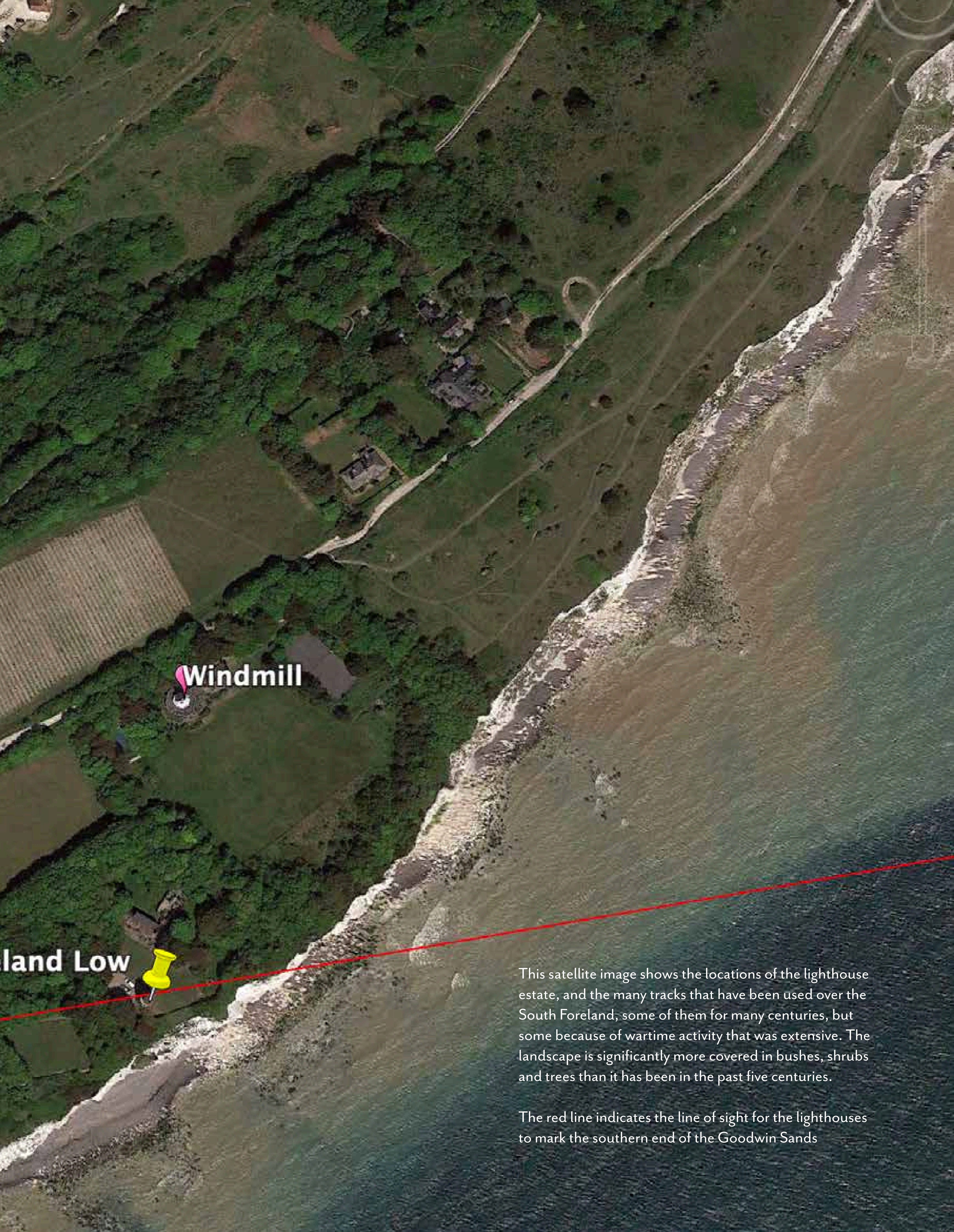
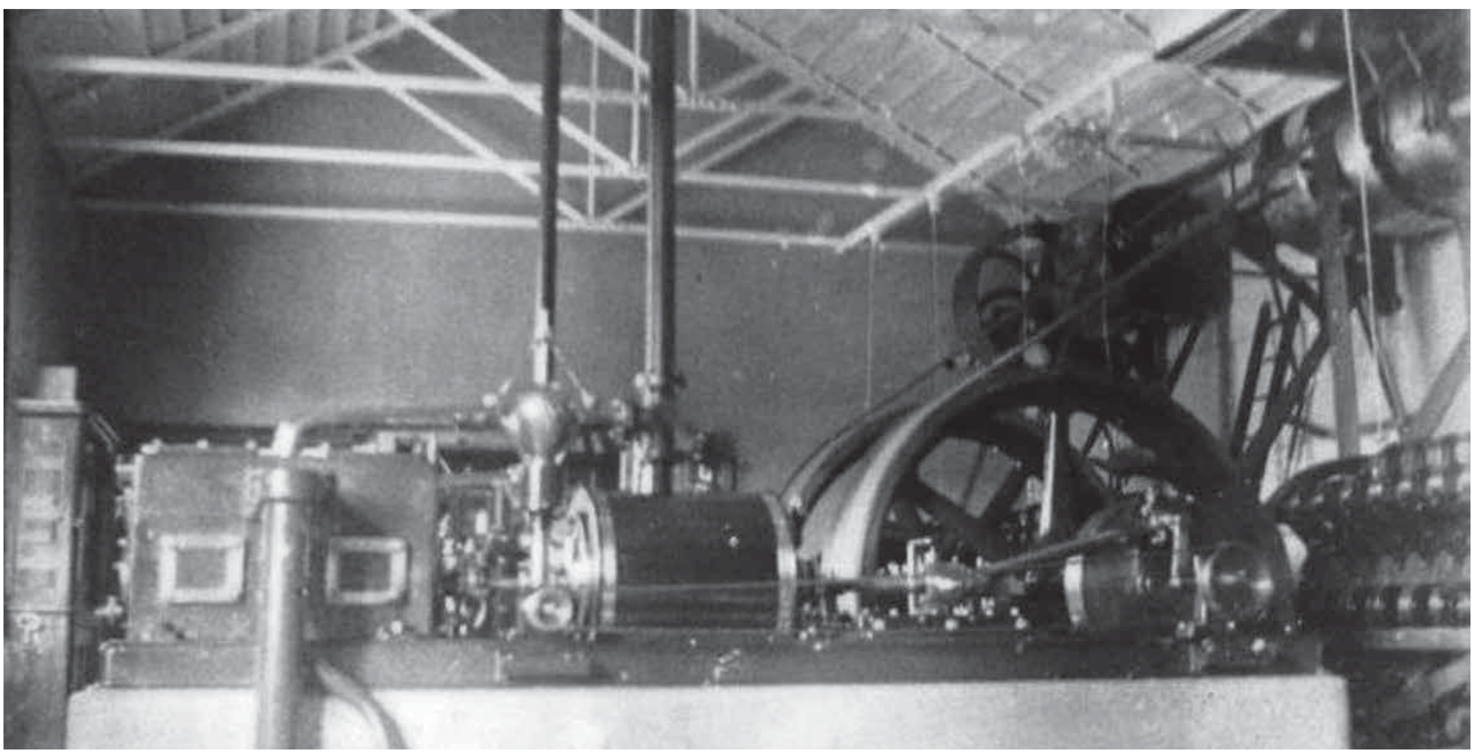

Lighthouse Road
Sea View Road
St Margarets Road
Beach Road
The Front
South Fore
Engine House
South Foreland High



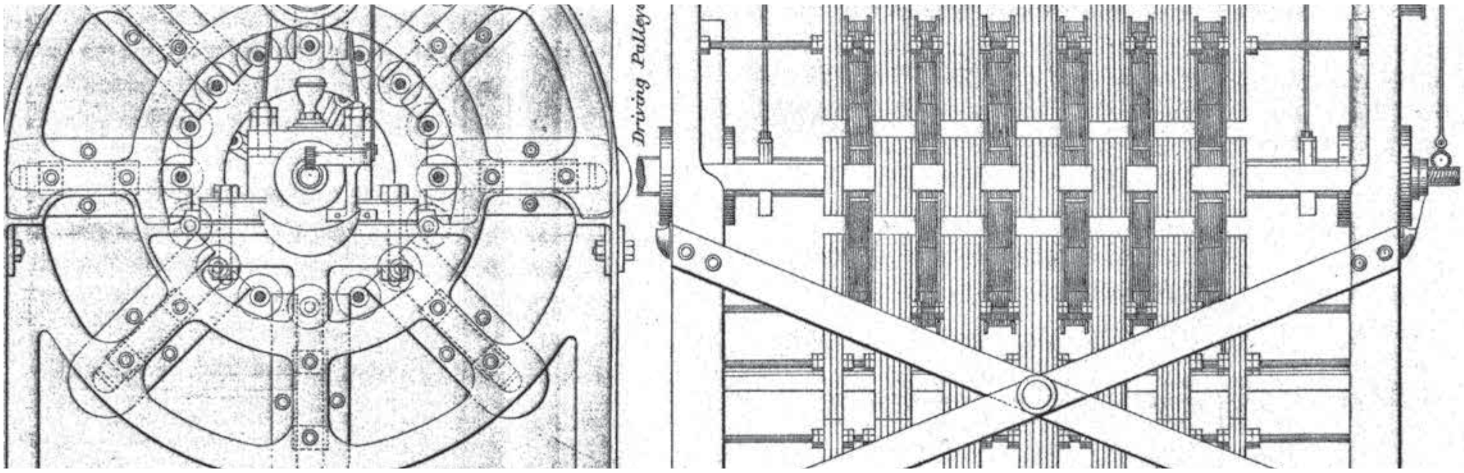

This satellite image shows the locations of the lighthouse estate, and the many tracks that have been used over the South Foreland, some of them for many centuries, but some because of wartime activity that was extensive. The landscape is significantly more covered in bushes, shrubs and trees than it has been in the past five centuries.

The red line indicates the line of sight for the lighthouses to mark the southern end of the Goodwin Sands

Above: By the 1860s, South Foreland had become one of the most significant lighthouse stations in the Trinity House jurisdiction. As the site for the development of cutting-edge technology, it required the construction of new buildings, an engine house, more accommodation and even pig sties.



Above: This rare undated photograph shows the inside of the engine house. One of the magneto-electric machines is on the far right, driven from overhead by belts connected to the large flywheel, centre-right. Sometimes it was necessary to mount the flywheels vertically so that they rotated in a pit in the floor, but here it appears to be in a purpose-built trough that contains the small, horizontal condensing engine, centre. Ancillary equipment to control the steam pressure is evident left of centre and a reservoir of water is on the left. Four of these arrangements were contained in the house, two each - one active and one reserve - for the High and Low lights.




# Leading Lights

Extracted from: Light On The Forelands by Ken & Clifford Trethewey, Jazz-Fusion Books (2022)

## South Foreland Becomes Experimental

As the location of choice for the development of cutting-edge technology; South Foreland becomes one of the most significant lighthouse stations in the world

The middle of the 19th century had become one of the most transformative periods in British history as the Victorian industrial engine shifted into a higher gear. The advancements of science had generated a new lower breed of men called engineers who had dirt on their hands. Their machines were big, heavy, loud, and dirty. Even this new-fangled electricity - a 'clean' science - was mucky on this scale.

At some point in the mid-1850s (we are not sure exactly when) teams of men arrived at South Foreland to build the new facilities required to house the new technology. Then, more teams arrived to manhandle the metal stuff that, once assembled into moving, throbbing lumps of dangerous mass, in a moment of carelessness, could break a man's toes or crush his hands. The result was the engine house, a large facility situated exactly midway between the two lighthouses.

Thanks to the hard work and resource of local heritage volunteers it is fortunate that we still have precious images of this new presence on-site for today there is no sign it was ever there, a sad indictment of the failure of 20th century industry to recognize the value of heritage. Progress was everything. History? What history?

All of those living at South Foreland in the late 1850s must have been bewildered at the sudden turmoil that had interrupted their lives, mystified by this new way of making light that they reckoned was more like electrickery. But their hardy nature no doubt overcame the disruption, and they made and lost new friends amongst the many faces that came and went with each new change. At least one lighthouse child was named after an engineer - for the best reasons, of course!

### Nature's Lightning Is Tamed

In an age of satellite navigation it is hard to imagine just how important it was to develop the brightest lights possible for the safety of mariners. Sea trade had become crucial to the progress of the nation and the consequent improvements to living standards, but, as British people became more experienced in their maritime capabilities, the loss of life at sea was probably second only to deaths in battle. Throughout the 18th and 19th century it was of primary importance to develop the best navigation lights possible, not only to reduce the maritime death toll but to protect the interests of the burgeoning economy. A constant stream of problems and inadequacies had been faced in the design and installation of any device that could improve upon those that had been tried before and found wanting. The success or otherwise of many trials was a source of constant argument amongst the stakeholders. But the most promising of all seemed to be the possibilities offered by the electric light.

Michael Faraday was always ready to accept an invitation to present his wisdom in the field to an audience of interested parties, and some of these lectures are recorded for us to read and admire. He had first been employed as a consultant to Trinity House in 1836, since when he had on many occasions kept a close eye on the developments of the time.

One of Faraday's early ideas for an electric light was to build upon the work of Joseph Watson which involved passing an electric current from a battery across a small gap between two rods of carbon. He spent two years from November 1852 evaluating this system before rejecting it on three counts - the light flickered too much, the fumes produced by the nitric acid battery were too great, and the operation of the light would require 'more intelligent lighthouse keepers.' Oh dear!

A second system, and one that was adopted, was proposed in the late 1850s by Holmes. He too used a carbon arc, but its power came from an electro-magnetic machine driven by a steam engine. Furthermore, Holmes had developed a mechanism that would ensure the distance between the carbon poles of the arc remained constant, allowing a sustained and constant quality of light to be produced. This was the machine that Faraday wanted to bring to South Foreland - and he did. The South Foreland High Light exhibited the first electric light to the world on Wednesday 8th December 1858.[1]

Reliability was Faraday's passion and as a consequence he personally undertook to monitor the light frequently, a task in which he showed an unstinting devotion, often suggesting modifications to his resident assistants. However, the light was required to function each and every night, and on those occasions when it could not do so George and his assistant had to resort to the old oil lamps, which Henry continued to maintain in the Low Light.

By 1860, now in the twilight of his career, Faraday's experience was unprecedented, even if he had never himself shown the desire to take an active role in the engineering for himself. On one occasion at his *alma mater*, the Royal Institution, his comments were sufficiently concise and non-technical to be well worth reproduction here.[2] As with all good presentational practice he began by outlining the background to the subject and status attained by the use of light from the burning of fuels, none of which had proved entirely satisfactory. He told his audience:

> *"Many compressed intense lights have been submitted to the Trinity House; and that Corporation has shown its great desire to advance all such objects and improve the lighting of the coast, by spending, upon various occasions, much money and much time for this end. It is manifest that the use of a lighthouse must never be failing, its service ever sure; and that the latter cannot be interfered with by the introduction of any plan, or proposition, or apparatus, which has not been developed to the fullest possible extent, as to the amount of light produced, – the expense of such light, – the wear and tear of the apparatus employed, – the steadiness of the light for 16 hours, – its liability to extinction, – the amount of necessary night care, – the number of attendants, – the nature of probable accidents, – its fitness for secluded places, and other contingent circumstances, which can as well be ascertained out of a lighthouse as in it."*

It is easy to dismiss the problem of creating effective lights as simple, but Faraday wanted to point out that successful engineering, and the final solution to an important problem like this, is much more complicated than it first appears.

Next, he outlined the current design of the complicated test equipment that had been developed by engineers from the science he had presented to them.

> *"The electric spark which has been placed in the South Foreland High Light by Professor Holmes, to do duty for the six winter months [1858-59], had to go through all this preparatory education before it could be allowed this practical trial. It is not obtained from frictional electricity,[3] or from voltaic electricity,[4] but from magnetic action.[5] –*

> *"The first spark (and even magnetic electricity as a*

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1 www.engineering-timelines.com and follow the links 'Who' and 'Lighthouses' . Confirmed also by Douglass. See Footnote 16 p194.

2 Faraday, M: "On Lighthouse Illumination - The Electric Light." Presentation to a Weekly Evening Meeting. *Proceedings of the Royal Institution*, Volume 3, (1860), pp220-223.

3 Electrostatics.

4 Batteries.

5 Electromagnetic induction.

*whole) was obtained 28 years ago.*[6] *If an iron core be surrounded by [copper] wire,*[7] *and then moved in the right direction near the poles of a magnet, occurrence of electricity passes, or tends to pass, through it. Many powerful magnets are therefore arranged on a wheel, that they may be associated very near to another wheel, on which are fixed many helices with their cores, like that described. Again, a third wheel consists of magnets arranged like the first; next to this is another wheel of the helices, and next to this again a fifth wheel, carrying magnets. All the magnet-wheels are fixed to one axle, and all the helix wheels are held immovable in their place.*

*"The wires of the helices are conjoined and connected with a commutator, which, as the magnet-wheels are moved round, gathers the various electric currents produced in the helices, and sends them up through two insulated wires in one common stream of electricity into the lighthouse lanthorn.*[8]

*"So it will be seen that nothing more is required to produce the electricity than to revolve the magnet-wheels. There are two magneto-electric machines at the South Foreland, each being put in motion by a 2-hp steam engine;* [9] *and, excepting wear and tear, the whole consumption of material to produce the light is the coke and water required to raise steam for the engines, and carbon points for the lamp in the lanthorn."*

Finally, Faraday explained the principle by which the electric spark was turned into such a successful and reliable light source.

*"The lamp is a delicate arrangement of machinery, holding the two carbons between which the electric light exists, and regulating their adjustment; so that whilst they gradually consume away, the place of the light shall not be altered. The electric wires end in the two bars of a small railway, and upon this the lamp stands. When the carbons of a lamp are nearly gone, that lamp is lifted off and another instantly*

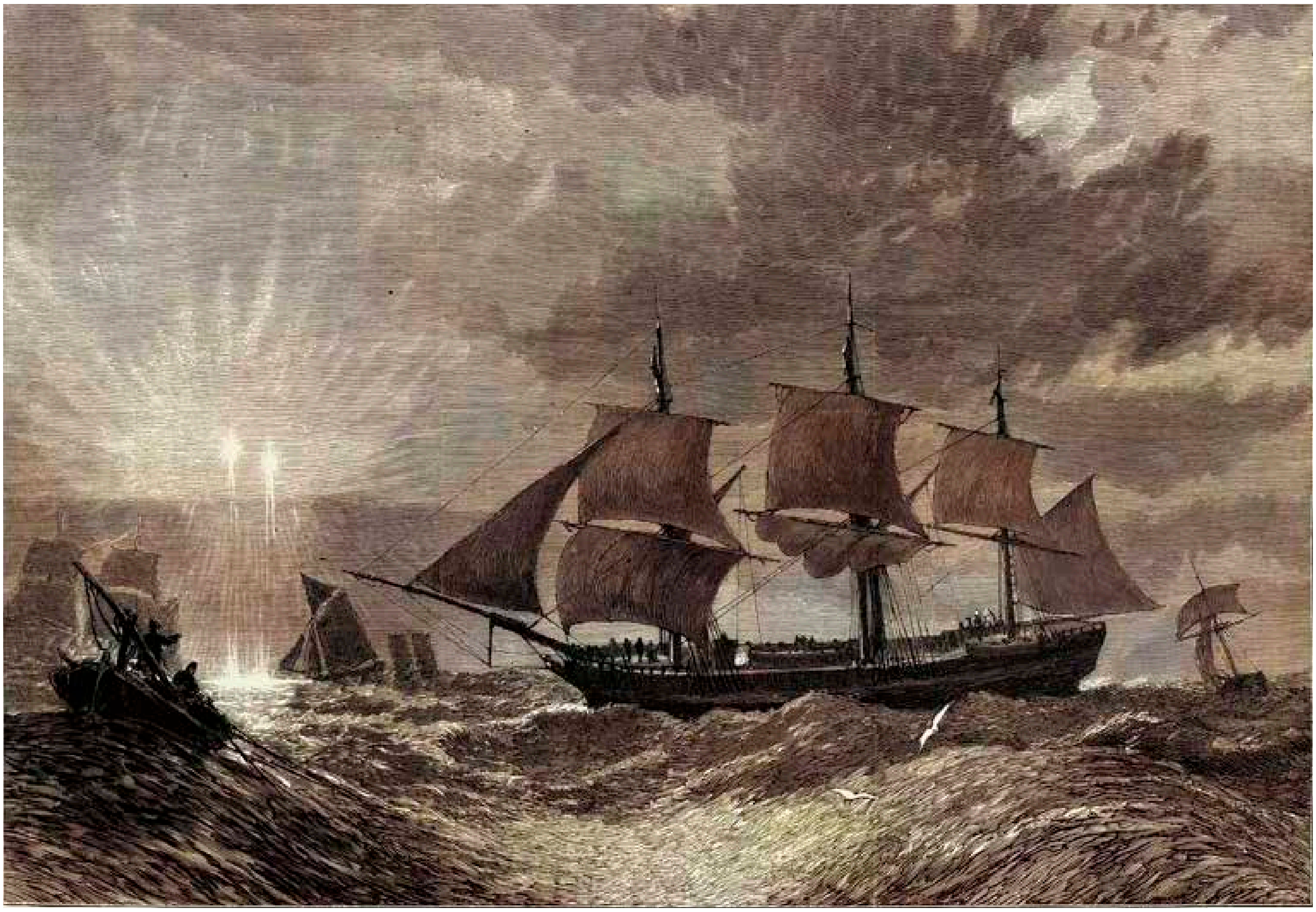
ABOVE: A preserved example of the carbon arc apparatus used to make the electric light at South Foreland. The apparatus was later installed at three more lighthouses before the end of the century. Two vertical brass rods - one short, one long - stand side-by-side. The two black carbon (actually graphite - like the 'lead' in a pencil) electrodes are mounted vertically on the rods, the lower electrode on the right (negative) rod and the upper electrode on the left (positive) rod. Their 'carbon points' face each other. As electric current arrives through the left rod and is carried to the tip of the top electrode it instantly creates a very large potential difference (voltage) across the gap. Then, just like lightning, the resistance of the normally insulating molecules of air between the two electrodes breaks down in such a way that electrical charge is transferred to the air molecules. These charged species are then attracted to the lower electrode where they give up their charge to the carbon and are carried away to the return path. As with lightning, an intensely bright spark is created by the passage of these charged air species across the gap. The electrodes should be closer together than shown here. The top electrode is fixed to a moveable mount on the left hand brass rod and can be slid up and down so that the spark is always maintained at the optimum brightness. As time proceeds, the electrodes burn away and must be periodically adjusted by the light keeper on duty to maintain a constant intensity. The risk of short circuits in the apparatus and unwanted sparking across metallic components is high and must be carefully considered in the design of the apparatus.

6 Faraday, M: *Philosophical Transactions*, 1832, p32.

7 Iron was used for magnets because of its intense magnetic properties. Copper would always be the best material for coils (helices) of wire because, after silver, it is the best conductor of electricity.

8 Lanthorn is the old name for the glazed lantern at the top of the lighthouse tower. In the first experiment, only the high light was electrified whilst the low light continued to burn oil, a decision that offered a good comparison.

9 Wood and coke furnaces were the heat source of choice at first. The next great step forward came at the end of the century with the invention of the internal combustion engine, of which diesel power was used almost exclusively throughout the 20th century where mains electricity was not available, and always for back-up.



Above: An old engraving of the twin lights of the South Foreland. Such intense brightness had never been seen before.

*pushed into its place. The machines and lamp have done their duty during the past six months in a real and practical manner."*

Faraday was pleased to announce the success of the trial and that, in his opinion, electricity was the best way forward for the future of lights in lighthouses.[10]

*"The light has never gone out, through any deficiency or calls in the engine and machine house: and when it has become extinguished in the lanthorn, a single touch of the keeper's hand has set it shining as bright as ever. The light shone up and down the channel, and across into France, with a power force surpassing that of any other fixed light within sight, or anywhere existence.*

*"The experiment has been a good one. There is still the matter of expense and some other circumstances to be considered; but it is the hope and desire of the Trinity House, and all interested in the subject, that it should ultimately justify its full adoption."*

It would be found that the job of the light keeper would be made easier because of less cleaning and maintenance than with the dirtier oil-burning equipment. That would have greatly pleased the Knott family and their colleagues who were not sure if they were still light keepers or engineers with dirty hands.

## Of Engines and Engineers

In the fledgling business of engineering, Thomas Newcomen had made one of the first claims to be called an engineer in 1712 with his steam engine, designed to remove water from the bottoms of tin mines in Cornwall and Devon. Another was the Scot, James Watt, who improved upon Newcomen's design in 1776. Between them, they trail-blazed a new profession. In ancient times to be an engineer was to be in charge of a crude military device for hurling rocks at an enemy. By the late Middle Ages, the name

10 One of the best sites for a display of early electrical equipment is at the Lizard lighthouse in Cornwall, described in some detail in Trethewey, K: *Lighthouses of Cornwall and Devon*, Jazz-Fusion Books (2020).

had died out, like its fiendish contraptions. (People hurled bullets instead!)

To apply the name 'engineer' to a person who devised solutions to practical needs was not done until the latter parts of the 19th century thanks to the new kinds of mechanical engines that helped to define the Industrial Revolution. John Smeaton was another candidate, although he had been an 'instrument maker' until his 1756-59 work in building construction earned him the later title of 'Father of Civil Engineering.' Somehow, massive crude structures like harbours, bridges and other buildings like lighthouses disqualified their creators from joining the men of metal like Telford, Stephenson, Brunel and others. (In fact, Smeaton had required a great deal of mechanical engineering to complete his famous project on the Eddystone and was as much a 'proper engineer' as anyone.) It was the oily hands of railway man George Stephenson who founded the Institution of Mechanical Engineers in 1847 to satisfy the needs of like-minded men of metal.

Even by Faraday's time, to be called an engineer was rare indeed. The first electrical engineer was probably Francis Ronalds who invented the electric telegraph in 1816 and publicized his vision of transforming the world with electricity, but Faraday always regarded himself as a scientist, and would have been insulted to have been described as an engineer. It was not until 1871 when the Institution of Electrical Engineers was founded to satisfy the needs of telegraph engineers - still the dominant aspect of electrical technology.

Meanwhile, Faraday's discovery had been recognized for the amazing opportunity it was by Professor Frederick Hale Holmes (1811-1875). For him, there was no barrier separating science from engineering - no shame associated with getting his hands dirty. He also realized how, through patenting his work, he could generate income to pay for the research and development in this expensive new business. He took the lead in Great Britain when in 1853 he showed how a machine he called an electro-magnetic generator could provide sufficient current to pass between two close (but not touching) carbon electrodes to produce a spark with an intense light (see p226). In 1856 he patented the magneto, a precursor to the modern alternator found in every common 20th century motor car. A magneto generated alternating currents; other designs had a device called a commutator that converted the a.c. into d.c.[11]

At a demonstration set up at the Trinity House Blackwall Depot on the River Thames, Holmes showed Faraday[12] how his machine could be used in lighthouses. Both men were convinced that the light produced could be far brighter than anything created by burning oil and Faraday had no hesitation in supporting its adoption in principle. The practice, however, still took a long time to develop for it was essential to be able to provide uninterrupted light every night throughout the hours of darkness, and that was a tall order. There were other significant safety considerations too with such high voltage electrical machines. Nevertheless, development went ahead.

By the late 19th century it was an engineer who officially took charge of the two lighthouses at South Foreland, the two at the Lizard, and the single lights of Dungeness and Souter Point. The engineer now replaced the post of principal keeper because of the special training needed to manage the much more technical aspects associated with the generation of electricity and light for what were in these times the brightest lights in the world.

### A New Baby For A New World

1859 was the year that the experimentation began and the two new keepers were to be a part of it together with Henry and George Knott, but George was distracted by Catherine's condition which culminated in the birth of their sixth child and fourth son on Wednesday 20th April 1859. They chose to name him Frederick, but by the time they took him for his christening at St. Margaret's parish church on Sunday 3rd July, they had added an extra name: the baby boy was baptised Frederick Warner Knott. Family legend[13] is that the second name was to mark their friendship with an electrical engineer who had come to the lighthouse with the new apparatus. Confirmation of the story was revealed in the *Illustrated London News* where an account was published of the experimentation in October 1859. It said that the power source was a magneto manufactured by Holmes & Warner, Engineers of Northfleet, Kent. Clearly, although the identity of Warner is currently unknown, he was the source

11 Alternating currents would later be found to be more reliable and effective and that is why our homes used it in the 20th century. It is arguable that we may return our homes to low power d.c. soon!

12 Faraday served as chief scientific advisor to Trinity House from 1836-66

13 He was our great-grandfather. This was recorded in writing by his nephew, Frederick Goldsack Knott of Barnstaple, and can be seen on p69.

of inspiration at the baptism of Frederick Warner Knott. Perhaps he had lodged with them. Perhaps he was at the baptism. He may even have been a Godparent. Whatever the reasoning, the use of his name suggests a close, friendly relationship between an engineer and George and Catherine Knott that now resides permanently in our family history.

## Transformative Times

Besides the transformation of heat energy into electricity, there was another obvious transformation at South Foreland with the construction of a large new building - a dedicated engine house exactly halfway between the higher and lower lights. Besides the few scarce images we have included here, the best written description by far can be found in the report by an American lighthouse engineer, Major George Elliott, making a tour of inspection for the benefit of his engineering colleagues in the USA.[14] We have included the diagrams and plans he made on p199 and p205. He described in detail the layout and functioning of the new equipment as it existed in 1873.

Progress in the development of improved electrical machinery continued apace after the death of Faraday in 1867. Another detailed report was supplied to the Institution of Mechanical Engineers by Professor Tyndall on the 17th of January 1879. Tyndall was a protégé of Faraday's having worked closely under him at the Royal Institution. Tyndall replaced Faraday as the Scientific Advisor to Trinity House and would later make major contributions of his own, especially in the developing field of fog signals. Highlighting the intense competition that took place with French engineers he wrote:

> *With regard to the application of electricity to Lighthouse purposes, the course of events was this: the Dungeness light was introduced on January 31, 1862; the light at La Hève on December 26, 1863, or nearly 2 years later. But Faraday's experimental trial at the South Foreland preceded the lighting of Dungeness by more than two years. The electric light was afterwards established at Cap Grisnez. It was started at Souter Point on January 11, 1871; and at the South Foreland on January 1, 1872. At the Lizard, which probably enjoys the newest and most powerful development of the electric light, it began to shine on January 1, 1878.*

14 Elliott, Major George H: "Report Of A Tour Of Inspection Of European Light-House Establishments Made In 1873," Government Printing Office, Washington, (1874).

## A Piece Of Sunlight Poured Out Upon The Night [15]

During the late 1850s there was a gradual realization among those interested in scientific developments that the character and efficacy of electric light had the potential to break out of the confines of the hitherto accepted concept of the battery to something much more exciting. Occasionally this debate spilled over into the pages of both national and provincial newspapers.

In 1859, a series of experiments were made at South Foreland lighthouse where the keeper, George Knott was soon to be transferred to the Smeaton Eddystone. The visits by eminent scientists and teams of associated workers with tons of test equipment would have caused great excitement to these humble working families, and much upheaval to the keepers' routines. The presence of two lights at South Foreland enabled direct comparisons to be made. The high light was installed with new apparatus that used the electric light, whilst the low light continued to use oil. Later, the Chief Engineer to Trinity House, Sir James Douglass, would observe:

> *"On the 8th. December, 1858, the electric light, produced by permanent magnets, was shown on the sea, for the first time, from the South Foreland high lighthouse; and thus were magnets serving, not only in the compass to direct the mariner in his course, but also, in producing a most intense light, to warn him of danger and guide him on his path."* [16]

The pace and programme of experiments at South Foreland would pick up considerably over coming months, inviting much discussion and controversy from people in all strata of society. On one occasion on Saturday 7 April 1860 the *Kentish Chronicle* published a small piece setting out the pros and cons of the argument in which the author must have sought the opinion of the great man himself.

> *"Professor Faraday recommends the magneto-electric apparatus and states that one worked by a 2-HP engine had been tried successfully for six months at the South Foreland Light and its illuminating effect had extended as far as the coast of France and seemed best adapted to penetrate even through haze and fog."*

This short piece clearly indicates that the initial

15 This was a headline used in the *Cornhill Magazine*.

16 Douglass, James N: "The Electric Light Applied to Lighthouse Illumination." The Institution of Mechanical Engineers, *Minutes of Proceedings*, Paper no 1639 March 25, 1879, pp79ff.

power source was a small stationary steam engine. However, a few words in a provincial newspaper were just the precursor to an announcement in the *Scientific Journal* that was reprinted in the *Reading Journal* on Saturday 21 April 1860 under the headline:

**"The Electric Light For Lighthouses"**

*"A magnetic light has been tried at the South Foreland Lighthouse. The magnetic light seen from the sea is like a little sun and like that luminary it 'sets' from the convexity of the earth. At 30 miles it does not appear to be the least dimmed and it even penetrates haze and fog so as to indicate its whereabouts. Although the light itself is only a spark of about a quarter of an inch long, it is too vivid to be stared at with an unprotected eye. Seen through black goggles, a beautiful cone of light may be observed falling from the upper carbon rod to the lower (one), very different in intensity to the glare of a murky coal fire, or even the luminous band of light from a reflector. From all we can hear the new light, if it can be rendered manageable, is as superior to the dioptric[17] as that is to the coal fire beacon. We wait with some anxiety for further particulars."*

Modern writers on the subject of the early attempts at creating an electric light, tend to dismiss this experiment as 'a failure,' but the contemporary newspapers do not give that impression. On the contrary, they exude an awesome wonderment that is quite understandable in a population familiar with nothing more than fires and candles for illumination, yet this description above would not be considered particularly scientific by some readers. Trinity House adopted a more open minded reaction which was reported in the *Kentish Gazette* on Tuesday 5th June 1860. It said:

*"We are informed that the electric light which has lately been experimented on at the South Foreland Light is to be tested at Dungeness. The object is to prove the efficiency of the electric light in a high and low situation. The limelight will probably be tried at the South Foreland in the autumn."*

The last sentence is very revealing and shows that Trinity House had embarked upon a prolonged series of investigations and tests and the South Foreland Light was the accepted test-bed. This status was to continue until the end of the century, but more of that later. Although there was no announcement declaring that the trial of the electric light at South Foreland had ended on a specific date, it can be inferred from the tone and dates

17 The light of the dioptric was assumed to be from burning oil.

ABOVE: An electro-magnetic generator that won the gold medal at the Electricity Exposition in Paris in 1881 - just one of many designs that had appeared since the original by Holmes (see p141).
BELOW, According to its badge, it was design No. 3L by A. de Meritens of 44 Rue Boursault Paris. The 19th c was a time of great competition between Britain and France in lighthouse technology

of the few newspaper reports, that it probably ceased at the end of March 1860 and this might further be supported by an announcement from an unexpected source.

Among the marriage announcements of the *Kentish Chronicle* for Saturday 14th April 1860 was the paragraph:

> *"At Trinity Church, Dover on (Friday) 6 April 1860 John Griffiths of the South Foreland Light to Sarah Louisa Rebecca, youngest daughter of Mr. John Chandler of Limekiln Street, Dover."*

This was a surprise. Griffiths had not been in the area for much more than year and he had been occupied with the running and maintenance of a light under exceptional conditions, yet here he was in Dover being married to a local girl. Perhaps he was taking advantage of the cessation of the trial to wed his sweetheart and bring her to the light before the next team of scientists arrived with their paraphernalia. Within a month, his colleague William Richards was celebrating the safe arrival of his first child to his wife Elizabeth at the Lower Light. It was a daughter whom they named Cecilia.

Amongst the scientific community, the results of the experiments were an unqualified success, even to the exacting standards of Faraday himself. With reference to the experiment made at South Foreland on the 20th of April, 1859, he says:

> *"The beauty of the light was wonderful. At a mile off, the apparent streams of light issuing from the lantern were twice as long as those from the lower lighthouse, and apparently three or four times as bright. The horizontal plane in which they chiefly took their way made all above or below it black. The tops of the hills, the churches, and the houses illuminated by it were striking in their effect upon the eye."*

Further on in his report to Trinity House, Faraday wrote:

> *"In fulfillment of this part of my duty, I beg to state that, in my opinion, Professor Holmes has practically established the fitness and sufficiency of the magneto-electric light for lighthouse purposes, so far as its nature and management are concerned. The light produced is powerful beyond any other that I have yet seen so applied, and in principle may be accumulated to any degree; its regularity in the lantern is great; its management easy, and its care there may be confided to attentive keepers of the ordinary degree of intellect and knowledge."*

## Foreign Competition Becomes Fierce

We have said little about events on the other side of the English Channel. When they were not distracted by their own military adventures, French scientists had competed strongly with their British counterparts. By the mid-19th century there was a cross-Channel batting of ideas with a fierce competitive edge. At first, the developments were manageable by individuals in their respective laboratories, but as the ideas blossomed into reality, the size of the projects quickly outgrew the capacity of the teams involved. Poor Professor Holmes who had worked so hard to create his electricity-generating machines found it hard to keep up as the scale of the operations increased. And, as with all engineering developments, his creditable efforts were not without their faults. Reporting in 1879, long after Faraday's death, to another meeting of learned gentlemen, Faraday's successor Professor Tyndall was able to give a considered opinion on a time of rapid developments. He wrote:

> *"The magneto-electric machine of the Alliance [French] company soon succeeded to that of Holmes, being in various ways a very marked improvement on the latter. Its currents were stronger and its light was brighter than those of its predecessor. In it, moreover, the commutator, the flashing and destruction of which were sources of irregularity and deterioration in the machine of Holmes, was, at the suggestion of Monsieur Masson, entirely abandoned; alternating currents instead of the direct current being employed. Monsieur Serrin modified his excellent lamp with the express view of enabling it to cope with alternating currents. During the International Exhibition of 1862, where the machine was shown, Monsieur Berlioz offered to dispose of the invention to the Elder Brethren of the Trinity House. They referred the matter to Faraday, and he replied as follows: 'I am not aware that the Trinity House authorities have advanced so far as to be able to decide whether they will require more magneto-electric machines, or whether, if they should require them, they see reason to suppose the means of their supply in this country, from the source already open to them, would not be sufficient. Therefore I do not see that at present they want to purchase a machine.' Faraday was obviously swayed by the desire to protect the interests of Holmes, who had borne the burden*

*and heat which fall upon the pioneer. The Alliance machines were introduced with success at Cape La Hève near Le Havre; and the Elder Brethren of the Trinity House, determined to have the best available apparatus, decided, in 1868, on the introduction of machines on the Alliance principle into the lighthouses at Souter Point and the South Foreland. These machines were constructed by Professor Holmes, and they still continue in operation.*

*"As their present scientific advisor, the Elder Brethren did me the honour of asking my opinion as to the course which they propose to pursue with regard to the introduction of these new machines. That opinion is expressed in the following extract from a report dated May 16, 1868: 'There is no doubt that electricity places at the disposal of the Elder Brethren a source of light next to the Sun itself in power, and for transcending any light obtainable from the combustion of oil. With regard to the practical application of the magneto-electric light, the question in my opinion, has been solved by the performance of the machine at Dungeness. That machine was one of the first, if not the very first, constructed with a view to lighthouse illumination. Defects inherent in first constructions were associated with the machine. If, notwithstanding these defects, some of which were very grave, the interruptions have been so few, it may be safely inferred that with our augmented experience, and with the improved apparatus now within our reach, the performance of the magneto-electric machine may be rendered practically perfect. It is with the profound conviction that the decision is a wise one that I learn the intention of the Elder Brethren to introduce this powerful source of illumination with all its recent improvements at certain prominent points on the coast of England."*[18]

## When Science Is Fogged

Many lighting experiments were carried out at South Foreland between 1858 and 1885. The strongest artificial light known, Professor Holmes's magneto-electric lamp, was tested, but it was not until fifteen years had passed that the electrical system finally replaced oil (at that light). Holmes's lamp was followed by Dr. Siemen's dynamo, which was considerably more efficient. Experiments with coal gas as a source of light were carried out over a number of years, and tests were made of the efficiency of sirens and gun shots as fog signals.

Britain's coastline was notoriously fickle when it came to fog. It could happen at any time and at any locality. A survey of the North Cornish coast before the building of the Longships light suggested that half of all wrecks in the area were the result of fog. It could happen suddenly and be gone almost as quickly. Sometimes it lasted for days and nights as a static, impenetrable blanket making navigation impossible. On other occasions it would be whispy and ceaselessly moving, deceiving the lookouts with its skittishness. The only method known to man at that time to counter it was noise, but for most of the 19th century it was bells and cannons that were associated with lighthouses.[19] Trinity House recruited gunners from Her Majesty's Royal Navy who had their own Establishment List for pay and promotion. This was not gainful employment, but there was little alternative. In fog, master mariners were desperate to know where they were, but at that time there was no other method available.

After extensive experiments managed by Trinity House at different locations, some at Lundy, the guns were replaced with rockets that exploded in the sky at about 200 metres with 7.5 ounce (210 g) charges of gun cotton, made by Brocks, the firework manufacturer. Fired at ten-minute intervals, they were in regular use at Flamborough by 1878 and Lundy the year after. On Lundy, the rockets were replaced by the new fog signals at the north and south lighthouses in 1897, but even that much heralded new technology did not prevent the battleship HMS Montagu from running into the island in fog in 1906.[20]

Trinity House issued a 'Notice to Mariners' on the 1st February 1872 announcing the permanent electrification of the South Foreland Lights, and the plural use must mean both lights were now emitting 'power and brilliancy.' Included in the 'Notice' was an alteration to the cut-off point of the light's arc to the north. It was now NE by N instead of N by E. What is missing from any news publication is a detailed technical description of the light source.

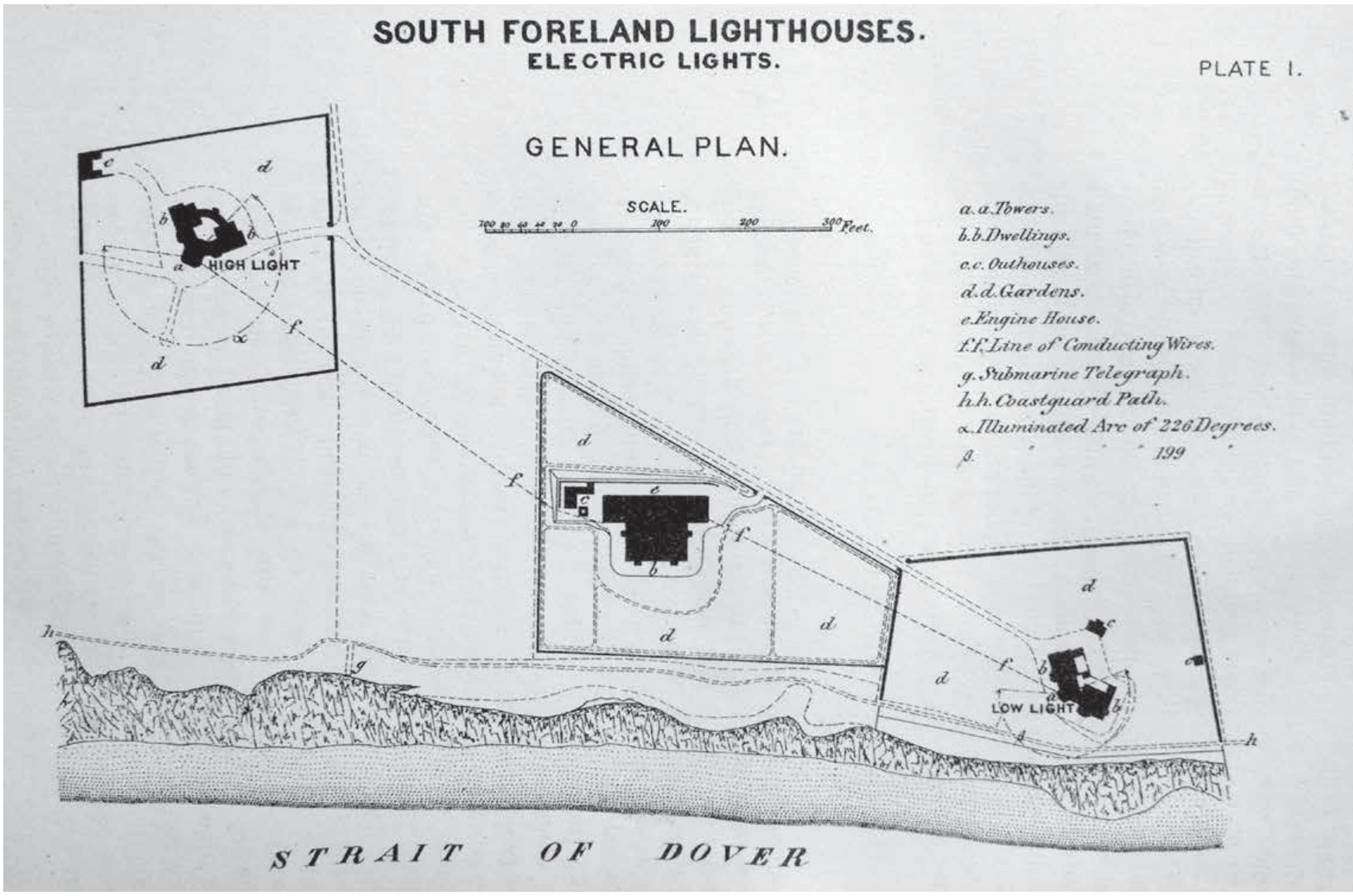
The experiments with fog signals began in

18 Tyndall: On the Electric Light, *Proceedings of the Institution of Mechanical Engineers*, Jan. 17, (1879).

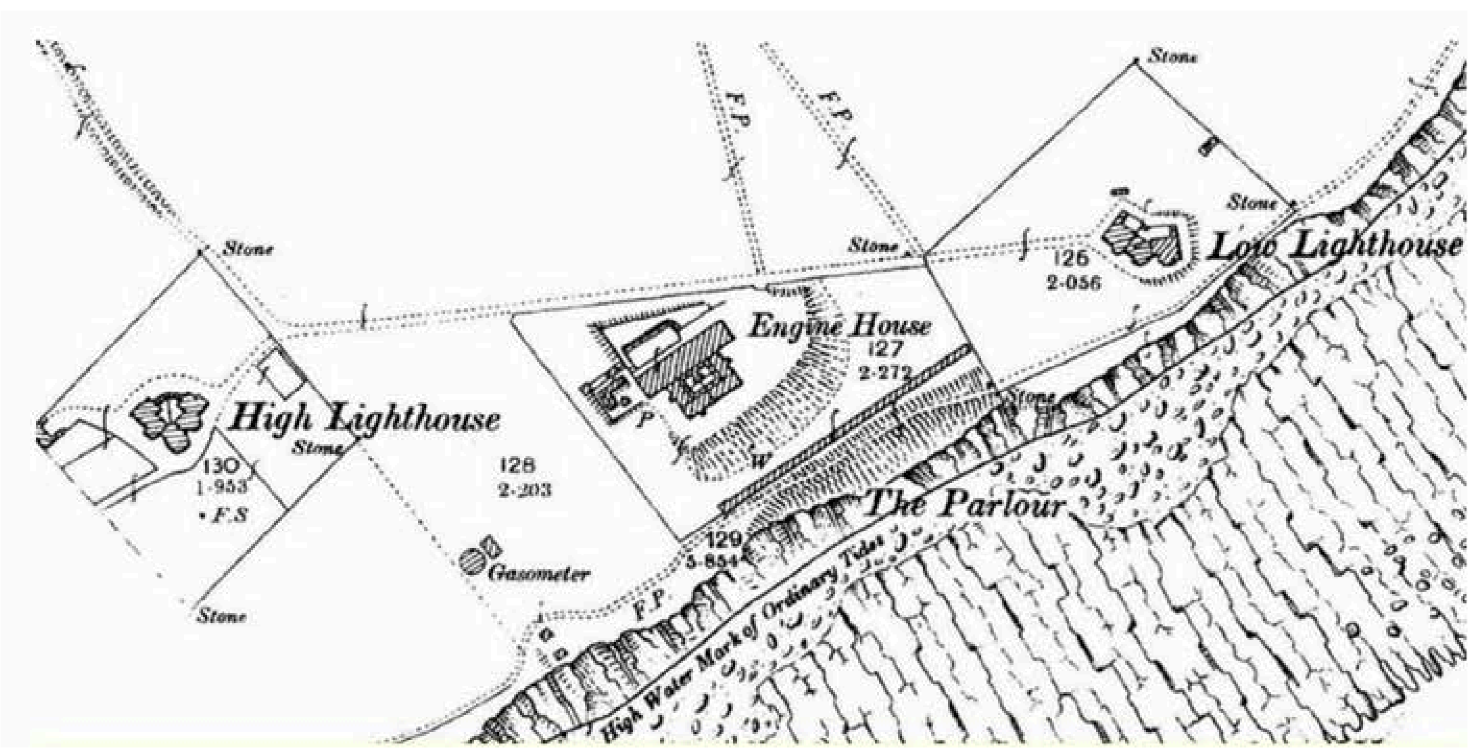
19 Fog signals are discussed at length in Trethewey, K: Lighthouses of Cornwall and Devon (2020)

20 Renton: Alan. "Lost Sounds." Whittles Publishing, 2001, p115.

This aerial photograph from 1931 adds context to the plan on the adjacent page. In the distance, top left, is Dover Castle. The engine house is clearly visible between the two lighthouses. Of especial interest is the recent large fall of rock directly in front of the Low Light.




ABOVE: A plan of the South Foreland lighthouse site in 1873 drawn by Major Elliott, compared with the Ordnance Survey map BELOW of the same location published in 1900. A significant difference is the addition of the long optical test building at the cliff edge in front of the engine house. It is shown in 1900, but not in the 1873 plan and was built for further testing later in the 1870s. The location of the well is the small square marked on both maps and labelled c amongst the outhouses on Elliott's map above. It is clearly shown as o in the detailed plan on p217.



the following year, 1873 and the results of the experimentation would catch up with George Knott at the new lighthouse at Bull Point in 1879 and would almost be his undoing. (Light signals are easily obscured from disinterested eyes, but very loud noise is generally a great nuisance to those in the vicinity, especially if it continued for days on end.)

Eventually inventors and entrepreneurs worked up a new technology that would replace the cannon, but it had to be developed and tested and the obvious place was at South Foreland. A report in the grandly named *Whitstable Times and Herne Bay Herald* [21] revealed what had been done at South Foreland. It read:

> *"Sir Frederick Arrow accompanied by two Elder Brethren of the Trinity House has been on a visit to the new fog horns that have been erected for experimental purposes near the lighthouses of the South Foreland and has tested their efficiency. Two of the horns are placed at the top and two horns at the bottom of the cliff. They are worked by steam and the noise they made was distinctly heard in Dover. It has not yet been decided whether they will be permanently fixed at the Foreland."*

It is not a very comprehensive statement and neither does it use the word 'siren', which was a later development, but I firmly believe that its guarded final sentiment was aimed directly at those who would have to live nearby. It was not a happy prospect. The noise was of such a magnitude that was beyond comprehension at that time and George Knott would eventually become a victim of it.

So important was it to understand the science of fog that Tyndall became one of the leading authorities on the subject. Indeed, it was the reason why the amazing decision was made to build a long 'photometric gallery' along the cliff edge. It was in this building that Tyndall conducted many experiments to determine the amount to which different concentrations of water vapour (fog) in the atmosphere caused attenuation of the light. This extraordinary science laboratory is easily visible in the aerial photo on p207 and remains of it are still to be found in the private garden of Cliffe House (p397). The author was fortunate to be able to inspect it in 2021. It was surely unique and it is regrettable that so far nothing has been found that enables us to add detail to the story.

21 *Whitstable Times and Herne Bay Herald*, Saturday 3 May 1873

LEFT: John Tyndall (1820-93); Director of the Royal Institution and Scientific Advisor to Trinity House.

## The Science of Fog and the Fog of Science

One of the worst situations in which a ship master can find himself is fog. In the time before modern navigational aids, he was literally sailing blind and there are many examples, reported here and elsewhere, of wrecks and loss of life in fog.

In 1860, the technology of lights was advancing rapidly, yet there was a dearth of good ideas for effective fog signals. There were only a few maritime fog signals in the whole of Europe and the USA. The only options were to use bells, guns or whistles, the last of which was still quite unusual except on ships. Bells had been used randomly in the 18th century, and more specifically in the early part of the 19th century, so even by 1860 the state of development of the audible warning technology was still in its infancy.

During the next ten years, some experiments were made to test the effectiveness of sound with distance by firing cannon at Dungeness. The results were always disappointing because there seemed to be little reproducibility in the experiments. The sound transmission varied enormously, even in very similar atmospheric conditions, which naturally led to the conclusion that fog signals were always going to be unreliable, a fact that later proved to be true.

John Tyndall succeeded Michael Faraday as Director at the Royal Institution of London and his research into the properties of sound transmission made him the leading authority from 1867 - the first attempt to develop the science for over 150 years. In Britain, there were just 16 fog signals in operation at lighthouses, almost all of them bells. Steam was only just beginning to overtake the use of sail to power ships. Remarkably, whilst captains of sailing ships would normally anchor in fog, captains of steam ships were expected to continue to make way in fog! In so doing, the vessels were expected to sound their steam whistles at least every two minutes.

The steam whistle had been invented in the 1830s and was an inefficient way of promoting a sound warning. In the 1840s a seaman called Admiral Taylor invented a device rather like a small pipe organ by which a hand-cranked jet of air created four notes in pipes of different lengths. Curiously he called it a telephone! However, his invention appears not to have been adopted.

The design principle in these cases came under the heading of a reed horn, not too dissimilar from a musical instrument such as a saxophone or a clarinet. On a steam ship it was easy to include a whistle as standard, but on a lighthouse the creation of steam was an extra burden. In Nova Scotia in 1854 it was noticed how low notes seemed to be more penetrating than high ones. As a result, a whistle with a low note was used in St John's harbour in 1857. Automation was added to a device a few years later when in 1861 a clockwork-actuated valve was patented. Although the idea was taken up in the United States, it was not adopted in Britain, except at Girdleness in Scotland where the whistle was installed in 1869 and others on the Clyde were used for nearly 30 years. When Dungeness became the centre of attention because of electrification in 1862, an American called Daboll demonstrated his invention of a reed fog signal, whereby the Stevenson brothers who were present from Scotland were impressed and installed the device at Little Cumbrae lighthouse in 1865.

By this time a typical design was using air compressed into reservoirs which then allowed air at appropriate intervals to escape and be blown across a steel reed, thus making the sound. The typical reed became 5 inches long and 2 inches wide and tapered to an eighth of an inch at the free end whilst being fixed at the other. Naturally the airflow induced vibration at the free end and the vibration created the sound of a note at the resonant frequency of the steel.

Air from the reservoirs was admitted to the reed box using a hand-operated valve. Both the air and the sound would emerge through a large trumpet in the atmosphere above the installation. Early devices had a long vertical tube with a trumpet at right angles, as shown above. However the geometry was later significantly modified.

The early use of a horse to compress the air was soon changed to one using a bespoke engine, and automation allowed improvement to the device still further.

Daboll patented his devices in the USA in 1860 and Great Britain in 1863. At Dungeness in 1862 with the Daboll system installed the reed was sounded at about 10 psi and the trumpet was 137 cm (4'6") long with a 53 cm (21 in) mouth and a 6.3 cm (2.5 in) diameter throat. This equipment remained in use until 1865 when it was replaced with a horn 2.74 m (9 ft) in length. By ensuring resonance between the reed and the trumpet, the efficiency of the sound created could be significantly improved. Rotation of the trumpet through an arc was another improvement.

The pressurizing of air as a useful function began with blowpipes as weapons, and were followed by bellows invented around 1500 BCE. Church organs were of course powered by bellows to compress the air which was then blown over the organ pipes in the same way as a simple whistle. A bellows is a hand-operated airbag, the bag often being made from animal skin. By increasing oxygen flow, a bellows enables the attainment of higher temperatures, for example, required in metallurgy where metals were separated from their ores, processes that were being developed from the Bronze Age onwards. Bellows were essential for attaining a good light from coal fires in early lighthouses.

Newcomen and Watt developed the first commercially successful steam engine in 1712, a device known as an external combustion engine, so the internal combustion engine had to wait almost 200 years for its invention when petrol and diesel engines came into use. It was the diesel engine of the 1890s that transformed lighthouses as much as it did road transport for it allowed the generation of electricity where mains supplies were not available. Even when it was, a diesel engine became an essential backup in case the mains electricity failed. It was the Gardner diesel engine that became the primary workhorse throughout the marine industry, whether for powering ships at sea or for generating electricity in lighthouses. Built from 1896 onwards in Manchester, these engines were to be found throughout the world of lighthouses, especially in those rock stations where mains electricity was not practicable.

By 1870, progress must have seemed agonizingly slow to ship masters whose needs were most pressing. Professor John Tyndall must have thought it a woeful situation and was anxious to make progress. In 1872, he proposed a meticulous set of experiments to compare the different methods available to him and received authorization from Trinity House to conduct his trials at South Foreland.

It seems that no-one had seriously compared the effects of the many different devices that had been manufactured, from the humble bell and whistle, to explosives and guns, and more complex designs involving pressurized air in sirens and horns.

*"On Monday, May 19 [1873], the experiment began. The instruments employed, which, under the direction of the Fog Signal Committee, had been previously mounted on the top and at the bottom of the South Foreland cliff, were the following:*

*"On the top were –*

*"A. Two brass trumpets, or horns, 11' 2" (3.4 m) long, 2 inches (5 cm) in diameter at the mouthpiece, and opening out at the other end to a diameter of 22½ inches (57 cm). They were provided with vibrating steel reeds 9 inches (20 cm) long, 2 inches wide, and ¼-inch (6 mm) thick, and were sounded by air of 18 pounds (1.24 Bar) pressure.*

*"B. A whistle, shaped like that of a locomotive, 6 inches (12.5 cm) in diameter, also sounded by air of 18 pounds pressure.*

*"C. A steam whistle, 12 inches in diameter, attached to a boiler, and sounded by steam of 64 pounds (4.4 Bar) pressure.*

*"The instruments at the bottom of the cliff were –*

*"D. Two trumpets or horns, of the same size and arrangement as those above, and sounded by air of the same pressure.*

*"E. A six-inch air whistle, similar to the one above, and sounded by the same means.*

*"The upper instruments were 235 feet (72 m)above high water mark; the lower ones 40 feet (12 m). A vertical distance of 195 feet (60 m), therefore, separated the instruments. A shaft, provided with a series of 12 ladders, led from the one to the other."* [22]

Tyndall's report continues:

*"The observations for the most part were made afloat, one of the yachts of the Trinity Corporation being usually employed for this purpose. Two stations had been established, the one at the top, and the other at the bottom of the South Foreland cliff; and at each of them trumpets and air and steam whistles of great size were mounted. The whistles first employed were of English manufacture, but intelligence having been received regarding a large United States whistle, and also a Canadian whistle, of great repeated power, the Elder Brethren had them subsequently added to the list.*

*"On the 8th of October another instrument, which has played an especially important part in these observations, was introduced. During my recent visit to the United States, I was favoured by an introduction to General Woodruff by Professor Joseph Henry of Washington. Professor Henry is chairman of the Lighthouse Board, and General Woodruff is Engineer-in-Charge of two of the lighthouse districts.*

*"I carried home with me a somewhat vivid remembrance of the mechanical effect of the sound upon my ears and body generally. Hence my desire to see the siren tried at the South Foreland. Informed by Major Elliott of the United States Army, that our experiments had begun, the Board forwarded to the Corporation, for trial, the instruments now mounted at the South Foreland."*

Experiments through June and July proved remarkably inconsistent. Contradictory results puzzled Tyndall who was unable to conclude or determine any correlation between atmospheric conditions and the sound being used. Acoustic range proved quite puzzling. Such inconclusive results were insufficient to persuade those in charge of the purse strings to make a large investment in any particular technology, but at least Tyndall was allowed to continue with his experimentation. Four years later, in 1878, another paper to the Royal Institution indicated that perhaps some progress had been made, if only in the understanding rather than the implementation.[23]

Improvements to fog signals were continually made throughout the 20th century, there being a far bigger variation in designs than were used for light sources. The opposite page illustrates just a few that, by today's standards, might be considered strange, to say the least.

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22 Tyndall, John: Copy Of Report By Professor Tyndall To The Trinity House, "Upon Recent Experiments With Regard To Fog Signals." Presented to TH Farrer, Board of Trade 22 May 1874 under order by the House of Commons. The shaft mentioned above has been of great interest elsewhere and is discussed on pages 199, 217, 220 and 247.

23 Tyndall, John: "Recent Experiments on Fog Signals." *Proceedings of the Royal Society*, 27 (1878) Issue 185189, pp24558. https://doi.org/10.1098/rspl.1878.0040.


Above Left: Two large black trumpets were used for the fog signal at the Lizard lighthouse and these remain in place today, along with the machinery used to make the signal.
Above Right: An old postcard of the horn-type of signal used at Flamborough Head (a site where cannon had once been used) until they, in turn, were replaced by improved designs..



Above Left: At St Catherine's lighthouse a similar design was at first used in a building remote from the tower.
Above Right: Later, a new tower was built in front of the lighthouse and carried a new fog signal on top which itself was subject to several changes throughout the 20th century.
Left: Sometime after 1911, Lord Rayleigh was conducting yet more experiments to improve sound signals in fog. This image shows the very large trumpet that was tested for a number of years at Trevose Head in Cornwall, but never seriously adopted elsewhere.

## Major Elliott Describes The Keepers

Major Elliott was impressed with the light keepers he talked to.

*"Two keepers are designated for each tower, who, in addition to their other duties, make daily observations with the barometer and with wet and dry bulb thermometers, keeping memoranda for the use of some department of the government. The two principals, who are assistants to the engineer, I found to be very intelligent men who seemed thoroughly to understand the magneto-electric machines, and who gave me a very accurate account of their operation. One of them was by trade a watchmaker, and the other a stone mason. The latter told me, with evident pride, that he had laid all the stones at the Bishop Rock, near the Scilly Islands, one of the most exposed stations in the English service, and had been for some years the principal keeper of that light, a position he was obliged to resign, the close confinement affecting his health. Each of these men had been more than 15 years in the service."* [24]

### *Frederick and Sophia Spurr*

Frederick Spurr was born in St. John's, Westminster in 1832 and after leaving school he was apprenticed to Thomas Cribb (32) of Vine Cottage, Hampstead as a clock and watchmaker. It was quite normal for a tradesman to have only one apprentice as they lived 'all found' with the family, who in this case was Jane Cribb (36) and three very young children.[25] At the beginning of 1855 Frederick was still in London as at sometime in the early part of the year, he married Sophia Tunsley somewhere in the Kensington District.

In 1861 the parish that Frederick claimed as his own was also home to a William Spurr (45) who was a gilder and his daughter Isabella was described as a 'clockmaker' in spite of being only 15 years old. Yet where was that home? It was 80 Regent Street.[26]

Meanwhile Frederick and his family were in West Wales as Frederick did his time on a rock lighthouse as a newly fledged lightkeeper. His family was now three children and the eldest two had been born in the district of Uxbridge, but the youngest had been born in Milford just ten months previously. They were now found in Charles Street, Steynton, Milford (Haven).[27] Their choice of residence seemed to be the one used by the families of those who kept the South Bishop light and was dictated by his month-long leave periods, but the light was a new tower in 1861 and only recently completed.

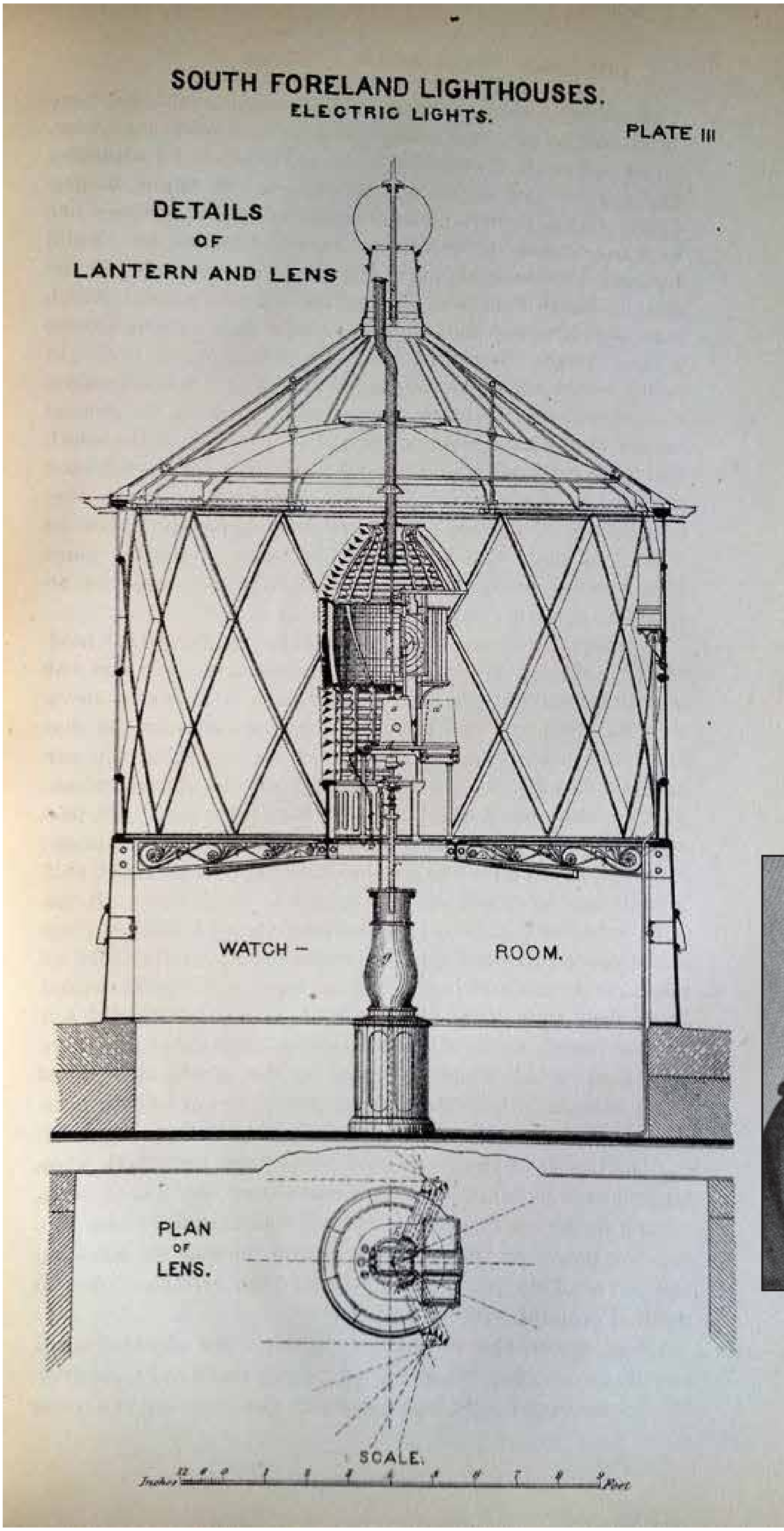
Two more children were born in the 1860s, the first in the early summer of 1864 in St. Merryn which means time on the light on Trevose Head and this was followed by a spell in Plymouth and very probably the Breakwater Light as his time on the South Bishop had excused him from serving on the Eddystone. Their son Frank Alfred was born in Plymouth in 1868 suggesting that their move to South Foreland may have been as recent as 1870.[28]

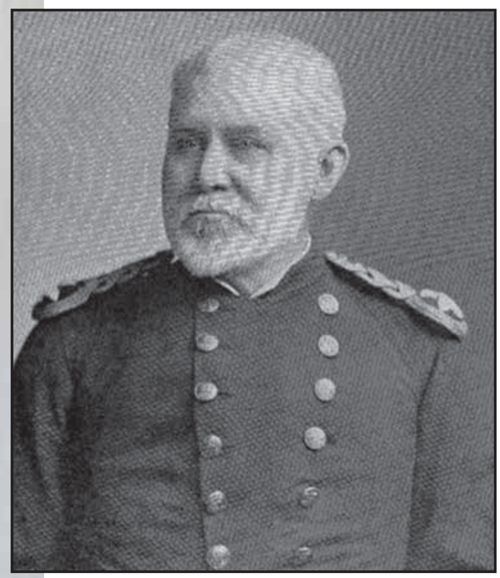
A sixth child, a son named Archibald was born to Sophia at South Foreland in 1873, the year of the visit of Major Elliott after which they packed their bags and found their way to Haisbro' in Norfolk where Frederick could be found as its Principal Keeper.[29] He must have been at Haisbro' for about 20 years as he was still there in 1891 and ten years later, in 1901, when he said he was 67, he and Sophia had retired to live with their eldest son in Handsworth, Staffordshire.[30] He died in 1903/2Q aged 69 and his wife followed him shortly afterwards in 1903/4Q aged 73. Their deaths were registered in the West Bromwich District of Staffordshire, far from the sea.

### *John and Elizabeth Williams*

The man who built his own lighthouse was John Williams, baptised to John and Grace Williams, a labourer and his wife, of Chiprase St. Enoder on the 6 March 1822. It was 40 miles from St. Enoder to St. Just in Penwith, almost half the length of Cornwall, but there was no future on the land. Cornishmen were intent upon burrowing into it for its hidden wealth. Tin, copper, china clay and granite, all lay beneath the surface. Yet John Williams had grown up out of doors surrounded by open fields. He did not want to be a prisoner of his work. He wanted to retain his contact with the wind and the weather. How he came to be a stonemason will never be known, but St. Just was the place for employment, lots of it, building engine houses, sheds and stables. John Williams married Elizabeth Gibson in the parish church of St. Just in Penwith on 2 November 1844 when she was only 17 years old and he was 23. Both lived in Church Town and her father was a coastguard, but her husband was a mason and he was not content to stay in St. Just. Towards the end

24 Elliott, p72.
25 1851 Census HO107/1492 Folio 355 Page 14
26 1861 Census RG09/50 Folio 82 Page 15
27 1861 Census RG09.4160 Folio 67 Page 17
28 1871 Census RG10/1008 Folio 64 Page 28
29 1881 Census RG11/1920 Folio 107 Page 5
30 1901 Census RG13/2712 Folio 61 Page 25



ABOVE: A lighthouse engineer from the USA, Major (later Colonel) George H. Elliott, US Army came in 1873 to see the new technology at South Foreland and wrote a detailed report about the lighthouse.

of 1848 John and Elizabeth were on St. Mary's in Scilly, when their third child was born, but it is unclear what work had attracted John to the islands. It is known that a small facility was built on Rosevear in 1847 for the men building the new lighthouse on the Bishop Rock. It was intended to reduce the travelling time to and from the Rock. It included a dormitory, mess, workshop and forge on a relatively flat area on a small island close to the Bishop and within the Western Rocks that is just 14 feet above high water mark. Yet there were times when the men could not get off and were forced to eat limpets. Was this what had brought John Williams to the Scillies and how had he known about it?

James Walker was a man familiar with the moods of the weather. He had to be. He was a lighthouse engineer and at the end of the working season of 1849 he had just finished an unusual screw pile lighthouse using only metal legs and bracings. He knew that the six dark months of the year could easily generate thirty storms. He also knew that the winds could exert 7000 lbs per square foot pressure on his lighthouse, but he thought that the seas would wash right through its open structure. He did not expect the weather to destroy it.

On Tuesday 5 February 1850 a storm arose that reached its peak before midnight. When morning broke on Wednesday, the light was gone. Everyone wrote that it had been washed away, but the keepers on the Longships told their agent at their relief, that the sea state on that day had been favourable. Their lighthouse had stayed dry, as neap tides had taken much of the force from the sea. It was their opinion that the light had been blown away. Yet, had it not been for that violent storm, John Williams would never have become a lightkeeper.

By July 1850 Trinity House had decided that the lighthouse would be built in stone and several workmen had arrived on St. Mary's to begin preparations. The first stone must have been laid during 1851, but where Walker wanted to lay it was 1 foot below the low water mark so he had to build a coffer dam around the base so that the masons could work fast and continuously without interference from the sea.

At the 1851 census John Williams was in the care of a landlady as his wife had returned home for the birth of her fourth baby, but the census does not highlight any particular concentration of stonemasons on the island. Now that work was under way, a work yard had been established on St. Mary's where the stone was dressed, trial fitted and numbered and there must have been occasions when John worked there. The Foundation Stone was laid in the 14 July 1852 and this stone was very likely to be several courses above the first and somewhere convenient for a dignitary to officially mark its presence.

Between 1853 and 1859, John and Elizabeth Williams completed their family with three daughters born on St. Mary's and during that time the lighthouse builders completed the light tower with 2,500 tons of granite blocks each weighing from 1 to 2 tons and transported to the Rock on a barge built on Porth Cressa beach which began work on the 5 June 1853.

The lamp was lit on the 1 September 1858 and long before that day arrived there had to be two semi-detached cottages built on St. Mary's that would house the families of the four keepers who would arrive to man the light. Those cottages were also built of granite and the site chosen for them was on the Garrison facing the lighthouse that was a good six miles to the south west.

John Williams had ample opportunity to work in the dressing yard, on the lighthouse and on the Bishop Cottages, as they became known, but his ambition had changed. He wanted to be a lightkeeper and he wanted to be the first keeper on the Bishop Rock. He had so impressed the supervisors of the project with his attitude that they made his wish come true and broke all the rules that the Trinity House was trying to put into place. He probably left the Bishop Rock during 1869 after 11 years on the tower and it is suggested that he had stood down from being the Principal Keeper at his own request. South Foreland was now the responsibility of George Thomas, but his dialogue with the Major Elliott suggests that John Williams had something of a charismatic presence among the lighthouse fraternity which never failed to impress.

In 1901 John and Elizabeth were enjoying their retirement at Portscatho on the south coast of Cornwall close to the light at St. Anthony Head overlooking the magnificence of Falmouth Bay.

Above: Aerial photo from 1941. The low lighthouse buildings are still intact and the proximity to the cliff edge is of note.
Below: Aerial photo from 1931. Note the remains of the long photometric gallery on the seaward side of the engine house.