

Preface

Vacuum tubes have been around for a very long time. Appreciated for their distinctive sound, amplifiers built around tubes have found a permanent home with audio enthusiasts and experimenters alike. This book is intended for hobbyists interested in understanding tube technology and building high-fidelity audio amplifiers.

This book covers the theory and operation of vacuum tubes and audio amplifier circuits, and includes practical projects for the experienced hobbyist. The theory of tubes and amplifier circuit design is covered from a classical perspective, drawn from some of the classic work on the subject written by Karl Spangenberg as part of the McGraw-Hill *Electrical and Electronics Engineering Series* published in the mid-1940s. The idea for this book, in fact, came from a chance opportunity to acquire several books in the series.¹ Some of the theory of tube operation and basic circuits described in the projects contained in this book are adapted from another classic publication, the *RCA Receiving Tube Manual*.² Complementing this classical approach to amplifier design are current devices that preserve the many sonic benefits of the “tube sound.”

A suite of projects is included for the reader to construct high-fidelity audio amplifiers and related equipment at a variety of levels of sophistication, power output, and construction preferences. This book also reviews the tradeoffs that engineers must make in designing an audio amplifier and helps the reader tailor particular circuits to meet their own objectives.

In each case, we begin with a basic circuit design from the *RCA Receiving Tube Manual* and build it—with additions, improvements, and modifications along the way based on experience gained from the project. This approach mirrors the techniques used by experimenters and hobbyists for decades. The goal is to produce a useful end product, learn something about the circuit, and have fun doing it.

The initial platform for each project is a test bed where variations on the basic circuits are tried and documented. The end result is a final design that is built as a showcase project. The test bed approach is very useful, since few projects turn out as expected the first time. Design, of course, is an iterative process.

¹ I highly recommend Terman's, *Radio Engineering* (1947) and Spangenberg's *Vacuum Tubes* (1948). These books have been long out of print; however, they are occasionally available from technical libraries.

² Also recommended, and also long out of print.

The audio projects presented in this book will be a finishing point for some, and a starting point for others. No doubt some readers will want to continue improving and tweaking the designs to gain the last bit of performance. Others will be content to finish the project and move on to something else.

In preparing this book, the author considered various ways of handling projects. The primary options included: 1) offer a large number of circuits with little supporting detail, or 2) offer a small number of circuits with considerable supporting detail. The author took option #2. Underlying this approach is the assumption that most readers will either be coming to vacuum tube audio projects for the first time or coming back after many years (or decades) of doing something else as a hobby (like building computers and then fighting with the software).

For audiophiles who have been building vacuum tube amplifiers for some time, there are a number of books containing interesting circuits intended for the veteran builder. In this book, we take a slower, more detailed, more methodical approach.

One of the challenges in building vacuum tube projects today is finding the parts necessary to complete the product. The author has attempted in all projects to specify parts that can be acquired readily at a reasonable cost. Anyone working on vacuum tube projects will appreciate the difficulty of finding the right part. Sometimes compromises are necessary to avoid spending considerable time and money acquiring a particular device. For these situations, the author has attempted to outline the options and tradeoffs.

The appeal of vacuum tube-based amplifiers is well known. For many enthusiasts, the challenge is largely how to make these systems understandable and to make the projects practical to build. The projects in this book include detailed schematic diagrams, layout suggestions, and parts lists. Every effort has been made to document projects that are useful, practical, and fun to build.

Like any book, this one is based on the experiences and interests of the author. Over the years there have been a number of excellent books published on the subject of audio amplifiers. Some of these books are highly technical and intended for audiophiles who are looking for peak performance from their systems. Others are hobbyist books that focus strictly on projects. This book falls somewhere in between. A concerted effort has been made to include background theory and operation of vacuum tubes. However, this book does not go into the level of detail provided by other authors who have written excellent highly technical books on the subject.³ If you are looking for a book that will help you design an amplifier from the ground up and construct key components to achieve the last measure of performance from your system, this book is probably not what you are looking for. If, on the other hand, you have an interest in vacuum tube audio amplifiers and want to build a system as hobby, this book is probably for you.

The book includes a considerable amount of detail on fundamental principles. It is the author's belief that good design can come only from a firm understanding of the fundamentals. To that end, much of this material is developed from previous

³ Notable among these is Morgan Jones and his McGraw-Hill titles *Valve Amplifiers*, 3rd ed., and *Building Valve Amplifiers*.

publications by the author (there are about 30 at last count). Readers interested in exploring the fundamental principles in greater detail are encouraged to check out the references noted in each chapter.

In the realm of audio amplifiers, a logical division can be made between audio systems intended for faithfully amplifying input signals and those intended for applications where the characteristics of the amplifier are adjusted to yield a particular “sound.” A common example of the latter is the guitar amplifier. This is a specialized area of audio technology that deserves, and has, a following of its own. Many books are available that cover this technology in detail. This book is not one of them.

Fortunately, a wide variety of publications are available to audio enthusiasts and experimenters that cover a wide range of interests. In addition, vacuum tube suppliers have online web resources that provide valuable data and insight into use of specific devices. Readers are encouraged to utilize all available resources, since each has its place in the realm of education on the fascinating topic of vacuum tubes. In addition, several web-based bulletin boards are available where members discuss projects and solve problems.⁴

The objectives of this book can be distilled to the following:

- Reaffirm an appreciation for vacuum tubes
- Provide readers with a firm understanding of the operation of tubes and related components
- Build some interesting and useful audio devices
- Have fun

Readers of a certain age will likely recall the Heathkit products that were widely marketed during the 1960s and 1970s. (There were others in the space as well.) While these kits may not always be remembered for their high-end sonic audio offerings,⁵ they nonetheless imparted in the hobbyists who bought them a fondness for building electronic devices and then enjoying the fruits of their labors. It is my hope that this book will recapture that spirit.

—Jerry Whitaker

⁴The site “diyAudio” is one such service: www.diyaudio.com/index.php

⁵There are notable exceptions, such as the WM-5 amplifier—a nice sound in any decade.