

ROYAL METEOROLOGICAL SOCIETY.

THE usual Monthly Meeting of the Society was held on Wednesday evening, March 16, at the Society's house, 49 Cromwell Road, *Sir Gilbert Walker*, C.S.I., F.R.S., President, in the Chair. As is customary in March, the Meeting took the form of a Lecture (The Symons Memorial Lecture), which was delivered by *Prof. G. I. Taylor*, F.R.S., of which the following is an abstract:—

TURBULENCE.

Turbulence is a condition of motion in a stream of fluid which occurs when it flows past solid surfaces or when two layers of fluid flow over one another. Though the details of the motion are too complicated for mathematical analysis, many things are known about the effect of turbulence on the condition of the atmosphere and about the mean values of quantities connected with turbulence.

The effect of turbulence in propagating heat and water vapour into the atmosphere was discussed, and their connection with the friction of the wind on the ground, which is also due to turbulence. Turbulence increases the diffusing power of air till it is 100,000 times as great as that of air at rest. So great is this effect that in the case of tidal motions in the sea it is possible to prove that turbulence is responsible for the gradual slowing-down of the Earth's rotation, and consequent lengthening of the day which astronomers have been able to observe.

Some observations of the details of turbulence show that eddying motion in the atmosphere is spread out equally in all directions in space. Records of a universally-jointed wind-vane were shown, proving that at some height above the ground vertical and lateral components of eddying motion are equal.

The lecture was illustrated by an experiment showing the effect of stratification of density in preventing the formation of turbulence.

Herschel's First 40-foot Speculum.

(See Plate facing p. 101.)

It is well known that Sir William Herschel made two mirrors for his great 40-foot telescope. The first was cast in London on 1785 October 31. Its exact composition is unknown—indeed, it appears that even Herschel himself was not fully informed

upon this point, since we are told that he was forced to rely on the assurances of the founder, who had procured the metal ready mixed. All we know is that fourteen slabs of "hard metal" and seven of "white metal" were used. The mirror, which appears to have been successfully cast at the first attempt, weighed 1023 lbs. in the mould. On cooling, however, it was found to be far from uniform in thickness, being thinner by 0.9 inch at its centre than at the edge, where the metal was about two inches thick. Considerably more than a year was occupied in grinding and polishing the great speculum, and it was not until 1787 February 19 that an actual trial was made of its performance in the telescope. Of this occasion Herschel writes: "The apparatus for the 40-feet telescope was by this time so far completed that I could put the mirror into the tube and direct it to a celestial object; but having no eye-glass fixed, nor being acquainted with the focal length which was to be tried, I went into the tube, and laying down near the mouth of it I held the eye-glass in my hand, and soon found the place of the focus. The object I viewed was the nebula in the belt of the Orion, and I found the figure of the mirror, though far from perfect, better than I had expected. It showed the four small stars in the nebula and many more. The nebula was extremely bright."

Thereafter, some further improvement was made in the figure of the speculum, but it soon became evident that no really satisfactory results could ever be obtained with it; for, as Herschel afterwards wrote, it proved "much too thin to keep its figure when put into the telescope." Meanwhile, however, a second speculum had been successfully cast, containing 75 per cent. of copper and 25 per cent. of tin. This was of uniform thickness ($3\frac{1}{2}$ inches) and weighed 2118 lbs. It was finally completed for use on 1789 August 28; and, as it proved satisfactory, the first mirror was very little used after this date.

The second, or thicker, mirror now came into regular use, being re-polished at intervals up to 1809. It was left in the telescope when the latter was finally dismounted at the end of 1839; but when, in 1867, the fall of a tree crushed a large part of the tube (which was lying horizontally, supported by stone blocks at either end), the speculum was removed and laid on one side for a time. Finally, in 1871, it was removed to its present resting-place in the hall of Observatory House, Slough.

The first mirror, which was last polished in 1797, was not heard of again until 1840. In that year Sir J. F. W. Herschel moved with his family from Slough to Hawkhurst. Some of the heavier instruments and apparatus, including the 40-foot telescope, were left behind; and, in an inventory written at the time in Sir John's own hand, there appears the following item: "In the Observatory, beneath stair, one 40-foot mirror, with case and cover." Now the space under the stairs in the Cottage* is ordinarily inaccessible, being confined on three sides by brick walls. Some years ago, during some alterations to the Cottage, advantage was taken of the removal of a stair-board to make a cursory examination of the space thus shut off. The narrowness of the enclosure and the poorness of the light made a satisfactory examination difficult. Moreover, the workman who made it does not appear to have had a really clear idea of what he was looking for. Be this as it may, he reported that the recess contained simply the light metal cover of what must have been a 4-foot mirror, and that the mirror itself was no longer there.

Thus it came about that attention was directed elsewhere in the search for the speculum. Among other things, the possibility of the mirror being buried somewhere in the grounds was seriously considered, and some vague plans were made for locating it through the medium of its gravitational field. Meanwhile, it occurred to the writer that the evidence concerning the precise contents of the staircase-recess was not altogether satisfactory. Accordingly, on 1927 February 2, with the permission of members of the Herschel family, some boards were removed from the landing at the top of the stairs. The recess was thus revealed, and after the introduction of sunlight by means of two mirrors it could be thoroughly examined. All that could be seen on a casual inspection was a somewhat rusty iron ring, about 4 feet in diameter and 5 inches deep, leaning nearly upright against one of the brick walls (plastered over just here) and covered in front with a close-fitting lid of thin metal. The iron ring, which was not unlike the tyre of a cart-wheel, was obviously the cell of a large mirror and was quite separate from the tin cover. On removing the latter, which was provided with six handles, the mirror itself was at once seen, occupying the front portion of the cell, close under the cover. This fact, combined with the thinness of the speculum and the

* This building, in the grounds of Observatory House, Slough, is always referred to as the "Observatory" by Sir William and Sir John Herschel, and also, of course, by Miss Caroline Herschel.

depth of the cell, was no doubt responsible for the false impression produced on the earlier occasion already mentioned; for, in a bad light and without measurement, the iron rim, projecting back nearly three inches from the rear surface of the mirror, might well have been taken to be part of the cover.

The surface of the mirror, as first revealed, was thickly coated with dust. When the latter had been gently removed with a wet sponge, and the mirror carefully dried, it became evident that the polish was greatly superior in condition to that of the second mirror. There was naturally some tarnishing of the surface, but there was none of that fine pitting and crystallization which is, unhappily, so marked a feature of the thicker speculum. Probably the relative dryness of the air in the cottage had much to do with the preservation of the polish.

On 1927 March 4, Sir J. C. W. Herschel superintended the removal of the mirror from its recess to a place of honour in the Cottage library. To make the removal possible, one half of each of the eight lower treads of the staircase had been removed on the previous day; and with the help of four men, the speculum was gently rolled on its edge, cover and all, along a pathway of thick coconut-matting. It was finally brought to rest in a position precisely similar to that in which it had been found, *i. e.*, leaning against a wall at the same angle as before, and with the same point uppermost. The cover having been removed, it was now possible to make a much more satisfactory examination of the mirror and its cell than could be carried out in the confined space beneath the stairs.

The thickness of the speculum at its edge was measured at several points, and found to be 1.9 inches. The total diameter of the casting is about $48\frac{1}{2}$ inches; but as there is a $\frac{1}{4}$ -inch "step" running all round the front edge to keep the mirror in its cell, the diameter of the polished surface is reduced to exactly 48 inches.

The back of the mirror is not ground, but the surface is fairly even. At the centre is a smooth patch, about three inches across, which appears to mark the spot where the "feeder" of the casting was sawn off after the cooling of the mass.

The cell proper is of wrought iron, $\frac{7}{8}$ inch thick in front and $\frac{9}{16}$ inch thick behind the step in the speculum. The depth of the cell is $3\frac{1}{8}$ inches, and, outside this, at the back, is bolted an overlapping ring of hoop iron, $\frac{1}{8}$ inch thick and $2\frac{1}{2}$ inches deep. This has at its rear edge nearly 80 small projections, placed at intervals

of two inches. The over-all depth of cell plus outer rim is, excluding the projections, $4\frac{1}{2}$ inches.

The mirror is held in place by six screws, which work in lugs bolted through the cell at regular intervals. There are three rings, set 120 degrees apart, at the back of the cell, which were evidently used for suspending the whole mass when the mirror had to be lifted on to and off the polisher. The projections at the back of the hoop-iron ring were obviously for the gradual rotation of the mirror, by means of a ratchet, during the process of polishing.

The cover is of thin sheet iron, very well preserved and free from rust. It is painted a dark green on the outside, and is braced by six radial ribs and ornamented at intervals round the edge with stars, stamped in relief. The edge is turned over to the depth of about one inch, and it fits the cell very exactly.

As soon as the mirror was secured in its new position, the surface was carefully cleaned with precipitated chalk and alcohol—a method recommended to the writer by Prof. Newall. A most striking improvement in the reflectivity of the surface was the result, and a very large part of the tarnish disappeared altogether. It is now hard to believe that 130 years have passed since the mirror was properly polished.

Of the two photographs which form the Frontispiece of this number, the first was taken, with the help of Miss Mira Harcastle, on the night of March 3, the eve of the mirror's removal to the library. The second was taken on the afternoon of March 12, with the assistance of Miss Caroline Herschel.

W. H. STEAVENSON.

Eclipse Expeditions to Norway.

CUSTOMS OFFICE REGULATIONS.

A CERTAIN number of scientific expeditions from various countries are expected to visit Norway next summer in order to study the Total Eclipse of the Sun, which is taking place on June 29, 1927.

On this occasion it is recommended that the head of each expedition procures from the competent Authorities in his own country a certificate of about the following contents:—

I, the Undersigned,, do hereby certify that Mr. N. N. is the head of a scientific expedition which is proceeding to Norway to observe the total eclipse of the Sun, which is taking place on June 29, 1927.