would be secured. In a sense it is not the mercury present in the bath that supports the weight, but that which is absent, for if the bath is quite filled with mercury before introducing the float, on doing so, just as much mercury will overflow as balances the weight floated, and the quantity remaining is of no consequence, so long as it has head enough to exert sufficient pressure on the bottom of the float. This arrangement enables us to drive the optic much faster than the old chariot would go, although such have been speeded up by the use of ball bearings in the carrying wheels, or by running the smaller sizes at least on a ring of steel balls. Thus, the South Head light takes 16 minutes to make one revolution, while Norah Head and Cape Byron revolve in 10 seconds—so we can use fewer panels and get a lighter and cheaper optic with the same or better results. The favourite modern system is to use two large panels of circular outline, placed back to back like an oyster shell, hence known as the bivalve arrangement, each of which concentrates the light received over its whole area into a beam of small divergence and hence great intensity, which, sweeping round the horizon with great angular velocity, is seen by the observer for only the fraction of a second.

In France, where these "feux eclairs," or lightning flashes, were first introduced, one-tenth of a second is made the standard duration of a flash, in Britain one-fifth second is preferred, and in New South Wales, this longer, or, at any rate, not so short, a period has been chosen for our two "lightning flashers"—Norah Head and Cape Byron. Although such flashes may be quite perceptible, unless they succeed each other at short intervals, there is a difficulty in getting a bearing of the light taken, hence the intervals of darkness should not exceed five seconds. Everyone who has been at sea must have noted the annoying way in which a flashing light, after a long interval of darkness, seems to bob up in quite a different place from before, and if the light is not to be "like the borealis race which flit ere you can point the place," a reasonable frequency is necessary—Norah Head gives a flash lasting one-fifth of a second every five seconds, and Cape Byron was originally designed for the same, but to distinguish it from Norah Head, being constructed about the same time, and to try Brebner's system of occulting shutters, this latter apparatus was added, which cuts out the light at every alternate revolution, so that the flashes of one-fifth of a second succeed each other every five and fifteen seconds alternately. As the lights are 300 miles apart, there is no great need for distinguishing them from one another, and the long interval of darkness impairs the usefulness of Cape Byron considerably, consequently it has been decided, at the end of this month (July, 1905) to remove the occulting gear and restore to the light its full power.

In France and England, the latest practice seems to be to strike a mean between one-tenth and one-fifth second in the duration of the flash. One-tenth is found too short for the eye to have full perception; and in England it is being found better to make the frequency often, although by doing so the duration is reduced. The powerful electric light at St. Catherine's (Isle of Wight), which used to give a painfully dazzling long flash of five seconds very half-minute, has just been altered to give one-fifth second flash every five seconds; while the new electric light at the Lizard, which gave, when installed in 1902, this character of one-fifth in five, has also been altered to give about one-eighth in three seconds, by increasing the speed of rotation.

But though the flashes are less than momentary, their intensity is such that we may reckon Cape Byron and

Norah Head amongst the world's more powerful ones, Cape Byron giving a beam of 145,000, and Norah Head of 110,000 candles. A very intense light is in itself objectionable, as it affects the eye so as to produce the effect of absolute darkness on its disappearance, but it is necessary if we want a long range and penetrating power. In a clear atmosphere, the range of a moderately powerful light is its geographical one, that is, it extends to the horizon, whose distance depends on the earth's curvature, the refraction of the air, and the height of the source of light above the sea. Hence the visible distance of a light in clear weather is determined chiefly by its elevation, and to compare the power of lights by their ranges as given in official lists is misleading. Norah Head has a nominal range of 18 miles, but can be seen in clear weather from the South Head Light, 45 miles off, this, of course, being due to the elevation, 346 feet, of the South Head Light above the sea. Even an ordinary kerosene lamp as used in night signalling on the heliograph system, can be seen in clear weather with a glass at 40 miles, if the elevation permits. Had we always a clear atmosphere then, the higher the lighthouse the better, but unfortunately at great elevations we often have cloud and fog while the sea is clear below. The highest placed light in the world is perhaps Gavdo Island, south of Candia, 1181 feet above the sea, which is nominally visible for 25 miles, but has been seen 43 miles off. We have a good second to it in Australian waters, Deal Island, in the Kent Group in Bass Straits, 957 feet high, which should be visible for 36 miles, but the remark on it in the Admiralty list of lights is,—"the light is often obscured by fogs." Lundy Island light, in St. George's Channel, which had a height of 540 feet, was, in 1897, removed principally for this reason, being replaced by two lights at the extremities of the Island of 165 and 175 feet elevation respectively; and Beachy Head light in the English Channel was recently re-built at the foot of the cliff on which it used to stand, 150 feet below its former position. Even in an absolutely transparent atmosphere, while the intrinsic brightness of the light would remain the same whatever the distance, its candle power would diminish as the square of the distance increased, or its luminous range would be proportional to the square root of the candle power. But we never have such an atmosphere. The clearer the air the bluer the sky, and this blueness seems caused by exquisitely minute dust particles of some sort in the air. When these are comparatively few, the blue is deeper and darker; when they increase, the colour pales through ultramarine and turquoise and milk-and-water tint to a hazy white. They veil from us the absolute blackness, the outer darkness, of the interstellar vacuum, which we would see, spangled with stars even in the noontide sun, otherwise.

Thus, even in clear weather, about one-twelfth of the light is lost in the first mile. The researches of the French Lighthouse Administration have shown that the co-efficient of transparency is never more than .96 per kilometre, and is in hazy weather in the Channel .7, while in really thick weather it is considerably lower. Point 96 corresponds to about .926 per nautical mile, that is, only 926/1000 of the light gets beyond a mile distance. As we go farther in a uniform atmosphere, the light decreases at compound interest, so that the co-efficient becomes .926 squared at 2 miles, and .926 to the 20th power, or only .215 at 20 miles. If we take .7 per kilometre, the co-efficient for hazy weather, which is about .51 per mile, at 10 miles about 1/800, and at 20 miles only 15/10,000,000 of the light gets through, so that at the latter distance it would be quite invisible, especially as the abovementioned law of inverse squares makes the intensity of the illumination at 20 miles only 1/400 of what it would be even in a transparent atmosphere at 1 mile.

Thus while all we can do to increase the range is to increase the candle power, the range increases at a vastly smaller rate, especially in hazy atmospheres. In the English Channel, a light of 5,000,000 candles has in average weather a range of 44 miles, while increasing it to 10,000,000 candles gives only 5 miles more, or 49 miles. In the clear air of the Mediterranean, and, doubtless, also under our blue Australian sky, a light of half-a-million candles has as great a range as one of five millions in the Channel.

Hence we find the most powerful lights of Europe and America on the foggy shores of the North Atlantic, and the narrow seas of the North with the exception of the Mediterranean lights of Tino near Genoa and Planier near Marseilles, which are in the front rank. The Navesink light near Sandy Hook, in New York Bay, gives the most powerful flash yet emitted, a beam of 90,000,000 candles. Established in 1898, it is of the same order and character as Norah Head, a bi-valve of 700 m.m. focal distance, but it is lit by electric arc, and the flash lasts but one-tenth second, as against Norah Head's one-fifth. The United States were very backward in adopting the electric lighting of their principal landfalls, but when they began, they did so emphatically. They made a start we may say in 1886, with "Liberty enlightening the world," the colossal statue on Bedloe Island, New York—holding up an electric torch of 60,000 candle-power, with red and green electric jewels in her coronet, but Navesink is erected on business principles.

In France it has been found better to use a double apparatus than to put all the lights in the one optic. The new powerful lights at Ushant, the monumental "Phare d' Ecmuhl" at Penmarch, and others have twin lamps on the same revolving platform, each with four panels so that they give four lightning flashes per revolution; corresponding panels of each lamp being accurately parallel, so that the double flash of over 30,000,000 candles appears as one. It is found that a greater candle power is obtained with two arc lamps than with a single one, using the same amperage and voltage. Several of their new oil lights are arranged similarly—the Isle Vierge for instance, which was shown in the Paris Exhibition of 1900, and uses an incandescent mantle with petroleum vapour.

What seems wanted in our lighthouses is a means of throwing a beam of light of small divergence vertically upward; it would illuminate the clouds overhead, and send a shaft of light through the haze which would often be of great service, though in clear weather it would be lost or unnecessary. Shipmasters can frequently locate a light from the undesigned glare it produces in the sky while the light itself is invisible, and it would not be difficult to enhance this effect.

The map shown gives the position of our New South Wales lights, their luminous ranges being indicated according to the Admiralty list. The English Channel, with the principal English and French lights is shown to the same scale.

Thus these two great nations celebrate their "entente cordiale" by illuminating the great maritime "trunk road" to Northen Europe, and New South Wales beams across the Pacific to the great republics of the West.

DESCRIPTION OF DIAGRAMS.

Incandescent Petroleum Burners.—The two burners marked "French Service des Phares" (Plate vii. Figs. 1 and 2), were exhibited at the last Paris Exhibition. The petroleum (ordinary kerosene) is forced up by pneumatic pressure through the tube surrounding the mantle and is there vaporised, the vapour mixes with air at the nozzle, and burns under the mantle as ordinary gas does. The lower figure shows the vaporiser on one side of the mantle only, the supply pipe being behind it, so as to avoid the double shadow the first arrangement gives, the tubes being connected by means of a nipple with a removable screw cap for cleaning purposes.

Matthew's burner described at the St. Louis Congress is somewhat similar, instead of a plain tube there is a coil enclosed in a small casing over the mantle—this, of course, obstructs much of the light that would go to the upper parts of the optic. Chance's burner (Plate viii. Fig. 3) is sketched along with the pneumatic forcing arrangement for the oil. The pump fills one receiver with air at five or six atmospheres pressure, this passes through a reducing valve to the second receiver, in which is the oil, and forces it up to the lamp, where it is vaporised by a subsidiary flame near the base, the mixed vapour and air passes up to and burns under the mantle, giving a shadowless emission of light. Lepante's lamp is similar—the pressure drums and arrangement for mounting the lamp on the column for suporting an ordinary oil lamp are indicated.

The burner shown in action works also with a subsidiary flame to vapourise the oil. It is by Messrs. Schmidt & Ford, of Sydney, and has been tried in place of one of the oil lamps at Hornby Lighthouse for some months, and works steadily and well.

Red and White Flash Equalising Optic (Plate viii. Fig. 4).—A red glass screen intercepts and colours about one-half the direct light of the burner, and this is concentrated by an optical arrangement which combines the rays into a beam with only 8 or 10 degrees divergence. Only about half the direct light on the other side passes through the optic, which gives the white flash of the same divergence, the other half being stopped by mirror screens which reflect it back, through the focus and the red screen, to reinforce the red light on the other side. A good deal of this reflected light is stopped by the burner and flame, which are opaque, but it is not wholly lost, as it would be if the screens did not reflect. The diffiused light between the optics is lost and soon becomes invisible, much of it being stopped by the framing of the apparatus.

Characteristics of New South Wales Lights (Plate ix.). —The circular figures show the number of flashes or beams simultaneously emitted by the revolving optics, the radical white spaces corresponding to the number of lenses or panels in each. The sequence of flash and eclipse is shown by the rectangular figure. Thus Cape Byron and Norah Head each give two flashes per revolution, as they have bi-valve optics, making a revolution in 10 seconds, hence they give each a brief flash every 5 seconds. This is modified in the Cape Byron arrangement by occulting shutters worked by cams which eclipse the flashes every alternate revolution, thus the actual sequence is flashes every five and fifteen seconds alternately—these shutters ar to be removed at the end of this month— S. Solitary and Seal Rocks Lights have very similar characteristcs, a long flash (five and seven seconds respectively) every half-minute, but Seal Rocks' optic has double the number of panels that South Solitary has, and takes double the time to make one revolution. Sydney South Head, or Macquarie, electric light is similar in character to Seal Rocks, but on a larger scale, while it revolves even more slowly, taking 16 minutes to make a revolution and giving a flash of eight seconds every minute. The greater part of the light emitted toward the landward side is reflected back seawards by a fixed, curved, di-optic mirror, which sends it back past the focus to the seaward panels. As the carbons and carbon-holders would stop nearly all this light if directed exactly to the focus, the reflected light is made to pass a little to one side of these, and hence is not accurately concentrated in the merging beams, but is not wholly lost. Montagu Island light is a combination of a flash and a diffused light; the four flashing spherical lenses concentrating the light horizontally as well as vertically, while the four intermediate cylindrical ones only affect the vertical divergence, allowing the light to spread horizontally, consequently their beams get invisible long before the others, and at long distance it appears a flashing light with long eclipses, and is hence vague in character. Point Stephens has a red or white flash every minute, separated by a short eclipse; the concentration is effected by metallic parabolic reflectors at the back of each lamp, and the flashes are not so sharply defined as with di-optic arrangements. The colour of the red light is produced by using ruby glass chimneys instead of white, which is a slight improvement on the use of plain red glasses in front of the reflectors; but the white flashes can be seen at a much greater distance than the red.

Smoky Cape Light.—This gives three short flashes every half-minute, the optic having nine panels arranged in groups of three, so that in sectional plan it is somewhat triangular, each side having three panels making very obtuse angles with each other. Point Perpendicular light at Jervis Bay is similar, but the revolution is made in one minute instead of 90 seconds, as at Smoky, so that the group of flashes occurs every twenty seconds. This is as fast as it is convenient to rotate a large-sized apparatus carried on rollers. These two lights are, after the "feux-eclairs" of Cape Byron and Norah Head, the most modern on our coast.

Norah Head Lighthouse (Plates x. and xi.).—Two order "feux-eclair" di-optric apparatus. This shows general arrangement of lenses, lamps and rotating machinery. The cast-iron mercury tank is annular in form, supported in a central fixed post by a large nut running on a screw thread cut in lower part of post, so that the tank or bath may be raised or lowered by turning it round, there being set pins to lock it in position. The filling cup and draw-off cock for mercury are shown. The hollow annular float carrying the platform and lamp nearly fills the bath, floating in about 3cwt. of mercury. There are two rings of ball bearings round the central post to keep the arrangement steady. The annular rack or spur wheel bolted to the top of the float is driven by a pinion worked by clockwork, the clock mechanism being driven by a weight suspended in a tube going down the centre of the tower to the ground. This has to be wound up by the keeper every two hours or so, although there is drift enough to run all, or nearly all, night; a device on the clock ensures its working even when winding up the weight. The lamp is supplied from the reservoirs at either side, either of which holds enough for a night's consumption, the oil drips into the constant level cup at about the level of the burner, and is thence led by pipes to the wicks, the overflow from these and from the c.l. cup being caught in the pans on the platform. The glass chimney of the lamp is surmounted by a sheet iron one (not shown) leading up to the top of the lamp room, with a damper in it, by manipulating which the flame is regulated, the wicks not being touched after once lighting. Access to the interior of the optic is got through a hatchway in the platform and a ladder from the top of the float, revolving with it, but the attendant keeps his watch and regulates the damper outside.

Norah Head Lighthouse was erected in 1902, at "Bungaree Norah," the entrance to Tuggerah Lake, 20 miles south of Newcastle; a view of the tower, built of concrete blocks, with a stone parapet (trachyte) round the gallery is given.