books

A no-nonsense approach to holography

Optical Holography

R. J. Collier, C. B. Burckhardt, L. H. Lin.

605 pp. Academic, New York, 1971. $22.00

Reviewed by E. N. Leith

Since the newly-awakened interest in holography began in 1963, nearly a dozen books on holography have appeared or have been prepared. This book, the newest, has much to recommend it. It is by far the largest and most complete; in general, it covers the subject more broadly and in greater depth than any other. Moreover, it is well written and highly readable.

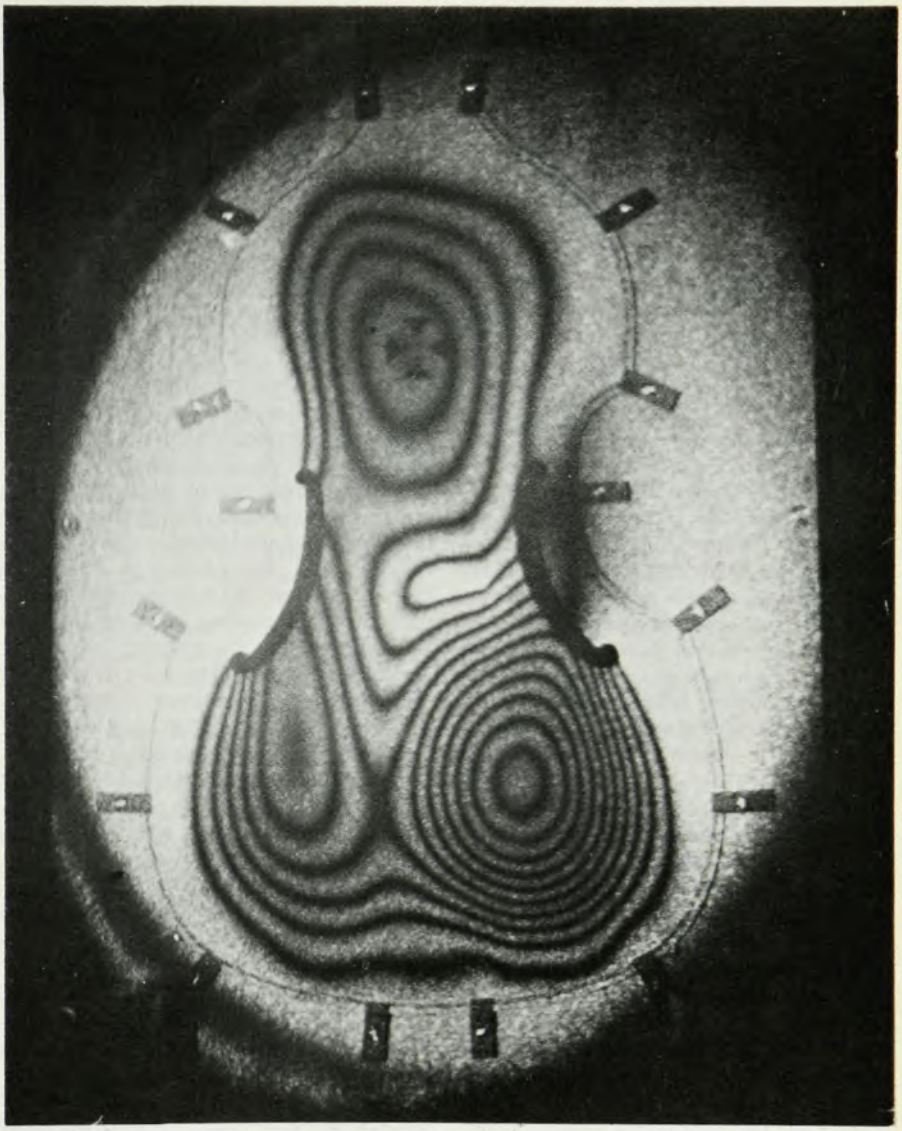
The authors, members of a Bell Laboratories research team that began exploring holography as early as 1963, are eminently qualified to write such a comprehensive book. The papers of Robert J. Collier and his colleagues at Bell have been many and always among the best. The Bell Labs holographers excelled in theory, experiment and creativity.

The present volume can be read profitably by those who are well grounded in holography, as well as those having a background in physical science who desire to study holography seriously.

For those whose background in holography, or indeed, physical optics, is weak, introductory chapters are provided on basic physical geometrical optics and on the Fourier transform method for linear system analysis. Other, more specialized instances of basic theory are introduced, as needed, in connection with the topics under discussion. Among them are the concept of the coherent and incoherent transfer functions, elements of the theory of partial coherence, and the Fourier-transforming properties of lenses. Consequently, the book is self-contained even though it is far from elementary. Topics peripheral but important to holography, such as light sources and recording materials, are also treated at some length.

The exposition of holography proceeds as follows: Chapters 1 through 3 introduce basic concepts, the historical development, and the basic analysis of simple holograms. These are easily read. Chapters 4 through 7 introduce the physical concepts and analytical techniques of holography that prepare the reader for the later chapters. Chapter 8 gives a rather extensive treatment of the theory of plane holograms and is probably the one chapter most central to present-day holography.

Following this is a treatment of volume holograms. This is one of the



A treble-viol top plate vibrating at 503 Hz. This holographic reconstruction was made by Carl-Hugo Ågren and Karl A. Stetson in the course of their work on the application of the techniques of vibration analysis by hologram interferometry to the study of stringed-instrument response. Shown is an oversize viol designed by the researchers.

most abstruse areas in holography and, even today, much important theory remains to be developed. There are three basic levels of analysis: a very simple, semi-quantitative approach in terms of constructive interference from partially reflecting surfaces; an intermediate level, sometimes called the "weak theory" of diffraction, which is an obvious extension to three dimensions of the basic Kirchhoff diffraction integral; and a rather rigorous treatment that includes interactions between incident and diffracted beams as they travel together through the hologram. Only this latter theory predicts the relative intensity of the various diffracted orders. After an introduction using the first approach, the authors, in a surge of extraordinary ambition, launch into a theory of the third type —the coupled-wave theory. The reader will find this chapter difficult compared to the rest of the book, yet the additional effort required here is quite rewarding.

An extensive discussion of the materials used for recording holograms is given. This includes photographic film—the most common one—as well as some of the new materials such as thermoplastics and ferroelectric crystals. Also included are important experimental procedures.

The second half of the book deals with more specialized topics and applications. The two most important applications, at present, appear to be hologram interferometry and information storage; these appropriately receive the most extensive treatment.

This book covers holography across the board; no major areas seem to be slighted as some authors tend to do through over-emphasis of their own work. Is this balance the result of a conscious effort or is it a natural consequence of a broad range of experience by the authors and their colleagues? Most likely the latter, since the Bell Laboratories activity reached into most of the major aspects of optical holography.

Technical and historical accuracy, often a problem when the subject is new and the growth explosive, leaves little to be desired in the present volume. Certainly much nonsense has crept into the holographic literature, sometimes as a result of sloppy scholarship, sometimes as a consequence of over-zealous promotion. The careful scholarship and the broad, thorough grasp of the subject exhibited by these authors is, therefore, most gratifying.

Not that I consider the book to be perfect; for example, the chapter on computer-generated holograms fails to note or reference the paper of Adam Kozma and David Kelly, who first introduced them and have, by at least a year, the earliest published paper on this topic. These and other criticisms one might invoke are, however, quite minor; no text on holography can boast better accuracy and some fall decidedly short of the standard given here.

Other treatments of this popular subject will presumably make their appearance, but I doubt that they will excel the present volume.

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The Royal Institution Library of Science: Physical Sciences.

W. L. Bragg, G. Porter, Eds.

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In these ten volumes there are reprinted the "Friday Evening Discourses in Physical Sciences" held at the Royal Institution from 1851 to 1939. Such discourses are given on each Friday between October and June, the speaker being an acknowledged expert or authority, and his obligation being to present an authoritative general review of some topic—often part of his own on-going research—without assuming specialized knowledge on the part of his audience. The present series begins with 1851, because only then did the practice begin of publishing abstracts or accounts of these discourses. The terminal date was chosen arbitrarily, for the discourses continue to the present day.

The series opens with Michael Faraday on "The magnetic characters and relations of oxygen and nitrogen" (24 January 1851), and closes with John D. Cockcroft on "New phenomenon in liquid helium." The presentations vary greatly in length; generally they get longer in the more recent years. A paper by the astronomer-philosopher Herbert Dingle (vol. 10; 26 November 1937) is 31 pages long, Lord Kelvin's "Nineteenth century clouds over the dynamical theory of light and heat" (vol. 5; 27 April 1900) fills 35 pages, whereas W. J. M. Rankine's report of his lecture (vol. 2; 26 May 1871) is so brief that it barely exceeds a single printed page.

Because many lecturers present the recent advances in a given field, these volumes provide an admirable panorama of the glorious days of classical physical science, enlivened by insights into great discoveries. A change occurs in volume 5, because there are disturbing new developments that begin to shatter the traditional physics; this volume contains two discourses by J. J. Thomson, one on "Cathode rays," the other on "The existence of bodies smaller than atoms." In the same volume, Henri Becquerel tells about "*La Radioactivité de la matière.*"

In 1851, when this series of lectures begins, the chief subjects of interest prove to have been the theories and phenomena of magnetism and of color, aspects of organic chemistry, molecular physics, and electric discharges. At the mid-point of the series, classical physics is seen to falter—the reader can almost relive the reaction of the audience on hearing J. J. Thomson's first announcement (at the Royal Institution, in his discourse on "Cathode Rays" in 1897) that he had identified the electron as a body that must be a constituent of all atoms. In his *Recollections and Reflections* (G. Bell, London, 1936, page 341), Thomson recalled how, at first, "there were very few who believed in the existence of these bodies smaller than atoms." He was told "long afterwards by a distinguished physicist who had been present at my lecture at the Royal Institution that he thought I had been 'pulling their legs'." In the lecture, Thomson referred to William Prout (who "believed that the atoms of all the elements were built up of atoms of hydrogen") and Norman Lockyer (who "had advanced weighty arguments, founded on spectroscopic consideration, in favour of the composite nature of the elements").

The exciting parade of the "New Physics" largely dominates these discourses from 1897 onwards. There are more presentations by Thomson, followed by descriptions of radioactivity by Henri Becquerel and Pierre Curie, and a whole series of discourses by Ernest Rutherford. Turning the pages of these volumes, the reader encounters C. T. R. Wilson on the cloud chamber, Frederick Soddy on isotopes, Charles Barkla on x-rays, Pieter Zeeman on magneto-optics, William Bragg on x-rays and crystals, and James Jeans on quantum theory and the new mechanics. Since these ten volumes deal with "physical sciences" (others will be devoted to astronomy, to the earth sciences, to the biological sciences, and to other aspects of applied and social science), there are also discourses on chemistry, including one by Dmitri Mendeleev, and an especially interesting account by Klaus Hofmann of the syntheses of mauve and magenta.