

# Vacuum Tube Design

RCA Manufacturing Company, Inc.  
Harrison, New Jersey

Privately issued by RCA Manufacturing Co., Inc.  
for use of its employees and for restricted  
distribution.

## PREFACE

The material comprising the twenty-six lectures contained in this book formed the basis of a course on vacuum-tube design given by RCA engineers for company employees during the Winter of 1937 and the Spring of 1938. The lectures were intended to provide a review of the basic principles underlying the design and manufacture of vacuum tubes. They appear in the order in which they were presented and in a few instances include new material added at time of publication.

Each lecturer has treated his subject according to his own viewpoint. In general, the treatment is non-mathematical. Numerous formulas and charts of particular interest to the design engineer have been included.

Throughout the book, numerous references to sources of information have been given. References to published material list the publication; those to unpublished material are keyed. The keyed sources are available to authorized persons for reference purposes in our Library.

The Editors

Harrison, New Jersey  
December, 1940

## CONTENTS

Lecture 1	<i>FILAMENTS AND CATHODES - Part I</i>	E. A. Lederer	1
Lecture 2	<i>FILAMENTS AND CATHODES - Part II</i>	E. A. Lederer	11
Lecture 3	<i>HEATERS AND HEATER-CATHODE INSULATION</i>	G. R. Shaw and L. R. Shardlow	24
Lecture 4	<i>PHOTOELECTRIC AND SECONDARY EMISSION</i>	L. B. Headrick	34
Lecture 5	<i>LUMINESCENT MATERIALS</i>	H. W. Kaufmann	51
Lecture 6	<i>CONTACT POTENTIAL, PUMPS, AND GETTERS</i>	E. A. Lederer	58
Lecture 7	<i>METALLURGICAL PRINCIPLES</i>	S. Umbreit	73
Lecture 8	<i>METALS FOR VACUUM-TUBE CONSTRUCTION</i>	S. Umbreit	82
Lecture 9	<i>GLASS AND ITS PROPERTIES</i>	G. R. Shaw and C. A. Jacoby	91
Lecture 10	<i>CONSTRUCTION TRENDS IN RADIO TUBES</i>	N. R. Smith	103
Lectures 11, 12, 13, and 14	<i>SPACE-CURRENT FLOW IN VACUUM-TUBE STRUCTURES</i>	B. J. Thompson	115
Lecture 15	<i>ELECTRON OPTICS — Part I DETERMINATION OF ELECTRON TRAJECTORIES</i>	V. K. Zworykin and G. A. Morton	124
Lecture 16	<i>ELECTRON OPTICS — Part II ELECTRON-OPTICAL SYSTEMS WITH CYLINDRI- CALLY SYMMETRICAL FIELD-PRODUCING ELEMENTS</i>	V. K. Zworykin and G. A. Morton	136
Lecture 17	<i>ELECTRON OPTICS — Part III ABBERATIONS IN ELECTRON OPTICS</i>	G. A. Morton and E. G. Ramberg	153
Lecture 18	<i>RADIO RECEIVING TUBE COMPONENTS AND THEIR MANUFACTURE</i>	N. R. Smith	168
Lecture 19	<i>ANALYSIS OF RECTIFIER OPERATION</i>	O. H. Schade	174
Lecture 20	<i>THE DESIGN OF AUDIO AMPLIFIER AND POWER OUTPUT TUBES</i>	S. W. Dodge	194

## CONTENTS (cont'd)

Lecture 21	<i>THE DESIGN OF RADIO-FREQUENCY AMPLIFIER TUBES</i>	T. J. Henry	203
Lecture 22	<i>THE DESIGN OF DETECTORS AND CONVERTERS</i>	T. J. Henry	209
Lecture 23	<i>THE DESIGN AND CONSTRUCTION OF TRANSMITTING TUBES</i>	E. E. Spitzer	218
Lecture 24	<i>THE DESIGN AND CONSTRUCTION OF CATHODE-RAY TUBES</i>	W. H. Painter	226
Lecture 25	<i>ELECTRON BEAMS AND THEIR APPLI- CATION IN RADIO TUBES</i>	H. M. Wagner	234
Lecture 26	<i>THE DESIGN AND PERFORMANCE OF RECTIFIERS</i>	A. P. Kauzmann	249