rendered to the country by Mr. J. B. Redman, who had given much attention to the question of coast erosion, and to whom the British Association Committee was greatly indebted. The speaker then proceeded, by the aid of diagrams and drawings on the blackboard, to describe the mode in which the sea acts on coasts of various kinds, and stated the rate at which erosion is taking place in different parts of the country. It was greatest along the coast of Holderness and Norfolk, where the sea gained on the land at the average rate of from 2 to 3 yards per year. But locally and during exceptional gales the rate was much higher. On January 30, 1877, parts of Norfolk lost an average of 3 yards for several miles, and near Bacton the loss was 15 yards. Typical instances of erosion were cited, among the places mentioned being Folkestone, Brighton, Worthing, Bournemouth, Westward Ho! and Pembrokeshire. The speaker then went on to describe the shingle beaches and their changes, and to discuss the effects of natural and artificial groynes. On the south coast of England the shingle travelled from west to east, and if left to itself it would form a natural protection along the greater part of the coast, and the average amount of erosion would be small. But in certain places land-owners, town-councils, and other corporations desired that there should be no loss of land, and they erected groynes to collect the shingle, and so robbed the coast to the east of its natural protection. Worthing was heavily groyned and the shingle largely collected, but just east of the town the coast was rapidly receding. Folkestone pier was a large groyne which had collected an extensive area of shingle on its west side; Copt Point and Eastwear Bay, once protected by a continuous band of shingle, were now nearly bare, and the coast was rapidly going. At Copt Point land was laid out for building, and roads were made; but the notice-board advertising "this desirable freehold building land," was seen half-way down the cliff. Natural groynes were sometimes recklessly destroyed, and this was the case at Hengistbury Head, where ironstone was quarried from the cliff and foreshore; the reef had held back sufficient shingle to protect the land to the west, but when the reef was removed, the shingle travelled on, and the land rapidly receded. Great damage was done by taking shingle for road metal, ballast, or other purposes. The amount so taken appeared small and unimportant because a single storm might throw up as much as might be taken in many months, but the aggregate amount so removed was enormous, and must tell in time. It had been estimated that the shingle removed near Kilnsea in twenty years represented a bank 3 miles long, 31 yards wide, and 6 feet deep. It was interesting to note that the erosion of that part of the coast averaged only from three-quarters of a yard to a yard and a half per year for some time before the shingle trade was so largely developed; but later on, owing to the loss of the shingle, the rate of erosion rose from 3 to 6 yards per year. The change might not be entirely due to the cause mentioned, but it clearly was so to a large extent. Although the Board of Trade had now stopped the practice at that part of the coast, it was still in full action in a large number of places. The speaker then passed to the consideration of the land gained from the sea. A great part of the material worn from the coasts of Holderness and Norfolk was carried into the estuaries of the Humber and the Wash, and there formed banks of sand and silt of great hindrance to navigation, but when reclaimed of great agricultural value. Recent estimates showed that the area of land thus made in the Humber and Wash was far in excess of that lost. Taking the whole coast-line of England, it was probable that the total area of land was as great now as it was 500 years ago. Although the general result of a survey of this question was less serious than was generally supposed, it was evident that greater control was requisite over the action of land-owners and public bodies along the coast. The powers now vested in the Board of Trade might be more rigorously and systematically applied, or fresh powers obtained. This was especially desirable along the south coasts, as there the damage done by reckless groyning was enormous, but the area of land now gained was small.

OBSERVATIONS ON HEREDITY IN CATS WITH AN ABNORMAL NUMBER OF TOES

IN 1883 I contributed an article to NATURE (vol. xxix. p. 20) upon this subject, giving an account of my observations from 1879 up to the date at which the paper was written. The last observation was concerned with a family of four male tabby kittens, all of which possessed the abnormality to a very marked extent. This was the first family produced by a female tabby (and slight tortoiseshell) cat which, when born, was the most abnormal form which had come under my notice, possessing two extra toes on all the paws, *i.e.* seven on each fore-paw and six on each hind-paw. The right paws of this cat were figured in

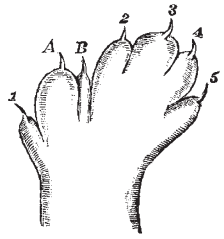


FIG. 1.—Right fore-paw from above, with extra toes.

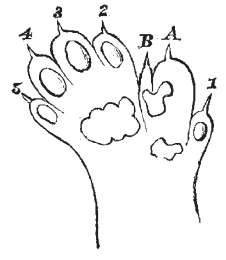


FIG. 2.—Right fore-paw from below, with extra toes.

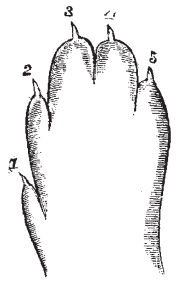


FIG. 3.—Right fore-paw from above, normal.

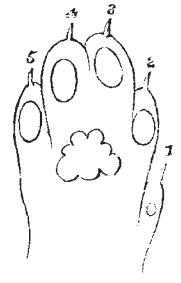


FIG. 4.—Right fore-paw from below, normal.

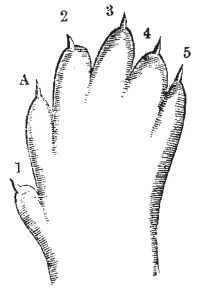


FIG. 5.—Right hind-paw from above, with extra toes.

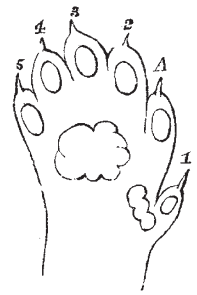


FIG. 6.—Right hind-paw from below, with extra toes.

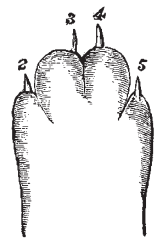


FIG. 7.—Right hind-paw from above, normal.

FIG. 8.—Right hind-paw from below, normal.

the paper referred to, together with the corresponding paws of a normal cat, for comparison. These figures are now reproduced in order to illustrate the present paper. I quote the description of the figures from the previous paper. "It is seen that the extra toes (in the fore-feet) are those labelled A and B (in Figs. 1 and 2), and they confer the extraordinary breadth upon the foot. The most recently added is B, which is still

partially coalesced with A, and has but one pad in common with it (Fig. 2). . . . There is seen to be an extra pad behind the additional toes, of which there is no trace in the normal foot." In some families to be described, and also in two previously noted, the large extra toe, A, is present, while the insignificant pollex (Fig. 1, 1) is absent, and thus the paw appears extremely broad, although with only the normal number of toes. In the hind-paws (Figs. 5 and 6) "there is little doubt that the innermost toe 1 is the hallux lost in the normal foot. . . . The second extra toe is that labelled A. . . . On the under side (Fig. 6) all the toes have separate pads, and there is an additional pad behind the extra toes," which is sometimes fused with that behind the normal toes.

This cat produced her first family, described in the previous paper, on July 10, 1883. Continuing the observations from that date, the next family (of four tabby kittens) was born in June 1884. (1) and (2) were normal—a male and a female. (3)—a female—possessed six toes on the fore-paws, each toe with a separate front pad, and a bifid hind pad (distinct from that for the other toes) to the two inner toes (1 and A in Figs. 1 and 2); the toe shown in the figure and absent in this kitten is of course that marked B—the last to be added in all cases. The hind-paws possessed six toes each, as in the mother, and with the same arrangement of pads as in her left hind-paw, *i.e.* with separate front pads to each toe (as in Fig. 6), but with the hind pads for the extra toes 1 and A continuous with those for the four normal toes (unlike Fig. 6 in this respect). (4), a female, possessed seven toes on the right fore-paw; the front pads separate except in the case of those for the toes A and B, Fig. 2, which were slightly fused. The hind pad for the three innermost toes was quite separate from that for the others. This paw, in fact, almost exactly resembled that of the mother-cat on the same side, shown in Figs. 1 and 2. The left fore-paw possessed six toes, the small one marked B in Figs. 1 and 2 being absent. The pads were in other respects similar to those of the right paw. Thus the relative amounts of abnormality on the two sides are as with the mother, the preponderance being on the right side in both cases. But the difference is here greater in both directions, the right paw having rather more abnormality than in the mother, because of the less complete fusion between the front pads of the toes A and B, while on the left side the abnormality is much less than in the mother, in the complete suppression of the toe B. The hind-paws were as in the last kitten, and similar to the left hind-paw of the mother.

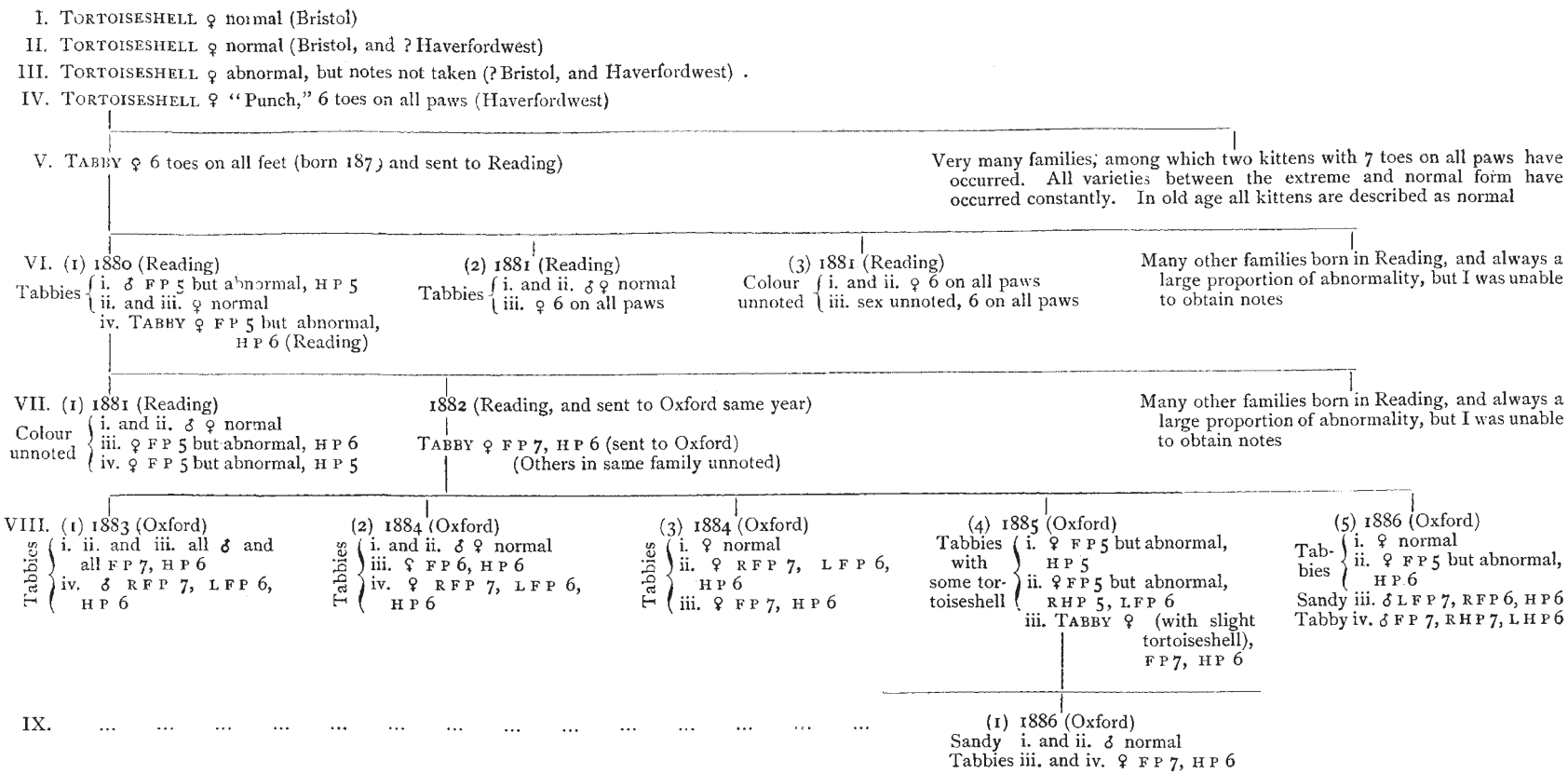
The next family (of three) was born September 22, 1884. (1), a female tabby kitten, was normal. (2), a female tabby kitten, possessed seven toes on the right fore-paw, with separate front pads to each toe and the hind pad as in Fig. 2. The innermost claw was double, the two divisions being arranged vertically one above the other, the lower being small and incomplete. In this respect, and in the separate front pad to the toe B, this paw is far beyond the mother's paw of the same side in abnormality. The left fore-paw possessed six toes, that marked B being absent. Otherwise the arrangement of pads was similar to that shown in Fig. 2. Hence this paw is more normal than that of the mother on the same side, and both fore-paws compare with those of the mother in the same manner as those of No. 4 of the last family, the only difference being the even greater abnormality of the right paw in the present instance. The hind-paws possessed six toes with separate front pads and continuous hind pads, as in the left hind-paw of the mother. (3), also a female tabby kitten, possessed seven toes on both fore-paws. The arrangement of pads on both paws was similar to that on the left fore-paw of the mother, except that the toe B could not be said to possess a front pad at all. The hind-paws were as in the last kitten and the left hind-paw of the mother.

The next family (of three) was born in September 1885. (1), a female tabby and slight tortoiseshell kitten, possessed the normal number of five toes on the fore-paws, but the foot appeared almost as broad as in the abnormal kittens. This was because the large extra toe (A in Figs. 1 and 2) was present while the much smaller pollex 1 was absent. The front pad of the large abnormal toe was also slightly bifid, so that there was some indication of the next small toe B. The hind-paws possessed five toes with separate front pads and fused hind pads. (2), a female tortoiseshell and tabby kitten, possessed fore-paws like those of the kitten just described. The right hind-paw was also similar, with five toes, but the left possessed six like the mother. The front pads were separate, as usual, on the hind-paws. (3), a female tabby and slight tortoiseshell kitten, with fore-paws having seven toes like the mother, and also resembling her in the difference between right and left. The right paw possessed most abnormality, and was more advanced than the mother, as all the toes—even that marked B—possessed separate front pads. On the left side, however, the toe marked B possessed no separate pad. The hind-paws were like those of the mother, possessing six toes with separate front pads. This kitten was given to a friend, and will be again referred to.

The next and last family (of four kittens) up to the present time was born about July 1, 1886. (1), a female tabby kitten, was normal. (2), a female tabby kitten, possessed five toes on the fore-paws, but the feet were very broad, because the large abnormal toe (marked A, Figs. 1 and 2) was present instead of the small pollex. The hind-paws possessed six toes like those of the mother. (3), a male sandy kitten, possessed seven toes on the left fore-paw, the innermost (pollex) being *exceedingly* small and rudimentary, while the right paw possessed only six toes, the pollex being absent, although both abnormal toes (A and B, Figs. 1 and 2) were present. In this kitten the difference between the sides is therefore the reverse of that in the mother. The hind-paws possessed six toes like those of the mother. (4), a male tabby kitten,—by far the most abnormal form which has yet come under my personal notice. Both fore-paws have seven toes, each possessing a separate front pad, while the claw of the small toe B is well formed and large, and its pad is large and quite distinct and separate from that of A. The claw of the pollex 1 on both sides is partially divided (towards the apex) into a large upper, and rather smaller lower, division. This tendency towards a vertical proliferation has been already described in one of the kittens of the family born September 22, 1884. In the hind pads this was also the most abnormal form yet seen, for, interior to the normal fused hind pads for the four normal toes 2, 3, 4, and 5, were arranged three pads forming an almost continuous series with each other and with those belonging to the four normal toes. These three pads diminished in size from within outwards, and the one behind the toe B was very small, and was somewhat separated from the others, and especially associated with the internal side of the fused normal pads. The hind pads for the toes 1 and A were fused, but a distinct furrow indicated the line of separation. There was no practical difference between the fore-paws of the right and left side. The right hind-paw possessed *seven* toes, or three more than in the normal animal. This is the first time that I have come across so great an abnormality in the hind-paws, although Mr. Vaughan remembers it on both right and left sides in two individuals. All the seven toes are large and distinct, and have separate front pads. Interior to the normal fused hind pads, and continuous with them, is an ill-defined series of three pads, irregularly diminishing in size towards the interior, and crowded together so that the innermost is not behind the innermost toe. The foot is somewhat deformed. The left hind-paw possesses the usual six toes with separate front pads and fused hind pads.

I now return to (3) of the family mentioned before the last—the highly abnormal female tabby which was given to a friend in Oxford. This cat produced a family (of four) on July 10, 1886. (1) and (2), both sandy male kittens, were normal; (3) and (4), both tabby female kittens, were like the mother, possessing seven toes on the fore-paws and six toes on the hind-paws. These two kittens were given to Prof. Meldola and Mr. W. White, and I trust that they will be frequently referred to in some future number of NATURE. I am now able to give a somewhat longer account of these two kittens. In Prof. Meldola's kitten the left fore-paw is somewhat less abnormal than the right, because the toe B is very small, although it possesses a front pad separate from that of A. Of course the pollex 1 has a distinct front pad. There is a single, although somewhat divided, hind pad for the three inner toes, separate from the normal pad behind the four outer digits. On the right side the toe B is large, but the arrangement of front and hind pads is the same as that on the left side. The hind-paws have large and distinct front pads on all the six toes of both sides, and the hind pads of the abnormal toes form a continuous series with those behind the normal digits.

The fore-paws of Mr. White's kitten are precisely similar in every respect, the toe B being much larger on the right side, and the arrangement of pads being exactly the same. The hind-paws only differ in the fused hind pads for the abnormal toes being somewhat separated from those behind the normal



Capitals used for those female cats which have produced families of which some note has been taken

"I., II.," &c. = generations

"1, 2," &c. = families

"i., ii.," &c. = kittens in each family

Dates and localities indicate times and places of birth of the families to which they are affixed

"FP" = fore-paw { the numbers after = toes

"HP" = hind-paw { the letters R or L before = right or left side

"FP 5 but abnormal" indicates that the small pollex is absent, but the large abnormal toe A in Figs. 1 and 2 is in its place, making the paw abnormally broad, although with only the normal number of toes

digits on the left side, while the two sets are continuous on the right paw, as in Prof. Meldola's kitten.

All the observations recorded in this paper were made in Oxford. The abnormality has now been observed through nine generations, and I have recorded notes of ten families, so that now there is sufficient material to present in a tabular form.

The notes given in this paper are much more complete than before, because the families were born in my own house or in that of a friend living near, who kindly gave me every opportunity of making notes. The results, however, would have been far more extensive if I had received intelligence of the birth of families in various quarters to which kittens had been sent.

I believe there is little doubt that the next period of three years will produce much better results in this way, for at the recent meeting of the British Association at Birmingham I exhibited the cats, and was able to give away three abnormal females to scientific gentlemen (Prof. Haddon, Prof. Meldola, and Mr. W. White) who I am sure will assist me by sending complete accounts of all the families born. I remarked in my last paper on the immense strength of heredity which was shown in the observations then recorded, remembering that the results were in all cases due to the mothers of the families. The continued observations now published serve to illustrate the same facts. As I said before, "it is practically certain that the fathers of the families have always been normal." There has, indeed, been an abnormal male cat in Oxford for the last two years—one of my kittens which I gave to Prof. Moseley for a museum specimen, and which has been kept in order that it may be quite mature. But this cat lives at some distance from my house and that of the friend to whom I gave the female kitten in 1885, and it has never been seen in our neighbourhood, while numbers of normal cats have been seen in company with our abnormal females. But nevertheless a family containing abnormal kittens was born in a house near that in which Prof. Moseley's cat is being kept, and of which, of course, the latter must be the male parent. Unfortunately, as in so many other cases, I was unable to obtain any data, and the kittens are, I believe, all dead.

We therefore see in these observations a proof of the extraordinary ease with which a distinct breed can be produced from a spontaneously appearing variety. In spite of all the swamping effect of continual and uninterrupted crossing with the normal form, I have never been able to record a normal family, while in many cases some of the kittens were equal to, or even beyond, the abnormal parent in her peculiarity. This being the case, it is clear that a breed would have been quickly established if abnormal males had been selected to pair with the abnormal females. These observations have, therefore, an interesting bearing upon the existence of such a local breed as the tailless Manx cats, as Prof. E. Ray Lankester pointed out to me when talking over the subject. Prof. Lankester supposes that a tailless individual appeared spontaneously, and that it was considered interesting and a curiosity; and when the abnormality re-appeared in some of the off-spring, these were kept in preference to the normal forms. It seems quite certain that the result might have been produced in this way, and I have arranged with Dr. Grabham, of Madeira, that some of my abnormal kittens shall be sent to him to turn loose upon some neighbouring Atlantic rock on which rabbits are the only other living mammals. I should add that Prof. Lankester found a support for the theory of the origin of the Manx breed of cats in the fact that there are tailless breeds of other animals which are also fashionable in the locality, and which seem to point to the existence of the same peculiarities of taste working upon a spontaneous variety. In fact, as Prof. Lankester suggested, the people may have rather looked out for other tailless or abnormally short-tailed animals, when their interest had been excited by the existence of one such breed. But the observations here recorded have also a bearing upon those cases in which natural, instead of artificial, selection has been the agent. Granting, as I believe we must do, that some adaptive characters of great importance owe their beginning to flashes of structural or functional originality—appearing suddenly and spontaneously in one individual, as the extra digits appeared in the ancestor of my cats,—we see from these observations that in spite of all the effects of constant intercrossing with normal forms, there would be a most persistent offer of material upon which natural selection might work, for the variation would appear to a greater or less extent in a very large proportion of the individuals of the various families produced, while again and again the peculiarity would be inherited in a form equal to or even beyond that of the parent. It is therefore of interest to actually test a few instances in as complete a manner as possible, taking care that only one parent possesses the abnormality, for this is what must have happened for the first few generations of any such variety which originally appeared *in a single individual in a natural state*. It is chiefly with the object of adding another to the instances already known and worked out that these observations have been undertaken, and will be continued and rendered as complete as possible. It need scarcely be pointed out that such instances differ essentially from all the cases in which breeds of domestic animals have been established, for in these well-known and numerous breeds heredity has had undisturbed possession of the field, without any confliction between the normal and abnormal forms, except indeed in the case of the first family produced by the original parent of certain breeds of which the peculiarity appeared spontaneously in a single individual, as in the breed of "otter" sheep.

EDWARD B. POULTON

LIGHTHOUSE ILLUMINANTS[1]

THE details of the construction of the three towers and lanterns, and of the lenses and lamps in each lantern, of the magneto-electric machines, and of the gas-works, have no doubt been placed on record, and will be reported by the Trinity House engineers. But the following may serve as a general description of the arrangements.

Three low towers, constructed of massive timber, have been erected in a line inland from the higher of the two permanent lighthouses on the South Foreland, the nearest being 245 feet distant from the lighthouse, and the three being separated one from another by intervals of 180 feet. Their height, varying with the level of the ground, so that the lanterns may be on the same level, is from 20 to 30 feet; upon these structures rest three similar lanterns about 20 feet in height and 14 feet across. Within the lanterns are columns of lenses forming two opposite sides of a hexagonal framework which rises from the base to near the top of each lantern. The whole framework can be made to revolve so that either column of lenses may be made to face in any direction; each column consists of three or four similar lenses superposed, but the lenses forming different columns are different in their purpose and structure, and in their size. One column in each lantern consists of lenses designed to gather the divergent rays which fall upon them from the central source of light into a level sheet which spreads over the surface of sea or land, but not downwards or upwards; each of these lenses is a segment of a cylinder, and may be described as a cylindrical lens. The opposite column in the gas and oil lanterns consists of lenses designed to gather the divergent rays, not into a sheet, but into a single cluster or cone of small vertical angle, which is sent forth horizontally in any one direction. These lenses are made up of a central circular lens, surrounded by annular prisms and segments of such prisms, the whole fitting into a rectangular frame; they may be called annular lenses. The corresponding column of lenses used with the electric light consists of cylindrical lenses with condensing prisms placed in front of them; the cylindrical lens flattens a broad cone of light into a fan, the condensing prisms close the fan.

The size of the cylindrical lenses placed in front of the gas and oil lamps is the same, but the lenses in front of the superposed electric lights are smaller. The annular lenses, of which three form a column in the oil lantern, are each 6 feet 3 inches in height, while the four superposed annular lenses in the gas lantern are each 3 feet 9 inches in height. Both sets of annular lenses have the same width, namely, 3 feet 5 inches.

The electric lights are large arc lights, supplied with the electric current by three magneto-electric machines, which are worked by the steam-engine in the engine-house built for the ordinary work of the station. The electrical apparatus is of the construction of Baron de Méritens.

The gas-burners tried hitherto are of Mr. Wigham's construction, consisting each of a multitude of small fish-tail jets on brass stems about 6 inches long and an inch one from another, arranged on the same level in concentric rings. A tall funnel, a few inches above the cluster of burners, draws their flames together into the form of a bell. The number of concentric rings may be changed quickly so as to increase or reduce the size of

[1] Preliminary Report of Mr. Vernon Harcourt to the Board of Trade on the Experimental Lights exhibited at the South Foreland.