Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.	
U Cephei	0 52·5	81 17 N.	June 4,	23 49	*m*
S Cancri	8 37·6	19 26 N.	,, 5,	3 18	*m*
R Virginis	12 32·9	7 36 N.	,, 7,		*M*
δ Libræ	14 55·1	8 5 S.	,, 3,	22 7	*m*
R Ursæ Minoris	16 31·5	72 30 N.	,, 3,		*M*
U Ophiuchi	17 10·9	1 20 N.	,, 6,	3 14	*m*
			,, 6,	23 22	*m*
X Sagittarii	17 40·6	27 47 S.	,, 7,	0 0	*m*
U Sagittarii	18 25·6	19 12 S.	,, 2,	2 0	*m*
			,, 5,	1 0	*M*
R Lyræ	18 52·0	43 48 N.	,, 5,		*M*
R Sagittæ	20 9·0	16 23 N.	,, 7,		*m*
U Capricorni	20 42·0	15 12 S.	,, 7,		*M*
W Cygni	21 31·9	44 53 N.	,, 8,		*M*

M signifies maximum; *m* minimum.

GEOGRAPHICAL NOTES.

At the anniversary meeting of the Royal Geographical Society on Monday, the medals and other honours already announced in NATURE were awarded. Dr. Radde, of Tiflis, appeared in person to receive his medal, which he acknowledged briefly and appreciatively. The address of the President, General Strachey, was of more than usual interest. After referring to the geographical events of the year, he took up the subject of Central Africa, its future exploration, and its subjection to the commercial and civilizing influence of Europe. General Strachey reviewed the results of European contact with the various other parts of the world, savage and semi-civilized. "There is no room to doubt," he said, "that the occupation of the earth by man in the many various modes presented to us has been determined mainly by the physical conditions of the surface, the distribution of land and sea, and the nature of the climate, operating in conjunction with the particular inherited capacities of the several branches of the human race, which have themselves been largely determined by these same physical conditions. The diffusion of races, and their more or less permanent occupation of various parts of the earth, have necessarily been regulated by their relative powers of adapting themselves to, and taking advantage of, the facilities for existence offered by the regions they occupied, and of resisting adverse pressure of all sorts brought to bear upon them from without. Among the best safeguards against that form of pressure which consists of the intrusion of other races, have ever been isolation by the ocean, or by high mountains, great land distances, forests and deserts; and hence it has been that the interiors of the great continents have for the most part been last explored, and their inhabitants least disturbed. As the first of these defences was weakened by the development of the art of navigation, the progressive races of Europe began to seek for fresh scope for their activities in many distant regions, thus for the first time rendered accessible to them. From very small beginnings within the Mediterranean, which for several centuries gained strength only by slow degrees, at length burst forth some 400 years ago the stream of conquest and commercial adventure which has in our time been carried across every part of the ocean; and has beaten on all its shores, throwing open an infinitude of lines of attack for the inroads of European progress upon regions previously resting in various conditions of relatively primitive stagnation." General Strachey then, in a highly suggestive manner, reviewed the methods and results of European conquest or European civilization in North, Central, and South America, Australasia, India, China, North Africa and South Africa, and, coming finally to Central Africa, he pointed out that the conditions there were peculiar and required peculiar treatment. "The vast area of tropical Africa," he said, "its climate, often so hostile to Europeans, and the numbers and character of the population, combined with the peculiar difficulties attending all transport in the interior, have retarded the progress of geographical discovery, and obstructed that intercommunication between neighbouring districts which supplies the natural machinery by which the progress of the less advanced races is carried forward. It is impossible to suppose that the impression to be made on these countries by the mere handful of men of northern race who are now scattered along its coasts or at a few points in its interior, can be anything but extremely slow, and it is hardly less certain that under the wholly different conditions that Central Africa presents from those of any other country hitherto brought within the operation of the process of civilization, the form which that process will take, and its results, will be very different from anything that past experience can suggest. The possibility of any colonization by direct immigration on such a scale as to produce effects in any way analogous to those obtained in North America or Australia is obviously excluded; the condition of the people over the greater part of the continent renders it equally impossible to look forward to a time when systems of administration at all approaching that of India could be established; and amalgamation between European settlers and the indigenous races appears no less out of the question. The operation of bringing a population such as that of Central Africa under the restraints of civilization will necessarily be a long and no doubt in some respects a painful one, for assuredly the conflict with slavery, cannibalism, and massacre cannot be carried to a successful issue by gentle means alone. The dangers that attend precipitation, with consequent reaction, have been already exemplified too plainly, and by the sacrifice of too many noble lives; and in circumstances such as those that here have to be dealt with, toleration of unavoidable evil at the outset may well afford the best and most certain means of introducing permanent improvement. Nor can I see any reason to question the conclusion that the best method of entering on this gigantic task is that which the general sense of Europe has practically resolved to adopt—namely, to form commercial associations intrusted with the exercise of reasonable administrative authority within the several areas assigned to them, hoping that thus the African population may by degrees be taught that the path to social and material comfort and well-being lies through well ordered industry and peaceful occupations; in imparting which lessons the earnest co-operation of the many purely philanthropic missions already established among these people may be most confidently counted on."

BEACON LIGHTS AND FOG SIGNALS.[1]

II.

In 1876, Mr. Julius Pintsch, of Berlin, patented in this country his system of illuminating buoys or other floating bodies by compressed oil gas, and in 1878 one of these buoys was experimentally tried at sea with success by the Trinity House. The system is similar to that previously adopted by Mr. Pintsch with great success in the lighting of railway carriages, but with the addition for buoys of a specially constructed lantern, containing a small cylindrical lens for fixed light. Through the kindness of the Pintsch's Lighting Company, we have here one of these apparatus, producing an intensity in the beam of about twenty candle units. With the charge of gas contained in the buoy, the light is shown continuously, night and day, from two to four months, according to the dimensions of the buoy, without refilling or requiring any other attention except occasional cleaning of the lens and the glazing of the lantern. In 1883, Mr. William B. Rickman patented a very ingenious addition to this apparatus for producing occulting or flashing light. The apparatus is automatically worked by the issuing compressed gas on its way from the buoy to the burner. After passing the regulator where the pressure of the gas is reduced for burning, it enters a cylindrical chamber covered with a diaphragm of very flexible specially prepared leather, this diaphragm, on being slightly raised by the in-flowing gas, communicates motion to a lever, which, assisted by a spiral spring, closes the inlet pipe, and opens at the same time the passage to the burner. As the gas passes on and is consumed at the burner, the diaphragm by its own weight, assisted by the spring, sinks, and touching the lever, closes the outlet aperture to the burner, and at the same moment opens the inlet of the gas from the buoy for another charge. Thus the light is extinguished while the gas is entering the chamber, and until the latter is refilled, when the passage from the buoy is again closed by the rising of the diaphragm. A small pilot jet is constantly burning to insure the re-ignition of the gas when re-admitted to the burner. It is evident that several characteristic distinctions of light may be obtained by modifications of this ingenious apparatus. About 150 buoys lighted on the Pintsch system are already rendering valuable

[1] Friday evening discourse delivered at the Royal Institution by Sir James N. Douglass, F.R.S., on March 15. Continued from p. 91.

service to mariners in various parts of the world. For the more important stations at sea where light-vessels are now employed the system is considered to be yet wanting in that trustworthiness which should be the leading characteristic of all coast lighting. Very important experiments have lately been made by the Lighthouse Board of the United States, at their General Depot at Tompkinsville, New York, with buoys lighted electrically by glow lamps, operated through submarine conductors from the shore. These experiments have proved so successful that an installation for marking the Gedney's Channel entrance of Lower Bay, New York Harbour, with six buoys and 100-candle glow lamps, was lighted on November 7 last. Gas buoys were considered inapplicable for this special case, owing to their form and size rendering them liable to break adrift, particularly when struck by floating ice or passing vessels. The buoy adopted for the service consists of a spar 46 feet long, having its lower end shackled direct to a heavy iron sinker, resting on the bottom. At the upper end the buoy is fitted with an iron cage inclosing a heavy glass jar, in which is placed the glow lamp of 100 candle units intensity. The cable is secured by wire staples in a deep groove cut in the buoy and covered by a strip of wood. For a distance of several feet at the lower end of the buoy the cable is closely served with iron wire, over which is wound spun yarn to prevent injury from chafing on the shackle and sinker. The central station on shore, with steam-engines and dynamos in duplicate, is on Sandy Hook, at a distance from the extreme buoys of about 3 nautical miles. The installation is reported to be working continuously and successfully. For auxiliary or port lights on shore where no collisions can occur, the Pintsch gas system is found to be very perfect. At Broadness, on the Thames, near Gravesend, the Trinity House erected in 1885, an automatic lighthouse illuminated on Pintsch's system, as shown by the diagram. This small lighthouse shows a single flashing light at periods of ten seconds, the flashes having an intensity of 500 candle units. The flashes and eclipses are produced with perfect regularity by special clockwork, which also turns on the gas supply to the burner at sunset and off again at sunrise. It is also arranged for periodic adjustment for the lengthening and shortening of the nights throughout the year. This automatic light is in the charge of a boatman, who visits it once a week, when he cleans and adjusts the apparatus, and cleans the glazing of the lantern. An automatic lighthouse similar to that at Broadness has been lately installed at Sunderland by the River Wear Commissioners, on a pier which is inaccessible during stormy weather. In 1881–82 several beacons automatically lighted by petroleum spirit, on the system of Herr Lindberg and Herr Lyth, of Stockholm, were established by the Swedish lighthouse authorities, and are reported to be working efficiently. In 1885 a beacon or automatic lighthouse on this system was installed by the Trinity House on the Thames, near Gravesend, and has been found to work efficiently. The light is occulting at periods of about two seconds; the occultations are produced by an opaque screen, rotated around the light by the ascending currents of heated air from the lamp acting on a horizontal fan. As there is no governor to the apparatus, the periods of the occultations are subject to slight errors compared with those of the gas light controlled by clockwork. In 1844 an iron beacon lighted by a glow lamp and the current from a secondary battery was erected on a tidal rock near Cadiz. Contact is made and broken by a small clock, which runs for twenty-eight days, and causes the light to flash for five seconds at periods of half a minute. The clock is also arranged for eclipsing the light between sunrise and sunset. The apparatus is the invention of Don Isaas Lavaden, of Cadiz, to whom I am indebted for kindly showing me the light in action when on a visit to Cadiz in 1885. There is every probability that automatic beacons lighted either by electricity, gas, or petroleum spirit, will in consequence of their economy in maintenance be extensively adopted in the future.

Coal and wood fires, the flames produced by the combustion of tallow, nearly all the animal, vegetable, and mineral oils, coal and oil gas, and the lime-light, have been employed from time to time in lighthouse illumination, and last but not least, the electric light. None of these illuminants have received such universal application in all positions both ashore and afloat as mineral oil at the present moment, and justly so, when we consider its efficiency and economy for the purpose. So recently as 1822, the last beacon coal fire in this country was replaced by a catoptric oil light, at Saint Bees Lighthouse, on the coast of Cumberland. We have here diagrams of two of these coal fire beacons, one of them designed and erected by Smeaton in 1767 on his lighthouse at the Spurn Point, on the east side of the entrance to the Humber. So late as 1845, sperm oil was entirely used in the lighthouses and light-vessels of the Trinity House; but, shortly afterwards, colza was adopted with the same efficiency, and with a saving in annual cost of about 44 per cent. In 1861, experiments were made by the Trinity House for determining the relative efficiency and economy of colza and mineral oil for lighthouse illumination; but owing to the imperfect refinement of the best samples of the latter then procurable in the market, together with its high price, the result of the investigation was not so satisfactory as to justify a change from colza. In 1869, the price of mineral oil of good illuminating quality, and safe flashing-point, was found to be procurable at about half the price of colza, when the Trinity House determined to make a further series of experiments, and by these it was ascertained that, with a few simple modifications of the argand burners then in use, they were rendered very efficient for the purpose; it was also found that these burners were thus considerably improved for the combustion of colza. A change from colza to mineral oil was then commenced, and mineral oil is now generally adopted in the lighthouses and light-vessels of the Trinity House service; and with even greater economy than was at first anticipated, the price of this illuminant being now rather less than one-third that of colza. The most powerful oil burner then in use was one of four concentric wicks, the joint production of Arago and Fresnel, and adopted by the French lighthouse authorities about the year 1825, in conjunction with the then new dioptric system of optical apparatus of Fresnel. The standard intensity of the combined flames of this burner, one of which we have here, was 250 candle units. A further development was made during the experiments of the Trinity House in 1871, by increasing the number of wicks from four to six, which more than doubled the intensity of the light, while effecting a condensation of the luminary per unit of focal area, or, in other words, improved the optical efficiency 70 per cent. We have here also one of these burners.

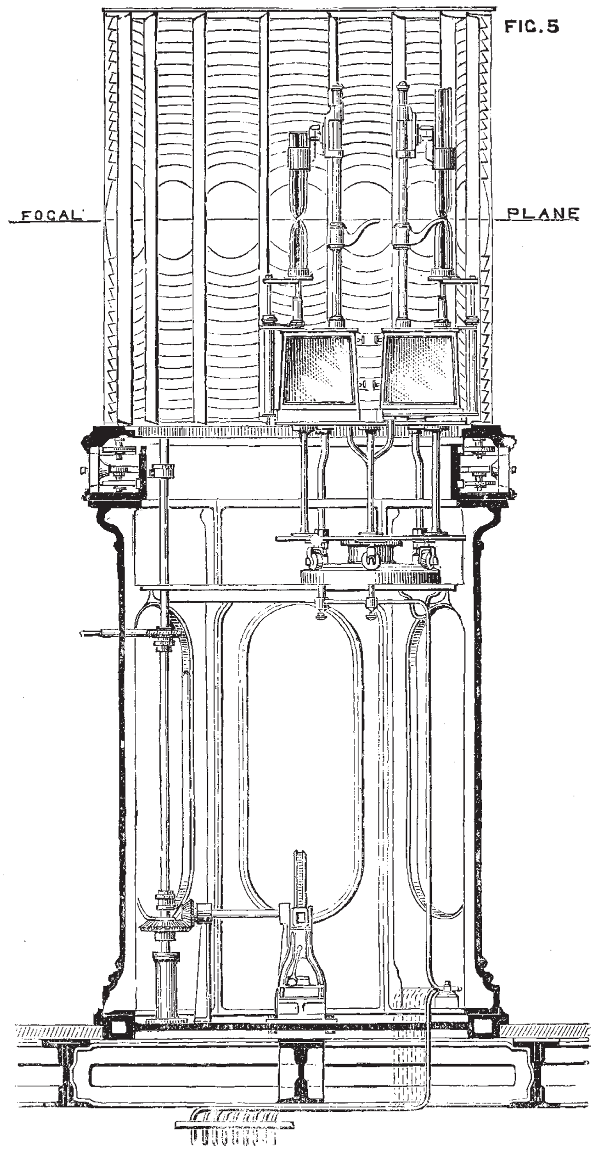
I have since devised an argand burner for the combustion of all illuminating gases and oils, whereby still further condensation of the flames, together with greater intensity and economy of combustion, is obtained, and the glass chimney is protected from breakage. These improvements are effected by a special arrangement and distribution of the air currents through the rings of flame, and between them and the glass chimney. We are thus enabled on this system to increase the dimensions of lighthouse burners, for gas and oil, for ten or more rings of flame. With ten rings, we obtain an aggregate intensity, when burning cannel gas and good mineral oil, of considerably over 2000 candle units, while the improved efficiency of the luminary for optical cendensation of the radiant light per unit of focal area, as compared with the luminary of the Fresnel four-wick oil burner, has been in each case increased 109 per cent. With reference to the perfect combustion of these highly condensed flames, I may state that the efficiency for gas is exactly double that of the London standard argand burner, viz. when consuming gas of the London standard of sixteen candles, the light produced is at the rate of 6·4 instead of 3·2 candles per cubic foot. In addition to a single ring gas burner of this type we have two burners of the ten rings of flames, and models of their flames, one for gas and the other for mineral oil. These burners are all of the Trinity House new pattern, both gas and oil, and they are of the same general arrangement for combustion, except that the oil burner is provided with cotton wicks. Both produce flames of nearly the same form, dimensions, intensity, and colour.

The first application of coal gas to lighthouse illumination was made at the Troon Lighthouse, Ayrshire, in 1827; and in 1847 it was adopted at the Hartlepool Lighthouse, Durham, where for the first time it was employed in combination with dioptric apparatus of the first order of Fresnel. The slow progress made with coal gas in lighthouses, except for harbour lights, where the gas could be obtained in their vicinity, as at Hartlepool, was chiefly due to the great cost incurred in the manufacture of the small quantity required, and at the usual isolated positions occupied by coast lighthouses, involving extra cost both for labour, and for the extra transport of the coal. In 1865, the attention of lighthouse authorities was directed to gas, as an illuminant for lighthouses, by Mr. John R. Wigham, of Dublin, whose system was tried in that year, at the Howth Bailey Lighthouse, Dublin Bay. The gas burner of Mr. Wigham, one of which we have here, consists of seven concentric rings, of single flat-flame burners, amounting in the aggregate to 108. The burner is used without a glass chimney, and thus there is no appreciable condensation of the group of flames, for their employment at the focus of optical apparatus, and the relative aggregate intensity of the seven rings of flat flames per unit of focal area, as compared with the four concentric flames of the old four-wick oil burner of Fresnel, is only $2\frac{1}{2}$ per cent. higher than the latter. The burner has five powers, for varying states of the atmosphere. For the minimum intensity, 28 jets are employed; and with the whole 108 jets there is a maximum aggregate intensity of the flames with cannel gas of about 2500 candle units. Several lighthouses on the coast of Ireland have been illuminated with gas, on the system of Mr. Wigham, and two at Haisborough, on the coast of Norfolk. In 1878, Mr. Wigham installed at the Galley Head Lighthouse, County Cork, his system of superposed gas flames, and group-flashing light, which consisted of four of his large gas burners vertically superposed. In conjunction with these were four tiers of first order annular lenses, eight in each tier. By successive lowering and raising of the gas flames at the focus of each tier of lenses, he produced his group-flashing distinction. This light shows, at periods of one minute, instead of the usual single flash from each lens, or vertical group of lenses, a group of short flashes, varying in number between six and seven. The unavoidable uncertainty with this system in the number of flashes contained in each group is unfortunate for the mariner, who, with the continued increase in the number of coast lights, requires the utmost precision in the distinctive character adopted for each.

In 1857, an experimental trial of the first magneto-electric machine of Holmes, for the practical application of the electric light, was made by the Trinity House at Blackwall, under the direction and to the great delight of their scientific adviser, Faraday; and after a series of experiments the satisfactory report of Faraday encouraged the Trinity House to order a practical trial of a pair of the Holmes machines. The trial was made at the South Foreland High Lighthouse by Faraday and Holmes on December 8, 1858, when electricity was found to be a formidable rival to oil and gas for lighthouse illumination, and this position it maintains to the present day. The trials of this arc light were made at the focus of the first order dioptric apparatus for oil light, which was very imperfect for the purpose, but they were sufficiently encouraging to lead the Trinity House, under the advice of Faraday, to proceed further with the electric light for lighthouses. Faraday thus wrote in his report to the Trinity House:—"I beg to state that, in my opinion, Prof. Holmes has practically established the fitness and sufficiency of the magneto-electric light for lighthouse purposes, so far as its nature and management are concerned. The light produced is powerful beyond any other that I have yet seen so applied, and in principle may be accumulated to any degree; its regularity in the lantern is great, its management easy, and its care, there may be confided to attentive keepers of the ordinary intellect and knowledge."

These truly prophetic words of Faraday's have been entirely realized. Electricity still stands foremost in the illumination of our coasts, and appears destined to be one of the greatest blessings ever conferred on humanity, and more especially on "those who go down to the sea in ships." On February 1, 1862, Holmes's machines and apparatus for electric light were installed at Dungeness Lighthouse; and in 1863, the French lighthouse authorities followed, by an installation of the Alliance Company's magneto-electric machines and apparatus for fixed lights at each of the two lighthouses at Cape La Hève. We have here the first dioptric apparatus designed and manufactured by Messrs. Chance Brothers and Co., of Birmingham, for the electric fixed light at Dungeness. We have also one of the Holmes lamps employed there. The lamp used at the previous experiments was devised by M. Duboscq, of Paris. This lamp of Holmes's is similar to those of Duboscq and Serrin, excepting that the upper and lower carbons and holders are balanced and regulated through pulleys and small catgut cords, instead of by rack and pinions. The carbons are $\frac{1}{4}$ inch square, and the mean intensity of the light in the arc was 670 candle units nearly. We have here samples of the carbons employed from time to time in the development of the electric light in lighthouses; we have also a Bergot lamp fitted with the fluted form of carbons I have recently devised. They are of the dimensions now in use in the optical apparatus at the St. Catharine's Lighthouse, and are giving a mean intensity in the arc of 40,000 candle units (Fig. 5). Cylindrical compressed carbons were soon manufactured for the electric light, and were found to be more homogeneous in quality, and the flickering of the light less, than with the original square carbons, which were simply sawn from the residual carbon of gas retorts; but there was still the objectionable crater at the points, whether direct or alternating currents were employed, involving flickering from the incessant shifting of position at the points. A considerable loss of radiant light was also involved, particularly when condensing it optically. The flickering was somewhat reduced by an improvement of Messrs. Siemens', in providing the carbons with a graphite core, but with the increasing powers of currents,

FIG. 5



and in the necessary dimensions of carbons, the results were far from satisfactory. With the fluted form of carbon shown on the diagram, the formation of the crater is prevented, and the arc is held centrally at the points of the carbons; there is thus, in addition to comparatively steady light, nearly uniform radiation in azimuth, and over a greater vertical angle for optical condensation. It now appears to me, after some practical experience with this form of carbon, that it is impossible to determine a practical limit to the dimensions of carbons that may be efficiently employed. With carbons of the actual size shown on the diagram, an intensity of about a million candle units should be produced in the arc, and about 150 millions of candle units in the condensed flashes from the optical apparatus of the dimensions now employed for oil and gas flames in lighthouses. Such an intensity is about four hundred times that possible at the focus of such apparatus with a flame luminary. Such results as these were probably in the mind of Faraday when he reported that "in principle this light may be accumulated to any degree." Flashes of the great intensity here referred to could only be employed in atmosphere impaired for the transmission of light. In clear weather they would be found to be far too dazzling to the eyes of the mariner, when an intensity of about 50,000 candle units is found to be sufficient for his guidance, and in thick fog no possible intensity can be of practical value for navigation. There are, however, various gradations of impaired atmosphere between clear weather and thick fog, in which the highest available intensity is doubtless desirable at many important landfall stations for obtaining the greatest possible range of visibility. On the other hand, at the majority of stations in narrow waters, the maximum intensity now obtained with flame light is found to be more generally efficient for navigation than higher intensities.

In 1881, the question of the relative merits of the three lighthouse illuminants—electricity, gas, and mineral oil—was receiving the attention of the lighthouse authorities of this country, which resulted in the Trinity House accepting the responsibility of carrying out an investigation at the South Foreland, of universal importance to the mariner. In the photometrical and electrical portions of this work, the Trinity House were aided by the labours of Prof. Harold Dixon, F.R.S., and Prof. W. Grylls Adams, F.R.S., which contributed very largely to the success of the investigation. The experiments were carried on during a period of over twelve months, and a vast amount of very valuable evidence was collected from numerous observers, trained and untrained, scientific and practical. The Report of the Committee was presented to both Houses of Parliament, by command of Her Majesty, in 1885. The final conclusions of the Committee are given in the following words: "That, for the ordinary necessities of lighthouse illumination, mineral oil is the most suitable and economical illuminant, and that for salient headlands, important landfalls, and places where a very powerful light is required, electricity offers the greatest advantages."

I have already referred to the necessity, with the present development of maritime commerce, that every beacon light maintain a clearly distinctive character. When the optically unaided flames of coal fires were the illuminants of our lighthouses, distinctive characters, owing to the small number of lights then employed, were of little importance, and the only distinctions then possible were the costly ones of single, double, or triple lighthouses at one station; but, with the enormous increase that has since occurred in the floating commerce of the world, and with the necessary laws now in operation, requiring all vessels to carry lights, trustworthy individuality in coast beacon lights has become a positive necessity. Until very recently, the distinctive characters consisted of the following, viz. fixed white, fixed red, revolving white, revolving red, and revolving white and red alternately. The revolving lights showed a flash at periods of ten seconds, twenty seconds, thirty seconds, one minute, two minutes, three minutes, and four minutes. There were also intermittent or occulting lights, having an eclipse at periods of half a minute, one minute, or two minutes. It is now generally considered that fixed lights are no longer trustworthy coast signals, owing to their liability to confusion with other lights, both ashore and afloat. It is also considered that, in these days of high-speed vessels, the period of the character of a coast light should not, if possible, exceed half a minute. The revolving or flashing class of lights are probably the most valuable, on account of their superior intensity as compared with the fixed or occulting class, the light during the intervals of eclipse being condensed into each succeeding flash, by the revolving lenses or reflectors, and thus, with the same expenditure of the illuminant, an intensity is obtained in the flashes of five to eight times that of the fixed or occulting class. Where local dangers are required to be guarded by coloured sectors of danger light with well defined limits, this can only be accomplished with the fixed or occulting class of lights. We will illustrate this with the model before us. We will also show the clear difference of character, not generally realized, between flashing and occulting lights. A system of occulting lights for lighthouses was proposed by the late Charles Babbage, F.R.S., in 1851, but as it excluded the flashing or most powerful of the existing lights, it did not receive much favour from lighthouse authorities. In 1872, distinctive characters for coast lights was the subject of a paper by Sir William Thomson, F.R.S., at the Brighton meeting of the British Association for the Advancement of Science, when he directed attention to the extreme importance of ready identification of lights at sea, and proposed the use of quick-flashing lights, their flashes being of longer or shorter duration; the short and long flashes representing the dot and dash of the Morse alphabet as used in telegraphy. It was found, however, that the number of symbols in our alphabetical code would not be sufficient, on a thickly lighted coast, to insure individuality, and render each distinction perfectly trustworthy. Further, that very rapid repetition of each symbol is not required by the mariner, and would involve loss of accumulative power in the flashes, besides incurring unnecessary wear and tear in rotating heavy optical apparatus. Yet much is to be done in the direction of simple distinction. At the Montreal meeting of the British Association, in 1884, I submitted a paper on "Improvements in Coast Signals," in which were suggested, two alphabetical codes of flashing lights, and one of occulting, all having the same period of the symbol, viz. half a minute. In one of the codes of flashing lights, long and short flashes were proposed, as previously by Sir William Thomson; and in the other there were proposed white and red flashes. In the occulting series, long and short eclipses were proposed to be substituted for the long and short, or white and red, flashes, of the flashing codes. The system has the advantage of application to all existing lighthouse apparatus, and many lights have been altered to selected symbols of each of these series.

Little was ever accomplished in the way of warning or guidance to the mariner, during fog, until about the middle of this century. Previously, a few bells had been established at lighthouses in this country and abroad, and gongs of Chinese manufacture had been in general use on board our light-vessels, but both instruments are now acknowledged to be wanting in the efficiency now demanded in fog, to meet the requirements of navigation. The first important improvement in fog signals for the service of mariners was made by the late Mr. Daboll in 1851, who submitted to the United States Lighthouse Board, in that year, a powerful trumpet, sounded by air compressed by horse-power. The apparatus was installed at Beaver Tail Point, Rhode Island, and the favourable results obtained with it stimulated Mr. Daboll, under the encouragement of the United States lighthouse authorities, to the further development of the apparatus; and ultimately he employed Ericsson's caloric engine as the motive power, with automatic gearing for regulating the blasts. In 1854, some experiments on different means of producing sounds for coast signals were made by the engineers of the French Lighthouse Department, and in 1861–62 MM. Le Gros and Saint-Ange Allard, of the Corps des Ponts et Chaussées, conducted a series of experiments upon the sound of bells, and the various methods of striking them. In 1862, Mr. Daboll submitted his improved fog trumpet apparatus, of about three horse-power in the blasts, to the Trinity House, who, under the advice of Faraday, made experimental trials with it in London, and afterwards gave it a practical trial at the Dungeness Lighthouse, where experiments were made with it, against bells, guns, and a reed fog-horn of Prof. Holmes, whose services have been already referred to in connection with the first practical application of the electric light. This fog-horn of Holmes was sounded by steam, direct from one of the boilers employed at the station for his electric light. The results of these experiments were in favour of Daboll's trumpet; and in 1869, one of these instruments was installed on board the *Newarp* light-vessel. In the same year, Holmes having effected further improvements with his steam horn, his apparatus was fitted on board two light-vessels, and sent out to the coast of China, where they were found to give great satisfaction, as compared with gong signals. In 1863, a Committee of the British Association for the Advancement of Science memorialized the President of the Board of Trade, with the view of inducing him to institute a series of experiments upon fog signals. The memorial, after briefly setting forth a statement of the nature and importance of the subject, described what was then known respecting it, and several suggestions were made relative to the nature of the experiments recommended. The proposal does not appear to have been favourably entertained by the authorities to whom it was referred, and the experiments were not carried out. In 1864, a series of experiments was undertaken, by a commission appointed by the Lighthouse Board of the United States, to determine the relative powers of various fog signals which were submitted to the notice of the Board. In 1872, a Committee of the Trinity House, with the object of ascertaining the actual efficiency of various fog signals then in operation on the North American continent, visited the United States and Canada, where they found in service, Daboll's trumpets, steam whistles, and siren apparatus, sounded by steam and compressed air; these latter apparatus were devised by Mr. Felix Brown, of Progress Works, New York; and from the report of the Trinity House Committee, it does not appear that they were greatly impressed with this instrument, but probably they had not an opportunity of testing its real merits as compared with other signals. The late Prof. Henry, of the United States Lighthouse Board, entertained a very high opinion of the siren; and on his advice, and the urgent recommendation of Prof. Tyndall, one of these instruments was sent to England, and included in the fog signal experiments at the South Foreland in 1873-74. This investigation was carried out by the Trinity House, with the view of obtaining definite knowledge as to the relative merits of various sound-producing instruments then in use, and also of ascertaining how the propagation of sound is affected by meteorological phenomena. Prof. Tyndall, as scientific adviser of the Trinity House, conducted the investigation, aided by a Committee of the Trinity House, and their engineer. These experiments were extended over a lengthened period, in all conditions of weather, and the well-known scientific and practical results obtained, together with the ascertained relative merits of sound-producing instruments for the service of the mariner, have proved to be of the highest scientific interest and practical importance. The investigation at the South Foreland was followed up by the Trinity House with further explosive fog signal experiments, in which they were assisted by the authorities at Woolwich Arsenal with guns of various forms, weight of charges, and descriptions of gunpowder. The powders tested were (1) fine grain, (2) larger grain, (3) rifle large grain, and (4) pebble. The result placed the sound-producing powers of these powders exactly in the order above stated; the fine grain, or most rapidly burning powder, gave indisputably the loudest sound, while the report of the slowly burning pebble powder was weakest of all. Here again the greater value of increased rapidity of combustion in producing sound was demonstrated. It was found that charges of gun-cotton yielded reports louder at all ranges than equal charges of the best gunpowder; and further experiments proved that the explosion of half a pound of gun-cotton gave a sound equal in intensity to that produced by three pounds of the best gunpowder. These investigations led the Trinity House to adopt gun-cotton for fog signals at isolated stations on rocks and shoals, as already described, where, from want of space, nothing better than a ball, or gong, it had hitherto been possible to apply. Of all the sound signals now employed for the warning and guidance of mariners during fog, viz. bells, gongs, guns, whistles, reed trumpets, sirens, and sounds produced by the explosion of gun-cotton, the blasts of the siren and explosions of gun-cotton have been found to be the most efficient for coast fog signals; therefore these signals have received the greatest care and attention in their development. The siren doubtless ranks first for stations wherever it can be applied, chiefly on account of its economy in maintenance, and the facility it affords for giving prolonged blasts of any desired intensity or pitch, and thus providing any number of trustworthy distinctive characters that may be required to insure individuality in the signal. Sirens are now employed at many floating and shore stations of the Trinity House; and one, recently installed at Saint Catharine's Lighthouse, Isle of Wight, of the automatic Holmes type, of which we have here a model, absorbs during its blasts not less than 600 horse-power. The audibility of the blasts of this instrument may be considered to be trustworthy at a range of two miles under all conditions of foggy atmosphere, on the sea surface, over which it is intended to be sounded. It is very desirable that for many landfall stations a greater trustworthy range be provided for the mariner, but this can only be afforded by such increased power as would be required for a more powerful electric light installation, to serve the mariner in other gradations of thick atmosphere. A very important improvement and economy has lately been effected in the sirens of the Trinity House, by rendering them always instantaneously available for sounding at their maximum power. This is accomplished by the storage of a sufficient quantity of compressed air, at a pressure considerably above that required for sounding, to work the siren during the time required for raising steam and starting the engine. The signal is thus always in readiness for immediate action day or night, with an expenditure of fuel only incurred during fog, which fortunately on the coast of this country does not exceed an average of 440 hours per annum. The experience yet gained with the most powerful fog signals now in use, although these apparatus far exceed in efficiency for the service of the mariner in fog any light that science can provide, is not yet so satisfactory as we could desire. The best signal is, as I have already stated, occasionally not heard, under certain atmospheric conditions, beyond two miles; while under other conditions, not apparent to the mariner, the signal is distinctly audible at ten miles; therefore there is much to be desired in the development of the means of propagating sound waves, and in rendering them audible to the mariner. In conclusion I would venture to state that, with the best light and sound signals that can be provided, there are conditions of the atmosphere in which the mariner will earnestly look and listen in vain for the desired light or sound signal, and he must still, under such circumstances, exercise caution in availing himself of their guidance, and never neglect the assistance always at hand of his old trusty friend the lead.

PRELIMINARY REPORT OF THE NEWALL TELESCOPE SYNDICATE.[1]

At the end of the Lent Term the Syndicate met for the first time and drew up a Report to the Council of the Senate, recommending that a Committee of experts should go to Gateshead to view Mr. Newall's telescope and report on its condition and capabilities. A letter of acknowledgment was also sent to Mr. Newall thanking him for his generous offer.

In consequence of their recommendation, Mr. Christie, Astronomer Royal, Mr. Common, F.R.S., and Mr. Graham, First Assistant at our Observatory, went to Gateshead and made a thorough examination of the telescope and of its accessories. They reported to the Syndicate as follows:—

Report on Mr. Newall's 25-inch Refractor.

We the undersigned, being the Committee appointed by the Newall Telescope Syndicate to inquire into and report on the condition and capabilities of the above instrument, beg to submit the following report as the result of an examination made on March 28 and 29. For convenience of reference we have divided the report under three heads:—

1. On the present condition of the telescope and dome.
2. On the necessary work to be done in removing and re-erecting, to put the whole in an efficient state.
3. The capabilities of the instrument when re-erected.

I. On the evening of March 28, the sky being overcast, the quality of the object-glass was tested by artificial stars, formed by the light of a lamp shining through holes in a metal screen, placed at a distance of about 1500 yards. The result of those tests, which it is unnecessary to specify more fully, was sufficient to enable the Committee to come to the conclusion that the object-glass is a remarkably fine one, entirely free from any defect. On the conclusion of those tests about midnight, and as the Committee were about to leave, the sky cleared to a slight extent, and at intervals the telescope was turned upon some stars and upon Saturn. Owing to the state of the atmosphere, the definition was very variable, but the Committee saw enough to confirm them in the opinion they had already formed as to the excellent quality of the object-glass. During these examinations and tests the mounting showed itself to be extremely steady and quite free from vibration. On the morning of the 29th the Committee again met at Ferndene to complete the examination of the instrument and dome by daylight. The telescope is no doubt so well known that it is not necessary to state further than that it is a first-class instrument, mounted on the plan of the elder Cooke, and that it is fully provided with all the necessary appliances to make it an extremely convenient and easily managed instrument.

The condition is such that the necessary cleaning, painting, lacquering, &c., more fully described in the next section, will not be an expensive matter.

The dome and substructure were next inspected. From the brick wall, which rises to a height of about 2 feet, the whole is of iron, the various parts, including the dome, being bolted

[1] Reprinted from the *Cambridge University Reporter*, May 21.