THE ARRL HANDBOOK FOR RADIO AMATEURS 2000

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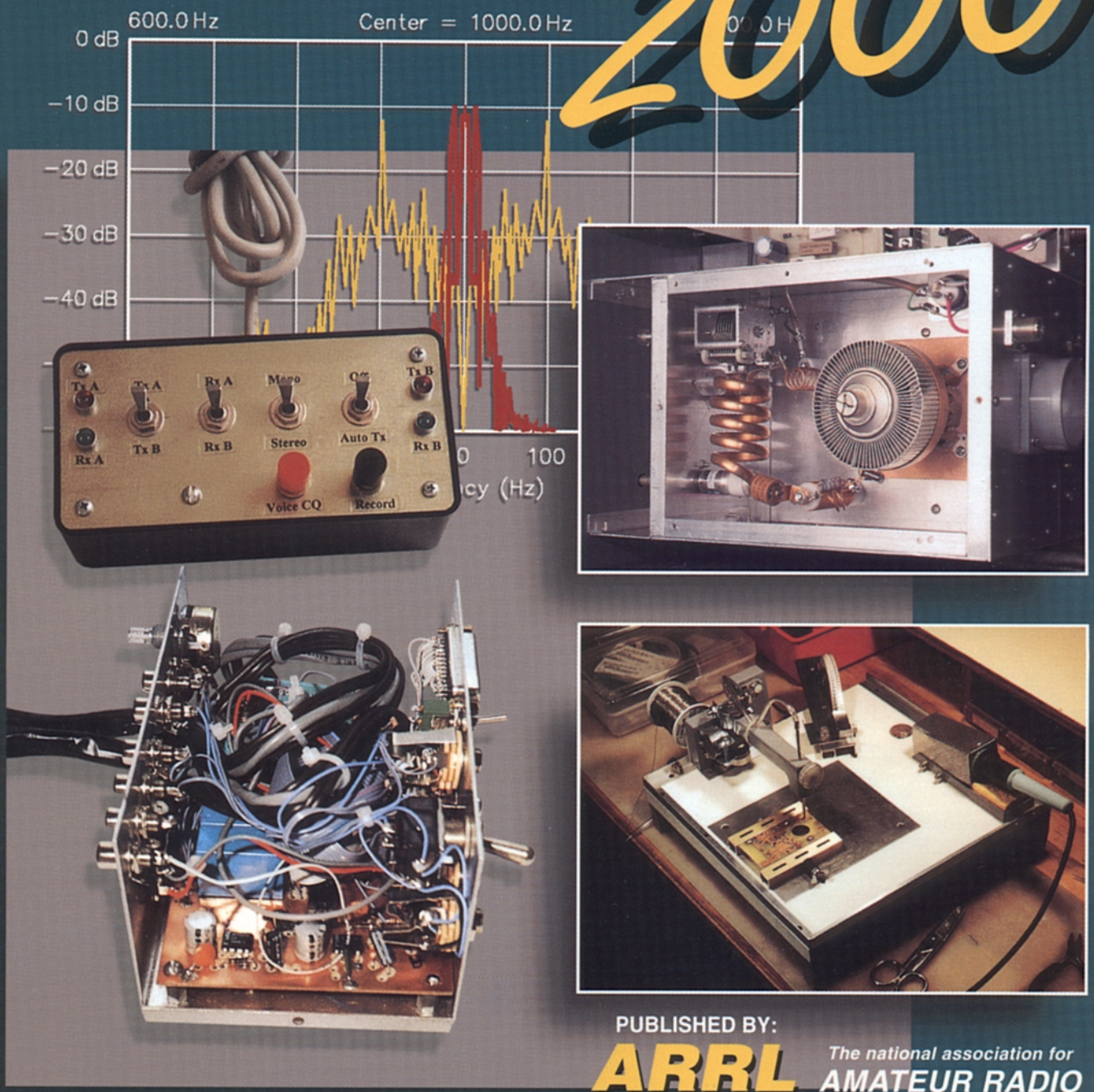
The Standard in Applied Electronics and Communications



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The ARRL Handbook

For Radio Amateurs

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The Cover

Front cover: At left, remote control head and switchbox for N6BV's computer-controlled two-radio switchbox in Chapter 22. At top right, interior of W1QWJ's 6-meter 4CX1600B amplifier in Chapter 13. At bottom right, the vacuum manipulator for chip components described in Chapter 22.

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Contents

Foreword

Welcome to the year 2000 edition of *The ARRL Handbook for Radio Amateurs*. There is something magical and exciting about the end of one century and the beginning of another.

As I write this in the summer of 1999, I can't help but reflect back on Amateur Radio and how it has changed during the twentieth century. We've certainly come a long way from the days of Guglielmo Marconi—who considered himself a dedicated amateur, although he never held a call sign. He conducted his successful transatlantic test in 1901, with a spark-gap transmitter and a huge MF antenna and counterpoise in St John's, Newfoundland. Many amateurs were in the forefront of exploring this new communication technology back in the early years of the twentieth century. Some became skilled engineers and scientists who helped advance the state of radio science. Many others were not trained as engineers and scientists, yet they too advanced the state of the art, simply because they were enthusiastic about radio itself.

At the end of the twentieth century, we find ourselves surrounded with all sorts of communication technology. You too must notice the number of people walking down city streets with cellular phones held closely to their ears. They're gabbing away, with little realization of just how miraculous a cell phone would seem to someone from the end of the nineteenth century! A lot has happened in the last 100 years.

Indeed, some doomsayers in Amateur circles gloomily predict that the incredibly explosive growth of the Internet, plus the ready availability of cellular, spread spectrum and even commercial satellite phones, all spell the inevitable doom of Amateur Radio. I'm convinced this is not true, nor is decline inevitable.

First and foremost, we hams are *Radio Enthusiasts*. While we are justifiably enthusiastic when we can talk with someone halfway around the world, we're not content just to use the radio as some sort of an appliance. We enthusiastically want to know *how* and *why* a radio does what it does. We study hard to secure our amateur licenses and to understand the theory behind the wonderful gadgets we use to communicate. And we like to spread our knowledge of—and our enthusiasm for—this radio hobby.

Ever watch a youngster make his or her first contact on the air as a newly ticketed ham? No matter how sophisticated or jaded he or she is, no matter how skillful that youngster might be on the Internet, put him or her behind a microphone or a telegraph key, and watch how nervous he or she becomes. No doubt, you vividly remember your own first, sweat-drenched contact. I could barely stop shaking enough to make my first QSO!

Why does that happen? It's partly because we can appreciate the technical aspects of launching a signal into the ionosphere, where it may—or may not—bounce successfully to someplace, perhaps halfway around the world or perhaps just to the next block. Most of all, however, we know that there is a real, live human being on the other end of the contact. And we know that he or she is listening and speaking to *us*, not some anonymous group of netizens in an Internet chat room! The wonder, the magic and the mystery of being able to communicate with other radio enthusiasts keeps a ham interested for decades and decades.

And what does all this have to do with this large book sitting in front of you? This is one of ARRL's flagship publications, the 77th edition of a classic started back in 1926. It contains a lot that a ham

Foreword

can get truly enthusiastic about! It is chock-full of technical and reference material, written in a manner designed to edify, instruct and inform, not mystify and impress. There are dozens upon dozens of practical projects you can build to reinforce your knowledge of the theory of radio and electronics.

The *ARRL Handbook for Radio Amateurs* is the definitive reference source for all hams. It contains the information you need to stay abreast of what's new in the world of communication technology. For example, there's coverage on one of the hottest new modes in ham radio—PSK31. There's also a brand-new computer-controlled two-radio switchbox for efficient contesting operation. And there's even a clever home-brew vacuum operated pick-and-place SMD component handler.

Want to join the big boys on 6 meters? We have a potent new 4CX1600B kW amplifier for this band. Six meters has been attracting many new enthusiasts ever since Cable TV became widespread, virtually eliminating problems with TVI on Channel 2.

This *Handbook* has a new section by W3NQN and W0IYH on output filters for power amplifiers, and KE2QJ has written an expanded section on HF mobile antennas. After all, the latest crop of tiny transceivers for HF + VHF/UHF fit nicely in your car or home station. HF mobile operation is becoming very popular again.

The twenty-first century will no doubt be filled with surprises and delights as technology marches forth in ways we find as hard to imagine now as our predecessors of a century ago. There's something for every ham in the 30 chapters and 1200 pages of this classic, yet thoroughly modern, book!

David Sumner, K1ZZ
Executive Vice President
Newington, Connecticut
September 1999

The Amateur's Code

The Radio Amateur is:

CONSIDERATE…never knowingly operates in such a way as to lessen the pleasure of others.

LOYAL…offers loyalty, encouragement and support to other amateurs, local clubs, and the American Radio Relay League, through which Amateur Radio in the United States is represented nationally and internationally.

PROGRESSIVE…with knowledge abreast of science, a well-built and efficient station and operation above reproach.

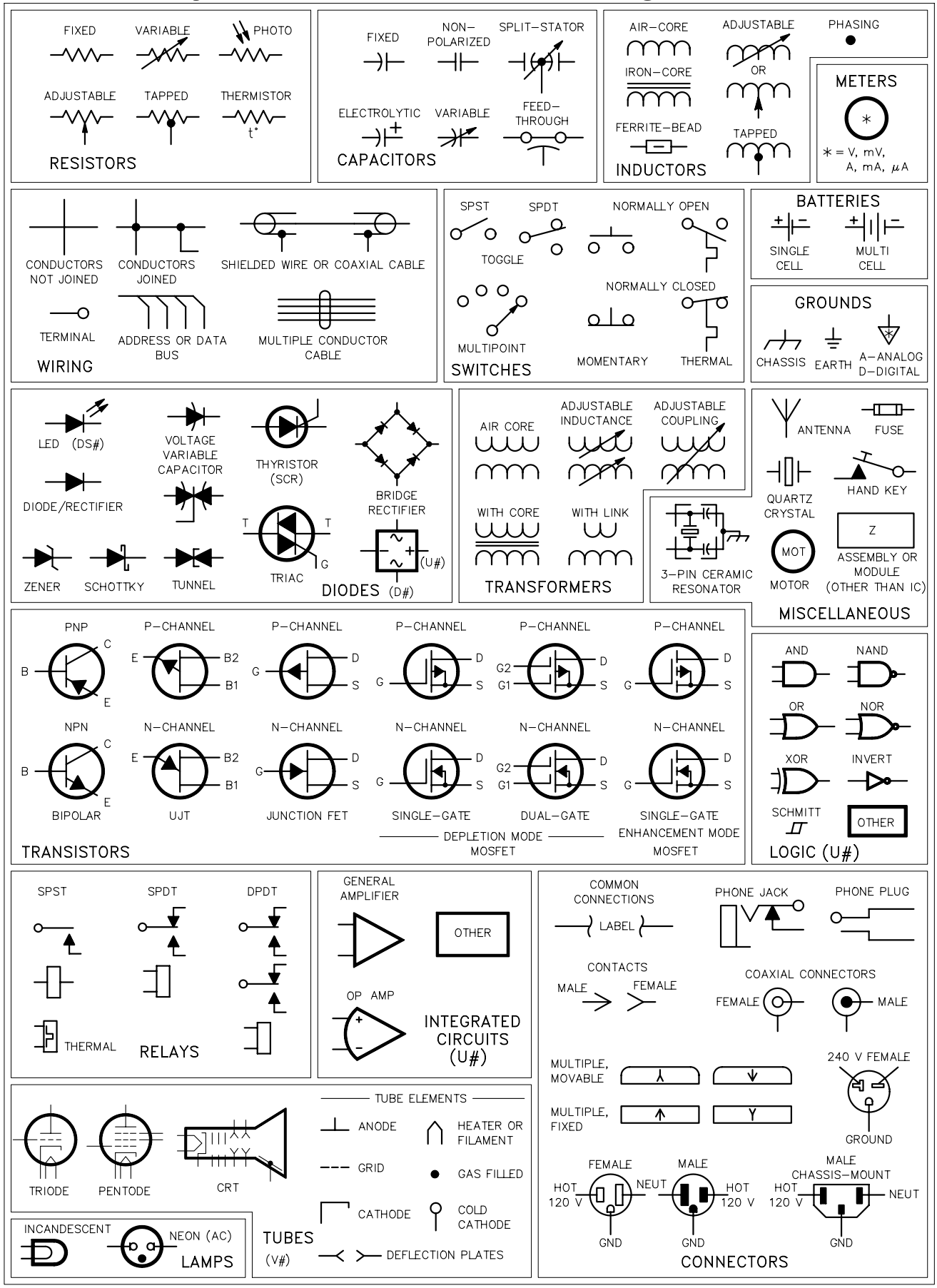
FRIENDLY…slow and patient operating when requested; friendly advice and counsel to the beginner; kindly assistance, cooperation and consideration for the interests of others. These are the hallmarks of the amateur spirit.

BALANCED…radio is an avocation, never interfering with duties owed to family, job, school or community.

PATRIOTIC…station and skill always ready for service to country and community.

—The original Amateur's Code was written by Paul M. Segal, W9EEA, in 1928.

Schematic Symbols Used in Circuit Diagrams



Handbook Software

The 1996 Edition was the first to include bundled software. The software proved to be a valuable addition for many readers. On the other hand, bundling the disk with the printed book increased its cost. A readership survey indicated clearly that keeping the cost of the book as low as possible was more important than the bundled disk.

For this reason, we will again be making the software for the 2000 Edition available separately.

DOWNLOADING HANDBOOK SOFTWARE

You can download HANDBK00.ZIP from the Product Notes section of the ARRL Web site: **http://www.arrl.org/notes/**. Simply click on **Download Handbook Disk**. The Handbook software can also be found on this CD, in the **\software** directory.

A description of the software appears elsewhere in this book.

The ARRL—At Your Service

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If all else fails, send e-mail to **hq@arrl.org** and it will be routed to the right people or departments.

TECHNICAL INFORMATION SERVER

If you have Internet e-mail capability, you can tap into the ARRL Technical Information Server,

otherwise known as the *Info Server*. To have user instructions and a handy index sent to you automatically, simply address an e-mail message to: **info@arrl.org**

Subject: **Info Request**
In the body of your message enter:
HELP
SEND INDEX
QUIT

ARRL ON THE WORLD WIDE WEB

You'll also find the ARRL on the World Wide Web at:
http://www.arrl.org/
At the ARRL Web page you'll find the latest W1AW bulletins, a hamfest calendar, exam schedules, an on-line ARRL Publications Catalog and much more. We're always adding new features to our Web page, so check it often!

WOULD YOU LIKE TO WRITE FOR ARRL?

We're always looking for new material of interest to hams. Send a self-addressed, stamped envelope (2 units of postage) and ask for a copy of the *Author's Guide*. (It's also available via the ARRL Info Server, and via *ARRLWeb* at **http://www.arrl.org/qst/aguide/**.) The guide contains all the information you'll need to craft an article to meet our requirements. Send article ideas or manuscripts to the attention of the *QST* editor (e-mail **qst@arrl.org)** or book editor (**pubsfdbk@arrl.org**).

INTERESTED IN BECOMING A HAM?

Just pick up the telephone and call toll free 1-800-326-3942, or send e-mail to **newham@arrl.org**. We'll provide helpful advice on obtaining your Amateur Radio license, and we'll be happy to send you our informative Prospective Ham Package.

ARRL AUDIO NEWS

The best way to keep up with fast-moving events in the ham community is to listen to the ARRL Audio News. It's as close as your telephone at 860-594-0384, or on the Web at **http://www.arrl.org/arrlletter/audio/**.

ARRL Handbook CD Companion Software

Included on this CD-ROM is companion utility software that pertains to information and projects in the *Handbook* or is generally useful to hams. To use the companion software, you need an IBM PC-compatible computer with approximately 3 MB of free hard-disk space if you want to install all of the programs. The *TISFIND* and *SVCFILT* applications run only under Microsoft *Windows* or an equivalent operating system. The others require DOS.

To install the companion software:

1) Close any open applications and insert the CD-ROM into your CD-ROM drive.

2) From the *Windows* Program Manager, select the **File** menu and choose **Run**. (For *Windows 95* users, click the **Start** button and choose **Run**.)

3) Type **d:\software\setup.exe** (where d: is the drive letter of your CD-ROM drive; if the CD-ROM is a different drive on your system, type the appropriate letter) and press **Enter**.

4) Follow the instructions that appear on your screen.

The companion utility software *Windows* programs are located in the **ARRL Handbook Programs** program group. The DOS programs can be found in the HBKSW directory on your hard drive (they may be in a different directory if you specified one during installation). The programs are described in the following section. See the Help file in the **ARRL Handbook Programs** program group for more information.

SOFTWARE DESCRIPTIONS

CONV.BAS runs the "PC Voltmeter and SWR Bridge" in the **Station Accessories** chapter. It accepts analog input and sends the digital value to your computer printer port. *FINDLPT.BAS* helps you find the addresses of the printer ports for use with the "PC Voltmeter and SWR Bridge" project.

ACTFILT.EXE designs some simple active filters. See "Active Filters" in the **Filters** chapter for details of the filters.

CTL3DV2.DLL is a Windows DLL that may be needed with TISFIND. See **TISFIND** below.

ELLER.EXE consists of program and support files to calculate placement and length for a coil-loaded shortened dipole using an existing pair of inductors. See "Computer-Aided Design of Loaded Short-Doublet Antennas," in the **Antennas** chapter.

INSTALL.EXE reads this file and installs the software on a hard disk. TISFIND requires a separate installation under Windows. See instructions under **TISFIND**.

GRIDLOC.BAS converts latitude/longitude coordinates to four-character (such as FN42) grid square locations. *GRIDLOC.EXE* is a compiled version of the *.BAS* program.

MORSE.EXE sends and receives CW. See "Quick and Easy CW with your PC" in the **Station Accessories** chapter for details.

SHADOW.EXE locates local true north in order to orient directional antennas. See "North Shadow" in the **Antennas and Projects** chapter for details.

PWRSPLY.BAS calculates the characteristics of various power supplies and regulators. *PWRSPLY.EXE* is a compiled version of the *.BAS* program.

PINET.EXE consists of several programs to aid design of Pi and Pi-L matching networks, as described under "Tank Output Circuits" in the **Amplifiers** chapter.

PRODREV.ADB is the *QST* Product Review database, a comprehensive listing of reviews from 1970 to the present. TISFIND.EXE (see **below**) is used to search this data.

README.TXT is the README file for the disk.

SAFETY.TXT consists of the complete list of RF Safety references.

SVCFILT.EXE is a program that designs passive element filters using standard value capacitors. A complete help file is included.

TIS.EXE contains TISFIND.EXE (and related files), a Windows database look-up program used to view databases distributed by ARRL. Included with TISFIND is the ARRL TIS Address Database, which contains address and contact information for over 1000 companies and organizations of interest to amateurs.

TLI.EXE contains the files TL.EXE and TL.DOC. TL.EXE computes many parameters for transmission lines, as well as for antenna-tuners—including losses and stresses. See the **Transmission Lines** chapter.

TUNER.TXT contains tables that show losses measured under various load conditions with the new high-power antenna tuner.

UTCZONE.BAS is a handy program that gives the UTC zone and time offset for each zone. *UTCZONE.EXE* is a compiled version of the *.BAS* program.

VESTER_F.EXE contains the many files that make up the slow-scan TV system described in the **Modulation Sources** chapter. Be sure to read the README files.