

pected bonanza to the French people. May its credit be preserved, may it be finished with less money and in less time, and may the undertaking bring in greater returns to the original investors, than now appears probable, thus once more defeating the skeptical and scoring another victory at Panama for De Lesseps only second to his well-earned triumph at Suez. No ultimate result less auspicious will gratify the well wishes of all who appreciate the vastness of the undertaking.

FREDERICK G. CORNING.

Mills Building, New York.

THE ELECTRIC LIGHTHOUSE ON THE ISLE OF MAY.*

By DAVID A. STEVENSON, B.Sc., F.R.S.E.,
M. Inst. C.E.

THE lighthouse situated on the Isle of May, at the mouth of the Firth of Forth, has recently been lighted with electricity, and as this light, besides being, the author believes, the most powerful in the world, possesses several novel features, he has the pleasure of offering the following notes regarding it, trusting that they will prove of interest in connection with the visit to be made to the lighthouse on the occasion of the present meeting.

Previous Lighting.—The Isle of May was originally lighted in 1636 with an open coal fire. In 1816 the com-

lies, an engine house, boiler house, chimney stalk, workshop, coal store, etc. It was decided to place the whole of the new buildings and machinery near the base of the island, and to lead the current up to the tower by conductors. This decision was arrived at, because it was considered that the fact of being able to place the engines close to the small natural fresh water loch, situated 270 yards from the light and 175 ft. below it, from which fresh water for feed and condensing purposes could be readily obtained, and also the saving which would be effected by not having to convey the fuel to the top of the island or to pump up water, would compensate for the loss of energy due to such a length of conductor; while the saving of the cost of carriage of the materials and machinery to the top of the island, and of piping and pumping machinery, would more than counterbalance the original cost of the conductors. The buildings were constructed in a plain and substantial manner of fire-brick, built in Portland cement, and roofed with concrete and Val-de-Travers, carried on rolled beams and buckle plates. This part of the work was executed in an expeditious and satisfactory manner by the contractors, Messrs. Stratton, Edinburgh, notwithstanding the difficulty of getting materials taken to and landed on the island.

Generators.—It was originally intended by Messrs. Stevenson to use the Brush compound-wound Victoria dynamo, giving a continuous current, and supplying a single automatically-fed arc lamp, with the positive

age current of 220 amperes is developed, thus yielding an electrical energy of 8,800 watts or 11.7 horse power in the external circuit. The five rings are so arranged that one-fifth, two-fifths, three-fifths, four-fifths, or the whole of the current of a machine can at pleasure be sent to the distributor for transmission to the lantern; and further, the two machines can be coupled, and the full current from both be employed.

Engines.—Fig. 2, one-eighth full size. The machines are placed in the engine room, bolted down to concrete foundations, and are driven through a counter-shaft by belting from the engines. There are a pair of horizontal surface condensing steam engines, each with two cylinders of 9 in. diameter and 18 in. stroke, making 140 revolutions per minute, and each indicating 17.7 horse power with 40 lb. steam pressure above atmosphere and 11 lb. vacuum. To provide against accident or failure of water supply, they have been arranged so as to be capable of being worked either condensing or non-condensing. Either of them is sufficient to drive one machine, the other engine being idle; or the two can be used together for driving both machines in thick weather. The steam to both cylinders is regulated by an equilibrium throttle valve, which is controlled by a high speed governor, adjusted for the engine to run at the normal speed of 140 revolutions per minute. Single in place of compound engines were adopted, because they are less complicated and better suited for the less skilled attendance of ordinary light keepers. Probably also greater regularity in driving has thus been secured, which is, of course, a matter of the greatest importance in electric lighting, especially where, as in this case, there is only a single arc lamp in the circuit forming the resistance. The result has been eminently satisfactory; and the engines, which were built by Messrs. Humphreys & Leith, are a most excellent piece of work.

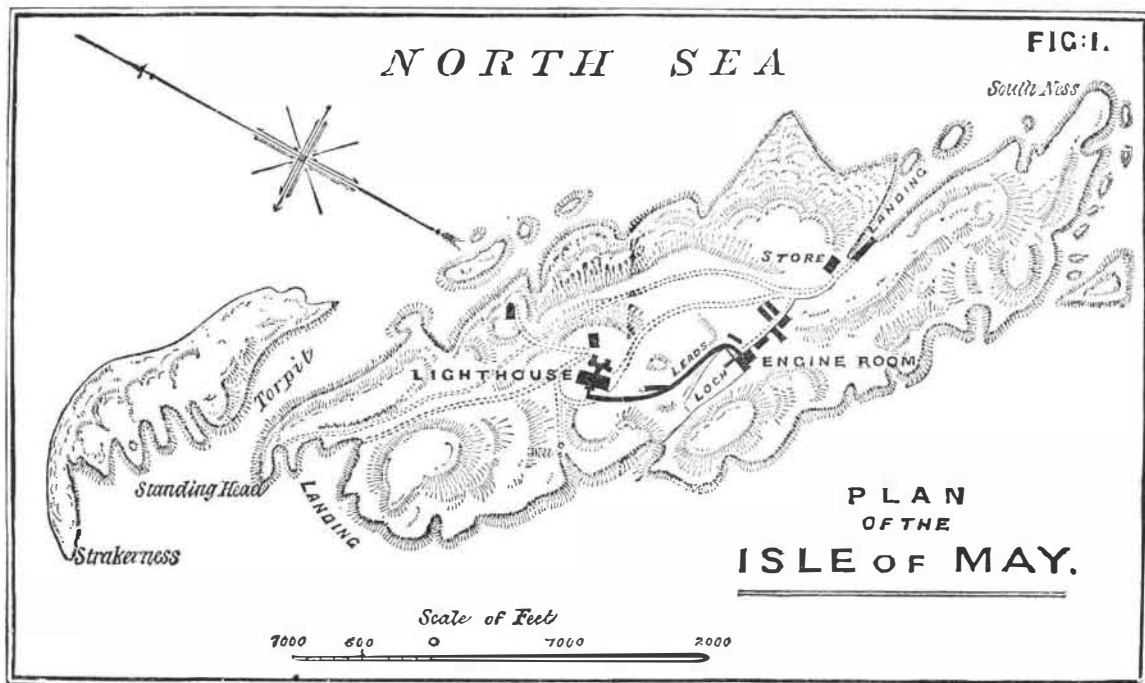
Boilers.—There are two steam boilers, of which only one is in use at a time, the other being spare. Each is 20 ft. long and 5 ft. 6 in. diameter, with one furnace flue 3 ft. diameter and 8 ft. long, having six cross Galloway water tubes. The shells are of best $\frac{3}{8}$ in. steel plates, with the longitudinal joints double riveted; and they were tested up to 110 lb. per square inch, the working pressure being 40 lb. The feed is principally rain water collected from the roofs and the pavement of the court; but water can, if required, be taken from the small loch, which is also used for condensing purposes. The coal consumption is 1 cwt. per hour of lighting, which includes banking the fires during the day.

Conductors.—The current generated in the engine room is conveyed to the lantern by leads, which consist of copper rods of 25 mm. or 1 in. diameter, covered with a double waterproof wrapper. This is the first time that copper rods have been used for conducting the current for lighthouse illumination. They are constructed in 14 ft. lengths, the joints being formed with a zigzag scarf screwed up tightly by gun metal coupling boxes with four bolts in each. They are carried by timber bearers, placed in a groove made for them in the side of a concrete wall running from the engine room to the tower. The total distance to the lantern is 880 ft. Several bends are introduced to allow for expansion and contraction due to changes of temperature. The loss in the leads was expected not to exceed one-sixth of the total energy generated; but it is considerably more than this, amounting to at least one-fifth. It is hoped, however, that an improvement will yet be made in this particular.

Lamps.—The lamps, of which there are three, one in use and two spare, are of the Serrin-Berjot type, with some modifications, notably the shunt or by-pass, first introduced in the South Foreland experiments on the suggestion of Dr. Hopkinson, whereby a large percentage of the current goes direct to the lower carbon, and only an amount sufficient to regulate the carbons is passed through the lamp. This is a great improvement, and prevents injury to the lamp from heating. The weak point about it, in the lamps sent to the Isle of May, was that the contact between the lower carbon holder and the by-pass, being necessarily a sliding contact, was effected by copper wire brushes, and these were found to wear out rapidly. On the suggestion of Mr. Munro, the engineer in charge of the station, a simple form of mercury contact has been substituted and works quite satisfactorily.

Carbons.—The carbons in use are 40 mm. or 1.6 in. diameter, but if desired 50 mm. or 2 in. carbons can be used when both machines are running. They are Siemens make, and have a soft central core of pure graphite, which has the effect of causing them to burn with greater regularity and steadiness than they otherwise would, and prevents a crater from forming and remaining at one side. The rate of consumption of the 40 mm. carbons is $1\frac{1}{4}$ in. per hour, or 2 in. including waste. The power of the arc is estimated at 12,000 to 16,000 candles, when one machine only is running.

Dioptric Apparatus.—Figs. 3 and 4, half full size. The dioptric apparatus, which was manufactured from Messrs. Stevensons' designs by Messrs. Chance, of Birmingham, is of a novel description, the condensing principle being carried further than in any apparatus previously constructed. The principle consists of darkening certain sectors by diverting the light from them, and throwing it into the adjoining sectors so as to re-enforce their light. Thus the power of the light is increased in proportion as the dark are increased. The light gives four flashes in quick succession every half minute; and during the bright periods the effect of this concentration of the rays is that the light radiating naturally from the focus is increased in power fifteen times in azimuth in addition to the vertical condensation, excepting, of course, the loss due to reflection and absorption. The apparatus which effects this result is a second order fixed light apparatus of 1,400 mm. or 55 in. diameter, which operates on the rays in the vertical plane. Outside of this there is a revolving cage of straight vertical prisms, extending the full height of the fixed apparatus, or $5\frac{1}{2}$ ft., and composed of two panels on opposite sides of the center, each operating in the horizontal plane on 180° of the light coming from the fixed apparatus, in such a way as to condense the whole 180° into four flashes of 3° each—that is, 45° into 3° , with the proper intervals of darkness between them. This cage of glasswork is caused to make one complete revolution every minute round the fixed apparatus, thereby producing the characteristic of four flashes every half minute. The fixed light apparatus is not of the ordinary Fresnel



missioners of northern lighthouses, having previously purchased the island, with the right to levy tolls for the lighthouse, altered the light to Argand lamps with silvered parabolic reflectors. In 1836 it was converted to the dioptric system, with a first order fixed light apparatus and a four-wick burner; on the 1st December, 1886, the electric light was substituted, and shown in connection with a dioptric condensing apparatus. For the last fifteen years, the commissioners of northern lighthouses, acting under the advice of their engineers, Messrs. Stevenson, had been anxious to establish an electric light on the Scottish coast, but it was not till 1883 that the board of trade were able to sanction the expenditure, and suggested its introduction at the Isle of May on the ground that "there was no more important station on the Scottish shores, whether considered as a landfall, as a light for the guidance of the extensive or important trade of the neighboring coast, or as a light to lead into the refuge harbor of the Forth." Notwithstanding the difficult access and isolated position of the Isle of May, distant five miles from the Fife shore, which is the nearest land, it was resolved to accept the view of the board of trade, and to introduce the electric light there. The necessary plans and specifications were accordingly prepared by Messrs. Stevenson, and the works, begun in June, 1885, were completed and the new light installed by 1st December, 1886.

Site.—Fig. 1. The existing establishment consisted of a lighthouse tower with accommodation for three keepers, placed on the summit of the island; and the additional buildings which it was necessary to provide were dwellings for three more keepers with their fami-

carbon below. This system was selected as being at once cheaper and as giving a stronger light power for the engine power applied than the magneto-electric machines, which had hitherto, with success at least, been exclusively used in lighthouses. The placing of the positive carbon below was adopted in order that the strongest light might be thrown upward, so as to be dealt with by the upper part of the dioptric apparatus, and thus be more effectively utilized. The Brush company at once set to work to produce a lamp of the above description, giving with a current of 100 amperes and 70 volts a light of 30,000 candle power in a horizontal line, steady and suitable for burning in a lighthouse. This unfortunately they were unable to accomplish, even after numerous trials; and at last, as the buildings on the island were nearly completed and it became necessary at once to procure reliable apparatus, recourse was had to the more expensive alternate current machines of De Meritens, which though not so powerful, are admirably steady in working, and had given excellent results in several lighthouses and also at the South Foreland experiments. The generators at the Isle of May are two of De Meritens' alternate current magneto-electric machines of the L type, and are of the largest size hitherto constructed, weighing about $4\frac{1}{2}$ tons each. The induction arrangement of each machine consists of five sets of twelve permanent magnets, sixty in all; and each magnet is made up of eight steel plates. The armature, 2 ft. 6 in. diameter, is composed of five rings with twenty-four bobbins in each, arranged in groups of four in tension and six in quantity. It makes 600 revolutions per minute. With the circuit open, each machine develops an electromotive force of 80 volts, measured at the distributor; and with the circuit closed through an arc, 40 volts. An aver-

* Paper read at the Institution of Mechanical Engineers, at Edinburgh.

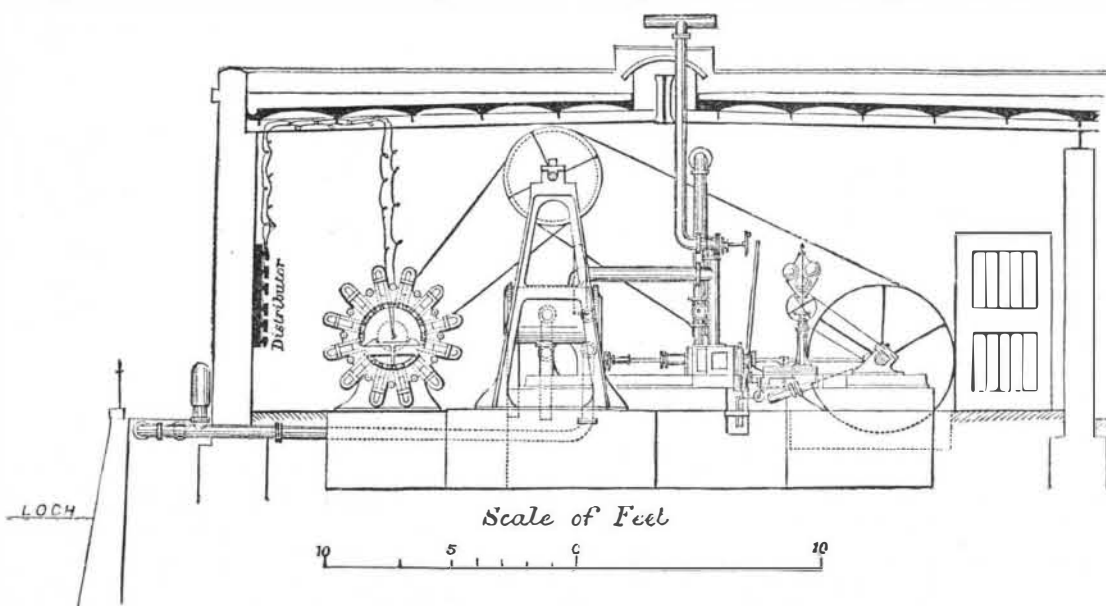


FIG. 2.—SECTION OF ENGINE ROOM.

section, but has the refracting portion confined to an angle of 10° , the upper and lower reflecting prisms being carried nearer to the focal plane. This design, although involving the loss of some light, facilitated the adoption of the late Mr. Thomas Stevenson's proposal of dipping lights in fog, so as to be able to direct the strongest part of the light to the horizon in clear weather, and in fog to a point only three to five miles distant. Such a change could be most easily produced by simply raising and lowering the level of the radiant in the apparatus; but there was a difficulty in doing so in an ordinary optical apparatus, inasmuch as, when the position of the radiant was altered, the rays from the reflecting prisms, above and below the refractor, would be sent in an opposite direction to those coming from the refractor. This form of the fixed-light apparatus was also specially necessary at the time the apparatus was designed, because it was then intended, as already mentioned, to use a continuous current machine with the positive carbon below; and consequently the strongest part of the light would have been dealt with by the upper reflecting prisms. By making the apparatus almost entirely of totally reflecting prisms, instead of refracting and reflecting combined, all the prisms act in the same way, so that by lowering the radiant the whole of the light from every part of the apparatus can be dipped simultaneously to any required extent, with the exception of a small piece in the center, which is left a refractor, and which will send light to the horizon when the other part of the apparatus is dipped. In clear weather the three upper prisms send their light from $\frac{1}{2}^\circ$ above the horizon to 3° below it; the rest of the upper prisms and all the lower ones send their light to the horizon, and the refracting portion from 3° to 5° below the horizon. The dipping of the light during fog has not yet been used, but as soon as the light keepers, who, with the exception of the engineer, were the ordinary keepers in the

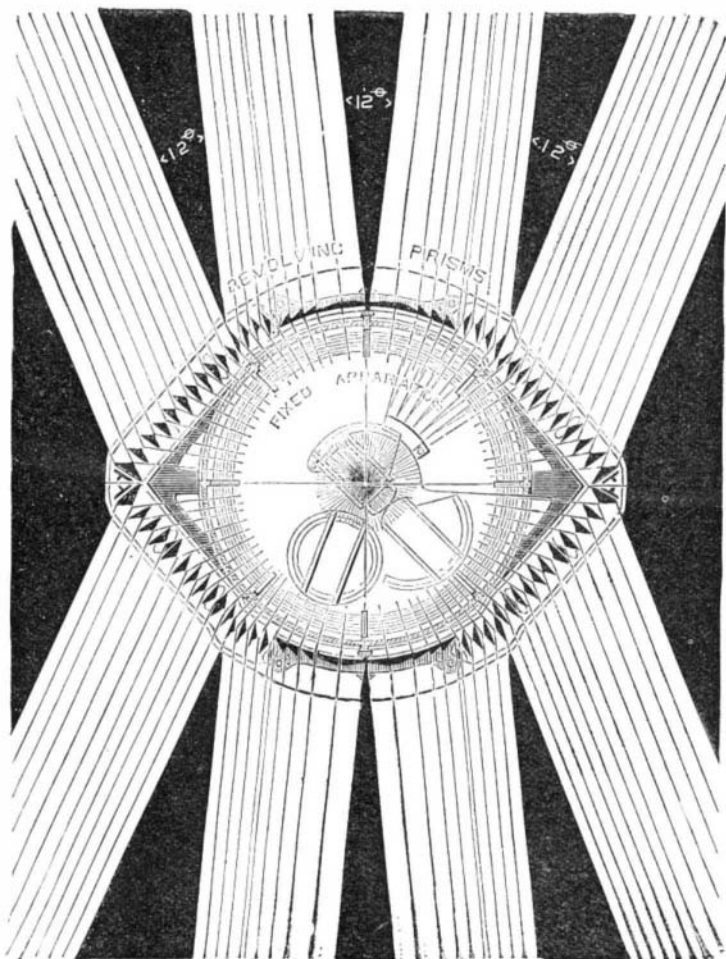
light room into the apparatus, the lamp in focus with drawn on to one of the turn tables and the fresh lamp run into focus, the original lamp shunted on the hoist and lowered out of the apparatus, all in about eight seconds. A three-wick paraffine oil lamp is kept trimmed and ready for use, in case of a failure of the electric current, and it can be lighted and put in focus in about three minutes. Within the case, and placed at one side of it, is a train of wheelwork, actuated by a weight with a fall of 60 ft. down the center of the tower. This machine drives the revolving cage of vertical prisms by a shaft which passes up through the top of the case, with a pinion working in an internal wheel of 4 ft. $10\frac{1}{2}$ in. diameter secured to the carriage of the cage. This machine is carefully boxed in, to prevent the dust from the incandescent carbons finding its way into the bearings, whereby great trouble has been caused at various lighthouses.

Power of Light.—The resulting beam of light from this apparatus is about 3,000,000 candles when one machine is in use, and with both machines 6,000,000; that is, about 300 and 600 times more powerful than the old fixed oil light. When the three wick oil lamp is put in the focus of this apparatus, the emergent beam is more powerful than the old fixed oil light with a four wick lamp, which was 9,446 candles. The light has been picked up and recognized by sailors at forty and fifty miles off, by the flashes illuminating the clouds overhead, although the geographical range of the light is only twenty-two miles. The engine room is connected by telephone with the light room; and the houses of the keepers are connected by air whistles or electric bells with either the light room or the engine room.

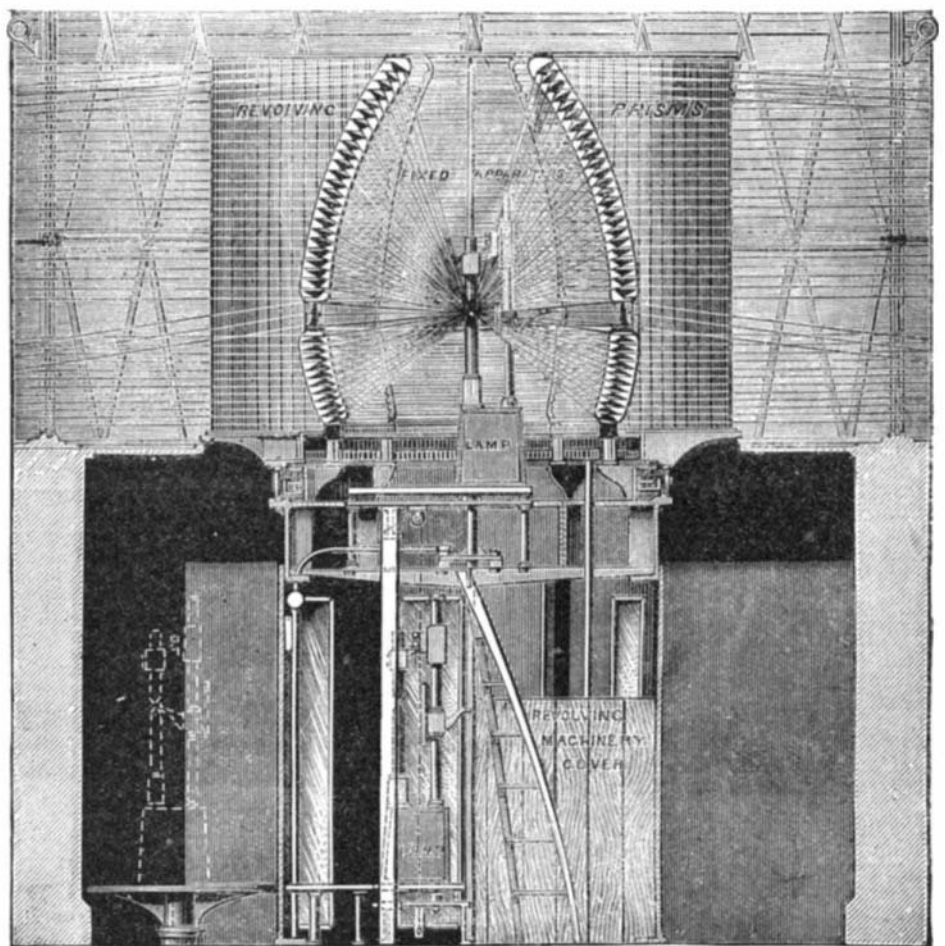
Men Employed.—The establishment consists of an engineer, four keepers, and an occasional or auxiliary keeper. The engineer, who is responsible for the management of the station, does not take a regular watch, but visits the engine room and light room occa-

who live in view of the Isle of May light, that this light, which is so extremely brilliant in clear weather as to cast shadows at a distance of ten and fifteen miles, is so cut down by fog that some even go the length of believing the old oil light was better in fog. All who have experience of the electric light are quite prepared for the first part of this statement, while the last, it need hardly be said, is a mistake, inasmuch as the electric arc has been proved, both by experiment in natural and artificial fog, and also by observations on existing lighthouses lighted by electricity, to be in all circumstances of weather the most penetrating. Every night at 12 o'clock the lightkeepers at St. Abbs Head, 22 miles distant, where there is a first order flashing light and one of the most powerful oil lights in the service, observe the Isle of May light, while the keepers there also observe the St. Abbs Head light. The result of the last five months' observations is that the Isle of May light is seen one-third oftener from St. Abbs Head than the St. Abbs Head light is seen from the Isle of May. It is perfectly true, however, that the superiority which is so apparent in clear and rainy weather is very much reduced in hazy weather, and practically disappears in very dense fog. Looking to this fact, and to the large first cost and annual maintenance, the author feels that the conclusion arrived at by the Trinity House is sound, that electricity should be used only for important landfall lights.

If, however, the most powerful light is desired independently of cost, then the electric arc has no rival. And if the further expense is to be incurred of introducing bifiform, trifiform, quadrifiform, or even double quadrifiform lights, then the electric light is better adapted than any other illuminant, because, on account of its focal compactness and other properties, it can be so dealt with by suitably designed dioptric apparatus that the whole light evolved is effectually utilized. This is not the case with the large gas or oil



HORIZONTAL SECTION THROUGH FOCAL PLANE.



VERTICAL SECTION THROUGH APPARATUS AND LANTERN.

THE ELECTRIC LIGHT ON THE ISLE OF MAY.

service, and knew nothing of electric lighting, have become thoroughly familiar with their duties, it is intended to introduce it, and probably in the same way to employ a less powerful current, and say 25 mm. or 1 in. carbons in very clear weather, while both machines, with 50 mm. or 2 in. carbons, will be used in very thick weather.

Lamp Changing and Revolving Arrangements.—Fig. 3. Standing in the center of the light room is a circular case, 5 ft. 8 in. diameter and 5 ft. 4 in. high, formed of cast iron pillars filled in between with glazed doors. The top of this case carries the fixed light apparatus, as well as a steel roller path 5 ft. 10 in. diameter, on which the carriage supporting the cage of vertical prisms travels on twelve steel rollers. The top of the case also serves as the service table, on which the electric lamp stands when in focus. Access to the interior of the apparatus and to the lamp is obtained from the inside of the case, through a trap in the top of it. Some difficulty was experienced in devising a suitable system of readily substituting one lamp for another, when it may be desired to change them, or in the event of the one in focus going wrong. The difficulty arose from the necessity of keeping the spare lamp out of the apparatus entirely, so as to prevent its interfering with the light emanating from the lamp in use, as the light shows all round the horizon. The change is accomplished by means of an arrangement of rails, and three turn tables or shunt tables, on which the lamps can be freely run, and which are placed on the service tables. One of these is in the center of the apparatus, and one is on a trap door, working vertically in guides and counterbalanced, in the manner of a hoist, whereby a lamp can be lowered from the level of the top of the case to the floor of the light room. Here the lamp is again received on rails, on which it can be conveniently run out of the case, to be recarboned and adjusted. In this way a lamp can be raised from the floor of the

sionally during the night. Two of the keepers attend to the light room duty and two have charge of the engines and boilers, relieving each other in regular watches. The auxiliary keeper does any odd duties, such as carting fuel, etc.; and in the event of any of the others being ill, takes his place. Since the light was first exhibited, the machinery and electrical appliances have worked without a hitch, and recourse to the oil lamp has been unnecessary. This is the more gratifying when it is remembered that the men in charge, with the exception of the engineer, were new to the work, and that the light was started at a period of the year when the hours of lighting were longest, namely, sixteen hours.

Cost.—The new buildings, engines, electric machines, lamps, etc., have cost £15,835; and the buildings, lanterns, etc., previously on the island, which have been utilized, may be valued at £6,600. Thus the total cost of the installation may be taken at £22,435; and the cost of maintenance will not exceed £1,050 per annum. These figures are very moderate, considering the great power of the light and the isolated position of the lighthouse. To compare the cost of this installation with what it would have been if oil were the illuminant, there must be added to the above £6,600 for buildings, a sum of £2,925 for the cost of the apparatus and machine, etc., making a total of £9,525, while the cost of maintenance would have been £330 per annum. Taking these figures, and adding to the maintenance $3\frac{1}{2}$ per cent. on the original outlay, it is found that while the oil light would cost 34s. per hour, and 0.00017d. per candle power per hour, the electric light costs 9 66s. per hour, or two and three quarter times more, and 0.00038d. per candle power, or less than one quarter of what the oil light would cost per candle power. This is taking the electric light power of one machine. Surprise has frequently been expressed by masters of vessels, and by residents on the neighboring shores

flames generally used in the multifiform system, in which for this and other reasons a considerable loss of light is incurred. Moreover, the coolness of the electric arc renders multifiform lights really practicable with electricity, which can hardly be said to be the case either with gas or oil.

Hyper-radiant Apparatus.—In the author's opinion, however, it is only in very exceptional cases indeed that electricity should be used; and he considers that a single oil or gas burner placed in the focus of a proportionately sized dioptric apparatus is sufficient for the generality of cases; and that any additional outlay which can be permitted should be expended in establishing a powerful sound signal to be used during fog when the light is obscured and when for all practical purposes even the electric light itself would also be obscured. This is specially the case since the introduction, on Messrs. Stevensons' suggestion, of hyper-radiant apparatus suited for use with burners of large diameter. As the result of experiments made in Edinburgh in 1869, they pointed out that the effectiveness of the large Wigham burner was to a great extent lost in revolving apparatus, because much of the light was ex-focal. A year or two ago, when the Commissioners of Northern Lighthouses resolved to increase the size of the burners in some of their lights, an experimental lens of 1.330 mm. or $52\frac{3}{4}$ in. focal distance, designed by their engineers, was constructed by Messrs. Barber and Fenestre, and by the courtesy of the Trinity House was fully experimented upon at the South Foreland, on the termination of the experiments conducted there with electricity, gas, and oil. From experiments made by Sir James Douglass and the author, and from photometric observations by Mr. Harold Dixon, the expectations of Messrs. Stevenson were fully borne out, and the following conclusions seem warranted: That a single burner, shown in a complete panel of a revolving apparatus of the hyper-

radiant kind, would give a more powerful light than burners and ordinary Fresnel lenses, arranged as bifurcated, and would be of equal power to trifurcated; while the consumption of oil or gas would be one-half or one-third respectively. Moreover, all the disadvantages of superposed lenses, including excessive heat in the light room, difficulty in the management of the burners, and obstruction of light by the necessary ventilating tubes, would be avoided. The result of the above experiments has so conclusively established the advantages of the hyper-radiant apparatus that the American Lighthouse Board have since ordered a complete apparatus of this kind; while the Trinity House and the Irish Lighthouse Board have adopted this size of lens recently ordered by them on Mr. Wigham's bifurcated principle.

THE PROGRESS OF GEOGRAPHY.

At the anniversary meeting of the Royal Geographical Society, held on May 23, 1887, General R. Strachey, the vice-president, delivered an address, from which we take the following extracts:

The attention of geographers during the year, as far as regards Africa, has been chiefly directed to the basin of the Congo, where many explorers, of various nationalities, have been employed in exploring and surveying the numerous streams which combine to make the Congo one of the greatest fluvial systems of the world. Other explorers have been engaged in the same region in examining into its economical and prospective commercial resources, but at present without definite results. An excellent summary of the geographical work done in the Congo region up to the middle of last year was given to the society in this hall, in June last, by Sir Francis De Winton, who had then recently returned from his two years' administration of the country. The most important of the new explorations he described was that of Lieut. Wissmann and his party, who had embarked on the upper waters of the Kassai River, near the part made known to us by Livingstone and Cameron, and navigated it to its junction with the Congo. Since then Dr. Wolff, one of Wissmann's companions, has explored the Sankuru, a large northern tributary of the Kassai, and found it navigable for a long distance. One result of this latter exploration is to show that another navigable river of the far interior, the Lomami, enters the Sankuru from the northeast, and that it is a distinct river from the Lomami of Cameron, recently ascended by Grenfell, which enters the Congo near Stanley Falls.

The direction which the Kassai takes—in a long curve, from southeast to west-northwest—causes it to be the recipient of nearly all the drainage of the southern half of the Congo basin, and near its junction with the main stream it adds to its volume the waters of another great tributary, the Quango, besides the Mfini, from a chain of great lakes further north. The united waters are poured into the Congo through the Kwa, which, according to Mr. Grenfell's measurement, is contracted in its passage through a range of low hills, and at its mouth is only 700 yards wide (a little higher up only 450 yards); the depth of the swiftly flowing stream Mr. Grenfell was unable to ascertain, as no bottom was touched with a line 120 feet long.

The prospective value to the Congo State of the Kassai, with its immense mileage of navigable waters flowing through fertile plains, is acknowledged on all hands. Already stations have been founded on its banks, and Portuguese traders are choosing the newly discovered river route in preference to their old inland road into the interior from Loanda. It has been during the past few months repeatedly reascended by river steamers; once by Sir Francis De Winton himself.

Equal in importance and extent have been the explorations and surveys along the main river and many of its tributaries carried out by Mr. Grenfell. The chief of these explorations were noticed by the Marquis of Lorne in the address of last year; and a brief general account of his surveys was given, together with a reduction of his admirable series of river charts, in the October number of our proceedings. Since then Mr. Grenfell has added to his achievements the ascent of the unknown portion of the Quango between its junction with the Kassai (or Kwa) and the Falls of Kikunji, which latter was the farthest point, coming down river, reached by a former traveler, Von Mechow.

Other considerable additions have been made to our knowledge of the Congo region by Lieuts. Kund and Tappenbeck, members of a scientific expedition sent out in 1884 by the German African Association. These courageous travelers, instead of following the courses of the rivers like others, and gleaning information only of the country and people along the banks, struck across the country, first from Stanley Pool to the south, and thence toward the east, crossing in succession all the southern tributaries, from the Quango inclusive to the Lukenye, beyond the Kassai; a toilsome and dangerous march of about 600 miles. Another member of the same expedition, Dr. Buttner, made also a land journey, of less extent, but not less interest. Starting from San Salvador, the old capital of the Congo, he traveled eastward and crossed the Quango, reaching the capital of a negro potentate named Kasongo, whence he struck northward to the main Congo above Stanley Pool. Much valuable information regarding the configuration of the country and the ethnology and products of the interior was obtained on these two journeys. We learn, for example, that the whole western section, to a distance of some 400 miles inland, is a hilly country cut up by deep valleys, to which succeeds, further inland, a wide stretch of undulating plains, wooded only along the courses of streams, and that it is only when the eastern side of the Kassai is reached that continuous tropical forest is met with.

North of the Congo the French have been active both in completing the pioneer exploration of their new possessions and in laying down with scientific precision large tracts of country imperfectly known. The most important work of the latter kind is that of Capt. Rouvier, the representative of France on the joint commission for laying down the boundary between the Congo State and the French possessions. This accomplished surveyor fixed numerous positions by a long series of observations both for longitude and latitude, and his report, which will be accompanied by an atlas of thirty-eight maps on various scales, will form a solid contribution to our geographical knowledge of the

region. An important pioneer exploration, about the same time, was made by M. Jacques De Brazza, brother of the eminent traveler, to the north and east of the French stations on the river Ogowe, undertaken soon after Mr. Grenfell's discovery of the magnitude of the Mobangi, and apparently with the object of ascertaining whether that great river flowed within the French boundary as fixed at the Berlin conference. After a journey of a month's duration through dense forests, M. De Brazza emerged on an open plain, through which flowed, not the Mobangi, but the Sekoli, an independent tributary of the Congo lying far to the westward. After a fruitless attempt had been made to penetrate beyond this river, his party built canoes and descended the Sekoli to its mouth.

It has been recently announced that by arbitration the French boundary has been extended a little farther to the east than fixed by the Berlin conference, so as to include the right bank of the Mobangi. A complete and very useful *resumé* of all the geographical work accomplished by recent French explorers in the Ogowe-Congo region, by Major De Lannoy De Bissy, was contributed to our proceedings for December last, illustrated by a map reduced from the French surveys.

Public interest has recently been directed toward the region north of the Congo, and the practicable routes it may offer to the Niam-Niam countries and the Egyptian Soudan, in consequence of the dispatch of the expedition under Mr. Stanley, for the relief and rescue of Emin Bey, which has adopted the Congo route to the Upper Nile in preference to the more direct and shorter route inland from Zanzibar. A paper giving a *resumé* of all published information regarding this region was recently read in this hall by our accomplished young colleague, Mr. J. T. Wills. Since then, you have had before you the greatest of all travelers in this little known region, Dr. Junker, and heard his own account of his six years' explorations. The wide open plain country lying between the Congo and the Nile, which Dr. Junker described to us, is watered by numerous streams, the chief of which, the Welle-Makua, flows westerly in the direction of the Upper Mobangi, and judging from Dr. Junker's maps, it is difficult to dispute his conclusion, in which Mr. Wills agrees, that the two rivers are the same.

Other geographers believe that the Welle-Makua belongs to the Shari system and flows into Lake Chad. The alternative offers one of those problems in which speculative geographers seem to delight; but in this case it will not be long before a solution is arrived at in the only satisfactory way—namely, by actual exploration. Meantime we learn, by the latest news from the Congo, that Mr. Stanley has chosen to adopt a somewhat more direct route to Emin Pasha than that first proposed—namely, from the Congo near Stanley Falls by land to the shores of the Albert Nyanza.

Two more journeys across the continent have been brought to a successful conclusion during the past year. One by M. Gleeup, a Swedish officer, formerly in the service of the Congo State, who crossed from Stanley Falls to Zanzibar, and the other by the experienced traveler and geologist, Dr. Oscar Lenz, who undertook, in 1885, an expedition for the purpose of reaching Dr. Junker and Emin Pasha *via* the Congo. Reaching Stanley Falls in February, 1886, Dr. Lenz was unable to obtain men from the Arab traders there to accompany him on the march through the unknown country between that point and the Upper Nile, and proceeded to Ujiji in the hope of meeting with better success there, and advancing northward along the eastern side of Lake Tanganyika. The disturbed state of the country and the excitement in Uganda made this impossible, and he took the Tanganyika and Nyassa route to the Indian Ocean, emerging at the Portuguese settlement of Quillimane.

Further south, Dr. Hans Schinz, a learned botanist and ethnologist, has been exploring with fruitful results the region between the Kunene and Lake Ngami.

On the eastern side of the continent our society is especially interested in the expedition of Mr. J. T. Last, who was commissioned by us in the summer of 1885 to proceed to the region between the Rovuma and the Zambesi, and follow up the work of Mr. O'Neill by exploring the Namuli Hills and the Lukugu Valley. We hear by recent telegram of his safe arrival at Zanzibar, and may shortly expect him home to give us in person an account of his journey. The letters which we have received from him from time to time have informed us that he has carried out his programme, though he found the summit of the Namuli Hills inaccessible, and, in addition, traversed the whole region a second time, striking into the interior from Quillimane, and emerging at Ibo on the Mozambique coast.

Count Pfeil, one of the most active of the pioneers in the newly acquired German Protectorate of Eastern Tropical Africa, published last year an account of his two journeys in Khutu and in the neighboring region, a country previously known to us only through Thomson's expedition to the Central African Lakes. Some additions to our knowledge of the geography of this part of the African interior have resulted from Count Pfeil's labors, the most interesting of which is the discovery of the main stream of the Ulanga, or upper course of the Rufigi, a river which this explorer claims to be of some importance, and which he navigated in a boat for upward of 150 miles.

The unsuccessful attempt of the experienced African traveler Dr. Fischer to carry succor to Dr. Junker in 1885-86, a mission with which he was charged by that traveler's family, would have excited great interest in the earlier days—not long past—of Central African travel. The route he took led for several hundred miles through a totally unexplored country, namely, from the Pangani westward across the region which still remains a great blank on our maps to the caravan route between Unyanyembe and Victoria Nyanza. He reached the southern shores of the Victoria in January, 1886, but found it impossible to obtain leave to pass through the territory of the fanatical king of Uganda. Turning backward, he made a valiant attempt to reach the Upper Nile by the eastern side of the great lake, but his supplies failed him by the time he arrived at Lake Bahringo, and he returned with a sorrowful heart to the coast. He did not long survive the fatigues of this arduous journey, but died soon after his return to Europe, in November last.

In the continent of Asia the most important addition to our accurate geographical knowledge of the interior is no doubt that gained by the joint Russian and British commission, which has been engaged on the sur-

vey of the northern frontier of Afghanistan from the borders of Persia to the Upper Oxus, but pending the diplomatic settlement of disputed points this information has not been made public, though it will doubtless soon become available.

A brief note of a portion of this work, describing surveys made by Capt. Maitland and Talbot, between the Hari-rud and Bamian, connecting Herat with the last named place, and also with points north of the Oxus, and the neighborhood of Kunduz, has appeared in our proceedings. The total area surveyed amounts to about 120,000 square miles, mapped on the scale of one-quarter inch to the mile, in sixty sheets. These brilliant results are believed to be unique in the annals of surveying. The chief of the British topographical staff, by whom these surveys were undertaken, was Colonel Holditch, to whom one of the gold medals has now been awarded, in recognition of the valuable services to geography rendered by him in this and other similar enterprises.

Much valuable geographical work has also been accomplished by Mr. Ney Elias, the gold medalist in 1873, who was dispatched from Ladakh on a mission to Chinese Turkistan, and diverging westward at Yengi-Hissar, traversed the Pamir Plateau for a distance of 360 miles, to the Khanat of Shignan. The details of this journey have not yet been made known by the Indian authorities, but Sir Henry Rawlinson has communicated to our proceedings a note in which he points out that his former suggestion that this route, first brought to notice by Major Trotter, was probably that by which caravans of Rome passed from Bactria, and had been used as a military road in comparatively modern times, is confirmed by the additional light thrown on the subject, and he identifies the lake *Rang-Kul*, visited and described by Mr. Elias, as the famous Dragon Lake of Buddhist cosmogony, and as answering very closely to the description given by the Chinese traveler Hwang-tsang in the seventh century.

Mr. A. D. Carey, a gentleman in the Indian Civil Service, has in a most enterprising manner devoted a period of leave of absence to a very remarkable journey in Eastern Turkistan and Tibet, and has traversed a large part of those central regions which have lately been made known by General Prejevalsky, and of which a brief *resumé* was given in the last presidential address. Accompanied by Mr. Dalgleish, an enterprising trader, who had previously visited Eastern Turkistan, he started from Ladakh in the summer of 1885, taking a route which had never before been trodden by a European, from Leh eastward across the high Tibetan plateau, and descending to Kiria by an extremely difficult and rugged defile *via* Polu. After a short stay here, he traversed the desert northward, along the course of the Khotan River, and arriving at the Tarim, crossed that river to Shah-yar and Kuchar.

At the end of the year he tracked the Tarim to Lake Lob, and proceeded thence in a southward direction to the foot of the great escarpment which in this meridian forms the northern limit of the Tibetan highlands, where he wintered, and made a fresh start across the Altyn Tagh in the spring of 1886. No news having been received of him for many months, his friends had begun to fear for his safety, but all anxiety has been set at rest by recent telegrams from India announcing his safe arrival at Ladakh at the end of the winter. Considering that Mr. Carey traveled without escort and unarmed, and that his journey has been performed on slender means through vast unknown tracts peopled by tribes supposed to be of hostile and fanatical temper, his exploit is one of the most remarkable in the recent annals of adventurous travel.

Northward of Khatmandu, the capital of Nepal, about 400 miles of entirely new traverse in Nepal and Tibet has been contributed by a native explorer, surnamed M—H., besides a confirmation of the details of a hundred miles of ground previously traveled over. It is regretted that the explorer brought back no determinations of heights, which would have been most interesting, for he crossed the main ridge of the Himalayas by one of the highest passes (the Pangu-la), and approached within fifteen miles of Mount Everest. Another native surveyor, R—N., who accompanied Colonel Tanner in his explorations on the Tibetan border in the autumn of 1884, was dispatched across Bhutan and the mountains to the east to reach Gyala Sindong, the lowest point yet reached on the Sanpo, and, starting from the left bank of the river, to find his way back to India by any practicable route, without recrossing the river.

The object was to set at rest the vexed question of the connection between the Brahmaputra and the Sanpo on the one hand and the Iravadi on the other. The explorer met with bad luck at the outset, from the fact of there being hostility between Tibet and Bhutan, a state of things which had closed all the passes into Tibet. He therefore had to find his way back to India down the Hachhu and Wongchu Rivers to Baxa, having been detained and kept under surveillance for ten days by the *jongpon* of Chukhajong. His next attempt was made from Dewangiri, whence he proceeded by a pretty direct route to the Monlakachung Pass, and thence to the vicinity of Seh, a very large monastery on the Lhobra River, the position of which had been previously obtained from the north by Lama U—G.'s traverse of 1883.

Here, in consequence of the rumors regarding the advance of the Tibet Mission from the south, and of a party of Russians from the north, the officials absolutely stopped his further progress, and kept him in custody for nine days, and then conveyed his party under escort to Seh. From here he escaped with his party by night, and keeping away from the beaten tracks, found his way to Menchuna (lat. 28° N., long. 92° E.), and thence, *via* Tawang, to Odalguri, along the route formerly traversed by Pundit Nain Singh. His work furnishes about 280 miles of new route survey, and throws light on the general geography of Bhutan, besides forming a connection with the work of Pemberton (1838) from the south and of the Pundit and the Lama from the north.

Another journey carried out by three English gentlemen through the heart of Manchuria, from south to north from the shores of the Yellow Sea, and from west to east to the Russian settlement of Vladivostok on the Pacific coast, also calls for notice. The party consisted of Mr. H. E. M. James, of the Indian Civil Service; Mr. F. E. Younghusband, of the King's Dragoon Guards; and Mr. H. Fulford, of the Chinese Consular Service. We have received at present brief accounts