SELECTION

OF PAPERS

REGARDING THE CONSTRUCTION

OF A

LIGHT HOUSE ON THE ALGUADA REEF.

I.

NOTE BY THE MOST NOBLE THE MARQUIS OF DALHOUSIE.

PASSING down the coast of Arracan we found the weather so fine as to admit of our passing close to the Alguada Reef.

This dangerous and dreaded line of rocks lies to the southward of Cape Negrais, at about ten miles below Diamond Island. It is very low, extends for probably a mile in length, and renders a divergence from the direct course between Calcutta and the Irrawaddy so necessary in common prudence, as to cause the loss of usually half a day in the passage. The Rear Admiral, before he left the station, urged upon the Government the expediency of erecting a Light House upon the reef, and the Government promised that the practicability of doing so should be examined as soon as an Officer could be spared for that purpose.

2. To-day I landed upon the reef. I found it composed of sandstone, laid by nature in parallel lines, and thrust up on edge with an inclination to the eastward, like all the rock and cliffs upon this eastern portion of the Bay of Bengal. It is covered with oyster and shell fish, and bears no appearance of vegetation, nor is there the smallest quantity of earth or even sand upon it.

Time did not admit of walking over the whole reef, but even close to the spot where we landed, there was a broad and comparatively level space of not less than twenty-five yards, which would give ample room for the foundation of any building that might be required. It is my impression that, if a site were selected towards the northern end of the

main reef, where an outer reef protects it towards the East, and where the roll of the sea in the S. W. Monsoon will partly expend itself on the southern portion of the reef before it reaches the site, a Light House, either of stone or of iron, might be erected without any great difficulty or cost.

3. If on my arrival at Rangoon I should find an Engineer Officer disposable, I shall despatch him at once to the reef, in order to his examining it and furnishing me with a preliminary Report on the subject while I am in this part of the world.

DALHOUSIE.

H. Co.'s STEAMER *Zenobia*,
13*th December* 1853.

No Officer appears to be immediately available for this duty at Rangoon. I request, therefore, that a letter may be addressed to Major Fraser, stating generally these views and expressing my wish that an Engineer Officer may, if possible, be deputed from the Pegu or Tenasserim Provinces to examine and report upon the reef during the present season.

DALHOUSIE.

17*th December* 1853.

II.

EXTRACT from a Despatch from the Hon'ble the Court of Directors, to the Government of India, in the Public Works Department, No. 47 *of* 1856, *dated* 27*th May.*

Para. 4.—"The necessity of a Light House on the Alguada Reef seems to be sufficiently established; but no adequate information has been afforded to us as to the conformation of the reef and the adjacent rocks, or the nature of the building which would be best suited for the situation. We trust that it will be in your power, without delay, to depute an Engineer Officer to make the necessary surveys, plans and estimates, for the proposed work, and we direct that the same, when obtained, may be forwarded to us with an expression of your opinion on the subject."

III.

EXTRACT from a Letter from the Secretary to the Government of India, Public Works Department, to Lieutenant A. Fraser, No. 5055 *of* 1856, *dated* 21*st October.*

Para. 3.—"You will, of course, make a minute and careful survey of the reef, including soundings to some distance on every side of it, nature of bottom, character of rock, direction and force of tides, and you will endeavour to obtain the best information that can be had as to the probable force of the sea in the South-West Monsoon, and the elevation that it may be necessary to give the Tower in reference to the distance from which it should be seen by vessels approaching from different directions.

4. Bearing in mind the different forms, whether of stone or iron, in which it may prove best to construct the Light House, the various local circumstances affecting the successful execution of each of these will doubtless suggest themselves to you. Give this your careful consideration now, so that you may go to Pegu provided with whatever instruments or apparatus may be necessary for the investigations that you will have in view.

5. You will, among other things, endeavour to ascertain during what period of each season it will be possible for the work to proceed, and during what period the Light House, when completed, is likely to be unapproachable, and therefore incapable of receiving supplies and stores; and after the survey is finished before quitting Burma, you will obtain as much information as possible as to the best localities for stone and other materials likely to be required.

6. Having completed these enquiries as speedily as may be consistent with a thorough performance of the duty, you will return to Calcutta and submit a brief Report of what you have observed and done. You will then proceed to England, stopping by the way at Galle, with a view of availing yourself of such experience as may have been gained in the course of the operations now in progress under Mr. Poingdestre for the erection of a Light House on the Bass. After your arrival in England, you will specially report yourself to the Hon'ble the Court of Directors, and with their credentials, you will communicate with Mr. Allan Stevenson or other gentlemen eminent in this branch of engineering.

7. After visiting the most remarkable Light Houses in positions analogous to that of the Alguada, you will then prepare your designs, and through the Hon'ble Court's intervention, submit them for the criticism and correction of the high authorities alluded to. You will then make arrangements for the supply of whatever material and appliances it may be advisable to obtain in Europe, and having seen these despatched, you will return to India, bringing with you such staff as it may appear desirable, with the assent of the Hon'ble Court, to employ."

IV.

REPORT ON THE ALGUADA REEF BY LIEUTENANT A. FRASER, ENGINEERS, EXECUTIVE ENGINEER, ALGUADA REEF LIGHT HOUSE.

I arrived at Rangoon on the 12th December 1856, and proceeded per Hon'ble Co.'s River Steamer *Mahanuddy* to Bassein, where, agreeably to the Commissioner's orders, the Hon'ble Co.'s Steamer *Enterprize* was placed at my disposal.

Arrival at Rangoon, and proceeds to Bassein in the *Mahanuddy*.

2. On the 24th December, I removed from the *Mahanuddy* into the *Enterprize* off Dalhousie, and the former vessel returned to Rangoon.

Joins the *Enterprize*, Commanded by Captain Brett.

3. Before proceeding to visit the reef, it appeared to me an important point to examine carefully, and fix by as accurate a survey as the means and time at my disposal would allow, the position and general features of Negrais and Diamond Islands, and the shores in the vicinity of Pagoda Point, and Porian Point at the mouth of the Bassein River. These being the nearest land to the reef, it was obvious that one or other of these situations would be found the most convenient for the depôt of

Necessity of surveying position, and general features of the shores in the vicinity of the reef for the selection of a place on which to form a Depôt.

stores and materials and for the workmen during the South-West Monsoon, whilst the Light House was being erected.

Submits drawings as follows:
1. General plan of the coast.
2. Plan of reef showing soundings.
3. Drawing of Diamond Island.
4. Ditto of Negrais Island.
Refers to Journal for further information regarding survey.

4. To detail here all the operations of the survey would take up more space than the relative importance of this branch of the subject would justify. Drawings of each of these places are submitted as the result, and should further particulars be desired, I must refer to the journal, a copy of which is appended to the Report.

Position of the reef, its general direction and form; the general height above low water of the eastern ridge and its general conformation.

5. On the 28th December 1856, being the day of the highest spring tide, I landed for the first time on the Alguada Reef. Its position, as fixed by subsequent observations, is six miles 540 yards distant from Pagoda Point bearing 23° 30′; from Diamond Island four miles 1093 yards bearing 54° 30′; from Porian Point eight miles nearly, bearing 78° 10′. It consists of two totally distinct ridges of rock, running parallel to each other, in a direction 51° East of North; separated by a channel a quarter of a mile wide, of a depth varying from 2 to 3½ fathoms, with a small detached rock in the centre appearing above the surface at low water. The eastern ridge is about ¾ mile in length, by 150 to 200 feet wide at low water, and an average height of seven feet above low water mark, rising gradually, though with frequent breaks and changes of level, from the surface of the water at the N. E. to 14 feet at the S. W. end. For about 900 feet from the latter extremity, the ridge is continuous, and easily traversed. After this it becomes broken and divided by ravines and gullies, rendering a passage across them a work of some difficulty and danger. After 2500 feet, the remainder consists of nothing but detached rocks totally unapproachable, except by boat.

The western ridge.

6. The western ridge commences from a point nearly abreast the centre of the eastern ridge, and thence runs parallel to it for about the same distance. It is entirely composed of detached and isolated rocks, the largest of which we found on landing to be not more than five yards wide by 20 yards long.

7. The rock of which the entire reef consists is sandstone, much scored into parallel and alternate ridges and gullies by the incessant action of the waves, though from the uniformly inclined position of the strata, one would be led to suppose that other disturbing agency than the waves had been at work to produce the formation. The West slope of all these ridges is steep, and in some places perpendicular or even beetling over; the eastern slope is uniformly inclined at a much lower angle. This remark is equally applicable to the general conformation of the entire reef, as it is to its several component parts.

The nature of the rock of which the reef is composed.

8. The rise and fall of spring tides as found by the means of several observations, I found to be nine feet, which coincides with the rise and fall as fixed by Lieutenant Ward, Indian Navy, who notes it in his Chart as nine feet.

The rise and fall of tides.

9. During the time I was engaged upon the reef, Captain Brett, Commanding the *Enterprize*, on one occasion, and his 3rd Officer, Mr. Cookson, on another, at my request took notes of the direction and force of the tides. From the Memos. furnished by those Officers, (*vide* Appendix I.), it appears that the spring tides ebb and flow with a velocity of from one to two knots per hour, that the flood tide runs in a direction between E. S. E. and South, whilst the direction of the ebb varies between W. by N. and S. W. This corresponds with the course of the tidal wave as given in Johnston's Physical Atlas. It is there shown that advancing from the great reservoir of ocean round the South Pole, the tidal wave flows into the Indian Ocean, and proceeding northward impinges upon the projecting point of Cape Comorin. Here dividing in two, the western half runs up the Arabian Sea into the Persian Gulf, whilst the eastern half courses up the Bay of Bengal, which again breaking on Cape Negrais, the western wing rushes on, until narrowed by the converging shores at the head of the bay, it forms the well known bore in the Hooghly, whilst the eastern wing in like manner, is forced at the head of the Gulf of Martaban up the Sittang, causing the still more celebrated and terrible bore in that river.

The velocity and direction of the tides.

10. Careful soundings have been taken all round the reef, in every direction to a considerable distance, by the Officers of the *Enterprize*, under my directions. These are

Soundings around the reef.

all laid down on my plan of the reef, which accompanies this Report. The depth of water is from one to four fathoms.

11. The bottom close around the reef is almost entirely rock, at a little distance off it is formed of sand and shells, with patches of rock scattered over it in all directions.

The bottom near the reef.

12. After carefully examining every part of the reef which was at all accessible, I finally fixed upon a plateau on the eastern ridge, 600 feet distant from the S. W. extremity, as the site most suitable for the erection of the Light House. The reasons which induced me to come to this conclusion are as follows:

The site for the Light House. Model thereof submitted.

1*st*.—The reef at this place is a firm solid mass of rock, presenting a nearly level surface of 100 feet in width, with an average height of 1·1 feet above high water spring tides.

2*nd*.—Although the rock at the southern point of the reef is higher, being 4·5 feet above high water, the space there is so contracted, being only 31·5 feet at highwater in width, that I considered it impracticable to build upon it a Light House of sufficient base to admit of the erection of a Tower of the dimensions which the nature of the case requires. Next to this, the proposed site is higher than any other portion of the reef.

3*rd*.—The western ridge covering as itdoes only the northern half of the eastern ridge from the influence of the South-West Monsoon, the further the Light House can be placed from the southern end of the reef, the more shelter it will obtain from that quarter, where the greatest danger is to be apprehended.

4*th*.—The workmen during the N. E. Monsoon, and whilst the erection of the Light House is in progress, will have to live chiefly, if not entirely, on the reef.* It is of more importance even that the quarters for their accommodation should be raised as much as possible above the wash of the sea, than the foundation of the Light House. For this purpose I am of opinion that the S. W. Rock is peculiarly adapted, being within easy distance of the site of the Light House, and the intervening portion of the reef presenting no obstacles to the workmen passing and re-passing from the one to the other at all times of the tide, except perhaps in very tempestuous weather, with perfect safety.

* See Final Report, Sec. III. para. 6.

5th.—The western face of the plateau falls perpendicularly from 10 to 12 feet, and the waves consequently dash against it with much violence. It is, however, in some measure protected by three parallel low ridges of rock lying in front of it, whilst the eastern face slopes easily and gradually to the water's edge, and it is here that I almost always effected a landing after finding every other part of the reef on either side too dangerous to approach whenever there was any wind or ground swell.

Force of the sea.

13. During the whole time I was off the reef, although several times the wind was blowing fresh, and there was a heavy swell, still there was nothing to indicate in any degree what the force of the sea might be when lashed into fury by a gale from the S. W. I have, however, taken every opportunity of making enquiries on this point from Masters of vessels and other nautical men who have had experience of this coast at all seasons of the year. They all of them agree that, although a tremendous sea does undoubtedly break over the reef during the S. W. Monsoon, it does not equal in violence the force of the waves during a storm in the British Channel or around the coast of England. It may then, I think, be safely assumed that the Light House on the Alguada Reef will not be exposed to a greater pressure than that on the Skerryvore, and that consequently the force of the sea, as calculated by Mr. Allan Stevenson, *viz.* 6,000 lbs per square foot, which though confessedly deduced from imperfect data, has been found a safe practical guide, may be taken as the maximum force which I shall have to overcome.

The nature of the material to be employed in the construction of the Light House.

14. * Having fixed upon the situation for the future Light House, the next point that arose for consideration was the nature of the material of which it should be composed. There are three varieties of Light House from which to make the selection—

1. Of Iron.
2. Of Stone.
3. Foundation of Stone, superstructure of Iron.

The first is advocated by His Excellency Admiral Sir Fleetwood Pellew, the late Naval Commander-in-Chief in the Indian Seas, on the grounds of its facility of erection and economy.

Captain Rogers, Superintendent of Marine, recommends a structure resting on substantial pillars (of iron I presume) 20 feet high, from the

* See Final Report, Sec. I.

top of which a column is to spring for the lanthorn shaft 50 feet higher with dwellings for the Light House-keepers projecting on either side 12½ feet beyond the head of the pillars, supported on wrought or cast iron beams. With all due deference to these two high authorities, all the information which I have as yet been able to collect, and the inspection of the reef which I have just completed, leads me strongly to incline to the opinion that not only would such a Light House, as that proposed by Captain Rogers, be exceedingly unsafe from so large a portion of it projecting beyond the base, having a strong tendency to throw out the centre of gravity and to cause the Tower to fall, but that iron in any form is not adapted for a Light House in so exposed and dangerous a situation as the Alguada Reef.

Mr. A. Stevenson's opinion regarding iron Light Houses in exposed situations.

15. Doubtless at first view, iron appears to be indicated as economical and easy of construction, as the several parts could be manufactured in England, and readily as well as rapidly put together on the reef, and also, which is as important a point as either of the former, from the increased interior space for dwelling-rooms and stores, afforded by the thinness of the outer walls. Still Mr. Allan Stevenson has so forcibly pointed out the objections to the use of iron, and the superiority of stone for the material of a Light House, that I cannot do better than quote his words in summing up the comparative *merits of the two.* "Such structures (*viz.* those of iron) for situations of great expo-
" sure would, undoubtedly, be less costly than those of masonry, but
" their stability confessedly depends upon their *strength* rather than
" their *weight*, and in many situations it might ultimately be resolved
" into the security of the fixtures which attach them to the rock. There
" is, undoubtedly, reason to fear that in structures of great height,
" urged by the continual force of the waves and winds, a gradual deterio-
" ration of the fixtures may result from long continued tremor, or that
" the pillars might suddenly sustain very serious injury from the impact
" of heavy bodies thrown against them by the waves, and while in
" proportion to the difficulty of the situation, the expense of the stone
" structure would increase, so the undesirableness of being forced to
" renew any structure would increase also; and thus, while in many such
" places, the iron Light House may be the most convenient and least
" expensive, the stone Tower is the more satisfactory and durable when

"completed. I should, therefore, in general, say that nothing short of "absolute necessity can justify a preference of iron over stone for the "purposes of a Light House exposed like the Eddy Stone, the Bell Rock, "and the Skerryvore, to the full fury of the waves. The gradual change "of cast iron by the action of the marine acid, forms another element "in the question as to the fitness of such structures for rocks washed by "the sea."*

Recommends a Tower entirely of stone.

16. Satisfied by these cogent reasons that the Light House must at least in great part be built of stone, I would complete it entirely of that material as more durable and more sightly than one partly of stone and partly of iron, and as all the establishment for quarrying, dressing, and putting together the stone for the foundation would have to be organized, there could be but little, if any, immediate saving effected by employing iron for the superstructure, whilst ultimately it would certainly prove the most costly. I am further of opinion, that an iron Light House would hardly be habitable in the hot season from the great heat.

Recommends an elevation of 110 feet for the Tower above high water mark.

17. † In determining the elevation necessary to be given to the Tower, the first object was to ascertain the distance from which the light would be required to be visible. Captain Brett and other nautical men, whose opinions I asked on the subject, agreed that 20 miles would be sufficient to ensure all vessels passing through the Preparis Channel making the light. At the same time less than that distance would hardly suffice, inasmuch as after the Light was established, Commanders of vessels, instead of as now carefully and anxiously giving the reef as wide a berth as possible, will run directly for it as a leading mark and fresh point of departure. According to the Table given by Mr. Allan Stevenson, the elevation to be given to a light to render it visible to an observer's eye, 25 feet above the level of the surface of the sea, at a distance of 20 miles, would be 110 feet. Supposing then the Tower to be 110 feet above high water mark, the light would be visible from the mast head of the smallest vessel 20 miles off, and from the mast head of large vessels which may be taken on an average as 50 feet high, it could be seen as far as 23 miles.

* See Final Report, Sec. I. para. 2.

† See Final Report, Sec. I. para. 11.

18. The dimensions of the four principal Light Houses on England's coasts in situations analogous to the Alguada Reef, are as per margin; fifty feet, therefore, will be fully sufficient to allow for the diameter of the base as far as stability is concerned; but I expect I shall have to enlarge the size of this Tower to allow of sufficient space interiorly for the stores and provisions which will have to be laid in for a much longer period than is necessary in England, owing to the prolonged difficulty and danger of approach during the S. W. Monsoon. Should further enquiry prove that such is the case, the plateau on which I have fixed as the site for the building, is capable of admitting a safe and solid foundation of fully 60 feet in diameter, which must be ample for all purposes.

	Height Ft.	Diam. at Base.	Diam. at Top.
Skerryvore	158	42	16
Bell Rock	100	42	15
Eddystone	68	26	15
Caulingford	111	48	not given.

The site fixed on will allow a diameter of 60 feet for the base of the Tower.

The nature of the light to be placed on the Tower.

19. * The next question that occurs is the nature of the light to be placed on the Tower. There are three classes into which the illumination of Light Houses are divided—

1*st.*—The Catoptric.
2*nd.*—The Dioptric.
3*rd.*—The Catadioptric.

The first consists of several lamps, the divergent rays from which are collected and evenly dispersed on the horizon by means of reflecting mirrors. The second where the same result is effected by the rays from a single lamp being refracted through lenses and prisms. The third in which a single lamp is also employed and the light evenly diffused by means of a combination of both mirrors and lenses. In a brief Report, such as I have been directed to submit, it would be impossible to discuss fully the distinctive peculiarities of these several systems, or the particular qualities in which one appears superior to the others. Nor is it necessary that I should do so, as my present views on this, as well as on other heads of the subject, will have to be submitted to the test of the investigations I shall have to institute in England, and will be much modified and directed by the experience of eminent men in Europe who have made this branch of science their study.

* See Final Report, Sec. II.

20. At present, therefore, I would only remark, that the Dioptric or Catadioptric system is recommended by its superior power, and is indisputably the most perfect method of illumination with which we are at present acquainted, whilst at the same time it is more economical to maintain, the annual expenditure in England for a Dioptric Light being £ 140-3-8 less than for a Catoptric. At the same time, I am inclined to the belief, that these advantages are more than counterbalanced by the complex nature of the machinery of the Dioptric Light, rendering it liable to get out of order, in which case the difficulty of repairing it in such a situation as the Alguada Reef, isolated as it is and cut off from all extraneous assistance during a great portion of one-half of each year, would be very great, and still more so by the apprehensions I entertain of the probability of the Light House-keepers through accident or negligence allowing the light to go out, in which case the results might be of the most disastrous character. In the Catoptric Light, there are a number of separate lamps, which are on the fountain principle, and consequently perfectly simple and devoid of all complicated mechanism, there is, therefore, little risk of their getting out of order. In a fixed Catoptric Light of the first order, there are 26 of these separate lamps, and it is obvious, therefore, that even supposing two or three of these to go out, the consequences would be as nothing in comparison to the extinction of the single light of the Dioptric apparatus, which would leave the entire horizon totally deprived of illumination. There is one more point to be considered, *viz.*, whether the light shall be fixed or otherwise. The different varieties of revolving, of reciprocating and flashing lights, have been introduced for the purpose of enabling a vessel approaching the coast to distinguish the different lights, and so obviate the danger of accident which would arise from the possibility of her mistaking one for another; no fear of the kind exists with regard to the Alguada Reef, nor is there any particular dangerous quarter in the vicinity which it would be desirable to indicate by a red light or a dark shadow. I conceive, therefore, that a plain fixed white light would be most suitable, as being the most simple and consequently less liable to derangement, and the valuable space which would be occupied by the machinery of the other kinds, will be available for stores, &c.

Recommends a fixed Catoptric Light.

21. The season during which it will be found practicable to carry on the construction of the Light House on the reef itself, will extend from about the middle of November to the end of April. In May, the S. W. Monsoon commences, and although its violence is generally exhausted by the middle of October, it takes some time for the sea so long lashed into fury by the continued driving of the winds in one direction to subside, and the final departure of the Monsoon is generally attended by a storm of more or less violence, while a gale of similar character may be likewise looked for at its commencement in May.

The season during which work can be carried on in the reef.

22. Experience can alone determine upon the possibility of landing on the reef during the S. W. Monsoon, and consequently on the time for which the Light House, when finished, must be provided with stores and with food, fuel, and water for its inhabitants; but accommodation for six months' supply must be provided for in the design for the building. It is the opinion of most persons in Pegu competent to judge, that during the breaks which always occur in every Monsoon at irregular intervals, and of uncertain duration, opportunities will occur of landing supplies for the Light House, provided that means are afforded of facilitating the operation by the aid of a pier with a moveable crane at its extremity.

The time during which the Light House, when complete, will probably be unapproachable, and the accommodation for supplies which must be arranged for in designing the building.

23. The conformation of the reef on the eastern side of the Light House site, appears particularly adapted for the construction of such a pier. The eastern will be the lee side during the S. W. Monsoon, and the ridges slope gradually down to the water's edge with sufficient water to allow of boats approaching near enough to discharge their cargo, without being stove in upon the rocks below the surface on the recoil of the swell. This is the spot upon which I almost always landed on my recent visit, and it was frequently the only place on which the boats could approach after numerous trials on both sides of the reef. At first, as a temporary measure, it would be sufficient to fill up the irregularities of the surface caused by the gullies that separate the successive parallel ridges with loose broken stone; this eventually would have to be retained between sea walls of regularly built masonry jointed and joggled together. A structure of this kind in that compara-

On the construction of a pier to the eastward of the Light House, to facilitate landing stores and materials.

tively sheltered position may fairly be expected to withstand the impact of the sea, and boats anchoring a few feet in front of the head of the Pier under the projecting arm of the crane at its seaward end; men and stores could, I should conceive, be landed from them in favorable weather, if ordinary care and precautions are taken to avoid accident.

24.* The quantity of space for the interior of the Light House is a point on which I do not at present feel qualified to offer any opinion. So many elements have to be taken into consideration, the nature of the lights, the number and race of the light-keepers, the different description of stores required for the efficient maintenance of a light, and the cubical contents of such stores have all to be well weighed and determined upon before even an approximate solution of this important question can be arrived at.

Regarding the quantity of space required for the interior of the Light House, unable at present to come to a decision on this point.

25. In order to maintain the communication between the Light House and Depôt on shore during the time the works are in progress, a Steamer will be required to be permanently assigned for this exclusive service. As she will have at times to be exposed to very bad weather, replete with dangers of every description, it will be necessary that she should be a vessel of good sea-going capabilities, and with engines of sufficient power to enable her to contend successfully against the violence of the winds and waves, and rapidly to run from exposed situations into others where she can be in comparative security. She will also have to tow heavy lighters, laden with stones, from a distance, and it will be an object of the greatest importance to lose as little time as possible in any of the operations restricted to the continuance of the N. E. Monsoon.

States the necessity of having a Steamer assigned for the exclusive service of the Light House works.

26. I fear that it will not be found practicable to keep a life-boat of any description on the reef, or, should this be possible, to launch her from it amidst the boiling surge that rages around it; at the same time the number of persons who can be accommodated within the Light House will be so small, that supposing the other difficulties to be overcome, there seems little chance of their ever being able to man her. I shall, however, direct my particular attention to this when

Points out the usefulness of a life-boat on the reef after erection of the Light House.

* See Final Report, Sec. IV.

in England, as such a boat might be the means of saving many lives from wrecks, and would be otherwise useful in communicating between the Light House and the Steamer, or even the adjacent shore in case of unforeseen extreme emergencies.

27.* A Barrack will have to be constructed on the reef for the accommodation of the workmen whilst engaged in the erection of the Light House. The situation for this I have already indicated in paragraph 12. It will have to be erected on pillars of either wood or iron, disposed in a conical or pyramidal form, as giving the utmost possible stability, connected and strengthened by wrought iron ties and braces, the pillars being secured to the rock by means of Lewises.

Barrack for workmen, its situation and proposed construction.

28.† The foremen of the works I should propose bringing out from England, as it will be necessary that the ordinary workmen should be directed and superintended by men of experience and ability. The great expense of English labor in this country, and the disappointment and loss of invaluable time which would ensue from their constitutions not being acclimatized, and the sickness to which they would be liable in so exposed a situation where shelter from the burning sun and the driving spray is not even to be thought of, are insuperable objections to the employment of Europeans in the merely mechanical part of the work; nor do I think that any reason exists for regretting their absence. I believe that at Hong-Kong, where all buildings of the least pretension are constructed entirely of granite which abounds in that vicinity, Chinese masons can be found who will readily consent to engage themselves to work at the Light House, and who will succeed nearly, if not quite, as well as Europeans in the erection of the Tower.

Proposes to bring out Superintendent from England, ordinary workmen from China, supposing a stone Light House be fixed upon.

29. My survey of the shores and Islands at the mouth of the Bassein River, led me to fix upon Diamond Island as in all respects the most suitable situation in which to establish the Depôt for stores and materials during the progress of the works, and for the subsequent maintenance of the light. The Island is $4\frac{3}{4}$ miles distant from the reef. It is irregular in form, about a mile and a half in circum-

Recommends Diamond Island as the Depôt for stores, &c., and assigns reasons for fixing on that spot.

* See Final Report, Page

† See Final Report, Page

ference, surrounded by a belt of sandstone rocks, but to the East and a little to the South of the North Point, a break in the reef affords a safe entrance and landing place for boats at all seasons of the year. The Island itself forms a shelter and break-water from the winds and waves of the S. W. Monsoon. Above the rocks there is a girdle of loose sand from the upper edge of which the ground rises abruptly, and the whole of the interior from this line is covered with a dense and almost impenetrable jungle. A portion of this on the eastern face (which is marked in the sketch of the Island accompanying) will have to be cleared, and the space so rendered available, will be amply sufficient for all the buildings that will be required for my own residence, the store-rooms, workmen's barracks, &c., &c. The line of clearing I have indicated in the plan will open out the Alguada Reef, so as to render any signals from thence visible all over the Depôt, and *vice versâ*, whilst at the same time the jungle left to the westward and southward portions of the Island will afford an indispensable and efficient shelter from the S. W. Monsoon. Captain Brett informs me that he often anchored off the landing place in very bad weather, and that he considers it a safe berth for the attendant Steamer at any period of the year. Fresh water is found in small holes in the bed of a nullah which appears to form the principal drainage of the various ridges and spurs that fill up the interior of the Island. It is at present scanty in quantity; but the Burmese collectors of turtle's eggs, who reside on the Island, report that during the rains a considerable volume of water passes through that channel, which might be retained by a bund if made sufficiently strong. I noticed the remains of one they had constructed; but being very rudely put together, it had burst and the water escaped. They also stated that good water was obtainable in considerable quantities a little below the surface by sinking wells.

30. Diamond Island, thus affording all the requisites for a Depôt, very safe anchorage, accessibility, sufficient space and fresh water, I deem it superfluous to discuss the comparative merits of Negrais Island, Pagoda Point, and Porian Point, which are so much more distant from the reef.

31. Having thus completed my observations of the Alguada Reef, and its neighbouring shores, and finding that the stone, of which they were composed, was uniformly a soft and friable sandstone, I deemed it important to ascertain whether a report, which I had heard, of the existence of granite in the Island of Callagouk was correct, and whether I could rely upon that place, or any other which I might discover in its vicinity, for the supply of a material of the requisite hardness and durability, and in sufficient quantity for the completion of the Light House.

32. I accordingly proceeded to Callagouk, an Island on the coast of the Tenasserim Provinces, 30 miles to the South of the entrance to the Moulmein River. The Steamer anchored on the East of the Island between it and the main land. It is about five miles long, and half a mile broad, uninhabited, consisting of a ridge of considerable elevation, covered with dense jungle. I landed on a mass of rock forming one point of a sheltered bay, and found that the whole of it was granite; and continuing my researches, it appeared that the whole Island was composed of stone of the same description—specimens accompany the Report. It is a coarse-grained stone, composed of black mica quartz and felspar, the latter superabundant and in extremely large crystals, causing me to entertain some apprehension, that if exposed to the constant action of the waves, it would in time decompose, leaving large cavities which would ultimately tend to the disintegration of the mass; and in this opinion I have been somewhat confirmed since my return to Rangoon by Dr. Brandis, Superintendent of Teak Forests, a gentleman who has made geology and mineralogy his study.* It must be borne in mind, however, that I had neither the time nor the appliances for boring or blasting the solid rock, and the specimens which I have collected are consequently only the pieces that I could break off from the outer corners with a heavy iron hammer.

33. Should the Callagouk granite be found to answer, no place could possibly be better adapted for the purpose than it is by nature. The roadstead, about three miles broad between the Island and the mainland, affords a perfectly safe anchorage to vessels of any draught at all seasons of the year. The bay on which I landed, is just inside the southern end of the Island, about half a mile broad, and a quarter of a mile deep, with a hard sandy beach extending round it from point to point; the soundings in a straight line from point to point are 2 to 2½ fathoms, which depth of water is obtained within 10 yards of the points. Here then is a natural harbour, of the best possible description for lighters,

* Mr. Oldham has since given a favorable report to the Hon'ble the Court of Directors on the stone.

for the conveyance of stone, which they can take away actually from the water's edge, and also for the attendant Steamer, should she be required to call there, or for any vessel engaged in the Light House works.

States that fresh water is to be found in Callagouk, and points out its position.

34. It is noted in the Charts that fresh water exists; but though I proceeded in search of it, I had not succeeded in finding it, when darkness compelled me to return to the Steamer. I have since learnt from Captain Booth at Moulmein, that he has seen a stone tank filled with beautiful water, situated on the North point of the Island, and only a few hundred yards beyond the spot at which I discontinued my search.

Gives the distance of Callagouk from the reef, and shows how workmen may be supplied with provisions.

35. Callagouk is 210 miles distant from the Alguada Reef, and being to windward of it during the N. E. Monsoon, the conveyance of stone which would be confined to that season would be much facilitated, while the workmen employed in the Island might be supplied with provisions from Amherst by means of the Steamer attached to the Tenasserim Provinces in her monthly voyage to Tavoy and Mergui, without extra cost to Government.

36. I also visited Green Island, immediately in front of Amherst. The stone here, as appears from the specimens, is of a much closer and finer grain, and is so far superior to that at Callagouk, but the rock appears to be less solid, being split into fissures, and intersected with veins of mica and disintegrated granite, so that it is doubtful whether I could obtain blocks of sufficient size for the Light House. But even should this prove a groundless apprehension, the very small size of the Island, which is not more than half a mile in circumference, its exposed and dangerous position with the Amherst Reef, and a rocky shore to Leeward, and the absence of any safe anchorage in its vicinity, the difficulty of landing on it at any time, and the impossibility of doing so in bad weather, in the S. W. Monsoon, renders it utterly ineligible as a quarry for the Light House.

The arrangements that will have to be made, should the Callagouk granite not be found good enough for building.

37. If then the Callagouk granite is not considered good enough to warrant its use, all idea of obtaining material in this country must be abandoned, and the stones will have to be quarried and prepared in England, and put together on the reef. The uncertainty and danger of delay inseparable from this arrangement through the non-arrival or loss of the ships which bring out the stone, together with the manifest advantages attendant on the developing the resources of the country, the consequent fulfilment of the repeatedly expressed desire of the Government to render it as independent as possible of aid from England, and the convenience to Pegu and Tenasserim Provinces, and possibly to Calcutta itself, of being able to indent upon these quarries, when once opened for an inexhaustible supply of the most durable building stone for public and private buildings, lead me strongly to hope, that the granite of Callagouk may not be too hastily condemned, because it is not as perfect as it might be, and that this Island, so favorably situated, and so well adapted in all respects for the purpose in view, may be fixed upon as the place from which I am to draw my materials.

In case the Callagouk stone be approved, Hong-Kong is the source from which quarry-men should be obtained.

38. Should this be the case, Hong-Kong is the source from which I would obtain quarry-men, for the same reasons as expressed in paragraph 28, regarding the class of workmen to be employed in building the Light House. Captain Brooking and Captain Brett have visited Hong-Kong, and both agree as to the dexterity and skill of the Chinese in quarrying granite, no less than in the subsequent operations of dressing and putting it together.

39. If it could be insured that all the ships laden with stone from England should arrive safely and regularly with their cargoes, it might possibly be more economical to obtain it thence than to have a quarry at Callagouk, the first establishment of which must be expected to be attended with expense. In the former case, however, the entire amount will be sunk in the Light House, and lost to this country, whilst in the latter, it will open a new field of employment for the people, and afford a new material, not only for any other Light Houses that may be required, but generally for the public works of the eastern coast.

The establishment of boats for the erection of a Light House of stone, the material being procured at Callagouk.

40. Two Lighters of about 80 tons would be required for the transport of stone from Callagouk to the reef, and two smaller ones of about 30 tons to ply between the Depôt on Diamond Island and the Light House. I have requested Captain Brooking, Superintendent of Irrawaddy Flotilla, to furnish me with a memorandum descriptive of the kind of vessel of each class he would recommend as most

suitable, her rig, the number of hands sufficient to man her efficiently, the time and the cost of construction, and the expense of subsequent maintenance. This, when received, will be appended to this Report.*

The limestone found at "Kyouk Thembau," about 30 miles above Dalhousie, its accessibility, and the means of transport.

41. On coming down from Bassein, I stopped at a village called Kyouk Thembau, where I understood lime was obtainable. It is 30 miles above Dalhousie on the right bank. Here, and at the village of Thama-dewa, half a mile below it, I found sufficient limestone for a hundred Light Houses, (specimens accompany). A tidal nullah runs up to the foot of the hill where it is found, navigable for any sized boats, as far as I went up, about two miles. Here we found a lime-kiln, and the hill was pointed out about one mile further on. The creek was said to be navigable up to the hill itself by boats of fifty baskets, or about one ton burthen.

Acknowledges assistance received from Captain Sparks, late Deputy Commissioner at Rangoon.

42. Before leaving Rangoon, Captain Sparks, who was awaiting orders to return to Madras, expressed a wish to accompany me and render me any assistance in his power. Having obtained the sanction of the Commissioner, he remained with me the whole of the time, and to his efficient aid I am greatly indebted for the fulness of this Report, whilst the survey I could scarcely have completed at all, in the short time allowed me, without him. To him I also owe the suggestion of the model of the portion of the reef on which I propose to build the Light House, and the contouring of which he conducted whilst I was employed making a drawing of the entire ridge. I found him perfectly competent to carry on any surveying operations, whilst his special acquaintance with the country, the people, and their language, and his general knowledge on the various subjects we have had to discuss together, have been of infinite service.

Acknowledges assistance received from Captain Brett, and the Officers of the Hon'ble Company's Steamer *Enterprize*.

43. From Captain Brett and his Officers, especially Mr. Johnson, I have received most cordial and efficient assistance. It would often have been easy to have raised difficulties in my way by objecting on account of the weather, and dangerous nature of the coast, to run the ship within easy distance of the point on which I wished to land, or to lower boats to convey me on shore, and it would have been impossible for me, professionally unskilled

* See Appendix No. II.

in such matters, to have over-ruled these objections; but so far from this being the case, I invariably found every possible facility afforded me, and all the resources of the ship in the way of boats, men, spars, rigging for flag staffs, carpenter's labor, &c., were placed at my disposal as soon as asked for.

Conclusion.

44. In conclusion I beg to state that, having been instructed to submit a "Brief Report," I have endeavoured to condense my materials as much as possible. The varied and comprehensive character of the points which I have been obliged to touch upon, have, however, extended it beyond the limits within which I should have wished, if possible, to confine it, although I have omitted every thing that did not appear to me of sufficient importance to be introduced into the body of the Report. In order, at the same time to show clearly how I have been employed, I have kept a journal in which I have noted down, day by day, every thing of interest as it occurred, and beg to attach a copy of it for reference, should a fuller detail of my proceedings be required.

The Journal will be submitted if called for.

A. FRASER, *Lieut., Engineers,*
Executive Engineer, Alguada Reef Light House.

RANGOON,
11*th February* 1857.

APPENDIX No. I.

Memo. on the velocity and direction of Tides as taken by Captain Brett and Mr. Cookson.

Date.	Hours.	Direction of Tides.	Per hour. Rate.	Direction of Winds.	Soundings	Remarks.
1856.	A. M.	Flood.	Knots.			
Dec. 29th	10-30	E. S. E.	1 ½	N. N. W.		
„	12	S. ½ E.	¾	N N. W.		
	P M.					
„	0-30	High Water.		N. N. W.		
„	1-45	„	„	„		
„	2-00	W. by N.	1 ½	N. N. W.		
30th	8 A. M.	Flood E.	1 ¼	N.	7 ¾	
	9 A. M.	S. E.	1 ½	N.	7 ¼	
	10 A. M.	S. E.	1 ¾	N.	8	
	11 A. M.	S. E.	2	N W.	8	
	12 noon	S.	1 ¾	N. W.	8 ¼	
	1 P. M.	S. S. W.	1 ½	N. W.	8 ¼	
	1-30 P. M.	S. S. W.	1	N. W.	8 ¼	
	2-30 P. M.	S. W.	1 ¼	N. W.	7 ½	
	3 P. M.	S. W.	1 ¼	N. W.	7 ½	
	4 P. M.	S. W.	1	N. W.	7 ½	
	5 P. M.	S. W.	1	N. W.	7 ½	
	6 P. M.	S. S. W.	1	N. W.	7 ½	

Enterprize anchored ¾ mile S. S. E. of the Alguada Reef sunken rocks at 1.45 P. M. Sighted the western

A. FRASER, *Lieutenant,*

Executive Engineer, Alguada Reef Light House.

RANGOON,
11th February 1857.

APPENDIX No. II.

No. 367.

To

LIEUTENANT A. FRASER,

Executive Engineer, Alguada Reef Light House.

SIR,

IN reply to your letter No. 6 of the 21st Ultimo, requesting information on certain points in connection with the construction of two lighters and two boats you propose to have built for the purpose of carrying out your operations in the erection of the proposed Light House on the Alguada Reef, I beg in reply to furnish you with the following Memorandum, which, I regret, owing to my time being wholly occupied in my official duties, is unavoidably brief, void of information as to details, and unaccompanied by sketches of the kind of boats which I consider best adapted for the duties.

These vessels of each class should be built with solid bottoms as high as the first futtock, so as to ensure less chance of injury by their accidentally grounding when laden; and unless a jetty is constructed, or a strong framing made to protrude from the reef for the smaller class to lay alongside of, it will be necessary to fit them with strong diagonal chafing pieces outside, to stand the shocks and friction they will otherwise encounter when discharging their cargoes at the reef.

Rigging should be avoided as much as possible, and the masts made of such proportion as not to be dependent on it for support. I would recommend that each class be fitted with two masts, placed far apart, to admit of a clear space for receiving and discharging the heavy weights they are intended to convey, and the decks made for large hatches in the centre, fore and aft. With regard to the numbers and maintenance of their crews, as they will not have to hoist the cargoes in or out, a sufficient number are required for the purpose only of working or

navigatingthem. I would, therefore, recommend that the larger class should have—

One Serang or Gunner	Co.'s Rs.	50	0	0
Two Sookunnies, each at 25	„	50	0	0
Twelve Lascars „ „ 12	„	144	0	0
One Bundarry	„	12	0	0
Co.'s Rs.		256	0	0

And the smaller class—

One Serang...	Co.'s Rs.	40	0	0
One Sookunnie	„	25	0	0
Eight Lascars, each at 12	„	96	0	0
One Bundarry	„	12	0	0
Co.'s Rs.		173	0	0

In addition to the above rate rations should be allowed. With regard to the estimated time and expense attending the construction of these vessels, I have called on the Government Builder, who informs me that those of tons 30 can be built each at a cost of Rupees 8,000, and the larger of tons 80 each at Rupees 20,000, and could be completed in the Government Dockyard at this place in twelve months.

The above estimate includes building and coppering only; the equipment will be an additional outlay.

I have, &c.,

A. BROOKING,

Superintendent, Irrawaddy Flotilla.

RANGOON,
7th February 1857.

APPENDIX No. III.

Specimens of Stone accompanying Report.

No. of Specimen.	Where found.	Remarks.
I	Granite from Callagouk..	Callagouk is an Island about 30 miles below Amherst, 210 miles from the Alguada Reef.
II		
III		
IV	Sandstone from the Alguada Reef.	
V		
VI		
VII		
VIII	Ditto from Diamond Island.	
IX	Stone from Negrais Island.	
X		
XI		
XII	Porian Point.	
XIII	Pagoda Point.	
XIV	Green Island	Close off Amherst at the mouth of the Moulmein River.
XV		
XVI		
XVII		
XVIII		
XIX		
XX	Limestone, Kyouk Thembau	A village about 30 miles above Dalhousie, on the right bank of the Bassein River.
XXI		

A. FRASER, *Lieutenant,*

Executive Engineer, Alguada Reef Light House.

V.

EXTRACT from a Letter No. 1437, *dated 27th March* 1857, *from Colonel W. E. Baker, Secretary to the Government of India, to Captain D. Robertson, Officiating Superintendent of Marine.*

1. THE Government of India have, as you are aware, decided upon the erection of a Light House on the Alguada Reef. As at present informed, the Government is disposed to consider that the light should be *fixed*. But an important element in the final decision of this point, and of the system of illumination to be adopted, is the extent of the horizon over which the light should be visible, and as the data appear to be defective in this respect, I am directed to request that you will be good enough to take what measures you may think fit for obtaining trustworthy opinion supon this subject, having due regard to the quarters from which the Coast may be approached, and those from which it may be inaccessible to shipping.

2. I am at the same time to request, that you will obtain and transmit to this Department, any information within your reach as to the probable period during which a Light House situated on the Alguada Reef might probably be unapproachable from bad weather or heavy sea, and for what length of time therefore the supplies for the Light-keepers should be calculated, and whether, in this climate, or with the class of persons who would probably be employed on such a duty, any special arrangements or allowance for the stowage of stores would be requisite different from those called for in isolated Light Houses in European seas. It might also be desirable that you should endeavour to calculate the space that would be requisite for the supplies of the Light-keepers for the longest period during which they would be likely to be cut off from external communication. The room for the light itself and its stores and appurtenances will, of course, depend on the nature of the light, and may be left to be determined by Lieutenant Fraser hereafter.

VI.

EXTRACT from a Letter No. 1811, *dated 2nd April* 1857, *from Captain D. Robertson, Officiating Superintendent of Marine, to Colonel W. E. Baker, Secretary to the Government of India, Public Works Department.*

The extent of the horizon over which the light should be visible.

2. I AM of opinion that the light on the Alguada Reef should be a revolving or flashing one, (visible all round the horizon), to distinguish it from the lights which are so constantly seen on the Coast. The height of the tower should be 100 feet above the level of high water mark; at an elevation of 12 feet from the deck of a ship it would be visible 15½ miles, and from the mast head of a large ship, it would be seen upwards of 20 as per margin; having made the light, a ship could shape her course to any part of the Coast.

HEIGHT.	
100 feet	11½
12	4
	15½
or	
100	11½
Mast head 80 feet	10½
	22

3. For six months in the year, *viz.* during the S. W. Monsoon, the building could not be carried on, *viz.* from the end of April to October, though there may occasionally be breaks of a few days at a time. It would, therefore, be necessary to have a supply of provisions in the Light House for six months. A calculation of the several articles of food might easily be computed, when the number and description of establishment are known, and also the space the provision would occupy. A depôt might be made on Diamond Island, and advantage taken when the weather is moderate for the people to go for a supply of vegetable and fruit.

The probable period during which a Light House situated on the Alguada Reef might probably be unapproachable from bad weather.

VII.

No. 2312.

To

HIS EXCELLENCY SIR J. BOWRING,

Governor of Hong-Kong.

PUBLIC WORKS DEPARTMENT,
MARINE.

SIR,

THE Right Hon'ble the Governor General of India in Council having determined on the construction of a Light House on the Alguada Reef, off the head land to the North-West of the mouths of the Irrawaddy, I have been directed to address your Excellency, relative to the terms on which Chinese masons and quarrymen, skilled in working and quarrying granite, of which material it is proposed to build the tower of

the Light House, might be obtained from Hong-Kong, for employment, for a limited period, under the Engineer Officers who will be placed in charge of this structure.

2. It is understood that expert workmen, such as have been mentioned, can be procured without difficulty at Hong-Kong, and any information that you could be good enough to procure and transmit to me, relative to the terms of wages, &c., on which the services of such men could be obtained, would be thankfully acknowledged by His Lordship the Governor General.

3. The precise number of men who will be required, the period at which the work is likely to be put in hand, and the Port to which the men should be directed to proceed, will be communicated to you in full detail hereafter, should the plan of obtaining these workmen from Hong-Kong appear to be advisable, on the receipt of the information which I have been directed to request your Excellency to be good enough to furnish.

I have, &c.,
W. E. BAKER, *Colonel*,
Secy. to the Govt. of India.

FORT WILLIAM ;
The 12th May 1857.

No. 2313.

COPY of the foregoing forwarded to the Governor of the Straits Settlements, with a request that he will be good enough to report, with as little delay as possible, whether he considers that a provision of masons and quarrymen, skilled in working and quarrying granite, can be procured at any of the Straits Settlements, on terms more favorable than those which are likely to be demanded by men engaged from Hong-Kong, and whether the experience of the construction of the Horsburgh (Pedra Branca) Light House affords any information which can be made available, and which might be useful in reference to the present undertaking.

VIII.

No. 27.

To

THE HON'BLE W. T. BRIDGES,
Acting Colonial Secretary, D. C. L.

SIR,

IN obedience to the orders of His Excellency the Governor, directing me to report on the subject of a despatch received from the Secretary to the Government of India, as to the practicability of procuring workmen for the purpose of erecting a Light House, I have the honor to state that Tsung Ayee, Contractor here, has offered to supply men at the under-mentioned rates, and on the conditions stated, *viz.* :—

Stone-cutters at $ 10 per month.

Stone-carriers at $ 6 per month.

Smiths for tempering tools at $ 16 per month. (1 smith necessary for every 40 stone-cutters.)

Conditions.—The Government to provide passages for the workmen from and back to China. One-half wages to be paid from the date of embarking, and full wages from the day of commencing work, the workmen providing themselves with food and necessary tools.

I have, &c.,
(Signed) D. R. CALDWELL,
Regr. Genl. and Protector of Chinese.

REGISTRAR GENERAL'S OFFICE;
Victoria, Hong-Kong,
The 12th June 1857.

(True Copy)
W. T. BRIDGES,
Acting Colonial Secretary.

IX.

No. 64 OF 1857.

To

THE SECRETARY TO THE HON'BLE THE GOVERNOR.

SIR,

WITH reference to your communication No. 252, dated 2nd Instant, I have the honor to forward, for submission to the Hon'ble the Governor, a Memorandum drawn up by Mr. Bennett, regarding the Horsburgh Light House.

2. From enquiries that have been made, I anticipate there would be considerable difficulty in obtaining sufficient number of Chinese stone-cutters to proceed to Rangoon, and even if obtained, there would be no certainty as to their remaining.

3. Should His Honor think it advisable, I have no doubt that stone to any amount could be quarried and cut at Pulo Obin by Chinese workmen obtained in the Straits, and afterwards shipped to the Irrawaddy; this, however, would perhaps be an expensive operation, and of course it would be necessary for the Engineer Officer employed in the construction of the proposed Light House, to visit Singapore for the purpose of preparing the necessary moulds, &c.

4. A full account of the Horsburgh Light House is given in the Journal of the Indian Archipelago for July and August 1852.

I have, &c.,

C. A. PURVIS, *Captain*,

Offg. Executive Engineer,

Superintendent of Convicts and Roads.

SINGAPORE,
The 30th June 1857.

(True Copy)

J. F. A. McNAIR,

Offg. Secretary to the Governor.

MEMORANDUM REGARDING THE HORSBURGH LIGHT HOUSE.

HORSBURGH Light House is built of cut granite and brick in mortar. The foundations are laid about 24 feet above high water mark; the exterior diameter at base is 26 feet; the interior diameter throughout the height is 10 feet; the foundations are cut into the solid rock in successive steps each 12 inches deep. There are ten courses of irregular stepping of 12 inches. The first regular bed of cut stone was laid 12 inches high and 18 inches deep into the walling, and at every 6 feet a header or binder of 5 feet was laid so as to be well built into the brick-work.

The total thickness of the wall was then 6½ feet; the next course of stones 12 inches high and 12 inches deep with headers or binders

running into the wall, so each alternate course was 18 and 12 inches respectively; each course having binders. This was the mode of construction throughout the building, up to the last course, which was laid of granite 12 inches thick, the interior being supported by brick vaulting built in cement, on which the machinery rested; at each 10 feet a brick vault was built for store-rooms, keepers', visitors' rooms, &c.

The thrust was counteracted by an iron ring let into the granite course and run in with lead.

Early in 1850, moulds were made in Singapore for each course of stone work, with *iron set levels* to correspond, with all other necessary arrangements for an early start to the rock, on which the building was to be erected.

It was the original intention of Mr. Thomson to have dressed the granite on the rock; but various considerations induced him to abandon this idea;—the difficulty of getting Chinese to go out to the rock, where neither vegetation nor water was to be procured, and also entirely away from any access to market. During the erection, there was enough of men to provide with water and food, independent of stone-cutters, so that experience showed afterwards that the fewer in number on the rock the better. It was then determined to cut the granite on the small island of Pulo Obin.

Considerable difficulty had to be overcome to get the Chinese into a sort of system of work; there being few men to commence the work, they asked high wages, were careless what kind of work they executed, and almost did nothing.

Chinese were invited, and hearing good pay was being given, after some months a good many men were collected. The work was then offered by contract, which at first was high; but as more men collected from the neighbouring states, contracts were readily taken up at moderate prices. They also now were much improved in splitting and preparing the blocks, as also the ready manner in which they handled their tools, so that towards the latter part of the work, stone work was contracted for about the same prices as stone work at home, and was also well executed, being straight cut and well jointed; in fact at this period there was no difficulty in getting work to any amount done.

The stone-cutters that were sent out to the rock to cut and prepare the foundations gave no end of trouble; they only would work when they liked—in rain they would not, in sunshine it was hot—they wanted

to go to Singapore, it was a holiday, their opium was done, or some really frivolous excuse. At last, however, they got done, and were sent away ;— they glad to get clear of the place, and we as heartily glad to get rid of them.

The other Chinese that remained on the rock were the bricklayers, their coolies and carpenters. With them we had no difficulty, others being readily procured at Singapore if they went away ; but I may here mention that the bricklayers without any change continued throughout the work, and one was subsequently employed as head builder at Raffles Light House, and is now permanently employed by Government.

After the Light House had been finished, and there being no steady demand for stone-cutting, at least nothing like the former amount, the party of stone-cutters dispersed, some to spend their money in China, some to Rhio, others to Johore and the Malacca tin mines ; so that after three months, only a few could be found in the place, and still only a few remain, and none to which any large contract could be trusted, having no really responsible headman amongst them.

From enquiries that have been made relative to the request contained in His Honor's letter No. 252, dated 22nd June 1857, there are a few men that might be induced to embark for Rangoon, but only in very small numbers and inferior workmen. If contracts were offered in Singapore, no doubt after a time men could be got to execute them at perhaps former prices, the stone-cutters being the worst of all the Chinese to manage. They are more addicted to smoking opium, gambling, and drinking samsoo than any other artificers that we had to work with at the Light House. We always calculated that one-third of the number would not work from sickness or some other cause. Good stone-cutters, when working monthly, got from $ 15 to 10 per month ; during the month they generally worked about twenty-two days, their pay being reduced in proportion.

If by contract for splitting and dressing blocks, various prices were given, but the average of good work was about 75 to 100 cents per cubic foot. This included fitting and laying down on the platform and putting in the Government boats ready for shipment to the Light House.

Taking all into consideration, I am induced to think that there would be great difficulty in procuring stone-cutters in sufficient number to embark for Rangoon, and also probably when they were there they would have to be taught, which was often the case at the Horsburgh Light House.

JOHN BENNETT,
Asst. to the Supdt. of Convicts and Roads, and Executive Engineer.

SINGAPORE.
The 30th June 1857.

X.

No. 17 OF 1857.

To

THE HON'BLE THE COURT OF DIRECTORS OF THE EAST INDIA COMPANY.

PUBLIC WORKS DEPARTMENT,
PUBLIC.

HON'BLE SIRS,

IN continuation of our letter No. 82 of 1856, dated 5th November, we have the honor to report, for the information of your Hon'ble Court, the further steps that have been taken regarding the Alguada Reef Light House.

2. Lieutenant Fraser having been relieved of his duties in Fort William, proceeded to Rangoon early in December last, and immediately entered upon the examination of the Alguada Reef and the neighbouring coasts. Having completed his enquiries in the course of the months of January and February, he returned to Calcutta, and having submitted his Report in due course, we permitted him to proceed to Ceylon, *en route* to England, as had been originally intended.

3. Lieutenant Fraser's Report, a copy of which accompanies this dispatch, is a very interesting and practical document. It furnishes full information on all the more important facts that have to be considered in connection with this undertaking. For the details of these matters, we beg to refer your Hon'ble Court to the Report itself.

4. It will not be necessary for us to follow Lieutenant Fraser's discussion of the various subjects with which he has dealt ; we purpose only to advert to certain points, which seem to call for special remark,

and to inform your Hon'ble Court of the more immediate steps that we have taken, and still propose to take in the matter.

5. The question of the nature of the light is one of primary importance, and though it must finally be decided on information to be obtained in Europe, from the persons most conversant with such subjects, there are some points in connexion with it to which we would specially allude.

6. In a sea light of the first order, such as this would be, and where there was no risk of confusion with other lights, it seems expedient that the light should be fixed. In determining further, whether the light shall be on the catoptric or dioptric principle, the question will, in some measure, be involved, of the extent of horizon which should be illuminated. From the position of the Reef it would appear that the illumination should extend, if not entirely over the whole circumference, at least over five-sixths of the circle, or even more. This is a matter of some moment, and will, of course, require a different treatment, from the case of a light which can only be approached in one direction, and which need, therefore, only give a ray of limited angular extent. We have alluded to this point more prominently, as it is not adverted to by Lieutenant Fraser. His impressions in favor of a catoptric light are, no doubt, based on many good arguments; but the special adaptation of a catoptric light to the sort of position in which the Alguada Reef light will be placed, will, we think, make it advisable to have this question very fully considered, under the advice of the highest authorities on such things, before a final decision is come to.

7. We fully concur with Lieutenant Fraser in thinking that the Light House should be built of stone, but would at once absolutely disapprove of the idea of procuring the materials from England. The granite which Lieutenant Fraser mentions as available on the Tenasserim Coast, at Callagouk, distant about 200 miles from the Reef, seems suitable. Specimens have already been dispatched to England, from which your Hon'ble Court will be able to judge of its fitness for the purpose; but a report on its quality, as a building material, will also be obtained from Mr. Oldham. Should this opinion be unfavorable, enquiries will be made regarding the material employed for the Horsburgh Light House, which is understood to be a well built structure.

8. Lieutenant Fraser's suggestions, as to procuring quarrymen and masons from Hong-Kong, in the event of the Callagouk granite being

approved, seem worthy of being followed out, and the necessary steps will be taken, when that question is disposed of; the skill of the Chinese masons is admitted on all hands.

9. The selection of Diamond Island as a depôt, while the works are in progress on the Reef, has our approval, and orders have already been issued to the Engineer Authorities in Pegu, to make the necessary clearances and other arrangements mentioned by Lieutenant Fraser.

10. Orders have likewise been given for the immediate construction of two lighters, for the conveyance of materials and stores to the Reef, and measures will be adopted for having a steamer in readiness, at the commencement of the ensuing fair season, for the exclusive duty of attending to the requirements of this undertaking.

We have the honor to be, &c.,

CANNING.
J. DORIN.
J. LOW.
J. P. GRANT.
B. PEACOCK.

FORT WILLIAM,
The 15th April 1857.

(True copy)

W. E. BAKER, *Colonel,*
Secretary to the Government of India.

No. 1824.

COPY of the foregoing forwarded to Lieutenant A. Fraser, for information.

By order of the Right Hon'ble the Governor General in Council,

R. STRACHEY, *Major,*
Under Secy. to the Govt. of India.

PUBLIC WORKS. DEPT.,
The 15th April 1857.

XI.

No. 20.

To

SIR J. C. MELVILL, K. C. B.,
Secretary to the East India Company.

SIR,

WITH reference to your letter dated 28th May 1857, I have the honor to report, that I have visited the "Eddystone" Light House off Peymouth, and that building off the Scilly Isles, "The Bishop," that I have received intimation from the Board of Commissioners for Northern Light Houses, that it would be convenient for me to visit the Light Houses on the Coasts of Scotland during next month, and that I purpose proceeding to Edinburgh next week. After my return from Scotland it is my intention to submit a report for the information of the Hon'ble Court, together with a design for the Light House which I propose for the Alguada Reef.

Before proceeding to Scotland, however, and with reference to the late news from India, and the order for all Officers on furlough to return thither, I should be glad to know whether it is probable that my services may be required in that country.

I trust that it is needless for me to state that to serve the Government of India in that manner which by it may be considered most fitting, is the earnest desire of their

Most obdt. and humble Servant,
A. FRASER,
Ex. Engr. Alguada Reef Light House.

14, ST. JAMES' SQUARE,
The 16th July 1857.

XII.

To

LIEUTENANT A. FRASER.

30th July 1857.
EAST INDIA HOUSE,

SIR,

I HAVE received and laid before the Court of Directors of the East India Company your letter, dated the 16th Instant, reporting the measures you have taken and propose yet to take, with the view of gaining the information necessary to enable you to prepare a design for the intended Light House on the Alguada Reef; but with reference to the late disturbances in India, requesting to be informed, before taking any further steps in the matter, whether it is the desire of the Court that you should at once return to that country. In reply, I am commanded to state that the Court consider the purpose for which you were deputed to this Country by the Government of India to be of great importance, and they do not, therefore, deem it desirable that you should relinquish the duty on which you are now engaged, and which they hope you may be able to complete at no distant period. I am at the same time commanded to forward to you, for your information, a copy of a recent letter from the Government of India, with their proceedings, subsequent to the receipt of your Report of the 11th February last. From these you will perceive that the Government are disposed to differ from you on some points adverted to in your Report, especially as regards the nature of the light to be provided for the proposed Light House. The Court do not, however, wish to fetter you in the exercise of the discretionary power which has been entrusted to your hands; but rely on your obtaining from the best authorities in this country complete information on all matters connected with your work.

Public Works Letter dated 15th April (No. 17) 1857.

I am, &c.,
J. C. MELVILL.

XIII.

No. 39.

To

THE OFFG. SECY. TO THE GOVERNMENT OF INDIA.

SIR,

WITH reference to Colonel W. E. Baker's letter, No. 5055 of the 21st October 1856, I have the honor to report my return from England yesterday per S. S. S. *Granada*, having completed the enquiries that I was desired to make in the 6th paragraph of the above quoted letter.

2. I beg to annex a copy of Sir J. C. Melvill, K. C. B.'s letter, of the 20th January last, directing my return to India, together with copy of my reply dated 28th Idem.

3. A copy of my Report on the measures that should be adopted for the erection of a Light House on the Alguada Reef (the views expressed in which Report the Hon'ble Court have been pleased generally to approve), is also enclosed. The plans and appendices mentioned in the Report were submitted, with the original, to the Hon'ble the Court of Directors.*

I have the honor to be, &c.,

A. FRASER, *Captain*,

Ex. Engr. Alguada Reef Light House.

Calcutta, 10*th April* 1858.

XIV.

To

LIEUTENANT A. FRASER.

SIR,

I HAVE laid before the Court of Directors of the East India Company, your letter dated 10th Ultimo, in which, with reference to my letter communicating to you the Resolution of the Government of India to defer the construction of the proposed Light House on the Alguada Reef, you request the orders of the Court as to obtaining from

* These plans and reports have not been received in India, but a general map of the position of the Reef, a plan of the Reef itself, and an elevation and section of the Light House are given at the end.

the correspondents of Messrs. Todd, Findlay and Co., at Glasgow, an estimate of the probable cost of supplying stone for the Light House from this country, and expressing a hope that the Court will pronounce an opinion on the Report on the Light House which you have submitted, and on the views therein stated.

In reply, I am commanded to state that the Government of India having formerly so strongly disapproved the idea of obtaining the materials of the intended Light House from England, and a favorable opinion having now been given by Mr. Oldham as to the suitability of the granite of Callagouk for the purpose, it does not seem to the Court necessary that you should defer your departure for India, for the purpose of entering into any correspondence in this country regarding the supply of stone for the Light House.

The Court have read with great interest the Report submitted with your letter of the 2nd November 1857, and desire me to express their full satisfaction with the manner in which you have fulfilled the commission entrusted to you by the Government of India. The Court are inclined to approve both the plan of construction and the mode of illumination proposed by you, and to give the preference to an edifice constructed entirely of granite, as you seem to consider most desirable. As, however, under present circumstances, there will be ample time for the Government of India to consider the subject in all its bearings, the Court do not think it necessary to pronounce a positive opinion on the several points involved in your Report. The Court will transmit your proposals to the Government of India without delay, and will authorize that Government to carry them into effect, as soon as circumstances will allow, subject to such alterations as they may deem requisite; and the Court trust that it will not be found necessary to defer for any very long period the execution of the important work which has formed the subject of your investigations.

I am, &c.,

JAMES C. MELVILL.

(True copy)

A. FRASER, *Captain*,

Bengal Engineers.

EAST INDIA HOUSE,
The 20th January 1858.

XV.

To

SIR JAMES C. MELVILL, K. C. B.,
Secretary East India Company.

SIR,

I HAVE the honor to acknowledge the receipt of your letter of 20th Instant, transmitting the command of the Hon'ble the Court of Directors, that I should return to India, and beg to report that I have booked my passage *viâ* Marseilles to Calcutta by the P. and O. Company's Mail Steamer that leaves Southampton on the 20th Proximo.

* * * * * *

2. I am sincerely glad that my labors in this country have met with the approbation of the Hon'ble Court, and extremely sorry that circumstances have prevented the carrying out, at present, the project of a Light House on the Alguada Reef. By the time I return to India, I shall be fully prepared in all details, and ready to proceed with the work whenever the Government of India may see fit to order.

I have, &c.,

A. FRASER, *Lieut.*,
Ex. Engr. Alguada Reef Light House.

(True copy)

A. FRASER, *Captain*,
Bengal Engineers.

14, ST. JAMES' SQUARE,
The 28th January 1858.

XVI.

REPORT

For the information of the Honorable the Court of Directors of the East India Company, on the measures that should be adopted for erection of a Light House on the Alguada Reef.

1. Having, agreeably to the orders of the Government of India, communicated through their Secretary in the Public Works Department, Lieutenant-Colonel W. E. Baker's letter, No. 5055, dated 21st October 1856, examined and reported on the eligibility of the Alguada Reef as a position for a Light House; and having submitted drawings and plans of the Reef, together with my opinion* as to the nature of the building that should be erected thereon, and the light that should be exhibited; I have now the honor to report that I have visited the chief Light Houses on the coasts of England and Scotland in positions analogous to that of the Alguada Reef, and many others as mentioned in the note,† and that having been in communication with the Engineers, under whose superintendence these several Light Houses are placed, I am able to give an opinion on the several subjects upon which the Government of India require information, and to investigate which I had the honor of being deputed to England.

2.—It appears desirable to consider the subject under the following heads :—

I. The tower : its material, height, and form.
II. The light.
III. The apparatus and staff required from England to open quarries and erect buildings.
IV. The light-keepers and the stores.
V. The depôt.
VI. The cost of erection.
VII. The cost of maintenance.

* See my Report dated February 1857, together with model, plans, and specimens which accompanied the Government of India's Despatch to the Honorable Court, No. 17 of 1857, dated 15th April 1857.

† Eddystone ; Bishop ; Breakwater Light, Plymouth ; Bell Rock ; Cromarty Harbour Light ; Tarbetness ; Pentland Skerries, 2 Towers ; Sumburgh Head ; Brassa Sound ; Whalsey out Skerries ; North Unst ; North Ronoldsay ; Hoy Light Houses—high and low Towers ; Skerryvore ; Ardnamurchan.

SECTION I.—THE TOWER : ITS MATERIAL, HEIGHT AND FORM.

1.—On an exposed situation like the Alguada Reef, with nothing to stop the sea between it and the South Pole—a sea urged on by a constant South-West wind, with severe storms during half the year, against a position only one foot above high water spring tides, it is clear to me that a Tower should be built of materials arranged in one of the four following forms :—

I. Of granite throughout.

II. Of granite exteriorly, with a heart of a softer and less expensive material, either brick or sandstone.

III. Either of the above to the height where the sea expends its greatest force, and above entirely of brick or sandstone.

IV. Either of the above Nos. I. or II. to the height mentioned in No. III., with a superstructure of iron and concrete.

2. Of all the above, there can be no doubt that granite will make the most perfect building.

The advantages of a stone over an entirely iron structure (I speak here of plate iron Light Houses as usually constructed), were fully considered in the 14th, 15th and 16th paragraphs of my Report above alluded to ; and it appears only necessary to state that the opinions therein expressed have been fully confirmed from experience and information gained in England and Scotland. But there is one fact not mentioned in that Report that seems to place the use of cast iron, within the influence of sea water, out of the question.

On my visit to the Bell Rock in August last, I examined some of the cast iron work used in the tramway from the landing place to the Light House. This iron work was said to have been on the rock since the building of the Light House in 1810. It may have been renewed since that period, but that of course would only add to the value of the argument against the use of cast iron. It could not have been more than forty-seven years on the rock. This tramway is supported on cast iron stools, whose feet are fixed to the rock by means of batts and spearbolts. These feet are quite saturated with sea water. I chipped off portions, and these could be cut with a pen-knife as easily as the lead in a lead pencil. I brought specimens away with me. The process of softening is evidently going on, and as soon as the metal is sufficiently weakened, a heavy sea will come and carry the whole arrangement away.

3.—I did, at one time, think that by the use of iron in combination with concrete, I should have got over all the arguments given against the use of cast iron—as I proposed to do away with all fastenings, and trust to weight, as in a stone building—and even should I not have obtained economy, I should at all events, have obtained facility of construction. I calculated that the iron would be about the same expense in this form, and provided always that I could get my material conveyed to the spot without accident, I calculated I should be able to build the iron structure in one season, whereas the stone will take at least three, possibly four. But the want of durability of iron when exposed to sea water was a point I had not considered, and which, from personal observation, renders its use, I think, quite out of the question, at all events for the foundation.

4.—I think, therefore, that there can be no doubt that the building should be of stone; that granite being procurable of a durable quality should be used, that whether it should be used altogether, or whether either of the Forms, II III or IV, should be adopted, should depend upon the quarry at Callagouk. (See paragraphs 32, 33, 34, and 35 of my Report above alluded to.) That the working of this quarry should be considered a matter of future report. Should it prove easily workable, with no greater expense than anticipated, the whole building should be of the granite procured thence. Should its working prove difficult and expensive, I would build the first 30 feet of granite solely—the remainder of sandstone, brick, or iron. Should the quarry turn out extremely difficult and expensive to work, I would merely use the granite as an exterior shell for the lower part, and build the heart and superstructure of sandstone, brick, or iron. When I say brick, I mean brick of a peculiar composition, strength, and weight, such as I have seen being used in the erection of some of the Light Houses building by the Northern Board, and of which I submit a specimen furnished to me by Messrs. D. and T. Stevenson, Engineers to that Board. I have actually taken up one of these bricks and thrown it down with all my strength, so that the flat side should come in contact with the edge of a stone, and the brick has received little or no injury.

5.—I have, therefore, estimated for one building solely of granite from foundation to lantern ; for a second, with granite foundation and brick superstructure ; and for a third, with granite foundation and

iron superstructure. I merely do this to give comparison of cost, it being understood that I recommend the entire granite building, and that any modification is solely to depend upon future report as regards the working of the Callagouk quarry. My estimates are given with some reserve, as the only data I have are—

1*st*.—Mr. Thomson's account of the building of the Horsburgh Light House, which, though a very difficult work, was erected under much more favorable circumstances. The quarry of Pulo Ubin, whence the stone was obtained, having been little more than 20 miles from the rock, whereas the quarry for the tower on the Alguada Reef is 210 miles distant. The Alguada Reef, moreover, being much more exposed will require more care, heavier stones, and stronger apparatus. The workmen for the quarry for the latter again have to be brought from a distance, housed and fed on a desert island; whereas Singapore, only 15 miles from Pulo Ubin, supplied the workmen, and that quarry had been before opened.

2*nd*.—My own experience in brick work and labour in Burmah.

6.—In the 17th paragraph of my Report to the Government of India, I recommended 110 feet as the height of the Tower, but, from experience gained in this country, I see reason to alter this view.

The ALGUADA REEF is the most prominent point of a line of coast, and first made on oversea voyages, whether by ships or steamers coming from North, South, West, or South-East. It is my intention, in consequence, to recommend the *most powerful* light; this light should be at such a height as will give the mariner a good offing of at least from 16 to 25 miles.

The establishment I shall hereafter propose will require the following accommodation:

1. The Light-room.
2. The Oil Store.
3. The Visiting Officer's Room; Library and Sitting Room for the European Light-keepers.
4. The Sleeping-room for Ditto.
5. Ditto for Native Ditto.
6. Kitchen.
7. European Provision Store.
8. Native Ditto.
9 and 10. Fuel and Water.

In order to obtain this accommodation, I thought at first of giving larger space by an increase in the diameter of the rooms, and, consequently, of the base—leaving the height at that originally fixed; but, irrespective of the large additional surface thus given to the impact of the waves, it became evident that I thus not only increased the expense and difficulty of building the Light House, the chief of which will be at the base, but I also lost the immense advantage of the extended offing to ships approaching the light.

7.—Of all the Light Houses that I know or have visited, the Skerryvore, designed and erected by Mr. Alan Stevenson, on the Western coast of Scotland, is in the position most analogous to that of the Alguada Reef.

Every Engineer is, of course, desirous of submitting original designs; but so perfect in every way does this structure appear to me to be, not only in design, but in workmanship, and not only in beauty of appearance, but in accuracy of calculation with reference to stability, that I feel quite sure I can do no wrong in taking it as my model, with, of course, certain interior alterations necessary to the different interior arrangements that will be required to suit it for the dwelling-place of people of different races, and in a different climate: and if I can, with the comparatively unskilled labour I shall be able to obtain, execute the work on the Alguada Reef in the same successful manner as that has been executed on the Skerryvore, I feel that, though I may have shown no originality of design, I shall be entitled to no small credit in the construction.

8.—The diameter of this Tower (see Plates III. and IV.) is 42 feet, the height of the shaft is 120 feet, and the diameter at this height is 16 feet. Above the shaft is a cylindric belt, 18 inches deep, surmounted by a cavetto 6 feet high, with 3 feet projection. The cavetto supports an abacus 3 feet deep, the upper surface of which forms the balcony. On the abacus rests the parapet, and on it the lantern. The outer surface of the shaft is formed by the revolution of an hyperbola round its asymptote as a vertical axis—the radius at the base being 21 feet, and at the top 8 feet. The contour of the cavetto is obtained from the quadrant of an ellipse revolving about the centre of the Tower with a radius of 8 feet on the level of its transverse axis.

9.—In adopting this curve for his Light House, Mr. Alan Stevenson observed, in reference to the stability of buildings exposed to the force of the sea, that the sum of our knowledge appears to be contained in the following proposition—"That, as the ultimate stability of a sea-tower, viewed as a monolithic mass, depends, *cæteris paribus*, on the lowness of its centre of gravity, the general notion of its form is that of a cone; but that, as the forces to which its several horizontal sections are opposed decrease towards its top in a rapid ratio, the solid should be generated by the revolution of some curved line convex to the axis of the Tower, and gradually approaching to parallelism with it." He then goes on to show that he tried several forms, and proves a clear superiority of the hyperbolic curve over all others, as far as the advantageous arrangement of the materials is concerned. He likewise shows, in a table given below, the ratio of the height of the centre of gravity above the base to the height of the Tower in the Eddystone, Bell Rock, and Skerryvore, and in contrasting the different outlines of the three observes that that of the last-named approaches more nearly that of a conic frustrum than those of the other two, and the following considerations led him to the adoption of that form. He considered that in the first two the thickness of the walls at the top had been reduced to the lowest limits of safety; and from my own inquiry, in the Eddystone the tremor caused by heavy seas was greater than I could have believed. Again, by increasing the thickness of the top, as in the Skerryvore, the projection of the base is diminished, and thus less concavity of figure is produced, thereby allowing the stones at the base to receive the effect of the superincumbent mass as a means of retaining them in their places,

Light House.	Height of Tower above 1st entire course. (H)	Contents of Towers.	Diameter.		Distance of Centre of Gravity in Feet from Base. (G)	$\frac{H}{G}$
			Base.	Top.		
Eddystone ...	68	13,343	26	15	15·92	4·27
Bell Rock ...	100	28,530	42	15	23·59	4·24
Skerryvore ..	138·5	58,580	42	16	34·95	3·96

and the more perfectly does this pressure act as a bond of union among the parts of the Tower. With a more curved outline the stones at the base are necessarily further removed from the line of the vertical pressure at the top. This vertical pressure, Mr. A. Stevenson further remarks, operates in preventing any stone being withdrawn from the building, in a manner much more satisfactory than the effect of any elaborate dovetailing and joggling, which he considers chiefly useful in the early stages of the progress of the work, before the superstructure is raised to such a height as to prevent heavy seas breaking right over it; and when dovetailing and joggling are saved much expensive dressing of stones is also saved. I observe that in the Light House now building on the Bishop Rock, off the Scilly Islands, the lower part of the outline has been broken from the curve into a succession of vertical steps. I believe the object of this has been to cover the joints from the sea; but, (I say so with diffidence) this appears to me a mistake, as by this arrangement so many more horizontal sections are exposed to the impact of a heavy sea at the same instant, than would be the case were the curve continuous.

10.—I therefore think the Honorable Court can do no better than authorise Mr. A. Stevenson's design for the Light House on the Skerryvore, shown in the accompanying Plates III. and IV., as the model of form on which to build the one proposed for the Alguada Reef.

11.—The focus of the light will be 142·5 (= height of tower) × 1·1 (= height of site above spring tides) = 143·6 feet above high water spring tides, which height will permit the light to be seen, supposing the eye of the observer on the horizon, and taking into consideration the effect of atmospheric refraction, at a distance of 15·85 miles. If we take the height of the observer's eye to be 20 feet above the horizon, then the light will be visible at a distance of 21·766 miles, and at 50 feet above that level, 25·204 miles.

Section II.—The Light.

1.—In the 19th and 20th paragraphs of my Report to the Government of India, mentioned in the 1st paragraph, I recommended a fixed catoptric light for the Tower on the Alguada Reef; but this recommen-

dation was accompanied by the following remark, that "my present views "on this as well as on other heads of the subject, will have to be "submitted to the test of the investigations I shall have to institute "in England, and will be much modified by the experience of eminent "men in Europe, who have made this branch of science their study."

2.—The Government of India in their despatch to the Honorable Court, No. 17 of 1857, dated 15th April 1857, paragraph 6, state that "in a great sea light of the first order, such as this would be, and where "there was no risk of confusion with other lights, it seems expedient "that the light should be fixed. In determining further whether the "light shall be on the catoptric or dioptric principle, the question will, "in some measure, be involved of the extent of horizon which should "be illuminated. From the position of the Reef it would appear that "the illumination should extend, if not entirely over the whole "circumference, at least over five-sixths of the circle, or even more. "This is a matter of some moment, and will, of course, require "different treatment from the case of a light which can only be "approached in one direction, and which need, therefore, only give "a ray of limited angular extent. We have alluded to this "point more prominently as it is not adverted to by Lieutenant "Fraser. His impressions in favor of a catoptric light, are, no doubt, "based on many good arguments, but the special adaptation of a "cata-dioptric light, to the sort of position in which the Alguada Reef "Light will be placed, will, we think, make it advisable to have this "question very fully considered under the advice of the highest "authorities in such things before a final decision is come to."

3.—In my examination of the several Light Houses under the Northern Board, I accompanied Mr. Thomas Stevenson, C. E., and had, consequently, many opportunities of obtaining information on the subject of the several systems of optical illumination, and he gave me to read a report prepared by Messrs. D. and T. Stevenson on the comparative merits of the catoptric and dioptric systems. I cannot do better than extract the views contained in that Report, as they appear to me so convincing that the system of catoptric illumination must be considered obsolete and useless as compared with the dioptric.

4.—They consider that optical arrangement the most perfect which embraces the following principles:

1*st.*—Which employs optical agents that absorb the smallest number of rays, and produce the smallest amount of irregular scattering of rays.

2*nd.*—Which sends the greatest number of rays to the eye of the most distant observer, provided the light remains long enough in view to answer the purposes of navigation.

3*rd.*—Which produces the required effect with the smallest possible number of optical agents.

4*th.*—Which has no unnecessary divergence, but which illuminates that arc only that requires illumination.

From the above principles, for comparison of the two systems, they go on to consider—

1*st.*—What is the best material for the construction of apparatus.

2*nd.*—What the best arrangement of the optical agents that are employed.

5.—They then state that in catoptric systems they include all optical apparatus in which reflection is produced by metallic surfaces only.

In dioptric, all optical apparatus which consists of glass only, whether acting by refraction or total reflection—and

In cata-dioptric, any combination of a metallic with a glass optical agent.

6.—They then clearly show the superiority of glass over metallic media—that from numerous experiments not much more than *one-half* (·556) of the light incident on silver plate polished, as in Light House reflectors, is reflected—which, when compared with Professor Potter's valuation of totally reflecting prisms, gives a gain of 2-10ths (·210) in favor of glass over metal, and from their own experiments this valuation is rather larger.

7.—The following are further advantages given by Messrs. Stevenson of glass over metal.

Curves formed of glass admit of greater accuracy in form than those of metallic reflectors—the process of forming the two being, in the former case, by machinery, in the latter, by hand.

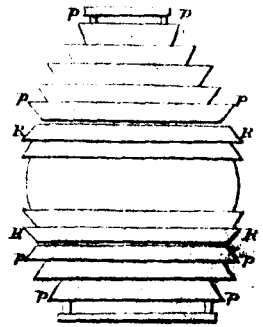
The polish in glass is given once for all. The metallic polish (as I have myself observed in the several Light Houses where reflectors are

used) is constantly undergoing deterioration from atmospheric oxidation, and from the powder employed in cleaning. The brilliancy too of the metallic reflectors has to be daily renewed by different light-keepers, from whom it may receive permanent injury.

These opinions, supported as they are by experiment and experience, in favor of glass over metal as an optical agent, are, I consider, absolutely unanswerable.

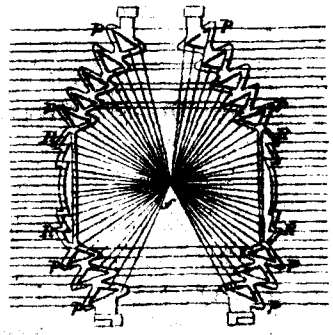
8.—Having proved the superiority of glass over metal as an optical agent, Messrs. Stevenson proceed to discuss the best optical arrangement of apparatus, and, first, of *Fixed Lights*. In Fresnel's fixed light apparatus, see Figures 1 and 2, where the object is to illuminate constantly the whole horizon, the entire sphere of light is emitted parallel to it by the simplest conceivable combination of the best optical agent (glass). R. R. is the cylindric refractor—p.p. the totally reflecting prisms, which, catching the rays falling upon their inner sides from the focus f., totally reflect them from the upper sides, and, finally, project them from the outer side parallel to the rays from the refractor itself. The light, therefore, formerly expended in illuminating the poles, is now usefully employed to lengthen the vertical strip of light, produced from the cylindric refractor. Messrs. Stevenson consider this arrangement as "the optimum" for fixed lights.

Fig. 1.



Front Elevation.

Fig. 2.



Section

9.—But it is clear to me that, whether catoptric, dioptric, or catadioptric arrangements be employed for illumination, a more powerful effect is produced by a revolving than by a fixed light, the number and power of lamps in the catoptric, or the power of the single burner in the dioptric system, being in each case the same. For [illegible] fixed light, the rays from the lamps [illegible] to be distributed, as in Figure 3, over the entire circle, whereas in the revolving light, giving a certain number of flashes—say eight—Figure 4—rays that would have been employed in illuminating the arcs *a*, *a*, &c., are concentrated in the beams *b*, *b*, *b*, &c., and consequently, these beams give a more powerful light, and each beam can be seen from a greater distance. I am, therefore, of opinion that a revolving light should be given for the Alguada Reef, and that only one optical agent (glass) should be employed in the construction of the apparatus. I find the Superintendent of Marine at Calcutta, in his letter, dated the 2nd of April 1857, a copy of which accompanied the Government of India's despatch to the Honorable Court of Directors No. 17, dated 15th of April 1857, is of opinion that the light should be revolving or flashing.*

Fig. 3.

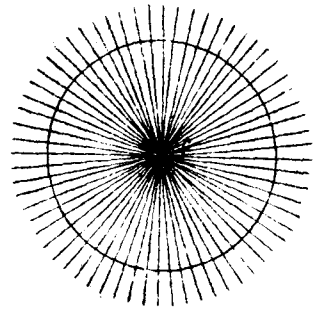
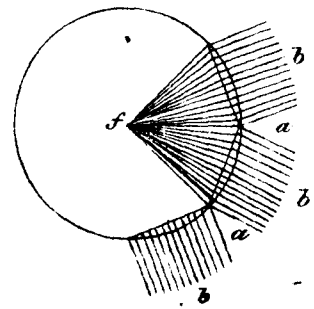


Fig. 4.

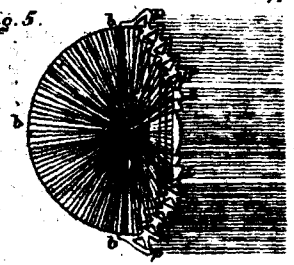


* The present Superintendent recommends a fixed light, No. XVIII.

10.—In writing of revolving lights, Messrs. D. and T. Stevenson seem o recommend either of the following arrangements of apparatus for great ea lights in insular situations. The holophotal catadioptric arrangement, here independent burners are used—see drawing, Figures 5 and 6. n this case the whole apparatus consists of reflectors, and totally

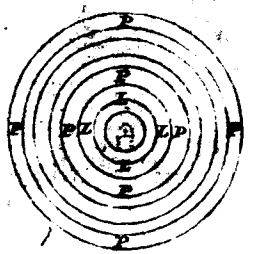
Holophotal apparatus with new form of lens.

Fig. 5.



Section.

Fig. 6.



Front Elevation

reflecting prisms of glass of a peculiar construction, which prisms were first used in light Houses, on their recommendation, at Horsburgh revolving light, in 1851; and they are now preparing apparatus, on this principle, for the Board of Works, Newfoundland. In the above Figures *L* is the lens, *p* the totally reflecting prisms, and *b* the spherical mirror.

They think this principle the most eligible for lights in distant and inaccessible places, but observe that glass is generally adopted in first order apparatus, having a single central burner, with the frame-work revolving round it. I saw an example of this kind of light at North Ronoldsay, which is a beautiful apparatus; there are sixteen arcs of illumination, and these arcs pass by the focus with such a speedy move ment of the clock work, that the light emitted is a flashing light. By having a smaller number of sides to the framework, with a slower movement, the light, with similar apparatus, becomes plain revolving the successive beams coming to the eye and remaining in it for longe

intervals, and the flash being of greater strength, proportional to the smaller number of faces.

Fig. 7.

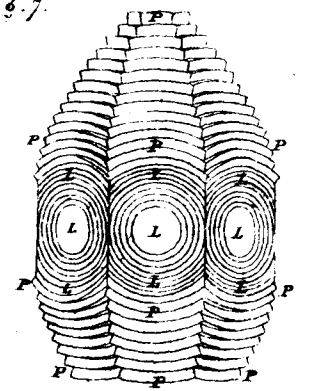
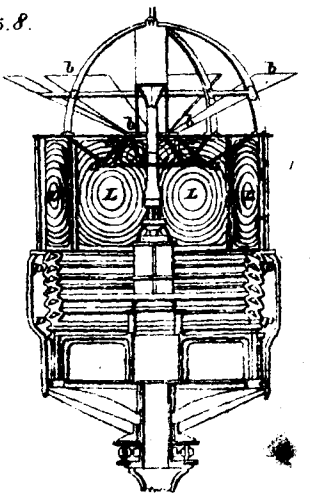


Fig. 8.



By the last arrangement, (see Figure 7,) the effect is obtained by a single optical agent, *L*. are the lenses and *P*. the catadioptric prisms; but in Fresnel's revolving light, (see Figure 8,) such as that employed at the Skerryvore, the light that passes below the lens *L*. *L*., appears as a fixed light from the prisms *p*. *p*., and that passing above the lens, is subjected to the action of inclined mirrors *b*. *b*., and lenses *a*, *a*., by which Fresnel himself is stated to have admitted that there is a loss of about half the light incident on that portion of the apparatus; while in the revolving holophotal apparatus, Figure 7, the *whole* light is condensed into the arcs of useful illumination only.

11.—In my report of February last on this subject to the Government of India, paragraphs 19 and 20, I stated after describing the several systems of illuminating Light Houses, that

"I would only remark that the dioptric and catadioptric systems are "recommended by their superior power, whilst at the same time they "are more economical to maintain. That I was inclined, however, to "believe that these advantages are more than counterbalanced by the "complex nature of the machinery of the dioptric light, rendering it "liable to get out of order, in which case the difficulty of repairing it "in such a situation as the Alguada Reef, isolated as it is, and cut "off from all extraneous assistance during a great portion of one-"half of each year, would be very great; and still more so by the "apprehensions I entertain of the probability of the light-keepers, "through accident or negligence, allowing the light to go out, in "which case the results might be of a disastrous character. In the "catoptric light there are a number of separate lamps, which are on "the fountain principle, and consequently, perfectly simple, and devoid "of all complicated mechanism; and supposing in a first order light "two or three lamps were to go out, the consequences would be as "nothing in comparison of the extinction of the single flame of the "dioptric burner."

The first part of these objections to the dioptric system I consider, from information and experience gained since I have been in England, unsound—for though I do not think the mechanical lamp, which pumps up the oil to the wick by clock-work, and is generally used in the Northern Light Houses for dioptric apparatus, a good arrangement for the Alguada Reef Light—yet for this may be substituted an arrangement for the supply of oil similar to that employed in the Eddystone, which appeared to me simple, giving as efficient a supply and overflow of oil to the wicks as required; while the machinery for the revolving apparatus requires no more room than a fixed light, and when well and substantially made, as in the North Ronoldsay and Skerryvore, I see no chance of its getting out of order with common attention from the light-keepers.

The last objection, if considered valid, would induce me to adopt the holophotal dioptric apparatus, all of glass, with independent

burners. (See Figures 9 and 10.) This arrangement of apparatus, as described by the inventor, Mr. Thos. Stevenson, (See holophotal system of illuminating Light Houses by Thos. Stevenson, F.R.S. E., C. E., &c., &c.,) consists in replacing the hemispherical reflector of metal or silvered glass, as above described, (paragraph 10—Figures 5 and 6,) by means of a polyzonal totally reflecting hemisphere of glass—vide Figure 9. By these means reflection from metallic specula is abolished, and the principles of total reflection and simple refraction are substituted.

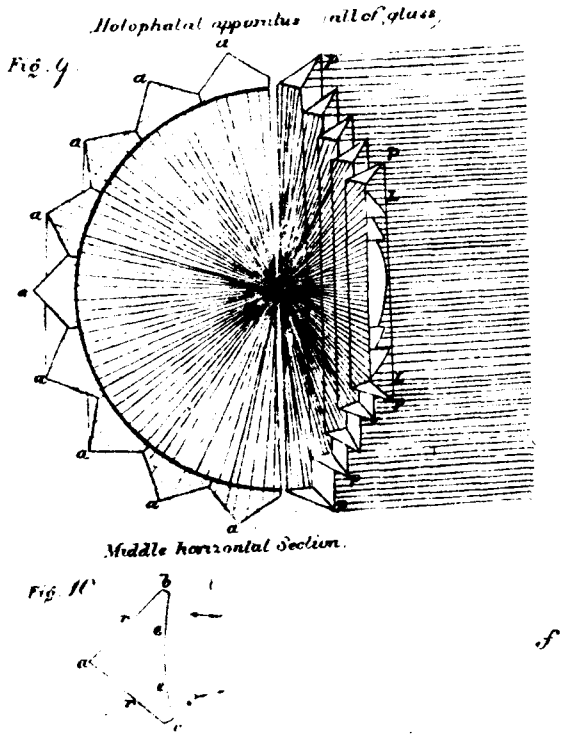


Figure 10 shows the action of these glass zones—*f.* shows the flame —*b. c.* is concave, the centre of curvature being in *f.* the centre of the flame; any ray proceeding from *f.* is received at *e.* as a normal to the surface* *b. c.*, and passes on without deviation to the surface *a. b.*, where it is totally reflected at *r.*, at *r'.* it again suffers total reflection, and emerges in a radial direction at the point *e.*, and so for all the rays. But I am inclined to recommend the holophotal apparatus,

* *N. B.*—A ray of light impinging on the inner surface of a glass prism so that the angle (Fig. 10) *frb* is *less* than 48° 10′ cannot pass through it, but is all reflected into the interior of the prism. The surfaces of the prisms (*p*) and (*a*) Fig. 9 are cut on this principle.

all of glass, with one central burner, with the glass frame revolving round the burner, (See Figure 7, paragraph 10,) as being the most simple, the most efficient, and least liable to injury, or to require repair, and at the same time most economical in maintenance, while two spare lamps would always be in readiness if anything should get out of order.

12.—I think there can be no doubt that the light on the Alguada Reef should be visible all round the compass. It is the most prominent point of a line of coast, and that first made not only by ships making for the Bassein River, but by all ships making the coast, or sailing from port to port on the coast, or from the opposite coast,* and it should therefore be visible from Pagoda Point (going West), round to Porian Point, which comprises 305° 20′ of the entire circle. The remainder of the circle, or 54° 40′ is the angle comprised between Pagoda Point (going East) and Porian Point, and should likewise be illuminated, for by keeping the light on a proper bearing, vessels leaving the Bassein River can clear all dangers, whether of flats on the Porian side or of the Reef itself. Vessels would not attempt to leave in a foggy night, and therefore, no danger could be anticipated from Diamond Island, which would be clearly visible. For vessels going in, if any danger be anticipated from the Phœton Shoal, the single reflector lamp I propose for Diamond Island might have such divergence as to point out to vessels coming within its influence that it was time to put about. I did not advert to this matter in my former report, as I was of opinion that it did not admit of hesitation.

13.—I will conclude this portion of the subject with a few quotations from the "Report on the condition of the Light House Establishment "of the United States."

Page 13.—"The Board, therefore, recommend that the Fresnel, "or lens system, modified, in special cases, by the holophotal appa- "ratus of Mr. Thomas Stevenson, be adopted as the illuminating "apparatus for the lights of the United States, to embrace all new "lights now or hereafter authorized, and all lights requiring to "be renovated, either by reason of deficient power or defective "apparatus."

* Calcutta, Chittagong, Akyab, Kyouk Phyoo, Sandoway, Dalhousie, Bassein, Rangoon, Moulmein, Madras, &c. &c.

Page 56.—"The consideration of the systems of illumination of 'France, Great Britain, and other countries of Europe, where modern 'improvements have been introduced, or are being introduced, will 'prove that reflector lights are being abandoned for better and more 'economical systems. Good reflectors of the form used in the best 'conducted lights, reflect but half the light which is thrown upon 'them—imperfect ones much less."

Page 58.—"The very great economy and efficiency of the lens or 'Fresnel lights, as contrasted with the reflector lights, will appear in 'the course of this report. It amounts to a gain of at least 3½ (3.6.) to 'one, on an average, when the two systems are equally well fitted and 'cared for, and in some cases to four times under similar circumstances."

Page 77.—"The experience in relation to lenses has not been con- 'fined to any one country; even in our own, with but three stations, 'the results are most conclusive in their favor."

Section III.—The Apparatus and Staff required from England to open the Quarry and erect the Buildings.

1.—Should the Honorable the Court of Directors be pleased to approve of the views laid down in the 1st Section of this Report, I should require the following machinery and tools from England:—

Cranes.	Blasting Tools.
Winches.	Stone-cutters' ditto.
Anchors.	Carpenters' ditto.
Forges.	Smiths' ditto.
Rails.	Chains.
Waggons.	Ropes.
Quarry Tools.	Cables.

The apparatus I shall require will cost about 2400 pounds. I should wish to order the articles myself, and see the machinery tested and despatched, as desired by the Government of India in the 7th paragraph* of Lieut.-Colonel Baker's letter, No. 5055, dated 21st October

* * * * * "You will then make arrangements for the supply of whatever "materials and appliances it may be advisable to obtain in Europe, and, having seen these "despatched, you will return to India, bringing with you such staff as it may appear desira- "ble, with the assent of the Honorable Court, to employ."

1856, before leaving England. They should be sent out in a ship bound for Moulmein or Rangoon, as may prove the most advantageous with reference to the class of ship. The steamer that the Government of India promise me, should be waiting the arrival of the ship at the Port that may be determined, to receive the stores.

2.—The following staff would be required—one good Superintendent for the quarry, a practical Quarryman, on a salary not exceeding £15 per month, or in Indian currency at the rate of two shillings per rupee.

One good working Engineer and Mechanic, on a salary not exceeding £25 per month.

One good Builder, on a salary not exceeding £20 per mensem.

The salaries to commence from date of engagement. The men to give security in £100 each to remain—except in case of certified* sickness—till the work is completed. Passage out and home again, on completion, to be found by the Government. If the security cannot be paid at once, one-third of the salary to be deducted till made up.

If the men after completion of work choose to remain in India, the value of their passage home to be given them as a bonus, with clearance of further claims on the Government.

If the men have behaved well, further employment to be given in India to them, on salaries not less than those above recommended, provided always the Government have employment to give.

The men to obey the orders of the Government of India, or the Officers it may appoint over them in all things, and to receive their pay in such manner, and at such periods, as the Government appoints for the issue and receipt of pay of their military servants.

Misconduct to be punishable in such manner as the Government shall see fit to order.

The men to be entitled to similar medical attendance as I myself would receive in cases of sickness, at the Government expense.

A legal agreement to the above effect to be taken from the men.

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* To be certified by a Surgeon, or Assistant-Surgeon in the Queen's or Company's Service, confirmed by the Medical Board, or other authority, in the usual manner.

3.—The last-mentioned of the three workmen, *viz.*—the Builder, I would send home for at a future period. I should not require his services this season, as the only work that can be done at the Rock previous to the next S. W. monsoon, will be quarrying out the pit for the foundation of the Light House. During the whole of the next wet season, I should be entirely (the Rock being unapproachable for work from May to October) employed in preparing the stones for the Light House. I should wish, if possible, to get the foundation ready in March and April next, so as to have it quite prepared for a long season's work from the following October, for which purpose every exertion would be employed to prepare as many courses as possible at the quarry at Callagouk previous to that month.

4.—As soon as I have despatched this necessary apparatus by sea round the Cape, and the staff (the Quarryman and Engineer) I have proposed with it, it would be desirable for me to return to India overland, to collect the workmen and be ready to commence operations as soon as the tools, &c., arrive.

5. There appears no necessity for any arrangements for the light apparatus till the season in which I am able to report the tower ready for its reception, and there will thus still be time for, if necessary, further consideration of the nature of the light that should be exhibited; but I should wish the authority of the Honorable Court to communicate with Messrs. D. and T. Stevenson, Engineers to the Northern Light House Board, on the subject of the light, and that they should be permitted to make arrangements for its supply when required.

6.—Most Light Houses that have been built on the coasts of England and Scotland have had provided for the habitation of the workmen a barrack of a very expensive description; but this has been absolutely necessary, and probably a saving of expense and life where the position is liable to visitations of severe storms at all times of the year. But at the Alguada Reef we are tolerably safe from storms of a very severe character from November to April inclusive; and from May to October no work can possibly be carried on, as it is more or less a storm the whole time. It would, therefore, appear only necessary to provide temporary accommodation for the former period, and which should be altogether removed when the workmen retire from the Rock for the S W. monsoon.

Section IV.—The Light-Keepers and the Stores.

1.—It will not answer to have an entirely native establishment; so important a light could not be entrusted to natives alone, as they never could be made to understand the great responsibility of their situations. Neither would it do to have an entirely European establishment, as less than four men in the Light House would hardly suffice for the duties in that climate, and other four would be required as a relief at the depôt, and this would vastly increase the expense of maintenance. A mixed establishment is therefore recommended as follows—

European	One principal Keeper, at	Company's	Rupees	100
	One Assistant ditto, at	„	„	90
	One 2nd ditto ditto, at	„	„	80
Native	Two Syrangs, at 25 each	„	„	50
	One Tindal, at 16	„	„	16
	Eight Lascars, at 10 each	„	„	80
	Two Cooks, at 10 each	„	„	20
	Total per mensêm, Company's Rupees			436

Of the above, the following should always be in the Light House—

Two European Light-keepers.	Four Lascars.
One Syrang.	One Cook.

The remainder, *viz.*:—

One European Light-keeper,	One Tindal,
One Syrang,	Four Lascars,
One Cook,	

should be stationed at the depôt at Diamond Island, ready to relieve those at the Light House, at such periods as greater experience at the Rock will determine. Present knowledge would go to prove that the Rock is unapproachable from May to September inclusive, and even in October the Rock is dangerous of approach, as will be seen from the following description of it by Mr. Login; though probably, from want of perfect knowledge of the Reef and its neighbourhood, the danger has been somewhat exaggerated.*

* Description by Mr. Login of the rescue of 11 men (coolies) out of 300 wrecked in October 1855, on the Alguada Reef.

"On the morning of the 26th October 1855, on sighting the Reef, we "observed some men standing on the highest point. I volunteered my "services, and with Mr. Hulke, the first Officer (of the Honorable "Company's steamer *Enterprise)*, left the steamer about a mile East of "the Reef in two boats. On approaching the Reef on the East side, we "found it impossible to come nearer than 200 yards to where the men "stood, on account of the shallow water and surf. There was also "rather a stiff breeze and heavy swell from the S. S. W. at the time. "We were therefore obliged to round the South end of the Reef, and "anchored our boat 30 yards West of the Rock on which the coolies "were. It was 11 A. M. when we arrived, and top of high water spring "tides, the rise and fall being 9 feet. There being deep water (4 "fathoms nearly) close up to the West face of the Rock, we could, by "paying out line, approach to within 10 or 15 yards in comparative "safety, (as the force of the sea was broken by the most Southern Rock), "but we could not land. After passing a line on shore, we got the "eleven coolies safe in the boat, all that remained of 300 men. When "a heavy sea came the water rose to about a foot above the *highest* "point,* so the coolies had to stand when it was high water. From "exhaustion and being no longer able to stand, 20 men had been washed "off the day previous to our coming, they having been fourteen days "without food or water, except the little rain they could catch with "their clothes. There was not a vestige of the wreck to be seen, and "the only stick I saw was a piece of bamboo the coolies had a bit of "rag tied to as a signal to us."

2.—Now, the South-West monsoon has generally somewhat moderated by the 26th October, the idea of landing earlier, therefore, is somewhat discouraged; but it must be remembered that this attempt was made at the very worst time, the top of spring tides; and I am inclined to believe, with proper means provided, there must be a short time almost in every month during which, at low water, men may land or be taken off the Reef, although stores, probably, could not be so with any safety.

3.—From Mr. Login's description, it appears that, had the Light House been on the Rock, the whole of these unfortunates, 300 in number, might have been saved—for, immediately the men had landed, signals

* It is here worthy of remark that the only available site for the Light House is a little over six feet *lower* than this "highest point."—A. F.

would have been made from the Light House to Diamond Island, the "Tender" would have come out, and the same means as adopted by Mr. Login and Mr. Hulke, would have sufficed to have saved the whole.

4.—It is unnecessary here to detail all the arrangements of the different rooms that I have made for the comfort and subsistence of the Light-keepers, European and Native, and for the stowage of the oil and stores, for the due maintenance of the light. It is sufficient to say that ample room for this purpose has been provided for provisioning, watering, and storing the building for seven months, with water, at four gallons per man per diem; and that by the additional precaution of forming a groove on the outer edge of the stone balcony at the top of the Light House, so that the whole of the rain water falling on the surface of the dome, lantern, parapet, and balcony, shall be conducted to the water tanks, I provide an ample additional supply, as the fall of rain during the unapproachable season may be taken at between 80 and 90 inches.

5.—The whole of the provisions should be provided by the Government, for obvious reasons, on the scales given in Section VII. I would allow no spirits, except for medicinal purposes; malt liquor should be the only beverage, besides water.

6.—A code of rules will have to be adopted for observance by the Light-keepers, European and Native. I merely state here generally that the charge of the Light House will be under the Europeans, and that the Natives will have the duty of watchmen while the lamp is lighted. Proper arrangements have been thought upon for calling the men below to their duty in the light-room by means of whistles, &c.

Section V.—The Depôt.

1.—At the depôt on Diamond Island should be situated the dwelling houses of the Europeans, and a barrack for the Native Light-keepers. There should also be a signal tower, about fifteen feet high, furnished with a telescope, signal mast, and a small reflector lamp, to point out the course for boats leaving the Rock, in case they should be overtaken by night previous to the completion of business at the Light House.

2.—The European Light-keepers should, if possible, be married, and their dwelling-houses should be comfortable; erected of, if the quarry turn out well, rubble stone. I think each of the three men should have

three rooms; one sitting room and two bed rooms, with a bathing room off one of the latter, and a store room off the former. The houses should be furnished with plain strong furniture at the expense of the Government.

3.—A piece of ground should be inclosed as a garden, in which to grow vegetables, &c., if the land turn out capable of producing vegetables. The men should keep their own servants, except their cook, and supply their own liquor and provisions at the depôt; but Government must provide quarters for the servants, which, besides the cook, will consist of a dhobie and a bheestee for the whole, and a private servant (khidmutgar) for each man. It is not possible to send in plans of these buildings, as I have no sections of the ground, but an approximate estimate is made in the next section, of their cost, as also of the signal tower and barrack for the natives. The wives of the Light-keepers will, of course, always remain at the depôt.

4.—A Light House "Tender" should be also retained at Diamond Island—a sailing vessel, cutter rigged, with two boats attached. The European Light-keeper, syrang, tindal, the four lascars, and cook, off duty, could man her when required. A small harbour might be formed for her at the landing place, sheltered from the heavy storms of the S. W. monsoon.

5.—The tindal would always remain at the depôt, and would have constant charge of all stores (which should be kept in the lower part of the signal tower), whether for the provisioning of the Light House, &c., or of spare rigging, sails, &c., of the tender.

6.—The whole of the buildings, keepers, vessel, boats, &c., should be under the orders of the Master Attendant of Dalhousie, unless it be hereafter determined to form a Light House Department, which, I think, with the increasing number and importance of lights on the coasts of India, will be urgently required, not only for the maintenance of existing Light Houses, but for taking measures for the building of others in positions where Light Houses are nearly as much required as upon the Alguada Reef.

Section VI.—The cost of Erection.

1.—As I have already stated, any estimate that I give of the probable cost of a Light House on the Alguada Reef is submitted with a

considerable degree of reserve, and merely to afford the Honorable Court an opportunity of estimating, within a hundred pounds or so, the expense of a work the execution of which they have decided upon.

	Company's Rupees.
2.—The solid contents of the tower, after deducting the interior space, is 58,580 cubic feet. The cost of granite for the Horsburgh Light House, delivered and dressed at the quarry of Pulo Ubin, only twenty-five miles from the site of the Light House, was 1.05 dollars = 2·3625 Company's Rupees per cubic foot, taking the dollar = 4s. 6d. and the rupee = 2s. Considering that the quarry at Callagouk is 210 miles from the Reef, that I shall have to procure the workmen from a distance, house them and feed them on a desert island, sixty miles from the nearest place (Moulmein), where provisions, &c., can be obtained ; that all the machinery will be heavier than that used for the Horsburgh, that I include the delivery at the Rock, the cost of boats and maintenance of crews, putting the stones on board at Callagouk and landing at the Rock, items not included in Mr. Thomson's expenditure on this account, I do not think I over-estimate this expenditure at five Rupees per cubic foot, that is, 58580 cubic feet of dressed granite at the Rock at Company's Rupees 5-0-0 per cubic foot, Item I.	292900 0 0
3.—The lime being near at hand and the best soorkhee to be made in Calcutta, I may assume the outside cost of the mortar for the whole of the Tower, Item II.	5000 0 0
4.—The labor in Calcutta for brickwork is Company's Rupees three (3) on an average per 100 cubic feet; in Rangoon it was double that. If, therefore, considering the height of the tower, the numerous interruptions that may occur, the more expensive	
Carried forward.	297900 0

	Company's Rupees.
Brought forward	297900 0 0
workmen, their being housed and fed, I assume five times that amount, or 15 Rupees per 100 cubic feet, I am not beyond the probable expenditure on this head, and I have Item III. as follows :—58580 cubic feet of stonework, labor at 15 Rupees per 100 cubic feet	8787 0 0
5.—Messrs. D. and T. Stevenson give the estimate of the light apparatus I recommend, which, including freight, labor of fixing, &c., will be as follows, Item IV. Light apparatus	35000 0 0
6.—There are about 4000 superficial feet of interior panelling, which, of teakwood, including all interior doors, but not the mountings, at 3 Rupees per foot, will make Item V.	12000 0 0
7.—The plate glass for windows, &c., will be Item VI.	1000 0 0
8.—The oil cisterns of tin, with pumps, funnels, and pipes, of copper, will be Item VII.	1500 0 0
9.—The interior fittings and mountings of whistles, clocks, thermometer and barometer, locks and keys, hinges, Lewis bats of brass or gun metal for entrance door and shutters, including exterior door and shutters, will be Item VIII.	2000 0 0
10.—The cast iron water tanks, and coal and wood boxes for interior will be Item IX.	2000 0 0
11.—Cooking apparatus and stoves, iron smoke tubes, and utensils, will be Item X.	1500 0 0
12.—The cast iron railing for balcony. Item XI.	500 0 0
13.—A wrought iron ladder from rock to entrance door, and interior ladders from room to room, will be Item XII.	1200 0 0
14.—Furniture, bedding, books, utensils, &c., will be Item XIII.	2000 0 0
Carried forward	365387 0 0

	Company's Rupees.
Brought forward	365387 0 0
15.—A lightning conductor, Item XIV.	700 0 0
16.—Balcony flag staff, with ball for signals of copper, with bell metal base, Item XV.	700 0 0
17.—Cast iron tanks required for work people while building the Light House, Item XVI.	200 0 0
18.—Fog Bells, with machinery complete, and pair of light sheers for hoisting up oil barrels for balcony, Item XVII.	2000 0 0
19.—The cost in Bengal of an Overseer's House, which is about the class of building adapted for the Light-keepers, is Company's Rupees 4000. On Diamond Island, with lime near at hand, and no difficulty in landing, a little more than that sum would cover this expense, or Company's Rupees 5000 each for three Light-keepers, including outhouses for servants,	
Item XVIII.—Dwelling houses for three European Keepers, at 5000 Rupees each	15000 0 0
Item XIX.—The Signal Tower	2000 0 0
Item XX.—Furnishing the houses at 500 Rupees each	1500 0 0
Item XXI.*—Furnishing the signal tower with flag-staff, telescope, reflector lamp, signals, &c., &c.	1000 0 0
Item XXI.—The barrack for natives	2000 0 0
Item XXII.—Signal lamps, temporary flag-staff, and maintaining the same while the Light House is in progress	1500 0 0
Item XXIII.—Forming small harbour at Diamond Island	2000 0 0
20.—A tender, with boats, for the future service of the Light House, will be Item XXIV...	15000 0 0
Total	408987 0 0
Contingencies at 5 per cent. Item XXV	20449 0 0
Grand Total	429436 0 0

Company's Rupees.

21.—The cost of the whole work therefore ıy be abstracted as follows :

ABSTRACT.

1.—Building the tower entirely of granite, inıding machinery, labour, and materials, or Items , II., III., above, at Company's Rupees 5.2353 per ıbic foot	306687 0 0
2.—A first-class dioptric holophotal apparatus, ıcluding lantern, dome, 8 lenses, and holophotal risms, revolving machinery, and stores. Item IV.	35000 0 0
3.—The fittings of the tower, or Items V., VI., /II., VIII., IX., X., XI., XII., XIII., XIV., XV., XVI., and XVII.	27300 0 0
4.—Cost of the depôt at Diamond Island, Items XVIII., XIX., XX., XXI., XXII., XXIII.	25000 0 0
5.—Ditto of tender and boats Item XXIV.	15000 0 0
	408987 0 0
6.—Contingencies at 5 per cent., Item XXV ...	20449 0 0
Total cost of granite Tower	429436 0 0

22.—If brick be used in superstructure, brick masonry may be done at the Rock at about one Rupee per cubic foot. The first 26 feet must be still of granite, and solid, and to this height the frustrum contains about 27110 cubic feet, therefore 58580—27110 = 31470 cubic feet = quantity of brickwork in superstructure, but the cost of apparatus would slightly increase the rate for a smaller amount of work, therefore the cost of a tower with brick superstructure may be abstracted as follows :—

ABSTRACT.

1.—27110 cubic feet of granite work, to 26 feet in height, at six Rupees per cubic foot	162660 0 0
2.—31470 cubit feet of brick superstructure, at 1 Rupee per cubic foot	31470 0 0
3.—Light apparatus, &c.	35000 0 0
4.—Fittings	27300 0 0
Carried forward	256430 0 0

	Company's Rupees.		
Brought forward	256430	0	0
5.—Depôt	25000	0	0
6.—Tender, &c.	15000	0	0
Total	296430	0	0
7.—Contingencies, at 5 per cent	14821	0	0
Total cost of Tower of granite to 26 feet in height, with brick superstructure	311251	0	0

23.—If iron be used in superstructure the abstract of cost will appear as follows :—

ABSTRACT.

1st.—27110 cubic feet, granite work, to 26 feet in height, at six Rupees per cubic foot	162660	0	0
2nd.—Iron superstructure and concrete, Plate II.	203900	0	0
3rd.—Light apparatus	35000	0	0
4th.—Fittings	27300	0	0
5th.—Depôt	25000	0	0
6th.—Tender	15000	0	0
Total	468860	0	0
7th.—Contingencies, at 5 per cent.	23443	0	0
Cost of a tower of granite to 26 feet in height, and iron superstructure	492303	0	0

24.—Should it be thought desirable (which, however, as already stated, I do not recommend) to have a superstructure of plate-iron, the above estimate would be reduced as follows :—

ABSTRACT.

1st.—27110 cubic feet of granite, at six Rupees per cubic foot	162660	0	0
2nd.—Plate-iron superstructure	93900	0	0
3rd.—Light apparatus	35000	0	0
4th.—Fittings	27300	0	0
5th.—Depôt	25000	0	0
Carried forward	343860	0	0

	Company's Rupees.		
Brought forward	343860	0	0
6th.—Tender	15000	0	0
	358860	0	0
7th.—Contingencies at 5 per cent...	17943	0	0
Total cost of a Tower with granite to 26 feet in height, and plate-iron superstructure	376803	0	0

25.—In the two last estimates I have not entered into the details of iron work, as this Report has already extended to a greater length than I desired, but they have been fully considered, and such details as may be required can be produced. But if the cost of the granite Light House be considered too great *now*, or should it be found necessary to report that the estimate will be exceeded, by reason of difficulties, not now anticipated, in the working of the quarry of Callagouk, I think the brick superstructure should be adopted, as not only being less in actual cost, but more durable than the plate iron.

26.—I have not considered above the cost of a sand stone superstructure ; it would be about a mean between that of the entirely granite and the brick.

ABSTRACT.

1st.—27110 cubic feet of granite at six Rupees per cubic foot	162660	0	0
2nd—31470 cubic feet of sandstone superstructure, at three Rupees eight annas per cubic foot ...	110145	0	0
3rd.—Light apparatus	35000	0	0
4th.—Fittings	27300	0	0
5th.—Depôt	25000	0	0
6th.—Tender	15000	0	0
	375105	0	0
7th.—Contingencies at 5 per cent.	18755	0	0
Total cost of a Tower of granite to 26 feet in height, and superstructure of sand stone	393860	0	0

27.—But to all the above estimates has to be added the cost of the foundation pit, which will have to be excavated in the Reef to the depth of about four feet, and this will cost as follows :—

	Company's Rupees.		
A cylindric pit, four feet deep, and 42 feet diameter = 5541·7824 cubic ft., including excavation and filling in with granite masonry, at 6 Rupees per cubic ft	33251	0	0
Contingencies, at 5 per cent	1662	0	0
Grand total cost of excavation and filling in for foundation	34913	0	0

This sum is constant for all, therefore the total cost of each kind of Light House in Indian and English currency is as follows :—

Nature of Building.	Total cost of Tower.	Cost of foundation.	Grand total cost.	
			Com. Rupees	£
1st. Granite tower, ...	429436	34913	464349	46435
2nd. Ditto to 26′ in height, with brick superstructure.	311251	34913	346164	34617
3rd. Ditto to 26′ in height, with iron superstructure ...	492303	34913	527216	52722
4th. Ditto to 26′ in height, with plate iron superstructure	376803	34913	411716	41172
5th. Ditto to 26′ in height, with sand-stone superstructure	393860	34913	428773	42877

It will be seen that, in the above estimates, I have preferred combining two materials, by placing the one *above* the other, to that of forming the exterior of one material and the interior of another,

Sand-stone.....	·001743	because, although expansibility is
Cast-iron	·00114676	hardly appreciable, yet it is some-
Peterhead granite.	·0008968	thing—see "Transactions of the
Aberdeen ditto ...	·00078943	Royal Society of Edinburgh,"
Brick	·0005502	where this action of certain sub-

stances is given. By the former method of arranging the materials employed, no tendency to separate can take place.

28.—The Horsburgh Light House (situated at the Eastern extremity of the Singapore Straits about 37 miles from the town of that name), built by Mr. J. T. Thomson, F. R. G. S., Government Surveyor, being the only building in the East of a similar description to that proposed for the Alguada Reef. I thought, after I had completed the above estimates, that a comparison of the estimated cost of the latter might be usefully made with the actual cost of the former, as given at page 115 of Mr. Thomson's account of the Horsburgh Light House.

The Horsburgh Tower contains about 11,000 cubic feet of masonry. The Tower proposed for the Alguada Reef contains 58,580 cubic feet, or over five times the content of the former.

This difference is attributable to the following causes :—

1st.—Mr. Thomson obtained a natural foundation of solid rock 22′ 3″ above ordinary spring tides. I have a foundation only one foot above the same, and therefore have to build an artificial foundation to get into the same position as Mr. Thomson was at the commencement of his work.

2nd.—The Alguada Reef having greater exposure, and being approachable only at long intervals, requires a building of greater solidity, more careful and expensive construction, and superior accommodation to that on the "Pedra Branca" Rocks.

3rd.—The Alguada Reef is a position in which a great sea-light is necessary, and a more lofty tower, exhibiting a more powerful light (consequently allowing a more extended offing,) is required for the purpose.

Now, deducting the cost of the light apparatus, I find the Horsburgh Light House cost £4,000, and, on the same data, a building five times that size would have cost £20,000.

And, deducting the cost of the light, also the cost of the tender and Light-keeper's houses (expenses not included in the cost of the Horsburgh building), I find my estimate for the Tower on the Alguada Reef, *entirely* of granite, is £33,000, and with the same deductions from the probable cost of the Tower on the Alguada Reef, with granite foundation and brick superstructure, I find my estimate is about £23,000. Now, in comparing the two, it must not be forgotten that the Horsburgh Tower is only a granite shell, with brick hearting, with a foundation 23 feet in height made to hand. The excess, therefore,

in my estimate of £13,000 in the one case, and £3,000 in the other, considering the relative distances of the quarries, and other circumstances not favorable to economy, with regard to the Alguada Reef (more fully entered into in the 2nd paragraph of this Section), can be fully understood.

29.—Under these circumstances, I am satisfied that my estimates are not too high according to the best data available. I can only hope they are not too low; but can assure the Honorable Court that my best exertions shall not be wanting, as I trust they never have been during my service, to prevent any unnecessary expense, whatever kind of building they may be pleased to sanction.

Section VII.—The cost of Maintenance.

1.—It appears desirable to give a general view of the whole undertaking, and I, therefore, conclude my Report with an estimate of the probable annual cost of maintaining the light after the erection of the Tower.

Company's Rupees.

2.—A first-order 4-wicked lamp consumes one gallon of oil in five hours. The average duration of night may be taken at ten hours. The expenditure of oil per annum will, therefore, be 730 gallons. An imperial gallon of oil weighs, on an average, 9·3 pounds. The weight of a Calcutta maund = 74·66 pounds = 8 Imperial gallons. Cocoanut oil is procurable in Calcutta at 14 Rupees per maund. Therefore, the cost of consumption of one year of oil $= \frac{730}{8} \times 14$ = Item I 1278 0 0

3.—The cost of cotton, wicks, cloth, cleaning powder, leathers, chimneys, paint and varnish for lantern and railings, &c., will be Item II. 400 0 0

Carried forward 1678 0 0

Company's Rupees.

Brought forward 1678 0 0

—The establishment of Light-keepers at npany's Rupees 436 per mensem (see Section , paragraph 1) will be Item III., per annum ... 5232 0 0

5.—The reflector lamp at the Signal Tower on amond Island will be a single Argand lamp, rning one gallon in 93 hours, or 40 gallons per mum, or 5 maunds at 14, Item IV.... ... ... 70 0 0

The cost of cotton, wicks, &c., &c., Item V... ... 20 0 0

6.—The wear and tear of furniture, boats, sails, igging, signals, burners, &c., may be put down at 50 Rupees per mensem, Item VI., per annum 600 0 0

7.—The following is the allowance made to Europeans and Natives serving on board the ships of the Honorable Company's Navy, for which information I am indebted to Mr. Mason, of the Marine Department, East India House, though he is not responsible for the prices set down :—

	lb. oz. R. A.	R. A. P. A. P.
Fresh or Salt Meat ...	1 0 at 0 8 per seer	... 0 4 0
Fresh Bread or Biscuit,	1 0 „ 0 8 „ „	... 0 4 0
Rice	0 8 „ 0 1 „ „	... 0 0 3
Dholl ...	0 2 „ 0 1 „ „	... 0 0 1
Ghee ...	0 1 „ 1 0 per 3 seers	0 0 4
Salt ...	0 1 „ 0 2 per seer	... 0 0 1
Vegetables..	0 8 „ 0 4 „ „	... 0 1 0
Flour ...	2 0 „ 0 2 „ „	... 0 2 0
Per European per idem		11 9
Raisins ...	0 8 „ 0 4 per seer	... 0 1 0
Vinegar ...	½ pint „ 0 6 per pint	... 0 3 0
Carried forward		0 4 0 11 9 7600 0 0

	lb.	oz.	R.	A.		R.	A.	P.	A.	P.	Co.'s Rupees		
Brought forward						0	4	0	11	9	7600	0	0
Tea ...	2½	at	2	8	per seer...	0	3	2					
Sugar ...	1	2	„	0	4 „ „ ...	0	2	3					
Mustard ...	0	1	„	0	8 „ „ ...	0	0	3					
Coffee ...	0	12	„	1	12 „ „ ...	0	10	6					
Per European per week 7						1	4	2					
						0	2	11	2	11			
Total per European per diem									14	8			
Add one bottle Beer per diem...									4	0			
Total liquor and provisions per diem Rupees									1	2	8		

Say, therefore, the cost of provisions for the European per diem (including freight, &c.) be Rupees 1-4 we have Item VII. for two Europeans per annum 912 8 0

The Natives are allowed as follows :—

	lb.	oz.	R.	A.		R.	A.	P.	A.	P.
Fresh Meat	0	4	at 0	8	per seer...	0	1	0		
Rice	1	4	„ 0	1	„ „ ...	0	0	8		
Dholl ...	0	4	„ 0	1	„ „ ...	0	0	2		
Ghee... ...	0	2	„ 1	0	per 3 seers	0	0	8		
Salt Fish ...	0	3	„ 0	6	per seer...	0	0	7		
Salt	0	8	„ 0	2	„ „ ...	0	0	0½		
Vegetables..	0	8	„ 0	4	„ „ ...	0	1	0		
Per Native per diem...									4	1½
Chillies ...	1	oz.								
Coriander Seed	„									
Turmeric ...	„				4 oz. spices, at 8 annas per seer	0	1	0		
Cummin Seed	½	„								
Garlic... ...	„									
Per Native per week 7						0	1	0	(0	2
Total per Native per diem Co.'s Rupees									4	3½

Carried forward 8512 8 0

	Company's Rupees.		
Brought forward	8512	8	0
Say, therefore, the cost of provisioning the native (including freight, &c.) is per diem Rupees 0-5-0., I obtain Item VIII., or the provisions for six natives per annum	685	8	0
8.—I would store about six tons of coal in the Light House, which would take up 300 cubic feet of the fuel store, and calculating coal at 15 Rupees per ton, Item IX. will be	90	0	0
The remainder of the fuel may be wood, which could be obtained on Diamond Island at no expense by the men off duty.			
Total	9288	0	0

9.—The cost of maintenance may therefore be abstracted as follows :—

ABSTRACT.

Item I.—Oil	1278	0	0
Item II.—Cotton wicks, cloth, &c., &c.	400	0	0
Item III.—Establishment : European and Native ...	5232	0	0
Item IV.—Reflector lamp at depôt	70	0	0
Item V.—Cotton wicks, &c., for ditto	20	0	0
Item VI.—Wear and tear of furniture, &c.	600	0	0
Item VII.—Rations for Europeans	912	8	0
Item VIII.—Rations for Natives	685	8	0
Item IX.—Fuel	90	0	0
	9288	0	0
Contingencies at 5 per cent.	464	0	0
Grand Total—£975 per annum for maintenance of Light House and Depôt	9752	0	0

10.—A comparison of the above, with the cost of maintenance of the Horsburgh Light House, as given by Mr. Thomson at paragraph 95 of his "account" of that building, will be satisfactory.

				Company's Rupees.		
Total annual expense of Horsburgh Light House				5856	0	0
But the following items (see paragraph 9) must be added, as they are not included in the above expenditure for maintaining the Horsburgh Light :—						
Items IV. V.—Cost of maintaining reflector lamp	90	0	0			
Item VI.—Wear and tear	600	0	0			
Item VII.—Rations for Europeans..	912	8	0			
Also cost of an additional European Light-keeper, at 100 Rupees per mensem	1200	0	0	2802	8	0
				8658	8	0
The estimated cost of maintaining the Alguada Reef light, including contingencies, is				9752	0	0
The difference to be otherwise accounted for is ...				1093	8	0

Now, Mr. Thomson calculates the cost of rationing his native establishment at only Company's Rupees 20 per mensem, whereas my calculation gives this amount equal to Company's Rupees 56.

Again, the oil for the Horsburgh light is calculated at only Company's Rupees 55 per mensem, that for the Alguada Reef is estimated at Company's Rupees 106, so that these differences appear as follows for the whole year :—

Rations, Company's Rupees 36 × 12	432	0	0
Oil, Company's Rupees 51 × 12	612	0	0
And the total difference, as nearly as possible, agrees with the above	1044	0	0

I would further here remark that there are only nine Argand lamps in the Horsburgh Light House, whereas the consuming power of a first order four wicked lamp, recommended for the Alguada Reef, is equal to about eighteen Argand lamps, and to this is attributable the excess cost of oil for the latter. I am unable to account for the difference of cost of rationing the natives, but think there must be some mistake on Mr. Thomson's part, as I see nothing unreasonable or unnecessary in the scale of provisions proposed for the men to be employed in the Alguada Reef Light House.

11.—In conclusion I would beg to report, for the information of the Honorable Court, that I have received every facility that could have been desired in the course of my enquiries on this subject from the Board of Trade, the Corporation of Trinity House, and the Board of Commissioners of Northern Light Houses, and that owing to the politeness of the latter I was permitted to accompany two of the Commissioners on their inspection of the Light Houses on the coast of Scotland, in their steamer *Pharos*, and was thus enabled to see so many of the Light Houses on the coasts, (not only those already built, but several in course of construction,) that it was unnecessary to incur the expense of visiting Ireland.

I trust the Honorable Court will see fit to order suitable acknowledgments to be made to the above authorities. And I would further beg to state that I have received much assistance and valuable information, both on the construction of Light Houses and the arrangement of optical apparatus for Light House purposes, from Thomas Stevenson, Esq., F. R. S. E., one of the consulting Engineers to the Northern Board, as also from Alexander Cuningham, Esq., Secretary to that Board, on the general working of the Northern Light House establishment.

My thanks are likewise due to Mr. Ditcham, the agent of the Trinity House at Plymouth, for facilities afforded me in visiting the Eddystone and Breakwater Light Houses, and to Mr. Douglass, the Superintendent of the works of the Bishop Light House, off the Scilly Islands, of which — Walker, Esq., is the Engineer. This last work was peculiarly interesting to me, as perhaps, saving the Bell Rock, this position is the most difficult in the world on which to construct a building of the kind, and showing, as it does, that the resources of engineering skill are unlimited ; it likewise proved to me that there was nothing to fear from a similar building on the Alguada Reef.

ALEX. FRASER, *Lieut.*,
Bengal Engineers,
Engineer, Alguada Reef Light House.

31*st October* 1857.

XVII.

No. 2542.

EXTRACT from the Proceedings of the Hon'ble the President of the Council of India in Council, in the Public Works Department, (Marine) under date the 2nd June 1858.

THE Hon'ble the President in Council observes that Captain Fraser having returned to India has presented a Report of the results of his enquiries in England on the subject of the Alguada Reef Light House.

* * * * * *

3. The question of the character of the light is clearly so far settled as to show that it should be a first class Dioptric or Fresnel light.

4. But bearing in mind that there are even now several lights in the Bay of Bengal, and that before long many others are certain to be erected, it is of some importance to decide what shall be the special character of this light; whether it shall be fixed or revolving, considering the inaccessible nature of the Alguada Reef during many months of the year, and that a revolving light must be dependent on machinery which eventually will certainly require repairs, and may break down any day, it seems to be the last course to determine that the Alguada Light shall be a fixed light. The question, however, may advantageously be re-considered in the Home Department, having reference to the other lights now existing, or likely to be set up in the Bay, considerations which may better be discussed in communication with the Marine Department.

5. The Hon'ble the President in Council further remarks that the Hon'ble Court, in transmitting a copy of Captain Fraser's Report, observe, that they reserve their opinion on certain points, as the general suspension of public works will also affect the execution of the Light House. The Hon'ble the President in Council, however, concurs fully in the views* of his Lordship the Governor General, that it will be expedient that the Government of India shall be put in possession of the Hon'ble

* *Vide* letter from Officiating Secretary with Governor General, No. 132, dated 10th May 1858.

Court's views on the whole subject without further delay, so that the work may be put in hand at the first possible opportunity, and that the Hon'ble Court should be addressed to this effect.

6. The Government also is of opinion that Captain Fraser's Report should be published, and desires that it may be printed with other papers explanatory of the facts of the case as a Number of the Selections of the Records of the Government of India.

(True Extract)
R. STRACHEY, *Major*,
Offg. Secy. to the Government of India.

XVIII.

No. 5507.

To
C. BEADON, ESQUIRE,
Secy. to the Govt. of India.
Dated the 23rd June 1858.

HOME DEPARTMENT.
MARINE.

SIR,

I HAVE the honor to acknowledge the receipt of Memo. No. 1527, from the Under Secretary, Government of India, dated the 17th Instant, with papers on the subject of the proposed construction of a Light House on the Alguada Reef.

2. The only question which appears to require my consideration and report is contained in the 4th paragraph of the proceedings of the Hon'ble the President in Council, in the Public Works Department, under date the 2nd June 1858, and has reference to the specific character to be given to the light.

3. On this point, I beg to submit, for the consideration of the Hon'ble the President in Council, that the light on the Reef should be a fixed white one, in preference to a revolving or flashing light, so that all

risks attending the machinery requisite for lights of the latter description may be obviated ; for although Captain Fraser, in his Report, states that he sees no chance of the machinery for the revolving apparatus getting out of order with common attention, still as this chance does exist, and as the consequence of such an accident would be most serious, it is advisable to select a form which is free from any such contingency.

4. It has been suggested that it may be desirable to give a specific character to each of the lights which will be erected on the neighbouring coasts, so as to prevent their being confounded with each other, and it is doubtless of great importance that this should be the case were such a mistake probable, but the only position for a light, which is at present contemplated, that could possibly be mistaken for the Alguada Reef, is the Cocos Island, 120 miles distant in a S. S. W. direction ; and as this island has a considerable elevation, so as to allow of a residence being constructed for the Light-keepers, and is accessible all the year round, the same objection, to the erection upon it of a Light House requiring machinery, does not apply with the force that it does to the Alguada Reef.

5. In conclusion it is almost needless for me to add how cordially I concur in the opinion expressed in the letter from the Public Works Department, that this work (the Light House in Alguada Reef) should be one of the first to be resumed by Government when circumstances at all permit.

I have the honor to be,

SIR,

Your most obedient Servant,

J. RENNIE,

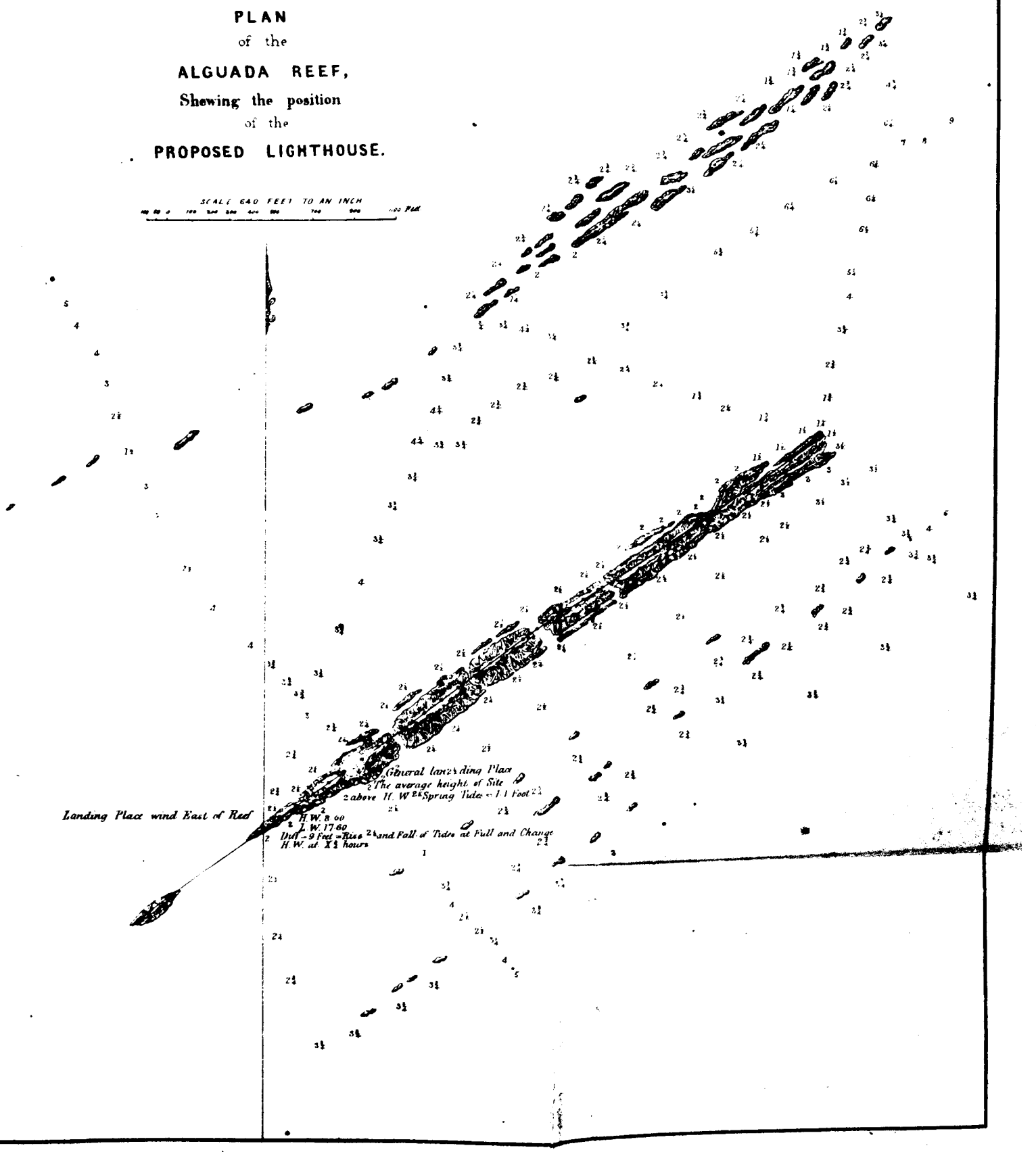
Superintendent of Marine.

FORT WILLIAM,
The 23rd June 185

JOHN GR... "BENGAL H...KARU" PRESS.

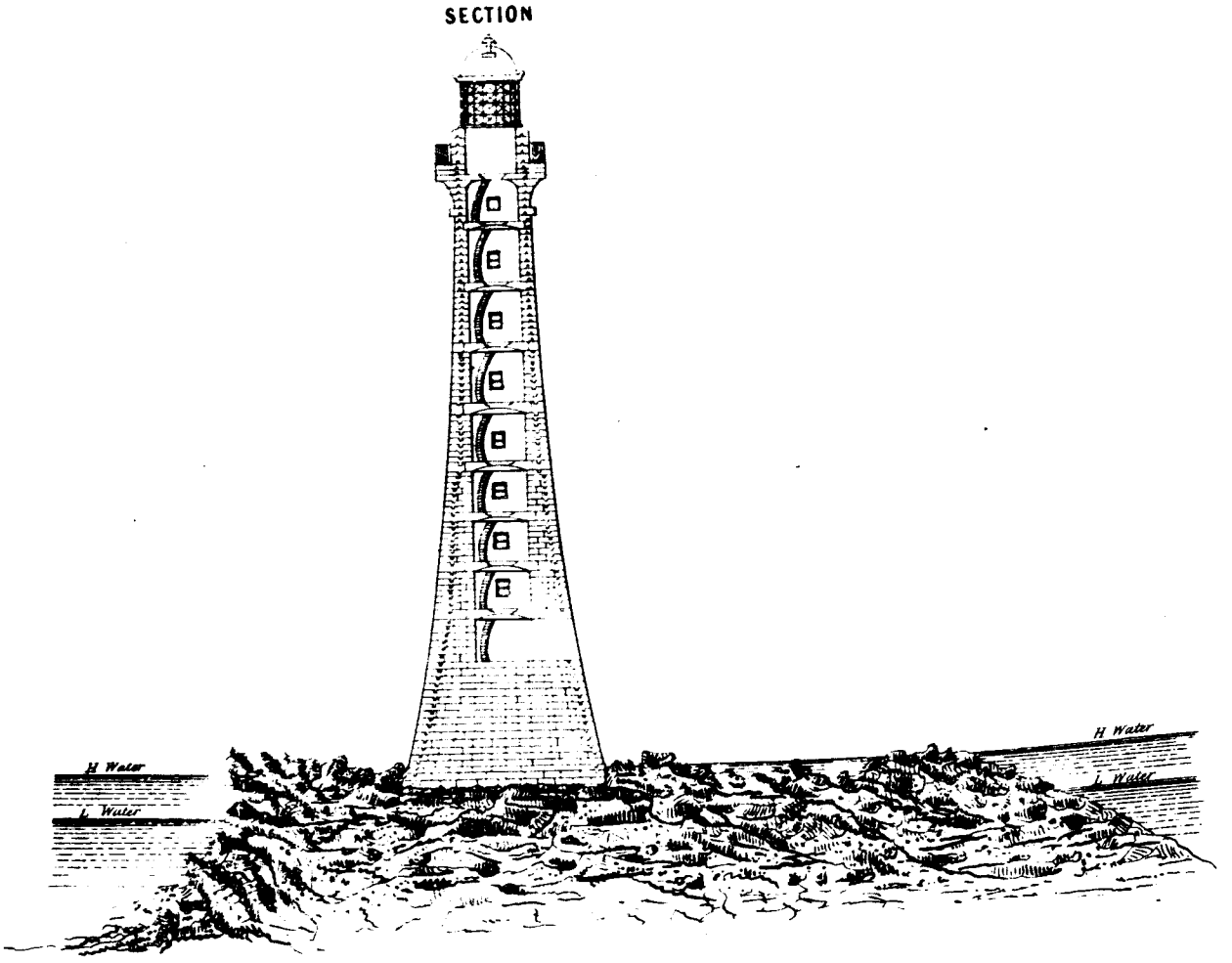
PLAN
of the
ALGUADA REEF,
Shewing the position
of the
PROPOSED LIGHTHOUSE.

SCALE 640 FEET TO AN INCH



LITHOG BY W.M. SMITH, SURV GENL'S OFFICE, CALCUTTA, DEC 1850.

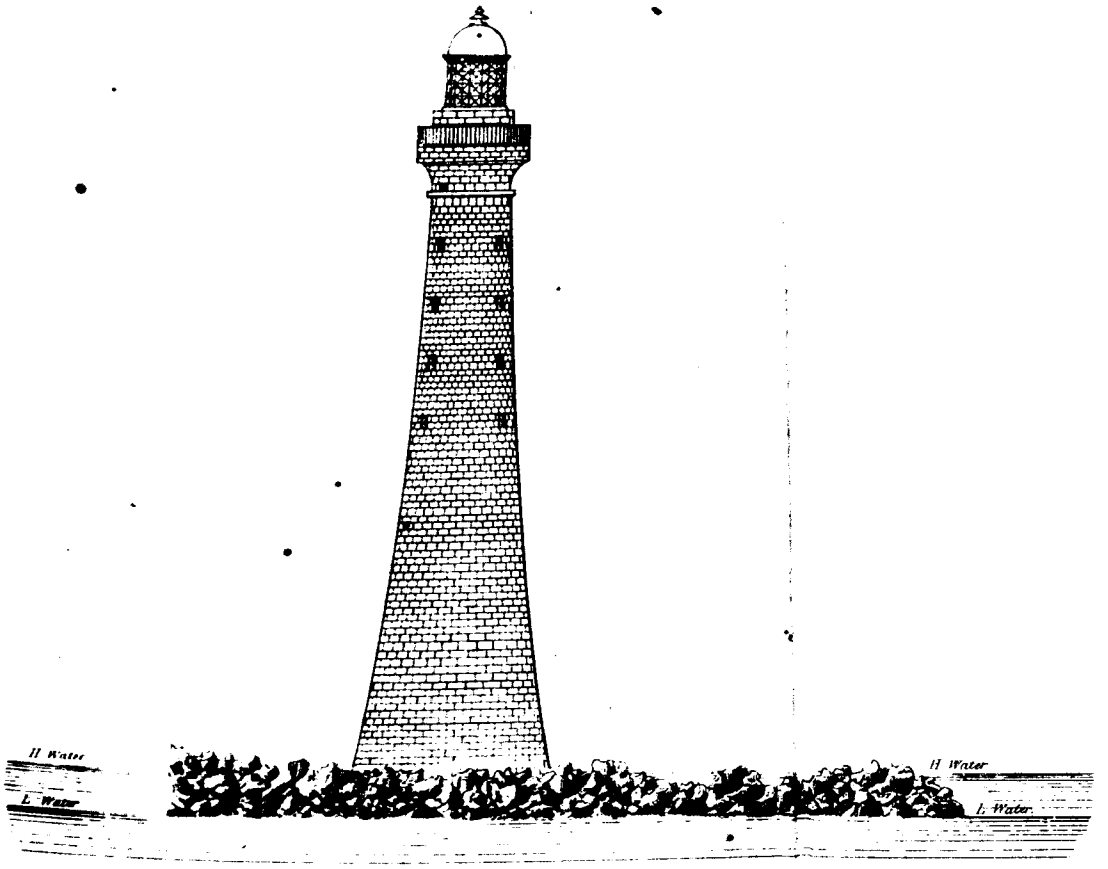
SECTION

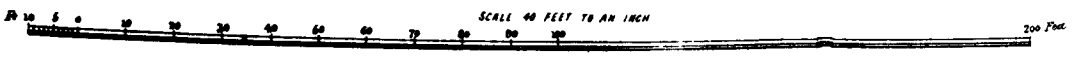


SCALE 40 FEET TO AN INCH

... PRINTED BY W.H. SMITH AT THE SURVEY GENERAL OFFICE CALCUTTA DECR 1850

ELEVATION





On Tracing Paper By J. Musgrove, and Lith By H M Smith at the Surv'r Genl's Office Calcutta Dec 1856