

Cambridge University Press

978-1-316-60186-0 - Modern Magnetism: Second Edition

L. F. Bates

Table of Contents

[More information](#)

## CONTENTS

*Preface* *page v**Chapter I. Fundamental Conceptions in Magnetism* *page 1*

Fundamental Definitions 1, Magnetic Shell 4, Permeability 5, Energy of Magnetisation 8, Classical Theory of Diamagnetism 9, Classical Theory of Paramagnetism 13, The Bohr Atom 17, Spatial Quantisation 20, The Vector Atom Model 22, The Pauli Principle 23, Russell-Saunders Coupling 25, Terminology 27, Stability Rules 28, The Periodic Table 29, The Splitting Factor 32, The Zeeman Effect 34, The Paschen-Back Effect 37, The Quantum Theory of Paramagnetism 39, The Magnetic Significance of Multiplet Widths 40, Saturation Phenomena 41, Paramagnetism Independent of Temperature 42, The Stark Effect 43, The Magnetic Properties of Free Molecules 44, Magnetic Properties of Matter in Bulk 47, Magnetic Properties of Free Electrons 50, The Quantum Theory of Diamagnetism 51, Fundamental Atomic Constants 53.

*Chapter II. The Production and Measurement of  
Magnetic Fields* *page 55*

The Solenoid 55, The Properties of Ferromagnetics, Ballistic Investigations 56, Magnetometer Investigations 59, Magnetic Viscosity 62, The Magnetic Potentiometer 63, Measurements with Short Specimens 65, Reversible and Incremental Permeability 65, The Steinmetz Coefficient 66, Special Ferromagnetic Materials 66, The Magnetic Circuit 68, Electromagnet Design 70, Magnets for Special Purposes 74, Permanent Magnets 76, Materials for Permanent Magnets 78, Extremely Intense Fields 80, Measurement of Strong Fields 81, The Fluxmeter 82, The Bismuth Spiral 86, The Electromagnetic Balance 86, Field Control and Stabilisation 87.

*Chapter III. Susceptibility Measurements with Iso-  
tropic Substances* *page 91*

Introduction 91, Forces acting on a Body in a Magnetic Field 92, Survey of Experimental Methods 95, The Gouy Method 97, The Quincke Method 100, Auer's Experiments 101, The Curie Method 103, The Sucksmith Ring Balance 105, The Föex and Forrer Balance 107, The Curie-Chéneveau Balance 108, The Method of Kapitza and Webster 108, The Rankine Method 110, Measurements in Very Intense Fields 111, Radiofrequency Measurements 114, Corrections

## CONTENTS

for Ferromagnetic Impurity 114, Temperature Control 117, Susceptibilities of Gases 118, Stössel's Experiments 119, Modern Forms of Faraday's Method 120, Special Test Bodies 121, Measurements with Vapours 123, Discussion of Experimental Data 124, Ions of the Rare Earth Group 127, Ions of the Iron Group 130, Useful Magnetic Data 132.

*Chapter IV. The Magnetic Properties of Crystals* page 133

Theoretical Considerations 133, The Significance of Measurements on Single Crystals 134, Jackson's Experiments 136, Experiments with Monoclinic Crystals 138, Immersion Experiments 139, Oscillation Experiments 140, Experimental Results 141, Metallic Single Crystals 144, Focke's Experiments 146, Vogt's Experiments 147, The de Haas-van Alphen Effect 148, Effects of Alloying on Crystal Diamagnetism 149, Collected Results 150, Ferromagnetic Crystals 150, Experimental Procedure 152, Weiss' Experiments 152, Experiments with Iron Crystals 155, Experiments with Nickel Crystals 159, Experiments with Cobalt Crystals 159, Single Crystals of Alloys 160, Theoretical Aspects of Ferromagnetic Anisotropy 160.

*Chapter V. Experiments with Single Particles* page 164

Theoretical Considerations 164, Experimental Aspects 166, The Rabi Method of Separation 167, Modern Technique 169, Experimental Results 171, Precision Measurement of the Bohr Magnetron 172, Measurements with Atomic Hydrogen 177, Experiments with Diatomic Gases 177.

*Chapter VI. Nuclear Spins and Magnetic Moments* page 181

Introduction 181, Experiments of Rabi and Cohen 186, The Method of Zero Moments 187, The Determination of the Hyperfine-Structure Separation 190, The Magnetic Moment of the Proton: Experiments with Molecular Hydrogen 192, Experiments with Atomic Hydrogen 194, The Magnetic Moment of the Deuteron 197, The Process of Spatial Quantisation 197, The Magnetic Moment of the Neutron 200.

*Chapter VII. Gyromagnetic Effects* page 202

Introduction 202, The Properties of the Gyroscope 202, Types of Gyromagnetic Experiments 204, Barnett's Experiments on Magnetisation by Rotation 206, Experiments on Rotation by Magnetisation 209, The Direct Method 210, Simple Resonance Methods 214, Modified Resonance Methods 216, Errors in Resonance Measurements 219, Controlled Resonance Methods 219, Spin and Orbital Effects 221, Sucksmith's Experiments with Paramagnetics 222, Experiments with Rotating Magnetic Fields 229.

Cambridge University Press

978-1-316-60186-0 - Modern Magnetism: Second Edition

L. F. Bates

Table of Contents

[More information](#)

## CONTENTS

*Chapter VIII. Magnetic Saturation and Equation  
of State* *page 233*

Introduction to Theory of Ferromagnetism 233, Heisenberg's Theory of Ferromagnetism 239, The Approach to Saturation 241, Experiments of Weiss and Forrer 243, Fallot's Experiments 245, Image Effects 248, Domain Size Effect 249, Parasitic Magnetism 251, Ferromagnetic Gadolinium 252, Experiments with Ferromagnetic Alloys 252, Mott's Explanation of the Magnetic Properties of Alloys 255, Determination of Curie Points 256, Magnetisation at High Temperatures 259, Potter's Experiments 262, Discussion of Results 264.

*Chapter IX. Energy Changes associated with Re-  
versible Magnetisation* *page 268*

The Specific Heat of a Ferromagnetic 268, The Magnetocaloric Effect 272, Experimental Investigation of the Magnetocaloric Effect 275, Magnetocaloric Determinations of the Weiss Constant 277, The Law of Corresponding States 278, The Weiss Constant and Domain Size 279, The Magnetocaloric Effect with Paramagnetics 283, Experimental Details 285, The Production of Very Low Temperatures 287, Applications of Magnetic Cooling 289, The Temperature Scale below 1° K. 290, The Electrical Resistance of a Ferromagnetic 292, The Thermo-electric Properties of Ferromagnetics 296.

*Chapter X. Magnetostriction* *page 298*

Introduction 298, The Joule Effect 298, The Joule Effect with Single Crystals 301, The Joule Effect with Non-ferromagnetics 303, Becker's Theory of Magnetostriction Processes 305, Effects of Shape on Magnetostriction 307, Volume Changes in Magnetostriction 308, The Weiss Constant and Magnetostriction 309, The Villari Effect 310, The Wiedemann Effect 311, Initial Permeability and Magnetostriction 313, Magnetostriction Oscillators 314, The Magnetostriction Echo Depth Recorder 318, Surface Fields on Ferromagnetics 320, The Barkhausen Effect 321, Nature of the Barkhausen Discontinuities 323, Time of Duration of a Barkhausen Reversal 324, The Transverse Barkhausen Effect 325, Velocity of Propagation of Barkhausen Discontinuities 326.

*Chapter XI. Interpretation of the Hysteresis Cycle* *page 330*

Introduction 330, Factors affecting Direction of Domain Vectors 331, Domain Boundary Displacements 334, Examination of the Hysteresis Cycle 336, Adiabatic Temperature Changes accompanying Magnetisation in Moderate Fields 339, Experimental Studies 342, Outline of Results 344, Limitations of the Domain Concept 349.

Cambridge University Press

978-1-316-60186-0 - Modern Magnetism: Second Edition

L. F. Bates

Table of Contents

[More information](#)

## CONTENTS

*Chapter XII. Recent Work on Ferromagnetic Substances* *page 350*

Introduction 350, Bitter Magnets 350, The Properties of Permanent Magnets 351, The Economic Utilisation of Permanent Magnets 356, Magneto-resistance 361, Experiments on Single Crystals 365, The Torque Magnetometer 366, Rotational Hysteresis 367, Further Studies on the Approach to Saturation 370, Ferromagnetic Gadolinium 370, Néel's Work on Alloys 371, Sadron's Work on Alloys 371, Explanation of the Magnetic Properties of Alloys 372, Depression of the Curie Point 374, New Measurements with Alloys 375, Fluctuations of the Internal Field 375, Order and Disorder Phenomena 378, The Specific Heats of Ferromagnetic Metals and their Alloys 379, The Significance of  $\text{Ni}_3\text{Fe}$  380, The  $\Delta E$  Effect 381, The Earth's Magnetism 384.

*Chapter XIII. Recent Work on Weakly Magnetic Substances* *page 385*

Introduction 385, Feeble Paramagnetism, Antiferromagnetism and Metamagnetism 385, The Internal Field of Antiferromagnetic Substances 387, Cylindrical Pole-Pieces of Special Design 388, A New Electrodynamic Balance 389, The Magnetic Properties of Copper 389, The General Theory of Ferromagnetic Impurity 389, The Graphical Representation of the Curie Law 390, The Curie-Weiss Law 390, New Data for Rare Earth Ions 391, The Significance of Odd and Even Numbers of Electrons 391, Ions of the Iron Group 392, The Platinum and Palladium Groups 392, Metal Ions in Dilute Solution in a Solvent Metal 392, Standardising Solutions 393, The Properties of Dialogite 393, Data for Rare Earth Crystals 393, The Internal Fields of Copper Sulphate Crystals 394, Large Orbits in Graphite 396, The Effect of Impurities on Crystal Anisotropy 397.

*Chapter XIV. Radiofrequency Spectroscopy* *page 398*

The  $g$ -Factor of the Nucleus 398, The Formal Theory of Hyperfine Structure 399, Radiofrequency Spectroscopy 400, The Magnetic Moment of the Neutron 404, Resonance Absorption due to Nuclear Moments 406, Nuclear Induction 407.

*Chapter XV. Adiabatic Demagnetisation and its Applications* *page 408*

Theoretical Aspects 408, Thermal Insulation 409, Experiments with Solid Hydrogen 409, The Definition of  $T^*$  410, The Carbon Thermometer 411, The Measurement of absolute Temperature 412, The Lowest Attainable Temperature 415.

## CONTENTS

<i>Chapter XVI. Paramagnetic Absorption and Dis-</i> <i>persion</i>	<i>page 416</i>
Theory of the Phenomena 416, Hysteresis Phenomena 422, Nuclear Absorption Phenomena 422, Absorption in Ferromagnetic Substances 423.	
<i>Notes</i>	<i>page 424</i>
The Quadratic Zeeman Effect, The Jahn-Teller Rule 424, Uniform Fields in Solenoids, Demagnetisation Factors, Very Pure Iron, The Fluxmeter as a Null Instrument 425, Furnace Materials, Gyromagnetic Data for Alloys, <i>g</i> -Values for Paramagnetic Salts, Absorption of Microwaves by Oxygen 426.	
<i>Subject Index</i>	<i>page 427</i>
<i>Name Index</i>	<i>page 435</i>