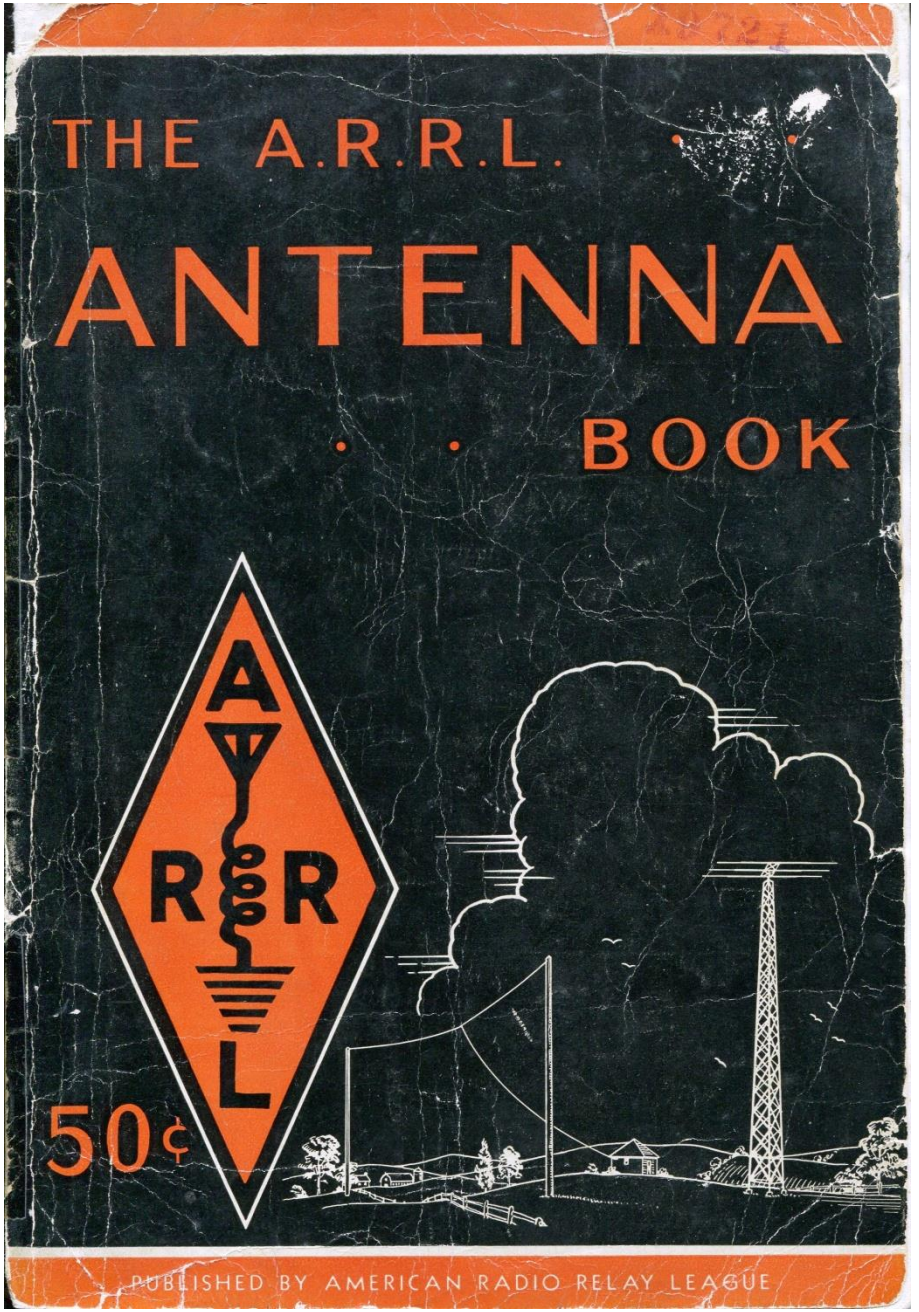
The ARRL Antenna Book in the Internet Age

Ward Silver NØAX

Dayton Hamvention 2016 – Antenna Forum

Some History

- First Edition - 1939
- Edited by *QST* Technical Editor, George Grammer W1DF and Asst *QST* Technical Editor, Byron Goodman W1DX
- 139 pages (about the size of a single issue of *QST*)



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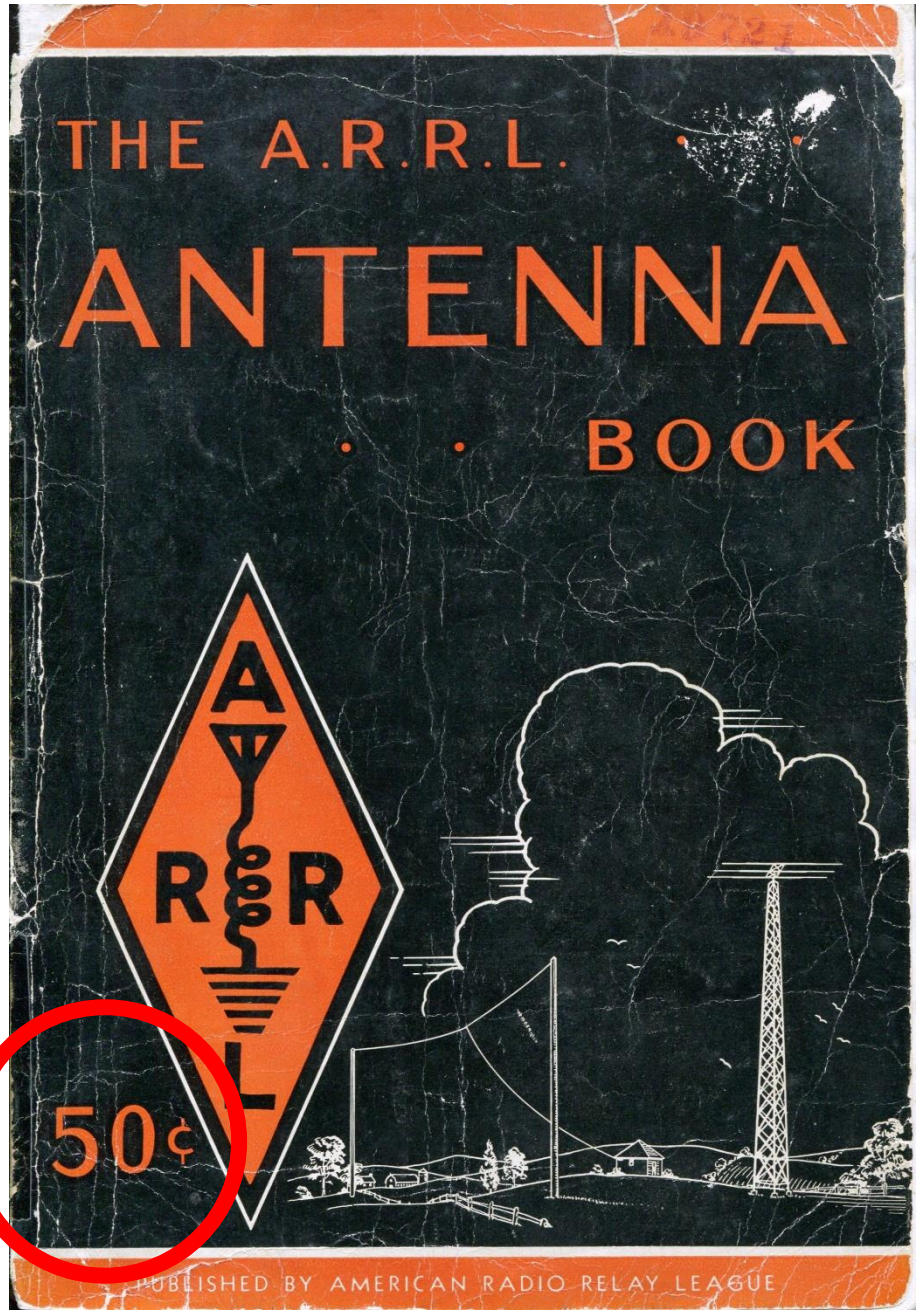
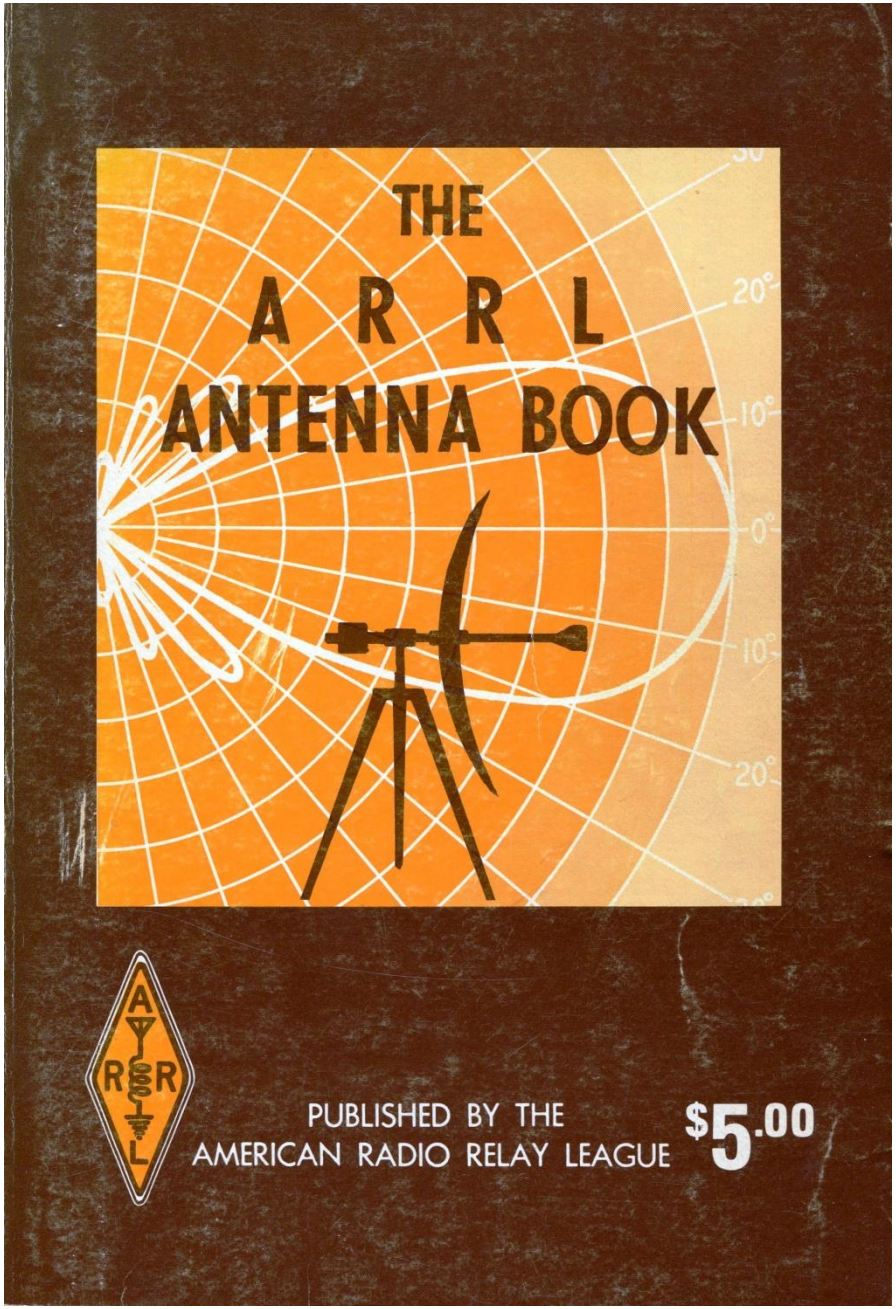


- 1950-70's editions (this is the 13th edition - 1974)
- Edited by Gerry Hall K1TD
- 336 pages
- Reflects changes brought about by WWII advances
- Coaxial cable, aluminum, traps, rotators!



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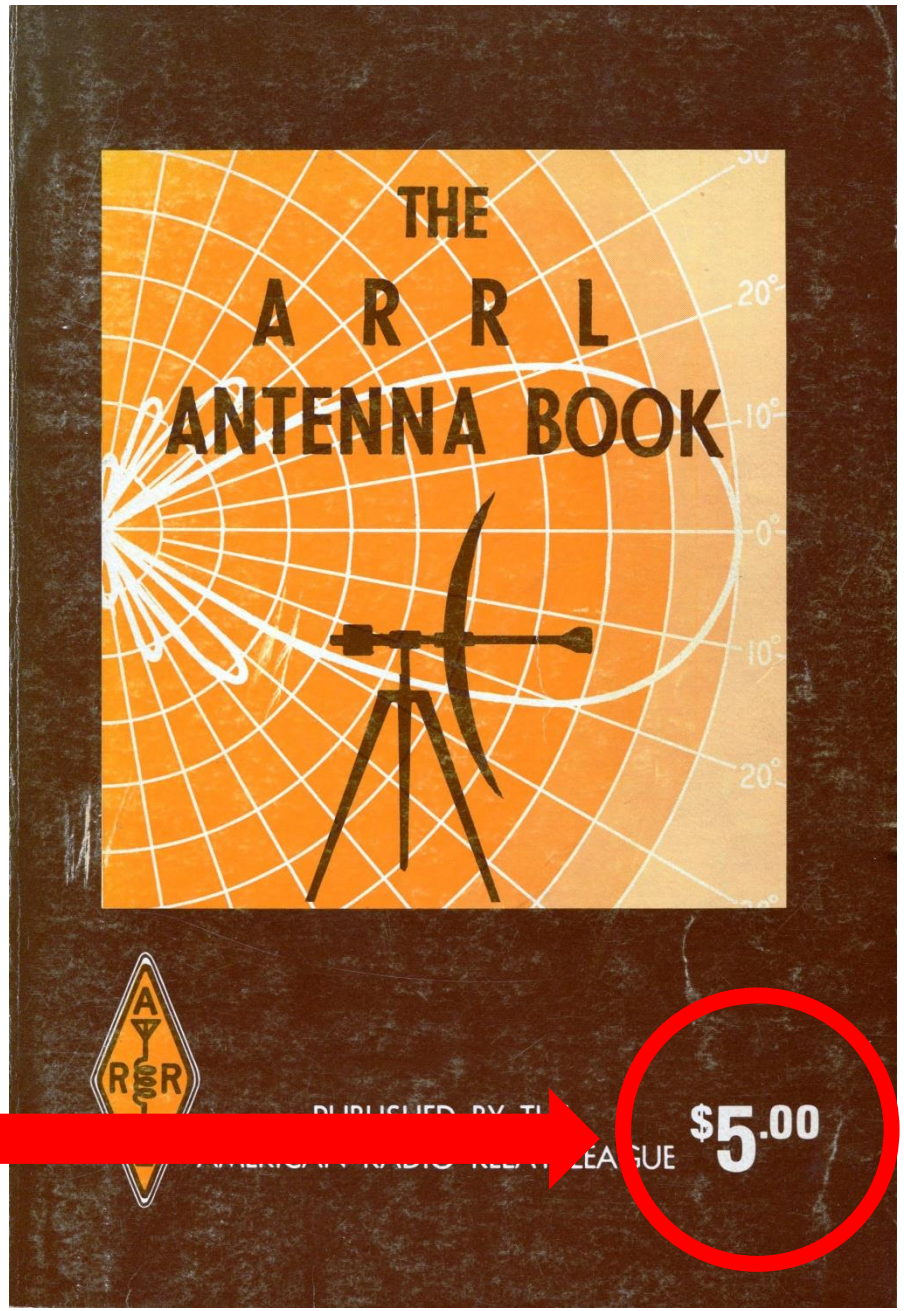
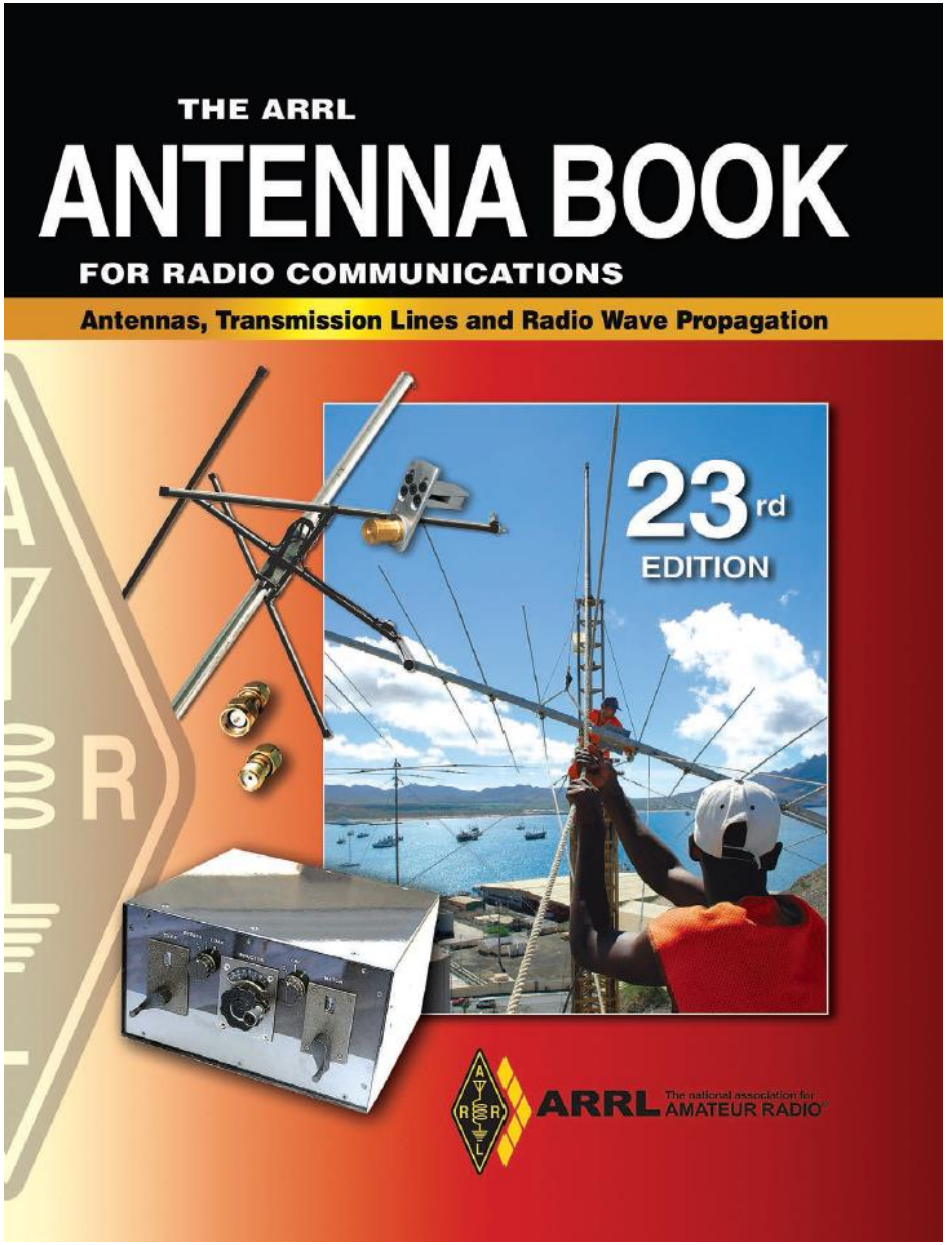
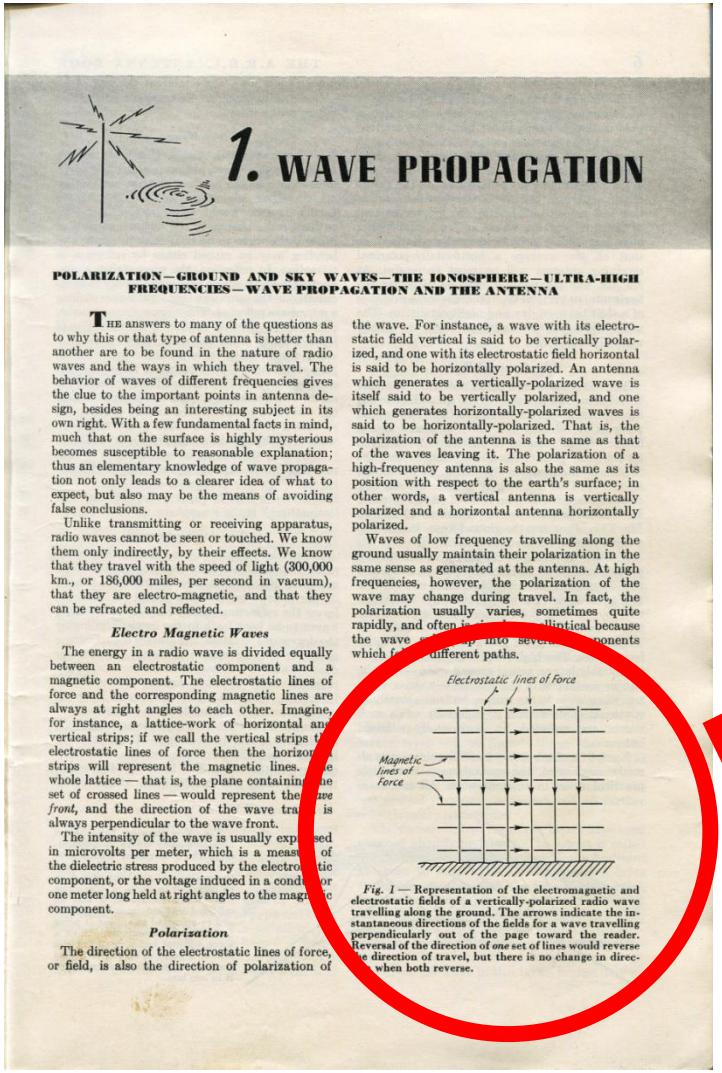


- Current size and format
- Many excellent editors, most recently Dean Straw N6BV
- More than 1000 pages
- Comes with CD-ROM and supplementary website but it's *still* ≈ 4 pounds…oof!



Some Things Will Never Change



1. WAVE PROPAGATION

POLARIZATION—GROUND AND SKY WAVES—THE IONOSPHERE—ULTRA-HIGH FREQUENCIES—WAVE PROPAGATION AND THE ANTENNA

THE answers to many of the questions as to why this or that type of antenna is better than another are to be found in the nature of radio waves and the ways in which they travel. The behavior of waves of different frequencies gives the clue to the important points in antenna design, besides being an interesting subject in its own right. With a few fundamental facts in mind, much that on the surface is highly mysterious becomes susceptible to reasonable explanation; thus an elementary knowledge of wave propagation not only leads to a clearer idea of what to expect, but also may be the means of avoiding false conclusions.

Unlike transmitting or receiving apparatus, radio waves cannot be seen or touched. We know them only indirectly, by their effects. We know that they travel with the speed of light (300,000 km., or 186,000 miles, per second in vacuum), that they are electro-magnetic, and that they can be refracted and reflected.

Electro Magnetic Waves

The energy in a radio wave is divided equally between an electrostatic component and a magnetic component. The electrostatic lines of force and the corresponding magnetic lines are always at right angles to each other. Imagine, for instance, a lattice-work of horizontal and vertical strips; if we call the vertical strips the electrostatic lines of force then the horizontal strips will represent the magnetic lines. The whole lattice — that is, the plane containing the set of crossed lines — would represent the *wave front*, and the direction of the wave travel is always perpendicular to the wave front.

The intensity of the wave is usually expressed in microvolts per meter, which is a measure of the dielectric stress produced by the electrostatic component, or the voltage induced in a conductor one meter long held at right angles to the magnetic component.

Polarization

The direction of the electrostatic lines of force, or field, is also the direction of polarization of the wave. For instance, a wave with its electrostatic field vertical is said to be vertically polarized, and one with its electrostatic field horizontal is said to be horizontally polarized. An antenna which generates a vertically-polarized wave is itself said to be vertically polarized, and one which generates horizontally-polarized waves is said to be horizontally-polarized. That is, the polarization of the antenna is the same as that of the waves leaving it. The polarization of a high-frequency antenna is also the same as its position with respect to the earth's surface; in other words, a vertical antenna is vertically polarized and a horizontal antenna horizontally polarized.

Waves of low frequency travelling along the ground usually maintain their polarization in the same sense as generated at the antenna. At high frequencies, however, the polarization of the wave may change during travel. In fact, the polarization usually varies, sometimes quite rapidly, and often is [illegible] elliptical because the wave [illegible] into several components which follow different paths.

Fig. 1 — Representation of the electromagnetic and electrostatic fields of a vertically-polarized radio wave travelling along the ground. The arrows indicate the instantaneous directions of the fields for a wave travelling perpendicularly out of the page toward the reader. Reversal of the direction of *one* set of lines would reverse the direction of travel, but there is no change in direction when both reverse.

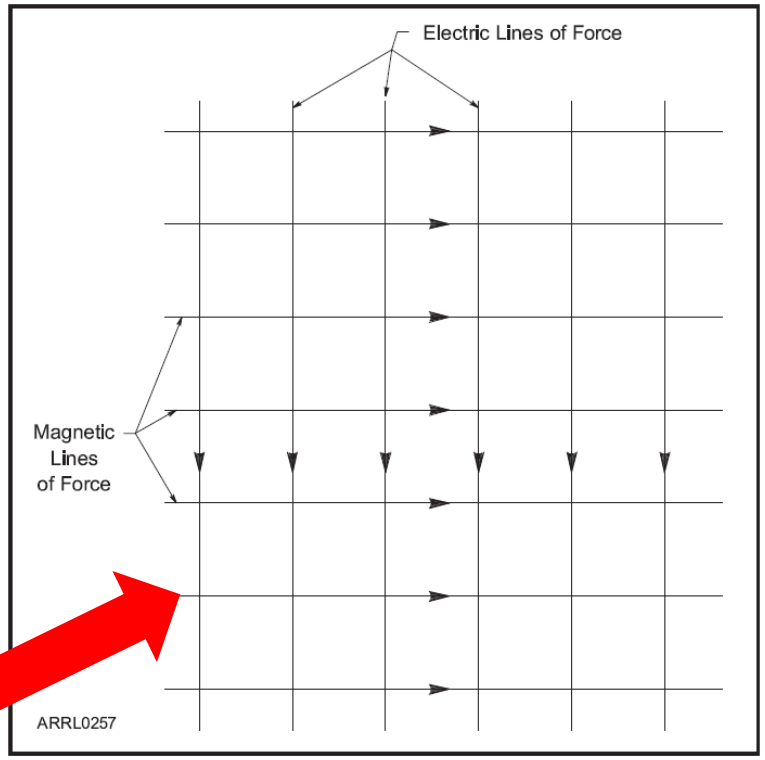
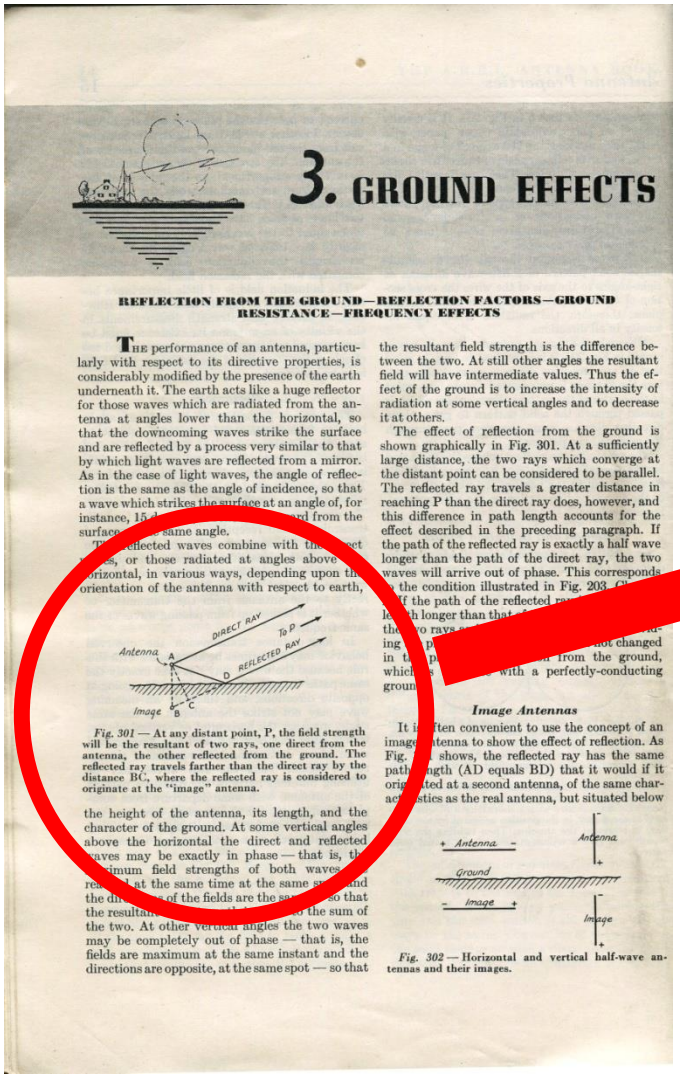


Figure 1.3 — Representation of electric and magnetic lines of force in an electromagnetic wavefront. Arrows indicate the instantaneous directions of the fields for a wavefront in a wave traveling toward you, out of the page. Reversing the direction of one of the fields would also reverse the direction of the wave.

Some Things Will Never Change



3. GROUND EFFECTS

REFLECTION FROM THE GROUND—REFLECTION FACTORS—GROUND RESISTANCE—FREQUENCY EFFECTS

THE performance of an antenna, particularly with respect to its directive properties, is considerably modified by the presence of the earth underneath it. The earth acts like a huge reflector for those waves which are radiated from the antenna at angles lower than the horizontal, so that the downcoming waves strike the surface and are reflected by a process very similar to that by which light waves are reflected from a mirror. As in the case of light waves, the angle of reflection is the same as the angle of incidence, so that a wave which strikes the surface at an angle of, for instance, 15 degrees is reflected from the surface at the same angle.

Reflected waves combine with the direct waves, or those radiated at angles above the horizontal, in various ways, depending upon the orientation of the antenna with respect to earth,

Fig. 301 — At any distant point, P, the field strength will be the resultant of two rays, one direct from the antenna, the other reflected from the ground. The reflected ray travels farther than the direct ray by the distance BC, where the reflected ray is considered to originate at the "image" antenna.

the height of the antenna, its length, and the character of the ground. At some vertical angles above the horizontal the direct and reflected waves may be exactly in phase — that is, the maximum field strengths of both waves are received at the same time at the same spot and the directions of the fields are the same so that the resultant is the sum of the two. At other vertical angles the two waves may be completely out of phase — that is, the fields are maximum at the same instant and the directions are opposite, at the same spot — so that the resultant field strength is the difference between the two. At still other angles the resultant field will have intermediate values. Thus the effect of the ground is to increase the intensity of radiation at some vertical angles and to decrease it at others.

The effect of reflection from the ground is shown graphically in Fig. 301. At a sufficiently large distance, the two rays which converge at the distant point can be considered to be parallel. The reflected ray travels a greater distance in reaching P than the direct ray does, however, and this difference in path length accounts for the effect described in the preceding paragraph. If the path of the reflected ray is exactly a half wave longer than the path of the direct ray, the two waves will arrive out of phase. This corresponds to the condition illustrated in Fig. 203 (C). If the path of the reflected ray is exactly a full wavelength longer than that of the direct ray, the two rays will again be in phase, the only change being that from the ground, which is assumed to be a perfectly-conducting ground.

Image Antennas

It is often convenient to use the concept of an image antenna to show the effect of reflection. As Fig. 302 shows, the reflected ray has the same path length (AD equals BD) that it would if it originated at a second antenna, of the same characteristics as the real antenna, but situated below

Fig. 302 — Horizontal and vertical half-wave antennas and their images.

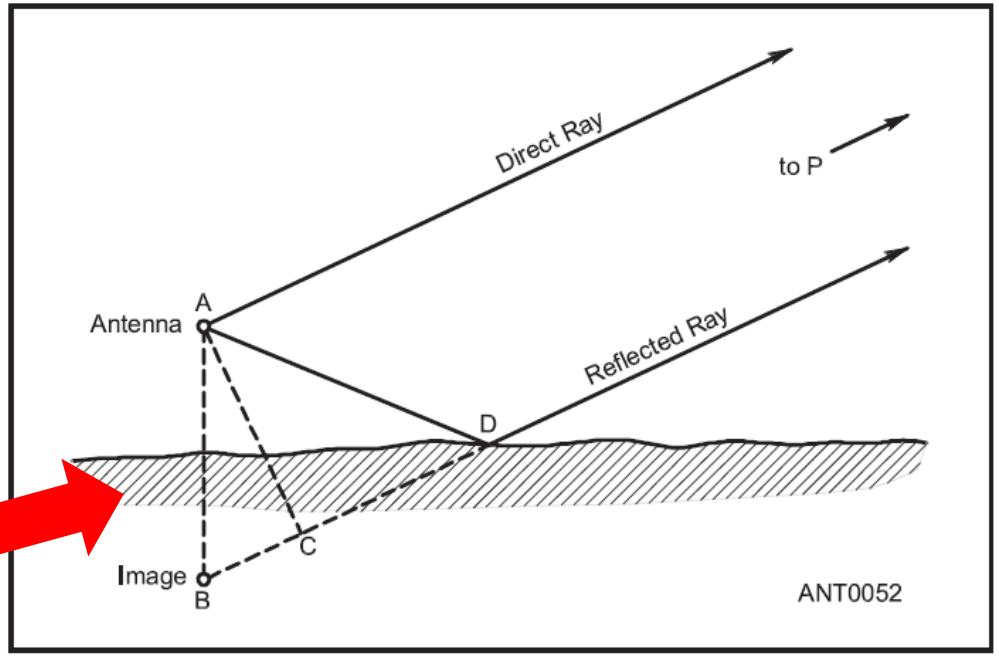


Figure 3.38 — At any distant point, P, the field strength will be the vector sum of the direct ray and the reflected ray. The reflected ray travels farther than the direct ray by the distance BC, where the reflected ray is considered to originate at the image antenna.

Some Things Will Never Change

Figure 13.9 — Two long wires and their respective patterns are shown at the left. If these two wires are combined to form a V with an angle that is twice that of the major lobes of the wires and with the wires excited out of phase, the radiation along the bisector of the V adds and the radiation in the other directions tends to cancel.

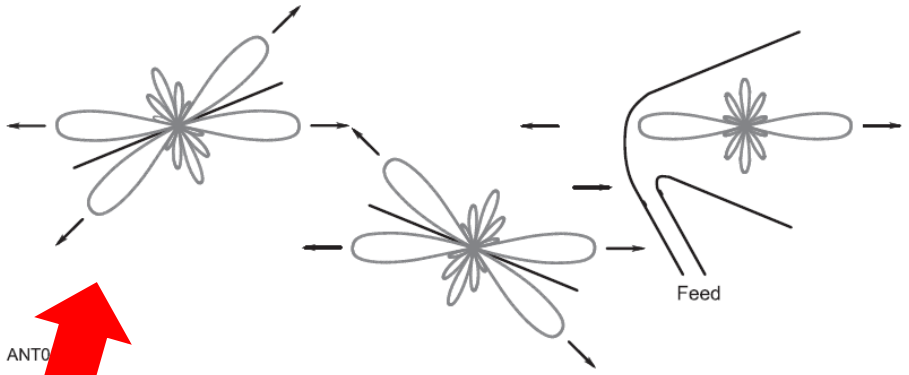


Fig. 1003 — Design chart for horizon-

ground slopes, the antenna should be made parallel to the ground and preferably with the open end of the V down the slope.

The gain of the V beam can be increased by stacking two beams one above the other, a half-wavelength apart, and feeding them so that the legs on one side are in phase with each other and out-of-phase with the legs on the other side. This will result in a greatly lowered angle of radiation. The bottom V should be at least a quarter-wavelength above the ground, preferably a half-wavelength

Two V beams can be broadsided to form a "W" array, giving greater gain. However, two feed lines are required and this fact, plus the five poles required

normally employed by amateurs because it restricts the use to one band, although it has proved to be quite effective in commercial work.

The V can be made unidirectional and aperiodic by terminating the ends of the V to ground through resistors. The resistors must dissipate almost half the power fed to the antenna and the ground connection must be an excellent one. Because of the practical difficulties involved, terminated V's are not often used, although they present excellent

Feeding the V

The V beam is most conveniently fed by parallel feeders, since they permit multi-band operation

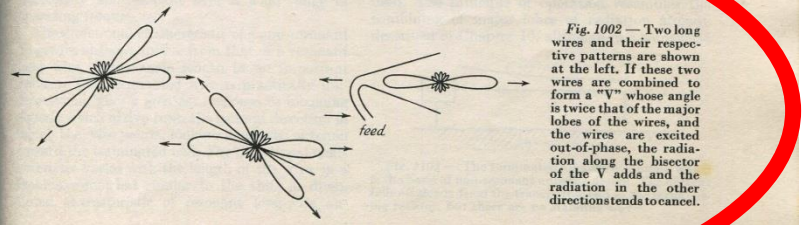


Fig. 1002 — Two long wires and their respective patterns are shown at the left. If these two wires are combined to form a "V" whose angle is twice that of the major lobes of the wires, and the wires are excited out-of-phase, the radiation along the bisector of the V adds and the radiation in the other directions tends to cancel.

Some Things Will Never Change

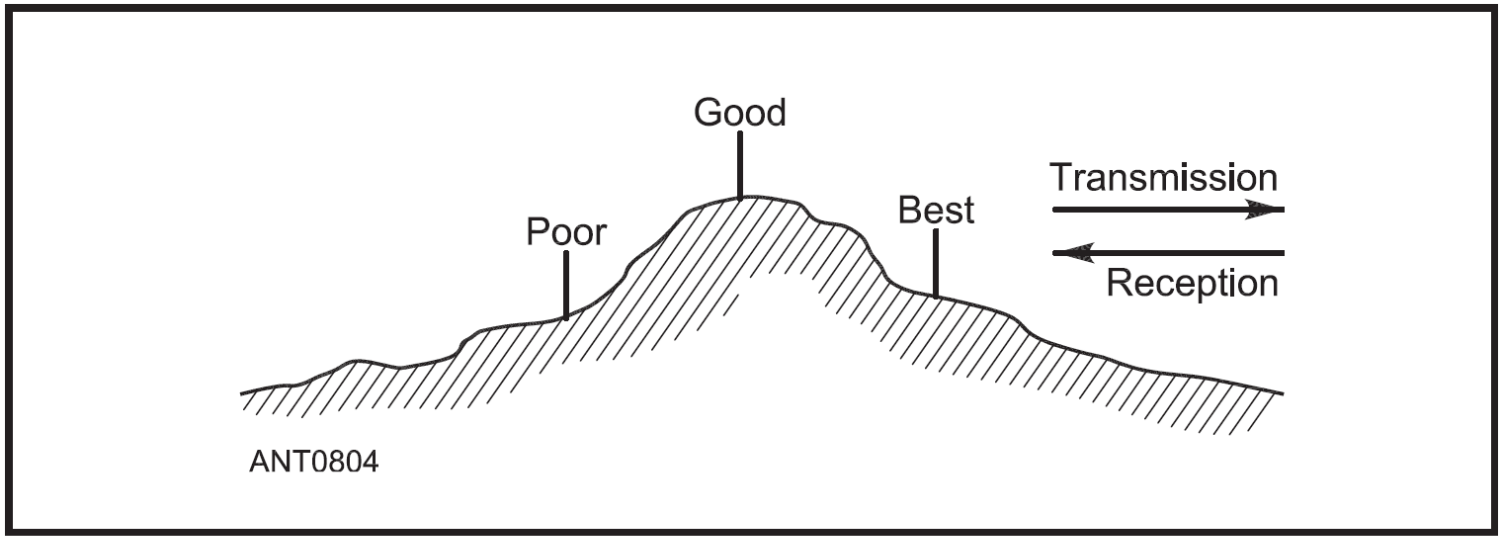


Figure 4.5 — Propagation conditions are generally best when the antenna is located slightly below the top of a hill on the side facing the distant station. Communication is poor when there is a sharp rise immediately in front of the antenna in the direction of communication.

New in the 23rd Edition

New Stuff!

- **High-performance at VHF/UHF by GØKSC**
- **Expanded treatment of HF ground effects by N6LF**
- **MF, LF propagation update by K9LA**
- **HFTA data set generation service by K6TU**
- **Grounding and bonding of antenna systems**
- **Updated tower work and safety by K4ZA**
- **Harmonic filters using coaxial stubs (W2VJN, K9YC)**
- ***NEC-2/NEC-4* and *4nec2* comparison by W8WWV**
- **Radial articles from *NCJ* by K3LC**

More New Stuff!

- Wide-band 80/75 meter antennas
- Multi-band antennas
- Moxons and Extended Double Zepps
- High-performance VHF/UHF beams by GØKSC
- Low-band receiving antennas
- More satellite antenna systems
- More balun designs and examples
- Software - www.arrl.org/arrl-antenna-book-reference
- Lots of supplementary material on the CD-ROM

New Areas to Cover

- Better treatment of "grounding"
- UHF and microwave antennas
- Continue to improve ground effect treatment
- How to account for the effects of terrain
- Mobile and portable antennas
- Stealthy installations
- Advances in receiving antennas and arrays
- Size and shape-adjusting antennas
- Meta- and other new materials

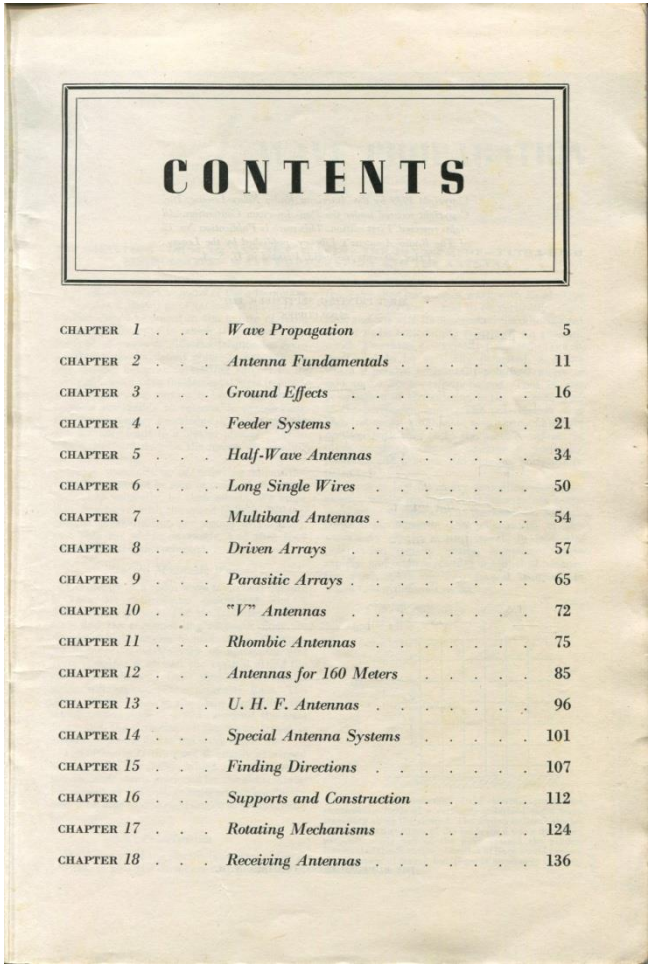
Antenna Book Philosophy

Philosophy to Date – One-stop Shop

- Basic theory and principles, including propagation
- Design equations and evaluation methods
- Best current practices in common uses
- Antenna and tower safety, tools and hardware
- Grounding, bonding, electrical safety
- "Reference" antenna designs
- Collections of "cookbook" designs
- Properties of materials

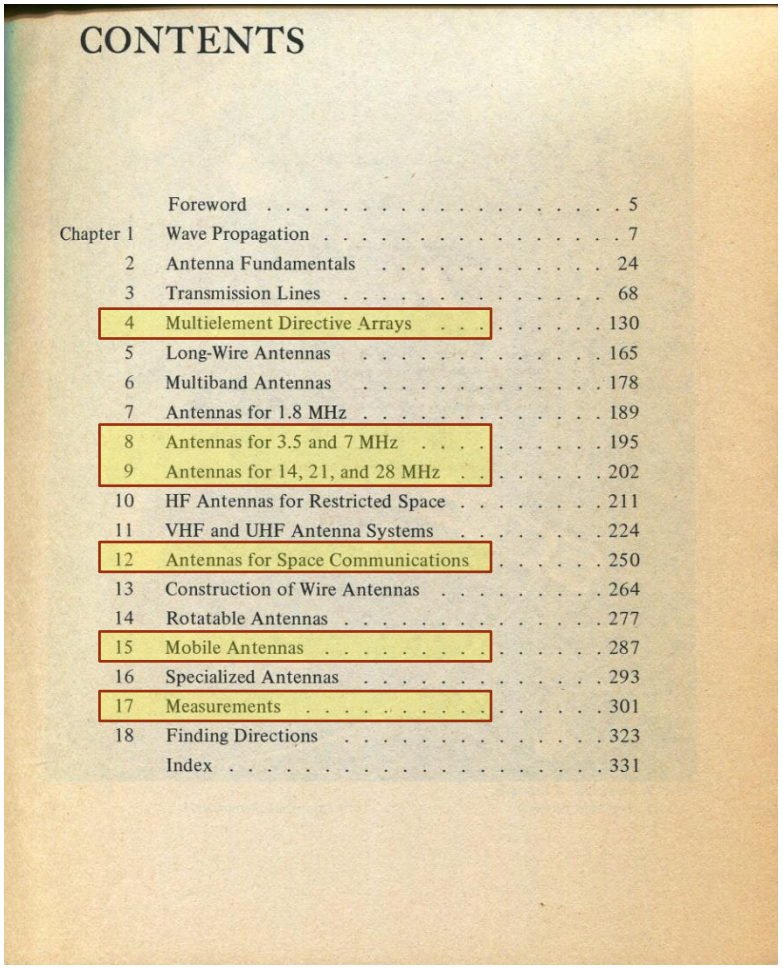
Antenna Technology Expansion

First Edition



CONTENTS

Thirteenth Edition



CONTENTS

23rd Edition

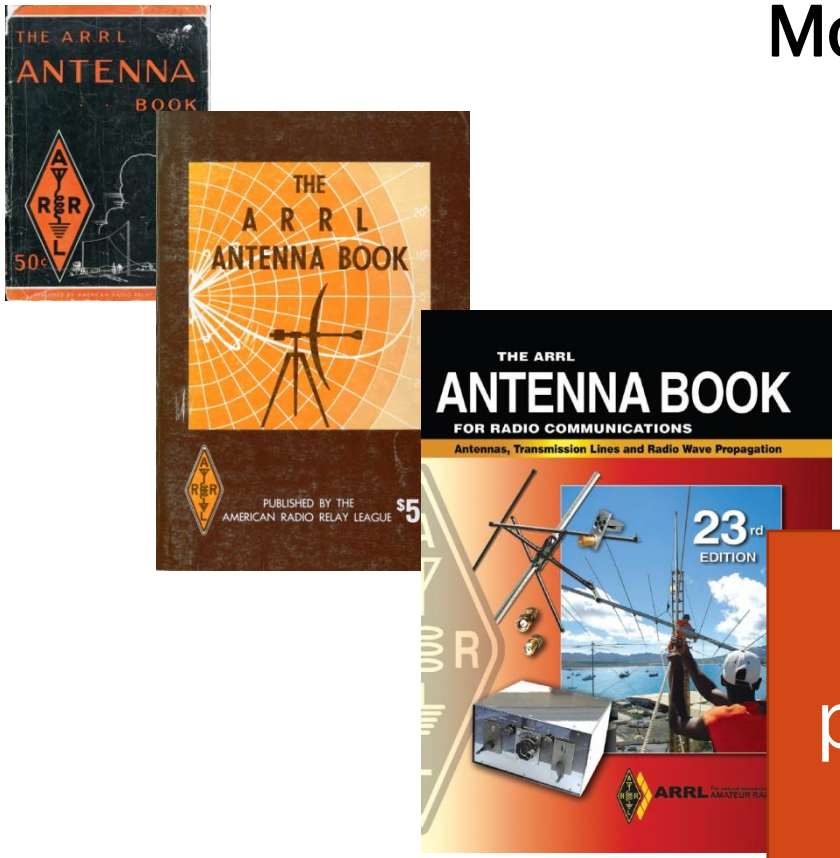
Contents

A detailed Table of Contents is included at the beginning of each chapter.

YIKES!!!

More bands & modes

More types & designs



2000+ pages and 20+ pounds ????

I Don't Think So!

Challenges Going Forward

Challenges Going Forward

- **Enormous amounts of material is available on-line (some of it is even true…)**
- **Most people under the age of 50 prefer electronic format on laptops, tablets, smartphones, ???**
- **Information is not hidden or expensive**
- **Paper takes longer to get and is expensive to store and deliver (and heavy)**
- **What are the *essential elements* that make a reference useful?**

What is the Antenna Book For?

- **Who is the "average" ham?**
- **What does the average need to know?**
- **What about the expert ham?**
- **What about the brand-new ham?**
- **What does the reader need to learn?**
- **How can the Antenna Book teach it?**

These are all important questions!

Antenna "Book" Essentials

- ***Curated*** **material, reviewed by experts, selected for the particular application (i.e. ham radio)**
- **Teaching materials that are *effective* for the particular audience (i.e. hams)**
- **Best practices distilled into reference applications, *readily adaptable* to individual circumstances**
- ***Reference designs*** **that identify important design decisions, assumptions, and criteria**
- **Available to hams at a *reasonable cost in the format they want***

Possible Solutions

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- **Online website with limited hard copy access**
- **Subscriptions to an online PDF or equivalent**
- **Proprietary formats such as Kindle**
- **Smaller printed volumes (theory, HF, VHF/UHF, systems, etc) with online supplements**
- **Printed fundamental sections, everything else on a website for members-only**

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- **What are your ideas?**
- **Have Tim Duffy come over and build it for me!**

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The New Reality

- **Print is going away – we *all* just have to get used to the idea**
- **Publishing reference works in the digital age is a hard problem if you can't give it away!**
- **Will curating and editorial review survive? Your support will be the answer…TBD!**

The Antenna Book – 24th Edition

- **Needs material on DIRT!**

As dirty as a little boy!

THANK YOU!!!