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SMEATON

AND

LIGHTHOUSES.

A POPULAR BIOGRAPHY, WITH AN
HISTORICAL INTRODUCTION
AND SEQUEL.

LONDON:
JOHN W. PARKER, WEST STRAND.
M.DCCC.XLIV.

PREFACE.

[iii]

One of the most useful and pleasing forms under which knowledge can be presented to the general reader, is that of the biography of distinguished men who have contributed to the progress of that knowledge in some one or other of its various departments. But it too frequently happens that the biographical notices of great men consist rather of personal, trivial, and unimportant details, than of a clear and broad outline of the influence which they exerted upon the pursuit and upon the age in which they were distinguished. The true object of biography is, in tracing the progress of an individual, to show clearly what result his active life has produced on the well-being of his fellow-men, and also what is the position which he occupies as one of the 'great landmarks in the map of human nature[1].'

Yet we are not satisfied with a biography which regards its subject in his public capacity alone: we are naturally curious to ascertain whether the same qualities which rendered him celebrated in public followed him likewise into private life, and distinguished him there. We regard with [iv] interest in his private capacity the man who has been the originator of much public good; we look with an attentive eye on his behaviour when he stands alone, when his native impulses are under no external excitement, when he is, in fact, 'in the undress of one who has retired from the stage on which he felt he had a part to sustain[2].'

But a detail of the public and private events in the life of a distinguished man do not alone suffice to form a just estimate of his character. The reader requires to be made acquainted with the state of a particular branch of knowledge at the time when the individual appeared whose efforts so greatly extended its boundaries;—without this it is quite impossible to estimate the worth of the man whose life is being perused, or the blessings and advantages conferred upon society by his means.

On the other hand, in tracing the history of any particular branch of knowledge, unless connected with biography, we lose sight of individual efforts;—they are mingled with the labours of others, or are absorbed into the history of the whole, and are consequently no longer individualized:—hence we are likely to fail in recognizing the obligations due to our distinguished countrymen, or to deprive of their just merit those of our foreign brethren whose useful lives have influenced distant lands, as well as their own.

With these views we propose to connect the name of SMEATON with the interesting subject of [v] LIGHTHOUSES. In the *first* place, we propose to present a brief history of Lighthouses, up to the time when Smeaton gave a type for this peculiar class of buildings upon dangerous and difficult points of coast; *secondly*, a general sketch of the life of Smeaton, so far as his very brief biographers will allow; and *thirdly*, a history of the improvements in Lighthouses which have been effected since the erection of the Eddystone.

In this compilation, the writer desires to express his obligations to the following works: *A Narrative of the Building, and a Description of the Construction of the Eddystone Lighthouse with Stone*, by JOHN SMEATON, fol. London, 1791;—Mr. HOLMES's short *Memoir of* SMEATON;—The Communication of Mrs. DIXON, Smeaton's daughter, to the Institution of Civil Engineers;—*An Account of the Bell-Rock Lighthouse, including the Details of the Erection, and peculiar Structure of that Edifice*, by ROBERT STEVENSON, 4to. Edin. 1824;—*The Edinburgh Encyclopædia*, and the *Encyclopædia Britannica*;—An article *on Lighthouses*, by M. ARAGO, in the *Annuaire*;—*The Civil Engineer's and Architect's Journal*;—*The Nautical Magazine*;—and the *Annual Reports of the Trinity House* presented to the House of Commons. [vii]

FOOTNOTES:

[1] Coleridge.

[2] Coleridge.

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SMEATON AND LIGHTHOUSES.

CHAPTER I.

[9]

EARLY LIGHTHOUSES.

Origin of Lighthouses—Beacon Fires—Character of the Early Watch-towers—Cressets—Colossus of Rhodes—The Pharos of Alexandria—Epitome of Ancient Lighthouses—The Tour de Corduan.

THERE is perhaps nothing better calculated to impress us with the skill and ingenuity of man, and the power which scientific knowledge imparts, than the sight of one of the beautiful Lighthouses of modern times. Rising, it may be, from the point of a jutting rock amidst the dashing and roaring of the breakers, it is exposed to the utmost fury of the storm: graceful in its proportions, and uniting the elements of security and beauty, it resists the terrific assaults of the winds and waves, and bears aloft to the help of the tempest-tossed mariner, the warning light that bids him shun the rocky shore. The skill now attained in the construction of Lighthouses has been of slow and difficult acquirement, the fruit of much patient and persevering toil, and of many painful experiences: it will, therefore, be interesting to trace the steps by which a result so important in the history of commerce has been successfully achieved.

At a very early period it was customary to light up beacon-fires along the most frequented coasts. These fires were kindled on the summits of lofty towers, which served the double purpose of lighthouses, and temples dedicated to the gods. Here sacrifices were offered to appease the storm, and prayers were made for the safety of the mariner. Thus these lighthouse-towers were [10] invested with a sacred character: their beacon-fires were said to be inextinguishable; their priests performed the rites and practised the arts of divination, inquiring into the success of a proposed voyage, and making votive offerings for past deliverances.

Hence it may naturally be supposed, that within these watch-towers was to be found most of the nautical knowledge of the time; that here were deposited such observations on the heavenly bodies as were attainable at that early period; also rude charts of the coast, originally perhaps traced upon the walls, and afterwards formed into primitive maps by being transferred and extended upon papyrus leaves. Here too the young seaman might come for instruction in the art of navigation, simple and imperfect as it must have been. Here too the aged seaman buffetted by the storm might seek refuge from its fury, obtain rest and refreshment, and instructions for the continuance of his voyage.

These ancient lighthouses appear to have consisted of a tower of masonry of large dimensions; circular or square in form; containing numerous apartments and a battlemented top, within which was raised a kind of altarpiece covered with a plate of brass. Upon this brazen hearth a chauffer of curious workmanship was placed: it was in some cases supported upon dolphins; and the grating was decorated with foliage and emblematical devices.

The materials employed for maintaining a light in this chauffer were, doubtless, similar to those in the ancient cressets, or lights of the watch, which were in use not only as beacons, but as common street-lights, before either oil or gas-lights were known. Some of these cressets were formed of a wreathed rope, smeared over with pitch, and placed in an elevated cage of iron, others contained combustible materials in a hollow pan. Occasionally these primitive street-lights were placed at the summit of a pole, from either side of which, projecting pieces of wood formed a ready mode of ascent to trim the light, and obviated the need of a ladder for that purpose. [11]

Before the discovery of the magnetic needle or its application at sea, the towers above referred to were very numerous; so much so that nearly every promontory is said to have been decorated with its lighthouse or temple, and this was the more necessary, since the mariner dared not venture out of sight of the coast, but followed with attention all its little windings and bendings.

There is every reason to believe, that the gigantic figure known as the Colossus of Rhodes formed one of the most celebrated beacon-fires of antiquity. About three hundred years before the Christian era, Charles the disciple of Lysippus constructed this brazen statue, the dimensions of which were so vast that a vessel could sail into the harbour between its legs, which spanned the entrance. It was partly demolished by an earthquake about eighty years after its completion; and so late as the year 672 of the Christian era, the brass of which it was composed was sold by the Saracens to a Jewish merchant of Edessa, for a sum, it is said, equal to thirty-six thousand pounds.

But the most celebrated lighthouse of antiquity was that erected about the year 283 B. C. by order of Ptolemy Philadelphus, on the island of Pharos, opposite to Alexandria. It is from the name of this island that lighthouses have received their generic name of Pharos. Strabo records, that the architect Sostratus, having first secretly carved his own name on the solid walls of the building, covered the words with plaster, and in obedience to Ptolemy's command inscribed thereon, 'King Ptolemy to the gods the preservers, for the benefit of sailors.' The height of this building is stated at four hundred feet; but this, as well as many other accounts relating to it, must be an exaggeration. A more modest account, given by the historian Josephus, is likely to be accurate; but even he states that the fire which was kept constantly burning at the top was visible by seamen at a distance equal to about forty miles.

The most remarkable lighthouses of ancient times were situated in and about the Mediterranean sea; they were generally placed upon extensive moles, or near the entrance of [12] harbours: some of them still remain. The Pharos of Alexandria, and that of Messina, still display their fires, but it is stated that they have shared in none of the improvements of modern science; that even in Spain and Portugal the lighthouse of Corunna, or famous tower of Hercules, exhibits merely a coal-fire with so faint a light that ships can scarcely perceive it until they are in danger of striking against the shores. Of these ancient lights there yet remain those on either side of the Dardanelles; one in the archipelago on the island of Milo, two in the gulf of Salonica, and one near Lagos in Romania; Malta, Leghorn, Civita Vecchia, Genoa, Malaga, Cape Tarifa, and other places, still preserve the fires which guided the prow and the galley of the masters of the old world.

The sum of our knowledge of the ancient history of lighthouses is neither accurate nor extensive: we proceed, therefore, to notice those of modern times. Passing by the many rude contrivances for lighting up a coast, consisting as they did chiefly of pots of fire mounted on poles or rocks, the first lighthouse which merits attention is the Tour de Corduan, which, on account of its architectural magnificence was long regarded as one of the wonders of the world, in the same way as the Pharos of Alexandria had been in ancient times.

The Tour de Corduan is situated on an extensive reef about three miles from land, at the mouth of the river Garonne, and from its position serves as an important guide to the shipping of Bordeaux, the Languedoc Canal, and all that part of the Bay of Biscay. It was founded in the year 1584, but was not completed until 1610, in the time of Henry IV. Its style of architecture is a mixture of classic and gothic, and so very elaborate, that a just idea cannot be formed of it without reference to drawings in detail. The building is one hundred and ninety-seven feet in height, and consists of a number of galleries rising above each other, and gradually diminishing in diameter. The base consists of an immense platform of solid masonry, surrounded by a wall [13] one hundred and thirty-four feet in diameter, so placed as to act as an outwork of defence to receive the chief shock of the waves. The light-keeper's houses and the store-rooms form a detached range of buildings on the great platform, from which a private staircase conducts to the light-room. At the entrance door of the main tower, the busts of Henry II. and Henry IV. are placed in niches, over these are the arms of France, and an emblematical figure of St. Mary, to whom the building is dedicated; there is also another female figure, holding a branch of palm in one hand and a crown in the other.

In the solid masonry of the platform is the fuel-store; over this is the great hall, twenty-two feet square with an arched roof twenty feet high. On this floor are also two wardrobes and other conveniences. Over the hall is the king's apartment, twenty-one feet square, with an elliptical roof twenty feet in height. This floor has also a vestibule, two wardrobes, &c. The third floor contains the chapel, in which a priest occasionally performs mass. Its diameter is twenty-one feet, and from the floor to the centre of the dome-roof the height is forty feet. It is highly adorned with mosaic, and is lighted by eight lantern windows. In the crown of the dome-roof is a circular opening surrounded by a balustrade, through which is seen the ornamental roof of the room above. This room is fourteen feet in diameter and twenty-seven feet high; it is used as a watch-room by the light-keepers, and was probably intended as a place to which they could be admitted to hear prayers or mass on the occasion of a royal visit. Over this room is an apartment capable of containing a stock of fuel sufficient for one night's consumption, and is so constructed as to be convertible into a room for the exhibition of a light, in case of accident or repairs being required in the main light-room. This is situated over the store-room just referred to, and is surrounded by a balcony and a circular stone parapet. The original lantern, or light-room, was constructed for the combustion of oak wood, exposed in a kind of chauffer raised six feet above the floor. The [14] room was not glazed, so that the smoke was carried out sideways in the direction of the wind.

The roof was furnished with a sort of chimney in the shape of a spire, which terminated the building with a ball. The whole light-room was of stone, and its height to the top of the spire-funnel was thirty-one feet.

From the rude mode by which light was obtained, the stone mullions which supported the cupola-roof became so much damaged, that in 1717 it was necessary to remove the light to the apartment below, till the light-room and upper works were restored. But the new light being so defective that it could not be seen at sea at a greater distance than six miles, many accidents and complaints arose, when it was determined to construct the light-room of iron instead of stone. By this means the light passed with less obstruction, and in 1727, after a lapse of ten years, it was again exhibited at its accustomed height and with increased brilliancy. The light was further improved in consequence of pit-coal being used instead of timber; and the interior of the roof was converted into a kind of inverted conical reflector, the point of which projected downwards, and its base extended nearly to the full size of the roof. Still, however, the light being exposed in an open chauffer, was little to be depended on at any great distance from the shore, so that about the year 1780 reflectors and lamps were introduced, and in 1822 the light received its last improvement by the introduction of Fresnel's beautiful apparatus.

Chapter II.

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THE LIGHTHOUSES OF ENGLAND.

Management of English Lighthouses—The Trinity House—Early History of this Corporation—Management of Lighthouses vested in —The Power of the Crown to grant Patents for Lighthouses—Recent Law for the Regulation of Lighthouses—Revenue of Corporation—Rates of Dues—How collected and disbursed—Constitution of the Corporation—The Public Lights of England.

It will now be necessary to give some account of the important institution to whose members is entrusted the management of Lighthouses, and of various interests connected with the Seamen and Shipping of this country. This is the Corporation of the Trinity House of Deptford Strond, whose full title is as follows:—'The Master, Wardens, and Assistants of the Guild, Fraternity, or Brotherhood of the most glorious and undivided Trinity, and of St. Clement, in the parish of Deptford Strond, in the county of Kent.'

The early records of this corporation were destroyed by fire in 1714, so that the origin of the institution cannot be precisely stated. But it appears that the purpose for which it was first established was, for the increase of correct information of the intricacies of navigation connected with the channels leading into the Thames, and with the river itself, and that the society was originally an association of seamen formed for the purpose of forwarding and assisting the attainment of the object.

In the reign of Henry VIII. the arsenals of Woolwich and Deptford were founded, the latter being afterwards put under the direction of the Trinity House. It is in this reign that we meet with the first official document relating to the establishment at Deptford Strond. A royal charter of incorporation was granted in the sixth year of the reign, wherein Henry grants license to his [16] beloved people and subjects, the shipmen and mariners of England, to *new begin*, erect, create, ordain, found, unite, and establish a certain guild or perpetual fraternity of themselves and other persons, as well men as women, in the parish-church of Deptford Strond, in the county of Kent. This charter permits the brethren to elect one master, four wardens, and eight assistants, to govern and oversee the guild, and have the custody of the lands and possessions thereof, &c. Queen Elizabeth, in the first year of her reign, recognised all the rights and immunities of the corporation, and in the eighth of her reign an act was passed enabling them to preserve ancient sea-marks, to erect beacons, marks, and signs for the sea, and to grant licenses to mariners during the intervals of their engagements to ply for hire as watermen on the river Thames. This act recites the destruction of steeples, woods, and other marks on the coasts, whereby divers ships had been lost, to the great detriment and hurt of the common weal, and the perishing of no small number of people, and forbids the destruction of any existing marks after notice under a penalty of one hundred pounds.

In the reign of James I. a question arose as to whether the privileges granted to the Trinity House by the act of 8th of Elizabeth included *lighthouses*, which, it would appear, were not introduced in England at the time it was passed. The opinion of Sir Francis Bacon was sought in the matter, and on it an order in council was founded, 26th March, 1617. The opinion was,—'That lighthouses are marks and signs within the meaning of the statute and charter. That there is an authority, mixed with a trust settled in that corporation, for the erection of such lighthouses, and other marks and signs as may serve from time to time, as the accidents and moveable nature of the sands and channels doth require, grounded upon the skill and experience which they have in marine service, and this authority and trust cannot be transferred from them by law, but as they only are answerable for the defaults, so they only are trusted with the performance, it being a matter of a high and precious nature, in respect of the salvation of ships and lives, and a kind of [17] starlight in that element.'

There is reason to believe that this sensible decision of the attorney-general was not altogether pleasing to the king, whose habit of selling monopolies and patents was thereby checked. That this was the case appears from the fact, that, on Sir Francis Bacon becoming lord-keeper, the same point of law was revived before his successor in the office of attorney-general, Sir Henry Yelverton. The result of this was a report that suited the king's purposes better at the time, but was subsequently the cause of much evil, loss, and expense, because the management of several lighthouses was thenceforth entrusted to individuals. Without interfering with the authority already possessed by the Trinity House, this report states that the crown had also a power and right by the common-law to erect such houses. 'And therefore,' says the report, 'howsoever the ordinary authority and trust for the performance of this service is committed to the said corporation alone, as persons of skill and trust to that purpose, yet if they be not vigilant to perform it in all places necessary, his majesty is not restrained to provide them according to his regal power and justice, for the safety of his subjects' lives, goods, and shipping, in all places needful.'

Thus patents for and leases of lighthouses were granted to private individuals, and were no longer the exclusive right of the Trinity House. This state of things continued from that period nearly to the present time. But the inconvenience and disadvantage resulting from the measure had long been felt, and it was found that the lighthouse system was, in too many instances, conducted with a view to private interest rather than public good. An act was therefore passed, in the sixth and seventh years of the reign of his late majesty William IV., in order to the attainment of uniformity of system in the management of lighthouses, and the reduction and equalization of tolls payable in respect thereof. By this act provision was made for vesting all the lighthouses on [18] the coast of England in the corporation of the Trinity House, and placing those of Scotland and Ireland also under their supervision. All the interest of the crown in lighthouses possessed by his majesty was vested in the corporation, in consideration of three hundred thousand pounds allowed to the Commissioners of Crown Land Revenue for the same, and the corporation were permitted to buy up the interests of the various lessees of the crown and of the corporation, as well as to purchase the other lighthouses from the proprietors of them, subject in case of dispute to the assessment of a jury. Under this act purchases have been made by the corporation of nearly the whole of the lighthouses not before in their possession, the sum expended for that purpose amounting to nearly a million of money.

The revenues of the corporation, which are very considerable, are derived from tolls paid by the shipping deriving benefit from the lights, beacons, and buoys, and from the ballast supplied. Also from lands, stock, &c. held by the corporation, partly by purchase, partly from legacies, &c. and donations of private individuals. The whole of these revenues are employed in necessary expenses, such as constructing and maintaining their lighthouses, and lights, beacons, and buoys, and the buildings and vessels belonging to the corporation, in the salaries of the officers of their different establishments, and in relieving decayed seamen and ballastmen and their widows. Many almshouses have been erected and are maintained from the same funds.

The present house of the corporation is on Tower Hill. It was built by Wyatt in 1793. It is of Portland stone, with a rustic basement, over which is one story adorned with Ionic columns and pilasters. The Trinity House was formerly in Water Lane, where it was twice destroyed by fire. The members of the corporation are chosen from among the highest ranks: of the thirty-one elder brethren, eleven are noblemen and heads of the government departments, admirals, &c. These are styled honorary members, and have no pecuniary advantage from their connection with the [19] institution. The present master is the Duke of Wellington. Mr. Pitt filled that office for seventeen years, and William IV. was master at the time of his accession to the throne. Different committees are appointed for attending to the various duties of the corporation. The deputy master and elder brethren are from time to time employed in making voyages of inspection of their lighthouses and lights, beacons and buoys, and in making surveys &c. on the coast, and reports on maritime matters. The salary of the deputy master is six hundred pounds per annum, and of the elder brethren three hundred pounds each per annum. The duties of the corporation also extend to the examination of such boys of Christ's Hospital as shall be willing to become seamen, and to apprentice them to commanders of ships. Also, the appointment of all pilots into and out of the Thames, prohibiting under penalties all other persons from exercising the office; the punishment of seamen deserting, &c. All masters of the Navy, as well as the pilots, also undergo examination before this corporation.

The rate of dues chargeable by the Trinity House before the passing of the Act of 1836, varied from one sixth of a penny to one penny per ton, on each light passed; and it appears from the Parliamentary Report, that in 1832 the net amount of revenue was seventy-seven thousand three hundred and seventy-one pounds, and the expense of maintaining the lights thirty-six thousand nine hundred and four pounds, leaving a surplus of forty thousand four hundred and sixty-seven pounds, to be expended in charity to the amount of thirty-five thousand, and the rest in the erection of new lighthouses, and the maintenance of the general establishment. By the new Act the duties levied under former Acts were repealed, and it was enacted that every British vessel, and every private foreign vessel should pay the toll of one half-penny per ton for every time of passing, or deriving advantage from any light, with the exception of the Bell-Rock, for which one [20] penny per ton is the toll. Every foreign vessel not privileged must pay double toll. Exemptions were made in favour of the King's vessels, those of Trinity House, and all vessels going in ballast or engaged in the herring fishery. Power was given to the commissioners of northern lighthouses to erect beacons, and moor buoys, and the harbour-lights on the Scotch coast were placed under their controul. This Act also confers on the Trinity House the power of entering any lighthouse

under the charge of other boards, to inspect their condition, and it gives them a controul as to the erection of new lighthouses, or the alteration of those already existing, both in Scotland and Ireland. In the event of any differences of opinion between the three boards, appeal is to be made to the Privy Council. It is also enacted, that accounts of the receipt of all monies, and a report of all alterations made during the preceding year, be annually laid before each House of Parliament.

The public lights of England, including Heligoland (a small island belonging to England situate about twenty-five miles from the mouth of the Elbe), amount to seventy-one in number, and have been arranged in the following classes.

1.	Those belonging to and under the management of the Corporation of the Trinity House	55 lights
2.	Those in the charge of individuals under lease from the Trinity House, and having different periods to run	3 "
3.	Those let by the Crown to individuals for a period of years on leases renewed since the year 1822	7 "
4.	Lights originally held under patents subsequently sanctioned by Acts of Parliament, and now in the hands of proprietors	4 "
5.	At Heligoland	1 light
6.	One floating light at Benbridge Lodge	1 "
	Total number of public general lights in England	71 lights

A list of the lighthouses of the British Islands, corrected to July, 1836, is published at the Hydrographic Office, Admiralty.

Chapter III.

[21]

HISTORY OF THE EDDYSTONE LIGHTHOUSE TO THE TIME OF SMEATON.

The Eddystone Rocks—Their situation and dangerous Character—The first Lighthouse by Winstanley—Its progress and Completion—Its awful Fate—Rudyerd's Lighthouse—Description of—Its Destruction by Fire—Smeaton appointed to construct a New edifice.

The Eddystone Rocks are situated nearly S. S. W. from the middle of Plymouth Sound, and at a distance from the port of Plymouth of nearly fourteen miles. They are remarkable for the great variety of contrary sets of the tide or current among them, and hence it is supposed they derived their appellation. From various causes the currents in the district of the channel where these rocks lie are so exceedingly irregular, that it requires much knowledge of the local situation to shun the dangers connected with them. Supposing a line to be drawn between the Lizard and the Start points, the Eddystone rocks would be found nearly on, or a little within that line. The nearest point of land to these rocks is the promontory called Ram-head.

As the Eddystone rocks lie nearly in the direction of ships coasting up and down the channel, they were, previous to the erection of the lighthouse, extremely dangerous, and often fatal to ships, particularly to such as were homeward bound from foreign parts; so that many rich vessels were actually lost on these rocks, it being not unusual for the most careful mariner to run his vessel upon them during the night, or in foggy weather at high water, when the whole ranges of the rocks are entirely covered.

If the situation of the Eddystone rocks be considered with reference to the ocean and the Bay of Biscay, it will be seen that they lie exposed to the great and heavy swells which come in from [22] all the south-western points of the compass. Indeed, it is a fact well known to mariners, that all the heavy seas from those quarters come uncontrolled upon these rocks, and break on them with the utmost fury. The particular conformation of the rocks also tends to augment the force and height of the seas, for they not only stretch across the channel in a north and south direction to the length of above one hundred fathoms, but they lie in a sloping manner toward the south-west quarter. The effect of this slope in stormy weather is to increase the swell of the seas to a frightful extent; and even in calm weather, when the sea is to all appearance smooth and unruffled, the ground-swell from the ocean continues, and meeting the slope of these rocks, the waves often break upon them with great violence.

The largest and highest of the Eddystone rocks is now called the House-rock, because every building which has been attempted has had its foundation there; but even on this the most favourable spot for such efforts, there is a peculiar difficulty, arising out of its shape and position. There is a sudden drop in the surface of the rock, forming a step of about four and a half or five

feet high, the upper part somewhat over-hanging the perpendicular, so that the seas, which in moderate weather come swelling towards that step, meet so sudden a check thereby that they frequently fly to the height of thirty or forty feet. This proved a great interruption to the works during the building of the lighthouse, for the water coming down from this height on the area of the building completely wetted the work-people, and either suspended their employment or caused them to execute it in a very uncomfortable situation. This is not the case at all times, but only when the ground-swell comes in from the bay, which, however, is constant during south-westerly winds, and for some time after they have subsided.

It would appear that the many fatal accidents which occurred to homeward-bound ships had long made it much desired, as it was highly necessary, that some beacon should be erected on [23] the Eddystone rocks. The formidable nature of the undertaking, and the almost insuperable difficulties connected with it, may be supposed to have long repressed the ardour of the zealous and the humane; but at length, in the year 1696, a person was found hardy enough to undertake the task, and he was soon invested with the necessary powers to put it in execution.

This person was Mr. Henry Winstanley, of Littlebury, Essex, whose mechanical abilities had previously been known rather by a series of eccentric contrivances than by any remarkable proof of skill. For instance:—in his house at Littlebury, if a visitor entered an apartment and saw an old slipper lying on the floor, and very naturally proceeded to kick it aside with his foot, a ghost-like figure would immediately start up before him, and if he retreated from it and took his seat in a chair, a couple of arms would immediately clasp him in, so that it would be impossible to disengage himself without the assistance of an attendant.

These unpleasant jokes were not confined to the house; for if the unfortunate guest took refuge in the garden, and unwittingly entered the summer-house by the side of the canal, immediately he was sent out afloat to the middle of the water, and could not possibly make his escape without the intervention of the manager. These tricks were apparently played for mere amusement; but Mr. Winstanley at one time turned his mechanical contrivances to account, by establishing an exhibition at Hyde-Park Corner, called ‘Winstanley’s Water-Works,’ the price of admission being one shilling each person.

Unimportant as these particulars may appear, they serve to mark the turn of mind of the first engineer of the Eddystone, and to account in some degree for the whimsical nature of the buildings erected by him.

From Winstanley’s own narrative, we find that he began his lighthouse in 1696, and that it took more than four years in building, both on account of the greatness of the work, and the difficulty [24] and danger of getting backwards and forwards to the place. Though nothing was attempted except in the summer season, yet even then, the weather at times would prove so unfavourable that for ten or fourteen days together, owing to the ground-swell from the main ocean, the sea would be raging about these rocks, while calm elsewhere, and fly up more than two hundred feet, burying all the works, and making it impossible for the engineer to approach.

The first summer was spent in making twelve holes in the rock, and fastening twelve large irons to hold the work that was to be done afterwards. It appears that Winstanley and his party made single journies every time from Plymouth, and had not any store-ship lying at moorings as a place of constant retreat. This was a great oversight, and unnecessarily retarded his work. Many journies were taken in vain, when no landing could be effected, and during the work the hours of labour were needlessly curtailed by preparations for the safety of the materials during their absence, and also for their own departure.

The second summer was employed in making a solid round pillar, twelve feet high and fourteen in diameter. This was an important step: the workmen had now some small shelter, and something to hold by. The season also proved rather more favourable than the preceding; but the labour of conveying materials, and making them secure, or returning them to the boats every night when they left work, was very great.

During the third year, this pillar was made good at the foundation from the rock to sixteen feet in diameter, and the edifice was raised to the height of eighty feet. ‘Being all finished,’ says the engineer, ‘with the lantern, and all the rooms that were in it, we ventured to lodge there soon after Midsummer, for the greater dispatch of the work. But the first night the weather came bad, and so continued, that it was eleven days before any boats could come near us again; and not being acquainted with the height of the sea’s rising, we were almost drowned with wet, and our [25] provisions in as bad a condition, though we worked night and day as much as possible to make shelter for ourselves. In this storm we lost some of our materials, although we did what we could to save them; but the boat then returning, we all left the house to be refreshed on shore: and as soon as the weather did permit we returned and finished all, and put up the light on the 14th November 1698; which being so late in the year, it was three days before Christmas before we had relief to go on shore again, and were almost at the last extremity for want of provisions; but by good Providence, then two boats came with provisions and the family that was to take care of the light, and so ended this year’s work.’

The fourth year was spent in strengthening and enlarging the structure. The sea had considerably damaged the building during the winter, and at times the lantern was so completely buried beneath the waves, that it was thought expedient to raise the height of the edifice. Early in the spring the building was encompassed with a new work of four feet thickness from the foundation, and all was made solid nearly twenty feet high. The upper part of the building was

taken down, and every part was enlarged in its proportion. The height was increased forty feet; and yet the sea, in stormy weather, flew, to all appearance, one hundred feet above the vane. Mr. Winstanley has left no description of this structure; but a print, from a drawing said to have been made on the spot, was extant in Smeaton's time, so that he describes it as consisting of a store-room, with a projecting cabin to the south-east, a kitchen, a state-room, a lodging-room, an open gallery or platform, an attending or look-out room, and a lantern for the lights surrounded by a gallery or balcony[3].

Thus Mr. Winstanley's lighthouse was completed in 1700, and though destined to remain but a [26] short time, it was a most important and heroic step accomplished. Mankind were now convinced that the erection of a building upon the Eddystone rocks was not an impracticable thing, though long deemed so; and if experience now proved that the shock of the surges was augmented, by the interposition of the building, to a furious extent, it also led the way to further trials and expedients to counteract that shock.

In November 1703 Mr. Winstanley went down to Plymouth to superintend some repairs that had become necessary to the lighthouse; and when he was about to proceed with his workmen to the spot, some of his friends, convinced from the structure of the lighthouse that it could not last long, ventured to intimate their suspicions to him, and to warn him of danger. His reply was, that he felt so convinced of the strength of his building, that he only wished he might be there in the greatest storm that ever blew under the face of heaven, that he might see what effect it would have upon the structure. It is painful to record this presumptuous wish, and still more so to relate its fulfilment.

Mr. Winstanley with his work-people and light-keepers had taken up their abode at the lighthouse, when a dreadful storm began, and in the night of the 26th of November reached a terrific height. Indeed of all the accounts which history furnishes of storms in Great Britain, none is to be found of a more awful and devastating nature than this. Plymouth itself suffered severely; and when morning came, and the height of the tempest was past, there was an eager look out in the direction of the lighthouse, to see what injury it might have sustained. But the waters rushed on over the Eddystone rocks, no longer impeded by the lofty structure that had been reared with such pains and cost. Winstanley, his work-people, his light-keepers, his boasted structure—all had been swept away by the resistless fury of the winds and waves; and not only this, but a homeward-bound vessel, the 'Winchelsea,' deprived of the warning light that might have averted [27] her fate, struck upon these rocks, and lost nearly her whole crew. This lamentable event is detailed in most of the public papers of the day; and the loss to the nation, as it respected Winstanley himself, who was deemed the only person able to reconstruct the edifice, deeply deplored.

Three years elapsed ere the necessary steps were taken fur commencing anew this most useful work. It appears from this that some obstructions to the undertaking were offered, since it was not until the 4th of Queen Anne that an Act of Parliament was obtained for the better enabling the Master, Wardens, and Assistants of Trinity House, Deptford Strand, to rebuild the Lighthouse. The act runs thus: 'And whereas there now is, and time out of mind has been, a very dangerous rock, called the Edystone lying off of Plymouth, in the county of Devon, upon which divers ships and vessels have been cast away and destroyed: and whereas upon application some time since made to the said Master, Wardens, and Assistants, by great numbers of masters and owners of shipping to have a lighthouse erected upon the said rock, offering and agreeing in consequence of the great charge, difficulty, and hazard of such an undertaking, to pay the said Master, &c. one penny per ton outwards, and the like inwards, for all ships and vessels which should pass such lighthouse, (coasters excepted, which should pay twelve pence only for each voyage,) they, the said Master, &c. having a due regard to the safety and preservation of the shipping and navigation of this kingdom, did in the year 1696 cause a lighthouse to be begun to be erected upon the said rock, and in three years a light was placed therein; and the said lighthouse in the term of five years was with much hazard and difficulty, and at a very great expense, fully built and completed, to the great satisfaction of the flag-officers and commanders of the fleet and ships of war, and of all other concerned in trade and navigation, the same being not only useful for avoiding the dangerous rock upon which it was built, but also as a guide and [28] direction to ships passing through the channel from and to all parts of the world. And whereas the said lighthouse was preserved and kept up for several years, notwithstanding the great force and violence of the wind and sea, (to which it was exposed,) until the late dreadful storm in November 1703, when the same was blown down and destroyed: and whereas it was found by experience that the said lighthouse (during the standing thereof) was of public use and benefit to this kingdom, a means to preserve her Majesty's ships of war, and the shipping, lives, and estates of her subjects. And forasmuch as the speedy rebuilding the said lighthouse is absolutely necessary for avoiding the dangers attending the trade and navigation of this kingdom, and in regard the same work is of great charge, hazard, and expense, and all due and proper encouragement ought to be given thereto; to the end therefore that the said Master, &c. may be encouraged to new-erect and build, or cause to be new-erected and built, the said lighthouse with all convenient speed, and constantly keep and maintain the same for the benefit of the navigation and trade of this kingdom, be it enacted, &c.' It then proceeds to enact the payment of the duties above mentioned, and double on foreign vessels, 'from and after the kindling or placing a light useful for shipping in the said lighthouse.' In 1706 a lease of ninety-nine years was granted by the corporation of Trinity House to a Captain Lovet, who undertook the management of the affairs connected with the building. The choice Captain Lovet made of an engineer, or architect and surveyor, may seem a strange one. He deputed to that office John Rudyerd, a silk-mercer

who kept a shop on Ludgate Hill.

It does not appear that this Rudyerd had been bred to any scientific profession. On the contrary, it is reported that his parents and family were vagrants, and notorious for the badness of their characters; but that from something promising in the aspect of this boy, a gentleman took him into his service, and gave him instruction in reading, writing, accounts, and mathematics, in [29] all which the boy made ready progress; so that his master was enabled to gratify his benevolent intention of advancing him in life, and recommending him to some employment above the rank of a servant. Thus was laid the foundation of his future success.

No doubt Captain Lovet had become well assured of the genius of this man, ere he entrusted him with a work for which no previous experience had qualified him. At any rate, the choice was a wise one. Rudyerd's designs proved admirable, and his want of personal experience was in a great degree supplied by the help of Messrs. Smith and Norcutt, shipwrights from Woolwich, who worked with him the whole time.

Rudyerd saw the errors in Winstanley's building, and avoided them: instead of a polygon, he chose a circle for the outline of his building, and carried up the elevation in that form. He studied use and simplicity instead of ornament; therefore he dispensed with the open gallery and other unnecessary appendages of the former building. After the completion of his work, Rudyerd published a print of his lighthouse, entitled 'A Prospect and Section of the Lighthouse on the Edystone Rock off of Plymouth;' with the motto, *Furit natura coercet ars*, dedicated to Thomas Earl of Pembroke, then Lord High Admiral.

Rudyerd did not fail to observe that owing to the very considerable slope of the surface of the Eddystone rock, nothing would stand upon it without artificial means: he therefore concluded, that if the rock were reduced to level bearings, the heavy bodies to be placed upon it would then have no tendency to slide. He therefore intended to have reduced the inclined surface to a set of regular steps, which would have been attended with the same good effect, as if the whole could have been reduced to one level; but in consequence of the hardness of the rock, the shortness and uncertainty of the intervals in which this part of the work was performed, and the great tendency of the laminæ of the rock to rise in *spawls*, according to the inclined surface when acted upon by tools with sufficient force to make an impression, this part of the work, *i. e.* the [30] reducing of the rock to steps, was never perfectly carried out. The face of the rock was, however, divided into seven rather unequal ascents: thirty-six holes were cut in the rock, to the depth of from twenty to thirty inches. These holes were six inches square at the top, gradually narrowing to five inches, and then spreading again and flattening to nine inches by three at the bottom. They were all cut smooth within, and with great dispatch, as Rudyerd himself informs us, (though the stone was harder than any marble or stone thereabouts,) with engines for that purpose. Every cramp or bolt was forged exactly to the size of the hole it was designed to fill, weighing from two to five hundred weight, according to its different length and substance. These bolts or branches served to fasten the foundation to the rock.

The method of fixing these branches in the rock was ingenious, and proved quite effectual; so that when Smeaton took out some of these branches more than forty years afterwards, they were perfectly sound, and the iron had not even rusted. When the holes were finished and cleared of water, Rudyerd caused a considerable quantity of melted tallow to be poured into each hole: the iron branch was then heated to a blue heat, and being put down into the tallow, the key was firmly driven in. Thus all the space unfilled by the iron would become full of tallow even to overflowing. While all remained hot, a quantity of melted pewter was poured into the chinks, and drove out the remainder of the tallow, thus effectually filling up every crevice.

When all the iron branches were thus made fast in the solid rock, Rudyerd proceeded to fix a course of squared oak timbers lengthwise upon the lowest step, so as to reach to the level of the step above. Another set of timbers were then laid crosswise, so as to cover those already laid down, and also to carry the level surface to the height of the third step. The third stratum was again laid lengthwise, the fourth crosswise, &c., until a basement of solid wood was raised, two complete courses higher than the highest part of the rock; the whole being fitted together, and to [31] the rock (by means of the branches) as closely as possible; while all the timbers, in their intersections with each other, were trenailed together.

The branches originally let into the solid rock were perforated in their upper parts, some with three and some with four holes, so that in every pair (collectively called a branch) there would be about seven holes; and as there were at least thirty-six original branches, there would be two hundred and fifty-two holes, which were about seven-eighths of an inch in diameter; and consequently were capable of receiving as many large bearded spikes or *jag-bolts*, which being driven through the branches into the solid timber held the mass firmly down; while a great multiplicity of trenails in the intersections confined the strata closely and compactly together.

In this way, by fixing layer upon layer of solid squared oak-timber of the best quality, Rudyerd was enabled to make a solid basement of the required height; but in addition to this he judiciously acted upon the principle that *weight is most naturally and effectually resisted by weight*. He considered that all the joints of these timbers were pervious to water, and that it was not possible that every portion of the ground layer should be precisely and entirely in contact with the rock; and he was well aware that where the contact was not perfect, so as to exclude the water therefrom, though the separation was only of the thickness of writing-paper, yet the action of a wave upon it edgewise would produce an equal effect towards lifting it upwards, as if it acted immediately upon so much area of the bottom as was not in close contact. To counteract

therefore every tendency of the seas to move the building in any direction, he interposed strata of Cornish Granite. Thus the foundation was of oak as far as two courses above the top of the rock, then five courses of stone were added, of a foot each in thickness, and these were kept together and secured by cramps of iron. Two more courses of timber then followed, and thus was finished [32] the entire solid portion of the basement.

Rudyerd's lighthouse was begun in July 1706, and completely finished in 1709. The entry door was full eight feet above the highest part of the rock, and therefore an iron ladder of great strength was employed as the mode of ascent. The floor of the store-room was laid at the height of twenty-seven feet above the rock. Four rooms, one above another, and the lantern, with its balcony, completed the edifice. The main column of the building consisted of one simple figure, being an elegant frustum of a cone, unbroken by any projecting ornament, or any thing whereon the violence of the storms could lay hold, being, exclusive of its sloping foundation, twenty-two feet eight inches upon its largest circular base; sixty-one feet high above that circular base; and fourteen feet three inches in diameter at the top. The whole edifice, with the exception of the courses of granite at the base, which may be regarded as ballast, was composed of timber, skilfully joined and fitted, and exhibiting an excellent specimen of shipwrights' work. All the window-shutters, doors, &c. were so formed as when shut to fall in with the general surface, without making any unevenness or projection. The only projecting parts in the whole building were a simple cornice nine inches wide, for the protection of the windows of the lantern, which could not of course be defended by shutters, and another cornice of similar width at the base, which filled up the angle between the upright timbers of the building and the sloping surface of the rock. The lantern was an octagon of ten feet six inches in diameter, externally, and above it, was a ball of two feet three inches diameter. The whole height of the lighthouse, from the lowest side to the top of the ball, was ninety-two feet.

Rudyerd's lighthouse stood in need of no material repairs for some years; but at length the upright timbers were considerably damaged by the attacks of a small worm, and were consequently subject to extensive reparation. For many years after the establishment of the [33] lighthouse, it was attended by two light-keepers only, whose duty it was to keep the windows of the lantern clean, and to watch four hours alternately, for the purpose of snuffing and renewing the candles. Each at the conclusion of his watch took care to call the other, and see him on duty before he retired. The duties of the lighthouse did not actually require more than two men for this service; but a painful incident which occurred at the period we are referring to, caused a change in this respect. One of the two light-keepers was taken suddenly ill, and died; and the survivor had no means of making any one acquainted with the circumstance. The signal, when anything was wanted by the light-keepers, was to hoist a large flag upon a flag-staff from the balcony rails, so as to be fully extended in the wind, clear of the building. This flag-staff could be seen in moderate weather from the heights about Ram-head; and that it might never be hung out in vain, a reward of half a guinea was given to the first person who brought tidings of the fact to the agent at Plymouth; and this agent immediately sent out a boat, to land at the rock (if possible), and ascertain what was wanted. The remaining light-keeper, on this occasion, hoisted the accustomed signal, which was also observed on shore; but so boisterous was the weather, that, for a long time, it was impossible for a boat to approach within speaking distance of the rocks. During this period, the living man found himself in a most awful and distressing situation: he knew not how to dispose of the corpse; for if he threw it into the waves, which was his only means of getting rid of it, he feared that he might be charged with the murder of his companion; and yet each day that it remained, it was endangering his own life, by the extremely offensive condition to which it was reduced. When, at last, the people from the boat effected a landing, they found the whole building filled with the most insufferable odour, and the dead body in such a state that it was impossible to remove it to Plymouth for interment: they therefore consigned it [34] to the sea; but it was a long time before the rooms could be purified or made healthful.

This circumstance induced the proprietors of the lighthouse to employ a third man; so that, in case of a future accident of the same nature, or the sickness of either, there might be constantly one to supply the place. This regulation afforded a seasonable relief to the light-keepers; for as soon as three were appointed to the service, a rule was made that in summer each man in his turn should be permitted to go on shore, and spend a month with his friends and acquaintance.

That a residence in the lighthouse, solitary and desolate as it must have been, was considered no hardship by those who undertook the office, the following anecdote will prove. A skipper was once carrying out in his boat a new light-keeper to the rock. The man had been a shoemaker, and the skipper said to him, 'Friend Jacob, how is it that you choose to go out to be a light-keeper, when you can earn, as I have been told, half-a-crown or three shillings a day on shore, by making leathern hose,—the light-keeper's salary is but twenty-five pounds a year, which, you know, is scarce ten shillings a week?' 'I am going to be a light-keeper,' said the shoemaker, 'because I don't like *confinement*.' This answer naturally excited the skipper's merriment, and the shoemaker explained his meaning to be that he did not like to be *confined to work*.

These dwellers on the rock were cut off from all communication with their fellow-creatures for weeks and months together during stormy weather; and it might naturally be expected that under these circumstances they should be bound to each other by ties of brotherly feeling and goodwill. But dissension and strife are not shut out from the human bosom by mere retirement from the busy scenes of life. When only two light-keepers inhabited the building, it happened that some visitors, who had repaired thither to gratify their curiosity by an examination of the lighthouse, observed to one of the men, how very comfortably they might live there in a state of

retirement. ‘Yes,’ said the man, ‘we might live comfortably enough, if we could have the use of our tongues; but it is now a full month since my partner and I have spoken to each other.’ [35]

Connected with Rudyerd’s lighthouse an anecdote is told of Louis XIV. which is honourable to his feelings. During the progress of the work at the Eddystone rocks, a French privateer seized the men employed on the building, and took them, together with their tools, to France, expecting to be handsomely rewarded. While the captives lay in prison, the transaction reached the ears of the monarch. He immediately ordered them to be released, and the captors put in their place, declaring, that though he was at war with England, he was not at war with mankind. He observed that the Eddystone lighthouse was so situated as to be of equal service to all nations having occasion to navigate the channel that divides France from England, and he therefore directed the men to be sent back to their work with presents.

The value of the principles on which Rudyerd had conducted his work was abundantly proved by the fact, that his lighthouse continued to brave the force of the storms for upwards of forty-six years, and at the end of that period was destroyed, not by water, but by fire. This sad calamity happened on the 2nd of December, 1755. It has never been possible fully to investigate the cause of the building taking fire, but it appears to have commenced in the very top of the lantern or cupola. As the whole building was of wood, it is possible that the heat of the candles in the lantern, continued during the long period of between forty and fifty years, might have brought the thin boards which lined the cupola to such a state of dryness and inflammability, that, together with the soot which encrusted it, and which was formed from the smoke of the candles, it might have been as liable to take fire as a mass of tinder, and a single spark from one of the candles would be sufficient to effect the mischief. The light-keepers themselves attributed the fire to the copper funnel of the kitchen chimney which passed through the cupola. However this might be, the three light-keepers alone remained in the edifice, and when one of them, whose turn it was to watch, went into the lantern at about two o’clock in the morning to snuff the candles he found a dense smoke, and upon his opening the door of the lantern into the balcony, a flame instantly burst from the inside of the cupola. The man alarmed his companions, and they used their utmost endeavours to extinguish the fire, but on account of the difficulty of getting a sufficient supply of water to the top of the building, they soon found their efforts vain, and were obliged to retreat downwards from room to room as the fire gathered strength. Early in the morning the fire was perceived by some fishermen, and intelligence being given, a boat and men were sent out to the relief of the poor light-keepers. The boat reached the place at ten o’clock, after the fire had been burning eight hours. The light-keepers had been driven not only from all the rooms and the staircase, but to avoid the red hot timber, and the falling of the bolts upon them, they had been forced to creep into a hole or cave on the east side of the rock, where they were found almost in a state of stupefaction. There was great difficulty in getting them off the rock, for the surf was too high to enable the boat to effect a landing; but the men themselves becoming conscious of their perilous situation, and of the efforts that were being made to save them, adopted the only means of escape which now remained. By great efforts, a small boat had been got near enough to throw a coil of rope upon a projection of the rock, and the sufferers had sufficient remaining energy to lay hold of it, and one by one to fasten it round their bodies and jump into the sea. Thus they were towed into the small boat, and thence delivered to the large one, which returned with them to Plymouth. No sooner, however, were they set on shore than one of them made off, and was never afterwards heard of. This suspicious circumstance would naturally induce the idea that the man had himself originated the conflagration; but the fact of its being a lighthouse with no means of retreat for the inmates, and every reason to believe that they must perish with the building, is much opposed to this idea. In giving an account of this circumstance, Smeaton says, ‘I would rather impute his sudden flight to that kind of panic which sometimes, on important occasions, seizes weak minds; making them act without reason, and in so doing commit actions whose tendency is the very reverse of what they desire.’ [36] [37]

Of the other two light-keepers, one, named Henry Hall, had received injuries of a most serious nature; and his case is not a little extraordinary. At the time of the fire, there was, according to the usual custom, a tub of water standing in the lantern of the lighthouse; and when this man perceived the flames, he immediately exerted himself to the utmost in throwing buckets of water up into the roof of the cupola. As he was doing this, and looking upwards to see the effect of his endeavours, a quantity of lead, dissolved by the heat of the flames, suddenly rushed from the roof, and fell upon his head, face, and shoulders, burning him in a severe manner. At this moment his mouth happened to be open, and he persisted in declaring that some lead had gone down his throat, and was the cause of violent internal pain. When removed to his cottage at Stonehouse, he invariably told Dr. Spry, the medical man who attended him, and who constantly administered the proper remedies for the burns and injuries he had received, that if he would do anything effectual to his recovery, he must relieve his stomach of the lead, which he was sure it contained. This story appeared quite incredible to Dr. Spry, who did not believe that any human being could exist after receiving melted lead into the stomach; much less that he should afterwards be able to bear towing through the sea from the rock; and also the fatigue and inconvenience from the length of time employed in getting him ashore, before any remedies could be applied. The man went on without much change for the better or for the worse. He took medicines, and swallowed many things both liquid and solid, until the tenth or eleventh day, when he suddenly grew worse, and on the twelfth day, being seized with cold sweats and spasms, he soon afterwards expired. On a subsequent examination of the stomach, Dr. Spry found, to his astonishment, a solid piece of lead of a flat oval form, which weighed seven ounces and five drachms. Smeaton saw this piece of lead, and observed that part of the coat of the stomach had firmly adhered to the convex side of it. Dr. Spry transmitted an account of this very singular case to the Royal Society: but it was not [38]

received with entire belief until he had, by subsequent experiments upon animals, borne out the fact that it is *possible* for melted lead to be received into the stomach without the immediate death of the sufferer; though more probable that, in the great majority of cases, instant death would be the result.

But to return to the Eddystone rock. Notwithstanding every exertion was made to subdue the flames, the lighthouse was totally consumed, even to the massive foundations, and nothing was left upon the rock but a number of the iron cramps and branches.

The value of a lighthouse on the Eddystone rock had now been so fully proved, that no time was to be lost in endeavouring to build a new one in the place of that which had been so unfortunately destroyed. An application was made to the President of the Royal Society, requesting him to point out a person who might appear worthy to be entrusted with the work. Lord Macclesfield (the then president) replied 'that there was one of their own body whom he could venture to recommend to the work; yet that the most material part of what he knew of him was his having within the compass of the last seven years recommended himself to the society by the communication of several mechanical contrivances and improvements; and though he had at first made it his business to execute things in the instrument way (without ever having been bred to the trade), yet on account of the merit of his performances he had been chosen a member of the [39] society; and that for about three years past, having found the business of a philosophical instrument maker not likely to afford an adequate recompence, he had wholly applied himself to various branches of mechanics.' The earl went on to say that this person was then in Scotland, or in the north of England, and he should recommend the statement of the business to him, being fully confident that he would undertake nothing which he did not feel himself competent to perform.

The person thus referred to was John Smeaton, whose history, so far as the scanty materials will allow, shall here be given to the reader.

FOOTNOTES:

[3] It was commonly said at the time, that during a hard gale the sea ran so high that it was very possible for a six-oared boat to be lifted by the waves, and driven through the open gallery of the lighthouse.

CHAPTER IV. [40]

BIOGRAPHICAL NOTICE OF SMEATON.

Birth of Smeaton—His early Character and Employments—Educated for an attorney—His dislike of that profession—Becomes Philosophical Instrument Maker—His Scientific Inquiries—Is appointed to build the Eddystone Lighthouse—His subsequent Employments—Public Works designed and completed by him—His Literary Works—His last Illness and Death—His Character—Illustrative Anecdotes.

JOHN SMEATON was born the 28th of May, 1724, at Ansthorpe, near Leeds, Yorkshire. Little is recorded of his parentage or early education: but we find that his father was a respectable attorney, and that the family lived in a house built by the grandfather of the younger Smeaton.

Smeaton seems to have been born an engineer. The originality of his genius and the strength of his understanding appeared at a very early age. His playthings were not the toys of children, but the tools men work with; and his greatest amusement was to observe artificers at work, and to ask them questions. Having watched some millwrights at work, he conceived the idea of constructing a windmill, and to the alarm of his friends was one day perceived on the top of his father's barn attempting to fix his model. On another occasion he accompanied some men who went to fix a pump at a neighbouring village, and observing them cut off a piece of bored pipe, he managed to procure it, and made a working model of a pump that raised water very well. These anecdotes are related of him while he was yet a mere child in petticoats, and probably before he had attained his sixth year. At the age of fourteen or fifteen he had made for himself an engine to turn rose-work, and he made several presents to his friends of boxes in wood and ivory, as [41] specimens of its operation.

In the year 1742, Mr. Holmes, afterwards his partner in the Deptford Water-works, visited Smeaton and could not conceal his astonishment at the mechanical skill displayed by the young engineer; he forged his iron and steel, and melted his metal; he had tools of every sort for working in wood, ivory, and metals. He had made a lathe, by which he had cut a perpetual screw in brass, a thing very little known at that day. All these resources were not furnished to him by rich and wealthy parents, nor had he the advantage of masters in his various pursuits; on the

contrary, by the strength of his genius, and by indefatigable industry, he acquired at the age of eighteen an extensive set of tools, and the art of working in most of the mechanical trades, and Mr. Holmes, himself a good mechanic, says that few men could work better.

Astronomy was one of his most favourite studies, and he contrived and made several astronomical instruments for himself and friends. In later years, after fitting up an observatory at his house at Ansthorpe, he devoted much time to it when he was there, even in preference to engineering.

Smeaton's father being an attorney was desirous to educate his son for the same profession. He was therefore sent to London in 1742, where during a few terms he attended court; but finding the legal profession distasteful to him, and not to suit "the bent of his genius," he wrote a strong memorial on the subject to his father, who had the good sense to allow him from that time to pursue the path which nature pointed out to him. He continued to reside in London, and about the year 1750 he commenced the business of mathematical instrument maker. In 1751 he invented a machine to measure a ship's way at sea, and a compass of peculiar construction, touched by Dr. Knight's artificial magnet. He made two voyages in company with Dr. Knight for the purpose of ascertaining the merits of these contrivances. [42]

In 1753 he was elected a fellow of the Royal Society, and his admirable papers inserted in the Transactions of that body sufficiently evince how highly he deserved that distinction. In 1759 he received by an unanimous vote their gold medal, for his paper entitled 'An Experimental Inquiry concerning the natural powers of wind and water to turn mills and other machines depending on a circular motion.' This paper was the result of experiments made on working models in 1752 and 1753, but not communicated to the society till 1759, by which time he had had abundant opportunity of applying these experiments to practice in a variety of cases, and for various purposes, so as to assure the society that he had found them to answer. He discovered by these means that wind and water could be made to do one third more than was before known. In the year 1754 he made a voyage to Holland, travelling for the most part on foot, or in the trekschuiten or drag-boats, the national conveyance of the country, and thus made himself acquainted with the most remarkable works of art in the low countries.

In December 1755 the Eddystone lighthouse was burnt down. Mr. Weston the chief proprietor, and others, were desirous of rebuilding it in the most substantial manner, and through the recommendation of the Earl of Macclesfield, whose friendly conduct to Smeaton we have already noticed, they were induced to appoint Smeaton as the most proper person to rebuild it.

Smeaton undertook the work, and completed it in the summer of 1759. The history of this great undertaking belongs to another section of this notice. The completion of the work does not seem to have had the immediate effect of procuring him full employment as a civil engineer: in 1764, being in Yorkshire, he offered himself a candidate for the office of one of the receivers to the Greenwich Hospital estates[4]; and on the 31st December in that year he was appointed, at a full [43] board at Greenwich Hospital, in a manner highly flattering to himself. In this appointment he was greatly assisted by his partner Mr. Walter, who managed the accounts, and left Smeaton leisure and opportunity to exert his abilities on public works, as well as to make many improvements in the mills, and in the estates of Greenwich Hospital. By the year 1775 he had so much business as an engineer, that he wished to resign this appointment, but was prevailed upon to continue in the office about two years longer.

Among the many valuable public services of Smeaton a few only can be mentioned in this place. He completed the erection of new lighthouses at Spurn Head at the mouth of the Humber: he built the fine bridge over the Tay at Perth: he laid out the line of the great canal connecting the Forth and Clyde; and made the river Calder navigable; a work that required great skill and judgment, on account of its impetuous floods. On the opening of the great arch at London Bridge by throwing two arches into one, and the removal of a large pier, the excavation around and under the starlings was so considerable, that the bridge was thought to be in great danger of falling. Smeaton was then in Yorkshire, but was sent for by express, and arrived with the utmost dispatch: on his arrival the fear that the bridge was about to fall prevailed so generally, that few persons would pass over or under it. Smeaton applied himself immediately to examine it, and to sound about the starlings as minutely as possible: his advice to the committee was to repurchase the stones which had been taken from the middle pier, then lying in Moorfields, and to throw them into the river to guard the starlings. This advice was adopted with the utmost alacrity, by [44] which simple means the bridge was probably saved from falling, and time afforded for securing it in a more effectual manner. 'This method of stopping the impetuous ravages of water,' says Mr. Holmes, 'he had practised before with success on the river Calder; on my calling on him in the neighbourhood of Wakefield, he shewed me the effects of a great flood, which had made a considerable passage over the land; this he stopped at the bank of the river, by throwing in a quantity of large rough stones, which with the sand, and other materials washed down by the river, filling up their interstices, had become a barrier to keep the river in its usual course.'

In 1771 Smeaton and Holmes made a joint purchase of the water-works for supplying Deptford and Greenwich with water. On examining the books of the former proprietors, it appeared to have been a losing concern during many years; but the skill of Smeaton soon brought the undertaking into such a state as to be of general use to those for whom it was intended, and moderately profitable to himself and partner. In noticing this subject Mr. Holmes makes a few general remarks on the character of Smeaton:—'His language either in speaking or writing was so strong and perspicuous, that there was no misunderstanding his meaning, and I had that

confidence in his abilities as never to consider any plan of improvement which he proposed, but only to see it executed with scrupulous exactness; at the same time, he was so open to reason in all matters, that during a constant communication of our opinions for upwards of twenty years, after we had laid them fully before each other we always agreed, and never had the slightest difference.'

It must be remembered that Smeaton lived before the time when the genius of Watt had rendered the steam-engine the useful and obedient servant of man; and consequently that much of the power now furnished by steam was then supplied by the wind. Hence the mechanics of windmills was an important study to the engineer, and Smeaton erected a vast variety of mills in [45] which he turned to useful account the results of his experiments in 1752 and 1753. His usual habit was to confirm the conclusions of theory by direct experiment. He also erected a steam-engine at Ansthorpe, and made experiments thereon to ascertain the power of Newcomen's engine, which he improved and brought to a far greater degree of certainty both in its construction and powers.

During many years the opinion of Smeaton was held in such high esteem, that no great works were undertaken throughout the kingdom without first applying to him; he was constantly consulted in parliament, and was regarded as an ultimate reference on all difficult questions connected with his profession. It was his constant practice to make himself fully acquainted with every subject before he would engage in it, and then his known integrity and lucid powers of description secured the respect and attention of all. In the courts of law he was frequently complimented by Lord Mansfield and others for the new light he threw on difficult subjects.

About the year 1785 Smeaton's health began to decline, and he then endeavoured to retire from business in order to gain time to publish an account of his inventions and works. This was one of the wishes nearest to his heart, for, as he often said, 'he thought he could not render better service to his country than by doing that.' He had just completed his account of the Eddystone lighthouse when he was prevailed on to continue his services as engineer to the trustees for Ramsgate harbour. The works at Ramsgate were begun in 1749, but had been conducted with very indifferent success until Smeaton was called in to superintend them in 1774. He completed the magnificent pier and harbour of this place in 1791, and thus established a secure and much needed place of shelter in the Downs.

A man whose life is so beneficially devoted to the service of the public can scarcely hope to enjoy leisure and retirement during which he may look back upon the past, and leave a written [46] record of his exertions. Smeaton was so constantly and urgently employed that he could not achieve much with his pen. On the 16th September 1792, he was seized with an attack of paralysis induced by over-exertion, and this attack carried him to the grave on the 28th of the next month, in the 69th year of his age.

During his illness he dictated several letters to his old friend Mr. Holmes. In one of them he describes minutely his health and feelings, and says, 'in consequence of the foregoing, I conclude myself nine-tenths dead, and the greatest favour the Almighty can do (as I think) will be to complete the other part, but as it is likely to be a lingering illness, it is only in His power to say when that is likely to happen.' His daughter, Mrs. Dickson, says that he always apprehended the attack which terminated his life, as it was hereditary in his family. He dreaded it only as it gave the melancholy possibility of outliving his faculties, or the power of doing good; or, to use his own words, 'lingering over the dregs after the spirit had evaporated.' Indeed, the decay of his mental faculties seems to have been that which he most dreaded. He would sometimes complain of slowness of apprehension, and would then excuse it with a smile, saying, 'it could not be otherwise, the shadow must lengthen as the sun went down.' When seized with paralysis he was resigned to the event, anxious to soften any alarm to his family, and was thankful that his intellect was spared. But his invariable wish was to be released. He expressed particular pleasure in seeing the usual occupations of his family resumed; and reading, drawing, music, and conversation excited the same interest and the same cheerful and judicious observations as ever. One evening he was requested to explain some phenomena respecting the moon, which was seen from the room shining brightly. He gave a full explanation, then fixed his eyes full upon the object in question, and after regarding it stedfastly for some time, he observed, 'How often have I looked up to it with inquiry and wonder, and to the period when I shall have the vast and [47] privileged views of an hereafter, and all will be comprehension and pleasure.'

We learn from his daughter Mrs. Dickson, that early in life Smeaton attracted the notice of the eccentric Duke and Duchess of Queensbury, on account of the strong personal likeness which he bore to their favourite Gay the poet. Their first acquaintance was made in a singular manner: it was at Ranelagh when walking with Mrs. Smeaton, he observed an elderly lady and gentleman gaze steadily upon him, they stopped and the duchess said, 'Sir, I don't know who you are, or what you are, but so strongly do you resemble my poor dear Gay, that we *must* be acquainted; you shall go home and sup with us, and if the minds of the two men accord as do the countenance, you will find two cheerful old folks who can love you well, and I think, (or you are an hypocrite) you can as well deserve it.' The invitation was accepted, and as long as the duke and duchess lived the friendship was cordial and uninterrupted. During his visits cards were sometimes introduced. Smeaton detested cards, and could not confine his attention to the game. On one occasion the stakes were already high, and it fell to Smeaton to double them when, neglecting to deal the cards, he was busily occupied in making some calculations on paper which he placed upon the table. The duchess asked eagerly what it was, and Smeaton replied coolly, 'You will recollect the field in which my house stands may be about five acres three roods and

seven perches, which, at thirty years' purchase, will be just my stake, and if your grace will make a duke of me, I presume the winner will not dislike my mortgage.' The joke and the lesson had their effect, for they never played again but for the merest trifle.

Smeaton procured a situation in a public office for a clerk in whom he placed the greatest confidence, and jointly with another became security for him to a considerable amount. This man committed the crime of forgery, was detected and given up to justice. Mrs. Dickson says, 'The same post brought news of the melancholy transaction, of the man's compunction and danger, of [48] the claim of the bond forfeited, and of the refusal of the other person to pay the moiety! Being present when he read his letters, which arrived at a period of Mrs. Smeaton's declining health, so entirely did the command of himself second his anxious attention to her, that no emotion was visible on their perusal, nor, till all was put into the best train possible, did a word or look betray the exquisite distress it occasioned him. In the interim, all which could soothe the remorse of a prisoner, every means which could save (which did, at least from public execution,) were exerted for him, with a characteristic benevolence, active and unobtrusive.'

Smeaton was a man of indefatigable industry and great moral probity. With ample opportunity of amassing wealth, he rendered its acquisition but a secondary object on all occasions; his first aim always being to execute the task intrusted to him in the most skilful and perfect manner. Had his object been to amass a fortune, he might have received many lucrative appointments besides those which he actually held. The empress Catherine of Russia attempted to secure his services for her own country by most magnificent offers; but Smeaton preferred to dedicate his time and talents to the service of his country. 'The disinterested moderation of his pecuniary ambition,' says his daughter, 'every transaction in private life evinced; his public ones bore the same stamp; and after his health had withdrawn him from the labours of his profession, many instances may be given by those whose concerns induced them to press importunately for a resumption of it; and when some of them seemed disposed to enforce their entreaties by further prospects of lucrative recompense, his reply was strongly characteristic of his simple manners and moderation. He introduced the old woman who took care of his chambers in Gray's Inn, and showing her, asserted 'that her attendance sufficed for all his wants.' The inference was indisputable, for money could not tempt that man to forego his ease, leisure, or independence, whose requisites of accommodation were compressed within such limits!' Before this, the princess Daschkaw made an apt comment upon this trait of his character; when, after vainly [49] using every persuasion to induce him to accept a carte blanche from the empress of Russia as a recompense for directing the vast projects in that kingdom—she observed 'Sir, you are a great man, and I honour you! you may have an equal in abilities, perhaps, but in character you stand single. The English minister, Sir Robert Walpole, was mistaken, and my sovereign has the misfortune to find one man who has not his price.'

In all the social duties of life Smeaton was most exemplary; and he was a lover and encourager of real merit in whatever station of life he found it. To strangers his mode of expression appeared warm and even harsh; but Mr. Holmes refers it to the intense application of his mind, which was always in the pursuit of truth, or engaged in investigating difficult subjects: hence, when anything was said that did not tally with his ideas, he would sometimes break out hastily. As a friend, he was warm, zealous, and sincere; as a companion, always entertaining and instructive, and none could spend their time in his company without improvement. In his person Smeaton was of middle stature, but broad and strong-made, and possessed of an excellent constitution. He was remarkable for the plainness and simplicity of his manners.

After his death, his papers consisting of plans, reports, and treatises, on almost every branch of engineering, were published by the Society of Civil Engineers.

FOOTNOTES:

[4] This was the Derwentwater Estate which was forfeited in the year 1715, and its revenues applied by Parliament towards the funds of Greenwich Hospital. It consists of mines of lead, containing much silver, as well as lands. It required careful management, and the knowledge of mining details to make it profitable. Smeaton contrived more efficient machines and better modes of working the mines and managing the estate.

CHAPTER V. [50]

THE EDDYSTONE AS A TYPE OF ENGLISH LIGHTHOUSES.

A Stone Lighthouse proposed—Smeaton's first Visit to the Rock—Operations of the First Season—Second Season—Structure of the Foundation—Ingenious Mode of securing the Stones—Third Season—State of the Work—Progress and Description of the Work—Accidents to the Engineer—Proposal to exhibit a Light before the completion of the Building refused—Fourth Season—Completion of

the Work—Appearance of the Lighthouse during a Storm—Situation of the Light-keepers.

To return to the history of the Eddystone Lighthouse. When the proposal relating to the rebuilding of this edifice was made to Smeaton, and when he had duly weighed the subject in his own mind, he delivered his decided opinion that the building ought to be constructed *entirely of stone*. Some opposition was at first raised against this idea, but the proprietors were at length so well satisfied with the plans submitted to their inspection, and with the plain, straightforward reasoning of Smeaton on the matter, that they left the whole affair in his hands. Their chief objection had arisen from the opinion, supported by that of the best judges, that the safety and continuance of Rudyerd's lighthouse during so many years, had in a great measure depended on the elasticity of the materials of which it was composed, which enabled it to give way to the shocks of the sea. Indeed it was affirmed, that in violent storms the motion of that wooden edifice was so great that trenchers and other articles were thrown from the shelves in the upper rooms. Smeaton answered to this, that the great agitation of the late building arose from its want of *weight*, as well as want of strength; that the edifice he had in view would be much *heavier* and much stronger, so that the building would not give way to the sea, but the sea would give way to the building. [51]

In the spring of 1756 Smeaton first visited and examined the Eddystone rock, proving, as his predecessors had done, the extreme difficulty of gaining a landing, or of remaining long enough on the rock to carry on his observations. These difficulties suggested to him the important and valuable expedient of keeping a vessel fixed within a quarter of a mile of the rock, which should be capable of lodging the workmen and their tools, and thus enable them to take immediate advantage of any favourable opportunity of putting out their boat and conveying materials at once to the Eddystone, instead of having to take the voyage from Plymouth on each occasion.

The first actual work done on the rock was in August, 1756. Two companies of workmen were employed, each remaining at the work a week, that every opportunity might be made the most of, and the men relieved by visits to the shore. A sloop, a large yawl with sails and oars, and a boat, were employed to expedite the work. The sloop formed the lodging for the company working at the rock, and was anchored at a short distance from it. The sloop was afterwards replaced by a larger store vessel, called the Neptune Buss. The weather from the 27th of August to the 14th of September happened to be favourable to the work, so that the companies were employed on it at every tide. After this, unsettled weather began to prevail, so that Smeaton was obliged to be satisfied with the progress already made, which consisted in the mere preparation of the House-rock for the intended edifice, by cutting two new steps in the lowest part of the sloping side of the rock, and forming anew the five steps which remained of the efforts of Rudyerd. Dove-tailed recesses were also cut in all these steps for the reception of the stone-work. The remaining part of the autumn was spent in expediting necessary work on shore, such as completing the work-yard with its machinery and conveniences, and then preparing the granite and Portland stone, of which the lighthouse was to be made. The desirability of doing as much of the work as possible on shore, became more and more apparent, as experience showed the dangers and accidents likely to occur at the rock. During this winter Smeaton began seriously to consider the great importance to his work, of getting the most perfect cement possible, to resist the extreme violence of the sea. He found that nothing of the resinous or oily kind would answer, as it was impossible to get a dry surface at the rock. He therefore went through a complete set of experiments on cements with a view to produce one which would, in despite of water almost continually driven against it with every degree of violence, become so firm in its consistence and adhesion to the stone, that it should compose one even regular surface with the stone, without needing hoops of iron or copper to surround the horizontal joints. In this endeavour he considered himself at length completely successful. [52]

At the beginning of June, 1757, Smeaton renewed his work at the Eddystone rock. The first proceedings were to fix some timbers to the east side of the rock merely as a defence to the boats, which were frequently damaged by running against the sharp edges; and also to erect shears, windlass, &c. The first stone was laid in its place on the 12th of June. This stone weighed two tons and a quarter, though the ordinary weight of the stones did not exceed one ton each. The first course consisting of four stones was finished during the next day. By Smeaton's plan the stones were most ingeniously dove-tailed together and into the rock, so that when once fixed, it was impossible for one stone to be separated from the rest. The second course of stones was not completed until the 30th of the same month; several accidents having occurred to hinder the progress of the work; yet Smeaton was in no wise disheartened, for in establishing these two courses he considered the most difficult and arduous part of the work to be already accomplished, since these courses brought him up to the same level where his predecessor Mr. Rudyerd had begun. On the 11th of July the third course, consisting of twenty-five pieces, was completed, and on the 31st the fourth course of twenty-three pieces. The fifth course was closed in on the 5th of August. When the sixth course was completed, which was on the 11th of that month, Smeaton had the satisfaction to find that the sea did not now invariably wash over every part of their work at each tide, which had always hitherto been the case in the course of laying the previous courses. The greatest difficulties were now considered to be successfully surmounted, as each succeeding course gave them more time and more room, and they had brought their work to a level with the highest part of the rock. [53]

Up to this point all the courses had been begun by the stones that were securely dove-tailed into the rock, and further made fast by oak-wedges and cement. To receive these wedges, two

grooves were cut in the waist of each stone, from the top to the bottom of the course, of an inch in depth and three inches in width. The care with which the foundation-work was carried on may be gathered from Smeaton's description of the manner of laying each stone. 'The stone to be set being hung in the tackle, and its bed of mortar spread, was then lowered into its place, and beat with a heavy wooden maul, and levelled with a spirit level; and the stone being accurately brought to its marks, it was then considered as set in its place. The business now was to retain it exactly in that position, notwithstanding the utmost violence of the sea might come upon it, before the mortar was hard enough to resist it. The carpenter now dropped into each groove two of the oaken wedges, one upon its head, the other with its point downwards, so that the two wedges in each groove would lie heads and points. With a bar of iron about two inches and a half broad, a quarter of an inch thick, and two feet and a half long, the ends being square, he could easily (as with a rammer) drive down one wedge upon the other; very gently at first, so that the [54] opposite pairs of wedges being equally tightened, they would equally resist each other, and the stone would therefore keep place. A couple of wedges were also, in like manner, pitched at the top of each groove; the dormant wedge, or that with the point upward, being held in the hand, while the drift-wedge, or that with its point downward, was driven with a hammer. The whole of what remained above the upper surface of the stone was then cut off with a saw or chisel: and generally, a couple of thin wedges were driven very moderately at the butt-end of the stone; whose tendency being to force it out of its dove-tail, they would, by moderate driving, only tend to preserve the whole mass steady together, in opposition to the violent agitation that might arise from the sea.' In addition to this, a couple of holes having been bored through every piece of stone, one course was bound to another by oak trenails driven stiffly through, and made so fast that they could more easily be torn asunder than pulled out again. 'No assignable power,' says Smeaton, 'less than what would by main stress pull these trenails in two could lift one of these stones from their beds when so fixed, exclusive of their natural weight, as all agitation was prevented by the lateral wedges.' The stone being thus fixed, a proper quantity of mortar was liquefied; and the joints having been carefully pointed, up to the upper surface, this mortar or cement was poured in with iron ladles so as to occupy every void space. The more consistent parts of this cement naturally settled to the bottom, and the watery parts were absorbed by the stone: the vacancy thus left at the top was repeatedly refilled, until all remained solid; the top was then pointed, and, when necessary, defended by a coat of plaster. When the whole of the foundation was in this manner brought to a level, some other means was necessary of attaining the like degree of security. For this purpose the central stone of the sixth course had a hole of one foot square cut quite through the middle. Eight other depressions of one foot square and six [55] inches deep were also sunk at equal distances in the circumference. A plug of strong hard marble, from the rocks near Plymouth, one foot square and twenty-two inches in length, was set with mortar in the central cavity, and fixed firmly therein with their wedges. This course was thirteen inches in height, so that the marble plug, which reached through it, stood nine inches above the surface. Upon this the centre-stone of the seventh course was fixed, having a similar hole made in its centre, bedded with mortar and wedged as before. By this means no force of the sea acting horizontally upon the centre-stone, less than what was capable of cutting the marble plug in two, was able to move it from its place; and to prevent the stone the more effectually from being lifted, in case its bed of mortar should happen to be destroyed, it was fixed down by four trenails. The stones surrounding the central stone were dove-tailed to it in the same manner as before, and thus the courses proceeded with no other interruption than arose from the nature of the situation.

Smeaton tells us that when the work had proceeded so far as to afford a level platform, the pleasure he took in it, and the novelty of the thing, led him to walk to and fro upon it with much complacency. But making a false step, and not being able to recover himself, he tumbled over the brink of the work down among the rocks on the west side. The tide had then retreated, so that no serious result happened, but in his fall he dislocated his thumb, and as no medical aid could be procured, he set it himself, and then returned to his work. It was more than six months, however, before he recovered the full use of his thumb.

Owing to very boisterous weather, and repeated losses of the necessary materials left on the rock, the seventh course was not laid until the 7th of September. But Smeaton had the satisfaction to find that all the work actually completed, stood the utmost severity of the weather unmoved. At this time the sea became so calm that the work proceeded rapidly, and for three days in succession the top of the work was not wetted. The eighth course was completed on the [56] 13th, but the weather again becoming unfavourable, the ninth was not finished until the 30th, and here Smeaton found it desirable to close the operations for this year.

The ensuing winter was of so stormy a nature as severely to test the strength of the work at the Eddystone. Smeaton went early in the spring to view it, and says, 'I was much surprised, notwithstanding what had been reported of the soundness of the work, to find it so perfectly entire, for, except a small spawl which had been washed from the rock itself, the whole did not seem to have suffered a diminution of so much as a grain of sand since I left it on the 1st of October: on the contrary, the cement, and even the grouted part, appeared to be as hard as the stone itself, the whole having become one solid mass, and, indeed, it had quite that appearance, as it was covered with the same coat of sea-weed as the rock, the top of the work excepted, which was washed clean and white.'

Various disasters to the vessels, moorings, &c. near the rock retarded the work in the spring of 1758. It was not till the 10th of July that the eleventh course was finished. Twelve days afterwards the twelfth course was laid down. After this the work went on better, so that on the

8th of August the fourteenth course was completed, and with it what was called the fundamental solid. From hence begins the building also called the Solid, which includes the passage from the entry-door to the well-hole for the stairs. It was now necessary for the sake of the well-hole to omit the centre-stone. The four stones surrounding the centre were therefore fastened together by what are called hook-scarf joints, so as to compose, in effect, one stone. Means were also taken to prevent them from shifting, or being lifted out of their position.

From the 9th to the 20th of August there was an uninterrupted continuance of fine weather, so that great progress was made. By the latter day the eighteenth course was completed, which reunited the building into a complete circle, by covering the passage to the staircase. Over the head of the entry-door the figures 1758 were cut in deep characters. During another month, by [57] great exertions, the twenty-fourth course was reached and completed. This course finished the Solid, and formed the floor of the store-room, so that Smeaton had every reason to be satisfied with the work of this season; yet as he had been long meditating on the advantage to the public which would accrue from setting up a light during that very winter, he resolved to make a vigorous effort to get the store-room completed and a light erected above it.

The building had hitherto been carried up solid as high as there was any reason to suppose it exposed to the heavy stroke of the sea, *i. e.* to thirty-five feet four inches above its base, and twenty-seven feet above the top of the rock, on the common spring-tide high-water mark. At this height it was reduced to sixteen feet eight inches diameter; and it was necessary to make the best use of this space, and make all the room and convenience therein that was possible, consistent with the still necessary strength. The rooms being made twelve feet four inches in diameter would leave twenty-six inches for the thickness of the walls. These walls were made of single blocks in the thickness, so shaped that sixteen pieces formed a complete circle, and from their figure composed a stout wall. These pieces were cramped together with iron, and also secured to the lower courses by marble plugs as before. To hinder the passage of wet through the upright joints, flat stones were introduced into each joint so as partly to be lodged in one stone, partly in another, thus making it tolerably certain that the rooms would be kept comfortable and dry in all weathers. On the 30th of September the twenty-eighth course was completely set. This and the next course received the vaulted floor, which made the ceiling of the store-room and floor of the upper store-room. For further security, therefore, there was a groove cut round the upper surface of this course, in which was placed a circular chain of great strength. Upon this chain, in the groove, was poured melted lead, until the cavity was filled up. The next course was then laid on, and this was also secured by a chain in like manner, it being considered that the courses on [58] which the floors rested demanded every possible security. The formation of the floors, and the care taken to avoid the danger of lateral pressure on the walls, is worthy of notice. Each floor rested upon two courses; being firmly supported by a triple ledge going circularly round the two supporting courses. ‘Had each floor,’ says the architect, ‘been composed of a single stone, this lying upon the horizontal bearings furnished by these ledges, would, while it remained entire, have no lateral pressure or tendency to thrust out the sides of the encompassing walls; and that in effect the several pieces of which the floors were really composed might have the same property as whole stones, the centre stone was made large enough to admit of an opening, from floor to floor, to be made through it; and being furnished with dove-tails on its four sides, like those of the entire solid, it became the means by which all the stones in each floor were connected together; and consequently, the whole would lie upon the ledges like a single stone, without any tendency to spread the walls. But if by the accident of a heavy body falling, or otherwise, any of those stones should be broken, though this might not destroy its use as a floor; yet the parts would then exert their lateral pressure against the walls; and, therefore, as a security against this, it became necessary that the circle of the enclosing walls should be bound together, and the building, as it were, *hooped*.’ Thus assiduously did Smeaton urge forward the work, yet without neglecting any of the necessary precautions for its safety. By the 10th of October he had nearly completed all the necessary arrangements for establishing a light and light-keepers at the Eddystone during the same winter, when he received an unexpected and painful refusal from the Corporation of Trinity-House, to the effect that ‘on reading the Acts of Parliament, the application from the merchants and owners of ships, and Winstanley’s narrative of the first lighthouse erected there, they are of opinion that a light cannot be exhibited on the Eddystone Rock till the lighthouse is re-built.’ [59]

Smeaton employed the winter of 1758-9 in London, preparing everything for the final work at the Eddystone the ensuing season. He formed and made out designs for the iron rails of the balcony, the cast iron, the wrought iron, and the copper-works of the lantern, &c. There was a violent storm on the 9th of March, 1759, which it was supposed might have damaged the unfinished lighthouse, as it had done very great damage to the ships and houses at Plymouth. As soon as it was possible to effect a landing the works were visited and a report sent to Smeaton. From this he found, with pleasure, that not only the solid but the hollow work remained perfectly sound and firm; all the mortar having become quite hard, and every part of the work just as it was left by the workmen in October.

The commencement of the work for the next and last season, took place on the 5th of July. On the 21st of the same month the second floor was finished, and by the 29th the fortieth course of stone was laid down, and the third floor finished.

The main column of the lighthouse was completed on Friday, August 17th. It contained in all forty-six courses of stone, and reached the height of seventy feet. The beds for the light-keepers were fixed in the uppermost room, and the kitchen with its fire-place in the room below it,

whereas in the former house, the kitchen had been the upper room, doubtless, because the funnel for the smoke would be shorter. But Smeaton having been informed that with the former arrangement the beds and bedding were in a very damp and disagreeable state, proposed to remedy the evil by allowing the copper funnel to pass through the bed-room, and thus to dry the air. This plan completely answered the desired end; though it must be observed, that the whole edifice, even those portions of it which were continually subject to the action of the waves, were much more impervious to moisture than Rudyerd's edifice; as may naturally be imagined from the difference of material used in the building of the lighthouse, and the well-known quality of granite to resist humidity. In the upper room, therefore, were fixed three cabin-beds to hold one [60] man each, with three drawers and two lockers in each to hold his separate property. In the kitchen, besides the fire-place and sink, were two settles with lockers, a dresser with drawers, two cupboards and one platter-case. In the lantern a seat was fixed to encompass it all round, except at the doorway, and this served equally to sit upon, or to stand and snuff the candles; also to enable a person to look through the lowest tier of glass-panes at distant objects, without having occasion to go on the outside of the lantern into the balcony.

Besides the windows of the lantern ten other windows were constructed for the edifice, namely, two for the store-room, and four each for the other two rooms. In fixing the bars for these windows, an accident occurred which had nearly proved fatal to Smeaton, and which he thus describes:—'After the boat was gone, and it became so dark that we could not see any longer to pursue our occupations, I ordered a charcoal-fire to be made in the upper store-room, in one of the iron-pots we used for melting lead, for the purpose of annealing the blank ends of the bars; and they were made red hot altogether in the charcoal. Most of the workmen were set round the fire, and by way of making ourselves comfortable, by screening ourselves and the fire from the wind, the windows were shut; and, as well as I remember, the copper cover or hatch put over the man-hole of the floor of the room where the fire was; the hatch above being left open for the heated vapour to ascend. I remember to have looked into the fire attentively to see that the iron was made hot enough, but not over-heated: I also remember I felt my head a very little giddy; but the next thing of which I had any sensation or idea, was finding myself upon the floor of the room below, half drowned with water. It seems, that without being further sensible of anything to give me warning, the effluvia of the charcoal so suddenly overcame all sensation that I dropped down upon the floor; and had not the people hauled me down to the room below, where they did not [61] spare for cold water to throw in my face and upon me, I certainly should have expired upon the spot.'

By unremitting exertions on the part of Smeaton and his work-people, the balcony-rails, the lantern, with the cupola and gilt ball, the lightning-conductor, and, in fact, all the remaining parts of the lighthouse, with the stores and necessary furniture, were set in their places by the 16th of October, on which day a light was once more exhibited on the Eddystone Rock.

It may be imagined that Smeaton took peculiar pleasure in this beautiful monument of his skill and ingenuity. He slept in the lighthouse, viewed it from sea and land, and made every observation that an ingenious and clever man might be expected to make. The account he gives of its appearance after a storm, as he viewed it with his telescope from the garrison at Plymouth, is this: 'Though I had had many opportunities of viewing the unfinished building, when buried in waves in a storm at S. W., yet never having before had a view of it under this circumstance in its finished state, I was astonished to find that the account given by Mr. Winstanley did not appear to be at all exaggerated. At intervals of a minute, and sometimes two or three, I suppose when a combination happens to produce an overgrown wave, it would strike the rock and the building conjointly, and fly up in a white column, enwrapping it like a sheet, rising at least to double the height of the house, and totally intercepting it from sight; and this appearance being momentary, both as to its rising and falling, one was enabled to judge of the comparative height very nearly, by the comparative spaces alternately occupied by the house, and by the column of water, in the field of the telescope.'

The year 1759 closed with a series of very stormy weather, and as this was the first winter's trial of the lighthouse, it may be supposed that there was some anxiety among the more timid and doubting of those concerned in it. Especially was the courage of the light-keepers put to the test. When a boat could come near them after one of these storms, a letter was sent by Henry [62] Edwards, one of the light-keepers, to the manager of the works acquainting him that they had had such bad weather, and that the sea ran over the house in such a manner, that for twelve days together they could not open the door of the lantern or any other. 'The house did shake,' says the poor light-keeper, 'as if a man had been up in a great tree. The old men were almost frightened out of their lives, wishing they had never seen the place, and cursing those that first persuaded them to go there. The fear seized them in the back, but rubbing them with oil of turpentine gave them relief.'

Meanwhile the lighthouse itself bore the storm admirably, and suffered nothing from it. Two years afterwards a tempest of unusual violence occurred, causing much loss of life and property at Plymouth. Eighty thousand pounds' worth of damage were done in the harbour and sound, and a friend of Smeaton's, after writing a full description of the several disasters, adds, 'In the midst of all this horror and confusion, my friend may be assured that I was not insensible to his honour and credit, yet in spite of the high opinion that I had of his judgment and abilities, I could not but feel the utmost anxiety for the fate of the Eddystone. Several times in the day I swept with my telescope from the garrison, as near as I could imagine, the line of the horizon, but it was so extremely black, fretful, and hazy, that nothing could be seen, and I was obliged to go to bed that

night with a mortifying uncertainty. But the next morning early, I had great joy to see that the gilded ball had triumphed over the fury of the storm, and such an one as I had no conception of. I saw the whole so distinctly from the bottom to the top, that I could be very sure the lantern had suffered nothing. It is now my most steady belief, as well as everybody's here, that its inhabitants are rather more secure in a storm, under the united force of wind and water, than we are in our houses from the former only.'

After this trial of the strength of the lighthouse, there seems no longer to have been any [63] apprehension concerning it. The light-keepers even became attached to the spot, and found it a remarkably healthy and comfortable abode. There were often as many as half a dozen applications for the office, although the salary was only twenty-five pounds per annum.

One of the light-keepers, after a residence of fourteen years on the rock, became so much attached to the place, that for two summers he gave up his turn of going on shore to his companions, and declared his intention of doing so on the third; but being over-persuaded he went on shore to take his month's turn. At the lighthouse he had always been a decent, sober, well-behaved man; but he had no sooner got on shore than he went to an alehouse and became intoxicated. This he continued the whole of his stay; which being noticed, he was carried in an intoxicated state on board the Eddystone boat and delivered in the lighthouse, where he was expected to grow sober; but after lingering for two or three days, he expired. Vacancies, however, seldom occurred in the lighthouse. Smeaton mentions several men who had served there to his knowledge ten, fifteen, or twenty years.

Having thus conducted our readers to the close of Smeaton's arduous undertaking, and noticed its complete success, we may proceed to describe the more remarkable lighthouses erected in other portions of the kingdom subsequent to the labours of this celebrated engineer.

Chapter VI. [64]

THE NORTHERN LIGHTHOUSES.

Importance of Lighting the Scottish Coast—Formation of Board of Commissioners of Northern Lighthouses—Early Proceedings of the Board—Principal Northern Lighthouses—The Isle of May Lighthouse—Loss of two Frigates—Application of the Admiralty to the Lighthouse Board, by whom the Duties and the Island of May are purchased—Numerous Shipwrecks on the Island of Sanday—Foundation-stone of Start-Point Lighthouse laid—Rev. W. Traill's Address upon the occasion—Subsequent Proceedings on Sanday Island—North Ronaldsay Lighthouse—Melancholy Accident—Importance of the Northern Lighthouses.

The coast of Scotland is deservedly celebrated for the skill and enterprise of its lighthouse system. This coast, extending to about two thousand miles in circuit, is, perhaps, the most dangerous of any in Europe. Previous to the erection of efficient lighthouses, it was frequently strewed with wrecks, and proved how inadequate to the protection of the mariner were the few feeble lights which were then under the controul of private or local trusts. Accordingly, in the year 1786, the Commissioners of Northern Lighthouses were, by Act of Parliament, erected into a board, consisting of his Majesty's advocate and solicitor-general, the chief magistrates of the principal burghs of Edinburgh, Glasgow, Aberdeen, Inverness, Campbeltown, and the sheriffs or judges ordinary of maritime counties. The preamble to the act states, 'That it would conduce greatly to the security of Navigation and the Fisheries if *four* lighthouses were erected in the northern parts of Great Britain;' namely, one on Kinnaird Head, in Aberdeenshire, one on the Orkney Islands, one on the Harris Isles, and one at the Mull of Kintyre, in Argyleshire. Such appears to have been the state of trade in Scotland about sixty years ago, that the erection of four lighthouses was all that was contemplated. But no sooner were these four lights erected [65] than their importance to navigation was immediately acknowledged, and frequent applications were made on the part of the shipping interest to erect others. Accordingly as the funds of the board allowed, lighthouses or other means of exhibiting lights have been erected upon many promontories of the main land, or upon islands and reefs lying off the coast of Scotland, including the Isle of Man.

These lighthouses being for the most part situated in remote and inaccessible districts, it was resolved 'that the engineer should charter a vessel annually, to carry a full complement of stores and other necessaries for the use of the lights, and such artificers, implements, and materials, as might from time to time be found necessary for making repairs at the lighthouses;' the engineer was also to pay an annual visit to each lighthouse, and report upon the state and condition of the buildings, and the conduct of the light-keepers.

No public lights on the Scotch coast are in the hands of private individuals. All the light-dues collected from the general shipping in Scotland are received by the commissioners for public use. There are now twenty-five land-lights under the charge of the commissioners, for which due-lights are levied; and there are twenty-eight local or harbour-lights under the management of

trustees and corporate bodies, maintained by the dues levied on the trade of the respective ports where the lights are situated, and on vessels resorting to them. Some of these lights are established by Acts of Parliament, others are secured by ancient charters to the fraternities of the ports, and others were erected and are maintained by the ship-owners and merchants of the ports.

The earliest public light on the Scottish shores is that situated on the Island of May. This island holds a prominent position at the entrance of the Frith of Forth, and from its connection also with the estuary leading to the capital of Scotland and the principal ports of her commerce, the want [66] of a light seems to have been experienced at an early period. Over the entrance-door of the old lighthouse-tower a stone, neatly cut into the figure by which the sun is usually represented, bears the date 1635.

Much dissatisfaction was produced after the Union, in consequence of English and Irish vessels being charged with double rates as foreigners. The light being also a coal-fire exposed in an open chauffer, was found to be insufficient. Accordingly, in the year 1786 the Chamber of Commerce of Edinburgh made certain representations to the proprietor which induced him to increase the magnitude of the light; the chauffer was accordingly enlarged to the capacity of a square of three feet; and instead of about two hundred tons of coal per annum, formerly consumed, the quantity of fuel was now doubled. From this period the light of May became the most powerful coal-light in the kingdom, although from its exposure it was still found to be very unsteady in bad weather, when most required by the mariner. Lime-kilns and other accidental open fires upon the neighbouring shores, were also apt to be mistaken for the Isle of May chauffer. To obviate such dangerous mistakes, there was no other method but the introduction of a light from oil, with reflectors inclosed in a glazed light-room. Related ineffectual applications to the Duke of Portland (who by marriage had obtained possession of the light and Isle of May) served only to illustrate how very objectionable it is to allow lighthouses and other public works to be carried on by a private individual for his sole profit. It happened, however, that among numerous other disasters, two of his Majesty’s ships, valued at not less than a hundred thousand pounds, were, on the 19th December, 1810, wrecked near Dunbar, in consequence, it is believed, of the light of a lime-kiln on the coast of Haddingtonshire having been mistaken for the coal-light of the Isle of May. This disaster attracted the notice of the Admiralty to the Isle of May light, when it was proposed to place it under the control of the Commissioners of Northern Lighthouses. After many [67] negotiations an Act of Parliament was passed in the session of 1814, empowering the commissioners to purchase the light duties and the Island of May, for the sum of sixty thousand pounds. This was accordingly done, and on the completion of the purchase, the first act of the commissioners was to reduce the light-duty to all British vessels, so that English and Irish ships were no longer treated as foreigners, by paying double duty. Immediate measures were also taken for altering and improving the light; a new lighthouse was erected, and a light from oil, with reflectors, was exhibited on the 1st February, 1816, after the existence of a coal-light during one hundred and eighty-one years. The old lighthouse-tower was reduced in height, and converted into a guard-room for the use and convenience of pilots and fishermen.

Soon after the establishment of the Board of Commissioners, repeated applications were made for the erection of new lighthouses, in order to avert the misfortunes which occurred every year, especially on the low shores of the northern isles of Orkney. In the year 1789 a lighthouse had been completed at North Ronaldsay, but the experience of twelve years had proved that this was not calculated to prevent the numerous wrecks on the islands of Sanday and Stronsay. In 1796, when the engineer was on his annual visit, he was struck at seeing the wreck of three homeward-bound ships upon the island of Sanday, though situate only about eight miles southward of the lighthouse of North Ronaldsay. In the three following years no fewer than eight ships were wrecked upon the same fatal island. It was therefore resolved, in 1801, that a stone-tower or beacon should be erected upon the Start Point, which forms the eastern extremity of the low shores of the Island of Sanday; the building to be constructed in such a manner that it might, if necessary, be converted into a lighthouse.

In the year 1802, Mr. Stevenson, the engineer of the Northern Lighthouses, sailed on his annual voyage of inspection, taking with him a foreman and sixteen artificers to commence the [68] works at Start Point. The vessel reached Orkney by the 20th April, and even at this advanced part of the season the islands were covered to the depth of six inches with snow. This, at any time, is rather uncommon in Orkney; but such had been the severity of this season in the northern regions, that a flock of wild swans, which in severe winters visit these islands, were still seen in considerable numbers upon the fresh-water lakes of Sanday. Those large birds are supposed to migrate from Iceland, but are rarely seen in Orkney later than the month of March; so that their appearance in the latter end of April was regarded as a mark of a very severe and long-continued winter in the higher latitudes.

There being no workable sand-stone on Sanday island, a quarry was opened on the contiguous island of Eda, where it occurred of a tolerably good quality. In order to render the building substantially water-tight, it had been originally intended to make it wholly of hewn-stone built in regular courses; but the quarry of Eda being about fourteen miles distant from the works, the stones had to be conveyed by sea through rapid tides; and there being but indifferent creeks or havens, both at the quarry and at the Start Point, it was found necessary to make only the principal stones of hewn work, while the body of the work was executed in rubble building, for which excellent materials were at hand, consisting of a sort of sand-stone slate or micaceous schist. The encroachments of the sea had heaped up immense quantities of these stones at high-

water mark all round the Start Point, the shores of which appeared like the ruins of the wall of some large city.

By the middle of the month of May sufficient materials were collected for commencing the building. The workmen having expressed a wish to have the foundation-stone of the beacon laid with masonic ceremony, preparations were accordingly made. ‘The year of our Lord 1802’ was cut upon the foundation-stone, in which a hole was perforated for depositing a glass phial containing a small parchment-scroll, setting forth the intention of the building, the official [69] constitution of the Commissioners of Northern Lighthouses, and the name of their engineer. It also contained several of the current coins of George III. in gold, silver, and copper. The day fixed for the ceremony was the 15th of May. The weather was dry and tolerably agreeable, though cold with snow upon the ground; the thermometer stood at 35° in the shade at noon. The influx of so many strangers to the island for this work, and the novelty of the intended ceremony, caused most of the inhabitants to be present to witness it. Every thing being prepared, the engineer, assisted by the foreman of the works, applied the square and plummet-level to the foundation-stone in compliance with ancient custom. The phial was then deposited in the cavity prepared for it in the stone, and carefully covered up with sand, when the masonic ceremony was concluded in the usual manner. The Rev. Walter Traill, minister of the parish, then offered up a most impressive prayer, imploring the blessing of heaven upon the intended purposes of the building, and then delivered the following address:—

‘This moment is auspicious. The foundation-stone is laid of a building of incalculable value;—a work of use, not of luxury. Pyramids were erected by the pride of kings, to perpetuate the memory of men, whose ambition enslaved and desolated the world. But it is the benevolent intention of our government, on this spot, to erect a tower—not to exhaust, but to increase the wealth and protect the commerce of this happy kingdom. To the goodness of God, in the first place, we are indebted for a degree of prosperity unknown to other nations. In the next place, we owe our happiness to our insular situation, and attention to maritime affairs. Faction and civil war have at this period laid waste the fairest countries of Europe; while peace has flourished within our walls. Agriculture, commerce, and their kindred arts, have prospered in our land. British oak hath triumphed; victory hath been attached to the British flag; and British fleets have [70] ridden triumphant on the wings of the wind. Consider the great national objects for which this building will be erected. To protect commerce, and to guard the lives of those intrepid men who for us cheerfully brave the fury of the waves and the rage of battle. The mariner when he returns to the embraces of his wife and children, after ascribing praise to the Great Giver of safety, shall bless the friendly light which guided him over the deep, and recommend to the protection of heaven those who urged, who planned, and who executed the work. This day shall be remembered with gratitude. It shall be recorded, that at the beginning of a new century the pious care of government was extended to this remote island. These rocks, so fatal to the most brave and honourable part of the community, shall lose their terror, and safety and life shall spring from danger and death. Even you, my friends, who are employed in the execution of this work, are objects of regard and gratitude. You have, for a season, left the society of your families and friends, to perform a work of high interest to your country and to mankind. I am confident that you will act, in all respects, so as to deserve and obtain the esteem of the people who now surround you. I hope that they will discharge to you every duty of Christian hospitality, and that you will have no occasion to feel that you are strangers in a strange land. It becomes us to remember that all the affairs of men are dependent on Providence. We may exert talents and industry, but God only can bless our exertions with success. Let our trust be in Him. Let us humbly hope that He will bless this day and this undertaking. Through His aid may there arise from this spot a tower of safety and protection to the mariner of every tongue and nation.’

The whole of this scene is described as being very impressive; to which the plain, decent, and respectable appearance of the people collected on the occasion not a little contributed.

By continuing steadily at work during the summer-months, the beacon was finished in [71] September. It was terminated, at the height of one hundred feet above the medium level of the sea, with a circular ball of masonry measuring fifteen feet in circumference.

The completion of this beacon did not, however, prevent the frequent occurrence of shipwreck upon the island. It had even become proverbial with some of the inhabitants to observe, ‘that if wrecks were to happen, they might as well be sent to the poor island of Sanday as anywhere else.’ ‘On this and the neighbouring islands,’ says Mr. Stevenson, ‘the inhabitants have certainly had their share of wrecked goods; for here the eye is presented with these melancholy remains in almost every form. For example, although quarries are to be met with generally in these islands, and the stones are very suitable for building dikes, yet instances occur of the land being enclosed, even to a considerable extent, with ship-timbers. The author has actually seen a park paled round, chiefly with cedar-wood and mahogany from the wreck of a Honduras built ship; and in one island, after the wreck of a ship laden with wine, the inhabitants have been known to take claret to their barley-meal porridge, instead of their usual beverage. On complaining to one of the pilots of the badness of his boat’s sails, he replied to the author with some degree of pleasantry, “Had it been His (God’s) will that you came na here wi’ these lights, we might a’ had better sails to our boats, and more o’ other things.” It may further be noticed, that when some of Lord Dundas’s farms are to be let in these islands, a competition takes place for the lease; and it is understood that a much higher rent is paid than the lands would otherwise give, were it not for the chance of making considerably by the agency and advantages attending shipwrecks on the shores of the respective farms.’

In his Report to the Board in the year 1805, Mr. Stevenson proposed that the Start Point beacon should be converted into a lighthouse, and that the north Ronaldsay light should be discontinued, and its tower converted into a beacon, as wrecks were found to happen [72] comparatively seldom upon that island, while hardly a year passed without instances of this kind in the Island of Sanday; for owing to the projecting points of this strangely formed island, the lowness and whiteness of its eastern shores, and the wonderful manner in which the scanty patches of land are intersected with lakes and pools of water, it becomes even in day-light a deception, and has often been fatally mistaken for an open sea. After taking the opinion of persons acquainted with the navigation of these seas, the change was adopted; the works at the Start Point were commenced early in the summer of 1805; by the month of November the light-room was finished, and the light exhibited on the 1st January, 1806.

A melancholy story is connected with the completion of the lighthouse on this fatal island. The principal mason and his assistants being desirous of returning home, proceeded to Stromness on the mainland of Orkney, from whence they were most likely to get a passage to the southward. The party consisted of six in number; and the foreman's brother, wishing to go directly to his native place, took his passage in a vessel bound from Stromness to Anstruther, while the rest embarked on board a schooner bound for Leith.

The vessel sailed with a fair wind early on the 24th December, 1806. On the following morning they got sight of Kinnaird Head lighthouse in Aberdeenshire, and had the prospect of speedily reaching the Frith of Forth; but the wind having suddenly shifted to the south-east, and increased to a tremendous gale, the vessel immediately put about, and steered in quest of some safe harbour in Orkney. At two o'clock in the afternoon she passed the Portland Frith, and got into the bay of Long Hope, but could not reach the proper anchorage; and at three o'clock both anchors were let go in an outer roadstead. The storm still continuing with unabated force, the cables parted or broke, and the vessel drifted on the island of Flotta. The utmost efforts of those on board to pass a rope to the shore, with the assistance of the inhabitants of the island, proved [73] ineffectual; the vessel struck upon a shelving rock, and, night coming on, sunk in three fathoms water.

Some of the unfortunate crew and passengers attempted to swim ashore, but in the darkness of the night they either lost their way, or were dashed upon the rocks by the surge of the sea; while those who retained hold of the rigging of the ship, being worn out with fatigue and the piercing coldness of the weather during a long winter night, died before morning,—when the shore presented the dreadful spectacle of the wreck of no fewer than five vessels, with many lifeless bodies.

During successive years the commissioners erected a number of lighthouses, and laboured with anxious care to render them as efficient as possible. In some cases where the nature of the accommodation at the lighthouse stations would permit, a guard-room was provided for pilots, and shipwrecked mariners were lodged, and, in necessitous cases, they have even been allowed a sum of money to clothe and carry them to their respective homes. 'In this way,' says Mr. Stevenson, 'it has not unfrequently fallen to the lot of the keepers of the northern lighthouses, to save the lives of perishing seamen, to succour many poor fishermen and pilots, as well as the half-starved and unlucky individuals of water-parties, when driven by stress of weather to these lone places of abode for safety and shelter. In these varied forms, it will not be too much to suppose, that the practice of protecting the navigator in distress, which is said to have formed a chief part of the design of the fire-towers and nautical colleges of the ancients, is thus in some measure restored.'

Chapter VII. [74]

THE BELL-ROCK LIGHTHOUSE AS A TYPE OF SCOTTISH LIGHTHOUSES.

History of the Inch-Cape or Bell-Rock Lighthouse as a Type of the Northern Lighthouses—Position and Dangerous Character of the Bell Rock—Ballad of Sir Ralph the Rover—Proposal to erect a Lighthouse—Mr. Robert Stevenson selected as Engineer—Survey of the Rock—Exhibition of a Floating Light—Preparations for the Lighthouse—First Season on the Rock—Alarming Situation of the Engineer and Men—Effects of the Stormy Sea on the Rock—Erection of Beacon—Winter Employment—The Second Season—A new Tender employed—Praam-boats and Stone-lighters—Progress of the Work—Remarkable appearance of the Rock—Foundation Stone laid—First continuous Course of Masonry—Its Contents—Third Season—Progress of the Work—Winter Operations—Fourth Season—The Beacon used as a Dwelling—Its Interior described—The Engineer's Cabin—The Lighthouse nearly finished—Mr. Smeaton's Daughter visits the Works—Last Stone laid—Light advertized—Lighthouse described—Action of the Sea and of Stormy Weather upon the Lighthouse—Internal Economy of the

‘*Pharos loquitur.*

‘Far in the bosom of the deep
O’er these wild shelves my watch I keep,
A ruddy gem of changeful light,
Bound in the dusky brow of night.
The seaman bids my lustre hail,
And scorns to strike his timorous sail’[5].

The most celebrated lighthouse in Scotland is that situated on the dangerous reef called the Inch Cape or Bell Rock. This lighthouse may fairly aspire to the title of the Eddystone of Scotland, whether we regard its high importance to navigation, the danger and difficulty of its erection, the beauty of its form, or its interesting history. [75]

The Inch Cape or Bell Rock is situated on the northern side of the entrance of the Frith of Forth at a distance of eleven miles from the promontory called the Red Head, in Forfarshire. The dimensions of the north-eastern or higher compartment of the rock where the lighthouse is built are about four hundred and twenty-seven feet in length and two hundred and thirty feet in breadth. Besides these dimensions, the south-western reef extends about one thousand feet from the main rock. The greatest length of the rock, which may be said to be dangerous to shipping, is about one thousand four hundred and twenty-seven feet, and its greatest breadth about three hundred feet. It is about twelve feet under water at the ordinary height or perpendicular rise of spring tides. In point of situation, this rock is one of the most dangerous on the coast of Great Britain; for while it lies in one of the most frequented estuaries, it is much lower in the water than any rock on which lighthouses are usually erected; and hence the mariner had formerly no warning of his danger when in its vicinity. Indeed, in fine weather the sea is often so smooth, that the place of the rock could not be pointed out from the appearance of the surface. The Bell Rock was therefore considered for ages as the chief obstruction to the navigation of the Frith of Forth, and the want of some mark to point out its position was long lamented. Tradition says, that the abbots of the ancient monastery of Aberbrothock succeeded in fixing a bell upon it in such a way as to be rung by the agitation of the waves. It is further stated, that a band of pirates having carried off the bell, were in a subsequent voyage all lost on the Bell Rock. This legend is beautifully told by Mr. Southey in the following ballad. [76]

SIR RALPH THE ROVER.

No stir in the air, no stir in the sea,
The ship was still as she could be;
Her sails from heaven received no motion,
Her keel was steady in the ocean.

Without either sign or sound of their shock,
The waves flow’d over the Inchcape Rock;
So little they rose, so little they fell,
They did not move the Inchcape bell.

The abbot of Aberbrothok
Had placed that bell on the Inchcape Rock;
On a buoy in the storm it floated and swung,
And over the waves its warning rung.

When the rock was hid by the surge’s swell,
The mariners heard the warning bell;
And then they knew the perilous rock,
And blest the abbot of Aberbrothok.

The sun in heaven was shining gay,
All things were joyful on that day;
The sea-birds scream’d as they wheel’d round,
And there was joyaunce in their sound.

The buoy of the Inchcape bell was seen,
A darker speck on the ocean green;
Sir Ralph the Rover walk’d his deck,
And he fix’d his eye on the darker speck.

He felt the cheering power of spring,
It made him whistle, it made him sing;
His heart was mirthful to excess,
But the Rover’s mirth was wickedness.

His eye was on the Inchcape float,
Quoth he, ‘My men, put out the boat,

And row me to the Inchcape Rock,
And I'll plague the abbot of Aberbrothok.'

The boat is lower'd, the boatmen row,
And to the Inchcape Rock they go;
Sir Ralph bent over from the boat,
And he cut the bell from the Inchcape float.

Down sunk the bell with a gurgling sound,
The bubbles rose and burst around;
Quoth Sir Ralph, 'The next who comes to the rock
Won't bless the abbot of Aberbrothok.'

Sir Ralph the Rover sail'd away,
He scour'd the seas for many a day;
And now grown rich with plunder'd store,
He steers his course for Scotland's shore.

So thick a haze o'erspreads the sky,
They cannot see the sun on high;
And the wind hath blown a gale all day,
At evening it hath died away.

[77]

On the deck the Rover takes his stand,
So dark it is they see no land:
Quoth Sir Ralph, 'It will be lighter soon,
For there is the dawn of the rising moon.'

'Canst hear,' said one, 'the breakers roar?
For methinks we should be near the shore;'
'Now where we are I cannot tell,
But I wish we could hear the Inchcape bell!'

They hear no sound, the swell is strong,
Though the wind hath fallen they drift along,
Till the vessel strikes with a shivering shock,
'Oh Christ! it is the Inchcape Rock.'

Sir Ralph the Rover tore his hair,
He curst himself in his despair;
The waves rush in on every side,
The ship is sinking beneath the tide.

But even in his dying fear
One dreadful sound could the Rover hear,
A sound as if with the Inchcape bell,
The devil below was ringing his knell.

But whatever may be the truth of these traditions, it is certain that for a long period, perhaps centuries, no permanent distinguishing mark was attached to the rock until the building of the present lighthouse, whose history we have now briefly to state.

On the appointment of a board for the erection of lighthouses in Scotland, the public anxiously expected that some means would be taken to guard the mariner from this fatal rock; but the difficulties of the undertaking, the great expense, and the inadequate funds of the board, all contributed to promote delay. In the winter of 1799 the northern coast of Great Britain was visited with a dreadful storm, and no less than seventy vessels were wrecked upon the coast of Scotland. This calamity excited so strong a sensation that the attention of the board was at once directed to this object; and in 1802 application was made to Parliament to enable the commissioners of the northern lighthouses to levy certain additional duties, and empower them to borrow a sum of money for this work. The Act was not obtained until 1806; but when obtained, this highly important work was immediately undertaken.

A variety of plans were submitted to the consideration of the lighthouse board. The beacons of spars which had been erected on the rock had been washed away, and many persons feared that a more solid structure would share the same fate. Considering that the rock was frequently under water to the depth of twelve feet, some proposed to erect a building which should stand on pillars of cast-iron or of stone. The commissioners, however, wisely referred the matter to Mr. Robert Stevenson the engineer, who was to survey the rock, and report upon the practicability of erecting a lighthouse upon it. The survey was accordingly made; and during its progress, many instances were discovered of the extent of loss which this reef had occasioned, and many articles of ships' furnishings were found, as well as various coins, a bayonet, a silver shoe-buckle, and many other small objects. The result of this survey was a report from Mr. Stevenson to the effect, that a work of stone similar to that of the Eddystone lighthouse was practicable; and having sent in his plans, the commissioners submitted them to Mr. Rennie, who gave them his cordial concurrence; and the work was accordingly proceeded with.

[78]

The time that remained after the passing of the Act in 1806 was employed in making the necessary preparations for the summer of the next year; and the commissioners being authorized to collect duties on the exhibition of a floating light, a vessel was employed to serve the double purpose of a floating light, and a tender for the workmen employed in the building. Accordingly in July a Dutch fishing vessel was moored off the Bell Rock, at the distance of about two miles, in a depth of about twenty fathoms water; her crew consisting of a master, eight able seamen, and a boy. This strong crew was necessary, in case the vessel should accidentally drift from her station, and to enable them to light or lift their moorings after every gale of wind. The vessel was rigged with three masts, on each of which a lantern was so placed that the light could be seen in all directions.

The stones and machinery were prepared in a work-yard provided for the purpose at Arbroath, the nearest harbour on the adjacent coast. In this place barracks were erected for the workmen, [79] that they might at all times be ready night or day to go off to the Bell Rock. A sloop, named the 'Smeaton,' (in honour of the great engineer who had left so splendid a pattern for the present structure,) had been built expressly for the Bell-Rock service, to be employed as a tender for the floating light, and as a stone-lighter for the use of the work: it served also to convey the workmen to and from the rock.

On the 17th August 1807 the work on the rock was begun. The first employment was to bore a sufficient number of holes for receiving the ends of beams, for the support of a wooden beacon or workshop and temporary residence for the workmen. But this was no easy task. The hard compact nature of the sand-stone of which the rock is composed soon blunted the tools, and rendered necessary the constant employment of a smith with his forge. But the operations of this useful artificer were even more difficult than those of the stone-cutters. It often happened that after the flood-tide had obliged the pickmen to strike work, a sea would come rolling over the rocks, while the smith was in the middle of a 'favourite heat,' dashing out the fire, and endangering his indispensable instrument, the bellows; or if the sea was smooth, the smith had often to stand at work knee deep in water, and the tide would rise imperceptibly, first cooling the exterior of the fire-place or hearth, and then quickly blackening and extinguishing the fire from below. Mr. Stevenson describes it as amusing to witness the perplexing anxiety of the smith when coaxing his fire, and endeavouring to avert the effects of the rising tide. Sometimes, while his feet were immersed in water, his face was not only scorched but continually exposed to volumes of smoke and sparks of fire. A great object therefore, of the beacon was to remove the smith above the reach of the highest tide.

One effect of visiting the rock at every tide, and carrying on this noise and traffic, was to banish the herd of seals which had hitherto frequented it as a resting-place during low water. As many [80] as fifty or sixty of these animals had been seen at one time on the rock, but now not more than one or two occasionally appeared, and these confined their visits to the detached outlayers of the rock, from whence they would gaze on the workmen with that look of curiosity so remarkable in this animal. Mr. Stevenson was desirous of protecting them, in hopes of taming them, so as to gain that facility of studying their habits which was afforded at Small's Lighthouse, off the coast of Pembrokeshire, a favourite resort of seals, where, by gentle treatment, they had become so tame and familiar as to eat bread out of the hands of the light-keepers.

The operations of this season were difficult and hazardous, the men having to row in boats at every tide from the rock to the floating-light; and the wind often shifting suddenly, the exertion of rowing was very great, although the distance was but two miles. When at the rock, the men had presently to work knee-deep in water; and the roughness of the sea was often such as to suspend the work for days together, during which time the floating-light would roll so unmercifully, that to put out a boat would have probably ensured its instant destruction.

During this early stage of the work there was a moment of appalling danger, which must be noticed in detail. On the 2nd of Sept. 1807, there were thirty-two persons upon the rock; and while all the artificers were busily occupied, a gale arose, during which the 'Smeaton' broke adrift from her moorings. In this perilous predicament, placed upon an insulated rock far out in the ocean, which, in the progress of the flood-tide, was to be laid under water to the depth of at least twelve feet, in a stormy sea, the feelings of the engineer may be better conceived than described. There were, at this period, only two boats attached to the rock, whose complement, even in fair weather, did not exceed twenty-four sitters; but to row to the floating-light, with so much wind, and so heavy a sea, a complement of eight men for each boat was as much as could [81] possibly be attempted, so that, in this way, about one half of those employed on the rock must be left unprovided for. Under these circumstances, had Mr. Stevenson ventured to despatch one of the boats, in expectation of either working the 'Smeaton' sooner up towards the rock, or in hopes of getting her boat brought to the assistance of the rest, this must have given an immediate alarm to the artificers, each of whom would have insisted upon taking to his own boat, and leaving the eight artificers belonging to the 'Smeaton' to their chance.

The unfortunate circumstance of the 'Smeaton' and her boat having drifted, was for a considerable time, known only to Mr. Stevenson and to the landing-master, who removed to the further part of the rock, where he kept his eye steadily upon the progress of the vessel. While the artificers were at work, chiefly in sitting and kneeling postures, excavating the rock, or boring with the tools, and while their numerous hammers, and the sound of the smith's anvil continued, the situation of things did not appear so awful. In this state of suspense, with almost certain destruction at hand, the water began to rise upon those who were at work on the lower parts of the sites of the beacon and lighthouse. From the run of the sea upon the rock, the forge-fire was

sooner extinguished than usual; and the volumes of smoke having ceased, objects in every direction became visible from all parts of the rock. After having had about three hours' work, the men begun, pretty generally, to make towards their respective boats for their jackets and stockings, when, to their astonishment, instead of three, they found only two boats, the third being adrift with the 'Smeaton.' Not a word was uttered by any one, but all appeared to be silently calculating their numbers, and looking to each other with evident marks of perplexity depicted on their countenances. The landing-master, conceiving blame might be attached to him for allowing the boat to leave the rock, still kept at a distance. At this critical moment Mr. Stevenson was standing upon an elevated part of the rock, where he endeavoured to mark the [82]
progress of the 'Smeaton,' not a little surprised that her crew did not cut the praam adrift which greatly retarded her way. The workmen looked steadfastly at their leader, and turned occasionally towards the vessel still far to leeward. All this passed with the most perfect silence, and the melancholy solemnity of the group was such that, Mr. Stevenson states, it left an impression never to be effaced from his mind.

In the meantime Mr. Stevenson was considering various schemes which might be adopted for the general safety of the party, in hopes that the 'Smeaton' might be able to pick up the boats to leeward when they were obliged to leave the rock. He was, accordingly, about to address the artificers on the perilous nature of their situation, and to propose that all should unstrip their upper clothing, when the higher parts of the rock were laid under water,—that the seamen should remove every unnecessary weight and encumbrance from the boats, and a specified number of men should go into each boat, and that the remainder should hang by the gunwales, while the boats were to be rowed gently towards the 'Smeaton,' as the course of the 'Pharos' or floating-light lay rather to windward of the rock. But, when he attempted to speak, his mouth was so parched that his tongue refused utterance, and he says, 'I now learned by experience that the saliva is as necessary as the tongue itself for speech.' He then turned to one of the pools on the rock, and drank a little salt-water, which produced immediate relief; and his delight was in no small degree increased when, on rising from this nauseous beverage, some one called out, 'A boat!' 'A boat!' and on looking round, at no great distance, a large boat was seen through the haze making towards the rock.

The effect of this accident was, that when the bell rung next morning, and the workmen were mustered, out of twenty-six, only eight, besides the foreman and seamen, appeared on deck to accompany the engineer to the rock. 'The use of argument to persuade the men to embark in [83]
cases of this kind would have been out of place, as it is not only discomfort, or even the risk of the loss of a limb, but life itself, that becomes the question.' The boats proceeded with the eight willing workmen: four hours were passed upon the rock, and, on returning to the 'Pharos,' the eighteen men who remained on board seemed quite ashamed of their cowardice; and on again proceeding to the rock, they were the first to embark. This was the only instance of refusal to go to the rock.

Shortly after this occurrence, the whole party on board the Pharos was exposed to a fearful gale, which kept them from the rock during ten days and exposed them to imminent danger. The floating-light broke adrift, but, providentially, no damage was sustained. This circumstance, however, imparted a character of extreme hazard to life on board the floating-light, that it was difficult to provide sailors to man her. On landing upon the rock the effects of the gale were at once apparent. Six large blocks of granite, which had been landed by way of experiment, had been removed from their places, and by the force of the sea thrown over a rising ledge into a hole at the distance of twelve or fifteen paces; a sufficient evidence of the violence of the storm and the agitation of the sea on the rock. The smith's forge was also shifted from its place—the ash-pan of the hearth with its ponderous cast-iron back had been washed from their places of supposed security, the chains of attachment broken, and these weighty articles found at a very considerable distance in a hole of the rock.

Although the sea often had a most frightful appearance, yet the beacon divested the Bell Rock of many of its terrors: its beams afforded an excellent guide to shipping, and old sailors frequently expressed their admiration at the change of circumstances which led to their cruising with so much confidence both by day and night in the immediate vicinity of this dangerous rock. It also had a beneficial influence on all who were actively engaged about the lighthouse by inducing a greater confidence of safety, so that at all times when a boat could be put to sea or [84]
approach this sunken reef, there was not that actual danger in landing which formerly presented itself, because in the event of the tender going adrift or a boat happening to be wrecked upon the rock, the beacon could be looked to as a refuge till assistance arrived.

On the 6th October, 1807, the works were relinquished for the season. The time which had been spent in the rock amounted only to one hundred and eighty hours, of which one hundred and thirty-three, or about thirteen and a half days of ten hours each, could be said to have been actively employed, and yet during this period, besides the erection of the principal beams of the beacon-house, some considerable progress had been made in preparing the site of the lighthouse. 'This reason's work,' says the engineer, 'affords a good example of what may be executed under similar circumstances, when every heart and hand is anxiously and zealously engaged, for the artificers wrought at the erection of the beacon as for life; or somewhat like men stopping a breach in a wall to keep out an overwhelming flood.'

During winter the men were busy in the work-yard preparing the stones and laying them course by course upon a stone basement, equal to the foundation course of the lighthouse. Here the stones were fitted into their places, and carefully numbered and marked as they were to lie in

the building; a necessary operation, the several courses being dove-tailed and connected together, so as to form one mass from the centre to the circumference of the building. The stones were also bored or fixed with trenails of oak and joggles of stone, after the manner of the Eddystone lighthouse, and in this state they were laid aside, and in readiness for being shipped in lighters for the rock.

Considering the importance of a light on the Bell Rock, it was at first determined that the whole outward casing of the lighthouse should be of granite, and that sand-stone should be used only for the interior work; but from the difficulty of procuring a sufficient supply of granite, it was [85] afterwards found necessary to restrict the use of it to the lower courses of the building. The granite was from the Rubislaw quarry, and was so compact, that it contained only about thirteen and a half cubic feet to the ton. The sand-stone was from the Mylnefield quarry, and contained fifteen feet to the ton.

As soon as the weather would permit, the operations of the second season commenced at the rock. The arrangements for carrying on the works were made on an improved scale. A new vessel (named the Sir Joseph Banks) was provided as a tender for lodging the workmen off the rock, instead of the floating-light. The new tender was well supplied with cooking apparatus, provisions, water, fuel, &c.; the space not used as birthage, &c. was occupied with casks of lime, cement, and other articles required for the work. The advantage of this new arrangement was, the ease with which the tender could be brought to the lee side of the rock, to take the people on board at any emergency; whereas, the floating-light, being moored as a guide to shipping, could not be moved about so easily, to serve the purposes of the workmen. Every precaution was also taken to render the praam-boats or stone-lighters buoyant, for such was the presentiment of danger attached to the landing department, that, in addition to a water-tight lining, each praam was provided with twelve strong empty casks, which were stored in the hold, and were sufficient to float and render her buoyant in case of accident. The praams therefore became so many life-boats, moored in the neighbourhood of the rock. The Sir Joseph Banks was also furnished with large landing boats and a life-boat.

The beacon had resisted the wintry storms tolerably well. Indeed, the force of the waves upon the rock was not so great as might have been expected, from an interesting and unlooked-for cause, namely, the extensive beds of marine plants which grow upon it. ‘It often happened,’ says Mr. Stevenson, ‘when heavy seas were rolling along the Bell Rock, which at a distance threatened to overrun the whole, that, upon reaching these beds of fuci, with which the flat and [86] level parts of the rock were thickly coated, the velocity and force of the waves were immediately checked, and in a great measure destroyed.’

On the 25th of May 1808, the operations of the second season were commenced with very different feelings, to those experienced during the previous year, when every step was attended with a great degree of doubt, uncertainty, and danger; but the preparations and precautions, which had been so wisely adopted, gave a security and promptness to the work, which relieved all concerned in it of much anxiety. Landing upon the rock was at all times difficult, but, so long as the boats were kept from striking upon it, the spray which came on board was but little heeded.

During the early part of this season the work proceeded as follows: The workmen landed on the rock at low water, and immediately began to bale out the water from the foundation pit, while the pumps were also kept in action. The work was proceeded with on the higher parts of the foundation as the water left them. The pumps being placed diagonally, about twenty men were employed to work each pump; and thus this great body of water, extending over a circular area of forty-two feet diameter, and of the average depth of two feet, could be drawn off in half an hour. The men then proceeded, for about two hours and a half, to level the foundation with their picks, some of the sailors being employed in clearing away the chips, and conveying the iron tools to and from the smiths on the beacon, where they were sharpened. When the sea broke in and overflowed the pit, the party returned in boats to the tender.

The appearance of the rock about this time is thus described: ‘Its surface was crowded with men, the two forges flaming, the one above the other, upon the beacon, while the anvils thundered with the rebounding noise of their wooden supports, and formed a curious contrast with the clamour of the surges.’ Sometimes, when the sea was smooth, the beacon had the appearance of being afloat upon the water, with a number of men supporting themselves in every [87] variety of attitude and position; while from the upper part of this wooden house, such volumes of smoke ascended from the forges, that strangers at a distance often mistook it for a ship on fire. When working by such light at night, the rock presented a remarkable aspect to the distant shipping, the numerous lights flitting about, apparently below the surface of the water, having a curious and fanciful appearance. To the workmen themselves, the effect of extinguishing the torches was sometimes startling, and made the darkness of the night quite horrible, while the sea would assume that phosphoric appearance so familiar to the sailor, and dash upon the rock like so much liquid fire.

As the work proceeded, the smiths were sometimes left on the beacon throughout the day, and the noise of their anvils was an excellent guide to the boats in foggy weather. This circumstance confirmed the engineer, as to the propriety of erecting in the lighthouse large bells, to be tolled by machinery day and night, during the continuance of foggy weather, by which the mariner may be forewarned of too near an approach to the rock.

The foundation pit having assumed the appearance of a large even platform, and the tides

being favourable, it was determined to lay down the first course, which consisted of a few irregular and detached stones for making up certain inequalities in the interior parts of the site of the building. Having taken the dimensions of the first or foundation stone, a model of its figure was made, and this was taken by the engineer in a fast-rowing boat to the work-yard at Arbroath: two men were immediately set to work upon one of the blocks from the Mylnefield quarry, and as the stone-cutters relieved each other, and worked without intermission, the stone was soon prepared, and sent off next day in one of the stone-lighters. On the 9th July the stone was placed in a praam-boat, decorated with colours for the occasion. Flags were also displayed upon the beacon and from the shipping in the offing. The stone was gently lowered into the water, which [88] occupied the site of the building, amidst the cheering of all present. The stone was necessarily landed at high water, for want of a sufficient length of railway for conveying it along the rock at low water to the site of the building.

On the 10th July the sailors displayed their flags at all points, and as many as could be spared from the floating-light and the tenders landed to witness the long desired ceremony of laying the first stone of the lighthouse. The importance of the building was such, that but for the perilous and uncertain nature of any arrangement which could have been made for this ceremony, instead of its having been performed only in the presence of those immediately connected with the work, and a few casual spectators from the neighbouring shore, reckoning in all about eighty persons, many thousands would have attended upon an occasion which must have called forth the first dignitaries of the country in conferring upon it the highest honours of masonry.

At eleven o’clock the foundation stone was laid to hand. It was square in form, and contained about twenty cubic feet, and had no other inscription than the date 1808. The engineer, attended by his three assistants, applied the square, the level, and the mallet, and pronounced the following benediction: ‘May the Great Architect of the universe complete and bless this building.’ Three hearty cheers were then given, and success to future operations drunk with the greatest enthusiasm. When the tide began to overflow the site the whole party returned to the ship; prayers were read, and every heart, doubtless, felt more than usually thankful.

The first continuous course was now landed on the rock and laid down. Mr. Stevenson gives an enumeration of the various kinds and quantity of the work in this single course. Although only one foot in thickness it contained five hundred and eight cubic feet of granite in outward casing; eight hundred and seventy-six cubic feet of Mylnefield stone in the hearting; one hundred and [89] four tons of solid contents; one hundred and thirty-two superficial feet of hewing in the face-work; four thousand five hundred and nineteen superficial feet of hewing in the beds, joints, and joggles; four hundred and twenty lineal feet boring of trenail holes; three hundred and seventy-eight feet lineal cutting for wedges; two hundred and forty-six oaken trenails; three hundred and seventy-eight oak-wedges in pairs.

In the work-yard about sixty men were employed in hewing and preparing the various courses of the solid part of the building. The second course, which contained some very weighty stones, was laid down upon the platform in the middle of the yard, each stone being carefully fitted and marked as it was to lie in the building.

By the end of this season the building was brought to a level with the highest part of the margin of the foundation pit, or about five and a half feet above the lower bed of the foundation-stone. The number of hours work upon the rock this season at low water amounted to about two hundred and sixty-five, of which number only eighty were employed in building.

The third season was commenced early in the spring of 1809. The first works consisted in laying down mooring-chains with floating-buoys, for mooring the stone-lighters and praam-boats; the beacon was also fitted out as a more permanent residence for the workmen, in order to lessen the amount of sickly motion which is so distressing to landsmen in a rough sea. By the end of June the men were able to work upon the masonry while the rock was under water; and on the 8th July, for the first time, the tide ceased to overflow the building at low water. With considerable exertion the solid part of the building, which reached to the height of thirty feet, was completed by September. By continuing the works a month or two longer a much greater height might have been attained, but as the engineer foresaw that a diligent employment of the [90] next season would suffice for the completion of the work, he deemed it advisable to leave the house in its present solid defensible posture, on which the sea had much less hold, than if part of the hollow portion had been built.

The winter months were occupied in preparing the upper courses; but in consequence of severe frosts, several excellent and valuable stones from the Mylnefield quarry were destroyed by absorption of moisture from the air, which moisture expanding in the act of freezing, split the stones, and rendered them useless. It was therefore determined to construct the cornice of the building, and the parapet of the light-room of the Liver Rock, of the Craig-Leith quarry, celebrated for its durability and beauty, and for its property of not being liable to be affected by the action of frost. These stones were prepared at Edinburgh during the winter, and the iron frame-work, and the several compartments of the light-room got ready.

Having during two seasons landed and built upwards of one thousand four hundred tons of stone upon the rock, while the work was low down in the water, and before the beacon was habitable; and finding that it did not now require more than about seven hundred tons to complete the masonry, there was every prospect of finishing the lighthouse during the season. But as the success of the work depended wholly upon the stability of the beacon, every possible attention was bestowed upon it, and visits made to the rock during the winter months when the

weather would allow.

On the 10th of May operations for the season were commenced. The building to the height of fifteen feet above the rock was found to be thickly covered with fuci: on the east side the growth of sea-weed was observed to the full height of thirty feet, and even on the top or upper bed of the last-laid course it had grown so as to render walking somewhat difficult. The men therefore set to work to scrape off the sea-weed, in order to apply the moulds of the first course of the staircase. [91] The engineer had also to fix the position of the entrance-door, which was regulated chiefly by the appearance of the growth of the sea-weed on the building, indicating the direction of the heaviest seas, on the opposite side of which the door was placed.

The artificers now took permanent possession of the beacon, and were all heartily rejoiced at getting rid of the trouble of boating, and the sickly motion of the tender. The beacon, which has been so often named, and which proved a source of so much comfort to the men, and of benefit and dispatch to the work, stood well during the five years that its services were required. In its present complete form it consisted of three floors, one of which was occupied as the cook-house and provision store; the second, which was much encumbered by the meeting of the principal beams, formed only two cabins, one for the engineer, and the other for the foreman. In the third compartment were three rows or tiers of beds, capable of accommodating about thirty men. Below these three floors was the temporary floor at the height of twenty-five feet above the rock, used for preparing mortar and for the smith’s workshop. The beacon was connected with the building by a gangway, or bridge of timber.

Mr. Stevenson has given an interesting description of his cabin in the beacon, where he had passed many weeks ‘in a kind of active retirement, making practical experiment of the fewness of the positive wants of man.’ This cabin measured not more than four feet three inches in breadth on the floor; and though, from the oblique direction of the beams of the structure, it widened towards the top, yet it did not admit of the full expansion of his arms when he stood on the floor, while its length was little more than sufficient for suspending a cot-bed during the night. This was tied up to the roof during the day, thus leaving free room for the admission of occasional visitants. ‘His folding-table was attached with hinges immediately under the small window of the apartment, and his books, barometer, thermometer, portmanteau, and two or three camp-stools, [92] formed the bulk of his moveables. His diet being plain, the paraphernalia of the table were proportionably simple, though every thing had the appearance of comfort, and even of neatness, the walls being covered with green cloth formed into panels with red tape, and his bed festooned with curtains of yellow cotton-stuff. If, in speculating upon the absolute wants of man in such a state of seclusion, one was reduced to a single book, the Sacred Volume, whether considered for the striking divinity of its story—the morality of its doctrine—or the important truths of its Gospel, would have proved by far the greatest treasure.’

As the building rose in height the action of the sea upon it was regarded with much interest. When the wind was blowing, accompanied with a heavy surf upon the rock, the appearance towards high water is described as being very grand and wonderful. Waves of considerable magnitude rose as high as the solid or level of the entrance-door which was to the leeward; but on the windward side the sprays flew like lightning up the sloping sides of the building, occasionally wetting the artificers, and interrupting their operations on the top of the walls.

In the early part of July, the works being nearly completed, great interest was excited by a visit from Mrs. Dickson, the only daughter and surviving relative of Mr. Smeaton. She was conveyed to the building on board the ‘Smeaton,’ which had been thus spontaneously named by the engineer from the sense of the obligation which a public work of the description of the Bell Rock owed to the labours and abilities of Mr. Smeaton. Mrs. Dickson seemed to be quite overcome with the many concurrent circumstances which tended in a peculiar manner to revive and enliven the memory of her departed father.

The 29th of July was a day of great rejoicing at the Bell Rock. The last stone was landed, and that it might lose none of its honours, the same praam-boat with which the first stone of the building had been landed was appointed also to carry the last. The weather being remarkably [93] fine, all the ships and the craft hoisted flags; the praam which carried the stone was towed by the seamen in gallant style to the rock, and on its arrival cheers were given as a finale to the landing department. On the next day, the ninetieth or last course of the building having been laid, the lintel of the light-door room, being the finishing stone of the exterior walls, was laid with due formality by the engineer, who at the same time pronounced the following benediction, ‘May the Great Architect of the Universe, under whose blessing this perilous work has prospered, preserve it as a guide to the mariner.’

The remaining details, referring chiefly to the completion of the interior of the lighthouse, are not of general interest. They were so far advanced by the end of the year 1810, that the light was advertised to the public to be exhibited every night from the 1st of February 1811. The advertisement stated the following particulars:—‘The light will be from oil, with reflectors placed at the height of about one hundred and eight feet above the medium level of the sea. To distinguish this light from others on the coast, it is made to revolve horizontally, and to exhibit a bright light of the natural appearance, and a red-coloured light alternately, both respectively attaining their greatest strength, or most luminous effect, in the space of every four minutes; during that period the bright light will, to a distant observer, appear like a star of the first magnitude, which after attaining its full strength is gradually eclipsed to total darkness, and is succeeded by the red-coloured light, which in like manner increases to full strength and again

diminishes and disappears. The coloured light, however, being less powerful, may not be seen for a time after the bright light is first observed. During the continuance of foggy weather and showers of snow, a bell will be tolled by machinery, night and day, at intervals of half a minute.' By this management the light was found to be so powerful as to be seen and readily distinguished at the distance of six or seven leagues in a clear atmosphere. On the exhibition of this light the floating light was discontinued. [94]

Having thus traced the building through some of its principal stages, a brief view in its complete state may here be desirable. This lighthouse is a circular building, forty-two feet in diameter at the base and thirteen feet in diameter at the top. The masonry is one hundred feet high, and the whole structure, with the light-room, measures one hundred and fifteen feet. The ascent from the rock to the entrance-door is by a kind of trap-ladder, which is a difficult mode for any but the light-keepers, who are accustomed to it. Other persons are generally hoisted up in a chair by a moveable crane. From the entrance a circular stair leads to the first apartment, which contains the water, fuel, &c. The communication with the other apartments is by means of wooden steps. The three lower apartments have two windows each, and the upper rooms four windows each. All the windows have double sash-frames, glazed with plate-glass, besides storm-shutters of timber. The light-room is octagonal, twelve feet across and fifteen feet high. It is framed of cast iron and glazed with polished plate-glass, each plate measuring two feet six inches by two feet three inches, and being one-fourth of an inch thick. It is covered with a dome and terminates in a ball. It is also furnished with a lightning-conductor. In the year 1816, the whole exterior surface having become much discoloured by the sprays of the sea, was painted in oil of one uniform tint.

In the course of the first winter some interesting observations were made upon the action of the weather and the general appearance of the lighthouse. During rough weather a tremulous vibratory motion was found to affect the whole house. The tremour was especially felt in leaning against the walls in the upper apartments when the wind was blowing fresh, or when the house was struck by a sea or by a boat coming suddenly against it, and might be compared to that which is perceptible in a common house upon the slamming of particular doors, or when a carriage makes a rattling noise in passing along the streets. But this effect is attended with no real danger. The late eminent Professor Robison told Mr. Stevenson that when he visited the Eddystone Lighthouse, something having forcibly struck the building, he was sensible of a vibratory motion in one of the rooms in which he was then sitting; but instead of producing any alarm in his mind, he assured his friends that it was to him the strongest proof of the unity and connection of the fabric in all its parts. [95]

During the storms of winter, Mr. Stevenson says that from the Forfarshire coast 'the lighthouse appeared in one of its most interesting aspects, standing proudly among the waves while the sea around it was in the wildest state of agitation. The light-keepers did not seem to be in motion, but the scene was by no means still, as the noise and dashing of the waves were unceasing. The seas rose in the most surprising manner to the height of about seventy feet above the rock, and after expending their force in a perpendicular direction, fell in great quantities round the base of the lighthouse, while considerable portions of the spray were seen adhering, as it were, to the building, and gathering down its sides in the state of froth as white as snow. Some of the great waves burst and were expended upon the rock before they reached the building; while others struck the base, and embracing the walls, met on the western side of the house, where they dashed together and produced a most surprising quantity of foam.'

The regulations observed in attending the Bell-Rock may be briefly stated. The nearest town to the lighthouse is that of Aberbrothock, or Arbroath, in Forfarshire, about eleven miles distant. A handsome cutter, called 'The Pharos,' is stationed here as a tender to the lighthouse. This vessel goes off to the rock every fortnight, or in the course of each set of spring-tides, to relieve the light-keepers and to supply the house with fuel, provisions, &c. There are four lighthouse-keepers, three of whom are always on duty, while one is ashore. If the weather offers no impediment, the light-keepers are each six weeks at the rock and a fortnight ashore with their families. The salaries are from fifty to sixty guineas per annum, with a stated allowance for each man of bread, beef, butter, oatmeal, vegetables, and small-beer, with fourpence a day extra for tea, &c. They have also a suit of uniform clothes every third year. Mr. Stevenson says that the light-keepers were, upon the whole, pleased with their situation, and talked in a feeling manner of the hardships of mariners whom they often saw tossed about during the storms of winter. [96]

According to the present system of Northern lighthouses, the watches in the light-room are as regularly relieved as on ship-board. The keeper is liable to immediate dismissal if he leave the light-room before being regularly relieved; and for securing order and regularity in this respect a time-piece is placed in each light-room, and bells are hung in the bed-rooms of the dwelling-houses. At some of the stations the light-room and the bed-rooms are connected by a set of tubes, by blowing gently into which the keepers on watch can sound an alarum-bell in the room below, and rouse his comrade to change guard. The man below answers this call by a counterblast through the tubes, and a small index in the light-room is thereby raised to signify that the signal has been obeyed.

At Arbroath suitable buildings are erected for the light-keepers' families, with each a piece of enclosed ground, and a seat in the parish-church. Connected with these buildings are store-houses, a room for the master and crew of the attending vessels, and a signal-tower fifty feet high, at the top of which is a small observatory furnished with an excellent achromatic telescope, a flag-staff, and a copper signal-ball measuring eighteen feet in diameter. By means of this and a

corresponding ball at the lighthouse, daily signals are kept up to signify when *all is well*. Should the ball at the rock be allowed to remain down, as is the case when anything is particularly wanted, or in the event of sickness, the tender immediately puts out to sea.

The expense of this great national undertaking, together with the buildings at Arbroath, the attending vessel, and the first year's stores, amounted to about sixty-one thousand three hundred and fifty pounds. [97]

We cannot close this notice of the Bell Rock lighthouse without recording a curious accident which occurred on the night of the 9th February, 1832, about 10 o'clock. A large-herring gull struck one of the south-eastern mullions of the light-room with such force, that two of the polished plates of glass measuring about two feet square and a quarter of an inch thick, were shivered to pieces, and scattered over the floor, to the great alarm of the keeper on watch, and the other two inmates, who rushed instantly into the light-room. It happened fortunately, that although one of the red shaded sides of the reflector-frame was passing in its revolution at the moment, the pieces of broken glass were so minute, that no injury was done to the valuable red glass. The gull was found to measure five feet between the tips of the wings. In its gullet was found a large herring, and in its throat a piece of plate-glass about an inch in length.

While the Bell-Rock lighthouse was in progress, Mr. Stevenson was often struck with the frequent and distressing occurrence of shipwrecks at the Carr Rock. The Carr forms the seaward termination of a reef of sunken rocks which appear at low water, extending about a mile and three quarters from the shore of Fifeness, on the northern side of the entrance of the Frith of Forth. The very dangerous position of this rock, as a *turning point* in the navigation of the northern-bound shipping of the Frith, required that this rock, in connection with the several lighthouses of the Bell Rock, Isle of May, and Inchkeith, should be made as easily distinguishable to the mariner as possible. In the course of nine years no fewer than sixteen vessels had been either lost or stranded on the Carr Rocks. Therefore, in 1809, moorings were laid down for a floating buoy, 'but owing to the heavy swell of sea and the rocky sand-stone bottom on this part of the coast, it was found hardly possible to prevent the buoy from occasionally drifting, even [98] although it had been attached to part of the great chain made from bar-iron an inch and a half square, with which the Bell-Rock floating-light had been moored for upwards of four years without injury. The moorings of the Carr Rock buoy, from the continual rubbing upon the sand-stone bottom, were worn through with the friction in the course of ten months; and during the four years which it rode here, though regularly examined and replaced in the proper season of the year, it was no less than five times adrift, to the great inconvenience and hazard of shipping.'

Such being the case, it was resolved, however difficult and perilous the undertaking, to erect a beacon of masonry upon the rock. The length of the Carr Rock, from north to south, measures seventy-five feet, but its greatest breadth, as seen at low-water of spring-tides, is only twenty-three feet; hence it was not possible to obtain a base for a building of greater diameter than eighteen feet. The surface of the rock was also so rugged that it was necessary to excavate part of the foundation-pit of the building to the depth of seven feet. The difficulties were still further increased on account of the foundation being partly under the level of the lowest tides, so that a coffer-dam was required. It was further necessary, after each tide's work, to remove and carry ashore part of this coffer-dam; so that on the return of the workmen at ebb-tide much time was lost in readjusting the coffer-dam, and in pumping the water out of the foundation-pit.

Some idea may be formed of the difficulties attending the early stages of this work, from the fact that during the whole of the first season, or summer of 1813, the workmen could not command more than forty-one hours' work upon the rock; during the second season the time was only fifty-three hours. These two years were entirely occupied in excavating and preparing the foundation, and in laying ten stones, or the half course of masonry, which brought the foundation to a uniform level for the first entire course of the building. Mr. Stevenson contrasts this slow [99] progress with that made at the Bell Rock during the first two seasons. Although this building was situated twelve miles from the shore, three courses were erected, the diameter of the base being forty-two feet, besides the erection of a beacon-house or barrack for the workmen. 'The establishment for the works at the Bell Rock was of course on a much larger scale than that of the Carr Rock; but still the latter was equally effective, and the same apparatus, artificers, and seamen, were employed at both.'

During the third year's work, the second course of the masonry was completed upon the Carr; and nine stones of the third course were laid by the 3rd of October, when a heavy ground-swell obliged the workmen precipitately to leave the rock and take to their boats. Before the cement was fixed, the surge of the sea had washed it out; the oaken trenails were wrenched off, and the whole of the nine blocks of stone swept off the rock and lost in deep water, though they had been completely dove-tailed and fitted on the same principles as the masonry of the Bell-Rock lighthouse, where not a single stone was lost during the whole progress of the work.

During the fourth season, the operations were retarded by several untoward accidents. The wind and the waves sometimes destroyed in a moment the labour of weeks; but by dint of skill and untiring patience and industry, they succeeded by the month of November in completing the sixteenth course, which raised the building to the height of about twenty feet.

The fifth year was particularly unfortunate. The whole of the masonry having been completed, the coast was visited in November with a gale of wind, accompanied with a heavy swell of sea,

which washed down the upper part of the building, and reduced it to the height of the fifth course, which formed part of the fourth year's work. It was therefore determined to modify the [100] original design of the work. Instead of completing this beacon with masonry, and providing the machine and large bell, which was to have measured five feet across the mouth, to be tolled by the alternate rise and fall of the tide, it was now determined to erect six columns of cast iron upon the remaining courses of masonry, to terminate in a cast iron ball of the diameter of three feet, formed in ribs, elevated about twenty-five feet above the medium level of the sea. This beacon was completed in September 1821.

FOOTNOTES:

[5] Lines written by Sir Walter Scott in the Album of the Bell-Rock Lighthouse, when he visited it in 1814.

Chapter VIII. [101]

LIGHTHOUSES ON SAND AND CAST-IRON LIGHTHOUSES.

Floating Lights—Objections to—Mitchell's Screw-moorings—Experiments on the Maplin Sand—Foundation—Erection of Screw-pile Lighthouse—Details of the Wyre Lighthouse—Proposed Lighthouse on the Goodwin Sands—Metallic Lighthouses—Advantages of Metal over Stone—Details of Cast-iron Lighthouse at Morant Point, Jamaica.

Those dangerous approaches to a coast which, from the nature of the soil, have not till very lately admitted of the erection of a permanent lighthouse, are usually indicated to the navigator by floating lights; but these being nothing more than large lanterns suspended in the rigging of a vessel, necessarily possess but feeble illuminating power. This power is still further diminished in a gale of wind, when it is most wanted, by the pitching and floundering about of the vessel: every now and then she is submerged in the trough of the sea, covered with spray and drift, or, what is most to be dreaded, she is liable to be blown away from her moorings; an accident which has been productive of the most disastrous consequences to life and property.

The details already given will convey some notion of the difficulty and danger of planting a lighthouse on the solid rock in a stormy sea; we may naturally suppose that this difficulty and danger must be enormously increased in erecting a permanent residence on the shifting sands. Such, however, is by no means the case; one of the recent triumphs of engineering has proved that it is not always folly to build a house upon the sand.

This remarkable result has been accomplished chiefly by means of Mitchell's screw-mooring, [102] an instrument which consists essentially of an enormous cast-iron screw of about one turn and a half, having a hollow cylindrical centre; a wrought-iron spindle passes through the cylindrical socket; it is somewhat tapering in form, and when driven up tight is fixed thereto by a forelock passing through both; it is formed with a square head to receive the key for screwing it into the ground. It is also furnished with a collar of wrought iron fitted so as to turn freely on the upper part of the shaft of the spindle below the collar.

The attention of the Trinity House having been called to this instrument, it was considered applicable to the establishment of lighthouses on sands; and accordingly a series of experiments was undertaken at the cost of that honourable body. The spot selected for the purpose was on the verge of the Maplin Sand lying at the mouth of the Thames, about twenty miles below the Nore, forming the north side of the Swin or King's Channel, which, on account of its depth, is much frequented by large ships, as also by colliers and other vessels from the north sea. The sand is shifting, and is dry at low water spring-tides, and hitherto a floating light has been maintained upon it. On this spot it was proposed to erect a fixed lighthouse of timber framing, with a lantern and residence for the attendants.

In the month of August 1838, operations were commenced by inserting nine of Mitchell's patent mooring-screws, each four feet and a half in diameter, and furnished with shafts of wrought iron about twenty-five feet in length and five inches thick. One of these screws served as a centre to the remainder, which occupied the angles of an octagon forty-two feet in diameter. The screws were turned into the sands to the depth of twenty-one feet and a half, the upper extremities being left standing about five feet above the surface of the sands. For the purpose of fixing the screws, a stage or raft of timber, thirty feet square, was floated over the spot, with a capstan in the centre, which was made to fit on the top of the iron shaft, and firmly keyed to it. A [103] power of about thirty men was employed for driving the screws, and their labours were continued until their united force could scarcely turn the capstan. This stage or raft, which had been formed in two thicknesses crossing each other at right angles, and bolted at their intersection, was, as a precautionary measure, allowed to remain. It covered the whole site within the piles, and also

extended some distance beyond them. A curb about eighteen inches high was raised round this stage; on its surface was arranged a quantity of brushwood, and then about two hundred tons of rough stone, which sunk the stage into the sand and prevented it from being displaced. Between the spaces of the stage and the brushwood the sand was allowed to wash its way, and it soon filled the interstices of the stone. The whole mass soon became embedded below the surface of the sand, and gave considerable lateral support to the piles, and formed a solid body for the water to wash upon.

In this state the whole was allowed to remain for about two years, during which time every change in the surface of the sand was observed, and although early in the year 1839 violent storms occurred, yet the screw-piles stood firmly, and the sand at no time was lowered more than three feet. In August 1840 the raft was found to have completely settled down, the piles were as firm as if they had been screwed into clay; a lighthouse was therefore erected within the short space of three months; and on the 16th February, 1841, a dioptric fixed light was exhibited off this dangerous spot, and was visible ten miles off in all directions.

But while the preparatory steps for this lighthouse were being taken, a screw-pile lighthouse was begun and completed at Port Fleetwood on the Wyre, near Lancaster; which being the first of the kind ever constructed, deserves particular notice.

The preparatory stages were of a similar nature to those already described. The foundation was formed of seven screw-piles, six occupying the angles of a hexagon forty-six feet in diameter, and the seventh being placed in the centre. From each screw proceeded a pile fifteen feet in length, [104] at the upper end of which was another screw for securing a wooden column. These columns were prepared of Baltic timber; the one in the centre was fifty-six feet, and each of the remainder forty-six feet in length, bound firmly round with iron hoops and coated with pitch.

The framing upon which the house stands is firmly secured round the centre column and to the heads of the outer columns by means of hollow cast-iron capitals let down over the heads of the columns and secured with screw-bolts. To give lateral strength to the building, round iron angle-braces were applied, by which means a resisting power equal to at least three hundred and fifty tons is presented in every direction.

The platform upon which the house stands is twenty-seven feet in diameter. The dwelling-house is twenty feet in diameter, and nine feet high: it has an outside door, and three windows, and is divided into two apartments, one having a fire-place; the floor is tiled, and the walls and ceiling lathed and stuccoed. Access to the platform is secured by means of a Jacob’s ladder of wrought iron secured to one of the columns: access to the lantern is by a winding stair within the house.

From the summit of the house rises the lantern; it is twelve-sided, ten feet in diameter, and eight feet high. The light is thus elevated about forty-six feet above low-water level. It is of the dioptric kind, and is bright, steady, and uniform, ranging over an horizon of eight miles, and visible at the distance of ten miles from a coaster’s deck. During foggy weather a bell is tolled by machinery. Tide-time for vessels of twelve feet draft is also denoted by signals. Signals put out by vessels requiring a Wyre pilot will also be understood at this lighthouse, where corresponding signals are hoisted until the pilot is provided.

This admirable and useful structure was erected in two of the shortest day months of the year, in which time day-light did not occur at any low-water period; the workmen therefore had to depend on torches and moonlight. Nor is the portability of this form of building its least [105] advantage: should there occur any local changes which might threaten the safety of the house, it can be taken down, and erected in another site within a month.

Perhaps one of the boldest schemes ever devised for lighthouses was the structure proposed to be erected by Mr. Bush, on a plan patented by him, on the Goodwin Sands, or on the Varne in the channel between Folkestone and Cape Grisnez, in four fathoms water. This plan, was recommended to the consideration of parliament by several merchants, ship-owners, and other influential persons. The building proposed to be called ‘The Light of all Nations,’ was to consist of a Doric column one hundred and twenty-five feet high supporting a lantern twelve feet in diameter, surmounted by a colossal statue of the Queen, her sceptre being the point of a lightning-conductor. This column was to rise from a base one hundred feet in height, and fifty in diameter, to be formed by a caisson composed of cast-iron plates bolted together: the part under water was to be divided into four pyramidal chambers, opening into and supporting one another; the lower one resting on the rock beneath the sands, and the whole forming a conical core to the cylindrical base. The only part of this plan that was executed was the cast-iron caisson, which was deposited in its place among the sands. In this situation, during one dark and stormy night, it was struck by a ship and shivered to a thousand fragments. This untoward accident has led to the abandonment of the design.

One of the characteristics of this country is the mode in which we lay out the mineral wealth which nature has bestowed upon us so liberally in the shape of coal and iron. With the assistance of the former we mould the latter into a thousand shapes of usefulness, neatness, and durability, and so much attached are we to this material, that it is daily superseding the use of the more cumbrous wood and stone, and other substances which were once in great demand. Iron [106] furnishes most of the multifarious instruments required in the mechanical and agricultural arts—it ministers alike to war and to peace, by furnishing the sword and the ploughshare. It supplies some of the most useful domestic apparatus for the kitchen, the parlour, and the bed-room, and now even the bedstead itself may be formed of iron. It has been long used in some of our great

public works: we have iron roads—iron bridges—iron statues—steam-boats of iron—houses of iron, and lastly, iron lighthouses.

The suggestion of metallic lighthouses originated a few years ago with Captain Sir Samuel Brown, when it was proposed to place a lighthouse on the Wolf Rock near Land's End, a position where it would be exposed to the most violent storms of the Atlantic. A plan for the erection of a stone lighthouse on this point had already been drawn up by Mr. Stevenson, which plan, Captain Brown thinks would require fifteen years for its execution, and cost one hundred and fifty thousand pounds. Captain Brown undertook to erect one of bronze ninety feet high for fifteen thousand pounds, and to complete it in four months. This plan, from whatever cause, was not entertained, and with the exception of a small lighthouse erected on the Gravesend pier, metallic lighthouses excited no attention until the year 1840, when application was made to Mr. Alexander Gordon, the eminent engineer, by the commissioners appointed by the House of Assembly, in the island of Jamaica, to light a dangerous point in that island, called Morant Point, for the erection of a suitable lighthouse at the smallest possible cost. On this occasion Mr. Gordon proposed the erection of a cast-iron structure, resembling in outline that of the Celtic towers of Ireland. His plans and estimates having been accepted, they were executed with remarkable celerity; and from an account furnished by Mr. A. R. Renton, (the manager of the factory at which the work for the lighthouse was done,) we derive most of the following particulars.

The advantage which iron, when not in contact with sea-water, possesses over stone or other [107]
materials, is that upon a given base a much larger internal capacity for dwellings and stories can be obtained, with equal stability. With this material plates can be cast in large surfaces, and with but few joints. A system of bonding the plates may also be adopted, which will ensure the perfect combination of every part, so as to form an entire mass, and thus the best form for strength and stability can easily be obtained. From the comparatively small bulk and weight of the component parts of the structure great facilities are afforded for transporting and erecting it. Thus, in less than three months from the date of the contract, the lighthouse about to be described was cast and erected on the contractor's premises, and it was expected to have the light exhibited in Jamaica in three months more. The whole expense was said not to exceed one-third the cost of a similar building in stone.

The structure was to be founded on a coral rock a little above the level of the sea; the face of the rock is about ten feet below the surface of the sand, and was to be excavated to receive the base of the tower, resting on and cased with granite, to prevent the natural filtration of the sea-water from acting upon the iron. This course of granite is grooved to receive the flange of the lower plates of the tower, from which lightning-conductors are to be continued to the sea. The tower is of course itself a lightning-conductor of the best kind. The diameter of the tower-shaft is eighteen feet six inches at its base, diminishing to eleven feet under the cap; it is formed of nine tiers of plates each ten feet in height, varying from one to three quarters of an inch thick. The circumference is formed of eleven plates at the base, and nine at the top: they are cast with a flange all round the inner edges; and when put together these flanges form the joints, which are fastened together with nut and screw-bolts, and caulked with iron cement. The cap consists of ten radiating plates, which form the floor of the light-room; they are screwed to the tower upon twenty pierced brackets, and are finished by an iron railing. The lower portion, namely, twenty- [108]
seven feet, is filled up with masonry and concrete, weighing about three hundred tons, and so connected with the rock itself as to form a solid core of resistance. The remaining portion of the building is divided into store-rooms and berths for the attendants in the lighthouse.

The light-room consists of cast-iron plates five feet high, on which are fixed metal sash-bars filled with plate-glass; these, terminating with a point, are covered with a copper roof, whence rises a short lightning-rod, trebly gilt at the point. The light is of the revolving kind, consisting of fifteen Argand lamps and reflectors, five in each side of an equilateral triangle, and so placed as to constitute a continuous light, but with periodical flashes. The Admiralty notice which announced the light for exhibition on the 1st November, 1842, states that the centre of the light is ninety-six feet above the level of the sea, and in clear weather the light can be seen from a distance of twenty-one miles.

To preserve as low a temperature as the circumstances and climate will permit, the iron shell was lined with a non-conducting material, as slate or wood, leaving an annular interstice, through which a constant ventilation is effected, so as to carry off the excessive heat.

To preserve the two lower tiers from rusting, they are coated with coal-tar. The tower itself is painted white. The only brasing which has been thought necessary is a few cross tiers at each horizontal joint, over which the iron-tongued wood-floors are laid.

The several rooms are provided with fire apertures, fitted with oak sashes filled with plate-glass. The approach to the doorway, which is about ten feet above the level of the sand, is by means of stone-steps; ladder-irons are also provided in the event of the stone-steps being carried away by a hurricane.

Over the entrance is a large tablet of iron supported by two smaller ones; and on them, on bas-relief, are inscribed the date of erection (1842), the names of the commissioners, of the engineer, [109]
founder, &c.

The whole of the castings were executed at the foundry (late Bramah and Robinson's) at Pimlico, and put together in the yard of the manufactory, prior to their removal to Jamaica, where

the work was re-erected by a derrick and crab from the inside, without the aid of any external scaffolding.

It is said that the whole expense of the lighthouse, including the passage over the Atlantic, did not exceed seven thousand pounds, and that the entire weight of the iron-work is about one hundred tons. The masonry was also prepared in this country, which (from the absence of building-stone in Jamaica) was found to be more economical than if the work had been done on the spot. Mr. Grove, as clerk of the works, and two labouring engineers, who had attended to the execution of the work in England, were sent out for the purpose of erecting the lighthouse, and the necessary apparatus upon the site which had been selected. The elevation of the lighthouse above the level of the sea is one hundred and three feet.

Since the completion of this lighthouse, Mr. Gordon has been employed by the Ordnance Office to furnish designs and specifications for a tower on the same principle, but of larger dimensions and improved details, which is to be erected on Gibbs' Hill, in the island of Bermuda.

[110]

Chapter IX.

THE LIGHTHOUSE SYSTEM.

Imperfect Illumination of the old Lighthouses—First Improvements—The Argand Lamp and Reflecting Mirrors—Revolving Lights—The Catoptric System—Varieties of Lights—The Dioptric System—Its Details—Introduction of this Method into Great Britain—Comparison of the two Methods—The Drummond and Voltaic Lights—Gurney's Lamp—Captain Basil Hall's Experiments—Ventilation of Lighthouses.

Since there is something more or less common in the modes of lighting and in the general economy of all lighthouses, a general view of the subject is likely to prove of more interest than particular details.

In consequence of the rotundity of the earth, the distance at which a beacon light ceases to be visible depends upon its elevation. The height to which a lighthouse may be carried is a simple question of expense. The greater part of the pharos of the Romans were much higher than the most celebrated modern towers. Yet, as it respects optical effect, the feeble rays which were diffused from the wood or coal-fires at their summits, could never have traversed the thick fogs which in all climates occasionally overspread the lower regions of the atmosphere.

Nevertheless, as to the strength of the light, the modern lighthouses were, until lately, little superior to the ancient. At the time of the erection of the Eddystone lighthouse civil engineering was greatly in advance of practical optics. That noble structure was lighted by tallow candles, without reflectors or the aid of any kind of apparatus for concentrating the light. 'For more than half a century this feeble light was all that directed the mariner in the very high-road of commerce.' So late as the year 1811 it was lighted with twenty-four wax candles. In 1812 the Lizard lighthouse, certainly one of the most important in the kingdom, was maintained with coal-fires. The Bidstone, a leading light to the port of Liverpool, was furnished with an enormous spout lamp, with a wick twelve inches in width, the smoke from which was so great as to completely darken the upper surface of its reflector. The first important improvement was the introduction of that admirable invention the Argand Lamp, with a double stream of air. Four or five of these lamps would doubtless give as much light as the large fires kept by the Romans; but if those lamps are furnished with reflecting mirrors, the luminous effect is prodigiously increased.

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The light of inflamed bodies spreads itself equally in all directions. One portion is absorbed by the ground, another is dissipated in space. The navigator, whose route we are anxious to enlighten, profits only by the rays that proceed in a horizontal direction, or nearly so, from the lamp to the sea. But such of the horizontal rays as are directed towards the land are of course entirely lost to the purposes of the lighthouse. This zone of horizontal rays forms not only a very small portion of the total light, but has also the serious inconvenience of becoming much weaker by divergence, so as to convey to a distance but a very feeble light. To destroy this divergence, and to profit by all the light of the lamp, was the task to be accomplished, before lighthouses could be rendered useful to the full extent.

The application to this purpose of deep metallic mirrors, known under the name of parabolic mirrors, has been found effectual to the purposes required. When a lamp is placed in the focus of such a mirror, all the rays which emanate from it are reflected from the polished surface, and converge in one direction: their original divergence is destroyed, and they form, as they issue from the apparatus, a cylinder of light, parallel with the axis of the mirror. This light would be transmitted with undiminished brilliancy to a great distance, did not the atmosphere absorb a portion of it.

It must, however, be admitted, that this method is not free from defect. It is true, we direct towards the horizon of the sea, a vast number of rays, which would have been lost upon the

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ground, in space, or landward; we also destroy the primitive divergence of those rays which fall within the range of the seaman; but the cylinder of reflected light is of no greater size than that of the mirror; the zone which it illuminates has precisely the same dimensions, at whatever distance, and, unless we employ a number of similar reflectors differently inclined, there will be a number of large spaces in the horizon completely obscure, from which the pilot will never see any signal whatever. This serious objection has been removed by imparting, by means of clock-work, a uniform rotatory motion to the reflector. The collection of rays proceeding from the mirror is thus directed to all the points of the horizon in succession. Every vessel perceives the signal-light during one instant, and immediately after it is seen to disappear; and if, in a great extent of coast, the different lights revolve in different times, the various signals become thus individualized. According to the interval of time, which elapses between two successive appearances or eclipses of the light, does the sailor recognize the part of the coast which is in view: he is thus no longer liable to mistake a planet, or a star of the first magnitude, at its rising or setting, or a fire lighted on the coast by fishermen, charcoal-burners, &c. for the light of the lighthouse; mistakes, which have often led to the most deplorable wrecks.

The reflectors originally employed were casts in plaster of Paris, from a mould formed to the parabolic curve, and lined with facets of mirror-glass. The power of these reflectors, however, was comparatively small, from the reflecting surface being composed of numerous pieces, in each of which only one point coincided with the curve of the parabola.

The Trinity House having been at great pains to improve the reflecting apparatus on the coast of England, with the advice and assistance of eminent scientific men, adopted parabolic reflectors made of silvered copper; and these, from their superior effects, have ultimately been introduced [113] into all the lighthouses of the united kingdom. In the northern lighthouses, the reflectors consist of copper coated with silver, in the proportion of six ounces of silver to one pound avoirdupois of copper, which are rolled together, and then, with much labour and great nicety, by a process of hammering and polishing, formed to the parabolic curve of a mould made with mathematical precision. The focal distance of the curve is four inches. The diagram for the Bell-Rock reflectors was drawn by Professor Leslie, and the mould was made by Mr. Adie the optician. The powers of this elegant production of the mechanical art are said to be quite astonishing; and by comparing its highly-polished and regularly-curved surface with the previous glass reflector, the superiority of the former seems to be immense: indeed, its influence extends to the horizon formed by the height of the lighthouse-tower and the earth’s curvature. The reflectors in general use measure over the tips twenty-one inches as applicable to stationary, and twenty-live inches for revolving lights.

The Catoptric or reflecting system was first adopted under the direction of Borda, at the Corduan Lighthouse, probably about the year 1780. The system was soon introduced into England; and one of the first acts of the Northern Lights’ Board, so early as 1786, was to substitute reflectors in place of coast-lights, which till then had been the only beacons on the Scotch coast.

In the improved lights the best spermaceti oil and the Argand lamp have been introduced. The keepers are professionally adepts in the management of lamps; and should a drop of oil be spilt, the floor is covered with painted floorcloth to receive it. The Argand lamp-burners are tipped with silver, to prevent the waste and imperfection to which copper is subject, from the excessive heat of the burner.

In appearance the lights may be classed as *stationary*, *revolving*, *flashing*, and *intermittent*. In the first, as its name implies, the light has a steady and uniform appearance, and the reflectors, which are smaller than those used for revolving lights, are ranged in circular zones upon a [114] chandelier or piece of iron frame-work, with their axes inclined at such an angle as shall enable them to illuminate every part of the horizon. The *revolving* light consists of a frame built upon a perpendicular shaft, and the reflectors, which are of large size, are ranged on perpendicular planes or faces, which are made to revolve in periodic times, by means of a train of machinery kept in motion by a weight. When one of those illuminated planes or faces is brought towards the eye of the observer, the light gradually increases to full strength: when, on the contrary, the angle between two of these faces comes round, the observer is in darkness. By these alternate changes, the characteristic of the lighthouse is as distinctly marked to the eye of the mariner as the opposite extremes of light and darkness can make it. The *flashing* light is a modification of the revolving light, and is practically a beautiful example of the infinite celerity of the passage of light. The reflectors are here also ranged upon a frame, with faces which are made to revolve with considerable rapidity; and the light thus emerging from a partial state of darkness exhibits a momentary flash, resembling a star of the first magnitude, and thereby produces a very striking effect. The *intermittent* light bursts suddenly into view, like a star of the first magnitude, and continues a stationary light a minute and a half, when it is as suddenly eclipsed for half a minute; and by this simple arrangement a strongly marked distinction in the lights of the coast is introduced. This is accomplished by the perpendicular motion of shades before the lights. A variety of all these lights is introduced by interposing before the reflectors plates of red glass, which produce the beautiful red light alluded to in the lines of Sir Walter Scott, when he notices the ‘ruddy gem of changeful light.’ The red and white light is caused by the revolution of a frame on the sides of which the lights are placed alternately, with and without coloured media. There are varieties in this kind of light, some being so arranged that two white lights should be seen in succession, and then one red; and others, that two red should be seen, and then one white. When [115] there is a necessity for what is called a *leading-line*, as a guide for taking some channel, or

avoiding some danger, *double lights* are exhibited from two towers, one of which is higher than the other; and when seen in one line, these form a direction for the course of the shipping.

When the French were recovering from the long night of terror, during which their commerce had been ruined and their ships disabled, they directed attention to lighthouses, and resolved to discard the very imperfect and insignificant reflectors then in use. They investigated the subject with their usual scientific skill, and the result was the invention and adoption of the system of lenses instead of reflectors, known as the Dioptric system.

A transparent lens reduces to parallelism all the luminous rays which traverse it, whatever be their original amount of divergence, provided these rays proceed from a point or focus suitably situated. The substitution of glass lenses for reflectors is not a new idea, since we find that a proposal to that effect was made by a London optician to Mr. Smeaton, in 1759, for illuminating the Eddystone lighthouse, but was not adopted by him. M. Fresnel mentions that lenses had been used in England so far back as 1789, in the tower light-room at Portland Island, but from some cause or other were discontinued.

On account of the great loss of light by reflexion at the surface of mirrors, the French adopted the lenses, and they soon discovered the source of failure in our use of them; they saw that, in order to render lenses superior to reflectors, the intensity of the illuminating flame must be considerably increased, as well as the size of the lenses; also, that these lenses must have a very short focus; and that, if constructed by the ordinary rules, their thickness would be great, their transparency diminished, and their weight far too great for the safety of the machinery whereby the lights were revolved. Fresnel therefore adopted the ingenious device proposed by Condorcet, that of constructing a lens of a number of distinct pieces. This method was also proposed by Dr. Brewster, in 1811. Fresnel also invented a lamp, with a number of concentric wicks, the lustre of which was twenty-five times greater than the best lamps then existing. [116]

In a lighthouse on the dioptric system, the lantern is constructed with eight sides, which form an octagonal prism around the lamp in the centre. The centre of each side is occupied by a plano-convex lens, something similar to a burning-glass, having a diameter of about fifteen inches. This central lens is not sufficient to cover the entire side. Indeed, a lens of sufficient size for the purpose would be very costly and bulky, even supposing it could be manufactured. To remedy this defect, the central lens is surrounded by a series of glass rings, the external surface of which is so formed as to have precisely the same optical effect as the great central lens. A transverse section of one of these zones or rings presents the form of a wedge, one side of which is slightly curved.

By this arrangement each lens transmits to all the points of the horizon in succession a light equivalent to that of from three to four thousand lamps with double currents, and eight times greater than the light produced by the silver parabolic reflectors; it is, according to Arago, the same amount of light as would be obtained if it were possible to bring together the third of the whole number of gas-lights which illumine the streets, the shops, and the theatres of Paris; and this wonderful result is obtained from a single lamp.

This lamp has four concentric burners, which are defended from the action of the excessive heat produced by their united flames, by means of a superabundant supply of oil, which is thrown up from the cistern below by a clock-work movement, and constantly overflows the wicks. A very tall chimney is necessary in order to supply fresh currents of air to each wick with sufficient rapidity to support the combustion. The carbonization of the wicks is not very rapid; and after they have been burning a long time, the flame is not sensibly diminished, as the great heat evolved from the mass of flame promotes the rising of the oil in the cotton. [117]

In the year 1820, in the course of some investigations connected with the Trigonometrical Survey of Great Britain, and conducted by a deputation of scientific persons from London and Paris, M. Fresnel exhibited from the French side of the channel, by means of his lens and a large lamp, a powerful light which was observed by the English across the channel. The brilliancy of this light so struck Lieut.-Col. Colby, of the Royal Engineers, who was engaged in these observations, that he immediately corresponded with Mr. Stevenson as to its probable use upon the Scottish coast. A considerable time was occupied in inquiry and negotiation, when at length, on the 26th October, 1836, the light at the Isle of May was changed from the catoptric to the dioptric system, and a committee of the Royal Society of Edinburgh met at Dunbar, a distance of thirteen miles from the lighthouse, to make observations on the two lights, which were exhibited in contrast. In their report they conclude:—

‘1. That at a distance of thirteen miles the mean effect of the new light is very much superior to the mean effect of the old light (perhaps in the ratio of two to one). 2. That at *all* distances the new light has a prodigious superiority to the old, from the equality of its effects in all azimuths. 3. That the new light fulfils rigorously the conditions required for the distribution of light to the greatest advantage. 4. That at distances much exceeding thirteen miles, the new light must still be a very effective one, though to what extent the committee have not observed. The light is understood to be still a good one, when seen from Edinburgh at a distance of about thirty miles.’

On a further comparison of results, it was found that the light of one of the great annular lenses, used in the revolving lights of the first order, was equal to the united effect of about eight of the large reflectors employed in the revolving lights on the Scottish coast. At the Isle of May and Inchkeith the quantity of sperm-oil consumed by the great lamp is equal to that burned by fourteen of the Argand lamps used in the Scotch lights. Hence by dioptric means the [118]

consumption of oil necessary for the fourteen reflectors will produce almost as powerful a light as that which would require the oil of twenty-four reflectors in the catoptric system, and consequently there is an excess of oil equal to that consumed by ten reflectors, or four hundred gallons in the year against the Scotch system.

The Dutch were the first to adopt Fresnel's system. In the year 1834 the Commissioners of Northern Lighthouses sent Mr. Alan Stevenson to Paris to inspect the system, and his report was so favourable, that the reflecting apparatus of the revolving light at Inchkeith was removed, and the dioptric instruments substituted. The new light was exhibited on the evening of the 1st of October, 1835, and so great was the satisfaction afforded, that a similar change was made at the fixed light of the Isle of May. The Trinity-House of London followed next in adopting the improved system, and a revolving dioptric light of the first order was erected at the Star Point in Devonshire.

In the lighthouses of this country sperm-oil is the most usual fuel. In France[6] an oil is burned called Colza oil, expressed from the seeds of a species of wild cabbage. In the lighthouses on the Mediterranean olive-oil is used. In a few lighthouses near large towns coal-gas has been advantageously adopted. Much also has been said in favour of the Drummond and Voltaic lights, which, on account of their prodigious intensity would appear to be most desirable; but the uncertainty which attends their exhibition renders it at present impossible to adopt them: but there is a yet more fatal objection—the smallness of the flame renders them wholly inapplicable to dioptric instruments, which require a great body of flame in order to produce a degree of divergency sufficient to render the duration of the flash in revolving lights long enough to answer the purpose of the mariner. [119]

In the year 1835, Mr. Gurney proposed a lamp of great power in which the flame of oil or wax was sustained by streams of oxygen gas, a method said to be more economical than the combustion of oil in atmospheric air. The Trinity House entertained the proposal, and instituted a number of experiments. In applying this light to reflectors it is intended to use three small flames, each about three-eighths of an inch in diameter, productive, it is said, of an effect equal to that of ten Argand lamps. But for lenses the burner has seventeen films of flame, and is said to possess six times the power of the Fresnel lamp.

In the year 1840, Captain Basil Hall instituted a series of experiments to ascertain whether the well-known superior brilliancy of a revolving light could not be obtained for a fixed or continuous light, that is, for one equally visible in all directions at the same moment. His idea was, that by giving a certain velocity of revolution to a series of lenses round a fixed light, as in Fresnel's arrangement, a continuity of illuminative power, equal almost in brilliancy to that of a slowly revolving light, might be produced. The apparatus was arranged so as to cause a series of eight lenses one foot in diameter and three feet focal distance to revolve with any velocity up to sixty revolutions per minute round a central lamp. The light from this lamp being concentrated by refraction through the eight lenses into eight pencils, having a divergence of about eight degrees each, illuminated when at rest not quite fifty degrees of the horizon; but when this system of lenses was put into rapid motion, every degree of the three hundred and sixty degrees of the horizon became illuminated, so that to spectators placed all round the horizon the light would appear continuous and equally brilliant in every direction. The only question would be, whether or not this continuous light is essentially less intense than the light seen through the lenses at intervals when in slow motion; and this is a point which further inquiry must decide. [120]

One of the causes which has tended to improve the brilliancy of lighthouses, has produced inconveniences, which long existed without remedy. During the combustion of a pound of oil, the union of its hydrogen with the oxygen of the air produces more than a pound of water in the state of vapour. When a cold wind is blowing upon the lantern of the lighthouse from without, this vapour is condensed into water upon the inner surface of the glass, and in very severe weather forms a crust of ice, in some cases, as much as four inches thick in the course of one night. This not only very much dims the brilliancy of the light to the sailor, but also entails a great amount of labour on the light-keepers, and injury to the lantern. The combustion of the oil also produces a large quantity of carbonic acid gas, which is of a very deleterious nature, and in many cases rendered the light-keepers' rooms almost uninhabitable. Under these circumstances, the Trinity House made application to Dr. Faraday to investigate the subject, with a view to the discovery of some remedy. With his usual skill and sagacity, Dr. Faraday instituted a number of inquiries and experiments, and visited some of the principal lighthouses. The result was the contrivance of a complete method of ventilating lighthouses. On the dioptric system, the remedy was simple: it was merely to erect a tall chimney over the central lamp, and lead it out at the roof; by which means, the draught of the lamp was improved, and all the products of combustion carried off. On the catoptric system, with revolving lights, each lamp was furnished with a chimney, which passed out at its upper extremity, through a small hole in the reflector into a fixed central hollow shaft, which served the purpose of a ventilating chimney to all the lamps. These plans are said to have been eminently successful in removing the inconveniences, which rendered the light less efficient, and the lighthouse an unwholesome and even dangerouse place of abode.

[6] In the year 1836 the coast of France were provided with no less than ninety-six lighthouses.

THE END.

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These suggestions he is now carrying out, in compliance with certain conditions, namely, that the works produced shall be unexceptionable in subject and in treatment; that the series be sufficiently varied to meet the requirements of all classes of readers; and that each book shall be complete in itself, and procurable for a very small sum.

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A History of the French Revolution; its Causes and Consequences. Newly written for this Collection.

The Ruins of Rome and their Historical Associations; including an Account of the Modern City and its Inhabitants.

The Private Life, Manners, and Customs of the Ancient Romans. From the French of D'Arnay; carefully edited, and forming a valuable work for study or amusement.

Constantinople and its Historical Associations; with some Account of its Institutions and the Manners and Customs of the People.

History of the Rise and Progress of the Trading Communities of the Middle Ages.

Trading Communities of Modern Times; a Popular View of the Origin, Structure, and General Tendency of the Joint-Stock Trading and Commercial Bodies of Modern Times.

The Ruins of Athens and their Historical Associations; with Notices of the Modern City and its Inhabitants.

A History of London, Ancient and Modern.

A History of the Endowed Schools of Great Britain.

The Incas of Peru, with some Account of the Ruins of their Greatness.

A popular History of the British Army.

A popular History of the British Navy.

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II. Popular Biography.

One of the most useful and pleasing forms under which knowledge can be presented to the general reader is that of the Biography of distinguished men, who have contributed to the progress of that knowledge in some one or other of its various departments. But it too frequently happens, that the biographical notices of great men consist rather of personal, trivial, and unimportant details, than of a clear and broad outline of the influence which they exerted upon the pursuit and upon the age in which they were distinguished. The true object of Biography is, while tracing the progress of an individual, to show not only what result his active life has produced on the well-being of his fellow-men, but also the position which he occupies as one of the "great landmarks in the map of human nature."

Yet we are not satisfied with a biography which regards its subject in his public capacity alone: we are naturally curious to ascertain whether the same qualities which rendered him celebrated in public, followed him likewise into private life, and distinguished him there. We regard with interest, in his private capacity, the man who has been the originator of much public good: we look with an attentive eye on his behaviour when he stands alone, when his native impulses are under no external excitement; when he is, in fact, "in the undress of one who has retired from the stage on which he felt he had a part to sustain."

But a detail of the public and private events in the life of a distinguished man, do not alone suffice to form a just estimate of his character. The reader requires to be made acquainted with the state of a particular branch of knowledge, at the time when the individual appeared, whose efforts extended its boundaries. Without this it is impossible to estimate the worth of the man, or the blessings and advantages conferred upon society by his means. [7]

On the other hand, in tracing the history of any particular branch of knowledge, unless connected with Biography, we lose sight of individual efforts; they are mingled with the labours of others, or are absorbed into the history of the whole, and are consequently no longer individualized: hence we are likely to fail in recognising the obligations due to our distinguished countrymen, or to deprive of their just merit those of our foreign brethren, whose useful lives have influenced distant lands as well as their own.

With these views it is proposed that each Biography shall consist of three distinct portions:

1 The history of a particular department of knowledge, up to the time when the individual appeared by whom its boundaries were extended.

2 A *general* sketch of the life of such individual, with *particular* details of the improvements effected by him.

3 The progress of such branch of knowledge, from the date of such improvements up to our own times.

The following subjects will be immediately published:

Smeaton and Lighthouses.
Sir Joseph Banks and the Royal Society.
Sir Humphrey Davy and the Safety Lamp.
Linnæus and Jussieu; or, the Rise and Progress of Systematic Botany.
Cuvier and his Works; or the Rise and Progress of Zoology.
Brindley and Canals.
Watt and the Steam-engine.
Wedgwood and Pottery.
Telford and Roads and Bridges.
Caxton and the Printing Press.
Galileo and the Telescope.
Sir Isaac Newton and the Progress of Astronomical Discovery.
Sir Christopher Wren and St. Paul's Cathedral.
Addison and the English Essayists.
Jeremy Taylor and some Account of his Times and Works.
Wilberforce and the Slave Trade.

Each work being a Popular Biography, with an Historical Introduction and Sequel. [8]

III. Popular Science and Art.

When we contemplate the arts and processes of civilized life, we cannot but be struck with the vast amount of invention and ingenuity required for their gradual development. Not an article of clothing or of furniture, not an instrument, implement, or machine, could have been brought to the state in which we find it, without many successive steps of invention, due to different minds, supplied at different times, and brought to light in different countries. But in devoting several of our volumes to the Useful Arts, we shall not be unmindful of the fact, that Art is the application of Science to a practical end. It is proposed, therefore, under the comprehensive title of *Popular Science and Art*, to include portions of our knowledge of animate and inanimate nature. The object will be to assist the general reader to regard with an intelligent eye the varied phenomena of nature, to gratify the laudable desire of understanding what he sees, and of preparing him in some measure to enter more fully upon the study of a given subject. In this way, it is hoped to effect a useful purpose, by connecting Science and the Useful Arts; for "it is not, surely, in the country of Arkwright, that the Philosophy of Commerce can be thought independent of Mechanics; and where Davy has delivered lectures on Agriculture, it would be folly to say that the most philosophic views of Chemistry were not conducive to the making our valleys laugh with corn."

The works already prepared, or in course of preparation, for this division, comprise the following subjects:

The Useful Arts employed in the Production of Food.
The Useful Arts employed in the Production of Clothing. 2*s.* 6*d.* 2*s.* 6*d.*
The Useful Arts employed in the Construction of Dwelling Houses. [9]
The Writing-Desk and its Contents, taken as a Text for the Familiar Illustration of many important Facts in Experimental Science. 2*s.*
Examples of Mechanical Ingenuity.
The Philosophy of the External Senses.
Ancient and Modern Modes of Measuring Time, with curious Illustrations of the application of Clockwork.
The Rise and Progress of Agriculture.
The Natural History of Birds and Insects injurious to Farming and Gardening.
The Wonders of the Microscope.
Mathematical Magic.

The Fine Arts will also form an interesting portion of this division. The object will be, in a few popular histories, to trace the origin, rise, and progress of Sculpture, Painting, Engraving, Music, &c., and their influence on mankind.

IV. Popular Voyages and Travels.

Few subjects are more attractive than the narratives of celebrated travellers. Although they tell us of beings who speak another tongue, inhabit a different clime, differ altogether from ourselves in manners, customs, dress, and institutions—yet the sympathy which man feels for his fellows makes us delight in all the details which talent and enterprise procure for us. The personal narrative of the traveller has also a great charm; we seem to participate in his dangers, excitements, and pleasures; we add to our knowledge in his company; and the truth and sincerity

which pervade the narrative, make us feel a personal interest in the narrator. It is intended to reprint some of the narratives of our old English Navigators, especially those of Discoveries, which have had most influence on the progress of Geographical Knowledge. It will not be an objection that these eminent men lived at a period of time distant from our own; for their Narratives are full of truths, told with plain simplicity. [10]

But the important labours of modern travellers will not be forgotten. In describing several interesting portions of the earth's surface, we shall avail ourselves of the most trustworthy individuals, and by a careful comparison of statements and details, we hope to present graphic descriptions of some of the most celebrated countries of the world; as well as of those which have only of late years been explored. Many voyages of discovery have had their proceedings recorded in large quartos, the price of which places them above the reach of the general reader, while their scientific details render them unfit for popular use: a digest of these works, containing an epitome of the lighter portions, and the results of the scientific discoveries, may prove acceptable.

The following works are being prepared for publication:

The Life, Adventures, and Discoveries of Captain William Dampier; including a History of the Buccaneers of America.

Captain Cook and the Circumnavigation of the Globe.

An Overland Journey and a Steam Voyage to India.

Voyages and Discoveries in the South Polar Regions.

Voyages and Discoveries in the Northern Polar Regions.

Voyages and Discoveries in Australasia and Polynesia.

To these will be added digests of Travels and Adventures in various Countries of the Old and New Worlds.

V. Popular Tales and Fiction.

The design of this Collection embraces many favourite old works, which, though containing much that has instructed and delighted our predecessors, are, nevertheless, but ill adapted in their original form for general perusal. Among these may be reckoned some works of fiction, the excellencies of which are often obscured by a grossness of style not uncommon at the time when they were composed, but which justly excludes them from family-reading in the present day. [11] Such works would be acceptable if freed from objectionable passages; and in undertaking to accomplish this reform, without detriment to the spirit of the original, the Publisher relies on the approbation of a large class of persons, who will thus be enabled to place in the hands of the young, purified editions of those romantic and interesting tales which are naturally sought for by youthful readers, whose hands they might otherwise reach, tainted with their original impurities. Every work will be prepared for this series by a careful editing, in order to suit the general tone of thought, principle, and feeling which will pervade the whole Collection, and no work will be admitted, the name of whose author is associated with considerations painful to Christian feeling, good taste, or propriety.

Among the new works intended to be included in this division, may be mentioned a series of tales, illustrative of the manners and customs of the people of different climes. Of these, the following, among others, are ready for early publication:

Norah Toole, a Tale of Ireland; My Son Mike, or, the Irish Emigrant in the United States; and Rob Maxwell, a Tale of the Highlands of Scotland.

The Spanish Merchant and his Daughter, or, Life in Spain; a Tale illustrative of Domestic Manners and Customs.

Van-ti, or, Life in China; The Leicesters, or, Life in Hindostan.

The Merchant and the Friar; or, Truths and Fictions of the Middle Ages. A New Edition, revised by the Author.

The Life and Adventures of Peter Wilkins, a Cornish Man. Carefully revised and corrected.

The most Delectable History of Reynard the Fox; an old Romance, thoroughly revised and corrected.

The Life and Adventures of Robinson Crusoe, newly revised; with a new Introduction, and Illustrations.

[12]

VI. Popular Miscellanies.

Under this head will be published, works of a miscellaneous nature which do not fall strictly under any of the foregoing divisions, or which may include several of those divisions. Among the former may be mentioned a short series of works on in-door and out-door amusements, the object of which is to furnish young persons with sources of amusement, innocent in their kind, and healthful in their application both to mind and body. Among the in-door amusements may be mentioned a volume which is nearly ready for publication on the game of Chess. Experience has shown that where Chess is introduced as an amusement into families and schools, it exerts a

highly beneficial influence, by exciting a taste for more exalted sources of recreation than are afforded by *games of chance*, which so far from producing a beneficial influence on the mind, are apt to disturb the temper, excite animosity, and foster a spirit of gambling. Chess, on the contrary, is an effort of pure skill; it gives healthy exercise to the mental powers; it requires caution and forbearance on the part of both players; it leaves the victor satisfied with having won the game without the additional stimulus of 'a stake;' and it entails no humiliation on the vanquished, but rather prompts him to greater exertions. We propose, therefore, to give the history and antiquities of the game of Chess, together with a series of Easy Lessons, the object of which will be to make the young student acquainted with a few of the leading features of the principal openings, that he may form some idea of the richness of the territory of Chess, and to add a selection of Chess Problems. Chess Problems form one of the most attractive departments of the game; they enable us, more perhaps than anything else, to appreciate the subtle skill and resources of a first-rate player, and tend to elevate Chess to the rank of mathematical science. [13]

Among the works which include several of the foregoing divisions, is one in four volumes, illustrating the Progress of the Year, wherein the information given is arranged under the form of Daily Headings. All the varied phenomena of nature; the animals, the plants, the minerals, assume different phases, according to the means and acquirements of the observer, the progress of science, and the climate under which the descriptions are given. As science advances, the descriptions of naturalists admit of modification and addition, in order to keep pace with the progress of discovery; hence our Year-books require renewal from time to time. The present is an attempt to furnish a seasonal account of the natural phenomena of the year, in conformity with the present state of knowledge. The work, however, will not be confined to natural history, but will be varied with notices of the arts, antiquities, manners and customs of our native country; choice selections from our prose writers and poets; and a series of papers expressly adapted for Sunday reading, so that on whatever day, and at whatever season, the book be taken up, something appropriate of an instructive and amusing nature may be found, calculated either for family reading, or solitary perusal, as a fireside manual, or a travelling pocket companion.

The following works are intended for early publication:

Chronicles of the Seasons, or the Progress of the Year; being a Course of Daily Instruction and Amusement from the Popular Details of the Natural History, Science, Art, Antiquities, and Biography of our Father Land. In Four Books. Book the First, containing the Months of January, February, and March.

3*s.* 6*d.*

The History, Antiquities, and Curiosities of the Game of Chess; including a Selection of Games, illustrative of the Various Openings, Analyzed and Explained for the use of Young Players; together with a Choice Selection of Chess Problems. [14]

The Sea—the Highway of the World; or the History and Practice of Navigation, in Ancient and Modern Times, familiarly explained.

The Houses of all Nations; or some Account, Historical and Descriptive, of the Progress of National and Domestic Architecture in all Parts and Ages of the World.

The Games and Sports of the Ancients and Moderns.

An Account of Shipwrecks, Fires, and other Calamities, at Sea.

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