

the preparation of estimates for a second direct line between London and Brighton, and was appointed by Vice-Chancellor Malins one of the official liquidators of the Imperial Land Company of Marseilles. In the summer of 1873 excessive application to his professional duties brought on symptoms of disease, which he unfortunately disregarded, until a fit of fainting with which he was seized during his summer holiday at Folkestone revealed the existence of heart disease. His anxiety to fulfil the duties of his office in the liquidation of the Marseilles Land Company induced him to break in upon his holiday, and to leave Folkestone for Paris. On the 4th of September he arrived there in apparently good health; but in the course of the same evening he became hysterical, and expired suddenly at the Hotel Westminster whilst the medical attendant who had been sent for was preparing a night draught for him at a neighbouring chemist's. His remains were removed to England, and are interred at Kensal Green.

Mr. Samuelson was elected a Member of the Institution on the 1st of April, 1862. He was also a Member of the Institution of Mechanical Engineers, and of the Institution of Naval Architects. He was one of the original promoters of the volunteer movement in Hull, and held the rank of captain in the East Riding of York Volunteer Artillery under his brother, Mr. Martin Samuelson, as lieutenant-colonel.

MR. JOEL SPILLER was born in the year 1790 at Buckland Brewers, North Devon. While yet an infant his parents removed to Exeter, in which city the first twenty years of his life were spent; but as the metropolis was at that time considered the only place likely to afford an opening for an enterprising youth, thither, in 1810, young Spiller made his way. He appears to have begun the real business of life under the late Sir Marc Isambard Brunel, M. Inst. C.E., in whose celebrated saw and veneer mills at Battersea Mr. Spiller was employed as an assistant. While here, he was specially entrusted with the manufacture of crystallized tin-foil sheets, which were largely used for ornamental purposes. The process as carried on by Sir M. I. Brunel was a secret one, and Mr. Spiller was the only operative to whom the method of production was known. He remained at the Battersea Mills until they were burnt down, about the year 1814, when he set up for himself, at first on the Middlesex side of the River Thames, but soon afterwards, he removed to Battersea, where for forty years he carried on the business of a millwright and engineer.

On the 24th of September, 1835, he took out a patent (No. 4,916) for machinery to be employed in the working of pumps. In France at that time the manufacture of sugar from beetroot was a very extensive one. Mr. Spiller supplied most of the machinery required, and these "differential pumps" were in all cases adapted to the hydraulic presses for extracting the juice from the pulp. The application was as follows: Supposing two wheels to be geared together, one having a hundred, and the other one hundred and one teeth. On the face of each wheel there was a crank-pin working a similar force-pump, one foot and delivery valve serving for both pumps. At the first rise of the ram of the press, the two crank-pins occupied such a relative position that both force-pumps descended together, and discharged the combined volume of their plungers into the press. After a revolution of the wheels, one plunger would be the hundredth part behind the other in its stroke, and this diminishing action continued till at last one plunger came to the top of the stroke and its fellow at the bottom. At this point, of course no water would be discharged by the pumps; but then the ram of the press had reached the limit assigned for compression. By this curious action the desired effect was obtained of proportioning the quantity of water to the force of compression required, the full volume of the pumps being thrown at the beginning of the rise of the ram, which diminished to nothing at the end. Mr. Spiller was also engaged, in conjunction with the late Mr. Barnes, on works in connection with the River Seine. While in France he was much pressed to remain and be naturalized, and a lucrative offer of partnership was made to him; but the French mode of life not pleasing him, he declined to surrender his birthright, and elected to remain an Englishman.

Mr. Spiller's name is, however, principally associated with the establishment of steam navigation on the River Thames, especially for the above-bridge traffic, between Putney and London, to which his attention was turned as early as the year 1832. Clearly foreseeing that the cumbrous marine engine then commonly in vogue was not adapted to the small boats which alone could perform the proposed service, all his energies were directed towards contriving a more compact arrangement of the necessary machinery. His friends were subsequently informed that a steamboat could be constructed which should be capable of navigating the shallow water of the Thames at all times of the tide at a good speed, and with ample accommodation for passengers. Being encouraged to persevere, he constructed, upon the model of an eight-oared boat in possession of the Leander Rowing Club of London, his first

steamboat. This vessel was 65 feet long, 7 feet broad, and 4 feet deep, with raised cabins and engine-room, and was divided into three compartments. It was propelled by a pair of three-horse engines with oscillating cylinders, one condenser, and two air-pumps worked by an eccentric on the main shaft. The slides were of the short D type, worked by a rack and sector, fixed on a spindle; on this spindle there was a cross bar, having a pin at each end for the eccentric rod to work upon—the one pin being for the forward, and the other for the backward motion of the vessel,—the eccentrics being fast on the shaft. Steam was supplied from a common flued boiler with two furnaces, and the working pressure was 3 lbs. per square inch. The boat was christened the 'Star'; but, after repeated trials, she failed to satisfy the expectations that had been entertained, for the boiler did not generate steam sufficient to maintain the full pressure, and the speed was not so great as was anticipated. Upon testing various-shaped paddle-floats, some half-circular, some square, &c., the shallow parallelogram was found to be the most effective. A new vessel was laid down in 1833, about 75 feet long and 8 feet beam, with raised cabins as in the other. She was superbly fitted-up, and the charge was to be 1s. for each saloon passenger, and 9d. for each fore-cabin passenger, for every journey from Putney to London, or *vice versâ*. The engines were constructed with oscillating cylinders on the same model as the others, with some slight alterations. The boiler had oval copper tubes through which the fire passed, and the shell of the boiler was sufficiently strong to bear a pressure equal to 6 lbs. per square inch. This vessel was named the 'Fly,' and was licensed to carry one hundred passengers. The journey between Putney and London was performed, at low water, against the tide, in one hour and a half, including stoppages, and with the tide in one hour, and the boat made two 'down' and two 'up' trips every day. The greatest defect in this boat was the difficulty of maintaining steam at the increased pressure in the boiler, which often caused delay and annoyance to the passengers. This deficiency in the boiler gave Mr. Spiller considerable trouble and anxiety. He thought of the application of heat to the lower part of a square chamber filled with tubes of 1 inch diameter, the tubes having an inclination of about 3 inches per 1 foot in length from back to front. The effect was to cause the steam and heated water to rush to the top, and the colder stream to descend to the lowest point, thus producing a constant circulation, and obtaining a great heating surface in the smallest space possible. After several trials to ascertain the quantity of fuel consumed,

compared with the previous quantity, it was found to be one-third less. A new method was adopted of supplying air to the furnace, which was constructed to burn oven coke to obviate the smoke nuisance. The system was to rest the bottom of the boiler upon an air-tight box, with a small opening, in which was inserted a mouthpiece of a fan or blower, driven by an endless chain from the main shaft, over toothed wheels to prevent slipping, thus forcing a strong current of air through the furnace bars with great effect. This was a most important addition, and was completely successful. The steam could be maintained at full pressure, the weight was reduced by one-third, and the space occupied was reduced by one-half. The boiler was placed in the 'Fly' in the year 1834, and she was much improved in speed and a lighter draught obtained. At first everything was against the 'Fly.' The prejudice of the watermen was intense; no one would navigate the boats, and no waterman would take a passenger to or from them. However, the public support enabled Mr. Spiller ultimately to live down all opposition.

A patent was obtained for a boiler on this principle, which is thus described in the "Abridgments of Specifications relating to the Steam Engine," vol. i. p. 360, 1871:—

"A.D. 1835, September 24.—No. 6,897. Spiller, Joel.—Boiler. A 'tube chamber,' having the 'egress flue' or chimney at its upper part, is placed in the centre of the boiler, and beneath it the fire chamber and ash-pit. A number of straight tubes, about an inch in diameter, open at each end, are placed across the tube chamber, and passing through its sides communicate with the body of water within the casing surrounding them. They are placed in parallel rows, one row above another, leaving space between the rows and each tube for the free passage of the air around them; each tube and row lies at an angle with the horizon. The steam in ascending to the higher ends of the tubes draws a constant supply of water from their lower ends, and a rapid circulation is produced. A 'dashing plate' in the steam chamber prevents the rise of water with the vapour. For marine engines, a wind-fan may supply a current of air to the fire chamber."

In 1836, Mr. R. J. W. Leith and two or three friends started the London and Westminster Steamboat Company, the first of several companies which maintained a service of small passenger boats between London Bridge and various places higher up the river. The London and Westminster Company's steamers were known as the 'Flower Boats,' and ran from and to the Surrey side of Westminster Bridge. Of the original boats, five, viz., the 'Rose,' the

'Lily,' the 'Iris,' the 'Daisy,' and the 'Shamrock,' were engined by Mr. Spiller. The engines were made in various ingenious ways, mostly with the object of getting rid of the beam, and were supplied with steam by the patent tubular boilers before referred to. The pistons of these engines had metallic packings, then scarcely known or used in marine engines; but Mr. Spiller found that unless the springs for forcing out the segments were strong enough to resist the pressure of the steam, they were forced inwards, allowing the steam to pass. He then thought of making his piston packings act on the same principle as the cup leather of a hydraulic press or pump, so that the pressure of the steam itself should force the packing out against the cylinder. To effect this, the pistons were made in one casting—that is, without any separate top and bottom plate. Around the piston there were two broad grooves, separated by a solid part of the piston as a ring or mid-rib. The packing rings occupied the two outer grooves, fitting loosely, but being quite steam-tight on the mid-rib, being kept in contact therewith by a few springs. There was ample space left over the opposite packing rings for steam to get behind them to force them outwards. From their loose fit it was impossible that the packing rings could ever stick fast in the grooves. These pistons were found to work so excellently that Mr. Spiller continued to make them as long as he remained in business. The idea had not been published, and has been re-invented many times since.

The object of the tubulous boiler was to obtain steam of a comparatively high pressure (40 lbs. or 45 lbs.) without the danger of explosions, the recurrence of which had begun to give steam-boats an unenviable notoriety. Mr. Spiller's views seem to have tended towards the employment of the compound principle, now so profitably applied in connection with the marine engine; but at this time he had not proceeded so far in his practice, and he confined himself to designing various modifications of detail in the single-cylinder engines then in use. The invention of the water-tube boiler was highly esteemed, other makers of marine engines eagerly adopting it, and paying Mr. Spiller the usual royalties. Though the water-tube arrangement has been superseded by the ordinary return-flue-tube boiler for river boats, owing doubtless to the difficulty of making the tube-connections tight in the case of large boilers, as well as of ascertaining in which tube a leak arose, and the necessity of letting down the pressure before a tube could be plugged, yet, latterly, the water-tube system has again been brought prominently forward, various expedients being resorted to in order to effect the due circulation of the water. In

one of the most recent of these arrangements, the principle is adopted of inclining the tubes at an angle with the horizon, thus reverting to Spiller's system of nearly forty years ago in its entirety.

A notable illustration of Mr. Spiller's prescience is afforded in the fact of his having, in those early days, built and worked engines with high and low-pressure cylinders on the principle of the modern compound marine engine. The credit of initiating this system has been publicly awarded to Mr. Spiller. Mr. F. J. Bramwell, F.R.S., M. Inst. C.E., in a Paper read before the Institution of Mechanical Engineers at Liverpool, in July 1872,¹ stated that "About the same time, but it is believed somewhat before the time of the 'Cricket,' Mr. Spiller, of Battersea, made a small river steamer, which ran for many years, with one high-pressure and one low-pressure cylinder." The boat thus referred to was called the 'Era,' and ran regularly between Putney and London Bridge. It was engined on the system of a Swede named Zander, and attracted considerable attention.² Another boat, termed the 'Sunbeam,' was built shortly afterwards, containing some curious novelties. The steam was worked at a high rate of expansion in single cylinders, which were steam-jacketed. The engines were of the 'steeple' kind, and actuated very large paddle-wheels. The boat lay low in the water, and its long, sharp bows and fine lines gave it an appearance of great speed. It was elegantly fitted up for passenger accommodation, and had a long career, its last appearance being some four or five years ago, when it was recognised performing the functions of a tug to a string of coal-barges, its dingy condition altogether belying its name. A shorter and a more dramatic career attended a rival boat. After the 'Era' and the 'Echo' had run without mishap for several years, the ill-fated 'Cricket,' which carried passengers from the Strand to London Bridge, at the charge of one halfpenny each, burst its boilers while taking in passengers at Hungerford pier, and caused great loss of life. It is fair, however, to record that the jury which sat on the bodies exonerated the maker of the engines, Mr. Joyce, of Green-

¹ *Vide* "On the Progress effected in Economy of Fuel in Steam Navigation considered in Relation to Compound-Cylinder Engines and High-Pressure Steam." Proc. Inst. M.E. 1872. Page 130.

² A similar boat (the 'Echo'), built and engined by Mr. Spiller in 1841, worked to Richmond. The engines were on the Zander principle, and had one small cylinder (high pressure) and one large cylinder (low pressure) working on cranks at right angles. These engines worked very economically. The pressure used was 45 lbs. per square inch, then considered high.

wich, from blame in the matter, it having been proved to their satisfaction that the explosion was due to the action of the engine-men in overloading the safety-valve.

The engines of the 'Era' and the 'Echo' were entirely novel in their construction, embodied so many inventions from the ingenious mind of Mr. Spiller, and have been proved by years of effective working to be successful, that they may be recorded amongst useful discoveries unpublished. The steam was first worked in a small cylinder. From this it passed into an intermediate chamber, clothed with felt, of considerable capacity, in order to maintain a nearly constant pressure. From this chamber the steam was led into the large cylinder; from thence it was finally exhausted into a surface condenser. The cranks were set at right angles, and the areas of the two cylinders being duly proportioned to the relative pressure, the motion and power were thus equalised. The steam was worked expansively in the small cylinder, so as to bring the terminal pressure nearly down to that in the intermediate chamber, thus preventing loss from the sudden grade to a lower pressure. A curious feature of the intermediate chamber consisted in its being entirely filled with an immense number of minute trays, composed of strips of embossed copper. This was the main principle in Zander's patent. His theory was, that at the termination of the stroke of the high-pressure piston water would collect in these trays, to be evaporated on the first readmission of fresh steam at the commencement of the next stroke. However, no proof was obtained that any water ever did become deposited in this way; and Mr. Spiller had so little faith in these trays, that he often said the engines would be better without them.

Another novelty in these engines was the surface condenser, which had neither tubes nor packed joints. Each separate element of the condenser was made up of two large square sheets of thin copper; the edges of each of these were dished up to form a flange or rim, like an ordinary tray, one quarter of an inch deep, so that when placed together there would be half an inch between them. In order to prevent the sheets from collapsing by the pressure of the atmosphere, they were kept asunder by an assemblage of $\frac{1}{4}$ -inch copper strips, rolled or crimped in a zigzag or undulating form, and equally distributed over the plates. On account of this bending no tilting could occur, and the extent of the condensing surface was greatly augmented; for it was rightly considered that the conduction from the trued edges of these strips bearing on the outer cool plates would be equivalent to extra cold-water surface. There was a circular hole for the entry of the exhaust steam in the centre

of each plate, and between the two a gun-metal ring, half an inch thick, with a number of circumferential through holes. Everything being set in place, the two plates were lightly riveted together at the edges (the lap of the joints having previously been well tinned), and were finally fused together and made good with soft solder. The required number of these elements were united and put together by placing between them flanges or large gun-metal washers about one quarter of an inch thick, of the same inside and outside diameters as the internal ones. The joint was made tight on both sides with canvas collars, and the usual red and white lead. A strong rod was passed through the whole series, with screwed ends reaching through the bends of the elbows of the inlet and exit pipes, so that when the nut was tightened up all the flanges were brought together at once. This simple arrangement was placed to fit close on the opposite sides in a sheet-iron tank, the inlet above and the outlet below, and cold water from the circulating pump was caused to traverse through the quarter-inch spaces between the elements. As this ingenious arrangement had only one centre of connection and point of support, it was quite free from the irregular expansion so fatal to all joints; and during the many years that these condensers were under the knowledge of our informant¹ he did not hear of any leakage, nor were the condensers ever taken asunder for repair, and a high rate of vacuum was always maintained.

The marine engines herein referred to were run at a high piston speed for the sake of lightness of machinery; and in the 'Echo' the engine-shaft (with outside cranks) was geared down on to the paddle-shaft. A difficulty had, therefore, to be overcome in contriving an air-pump valve that would act quickly and without battering itself to pieces. The great success of the modern high-speed direct screw-propeller engines is due to the use of vulcanised india-rubber for the pump valves; but this material was unknown in those days, and metal had to be employed. In the large slow-going marine and land engines the old "butterfly," or flap valve, was nearly the only one in use. With rapid reciprocations this failed, and was quickly destroyed. The air-pump valves of Mr. Spiller were constructed as follows: The footplate and bucket were drilled through with a number of holes an inch or more in diameter. Each of these was covered by an independent valve, consisting simply of a thin turned disc of gun-metal. The rise of the series was limited to something less than half the diameter by an upper

¹ Mr. F. H. Wenham.

grating bolted to the piston. From this casting descended a number of pegs, close to and surrounding each disc in threes; these served as guides to keep them all in place. These pumps, after years of work, were proved to be very effective, prompt in action, and at the same time enduring, from the extreme lightness of the little valves.

These boats are thus referred to, as in them was shown the germ of a principle which has since developed to giant proportions in the steamers of the chief ocean navigation companies.

Many are the inventions and improvements that Mr. Spiller's clear-seeing eye and most fertile brain have given to the world, for which he never cared to gain either wealth or credit. "What matters it," he would say, "who did it, so that the thing is done?" Mr. Spiller claimed to have invented the 'sweep' or 'arch motion,' which enabled the eccentric to act on the valve without being influenced by the vibration of the cylinder. He is stated to have applied this principle to passenger boats, when it was perceived by the quick eye of an engineer passenger, who, observing "That's good," at once took the free gift, and the 'sweep' has since been generally adopted. There exists a difference of opinion as to this alleged circumstance, some engineers asserting that Mr. Spiller's boats were not fitted with oscillating engines; but Mr. William Milward says: "In 1869, Mr. Spiller showed me a letter, in Cardiff, which he had received from the late Mr. Joseph Miller, M. Inst. C.E., written from Philadelphia. Mr. Miller thanked Mr. Spiller for his invention of the 'sweep' motion in oscillating engines, and attributed his success to the use of Mr. Spiller's invention." Mr. Spiller's widow also states, that though, from her ignorance of mechanics, she is unable to recall the terms in which her husband stated the nature of his invention, yet that it was such as to render the oscillating cylinder available (or desirable) for marine engines, when it was not so without it.

Mr. John Bourne, so well known in connection with Indian steam navigation, writes: "I should be disposed to say, from what I remember of Spiller's boats, that his main merit consists in the introduction of small double engines, well proportioned and neatly made, and with small boilers on his principle, which were lighter than flue boilers. On the Clyde, at this time, the boats were uniformly larger, generally had single side-lever engines and flue boilers, and were less compendious and refined than Spiller's boats on the Thames."

On March 9, 1841, Mr. Spiller was elected a Member of the Institution of Civil Engineers, "because of his extensive engage-

ments as a Civil Engineer and as a manufacturer of steam-engines both in England and abroad, and because of his attainments in theoretical and practical science." He regularly attended the meetings, and frequently took part in the discussion of subjects with which he was familiar, such, for instance, as the resistance to bodies passing through water, Ericsson's caloric engine, &c. He made a series of careful experiments with screw propellers, at a time anterior to those of the late Sir F. P. Smith, but finding that the screw did not give such good results as the paddle, he gave up the idea, though unwillingly.

In 1850 Mr. Spiller patented an ingenious arrangement for cleansing and separating wheat. The machine was exhibited in the Great Exhibition of 1851, where he had the pleasure of explaining its action to the Queen and the late Prince Consort. This apparatus was employed in the last important work upon which he was engaged while at Battersea, a steam flour mill for his cousin, Mr. Joel Spiller, of Bridgewater. It was erected at Cardiff in 1853, and soon after, his cousin dying, Mr. Spiller went to take charge of the mill, selling his business at Battersea, and thereby severing the associations of forty years.

Mr. Spiller took a great interest in the science of horology. A love for it seemed to be innate, for in his boyish days he was fired with the desire "to make a real live clock;" and he managed to attain this object of ambition. Securing to himself some stray discarded bits of clockwork and metal, he day after day worked with untiring patience; then mounting a loft, reached only by a ladder, he proceeded to bring life to his creation. One day the father was asked to visit the loft, as there was something there to look at; and great was the boy's delight when, to the inquiry, "How came it there?" he was enabled triumphantly to reply, "I made it, father." This little anecdote, related by Mr. Spiller not long before his death, shows the bent of his early genius. On retiring from more active life he gave much time and thought to bring into practical working an idea for an escapement different in principle from any yet known. At length, after many trials came success, and, about the year 1860, one of the clocks to which the escapement was applied was tested by a transit, the result being a variation of only eight-tenths of a second in one hundred and twenty-eight days' observations taken three times. Publicity was to be given to this invention at the International Exhibition of 1862, but circumstances induced its withdrawal after a place had been assigned for it. His latest idea was to present one of these clocks to the Royal Observatory at Greenwich.

[1873-74. N.S.]

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Towards the end of the year 1860 Mr. Spiller definitively left Cardiff, and, after five years' residence at Bridgewater, the last seven years of his life were spent in peaceful enjoyment at a retired country home, Salcombe Lodge, in the beautiful vale of Sidmouth, in his native county of Devonshire. When he had long passed the allotted span of human existence, so unbroken was his health, both of mind and body, that not only could he enjoy a walk to the top of one of the steep Devonshire hills, and work for hours together at the bench, but he wrote several able letters for publication, and still acted as a Consulting Engineer. He said he felt as capable of continuous thought as ever, and that he could scarcely believe so many years had passed over him. Mr. Spiller was an earnestly religious man, and the manuscripts he leaves bear testimony how far above the fleeting concerns of time he esteemed all that relates to God and eternity. His death, which took place on the 29th of May, 1873, from the breaking of a blood-vessel, was for him but the natural ending of a blameless, well-spent life. He lies buried in the little churchyard at Salcombe Regis.

Mr. Spiller's skill and ingenuity as an engineer were very great; but he was wanting in commercial capacity, nor had he the desire for riches, and hence he did not acquire a large fortune, which otherwise he might have done. He was one of those modest, unpretentious men whose existence tends to strengthen the national life and to command general respect.

Mr. FREDERICK AYRTON, the eldest son of Mr. Frederick Ayrton, a solicitor of Gray's Inn, was born in London on the 20th of March, 1812. After being educated at Ealing school, he was entered at Addiscombe in 1826 as a cadet for the East India Company's army. He passed that seminary for the Artillery, and in June 1828 was appointed a 2nd Lieutenant of the Bombay Artillery.

He returned to England in 1832, in consequence of ill health, when he seized the opportunity of studying, under the late Mr. Brunton, civil engineering. The late Mr. Robert Stephenson, having become acquainted with him, wished him to retire from the army, and become an Assistant Engineer on the London and Birmingham railway, then in course of construction, but he preferred the army.

On returning to India, at the end of 1835, he was employed in superintending experiments for boring for water in the island of Colaba, which however did not prove successful. He was next engaged on survey duties in the Deccan. He was promoted to the