

CONTENTS

1	GEN	ERAL INTRODUCTION	
	1.	History of the operational calculus	page 1
	2.	The operational calculus based on the Laplace transform	2
	3.	Survey of the subject-matter	5
п		FOURIER INTEGRAL AS BASIS OF THE OPERA-	
		FIONAL CALCULUS	7
	1.	The Fourier integral	9
	2.	A pair of integrals equivalent to the Fourier identity	y
	3.	Parallel displacement of the path of integration in the integral $(5b)$	11
	4.	Rotation of the path of integration in the integral (11b)	12
	5.	Strip of convergence of the Laplace integral	13
	6.	The language of the operational calculus	18
	7.	Operational calculus based on one-sided Laplace integrals	20
III	ELE	MENTARY OPERATIONAL IMAGES	
	1.	Introduction	22
	2.	Images of polynomials; the Γ -function	23
	3.	Images of simple exponential functions	26
	4.	Images of complicated exponential functions	27
	5.	Images of trigonometric functions	29
	6.	Images of logarithmic functions	3 0
	7.	Well-known integrals of the Laplace type	31
1 V	ELE	MENTARY RULES	
	1.	Introduction	3 3
	2.	The similarity rule	33
	3.	The shift rule	34
	4.	The attenuation rule	3 8
	5.	The composition product	3 9
	6.	Repeated composition product	43
	7.	The image of the product of two originals	47
	8.	The differentiation rule	4 8
	9.	The integration rule	51
	10.	Rules for multiplication by t^n	53
	11.	Rules for division by t, and related integrals	53
	12.	Rules for the treatment of correlation functions	55
v	THE	DELTA OR IMPULSE FUNCTION	
	1.	Introduction	5 6
	2.	The unit function	5 6
	3	The & function as derivative of the unit function	59



X

		CONTENTS	
	4.	History of the impulse function	page 62
	5.	The sifting integral as a Stieltjes integral	66
	6.	The image of the δ -function	68
	7.	Functions approximating the δ -function	70
	8.	Applications of the δ -function	74
	9.	Series of impulse functions	78
	10.	Derivatives of the δ -function	80
	11.	Note on the theory of distributions	84
VI	QUE	STIONS CONCERNING THE CONVERGENCE OF THE DEFINITION INTEGRAL	E
	1.	Introduction	85
	2.	Extensions of the definition integral	85
	3.	The operational treatment of some special series	87
	4.	The strip of convergence of operational relations	91
	5.	Particular cases of the strip of convergence	94
	6.	Absolute convergence	96
	7.	Uniform convergence	97
	8.	Summable series	100
	9.	Summable integrals	102
	10.	The behaviour of the definition integral on the boundaries of the strip of convergence	f 104
	11.	The inversion integral	106
	12.	Adjacent strips of convergence for the same image	109
	13.	Operational relations having a line of convergence	113
	14.	Symmetry between the integrals of definition and inversion	115
	15.	Uniqueness of the operational relations	117
VII		MPTOTIC RELATIONS AND OPERATIONAL TRANS POSITION OF SERIES	-
	1.	Introduction	121
	2.	Abel and Tauber theorems	122
	3.	Abel theorems	124
	4.	Real Tauber theorems	128
	5.	Complex Tauber theorems	130
	6.	Operational equalities	133
	7.	Asymptotic series	134
	8.	Operational transposition of power series in p^{-1} and in t	136
	9.	Transposition of series with ascending powers of p	139
	10.	Expansion in rational fractions (Heaviside's expansion theorem II)	1 142
	11.	Transposition of other series	147
	12.	A real inversion formula	148



		CONTENTS	хi
VIII	LINEAR DIFFERENTIAL EQUATIONS WITH CONSTANT COEFFICIENTS		
	ı.	Introduction pag	e 152
	2.	Inhomogeneous equations with the unit function at the right	152
	3.	Inhomogeneous equations with arbitrary right-hand member	155
	4.	Differential equations with boundary conditions	157
	5.	Admittances and impedances	161
	6.	Transient phenomena	167
	7.	Time impedances	170
	8.	Series for small values of t . Heaviside's first expansion theorem	171
	9.	Classification of admittances	173
IX	SIM	ULTANEOUS LINEAR DIFFERENTIAL EQUATIONS WITH CONSTANT COEFFICIENTS; ELECTRIC-CIRCUIT THEORY	
	1.	Introduction	175
	2.	Equations of electric-circuit theory	175
	3.	Transposition of the circuit equations; mutual impedances and admittances	1 7 7
	4.	Time admittances of electric circuits	180
	5.	Applications of the general circuit theory	182
	6.	Circuit equations with initial conditions	184
	7.	Ladder networks; filters	185
	8.	Lattice networks	194
x		EAR DIFFERENTIAL EQUATIONS WITH VARIABLE COEFFICIENTS	
	1.	Introduction	200
	2.	Laguerre polynomials	201
	3.	Hermite polynomials	204
	4.	Bessel functions (operational relations)	207
	5.	Bessel functions (applications)	214
	6.	Legendre functions (operational relations)	220
	7.	Legendre functions (applications)	224
	8.	Hypergeometric functions	2 25
XI		RATIONAL RULES OF MORE COMPLICATED CHARACTER	
	1.	Introduction	232
	2.	Rules obtained when p is replaced by a function of p	232
	3.	Rules obtained when t is replaced by a function of t	237
	4.	The exponential transformation: $t \rightarrow e^t$	23 8
	5.	Exponential operational relations for power series, in particular hypergeometric series	243
	6.	Rules concerning series expansions	249



xii		CONTENTS	
	7.	Equalities in connexion with a single operational relation page	253
	8.	Equalities in connexion with a pair of simultaneous relations (exchange identity)	254
XII	STE	P FUNCTIONS AND OTHER DISCONTINUOUS FUNCTIONS	
	1.	Introduction	257
	2.	Operational relations involving step functions jumping at integral values of t	258
	3.	The saw-tooth function	260
	4.	Arithmetic functions in connexion with θ -functions	263
	5.	Arithmetic functions in connexion with Dirichlet series	266
	6.	Step functions of argument equal to the summation variable in a series	272
	7.	Contragrade series	274
хш	DIF	FERENCE EQUATIONS	
	1.	Introduction	277
	2.	Difference equation for the 'sum'	278
	3.	General linear difference equations with constant coefficients	281
	4.	Linear difference equations with variable coefficients	285
	5.	Connexion between differential and difference equations	287
	6.	Operational construction of difference equations	289
xıv	INT	EGRAL EQUATIONS	
	1.	Introduction	2 92
	2.	The integral equation for the moving average	293
	3.	Integral equations of the first kind with difference kernel	30 0
	4.	Integral equations of the first kind with kernel reducible to a difference kernel	3 05
	5.	Integral equations of the second kind with a difference kernel	307
	6.	Homogeneous integral equations	3 10
	7.	The operational construction of integral equations	312
	8.	Note on the operational interpretation of the Wiener-Hopf technique	313
xv		TIAL DIFFERENTIAL EQUATIONS IN THE OPERA- TIONAL CALCULUS OF ONE VARIABLE	
	1.	Introduction	314
	2.	Homogeneous linear partial differential equations (general solutions)	317
	3.	Homogeneous partial differential equations with boundary conditions	322
	4.	Quasi-stationary theory of electric cables	325
	5.	Inhomogeneous partial differential equations	330



		CONTENTS	xiii	
xvi	SIMULTANEOUS OPERATIONAL CALCULUS			
	1.	Introduction pag	ie 334	
	2.	General theory	334	
	3.	Second-order differential equations of the hyperbolic type with constant coefficients and two variables	344	
	4.	Hyperbolic differential equations of the second order in more than two independent variables	352	
	5.	Elliptic differential equations	355	
	6.	Simultaneous partial differential equations	361	
	7.	Partial difference equations	3 65	
хvп	GRAMMAR'		373	
хvш	'DICTIONARY'			
	LIST	OF AUTHORS QUOTED	411	
	GEN	ERAL INDEX	413	