were of special interest; earthquakes were reported in New Hampshire and California on the 19th, and in Maine on the 31st.

HISTORY OF THE APPLICATION OF THE ELECTRIC LIGHT TO LIGHTING THE COASTS OF FRANCE.

I.

THE value to navigation of thoroughly lighting our coasts is too evident to require any argument in its favor; and, in view of the immense interests at stake, there is no question but that improved methods of lighting should be adopted, almost regardless of expense, providing that the advantages gained are in any way commensurate with the cost.

France has long appreciated this; and it is to her that the world owes the Fresnel lens and many improved lamps burning successively whale, vegetable, and mineral oils. She has finally led the way, as usual, in the use of the electric light, which has been definitely adopted for the lighting of her coasts, after many expensive and conclusive experiments; and, when the plan has been fully carried out, France can boast of having the best and most systematic method of coast-lighting of any country in the world.

The United States has followed France. Our optical apparatus has been almost exclusively imported from that country. We use lamps made after French patterns, and now we are making experiments to determine its value for our lighthouses. This is deemed sufficient excuse for giving full details of the French system. The information has naturally been mostly obtained from French sources.

It was in 1863 that the electric light was for the first time used in lighthouses. The experiment was made with an Alliance machine in the first-order lighthouse of la Hève, near Havre; and the results were so satisfactory that doubtless all the lighthouses would have been immediately furnished with electric lights, had it not been for the great expense attending a general alteration. It was proved that the electric light was seen about eight kilometres farther than the oil-light, and that, in time of fog, the range of the former light was more than double that of the latter.

M. Quinette de Rochemont, ingénieur des ponts et chaussées, published in 1870 a report upon the lighthouses at la Hève. Below are some extracts: —

"The electric light having been installed for six years at la Hève, enough time has elapsed to allow us to form an exact idea of the value of this means of producing light for the lighting of coasts. Sailors take pleasure in recognizing the good services rendered them by the electric light. The advantages of the system have been highly appreciated: the increase of the range of the light is very apparent; and, above all, in slightly foggy weather, many ships can continue their voyage, and enter the port at night, which they could not do when oil was used. The light, which at first was rather unsteady, gradually acquired a remarkable fixity, — thanks to the improvement of the apparatus and to the experience gained by the keepers. The fears which were at first entertained regarding the delicacy of certain parts of the apparatus are not realized in practice. The accidents have been rare, the extinctions short and very few, — two only during this period of six years having had a notable duration: one, of an hour, was due to an accident to the steam-engine; the other, of four hours, should, it appears, be attributed to malevolence. Under these circumstances it seems hardly worth while to worry about possible accidents."

Since 1863 experience has only confirmed the favorable views of M. Quinette. The lighthouses of Gris-Nez, France; Cape Lizard, England; Odessa, Russia; and Port Said, Egypt, — have been provided with electric apparatus; and there is a question of placing it in the lighthouses of Planier and Palmyre, France, and in several lighthouses in other foreign countries.

The following information was furnished by MM. Sautler and Lemonnier: —

"When the light is to be fixed, the optical part of the apparatus is composed of a lenticular drum of proper form, which renders the rays horizontal in the vertical plane while allowing them to diverge in the horizontal plane. The dimensions of this drum vary from a diameter of half a metre for a fourth-order light to one metre in a first-order light. This increase in diameter of the apparatus is sensibly proportional to the increase in diameter of the carbon-pencils between which the voltaic arc is produced, and which determines very nearly the dimensions of the electric light. It follows from this, that the vertical divergence remains the same in the different types of apparatus. When the light is to be revolving, the fixed lens is surrounded by a movable drum formed of straight vertical lenses of which the form varies according to the characteristics desired to be given to the light."

Revolving electric lights have this great advantage over revolving oil-lights: the flashes can be given a duration equal to that of the eclipses. In oil-lights, when the light is concentrated in the form of flashes, there are two ends in view: 1°, to augment the intensity, and consequently the range, of the light; 2°, to create an appearance different from that of a fixed light. The first can only be obtained by giving the flash a duration much shorter than that of the eclipse; or, in other terms, by making the angle of the luminous beam a small part of the angle subtended by the lens. Moreover, this angle depends on the dimensions of the *foyer*,[1] and it can only be augmented either by increasing this dimension or by changing the focal distance of the lens, thus losing a part of the light, since the divergence is produced not only in the horizontal plane, — the only one in which it is utilized for prolonging the flashes, — but in every direction. With the combination of vertical lenses and a cylindrical drum which serves to produce flashes when electricity is used, the divergence of the beams can, by giving the vertical lenses a proper curvature, be augmented as much as desired in the horizontal plane, and the duration of the eclipses be diminished in proportion, while the range of the smallest electric light used will nevertheless remain much greater than that of the most powerful oil-light.

For example: the luminous intensity of an annular panel of 45° of a first-order revolving light with a six-wick lamp equals 9,847 carcels. This is the greatest intensity obtained with an oil-lamp. The divergence of the beam given by this same panel is 7° 7′, and the duration of the flash is about one-sixth part of the eclipse which precedes and follows it.

By applying the methods of M. Allard to the photometric measurements of electric lights, it is found that the luminous intensity of a fourth-order electric light, with a lens half a metre in diameter, and fed by a small model Gramme machine, equals at least 20,000 carcels; and when concentrated by means of straight movable lenses in beams having a divergence such that the durations of the eclipses and flashes shall be the same, its intensity will be equal to 40,000 carcels: that is to say, that it will be four times more intense than that of the most powerful oil-lamp, and with a much shorter duration of eclipse.

By means of electricity such immense quantities of light are produced, that it is not necessary to take into account more or less beams in order to augment the range; the only object of the movable lenses being to produce characteristic appearances which distinguish clearly each lighthouse from its neighbor. These characteristic appearances, the method for producing them, and the system now adopted in France, will be mentioned farther on.

The different lights which serve for the lighting of French coasts are designed so as to answer the different needs of navigation; and their importance varies in consequence according to the rôle they are called upon to play, of which the most important is that of signalling to navigators their approach to land: and the lights constructed for this end are placed in preference upon more or less advanced headlands; which form, according to the expression of M. L. Reynaud, "the angles of a polygon circumscribing all dangers." These are the lights which should have the greatest luminous power, and which, therefore, constitute *first-order lights*.

Between these extreme points indicating the general contour of the coast, the latter still presents advanced points which should become centres of lights of less importance, and serve to guide the vessels to their harbors. The secondary lights placed on these points are called *second-order lights;* and merit their name, not only by their position, but also on account of the less power given to their optical apparatus. Along the route thus traced for navigation are also found localities which it is important should be pointed out to sailors: these are, for example, sand-banks, sunken rocks, islets, etc. From these arises the necessity of luminous *foyers* of various intensities, and the creation of *third-*, *fourth-*, and *fifth-order*, and of even less powerful, *lights*, such as are placed in harbors on the end of jetties, to show vessels the entrance to the channel.

In addition, among all the lights of different orders, some, placed on an island, are designed to throw their light entirely around them; others, built on an advanced promontory or established on a straight part of the coast, only send their rays on a fraction, more or less great, of the zone which surrounds them; finally, others only have to light a determined point: hence the distinction of lights in *lights of all the horizon*, *of three-fourths the horizon*, *of two-thirds the horizon*, etc.

Until 1863 all the lights of the French coasts were furnished with apparatus for oil; and it was not until this epoch that there was installed, at one of the two lights of la Hève, the first apparatus for lighting by electricity. After a year and a half of experiment, the result having been most satisfactory, it was decided to light in the same way the second light of la Hève; and, about two years later, the electric light was also placed in the lighthouse at Cape Gris-Nez. Matters remained in this condition until within the last few years; and, while England counted on her coasts six electric lights, the three which we have just mentioned were the only ones in existence in France. Lately, the reconstruction of the light-house of Planier having been

[1] The French word *foyer* means literally a *hearth, a place where something is burnt*, and, in the sense used here, *the source of light and heat*, — the *space occupied by the flame of a lamp or by the electric arc*. The word is so useful that I take the liberty of using it in place of an English paraphrase.

judged necessary, it was decided to use the electric light in it; and the same decision was taken regarding the lighthouse of la Palmyre, whose luminous intensity was recognized as insufficient.

But the good results given by the electric light at la Hève and at Cape Gris-Nez called attention to the more general service it could render; and on the 27th January, 1880, after a long study of the question, M. Allard, director of the French lighthouse department, presented to the minister of public works an important report, recommending the general adoption, upon the whole extent of the French coasts, of electric lighting. This report was approved on the 4th December, 1880, by the Conseil général des ponts et chaussées; and the principle of electric lighting has just been adopted for the entire extent of the coast. This decision was so important that it seems proper to mention here the principal points of M. Allard's report, to make known the arguments brought to the support of using the electric light, and the results obtained in various trials, and, finally, to give details of the electric installations of this nature actually in use.

Before mentioning the considerations in favor of changing oil for electricity, we must speak a few words on the range of lighthouses. The *range* is the distance to which the light is visible at sea; the *circle* of range has this distance as a radius, and the light as a centre. The range of a light depends not only upon the optical conditions in which the light is placed, but also upon its height above the level of the sea. Thus there is a distinction between the *geographical range* and the *luminous range;* the latter being the one under consideration. It increases with the transparency of the atmosphere, which is very variable, and changes with the locality; thus, on an average, it is much greater on the Mediterranean than on the south-western coasts of France, greater on the latter than on the shores of Brittany, and becomes the least in the British channel. Moreover, the transparency varies according to the seasons; and there are, during the year, a certain number of more or less foggy days, during which the transparency of the air and the range of the light are both diminished. It is impossible, therefore, to fix the range as a certain quantity; and it is necessary to establish a mode of designating the varying range. To do this, observations are made during the year on the variations of the range; the foggiest nights are then omitted, and the minimum range for the remainder of the year represents the range for that portion of the year. If, for example, thirty nights, or one-twelfth of the year, are deducted, and, during the remainder of the year, the smallest range is twelve nautical miles, it is considered that the light under consideration has a range of twelve miles for eleven-twelfths of the year. In short, the range of a light during a portion of a year is the distance at which it is always visible during that portion.

In order that the lighting of coasts be efficient, it should be continuous, so that a vessel sailing along the coast, as soon as it passes the range of one light, should come within that of the next; in other words, that the *circles* of range should cut each other successively. With the system of oil-lights now in use, this is actually the case, but only during half the year: during the other half, the oil-lamps have not sufficient power. It will be very different when the electric light is used. The ranges will be increased, and the circles of ranges will cut each other during eleven-twelfths of the year.

The accompanying outline map, Fig. 1, shows what would be the ranges if the electric lights were used, supposing that each light had a mean intensity of 125,000 carcels. The dotted lines show the present ranges with oil-lamps. When the electric light is adopted, the range of the new lights will be 27.7 nautical miles in the Mediterranean for $\frac{14}{15}$ of the year, 19 to 21 miles in the British channel for $\frac{10}{12}$ of the year, and 22 to 26.5 miles on the Atlantic coast for the same period.

If the increase in the range, by using the electric light, is a powerful consideration in favor of this system, objections may, however, be made on the score of economy. The report of M. Allard shows that the expense of executing the entire programme, even including the installations of steam-sirens, will not exceed $1,600,000; which is very reasonable compared with the results obtained. Besides, the cost of maintenance of electric lights is not, as one might have supposed, much greater than that for oil-lights. Thus the annual expense of a first-order oil-light is about $1,660 per year; while for each electric light-house at la Hève the cost is $2,270, and for that of Cape Gris-Nez $2,680. If it is desired to compare the cost of a unit of light for a lighthouse lit by oil with one lit by electricity, it is found that the former costs $81 per unit, while the latter is $22 at Cape Gris-Nez, and $19.40 at la Hève.

It should be said here, that there is only taken account of, in the above figures, the light of the *foyer* itself, independently of the optical apparatus; which, by concentrating the rays, augments the intensity very considerably.

The number of electric lights comprised in the project is forty-six, counting as two the double lights of la Hève, of la Canche, and of Hourtin. Of this number there are thirty-eight of the first order, two of the second order, five of the third order, and a new one to be placed at the south of Paimpol. Four of these lights are already, or are about to be, lighted electrically.

As to the distribution of the lights, it is easy to follow it upon the map, Fig. 1: almost everywhere the circles of ranges cut each other; and, where there is a gap, it will be filled with an oil-light. This map also gives the distinctive characteristics of the different lights, and this is a most important point to be considered.

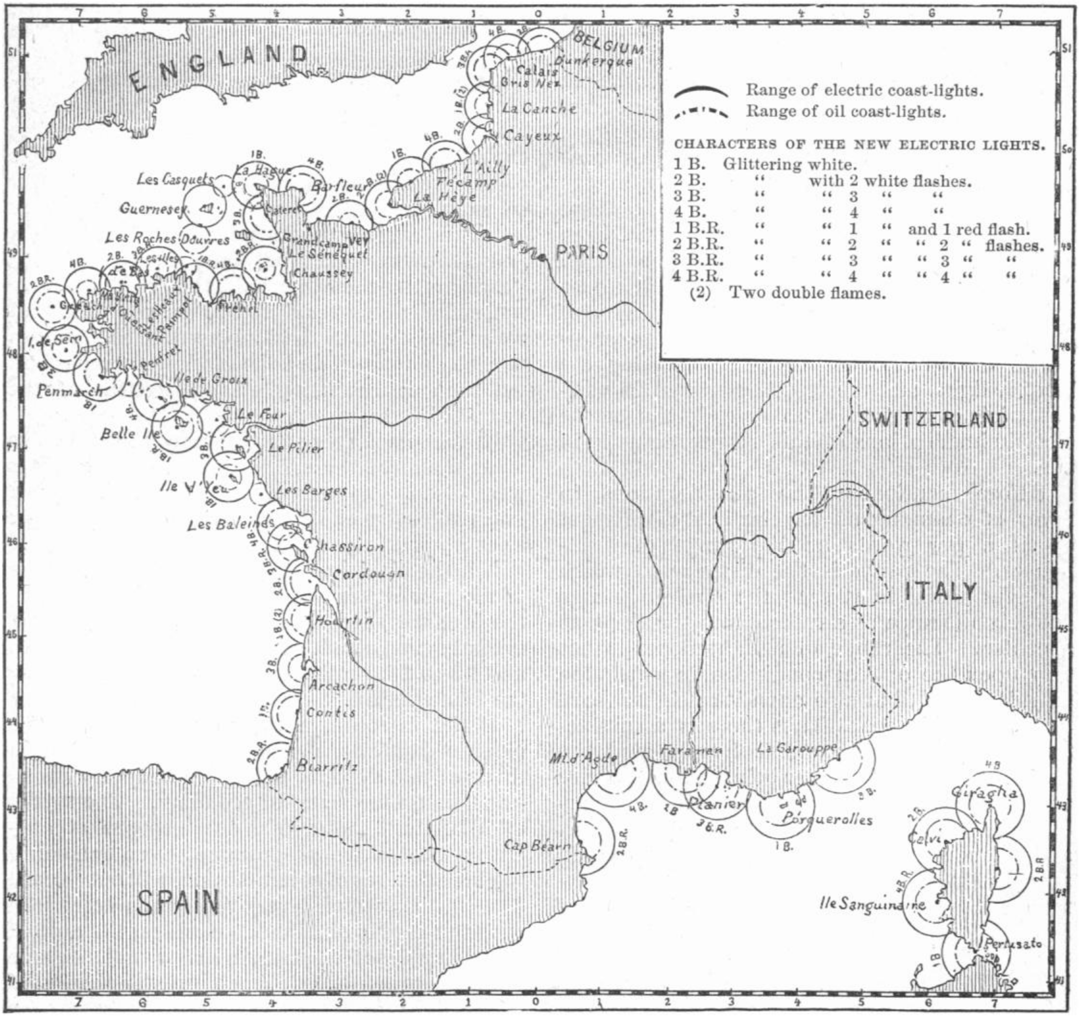

FIG. 1.

In a good system of coast-lights, the neighboring lights should have very distinctive characteristics, in order to avoid all possible confusion. In the existing system, these conditions obtain; and the first idea which naturally presented itself was to retain the old characteristics, simply substituting the electric for the oil light, so that there would be no change from that to which sailors were accustomed: but the existing characteristics are, in some ways, inconvenient, and it has been decided to replace them by others; which, by making the lights more easy to be distinguished, will, besides, increase the range.

The present characteristics are as follows: —

1. A single fixed light.
2. A double fixed light.
3. An eclipsed light, with flashes every half-minute.
4. An eclipsed light, with flashes every minute.
5. A fixed light varied by flashes every four minutes.
6. A fixed light varied by red flashes every four minutes.
7. A light with alternate red and white flashes.

Fixed lights are obtained with a Fresnel apparatus with cylindrical lenses; the double fixed light, by two lights situated at such a distance that they can easily be distinguished from each other, but still appear to form a pair. Fixed lights will eventually disappear, because they have a less range than flashing lights, and also are liable to be confounded with other fixed lights not belonging to a system of coast-lighting.

Flashing lights are obtained by means of optical apparatus having generally eight faces: each face comprises, first, a lens of the same width as the face, then, above and below, portions of rings having as a common centre the centre of the lens. The apparatus thus gives rise to eight beams of light, separated by dark intervals; and, when it is turned, the navigator sees alternately a flash and an eclipse. The intervals between the flashes depend upon the rapidity of rotation. This light has the inconvenience of requiring sustained attention, and of consulting a timepiece to tell the length of the interval. It should be suppressed.

The fixed lights varied by flashes are obtained by means of an apparatus for a fixed light around which turn two or three vertical lenses which give flashes, either white or red, or alternately white or red, at intervals of some minutes. These slowly revolving lights have the same fault as the preceding, and will also eventually disappear.

The characteristic which will be generally adopted is that of a *scintillating* light. To produce it, a fixed-light apparatus is employed, around which revolves a drum of lenses, placed vertically, composed of straight glass bars of lenticular cross-section; each of these concentrates the horizontal rays, and consequently produces a flash. During a rotation, if all the lenses are alike, the navigator will see a series of equal white flashes, producing a scintillating light. If the vertical lenses are alternately red and white, there will be alternately a red and white flash, and a compound red-and-white scintillating light will result. In the same way, by placing the lenses in groups, there can be two, three, four, or more white flashes, followed by a red one. It should be remarked, that, in this case, as the red color diminishes the luminous intensity, the red lens should have larger dimensions to compensate for this loss: as this causes a loss of light, M. Allard prefers, in most cases, to separate the group of white flashes simply by an obscure interval. This is obtained by a simple modification in the form of the vertical lenses. There are thus the following eight characteristics: —

1. White scintillating light.
2. Light with alternate red and white flashes.
3. Light with two white flashes and one red successively.
4. Light with three white flashes and one red successively.
5. Light with four white flashes and one red successively.
6. Light with two white flashes, with intervals of obscurity.
7. Light with three white flashes, with intervals of obscurity.
8. Light with four white flashes, with intervals of obscurity.

These are the only characteristics which have been definitely adopted. They have the advantage of being readily recognized without consulting a timepiece.

LETTERS TO THE EDITOR.

The new comet in Pegasus.

I DESIRE to give publicity to the following statement regarding the priority of discovery of the new comet in Pegasus. I discovered it at seven o'clock last evening; and, as soon as the direction and rate of motion was ascertained, I repaired to the telegraph-office (a mile away), and telegraphed its discovery to several astronomers, and to Professor Pickering to cable to Europe. In journeying thither I must have passed the messenger-boy with a telegram from Mr. W. R. Brooks of Phelps, N.Y., which I found at the observatory on my return, announcing to me his discovery of the same object.

It was then too late to undo the mischief I had innocently done. In fact, I was not even then sure that there was any guilt attaching to the transaction, as he did not give the time of discovery. He immediately wrote, however, giving the time as forty-five minutes past six, local time, which letter reached me to-day.

I consider it my duty to give to the world the above facts, that no injustice be done to Mr. Brooks. No instance occurs to me of a comet having been discovered by two persons so nearly simultaneously.

The comet is quite bright, with a strong central condensation, though no nucleus could be detected. Its tail was about 40′ in length, faint, straight, and narrow.

The shutter of the dome of the observatory is undergoing some slight repairs, which prevented the use of the 16-inch refractor; and I was, in conse-