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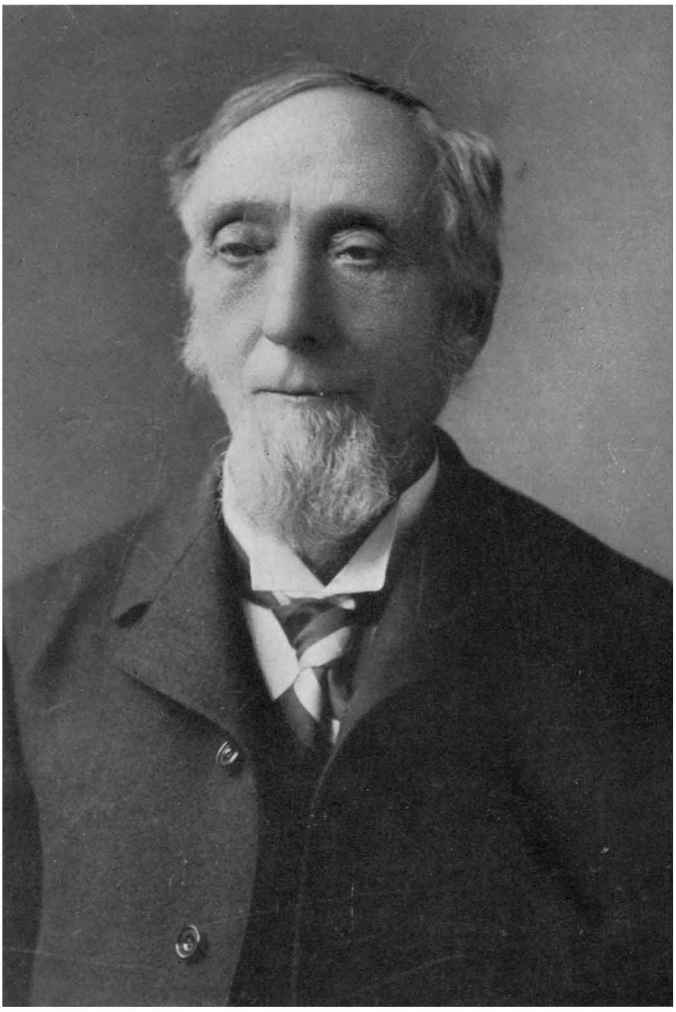

Chas. A. Schott

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CHARLES ANTHONY SCHOTT.

It is inevitable that those to whom is vouchsafed a long life of usefulness should outlive the friends of their youth. One who would at this late day speak of the early life of our colleague, CHARLES ANTHONY SCHOTT, will find that his life was wholly devoted to the work of the Coast Survey. His companions of those days have passed away; were they living we cannot doubt that they would give one universal testimony. The indefatigable Bache would recall his own visit to Germany in 1836-1838, his inquiry into the condition of scientific education, and his eventual report thereon. He would recall an interview with Gauss and his account of the geodetic and magnetic work in which that gifted man was interested. He would recall that he had himself visited the Polytechnic School at Carlsruhe and knew that any graduate from that institution, where Schott began study three years later, would be a desirable addition to America and to the Girard College that was then uppermost in his mind. He would tell us of Humboldt, of Sabine, of Bessel at Königsburg, of Struve at Dorpat, and of the great works they were doing for the benefit of the world. Bache esteemed highly the educators and the scientists of Europe and did not hesitate to employ both in American works.

It is not a light matter to properly depict the strength and work of one who, like Carl Anton Schott, left the impress of his own character and of his example on every detail of such a great national undertaking as our Coast and Geodetic Survey, and equally so on every man associated with him in the prosecution of the work of the Survey. As a great man's influence never ends, so also there is no definite finality, no end, to a great survey; it runs along for centuries, ever responsive to the strain of the increasing needs of a growing population and an enlarging domain. Granting that we must protect our shipping by surveying, mapping, and guarding our coasts; that we must map our interior lands to keep up with increasing business enterprises, and that we must do this with every new addition to our possessions; it follows that the Survey becomes one of

our permanent institutions, essential to our prosperity. It must increase in thoroughness, efficiency, and expense so long as our Republic preserves its vitality and energy. Its activity must penetrate into every branch of knowledge and into every new path of exploration.

We vividly realize the pleasure it must have given Schott, from his youth onward to old age, to take such an important part for over 50 years in framing the fundamental organization of the Survey and its attendant geodesy. From his early education at Carlsruhe as a civil engineer, and from his first employment, at the age of 22, by Bache, he appreciated the importance of a thorough knowledge of field work as well as office work; his own activities in every line of work have served as ideals for hundreds of expert assistants. The hydrography of harbors, channels, rivers, and oceans, the details of the minute accuracy of base-line measurements, the sources of errors in geodetic triangles, the methods of determining astronomical latitudes and longitudes, the methods of hypsometric determinations, the errors of magnetic and pendulum apparatus, were all known and appreciated and many of them greatly improved by him, to say nothing of the effective systematization introduced by him into all computations and office work.

Schott's six years of study at the Carlsruhe Polytechnic afforded him the basis for his life work. His early years were spent in helping Bache to lay solid foundations for the structure that was to bring honor to all engaged upon it. He brought to us from Germany those abilities and tendencies that by inheritance and education characterize the great German nation, to which we are ourselves so closely related. European civilization has developed innumerable peculiarities, characteristic of nations, families, localities, and the progress of the age. These have been brought across the Atlantic from Europe to America with each successive wave of migration. The ideal example set before us by Schott, his energy, adaptiveness, perseverance, both intellectual and physical, his love of home, drawing, painting, and mathematical precision, are to be held as most precious characteristics.

Our colleague was born at Mannheim on the Rhine, in the Duchy of Baden, August 7, 1826, the oldest son of Anton Carl

Schott and Anna Maria Hoffmann. The inheritance of some property by the mother sufficed to insure the comfort of the family during the succeeding years. The happiness of the child at home is well assured by a glance at the sweet little "new year's poem" read by him on January 1, 1833, as a tribute to his parents on that annual holiday. "To your faithfulness alone I owe my happiness" is the prevailing sentiment that pervades his lines. Many years later, when his own children begged for some sketch of his early life, he wrote a page or two from which I am allowed to quote:

AUTOBIOGRAPHY OF THE EARLY LIFE OF CHARLES ANTHONY SCHOTT.

"As the most momentous question in any biographical sketch is that of birth, I begin with that event, which happened to me on August 7, 1826, at Mannheim, in the Duchy of Baden, at the confluence of the Neckar and the Rhine. My parents belonged to the middle class, my father being a merchant, the son of a judge, who left him no fortune in consequence of the Napoleonic wars, which were particularly hard on the inhabitants of the Rhine provinces. My mother, however, being an heiress, placed us in comfortable circumstances.

"It was stipulated at the marriage of my parents that any children that might be born should be reared in the Lutheran faith. Although my father was christened in the Catholic church he was nevertheless a man of free thought. All religious ideas that I ever had were due to my mother's influence. I had two sisters and one brother, my sister Anna being the only one who lived to old age.

"My earliest recollection is of my crying on being unable to open my eyes one morning, they being glued together. My second, a walk across the market-place with my parents. We met an acquaintance who asked me, 'How old are you?' My mother told me to say, 'I am in my third year.' My first memory of school days is learning to read my letters from a book spread on the teacher's lap. Sitting one day in a big arm-chair, one of my parents asked me, 'Karl, do you want to go to school?' I said, 'Yes,' and was promptly sent to the free public school, being then six years old. Here I was taught the rudimentary studies—reading, writing, spelling, arithmetic, and a little geography—for three years. At this time we had a French governess at home to drill us in the French language.

"At the age of ten or eleven I entered the Lyceum or classical school at Mannheim, where I was pestered with Latin for four years and one year with Greek, to my great disgust, as I had more aptitude and keen sense for natural history. Beside the classics we had mathematics, natural history, geography, and, the last year, rudiments of physics, but no teaching in other language than the German and no history except the

ancient. The whole plan of the Lyceum was conducted with the idea of cutting off all liberal thought and severing all connection between Roman and Greek history and modern history. One redeeming feature was the admittance of some athletic sports. Attendance on religious instruction was compulsory, with an effect only skin deep. That I must have had something of an inquisitive mind I infer from the fact that my schoolmates nicknamed me *'Vir doctus.'*

"Having shown some talent and inclination for mechanics and an eagerness for scientific study, my father determined to send me to the Polytechnic School at Carlsruhe, in 1840, to perfect myself in civil engineering. For the first two years I was placed in the home of the professor who had charge of the physical laboratory, where I laid the foundation of experimental inquiries. Here I received a stimulus and became conscious of a desire and capacity for serious work. I enjoyed the utmost freedom as to the workings of my own mind, absorbing with intense interest not only the multifarious topics taught, but making independent investigations and associating myself with kindred minds for pursuit of other knowledge, especially the rudiments of astronomy, for which at that time no chair existed. With a small hand telescope, a home-made sun dial, and a star chart, I acquired some knowledge of the constellations, and with the help of Littrow & Bode's 'Astronomy' I was enabled to compute lunar and solar eclipses, to my intense gratification. I here also learned to handle magnetic instruments, to which in later life I devoted much time.

"The three preparatory departments of the Polytechnic were successfully passed, and the last three years were devoted especially to engineering, so I graduated at the age of 20 as civil engineer of Baden. Of six graduates I came out as number 2 of the class of 1847. These six years at Carlsruhe I reckon among the most pleasant of my life, making frequent excursions on foot through the Vosges Mountains and the Schwarzwald, gratifying also my love for drawing and sketching. Later I penetrated into Switzerland and upper Italy, Lombardy, Milan, and Venice, also visiting the art galleries of Munich to study their treasures.

"I expected soon to enter the service of the State, as the railroad development at that time required engineering ability; but in this I was disappointed, owing to the great political agitation for freedom in Germany, known as the revolution of 1848. After shouldering a musket for a short time in the liberal ranks, and not finding military life congenial, and seeing no early chance of making a living, I obtained leave of absence from the State to visit the United States, with a view of perfecting myself in my profession. About this time my father met with reverses in business, and had the misfortune to become blind; this forced me to rely upon my own resources.

"With about $150, I set out for America, in June, 1848, at the age of 21."

As above stated, and after serving the State for a year, Schott obtained leave of absence, in 1848, to visit the United States, "with a view of perfecting myself in my profession," as he says. But if he entered our Survey with the idea that it was only a temporary employment, and that he should eventually return to Mannheim, he was very happily disappointed, for he never left its service. Eventually he became a naturalized citizen of the United States. He served our Government and the Coast Survey to the day of his death, July 31, 1901, a little less than 53 years.

His voyage, starting from Mannheim on Thursday, June 15, and ending in New York City on Tuesday, August 8, 1848, is fully narrated in a daily journal still preserved by his family and which I have been permitted to inspect. This journal is full of remarks bearing upon such matters as a most intelligent engineer and student would be likely to note, notwithstanding the great difficulties under which he labored, in company with many others, on an English sailing ship of about 1,500 tons. The vessel is spoken of as the *Prince Albert of London,* and it progressed under sail very slowly. He gives an interesting analysis of the psycological phenomena attending the four movements of the ship "lengthwise, crosswise, vertically, and twisting for two days and three nights; and I have scarcely any seasickness, but a slight headache." "Smoking and the cloudy weather of the English Channel produce no seasickness like that of English passengers who eat much meat; but now and then a thought of homesickness." He gives many suggestions with regard to the provisions that each passenger must provide for himself or else buy of the ship's cook. He is particularly interested in the navigation of the vessel, the sextant observations for latitude and longitude, the currents of the water in the ocean, the variety of birds above the ocean, and the animal life in the ocean, of which he writes like a young naturalist on his first voyage of discovery. Undoubtedly, the journal was written for transmission to his parents and must have furnished the basis for many interesting letters. Those were the days preceding regular steamship navigation across the Atlantic, but he had seen something of steamboats on the Rhine. His steamboat experience of 24 hours from Rotterdam

to London (June 20, noon, to June 21) on the *Batavia,* with colossal engines of 200 horsepower, had given opportunity for many personal experiences. To him "London seems smoked like a ham in a chimney and is thoroughly unpleasant to me as a residence." The captain of the *Prince Albert* sailed slightly south of New York, against the Jersey coasts, where he was becalmed, "so that we should not have arrived for two days longer had it not been for a steamer that picked us up 40 miles from New York." What a contrast between the present days and those when, as he says, "we passed the quarantine, and at a short distance from the city the luggage was examined, but in a very superficial manner, so that one might smuggle as much as one wished." He had had a premonition that he should arrive on the twenty-second anniversary of his birthday, and doubtless he wished it to be so, for his journal concludes with the words, "Now that I have safely arrived, may my other wishes also soon be realized."

Having landed in New York August 8, 1848, but scantily provided with money and conscious of the failing strength of his father, we feel assured that Schott must have found some temporary employment, being thrown upon his own resources while looking about for an opening in his profession as engineer. It is said, on credible authority, that Schott came with letters of introduction to a very distinguished countryman and compatriot, Theodore E. Hilgard,* of Zweibrücken, the ducal city of the Palatinate, not far from Mannheim, and which after various vicissitudes had been returned to Bavaria as a part of her possessions by the Treaty of Luneville about 1814. He was an eminent German jurist and author, who had migrated to America and settled with his family, in 1835, on the

* Theodore E. Hilgard, the father of J. E. Hilgard, was the cousin of Gustavus Hilgard; the latter was the father of Ferdinand Heinrich Gustav Hilgard, who was born at Speyer in 1835 and educated at Zweibrücken and Munich. Emigrating from the latter city, he stayed for a while with his grand-uncle, Theodore, near Belleville. Eventually Ferdinand became famous under his adopted name as Henry Villard, the American journalist and financier, who died in 1900. The students of eugenics will be interested to know that from the single grandparent in Zweibrücken (Jacob Hilgard and Marie Dorothea Engelmann) there descended men of such eminent ability as Theodore E., born 1800; Gus-

prairie near Belleville, Saint Clair County, Illinois, when his eldest son, Julius Erasmus Hilgard, was 10 years old. The son removed to Philadelphia in 1843, at the age of 18, to pursue the study of civil engineering. Here he became acquainted with Bache, who had been appointed Superintendent of the Coast Survey in 1845 and who soon added J. E. Hilgard to his civilian force. Doubtless it was through Hilgard that Schott was brought to the notice of Bache and into the service of the Coast Survey, his appointment dating from December 8, 1848. At that time Bache, the Superintendent, at the age of 37, Hilgard at 23, and Schott at 22, formed a trio of young men by whom the Survey was to be moulded into its present shape.

Should we not stop a minute to consider and compare Bache, the organizer of men; Hilgard, the man of affairs; Schott, the adviser and computer in great geodetic operations.

The most prominent trait in the life of that gifted man, Alexander Dallas Bache, was his wisdom and ability in calling to himself and holding the great body of men needed to do his work in the best possible manner. The reorganization of the Survey, in 1843, was but a natural culmination of his early work as chemist in the University of Pennsylvania and his work as educator in Girard College. He had a perfect appreciation not only of the needs of the Survey, but of the character of the American people. He inherited the ability and wisdom of his grandsire, Benjamin Franklin; he had been trained in the discipline and traditions of West Point; he was devoted to exact science and an authority on everything bearing on education. Thrown into daily contact with the ablest men in every department of life, gifted with unusual geniality, acceptable to every element in American society, he gathered together the army, the navy, the civilians and the scientists, the beginners

tavus, distinguished in law; Julius E., born 1825, distinguished in physics; Theodore, born 1828, professor at the University of Munich; Heinrich Villard, born 1835, the financier; Eugene Waldemar, born 1833, the American geologist and chemist, and finally Otto Hilgard Tittmann, the son of Rosa Hilgard, born at Belleville in 1850, who entered the Coast Survey in 1867 and has been its Superintendent since 1901. Dr. George Engelmann, the botanist of St. Louis, and his cousin, J. E. Hilgard, the physicist, were among the founders of our National Academy of Sciences.

and the experts into one harmonious mass of active workers, among whom none were more enthusiastic and active than Hilgard and Schott.

After spending a few months in New York, Schott appears to have applied for work under Bache, or rather with Hilgard, who was just a year older than himself and had had analogous education, but not quite so much severe training. They were equally industrious and enthusiastic, and from that time onward were closely associated in all the work of the Survey until the resignation of Hilgard in 1885. Bache always praised them both for these same qualities; but as Hilgard developed in the humanities, while Schott devoted his whole thought to the intricacies of the fundamental geodetic operations, therefore Bache, as General Superintendent, soon perceived that Schott, as a trained engineer, mathematical geodesist, and clear-headed magnetist, was the man to whose hands all intricate calculations could be safely intrusted. Thus it came about that long after the death of Bache (February 17, 1867) the computing division, the vital heart and vivifying blood of the whole Survey, continued to receive the impress of Schott's sturdy character, his thoroughness, honesty, modesty, fairness, perseverance, persistent search for error.

Are not these traits the natural results of the habit of thought incidental to a thorough university training? In the delightful days of college life and university life it is the senior professor whose kindly words do honor to himself and his students also by public recognition of the merits of the young candidates for university degrees. The encouragement and stimulus thus given to a modest young man in his long search after the hidden truths of nature is the most admirable feature of student life. It was this that gained the devotion and love of many a student of Neumann, Bessel, Struve, in the early days when Germany was teaching the world that her strength lay in the fullest recognition of every man's originality and ability. Her query was, "Whose brain thought of this? Show me the man." It was this spirit of good work and full credit that filled the air at Mannheim and Carlsruhe in those troubled days of 1848. Those were the days that tried men's souls in Germany. My own revered instructor, General Koerner, of

the College of the City of New York, was one of the many then expatriated, and fortunate it was for me that, in 1850, in New York he found employment for his talents in descriptive geometry. No wonder that Schott left Mannheim to find peace and work in the new world.

A beautiful testimony to Schott's character and influence in life was summed up in the mortuary tribute expressed by his associates on August 1, 1901:

"He was enthusiastic, faithful, and diligent in all duties he was called upon to perform, and through his learning and probity earned a reputation extending over two continents which is most worthy of emulation. Conscientious and expert in his specialties—geodesy and terrestrial magnetism—his labors added immeasurably to the reputation of the Bureau and of his comrades who gathered the material he so ably discussed. The methods of computation now in use in the Bureau are an indelible record of his ability. His high ideals of duty and his tireless and persistent striving for them, made him stand forth as a noble example of the best type of public official, and his uniform kindliness endeared him to those who knew him as a friend."

BIBLIOGRAPHY.

It will be profitable to consider in detail some of Schott's works. These are mostly official publications of the Coast Survey and are enumerated in detail in the appended bibliography, for which we have to thank Mr. Ralph M. Brown, the Librarian of the Coast and Geodetic Survey. We have arranged the titles chronologically in order that one may follow the steady development of the broad system of study that Mr. Schott maintained during his lifetime. It is to be noted that the natural quietness and the perfect modesty of our colleague rarely allowed him to read any special memoir in public. His life was one of quiet thought and labor; his best judgment was daily called forth in matters of the highest precision; he was the best of advisers, but not given to public expositions or popular display. Having become a citizen among us, having entered the congenial service of Bache and his adopted country, he remained in continuous service from December, 1848, to July, 1901. These 53 years, through many changes of administration, enabled him to carry to perfection a great systematic work; he was our ultimate authority during his life-

time in matters relating to geodesy, terrestrial magnetism, practical astronomy, standards of length, hypsometry, and climatology. Probably no one in this country has covered so wide a range of close study, accurate knowledge, and laborious computation. The list of his publications constitutes an impressive monument, built of his own works, better than a marble cenotaph raised to his memory.

HYDROGRAPHY AND OFFICE WORK.

The first practical problems of the United States relative to the coast consisted in determining the locations of dangers to navigation, such as rocks, shoals, and the treacherous currents due to winds and tides. Schott's attention had been drawn to this subject first when he left Rotterdam and sailed from London along the shores of Kent and through the English Channel, and again when he skirted the American coast of New Jersey northward to New York. These were his first experiences in oceanic coastal waters. He was quick to perceive the sources of danger, and asked Bache that his official duties might include hydrographic service as well as office work in Washington.

The first office buildings of the Coast Survey were in some old residences adapted to office work, on the southerly slope of Capitol Hill, adjacent to the residence of Daniel Carroll, of Duddington. They are now replaced by Government structures. The delightful southeasterly breeze of summer was in those days filled with mosquitos and malaria from the canals and marshes, but the progress of recent years has removed the canals and marshes and other objectionable features. The shambles and slave-pens, the old railroads, the telegraph poles, the surface drains, the yellow fever and the cholera of 1830-1860 have given place to our model city of the present century.

In those days it was a physical relief and an intellectual advantage to escape from office work in the summer months and devote that season to the field work and the pure air implied in hydrography and geodesy. Both Bache and all of his assistants profited by such summer months of field work. The semi-annual transfers of duty from Washington northward or southward, or even from the Atlantic to the Pacific coasts, became an important hygienic feature in the office work. Thus

it was that in the very beginning Schott was assigned as occasion demanded, alternating between hydrography, geodesy, and the computing division. After his first assignment, in 1848, to the latter division he was soon drawn away, namely, October, 1849, to hydrographic work in Albemarle Sound and Mobile Bay, under Commander James Alden. In August, 1861, he made the survey of Casco Bay, and in 1863 determined the location of all the fortresses or earthworks thrown up for the defenses of the city of Washington.

THE COMPUTING DIVISION.

Early in Schott's official life Bache had perceived his special fitness for extensive geodetic computations. For some years the computing division was officially in charge of Schott only during the absence of J. E. Hilgard; but the gradual extension of the work and his evident fitness brought about a reorganization, in 1854, and on July 1, 1855, Schott became wholly responsible for this division and so remained for 45 years. Bache realized the absolute dependence of the Survey upon men thoroughly trained in both mental work and physical work—the sound mind in the sound body. Such men as A. A. Humphreys, of West Point; James Alden, of the Navy; Sears C. Walker, among the astronomers; C. A. Schott, of the Polytechnic School; he could always rely on implicitly. He seemed instinctively to know where to look for his assistants and whom to choose. In his annual report of 1848, page 57, Bache says:

"A superficial examination of the subject, or the taking for granted of a prescribed routine, is apt to impress one with notions of the great accuracy of results in which are concealed constant errors of grave importance. Turning up the surface develops these concealed errors and leads to scientific discovery. The action of different minds accelerates the progress of truth, and on this account I have published a paper of Assistant Sears C. Walker." . . .

It was by "turning up the surface" that Walker discovered, in 1847, the old observations of Neptune by Lalande, on May 16, 1795.

In his report of 1850 Bache says that George Davidson, H. M. Harrison, James S. Lawson, and John Russell, in April,

1850, "volunteered to serve in any extremity and in any duty, however hard or manual, relating to the survey of the coast of California." This was his way of securing men who proved their faithfulness during many subsequent years. This was the beginning of the California surveys and the strenuous rush work of 1850. The extension of the Survey to the Pacific coast made it necessary for Schott to be called in, on July 18, 1850, from his hydrographic work under James Alden, and brought about a more detailed organization of all office work. Probably the first evidence of his genius consisted in his comparison, during 1848 and 1849, of the first and second sets of computations of the observations for latitude with the zenith telescope, at the station Unkonoonuc, for the method was novel and the sources of instrumental error as yet unknown.

Every successive annual report of the chief bears witness to the steadily increasing impression made upon all by his genius and his work. Thus, in 1851, page 93, Bache says:

"He has great aptitude for scientific investigations, whether pertaining to astronomical, magnetic, geodetic, or hydrographic subjects, and his zeal and industry are fully equal to his ability."

Again, in his report for 1853, on pages 8 and 9, he writes:

"The computing department of the office has attained a position of efficiency worthy of all praise, and of special mention in enumerating the permanent results of the work, though this has been due not to the efforts of one, but of many years, combined with remarkable zeal and assiduity directed by clear intellect and ample knowledge."

Bache kept the personal acquaintance and oversight of every man; neither navy, nor army, nor civilian, nor scientific alone, but each and all together. In the report for 1854 Bache agrees with Captain Benham, who was then in charge of the office, that "the computing division is an excellent organization, the most regular, efficient, and economical of any of the branches of the office." On July 1, 1855, Schott was made chief of the computing division and his colleague, Hilgard, soon became chief of the office work in general. In connection with successive increases in salary, which are generally accompanied by a few words of commendation, we find, on page 155 of the report for 1858, Bache says:

"I agree with Palmer, in charge of the office, that the ability, industry, and strict attention to duty that characterize the chief of the computing division are rarely equalled. His health suffers from the confinement to which his duties have subjected him."

The successive appointments and responsibilities which came to Schott are here brought together:

1848, Dec. 6. Appointed in the Coast Survey at $25 per month and assigned to computing division.

1849, April —. Assigned as hydrographic draftsman under Lieut. James Alden to the schooner *J. Y. Mason,* operating in Albemarle Sound.

1850, do. do. Operating in Mobile Bay.

1850, July 17. Returned to the computing division.

1853, Dec. 3. Received naturalization papers as an American citizen.

1854, Jan. 1. Marriage to Teresa Gildermeister at Washington, D. C.

1855, July 1. Appointed chief of computing division, Coast Survey.

1861, Aug.-Oct. In charge of the schooner *Joseph Henry,* making hydrographic survey of Casco Bay, Maine.

1862, ————. [Hires a negro as his substitute for army service during the Civil War. The Royal Society of London sends him a letter of thanks for his reduction of tidal observations in the Arctic Seas made by Elijah Kent Kane.]

1863, ————. [By request of Major Barnard he determined the positions of the fortifications erected in defense of Washington. September 28, date of marriage to Bertha Gildermeister at Prairie Home, Illinois.]

1869, Jan. 1. Conducted a party to Illinois to observe total eclipse of the sun.

1870, ————. Sent to Catania, Sicily, as a member of the Superintendent's party to observe total eclipse of the sun.

1871, ————. A founder of the Philosophical Society of Washington.

1872, ————. Elected a member of the National Academy of Sciences.

1874, ————. Made a member and Fellow of the American Association for the Advancement of Science.

1896, ————. Made a member of the Sociedad Cientifico Antonio, Alrata, Mexico.

1898, ————. Represented the Coast and Geodetic Survey at International Conference on Terrestrial Magnetism at Bristol, England.

1898, ————. Made a member of Washington Academy of Sciences.

1898, ————. Awarded the Wilde Prize by the French Academy of Sciences.

1899, Feb. 4. Wilde Prize delivered by President McKinley in person.

1899, Dec. 31. Relieved from duty as Chief of Computing Division and assigned to charge of computation of arc measures.
1900, ———. Transcontinental Triangulation, etc., published.
1901, ———. The manuscript of the Eastern Oblique Arc completed.
1901, July 31. Died at Washington, D. C.

LONGITUDE AND LATITUDE.

Among the many innovations on methods that were formerly in use in Europe, one of the first to be encouraged by Schott and adopted by the Coast Survey was the so-called American method of recording by chronograph the observations made with the astronomical transit. Then quickly followed the application of this method to the determination of differences of longitude by the use of the Morse system of electro-magnetic telegraph. It would seem that crude forms of chronograph, with the complementary appliances added to the astronomical clock, were first devised by O. M. Mitchell, founder of the observatory at Cincinnati, his assistant, Mr. Twitchell, and his friend, Professor Locke, all of Cincinnati; but these were soon replaced by the Bond spring-governor. The gifted Sear C. Walker,* one of the first men secured by Bache for assistant in the Coast Survey, in 1847, was in charge of all longitude work until his death, in 1853. To Walker we owe the rapid development of this new American method of determining longitudes, which was subsequently perfected by our late colleague, Benjamin Apthorp Gould. To Mr. Schott fell the special duty of adjusting these most accurate longitudes into a homoneneous system. His report on the telegraphic longitude network of the United States and its connection with that of Europe by cable gave us the best results on that subject that we could have at that date. The recent application of radio-electric waves to the same purpose seems also to have been first tried by the Coast and Geodetic Survey, and is no greater advance on Walker's telegraph method of 1847 than was that on the eye and ear method of previous centuries.

* Born 1805 in Massachusetts; graduated at Harvard 1825; founder of the observatory of the Philadelphia High School; appointed in the Naval Observatory at Washington in 1845.

Schott's initiation into the new ideas that were suggested in America covered not merely the application of the electric telegraph to longitude work, but equally so the application of Talcott's zenith telescope to the determination of latitudes, which rapidly replaced the prime vertical and other apparatus. In recent years the demonstration by S. C. Chandler of actual periodical variations in terrestrial latitudes and the corresponding periodical shift of the earth's polar axis was accepted by Schott with the liveliest interest, and in the light of this discovery he at once proceeded to review the observations of latitude made by numerous persons for use in the Coast Survey. He had previously given special attention and instructions as to the Coast Survey method of using the zenith telescope and had declined to order apparatus of the Repsold vertical circle type, having decided that the method of Capt. A. Talcott gave most reliable results.

CHARTOGRAPHY.

The methods of projecting or developing the surface of a spheroid on a flat surface of paper afford endless problems of importance to the geographer. Schott's decision was strongly and consistently in favor of the polyconic projection for many cases, and especially those in which large portions of the earth's surface are involved. Of course, a special system of projection must be adopted to suit the nature of a given problem, and he gave us a lucid, comprehensive summary of our knowledge on this subject, showing the relative values of the polyconic and other projections. The polyconic seems eminently adapted to some meteorological problems, and has lately been urged upon the attention of the international meteorological committee; but we still need a more appropriate projection—probably a modification of the polar projections.

The extensive memoir on projections by Craig and the comparisons by Schott, as well as his extensive tables for the use of the chartographer, constitute valuable additions to our knowledge of the subject.

MISCELLANEOUS OBSERVATIONS.

Several applications of mathematical methods to the needs of the work of the Survey led Mr. Schott to the consideration of special formulæ for interpolation. Thus we find a memoir by him, in 1860, on Cauchy's formula, and again one on the development of Bessel's functions, and another one on the solution of normal equations by indirect elimination.

A few personal observations of astronomical character were published by Schott, such as his observations of the variable star Algol, in 1856 and 1858, and his observations of solar spots, in 1860, 1861, 1862, enough to show that he was always willing to devote a few minutes of his precious time to assist others in gathering the facts needed in a new field of research.

TERRESTRIAL MAGNETISM.

Terrestrial magnetism occupied a large share of Mr. Schott's attention. His collections of original data on this subject are undoubtedly the most extensive of any that have been made relative to North America. They cover the widest range, both geographical and chronological; they were made the basis of the first detailed map of isogonic lines and of a study of the secular variation in magnetic declinations.

A historical review of the work of the Coast Survey in connection with terrestrial magnetism was published by Schott in the report of the Survey for 1888.

Our knowledge of terrestrial magnetism owes its present advanced condition to the universal interest in the magnetic needle, which has always been a puzzle to mariners, surveyors, and philosophers. Systematic observations of the needle were undertaken by all nations under the stimulus given by Alexander von Humboldt, Carl Friedrich Gauss, and General Sabine. They urged that Bache take up the subject, and the trustees of Girard College authorized him to build our first magnetic observatory in 1838. Observations at this observatory were made from 1840 to 1845, and in its connection a general magnetic survey of Pennsylvania was made, in 1840, by Bache. When he became the Superintendent of our Coast Survey, in 1843, he quickly saw that all this was but prepara-

tory to a great public work, and into this work Schott entered with delight. His own masters in Germany had imbued him with a sense of the importance of magnetics, and also with the pleasure of research in an unknown field. With Gauss and Weber as his great exemplars, Schott devoted all available time to magnetics. The accompanying bibliography shows the great work that he accomplished—an extensive collection of old American data; a complete new reduction of all the Girard College work; the construction of new apparatus and the determination of new values for dip, declination, and intensity at many American stations; an exhaustive study of the magnetic condition on board ships and the correction of the standard binnacle compass; the influence of the aurora; earth currents and magnetic storms and their relation to spots on the sun and the secular variation of the needle—until finally, in 1898, the council of the Academy of Sciences of France unanimously awarded to our colleague the gold medal established by Henry Wilde, and did not hesitate to say:

"The extensive work accomplished by Mr. Schott cannot be stated in a brief résumé. . . . The whole of this work furnishes one of the most important contributions in the history of terrestrial magnetism, and the committee is unanimous in awarding the Henry Wilde Prize to Charles A. Schott."

The transmission of this medal to President McKinley and its presentation to Mr. Schott at the White House, February 4, 1899, formed a very pleasant episode. An extract from the President's remarks will always be worth reading:

"I congratulate you . . . that you have been chosen from all the world as the one most worthy to receive this great honor. It is especially pleasant in this age, when international relations are of high importance, to know that this fine prize, founded by an Englishman, has been awarded by Frenchmen and won by an American."

In connection with the Wilde Prize, Dr. Henry S. Pritchett, who was at that time Superintendent of the Coast and Geodetic Survey, writes as follows:

"I knew Mr. Schott for a long time when I was an assistant to the Naval Observatory, but of course came to know him better when I went to the Coast Survey as Superintendent, in 1897. He was then the chief of the computing division, and it would be impossible to state too

highly his ability and zeal in this work. For years past he had been the strength of the Survey in its geodetic computations and operations. One incident which I remember with great pleasure was the conferring upon Mr. Schott, in 1899, of the prize awarded by the French Academy. He had been subjected to so many annoyances and difficulties that I asked President McKinley to confer this prize in person, and this was done at the White House, in the presence of a number of Mr. Schott's colleagues."

When the news of this honor reached Mannheim, that city realized that it also had a share in this distinction. The sweet character of this most modest and lovable of men, who was known to most of us only as the disciple of rigorous mathematics, is shown by his lasting affection for the home of his childhood and by his happiness at being once more brought into close connection with the scenes of his boyhood and the friends he had left just 50 years before.

The letter from the Mayor of the city of Mannheim with reference to the Wilde Prize is not in my hands, but I quote from a rough draft of Schott's reply:

"It has been one of my greatest pleasures to receive the sentiments expressed in your letter of December 16, referring to the occasion of the Wilde Prize lately awarded to me. What is most gratifying is the high appreciation on your part of any distinction conferred on one of the citizens of Mannheim, however long since and far away he may have wandered from his native town.

"I must recognize the fact that whatever success in after life I may have attained is in a great measure due to the solid foundation laid in my early education in the city of my birth and later on at Carlsruhe.

"After passing my State examination as civil engineer and anxious for active work, I left home in the disturbed year 1848, and was fortunate enough to find here a field open for my taste and ambition.

"I desire to thank you most sincerely for the transmission of the kind and appreciative sentiments sent me from my native town, which, I must confess, have once more strongly reminded me of the bonds which bind together my early and later life."

In Mr. Isaac Winston's contribution to our knowledge of Mr. Schott (*Science,* August 9, 1901) he mentions that the early recognition by Bache of Schott's ability, zeal, indefatigable industry, vast mental resources, caused his prompt assignment to the computing division and offered a wonderful opportunity to a man capable of distinguishing himself, and this

was realized to its fullest extent by Mr. Schott. He was placed in charge, in 1855, after jointly sharing its responsibilities with Mr. Hilgard, who was often absent in field work. From this time onward geodesy and magnetics claimed an equal share in the office work; meteorology and climatology as a part of terrestrial physics took up a greater part of his non-official time.

By such huge labors as these one must necessarily become a computing machine and an automaton; only the most rigid systematic economy of time and strength could enable one to endure this life-long habit of thought. Both quickness of action and economy of health were favored by his habit of standing at his work desk, thereby contributing to a state of health so perfect that no infirmity attacked him until the last few months of his life. He was always able to throw off the work and worries of office life and to find complete recreation in drawing and painting. Many specimens of the latter are still preserved.

CLIMATOLOGY.

Climatology afforded an attractive field for the gifted countryman of Humboldt, Kaemtz, Mahlmann, Lamont, Dove, and other students of physical geography. In addition to his extensive official works, Schott found time to publish a long series of volumes on the climate of America, beginning first with his temperature tables, 1876, and including the climate of the American polar region, meteorological observations in the Arctic Seas, similar observations in Arkansas, auroral observations at Lady Franklin Bay, magnetic observations at Point Barrow, and precipitation in the United States. Each of these volumes contains elaborate discussions of fundamental climatological data, and would give our colleague a place among the most prominent climatologists were he not already the most distinguished magnetist and geodesist of America.*

*As my four charts in Walker's "Statistical Atlas" of 1873 have by some been attributed to Schott and by others to Jackson and again to General Myer, it is proper to state that documents signed officially by high authorities sometimes originate with subordinates and are merely communicated over official signatures.

Unfortunately, the data in hand for climatological charts were in those days not sufficiently extensive to allow of reducing all the data to any given fundamental interval, as is now possible, owing to the accumulated 40 years of research by the United States Weather Bureau, therefore those pioneer charts are gradually being supplanted; but this does not destroy their character as having been an important step upward in this branch of science.

In 1862, in his reduction of the observations by McClintock, Schott gave us the first published table for converting the Smithsonian scale of ten arbitrary terms for the strength of the wind into the equivalent velocity in miles per hour. In the annual Coast Survey report for 1869 he was the first to invert the ordinary hypsometric formula, and thus make the barometric readings the basis of a computation of the average temperature of the air between any two stations. Thus he first demonstrated the truth of Ferrel's early assumption that there is only a very slight diurnal variation in the average temperature of the whole mass of air; the ordinary diurnal variation for any locality belongs to the ground and the air that is nearest thereto and not to the free air in the upper regions. A few years later this fact was also recognized in an extensive work by Ruhlmann (Leipsic, 1872), and ever since that date we have been justified in adopting a more uniform temperature throughout the day for the computation of altitudes by barometric readings. Of course, the same principle holds good when we consider the problem of reducing to sealevel any barometric observations made at a considerable height above the sea. This idea was embodied, in 1871, in the abolition of current temperatures when reducing stations from great altitudes to sealevel for the purpose of drawing isobars on our tridaily maps for the morning, afternoon, and midnight. This idea was also embodied in a recommendation made in 1885 by Gen. William B. Hazen, as chief of the Weather Bureau, to the International Congress held in Paris, namely, that only fairly uniform temperatures, changing slowly from day to day and hour to hour, should be used in computing the reductions to sealevel. Subsequently Prof. William Ferrel indorsed the same method and it is now in almost universal use; so inti-

mately are geodesy and meteorology thus associated together.

Another point of contact relates to the adjustment of the horizontal levelings and vertical angles of geodetic triangles. In the case of vertical angles the measurement and computation of the atmospheric refraction is the fundamental question, and with this is associated the question of accurate hypsometry. On all these subjects, which may be called the mutual relations between the atmosphere and geodesy, many different memoirs, perhaps 30 in all, were written by Schott.

BASE-LINES AND METRIC STANDARDS.

The methods of measuring base-lines for the primary triangulation occupied our colleague's attention from an early date. New forms of compensated bars and new methods of transferring the measurement of one base-line to check measurements secured by measuring some distant base-line were always a delight to him. In general, however, it was absolutely necessary to secure consistency throughout the long years that elapsed between the first measurement of 1847 and the last adjustments of 1902. Of course, such consistency could only be secured by the retention of uniform methods of observation and computation throughout. Therefore the exigencies of the service may be said to have evolved the man, who was both conservative and progressive—a man who knew how and where and when to make changes that would not affect the final results disastrously.

One of the ultimate objects to be kept in mind in such extensive geodetic work is the determination of the true curvature of the earth for this part of the globe, and on this point Mr. Schott was very clear. There could be no gain in adopting a special curvature for the American continent until arcs of longitude as well as arcs of the meridian should have been measured.

Of course, the great geodetic operations of the United States must be combined with those of all other portions of the globe in order to improve our knowledge of the figure of the earth. But this cannot be done unless the base-measuring apparatus has been compared most carefully with the standards used by European geodesists. We therefore find a lucid memoir by

Schott on the relation of the metric standards of length in Europe and those used by the United States, the Coast and Geodetic Survey, and the United States Lake Survey.

GEODESY.

No better presentation of the breadth of Schott's comprehension of the province of our Survey can be desired than that given in his unpublished report of 1885 on "the Geodetic Survey of the United States, its objects and operations, considered from a theoretical and practical standpoint."

In the manuscript of this special report, communicated January 2, 1885, to J. E. Hilgard, as Superintendent of the Survey, we find a detailed statement of "the province and operations of a Geodetic Survey." Geodesy, astronomy, hypsometry, topography, gravitation are each properly evaluated and coördinated. The configuration of the true geoid as a slightly irregular modification of the fundamental spheroid is dwelt on as due to natural causes. The effect of the attraction of external mountains and internal excesses or deficits, on the equipotential surfaces under and over oceans and continents, the resultant variations both in the force of gravity and in the deflection of the plumb-line from the vertical, were clearly recognized; but the later ideas of isostasy and compensation as maintained by Dutton, in 1892, and demonstrated later by Hayford, were refinements for which practical geodesists were not yet prepared.

Little by little as Schott perceived the many new ideas that tended to dissipate his rapidly diminishing energies; as the founders dropped away and his earlier personal supporters found rest in the grave, he realized that he must relinquish every branch of work that did not bear directly on the computation of the results of the great triangulations that he wished to carry to their conclusion. Having divested himself of other details, he devoted his last years to the arrangement and, as it were, the codification of general results relative to two great geodetic arcs. The most delicate question, both in theory and practice, was the distribution of irregular densities within the earth and its effect upon deflections of the vertical and on the local forces of gravity. The first extensive discussions of

this subject had been by Archdeacon J. H. Pratt, of India. Isostasy had been defended strongly by C. E. Dutton, in 1892, and provisionally adopted by Helmert in his treatise on geodesy, in 1884. Since Schott's death, in 1901, isostasy, with definite ideas as to compensation, has been worked over thoroughly and with brilliant results by Hayford, in 1906, constituting, as Helmert once said, "a new epoch in geodesy." But during Schott's lifetime these seemed to him to be matters of subsidiary importance, and he was justified in omitting them from consideration until he had finished his first approximation to that figure that is appropriate to our knowledge of the American continent. In a similar way the study of the influence of the diurnal rotation of the earth on the east-west tidal strains as compared with the north-south strains is the important but minor matter investigated in the prize essay of 1912 by Prof. J. E. H. Love. The question whether the earth is a failing structure; the transmission and refraction of earthquake waves; the general character of variations of density, rigidity, and viscosity deep down within the solid earth, and other problems that are now of importance belonged to a future generation. Mr. Schott confined himself to the computation, in the customary manner, of the arcs already measured. The deflections were treated as though they were accidental errors. Hayford's method corrects the deflections (with a high degree of approximation), and hence nearly true curvatures are obtained. Schott had not found this method, and could not even attempt to correct for visible topography. Hayford had to devise new methods of computation to overcome the physical labor of doing what appeared to be an impossible undertaking with the means at his command.

A recent letter from Professor Hayford, who is now Director of the College of Engineering at Evanston, Illinois, says:

"Mr. Schott was remarkable for his extremely methodical ways, his German thoroughness, and his intellectual honesty. For fifty years he worked with clocklike precision of movement, not hastening in supposed emergencies nor slowing in dull times. His mental habits were like his physical habits—regular and methodical. He had definite plans as to what should be done and moved forward toward accomplishing those plans with patient persistence, passing many other more brilliant men in the march of progress by virtue of the cumulative effect of his

patient persistence and his careful methods. It is my belief that next to F. R. Hassler he left more influence for good on the Coast and Geodetic Survey than any other man who has ever been connected with it."

The tangencies of continental outlines and of mountain ranges to the polar circles were emphasized by Robert Dale Owen, geologist of Kentucky. The fact that all these lines run tangent to the two polar circles shows that general faults have occurred during certain geological ages only when the strains in the earth's crust have been a maximum, and such can occur only when the sun and moon act together at apogee and perigee, just as with the ocean tides. The strains are due essentially to the push and pull of the ellipsoidal or equatorial bulge and have some hidden relation to terrestrial magnetism. The innumerable cracks and faults throughout the earth's crust show that although each bit of rock is rigid, yet the mass as a whole may be treated as a viscous globe, in which each uncracked piece of rock is as it were an independent molecule. A great fault or crack is located along the great circle of the Rocky Mountains, the Andes, Japan, the mountains of central Africa, and these constitute but a belt of weakness in the whole outer crust, extending entirely around the globe, giving us an aqueous and a continental hemisphere. The province of geodesy is to determine, first, approximately and then more exactly the shape of this resulting irregular globe. Every thought in Schott's life-work had this object in view, and it was fortunate that his health and strength were spared to give us a first approximation to the shape of the North American continent as the logical conclusion of the totality of the geodetic work that had been conducted for fifty years by the whole Survey under his general guidance and detailed supervision.

The most remarkable of modern philosophers and the most modest—Sir Isaac Newton—knew that the earth must be a spheroid of revolution. Its dimensions were deduced very closely by Bessel in 1840, and Clarke in 1865 and 1880, based on measures made in the meridian, in Europe, Africa, India, and equatorial America. Pierce added to the conscious dignity of our Survey by enforcing its broad duty as both a Coast and a Geodetic Survey. Under his superintendency an arc of the

parallel from New York to San Francisco was authorized. This was additional to the oblique arc from Maine to Florida that was begun in the early days of the Survey, to which a meridional arc from Texas to Dakota is now added. Of all these far-seeing men it was Schott alone who was spared to see the completion of the longitudinal and the oblique arcs—arcs of unsurpassed extent and accuracy. A thousand men had lived and worked, grown old and died, and still the work had gone on. The Mexican war, the Civil war, and the Spanish war had rolled over us like waves in the progress of the nation. Inventions and ideas by the thousand had contributed to the accomplishment of the work of the Survey, and still it went on; still Schott labored persistently in his little office-room, devotedly hoping and praying that he might live until the first results were attained as to the curvature of the globe. All had started out together, in 1843-1848, as geodetic pioneers in these new lands; the country had spread from the Atlantic to the Pacific; it had taken in Texas on the south and Alaska on the north; it had assumed control from Porto Rico to the Philippines. Schott could only hope to determine as a first step whether the curvature of America agreed with that of Europe, and well pleased were all to learn that his computations for our continent fell midway between the results of Bessel and Clarke for Europe.

Such a calculation as this, enlarging and fixing our ideas of the powerful action of gravity over the whole globe, may well have called forth emotions in his mind like those experienced by Sir Isaac Newton when he demonstrated that universal gravitation kept the earth and the moon in their proper places with respect to the sun. Schott's name is attached to these two great works on the longitudinal and the oblique arcs, but he added to his fame and reputation when he recognized a fact that is implied in his statement, "We have accomplished the work; but not I alone." It is thus that he stands at the summit of the pyramid that the whole Survey had erected, when he emphasizes the unity of all their labors. It was the culminating contribution by America to the sum total of human knowledge regarding the exact shape of this globe of earth as the home of mankind. We place Schott's name beside those

of Benjamin Franklin, Alexander Dallas Bache, Joseph Henry, and all others who have relinquished their own personal inclinations in order to carry out, unselfish to the end, the great works that each felt called on to do. Many a man seeks for that which gives personal ease and pleasure, but few seek for the highest usefulness that they are capable of.

In a letter extending the sympathy of the Prussian Geodetic Institute to the Coast Survey on the loss which the latter had susained in the death of Schott, the eminent Director, Dr. George Helmert, thus refers to Schott's activity:

"I am pleased to think that it was a German who developed for so many years such a wonderful activity in the Survey, and thus Mr. Schott did not only render great services to science by his successful work, but contributed to the esteem which two great nations have for each other."

The completion of the two arcs already mentioned marks an epoch in the geodesy of the world. Such gigantic works require very fortunate and rare combinations of national funds, stable governments, learned theories, convenient opportunities, and well-trained experts. The administration of F. R. Hassler, 1806 to 1843, was necessarily occupied with details of small extent and daily importance, nor was the wealth of the young nation at that time favorable to such a great work. The administration of the gifted Bache, 1843 to 1871, was crowded with a multitude of duties—novelties of organization and momentous national difficulties. The later administrations of Patterson, Pierce, Hilgard, Mendenhall, Pritchett, and the present long administration of Tittmann have enabled Schott and his successor, Hayford, to accomplish great works, for which the Survey now becomes famous in the field of scientific research.

Our globe incites to innumerable problems, and every advance in our knowledge suggests still others. Perhaps those that press most earnestly for speedy solution relate to earthquake phenomena and the internal structure of the globe. Both geodesy and meteorology require so-called reductions to sea-level; the former would reduce pendulum observations of gravity; the latter would reduce barometric observations of

air pressure, and each requires some knowledge of the other. The fact that Hayford has shown that the observed deflections from the vertical, and that Bowie has shown that the observed variations in the intensity of gravity, are both satisfactorily explained by a proper consideration of isostasy and compensation, justifies our belief that future researches will give us correct ideas on the questions discussed by A. E. H. Love: Some Problems of Geodynamics (Cambridge, 1911). In this connection it would seem proper and necessary for the Survey to enter also into the study of seismology, which is now prosecuted so vigorously in Europe and promises to give us definite knowledge with regard to the interior of the globe.

The progress in terrestrial magnetism made by Bauer leads us to hope that another step may be made when we understand the influence of earthquake shocks in rearranging the subpermanent magnetic conditions of rocky strata. Some ideas on this subject were presented to the National Academy in 1887, which were subsequently published in 1889, at pages 8-17, of my "Preparatory Studies," and may possibly be worth considering. It was Francis Bacon, of 1605, who said: "Knowledges are as pyramids whereof history is the basis; so of natural philosophy the basis is natural history; the stage next this basis is physic; the stage next the vertical point is metaphysic." Nowadays we omit the metaphysics, but are busy enough with natural philosophy and physics.

The few words that we have given relative to history and physics must now be concluded with a tribute of affection and respect as to Schott's personal influence. From 1860 to 1867 I was only an humble aid in the Coast Survey, but I had known him by correspondence for a few years. My first personal interview and conversation was on the 3d of May, 1867, and I shall never forget the smile of genial sympathy as he discussed with me the need of greater accuracy in every line of work bearing on astronomy and geodesy; the need of divesting ourselves of every trace of injustice; the need of frankness and an honest recognition of assumptions that secretly beset every investigator. He entered lovingly into ideas that I brought back from Poulkova and into plans of astronomical work. He was the most helpful of friends, equally ready to give advice

or to do helpful work. His long experience had inculcated the habit of patience in dealing with men. He knew how difficult it is for one man to see into a problem with the mental eyes of another. I could never think of him as arbitrary or as saying anything that injured the progress of any worthy individual. His wide experience and greater knowledge seemed always to harmonize with and widen the knowledge of others. His judgment and my theories sometimes coincided, and there was an affectionate aspect to our friendship, a mutual appreciation, a respectful confidence, such as must have been deeply realized by others as well as myself.

Mr. Vinal, who came into the service 10 years after myself, was impressed like myself. He writes:

"Mr. Schott was a man of earnest purpose, having at all times the best interests of the service at heart, systematic and thorough in all that he undertook. He accomplished a great work, as evidenced by his numerous reports and publications. All that come after him can only follow where he led."

A few paragraphs from Prof. T. C. Mendenhall, who was Superintendent during the years 1889-1894, may properly conclude these lines:

"My acquaintance with Schott began a good many years before it was my pleasure to be officially associated with him in the Coast and Geodetic Survey.

"During that association, lasting more than five years, my admiration for him increased, and there was added to it a genuine affection growing out of his many charming personal qualities which were revealed, it sometimes seemed, almost reluctantly. In the hundred years of its existence the Coast Survey has enjoyed the services of many devoted and unselfish men; but few others, if any, have equalled Schott in the faithful and conscientious devotion of his best abilities to the discharge of his duties. The best interests of the Survey and its work invariably received his first consideration.

"The computing division, over which he presided, was as important to the whole organization as is the heart to that of a living man, though like that its work seemed to many almost painfully monotonous. His peculiar fitness for it was shown by the fact that to him it was never irksome. On the contrary, I am sure he found delight in the laborious calculations in which he and his staff were continually engaged, for he knew that here was the crucible in which all of the various operations of the corps were at last tried out. He was quick to

recognize the excellence of a field officer's work when found satisfactory, after his rigid tests had been applied, and although by nature reserved in disposition and never lavish in praise, he was always glad to call generous attention to such work. On innumerable occasions he brought to me a few sheets of final computations, proving the high precision and satisfactory character of a bit of field work, and I do not believe the observer himself could have found more pleasure in the results. In time I came to regard him as an excellent judge of the abilities and merits of men, for his conclusions were founded on tests of actual performance, uninfluenced by personal preference or prejudice.

"His scientific work was characterized by a painstaking thoroughness which marked everything he did. Although along certain lines, notably that of terrestrial magnetism, he was recognized as one of the world's first authorities, yet I do not believe that his scientific investigations have yet received the general recognition and commendation to which they are entitled in virtue of their importance, extent, and high character. Although a man of no uncertain mind regarding scientific questions upon which he believed himself competent to speak, Schott was excessively modest and often declined to express views to which the scientific world would have listened with both pleasure and profit. Indeed, it was difficult to induce him to read a paper before small scientific societies, of which he was himself a member. Through long, industrious years his work went on quietly, much of it attracting little attention at the time. Few men have done so much with so little attending noise, and in this respect, as well as in many others, the example of his life may wisely be studied by those who have survived him."

In conclusion one may be allowed to express regret that those distinguished chiefs of the Coast Survey—A. D. Bache, Benjamin Pierce, Carlisle Patterson, J. E. Hilgard—with whom Schott had served for so many years, cannot testify to us today as to their appreciation of his early services. I have quoted only from their successors—Mendenhall, Pritchett, and Tittmann—as to his later work. A few words from many of his old associates would have most gracefully concluded our brief review; but they, like him, repose under the green turf, in the silence of death. Only the organization of the Survey still stands—a permanent living monument to the foresight, energy, and ability of its founders. Through our Coast and Geodetic Survey new chapters have been added to the history of geodesy. It has been the foster-parent of new branches of exact science and has earned an imperishable crown of gratitude from all students of terrestrial physics.

A CATALOGUE OF THE WORKS (ABRIDGED TITLES) OF CHARLES ANTHONY SCHOTT,

ASSISTANT, U. S. COAST AND GEODETIC SURVEY, 1848–1901.

Compiled by Ralph M. Brown, October, 1908.

ABBREVIATIONS.

app.	Appendix.	Rep.	Report.
Bull.	Bulletin.	Sep. publ.	Separate Publication.
pp.	Pages.	Spec. publ.	Special Publication.
pt.	Part.		

Amer. Assoc. Adv. Sci.	American Association for the Advancement of Science.
Amer. Journ. Sci.	American Journal of Science.
Trans. Amer. Soc. Civ. Eng.	Transactions American Society of Civil Engineers.
Astron. Journ.	Astronomical Journal.
Astron. Jahresber.	Astronomischer Jahresbericht.
Nat. Acad. Sci.	National Academy of Sciences.
Nat. Geogr. Mag.	National Geographic Magazine.
Rep. U. S. Coast Geod. Surv.	Report of the U. S. Coast and Geodetic Survey.
Sci. Amer. Suppl.	Scientific American Supplement.
Smiths. Contr. Knowl.	Smithsonian Contributions to Knowledge.
Smiths. Misc. Coll.	Smithsonian Miscellaneous Collections.
Terr. Magn.	Terrestrial Magnetism and Atmospheric Electricity.
Bull. Phil. Soc. Wash.	Bulletin of the Philosophical Society of Washington.

Tables for projecting maps, with notes on map projections. (With E. B. Hunt.) Rep. U. S. Coast Geod. Surv., 1853, app. 39, pp. 96-163.

On the currents of Nantucket shoals. Rep. U. S. Coast Geod. Surv., 1854, app. 48, pp. 161-166.

Currents in Muskeget channel and off the northeast coast of Martha's Vineyard. Rep. U. S. Coast Geod. Surv., 1854, app. 49, pp. 166-168.

Tidal currents of Long Island sound and approaches. Rep. U. S. Coast Geod. Surv., 1854, app. 50, pp. 168-179.

Adjustment of horizontal angles of a triangulation. Rep. U. S. Coast Geod. Surv., 1854, app. 33S, pp. 70-95.

Discussion of the secular variation in the magnetic declination on the Atlantic and part of the Gulf coast of the United States. (Ed. I.) Rep. U. S. Coast Geod. Surv., 1855, app. 48, pp. 306-337.

Results of observations for magnetic declination, dip, and horizontal intensity. Rep. U. S. Coast Geod. Surv., 1855, app. 49, pp. 337.

Solution of normal equations by indirect elimination. Rep. U. S. Coast Geod. Surv., 1855, app. 40, pp. 255-264.

Discussion of the secular variation in the magnetic declination on the Atlantic and Gulf coasts of the United States, from observations in the 17th, 18th, and 19th centuries. (Abstract from a report to the superintendent of the Coast Survey, dated July 6, 1855. Rep. U. S. Coast Surv., 1855, app. 48, and communicated by authority of the Treasury Department.) Proc. Amer. Assoc. Adv. Sci., vol. 9, Aug., 1855, pp. 160-175. Suppl. Amer. Assoc. Adv. Sci., vol. 10, Aug., 1850, pp. 173-177.

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Magnetic observations made at stations in Delaware, Maryland. and Virginia. Rep. U. S. Coast Geod. Surv., 1856, app. 29, pp. 226-227.

Results of observations for magnetic declination, dip, and horizontal intensity at stations in Delaware, Maryland, and Virginia. Rep. U. S. Coast Geod. Surv., 1856, app. 30, p. 227.

An attempt to determine the secular change of the magnetic declination on the western coast of the United States. Rep. U. S. Coast Geod. Surv., 1856, app. 31, pp. 228-235.

Discussion of the secular variation of the magnetic inclination in the northeastern states. Rep. U. S. Coast Geod. Surv., 1856, app. 32, pp. 235-245.

An attempt to determine the secular variation of the magnetic inclination on the western coast of the United States. Rep. U. S. Coast Geod. Surv., 1856, app. 33, pp. 246-249.

Discussion of the secular variation of the magnetic inclination in the northeastern states. Proc. Amer. Assoc. Adv. Sci., vol. 10, Aug., 1856, pp. 177-187. Rep. U. S. Coast Geod. Surv., 1856, app. 32.

Determination of the probable error of an observation from the differences of the observations from their arithmetical mean. Rep. U. S. Coast. Geod. Surv., 1856, app. 59, pp. 307-308.

Contribution to our knowledge of the climate of the American polar regions, with an accompanying illustration. In E. K. Kane, Arctic explorations, vol. 2, pp. 426-428. Philadelphia, 1856.

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