

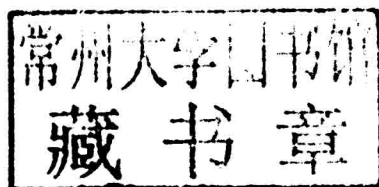
OCEAN WAVES
AND
KINDRED GEOPHYSICAL PHENOMENA

by
VAUGHAN CORNISH, D.Sc.

With photographs by the Author

AND
ADDITIONAL NOTES

by
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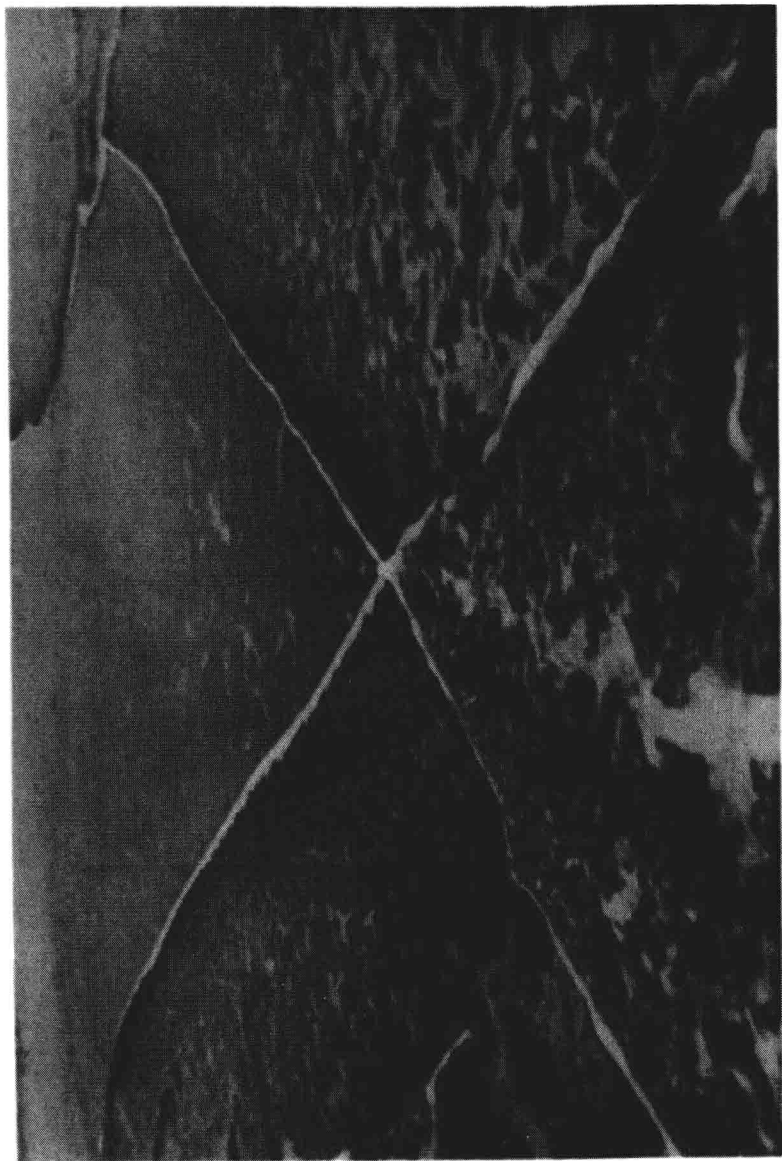
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OCEAN WAVES
AND
KINDRED GEOPHYSICAL PHENOMENA



1. CROSSING WAVES IN SHALLOW WATER
(Branksome Chine near Bournemouth)

To
HERBERT JOHN FLEURE
D.Sc.

IN TOKEN OF
REGARD AND ESTEEM
I DEDICATE THIS
BOOK

PREFACE

This narrative of nature study contains an account of the author's original contributions to the knowledge of the waves which are raised by wind upon the ocean, of the kindred forms which wind and currents raise and propel in sand and snow, and of tidal bores and other progressive waves in rivers which travel under the action of gravity alone.

The research originated under the following circumstances. In the early 'nineties, after searching the South Coast for a place of residence, I found a beautiful, and at that time secluded, spot on the cliffs near Branksome Chine, between Bournemouth and Poole Harbour, and living here within a stone's throw of the shore, I was mastered by the fascination of the waves that broke in ever-changing cadence on the beach. Near by, moreover, a little stream making its way through the beach threw the sandy bottom into curious undulations which actually travelled up-stream against the current by which they were formed; and a mile or two away on the dunes near Poole Harbour the wind drove the dry sand in wave processions.

My time was my own, and I decided to investigate these various wave phenomena. In the course of a few years, however, I was confronted with a disagreeable alternative, for I had either to leave the research incomplete or give up my beautiful home and travel widely

in search of waves. I decided on the latter course, and the present volume gives a summary of the results of my observations both in England and abroad. I have never again had a house with such a view as that from my former home on the cliff, but I have compensations in the memory of many wonderful sights in storms at sea; of snow-waves moving in ghostly procession across the Canadian prairie; of sand-waves, rank behind rank, driven by the desert wind; of the onset of the tidal bore in the Severn and the Trent, and of Leaping Waves in the Rapids of Niagara.

In one respect only was my work, for a time, disappointing. Part of my purpose was to provide the mathematician with numerical data for the further development of the theory of water-waves, and to enlist his interest in the progressive undulations of granular material. But there are fashions in mathematics as in all human pursuits, and I had to wait no less than thirty years before a younger generation of mathematicians, more interested in "turbulence" than their classical Victorian predecessors, began to develop the material which I had collected. Foremost among these was my friend Dr Harold Jeffreys, whose "Additional Notes" at the end of this volume generalise and extend the results of my observations and measurements.

VAUGHAN CORNISH

Inglewood, Camberley, Surrey
14 November 1933

BIBLIOGRAPHY

Selected list of original contributions by the Author upon Waves and kindred phenomena.

1. "On the Formation of Sand-Dunes", *Geogr. Journ.* March 1897.
2. "On Desert Sand-Dunes Bordering the Nile Delta", *Geogr. Journ.* Jan. 1900.
3. "On Sand Waves in Tidal Currents", *Geogr. Journ.* Aug. 1901.
4. "On Snow-Waves and Snow Drifts in Canada", *Geogr. Journ.* Aug. 1902.
5. "Progressive Waves in Rivers", *Geogr. Journ.* Jan. 1907.
6. "The Jamaica Earthquake (1907)", *Geogr. Journ.* March 1908.
7. "On the Cause of the Jamaica Earthquake", *Geogr. Journ.* Sept. 1912.
8. "Ocean Waves, Sea Beaches and Sandbanks", *Journ. Roy. Soc. Arts*, Nov. 1st and 8th, 1912.
9. "Observations of Wind, Wave and Swell on the North Atlantic Ocean", *Q.J. Roy. Met. Soc.* April 1926.
10. "Waves in Granular Material Formed and Propelled by Winds and Currents", *Monthly Notices of R.A.S., Geophysical Supplement*, July 1927.
11. *Waves of the Sea and other Water Waves*. Pub. T. Fisher Unwin (London, 1910), 8vo, 374 pp., with 50 photographs taken by the Author.
12. *Waves of Sand and Snow and the eddies which make them*. Pub. T. Fisher Unwin (London, 1914), 8vo, 383 pp., with 88 photographs taken by the Author, 30 diagrams and 2 maps.

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