XXIV.—*On the Illumination of Light-houses. By Lieut.* Thomas Drummond, *of the Royal Engineers. Communicated by Lieut. Colonel* Colby *of the Royal Engineers, F.R.S.*

Read June 17th, 1830.

In a former paper which the Royal Society has done me the honour to place among its Transactions*, a method of producing intense light is described, the object of which is to render visible distant stations in geodetical operations. At the conclusion of that paper I ventured to suggest that this method might be found useful for other purposes besides that for which it had been contrived; and more especially for the illumination of light-houses.

Soon after its publication, I received, through my friend Colonel Colby, a communication from the Trinity House, under whose jurisdiction and management the greater number of light-houses on the coast of England and Wales are placed, intimating the intention of that Corporation to give the method proposed a fair trial, whenever the apparatus should be brought to such a state of perfection as would ensure the steady continuance of the light, while at the same time it admitted of being entrusted with safety to the hands of the ordinary attendants. A good deal remained to be accomplished before this degree of simplicity could be considered as attained: nevertheless, the offer of the Corporation was prompt and liberal; and, with the assurance that the time and labour devoted to this object would not be vainly and unprofitably expended, I was anxious to undertake the necessary experiments without delay.

The survey of Ireland, however, had just been commenced; and being employed on that service, I found it impossible to continue these experiments, in the first instance from constant occupation and absence from London, and latterly from a long and severe illness, the consequence of a very laborious and anxious duty in Ireland.

During the last winter, however, I was again able to return to this subject,

* Phil. Trans. 1826, Part III. page 324.

and take part in a course of experiments instituted by order of the Trinity House, and carried on under the direction of the Committee for the Management of Light-houses, with a view to ascertain the relative merits of different methods either adopted or proposed to be adopted in the illumination of light-houses. The result of these experiments I have received permission to communicate to the Royal Society; but in order that the particular methods to which they refer may be better understood and more fully appreciated, a few preliminary observations may be necessary.

The more rude and ancient methods of illuminating light-houses with open coal fires, with common lamps or candles, sometimes aided by reflectors composed of small facettes or plane mirrors*, have in this country been completely superseded even in light-houses of secondary importance; and it may be said that there is only one method now in use for this purpose along the coast of Great Britain and Ireland. This consists in the use of a parabolic reflector of about three or four inches focal length, and from twenty-one to thirty inches in diameter, illuminated by an Argand lamp, seven-eighths of an inch in diameter, placed in the focus. The reflector is hammered out of a plane surface consisting of two plates of silver and copper rolled out together, and though executed with great skill, considering the means, cannot be regarded as a very perfect instrument. This description must be understood as applying only to light-houses under the management of public bodies: with respect to those which have been let to private individuals, I have no very accurate information; but, if they should, on examination, prove to be of an inferior order, it would only be the natural consequence of so pernicious a system.

In fixed lights the number of these reflectors varies according to the portion of the circumference required to be illuminated; but it should not be less than this arc divided by the angle of divergence of the reflected light. At the Eddystone, where the whole circle requires to be illuminated, the number

* The Eddystone till the year 1811 was lighted with 24 wax candles. Up to that time it was in the hands of private individuals; but on the expiration of the lease the Trinity House took it under their own management, and immediately substituted lamps and reflectors. The Bidstone, a leading light to Liverpool, consisted of a large built reflector, about 10 feet in diameter, lighted by an immense spout-lamp with a wick about 12 inches wide, from which a volume of smoke arose that completely intercepted the light from the upper part of the reflector.

should not be less than $\frac{360}{17} = 21$: if it be less than this, there must be dark spaces diverging from the light-house as a centre, in which nothing but the unassisted light of a single Argand will be visible.

In revolving lights there are five, seven, and even ten reflectors on a side, the number of sides being usually three or four. In the light-houses lately erected on Beachy Head, and on the Perch Rock at the mouth of the river Mersey, there are thirty reflectors in each, disposed on three sides, each bearing ten reflectors. These are the latest, and may be considered as the best specimens of this method of illumination; being about ten times more powerful than the ordinary fixed lights. In some few instances oil gas has been introduced, but the intensity of the flame being very little, if at all, superior to that of an Argand lamp supplied with the best spermaceti oil, little or no advantage can be expected from this introduction, as far as regards the brilliancy of the light, when reflectors are used.

About thirty-eight years ago the experiment was tried, in three or four light-houses, of substituting glass lenses instead of metallic parabolic reflectors. These lenses were 20 inches in diameter, of 19 inches focal length, and about 5 inches thick; but from the imperfection of form and the badness of material, the light transmitted by them appears by our late experiments to be about one-third of that of the reflectors now in use, while their divergence is so small, that at $1\frac{1}{3}°$ on each side of the axis they cease to be visible. With a view probably to remedy these defects, a somewhat extraordinary arrangement was adopted, viz.—the addition of parabolic reflectors behind the lenses. It is true that by this means some addition is made to the direct light of the lens, and, what is of more consequence, the divergent light is increased so that at an angle of about 3° with the axis, it is equal to about thirteen times the light of an Argand. So far therefore the reflector, though but a small portion of it comes into use, contributes to the effect of the lens; but the converse experiment does not appear to have been tried, viz.—how far the reflector was improved by the lens placed before it; otherwise it would quickly have been perceived that the effect of the reflector alone was about double the united effects of the reflector and lens; while at the same time its effective divergence was also greater, being about eight times that of the combined lens and reflector, at an angle of 3° on either side of the axis.

This plan was fortunately never very extensively adopted; and in those light-houses belonging to the Trinity House, where it was tried, it has subsequently been discontinued, and the lenses replaced by reflectors. The North Foreland, however, under the management of the governors of Greenwich Hospital, still remains a solitary example of a method which cannot be too soon abandoned, more especially since the remedy is so easy,—merely to remove the lenses, and leave a free and unobstructed passage to the light of the reflectors.

Another mode, differing from any of those now described, has lately been introduced into France by MM. Arago and Fresnel, which rivals the most powerful of our lights in brilliancy, and surpasses them in economy and facility of management. A large Argand lamp with four concentric wicks, the exterior of which is $3\frac{1}{3}$ inches in diameter, occupies the centre of the light-house. Around this powerful light eight magnificent lenses 30 inches square are disposed, touching each other at the edges, and forming a hollow octagonal prism about the lamp. Above these, smaller lenses of a similar construction, but in the form of trapezoids, are placed, inclining towards the centre till their axes form angles of about 50° with the horizon, at which inclination their sides come into contact, and thus completely inclose the central light. By the intervention of plane mirrors, the beams of light issuing from the secondary lenses are rendered parallel to those of the principal; but by the same means a horizontal deviation of about 7° is given to them, so that this addition to the light is made to contribute to the divergence and consequent duration of light when revolving, rather than to add to its brilliancy. The lens, which is plano-convex, is of a peculiar construction, being formed of separate rings or zones, whose convex surfaces preserve nearly the same curvature as if they constituted portions of one complete lens, the interior and useless part of the glass being removed; so that a section of these zones resembles a wedge placed with the edge uppermost; one side, that next the lamp, being a straight line, the other an arc of a circle*.

The idea of such a lens appears first to have occurred to the celebrated Buffon, when engaged in some experiments on burning-glasses; but he supposed, what is not possible, that it might be ground out of one large piece of glass. Dr. Brewster, in an article on the same subject in the Edinburgh

* Fresnel, Mémoire sur un nouveau système d'eclairage, lu à l'Academie des Sciences, 1822.

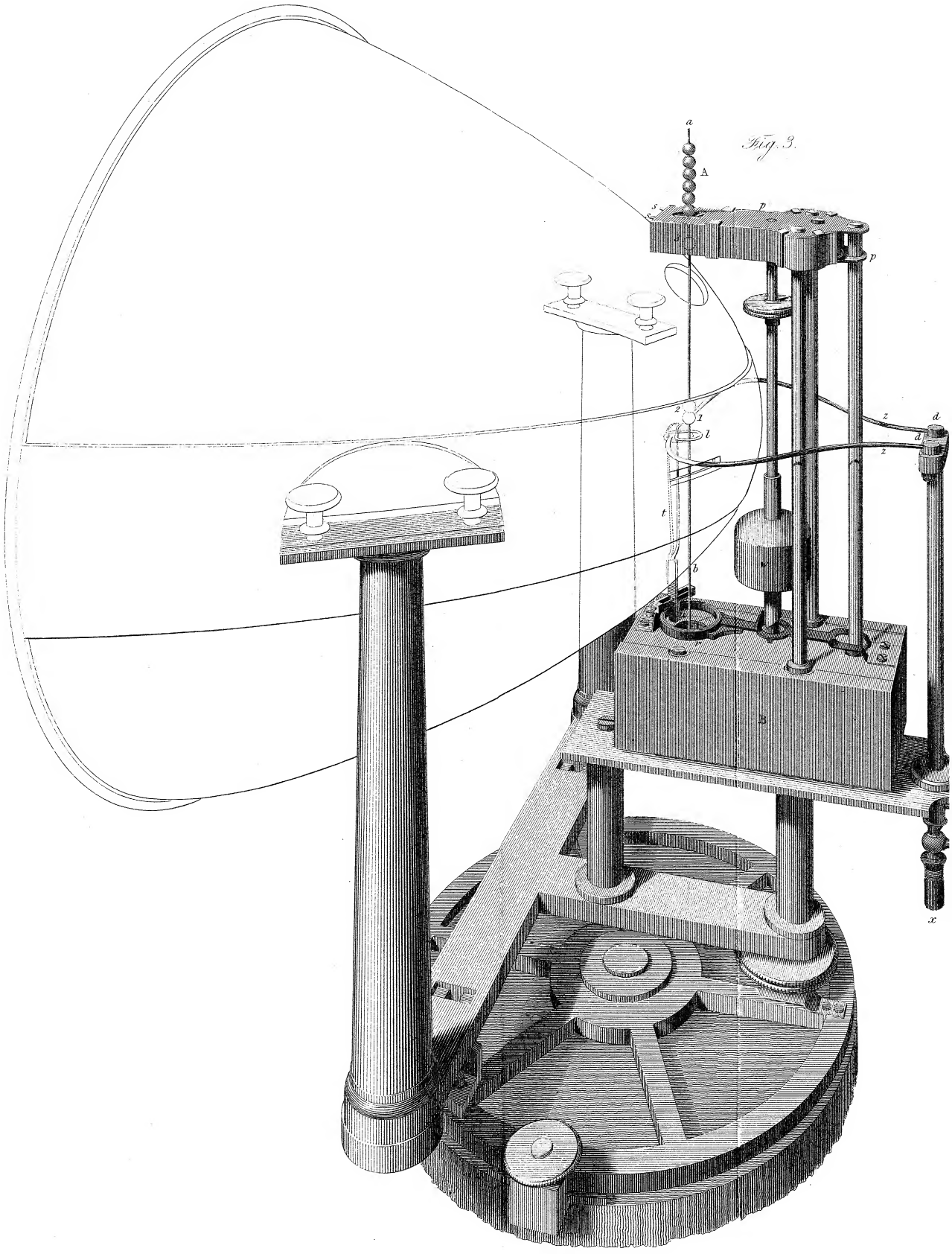


Fig. 3.
a
A
s
p
p
z
l
l
z
d
d
z
t
b
B
S
x

Fig. 1.

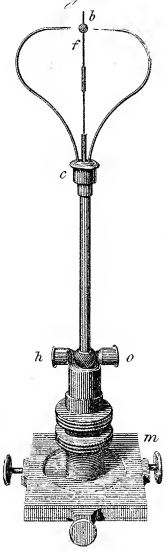


Fig. 2.

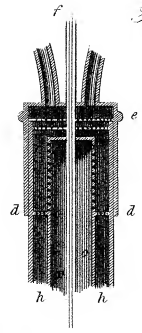
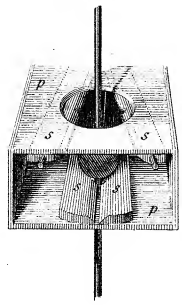


Fig. 4.



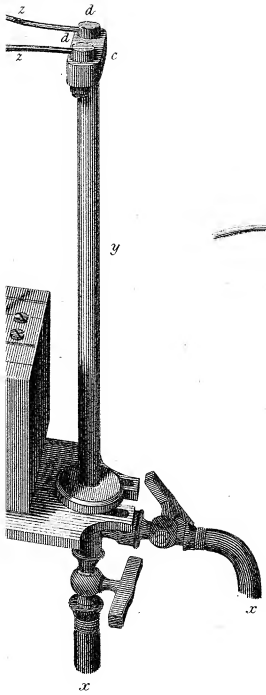


Fig. 5.

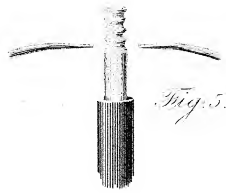
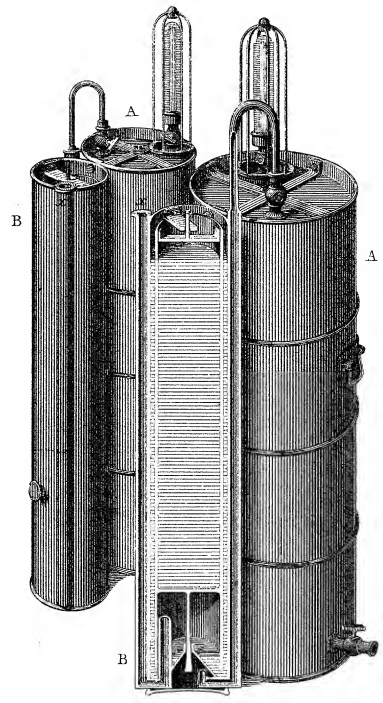


Fig. 6.



Encyclopedia, in 1811, showed that it might be built of separate pieces; and this was an important step, inasmuch as it rendered of easy execution what was before impracticable. To Dr. Brewster therefore the priority of suggesting this improvement is due. To MM. Arago and Fresnel, obviously unacquainted with what had been previously done or recommended, belongs the praise of having first got such a lens constructed, of combining it with a very powerful lamp, and above all of giving it a most useful and beneficial practical application.

The Cordouan light-house at the mouth of the Garonne, the difficult entrance to Bourdeaux, has been fitted up in this manner; and as the lens and lamp used in our experiments were purchased at Paris of the same makers, a pretty accurate estimate may be formed of its merits when compared with the light-houses of this country.

Such are the methods at present in use in the best light-houses of Great Britain or France. The third and last method is that which I have ventured to propose, and in which the light is derived from a source altogether different from the preceding two; a ball or cylinder of lime, intensely ignited, being substituted for the Argand lamps.

For the purposes of a survey, when portability rather than economy is the more important object, this intense heat was obtained by directing a stream of oxygen gas through a flame of spirit of wine: but for a light-house, where, from the long continuance of the light, economy is a primary object, and portability is no longer required, it was desirable if possible to substitute hydrogen gas for the alcohol. As the effects produced in this manner are very remarkable and considerably exceed those formerly obtained, I shall now give a short description of the apparatus, and then proceed to state the results of our experiments.

Plate XII. fig. 1. represents the lamp. The two gases, oxygen and hydrogen, proceeding from separate gasometers, enter at *o* and *h*, but do not mix till they arrive at the small chamber *c*, of which fig. 2. is a section: into this chamber the oxygen gas from the inner tube is projected horizontally through a series of very small apertures, and the hydrogen gas rises vertically through a series of similar apertures at *d*. The united gases then pass through two or three pieces of wire-gauze placed at *e*, and being thus thoroughly mixed, issue through the two jets against the ball *b*. To prevent the wasting of the ball opposite

the two jets, and at the same time to diffuse the heat more equably, it is made to revolve once in a minute, by means of a movement placed underneath the plate *m*, and with which the wire *f*, carrying the ball and passing through the stem, is connected. Notwithstanding, however, this arrangement, the effect of the heat is such as gradually to cut a deep groove in the ball, so that at the end of about 45 minutes it becomes necessary to change it*. In a light-house where it is of essential consequence to maintain a constant light, it would be unsafe to entrust this to an attendant, and hence the necessity of devising some means for remedying this inconvenience. The apparatus represented by fig. 3. is designed for this purpose, and is drawn in the manner in which it is applied to a reflector, the dotted outline of which is shown.

The wire *a b* passes through the focus of the reflector, and upon it are placed the number of balls at A, required for any given time; these, by means of the shears *s*, as shown in fig. 4, are admitted between the plates *p p*, and thence permitted to fall in succession to the focus. No. 1. represents the focal ball; about two minutes before the change, the ball 3. falls into the position 2, where it becomes gradually heated. At the end of that time, the curved support *t*, moving on a pivot, is thrown into the position represented by the dotted line, by the momentary descent of the ring *r*, which, receiving an impulse from the weight *w*, acts upon the extremity *u* of the support. No. 1. falls, but is prevented from descending more than its own diameter by the loop *l*, and No. 2. following it, occupies the focus. The support *t*, being immediately released, returns by the action of a spring to its former position, retains No. 2, and suffers No. 1. to escape through the loop into the cistern.

The wire *a b* and the support *t* revolve together, and carry round the focal ball, which is ignited as in fig. 1. by the two jets *z z*. These jets, which are moveable round the joints *d d*, enter through small apertures cut in the sides of the reflector, and are easily adjusted to the proper distance from the ball.

Wherever the light is required to be diffused equally around, the renewal of the lime may be effected still more easily, by using a cylinder as represented in fig. 5, instead of a ball, which being gradually raised while revolving, brings fresh portions in succession opposite the jets. In a reflector, a cylinder occa-

* When a cylinder is used instead of a ball, a ring of minute crystals is found adhering to the surface above and below this groove.

sions partial shadows at the top and bottom; still, however, the simplicity and certainty with which it may be renewed will probably entitle it to a preference even in this case.

These different instruments were prepared by Mr. Simms of Fleet-street, to whom, for various ingenious suggestions, for the trouble which he has bestowed upon them, and the assistance which he contributed during the progress of the experiments, I am greatly indebted.

The apparatus for supplying the lamps with gas is represented in fig. 6. It consists of two strong cylinders, A, 3 feet high, the one for oxygen, the other for hydrogen: the gas is compressed two or three times in each, the latter by being generated under pressure, the former by being pumped in. To each of these gas-holders, a governor, B, is attached, of one of which a section is shown; by which means, whatever be the variation of pressure in the gas-holder, provided it exceed that of the governor, the gas will issue at x with a uniform and constant stream; in the present instance under a pressure of 30 inches of water. Although this apparatus was of great use in the experiments at the Trinity House, and subsequently at Purfleet, by enabling me to keep within a small compass a supply of gas sufficient for two hours consumption, and even to renew it without impeding the progress of the experiments, yet I may remark, that on a large scale the gasometers required would be much more simple, since compression would no longer be required. This apparatus was made for me by Mr. Samuel Crosley, the ingenious inventor of the gas-governor.

Our first experiments were on the illuminating powers of the different lights, independently of the lenses or reflectors with which they are generally used. The method of shadows and that of equally illuminated surfaces, both depending on the same principle, but requiring different instruments, were employed*; the former after the manner of, and with all the precautions recommended by, Count Rumford †; the latter according to the arrangements proposed by Mr. Ritchie ‡, who was kind enough on this occasion to make several experiments with his own instruments, and without being made acquainted with the results previously obtained by us. The standard we used was an excellent

* Bouguer, Traité d'Optique.

† Phil. Trans. 1794, Part I. page 67.

‡ Phil. Trans. 1825, Part I.

Argand lamp $\frac{7}{8}$ inch in diameter, supplied with the finest spermaceti oil, and capable of supporting a flame $1\frac{3}{4}$ inch in height. The following results were obtained:

			Standard.		Wax candles, $1\frac{1}{8}$ inch diam., the wick consisting of 40 threads.
French lamp, Mean of	5	observations by shadows . .	1	=	9.1
———	9	——— . .	8.7	10.4* =	94.6
———	6	——— by illuminated surfaces	12.1		
Oil gas burner, same diam. as standard	4	——— by shadows	0.95	=	8.7
Lime-ball or cylinder $\frac{3}{8}$ inch diam.	2	———	9.2	13.5 =	122.9
	2	———	10.4		
	4	——— by illuminated surfaces	18.6		
	10	———	16.0		

The light of the ball, depending upon the intensity of the heat, is very different at different parts, being greatest opposite the jets, and diminishing towards the sides. The mean of the greatest and least intensity is taken in the above Table; and moreover, though the greater number of observations might appear to warrant giving greater weight to their results, yet being made on the same day, and under the same circumstances, it was found that the results seldom differed, whatever might be the number of observations; hence the arithmetical mean is taken, and we obtain this remarkable result,—that the light emitted by a lime-ball only $\frac{3}{8}$ of an inch in diameter, heated by two jets, is equal to 13 Argand lamps.

With respect to the intensity or intrinsic brightness of the different lights, the property on which their utility in light-houses more immediately depends, we have the following results:

The intensity of				Mean.	
French lamp, Mean of	11	observations by shadows . . =	4.1	4.0	times the intensity of the Standard.
———	8	——— . . =	3.8		
Oil gas	6	——— . . =	0.85 †		
Lime	6	——— . . =	263.9	264.1	
———	3	——— by illuminated surfaces =	264.4		

* The result given by FRESNEL, in the memoir quoted above, considerably exceeds this, being stated at 17 lamps of Carcel. I know not to what cause this difference is to be attributed.

† This low degree of intensity indicates impurity in the gas.

These results were obtained by screening the different lights, and then placing equal apertures opposite each, changing the apertures and taking the mean to destroy the effect of any inaccuracy in size. The intensity of the lime-ball being therefore 264 times that of the Argand lamp, a single reflector illuminated by the former will be equal to 264 reflectors illuminated by the latter; but the divergence of the reflected light, depending upon the size of the luminous body in the focus, will be smaller with the ball than with the lamp in the proportion of about 3 to 8: hence in such a light-house as that of Beachy Head, 8 reflectors may be substituted for 30, and yet an effect would be produced 26 times greater than that of the present light, the most perfect of its kind in this country.

By similar experiments it was found that the French lens was equal to 9.1 reflectors; and if the effect of the additional lenses and reflectors which ought to accompany it, and which has been estimated at one-seventh, be added, then the lens is equal to 10.4 reflectors. In like manner, therefore, the effect of a single reflector with a lime-ball would be equal to 25 times that of such a combination of lenses.

Such appear to be the singular and important results of our late experiments at the Trinity House, made as they have been with every precaution by different individuals, with different instruments, and unbiassed by the knowledge of each other's results. I see no reason to doubt their accuracy; and the comparative appearances of these different lights, when exhibited at a distance of ten miles, to which I shall presently allude, though not admitting of being reduced to numbers, confirm the striking superiority of this method of illumination.

It may now perhaps be asked, At what expense can such a light be maintained? Can the gases by which the requisite heat is produced be procured at such a price as to compete with oil or coal gas? The data I possess for forming an estimate of the expense of the gases are very scanty, but the quantity consumed was accurately determined; at the same time the consumption of the other lights was also tried, and the results are as follow:

	Consumption in $3\frac{1}{4}$ hours.	Expense per hour.
An Argand lamp seven-eighths of an inch in diameter	1 gill	0.69 penny
The same placed in a reflector . .	$1\frac{1}{5}$ gill . . .	0.83 penny
The French lamp	2 qts. $\frac{1}{2}$ pt. . . .	1*s.* $2\frac{1}{2}$*d.*

The lime requires 4 cubic feet of hydrogen and 2 of oxygen per hour, and the probable expense is 5*d.* per hour.

In a revolving light of the first class, containing 30 reflectors, the expense per hour would therefore be about 2*s.* 1*d.* If the French method were employed, the increase of light would be $\frac{1}{20}$th, and the expense only 1*s.* $2\frac{1}{2}$*d.* per hour. If six reflectors illuminated with lime-balls were used, which would probably be sufficient, the probable expense would be 2*s.* 6*d.* per hour, and the increase of light 26 times.

If this estimate be erroneous, I think it will prove to be so in excess: admitting, however, that the expense should, in the first instance, somewhat exceed what has been stated, it may in this as in every similar instance be expected that after a little experience a considerable reduction would be effected. This is a new source of artificial light, differing from every other at present in use, and the materials by which it is produced are among the most abundant products of nature; but never having yet been applied on a great scale to any practical purpose, it has not hitherto been an object to obtain them in a separate state at a small expense. When this is effected, it will no doubt receive many useful and important practical applications.

Meanwhile, however, the case in question may perhaps be regarded as one where expense ought not to be a primary object of consideration. On all ordinary occasions, the preference of one mode of illumination to another is a question of convenience, luxury or economy; but in this it assumes a more important character, for it involves to a great extent the preservation of life and property.

To complete the preceding account, it only remains to add a description of the appearances presented by the different lights when exhibited at a distance; and to those who have entered with any degree of interest into the above details, such a description, it is hoped, cannot fail of proving acceptable.

The experiments at the Trinity House being concluded, the whole of the apparatus was removed to Purfleet, where on a knoll of chalk about 100 feet above the river a temporary light-house had been erected, and being fitted with the requisite machinery, the different lights were made to revolve in succession, and the appearance which they presented, as well as the duration of the light, were observed from the Trinity Wharf at Blackwall, a distance in a straight line of $10\frac{1}{4}$ miles.

The four faces of the revolving machine were thus occupied:

No. 1. A single reflector 21 inches diameter, 3 inches focal distance, with an Argand lamp.

No. 2. Seven reflectors with ditto.

No. 3. French lens, with its lamp.

No. 4. Single reflector with lime-ball.

The respective lights were accurately placed in focus.

On the evening of the 10th of May, the machine performing one revolution in eight minutes, Captain PELLY of the Trinity House made the following observations on the different lights from the Trinity House Wharf, Blackwall, $10\frac{1}{4}$ miles distant.

No.	Duration.		Divergence.	Computed maximum Divergence.
	min.	sec.	°	°
1	0	25	17.40	17.81
2	0	25	17.40	17.81
3	0	7	5.17	5.18
4	0	9	6.12	6.7

When No. 4, the reflector lighted with the lime-ball, was turned towards the Wharf, the light was so great that the shadow of the hand and fingers was distinctly visible even on a dark brick wall, while no such effect was discernible when the other lights were turned in the same direction.

In order more justly to estimate their comparative effects, No. 4. was removed to a temporary tent about twenty-five yards to the right of the light-house, as far as the edge of the cliff would permit, and on the evenings of the 25th and 31st May regular series of experiments were made. Being engaged at Purfleet, directing these exhibitions, I never had an opportunity of witnessing their effects at Blackwall; but Captain BASIL HALL, R.N., who from the interest which he took in these experiments was an attentive observer of all that occurred, has at my request kindly favoured me with the following interesting account:

4, St. James's Place, 1st June 1830.

"My dear Sir,

"You wished me to take particular notice of last night's experiments with the different kinds of lights exhibited at Purfleet, and observed at the Trinity

Wharf, Blackwall; but I have little to add to what I told you respecting those on the evening of the 25th instant: indeed it is not within the compass of language to describe accurately the details of such experiments, for it is by ocular evidence alone that their merits can be understood.

"Essentially the experiments of last evening were the same as those of the 25th, and their effects likewise. The degrees of darkness in the evenings however were so different, that some particular results were not the same. The moon last night, being nine or ten days old, lighted up the clouds so much, that even when the moon herself was hid, there was light enough to overpower any shed upon the spot where we stood by your distant illumination: whereas on the 25th, when the night was much darker, the light cast from the temporary light-house at Purfleet, in which your apparatus was fixed, was so great that a distinct shadow was thrown upon the wall by any object interposed. Not the slightest trace of any such shadow, however, could be perceived when your light was extinguished, and any of the other lights were exposed in its place.

"In like manner on the evening of the 25th it was remarked by all the party at the Trinity Wharf, that, in whatever direction your light was turned, an immense coma, or tail of rays, similar to that produced by a beam of sun-light in a dusty room, but extending several miles in length, was seen to stream off from the spot where we knew the light to be placed, although, owing to the reflector being turned too much on one side, the light itself was not visible.

"Now, last night there was none of this singular appearance visible; but whether this was caused by the presence of the moonlight, or by the absence of the haze and drizzling rain which fell during the evening of the 25th, I cannot say. I had hoped that the appearance alluded to was to prove a constant accompaniment to your light, in which case it might, perhaps, have been turned to account for the purposes of light-houses. If in hazy or foggy weather this curious effect of reflected light from the atmosphere be constant, it may help to point out the position of light-houses, even when the distance of the observer is so great that the curvature of the earth shall render it impossible for him to see the light itself.

"The following experiments tried last night were the same as those of the 25th, and certainly no comparative trials could be more fairly arranged.

"Exp. I. The first light exposed was the single Argand burner with a reflector. This was quite distinctly seen, and all the party admitted it to be a good light. After several minutes this was put out.

"Exp. II. The seven Argand burners were next shown, each in its reflector; and this was manifestly superior to the first; but how much so I cannot say, perhaps four times as conspicuous. Both these lights had an obvious tinge of brown or orange.

"Exp. III. The third light which was exposed, (on the seven Argands being put out,) was that behind the French lens; and I think it was generally admitted by the party present, that this light was whiter and more intense than that from the seven Argands, though the size appeared very much the same.

"Exp. IV. The fourth light was that which you have devised, and which, instead of the clumsy word 'Lime', ought to bear the name of its discoverer. The Drummond light, then, the instant it was uncovered, elicited a sort of shout of admiration from the whole party, as being something much more brilliant than we had looked for. The light was not only more vivid and conspicuous, but was peculiarly remarkable from its exquisite whiteness. Indeed there seems no great presumption in comparing its splendour to that of the sun; for I am not sure that the eye would be able to look at a disk of such light, if its diameter were made to subtend half a degree.

"The next series of experiments was the most interesting and decisive of all. Each of the lights above enumerated, viz. the single Argand burner, the seven Argands, and the French lens, were exposed, one at a time, in company with your light, in order to try their relative brilliancy.

"First comparative Experiment.—The single Argand burner was first exposed to this comparative ordeal, and nothing could be more pitiable than the figure it cut. Many of the party could not see the Argand light at all; while others could just detect it 'away in a corner,' as some one described it. It was also of a dusky orange tinge, while your light was of the most intense whiteness*.

"Second comparative Experiment.—The seven Argand burners were now substituted in place of the single light. All the party could now see both

* To many, the rays from the brighter light appeared, when seen with the naked eye, to extend across and envelope the fainter light, though the perpendicular distance between them was twenty-five yards.

lights, but the superiority was not much less obvious. I really cannot affix a proportion either as to size or brilliancy; but I should not hesitate to say that your light was at least six or eight times as conspicuous; while in brilliancy, or purity, or intensity of light, (for I know not precisely what word to use to describe the extreme whiteness,) the superiority was even more remarkable. All this which I have been describing was expressed, and appeared to be quite as strongly felt by the rest of the company, to the number, I should suppose, of five-and-twenty or thirty persons, who were all closely on the watch.

"Third comparative Experiment.—The next comparative trial was between the French lens and your light. The superiority here was equally undeniable; though the difference in the degree of whiteness was not so remarkable. The French light, however, is so nearly similar to that from the seven Argands, that the comparison of each of them with your light gave nearly the same results, and all equally satisfactory on the score of your discovery.

"Final Experiment.—The flashes with which the experiments concluded were very striking, and might I think be turned to great account in rendering light-houses distinct from one another. The revolutions were not effective, and, as I said before, there was no appearance last night of those enormous comets' tails which swept the horizon on the night of the 25th, to the wonder of all who beheld them: neither could there be detected the slightest trace of any shadow from the light thrown towards us, and I suspect none will ever be seen, when the moon, whether the night be clouded or not, is of so great a magnitude.

"Such is the best account I can give of what we witnessed; and I need only add that there seemed to be amongst the company but one opinion of the immense superiority of your light over all the others brought into comparison with it.

"I am, &c.

"Basil Hall."

The advantage of such a light being fully recognised, attention may now be exclusively directed to remove some of those minor obstacles that might render its use in light-houses objectionable; and I have great pleasure in adding that the Trinity Corporation are desirous that every facility in their power should

be afforded with a view to effect this object, and that a series of preliminary experiments is accordingly to be carried on at their expense.

Simple as the apparatus and the experiments now described may appear, they have occasioned more trouble and anxiety than would be supposed by those who have not been engaged in similar pursuits; but, on the other hand, I fully acknowledge the encouragement derived from the interest which they appeared to excite.

His Royal Highness the Duke of CLARENCE, Master of the Trinity Corporation, was pleased to be present on one occasion, and remained more than an hour, entering with great interest into the details, and expressing himself much gratified with the effects which were produced.

Sir GEORGE COCKBURN and Mr. BARROW from the Admiralty, and several other naval men whose opinions on such subjects are entitled to the utmost deference, not only attended at the Trinity House, but went afterwards to Blackwall to observe the relative appearance of the lights when exhibited at a distance. The night of the 31st May had been appointed by the Deputy Master for this purpose; and, being desirous that the subject should be fully scrutinized, I was glad to learn on returning from Purfleet that, besides the gentlemen immediately connected with the Trinity House, the experiments described in Captain HALL's letter had been witnessed by Admiral Sir THOMAS HARDY; by the LORD ADVOCATE of Scotland, one of the Commissioners for the northern light-houses; by Sir THOMAS BRISBANE, Colonel COLBY, Captain BEAUFORT, Hydrographer to the Admiralty, and several other individuals eminent for their professional and scientific attainments; and as far as I have been able to learn, the opinions of these distinguished persons coincide with those expressed by Captain HALL, who in fact, as he has given me authority to state, endeavoured to frame his account of what passed in strict conformity with the general sentiments of the party, and neither to exaggerate nor under-rate any of the results.

It now only remains for me to perform the agreeable task of bearing testimony to the liberal spirit evinced by the Trinity Corporation on this occasion, and to the desire which they have manifested of facilitating, by every means in their power, the introduction of this method of illumination into light-houses. Indeed I hesitate not to express my belief that, if this do not take place, it will arise

from some insurmountable difficulties in the way of its practical application, and not from the want of a full and impartial trial on the part of that body, to whom these establishments are entrusted.

I owe this acknowledgement in an especial manner to JOHN WOOLMORE, Esq. the Deputy Master of the Corporation, to Captains CLARKE, PELLY and BROWNE, the gentlemen constituting the Light Committee, for the fairness and impartiality of their decisions, as well as the indulgence which they extended to those defects inseparable from a new apparatus; and to Mr. HERBERT the Secretary, for his uniform desire to promote every arrangement that appeared likely to bring this inquiry to a satisfactory termination.

To these acknowledgements I may be permitted to add my obligations to my commanding officer and friend Colonel COLBY, for the facilities he has afforded me in carrying on these experiments, and for the advice and assistance which he has on this and many other occasions so kindly rendered me.

London, June 17th, 1830.