1.

GROUP-FLASHING LIGHTS.

[*Pamphlet first published in October*, 1874.]

EXTENSION of trade, and the consequent increase in the number of Lighthouses upon frequented coasts, continually causes a demand for greater variety in the appearance of Lights, in order to avoid confusion from the nearness of Lights of the same character. This is apparent in the fact that the scheme proposed by the first French Lighthouse Commission, and intended to be complete, has subsequently required extension. The first French scheme admitted but three distinctions, the fixed Light, and revolving Lights with flashes every minute and every thirty seconds. Now, the French system comprises quick-flashing Lights, revolving Lights with red flashes alternating with white, and fixed Lights varied by flashes; of the last there are no less than twenty-three on the French coast. Indeed the use of red at all in revolving Lights, involving as it does a serious tax on the luminous power of the flashes, or increased expense for the same power, sufficiently indicates that new combinations are, and will continue to be required. Our present purpose is to offer in a complete shape two new forms of Lighthouse apparatus, and to point out the advantages they possess over some very useful forms now in use. Before doing so it will be well to examine what are the qualities of a good Light. That for any given cost the intensity of the light should be as great as possible, or conversely, that when a given intensity of light is required it should be attained at a minimum expense, is obvious. Most distinctions of beacons depend on the succession of intervals of light and darkness.

The following are suggested as rules of comparison of the efficiency of such distinctions :—

1. The Light must not be too long obscured or an accident might occur in the interval, which a sight of the Light would have prevented. What period of darkness is admissible is a nautical question, and will depend on the position the Lighthouse occupies and the nature of the traffic which it has to guide. Flashes at intervals of as much as three minutes have been in use, but the tendency is to prefer shorter periods, as in the case of South Stack, which is to be altered from flashes every two minutes to flashes every minute. We may therefore assert that, other things being the same, the efficiency is increased as the time of eclipse is shortened.

2. Unless the eclipse is very short it is necessary that the duration of the flash should be sufficient to take the bearing of the Light. It is this among other reasons which necessitates a special form of revolving dioptric apparatus for condensing the electric light; with the usual form for oil flames, the flash of a half-minute electric light would last but the fraction of a second. What time is sufficient for taking a bearing, is again a purely nautical question, but we may safely say that a flash of considerable duration is more useful than one which gives bare time for observation.

3. The character of the Light must not be too long in declaring itself, in other words the Light must pass through its phases in a reasonable period of time, indeed the shorter this period the better. The fixed and flashing Lights of the French system are usually characterised by a bright flash, preceded and followed by a very brief eclipse, occurring every three or four minutes; not less than that period of watching is needed to identify the Light. It is a question for those whose experience justifies an expression of opinion, whether in some circumstances such a length of time is not too much. In this respect the revolving Lights with red and white flashes combined, are less favourable than the ordinary revolving Lights of the same period; for example, to distinguish a half-minute revolving Light showing red and white flashes alternately, from one in which there is a red followed by two whites, requires a minute and a half. Suppose the navigator first sees a white flash, then a red and again a

white, a minute has passed and he must still wait thirty seconds to see if the next flash will be white or red. It should, however, be observed that this remark only applies to the hypothetical case in which two such Lights are placed near each other.

4. One point insisted upon by Authorities who have themselves had nautical experience is, that the distinctions should be as simple and easy to apprehend as possible. It is mainly on this account that the scheme proposed by Mr Babbage never received any practical recognition. For the same reason it is unwise to trust too much to any but very marked differences in the period of ordinary revolving Lights. A forty-five second should not be considered safely distinguishable from a minute flash.

5. The characteristic appearance of the Light must be maintained at all distances and in all states of the weather in which the Light can be seen at all. If red and white flashes are combined, the portion of light devoted to each flash must be such that they shall have equal penetrating power. It would appear that the fixed and flashing Lights so popular on the French coast, would lead to mistakes at times when the feeble fixed Light is obscured, if the intervals of the flashes were not so long as to distinguish them from the ordinary revolving Lights.

The additional source of variation which I now propose is, that revolving apparatus should be constructed to exhibit two or three white flashes in rapid succession, in place of one at stated intervals of time. This would increase the capacity for variation of the revolving Lights three-fold, we should have single, double and triple flashes at whatever intervals are now considered suitable for revolving Lights. The optical apparatus for producing such combinations would be simple and cost little more than an ordinary revolving Light. For the double flash of the first order we should require a twelve-sided Light, the axes of the panels being placed at unequal intervals, alternately 15° and 45° (Fig. A.); the effect of this would be, that, with an apparatus completing a revolution in three minutes, and using as source of light the usual four-wick flame, there would be a flash of about 2″ duration followed by about 5½″ dark, again a flash of 2″, this double flash being separated from the next by about 20½ seconds of darkness. The ordinary eight-sided revolving Light condenses 45° of the light of the flame into about 4° in azimuth, thus producing a flash

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of intensity $11\frac{1}{4}$, if the continuous light of the fixed apparatus be taken as unity. In the double flashing Light each panel has 30° in azimuth, and would therefore give to each flash an intensity represented by $7\frac{1}{2}$. Let us see how far this form of Light fulfils the requirements of a good Light. With periods of half a minute the longest eclipse would be $20\frac{1}{2}$ seconds, giving a slight advantage over a half-minute Light with eight sides, which is eclipsed for about 27 seconds. The two flashes near to each other would be almost as convenient for taking a bearing as a continuous flash lasting from the beginning of the first flash to the end of the second; we may therefore consider that we have $9\frac{1}{2}$ seconds available to take a bearing. It would only be necessary to see the two flashes in succession to identify the character of the Light, $9\frac{1}{2}$ seconds would suffice without any counting to

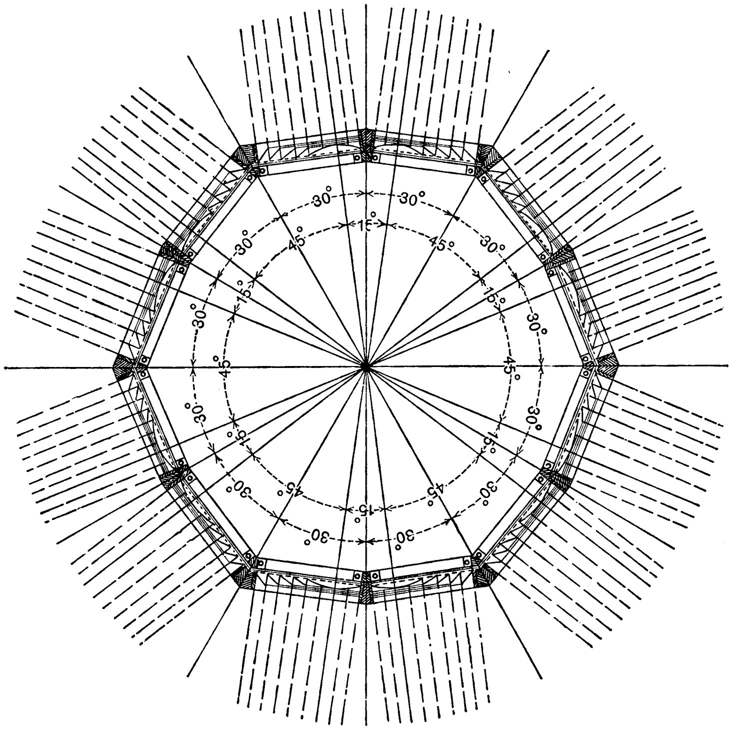

FIG. A.

recognise what the Light might be. The peculiarity of such a Light would lie, not in the precise periods between the flashes, but in the flash being a double one. No timing or counting is requisite, for the double and triple flash would be distinguished without any conscious process of counting. The two flashes of the pair being exactly of the same power, the general appearance of the Light must be always the same.

The triple flash would be conveniently obtained by a revolving apparatus of fifteen sides covering 24 each, the axes of the panels being placed at intervals of 48° and 12°. From such an apparatus, if a group of three flashes is to be exhibited every half-minute, each flash would last nearly two seconds, and the three would be separated by dark periods of three seconds. We should thus have a longest period of darkness of eighteen seconds, and twelve seconds in which to take a bearing. An apparatus giving four flashes in a group could be readily and economically formed of sixteen sides, there would not be the slightest difficulty in construction, and the flash would be of the same power as that of an ordinary sixteen-sided revolving Light. But it is doubtful if the need for counting so many as four flashes would not be found an unnecessary complication. All I would say here is that such a Light can easily be made.

The electric spark lends itself more readily than an oil flame to the production of any desired arrangement of the flashes of a revolving Light. Perhaps as unmistakable a form as any that could be suggested, would be a number of very quick flashes and eclipses, constituting a group which should recur at stated intervals.

It is worthy of notice that if a coast were lit on a system based on the use of group flashes, the appearance of the Light could be made to correspond to the blasts of the fog-horn or the strokes of the fog-bell; a group of three flashes, at intervals of thirty seconds, would naturally be used in conjunction with a fog-signal, sounded three times in succession at the same interval.

The following Table is intended to show the comparative advantages and disadvantages of group flashes, and the best forms of revolving Lights now in use. In this table the flashes or groups of flashes are supposed to have a half-minute period, the apparatus to be of the first order, and the divergence due to magnitude of flame to be 4°. The first column gives the power of the flash, the fixed Light being taken as unity.

	Power.	Time available for taking a bearing.	Time which may be required to identify the character of Light.	Greatest duration of darkness.	Percentage of whole Light wasted by use of colour.
Eight-sided revolving Light, of the usual form	$11\frac{1}{4}$	$2\frac{2}{3}$ Seconds.	30 Seconds.	$27\frac{1}{3}$	—
Sixteen-sided ditto	$5\frac{5}{8}$	$5\frac{1}{3}$,,	30 ,,	$24\frac{2}{3}$	—
Twelve-sided Light, giving a double flash	$7\frac{1}{2}$	$9\frac{1}{2}$,,	10 ,,	$20\frac{1}{2}$	—
Fifteen-sided Light, giving a triple flash	6	12 ,,	12 ,,	18	—
Nine-sided Light, giving a red flash, followed by two white.........................	$6\frac{1}{3}$	3 ,,	90 ,,	27	36·84
Sixteen-sided Light, giving white and red alternate...	3	$5\frac{1}{3}$,,	90 ,,	$24\frac{1}{3}$	46·66
Eight-sided Light, red only...	$4\frac{1}{11}$	$2\frac{2}{3}$,,	30 ,,	$27\frac{1}{3}$	63·66
Sixteen-sided Light, red only	$2\frac{1}{22}$	$5\frac{1}{3}$,,	30 ,,	$24\frac{2}{3}$	63·66

It will be observed that in power, the double flash ranks second; in duration the group flashes are best, as also in respect to time required for identification.

Group-Flashing Lights can readily be obtained on the Catoptric system, or by using a number of small Holophotes, but such Lights would be subject to all the objections to which revolving Lights with single flashes produced by many lamps are obnoxious.

NOTE.—The Hopkinson Group-Flashing system was for the first time applied, in 1875, to the Catoptric Floating Light on the Royal Sovereign Shoals, near Beachy Head, and has since been applied to several Lightships of the Trinity Corporation.

The first Land Light on this system was for Tampico Lighthouse, Gulf of Mexico, Second Order triple-flashing, in 1875. Eighteen Sea Lights in all, and two Harbour Lights, have been constructed by Messrs Chance Brothers and Co., Limited, since 1875.

The Group-Flashing system has also been adopted by the French makers, who have, since 1876, supplied many lights to foreign Governments.

December, 1890.

2.

THE ELECTRIC LIGHTHOUSES OF MACQUARIE AND OF TINO.

[From the *Proceedings of The Institution of Civil Engineers*, Vol. LXXXVII. Session 1886–87. Part I.]

THE subject of the use of the electric light in lighthouses was fully discussed at the Institution in 1879, when Papers by Sir James Douglass, M. Inst. C.E., and by Mr James T. Chance, Assoc. Inst. C.E., were read*.

The subject has been further elaborately examined by Mr E. Allard†, and more recently in practical experiments, made at the South Foreland, exhaustively reported on by a Committee of the Trinity House‡. The justification of the present communication is that, at the lighthouses of Macquarie and of Tino, the optical apparatus is on a larger scale than has hitherto been used for the electric arc in lighthouses, and presents certain novel features in the details of construction. Further, as regards the electrical apparatus, tests were made upon the machinery for Macquarie when it was in the hands of Messrs Chance Brothers and Company, which still possess some value, although five years old; and, in the case of Tino, the machines are practically worked together in a manner not previously used otherwise than by way of experiment.

* *Minutes of Proceedings Inst. C.E.* vol. lvii. pp. 77 and 168.

† *Mémoire sur les Phares Électriques*, 1881.

‡ Report into the relative merits of Electricity, Gas, and Oil as Lighthouse Illuminants. Parts 1 and 2. PP. 1885.

In the case of both lighthouses, Messrs Chance Brothers and Company, of Birmingham, entered into a contract for the supply of all the apparatus required, including engines, machines, conductors, lamps, optical apparatus, and lanterns; and Sir James Douglass, Engineer-in-Chief of the Trinity House, acted as Inspecting Engineer to the respective Colonial and Foreign Governments.

As these two lighthouses present many features in common, it may be most convenient to give a full description of the earlier lighthouse, and then limit the description of Tino to those points in which it differs from Macquarie.

Macquarie.

This lighthouse is situated on South Head, near Sydney, the precise position being shown in a copy from the chart, Fig. 1. A lighthouse was first placed at this important landfall in 1817. The focal plane is 346 feet above the sea, and the distance of the sea-horizon is therefore 21·6 nautical miles, and the range about 27 nautical miles for an observer 15 feet above the sea.

Optical Apparatus.—The light is a revolving one, giving a single flash of eight seconds duration every minute. On account of the considerable altitude of the lighthouse, it was necessary to secure that a substantial quantity of light should be directed to the nearer sea; but it was also essential, on account of the exceptional power of the apparatus, that this dipping light should only be a small fraction of that sent to the horizon, otherwise its effect would be excessively dazzling. Many years ago, Mr James T. Chance urged that it was not wise to make use of very small apparatus for the electric arc, because a larger apparatus renders it possible for the optical engineer to effect with greater precision the distribution of light which is most desirable, and because any trifling error which may occur in the position of the electric arc has, with the larger apparatus, a less marked effect on the light as seen from the sea. In the lighthouses of Souter Point, the South Foreland, and the Lizard, the third-order apparatus of 500-millimetre focal length was adopted. Optically, the larger the apparatus used the better, but there might be some question whether, on purely optical grounds, the advantage of going beyond the third order is sufficient to justify the additional expense, but in the case of a revolving apparatus, the third order is a very inconvenient size for the service of the lamp; it is too large to be conveniently served from the outside, and too small to admit the attendant within it with comfort. With the large currents, which are now easily obtained and are likely to be used in lighthouses, a first or second order apparatus has the further

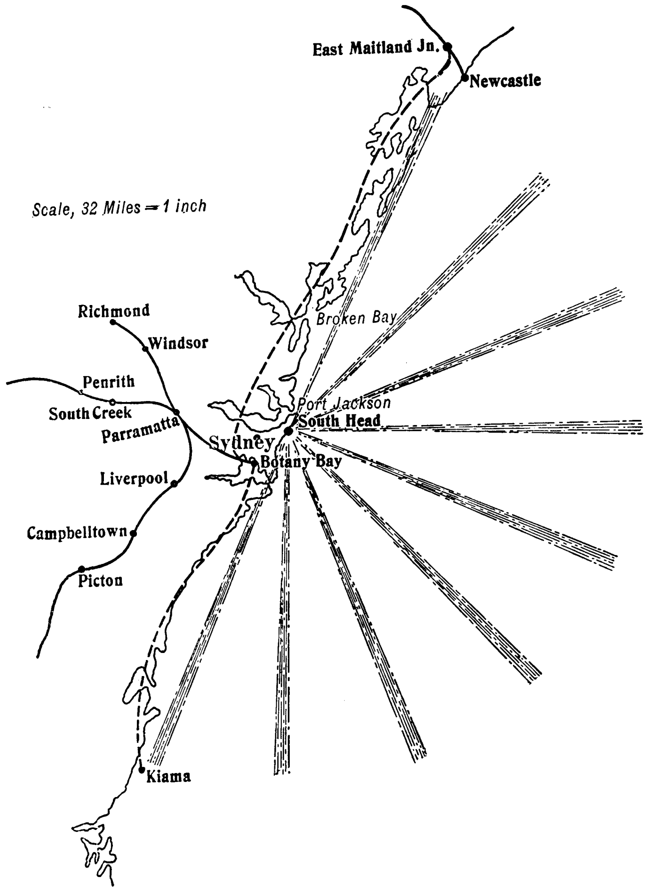

Fig. 1.

advantage that it is less liable to injury from particles thrown off from the heated carbons. In the case of Macquarie, it was decided to adopt an apparatus of the first order, 920-millimetre focal length; it was further decided that the optical apparatus should produce its condensing effect by means of a single agent; that is to say, the vertical straight prisms which were used in Souter Point and other revolving electric lighthouses should be dispensed with. The condensation and distribution of light necessary may be obtained by means of a single agent, with apparatus such as has been proposed by Mr Alan Brebner, jun., Assoc. M. Inst. C.E.*; but this construction is open to the objections that it is somewhat costly, and that it increases the length of the path of the rays through the glass, and consequent absorption. A practically better plan is to adopt forms not differing very greatly from those introduced by Fresnel; to specially arrange them for the purpose in hand, and to accept certain consequent minute deviations from a mathematically accurate solution for the sake of advantages of greater importance, when all the actual conditions are taken into account. Fig. 2 shows the optical apparatus in vertical section; the upper and the lower totally-reflecting prisms are, as is usual in revolving lights, forms of revolutions about a horizontal axis; they direct the light incident upon them to the horizon and the distant sea from 10′ above the horizon to 30′ below; they are specially adjusted to distribute the light in azimuth over the arc of 3° necessary for a proper duration of flash.

The refracting portion of the apparatus has the profile so calculated that the central lens, and the three rings next to the lens above and below, direct their light to the horizon without vertical divergence, except what is due to the size of the arc; the light for the nearer sea is obtained from the remaining ten lens-segments, Nos. 5 to 9 inclusive, above and below the centre, counting the centre as No. 1, the distribution being according to the following Table, in which the first column gives the denomination of the elements of the lens in accordance with the numbers marked upon the section; the second, the angle between the direction of the sea-horizon and the ray emerging from the upper limit of the element; the third, the angle between the direction of the sea-horizon and the ray from the lower limit of the element, the negative sign denoting that the emerging ray

* *Minutes of Proceedings Inst. C.E.* vol. lxx. p. 386.