ever, that spherical aberration has little, if any thing, to do with it, as, in lenses constructed on the modern curves, this defect has been practically reduced to zero. If now we take a perfectly corrected, wide-angled lens, and focus it on the centre of the plate, we shall find that the objects near the edges are somewhat indistinct, and by no possible combination of curves can this difficulty be wholly remedied; it is, however, reduced proportionally to the size of the stop employed. It has been shown, by Prof. E. C. Pickering and Dr. C. H. Williams (*Proc. Amer. acad.* 1875, 300), that, with a single lens, a series of concentric circles would be focused on a spherical plate whose radius of curvature was 0.7 the focus of the lens. On the other hand, the diameters of these circles could only be accurately focused on a spherical plate whose radius of curvature was 0.3 of this focus. As far as the writer is aware, no name has ever been given to this optical defect; but for convenience' sake it might be called the *field aberration.*

If the central object on the plate is of the most interest, we shall focus on it, and then push in the plate as far as possible without injuring the central definition, to obtain the best possible result at the edges. Supposing now we insert a smaller stop, the definition over the whole plate will be improved certainly; but, that at the centre having been sufficiently sharp before, we can now afford to push in the plate a little farther still, and obtain better definition at the edges, without perceptibly injuring that at the centre. Therefore, on theoretical considerations merely, we should always focus with the stop we are going to use. But, on the other hand, for lenses of less than 45° angle, or when the illumination is very faint, the practical advantage of a bright image for focusing would more than compensate for the advantages of using the other stop. In practice, for accurate work, the best way would be to determine once for all the difference of focus required by each stop, and then focus with the largest, and apply the proper correction, depending on the stop used.

W. H. PICKERING.

HISTORY OF THE APPLICATION OF THE ELECTRIC LIGHT TO LIGHTING THE COASTS OF FRANCE.[1]

II.

THE Serrin regulator, arranged for alternating currents, has been adopted as the standard lamp. No other apparatus has given better results. Especially with alternating currents, its working is excellent, because the armature of the electro-magnet detaches itself very easily; and besides, as the consumption of both carbons is uniform, the arc remains absolutely fixed.

The machines for generating the current have been of late years the subject of attentive study, which has been unfortunately confined to three types, — the Alliance, Gramme, and de Meritens. The luminous intensities of each of these machines have been measured under carefully arranged conditions. Photometric measurements in such cases are rather delicate. To make them, since the intensity varies in the vertical direction with different heights, a movable mirror is used, which is placed at different heights in the same vertical plane, and which, in each position, throws the rays on the photometer; and thus the average intensities could be obtained. But, as the intensity of the electric light constantly varies, it was necessary to make the observations at one-minute intervals for each position of the mirror. It is not necessary here to go into the details of construction of the different machines; the table below gives the results obtained.

MACHINES.	Number of revolutions per minute.	Horse-power.		Luminous intensity.	
		Total.	Less power used in transmission.	Total.	Per horse-power.
				Carcels.	
Alliance	450	5.18	4.62	275	59.5
Gramme, No. 1 .	550	12.04	11.48	1,010	88.5
" No. 2 .	600	6.01	5.45	493	90.0
" No. 3 .	680	7.06	4.20	342	81.4
De Meritens . .	790	8.06	7.50	536	84.8

It will be seen, that the Alliance machine gives a far less intensity per horse-power than the two others, which are approximately equal. The de Meritens has certain characteristics of stability and solidity which the Gramme machine does not possess; it was, besides, preferred to use alternating currents. For these reasons it has been adopted, and will be installed in all the new lighthouses.

The figures giving the intensity in the preceding table refer to the naked light. When this is placed in a fixed-light apparatus, these intensities become, in round numbers, 12,000 carcels with the Alliance, and 20,000 carcels with the Gramme No. 2. The flashes increase

[1] Continued from No. 5.

the intensity still more. In a scintillating light with red and white flashes there is an intensity

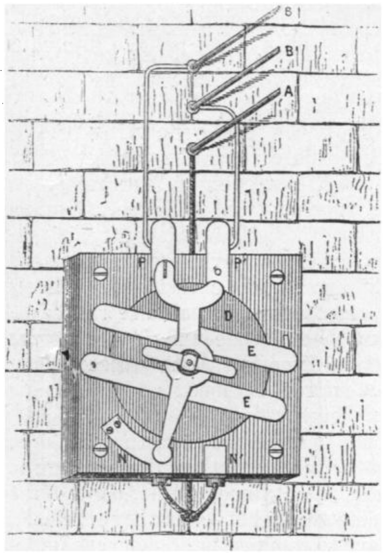

FIG. 2.

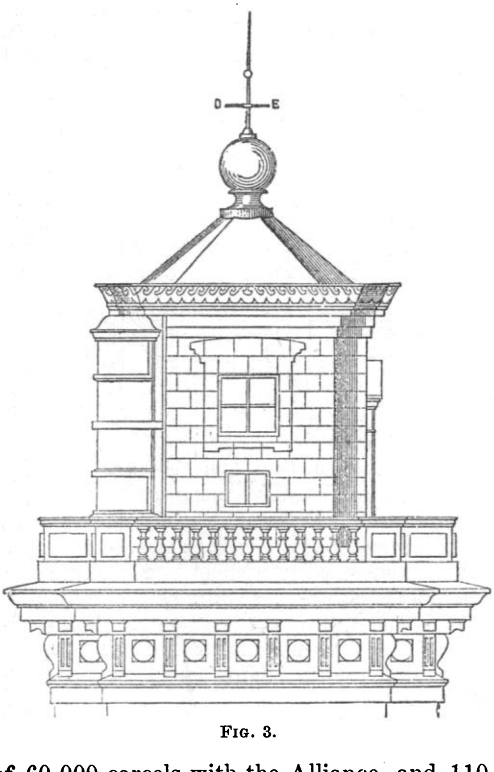

FIG. 3.

of 60,000 carcels with the Alliance, and 110,000 carcels with the Gramme machine; with a scintillating light with groups of white flashes, 90,000 carcels for the former, and 150,000 carcels with the latter. The intensities with the de Meritens machine are about the same as with the Gramme; and 125,000 carcels may be taken as the average intensity when the electric light is used.

Some details will now be given of the installations actually existing, and of those in process of construction; specially describing the lights of la Hève, the first in date to be electrically lighted, and the Planier light, whose installation has just been completed.

The lights of la Hève, situated on the cape of this name and on the top of the cliff, are, from this fact, very elevated: so the towers themselves are not of great height. Both

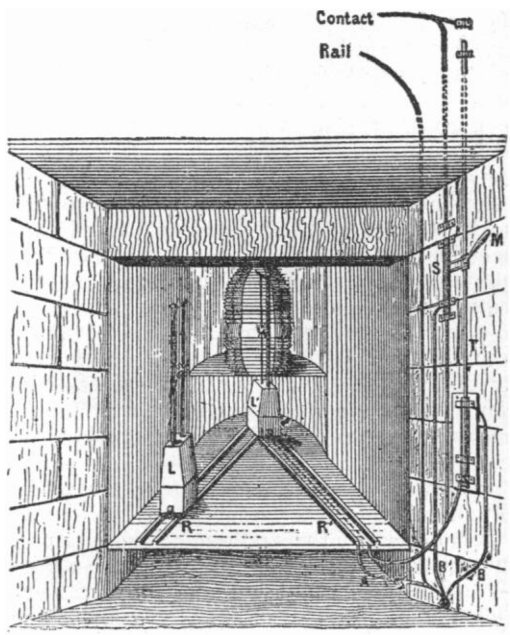

FIG. 4.

towers are square, and are placed about sixty metres apart; between them being the long building containing the steam-power, generators, and quarters for the keepers.

There are four Alliance machines, — two for each light. The two on the left supply the left-hand tower; and the two on the right, the tower on the right hand. The conductors leading the current from the generator are first thick copper rods connected with the commutator, Fig. 2. The rod A communicates with the two similar poles of the two machines, the rods B and B′ being connected to the opposite poles. Ordinarily one machine supplies each light. Thus the current arrives by A, and, without traversing the commutator, goes by the cable to the regulator (or lamp); thence it returns by the second wire of the same cable to N, follows the vertical conductor to P, and returns to the machine by the rod B. If it is desired to use the machine corresponding to

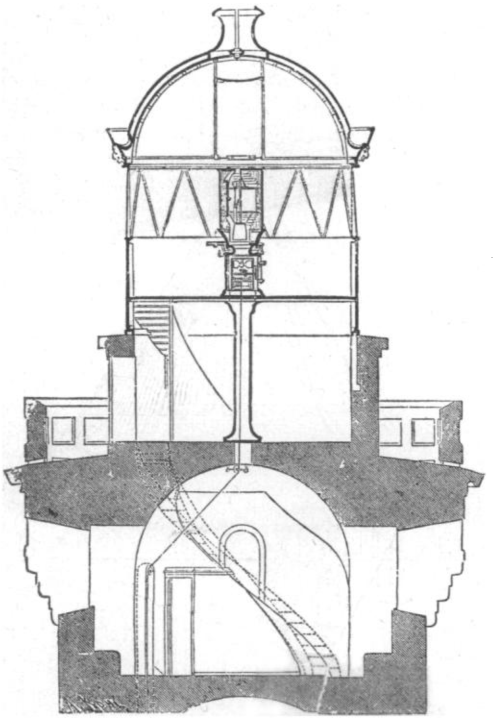

FIG. 5.

the rod B′, the central handle is turned, thus bringing the plate D in contact with P′ instead of P, retaining always the contact at N. In this case the current arrives, as before, at A, goes to the regulator, returns again, but passes this time from N to P′, and thence to the machine by B′.

In foul weather, or whenever it is necessary to increase the luminous intensity, both machines are coupled in quantity. The commutator is then turned until the plates E and E′ are in contact, — the one with P′ and N′, the other with P and N; the return current flowing simultaneously by B and B′.

The tower of each light is surmounted by a square structure, at one of the angles of which is the optical apparatus. This is clearly shown in Fig. 3. A kind of glass drum closes the open angle of this structure which is in two stories, in each of which is a distinct optical apparatus. The intention of this arrangement is to allow one optical apparatus to be instantly replaced by the other, in order to avoid total extinction in case of accident. In each story, there are two regulators, which can be substituted for each other by means of the crossed rails shown in Fig. 4. The cable with three conductors leading from the commutator, previously described, arrives at the lower story. One of the conductors (A) is connected to the metal platform carrying the rails, also metallic; the conductor B connects with the sliding rod of the long bolt M T. When this bolt is lowered, it connects the conductor B′ with a wire going from the bottom staple of the bolt to a spring contact under the lamp. The latter re-

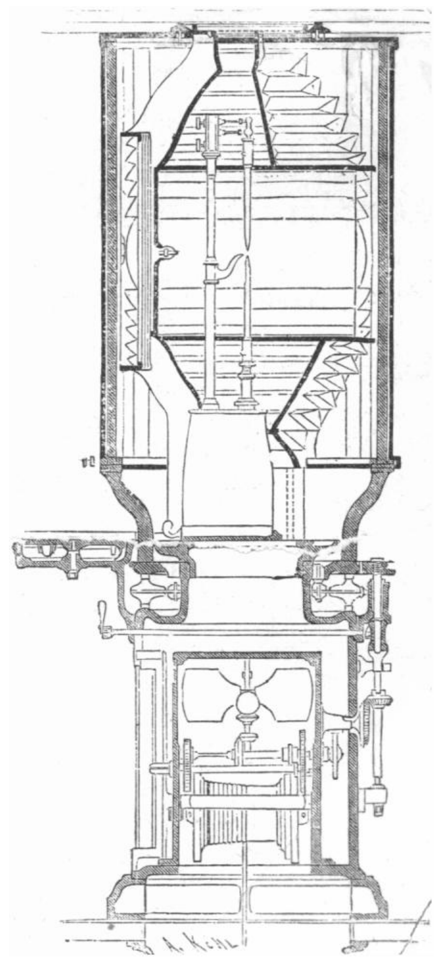

FIG. 6.

ceives the current, partly by the rails, partly by the contact underneath. The wire B communicates with a smaller bolt sliding at the same time with M T, and whose lower staple is connected to the wire coming from the staple of the larger bolt; so that, when the current passes by B′, it always traverses the lamp, and, when the two machines are at work together, the two currents are united by the connection between the two staples. The upper staples are connected in the same way to the apparatus in the second story; and, when the bolts are raised, the upper lamp is lighted.

The regulators can thus be changed in two ways, — either by drawing the lamp at work back on the rails, and quickly pushing the other one in its place; or by manipulating the commutator bolt, which shifts the luminous

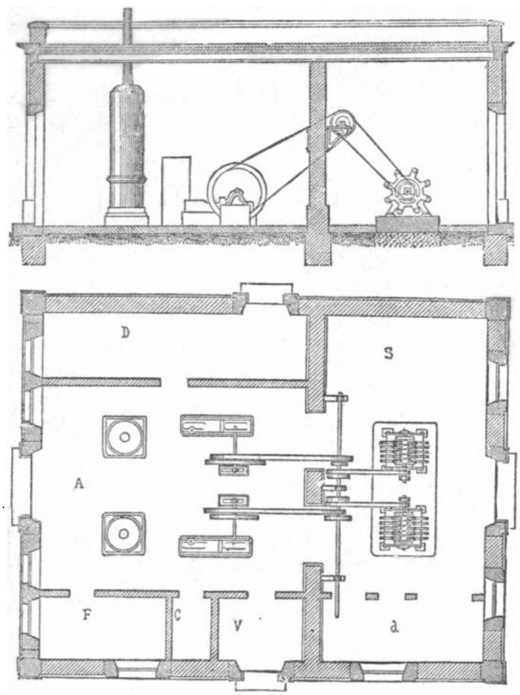

FIG. 7.

A. — Engine and boiler house. S. — Electric generator room. F. — Forge and heavy repair-shop. d. — Shop for light repairs. D. — Coal dépôt, with water-tank underneath. c. — Water-tank. V. — Vestibule.

arc from one story to the other. Since the establishment of the lights at la Hève, the latter means have been found superfluous, and will no longer be employed.

The light of Planier, which has just been finished, is about eight nautical miles from the port of Marseilles, upon a rock. It is a tower sixty metres high, and eighteen metres in diameter at the base, which rests on the rock itself.

Fig. 5 gives the details of the summit of the tower, and Fig. 6 those of the optical apparatus. In the latter figure are shown the fixed-light apparatus, and, movable around it, the drum, with vertical lenses. The mechanism for driving the latter is given in considerable detail.

In this apparatus the changing of the regulators is effected by means of a system of two pairs of rails; but they are not placed at an acute angle, as at la Hève. One enters direct

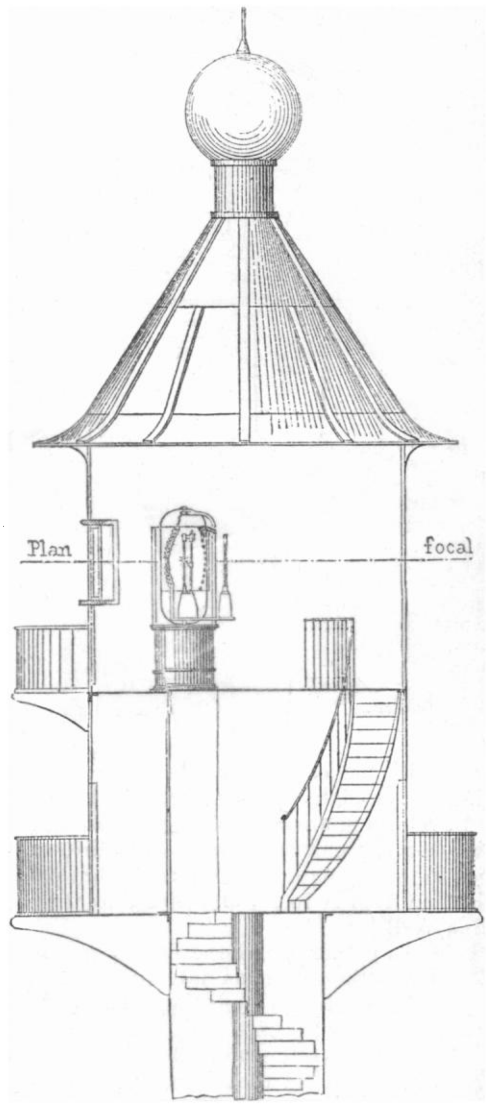

FIG. 8.

into the optical apparatus; the other is placed outside, and at right angles to the first. At their junction is a turn-table; and, with this arrangement, the manoeuvre of changing the lamps takes no longer than with oblique rails.

The de Meritens machines, which feed the regulator, are placed in a special building.

The plan and elevation of this building, which will serve as a type for those installed in most of the lighthouses, is shown in Fig. 7.

The Planier is a full horizon light. Its characteristic is that of three white flashes separated by a red flash. Its range, like that of all the new lights in the Mediterranean, is twenty-seven nautical miles for fourteen-fifteenths of the year.

We have mentioned that the transformation of the Palmyre light is also in progress. This, unlike the Planier, will throw a beam in one direction only; and the arrangement of the lantern is therefore slightly different. It is shown in Fig. 8. The general disposition resembles, up to a certain point, that of la Hève. The optical apparatus for the new fixed lights will have a diameter of 0.6 met., instead of 0.3, as was formerly employed. With the revolving cylinder of vertical lenses, this diameter will reach 0.7 met.

CRITICISM OF PROFESSOR HUBRECHT'S HYPOTHESIS OF DEVELOPMENT BY PRIMOGENITURE.

EVOLUTIONISTS have hitherto been puzzled to find a full and satisfactory explanation of the persistency of certain types, such as the familiar Lingula and others, through long periods of the earth's past. Prof. A. A. W. Hubrecht of Utrecht has offered, in his inaugural address, an hypothesis which he thinks adequate to solve this problem. The address is published in full in Nature, nos. 690–691. We may pass over the first part, which contains familiar matter only, and which, therefore, we venture to advise scientific readers to skip. The presentation of the author's own views begins near the bottom of the first column on p. 302. The habit of needless diffuseness in writing is a very grave encumbrance to scientific literature, and ought always to encounter the critic's emphatic condemnation.

The theory which Professor Hubrecht has advanced appears to us not only untenable, but unscientific; we think it might be characterized as pure speculation of that reckless quality which of late years has crept into zoölogy, considerably to the discredit of the science. To justify this condemnation, we will first state the author's hypothesis, and afterward the objections to it.

The hypothesis may be summarized as follows: 1. In many animals the period of reproduction is a prolonged one; so that there are young born of young parents, others of old parents, and, of course, of parents of intermediate age. A distinction therefore exists between first-born and last-born posterity. 2. Similarly, these first-born will likewise have first- and last-born; so, also, will the last-born; consequently there will be one set of generations of the first-born, and another set of the last-born. 3. In the first series the generations will follow rapidly, in the second series slowly, upon one another; hence, from a given pair, there will be in time numerous descendants; "a small number of these being descendants in a direct line of the first-born of every successive generation, another small number being the descendants in a direct line of the last-born of every successive generation." Consequently, of the contemporaneous generations, the individuals of the first set would have numerous ancestors; those of the second set, not nearly so many. 4. The age of the parent affects the character of the progeny. Of this, Hubrecht is able to bring forward only one example, — apparently the only one known to him; namely, that Stone found in the McCloud River that the eggs of young salmon are smaller than those of old salmon. 5. "I must now call your attention to the second cardinal point. . . . Heredity has, indeed, invested them [the progeny] with peculiarities, part of which show themselves in their organization; another part remaining latent, and only attaining development in following generations. Such a latent potential energy towards eventual modification of the individual or his progeny must needs find more occasions to unfold itself in the first-born, *simply because these are possessed of a larger number of ancestors*" (the italics are ours). 6. Asexual-reproduction is accompanied by less variation than sexual.

From these premises, the deduction: that the first-born of sexual generations are the principal variants, and *ergo* the principal source of new species; and the last-born, *per contra*, the representatives of stability.

In rejoinder to this plausible but specious argument, our contention is, *first*, that we cannot assume that there are really any series of first- and last-born; *second*, that, granting the distinction between them, it cannot be assumed that one is more variable than the other; *third*, granting both these premises, the facts of zoölogy cannot be made to show that the permanence of types is derived from the last-born, nor that the evolution of new species depends on primogeniture to any considerable extent.

First, Any succession of first-born would depend upon both parents being first-born; and the probability of both parents so being for any considerable number of generations is so infinitely small that it might be called zero. Let us take a species which pairs (a bird, for example), and where the male fertilizes only one female. Let us assume that in a given locality there are ten of each sex, and of various ages, and that there is an equal chance of any two pairing; then the probability of the first-born male pairing with the first-born female would be 1 in 100. The chances of the next set pairing in the same manner would be also 1 in 100, if we further assume, what is the usual case, that the number of individuals remains constant. The chances of both pairs being first-born would be 100×100, or 10,000. In nine generations the chance of their being all first-born would become 1 in 1,000,000,000,000,000,000 (one million million million). Now, for birds which become mature in one year, these are the chances for nine years. Birds are known first from the Jurassic, which we will call for convenience 1,000,000 years ago; so that it might prove laborious to write out the chances for that period, the chance being the last term of a geometrical progression of which one million is the number of terms, and one hundred the ratio. Yet we have taken a case exaggeratedly in favor of Hubrecht's view. It were possible to adduce many arguments to show that the habits of animals often render the existence of a series of first-born improbable; but the previous calculation sufficiently disposes of Hubrecht's fundamental assumption. And, moreover, every such calculation would lead to essentially the same result, whatever the figures chosen to start with might be, because the chance is the last term of a geometrical progression. If Pro-