Preface

The subject of contact mechanics may be said to have started in 1882 with the publication by Heinrich Hertz of his classic paper *On the contact of elastic solids*. At that time Hertz was only 24, and was working as a research assistant to Helmholtz in the University of Berlin. His interest in the problem was aroused by experiments on optical interference between glass lenses. The question arose whether elastic deformation of the lenses under the action of the force holding them in contact could have a significant influence on the pattern of interference fringes. It is easy to imagine how the hypothesis of an elliptical area of contact could have been prompted by observations of interference fringes such as those shown in Fig. 4.1 (p. 86). His knowledge of electrostatic potential theory then enabled him to show, by analogy, that an ellipsoidal - Hertzian - distribution of contact pressure would produce elastic displacements in the two bodies which were compatible with the proposed elliptical area of contact.

Hertz presented his theory to the Berlin Physical Society in January 1881 when members of the audience were quick to perceive its technological importance and persuaded him to publish a second paper in a technical journal. However, developments in the theory did not appear in the literature until the beginning of this century, stimulated by engineering developments on the railways, in marine reduction gears and in the rolling contact bearing industry.

The Hertz theory is restricted to frictionless surfaces and perfectly elastic solids. Progress in contact mechanics in the second half of this century has been associated largely with the removal of these restrictions. A proper treatment of friction at the interface of bodies in contact has enabled the elastic theory to be extended to both slipping and rolling contact in a realistic way. At the same time development of the theories of plasticity and linear viscoelasticity have enabled the stresses and deformations at the contact of inelastic bodies to be examined.

Somewhat surprisingly, in view of the technological importance of the subject, books on contact mechanics have been few. In 1953 the book by L.A.Galin, *Contact Problems in the Theory of Elasticity*, appeared in Russian summarising the pioneering work of Muskhelishvili in elastic contact mechanics. An up-to-date and thorough treatment of the same field by Gladwell, *Contact Problems in the Classical Theory of Elasticity*, was published in 1980. These books exclude rolling contacts and are restricted to perfectly elastic solids. Analyses of the contact of inelastic solids are scattered through the technical journals or are given brief treatment in the books on the Theory of Plasticity. The aim of the present book, however, is to provide an introduction to most aspects of the mechanics of contact between non-conforming surfaces. Bodies whose surfaces are non-conforming touch first at a point or along a line and, even under load, the dimensions of the contact patch are generally small compared with the dimensions of the bodies themselves. In these circumstances the contact stresses comprise a local 'stress concentration' which can be considered independently of the stresses in the bulk of the two bodies. This fact was clearly appreciated by Hertz who wrote: 'We can confine our attention to that part of each body which is very close to the point of contact, since here the stresses are extremely great compared with those occurring elsewhere, and consequently depend only to the smallest extent on the forces applied to other parts of the bodies.' On the other hand, bodies whose surfaces conform to each other are likely to make contact over an area whose size is comparable with the significant dimensions of the two bodies. The contact stresses then become part of the general stress distribution throughout the bodies and cannot be separated from it. We shall not be concerned with conformal contact problems of this sort.

This book is written by an engineer primarily for the use of professional engineers. Where possible the mathematical treatment is tailored to the level of a first Degree in Engineering. The approach which has been followed is to build up stress distributions by the simple superposition of basic 'point force' solutions - the Green's function method. Complex potentials and integral transform methods, which have played an important role in the modern development of elastic contact stress theory, are only mentioned in passing. In this respect the more mathematically sophisticated reader will find Gladwell's book a valuable complement to Chapters 2-5.

This is a user's book rather than a course text-book. The material is grouped according to application: stationary contacts, sliding, rolling and impact, rather than the usual academic division into elastic, plastic and viscoelastic problems. The stresses and deformations in an elastic half-space under the action of surface tractions, which provide the theoretical basis for the solutions of elastic contact problems, have been treated in Chapters 2 and 3. Results derived there are used

throughout the book. These chapters may be regarded as appendices which are not necessary for a qualitative understanding of the later chapters.

In my own study of contact mechanics, which has led to this book, I owe a particular debt of gratitude to R.D. Mindlin, whose pioneering work on the influence of tangential forces on elastic contacts stimulated my early interest in the subject, and to D. Tabor whose revealing experiments and physical insight into surface interactions gave rise to many challenging contact problems.

Several chapters of the book have been read and improved by colleagues whose knowledge and experience in those areas greatly exceeds my own: Dr J.R. Barber, Prof. J. Duffy, Prof. G.M. Gladwell, Dr J.A. Greenwood, Prof. J.J. Kalker, Prof. S.R. Reid, Dr W.J. Stronge and Dr T.R. Thomas. The complete manuscript was read by Dr S.L. Grassie who made many valuable suggestions for improvements in presentation. Responsibility for errors, however, is mine alone and I should be very grateful if readers would inform me of any errors which they detect.

The diagrams were carefully drawn by Mr A. Bailey and the manuscript was most efficiently typed by Mrs Rosalie Orriss and Mrs Sarah Cook. Finally my wife assisted in innumerable ways; without her patience and encouragement the book would never have reached completion.

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