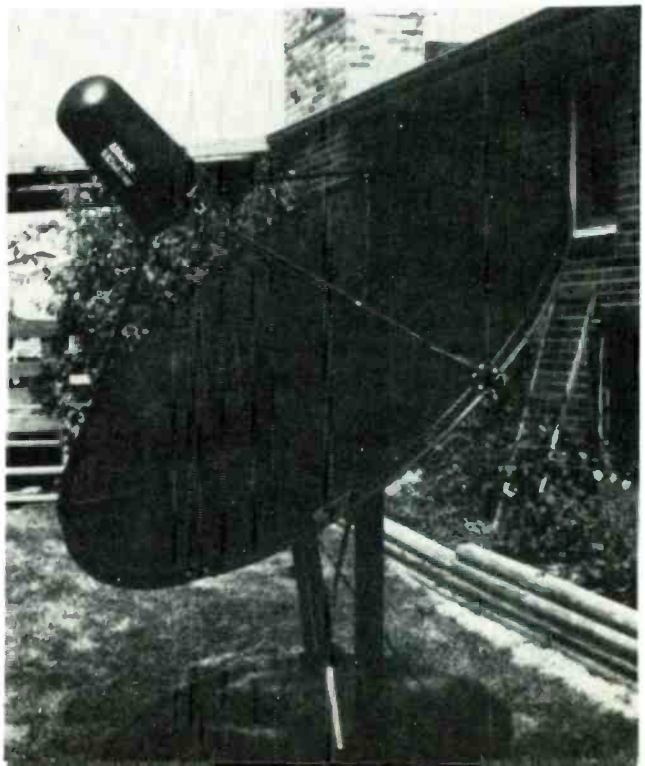
If you work indoors, place some cardboard or an old mat on the floor. When the dish is flipped over during assembly so that it is right side up and the floor is not protected, the dish's sharp edges will scratch hard wood floors or tear rugs.

Once outdoors, the dish was assembled on the supportive frame of the patio mount and the alignment procedure took place as directed in the Black Widow's system manual.

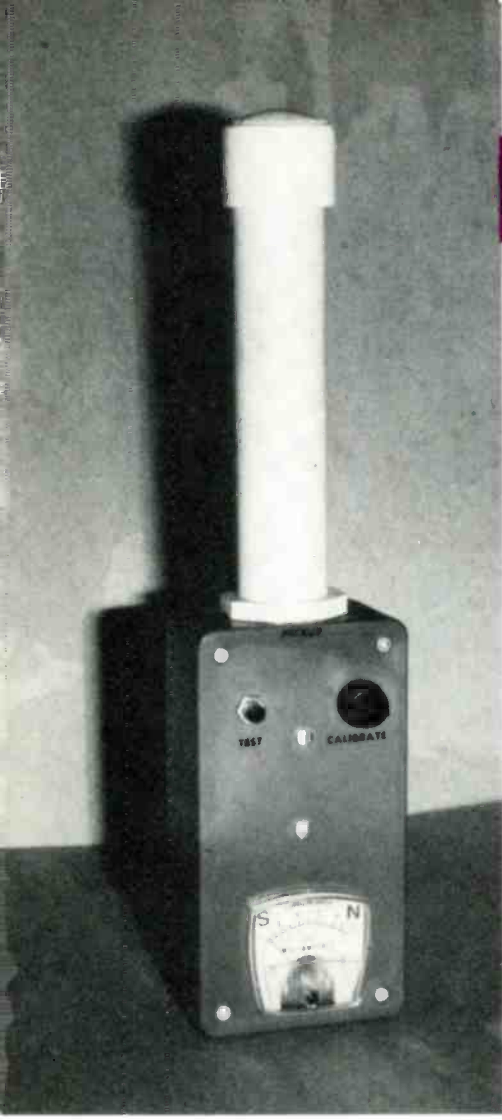
Drake supplied a magnetic compass to be used during the dish-alignment procedure. We found it necessary to replace the compass supplied with the Black Widow with an inexpensive unit obtained at our nearby official Boy Scout supplier.

The actual site selected avoided having the received signal passing through tree branches and the overhead telephone lines. We did not expect any trouble from the 'phone line, but we did not open the door for any, either! So, follow the instruction manual as we did—you will pull in a quality television picture from the SATCOM-F4 satellite on the *first try* as we did!

During the initial installation and alignment stage of the dish, sandbags were not used to load down the dish's frame on the ground. That was done afterwards to our regret—we accidentally moved the axis of dish off the satellite. That goes to prove that even editors should follow manufacturer's instructions very carefully! *(Continued on page 97)*



The six-foot dish of the Series II is secured to a polar mount. As the antenna is rotated on its polar axis, the dish scans the available satellites viewable from your locale.



THE MAGNET

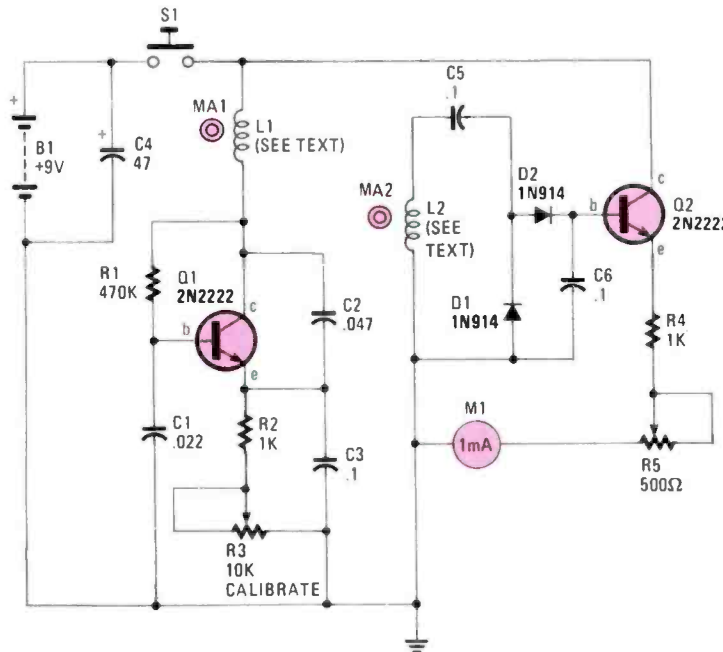


Fig. 1—In the schematic diagram of the Magnetometer note that along with the two coils, L1 and L2, there are also two magnets, MA1 and MA2. Together, those components form the sensory portion of the circuit.

THE PERMANENT MAGNET IS ONE OF THE OLDEST MYSTEries of science, and probably the least-understood component used in our modern-day technology. Through years of enormous growth in the electronics field, engineers, technicians, and home experimenters have been given hundreds of choices of testing and measuring instruments to aid in designing and troubleshooting of electronic circuits. But somehow, until now, a simple electronic device to check magnetism has been left out or forgotten.

With the **Hands-on Electronics** *Magnetometer*, magnets can be checked for field strength, two or more magnets can be matched, and the north and south poles determined. Beside all of the above uses, the Magnetometer is a fun-to-build construction project and not likely similar to anything that you have built in the past.

How It Works

Refer to Fig. 1. Two general-purpose NPN transistors, Q1 and Q2, do the work, and a special hand-wound, dual-coil probe ferrets out the magnetism. Q1 and its associated components form a simple VLF oscillator circuit, with L1, C2, and C3 setting the frequency. The VLF signal received by the pickup coil, L2, is passed through C5 and rectified by diodes D1 and D2. The small DC signal output from the rectifier is fed to the base of Q2 (configured as an emitter follower), which is then fed to a 0–1 mA meter, M1.

L1 and L2 are identical coils wound on each end of a 5 ¼ × ⁵⁄₁₆-inch ferrite antenna rod. A doughnut magnet is placed at each end of the ferrite rod to magnetically bias the ferrite material. With the two magnets, MA1 and MA2, in the proper polarity and placement on the rod, the ability of the ferrite core to transfer energy from L1 to L2 is reduced. If the magnetic field of MA2 is reduced (by bringing a "N" pole of a magnet close to the "N" pole of MA2), the efficiency of the

PARTS LIST FOR THE MAGNETOMETER

B1—9-volt, transistor-radio battery
C1—0.002µF, 100-WVDC, polyester capacitor
C2—0.047µF, 100-WVDC, polyester capacitor
C3, C5, C6—0.1µF, 100-WVDC, polyester capacitor
C4—47µF, 16-WVDC, electrolytic capacitor
D1, D2—1N914 small-signal silicon diode
M1—0–1mA, DC milliammeter
MA1, MA2—Doughnut magnet, 1⅛-inch diameter (Radio Shack 64-1885)
Q1, Q2—2N2222, 2N5249, 2N2924, etc., NPN transistor
R1—470,000, ¼-watt, 5% resistor
R2, R4—1000, ¼-watt, 5% resistor
R3—10,000-ohm, linear-taper potentiometer
R5—500-ohm trimmer potentiometer
S1—Normally-open, pushbutton switch

ADDITIONAL PARTS AND MATERIALS

Printed-circuit materials, 6 × 3³⁄₁₆ × 1⅞-inch plastic case (Radio Shack catalog #270-223), 6½-inches of 1¼ diameter PVC tubing, plastic pipe cap, plastic pipe coupler, 34 feet of #24 magnet wire, 5¼ × ⁵⁄₁₆-inch ferrite rod (loop-antenna rod), super glue, wire, solder, etc.

TESTER

By Charles D. Rakes

This Magnetometer is assembled from a handful of readily available components —now you can test the field strength of magnets.

ferrite rod is increased and more energy is transfer from L1 to L2 and is indicated by an increase in the reading of M1.

That increased reading indicates that the north pole of a magnet is facing the probe's end. If the south pole of the magnet is brought near the probe, the magnetic biasing increases, decreasing the ability of the ferrite rod to transfer energy. A reduction in meter reading indicates that the south pole of the magnet is facing the probe's end. The amount of increase or decrease in the M1 reading indicates the *relative* strength of the magnet under test.

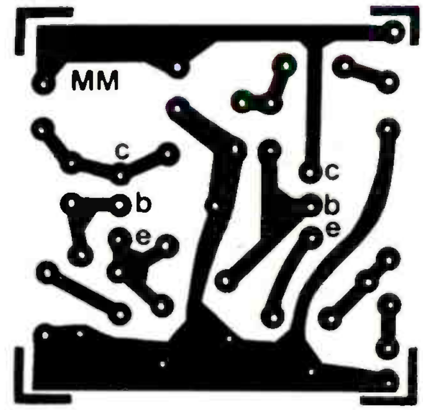


Fig. 2—The full-scale foil pattern shown may be lifted from the page and used to etch the printed-circuit board for the Magnetometer.

Magnetometer Construction

The author's first version was constructed on perfboard, but later transferred to printed-circuit board for neatness. A printed-circuit foil pattern for the Magnetometer is shown in Fig. 2. A plastic economy case, measuring 6 × 3³⁄₁₆ × 1⅞-inches, was used to house all components, except the probe. It doesn't matter what layout you choose, just as long as all metal and magnetic materials are kept a few inches from the ferrite probe. If all of the components are to be mounted in the same cabinet, it may be necessary to use a larger case.

If a printed-circuit board is used, follow the component layout for the author's prototype: By doing so, it should only take a short time to complete the construction. See Fig. 3. On the other hand, if you opt to go with perfboard construction, a somewhat larger board than that required for printed-circuit construction may be needed.

The next step is to prepare the cabinet that will house the Magnetometer. The author's unit was housed in a plastic economy case, measuring 6 × 3¹⁄₁₆ × 1⅞-inches. Start by

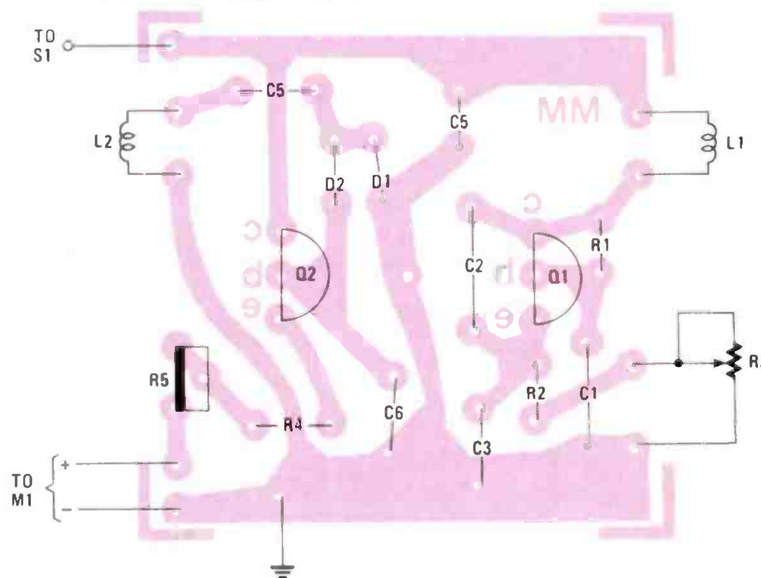


Fig. 3—An x-ray view of the printed-circuit board showing the parts layout for the Magnetometer. Coils L1 and L2 are shown as if mounted in the printed-circuit board, but they are not. Instead, they are wound around the ferrite rod and attached to the printed circuit.

The Magnetometer's printed-circuit board, controls, and meter are mounted to the lid of the case and connected to the probe portion of the project through a hole drilled in the case.

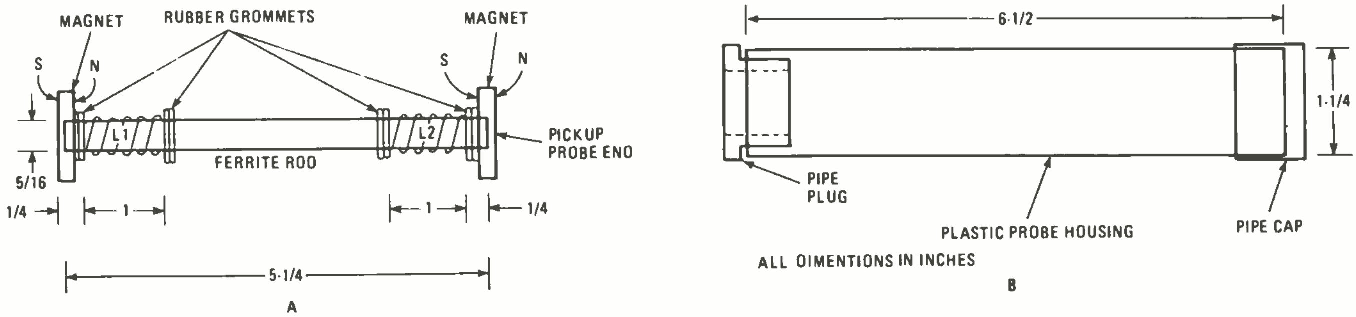
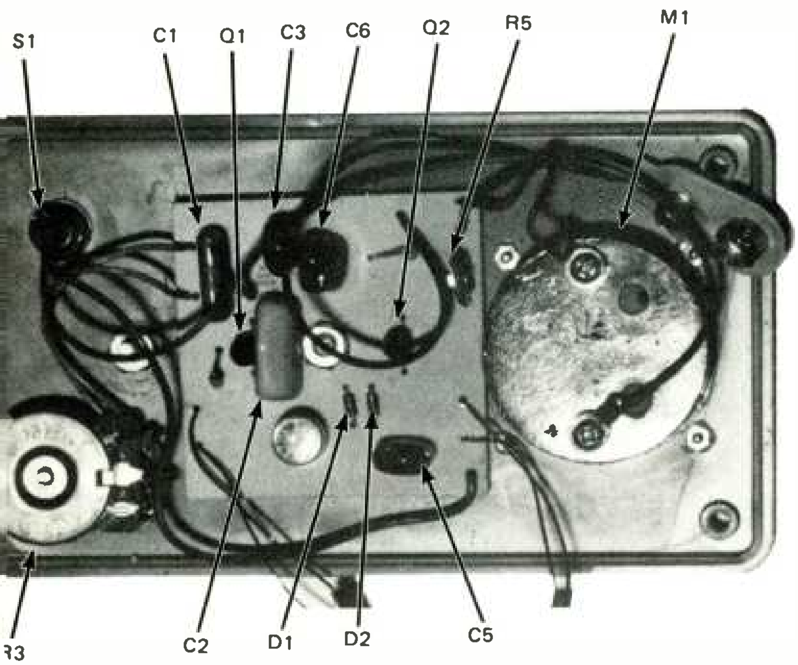


Fig. 4—The sensor probe is fabricated using the specified parts (see text for details). Grommets can be glued in place on the ferrite rod to act as a border when winding the coils.



A view inside the Magnetometer project pinpointing the printed-circuit board and major circuit components.

drilling holes in the lid of the cabinet for the mounting hardware, CALIBRATE potentiometer R3, switch S1, and the milliammeter. The location of the meter, switch, potentiometer, and circuit board can follow the author's layout, or any other pattern that suits your fancy. Then drill a hole in the cabinet at one end, through which the wires from the probe will be connected to the printed-circuit board. (The photos will give you a good idea of the construction action that was taken.) Once that construction is done, it's time to whip up the probe portion of the Magnetometer project.

Building the Probe

A 5¼ × 5⁄16-inch ferrite antenna rod, of the type found in portable radios, is used as the core of the pickup probe. If you cannot find the exact antenna rod, most any similar rod will do; and with a little experimenting, you should be able to obtain similar results.

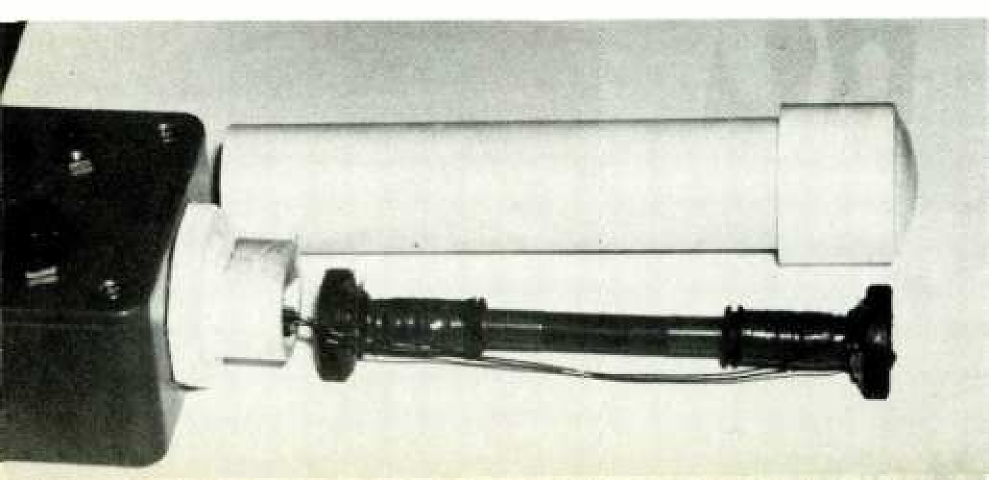
Refer to the Fig. 4 for the following steps. Place two grommets on each end of the ferrite rod, as shown in Fig. 4A, spaced about an inch apart, as shown, leaving ¼-inch at each end of the rod for the bias magnets. Cut two 17-foot lengths of No. 24 copper, magnet-wire, and wind two identical coils at each end of the ferrite rod between the grommets. Each coil should come to about 3¾ layers. Winding direction or lead polarity is unimportant. Leaving about 12-inches of wire from the coils for connection to the circuit board, wrap tape around each coil when finished.

The probe housing can be fabricated from plastic PVC tubing, in the same manner that the author did, by following Fig. 4B, or you can create your own version. Just be sure to use nonmetallic material for the enclosure. Once the probe is complete, connect it to the circuit board, through the hole in the cabinet, and make a final check for errors.

Final Preparations

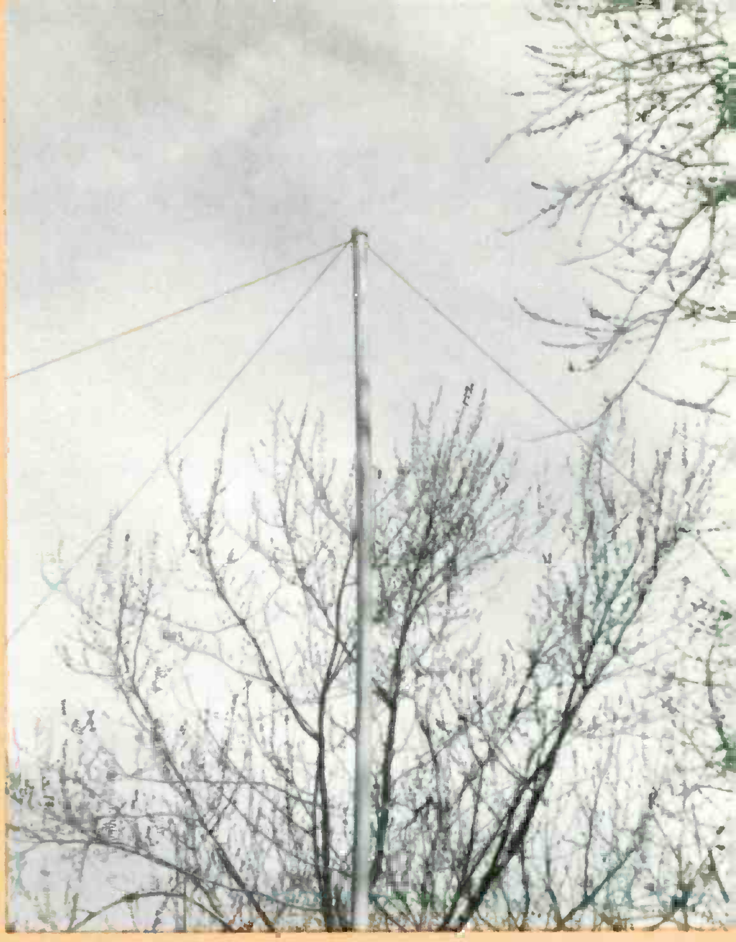
After both coils are wound and connected to the circuit, and all remaining connections have been completed, set the 500-ohm trimmer potentiometer (on the circuit board) ap-

(Continued on page 98)



The Magnetometer's housing is outfitted with a plastic pipe plug through which the probe and the printed circuit are connected. Once connected, the probe is placed inside its PVC housing and covered with a plastic pipe cap. Then the probe assembly is affixed to the project box by pushing the PVC tubing over the plastic pipe cap.

FLEXO SWL AERIAL



Try this antenna switching arrangement and improve your SW reception.

By Ed Noll

☐IF YOU'VE EVER HAD DIFFICULTY IN CAPTURING THOSE frequencies on the fringe of the shortwave spectrum, you probably know what a blessing it would be to have more than one antenna at your disposal. Now you can—well, not really. But, the *Flexo SWL Aerial* can make it seem as if you do.

The Flexo SWL Aerial is an antenna/antenna-switching system that improves reception by adding flexibility to a single-antenna installation, making it seem as if you have more than one antenna. Flexo's extended performance better accommodates the extraordinary frequency span occupied by the many shortwave-broadcast bands. In effect, you have more than one choice in dealing with the variables of antenna length, line length, angle-of-signal arrival, and propagation conditions.

With the Flexo, sensitivity is made more uniform over the entire shortwave spectrum. It provides more than one choice in finding an optimum signal-to-noise (S/N) or signal-to-interference ratio when attempting to pull in a specific station. If you listen only to strong signals, the Flexo won't do much for your receiver's performance because of the high-sensitivity, high-selectivity, and automatic-gain characteristics of the latest receivers. However, if difficult receiving conditions and weak-signal identification are your bag, give it a try.

When a signal is weak, despite the high sensitivity of the receiver, even a couple of dB of extra-input signal may help you obtain an ID. Sometimes a weak signal with a better S/N or signal/interference ratio can do the same thing for you. Even the strong signals take brief fades, so a more solid lock is attractive to the music-loving enthusiast. Since the needs of shortwave listeners tend to vary, we'll describe both a simple two-wire Flexo and a really different three-wire version.

The Two-wire Flexo

A complete Flexo antenna and switching arrangement is given in Fig. 1. Basically, as shown in Fig. 1A, the antenna is cut as a dipole on the 60-meter band. A coaxial transmission line feeds the signal to the Flexo switch that comes ahead of the short piece of coax that connects the switcher output to the receiver. Note that one antenna wire separates from the usual straight lineup of a dipole element in the horizontal plane.

As shown in Fig. 1B, that antenna element can be angled

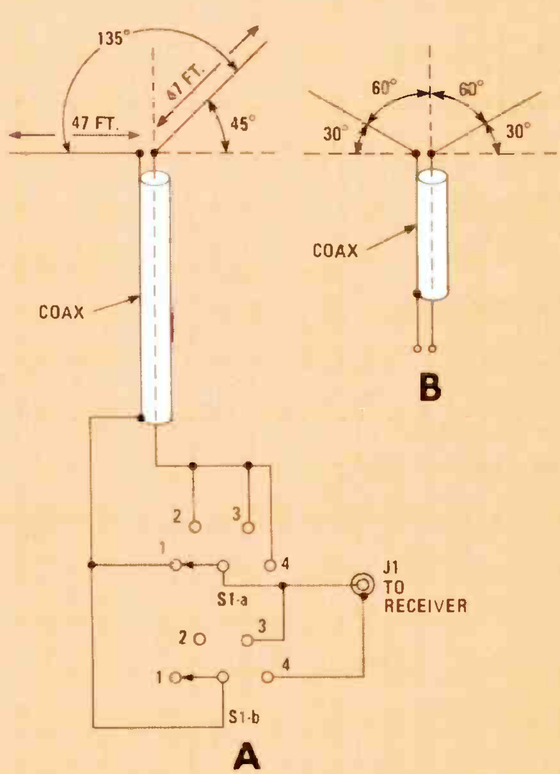


Fig. 1—The two-wire Flexo SWL Aerial gives you four possible combinations. For example, when S1 is set to position 1, the horizontal element is connected directly to the center conductor, which feeds the signal to the receiver. Position 2 connects the element that's slanted at 45-degree angle. In position 3, both elements are connected to the center conductor. But position 4 gives a dipole configuration, with one element connected to the center conductor and the other connected to the braided shielding.

PARTS LIST FOR THE FLEXO SWL AERIAL

J1—Insulated phono-jack
S1—2-pole, 4- or 6-position switch (see text)
Antenna elements—bare copper wire, AWG #16 or #14
Antenna mast—PVC pipe
Down lead—coax cable, or insulated wire (see text)
Metal cabinet, guys, nuts, bolts, etc.

up to as much as 60 degrees on either side of the center. Thus, it can be positioned to accommodate the mounting space that's available in your back yard.

In tests, it has been found that more reception flexibility is obtained with one element angled rather than straight. The antenna performs pretty much as a dipole on the 41- through 60-meter bands. On the remaining higher-frequency bands, other switch settings were often preferable to the dipole connection. Remember that the antenna wires become longer in terms of wavelength at the higher frequencies and, therefore, often perform more like a long wire.

The antenna mast was made of telescoped sections of PVC piping (as shown in the photos). The coaxial transmission line is fed to the top of the PVC mast by cutting a hole in the mast at about chest-height. The connection of the the inner conductor and conducting braid (outer conductor) of the coaxial line at the top of the mast is shown in Fig. 1. Two bolts serve as the antenna terminals. It is to those terminals that the antenna wires were attached using solder rings. The elements were then stretched out in an inverted-V fashion and brought down to two metal fence posts at ground level. In effect, you are constructing a 60-meter inverted dipole, but one with the antenna wires not necessarily in one line.

There are four possible ways to use the two conductors at the listening-post end of the coaxial transmission line. You can use the two separate conductors individually (an either-or arrangement) or connected in parallel. The fourth arrangement would be dipole fashion. The four possible choices are made available by a four-position, two-pole switch. The two switch sections are shown as S1-a and S1-b in Fig. 1A. In switch position 1, the braid of the coaxial line from the antenna is connected to the inner conductor of the short section of coax line that runs to the receiver input. In effect the coaxial braid and one of the 47-foot antenna wires is being used as a single-wire feed antenna.

Notice that the braid does not connect to the center conductor of the coax line. On position 2 of the switch, the center

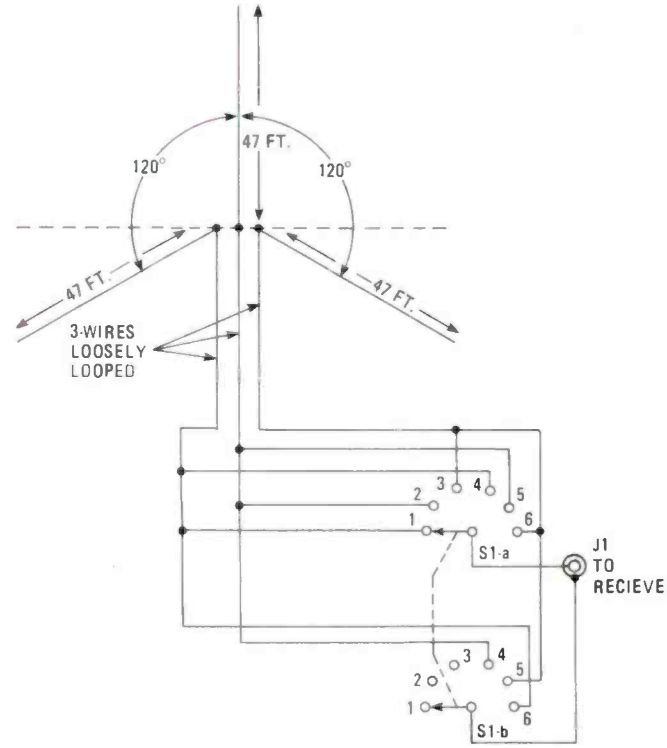
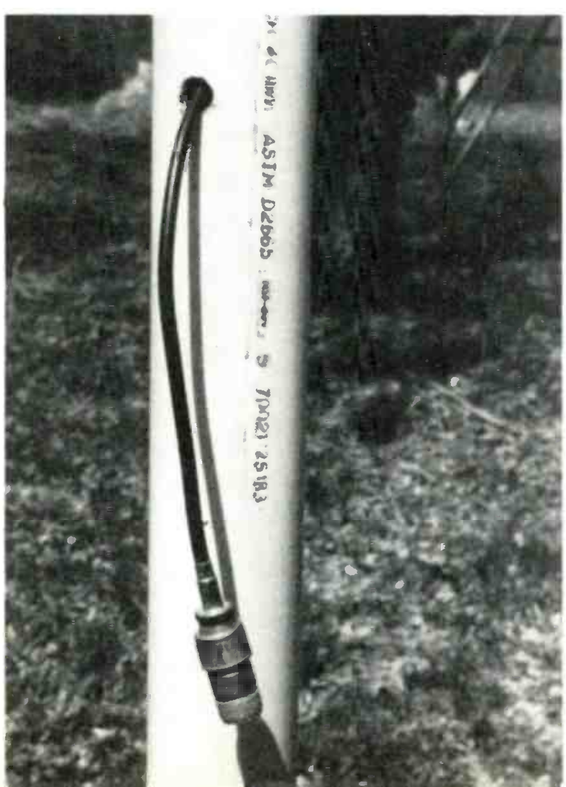


Fig. 2—The three-element Flexo installation provides greater flexibility over the two-wire type by allowing six combinations.



This view of the top of the PVC piping shows that the coax cable terminates in large ring tongues, which are then secured to the mast using nuts and bolts. The antenna wires are then connected to the bolts.

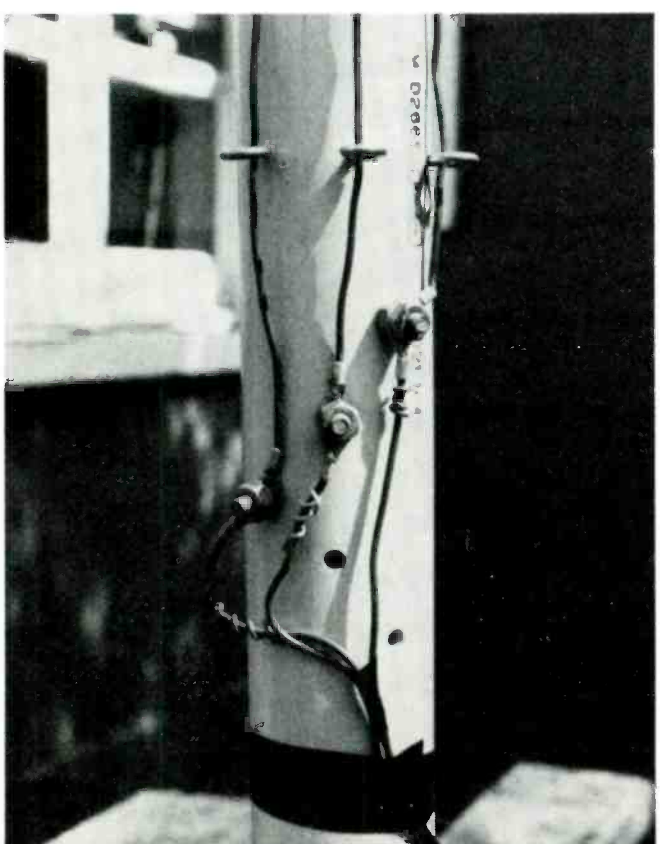
The coax cable is fed through a hole, drilled about chest-high in the PVC piping, to the top of the mast.

conductor of the coax line and the antenna element serve as a single-wire antenna. In position 3, the braid and the center conductor of the coaxial feed line coming from the antenna is connected to the inner conductor of the short section coax line that channels the input signal to the receiver. In that arrangement, both antenna wires are connected to the receiver in a single-wire feed arrangement. On position 4 the center conductor of the coaxial line from the antenna is connected to the center conductor of the short section of coax line that feeds the receiver. The outer conductor (braid) of the coaxial transmission line from the antenna is connected to the braid of the short section of coax connected to the receiver. In that arrangement, the antenna operates as a true dipole.

In putting the Flexo switching arrangement together, you must make certain that the braid of the transmission line from the antenna is not connected directly to ground in the switching box. The only time that the braid is connected to ground is when S1 is in position 4. In the author's switching arrangement, the switch was built into a small metal box measuring 3 ¼ × 2⅛ × 4 inches. On the rear of the box, the author mounted two isolated terminals (as shown in the photos) to which the coaxial line from the antenna is connected. To the left of that is a shielded phono-jack to which the coax line feeding the receiver is connected. If you have trouble finding a two-pole, four-position rotary switch, a two pole, six-position switch may be substituted.

The Three-Wire Flexo

Another Flexo uses three antenna wires and a three-conductor transmission line as shown in Fig. 2. In that arrange-

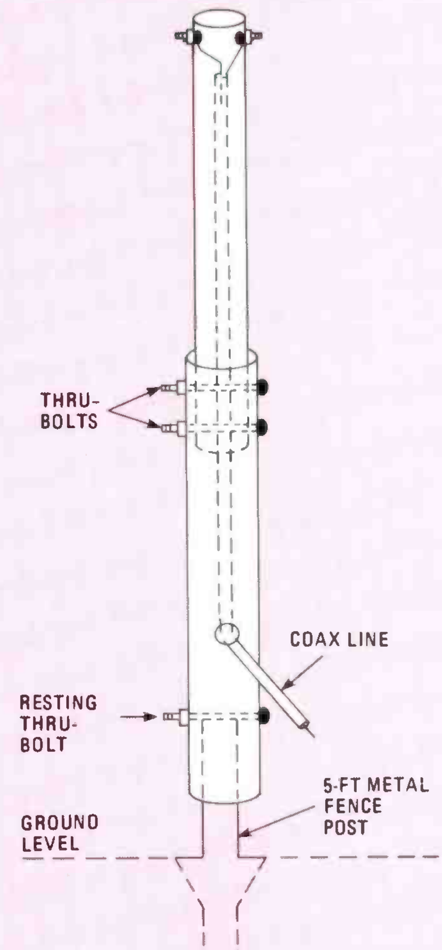


Note that in the three-element installation, the down leads are run down the outside of the PVC piping through screw-eyes, and are connected to the feed-in by bolts mounted on the mast.

PVC MAST CONSTRUCTION

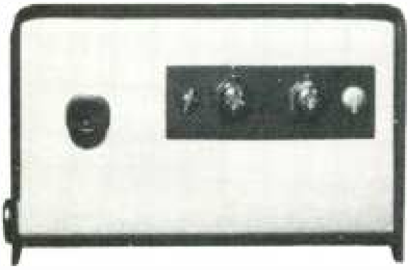
An antenna mast can be easily built from telescoping sections of PVC tubing and a few nuts and screws to hold the structure together. A 5-foot metal fence post, embedded in the ground, is used as a foundation for the mast. Two 10-foot sections of PVC tubing can be used to construct a mast about 18-feet high.

Begin with a 2-inch diameter section of PVC tubing and insert a second 1½-inch diameter section of tubing, to a depth of 2 feet, into one end. Drill holes through the overlapping sections of tubing and bolt together. Insert and connect the signal-carrying ca-

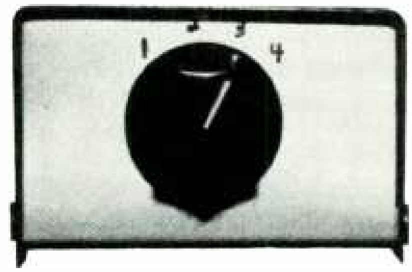


ble as needed. Connect the wires that will act as the RF pick-up element. If guys are to be used, connect them now. Use nylon stranded rope—the smallest diameter you can buy. Drop the mast over the fence post and secure with bolts. And finally, secure the guys. Taller masts can be built by using longer or additional lengths of PVC tubing.

If a taller mast is desired, simply add to the length by joining two 2-inch diameter sections of PVC tubing, using a 3½-foot length of 1½-inch diameter tubing as a joint support. Insert the joint support about 2 feet into the lower section of the mast. Drill holes and bolt the two sections together. Secure the upper section in the same manner, with the two outer lengths of tubing forming as tight a joint as possible. Finish up by adding the RF pick-up element, signal-carrying cable, etc., as needed. ■



The switch box is simply an inexpensive metal cabinet that houses the selector switch, with the switch positions labeled on the front. On the rear of the cabinet, two screw- type terminals are mounted to which the feed line is attached. A shielded phono jack is also provided as the receiver connection.



ment, the three antenna wires are spaced 120 degrees in the horizontal plane. It, too, is erected in the inverted-V fashion. The ends are dropped down to three metal fence posts near ground level. A look-up view of that configuration is shown in the photos. The three transmission line wires run down the outside of the PVC mast through screw eyes to the three terminals that are mounted in the PVC piping at chest level. From there a three-wire transmission enters the radio room and connects to the Flexo switcher.

When there are three wires that are a part of the transmission line, there are as many as twelve individual combinations that can be switched in. However, the six combinations alloted by the arrangement shown in Fig. 2 provide good results, and little improvement can be obtained with additional combinations. The switching arrangement shown can select any individual wire for use as a long-wire antenna. The remaining three positions use the antenna wires in three separate dipole configurations. As a result, the Flexo also demonstrates some limited directivity operating as a switched dipole configuration on the lower-frequency, bands.

On the higher-frequency bands, the single-wire combinations as well as the dipole combinations can display directivity. However, the most favorable attribute is the fact that it gives you six combinations to choose from in obtaining the best clarity possible for difficult propagation and interference conditions. Don't expect it to be a cure-all; some additional options may be necessary under difficult conditions.

The switch is a two-pole, six-position type as recommended previously. Note that S1-a selects one of the individual antenna wires when in positions 1, 2, and 3. Those same positions on S1-b are left unconnected. Thus, you are operating with a single-wire feed for the first three positions and true coaxial feed for the latter three positions. The last three positions—4, 5, and 6—of switch S1-b connect the wires in pairs to obtain a dipole configuration. In the 4, 5, and 6 positions, an appropriate antenna wire is connected to the braid of the small section of coaxial line that connects the output of the switcher to the receiver.

In checking out your results, it may be advantageous to wire the switcher in terms of the physical positioning of each antenna wire. In wiring the FLexo switch, be certain to mount three insulated terminals for connecting the wires from the antenna. You can use the same size box as for the previous antenna. However, a wider spacing among the wires and easier wiring are possible with the use of larger size case.

The possibilities are many. You may want to do some active experimentation with the Flexo to come up with the SWL antenna best suited to your property limitations. ■

Electronics Discover First Planet Outside Solar System

A TEAM OF ASTRONOMERS HAS DIScovered what may be the first planet ever observed outside the solar system. When the discovery is verified, it will climax a centuries-old quest to find such a heavenly body. The team consisted of Dr. Donald W. McCarthy, Jr. and Dr. Frank J. Low of the University of Arizona, and Dr. Ronald G. Probst of the National Optical Astronomy Observatories (NOAO). The presence of planets has been inferred by some astronomers because of the wobble of certain stars in their path across the sky, but never before has a companion to a star actually been seen and determined to be a planet outside the solar system.

The team astronomers used a relatively new technique, called *speckle interferometry*, to detect the heat from the planet in the infrared region of the electromagnetic spectrum. That enabled them to overcome the blurring caused by turbulence in the earth's atmosphere that ordinarily would hide the dim planet in the glare of the much brighter star. The researchers used the 158-inch (4-meter) Mayall Telescope at NOAO's Kitt Peak National Observatory and the 90-inch (2.3-meter) telescope at the University of Arizona's Steward Observatory.

The planet orbits the intrinsically faint star Van Biesbroeck 8 (VB-8) in the Milky Way constellation Ophiuchus, about 21 light years from earth. The star was named after George van Biesbroeck, a Belgium-born American astronomer who discovered it in 1961.

The astronomers said they think the newly discovered planet is a gaseous object resembling Jupiter in appearance and substance. The planet has been calculated to be between 30 and 80 times as massive as Jupiter, the fifth planet from our sun. The new planet has a mass about one thousandth that of our sun. The planet's surface temperature is estimated to be about 2,000 degrees Fahrenheit compared with the sun's surface temperature of about 9,000 degrees Fahrenheit.

The existence of planets as large as that has been theorized by astronomers who coined the term *brown dwarf* to designate them. Brown dwarfs are objects that are much cooler than *red dwarfs*, which are the coolest stars known.

The star VB-8 is roughly 10,000 times fainter than the faintest star visible with the naked eye. If observed in visible light, the planet would appear about 100,000 times fainter than the star which it orbits.

"The body identified as a planet is too dim and too cool to be a star," Dr. McCarthy said. He stressed that more studies must be done to determine characteristics of the planet—such as its orbital period, its mass, and its chemical composition.

The astronomer said they have eliminated the possibility that the planet is a background object unrelated to the star VB-8. "For the present," they said, "we assume the new source is a close physical companion to VB-8 and we designate it VB-8B."

In a report submitted to Astrophysical Journal Letters, the astronomers said; "We have detected via infrared speckle interferometry a faint, very cool source one arcsecond (600 million miles) from (the star) VB-8."

The properties of the source—such as temperature, radius, and energy output—"are consistent with a substellar mass companion, i.e. a planet." Now, we leave to your imagination the possibility that smaller planets orbit star VB-8 of a size, density and distance from that star that may support life in another world! ■

The question is no longer, "Can the blind be made to see?," but rather, "when?" The path may be through electrical stimulation of the brain!

The Dawn of Artificial Vision

By Jonathan Alan Gordon

HAVE YOU EVER HAD A CAMERA'S FLASHBULB GO OFF IN your face? Perhaps, it was at Thanksgiving when your favorite uncle was showing you the ease with which the bulb would go into the flash socket. When it went off in your eyes, what did you see? Did you see a big blob of light that took a few minutes to go away? Researchers call that light an *osphene*—a luminous impression (after image) due to excitation of the retina. Inventive researchers are attempting to produce hundreds of phosphenes—not big ones like those produced by the flashbulb, but little ones—by electrically stimulating the brain with electrodes.

While watching PBS television one night, a short film clip was shown of a patient on an operating table. He said he saw light every time the back of his brain was electrically stimulated by the surgeon. To make a long story short, neurophysiology was a pet subject of mine when I was in college, and the PBS film clip perked up my interest. I wanted to investigate further, so I went to the nearby library of State University of New York at Stony Brook Medical School. The following is a summary of my search for results on *intracranial neural prosthetics* (devices to replace a missing part of the body that is under the skull and acts on nervous system) for the visually handicapped.

Background Information

Over the past few decades, numerous attempts have been made to stimulate the visual centers of the brain, including such general techniques as micro-electrode insertion, macro-electrode probes, magnetic devices, and various injected chemicals. More specifically, there have been attempts to electrically stimulate the visual cortex of the occipital lobe to emulate, as far as practical, the normal cortical stimulation by nerve projections arriving from the optic nerve.

It has been found that point electrical stimulation of the visual cortex produces a spot of white light called a phosphene. Researchers have suggested that it should be possible to make a neural prosthesis (based on the phosphene) that will permit blind persons not only to avoid obstacles in their environment, but to read print or handwriting; perhaps at speeds comparable to sighted persons.

It was found through experimentation that artificial vision created by electrical stimulation of the visual cortex does not require training to interpret; indeed, the phosphenes are understood immediately by the blind as visual information. That's in contrast to other aids for the blind that convey coded information by either tactile sensation or auditory sound. The practical application and further development of such devices have been hampered by the difficulty in training patients to interpret the coded signals.

It was not until 1968 that G.S. Brindley and W.D. Lewin developed the first neural prosthesis to examine whether a useful device could be implanted that would stimulate the occipital lobe and, thus, provide some degree of visual sensation for the subject. Their device, however crude, consisted of a *subcutaneous* (beneath the skin) array of 80 radio receivers joined by cable to the intracranial part of the implant. Each of the receivers was connected to an intracranial electrode and activated by an oscillator tuned to the appropriate frequency and pressed against the scalp, stimulating the cortex through the electrode. Their findings suggested that 600 channels would make it possible, with the aid of automatic scanning, to achieve a normal reading speed for the patient.

Nine years later, through the pioneering efforts of Brindley and Lewin, the Dobelle (1977) implant proved that a matrix of 64 electrode stimulators could be automatically controlled by a computer to stimulate the visual cortex and, produce useful and intelligent patterns recognizable by a blind subject. The array implant consisted of 64-platinum disk-electrodes (1-mm in area) arranged in an 8 × 8 hexagonal array on 3-mm centers in a Teflon ribbon cable. The implant, being

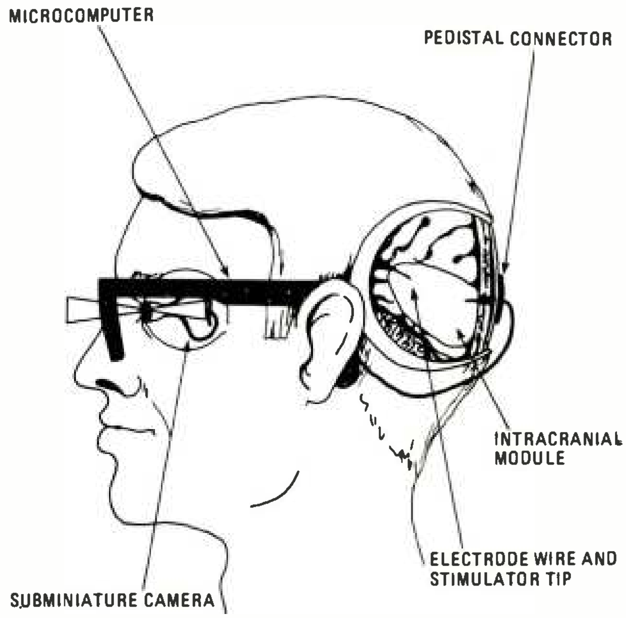


Fig. 1—In the Dobelle device of the future, a glass eye, containing a subminiature camera, might be surgically implanted in the orbit and attached to the eye muscles. An intracranial module embedded in the visual control center of the brain would receive signals (based on the input from the camera) via a micro-miniature computer contained in ordinary eyeglasses, thereby, stimulating the visual center, giving rise to the sensation of sight.

only experimental in nature, was removed after the data was collected and recorded.

There have been various problems associated with neural prosthetic devices. In the Brindley and Lewin device, the design of 80 radio receivers took up so much area that almost the entire right hemisphere was required for its installation. The unit's bulk increased the risk of infection and equipment breakdown, which was inconvenient and costly. Another significant disadvantage was the number of useful electrodes, being only 80 in number. Lastly, their method of stimulating the receivers was crude and inefficient, resulting in poor phosphene control and resolution.

Although the Dobelle device solved the bulk problem and used a computer for automatic scanning of the electrodes, it was still not a permanent implant design. In addition, it did not contain enough stimulators to be useful as an aid to transfer information. Nevertheless, that implant collected sufficient data to determine future prosthesis design and also collaborated the findings of Brindley and Lewin.

The future Dobelle device might be similar to the illustration in Fig. 1, with a subminiature camera installed in a glass eye and surgically implanted in the orbit and attached to the eye muscles. A miniature computer, built into the frame of regular glasses and attached via platinum connectors to the cortical implant, would allow complete mobility, shifting the field of view the way the rest of us do—that is, by moving the eyes. Since the computer would be dedicated to one function, its size could be very small and its power requirement very low.

The subminiature camera functions as a data collector or input device. The video-image data collected by the camera is transferred to the microcomputer, which encodes the input data to a form usable by the implant. The computer is tied to a pedestal connector that protrudes through the skin. That connector ties the computer to the intracranial module, which, in turn, connects to the stimulator tip, embedded in the visual cortex.

Curious as to whether there had been any inventions relating to electrical stimulation of the brain to create the sensation of sight to aid the blind, a patent search was conducted. It was found that a patent (No. 2,721,316) was issued to Shaw in October of 1955. As illustrated in Fig. 2, it related to a system specifically for informing a blind person of the level of ambient light.

A photosensor element, positioned to determine the ambient light, and various circuits are provided to produce either changes in the output current or changes in frequency of the output pulses dependent upon the level of ambient light. The electrical signals are fed via conductors, and an implanted socket and plug arrangement to an electrode(s) embedded in the brain of the subject. The Shaw patent is significant, in that it is the only patent found showing electrodes implanted in the visual cortex of the patient.

The Experience of Sight

Almost everyone believes that we see with our eyes. But to study the phenomenon of sight more closely reveals something quite different. Figure 3 illustrates a comparison between physiologically and artificially induced vision. The eyes can be thought of as sensors. Light enters the eye, striking the retina, which changes the energy into neural impulses. The impulses travel via the optic nerve to an intermediate midbrain nucleus called the lateral geniculate. Nerve projections from there, then, travel to the occipital lobe located to the extreme back of the head, which is the primary visual cortex.

Other regions of the brain then interpret the visual image as a recognizable object. The crucial question now becomes: Can researchers bypass the physiological system and emulate the neural activity of the visual cortex artificially by direct electrical stimulation of the occipital cortex tissue?

In the Dobelle implant of 64 electrodes, not all of them caused a phosphene, nor (as Fig. 4 shows) did they all line up in nice neat rows, either. What's required to have a workable model is hundreds of phosphenes that can be lined up like the pixels of a television set. The image seen by a blind person would then be equivalent to old-time television where a matrix of TV phosphor pixels is analogous to a matrix of visual phosphenes.

Phosphenes: Cause and Effect

A *osphene* is a white spot of light in the blind person's visual field. The blind person generally describes the phosphene's size as an area about the size of a quarter at arm's

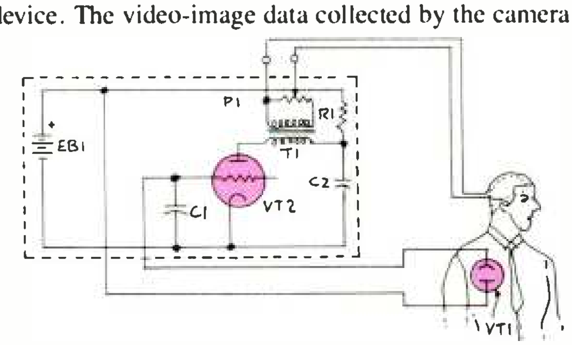


Fig. 2—This illustration shows a system, for which J.D. Shaw was issued a patent in 1955; it was specifically designed for informing the blind of ambient light levels.

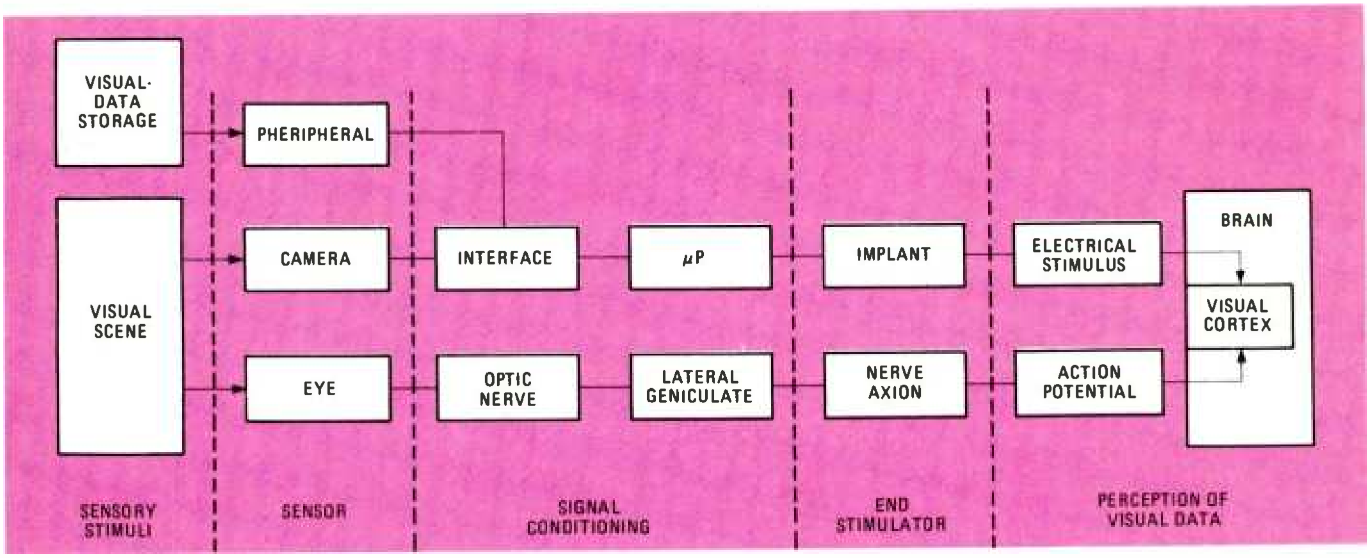


Fig. 3—A comparison between physiologically and artificially induced sight. Note the relationship between the various parts of the artificial vision system and its natural counterpart.

length. The brightness of a phosphene is most easily controlled by changes in pulse amplitude, irrespective of other stimulation parameters involved. Monophasic (+ or −) and biphasic (+/− and −/+) stimulations have been explored with and without capacitive coupling. Monophasic peak-current thresholds of 1 mA to 5 mA are typical, as are symetrical biphasic peak-to-peak of thresholds of 1 mA to 10 mA, depending on such factors as frequency, pulse duration, pulse amplitude, and pulse-train duration. In practice, using any of the above stimulus parameters produces the same phosphene response, although biphasic stimulation causes the least electrolytic or electrophoresis damage.

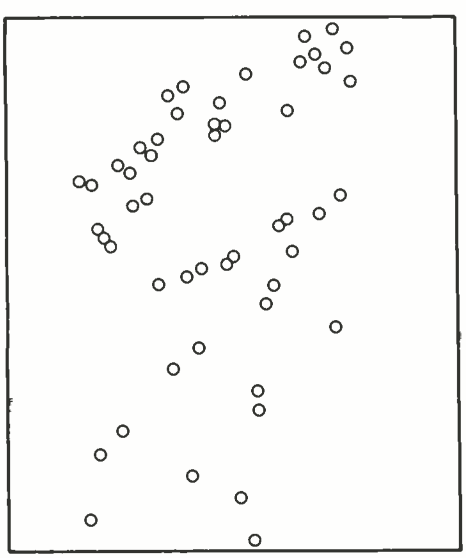


Fig. 4—The visual field of phosphenes caused by 64 electrodes implanted in the visual cortex using the Dobelle device.

It appears that phosphenes produced by electrodes 2- to 4-mm apart can be easily distinguished. By stimulation of several electrodes simultaneously, the blind subject can be caused to see predictable patterns, while electrodes at smaller distances cause each phosphene to fuse into a single oblong shape. Phosphenes ordinarily disappear promptly when stimulation ceases and appear immediately when stimulation begins, and continues until stimulation stops again. Changes in electrode size or configuration have little effect on the subjective sensation of phosphenes.

At least two electrodes are required to connect a current source to the cortical tissue. With monopolar stimulation, as shown in Fig. 5, a small active electrode is applied to the target cortical area whereas a much larger indifferent electrode is placed on some remote neural region as under the scalp. Optical couplers provide isolation between patient side and computer-circuitry side.

Visual Prosthesis Market

Approximately 110,000 persons in Canada and the United States are totally without useful sight, and approximately 400,000 persons have sufficiently serious deficits to be classified as "legally blind." Fewer than 20 percent of those afflicted can read braille.

It should be pointed out that once such a prosthesis is made available, a host of peripheral devices must be developed and marketed; for example, coded movies, magazines, atari-like games for amusement and school study aids. What about special adapters for reading the newspaper? Blind persons would hook up their home computers to a phone modem and dial a newspaper, which would then send the paper's contents or other information via data-communication networks. ■

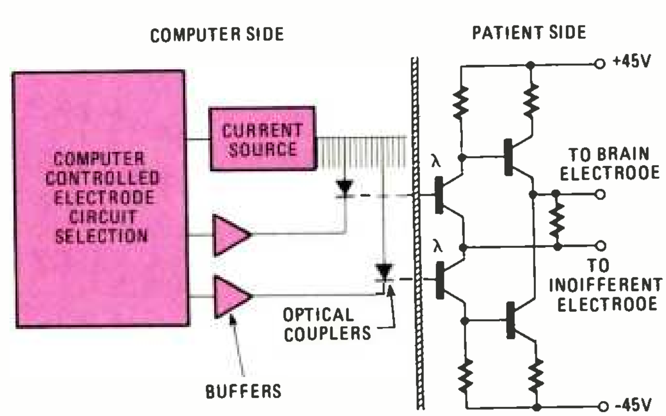


Fig. 5—The Dobelle device using monopolar, biphasic stimulation: A small electrode is applied to the cortical tissue, while a large indifferent electrode, placed under the scalp, is used for the return current.

SUPER ESP TESTER

Test your ability to foresee the future, while learning about the binary numbering system.

RESEARCHERS IN THE FIELD TELL US THAT EVERYONE possesses latent powers of *extra-sensory perception* (ESP)—some to a greater degree than others. It is also generally believed that the more that ability is exercised, the stronger it becomes. If you would like to find out what your potential is, this gadget can help you. Since the odds of making a correct guess by chance are 1 in 16, a consistent high score would indicate a strong latent ability.

Based on the binary numbering system, the tester is also educational—illustrating the use of the binary, base-two, number system that's used in digital circuits and computers. The two sets of 4-bit binary numbers used in the tester are only capable of registering from 0 to 15 (8 + 4 + 2 + 1), with 0 counting as a number like any other. That gives a total of 16 possible numbers to be *hidden* in the machine's memory.

How It Works

In the schematic diagram of Fig. 1, the 555 timer (U1) is operated as a squarewave generator. The generator runs as long as power is applied to the circuit. When S1, LOAD, is momentarily pressed, the squarewave output of U1 is fed into U2, which is connected to count the incoming pulses. When

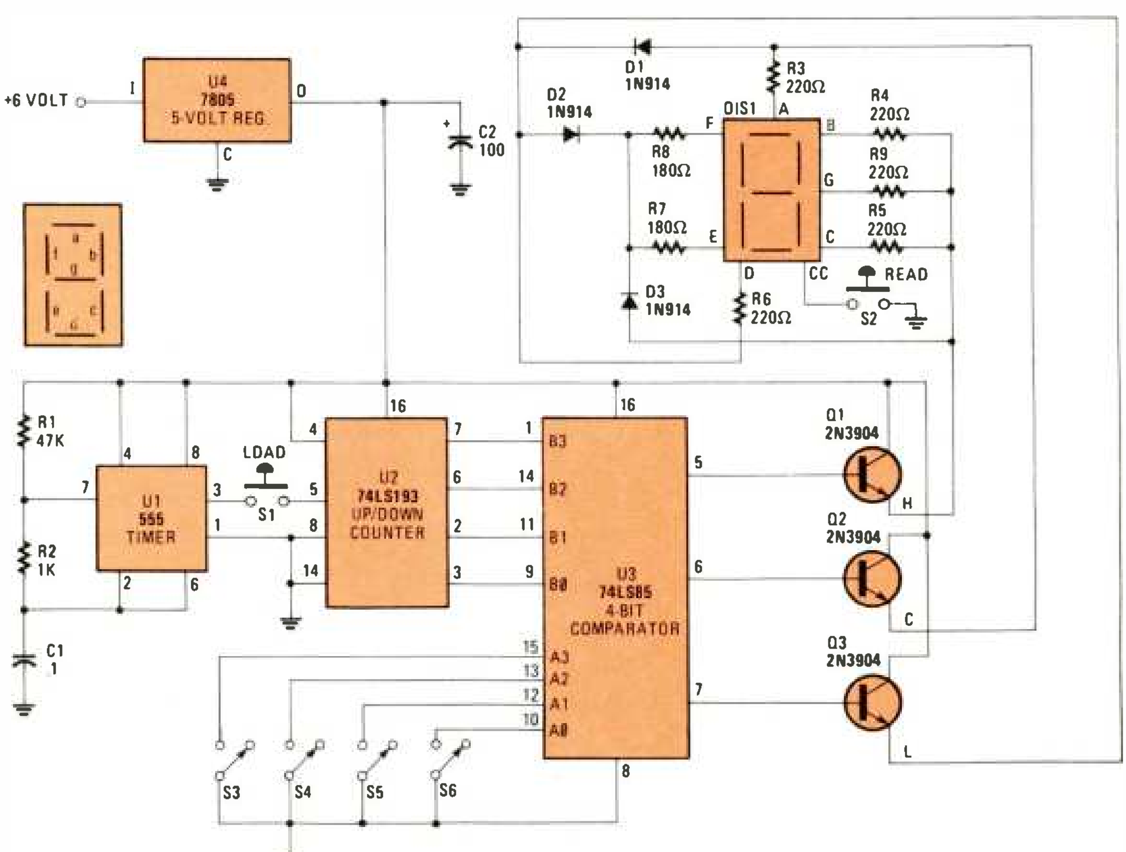
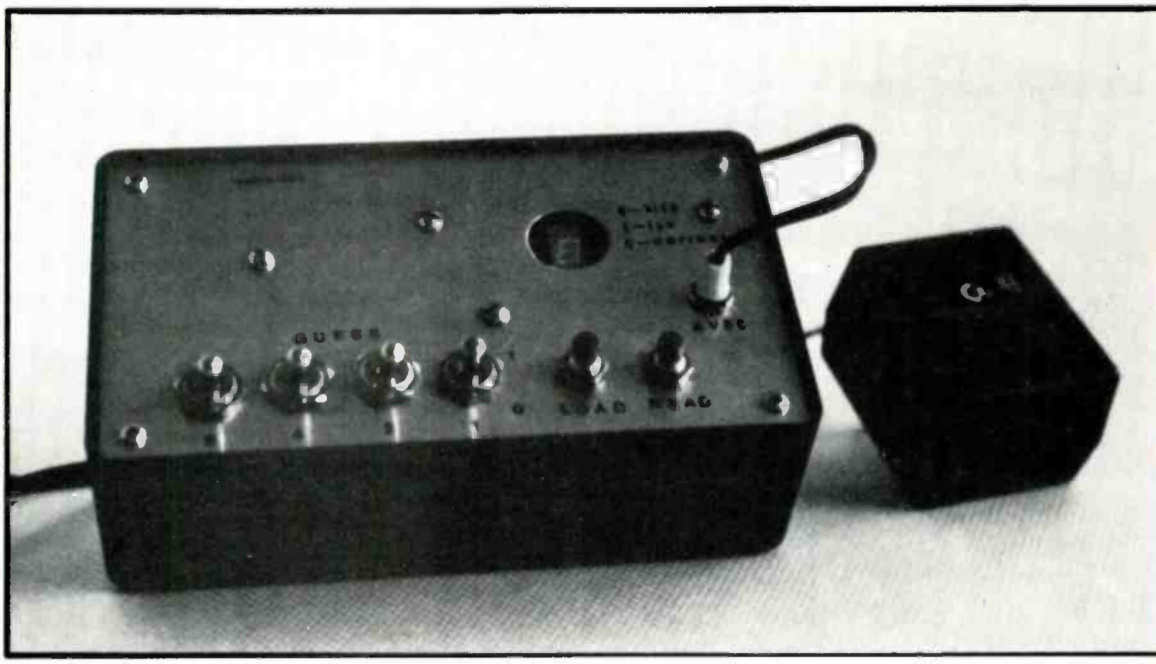


Fig. 1—The schematic diagram of the ESP tester shows DISP1, a seven-segment display, used in a way that's a far cry from the ordinary. That unit is used to show letters instead of the usual numerical readout, with a 4-bit comparator (U3) controlling the display. Depending on which output of U3 goes high, either an "L," "H," or a "C" appears.



By
John
Porter

the count reaches 15, U2 then recycles to 0 and starts over again. Since U1 puts out about 1000 pulses per second (1 kHz), you have no way of knowing what number is loaded into U2 when S1 is released. U2 translates the count into a 4-bit binary number, which is then fed to U3, a 4-bit magnitude comparator. The comparator determines whether or not its two inputs are equal, or if one signal is greater than or less than the other signal.

One of those inputs is, of course, the output of U2 and the other is derived from the setting of four SPST switches, S3–S6. A closed switch indicates a "0" or low, and an open switch indicates a "1" or high. By choosing a combination of 1's and 0's, any number from 0 to 15 may be entered. If the number entered via the switches is lower than the random number output by U2, then pin 7 of U3 goes high, turning on Q3. That causes an "L" for low to appear on the readout, DISP1, when S2 is depressed.

On the other hand, if the number entered is higher, pin 5 of U3 goes high. Now, Q1 is turned on, causing an "H" for high to appear. But if the inputs are equal, pin 6 goes high, and a "C" for correct appears. (Note the unusual use of the seven-segment, light-emitting diode display to read out letters rather than numbers.)

It would be difficult to tell if a correct guess resulted from a mental impression of what was stored in the memory or was a form of precognition—a crude form of seeing the future—causing you to lift your finger from the LOAD button at the precise instant the counter reaches the number you are going to load into the circuit via S3 through S6.

Since this circuit generates random numbers, it could conceivably be used for gambling purposes, although that's a no-no! (Illegal and all that, you know.) While intended mainly for fun, the author would like to hear from anyone who consistently attains high scores.

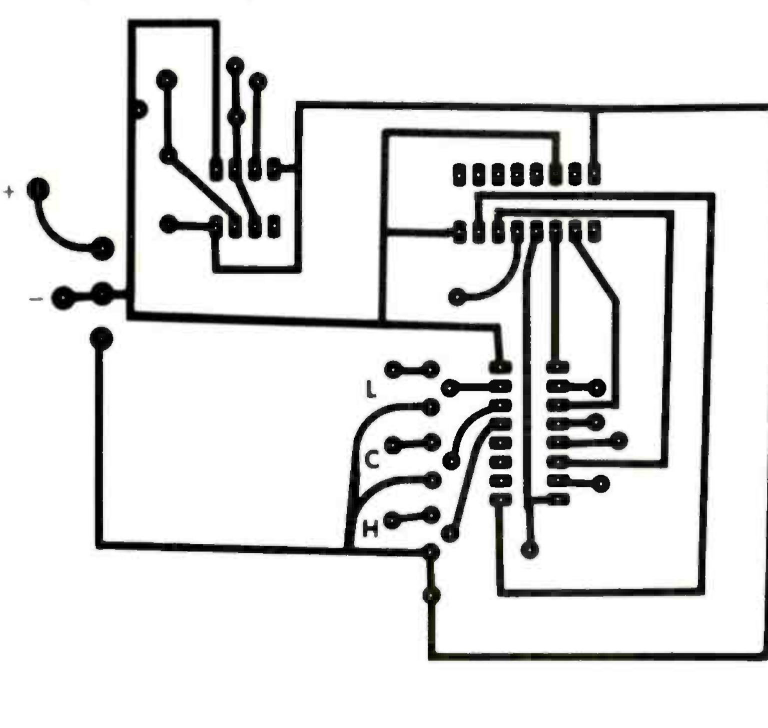


Fig. 2—Full-scale template of main printed-circuit board.

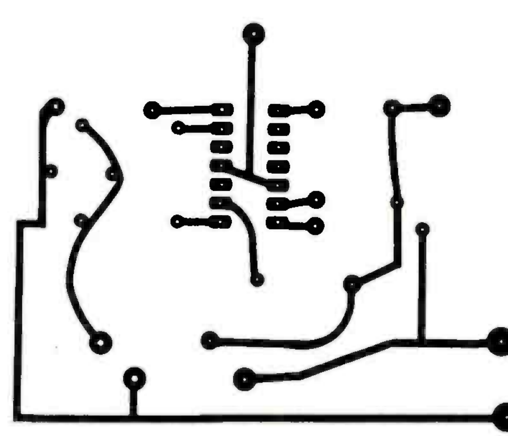
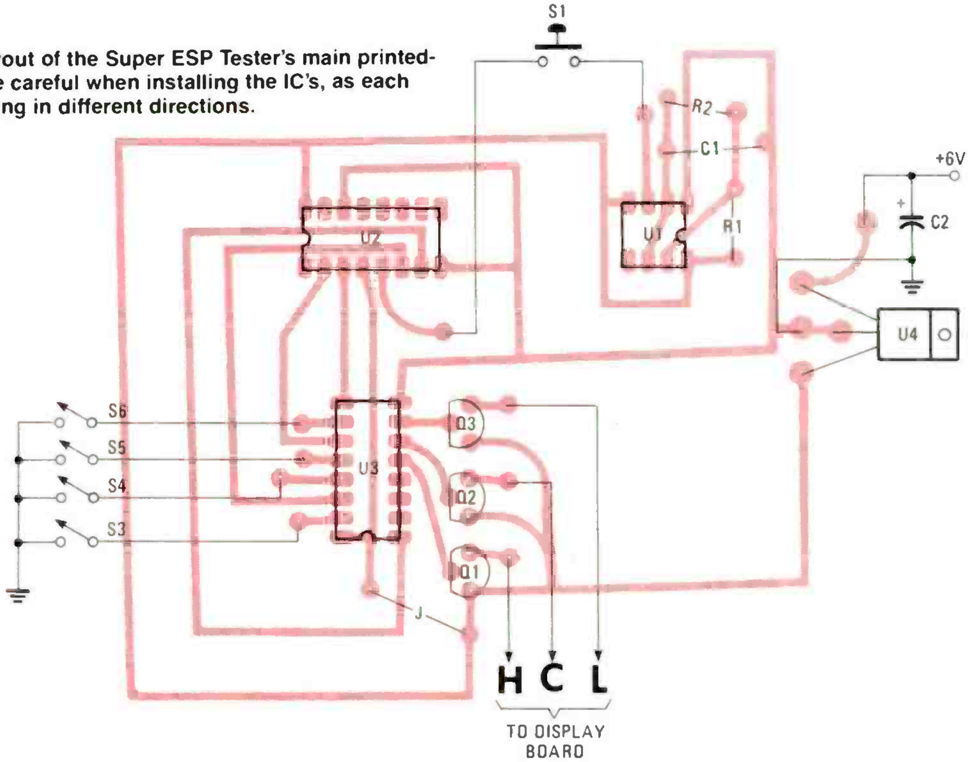


Fig. 3—Full-scale template of the display printed-circuit board for the Super ESP Tester.

Fig. 4—Parts layout of the Super ESP Tester's main printed-circuit board. Be careful when installing the IC's, as each has its pin 1 facing in different directions.

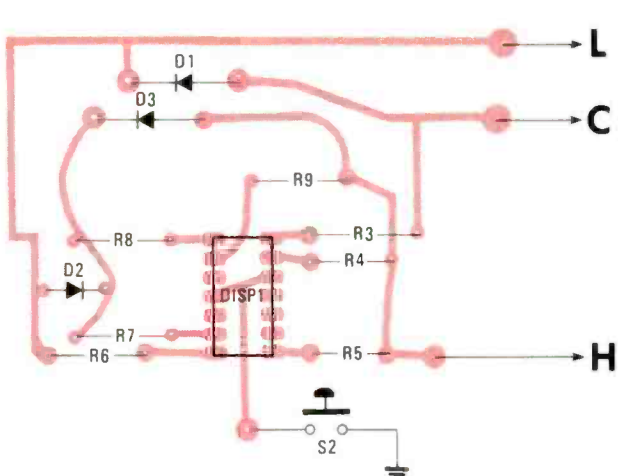


Construction

The printed-circuit layout is not critical and the circuit is not normally susceptible to hum or interference problems. The author's prototype (as shown in the photos) was built on two separate PC boards. Full-scale templates for the two boards are shown in Fig. 2, the main circuit board, and Fig. 3, the display board. Those foil patterns can be lifted from the page with Lift-it film, and etched using the photo-resist etching method. Once the boards are etched, its time to put the circuit together.

Integrated-circuit sockets are recommended for the integrated circuits and display module. Although not necessary, IC sockets do make assembly a lot easier by acting as markers. The 7-segment display was mounted in a 14-pin DIP socket, mostly to give the proper mechanical clearance.

Fig. 5—Parts layout for the Super ESP Tester shown on the x-ray view of the display printed-circuit board.



Refer to Fig. 4 and Fig. 5, the parts layout for the main circuit and display boards, respectively. Begin by installing the passive components, resistors and capacitors, first; then move on to the semiconductors, populating one board at a time. *(Continued on page 98)*

PARTS LIST FOR THE ESP TESTER

SEMICONDUCTORS
D1–D3—1N914 diode or equivalent
DISP1—MAN-84A, 7-segment, common-cathode LED display
Q1–Q3—2N3904 general-purpose, silicon, NPN transistor
U1—555 timer, integrated circuit
U2—74LS193 4-bit, up-down counter, integrated circuit
U3—74LS85 4-bit comparator, integrated circuit
U4—7805 positive 5-volt, 1-A regulator, integrated circuit

RESISTORS
(All resistors ½-watt, 10% fixed units)
R1—47,000-ohm
R2—1000-ohm
R3–R6, R9—220-ohm
R7, R8—180-ohm

ADDITIONAL PARTS AND MATERIALS
C1—0.1-µF, 15-WVDC, ceramic capacitor
C2—100-µF, 16-WVDC, electrolytic capacitor
S1, S2—Normally-open, single-pole, single-throw (SPST), momentary-contact pushbutton switch
S3–S6—Single-pole, double-throw (SPDT) slide switch
Printed-circuit materials, enclosure, 6-volt DC wall-pack supply, hook-up wire, solder, hardware, etc.

DIGITAL FUNDAMENTALS

We peer into memory IC's to see how data storage-cells are formed!

LESSON #7—MEMORY CIRCUITS

By Louis E. Frenzel, Jr.

□THE BASIC CIRCUIT FOR STORING BINARY DATA IN DIGITAL circuits is the flip-flop. In a previous lesson, you saw how flip-flops could be combined to form storage registers capable of remembering a binary word of any length. You also saw how flip-flops could be combined to form counters and shift registers where binary numbers could be manipulated in a variety of ways.

All digital equipment contains one or more counters or registers to store and manipulate the binary data. But as you probably know, there are some kinds of digital equipment that require the ability to store large amounts of binary data. The most obvious example, of course, is the digital computer whose memory is capable of storing many thousands of instruction and data words. Other kinds of digital equipment also have the need to store large amounts of data. To meet that requirement, special electronic memory circuits have been developed. Like counters and registers, some of those memory circuits are made up of flip-flops. In other memory circuits, different kinds of storage elements are used.

In this lesson, you'll learn about integrated circuits designed specifically for storing large amounts of digital data, and how they are used in computers and other digital equipment.

Memory Organization and Operation

An electronic memory is a place where hundreds or thousands of binary words may be stored. The memory is divided up into discrete locations where a fixed-size binary number may be stored. Those individual word-storage locations are, in turn, made up of bit memory elements such as flip-flops and other circuits (which we'll discuss later). The organization of such a memory is illustrated in Fig. 1. Its two key characteristics are the number of bits per word and the total number of word-storage locations.

Most electronic memories are capable of storing standard binary word sizes such as 4, 8, 16, and 32-bits long. Of course, other sizes can be created. The total word-storage capacity of a memory also varies widely. Typical sizes are 256, 1024, 4096, 16,384, 65,536 words. You've probably recognized that all those memory sizes are some power of two. Both the word length and the memory size, of course, are dependent upon the application in which they are used.

To describe memories, we use a *shorthand* notation that gives both the memory and word sizes. For example, the designation 1024 × 4 refers to a memory containing 1024 four-bit words; the designation 1K × 4 is used to define the same memory. In other areas of electronics, K usually means 1,000; but in memory jargon, K = 1024—which is an even power of two. Using that method any memory size can be designated. For example, a memory capable of storing 65,536 bytes would be designated as 64K × 8; a 256K memory for 32-bit words would be designated 256K × 32.

Address

To locate a specific word in memory, each word is given a unique number called an *address*. In Fig. 1, for example, the 4K × 8 memory has 4096 storage locations, numbered from 0 through 4095, for byte-length words. The numbers are the addresses, and are used to reference a specific storage location.

To use an electronic memory, you first apply an address to it. The address is a multi-bit binary word. A specific number of address bits are required to address the memory locations. For example, with a 12-bit address, 4096 individual states can be defined (2 to the 12th power = 4096), which means that a 12-bit word would be used for the address of the 4K memory in Fig. 1. A 16-bit address would permit up to 64K (65,536) memory locations to be addressed. The table in Fig. 2 shows the number of locations different word sizes can address.

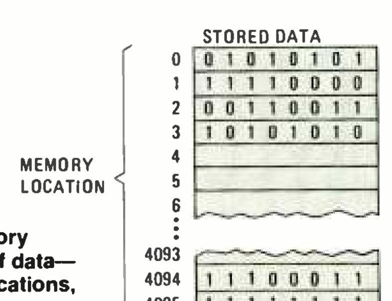


Fig. 1—This illustration of the organization of a memory chip—which is capable of storing 4K or 4096 bytes of data—shows that the chip is made up of several storage locations, each having its own distinct address (0–4095).

NUMBER OF BITS IN ADDRESS WORD	NUMBER OF MEMORY LOCATIONS
8	256
10	1024 (1K)
12	4096 (4K)
16	65,536 (64K)
20	1,048,576 (1M)
24	16,777,216 (16M)
32	4,294,976,296 (4G)

K = KILO WORDS = 1024
M = MEGA WORDS= 1,048,576
G = GIGA WORDS = 1,073,741,824

Fig. 2—Unlike other areas of electronics, where 1K represents 1000, in memory jargon, 1K means 1024.

Store and Recall Operations

Once the address has been applied and a specific storage location enabled, a read or write operation is performed. A *read* operation simply means that the binary number stored in the addressed location is recalled—read out or transferred for use elsewhere. The read operation is non-destructive, in that the contents of the addressed memory location is retained.

A *write* operation is the process of storing new data in the addressed memory location; the operation is equivalent to loading a storage register.

Access Time

The most important specification of any memory device is its access time—the time it takes for a word stored in a memory to be addressed and read out. It is that interval between the application of the address and the appearance of the data at the output.

Most MOS memories have access times in the 100 to 500 nanosecond (ns) range. Bipolar TTL memories have access times in the 20 to 90 ns range.

Random-Access Memories

The organization of the memories that we've just discussed are generally referred to as *random-access* memories (RAM's). As its name implies, any specific memory location may be accessed at random. Early computer memory designs used a serial data-storage format, which required that data stored in memory be accessed sequentially. A given word could not be directly selected; instead it was necessary to wait for that word to come around.

Today's electronic memories are parallel devices and any given memory location may be accessed directly without reference to any other memory location. Random-access memories break down into two basic types: *read/write* and the *read-only* memories. The read/write device permits both storage and retrieval operations to take place. New data may be stored in any memory location and any location may be accessed and recalled. Such memories are generally referred to as random-access memories or RAM for short.

The other type of random-access memory is the read-only memory or ROM. Data is permanently stored in such memories. The desired data is stored in memory at the time that the circuits are manufactured; but in some types of ROM's, the data may be stored later by the user. In either case, data storage is permanent. Once the data is written into the memory, it cannot be destroyed or changed; because of that, only read operations are possible thereafter. There are many applications where it is desirable to permanently store data or programs.

Read-only memories are said to be *non-volatile* because their contents are retained even when power is removed from the circuit. In read/write memories, all data stored in the memory is lost when power is turned off; such memories are said to be *volatile*.

Despite the fact that both read/write and read-only memories are of random-access organization, read/write memories are usually referred to as a RAM and read-only memories are simply called ROM. Both types will be discussed in detail in the following sections.

RAM Storage Cells

There are two basic types of storage cells or elements used in read/write memories—*static* and *dynamic* cells—both of which store one bit. Each type has its advantages and disadvantages. In most cases, the memory cells are made up of metal-oxide semiconductor, field-effect transistors (MOSFET's). Each storage element is capable of storing one bit. Many thousands of storage cells can be fabricated on a single silicon chip. By combining a number of the chips, you can form a memory of any desired size. Let's take a look at how the static and dynamic cells work.

Figure 3 shows a diagram of a typical static-memory storage cell. The basic storage circuit is a latch or flip-flop made up of enhancement-mode MOSFET's Q1 through Q4. Q1 and Q2 are the active transistors, while Q3 and Q4 are MOSFET's, which have been biased into conduction and act strictly as load resistors.

The circuit in Fig. 3 has two stable states. One state is

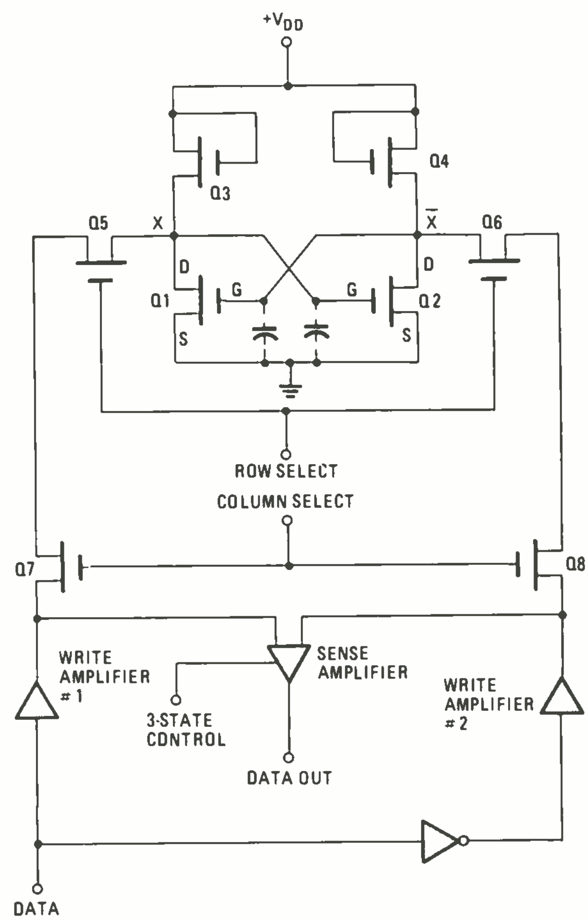


Fig. 3—This diagram of a single storage element in a static-memory chip illustrates the operation of each cell in the memory. In the static-memory cell, the storage element is a flip-flop.

where Q1 is conducting and Q2 is cut off. With Q2 cut off, the supply voltage through Q4 on the gate of Q1, keeps Q1 conducting. With Q1 conducting, its drain is near 0 volts and below the conduction threshold of Q2. Therefore, Q2 remains off.

The other stable state is where Q2 is conducting and Q1 is cut off. With those two states, either a binary 0 or binary 1 can be represented. The gate to source capacitances of Q1 and Q2 are charged through either Q3 or Q4 to keep the conducting transistor on. All of the additional circuitry in Fig. 3 is used for storing data in the cell or reading it out. Transistors Q5 and Q6, as well as Q7 and Q8, are switches used for addressing purposes.

In most memories, each storage cell is part of a matrix of storage cells arranged in a row and column format. To address a particular cell, address signals activate the desired row and column in which the cell appears. (See Fig. 4.)

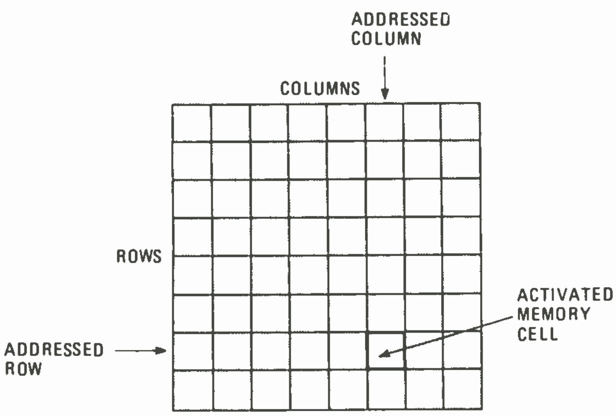


Fig. 4—Most semiconductor memories are organized in a matrix of storage cells. To access a particular cell, one row and one column must be activated.

In Fig. 3, when a binary 1 is applied to the row-select line, transistors Q5 and Q6 conduct, allowing the signals at the drains of the flip-flops, X and $\overline{X}$, to be passed through to Q7 and Q8. When the column-select line is binary 1, Q7 and Q8 are also turned on. At this point, the latch output signals pass through Q5 and Q7 as well as Q6 and Q8 and appear at the inputs to the sense amplifier. The binary state stored in the flip-flop appears at the sense amplifier output. Usually the sense amplifier is a three-state device whose output can be turned off or effectively disconnected from the output so that the memory cell can be used in bus configurations.

To write data into the circuit, both the row- and column-select lines are made binary 1 so that transistors Q5 through Q8 conduct. The data to be stored in the circuit is then applied to the data-input line. To store a binary 0, a binary 0 is applied to the data-input line. The signal is then applied to write amplifier 1, and to write amplifier 2 through an inverter. That results in write amplifier 1 outputting a zero, while amplifier 2 outputs a 1.

The zero output of write amplifier 1 pulls the drain of Q1 low. Since Q5 and Q7 are conducting, they appear to be a near short circuit; and therefore, regardless of the state of the latch, the drain of Q1 goes to binary 0. That turns Q2 off, if it should happen to be on, which, in turn, causes Q1 to conduct. The circuit holds that state storing a binary 0. If a binary 1 were applied to the data input, the output of write amplifier 2 would be binary 0, causing the drain of Q2 to be pulled low through Q6 and Q8. The drain of Q1 (X) would go high, therefore, storing a binary 1.

The basic storage element in a dynamic memory cell is a capacitor. When the capacitor is discharged, it is storing a binary 0. When it is charged, it is storing a binary 1. Dynamic memory IC's pack thousands of tiny capacitors on the chip with related control circuits to read and write information. A simplified drawing of a typical dynamic storage cell is shown in Fig. 5. Transistors Q1 and Q2 are switches that permit access to the storage capacitor. As in most memory architectures, dynamic cells are arranged in the form of a matrix with rows and columns. To access a given memory cell, the specific row and column in which it appears is activated by row- and column-address signals.

In Figure 5, the row-address signal is applied to Q2 and the column-address signal is applied to Q1. When the transistors are turned on by the address signals, data may be stored in or read out of the capacitor. If data is to be stored, it is applied to the data-input line and passed through the write amplifier, which causes the capacitor to charge or discharge through Q1 and Q2.

To read data out, the charge stored on the capacitor simply is connected to the read-amplifier input through Q1 and Q2. The capacitance of the tiny capacitor in each storage cell is only a fraction of a picofarad. And while it is very small, it's still capable of holding a charge that can determine the binary state of the cell. However, leakage in the circuit causes the capacitor to discharge over time. While MOSFET circuits are typically very high impedance in nature, with such a small capacitance, the discharge still occurs.

The effect of such leakage is that the state of the cell changes over time. Of course, such a memory is not reliable. To overcome the problem, dynamic memory cells are periodically refreshed. That is, special circuitry in the dynamic memory periodically looks at the state of the cell and refreshes it—either charging or discharging—to keep the charge on the cell strong. In most memory IC's, the refresh operation takes place approximately every 2 to 4 milliseconds. The refresh circuitry reads the state of the cell and reapplies it to ensure data integrity.

The entire refresh operation is transparent to the user who never knows that it's going on.

Typical RAM IC's

Now let's take a look at some typical static and dynamic memory IC's. Many manufacturers supply a wide variety of memory-chip configurations. However, over the years, some configurations have become more or less a standard. For

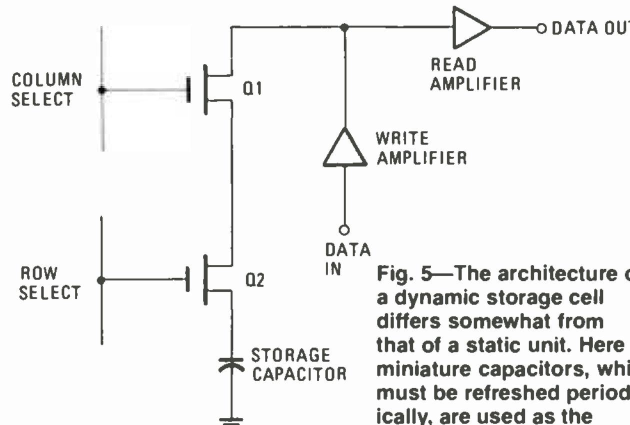


Fig. 5—The architecture of a dynamic storage cell differs somewhat from that of a static unit. Here miniature capacitors, which must be refreshed periodically, are used as the storage elements.

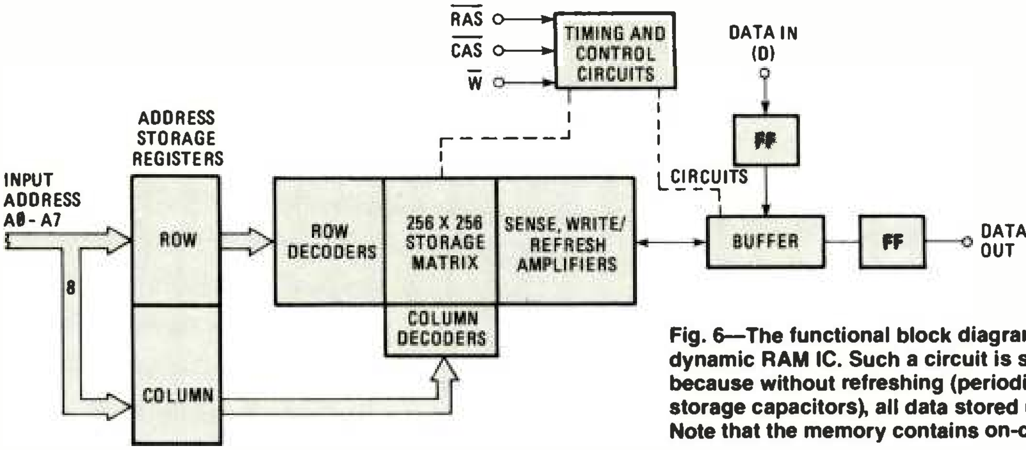


Fig. 6—The functional block diagram of a 4164, 64K × 1 dynamic RAM IC. Such a circuit is said to be volatile because without refreshing (periodically recharging of the storage capacitors), all data stored in memory would be lost. Note that the memory contains on-chip refresh circuitry.

example, most dynamic RAM's come in one of four configurations: 4K × 1, 16K × 1, 64K × 1, and 256K × 1. The 64K × 1 chip contains 65536 storage locations for 1-bit binary words. Naturally, to form large memories, many chips must be put in parallel; to form a 64K × 8 memory would require 8 of the chips.

Static-memory circuits are available in a wider range of configurations. However, because static-memory cells contain many more components, they take up much more space on a chip. As a result, static memories typically are capable of storing less data than dynamic RAM's. Today a practical commercial dynamic RAM is capable of storing up to 256K bits. Typical static RAM's have a maximum storage capacity of 64K bits. As for memory organizations, static RAM's are available in some of the following configurations: 4K × 1, 1K × 4, 4K × 4, 4K × 16, and 8K × 8.

An example of a dynamic memory is Texas Instruments' popular 64K × 1 dynamic RAM, the 4164. That chip, made by many manufacturers under different model numbers, is widely used for personal-computer memories. Housed in a standard 16-pin dual in-line package (DIP), it operates from a single +5 volt supply, and has a typical access time of 150 ns. A simplified block diagram of the 4164 is shown in Fig. 6.

The dynamic memory cells themselves are organized into a matrix of 256 rows and 256 columns capable of storing 65,536 bits. Note that the 4164 has 8 lines labelled A0 through A7. With 8 address bits, 256 separate storage locations can be addressed. The question is: How do we address the full 64K? To address 64K bits requires a 16-bit address. The 16-bit address is fed to the chip as two 8-bit segments. The 8 least significant bits of the address are first applied to the address line and are strobed into the row address register with a control signal called RAS.

The higher order 8 bits of the address are then placed on the 8 address lines, loaded into memory by the control signal, $\overline{\text{CAS}}$, and stored in the column-address register. Both the row- and column-address registers feed row and column decoders that convert the 8-address bits into 256 lines. One column-decode and one row-decode output is required to activate each memory cell. Once a particular memory cell has been addressed, a read or write operation is then performed. The $\overline{\text{W}}$ input line selects the mode. If $\overline{\text{W}}$ is high, a read operation is performed; if it's low, a write operation is performed.

Assuming that a read operation has been selected, the addressed storage cell will be enabled. A sense amplifier reads the charge stored on the cell capacitor and passes it through to a data-output flip-flop. For a write operation, $\overline{\text{W}}$ is made binary 0. The bit to be stored in the selected cell is placed on the D-input line and stored in a flip-flop. When control signal $\overline{\text{CAS}}$ goes low, the data is stored in the selected cell.

Finally, keep in mind that, because this is a dynamic memory circuit, a refresh operation must be performed. In the 4164, a refresh operation is performed approximately every 4 milliseconds. The row address is incremented by an external counter and after each count, the $\overline{\text{RAS}}$ line is strobed, which causes the 256 bits in each row to be refreshed.

Static RAM

The 2114, a popular 4K-bit static RAM, is organized in a 1K × 4 configuration, meaning: It can store 1024 four-bit words. Since the 2114 can address 1024 words, it uses a 10-bit address word. Housed in an 18-pin DIP, it operates from a +5 volt supply, and has a nominal 250 ns access time. Figure 7 shows a simplified block diagram of the 2114.

The memory cells are arranged in a 64 × 64 matrix, producing 4096 individual storage cells. Six of the address bits A3–A8 are applied to a row-select decoder that's used to enable the 64 rows of storage cells. The other 4 address bits (A0, A1, A2, A9) are applied to a column decoder. The 16-

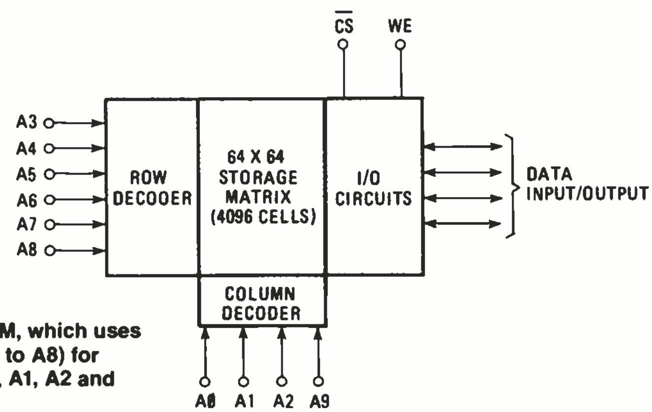


Fig. 7—Block diagram of the 2114 4K-bit RAM, which uses a 10-bit address code; six address lines (A3 to A8) for the row decoder and four address lines (A0, A1, A2 and A9) for the column decoder.

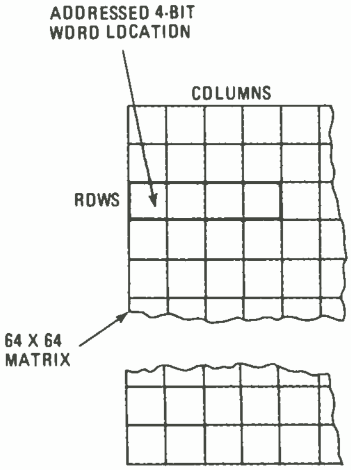


Fig. 8—The 2114, with its 1K × 4 configuration, can store 1024 4-bit words. The memory is arranged in a 64 × 64 matrix, providing 4096 individual storage cells.

column decode outputs are used to enable 16 4-bit words, as illustrated in Fig. 8. For a given address, one of the 64 rows will be enabled. The column decoder enables four columns simultaneously, thereby defining a 4-bit word in the selected row.

In this memory, 4 pins are used for both input and output (I/O). The write-enable (WE) input signal determines whether a read or write operation is to be performed. If the WE signal is low, a write operation is performed. The data on the four I/O pins are accepted as inputs and stored in the memory locations selected by the address.

When the WE line is high, a read operation is designated. The 4-bit word stored in the location designated by the address is read out and placed on four I/O pins. A chip-select (CS) signal is used to enable the chip. When CS is high, the chip is disabled and no read or write operations take place. However, when the CS is low, the chip is selected or enabled and a read or write operation may occur.

Read-Only Memories

A read-only memory (ROM) is a semiconductor circuit in which a number of binary words has been permanently stored. An input address selects the desired word to be read out. Read-only memories are used in those applications where it is desirable to permanently store binary information. In a computer, for example, it is usually desirable to incorporate a ROM that contains instructions that make up frequently used programs. In that way, it is not necessary to load the computer RAM from some external peripheral device with those programs.

ROM's are also used in various logic applications. By assuming that the address lines are inputs and the data lines are outputs, the ROM can be considered as a form of combinational logic circuit. By storing specific bits in the ROM, it can perform a wide variety of special functions, such as code conversion and table-look-up functions, that are less conveniently implemented with more conventional combinational logic circuits.

Diode Matrix ROM

To better illustrate the concept of a ROM, refer to the circuit in Fig. 9, a simple 8 x 4 ROM. That is, it stores eight 4-bit words. A 1-of-8 decoder circuit is used to translate a 3-bit address word into 8 output lines. In that particular circuit, for a given address, only one output line will be active. The decoder has active-low outputs, which simply put, means that the enabled output line will be binary 0 while all other output lines are binary 1.

The data is stored in ROM by the presence or absence of a diode. Whenever a binary 0 is desired in one of the words, a diode is connected between the decoder output and the ROM output line where the 0 is desired. Assume that the input address is 001. That means that the 1 output line will go low, causing diodes D1, D2 and D3 to conduct. Therefore, they effectively bring the output lines to which they are connected low. Since all of the other decoder-output lines are high, the remaining diodes in the network are cut off. Therefore, the other output lines are high at this time. The output word DCBA then is 0100.

While small simple ROM's can be constructed using the diode-matrix technique, in most applications, prepackaged ROM circuits are used because they're capable of storing many more bits of data and are far more useful.

There are two basic types of ROM's: mask-programmable and electrically-programmable. Mask-programmable devices are programmed during the manufacturing process. A special mask, conforming to the bit pattern stored in memory, is custom-designed to interconnect the circuits on the ROM chip. In other words, the data to be stored is permanently manufactured into the device and cannot be changed.

Electrically programmable ROM's called PROM's (programmable read-only memory) can be programmed by the user. When the ROM comes from the manufacturer, it con-

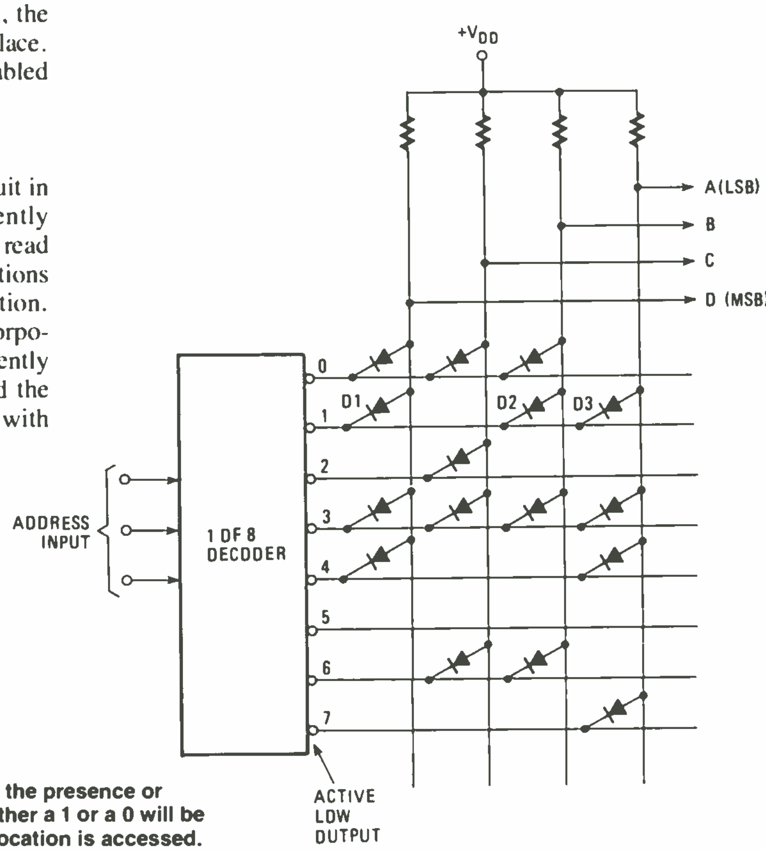


Fig. 9—In this illustration of a ROM, the presence or absence of a diode determines whether a 1 or a 0 will be sensed when a particular memory location is accessed.

tains all binary 0's or all binary 1's depending upon the circuitry involved. The user places the ROM in a special programming instrument called a PROM programmer and enters the data to be stored. In some cases, data storage is permanent. But, at other times, data storage is semi-permanent; that is, the data remains in memory even when power is removed from the circuit, but can either be erased or reprogrammed.

In high-volume production applications, where the information to be stored is reliable, masked ROM's are to be preferred because of their very low cost. On the other hand, where the data to be stored may change for some reason, PROM's are preferred. During the design process of any equipment using a ROM, the program or data may change several times as the "bugs" are worked out or as performance is improved. Even in production units, it may be desirable to up-date the ROM if an important change occurs. In such applications, PROM's are preferred.

However, PROM's are far more expensive than mask ROM's for most applications. During the development process, however, nothing can beat a PROM for flexibility and ease of up-dating. Both masked and programmable ROM's are made with both MOS and bipolar technology. Most ROM's are of the MOS variety because of their low-cost and high storage density—currently up to 256K-bits per chip.

On the other hand, bipolar ROM's are much smaller. But because the circuitry is more complex and dissipates more power, it takes up more space on the chip; thus, fewer bits can be stored. Most bipolar ROM's are small and are limited in practice to only several thousand bits. The big advantage of the bipolar ROM over the MOS ROM is speed. Access time for a typical MOS ROM is in the 200- to 500-nanosecond range, while bipolar ROM's have access times of typically less than 100 nanoseconds. In fact, bipolar ROM's with

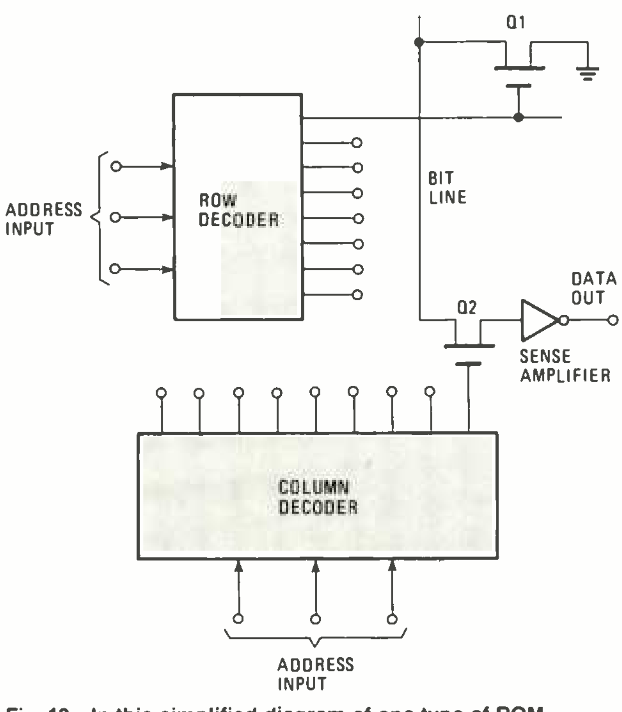


Fig. 10—In this simplified diagram of one type of ROM structure, the presence or absence of a MOSFET transistor (in this example, Q1) at each possible junction determines whether 1 or 0 is stored. If a MOSFET exist (meaning, is connected) at the junction, a binary 1 is stored, but if not, a binary 0 is stored.

access times in the 20- to 50-nanosecond range are available for high speed applications.

In most applications, you will encounter the MOS ROM, which is available in a wide variety of sizes. The main difference between ROM and RAM organization is that while typical dynamic RAM's are designed to store multiple one bit words, ROM's are usually organized to store bytes (8 bits). Typical ROM storage configurations are 1K × 8, 2K × 8, 4K × 8, 8K × 8, 16K × 8, and 32K × 8.

Masked MOS ROM

Most MOS ROM's use the row and column matrix structure discussed earlier. Two sets of decoders, one for rows and another for columns, are used to address a matrix of storage elements. The state of the storage elements determine whether a binary 1 or binary 0 is stored.

Figure 10 shows a simplified diagram of one type of ROM structure. In this circuit, the presence or absence of a MOSFET (Q1) at each possible matrix junction determines whether a binary 1 or binary 0 is stored. If the MOSFET exists, a binary 1 is stored. If the MOSFET does not exist, a binary 0 is stored. MOSFET's exist at every junction, but the mask determines which ones are connected and which are not connected.

In connection with the MOSFET transistors storage elements, another transistor (Q2) is associated with each column. The column decoders turn the MOSFET's on or off as required. To select a particular bit in ROM, an address is given to the row and column decoders and each, in turn, activates one line. If the output of the activated row decoder is binary 1, Q1 (if it exists) is turned on, causing a binary 1 to appear on the bit line. The column decoder output turns on Q2.

Therefore, the sense-amplifier output will see ground or binary 0 through Q1 and Q2. The output, therefore, will be a binary 1. If the transistor, Q1, does not appear in the matrix, effectively an open circuit exists. The bit line being open causes an open condition to appear at the output amplifier if Q2 is turned on, placing a binary 0 to at the output.

Bipolar PROM's

Bipolar ROM's are made programmable by placing a fuse element in the circuit, as illustrated in Fig. 11. Note that the output of a decoder is used to enable a bipolar transistor at each matrix junction. The emitter of the transistor is connected to the column output line through a tiny nichrome (a combination of nickel and chrome) or silicon fuse. If the output of the decoder is high, the transistor turns on. If the fuse is good, a binary 1 is applied to the output amplifier; that results in a binary 0 output.

To cause a binary 1 to appear at the output, the fuse can be blown. A high current is passed through the fuse which causes it to open. Now when the decoder output is high, the transistor does not conduct because its emitter circuit is open. The resistor at the input to the output amplifiers holds the input low, resulting in a binary 1 at the output. Once the fuses are blown in such a PROM, data is permanently stored there and cannot be changed.

The advantage of such a ROM is that it can be programmed in the lab by the design engineer or in the field by the service technician rather than at the factory. The disadvantage is that such permanence is often undesirable. During the engineering design process it may be desirable or necessary to change the data stored in the ROM. That means that an entirely new

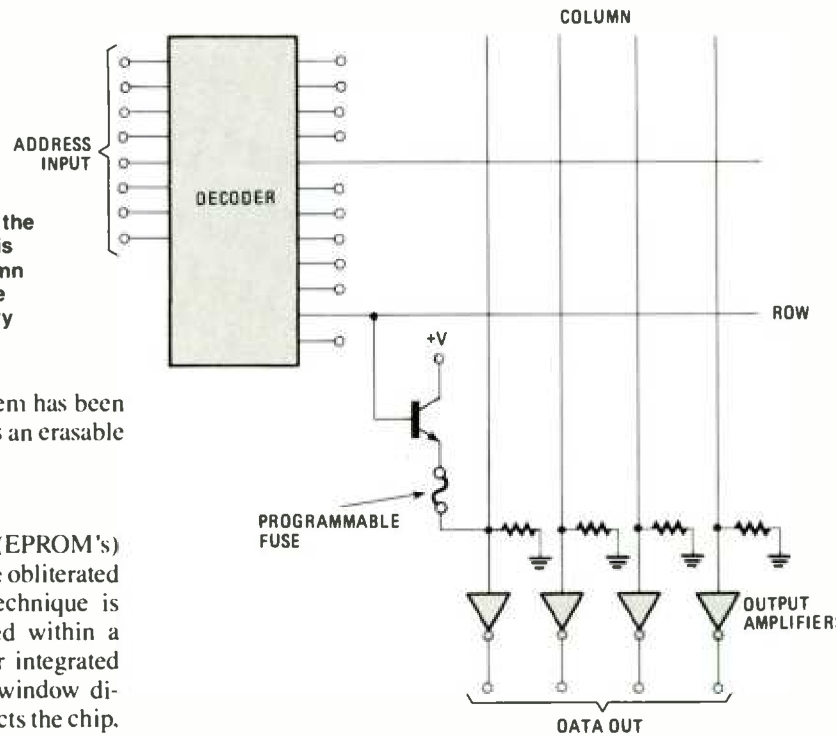


Fig. 11—Bipolar ROM's are made programmable by the inclusion of a tiny nichrome or silicon fuse, which is placed between the transistor emitter and the column output line. If the fuse is good and the output of the decoder is high, the transistor turns on and a binary 1 is applied to the output amplifier.

ROM must be programmed. However, the problem has been overcome by an improved kind of ROM known as an erasable PROM.

Erasable PROM's

Erasable programmable read-only memories (EPROM's) are a special type of MOS ROM whose data can be obliterated when necessary. The most common erasing technique is ultra-violet light. The chip is usually contained within a standard dual in-line package as are most other integrated circuits. However, there's a transparent quartz window directly over the chip that physically seals and protects the chip, while allowing light to pass through. If ultra-violet light is applied to the chip for a short period of time, all the data stored in the chip will be erased. Typically all the bits in the storage matrix are set to binary 1 by the process. By being able to erase the chip, it can be reprogrammed and reused.

The structure of an EPROM is similar to other MOS ROM's, in that, it consists of rows and columns of MOS transistors. In the EPROM, a special floating-gate MOSFET is used at each matrix junction. The floating gate means that the gate element of the MOSFET is not physically connected to anything. It is the charge on the gate that determines whether or not the MOSFET conducts or is cut off. The state of the MOSFET, of course, programs a binary 0 or binary 1 into the matrix.

To program the chip, a high source-to-drain voltage is applied to each MOSFET for a given period of time, which causes an avalanche breakdown in the PN junction between the gate and the source. Current flows and some of the electrons pass through to the gate, therefore, giving it a negative charge. With the gate sufficiently charged, the programming voltage is removed. Now, when power is applied to the PROM, that MOSFET (P-channel) conducts. Because the gate is isolated and insulated from the rest of the structure, it retains its charge for a considerable period of time. Where the MOSFET's are conducting, binary 1's are stored. To program binary 0's, the MOSFET's at the desired location are not subjected to the high programming voltage.

To erase the stored data, the MOSFET is exposed to ultra-violet light, which removes charge on the gate. It takes approximately twenty minutes of intense ultra-violet light to completely erase the chip. Since ultra-violet light is contained within normal ambient lighting, it too can be used to erase the chip. But, because the ultra-violet content of most normal lighting is low, erasure would take a considerable amount of time. Nevertheless, it does happen. Therefore, once an EPROM is programmed, the quartz window must be covered to prevent accidental erasure.

A variation of the floating-gate MOS ROM is an electrically erasable version known as an EEPROM, which is programmed in the same way as the light EPROM's. The floating gate MOSFET's are charged or discharged as desired to store the desired bit pattern. To erase the EEPROM, however, an electrical pulse can be applied. The pulse, usually about 20 volts, removes the charges stored on the MOS gates. The entire chip or *only* individually addressed words may be erased.

EEPROM's have become extremely popular because they possess not only the advantages of permanent data storage, but combine the ability to erase and reprogram by an electronic process. ■

SHORT QUIZ ON LESSON #7—MEMORY CIRCUITS

1. An 8K × 4 memory contains how many bits?
a. 8192 b. 32000 c. 32768 d. 65536

2. The common name for a read/write memory is ________.

3. The interval between address application and data output is called the ________ ________.

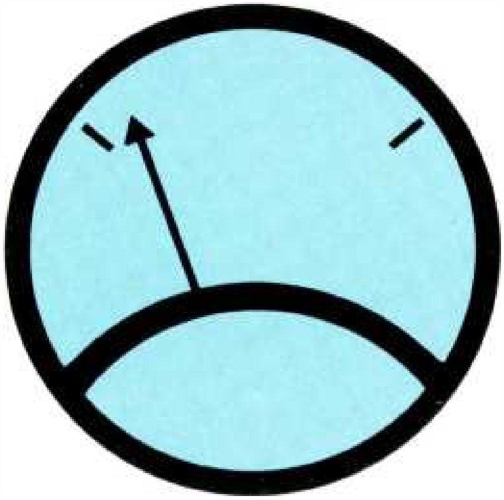
4. Most memory cells are organized as a ________ of ________ and ________.

5. A static memory storage cell is a ________ ________.

6. The basic storage element in a dynamic cell is a ________.

7. The numerical location of a word in memory is called the ________.

(Continued on page 104)



Making MILLIOHM

Getting an accurate milliohm reading is easy,

HAVE YOU EVER BEEN FRUSTRATED IN A VAIN ATTEMPT to measure small resistances in a current shunt, coil, heating element, motor winding, tube filament; or on a PC board, down a power line, on a micro bus, in a light bulb, etc? If you've spent any time at all doodling around with electronics, the problem of measuring small resistances is bound to have reared its ugly head once or twice.

For example, how many times have you slapped your analog multimeter across a component and watched the needle go to zero (as in the case of a current shunt) when you knew better? Even if you used a DMM to measure some similarly low-resistance value, the results would have been pretty much the same—with the digital display alternating between 0 and 1—because most DMM's have a ±1-digit quantization error. But there is a better way!

General Outline

A simpler and definitely cheaper solution to measuring small resistances is to build an *el cheapo* constant-current source, attach it to the device that you want to measure, and read the voltage drop across it, while monitoring the current through it. From then on, it's all academic. That is, if a 100-mA current source is fed to a meter shunt, and DVM, DMM, millivoltmeter, microvoltmeter, etc., used to sense the voltage drop across the shunt, by Ohms Law, $E = IR$, the DVM or metering device will also read the resistance of the shunt. (Remember, the voltage drop is proportional to the resistance at a given I_{IN}).

The voltage resolution of the metering device determines how small or large a current source is required. For example, the voltage drop across 1, .1, .01, and .001-ohm resistances is 100 mV, 10 mV, 1 mV, and .1 mV, respectively, with a 100 mA source applied; and 1000 mV, 100 mV, 10 mV, and 1 mV, respectively, with a 1 A applied. Given those variables, it is a simple matter to determine the value of a small resistance:

$$R = E/I.$$

Now, if you already have a meter capable of millivolt or microvolt measurements, all you need is a current source. A meter capable of microvolt readings would even allow a 10 mA source to be used. And if you don't have a meter capable of even millivolt readings, you can either "soup" up what you have, or build a simple metering circuit that can handle that low voltage range—which is a lot easier than you might think. (But, more on that later.)

The important thing to realize is that the four-wire method of determining resistance (current source, with metering devices across and in parallel with the *d*evice *u*nder *t*est or DUT), eliminates the problems associated with contact and lead resistance, which can skew the results, as those resistances can exceed that of the unit that you're trying to measure.

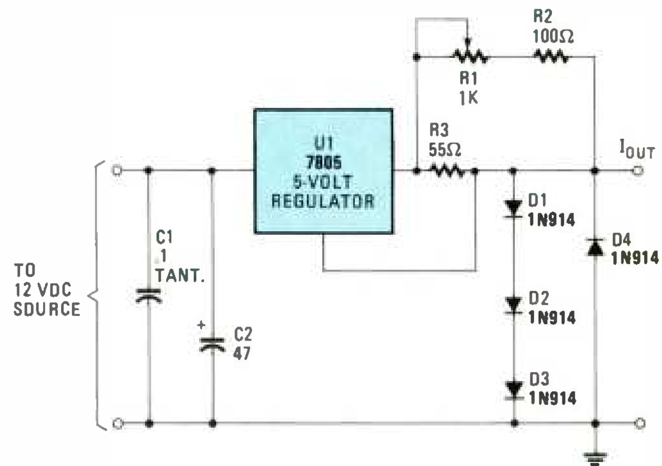


Fig. 2—A 100-mA constant current source can be created from a 7805, 5-volt regulator and a few additional components.

Three Simple Current Sources

Both simple and cheap current sources can be made from standard three-terminal regulators, like the LM309, LM7805, and others. Using a three-terminal regulator, as shown in Fig 1, a constant current, I_L, is delivered to the load, R_L, such that $I_L = V_{REG}/R1 + I_Q$ for $0 \geq R_L \geq (V_{IN} - V_{REG} + V_{DROPOUT})/I_L$.

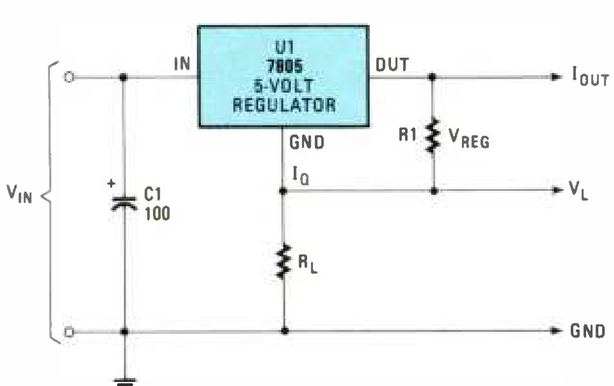


Fig. 1—A circuit capable of a constant-current output can be built from three-terminal regulators, such as the LM309, 7805, etc.

By D.E. Patrick

MEASUREMENTS

when you know how to go about it!

The output impedance is given by:

$$Z_O + \Delta V_O/\Delta I_L = 1/\Delta I_Q/\Delta V_{IN} + \Delta V_O/\Delta V_{IN}$$

where $\Delta I_Q/\Delta V_{IN}$ is the quiescent current (I_Q) change per input volt of the regulator and $\Delta V_O/\Delta V_{IN}$ is the line regulation (L_R), which is the change in regulator output per input voltage change at a fixed I_O. Thus, we can build a primitive 100 mA current source around an LM7805, like the one shown in Fig. 2.

The output of a standard 12-volt battery eliminator (wall-mounted power supply) is applied to U1, with U1's output adjusted to 100 mA using R1 (which provides an output current swing of about 87 to 114 mA). Diodes D1 thru D4 limit output voltage under no-load conditions.

Unfortunately, most ordinary three-terminal regulators have some problems—quiescent current is usually somewhere around 10 mA, resulting in an output current error of 1 percent error with a 1 ampere output, and even more at lower current outputs. In addition, most three-terminal regulators require a 7-volt input for proper operation. However, all of the problems associated with three-terminal regulators in constant current arrangements can be eliminated by using the LM317 positive, adjustable voltage-regulator. The LM317, with error current in the range of 50 mA from the adjustment terminal, can operate from a 4.2-volt supply delivering 1.5 A, while still providing .5 A at a V_{IN} of 3.2 volts.

Figure 3 shows both the basic constant-current configuration and an extended version, which is the basis of our small resistance metering scheme. The output current provided by the basic configuration shown in Fig. 3A is given by:

$$I_{OUT} = 1.25V/R1$$

where 0.8 ohm $\geq$ R1 $\geq$ 120 ohms, with 10 mA $\geq I_{OUT} \geq$ 1.5 A. However, using a negative supply and a second LM317 as a reference, the configuration in Fig. 3B provides 0 mA $\geq I_{OUT} \geq$ 1.2 A. Current limiting is performed by U1, while U2 acts as voltage reference. Current sensing is performed by R1, and R2 sets the the circuit's current limit by cancelling out part of the reference established by U2 as it is adjusted.

At low-current outputs, regulation is degraded by the voltage sensed across R1, which at 50-mA would only provide a 50 mV drop. R1 and the supply rejection of the LM317 limits current regulation to about 3 percent for a 40-volt change across the device. However, by limiting the voltage change across the device for the same 100-mA output of the circuit in Fig. 2, we can get current regulation in the 1-percent range, and better, than that of a high-current output. But, the double-regulator configuration in Fig. 3 allows us to get a 0 mA output, which is not possible with single-unit, three-terminal current sources.

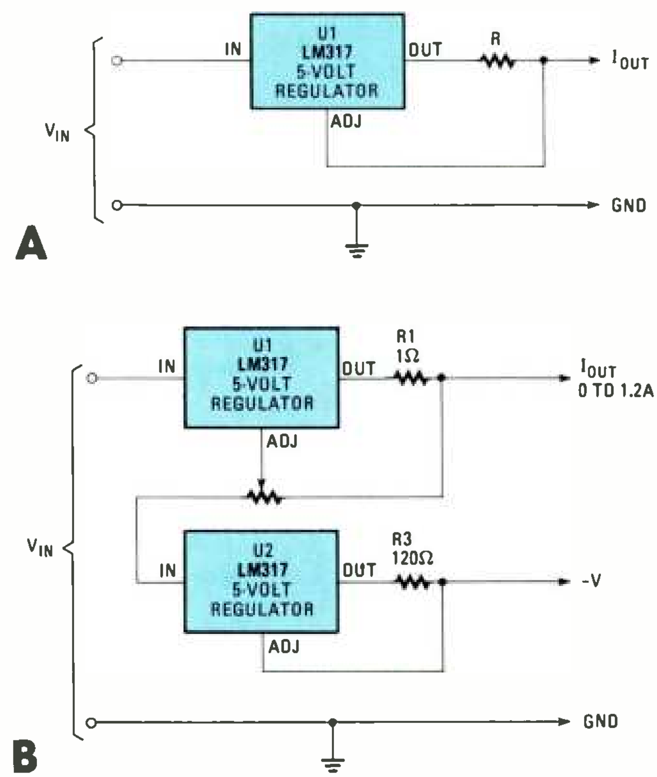


Fig. 3—Both the basic (A) and an extended version (B) of the constant-current setup is shown built around the LM317 positive, adjustable regulator. By using the LM317, most of the problems associated with using three-terminal regulators in constant-current applications can be eliminated.

Low-voltage Metering Circuit

The analog millivoltmeter circuit shown in Fig. 4 is built around a single op-amp IC, which provides 5-mV full-scale deflection at 50 μA, using a 0 to 50 μA meter. However, additional gain can be achieved by cascading more op-amps if desired. For example, with additional gains of 10 or 100, we would have a .5- to 500-μV or .05- to 50-mV analog meters.

Also, the basic three-step attenuator, providing a range of from 500 mV to 5 mV using a 900,000-ohm, 90-000-ohm, and 10,000-ohm resistor (R7, R8, and R9, respectively), can be expanded as desired. For example, a 900,000-ohm, 90,000-ohm, 9,000-ohm, 900-ohm, 90-ohm, 10-ohm; or 900,000-ohm, 90,000-ohm, 9,000-ohm, 900-ohm, 100-ohm sequences might just as well have been chosen. Metal film or wirewound 1-percent resistors are recommended if you're aiming for accuracy and stability.

However, 5-percent or 2-percent units may be substituted: Resistors within 1 percent of the specified values can gener-

(Article continued on page 101)

THE WAILING SIREN

This siren circuit can be custom tailored to produce the most attention-getting effect possible!

By Robert F. Scott

☐DURING THE TIME OF THE ROMAN EMPIRE, GLADIATORS were brought into the arena amid the blasts of trumpets. In the early west, cavalry troopers were spurred on into battle by the staccato notes of "Charge" played on a bugle. While those brassy monotones are useful attention-getters, nothing draws attention as quickly as the two-tone warbling "hee-haw" sound of European emergency vehicles, or the strident "whee-oo whee-oo" and the repetitive "wheep-wheep" yelps emitted by the sirens of some fire, police, and emergency vehicles.

An electronic siren—offering the wails, yelps, and warbles at a flick of a switch, and variable pitch and pulse controls so you can tailor the siren sounds to your preference—can cost several hundred dollars. But, the *Wailing Siren* that we'll describe can be tailored to produce any one of those sounds, and can be put together for just a few cents. We'll identify the frequency-controlling components in the circuit, so that you can provide the effects that you want.

The wailing sound—called the *American Siren* in foreign countries—produced by this circuit is most often associated with fire-emergency vehicles. But it can also be used as an alarm in schools or industrial plants, as well as in other signalling applications.

A Look at the Circuit

Figure 1 shows a schematic diagram of Wailing Siren. Transistors Q1 and Q2, with feedback provided via C1 from the collector of Q1 to the base of Q2, forms a voltage-controlled oscillator (VCO). Depending on the voltage applied to Q2's base, the frequency range of the VCO is around 60 Hz to 7.5 kHz. The instantaneous voltage applied to the base of Q2 is determined by the values of C2, R2, R3, and R4.

When pushbutton switch S1 is closed, C2 charges fairly rapidly to the maximum supply voltage through R2, a 22,000-ohm fixed resistor. That causes the siren sound to rise rapidly to its highest frequency. When the button is released, the capacitor discharges through R3 and R4 (a combined resistance of 124,000 ohms), causing the siren sound to decay from a high-pitched wail to a low growl. If you want to experiment with the pitch of the sound at its highest frequency, try different values of C1. Increase its value for lower notes, and decrease it for a higher frequency. Different values for R2 will change the attack time. A 100,000-ohm resistor provides equal attack and decay times.

The way you hanole the pushbutton can vary the effect

(Continued on page 98)

PARTS LIST FOR THE WAILING SIREN

C1—0.01-µF, ceramic disc capacitor
C2—100-µF, 35-WVDC, electrolytic capacitor
Q1—2N2904 or MPS2907 low-power silicon PNP audio transistor, 400-mW, or greater, dissipation (Radio Shack No. 276-2023 or equivalent)
Q2—2N2222, or equivalent, general-purpose NPN audio transistor
R1—10-ohm ¼-watt, 5%, fixed resistor
R2—22,000-ohm (see text) ¼-watt, 5%, fixed resistor
R3—68,000-ohm ¼-watt, 5%, fixed resistor
R4—56,000-ohm ¼-watt, 5%, fixed resistor
S1—Pushbutton switch, normally open

ADDITIONAL PARTS AND MATERIALS

PC board, perfboard, or experimenters board (Global Specialties 300 PC Experimenter board), speaker to suit application 35 to 50-ohms with R1 removed; 8 to 16 ohms with R1 (see text), wire, solder, etc.

Fig. 1—The Wailing Siren, which consists of readily available parts, can be tailored to produce the desired audio output.

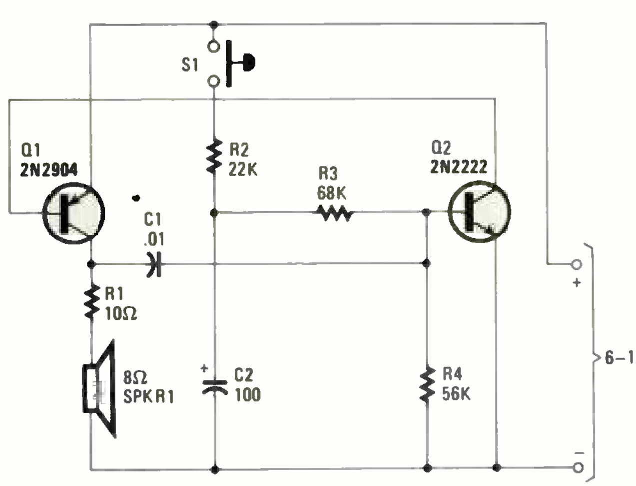
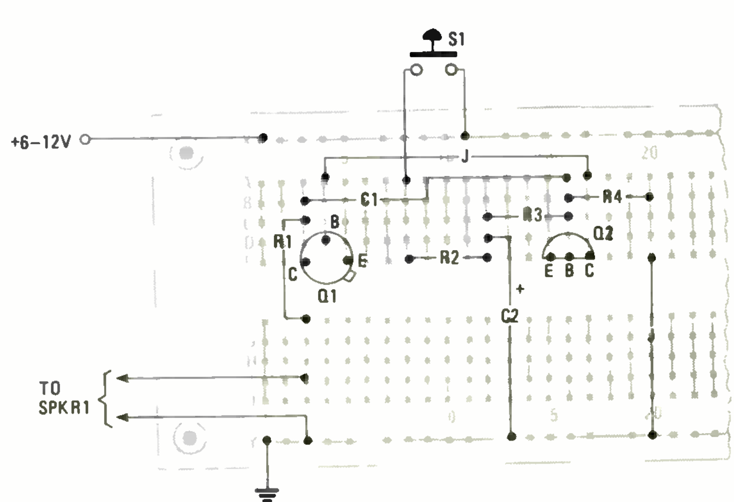


Fig. 2—The circuit can be laid out on experimenter's board as shown here or, if desired, perfboard or PC board may be used.



FREQUENCY COUNTER

Now you can have the convenience of a handheld, digital universal counter for less than half the price of a commercial unit!

By D.E. Patrick

IF YOU'VE EVER DESIGNED, BUILT, OR SERVICED ANY equipment in which signal frequency was critical, then you've probably found yourself, on several occasions, thumbing through the many brochures and catalogs put out by various scope and counter manufacturers and suppliers. Counters, which are usually the cheaper of the two instruments, can run from just under \$200 to well over the \$1000 mark. However, with just a little effort, you can build 120-MHz (and better) hand-held, battery-powered, *frequency only* or *universal* counters for \$50 to \$75.

The difference between frequency only and universal counters is that the former, as its name implies, is a straight frequency counter with none of the frills. The universal counter, on the other hand, performs several other functions aside from normal frequency measurement: Time interval and period counting, and frequency ratio (in which the ratio of two input frequencies are compared) are all possible with such a counter.

The circuits that we'll view here are based on Intersil's ICM7216 family of 10-MHz counter chips, which come in four flavors; A, B, C, D. By combining just one of that family with 3 or 4 additional integrated circuits and some seven-segment displays, you can build a hand-held or benchtop frequency counter at a fraction of the cost for a commercial unit.

Sizing up the ICM7216

Figure 1 shows the pinout diagrams of each of the four units in the ICM7216 family. The A and B devices (Fig. 1A and Fig. 1B, respectively) are fully-integrated, universal counters. Each contains a high-frequency oscillator, decade timebase counter, an 8-decade data counter, and latches; a 7-segment decoder, digit multiplexers, and 8-segment and 8-digit drivers (to directly drive large multiplexed displays).

The counter inputs are rated for a maximum signal frequency of 10 MHz in the counter and unit modes, and 2 MHz in the others. For period and time interval measurements, the 10-MHz timebase gives a 0.1-μs (10^{-6} second) resolution, while in the time interval and period averaging modes, a resolution in the nanosecond region can be expected. The frequency mode allows the user to select accumulation times of 0.01, 0.1, 1, and 10 seconds, allowing for a resolution of 0.1 Hz in the least significant digit.

The C and D units (Figs. 1C and Fig. 1D, respectively) function as frequency-*only* counters (as described for the A and B devices). All versions (A–D) feature leading zero blanking, with the frequency being displayed in kHz. The A and B devices show time in μs. The display is multiplexed at 500-Hz with a 12.2 percent duty cycle for each digit. Both A and C suffix versions are designed for common-anode displays with peak-current requirements of 25 mA, while B and D units are common-cathode types requiring 12 mA of peak current. Now, let's take a close look at the ICM7216 series' function, range, and control inputs, all of which may be used or deleted as your application dictates.

Controlling The Counters

All of the control inputs of the ICM7216 family are time multiplexed to select the input function, range, etc., which sounds a lot more complicated than it really is. Control over the unit is accomplished by simply connecting a selected digit output to the input pin that gives the desired function, range, etc. The frequency, period, frequency ratio, time interval, unit counter, and oscillator frequency functions are selected (A and B units only) by connecting the pin 3 function-select input to one of the data outputs (D_1–D_8). For instance (refer to Table 1), if output D_2 is connected to pin 3, the unit is set to the frequency-ratio mode; connecting D_8, puts it in the period mode and so on.

In a similar fashion, range is selected on all the versions by connecting pin 14 (range select) to the D_1, D_2, D_3, or D_4 outputs for .01-sec/1-cycle, .1-sec/10-cycle, 1-sec/100-cycle, or 10-sec/1000-cycle frequency gate or period range times, respectively. But remember, the period input capability is available on A and B versions, only. The blank display, display test, 1-MHz select, external-oscillator enable, external-decimal-point enable (C and D versions only), and test functions are selected by connecting the pin 1 control to the D_4, D_8, D_2, D_0, D_3, and D_5 outputs, respectively. (See Table 1.)

Note that an external decimal point input is available at pin 13 of the C and D versions only (Fig. 1C and Fig. 1D), and the decimal trigger point is output for the same digit that is connected to pin 13. That allows the external decimal point function on C and D versions to be easily shifted two positions when a prescaler is being used. On all versions, fre-

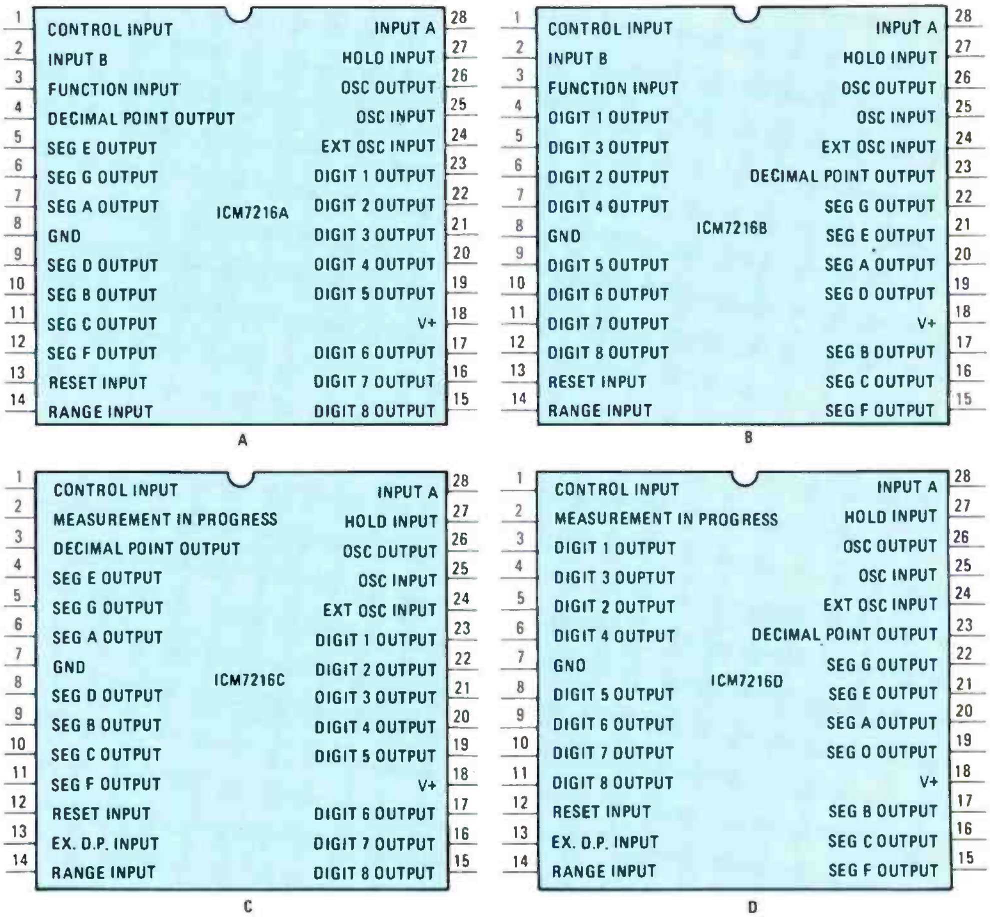


Fig. 1—The ICM7216, available in four "flavors" (A, B, C, and D), is a fully integrated 10-MHz counter that has on board all the necessary circuitry to build either a universal or frequency-only counter. The A and B units are universal counters, while C and D devices function as frequency-only counters. The A and C units are designed for use with 7-segment, common-anode, light-emitting diode displays; while, B and D suffix devices are compatible with common-cathode displays.

Function Input	FUNCTION	DIGIT
Pin 3 CD-7216A & B Only	Frequency Period Frequency Ratio Time Interval Unit Counter Oscillator Frequency	D_0 D_7 D_1 D_4 D_3 D_2
Range Input Pin 14	.01 sec/1 Cycle .1 sec/10 Cycles 1 sec/100 Cycles 10 sec/1K Cycles	D_0 D_1 D_2 D_3
Control Input Pin 1	Blank Display Display Test 1 MHz Select External Oscillator Enable External Decimal Point Enable Test	D_3 and Hold D_7 D_1 D_0 D_2 D_4
External Decimal Point Input Pin 13, CD-7216C & D Only	Decimal point is output for same digit that is connected to this input	

quency is normally displayed in kHz with leading zero blanking, while the A and B versions show time in milliseconds. Overflow, for the entire series is indicated by the decimal point output of digit 8.

Signal Conditioning Circuits

Before the ICM7216 series of counters can be expected to function properly, there are some things that must be done; preconditioning of the input signal is probably the most important. Figure 2 shows two *el cheapo* conditioning circuits; one based on the 7404 hex inverter (U1 in Fig. 2A) and the other on a MC10216 triple-line driver (U2 in Fig. 2B). Both circuits provide sensitive, high-impedance, wide-bandwidth front ends. The transistors pairs (Q1/Q2 and Q3/Q4) in their respective circuits provide a high-impedance input. U1 and U2 each contribute additional gain and Schmitt trigger outputs.

The configuration in Fig. 2A can be used at frequencies in excess of 30 MHz, with typical sensitivities of under 40 mV. That circuit, which consists of readily available parts, can be used to directly feed the input of the one of the counter IC's. But if you intend or expect to use your counter in the realm of frequencies that lie beyond the 10-MHz mark, then you'll need a bit more than a simple preconditioning circuit. The Fig. 2B configuration (useable at frequencies in excess of 120 MHz) is suitable for driving a prescaler to extend the maximum range of the counter IC. By using National's DS8629 120-MHz,, divide-by-100 prescaler in conjunction with one of the Intersil chips, the counter's frequency range can be extended to about 120 MHz. That inexpensive chip contributes high-frequency capability; and with the capacitor values shown, the circuit is usable over the same low range as the

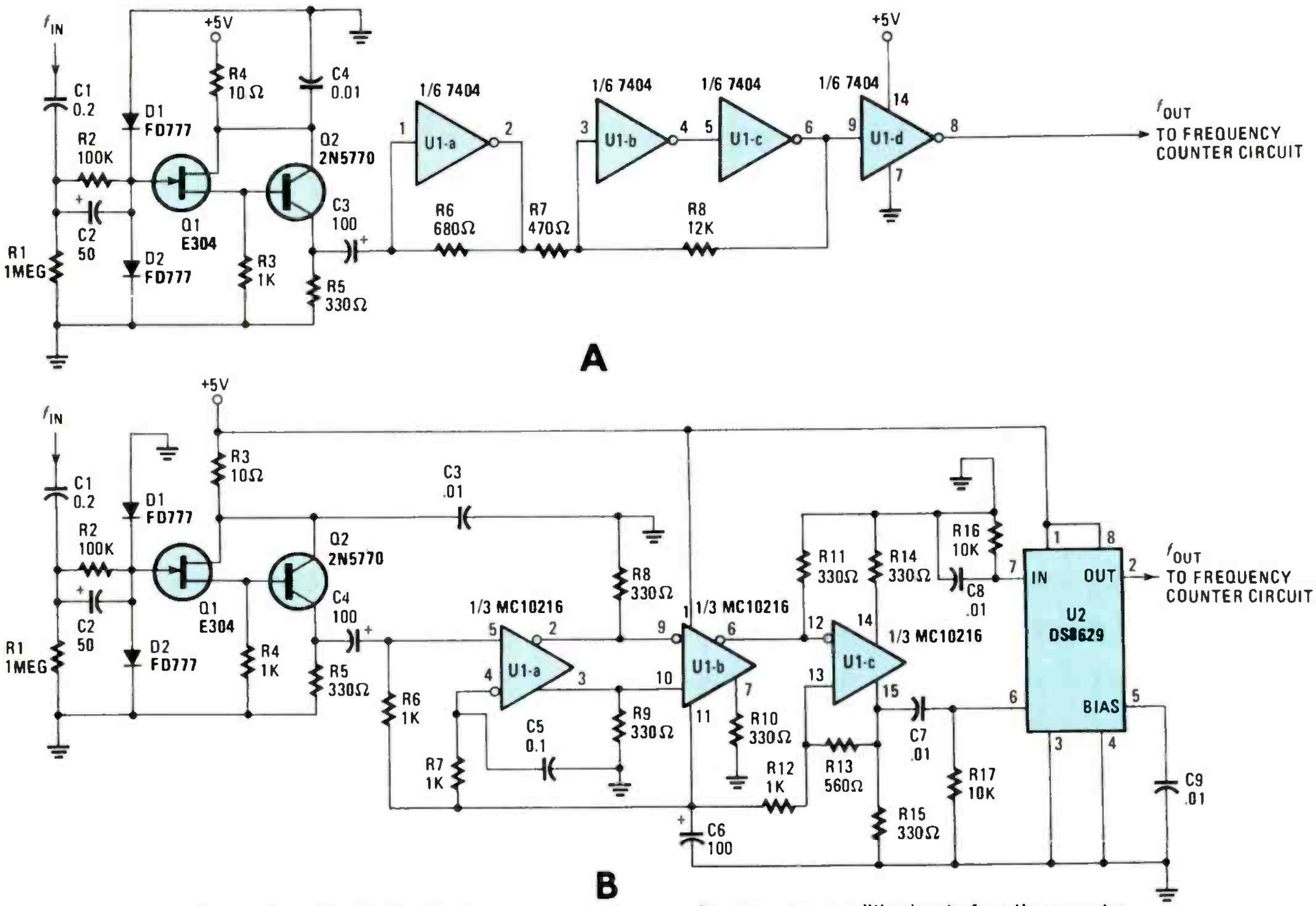


Fig. 2—Intersil's single chip frequency counters require some preconditioning before they can be expected to function properly. The circuit in A is useable at frequencies up to about 30-MHz, and may be used to directly feed a 10-MHz counter. But for higher frequencies, such as encountered in video and digital circuits, the 2 configuration is the way to go.

PARTS LIST FOR THE 120-MHz UNIVERSAL FREQUENCY COUNTER

SEMICONDUCTORS

D1–D4—FD777 fast-switching, signal diode
D5–D9—1N914 silicon small signal diode
DIS1–DIS8—HP5082-7440 8-digit, HP5082-7441 9-digit, or FND-367 single-digit, seven-segment, common-cathode display; or FND-366 single-digit, seven-segment, common-anode display (see text).
LED1—Jumbo red light-emitting diode
Q1, Q3—E304 FET transistor
Q2, Q4—2N5770 bipolar silicon transistor
U1, U3—MC10216 line receiver, integrated circuit
U2, U4—DS8629 120-MHz, divide-by-100 prescaler, integrated circuit
U5—ICM7216 10-MHz frequency counter, integrated circuit (see text)
XTAL1—10-MHz crystal

RESISTORS

(All resistors ¼-watt, 5% fixed units)
R1, R18—1-Megohm
R2, R19—100,000-ohm
R3, R21—10-ohm
R4, R6, R7, R12, R20, R23, R24, R29—1000-ohm
R5, R8–11, R14, R15, R22, R25–28, R30, R31—330-ohm
R13, R30—560-ohm
R16, R17, R33, R34, R36–R39—10,000-ohm
R35—22-Megohm
R40–R49—600-ohm

CAPACITORS

C1, C10—0.2-μF, 16-WVDC, ceramic disc
C2, C11—50-μF, 16-WVDC, electrolytic
C3, C7–C9, C12, C16–C18—0.01-μF, 16-WVDC, ceramic disc
C4, C6, C13, C15—10-μF, 16-WVDC ceramic disc
C5, C14—0.1-μF, 16-WVDC, ceramic disc
C19—39-pF, 16-WVDC, ceramic disc
C20—20-pF, trimmer
C21—20-pF, 16-WVDC, ceramic disc

SWITCHES

S1, S2—SPST, normally-open pushbutton
S3, S4—SP6T, rotary
S5–S9—SPST, toggle

ADDITIONAL PARTS AND MATERIALS

Printed-circuit materials, enclosure, IC sockets, battery and holder, solder, wire, silicon cement, test lead and clips, etc.
Note: The ICM7216, C and D versions, is available from Digi-Key Corp (701 Brooks Ave. So., P.O. Box 677, Thief River Falls, MN 56701; 1-800/344-4539). The DS8629 120-MHz prescaler is available from Jameco Electronics (1355 Shoreway Road, Belmont, CA 94002; 415/592-8097).

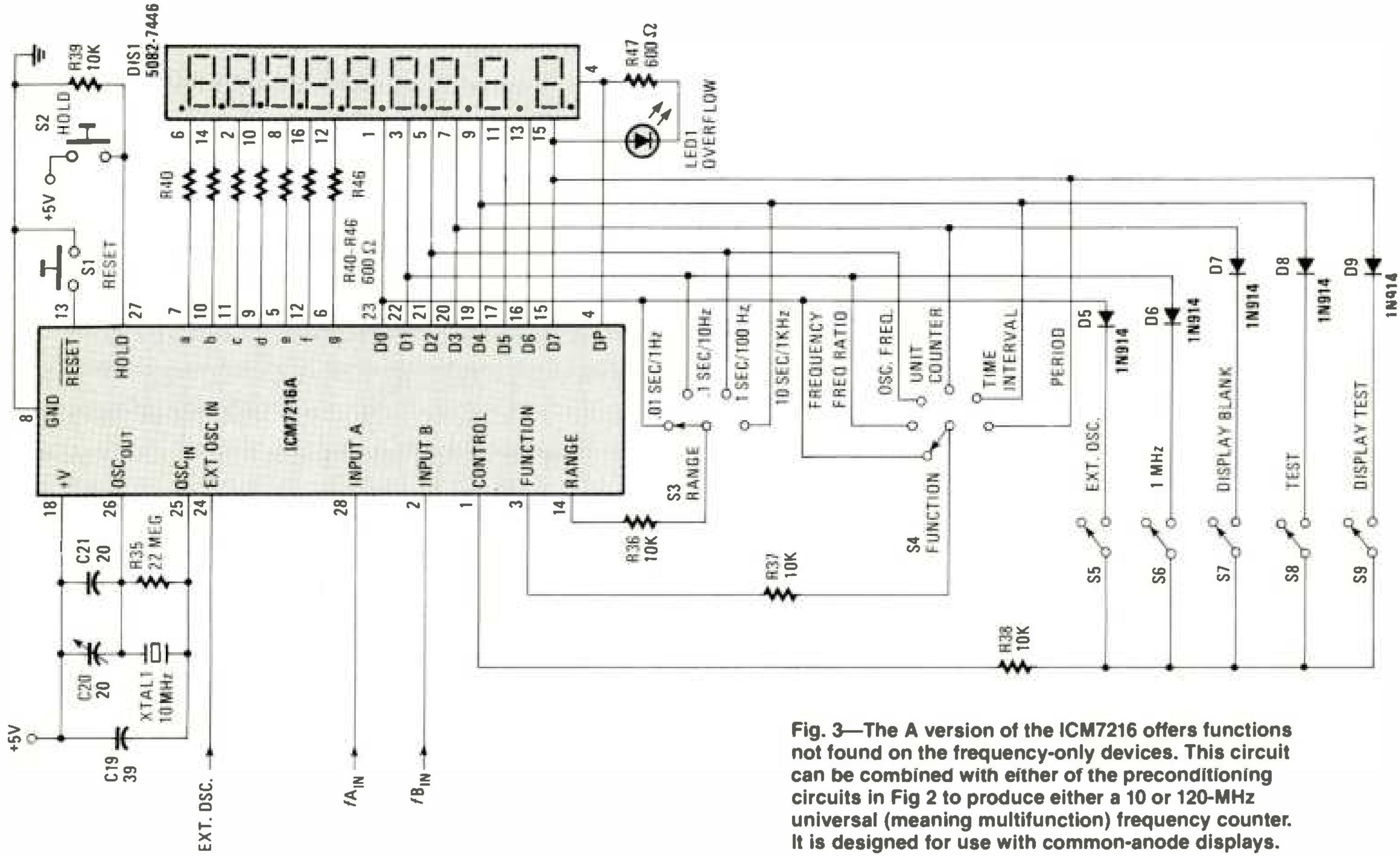


Fig. 3—The A version of the ICM7216 offers functions not found on the frequency-only devices. This circuit can be combined with either of the preconditioning circuits in Fig 2 to produce either a 10 or 120-MHz universal (meaning multifunction) frequency counter. It is designed for use with common-anode displays.

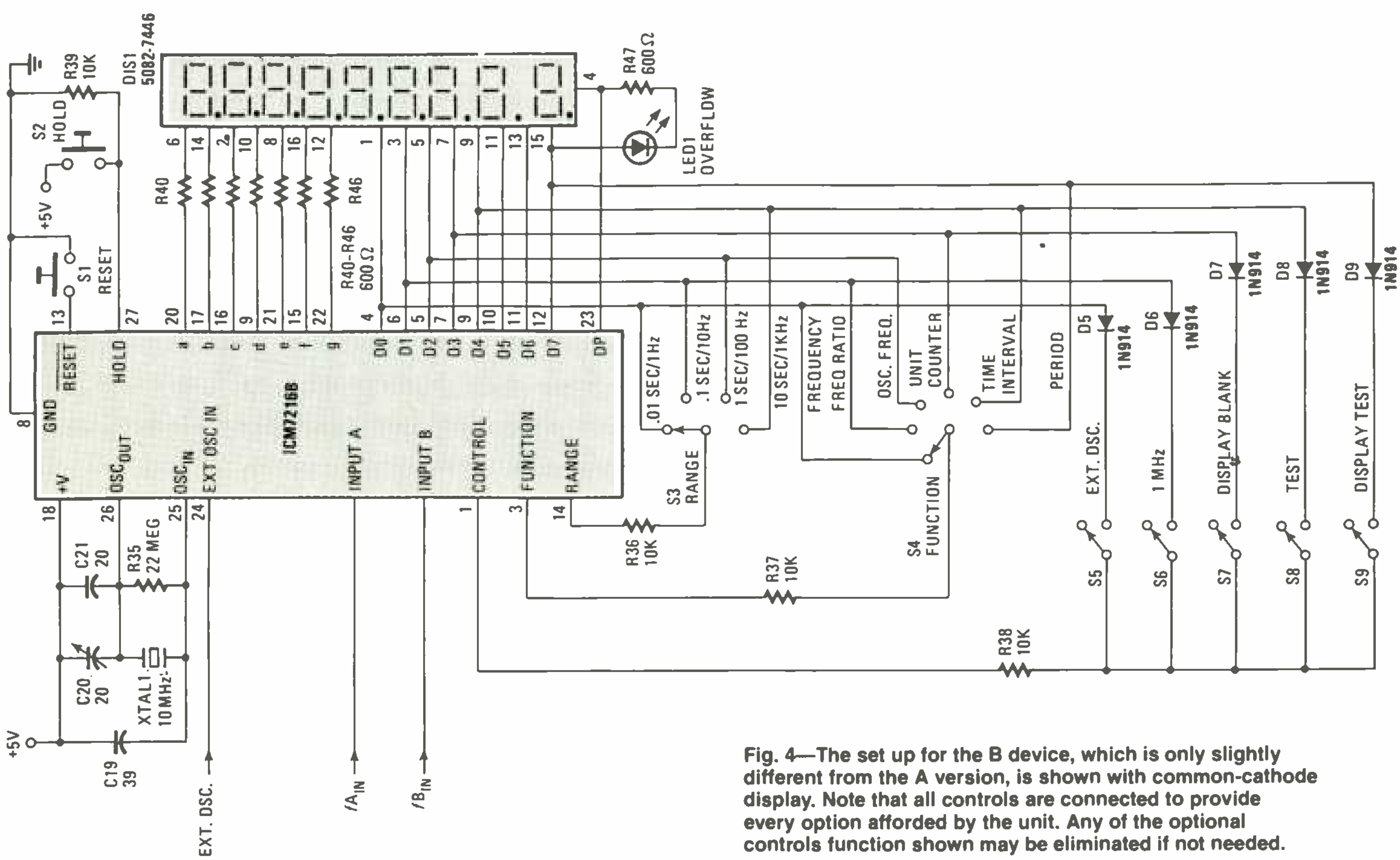


Fig. 4—The set up for the B device, which is only slightly different from the A version, is shown with common-cathode display. Note that all controls are connected to provide every option afforded by the unit. Any of the optional controls function shown may be eliminated if not needed.

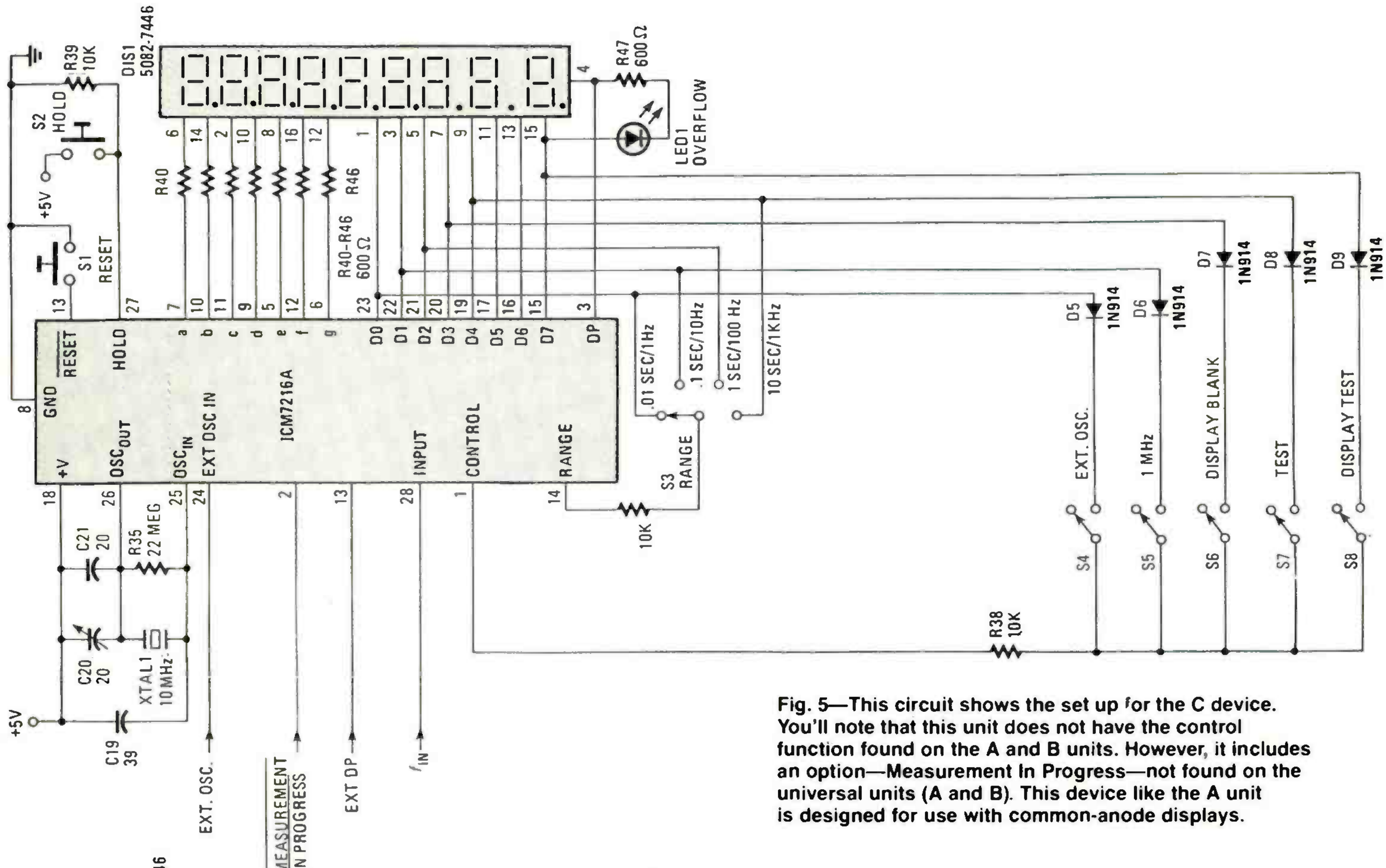


Fig. 5—This circuit shows the set up for the C device. You'll note that this unit does not have the control function found on the A and B units. However, it includes an option—Measurement In Progress—not found on the universal units (A and B). This device like the A unit is designed for use with common-anode displays.

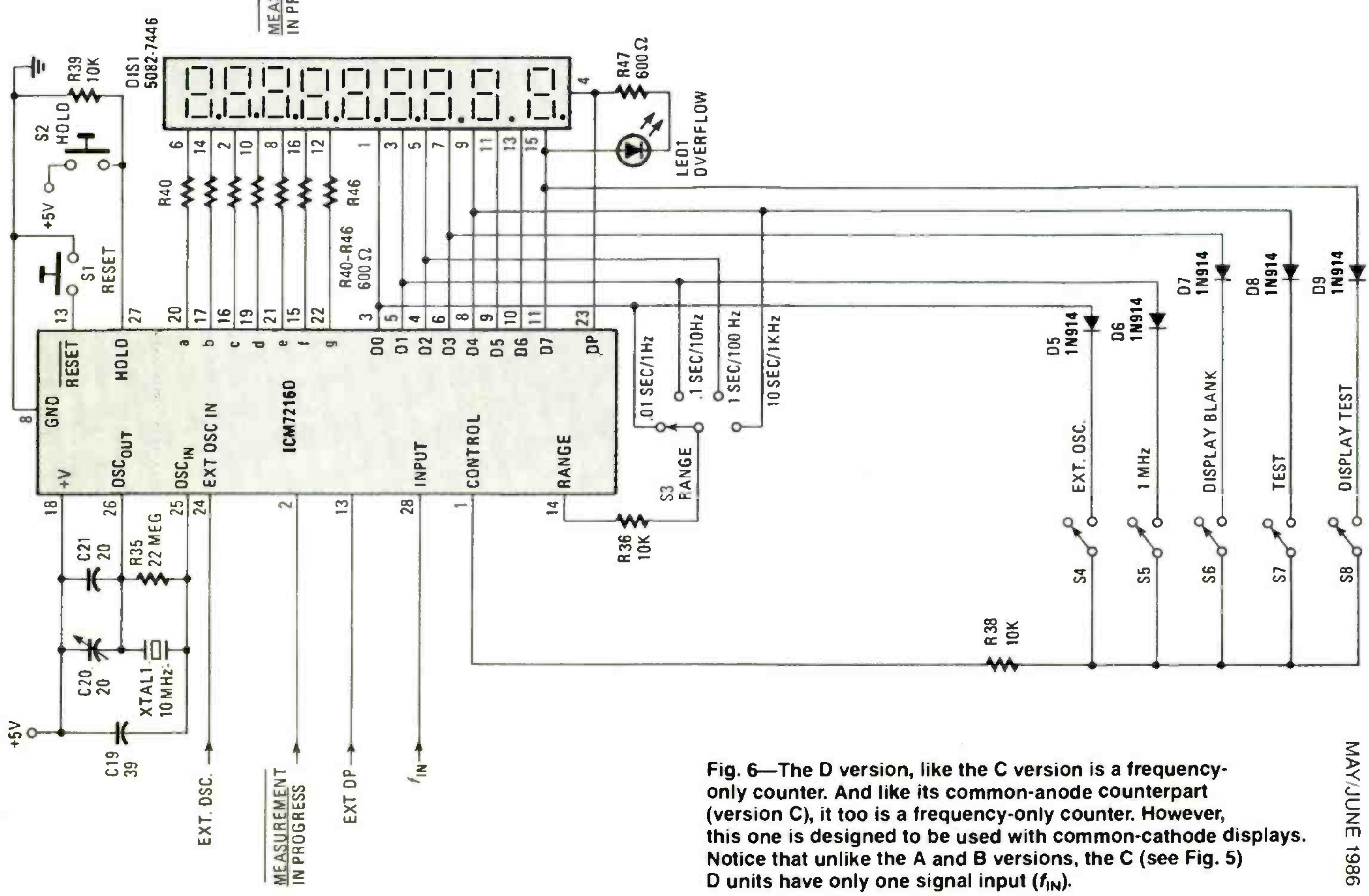


Fig. 6—The D version, like the C version is a frequency-only counter. And like its common-anode counterpart (version C), it too is a frequency-only counter. However, this one is designed to be used with common-cathode displays. Notice that unlike the A and B versions, the C (see Fig. 5) D units have only one signal input (f_{IN}).

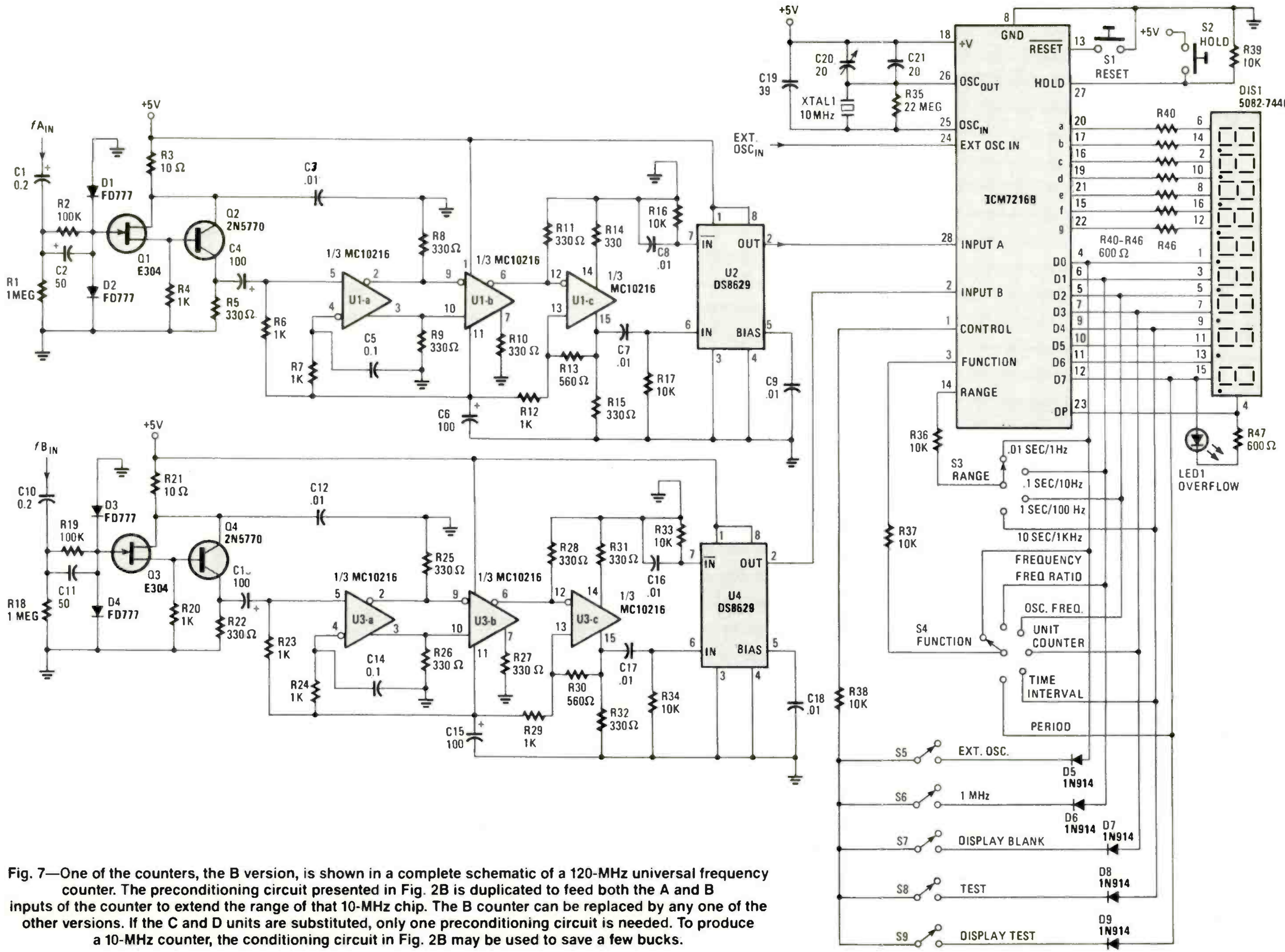


Fig. 7—One of the counters, the B version, is shown in a complete schematic of a 120-MHz universal frequency counter. The preconditioning circuit presented in Fig. 2B is duplicated to feed both the A and B inputs of the counter to extend the range of that 10-MHz chip. The B counter can be replaced by any one of the other versions. If the C and D units are substituted, only one preconditioning circuit is needed. To produce a 10-MHz counter, the conditioning circuit in Fig. 2B may be used to save a few bucks.

circuit Fig. 2A—but with greater sensitivity (10 mV or less).

The DS8629 has probably found more use in FM receivers than in counter circuits. But since it can be driven differentially with a 200-mV signal, or single-ended with a 600-mV signal, it is well suited for our application. Its MECL front end can handle sinewave inputs and its TTL-compatible output can drive a counter; for that reason, you might even consider using the DS8629 without preconditioning. However, it's touchy front end and minimum slew rate requirement of 100V/μs dictates preconditioning, or that it be used at frequencies in excess of 30 MHz, or so.

The conditioning circuits feed one of Intersil's ICM7216 series of counters (either directly or via the prescaler). The counter, in turn, directly drives an 8 or 9-digit seven-segment display. You'll note that the Intersil chip has provisions for only an eight-digit display; the use of a nine-digit display will be explained shortly.

Frequency Counter Circuits

Now let's turn our attention to Fig. 3 through Fig. 6, which show setups for each of the four versions of the ICM7216. Note that each is shown without preconditioning circuitry, which has already been discussed. (Preconditioning and counter circuits are later combined to produce a working 120-MHz universal or frequency *only* counter.) Figure 3 shows the overflow connections are made on the A version between the cathode of decimal point output at pin 4 and digit 8's anode at pin 15. In Fig. 4—using the B unit—the overflow connections are made between the cathode of digit 8 at pin 12 and anode of the decimal point at pin 23. For the C unit (see Fig. 5), overflow connections are made between the cathode of the decimal point output at pin 3 and the digit 8 anode at pin 15. And finally in Fig. 6, using the D version, the overflow connections are between the cathode of digit 8 (pin 11) an the decimal point anode (pin 23).

In addition, the C and D versions both have MEASUREMENT-IN-PROGRESS control pins that are seldom used. All versions can be operated from a 5-volt power supply, and each has a display off function that puts the unit into a low-power mode, and holds and resets the inputs—they can also be used with 1-MHz or 10-MHz crystal oscillators. Regardless of the counter version that you choose it will need one of the conditioning circuits that we've covered to ensure that it works properly.

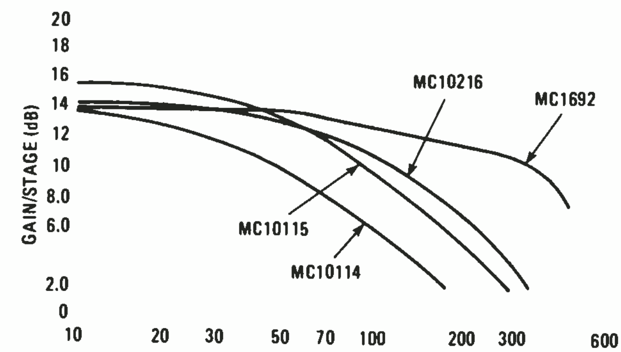
For the greatest flexibility, the A or B versions of the ICM7216 are just what you need, particularly when building or servicing devices wherein different stages are gated on at different rates and those rates are dependent on each other. Not only are those two counters useable in low-frequency applications, like audio, but will also prove invaluable in upper frequency applications, say video, or even digital.

120-MHz Universal Frequency Counter

An overall schematic of a 120-MHz universal counter, using the B device, is shown in Fig. 7. Note that both the A and B inputs of the counter are preceded by the preconditioning-prescaler circuit of Fig. 2-b. The R2/C2 and R19/C11 combinations feed source follower transistor pairs, Q1/Q2 and Q3/Q4. Those pairs provide a high-impedance signal input, while contributing a low-impedance output to U1 and U3, respectively. The diode pairs (D1/D2, and D3/D4) that precede the transistors, in conjunction with C1/R1/R2/C2 and C10/R18/R19/C11, respectively, limit input-signal levels.

The signal though transistors Q1 and Q2 is capacitively coupled to U1, which functions as a dual op-amp/Schmitt trigger combination, and U1 provides additional gain. U1 is fed a constant DC bias at pins 5, 11, and 13. U1-a (configured as a differential amplifier) amplifies the voltage difference between pins 4 and 5. That increased signal level is then further amplified by U1-b, resulting in a 20 to 30 dB gain beyond that provided by the Q1/Q2 combination. The amplified output of U1-b at pin 6 feeds U1-c pin 12, while pin 13 of U1-c is held at a fixed reference via the bias on pin 11, plus the hysteresis bias through R13. Thus, when the voltage at U1-c pin 12 rises to a level equal to that on pin 13, the Schmitt trigger changes state.

The voltage level that causes the Schmitt's change of state at pin 12 is composed of the incoming signal, plus DC bias level and hysteresis. So, when the hysteresis or positive feedback voltage at pin 13 starts to decrease, we get the fast flip action typical of any Schmitt trigger. Taking the reverse of that, when the voltage level at U1-c, pin 12 dips below the lower level established at pin 13, the Schmitt reverts to its original state. The gain versus frequency for several MECL line drivers is shown in Fig. 8A, with MECL Schmitt trigger and hysteresis curves shown in Fig. 8B. As you can see, the MC10216 is usable at frequencies up to 300 MHz, but gain drops off accordingly.



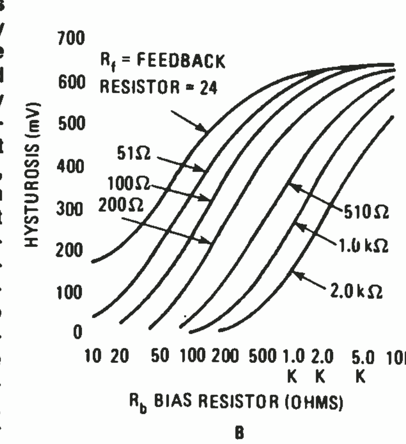


Fig. 8—The gain-vs.-frequency curves of several MECL devices are shown graphically in *A*. Note that the 10216, the device used in our high-frequency preconditioning circuit, is usable to about 300-MHz. However, since our circuit has a high-frequency limit of 120-MHz (as dictated by the prescaler), the other devices should also serve well in this application. In *B*, the graph shows the hysteresis afforded MECL devices by the resistor values shown.

In any event, the output of U1-c is capacitively coupled to U2, our prescaler. As we stated earlier, differential or single-ended drives are permissible with the DS8629; but when driven single ended, as shown in Fig. 7, the unused input (in our case, pin 7) should be bypassed to ground with a small capacitor. The capacitance value given, 0.01μF, is sufficient if only high frequencies are to be input to the prescaler, but should be increased for lower frequencies. Also, note the

(Continued on page 102)

By Herb Friedman

FRIEDMAN ON COMPUTERS

Modems, menus, messages—communications!

IT SEEMS THAT ALMOST EVERYONE IS peddling on-line information services these days. If it's not someone selling a multi-purpose service such as *The Source* and *CompuServe*, it's a narrow-purpose database listing entertainment in your town, or it's on-line electronic banking, or educational research, or whatever—you name it and someone will create a database.

Regardless what kind of information is stored in an on-line database, you access the information through your personal computer, a modem, a dial-up telephone connection, and most important, some kind of software that interfaces your computer to the modem and the on-line information service.

While it would appear simple enough to write a program that allows a home computer to access an on-line database, as with everything else for which the number of possible users runs into the millions, everyone wants a piece of the cake. Almost weekly, certainly monthly, several communications programs are introduced into the marketplace, each claiming to be better than all others.

As you might expect with anything that claims to be better than everything else, the complexity and the number of features offered by these programs has gotten out of hand (along with the selling price), and many of these "sophisticated" communications programs are so difficult to use that one must be almost a journeyman computer expert just to get the modem to *autodial* a telephone number. The important question for the potential user, therefore, is not how many features are provided by the software, but rather, what features are really needed.

Modems

All conventional "modem" programs for personal computers interchange data in ASCII. Unfortunately, ASCII is subject to glitches caused by noise on the communications path, which in plain English means the telephone line. Normally, it doesn't take too much effort or intelligence to fill in one or more glitched characters—the hearing impaired do this all the time when reading "real-time" closed captioning on television programs. For example, If you receive a message that says "Your local movie is playing *Bark to the fiture*," you've got a pretty good idea that the movie is the popular *Back to the future*. On the other hand, computer programs cannot tolerate any glitches: Usually, one single incorrect byte will cause a program to crash.

So, if you're downloading a program from a host computer, you must be certain it's received error-free, and this is accomplished through what we call *binary* exchange. Although modem programs intended for the interchange of text generally accommodate only ASCII data, software intended for exchanging text and programs generally provide for both ASCII and binary exchange; the ASCII is used for text and binary is used for downloading or uploading programs, or for 100% accurate text.

Protocol

For 100% accurate data exchange, the program must be also be capable of what is called "protocol communications," which means there must be some way for the receiving computer to check the incoming signal for accuracy, and if necessary, request one or more repeat transmissions from the host (information provider) until the data is received error free. The means whereby the two computers automatically check the signal reception and repeat the data exchange when needed, and the electrical signals which convey the interchange instructions is called the "protocol."

There are several protocols in common use; the most popular being the one in the public domain known as XMODEM (and its variations) and the one used by the *Crosstalk* communications program. The problem is, however, that the more flexible one makes the protocol and its use, the more complex the installation and use of the modem program becomes.

For example, Fig. 1 shows the main menu of a program called *TELCOM* for early Radio Shack Model I and Model III/4 computers. Obviously, it's simple enough to use: Much of the menu is self explanatory. Program variables are such things as the baud rate, parity, custom messages, character translations, etc. *TELCOM* buries these user-programmed functions so the user is confronted with a simple and easy to use menu. If several on-line services require different functions, individual versions of the program can be saved under different filenames, such as *TELCIS* for *CompuServe* and *TELSOURC* for *The Source*.

Users requiring instant control over all operating parameters are more likely to want software that presents all the variable functions, such as those on the screen from *Crosstalk*, shown in Fig. 2. Any function or parameter can be changed by simply punching it in on the command line. For example, if you want to save the incoming text in the buffer, you would simply enter CA + (for CApture *on*) on

(Continued on page 107)

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....... Telcom II -- Copyright (C) 1982 By Bryan Mumford .......
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.     Mumford Micro Systems - Box 400 - Summerland, CA 93067     .
.                                                               .
.                                                               .
.   1 = Terminal Mode                  4 = Send A File          .
.   2 = LYNC Protocol Mode             5 = Receive A File       .
.   3 = Program Variables              6 = Dump Buffer On Disk  .
.                                                               .
.                                                               .
.                      0 = Return to DOS                        .
.                                                               .
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. REGISTERED TO: HERB FRIEDMAN - REVIEW COPY - SERIAL # 22524  .
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```

Fig. 1 Here's a printout of the main menu for the program *Telcom*. It's very simple and to the point eliminating a time-consuming break-in periods.

The TTL Clock

(Continued from page 51)

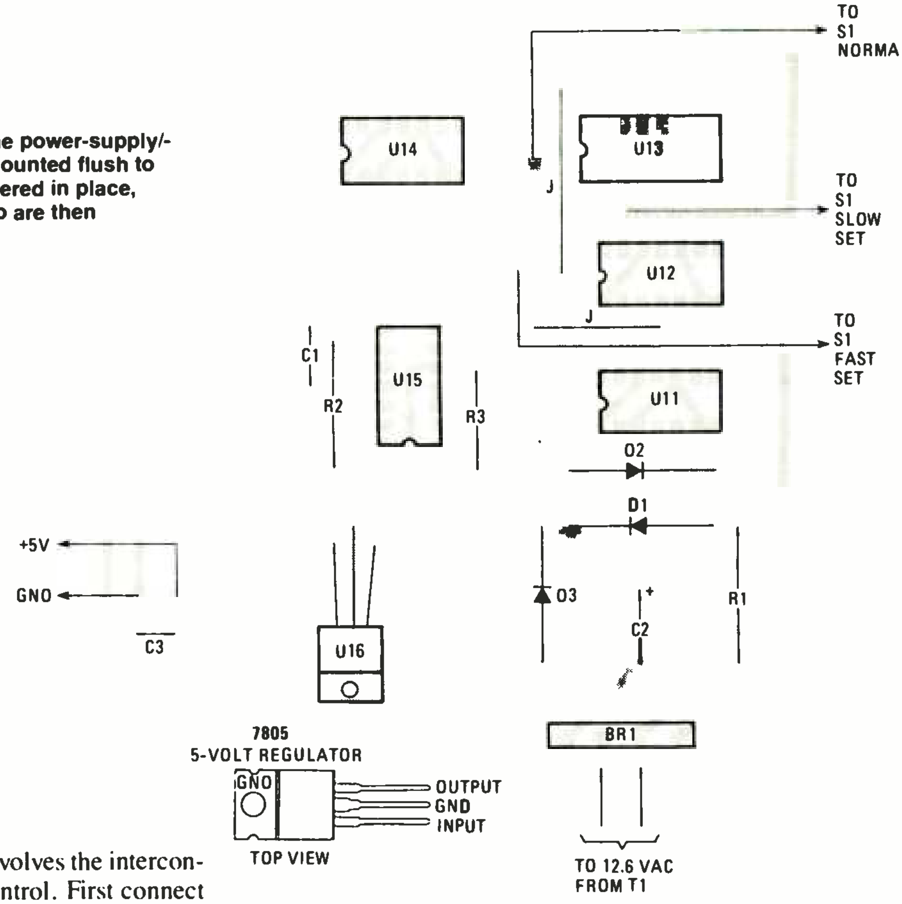


Fig. 9—The parts-placement diagram for the power-supply/-frequency-divider board. The heatsink is mounted flush to the board with the U16 regulator, once soldered in place, bent back flat against the heatsink. The two are then secured to the board with a screw.

tors) and then the semiconductors. Be sure to observe correct polarity when installing the electrolytic capacitor, C2, and to arrange the diodes with the proper orientation. Now take the chips out of their packages, straighten any bent pins, and align each unit with its corresponding socket. Gently press the chips into their sockets, making sure that they are properly seated and no pins are bent under the chip. Once in their respective sockets, the integrated circuits are safe, to some extent, from electrostatic discharge. When mounting the voltage regulator, it's a good idea to use silicon grease to aid in the transfer of heat from the regulator to the heatsink. The heatsink is mounted flush to the board and the regulator, U16, bent back to lie flat on top of the heat sink (see photos).

The final assembly of the TTL Clock involves the interconnection of the three boards and the S1 control. First connect wires from the points indicated in the layout of the power supply/frequency divider board to separate taps of S1. From the wiper arm of S1, bring out a wire to the point indicated on the counter/display-driver board. Connect wires from +5V and ground outputs of the power supply/frequency divider board to the counter/display driver board. Now connect T1's secondary to the power-supply input with fairly long lengths of wire.

Now all that's left to do is to connect the counter/display driver board to the the display board, using the 34-conductor ribbon cable. This portion is laid out simply enough so that you should have no difficulty in making the connections. Note that on the display, board there are two connection points labeled + V; either or both may be used, although only one is needed. Other than that, all you have to do is to connect the appropriate segments. For instance, A in the section labeled "To U2" on the display board goes to the section on the labeled "To DISP2" on the counter/display driver board. In other words, DISP3 goes to U3, DISP4 to U4, and so on. Note that the B and C segments of DISP1 are tied to the same trace on the counter/display driver board.

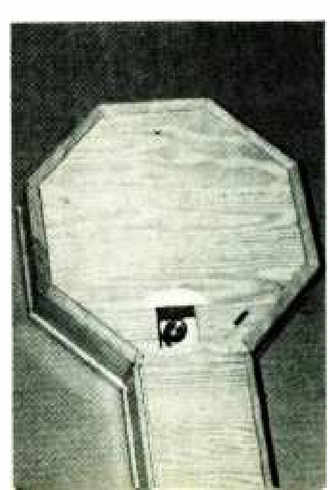
Once all connections have been made, check to make sure that all wires are correctly attached and that there are no solder bridges. Finally, be sure that all components are mounted. That completes the construction of the TTL Clock.

Checking The Operation

Once you are satisfied that all work has been properly completed, power-up the circuit by plugging it into an AC outlet. Upon application of power, 0:00 should be displayed. Set the switch to the FAST mode to check the illumination of each segment in the display. Once that is done, set the switch to SLOW to check for proper sequence of numbers. Check for proper timing by setting S1 to FAST; that should advance the display at a rate of 1 hour per second. (There should be 60 Hz at the FAST mode tap). In the SLOW mode, the display advances at rate of 1 minute per second (1 Hz). And in the NORMAL mode, the display's progression is at a rate of 1 count per minute (a frequency of 0.0167 Hz).

If either the timing or counting is incorrect, check the appropriate counter/divider circuits for defects, such as incorrect wiring. Make sure that the integrated circuits are in the proper place. For example, it is possible to mistake the 7490 for the 7492 or vice-versa since they both have similar pinouts and functions: They are not interchangeable in this application. If the Clock refuses to count at all, check the 74121, U15, and its related parts; it's possible that the chip is defective.

However, the more likely trouble spot is R3; if it is outside of the specified range, the 60-Hz line frequency is being



Every digital clock has a time-setting switch. The knob for S1 can be seen at the rear of the clock. Four positions provide a time-holding feature, a slow set where the time advances slowly, a fast set when the time advances rapidly, and a normal running position once the correct time has been achieved.

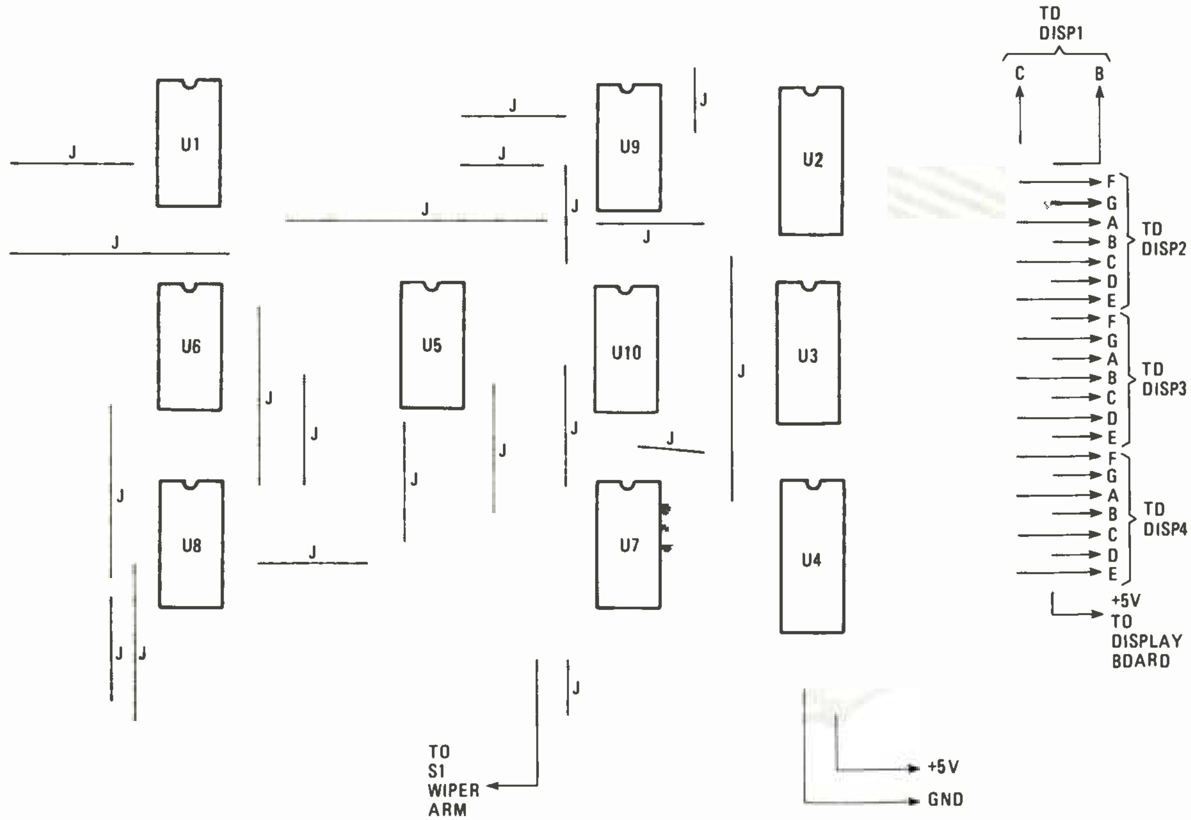


Fig. 10—The parts-placement diagram for the counter/display driver board. A 34-conductor ribbon cable is used for connections between this board and the display board, although only 24 are actually used. The parts are placed on the circuit board in about the same position as shown in the schematic diagram, Fig. 2. Align the pins of each chip with its appropriate socket and be sure that those tiny wonders are properly seated, and make sure that no pins bend under the chip.

filtered. Try increasing the resistance. A simple way to correct the problem is to temporarily connect a potentiometer in place of R3 and set S1 to FAST. Decrease the resistance across the potentiometer until the count stops. Now cut back a bit on the resistance until the count resumes at a normal pace. Finally, measure the resistance to determine the value of R3: Repeat a few times until you are satisfied with the results. Once you have determined the value needed, substitute a fixed resistor of the same value.

Also check that the voltage drop between R1 and D1 is not so large that it does not meet the input requirements of U15. If the problem seems to be in that area, lower the value of R1. If you use the parts specified, you should have no problems. However, should you make a substitution, be sure that you check the specifications to be sure they will operate properly.

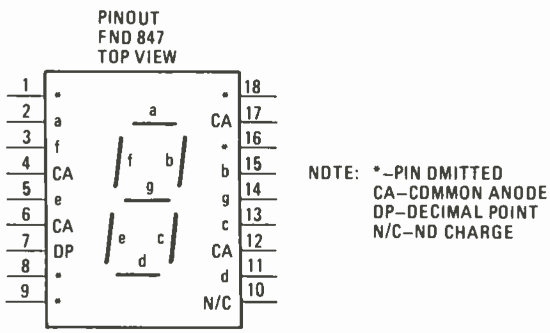


Fig. 11—A pinout-location diagram for the FND847 display module is given so that if the unit specified can not be easily obtained, substitutions may be made.

Finishing Touches

Once the Clock is operational, it is time to put the circuit in a case. The author chose a schoolhouse clock design (as shown in the photos), which left plenty of room for future circuits. Provisions on the circuit board have been made for time sensors should you, at some time in the future, decide to add an alarm or chimes. You might also consider creating your own display using discrete light-emitting diodes arranged in a seven-segment pattern (see Fig. 11).

One way of handling such an arrangement is to use transistors (which would act as switches) to turn on the LED's. Since the outputs of the 7447 (the seven-segment driver) are active low, PNP transistors must be used. NPN can also be use by placing inverters between the NPN unit and the segment driver (one for each driver). But that only adds to the cost of construction. ■

Fence Charger

(Continued from page 55)

an enclosed area. That is often used for animal control, as barbed wire fences are much cheaper to install and maintain than either mesh or chain link.

For applications where a greater degree of security is needed, a conventional chain-link fence can be installed and topped with a strand or two of charged wire. Such security measures are often used at industrial sites to prevent people from scaling the fence.

When installing the charger, there are two things that you must keep in mind. The first, of course, is the fact that the charged wire must be isolated from the rest of the fence to avoid shorting out the system. For barbed wire fences using wooden posts, there are ceramic insulators that are designed for just that purpose. The insulator, which can be obtained from most any large hardware store, has a nail through the middle of two ceramic disks that supports the wire to keep it away from the fence post. Chain link uses glass or plastic insulators that keep the charged wire from shorting to the metal fabric.

Second, you must establish a good ground in order for the system to be effective. That ground will be used as one voltage leg and the charged wire as the other. For it to work, you must come in contact with both ground and the coil's output voltage. Ground connections can be secured in several different ways. The easiest is to use a cold water pipe. When using a water pipe, however, make sure that it's metal—not plastic—and that it is well planted; otherwise it may present a shock hazard. And never, but *never*, use a gas pipe for an electrical ground. If you do, it may be the *last* thing you ever do!

An electrical ground can also be established by driving a metal stake into the ground. When using that technique, it is best to treat the soil first by leaching it with salt. That is done by simply spreading a good quantity of rock salt on the area and then watering it well. Do that a couple times so that the salt ions have an opportunity to work their way into the dirt. Then pound a metal stake (grounding rod) into the ground. Copper, although more expensive, is the best choice for the grounding rod. Once your ground is established, all you have to do is connect the earth lead of the Fence Charger to the ground stake and the hot lead to the fence wire.

The Fence Charger is powered by a 12-volt battery. Since the current drain is minimal, almost any 12-volt battery will work, including flashlight batteries. A fully-charged car battery, for instance, will power the Fence Charger for about three months. Rechargeable gel-cell batteries also work well in this application. A six ampere-hour (ah) gel-cell, such as the Powersonic PC-1260, will keep the charger alive for almost a month. Battery power lets you locate the Fence Charger where it is needed.

The only adjustment you'll need to make to the circuit is the pulse rate. It is adjustable from about 30 to 64 pulses per minute using R5. The pulse rate is determined by your security situation, but keep in mind that a slower rate uses less battery power than does a faster one. The LED indicator will flash each time the coil is pulsed, making your adjustment a lot easier.

Well, there you have it: a practical Fence Charger for a mere pittance. A periodic check on the battery's condition is all you ever need to do to know that your possessions are safely secured from unwanted visitors. ■

Your first TVRO system

(Continued from page 61)

The Law

Before actually buying the equipment, it's wise to check your local zoning regulations; some municipalities have passed ordinances that prohibit residents from installing dishes. SPACE, the satellite TV industry's trade association, has been actively dealing with unreasonable and restrictive zoning laws. To check the legislation in your area, write to SPACE, 300 N. Washington St., Alexandria, VA 22314; or call 703/549-6990.

Buying a TVRO system is a sizeable investment, and you want to buy from a dealer who can reasonably assure you that your equipment will be serviced and maintained locally in the years to come.

The dealer should either send a member of his staff to your home to do a preliminary site inspection or offer a money-back guarantee if interference is found after installation. Generally, if a dealer has done other installations in your vicinity, he'll know whether your home is located in a problem area, so on-site inspection is often unnecessary. But, it's critical that prospective buyers check that point out. As an alternative, talk to neighbors who have installed dishes—the dishes are easily detectable, and the owners usually offer their advice freely and in great quantity. This installation article cannot delve deeply into all of the electronic features in the Black Widow TVRO Systems. To get all the information, it is suggested that the reader either write directly to R.L. Drake (address in article) or Circle No. 950 on Reader Free Information Card. ■

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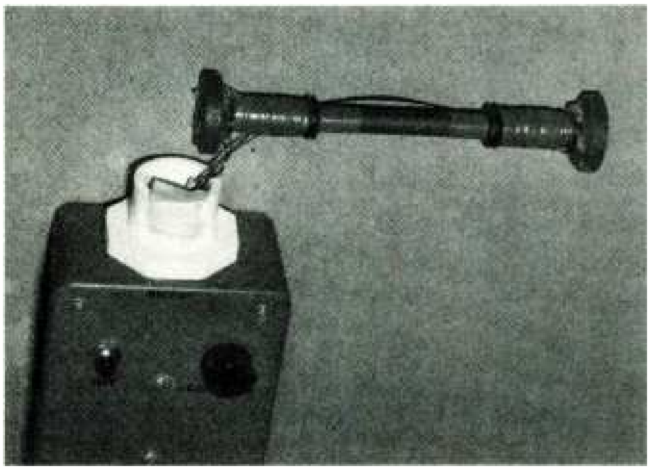
The Magnet Tester

(Continued from page 64)

proximately 80 percent clockwise, or where only about 100-ohms is in the circuit. Set the CALIBRATE control, R3, to approximately 70 percent clockwise, or where only about 3000-ohms is in the circuit. Connect a 9-volt battery and press the TEST switch, S1. The meter should read full-scale or even peg full-scale; if so, everything in the Magnetometer's circuit is performing as it should.

Now we will need to cheat a little by using a small compass to identify the north and south poles of the two doughnut magnets. Determine the north poles of both magnets and mark for easy identification. Remember that the north-seeking pole of the compass will point to the north pole of the magnet—the north-seeking pole is actually the south pole; opposite poles attract. Place one of the magnets over the end of the ferrite core nearest to L1. Position the "north" pole toward L1 and super glue in place about halfway on the core, so that the ferrite rod is only sticking halfway through the magnet. Turn the power on; since a pushbutton switch is used, jumper the S1 terminals. The meter should now read somewhat lower than it did without the bias magnet.



If you wish, the plastic pipe can be made longer so that the magnets will be farther from any ferroalloy on your person.

Place the other magnet on the ferrite rod next to L2 with the "north" pole facing away from the coil, move the magnet toward L2 until the meter drops to midscale, and glue in place. With the correct setting of both magnets, the Magnetometer will correspond almost linearly in sensitivity to both "north" and "south" poles of any magnet under test. To be sure that both magnets stay in place, a small amount of silicon cement can be used to hold the magnets more securely, and doubles as a shock-absorber should the unit be dropped.

Calibration and Use

To calibrate the Magnetometer, position the probe away from any magnet or metal and adjust CALIBRATE control, R3, for a midscale reading on M1. For the best results, the magnet under test should be free-standing (not coupled to any metal object), which, of course, is not always be possible in every application. Direct the probe's end at either pole of the magnet under test and press the TEST switch.

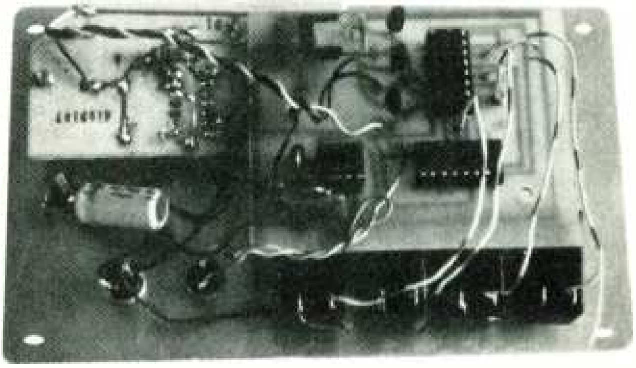
The direction of the meter reading indicates the pole, either "north" or "south," and the amount of movement indicates the strength of the magnetic field. Now it's up to your imagination and needs to put your Magnetometer to its best use. Have fun. ■

Super ESP Tester

(Continued from page 76)

Once both boards have been assembled, check your work for wiring errors and solder bridges. If all is well, the entire works can then be mounted on the back of the front panel, using 8-32 machine screws and spacers. By drilling ⅛-inch holes in the PC board and aligning them with appropriately placed holes on the front panel, the machine screws will self-thread into them, eliminating the need for nuts.

Power for the circuit is supplied by an ordinary 6-volt, wall-mounted power supply like those used for tabletop games, calculators, and the like. However, if you so choose, you can quite easily build a power supply and mount it inside the cabinet with the rest of the project. The 6-volt input is filtered by C2 (which is mounted on the front panel) and regulated to 5 volts by U4 to supply the proper voltage for the TTL integrated circuits. The 74LSXX series was used to reduce current drain. Although the original was housed in a Radio Shack 6¼ × 3¼ × 2-inch project box, any suitable enclosure will do. ■



The Super ESP Tester is built on two small printed-circuit boards to allow them to be easily mounted to the back of the front panel of the project box. Note that a large electrolytic capacitor (C2) is mounted on the panel as well.

The Wailing Siren

(Continued from page 86)

obtained from the siren. Hold it down for relatively long periods and you'll get the "bwaamp" sound of the "village fire alarm;" pulse the button more rapidly and you get the demanding "give way" sound of emergency vehicles.

Construction

The Wailing Siren circuit can be put together using the construction method that you're most confortable with. The author chose to build the project on a piece of experimenters board, as shown in Fig. 2, which measures about 2 × 2-¾ inches. A 35- or 50-ohm speaker is recommended as the output device for the circuit, as it will provide a more suitable load for Q1.

When you first start using the circuit, feel Q1 for any discernable rise in temperature. You may need to use a small heat sink and increase the resistance of R1 to around 27 ohms to limit power dissipated in the device.

If you want to drive a PA system or a more powerful amplifier, eliminate the speaker and increase the resistance of R1 to 50 ohms. Feed the external amplifier from Q1's collector through a 10-μF blocking capacitor. ■

Making Miliohm Measurements

(Continued from page 85)

ally be selected from 2-percent, 5-percent, and 10-percent values. For instance, a 910,000-ohm resistor with a 5-percent tolerance can have a actual value some where between 865-ohms and 956,000 ohms. By measuring a couple of 910,000-ohm units, you can get the specified values for the circuit.

In any case, good op-amps like an NE536, LM355/56, etc., can be used to provide gain and isolation for the meter, which is in the op-amp's feedback loop. D1–D4 protect the op-amp and meter, while R2 and R3, respectively, act as BALANCE and ZERO adjustments. The op-amp's gain is set by R6, R4, and R5; by changing their value, the meter scale and/or gain can be changed. Capacitors C1 thru C4 act as bypass capacitors. *(Turn to next page)*

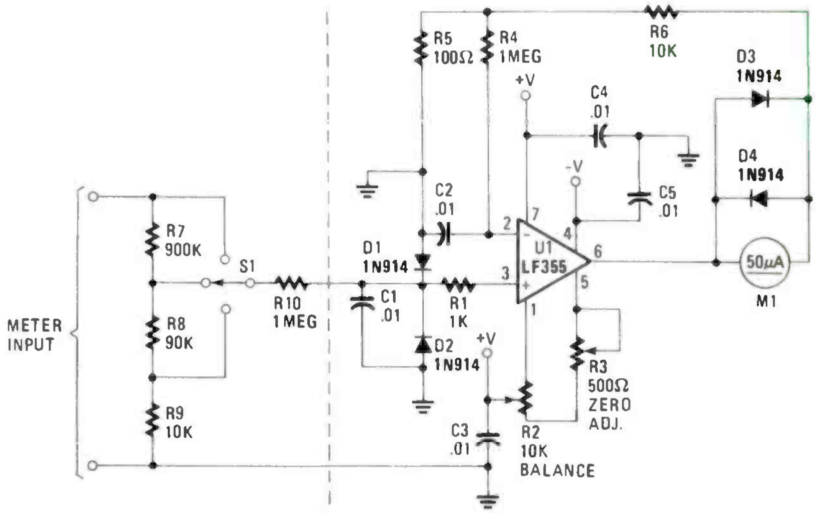


Fig. 4—This analog millivoltmeter, using the LF355 JFET op-amp, can be put together for just a few bucks. And the three-step attenuator network, consisting of R7–R9, can be expanded for greater range and versatility.

PARTS LIST FOR THE MILLIAMMETER CIRCUIT
(See Figure 4)

C1–C5—0.01µF, ceramic, disc capacitor
D1–D4—1N914 small-signal, general-purpose, silicon diode
M1—Analog milliammeter, 50-µA full-scale deflection
R1—1000-ohm, ¼-watt, 5%, fixed resistor
R2—10,000-ohm, potentiometer
R3—500-ohm, potentiometer
R4, R10—1-Megohm, ¼-watt, 5%, fixed resistor
R5—100-ohm, ¼-watt, 5%, fixed resistor
R6, R9—10,000-ohm, ¼-watt, 5%, fixed resistor
R7—900,000-ohm, ¼-watt, 5%, fixed resistor (see text)
R8—90,000-ohm, ¼-watt, 5%, fixed resistor (see text)
U1—LF355 monolithic, JFET-input, op-amp, integrated circuit
Printed-circuit material, or perfboard, hookup wire, solder, cabinet, etc.

PARTS LIST FOR THE TWO-REGULATOR CONSTANT-CURRENT SOURCE
(See Figure 3)

R1—1-ohm, ¼-watt, 5%, fixed resistor
R2—150-ohm trimmer potentiometer, PC mount
R3—120-ohm, ¼-watt, 5%, fixed resistor
U1, U2—LM317, positive adjustable regulator, integrated circuit
Perfboard or printed-circuit materials, hookup wire, solder, cabinet, etc.

3^{50}

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Making Miliohm Measurements

(Continued from previous page)

Calibration and Setup

Regardless of the constant-current circuit chosen, for stability, allow it to warm up for 5 or 10 minutes before using. Their outputs can be adjusted in one of two ways. First, using a DMM or multimeter of known accuracy, their outputs can simply be adjusted to the desired output current. Second, using a 1-percent or 0.5-percent resistor of known value, placed across the output terminals of the current source, in parallel with a DVM, DMM, or millivoltmeter described, the voltage drop across the device can be adjusted so that

$$I_{OUT} = E_{READ}/R_{KNOWN}.$$

In the case of the analog millivoltmeter (shown in Fig. 4) or a similar circuit, the BALANCE and ZERO controls will interact. The easiest setup, then, is to put the input attenuation on its highest setting; set the ZERO ADJUST to mid-range and adjust the BALANCE control so that the meter is on scale. Then, go back to the ZERO ADJUST and set the meter to zero. It may be necessary to go back and forth several times until you get it right, however. Well, there you have it—a simple setup, for next to nothing, that lets you measure those *next-to-nothing* resistances. ■

Designing Frequency Counters

(Continued from page 95)

100,000-ohm resistor in parallel with the bypass capacitor. It is so placed to keep the prescaler from breaking into oscillation when signal is interrupted while operating in the differential mode.

The Display Units

There's nothing critical about the displays used in our counters. Whether the universal or frequency *only* counter (common cathode or common anode) is chosen, either multidigit or single-digit displays can be used. Since the ICM7216-B is design for common-cathode displays, Hewlett Packard's HP-5082-7440 (8-digit) and HP-5082-7441 (9-digit) low-power display boards are prime candidates for hand-held applications. The counters have provisions for only eight digits, thus, the final digit of the 9-digit 5082-7441 can be used to eliminate the separate overflow indicator, LED1, by using it in place of the decimal point.

Good reliability can be expected when the HP-5082-7440 is driven by as little as 250-µA per segment I_{avg} (average current), making it especially well suited for battery operation, where I_{avg} is usually around 3-mA maximum per segment with a P_d at 50-millivolt maximum per digit. Further, the approximately 2-inch and 2.4-inch board length of 7440's and 7441's lend themselves to extremely compact designs.

On the other hand, there's a wide variety of display types and schemes that will work as long as you don't exceed the specification of the unit. In addition, by careful selection of limiting resistors, you can set the display drive current to any convenient value, and/or limit P_D. The FND-367 common-cathode and FND-366 common-anode (CA) displays, which are usable in high ambient light applications, offer some other possibilities. However, the best displays for the money can be had by shopping the numerous surplus listings.

Construction Hints

When building any one of the four counters, it's recommended that double-sided PC board be used, which allows the board traces to act as shielding, and also provides a limited degree of heat sinking, needed for U2. Although the circuit layout is not critical, the display should be placed some distance from the counter IC. And the input leads should be placed as far from the display as possible.

The crystal oscillator and associated components should be located as close to U2, the counter chip, as practical to minimize stray pickup. The external oscillator can cause undesirable shifts in either one or the other's frequency, so some care should be exercised. Once you have etched the board and obtained the parts, you can begin stuffing the board. Start by installing sockets in the integrated circuit positions. Then, using the sockets as markers, insert and solder the passive components: Resistors, capacitors, diodes, etc. As always, check your work for solder bridges, inappropriatly installed components, and so on.

Next, bring out wires and connect to your control options and display circuit to the counter assembly. Since oscillator frequency is critical to the accuracy of the circuit, it may be necessary to adjust the variable capacitor, C20. To do so, apply power (a nine-volt transistor radio type battery should do) and connect a known frequency to f_{IN} and observe the display. A scope and a 555 oscillator is one way to go. Another way is to use a function generator. Adjust the C20 until the display and the known input frequency are equal (or as close as possible). Once adjusted, set the assembly aside and prepared the cabinet that is to house the counter circuit.

Make a cutout in the cabinet for the the display. Start with a cutout that's slightly smaller than the the display and file uniformly until it is large enough to accommodate the display. Install your bezel and/or red filtering material. If no bezel is used, the red filter may be affixed to the cabinet with a silicone cement. Drill holes for the controls; the size of which depends on the switches that you're using. Mount the battery holder and the switches, and solder the appropriate wires to the controls. Close up the cabinet and you're ready to go. ■

Baffles, Boffles, Boxes, and Vents

(Continued from page 36)

nance occurs at a frequency approximately at the bass resonance of the speaker. In that region, energy from the rear of the cone emerges from the vent sufficiently phase-shifted to reinforce direct radiation from the front of the cone.

The reflex system effectively achieves a similar end result to the acoustic labyrinth, and does so without the partitions. And because it uses, rather than suppresses, energy from the rear of the cone, it offers somewhat greater acoustic efficiency than a fully sealed system, particularly in the bass region.

One of the all-time champions of that method, Gilbert Briggs of Wharfedale, had this to say: "From the point of view of size, cost, and ease of construction, the vented enclosure seems to pay the highest dividends in terms of bass output, provided vent resonances below about 50 Hz are adhered to. A higher resonance frequency may be obnoxious." The vented system worked well for Briggs because, in his day, Wharfedale was mainly concerned with large speakers in large enclosures and resonances generally in the under-50 Hz region. What he and his contemporaries didn't

(Concluded on page 104)

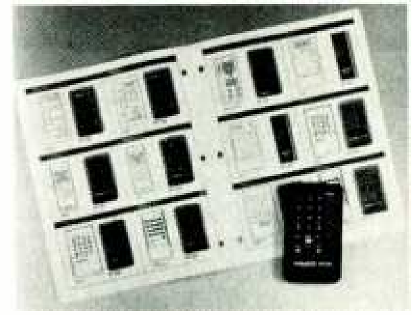
New Product Showcase

(Continued from page 15)

and cursor draw. This course can be ordered through MicroVideo Learning Systems, 119 West 22nd Street, New York, NY 10011; or call toll free 800/231-4031 (in New York State 212/255-3108). the package retails for $495 in either VHS or Beta formats, and $595 in 3/4-in. tape. Other training tapes available from MicroVideo include 1-2-3 (version 2.0), Symphony, dBase III, Wordstar, the IBM PC Primer, Multimate and Wang Word Processing.

TV RC Transmitter Replacements

The line of ECG Remote Control Transmitters is described in a 26-page cross-reference guide published by Amperex. A typical two-page section of the guide and one of the ECG transmitters is shown in the photo below. The units are intended for use with television sets, video cassette recorders and channel converters. The product line includes 71 ECG types which replace more than 170 of the most popular original equipment models. All units are completely new, not rebuilt, and each is individually packaged.



CIRCLE 935 ON FREE INFORMATION CARD

One section of the cross-reference guide lists original transmitter numbers crossed to the correct ECG replacement type, the second section crosses equipment model numbers to the appropriate ECG transmitter and the third section contains illustrations of original transmitters and equivalent ECG replacements.

The ECG Remote Control Transmitter line is available form franchised distributors of ECG products. For the name of the nearest distributor, consult *Electronic Parts & Supplies* in the telephone directory yellow pages; or call toll-free 800/225-8326 or in Maine, 890-6107.

AM-Stereo Signal Generator

Leader Instruments's AM Stereo Synthesized Signal Generator, Model LSG-245, is an affordable test instrument for Motorola's C-QUAM system. The LSG-245 can be used over the entire AM band, as well as at the IF, in addition to providing a wide variety of modulation and output conditions. The LSDG-245's a signal source for sensitivity, separation, selectively, distortion and other tests on today's AM-stereo receivers.

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Baffles, Boffles, Boxes, and Vents

(Continued from page 102)

fully realize was that then-current design guidelines did not take into account factors that were vital to compact systems.

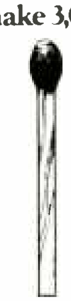
So when compact reflex systems began to appear on the market, the bass characteristics of some were indeed sufficiently obnoxious to earn them a reputation as *boom boxes*! In an attempt to curb objectionable resonance effects, designers resorted to a variety of measures, including internal partitions (curtains), padding, filling, and acoustic filters across the vent.

It was left to an Australian engineer, Neville Thiele, and others to perform a detailed mathematical analysis of the reflex system. It has since been translated into computer programs, making it possible to predict accurately the performance of various driver/enclosure/vent combinations, and to give the "thumbs down" to basically unsuitable drivers or to impractical specifications.

The work has also rendered obsolete most articles on the subject from the 1950's and 1960's, along with ideas for *doctoring* systems that were probably ill-conceived in the first place! But, equally, it has made it possible for companies with engineering know-how to design and/or manufacture a range of vented systems based on proven technology rather than *guesstimation*. The one lament is probably that modern reflex-enclosure design cannot be reduced to a few simple tables and graphs for use by non-technical hobbyists. If you want to build a reflex system, base it on a proven design from a reliable source.

How do reflex and fully-sealed systems compare in terms of performance? In general, reflex systems should have the advantage in terms of efficiency, particularly in the bass region, but they are probably less practical for very small enclosures. Both have strong support, however, and our advice is simply to invest in the system that seems to best meet your needs, be it sealed or vented! ■

One tree can make 3,000,000 matches.



One match can burn 3,000,000 trees.

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Digital Fundamentals—Lesson 7

(Continued from page 83)

8. In order to prevent data loss in a dynamic memory, a __________ operation must be periodically performed.

9. How many words may be addressed with 8 bits?
a. 256 b. 512 c. 1024 d. 2048

10. The two basic types of ROM's are __________ and __________.

11. What binary numbers are stored in addresses 2, 3, 5 and 7 in Figure 9?
2 __________ 3 __________
5 __________ 7 __________

12. Which of the following are volatile or non-volatile?
RAM __________ ROM __________

13. Data is stored in a PROM using a device called a __________ __________.

14. EPROM's can be erased with __________ __________ or an __________ __________.

15. A store operation is called a __________, and a recall operation is called a __________.

ANSWERS TO QUIZ QUESTIONS

1. c. 32,768 (8K = 8192 × 4 = 32,768)
2. RAM
3. access time
4. matrix, rows, columns
5. flip-flop (latch)
6. capacitor
7. address
8. refresh
9. b. 512
10. masked and programmable
11. 2—1011
3—0000
5—1111
7—1101
12. RAM—volatile
ROM—non-volatile
13. PROM programmer
14. ultra-violet light,
electrical pulse
15. write, read

New Product Showcase

(Continued from page 22)

tools (with built-in pin straightener), screwstarter, key-cap puller, spudger/DIP switch setter, and a disposable penlight. Tools are contained in a compact (7 x 7 x 1-in.) zipper case of deluxe padded vinyl with rich velvet interior.

For more information or a free catalog of other tools and accessories for computer and peripherals, write to Jensen Tools Inc., 7815 S. 46th Street, Phoenix, AZ 85044; or telephone 602/968-6241.

Printed-circuit Board Software

Dasoft Design Systems offers new CAD software for printed-circuit boards, the Dasoft-PC2, for the IBM XT, AT. Cutting printed-circuit board design time from concept to camera-ready art, the software has a mouse-driven user interface combined with an enhanced graphic system.

Among the innovations of the menu-oriented software are: an auto-router, expandable symbol library, enhanced footprint editor with six pad shapes, and user-definable pad layouts, and a component data-book library of 600 commonly-used parts.

The mouse lets the user move easily throughout the software's many features. The user selects functions by positioning the cursor over menu items and tapping the appropriate key on the mouse.

New symbols can be added to the library or schematics using a simple graphics editor. Users can build custom shapes on a scaled grid for each design, selecting from circle, curve and straight line functions. Special routines are provided for entering pin numbers, pin names and unit designation positions.

Capable of handling any size schematic, A through F or custom, and printed-circuit boards up to 160 sq. in., the software automatically handles screen

CIRCLE 954 ON FREE INFORMATION CARD

scaling. From a display of the entire page or board, the user can zoom to smaller areas to work with schematic or layout details.

Using the net list created by the schematic editor, the auto-router works with a variety of pad shapes and sizes—even the single-sided pads used in surface-mount technology (SMT). The router will run either automatically or with user-specified routing rules.

The Dasoft-PC2 can be used on the IBM XT, AT and compatibles with 512K bytes of RAM, monochrome graphics card, hard disk storage and a mouse. The software also runs on the AT&T 6300 and the NEC 9801. It drives most popular plotters including those from: Hewlett-Packard, Houston Instruments, Western Graphtek, Ioline, and other compatible units.

This software is currently available from stock for $3,495, which is far less than competitive schematics programs. For more information, contract Dasoft Design Systems, Inc., 2550 Ninth St. Suite 113, Berkeley, CA 94710; or telephone 415/486-0822.

The products presented in this page and on pages 8, 12, 14, 15, 22, and 103 are keyed by Circle Numbers that indicate literature and other information are available free! See Free Information Card for details ■

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BUILD this five-digit panel meter and square wave generator including an ohms, capacitance and frequency meter. Detailed instructions $2.50, refundable plus 50 cents, **BAGNALL ELECTRONICS**, 179 May, Fairfield, CT 06430.

CRYSTAL radio sets, plans, parts, kits. Catalog $1.00. **MIDCO**, 660 North Dixie Highway, Hollywood, FL 33020.

SB3 descrambler parts to construct in Feb/84 Radio-Electronics. $49.95. (Dealer inquiries invited). **Crosley (F)**, Box 840, Champlain, NY 12919.

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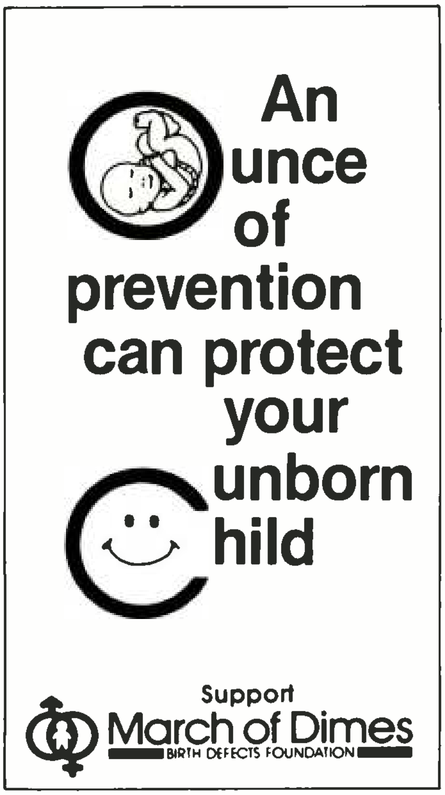

Friedman on Computers

(Continued from page 94)

the command line. Similarly, if you wanted to change the dialing prefix of your *automodem* from dial tone (ATDT) to rotary *pulse*, you would enter DP ATDP on the command line. Entering an NU (number) command with a telephone number will cause the modem to automatically dial the number.

As you can see, just about any feature is possible from menu selection. Some programs, such as *Crosstalk*, even permit the user to create telephone directories, which are accessed via the command line by punching in a single number representing the directory listing.

But keep in mind that all these extra features really make it more difficult to run the software in certain modes. If you're into on-line communications, you'll probably have the easiest time of it with software primarily oriented towards exchanging ASCII text. On the other hand, if you're into exchanging binary data such as programs and spreadsheet templates, life will be a lot easier if the modem software is primarily geared for protocol exchange. Just to illustrate what we mean, the simple *Crosstalk* command "XT B:*.*" will seize control of the receiving computer, transmit all your drive B: files, automatically store them on a disk under the correct filenames on the receiving computer, and all this with full error checking. Similarly, the command "XR *.BAS" will cause the other computer to automatically transmit and store on disk in your computer all the programs it has on its default drive having the .BAS extension.

Almost as a general rule, ASCII and binary operations are mutually exclusive, so if you're into both, it might be advantageous to utilize two communications programs; one oriented towards text, the other to protocol exchange. ■

```
                  CROSSTALK - XVI Status Screen                 On line

NAme     CROSSTALK defaults (Hayes Smartmodem)      LOaded    E:STD.XTK
NUmber                                              CApture   Off

 Communications parameters                           Filter settings
 SPeed 300    PArity None   DUplex   Full           DEbug    Off   LFauto   Off
 DAta  8      STop   1      EMulate  None           TAbex    Off   BLankex  Off
 POrt  1                    MOde     Call           INfilter On    OUtfiltr On

 Key settings                                        SEnd control settings
 ATten  Esc                 COmmand  ETX (^C)       CWait    None
 SWitch Home                BReak    End            LWait    None

                       Miscellaneous parameters

 DRive   E:                 ACcept   Everything     PWord
 DPrefix ATDT               DSuffix  !              TUrnarnd Enter
 PRinter Off                UConly   Off            ANswback Off
 PMode   1                  BKsize   1              DNames   200

 Command? _
```

Fig. 2 Should you need greater control of operating parameters, *Crosstalk* is an easy and understandable access. More details in text.

ADVERTISING INDEX

HANDS-ON ELECTRONICS magazine does not assume any responsibility for errors that may appear in the index below.

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Letter Box

(Continued from page 6)

The main characteristic of those generators is the hollow sphere. Normally, if you touch a charged belt to a piece of metal, only part of the charge will transfer. If you suspend a charged object inside a hollow sphere and let it touch the inner surface, all the charge on the object will flow to the sphere and travel to the outside surface. That is how the generator steps up the 10,000 volts from the transformer to a high voltage. The charge on the belt thinks the inside of the sphere is ground, no matter how high the voltage is on the outside. All the charge on the belt flows onto the sphere. It spews into the air after charging the sphere to a high voltage.

The 10,000 volt supply must be DC for the generator to work. A simple transformer won't put a DC charge on the belt. The rectifier voltage tripler has diodes in it and will correct the problem. A very high supply voltage isn't required. What you really want to have is wide belt running fast, and a sharp edge on the charge wipers.

The Van de Graaff generator is an ideal constant current source. A couple of microamps always flow up the belt and out the sphere. If the sphere is shorted to the case, the current goes through the wire. That current can be measured on a normal microammeter. If all shorts are removed, the same current just pushes its way through the air! The push is the high voltage. The generator supplies a few microamps at any voltage, somewhat like large batteries which supply a few volts at any current.

Come see the big generator at the Museum of Science in Boston. It is Van de Graaff's old lab generator. it's rated at two million volts, and makes big sparks.
William J. Beaty
Electronics Head
Museum of of Science
Boston, MA

(Turn page)

Letter Box

(Continued from previous page)

A Note from Rip Van Winkle

There is more to finding solutions that meets the eye. Many years ago I used to experiment with things "electronic"? At that time there were places such as Bursteen Applebe, Allied Radio, Lafayette Radio, and a few others where one could order parts and gadgets.

Also, it seemed that they were aware that every experimenter did not have a degree in electronics engineering. At any rate, when I retired from teaching at a small college not long ago, I decided it was time to take up where I left off. Good Lord! I looked through a magazine and found parts that sounded like a disease. They ranged from TTL to CMOS. I wondered if I had fallen into a time machine.

I suddenly realized that while I was teaching students math, I had spent all that time getting ignorant. That was bad enough, but then I spotted an advertisement for **Hands-On Electronics**. I thought, "This is what I need". So I subscribed! Lo and behold, I get nice pictures and articles written in a language I never heard before.

I don't expect you to turn your magazine back to the dark ages just for one dummy, but I dare you to ask in print for letters from those who would like to see an article now and then for a real honest-to-Pete beginner. You might be surprised. The worst part is that there is no place for us to turn. There aren't even any mail-order firms to order from unless you want an "EPROM", and I went to my last prom when I was a Junior.
J.M., Virden, IL

Take a peek into this issue, and you'll find a simple project or two with which most beginners will have success.

There's an Easier Way

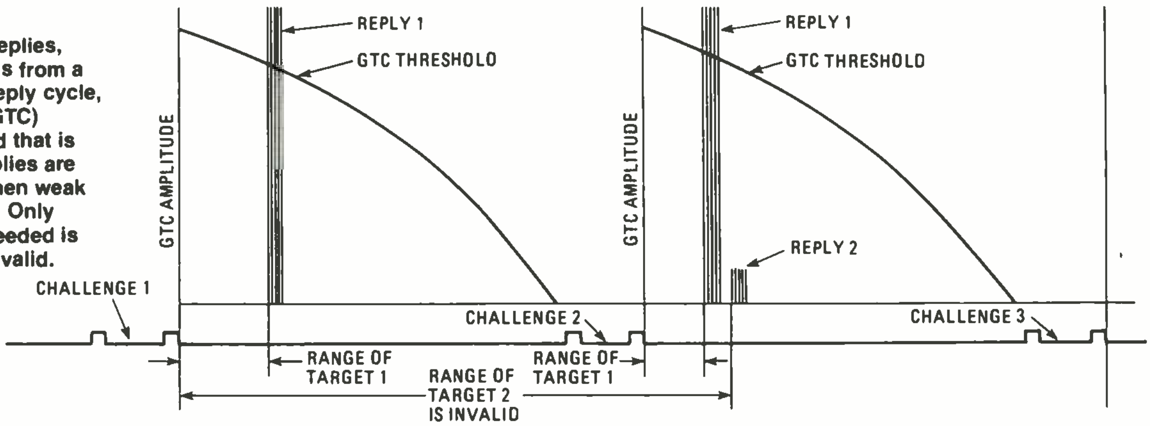
I would appreciate it if you could send me a copy of a fence charger that operates on a 117-volt AC line. There was one published in the December, 1964 issue of *Popular Electronics*, page 57, but it is battery operated.
H.H., Lake Worth, FL

Not knowing exactly what is in the issue specified, I suggest that you assemble the unit we have in this issue of **Hands-on Electronics**. *And, for AC line operation, install a battery eliminator.* ■

Beacons

(Continued from page 44)

Fig. 13—To allow the recognition of valid replies, while rejecting signals from a previous challenge-reply cycle, a gain time control (GTC) generates a threshold that is high when strong replies are expected, and low when weak signals are expected. Only when the GTC is exceeded is the reply considered valid.



challenge 1 and is within radar range. Thus, the reply pulse amplitude is greater than the GTC threshold. But, REPLY 2 is invalid since it's a target's reply from challenge 1 and is outside the radar's range. The reply pulse amplitude, therefore, is less then the GTC threshold.

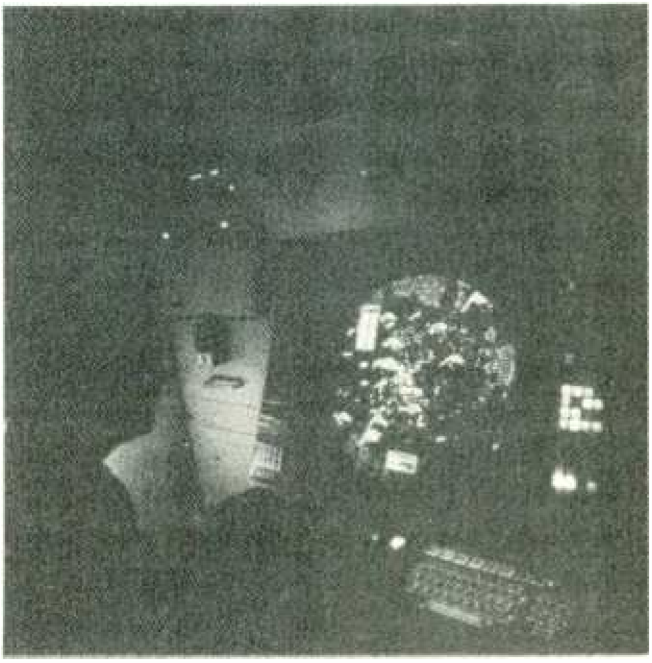
Pie a la Mode

One question that might be raised is, "Why are there different challenge modes? Wouldn't a single mode work just as well?"

A single mode might be capable of handling all the traffic, but it wouldn't be desirable. The ability to challenge in different modes or interlace the interrogations is important to identifying and tracking a multitude of civilian, commercial, and military targets.

There are also plenty of other modes in other frequency bands. ATCRBS, for example, uses the L-Band and Ku-Band (although some military modes use the X and C bands) to challenge and identify such targets as missiles and satellites.

The next time you drive past the airport and see that whirling bedspring-type antenna, consider the multitude of electronics being used to detect and sort out the aircraft in the vicinity. Only the surface of the total electronics used by that antenna has been covered here. Landing-approach radar, communications, and a host of other airport electronics were not touched in this article. ■



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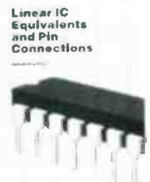

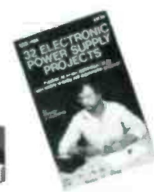
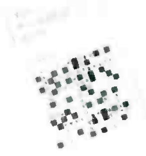


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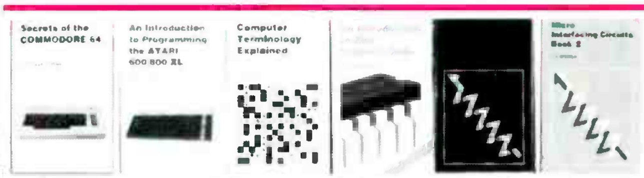

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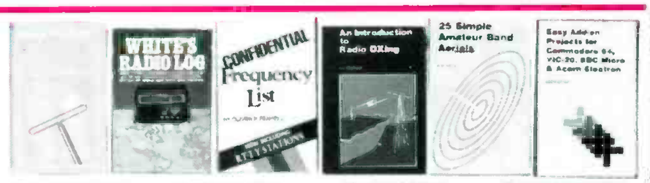

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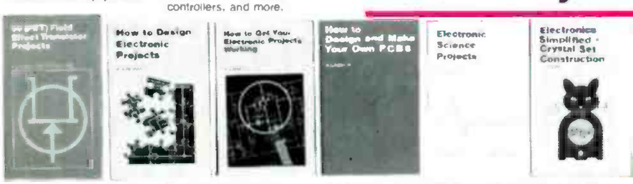

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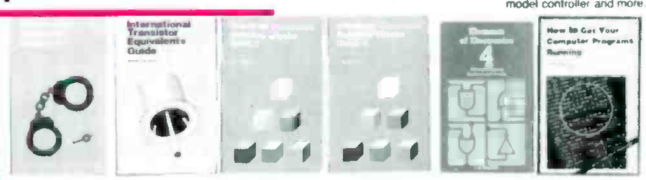

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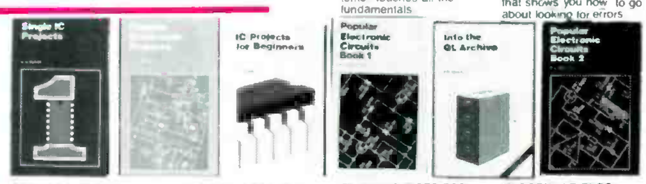

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