ASTRONOMISCHE NACHRICHTEN.

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Schreiben des Herrn *William Lassell* an den Herausgeber.

(Hierzu eine lithographische Zeichnung.)

As the term of my three years residence here is drawing to a close, and as some considerable time must elapse before the results can be published in detail, I have thought that a brief notice of the character of the work in which I have been engaged, and the Instrument I have employed, may be in some measure acceptable to the readers of the „Astronomische Nachrichten".

The Telescope is a Newtonian Reflector, equatoreally mounted on generally the same principle as that on which my nine-inch und two-foot Telescopes were mounted; and which has been described in the memoirs of the Royal Astronomical Society. The aperture is exactly four feet. There are two large specula, respectively of the foci of 441,8 and 448,1 inches. They are about 4½ inches thick and weigh separately about 2700 ℔. The length of the tube is 37 feet and its diameter 4 ft. 3 ins. It is a lattice or skeleton tube, made of flat bars of iron joined, (with spaces between, nearly equal to the breadth of the bars) by flange-rings at convenient distances. The object of making the tube in this form, was to prevent the possibility of any currents of differently heated air in the tube, or of any inequality of the internal and external temperatures — it appears to answer this end perfectly.

The principle of mounting, even when carried out on this large scale, I consider successful, and I have not been annoyed by any sensible amount of flexure in the frame-work in the course of its use. Up to the latitude of this place 35°55′ it answers well; but I should hesitate to erect it in a much lower latitude without some modification. There is no roof or covering over the Telescope; but the observer or observers, are protected by being placed in one or other of the storeys (according to the altitude of the object to be viewed) of a Tower, which affords a means of getting conveniently at the eye-piece; and which when the Telescope points to the Zenith, is about 39 feet from the ground.

A staircase within the Tower, leads to the different storeys, which are about 4 ft. 6 ins. square and afford abundant room for papers, micrometers, eye-pieces, lamps, and any other small apparatus required; beside furnishing to the observer a most grateful shelter from the dew, and occasionally from an inclement wind. The Tower is carried round on a circular railway, and has beside, a revolution on its axis, and a radial motion to and from the Telescope: so that at most altitudes and hour-angles, the eye-piece is easily accessible. It has been however our practice generally, for the most obvious reasons, to observe within three hours of the meridian East or West.

I have not attempted to carry on the Telescope by a driving clock, properly so called, as the great weight, amounting to many tons on the bearings, would make it a difficult problem. I have however a system of wheelwork, terminating in a fly-wheel and winch-handle, which I might almost say answers equally well. The train is so regulated that to give the Telescope a sidereal motion it is only necessary to turn this winch-handle once, accurately, in every second. A sort of skeleton-clock giving motion to a loud-beating pendulum, is placed adjacent to the handle, and it is the duty of an assistant, (he may be merely a peasant) to take his place at this winch, giving it one revolution for every vibration of the pendulum. The fly-wheel, generally insures the uniformity of each revolution, and a very short initial training is generally sufficient to enable the workman to make the revolutions perfectly coincident with the beats of the pendulum. In some respects this mode of driving is superior to the ordinary mode; for it can be instantly interrupted, or accelerated, or retarded, at pleasure, when required for any special purpose. The amount of labour is not great, as it may be continued for hours without being oppressive.

Attached to this regulating clock are two dials, the finger or index of one of them having a retrograde motion and the dial figured accordingly; while the other is direct. The first of course belongs to the eastern hour-angle, which is constantly diminishing — the second to the western. Being set to the present hour-angle at the commencement by the observer — if from clouds or any other cause the observation is interrupted — when the sky clears, the assistant can, by mere inspection of the dial, bring up the Telescope to correspond with it, by another winch having a quick motion; without the observer having to descend from the Tower, or interfere in any way.

Two assistants are all the observer requires, and they are far from being constanly engaged. One or other of them (and they generally interchange during a long night's observation), is occupied pretty constantly in driving the Telescope — the other fitfully, in carrying on the Tower, as the Telescope retreats from it. I may remark that I have often been struck with the convenience — I had almost said luxury — of observing which has been made compatible with so large a Telescope. Almost all altitudes are equally convenient, by the adaptation of the several attitudes of kneeling, sitting or standing — none of them irksome, when not continued too long, and the head is atways in a comfortable position, which I am persuaded influences not merely the convenience, but the accuracy of observation. And this too, sheltered from the dew, and all the apparatus drawing materials etc. almost within arm's length.

The adjustments of the Instrument have not sensibly varied since it was first erected, i. e. there have been no changes which can be traced to any alteration of either Polar- or Declinationaxis. I do not however mean to say that the Telescope can be used otherwise than differentially for giving any accurate places; nor, that it is not liable to a change of 3 or 4 minutes of arc at widely different hour-angles: but these errors seem to arise partly from minute changes in the position of the great speculum, (which it is well known cannot be constrained) as it necessarily rolls over somewhat in changing from East to West. The errors however have generally been so moderate in amount, as to give us no trouble in the kind of work we have pursued; and generally so nearly constant at about the same hour-angles, as to make it an necessary to spend time in investigating which of the many minutes disturbing causes, have had the greatest share in the effect. During the three years the large mirrors have been repeatedly polished and interchanged in every case involving a complete readjustment of both large and small specula; but the corrections generally remain within such nanon limits as to present no difficulty or inconvenience.

The Telescope being entirely in the open air and exposed to every change of weather and temperature; the specula, both large and small, must necessarily be subjected to more exposure than if they were in a closed building — especially the plane specula, placed high in the air at the upper end of the tube. Yet the only two planes, which have been in use, have never been repolished, and I am not certain, that there is a sensible deterioration of lustre in either of them. It is however practically of much more importance that the surface of the plane should be purely brilliant, then that that of the concave should be so. In case of any decay of the latter, the means are at hand in the polishing machine and by the occupation of a single day, of renewing the surface, without any risk of spoiling it. I have nevertheless, I believe, never had occasion to repolish for that reason alone.

The two systems of levers for zenithal and horizontal support of the great speculum, which I first applied to the two-foot speculum, and which have been described in one of the Reports of the British Association; have, with slight modification, been applied to these large specula with equal success. I find these levers quite essential to eliminate inevitable flexure and give round images of the stars.

During the major part of my residence here, the planets have been observed whenever favourably situated, especially Mars, Saturn, Uranus and Neptune. Jupiter and Venus have also been observed, but with less frequency and less important results.

Neptune has received especial attention, and observations of his satellite have been made on almost all suitable occasions. A series of measures also of his diameter, (and that of Uranus) has been made with a double-image micrometer. A careful scrutiny of the neighbourhood of the planet has been made whenever atmospherical circumstances warranted it, with a view to the detection of any other satellite, but without leading even to the suspicion of one. The known satellite is so well seen, especially when more than 8 or 9 seconds central distance from the planet, even in bright moonlight and without any extraordinary atmospherical circumstances, that I have arrived at a firm conviction that the planet is attended by no other satellite, which will bear comparison in magnitude with the known one — not greater certainly than Dione or Rhea among Saturn's satellites bears to Titan. It may indeed be possible that a faint satellite several minutes distant might exist, though I have no suspicion of any, and one so situated would be very difficult to recognize, among the numerous minute stars which a telescope so large as this generally reveals.

The same kind of observation has been made upon Uranus and his satellites, without leading to the discovery of any additional ones. The two interior satellites discovered by me in 1851 (see Monthly Notices of the Royal Astronomical Society, Vol. XI, page 248 and Vol. XII, page 15) are very much fainter than the satellite of Neptune, or than Oberon or Titania, yet I have been able frequently to see them, sufficiently to make a rough estimate of their places, even in brilliant moon-light, with this powerful Telescope. As I have in the absence of the Moon, and under the most favourable atmospherical circumstances, sought diligently for additional satellites, without being able even to suspect any, aided moreover by the careful scrutiny of my friend and assistant Mr. *Marth*; I have the fullest conviction, that the two first discovered by Sir *William Herschel* in 1787, commonly known as the bright satellites, — and these two, are all of which the existence has been any way proved. I am also persuaded, that if any others exist, they must be sensibly fainter than the faintest of these; unless as I have surmised in the case of Neptune, there may be an excentric remote satellite, of at least three or four month's period, which, in the crowded part of the sky where the planet now is, it would be very difficult to detect. Indeed in observing the planet as now situated, we should be very frequently embarrassed in recognizing the satellites, by the presence of numerous minute stars, if we were not directed to their approximate places by an ephemeris previously prepared.

From all my experience in the examination of the satellites of this planet, I cannot escape the conclusion that Sir *William Herschel*'s observations, and also some later ones of presumed satellites, must have really been of small stars, which in any telescope large enough to show the true satellites well, are seen to accompany them pretty frequently in most parts of the heavens. I feel therefore tempted to express an opinion that it is now time that in all future Treatises on Astronomy the proper number of known satellites should be assigned to these two planets — namely to Uranus four, and to Neptune one. I notice, that a beautifully illustrated and generally well-written popular Treatise on Astronomy, has been recently published in France, which assigns to Uranus e i g h t satellites, and to Neptune t w o.

It may be worth remarking that in March next, Uranus will be very nearly in the same position as when first discovered — just completing one sidereal revolution.

Assiduous attention has also been given as may be supposed, to the planet Saturn and his fainter and closer satellites. Titan and Japetus, as they can be equally well observed with smaller telescopes, have had less of our notice; but Hyperion and the nearest five, have been very carefully looked after.

In observing the closest satellites, we have found the most accurate mode to be, to note the t i m e s, when they respectively reached elongations, preceding or following, equal to the distance of a tangent to the end of the ring, from its minor axis. Occasionally, when circumstances permitted, an imaginary tangent to the half-projection of the ring, or the limb of the planet, was taken, instead of the outer edge of the ring. Experience in this mode of estimation has led to very great confidence in its accuracy, especially when the passage of the same satellite over the four points — i. e. over the tangent, north and south, preceding, and north and south, following, can be observed. I have no doubt whatever, that these determinations give far more accurate results, than can be obtained by more direct micrometrical measurements.

To make these observations with the smallest loss of time, it has been Mr. *Marth*'s practice to compute an ephemeris of the approximate times when these phenomena would happen; and, in observing the times of these contacts, it would occasionally appear, that the limit of inaccuracy did not exceed one minute of time. In addition to these elongations, the passages of the satellites over the apex of the ball, north or south, were observed when practicable.

Another important result has suggested itself during the practice of this method — that, if a sufficient series of observations could be made more exact dimensions of the rings, as well as any excentricities which may exist in them, would probably be developed in the series. As many refracting telescopes of large aperture (eight or nine inches) now exist, have thought some of the possessors of them might be induced to take up this work, for which such telescopes are I think quite competent, if the approximates of these phenomena were given. I have therefore suggested to Mr. *Marth* the calculation of the enclosed ephemeris for the next opposition of the planet.

The ephemeris gives the distance in semi-diameters of the ring, of the satellites from its minor axis, the letter *p*, of course indicating preceding, and the letter *f*, following. The other co-ordinate need not be given, bearing in mind, that if the motion be from *p* to *f*, the satellite passes on the north side of the major axis, and if from *f* to *p* on the south side.

At the end of the ephemeris is a short table of the lengths of the apparent semi-minor axes of the orbits of the several satellites, in the same terms, for three epochs of next apparition; from which it may be inferred how much, north or south, of the ring's major axis, the satellite is, when it passes these imaginary tangents. It also will appear from this, that Rhea already passes too far north and south, for the most accurate estimation. But Tethys will be well situated, and, being generally somewhat brighter than Dione, will be perhaps the most suitable. I may mention here that the period of Mimas which Mr. *Marth* had deduced from my old observations, has required little alteratino, the true sidereal period being $0^{d}9424240$ or $0^{d}22^{h}37^{m}5^{s}43$.

It may be useful in observations for determining the dimensions of the rings, to state, that the times required for the satellites respectively to traverse the whole length of the ring, are for Rhea $9^{h}2^{m}$, Dione $7^{h}44^{m}$, Tethys $6^{h}56^{m}$, Enceladus $6^{h}23^{m}$ and for Mimas $5^{h}57^{m}$.

It will be remarked, that the interval between the epochs for each day in the ephemeris is three hours — it would have been easy to have added an intermediate epoch, but it would have occupied much more space in printing. If however the ephemeris should be found useful, and an extension of it is desired, Mr. *Marth* will be happy, to extend it to the remaining half of Saturn's opposition, with shorter intervals, if such a wish be intimated in time.

A series of drawings I have made of the surface of Mars, during and since his late opposition, has been more interrupted than I should have thought possible in this climate; the weather during the last two months, having been quite as unfavourable for observation as it usually is in England at the same season.

Another object I have not less auxiously pursued during my sojourn here, has been the delineation of the most conconspicuous, or remarkable planetary and other Nebulae, of which I have made a good many drawings, including an elaborate one of the great Nebula in Orion, not yet finished. I have found great difficulty in some attemps I have made to get these drawings faithfully copied, and my want of complete success induces me to postpone until my return to England, any further steps towards their publication.

All these objects being first satisfied, Mr. *Marth* has been very industriously scrutinizing the heavens when the moon was absent for Nebulae.

In this portion of the work I have personally taken a very small share, and as it has only been pursued in the absence of other demands, it cannot be supposed that the scrutiny even of those parts of the heavens subjected to it, can have been very perfect. A good many new Nebulae however have been found, some description of which I hope to be able to give at a future time.

Ephemeris of the five inner satellites of Saturn.
For 12^h and 15^h Greenwich Sidereal Time.

1865	Rhea	Dione	Tethys	Encel.	Mimas
Febr. 9	f. 0,54	f. 2,56	p 0,39	f. 1,26	p. 1,35
	1,19	2,76	1,21	0,39	0,77
10	f. 3,87	p. 0,89	f. 0,76	f. 1,04	p. 1,19
	3,84	1,59	1,51	1,64	0,33
11	f. 0,88	p. 1,40	p. 1,10	p. 1,54	p. 0,88
	0,22	0,66	1,76	0,85	f. 0,17
12	p. 3,55	f. 2,73	f. 1,42	p. 0,61	p. 0,45
	3,76	2,46	1,96	1,40	f. 0,65
13	p. 2,18	p. 2,19	p. 1,68	f. 1,71	f. 0,04
	1,59	2,58	2,09	1,24	1,03
14	f. 2,75	f. 0,16	f. 1,90	f. 0,13	f. 0,52
	3,18	0,94	2,16	1,05	1,28
15	f. 3,18	f. 1,98	p. 2,05	p. 1,75	f. 0,93
	2,75	1,35	2,16	1,53	1,36
16	p. 1,59	p. 2,77	f. 2,14	f. 0,35	f. 1,22
	2,18	2,71	2,09	p. 0,63	1,27
Febr. 17	p. 3,76	f. 1,67	p. 2,17	f. 1,65	f. 1,36
	3,55	2,22	1,95	1,70	0,99
18	f. 0,21	f. 0,57	f. 2,12	p. 0,81	f. 1,31
	0,88	p. 0,22	1,76	f. 0,16	0,60
19	f. 3,84	p. 2,42	p. 2,00	p. 1,43	f. 1,08
	3,87	1,94	1,50	1,75	0,12
20	f. 1,19	f. 2,61	f. 1,83	f. 1,21	f. 0,72
	0,54	2,77	1,21	0,33	p. 0,37
21	p. 3,41	p. 1,02	p. 1,63	f. 1,09	f. 0,26
	3,67	1,71	0,87	1,65	p. 0,82
22	p. 2,43	p. 1,26	f. 1,31	p. 1,51	p. 0,24
	1,88	0,52	0,51	0,78	1,15
23	f. 2,53	f. 2,69	p. 0,98	p. 0,67	p. 0,70
	3,00	2,39	0,13	1,44	1,34
24	f. 3,35	p. 2,28	f. 0,63	f. 1,69	p. 1,07
	2,97	2,63	p. 0,26	1,19	1,34
25	p. 1,30	f 0,31	p. 0,25	f. 0,20	p. 1,31
	1,91	1,08	f. 0,63	1,11	1,17
26	p. 3,82	f. 1,87	p. 0,14	p. 1,75	p. 1,36
	3,66	1,23	0,99	1,49	0,85
27	p. 0,09	p. 2,77	f. 0,51	f. 0,28	p. 1,23
	f. 0,58	2,68	1,32	p. 0,69	0,41
28	f. 3,79	f. 1,79	p. 0,87	f. 1,67	p. 0,94
	3,87	2,31	1,60	1,68	f. 0,09
March 1	f. 1,48	f. 0,36	f. 1,21	p. 0,74	p. 0,53
	0,83	p. 0,37	1,84	f. 0,23	f. 0,57
2	p. 3,25	p. 2,34	p. 1,51	p. 1,47	p. 0,05
	3,57	1,82	2,01	1,75	f. 0,97
3	p. 2,66	f. 2,66	f. 1,76	f. 1,15	f. 0,44
	2,14	2,77	2,12	0,25	1,25
4	f. 2,28	p. 1,17	p. 1,96	f. 1,15	f. 0,88
	2,79	1,83	2,17	1,68	1,36
5	f. 3,50	p. 1,12	f. 2,09	p. 1,47	f 1,19
	3,15	0,36	2,15	0,71	1,30
6	p. 1,02	f. 2,65	p. 2,16	p. 0,74	f. 1,35
	1,65	2,30	2,05	1,48	1,05
7	p. 3,86	p. 2,37	f. 2,15	f. 1,67	f. 1,33
	3,75	2,68	1,89	1,12	0,67
8	p. 0,39	f. 0,45	p. 2,09	f. 0,28	f. 1,13
	f. 0,28	1,22	1,67	1,17	0,20
9	f. 3,72	f. 1,74	f. 1,95	p. 1,75	f. 0,78
	3,85	1,06	1,40	1,45	p. 0,30
10	f. 1,74	p 2,77	p. 1,75	f. 0,20	f. 0,33
	1,12	2,63	1,09	p. 0,77	p. 0,75
11	p. 3,09	f. 1,91	f. 1,49	f. 1,69	p. 0,17
	3,45	2,40	0,74	1,66	1,11
12	p. 2,86	f. 0,25	p. 1,19	p. 0,66	p. 0,64
	2,38	p. 0,54	0,36	f. 0,31	1,32
13	f. 2,05	p. 2,24	f. 0,85	p. 1,51	p. 1,03
	2,58	1,69	p. 0,02	1,75	1,35
14	f. 3,61	f. 2,71	p. 0,49	f. 1,08	p. 1,28
	3,31	2,77	f. 0,41	0,17	1,20
15	p. 0,50	p. 1,32	f. 0,11	f. 1,21	p. 1,36
	1,38	1,95	p. 0,78	1,70	0,90
16	p. 3,87	p. 0,96	f. 0,28	p. 1,42	p. 1,27
	3,81	0,19	1,12	0,64	0,47
17	p. 0,68	f. 2,59	p. 0,66	p. 0,81	p. 0,99
	0,01	2,20	1,43	1,52	f. 0,01
18	f. 3,63	p. 2,45	f. 1,01	f. 1,64	p. 0,60