Sir FREDERICK ARROW said, although familiar with the details of the work, he was struck, as the Paper was being read, with the mention of the late Mr. Robert Stevenson (M. Inst. C.E.) in connection with the undertaking, and the time that Engineer estimated it would take to build a lighthouse on the Wolf Rock, and the sum it would cost. Great progress had been made in engineering science in the interval. It was not that Mr. Stevenson was under the mark; but that the progress of engineering, and the intelligence that pervaded all classes of Engineers, had enabled the work now to be brought to a practical success, at a much less outlay of time and of money. That it had been so was a source of thankfulness, not only to the Elder Brethren of the Trinity House, but to the community who paid for these lighthouses, which were a great boon to trade and commerce, and a blessing to humanity. The Wolf Rock, which was only uncovered for a short time during every tide, was until a few months ago the dread of the mariner, and, as a seaman, he had passed many an anxious night in its vicinity, thinking of the danger, and seeking to avoid it; but in taking a ship past it now, he should seek the path of safety, which the lighthouse afforded. Great personal as well as moral courage had been displayed in carrying out this work, which was so beset with difficulties and dangers, that the people engaged upon it might be said frequently to have carried their lives in their hands.

Mr. VIGNOLES, President, took the opportunity of observing, on the similarity of names, that the Robert Stevenson alluded to in the Paper was the late Engineer of the Commissioners of Northern Lights, and not Robert Stephenson the railway Engineer. It was only due to Mr. Robert Stevenson, whose great work was seen in the Bell Rock lighthouse, and to his sons who were successfully following the same path, that this distinction should be made, inasmuch as some of the younger members of the Institution might not be aware of it.

Mr. W. PARKES congratulated Mr. Douglass on having completed this important work. The Paper was one of a class which gave but little field for discussion. There was nothing in the design which called for criticism. The original type, the Edystone, had, in all cases of rock lighthouses, been followed with comparatively little variation; and the improvements effected had generally been from the greater facilities of carrying out the work; for instance, Mr. Douglass had spoken of the employment of steam, and he thought there were some improvements in the methods of landing the stones since Smeaton's time, which seemed to have been exceedingly complete in this case. It was only on studying the Paper, that the merits of this work could be thoroughly appreciated. It was in the perseverance from day to day, and in watching every opportunity, even with risk to life, to get a few hours' work at a time

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on the rock. The little he had himself done in this way was not to be compared with the dangers and difficulties which the Author and his assistants had contended with. With regard to the details of construction, he would ask Mr. Douglass whether, with the excellent material now obtainable, it might not be possible to reduce the work in the most difficult part, viz., in preparing the foundation? He thought time would be saved if a bed were cut for the outside ring of stones only, instead of over the whole area of 40 feet in diameter, and if the interior was levelled up with rubble work, in Roman or other quick-setting cement. Considerable advance had been made since Smeaton's time in the manufacture of cement. No doubt the mortar which was used at the Edystone was first-rate of its kind, though far inferior to the cement of the present day. In works exposed to the force of the sea, Portland cement when once set was almost as good as stone itself. At Dover and at other places, where fine granite masonry was used, the granite had separated rather than the cement. The dovetailing system was originally introduced by Smeaton, but then he had only hydraulic lime mortar, which, though good of its kind, was comparatively slow-setting. It appeared that a course of stones in this work was carried away by a heavy storm, but there was evidence of wreck having struck it. Would it be possible for the sea itself, without the assistance of wreck, to carry away a course, or part of a course, of stones solidly set in Portland cement? He thought not, and that it would be like the solid rock itself. The cutting of the stones into complicated shapes must be a source of considerable expense, and although the cutting was done on shore it must, he thought, involve some complication in the setting of the work, and he would ask the Author to state his opinion upon the real advantage of that from his own experience. Mr. Parkes was satisfied that, in any position where the work was exposed to the action of the waves, a stone tower was the only kind of structure that ought to be attempted. He believed every cast-iron lighthouse so exposed had been more or less a failure. The first was the Bishop, which was washed away: a stone tower was substituted, and it stood. Then there was the Great Basses lighthouse, on which Mr. Douglass' brother was now employed. In that an amount of money was spent in cutting the foundation and erecting a flagstaff equal to the whole cost of the Wolf Rock lighthouse; and the difficulty was enhanced by the great amount of work required in cutting the foundations for the cast-iron plate lighthouse. That could not be said to be a failure, however, of the structure itself, because the original design was never carried out. In the case of the Roman Rock lighthouse, in Simon's Bay, Cape of Good Hope, three years were occupied in preparing the foundation on the rock, and the lighthouse was erected in a short time;

but a few weeks after completion it cracked, and had to be patched up.¹ He was not aware of any other case in which iron lighthouses had been commenced under the wash of the waves. Although all the stone lighthouses had succeeded admirably, he thought the adoption of them might be carried too far; and that for Engineers to adopt this plan of lighthouse, in positions free from danger from the sea, when a different structure might be erected to answer all the purposes in much less time and at much less cost, was an evidence of some want of original resources.

MR. GREGORY, Past-President, said that although there might be few who were in a position to criticise the Paper, or enter into the discussion of it, still all must admire the perseverance and the ability displayed in carrying out the work. The great element of success in such a work was, as recorded by Smeaton in his celebrated "Narrative," the overcoming of difficulties which presented themselves day by day, and which occupied and absorbed the brain and life of the Engineer; while at the same time they give very little note of their existence, and could only be thoroughly known by those who had sustained such labours themselves. Having, in conjunction with other members of the Institution, been appointed a juror at the Paris Exhibition of 1867, he might remark that the two branches of construction in which English Civil Engineers chiefly distinguished themselves were in machines for the destruction of their kind—great guns and materials of warfare—and in appliances for saving life, and especially in lighthouse structures and apparatus, to which the Trinity House so largely contributed. He might add that the French Engineers, who had thoroughly mastered this subject, expressed great admiration at the Exhibition of lighthouse apparatus, which illustrated the position of that science in Great Britain, and bore testimony to the perfection of the works carried out by the Trinity House under the direction of such men as Sir Frederick Arrow, the Deputy Master and the other Elder Brethren, and under such practical Engineers as the Author of this Paper.

DR. W. POLE, while bearing his tribute of admiration, both to the work and to the Paper, would only make a remark or two on an incidental point, namely, the arrangement for signalling during the prevalence of fogs. The provision here, as in most other cases, was by means of a bell, struck at intervals; but a bell was not very powerful for the purpose; he believed its sound was less penetrating in a foggy than in a clear atmosphere, and vessels might come into dangerous proximity with a rock without either seeing the light or hearing the bell. The subject was an important one,

¹ *Vide Minutes of Proceedings Inst. C.E., vol. xxviii., p. 49.*

and it had been long under the consideration of the Corporation of the Trinity House. He had lately had an opportunity of inspecting a new apparatus erected at the St. Catherine's lighthouse in the Isle of Wight, and probably some account of it might be interesting. The instrument was, he believed, an American invention, and consisted of a large metal horn blown by compressed air, and giving a very powerful piercing tone. The sound was produced, however, not on the principle of the ordinary horn or trumpet, but on that of the clarinet, or the brilliant trumpet pipes of an organ. The tone in these was due to what was called a reed—a thin tongue of elastic material, placed so as to cover a long opening, or slit, leading into the pipe of the instrument. The reed was fixed at one end, the part over the opening being left free to vibrate. When it was attempted to drive a current of air into the tube through the slit covered with the reed, the latter, by its flexibility and elasticity, alternately covered the opening and left it again, allowing a jet of air to enter the tube every time the opening was left free. By this action the reed was set in quick vibrations, and the puffs of entering air, following each other in regular succession, and with great rapidity, gave rise, on well-known acoustical principles, to a musical tone. The fog-horn was on this construction, but with all its parts magnified to colossal dimensions. The reed, instead of being, as in the clarinet, a thin strip of wood, or, as in the pipes of an organ, a small leaf of brass, was here a thick plate of hard steel 5 inches long, 2 inches wide, and $\frac{1}{4}$ of an inch thick at the root, tapering to $\frac{1}{8}$ th of an inch at the loose end. This was enclosed in a box, communicating with the reservoir of compressed air. The air, after passing through the opening over which the reed was placed, entered the main tube of the horn, which was of brass, 8 feet or 10 feet long, gradually expanding in diameter till it finished in a bell-mouth 2 feet wide. The tube was placed vertically, and passed through the roof of the building, its upper part being bent into an elbow, so as to make the bell part horizontal, delivering its sound straight out to sea. The pressure of air required to sound the horn was from 5 lbs. to 10 lbs. per square inch. In the apparatus Dr. Pole saw, it was compressed by a hot-air engine, also of American contrivance; but this seemed to him clumsy and complicated, troublesome to manage, and possibly not altogether trustworthy; and he would venture to suggest to the authorities of the Trinity House, whether a small steam engine would not be much simpler, and more to be depended on. As the headland where this apparatus was erected stood well out in the Channel, it was necessary to extend the signals over the whole southern semicircle from east to west. To enable the horn to cover this large extent of arc, it was made to revolve slowly, so as to

present its bell successively in all directions, and so to deliver its warning to all parts of the sea within its range. The sound was not continuous, but was interrupted, at intervals, like a flashing light; and it was evident that, by varying the intervals, such signals might be made to give varying indications, so as to identify the places they proceeded from, an application, in fact, of the general principle of revolving lights. The revolution of the horn, and the alternate admission of air to, and exclusion from, the pipe, were regulated by machinery actuated by the engine. The tone was very loud when heard in the line of the bell, and he believed it had peculiar power in piercing the fog; it was heard out to sea for many miles' distance. He thought, on the whole, it was a very ingenious arrangement, and if experience proved it to be effective, it would no doubt be exceedingly useful in a climate so liable to mists as that of the British Islands.

Captain OWEN said, having been acquainted with all Mr. Douglass' proceedings in connection with lighthouses, and with those of Mr. Douglass, sen., he was struck with the modest way in which these proceedings had been narrated by the Author. If young Engineers wanted to obtain Mr. Douglass' qualifications they must do as he had done; he knew how to take a tool out of a workman's hand and to do the work himself. Mr. Douglass was not only an Engineer, but he was a blacksmith, a carpenter, and a mason in his own person, as well as a seaman. Captain Owen was personally interested in the building of the Bishop and the Wolf Rock lighthouses, and only such men could make any progress in works of this kind, and carry them out to completion.

Mr. G. R. STEPHENSON said he had passed the Wolf Rock many times under great trepidation, and felt much satisfaction at the completion of the lighthouse, though he was not prepared to discuss the details of it; if indeed there was anything to discuss in the admirable way in which the proceedings had been conducted from the commencement to the completion. He knew of no site or position for a lighthouse which required more skill, or involved more difficulties and dangers, than was the case with the Wolf Rock structure. He regarded its erection as one of the greatest boons to the commerce of the country. It would be the means of saving thousands of pounds' worth of property in a year, besides human lives. Instead of that spot being shunned, it would now be anxiously sought for, as one of the best landmarks that could be obtained. He had made the Channel when he had not been able to take any previous observations for five or six days, and was obliged to run up at hazard. If this lighthouse had been there, he should have sought it, and having found it, he would have been sure of a safe run up Channel. He would only add that the Robert Stevenson mentioned in the Paper was not his relative;

but he was as distinguished in the works he had executed in light-houses as his relative had been in other branches of engineering.

Mr. REDMAN said, in the year 1840 he was engaged by the late Mr. Walker (Past-President, Inst. C.E.), for the Corporation of the Trinity House, in making a survey of the Tuskar Rock in the Bristol Channel, and on that occasion he made the acquaintance of the Author of this Paper and of his father. The Tuskar Rock presented great difficulties; there was a rapid tideway, and the most prominent and salient points barely reached half-tide level. An area of 120 acres of carboniferous limestone was exposed for a short time, and a beacon was subsequently erected on it somewhat of the character of the Wolf Rock beacon; but it was supported by stays, in the same way as the mast of a ship was sustained by the standing rigging. That beacon was now in its original condition. After waiting for a fortnight, he determined to start one morning, contrary to the advice of the elder Mr. Douglass, to commence the survey, but he was unable to land on the rock. During the subsequent spring tides, he completed the survey and made a report in reference to the beacon. To show the hazard attending works of this kind, he might mention that, on the occasion of the Elder Brethren of the Trinity House visiting another work in that district at about that period, the boat in which they were conveyed capsized, and three of the number were drowned. As there was no opportunity of strengthening the Wolf Rock beacon by the addition of stays, the mast was broken off, and several succeeding ones had failed.

A somewhat similar plan was resorted to, in preparing the foundation of the Wolf Rock lighthouse, as had been followed in preceding structures of this form, of which the Edystone might be taken as the type, and no greater tribute to the talent of Smeaton could be paid. The use of cement or concrete for obtaining level steps might be applicable to many sites, but the dense nature of the porphyritic mass supporting a granite column rendered the intervention of a foreign medium hazardous. In a case of this kind, too great care could not be taken in dovetailing the courses, and the additional cost thus incurred, when spread over the total cost of the lighthouse, must be so slight as to warrant the precautions judiciously observed by the Author. For the base of the lighthouse a system had been followed, which was originated, he believed, by Mr. Walker, and was first adopted in the case of the lighthouse at the entrance of the Menai Straits. In that instance curved faces were replaced by offsets at the base of the tower. He believed Mr. Walker considered they had the effect of breaking up the waves, and checking their tendency to shoot up the face of the tower. Perhaps the only defect in the Edystone was the want of altitude; and in a heavy gale the light was almost submerged by the water

running up the tower.¹ That had been prevented in succeeding lighthouses by the greater altitude of the tower.

A simpler form of dovetailing had been employed in the Skerryvore, the Bell Rock, and the Menai lighthouses, viz., that of plain joints radiating from the centre, with the courses joggled to those below, and a cube of harder material, as slate, inserted diagonally in the joints. When an entire ring was set in that way, the system was as perfect as any other with which he was acquainted. The courses adopted by Smeaton were a complete Chinese puzzle; no one stone could be taken out without affecting all around it; and Smeaton was not content with dovetailing the external ring, but every succeeding ring was most ingeniously dovetailed. The total cost of the Wolf Rock lighthouse contrasted favourably with that of other lighthouses of a similar character. The Skerryvore had been referred to by a parliamentary committee as entailing a vast outlay for a single light; but the mass of the Skerryvore was about three times the mass of the Edystone, and the height of the tower was 158 feet, while that of the Edystone was only 90 feet.

With reference to the saving of life by the establishment of lights, it was an acknowledged fact that, prior to the lighting of the Western or Scilly Isles, the number of wrecks was quadruple what they had been subsequently, though the tonnage was only about one-fourth what it was at the present day. It was a curious fact that there were other Wolf Rocks in the islands of the North Atlantic, on the east coast of Labrador, in the Gulf of St. Lawrence, and in the North Pacific—all no doubt deriving their name from the terror inspired by their position.² He trusted that this work

¹ *Vide* a large engraving, with the sea breaking over the lantern, "The Edystone lighthouse *during* the storm, 22nd and 23rd November, 1824," painted and engraved by Wm. Daniell, R.A., 6th July, 1825.—J. B. R.

² A reference to the list of authorities will show how the nomenclature has oscillated:

Yulf (Sax.), Yulf, Wolf.		
Sea Mirrour, Amsterdam,	"Wolf"	A.D. 1658
De Wit's Atlas, Ditto,	"The Gulfe"	1688
Le Neptune François, Ditto,	"Le Loup"	1692
Ditto, English Channel,	"Let housen de Wolf"	1693
Edmund Halley, English Channel,	"Gulf"	1701
Joannes Van Keulen, Ditto, Amsterdam,	Ditto	1751
Borlase, Islands of Scilly, pp. 1 and 2,	"Gulph" or "Wolf"	1756
Greenville Collins,	"Gulfe"	1760
Chart No. 13 ^a .—"Neptune," L'An VI. de la République, Paris,	"Gulf ou Wolf"	
7.—Ditto, "Mers du Nord," Paris,		
Depôt de la Marine,	"Gulf Roche"	1776
42.—Ditto, English Channel,	"Wolf Rock or le Loup"	
		1798-1802
46.—Ditto, Land's End, "Des Sorlinges," Depôt Genl. de la Marine, 1825, Lt. Mackenzie,	"Wolf Rock"	1792

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might redound as much to the credit and the future prosperity of those connected with it as the Edystone had done to Smeaton.

Mr. J. COODE observed that Dr. Pole had referred to a remarkable instrument, introduced for the purpose of signalling during fogs. Believing as he did that the instrument was destined to work an entire revolution in fog signalling, he thought it was only right that the name of the inventor, Mr. Daboll, an American, should be put upon record. With respect to the volume of sea thrown over the Edystone during heavy weather, he might remark that the greatest obscuration of the light did not occur at the height of a gale, but afterwards, when the great rollers ran over the sloping back of the rock and up the lighthouse; the vignette in Smeaton's Narrative was not in the slightest degree an exaggeration of what happened on such occasions.

He could not assent to the statement that Portland cement was a material which, in works exposed to the wash of the sea, was as strong as the stone itself. That remark must be received with considerable qualification. At the end of a month or three months it might approximately possess the strength of stone, but prior to that it did not. It was difficult to get at the same time a quick-setting and a very strong cement. Some time ago he imported a cargo of foreign cement, the only one of the kind, he believed, that had been brought to this country. It was obtained from a little seaport called Zumaya, on the north-east of Spain, about 20 miles west of San Sebastian. Its strength, combined with quick-setting properties, was remarkable. By experiment he ascertained that, at the end of eight hours, the usual test brick of $2\frac{1}{2}$ superficial inches bore a tensile strain of 177 lbs., while Portland cement gauged at the same time sustained only 91 lbs.; in the same way, at the end of twenty-four hours, it bore nearly double the strain of Portland; but at forty-eight hours the Portland overtook it. At the end of seven days the Zumaya cement bore a strain of 518 lbs. He thought that the original test required by the Metropolitan Board of Works was 400 lbs. at the end of seven days,¹ and that this had been subsequently raised to 500 lbs.; his own test for Portland cement at the end of seven days was 750 lbs. If, as was probable, another cargo of the Spanish cement should be imported, he would test it further and lay before the Institution an account of the results he obtained. The superiority of this cement,

It may be observed that Laurence Nowell, 1576, Dean of Lichfield's Map, has "y^e Gulfe" written against the main, West of Mount's Bay; and Saxton's 'Anglia' Cornwall, Lord Burreleigh's Book, Royal MSS., 18 D. III. B. Musm., 1579, has "The Gulfe" written against the Rock and not the Bay. Le Neptune François, quoted in y^e list, 1692, has "Golfe de Monsbaye" against the Bay (Mount's Bay). —J.B.R., April 25th, 1870.

¹ Vide Minutes of Proceedings Inst. C.E., vol. xxv., p. 67.

in its quick-setting properties, over the Portland, was shown in the case of a temporary wall put up to protect works on a fore-shore; the front of the wall was set in Zumaya cement and the back in Portland cement, when on the tide rising with a chopping sea which overtopped the wall, that portion of the back of the wall which had been set during the preceding tide was completely destroyed, while the front which had been set in the Zumaya cement remained entire. Mr. Coode added that the Zumaya cement did not weigh more than 84 lbs. to the bushel, and the cost in this country was only slightly in excess of Portland.

Mr. BEARDMORE remembered the late Mr. Walker mentioning the difficulties encountered in connection with the beacons on the Wolf Rock. It would be interesting to learn the cause of the destruction of the beacons, as associated with the unknown question of what was the maximum force of waves upon an object in the sea. From what he had observed of the action of the sea on the Edystone, he believed the ordinary circular form of lighthouses greatly mitigated the blows from the sea as compared with a breakwater.

Mr. M. BEAZELEY referred to the remark, that the present mode of construction of lighthouses was merely a reproduction of the Edystone: that was a mistake. The mode of dovetailing and joggling the stones together in the Wolf Rock lighthouse was entirely different from that adopted by Smeaton, and did not bear any relation to it. However excellent the mode in which the stones were put together at the Edystone, to prevent one stone from being drawn out without drawing out the neighbouring ones, it nevertheless formed no side bond from one stone to another. In the Edystone lighthouse there was no tie of stone from one course to another: but in the Wolf Rock lighthouse the stones had a side tie; they were dovetailed one into the other, and by means of the top band, the courses were so firmly tied together that one stone almost became part of the other stone; in fact, by this means there was such homogeneity of construction that, when the tower was put together, it became as it were one solid piece, and he could not conceive any other mode in which such uniformity of construction could be obtained. Then, again, this mode of construction did not interfere with the rapidity of setting the stones, which was of great importance, because, in a work like this, especially in the lower courses where green water was liable to come over the stones a short time after they were set, it was of vital consequence to get as great a weight put together in one tide as possible, and the stones when set formed such a tie, that when the water came over them they could not be displaced or lifted without the top band being torn away. That the dovetailing did not delay the setting of the work might be inferred from the fact, that it was a common

occurrence, when making two tides a-day, to discharge and set from twenty-eight to thirty-two stones from the barges, and those stones varied in weight from 2 tons to 3 tons each. The actual cost of the extra stone and the extra labour bestowed upon that apparently elaborate work, on the total cost of the stone dressing and of the stone, was under 5 per cent.; and the total cost of the dovetail bands, and extra stone on the whole cost of the work, was under 1 per cent. Considering that this mode of joining the stones insured the permanent stability and safety of the whole structure, 1 per cent. on the total cost of the tower was but a small addition. Nor must it be looked at in that light only, for if a course of stone had been lost from the effect of a heavy storm, it would have stopped the work for an entire working season. It was not only the actual small increased cost of this mode of preparing the stones which had to be considered, but the security obtained thereby whilst setting the courses, in such an exposed situation as the Wolf Rock. The term "Wolf," was quite modern, and had been applied to the rock almost within the recollection of persons living; in fact, many persons at the Land's End still called it, as it was spelt on old maps of the time of Queen Elizabeth and of Charles the Second, the "Gulf" Rock.

Mr. PARKES in explanation, said it was evident that the lower courses of stone exposed immediately to the wash of the sea should be set, whether dovetailed or not, in some quick-setting cement, and not in Portland. His remarks about Portland cement had reference to the courses above the immediate wash of the sea, where its strength might be considered as a substitute for dove-tailing.

Mr. DOUGLASS, in reply upon the discussion, said, that the surface of the Wolf Rock unfortunately dipped to the eastward, which was from the direction of the heaviest seas. At the outer part of the lower side of the rock, the masonry was let into the rock on an average about 12 inches, while on the opposite side the average depth cut was from 5 feet to 6 feet. In such a position it was decidedly the most economical and the safest course to excavate the whole surface of the foundation. In the case of the Longships, the rock was only cut away for the outer ring of masonry, and a core of the rock was left 12 feet high. The preparation of the foundation for a rock lighthouse was entirely dependent on the form and material of the rock. With some rocks it might be necessary to sink considerably deeper than with others. At the Wolf the rock was hard and compact, and the excavation of a few inches only on the lower side was necessary; but in the case of a softer rock, he should say it would be desirable to go much farther; for with a granite tower, which was supposed to last an indefinite time, provision should be made against the possible undermining of

the first courses of the masonry, by the natural decay of the surface of the rock at the base of the tower. The small additional cost of dovetailing work of this kind, viz., 1 per cent. on the total cost of the structure, or 5 per cent. upon the cost of the granite dressed, was scarcely worth considering. In preparing the design for a tower of this kind, the engineer had to adapt the height of the structure to local circumstances, and to provide cubical space for the efficient service of the light and for the comfort of the keepers. Then the material in the structure should be reduced to a minimum, because every unnecessary foot of material in the building was only adding so much unnecessary resistance to heavy waves; and on that account he considered every stone should be put together in the best manner, so as to produce, as nearly as possible, a solid post of granite. He believed this tower was so put together, that if held out horizontally it would not part from the rock. Again, dovetailing added considerably to the rapidity with which the work could be executed; and with the sea washing over the lower portion of the work, more stones might be set, dovetailed in this manner, than with any other system of dovetailing that he was acquainted with. If the stones were bedded in the ordinary way, the sea would force the cement out of the bed and joints; but with this method of dovetailing, the wash of the sea was only felt in front of the stone, and did not affect the band or the back of the wall. He could never have risked cement rubble at the Wolf Rock. In some situations, no doubt, it might be used with advantage, but not in such an exposed position. The second beacon erected on the Wolf Rock was a cone formed of cast-iron plating, and filled with cement rubble. As each horizontal tier of plates was completed the cement rubble was built in, and left with its surface about 2 feet below the top of the plating. It often happened when the men returned to their work after stormy weather, that a great part of the filling was washed out, and many of the stones converted into boulders, by being churned in the iron tub or casing. If the rubble work had been fully exposed to the sea, it could be easily imagined that the whole would have been carried off.

The fog bell that had been put up, appeared, with the present knowledge of fog signals, to be the only one that could be used in this tower with advantage. The Daboll fog signals in use at St. Catherine's, Isle of Wight, and at Dungeness were worked by Ericson's caloric engines, of from 2 H.P. to $2\frac{1}{2}$ H.P., and the instruments were very efficient. That at Dungeness had been heard on board the Varne light vessel, at a distance of $11\frac{1}{2}$ nautical miles. A steam trumpet, designed by Professor Holmes, the inventor of the magneto-electric machine, in 1858, was exhibited at the Paris Exhibition, as well as the fog horn of Mr. Daboll, by the Corporation of the Trinity House. There could be no better proof of the

power of Professor Holmes' instrument than the fact, that it was forbidden to be blown in the park after the first day.

A comparison of the cost of the Wolf Rock lighthouse with other works of the same kind in Scotland and in England was attended with some difficulty. In the first place, there was the question of the height of the base above low water of spring tides; then there was the amount of the rise and fall of the tide, the exposure of the site, the distance from land, and other considerations; but he gave the particulars as follows:—

—	Total Cost.			Cubic Feet.	Cost per Cubic Foot.		
	£	s.	d.		£	s.	d.
Edystone . . .	40,000	0	0	13,343	2	19	11½
Bell Rock . . .	55,619	12	1	28,530	1	19	0
Skerryvore . . .	72,200	11	6	58,580	1	4	7¾
Bishop Rock. . .	34,559	18	9	35,209	0	19	7½
Smalls	50,124	11	8	46,386	1	1	7¼
Hanois	25,296	0	0	24,542	1	0	7¼
Wolf Rock . . .	62,726	0	0	59,070	1	1	3

Considering the exposed position of the Wolf Rock, the cost of the lighthouse erected there compared very fairly with the cost of any existing work of the kind.

Mr. HAWKSLEY, Vice-President, said, he had been charged by the President to express his admiration for the Paper and for the drawings by which it had been illustrated; and to add, as must indeed be evident to every one, that the completeness of the communication in all respects could only have been arrived at by an expenditure of considerable time, trouble, and money, for which the thanks of the Institution were eminently due to Mr. Douglass.