THE GREAT PARIS TELESCOPE.

DURING two or three visits to Paris and Nice some years ago, I discussed with many French astronomers, whom I was privileged to count among my personal friends, the question of the large telescopes of the future. Among the conclusions come to, the first was that the glass industry was not in a position to grapple with astronomical requirements, and hence when reflectors of 8 or 10 feet diameter were talked of it was understood that they must be made of porcelain with a glass surface. Other conclusions were that the coudé mounting designed by M. Lœwy, and carried out so far as the optical parts were concerned by the brothers Henry, should be replaced with object-glasses of or about 25 inches by the use of a siderostat.

I subsequently (1884) gave two lectures at the Society of Arts on these and other questions,[1] in which I pointed out what I considered the best way of using an 8-foot reflector, and with regard to refractors I said: "With an object-glass of 30 inches diameter for physical observations I should certainly prefer the siderostat, thus reducing the cost of an instrument of this size to about one-third of the present price."

During the last few years we have heard a great deal of an enormous telescope to be constructed on the

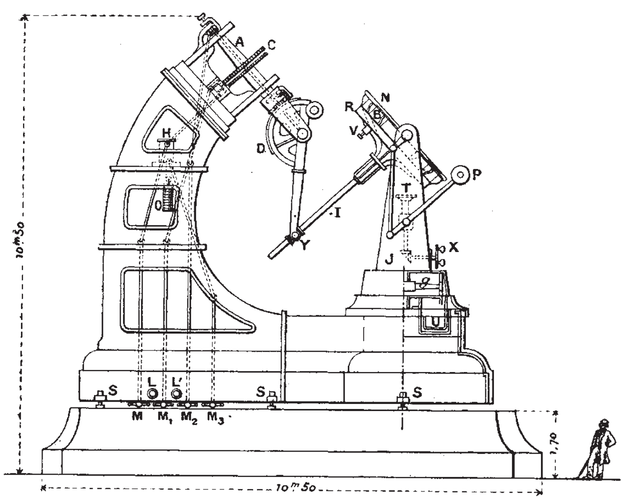

FIG. 1.—The siderostat.

occasion of the Paris Exhibition of 1900; a reflector of 10 feet aperture, such as was discussed in 1875, was indeed spoken of at one time, and renewed one of the old discussions, but it would seem that now as then the glass industry is not able to furnish a disc of this size, for after all it has been determined to construct a refractor, and mount it as I suggested nearly twenty years ago in front of a siderostat.

I have recently received from "Le Conseil d'Administration de la Société l'Optique" details of the scheme which it is proposed to carry out; while information regarding the telescope and siderostat has been given in the *Annuaire du Bureau des Longitudes*, and more recently in the *Scientific American*.

The Council in its memorandum is at some pains to excuse the exaggerations which have been so generally made regarding the power of the new telescope. They state that they hope for such a magnifying power that the surface of the moon will be seen as if our satellite were only 67 kilometres away from us. Under these conditions it was calculated that an object of one metre square might be seen. Hence the short phrase "La lune à un metre," and the consequent nonsense. One of the objects which finally determined the siderostat arrangement was the desirability of having a very long focus, and a focal length of 100 metres (328 feet) has been decided upon.

M. Deloncle seems to be the chief of the band of astronomical amateurs who have enabled MM. Gautier and Mantois to employ their well-known skill. M. Despret, the Director of the Jeumont Glass Works, has produced the siderostat mirror which has a diameter of 2 metres, a thickness of 30 centimetres, and a weight of 3600 kilos. This certainly could not have been produced with the appliances in use twenty years ago.

The siderostat avoids all the expense of a dome—even if one of 340 feet diameter could be constructed—and saves considerable expenses for installation; it secures greater stability, and saves the astronomer unnecessary fatigue and serious loss of time.

The apparatus constituting the instrument termed a siderostat comprises a pedestal of cast iron, the north part of which supports the polar axis, and the south part the mirror with its frame. The cast iron pedestal, 8 metres long by 8 metres high, is furnished with six screws, which fit in sockets fixed to the stone base 1·70 metres high.

The north part of the pedestal supports the polar axis with its divided and driving circles. This axis is driven by a clock-work movement by means of a tangent screw.

At the lower end of the polar axis a fork is fixed, to which are adjusted the pivots of the declination circle. The toothed declination wheel is set in motion at the foot of the instrument by a handle placed beside that one which produces movement in right ascension; both of these are near the two telescopes which serve for the reading of the two circles.

The mirror, with its cell, has a total weight of 6700 kg.

This cell of cast steel is furnished with two pivots; to the back is fixed the directing rod. The interior of the cell is covered entirely with felt, in such a way that the mirror has no point of contact with the metal. Being supported by as great a surface as possible, all deformations are avoided.

The mirror and its cell are kept in equilibrium by a system of levers and counterpoises; the pivots rest on rollers adjusted at the top of the frame, which permits a circular movement by a vertical shaft and a system of independent rollers between two rails.

The base of this frame floats in a cavity two metres in diameter on the south side of the pedestal, containing sufficient mercury to float $\frac{9}{10}$ of the total weight of the movable part, which weighs 15,000 kg.

The clock-work movement is set in action by a weight of 100 kilos. The total weight of the siderostat is 45,000 kg.

To cast the mirror a special furnace was made at the Jeumont Works, capable of holding over twenty tons of glass. This enormous plane mirror was, naturally, the most difficult part of the apparatus to make.

The mould, 2·05 metres in diameter and 0·30 metres in height, was placed on a wagon near the furnace, in order to receive the melted glass coming from the crucible. When the mould was full, the wagon was immediately taken to an annealing oven of the right temperature and then walled up; the cooling lasted a month. The operation of annealing the glass is very difficult to carry out; numerous experiments had to be made; out of twelve discs only two have been successful.

The transportation of such a huge disc of glass to Paris was a difficult matter, and a special train carried it there, and it was conveyed to the optical establishment at night, in order to have a clear roadway.

[1] Cantor Lectures: "Some New Optical Instruments."

The discs for the object-glasses, visual and photographic, of 1·25 metres in diameter, were cast by M. Mantois; the flint weighs 360 kilos., and the crown 220, and the figuring, polishing and mounting of these enormous discs have been confided to M. Gautier.

The following interesting account of the casting of the glass for the lenses is given in the *Scientific American*:—

"Great attention was paid to the casting of the glass. Specimens of the glass were constantly taken out during

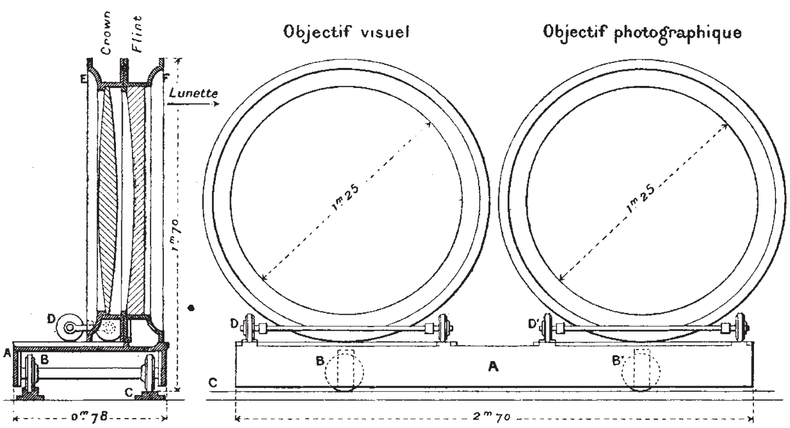

FIG. 2.—The object-glasses.

the heating and examined with a lens under different conditions of illumination in order to judge of the degree of purity which they have reached. After several specimens have been found to be free from bubbles the temperature is reduced, the glass thickens, the crucible is opened, and a certain portion of the surface is skimmed off to get rid of impurities. The glass is then stirred, and the cooling is allowed to proceed rapidly for five or six hours until the surface of the glass emits a well-defined sound when it is struck with an iron bar. After this step it is necessary to proceed with annealing. The furnace is walled up and a cooling is allowed to proceed, which requires from four to six weeks. When the crucible is opened the glass is found to have been broken into pieces of varying sizes. In order to obtain a 792 pound flint glass lens it is necessary to find a block which weighs nearly 1300 pounds, and such a block having been found among those in the furnace it is removed and placed upon a car. Slabs of glass are sawed from two parallel sides in order to obtain polished surfaces that facilitate a perfect examination of it. The striæ in the surface are removed, and if after this the block exhibits any defects situated at such a depth that they cannot be removed, it is submitted to a moulding which changes its form and brings the chief defects near the surface. The block is placed in a mould of refractory clay and put into a furnace and heated to 800° to 900° Centigrade. By this means it becomes slowly heated and softened until it assumes the form of the mould, but it must not become fused, or the whole operation must be gone over again. If the outcome of the process is successful, the glass is slowly annealed, and is then taken from the mould and examined anew. If any defects deep in the glass are seen, a second operation is begun with a mould of another form. Finally, when the glass is very pure and perfect, another and final moulding produces the plano-convex lens. After this comes another heating and cooling which takes two or three weeks."

Telescope.—The telescope tube, which is of sheet steel 2 mm. thick, weighs 21,000 kg.; it is 1·50 metres in diameter, and is composed of twenty-four pieces united by bolts. It rests on eight supports of cast iron resting on stone pillars. In view of expansion, the supports move on rails fixed to the pillars.

I confess this *iron* telescope tube astonishes me.

The two object-glasses are both mounted on the same carriage, which moves on rails in such a manner as to place them easily, the one or the other, at the end of the tube; the weight of each of these object-glasses, without their cell, is about 600 kg., and with the cell 900 kg. Each lens is adjusted in a separate cell; that of the crown is carried on rollers, in order to be able to remove it from the flint and render the cleaning of each disc easy.

The tube carrying the eye-piece is supported by four wheels on rails. It is attached to the telescope tube by an adjusting screw 1·50 metres long, which is used for focussing. In the interior of this tube there is another 1·20 metres in diameter, which can be rotated by clockwork. This carries the adapter for the eye-piece end, which is made to slide in two rectangular directions by means of screws. The eye-piece end can carry either an eye-piece, a micrometer, a photographic plate, or a projecting lens.

By means of the arrangements realised in the eye-piece the observer is rendered independent of the apparent movement of the heavens, and is enabled to follow the object in right ascension and declination.

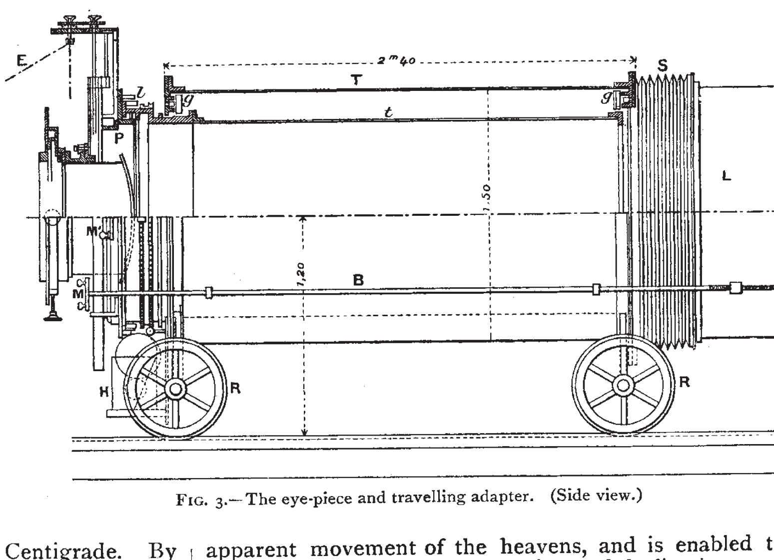

FIG. 3.—The eye-piece and travelling adapter. (Side view.)

It is stated that M. Gautier has been entirely successful, not only with the plane mirror, but with the two object-glasses.

The grinding apparatus consists essentially of a large cast iron plate, *C*, covered with an inch of flannel, upon which the glass disc, *A*, was carefully laid. The *Scientific American* thus describes it :—

"This plate revolves slowly around a vertical axis by gearing, G, the whole being stepped in a cone. Above

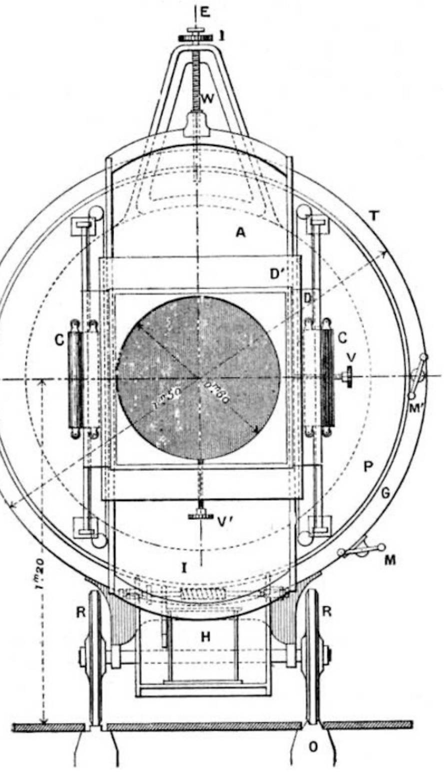

FIG. 4.—Details of the eye-piece. (Front view.)

there is a stationary circular bronze rubber, B, $47\frac{1}{4}$ inches in diameter, which is given a reciprocating motion by a slider, I, thus passing across the face of the mirror travelling in a circle beneath it. The perfect revolution of the plate and the accurate adjusting of the slides and their parallelism resulted in the production of a perfect mirror. It required three months to adjust the slides alone. The grinding of the mirror was done with a mixture of emery and water. During this operation a workman always stood at a respectful distance from the apparatus so as not to change the temperature of it. From time to time he injected a mixture of emery and water by means of a syringe into a channel running through the grinding plate and ending at the centre. This work was carried on generally from 2 till 5 o'clock in the afternoon, the time of day when the temperature does not change perceptibly. The entire morning was devoted to the cleaning of the machine, and to the verification of the parallelism of the grinding plate with the surface of the mirror, an operation which was performed with four scales which were accurate to $\frac{1}{1000}$ of a millimetre."

"As the grinding proceeded, finer and finer emery was used, and the closer the grinding plate was brought to the surface of the glass. With the finest emery the distance between the plate and the glass was 0·008 inch. The grinding lasted eight months and was followed by the operation of polishing, which required two months The lower surface of the polishing plate was covered with a sheet of albumenised paper like that used in photography, but unsensitised. The workmen spread upon this paper a small quantity of the finest Venetian tripoli and as much as possible was removed with a soft brush. The distance between the rubber and the surface of the glass was 0·0012 of an inch."

"This method of treatment, notwithstanding its delicacy, produces enough heat to render the mirror slightly convex and cause it to draw away more strongly in the centre, so that, upon cooling, it was hollowed at this point. In order to surmount this difficulty the slides were given a curve of which the pitch was 0·4 of an inch. The heat was diminished by operating the machine for a minute and then stopping for a quarter of an hour. When the hand is applied to the mirror, there occurs an extension of 0·0012 of an inch, which is sufficient to distort completely for four or five minutes the image of the flame of a lamp placed at one side of the plate and observed from the other with a small telescope arranged for the purpose. The next operation to be performed is the silvering, and, of course, it will have to be silvered anew from time to time. The mirror protrudes 5·4 inches from its tube or cell, which will be made to swing so as to bring the surface to be silvered underneath. The reservoir containing the bath will be lifted by means of a winch until the mirror enters it at a proper depth. When the operation is finished, the reservoir will be lowered and the silvered surface turned upward and the mirror readjusted in its cell."

I am indebted to M. Gautier for the use of the illustrations, which have already appeared in the *Annuaire Scientifique du Bureau des Longitudes*.

It is the intention of the Syndicate to erect in connection with this telescope a Palais de l'Optique near the Eiffel Tower, containing a hall capable of holding some 4000 persons, and in fine weather images of the various celestial bodies are to be thrown on a screen 20 metres in the side by means of secondary magnifiers. Thus an image of the moon 16 metres in diameter, and of Mars 3·70 metres in diameter, are promised to the abonnés.

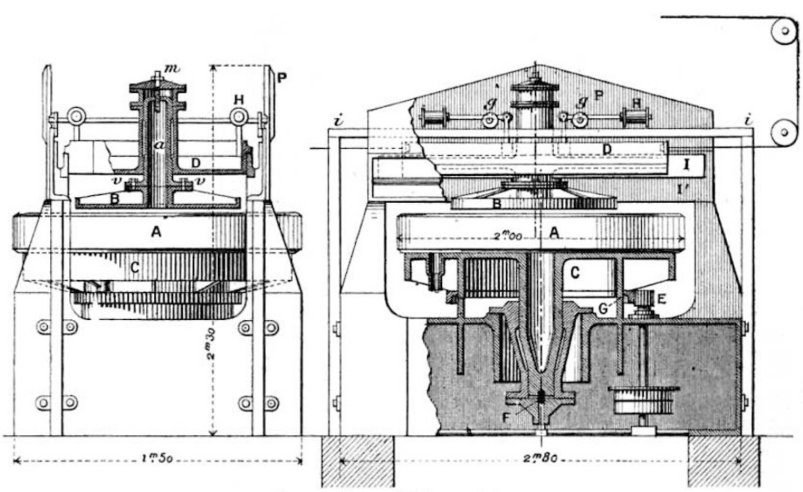

FIG. 5.—The polishing machines.

No doubt the great telescope will be largely capable of advancing science, and this will certainly be taken advantage of by the highly skilled French astronomers. Its erection, therefore, will be a great gain.

Whether the hoped-for 6000 visitors (paying, we presume, a franc each) per half-hour night and day will visit it and help to provide the sinews of war is another matter. NORMAN LOCKYER.

GEOLOGICAL SURVEY OF THE UNITED KINGDOM.[1]

REPORTS of the progress of the Geological Surveys in India and Canada have already been noticed in NATURE. The report of our home survey has since been issued by the Director-General, Sir Archibald Geikie. It is more voluminous than those of the other countries, and appears rather to be a full record than a "Summary" of the observations made during 1898 by the staff of the Survey. Whatever may be said concerning the state of our knowlege of geology in England and Wales, in Scotland and in Ireland, it cannot be gainsaid that very much remains to be done both from a scientific and a purely economic point of view. The report before us is a striking testimony to this, and when we consider the limited staff and poor equipment of our Survey, it is surprising how much has been done to further the progress of knowledge.

So far as the main field-work of the Geological Survey is concerned, the mapping of entirely new areas has been confined to the mountainous regions of Scotland and to the islands of Arran, Jura and Skye; but it is not in these areas alone that fresh observations of striking importance have been made. Re-surveys are being made of the coal districts of South Wales, North Staffordshire, Leicestershire and South Derbyshire; of the mineral districts of Cornwall and Devon; and of the agricultural districts of the southern and midland counties. In all these cases the work done actually amounts to a new survey, on a larger scale than the original map, and carried out with that attention to minute accuracy which nowadays is absolutely essential. Revisions have also been made in the Silurian areas in Ireland.

A glance at the little index-maps which accompany this report show how much field-work yet remains to be done. Of the 131 sheets of the Scottish one-inch map, fifty-nine only have been published. In England and Wales ninety-nine only of the 360 one-inch new series maps have been published. It has long been recognised that for practical purposes a survey on a scale smaller than six inches to a mile is of little value. The work of the Survey has for many years been conducted on the larger maps, MS. copies of which are deposited for public reference in the Survey Offices in London, Edinburgh and Dublin. In illustration of certain mineral areas and other regions, a number of six-inch maps have been published, but the issue of further maps was some few years ago discontinued, mainly, we believe, on account of the expense of engraving. Cheaper processes, however, are available, and it is to be hoped that the publication of six-inch maps may ere long be resumed. It is not only in mineral areas that these maps are utilised—they are quite as necessary in inquiries relating to water-supply, sanitary engineering, and agriculture. In these important questions the highest attainable accuracy is as necessary as in mining questions. Those who compare the earlier published one-inch maps with the new series of geological maps in England and Wales will recognise the great advances which have been made in the method of mapping, and if these again are compared with the six-inch maps (*e.g.* of the South Wales coal-field) it will be seen how much work is lost or obscured in the small one-inch reproduction. This difference was strikingly shown in the one-inch and six-inch maps of the Durness area in Scotland, published a few years ago.

The present "Summary," like the first of the series which was issued a year ago, is arranged stratigraphically, commencing with the Pre-Cambrian and continuing to the Recent deposits; it contains also records of new railway-cuttings and well-borings, and accounts of the microscopic and chemical work carried on in the Petrographical Department and of the varied work performed in the Palæontological Department. Brief notice is also taken of the numerous public and private inquiries made at the offices of the Survey, work which increases from year to year, as help and advice in reference to water-supply, soils, sites for houses, building-materials, various ores and minerals, are as far as possible freely given to those who seek them.

That the field-work of the Survey must be conducted on a strictly scientific basis is not to be questioned. Economic results must follow, and they may not always be apparent at the time of the survey. It is, however, satisfactory to find that discoveries of importance have been made.

The puzzling question of the age and origin of the Highland schists continues to attract a large amount of attention. The evidence gathered tends to show that the "Moine-schists" of the north-west highlands are metamorphosed arkoses, sandstones, and argillaceous rocks, and that there is unconformity between them and the older (Archæan) gneisses. Associated with the schists are several types of foliated igneous rock, and these in some cases were intruded into the original sediments before their present foliated structures were developed. The Dalradian or so-called Younger Schists of the central highlands have also received much attention, and structures similar to those seen in the Moine Schists have been recognised in these rocks in the Braemar area. What is termed the "hornfels" type of alteration, producing a cordierite-hornfels, has been found where the old granites, such as that of Ben Vuroch, were intruded prior to the movements causing schistosity. This type of metamorphism is not observed in connection with later granitic intrusions, such as those of Cairngorm and Lochnagar. Interesting observations are made on the intrusions of these younger granites, and it is inferred that in the case of Cairngorm the mass, on its southern side, took the form of a cake or sill with vertical or highly inclined edges. The metamorphic changes produced in the bordering rocks by the masses of granite and by various igneous dykes are fully dealt with.

The Cambrian limestones in Skye have yielded a number of fossils which connect them with the Balnakiel and Croisphuil groups of Durness. Several of the species occur also in Newfoundland—and these indicate a horizon below the Arenig formation.

Analyses have been made of Cambrian dolomites from Skye and Durness.

Among the Silurian rocks in Ireland several horizons have been determined by means of Graptolites and other fossils. It is observed that the older rocks of the south-eastern portion of that country have undergone much crushing and deformation, and in the Ribband Series (of Arenig age) the grit-bands are curiously broken up, portions of grit having been pushed into the argillaceous strata so as to produce a brecciated appearance, deceptively like that of a conglomerate; indeed, some of these crush-breccias have actually been described as conglomerates. From the Upper Silurian rocks of Central Scotland a new genus of fishes (*Ateleaspis*) is recorded, and also a new species of *Eurypterus*.

Observations are made on the Old Red Sandstone of Caithness, Ross-shire, the Lorne, and South Wales. In the Lorne district a fish-bed has been discovered on the mainland shore of Kerrera Sound, about three miles south of Oban. The volcanic rocks in the Lower Old Red Sandstone form a conspicuous feature in this region.

[1] "Summary of Progress of the Geological Survey of the United Kingdom for 1898." Pp. v + 216. (London: Printed for H.M. Stationery Office, 1899.)