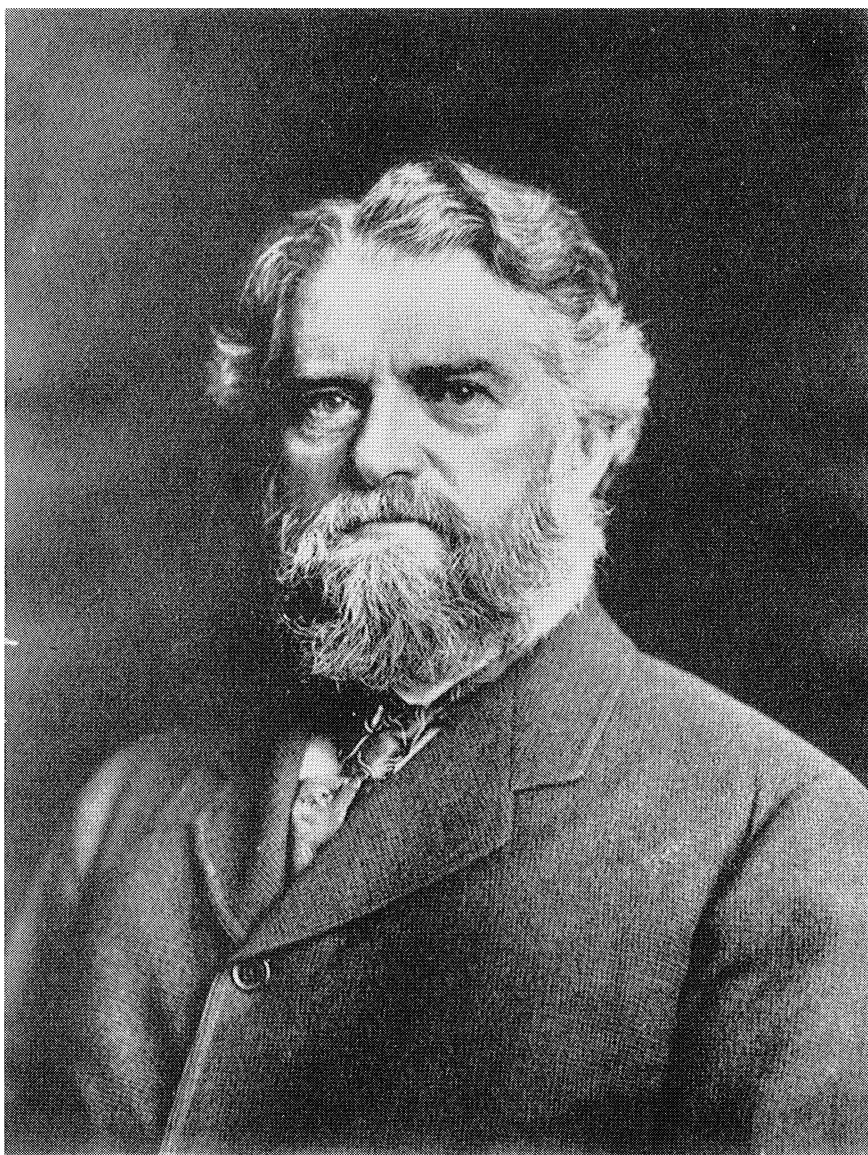


82. "Examples of periplegmatic orbits," *AJ*, v. 24, 1904, p. 9-14.
83. "The theorems of Lagrange and Poisson on the invariability of the greater axes in an ordinary planetary system," *AJ*, v. 24, 1904, p. 27-29.
84. "Comparison of the new tables of Jupiter and Saturn with the Greenwich observations of 1889-1900," *AJ*, v. 24, 1904, p. 60-61.
85. "Development of functions in power series from special values," *AJ*, v. 24, 1904, p. 123-128.
86. "Deduction of the power series representing a function from special values of the latter," *AJM*, v. 27, 1905, p. 203-216.
87. "Integrals of planetary motion suitable for an indefinite length of time," *AJ*, v. 25, 1905, p. 1-12.
88. *The Collected Mathematical Works of George William Hill* (CI Pub.), Wash., D.C., 4v., 1905-1907. These v. were ed. by Hill; they include all of the items except the 17 which are starred (*).
89. "Application of the Delaunay transformation in the planetary theories," CI Pub., no. 9, v. 4, 1907, p. 345-391.
90. "Remarks supplementary to memoir no. 79," CI Pub., no. 9, v. 4, 1907, p. 392-397.
91. "Development, in terms of the true anomaly, of odd negative powers of the distance between two planets moving in the same plane," CI Pub., no. 9, v. 4, 1907, p. 398-407.
92. "On the construction of maps," CI Pub., no. 9, v. 4, 1907, p. 408-418.
93. "Dynamic geodesy," CI Pub., no. 9, v. 4, 1907, p. 419-452.
- *94. "Attraction of the homogeneous spherical segment," *AJM*, v. 29, 1907, p. 345-362.
- *95. "Subjective geometry," *AMS Bull.*, v. 14, 1908, p. 305-313.
- *96. "The Jovian evection in the lunar theory," *AJ*, v. 25, 1908, p. 193-196.
- *97. "Biographical memoir of Asaph Hall 1829-1907," *NAS Biog. Mem.*, v. 6, 1908, p. 241-309.
- *98. "Motion of a system of material points under the action of gravitation," *AJ*, v. 27, 1913, p. 171-182.
- *99. "The secular perturbations of the four outer planets," *AJ*, v. 28, 1913, p. 59-71.
- *100. "Hypergeometric series and Walker's table of the Leverrier coefficients," *AJ*, v. 28, 1914, p. 93-100.
- *101. Reviews of books by J. N. Stockwell in *Analyst*, 1882; and by Gylden in *AJ*, 1894.

4. SIMON NEWCOMB

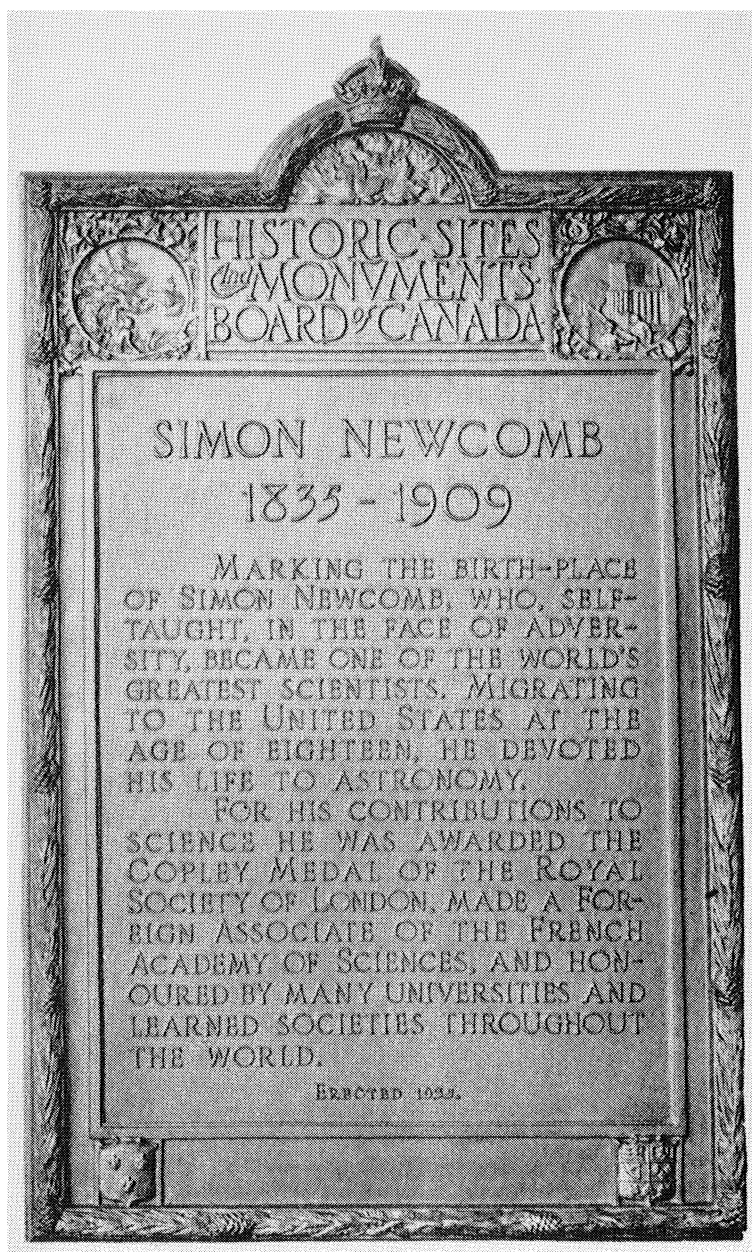
CURRICULUM VITAE.—B. Wallace Bridge, Nova Scotia, Can. 12 Mar. 1835; d. Washington, D.C. 11 July 1909. Taught by his father. Came to U.S. in 53. Teacher in a country school at Massey's Cross Roads, Md. 54, and in the village school at Sudlersville, Md. 55. Computer in Nautical Almanac Office, Cambridge, Mass. (Jan. 57-Sept. 61; office moved to Washington in 66). Prof. math. U.S. Navy (Sept. 61-Sept. 77; senior prof. math. and supt. Naut. Alm. Office Sept. 77-Mar. 97). Lect. in Columbian, afterwards George Washington, U. (73-84; prof. astr. 84-86). Prof. math. and astr. JHU (Oct. 84-Dec. 93; 98-00; prof. math. emeritus 00-09). Lect. U. California summer 07. Became citizen of U.S. probably sometime 57-61.

HONORS.—Expedition, directed by S. Newcomb and W. Ferrel, to observe total solar eclipse Lake Winnipeg, Can., July 60. Fellow AAAS 60. Mem. NAS 69. In U.S. Govt. expd. solar eclipse to Des Moines, Ia. Aug. 69, to Gibraltar Dec. 70, to Separation, Wyo. July 78, and to Cape of Good Hope Dec. 82 (see Bibl. nos. 21, 26). Hon. LL.D. Columbian U. 74. Corresp. mem., sect. astr. Acad. des Sci., Institut de France 74. Awarded Gold Medal RAS for his "tables of Neptune and Uranus and other mathematical works" 74. Offered directorship Harvard Obs. 75. Hon. master of math. and Ph. Nat. D., U. Leyden 75; on the celebration of the 300th anniversary of its founding. Hon. LL.D. Yale U. 75. For. assoc. Royal Swedish Acad. Sci. 75. Corresp. mem. Imp. Acad. Sci., Leningrad 75. Corresp. mem. Royal Bavarian Acad. Sci. 76. P AAAS 76; ret.



Simon Newcomb

1897



TABLET IN MONUMENT ERECTED BY THE CANADIAN GOVERNMENT

add. "The course of nature" (no. 44). Assoc. Royal So. Sci., Upsala 77. For. mem. RS London 77. Mem. Amer. Phil. So. 78. For. mem. So. Dutch Sci., Haarlem, and awarded by this So. Huygens Medal 78; biennially "awarded to the individual who by his researches and discoveries or inventions during the previous twenty years had in the judgment of the Society distinguished himself in an exceptional manner in a particular branch of science." Hon. mem. Cambridge Phil. So. 78. P Phil. So. Wash. 79-80 and 08. Lect. (4 lects.) on political economy at Harvard U. 79-80. For. fellow RS Edinburgh 81. Chm. NAS advisory comm. on meteorology 81-84. One of three administrators for NAS of the Watson Fund providing means for supporting research and the award of the Watson Gold Medal 81-09; he was chm. board of trustees 87-09 (E. W. Brown received this medal in 37). Lowell Lect. (12 lects.) Boston 81-82; "History of astronomy." For. mem. Royal Physiographic So., Lund 81. Hon. mem. Royal Irish Acad. 82. VP NAS 83-89. Corresp. mem. Prussian Acad. Sci. 83. Hon. LL.D. Harvard U. 84. Corresp. mem. BAAS 84. Ed.-in-chief *AJM* 85-93, 99-00; assoc. ed. 78-79, 95-98, 01-08. P Amer. So. Psychical Research 85-86. Offered presidency U. California 85. Hon. Ph.D. U. Heidelberg, on the celebration of the 500th anniversary of its founding 86. Hon. mem. (at same time as Chrystal and Sylvester) of Assoc. for the Improvement of Geom. Teaching, afterward Math. Assoc., London 86. P Alumni Assoc., Lawrence Sci. School, Harvard U. 86. P Political Economy Club of Amer. 87. Russian emperor ordered portrait painted and placed in gallery of famous astronomers at the Pulkovo Obs. 87. Hon. LL.D. Columbia U. on the occasion of its centenary cel. 87. Hon. mem. Manchester Lit. and Phil. So. 87. Presented by U. Tokyo with pair bronze vases of exquisite workmanship 88. In recognition of his great services in securing for Pulkovo Obs. a large object glass, presented by the Czar of Russia with a rare vase of jasper 89. Awarded Copley Medal RS London, for contributions to the progress of gravitational astr. 89; the medal was accompanied by a check for £50. Hon. mem. N.Y. Acad. Sci. 91. One of 21 eminent scientific men elected Hon. mems. Royal Institution G.B., on the cel. of the Faraday centenary 91. Hon. mem. comm. organization Fifth Intern. Congress Geologists, Wash. 91. Hon. LL.D. U. Edinburgh 91. Hon. mem. Astr. and Phys. So. Toronto now RAS Can. 91. For. assoc. Royal Acad. Sci., Brussels 91. Hon. Sc.D. U. Dublin in cel. tercentenary of its founding 91. Hon. Ph. Nat. D. U. Padua in cel. tercentenary Galileo's appointment as prof. 92. Winner first prize \$150, of two "citizenship prizes" offered by the Anthropological So. of Wash. for the best essay on an assigned topic, "The elements which make up the most useful citizens of the United States" 94. Math. ed. *Science* 95-03. Awarded *AJ* prize of \$400 for the "most thorough discussion of the theory of the rotation of the earth with reference to the recently discovered variation of latitude" 95. Elected one of eight for. assoc. Acad. des Sci., Institut de France to succeed Helmholtz 95; first native Amer. since Franklin so honored. For. assoc. astr. sect. Acad. Lincei 95. Hon. mem. Imp. Acad. Sci., Leningrad 96. Officer Legion of Honor, France 96; authorized by Congress to receive this decoration (see *Congr. Records*, 3 Mar. 97) 96. Hon. LL.D. U. Glasgow 96. Hon. Sc.D. U. Cambridge 96. Hon. LL.D. Princeton U. 96. P AMS 97-98; ret. add. "The philosophy of hyperspace" (no. 112). Awarded the Schubert Prize (about \$460) by the Imp. Acad. Sci., Leningrad 97. Corresp. mem. Imp. Geographical So., Leningrad 97. At 21st anniversary cel. of founding JHU requested by faculty and friends to sit for portrait, painted by R. G. Hardie, to be given to the U.; reproduced in *AJM* 99. For. assoc. Italian So. Sci. (dei XL) 97. Hon. corresp. mem. Royal So. Arts 97. First recipient Bruce Gold Medal, from the ASP 97; the So. had to select recipient from nominees by directors of six observatories Berlin, Greenwich, Harvard, Lick, Paris, and Yerkes, but one name stood forward so prominently the So. could but set the seal of its approval upon the verdict of its peers. Cape Newcomb of the Hoyt Islands, Hubbard Bay, W. Greenland named after S. Newcomb (see *Nat. Geogr. Mag.*, v. 9, p. 3) 98. For. assoc. Royal Inst. Sci. Letters and Arts, Venice 98. Hon. mem. Colonial So. Mass. (one of nine) 98. Hon. mem. Royal Acad. Sci., Amsterdam, 98. Hon. D.C.L. Oxford U. 99. Assoc. corresp. mem. Royal Inst. of Sci. and Letters, Milan 99. For. corresp. Bureau of Longitudes, Paris 99. First P Astr. and Astrophys. So. (now Amer. Astr. So.) and reelected annually until he requested and insisted on relief from the duty 99-05. Hon. LL.D. U. Cracow, Austria on the cel. of the 500th anniversary of its foundation 00. One of two receiving first award of Sylvester Prize of JHU, a bronze medallion of J. J. Sylvester, framed in oak 01; the

first impression of the tablet was presented to Lord Kelvin and the second "to Simon Newcomb, a distinguished astronomer, who has been a friend of the university from its inception, and who guided the affairs of the mathematical department." Hon. mem. Russian Astr. So. 01. Hon. mem. Royal So. New South Wales, Sydney 01. Hon. LL.D. JHU at the cel. of the 25th anniversary of its founding, "in recognition of his preeminent attainments and important discoveries in science," 02. Hon. mem. Astr. So. Mexico 02. Presented to King Vittorio Emanuele III of Italy 02. Hon. Math. D. U. Christiania in connection with the cel. of the centenary of the birth of Niels Henrik Abel 02; Newcomb went as delegate from NAS, and during the cel. was presented to King Oscar of Sweden and Norway. Appointed one of five mems. advisory comm. in astr. for the Carnegie Inst. 03; during 03-08 Newcomb received \$28,000 in grants towards expenses of his investigations. For. Secy. NAS 03-09. Mem. comm. Amer. Phil. So. to organize bicentenary cel. of Franklin's birth 03. Presented to King Edward VII of England 03. P Intern. Congress of Arts and Sci., Louisiana Purchase Exposition, St. Louis Sept. 04; as P of the Congress he made a special trip to Europe to secure cooperation of leading European men of sci. VP BAAS 04. Corresp. mem. Royal Acad. Sci., Vienna 04. Hon. LL.D. U. Toronto 04. Corresp. mem. Royal Acad. Sci., Turin 05. Corresp. mem. Nat. Inst. of Geneva, Switzerland 05. Knight of the Order Pour le Mérite for Sci. and Arts, Prussia 05; bill granting Newcomb permission to accept this decoration became law Apr. 06. P Cosmos Club, Wash. 06-07. Mem. Board of Overseers Harvard U. 06-09; first election to this body of a grad. of Lawrence Sci. School not already a grad. of the C. Hon. mem. Royal Acad. Sci., Letters and Arts, Padua 06. Commissioned rear-admiral U.S. Navy 06. Commander of the Legion of Honor, France 07. Hon. fellow (one of twelve) Phys. So., London 07. For. mem. So. Sci., Christiania 07. For. mem. Royal So. Sci., Göttingen 07. A VP and invited speaker fourth Intern. Congress Mathems., Rome, Apr. 08. Received in audience by Emperor William II Germany, and lunched with his Majesty and the Empress Aug. 08. VP Amer. Phil. So. 09. Medallion of Newcomb in the sci. panel of one of two bronze doors, designed and modeled by Louis Amateis, for the U.S. Capitol 10. Cut-stone monument with inserted bronze tablet, erected by The Historic Sites and Monuments Board of Canada on the site of Newcomb's birthplace, Wallace Bridge, Nova Scotia, unveiled 30 Aug. 35; see photograph of monument, and add. of R. C. Archibald, *Scripta Mathem.* v. 4, 1936. Bronze bust by Frederick MacMonnies unveiled in the Hall of Fame, N.Y.U. 28 May 36; received 78 out of 100 votes in 35.

BIOGRAPHICAL NOTES.—Simon Newcomb's ancestry was chiefly English, and in minor degrees Scotch, French, German, and Irish. His ancestors in every line had crossed the Atlantic long before the American Revolution, and the American descent was almost entirely through New England families. Simon Newcomb's paternal grandfather removed to Nova Scotia in 1761. His father John Burton Newcomb was a school teacher, and his gifted mother Emily Prince bore two daughters and five sons, of whom Simon was the eldest.

Since no other American scientist has ever accumulated such an extraordinary collection of honors as those listed above (and the list might have been considerably extended) an attempt will be made to record some brief suggestions as to reasons for such acclaim. (I shall often closely follow E. W. Brown's sketch which is especially valuable.) First of all it should be borne in mind that more than forty years have passed since Newcomb became president of the Society, and that in the same year he retired from his position as Superintendent of the Amer. Ephemeris and Nautical Almanac. This was before the founding of the Amer. Astr. So. and before many later extraordinary astronomical developments in Amer-

ica. His connection with the Nautical Almanac Office was for yet another forty years earlier, namely 1857–97. Even during the first decade of this period, with the Civil War and consequent disorganization of Govt. work, Newcomb began an investigation on the asteroids which resulted in one of his most important papers (no. 8). This virtually disposed of the explosion theory of Olbers put forward to account for the existence of these minor planets. Already at this time he displayed a grasp of the general principles of celestial mechanics and the methods of dealing with observations, always such a marked feature of all his researches. In 1869 he completed a four-year program of star observations, planned with great care and resting on its own foundations. Discussion of the observations revealed, as he had expected, the presence of systematic errors in existing catalogues of star positions. As his knowledge extended from the fixed stars to the moon, he was becoming more and more impressed with the confusion assailing exact astronomy because of the different values of the constants used by different observers. Two gigantic plans gradually matured in his mind. The one was a determination of all the constants of astronomy and their reduction to a homogeneous system, which would involve extended work on the theories of the planets and satellites. The second was the resolution of the lunar motions and the test of the law of gravitation which a comparison of the lunar theory would involve. The first plan was achieved, and the immense mass of work summarized in a little volume of 1897, *Elements of the Four Inner Planets and the Fundamental Constants of Astronomy* (no. 106). This gathers together his life work and constitutes his most enduring memorial. Leading up to results here won, are his publications, nos. 16, 27, 75, 98, 100, 104, 105, 111, 113, and 114. The theory was not the heaviest part of the work. All known observations had to be collected and compared. It was here that Newcomb's particular genius for the organization of huge masses of material, and his firm grasp of the facts which could be deduced from them, was given free play. The mutual perturbations of Jupiter and Saturn are so large that the problem of unravelling their motions is a much more difficult application of planetary theory than the other six large planets require. For the successful completion of Newcomb's scheme within his life time it was necessary that these two planets should be treated by another hand, and he enlisted the services of G. W. Hill who spent ten years on the work. Newcomb's determination of the solar parallax in 1862 (no. 18) as $8''.848$, he corrected to $8''.790$ in 1897. In order to fix the constant of aberration, a fresh determination of the velocity of light was carried through with Michelson (no. 82). Greatly increased facilities for observation were made possible in 1873 when he had secured a large refracting telescope for the Naval Obs. His founding of the remarkable series, *Astr. Papers prepared for the Use of the Amer. Ephemeris and Naut. Alm.* (*APAE*) made the results of latest research generally available.

As early as 1859 Newcomb compared observed places of the moon with those given in the Ephemerides, and his last, but one of his best, paper (no. 149) dealt with the motions of the moon and was finished only a month before his death. Other publications in this connection were nos. 19, 20, 23, 25, 39, 99, 145, and 146. In these his personal contributions were numerous and interesting, especially no. 39 in which he added observations carrying back the period dealt with by Hansen for at least 75 years. He had always hoped to prepare a new set of tables of the moon's motion but this was to be finely achieved by E. W. Brown at a later day.

One of Newcomb's rare excursions into pure theory is contained in "The general integrals of planetary motion" (no. 32) and it consists of an attempt to show how the coordinates of a planet, under the attraction of any finite number of planets, may be represented by trigonometric series. Poincaré has used this paper as a text for his investigations into the possibility of such developments (see Poincaré, *Les Méthodes Nouvelles de la Mécanique Céleste*, v. 2, 1893). Another very interesting and little known excursion into non-euclidean geometry (no. 36) was founded on the ideas of Riemann's celebrated doctoral dissertation, and is quoted extensively in Sir Robert Ball's article on measurement in the *Encycl. Brit.*, 9th ed. In the very first paper in *AJM* Newcomb proved (no. 42) a theorem, concerning geometry in fourth dimension, which is often quoted (see chap. I). Turning to Newcomb's other mathematical work, Cayley characterized the memoir on the perturbations of the moon (no. 25) as follows: "from the boldness of the conception and beauty of the result a very remarkable one, and constitutes an important addition to theoretical dynamics." Newcomb was the author of a series of school and college mathematical text-books (nos. 60, 61, 66, 67, 68, 77, 78, 91) which did not have a large sale, except in the case of the mathematical tables (no. 66) which went through many editions. He was, naturally, much interested in questions in the theory of probabilities and least squares (nos. 6, 7, 9, 10, 11, 28, 59, 86, 142). In an address before NYMS in 1893, on modern mathematical thought (no. 101), he began with a disclaimer of any right to be considered a mathematician in the modern sense of the word, but from the remarks which follow it is evident that he had not only read but had devoted much thought to modern ideas on hyperspace, group theory, projective geometry and the like. His presidential add. was on the philosophy of hyperspace (no. 112). We have noted above that he was editor-in-chief of *AJM* for a number of years and prof. of math. and astr. at JHU, where he was one of the first to receive appointment as lecturer on its opening in 1876. In many of the early years he served as examiner in math. and economics. Further indication of Newcomb's interest in the teaching of mathematics (see no. 95, 139) is furnished by the fact that he was chm. of the comm. of ten on math. in secondary education appointed in 1892 by

the comm. of the National Education Assoc. of the U. S. The report adopted had a large influence on the teaching of mathematics; the chairman's part in its preparation was considerable.

Among Newcomb's astronomical works reference may be made only to his remarkable *Popular Astronomy* (no. 40) which went through many editions and was translated into Norwegian, Russian and German; to his *Astronomy for Everybody* (no. 125) translated into Russian, German, Swedish, and Bohemian and still annually selling by the thousand in American department stores; to his *Compendium of Spherical Astronomy* (no. 137), still the best of its kind. In the field of Political Economy Newcomb published in 1865 at his own expense, *A Critical Examination of our Financial Policy during the Southern Rebellion* (no. 15) and during the next forty years he wrote many articles, and three other v., including a large work on *Principles of Political Economy* (nos. 33, 84, 85) which was several times reprinted. Newcomb was ranked high as an economist by Irving Fisher and President Hadley of Yale U. and there is little doubt that if he had chosen economics as the chief field of his endeavors he would have been among the foremost of modern economists. He was P Political Economy Club of America in 1887.

He discussed in print various questions connected with meteorology, aerial flight, occultism, life insurance, and a host of other topics. Stories (nos. 107, 130) and even a novel (no. 121) also flowed from his pen. In the novel, airships of the Zeppelin type are successfully employed. Newcomb was sceptical of the possibility of airplanes, since he failed to conceive of motors such as were developed soon after his death. Some samples of his collections of encyclopedia articles are indicated below (nos. 96, 122, 123, 131, 148).

He was indefatigable in his attendance at congresses, scientific meetings and academic functions. At many gatherings of this kind he was a singularly effective presiding officer, and entered upon such duties with pleasure. He rendered exceedingly valuable service in connection with several of the world's great telescopes, and his other contributions to the work of many observatories were great.

"Newcomb's work, driven by untiring energy and guided by philosophic intelligence for more than half a century, placed him at the head of his profession in America, and gave him membership in a small class of the most productive astronomers of all countries and all centuries. His influence upon the development of the science was exerted by speech and by letter as well as by published paper and volume. It was potent with beginners and assistants as well as with veterans and directors. It was applied with singleness of purpose, and solely in the interest of the science. Those who discussed astronomy with Newcomb had the impression of obtaining astronomy in the abstract, impersonal and disembodied, and

on that account his scientific associates often failed to understand his personality. A survey of Newcomb's activities leads to the view that he was intellectually a giant." (Campbell).

His favorite motto was, "Whatsoever thy hand findeth to do, do it with all thy might." That, irrespective of his surroundings, he could with all his might concentrate on any subject, explains, in part, the extraordinary extent of his achievements. In the honors showered upon him as a result of these, Newcomb always took a naive pleasure. He spoke French and German fluently and knew sufficient of the languages of Italy and Sweden to be able to travel in these countries with comfort. Accustomed from childhood to long walks he continued this form of exercise throughout life, walking daily several miles between the close of office hours and dinner. On Sundays the walks were much longer. Nothing delighted him more than his walking trips in Switzerland while he was abroad. Even when he was seventy years old he climbed to the chalet high up the side of the Matterhorn, a feat almost unprecedented for a man of his age. He was a lover of travel. Only intimates would know that he was full of fun and loved to romp with his children, when they were young. He read history and other literature extensively and could recite page after page of poetry. He delighted in art and never went abroad without spending many hours in famous galleries and enjoying paintings. Of music he knew nothing. In fact, he used to say that he did know enough to distinguish between Old Hundred and Yankee Doodle because the former was slow and the latter quick. He never went to the theater nor learned to play the usual card games, but he was an expert chess player and during an ocean voyage is known to have carried on four games simultaneously without reference to any chess boards. His wide and varied reading, combined with accurate memory and universal interest, made his conversation virile and enlightening. His wife was a granddaughter of F. R. Hassler, the first superintendent of the U. S. Coast Survey. One of Newcomb's grandsons is Hassler Whitney, professor of math. at Harvard U. and one of America's most gifted younger men (see *Scripta Mathem.*, v. 4, p. 284).

SOURCES.—E. W. Brown, *AMS Bull.*, v. 16. G. W. Hill, *Science*, n.s., v. 30. R. C. Archibald: (a) "Bibliography of his life and work," *NAS Mem.*, v. 17, 1924; (b) *Science*, n.s., v. 44, 1916, p. 871-878, list of honors, etc. A. Cayley, *RAS MN*, v. 34, 1874, p. 224-233. I. Fisher, *Econ. Journ.*, v. 19, 1909. M. Loewy, *Nature*, v. 60, 1899. W. W. Campbell, *NAS Mem.*, v. 17. H. H. Turner, *RAS MN*, v. 70. S. Newcomb, *Reminiscences of an Astronomer* (no. 128). B. M. Newcomb, *Andrew Newcomb 1618-1686 and his Descendants*, New Haven, Conn., 1923. Mrs. S. N. Merrick (S. Newcomb's sister), *McClure's Mag.*, v. 35, 1910, with many illustrs. Carnegie Inst., *Year Books*, nos. 1-8, 1902-09. Information from Dr. Anita McGee, daughter of S. Newcomb.

BIBLIOGRAPHY

I have elsewhere given Newcomb's Bibliography in great detail, 542 items: 319 under the general heading of "astronomy," 35 under "mathematics," 42 under "economics," 146 under "miscellaneous." Some of these items, apart from his 35 books, are quite extensive, for example

the 73 cyclopedia articles in no. 96 below. Others are very brief like his first publication (no. 1), a letter to a newspaper, and an anonymous note on B. Peirce (no. 31). In the present Bibliography nearly 400 items have been omitted, but an attempt has been made to preserve sufficient to suggest everything which is of outstanding significance, or which is of special interest from a mathematical point of view, and to illustrate the extraordinary diversity of Newcomb's interests and activities. The first three items (nos. 1-3) are given simply because they are the first three, although the first had interesting repercussions (see no. 94). All of his books and all foreign translations of items have been listed. Samples of his anonymous reviews and editorial notes have also been included; of the latter in the *Nation*, authorship was determined from the editorial file in New York City nearly thirty years ago. All items are here arranged chronologically regardless of topics.

1. "Velocity of meteors. Motion of bodies impelled by a single center of force," *National Intelligencer*, Wash., May 26, 1855, col. 2.

2. "Elements and ephemeris of the fifty-fourth asteroid" (with T. H. Safford), *AJ*, v. 5, 1858, p. 162.

3. "Elliptic elements of comet, 1858, V," *AJ*, v. 5, 1858, p. 178.

4. "On a method in dynamics," *AJ*, v. 5, 1858, p. 121-127.

5. "Note on differentiation," *Runkle's Math. Mo.*, v. 1, 1859, p. 396-397.

6. "Notes on the theory of probabilities," *Runkle's Math. Mo.*, v. 1, 1859, p. 136-139, 233-235, 331-335, 349-350; v. 2, 1860, p. 134-140, 272-275; v. 3, 1861, p. 68, 119-125, 341-349.

7. "Solutions of problems in probabilities," *Runkle's Math. Mo.*, v. 1, 1859, p. 349-350.

8. "On the secular variations and mutual relations of the orbits of the asteroids," *AAcAS Mem.*, n.s., v. 5, 1860, p. 123-152.

9. Solution of prize question: "Two rods 2 and 4 feet long, respectively, having their middle points connected by a string 1 foot in length are thrown up; show that the chance of their crossing is $1/2 + 2/\pi^2$," *Lady's and Gentleman's Diary*, 1860, p. 67-68.

10. "On the objections raised by Mr. Mill and others against Laplace's presentation of the doctrine of probabilities," *AAcAS Proc.*, v. 4, 1860, p. 433-440.

11. Solution of the problem: "Two great circles are drawn at random on a sphere. What is the probability that their mutual inclination, taken less than 90° , will be contained between any given limits, as n and m ?" *Runkle's Math. Mo.*, v. 3, 1860, p. 68-69.

12. "On the mathematical theory of heat in equilibrium," *Runkle's Math. Mo.*, v. 2, 1860, p. 346-351.

13. "Modern theoretical astronomy," *N. Amer. Rev.*, v. 93, 1861, p. 367-390. [Anonymous.]

14. "Investigation of the dynamical theory of gases," *AAcAS Proc.*, v. 5, 1861, p. 112-114.

15. *A Critical Examination of Our Financial Policy during the Southern Rebellion*, New York, 1865, 222 p.

16. *An Investigation of the Orbit of Neptune, with General Tables of its Motion*, Wash., 1866, 6+111 p.

17. "Our financial future," *N. Amer. Rev.*, v. 102, 1866, p. 100-135.

18. *An Investigation of the Distance of the Sun and of the Elements which depend upon it, from the Observations of Mars made during the Opposition of 1862, and from other Sources*, Washington, 1867, 29 p.

19. "On Hansen's theory of the physical constitution of the moon," *AAAS Proc.*, v. 17, 1868, p. 167-171; abridged in *AJS*, s. 2, v. 46, 1868, p. 376-378, and *Phil. Mag.*, s. 4, v. 37, 1869, p. 32-35.

20. "Comparaison de la théorie de la lune de M. Delaunay avec celle de M. Hansen," *CR Paris*, v. 46, 1868, p. 1197-1200.

21. *Report on Observations of the Total Eclipse of the Sun, Aug. 7, 1869*. Conducted under the direction of Commodore B. F. Sands, Wash., 1869, 214 p. (reports from ten scientists; S. Newcomb's report, p. 5-22); *Wash. Obs.*, 1867, app. 2, 1870.

22. "Aperçu d'une méthode directe et facile pour effectuer le développement de la fonction perturbative et de ses coefficients différentiels," *CR Paris*, v. 70, 1870, p. 385-388.

23. "Sur les inégalités de la lune dues à l'action des planètes," *CR Paris*, v. 71, 1870, p. 384–386.
24. "The let-alone principle," *N. Amer. Rev.*, v. 110, 1870, p. 1–33.
25. "Théorie des perturbations de la lune qui sont dues à l'action des planètes," *Journ. d. Mathém.*, s. 2, v. 16, 1871, p. 321–368; abstract in *CR Paris*, v. 72, 1871, p. 403–406.
26. *Reports on Observations of the Total Solar Eclipse of December 22, 1870* [at Gibraltar], Wash., 1871, 132 p. (S. Newcomb's report, p. 5–24, is one of five); *Wash. Obs.*, 1869, app. 1, 1872.
27. *An Investigation of the Orbit of Uranus, with General Tables of its Motion*, Wash., 1873 7+288 p.
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5. ROBERT SIMPSON WOODWARD

CURRICULUM VITAE.—B. Rochester, Mich. 21 July 1849; d. Washington, D. C. 29 June 1924. Received preparatory educ. at the acad. in his native town before entering U. Michigan (68–72; C. E. 72). Assist. engineer U. S. Lake Survey 72–82; assist. astronomer U. S. Venus commission 82–84; astronomer, geographer, and chief geographer U. S. Geol. Survey 84–90; assist. U. S. Coast and Geodetic Survey 90–93. Prof. mechanics Columbia U. (93–99; dean of school of pure science 95–04; prof. mechanics and math. phys. 99–04). P Carnegie Institution of Washington 13 Dec. 1904–1 Jan. 1921.

HONORS.—Assoc. ed. *AM* June 88–June 99. VP AAAS and chm. Sect. A, math. and astr. 89. Hon. Ph.D. U. Michigan 92. Assoc. ed. *Science* 94–24. Treas. AAAS 95–24. Treas. AMS 95–96. Mem. NAS 96. Assoc. fellow AACAS 96. VP AMS 97–98; P 99–00. P AAAS 01. P N. Y. Acad. Sci. 01. Mem. Amer. Phil. So. 02. Hon. LL.D. U. Wisconsin 04. Hon. Sc.D. Columbia U. 05. Hon. Sc.D. U. Pennsylvania 05. Starred *Amer. Men Sci.* 06. P Phil. So. Wash. 10. Hon. LL.D. U. Michigan 12. P Lit. So. Wash. 13–14. Hon. LL.D. JHU 15. P Wash. Acad. Sci. 15. Mem. Naval Consulting Board 15–24. Chm. Sect. on astr., meteorology, seismology, Second Pan-Amer. Scientific Congress, Washington, D. C. 16.

BIOGRAPHICAL NOTES.—Dr. Woodward was a son of Lysander and Peninah A. (Simpson) Woodward. His father, who was of New England ancestry, settled in Michigan about 1835. He was one of the most progressive farmers of the state, sought to apply scientific principles to the operation of his farm, and took a keen interest in public affairs. His mother belonged to a family prominent in the annals of Connecticut. Already in his primary triangulation work on the Great Lakes Dr. Woodward acquired what turned out to be a life-long interest in the earth as a whole—its shape, its tides, its atmosphere, and a host of geophysical problems, many of which still await solution. The service on the Venus Commission was under Asaph Hall, the discoverer of the satellites of Mars. Thus twelve years after graduation were spent in geodetic and astronomical work of the highest precision. It was during the next six years that Woodward wrote his most important scientific papers (e.g. nos. 19, 26, 27, 28). These contributions were geophysical, having in part to do with the deformation of the earth's surface as the result of the removal or addition of load over a large area, and in part with the secular cooling of the earth. He also studied the field methods for topographical mapping and for primary and secondary triangulation and put them on a practical engineering basis. During his years with the Coast and Geodetic Survey he worked on the problem of base-line measurement in primary triangulation, and he developed the iced-bar apparatus for measuring base-lines and calibrating steel tapes and was the first to prove that base-lines could be measured with sufficient accuracy by means of long steel tapes. This work was of fundamental importance to geodesy and resulted in the saving of much expense and

time in field work; also it placed the primary triangulation work of the Coast and Geodetic Survey on a higher plane than had been previously possible.

During the twelve years at Columbia he was remarkably successful both as teacher and as administrator. He had a most attractive, genial, and lovable personality, and his advice was being so constantly sought by students and members of the faculty, that he found it very difficult to pursue the mathematical work to which he had looked forward. He was a member of the Society from May 1891 and became successively its treasurer, vice-president and president. His *Higher Mathematics* (no. 43) edited in collaboration with Mansfield Merriman (1848–1925), in different forms attained to some popularity, and his own part has been translated into French since his death. More than one of his publications display power in applying mathematics to practical problems. Among the 80 mathematicians and 150 physicists arranged according to their rating by colleagues in 1903 Woodward was twenty-first in the first group and eleventh in the second (*Amer. Men Sci.*, 5th ed.).

Andrew Carnegie gave bonds valued at more than ten million dollars to establish at Washington an Institution to promote study and research. Daniel C. Gilman, president emeritus of the JHU, was its first president, but he undertook the task only temporarily until the best man for the position could be selected. When Dr. Woodward became president, the Institution was only two years old and had still to determine the best policies to follow. At this critical period, his mature judgment and experience, his clarity of vision, common sense, enthusiasm, and geniality, led, after much travail, to the establishment on a firm foundation of an Institution which has very notably promoted learning in this country. On looking back over his years of activity, he states in his last report as president that "probably no other organization in the evolution of learning has been so beset by what Dr. Johnson called the anfractuosities of the human mind as the Carnegie Institution of Washington." Prof. J. M. Cattell reports that the late physicist, Prof. O. N. Rood, once said that "he liked to go to faculty meeting in order that he might sit and look at Woodward" (*Columbia U. Quart.*, v. 7).

Karl W. Woodward, professor of forestry at the U. New Hampshire is one of three sons of Dr. Woodward.

SOURCES.—F. E. Wright, memoir, bibl., portrait, *Geol. So. Amer., Bull.*, v. 37, 1926. F. E. Wright, *DAB*, v. 20, 1936. *Universities and their Sons*, Boston, v. 2, 1899, portrait. *Nat. Cycl. Amer. Biog.*, v. 13, 1906, portrait. *Who's Who in Amer.*, v. 12, 1922. *Amer. Men Sci.*, 3d and 5th eds.

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