Nature に紹介された寺田寅彦の論文(1)

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寅彦先生のお弟子の中谷宇吉郎は，先生の研究業績にふれ，「英国の科学雑誌ネーチュア誌（*Nature*）に，世界の目ぼしい研究を毎回少数づゝ拾って紹介してゐる中に，先生の研究がわが国からは一番多く紹介されてゐたやうである」－ と述べている.

＃中谷：「文化史上の寺田寅彦先生」.『冬の華』. 岩波書店. 1938. p. 271～278.

実際にあたってみると，他の日本人研究者の名前も散見するが，寺田は 22 件もあり傑出している. 中谷の云うとおりだ. では，寺田のどういう論文が取り上げられ紹介されたか，調査結果を，*Nature* の発行年月順に，以下の要領で記す.

A：*Nature* 誌上における寺田論文紹介記事の書誌データ（タイトル. 巻号. 発行年月日. ページ).

B：紹介された寺田の論文の書誌データ（著者［共著者］. タイトル. 誌名. 巻号. 発行年月. ページ). ［論文 no. ］(『寺田寅彦全集 科学篇』［*Scientific Papers*］収録論文に付与されている番号).

C：*Nature* 誌の紹介記事からの一部引用（原文のまま).

D：参考情報（当該論文の解説，評価など／適切な文献が見当たらない場合は空欄のまま).

■1. 錯視.

A. ［Optical Illusion］. *Nature*. Vol. 70, No. 1805. 1904. 6. 2. p. 107.

B. T. Terada：［Optical Illusion］. 出版された論文の紹介ではなく，編集者あての Letter の紹介である.

C. 「Mr. T. Terada writes to us from the College of Science, Tokyo, to direct attention to an optical illusion observed when lycopodium powder strewn on the surface of water is made to gyrate by a jet of air. After the whirling powder has been fixedly regarded for some time, and the eyes are directed to an adjoining table, the surface of the table appears to move in a direction contrary to that of the lycopodium」.

D−1. 生理光学的現象を見いだした寺田の，*Nature* 編集者あての報告が〈Notes〉欄に紹介される. 寺田門下の田幸彦太郎の解説を引く.「石松子の粉を水面に散布しこれに空気の jet を斜めに吹き付けてやると，粉は表面の水と共に流れて美しい縞模様を画く. 瞳を粉から急にそのテーブルの上に落すと，こんどはテーブルの面が粉とは反対の向に走るやうにみえる」(田幸：「生理光学的現象」.『思想』. 166 号. 1936. 3. p. 116～120).

D−2. 大山 正は，寺田の錯視研究の現代的評価を試みている.「初期の研究では，水面の縞の動きを観察しつづけた後，目をほかの方向に向けると，止っているはずの面に，水面の動きと逆方向の動きが生じることをとり上げているが，これは運動残像とか滝の錯覚と呼ばれ，19 世紀中葉から生理学者や心理学者の間では知られた現象であり，今日では大脳視覚野の運動検出機構の順応で説明されている. また，回転する扇風機の金属の羽根の背後に色づいた斑点が見えることも報告している［論文 no. 23］. これは，フェヒナー

以来知られている主観色の一種と想像されるが，回転速度などの条件が不明で，正確な論評はできない．いずれにせよ，読んだり聞いた知識でなく，つねに自分自身の目で発見したことに敬意を表したい」（大山：「視覚研究と物理学者」．『科学』．66 巻 10 号. 1996. 10. p. 756～758）．

■2. 潮汐の副振動.

A. The Secondary Oscillation of Ocean Tides. *Nature*. Vol. 78, No. 2020. 1908. 7. 16. p. 249～250.

B. K. Honda, T. Terada, Y. Yoshida and D. Isitani：An Investigation on the Secondary Oscillation of Oceanic Tides. *Journal of the College of Science, Tokyo Imperial University*, Vol. 24. 1908. 3. p. i～viii, 1～110.［論文 no. 36］.

———. *Publications of the Earthquakes Investigation Committee in Foreign Languages*, Vol. 26B, 1908.［論文 no. 37］.

C.「… From this it appeared that the whole mass of water in the bay was in simultaneous oscillation in a stationary wave, analogous to the sound−wave in an open organ pipe, and that the bay selected from the multitudinous ocean waves of various period the particular one to which it was able to respond, and, like a resonator with sound−waves, magnified and made it conspicuous. This conclusion was verified by experimental investigation. … 」.

D−1. この論文の価値の高さは，*Nature* 誌上において，図入りで 2 ページもの誌面をさき，紹介するという 破格の扱い方によく現われている（**本稿末に縮小して転載**）．寺田門下の宇田道隆は，「Krümmel などの外国の海洋学書に〈日本人の成しとげた優秀な研究〉と賞賛，広く引用された」と記した（宇田：『海洋研究発達史』〈海洋科学基礎講座・補巻〉．東海大学出版会． 1978. p. 299～305）．

D−2. 宇田の指摘［**D−1**］をうけて大森一彦は，Krümmel の本を探してみた．

Otto Krümmel：*Handbuch der Ozeanographie*［海洋学ハンドブック］. Stuttgart, J. Engelhorns Nachf. 1911. xvi ＋766p. ＃東北大学附属図書館北青葉山分館所蔵.

という浩瀚な本である．〈§ I−Ⅷ. Stehende Wellen〉［定常波］の章の， p. 161～162 と, p. 184～185 の 2 か所に，この論文が引用され，図入りで，詳しく解説されているのを見いだした．

D−3. 椎貝博美は，「この論文は，まことにすごい論文で，1908 年に港湾振動に関するほとんどのことをやってしまっていた．… 本多，寺田らは，理論計算のみならず，港の模型を作り，そこに任意の波を振子の組合わせによって発生させて，理論の検証を行っています．… そして，任意の形状の湾に対して，共振周期を求める式を導いて，理論と実験との検証を行っています」と述べた（椎貝：「番外日本土木史 (2) 寺田寅彦」．『土木学会誌』． 67 巻 11 号. 1982. 10. p. 77）．

D−4. 寺田門下の中野猿人は，この論文中の言葉〈鳴門の潮流は，あたかも風琴管の口に吹きつけられた気流と同じで，気流が風琴管内に気柱の定常振動をひき起こすと同じく，太平洋から播磨灘に向かって突進する潮流は，潮憩湾内に水の定常振動をひき起こす〉を引き，著者らの考察を詳しく解説した（中野：『海の

談話室』. 講談社. 1970. p. 3〜9).

D−5. 上田 寿は，論文中の言葉〈湾あるいは海の一部分は流体振子のように固有の振動周期で振動する〉を引き，この研究の背景，経過，意義につき詳しく解説した(上田：「寺田寅彦の科学随筆」.『槲』(寺田寅彦記念館友の会). 特集号. 1995. 5. p. 1〜10).

■3. 錯視.

A. ［Optical Illusion］. *Nature*. Vol. 78, No. 2020. 1908. 7. 16. p. 255.

B. T. Terada：［Optical Illusion］. 出版された論文の紹介ではなく，編集者あての Letter の紹介である.

C. 「… After watching drops falling at the rate of about one a second into the centre of a small pool, and so causing circular ripples, he turned his eyes to a spot on a neighbouring bush. The bush appeared to contract slowly towards the point looked at, but the contracting motion was slower than the diverging motion of the ripples. A similar effect was noticed by looking at the ground or at wall」.

D. ———.

■4. 地震波の速度.

A. Velocities of Earthquake Waves. *Nature*. Vol. 90, No. 2256. 1913. 1. 23. p. 579.

B. T. Terada : On the Velocity of Sea−Waves. *Proc. Tokyo Math-Phys. Soc.*, Ser. Ⅱ, Vol. 6, No. 12. 1912. 6. p. 260〜265.［論文 no. 46］.

C.「In the Proceedings of the Tokyo Mathematico-Physical Society, vi., 17, Mr. T. Terada considers the experimental fact that the velocities of earthquake waves fall short of the values calculated by hydro-dynamical methods. … The results show that the explanation is a plausible one, …」.

D. ———.

■5. 地震の頻度と気圧の勾配.

A. Seismic Frequency and Isobar Gradient. *Nature*. Vol. 95, No. 2382. 1915. 6. 24. p. 461.

B. T. Terada : On the Relation between Seismic Frequency and Isobar Gradient. *Proc. Tokyo Math-Phys. Soc.*, Ser. Ⅱ, Vol. 4, No. 22. 1908.[ ]. p. 454〜459. ［論文 no. 43］.

C. 「In the Proceedings of the Tokyo Mathematico−Physical Society for 1909 and 1913 Prof. Terada and Dr. Hasegawa discussed the possibility of the barometric gradient over a region subject to earthquakes being one of the contributory causes of their production. … 」.

D−1. 寺田は，これと同内容の論文を和文で発表しているので，一部抄出する(文語文を口語文に書き改め，一部意訳した).〈地震と気圧との関係についての先行研究はあるが，地震と気圧の勾配との関係についての詳細な調査はなかった．地殻の構造は複雑なため， 地殻の全面に均一な圧力を加えても，その各部における歪みは一様ではないが，特に地殻の一局部を捻り，あるいは曲げるような歪みを起こすのは，むしろ気圧

の勾配の影響が大きいと思われる．この考えに基づき，日本各地の比較的狭い区域 5 か所に限り，地震の分布と気圧の勾配との間に何等かの関係がないか調べた．結果は，両者の間に何等かの密接な関係があることを想像させるに足ることが認められた〉（寺田：「地震の頻度と気圧の勾配との関係に就て」．『気象集誌』．28 年 1 号. 1909. p.1～11／論文 no. 邦 2).

D−2. 長岡半太郎は，寺田のこの論文をうけて，理論的考察を行った（ H. Nagaoka : Problem of Surface Loading with Applications to Geophysical Phenomena. *Proceedings of the Tokyo Mathematico−Physical Society*. Ser. Ⅱ, Vol. 6. 1912. 3. p. 208～215）．木村東作は，これを次のように解説している．「（長岡は）一般式からはじめて，今度は表面荷重によって生ずる表面の傾きを論じる．そして，圧力勾配の極大点付近に弾性の破壊点が見出されることを指摘する．また，最大の傾斜角をもった場所は圧力勾配の極大点付近にあり，これは寺田の研究に一致するという」（木村：『長岡半太郎伝』．朝日新聞社．1973． p. 367）．

D−3. 科学史研究者の泊 次郎は,「大森房吉は… 地震発生と気圧との関係を調べ，気圧が高いときに地震が多く起きる傾向が見られる，との論文をいくつも書いた．これに対して寺田は，気圧の大小よりも気圧の勾配の大小の方が地震発生に影響を与えるのではないかと考え，中央気象台がまとめた気圧分布と大森から提供された地震データを比較研究した．しかしながら，この論文では明確な結論は得られていない」と述べた（泊：『日本の地震予知研究 130 年史』．東京大学出版会．2015. p. 160）．

■6．日本の低気圧性降雨の分布.

A. The Distribution of Cyclonic Precipitation in Japan. *Nature*. Vol. 97, No. 2444. 1916. 8. 31. p. 550.

B. T. Terada, T. Yokota and S. Otuki : On the Distribution of Cyclonic Precipitation in Japan. *Journal of the College of Science, Tokyo Imperial University*, Vol. 37, Art. 4, 1916. 1. p. 1～32. ［論文 no. 55］.

C.「The paper is partly a statistical investigation of the influence of land and water in modifying the rainfall from 1905 to 1915, but contains also an attempt to analyse the factors that determine the unsymmetrical distribution of precipitation. … The whole discussion is some−what hypothetical, …」.

D. ―――.

■7．地磁気の脈動.

A. Terrestrial Magnetic Oscillations. *Nature*. Vol. 101, No. 2534. 1918. 5. 23. p. 233. By C. Chree.

B. T. Terada : On Rapid Periodic Variations of Terrestrial Magnetism. Part I and Ⅳ. *Journal of the College of Science, Imperial University of Tokyo*, Vol. 37, Art. 9. 1917. 5. p. 1～23, 23～47, 47～85 . ［論文 no. 58～60］.

C.「The paper referred to below is an important contribution to our knowledge of oscillations in the magnetic elements, especially those of shorter period termed “pulsations” by van Bemmelen. … 」.

D−1. 永田 武はこの研究の意義につき，次のように述べている.「地球磁場の日周変化や太陰時変化の組織的研究は，主として英国において今世紀の初めに行われた… わが国におけるこの方面の最初のまとまった論文として寺田寅彦先生の “On Rapid Periodic Variations of Terrestrial Magnetism” は，当時の地磁気脈動の論文として完璧に近い内容と言えるであろう．…（論文中の）数理的議論の部分は現在の地球内部電磁感応論からみても正しい内容である」（永田：「地球磁気学 100 年の歩み」.『自然』. 29 巻 8 号. 1974. 8. p. 28〜46）.

D−2. 畠山久尚は語る.「これは三崎油壺の洞窟の中で得た地磁気三要素の磁気記録を整理して出された結果である．… 巻頭には〈在職二十五年を祝して田中館愛橘教授に捧げる〉と印刷してある．この地磁気脈動観測のことは，田中館先生の提唱で，震災予防調査会の仕事として，地震と地磁気変動の関係を見つけたいということで始まったものである… 結論を言うと，地磁気変動と地震の関係はないが地磁気脈動のいろいろの性質を余す所なく解析され，数理的に地殻の電磁感応を扱って，実測結果と比較することをやっておられるのである」（畠山：「火災論，雷そして地磁気脈動」. 宇田道隆編『科学者 寺田寅彦』〈NHK ブックス・225〉. 日本放送出版協会. 1975. p. 91〜109）.

■8. 気圧の日変化.

A. Diurnal Variation of Atmospheric Pressure. *Nature*. Vol. 101, No. 2535. 1918. 5. 30. p. 253〜254. By W. W. B.

B. T. Terada, M. Kiuti and Z. Tukamoto：On Diurnal Variation of Barometric Pressure. *Journal of the College of Science, Tokyo Imperial University*, Vol. 41, Art. 1. 1917. 11. p. 1〜30. ［論文 no. 62］.

C. *Nature* の記事は，〈Diurnal Variation of Atmospheric Pressure〉 のタイトルのもと，寺田らのほか，複数の研究者の研究をも合わせ紹介している．関係部分を引く．「Three Japanese investigators from the Geophysical Seminary of the Physical Institute, Tokyo, contribute an account of a preliminary attempt to trace more detinitely the mechanism of these local influences , one of the most obvious of which , under the name of “continentality,” has recent been attracting the attention of Mr. C. E. P. Brooks in this country in connection with climate, and with a purely geographical theory of the Ice age. … 」.

D. ———.

■9. 日本の降雨に及ぼす地形の影響.

A. Effect of Topography on Precipitation in Japan. *Nature*. Vol. 105, No. 2645. 1920. 7. 8. p. 599〜600. By W. W. B.

B. T. Terada, M. Isimoto and M. Imamura：On the Effect of Topography on the Precipitation in Japan. *Journal of the College of Science, Tokyo Imperial University*, Vol. 41, Art. 5. 1919. 6. p. 1〜23.［論文 no. 68］.

C. *Nature* の記事は，〈Effect of Topography on Precipitation in Japan〉 のタイトルのもと，寺田らの

ほか，複数の研究者の研究をも合わせ紹介している．関係部分を引く．「At first sight, Prof. Terada's contribution in the Journal of the College of Science, Tokyo Imperial University (vol. xli., art. 5), appears to be only a supplement to previous work of Profs. Nakamura and Fujiwhara, but one or two comparatively fresh notes are struck. … This is now described by Prof. Terada as a case more of parallelism than of cause and effect, for he prefers to attribute both phenomena to barometric changes rather than to associate the instability of the soil with percolation. … 」．

D−1．この論文につき寺田自らが解説しているので引く．「地震の頻度と気象現象との間に存在するらしい関係［について］寺田博士は，我が国に於ける降水量の地理的分布に関する研究からして，中部日本に於ける一般の気圧の傾度が，地震の頻度と其の地方の降水量とを二つ乍ら定めるものであらうと考へられて居る」（寺田寅彦・松澤武雄原著／坪井忠二訳補：「我が国に於ける地震学の発達」．物理学輪講会同人編『物理学文献抄』．第 2 輯．岩波書店．1928. p. 19〜20）．

D−2．泊 次郎の本：「寺田は，日本海側と太平洋側の気圧の差が大きい年には，発生した地震の数が多い傾向が見られるとの論文を書いている」（泊：『日本の地震予知研究 130 年史』．東京大学出版会．2015．p. 160）．

■10．太陽の活動と地磁気．

A．Sunspot Frequencies and Terrestrial Phenomena—An Interesting paper . *Nature*. Vol. 119, No. 2990. 1927. 2. 19. p. 293.

B．T. Terada : On Some Remarkable Relation between the Yearly Variations of Terrestrial phenomena and Solar Activities. *Journal of the College of Science, Tokyo Imperial University*, Vol. 44, Art. 6. 1923. 1. p. 1〜20.［論文 no. 77］．

C．*Nature* の記事は，〈Our Astronomical Column〉欄の複数の記事の 1 編として紹介されている．関係部分を 1 部抄出する．「The association of earthquakes with spot frequencies in the north and south hemispheres of the sun, called N and S, is examined, and Terada finds that for some places in Japan and Jamaica, minima of earthquake frequency occur in years when $N - S$ is small, while for others, maxima occur under these conditions：some places show neither feature. … The idea that important geophysical phenomena depend on the difference of the sun's activities in the northern and southern hemispheres is so important that Prof. Terada's future papers will be awaited with much interest」．

D．寺田自らの解説を引く．「近頃，寺田博士の研究によると，或地方の気圧の年々の変化と，太陽の斑光［黒点］の分布を示す因数との間の相関関係を調べてみると，地方によって大体二つの種類があって，お互に逆の性質を示す地域に分れるといふ事である．其上，此の二種類の地方の分布が，上に述べた地震についての二種類の地方の分布と，非常によく似ていると云ふ事である」（寺田寅彦・松澤武雄 原著／坪井忠二訳補：「我が国に於ける地震学の発達」．物理学輪講会同人編『物理学文献抄』．第 2 輯．岩波書店．1928. p. 12）．

■11. 流体の運動.

A. Fluid Vortices. *Nature*. Vol. 120, No. 3030. 1927. 11. 26. p. 784.

B. T. Terada and K. Hattori：Some Experiments on Motion of Fluids. Part I, Ⅱ and Ⅲ. *Reports of the Aeronautical Research Institue, Tokyo Imperial University*. Vol. 2. No. 16. 1926. 5. p. 85～112.［論文 no. 83］.

C.「With the object of supplying data for a more complete mathematical treatment of the vortices formed in a fluid about a body rotating in it, or if this should prove impossible , for a qualitative treatment of the problem. Messrs. T. Terada and K. Hattori, of the Aeronautical Research Institute of the University of Tokyo, have made a photographic study of the forms of these vortices under various boundary conditions. ... 」.

D. 寺田門下の玉野光男はこの論文を詳しく解説しているので抄出する.「第 1 部に報告された実験は，大正 11 年 6 月中頃から始められたもので，当時突発した航空船の爆発事件の原因調査の仕事に関係を持たれていた先生は，気球から漏れでる水素の拡がり方などを調べる目的で行われたものであった．実験はガラス張りの箱の中に水を満たし，その底においた素焼の管から色のついた軽い液体を滲みださせ，その液が水の中を立ち昇って行く模様を写真にとってしらべた．… この実験により，漏れでた軽い液体は，水の中を単なる拡散の法則によって拡がるのでなく，漏出の際生ずる渦の作用を考慮しなければならないことが指摘された．… 第 2 部では，対流による液体運動の研究実験を述べている．長方形のガラス張り容器の中に水を入れ，容器の底のいろいろの場所におかれた電熱板によってどんな流体運動がおこるかを調べた．水の運動状態を知るために，水の中に細かいアルミニウムの粉末を散らし，これに適当な照明をして多数の写真をとって運動の模様を調べた．このような場合の水の運動は，普通に考えられるような簡単な定常的な循環流ではなく，幾つかのまとまった渦巻ができ，それらの渦巻の分布や相互作用によって極めて複雑な流が生ずる．この複雑な運動を通観して… 一般的な考え方に達した．第 3 部では，先生が大正 12 年の関東大地震の際，東京に生じた大旋風について，震災予防調査会の仕事に関連して，特に関心をもたれた竜巻の生成に関する実験的研究の一部が述べられてある」（玉野：「寺田先生と渦に関する研究」. 宇田道隆編『科学者 寺田寅彦』〈NHK ブックス・225〉. 日本放送出版協会. 1975. p. 151～172）.

■12. 電気火花.

A. Electric Sparks. *Nature*. Vol. 122, No. 3063. 1928. 7. 14. p. 73～74.

B. T. Terada and U. Nakaya：Experimental Studies on Form and Structure of Sparks. Part I, Ⅱ and Ⅲ. *Scientific Papers of the Institute of Physical and Chemical Research*, Tokyo, Vol. 8, No. 131. 1928. 2. p. 1～19；Vol. 8, No. 135. 1928. 2. p. 63～82； Vol. 8, No. 138. 1928. 3. p. 103～129.［論文 no. 99, 101, 109］.

C.「The three experimental papers on the form and structure of electric sparks, by T. Terada and U. Nakaya, published in volume 8 of the *Scientific Papers of the Institute of Physical and Chemical*

Research, Tokyo, are instructive to scientific workers and will be useful to magneto manufacturers. The authors point out that our present knowledge of the form and structure of sparks is not much greater than in the days of Franklin and Lichtenberg. ... 」.

D. 中谷宇吉郎が，一系のこの研究の意義を解説しているので引く．「1 気圧の空気中の火花は，電極間の距離が短い間は直線で最短距離を飛ぶが，少し長くなると普通は稲妻形とも称すべき折れ曲った形をとる事は，周知の事実である．… 此等の簡単な然し乍ら火花に関する直接の性質に関する研究は，従来殆んど閑却されて居て，驚くべき多数の文献は殆んど低圧の所謂 真空放電，又は 1 気圧中では極く短い火花に就いて，其の火花電圧，火花の遅れ等の “数値を測定” する事に限られて居る．数値の測定には再現可能で一番簡単な条件を選ぶ必要がある，それで不規則な形をとる長い火花は，再現不能として研究の対象にされない傾があった．然し以下に述べる様に火花の型を分類し，その成立の条件を精しく調べると，各々の型については再現が可能であり，同一型に属する個々の火花に就いては，統計的法則の成立の可能性がある事が分った」（中谷：『気体内電気現象』〈岩波講座 物理学及び化学．物理学．Ⅶ. B〉. 1931. 「§29. 電気火花の形及び構造の研究」. p. 61～66）.

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g. 2. At surface, where the veins have been fected by atmospheric agencies, there is a high pro- rtion of metallic silver. Much of the ore shipped 1904 was largely composed of native silver. The scovery at Cobalt is an indication of Canada's bright ospects of becoming a more important mineral- oducing country. In North America the territory ntrolled by Great Britain exceeds that of the United tates. But of this immense area of 3,600,000 square

FIG. 2.—Metallic Outcrop of Silver Ore, Cobalt. From "Mines and Minerals of the British Empire."

miles only a very narrow fringe has even been ex- plored, and yet the rocks of which a very large pro- portion of the unexplored area is in all probability composed are those which in the United States carry the most valuable mineral deposits. Here, and in other parts of the Empire, the world awaits the estab- lishment of new mining regions to compensate for the steady impoverishment of the old.

THE SECONDARY OSCILLATIONS OF OCEANIC TIDES.[1]

TIDAL observers have long known that at certain stations, mostly situated on bays or indentations of the coast, the simple curve of the tide-gauge is complicated by oscillations of level, often of consider- able range and regularity of period. At first sight nothing could be further removed from the study of earthquakes than these irregularities of the tidal oscillation, but a connection has been discovered by the Japanese Earthquake Investigation Committee, whose diverse activity leads it to the study, not only of everything directly or indirectly connected with earthquakes, but also of everything which resembles their effect. The discovery, by Prof. Omori, that the periods of the earthquake-produced sea-waves were not uniform at neighbouring stations, but in each case agreed with those of the secondary oscillations of the tidal curve, naturally led to an investigation of this phenomenon, which has been noticed and made the subject of speculation by various observers. The investigation was carried out under the direction of Prof. H. Nagaoka, and has been published in a bulky and profusely illustrated quarto volume.

After a description of the improved and portable form of tide-gauge which was invented for the in- vestigation, the ordinary gramograph being unsuitable and the ordinary tide-gauge too cumbrous, we have a detailed account, illustrated by reproductions of the tide curves and charts, of the records from fifty-one stations on the Japanese coasts. A general summary of the results is given, from which it appears that on the open Pacific coast, or in a bay of considerable area communicating with the sea by a narrow outlet, the tide curve is of a simple character, the secondary oscillations being small and irregular; but in more open bays, the breadth of which is not too large in com- parison with their length, secondary oscillations are conspicuous, and often show great regularity of period. Simultaneous observations at different places along the shore-line showed that the phase of oscillation was usually the same throughout the bay, and that the oscillations which were conspicuous within the bay could be detected, with the same phase, but much reduced amplitude, at its mouth. From this it ap- peared that the whole mass of water in the bay was in simultaneous oscillation in a stationary wave, analogous to the sound-wave in an open organ pipe, and that the bay selected from the multitudinous ocean waves of various period the particular one to which it was able to respond, and, like a resonator with sound-waves, magnified and made it conspicuous.

This conclusion was verified by experimental in- vestigation. Models, to scale, of the bays were made and sunk to the appropriate level in a large tank of water; in this tank was immersed a leaden ball which, being attached to a simple or a horizontal pendulum, could be set in oscillation with any desired period, and by its movement communicate to the water in the tank a periodic oscillation, unaccompanied by any appreciable surface-wave; reflection from the walls of the tank being checked by a thick layer of damping material—wood-shavings, to wit. By exciting waves with this arrangement the water in the model of the bay was put into standing oscillation, the amplitude of which was generally small; as the period of the pen- dulum approached the proper period of the bay, the amplitude of oscillation gradually increased, and, when the period exactly coincided with that of the model, the amplitude reached its maximum, con- tinuing, with a regular period, after the pendulum was stopped. The phase of the water particles was the same for all parts of the bay when the oscillation was a fundamental one, but a binodal or trinodal oscil- lation was easily produced in an elongated bay.

An ingenious development of the experiment con- sisted in sprinkling aluminium powder on the surface of the water and photographing the model with a camera suspended vertically above it; by giving an appropriate length of exposure, the movement of the particles reproduced the course of the stream-lines on the resulting photograph. In Fig. 1 we repro- duce one of these photographs, showing the motion where the induced wave is the fundamental oscilla- tion, in which the mouth of the bay is a node for

[1] "An Investigation on the Secondary Undulations of Oceanic Tides, carried out by the Order of the Earthquake Investigation Committee during 1903-6." By Drs. K. Honda, T. Terada, Y. Yoshida and D. Isitani. Preface by Prof. H. Nagaoka. Pp. viii+153; 93 plates, 2 frontispieces. Published as No. 26 of Publications of the Earthquake Investigation Com- mittee in Foreign Languages, and as vol. xxiv. of the Journal of the College of Science, Imperial University of Tokyo. (Tokyo, 1908.)

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vertical and a loop for horizontal motion, while the head is a loop for vertical and a node for horizontal

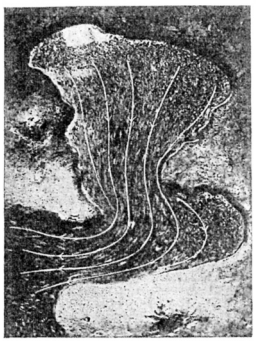

FIG. 1.—Model of Aomori Bay, showing stream lines of fundament l oscil- lation : period 4·453 in model, representing 303 m. in the bay itself.

motion. The period of this oscillation in the model was 4·45 seconds; the factor, corresponding to the scale adopted, being 4090, this represents a period of

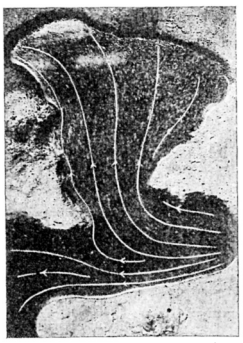

FIG. 2.—Model of Aomori Bay, showing stream lines of lateral oscillation : period 1·63 in model, representing 108 m. in the bay itself.

303 m. in the actual bay, in which a periodic oscillation of 300 m. was observed. Besides this fundamental wave, the water within the bay could be set into lateral oscillation, as shown in Fig. 2, with a period of 1·60 s. in the model, representing 108 m. in the actual bay, where a well-marked regular undulation of 103 m. was observed.

The account of the experiments is followed by a mathematical treatment of the subject, and a calcula- tion of the periods of the stationary waves for each of the bays investigated, a calculation which gave results in general, and sometimes in close, accordance with the observed periods. Finally, there is a suggestion that the great increase in the range of tides near the head of large bays may be partly due to this cause. The Bay of Fundy is celebrated for the great range of the tide near its head, where the difference between high and low water is from 50 to 70 feet, while near the mouth the range is not more than 7 to 10 feet; the difference is partly attributable to the banking of the tidal wave as it travels up a narrowing channel, but, the fundamental period of oscillation of the bay being about twelve hours, it is by no means improbable that this has a material effect in increasing the range of the semi-diurnal tide, with which it approximately agrees in period.

We have indicated sufficiently the scope of this important memoir, the unseismological interest of which has been recognised by its simultaneous appearance as one of the publications of the Earth- quake Investigation Committee and as a volume of the Journal of the College of Science of Tokyo.

VESTIGES OF SCALES IN THE FOX.

IN the case of such a familiar animal as the fox it might well have been supposed that everything worth knowing in the matter of its bodily structure had already been recorded. That this is not so is demonstrated in an article by Mr. K. Toldt, of Vienna, published in the April number of the *Zoologischer Anzeiger*, where it is shown, on what appears to be practically conclusive evidence, that the fox is descended from ancestors the bodies of which appear to have been clothed with horny scales like those of the pangolins, or scaly ant-eaters. Although these scaly ant-eaters are the only living mammals the bodies of which are com- pletely covered with overlapping scales, armadillos furnish us with an example of another type of armour in the same class; while there are several groups of mammals in which some portion of the body is scaly. In the rat, for example, the whole tail is scaled, and more or less distinctly scaled areas are met with in several porcupines and certain other rodents, as well as on the tail of the great South American ant- eater. In all cases where hairs grow from the body between the scales (as they almost invariably do), such hairs, in place of being scattered about in an ir- regular manner, have a certain definite arrangement. They grow, for instance, in isolated bundles, arranged in some cases in groups of three or four, and placed at regular intervals from one another.

From the fact that the hairs are arranged in this peculiar and definite fashion in a number of species which show no traces of scales, it has been suggested that such mammals trace their descent from scale- clad ancestors.

Careful examination of the skins of young foxes has enabled Mr. Toldt to announce, not only that the hairs are arranged in this peculiar fashion, namely, in groups of three bundles, each containing some fourteen or fifteen hairs, but likewise that the skin itself actually exhibits a structure such as would be presented by that of a pangolin after the scales had been pulled out. Viewed through a microscope, the skin presents,

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■本多・寺田らの論文 The Secondary Oscillation of Ocean Tides の紹介記事[文献 No. 2].