

CONTENTS

PREFACE	9
1. EQUIVALENT ELECTRICAL CIRCUITS OF THIN DIAPHRAGMS	11
1.1 Introduction	11
1.2 Circular diaphragm	12
1.3 Equivalent circuit of a thin annular diaphragm	16
1.4 Thin rectangular diaphragm	33
1.5 A thin diaphragm as part of an electrostatic transducer	36
1.5.1 Introduction	36
1.5.2 Quasistatic stability of a single-acting transducer	38
1.5.3 Stability of a push-pull transducer	50
1.5.4 Electrostatic transducer with a thin annular diaphragm	52
2. EQUIVALENT CIRCUITS OF THIN PLATES AND BARS	58
2.1 Circular plates	58
2.1.1 Introduction	58
2.1.2 Equivalent circuit of a thin flexurally vibrating circular plate clamped at the edge	59
2.1.3 Equivalent circuit of a circular plate supported at the edge	65
2.2 Transverse vibration of bars and their equivalent circuits	68
2.2.1 Introduction	68
2.2.2 A uniform bar of rectangular cross-section clamped at both ends	70
2.2.3 Uniform bar of rectangular cross-section supported at both ends	75
2.2.4 Uniform bar of rectangular cross-section clamped at one end and free at the other	79
2.3 Longitudinal vibration of thin rods	82
2.3.1 Introduction	82
2.3.2 Longitudinal vibration of a free-free bar with structural damping	84
2.3.3 Longitudinal vibration of a free-clamped bar with structural damping	90
3. SOLID-STATE WAVEGUIDES OF UNIFORM AND NON-UNIFORM CROSS-SECTION	95
3.1 Introduction	95
3.2 Hyperbolic waveguides	96
3.2.1 Wave equation of a hyperbolic waveguide	96
3.2.2 A hyperbolic divergent waveguide of finite length	99
3.2.3 Hyperbolic divergent waveguide of infinite length	102
3.2.4 Exponential waveguide of finite length	107
3.2.5 Input impedance of convergent and divergent exponential waveguides of infinite length	108

3.3 Conical waveguide of finite length	109
3.3.1 Wave equation of a conical waveguide	109
3.3.2 Convergent conical waveguide	110
3.3.3 Divergent conical waveguide	113
3.4 Analogue circuit of a solid-state waveguide	114
3.5 The effect of lateral displacement in a mechanical waveguide with a longitudinal wave	119
3.5.1 Introduction	119
3.5.2 Wave equation of a waveguide with lateral displacement	123
3.5.3 The measurement of dispersion in a cylindrical waveguide	133
3.5.4 Waveguides of non-uniform cross-section	136
3.6 Bessel waveguides	138
3.6.1 Introduction	138
3.6.2 A Bessel waveguide of finite length	138
3.6.3 A Bessel waveguide of infinite length	142
3.7 Some applications of equivalent circuits of solid-state waveguides	144
3.7.1 Waveguides of constant cross-section	144
3.7.2 Waveguides of non-uniform cross-section	152
3.7.3 Piezoelectric transducer with waveguides	161
4. ACOUSTIC SYSTEMS WITH DISTRIBUTED ELEMENTS	173
4.1 Acoustic waveguides	173
4.2 Equivalent circuits of air-gaps	178
4.2.1 Air-gap with a centric opening	178
4.2.2 Air-gap with an opening on the circumference	185
4.2.3 Air-gap at low frequencies	192
4.2.4 Air-gap with an annular opening	195
4.2.5 Air-gap under a rectangular diaphragm	197
4.2.6 Impedance of an air-gap between two parallel planes	204
4.2.7 Resistance of an air-gap under a rectangular diaphragm	213
4.2.8 Resistance of an air-gap under a circular diaphragm	216
4.2.9 Resistance of an air-gap between two parallel planes at low pressure	226
4.3 Applications of the theory of acoustic waveguides	228
4.3.1 Divergent conical horn of infinite length	228
4.3.2 Hyperbolic divergent waveguide of infinite length	229
4.3.3 Hyperbolic waveguide of finite length terminated by an infinitely long conical waveguide	232
4.3.4 Waveguide of finite length terminated by an infinite impedance	236
BIBLIOGRAPHY	240
INDEX	242