

**GRAPHICAL STATICS, TWO  
TREATISES ON THE GRAPHICAL  
CALCULUS, AND RECIPROCAL  
FIGURES IN GRAPHICAL STATICS**

Published @ 2017 Trieste Publishing Pty Ltd

ISBN 9780649097982

Graphical statics, two treatises on the graphical calculus, and reciprocal figures in graphical statics by Luigi Cremona

Except for use in any review, the reproduction or utilisation of this work in whole or in part in any form by any electronic, mechanical or other means, now known or hereafter invented, including xerography, photocopying and recording, or in any information storage or retrieval system, is forbidden without the permission of the publisher, Trieste Publishing Pty Ltd, PO Box 1576 Collingwood, Victoria 3066 Australia.

All rights reserved.

Edited by Trieste Publishing Pty Ltd.  
Cover @ 2017

This book is sold subject to the condition that it shall not, by way of trade or otherwise, be lent, re-sold, hired out, or otherwise circulated without the publisher's prior consent in any form or binding or cover other than that in which it is published and without a similar condition including this condition being imposed on the subsequent purchaser.

[www.triestepublishing.com](http://www.triestepublishing.com)

**LUIGI CREMONA**

**GRAPHICAL STATICS, TWO  
TREATISES ON THE GRAPHICAL  
CALCULUS, AND RECIPROCAL  
FIGURES IN GRAPHICAL STATICS**



CREMONA'S  
TWO TREATISES ON GRAPHICAL STATICS

*HUDSON BEARE*

London  
HENRY FROWDE



OXFORD UNIVERSITY PRESS WAREHOUSE  
AMEN CORNER, E.C.

# GRAPHICAL STATICS

TWO TREATISES

ON THE

GRAPHICAL CALCULUS

AND

RECIPROCAL FIGURES IN GRAPHICAL STATICS

BY

LUIGI CREMONA

LL.D. EDIN., FOR. MEMB. R.S. LOND., HON. F.R.S. EDIN.

HON. MEMB. CAMB. PHIL. SOC.

PROFESSOR OF MATHEMATICS IN THE UNIVERSITY OF ROME

TRANSLATED BY

THOMAS HUDSON BEARE

B.SC. LOND., ASSOC. M. INST. C.E., F.R.S. EDIN.

PROFESSOR OF ENGINEERING AND APPLIED MECHANICS, HERIOT-WATT COLLEGE, EDINBURGH

Oxford

AT THE CLARENDON PRESS

1890

[All rights reserved]

## TRANSLATOR'S PREFACE.

---

FOR some years I had used a rough English manuscript summary of Professor CREMONA'S works on the *Graphical Calculus* and *Reciprocal Figures*, while reading with engineering students of University College, London. As English versions were much wanted, I was advised by Professors PEARSON and KENNEDY to ask the consent of Professor CREMONA to my undertaking their translation, and at the same time they supported my application to the Delegates of the Clarendon Press that they should become the publishers. To both applications a most cordial consent was given; and I take the opportunity of thanking both the Author and the Delegates for the trust they have reposed in me. The translations have been revised by Professor CREMONA and certain portions (in particular Chap. I. of *Reciprocal Figures*) have been entirely written by him for the present English edition. I regret that a long delay has occurred in the appearance of this book, due chiefly to pressure of work both on the part of myself and Professor CREMONA.

I feel sure that the translation will supply a long-felt want, and be found extremely useful by students of engineering and the allied sciences, especially by those whose work compels them to pay attention to graphical methods of solving problems connected with bridges, roofs, and structures presenting similar conditions.

THE TRANSLATOR.

HERIOT-WATT COLLEGE, EDINBURGH.



# CONTENTS.



TRANSLATOR'S PREFACE .. .. .	Page v
------------------------------	-----------

## ELEMENTS OF THE GRAPHICAL CALCULUS.

AUTHOR'S PREFACE TO THE ENGLISH EDITION .. .. .	xv
---	----

### CHAPTER I.

#### THE USE OF SIGNS IN GEOMETRY.

Art.		
	1. Rectilinear segments, negative and positive sense .. ..	1
	2. Relation between the segments determined by 3 collinear points .. .. .	2
	3. Distance between 2 points .. .. .	3
	4. Relation between the segments determined by $n$ collinear points .. .. .	3
	5. Positive and negative direction of a straight line .. ..	3
	6. Relation between the segments determined by 4 points on a straight line .. .. .	4
	7. Relation between the distances of any point from three concurrent straight lines in its plane .. .. .	4
	8-9. Angles, negative and positive sense .. .. .	6
	10. Relation between the angles formed by 3 straight lines in a plane .. .. .	7
	11. Expression for the angle between two straight lines .. ..	8
	12. Areas, negative and positive sense .. .. .	8
	13-14. Relation between the triangles determined by 4 points in a plane .. .. .	9
	15. Relation between 5 points in a plane, 4 of which form a parallelogram .. .. .	10
	16. Relation between the distances of a point and 3 non-concurrent straight lines in its plane .. .. .	10

Art.	Page
17. Circuits, simple and self-cutting, Modes .. .. .	12
18-23. Areas of self-cutting circuits .. .. .	12
24. Reduction of self-cutting to simple circuits .. .. .	18
25. Relation between two polygons with equipollent sides .. ..	20
26-30. Areal relation of a pole and system of segments equipollent to a closed or open circuit .. .. .	21

## CHAPTER II.

## GRAPHICAL ADDITION.

31-33. Geometrical sum of a series of segments given in magnitude and sense .. .. .	24
34. The sum of segments independent of their order of construction	26
35-38. Cases where the sum is zero .. .. .	27
39. Geometrical subtraction .. .. .	28
40-42. Projection of segments and circuits .. .. .	28
43-45. Theorems for 2 systems of points, when the resultants of the segments joining each system to the same pole are equal .. .. .	29
46-48. Extension of the word sum to include absolute position	31
49-52. Constructions for completely determining the sum ..	32
53. Case of parallel segments .. .. .	35
54. Case of 2 parallel segments .. .. .	35

## CHAPTER III.

## GRAPHICAL MULTIPLICATION.

55-56. Multiplication of a straight line by a ratio .. .. .	37
57. Division of a straight line into equal parts .. .. .	38
58. Division of angles into equal parts. Spiral of Archimedes	39
59-62. Multiplication of a number of segments of a straight line by a constant ratio. Similar point rows .. .. .	39
63-64. Multiplication of a system of segments by a system of ratios .. .. .	42
65-67. Case where these segments are parallel, and other cases	45
68-69. Multiplication of a segment by a given series of ratios ..	49
70-72. Other constructions for same problem .. .. .	51

## CHAPTER IV.

## POWERS.

Art.	Page
73. Multiplication of a segment by the $n^{\text{th}}$ power of a given ratio	54
74-75. Other constructions for same problem .. .. .	55

## CHAPTER V.

## EXTRACTION OF ROOTS.

76-77. Equiangular Spiral .. .. .	59
78-82. Properties and construction of the spiral .. .. .	60
83-84. Application of it to the extraction of roots .. .. .	63
85. Extraction of square roots .. .. .	64
86. The Logarithmic Curve and its properties .. .. .	64
87. Construction of the Curve .. .. .	66
88. Construction of tangents to the curve .. .. .	67
89. Applications of the curve .. .. .	68

## CHAPTER VI.

## SOLUTION OF NUMERICAL EQUATIONS.

90-91. Lill's construction of a complete polynomial .. .. .	70
92-93. Reduction of the degree of an equation .. .. .	73
94. Equations of the second degree .. .. .	75

## CHAPTER VII.

## REDUCTION OF PLANE FIGURES.

95-96. Reduction of a triangle to a given base .. .. .	77
97-100. Reduction of a quadrilateral .. .. .	78
101-103. Reduction of polygons .. .. .	80
104-105. Reduction of sectors, and segments of a circle .. .. .	82
106-107. Examples, figures bounded by circular arcs and rectilinear segments .. .. .	83
108-110. Reduction of curvilinear figures in general .. .. .	86
111. Application of the reduction of areas to find the resultant of a number of segments .. .. .	87