

CONTENTS

I. INTRODUCTION	
1.1. The role of electrical contacts	1
1.2. The nature of contact problems	3
1.2.1. Arc transfer	3
1.2.2. Fine transfer	5
1.2.3. Contact resistance	6
1.3. Scope of the treatment of the subject	7
1.3.1. Microscopic molten-metal bridges	7
1.3.2. Applications to metal physics	8
1.3.3. Erosion due to electrical discharges	8
1.3.4. Surface films	8
II. FUNDAMENTAL CONCEPTS	
2.1. Nature of contact	9
2.2. Constriction resistance	11
2.3. Effect of pressure on contact resistance	16
2.4. Contact temperature: the ψ , θ theorem	17
III. EARLY WORK ON CONTACT BRIDGES	
3.1. The microscopic bridge and fine transfer	27
3.2. Experimental data on bridges	29
3.2.1. Early work	29
3.2.2. Observations on bridge growth and stability	35
3.2.3. Bridge size	38
3.3. The bridge and fine transfer	42
3.3.1. The Thomson effect	42
3.3.2. Results of Betteridge and Laird	43
3.3.3. Results of Holm	44
3.3.4. Results of Paetow	46
3.3.5. Results of Dietrich and Heumann	47
3.4. Critique	51
3.4.1. Data on transfer	52
3.4.2. Effects of self-inductance	55
IV. THE MECHANISM OF FINE TRANSFER	
4.1. Mathematical theory of thermo-electric temperature asymmetry in a bridge	59
4.1.1. The generalized ψ , θ theorem	59
4.1.2. The maximum temperature in a contact bridge	62
4.2. Determinations of the Thomson coefficient	68
4.2.1. Change of sign	68
4.2.2. Lander's results	70

4.3. Other mechanisms	74
4.3.1. The thin film mechanism of Köhler	74
4.3.2. The charged droplet theory of Bühl	76
4.3.3. Transfer at make in the absence of electrical discharges	77
V. STABILITY AND SHAPES OF MOLTEN-METAL BRIDGES	
5.1. General considerations	80
5.2. A similarity theorem for electrical contacts	81
5.3. Shapes of molten-metal bridges	82
5.3.1. Surface tension effects	82
5.3.2. Determination of shape	87
5.3.3. Electrodynanic forces	89
5.3.4. Circuit instability	91
5.4. Visual study of stability and rupture of molten-metal bridges	93
5.4.1. Objects and procedure	93
5.4.2. Large iron bridges	95
5.4.3. Nickel	96
5.4.4. Copper	98
5.4.5. Platinum	99
5.4.6. Palladium	101
5.4.7. Gold	102
5.4.8. Silver	103
5.4.9. Conclusions	104
VI. PROPERTIES OF METALS AT HIGH TEMPERATURES	
6.1. Conductivity	106
6.2. Voltage, current, and maximum temperature in a conductor	107
6.2.1. Voltage	108
6.2.2. Current	109
6.2.3. The Thomson shift	110
6.2.4. Determination of λ , κ , and σ	111
6.2.5. Effect of radiation on the temperature distribution in a short wire	113
6.2.6. Measurement of temperature	115
6.3. Results for platinum	117
6.3.1. Experiments on platinum wires	117
6.3.2. The ratio of thermal to electrical conductivity up to the melting-point	119
6.3.3. The ratio of thermal to electrical conductivity above the melting-point	120
6.3.4. Rupture voltage of platinum	123
6.4. Thermo-electrical properties of metals at high temperatures	124
6.4.1. Procedure	124
6.4.2. Apparatus	125
6.4.3. Results for platinum	126
6.4.4. Results for palladium	129
6.4.5. Results for silver and gold	130
6.4.6. Results for copper	131
6.4.7. Conclusions	131

VII. EROSION AND TRANSFER

The Study of Contact Erosion by Optical Methods

7.1. Purpose and procedure	133
7.2. Erosion patterns of platinum	134
7.2.1. Simplest pattern at $L = 6 \times 10^{-8}$ H	134
7.2.2. Pattern for $L > 6 \times 10^{-8}$ H	136
7.2.3. Pattern for $L < 6 \times 10^{-8}$ H	137
7.3. Pattern of palladium	137
7.4. Patterns of silver and gold	138
7.5. Pattern of nickel	138
7.6. Pattern of copper	139
7.7. Pattern of molybdenum	139
7.8. Conclusions	140

The Study of Transfer using Radio-active Isotopes

7.9. Purpose and technique	142
7.10. Transfer in a platinum contact	144
7.11. Conclusions based on radio-tracer experiments	147

General Summary concerning the Bridge and the Mechanism of Fine Transfer

7.12. General conclusions	152
7.13. The mechanisms of transfer	153

VIII. DISCHARGE PHENOMENA AT CONTACTS

8.1. Physical processes in arcs	158
8.1.1. The role of electrodes	158
8.1.2. The electrode hot-spot	160
8.1.3. The energy balance and evaporation	161
8.1.4. Further aspects of electrode loss	163
8.2. The direction of matter transfer in arcs	165
8.2.1. The short arc	165
8.2.2. The longer arc	166
8.2.3. Matter transfer	168
8.3. Discharges at break	169
8.3.1. High-power circuits	169
8.3.2. Electrode materials	171
8.4. Oscillatory arc currents	172
8.4.1. Local oscillatory circuit	172
8.4.2. Oscillatory contact voltages	174
8.5. Self-quenching arcs	175
8.5.1. By electron attachment	175
8.5.2. By diffusion	176
8.5.3. By heat loss	177

8.6 Discharges at make	177
8.6.1. The problem	177
8.6.2. Phenomena at closure	179
8.7. Mechanism of initiation of discharges	182
8.7.1. Experimental investigation	182
8.7.2. Influence of surface states—inorganic films	183
8.7.3. The influence of the electric field	184
8.8. Influence of organic activation	186
8.9. Sealed contacts and controlled atmospheres	188
8.9.1. Sealed tubes	188
8.9.2. Surfaces of sealed contacts	188
8.9.3. Arcing in sealed contacts	190
IX. SURFACE FILM PHENOMENA	
9.1. Problems of light-duty contacts	193
9.2. Quasi-static contacts. Fairweather's experiments	194
9.2.1. Effects of corrosion on a closed metallic contact	194
9.2.2. Experimental results: closed contacts	196
9.2.3. Closure of a corroded contact	197
9.2.4. Experimental results: closure	198
9.3. Microphonic noise	200
9.4. Sliding contacts	202
9.4.1. General considerations	202
9.4.2. Noble metals	203
9.4.3. Base metals	204
9.4.4. Data for the two-motion switch	206
9.5. Carbon brushes	209
9.5.1. Abnormal wear	209
9.5.2. The mechanism of wear	210
BIBLIOGRAPHY	212
INDEX	215