Mr. Henderson said he had been anxious to furnish some detailed particulars as to the construction of lighthouse apparatus and lanterns, inasmuch as the Paper by Mr. Chance treated exclusively of the optical portion of the subject: the two Papers together might, he thought, be regarded as illustrating the best lighthouse practice of the day. He had not brought forward the system of lights constructed of metallic reflectors, because there were many published treatises on that subject, among which might be mentioned the one by M. Léonce Reynaud. There were at present four different varieties of lanterns in use in this country, each of which had its own supporters. In arriving at an opinion as to which lantern was the most advantageous, he thought economy of light and money were both elements of great importance.

Mr. Redman directed attention to the fact that the use of lenses for lighthouse purposes was of English origin. The lenses originally employed were of one piece of glass for the entire height, but the thickness of the lens, and the consequent absorption of light were so great, that lenses of that kind were abandoned. Buffon first proposed the grinding of the lenses in steps, or concentric rings, to overcome this objection; but the difficulty of shaping a solid piece of glass to this form led to its abandonment. Condorcet, in 1773, suggested the 'building up' of the lens in separate pieces. Sir David Brewster also, in 1811, and Fresnel, in 1822, proposed the same method, and the latter first applied it practically, and it was generally assumed without previous knowledge of what had been done by his predecessors. As far back as the year 1827 experiments were made by the Trinity House with Sir David Brewster's lenses, which were abandoned; so that in reality the present system of French lights was, to a great extent, of English origin. He might add that lenses were first used on the south coast of England sixty years or seventy years back.

Mr. Wilfrid Airy remarked that, according to the proportions given by the Author, the glass, as made by the French and the English manufacturers, differed materially in quality. In the French article there was a preponderance of lime over soda, while in the English glass the soda was in excess of the lime. He could not but think that a very different glass must result from such dissimilar admixtures, and he would ask whether, in addition to the difference in the refractive index, the one was not harder than the other, and also unlike in colour? It was stated that a margin of $\frac{1}{8}$ inch was allowed round the lens as it was cast. As the grinding of glass was a laborious process, he thought it would be desirable, if possible, to reduce that margin, unless it was necessary, from the purity of the glass being injured to that depth from contact with the mould, or in consequence of inaccuracy in the casting, so as to allow of the grinding it up to the true shape.

Admiral COLLINSON considered the Author's lantern adapted to show the light on the horizon, but that from its form it was likely to obstruct the light between the line of the horizon and the lighthouse, a point of importance where lighthouses were placed at a great elevation. In the course of the present year the Trinity House had made experiments to ascertain the relative advantages of petroleum and colza oil. It was found that paraffin oil did not give so much light as colza oil, that it caused the wicks to char, and that there was a difficulty in getting up the flame again when a four-wick First Order or a three-wick Second Order light was trimmed: the use of paraffin was consequently abandoned until a description of wick adapted to its consumption was introduced. A few years ago a sample of oil sent to the Trinity House was tested and approved; but after the oil was issued, complaints came in from the lighthouse-keepers that the lights could not be maintained; and in corroboration a representation was made by the Captain of one of H.M.'s ships, that the Edystone light was on one occasion not visible for fifteen minutes. The Trinity House authorities had some difficulty in discovering how the oil was adulterated; eventually it was found not to stand the test of temperature, the sample oil freezing at a lower temperature than the oil which was delivered. The contract was declared void, and the oil was returned. The Author had suggested the use of the dioptric apparatus on floating light-ships. The Trinity House would gladly adopt such a combination, if it were possible; but hitherto the difficulty of trimming the lamp in a gale of wind was so great, owing to the motion of the ship, that it could not be rendered practically efficient. Mr. Douglass had a proposition before the Trinity Board to substitute iron for wooden masts, by which the ventilation and supply of air for the lamps would be greatly improved. But at present the Board were unhesitatingly of opinion, that the catoptric system was better suited for the service of the floating lights than the dioptric. Such was the perfection arrived at, in consequence of the experience gained by the Trinity House, that in a period of seven or eight years only one vessel had drifted from her moorings.

The different character of the lights was perhaps the most important point of all. Sea-lights were multiplying so rapidly in every direction that it was difficult to distinguish one from the other, notwithstanding the use of red and green-coloured glass and that some lights were fixed while others revolved. The Author of the Paper was present when the green light was tested, under favourable circumstances, in the case of a Second Order light at Lowestoft; the green light on a hazy evening was then so obscured at a distance of $2\frac{1}{2}$ miles, that it was found necessary to replace it by a bright light. Green lights must therefore be regarded as available only for very short distances. In red lights, no doubt, many rays were lost;

however, at the Rock Lighthouse, at Liverpool, by the addition of more burners to the catoptric apparatus, the red light had been brought on an equality with the white light. It was two years since he had visited that light, but it had been subsequently altered and improved, and he was informed by the light-keepers at Orme's Head, that on a foggy night the light first seen was the red. This was a point of importance, because, recently, the Master of one of H.M.'s ships, in coming up the Channel, and sighting Ushant, where the light had two white faces and one red one, had been unable to make out the red face at all, so that it would appear that, under certain conditions of weather, the red light was obscured; thus not only was the distinctive character of the colour of the light in question destroyed, but the duration of the flash as a revolving light was altered. The Trinity Board intended to establish a revolving light on the Wolf Rock in that neighbourhood on the dioptric system; and Mr. Chance had so arranged the flashes that the red light and the white were of equal intensity. The importance of these distinctions was shown in the mistakes made by uneducated people. The year before last a representation was sent in to the Board of Trade, that a man had mistaken the Galloper Light for the Leman and Ower Light. The two light vessels were 90 miles apart, and both carried two lights, the one a revolving and a fixed light, and the other two fixed lights: yet this man explained, as the reason for his ship going ashore, that he mistook the one light for the other. In another instance the Captain of a small Danish schooner, bound for London, sailed past Harwich up the River Stour, mistaking Landguard Fort and Harwich for Tilbury and Gravesend. Hence it would be inexpedient to establish any lights but such as could be perfectly understood by the simplest people. The question of fog-signals was intimately connected with light-house efficiency, and was, in his opinion, of equal importance with the subject now under consideration. He trusted, therefore, that, on some other occasion, it might be brought forward for discussion.

Mr. James N. Douglass, Engineer to the Trinity House, said, the various forms and sizes of dioptric apparatus in use for oil-lamps had been fully described in the Paper; but a question of great importance at the present moment was the description of apparatus to be employed in future with the electric light. The dioptric apparatus at Dungeness and at Cap le Havre belonged to the Sixth Order; and experiments made by the Trinity House at the Paris Exhibition of 1867, with a Third Order apparatus for a fixed light, seemed to point to this, or even a larger apparatus, as the most efficient instrument for fully developing and maintaining a steady electric light. This matter was, however, still the subject of further experiment and practical test by the Trinity

House, and would doubtless receive at the hands of their scientific adviser, Professor Tyndall, the fullest investigation.

Petroleum had been referred to by the Author as better suited for lamps than the colza oil at present used for lighthouse illumination; but this only applied to small single-wick lamps. When compared with the three and four concentric-wick oil-lamps of the Second and First Order lights the result was not so good. Experiments had recently been made by the Trinity House with the First Order petroleum lamp of Captain Doty—one of the best that had yet appeared; but the luminous intensity of the light was found to be only three-fourths that of the oil-lamp of the same size. He thought, however, much was yet to be accomplished with petroleum for the illumination of lighthouses. In his observations he would distinguish the framing of the lantern from that of the dioptric apparatus, by giving the latter its technical title of armature. The cylindrical form for the lantern was doubtless the best, both optically and for strength, and the framing having the greatest inclination would intercept a minimum of the vertically elongated beam of light sent from the dioptric apparatus. This question of inclination also applied to the armature of the apparatus, and hence it was of much greater importance as regarded obstruction of light than in the framing of the lantern, being so much nearer to the radiant. Fig. 1, page 39, showed a development of 180° of the helical framing of his cylindrical lantern, with the obscuration due to the armature of the apparatus on the same plane. The image of the flame was shown by dotted lines.

In the diagonally framed lantern of Messrs. Stevenson, and the cylindrical vertically framed Trinity House lantern, the interception of light had been reduced to a minimum, and the interception was almost uniformly distributed over the illuminated area of the sea surface. In Messrs. Stevenson's lantern the maximum interception of the transmited light from an apparatus for fixed light was 4·9, the minimum 4·0, and the mean 4·45 per cent. In the Trinity House lantern the maximum interception was 3·5, the minimum 2·9, and the mean 3·2 per cent., not 6·8 per cent., as stated in the Paper. The comparative advantages of the lighthouse lanterns adopted by the Trinity House and by the Commissioners of Northern Lights had lately been under the consideration of the Board of Trade, and the subject had been investigated by Professor Tyndall, Messrs. Stevenson, and himself.[1]

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[1] Mr. Douglass presented to the Institution, for the Library, a copy of the "Correspondence relative to the comparative advantages of the Lighthouse Lanterns adopted by the Corporation of the Trinity House and the Commissioners of Northern Lighthouses." 1867–8. London, 1868. [Inst. C.E. Tracts, fol., vol. xi.] —Sec. Inst. C.E.

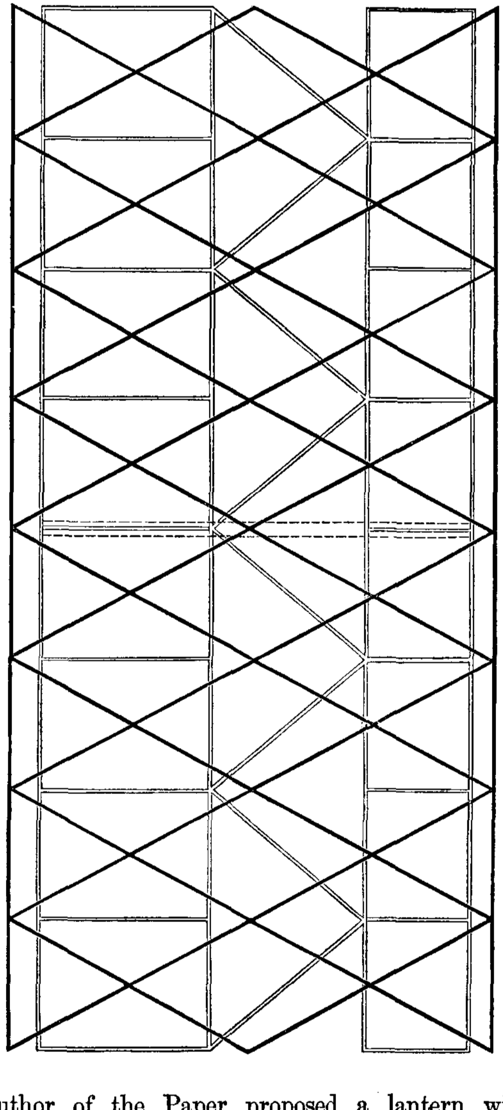

Fig. 1.

Scale 4 feet to 1 inch.

The Author of the Paper proposed a lantern with a new arrangement of framing, as shown in Plate 4, Fig. 43, having partly vertical and partly inclined framing; all of which was to coincide optically with the armature of the dioptric apparatus. Now, with the heavy vertical armature of the early dioptric apparatus, where on the bearing of each vertical portion of the armature 50 per cent. of light was in some cases intercepted, it was doubtless the best arrangement to make the framing of the lantern coincide optically with the armature of the apparatus; but with the improved lanterns of Messrs. Stevenson, or of the Trinity House, it would be a decided step backwards. As the lenticular belt of the dioptric apparatus was found to have an illuminating value of 70 per cent. of the whole instrument, it was evident that the least interception of light was obtained by the greatest inclination of the armature of the refracting panels of the instrument. In the latest English and Scotch lights the inclination was about 21°, and the interception of the transmitted light was only 4·5 per cent., and there was reason to expect that Messrs. Chance would succeed, by giving greater inclination to the framing of the armature, and by making it thinner, in further reducing the interception of light. The above interception, added to the maximum interception due to the framing of the Trinity House lantern, gave 8·0 per cent. as the aggregate maximum interception of the transmitted light due to the armature of the apparatus and the framing of the lantern. But to attain optical coincidence between the armature of even the present apparatus and the framing of a lantern, the inclination of the framing would be so much increased, owing to increased radius, as to render it beyond the limit of safety for the structure. The Author therefore proposed a safer inclination for the lantern framing (Plate 4, Fig. 43), and by arranging the armature of the dioptric apparatus to coincide optically with it, the latter attained an inclination of only 11° (Plate 2, Fig. 22). And the interception with this armature was found to be 8·6 per cent. of the transmitted light, or nearly double that of the dioptric apparatus at present in use. He would further add that the form of lantern framing proposed was very imperfect, as no diagonals were carried down to the base of the structure. This want of bracing in many vertically framed lanterns caused straining, and consequent loosening, and frequent breakage of the glass during storms. He might remark that there had been no fracture of the glass with the cylindrical Trinity House lanterns, and one of the fifteen lanterns now erected had been in position more than two years. The two horizontal bars proposed were objectionable: these bars must be placed optically coincident with the horizontal armature of the apparatus, or they would further intercept the light. Besides, horizontal bars were more liable to cause leakage than the other portion of the framing, and there was the additional objection that during snow storms snow would accumulate more rapidly upon them than upon inclined bars, to the detriment of the light. In the Trinity House lantern it was, to use the words of the late Professor Faraday, "nearly a matter of indifference as regards shadow how the uprights of the optical apparatus were placed in relation to such a lantern." This was of great importance to the lighthouse engineer as it left him free to readjust the dioptric apparatus to meet any altered conditions of the local navigation, or to change the size, or improve the form of the apparatus without interfering with the construction of the lantern.

Although the Author was of opinion that the Trinity House lantern was expensive, from the amount of workmanship of a costly class, and from the glass cut to waste, he could state that in the fifteen Trinity House lanterns constructed from his designs a high standard of material and workmanship had been insisted on, especially as regarded the glass, and it was the opinion of Professor Tyndall that even greater optical perfection would yet be obtained in the glass portion of the structure. The average actual cost of six First Order 14-feet lanterns, fixed complete at English lighthouses, had been £1,244 13*s.* 2*d.*, and he was sure that cost would compare favourably with that of any similar work either in this country or on the Continent.

Mr. William Parkes remarked that, before the dioptric system was introduced, the only lantern in existence had upright standards and rectangular framing. That answered the purpose tolerably well with the old catoptric or reflecting lights, with several lamps distributed over a considerable width within the lantern. But as in the dioptric apparatus there was a single central lamp, the light from which was refracted into a narrow vertical line of illumination, it was evident that, if an upright standard came between the spectator and that line, a large proportion of light would be obscured. On the introduction of the dioptric system, the question of the lantern framing was taken up, nearly simultaneously, by the late Mr. James Walker (Past President Inst. C.E.) for the Trinity House, and by the late Mr. Alan Stevenson (M. Inst. C.E.) for the Commissioners of Northern Lights. Mr. Stevenson arrived at a solution of the question not very different from that to which Mr. Douglass had come; but the construction was dissimilar. The main difference, so far as obscuration was concerned, was this—Mr. Stevenson introduced certain horizontal members into the framing which Mr. Douglass had done away with. Mr. Walker's lantern had inclined, but not altogether diagonal, standards, like those of Mr. Stevenson and of Mr. Douglass. Mr. Parkes had adopted a form of framing similar to Mr. Walker's, which had the advantage of simplicity of construction and facility in erection. He had estimated the obstruction caused by the different lanterns, and had found the proportion of the area of opaque framing to that of the whole glazed surface was 5·7 per cent. in his lantern; but that was not equally distributed round the circle. The circle was divided into twenty-four arcs, alternately of 13° and 17°. In the arcs of 13° the obscuration was about 11 per cent.: in the arcs of 17° it was about 2 per cent. The merit or demerit of a lantern was to be measured by the amount of obscuration in the most obscured part, and that in his lantern was 11 per cent. In Mr. Douglass' lantern, and he believed also in Mr. Stevenson's, it was 6·8 per cent. Mr. Douglass said it was only 3·2 per cent. Probably this result was obtained by a different method of calculating the obscuration; but if this method, whatever it might be, were equally applicable to both, the proportion of obscuration in the one lantern to that in the other must remain about the same; so that the maximum obscurations in Mr. Parkes' lantern to the nearly constant obscuration in Mr. Douglass' would be in the proportion of about 11 to 7. No doubt Mr. Douglass' lanterns were in theory superior in that proportion; but he believed that, up to the present time, Mr. Douglass had not succeeded in getting them made at so low a price as those on Mr. Walker's system, and that they could not be erected on the lighthouse towers in so short a time. The question was whether these disadvantages were a sufficient set-off against the theoretical superiority of Mr. Douglass' lantern. He believed Professor Faraday's report, with regard to the obscuration of Mr. Douglass' helical lantern, was, that practically there was no shadow. If this were the case with a calculated obscuration of nearly 7 per cent., it could not be very serious with a calculated obscuration of 11 per cent., and he therefore doubted whether there was sufficient inducement to spend extra money and time upon these lanterns, which were complicated in construction and took a long time to erect. The time required for the erection of the lantern on a lighthouse was of importance, as it involved keeping up an expensive establishment for very little work, and it was an object to do the work in four or five weeks instead of as many months. It ought further to be stated, that the advantage in Mr. Douglass' lantern applied only to fixed lights, which showed a thin vertical line of illumination. In revolving lights, the illuminated column having a considerable width, the obscuration caused by the framing was of less importance; but in those cases the advantage, such as it was, would be with Mr. Walker's lanterns, as the arcs of small obscuration would have to be taken into account, as well as those in which the obscuration was greater.

Mr. W. H. Cutler considered the magneto-electric light, of all known kinds of light, was the most appropriate for lighthouse purposes. To work the magneto-electric light apparatus a small engine was required; and if the light went out, or there was such a thick fog that it was of no use, the engine would be available to work a fog horn, a specimen of which was exhibited at the Paris

Exhibition of 1867. Reports had been received that the sound, which was produced by vibration, could be heard at a distance of 16 miles. Two single-acting air-pumps, connected by three oval wheels, threw a continuous stream of air into an air vessel, at a pressure of about three atmospheres: thence it was taken, as required, through a small square metal box to the horn. The metal box had a partition in it, and through the partition there was a slot, about 6 inches long and $\frac{3}{4}$ inch wide. Over the slot, and firmly secured at one end, was a tongue of brass, rather more than $\frac{3}{16}$ inch thick. The compressed air rushing past this tongue caused it to vibrate, and produced the sound, which could be varied by moving a triangular slide along the metal tongue. He thought the electric light apparatus and the fog horn should be supplied to all lighthouses, so that they might be useful in foggy as well as during clear weather.

Captain Owen observed that the Trinity House had adopted an efficient horn, which was used when the lights were obscured by fog; but it was not intended to replace the lights when they accidentally went out. The late Professor Faraday once said at the Trinity House, that inasmuch as the sun itself was unable to penetrate a dense fog, so no electric or any other light could be expected to do so. The fog horn was there as a warning when the light was obscured; and although the electric light answered very well, even it could not penetrate a fog. With regard to the lanterns which had been referred to, he was at the Trinity House when Mr. Walker's lantern was introduced, but it was not better than that which was then in use.

Dr. Gladstone thought the arrangement of the framework of the panels of considerable importance, as the fear of the diminution of light by upright frames was by no means an imaginary one. Once when he was passing the fixed light at Berwick it was supposed that something had got in the way of the light, or that it had gone out, although no vessel was visible between him and the lighthouse. It appeared afterwards, on inspecting the apparatus, that a bar intercepted the light at the point of observation, so that practically the light was for the time extinguished. That was an extreme instance, which, he believed, would not occur with any Trinity House apparatus. He had seen in one of the lights in Scotland, a contrivance by Mr. Stevenson for gathering up the rays and sending them in a particular direction. The optical apparatus was excellent, but, owing to an upright bar in the lantern, the object of the arrangement of the prism was in a great measure defeated. As far as he was aware, there was only one apparent light on the British coast, that at Stornoway, in the Hebrides, where a small contrivance on the top of a rock reflected the light thrown from the shore by means of a mirror; but it was not very successful. At Odessa, he believed the light was a dioptric, which was best suited to the purpose, as it condensed a larger portion of light. He should like to hear whether that description of light was successful beyond the distance of 1 mile; because if that were the case, there were many places on the English coast where an apparent light would be of service. Though pleased to hear of the success which had attended the efforts of the Trinity House to bring the luminous effect of the red light to a par with that of the white, especially as it enabled alternate red and white to be better shown as a distinctive light, there were certain disadvantages connected with the use of any coloured light. At present there was no way of colouring light without a great number of its rays being absorbed. Then supposing the red and the white lights to be of apparently the same strength, if a mist came on the red light would be the stronger of the two, because fog absorbed the blue and green rays; and there might be other meteorological conditions which produced peculiar effects. Again, many people were colour blind, and could not distinguish between white light and red light. He knew a person who could only distinguish the difference between a revolving red and white light by describing the red light to be duller than the white; and such instances of colour blindness were far from uncommon. At the same time he should be sorry if the beautiful red and white revolving lights now in use were abolished, on account of their importance as distinctive lights. The question of fog signals deserved a great deal of consideration; but it was beyond the special subject which had been introduced in the Paper.

Mr. Beazeley remarked that Mr. Parkes had calculated the amount of opacity (or obstruction of the framing) of a lantern, by taking the total area of the standards and the total area of the face of the lantern, and deducing a percentage from those data. He considered that was a mistaken way of treating the question. In a dioptric apparatus the light was concentrated into a narrow column, or elongated image of the flame, with which alone the mariner had to deal; and all that had to be taken into account, in estimating the percentage of obstruction in any lantern, was the amount of the framing which could at any one time come across that narrow bar of light. No man's eye could at one time take in the whole light diffused over an arc of 13°; and, the image of the light being a narrow column, the calculation of obstruction diffused over the whole illuminated arc was beside the question.

With reference to the greater length of time required to erect the Trinity House lanterns, as compared with those of the ordinary pattern, he would remark that it had been sought to obtain the utmost amount of rigidity by riveting instead of screwing the framing together. The latter could be done more quickly than riveting, but it did not produce the same amount of homogeneity in the structure, and did not bring the surfaces of the metal together with the same certainty.

Mr. T. A. Rochussen stated, that when Mr. Douglass' lantern was in course of conception, he had been asked whether it would be possible to produce sections of the sash and sill bars of steel sufficiently strong to bear the weight of the roof, and to withstand the force of the wind; and at the same time to weld together in such a form, and at such short angles as were represented in Fig. 1, p. 39. As an ironmaster there was little to be got from it; but regarding it from a sailor's point of view, and knowing the importance of good lights on all coasts, he had the required section cut, and the steel rolled. That sash could be applied either for a railway station roof, or any other roof of large size; and thus it might turn out valuable in a way which Mr. Douglass perhaps did not anticipate. It was a question whether the material should be cast steel of great elasticity, or puddled steel easily welded. Knowing that gun-metal framing was largely adopted, he tried the comparative strength of the different metals by hydraulic pressure, and found that strong fibrous iron burst under a pressure of thirty-four atmospheres at an angle of 160°; that gun-metal gave way at an angle of 160°, with a pressure of thirty-seven atmospheres; that fine grain iron would bear thirty-nine atmospheres, and simply show a slight crack in the skin, at an angle of 165°; while the steel at an angle of 165° resisted a pressure of fifty-four atmospheres without cracking. He would take the opportunity, as an old sailor, to find fault with the perfection now sought to be obtained in these lights. Every ray of light was reflected by the lens so completely to the horizon, that the light of a candle held over the flame would not project a cone of shadow on the roof of the lantern. Now of the various elements that guided navigators one was an upward glare of light in the sky. In the hazy climate of northern countries, a vessel often sailed through a zone of low dense fog, and a light which would then be obscured, though close at hand, might be so arranged as to throw some rays upwards, and reflect a glare from the clouds. The loss of light by a cone of shadow of between 3° and 7° was of little importance: but a beam of light of 4° would be a great advantage were it visible only as a glimmer over a topsail-yard, when the light itself could perhaps not be seen from the lower yard.

Mr. Henderson, in reply, observed that he had not gone into the question of the electric light any further than to give the two sections of apparatus made for the Trinity House. The smaller, or Sixth Order, was constructed with a helical intermediate rack, extending over the upper and lower prisms as well as the lenses. This, the first application of the kind, had since been adopted by the French. The larger one, or Third Order, was constructed on his plan of excentering the joints of the upper and lower panels of reflectors, with inclined framing for the lens panels, similar to that shown for a First Order fixed light in Fig. 22, Plate 2. It was questionable if the Third Order was the most suitable size for the electric light. A Second Order would be better for the speedy admission of an oil lamp into the focus, in the event of an accident happening to any part of the electric light-producing apparatus.

He agreed with Mr. Douglass that the circular form of glazing was the best, but he was at variance with him in respect to the arrangement of the framing. In a First Order, the height of the apparatus giving forth light was 8 feet $8\frac{1}{2}$ inches; 5 feet $1\frac{1}{8}$ inch being above the focal plane, and 3 feet $7\frac{3}{8}$ inches below it. If divergence were neglected, there would remain to be considered a portion of the glazing of the lantern of only 8 feet $8\frac{1}{2}$ inches in height. The diameter of the Trinity House lantern, to the inner edge of the framing, was 13 feet $8\frac{1}{2}$ inches, giving an area of light of $3{\cdot}1416 \times 13$ feet $8\frac{1}{2}$ inches $\times$ 8 feet $8\frac{1}{2}$ inches, equal to 54,005 square inches. There were thirty-two inclined bars in the lantern, each 10 feet $2\frac{1}{2}$ inches long, and $\frac{15}{16}$ inch thick, so that an area of 3,675 square inches of the light of the lantern was obscured, equal to 6·8 per cent., or to a horizontal band of obscuration 7·1 inches deep carried all round. In comparing the improved system with the above, the same diameter must, of course, be taken, then the obscuration would be as follows:—

						Sq. Inches.
Opposite upper prisms	sixteen bars	3 ft. $5\frac{7}{16}$ in. long	$\times$	$\frac{15}{16}$ in. thick	=	621·56
,, lenses	thirty-two ,,	3 ft. $6\frac{1}{2}$ in. ,,	$\times$	$\frac{15}{16}$ in. ,,	=	1275·00
,, lower prisms	sixteen ,,	1 ft. $11\frac{11}{16}$ in. ,,	$\times$	$\frac{15}{16}$ in. ,,	=	355·31
Area in square inches of total obscuration					=	2251·87

which was equal to 4·17 per cent.—a difference of 2·63 per cent. in favour of the latter system simply considered as a lantern framing without reference to the apparatus. In the optical apparatus at present used by the Trinity House 4·5 per cent. of the surface of the glass was obscured by the framing of the apparatus, and this latter obscuration was in addition to that caused by the lantern framing, as the two did not coincide, Fig. 34, Plate 3. In the improved system, the obstruction of the apparatus might remain at 4·5 per cent.; but every part covered, or coincided optically with, a corresponding portion of the lantern framing, so that the total loss, when the triangular system of supports to carry the upper cupola was complete, was exactly that of the apparatus. In practice the total loss could not well be reduced under 5 per cent., but it would be more uniformly distributed than by any other method. He had quite recently been shown a copy of the reports by Mr. Douglass and the Messrs. Stevenson on the Trinity House and Scotch lanterns, from which it appeared that the Messrs. Stevenson, using the same method of calculation as himself, found the obstruction of light in the Trinity House lantern to be 6·8 per cent., as given in the Paper. They also stated that the horizontal part of their lantern framing stopped no light, as it was in the shadow of the corresponding framing of the apparatus. The cost of the Trinity House framing, 14 feet diameter, and 10 feet high, was—

	£.	s.	d.
3,778 lbs. of steel framing, at 1*s.* 9*d.*	330	11	6
1,267 „ gun-metal capping, at 2*s.* 6*d.*	158	7	6
Cylindrical glazing, ½-inch thick.	362	6	3
Total cost	£851	5	3

The total cost of the improved lantern, at the same schedule of prices, with the same section of steel, was—

	£.	s.	d.
3,576 lbs. of steel framing, at 1*s.* 9*d.*	312	18	0
1,063 „ gun-metal capping, at 2*s.* 6*d.*	132	17	6
Cylindrical glazing, ½-inch thick	233	13	0
Total cost	£679	8	6

Thus a saving of £171 16*s.* 9*d.* was effected in addition to the economy of light. It was not, however, necessary to adopt a diameter of 14 feet, or to use plate glass ½ inch thick. He preferred a diameter of 12 feet 6 inches for the inside of the glass, allowing an internal diameter of blocking of 12 feet, and he thought ⅜ inch was ample thickness for the plate glass. The Messrs. Stevenson and the French Engineers preferred a diameter of 12 feet, the former using glass ¼ inch thick in all their lanterns. Spare panes were supplied with every lantern, but in addition there should always be storm-panes, as they could be erected in case of necessity in a few minutes. Every attempt of the light-keeper to maintain a good flame, or even any flame, would be futile, if a single pane were broken so as to let in the wind. A lantern framing of the improved system, having an internal diameter within the glass of 12 feet 6 inches, and glass ⅜ inch thick, would cost about £425, or one half of what was now paid by the Trinity House. The extra cost of an increased diameter of glazing did not stop there, but extended to the cupola, blocking, and finally to the tower itself.

The reports on lanterns laid before the Board of Trade, and referred to by Mr. Douglass, related to two forms of lanterns only, that adopted by the Trinity House and the other by the Commissioners of Northern Lights; and no mention was made of the improved system of framing. He did not adhere to any particular inclination for the lens panels, but when that inclination was settled, the lantern should be constructed to correspond. The uniformity of the light from the apparatus used by Mr. Douglass would be improved by having the racks of the upper and the lower reflectors placed so as not to come vertically over each other. He strongly disapproved of vertical framing for the reflectors, while inclined framing was used in the lantern; and of inclined framing for the reflectors, when a different inclination was used in the lantern; as under such circumstances the framing of both the apparatus and the lantern stopped light. The Trinity House light at Gibraltar was marred by the vertical lantern bars not coinciding with the vertical framing of the apparatus, by which the obscuration of light was more than doubled.

As lanterns of a sufficient strength could be constructed on any of the known plans, it was unnecessary to discuss which form of framing was theoretically the most perfect, in regard to a maximum strength with a minimum weight of material; but it was important to construct a lantern of ample strength with a minimum loss of light, and at the least expense. He claimed for his lantern superiority in these three points. He considered a shallow capping $\frac{1}{8}$ inch thick more suited to prevent the accumulation of snow on the lantern framing than one upwards of 1 inch deep, as used by Mr. Douglass. During a snow-storm one of the light-keepers should be outside the lantern to sweep the snow off the capping and glass. He was of opinion that Mr. Douglass' lantern would carry a greater bulk of snow than any other. No doubt, when Professor Faraday reported in reference to Mr. Douglass' lantern that it was "nearly a matter of indifference as regards shadow how the uprights of the optical apparatus were placed in relation to such a lantern," he was aware that the whole of the framing would stop light, no matter where placed.

The composition of the glass varied considerably; and as a natural result the index of refraction, colour, hardness, and non-liability to change colour, all varied. The allowance of $\frac{1}{8}$ inch for grinding was necessary on account of the rough surface of the cast glass, the inaccuracy of shape resulting from the imperfection of the moulds, and the contraction in cooling and handling which sometimes took place before the glass was set.

The lantern which he had described was as good as any of the old lanterns for illuminating the sea from the horizon to the tower: it was also suited for any required dip, as that was accomplished in the apparatus, and no obstruction resulted from the lantern framing, unless it was incorrectly placed. The brightest light was generally sent to the horizon, but with a properly adjusted apparatus there would be a good light in-shore.
