SAMUEL PIERPONT LANGLEY.

BY MARCUS BENJAMIN.

Samuel Pierpont Langley was born in Roxbury, now a part of Boston, Mass., on August 22, 1834.

His early education was acquired at the Boston Latin and High Schools, but he did not go to college, then associated almost exclusively with the idea of a classical education, as his strongest bent was to those scientific investigations which have been the occupation of his later life.

In this connection he says: "I can hardly recall the time when a treatise on astronomy, even though then unintelligible, had not a curious attraction for me; and one of my very early childish experiences was in connection with my inquiries as to the reason why the glass in a hot-bed I saw kept the contents warm. That none of the elder people I questioned saw any difficulty about it, and that I did so, seems to me to indicate an early bias to studies on such subjects as those connected with radiant heat, in which I attribute any subsequent success I may have met with largely to the fact that their pursuit has always been in accordance with my inherent tastes and wishes."

The school days over, he turned his attention to astronomy; but finding that it could not yield a support for many years, he looked for a temporary substitute to civil engineering as a profession whose base was mathematical, while special circumstances led him later to the practice of architecture, so that it was not until he was thirty that he found himself free to return to the chosen work of his life.

In 1864, in company with his brother, John W. Langley, now Professor of Chemistry at the University of Michigan, he visited Europe, and took every opportunity of visiting observatories and meeting astronomers, although the journey was made more for recreation than for study.

After an absence of over a year, he returned to the United States, and during the summer of 1865 he entered the Harvard College Observatory, then under the directorship of Joseph Winlock, as an assistant.

His stay at Cambridge was of short duration, for, on the recommendation of Professor Winlock, he was appointed assistant professor of mathematics in the U. S. Navy, and assigned to duty at the Naval Academy, in Annapolis.

Prior to the war, a small observatory had been built in Annapolis by Professor William Chauvenet, but the subsequent transfer of the academy to Newport, R. I., had prevented any work of importance being undertaken, and the instruments were practically unused. Professor Langley's first duties consisted in remounting them and placing the observatory in working order.

In 1867, he was invited to the charge of the Allegheny Observatory, near Pittsburg, and situated on one of the high hills above the Ohio River.

The endowment of the chair only provided for the observer's salary, while beyond the observatory building and a mounted equatorial of thirteen inches aperture, there was no equipment, so that a definite income to provide the means for research was one of the first necessities to be obtained. This income he himself acquired for the observatory by introducing the then novel system of time service for regulating the public time of Pittsburg and of numerous private offices, also furnishing standard time for the entire railway system centering in Pittsburg. The beats of the standard clock of the observatory were daily sent out automatically by electricity over the telegraph lines from New York and Philadelphia, west as far as Cincinnati and Chicago, north to Lake Erie, and south to Washington. This system of time is still in full operation, and has always maintained a high reputation for accuracy.

Indeed, it is not too much to say that the time service, now so universal in the United States, was inaugurated on its present practical standing by Professor Langley. Not that time had not been occasionally communicated to the public by other observatories, such as the Dudley Observatory, in Albany, N. Y., by Dr. Benjamin A. Gould, but that the extended, regular and official connection with railroads, cities, and the public generally, which has since become common throughout the country, was originated as a system at the Allegheny Observatory in 1869.

In 1870 it became possible for him to turn his attention to original investigation, and since then, by a brilliant series of valuable researches in the domain of solar physics, Professor Langley has achieved a reputation that has carried his name beyond our own shores.

One of his earliest papers, "On the Minute Structure of the Solar Photosphere,"* contains the results of two years' work, and includes his discovery, which has since been confirmed by other authorities, that four-fifths of the sun's light comes from less than one-fifth of its surface. One of the most detailed representations of a sun spot which had been published up to that time accompanied this paper. Edward S. Holden, president of the University of California, says: "This paper is fundamental. It treats of a subject of which little had been accurately known, and it leaves this subject in a satisfactory and settled condition."

* American Journal of Science, February, 1874

"Studies of the External Aspect of the Sun,"* published soon after, contained his well-known engraving of the "typical sun spot," which has received the very highest praises from competent judges, and which has been copied by nearly every author on the subject. It was executed for the purpose of giving material for passing judgment on the current theories of sun spots, and had undoubted influence in determining the present belief that the surface of the sun was essentially gaseous or cloudlike.

The existence of a remarkable thermochroic action in the solar atmosphere, such that the vibrations of great wave-length are less absorbed than the visible and ultra-violet, was the subject of a series of papers published in the *Comptes Rendus*.† In these he also showed that no such difference between the polar and equatorial radiation existed as had been asserted by Secchi.

It followed from the first of these facts that sunlight before absorption contains immensely more blue than we habitually see, and that what we call "white" light is really the product of a selective process in the sun's and earth's atmospheres which has sifted out most of the blue before it reaches us, so that the light of common day is but the dregs of what originally started from the sun.

PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

A study of the influence of sun spots on terrestrial climates was the investigation which he next took up. In a paper which he contributed to the *Monthly Notices of the Royal Astronomical Society*,‡ he describes new methods of determining whether sun spots directly affect our climates or not. As a mere interruption of a given quantity of solar heat, he shows that their total effect on terrestrial climates cannot alter the mean temperature of the earth as much as one degree Fahrenheit. Whether they are indices of some remote action having an influence upon the climate, he does not undertake to say.

In October, 1878, he announced§ his discovery of the duplicity of the "great A" group of the solar spectrum. At the same time he published his paper "On the Temperature of the Sun," in which he gives the results of comparison of the heat and light of the sun with that of the molten steel in the Bessemer converter. The temperature of the sun was then believed by leading men of science to be only about 1,500° C., and Langley furnished proof that it was very much higher than physicists, misled by Dulong and Petit's law, had placed it. That this law was here thoroughly unreliable was demonstrated—a statement which is now fully conceded.

* *Journal of the Franklin Institute*, August and September, 1874.
† March 22, 29 and September 8, 1875.
‡ November, 1876.
§ *Proceedings the American Academy*, October, 1878.

More delicate methods were needed for measuring the radiant energy of the sun, of which he believed two-thirds unexplored for want of proper apparatus, since the thermopile, the most delicate instrument science then possessed for this work, was insufficient for these new investigations, and so he devoted the year 1880 to experiments for the construction of a new instrument for analyzing and measuring this and like forms of energy. This instrument, which he called the bolometer, acts by means of a double system of extremely thin platinum strips, through which a current is made to pass. A sensitive galvanometer connected with both systems keeps its needle steady when the currents are equal. If one system is exposed to heat radiations while the other is protected from them, the temperature of the first is raised, its electric resistance is increased, and the battery currents through the two systems and the galvanometer no longer balance. The galvanometer needle then moves, and the amount of this motion measures the amount of heat disturbance. The sensitiveness of the instrument is far greater than that of the most delicate thermopile, and its constancy specially fits it for its work.*

His first research with this new instrument showed experimentally that the maximum of heat in the normal spectrum was in the orange, and subsequently that the amount of heat which the earth receives from the sun had been greatly underestimated, on account of the previous inability to measure the solar heat in sufficiently small portions of the spectrum. Improved methods for the determination of the "solar constant," that is, the amount of heat received from the sun, were pointed out.

In several memoirs† presented to the French Academy of Sciences he likewise described the leading facts in regard to the distribution of energy in the normal spectrum from the sun, and the distribution of this solar energy before absorption by the earth's atmosphere.

Professor Langley had accomplished so much of value bearing on the science of terrestrial meteorology, that in 1881 he was invited to organize and take charge of an expedition sent out under the joint auspices of the Allegheny Observatory and the United States Signal Service to the Sierra Nevadas of Southern California, for the purpose of applying his improved methods under the most favorable conditions. Mount Whitney, some 15,000 feet high, was chosen as the point of observation.

The results of his work were extensively published in journals both at home and abroad, but most fully as "Researches in Solar Heat and its Absorption by the Earth's Atmosphere," in "The Professional Papers of the Signal Service, No. 15" (Washington, 1884). It was shown that the nature, as well as the amount, of the absorption of the solar rays had been completely misunderstood, and for the first time the general outlines of the actual facts were given. A map accompanied this memoir, giving newly explored regions, the infra-red solar spectrum, with numerous lines and bands, hitherto unknown, and, what was wholly new, with their places fixed upon the normal or wave-length scale by direct observation.

If these statements do not convey to the reader a clear idea of the general scope of the work, we may summarize it otherwise as an investigation of the till now nearly unknown major portion of that energy on which all organic life depends. This, it is to be understood, is the real and practical purport.

Finally, the value of the solar constant, fixed by Pouillet at 1·76 calories, was raised to 3 calories.

In October, 1883, he read a paper‡ before the National Academy of Sciences on the "Experimental Determination of Wave Lengths on the Invisible Prismatic Spectrum," in which he fixes the wave lengths of solar heat throughout the whole extent of the spectrum, previous information having restricted our knowledge to the visible portion only.

During the same year he showed,§ both from theoretical considerations and by experiments, that the absorption of the solar rays by the earth's atmosphere is at least double what it has commonly been supposed to be.

Contemporaneous work was not neglected by these researches to which we have previously alluded, for Professor Langley participated in the expedition sent out by the United States Coast Survey to observe the total eclipse of 1869. On this occasion he was stationed at Oakland, Ky. In 1870 he was sent to Xeres, Spain, on similar work, and there determined the polariza-

* See "The Bolometer and Radiant Energy," *Proceedings of the American Academy*, January, 1881; "The Bolometer," *Proceedings of the American Meteorological Society*, December, 1880; and "The Actual Balance," *American Journal of Science*, March, 1881.
† *Comptes Rendus*, 21st March and 18th July, 1881.
‡ *American Journal of Science*, March, 1884.
§ "On the Amount of the Atmospheric Absorption," *American Journal of Science*, September, 1884.

tion of the solar corona to be radial. The total eclipse of 1878 he observed from Pike's Peak, and published his results in the reports of the Washington Observatory.

The transit of Venus in 1874, and again in 1882, also the transit of Mercury in May, 1878, form the subjects of papers published by him on the occasions specified.

His more popular writings include an account* of "Wintering on Etna," where he spent some weeks during the winter of 1878-79, for scientific purposes, living a hermit's life in a hut, three hours' journey above the inhabited zone, and of the modern astro-physical researches in a series of papers called the "New Astronomy," published in the *Century Magazine* at various intervals, beginning in September, 1884.

Professor Langley has visited Europe five times, and his last voyage was made in response to an invitation from the Royal Institution of Great Britain to lecture before that body. His subject was "Sunlight and the Earth's Atmosphere," and was delivered on April 17, 1885. The reception which he received is one of the gratifying evidences of the fact that science knows no country, and that genius is accorded its recognition irrespective of nationality.

A further token of this feeling was manifested during the present year by his receipt from the Royal Society of Great Britain of the gold and silver medals from the bequest of Count Rumford. Professor Langley also received, in 1887, the gold and silver medals from the Rumford fund, administered by the American Academy of Arts and Sciences. The two distinct foundations of Count Rumford were thus independently represented. In 1885 he was awarded the first "Henry Draper gold medal" by the National Academy of Sciences, for his work in astronomical physics.

He received the degree of LL.D. from the University of Wisconsin in 1882, and during the same year that of Ph.D. from the Stevens Institute of Technology. In 1883 the University of Michigan conferred upon him the degree of LL.D., and in 1887 he received a similar honor from Harvard University at its bicentennial celebration. In January, 1887, in addition to his duties at the Allegheny Observatory, he accepted the office of assistant secretary of the Smithsonian Institution in Washington.

Professor Langley is a member of the following societies: American Philosophical Society (April 16, 1875); the National Academy of Sciences (April 19, 1876); associate fellow of the American Academy of Arts and Sciences (February 14, 1883); and abroad, of the Astronomische Gesellschaft (September 14, 1871); honorary member of La Societe de Physique et d'Histoire Naturelle de Geneve (March 20, 1879); corresponding member of the British Association for the Advancement of Science (November 28, 1882); associate of the Royal Astronomical Society (December 14, 1883); and honorary member of the Manchester Literary and Philosophical Society (April 19, 1887).

Prof. Langley was elected a member of the American Association for the Advancement of Science in 1869, and was advanced to the grade of fellow in 1874. He was elected secretary of the section of mathematics and physics in 1875, and presided over this section in 1879, where he delivered his retiring address on "The Progress of Solar Physics." At the Buffalo meeting of this association, held in 1886, he was elected president, and therefore presided at the great meeting held at Columbia College, in New York, this year.

New Fast Boats.

The large steel paddle steamer Empress, built to the order of the London, Chatham, and Dover Railway Company, for their service in the English Channel, by the Fairfield Shipbuilding and Engineering Company, Limited, was lately run over the measured mile at Skelmorlie, on the Firth of Clyde. Notwithstanding the high head wind that was blowing and the heavy sea that was running at the time, the vessel attained a speed of 21·3 knots (over 24½ miles) per hour. The vessel measures 325 ft. by 34 ft. 9 in. by 22 ft. to upper deck, and is divided into eight water-tight compartments. She has a gross register of 1,200 tons, and is similar in design to the Victoria, which was built in the same yard last year. There is a rudder at each end to facilitate the movements of the vessel in entering and leaving harbors. The vessel is supplied with a set of compound diagonal direct-acting engines, and the boilers, which are constructed of steel, are adapted for a working pressure of 110 lb. per square inch. She is fitted with an electric light installation, and is otherwise most completely equipped.

A successful trial trip was recently made on the Clyde by the new steel screw steamer Victoria, the largest and latest addition made to the great fleet of the Peninsular and Oriental Steam Navigation Company. This is a vessel of 6,267 tons gross register. She measures 465 ft. 9 in. (on load water line) by 52 ft. by 37 ft., and is fitted with triple expansion engines of 7,000 horse power indicated, the cylinders being 40 in., 60 in., and 100 in. in diameter respectively, and the length of piston stroke being 6 ft. She has accommodation for 154 first-class saloon passengers, 156 second-class, and 460 third-class passengers. All the fittings, mechanical appliances, and equipment generally are in keeping with the magnificent character of the steamer. On her trial over the measured mile at Skelmorlie the Victoria attained a speed of 17·4 knots, or nearly 20 miles per hour. This vessel makes up a total of about 100,000 tons of new shipping built by Messrs. Caird & Co. during the past fifteen years for the Peninsular and Oriental Company.

* *Atlantic Monthly*, July, 1880.

PNEUMATIC GUN CARRIAGE AT SANDY HOOK.

(*Continued from first page.*)

nished with a lever on its collar, and this lever instantly responds to the shock of recoil and automatically holds the gun in its vise-like grip, and then, when it is wanted in battery or at the rear buffer, in order to receive its new charge, releases it instantly. To the cross transoms of the slide the running cylinders are attached, furnished with pistons having rods leading to the forward transom of the brackets of the sliding carriage on which the gun rests.

There is a slot motion to the attachment of the collar of the piston rod to the carriage, in order that there shall be free play after firing in the strain on the piston rod in the box at the end of the piston head. Supply and exhaust pipes having reversing valves are furnished the running cylinders, in order to supply compressed air at any pressure. By an admirable arrangement, any amount of air pressure may be left at the rear end of the cylinder after firing, which, as will readily be seen, may be utilized in picking up the recoil, and, by means of the clutch lever, instantly forcing the gun back in battery. No tackle or winch or chain gear is required in training. At the rear end of the carriage is a pair of oscillating cylinders arranged horizontally and affixed to a worm geared in a worm wheel having a pinion geared in a cogged wheel, so arranged that any movement, up or down or lateral, will serve to work the piece in any direction. There is no center of axis or movement of these oscillating cylinders, because of the nice arrangement of the parts, and so there is no occasion for slide valves for a reverse motion; double pairs of supply pipes, which lead to the cylinder bases on either side of the running support, doing this work.

A smart press upon the lever, let it be to one side or to the other, and the training engine moves the gun in response. A cylinder furnishes the power for elevating or depressing the piece. This cylinder is of the upright description, and has enough draught to give whatever air pressure is required. At the breech of the gun, and on either side of it, there are racked standards fitted with a working slot, with a compress or screw surrounding a racked die, and, when the screw lever is touched, the breech of the gun, ponderous as it is, is firmly secured in any position.

The air compressor and the receiver, being wholly underneath the carriage, are out of harm's way; not only, as said before, protected from flying shot, but in no danger from contact with the cartridge car and other heavy moving apparatus. A word should be said here in special commendation of the stand-by recoil check, than which it is hard to conceive of a more ingenious and serviceable contrivance in modern gun gear. The best work of man's hand is but imperfection, and the wise mechanician, knowing this, invariably places a safeguard of reserve in attendance upon even the most cunningly contrived device. And so it is that the Pownall type of pneumatic gun carriage has connected with it this stand-by recoil check, so that, should mishap befall the compressed air machinery or pipes, in battle, the turn of a lever and clutch brings this piece of mechanism quickly into play, and it easily takes the place of the defective recoil check. The reserve check is not fitted with cogged gearing like its prototype, being of still simpler construction. It keeps its parts smooth by attrition, running with the other apparatus, though taking no part in the work of the carriage save, as said before, in case of emergency.

The pneumatic gun carriage shown in the cut stands upon masonry, this being the form of base always constructed in land works for heavy gun carriages. Aboard ship, however, the modern gun deck, barbette tower, or turret, can readily be given sufficient stability for its use. Indeed, the pneumatic gun is especially adapted for sea service, because, receiving and dispelling the shock of recoil wholly within itself, it requires no roadway, comparatively little sea room, and is never cast loose at the end of a line, as was the case with the old style guns. These were so light that when one of them carried away its line and rolled from side to side of the ship, if she were laboring in the sea, it was dangerous to life and limb until caught and lashed, but in no wise threatened the stability of the ship; while the heaviest guns of to-day, should they break loose and go crashing to leeward at the critical moment when the lee guards were under, might even endanger the ship. As was shown in a recent number of the SCIENTIFIC AMERICAN, the hydraulic gun carriage has similar advantages in this respect and in others. Indeed, when one studies the relative merits of these two admirable mechanisms, to wit, the pneumatic and hydraulic gun carriages, it is not difficult to understand why authorities differ so widely as to which is the most effective type.

Much has been alleged as to the uncertainty of water or other liquids to perform the function allotted to them in the cylinders of the hydraulic gun; yet, while it is true that water cannot be thus used with safety during a period of low thermometer, and that spirits of wine, alcohol, and the like in the presence of oil and dust are apt to cloy and clog, it may also be said that machinery for compressing air does not always work smoothly, some parts of it, unless great care be taken, being peculiarly liable to mishap. The Advisory Board of Naval Officers agreed with the Ordnance Committee that the hydraulic carriage was to be preferred for the new cruisers, after a careful and comprehensive examination of both types, while, at the same time, a board similarly made up of officers of the Royal Navy decided in favor of the pneumatic gun carriages for two new ships for the British navy. The type of ship in the two cases was, it is true, quite different, yet the fact remains that the two boards summed up merits and effects quite differently, and, with what might be called the same premises, arrived at conclusions widely separated the one from the other. It must, however, be regarded as a fortunate circumstance that both these, which, as said before, are the principal types, are having a thorough trial under circumstances quite similar to those for which they are designed, because these continual trials will bring out the merits and defects with emphasis, and hence lead to perfecting either the one or the other, or, perhaps, as is most likely and most desirable, both.

Reading without Eyes.

W. H. Murray, a colporteur of the National Bible Society of Scotland, has devised a system of raised characters by which the blind are enabled to read. Says the *Missionary Herald:* We have recently received from Miss C. F. Gordon Cumming, the well-known traveler, an interesting account of this effort to reach a large and suffering class in China. It is estimated that there are over 500,000 blind persons in China. Miss Cumming reports that Mr. Murray began life as a working sawmiller in the south of Scotland; but, having by an accident lost one arm, he became a colporteur in Glasgow, and subsequently went to Pekin. His pity having been aroused for the innumerable blind whom he met everywhere, he has given every spare moment for eight years to the study of a system by which they might be enabled to read. In place of the four thousand characters in ordinary use among the Chinese, he uses embossed dots representing some four hundred and twenty sounds; and his first experiment with a blind beggar from the streets, who was enabled to read fluently within six weeks, showed that the system was practicable. A school was opened at Pekin, and blind boys learned to read with great accuracy and rapidity—indeed, very much more speedily than their companions who had eyesight could learn to read the ordinary Chinese characters.

Progress of English Marine Engineering.

The steamship Ohio, an American built vessel of 3,325 tons, belonging to the International Navigation Co., has lately been repaired in respect to her machinery by James Houden & Co., Glasgow. Her original engines and boilers, 2,100 h. p., have been removed and new ones of equal power put in. The new engines are of the triple expansion type, with three cylinders, 31, 46, and 72 in. diameter, 51 in. stroke. The trial of the new mechanism lately took place, and the results were quite remarkable. The mean indicated h. p. was 2,124, consumption of coal 1·23 lb. per indicated h. p., speed 14·12 knots, or about 16½ miles per hour. The new machinery occupies much less space than the old, thus giving more room for cargo, besides increasing the speed and lessening the consumption of fuel.

We think it doubtful whether there is any concern in this country at present able to engine a ship like the above, and warrant the economies mentioned.

Aluminum Steel.

The *Iron Trade Review*, of Cleveland, says: Some important and very satisfactory experiments have been made at the Cleveland Rolling Mill Company's works during the last two weeks in treating Siemens-Martin steel with small percentages of aluminum manufactured by the Cowles Electric Smelting and Aluminum Company, of this city. The result of the work proved conclusively that a small quantity of aluminum freed the steel from blow-holes and increased the tensile strength somewhat without increasing the elongation, besides adding very materially to the fluidity of the bath, thereby producing much sharper castings. It has not yet been determined how small percentages of aluminum are necessary to secure the required products, but from one-tenth to one-twentieth of one per cent gave satisfactory results. The castings made showed a tensile strength as high as 140,000 pounds to the square inch. The alloy was applied in the form of broken ferro-aluminum.