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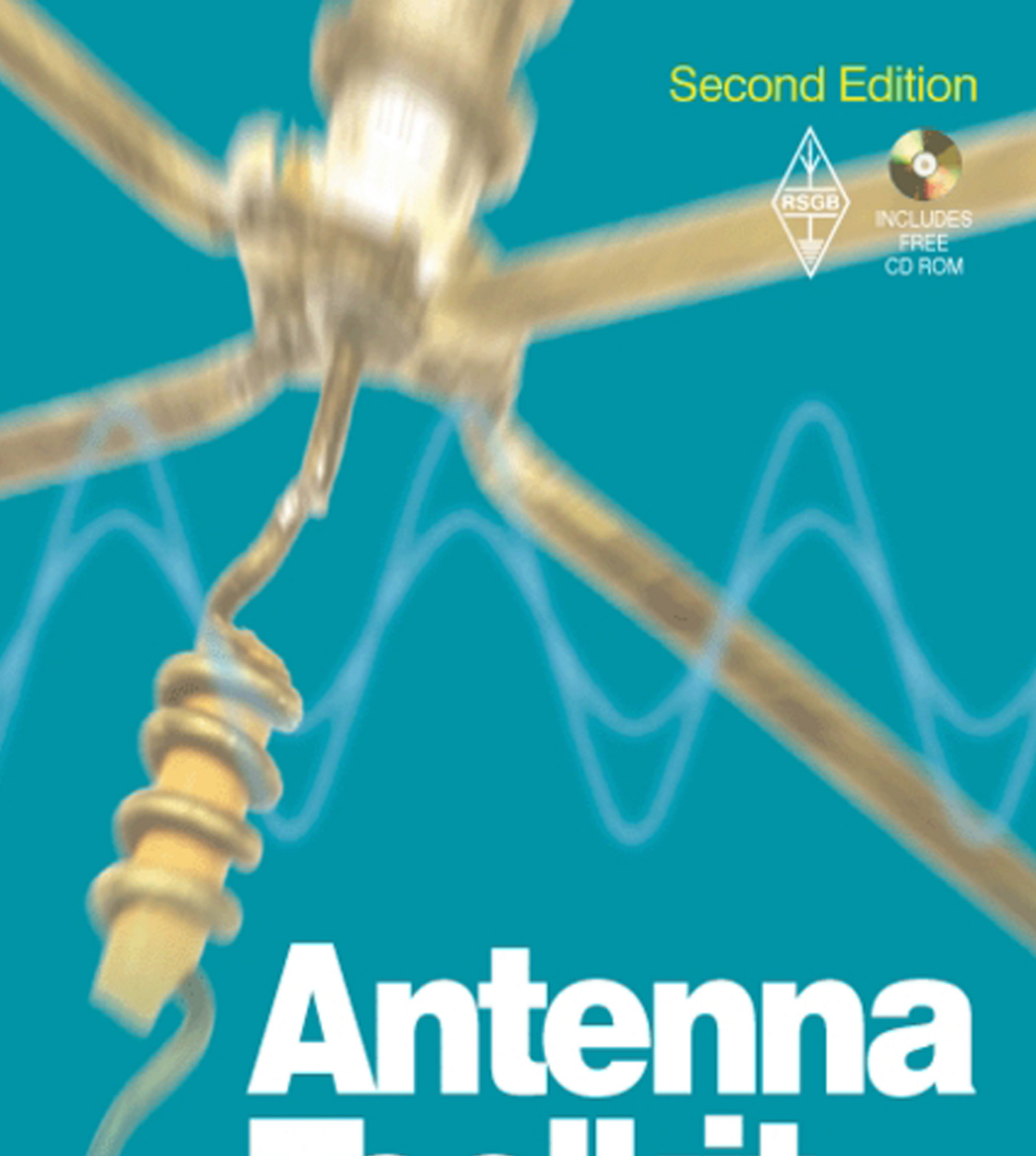

Antenna Toolkit

Joe Carr

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Preface

If you are interested in amateur radio, short-wave listening, scanner monitoring, or any other radio hobby, then you will probably need to know a few things about radio antennas. This book is intended for the radio enthusiast – whether ham operator, listening hobbyist, or radio science observer – who wants to build and use antennas for their particular requirements and location. All of the antennas in this book can be made from wire, even though it is possible to use other materials if you desire.

These antennas have several advantages. One of the most attractive is that they can provide decent performance on the cheap. As one who has lived through the experience of being broke, I learned early to use bits of scrap wire to get on the air. My first novice antenna back in the late 1950s was a real patched-together job – but it worked really well (or so I thought at the time!).

Another advantage of wire antennas is that they are usually quite easy to install. A couple of elevated supports (tree, roof, mast), a few meters of wire, a few bits of radio hardware, and you are in the business of putting up an antenna. As long as you select a safe location, then you should have little difficulty erecting that antenna.

Finally, most high-frequency (HF) short-wave antennas are really easy to get working properly. One does not need to be a rocket scientist – or professional antenna rigger – to make most of these antennas perform as well as possible with only a little effort. There is quite a bit of detailed technical material to digest if you want to be a professional antenna engineer, but you can have good results if you follow a few simple guidelines.

SOFTWARE SUPPLEMENT TO THIS BOOK

At the time this book was conceived it was noted that the technology now exists to make Microsoft Windows-based antenna software available to readers along with the book. The software can be used to calculate the dimensions of the elements of most of the antennas in this book, as well as a few that are not. There are also some graphics in the software that show you a little bit about antenna hardware, antenna construction, and the like.

ANTENNA SAFETY

Every time I write about antenna construction I talk a little bit about safety. The issue never seems too old or too stale. The reason is that there seem to be plenty of people out there who never get the word. Antenna erection does not have to be dangerous, but if you do it wrong it can be very hazardous. Antennas are deceptive because they are usually quite lightweight, and can easily be lifted. I have no trouble lifting my trap vertical and holding it aloft – on a windless day. But if even a little wind is blowing (and it almost always is), then the 'sail area' of the antenna makes it a lot 'heavier' (or so it seems). Always use a buddy-system when erecting antennas. I have a bad back caused by not following my own advice.

Another issue is electrical safety. Do not ever, ever, ever toss an antenna wire over the power lines. Ever. Period. Also, whatever type of antenna you put up, make sure that it is in a location where it cannot possibly fall over and hit the power line.

The last issue is to be careful when digging to lay down radials. You really do not want to hit water lines, sewer lines, buried electrical service lines, or gas lines. I even know of one property where a long-distance oil pipeline runs beneath the surface. If you do not know where these lines are, try to guess by looking at the locations of the meters on the street, and the service entrance at the house. Hint: most surveyers' plans (those map-like papers you get at settlement) show the location of the buried services. They should also be on maps held by the local government (although you might have to go to two or three offices!. The utility companies can also help.

A NOTE ABOUT UNITS AND PRACTICES

This book was written for an international readership, even though I am American. As a result, some of the material is written in terms of US standard practice. Wherever possible, I have included UK standard wire sizes and metric units. Metric units are not in common usage in the USA, but rather we still use the old English system of feet, yards, and inches. Although many Americans (including myself) wish the USA would convert to SI units, it is not likely in the near future. UK readers with a sense of history might recognize why this might be true – as you may recall from the George III unpleasantness, Americans do not like foreign rulers, so it is not likely that our measuring rulers will be marked in centimeters rather than inches.* For those who have not yet mastered the intricacies of converting between the two systems:

1 inch = 2.54 centimeters (cm) = 25.4 millimeters (mm)
1 foot = 30.48 cm = 0.3048 meter (m)
1 m = 39.37 inches = 3.28 feet

Joseph J. Carr

*I apologize for the bad play on words, but I could not help it.

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CHAPTER 1

Radio signals on the move

Anyone who does any listening to radio receivers at all – whether as a ham operator, a short-wave listener, or scanner enthusiast – notices rather quickly that radio signal propagation varies with time and something mysterious usually called 'conditions.' The rules of radio signal propagation are well known (the general outlines were understood in the late 1920s), and some predictions can be made (at least in general terms). Listen to almost any band, and propagation changes can be seen. Today, one can find propagation predictions in radio magazines, or make them yourself using any of several computer programs offered in radio magazine advertisements. Two very popular programs are any of several versions of IONCAP, and a Microsoft Windows program written by the Voice of America engineering staff called VOACAP.

Some odd things occur on the air. For example, one of my favorite local AM broadcast stations broadcasts on 630 kHz. During the day, I get interference-free reception. But after the Sun goes down, the situation changes radically. Even though the station transmits the same power level, it fades into the background din as stations to the west and south of us start skipping into my area. The desired station still operates at the same power level, but is barely audible even though it is only 20 miles (30 km) away.

Another easily seen example is the 3–30 MHz short-wave bands. Indeed, even those bands behave very differently from one another. The lower-frequency bands are basically ground wave bands during the day, and become long-distance 'sky wave' bands at night (similar to the AM broadcast band (BCB)). Higher short-wave bands act just the opposite: during the day they are long-distance 'skip' bands, but some time after sunset, become ground wave bands only.

The very high-frequency/ultra high-frequency (VHF/UHF) scanner bands are somewhat more consistent than the lower-frequency bands. But even in those bands sporadic-E skip, meteor scatter, and a number of other phenomena cause propagation anomalies. In the scanner bands there are summer and winter differences in heavily vegetated regions that are attributed to the absorptive properties of the foliage. I believe I experienced that phenomenon using my 2 m ham radio rig in the simplex mode (repeater operation can obscure the effect due to antenna and location height).

THE EARTH'S ATMOSPHERE

Electromagnetic waves do not need an atmosphere in order to propagate, as you will undoubtedly realize from the fact that space vehicles can transmit radio signals back to Earth in a near vacuum. But when a radio wave does propagate in the Earth's atmosphere, it interacts with the atmosphere, and its path of propagation is altered. A number of factors affect the interaction, but it is possible to break the atmosphere into several different regions according to their respective effects on radio signals.

The atmosphere, which consists largely of oxygen (O_2) and nitrogen (N_2) gases, is broken into three major zones: the **troposphere**, **stratosphere**, and **ionosphere** (Figure 1.1). The boundaries between these regions are not very well defined, and change both diurnally (i.e. over the course of a day) and seasonally.

The troposphere occupies the space between the Earth's surface and an altitude of 6–11 km. The temperature of the air in the troposphere varies with altitude, becoming considerably lower at high altitude compared with ground temperature. For example, a +10°C surface temperature could reduce to −55°C at the upper edges of the troposphere.

The stratosphere begins at the upper boundary of the troposphere (6–11 km), and extends up to the ionosphere (≈50 km). The stratosphere is called an **isothermal region** because the temperature in this region is relatively constant despite altitude changes.

The ionosphere begins at an altitude of about 50 km and extends up to 500 km or so. The ionosphere is a region of very thin atmosphere. Cosmic rays, electromagnetic radiation of various types (including ultraviolet light from the Sun), and atomic particle radiation from space (most of it from the Sun), has sufficient energy to strip electrons away from the gas molecules of the atmosphere. The O_2 and N_2 molecules that lost electrons are called **positive ions**. Because the density of the air is so low at those altitudes, the ions and electrons can travel long distances before neutralizing each other

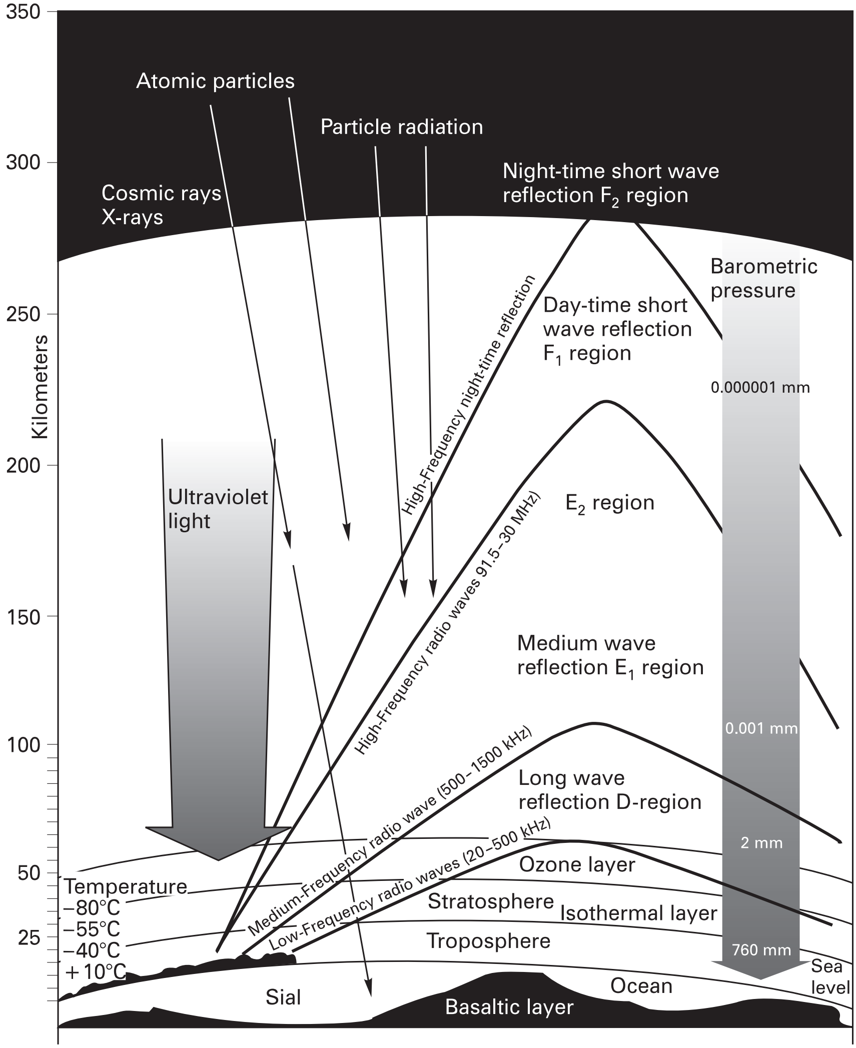

FIGURE 1.1

by recombining. Radio propagation on some bands varies markedly between daytime and night-time because the Sun keeps the level of ionization high during daylight hours, but the ionization begins to fall off rapidly after sunset, altering the radio propagation characteristics after dark. The ionization does not occur at lower altitudes because the air density is such that the positive ions and free electrons are numerous and close together, so recombination occurs rapidly.