CONTENTS

	Preface							
I.	Introduction							
	Advances in Cryogenic Technology							
	Industrial Application of Cryogenics							
	Cryogenics in Rocketry							
	Engineering Research and Development at Low Temperatures							
	Summary							
II.	Liquefaction of Gases							
	Ideal Gas Liquefaction Process							
	Liquefaction of Air							
	Critical Components of Liquefiers							
	Liquefaction of Hydrogen							
	Liquefaction of Helium							
III.	Separation of Gases							
	The Rectifying Column							
	Separation of Air							
	Separating Helium from Natural Gas							
	Separating Deuterium from Natural Hydrogen by Distilling							
	Liquid Hydrogen							
	Purification							
IV.								
_ , ,	Cooling by Adiabatic Demagnetization							
	Cooling by Adiabatic Demagnetization							
	Cooling by Adiabatic Demagnetization							
	Cooling by Adiabatic Demagnetization							
	Cooling by Adiabatic Demagnetization The Process of Adiabatic Demagnetization The Low Temperature Records A Magnetic Refrigerator Vapor Pressure of Helium at Very Low Temperatures							
V.	Cooling by Adiabatic Demagnetization The Process of Adiabatic Demagnetization The Low Temperature Records A Magnetic Refrigerator Vapor Pressure of Helium at Very Low Temperatures Low-Temperature Thermometry							
	Cooling by Adiabatic Demagnetization The Process of Adiabatic Demagnetization The Low Temperature Records A Magnetic Refrigerator Vapor Pressure of Helium at Very Low Temperatures Low-Temperature Thermometry Temperature Scales and Fixed Points							
	Cooling by Adiabatic Demagnetization The Process of Adiabatic Demagnetization The Low Temperature Records A Magnetic Refrigerator Vapor Pressure of Helium at Very Low Temperatures Low-Temperature Thermometry Temperature Scales and Fixed Points Gas Thermometry							
	Cooling by Adiabatic Demagnetization The Process of Adiabatic Demagnetization The Low Temperature Records A Magnetic Refrigerator Vapor Pressure of Helium at Very Low Temperatures Low-Temperature Thermometry Temperature Scales and Fixed Points Gas Thermometry Vapor-Pressure Thermometry							
	Cooling by Adiabatic Demagnetization The Process of Adiabatic Demagnetization The Low Temperature Records A Magnetic Refrigerator Vapor Pressure of Helium at Very Low Temperatures Low-Temperature Thermometry Temperature Scales and Fixed Points Gas Thermometry Vapor-Pressure Thermometry Thermoelectric Thermometry							
	Cooling by Adiabatic Demagnetization The Process of Adiabatic Demagnetization The Low Temperature Records A Magnetic Refrigerator Vapor Pressure of Helium at Very Low Temperatures Low-Temperature Thermometry Temperature Scales and Fixed Points Gas Thermometry Vapor-Pressure Thermometry Thermoelectric Thermometry Resistance Thermometry							
	Cooling by Adiabatic Demagnetization The Process of Adiabatic Demagnetization The Low Temperature Records A Magnetic Refrigerator Vapor Pressure of Helium at Very Low Temperatures Low-Temperature Thermometry Temperature Scales and Fixed Points Gas Thermometry Vapor-Pressure Thermometry Thermoelectric Thermometry Resistance Thermometry: Magnetic Thermometry: Determining Temperatures Produced							
	Cooling by Adiabatic Demagnetization The Process of Adiabatic Demagnetization The Low Temperature Records A Magnetic Refrigerator Vapor Pressure of Helium at Very Low Temperatures Low-Temperature Thermometry Temperature Scales and Fixed Points Gas Thermometry Vapor-Pressure Thermometry Thermoelectric Thermometry Resistance Thermometry							

x CONTENTS

VI.	Insulation						
	Vacuum Insulation						
	Gas-Filled Powders and Fibrous Materials						
	Solid Foams						
	Comparison of Insulations						
VII.	STORING AND TRANSPORTING LIQUEFIED GASES						
, 11.	Dependence of Rate of Evaporation upon Size and Shape of Vessel						
	Portable Commercial Containers for Liquid Oxygen and						
	Nitrogen						
	A Large Stationary Container for Liquid Oxygen						
	Liquid-Nitrogen-Shielded Dewars						
	A Helium-Refrigerated Transport Dewar						
	A Hydrogen-Refrigerated Dewar						
	A Large Powder-Insulated Transport Dewar for Liquid Hy-						
	drogen						
	Shipping Helium as Liquid Rather than High-Pressure Gas .						
	Using Refrigerative Value of Escaping Vapor to Reduce Storage						
	Loss						
	Stratification						
	Liquid Level Indicators						
VIII.	Transfer of Liquefied Gases						
	Two-Phase Flow						
	Cool-Down						
	The Case of Zero Delivery						
	Transfer Through Uninsulated Lines						
	Transfer Lines Insulated with Porous Materials						
	Vacuum-Insulated Transfer Lines						
	Valves for Cryogenic Liquids						
	Pumping Cryogenic Liquids						
	Long-Distance Transfer						
IX.	Properties of Cryogenic Fluids						
	Oxygen						
	Nitrogen						
	Air: Mixtures of Oxygen and Nitrogen						
	Hydrogen						
	Specific Heats						
	Helium						
X.	Low-Temperature Properties of Structural Materials						
Λ .	Mechanical Properties						
	Specific Heat						
	Thermal Expansion						
	Electrical Resistance						

CONTENTS				x i
Thermal Conductivity				343
Emissivity, Reflectivity and Absorptivity.				346
Thermoelectric EMF	,			350
Appendices: Tables of Conversion Factors				353
Subject Index				359
NAME INDEX				365