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NOVEMBER 1992 ®

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NOVEMBER 1992, VOLUME 9, NO. 11

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EDITORIAL

CONSUMER ALERT

Even in good times, companies are always on the lookout for ways to improve their bottom line, and consumers are determined to find the best value for their dollars. Under economic conditions like the ones we currently face, those natural tendencies can be dramatically magnified. The result is that companies sometimes choose suppliers based more on cost than quality, and consumers sometimes bypass well-known brands in favor of less-expensive alternatives.

A product that provides comparable performance at a lower cost is a true bargain. By contrast, products that provide vastly inferior performance—or worse, that actually cause damage to something else—are no bargain at any price.

This month, **Popular Electronics** presents a report that anyone who buys or uses videotape must read. In it, Len Feldman—one of this country's best known consumer-electronics writers—reports on videotapes that at best provide mediocre performance, and at worst could possibly damage a VCR.

Backed by tests performed by Advanced Product Evaluation Laboratories, the article names names, and pulls no punches. It details how these tapes fall short, what to be alert for in brands other than those specifically mentioned, and how even the VHS logo provides no guarantee of acceptable performance.

If you buy or use videotape, this information is critical to the performance of your video gear. The story begins on page 31.

Carl Laron
Editor

LETTERS

A YOUNG READER'S REMARKS

I'd like to begin by saying that I think **Popular Electronics** is an excellent magazine, and that I've been following it for about a year now. I am 15 years old and I live in Airdrie, Alberta, Canada. That creates a great number of problems for me. First of all, almost every supplier of electronic goods mentioned in your magazine's "Market Center" is located in the United States. When I order something, I must pay additional shipping fees, GST, duty, and any other applicable taxes in U.S. dollars, which ends up being quite expensive for a 15-year-old once the extra 19% is added for currency exchange. I enjoy and thrive on building and learning from as many **Popular Electronics'** projects as I can, and would like to find suppliers who are located in Canada and are more accessible to me. I would greatly appreciate it if someone had a list of such suppliers.

Second, I'd like to say thanks to J.G. of Bridgeport, CT, whose letter appeared in the July 1992 issue. I appreciate his encouragement of young people who wish to become engineers and who enjoy electronics as a hobby. We need all the encouragement we can get these days.

Finally, I'd like to send out a request to other readers. I have just ventured into the world of microcontrollers, and have purchased a Motorola M68HC11EVBU board. I've been trying to figure out the basics of the assembly language for the controller. I have been successful in creating programs that do such things as adding and subtraction, but I'd like to put the controller to more challenging uses, such as in automation applications for things in my room (door lock, voice recognition, etc.). I would appreciate any ideas or help that anyone could offer.

Once again, thanks to **Popular Electronics** for all the support I've received from it in the past. I will continue to read it and build the projects for a long time to come.

Wesley d'Haene
450 Summerwood Place
Airdrie, Alberta
Canada T4B 1W5

HAVES & NEEDS

I need a Heathkit manual for an ignition analyzer model IO-20. I'm willing to pay copying costs and postage. Thanks a lot!

Ed Nell
103 Bar Harbor Road
Freehold, NJ 07728

Thank you for putting my letter in the May issue of **Popular Electronics**. I've already received several letters, and I was able to get the schematic I needed.

Now I need a ribbon for an Adam Colecovision word processor that I bought in a thrift store. Perhaps you could help me with that also—although from now on I intend to specialize in old audio equipment.

By the way, your article on antennas in the May, 1992 issue (*Wire Beams: Gain on the Cheap*) was excellent.

Karl G. Maeder
2340 Tahoe Circle
Hemet, CA 92545

I've been reading **Popular Electronics** since it first came out in 1954. I need information or a book on how to use RF signal generators. Please help me out!

Daniel Seidler
3721 West 80th Street
Chicago, IL 60652 ■

NOVEMBER 1992

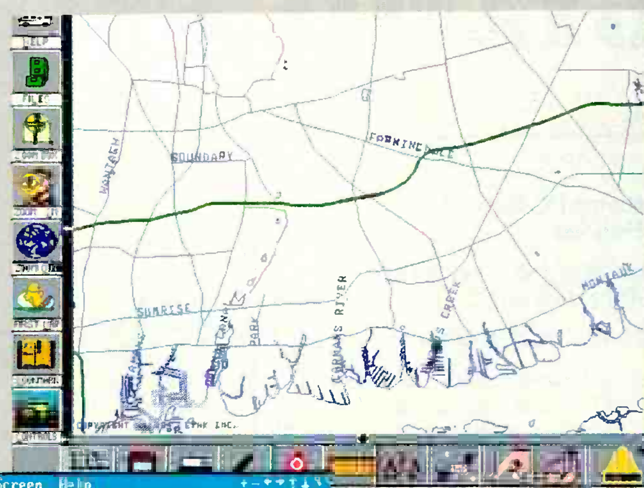
GIZMO®

A CHRONICLE OF CONSUMER ELECTRONICS

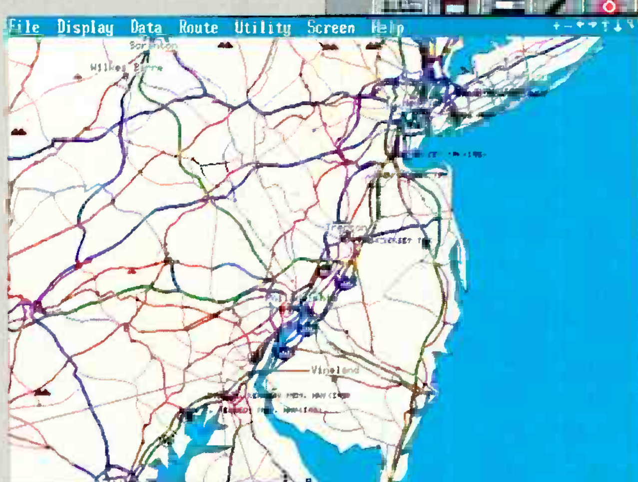
VOLUME 5, NUMBER 11

Mapping Your Progress

STREET ATLAS USA. Published by: DeLorome Mapping, Lower Main Street, P.O. Box 298, Freeport, ME 04032. Price: $ 169.
AUTOMAP. Published by: Automap, 9831 South 51st Street, Building C-113, Phoenix, AZ 85044. Price: $99.95.
PC MAPS. Published by PC Maps Corporatoin, P.O. Box 581871, Houston, TX 77254. Price: $99.



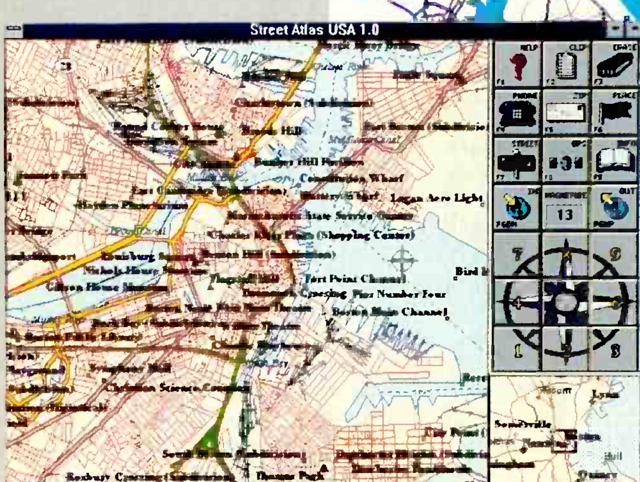
We remember a weekend trip we once took to Cape Cod, Massachusetts. Our decision to go was pretty much a spur-of-the-moment one. We didn't have time to get good maps, and assumed that our standard interstate-highway map and our general knowledge of geography would be sufficient. As it turned out, one of our most vivid memories of that vacation—one that we now laugh about—was of us getting hopelessly lost after we left the interstate in search of a gas station.



Another memory we have—and one about which we still don't laugh—is of a time we were planning a trip to a trade show in San Francisco. During the trip, we planned to stop by a couple of Silicon Valley businesses. But because we had never been there previously—and couldn't get any detailed maps locally—we had a hard time planning things out, and ended up wasting an entire day of our West Coast trip.

And then there's the time we were trying to come up with a decent map that would direct friends to our house for a holiday party. We thought our hand-drawn maps were pretty good. The guests who got lost thought otherwise.

We probably could have avoided all of those pitfalls with three interesting map programs: *Automap*, a U.S. trip-routing program; *PC Maps*, a local street map; and *Street Atlas USA*, a CD-ROM-based street atlas of the entire country.



STREET ATLAS USA

Our first reaction to Street Atlas USA was amazement. Now, we don't get amazed by technology very often because we see so much of it. we've been familiar with CD-ROM's for years, and we know that a disc can hold almost 700 megabytes of data, which is an extraordinary amount. But we had no idea that it was possible to fit a map of the United States—with details on every street—on a CD-ROM disc.

Street Atlas USA amazed us not only with the amount of data contained in "only" 450 megabytes on a CD-ROM, but also with the fact that the raw data for the disc came from the U.S. Census Bureau in files that were about 14 gigabytes long! DeLorme compressed the information, using a proprietary compression al-

TURN PAGE FOR CONTENTS

This month in GIZMO®

Gizmo is published by Gernsback Publications, Inc., 500-B Bi-County Blvd., Farmingdale, NY 11735. Senior Writers: Chris F. O'Brian and Teri Scaduto. Contributor to this issue: Frank Barr, Advanced Product Evaluation Laboratories.

gorithm, into a 450-megabyte indexed database.

We all have various maps around the house. There's usually a world atlas (which is almost certainly out-of-date), a map of the U.S. showing major interstates, perhaps some regional maps for short vacations, and a local atlas that shows all local streets. Imagine having a local atlas for every county in the U.S. That's essentially what Street Atlas USA provides.

Although there are many businesses—trucking companies, for example—who would find Street Atlas USA valuable, almost half of the people who are buying the program are just normal people who like maps. (We fall into that category.) DeLorme could have priced the CD-ROM at whatever the company felt the market would bear. We're glad, and impressed, that they kept the price so reasonable.

Street Atlas runs under Windows and, of course, requires a CD-ROM drive. Color is an important component to the map displays, and we think a color monitor is essential. As with most Windows applications, a mouse is strongly recommended. You'll need about 2 megabytes of free space on your hard disk, because the automatic installation procedure copies some executable programs and dynamic link libraries to the drive, which improves performance.

The full-screen Street Atlas display is divided into three main sections. The largest is the map display. On the right-hand quarter of the screen are a "remote-control panel" and an inset low-detail overview map.

The main map can show detail in one of 16 resolutions, from Magnitude 3 (which shows the 48 contiguous states, most of Canada and Mexico, and a portion of Alaska), to Magnitude 18 (which shows an area of about one acre). The overview map always displays a resolution lower than the main map (in Magnitude 13, the overview is a world map), and indicates what's shown in the main-map display with a box.

Above the overview map window is a nine-key "compass" keypad. Clicking on any of the direction keys—or pressing the indicated number on your keyboard—lets you pan or scroll the map in that direction. You can also pan the map by clicking on part of the screen that will become the new center.

The top of the remote-control panel is a 12-button keypad that lets you operate the main program functions. You can, for example, zoom in or out by clicking on the appropriate buttons or by using the PGDN or PGUP keys. The magnitude or zoom-level of the main map is shown on the MAGNITUDE button, which is between the two zoom buttons. Unfortunately, you cannot click on the MAGNITUDE button and zoom to a given magnitude directly. You can, however, draw a box (using the mouse) around the area you would like to zoom into.

Other keys access the impressive search functions of Street Atlas. Three main choices are available: You can search by the name of a town, its 5-digit zip code, or the telephone area code and exchange. After you narrow the search area by one of those search methods, you can also search for a specific street name.

Let's assume, for example, that you wanted to find where jazz saxophonist Charlie Parker grew up. You could click on Place, and enter the name of the town—Kansas City, KS. (If there is no exact match, a selection of choices that are alphabetically closest will be displayed.) When you select the city or town, you will be presented with a map of the city at Magnitude 13, which provides a view of about 4 miles × 4 miles. You can then search for a given street—Freeman. To be found, the street must be in the area shown on the screen, although it may not be visible to you. You can even look up the locations of some of the nightclubs in Kansas and Missouri in which he used to play.

An alternative search method would be to enter the telephone area code and local exchange. We were interested in finding out where DeLorme Mapping's offices were located. Since we knew the company's telephone number, we simply entered the area code (207) and then the exchange (865). We were then presented with a 4 mile × 4 mile view of Freeport, Maine (the same view as if we had entered "Freeport, ME" in the Place submenu).

The third search method is by Zip code. Entering 04032 in the appropriate dialogue box would again bring us to a 16-square-mile view of Freeport.

The high-quality maps include more than just streets: Rivers, lakes, and some smaller bodies of water are visible, as are some parks, airports, colleges and universities, and points of interest. Railroad tracks are identified, although train stations, for the most part, are not. You can click on unlabeled points to find out what they are—although you won't always get an answer.

The weakest point of Street Atlas USA is its print capability—it doesn't have any. You can, however, save maps to the Windows clipboard, and then manipulate or print the image using a graphics program such as Windows Paintbrush.

Unfortunately, no map can ever be completely up to date—as soon as any map is published, it immediately starts to become out of date. Street Atlas USA, however, seems to come very close to being up-to-date. One easy test that we've found for maps is to try to locate Bi-County Blvd., the home of **Popular Electronics'** main offices. The street is relatively new, just over six years old. We couldn't find it, although an equally new adjoining street was shown. We can't really complain about the oversight—a check of 1992-edition street atlases available locally (from the Hagstrom and Geographica map publishers) didn't show either street.

The paper atlases did contain some information not contained in Street Atlas USA—public schools, and commuter rail stations, for example. Yet the CD-ROM atlas contained some information we couldn't find in our atlases, mostly the names of some small islands and creeks. Street Atlas USA does contain political boundaries, but not necessarily an indication of what the boundaries separate. For example, the boundary between Nassau and Suffolk counties on Long Island is shown, but when you click on it to find out what it is, "boundary" is all that is displayed.

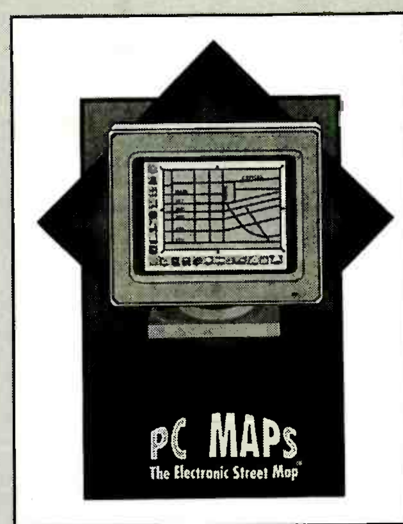
It's easy for a critic to complain about features that could have been included in Street Atlas USA that are missing. Although we've done just that, we're extremely impressed by the product and its price. We're looking forward to seeing future versions of the program—especially one now in the works that will let you enter data from a GPS (global positioning satellite) receiver and find your location.

As impressive as Street Atlas USA is, it's not for everyone—not everyone needs a computerized street atlas of the entire country. Several local business people we showed the CD-ROM version to said they would indeed like to have it, but they'd rather have a similar product that covered only a specific area, and didn't require a CD-ROM drive. For them, another program, PC Maps might be the answer.

PC MAPS

PC Maps is a street-map program for IBM PC's and compatibles. Versions are available for more than 120 metropolitan areas. We examined two maps: One was of New York City and Hudson County, NJ and the second was of Long Island, NY. (The PC Maps package contains the program itself and one map database. Additional map databases are available for $39.)

PC Maps is based on development tools and electronic map databases that were created by Etak, Inc. of Menlo Park, California (the same company that created the database used in the Blaupunkt TravelPilot



CIRCLE 51 ON FREE INFORMATION CARD

car-navigation system we reviewed in our June 1992 issue)

In some respects, PC Maps is similar to Street Atlas USA. You can search for streets, re-center the map, and zoom in and out. PC Maps operates faster because it's not a Windows application, its search database is (naturally) smaller, and it doesn't rely on relatively slow CD-ROM drives.

PC Maps has relatively modest system requirements. Your PC must have 640 kilobytes of memory, it must be running MS-DOS 2.0 or higher, and it must have an EGA or VGA graphics adapter and monitor. A hard drive is a practical necessity: The individual city maps range in size from 1.29 megabytes for Reno, Nevada to 18.06 megabytes for "Large" Dallas–Fort Worth (there is also a map of "Small" Dallas–Fort Worth). Some other file sizes for comparison are: Salt Lake City, 4.13 megabytes; Philadelphia, 9.0 megabytes; Indianapolis, 3.01 megabytes.

Although you can load more than one map database onto your hard drive, you can access only one at a time. For example, even though we used both the Long Island and the New York City maps—two adjacent areas—we had to switch databases when we got to the border of one or the other.

The PC Maps screen features menu bars along the left and bottom edges. The map occupies the rest of the screen, with the exception of a thin border around the map that contains scrolling "buttons" for panning the map.

Although a mouse can be used with PC Maps, it is not essential. We found ourselves using a combination of a mouse and the keyboard, because all of the menu icons can be accessed with a single keystroke. (Our description will assume that a mouse is used.)

The search functions are accessed with the FIND button, which brings up a dialogue box in which you can enter the address, street, cross street, and town. You need not completely fill in the search parameters, but you must enter at least a street name. If there is more than one match, you will be presented with a list from which you can select your choice. We entered "Main St." and were presented with a list of 25 possibilities—only the first 25 that PC Maps found in its Long Island database. Entering a cross street or town would have narrowed the search considerably.

Zooming can be handled in two ways. You can choose to ZOOM IN and ZOOM OUT from the menu bars, or you can draw a zoom box that lets you define the size of

PC Maps makes printing a custom map easy.

the area that you wish to see in more detail.

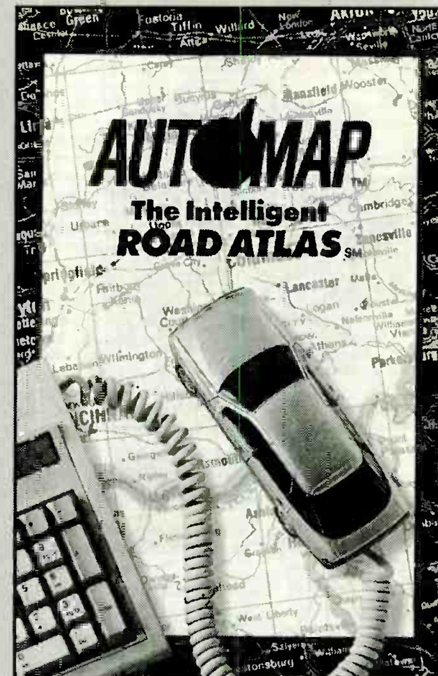
Five "bookmarks" can tag up to five map views, which allows you to quickly bounce back and forth between the five views. The bookmarks are only temporary, however. When you exit the program, they are not saved.

A "You're Here" command brings up an inset map that shows an overview of the main map is set in a larger geographical area. You can also bring up a grid or a scale to give you a quick idea of distances.

To determine distances more accurately, you can use the DISTANCE command, which lets you measure the distance between two points. You can string points together along your route to get a total distance. Unfortunately, you cannot scroll the map when you are measuring distances. That becomes inconvenient if you need to measure the distances along smaller streets, which become visible only when you zoom in sufficiently. You can, of course, measure the distances in one map, exit the distance mode, scroll the map, and re-enter the distance mode. Then, however, the program won't keep a running total of the distance measured.

When you zoom out, some streets disappear from the map. Others appear, but without their names. You can, however, point to any street to find its name. It's also possible to display full information at all zoom levels—assuming you have enough memory—but the screen becomes unreadable when you do.)

One of the strong points of PC Maps is that it allows you to tailor the maps you define to your own requirements. You can add symbols—dots, pins or map tacks,



CIRCLE 52 ON FREE INFORMATION CARD

squares, and triangles—although you cannot change their size or orientation. You can also draw circles, rectangles, lines, and arrows of any size you choose. Text and titles can be added, too, but the program gives you no control over text size.

You can print your finished map to Epson or Hewlett-Packard LaserJet printers (or compatibles) in low- or high-resolution forms. If you are unhappy with the look of the map and want to customize it further, you can export the map as a PCX file, and then use a graphics-editing program to tailor it further.

Using PC maps, we were able to print direction sheets to get friends to our homes, and business associates to our offices. (Like Street Atlas USA, PC Maps does not include the street on which the main office of **Popular Electronics** is located. We were able, however, to edit the map in PC Paintbrush to include the street.)

The two programs we've mentioned so far do an excellent job of finding the locations of streets and towns. But they can't necessarily tell you how to get from one place to another. There is, however, a program that can: Automap.

AUTOMAP

Automap is billed as "the intelligent road atlas." Designed for anyone planning a vacation or business trip, Automap asks where you're going, where you're starting from, the type of roads on which you want to travel, and any places you want to avoid. The program will then plan your route, and show you the results as an on-screen map, or as a list of directions.

The system requirements for Automap are rather modest. Any IBM-compatible PC with at least 512 kilobytes of memory and a hard disk with about 4 megabytes of free space should do. A wide variety of graphics adapters—from CGA and Hercules to super VGA—are supported, although we wouldn't recommend running the program on a PC with anything less than color EGA graphics. A wide variety of printers—from dot-matrix to color to laser—are also supported. A mouse is recommended.

The idea behind Automap is great. When we travel on a long car trip, we love to bring along maps, direction sheets and timetables. It makes the journey much more pleasant because we never feel that we're lost, we know how much longer we'll be driving, and we have something specific with which to answer the "are we there yet" questions. Maps are important enough to us that it is one of the main reasons we joined AAA. The AAA Triptik maps are superb and their route planners are very informative.

Automap doesn't come close to replacing the AAA services and maps, but it's an impressive program nonetheless. Not only can you enter your starting and ending points, you can select towns or some points of interest you want to visit on the way. You can display maps in varying levels of detail, and print out different versions with a minimum of effort. You might, for example, print one map showing the interstates on which you'll be traveling, and another one showing all of the parks and recreation areas you'll be passing on the way.

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references... route from Babylon to Baltimore
peeds...
ourtesy lines... s 50 min. Distance 243 miles.

Time		Road	For	Di	Towards
12:00	DEPART Babylon (New York) on the	Unknown	3 mil		
12:07	At N Bay Shore take the	No name	3 mil	N	Deer Park
12:10	At Deer Park stay on the	No name	4 mil	SW	W Babylon
12:15	At W Babylon go onto	S. St Pkwy	2 mil	SW	Levittown
12:17	At N Massapequa stay on the	S. St Pkwy	6 mil	W	Levittown
12:24	At N Bellmore stay on the	S. St Pkwy	3 mil	W	Valley Strea
12:27	At Uniondale stay on the	S. St Pkwy	9 mil	W	Valley Strea
12:36	At Franklin Square go onto	Laurelton (Belt)	3 mil	W	Valley Strea
12:38	At Valley Stream bear left onto	S27	4 mil	W	(Jfk Int'l A
12:45	At Jfk Int'l Airport stay on the	S27	2 mil	W	
12:47	Bear left onto	Shore Pkwy	13 mi	SW	(Brooklyn)
13:07	Turn left onto	I278	7 mil	W	
13:18	Turn off onto	No name	8 mil	S	Perth Amboy
13:27	At Perth Amboy go onto	S440	8 mil	W	Piscataway
13:37	Turn left onto	New Jersey Tpk	13 mi	S	Vineland
13:51	At Spotswood stay on the	New Jersey Tpk	8 mil	S	Vineland

Automap can print a detailed list of directions for your travels.

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Automap's user interface is through three main screens: the Map screen, Journey screen, and Table screen. The Map screen, obviously enough, shows a map. It is possible to plan your route by using the menu bar across the top of the screen, and by pointing to your starting and ending points. You may prefer, however, to enter the information in the Journey screen, where you type in your start points and destinations in text.

When your route is calculated, the result can be shown either on the Map (which shows the route by flashing the appropriate roads) or on the Table screen, which gives you a textual description of your route.

Let's say, for example, that you want to take a trip from Hope, Arkansas to Washington, DC, but you also want to pass through Daniel Boone National Forest in Kentucky. In the Journey screen (our preferred way to input such information), you would type in the start point of Hope (which won't be found unless you instruct the program to search through its database of smaller towns—according to the company, the database contains over 50,000 cities and towns). You could enter a starting time (which is useful because your direction sheet is printed out with the expected arrival times at various points). You then would enter your end point and any way points at which you want to stop. The only stop on this planned trip would be Daniel Boone National Forest (which the program again won't find unless you request it to search its database of "other features").

When you're ready to have Automap plan your route, you will be asked for the type of search you want: quickest, shortest, alternative, or a preferred route, in which your travel preferences (a dislike of interstates, for example) are taken into account.

We tried many hypothetical trips from our Long Island home base to various cities, including some of the major Canadian cities that are included in the database. For the most part, it chose reasonable routes. It duplicated some of the routes we've driven to get to different cities. And it got us into other cities in the way we probably would have chosen had we used a good interstate map. At the start point of the trip, however, it suggested routes that didn't make much sense. On many trips off Long Island, for example, it chose routes that would have taken us at least 15 minutes out of our way, or put us on heavily trafficked roads that we would have avoided at any cost. It didn't know the names of some major roads, and also didn't know about one of the two major ferry services serving Long Island. Some of those omissions are undoubtedly due to the programming being done in Britain using information from federal and state agencies in the U.S.

We found the program to be easy enough to use, although the menu structure can be a little bit confusing. To see more small towns on screen, for example, choosing "More Detail" wouldn't help. Choosing "Smaller Towns" from the Overlay menu (which is a submenu of the Data menu) would get you the display you wanted.

We did like the additional information available from the program's database. It's a simple matter to find out, for example, the population of states and cities, the number of licensed drivers and registered vehicles, and such traffic laws as whether seat belts are required. (Unfortunately right turns on red lights are not mentioned.) Tourist information numbers are also provided, which means that you'll be able to get the detailed information that you need to have a successful trip.

Finally, you can play games with Automap. You'll be quizzed, for example, on distances between cities, or asked to point to a given city on the map. That geography lesson alone might make the program worthwhile, and certainly makes it one that the whole family can use.

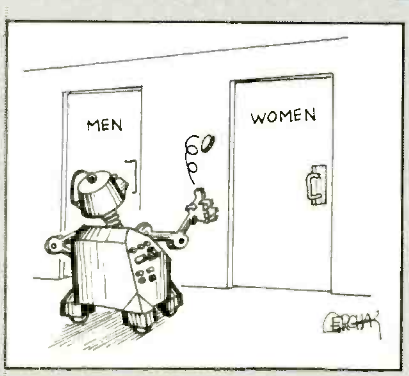
WRAPPING UP THE MAPS

Now that computer-mapping programs have hit the low-price popular market, are paper maps a thing of the past? We don't think so. But we will no longer rely solely on paper maps.

Each of the three programs has features that make it worthwhile. For example, we can certainly imagine having PC Maps available on a laptop in our car. It's a sensible way to schedule deliveries and to find your way around town.

Street Atlas USA, our favorite program of the three, is perfect for anyone who likes maps. (Almost half the sales of the disc so far have been to people who don't have any business or other pressing reason for having a street map of the entire country.)

Although Automap didn't live up to our initial expectations, we have to recommend it, too. Since many people find that half the fun of a vacation is in its planning, Automap will certainly make a lot of people happy. Its educational possibilities alone make it worth its cost. ■



Non-Standard VCR

IMAGE TRANSLATOR MODEL 610IT3 60/50 DIGITAL FRAME STANDARDS CONVERTER VCR. From Instant Replay, 2601 South Bayshore Drive, Suite 1050, Coconut Grove, FL 33133; 1-800-749-8779; $795.

If it's your job to videotape the family reunion and send copies of the video to family members in various countries around the world once a year, your best bet probably would be to have the original professionally converted from NTSC to PAL or SECAM and copied. If, on the other hand, you're a foreign-film buff who relies on friends overseas to send you obscure titles on tape, or you work for a multinational corporation and frequently exchange videos for training, product demonstrations, and meetings with other offices, multi-standard VCR's might represent a more convenient and possibly more cost-effective solution.

Instant Replay sells a line of multi-standard VCR's that ranges from a portable $600 unit to a $2000 Super-VHS hi-fi unit. Our test unit was a middle-of-the road-model, the two head VHS *Image Translator 610IT3*.

At first (and even second or third) glance at the Image Translator looks no different from any other front-loading VCR. The front panel is cleanly designed, with controls hidden behind a swing-down door; only the ON/OFF and STOP/EJECT buttons and the LCD readout are visible. Nor does opening the door give any clue to the VCR's multi-standard capabilities; hidden behind the door are the VCR/TV selector, play controls, the REC button, and channel up/down keys. The rear panel has nothing out of the ordinary—audio and video inputs and outputs, VHF/UHF antenna input and output, and a channel-3/4 switch. The remote control has 26 keys as well as a numeric keypad, but none of those is used to switch between video standards.

Not even the manual that accompanied our test unit mentioned the standards-conversion ability. It did, however, contain a one-page instruction addendum that was probably originally intended for a different model, since it says that "the Translator switch is located on the concealed front panel . . ." and "replaces the child lock switch." Our unit had neither a translator switch or a child-lock switch. We finally found an unlabeled toggle switch on the side of the unit. Experimentation revealed that moving it toward the front of the unit worked for NTSC, and pushing it backward was for PAL and SECAM.

LABORATORY TESTS

The video frequency response of a VCR is a measurement of how accurately it can reproduce signals of different frequencies that it is called on to record. It is measured by recording a multiburst test signal, which contains bursts of several specific frequencies. The recorded signal is then played back and observed on a waveform monitor. In an ideal world, the frequency response of a VCR would be flat. In the real world, the response of a VCR drops off at higher frequencies.

As shown in the table and multiburst test patterns, the Instant Replay Image Translator did a pretty good job in the NTSC mode. Its frequency response was down 2.25 dB at 2 MHz, and 11.3 dB at 3 MHz. Using a PAL test tape, its frequency response was measured to be down 9.86 dB at 2 MHz, and 13.4 dB at 3 MHz. Although the PAL results are significantly worse than the NTSC results, those numbers are equivalent to those of many standard VCR's we've seen.

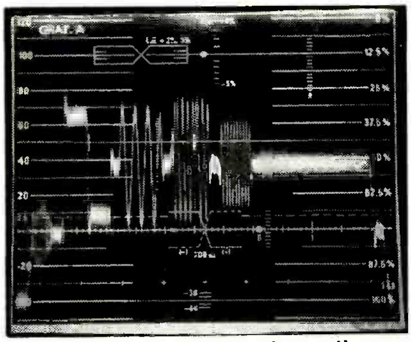
The signal-to-noise ratio is a measurement of the amount of unwanted noise on a fixed, flat-field video signal. A red field, used in our lab tests, is usually preferred to measure the chroma signal-to-noise ratio. AM chroma measurements indicate the strength of the color signal, while the PM chroma tests indicate the purity of the color signal. Interestingly, the measurements made for the PAL test tape yielded the highest results. The NTSC record/playback results are lower than we would expect to see.

The luminance signal-to-noise measurements indicate the brightness and detail that you can expect to see in recorded videos. The measurements on the Image Translator were unexceptional at best.

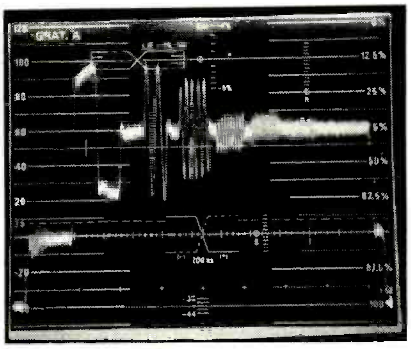
On a brighter note, the Image Translator offered good stairstep linearity, deviating no more than 2% from perfect linearity. Its performance was worse, but definitely acceptable, in the PAL playback mode.

The audio measurements show a reasonably poor signal-to-noise ratio and THD performance, and acceptable frequency-response characteristics.

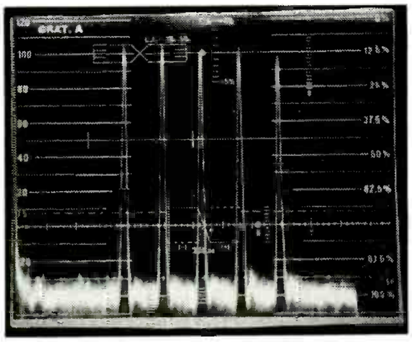
In summary, if not for the multi-standard capabilities of the Image Translator, we would not be overly impressed by its performance.



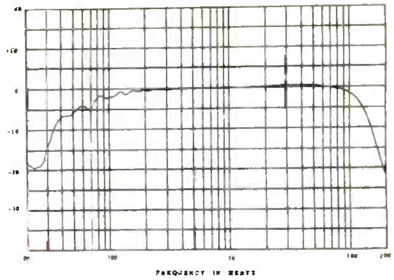
The multiburst pattern shows the acceptable frequency response performance of recorded NTSC signals.



Playing back a PAL test tape yielded response results that were significantly worse than those obtained from NTSC recordings, but still acceptable.



Measurements made when playing back a PAL test tape showed acceptable stairstep linearity.



The frequency response of the audio section of the Image Translator for NTSC recordings in SP mode.

TEST RESULTS—VIDEO SECTION*

Frequency Response (@2.0 MHz)	
NTSC record/play out	−2.25 dB
PAL test tape play	−9.86 dB
Signal-to-Noise Ratios	
Red Field Chroma	
NTSC AM	39.7 dB
NTSC PM	36.2 dB
PAL AM	41.0 dB
PAL PM	36.1 dB
Luminance	
50 IRE	
NTSC	33.2 dB
PAL	35.1 dB

TEST RESULTS—AUDIO SECTION (NTSC)

Output Level	
(0 dB reference level, 1 kHz)	0.49 volts, 1.53% THD (SP) 0.45 volts, 2.04% THD (SLP)
Signal/Noise ("A" weighted)	41.4 dB (SP) 42.2 dB (SLP)
Flutter	0.17% avg; 0.20% pk (SP) 0.32% avg; 0.40% pk (SLP)

ADDITIONAL DATA

Weight	8¾ pounds
Dimension (H × W × D)	3½ × 14$\frac{15}{16}$ × 11⅞ inches
Power Requirement	16.5 Watts
Fast Forward Time (T-120)	3:53
Fast Rewind Time	3:10

*All PAL measurements are made with a PAL test tape.

Video Standards: *Parlez-vous* PAL?

Anyone who travels internationally expects to encounter communication problems in foreign countries, due to the different languages used. Savvy travelers are also aware of the problems caused by trying to use American electrical appliances in Europe, because of the differences in voltage and frequency of the power lines. To minimize some of those problems, travelers often carry multilingual dictionaries and voltage converters.

Perhaps not so well known is that similar barriers exist between televisions around the world, which operate under one of three different broadcast standards—NTSC, PAL, or SECAM—or, to make matters worse, a variation of one of those three. In the 1990's, when world travel, multinational corporations, and widespread immigration have made the world seem smaller, and when camcorders and VCR's have made video a portable medium, it seems ridiculous to have different standards. Hindsight is always 20/20, but when video standards first were introduced—in the years following World War II—there was no talk of the "global village" and television was still a local medium. No one thought about people using video cameras to send tapes of the grandchildren to relatives in foreign countries, or large corporations making training tapes to be used in branch offices in various countries.

NTSC, PAL, SECAM

It took three years of negotiations for NTSC, named after the National Television System Committee, finally to be declared a uniform standard in the United States by the FCC in 1953. The NTSC standard uses a scanning rate of 60 cycles per second, which corresponds to the frequency of the AC power lines in the United States. Each 1/60-second image, called a field, is made up of either even or odd lines drawn by the picture tube's electron gun. Each pair of fields makes a single frame—a full resolution image with 525 scan lines, that is actually a combination of the odd and even fields that have been interlaced.

The PAL (or Phase Alternate Line) standard, developed to match the 50-cycles-per second AC power available in Europe, Asia, and Africa, is a 25-frame-per-second system. With the slower frame rate, there is more time to transmit a higher resolution picture—625 lines—while still using the same bandwidth for broadcasting. SECAM (for *Sequential Couleur avec Memoire* or color sequence with memory) also is a 25-frame-per-second system.

So, right from the beginning—in the days of black-and-white, vacuum-tube sets—two factors were incompatible: resolution and field frequency. The advent of color television only made matters more complicated. While it made sense at the time to make color television standards backward-compatible, so that black-and-white TV's could display a monochrome image from the color broadcasts, that simply introduced a third incompatibility: chrominance, or color information.

All color television systems use the same basic scheme. The color information or chrominance is made up of three signals representing television's primary colors—red (R), green (G), and blue (B)—that are combined with each other and with the black-and-white (or luminance) information.

The NTSC system transmits only the luminance, R, and B signals. A decoder in the TV tuner then derives the G signal using the mathematical relationship between the color components. Some problems resulted from that solution, however—ones that were serious enough to inspire the nickname "Never Twice the Same Color" for NTSC. The NTSC color subcarrier, which uses amplitude modulation (AM), is in the middle of the luminance spectrum; that sometimes results in interference—usually in the form of shimmering patterns that are most obvious when someone on screen is wearing a checkered jacket. The noise added to the color signal during transmission adversely affects NTSC signals. Finally, TV decoder phase-shifting changes the tint, making manual tint-controls a requirement on NTSC sets.

Based on the assumption that any two adjacent lines have the same phase distortion, the PAL system compensates for tint changes by shifting the phase of every other line by 180 degrees. The receiver then averages the phase from successive lines, canceling out undesired phase changes and eliminating the need for manual tint controls.

The SECAM standard is based on the same number of scan lines and frame rate as does PAL, but frequency modulation (FM) is used to process the video signal before transmission, although the final composite signal is broadcast in AM. The SECAM color-encoding technique is also different in that each scan line contains information about only one primary color. The next line contains the second color, and the missing third color is derived from the previous lines by the receiver.

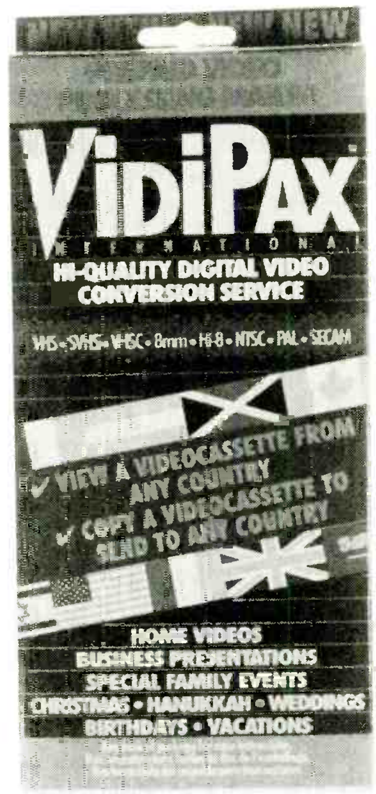
If you bring your travel iron along on your European vacation, a simple voltage adapter allows it to run on the different electrical system. Unfortunately, there's no little add-on adaptor that allows you to watch videos recorded on an NTSC VCR on a PAL or SECAM TV and VCR. To get a clear color picture, three factors must match: scan rate

The standard must be selected while the power is off or you'll have no success watching non-NTSC tapes unless you unplug the unit from the wall and reset it. The VCR can produce a 525-line, 60-Hz NTSC signal from a 625-line, 50-Hz videotape. The converted output is compatible with all NTSC TV's and can be recorded by an ordinary VCR for standards-conversion purposes (although you can't make dupes of copy-protected tapes). SECAM tapes play back in black-and-white only.

We were able to try out the conversion capability using foreign commercial tapes: the German version of Eddie Murphy's *Coming to America*, *Der Prinz aus Zamunda* in PAL, and a French version of a horror flick called *Possession: The New War of the Worlds* in SECAM. In addition, (number of frames per second), resolution (number of scanning lines), and chrominance (color signals). PAL and SECAM are somewhat compatible, since they have the same resolution and scan rate, but usually the color information is lost when you try to play one type of tape on the other type of system. When you try to view an NTSC tape on a PAL or SECAM VCR, the result is a scrambled picture and garbled sound—unless you have a multi-standard VCR, or have the tape professionally converted to the correct standard. In this month's **Gizmo**, we take a hands-on look at one multi-standard VCR, the Instant Replay 610IT3 Image Translator 50/60. Another option is the VidiPax conversion service.

People who occasionally need to send a videotape overseas—sending their parents in Europe videos of their grandchildren at their birthday parties and Christmas, for instance—would be better off having those tapes professionally converted to PAL or SECAM than using an expensive multi-standard VCR. The conversion process is complex and costly for small-scale local shops to handle, so professional video-conversion services often were difficult to locate and expensive once found, charging up to $100 for an hour of videotape.

VidiPax International (P.O. Box 2, Eldred, NY 12732) offers a convenient and relatively inexpensive alternative. Similar to the prepaid processing mailers that are commonplace in the film-developing industry, the VidiPax mailers can be purchased at electronic, video-rental, photography, and drug stores around the country. (For a dealer near you, call 914-557-3600.) The mailers are then used to send a videotape to VidiPax, where it will be converted to either PAL or SECAM. An order form printed in



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English, French, and Spanish is included. You don't even have to specify which standard; just tell VidiPax in which country it will be played, and they will convert it to the correct standard. A week or two later, you'll receive both your original and the converted duplicate by UPS. We had good results when we had VidiPax duplicate a video test-standards tape into both PAL and SECAM. (Details appear in the Instant Replay VCR article.)

VidiPax uses a complex digital technique to convert the tapes. Remember, three areas of incompatibility must be overcome: resolution, field frequency, and color information. Instead of simply cutting off some of the video, as is done in some multi-standard VCR's, VidiPax uses digital interpolation to take care of the differences in resolution. The video lines are digitized, and then the lines that should be added or subtracted are averaged, or interpolated.

Differences in field rates are reconciled by the process in a similar manner, by digitizing and interpolating fields in the time domain. A technique that is called motion-vector analysis tries to anticipate motion and selectively interpolate using different algorithms to reduce visual artifacts.

Chrominance transcoding is done by keeping track of the color information for each video line and encoding it in the new standard in the final digital-to-analog stage of the conversion process. The content of that line will be determined by the scanning line and field frequency that has occurred.

Although the standards-conversion process is fairly complex, and involves sophisticated equipment, by performing the standards conversions at one central location the price can be kept to a reasonable level. The $39.95 mailer is good for up to one hour of digital conversion. Each additional hour of tape converted costs $7.50 more, and duplicate tapes cost $15 each. Once the processing is complete, your original tape and the converted version are returned to you by VidiPax. The company will also convert from VHS to 8mm at no additional charge. ■

we had our own tapes that had been converted using the VidiPax standards-conversion service (see box). For test purposes, we first made a tape of a laser-disc called "A Video Standard" (published by Reference Recordings), which contains video test patterns and audio and video test signals that let you determine the accuracy of your equipment's reproduction. We sent that tape off to VidiPax, where copies were made in both PAL and SECAM.

The results were nowhere near perfect video in either PAL or SECAM mode, although the quality of PAL tapes was somewhat better than that of SECAM tapes, even without considering the lack of color in the SECAM version. SECAM tapes had poorer resolution and noticeably poorer audio quality. The PAL tapes, while better than those recorded and played back in SECAM, suffered in comparison to NTSC tapes. The most noticeable and annoying problem was a picture that bounced continually—something not indicated in our laboratory tests. Playing with the sharpness control on the back of the unit helped to get the color level correct—but that control isn't even mentioned in the manual (or shown on any of the equipment drawings), and its placement is anything but convenient.

Whether you're using the Image Translator VCR to watch videos recorded in PAL, SECAM, or NTSC, or simply using it to tape your favorite TV shows, the unit offers many features that you'd expect to see on a decent VCR—but certainly not everything you'd expect to see on a $795 unit. There are some trade-offs for the standards-converting capability. The Model 610IT3 is a two-head unit, and lacks hi-fi stereo sound, which we consider important. Instant Replay does offer other standards-converting VCR's with all the bells and whistles—Dolby Surround Sound, S-VHS, four heads—but at an even higher price.

The model that we tested was not completely Spartan; it did offer some valuable convenience features. On-screen programming is used to set the date and time (you can call up a monthly calendar screen that has today's date flashing or a time/date screen); to add or delete channels either manually or automatically. Each function is easy enough to accomplish, and those who get easily flustered by VCR programming will appreciate on-screen prompts such as "To end push program." You can set the timer recording for single events, or to record the same show every day or every week. You can also use one-touch recording to set the VCR to record in half-hour time increments up to 11:30 PM on the next day.

Although each of those recording methods is quite easy to use, we did encounter some problems caused by power interruptions. If the power interruption occurred in the middle of recording, the Image Translator VCR stopped and didn't come back on when power was restored. If it was programmed to tape shows later, that information was lost. And, as much as we hate being confronted by a host of LED's flashing "12:00" each time the power is restored, it's better than the Image Translator's solution, which is to display the wrong time (the correct time minus the five minutes it took for power to be restored). It's all too easy to not notice the time discrepancy and end up missing the first five minutes of the next show you tried to tape.

On the other hand, the Model 6101T3 has a feature that we particularly liked: time search. Time search allows you to fast forward and rewind by specific lengths of time. Say, for instance, that the family had to go out on a Wednesday evening and you set the VCR to record everyone's favorite game show *Jeopardy* (7:00–7:30), a documentary that your daughter had to watch for a social studies assignment (6:00–7:00), and *Beverly Hills 90210* for the kids (9:00–10:00). Instead of rewinding the tape and fast-forwarding through *Jeopardy* to get to the documentary that she had to watch, your daughter could rewind it, set the time search for 30 minutes, and the VCR would automatically bring the tape to the beginning of the documentary. That feature works in reverse, too. If your daughter decided she'd rather watch *Beverly Hills 90210* first, she could set the timer search to rewind for one hour.

All in all, the Image Translator VCR was easy and convenient to use. Most of its functions could be operated intuitively, and the remote control featured well-marked, well-placed keys. When we used the Image Translator as an everyday VCR, taping and playing back television shows, we had few complaints. When using it as a standards-converting VCR, however, some problems arose. We recognize the complexity involved in the standards conversion process, and appreciate having the ability to view PAL and SECAM videotapes in the U.S., even if the quality wasn't great. The poor picture and sound quality didn't bother us as much as the poor placement of the standards-conversion controls and the lack of instructions about using that feature, which, after all, is its claim to fame. ■

The Toys of Summer

BIG LEAGUE BASEBALL ELECTRONIC ENCYCLOPEDIA. Manufactured by: Franklin Electronic Publishers, Inc., 122 Burrs Road, Mt. Holly, NJ 08060. Price: $129.95.

We are not big fans of baseball—we seldom watch games on television, and pay only fleeting attention to the scores and standings printed in the sports pages each day. We consider ourselves Yankee fans, but we couldn't name this year's infield without help. ("Fair-weather fans" is probably more accurate—we can still recall the entire Yankee lineups, and even some of their jersey numbers, from the spectacular 1977 and 1978 seasons!)

Yet whenever we travel during the warm months, on either business trips or vacations, we try to catch a major-league ball game. There's something about attending a live baseball game that transcends simply watching a sporting event. Baseball is so firmly entrenched in our culture that to be there is to experience a bit of Americana. We love the sameness of each game—the classic duels between pitcher and batter, the teamwork of a closely knit infield, the sound of bat striking a home run—and the little differences that make each ball park and home-team audience unique. We love listening to the fans in neighboring seats (who are almost always more knowledgeable and more vocal than us) discuss strategy, tell tales of other games, and throw around statistics and sometimes-scathing comments. (Fans can be far more entertaining than sportscasters. Our favorite line: The guy sitting in front of us, responding to someone's remark about a batter known for taking his time at the plate, said, "Yeah, he's what you might call a human rain delay.")

Even though baseball doesn't have the fast action and excitement of hockey, football, or basketball, it has a history that lives on in tradition, in legend, in stories handed down for generations—and in statistics. There were unbeatable teams, classic games, historic hits, and larger-than-life heroes. And true baseball fans, be they absent-minded professors or high-school dropouts, can remember who won the series in 1952; can rattle off statistics about every player on the 1967 White Sox; and can explain the meaning of RBI, HR, E, AB, ERA, and a host of other statistical abbreviations. Perhaps it's baseball's leisurely pace that's allowed the time for such intense examination of games and teams past—after all, the fans and sportscasters need something to discuss during pitching changes or when a "human rain delay" steps up to the plate!

Now even folks like us can have baseball facts and figures at our fingertips at all times, thanks to *Franklin's Big League Baseball Encyclopedia Model HR-61*. Those facts and figures include more than 620,000 batting statistics, 270,000 pitching stats, and biographical information about every player in the history of major league baseball. Moreover, you can manipulate the data in the Baseball Encyclopedia to discover who was the all-time leader in home runs (Hank Aaron, 755) or who had the worst batting average in the American League in 1971 (Dean Chance,

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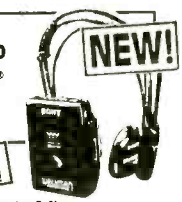

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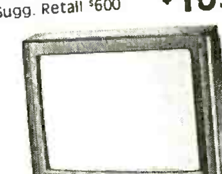

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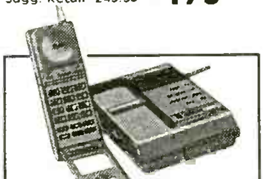

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0 for 21). If you're more interested in heavy players than heavy hitters, you can even find out which ball player weighed the most (Walter "Jumbo" Brown, 295 pounds).

Weight isn't a problem for the Big League Baseball Encyclopedia, however. Bearing no resemblance to those hefty, old-fashioned books of baseball stats with complex cross-referencing systems, the electronic version is sized to fit in a shirt pocket, and weighs only five ounces. It comes with a protective vinyl cover and a quick reference card that provides operating pointers when the manual isn't at hand. Searches can be initiated in several ways, and cross-referencing is done at the push of a button.

You can search for statistics by keying in (on the QWERTY-style keypad) the player's name (first, last, or both), the team name or city, or the league. Even nicknames will work: Catfish, for James "Catfish" Hunter, for instance. And Franklin's built-in phonetic spell-checker will correct misspelled players' names and offer alternatives for guesses.

When an individual player is called up, Big League Baseball's three-line, 24-character LCD readout will show his full name on the first line. Arrow keys are used to scroll across the line, which also includes BL/TL (bats left/throws left for a southpaw) or BR/TR; birth and death (if applicable) dates; weight; and height. The second line displays headings for the columns of statistics that follow: for pitchers, IP (innings pitched), ERA (earned-run average), W and L (wins and losses), SV (saves), ER (errors), SO (strike outs), H (hits); for batters, AB (at bats), BA (batting average), HR (home runs), RBI (runs batted in), H (single-base hits), 2B (doubles), 3B (triples), R (runs scored), and SB (stolen bases). Career totals are displayed on the third line. Each subsequent line shows the year, team, and league, and the players statistics for that year.

When searching by team, you can key-in the team name to see a complete year-by-year history of the team. Typing in "Red Sox" will call up first the 1901 Boston Red Sox (A) (for American League), followed by team-total batting averages and then individual players' averages (Cy Young batted .209 that year). A press of the BAT/PITCH key calls up the pitching stats. A press of the NEXT key brings up the next year. If a team has played in more than one city, a list of options will appear. Typing in "Dodgers" brings up the choices "1958–91 LA Dodgers" and "1890–1957 Bro Dodgers," for instance. Similarly, typing in "NY" calls up the team choices: 1903–91 NY Yankees, 1962–91 NY Mets, 1883–1957 NY Giants, and 1876 NY Mutuals—a team that none of the native New Yorkers here at **Gizmo** had ever heard of. There's no need to scroll through fifty screens if you want to take a look at the 1950 Yankees; you can simply type in "1950 Yankees" to go directly to that year.

Once you've called up a team, cross-referencing to individual players is a snap. You simply move the cursor to the player whose stats you want to see and press ENTER. A press of the BACK key returns you to the team-info screen.

You can find teams' win/loss records and final league standings for any year by typing "AL" or "NL" followed by the year, and can see complete stats for any of those teams by pointing the cursor at them and pressing ENTER. You can also find out the results of any World Series by typing in "WS" and the year.

All of those functions are simply the basics of the Big League Baseball Encyclopedia. Its compact size, easy cross-referencing, and automatic spell correction do set it apart from any written baseball encyclopedia. But the unit's electronic search capabilities, which allow you to create your own statistical lists, make it truly unique.

Typing in "MAX" or "MIN" before any stat abbreviation will result in a list of the players with the most or least; that works for all pitching and batting stats, as well as biographical information (age, height, and weight). You can find out maximum and minimum ratios—for example, most home runs per at bats, by typing in "Max HR/AB."

The results of those two examples are quite different. The most-home-runs list comes as no surprise, starting off with baseball legends Hank Aaron, Babe Ruth, and Willie Mays. The players with the most home runs per at bats are not as well known—Frank O'Connor was up at bat twice and hit one homer, Luke Stuart and Jeff Bittiger were each one for three.

You can further hone your search by adding limiters—"GT" for greater than or "LT" for less than. To discover who has the most home runs and has a batting average under .250, you would type in "MAX HR BA LT .250" and find Dave Kingman (442 home runs, .2359 average) at the top of the list. You can use years or teams (or both) as qualifiers separately from, or in addition to, "MIN/MAX" and "GT/LT." For instance, "MAX HR BA LT .250 METS 1969" would create a list with Ed Kranepool (11 homers, .2380 average) at the top. Each list can contain up to 30 names. To learn more about any player in a list, you can move the cursor to his name and press the enter key to cross-reference.

When you consider the number of qualifiers and statistics contained in Big League Baseball, you'll soon realize that the possibilities are close to endless—at least, you're far more likely to run out of curiosity long before it runs out of possible list combinations.

We do have a few complaints, however. First, we weren't crazy about either the keyboard layout or the tactile response of the keys. The ENTER key was in the space normally occupied by the space bar, which created some problems, and the number keys run from zero through nine instead of one through zero as they would on a standard keyboard. Second, we strongly feel that the players' field positions should have been included. Third, we would like to have seen included statistics on walks—there have been quite a few players known for their ability to draw bases on balls.

The Big League Baseball Encyclopedia does a great job of providing pitching and hitting stats; perhaps it's too much to ask for fielding stats as well. Yet even though baseball drama revolves around the pitcher and the batter, it's often fielding that makes or breaks a game. With the electronic encyclopedia, you can call up the Chicago Cubs in the early years of the century and find Joe Tinker, Johnny Evers, and Frank Chance on the roster, but you won't learn anything about the famous Tinker-to-Evers-to-Chance double-play combination.

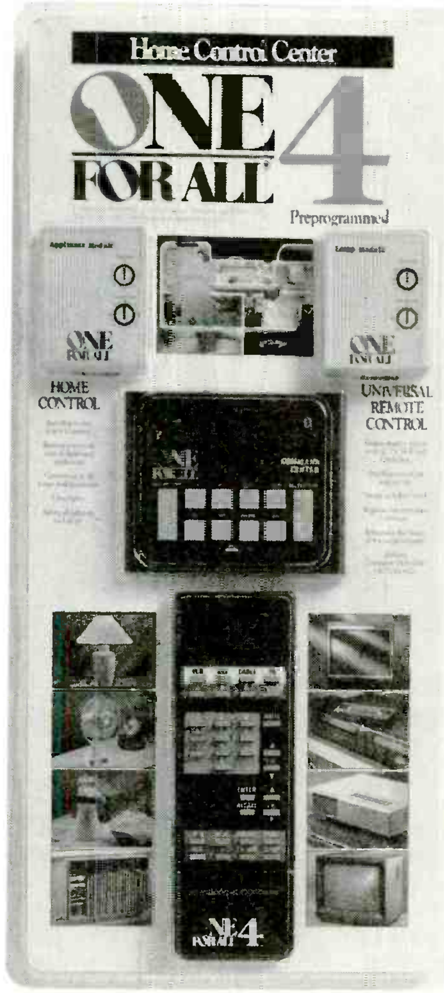
In a similar vein—although we're not sure if this is a plus or a minus—some of the unit's answers to our inquiries were intriguing enough to send us to the written books (and to call our fathers) for more details than could be provided by the statistically oriented electronic encyclopedia. For instance, our search for the major leaguer who weighed the least came up with Eddie Gaedel, who weighed 65 pounds and was only 3 feet, 7 inches tall! Still more perplexing, we learned that in his one season with the St. Louis Browns in 1951 he had no at bats—in fact, all his stats were zeros. It turns out that Browns' owner Bill Veeck brought in a dwarf to force a walk. Gaedel was at bat once, crouched over the plate to present the pitcher with a six-inch strike zone, and drew a walk. Outraged baseball commissioner Ford Frick quickly called an end to Gaedel's major-league career.

Of course, baseball is a unique amalgam of statistics and stories, and Big League Baseball provides the quickest statistics that we've ever seen. In fact, its good points far surpass its drawbacks, even for people who aren't obsessed with the game. Because it's so easy to use, you never get bogged down or frustrated. The manual clearly explains how to set up complex questions, the quick-reference card provides reminders, and there's even on-screen help to get you out of any potential jams. We loved the nostalgia of calling up favorite teams, checking out what was happening in the years in which we were born, and perusing the careers of favorite players. ■

Home Control for Couch Potatoes

HOME CONTROL ONE FOR ALL 4 UNIVERSAL REMOTE CONTROL WITH HOME CONTROL MODULES. From Universal Electronics, Inc., 6138 Riverview Road, Peninsula, OH 44264; Price: $99; additional control center module: $39.95, additional lamp/appliance modules: $19.95.

Confirmed Gizmologists aside. Americans are a wary lot when it comes to technological innovation. It takes a while for new gadgets—even those that promise to make life noticeably easier—to catch on with mainstream America. But once a device gains the nation's trust, watch out! It zooms from gadget status to necessity. and absolutely *everyone* must have at least one. That's happened with televisions, VCR's, microwave ovens, and personal stereos. And it's certainly happened in a big way with remote-control units—devices that. when first introduced, met with skepticism: "Why would I need a remote control when I'm perfectly capable of getting up, walking across the room. and changing the channel?" By now, perhaps the flesh is still able but the will is weak—a whole country of couch potatoes would never dream of leaving their sofas when they can simply press a button to raise the volume, or hit the PLAY button to watch a video.



CIRCLE 56 ON FREE INFORMATION CARD

Yet those same millions of people are reluctant to get involved with similar devices that would allow them to turn on a popcorn maker to cook up a snack while watching that video, or to dim the living room lights when the movie started, or to turn off all the lights in and outside the house, and activate the security system, when the movie ended and they were ready to turn in for the night—all without leaving the comfort of their arm chairs.

Although Smart Houses are still futuristic dreams for most of us, and the CEBus standard is still not in place, there are plenty of home-automation devices available today. Many non-Gizmologists of our acquaintance have garage-door openers, and some even use device timers to switch lights on and off at different times when they're on vacation. But we don't have any friends or relatives who use a remote control to switch on or off, or dim lights, or to turn appliances in other rooms on or off. They are as reluctant to experiment with home automation as they are dependent on remote controls for operating their audio/visual equipment.

Just how dependent are they? There's an estimated 200 million remote controlled devices on the market today—that's practically one per person!—and Tom Tyler, president of *Universal Electronics*, expects that number to reach 370 million by 1995. That means that the average consumer, who now has three remote controls laying around the house. will have six by 1995. Universal remotes are also becoming increasingly popular as "clutter-busters," replacing several original remotes with just one unit. And about 16 million remote controls must be replaced each year due to loss or breakage of the original.

Universal Electronics has decided to use America's dependence on remote controls to counteract their reluctance to home automation—while expanding their share of that lucrative replacement-remote market—by packaging a universal remote control with a home-control system that can operate as many as 16 different devices remotely. Called the *Home Control Center One For All 4*, the system consists of a command center module. a lamp module, an appliance module, and a universal remote that can be used to control your TV, VCR, cable box, as well as various lights and appliances.

There are three types of universal remotes available on today's market. One type is the "learning remote," which learns the functions of the original, usually by placing the two units head-to-head and pressing the corresponding buttons on each, one at a time, until all functions are learned. That method is time-consuming, however, and won't work if the original is lost or broken. The second type uses a ROM (read-only -memory) chip that is preprogrammed with the function codes of various brands of TV's, VCR's, CD players, and the like. Using a ROM-based replacement remote is easy: You simply punch in the appropriate codes for your electronic equipment, which generally appear in the universal remote's owner's manual. Problems arise, however, if your gear is very old, very new, or somewhat obscure, and so is not covered by the lists of codes. And the ROM chip can't be reprogrammed to handle future models that you might decide to buy a few years down the road.

Universal's One For All 4 remote uses a patented RAM (random-access memory) chip that has the ability to be upgraded as you upgrade your equipment (and even upgraded to cover your very old components). The upgrade, while fairly easy to accomplish (it involves running a cable between a One For All remote and a computer that provides new product codes), must be done at Universal or one of its service centers, which is a bit inconvenient for users. But the company is so sure of its ability to match your equipment (with the exception of Bang & Olufsen products, which use a different IR frequency than any other products on the market), that they offer a double-your-money-back guarantee.

We had no problem entering the codes for a Sanyo VCR and Zenith TV using the sequence TV (OR VCR) - A - B - C - followed by the three-digit code listed in the manual. Unfortunately, we gained control of only the most basic functions of the two units. We were unable to access any on-screen menus for timed-taping, source selection, or any of the other functions that we frequently use. (That's the big advantage that the more complicated learning remote controls have over the ROM and RAM-based ones: By programming them key-by-key, you can replicate every function of the original remote.) We were also unable to find a code corresponding to the Instant Replay standards-converting VCR that we review elsewhere in this issue.

Universal provides a toll-free number for just such dilemmas. We were helped by a pleasant woman who informed us that although the All For One remotes are intended solely for basic operations, it is sometimes possible to access more sophisticated functions using various series of letters and numbers. Because they don't work for all models, the manual doesn't mention them. We lucked out with our VCR and TV: pressing VCR - A - 1 - 0 brought up our on-screen programming menu, allowing us to set the timer to record our favorite shows. We were able to operate the TV's picture-in-picture using a similar sequence, but we still couldn't get it to control some of the less-frequently-used functions. That could present a major problem for people whose sets lack front-panel controls for some of the more sophisticated functions—lose the original remote, and you're out of luck.

As far as the Instant Replay deck goes, neither our customer-service rep nor her manager could find any reference to it. She suggested that we try to "search the library." According to the manual, it's possible that the correct code for a piece of equipment is already in the All For One 4, but listed under a different manufacturer. You can search the entire library of devices by turning on the device, pressing A - B - VCR - C - POWER, and alternating between C and POWER until the VCR turns off. Although it might be necessary to repeat C - POWER as many as 50 times, the process doesn't take long. Once the device turns off, pressing the "A" key locks in the code. Unfortunately, searching the library didn't work with the Instant Replay VCR. (We suppose we could have tried to return the One For All 4 for "double-our-money"—but that wouldn't work with a unit that we'd only borrowed! Besides, it works quite well on the equipment that we use every day.)

Although it's called the All For One 4, the remote control can be used with only three video devices—a TV, a VCR, and a cable box. The fourth device key, labeled AUX on All For One 4's that are sold without the Home Control Center, is now labeled HOME CONTROL and is used to control lights and appliances.

Setting up the Home Control Center is no more difficult than preparing the remote for use with video equipment. The set comes with one command-center module, one appliance module, and one lamp module. Each command-center module can control as many as 16 lamp and appliance modules, which can be purchased separately for under $20. The command center is plugged into any standard wall outlet that's in the room where you would normally use the remote to control your video devices—probably either the family room or bedroom. Each module must be given its own unit code, which allows the command center to distinguish it from other modules. A screwdriver is needed to turn the selector on the front of each module to the desired number. The accessory modules then can be plugged into any outlets in the house or yard, and the devices to be controlled then plug directly into the modules. Once everything is plugged in, you program a home-control code in the same manner that you set the video-gear codes, using one of the three-digit codes provided in the manual.

Once the set up is complete, by aiming the remote control at the command center, you can remotely turn appliances and lights on and off. The infrared signals from the remote control activate the command center, which passes commands to the modules through your home's AC wiring. (You can also skip the remote control and use the keypad on the command-center module to directly control up to eight lights or appliances.) To remotely turn on the lamp that's connected to lamp module one, for instance, you would press HOME CONTROL - 1 - ON (the CHANNEL-UP key doubles as the ON control; CHANNEL DOWN and OFF also share a key). Other buttons on the remote control allow you to dim lights and to simultaneously turn on every light and to turn off every light and appliance that's hooked up to the system. It's not possible to turn on every appliance at once because some unwanted consequences can result if the remote is used carelessly. For instance, you wouldn't want to accidentally turn on a coffee maker that had no water in its carafe. The manual suggests attaching a label on which you've recorded the module number of each device under control to the back of the remote control for quick reference—and to make sure that you do not accidentally turn the wrong appliance on or off.

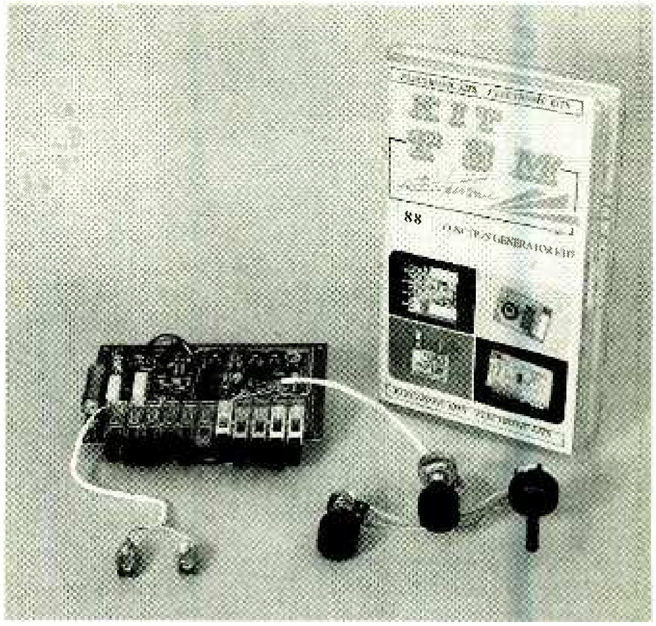
We didn't need a reference chart, because our test package came with only one light and one appliance module. We first tried it in the office, to control a desk lamp and a fan. Everything worked exactly as promised, and it didn't take long for the keystroke sequences to become second nature. Available outlets are at a premium in our office, and when we had to unplug the control module in order to plug our printer back in, for some reason the appliance module began to turn the fan on and off by itself at unpredictable intervals. That problem was remedied by resetting the command control module.

The outlet situation in our media room is somewhat better, and we didn't have the same problem there. Actually, even in our rather limited configuration (we used the system to control two lamps in the room), the Home Control Center One For All 4 both provided the convenience of one using remote for both TV and VCR and offered an excellent introduction to home automation. We particularly liked a feature called "Punch-Thru," which lets you operate several video devices simultaneously without having to repeatedly change device keys. For instance, if the last device key pressed was CABLE, you can still control the volume and mute keys on the TV and the VCR's play, pause, fast forward, reverse, and TV/VCR keys. We also liked being able to use a single remote control to either mute the TV or pause the VCR and turn up the lights whenever the phone rang while we were watching TV. We imagine that, with the addition of more modules, the ability to turn off the room lights, outside lights, and the upstairs ones that somehow were left on before dinner all at the push of a button, and then to turn on the bedroom lights also would be quite convenient.

We're sure that you can think of quite a few things around your own home that could be added to a home-control system like this one—and we're also sure that that's just what Universal intended. Let timid consumers get their feet wet with remote control of one lamp and one appliance, and once they're hooked, they'll come back for more. ■

A Hands-on Electronics REPORT

TSM FUNCTION-GENERATOR KIT



CIRCLE 119 ON FREE INFORMATION CARD

As user-built test equipment goes, this unit will perform well, but only for the builder who knows what he's doing.

It doesn't take much experience in electronics to teach you the value of a well-stocked test bench. Fortunately, by the time most of us have out-grown the multimeter-only phase of our hobby, we've gained enough skill to build at least some pieces of test equipment.

The *TSM Function-Generator Kit No. 88* seems just right for that level of experience—when you've already cut your teeth and need to take the next step. Unlike most TSM kits, the Function-Generator is not suitable for a rank beginner due to some idiosyncrasies in its assembly instructions. I'll point those out as I proceed to help those that wish to give the kit a try. The irregularities in the instructions should not significantly hamper the efforts of a seasoned kit builder. If you feel you fit that description, and don't mind a bit of a challenge, then read on . . .

Features. The specifications of the TSM Function Generator are appropriate for typical enthusiast use: It is capable of producing squarewaves, triangle waves, sawtooth waves, or sinewaves over a frequency range of from 8 Hz to 200 kHz, with signal amplitudes ranging from 1 mV to 1 volt. However, bear in mind that you really need an oscilloscope to calibrate the unit's sinewave output. The lack of an oscilloscope will not prevent you from calibrating the other waveforms, though.

It should be mentioned that the signal output is AC coupled. The unit has a synchronization output in addition to its signal output. That eliminates the need for putting a tee connector on the signal output to connect it to a frequency counter or the synchronization input on an oscilloscope. Further, since the "sync" signal is not amplified by the unit's output circuitry, you needn't worry about it overdriving the input stage of a frequency counter. This little feature comes in real handy during calibration (which I'll get to a little later in this article) as well as regular use.

Oddly, except for the label "Synch" [*sic*] near that output on the unit's schematic diagram, this useful feature is not mentioned or explained anywhere in the documentation. If I didn't understand the circuit's operation from the schematic, I would have had trouble determining what the output is for.

Almost everything you need is supplied with the kit. However, you will need to add a 12-volt DC, 300-mA power supply, two or three connectors (depending on whether your power supply requires a mating connector), an enclosure, and some wire to make the unit functional. (By the way, a tiny amount of wire *is* supplied in the kit, but it is not enough for all the on-board jumpers let alone the off-board controls and connectors.)

Of course, adding the obligatory power-on LED would be nice too. Purists might wish to add a power switch as well, but there is a multi-pole switch (used to set the amplitude scale) that has an unused section and an undesignated switch position that can be used for that purpose. Your kit might also require an additional knob for one of the controls, as one of the controls that came with my unit was too large for any of the supplied knobs. Alternatively, you can drill out one of the supplied knobs to suit that control. It's modifications like those that require some experience in electronics to recognize and take advantage of—they are not mentioned in the instructions.

On the plus side, the components and the circuit board are all high quality. The PC board is single sided and has a color-coded silk-screened pattern—one color for component

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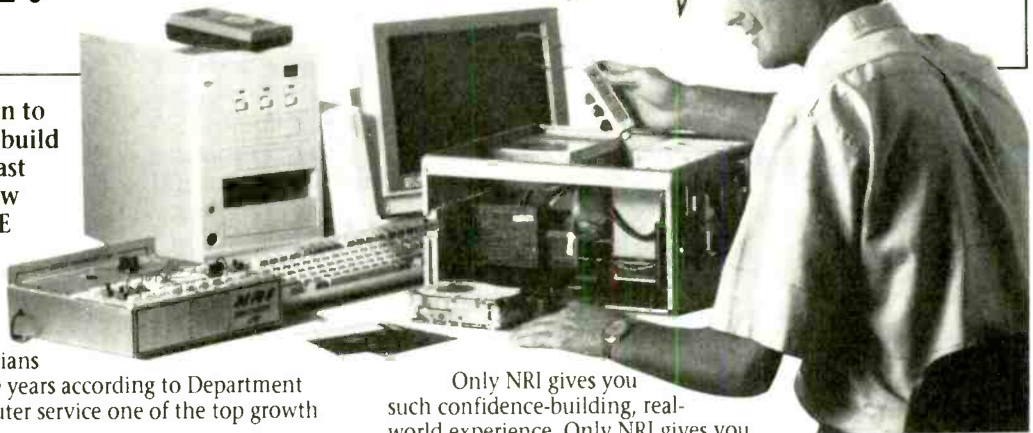

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City/State/Zip — Accredited Member, National Home Study Council — 18-112 outlines and designations, another color for the foil traces. The screen work makes board-stuffing and troubleshooting (if any is needed) pretty easy.

The controls also bear special mention; they are very nice. The waveform and frequency switches are ganged pushbuttons, just like the kind you would find on a manufactured function generator, so they are particularly pleasing. If you do a good job machining and labeling your enclosure (which will not be covered in this article), the unit can be made to look store-bought. The first step, of course, is to build the unit itself, which I'll discuss now.

Construction. Building TSM kits is usually pretty easy, and, with a few exceptions, the Function-Generator Kit followed suit. Oddly, there are some helpful soldering hints, pin-outs, parts-identification tips, and a color-code chart printed onto the binder of the TSM kit case, apparently to assist beginners. That's odd because a beginner requiring *that* much support would probably find the kit frustrating to build and calibrate because the instructions are poorly translated (I don't know what language they're translated from).

The literature that pertains to the kit itself is written in a "build it, adjust it, and use it" style—it doesn't contain any circuit theory. It does describe how to stuff a generic component into the board and advises that you install the components in the order that they appear in the parts list to avoid any difficulty. If you don't follow that sound advice you could end up covering the holes for some of the jumpers (referred to as "straps") with the rather large switch assemblies used by the unit.

However, this simple advice is made a little difficult to follow because of the Parts List. One problem with the Parts List was the use of commas in place of decimal points for some of the parts. For example, 6.8 was written 6,8 in some places. Also, many of the component values are specified as a range rather than a single value. For example, fixed resistor R10 could be any value from 180k to 200k. When faced with such ambiguous information an inexperienced builder might be tempted to match each part with its listing before stuffing anything into the board, blowing an evening just taking inventory. Of course, a more experienced hobbyist would solve this kind of puzzle by stuffing the *entire* board, prior to soldering. That way if you've placed a part incorrectly, it will become obvious before any soldering is done and can be easily corrected.

That bit of strategy behind us, there were a few more bridges (albeit, somewhat inconsequential to someone with experience) to cross while stuffing the board. For example, some of the holes for the non-polarized capacitors were spaced so close together that those components could not lay flat on the board. That increases their lead length, introducing additional stray inductance into the circuit. I suspect that that problem somewhat reduced the overall effectiveness of the completed function generator, as I'll point out later.

Once the on-board components were in place, I turned my attention to the off-board parts. Everything went pretty smoothly with the exception of

(Continued on page 88)

PRODUCT TEST REPORTS

By Len Feldman

Funai TVCP 9T 9-Inch TV/Video Cassette Player

How many times have you been away from home and wished you could rent and watch a videotape on a small, high quality TV set that's light enough to carry with you on a trip? Better still, wouldn't it be nice if that same TV set had a built-in video-cassette player, so you wouldn't have to bother hooking up a separate VCR when you wanted to watch a tape? Well, Funai Corporation (100 North Street, Teterboro, NJ 07608) has come up with just such a combination unit.

The Funai TVCP 9T combination TV/video-cassette player.

The TVCP 9T features a 2-rotary-head playback system. All three speeds (SP, LP, and EP) can be accommodated. If you insert a tape, power is turned on automatically and, if the safety tab on the tape has been removed, playback begins. At the end of the tape, the tape rewinds automatically, is ejected, and, unless "repeat playback" has been selected, the unit turns itself off.

The feature most likely to attract travelers to this unit is its two-way power capability, which lets you power the unit with standard AC voltage or from your car battery using the supplied car-battery cord. Since this TV set is likely to be moved from place to place, it is equipped with a "degaussing button," which corrects color by countering the magnetic influence caused by nearby appliances. The remote control supplied with the TVCP 9T lets you operate all the tape-transport controls, change TV channels, and adjust the volume level from your viewing chair. An on-screen display of selected channels and other operating functions makes control adjustment foolproof. High-speed picture search in either direction is possible when watching a tape, as is "freeze frame" or still-picture viewing. The frequency-synthesized TV tuner incorporated in this product can be tuned to any of 155 TV or cable channels, and random access to any numbered channel is possible, as is programming of the tuner to receive only those channels available in your area.

CONTROLS

Pushbuttons beyond the right side of the TV screen include the power switch and channel and volume up/down buttons. The video-cassette insertion slot is located below the screen, with a stop/eject button located to the left and below the tape slot. A swing-down door discloses controls associated with the video player as well as less-often-used controls associated with the TV set itself. With the door flap closed, play and tape-in indicator lights are visible on its front surface. When opened, access is gained to the rewind, play, fast forward and still buttons of the player, as well as to controls that adjust tracking, brightness, contrast, color, and tint. Also found here are the auto-repeat selector and a switch that selects either broadcast or cable TV frequencies for the TV tuner.

For private listening, a headphone jack is found on the left side panel of the cabinet. The rear panel of this combination unit houses the previously mentioned degaussing button, connection points for either the AC-line cord and the car-battery DC-supply cord, audio and video input and output jacks, and a connector for a 75-ohm antenna transmission line.

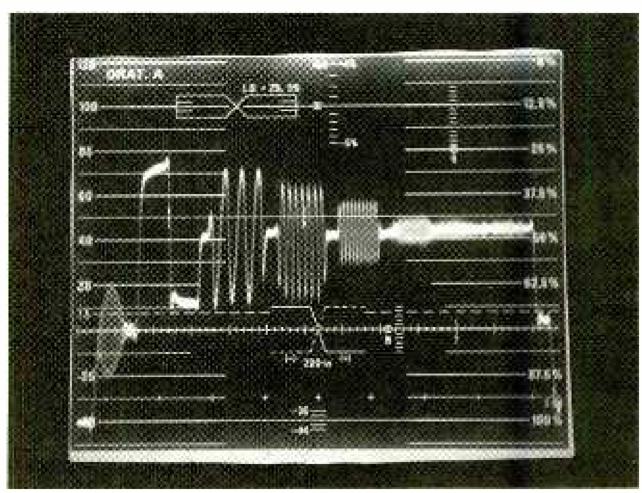
TEST RESULTS

Advanced Product Evaluation Labs (APEL) measured the performance of this unit both in terms of its capabilities as a TV monitor/receiver, and in terms of its operation as a video-cassette player. In the latter case, all measurements were made at the SP tape speed and, since this unit is a player only (as opposed to the usual VCR player/recorder), APEL used a prerecorded test tape.

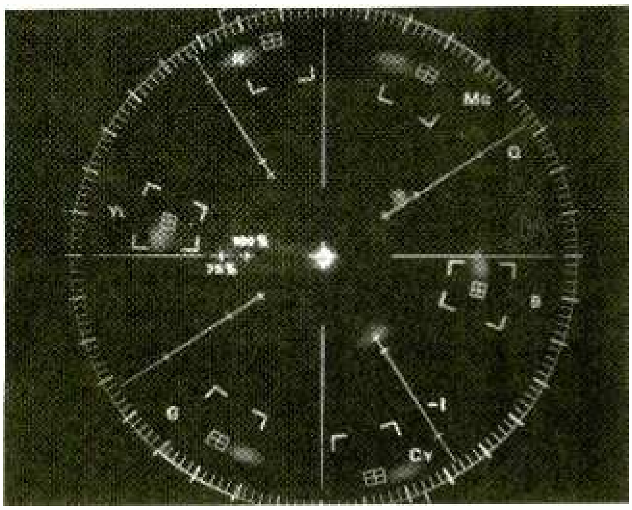
The maximum usable luminance for the TV screen measured 63 foot-lamberts, which, while not the brightest for a TV set of this tube size, was bright enough to view pictures in normal room lighting. Horizontal resolution measured 280 lines. (Maximum resolution possible for broadcast TV is about 330 lines.) The transient response was very good, as was color quality. Black level retention was a somewhat below average 70%, while overscan (the amount of picture deliberately extended beyond the screen width) was only 4%. TV-tuner sensitivity was very good, with reception at fringe-area signal strengths remaining quite acceptable. As for the audio section of the TV receiver, audio output via the separate output jacks was 0.43 volts at 0.04% distortion, with distortion decreasing to an even lower 0.03% when audio levels were backed down to −10 dB below reference level. Audio signal-to-noise ratio measured 68 dB, while the audio frequency response extended from 26 Hz to 13 kHz.

APEL used a prerecorded test tape made on Sony Pro-X tape to measure the performance of the tape player section of this TV/player combination. Using a multiburst test signal, frequency response was down by 6.64 dB at 2.0 MHz, or about average for a standard VHS format VCR operating at its SP speed. Red field chroma (color) signal-to-noise ratio measured 43.2 dB for AM noise and 34.9 dB for phase-modulation (PM) noise. The luminance (brightness) signal-to-noise ratio ranged from 43.4 dB to 43.8 dB, depending upon the reference luminance level at which APEL made the measurements. Color accuracy as indicated by a vectorscope, was very good.

Turning to the audio section of the tape player, APEL measured an audio output of 0.36 volts at a harmonic distortion level of 1.25%—again, about what one would expect from a VHS-format machine. Frequency response during playback of the test tape extended from 150 Hz to 13.4 kHz, while distortion at a −10 dB playback level was only 0.59%. Fast forward time for a 2-hour (T-120) tape was 3



Using a multiburst test signal, response was down 6.64 dB at 2 MHz. That is about average for a VHS machine.



As indicated by this vectorscope photo, the unit's color accuracy was very good.

TEST RESULTS—FUNAI TVCP 9T COLOR TV/VIDEO-CASSETTE PLAYER

Specification	Mfr's Claim	PE Measured
	TV Section	
Maximum usable luminance	N/A	63 foot-lamberts
Horizontal resolution	N/A	280 lines
Transient response	N/A	Very good
Black-level retention	N/A	70%
Color quality	N/A	Very good
Overscan (horizontal)	N/A	4%
Audio output	N/A	0.43 V, 0.04% THD
THD @ −10 dB	N/A	0.03%
Audio signal/noise ratio	N/A	68 dB
Audio frequency response	N/A	26 Hz to 13 kHz
Picture size (measured diag.)	9 inch	Confirmed
	Video-Cassette Player Section	
Video frequency response	N/A	−6.64 dB at 2 MHz
(at 3.0 MHz)	N/A	−15.0 dB
Video signal/noise ratio		
AM chroma	N/A	43.2 dB
PM chroma	N/A	34.9 dB
Luminance	N/A	43.4 to 43.8 dB
Audio output level	N/A	0.36 V @ 1.23% THD
Audio frequency response	N/A	150 Hz to 13.4 kHz
Harmonic distortion @ −10 dB	N/A	0.59% for 1 kHz
Fast forward time (T-120 tape)	N/A	3 min. 56 sec.
Fast rewind time (T-120 tape)	N/A	3 min. 50 sec.
Maximum power consumed (AC/DC)	70/50 W	63/44 W
Dimensions (H × W × D, inches)	13⅛ × 12½ × 13⅛	
Weight (lbs.)	23.4	Confirmed
Suggested retail price:	$399.00	

minutes and 56 seconds, while fast rewinding of the same tape took 3 minutes and 50 seconds.

With only the TV set operating, power consumed by this unit was 58 watts AC; if operated from a DC source, power consumption was 40 watts. With both the TV and player operating, power consumption increased to 63 watts AC or 44 watts DC.

HANDS-ON TESTS

In our hands-on tests of this dual-function product we were pleased to see how good TV reception was, even using an indoor "rabbit-ears" type passive antenna. Our lab is located some 20 miles from the transmitter sites of most of our locally available stations, but noise-free, "snow"-free signals were received for all.

In using the handheld remote that came with the unit, we noted that in addition to duplicating all of the controls and switches found on the set itself, the remote also had number buttons for accessing channels directly, a "cancel" button to cancel specific memorized channels, counter memory and reset buttons, a mute button (especially useful for eliminating the sounds of the more blatant and annoying TV commercials), and a "sleep" button that can be used to set automatic power shut-off at any time up to 2 hours in 30 minute increments. All of these "extras" made it a joy to operate all elements of this TV/Player using only the remote.

As for tape viewing, once a cassette was inserted in the slot, again, the remote handles all required functions and picture quality appeared to be almost as good as what we saw when watching broadcast or cable TV programming. Part of the explanation for this, of course, is the fact that we were watching on a small (9-inch, measured diagonally) screen. For all the advantages claimed for large-screen TV sets, it's important to remember that our NTSC system of TV is still limited to 525 lines—no matter what the size of the screen. So, the smaller the screen size, the crisper the picture seems to be.

For more information on the Funai TVCP 9T, contact the manufacturer directly, or circle No. 120 on the Free Information Card. ■


The Amazing Maze.

BAD VIDEOTAPES

BY LEN FELDMAN

Theoretically, any videotape bearing the VHS logo must have passed certain stringent tests developed by JVC, the inventors of the VHS video-recording format. In fact, JVC conducts ongoing tests to ensure that its tape manufacturing licensees maintain a proper level of quality in their video cassette tapes. But what happens if some maverick overseas manufacturers decide to bypass the licensing procedure and simply produce and market videotape of inferior quality and illegally apply the VHS logo to such products? Even worse, what happens if reputable firms buy such tape from unqualified manufacturers and then, in all innocence, have it packaged under their own familiar brand names? What's an unwary consumer to do?

It recently came to our attention that several tapes bearing unfamiliar brand names, all of them manufactured in mainland China, were competing in the marketplace against more familiar, well established tape brands. Further investigations disclosed that of the dozen questionable brands found, nearly half were not even licensed by JVC to carry the VHS logo. The following brands bear the trademark illegally: Haili, Mustang, Supra, Treasury, and Windsor. While the remaining seven brands are all licensed by JVC, the owners of those brand names do not, in fact, actually manufacture videotape. That means they are buying their tape from other manufacturers, some of whom may be the very same manufacturers who are using the VHS logo illegally and who, as our exhaustive tests show, are incapable of making videotape of acceptable quality. By way of comparison, we also measured the performance of three well-known, high-quality standard VHS tapes: TDK High Standard, Sony ES, and Scotch EG. It's important to note that we purposely selected these companies' standard (and lowest priced) videotapes whereas nearly all of the "Made In China" tapes are billing themselves as "High Grade" (hence higher priced) tapes!

These videotapes may bill themselves as "high grade," but their performance is decidedly low grade—and some could actually damage your VCR!

A brief summary of our findings with respect to each of the dozen "Made in China" tapes can be found later on in this article. A more detailed analysis can be found by consulting Table 1, which shows the test results for three samples of each tape. Let's now examine how those tests were performed, and what the numbers mean.

Test Procedures and Lab Measurements. The videotape testing was conducted by APEL (the Advanced Product Evaluation Laboratories). APEL tape tests were performed with three samples of each type of tape. The results shown in Table 1 represent the average performance of all three tapes. Prior to testing, all of the tapes were put into an environmentally controlled room at a temperature of 70°F and a relative humidity of 60% for at least 48 hours. These conditions were maintained during the tests as well, since many of the measurements are temperature and humidity dependent. Before actually measuring each tape, each cassette was bulk erased and "exercised" to prevent any settling of the tape. Each deck was thoroughly cleaned after each tape sample was tested to reduce any contamination between the tape samples.

How We Tested the Tapes. All samples were tested for video performance as well as for audio performance. Audio tests were confined to conventional

TABLE 1
VIDEO MEASUREMENTS

Tape Type	S/N Ratios Luma	S/N Ratios Chroma AM	S/N Ratios Chroma PM	Dropouts @ −18 dB Beg 5μs	Beg 15μs	Center 5μs	Center 15μs	End 5μs	End 15μs	Frequency Response (dB) 0.50 MHz	1.25 MHz	2.00 MHz	3.00 MHz	3.58 MHz	Signal Loss (dB)
Laser HQ Plus	48.1	44.1	39.7	127	79	37	21	86	57	0.0	1.3	−0.2	−3.7	−2.8	0.1
Certron High Grade	47.9	43.1	39.1	208	130	83	52	521	334	0.0	1.5	0.0	−3.2	−2.5	0.6
Tozai Prem. Grade	46.8	38.5	35.8	999	837	607	319	852	446	0.0	1.2	−0.5	−3.4	−2.6	0.1
Recoton High Grade	48.5	43.9	39.7	93	54	61	30	159	103	0.0	1.4	0.0	−3.2	−2.5	0.1
Treasury Prem. Grade	46.8	42.3	38.1	166	86	174	106	185	118	0.0	1.5	0.5	−2.7	−1.9	0.0
Windsor Super H.G.	46.6	38.6	36.9	309	190	134	81	941	547	0.0	1.1	−0.6	−3.7	−3.0	0.2
Silver Shadow H.G.	47.6	42.7	39.0	999	385	72	48	105	73	0.0	1.4	0.0	−3.2	−2.5	0.3
Gemini High Grade	46.8	41.6	38.3	106	69	165	115	384	248	0.0	1.3	−0.5	−3.0	−2.2	0.1
Haili	47.6	38.1	34.7	988	563	999	576	999	658	0.0	1.6	0.8	−1.5	−0.7	0.2
Universal Super HG	47.2	40.6	38.0	192	80	155	81	246	150	0.0	1.5	0.0	−2.5	−1.8	0.6
Supra	39.7	30.6	27.5	999	565	826	392	999	821	0.0	0.3	−3.9	−6.8	−6.4	0.0
Mustang Super HG	47.5	42.4	38.8	583	409	75	43	999	476	0.0	1.2	−0.3	−3.5	−3.1	0.3
Reference Tapes (for comparison purposes)															
TDK High Standard	48.4	43.1	39.3	21	13	17	9	23	13	0.0	1.3	−0.3	−3.6	−2.8	0.2
Sony ES	47.9	42.8	39.2	28	15	15	6	23	12	0.0	1.3	−0.5	−3.9	−3.2	0.2
Scotch EG	49.4	43.9	39.7	26	16	11	3	10	3	0.0	1.3	0.0	−3.3	−2.9	0.6

AUDIO MEASUREMENTS

Tape Type	Output @3% THD (volts)	THD −10dB (%)	S/N Ratio A-weighted (dB)	Uniformity (dB) Left	Uniformity (dB) Right	Bandwidth (−3dB) Low, Hz	Bandwidth (−3dB) High, kHz
Laser HQ Plus	0.77	0.15	50.6	0.2	0.7	42.5	11.2
Certron High Grade	0.71	0.17	49.4	0.3	0.6	43.2	11.9
Tozai Prem. Grade	0.80	0.15	51.6	0.6	1.1	43.0	11.0
Recoton High Grade	0.79	0.15	51.2	0.2	0.4	43.1	11.7
Treasury Prem. Grade	0.76	0.15	50.4	0.3	0.4	43.8	11.0
Windsor Super HG	0.71	0.17	48.6	0.4	0.6	43.7	11.9
Silver Shadow HG	0.69	0.16	49.7	0.3	0.6	43.0	11.6
Gemini High Grade	0.81	0.15	51.1	0.7	0.9	43.0	10.8
Haili	0.99	0.16	51.8	0.9	1.2	41.7	9.5
Universal Super HG	0.80	0.18	52.0	0.7	1.4	41.8	9.5
Supra	0.59	0.24	47.1	1.1	1.1	42.4	12.2
Mustang Super HG	0.79	0.18	50.5	0.3	0.4	43.1	11.5
Reference Tapes (for comparison purposes)							
TDK High Standard	0.75	0.15	51.2	0.2	0.4	42.5	10.9
Sony ES	0.82	0.17	51.7	0.2	0.2	43.1	10.7
Scotch EG	0.93	0.15	53.6	0.2	0.2	43.1	10.9

or edge-track recording and playback because the VHS Hi-Fi recording mode is not particularly dependent upon tape quality. Five major video-performance characteristics were measured: luminance (brightness) signal-to-noise ratio, chroma (color) signal-to-noise ratio, dropouts, video frequency response, and signal loss after repeated playings.

Video S/N Ratios. Luminance, or brightness signal-to-noise ratios, were measured with a reference recorded gray level of 50 IRE units. Each tape was then played back and the unweighted noise was measured over a bandwidth extending from 10 kHz to 4.2 MHz, without the chrominance (color) trap at 3.58 MHz.

Chroma signal-to-noise ratio tests were made using a red test-color field corresponding to the colors of a 75% amplitude, color-bar pattern. Both amplitude modulation (AM) and phase modulation (PM) chroma noise were measured over a bandwidth extending from 100 Hz to 500 kHz.

Video Frequency Response. Video frequency response is directly related to picture detail and resolution. The more uniform the response, and the higher the frequency to which it extends, the sharper and more detailed the picture you will be able to record and playback, assuming that your VCR's own frequency response is as good as or better than that of the tape you use.

To measure that important characteristic, APEL used a multi-burst test signal consisting of five bursts at discrete frequencies of 0.5 MHz, 1.25 MHz, 2.0 MHz, 3.0 MHz, and 3.58 MHz. The color-burst signal normally associated with that group of test signals was removed in order to prevent activating the color circuitry of the VCR. That circuitry, when activated in most VCR's, removes all frequencies above 3.58 MHz.

Dropouts. Perhaps the most important characteristic relating to videotape performance is the dropout count in a specified time period. Dropouts cause brief bursts of noise on your TV screen when you play back your tapes. Dropouts of very short duration can often be mistaken for noise, but in fact they represent imperfections in the tape where the video signal actually "drops out" or is substantially lowered in amplitude. Longer dropouts of 15 microseconds or more show up as highly visible and annoying horizontal streaks in a picture being played back. Tape dropouts were measured at three different locations on each tape. Generally, a higher dropout count can be expected near the beginning and end of a tape, while the lowest dropout count should occur near the center.

In our tests, a gray field of 50 IRE units was recorded at each section of the tape for one minute. The tape was played back and any signal reduction of 20 dB or more was counted as a dropout. Duration of the dropout was also measured, and dropouts were divided into short (5 microseconds) and long (15 microseconds or more) categories.

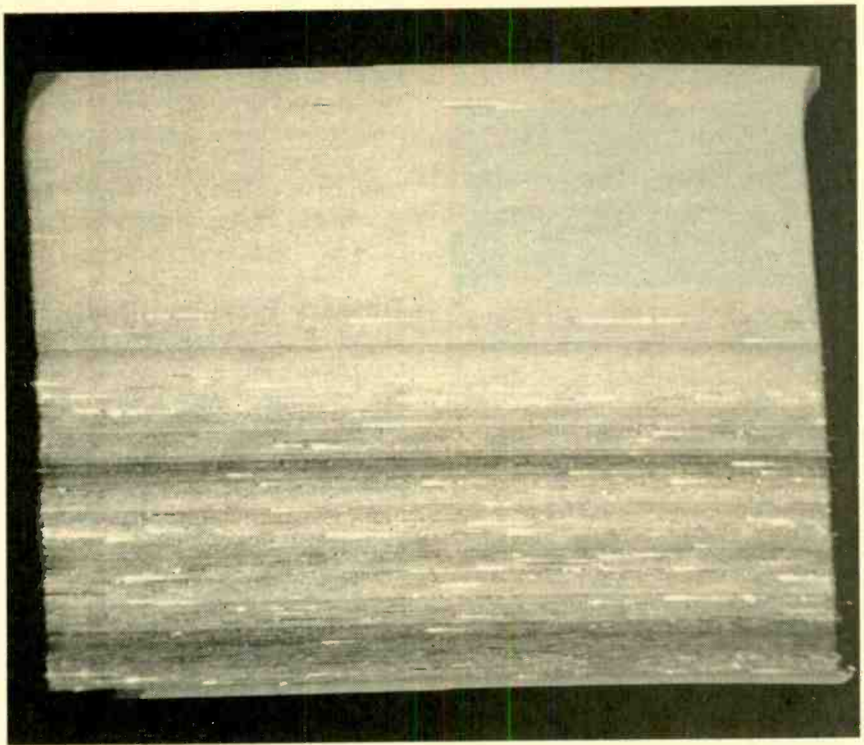


Fig. 1. Tapes carrying the Supra brand were the noisiest tested, with video dropouts exceeding 1000-per-minute.

Signal Loss. Some tapes begin to lose some of their signal with repeated playings. Obviously, if you plan to record an event or a program that you'd like to play over and over again and preserve for a long time, you will want to choose a tape that exhibits a low signal loss with repeated playings. In our measurements, each recorded cassette was played back ten times and the percentage of RF signal loss was measured.

Audio Bandwidth. One of the most important qualities of any audio recording is uniform frequency response or audio bandwidth. Because of the very narrow track and the slow longitudinal speed of videotape, its audio frequency response cannot be expected to be as good as that of even a low-cost audio cassette used in a relatively low-cost audio cassette deck. Nevertheless, some of the tapes tested exhibited somewhat better audio frequency response than did others. Dropouts can affect audio performance just as they can affect video performance. Since the audio track is positioned near the edge of the tape, audio dropouts can often be more serious than video dropouts if the magnetic coating is not uniform out to the very edge of the tape. In our tests of audio performance, a nominal "0-dB" reference level was determined by recording a 1-kHz signal that, when played back, produced 3% total harmonic distortion. The audio signal level available under those conditions was noted and it was against that reference level that other measurements were made.

Total Harmonic Distortion. Total harmonic distortion, or THD, was measured using a 1-kHz signal at a level 10 dB below the reference level. The lower the percentage, the better the tape in this regard. All of the tapes measured well below 0.5% under these test conditions, but there was still a fair degree of variation between them, with Supra offering the poorest readings (0.24%), and Laser HQ, Tozai Premium Grade, Recoton High Grade, Treasury Premium Grade, and Gemini High Grade offering the lowest distortion (0.15%).

Audio Signal-to-Noise Ratio. Audio S/N was measured by first making a recording with the inputs to the VCR shorted. The tape is then played back through an A-weighting network, and the level of noise measured is expressed as a number of dB lower than the reference level established earlier. The higher the dB number, the better the signal-to-noise ratio. All of the tapes except the Supra samples did quite well; better in fact than the capability of most VHS VCR's. In other words, with any of these tapes, the audio signal-to-noise ratio is likely to be a function of your VCR or camcorder rather than of the tape itself.

Uniformity. Audio uniformity measures the tape's ability to reproduce a steady-state audio tone (of 1 kHz) recorded at a constant amplitude for a period of three minutes, on both stereo channels. Variations in output level and even intermittent muting can occur for tapes that exhibit severe dropout characteristics and this is reflected in the test results. The poorest performer in this regard was the Supra tape. That should come as no surprise when you examine the high dropout count of these particular samples.

With that groundwork now out of the way, let's turn our attention to the tapes themselves and look at the highlights of our test results.

Laser HQ Plus. While the long term (15 μs or more) dropout count at the center of these tapes was the lowest of the dozen tapes tested, it was still many times greater than that of any of the reference tapes tested for comparison. Furthermore, dropouts at the

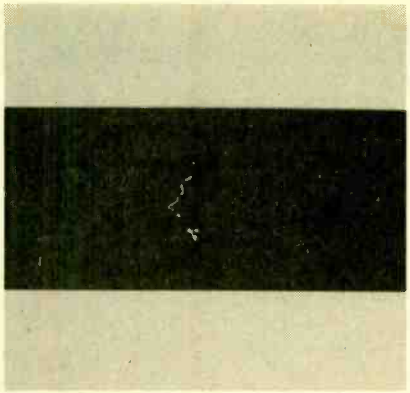


Fig. 2. Two of the three samples of Mustang Super High Grade tape had seriously damaged sections of tape.

beginning and end of the tapes were far beyond acceptable levels. Other video and audio characteristics were, on the whole, acceptable and comparable to those of the three reference tapes. This brand, as well as Certron, Gemini, and Recoton, previously used tape purchased in Hong Kong and Taiwan. All four brands appear to be using mainland China tapes in selected grades only.

Certron High Grade. Here is a tape brand that, in previous tests, yielded far more acceptable dropout numbers. This is typical of a tape distributor who is probably purchasing raw tape from a variety of sources, some better than others. In the case of the current "Made In China" batch tested by APEL, dropout counts were far beyond acceptable limits, both at the ends of the tape and in its center. Were it not for this important failing, other performance characteristics might have been deemed acceptable.

Tozai Premium Grade. Here's a case where APEL simply "stopped counting" short-term dropouts when the count reached over 1000! In addition, this tape exhibited uniformity problems during audio performance measurements.

The investigation, testing and research referred to in this article was conducted solely by the author. The test results, opinions and conclusions are those solely of the author and do not reflect those of the publisher. The publisher makes no representations as to the completeness or accuracy of the investigation, testing, research, test results, opinions or conclusions expressed by the author herein and disclaims any and all responsibility with respect thereto.

Recoton High Grade. As was true of the Laser HQ Plus samples, Recoton seems to control quality a bit better than the less familiar brands tested by APEL. Nevertheless, dropout counts for this so-called "High Grade" tape, even at its center, were higher than that of the low-cost reference tapes used for comparison purposes.

Treasury Premium Grade. This brand of tape is distributed by Thrift Drug Stores. While not apparent from the "averaged" figures shown in our charts, there was tremendous inconsistency among the three samples tested. For example, one sample actually exhibited acceptable long-term dropout counts at the center of the tape (35), while the poorest sample showed 221 dropouts for the same section of tape. There was considerable variation among the three samples in other audio and video performance characteristics as well.

Windsor Super High Grade. This tape, like so many of the other "Made In China" samples, exhibited very high video dropouts, especially at the beginning and ends of the tape. Video signal-to-noise ratios were also below average compared with the standard, low-cost, name-brand tapes measured for comparison purposes.

Silver Shadow High Grade. This brand is distributed exclusively by Woolworth. Two of the three samples tested had extremely high video dropouts and poor uniformity. While the third sample had lower dropout counts at the ends of the tape, but higher center-tape dropouts. In short, there was little consistency in the quality of these tapes from one sample to the next.

Gemini High Grade. Like the Certron and Recoton samples discussed above, previously measured samples of this tape brand made in Hong Kong or Taiwan, exhibited far better performance than the currently measured "Made in China" samples. The current samples were high in dropout counts even at the center of the tape, although other measured parameters compared favorably with the reference standard-grade tapes measured by APEL for comparison purposes.

Haili. These samples were among the worst of all the "Made In China" brands tested by APEL. Dropouts were extremely high over the entire length of all three samples tested. In addition, there were uniformity problems during testing of audio performance. In short, this tape exhibited not a single redeeming feature!

Universal Super High Grade. According to our investigations, this brand of "Made In China" tape has probably been on the market longer than any of the other brands tested. Its most serious problem was poor uniformity, but the samples also exhibited high dropout counts and poor audio bandwidth, as well as higher than average signal loss with repeated playings.

Supra. This brand is sold at Pathmark Supermarkets. APEL had to purchase 11 samples to try to find three that could be tested without damaging the VCR test bed. Video dropouts measured in excess of 1000-per-minute. (See Fig. 1.) These tapes proved to be the noisiest of any tested, both in terms of video and audio signal-to-noise ratios.

Mustang Super High Grade. Two of the three samples tested had seriously damaged sections of tape. (See Fig. 2.) Furthermore, one sample's tape broke while playing in the VCR and had to be repaired before it could be tested. Another sample's damaged tape section had to be removed before testing could be completed.

The Bottom Line. It should be abundantly clear from these test results that Mainland China has not yet mastered the technology required to produce high-quality (or even acceptable quality) videotape cassettes. Here we have a classic case of "buyer beware." Often, these tapes are sold alongside more established and recognizable, quality brands. By assigning "high grade" labels to them and pricing them at levels normally charged for "standard" grades made by reputable, recognized domestic, Japanese, Hong Kong, and Taiwanese tape makers, distributors of these off-brand tapes hope to appeal to uninformed buyers. Don't fall into the trap! ■

CHOOSING and USING

AUDIO and VIDEO TAPE

Select the best tape for any recording job, and ensure that the life of that recording does not end too soon.

BY MARC SPIWAK

Audio and videotape is so common nowadays that nearly everyone uses it on a regular basis. It's unfortunate though, that so many people using tapes don't know how to properly care for them—because tapes can have a very short lifespan if they're not taken care of. There's a lot you should know about tapes that will greatly lengthen their usable life. And if having your tapes in good working order for years to come is important to you, then there's also a lot you should know about what to look for when buying them in the first place.

Magnetic tape is made by coating a thin yet strong "ribbon," or tape, with a layer of magnetic-oxide particles. To record a signal, as the tape passes over the record head in a tape deck, the head arranges the polarity of the magnetic particles in a way that represents the signal. During subsequent playback of the tape, the magnetic particles recreate the original signal as the tape passes over the playback head.

Contrary to what many people believe, a recording on any kind of magnetic tape, digital or otherwise, is never absolutely permanent—especially if the recording will be repeatedly played back. Even though audio and video cassettes have tabs that can be removed to prevent accidental erasure, the coating of magnetic particles on the tape tends to deteriorate over time. Furthermore, playback actually wears away at the tape surface as the tape rubs up against the heads. (That's one reason why CD's are praised as being "indestructible." Nothing but a laser beam physically comes in contact with the recorded area of the disc to wear it out.)

We don't want you to get the impression that the recordings you make today will be gone in just a few years. Tapes stored in a sealed vault kept at precise temperature and humidity levels could probably be saved for your great grandchildren. The problem is that few people are going to go through all that trouble to preserve their tapes. Even so, there have been cases where master tapes have survived for many years, only to have the magnetic coating disintegrate as it is played back. Don't worry, though—with proper care, good quality tapes should deliver many years of entertainment.

Videotape Formats. Before we talk about how to care for videotape, let's first discuss what you should look for when buying videotapes. To begin with, there are many different videotape formats, with different kinds of cassettes.

As far as most consumers are concerned, VHS is today's king of the hill. Most people use VHS for their home-video recording and it's also by far the

VHS cassettes are by far the most common videotapes in use today. Many different grades of this tape are available.

VHS-C cassettes are much smaller than their VHS counterparts, yet they can be played in a standard VHS deck using an adapter that resembles a full-sized VHS cassette. Camcorders that use VHS-C cassettes can be made smaller and lighter, but the standard length of a VHS-C tape is only 20 minutes.

8mm cassettes are even smaller than VHS-C, and they can record two hours of video.

most rented format. Unfortunately, even though VHS is the most common format, it has a poor horizontal resolution—about 240 lines. The horizontal resolution translates into the maximum number of pixels, or individual dots that can be produced (or in this case recorded) on one horizontal line of video; the more dots, the sharper the picture.

Super VHS, or SVHS, has higher horizontal resolution—over 400 lines—but it must be viewed on a monitor with an "S" input to achieve the full benefits of the format. SVHS is not very popular at all. That's probably because you can never record a cleaner picture than what you receive, and for the signal quality most people receive from cable or broadcast TV, VHS is more than adequate. SVHS decks can record in both VHS and SVHS modes, depending on what type of tape is used. VHS and SVHS cassettes look the same, but special magnetic formulations are used in SVHS tapes to achieve higher frequency recording. A slight physical difference between the two cassettes prevents an SVHS deck from recording in the SVHS mode if a VHS tape is loaded. Obviously an SVHS recording can be played back only on an SVHS deck.

Another variation of VHS is VHS-C (or VHS-Compact), whic is a format that was developed fo use in camcorders. Basically, a V -C cassette is a miniature version a VHS cassette, and it contains the ame kind of tape, but in a length of only 20-minutes. That smaller cassette size allows manufacturers to downsize VHS-type camcorders considerably. The VHS-C cassettes can be played back in a conventional VHS deck using an adapter that resembles a full-sized VHS cassette. There's also an SVHS-C format, which is Super VHS tape in a C-sized cassette.

The newest videotape format is 8mm. Although its resolution is about the same as VHS, 8mm uses a much narrower ape than any of the VHS formats to provide two full hours of recording on a small cassette. The format was developed for use in very compact camcorders. Full-sized 8mm decks are also available for home use. They eliminate the wear and tear of playing back all of your 8mm tapes on your expensive 8mm camcorder. Unfortunately, the lack of readily available pre-recorded material has limited the comercial success of 8mm home decks.

A variation of 8mm, called "Hi8," has the same horizontal resolution as SVHS. But again, to see the improved resolution, playback requires an "S" input on the TV monitor.

While Beta is still used in some professional applications, and by some videophiles, the format has pretty much died as far as typical consumers are concerned. Very few places (if any) still rent Beta tapes, and blank tapes are becoming harder to find.

Selecting Videotape. All of the formats we've discussed have a special logo which should be printed on the box. The logo indicates that the tape meets certain specifications, regardless of who made it, and you shouldn't purchase a tape that does not bear the proper logo. Figure 1 shows what the logos look like.

Just as important as the logo is that you buy a good name brand tape that you've had good experiences with. Stay away from cheap no-name tapes that not only don't last very long, but may also damage your deck. A low-grade videotape can have a poor, flaky magnetic coating that will quickly wear away during recording

If you want to record music, these cassettes are the way to go. Perhaps the new DCC's will finally make these obsolete.

Fig. 1. These logos should be printed on the box of each format. Do not purchase a tape that does not bear the proper logo.

and playback—taking audio and video along with it. As the coating wears out, it'll leave heavy oxide deposits on the heads and other internal parts of the VCR. That can shorten the life of your VCR.

Evidence of a poor-quality tape, or one that's very worn out, is the presence of numerous dropouts, or white streaks running horizontally through the picture, and excessive video noise in general. Even if you have good luck with one no-name tape, another tape from the same manufacturer may turn out to be horrible—there's often very little quality control. And the cost advantage of no-name tapes can be as little as a dollar. Is it really worth it to save a dollar in exchange for a short-lived movie and extra wear and tear on your VCR? (For more on that topic, see "Bad Videotapes" elsewhere in this issue.)

For many of the formats we've mentioned, no matter who the manufacturer is, you'll find many different grades of tape; standard, high-standard, high-grade, super high-grade, professional, and so on. The manufacturer will list the recommended uses for the particular grade of tape. Standard-grade tape from a well-known manufacturer is usually more than adequate for everyday use—and certainly much better than any no-name tape. Despite any differences in formulation, there's often very little observable difference between standard and high-grade tape from the same manufacturer.

And note that you do not need any special "Hi-Fi" tape to record Hi-Fi. An all-time favorite movie or irreplaceable camcorder event might be worth investing in Hi-Fi-grade tape, but any decent-quality VHS tape will do fine most of the time. You do, of course, need a Hi-Fi VCR to record Hi-Fi.

General Practices. There are a few procedures and practices that should be followed to consistantly make better recordings. For example, one thing you should consider when recording is the tape speed. Most VCR's can record at two speeds, and many can record at three. That allows you to record 2, 4, or 6 hours of video on a standard T-120 tape. The tradeoff is that the picture and audio quality decrease as you slow down the tape—the picture more so than the audio. Prized recordings should always be done at the fastest speed.

Once you've made some prized videotapes, you'll certainly want to be able to get the most out of them. That can only be done if you maintain your VCR according to the manufacturer's recommendations. Cleaning the heads is mostly what's involved, and there are many different ways to do that. (A snowy picture is usually evidence of dirty heads—or worn out heads.) It's always best to follow the manufacturer's recommendations as to which head-cleaning method you should use. Because a VCR is a very complex device, those less technically inclined should leave maintenance to a professional. Even those who are technically inclined should consult and understand one of the many books and articles on the topic before attempting a VCR maintenance task such as head cleaning.

Many problems can arise when playing videotapes. Sometimes a problem is due to the VCR, but it can also be due to the video cassette. If you encounter a problem with one tape, recreate the conditions using a different tape and see if the problem goes away. If so, the problem is more than likely due to the tape and not the VCR.

Damaged tape—scratched, creased, etc.—can cause a picture to be unstable and contain various flaws. A stretched-out videotape can cause the top of the picture to wave back and forth. If a tape keeps stopping when you play, fast forward, or record, it could be due to binding within the cassette. If a VCR loads in a tape and then shuts down, it could be that the tape is wound too loosely. Should you find that you can't easily get a cassette to eject from the VCR, leave it in and have it properly serviced. Forcefully removing it can damage the VCR and/or the tape. Also, if a cassette seems to be making a lot of noise, it's best not to use it anymore. As a general rule of thumb, if your VCR has trouble with only one or two tapes, then the trouble is probably due to those tapes. If your VCR has trouble with most or all tapes, then the VCR is probably in need of maintenance or repair.

Audio-Tape Types. The audio cassette has been extremely popular for a long time. Four kinds of tape are available, all in the same type of cassette. However, most cassette decks can't record and play all four types of tape. Check your owner's manual to determine which types of tape your deck can use.

The first kind of tape is called "Type I," which is standard, or normal-bias tape. It's coated with a layer of ferric oxide, and can be used in any tape deck. Type II is high-bias tape, with a chromium dioxide magnetic layer. It's also referred to as CrO2, or chrome tape. A deck must have a high-bias setting to use chrome tape. A seldom-seen type III, or ferrichrome tape (FeCr), contains a mixture of both ferric oxide and chromium dioxide. The most advanced tape today, type IV, uses a layer of metal particles. However, to use it, the deck must have metal capability for recording and/or playback.

Concerning no-name audio cassettes: as with video tapes, our advice is don't buy them. And if you stick to a good brand, normal-bias (type I) tape is fine for most applications. As you go from type I to type IV, the signal-to-noise ratio, frequency response, and price increase. So select blank audio tapes according to your taste and budget. Today's best audio cassettes, using various noise-reduction schemes, and a good-quality deck, can capture nearly the full frequency response of a CD, with noise levels that are hardly noticeable.

Two last audio-tape formats worth mentioning are DAT, or Digital Audio Tape, and the soon-to-come DCC's, or Digital Compact Cassettes. DAT's have been around for quite some time, but were plagued with political problems in this country due to their ability to make near-perfect copies of CD's. They have not become popular, though, perhaps due to their high price and limited demand. The newer DCC decks will be able to make a digital recordings on DCC's *and* be able to play your old-style cassettes as well. Only time will tell if this new format will catch on.

Helpful Hints. Once you've captured all the subtleties of your favorite music on cassette, you will no doubt want to hear all those subtleties every time you play the tape. As with videotape, to do that you must keep your tape deck clean according to the manufacturer's recommendations. All parts in the tape path, including the heads, will develop oxide and dirt deposits on them over time. Oxide on the playback head will degrade the quality of the playback. If the record head is dirty, you'll be producing poor recordings to begin with. Dirt on the mechanical parts of the deck in the tape path can cause the deck to eat tapes, which is obviously not a good thing. Try to stay away from cassettes that are supposed to clean your deck simply by playing them—many of these "tapes" are very abrasive and do more harm than good. It's best to use plain old alcohol and cotton swabs (do not use rubbing alcohol that may contain additives that will leave a residue—use pure isopropyl alcohol only). Sometimes the manufacturer will also recommend that the heads be demagnetized. If so, a head demagnetizer is probably available where you purchased the deck.

If your deck is clean and in proper working order, and you still have trouble with a particular cassette, it's probably the cassette itself. A damaged cassette should obviously not be used. Also, a cassette that is very noisy when it operates (squeaky, for example) is a sure sign of trouble, and you should stop using it. If your deck keeps stopping while playing a particular tape, the tape is probably wound unevenly inside the cassette, causing it to stick. Sometimes you can remedy the problem by fast-forwarding and rewinding the tape a couple of times. If that doesn't help, you should discard the tape. Again, the same rule of thumb applies here: if your tape deck has trouble with just a few tapes, then the tapes are most likely at fault. If it has trouble with most or all tapes, then it's the deck.

Care of Magnetic Tape. Now that we know what to look for when buying magnetic tape, let's take a look at what you can do to make your audio and videotapes last as long as possible—aside from keeping your equipment in tip-top shape. Number one is to avoid touching the magnetic tape itself. Oil from your fingertips will damage the oxide.

When you go to play a tape that has been sitting in a warm and damp or cold and dry environment, it's best to wait a couple of hours before playing it. Otherwise, condensation can form on the tape. That can damage the tape itself, as well as the player.

It's also good if you try to minimize stops, fast forwards, and rewinds. Those actions put extra mechanical stress on the tape, which, over time, can stretch and distort—distorting the audio and video along with it.

Never overuse a tape. If you start to notice dropouts where parts of the audio or video are missing, the tape has had it. If you continue to use such a tape, it will probably begin to leave excessive oxide deposits in your deck. A tape that has gone through more than 200 record/playback cycles should be put out to pasture.

When you watch or listen to a tape, it's best to play the entire tape from beginning to end without stopping. Then store it without rewinding it. That's because a tape is wound on the reel with an even amount of tension when it is done slowly in the play mode, and it is best to store a tape when it is evenly wound. Tapes that are stored for long periods without being used should probably be rewound and played through at least once a year. That prevents the windings of tape from sticking to each other.

When you do store a tape, store it vertically. Storing a tape horizontally can damage the edges of the tape. Never store tapes in direct sunlight, and don't leave them in your car. Although you probably don't have much control over these next two items, tapes are best stored at a temperature of about 70 degrees Fahrenheit, and a relative humidity of about 50 percent. Note, however, that heat and humidity are worse for tapes than a cold and dry environment.

Last but not least, it's a good idea to keep tapes away from magnetic fields created by things like speakers and TV's. Actually it would be hard to damage a tape by resting it on top of a TV set or speaker—as proof, we've all probably done that at one time or another. However, long-term storage of a tape on top of a TV might eventually damage it. Airport metal detectors also create potentially damaging magnetic fields. However, the X-ray machines do not.

That's about all we have to say about magnetic tape. If you follow the guidelines we've provided, your tapes should last a lifetime—and maybe even your children's lifetime as well! ■

Learn some of the principles behind wireless communications by building this simple FM transmitter

BY DAN BECKER

Build a 49-MHz FM Transmitter

Today's consumers are offered an ever increasing variety of wireless gadgets, many of which operate in the 46- and 49-MHz FM bands. Walkie-talkies and cordless telephones are but two examples of that. Operating those gizmos is usually very easy. But simply operating them teaches you relatively little about what makes them tick. One way to learn about how such devices work is to build, maintain, and repair a few of those wireless "thingamajigs."

In this article, we are going to show you how to build a low-power transmitter that can be used with any compatible receiver: cordless telephones, walkie-talkies, baby monitors, etc. The *49-MHz FM Transmitter* described in this article, which is powered from a standard 9-volt battery, is capable of outputting 16 mW (milliwatts) of RF power. The circuit contains a voltage-controlled crystal oscillator (VCXO) to ensure RF-carrier stability. That helps to prevent signal drift.

In a frequency-modulated (FM) transmission, the RF carrier frequency (49.890 MHz in our case) must deviate (vary) in direct proportion to the amplitude of the audio or voice signal.

Circuit Description. Figure 1 is a schematic diagram of the 49-MHz FM Transmitter. The circuit consists of an audio amplifier, a low-pass filter, three RF stages, and a regulated-DC power supply.

The audio picked up by the microphone (MIC1) is fed to U2-a (half of an LM358 dual op-amp), which is configured as a non-inverting audio amplifier, the gain of which (approximately 500) is determined by R1 and R28. Capacitor C6 modifies the gain of the audio amplifier, effectively turning it into a high-pass filter. That results in a 13-dB gain at 100 Hz that increases 6-dB-per-octave to yield 33 dB at 1000 Hz.

In order to keep the audio bandwidth below 20 kHz (+/-10 kHz), the output of U2-a is fed to a low-pass filter, consisting of R7/C9. Together the low-pass filter and audio amplifier yield an overall cutoff frequency of about 4 kHz. The resulting signal is then coupled through R8 and R9 to the base of Q1—a buffer stage built around a 2N3904 general-purpose NPN transistor that's configured as a boot-strapped voltage follower. The output Q1 is fed back via C11 to the R8/R9 junction; that prevents Q1 from loading the low-pass filter.

The output of Q1 (taken from its emitter) is fed through R10 (which provides a means of adjusting the peak deviation) to a crystal-controlled Colpitts oscillator comprised of Q2, L1, D1, XTAL1, and several support components. Figure 2 shows a simplified schematic diagram of a Colpitts oscillator. In that circuit, capacitors C16 and C17 and inductor L provide feedback to Q2's input. However, a feedback network made with a conventional inductor would have a Q (quality factor) well below 100, allowing oscillation over a wide band of frequencies. That would make the output signal very unstable. To increase the oscillator's tuning sharpness (Q) and, by extension, its frequency stability, a quartz-crystal resonator is used. Inductor L represents the net result of three separate components: crystal XTAL1, tuning coil L1, and varactor diode D1.

The operation of a quartz crystal is best explained by a simplified equivalent circuit, like the one shown in Fig. 3. That model consists of a series-resonator network made up of C_m, L_m, and R_m, with a parallel capacitor, C_o, shunting the crystal's terminals. At the crystal's series-resonant frequency, the equal and opposite reactances of C_m and L_m cancel each other out, leaving the equivalent series resistance R_m.

However, our Colpitts oscillator requires an inductor between C16 and C17. Therefore, as with any series-resonant circuit, as the applied signal increases in frequency, inductive reactance dominates. Therefore, the crystal resonator is manufactured so that the desired operating frequency is slightly above the crystal's series-resonant frequency. That provides the needed inductor, but one with a Q of several thousand, which sharply tunes the feedback network to a single frequency.

Refer back to Fig. 1. In order to generate an FM signal, it is necessary to modulate the oscillator's frequency. The audio signal from the microphone is used as the modulating source. Diode D1, with a junction capacitance that's inversely proportional to the voltage between its anode and cathode, provides a convenient mechanism for varying the

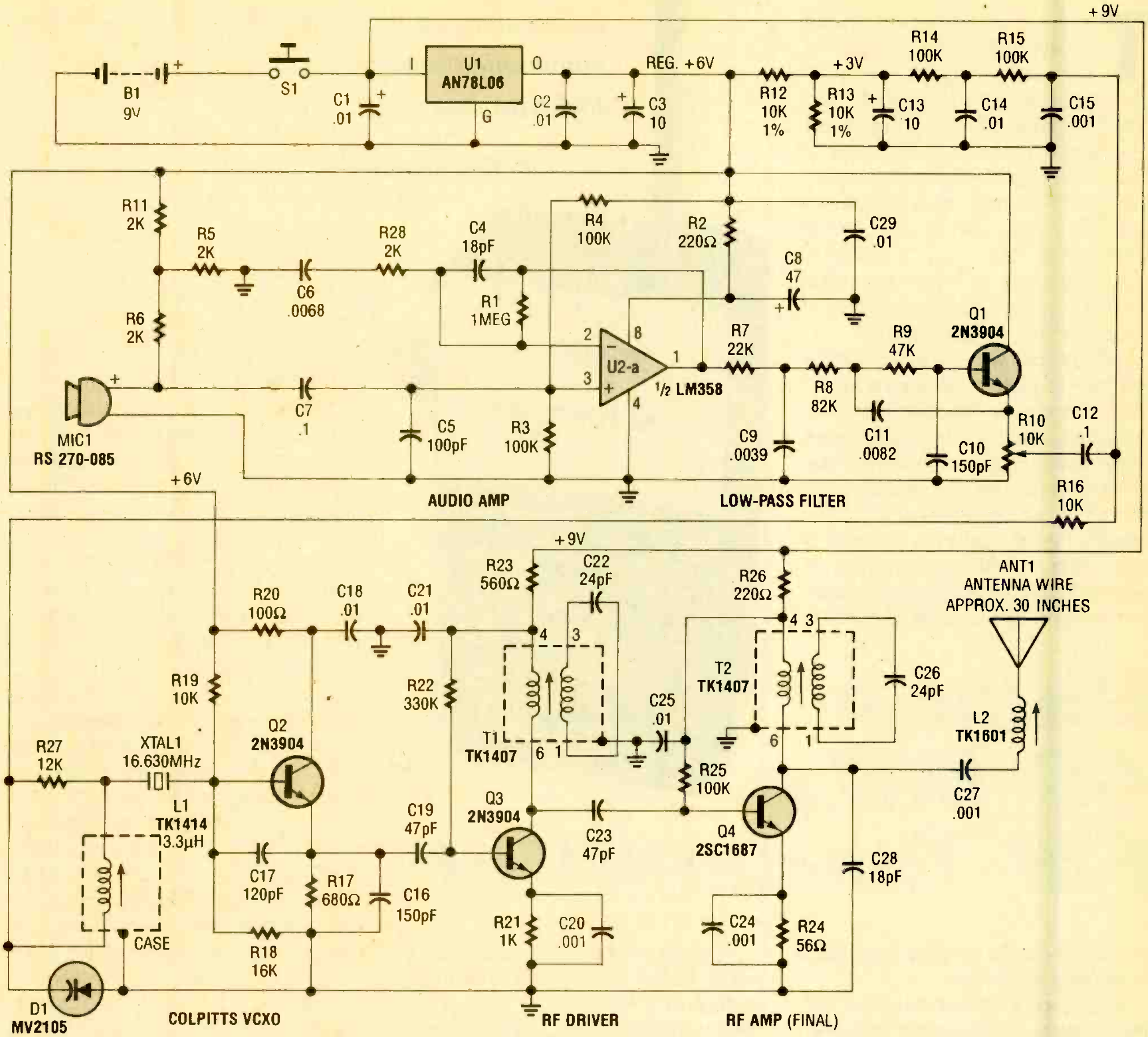


Fig. 1. The 49-MHz FM Transmitter consists of an audio amplifier, a low-pass filter, three RF stages, and a regulated-DC power supply.

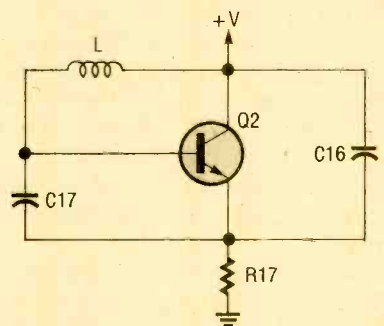


Fig. 2. Shown here is a simplified schematic diagram of a Colpitts oscillator. In that circuit, capacitors C16 and C17 and inductor L provide feedback to Q2's input. Inductor L represents the net result of three separate components: crystal XTAL1, tuning coil L1, and varactor diode D1.

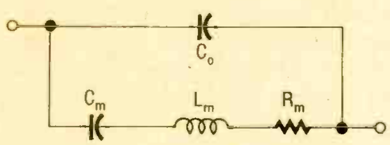


Fig. 3. The operation of a quartz crystal is best explained through this simplified equivalent circuit, consisting of a series-resonator network made up of C_m, L_m, and R_m, with a parallel capacitor, C_o, shunting the crystal's terminals.

resonant frequency of the oscillator's feedback network.

However, since D1 lowers the net inductive reactance of the crystal, L1 is included in the circuit to compensate for the loss. Inductor L1 can also be used to adjust the oscillator to the desired center frequency. Resistor R27 lowers the Q of L1, preventing spurious oscillations that may be caused by L1 resonating with the crystal's shunt capacitance.

Voltage divider R12/R13, along with a pair of low-pass filters (consisting of R14 and C14, and R15 and C15), set D1's quiescent point to 3 volts; that yields a junction capacitance (which varies by about 2-pF/volt of audio signal) of approximately 16 pF. Thus the audio-signal frequency modulates the oscillator. Because it is easier to vary the frequency of a 16-MHz crystal oscillator than that of a 49-MHz crystal oscillator, the circuit operates on the third sub-harmonic of the output frequency. For example, if a 49.890-MHz transmitter signal is desired, a 16.630-MHz crystal would be selected. Because Q2's output is rich in harmonics, the next stage is tuned so that it amplifies only the third harmonic (49.890 MHz) and ignores the 16.630-MHz fundamental frequency.

Since the third harmonic produces three times as much deviation as the oscillator's fundamental frequency, varying the fundamental frequency by +/-1.67 kHz yields a +/-5 kHz deviation at 49.890 MHz. That greatly reduces the demand on our reactance modulator. The output of oscillator is fed to the emitter-base junction of Q3 (an RF driver stage) through C19. By making C19 small (47 pF), Q3's low input impedance does not load or detune the oscillator. Resistors R21–R23 set Q3's quiescent DC emitter current to a fraction of a milliamp. However, drive from Q2 automatically increases that current to a few milliamps, producing significant RF-power gain. Capacitors C20 and C21 bypass RF current to prevent degenerative feedback.

A resonant tank circuit, comprised of T1 and C23, filters Q3's highly distorted collector current by creating a high impedance at 49-MHz, but a low impedance at the oscillator's fundamental and second harmonic. That allows Q3's collector to drive Q4 with a reasonably clean, 49.890-MHz signal through C23. The next RF-output stage, built around Q4, works pretty much like the Q3 driver stage. However, DC bias resistors R24–R26 are noticeably smaller than their Q3 counterparts. That causes a larger DC emitter current, and results in greater RF gain.

As with Q3, a resonant-tank circuit (consisting of T2 and C26) filters Q4's somewhat-distorted collector current. A reasonably clean output signal is taken from Q4's collector, and used to drive the antenna. The antenna-loading coil, L2, is used to tune out capacitive reactance, allowing Q4 to see a more resistive load. Capacitor C27 blocks Q4's DC collector voltage, while coupling its RF output to the antenna. Capacitor C28 improves the impedance match between Q4's output and the antenna, in addition to suppressing any spurious VHF emissions.

Power for the circuit is supplied by a 9-volt battery (B1). Alternatively, the circuit can be operated from any 9-volt DC source that's capable of supplying about 20 mA or so.

When S1 is pressed, 9-volts DC is applied across C1 to voltage regulator U1. Capacitor C1 protects U1's input from stray RF and voltage spikes. Integrated-circuit U1 regulates its 9-volt input to deliver 6-volts DC to all of the circuit except for the RF driver and final stages. If a regulator were not used, the RF carrier frequency could drift or change as the battery voltage decreased with age. Capacitors C2 and C3 minimize the noise and voltage spikes that are often generated by low-cost voltage regulators like U1.

Construction. The author's prototype was assembled on a printed-circuit board that measures about 1¹⁵⁄₁₆ by 2 inches. A full-size template of the printed-circuit artwork is shown in Fig. 4. Once you've etched your own board and gathered the parts listed in the Parts List, construction can begin. Most of the specified component values are not critical; so if your junkbox contains a reasonably close value to the one specified, use it. If you have a reasonably well-stocked parts bin, you probably already have more than half (if not all) of the passive components.

A parts-placement diagram for the printed-circuit board is shown in Fig. 5. It is recommended that an IC socket be provided for U2. Before you begin assembling the project, it is important that you decide at what frequency the circuit is to operate. The frequencies shown in Table 1 correspond to the 46- and 49-MHz cordless-tele-

PARTS LIST FOR THE 49-MHZ FM TRANSMITTER

SEMICONDUCTORS

U1—AN78L06 6-volt, 100-mA, low-power voltage regulator, integrated circuit
U2—LM358N low-power dual op-amp, integrated circuit
Q1, Q2, Q3—2N3904 general-purpose NPN silicon transistor
Q4—2SC1687 RF-amplifier, NPN silicon transistor
D1—MV2105, 15pF at 4-volts, varactor tuning diode (Motorola)

RESISTORS

(All fixed resistors are ¼-watt, 5% units, unless otherwise noted.)
R1—1-megohm
R2, R26—220-ohm
R3, R4, R14, R15, R25—100,000-ohm
R5, R6, R11—2000-ohm
R7—22,000-ohm
R8—82,000-ohm
R9—47,000-ohm
R10—10,000-ohm, trimmer potentiometer
R12, R13—10,000-ohm, 1%
R16, R19—10,000-ohm
R17—680-ohm
R18—16,000-ohm
R20—100-ohm
R21—1000-ohm
R22—330,000-ohm
R23—560-ohm
R24—56-ohm
R27—12,000-ohm
R28—2000-ohm

CAPACITORS

C1, C2, C14, C18, C21, C25, C29—0.01-µF, ceramic-disc
C3, C13—10-µF, 16-WVDC, tantalum
C4, C28—18-pF, ceramic-disc
C5—100-pF, ceramic-disc
C6—0.0068-µF, metallized-film
C7, C12—0.1-µF, metallized-film
C8—47-µF, 16-WVDC, electrolytic
C9—0.0039-µF, metallized-film
C10, C16—150-pF, ceramic-disc
C11—0.0082-µF, metallized-film
C15, C20, C24, C27—0.001-µF, ceramic-disc
C17—120-pF, ceramic-disc
C19, C23—47-pF, ceramic-disc
C22, C26—24-pF, ceramic-disc

ADDITIONAL PARTS AND MATERIALS

L1—TK1414 3.3-µH, 7.96 MHz Toko coil
L2—TK1601 1.6-µH, 25.2-MHz Toko antenna-loading coil
T1, T2—TK1407 0.41-µH, 49-MHz Toko RF transformer
MIC1—Electret microphone element
XTAL1—16.630-MHz, 32-pF parallel-resonant crystal
B1—9-volt alkaline transistor-radio battery
S1—SPST momentary contact pushbutton switch
Printed-circuit materials, antenna (27-inch whip or length of #22 wire), enclosure, 8-pin DIP socket, wire, solder, hardware, etc.

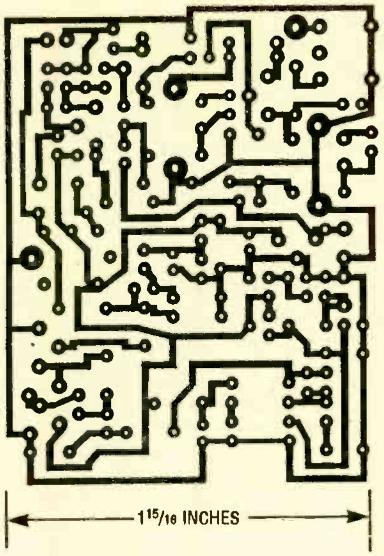


Fig. 4. The author's prototype was assembled on a printed-circuit board that measures about 1 15/16 by 2 inches. This full-size template of the printed-circuit artwork is provided so that you can etch your own printed-circuit board.

phone channels. However, many of those frequencies are also used by walkie-talkies, baby monitors, and numerous other wireless and experimental devices. To determine the required crystal frequency for the transmitter, divide the given channel frequency by three.

Once you've decided on the frequency of operation for your transmitter and obtained the required crystal, assembly can begin. Start by installing an IC socket where U2 is indicated in Fig. 5, and then install the passive components surrounding the socket. When assembling the circuit, mount all of the components close to the circuit board to keep lead length (and thus its reactance) to a minimum. Note: Because of the density in component placement, most of the resistors are mounted vertically.

Also note that except for the three electrolytic and the two metallized-film capacitors, all of the capacitors are low-voltage ceramic-disc units. After the passive components have been installed, mount and solder the semiconductors in place. Connect the positive lead of the battery connector in series with a SPST switch, making sure that that subassembly has sufficient (but not over abundant) lead length to reach the switch's mounting location. Connect that subassembly to the points on the board shown in Fig. 5. Finally, connect lengths of wire to the board where MIC1 and ANT1 are indicated.

The next step is to prepare the enclosure. Any enclosure of sufficient size can be used to house the 49-MHz FM Transmitter; just remember that the enclosure should have sufficient room to accommodate the circuit board as well as the off-board components (S1, ANT1, B1, and MIC1).

The first step in preparing the enclosure is to select a site on or within the enclosure for the off-board components—S1, MIC1, and ANT1. Drill holes at the selected sites for the components that will be located there. Mount the off-board components to the enclosure, and connect them to the circuit using the previously installed hook-up wire.

Note: If you intend to power the circuit from an alternate power source (a wall adapter, for example), install a 10-μH miniature RF choke in series with each supply lead, and then connect the positive lead in series with an SPST switch.

If you intend to use a telescoping whip antenna, be certain that it includes mounting hardware. Most

(Continued on page 92)

TABLE 1—FREQUENCY ALLOCATION

CHANNEL	BASE TRANSMITTER (MHz)	HANDSET TRANSMITTER (MHz)
1	46.610	49.670
2	46.630	49.845
3	46.670	49.860
4	46.710	49.770
5	46.730	49.875
6	46.770	49.830
7	46.830	49.890
8	46.870	49.930
9	46.930	49.990
10	46.970	49.970

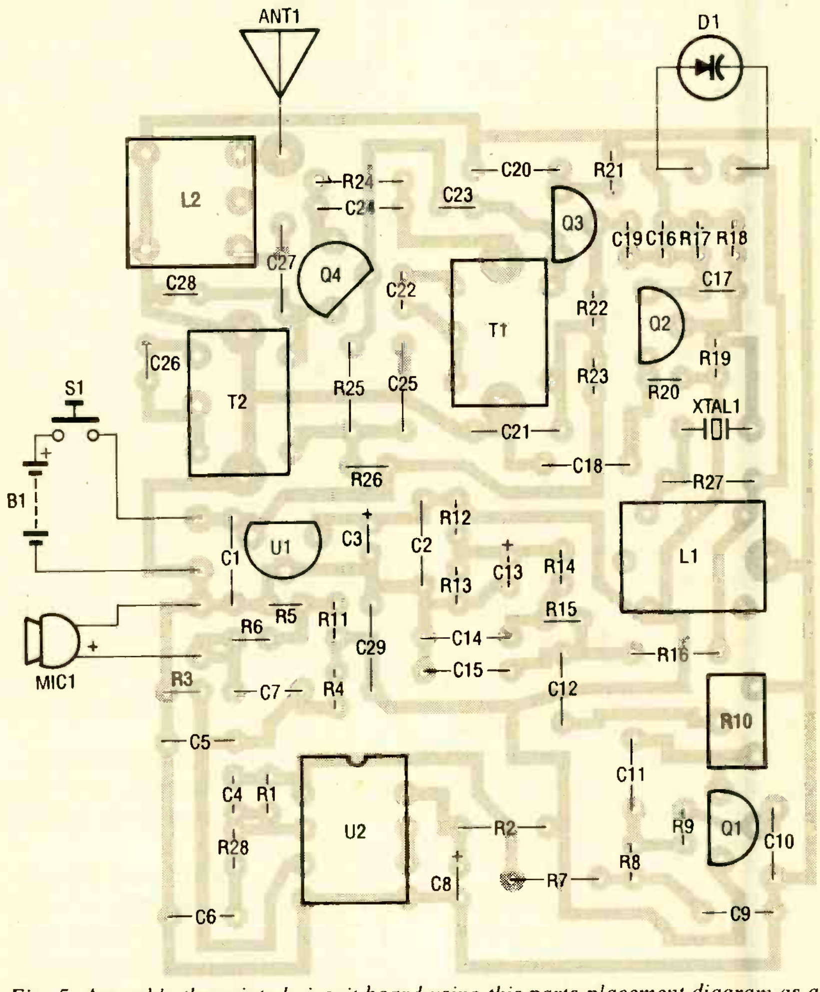


Fig. 5. Assemble the printed-circuit board using this parts-placement diagram as a guide. It is recommended that an IC socket be provided for U2. Before you begin assembling the project, however, it is important that you decide on what frequency the circuit is to operate and to select a crystal accordingly.

BY TERRENCE VAUGHN

Using a cable-ready VCR as a tuner can, in many cases, save the cost of renting a cable box. Unfortunately, doing so means always having to turn two units (both the TV and VCR) on or off due to the lack of switchable accessory outlets. Admittedly, that's a minor annoyance, but it is a constant one. Tiring of that inconvenience, I came up with the *VCR/TV Auto-Switch* described in this article.

What the VCR/TV Auto-Switch does is monitor the baseband-video output of your VCR. When a video signal is detected, the VCR/TV Auto-Switch automatically turns on your TV set or video monitor. Note, however, that this approach will not work with a television that stores channel or volume information in a volatile memory.

Build an Automatic Power Switch for your TV

Add an accessory outlet to your video system that turns on your TV whenever your VCR is turned on

How It Works. A schematic diagram of the VCR/TV Auto-Switch is shown in Fig. 1. The circuit is comprised of a 24-volt center-tapped transformer (T1), a 1-amp, 100-PIV fullwave bridge rectifier (BR1), and two 12-volt regulators (U1 and U2), which form a dual-polarity, regulated, power supply; a dual BiFET op-amp (U3) and a general-purpose NPN silicon transistor (Q1), which form the basis of a signal detector/trigger circuit; a 12-volt relay (K1); two AC sockets (SO1 and SO2); and a few additional components.

A voltage divider formed by R5 and R6 provides a very small positive offset to the inverting inputs of both U3-a and U1-b to help prevent false triggering. The circuit takes its input from the baseband-video output of your VCR via PL2 (an RCA plug that mates with the video-output jack of the VCR). When switches S1 and S2 are in the positions shown and the VCR is turned off, no signal is applied to the circuit (through PL2), so the input to op-amp U1-a is at zero volts, forcing its output low. That low is applied to the non-inverting input of U3-b, forcing its output low. The low output of U3-b holds Q1 at cutoff, keeping relay K1 from energizing, and the TV connected to SO2 from turning on. Note that when there is no signal present, the output of U3-b swings close to the negative supply rail, producing a negative voltage that exceeds the emitter-base breakdown voltage of Q1. Diode D2's function is to block the negative going output of U3-b, thereby preventing damage to Q1.

On the other hand, when the VCR is turned on, a baseband-video signal is applied to the circuit at PL2. That signal is routed to the non-inverting input of U3-a, causing the output of that op-amp to swing positive. The output of U3-a is fed through diode D1 (which passes only the positive portion of the signal), causing C11 to charge. Diode D1 also prevents the charge on C11 from being discharged through U3-a during U3-a's negative-going output transition. The charge on C11 is bled off via R7 during the negative-going output transition and power is removed from the circuit. The C11/R7 combination also forms a glitch filter, which provides a short time-delay that prevents a momentary signal loss from cycling the television or monitor off and on.

The output of U3-a is applied to the non-inverting input of U3-b, causing its output to go high. That high is applied to the base of Q1 through D2 and R8, causing Q1 to turn on.

When Q1 conducts, it, in turn, completes the ground path for the relay, causing it to energize. With the relay energized, AC line voltage is applied to SO2, automatically turning on the TV. Diode D3 is used to protect Q1 from the inductive kickback (spikes) caused by the relay's collapsing field. Without that protection, an inductive spike could cause Q1 to short, turning it into a three-legged Zener diode. That would result in the TV being on continually.

Switch S1 allows you to choose between auto and manual operation. When S1 is placed in the MANUAL position and S2 is set to the ON position, a positive voltage from the power supply is applied to the non-inverting input to U3-a, causing the TV to turn on as if the circuit were in the auto mode

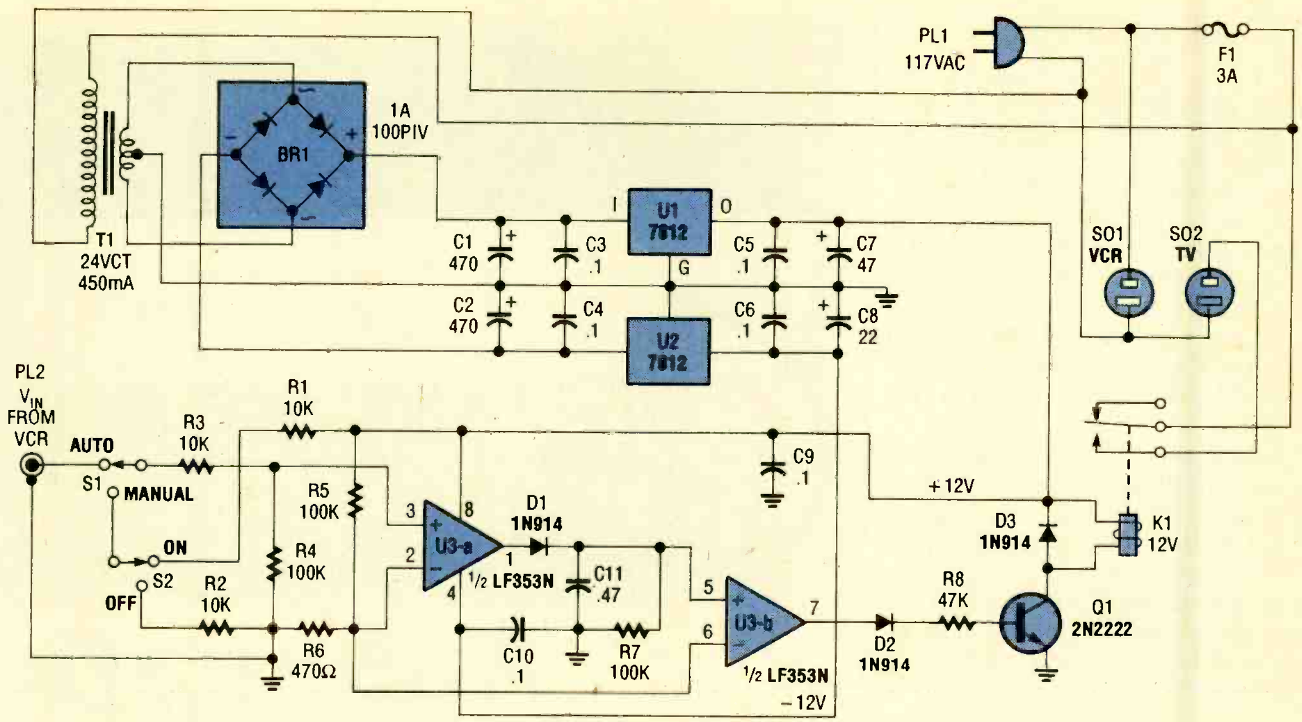


Fig. 1. The VCR/TV Auto-Switch is comprised of a 24-volt center-tapped transformer (T1), a 1-amp, 100-PIV, fullwave bridge rectifier, and two 12-volt regulators (U1 and U2), which form dual-polarity, regulated, power supply; a dual BiFET op-amp (U3) and a general-purpose NPN silicon transistor (Q1), which form the basis of a signal detector/trigger circuit; a 12-volt relay (K1); two AC sockets (SO1 and SO2); and a few additional components.

and a video signal from the VCR were present.

Construction. As shown in the photo, the author's prototype of the VCR/TV Auto-Switch was assembled on a section of copper-clad experimenter's board and point-to-point wiring was used to make the component interconnections. When assembling the circuit, all of the standard project-building precautions apply: Keep all leads as short as possible, and all power-supply bypass capacitors (C3–C6, C9, and C10) should be mounted as close to their respective IC's as possible. It is also recommended that an IC socket be provided for U3 (the op-amp).

Because 117-volts AC is applied to the circuit board via the relay, the board must be securely mounted on standoffs. In addition, wire connections to the relay should be made with wire of sufficient size to handle the AC-line voltage. Instead of enlarging the pre-drilled holes in the experimenter's board to accommodate 18-gauge (line-cord size) or heftier wire, the author used dual strands of 20-gauge hook-up wire for the relay, which is more than equal to a single 18-gauge wire. Mount the relay to the board and connect short lengths of wire to the relay contacts. Do not connect the relay-contact wires to SO2 and the AC line at this point; you will be instructed when to do so later on, during the checkout procedure.

Note that the circuit contains two AC sockets (SO1 and SO2): The two sockets are actually a single, standard duplex AC wall-outlet. The socket should be of the type that has break-away tabs between the two outlets. As shown in the schematic diagram, the cold (or neutral, large-spade side) remains as normal; however, the two hot tabs have been separated, with the hot side of SO1 going directly to the AC line, and the hot side of SO2 going to the relay's wiper.

For safety reasons, it is also important that the duplex socket (which is

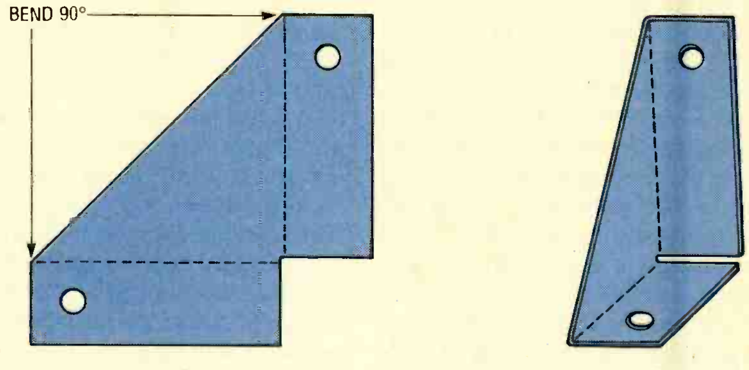
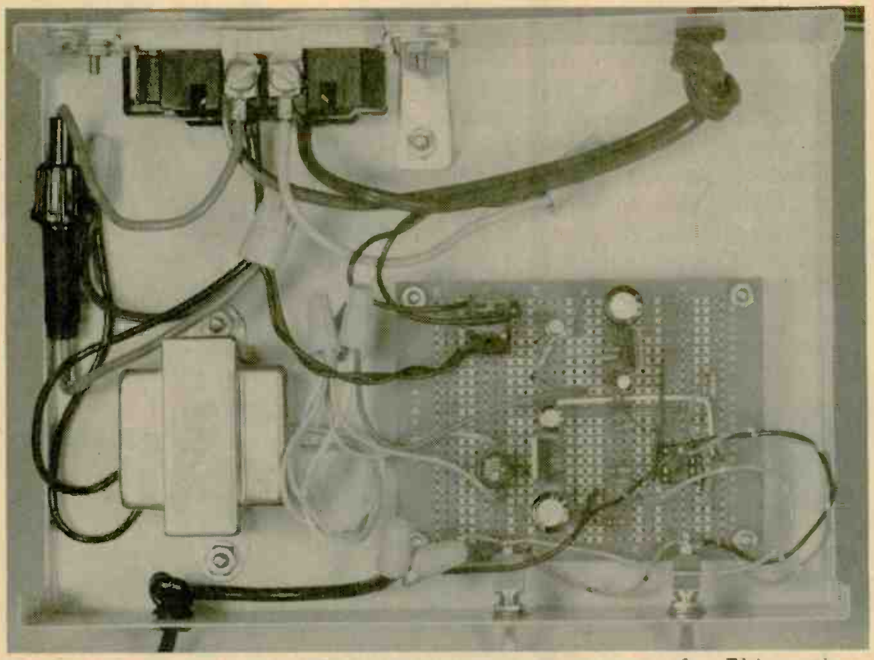
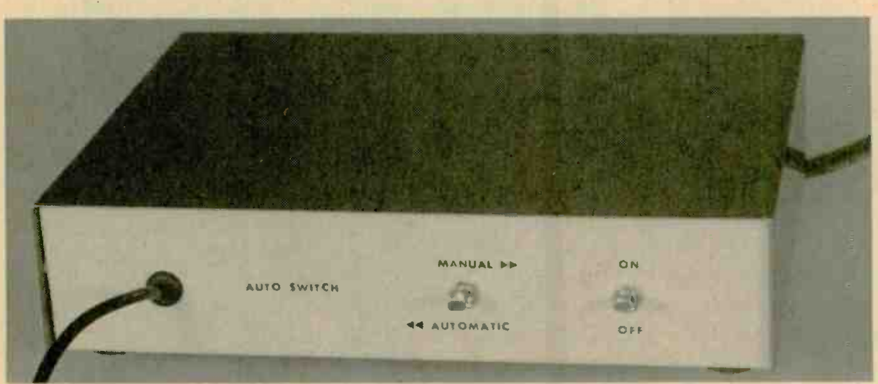


Fig. 2. For saftey reasons, it's also important that the duplex socket mounted to the rear panel of the enclosure be able to withstand power-cord insertion force without the case flexing and possibly forcing the AC wiring to contact the case or other components. To that end, reinforcing brackets fabricated from scraps of sheet aluminum were placed at one end (either end) of the outlet, although placing brackets at both ends makes for a much sturdier project.



Here is an inside view of the VCR/TV Auto-Switch. In the prototype, fuse F1 is not the board-mounted type; instead the author chose to use an in-line fuse. The enclosure for the project has enough space for the circuit board, as well as all of the off-board components.



Once the project enclosure has been drilled, labels can be affixed to the front and rear panels to indicate switch functions, and outlet designations.

PARTS LIST FOR THE VCR/TV AUTO-SWITCH

SEMICONDUCTORS

U1—7812 12-volt, 1-amp, positive voltage regulator, integrated circuit
U2—7912 12-volt, 1-amp, negative voltage regulator, integrated circuit
U3—LF353N or TL082 dual BiFET op-amp, integrated circuit
Q1—2N2222A general-purpose NPN silicon transistor
D1–D3—1N914 general-purpose, small-signal diode
BR1—1-amp, 100-PIV, fullwave bridge rectifier

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1–R3—10,000-ohm
R4, R5, R7—100,000-ohm
R6—470-ohm
R8—47,000-ohm

CAPACITORS

C1, C2—470-µF, 35-WVDC, electrolytic
C3–C6, C9, C10—0.1-µF, 50-WVDC, monolithic-ceramic or ceramic-disc
C7—47-µF, 35-WVDC, electrolytic
C8—22-µF, 35-WVDC, electrolytic
C11—0.47-µF, 35-WVDC, tantalum

ADDITIONAL PARTS AND MATERIALS

T1—24.6-volt, center-tapped, 450-mA transformer
F1—3-amp, fast-acting fuse
K1—SPDT 12-volt relay (Omron G2E-184P, All Electronics catalog #RLY 787)
S1, S2—SPDT toggle switch
PL1—Polarized AC power plug with line cord
PL2—Video dubbing (patch) cord, see text
SO1, SO2—117-volt duplex AC outlet
Experimenter's board, enclosure, fuse holder, 8-pin socket, standoffs, strain-reliefs or grommets, wire, solder, hardware, etc.

mounted to the rear panel of the enclosure in the prototype) be able to withstand the power-cord insertion force without the case flexing and possibly forcing the AC wiring to contact the case or other components. To that end, reinforcing brackets fabricated from scraps of sheet aluminum were placed at one end (either end) of the outlet, although placing brackets at both ends makes for a much sturdier project. Figure 2 gives details on how to fabricate the bracket(s).

Since the project is intended to be in constant use, it does not have a power switch; however, adding one certainly wouldn't hurt anything. It is essential that a polarized AC power cord be used to connect the circuit to the AC source. That's because the relay can interrupt only one line and that really should be the hot (small spade) side of the AC line cord. Modern electronics gear (particularly VCR's and TV's) may (and often do) also require the correct polarity. A three-wire plug and cord (with the ground wire connected to the case) is even better for PL1.

When it comes to PL2, you have a couple of options: You could use a jack instead of a plug for PL2, and use an RCA patch cord to connect the circuit to your VCR; or you can do as the author did, cut the connector from one end of a patch cord and connect the wires directly to the circuit board. With the latter arrangement, you could simply plug the unit into the VCR's baseband-video output.

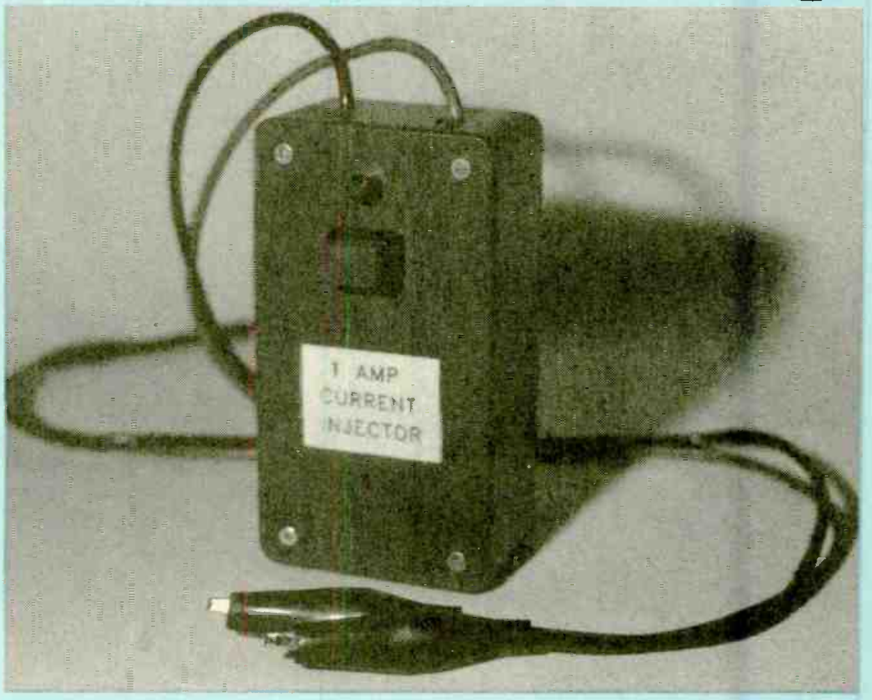
If you opt for the latter arrangement, cut off one of the RCA plugs and carefully remove one inch of the thin outer insulation, exposing the braided sheath. Bend the cable at the end of the insulation and spread the braid away from the bend. Pull the inner cable through the opening in the braid. Strip about ½ inch of insulation from the inner cable. Connect

(Continued on page 89)

Build a One-Amp Current Injector

If your multimeter is stumped when it comes to reading very low resistance, then this is the multimeter accessory you should build to extend its range.

BY DAVID A. JOHNSON



Have you ever been frustrated by your digital multimeter when trying to measure resistance below one ohm? If so you're probably not alone because most meters will only measure resistance down to the nearest 0.1 ohm. Well, in this article we'll show you how to build a DMM accessory that will enable you to accurately measure a resistance down to the nearest 0.0001 ohm. The unit injects a precise amp of current into the resistance to be tested. Then you simply use your DMM to measure the voltage drop produced by the injected current. With typical meters, resistances from 1 ohm to 0.0001 ohm can be measured with the aid of the current injector.

You should be able to find may uses for the unit. I have used it to measure shunt resistors, circuit-board-trace resistance, relay/switch contact resistance, and motor/transformer winding resistance. You can even use it to determine a wire's gauge by measuring its resistance per unit length or to test diode rectifiers or transistors at 1 amp.

It has some nice features. For example the injector circuit is powered from two "C" cells and features a power-on LED that doubles as a weak-battery indicator. Should the batteries need to be replaced, the LED will fail to turn on during operation.

How it Works. Figure 1 contains the schematic diagram for the One-Amp Current Injector circuit. The unit can be divided into three main sections: power supply, current controller, and battery-voltage monitor. Let's examine the power-supply section first.

The circuit is powered by two "C" cells, B1 and B2. A pushbutton switch (S1), which connects the batteries to the circuit, ensures that the system only draws power momentarily. The momentary operation of the switch also discourages prolonged measurement times, increasing the number of measurements that can be taken before the batteries need to be replaced. The large 100-µF capacitor (C1) helps dampen transients caused by the heavy DC current drawn from the battery during operation.

Because much of the unit's electronic circuits function better at more than 3-volts, the circuit contains a simple flyback voltage converter. It is based on a CMOS version of the classic 555 timer (U1) wired as a non-standard astable oscillator. When pin 7 of the timer (used as an active-low output in this circuit) turns on, current flows into the inductor (L1) from the 3-volt battery supply. When pin 7 turns off, the energy stored in the inductor emerges as a short voltage pulse, higher in amplitude than the supply voltage. Those voltage pulses are routed to a filter capacitor (C3) through a diode (D1). With the component values chosen, the voltage produced at C3 ranges from about 9 to 12 volts.

The current-control section uses a power MOSFET (Q1) to set the amount of current passed through the unknown resistance (R_x). By controlling the voltage applied to the gate terminal of the FET, it can be made to behave as a variable resistor and can, therefore, vary the current as needed.

For that reason, one comparator in an LM393 IC supplies the FET with a gate-control voltage. That section of the IC has been configured to operate as an operational amplifier with

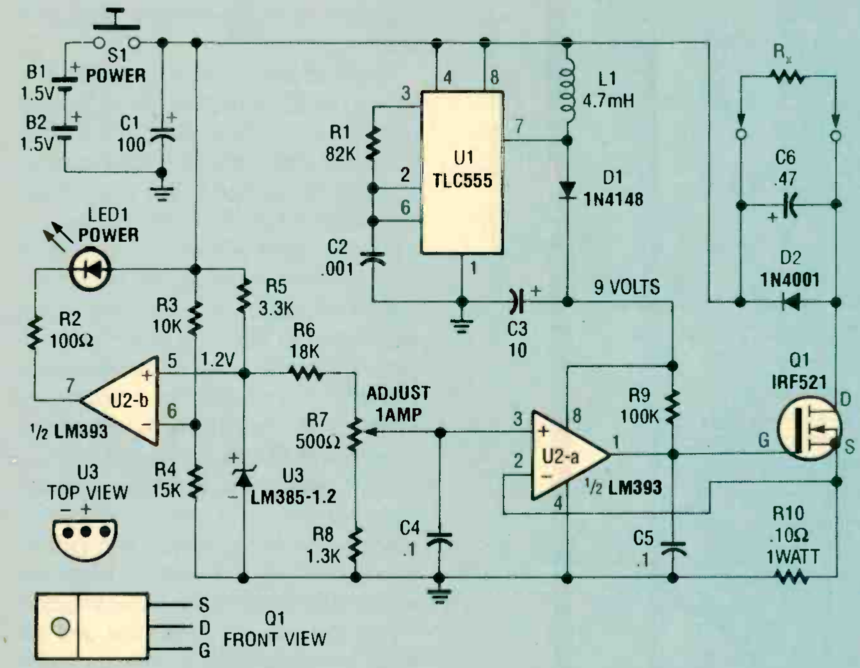


Fig. 1. The current injector can be broken down into three sections: the power supply (containing a DC-to-DC converter), a current-control circuit, and a battery monitor.

the aid of a resistor (R9) and a capacitor (C5). The two components form a filter network that helps stabilize the voltage fed to the FET. A regulated voltage, developed by a voltage-reference IC (U3) and a resistor (R5), is connected to the noninverting input of U2-a through a voltage-divider network consisting of R6, R7, and R8. The noninverting-input voltage sets the voltage level controlling the FET. Potentiometer R7 allows you to select the value of the noninverting-input voltage so you can precisely adjust the injector's output current to 1-amp.

The injector's output current, which passes through the unknown resistance and the FET (Q1), is also forced through an internal current-monitoring resistor (R10). The voltage developed across R10 is therefore proportional to the injector's output current. The current-monitoring voltage produced by R10 is fed to the inverting side of the control IC (U2-a). So the IC's output supplies the gate of the FET with the correct voltage to maintain the unit's output current at a fixed level.

Diode D3 and capacitor C6 are wired across the output terminals as protection. They absorb any energy that may be sent back to the circuit if you happen to measure a resistor with a large inductance.

The battery-monitor section also performs an important task. With two fresh "C" cells installed in the unit, a nominal 3-volts is supplied to the current control circuit. However, during operation, the battery voltage will drop. The unit will continue to operate properly as long as the battery voltage remains above 2-volts. The battery monitor's job is to light the power LED (LED1) as long as the battery voltage remains above 2-volts. Should the circuit need new cells, the LED will fail to turn on.

To do its job, the battery monitor uses the second half of the dual-comparator IC (U2-b). It is wired as a classic voltage comparator. The regulated voltage from the voltage reference IC (U3) is compared to a voltage developed by a voltage divider (made of R3 and R4) that is connected to the cells. As long as the voltage from the divider is greater than the reference voltage, the output of the comparator remains low, turning on the power indication LED.

Construction. As illustrated in Fig. 2, the unit's circuitry is housed in a project box (the author's was plastic) that you can purchase from almost any electronic-parts supply store. Using the figure as a guide, first glue a two "C"-cell holder to the inside bottom of the box, with the holder pushed to one end. Drill two 5/32-inch holes through the other end of the box to allow the injector's two current-carrying wires to exit. Then drill a 3/8-inch hole for the power switch and a 1/4-inch hole for an LED holder through the top cover of the box. With the holes drilled, you can then install the

PARTS LIST FOR THE ONE-AMP CURRENT INJECTOR

SEMICONDUCTORS

U1—TLC555CP CMOS oscillator timer, integrated circuit
U2—LM393N dual comparator, integrated circuit
U3—LM385BZ-1.2 voltage reference, integrated circuit
Q1—IRF521 or IRFZ12, 50-volt, 0.3-ohm power FET
D1—1N4148 general-purpose diode
D2—1N4001 1-amp, 50-PIV rectifying diode
LED1—Light-emitting diode, red, super-bright T-1¾ style

CAPACITORS

C1—100-µF, 10-WVDC, aluminum electrolytic
C2—1000-pF, 50-WVDC, ceramic or Mylar
C3—10-µF, 25-WVDC, aluminum electrolytic
C4, C5—0.1-µF, 50-WVDC, ceramic or Mylar
C6—0.47-µF, 50-WVDC, Mylar

RESISTORS

(All fixed resistors are ¼-watt 5% units unless otherwise indicated.)
R1—82,000-ohm
R2—100-ohm
R3—10,000-ohm
R4—15,000-ohm
R5—3300-ohm
R6—18,000-ohm
R7—500-ohm multi-turn trimmer potentiometer (Digi-Key CEG52 or equivalent)
R8—1300-ohm
R9—100,000-ohm
R10—0.1-ohm, 1-watt, (Digi-Key SC1A0.1 or equivalent)

ADDITIONAL PARTS AND MATERIALS

B1, B2—alkaline "C" cell
L1—4.7-mH choke coil (Digi-Key TK4320 or equivalent)
S1—Normally open, SPST, momentary-contact switch
Printed-circuit or perfboard, LED holder, 2 "C"-cell holder, enclosure, transistor heat sink, red and black hook-up wire, alligator clips (or equivalent), solder, etc.

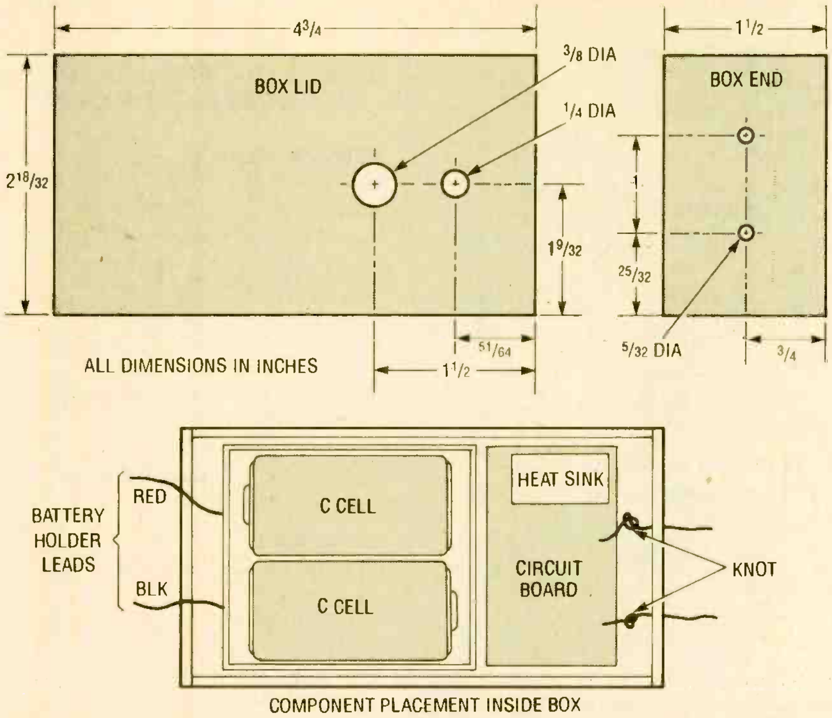


Fig. 2. If you drill your enclosure to these specifications you'll make the task of final assembly a lot easier. Remember to use a holder for the LED.

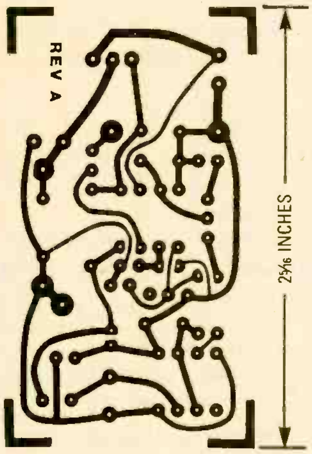


Fig. 3. Using this foil pattern to generate a printed-circuit board will make the assembly of your own current injector a snap.

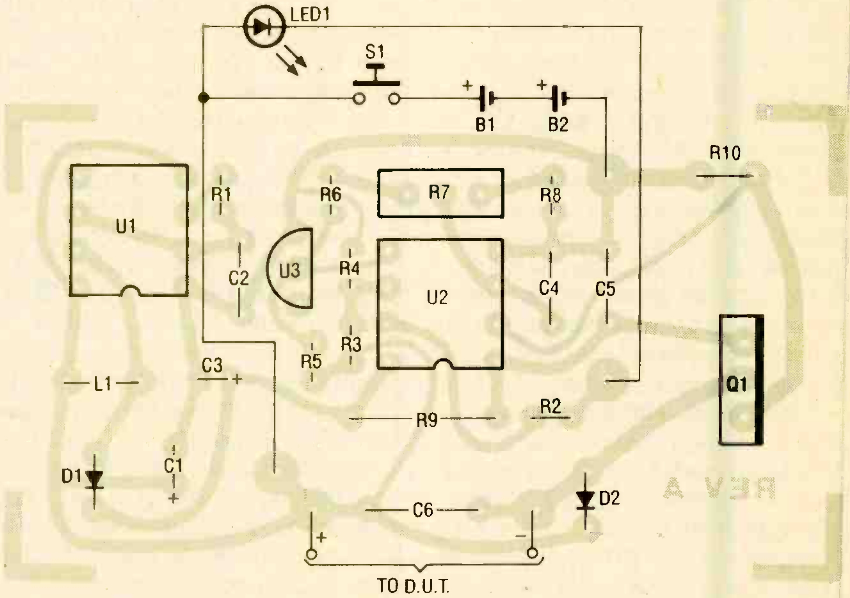


Fig. 4. Follow this diagram to stuff the circuit board. Be sure to orient all the polarity-sensitive parts properly as you proceed.

power switch and the LED (with a holder) in the top of the box.

Next, you'll need to build the rest of the circuit on a suitable platform. The circuit is not complicated and could easily be built breadboard-style. Alternatively, if you wish to, you can etch your own printed-circuit board using the foil pattern shown in Fig. 3. Consult the parts-placement drawing (see Fig. 4) for the correct component placement, being careful to note the orientation and polarity of the components.

When you install the FET (Q1), make sure that its body is about 0.15 inches above the board and that it is properly heat-sinked. Once you have soldered all the parts in place, carefully inspect the board for solder splashes, shorts, and misplaced components before moving on.

Next, use pieces of small gauge (No. 28–24) wire to connect the circuit board, battery holder, LED1, and S1 together as shown in Fig. 4. Solder all connections.

The next step is to prepare two test leads. Use standard No. 20–18 gauge red and black wires about 36 inches long. First solder alligator clips or other suitable probe tips to the end of the test lead wires. Next, feed the two wires through the holes in the end of the box. Once through the hole, tie a tight knot about 1 inch from the end of each wire to act as a strain relief. Finally, solder the leads to the indicated points on the circuit board, paying attention to the polarity—red for positive and black for negative

With everything installed, inspect the connections to make sure you followed the schematic and parts-placement diagram exactly. If you are satisfied everything is in order, you can install the two "C" cells. The unit still must be calibrated, so do not install the lid at this time.

Unit Calibration. You will need a good digital multimeter to accurately calibrate the unit. Before connecting the injector's output to the digital multimeter's leads, make sure the meter is set to measure DC amps (usually on a 2-amp scale), and not DC milliamps. **If you mistakenly set the multimeter to the milliamp or microamp scale, the 1 amp of current from the injector could blow the meter's protection fuse.**

(Continued on page 89)

Here is a circuit that leaves no doubt as to whether someone has been trying to reach you

Build A Voice-Mail Alert

BY STEVEN M. O'KELLEY

Recently, telephone companies began offering a new type of service; Electronic Voice Mail. Intended as a replacement for the answering machine, the service leaves a greeting and records messages from callers when a subscriber is unable to answer the phone. Typically, Voice Mail is activated after a preset number of rings to allow subscribers time to answer a call when they are at home.

Instead of using magnetic recording tape, the service records and stores the caller's message in digital form at the telephone-switching office. The user can then retrieve messages using any Touch-Tone telephone.

Even though Voice Mail has some nice advantages over its mechanical counterpart, there is still some room for improvement. For example, when a message has been left, the system lets you know by pulsing the first few seconds of dial tone when you pick up the handset. That means that someone who is in and out several times a day has to pick up the phone each time to check for messages.

While a device that automatically does this would be complex, the next best thing is easy. The simple circuit—dubbed the *Tel-Tale*—described in this article will detect when someone has called and flash an LED to alert you to check for messages.

How It Works. A schematic diagram of the Tel-Tale is shown in Fig. 1. The circuit is built around a couple of low-cost IC's: an H11C4 optoisolator/coupler with an SCR output (U1) and an LM3909 LED flasher (U2). The circuit is connected to the phone line's tip (green) and ring (red) wires in the same manner as any extension phone.

When the phone is on hook, there is about 48 volts DC across the line. A neon lamp (NE1) is connected in series with the tip conductor. Because NE1 requires about 60 volts to conduct, the circuit represents a high impedance to the line and no current flows. When a call is made to the covered line, a ring voltage—about 90 volts AC at 20 Hz—is applied to the telephone line by the telephone-switching office. During half of the cycle, current flows from the ring line through R1, D1, NE1, and C1 to the tip line. During the other half cycle, the current reverses and the LED portion of U1 conducts, triggering its internal SCR, allowing a small amount of current to flow through the SCR and R2. That current flow causes capacitor C2 to begin charging.

Integrated circuit U2 and capacitor C3 form a simple LED-flasher circuit that will operate on just over a volt. When the charge on C2 reaches the 1-volt level, U2 flashes LED1 and the charging cycle of C2 starts over. The LED continues to flash until S1 (reset) is pressed. Closing S1 deprives the SCR of holding current, thereby turning it off. The Tel-Tale remains in that state until re-triggered by the next in-coming phone call.

Construction. The prototype of the Tel-Tale was assembled on a small printed-circuit board, measuring about 1⅝ inches square. A template of the author's PC pattern is shown in Fig. 2. Note that in that diagram, only one set of IC pads (near the center of the board) are shown; the reason for that will become apparent in a moment.

Once you've etched your board and gathered all the parts listed in the Parts List, construction can begin. A parts-placement diagram for the Tel-Tale's printed-circuit board is shown in Fig. 3. In the author's prototype, a single 16-pin IC socket is used for both U1 and U2 (6- and 8-pin devices, respectively). You can do the same thing, or, if you happen to have 6- and 8-pin sockets on hand, you can use individual sockets. In any event, using sockets prevents damage to the IC's during soldering, and makes replacing either IC (should the need arise) simpler.

Once the IC socket (or sockets) is in place, install the rest of the components as shown in Fig. 3. Note that because of tight spacing R1, R2, and D1 were vertically mounted to the cir-

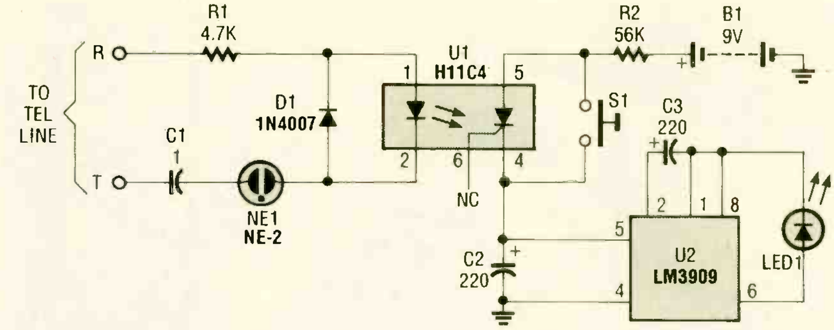


Fig. 1. The Tel-Tale is built around a couple of low-cost IC's: an H11C4 optoisolator/coupler with an SCR output (U1) and an LM3909 LED flasher (U2), and is connected to the phone line in the same manner as any extension phone.

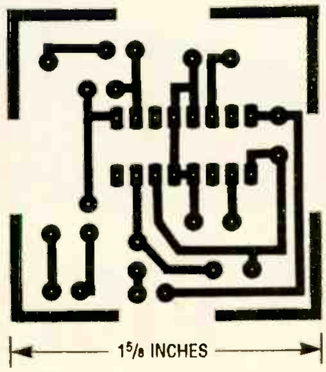


Fig. 2. The prototype of the Tel-Tale was assembled on a small printed-circuit board, measuring about 1 5/8 inches square, a full-size template of which is shown here.

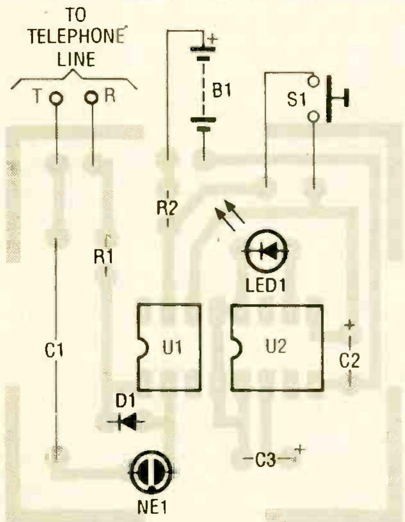
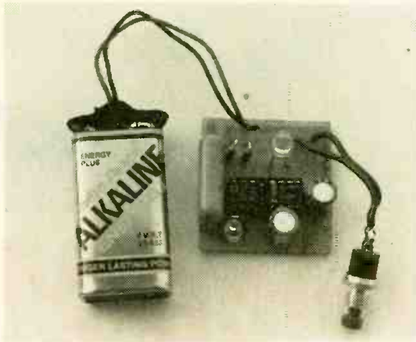


Fig. 3. Once you've etched your board and gathered all the parts listed in the Parts List, construction can begin, guided by this parts-placement diagram. In the author's prototype, a single 16-pin IC socket is used for both U1 and U2 (6- and 8-pin devices, respectively).

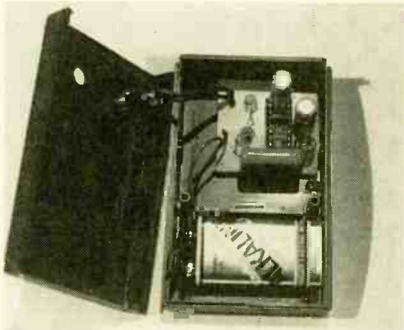
cuit board. When installing LED1, leave the leads long enough so that its lens will stick through a hole in the circuit's enclosure.



Here's the author's completed prototype.

The author's prototype was housed in a plastic Radio Shack enclosure (catalog number 270-293), which provides ample room for the circuit board and also has a built in battery compartment. The circuit board can be mounted using a small piece of double-sided tape. Switch S1 (either a pushbutton- or a toggle-type momentary single-pole unit) mounts to the case. Because the battery drain is low (about 0.3 mA), the author elected not to use an on/off switch in the design of this circuit.

If you have one of the older desk- or wall-type telephones, you may find that there is ample room to mount the circuit board and battery inside. Mount LED1 to the case of the phone and use a few inches of wire to connect it to the circuit. Most such phones also have a hook switch with unused contacts that can be used for S1. By using the hook-switch scheme, the circuit will reset itself whenever you use that phone.



The circuit can be mounted in a plastic project box or even within some telephones.

Installation. With your circuit completed, connect it to the phone line using standard quad telephone wire or a modular cord. The tip and ring inputs of the unit connect to the green and red wires, respectively, inside the telephone outlet. The Tel-Tale should be mounted so that the LED can be easily seen. The LED radiates most of its light in a narrow pattern so you should be looking into the top of the LED. The next time you are called, the circuit will flash. Even if you don't have Voice Mail, you may find this device handy. It will always let you know that someone has tried to reach you. ■

PARTS LIST FOR THE TEL-TALE

SEMICONDUCTORS

U1—H11C4 or NTE3046 optoisolator/coupler with SCR output, integrated circuit
U2—LM3909 or NTE876 LED flasher, integrated circuit
D1—1N4007 1-amp, 1000-PIV, rectifier diode
LED1—Super-bright LED (Radio Shack 276-087)

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1—4700-ohm
R2—56,000-ohm

CAPACITORS

C1—1-µF, 200-WVDC, metallized-film
C2, C3—220-µF, 10-WVDC, electrolytic

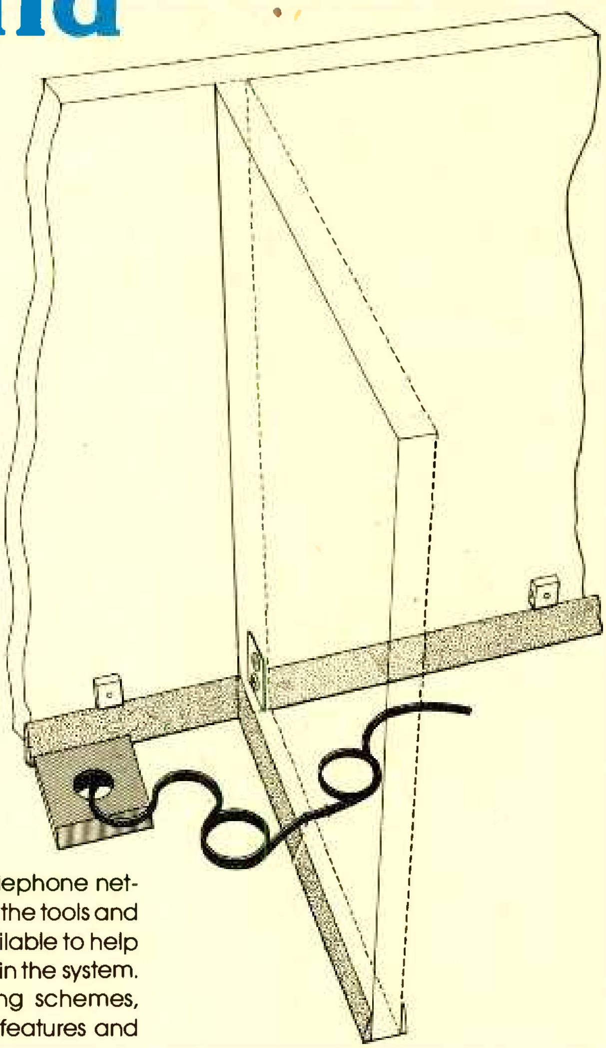
ADDITIONAL PARTS AND MATERIALS

S1—SPST momentary-contact toggle or pushbutton switch
B1—9-volt transistor-radio battery
NE1—NE-2 neon lamp
Printed-circuit board materials, enclosure, battery holder and connector, telephone wire, solder, hardware, etc.

Installing and Maintaining Telephone Systems

It's an easy job—if you follow these simple hints and procedures.

BY ROBERT A. YOUNG



With all the many features now offered on telephones, it is difficult to determine which model will give you the most bang for your buck! One of the more important questions that you must ask yourself is what is your greatest requirement from a phone? Is it to be your primary telephone? And, if so, will it work even when the power goes out? Will it be located in a lavishly (or even moderately) decorated room? And, if so, will it fit in with the decor of the room in which it will be located?

For many others, the question is does the phone offer all of the most modern conveniences? Is it pulse dial or touch tone? Does it include an answering machine? Is it cordless?, etc. Cost and manufacturer support are also important considerations. If it is defective or fails soon after it is purchased, what is the manufacturer's replacement/repair policy?

And what about the installation—should I have it installed by a "professional," or should I attempt it myself? Or, you may want to add a modular phone to an existing two-wire system, but haven't an inkling of how to go about accomplishing that task. Depending on your situation, installation can involve a bit more than simply pushing a modular plug into a modular jack. Yes, there are many points to consider when purchasing and installing a new telephone.

In this article, we'll show you how to install your own basic telephone network, and cover some of the tools and accessories that are available to help you to install and maintain the system. We'll also look at dialing schemes, and cover some of the features and options that are available on conventional and novel phones, cordless and non-cordless, and mobile and transportable phones.

We also cover some of the problems associated with purchasing your own phone to help you decide whether owning your own phone is in your best interests.

Basic Installation. In today's climate of deregulation, most (if not all) domestic telephones are installed by their owners. Modular telephone plugs make that task as simple as plugging in an electric lamp. Even older phones, those that do not have modular plugs, can be installed by the owner. In fact, older telephones can be adapted to modular installation, and *vice versa* (and we'll talk about that a little later in this article).

Regardless of the telephone's line-cord termination, all domestic phone installations begin with the basic quad-terminal connection block (see Fig. 1). The terminal block has four color-coded screw terminals, labeled R for red, G for green, Y for yellow, and B for black. The R and G (in telephone parlance, ring and tip, respectively) terminals are the main connection points for any telephone installation; they carry both the ring signal and verbal communications.

The Y and B terminals are used for other purposes. For instance, in older residential telephones, the Y and B terminals were connected to an external plug-in wall adapter that provided DC power to light the telephone dial.

If you are simply replacing an older existing phone with one of the newer modular units, all that you'll have to do is to replace the quad-terminal block's cover with a modular one (see Fig. 2). The cover, which is available from numerous local or mail-order

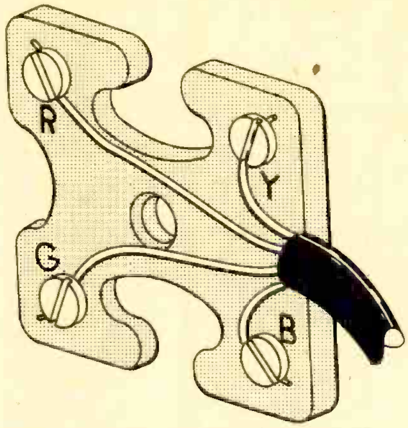


Fig. 1. Regardless of the telephone's line-cord termination, all domestic phone installations begin with the basic quad-terminal connection block like the one shown here.

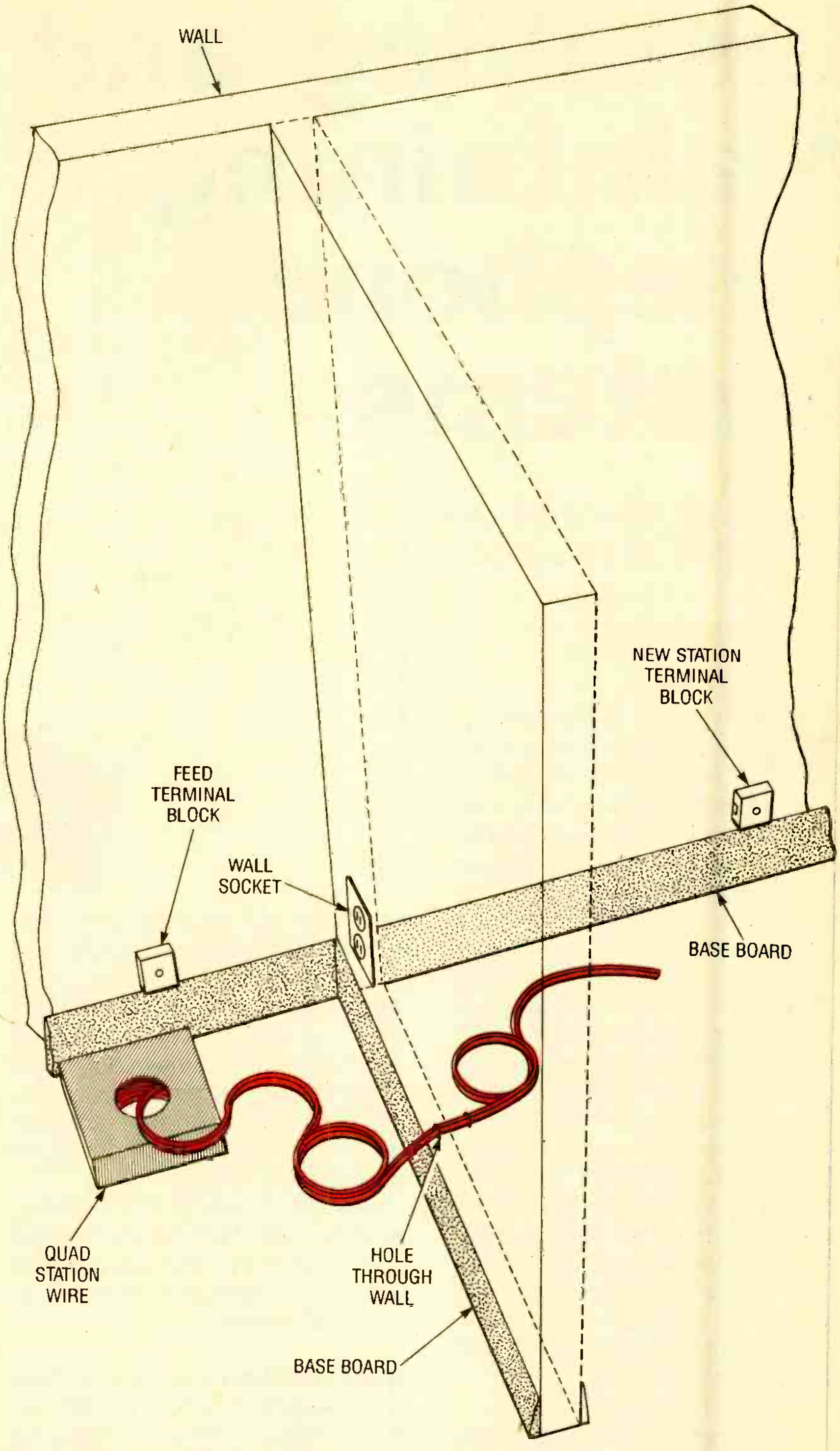


Fig. 3. When installing a new station, map out the route that the wire run is to take. If the new station is to be located in another room, which often requires that a hole be drilled through a wall, avoid (as best you can) AC receptacles.

sources, has four color-coded wire leads connected to a modular jack on one end and terminated in spade lugs at the other.

To install the cover, you simply remove the old cover and connect like-colored wires from the new cover to the right screw terminals on the quad-terminal block. **Do not** remove any existing wiring; It is probably either an outside feed line or a feed for a remote extension. Like-color wires are specified because you will occasionally find (depending upon the original installer) that the green wire is not always connected to the G terminal or that the red one is not connected to the R terminal—*i.e.*, the color-code is not always followed. In fact, in some instances (where the black and yellow wires are not being used for some other purpose), you may find the black and yellow wire used in place of the red and green. That's because, it was once common practice, when the red or green or both wires became open or shorted, to use the others as a substitute, rather that run all-new wiring.

Incidentally, although it is rare in this day and age, you may even run across twisted-pair telephone wire. In twisted-pair telephone set-ups, the two conductors are (well, usually are) color coded as well, via a strand of either red or green thread within the insulation of each conductor. In such cases, simply connect like colored wires as before.

Once all modular jack leads have

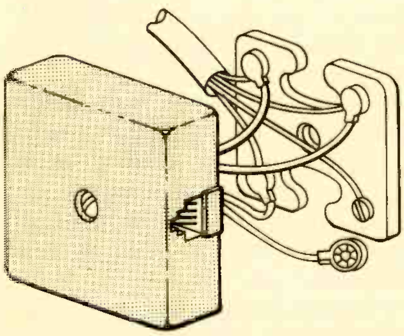


Fig. 2. To convert older installations to modular use, all you have to do is to replace the quad-terminal block's cover with a modular one, which has four color-coded wire leads that connect to the existing terminal block.

been matched to those on the terminal block, but before you mount the cover to the terminal block, it's a good idea to check the line. That can be done in two ways: You can either connect a phone to the modular jack or you can use one of the do-it-yourself telephone line testers that are on the market. The phone method is, of course, cheap and quick, but only gives a go or no-go indication; whereas commercially available testers will diagnose any problem. (See the "Repair" section of this article for more information of the use of telephone-line testers.) Once the telephone is found to be operating properly, all you have left to do is mount the cover to the terminal block.

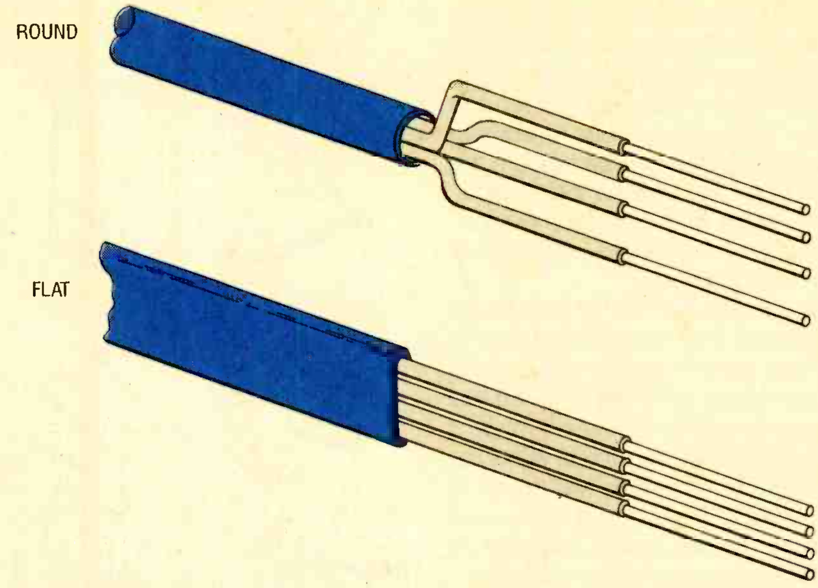


Fig. 4. Station wire—which is designed for both inside and outside use—differs from line cord in that its conductors are solid, as opposed to the stranded stuff used for line cord, and it is round rather than flat. The insulation of the station wire is also thicker than that of the line cord.

Adding a New Station. Adding a new station (extension phone) is nearly as easy as installing a new phone in an existing telephone outlet; the only difference is that you'll have to run wire from the closest terminal block to the new location and terminate it with a modular jack (see Fig. 3).

For the wire run, you'll need an appropriate length of quad color-coded station wire, not the flat line type. Station wire—which is designed for both inside and outside use—differs from line cord in that its conductors are solid, as opposed to the stranded stuff used for line cord (see Fig. 4). The insulation of the station wire is also thicker than that of the line cord. That's important since most wire runs are secured to the walls' base boards using a staple gun. If the gun is not properly positioned before the staple is released, it could (and often does) pierce the cable insulation. That often results in either shorting two or more wires or severing them altogether.

There are, of course, staple guns that are designed for wire installations. Such units are notched at the discharge point, so that the discharge point can easily be centered over the wire. That helps to prevent discharging the staple into the wire or its insulation. Such staple guns are available from many local and mail-order outlets that sell a range of do-it-yourself telephone accessories.

When installing a new station, first mount the new terminal block at the position that you've chosen for the new station. Then determine the most direct and convenient route from the closest existing station or terminal block to the new location. If the new station is to be located in another room, it may be (and usually is) necessary to drill a hole through a wall to get to that location. When drilling through a wall, be sure that you drill at a point that's a respectable distance from any AC receptacles—the consequences of such carelessness is obvious.

Drill a hole no more than a quarter of an inch in diameter. If it needs to be enlarged, that can be done with an awl (for plaster board also known as sheet rock) or a larger drill bit. It's easier to enlarge a hole than it is to fill it in. If the hole must be drilled through cement, cinder block, or any other similarly hard substance, you'll have to use a masonry bit.

Once a hole of sufficient diameter has been drilled, feed the station wire through the hole. It may be necessary to snake the wire through the hole (particularly where sheet rock is concerned). You won't need anything fancy, in fact, an old wire hanger (the thin kind) works very well.

Form a hook in one end of the snaking wire, strip away some of the outer insulation of the station cord, and twist the four leads together at the ends only (to form a loop for the hook). If it's too thick to fit through the hole, you can either twist two wires together or make a loop in a single wire and cut the unused leads close to the outer insulation to thin things out. But remember, fewer wires means you'll have to be more careful when pulling the wires through the hole—too much tension could snap the wire.

Hook the snake onto the wires, and feed the snake through the hole as far as you can, line up the station wire with the hole; if possible force the tip of the station wire into the hole. If necessary, flatten the hook and wire junction with a pair of pliers. From the other side of the wall, pull the snake with the station wire through to the other side. Continue to pull the wire through until you have more than enough to reach the new station site.

Starting from the new station location and leaving an extra five to ten inches or so, secure the station wire to the base board using your staple gun—keep the wire taut—working your way back to the hole in the wall. Working from the new station location back toward the feed-point location in that manner helps to cut down on wasted station wire at the end of the run.

From the other side of wall (beginning at the hole), secure the wire to the base board in the same manner, working your way to the feed-point terminal block. Go back to the new station location and connect the color-coded wires to the corresponding screw terminals on the terminal block, but do not tighten the screws. Now connect the spaded leads from the modular jack (cover assembly) to the terminal block and tighten the screw terminals; be sure to observe the color code. Then go back to the feed point and remove the terminal-block cover and connect the color-coded wires to the screw terminals at that end of the run.

Now for the moment of truth. Plug a telephone into the modular jack at the new station location. Lift the handset, and listen for a dial tone. If a dial tone is heard, try dialing out to see if the phone is working. If that works, ask the person that you've just called to give you a ring back. If that works, congratulations, you've successfully installed your own extension station.

Phone Conversions. An older telephone can easily be adapted to a modular system and *vice versa*. Figure 5A shows an adapter that allows you to use a modular telephone in an older plug-in system. Those plug-in stations are the forerunners of todays modular system, and in their day, were considered the "ultimate" in modern convenience.

It is easy to adapt older plug-in telephones for modular installation, using the adapters shown in Figs. 5B and 5C. In both cases the adapters are nothing more than a length of four-conductor telephone wire with one end terminated in a modular plug and the other end terminated in a plug-in jack. You'd simply plug the phone into the large square block and the other end of the adapter would be plugged into a modular jack. The only real difference between the adapter in Fig. 5B and one in Fig. 5C lies in the length of wire between the plug and jack.

Now if you're really a diehard, you can also open the phone and replace the old round quad (or dual, depending on the age of the phone being adapted) line cord (the cable that connects the telephone base to the telephone line) with flat modular-type line cord. Replacing the line cord can be done in one of two ways; you can use a replacement line cord (they're available from many local electronic suppliers), which typically have modular plugs at both ends, or you can make your own modular cable.

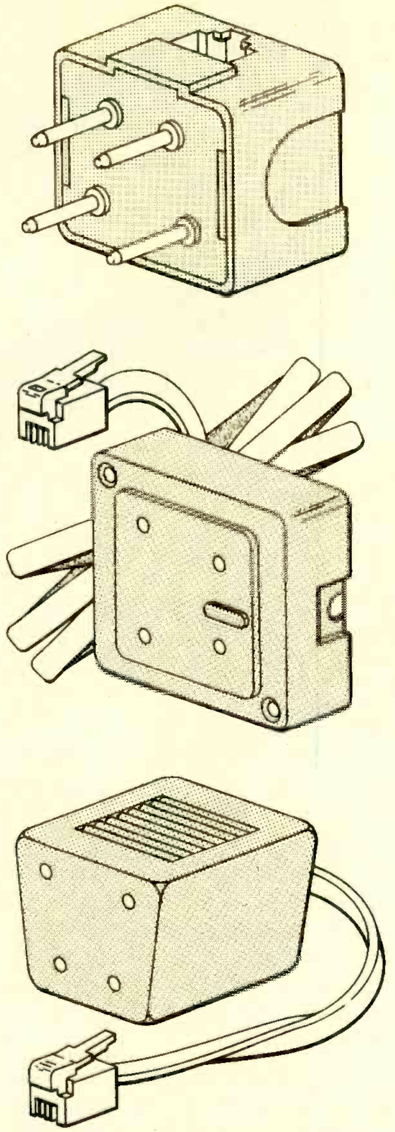


Fig. 5. The adapter in A allows you to use a modular telephone in an older plug-in system; the adapters in B and C can be used to make older plug-in telephones compatible with a modular system.

I prefer the make-your-own approach because any left-over quad cord (although it is not the best for such applications) can be used to install an additional modular jack for an extension at any location desired. In addition, making your own allows you to lengthen or shorten the line cord as you choose. (Those of my generation will recall the gouging you took when a 15-foot line cord was requested from the phone company.) The only difference between using replacement line cord and making your own is that the latter requires the additional step of connecting a modular plug to one end of the cord.

To use a replacement line cord, first remove the telephone face plate by removing the face-plate retaining screws (which are located on the underside of the phone). Then simply clip the modular connector from one end of the replacement cord, and strip back some of the outer insulation. Next strip the color-coded insulation from the conductors one at a time. Disconnect the original quad wire, one wire at a time, connecting the corresponding color from the new quad wire to the terminal previously occupied by the wire from the old line cord.

If you are making your own line cord, the next step is to connect a modular plug (see Fig. 6) to the free end of the line cord. Modular plugs, quad line cord, and the crimping tool (see Fig. 7) needed for plug installation are available from many local (Radio Shack, for one) and mail-order electronic suppliers. When purchasing modular plugs, be sure to get the four-conductor type. (There are also six-conductor units that are intended for more sophisticated units not normally found in the home.)

Once complete, the only thing left to do is replace the telephone's face plate, plug in your phone, and check its operation by placing a call.

Do-It-Yourself Line Repairs. Many residential consumers are opting to maintain their own domestic inside wiring rather than pay a monthly maintenance charge on their telephone bills. There are two reasons that one might choose that option. The most obvious reason is savings. While the cost of maintenance service is low

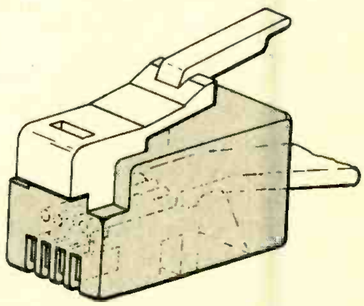


Fig. 6. Modular plugs are available from many mail-order and local, electronics and do-it-yourself home-fixings distributors. When purchasing modular plugs for domestic installations, be sure to get the four contact type, not the six conductor units.

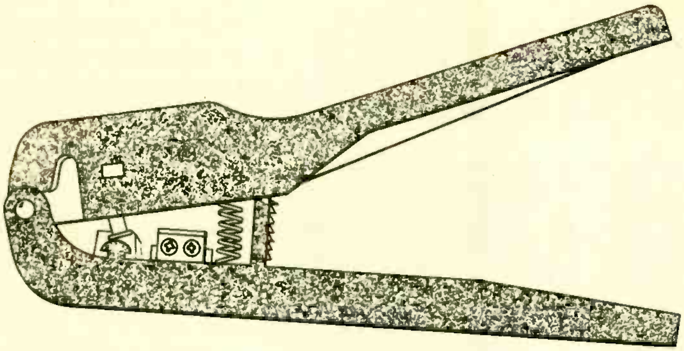


Fig. 7. This is what the crimping tool required to attach a modular plug to quad line cord looks like. To use it, simply load a plug into the tool, insert the line cord into the slot on the plug, and squeeze.

(averaging, typically, only a few bucks a month), you must be at home for those repairs, which could cost you many times its worth in lost wages. And that points to the other reason for maintaining your own inside wiring—convenience. Rather than sitting around for half a day waiting for a repairman (who may or may not show), you can repair or replace the wiring at your leisure.

There are many do-it-yourself telephone line testers on the market—such as Tele-Check Modular Line Tester from GC Electronics (GC-Thorsen, 1801 Morgan St. PO Box 1209, Rockford, IL 61105-1209; Tel., 815-968-9661; Fax, 815-968-9731) or Radio Shack's Phone Line Testers—that can be used to help maintain inside wiring.

Both units are extremely simple to use and, in fact, require no instructions to operate. You simply plug the tester's modular plug into the telephone line, and front panel labeling and annunciators on the tester give all the information that you'll need. A single LED located on the front panel lights green to indicate that the line is properly wired and functioning. The LED lights red to indicate reversed wiring, and white is used to indicate an open (or simply not operational) circuit.

The Tele-Check Modular Line Tester, from GC Electronics, has no controls to fiddle with and requires no instruction manual to operate. You simply plug it in and it diagnoses telephone-line problems, and informs you through a, front-panel mounted LED.

Dialing Schemes. All of today's phones use one of two dialing schemes—pulse dialing or touch-tone. Pulse dialing, the oldest of the two dialing schemes, is a method by which a local loop (a circuit within the telephone) is opened and closed at a specified rate. The opening and closing of the loop produces a series of pulses (representing the number being dialed) that are transmitted to your local telephone office, which, after decoding the transmitted pulses, connects you to the specified target station.

Although most of today's pulse-dial phones are operated by pushbutton, rotary units (which are still available) also fall into this category. The difference between pushbutton and rotary type of pulse-dial phones lies in the way the series of pulses representing the numbers being dialed are produced.

The touch-tone type, on the other hand, makes sounds like musical tones. The tones are produced as a dual-tone multi-frequency signal—a system by which two frequencies are mixed together to represent the number being dialed. Pulse-dial phones can be operated on touch-tone lines, but the same cannot be said for touch tone on pulse-dial equipped lines. Obviously, touch-tone lines offer more flexibility in selecting your phone, but touch-tone service also costs more. (Incidentally, most modern telephones offer switchable pulse-dialing or touch-tone compatibility.)

Even though most phone companies have switched to touch-tone service, it's a good idea to check with your local service provider to find out what dialing schemes are supported in your area. That's particularly important where touch tone is concerned for the reason mentioned above.

Features. Todays phones are available in a variety of styles (cartoon characters, etc.) and with many nifty features (such as cordless communication; built-in clock/radios; automatic answering machines; etc.). Some of the features, for instance clock/radios or automatic answering machines, require that the base unit (in addition to the usual telephone hook-up) be connected to an AC power source. And that brings another question into play; Will the basic phone still work if the AC power fails?

In addition, cordless phones can suffer from another (usually unforeseen) problem: the dead-battery syndrome. Because the handset of cordless phones are battery operated, it is wise to be certain that the battery or batteries used in the handset are commonly available units that will not "vanish" as the popularity of your phone fades. (I fell victim to that predicament.) Where possible, you should select a phone that uses standard batteries.

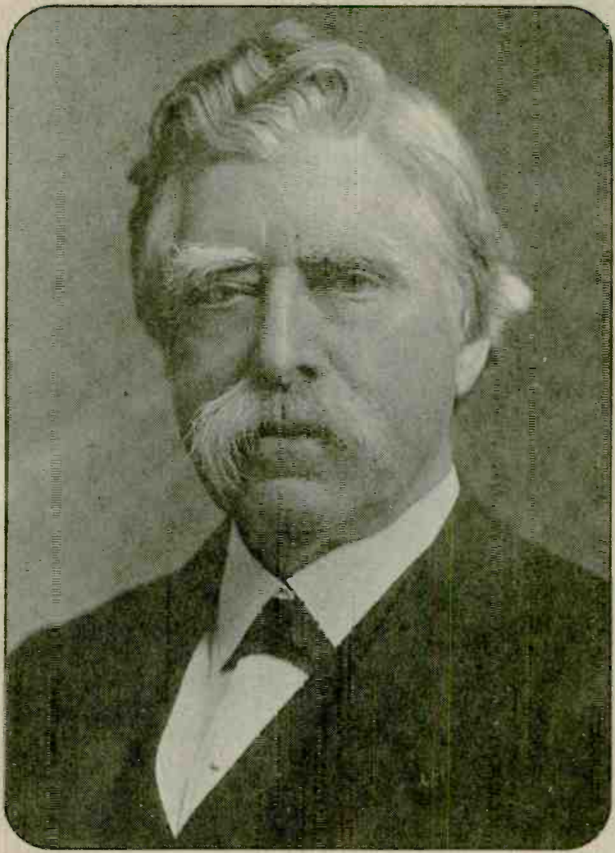
While modern features may be a strong selling point, those features can also be pitfalls; remember that the more features incorporated into the device, the greater the possibility of equipment failure.

Warranties. While few consider the possibility of telephone failure, manufacturers warranties should play a prominent role in your decision as to which unit to select. Before you buy, it's a good idea to ask to see a copy of the manufacture's warranty that covers the unit of interest. Find out if the product is backed by a well-established customer-service record. Sturdily built models are the best defense against frequent repairs, and the inherent headaches that go along with them. ■

DAVID HUGHES: Electromagnetic Pioneer

BY JAMES P. RYBAK

Had David Hughes not been discouraged by "experts" in 1880 concerning the significance of his work, the unit of frequency today might be called the "hughes" rather than the "hertz."



David Hughes was both dejected and angry as the three distinguished visitors from the Royal Society left his laboratory in London on February 20, 1880. Hughes had spent several hours demonstrating to them how a simple circuit, consisting of a microphone he had designed together with a telephone receiver, could detect at a distance the previously unknown "aerial electric waves" produced by a spark discharge. The distances over which Hughes could detect these waves sometimes exceeded a quarter mile.

The visitors included William Spottiswoode, President of the Royal Society, together with Professors Thomas Huxley and George Gabriel Stokes, honorary secretaries of that esteemed organization. Each was respected as an outstanding scientist.

The experiments had gone well and at first the visitors seemed astonished by the results. After a while, however, Professor Stokes began to assert that the results were not at all due to what Hughes referred to as "conduction of electric waves through the air." Rather, Stokes argued, what was being observed could be explained by known electromagnetic induction effects.

Hughes then carried out several additional experiments that pointed conclusively to the fact that the effects were not due to induction. Stokes, nonetheless, maintained his negative attitude, constantly "pooh-poohing" the results. Soon, Spottiswoode and Huxley joined Stokes in making acrimonious comments concerning Hughes' experiments.

The three men would not accept Hughes' contention that he had discovered a previously unknown type of "aerial electric wave." They did think, however, that Hughes had enough original material to write a paper for presentation to the Royal Society.

The dignitaries from the Royal Society became very displeased when David Hughes refused their suggestion that he give his detector circuit to the Society so that others could conduct similar experiments. Hughes maintained that the instrument he had developed for his research was for him alone to use.

Unwilling to risk further embarrassment, Hughes refused to write a paper describing his experiments until he had more proof concerning the existence of the new electric waves he knew he had generated and detected. However, that conclusive proof would be published in 1888, not by Hughes but by Heinrich Hertz. Many years passed before Hughes received the recognition he deserved for this earlier work.

A Musician Turned Scientist. David Edward Hughes was born on May 16, 1831 in London, but emigrated to the United States with his family when he was seven years old. His boyhood interests and talents were in music, not science.

Hughes joined the faculty of the Roseland Academy in Bardstown, Kentucky in 1851 as a professor of music. It is both surprising and fortunate, however, that his interests soon turned toward conducting mechanical and electrical experiments with laboratory equipment he designed and built by himself.

Hughes quickly became so accomplished in science he was appointed to the Chair of Natural Philosophy (science) at Roseland the following year. He now lectured in physics as well as in music.

Resigning his teaching position in 1853 so that he might devote more time to scientific experimentation, Hughes moved to Bowling Green, Kentucky. There he taught just enough private music lessons to be able to ear and to buy the materials needed to construct his laboratory equipment.

His goal was to design an improved automatic printing telegraph system.

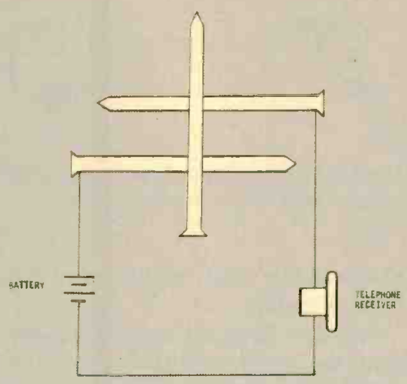
The printing telegraph equipment in use at that time was too complicated and unreliable for successful commercial use. The devices all employed some type of sequentially operated mechanism that typically required as many as twelve impulses of current to print a single letter.

These existing printing telegraph systems worked reasonably well provided the telegraph lines were short. Long telegraph lines, however, exhibited considerable capacitance that tended to merge the numerous individual current pulses required for each letter into one long continuous pulse. The result was that the print wheel failed to advance the required number of steps and the wrong letter was printed.

A Successful Printing Telegraph. By 1854, Hughes had developed an automatic printing telegraph system of his own design that worked extremely well. A sequentially operating mechanism requiring a series of current pulses was not employed by Hughes. In its place, he had developed a means for synchronizing the print wheel of the sending instrument with that of the receiving unit. Making the print wheels rotate in unison was the necessary improvement required to print the desired letters reliably.

Synchronization of the sending and receiving print wheels was achieved by having both units driven by identical clockwork mechanisms. The speed of each mechanism was governed by an adjustable, weighted vibrating spring. These speed-governing springs emitted the same musical frequency when the speeds of the two clockwork mechanisms were identical. The musical frequency generated by each spring was compared against a known frequency produced by a tuning fork. The rotations of the two print wheels were then started at the same instant through the transmission of initiating signals.

The printing telegraph equipment developed by Hughes was adopted almost immediately by the American Telegraph Company. Hughes then went to England in 1857 to find additional markets for his invention. The English did not show any interest in this



The "imperfect contacts" which existed between the metal surfaces caused the "H" shaped configuration of nails to function as a microphone.

invention produced by their native son.

Ironically, when the first submarine telegraph cable was laid across the English Channel a few years later, it became mandatory that both the English and the French use the same telegraphic equipment. The French would not consider using anything other than the Hughes printing telegraph. The English, therefore, were forced to adopt the equipment that they had so cavalierly rejected just a short time earlier.

Whether motivated by stubbornness or by conviction, the only place the English installed the Hughes printing telegraph equipment was at the London end of the trans-Channel line. The messages received by telegraphers in the rest of England continued to be written by hand.

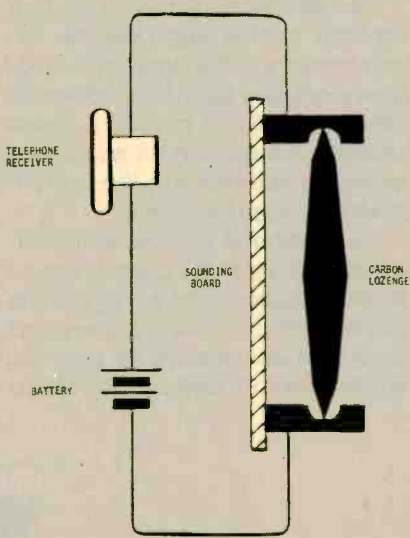
Virtually all of the other European nations, however, recognized the value of this new printing telegraph. France, Russia, Austria, and Turkey not only adopted Hughes' invention, they bestowed medals and honorary titles on him for this scientific achievement. The income Hughes received from licensing his printing telegraph made him independently wealthy by the time he reached middle age.

Despite the rejection by the English of his telegraphic printer, David Hughes returned to London in 1875 with his American-born wife to make his home. While he spent the remainder of his life in England, Hughes always retained his naturalized U.S. citizenship and maintained fond memories of Kentucky.

Experiments with Sound. Hughes was aware that the resistance of selenium changed when light was shined on it. He also knew that the resistance of most materials was significantly affected by changes in temperature. Perhaps, Hughes reasoned, sound waves would have a similar effect on some metals.

Ordinary wire conductors showed no sensitivity to sound waves or "sonorous vibrations" as Hughes called them. He also found that wires undergoing bending or stretching similarly were unaffected by sound waves. The wires being studied by David Hughes were made part of a current-carrying circuit that contained a telephone receiver.

The receiving unit of the telephone, first demonstrated by Alexander Graham Bell in 1876, proved to be a valuable research tool as well as an



The carbon lozenge microphone was reasonably sensitive and rugged.

important instrument for communicating. The same electromagnetic principles that made the telephone capable of receiving speech from distant points also made it capable of detecting other small fluctuations in electric currents. Hughes expected that the telephone receiver would easily detect any fluctuations in the current produced by sound waves.

Luckily, a wire broke one day while Hughes was carrying out an experiment to investigate the effects of sound waves on conductors being stretched. At the very instant the wire broke, an unusual "rushing" sound was momentarily produced by the telephone receiver. The phenomenon occurred every time Hughes repeated the experiment causing the wire to break.

Hughes tried to recreate the conditions at the instant of breakage by pressing together the ends of the wire with varying degrees of force. In the course of these attempts, he found that conductors touching each other under light but constant pressure responded well to sound waves.

Further experimentation led Hughes to arrange two clean, bright iron nails parallel to each other, but separated by a space of approximately one-half inch. A circuit was formed by connecting a battery and a telephone receiver in series between the two nails. The circuit was completed by laying a third nail across the other two so that an "H" shaped arrangement of nails resulted.

The resistance of the "imperfect contacts" that existed between the nails varied with the pressure fluctuations produced by the sound waves incident on those contacts. These changes in resistance caused corresponding variations in the current flowing through the circuit.

The telephone receiver in the circuit responded to the current fluctuations and reproduced the sound. This simple "microphone" Hughes had produced was reasonably sensitive, but the reproduced sound lacked

Hughes' first transmitting and receiving circuits were connected together by a wire.

some of the finer inflections of the original speech.

The term "microphone" had been used by Sir Charles Wheatstone in 1827 when he discovered that musical sounds could be transmitted through both metallic and glass rods. Hughes found the term aptly descriptive and adopted it for the various forms of sound transducers he developed.

Almost immediately, Hughes said of the microphone that "we may fairly look for it to do for us, with regard to faint sounds, what the microscope does with matter too small for human vision." To demonstrate this, he placed both a housefly and a three-nail microphone mounted on an empty matchbox under an inverted drinking glass. The experiment was successful with Hughes reporting that he "could hear the fly walking with a particular tramp of its own."

David Hughes continued to conduct experiments designed to improve his microphone. Arranging from ten to twenty nails in a square configuration that he referred to as a "log hut" resulted in both better sensitivity and somewhat improved fidelity. Still, Hughes knew, the quality of the reproduced sound needed to be improved even more.

A Much Improved Microphone. Something inspired David Hughes to return to his original three-nail "H" microphone design. This time, however, he placed a small amount of a fine zinc and tin powder mixture between the nails at the two points where the nails were in contact. The result was that speech was reproduced clearly in the telephone receiver.

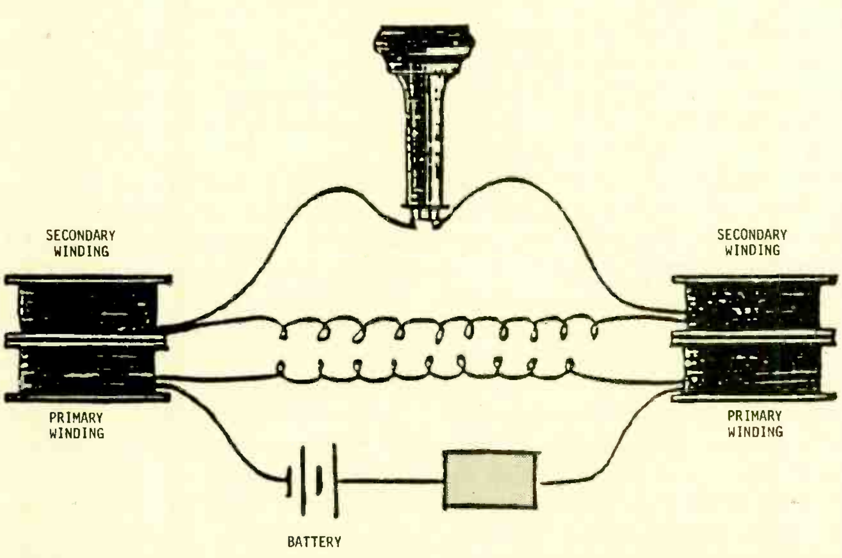
This latest discovery Hughes had made came to be known as the "multiple-contact" microphone. Clearly, however, nails and metal powder resulted in a microphone that was neither rugged nor convenient to use. Hughes now set out to find not only the best materials, but also the most practical arrangement of those materials for his microphone.

The improvement provided by the metal powder intrigued Hughes. He found that practically any metal powder would work reasonably well provided it did not become oxidized. Platinum powder did not oxidize, but was very expensive. Carbon proved to be both free from oxidation effects and inexpensive.

Hughes conducted many interesting experiments in which he tried a number of configurations and various combinations of materials. Very interesting and what initially seemed like extremely promising results were obtained when Hughes heated three small sticks of willow charcoal to white heat and plunged them into mercury. The mercury filled every pore of the carbon and remained imbedded as tiny droplets after the charcoal cooled.

The mercury-treated charcoal sticks then were arranged in the familiar "H" configuration. A more sturdy arrangement had a small lozenge shaped element of the mercury-treated charcoal loosely supported vertically between two blocks of carbon.

The microphones constructed from mercury-treated carbon had greater sensitivity and better fidelity than those of any other combination of materials Hughes had previously tried.



The rheotome (R) used in Hughes' induction balance to produce current pulses in the circuit's primary windings initially consisted of a mechanical interrupter, but later was changed to a ticking clock and microphone.

Unfortunately, the sound transmitting ability of these arrangements was not long lasting. Within a period of only several hours after their manufacture, the performance of the mercury-treated carbon microphones deteriorated to the point where they were no longer capable of transmitting any sound. Similar microphones constructed of untreated carbon experienced no deterioration of performance.

(Those interested in constructing working models of Hughes' microphones are referred to the article "Build an 'Antique' Microphone" by Stanley A. Czarnik that appeared in the January 1991 issue of **Popular Electronics**.)

Being already quite financially secure, Hughes sought only new scientific knowledge, not monetary gain, from his development of the microphone. In 1878, he concluded the report of his microphone research to the Royal Society by saying "I do not intend to take out a patent, as the facts I have mentioned belong more to the domain of discovery than invention." Hughes felt that his reward came from being able to share his findings with the scientific community.

Edison Did Similar Work. During the early part of 1877, Thomas A. Edison developed the first of several "speaking telegraph transmitter" designs for which he would be credited. These devices actually were telephone transmitters, or microphones, and were similar in some respects to the microphones developed by Hughes.

Edison's initial design consisted of a diaphragm connected by means of a spring to three platinum points immersed in a dish of carbon granules. Sound waves acting on the diaphragm caused fluctuations in an electrical current flowing through the carbon granules and platinum points. These current fluctuations could be converted back into clearly understandable speech by Bell's telephone receiver.

Edison then designed a more practical "speaking telegraph transmitter" by using a metallic diaphragm in direct contact with a carbon disc. A patent application was filed by Edison on this telephone transmitter on April 27, 1877. Unfortunately for Edison, legal actions by the Bell Telephone Company held up the granting of the patent for fifteen years.

Continuing his experimentation, Edison soon found that a small button of lamp-black carbon placed between two thin metal plates in series with a battery was a more efficient device for converting speech into electrical-current fluctuations. Edison applied for a patent on this telephone transmitter in 1878. The patent was awarded to him without any delays due to legal challenges.

Edison apparently had discussed his telephone transmitter designs with W.H. Preece, chief electrical engineer for the British Post Office and a renowned electrical authority. Preece is also known to have had technical conversations with David Hughes concerning the latter's microphone experiments.

Certain similarities clearly existed between Hughes' microphones and Edison's telephone transmitters. Edison charged that Preece had committed a breech of confidence by telling Hughes of his (Edison's) invention. A "straight steal" was the phrase used by Edison to describe how he believed Hughes had gotten the idea for the microphone.

Edison found, however, that very few other persons supported him in his slanderous accusations. The personal integrities of both Hughes and Preece were highly regarded. Edison was ill-advised to have conducted these personal attacks.

The differences between Hughes' microphones and the telephone transmitters designed by Edison far outnumber the similarities. Coincidence, rather than treachery, certainly seems to be the likely cause of the similarities that do exist.

Hughes' Induction Balance. The microphone was also to play an important part in the normal operation of an "induction balance" Hughes would soon develop. More importantly from a scientific standpoint, however, the microphone would also produce some unexpected results of great scientific significance when used with that balance.

The induction balance developed by Hughes in 1879 consisted of two separate induction coils, each with a primary and a secondary winding. The secondary windings of the coils were connected together so that, at "balance," the current induced in one secondary winding cancelled the current induced in the other.

The primary windings of the induction coils were connected in series with each other as well as in series with a microphone and a battery. The microphone together with a nearby ticking clock formed a "rheotome" (literally a "current cutter") that created periodic pulses in the battery current flowing through the primary windings of the induction coils.

The current induced in the second-

Books and Articles of Interest.

"David Edward Hughes, F.R.S., 1831–1900," G. Burniston Brown, *Notes and Records of the Royal Society (London)*, Vol. 34, No. 2, pp. 227–239, 1980.

"The Life and Work of David Hughes," Sydney Evershed, *Journal of the Institution of Electrical Engineers (London)*, Vol. 69, pp. 1245–1250, 1931.

The Telephone, the Microphone and the Phonograph, Count Theodore A. L. Du Moncel, Harper & Brothers Publishers, 1879, Reprinted by Arno Press, New York, 1974.

A History of Wireless Telegraphy, J. J. Fahie, Dodd Mead and Co., New York, 1901, Reprinted by Arno Press, New York, 1971.

"On the Action of Sonorous Vibrations in Varying the Force of an Electric Current," David E. Hughes, *Proceedings of the Royal Society (London)*, Vol. 27, pp. 362–369, May 9, 1878.

"On an Induction-Currents Balance and Experimental Researches Made Therewith," David E. Hughes, *Proceedings of the Royal Society (London)*, Vol. 29, pp. 56–65, May 15, 1879.

Old Wires and New Waves, Alvin F. Harlow, D. Appleton Century Co., New York, 1936.

"David Edward Hughes: inventor, engineer and scientist," J. O. Marsh and R. G. Roberts, *Journal of the Institution of Electrical Engineers (London)*, Vol. 126, pp. 929–935, 1979.

"The early history of electronics: I. Electromagnetics before Hertz," Charles Susskind, *IEEE Spectrum*, pp. 90–98, August 1968.

"The Localization of the Bullet in President Garfield's Body," (unsigned under "Notes"), *The Telegraphic Journal and Electrical Review (London)*, Vol. IX, pg. 317, August 15, 1881. ■

ary windings exhibited the pulsating characteristic of the primary current. A telephone receiver connected in series with the secondary windings converted the current pulses into an audible signal and served as an extremely sensitive balance indicator.

The induction balance concept did not originate with Hughes. Several researchers had developed a similar circuit some twenty-five years earlier. Hughes' contribution was the use of the microphone and the telephone receiver to substantially increase the sensitivity of the circuit.

Placing a piece of metal near one of the coils caused the circuit to become unbalanced. The degree of unbalance was a function of the mass of the metal or, for pieces of metals of like weight, the type of metal used.

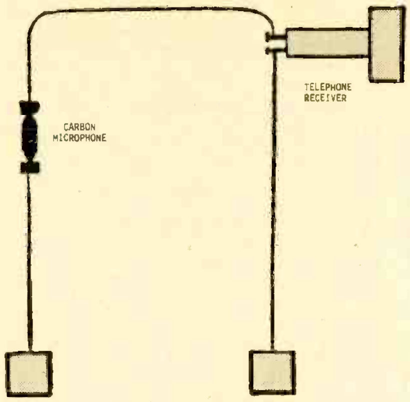
The sensitivity of the induction balance was sufficient to detect mass differences of less than one milligram in two samples of a pure metal. Similarly, the induction bridge could detect differences in purity as small as one part in ten-thousand in samples of equal mass.

Hughes' plan was to use the induction balance to gain information concerning the molecular structure of metals and alloys. He achieved only very limited success in this effort.

Of interest is the fact that Alexander Graham Bell used an induction bridge based on Hughes' design to locate the assassin's bullet in President Garfield. Despite success claimed in locating the bullet, physicians were unable to save the President's life.

Sparks Lead to a Discovery. Hughes' first series of induction-bridge experiments were conducted in the fall of 1879. In those early investigations, switch contacts operated by a clockwork mechanism served as the rheotome used to produce periodic current pulses in the bridge's primary coil.

With this arrangement, Hughes experienced trouble due to a clicking noise heard in the telephone receiver when he tried to balance the bridge. The clicking noise coincided with the sparks occurring across the contacts of the current interrupter mechanism. A spark, or "extra current" as Hughes called it, was produced at the contacts by the inductive voltage generated each time the current in the



Hughes improved his receiving circuit by grounding one side of both the carbon lozenge microphone and the telephone receiver.

primary coil was interrupted.

Hughes conducted numerous experiments before he convinced himself that the effects he was observing were not due to ordinary induction effects. He had studied extensively the induction effects that exist between telegraph wires and was considered an expert on the topic. Hughes knew that he was producing some new kind of "electric waves."

The sparking at the interrupter contacts actually was producing the electromagnetic waves James Clerk Maxwell had predicted mathematically some fifteen years earlier. To date, however, no one had succeeded in experimentally proving that these waves actually exist. Now, in 1879, Hughes apparently was both generating and detecting Maxwell's electromagnetic waves although he seemingly did not completely realize the true nature of the waves.

The audible response or "clicking" heard in the telephone receiver was due to the effects produced by a loose connection in the secondary circuit of the induction balance where that receiver was located. Suspecting that the loose connection was acting as what he called a "microphonic" contact, Hughes replaced it with one of his microphones, which consisted of a steel needle in light contact with a piece of carbon. The clicking in the telephone receiver persisted.

The First Coherers. Both the loose connection in the induction balance circuit and the steel-on-carbon contact of the microphone exhibited the same behavior that would be re-discovered in 1890 by the French scientist Eduard Branly and again, independently, in 1892 by the English physicist Oliver Lodge. As Hughes had not published his findings, neither Branly nor Lodge were aware of his earlier work.

The name given the phenomenon by Lodge was the "coherer" effect. The coherer would become the most widely used and dependable detector of electromagnetic waves available until the advent of the vacuum tube.

The coherer effect is both remarkable and simple. The contact between two conductors, barely touching each other, ordinarily is not sufficient to permit an electric current to flow. However, when a nearby spark discharge occurs producing electromagnetic waves, the conductors become fused together. When that occurs, current easily flows through the junction.

Branly found that fine, unoxidized metal particles packed between metal electrodes in a glass tube normally conduct electricity very poorly. The tube of particles becomes a very good conductor, however, when a spark discharge occurs nearby. Lodge observed the same phenomenon with two small polished metal spheres barely touching each other. In both cases, tapping is required after each spark discharge to return the devices to their non-conducting state.

Following the occurrence of a spark discharge, unoxidized metal conductors ordinarily remain joined together until lightly tapped. Coherers utilizing contacts comprised of certain other materials, however, are "self-restoring" in that they return to their non-conducting state without being tapped.

The loose contact in Hughes' original circuit together with the steel-on-carbon and carbon-on-carbon contacts in Hughes' later detector circuits formed "self-restoring" coherers. The momentary high conductivity of these contacts produced by the arrival of electromagnetic waves allowed a pulse of current to flow. That produced the clicking Hughes heard in the telephone receiver that was in series with the coherer contact.

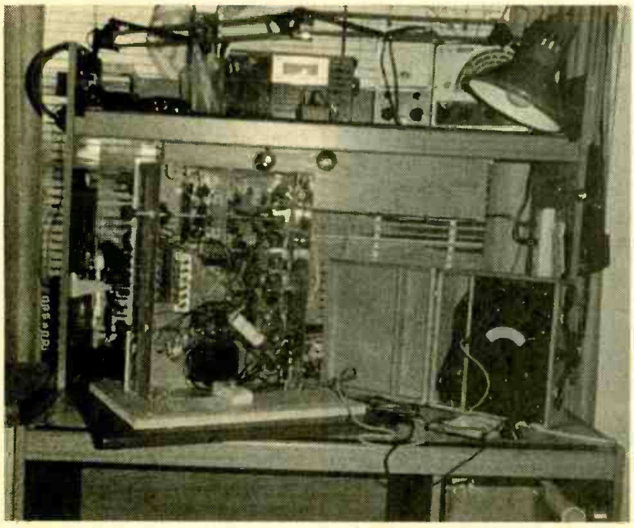
(Continued on page 90)

ANTIQUE RADIO

By Marc Ellis

Tips and Tidbits

Well, gentle readers, I have to start off this month's column with a confession. Most of you will be picking up this issue of **Popular Electronics** on the verge of the winter season. But the publishing timetable is such that I'm writing these words back near the beginning of summer. It's a summer that has been very reluctant to arrive at the midwestern location where I live, but the past few weeks have finally brought some fine weather.



A heavy chassis sits atop the lazy susan installed on Hipolit Ceckowski's well-organized service bench (see text).

The weather was fine enough to make me play hooky from the Hallicrafters *Sky Buddy* restoration project I've been chronicling on these pages. So as a result (blush), I have no progress to report. However, it's an ill wind that blows no good, and I have an excellent use for the space allotted to me in this issue.

I've recently received a few letters that tell stories or share information requiring a bit more space than I could allow in the typical crowded "Mailbag" column. And I've been saving a few others—some for quite a while. I've also been waiting for a chance to present more of the interesting photographs that were submitted with entries to the recent "With the Collectors" contest. It looks like my opportunity to run those letters and photos has finally arrived, so let's sit back, relax, and take an unhurried look at them.

DXING ON A RADIOLA III

Dr. Dan Fielder (Professor Emeritus, School of Electrical Engineering, Georgia Institute of Technology, Atlanta, GA 30332) has owned several radio models, now considered antiques, since the days when they were new. But his fondest memories are associated with the little Radiola III that he had as a child. For those not familiar with that diminutive yet sensitive set, the Radiola III is housed in a box that measures approximately 8 × 6 × 5-inches and contains just two tubes.

Both of the tubes are type WD-11's. One serves as a regenerative detector and the other as an audio amplifier. The set provided only earphone volume, though an accessory "balanced amplifier" (using another pair of WD-11's) could be added to drive a speaker. The set used no variable capacitors; instead, adjustable coils ("variometers") were used to control tuning and regeneration.

A friend of Dan's older brother, Walter Pierce by name, owned an identical Radiola III. Using this simple receiver, the young high-school student had set long-wave DX receiving records that attracted national attention back in the 1920's. For example, when *Radio Index* magazine ran a DX'ing contest, Walter won it with 656 verified foreign stations. Eventually, he accumulated verifications from more than 2600 stations in every country in the world.

At one point, Hugo Gernsback, founder of our publishing company and—at that time—editor of *Radio News* magazine, actually sent a writer to visit the Pierce home and document these feats. Recently, Dr. Fielder wrote to Walter and asked him to share his memories of this event and some of his DX'ing secrets, with the idea that the recollections might be printed in this column.

As evidenced by his detailed response, Mr. Pierce's memories of those eventful times are still quite sharp. When Armstrong Perry (Mr. Gernsback's representative) arrived, Walt tells us, "I was listening to LR9 in Buenos Aires, 1190 or 1200 KC, and he was amazed at the quality of the reception. Perry stayed overnight and next morning we tuned in JOAK, Tokyo; 1YA, Aukland, N.Z.; 2BL, Sydney, Australia, and many others. He was able to dispel all doubts that a farm boy in Saunderstown, Rhode Island could receive stations from all over the world."

Walt reports that the secret of his success was an unorthodox, and highly effi-

Hipolit Ceckowski's beautifully restored Grebe. He built the cabinet himself, copying it from a period photo.

Here's Dave Booth's (Westminster, MD) workbench and listening post. Dave was one of the winners in our "With The Collectors" contest (see July, 1992 column).

cient grounding system. The ground wire was connected to a leaky old Ford radiator buried up to its filler cap in the ground. The radiator was kept full of water so that the soil around it was constantly being moistened.

Additional grounding pipes were driven all around the radiator and connected to the main ground lead with heavy copper wire. The more ground pipes he connected, the better was the reception of weak stations. There were suggestions that reception might be further improved if he would substitute some of his dad's hard cider for the water in the radiator, but that particular experiment was never tried!

Walt usually began his listening sessions by checking for station KOA in Denver. If it was coming in well, he knew conditions were favorable and settled in for some serious DX'ing. Sometimes the session lasted all night. By 2 AM, most American, Canadian, and Mexican stations were shutting down, leaving the airwaves clear for the European stations—which were just beginning their broadcast days. Then, by 4 or 5 AM, the Japanese, Australian, and New Zealand stations would begin to come through.

Mr. Pierce's DX'ing activities ended in the late 1930's, when the American stations had become much more numerous and powerful, and had begun to stay on all night. That made it much more difficult to hear the foreign stations but, because of the difference in channel spacing (10 kHz for America, 9 kHz for Europe), it was still possible to hear DX between the stateside signals.

Many thanks to Walt and Dan for sharing these vivid memories of DX'ing in earlier times. And if anyone knows where a Radiola III can be obtained, or has one for sale, please contact Dan at the address given above. He'd love to get his hands on one again!

THE KAISER'S CLANDESTINE STATION

About a year ago, Ron Oberholtzer (North Cape May, NJ) sent me some mini-articles on subjects that he felt had been neglected by the antique-radio press. And since his experience with radio goes back some 70 years, he's speaking with some authority! I've been holding Bob's letter in my "use when I have space" file and here, at last, is an opportunity to discuss one of the items.

Bob writes that back in about 1915, before the U.S. entered World War I, the German high command decided that a radio station was needed on our shores to direct U-boat activity. Without notifying our government of their intentions, they selected a sparsely-populated marshy site near Tuckerton, NJ and began building. Though local help was used for construction, all materials were brought in by ship from Germany, helping to give the project a lower profile.

The high-powered installation wasn't exactly a secret, because it boasted a 300-foot high transmitting antenna (resting, Bob tells us, on a giant insulator) and several smaller receiving ones. But the isolated, inaccessible location, and the looser security of those times, allowed the station to operate for quite a while without attracting a lot of attention. It is thought that the order for the fateful sinking of the *Lusitania* was sent through Tuckerton.

Of course, our government eventually got wind of this operation, and the facility was confiscated after our entry into the war. At war's end, RCA acquired the property and used it as the site for a multiple-frequency shortwave transmitting station. In the late 1960's, RCA built a replacement station and sold the property to a developer.

The old tower was dynamited with much public fanfare, ending decades of radio operation on the site. But the street giving access to the area is still known as "Radio Road."

Thanks to Ron for sending in this information, and I'd be glad to hear from anyone who can supply more details. For instance, I remember once reading about a ham radio operator who exposed a secret German station during the same era. The Morse transmissions were encoded by mechanically speeding them up. But the resourceful ham recorded the bursts on an Edison cylinder and was able to play them back at a slower speed. Was the Tuckerton station the one involved? It would be interesting to know.

SOME HELPFUL TIPS

Interested in replicating shortwave sets of the 1930's and 40's using coil data from vintage construction articles? Billy Pogue (Lake Havasu City, AZ) recommends that you purchase the case of 72 pharmacist's bottles offered at $6.00 by American Science and Surplus, 601 Linden Place, Evanston, IL 60202-2610. Their dimensions and electrical characteristics are excellent for service as coil forms. If you need a plug-in unit, cement your "form" into a base taken from a broken tube.

Think the above is a good idea but don't know where to get your hands on a construction article? Billy suggests that you send for a catalogue from Lindsay Publications, Inc., P.O. Box 538, Bradley, IL 60915 (enclose a dollar with your request). Lindsay offers a rich variety of high-quality reprints, including many collections containing period shortwave hobby articles—some taken from our predecessor magazine *Short Wave Craft*.

Recently D. Derek Verner (Tuckahoe, NY) needed a 67½- volt "B" battery (Eveready 467) to power a piece of World War II surplus test equipment. Once available at a nominal cost from almost any drugstore, this battery is now available on special order for a price of about $30.00.

Not to be daunted, Derek tried another, more inventive approach. He purchased a number of 9-volt batteries on sale from Radio Shack. He soldered seven of them together to make a 63-volt unit. Then he added a 4½-volt battery obtained by slicing open another 9-volt job and separating out 3 cells.

Though Derek wasn't really going for an authentic look, he couldn't resist installing his creation in the old battery's carefully removed outer shell. It fit just fine. As a finishing touch, he filled the voids between the new battery and the old shell with some silicone caulk. Total cost: less than five dollars.

Hipolit J. Ceckowski (Vernon Hills, IL) sent me a shot of a lazy susan he made by pinning together two boards (their dimensions look like they might be approximately 10 inches by 2½ feet each) with a dowel. Even a large chassis becomes easy to work on when placed on the lazy susan, because it can be easily rotated, giving access to all sides.

In addition to that picture, I'm running another of 80-year-old Hipolit's shots showing his meticulously-restored Grebe. It's installed in a home-crafted cabinet copied from a photograph, and Hipolit also did extensive restoration work on the accompanying horn speaker. As you can see from the photograph, it was wonderful work!

WANTED: VINTAGE THEREMIN

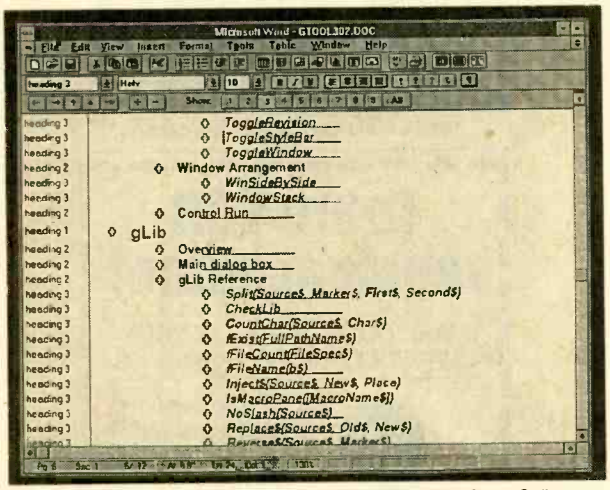
Do you have a vintage theremin you'd be willing to donate to a good cause? Contact Joseph O'Connell, Exhibit Planner, Liberty Science Center, Liberty State Park, 251 Phillip St., Jersey City, NJ 07304-4629 (phone 201-451-0006). The Center is a newly-opening, non-profit educational institution located on the New Jersey mainland at a point very close to Liberty Island and the Statue of Liberty. They'd love to acquire an original instrument. They have the know-how to restore a defective one, and they promise to display it prominently and with the proper recognition. ■

COMPUTER BITS

By Jeff Holtzman

Word BASIC

Last month, we discussed the emerging third wave in software evolution: integrated tool sets. As an example, we discussed the major features of Microsoft's Word for Windows 2.0 (WW2), which I consider to be the premier word processor for PC's. WW2 has four groups of features that make it the Mt. Everest of PC word processors: outlining, styles, templates, and the Word BASIC macro language. Last time, we talked about the first three; this time, we'll take a look at Word BASIC (WB).



The major features of Microsoft's Word for Windows 2.0—outlining, styles, templates, and the Word BASIC macro language—make it the Mt. Everest of PC word processors.

WORD BASIC

You can view WB as a version of BASIC that also happens to include extensive built-in support for text-processing operations (searching, replacing, formatting, etc.), as well as support for altering the environment itself. Conceivably, you could completely redefine menus, keystrokes, and toolbar functions to give WW2 a whole new look.

Table 1 summarizes the types of statements (that perform some task) and functions (that return information to a calling routine) available in WB. What can you do with WB that you can't do either in a word processor by itself, or in some programming language by itself?

You can use WB macros to insert arbitrary text strings (*e.g.*, time, date, author) into a document; count and display the number of words in a document; automatically format text in specified ways; cause particular actions to occur whenever you create a new document, open a pre-existing document, or close a document; move the insertion point to various places in the document and perform an arbitrary sequence of commands when you get there; display information on the screen; create (by visually drawing) dialog boxes that look and feel more or less like "real" Windows dialogs; set up "conversations" with other Windows applications; create libraries of WB routines to share or sell; clean up ASCII text files; replace formatting with ASCII codes for typesetting; and lots more.

The nice thing is that if you have learned BASIC—any dialect on any machine—it's easy to get up to speed with WB quickly.

EXAMPLE MACROS

The following are a couple of simple macros intended to give you a taste for what WB macros are like. The first (See Listing 1) is a macro that counts the number of words in a document and displays the value in a message box.

Note the "Sub MAIN" and "End Sub" surrounding the main body of the code. Every WB macro has a routine labeled "MAIN," and may optionally have other subroutines and functions as well. The routine works first by creating a data structure in memory corresponding to the Summary Info item of WB's File menu. The next line causes WB to update the values of that dialog box (*i.e.*, to count the words in the document). The next line brings the updated values to accessible variables. The MsgBox line then displays a particular variable, NumWords, in a simple message box with an OK button, which the user must click before other operations can continue.

You could change that line to read:

```
Print "Number of words: "
+ dlg.NumWords
```

in which case the value would display in the status line until the user pressed a key or performed some action with the mouse.

The next example (See Listing 2) shows a little routine that displays the ASCII/ANSI value of a character, and then offers to delete all occurrences of it from your file. It's useful for cleaning out junk from text files downloaded by modem or imported from other word processors. The macro will not replace ASCII NUL (0), a WB limitation.

In the listing, a backslash

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TABLE 1

Category	Statements	Functions
Movement and selection	Move and select text	Return information about the position of the insertion point and about the text currently selected
Formatting	Format the selected text	Return information about the formatting of the selected text
Editing	Insert and delete text, insert glossary items, add and delete rows and columns in tables	Return information about the result of editing operations
Control	Establish structures for repeating tasks, testing results, and defining routines	Return information about the Word environment, such as the current time or date, and converting data from one type to another
Views and windows	Change views in a document, move windows	Return information about the size and placement of document windows
Tools	Correspond to commands on the Tools menu for checking spelling, hyphenating, checking grammar, managing the macro-editing environment, and so on	Return information about the operation of the Tools commands being used
Dialog box	Create custom dialog boxes	Return information from built-in or custom dialog boxes
File	Open, save, close, and delete files	Return information about files
DDE (dynamic data exchange)	Establish links to other applications running in Windows	Return information to a macro from another application

LISTING 1

```
Sub MAIN
  Dim dlg As FileSummaryInfo
  FileSummaryInfo .Update
  GetCurValues dlg
  MsgBox "Number of words: " + dlg.NumWords
End Sub
```

("\") at the end of a line indicates that the next line is really a continuation of the current line. The routine uses a built-in WB variable called Selection$( ), which contains the text highlighted in the document at the time the macro runs, or only the character directly to the right of the insertion point if no text is highlighted. The macro first assigns to A$ the first (and possibly only) character in Selection$( ). Then the routine puts up a message box that displays the ASCII value of the character in A$, and asks whether the user wants to delete all occurrences of it. If so, the routine then invokes the built-in replace routine, telling it to replace

LISTING 2

```
Sub MAIN
  A$ = Left$(Selection$(), 1)
  A = MsgBox("Value of this character = " + \
  Str$(Asc(A$)) + ": Delete all occurences?",\
  "Jeff's Handy Dandy Cleaner Upper", 4)
  If a = -1 Then EditReplace .Find = A$, \
  .Replace = "", .WholeWord = 0,\
  .MatchCase = 0, .Format = 0, .ReplaceAll = 1
End Sub
```

all occurrences of A$ with a null (empty) string.

Those two examples barely scratch the surface of what WB can do. However, I hope they will inspire you to do some more research on your own. Next time, we'll discuss linking WinWord documents with files from other packages.

FOR MORE INFORMATION

The printed documentation that comes with WW2 provides almost nothing on WB. However, WW2 contains a fairly complete built-in on-line reference for all WB statements and functions; just highlight a keyword and press F1. For more in-depth coverage, you may want to refer to the following books on Word BASIC, all published by Microsoft (One Microsoft Way, Redmond, WA 98052: Tel. 206-882-8080; FAX 206-93MSFAX): *Using WordBasic, WordBasic Primer,* and *Microsoft Word Technical Reference.* The latter two were originally released for version 1.x of WinWord, but still have useful information and examples. Using WordBasic documents version 2.x, and has a thorough reference section, but fewer examples than the others.

The MSAPPS section of CompuServe has a forum dedicated to WinWord; lots of good hints and samples are available there. In particular, you'll want to check out several shareware packages of WB macros. Probably the best is the Gadfly Toolbox, which provides a useful set of macros including a version of File Open that allows you to select from a prepared list of your most-used subdirectories, as well as several macros for managing the toolbar, macro-keystroke assignments, and more. Also of interest is the Windows Office Power Pack (WOPR), which contains an editor for toolbar icons, and several ambitious, albeit buggy, fancy-print macros. By studying the macros contained in those packages, you can quickly become a WB *guru.* ■

CIRCUIT CIRCUS

By Charles D. Rakes

More High-Voltage Circuits

Last month, we took a look at a simple Tesla coil. This time around, we're going to explore a few more high-voltage circuits, the first of which is a more powerful Tesla-coil driver circuit that, when adjusted properly, can produce a small corona discharge at the top of the coil. The circuit will also produce a greater output in the energy-transmission mode of operation.

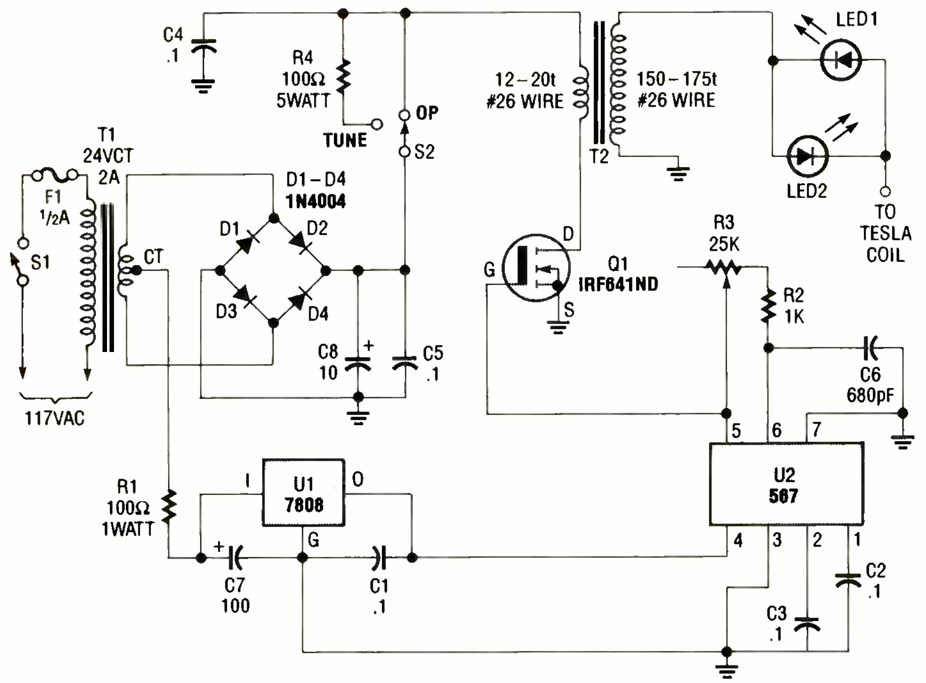

Fig. 1. The operation of this driver circuit—centered around a 567 tone decoder (U2), an IRF641-ND N-channel enhancement-mode hexFET (Q1), and a hand-wound step-up transformer (T2)—is rather straightforward.

DRIVER CIRCUIT

Figure 1 shows a schematic diagram of our first driver circuit. The operation of that circuit—centered around a 567 tone decoder (U2), an IRF641-ND N-channel enhancement-mode hexFET (Q1), and a hand-wound step-up transformer (T2)—is rather straightforward.

Transformer T1 (a 24-volt, 2-amp, center-tapped unit) and diodes D1–D4 (configured as a fullwave bridge rectifier) supplies about 35-volts DC to the drain of Q1 through the primary winding of T2.

A voltage plucked from the center tap of T1 is fed to a 7808 8-volt regulator (U1) and its output is used to power U2, which is configured as a tunable squarewave oscillator. With the component values shown, the oscillator operates at somewhere between 100 and 350 kHz, depending on the setting of R3. The output of U2 at pin 5 is applied to the gate of Q1, causing it to turn on and off in sync with the output of the oscillator. The on/off cycling of Q1 produces a continually rising and collapsing current in the primary of T2 that induces a current of greater magnitude in its secondary winding. The output of T2 is then applied to the Tesla coil through LED1 and LED2 (which serve as tuning indicators).

Transformer T2 was made by first winding between 12 and 20 turns of #26 enamel-coated copper wire on an Amidon Associates (2216 East Gladwick St., Dominguez Hills, CA. 90220) EA-77-250 ferrite "E" coil core for the primary, and then winding 150 to 175 turns of the same wire on top of that for the secondary winding.

Although transformer T1 is specified as a 24-volt unit, the circuit will work with units that have a lower voltage rating. If a lower voltage transformer is used in the circuit's power supply, the primary of T2 should have fewer windings—while staying within the 12- to 20-turns range—and the secondary should have more

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PARTS LIST FOR THE DRIVER CIRCUIT

SEMICONDUCTORS
U1—7808, 8-volt, 1-amp, voltage-regulator, integrated circuit
U2—567 tone decoder, integrated circuit
Q1—IRF641-ND or similar hexFET
D1–D4—1N4004 1-amp, 400-PIV, silicon rectifier diode
LED1, LED2—Light-emitting diode

RESISTORS
R1—100-ohm, 1-watt, 5%
R2—1000-ohm, ¼-watt, 5%
R3—25,000-ohm potentiometer
R4—100-ohm, 5-watt, 10%

CAPACITORS
C1–C5—0.1-µF, ceramic-disc
C6—680-pF, ceramic-disc
C7—100-µF, 50-WVDC, electrolytic
C8—10-µF, 50-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS
S1—SPST toggle switch
S2—SPDT toggle switch
F1—1-amp fuse
T1—24-volt, 2-amp, power transformer
T2—See text
Perfboard materials, enclosure, Amidon Associates, Inc., #EA-77-250 ferrite-core coil form and bobbin, heat sink, IC socket, molded AC power plug with line cord, wire, solder, hardware, etc.

turns. If the transformer has a higher output voltage rating (say 28 to 36 volts), increase the number of turns in the primary and decrease the number of secondary turns.

To obtain the best possible impedance match between your driver circuit and the Tesla coil, try experimenting with different turns ratios on T2. The time spent tweaking the driver circuit pays off in a better coil output.

To test the circuit in Fig. 1, connect its output to the bottom end of your test Tesla coil, place S2 in the TUNE position, apply power, and adjust R3 until LED1 and LED2 "burn" their brightest. Then flip S2 to OP (operate) and carefully re-tune the circuit for maximum output.

SOLID-STATE DRIVER

Our next circuit, see Fig. 2, takes a slightly different approach to generating a high-voltage output. In this high-voltage circuit, an automotive ignition coil driven by a solid-state circuit is used to generate about 10 to 25 kV.

In that circuit, as in the previous circuit, a 567 tone decoder (U1) is configured as a low-frequency, tunable, squarewave oscillator. The oscillator's output, at pin 5, is buffered by an emitter-follower, built around Q1 (a 2N3904 general-purpose NPN silicon transistor). The collector of Q1 is tied to the positive supply rail, so that when it turns on, a positive voltage is delivered to the base of Q2 (an MJE3055 NPN silicon power transistor). As the output of U1 alternately goes high and low, Q2 follows, producing a pulsating DC voltage (12 to 15 volt) in the primary of the ignition coil (T1). That causes an even higher voltage (up to 25 kV) to be induced in the secondary winding of transformer T1.

When assembling the circuit, the power transistor (Q2) should be mounted to at least a 2-inch square, aluminum heat sink.

Making sparks is easy with a solid-state driven coil. Simply position the ignition coil's output wire about ½ to ¾ inches from circuit ground (common) and set R4 for maximum resistance. Apply power and adjust R4 for the strongest spark. Right away you should also notice an unusual smell coming from the spark discharge. That's the smell of ozone. If you intend to experiment with the circuit for long periods of time, it's a good idea to do so in a well ventilated area.

Be careful when operating the coil because the sparks will shock you. With the Tesla coil operating at a much higher frequency, the shock hazard is lessened somewhat, but not eliminated, and it can still give you a slow-healing RF burn. **Hands off is the best advice you can get when dealing with any high-voltage circuit.**

CAPACITOR-DISCHARGE DRIVER

Next is a one-shot, capacitor-discharge, high-voltage generator, consisting of two transformers (T1 and T2), a diode (D1), a fairly large value capacitor (C1), and a SPDT switch (S2), as shown in Fig. 3.

When power is applied to the circuit, T1 steps the voltage up to about 150 volts. Diode D1 rectifies the secondary's AC output,

PARTS LIST FOR THE SOLID-STATE DRIVER

SEMICONDUCTORS
U1—567 tone decoder, integrated circuit
Q1—2N3904 general-purpose NPN silicon transistor
Q2—MJE3055 NPN silicon power transistor
D1—8-volt, ½-watt Zener diode

RESISTORS
R1, R2—100-ohm, ½-watt, 5%
R3—10,000-ohm, ¼-watt, 5%
R4—50,000-ohm, potentiometer

CAPACITORS
C1–C4—0.1-µF, ceramic-disc
C5—100-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS
T1—Auto ignition coil
Perfboard materials, enclosure, heat sink for Q2, IC socket, 12–15-volt DC power source, wire, solder, hardware, etc.

PARTS LIST FOR THE CAPACITOR-DISCHARGE DRIVER

D1—1N4004, 1-amp, 400-PIV, silicon rectifier diode
C1—2–10-µF, 250-WVDC, paper
T1—150-volt step-up transformer
T2—Auto ignition coil
S1—SPST switch
S2—SPDT switch
F1—1-amp fuse
Perfboard materials, enclosure, AC molded power plug with line cord, wire, solder, hardware, etc.

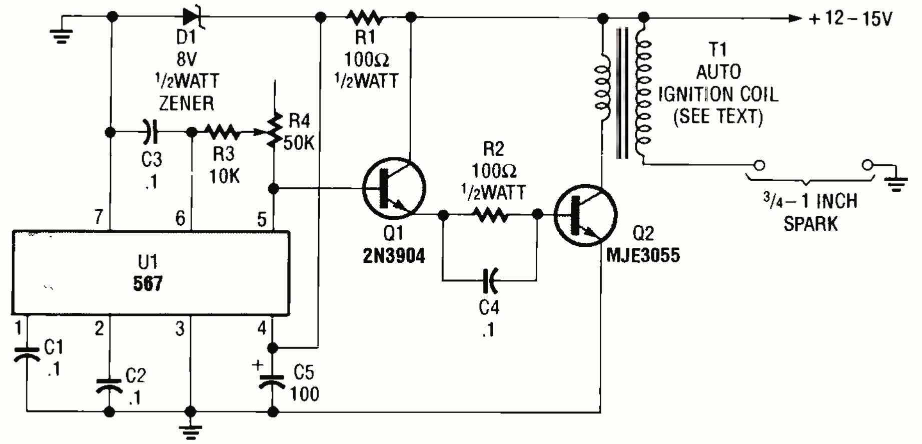


Fig. 2. The Solid-State Driver circuit takes a slightly different approach to generating a high-voltage output. In this circuit, an automotive ignition coil is used to generate from 10 to 25 kV.

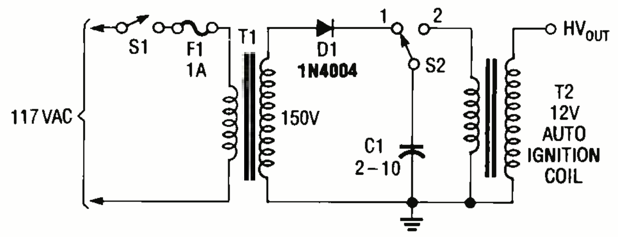


Fig. 3. The Capacitor-Discharge Driver—which is manually operated—consists of two transformers (T1 and T2), a diode (D1), a fairly large value capacitor (C1), and a SPDT switch (S2).

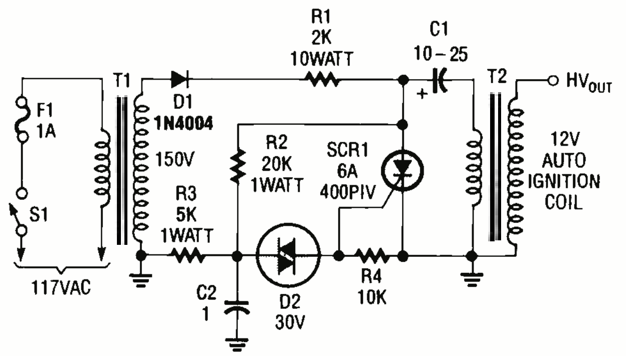


Fig. 4. The Regenerative Capacitor-Discharge Driver expands the previous circuit into a self-repeating, high-voltage generator.

PARTS LIST FOR THE REGENERATIVE CAPACITOR-DISCHARGE DRIVER

SEMICONDUCTORS

D1—1N4004, 1-amp, 400-PIV, silicon rectifier diode
SCR—6-amp, 400-PIV, (10 mA or less gate current) silicon-controlled rectifier
D2—30-volt diac, (Mouser #519-HT-32, or similar)

RESISTORS

R1—2000-ohm, 10-watt (see text)
R2—20,000-ohm, 1-watt
R3—5000-ohm, 1-watt, 5%
R4—10,000-ohm ¼-watt, 5%

CAPACITORS

C1—10- to 25-µF, 400-WVDC, electrolytic
C2—1-µF, 100-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

T1—150-volt, step-up transformer
T2—Auto ignition coil
S1—SPST switch
F1—1-amp fuse
Perfboard materials, enclosure, AC molded power plug with line cord, heat sink, wire, solder, hardware, etc.

producing a 200-volt peak, pulsating-DC output. With S2 in the position shown, C1 charges toward the supply voltage. Then when S2 is flipped to the other position, the charge on C1 is rapidly dumped to the low-impedance primary of an auto ignition coil (T2), resulting in a sudden burst of energy in T2's secondary.

The capacitor discharge method of generating high-voltage has been in use for several decades delivering fire to spark plugs in high-performance passenger and race cars.

REGENERATIVE CAPACITOR-DISCHARGE DRIVER

Our next circuit, see Fig. 4, expands the previous circuit into a self-repeating, high-voltage generator. In that circuit, AC line voltage is fed to T1 (a 150-volt step-up transformer). The output of T1 is fed to D1, which rectifies the AC voltage to provide a pulsating-DC output (of about 210 volts) that is fed through R1 to C1, causing it to begin charging toward the supply rail. At the same time, the voltage delivered to C1 is also fed through a voltage divider comprised of R2 and R3, causing C2 to begin charging.

When the charge on C2 reaches about 30 volts, diac D2 turns on supplying gate current to SCR1, causing it to fire, discharging C1 through the primary of T2 (the auto ignition coil), inducing a high-voltage output at the coil's secondary. When the charge on C1 drops below the SCR's holding level, the SCR turns off, C1 again begins to charge through R1, and the event is repeated.

The value of R1 determines the operating frequency of the circuit. The larger the resistance of R1, the slower the pulse rate. The smaller the resistance, the faster the pulse rate. The values of R2 and R3 can be varied to change C1's maximum charge voltage. Lowering the value of R3 increases the charge on C1, as well as the magnitude of the output voltage at the secondary of T2; increasing its value has the opposite affect.

That's all for now. Enjoy your experimenting until we meet here next month. ■

THINK TANK

By John J. Yacono

558 Finale

Last month, I continued our discussion on the 558 timer and presented some of the alarm circuits that I've received. This month, I'll continue with both themes, starting with some astable applications for the 558.

ASTABLE CONNECTIONS

Last month, I introduced the concept of connecting the sections of a 558 together to create long time delays, and to build sequential-timing circuits. That technique can also be used to design astable oscillator circuits.

A prime example of that is shown in Fig. 1. That circuit acts as an astable oscillator since each of its 558 sections triggers the other once it times out. Since the output of U1-b is used as the output of the circuit, its high time (set by the product of the values of R2 and C2) determines the high time of the circuit's output. After U1-b times out, section U1-a and its components (R1 and C1) determine how long it will be before retriggering U1-a, and thus the low time of the output. As in almost all 558 circuits, pull-up resistors (R3 and R4) are used to assist the open-collector outputs to produce logical highs.

The circuit may seem like a bit of overkill, especially since a typical 555 astable circuit only needs two resistors and one capacitor to do the same job. However, this circuit has advantages over its 555-based competitor. For one thing, since the low-time and high-time are pretty much independent of one another, the 558 astable oscillator can produce duty-cycle values that would require additional components for the standard 555 astable circuit. The 558 circuit as shown can be designed to produce duty cycles from almost zero to 100%.

Furthermore, selecting parts values is easier. If you know the low time you want, divide it by the value of the capacitor you wish to use for C1 and the result will be the value for R1. Perform that same procedure with the high time using the value of C2 to find the value of R2 and you're done. The values of the pull-up resistors (R3 and R4) are not too important since the 558 outputs can handle 100 mA of current (yes, *100*). Just make sure that they limit current enough to protect the load at the circuit's output.

There is a simple variation on this circuit that really blows the doors off the 555, see Fig. 2. It functions exactly like the circuit in Fig. 1, however a variable resistor has been added. It provides a frequency-control voltage to the VCO input of the 558 timer chip. Since both sections receive the same control voltage, the timing of each section is affected to the same degree. The result is a circuit that has a duty cycle that is independent of its variable frequency (try that with a 555 or two). That method allows timing adjustment over an impressive 50 to 1 range. By the way, that same trick can be used to vary the timing of all the stages in the sequential-timing circuits presented last month.

Besides that, there is a tricky way to get a single 558 to act as an oscillator (see Fig. 3). In that circuit,

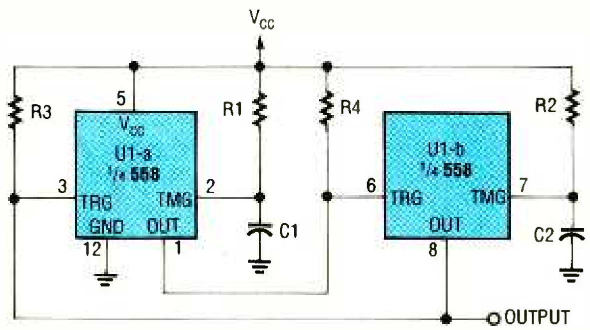


Fig. 1. Although it requires a few additional components, this astable oscillator can be designed to run rings around a 555-based version.

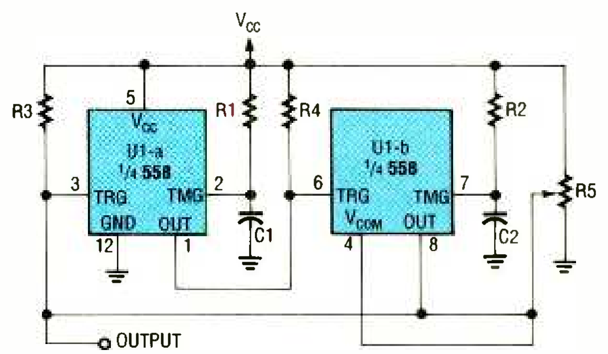


Fig. 2. By adding a potentiometer, the astable oscillator shown back in Fig. 1 can be turned into a constant duty cycle voltage-controlled oscillator with a 50-to-1 adjustment range.

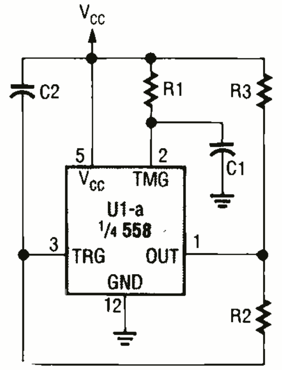


Fig. 3. A single 558 timer section can be used as an astable oscillator in a pinch. However, using this trick is only advised if the output load does not change too much.

the output of U1-a is used to charge a secondary RC-timing circuit (made from R2 and C2), which retriggers the monostable section. There is a drawback to the circuit, however: changes in the load at the output can alter the low time. However, in situations where that is not a concern and you wish to use some of the 558's other sections, this is a very handy circuit.

The last 558 circuit we'll explore is shown in Fig. 4. Once a trigger pulse is sent through D1, each section will trigger the next one in line, which is reminiscent of the sequential timers presented last month. However, since the last output in the series is connected back to the primary trigger input, the circuit retriggers itself time and again. Since the trigger pulse seems to travel around and around in the circuit, the design is called a "ring counter."

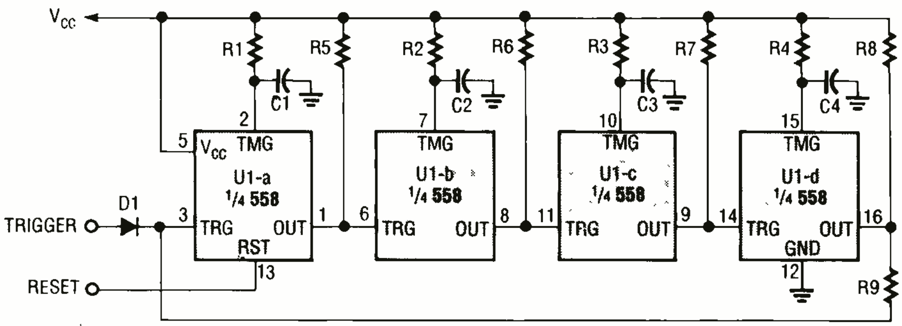


Fig. 4. This ring counter could be just the right control circuit for a sequential light display. Of course, you could add as many 558 sections to the loop as you need.

In the circuit, D1 and R9 keep the state of the output from disturbing the input trigger. Resistor R9 also keeps the reverse from happening when the unit is being externally triggered.

The circuit is really a good candidate for light displays. For example, with the proper interface components, the output of each section could be used to control one set of lights in a light-chaser circuit.

This is the last 558 circuit that I'll be presenting for now. However, I'd like to hear from people who use the 558 in their projects. If you have a working 558 design, or anything else applicable to this column, please send all the details to me here at *Think Tank*, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. If your submission is used, you'll receive a *Think Tank II* or other book as a reward. Now, let's look at what you've sent in, starting with a circuit made from two chained monostable timers.

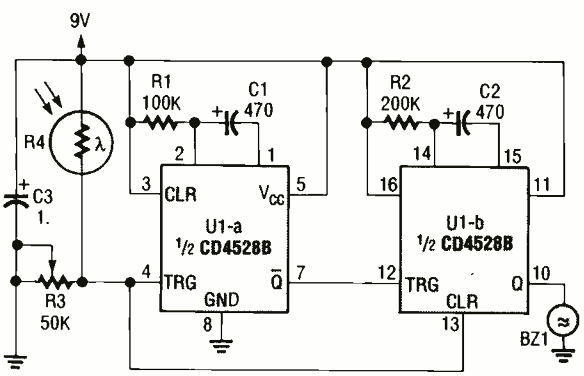


Fig. 5. Do you have someone in your house that forgets to close the refrigerator door? This may be a cure for their poor memory and your high-electric bills.

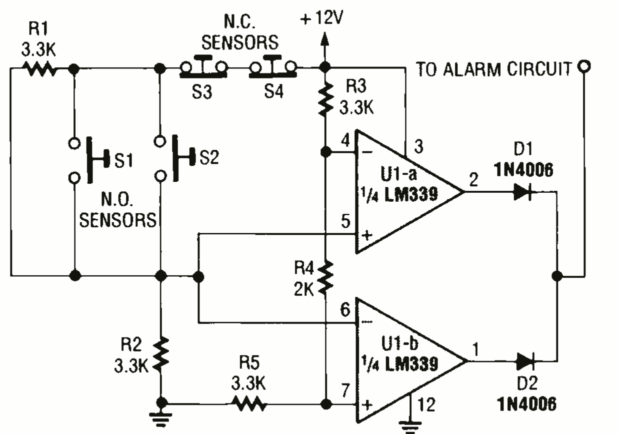


Fig. 6. This alarm actuator is a bit better than the usual alarm circuits found in this column because the wiring to the sensors is protected.

FRIDGE ALARM

The circuit shown in Fig. 5 could pay for itself and save you money if your refrigerator door is accidentally left open. When placed in a refrigerator (or other dark place), the circuit will sound an alarm for 30 seconds if the door is left open more than 15 seconds. That is accomplished by two monostable timer circuits—one composed of U1-a, R1, and C1, and the other made from U1-b, R2, and C2—and a light-activated trigger circuit.

The circuit is powered by a 9-volt battery placed in parallel with a 1-µF electrolytic capacitor. The light-dependent resistor that I used in the photodetector section measured 150k in light and 1.2k in darkness. For proper operation, the 50k potentiometer (R3) was adjusted to provide 8.5 volts to the input of the first one-shot in light (with the door open), and 1 volt in darkness (with the door closed).

When the door opens the first one-shot fires and places a low on the second one-shot's trigger input for 15 seconds—the delay before the alarm comes on.

(Continued on page 91)

HAM RADIO

By Joseph J. Carr, K4IPV

An Antenna For DX'ing The Low Bands

Now that winter's on its way, you might want to get down to some serious DX'ing. I don't know about your DX operations, but mine tend to be better in the dead of winter than in the summer because the low bands (160, 75/80, and 40 meters) get a lot of long skip during the winter months. So this time, we'll take a look at a low-frequency antenna that produces at least reasonable DX.

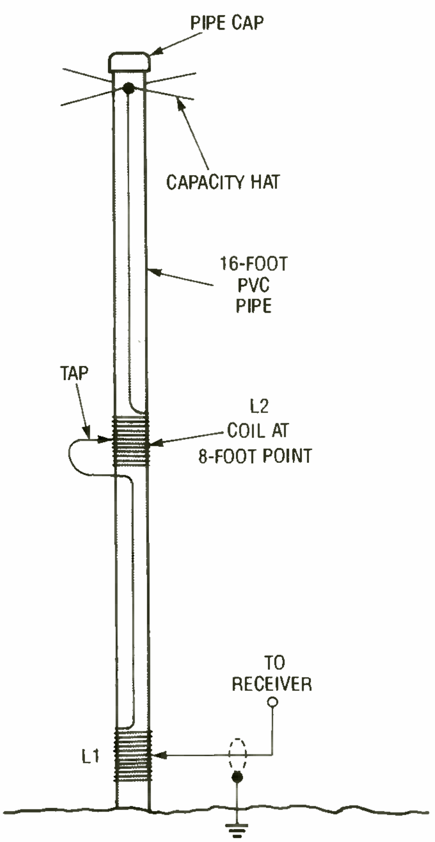


Fig. 1. A typical low-frequency antenna can be made from either a single 16-foot length or two 8-foot sections (coupled at the middle) of thick-wall PVC pipe, as shown here.

The old-fashioned dipole is still very popular for working the low bands. However, below 40 meters, you may be hard pressed to install a dipole at the optimal half wavelength. That's because even at 40 meters, the height would have to be around 65 feet. Because of the physical constraints inherent in low-frequency antennas, compensation antennas (which are a bit shorter) are sometimes used. Such antennas won't work as well as a full-sized antenna, but they work well enough to make life interesting.

LOW-FREQUENCY VERTICAL

Certain types of plumbing material have long been used in antenna construction. For example, in the days when copper tubing was inexpensive, copper verticals were popular for shortwave work. Of course, without a coating of clear lacquer or varnish, the copper soon turned an *ickey* green as the metal corroded.

Following World War II, aluminum tubing became popular with antenna builders. Since then, amateur-radio operators have used aluminum angle and tubing stock, along with sheet aluminum of various patterns (available from many of the larger hardware stores) for antenna construction.

Today, metal plumbing hardware has given way to plastic PVC tubing and pipe, which is also used for antenna construction (we'll explain how shortly). If the thick-wall variety (2 to 3 inches in diameter) is used, a PVC-pipe antenna can be reasonably self-supporting at heights of up to about 16 feet or so. Incidentally, 16 feet happens to be one of the standard lengths of PVC pipe. If, for any given installation, the PVC lacks stability (*i.e.*, it whips around too much even at low wind velocities), it can be stabilized with guy ropes.

Putting up PVC pipe antennas can be a little tricky. Some types of PVC are too flexible for antenna work. Check the stuff before buying it. Even relatively short lengths of PVC pipe sometimes need to be guyed when used for vertical antennas in order to prevent them from blowing around in the wind. Nylon rope will serve as reasonable guys (use three or four guys about ten feet up, or where it best provides support).

Wire antennas, especially those mounted on PVC pipe, can generally handle only a limited amount of RF power. Such antennas work well with power levels up to several hundred watts, but may arc or otherwise exhibit problems at kilowatt levels.

At this point, you may be wondering just how does a plastic pipe receive and transmit radio signals? That's a fair question, and it has a reasonable answer: it doesn't. The PVC pipe is used simply as a support for a vertical wire conductor (the actual antenna). That wire conductor can be run inside or outside of the pipe, and then anchored to the pipe with machine screws and solder lugs.

Figure 1 shows a typical low-frequency antenna that can be made from either a single 16-foot length of thick-wall PVC pipe, or two

8-foot sections coupled at the middle. That antenna, aside from the wire and PVC pipe, also has two coils, L1 and L2, incorporated into its design. Inductor L1 is used to match the antenna's feedpoint impedance to the receiver's 50-ohm input impedance. A length of 52-ohm coaxial cable is then used to connect a tap on L1 to the receiver. The coil can be from 8 to 10 turns of #12 or #14 enamel-coated wire for the 40- and 75/80-meter bands, and 15 turns for 160 meters. Of course, those are just starting points, may will be necessary to experiment to get the right number of turns.

The other coil in Fig. 1, L2, is a loading coil. It's used to increase the effective length of the antenna. All antennas that are used on frequencies lower than their natural resonant frequency exhibit capacitance. That capacitance has a capacitive reactance. The inductive reactance of the coil cancels capacitive reactance; L2 is needed to "tune" the antenna to the operating frequency.

For practical use in the 3.5- and 7-MHz bands (80 and 40 meters)—assuming a 2- to 3-inch PVC pipe and two vertical runs of #12 or #14 wire, each eight feet long—we can make L2 from 32 closely wound turns of #12 or #14 enamel-coated wire; 160 meters will require about 85 turns. The coil should be tapped every five turns or so, allowing you to increase or decrease circuit inductance (in order resonate the antenna) to accommodate different bands. A tap can be made by scraping the enamel coating from the wire at the correct point, and soldering a tap wire to it. Some hobbyists actually make little loops in the coil wire that are used as tapping points.

A capacitance hat is then placed at the top of the antenna. The capacitance hat, which broadens the bandwidth of the antenna, can be made from four 15-inch welding or bronzing rods, stiff solid wire, or brass hobby rods. The rods should be equally spaced around the antenna, and connected to the top end of the antenna wire.

Tuning a loaded vertical can be a little tricky if you do not have the proper equipment. The best way to tune the antenna is to use an RF wattmeter, VSWR meter, dip meter, a noise bridge, or some other instrument. Another, less precise, way is to pick a distant station operating with a strong signal on the frequency that you want to hear, and then find the correct tap using the receiver's S-meter. The maximum signal strength is theoretically found when the tap is correctly set.

The reason that the second method is less precise is that the changes are going to be very subtle. Indeed, so subtle that ordinary fading (and other variations) in the signal strength may easily be mistaken for the correct setting, or may even obscure the correct setting. For that reason, I recommend using an instrumentation approach.

LOW-FREQUENCY ANTENNA GROUND SYSTEMS

A good ground is important for all antennas, especially the unbalanced types like verticals, but it is even more critical when operating in the low-frequency bands. A very good earth ground, or to at least a multiple radial counterpoise ground, is essential.

Such a counterpoise need not have straight radials, but they should at least be resonant. Keep in mind that the efficiency of a compensation antenna is poorer than full-sized antennas at best, so we don't want to burn up any more signal in losses than is absolutely necessary.

A SAFETY NOTE

Erecting antennas can be a dangerous affair, so you are cautioned to follow **all** the rules. Don't even think about installing any antenna over a power line, or where it can fall on a power line if it gets away from you. And don't ever erect an antenna alone, always use the buddy system; I occasionally break that rule, and almost always regret it. Beside the fact that antenna work is hard work, there's always the possibility of injury. My own injuries have been limited, thank God, to a strained back or a turned ankle. But...it's always possible to hurt something vital (your neck, for instance), so get help.

SOFTWARE

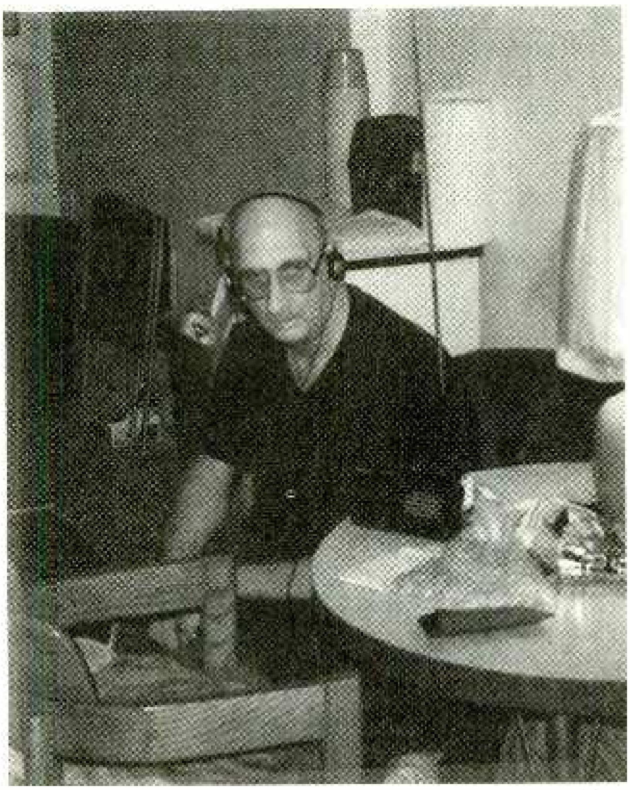
There's some new antenna software available for hams and SWL's building antennas. Called ANTLERS, the program calculates the lengths and certain other details for a wide variety of antennas. Not included in other programs is a function that calculates the inductance and resonating capacitance of radio direction-finding loops. The price of ANTLERS is $20 postpaid. Contact me at P.O. Box 1099, Falls Church, VA 22041 if you are interested in receiving a copy. ■

DX LISTENING

By Don Jensen

The Shortwave Revival

One of the more interesting developments in the world of world-band radio in the past decade has been the rebirth of private shortwave broadcasting in the United States. In the pioneer days of shortwave radio (more than 60 years ago) the first American SW stations were privately owned and operated. Most were low-powered experimental transmitters set up by a number of AM broadcasting stations that were seeking a wider audience than their medium-wave transmissions were reaching.



Las Vegas SWL Alan Smit says he likes to listen to the world news and music from overseas stations on his Radio Shack DX-350 receiver. Alan also notes that he is a registered monitor, WDX7DBE.

For the most part, those SW'ers relayed the parent station's regular programming. But as radio networks came to dominate AM radio in the U.S., stretching from coast-to-coast in the 1930's, those shortwave relays faded from the scene. With only a few exceptions, that left American SW broadcasting to the "big boys" of radio—the networks themselves, NBC and CBS, and the major electronic manufacturers, General Electric, Westinghouse, and the Crosley Corp.

Advertising revenue was the lure to private SW stations in the late 1930's and, in fact, some advertisers (Standard Oil, Firestone, Camel Cigarettes, Adams Hats) gave shortwave a try. But, by and large, commercial shortwave was a disappointment. Then came World War II, which changed things dramatically. The United States government, lacking a SW voice of its own, established the *Voice of America* in 1942, using the transmitters of the existing private stations. At war's end, the VOA was well established and has continued to grow in size and importance over the years, celebrating its 50th birthday this year.

While private SW broadcasting in the U.S. never died out completely, it did not regain the pre-war level of activity. That began to change, however, about a decade ago when interest revived. Again, as in the late 1930's, it seemed that there might be a future for commercial SW broadcasting. However, it was religious broadcasting that really sparked the revival of interest in private SW broadcasting in the United States. Let's take a look at some of the programming currently available from those U.S. shortwave outlets.

US SHORTWAVE BROADCASTS

WYFR, Family Radio—This religion broadcaster is the successor to pioneer station WRUL, which began broadcasting in 1931 from Massachusetts. Today WYFR's headquarters is in California and its transmitters are in Florida. At the time of this writing, it could be heard on 9,505 kHz, during the 0100–0500 UTC period.

WWCR, Worldwide Christian Radio—Religion and politics can be heard from this station based in Nashville, TN. Try this one on 5,935 or 7,435 kHz during the 0100–0600 UTC time slot.

WHRI, World Harvest Radio—This station, headquartered at South Bend, IN, is primarily a religious broadcaster, but it also carries other programming, including an English service of Croatian National Radio. Look for this one on 7,315 kHz during the prime evening-listening hours in North America, 0100–0600 UTC.

WCSN/WSHB, Christian Science Monitor—The Boston-based Christian Science Church, longtime publisher of a respected newspaper, entered the shortwave-broadcasting field a few years ago. It now has two Stateside transmitting sites: WCSN at Scotts Corners, ME, and WSHB, in Cypress Creek, SC. WCSN is scheduled, at this writing, for 0000–0200 UTC on 9,850 kHz, and at 0200–0400 UTC on 9,350 kHz. WSHB is scheduled for 7,385 and 9,455 kHz at the same time.

KVOH, High Adventures Ministries—The U.S. outlet of this religious network, which also has SW stations in Lebanon and the Pacific, broadcasts from Rancho Simi, CA. Frequencies to try are 17,775 kHz at 0000–0400 UTC and 9,785 kHz at 0400–0600 UTC.

WMLK, Assemblies of Yahweh—This persistent "Mom-and-Pop" station is operated by a small Pennsylvania religious sect. It has a limited schedule and a rebuilt shortwave transmitter operating from a former gas station; however, its small but dedicated staff has faithfully kept it on the air since 1985. Try for this one on 9,456 kHz at 0400–0900 UTC from Sunday through Friday.

WRNO Worldwide—This New Orleans-based SW'er is credited with starting the revival of private world-band radio in the U.S. Broadcaster Joseph Costello III believed that commercial SW was feasible in this country. And he seems to have proved his point since 1982. Try Saturday and Sunday nights at 0000–0300 (remember that's Sunday and Monday) UTC.

WJCR Worldwide—A relatively new SW voice is this religious station broadcasting from Upton, KY. Look for it during the North American evening hours of 0000–0600 UTC on 7,490 kHz.

Radio Miami International—This station, which has been airing Spanish programming via WRNO, says it expects to have its own station operating from Florida by year's end.

*Credits: Richard Hankison, KS; Morris Sorensen, ONT; James Feeley, GA; Al Gastle, ONT; Jerry Klinck, NY; Rich D'Angelo, PA; Mike Westdal, CA; Ontario DX Association, P.O. Box 161, Station A, Willowdale, ONT M2N 5S8, Canada; North American SW Association, 45 Wildflower Road, Levittown, PA 19057

TUNING THE UTILITIES

I recently received a letter from one of our readers in Hawaii. R. Souza of Wailuku on the island of Maui, writes: "I'm a longtime scanner hobbyist but recently I tried listening to shortwave *utilities* with my DX-440 receiver. Not long afterward, I heard transmissions from the space shuttle Atlantis at 9:20 P.M. local time on 14,295 kHz.

"For about 10 minutes, I heard the astronauts talking to mission control, telling of seeing meteorites, small in size, drifting toward Atlantis. The rest of the transmission was to weak to make out and then it faded."

Reader Souza's references to "utility" stations warrants a brief explanation for those who aren't familiar with the other side of SW/DX listening. You may be most familiar with shortwave-broadcast stations, those that air regular programming for general audiences. But, outside of the SW-broadcast bands are many other types of transmissions, one- or two-way communications, some voice (usually in single-sideband mode), CW code, radioteletype, FAX, etc. They include commercial and military communications, aeronautical and maritime traffic, weather, and much more.

Usually, DX'ers lump those varied radio services under the catch-all term, utility stations. Usually this column focuses on the SW broadcasters, but I do welcome reports on interesting utility loggings, which I will feature from time to time.

Getting back to R.S.'s letter, the logging most likely was a "real time" re-transmission of a live pickup from the shuttle aired by WA3NAN at the Goddard Space Center, Greenbelt, MD. Shortwave retransmissions of space communications date back to the early moon flights and continue to provide the SWL with fascinating listening!

His letter continues "Could you give me a shortwave SSB (single-sideband) frequency for the presidential plane, Air Force 1, or any other interesting utility frequencies?"

Well, R.S., I recently noted AF-1 communicating with Andrews AFB, MD, in USB (upper sideband) on 11,229 kHz. A couple of their other favorite frequencies are 5,696 and 8,984 kHz for Coast Guard communications, particularly during North Atlantic storms or hurricanes; 8,762 kHz, a frequency used by WOO, Ocean Gate, NJ, for high seas communications; or 6,753 kHz, used by the Canadian armed forces, Trenton, Ontario, for regular weather transmissions.

MORE LETTERS

Alan Smit, Las Vegas, NV, writes to say that he's a **Popular Electronics** subscriber and a regular reader of *DX Listening*. "I hope you can use my picture in your column," says Alan. You bet! And here it is. I always welcome photos—please identify the receiving equipment pictured too—and letters with logging reports, questions or comments on SWL'ing.

Norman F. Ives Jr., Selah, WA, has returned to the listening hobby he left years ago and was pleased to see an old familiar name on the newsstand. "It looks like the old *pop'tronics* of the late '60's and early '70's just a larger format. Is this the same magazine that used to have the DX Monitor's Club that issued me the monitor's ID, WPE1HQC? The magazine is as good as I remember. So is your column!" Today's **Popular Electronics**, Norman, is the successor to the magazine that you recall from 20 years ago, and it is still filled with the same sort of articles and columns you liked then.

As I have noted from time to time, in answer to other questions, *pop'tronics* long ago stopped issuing its monitor ID's, such as your WPE1HQC call letters. However, the program was continued by Hank Bennett's WDX Monitor Service (P.O. Box 3333, Cherry Hill, NJ 08034).

Anyone wanting details on how to get their own monitoring call (or in your case, Norm, converting your old ID to WDX1HQC) should send Hank a self-addressed stamped envelope.

DOWN THE DIAL

Here are some stations being reported recently.

ALGERIA—17,745 kHz. *Radio Algiers* has an English-language newscast at 1705 UTC, followed by identification and popular music.

BELGIUM—9,930 kHz. *BRT*'s regular English letter-box program, "Brussels Calling" has been noted on Wednesday at 0050 UTC.

IRAN—9,022 kHz. Look for the *Voice of the Islamic Republic of Iran*, Teheran, on this out-of-the-way frequency beginning at around 0300 UTC.

SUDAN—11,710 kHz. *SNBC* in Omdurman broadcasts in Arabic at around 1345 UTC and has been noted in the eastern U.S. ■

SCANNER SCENE

By Marc Saxon

Drive-Through Sermons

New from Radio Shack is the *Realistic PRO-43* handheld programmable scanner. This handful of power stores a full 200 memories (in ten banks) and covers the 30–54-, 118–174-, 220–512-, and 806–1000-MHz bands (except for the 800-MHz cellular frequencies).

Radio Shack's Realistic PRO-43, with 200 programmable memories, covers the popular military UHF band.

Here's a Realistic scanner that covers the exotic 225–400-MHz military UHF band that has been attracting so much interest! And, yes, both aeronautic bands are covered in AM mode, although the scanner can be switched into FM mode there if desired. There is some FM activity in the 225–400-MHz band. That band can be scanned or searched in 12.5-kHz increments.

The PRO-43 has a feature called HyperScan, which means that it scans at 25 channels-per-second but will search/scan at twice that rate. The unit's AM sensitivity is 2 μV at 20 dB (S+N)/N at 60% modulation, while the FM sensitivity is 1 μV at 20 dB (S+N)/N at 3-kHz deviation. The triple-conversion circuit has IF's on 610 MHz, 48.5 MHz, and 455 kHz. That provides selectivity of -6 dB at ± 10 kHz, and -50 dB at ± 20 kHz.

The scanner operates from six "AA" batteries, and can be used with NiCad batteries. An AC power supply/battery charger is available separately. A rubberized antenna with a BNC connector is supplied with the PRO-43. A large LCD readout displays frequencies as well as operating-status information (lockout, delay, priority, etc.)

This is an easy-to-use scanner, and comes in response to the many requests Radio Shack has received to bring out a handheld that included the UHF aeronautics band along with the other bands of interest.

At $349.95, we think that the PRO-43 is a fine addition to the Realistic line. You can see it at your local Radio Shack store.

NEWS & VIEWS

Most communications in the 225–400-MHz UHF military aeronautics band are in AM mode. As we mentioned above, sometimes you run into FM communications as well. We recently heard wideband FM (WFM) air/ground telephone calls being downlinked on 397.05 MHz. They were calls from aircraft "SAM-89671," which is the USAF plane assigned to the U.S. Secretary of State. Normally, we would have expected to hear those calls, along with Air Force One, Air Force Two, and other Special Air Mission (SAM) VIP aircraft, downlinked on 415.70 MHz (407.05-MHz uplink).

At other times, admittedly infrequently, we have monitored similar military-aircraft VIP air/ground phone-call downlink circuits in WFM mode on 336.8, 345.5, and 382.35 MHz.

We have found many interesting things to monitor in this UHF band, using regular AM mode. If your scanner covers this band, be sure to keep 239.8, 255.4, 282.8, 311.0, 319.4, 342.5, 344.6, 364.2, 372.2, 375.2, and 381.8 MHz plugged in. These frequencies produce interesting military aeronautic communications, ranging from the Strategic Air Command to U.S. Coast Guard Search and Rescue, as well as aeronautic weather and other information.

From Stamford, CT, comes a letter written by John Kocor. He asks if scanners that require plug-in crystals are a dead issue at this point. He also asked if we know of any sources for scanner crystals.

We wouldn't proclaim them to be totally "dead," but we feel quite comfortable in saying that they represent a technology that is rapidly fading into obscurity and disuse insofar as hobby monitoring is concerned. The development of programmable scanners saw to that. There are a couple of crystal sets for specialized uses that are still being sold, however, and many old crystal scanners probably still are used regularly. There may be some sources left for new crystals for those old Regency, Bearcat, Sonar, and other crystal scanners, but we don't know who or where they might be.

FREQUENCY SHORTAGE

Several months ago, we wrote about the strange mix of stations that use the low-power industrial frequencies such as 151.625, 154.57, and 154.60 MHz. Brian Mitchell, of Rapid City, SD, wrote recently to tell me that he has monitored undercover police officers using 154.60 MHz for surveillance operations.

Brian also sent a clipping from the *Rapid City Journal* that tells about how the local McDonald's restaurant drive-through shares one of those frequencies with the wireless microphone used by the priest at the nearby Cathedral of Our Lady of Perpetual Help. At times the church services come in so well at McDonald's that the drive-through employees have to shut off their two-way headsets and walk out to the cars to take the orders. While this interference is unusual, everyone concerned agrees that it is certainly better than if the interference had worked in the other direction, with orders for burgers and fries drowning out the church services.

McDonald's doesn't really find the interference a bother, and usually leaves the sermons playing in their systems. People stopping by say that they like hearing them.

FROM THE MAIL SACK

K.F. Sheehan of Decatur, IL, passes along some frequencies of interest in his hometown. Those include Howard Protective Service on 464.55 MHz, Showcase Cinemas on 154.60 MHz, and both Beaver Creek and Troy High Schools on 154.60 MHz.

A letter from RM1 Thomas R. Ziko, KA5EYY/4, who is with the U.S. Navy in Charleston, SC, asks if we can provide scanner frequencies relevant to NASA's space shuttle. There are zillions of frequencies used in the immediate launch and landing areas. The best bets for persons not directly in those areas would be 259.7 and 296.8 MHz, which are used when the shuttle is going to land and has re-entered the atmosphere. The crew communicates with chase aircraft on those frequencies.

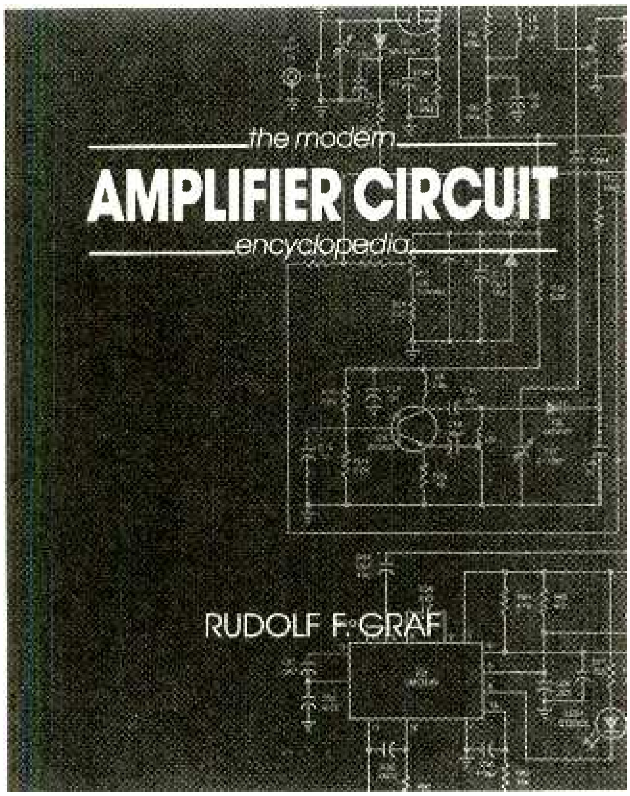
We want to see your frequencies, news clippings, questions, etc. Write to *Scanner Scene*, **Popular Electronics**, 500-B Bi-Country Blvd., Farmingdale, NY 11735. ■

ELECTRONICS LIBRARY

The Modern Amplifier Circuit Encyclopedia

by Rudolf F. Graf

A wealth of up-to-date amplifier circuits have been assembled in this one convenient sourcebook, which provides engineers, technicians, and students with fast, easy access to more than 250 practical, ready-to-use circuits. The book covers the whole spectrum of amplifier circuits, including audio power, high-frequency, operational, programmable, video, logarithmic-composite, wideband, audio-signal, instrumentation-logic, RF, transducer, stereo, voltage-controlled, and thermocouple circuits. The circuits appear in their original form to eliminate transcription errors, and are organized by application for easy reference. The schematics are accompanied by a brief explanation of how each circuit works, and the original source for each circuit is included for readers who want additional information.



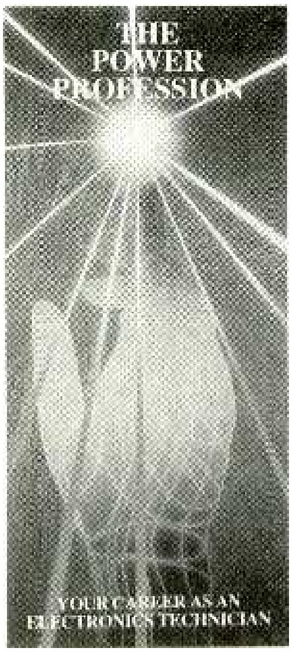
The Modern Amplifier Circuit Encyclopedia costs $12.95 and is published by TAB Books, Division of McGraw-Hill Inc., Blue Ridge Summit, PA 17294-0850; Tel. 1-800-822-8138.

CIRCLE 98 ON FREE INFORMATION CARD

THE POWER PROFESSION: YOUR CAREER AS AN ELECTRONICS TECHNICIAN

from The Electronics Industries Association

Are you considering turning your electronics hobby into a career? This 12-page brochure provides a glimpse of the professional world of electronics, explaining what you can expect if you become a skilled electronics technician. The pamphlet includes industry overviews, charts specific growth fields with projections to the year 2005, and outlines the training necessary to become an electronics technician, and describes various employment options. Addresses are provided for those interested in continuing their educations or obtaining more detailed information.



The Power Profession: Your Career as an Electronics Technician can be obtained by sending a legal-sized self-addressed stamped envelope to the Electronic Industries Association, Consumer Electronics Association, 2001 Pennsylvania Avenue, NW, Washington, DC 20006-1813.

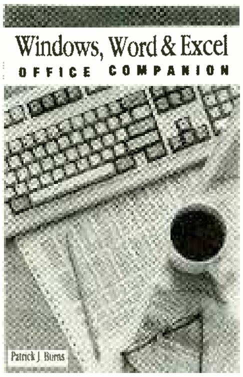
CIRCLE 93 ON FREE INFORMATION CARD

WINDOWS, WORD & EXCEL OFFICE COMPANION

by Patrick J. Burns

Since its 1990 release, Windows has sold more than 13 million copies and is approaching a 10% market share among PC users. This handy, three-in-one volume provides essential support for beginning-to-intermediate PC users who are making the transition from DOS to Windows. In three well-organized sections, the book acclimates readers to the Windows environment and explains how to use two of its most popular applications: the Microsoft Word data-processing and the Excel spreadsheet programs. Each section includes valuable information on basic commands and features, instructions for performing various tasks, and helpful tutorials. Dozens of tips, tutorials, illustrations, and shortcuts that are not found in manufacturers' reference manuals round out the book.

The book provides an extensive introduction to Windows,



covering both 3.0 and 3.1, that provides a transition from keyboard pressing to mouse clicking and acknowledges, on a task-by-task basis, when one method is more efficient than the other. In addition, it explains how to exchange spreadsheet data and word-processing text within the Windows environment, determine when and how to use the Program Manager, run several applications at once, work with File Manager, activate Print Manager, format documents, manage and automate Word for Windows applications, quick-start Excel, build a database, customize the Excel Word environment, and automate spreadsheet operations.

Windows, Word & Excel Office Companion costs $21.95 and is published by Ventana Press, P.O. Box 2468, Chapel Hill, NC 27515; Tel: 919-942-0220; Fax: 919-942-1140.

CIRCLE 92 ON FREE INFORMATION CARD

WEATHER RADIO

by Anthony R. "Tony" Curtis, K3RXK

Subtitled "A Complete Guide to Receiving NOAA, Volmet, Weather Fax, Weather Satellites, and Other Weather Information Sources," this may well be the only book to detail all the sources of weather information available via radio on longwave, medium wave, shortwave, VHF, and UHF. It explains how, when, and where to tune them, and includes details on picking up weather information from NOAA, marine weather, Volmet broadcasts, NavTex, and all the weather satellites. In addition, the book covers monitoring severe weather situations, amateur-radio weather-emergency net frequencies, land mobile-radio meteorological use frequencies, Coast Guard weather, and hurricane hunters. It even covers weather broadcasts for the Russian fishing fleet and iceberg patrols. The book also provides FAA and military weather sources, a master list of weather and weather-related frequencies, a Wind Chill Chart, and a Heat Index.

Weather Radio is available for $14.95 plus $2 shipping and handling from Tiare Publications, P.O. Box 493, Lake Geneva, WI 53147; Tel: 414-248-4847.

CIRCLE 91 ON FREE INFORMATION CARD

JENSEN "D" SUPPLEMENT

from Jensen Tools

This 84-page supplement to Jensen's 1992 catalog introduces new tools and test instruments for use in electronic design, assembly, and repair. It includes analyzers, monitors, meters, circuit testers, magnetic probes, static-control devices, soldering supplies, wire and cable, connectors, and other networking products. Many major manufacturers are represented in the supplementary catalog, which also features holding devices, lighting/optical aids, instrument cars, cases, and shipping containers.

The "D" Supplement is free upon request from Jensen Tools Inc., 7815 South 46th Street, Phoenix, AZ 85044; Tel: 602-968-6231.

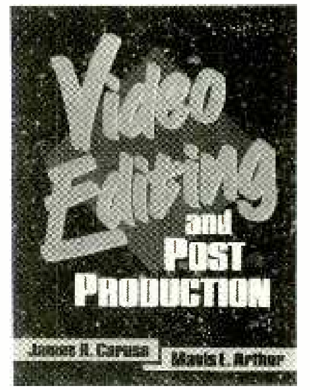
CIRCLE 90 ON FREE INFORMATION CARD

VIDEO EDITING AND POST PRODUCTION

by James R. Caruso and Mavis E. Arthur

Written for professionals as well as home-video enthusiasts, this book describes the essentials and importance of video editing and post production. The information presented in this book can help readers to produce a finished show that will entertain, inform, and enhance the viewer's enjoyment.

The book begins with an explanation of why video editing is necessary, and then goes on to enumerate the step-by-step procedures needed to organize all the elements that make up the final production, including budgeting. Subsequent chapters cover editing equipment, investigating what various pieces do and how they work; describe different types of edit systems and equipment that can be used; explore how to use different transitions between shots; and explains how audio affects production and how to edit and mix audio. The book



goes on to detail how to put together the final edit plan and maintain creative control and demonstrates how to actually edit the final show. Finally, the book examines how to make duplicates of the finished work for distribution.

The text is accompanied by numerous photos, illustrations, and charts. A glossary of terms is included.

Video Editing and Post Production costs $24.95 and is published by Prentice Hall, Englewood Cliffs, NJ 07632. ■

CIRCLE 89 ON FREE INFORMATION CARD

NEW PRODUCTS

Laser Detector

Wars tend to escalate, and the war between law-enforcement agencies and radar-detector owners is no exception. So it's not surprising that the newest police weapon—the laser speed detector—has been counterattacked by laser-gun detectors, even though the laser gun is still limited to a few scattered places in the country. *Bel-Tronics'* first entry in that market is the

LaserAlert, which uses an adaptation of the military laser technology used in the Gulf War to detect the police laser beam and alert the driver that his speed is being detected. LaserAlert is programmed to receive only police laser and to discriminate against other laser or optical sources and electromagnetic interference that might trigger false alarms.

Resembling a standard micro-sized detector, the LaserAlert can work as a stand-alone unit or can be teamed with most three-band radar detectors to provide complete X, K, Ka, and laser coverage. It can detect both of the laser guns currently in use: the Pro-Laser from Kustom Signal and the LTI 20/20 from Laser Technology, Inc. Features include a three-LED alert meter, dim/dark modes, distinct audible alert, a windshield mount, a hook-and-loop fastener, and a coiled power cord.

The LaserAlert laser-gun detector has a suggested retail price of $129.95. For more information, contact Bel-Tronics Limited, 20 Centre Drive, Orchard Park, NY 14127.

CIRCLE 101 ON FREE INFORMATION CARD

INK-JET PRINTER

Royal's CJP450 ink-jet printer is one of the only compact models on the market that provides Hewlett-Packard DeskJet Plus emulation. It also provides a high level of compatibility with industry-standard software, and is fully compatible with Windows 3.0, allowing users a sophisticated level of performance from their software. With laser-quality resolution of 300 × 300 dots per inch, the CJP450 prints at a speed of 80 characters per second (cps). Other features include the ability to print in both portrait and landscape orientations, as well as in a high-speed draft mode of 160 cps that allows users to create high-speed draft output while using only half the ink of the letter-quality mode. An optional 70-

page automatic sheet feeder provides virtually unattended printout of lengthy documents, and accommodates legal, standard, and European A-4 sized sheets. The ink-jet printer operates almost silently.

The CJP450 ink-jet printer has a suggested retail price of $499.95. For further information, contact Olivetti Office USA, Royal Consumer Business Products, 765 U.S. Highway 202, Bridgewater, NJ 08807-0945; Tel: 908-218-5518.

CIRCLE 102 ON FREE INFORMATION CARD

RECEIVER DOWNCONVERTER

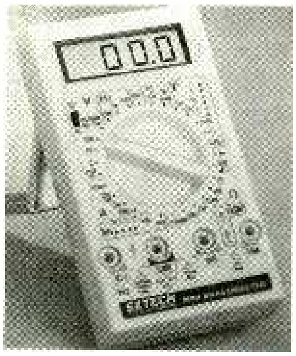
To extend the performance of test equipment and UHF communications receivers, *Ace Communications' DC 89* 800-MHz downconverter converts the frequency range of 806–900 MHz down to 406–500 MHz. The compact unit measures just 3 × 2 × 1½ inches. Frequency stability is assured by the use of a new surface-mount prescaler/synthesizer referenced to a precision quartz-crystal clock. For added versatility the DC 89 features BNC connectors and an internal battery; The converter can even operate on handheld receivers.

The DC 89 downconverter has a suggested retail price of $89. For additional information, contact Ace Communications, Monitor Division, 10707 East 106th Street, Fishers, IN 46038; Tel: 317-842-7115; Fax: 317-849-8794.

CIRCLE 103 ON FREE INFORMATION CARD

MULTIMETER/ THERMOMETER

Extech's Mini Rangemaster multimeter/thermometer combines a voltmeter, ammeter, ohmmeter, frequency counter, capacitance meter, transistor tester, diode checker, and thermometer in one compact, drop-proof case. Its 41 ranges include DC voltage from 200mV to 750 volts, AC voltage to 600 volts, DC/AC current to 10 amps, resistance to 2000 megohms, and frequency from 20 Hz to 200 kHz. A Type-K thermocouple input allows the user to make temperature measurements from −50° to 1400°F and from 0° to 750°C using any standard Type-K thermocouple. Other features include 0.05% basic DC accuracy, a rotary range-selection switch, a safety-yellow case, and a built-in



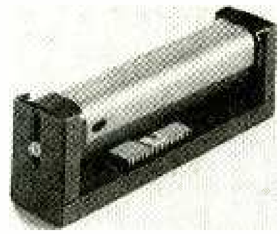
stand. The handheld instrument comes with a set of test leads, a bead-wire temperature probe, and a vinyl carrying case.

The Mini Rangemaster multimeter/thermometer has a list price of $99. For additional information, contact Extech Instruments, 335 Bear Hill Road, Waltham, MA 02154; Tel: 617-890-7440; Fax: 617-890-7864.

CIRCLE 104 ON FREE INFORMATION CARD

BATTERY-OPERATED EPROM ERASER

Designed with hobbyists and field technicians in mind, the *DE-1* EPROM eraser from *UVP* is battery operated, so work isn't limited to areas with wall-outlet availability. It can even be used in the car while traveling to another location. The DE-1 is small enough to fit into a tool kit, and can erase EPROM's in as little as two minutes. It features one 4-watt, 254-nm tube; a conductive foam pad to prevent electrostatic buildup; and a vertical sliding mechanism that



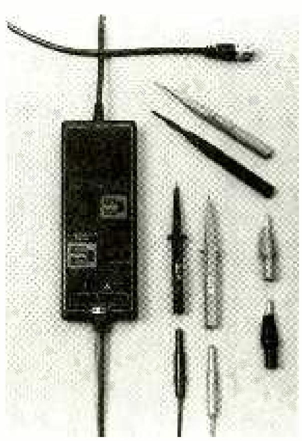
adjusts the light to the EPROM height. The DE-1 runs on four standard "AA" batteries, with an estimated battery life of more than five hours. The $1\frac{1}{5} \times 3 \times 6\frac{3}{4}$-inch device holds between three and eight EPROM's depending on their size.

The DE-1 EPROM eraser has a list price of $59.95. For further information, contact UVP, Inc., 5100 Walnut Grove Avenue, San Gabriel, CA 91778.

CIRCLE 105 ON FREE INFORMATION CARD

DIFFERENTIAL OSCILLOSCOPE PROBE

For measuring two points in a circuit without the necessity of a ground reference, *Test Probes, Inc* has introduced the *ADF15* differential oscilloscope probe. The two different input signals are processed in one probe on one scope channel. That design allows the oscilloscope to be grounded for safety while the measurements are made without expensive isolation amplifiers. It also eliminates errors caused by the differences between two amplifiers and two probes. Intended for differential measurements in switching power supplies, motor controllers that use thyristors and power MOSFET's, and similar devices, the probe makes accu-



rate measurements of small signal differences even in the presence of very high common-mode voltages. It has a bandwidth of DC-15 MHz and a switchable ×20–×200 attenuation ratio. It comes with standard probes, alligator clips, and spring-tip probes with banana plug leads.

The ADF15 differential oscilloscope probe costs $375. For more information, contact Test Probes, Inc., 9178 Brown Deer Road, San Diego, CA 92121; Tel: 619-535-9292.

CIRCLE 106 ON FREE INFORMATION CARD

PERSONAL ORGANIZER

Citizen's top-of-the-line personal calculator is the *ED-9000 Personal Digital Diary*. The ED-9000 offers a wide range of useful applications, including a checkbook planner, metric conversion, currency exchanger, expense tracking, and size conversion. With 128K of memory and "help" commands to assist the user, the handheld unit features a special F3 function key offering a window view display with a 24-item menu. The ED-9000 also allows data link capability for downloading to an IBM-compatible PC. A comprehensive telephone directory, a personal scheduler, a world-time clock, and a business-card function complement the calculator functions.

The ED-9000 Personal Digital Diary has a suggested retail price of $294.95. For additional information, contact CBM America Corporation, 2020 Santa Monica Blvd., Suite 410, Santa Monica, CA 90404; Tel: 213-828-8245; Fax: 213-838-0846. ■

CIRCLE 107 ON FREE INFORMATION CARD

TSM FUNCTION GENERATOR

(Continued from page 26)

one unlabeled terminal on the amplitude-scale switch. I buzzed the switch out with my multimeter to find that terminal "A" (as printed on the body of the switch) was the right one. With all the components installed, the unit was ready for calibration.

Final Adjustment. The calibration procedure proved to be the last hurdle to surmount. The process was slightly hampered by the fact that two off-board potentiometers have the same designations as two on-board pushbuttons. This is further aggravated by the fact that the amplitude-control potentiometer, which is labeled as P1 in the schematic, is called P1A in the calibration instructions. By the way, none of the control functions (frequency, amplitude scale, and amplitude) are mentioned in the documentation, only parts designations. I only learned what each control did by studying the schematic diagram.

The remainder of the calibration instructions are very difficult to sort out. They start by telling you to put one switch in an unlabeled position, and follow that up by telling you to "set" a pushbutton "for 1000 Hz," when the switch's real function is to select the sinewave output. Rather than continue to tear-apart the instructions, I'll just present my idea of how they should read to save space and help anyone wishing to build the project.

First, set all on-board trimmers to their mid position, and apply power. Turn the amplitude-control potentiometer (P1) completely clockwise, and set the amplitude-scale switch (S1) to the 1-volt position (the third position, moving clockwise). Push the 80–1000-Hz pushbutton (P3) and make sure the ×2 pushbutton (P1) is disengaged (or sticking out). Select sinewave output by pressing P6. Connect an AC voltmeter and an oscilloscope between the output at point F and point D (ground) on the circuit board. Set the scope for external triggering and connect its trigger input between points K and D on the circuit board.

Regardless of the waveform that appears on the scope, adjust RA5 so the frequency of the wave is 1000 Hz. Varying RA2 (which can be called the sinewave-shape adjustment) causes the output to transform from a triangle wave to a sinewave. Adjust that potentiometer to get the best sinewave possible. Now adjust RA1 (the symmetry trimmer) so the peaks in the wave look like the troughs. Adjust RA1 and RA2 again to get the best sinewave. Now adjust RA3 so the voltmeter reads 1-volt. If necessary, adjust RA1, RA2, and RA3 over again. Lastly, select triangle-wave output by pressing P7 and adjust RA4 till the multimeter reads 0.82 volt.

Summary of Operation. The completed circuit performed like a champ with but one exception: Unfortunately, no matter what I did, the unit refused to reach the maximum frequency of any of its ranges. I suspect that is probably due to stray inductance (as mentioned earlier) and the tolerance of the components. However, there is enough overlap between the different frequency ranges to prevent gaps in the device's overall frequency range.

One last item that bears mention is an undocumented pushbutton identified only as P10. Some examination of the circuit revealed that the pushbutton puts the unit into a frequency-shift keying (FSK for short) mode. Since there is no FSK input connection, the unit uses its output signal as the FSK input. The result is a strange signal that could be useful for ringing out cables, as the sound it would produce is probably most distinctive.

Although building the kit required some electronics sleuthing, I like the end result. To be completely honest though, my positive opinion is due in part to the fact that I didn't mind doing the extra homework myself. If you're like me in that respect, and you have some experience at electronics, then I recommend the kit. It will give you a little challenge for a couple of evenings, and a good piece of test equipment ever after once completed.

The TSM Function-Generator Kit No. 88 is available from American Design Components (815 Fairview Ave., Fairview, NJ 07022; Tel. 1-800-776-3700) as item No. 21260 for $38.95. Contact them directly for further information or circle No. 119 on the Free Information Card. ■

TV/VCR SWITCH
(Continued from page 45)

the outer sheath to circuit ground and the inner wire to switch S1. Strain reliefs should be provided for the power cord and the signal cable.

Once the circuit is completely assembled, visually check for wiring errors, solder bridges, cold solder joints, etc. Clear any problems that you find. Once everything appears okay, you are ready for the smoke test.

Smoke Test. At this point, all of the components except for U3 should be mounted on or connected to the circuit board in a manner that conforms to the schematic diagram in Fig. 1. **Do not** connect the wiring from the relay to the AC line yet. Check for continuity between both of the relay's AC contacts and the circuit board's ground. There must be no continuity. If there is, find and correct the problem.

Once all is okay, plug the unit in and check for the proper voltages at pin 8 (+12 volts) and pin 4 (−12 volts) of U3's socket. If the voltages on those pins are correct, unplug the unit and install U3. Reapply power and check for proper operation of the relay with S1 in the MANUAL position and S2 in the ON position. If that checks out, unplug the unit, and assuming everything is okay so far, complete the relay's AC wiring. Close up the case and apply power again. With switch S1 in the MANUAL position and S2 in the ON position, check for 117 volts AC at SO2 (the TV outlet).

When the unit has passed all tests, it's ready for use. Plug the VCR and TV into their respective outlets. Connect the signal cable to the VCR's baseband video output (video-dubbing jack). Place the VCR in the VCR mode by operating the TV/VCR switch. Many VCR's provide no baseband output unless they are placed in the VCR mode. The TV should be set to Channel 3 or 4, since the video source selected for viewing will be delivered to the TV (which functions as a monitor) through the RF or antenna input. Now check and verify the operation of the circuit.

Once the circuit has been verified as operational, you are ready to enjoy your new video accessory, and the convenience that it provides. ■

ONE AMP CURRENT INJECTOR
(Continued from page 48)

With everything ready, push and hold the current injector's power switch. Now adjust the trimmer potentiometer (R7) until you read 1.000 amp of current on the multimeter. That's it. You're done. Once you have calibrated the unit, you can attach the box lid using four screws.

Some multimeters cannot directly measure current or don't have a 2-amp scale. If this happens to be the case, you will need to measure the current indirectly with the use of an accurate resistor of known value. A 0.1 to 1-ohm, 1% precision resistor that can handle 1 amp would be ideal. Attach the current injector clips across the calibration resistor. Then, connect the digital multimeter leads across the resistor. Set the meter to measure volts. With everything connected, press and hold the power pushbutton on the top of the unit's box. Note the voltage reading and adjust the current-control potentiometer (R7) on the circuit board for a voltage reading equal to the resistor value. If all goes well, the unit is now ready for use.

Unit Operation. With fresh batteries installed, the FET (Q1) will dissipate a maximum of 2.5 watts. The transistor dissipation will be maximum when the unit is measuring resistances below 0.1 ohms. Although you installed a small heat sink onto the transistor, it could still get very hot if the unit is operated for longer than a few minutes. I recommend that you use the system only in a momentary manner. Connect it up to the resistor to be measured, attach your digital multimeter, then take a quick measurement.

With fresh alkaline batteries, you should be able to make hundreds of measurements before the batteries have to be replaced. Also, under weak-battery conditions the power LED may turn on when the unit is not connected to a resistor but will fail to turn on when a resistor is connected. This is caused by a drop in the battery voltage under a loaded condition. The best way to make sure the unit's battery is still good is by activating the unit while the two test clips are shorted together. If the light fails to turn on, replace the batteries. ■

DAVID HUGHES

(Continued from page 64)

New Circuits. Very quickly Hughes began to wonder whether the effects of the sparking could be detected at greater distances from their source. He now constructed a new secondary or detecting circuit consisting of a telephone receiver together with what he called his "thermopile."

This thermopile actually was nothing more than one of his carbon lozenge microphones. Perhaps Hughes used the term thermopile because he had observed earlier that heat enhanced the performance of microphonic contacts. Alternatively, he may have erroneously thought that some type of thermoelectric effects were present.

Hughes simplified his sparking circuit to include only a single cell in series with a clockwork mechanism interrupter and the primary of one of his induction coils. His transmitter and receiver were separated a distance of several feet and were connected by a wire.

By late October of 1879, Hughes found he could eliminate the induction coil from the sending circuit. Any electrical spark, no matter how it was produced, caused a sound to be heard in the telephone receiver.

The sending and receiving circuits now were located in separate rooms and were no longer connected together. Instead, the wire attached to the receiving circuit was separated from the sending circuit by a six-foot gap. In effect, Hughes had discovered the antenna and now was both sending and receiving wireless signals.

Soon, Hughes discovered that signals could be received at greater distances if both the transmitting and receiving circuits were connected to gas pipes buried in the ground. He then tried to improve reception even more by making the earth an integral part of the receiving circuit. One side of the telephone receiver was connected to a buried lead gas pipe while one side of the carbon lozenge microphone was connected to an iron water pipe.

Immediately, the clicking Hughes heard in the telephone receiver became louder. The two pipes of different metals, together with the moist earth, created a weak battery that increased the current flow and thus the sound heard in the telephone receiver when a spark occurred. Hughes quickly realized that putting a battery in the receiving circuit would eliminate the need for the two pipe connections.

An iron-carriage fender was connected to the transmitting circuit to see if that would improve the radiation of the waves. Soon, the iron was replaced with wire attached to pieces of wooden lath thereby creating a more effective transmitting antenna. Now signals could be heard at distances between the transmitter and receiver of up to sixty feet in the house.

Hughes now went outdoors to see if he could increase the distance between the sending and receiving circuits still further while still hearing the clicking sounds in the telephone receiver. Leaving his transmitter operating in his house, Hughes walked up and down the street with the thermopile detector and the telephone receiver. He was able to detect clicking sounds to distances in excess of a quarter of a mile.

Hughes noticed that the signals became weaker at some locations but then became stronger at others. That would seem to suggest the existence of "nodal" effects, clearly indicating that Hughes was indeed producing and detecting true electromagnetic waves.

Rejection by the "Experts." It was on February 20 in 1880 that Hughes invited the three chief officers of the Royal Society to witness his experiments. Hughes hoped that Spottiswoode, Huxley, and Stokes would confirm his conviction that an aspect of science that had never been previously observed was being demonstrated. These three leading English scientists, however, could not be convinced that David Hughes was demonstrating anything new.

David Hughes should have taken some consolation in the fact that George Stokes, the leader in downplaying the importance of these experiments, also had rejected as apparently "insignificant" several technical papers submitted to the Royal Society by such noted scientists as Michael Faraday and James Clerk Maxwell. Even if these facts had been known by Hughes, however, the knowledge probably would have provided him with little consolation.

Badly disappointed and very discouraged, David Hughes continued his experiments in hopes of producing convincing proof that a spark discharge did indeed generate the electric waves that, he believed, were "conducted" through the air. His enthusiasm for his work, however, had been subdued as a result of Stokes' disparaging remarks. Hughes never did achieve the conclusive proof that he sought and he never presented the paper to the Royal Society as was suggested by Spottiswoode, Huxley, and Stokes.

The World Hails Hertz. In 1888, the world recognized the German physicist Heinrich Hertz as the person who first verified experimentally that Maxwell's electromagnetic waves actually exist. Hughes acknowledged the success of Hertz with true sincerity and professionalism. He in no way tried to claim any priority of achievement for himself.

It was not until 1899 that Hughes could even be persuaded to write a summary of the experiments that he had conducted in 1879 and 1880. Without this summary written shortly before his death together with the laboratory notebooks his widow later gave to the British Museum, very little would be known about these experiments.

In that summary written in 1899, Hughes publicly stated that "Hertz's experiments were far more conclusive than mine, although he used a much less effective receiver than the microphone or coherer." Hughes blamed only himself for not having publicized his own experiments at the time they were conducted and for not having pursued his own work more vigorously.

The disagreement with Spottiswoode, Huxley, and Stokes did not destroy Hughes' relationship with the Royal Society. He was elected a Fellow of the Society later in 1880 and in 1885 was awarded that organization's gold medal for scientific achievement. So greatly admired was Hughes as a scientist, an inventor, and as a person, the Royal Society chose him as its President in 1886. ■

THINK TANK

(Continued from page 76)

After the 15 seconds elapses, the first one-shot output goes high again and its low-to-high transition triggers the second one-shot's input, which in turn sounds the alarm for 30 seconds. The buzzer will shut off anytime the door is shut as the clear input (pin 13) on the second monostable will be pulled low by R3 in darkness.

—*Brent Hoffman, Manchester, TN*

Would anybody care to try building this circuit with a 558? If so, you know where to send the results.

ONE BETTER

I have seen a variety of very clever alarm circuits in *Think Tank* over the years (*i.e.*, Burglar-Alarm UpGrade and Intrusion Alarm from the April, 1991 issue). However, as an alarm technician, it seems strange that most of those circuits neglect one very important feature needed to thwart today's skilled burglar: supervised field wiring from the panel to the sensors.

In such a system, like the one in Fig. 6, the sensor loop in the field can't be defeated by opening or shorting it—either case would cause a high output to the alarm circuit. Resistors R1 and R2 form a voltage-dividing network that holds pins 5 and 6 at 6 volts. The other resistors R3, R4, and R5 form another network that holds pin 7 of U1-b at 4.6 volts and pin 4 of U1-a at 7.6 volts. So the output of both comparators (which form a window comparator) will be low as long as the proper resistance (R1) is sensed at the end of the sensor zone. Diodes D1 and D2 are needed to isolate pins 1 and 2.

In the alarm trade, R1 is known as the E.O.L. (*end-of-line*) device. I used a 2k resistor for R4 to give me about a 2.7-volt window; that's not too large of a window, but wide enough to allow for any long runs of wire. As you can see by the diagram, the circuit will support both normally open and normally closed sensors so you can use whatever type of magnetic switches or other devices you have on hand.

—*Stephen Hughes, Irving, TX*

Definitely an improvement, although a thief could still defeat the sensors individually without ill effect. Also, I don't think the diodes are needed as the sections of the LM339 have open-collector outputs. By the way, to produce active highs, the circuit will require a pull-up resistor at its output.

Since there are no more letters on alarm circuits, let me take the time to answer a query about a very common practice in electronics—using wire nuts over solder joints.

HOT ISSUE

Fairly frequently in **Popular Electronics**, I see references in the articles to the fact that wire nuts should be used on AC connections as solder melts when passing high current. I don't understand this. Assume the connection has a resistance of between 0.001 ohm and 0.1 ohm. With a current of 10 amps, the heat dissipated would be $I^2R = 100R$, which would be between 0.1 watt and 10 watts. That is certainly not very much. Where's my error?

—*Fred S. Parmenta*

Your math is just fine, but your solder-joint resistance measurement is a little conservative. Solder joints for large connections, such as the ones necessary to connect heavy-gauge Romex, tend to have greater resistance (0.1 to 0.5 ohms is pretty typical). That's because during soldering the wire dissipates heat quickly, forming a colder joint. Anything above 0.15 ohms at ten amps starts generating heat dangerously close to that of a low-wattage soldering iron.

Also many AC devices pull very high amounts of current (called "in-rush current") when first turned on, raising the current ante as well. Each application of in-rush current will erode the junction, raising the resistance and the heat developed by the joint; not good.

And consider what would happen if the AC load shorts. For a brief period of time (before your household circuit breaker kicks in) a very large current will flow through the joint. That could be disastrous.

Further still, since the wires and solder are made of different alloys, the solder joint forms a two-junction thermocouple. So if you pass current through the junction, it will generate heat. That heat will be produced in the region where the wire and solder meet, thermally stressing that area. In other words, the greatest amount of heat will be produced in the most undesirable place. Over the years, that thermal stress will undo the solder joint.

Last, wire nuts are practical. Since you're going to have to insulate the solder joint anyway, why not use a wire nut? It will attach easier and stay on better than electrical tape. ■

49-MHZ FM TRANSMITTER

(Continued from page 42)

whip antennas are chrome plated and therefore do not readily accept solder. The mounting hardware makes it a lot easier to attach a lead wire to the antenna. Once all of the components have been installed or connected to the circuit board, check your work for accuracy. If all appears okay, move on to the test and adjustment phase of the construction.

Test and Adjustment. Before using the 49-MHz FM Transmitter, you must adjust R10, L1, T1, and T2. The tuning-core setting for L2 as supplied by the factory is satisfactory and should not require adjustment. When adjusting any of the Toko coils (L1, T1, and T2), use a $^{3}/_{64}$-inch blade, non-metallic alignment tool or, as a last resort, a jeweler's screwdriver. The cores are very brittle and fit snugly. Because of that, it is wise to avoid any unnecessary adjustments.

Initially, set R10 to about the 2-o'clock position. Fully extend the telescoping antenna, connect a 9-volt battery to the circuit, and press S1. Then, using a DC voltmeter, check for 3 volts at the R12/R13 junction; If the voltage is otherwise, the oscillator may not tune to the crystal's frequency. The core of inductor L1 may be adjusted to fine tune the oscillator's frequency. Generally, however, that is not required.

The cores of RF transformers T1 and T2 should be adjusted for maximum RF-output power. That is indicated by a dip in the DC emitter voltage, or a peak in reception range. As an alternative, you can lightly couple the probe of a 50- or 100-MHz oscilloscope to the antenna, and then tune T1 and T2 for maximum signal strength. Once the adjustments are completed, your transmitter is ready for operation.

Conclusion. The 49-MHz FM Transmitter offers many advantages over other 49-MHz transmitters and wireless microphones. Its highly stable VCXO keeps its signal locked on frequency. It's easy construction and low cost allow you to build as many transmitters you need to operate on the frequencies that are of interest to you. And the 9-volt power requirement allows you to use a battery or a 9-volt wall adapter. In addition, the 49-MHz FM Transmitter is just plain fun to build and use, offering insight into the world of RF circuits. ■

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Varactor Tuning Diode (Motorola)
Circuit Specialists
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Scottsdale, AZ 85271-3047
Tel. 800-528-1417

49.890 MHz Crystal (may be used at 16.630 MHz)
Jameco Electronics
1355 Shoreway Rd.
Belmont, CA 94002
Tel. 800-831-4242

2SC1687 NPN RF Transistor
MCM Electronics
858 E. Congress Park Dr.
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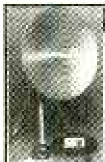

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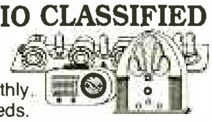

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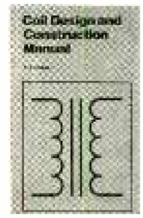

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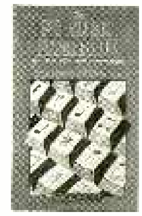

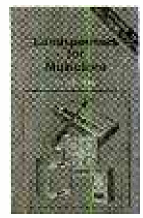

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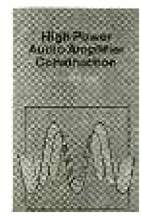

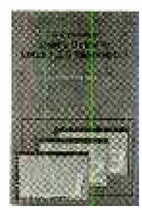

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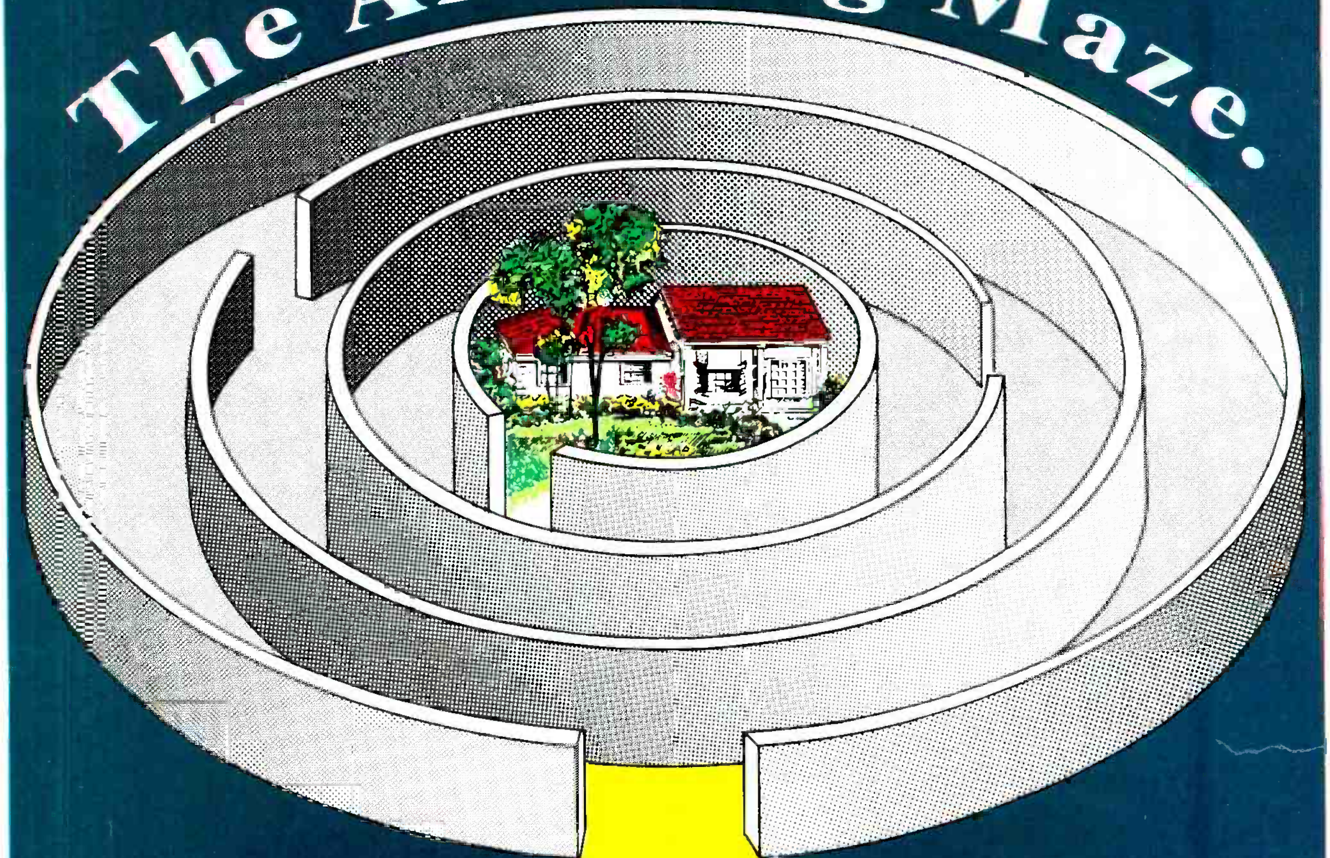

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