

CONTENTS

PREFACE	ix
LIST OF SYMBOLS	xi
INTRODUCTION	xv
1. BASIC PHYSICAL CONCEPTS	1
1.1 The Galvanomagnetic Effects	1
1.1a Hall angle ϕ	2
1.1b Hall coefficient and magnetoresistance	6
1.1c Mixed conduction	9
1.1d Planar Hall effect	12
1.1e Shapes of semiconductors and electrodes	16
1.1f Parameters important for galvanomagnetic devices	24
1.1g Thermal and thermomagnetic effects	27
1.2 Galvanomagnetic Materials	29
1.2a Electrons and holes in semiconductors	30
1.2b Temperature dependence of Hall coefficient	32
1.2c Dependence of Hall coefficient on magnetic induction	40
1.2d Dependence of the magnetoresistance on magnetic induction	44
1.2e Temperature dependence of magnetoresistance	49
2. DESIGN AND FABRICATION OF GALVANOMAGNETIC DEVICES	55
2.1 Growth of Semiconductors from the Melt	56
2.1a Indium antimonide	56
2.1b Indium arsenide	59
2.1c Mixed crystals of InAs and InP	61
2.1d Indium antimonide-nickel antimonide eutectic alloys	63
2.2 Preparation of Semiconductor Films by Vacuum Deposition	66
2.3 Structure of Hall Generators	69
2.3a Hall generators on non-ferromagnetic substrates	70
2.3b Hall generators on ferrite substrates	74
2.3c Vacuum deposited Hall generators	75
2.4 Structure of Field-plate Magnetoresistors	77
2.4a Disc magnetoresistors	78
2.4b The raster plate	79
2.4c The InSb-NiSb field-plate	80

3. PROPERTIES OF GALVANOMAGNETIC DEVICES	84
3.1 Hall Generator	84
3.1a Four-pole parameters	84
3.1b Linearity of the Hall voltage as a function of B	94
3.1c Temperature dependence	98
3.1d Residual Hall potential in zero magnetic field and induced potential	102
3.1e Self-induced magnetic field	108
3.1f Aging	112
3.1g Frequency dependence	116
3.1h Peak input power and loading	123
3.1i Noise	130
3.2 The Magnetoresistor Field-plate	133
3.2a Dependence of the resistance on the magnetic induction	134
3.2b Dependence of the resistance on temperature	137
3.2c Peak input power and loading	139
3.2d Self-induced magnetic field	147
3.2e Frequency dependence	152
3.2f Noise	155
3.2g Aging experiments	156
3.3 Changes in Electrical Properties on Irradiation with High-energy Particles	156
4. APPLICATIONS OF THE HALL EFFECT	160
4.1 Measurement of Magnetic Fields	161
4.1a Measurement and control circuits	161
4.1b Weak magnetic fields	170
4.1c Inhomogeneous magnetic fields	176
4.1d Measurement of tangential fields	179
4.2 Measurement of Quantities Representable by a Magnetic Induction	184
4.2a Measurement of d.c. currents and voltages	184
4.2b Measurement of angles	191
4.3 Contactless Signal Generation	193
4.3a Contactless signal generation without reaction	194
4.3b Contactless signal generation over a distance of several centimeters with ferrite Hall generators	199
4.3c Ferrite Hall generator with high resolution used for positioning	203
4.3d Positioning of soft-iron bodies	212
4.3e Transistor amplifier for contactless signal generation	215
4.4 Multiplicative Properties of Hall Generators	216
4.4a Analog multiplication	217
4.4b Power measurement	226
4.4c Modulation of small d.c. voltages and currents	231
4.5 Hall Effect Gyrator, Isolator and Circulator	234
4.5a Hall effect gyrator	234
4.5b Hall effect isolator	235
4.5c Hall effect circulator	240

5. APPLICATIONS OF THE MAGNETORESISTANCE EFFECT	242
5.1 Measurement of Magnetic Fields and Quantities Proportional to Magnetic Fields	242
5.1a Simple field-probe	242
5.1b Micro-probe	245
5.1c Gradient probes	245
5.1d Field-plate probe for weak magnetic fields	247
5.1e D.C. current transducer	258
5.2 Non-contacting Variable Resistance and Potentiometer	260
5.3 Modulation of Small D.C. Currents and Voltages	274
5.3a Conversion of a d.c. current into an a.c. voltage	276
5.3b D.C. to a.c. voltage conversion	281
5.3c Combination circuit for the conversion of d.c. currents and voltages into a.c.	283
5.3d Experimental investigations	288
5.3e Push-pull modulator	291
5.4 Multiplication	297
5.4a Multiplier circuits	297
5.4b Generation of a quadratic field-plate characteristic	302
5.5 Connecting the Field-plate to other Semiconductor Devices	309
5.5a Diode	310
5.5b Transistor	312
5.5c Tunnel diode	314
5.5d Thyristor	319
5.6 Contactless Control	322
5.6a Precise determination of position	322
5.6b D.C. motor controlled by field-plates	328
5.6c Power controlled by a field-plate	336
5.7 Feedback-coupled Field-plate	337
5.7a Field-plate in parallel with the excitation solenoid	338
5.7b Field-plate in series with the excitation solenoid	341
6. OTHER POSSIBILITIES FOR CONTROLLING THE ELECTRICAL PROPERTIES OF SEMICONDUCTORS BY MEANS OF A MAGNETIC FIELD	344
REFERENCES	350
PARAMETERS OF GALVANOMAGNETIC DEVICES	355
INDEX	357