Discussion.

Sir William White.

Sir WILLIAM WHITE, K.C.B., Vice-President, moved a vote of thanks to the Authors, and was sure that the members would heartily carry it. The Paper gave a large amount of information as to past practice in a very special subject, not merely as to the latest developments, but also as regarded the possibilities of the future.

Mr. Douglass.

Mr. W. T. DOUGLASS demonstrated, by aid of a model eclipser, the difference between the fixed, flashing, group-flashing and feu-éclair lights, and exhibited a series of slides illustrating the various kinds of optical apparatus and the lighthouses in which they were fixed.

Mr. Mallock.

Mr. A. MALLOCK understood that the total period of the signals in the feux-éclairs was reduced to 5 seconds as against about 1 minute formerly. He asked whether there was anything except the mechanical difficulties of the case which rendered it undesirable to very much reduce that 5-second period. He should have thought it would be preferable to have a whole signal completed in 2 seconds or $2\frac{1}{2}$ seconds, if it were possible. As long as the signals were really distinctive they could not be repeated too often. There was a relation between the number of signals given per revolution, the intensity of beam, and the complete period of revolution which, though probably well known, was not mentioned in the Paper. If I denoted the intensity of a source of light which, instead of radiating uniformly in all directions, were confined to a horizontal zone subtending a vertical angle α at the source, the intensity of the beam in the zone was $\frac{I}{\alpha}$. Again, if the light in this zone was by proper optical arrangements gathered into m equal beams, each of angular width β in a horizontal direction, the intensity in the beam was $\frac{2\pi I}{m\alpha\beta}$. Now, if t were the time for which the light must act on the eye in order that its full intensity might be felt, T the period in which the apparatus completed one revolution, and ω the angular velocity:—$\omega t = \beta$; also by definition $\omega T = 2\pi$; hence, if i = the intensity of the beam, $i = \frac{2\pi I}{m\alpha\beta} = \frac{2\pi I}{m\alpha\omega t} = \frac{IT}{m\alpha t}$. Taking t as $\frac{1}{10}$ second, and assuming that T should be 2 seconds (it should not be more), the degree of concentration of beam attainable when the light gave one flash, was $20\frac{I}{\alpha}$; for a two-

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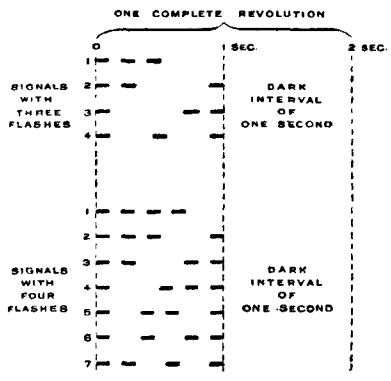
Mr. Mallock. flash light $10\frac{I}{a}$, three-flash light $6\cdot6\frac{I}{a}$, four-flash light $5\cdot0\frac{I}{a}$; and, if, for example, a, the vertical angle of the beam, was 3°, or say $\frac{1}{20}$, these expressions became respectively, 400 I, 200 I, 133 I, and 100 I, for the one-, two-, three-, and four-flash light, making its revolutions in 2 seconds. Thus, if the source was a 100-candle burner, the power of the beams was respectively 40,000, 20,000, 13,300, and 10,000 candle-power. This assumed that the whole of the radiation from the burner could be utilized. In practice, probably about 75 per cent. of these quantities could be realized. It would be seen, therefore, that the greater the number of flashes in each revolution the greater must be the initial candle-power of the source if the intensity of the beam was to remain the same. But in any case the intensity of these concentrated beams was so great, compared with what the same source would yield if used as a fixed light, that the loss, owing to the multiple character of the flash, was not very important as a matter of economy. Since with quick-flashing lights of this kind the interval between the recurrence of the flashes and not the duration of the flashes was the distinctive feature, and further, since one object of reducing the whole period of revolution was to make the recognition of the light dependent on the rhythm with which the flashes occurred, and not on timing the intervals between them, a single flash only offered one variety, and the same was true of two flashes. A three-flash light, however, yielded four quite distinct arrangements, and a four-flash seven, as shown in *Fig. 5*. That such forms of lighthouse signals would be advantageous and acceptable to mariners when once established he had little doubt, the curious thing was by what very slow steps lighthouse construction was tending in this direction, since the principle involved was first advocated by Lord Kelvin at the Brighton Meeting of the British Association in 1872. With reference to the ball bearings, the Authors stated that they only appeared to work satisfactorily on a small scale, and he should like to learn what the practical difficulties were with ball bearings when the size was increased.

Fig. 5.



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Mr. W. AMOR asked whether the eclipser, which was not described in the Paper, would enable lighthouses to carry out Lord Kelvin's proposal of flashing the name of the lighthouse by means of the Morse alphabet. Mr. Amor.

Mr. ARTHUR AYRES thought the Paper a most valuable one, throwing a new light on the subject of lighthouse illumination. With the use of such small apparatus as the third order, as the Authors suggested, it would be interesting to know how the powers were obtained, whether the burners were of uniform power, or whether burners of different powers would be employed to suit the apparatus; because with the electric light enormous power could be obtained, but with the oil light the power was limited. If large burners were used in small apparatus, such as the third order, there was greater heat to deal with, and mineral oil burners were very sensitive to heat. If the Authors had stated in the Tables the burners which they had used they would have been more complete. He also thought it would be well if Mr. Allard's formula could be quoted. Mr. Ayres.

The Paper certainly pointed to the necessity of an investigation of the relative merits of the two extreme systems, viz., the hyper-radiant and the feux-éclairs, and also the intermediate orders of dioptric apparatus. It was stated at p. 142 that a third-order lens was capable of producing the same results as lenses of the first and second order. If this could be clearly demonstrated by experiment there could be no doubt as to the economy in first cost and working expenses. It was stated that a standard form of apparatus could in fact be adapted for all purposes; but this was difficult to understand without fuller information. It was not stated what illuminants were intended to be used, whether electricity, incandescent coal-gas, compressed oil-gas, or mineral oil; mineral-oil burners were very sensitive, and required considerable attention and constant watching, and he thought some difficulty would be experienced in managing the burners in the focus of small apparatus rotating so rapidly; it was, moreover, doubtful whether a lamp-changing apparatus could be introduced in such small lenses. The lamp-changing apparatus, as shown in Fig. 3, Plate 5, carried the working and spare burners, in case it should be necessary to hurriedly substitute one for the other. He knew of no other arrangement by which the burners could be so readily changed. This apparatus was designed by him and was first used in the South Foreland experiments; it had since been very generally adopted. Referring to the tabulated results given in the Paper, it would add greatly to their value if

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Mr. Ayres. a column were added stating what burners were supposed to be used to give the candle-power stated in the first column of results, also the candle-power of the naked flames and their divergence. Notwithstanding the startling figures given in the case of the feux-éclairs system with flashes of $\frac{1}{10}$ second duration, there was much to be said in favour of such apparatus as those at Casquets and Lundy, and other similar stations. In hazy weather, or when slightly foggy, or when the fog was patchy, there would be a greater chance of catching a glimpse of such a light than in the case of rapid short flashes such as the feux-éclairs. Moreover, there was ample room within the larger apparatus to accommodate the lamp-changing apparatus. The new system, judging from the tabulated results and other considerations, had much in its favour, and presented a new field for investigation.

It was unfortunate that England should be considered so far behind other nations in the matter of lighthouse illumination, particularly considering the amount of time and money expended over the exhaustive experiments with electricity, gas, and oil at the South Foreland in 1885. He questioned whether the lighthouse system of Great Britain (all things fairly considered) was so far behind other nations. Mr. Bourdelle's new system dated 5 years after the South Foreland experiments; and it must be admitted as science never stood still, many improvements had doubtless been made, with the result that there was this new system to investigate and consider when building new lighthouses or improving old ones. The eclipsing apparatus referred to by the Authors was not new; it was first used by the Trinity House (designed by the late Dr. John Hopkinson) at St. Tudwall's lighthouse, Cardigan Bay, in the year 1876. The lens was a fixed second order, and the light was a 10-seconds occulting. The eclipsing apparatus referred to by the Authors was for producing a flashing-light with a third order panel, 180° in azimuth with a dioptric mirror in the rear, and rotated at a speed suitable to produce the desired period of the flash. It was stated that such an apparatus would achieve the same results as the larger and much more costly apparatus at the Casquets and Lundy; in fact, in the case of the former it was stated that the intensity of the light would be increased by 20,000 candles, with a saving in the first cost of £1,426. It would have been very useful and instructive had these figures been given in detail, for the want of which these extraordinary results could not be fully appreciated. Referring to the description given of the apparatus at Cape Leeuwin and Fish Point, which was stated to be a first-order apparatus of the bi-valve type, it was not explained

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what was meant by the bi-valve type; a description of this would be useful. Mr. Ayres.

Mr. E. Price Edwards remarked that the Authors had treated the subject purely from the theoretical point of view; he did not gather from the Paper that the nautical opinion was sufficiently set forth. It was probable that there would be great difficulty on the part of nautical men in appreciating very small and rapid flashes when they were in trouble in heavy weather, and when the sea was knocking their ship about, and they could hardly stand with a watch in their hands to count infinitesimal flashes and gather from them the character of the light. He did not wish to depreciate the theoretical excellence of the system regarded from the point of view of exactness of engineering calculations; but the practical part of the subject was one in which mariners would take the deepest interest, and he should have been glad to see in the Paper a statement that mariners generally agreed that extremely short and quick flashes were beneficial. With regard to the expression that this country was lagging behind, he thought that in the matter of lighthouse science Great Britain had progressed as rapidly as any country in the world; and that its coasts were lighted as well as, and in the majority of cases far better than, those of any other country in the world. Mr. Price Edwards.

Mr. W. T. Douglass, in reply to the Discussion, said there would be no difficulty in shortening further the period of a light from 5 seconds, the period of the feux-éclairs, to 1 second or 2 seconds, with this modern form of apparatus. He considered the fixed light of the past the light *par excellence;* and if the nearest approach to a fixed light, viz., one denoting its position every 5 seconds, or every 2 seconds, could be obtained, it would be all the more advantageous to the mariner. With reference to the question of ball bearings, the Cape St. Blaize apparatus had been working satisfactorily for 2 years. The bearing was a very small one, about 18 inches in diameter. He understood that the Trinity House authorities had tried one about 6 feet in diameter with balls of about 2 inches diameter, some 4 years ago, but it was never erected in a lighthouse. There was some difficulty with the friction of the balls against one another. After a trial in their workshops at Blackwall the experiment was abandoned. That was the only experience in connection with ball bearings working on a large scale which he had met with. By making the cam of the eclipser to repeat the Morse alphabet, there would be no difficulty whatever in bringing about Lord Kelvin's proposal for characteristics. As to whether it would be possible to obtain the large powers referred to in the Paper from the small apparatus, the powers referred to Mr. Douglass.

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Mr. Douglass. were calculated from Mr. Allard's formula; they were not the photometric results obtained by Trinity House, which were considerably less. Instead of using a panel of 60°, practically the whole circle of 360° was available, and therefore six times the power was obtainable. So far as he was aware the mariner had on all occasions been very grateful for the short flash. In the case of Cape Leeuwin, one of the commanders of the Peninsular and Oriental steamers, on sighting the light for the first time, wrote to the Premier of Western Australia expressing his gratification for this installation; he had seen the light at a distance of 38 miles. That was the opinion of a man who traversed the sea between England and Australia and practically saw the whole of the lights. So far as the Trinity House was concerned, the old lights were arranged for flashes of 10, 8, 6, 4, and 3 seconds' duration. Evidently the point in connection with quick-flashing lights had been appreciated, for in the light recently installed on Lundy Island the flash was reduced to $\frac{2}{3}$ second, and this practice was repeated at St. Mary's Isle. He was therefore in hopes that in the course of a few years the authorities would decide to further reduce the flash to the minimum perceptible, which was $\frac{1}{10}$ second.

Correspondence.

Mr. Bourdelles. Mr. O. BOURDELLES, of Paris, desired to acknowledge the courtesy with which the Authors had referred to the feux-éclairs and to their inventor, and to congratulate them upon the ingenuity of the arrangement which they proposed. He regretted, however, he was obliged to advance criticisms to which he considered the latter open. The first and most important had reference to the excessive speed which the action of the arrangement entailed, and the consequent serious loss of luminous power. In the feux-éclairs adopted in France, the optical apparatus consisted of contiguous lenticular panels, equal in number to that of the flashes which constituted the group. The portion of the horizon not occupied by the panels was furnished with a reflector, and the corresponding free space was used for conveniently carrying out the attendance to the burner and the repair of the apparatus. With such conditions one complete revolution of the system sufficed to emit the group composed of flashes, with short and long eclipses; the light was never eclipsed over the whole horizon, and it gave its full effect without interruption. The arrangement proposed, on the contrary, made one half revolution for each short eclipse

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