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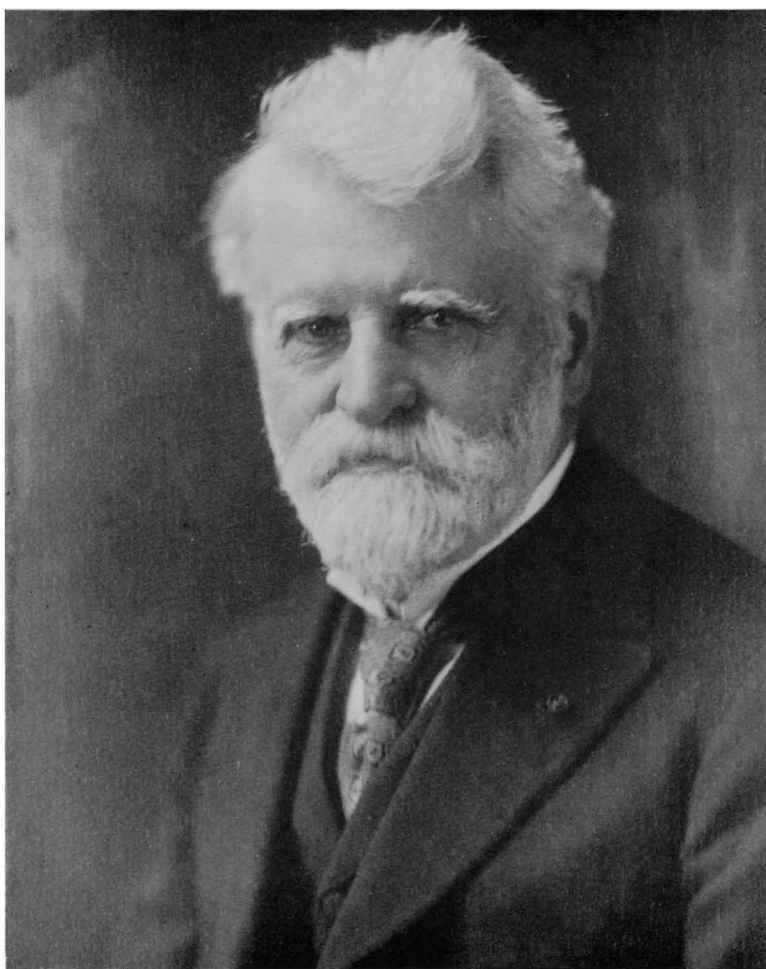
AMBROSE SWASEY

1846–1937

BY

DAYTON C. MILLER

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Ambrose Swasey, engineer, scientist, philanthropist, was born in Exeter, New Hampshire, on December 19, 1846; he died at the old homestead on the farm where he was born on June 15, 1937, aged 90 years and 6 months.

A group of pioneers, four hundred in number, including four non-conformist clergymen, came from old England to New England in the spring of 1629. John Swasey, founder of the Swasey family in America, and his two sons, Joseph and John, Jr., presumably were members of this group and they settled in Salem, Massachusetts.¹ The Governor of Salem, John Endecott, in this time of religious intolerance, showed great bigotry and harshness and expelled all Baptists, Episcopalians, and Quakers. John Swasey, being of the latter faith, was obliged to leave, about 1650, going to Satauket and later to Southold on Long Island. Joseph Swasey (second generation) the eldest son of John Swasey, remained in Salem and followed the humble occupation of fisherman. Joseph was one of the charter members of the first church organized in Salem, in 1629, this being the first Congregational Church in America. This Joseph Swasey had a son named Joseph (third generation) born in 1653 in Salem. The further line of descent is: Joseph, born in 1685, in Salem; Ebenezer, born in 1727, in Old Newbury, Massachusetts; Ebenezer, born in 1758, in Old Newbury; Nathaniel, born in 1800, in Exeter, New Hampshire.

Ambrose Swasey, the son of Nathaniel and Abigail Chesley Peavey Swasey, born in Exeter, New Hampshire, December 19, 1846, was the ninth in the family of ten children, seven sons and three daughters. Seven of the children lived to maturity, and reached ages of 30, 63, 69, 75, 76, 84, and 90 years.

The father, Nathaniel Swasey, who lived 90 years, "loved the work of farming"; he was active in the affairs of his native

¹ Benjamin Franklin Swasey, *Genealogy of the Swasey Family*, Cleveland, Ohio, Privately printed, 1910, 525 pages, with portraits and illustrations.

town, Exeter, and was elected to the Board of Selectmen in 1847-1848; in 1852 he introduced the first practical mowing machine in his county; his farm was developed and enlarged until it contained 250 acres. In addition to the training in the public schools, he received private tuition from a member of the faculty of Phillips Exeter Academy. His favorite studies were arithmetic, astronomy, ancient history, literature and poetry.

The mother, Abigail Peavey Swasey, died at the age of 77 years. "She was of a cheerful disposition and possessed refined manners; she loved above all else her home and children; she was an exemplary Christian and strove to inculcate in the minds of her children the importance of a religious life." Together with her husband, she joined the Baptist Church in 1840.

Ambrose Swasey once said, "All my brothers and sisters went to academies or colleges, but my only schooling came from the little country grammar school" at Exeter. However, his remarkable career is incontestable evidence that his real education continued without abatement throughout his life. Seven universities recognized his scholarly attainments by conferring honorary degrees, one "Doctor of Engineering," three "Doctor of Science" and three "Doctor of Laws".

There were no mechanical toys when Ambrose was very young but he soon learned to make his own. Mother's old spinning wheel and his jack knife helped in making a flax wheel. The old attic was his workshop and there he set up an improvised lathe. Then he made a working model of a mowing machine which is still in existence. Boys on old New England farms all had duties and Ambrose was in charge of the sheep and lambs which he loved and gently cared for. He was interested in music and played the flute. When he was eighteen years old, in 1865, his bent for machines and mechanical instruments prevailed, and he decided to enter upon a three-year apprenticeship in the newly established Exeter Machine Works.

Another young man of the same age as Ambrose Swasey, Worcester Reed Warner, born in Cummington, Massachusetts, in 1846, had no liking for farming as a life work and in 1865 he secured his first employment in the draughting room of the American Safety Steam and Engine Company of Boston. A few

months later the company transferred its work to Exeter, New Hampshire, and Warner went with them; he then entered upon an apprenticeship in the same shop where Swasey was working. The two enthusiasts soon became warm friends. As Ambrose started ahead of Worcester in the apprentice work, he finished first, and then to widen his experience he went to Paterson, New Jersey, to enter the employ of the Grant Locomotive Works. He soon found the work unsuited to his inclinations and perhaps, too, a bit of homesickness hastened his return to Exeter. Once again the two young friends spent the winter working in the shop, living and studying together, and planning for the future.

After Worcester Warner had completed his apprenticeship, the two young men started out to make their fortunes. In the spring of 1869 they wrote letters to four large manufacturing concerns, seeking positions as machinists, and received offers of positions from all four companies. As was to be expected, they chose to accept offers from the same concern, the Pratt and Whitney Company of Hartford, Connecticut, manufacturers of precision tools and machinery. After their first day's work, Warner remarked to Swasey, "Well, Ambrose, we have a very difficult job; there must be five hundred men ahead of us." However, they soon attracted attention by their special abilities in solving mechanical problems, and were advanced in rank so that the number of men ahead of them decreased.

In 1875 Ambrose Swasey received his first patent for the invention of an improved protractor for measuring angles with extreme accuracy. Thus is recorded one of the prominent characteristics of his entire life, the attainment of truth and precision. In the same year, a second patent was issued to him for an improved water meter.

In 1878, at the age of 32 years, Mr. Swasey was made superintendent of the gear cutting department of the Pratt and Whitney Company. He spent long evenings in his room studying books on machinery; his mechanical genius rapidly developed improvements in shop methods and eventually, in 1879, led to the design and construction of the Epicycloidal Milling Machine for producing true theoretical curves from which cutters for gear teeth are made. He invented also a new gear-cutting

machine for generating and at the same time cutting the teeth of spur gears, the process being a solution of the difficult problem in the interchangeable system of gearing.

Ambrose Swasey's breadth of knowledge, both practical and theoretical, was recognized in high places for, in 1879, he was visited at his work in the shop by a college official who offered him the position of Instructor in Mechanic Arts at Cornell University as the successor of Professor John E. Sweet. It was one of the greatest surprises of his life—that he, a youngster without college training, should be urged to enter upon such a career. He modestly underrated his own ability and the breadth and value of the training to be had in the old machine shops where men found joy in good workmanship, and in the training he had received on his father's fine old New England farm. He declined the invitation from Cornell University.

After eleven years with the Pratt and Whitney Company, in the spring of 1880, the two friends, Worcester Reed Warner and Ambrose Swasey, decided to go into the machine-tool business for themselves, in Chicago, under the firm name of WARNER & SWASEY, their initial investment being their combined savings up to that time, five thousand dollars. Four young men of Connecticut, George C. Bardons, William S. Lane, George D. Phelps, and Frank H. Woods, went with them and formed the nucleus of the new organization. After an experience of one year it appeared that this location was too far removed from the industrial east where their products were mostly used and from which they obtained supplies and skilled labor. They chose Cleveland, Ohio, as the location for their business, and early in 1881 Mr. Warner went to Cleveland to supervise the construction of their new shop on the site occupied by a portion of their present plant. On July 8, 1881, Ambrose Swasey came to Cleveland to join his partner; he was destined to become one of the city's most useful, most loved and most honored citizens.

The first order received by Warner and Swasey was for twelve hand lathes, from the Crane Company of Chicago. Machines for milling the cams of sewing machines were designed

and constructed; vertical milling machines for die sinking and similar purposes were made in large quantities. An important development was a horizontal boring machine. Later much attention was given to highly specialized brass-working machine tools. The turret lathe was destined from the beginning to be the principal product of the company. With the rapid growth of the modern method of interchangeable parts, a standard line of turret lathes was developed. The introduction of turret lathes in European countries, in unprecedented quantities, brought about further specialization in the product and a marked increase in production.

The business grew; but not as fast as might have been. These men were not primarily interested in mass production and mere money making. Mr. Swasey once said: "If we double our production, we must double the size of our shops. Then Warner and I would no longer be cheerful on top of our job, but would be bowed down beneath its burdens. As things now are, we have leisure to satisfy our individual fondnesses for fine mechanism, leisure to travel and to look about us, to pass some time with our friends and have time really to enjoy the good things of life."

The two men were so absorbed in designing and making fine machines, and their mutual trust was so great that they did not take the trouble to draw up a written agreement of partnership until the year 1900. In this year they organized and incorporated The Warner and Swasey Company. The company has branch offices in twelve cities in the United States and has three agencies in Canada and thirteen agencies in foreign countries, including Australia, Japan and India.

In his youth Worcester Warner found especial delight in the study of astronomy; his mother was a lover of books and a woman of exceptional intelligence, and gave him encouragement. He made a simple telescope with such means as were available. During his apprenticeship he continued his investigations and experiments, and later, in Hartford, in his leisure hours, he constructed a mounting for a portable telescope. This proved to be such a success that he built a still larger and more powerful

instrument. He drew his inspiration from such books as Mitchell's "Planetary and Stellar Worlds" and Burritt's "Geography of the Heavens."

Worcester Warner's enthusiasm for astronomy was absorbed and radiated by his companion and partner, Ambrose Swasey. During the few months when they were located in Chicago, they received orders for several small telescopes, such as had previously been made for their own use. It seems a most fortunate circumstance for the world of science that these two men, Ambrose Swasey and Worcester R. Warner, should have associated as partners. Although the making of astronomical instruments was not included in their original plans, yet Mr. Warner's interest in astronomy, combined with Mr. Swasey's exceptional ability as a mechanical engineer, very naturally led them to apply their facilities to the construction of astronomical instruments.

Early in 1881, in their Chicago factory, Warner and Swasey completed their first real astronomical telescope, an equatorial mounting of new design, for a nine and one-half inch object glass. This telescope, upon the recommendation of Mr. S. W. Burnham of Chicago, famous for his observations of double stars, was acquired by Beloit College, Beloit, Wisconsin. This first telescope gives evidence of Mr. Swasey's inherent characteristics in designing, efficiency, precision, and "architectural" beauty.

In 1882, a revolving dome, forty-five feet in diameter, was constructed to cover the 26-inch refracting telescope of the Leander McCormick Observatory of the University of Virginia. This dome represented marked improvements in design, as regards the operation of the shutter and the rotation of the structure. It moves with such ease that it may be revolved by the pull of one hand on the rope.

The design and construction of the Lick telescope was epoch making both in the science of astronomy and in the careers of Mr. Swasey and Mr. Warner. An authoritative account of the significance of this event was given by Dr. W. W. Campbell, President of the University of California and Director of the Lick Observatory, on April 23, 1924, when the American Society of Mechanical Engineers conferred the John Fritz Medal upon

Mr. Ambrose Swasey.² Extracts from this address are here given:

“Dr. Ambrose Swasey’s introduction to astronomy and astronomers occurred under unique and interesting conditions. In 1874, just 50 years ago, James Lick, a Pennsylvanian by birth and a Californian by adoption, gave to a Board of Trustees of the University of California the sum of \$700,000, ‘to provide for the construction of a telescope larger and more powerful than any in existence, and a suitable observatory connected therewith.’ The Trustees commissioned Prof. Simon Newcomb to visit all established makers of optical glass, lenses, and telescope mountings to secure data and advice which would guide them in deciding upon the size and kind of telescope to be constructed. The final decision was in favor of a 36-inch refractor. The making of the glass in the rough was entrusted to Feil & Son of Paris. The figuring and polishing of the glasses was undertaken by Alvan Clark & Sons, of Cambridgeport (now Cambridge), Massachusetts.

“There remained the extremely important question of the mechanical mounting of the telescope. The Trustees invited tenders of designs and bids, and several firms in Europe and America complied. The list included the leading builders of telescopes and one recently established firm, Warner & Swasey, of Cleveland, Ohio, then unknown to astronomers. The several plans were given consideration by experienced astronomers and engineers, as befitted the high responsibility, and by unanimous decision of the Trustees the award went to Warner & Swasey. It is worth noting that theirs was the highest of all the bids, but their design was so clearly the best that the firm’s inexperience in constructing telescope mountings was not permitted to influence the decision.

“In due time, in 1888, the James Lick telescope was erected on Mount Hamilton in California, fifty miles south of San Francisco, and put into commission. It was immediately satisfactory and successful in all of its parts and as a whole. In power and applicability it surpassed the expectation of astronomers everywhere. It immediately became, and for more than two decades remained, the leading astronomical instrument of its time. The bearings which guide its movements are so perfect that, although it weighs many tons, it can be swung easily from one position to another by hand. For 33 years I have made personal use of it

² *Mechanical Engineering*, 46, 368 (June, 1924). Edward S. Holden, *The Sidereal Messenger*, 7, 49-65 (1888). Simon Newcomb, *Harper’s Monthly*, 70, 399-406 (1885).

and my admiration for its design and workmanship has remained unabated. The instrument has been used through every good night in the last 36 years, save possibly half a dozen nights when the dome or some detail of the telescope mechanism was undergoing repair, and it works as well today (1924) as it did in 1888."

The plans for the Lick telescope called for an instrument to be used not only for visual observations but also for photographic and spectroscopic researches, specifications which were involved for the first time in the design of a large telescope. Mr. Swasey's design was novel and original and included polar and declination axes of steel with ball bearings and improved counterbalancing, besides many conveniences for the operation of the giant telescope.

Mr. Swasey went to Mount Hamilton in November, 1887, to supervise the erection of the telescope on the completed masonry foundation. The steel tube of the telescope is about 57 feet long. The 36-inch objective was mounted on the end of the tube by its maker, Alvan Clark, Junior, on December 31, 1887, and he was much perturbed when it was discovered that the focal length of the objective was six inches less than was specified in the order. Mr. Swasey soon relieved Mr. Clark's anxiety, and the next morning he proceeded to cut six inches off the lower end of the tube with a hack saw and to refit the breech block. On January 3, 1888, the telescope was first used to observe the star Aldebaran and the great Nebula in Orion, by Captain Richard H. Floyd, chairman of the Lick Trust, Mr. Swasey, Mr. Alvan Clark, Jr., and astronomer James E. Keeler. The performance of the telescope was highly satisfactory.

The Lick telescope proved to be so efficient that the United States Government, in 1893, commissioned Warner & Swasey to provide an entire new mounting for the 26-inch objective lens belonging to the United States Naval Observatory in Washington, and to equip the observatory with an elevating floor and a new dome.

The next great telescope of Mr. Swasey's design is the 40-inch refracting telescope of the Yerkes Observatory of the University of Chicago, located at Williams Bay, on Lake Geneva, Wiscon-

sin, together with the revolving dome ninety feet in diameter and the elevating floor seventy-five feet in diameter with a rise and fall of twenty-five feet. The telescope mounting was exhibited at the World's Columbian Exposition in Chicago in 1893, and was mounted in the observatory in 1896. The objective lens of this telescope, as that of the Lick telescope, was made by Alvan Clark & Sons.

The lines of the mounting of the Yerkes refracting telescope follow generally those of the Lick telescope, and, like the latter, it has functioned perfectly. These two great refractors, the largest in the world, were, to a greater extent than the later telescopes, peculiarly Mr. Swasey's own design in both form and mechanism, and mark a great advance not only in accuracy and mechanical performance but in beauty and harmony of line. All of Mr. Swasey's designs, whether of machine tools, scientific instruments or telescope mountings, were characterized on the one hand by the simplest possible mechanism to achieve the desired purpose, by absence of purposeless ornamentation, by suitable strength and ruggedness where required, and on the other hand by smoothly flowing, pleasing lines, and harmony and beauty of form. Mr. Swasey was unequalled in combining engineering requirements with a real artistic sense of symmetry and proportion.

The Lick telescope completed in 1888, with an objective lens 36 inches in diameter, and the Yerkes 40-inch telescope mounted in 1896, were then, and have remained, the largest refracting telescopes in the world. The emphasis of astronomical research has since changed from visual to photographic observation in which light-gathering power is more effective than magnifying power, and because of both optical and mechanical advantages the reflecting type of telescope has been adopted for instruments of larger size. Mr. Swasey took an active part in the design of the new type of telescope.

The first large reflecting telescope constructed by the Warner & Swasey Company, having a mirror 72 inches in diameter, was for the Canadian Government Observatory, near Victoria, British Columbia. This instrument, and the covering dome and observing bridge, completed in 1916, has numerous improvements in

the mounting and operating mechanism, all designed by Mr. E. P. Burrell, Works Engineer of the company, whose untimely death preceded that of Mr. Swasey by only four months. The 72-inch mirror and the optical accessories for this telescope were made by the John A. Brashear Company, Ltd., of Pittsburgh. Dr. J. S. Plaskett, who was the Director of the Observatory for twenty years, in his memoir³ of Mr. Swasey says:

“The beautiful lines of this mounting, unequaled in either earlier or later telescopes, and the symmetry and harmony of the design, were due to the engineering artistry of Mr. Swasey, who possessed a real genius in mechanical design with the beautiful and satisfying in appearance. This telescope set a new standard in accuracy, convenience and speed of operation, amply confirmed by the quality and quantity of the work produced in its twenty years of operation.”

A mounting for a 60-inch reflecting telescope and covering dome for the Argentine National Observatory at Córdoba was completed in 1922, and a 69-inch reflector with dome was made in 1923 for the Perkins Observatory of Ohio Wesleyan University at Delaware, Ohio. The optical parts of these telescopes were provided by J. W. Fecker, successor to the John A. Brashear Company.

At the time of Mr. Swasey's death there was nearing completion an 82-inch reflecting telescope, the largest and most advanced instrument yet constructed by the Warner & Swasey Company, for the McDonald Observatory of the University of Texas, located on Mount Locke, near Fort Davis, Texas. The company carried out in its own shops the grinding and figuring of the mirror and the optical accessories of a telescope for the first time, in connection with this instrument. The well-known optician, C. A. Robert Lundin, here accomplished the most accurate parabolic mirror ever constructed. The completed mounting was erected in the shops of the company and Mr. Swasey's friends gathered around this masterpiece of mechanical design on December 19, 1935, in celebration of his eighty-ninth birthday, doing honor to him and to the men whose skill he had

³ J. S. Plaskett, *Monthly Notices, The Royal Astronomical Society*, 98, 258-262 (1938).

helped to develop. The casting and annealing of the glass disk was completed by the Corning Glass Works in October, 1934. The grinding and figuring of its reflecting surface at the Warner & Swasey optical shop extended over four years to October, 1938. Dr. J. S. Plaskett, retired Director of the Dominion Astrophysical Observatory, acted as scientific consultant on this project. He remarks, "It can safely be stated that the quality of the 82-inch mirror of the McDonald Observatory is unequalled by any mirror previously made and tested."⁴ The formal dedication of the Observatory took place on May 5, 1939.

Mr. Swasey himself considered that his greatest achievement in the design of precision mechanism is the dividing engine for graduating circles, which was completed in 1898. This machine automatically graduates circles of any diameter up to forty inches, in degrees and minutes of arc, for use on astronomical meridian circles and transits for the determination of fundamental star places, and for instruments used in geodetic surveying. Precision is of supreme importance. The maximum error in the readings of the master circle is less than one second of arc, which ranks this engine as among the most precise of its kind in the whole world. There are 1,296,000 seconds in a complete circle; in a circle forty inches in diameter this machine does not make an error greater than $1/12000$ of an inch. The graduations on the inlaid silver band of the master circle of the dividing engine are so fine that they can scarcely be seen with the naked eye, yet the width of each line is twelve times the maximum error of the angular values which the engine produces automatically. Another description of the precision is that if the circle were enlarged to a diameter of six miles, no graduation would be out of its correct position by as much as an inch. In such an engine it is essential that the spindle carrying the master plate shall accurately fit into its bearing, and that the worm gear on the circumference of the plate and the screw for rotating the plate shall be perfect. Mr. Swasey was ably assisted in the machine work by Mr. Gottlieb L. Fecker as superintendent of the

⁴J. S. Plaskett, *The Astrophysical Journal*, 89, 84-98 (1939).

Instrument Department. Professor Edward W. Morley, of Western Reserve University, carried out the calibration of the circular graduation and verified the corrections to the screw and gear of the master circle. The circles for the large meridian circle of the United States Naval Observatory at Washington were graduated on this engine, and were found to be the most precise till then made.

At the time of the conferring of the John Fritz Medal, in 1924, Major General William Crozier, former Chief of Ordnance, United States Army, said: "I may have been fortunate enough to make some contribution in the service of the Army, not the least has been . . . the military discovery of Mr. Swasey; he is an engineer whose military services are worthy to rank beside those he has rendered the civil and scientific world. The first thing of which I shall speak is the instrument officially known as the Swasey Depression Position Finder."⁵ Warner and Swasey provided an instrument of this type meeting the requirement that it should show at once not only the range of a vessel at sea, but also the range and direction from each of several gun positions, variously placed. Another instrument of original design, produced under the personal direction of Mr. Swasey, is the "azimuth instrument," useful in seacoast defenses. Among the many kinds of equipment for use in the field are range finders of several types, gun-sight telescopes, commander's telescopes, telescopic musket sights, and prism binoculars. During the World War the Government required three important instruments from the company, telescopic musket sights, naval gun sights, and panoramic sights. The latter instrument is used for the direction of field artillery fire, and, during the period of greatest stress, was placed first in priority of all fire-control instruments for both the Army and the Navy. The panoramic sight was produced in a manner and on a scale so satisfactory that the Government awarded a Certificate of Merit, which was accompanied by the following citation by the Chief of Ordnance:

⁵ United States Superintendent of Documents, *Document Catalogue*, Vol. 7, pages 1060-1069; Vol. 9, pages 1336-1349, 5 plates.

“For exceptionally rapid development of manufacturing methods and quantity production on a vast scale of Panoramic Sights.”

Mr. Swasey traveled extensively in America and abroad; with Mrs. Swasey he made two trips around the world, westward in 1902-1903 and eastward in 1910-1911; he visited various Oriental countries in 1916; he made several trips to Europe.

On their second journey around the world Mr. and Mrs. Swasey visited China, for the second time, in January, 1911, and were impressed with the importance of religious and educational activities. At Swatow, China, he built for the Baptist Missionary Society a beautiful gateway arch and a highway leading from Swatow harbor to the mission. The gateway has been named “Swasey Arch.”

In 1913, after Mrs. Swasey's death, Mr. Swasey presented a Y. M. C. A. building to Canton Christian College (now Lingnan University) as a center of religious activities; the building contains a library, auditorium, club rooms, bowling alley, and other suitable equipment.

In 1916 Mr. Swasey presented a Science Building to the University of Nanking, China, and he received an urgent invitation to be present at the dedicatory exercises to be held early in 1917. Accompanied by his intimate friend, Dr. John A. Brashear, and by Dr. John R. Freeman and his two sons, Hovey T. and John R., Jr., he sailed from Vancouver, December 1, 1916, and landed at Yokohama on December 14. They journeyed across Japan and to Korea and arrived in Seoul on December 18. On the next day they were received by the Governor of Korea and visited the Oriental palace of the earlier Kings. This occurred on the afternoon of December 19, 1916, which was Mr. Swasey's seventieth birthday. Without his knowledge an elaborate birthday dinner was arranged for the evening.⁶ Several prominent men associated with the medical missionary and Y. M. C. A. work in Korea were invited.

⁶ John A. Brashear, *Autobiography*, edited by W. Lucien Scaife, page 189, New York, 1924. John R. Freeman, *Mechanical Engineering*, 46, 369-370 (1924).

After the dinner a mock ceremony was arranged with pomp and splendor, using antique Oriental garments, a gorgeous robe, a royal helmet, and a sword of state, centuries old; the reincarnated King, addressing Mr. Swasey, in giving the accolade said, "Rise, Sir Ambrose, Knight of the Kindly Heart." The title thus bestowed has been approved by all who knew Mr. Swasey.

The party travelled through Korea to Northern China and to Peking. Here they visited the Great Wall, and especially the remarkable Chinese Observatory on the Inner Wall of Peking, which was established in the thirteenth century. Several very impressive astronomical instruments made in France in the seventeenth century were mounted there; at the close of the Boxer Revolution in 1900, five of the instruments were removed by the Germans to the garden of the palace at Potsdam in Germany. Mr. Swasey took an active interest in the return of these instruments to their original foundations, in accordance with provisions of the Treaty of Versailles.

The party journeyed onward, visiting Hankow and other cities, and to Nanking, arriving the day before the dedication of the Swasey Science Building, which occasion was the reason for the visit to China. This notable ceremony, which took place on January 12, 1917, is described by Dr. Brashear in his Autobiography. Eighteen congratulatory addresses were made, to which Mr. Swasey responded, expressing his pleasure in presenting the Science Building. Dr. Brashear adds: "How strange it seemed to me to have come more than ten thousand miles from home, from the universities and schools I loved so well, to a so-called benighted land, to find such a beautiful building dedicated to science, to truth-seeking among the mysteries and marvels of God's universe!" The morning after the dedication, Mr. Swasey gave a brief address in the chapel. In the evening, the alumni association of the college held a banquet and after the banquet the party left for a night trip to Shanghai. They proceeded homeward by way of Manila, Hong Kong, Canton, Japan, Hawaii and San Francisco.

In his travels Mr. Swasey had become much impressed by the romantic beauty and the legends of the Orient. Carved

ivories made an especial appeal. While crossing the Pacific Ocean in 1916 he arranged with a friend, who was a missionary stationed in Burma, to obtain a pair of elephant's tusks. Five years later an exceptionally large and beautiful pair of tusks was secured, being four and a half feet long. A carefully chosen, artistic carver in ivory was commissioned to record a mythological Buddhist story.⁷ The entire surface of each tusk is exquisitely carved with a conventional design, there being twenty deep recesses, in each of which is a carved scene of the legend. There is a large teakwood base, carved to correspond with the ornamentation on the tusks, to which the tusks are attached in an upright position, by means of carved silver mountings. The artist and his assistant worked continuously for more than a year to complete this work. In accordance with his wish, after his death, these tusks were presented to the Smithsonian Institution and are now on exhibition in the Asiatic Hall of the United States National Museum.

Mr. Swasey received many formal honors, medals and degrees. In 1900 the Government of France conferred upon him the distinction of Chevalier of the Legion of Honor and in 1921 that of Officer of the Legion of Honor.

The United Engineering Societies conferred the John Fritz Gold Medal and Certificate upon Mr. Swasey on April 23, 1924; the certificate reads: "For his achievement as a designer and manufacturer of instruments and machines of precision, a builder of great telescopes, a benefactor of education, and the Founder of The Engineering Foundation." This medal is the most distinguished honor that can be awarded in the engineering profession. This medal was first awarded in 1902 to John Fritz, its founder; then to Lord Kelvin, George Westinghouse, Alexander Graham Bell, Thomas Alva Edison, and for the nineteenth award to Marconi, and to Mr. Swasey for the twentieth award.

In 1930 the Cleveland Chamber of Commerce awarded the bronze medal and certificate to Mr. Swasey, "For distinguished service to the City of Cleveland."

⁷ Ambrose Swasey, "Carved Ivory," a booklet of 41 pages, with many illustrations. Privately printed, Cleveland, 1927.

In 1932 the Franklin Institute awarded the Franklin Gold Medal and Certificate and also a Certificate of Honorary Membership in the Institute, the highest award in its power to confer. The citation reads: "In recognition of his development of methods and his invention of appliances . . . and of his scientific vision in the establishment of The Engineering Foundation for the promotion of research and its application in the various fields of engineering."

In 1933 Mr. Swasey was chosen by his fellow members of the American Society of Mechanical Engineers to receive the A. S. M. E. Medal "for distinguished service in engineering and science."

The Washington Award, a bronze tablet, was awarded in 1935 to Mr. Swasey by a commission representing The American Society of Civil Engineers, The American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, The American Institute of Electrical Engineers, and The Western Society of Engineers. The award is "In recognition of devoted, unselfish and pre-eminent service in advancing human progress."

The Hoover Gold Medal was awarded to Mr. Swasey at a dinner in his honor in connection with the annual meeting of the American Society of Mechanical Engineers in New York on December 2, 1936, a few days before his ninetieth birthday. This medal was perpetually endowed by Conrad N. Lauer, of Philadelphia, and had been awarded only once previously, in 1930, and then to Herbert C. Hoover, in honor of whom the medal is named. Mr. Hoover was present on the occasion of the award to Mr. Swasey and gave one of the principal addresses. The medal is awarded to a member of the engineering profession who, outside of and beyond professional duties, sets a high standard of leadership and performs distinguished public service. The award is determined by a joint board of representatives of the four national societies of mechanical, civil, electrical, and mining and metallurgical engineering.

On the occasion of the award of the Hoover Medal, on December 2, 1936, Mr. Swasey was presented with the Medal of Honor of the "Verein Deutscher Ingenieure" of Germany.

The citation states: "Outstanding designer of machine tools, astronomical and optical instruments, the founder of an enterprise which has gained world-wide reputation, the great benefactor of engineering research." The "enterprise" referred to is The Engineering Foundation. The citation was accompanied by a letter from the President of the German Society, stating that the presentation is in celebration of Mr. Swasey's ninetyeth birthday.

When a new minor planet or "asteroid" is discovered, astronomers give it a serial number, and they also allow the discoverer the privilege of choosing a name for it. As a tribute to Mr. Swasey on his eighty-eighth birthday, December 19, 1934, Dr. Otto Struve, Director of the Yerkes Observatory, who had discovered asteroid No. 922, gave it the name "Swaseya." The *a* was added to the name in accordance with the tradition that all names of asteroids shall end with *a*.

Seven academic institutions conferred honorary degrees upon Mr. Swasey. The degree of Doctor of Engineering, D. Eng., was conferred by the Case School of Applied Science in 1905, in recognition of his contributions to engineering and science which had been manifested in the designs of the Lick and Yerkes telescopes and of the precision dividing engine for circles. In 1910 Denison University conferred the Doctorate in Science, D. Sc., and in 1924 the University of Pennsylvania gave the same degree. The degree of Doctor of Laws, LL.D., was conferred by the University of California in 1925, by the University of Rochester in 1925, and by the University of New Hampshire in 1930. In 1931 Brown University awarded him the degree of Doctor of Science, D.Sc.

The wide scope of the activities in which Mr. Swasey was interested and the esteem of his associates is manifested by the large number of learned and scientific societies of which he was a member. The more important of these societies, with the dates of election and mention of official positions are the following. The National Academy of Sciences, 1922; the American Philosophical Society, 1919; the American Astronomical Society, 1918; the National Research Council, 1916, Patron; the American Association for the Advancement of Sci-

ence, Fellow, 1934; American Society of Mechanical Engineers, Charter Member, 1880, Vice President, 1900-1902, President, 1904, Honorary Member, 1916; American Society of Civil Engineers, Honorary Member, 1921; American Institute of Electrical Engineers, Honorary Member, 1928; Cleveland Engineering Society, 1882, President, 1894, Honorary Member, 1917; the Franklin Institute, Honorary Member and Medalist, 1932; New Hampshire Society of the Cincinnati, 1908, Honorary Member, 1919.

Mr. Swasey was elected a member of the British Astronomical Association, a society of active amateur astronomers, in 1897; in 1898 he was made a Fellow of the Royal Astronomical Society. He became a member of the Institute of Mechanical Engineers of Great Britain in 1898, and received Honorary Membership in 1921; in 1921 he was elected to Honorary Membership in the Institute of Mining Engineers of Great Britain. In 1921 the Société des Ingenieurs Civils de France bestowed Honorary Membership.

Mr. Swasey's list of honors is rivalled, indeed is exceeded, by the catalogue of his benefactions to religious organizations, to education, and to engineering and science. In the funeral oration at Exeter it was related that his first experience in giving was to go into the woods with his brother, there to chop two cords of wood and haul it to the Baptist parsonage. He was very modest and unostentatious regarding his philanthropies, and only those of a necessarily public nature are known. Reference has already been made to his gifts in China, the Highway and Gateway to Swatow, the Y. M. C. A. building at Canton, the Science Building at Nanking, and to the Oriental carved ivory presented to the Smithsonian Institution. Mr. Swasey made further gifts in trust of \$50,000 each to the Canton Christian College and to the University of Nanking, the proceeds to be used for current expenses.

In 1899, Mr. Swasey and his partner, Mr. Warner, presented a 10½-inch refracting telescope with a revolving dome to Western Reserve University; this instrument is mounted on the building of the Laboratory of Physics.

In 1910, Mr. Swasey presented to Denison University a beautiful astronomical observatory, constructed of white Vermont marble, together with a 9-inch equatorial telescope and a 4-inch combined transit and zenith telescope. He also presented a complete file of the *Proceedings of the Royal Astronomical Society of London*.

The Warner and Swasey Observatory of Case School of Applied Science, Cleveland, Ohio, was dedicated on October 12, 1920. The observatory and the 10-inch refracting telescope are the gifts of Worcester R. Warner and Ambrose Swasey. In the presentation address Mr. Warner said in part: "This telescope and dome are the ones that we had mounted between our residences in this city for twenty-five years, but they have been remodelled and all the improvements made since they were built have been embodied in the present instruments. The optical parts are the work of John A. Brashear. This telescope made a record years ago, for we exhibited it at the Paris Exposition in 1900. There were other telescopes exhibited from Germany, England and France, but this was the only instrument that received a gold medal." Mr. Swasey said in part: "Mr. Warner and I are often asked if building telescopes is our only business and sometimes I have answered that we get our money out of machinery and our glory out of telescopes. However, while the monetary reward may have been meager we have been amply compensated for all our astronomical work by the benefits we have received from the men of science with whom we have been associated at this work."

For the perpetuation of the gracious influence and memory of Mrs. Swasey, who died in 1913, Mr. Swasey established, in 1915, the Lavinia Marston Swasey Memorial Fund of \$300,000 for ministerial relief through the Northern Baptist Convention. In 1929 he contributed \$100,000 to the fund for the construction of a Library Building for the Colgate-Rochester Divinity School.

In 1916 Mr. Swasey made a contribution of \$52,500 to the endowment fund of Denison University, Granville, Ohio. In June, 1922, he formally offered to "provide sufficient funds to erect and equip a Chapel of ample capacity, designed and located

in conformity with the plans prepared by the architect of Denison University." The cornerstone was laid on November 4, 1922. The Chapel is an exceptionally beautiful example of the "colonial" style of architecture. The auditorium has a seating capacity of thirteen hundred persons. The gift, valued at more than \$300,000, included a fine three-manual pipe organ and a memorial bell tower in memory of Mrs. Swasey, the tower containing a carillon of ten bells.

Mr. Swasey was a Trustee of the Western Reserve Historical Society of Cleveland from 1912 till his death; in 1920 he created a trust fund of \$50,000 for the Society; he purchased and then presented to the Society for addition to its numismatic collection 900 Greek and Roman coins, and 1500 specimens of coins of the Chinese Empire dating back to the world's earliest metal coinage of about 800 years B.C.; he provided two especially designed steel cases for the numismatic collections.

On his eightieth birthday, December 19, 1926, Mr. Swasey sent a letter to the President of Case School of Applied Science, as follows:⁸ "For many years I have been greatly interested in your institution . . . and have been especially attracted to the Department of Physics . . . because of the work in scientific research. . . . I have today set over . . . one hundred thousand dollars (\$100,000) as an Endowment for a Chair of Physics. . . ."

Mr. Swasey was one of the founders of the American Society of Mechanical Engineers (1880) and served as President of the Society in 1904. For several years he considered how best to assist his fellow engineers, through his own society or some other organization, in working out problems for which till then no means had been provided. After consulting friends competent to advise, in 1914, he anonymously proffered a gift of \$200,000 to the United Engineering Society. The gift was accepted and "The Engineering Foundation" was established as a department of the United Engineering Society, to administer this fund, in the words of the donor, "for the furtherance of research in science and engineering or for the advancement in any other

⁸ *Science*, LXV, 9 (1927).

manner of the profession of engineering and the good of mankind." ⁹

The original gift, made in 1914, was \$200,000; to this Mr. Swasey added \$100,000 in 1918, \$200,000 in 1923, and \$250,000 in 1931; the sum of these gifts made in his lifetime is \$750,000. After his death it was disclosed that in 1923 he had begun to build up a trust fund for the further benefit of The Engineering Foundation. When this fund was delivered to the Foundation it amounted to more than \$89,000, making the total of his gifts \$839,000. He intended his contributions to be the nucleus of a larger endowment, to which others would contribute as the years passed.

The National Academy of Sciences took steps in 1916 toward organizing for services to our country in war and in peace a body whose membership should embrace representatives of many sciences and arts. The National Engineering Societies promptly cooperated in the creation of the National Research Council. Money was lacking with which to begin operations and the Engineering Foundation met the emergency. This was the Foundation's first notable undertaking, and it has continued to the present time its relationships with the Council.

The founder societies in 1919 assisted the National Research Council in establishing its Division of Engineering and Industrial Research in the after-war reorganization. Some members of the Board of the Engineering Foundation are also members of the Division of the National Research Council. The Foundation has provided offices for the Division in the Engineering Societies Building, New York, since May 1, 1919, and has cooperated with the Council in a number of research projects, including organization of Advisory Board on Highway Research, American Bureau of Welding and Personnel Research Federation; fatigue (endurance) of metals, marine piling, molding sands for foundries, pulverizing of ores, cements and fuels, heat transfer and electrical insulation; also compiling a directory of research laboratories in the industries of the United States.

⁹ Alfred D. Flinn, *Science*, 78, 424-428 (1933). The Engineering Foundation, *Annual Report, 1936-1937*, pages 12, 13, 20, 21, *et seq.* The Engineering Foundation, Otis Ellis Hovey, *Twenty-Five Years of Service, 1914-1939*, 85 pages, New York, 1940.

Betterment of engineering education has been promoted through assistance to the Society for the Promotion of Engineering Education in investigations of institutions, methods and needs, and its summer schools for engineering teachers.

The adequate development of the work of the National Academy of Sciences and the National Research Council required a building in Washington with proper facilities and of architectural impressiveness. An entire city block facing the Mall near the Lincoln Memorial was selected for the site, and funds for the purchase of the land were raised by subscription. Mr. Swasey contributed \$10,000 for this purpose.

Mr. Swasey served the United States Government in various capacities. In 1907 he was a member of the National Board of Trade and held the office of First Vice President. In 1909 President Theodore Roosevelt appointed him a member of the Assay Commission of the Government Mints, and President Taft appointed him to the same commission in 1913. From 1921 to 1926 he served on the Board of Visitors of the National Bureau of Standards; he took an active part in the selection of a Director of the Bureau in 1923. As a representative of the United Engineering Society and the Engineering Foundation he participated in the organization of the National Research Council in 1916 and was a member of its Division of Engineering and Industrial Research till 1927; he served on various important committees and was a Member at Large of the Executive Board of the National Research Council, 1921-1927.

Mr. Swasey was a member of the Jury of Awards of four important Expositions: the Tennessee Centennial Exposition, Nashville, 1897; the Pan-American Exposition, Buffalo, 1901; the Louisiana Purchase Exposition, St. Louis, 1904; and the Jamestown Tercentennial Exposition, Jamestown, 1907, being the Vice President of the Jury.

In 1914, in celebration of one hundred years of peace between Great Britain and the United States, the British Peace Centenary Commission purchased Sulgrave Manor, a charming Tudor House, located in Northamptonshire, England, which had been the home of George Washington's ancestors, and made it a permanent memorial. The Sulgrave Institution was organized in

this country to assist in obtaining a permanent endowment of \$100,000 for the memorial. Mr. Swasey was a member of the Board of Governors and he contributed \$1000 to this fund.

The Museum of the Peaceful Arts was organized in New York in 1927, being an International Industrial Museum illustrating the progress of civilization from the earliest times to the present. Later, this museum became the New York Museum of Science and Industry. Mr. Swasey was a member of the Board of Trustees from 1927 till his death.

In 1929 Mr. Swasey was appointed a member of the National Committee for the Benjamin Franklin Building and Endowment Fund of the American Philosophical Society, and he contributed \$25,000 to this fund.

Mr. Swasey was a member of the Baptist Education Society of the State of New York from 1928 and served as its President. He was a member of the Northern Baptist Convention and served on the Executive Committee and the Finance Committee from 1922.

Mr. Swasey was a member of the Board of Trustees of Denison University, Granville, Ohio, from 1897 till his death. He was President of the Board in 1922; in 1923 he resigned this office and was made Honorary President of the Board, which honor he held till his death.

Mr. Swasey was a Trustee of Western Reserve University from 1908 to 1913 and from 1930 till his death, 1937; he was a Trustee of Adelbert College from 1926 till his death.

Mr. Swasey was elected a member of the Corporation of Case School of Applied Science in 1922; and in 1929, upon the death of Worcester R. Warner who had been a member of the Board of Trustees of Case since 1889, Mr. Swasey was elected as his successor and continued a member of the Board till his death.

Mr. Swasey was a member of the Board of Trustees of Nanking University, China, from 1924 till his death in 1937.

Mr. Swasey was prominent in civic affairs in the city of Cleveland. He was a member of the Cleveland Chamber of Commerce since 1898, and served as its President in 1905. He was a Corporate Member of the Society for Savings Bank, and

for twenty-five years a Director of the Cleveland Trust Company. He was President of the Caxton Building Company.

Mr. Swasey was a Trustee of the Cleveland Young Men's Christian Association from 1912 till 1931, and was President of the Board of Trustees in 1917 and 1918.

Mr. Swasey was a Trustee of the First Baptist Church of Cleveland and was Honorary President of the Board of Trustees from 1922 to 1937. He contributed \$200,000 to the fund for the new church building in Shaker Heights.

Mr. Swasey was a Life Member and a Past President of the New England Society of Cleveland and the Western Reserve.

Mr. Swasey became a member of the well-known book-lover's club of Cleveland, the Rowfant Club, in 1896; he served on the Board of Fellows for the terms 1901-1904 and 1908-1914; he was President of the Club in the year 1912-1913. Mr. Swasey presented the Club with a medal in honor of John Hay; the medal was designed and executed by Victor David Brenner and one hundred and seventy exemplars were struck at the United States Mint in 1912, one exemplar being presented to each member of the Club.

Mr. Swasey and Mr. Warner appreciated the value of their apprenticeship training and resolved to offer greater opportunities in their own shops. In 1911 an Apprenticeship School was established under the direction of a regular Apprentice Instructor. Besides organized shop work the apprentice receives four hours each week of classroom instruction in subjects of direct practical value. For advanced and related subjects, the apprentice is urged to attend one of several available night schools. Through his official connection for many years with the Cleveland Young Men's Christian Association, Mr. Swasey was able to provide exceptional opportunities to especially deserving young men of high character and ability. Many of these apprentice graduates have come to positions of leadership and influence.

Mr. Swasey was a member of various clubs, among which are the Cosmos Club of Washington, the Union League Club, the Engineers' Club and the Grolier Club of New York, and the

Union Club of Cleveland; of the latter club he was a Director and he served as President for two terms.

Two and a half years after he became associated with the Pratt and Whitney Company, when he was nearly twenty-five years old, Mr. Swasey was married on October 24, 1871, to Lavinia Dearborn Marston, daughter of David Marston of Hampton, New Hampshire. Mrs. Swasey was reserved in manner, gracious, and deeply religious; she contributed in a large measure to his happiness and success. There were no children. Mrs. Swasey died on January 22, 1913. Mr. Swasey left a fund of \$30,000 in trust for the Congregational Church of Hampton, New Hampshire, in memory of Mrs. Swasey's mother.

The fine old farm, about a mile north of the town of Exeter, in New Hampshire, upon which Mr. Swasey's grandfather lived to the good old age of ninety-four years, and where his father spent his long life from 1800 to 1890, came into Mr. Swasey's possession, and he often went back to the old homestead where he spent the happy days of his childhood and youth. The old home was modernized on a modest scale and in excellent taste in 1903, and was occupied as a summer residence. Here Mr. Swasey died on June 15, 1937.¹⁰

On the western part of this estate there are two massive boulders rising to a height of ten feet, with flat surfaces on their adjacent sides, which have been used as an immense fireplace. This quaint upheaval of nature, in the early period of the town, was a resort for Indians, and later for vagabonds. In 1697 a party of Indians used the rocks as a "fort" from which to attack the town, and the name of "Fort Rock" has persisted. Mr. Swasey adopted the name "Fort Rock Farm" for his homestead and used this title on his stationery.

¹⁰ Immediately after Mr. Swasey's death the following biographical articles appeared: W. W. Campbell, "Ambrose Swasey, 1846-1937," *Publications of the Astronomical Society of the Pacific*, **49**, 179-185 (1937). Portrait. J. J. Nassau, "Ambrose Swasey, Builder of Machines, Telescopes and Men," *Popular Astronomy*, **45**, 407-418 (1937). Portrait, 6 illustrations; *Journal of Applied Physics*, **8**, 595-601 (1937). J. S. Plaskett, "Ambrose Swasey, Engineer, Scientist, Philanthropist," *Journal of the Royal Astronomical Society of Canada*, December, 1937, pages 409-416. Portrait. "Obituary Notice of Ambrose Swasey," *Monthly Notices of the Royal Astronomical Society*, **98**, 258-262 (1938).

Mr. Swasey was always deeply interested in the welfare of his native town of Exeter, a small city of about 5000 inhabitants, located in the southeastern corner of New Hampshire on the Exeter River, about thirteen miles southwest of the seaport, Portsmouth. He gave \$50,000 to the endowment fund of the local hospital, and \$25,000 to the Baptist Church of Exeter. He made further gifts to the church: the sum of \$5000, a pipe organ which he did not live to hear played, and two memorial windows. In 1916 he presented a pavilion, located in the public square in the center of the town. The pavilion is an architectural gem of great beauty, designed by the eminent architect, Henry Bacon, of New York. It is constructed of pink Milford granite and white marble, with eight marble columns supporting the copper roof. There is a bronze plate with the signs of the zodiac, and a bronze chandelier, and bronze railings and gate. The pavilion may be used for public speaking and for band concerts. The gift also includes a granite watering trough set at one side of the Square. He gave \$11,500 to the New Hampshire Society of the Cincinnati for the purchase of property for its "home" at Exeter.

Mr. Swasey caused to be filled in and beautified a strip of swampland, several hundred feet wide, on the right bank of the Exeter River (formerly called the Squamscott River), extending from the business center of Exeter, northerly about a mile to the old homestead, Fort Rock Farm. This has been named "The Swasey Parkway."

Mr. Swasey's active mind and optimistic spirit together with an unusually robust constitution enabled him to maintain a keenly intellectual and bodily activity until the end. In the summer of 1936 he visited his scientific friends in England. On the occasion of the presentation of the Hoover Medal in New York on December 2, 1936, a few days before his ninetyeth birthday, he took his full part in the ceremonies, including a brief speech expressing his thanks and appreciation for the honors bestowed upon him, and voicing the hope that the services rendered to humanity by the engineering profession would be enlarged in scope with the passing of time. In April, 1937, he attended the meetings of the National Academy of

Sciences in Washington, an annual event which gave him great pleasure, where his friends, who enjoyed the privilege no less, greeted him with rare affection. Four weeks later he was confined to his home in Cleveland by a cold; upon his insistent request, on June 9, he was taken to his ancestral home, Fort Rock Farm, in Exeter, New Hampshire, where he died from pneumonia on June 15, 1937, aged 90 years, 5 months, and 26 days. The body was brought to Cleveland for funeral services held in the First Baptist Church on June 18; the body was returned to Exeter where services were held on June 19 in the Baptist Church, and interment took place in the Exeter Cemetery where are buried the members of his family.

The conclusion of an address by Mr. Swasey before the Franklin Institute following the presentation of the Franklin Medal, in May, 1932, expresses his oft-repeated sentiments. "Man is never satisfied in his quest for knowledge . . . now turns to far distant galaxies. . . . May we not feel that the Creator of all things so fashioned the heavenly bodies and so directed their movements, that men of science might have opportunities for study. . . . As the astronomer reaches out and out into the galaxies of the heavens, and the physicist and geologist delve deeper and deeper into the mysteries of the earth, the words of the Psalmist come to us with increasing significance, 'The Heavens declare the Glory of God and the firmament showeth his handiwork.'"

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