# XXVIII. *On the Construction of Specula of Six-feet Aperture; and a selection from the Observations of Nebulæ made with them. By the Earl of* ROSSE, *K.P., &c., F.R.S.*

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THE period seems now to have arrived when it may be proper to lay before the Royal Society some further account of researches in sidereal astronomy, carried on with a Newtonian telescope of 6-feet clear aperture.

The observations extend over a period of about seven years, during which few favourable opportunities were lost; still in our climate, where there is so much cloudy weather, a year's work, measured by the number of hours when nebulæ can be effectively observed, is not considerable. Here in winter the finest definition we have, and the blackest sky, is usually before eleven o'clock, after which the sky becomes luminous, and the fainter details of nebulæ disappear. In spring and autumn the change is neither so early nor so decided; but the nights are shorter. Guided by Sir JOHN HERSCHEL'S admirable Catalogue, we have examined almost all the brighter known nebulæ except a few in the neighbourhood of the pole, and a great proportion of the fainter nebulæ. No search has been made for new nebulæ; very many, however, have been found accidentally in the immediate neighbourhood of known nebulæ, but for the most part they were faint objects presenting no features of interest. In every case where any peculiarity was detected, as for instance the convolution of a spiral, dark lines, or dark spaces, a rough sketch was made, and the more remarkable objects were selected for examination on favourable nights, when the details were carefully filled in, sometimes with the aid of the micrometer. The very faint objects, and even the brighter, where there was a simple gradation of colour and no peculiarity of form, after having been examined on a tolerably good night, were rarely examined again. In our ever-varying climate, when we employ high powers and large apertures, vision is impeded more or less by the unsteadiness of the air; it is impeded also by haze; and in both respects the condition of the air varies immensely from night to night, and from hour to hour. The speculum also is not uniform in its action. With such sudden alternations of temperature, in a moist climate, it is frequently dewed, and gradually tarnishes. Artificially heating it would be a remedy; but it would be an objectionable one, and we have not employed it. From all these causes we can scarcely say that any one object has been examined under a combination of favourable circumstances; still it is not now probable that with the present instrument any remarkable additions will be made to the details of nebulæ already carefully sketched, except in very favourable states of the atmosphere. Occasionally the air is so transparent and so steady, that magnifying power may be pushed very far; and then, perhaps, something new comes out. Such opportunities, however, are rare;

and the progress made is necessarily so very slow, that I think it would be inexpedient longer to keep back this paper in the distant hope of making it in some respects more complete.

As to the instrument, a slight description of it has already been given in the 'Transactions' for 1850, but without details, and in the 'Transactions' for 1840 the process employed in the construction of specula of 3-feet aperture was fully explained; but in passing from specula of 3-feet aperture, and about twelve hundredweight, to specula of 6-feet aperture and four tons, although the same principles were our guide, difficulties were encountered which called for new contrivances and additional precautions. It will, I think, be useful to give a short account of the process by which the 6-feet specula were made, and some details as to the mounting, supplying at the same time the best answers we can to the questions, so often put, What really are the optical powers of the instrument? What are the merits and demerits of its form of mounting, after an experience of more than ten years? Would it be possible to construct a larger one, and, if so, would there be anything gained? As there seems to be a desire to employ large instruments in different parts of the world, would it be possible to lay down instructions sufficiently precise to enable a mechanical engineer, without a previous apprenticeship, to undertake the construction of large instruments as a matter of business?

About one ton and a quarter of speculum-metal can be melted in one crucible; and up to that weight there is no difficulty whatever in casting a speculum, and the instructions in the 'Transactions' for 1840 are amply sufficient to enable any engineer to do so. Each time, however, the crucible increases in circumference from the pressure of the metal, and after seven meltings we found the increase to amount to 4 inches. One ton and a quarter is therefore about the limit for a separate melting, and for larger specula we must employ several crucibles. The tin and copper must be previously combined in smaller crucibles, holding not more than three or four hundredweight, as the heat required is much greater than in the second melting. Three crucibles were employed in casting the 6-feet specula; and we proceeded thus:—

The crucibles (which had been cast by Messrs. DEWER of London, with the precautions detailed in my former paper) were placed in three separate air-furnaces upon cast-iron stands about 8 inches deep, and of somewhat larger diameter than the crucibles, to protect them from the immediate current of air passing through the fire-bars. A brick pillar from the bottom of the ash-pit relieved the furnace-bars from the weight they would otherwise have had to sustain. The furnaces were round, 4 feet diameter, and 6 feet deep to fire-grate,—constructed as an ordinary air-furnace, with a door at the ash-pit to regulate the admission of air. The three furnaces were worked by one stack. In heating a crucible, it is necessary that the temperature should be raised gradually, *beginning at the mouth*; otherwise it will be very liable to crack. To satisfy this condition, the crucibles (of course empty) having been placed on their supports, and the furnaces filled with good peat, the fires were lighted at the top; and in about *ten hours* the crucibles were of a proper temperature for the reception of the speculum-metal, which of course was introduced gradually. In about twenty-six hours from the time the fires were lighted the metal was ready for pouring. Peat of good quality is about equal to wood in heating-power, when consumed in furnaces where there can be no accumulation of charcoal. The mould was constructed on the principles explained in my former paper; but, the scale being now so much enlarged, little matters of detail, which might have been before overlooked with impunity, were found to be of vital importance. The bed of hoop-iron was 6 feet 6 inches diameter, and 4 inches thick. We had not at the time a lathe sufficiently large to turn it; and therefore it was turned horizontally, on the machine which was to grind and polish the future speculum. To remove little irregularities arising from the imperfection of the turning-apparatus, the bed of hoops was ground for two or three days with a disc about 6 feet diameter, composed of fragments of sandstone cemented together within an iron ring. The annealing-oven was built on four arches communicating with two low chimneys. The floor being laid upon the arches, could easily be heated to redness. The interior of the oven was 8 feet by 10. For want of room, the brickwork at the ends was but 2 feet thick, the sides nearly 4. The thrust of the arch was, in the usual way, sustained by bolts. The crucibles were raised from the furnaces by a crane and tongs just as at the Mint, and placed in rings swinging on trunnions a little above the centre of gravity of the mass. The metal being of a proper temperature, levers were fixed upon the trunnions, and at a signal the crucibles were simultaneously inverted as rapidly as possible. The operation of pouring was accomplished in about three seconds. If the metal was not poured rapidly, the conducting-power of the iron surface is so great that partial solidification would take place, and the casting would be imperfect. In about twenty minutes the metal was solid throughout; the frame containing the sand forming the sides of the mould was then removed, and the speculum, being grasped by an iron ring, was drawn into its place by a capstan. The temperature of the oven was red, just perceptible in the dark, about 900°. All the apertures were then closed; and in about six weeks the speculum was cool. When removed from the oven the speculum was found perfect; but the radius of curvature was much longer than it should have been, which rendered the grinding a very tedious operation. The cause, however, was obvious; the floor of the oven had been laid carefully flat to prevent warping; no other precaution had been taken; indeed, no other had been necessary with the 3-feet specula.

The speculum was removed from the oven to the bed of supporting levers in the following manner:—A pit was dug about 4 feet deep, near the oven, commanded by a crane. The speculum, weighing about four tons, was drawn out of the oven in the same way that it had been drawn into it. Planks were provided for the speculum to slide upon to the edge of the pit, into which it was lowered gently, the ring still grasping it. The speculum was now resting principally upon its edge, the face supported by the side of the pit. By means of *wooden* handspikes, and with little effort, the speculum was made to rest entirely on its edge, bearing upon the soft earth. Two bars, 7 feet long each, and 2 inches square, one of them cranked in the centre, were placed against the back in the shape of a cross. To prevent metallic contact, the bars had been bound round with woollen cloth. Strong planks were placed against the face, and screw bolts were passed through the planks and projecting ends of the bars. The speculum was thus encased, and was easily raised by the crane *face up*. In the mean time a strong wooden platform had been made with three iron pillars securely fixed in it, about 2 feet long each, and so disposed as to support the speculum with the least strain. The frame carrying the supporting levers, to be hereafter described (Plate XXIV. fig. 1), was placed upon this platform, the three iron pillars passing through interstices in the levers; and the speculum was lowered till it rested upon the pillars, the levers being considerably below it. The bars and planks encasing the speculum were then removed, and the frame and levers raised by the crane till the speculum was completely supported by them. It now rested on its levers, and was taken to the grinding-machine. I have been thus minute in describing the means we had employed in removing the speculum from the oven, turning it over, and placing it on its bed of levers, as in the arts they have never to deal with a material at once so heavy and so brittle; and we were guided by long experience, which others may not have had.

This speculum had been more than a month upon the grinding-machine, and was just ready to be polished, when it was broken by an accident. Immediate preparations were made for recasting it. While the speculum had been in the annealing-oven we had finished a powerful lathe for turning the grinding-tools, with a slide-rest moving in the proper curve. The bed of hoops was placed upon that lathe, and its radius of curvature adjusted: the floor of the oven also was cut roughly to the same curve. As we were anxious to guard, as far as possible, against contingencies, and to secure a working speculum with the least delay, we were satisfied to employ an alloy somewhat lower than on the former occasion, and an ingot of speculum-metal was added which contained more than the proper proportion of copper. A little additional copper diminishes the brittleness considerably, while it increases the liability to tarnish.

The speculum was successfully cast, but the surface was covered with minute fissures, about the breadth of a horse-hair. These we resolved to grind out. The grinding was very tedious, partly owing to the metal being a little below standard, and partly to the deepness of the fissures. After the first day's grinding, the fissures, which previously were scarcely perceptible, became much enlarged, owing to the edges chipping away; and the whole surface thus became, as it were, covered with large wrinkles. The process of abrasion is necessarily extremely slow, as both the velocity and the pressure are kept within very narrow limits, to prevent the evolution of heat, which would crack the speculum. The grinding continued for nearly two months, the machinery working for part of the time at night; and a few of the fissures were so deep that even then the traces of them were perceptible. The speculum was then polished; and its performance fully equalled our expectations.

A telescope intended to be constantly employed requires two specula. We had now leisure to encounter delays and difficulties in endeavouring to procure a second speculum free from the defects of the one already finished. We had satisfied ourselves that the fissures were owing to our having employed the bed of hoop-iron in the state in which it was when taken from the turning-lathe. The surface, though nicely turned, was not as smooth as the surface of a solid disc would have been: a slight yielding at the edges of the hoop-iron, and a slight spreading under the pressure of the tool, had produced little irregularities; and although the surface had been carefully "black-washed," the speculum-metal had encountered too much friction in the act of contracting after it had become nearly solid, and thus had been filled with superficial rents. On the first occasion there had been no fissures, but the bed of hoop-iron had been ground; the remedy was therefore obvious.

The third speculum was successfully cast; but on opening a small aperture, and looking into the oven before it was quite cold, it was observed that the speculum was cracked through the middle. The temperature of the speculum was found not to be quite uniform; and that circumstance, taken in connexion with the direction of the crack, seemed to point out the cause: the ends of the oven, from want of room, had been made thinner than the sides. The first speculum had probably been strained by the same cause, and rendered more fragile.

The oven being ready, an attempt was made to cast a fourth speculum, which failed. We had each time, before the bed of hoop-iron became cold, saturated it with tallow to prevent the formation of rust between the hoops, which would have rendered the surface impervious to air; but just before it was again employed it was made red-hot, and the tallow burned out. On this occasion, by an oversight, the bed of hoop-iron had not been sufficiently heated, and there remained some of the tallow unconsumed, which, being vaporized in large quantities, produced an ebullition which made the casting as porous as pumice-stone. This speculum, of course, was not annealed, and the following day it was in small fragments.

The fifth speculum, being in every respect a perfect casting, without the slightest blemish and of a proper curvature, was ground and polished in about a month. It is desirable that the bed of hoop-iron when the metal is poured should be warm, so as to prevent the possible deposition of moisture; but if much hotter than this, it at once dries up the sand, and it is difficult to make the mould secure. In the whole of the operation I have described, one of the difficulties is to time each stage. If the mould was prepared too long, the bed of hoop-iron might become cold and damp; on the other hand, if the mould was not ready when required, it might be hazardous to keep the crucibles so long at the pouring-heat. It may, perhaps, be as well to add that the crucibles, when in the pouring-gimbals, require to be thoroughly skimmed, as particles of coal falling upon the hoop-iron would be immediately entangled in metal not rising to the top: the skimming should be done promptly, lest the metal fall below the proper temperature. Any considerable delay in drawing the speculum, when solid, into the annealing-oven would be fatal; therefore there should be ample capstan power to overcome the difficulty which usually is experienced in detaching the speculum from the mould.

The last speculum is but $3\frac{1}{2}$ tons, and is therefore considerably weaker than its predecessor; and by carefully comparing the two specula at low altitudes, we have been made thoroughly sensible of the great importance of strength in preventing flexure. There are little irregularities in the action of the supporting levers, which are much more injurious to the definition of the weaker speculum than the other; and although these irregularities may be susceptible of further diminution, I think there would still be sufficient gain to make it worth while to cast a third speculum considerably heavier than either of the others.

In the 'Philosophical Transactions' for 1840 I have endeavoured to explain the principle upon which the bed of hoop-iron acts; some, however, seem to have attributed larger effects to it than I have, and of a different kind. It has been supposed by some that a molecular change takes place, somewhat similar to that which has been observed in the case of very small portions of speculum-metal rapidly cooled, while by others the change has been compared to the "chilling of cast iron," to which I think it bears no analogy: cast iron when chilled becomes almost as hard as hardened steel; there is an exudation of graphite—in fact, a chemical change the exact nature of which seems to be imperfectly understood: there is no such change in speculum-metal, it becomes actually softer. To obtain sound castings, all which seems necessary is so to manage the process that solidification must begin at one surface and proceed regularly to the other. By employing the bed of hoop-iron the object is effected with certainty; but the engineer may employ other means, perhaps sufficient for the purpose, which, under varying local circumstances, may be cheaper and more convenient.

Possibly some useful hints may be gathered from a slight glance at the successive steps by which we obtained a clear view of the principle by which the founder should be guided in making large castings of speculum-metal.

About the year 1827, on commencing a series of experiments on speculum-metal, I procured a small flat speculum from Mr. TULLY, and two similar specula from Mr. CUTHBERT, as specimens of the art in its most advanced state. I also procured from Mr. CUTHBERT several small unwrought castings of about two ounces weight to practice upon. Mr. TULLY'S specula were cast in the ordinary way in sand, and polished with rouge: but Mr. CUTHBERT'S were cast in contact with iron, and so cooled instantaneously; they were polished with putty. All the specula for Mr. CUTHBERT'S microscopes were made in a similar manner. He was under the impression that speculum-metal cooled instantaneously was more suitable for his purpose than common speculum-metal—that it was sounder, more compact, and resisted better the action of emery. These specula were accidentally exposed to the air of the laboratory for a considerable time; and at length we remarked that Mr. CUTHBERT'S specula had somewhat lost their polish, while TULLY'S speculum was as bright as ever. The inferiority of CUTHBERT'S specula we attributed to an excess of copper, but with further experience we came to a different conclusion. We had several early samples of chilled speculum-metal, and corresponding samples of the same metal cooled gradually. They were obtained in this way:—In our experiments on the alloys of tin and copper, we were in the habit of taking out a sample after each addition of tin. When cool, a small piece was broken off the sample, and the fracture and colour examined; the remainder was then hastily ground and polished on a succession of revolving laps. The experiments were very numerous; and to save the time lost while the sample was cooling, we at first applied water cautiously, and then adopted the device of pouring the sample into a ring laid upon the face of an anvil. Samples of a few ounces weight frequently cracked upon the anvil, but with water they usually flew into many pieces. We soon, however, found that the attempt to save time by cooling the samples instantaneously was a step in the wrong direction, as it was only from samples cooled slowly that reliable information could be obtained as to the qualities of the future casting. There was, however, this result, that we at length came to the conclusion that instantaneous cooling was unfavourable to permanence of polish. In the progress of these experiments we also observed that the rods of speculum-metal formed in the air-holes of damp sand-moulds, also the thin plates formed at the junction of the upper and lower moulds, were of unusual strength. We were not then aware of the fact that alloys of tin and copper are softened by sudden cooling, which would have accounted for the liability to tarnish, and the great increase of strength.

Mr. POTTER, in Sir DAVID BREWSTER'S 'Journal' for 1831, directs attention to the *apparent* hardness and soundness of speculum-metal cooled instantaneously; but he does not appear to have operated upon a larger scale than Mr. CUTHBERT, his castings not exceeding $1\frac{1}{2}$ ounce. Mr. M'CULLAGH seems also to have noticed the same facts; and, indeed, it is not likely they could have been unnoticed by any one who had been engaged much in speculum-casting; but the obvious fact that any considerable mass of an alloy with such large expansions and contractions as speculum-metal, and so brittle, must fall to pieces if cooled rapidly, would have forbidden the attempt to manufacture large telescopes with such a material.

In all our earlier experiments the castings were made in damp sand, precisely as in the common process of casting iron or brass. Where the founder, however, aims at the best results, especially in brass-casting, he dries the mould: he thus escapes the mischief sometimes arising from the evolution of hydrogen, which, unlike steam, makes its way through the sand with difficulty. Steam in small quantity does no mischief, because it enters the interstices of the sand, where it is immediately condensed.

In the hopes of better results we dried the moulds; but, strange to say, the castings were less perfect. At the low temperature at which specula are cast, the tin acts but very little on water, and there is no injurious evolution of hydrogen; therefore, in that respect, there was nothing gained by drying the mould, while we found, after a great number of specula had been broken up, that in dry sand the progress of solidification had been less regular than in damp sand, and that this was owing to the circumstance that in dry sand the solidification had commenced irregularly in all directions, while in damp sand the upper surface had remained longer fluid than the lower surface, especially where the specula were of considerable thickness. To explain this, it is only necessary to remark that, when metal enters the damp-sand mould, heat will be immediately abstracted from it; and as it rises in the mould by each successive addition of hot metal, it will somewhat dry the upper sand-surface before the metal reaches it. When, therefore, the mould is full, the lower surface will be cooler than the upper: this does not happen when the mould is dry. In casting very thin specula, there is no time for successive actions; the upper and lower surfaces solidify simultaneously, and there is a tendency to separation in an intermediate plane. In some cases the separation was so complete, that a slight concussion actually divided the speculum into two discs. In discs of brass there is often, from the same cause, a very thin plane of porous metal running through the centre; and where this occurs in the plate of an air-pump, a bouching is inserted to cut off the communication between the external air and the central aperture. Keeping these facts in view, it would be naturally expected that by employing very open sand, as damp as possible, for the lower surface of the mould, and dry sand for the remainder, the best results would be obtained: and such was the case; and where other means are not at hand, specula of 10 or 12 inches diameter can thus be easily obtained, provided they are of considerable thickness. This device, however, was not successful when we endeavoured to procure thin plates to face the compound speculum described in the 'Transactions' for 1840; the solidification of the upper and lower surface was too nearly simultaneous, and therefore there was irregular contraction: consequently a metallic surface was employed, from which the plate was removed the moment it was solid.

There is yet another method of procuring excellent specula of moderate dimensions, which was dismissed, perhaps, in too summary a manner in the account of experiments in the 'Transactions' for 1840. It has this to recommend it, that it can be carried out by persons who have had no experience in the management of melted metal; and it is desirable to smooth the way, as far as possible, for beginners, who may, perhaps, by early success, be induced to proceed further. A cast-iron mould can easily be made at any foundry; it must be at least two and a half times as deep as the required speculum; it is to be placed in a temporary air-furnace, resting, like a muffle, upon two very strong deep bars, and is to be made perfectly level. The grate should be made of moveable bars, which can be withdrawn at the conclusion of the process, so that the fire may fall into the ash-pit. If charcoal is employed, the draught will be sufficient to produce the necessary heat without a chimney. The proper quantity of speculum-metal, in pieces, is then introduced, and the cover put on. It is important that no pieces of charcoal should get in before the metal is melted, as they will often be found in the face of the speculum. As soon as the metal is melted, the cover is taken off, and the moveable bars are drawn out. The metal is then stirred with a broad flat tool, passed everywhere over the surface of the mould to detach air-bubbles, and without loss of time a jet of water is thrown against the bottom of the mould, through a rose with exceedingly small holes, and distributed evenly. The action of the water must be suspended the moment the temperature of the mould is reduced to a dark red, lest it should crack; but the operation should be repeated at intervals of a few seconds, to keep the reduction of temperature permanent. As soon as the metal is solid at the surface, the furnace is to be closed up completely, and the speculum is thus annealed, the furnace acting as an annealing-oven. The blocks of speculum-metal, which were sawn up into plates, as described in the 'Transactions' for 1840, were made in this way, excepting that air was employed instead of water. A large hand-fan furnishes a sufficient blast; and when such an instrument is within reach, air is perhaps preferable to water, as it is more easily managed. The cracking of the moulds (the difficulty we encountered in the experiments alluded to) we subsequently ascertained was owing to excess of water. It is important that the temperature of the metal should not pass the melting-point, to prevent the large development of a crystalline structure.

Whether specula are cast according to the first process, when the moulds are of damp sand and solidification commences at the lower surface in the way I have explained—or by the second process, when the moulds are of iron and solidification also commences at the lower surface, owing to the action of some cooling medium, through the iron—or by the third process, when the same effect is produced by the exterior mass of iron which prevents the interior surface of the mould from attaining the temperature of fusing speculum-metal, the result is very similar: there is the same molecular arrangement more or less developed, and the fracture presents the same characters: the axes of the crystals are directed to the cooling surface, in obedience to the general law, stated by Mr. Mallet in the following words, that when the particles of crystalline solids* "consolidate under the influence of heat in motion, their crystals arrange and group themselves with their principal axes in lines perpendicular to the cooling or heating surfaces of the solid—that is, in the lines of direction of the heat-wave in motion, which is the direction of least pressure within the mass."

It is scarcely necessary to add that there is no resemblance in this molecular arrangement to that of a small speculum cooled instantaneously.

Enough has now been said to enable a skilful founder to follow the course which we pursued in casting specula of 6-feet aperture. The principles are, in fact, the same which he must have had in view in executing works of unusual difficulty in cast iron: with speculum-metal, however, the difficulties are far greater, and therefore every part of the operation must be more rigorously governed by sound principles.

The photograph of the speculum on its supporting levers (Plate XXIV. fig. 1) will give perhaps all the information which may be required as to the general nature of the arrangement. The ring in which the speculum is suspended was removed, as also some of the apparatus connected with the levers, to prevent confusion. The diagram fig. 2 represents in plan the arrangement of the levers. The cast-iron carriage, of about $1\frac{1}{2}$ ton weight, carries three ball-and-socket joints, directly under the centre of gravity of three equal sectors, into which the speculum may be supposed to be divided. The

* Mallet 'On the Construction of Artillery,' p. 7.

centre of the ball is in the centre of gravity of the triangle, not merely as respects its plane, but thickness also. These three triangles, which we call primary, carry at their angles, by ball-and-socket joints, nine secondary triangles, supported at their respective centres of gravity; and they, in a similar way, carry twenty-seven tertiary triangles, each carrying three gun-metal balls of $1\frac{1}{2}$ inch diameter,—in all, eighty-one balls, which support twenty-seven equal portions of the speculum. Between the balls and the speculum twenty-seven thin brass plates are interposed, attached to the speculum by pitched cloth, not so much with a view of giving support between the balls, which would probably be quite unnecessary, but to make a smooth surface for the balls to roll upon without grinding the back of the speculum true. In each ball there is a small hole, and a thin brass wire is inserted in it, and secured with a wooden peg; this wire passes through a small hole in the lever, and is attached to a thin brass spring at the back, which yields as the ball rolls, and brings it back to its proper place whenever the ball is free from pressure. Without this contrivance, a very slight jerk, when the plane of the speculum is nearly vertical, would cause the balls to fall from their places. In practice, the motion of the balls is of course very slight.

It is evident that so long as the speculum is horizontal, equal portions are carried equably, and it is almost as free from strain as if it was floating on mercury. As soon, however, as we incline the speculum to the horizon, the lever apparatus does not act so perfectly. It will have been observed that the levers are not in the same plane; and this is disadvantageous in two ways: first, although the primary triangles balance in every position on the ball-and-socket joints, and therefore are indifferent as to position, the centres of the ball-and-socket joints carrying the secondary triangles are unavoidably above the plane of the centres of the primary supporting balls, and still more are the ball-and-socket joints carrying the tertiary triangles; consequently the secondary and tertiary triangles, by their weight, exert a force tending to make the planes of the primary triangles rotate in a vertical plane, and so disturb the equilibrium. The tertiary triangles in a similar manner, but to a much less injurious extent, act upon the secondary triangles. The lever apparatus, deducting the primary triangles, weighs about 600 lbs.; were it lighter it would not have the necessary solidity; and the disturbing action of the weight is so considerable that, when not counterbalanced by subsidiary contrivances, the action of the speculum at low altitudes is much impaired by it. The contrivance we employ is a system of levers, connected by wires with the ball-and-socket joints which support the secondary triangles, and acting at right angles to the plane of the speculum. The primary triangles, thus relieved from all lateral strain, are in a condition to do their duty effectively; and that seems to be sufficient in practice. Of course another set of levers might be attached to the ball-and-socket joints supporting the tertiary triangles; and then the whole system would be perfectly counterpoised in every position; that, however, seems to be scarcely necessary. It is evident that, were it not for the balls interposed between the levers and the speculum, any lateral motion of the speculum would introduce a disturbing force which would destroy the equilibrium. Lateral motion, however, must always exist in the different positions of the telescope, owing to the elasticity of materials; and it must act injuriously in some degree, in proportion to the force required to move the speculum on the balls. Great care has been taken to make the fittings of the ring in which the speculum hangs as perfect as possible, and to connect its joints and bearings with the iron carriage, so as to reduce the lateral motion of the speculum to the smallest possible quantity. We have not tried Mr. LASSEL'S ingenious arrangement for relieving the edge pressure. Unless there were holes half through the speculum the experiment could not be fairly tried. Our 3-feet specula are also suspended in a ring, and are supported on fewer points by the lever apparatus, which, at a slight sacrifice of theoretical accuracy, has been thrown into one plane. We have rarely perceived any flexure of importance, except where the action of the levers had been impeded by rust; but the 3-feet specula, which weigh about thirteen hundredweight, are very much stiffer than the 6-feet specula, as is obvious on common mechanical principles. Upon the whole, I am inclined to think there is a better prospect of improving the definition of very large specula by increasing the original stiffness, than by endeavouring still further to eliminate slight disturbing forces.

The 6-feet specula were ground with an iron tool, divided into squares, precisely as the 3-feet specula. The squares were larger, about 2 inches each side, and were not formed by cutting but by casting. A tool cast from the same pattern was employed as a polisher, but the surface of the squares was cut up by turning, so as to leave no more than half an inch of continuous surface. The tools weigh about one ton one hundredweight each, and the iron is so disposed in them as to produce the utmost amount of stiffness. The photograph supplies all details (Plate XXIV. figs. 3 & 4).

In grinding, about two-thirds of the weight is at first taken off by a counterpoise acting through a system of levers attached to it in thirty-six points, on the same principle as the levers which support the speculum. As the process proceeds the contact becomes more general, the friction increases, and there is more heat developed; therefore the counterpoise is increased, till towards the conclusion the unbalanced weight of the grinder is reduced to about two hundredweight. Notwithstanding the great strength of the tool, we found that if after the grinding was over it was suspended by its centre, the flexure, after a week or two, became so great that on replacing it on the speculum and regrinding with it, the action commenced at the edge; it is therefore always, when not in use, suspended by its levers. The curvature of this tool was adjusted in the ordinary way by gauges. These, as they were to be employed in the adjustment of the speculum to focus, were made with great care. One side of each gauge was first made into a straight edge, by the well-known scraping process of Mr. WHITWORTH, and the two were then very slightly ground for a few minutes with fine emery to remove the marks of the scraper, but no more. Ordinates were then set out, an inch apart, and marked to the calculated length by means of an instrument applied to the straight edge, very similar to the joiner's gauge, but made of brass, with a fine scale and vernier. Through the extremities of the ordinates the curve was traced by means of a steel point, guided by a curved rule about 6 inches long. A pair of these little rules were made from calculated ordinates, and ground together. In adjusting the gauges to the curve so traced, nothing was employed but the file and scraper. The gauges were then slightly ground together with the finest emery and in very small quantity, and care was taken to distribute it evenly with a camel's-hair pencil. The grinding-tool was from time to time adjusted roughly to the curvature on a turning-lathe, which was accomplished with great facility, as the slide-rest was governed by a guide of the same curvature as the gauge, and there were adjusting-screws in the face-plate, by which the tool was made to run perfectly true each time it was replaced. When the curvature of the speculum was nearly exact, the remaining little changes in the radius of the tool were made with the file. We had no means of optically measuring the focus of the 6-feet mirrors while on the engine; therefore further precautions were taken. A brass wedge was made, about 3 inches long, at one end $\frac{1}{500}$th less than the vers sine of the circle of curvature, and at the other end $\frac{1}{500}$th greater. This wedge was cut into three parts, equal, greater, and less than the vers sine. A straight edge was then laid upon the speculum; and it was considered perfect when one of these just touched the straight edge, another passed under it without touching, and the third did not pass at all. So accurately was the adjustment as to focus made in this way, that neither of the specula differed from the calculated focus more than $1\frac{1}{2}$ inch.

The machinery is precisely on the same principle as that which we employ in working 3-feet specula, already described in the 'Transactions.' Instead of belts there are chains, working in V grooves. The driving-wheels are of wood, in several layers, the grain being disposed radially. The chains are made tight by straining-pulleys, and act perfectly. This species of machinery is neither compact nor elegant: when originally designed, its principal recommendation was facility of construction and facility of alteration, both important qualities where it was doubtful whether machinery unguided by hand, acting independently of the sense of touch, would answer at all. Some are surprised that machinery so rude should be employed, and successfully, in a mechanical operation where the utmost precision is required, a precision almost fabulous, and they compare it with the beautiful machinery in the mills where textile fabrics are made: but in figuring specula everything depends upon the principle; and so long as certain motions are communicated to the tool and speculum, machinery can do no more. The tool is raised and lowered by a screw passing through a carriage which moves upon a railway over-head upon the principle of the travelling crane, and the same mechanical arrangement removes the speculum with its lever supports from the grinding-machine to the truck upon which it is conveyed to the telescope. The screw is obviously the best mechanical power to employ, as its action begins and ends slowly, and there is therefore less danger of breaking the speculum. As a further precaution in raising or lowering the grinding-tool, thin wooden wedges between the tool and speculum are gradually introduced and withdrawn. In the final adjustment of the speculum to focus, the operation is much facilitated by a judicious management of the second eccentric; small variations in the radius of curvature are thus produced with great facility: where, however, there has been a considerable departure from the length of stroke necessary to produce a spherical figure, the speculum requires to be ground for twelve hours, or perhaps much longer, with the proper motions, before it is fit to be polished. Mr. WHITWORTH is of opinion that greater general accuracy of surface is obtainable by scraping than by grinding: the late Mr. A. ROSS, as high an authority as any one in everything relating to practical optics, held very nearly the same language*. He attributed the defective action of the grinding-process to the unequal distribution of the grinding-powder, which, accumulating at the centre by capillary attraction, and at the edges by mechanical action, unduly shortened the radius of curvature at the centre and lengthened it at the edge. He employed the grinding-powder dry in producing flat glass surfaces, and believed he thus obtained a better result. It appears to me that by cutting up one of the surfaces into minute squares, in the way we have so long practised, the causes of unequal action are eliminated. The subject is a very important one, as there appears to be no other probable means of working solid materials into accurate surfaces for optical purposes than by some modification of the ordinary process of grinding and polishing. In the 'Philosophical Transactions' for 1840, there is a sketch of a grinding-tool such as we employed in the construction of 3-feet specula; but I have scarcely noticed experiments on grinding, passing at once to the more important subject (as it appeared to me at the time), that of polishing. Something useful, however, may perhaps be extracted from our record of very numerous experiments on grinding plane and curved surfaces. In my very early experiments, the ordinary process for procuring a true plane by grinding three planes in alternate pairs was often repeated. Till we adopted the expedient of cutting up two of the surfaces into minute squares, our success was very limited. That device apparently removed all the difficulty, and we were then enabled to make large flat mirrors which bore the optical test well in *every part*, which was not the case before. When one of the surfaces is divided into minute portions, with sufficiently large and deep intervals, there can be no capillary action such as that described by Mr. A. ROSS; neither can there be an accumulation of grinding-powder anywhere, because an immediate escape for it is provided; and if the grinding-powder is employed in very small quantities, and no addition is made to it for three or four hours before the termination of the process, there will be a high degree of comminution, and only just a sufficient number of minute particles to keep up the abrading action, probably nowhere more than a single layer. We may form some idea of the accuracy thus attainable by examining with a microscope the particles of emery so comminuted. No parts can be acted upon strongly except where they deviate from a spherical surface; too violent contact then, and consequently a destructive action, is prevented by the moisture interposed. Under such circumstances, with unyielding surfaces, *time* obviously cannot enter as a disturbing element, because there is no abrasion when there is no close contact.

* HOLTZAPFFEL, Mechanical Manipulation, vol. iii. p. 1229.

The principle of Mr. WHITWORTH'S method may obviously be carried out, with glass or speculum-metal, by employing small laps and grinding-powders instead of the scraper; but as a scraped surface consists of a maze of curves of varying flexure, a surface ground in detail must always, I should think, in some degree partake of the same character, and, though it may not anywhere deviate much in general outline from the required form, minute deviations must exist in every part. M. FOUCAULT seems to have been successful in improving surfaces of moderate dimensions, by his ingenious process of testing and polishing in detail; how far such a process will succeed in improving large surfaces which have been in the first instance properly wrought, has not, as far as I am aware of, been ascertained. Our practice always has been to repolish when the surface, tested by the method described in the 'Transactions' for 1840, has proved to be defective. If a few glaring defects are at once seen, the whole surface is always faulty, though in a less degree.

The only change we have made in the polishing-machinery consists in substituting an elliptic for a circular wheel in driving the second eccentric. The major axis is at right angles to the throw of the eccentric, and is to the minor axis as three to one. The band is merely a rope working in a deep groove; and a straining pulley, freely acted upon by a weight, secures the necessary tightness in all positions of the ellipse. The obvious effect of this arrangement is to diminish the time the polisher overhangs the speculum, and so to reduce, to some extent at least, a source of error. We now employ in every case a separate tool for grinding and polishing, which is a great convenience, especially as we always regrind the speculum after it has been brought in from the telescope. There seems to be no doubt that in some cases considerable change of figure had taken place. The grinding-tool, when true, will be bronzed all over, and the speculum, when examined in every position as to light, will appear uniform.

We still consider the process of polishing described in detail in the 'Transactions' for 1840 as the best, with this addition, that we employ a combination of brown soap and ammonia, instead of pure water, during the latter part of the operation. We had then tried this lubricating mixture but too recently to feel justified in recommending it. The great objection, however, to the whole process is the difficulty of carrying it out. I have had communications from time to time from many persons in whose hands it has failed; and I am not surprised; for although everything has usually gone on smoothly when we were in the midst of experiments and in constant practice, yet after the lapse of even one year, when we have had occasion to repolish a speculum, there have been often disappointments. The difficulty arises from the necessity of employing two strata of resinous matter, one so hard, and both so thin. If in preparing the polisher the hard resinous composition is suffered anywhere to come in contact with the iron, the polisher will not retain its figure, and there will be a failure. A small chip of wood in the pitch will produce the same effect. If the water or lubricating mixture is supplied too sparingly, the polisher will begin to dry in spots, the rouge and abraded matter will collect there, and the thin stratum of pitch will be compressed till the accumulated matter resting upon the iron will act just as a chip of wood. If the lubricating fluid is a little in excess the rouge will run loose, the very hard resinous surface being able to retain but a very small quantity of it, and the incipient polish will disappear. An excess of rouge acts in the same way, while, if the rouge is not in sufficient quantity to keep up the cutting-action, the surface of the speculum loses its truth. The process therefore requires great attention throughout. Both the temperature of the water in which the speculum revolves and the temperature of the room, of course, must be properly regulated. The process does not proceed well unless the moisture between the speculum and polisher gently evaporates, so that drops of fresh fluid may be added from time to time, to carry away the undue collection of abraded matter. As the hygrometric state of the air varies, so will the quantity of fluid required to lubricate the surface; and that would be a source of considerable embarrassment, were it not that in dry states of the air the dew-point can be adjusted by a jet of steam. When the air is very damp we have no practical remedy; and therefore the operation is not then attempted.

We have often endeavoured to evade these difficulties by employing a surface less hard, supported by a thicker substratum of pitch; but there has been an evident sacrifice of ttruh of surface and figure, and we have failed in obtaining that very fine definition which resulted from the old process when perfectly successful. By the old process, a speculum of 3-feet aperture and 27-feet focus has been frequently made so perfect that in favourable states of the air it has defined sharply the dots and figures on a watch-dial distant 100 feet, the eye-glass being a single lens of one-eighth of an inch focus: such a speculum in ordinary weather perhaps does little more than one that is inferior to it, both, for instance, showing well the sixth star in the trapezium of Orion; but in extremely fine nights it displays its powers by resolving nebulæ in which no traces of resolution had been seen before, and by concentrating the light of minute stars and so rendering them visible.

If the vivid polish of a speculum employed in the *open air* was as enduring as that of glass, the difficulty of the process and its uncertainty without continual practice would have been no great objection to it; but when, on the contrary, it is necessary to repeat the process at intervals perhaps so long that minute details are not fresh in the memory, the task becomes the labour of SISYPHUS.

A very fine speculum loses much of its light and some of its truth of surface by being repeatedly dewed, especially if it has been several times cleaned, and for the ordinary work we are engaged in will be inferior to a moderately good speculum which is quite fresh.

The preparation of a polisher in the way formerly described is one of the great difficulties; a certain degree of manual dexterity is required, which can only be obtained by practice and kept up by practice. For many years we have very often prepared it in an easier way: some pitch of the proper consistence for polishing at 55° is put into warm water; and when soft, a little is taken out and rolled upon a wet board to the proper thickness. There is no difficulty in this, as the roller is governed by ledges of proper height at each side of the board. The surface of the pitch is wiped dry, and a thin stratum of the hard resinous composition in powder is sifted on. A large flat-iron, red-hot, is then passed over at a distance of 3 or 4 inches, and so slowly as just to fuse the resinous powder without making any change in its composition. The pitch, so prepared, is cut into squares of the proper size, and thrown into cold water till required. The polisher, warmed to about 80°, is then brushed over with very soft pitch, and, when the temperature has fallen to about 65°, the square pieces of pitch are arranged in their places and soon become quite fast. The whole of this operation requires little experience, and can be managed by common workmen—a great advantage. It has, however, this disadvantage, that the pitch is somewhat thicker than we should wish. In the 6-feet polisher the squares are $2\frac{1}{2}$ inches; and although the soft pitch in the circular grooves will no doubt yield a little, still we have a larger continuous surface than we had by the original process, and therefore the pitch requires to be thicker. The reason why with the long transverse strokes the pitch must be so thin is evidently this, that the polisher passes so far beyond the edge of the speculum. If we coat a polisher with pitch alone and of some thickness in the ordinary way, and then proceed to polish, we shall find that, if at any time we stop the machinery for a few moments when the polisher is at the extremity of the stroke, the pitch will change its figure. The change of course will be less as the stroke is shorter; but by prolonging the time, even with a very short stroke it will still be perceptible. So considerable is the change of figure under such circumstances, that after some time a distinct mark will be made by the edge of the speculum, and the projecting portions of the pitch becoming comparatively protuberant, unusual force will be required to effect the next stroke. These continual changes of figure, slight as they may be, will produce excessive action on the outer portions of the speculum. To meet this evil, if we diminish the length of the strokes much, we impair the self-correcting action to which we are mainly indebted for success. To explain this, let us suppose the throw of the first eccentric, B (see figure in 'Transactions' for 1840), to be reduced to a small quantity, and the action of the second eccentric, G, to be reduced in the same proportion, the speculum continuing to rotate; if the polisher and speculum are not truly portions of the same sphere, there will be unequal action at the centre or edge of the speculum, according as the polisher is more or less convex than it ought to be. In the first case, a depression will be formed at the centre of the speculum of a diameter proportional to the throw of the eccentrics; in the second case there will be an annular depression at the edge of the speculum. It is plain that the speculum cannot be restored to truth till the remainder of the surface has been lowered to the depth of the depression: this, however, will not be accomplished in practice if unequal action is continued even for a very short time. It may be thought that rigid identity of figure might be secured in the first instance; but this is practically impossible: the rouge cannot be distributed with perfect regularity; besides, as the temperature of the polisher varies, so does its radius of curvature. But even if perfect coincidence was secured at the beginning, it would not long continue. With very small motions the abraded matter would not be equally distributed, and, collecting in excess in some place, unequal action would be set up before the pitch had time to yield. If the excess was not at the centre, the depression would assume the character of a ring. The pitch at length yielding, the ring would not increase, but it would continue, and, a similar cause arising in another part of the polisher, a second ring would be formed, and so on. I have seen a surface of an annular character all over, the breadth of the rings depending on the adjustments of the eccentrics. Why the depressions once formed continue with so much persistency is evidently owing to the yielding character of the pitch, which, when the depression is of large area, becomes protuberant, precisely as it does where it overhangs the speculum, and so the cutting action is to some extent continued. An annular surface is produced by grinding, under similar circumstances, but the rings change their places frequently. The annular surface is always best-marked when the action of the second eccentric is suspended completely. To see the annular surface, the speculum must be slightly polished by rubbing it all over for a few minutes with a small lap covered with soft pitch and rouge. I need, perhaps, hardly add that the character of these surfaces can only be seen when they are examined by the light reflected from the watch-dial, in the way described in the 'Transactions' for 1840. As the throw of the eccentrics is increased the rings gradually disappear; and when they reach the proper positions the surface becomes quite uniform. We have often found it very useful, when the figure of the polisher was not satisfactory, to throw another movement into gear connected with the guide D, by which an occasional stroke was given of increased length: the cause of unequal action is thus immediately removed if it does not arise from some defect in the construction of the polisher, such as the contact of some unyielding substance with the iron. The experiments I have just referred to were of a very early date, but they were numerous and made with great care; I have therefore not thought it necessary to repeat them.

In the first polishing-machine we made, the polisher was connected with the eccentric B by means of a rigid bar passing through the guide D, the guide being furnished with an adjustment at right angles to the line joining the centres of the speculum and eccentric. The guide was equidistant from the centres of the eccentric and polisher, and the path of a point in the polisher was similar to that of the crank-pin of the eccentric. We found, however, that when the movements were very small the surfaces both in grinding and polishing became somewhat annular, and when the movements were large the figure was spoiled. We therefore substituted a jointed rod for the rigid bar, and added the second eccentric. From time to time we have returned to the rigid bar, tempted by its obvious advantages, and hoping in some degree to free it from its defects. It is an advantage that with it the movement of a point in the polisher is as the circumference of a circle, while with the jointed bar under similar circumstances it is as the diameter. In the one case there will be more than three times the amount of motion there will be in the other, and the polisher will overhang the speculum but for a moment at each stroke, instead of dwelling for a much longer time twice during each revolution of the second eccentric, and therefore there is not the same necessity for employing a very thin substratum of pitch; the process therefore is a much easier one. We have found that with the rigid bar, and, indeed, with the jointed one, a slight periodical movement of the guide D contributes much to free the surface from an annular character, for reasons which are obvious. The guide D is mounted now like the eccentric G, and a band from a small pulley on the axis of B, acting on a large one on the axis of D, effects the object in a very simple way.

When a speculum has been truly *ground* by the machinery acting with transverse strokes, the rigid bar will polish it on very easy terms, and for all the ordinary work of the observatory it will be sufficiently perfect.

We have long been in the habit of resorting to the rigid bar when out of practice and we required at once a fresh speculum.

A speculum of 3-feet aperture, which has usually been uncovered in all weathers for visitors, has frequently been so polished, and it has borne well a quarter-of-an-inch lens when tested with a watch-dial while on the engine. When a speculum of 6-feet aperture was last polished a rigid bar was employed; and the result was tolerably successful.

Since the publication of Mr. LASSEL'S experiments we have several times tried simple pitch, the movement being given by the rigid bar, but we have not succeeded in obtaining as good a surface or as fine definition as when the polisher was prepared in a more elaborate manner.

The combination of soap and ammonia which we employ may be prepared in this way. Half a pound of brown soap is dissolved in one quart of warm water, and one quart of strong water of ammonia is added. The bottle is then corked and shaken from time to time, for a week at least: we think it improves by keeping. One ounce of this mixed with eight ounces of water makes the lubricating fluid. The mixture should be made the day before, and kept in an open vessel, so that the excess of ammonia may evaporate. We were at first apprehensive that in employing this mixture we were endangering the hard film of the polisher, and so perhaps sacrificing to some extent truth of surface; but this was found not to be the case unless the ammonia was much in excess. As a kind of experimentum crucis, we polished specula with simple pitch rather softer than usual, employing pure water and the saponaceous mixture alternately, and found that the mixture was favourable to truth of surface instead of the reverse.

We have long ceased to make rouge, as it can be obtained of good quality from the rouge-maker.

In shaping the polisher by applying it to the speculum, we find it better that the polisher should be quite cold, while the pitch and resinous composition are slightly warm. We pass the flame of a few shavings or of wood-spirit under the polisher with its surface down, and instantly apply it to the speculum for half a minute. This is repeated till there is satisfactory contact. When the polisher was warm, we found it was difficult to avoid compressing the pitch too much. A crane makes the 3-feet polisher quite manageable; and a travelling crane, with railway overhead and screw, effects the same thing for the 6-feet polisher. Both polishers are provided with gimbals, so that they can be instantly turned over. Though it is better to prepare the polisher fresh each time, we have often employed the same polisher successfully two or three times. In that case the polisher must be washed, and when dry the surface is to be very slightly moistened with spirits of turpentine. A thin film saturated with rouge will thus be removed; and a flame passed under will evaporate the turpentine. The polisher is then to be inverted and warmed to about 80°, the face being uppermost and again turned over. If now a flame is employed cautiously two or three times at intervals, the pitch at each square will become protuberant, bearing the hard resinous film on its surface, and the polisher will be restored very nearly to the same state it was in when originally prepared.

No one will be so ill advised as to attempt to construct a large reflecting telescope without first collecting all the information to be obtained in books. In Mr. LASSEL'S paper in the 'Transactions' of the Astronomical Society he will have an excellent guide. Should he employ an apparatus similar to ours, the speculum is first to be truly ground with the jointed bar. The throw of the first eccentric is to be one-third the diameter of the speculum, and that of the second, measured at the speculum, about one-fourth. It will be better in all early experiments to rely on pitch alone, carefully adjusted to the temperature at which it is to be used, perhaps 55°. The jointed bar which was employed in grinding the speculum is to be exchanged for the rigid bar, the eccentric and guide being readjusted. When the speculum has been successfully polished a few times in this way, an attempt may be made to obtain a better result by facing the polisher with a hard resinous composition; and finally the jointed bar may be resorted to, but at the same time the thickness of the pitch must be greatly reduced.

As to the mounting, it is simple, and any engineer could execute it without difficulty, the photographs supplying the necessary information.

The tube is supported at its lower extremity by a massive universal joint. It is counterpoised by weights which are constrained to move in a circular arc which nearly coincides with the curve of equilibrium; and a steady strain is kept upon the suspending-chain by means of three weights attached to levers, which successively come into play as the tube approaches the zenith and passes north beyond it: the levers are about two-thirds of the length of the tube, and have cross heads at their lower extremities, which are formed into bearings; and when in their places, the cross heads are all parallel to each other and to the transverse axis of the universal joint, from which they are about 5 feet distant. The levers thus move steadily in one plane, that of the meridian. A chain connects the levers at the proper intervals and the tube with them; and as the tube descends, each lever takes its place successively in a deep recess in the ground, the chain subsiding into a heap. This contrivance is effectual, and the chain has never fouled. The three weights are of different sizes, so proportioned as to reduce as much as possible the deviations from exact equilibrium at different altitudes, due to the irregular action of the counterpoises, which move in an arc of a circle instead of the proper curve. A slow hand motion was originally fixed near the mouth of the tube, for raising or lowering it in taking measures; but we do not find it necessary. The telescope at the equator can conveniently follow an object three-quarters of an hour; and its motion is nearly equatorial: it would be almost exactly so if the pulley of the suspending-chain was in a line drawn from the axis of the universal joint parallel with the axis of the earth. The pulley, to give the chain more mechanical advantage in raising the telescope when very low, was placed above this line; but there was at the same time an arrangement made so that the chain might be brought, when necessary, by means of a grinding pulley, into the proper line. In practice we have found the movement of the telescope sufficiently equatorial without this: at a little distance, however, from the meridian, the plane of the position-circle of the micrometer deviates sensibly from a plane passing through the pole in all positions except when near the equator, as will be evident on considering the construction of the universal joint; and the distance from the meridian must be known where much precision is required in the reduction of the observations.

The motion in right ascension is by a rack the extremity of which bears by rollers on a circular arc of 40-feet radius. This rack is connected with the tube by a pinion, and the pinion is acted upon by an endless screw driven by a pulley, which pulley is driven by a band from a porter's wheel attached to the lower end of the tube. The pulley can also be moved by the observer; but this is not often necessary. The large circular arc is in pieces 5 feet long each, carefully planed, but not touching at their extremities, to guard against unequal action. The surface of each segment was adjusted separately to the plane of the meridian by a transit-instrument. And thus the means were provided for taking right ascensions with considerable accuracy. For polar distances there is a circle, 18-inches radius, at the lower end of the tube, furnished with a spirit-level; but for finding objects, there is an index of 6-feet radius connected with the transverse axis of the universal joint; so that the instrument can with the utmost facility be set roughly in polar distance. Means, of course, are provided for enabling the observer to reach the eyepiece in every position of the telescope. From 120° of polar distance to 80° this is effected by a stage, nearly counterpoised, which slides on bearers, the observer standing in a small gallery, to which he can communicate a transverse motion: the large stage is raised by a windlass; and, to guard against possible accident, there is an arrangement which locks it, completely under the command of the observer. From 80° to 50° the eyepiece is reached from the second gallery, and from 50° to 25° by the third. The fourth gallery, reaching to the pole, for which machinery was made at the same time as for the others, has never been put up, the other galleries so far furnishing ample employment for the instrument. The action of the galleries, and the way they are secured, is sufficiently evident from the photograph: they are of great strength, and in their construction, as well as in all other parts of the instrument from which there seemed to be a possibility of accident, the ordinary engineering rules as to strength have been considerably exceeded. The eyepiece arrangement consists of two adapters fixed into one slide, so that there are always two eyepieces, a high and a low power, which may be employed successively simply by moving the slide. The slide is counterpoised, and the eyepieces fit in without screws. The telescope is perfectly steady even in a high wind, and we have had occasionally very fine definition during a strong gale.

From the experience we have now had, I think I may safely say that, where objects are to be observed only at short distances from the meridian, this plan of mounting is convenient and effective, and I do not see room for any material improvement. Where observations are carried on systematically, I do not think there is very much disadvantage in the limited movement in right ascension. Objects are best seen near the meridian, and no object can be thoroughly examined in any other position. There is, indeed, a small portion of the heavens which can scarcely be observed in the perfect absence of twilight, and an object there situated would probably be better seen, even at some distance from the meridian, when it was perfectly dark; but that seems to be of little moment. The really important disadvantage of the limited equatorial movement seems to me to be this, that, where fine nights are extremely rare, with an instrument so limited it is impossible to turn them to the best account.

It now only remains to answer in the best way I can the questions—

First, What magnifying power can be usefully employed with a speculum of 6-feet aperture? I perceive, in looking through the observations, that the single-lens eyepiece, $\frac{1}{2}$-inch focus, being a power of about 1300, is often mentioned as giving better vision than lower powers. That, I presume, may be considered the highest power it has been found advantageous to employ in general observations upon the nebulæ. With the speculum of 3-feet aperture I have occasionally employed powers exceeding 2000 in bringing out minute stars; and the speculum of 6-feet aperture has sometimes been in sufficiently good order to admit of equal or perhaps higher powers; but in our climate the opportunities of employing such powers are rare, and of short duration.

Secondly, it has been asked, Could a telescope be made of larger dimensions, and would it be of service? I feel little doubt that both questions should be answered in the affirmative. A speculum of larger aperture would, probably, on favourable nights bring out faint details of interest in the nebulæ, and add to the number of known double and multiple nebulæ. Something, however, will perhaps be accomplished in that direction in our future observations, by employing silver for the second reflexion; but if ever telescopes of equal power are erected in climates more favourable than this, perhaps more will be effected than would be possible here by pushing increase of aperture to the largest practicable limits.

In making a selection from observations so numerous, there has been considerable difficulty. It was not always easy to decide how much it would be practicable to omit without the danger of conveying an erroneous impression—without, on the one hand, perhaps unduly weakening the evidence of the fact recorded, or, on the other, unduly strengthening it. For instance: if, in the observations of a particular object, we find it recorded on six different nights that a minute star was seen involved, and that on six other nights it was not seen at all, the twelve observations extending over a series of years, two cases might arise requiring very different treatment. First, if the nights when the star was visible were irregularly interspersed between the nights when the star was invisible, and we saw enough in the state of the atmosphere or speculum to account for the occasional invisibility of the star, it would probably be quite sufficient to enter one good observation when the star was distinctly seen. Suppose, however, that the nights when the star was seen were all included in the observations of the first three years, but that the nights when the star was not seen were in the observations of the last three years, then it would be necessary to enter all the observations, so that each person might be enabled to form his own opinion as to the cause of the discrepancy. 838 H., fig. 11, in the 'Transactions' for 1850, is a remarkable instance of this: from 1850 to 1858 the small star was not seen.

The details of faint nebulæ with curved or spiral branches have usually been made out by degrees, not only on successive nights, but often in successive years. In such cases we have not usually thought it necessary to give the early observations, or the observations on unfavourable nights, but merely a few good observations embodying the whole amount of information we had been enabled to obtain.

New nebulæ have not been looked for, our object being to scrutinize the more promising of the old ones; but new nebulæ have often been found in their immediate neighbourhood, and their places have usually been entered roughly in the observing-book, and a slight diagram made in the margin, so as to ensure their being easily found again: in such cases we have, to save space and diagrams, merely written "novæ near," and have only entered observations when the micrometer was employed. We have also, for the same reason, omitted many diagrams of known objects, where the positions and distances were merely estimated.

In the case of each object, we say "observed so many times;" that means that we have recorded observations of it on so many different nights: it may have been seen frequently on other occasions.

Where an object has been marked "observed several times," and nothing more, the inference is that with an instrument such as ours is, and in our climate, it would be waste of time to examine it further in the hope of making out details of interest.

It will be observed that the cases are very numerous where stars have been seen on the edges of nebulæ: we have taken care to enter each case, often, however, on the authority of a single good observation, as before explained.

The words "mottled" and "patchy" mean the same thing. Where the nebula is of that character, it is worth examining under favourable circumstances. The faint spirals have often been first seen as "mottled."

The word "finder" means the eyepiece with a large field. The telescope has no finder in the common acceptation of the word.

The letter "r" has been occasionally added to the description, and always in the same sense as that in which HERSCHEL employed it: I do not, however, attach much importance to the expression of opinion it conveys, because the question of resolvability can only be successfully investigated when the air is steady and the speculum in fine order. In the early observations with the 6-feet telescope we had the advantage of a very fine speculum; it had been polished at the close of a long series of experiments with 3-feet specula, when by practice every refinement of manipulation was fresh in the recollection; there were also at that time several very good nights; and many nebulæ were resolved. Very soon after, the spiral form of arrangement was detected; and our attention was then directed to the form of nebulæ, the question of resolvability being a secondary object. In the mean time the speculum, which had been frequently dewed and occasionally cleaned, had lost its fine edge, and was no longer in a state to deal with the question of resolvability. Our aim was to trace out faint details, and in that respect also the speculum had lost much of its power It was therefore repolished, and, though less perfect than before, did the work we required well. Since that, we have had perhaps two or three specula as perfect as the first one; but the mass of observations have been made with specula considerably inferior to it, and, I am sorry to say, very often not as bright as they should have been. The removing a 6-feet speculum from the telescope to the laboratory, repolishing it, perhaps several times, and replacing it, is a serious operation, and has often been too long postponed. While the telescope was in constant use in all weathers, it would have been a hopeless task to attempt to keep it in a state fit for the resolution of nebulæ, and the attempt was not made. I may, perhaps, mention that with the 3-feet speculum in fine order I have often detected resolvability when there was no trace of it with the 6-feet speculum in its ordinary working-condition.

The question of resolvability, therefore, I think, must remain to be taken up separately, when the finest instrumental means are available, and when it may no longer be necessary to subject the specula to the wear and tear of constant work.

As to the nebulæ which have nuclei, some are described as increasing in brightness very gradually to the centre, others very rapidly, and some as having a stellar nucleus, or perhaps a star in the centre. These descriptions, however accurately conveying the impressions made upon the eye at the time, cannot be taken as in all cases representing real physical facts. A star may have been mistaken for a condensed nucleus, or the reverse; and it is often impossible to say which of the two suppositions is the more probable. The remarks as to the question of resolvability apply with equal force to the questions relating to the structure of nuclei. It is, however, probably worth remarking, that, while amongst the clusters there are objects which, if removed to a sufficient distance, or examined with an instrument of insufficient power, may be supposed to be representations of nebulæ with centres of varying brightness or condensation, there seems to be no cluster with a central star of such surpassing magnitude that under any circumstances it could be taken as the representative of the class of objects described as having a star in the centre.

The little rough sketches in the margin are exact copies from the sketches made at the moment in the observing-book. There are usually several sketches of the same object made at different times; we have endeavoured to select the best.

As to the drawings, they usually represent the objects a little stronger than they appear on an ordinary night, but not stronger than on a fine night, when the air is clear and the sky black. Most of them have been repeatedly compared with the objects by different persons, and some have been several times sketched independently; so that I trust they are upon the whole accurate. The central portion of the nebula of Orion has been drawn with great care by Mr. BINDON STONEY, and Mr. HUNTER has been engaged this season in finishing the remainder; but another season will be required to complete the work.

Although there is probably no remarkable object in the list which I have not several times examined myself, for the great bulk of the observations I am indebted to the gentlemen at the time in charge of the Observatory. Mr. JOHNSTONE STONEY's observations commenced in July 1848; and in June 1850 he was succeeded by his brother, Mr. BINDON STONEY. He continued in charge of the Observatory till May 1852; after that, Mr. MITCHELL observed for about two years.

Mr. JOHNSTONE STONEY occasionally also worked with his brother, and sometimes with Mr. MITCHELL.

Though so many of the observations were made in my absence, they are not the less to be relied on: nothing was done by an unpractised hand, and no pains were spared to ensure accuracy. I refer with as much confidence to the observations of the two Mr. STONEYS and Mr. MITCHELL as if I had on every occasion been present myself, because I know that they had thoroughly mastered the instrument and the methods of observing before they recorded a single independent observation; they were, besides, eminently cautious and painstaking.

There are no micrometer observations by Mr. MITCHELL: I now rather regret it, as several cases of suspected change have recently been brought to light in arranging the materials of this paper. The fault, however, was mine. It appeared to me so highly improbable that any change would be detected, that I requested Mr. MITCHELL to press on and not spend time on the micrometer. The most remarkable case of suspected change is perhaps H. 1905. HERSCHEL gives a drawing of it, the axes of the two nebulæ in a line. On April 11, 1850, Mr. JOHNSTON STONEY remarks the two nebulæ not in a line. April 17, 1855, Mr. MITCHELL remarks the two nebulæ are not in a line, but the axes are parallel, and gives a diagram. At the present time they are neither in a line nor parallel, but inclined at an angle of about sixteen degrees. The micrometer is employed without illumination; various contrivances were tried for illuminating the lines in a dark field; but the darkness was not absolute, and faint details were obliterated. We therefore substituted bars for lines.

In the 'Transactions' for 1850 are given Mr. JOHNSTON STONEY's measures of H. 1622. M. OTTO STRUVE was good enough to send me measurements of the same spiral, and to direct my attention to the fact that Mr. STONEY'S positions are about two degrees in excess. A little consideration made it evident that the construction of the universal joint which supported the telescope was the cause of the error, and that a certain correction must be applied, depending upon the polar distance and the distance from the meridian. Mr. BINDON STONEY'S measures of H. 1622 are also given, as also his measures of H. 2060, and STRUVE'S measures of both. As OTTO STRUVE'S measures are no doubt as exact as possible, it will be easy to judge of the degree of dependence to be placed upon the other measures made by us.

As to the figured nebulæ, little can be added to the information contained in the general catalogue. Plates XXV. and XXIX. figures 7 and 35, are from sketches by Mr. HUNTER, but they had been previously sketched several times by others. We preferred Mr. HUNTER'S sketches, thinking they were upon the whole the most accurate, containing some additional details. Figure 43, the Dumbell, by Mr. BINDON STONEY, is based on micrometrical measurements, and is thoroughly to be relied upon. No stars are inserted which have not been measured. The powers used were low, the ordinary working-eyepiece: with high powers the faint details vanish.

The original observations are in books, in which they were entered each night: from time to time they were copied into a folio in the order of right ascension; and of that folio a copy was made for ordinary use in the Observatory. It will be easy therefore to supply, to any person who may be engaged in observing a particular object, all the information we possess. We have not given the places of the objects brought up to the present day, but merely HERSCHEL'S numbers, to save space.

It is hoped that further inquiry will be suggested by the questions raised in the following observations; they have already opened up to us new grounds for further research.

INDEX TO THE FIGURED NEBULÆ.—PLATES XXV. to XXXI.

| Figure. | Number in the observations. | By whom drawn. | Figure. | Number in the observations. | By whom drawn. |
|---|---|---|---|---|---|
| 1 | 15 | Mr. Mitchell. | 23 | 1306 & 1308 | Mr. Mitchell. |
| 2 | 156 | Mr. B. Stoney. | 24 | 1337 | " |
| 3 | 232 | Mr. Mitchell. | 25 | 1385 & 1392 | " |
| 4 | 241 | " | 26 | 1414 & 1415 | Mr. B. Stoney. |
| 5 | 242 | Mr. B. Stoney. | 27 | 1441 | Mr. Mitchell. |
| 6 | 262 | " | 28 | 1589 | " |
| 7 | 311 | Mr. S. Hunter. | 29 | 1650 | " |
| 8 | 315 | Mr. Mitchell. | 30 | 1713 | " |
| 9 | 327 | " | 31 | 1905 & 1906 | Mr. S. Hunter. |
| 10 | 131 | " | 32 | 1946 | " |
| 11 | 393 | Mr. B. Stoney. | 33 | 1968 | Mr. B. Stoney. |
| 12 | 421 | " | 34 | 2075 | Mr. Mitchell. |
| 13 | 689 | Mr. Mitchell. | 35 | 1744 | Mr. S. Hunter. |
| 14 | 692 & 693 | " | 36 | 2084 | Mr. B. Stoney. |
| 15 | 765 & 766 | " | 37 | 2099 | Mr. Mitchell. |
| 16 | 875 | Mr. G. J. Stoney. | 38 | 2139 | " |
| 17 | 1011 | Mr. Mitchell. | 39 | 2172 | " |
| 18 | 1052 & 1053 | Mr. B. Stoney. | 40 | 2241 | Mr. B. Stoney. |
| 19 | 1061 | " | 41 | 2245 | Mr. Mitchell. |
| 20 | 1111 & 1113 | " | 42 | 2297 | " |
| 21 | 1202 | " | 43 | 2060 | Mr. B. Stoney. |
| 22 | 1245 | Mr. Mitchell. | | | |

## EXPLANATION OF PLATE XXIV.

Fig. 1. The speculum upon its supporting levers, the apparatus by which the levers themselves are counterpoised having been previously removed to prevent confusion. 1. The lime-boxes, connected with the cover by sliding tubes. 2. The cover, which fits nearly air-tight. Before the cover is taken off, the lime-boxes are removed, all communication between the lime-boxes and speculum having been first intercepted by valves. Without this precaution, lime dust would make its way to the speculum. 3. Ring in which the speculum is suspended. 4. Supporting levers, which are shown in plan in fig. 10, where A represents a primary triangle, B a primary and three secondary triangles, and C one-third of the system complete, the dots being the balls. 5. The frame upon which the levers rest: a single casting. 6. A massive casting, which is bolted to the bottom of the table as soon as the speculum is in its place: it bears the wrought-iron girder (7) which holds the suspending-ring. 8. Turn-table for changing the specula: it is at the north of the telescope, close to the elevating-windlass.

Fig. 2. The same, with the weights and levers for counterpoising the secondary triangles. 9. The weight. 10. The common fulcrum of the levers. The levers are connected with the secondary triangles by slight straight rods.

Fig. 3. Grinding- and polishing-tool, seen at the back. It is suspended by gimbals; the tool can therefore be turned over easily from time to time, which is necessary in applying the pitch and resinous composition.

As soon as the tool is prepared the gimbals are removed; and it is then managed by the shackle in the centre. The shackle carries a triangle, with a lever at each angle. Each lever carries similarly two levers, connected at their extremities with T-shaped levers, which carry the tool by thirty-six points. The chain through which the counterpoise acts during the progress of grinding and polishing is hooked to the shackle, and the strain is thus distributed so equally that there is no sensible distortion.

Fig. 4. The same tool, seen in front. The straight grooves are produced by casting; and in this there is no difficulty, provided the pattern is nicely made. The little square blocks are kept in their places in the usual way by pins, and, remaining in the sand, are removed separately. The circular grooves are of course cut in the lathe.

Fig. 5 represents the telescope seen from the south-east, the stage of the first gallery being slightly raised.

Fig. 6, from the south-west, showing the machinery of the second and third galleries.

Fig. 7, from the south, showing the position of the telescope when a man enters the tube to fix the small speculum, and remove the cover of the large one, in preparing for the night's work.

Fig. 8, as seen from the north.

Fig. 9. The crane which carries the eastern counterpoise, on a larger scale.

The same parts are similarly lettered in all the figures. A, the cranes which carry the counterpoises. B, fig. 9, a guide-wheel by which the chain is kept in the axis of the crane in all positions of the counterpoise. The points of the shaft are placed eccentrically, so that it clears the wheel B when the telescope passes the zenith and moves north. F is of wood plated with iron, and is connected by rollers with the arc E, and by a rack and pinion with the tube. The pinion is driven by a wheel acted upon by an endless screw on the bar which carries the pulley N, fig. 7. The pulley N is driven by a band, and porter's wheel on the lower end of the tube, and thus the motion in right ascension is given. C, the principal counterpoises. D, the counterpoises of the stage of the first gallery. The stage is raised by increasing the action of the counterpoises D D. This is effected by chains attached to them, which pass underground to a small windlass. The counterpoises being rather less than the weight of the stage, it descends when the chains are relaxed. The stage carries the gallery G, which traverses on it in right ascension, motion being given to two of its wheels by a winch in the hand of the observer. E, an arc of cast iron made in pieces 5 feet long, not quite touching at the extremities, to guard against unequal expansion. Each piece was planed and accurately adjusted in the meridian by a transit-instrument. H, the second gallery. I, the third gallery. The galleries are supported by the beams *o*, which are plated with iron, and they are moved in right ascension by rack and pinion. P, tension bars to secure the iron framework carrying the wheels against which the beams press as the galleries are moved out. K, the cranes which carry the guy-chains, by which the counterpoises are constrained to move nearly in the curve of equilibrium. R, the chain which, passing over the pulley L, moves the telescope in polar distance. T, the chain of the principal counterpoise. In fig. 9 the chain M is seen, which raises three levers, each carrying a counterpoise. These levers successively coming into play as the telescope approaches and passes the zenith, maintain the chain R in such a state of tension, that the telescope obeys the windlass in every position. It has been found practicable so to adjust the levers that the residual error of compensation arising from the imperfect action of the guy-chains has been rendered almost insensible.

Fig. 11. Universal joint which bears the tube. A, bolts which secure it to the bottom of the tube. B B, two of the three adjusting-screws: these act against the carriage (5, fig. 1), directly under the ball-and-socket joint of the primary triangles. C, the axis perpendicular, and D the axis parallel to the horizon. The axis D gives motion to a large index for roughly setting the telescope in polar distance. E, a strong trussed framework of cast iron, secured to a solid stone foundation.

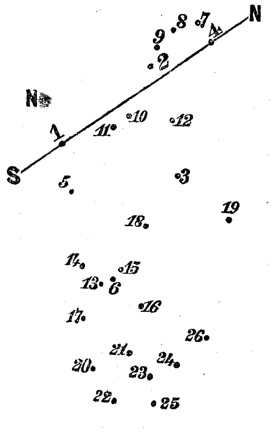
## *Abbreviations used in the Description of the Nebulæ.*

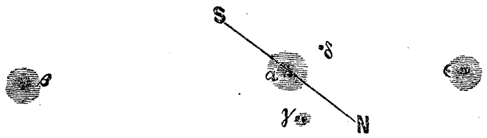
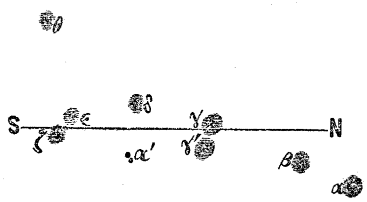
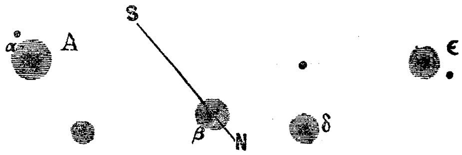
| | | |
|---|---|---|
| B | denotes bright. .......... | thus pB means pretty bright. |
| b | ——— bright, or brighter .... | — pbM means pretty bright in the middle. (Large B applies to the neb., small b to a part.) |
| br | ——— broad ............. | — 40″ br = forty seconds broad. |
| cl. | ——— cluster. | |
| d | ——— double ............ | — d∗= double star. |
| E | ——— elongated .......... | — E. n. and s = elongated in the direction north and south. |
| e | ——— extremely .......... | — eF = extremely faint. |
| F | ——— faint. | |
| f | ——— following .......... | — the f. of two = the following of two. |
| fig. | ——— figure. | |
| g | ——— gradually .......... | — gbM = gradually bright in the middle. |
| L | ——— large ............. | — pL = pretty large. |
| l | ——— little ............. | — lbM = little brighter in the middle. |
| M | ——— middle. | |
| m | ——— moderately ......... | — mbM = moderately bright in the middle. |
| neb. | ——— nebula. | |
| neby. | ——— nebulosity. | |
| n | ——— north. | |
| p | ——— preceding (when by itself or combined with n or s) ............ | — np = north preceding. |
| p | ——— pretty (in other cases). . | — pB = pretty bright. |
| pos. | ——— angle of position. | |
| R | ——— round. | |
| r | ——— resolvable. | |
| S | ——— small. | |
| s | ——— south (when alone or combined with p or f); suddenly (in other cases) | — sf = south following; sbM = suddenly brighter in the middle. |
| v | ——— very .............. | — vF = very faint. |
| vv | ——— extremely .......... | — vvF extremely faint. |

# SELECTED OBSERVATIONS OF NEBULÆ.

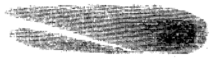
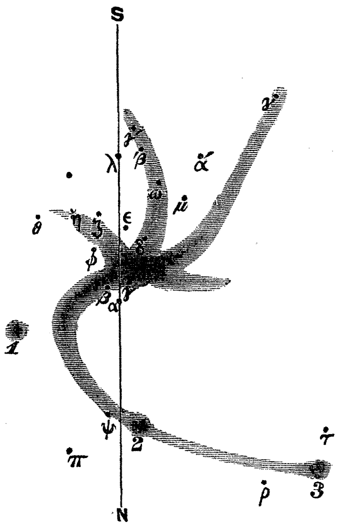
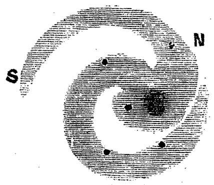
| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 1 | 2 | Nov. 4, 1850. Some stars seen in it, it is vF. Nothing further remarkable. |
| 2 | 1 | Sept. 18, 1857. 2 neb. nearly in line p. and f; about 14′ apart; the p. one is of irregular outline; F; bM. The f. one is S; R; pB; bM. |
| 4 | 1 | Oct. 23, 1857. E. n. and s; B nucleus. |
| 6 | 6 | Oct. 12, 1855. E. n. and s; has a central nucleus and a ∗ on edge, nf. the nucleus. |
| 13 | 7 | Resolvability not quite certain, irreg; R; nucleus. |
| 15 | 6 | Oct. 7, 1855. There are 6 or 8 ∗s of about 14–15 mag. and several smaller ones; I counted 7 knots, the 3 northern of which are the brightest; sketched. See fig. 1, [Plate XXV. |
| 16 | 1 | Sept. 19, 1857. S; R, or nearly so; and lbM. |
| 17 | 2 | Oct. 26, 1854. Several S; F. neb. visible at once in finder. 17 is R. and bM. |
| 21 | 9 | Spirality suspected, but more evidence wanting. Dec. 12, 1851. Nucleus; R. Oct. 22, 1857. I suspect outlying F. nebulosity, especially p. and f. |
| 23, 25 | 2 | Nov. 4, 1850. 23 is R; and S. 25 has nucleus, and is E; 3 others near. |
| 26 | 1 | Dec. 6, 1850. R; F. nucleus; 40″ br. |
| 29 | 4 | Aug. 21, 1852. Involves some ∗s, one of about 12th or 13th magnitude, E; vF. |
| 30 | 1 | Dec. 9, 1854. R; pL; bM. |
| 32 | 2 | Sept. 18, 1857. S; d. neb.; the n. one is E, sp, nf; bM. |
| 35 | 5 | Sept. 1849. r; L; and rather F. Oct. 7, 1855. 3 ∗s in it. |
| 37 | 2 | Nov. 24, 1854. Not L; R; bM; a B. ∗ close sp; r? |
| 40 | 2 | Dec. 6, 1850. sbM; another 18′ distant. |
| 42 | 2 | Nov. 24, 1854. R; bM. |
| 44 | 9 | Oct. 16, 1855. vL; mE. np. by sf; sharp nucleus, for some distance round which, the neb. is B, and then *suddenly* decreases; there is a B. ∗ np. the nucleus; and another involved in sf. end; another in p. border. Nov. 2, 1850. Spirality suspected. |
| 45 | 1 | Oct. 16, 1854. E. n. and s; many ∗s involved. |
| 46 | 1 | Dec. 7, 1857. s. of it is another neb.; E. nearly n. and s; 46 has B. centre; mE. n. and s, arms vF. |
| 47 | 4 | Nov. 3, 1855. Oval, and I think r; and has a ∗ at np. edge. |
| 50, 51 | | Drawing not complete. The following are measures of some of the ∗s involved:— |

| | | Pos. | Dist. |
|---|---|---|---|
| Dec. 18, 1851. | 1.13 | 248° | 6′ 13″ |
| | 1.14 | 243 | 5 14 |
| | 1.15 | 260 | 5 51 |
| | 1.16 | 260 | 7 42 |
| | 1.17 | 241 | 7 30 |
| | 1.18 | 280 | 4 22 |
| | 1.19 | 301 | 7 35 |
| Dec. 22, 1851. | 6.20 | 219 | 3 46 |
| | 6.21 | 246 | 3 6 |
| | 6.22 | 234 | 5 1 |
| | 6.23 | 258 | 4 46 |
| | 6.24 | 271 | 4 20 |
| | 6.25 | 252 | 5 40 |
| | 6.26 | 295 | 4 34 |
| Oct. 25, 1851. | 1.N | 83 | 2 2 |
| | 1.2 | 6 | 4 54 |
| | 1.3 | 309 | 5 1 |
| Oct. 28, 1851. | 1.4 | 1 | 7 25 |
| | 1.5 | 244 | 1 57 |
| | 1.6 | 254 | 6 13 |
| Nov. 24, 1851. | 1.7 | 8 | 7 32 |
| | 1.8 | 12 | 6 40 |
| | 1.9 | 11 | 5 46 |
| | 1.10 | 349 | 3 0 |
| | 1.11 | 345 | 2 10 |
| | 1.12 | 338 | 4 43 |

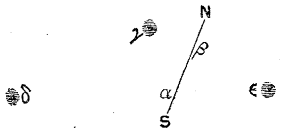


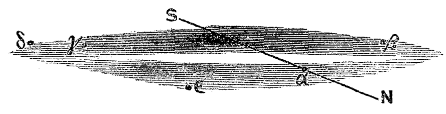
| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 53 | 1 | Sept. 19, 1857. S; R; vF; bM. |
| 54 | 2 | Nov. 22, 1854. pB; vS; R. |
| 59 | 3 | Dec. 22, 1848. 3 neb. in line, 2 of them "novæ." Oct. 23, 1856. 1st is R; pB; bM; and has nucleus; 2nd bM; E, ∗ involved; 3rd F; lE; bM. |
| 60 | 1 | Nov. 22, 1854. S; R; bM. |
| 65 | 3 | Sept. 18, 1857. S; pB. disc, in vF. haze of mottled neby. |
| 69 } 70 } | 7 | Oct. 3, 1856. 69 is S; B; R; with B. nucleus; 70 is F; E. and patchy. I sometimes thought it was formed of two knots involved in F. neby; there appears to be a nebulous connexion between them all. Nov. 15, 1857. The silvered mirror shows the object brighter than before, but no new details; definition bad. |
| 71 | 7 | Suspect spirality; light unequal. |
| 72 | 3 | Oct. 26, 1854. a F. object with two nuclei. |
| 78 } 79 } | 4 | Nov. 29, 1850. $\alpha$ is vlbM; $\beta$ has stellar point or nucleus. I suspect $\delta$ to be a F. neb.<br>Pos. Dist.<br>$\alpha\beta$ 219° 5′ 35″<br>$\alpha\gamma$ 315 1 8<br>$\alpha\delta$ 81 0 44<br><br>Nov. 3, 1855. 3 neb. nearly in line, sp, nf; $\beta$ is bM. and lE. p. and f; $\alpha$ is R; bM; with a d. ∗ np, and is the largest of the 3; $\varepsilon$ is S; F; R; $\delta$ is a ∗. |
| 80 | 1 | Oct. 3, 1856. pL; not vF. Its brightest part is a line running diagonally, and there is a knot at either end; believed to be a spiral. |
| 84 } 85 } 86 } | 4 | Nov. 4, 1850. Pos. Dist.<br>$\alpha\beta$ 169° 2′ 19″<br>$\beta\gamma$ 160 4 22<br>$\gamma\gamma'$ 201 0 34<br>$\gamma\delta$ 157 3 19<br>$\gamma\varepsilon$ 176 5 32<br>$\varepsilon\zeta$ 199 1 41<br>$\theta\varepsilon$[a] 79 4 55<br> |
| 87 | 3 | Oct. 26, 1854. A d. neb., both S; R; bM. |
| 89 | 8 | A cl. with much unresolved neby. |
| 90 | 1 | lbM. |
| 91 } 92 } | 1 | 3 neb. in a triangle. |
| 96 | 6 | Oct. 26, 1854. Lenticular n. and s. Thought I saw a ∗ at times in centre ($1\frac{1}{2}$-inch single lens); a lp. this is another vF. ray, np, sf, and which has no nucleus. Oct. 16, 1855. vF; E. n. and s; has nucleus; ∗ in n. end. Nov. 3, 1855. mE; pB. nucleus, and ∗ in n. end; np. this neb. is a ∗ of the 9th mag., and about the same distance p. this ∗ is another neb. vF; mE. Dec. 7, 1855. Seen as before; comp. neb. verified. Oct. 23, 1856. F. ray has nucleus and a ∗ in n. end. Sept. 18, 1857. E. n. and s; another vF. ray p, which is E. np. sf. |
| 98 | 1 | vF; R; S. |
| 99 | 1 | Oct. 3, 1856. S; F; R; bM; has nucleus. |
| 103 | 3 | Is n. of the 3rd of a group of 4 ∗s in line; 3 "novæ" near.<br><br>Pos. Dist.<br>Dec. 6, 1850. A$\beta$ 28° 7′ 36″<br>Dec. 7, 1850. $\beta\delta$ 40 4 6<br>$\beta\varepsilon$ 81 9 19<br>A$\beta$ 30 7 43 |
| 104 | 1 | Oct. 23, 1856. 6 neb., all visible at once in finder eyepiece; 2 of them E., the others S; R; bM. |
| 105 | 1 | Dec. 11, 1854. vmE; bM (speculum dewed). |
| 106 } 108 } | 8 | A variety of new nebulæ found, but observations too voluminous to transcribe. |
| 112 | 6 | Sketch made, but no interesting details. Nov. 30, 1850. vF, and p. a quadruple ∗. Oct. 23, 1851. 3 ∗s f. neb.; light unequal. Sept. 16, 1852. 2′ diameter; several ∗s in it; probably a F. cl. |

[a] This should be, I think, $\theta\zeta$. A S. d. neb. suspected below at $\alpha'$.

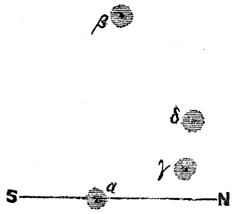
| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 113<br>114 | 2 | Both have nuclei; "nova" near. Nov. 16, 1857. 113 is E. p. and f; ✱ closely sp; 114 is R, with ragged edge and bM; "nova;" S; R; bM. |
| 115<br>121 | 1 | Oct. 3, 1826. The p. one is a pB. S. disc in F. outlying neby. The f. one is R; bM. |
| 116 | 1 | Dec. 18, 1851. s. end of neb. is like a brush or broom with a split.  |
| 118<br>120 | 2 | 4 neb. found, 2 have nuclei. 118 is S; R; 120 has 2 ✱s on np. edge; E. p. and f. |
| 119 | 1 | Dec. 9, 1854. pL; pB; bM to a nucleus. |
| 123 | 2 | Sept. 18, 1857. Rough sketch made; mE. np, sf; a F. triple ✱ f. |
| 128 | 3 | Nov. 28, 1856. L; B; mE; B. nucleus. "Nova" f. |
| 131 | 27 | Pos. Dist.<br>Nov. 29, 1850. αβ 215° 0′ 51″<br>αγ 163 0 56<br>αδ 160 2 56<br>αε 178 3 07<br>αζ 192 3 44<br>αη 206 4 14<br>αθ 224 4 58<br>Dec. 27, 1850. αμ 147 5 34<br>αλ 179 5 56<br>ακ 201 5 42<br>μν 143 6 28<br>α1 287 4 30<br>απ 341 6 45<br>Jan. 2, 1851. α2 5 5 18<br>αψ 357 4 42<br>α3 51 11 0<br>αρ 38 9 50<br>ατ 58 11 16<br>Dec. 23, 1851. αω 161 5 20<br>αα′ 149 6 53<br>αβ′ 172 6 32<br>αγ′ 174 7 18<br>αφ 205 2 22<br><br>For previous observations see Transactions, Part II. 1850.<br>Sept. 13, 1850. Large spiral full of knots; to nf. is a S. neb. B, which on a very good night might appear attached to spiral, than which it is brighter. Oct. 11, 1850. Spiral arrangement not clearly seen. Nov. 27, 1850. Arms of spiral scarcely seen; fog. Nov. 30, 1850. Spiral form very indistinct; wind very high from s. Oct. 22, 1851. Viewed for drawing, I should not have seen the spiral arrangement had I not observed it before. Oct. 25, 1851. Neby. extends for several minutes all round, perhaps for half a degree in radius. Oct. 29, 1851. Observed for drawing. Dec. 14, 1851. Sketched. Dec. 26, 1851. Drawn. Dec. 7, 1855. This neb. reaches in length through at least a field and a half of finder eyepiece. Mr. Stoney's drawing leaves out a great deal of the neby. about the centre, and ✱ suspected to left of centre of the trapezium of ✱s, perhaps others also. Nov. 15, 1857. There are 3 ✱s about the principal nucleus. Dec. 7, 1857. Carefully observed, with a view to a new sketch. Dec. 18, 1857. Carefully observed, and my sketch proceeded with. See fig. 10, Plate XXVI. |
| 132 | 1 | Nov. 28, 1856. B; S; R. nucleus, a ✱ p. and another n. |
| Nova. | | Nov. 29, 1850. A S. neb. or cl. with 3 ✱s in it. Æ $1^h\ 26^m$. N.P.D. 60° 35′. |
| 134<br>135 | 2 | Oct. 26, 1854. Both S; R; B. |
| 136 | | Sought for four times; not found. |
| 142 | 8 | Dec. 13, 1848. Rough sketch made. Spiral? Dec. 14, 1848. Confirmed last night's observation; feel confident it is a spiral. Oct. 24, 1851. Centre formed of ✱s; easily seen to be such; several ✱s through the neb.  |
| 143 | 1 | Oct. 3, 1856. vS; F; R; bM; had a ✱ close to n. edge. |
| 147 | 2 | Nov. 30, 1856. S; R; bM. to a nucleus. |

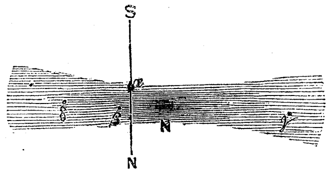
| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 148 | 1 | Dec. 11, 1854. S; R; bM. to a nucleus. |
| 149 | 3 | Nov. 30, 1856. Nucleus; E. np, sf. |
| 150 | 6 | A B. ray, with * in s. edge, a little f. the nucleus. |
| 151 | 2 | Oct. 3, 1856. Long; vF; vlbM. A B. * in p. edge. |
| 156 | 3 | Oct. 7, 1850. Light rather equable, a minute * in the p. part. Nov. 24, 1851. E; a * of 10th mag. nf. Sketched. Nov. 28, 1856. I see *s sparkling in it at times. See [fig. 2, Plate XXV. |
| 157, 159 | 4 | A group of 5 neb.; others near. |
| 161 | 2 | Oval; * in n. edge. |
| 162 | | Looked for 8 times. Dec. 18, 1848. Found * 7th or 8th mag. in place, but saw no nebulous atmosphere. |
| 163 | 1 | No nucleus. R; pF; bM. |
| 164 | 1 | Dec. 11, 1854. vB. nucleus. |
| 165 | 1 | Nov. 29, 1856. More E. than Herschel describes it; vbM. |
| 169 | 1 | A group of 5. Oct. 11, 1850. |
| | | Pos. — Dist. |
| | | $\alpha\beta$ 12° — 0′ 30″ |
| | | $\alpha\gamma$ 46 — 1 19 |
| | | $\alpha\delta$ 118 — 3 20 |
| | | $\alpha\varepsilon$ 296 — 1 59 |
| 172, 173 | 1 | Nov. 24, 1854. d. neb.; the p. one is pB; R; bM. The f. one is smaller and fainter, and lbM. |
| 175 | 1 | Oct. 11, 1850. d. neb.; about 18′ nf. (169); nf. is a 3rd F. neb. |
| | | Pos. 171° — Dist. 0′ 25″ |
| 181 | 7 | Branches suspected several times, but not distinctly seen. Has a comp. neb. 5′ or 6′ s. |
| 182 | 2 | Oct. 23, 1857. S; pB; R; bM. |
| 183 | 2 | Dec. 7, 1850. Nucleus E. np, sf. |
| 188 | 1 | Nov. 30, 1856. S; F; R; lbM. |
| 190 | 1 | Nov. 22, 1854. eeF; E; no nucleus. A * 10th mag. p: several S. *s near. |
| 193 | 2 | Dec. 18, 1856. bM. to a nucleus. E. sp, nf; S. * in s. end. |
| 194 | 1 | Some *s in it. |
| 195 | 2 | Nov. 30, 1856. E. sp, nf; a F. * follows closely; there is another F. * in n. edge. |
| 197 | 4 | Dec. 23, 1851. I suspect a F. appendage f; a d. * f. |
| 198 | 1 | Nov. 24, 1854. vF; mE; almost lenticular. |
| 199, 200, 201, 202 | 2 | Nov. 29, 1856. All are S; R; bM. |
| 205 | 1 | Nov. 28, 1856. S; R; lbM; a * in centre. |
| 207, 212 | 14 | Sept. 13, 1850. Between the 2 cls. there is a red * nearer the 2nd, and 2 more red *s f. 2nd cl. of 8th or 9th mag. |
| 208, 210 | | Nov. 3, 1855. A dark space running along s. side of nucleus of 210, and (Nov. 5, 1850) * in sf. extremity; r. Both have S. comp. nebs. s; 208 is E; * close f. centre. |
| 212 | 1 | No description. |
| 213 | 2 | Nov. 30, 1856. vS; eeF; R; vlbM. |
| 215 | 2 | Oct. 29, 1851. Nucleus; 5′ n. of d*. |
| 216 | 1 | Sept. 17, 1852. * in edge; perhaps like a snowdrop. |
| 217 | 4 | Sept. 14, 1850. Oval; mbM; pB; 50″ by 70″. |
| 218 | 7 | Dec. 27, 1850. Pos. of chink 19°. |
| | | Dec. 26, 1851. |
| | | Pos. — Dist. |
| | | $\alpha\beta$ 44° — 1′ 57″ |
| | | $\alpha\gamma$ 198 — 4 38 |
| | | $\alpha\delta$ 199 — 5 48 |
| | | $\alpha\varepsilon$ 211 — 2 38 |
| | | ray 23 — 10 29 |
| 219 | 1 | Nov. 28, 1856. d. neb.; components unite at p. end. The s. one is L, E, and gbM. The n. one is more E. and fainter, and also bM. |
| 221 | 2 | Oct. 23, 1857. L. but eF; mottled; *s in it, especially one closely n. of centre. |

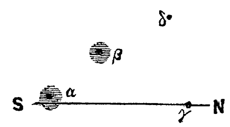
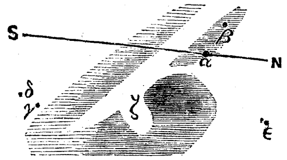


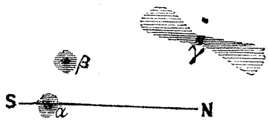
| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 222 | 1 | Sept. 14, 1850. 3′ by 50″; rather F. dash of light; a conspicuous ∗ nf. the M. outside edge. |
| 223 } 224 } | 2 | Nov. 29, 1856. 223 is pL; B; vbM; R? It seems to have some F. *mottled* neby. about it. 224 is vF; pL; vlbM. |
| 226 | 3 | Oct. 16, 1855. Oval; no nucleus; light pretty equable; major axis np, sf; clearly r. I can at moments see some of its ∗s. A B. ∗ at s. edge. |
| 229 | 1 | Nothing particular. |
| 230 | 2 | Nov. 24, 1851. Brightest part near p. edge; E. nnf. ssp; d. ∗ n, to which neb. does not reach. |
| | | Pos. Dist. |
| 231 } 233 } 234 } 237 } | 2 | Oct. 11, 1850. $\alpha\beta$ 83° 3′ 43″ |
| | | $\alpha\gamma$ 22 1 59 |
| | | $\alpha\delta$ 40 2 31 |
| | | Another about 12′ sf. |
| 232 | 9 | Oct. 12, 1855. Sketched; r. See fig. 3, Plate XXV. |
| 238 | 3 | Dec. 12, 1848. bM. nearly to nucleus. |
| 241 | 8 | Sketched twice, Dec. 11, 1854, and Nov. 23, 1857. See fig. 4, Plate XXV. |
| | | Pos. Dist. |
| 242 | 8 | Dec. 27, 1850. $\alpha$N 73° 0′ 54″ |
| | | $\alpha\gamma$ 81 3 19 |
| | | $\alpha\beta$ 331 0 29 |
| | | $\alpha\delta$ 282 1 39 |
| | | Sketched four times. See fig. 5, Plate XXV. |
| 244 | 1 | Nov. 28, 1856. Patchy; pL; mbM. |
| 246 | 2 | Spirality suspected; E; gbM. |
| 247 | 1 | vS; R; F; bM. |
| 254 | 1 | gbM. |
| 255 | 4 | Dec. 27, 1856. r; has 3 ∗s in edge, and I think I see one just p. the nucleus. |
| 256 | 1 | E. |
| 257 | 6 | Jan. 2, 1851. 5 knots; the p. one is d. neb. Dec. 26, 1851. A ruddy ∗ of 10th mag. p. 16′. |
| 258 | 4 | Nov. 30, 1850. A F. dash of light nearly p. and f; the n. edge is the best defined. |
| 262 | 12 | Sketched 4. Dec. 22, 1848. A blue spiral. Jan. 14, 1849. Spiral. Oct. 29, 1851. The central part is flatter on the f. side. Nov. 24, 1851. The central part is, I am nearly quite sure, spiral, sketched. Jan. 13, 1852. Spiral form of centre seen. Nov. 29, 1856. Details of drawing seen very well. Jan. 10, 1858. I can see nothing more than is given in the sketch, which appears to me correct, though perhaps it defines too well the edges of the B. central disc. See fig. 6, Plate XXV. |
| 263 | 1 | Dec. 7, 1850. R. nucleus. |
| 264 | 6 | Nov. 23, 1848. A curious object with dark spaces. Oct. 10, 1850. r. Oct. 16, 1855. Fine oval neb; has nucleus; light mottled; sometimes I thought I saw a dark bay n. of nucleus; certainly the neb. is brighter along the n. and nf. side than in the part intervening between that and the nucleus. Dec. 6, 1855. Previous suspicion as to direction and existence of dark streak confirmed; the nucleus and n. edge of neb. both seem r. |
| 265 | 2 | Jan. 7, 1849. F. patch, 2 ∗s perhaps, p. middle. |
| 266 | 3 | Jan. 14, 1849. vF; lE. |
| 269 | 1 | Very badly seen. |
| 271 | 3 | d., with another knot near. |
| 273 | 2 | Dec. 7, 1857. F; S; R; lbM. |
| 275 | 6 | Appendage suspected; E. n. and s; bM. |
| 276 | 2 | Dec. 7, 1857. vS; R; F; a S.∗ close sp. |
| 277 | 3 | Dec. 9, 1857. pB; oval; has a B. central nucleus; about 4′ n. is a F. E. neb. containing ∗s. |
| 279 | 1 | Dec. 11, 1854. Has a B. ∗ sp. the nucleus. |
| 280 | 3 | Badly seen. |
| 282 | 5 | Oct. 10, 1850. BM; r. |
| 285 | 6 | Nov. 29, 1851. E. p. and f; bM. |
| 286 | 8 | Oct. 30, 1851. E. p. and f; bM; between this neb. and 282 there are very few ∗s. |
| 287 | | cl. |

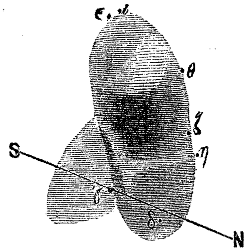


| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 288 | 1 | S; R; vF; bM. |
| 289 | 3 | Dec. 8, 1850. Double; $\gamma$ * of 9th mag; $\alpha$ is 289, and has a F. nucleus; $\beta$ "nova."<br>Pos. Dist.<br>$\alpha\gamma$ 2° 2′ 53″<br>$\gamma\beta$ 152 2 08<br>$\gamma\delta$ 103 1 54<br> |
| 290 | 5 | Nov. 23, 1848. Coarse, cl. strongly honey-combed. Would probably look annular with eccentric eyehole if it were far enough to be a neb. Nov. 21, 1851. The honey-combed appearance is caused by the disposition of the brighter *s; no spiral arrangement. |
| 292 | 3 | Jan. 17, 1855. r. Nov. 28, 1856. Edge ragged. |
| 293 | 4 | Dec. 16, 1848. A multitude of nebs. knots in the neighbourhood, principally p; counted 15; many more. Dec. 8, 1855. One of them F; has a * close sf. and looks like a snowdrop. |
| 294 } 295 } | 1 | Nov. 24, 1854. Two S. R. neb.; both bM. |
| 296 | 5 | Dec. 19, 1848. gbM; E. sp. nf. |
| 297 } 298 } | 10 | 2 "novæ." Oct. 10, 1850.<br>Pos. Dist.<br>$\beta\alpha$ 143° 1′ 35″<br>$\beta\gamma$ 11 6 1<br><br>Nov. 2, 1850. Another 8′ n. of $\gamma$. |
| 299 | 2 | Dec. 16, 1854. vF; lbM. to a nuc.; mE. np, sf. |
| 301 | | Scattered cl. |
| 302 } 303 } | 4 | 302, r.<br>303, mottled. |
| 304 | 1 | Jan. 17, 1855. d. neb.; both vS. and bM. |
| 305 } 306 } 307 } | 8 | Dec. 26, 1856. The p. one is vF. and light mottled. Oct. 7, 1850. 1st appears divided, and preceding part has a minute *. Jan. 22, 1851. f. the 3rd; 14′ is "nova." |
| 308 | 1 | Oct. 31, 1856. A fine d. * in a loose cl. |
| 309 | 2 | Oct. 26, 1854. S; R; bM. |
| 310 | | Cluster. |
| 311 | 9 | Sketched five times. Jan. 13, 1852. New spiral of an annular form round the *, which is central. Brightest part is sf. the *; spirality is vF; but I have no doubt of its existence. Oct. 7, 1855. Annular, but with a break in s. side of annulus, or perhaps spiral. Oct. 31, 1856. I feel certain of a dark space nearly p. the central *, but the shape of the whole is only conjectural; there is a * plain np. the neb. Dec. 7, 1857. Not vF, and the break in the s. side of the ring of neb. quite easily seen; *between* this ring and the central * is not black, but filled with more F. neby. Jan. 9, 1858. Observed for a sketch; last observation correct as to shape; the brightest part is sf, and the next brightest is on the opposite side, and with ½-inch single lens the whole annulus has a mottled look. Jan. 13, 1858. The whole edge was ragged and irregular, and the whole neb. much mottled. See fig. 7, Plate XXV. |
| 313 | 2 | Dec. 16, 1854. vF; S; R; lbM. |
| 315 | 16 | Sketched five times. Jan. 2, 1851. Dark space sf. neb.; though I did not see the F. neby. beyond the channel, I conjecture that it exists and fades off imperceptibly, somewhat like the drawing. Jan. 22, 1851. Observations of Jan. 2nd confirmed; F. neby. seen; B. part r. Nov. 29, 1851. Last season's observations confirmed as to shape. Dec. 22, 1851. Previous observations confirmed. Jan. 13, 1852. $\varepsilon$ is d; $\zeta$ is the angle of the brightest part. See fig. 8, Plate XXV.<br>Pos. Dist.<br>$\alpha\beta$ 57° 0′ 55″<br>$\alpha\gamma$ 204 3 50<br>$\alpha\delta$ 199 4 1<br>$\alpha\varepsilon$ 315 2 23<br>$\alpha\zeta$ 223 1 42<br> |

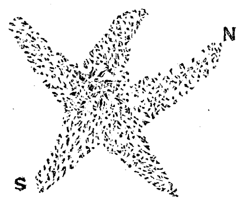
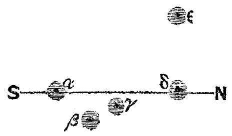
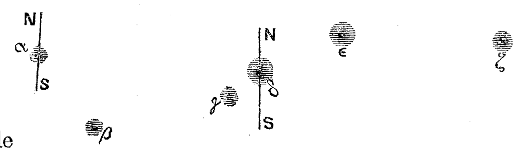
| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 316<br>317<br>318 | 7 | Dec. 5, 1850. α and γ are bM; γ is about 10′ nf. α, and has a brush-like elongation (see 242) at each end.<br>Pos. Dist.<br>Oct. 7, 1850. αβ 77° 0′ 56″<br>Dec. 5, 1850. αβ 75 0 58 |
| 319 | 2 | 3 "novæ" near. |
| 321 | 3 | Oct. 26, 1854. Has a ∗ at n. extremity; E. np. by sf; Herschel's d. ∗ nf. is triple. Jan. 15, 1855. The conspicuous ∗ involved in n. end of neb. has a F. comp; nf. itself very distinct with $1\frac{1}{2}$-inch single lens. |
| 320<br>322 | 1 | 3 neb. nearly in a line; one "nova"; 1st pL; F; R; 2nd pF; R; 3rd dull nucleus. |
| 327 | 10 | Sketched twice. Appears to be a spiral, but evidence not quite satisfactory. See fig. 9, [Plate XXV. |
| 331 | 1 | Nov. 29, 1856. 2 ∗s near edge; vS; irreg. R. |
| 334 | 6 | 4 neb. (3 "novæ"); one of them is E. |
| 336 | 6 | Jan. 13, 1858. B. centre; F. neby. stretches out a long way, involving a minute ∗ p. |
| 338 | | Oct. 26, 1854. A group of a few ∗s. |
| 339 | 1 | 2 nebs. knots. |
| 340 | 2 | "nova" near. |
| 343 | | Looked for seven times. Not found. |
| 347 | 15 | Dec. 11, 1850. A S. comp. p. and a d. ∗ n. Jan. 10, 1858. Looks like a F. haze enveloping 3 ∗s. |
| 349 | | Large loose cl. |
| 352 | 2 | Close d. neb. |
| 354 | | Dec. 28, 1856. Neat little cl; its centre consists of about 40 or 50 ∗s; the outlying ∗s are arranged in curved branches. |
| 355 | 5 | Nov. 29, 1848. Saw a multitude of ∗s and some unresolved neb. |
| 356 | | Looked for four times; not found, but nights bad. |
| 357 | 19 | Sketch not quite satisfactory.<br>Pos. Dist.<br>Nov. 29, 1851. γδ 351° 0′ 47″[a]<br>γζ 52 2 10<br>γη 40 2 16<br>γθ 70 2 53<br>γε 110 3 19<br>γι 104 3 37<br>Jan. 12, 1852. δγ 348° 1′ 36″. |
| 358 | | Coarse cl. |
| 359 | 1 | Dec. 28, 1856. Looks like a ∗ in vF. neb. atmosphere. lE. p. and f. |
| 360 | 43 | (Neb. of Orion.) Account of detailed observations postponed, as in 50 and 357. |
| 361 | 11 | Observations recorded in the 'Transactions' for 1850 fully confirmed. |
| 363 | 6 | Nov. 30, 1850. The luminous appearance extends about 15′ all round the ∗. |
| 365 | 3 | Oct. 23, 1851. r: I strongly suspect it is annular. |
| 368 | 8 | Feb. 9, 1852. Spiral arrangement sufficiently seen to confirm former observations. Jan. 9, 1856. Appears in finder a B. oval neb., with n. and nf. edges brightest and best defined, and sp. edge fading away gradually; with higher power there is seen a decided darkness at and between the ∗s, and I can confirm previous observations as to the curve formed by the brightest part of neb. Dec. 26, 1856. Nebulosity easily traced as in preceding sketch. |
| 370 | 1 | Jan. 21, 1857. r? suspect ∗ in centre. |
| 373 | 3 | Nov. 30, 1850. Same appearance as ε Orionis, but very much fainter. |
| 375 | | Jan. 17, 1855. A pretty close cl. of S. ∗s, followed by four or five B. ∗s. |
| 378<br>381<br>383 | 7 | Dec. 11, 1850. I saw no nebs. round 378; sf. about 20′ is a triple ∗, the middle one of which is pretty strongly nebs.; about 36′ f. (a little n.) is a d. ∗, whose brighter component is nebs.; 65′ f. 378 is a S. neb. with nucleus or stellar point. |
| 384 | 1 | No description. |
| 385 | 2 | A few B. ∗s; scattered. |
| 389 | | Dec. 28, 1856. Very loose cl. |



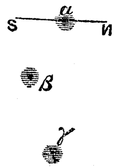


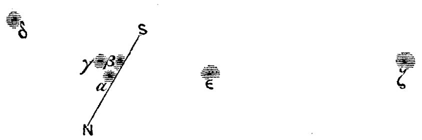
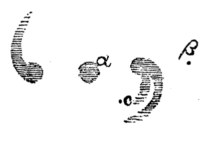
[a] Note by observer: "I have reason to believe that the distance of γδ is incorrect."

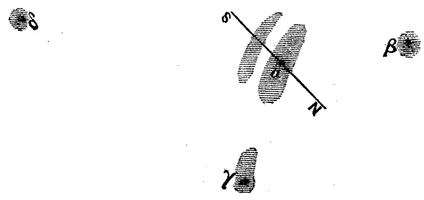
| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 390 | | Jan. 20, 1857. A close irregular cl. of vS. ∗s; figure as sketched, one ∗ rather brighter than the rest; forms as it were a nucleus, round which the others are grouped, but principally np. side of it.   |
| 393 | 15 | Sketched three times. Feb. 28, 1850. S. ∗ near a L. one; the L. ∗ f. the neb. has a comp; this, No. 393, is an enormous neby, which I traced f. and n. of it to a great distance, some degrees. It narrows at times to a band across the finding-eyepiece of about 6′ or 8′. I fancied the number of L. ∗s was greater in it than in the neighbourhood; I am certain the number of S. ∗s is much less. In a small space, taken at random in its neighbourhood, I reckoned upwards of 20 S. ∗s. In a similar space in it, taken at random, but 3. See fig. 11, Plate XXVII. |
| 399 | 11 | Feb. 22, 1851. 2 ∗s in p. part of the neb. Nothing additional to what is in the 'Transactions' for 1850. |
| 401 | 9 | No neby. found, and only a few ∗s arranged in pairs; no cl. Has there been a change here? |
| 403 | | R; with rays. |
| 404 | | Jan. 10, 1856. S. cl. of S. ∗s; oblong nearly p. and f. |
| 406, 407 | 12 | The southern one has nucleus. |
| 408 | 1 | |
| 409, 410 | 7 | Dec. 8, 1850. 5 nebulous knots.<br>Pos. Dist.<br>$\alpha\gamma$ 344° 2′ 32″<br>$\alpha\beta$ 323 1 . 46<br>$\alpha\delta$ 3 5 08<br>$\alpha\varepsilon$ 30 6 11   |
| 411 | | Nov. 25, 1851. A coarse B. cl. |
| 413 | | Jan. 20, 1857. Pretty cl. of pB. ∗s; centre nearly R. |
| 415 | | Jan. 8, 1851. A poor cl. |
| 421 | 6 | Nov. 23, 1851. v. close d. neb. below 4 ∗s. See fig. 12, Plate XXVII. |
| 425 | | Feb. 13, 1852. Coarse cl. |
| 424, 426 | 3 | Both bM. |
| 427 | | v. loose cl. |
| 428 | 2 | Feb. 1, 1856. vF. fan-shaped neb. involving 3 ∗s. |
| 430 | 2 | Jan. 31, 1851. Several knots around; 430 is E. np, sf. |
| 431 | 2 | Jan. 18, 1855. S. ∗ in s. edge. Jan. 25, 1857. r.? |
| 434 | 10 | ∗ in f. edge; r. |
| 439 | | Jan. 9, 1856. Loose cl; irreg; R. |
| 443 | | Jan. 30, 1856. About 25 or 30 ∗s of a curious shape. |
| 444 | 15 | Nov. 23, 1851. S. ∗ in f. end of np. appendage, also one nf. the neb. about 40″; nothing additional to description in 'Transactions' for 1850. |
| 446, 447, 448, 449 | 5 | Feb. 26, 1851.<br>Pos. Dist.<br>$\alpha\beta$[a] 222° 3′ 41″<br>$\beta\gamma$ 282 5 37<br>$\delta\varepsilon$ 291 3 49<br>$\varepsilon\zeta$ 267 6 47   |
| 450 | 25 | Although 21 observations have been made since the sketch appeared in the 'Transactions' of 1850, nothing additional has been discovered, except that the outer luminous ring is of unequal brightness. |
| 453 | 1 | Jan. 21, 1857. S. ∗ close to n. edge. |
| 454 | | Neat little cl. of vS. ∗s. It looks in finder like a r. neb. |
| 456 | 11 | Edge filamentous; r; vlbM. |
| 457 | 5 | Edge filamentous; r; looks like a globular cl. |
| 458 | 1 | No description. |
| 464 | 16 | Dec. 8, 1850. Dark space more eccentric than in the drawing in the 'Transactions' for 1850. The larger of the 2 ∗s is in the dark space, the other s. of it in the neb; a 3rd ∗ close nf. |
| 465 | 1 | Jan. 11, 1856. pF; bM; lE? |

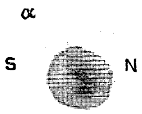
[a] $\alpha$, $\beta$, $\gamma$ and $\delta$, $\varepsilon$, $\zeta$ are distinct figures.

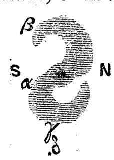
| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 468 | 5 | A group of 6 ∗s; no neby. |
| 469<br>470 | 1 | Feb. 20, 1851. A great many knots; reckoned 10 in a line nearly p. and f. |
| 471 | 1 | Jan. 9, 1856. d. neb. |
| 473 | 1 | Feb. 1, 1856. F. ray, with pB. nucleus; np. this is another neb. vF; E; with ∗ near nucleus. |
| 476 | 2 | Jan. 12, 1855. A F. ∗ p. and a nebulous knot f. |
| 477 | 1 | Another near, both F. S. |
| 478 | 16 | Jan. 20, 1855. I see 2 ∗s in p. edge with $\frac{1}{2}$-inch single lens. The smaller component of a double ∗ touches f. edge; light mottled. On several occasions spirality suspected, and rough sketch made. |
| 480 | Frequently. | Several observers have fancied that the ∗s exhibit some approach to a spiral arrangement, with cellular centre. No unresolved neby. |
| 481 | 1 | Jan. 20, 1857. ∗ in n. edge; centre r? |
| 482 | 1 | Nucleus; vF; R. |
| 483<br>484 | 3 | Jan. 31, 1851. 2 others near 483.<br>Feb. 26, 1851. Pos. Dist.<br>$\alpha\beta$ 242° 2′ 48″<br>$\alpha\gamma$ 319 5 36 |
| 486 | 3 | Feb. 16, 1855. L; vF; lE; light mottled; suspect dark spaces round the centre; F. stellar point or nucleus; several ∗s in edge and in it. Rough sketch made. |
| 487 | 1 | Jan. 25, 1857. Light mottled; B. ∗ n; a F. ∗ close nf. edge. |
| 489 | 10 | Feb. 14, 1857. Certainly a ∗ in centre or nucleus, and neby. projecting to sp. side, but eF. Mar. 10, 1858. (Definition very good.) Nucleus stellar; the brightest part of the neb. looks r. It is pL. and mottled; suspected spiral. |
| 491 | 15 | Sketched 6 times. Spiral. Jan. 29, 1856. Very well seen; previous observations confirmed. I have no doubt the neb. is a spiral. The f. half of neb. is the more difficult to see well. Mar. 10, 1858. Well seen; the whole neb. looks vB. and sparkling; part is clearly r; my former conjectures as to its shape confirmed. I used the highest single lenses. Mar. 11, 1858. (Definition very good.) Observed with same results as on last night. |
| 492 | 6 | But never well seen. |
| 494 | 1 | Jan. 20, 1857. vF; E; nearly n. and s; has a sharp pB. nucleus. |
| 495 | 2 | Feb. 28, 1851. Centre r; E. n. and s. |
| 496 | | Jan. 31, 1851. Coarse cl; lanes and openings without any ∗s whatever. |
| 497 | 4 | In the centre of a triangle formed by 3 minute ∗s; nucleus. |
| 498 | 2 | Feb. 22, 1857. 2 ∗s on np. edge; S; F; R; bM. |
| 499 | 3 | Nucleus; F. ∗ in p. edge; S; vF; R. |
| 504 | 2 | r; ∗ in f. edge. |
| 505 | 10 | Jan. 27, 1852. r. Feb. 9, 1855. Centre suddenly B; irreg. R. |
| 506 | 4 | Jan. 17, 1855. Centre suddenly B. with outlying F. neby, which involves a ∗ nnf. |
| 507<br>508 | 3 | Feb. 9, 1850. A fine object; 3 neb. forming a triangle; one B, another pB; the third the last degree of faintness. |
| 510 | 1 | 4 neb. here. The f. one is E. and has nuc; the others are S. and F. |
| 512 | 5 | Jan. 10, 1856. Not vS. but vvF. and flickering. Feb. 1, 1856. Nucleus and ∗ close to s. side of it, and two very indistinct branches of neby. From the tenour of the observations no doubt it is a spiral; the twist of the branches fully confirmed. |
| 513 | 9 | Nov. 30, 1850. S. ∗ in its nf. edge, perhaps not connected with the neb. The neb. had a brush-like appearance. Feb. 1, 1851. Dark space f. the ∗ between neb. and ∗, like the "snowdrop" neb. (see fig. 10, 'Transactions' for 1850). |
| 514 | 20 | Dark space suspected in centre, but never fully confirmed. Remarkable for extreme paucity of ∗s in neighbourhood. |
| 518 | 11 | Nucleus surrounded with L. F. neby. |
| 519 | 6 | Jan. 30, 1856. 4 ∗s in vF. neby. |
| 521 | 1 | Feb. 23, 1857. E; np; sf; mbM. |
| 522 | 4 | Light *not* equable; stellar nucleus?; ∗ in n. edge. |
| 526<br>527 | 3 | Feb. 9, 1855. Very close, almost touching. 526 is mbM; 527 is smaller, and lbM. Sketched. |
| 529 | 7 | March 9, 1852. e. close; d. neb. Jan. 20, 1857. These two are equal in size, and enveloped in F. haze of neby. |

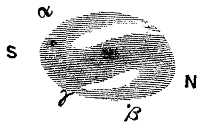


| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 530 | 7 | B. nucleus, surrounded by very extensive neby. |
| 531 | | Coarse cl. |
| 532 | 7 | Dec. 29, 1851. vL. lenticular ray, slightly concave towards np. direction; gvmbM; perhaps 10′ long. March 1, 1854. Uncertain whether nucleus is stellar. Query, parallel dark lines exterior to nucleus as in Andromeda. March 8, 1858. ∗ on np. edge is d. |
| 533 | 1 | March 11, 1858. 4 neb. here, nearly in line p. and f. |
| 535 | 9 | d. neb. surrounded with F. neby. |
| 536 | 6 | 6 knots in the immediate neighbourhood, two of which have ∗ in their edges. |
| 537 | 2 | ∗ with fan-shaped neb, very like Herschel's fig. A 2nd F. star involved in the neby. |
| 538 | 1 | March 1, 1856. F. bM. |
| 540 | 8 | r; d. ∗ in s. extremity; nucleus. |
| 542 | 1 | Feb. 19, 1855. vvF. nucleus; r. |
| 549 | 1 | Feb. 18, 1855. d. neb. |
| 550 | 1 | March 12, 1852. An amorphous mass of neby. of uneven character; E. p. and f. |
| 551 | 3 | Jan. 20, 1857. lE. p. and f; and vlbM. |
| 553 | 4 | Feb. 16, 1858. Nucleus; pB; E. nearly n. and s. |
| 555 | 3 | Dec. 29, 1851. A B. ray like 242. |
| 556<br>559<br>561 | 2 | 4 neb, one of them vvF. and one E. |
| 557 | 1 | Feb. 23, 1857. vF; lE; lbM. |
| 562 | 4 | vF. ray; np, sf. |
| 563 | 7 | Feb. 16, 1858. Mottled, and suspect spiral; r. March 11, 1858. B. ∗ close f. |
| 564 | 2 | March 26, 1851. vbM. |
| 566<br>567 | 1 | March 13, 1850. A third, and eF. neb. found. |
| 569 | 2 | lE. |
| 574 | 1 | Jan. 8, 1851. ∗ in edge; R; S. |
| 575 | 2 | Feb. 9, 1855. 2 neb. found; both F. and lbM. |
| 580 | 2 | March 15, 1855. E. nearly n. and s.; has a ∗ touching its nf. edge, and is mbM. |
| 581<br>582 | 5 | There are here 15 knots. The positions of six of them were taken.<br>Pos. Dist.<br>March 26, 1851. $\alpha\beta$ 226° 0′ 25″<br>$\alpha\gamma$ 237 1 12<br>$\alpha\delta$ 263 5 9<br>$\alpha\varepsilon$ 125 4 13<br>$\varepsilon\zeta$ 120 8 8<br>March 14, 1850. $\alpha\beta$ 235 about 0 30<br>$\beta\gamma$ 245 about 0 45<br> |
| 584 | 5 | The neb. involves one of Herschel's ∗s. |
| 587 | 1 | Mar. 15, 1855. Has a F. knot close np. |
| 588 | 1 | Nucleus. |
| 589<br>591 | 4 | 3 found; 2 of them E. and lbM. |
| 592 | 2 | ∗s in its edges, and suddenly condensed in the centre. |
| 593 | 5 | Feb. 14, 1855. Stellar points in outlying F. neby, especially two, which I can plainly see with the ½-inch single lens; sbM. |
| 594 | 1 | Mar. 9, 1858. E. neb. between 2 ∗s.  |
| 597<br>598 | 3 | Feb. 22, 1857. Fine d. neb, both mbM. and both E, especially the f. one, which seems to have a bend at $\alpha$. Query, a vF. neb. at $\beta$? Mar. 18, 1857. All the particulars of my last observation fully confirmed. " Nova " at $\beta$ seen.  |
| 600 | 3 | Feb. 19, 1855. pF; R; bM. to nucleus. |
| 604 | 24 | (18 times since 1850.) Nothing additional, except 3 ∗s as in diagram. Mar. 9, 1858. Very well seen; central nucleus looks r. A ∗ suspected at $\alpha$, and one or more in the F. neby. at $\beta$; and a ∗ seen at times quite steadily at $\gamma$. I employed the inch and ½-inch single lenses. March 11, 1858. Seen as well as on last observation. I have now verified the 3 ∗s which I then noticed.  |
| 610 | 4 | Mar. 24, 1857. Much mottled. Mar. 11, 1858. Has a d. ∗ in it. |

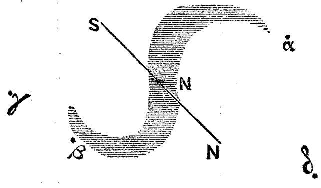
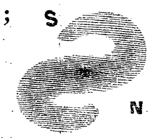
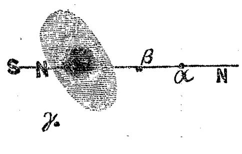
| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 613 | 1 | Feb. 18, 1855. vF; R; mottled?; ∗ in n. edge. |
| 622<br>624<br>627 | 8 | Feb. 1, 1856. 622 has nucleus, and is mE; its light is very unequal, and I suspect one dark lane running throughout its length; s. of nucleus. |
| 626 | 2 | Jan. 30, 1856. pL; vF; R; vgbM. |
| 630 | 1 | Mar. 5, 1851. S; lE; vgbM. |
| 634<br>636 | 4 | Feb. 19, 1855. The p. one is d; its comp. being immediately p. it, and lE. sp. by nf. |
| 635<br>637 | 2 | Mar. 9, 1852. n. one has a mottled appearance. |
| 638 | 1 | Jan. 25, 1851. r; 5 "novæ" near the most distant 11′. |
| 639 | 10 | Jan. 24, 1851. r; a S. ∗ near the middle, and another f. lenticular. Mar. 20, 1851. Patch and ∗ in p. end.<br>At 54° 46′ N.P.D. / $9^h$ 36′ Æ } ± A scarlet ∗ of 18th mag. |
| 640<br>641 | 1 | Several knots near. |
| 642 | 1 | 3 "novæ" near. |
| 644<br>647 | 2 | Feb. 26, 1851. p. one eF. |
| 650 | 2 | psbM. |
| 652 | 2 | Mar. 10, 1852. L. thin F. ray. |
| 656 | 4 | Mar. 15, 1855. Appendage to sp. edge, or rather a twist in that end towards the north. |
| 657 | 12 | vF; seems to have a split in f. end. |
| 659 | 2 | Nucleus or ∗ in M. |
| 660 | 1 | Nucleus or ∗ in M; light mottled; a S. ∗ nf. |
| 661 | 1 | Mar. 21, 1854. eeF. with B. centre; E, principally on f. side. |
| 663 | 3 | Jan. 10, 1856. Lent.; vbM; has a ∗ np. Query, a break in the neb. just p. the nucleus? |
| 665 | 1 | Mar. 18, 1857. Found here a ∗ with vF. neby. nf. it. |
| 667 | 3 | Mar. 24, 1857. pF; S; R; bM. |
| 668 | 6 | Mar. 11, 1848. Fine ray, with vB. nucleus. |
| 671 | 6 | Mar. 12, 1852. E. p. and f. |
| 675 | 4 | S. ∗ sp. edge. |
| 677 | 1 | Mar. 30, 1854. vF. |
| 678 | 1 | Mar. 27, 1854. 3 neb; the p. one vS. About 4′ f. is a S. lent. ray running nf, sp, and s. of this latter is another neb. about 5′ distant; R; both r. |
| 682 | 8 | Jan. 16, 1850. A F. spiral. Mar. 20, 1854. A F. ∗ immediately f.; spiral left-handed; very faintly seen; night bad. |
| 684<br>685 | 5 | 685 seems like 393, but instead of the ∗ having an approach to a nucleus. Jan. 30, 1856. About 5′ sp. 684 is a vvF. ray, extending n. and s. 684 has a B. central nucleus, with a sensible disk. |
| 688 | 4 | Suspected spiral. |
| 689 | 7 | Spiral. Feb. 1, 1856. The neby. connecting the three principal knots is vvF, but no doubt of its existence. Sketch made. See fig. 13, Plate XXVII. |
| 692<br>693 | 10 | March 15, 1850. 4 neb. here. α is 692, and β is 693.<br>Pos. Dist.<br>αβ 51° 5′ 50″<br>αγ 302 5 10<br>αδ 217 10 47<br>αβ 53 5 52<br><br><br>According to Herschel, the distance from 692 to 693 is 4′; this should be carefully looked after. Mar. 22, 1857. Sketched; α and γ r; nucleus of δ appears eccentric. See fig. 14, Plate XXVII. |
| 695 | 5 | March 3, 1850. Probably a F. spiral. March 24, 1857. ∗ in f. end; dark spaces throughout its length. |
| 696<br>699<br>700 | 1 | Feb. 16, 1855. They form an obtuse-angled triangle; the p. one is accompanied by 2 minute ∗s, one n. and the other nf; the next has also a minute ∗ as a comp. nf. |
| 698 | 1 | vF. |

| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 705 | 1 | March 3, 1851. d. ∗, with neb. to n. |
| 706 | | Looked for 5 times; not found. |
| 710 | 5 | March 11, 1858. 2 F. patches of neby. (of which one has nucleus); they form with a ∗ an obtuse-angled triangle, the intervening space being filled with F. neby. of a mottled character. |
| 711 | 4 | Feb. 18, 1852. pB; bM; E. sp, nf. |
| 713 | 1 | bM. |
| 714 | 2 | March 20, 1854. Dark spaces suspected. Feb. 9, 1855. Has a suddenly B. centre; vmE. |
| 718 | 1 | Has a ∗ closely sff. |
| 719 | 2 | Rather lenticular. |
| 720 | 2 | March 18, 1857. sp. edge is F, and not so sharp as the rest. |
| 721 | 2 | March 18, 1852. R; nucleus. |
| 724 | 6 | March 8, 1858. There is a B. streak, in which I certainly see ∗s sparkling, projecting a little from the edge of neb; the neb. is much mottled, and has a stellar nucl. |
| 727 | 1 | March 11, 1858. F; R; bM. |
| 728 | 5 | Jan. 10, 1856. I think the nucleus is not quite central. |
| 731 | 12 | March 5, 1848. Spiral arrangement well seen. March 11, 1848. Very cold; very windy; air steady; definition excellent; mirror bore a power of 700 with great precision; telescope as steady as a rock, although wind so high. Nebula well resolved into ∗ points. Saw a broad band at the bottom distinctly, and 2 at the top. March 28, 1848. Resolved by a power of 800, although night hazy. March 17, 1849. Like cl. in Hercules; dark spaces in B. part. |
| 732 | 1 | Between 2 ∗s, one of which seemed connected with the nebulæ. |
| 735 | 1 | Nucleus or ∗ in centre; S; R. |
| 737 | 4 | March 18, 1857. Mottled; suspect 2nd nucleus. |
| 739 | 8 | Jan. 27, 1852. vF. spiral with B. centre; S. ∗ sf. centre involved; two others f. |
| 743<br>749 | 14 | Both have B. L. centres enveloped in F. neby; much mottled. 743 sketched roughly twice. 749 sketched roughly four times. They are both represented as spirals, though the details are vF. |
| 748<br>751<br>753<br>754 | 3 | Mar. 23, 1851. The triple neb. is probably a spiral; dark spaces in it. |
| 750 | 4 | Feb. 1, 1856. lE; pB; mbM. |
| 755 | 3 | Feb. 23, 1857. mE. n. and s; bM. |
| 756 | 3 | B. streak through it suspected. |
| 757<br>758<br>761 | 3 | March 17, 1849. { 757 vB; L; R.<br>758 vB; R.<br>761 E; pB. |
| 765<br>766 | 9 | Feb. 9, 1855. 765 is, I think, a spiral, with *left-handed* twist; immediately f. is 766, which is B. and well-defined. I suspect F. neby, extending from 765 and running up through the other nebulæ. Feb. 14, 1855. Seen as before. In 765 the curve to the left is brightest near its extremity. Feb. 16, 1855. Certainly F. neby. extends between the two, as before suspected. Jan. 10, 1856. Nothing to add to former observations. Mar. 19, 1857. Observed to compare sketch. See fig. 15, Plate XXVII. |
| 768 | 1 | Nucleus. |
| 772 | 1 | Another neb. n. 3′ dist. |
| 773<br>775 | 7 | Both mottled. |
| 774 | 1 | Sharp nucleus; ∗ in nf. edge. |
| 777 | 3 | Mar. 29, 1856. A ∗ in s. edge, and a F. one in f. edge; 2 knots in n. edge. I think it r. |
| 778<br>779<br>782 | 3 | Feb. 9, 1855. Three in a line; the middle one is vB. and lenticular, and has the larger ∗ of a d. ∗ involved in f. end. |
| 783 | 1 | vF; lbM. |
| 785<br>787 | 3 | Mar. 5, 1851. At sp. edge of 787 a ring suspected, within which a dark band, then B. part. Mar. 30, 1856. 785 is E. sp. by nf, and its brightest part is nearest the p. end; also a ∗ in nf. edge. 787 is very curious. A R. bright nucleus, which is eccentric, and a dark curved passage sp. the nucleus, as in sketch. The neby. outside this dark place runs up perhaps to the streak marked α, which is vF, but of its existence I have no doubt.   |

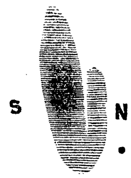
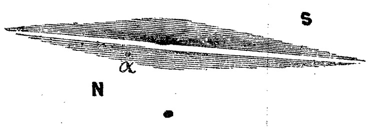
| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 786 | 1 | Stellar pt. or nucleus E. |
| 788 | 6 | Jan. 1850. Probably very remarkable; bad night. Feb. 1, 1851. f. division the brighter. Mar. 3, 1851. p. division pretty well seen. Mar. 8, 1856. mE; certainly dark spaces on each side of nucleus, but not well seen; that on f. side is the more distinct. Sketched roughly 3 times. |
| 789 | 1 | Jan. 21, 1855. pL; considerably E; BM, but no nucleus. |
| 790, 791 | 2 | Mar. 28, 1856. About 3′ apart; both F. and of nearly equable light. The n. one is a long narrow ray np, sf; the other is oval sp, nf. |
| 793 | 1 | A S. comp. dist. about 5′ or 6′. |
| 804 | 3 | April 9, 1852. I suspect a dark curved passage sp. centre. Mar. 15, 1855. Light mottled; I suspect a knot in p. and one in f. edge. Has a spiral appearance. |
| 805 | 6 | Mar. 12, 1855. Has a sharp B. R. nucleus in a disc of F. mottled neby. |
| 806 | 2 | Mar. 17, 1855. Oval; major axis nearly p. and f; nucleus vB. |
| 810, 815 | 4 | Feb. 22, 1857. mE; B. nucleus; arms F; patchy. Mar. 23, 1857. pL; nucleus vB, and has a sensible disc; arms vF. and patchy. 815 is F, nearly R, lbM. |
| 811 | 1 | R; gbM. |
| 812 | 1 | Query, is there a F. ring round it? |
| 813 | 5 | Mar. 1, 1854. Query, an oval spiral? |
| 814 | 2 | April 13, 1852. Neb. does not appear to reach the *. |
| 818 | 4 | Very like H. 2172. See figure. Mar. 29, 1856. The nucleus projects into the space along sp. edge; outside this dark space there is F. neby, which I see joining the neb. at n. A F. * at the opposite extremity. |
| 831 | 3 | April 3, 1851. Light mottled; vBM; knot in p. branch. |
| 838 | 42 | April 13, 1850. But one * seen. Feb. 1, 1851. 2nd * not seen; sky milky. March 3, 1851. 2nd * not seen; sky milky. March 5, 1851. 2nd * not seen. March 7, 1851. 2nd * not seen. April 3, 1851. 1st * only seen. Jan. 27, 1852. Only one * seen. March 12, 1852. Only one * seen. March 13, 1852. Only one * seen. March 20, 1854. 2nd * not seen, nor any of the F. details. March 30, 1856. 2nd * not seen, nor minute details. March 24, 1857. 2nd * not visible. March 8, 1858. 2nd * not visible, nor minute details. N.B. The 2nd * has not been seen since March 9, 1850. |
| 840 | 5 | March 17, 1855. mE. p. and f; vB. centre; the n. edge of central part seems sharpest, and outside it again I think there is F. neby; * in f. edge. A rough sketch represents it like 2172. |
| 841 | 3 | Suspected spiral, but a vF. object. |
| 843, 844, 845, 846 | 4 | 844 is a B. nebulous disc in a F. oval neby. |
| 847 | 1 | Mar. 19, 1852. E. np, sf; vB. centre. |
| 848 | 3 | Feb. 18, 1852. vbM; lE. |
| 849 | 1 | Mar. 29, 1856. S; pB; R; mbM. |
| 851 | 1 | "Nova" near; both are S; F; lbM; and 851 has nucleus. |
| *854 | 10 | Mar. 31, 1848. Curious neb. with B. nucleus at left; a little above and towards the right is a streak; spiral; resolved very well about the nucleus, but no other part. From the right, and apparently springing from the nucleus, a vF. portion of neb. extends for nearly 15′, gradually melting away. Apr. 3, 1848. Observed with the same results as on March 31st. April 17, 1849. 2 *s near nucleus, one sp, the other sf. it. Feb. 25, 1854. Suspect dark spaces on either side of nucleus. Mar. 1, 1854. Neb. mottled; p. observation confirmed. |
| 856 | 2 | 2 neb. found; the p. one has a sudden vB. nucleus, and is lE. np, sf; the other is about 15′ f; S; R; pF; vlbM. |
| 857 | 4 | Suspected darkness on either side of nucleus; E. See fig. 16, Plate XXVII. |
| 858 | 4 | Apr. 15, 1852. R. disc, BM, with vF. neby. round it of mottled character; probably it will be seen as spiral on a fine night. Mar. 30, 1856. Spiral with, I think, two arms, thus: these arms are broken and of unequal light; there are B. patches at $\alpha$, $\beta$, and $\gamma$ respectively; a F. * p. at $\delta$. Apr. 6, 1856. Seen as spiral. The f. branch comes down past the other, doubtless over it as at $\alpha$, and seems to originate from the p. side of nucleus. Mar. 24, 1857. The spiral arms are eeF, but there is no doubt of their existence as described in previous observations.   |

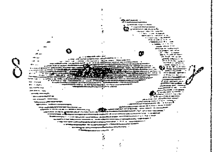
| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 859 | 2 | Apr. 1, 1848. pB; very long. |
| 860 | 1 | Apr. 9, 1852. I see nothing but a F. neb. 60″ near some ∗s of 8th and 9th mag. |
| 865 | 1 | bM. |
| 866<br>869 | 1 | Apr. 13, 1852. Large neb. is BM. It has a knot in sp. end, and a dark curved passage on p. and n. sides of centre; spiral. Small neb. f. has a S. ∗ immediately s. of it. |
| 875 | 6 | Sketched 4 times. Feb. 19, 1855. 3 ∗s in it; there is a mass of neby. f. the brightest part, with condensed portions through it. Disposed in curves? The F. ray extends many minutes s, gradually fading away. Mar. 17, 1855. There seems to be a knot at p. extremity, in which the neb. terminates in that direction, and immediately s. of this knot is a little dark bay. The branch running f. from this curves round towards centre. See figure. |
| 879 | 1 | Apr. 16, 1852. F. brush; night bad. |
| 881 | 1 | Nucleus. |
| 882 | 2 | Mar. 22, 1857. mE. sp, nf. and bM. |
| 887 | 2 | Mar. 17, 1849. Dark space f. centre strongly suspected. |
| 891<br>893<br>894<br>898 | 4 | Mar. 26, 1856. Of this group 894 is the largest and brightest; its light is patchy. |
| 895 | 2 | Mar. 28, 1856. Irreg; R, edge ragged; sbM; nucleus. |
| 896 | 2 | Jan. 27, 1852. Neb. divided into two parts, and F. appendage np. Apr. 15, 1852. Black line across; comp. scarcely visible. |
| 897 | 3 | Feb. 22, 1857. lE. sp, nf; gbM. to F. nucleus. |
| 901 | 1 | Mar. 23, 1857. F; E. np, sf; lbM. |
| 903 | 1 | E; vbM. |
| 908<br>911 | 3 | Jan. 27, 1852. 908 mottled, with S. ∗ involved; sp. it is a coarse d. ∗. 911 is irreg, with B. ∗ in s. edge, and having dark lanes through it. |
| 910 | 13 | Mar. 30, 1856. Examined attentively for a long time; it appears to be of the shape annexed, which exaggerates; there can be no doubt of the bend upwards at $\alpha$, and of the darkness about the nucleus; S. ∗ at $\beta$. Apr. 6, 1856. Seen pretty much as before; the upward bend at $\alpha$ is at a right angle. The p. branch reaches as far as $\gamma$; and I suspect a S. ∗ there. Mar. 8, 1858. This night is not as good as some on which I observed this object last year, but I can confirm my previous observations as to its general shape.   |
| 918 | 1 | Mar. 3, 1851. E; in the meridian vlbM. Another brush-like 20′ np. |
| 923 | 1 | Mar. 22, 1857. vS; R. |
| 925 | 2 | There is an appendage, perhaps an independent neb; r? |
| 930 | 3 | Between 4 ∗s, in the shape of a trapezium. |
| 931<br>932 | 1 | Feb. 24, 1852. 2 rays, forming an angle of about 100°; the s. one has a nucleus, and there is a knot at the n. extremity of the other. |
| 933<br>939<br>940 | 3 | 2 "novæ" near, probably a 3rd. 933 and 940 are E, the others R. |
| 936 | 2 | Apr. 1, 1848. A tolerably B. neb. with a smaller one f. |
| 943 | 5 | Spiral. Apr. 18, 1851. BM; F. neby. all round of a mottled character, knot or appendage in p. part. Apr. 10, 1852. Spiral? gbM. Mar. 1, 1854. Spiral arrangement; sky milky. |
| 945 | 1 | Apr. 11, 1850. Several ∗s near it, but few others in neighbourhood. |
| 946 | 3 | Mar. 8, 1858. S; lE. and pF. |
| 947<br>950<br>951<br>953 | 2 | All are S, R, and lbM. |
| 948 | 1 | bM. |
| 959 | 1 | Mar. 3, 1851. S; lenticular. |
| 960 | 1 | Feb. 17, 1855. A large number of pB. nebs. knots; I counted 8, probably there are more. |
| 967<br>968<br>969 | 1 | Mar. 28, 1856. The p. one is E. p. and f; the others are R; bM. |

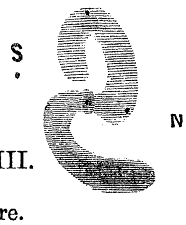
| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 971 | 1 | Mar. 29, 1856. Neat little ray np, sf; bM. |
| 973 | 1 | |
| 978 | 1 | Mar. 13, 1852. Oval; F. nucl; another F; S; 5′ nf. |
| 980 | 1 | Jan. 27, 1852. gbM; R; S. |
| 981 | 2 | April 13, 1855. Dull nucleus; edge ragged. |
| 982 | 4 | April 15, 1852. Spiral probably; knot in s. edge, and a * outside p. edge; another S. neb. 3′ sf, having * immediately n. of it. April 16, 1852. Spiral; last night's observation confirmed; the spiral branch seems to start from the s. edge and go round the f. and n. sides as far as the * p. April 19, 1857. A * np. and a * in s. edge. Seen thus:—The spiral branch is B. and easily distinguished at sp. edge (α); as it extends to f. edge it grows fainter, and I can trace it no further than β. The central neb. is vB, and has a B. nucleus. The S. neb. sf. is BM. and a lE. Apr. 20, 1857. Examined with 1-inch and ½-inch single lenses; last night's observation is correct. S  N |
| 983, 984 | 1 | S. * p. 983 about 1′. |
| 985 | 1 | Mar. 27, 1854. vF; r? |
| 988 | 2 | Feb. 24, 1852. lE. n. and s; bM. |
| 992 | 2 | Mar. 7, 1851. E; bM; nucleus. |
| 994 | 1 | 5′ long. |
| 1002 | 3 | Mar. 17, 1849. Suspect it to be a spiral; though two saw at moments ring round nucleus. Apr. 21, 1851. Spiral of the faintest class; the M. is pB, but the branches vF; conjectured form thus  Apr. 17, 1855, or thus . |
| 1005 | 3 | Apr. 11, 1850. Fine neb, but very bad night. |
| 1006 | 1 | vg. vlbM. |
| 1008 | 2 | * in nf. side; vF; E; B. nucleus. |
| 1009 | 2 | Apr. 13, 1852. Oval; gbM. |
| 1011 | 4 | Mar. 3, 1851. Lenticular; mottled. Mar. 30, 1856. mE. sp, nf; B. nucleus; very much mottled; the larger half of neb. lies to s. side of nucleus. A B. streak running obliquely through the nucleus, and another B. patch to s. end. Apr. 6, 1856. I see two patches in s. end, also a *. Apr. 19, 1857. Sketched. See fig. 17, Plate XXVII. |
| 1014, 1015 | 1 | Apr. 14, 1852. The s. one is E; the n. one has 2 *s involved. |
| 1017 | 1 | Mar. 27, 1854. Filamentous; r; * near centre. |
| 1018 | 3 | Jan. 10, 1856. pB. nucleus in a L. mottled disc of F. neby. Irregularly R. Another nf. |
| 1022 | 1 | Jan. 27, 1852. Long ray; gbM. |
| 1030 | 2 | Apr. 15, 1852. The neby. p. centre is mottled. |
| 1029, 1031 | 1 | The p. one is S. and the f. one vB. |
| 1033 | 4 | 3 "novæ"; one is S. and R, the others are E. |
| 1038 | 4 | Mar. 27, 1856. mE. n. and s; smbM. to a B. nucleus; a d. * involved in n. extremity; a B. * further distant n. |
| 1040 | 1 | Apr. 13, 1852. mE. sp, nf; * p. a S. R. neb. about 7′ np. it. |
| 1041 | 1 | Mar. 17, 1849. Roughly sketched; E, with a split or opening in the direction of major axis, and a * a little f. centre. |
| 1043 | 5 | Mar. 30, 1854. F; spiral? another neb. np. or nearly n; vF. about 5′ distant. Apr. 6, 1855. Query, of this form? S  N Its light is certainly patchy, and the neb. is lE. nearly p. and f; np. this object is another F. R. neb. with stellar centre. Apr. 13, 1855. Suspected shape as before, stellar centre. Apr. 16, 1855. My previous conjecture as to shape is rather confirmed by Mr. J. Stoney, who saw the p. branch turned off sharply to s. (nearly at a right angle), whereas the f. bend is not so sharp; but this latter branch reaches further round and is rather fainter. The whole object is vF. Mar. 27, 1856. Last year's observations fully confirmed. |
| 1045 | 1 | Apr. 26, 1851. Bicentral appearance is very indistinct; the light is mottled; E. ssp. and nnf. |

| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 1048 | 2 | Mar. 29, 1856. pL; B; mbM; r. |
| 1049 | 1 | Mar. 15, 1855. pF; R; lbM, but no nucleus. |
| 1051 | 1 | Apr. 18, 1851. S. * involved in f. part of it, precedes a * of 9th mag. 5′. |
| 1052 } 1053 } | 3 | Jan. 27, 1852. Spiral. Apr. 9, 1852. Previous observations confirmed; S. * np. it. Apr. 14, 1852. Drawing made. See fig. 18, Plate XXVII. |
| 1058 | 1 | Apr. 10, 1852. glbM; F. neby. round it; S. * south. |
| 1061 | 4 | Apr. 27, 1851. Spiral; I suspect the f. branch extends to α. * suspected at ϱ.<br>Pos. Dist.<br>Nα 64° 2′ 50″<br>Nβ 256 2 19<br>Nγ 228 3 17<br>Nδ 15 3 53<br><br>Apr. 29, 1851. Observed for drawing. May 3, 1851. Viewed in twilight; drawn. Apr. 19, 1857. The p. branch seems the brighter rather of the two, and more suddenly curved than the f. one, and both of them look not quite so sharp as given in the drawing. See fig. 19, Plate XXVII. |
| 1062 } 1063 } 1064 } | 1 | Badly seen. |
| 1066 | 2 | Mar. 12, 1850. Broad equable band; several conspicuous *s in it, especially near ends. |
| 1081 | 1 | Apr. 16, 1852. vS. * p. and a little n. of centre; I suspect another in n. branch; gbM. |
| 1084 | 1 | Apr. 16, 1852. Nucleus. |
| 1085 | 5 | Apr. 13, 1852. Brightest part a little eccentric; * p. is involved. I suspect (Mr. B. Stoney) a dark curved passage on s. of centre, probably new spiral. Mar. 30, 1856. I have little doubt this is a spiral, either *s  , which I rather believe, or  , a S. * p. Apr. 6, 1856. I think spiral with one branch; a B. part at α, and I suspect a * there. Mar. 24, 1857. Nothing to add to previous observations, which, however, I can fully confirm. Apr. 19, 1857. Observed. |
| 1088 } 1091 } | 2 | Apr. 21, 1851. 1st vF; 6′ ssp 2nd; 2nd vB. and mE; a d. * 5′ nf, whose smaller component is blue. |
| 1092 | 3 | Apr. 1855. Two neb. about 14′ distant, 45° nf. Is the s. one of this shape,  with a wedge-shaped division running downwards? The other neb. is lE. np. by sf; has nucleus, and is the larger and brighter of the two. Mar. 29, 1856. Last observation confirmed as to the shape of the s. one; the north one is, I think, a spiral of this shape; the branches vF.  |
| 1094 | 2 | Feb. 26, 1851. A long ray, much resembling 242. |
| 1105 | 4 | April 13, 1855. pB; R; bM, but no nucleus. |
| 1106 | 2 | April 1, 1848. A very close cl. of faintish *s, preceded by a S. neb. |
| 1107 | 2 | March 9, 1850. A long ray with mottled light. |
| 1108 | 3 | April 17, 1855. Has a B. R. nucleus, surrounded by much F. neby, which is patchy and involves a B. *. |
| 1110 | 1 | April 13, 1850. E. np, sf; 88″ by 50″. |
| 1111 } 1113 } | 4 | April 26, 1851. 1111 has a B. R. centre, with nucleus; then two dark spaces concentric, with nucleus; and outside these F. neby, as in figure. (δ) 1113 has F. nucleus, or stellar point.<br><br>αN 175° 2′ 25″<br>αβ 183 0 58<br>αγ 204 3 01<br>αδ 66 3 47<br>April 28, 1851. Previous observation rather confirmed; the dark spaces certainly exist, but I cannot be sure that appendages are not part of spiral branches. April 15, 1852. Last year's observation confirmed as to dark curved spaces p. and f. centre, and F. neby. outside them again. See fig. 20, Plate XXVII.<br> |

| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 1117 | 3 | April 25, 1854. R; has nucleus; * involved f. nucleus. |
| 1119 | 1 | Feb. 17, 1855. vB; R; bM; has 2 S. *s p. |
| 1120, 1121, 1122, 1124 | 1 | Jan. 28, 1849. Observed in haze. |
| 1128 | 1 | Apr. 6, 1856. F; bM; a B. * in sf. edge and a patch in np. end. Neb. is fully 4′ long. |
| 1129, 1136 | 2 | Feb. 26, 1851. The larger is vlbM; perhaps not R; S. one r. |
| 1131 | 3 | March 17, 1855. L. R; nucleus; * in nf. edge; mottled. |
| 1132 | 1 | March 9, 1850. A ray; diminution of light in neighbourhood of nucleus; edges parallel; night bad; remarkable object. |
| 1140 | 3 | April 6, 1855. Very like a distant cl. |
| 1144 | 1 | April 14, 1852. The brightest part in advance of the centre; vS. * n. |
| 1146 | 6 | March 8, 1856. Irreg. shaped neb. with nucleus eccentric, and a knot or appendage at f. end. March 27, 1856. There are 4 knots or *s in the neb, besides the B. patch to sf. side of nucleus. |
| 1147 | 1 | March 6, 1851. S. lenticular ray; B. nucleus. |
| 1148 | 1 | No description. |
| 1149 | 1 | March 15, 1849. Lenticular, with split in direction of major axis. |
| 1155 | 1 | No description. |
| 1156, 1158 | 1 | April 6, 1855. Both are R; pB; bM. |
| 1160 | 1 | April 18, 1855. pF; L. |
| 1162 | 2 | April 25, 1854. E. p. and f; bM. |
| 1167 | 1 | March 9, 1850. Great ray; night bad. |
| 1168 | 2 | April 10, 1852. Has E. appearance np, sf; F. neby. all round it. |
| 1171 | 1 | March 13, 1852. E. p. and f; nucleus. |
| 1173 | 7 | See the 'Transactions' for 1850. |
| 1175 | 4 | April 20, 1857. A vL. B. E. neb; much mottled. The f. edges are comparatively sharp and well defined, but in the p. and n. edge there is a great inequality of light; nucleus E; vB. part to n. of nucleus. |
| 1176, 1180 | 1 | April 16, 1852. gvbM; the f. one is much fainter. |
| 1178, 1183, 1187, 1189, 1190, 1194, 1201 | 1 | Apr. 13, 1852. The three or four brightest are E; gbM. |
| 1179 | 1 | No description. |
| 1185 | 2 | April 10, 1852. L; E. p. and f; arms F; * involved in p, and another * in f. arm, but a little further from centre. |
| 1186, 1188 | 2 | April 26, 1849. 3 in line; the f. one vF, the other two R; pB. nuclei. |
| 1195 | 1 | April 10, 1852. F. knot at end of p. branch. |
| 1197, 1200 | 1 | April 14, 1852. 1st E. * in np. extremity; 2nd F, almost planetary; another vF. and thin ray about 30′ f. |
| 1196, 1202 | 5 | Sketched 4 times. March 1, 1851. 1196 is bM, and has a vF. comp.; 1202 is a spiral, B. centre, and 2 knots. There is another neb. 10′ nf.<br>About 84° 34′ N.P.D., and $12^h 25^m$ Æ } There is a scarlet * 10m. and a F. E. neb. 10′ s. of it, with *s in it. See fig. 21, Plate XXVII.<br>April 9, 1852. Last year's observations confirmed. |
| 1204 | 2 | March 15, 1855. pL; mbM. to a sharp nucleus; mE. p. and f. |
| 1209 | 1 | April 24, 1854. Lenticular nnf. by ssp; F; vlbM (night bad). |
| 1211 | 1 | March 9, 1850. Spiral; a F. neb. f; roughly sketched. |
| 1212, 1221 | 1 | Feb. 17, 1855. 1212 is B, R, and smbM. 1221 is vB; mE. sp, nf, with a suddenly B. centre. |
| 1225 | 3 | April 13, 1855. vB. globular centre; E. p. and f. |

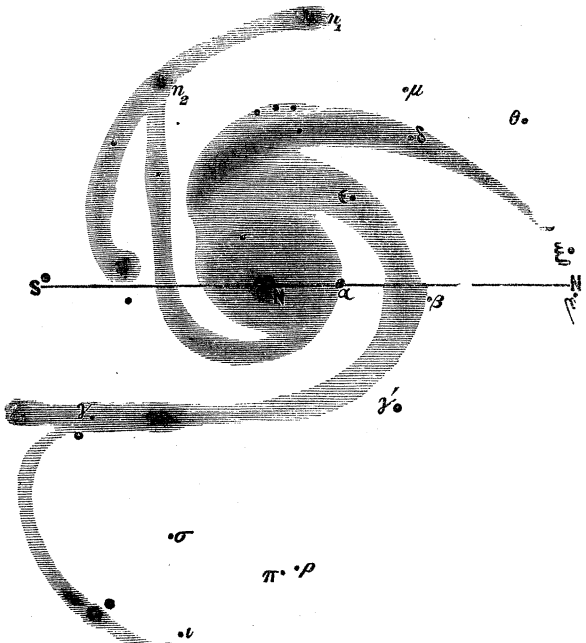
| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 1231 | 1 | April 10, 1852. Not R. |
| 1232 } 1236 } | 1 | March 6, 1851. vbM; edges fade off. 1236 is vF. |
| 1237 } 1250 } | 3 | March 13, 1852. 6 knots, one E. March 1, 1854. One has dark spaces about the nucleus. March 15, 1850. 12 knots examined. |
| 1239 | 1 | No description. |
| 1240 | 1 | April 24, 1854. R; B. nucleus; outline somewhat irregular. |
| 1242 } 1251 } | 1 | March 6, 1851. Both BM; B. * involved in 1st; 2nd is E. |
| 1245 | 4 | March 30, 1856. pB; E; nucleus. A B. streak runs up through the nucleus, growing broader at p. end; on either side of this I suspect dark spaces, and outside them again F. neby, especially to s. side of nucleus. April 19, 1857. Much E; instead of a nucleus it has a vB. narrow central streak; to the left of this I suspect a darkness; then outside this more F. neby, as in sketch. See fig. 22, Plate XXVII. |
| 1252 | 2 | April 17, 1855. There are here 4 neb; the 3 f. ones seem to be involved in a mass of F. neby. |
| 1253 | 1 | April 15, 1852. gvmbM; oval. Another 14′ sp; also vB. |
| 1258 | 4 | Sketched 3 times. April 12, 1849. Uncertain whether a d. nucleus, or nucleus and *; neb. decidedly darker in middle, following the nucleus, and rather brighter outside this. March 7, 1856. d. nucleus, or nucleus and *, which are eccentric, being nearer the sp. side; light uneven and patchy; suspect a darkness nf. the nucleus. March 8, 1856. Last night's observation confirmed. March 18, 1857. Seen as in the rough sketch subjoined; a * close sp. nucleus.   |
| 1262 | 1 | Feb. 16, 1855. E. sp, nf. |
| 1271 | 1 | April 25, 1854. L; svmbM. to a nucleus; pmE. p. and f. |
| 1274 } 1275 } | 1 | April 13, 1849. Found in this set 11 knots, of which 6 are 1203, 1237, 1244, 1253, 1274, and 1275; the remainder are "novæ," one of these latter being hollow in middle; probably a ring seen obliquely; a F. * n. of its middle; seen best with single lens. Remarkable object. |
| 1280 | 2 | March 26, 1856. E; B. nucleus; F. extremities. |
| 1281 | 1 | March 17, 1849. 3 nuclei, or 2 nuclei and *, and F. neb. outlying. |
| 1282 | 1 | April 11, 1852. gbM; oval; E. n. and s. |
| 1286 | 1 | April 18, 1855. Like a distant cl; vB. nucleus. |
| 1294 | 1 | Feb. 26, 1851. 4 found. |
| 1296 } 1298 } 1301 } | | April 10, 1852. 1301 is vgvbM. 1298 is smaller, and much the same character. |
| 1306 } 1308 } | 4 | Sketched twice. March 28, 1856. A rough sketch made; suspect spirality in the n. one; the large neb. has an appendage n. of nucleus and a little f. it. March 24, 1857. Examined to confirm drawing, which I think is pretty accurate. See fig. 23, Plate XXVII. |
| 1309 } 1315 } | 2 | A d. neb. |
| 1312 | 2 | March 9, 1850. Another spiral; dark spaces, especially one sf. nucleus. |
| 1332 | 1 | |
| 1333 | 1 | April 22, 1854. E. n. and s; nucleus vB; light uneven. |
| 1337 | 2 | April 19, 1855. Seen by myself, as represented (see fig. 24, Plate XXVIII.). Mr. Stoney, who was with me, did not see the F. curve at p. extremity, which therefore needs verification. I myself felt pretty certain of it. March 29, 1856. Seen as last year; sketched. See fig. 24, Plate XXVIII. |
| 1343 } 1348 } | 1 | April 16, 1852. gvbM; 2 others, both E. about 20′ s. of 1348. |
| 1345 | 3 | Feb. 19, 1855. E. p. and f? B. nucleus. |
| 1352 | 2 | April 11, 1852. A vL. ray; gbM; some *s involved. |
| 1357 | 3 | Roughly sketched twice. April 17, 1855. A beautiful object, very well seen in finding-eyepiece; the whole neb. (taking into account the appendage) is much broader at nucleus than elsewhere, narrowing off suddenly, and the nucleus projects forward into the dark space; and immediately opposite this the F.   |

| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| | | appendage is broadest and brightest. The ray is 12′ or 14′ long, and there is a F. ∗ at $\alpha$ (Mr. Stoney was with me). April 6, 1856. 15′ long, perhaps even longer; the ∗ opposite the nucleus is about two-thirds the breadth of the neb. distant. |
| 1358 } 1359 } | 2 | April 14, 1852. A curious d. neb; some other nebs. p. |
| 1362 | 3 | March 19, 1857. R; bM; L. but F; ∗ involved in p. edge. |
| 1363 | | Looked for twice; not found. Query, Is this 1358 and 1359? |
| 1368 | 3 | May 3, 1851. gmbM; lE. sp, nf; edges fade off very gradually. |
| 1382 | 2 | April 24, 1854. pB; has nucleus; E; F. ray f. April 25, 1854. Seen as last night, also the F. ray f; about 50′ p. is a B, R, pL. neb. f. a B. ∗. |
| 1385 } 1392 } | 6 | Sketched 3 times. April 10, 1855. Somewhat curved, like 2205. The s. branch is patchy, having 2 B. spots (see fig. 25, Plate XXVIII.); the n. branch is much the brighter. A S. ∗ p. the neb. About 6′ or 7′ n. of 1385 and a little f. is 1392, not so F. as Herschel describes it; the brightest part seems eccentric, being nearer the nf. edge. From this B. part I suspect a curve round n. to sp. April 13, 1855. Seen as before. March 8, 1856. The comp. n. (1392) I suspect, as before, to be a F. spiral. March 27, 1856. Better seen than on any previous occasion; the F. branch to the left extends round as far as the p. extremity of the B. branch. The comp. neb. suspected to have a twist in it, as before; sketched. |
| 1386 | 2 | April 11, 1852. gvbM; E. np, sf. |
| 1397 | | See the 'Transactions' for 1850. |
| 1402 | 1 | March 1, 1854. d. neb; F. neby. connects them. |
| 1403 | 2 | April 22, 1854. A remarkable object; spiral? |
| 1408 | 2 | April 5, 1851. L; vB; comp. neb. pB. |
| 1409 | 1 | March 7, 1856. lE. nearly p. and f. |
| 1411 | 1 | Feb. 26, 1851. p. part is broadened out; light unequal; night bad. |
| 1414 } 1415 } | 3 | April 26, 1851. Herschel's two neb. form one, the joining part in middle F, and vF. production of neb, as in sketch. April 9, 1852. Last year's observation confirmed; like a caterpillar on a leaf. April 20, 1857. I can confirm former observations in every particular, and think there are two additional ∗s in f. part. See fig. 26, [Plate XXVIII. |
| 1431 | 3 | Spiral? |
| 1436 | 1 | April 13, 1852. gvmbM; S. ∗ involved in f. part. |
| 1437 | 1 | April 15, 1852. gvmbM; oval. |
| 1441 | 8 | Feb. 16, 1855. vB. ray; a dark band across on each side of nucleus, separating it from the extremities. Feb. 17, 1855. Sketched. Feb. 19, 1855. The dark spaces which are visible in finder are not black, but only portions of fainter neby. April 6, 1855. Seen as before; dark lines very plain in finder. April 16, 1855. My sketch exaggerates the dark lines; they should be broader, and not so well defined. Mr. Stoney remarked a second dark line across the n. branch near its extremity. Mar. 7, 1856. Observed. Mar. 18, 1857. Dark spaces far apart, and not absolutely dark; suspect a dark space to right-hand side of nucleus. See fig. 27, Plate XXVIII. |
| 1451 | 4 | March 9, 1850. Another spiral; another neb. 15′ p. Feb. 26, 1851. Spiral; 2 arms, and some ∗s in f. arm; centre is B. 12′ p. and a little s. is another neb, E; and 30′ nf. is a 3rd, E. n. and s. April 15, 1858. vL. and vB. The centre itself is like an E. neb, with nucleus; this centre is enveloped in an irreg. ring or rings of nebulous light, as in the accompanying rude sketch, which does not contain all the details. sp. this object there is a S. neb. E. np, sf. and very patchy, and I suspect it to have a F. nucleus. May 3, 1858. I saw all the details in last observation, except that there was only one ∗ visible s. of nucleus instead of two, but this is not quite so good a night. The surrounding ring of neby. is of irreg. shape; it curves gently at $\delta$, but bends more sharply at $\gamma$, where it is brightest. The centre seems to reach up to and blend with the neby. at $\delta$.   |
| 1456 | 5 | April 9, 1852. Spiral; bears great resemblance to 1111. April 14, 1852. F. neby; 2′ radius extends all round, in which I think I see traces of spirality which exist certainly in the central part (Note by Mr. B. Stoney). A good night and speculum in good order would probably show this object distinctly. April 13, 1855. vlE. p. and f; dark ring round the nucleus; then B. ring exterior to this. The annulus, however, is not perfect, but broken up and patchy, and the object will probably turn out to be a spiral. There is much F. outlying neby. March 8, 1856. Annular at first look, but ring not perfect; centre vB. |

| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 1460 | 1 | April 25, 1854. mE. |
| 1462 | 3 | March 7, 1851. gvmbM. |
| 1466 | 2 | March 7, 1851. 8′ long; R; centre vB. |
| 1475 | 3 | March 1, 1851. Nucleus 2′ s. of * of 10th mag. At Æ $12^h 43^m$ and N.P.D. 60° 20′; "nova," with nucleus; E. |
| 1486 | 11 | March 11, 1848. Curious circular-shaped neb, with a dark and large spot at one side, around which is a close cl. of well-defined little *s. May 4, 1851. E. nearly p. and f. Herschel's dark space is a curved passage, extending from p. round the f. side of the nucleus by the n. |
| 1498 | 3 | Feb. 16, 1855. L. B. ray; nucleus oval and vB; there is a * involved in n. edge, a little preceding the nucleus. |
| 1499 | 1 | Apr. 17, 1855. vF; mE. sp. nf; has a plainly seen * at n. end, and either a * or what looks more like a B. little knot involved in s. end. |
| 1500 | 1 | Numerous neb. around. |
| 1509 | 4 | Apr. 18, 1855. Looks sometimes like 838 when badly seen, with a B. E. patch in centre and dark spots on each side of this; sometimes dark ring is seen all the way round, but blackest to right and left. The neby. round it is mottled. In looking for this I found at about Æ. $12^h 48\frac{1}{2}^m$, and a little n. of this set a F. d. neb. E. at right angles to each other. Mar. 29, 1856. Last year's observation correct; * in sf. edge; sketched. Apr. 24, 1857. Long and carefully examined; the B. centre is E. in the direction of * on edge, and on either side of centre there certainly exist dark spaces, as before remarked, giving it the look of 838; yet sometimes I thought I saw it with a break in the outer annulus. |
| 1515 | 1 | Mar. 24, 1857. vvF; lbM; vlE. np, sf. |
| 1525 | 1 | Apr. 27, 1854. vF; R. |
| 1536 | 1 | Apr. 18, 1855. Like a distant cl; 2 B. *s involved. |
| 1547 | 3 | Mar. 12, 1852. B. lenticular ray with E. centre. May 3, 1858. Sketched; like 2172 and 1357. |
| 1549 | 3 | May 3, 1856. gbM; B. nucleus; B. * in np. end. April 15, 1858. Very much mottled. |
| 1551 | 1 | Apr. 22, 1854. E. p. and f; bM. |
| 1556 | 1 | Spiral? |
| 1558 | | cl. |
| 1559 | 3 | Mar. 12, 1852. Light equable; E. sp, nf. |
| 1562 | 1 | Mar. 24, 1857. vF; lbM; lE. |
| 1564 | 2 | Mar. 1, 1851. vB. centre; has an appendage parallel to major axis. |
| 1569 | | cl. |
| 1570 | 3 | Spiral? darkness sf. nucleus. |
| 1576, 1577, 1578 | 3 | A group of 4. |
| 1580 | 2 | Apr. 25, 1854. R; bM; between 2 *s. |
| 1589 | 7 | Sketched three times. Apr. 29, 1856. The B. centre is E. but not in the direction of the neb. The whole neb. is much mottled. Apr. 15, 1858. I can add nothing to my drawing and observations of last year, which are fully confirmed. See fig. 28, [Plate XXVIII. |
| 1599, 1600 | 2 | Apr. 13, 1855. Both are S; R; pB; bM. Apr. 17, 1855. There is a 3rd vF. neb. nearly n. of the f. one of these two. |
| 1604, 1605 | 2 | Mar. 28, 1856. 1604 is lE; pB; has nucleus; and a * at np. end; 1605 is R; vF; and its light equable. |
| 1622 | 19 | Carefully observed since drawing published in the 'Transactions' for 1850. The outer nucleus unquestionably spiral, with a twist to the left; thus  |
| 1626 | 2 | Apr. 19, 1855. Oval; bM; * np. May 3, 1856. About 5′ nf. it is a vF. nebs. knot. |
| 1638, 1639, 1643 | 2 | May 3, 1856. 1638 is E; nearly p. and f; bM; 1639 is S; R; bM; 1643 is the largest; pB; R. and gbM; nucleus, round which I suspect dark spaces. |
| 1647 | 1 | Apr. 19, 1855. Not L; gbM. to a nucleus; mottled. |
| 1650 | 3 | Apr. 19, 1855. L; pb; B. nucleus; seen as in sketch, but not certain whether the lower branch joins the nucleus, or is only the continuation of the upper curve. Mar. 21, 1856. The p. arm *does* appear to originate from the nucleus, which is vB. and oval-shaped. Mar. 30, 1856. Seen as before. See fig. 29, Plate XXVIII.   |
| 1658 | 3 | Mar. 28, 1856. F. ray n. and s; no nucleus; light; equable. |
| 1659 | 2 | Mar. 24, 1857. S; vF; nearly R; brightest part is on sp. side of centre. |

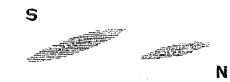
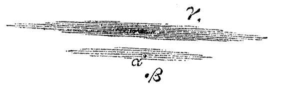
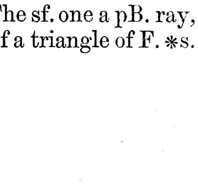
| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 1663 | | Splendid cl. |
| 1664 | 3 | Mar. 27, 1856. pL; pB; R; sbM; about 2′ or 3′ f. is a S. F. neb. |
| 1668 | 1 | May 3, 1850. A single B. ✱ at n, and a d. ✱ at s. end of this neb. Another neb; R; bM; sp. |
| 1669 | 1 | Apr. 11, 1852. A vF. amorphous-looking neb; S. ✱ in s. edge. |
| 1672 | 1 | Mar. 1, 1851. ✱ or nucleus in np. edge; 2nd vF; 3′ s; both E. p. and f. |
| 1676 }<br>1679 }<br>1680 } | 2 | All F. |
| 1695 | 1 | May 15, 1854. vF. in twilight; lbM. |
| 1697 | 2 | Feb. 19, 1855. mE. p. and f; L; pB; gbM. Mar. 24, 1857. Found here 3 neb. in a line sp, nf; all of them are bM. |
| 1703 | 1 | Apr. 14, 1852. gbM; L. vF. neb. 14′ s. of 1703; also a S, F, E. neb. 15′ p. and 2′ n. of 1703. |
| 1711 | 4 | Mar. 28, 1856. S; bM; dull nucleus; lE. |
| 1713 | 6 | Apr. 24, 1854. Centre pB; oval n. and s, and among several ✱s; I thought the n. end the broader, and suspected a dark space p. the nucleus. May 1, 1854. Singular object; the main body of neb. has a B. nucleus, and is E. n. and s; the southern end bends back suddenly at a sharp angle, and extends np. past the neb, ending in a B. R. patch or nucleus; 3 ✱s around the neb. Apr. 17, 1855. Mr. STONEY saw the p. branch extend *round* the s. end of the main neb. and continue on to n, when after a second turn it joined the nucleus. See fig. 30, Plate XXVIII. |
| 1714 | 3 | Feb. 19, 1855. pB; R; bM. to a nucleus. |
| 1715 }<br>1716 } | 1 | Mar. 9, 1851. 3 found; all S; F; R. |
| 1734 }<br>1735 } | 5 | Apr. 18, 1855. The n. one is spiral?; 3 ✱s in it; to myself it appeared to have a single branch running from below the nucleus round the n. and f. edges. Mr. STONEY suspects two branches. May 10, 1855. n. one suspected spiral as before; the s. one is, I think, lE. n. and s, and the ✱ between the two neb. is d.? Mar. 29, 1856. Suspect n. one as before; it is a very difficult object, and requires a fine night. Apr. 24, 1857. Last observation fully confirmed as to spirality of the n. one. I still think it has but one branch. The ✱ between the 2 neb. is d.  |
| 1741 }<br>1742 } | 3 | Mar. 28, 1856. 1741 is S; R; bM; pB; 1742 is S. ray nf, sp, and has a ✱ of 12th mag. at its s. extremity. |
| 1743 | 1 | Mar. 17, 1855. mE. p. and f; nucleus. Query, a knot in p. branch. |
| 1744 | 8 | Sketched 3 times. Mar. 1, 1851. Large spiral; faintish; several arms and knots; 14′ across at least. See fig. 35, Plate XXIX. |

| | | Pos. | Dist. |
|---|---|---|---|
| April 27, 1851. | αN | 195° | 1′ 22″ |
| | αβ | 345 | 1 50 |
| | αγ | 273 | 3 31 |
| | αδ | 74 | 3 1 |
| | αε | 74 | 1 38 |
| | $\alpha n_1$ | 99 | 5 37 |
| | $\alpha n_2$ | 135 | 5 2 |
| | αζ | 10 | 5 19 |
| | αη | 358 | 5 33 |
| | αθ | 44 | 5 1 |
| May 3, 1851. | αι | 240 | 8 34 |
| | ακ | 118 | 3 34 |
| | αλ | 112 | 3 29 |
| | αμ | 72 | 4 0 |
| | αν | 211 | 6 31 |
| | γρ | 263 | 2 56 |
| | γσ | 220 | 3 47 |

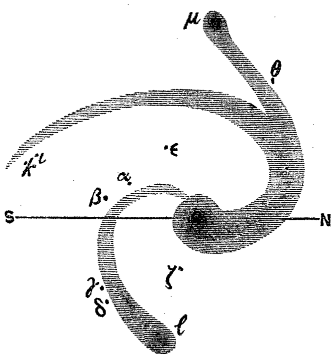



| | | |
|---|---|---|
| 1745 | 1 | Mar. 29, 1856. Has a nucleus; light very patchy; 3 ✱s in edge; vF. Query, spiral, with a right-handed twist? About 4′ f. is a S. pB. E. knot. |

| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 1746 | | Close, rather F. cl. |
| 1754 | 2 | Mar. 27, 1856. S; bM; mE. np, sf. |
| 1755 | 1 | Mar. 9, 1851. E. |
| 1757 | 1 | Mar. 29, 1856. 2 neb. 3′ apart; n. one vS; bM; the other a ray p. and f; nucleus. |
| 1762 | 2 | Apr. 13, 1850. 3 knots near. |
| 1764 | 1 | Apr. 19, 1855. Long narrow ray, with a S, R, vF. neb. sf. About 15′ np. of 1764 is another vF; and about 6′ p. and 1′ n. of this last is another eeF. |
| 1766 | 2 | Apr. 13, 1852. bM; S. * s. of it. Mar. 30, 1856. E. nearly n. and s; S. * sf; B. nucleus. |
| 1768 } 1769 } | 1 | Mar. 1, 1851. 1768 S; F; E; 1769, nucleus. |
| 1770 | 1 | Mar. 6, 1851. Another 5′ p, and another 10′ sp; vF. |
| 1771 | 5 | Apr. 10, 1852. Either a d. neb, or 2 knots of one neb. |
| 1773 | 2 | Apr. 29, 1856. mE; not F; lbM; major axis sp, nf. |
| 1774 | 1 | May 10, 1858. S; irreg; R. |
| 1776 | | Frequently observed; nothing certain. |
| 1778 } 1779 } | 4 | "Nova" near; 1st E, 2nd bM, 3rd vF. |
| 1782 } 1783 } | 4 | May 12, 1850. 1782 pB; L; gbM. 1783 vB; R; nucleus. Another L. F. ray about 16′ nf. 1783. |
| 1788 } 1789 } 1791 } | 2 | Only two found; both S; R; bM. |
| 1790 | 1 | May 15, 1854. pL; vF; lbM. |
| 1792 } 1793 } | 2 | Both F. |
| 1797 | 2 | Mar. 28, 1856. R; pB. Its brightest part is nearest f. edge, and forms a curve round n. |
| 1799 | 2 | Mar. 29, 1856. pL; lE. n. and s. |
| 1804 | 2 | Mar. 1, 1851. d; bM; two others F. |
| 1805 | 1 | Mar. 28, 1856. Long narrow ray; F; bM. |
| 1813 | 2 | Apr. 13, 1852. vgvlbM; filamentary appearance of the branches quite apparent. Though unmistakeably a cl, yet on a very bad night it would be seen as a neb. |
| 1815 | 1 | Apr. 17, 1855. E. sp. nf; nucleus. |
| 1817 | 1 | A B. d. neb. |
| 1818 | 1 | Apr. 19, 1849. r? |
| 1820 | 2 | Apr. 9, 1852. S; bM. |
| 1825 | 1 | Mar. 6, 1851. vlbM; S. * f. |
| 1829 | 1 | Mar. 1, 1851. Nucleus; lE. |
| 1833 | 1 | Apr. 14, 1852. R; vlbM. |
| 1835 | 1 | Mar. 29, 1856. pL; gbM; * in f. edge; between this * and the centre the neb. seemed black. |
| 1840 | 2 | May 10, 1858. lE; vF. and flickering. |
| 1842 | 2 | Apr. 11, 1850. Narrow ray; bad night. |
| 1843 | 1 | Apr. 26, 1851. Within trapezium of 4 or 5 *s; lE. n. and s; vlbM. |
| 1844 } 1845 } | 1 | Apr. 13, 1855. The p. one is lE. p. and f, and is the larger of the two. The other is S; R; pF. and bM. |
| 1848 | 2 | Apr. 11, 1850. E. Central part seems unsymmetrically placed with respect to general fig. of neb. Apr. 13, 1850. 3 "novæ" near; one of them mottled, and * in s. border. |
| 1851 | 3 | Apr. 16, 1858. S; B; with B. sharp nucleus, and * involved n. of nucleus; 2 "novæ" near. |
| 1861 } 1864 } 1865 } | 1 | Apr. 16, 1855. 1861 is a narrow ray; 1864 is S. and R; 1865 is quadruple, and suspected to be one neb. connected by F. neby. |
| 1854 | 6 | Nucleus; dark ring suspected, like 450, but no conclusive evidence. |
| 1857 } 1863 } | 3 | Apr. 7, 1851. Light mottled; another f. about 12′, and a little s; E; bM. Apr. 13, 1852. Spirality suspected. |
| 1870 | 2 | r; lbM. |
| 1872 | 2 | May 10, 1855. pB; R; nucleus; E; mottled. |
| 1873 | 2 | May 15, 1854. pB; S; R; bM. |
| 1874 | 2 | Apr. 25, 1848. E; * at each end. |
| 1879 | 2 | May 14, 1855. vF; nucleus or * in centre. |
| 1880 | 2 | May 16, 1855. 2 neb, with 3 B. *s in the neighbourhood. Both F. and E. |

| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 1881 | 3 | May 12, 1858. Close d. neb. |
| 1883 | 1 | May 14, 1851. pL; mE. ssp, nnf; has nucleus. |
| 1885 | 3 | May 12, 1858. Rather a B. ray; bM. and mottled. Its p. arm is brighter than the f. one. A F. neb. about 2′ p. |
| 1890 | 3 | May 1, 1854. F; pL; no nucleus; mottled. |
| 1891, 1893, 1895 | 2 | Apr. 3, 1854. 3 neb. in line, and another S. neb. near the f. one. |
| 1892 | 3 | May 1, 1854. Has a curved form between 2 ∗s, and in contact with them; there is a 3rd smaller ∗ close to the neb. on np. side. |
| 1894 | 4 | Mar. 1, 1851. B. in centre; E. |
| 1898 | 2 | Apr. 6, 1851. E. p. and f; r. Another vF; 3′ f. |
| 1901 | 1 | Apr. 19, 1849. 6 neb. found. |
| 1903 | 1 | May 3, 1851. E. |
| 1904 | 1 | Mar. 17, 1855. The atmosphere seems to exist. |
| 1905 | 6 | Apr. 28, 1848. Think the distance between the 2 neb. greater than in H's drawing. Apr. 11, 1850. The 2 neb. not in a line, and a F. connexion suspected. Apr. 17, 1855. These 2 neb. are not in a line but parallel; the distance between is considerable, but F. neby. suspected connecting them; they have a very hazy look, and the edges are not well defined. May 14, 1855. Seen as on last time. May 8, 1861. Sketched; axis not parallel, but inclined at an angle of about 16°. Fig. 31, [Plate XXVIII.   |
| 1907 | 3 | May 3, 1856. A B. S. ray sp, nf; has nucleus. |
| 1908 | 2 | May 16, 1855. Looks R. pB; mbM; nucleus. |
| 1909 | 8 | Apr. 13, 1850. vB; oval; E. np, sf; ∗ in np. end. "Nova" near; vS. |
| 1910 | 2 | Apr. 13, 1855. mE. n. and s; centre vB; extremities F. |
| 1911, 1912 | 2 | Apr. 25, 1849. 1911 vS; ∗ close to right. 1912 rather F; vS. ∗ involved. "Nova" f. and vF. |
| 1913 | 1 | 2 "novæ" f, apparently connected. |
| 1914 | 2 | Nucleus, and E. |
| 1915 | 3 | May 23, 1854. 2 neb. close together, n. and s. |
| 1916 | | A superb cl. |
| 1917 | 5 | Apr. 13, 1850. Very remarkable ray, 12′ or 15′ long; $\alpha, \beta, \gamma$, and $\delta$ are ∗s, of which $\alpha$ is F; a long split precedes the nucleus.   |
| 1919 | 2 | Spiral? |
| | | About $15^h\ 12^m$ Æ, 33° 55′ N.P.D. A pair of new neb, about 15′ asunder, np. and sf. The sf. one a pB. ray, the other F. and S, but neatly placed at one angle of a triangle of F. ∗s. |
| 1920 | 2 | Apr. 28, 1851. vlbM; E. p. and f. |
| 1923 | 4 | Mar. 17, 1855. S; R; bM. |
| 1924, 1925 | 1 | Apr. 11, 1850. Elegant little d. neb. |
| 1926 | 2 | May 3, 1856. pF; R; bM. |
| 1927 | 1 | Apr. 13, 1852. 3 neb; 2 pB, the 3rd S; E; F; 15′ sp. 1927. |
| 1928 | 2 | Mar. 17, 1855. E. np, sf; bM; not vF. |
| 1929 | 3 | F. dash of light. |
| 1930 | 1 | Apr. 3, 1854. R; B. nucleus. |
| 1931 | 2 | Apr. 13, 1855. Has a ragged edge and mottled look; about 6′ or 7′ nf. there is another.   |
| 1934 | 6 | May 6, 1850.<br>Pos. Dist.<br>AB 288° 7′ 53″<br>BC 299 6 28<br>CD 283 8 23<br>Suspect (A) to be a spiral, to be re-examined on a fine night. (B) a B. condensed oval neb. (C) vF. ray. (D) eeF; S. neb. May 14, 1850. (A) Dark spaces round on either side of nucleus, seen at moments; also a dark line running along the sf. edge, splitting off a part of neb, which has a B. knot to s, also some ill-defined dark space at n. end. Apr. 5, 1851. (A) spiral; a good deal of dark space round the nucleus, branches perhaps like 604.   |

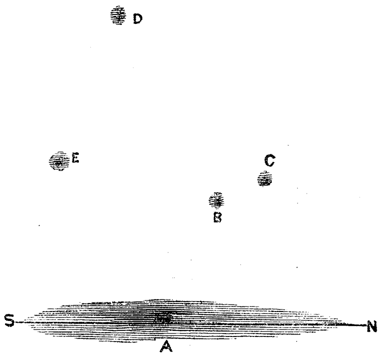
| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 1936<br>1937 | 2 | May 23, 1854. d. neb; both pB; R, and mbM. |
| 1938 | 3 | Mar. 9, 1851. BM; S. neb. p. |
| 1939 | 1 | May 30, 1851. Lenticular ray; bM; 4 *s close s. |
| 1942<br>1943 | 4 | May 14, 1855. Both S; R; lbM; S. * closely nf. the s. one. |
| 1946 | 11 | May 5, 1850. Strongly suspected to be annular neb. with * near the centre. Apr. 5, 1851. Like 450; dark ring plainer seen on p. part of neb; very S. * n; about $\frac{3}{5}$ diameter of neb. off. The f. part of dark ring a little broader than the p. part. May 3, 1851. Distance between nucleus and S. * |
| | | Dist. |
| | | May 3, 1851. 0′ 26″ |
| | | 0 32 |
| | | 0 31  |
| | | Pos. Dist. |
| | | May 4, 1851. 7° 0′ 25″ |
| | | 5 0 28 |
| | | 7 0 28 |
| | | May 29, 1851. The S. * scarcely seen; dark ring not at all. Apr. 3, 1854. The dark ring round nucleus seen pretty well; also the minute * n. of neb. See fig. 32, Plate XXVIII. |
| 1947 | 2 | May 22, 1854. vL; F; oval. |
| 1950 | 1 | vvF. |
| 1952 | 1 | vF; vlbM. |
| 1953 | 1 | Apr. 7, 1851. eF; 2 or 3 *s in edge. |
| 1958 | 1 | May 26, 1849. 2 new neb; one eF, the other S; 1958 R; bM. |
| 1960<br>1962<br>1963 | 2 | Another near. |
| 1964 | 1 | Apr. 19, 1855. S; F; R; bM. Another neb. 4′ nf. |
| 1968 | | cl. in Hercules. May 6, 1850. Seems to have a dark streak across the B. part a little above the centre. Apr. 6, 1851. Dark lanes seen which bear some resemblance to those in Neb. Andr. Apr. 27, 1851. Sketch made; dark spaces seen through mist. May 3, 1851. Sketched. May 26, 1851. Sketched. Apr. 17, 1855. The dark lanes are quite discernible in the finder eyepiece; they do not meet in the centre of the cl, but to sff. of it (see fig. 33, Plate XXVIII.). |
| 1969 | 2 | Apr. 19, 1855. The nucleus is nearest the p. edge, and light mottled. |
| 1970 | 8 | May 5, 1850. Intense blue centre fading off to some distance all around; S. *s to nf, to which neb. nearly extends. May 12, 1850. I fancied once or twice there were projections p. and f. (N.B. The existence of these not satisfactorily proved.) |
| 1971 | | cl; in finder eyepiece the branches have a slight spiral appearance. |
| 1972 | | cl; May 30, 1851. A dark lane above the centre quite across, or rather the upper one-sixth of cluster is much fainter than the rest. |
| 1979 | | cl; June 3, 1851. The outline not R; on s. side is an outlying portion separated from the chief portion by a dark passage. |
| 1981 | 2 | May 31, 1851. I suspect annular, but twilight leaves me quite uncertain; n. edge is the brightest. June 3, 1851. Annular, n. edge is the brightest. |
| 1983 | | cl; *s S. and very close together. |
| 1989 | 1 | May 29, 1851. Seen in twilight; looked very like a * of 9th mag. |
| 2019 | | cl. |
| 2023 | 11 | Never well seen on account of twilight. Nothing additional since 1844, except a pB. * sf. middle. |
| 2036 | | cl. |
| 2037 | 5 | Aug. 28, 1850. Annular or perhaps spiral, and * distinctly seen in dark part. The dark space is undoubtedly irregular in its form. Aug. 24, 1851. Annular; centre very suddenly darker than the rest of the neb; vS. * in np. edge of central part. |
| 2042 | | cl. |
| 2043 | 2 | Aug. 1, 1851. 4 *s in neb, and 2 more on p. edge. |
| 2045 | 3 | On very bad nights. |
| 2046 | | cl. |
| 2047 | 7 | Aug. 31, 1850. Centre rather dark. Aug. 1, 1851. The dark part is a little np. middle. |

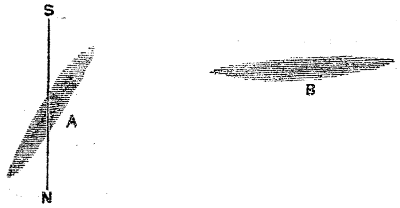
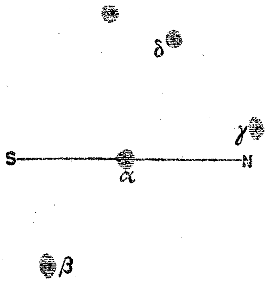
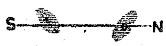
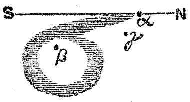
| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 2049 | | cl. |
| 2050 | 6 | Aug. 28, 1850. A very remarkable object, perhaps analogous to H. 450. The ring is not easily seen, but there can be no mistake about it; under the central ∗ there is a darkness. Aug. 22, 1851. sE. np, sf. |
| 2060 | 13 | Places of principal stars laid down, and a new drawing made. First observation Aug. 10, 1850, and last, Aug. 30, 1851. See end of Catalogue, and fig. 43, Plate XXXI. |
| 2064 | | cl. |
| 2071 | | cl. |
| 2072 | 8 | Aug. 23, 1851. Fine annular neb. like that in Lyra; R; the dark space is sE. p. and f; ∗ easily seen in np. edge, others suspected. Aug. 19, 1855. There is a conspicuous ∗ on the inner edge of the ring at np. side, and another fainter near this on the outer side. I believe the whole of this corner of the annulus is r, and can see the ∗s sparkling near the two already described. |
| 2075 | 11 | Roughly sketched five times. Aug. 10, 1850. ∗ or B. nucleus nf. the middle. A dark curved line p. this plainly seen, which at moments I fancied went round the sf. part. Sept. 9, 1852. This planetary neb. is a beautiful little spiral. Aug. 12, 1855. I think spiral, of the shape annexed. Aug. 16, 1855. The night bears ½-inch single lens *well*. There is a group of 4 minute ∗s p. the neb. Sept. 6, 1856. The details in my sketch of last year seem correct. I can trace the spirality distinctly. See fig. 34, Plate XXVIII.   |
| 2079, 2080 | 1 | 2079 vF; E; 2080 vF; S; R. |
| 2081 | | cl. |
| 2084 | 8 | Sept. 6, 1850. New spiral, with three branches, of which two terminate in knots, as in sketch; a fourth branch suspected. Sept. 8, 1850. Examined and drawing made.<br>Pos. Dist.<br>Sept. 9, 1850. cμ 87° 4′ 10″<br>cl 263 2 47<br>cα 158 1 41<br>cθ 67 3 34<br>cγ 221 2 21<br>Aug. 21, 1851. αc 325 1 36<br>αβ 213 0 33<br>Aug. 23, 1851. αγ 257 2 08<br>αδ 261 2 27<br>αζ 302 2 03<br>αl 281 3 26<br>αθ 37 3 46<br>αε 47 1 04<br>αμ 67 3 46<br>αι 162 1 56<br>ακ 169 2 14<br> <br>F. branch (D) p. centre seen. Sept. 6, 1855. The two f. branches A and B unite in one before meeting the nucleus. I certainly see a fourth branch D, which seems to join C in the same way before reaching the nucleus. Of the four, those which terminate in knots are the brightest. B is fainter, and D much fainter still. See fig. 36, Plate XXX. |
| 2086 | 1 | Aug. 21, 1857. R; vS; lbM. |
| 2087, 2089 | 2 | Aug. 27, 1857. A group of 5 neb; many ∗s among them. |
| 2088 | 10 | Aug. 5, 1851. The nebula resembles the Milky Way, and is full of dark uneven rifts or lanes. The p. edge is the brightest, and the M. is darker than the edges. Sept. 6, 1856. There are portions of its p. edge clearly r. |
| 2090 | | cl. |
| 2092 | 3 | Aug. 5, 1851. Resembles the neb. 2088, though on a much larger scale; the dark spaces have a rounder or more sack-like appearance, especially at the chief bend, where the neb. is also the brightest. It has several outlying portions of flocculent neby, especially at s. end. Sept. 3, 1855. General shape that of Herschel's figure, but several dark bays in it, and many more ∗s seen in and about it. |

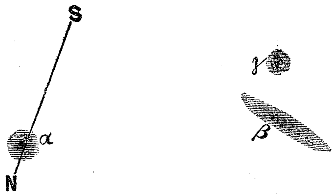
| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 2095 | 1 | Aug. 27, 1857. eF; vlbM; no nucleus; E. n. and s. |
| 2097 | 1 | Sept. 5, 1850. R; bM. |
| 2098 | 11 | Since published in the 'Transactions' for 1850. |
| 2099 | 6 | Aug. 19, 1855. The neb. has 3 knots in it; a drawing taken. Sept. 3, 1855. Seen as before, and sketch compared. Sept. 6, 1855. Observed. Sept. 6, 1856. Details as in sketch confirmed. It is vB. See fig. 37, Plate XXX. |
| 2102 | 3 | Sept. 29, 1850. 2′ long; E; nucleus. |
| 2106 | 1 | |
| 2109 | 1 | Aug. 27, 1857. vvF; irreg. R. |
| 2110 | | cl. |
| 2112 | 3 | Sept. 3, 1856. bM; edges indistinct; a * in nf. edge |
| 2120 | | cl. |
| 2121 | 2 | vF; lE. nearly n. and s. |
| 2122 | | No definite cl, but sky thickly studded with stars. |
| 2125 | | cl. |
| 2127 | | Loose cl. |
| 2128 | | cl. |
| 2130 | | A red * of about 12th mag. in a scattered cl. |
| 2132 | 6 | Sept. 18, 1857. Centre r; mottled; * in edge. |
| 2133 | | Searched for four times; not found. |
| 2135 | 2 | vF. |
| 2139 | 11 | Form not distinctly made out. See fig. 38, Plate XXX. |
| 2142 | 1 | Not well seen. |
| 2143 | 5 | Never well seen, being very low. |
| 2146 | 2 | E; lbM. |
| 2149 | 14 | Sept. 16, 1854. There can hardly be a doubt that this neb. is a cl. |
| 2150 | 4 | Oct. 23, 1857. lE. sp, nf. |
| 2151 | 2 | Sept. 20, 1857. There is a twist in the neb, but it is so F. that I cannot make out its shape. |
| 2152 | 1 | vF; lbM. |
| 2154 | | A poor loose cl, with red * of 9th mag. |
| 2156 }<br>2158 } | 1 | First has * in nf. edge, and is bM; the other is R; no nucleus. |
| 2157 | | cl. |
| 2160 | 4 | S; nucleus; forms a quadrilateral with 3 *s; F. outlying neby. extensive. |
| 2162 | 1 | bM; E. p. and f. |
| 2163 | | cl. |
| 2164 | 2 | Oct. 23, 1857. A vF. ray. |
| 2165 | 6 | About 24′ p. and 10′ n. is another vF; E. np, sf; 80″ long, 10″ broad. 2165 has a sharp nucleus, and is S. |
| 2166 | 2 | vF; pL. |
| 2167 | 5 | Oct. 2, 1856. * in centre; mottled; and * or knot in sp. edge. |
| 2168 | 2 | Oct. 7, 1855. E. n. and s; a vF. * nf. centre; centre B; extremities vF. |
| 2172 | 17 | The sketch conveys accurately the results of these observations. There are 5 knots near. See fig. 39, Plate XXX. |

Sept. 12, 1849.

| | | |
|---|---|---|
| AB | 62° | 63° |
| AC | 51 | |
| BC | 23 | 21 |
| BD | 116 | |
| AD | 96 | 98 |
| BE | 163 | |
| AE | 119 | 123 |
| DE | 243 | |
| Direction of A.... | | 174 |



| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 2173 } 2175 } | 9 | { Oct. 7, 1850. Upper neb. is equable in light, and is much the fainter.<br>Sept. 1849. Position of B 91°<br>Position of A 159<br>Dist.<br>Oct. 7, 1850. AB 97° 5′ 23″<br>A 157<br>B 91<br> |
| 2176 | 2 | Sept. 20, 1857. Narrow ray sp, nf; vvF. |
| 2178 | 1 | Planetary? |
| 2179 | 2 | S; R; bM; nucleus. |
| 2180 | 1 | vvF. |
| 2181 | 1 | F; S. |
| | | 7 knots found. |
| 2183 } 2184 } | 4 | Pos. Dist.<br>Nov. 27, 1850. $\alpha\beta$ 235° 5′ 29″<br>$\alpha\delta$ 73 5 44<br>$\alpha\gamma$ 18 5 41<br> |
| 2185 | 3 | Oct. 7, 1855. S; R; pB; mbM. |
| 2186 | 3 | Aug. 30, 1851. E. np, sf; light uneven. |
| 2189 | 4 | A group of 4 neb. |
| 2191 | 1 | No description. |
| 2195 | 3 | A group of 3 involved in vF. neby. |
| 2197 } 2198 } | 2 | { Each has a nucleus.<br>Pos. Dist.<br>Sept. 29, 1850. $\beta\alpha$ 178°<br>$\beta\alpha$ 178 1′ 35″<br>$\beta\alpha$ 176 1 34<br>$\beta\alpha$ 175 1 34<br>The last two observations probably most correct.<br>Position of axis of $\beta$ 225°<br>Position of axis of $\alpha$ 160<br> |
| 2199 | 3 | Sept. 16, 1854. ∗ in np. edge. ∗ seen in centre of nucleus? |
| 2200 | 2 | F; bM. |
| 2201 | 2 | Aug. 24, 1851. ∗ p. the nucleus; E. np, sf. |
| 2205 | 5 | Since 1850. Nothing further.<br>Nov. 26, 1850. Pos. Dist.<br>$\beta\alpha$ 23° 1′ 46″<br> |
| 2206 | 2 | Looks like a ∗ seen in haze. |
| 2208 | 1 | vF; several ∗s involved. |
| 2209 | 1 | Mottled; ∗ in np. edge. |
| 2210 | 1 | S; lE. p. and f. |
| 2214 | 3 | Nucleus. |
| 2215 } 2216 } | 2 | Oct. 9, 1850. Pos. 223°. Dist. 2′ 52″. |
| 2218 } 2219 } | 3 | Nov. 2, 1850. 4 neb. in the field. |
| 2220 | 1 | Nucleus. |
| 2221 | 1 | R; pL. |
| 2222 } 2223 } | 1 | Both R, and have nuclei. |
| 2224 | 3 | Sept. 16, 1852. Involves a vS. ∗ to nf. Another neb. 6′ p. and 1′ n. of it. |
| 2226 | 2 | Oct. 8, 1855. Outline irreg; pB. |
| 2227 | 1 | R. |
| 2228 | 5 | Like 242. Oct. 11, 1850. Much E. from np. to sf; gbM. to nucleus. Sept. 18, 1852. S. ∗ p. nucleus, and on edge of neby. |
| 2230 } 2231 } | 1 | Aug. 30, 1851. Another neb. f. 2231 about 12′, which is E. p. and f. |
| 2232 | 7 | Oct. 3, 1856. sf. edge is the brighter, and the more sharply defined. |

| Number in Herschel's Catalogue. | Number of times observed. | Description. |
|---|---|---|
| 2236 | | 3 or 4 conspicuous *s in it; not in a line between Herschel's two *s, the p. one of which is d. |
| 2237 | 2 | S; vF; R. |
| 2241 | 16 | Since the publication in the 'Transactions' for 1850. The outlying portions in the published sketch are parts of spiral branches. Figure 40, Plate XXX. represents it as seen on a very fine night (Sept. 16, 1852), with a freshly polished speculum which defined very sharply. Oct. 2, 1856. All the details in Mr. STONEY's drawing very well seen. Oct. 16, 1857. The spiral arms and the * in centre distinctly seen. |
| 2242 | | Oct. 23, 1857. R; pB; nucleus; another 6′ s; S; vF. |
| 2245 | 12 | Sketched 4 times. Nov. 5, 1850. I saw two knots and a dark space between them. I think the neb. is connected above the dark space. Nov. 27, 1850. 2 knots seen nearly n. and s, and a dark space between. Aug. 24, 1851. 2 knots and a dark space between, connected above by neby, as in sketch. Sept. 26, 1854. Certainly a spiral; some *s at moments visible. Oct. 17, 1854. Spirality distinctly seen. I thought the coil doubled in upon itself more closely than shown in Mr. STONEY's drawing, and that the central knot had a stellar nucleus. The whole neb. looked sparkling, though I could not see its separate *s. Nov. 22, 1854. Central nucleus stellar. The outer edge of the coil, just where it joins the external nucleus, seems brighter than the rest. Oct. 15, 1855. Seen to be spiral, as before. See fig. 41, Plate XXX. |
| 2248 | 2 | Oct. 8, 1855. eF; mottled and irreg. outline. |
| 2250 | | Looked for 4 times; not found. |
| 2257 | 1 | Nov. 4, 1850. Nucleus; a F. neb. f. about 2′. |
| 2258 | 1 | Oct. 17, 1854. R; pB; mbM. |
| 2260 | 1 | Nov. 13, 1854. E; bM; a F. * p. |
| 2261 | 4 | Oct. 24, 1857. Edge ragged; F. nucleus. |
| 2262 | 3 | Oct. 24, 1857. pB; R; mbM. |
| 2264 | 6 | Oct. 7, 1855. A F. suspicion of a dark ring round the B. centre. |
| 2267 | 1 | Nov. 17, 1854. lE. n. and s. |
| 2268 | 5 | Nov. 22, 1854. pL; R. A * precedes the nucleus (1-inch single lens); sp. this object there is a vS. E. neb. |
| 2271 | 4 | Aug. 24, 1851. A * with a S. neb. in contact. |
| 2273 | 1 | Oct. 12, 1855. A * p. touches the neb. A little np. is another neb. vvF. |
| 2274, 2275 | 15 | 3 neb. found Nov. 5, 1850.<br>Pos. Dist.<br>$\alpha\beta$ 114° 5′ 30″<br>$\alpha\gamma$ 128 5 34<br>$\beta$ 84 1 44<br> |
| 2278, 2279, 2280, 2281 | 2 | All R; gbM. |
| 2282 | 3 | bM. |
| 2284 | | cl. |
| 2290 | 6 | Oct. 31, 1855. pL; pB; has a F. but pretty sharp nucleus; edges ragged. |
| 2291 | 2 | pB; pmE. |
| 2297 | 13 | Oct. 12, 1855. pL; B; E; gmbM. A decided dark lane runs through it in the direction of its major axis. The neb. is rather narrower in the middle of its length, and spreads out laterally towards its extremities, fading away very gradually. Nov. 3, 1855. Seen as before; dark streak through centre quite plain. Sept. 9, 1856. Seen very well; dark lane through centre quite plain, especially with highest single lens. Oct. 3, 1856. I think I see right-hand side of centre to be composed of *s. It is brighter than the opposite side. See fig. 42, Plate XXX. |
| 2299 | 2 | Oct. 17, 1854. R; pB; bM. to a nucleus. |
| 2300 | 11 | Sept. 10, 1849. 2 S. *s near M. Oct. 7, 1855. No nucleus; 2 *s seen steadily. The centre of neb. looks darker than the rest. Oct. 8, 1855. There certainly exists a dark bay in the centre of the neb. between the two *s. |
| 2301 | 1 | Aug. 24, 1851. A S. lenticular neb. |

## Measurements of H. 1622 by Mr. Bindon Stoney, October 4, 1851.

| H. 1622, April and May, 1851. Object. | Mean of the observation of position. | No. of observation. | Greatest difference between observation and mean. | Mean of the observation of distance. | No. of observation. | Greatest difference between observation and mean. |
|---|---|---|---|---|---|---|
| | | | ° ′ | ″ | | ″ |
| 9 N | 49·37 | 2 | 1 0 | 88·20 | 2 | 0·3 |
| 9 *n* | 22·14 | 2 | 0 23 | 338·7 | 2 | 1·2 |
| 9 12 | 323·7 | 1 | ...... | 81·3 | 1 | |
| 9 15 | 336·37 | 1 | ...... | 187·5 | 1 | |
| 9 5 | 115·52 | 2 | 1 15 | 107·7 | 2 | 0·0 |
| 9 4 | 97·7 | 1 | ...... | 294·9 | 1 | |
| 9 2 | 45·37 | 1 | ...... | 377·7 | 1 | |
| 9 13 | 296·7 | 1 | ...... | 177·3 | 1 | |
| 9 14 | 326·37 | 1 | ...... | 234·9 | 1 | |
| 9 8 | 217·37 | 1 | ...... | 116·1 | 1 | |
| 9 7 | 196·37 | 1 | ...... | 93·3 | 1 | |
| 9 6 | 175·7 | 1 | ...... | 186·9 | 1 | |
| 9 10 | 201·37 | 1 | ...... | 48·9 | 1 | |
| 9 11 | 333·37 | 1 | ...... | 57·3 | 1 | |
| 9 16 | 249·37 | 1 | ...... | 201·9 | 1 | |
| 5 α | ...... | ... | ...... | 254·1 | 1 | |
| 5 β | ...... | ... | ...... | 94·5 | 1 | |
| 15 γ | ...... | ... | ...... | 300·5 | 1 | |

| Object. | H. 1622. Position as measured by | | | H. 1622. Distance as measured by | | |
|---|---|---|---|---|---|---|
| | O. Struve, 1851. | J. Stoney, 1850. | B. Stoney, 1851*. | O. Struve, 1851. | J. Stoney, 1850. | B. Stoney, 1851*. |
| | ° ′ | ° ′ | ° ′ | ″ | ″ | ″ |
| N 1 | 51 47 | 52 4 | ...... | 115·1 | 126·6 | ...... |
| N 2 | 54 48 | 54 0 | 44 27 | 518·0 | 300·0 | 289·27 |
| N 3 | ...... | 104 20 | ...... | ...... | 165·6 | ...... |
| N 4 | 108 54 | 111 57 | 112 42 | 243·63 | 243·6 | 243·95 |
| N 5 | 161 47 | 165 35 | 164 11 | 104·4 | 103·2 | 108·67 |
| N 6 | 190 24 | 191 42 | 191 54 | 250·0 | 234·0 | 249·12 |
| N 7 | 210 51 | 211 2 | 212 35 | 174·2 | 156·6 | 174·47 |
| N 8 | 221 25 | 220 49 | 222 43 | 202·6 | 176·79 | 203·57 |
| N 9 | 229 26 | 231 32 | 229 37 | 88·57 | 83·4 | 88·2 |
| N 10 | ...... | 223 30 | 219 37 | ...... | 106·94 | 133·77 |
| N 11 | 277 27 | 279 21 | 266 8 | 121·9 | 109·8 | 92·88 |
| N 12 | ...... | 274 23 | 273 40 | ...... | 117·67 | 116·15 |
| N 13 | ...... | 281 37 | 275 8 | ...... | 239·0 | 227·67 |
| N 14 | ...... | ...... | 305 11 | ...... | ...... | 240·39 |
| N 15 | 309 2 | 310 34 | 308 40 | 189·9 | 175·8 | 183·15 |
| N 16 | ...... | ...... | 243 30 | ...... | ...... | 286·62 |
| N *n* | 14 51 | 16 54 | 13 23 | 265·65 | 262·2 | 262·97 |

* In the reduction of these from the former Table, Struve's determination of N 9 has been used.

N.B. Struve's measurement of N 11 ought perhaps to be attributed to N 12.

List of Stars in the Dumb-bell Nebula, H. 2060, measured in autumns of 1850 and 1851. Origin taken at α (*a* of M. STRUVE); brightest star in sp. quarter. By Mr. BINDON STONEY.

| Name in observing-book. | M. Struve's name. | X. | Y. | No. of observation. | X in M. Struve's list. | Y in M. Struve's list. |
|---|---|---|---|---|---|---|
| | | ″ | ″ | | ″ | ″ |
| β | *d* | +154·4 | + 17·5 | 2 | +152·5 | + 12·8 |
| ζ | *c* | +325·3 | + 63·1 | 2 | +321·1 | + 62·8 |
| γ | *e* | +172·8 | + 98·6 | 3 | +172·5 | + 98·8 |
| δ | *f* | +172·3 | +144·5 | 2 | +174·6 | +142·2 |
| ε | *g* | +173·9 | +193·2 | 2 | +174·3 | +191·5 |
| θ | *h* | +246·2 | +100·5 | 2 | +251·1 | +101·7 |
| κ | *k* | +187·4 | −121·3 | 2 | +186·8 | −121·0 |
| μ | *w* | +323·5 | −115·0 | 2 | +317·7 | −102·0 |
| ο | *b′* | +303·6 | +183·4 | 2 | +308·3 | +186·3 |
| ρ | *b* | + 23·0 | +199·7 | 2 | + 21·6 | +199·7 |
| σ | *o* | + 46·8 | +149·5 | 3 | + 49·6 | +144·0 |
| π | *p* | + 48·1 | + 61·3 | 2 | + 60·6 | + 57·9 |
| τ | *a′* | − 10·9 | − 59·8 | 2 | − 12·3 | − 57·2 |
| η | *i* | +235·8 | + 70·8 | 1 | +238·2 | + 71·5 |
| ι | ... | +223·0 | + 51·4 | 1 | | |
| A | ... | + 54·4 | − 22·8 | 2 | | |
| λ | ... | +304·6 | + 21·3 | 1 | | |
| ψ | ... | + 73·6 | −136·8 | 1 | | |
| φ | ... | + 63·6 | −122·6 | 1 | | |
| ω | ... | +142·6 | + 60·4 | 1 | | |
| ν | *r* | +398·2 | − 91·6 | 1 | +396·9 | − 74·0 |

A is the extremity of the bright mass of nebulosity in the sp. quarter.

[*Observations of Stars in the Dumb-bell Nebula, Messier* 27, H. 2060. By M. O. STRUVE.

The following list of observations contains all stars which can be seen, by the Pulkova refractor, in the Dumbell Nebula. Sometimes I had a faint suspicion of some stars more visible on the ground of the nebula, but they were not seen distinctly enough to allow an exact micrometrical determination of their places. It will be interesting to see how many stars more Lord ROSSE's great reflector will show in this nebula; from this comparison some approximate judgment might be formed about the respective space-penetrating powers of the two instruments. My observations extend as far as I was able to trace the nebulosity. I think there is only one star in the lists situated quite out of the nebula. This star was observed merely for the sake of control. Probably Lord ROSSE's large reflector will extend considerably further the boundaries of the nebulosity; but to compare the relative powers of the two instruments, it will be necessary to confine the enumeration of the stars to the same boundaries which are approximately indicated by the stars in the following list. As fundamental point for the triangulation, I selected the star *a* of the 10th magnitude, situated near the S.W. corner of the nebula. It cannot be mistaken, for it is far the brightest object in the whole nebula. All observations have been made with illuminated wires in the dark field, and with a power of 207.

Observations.

| Date. | Object. | Magnitude. | Ang. Pos. | No. of measures. | Distance. | No. of measures. |
|---|---|---|---|---|---|---|
| 1851. Sept. 1 | *a b* | *b* =(11.12) | 6°·4 | 3 | 200″·4 | 3 |
| | *b b′* | *b′* =(11) | 92·7 | 3 | 282·3 | 3 not accurate. |
| | *a e* | *e* =(11) | 60·1 | 3 | | |
| Sept. | *a e* | ......... | 60·5 | 3 | 199·4 | 6 |
| | *c e* | *c* =(11.12) | 283·7 | 3 | 152·9 | 6 |
| | *a d* | *d* =(11.12) | 85·2 | 3 | | |
| | *e d* | ......... | 193·1 | 3 | | |
| | *e f* | *f* =(12) | 2·8 | 4 | | |
| | *b f* | ......... | 110·6 | 4 | | |
| | *b g* | *g* =(12.13) | 93·4 | 4 | | |
| | *e g* | ......... | 1·1 | 4 | | |
| | *e h* | *h* =(11.12) | 87·9 | 5 | | |
| | *c h* | ......... | 299·0 | 4 | | |
| Sept. 3 | *e i* | *i* =(12.13) | 112·6 | 4 | | |
| | *h i* | ......... | 203·1 | 4 | | |
| | *a k* | *k* =(11.12) | 123·0 | 4 | | |
| | *e k* | ......... | 176·4 | 6 | | |
| Sept. 12 | *a b* | ......... | 6·1 | 3 | 201·3 | 6 |
| | *a e* | ......... | 60·3 | 3 | 198·5 | 6 |
| | *e c* | ......... | 103·0 | 3 | 151·7 | 6 |
| | *a l* | *l* =(10.11) | 116·05 | 6 | ΔÆ=358·7 | 10 |
| Sept. 17 | *e m* | *m* =(12) | 168·7 | 4 | | |
| | *l m* | ......... | 268·9 | 4 | | |
| | *l n* | *n* =(12.13) | 258·2 | 4 | | |
| | *m n* | ......... | 180·3 | 6 | | |
| | *a o* | *o* =(13) | 19·0 | 4 | | |
| | *b o* | ......... | 156·3 | 4 | | |
| | *e o* | ......... | 290·2 | 4 | | |
| | *a l* | ......... | 116·00 | 4 | ΔÆ=359·9 | 10 |
| Sept. 22 | *a p* | *p* =(13) | 46·3 | 4 | | |
| | *b p* | ......... | 164·6 | 6 | | |
| | *a q* | *q* =(11.12) | 257·9 | 4 | 99·8 | 6 |
| | *l r* | *r* =(12.13) | 36·2 | 4 | | |
| | *e r* | ......... | 127·6 | 4 | | |
| | *s r* | *s* =(8) | 258·3 | 4 | | |
| Sept. 26 | *l t* | *t* =(12) | 24·9 | 4 | | |
| | *e t* | ......... | 142·4 | 4 | | |
| | *s t* | ......... | 247·0 | 5 | | |
| | *l u* | *u* =(11.12) | 118·2 | 6 | 77·9 | 9 |
| | *u v* | *v* =(12) | 343·3 | 6 | | |
| | *l v* | ......... | 89·5 | 5 | | |
| | *l w* | *w* =(13) | 346·3 | 4 | | |
| | *a w* | ......... | 107·8 | 4 | | |
| | *s w* | *x* =(13) | 256·3 | 4 | | |
| | *l x* | ......... | 82·9 | 4 | | |
| | *u x* | ......... | 37·4 | 6 | | |
| | *l y* | *y* =(12) | 190·5 | 4 | | |
| | *u y* | ......... | 256·9 | 4 | | |
| | *l z* | *z* =(12.13) | 234·6 | 5 | | |
| | *k z* | ......... | 130·3 | 4 | | |
| Oct. 3 | *a a′* | ......... | 192·1 | 4 | | |
| | *q a′* | ......... | 113·0 | 4 | | |
| | *a s* | ......... | Δδ=−42″·0 | 8 | ΔÆ=600·8 | 16 |
| | *a b* | ......... | 6·0 | 4 | 201·2 | 8 |
| Oct. 20 | *a e* | ......... | 59·9 | 3 | 198·5 | 7 |
| | *e b′* | ......... | 57·2 | 4 | 161·5 | 6 |
| | *e c* | ......... | 104·1 | 3 | 154·1 | 7 |
| Dec. 17 | *c d* | ......... | 253·8 | 5 | | |
| | *d h* | ......... | 166·1 | 4 | | |
| | *e l* | ......... | 148·72 | 4 | | |
| | *l u* | ......... | 119·5 | 4 | 79·9 | 6 |

From the preceding observations the following coordinates, X, Y, with regard to *a* have been deduced. X is the coordinate in the direction of Æ or $\Delta$Æ cos $\delta$; Y is the coordinate in declination or $\Delta\delta$. In this deduction, where the angles of position of any star were taken from three different points previously fixed, I have combined only those two directions which promised the most exact evaluation of the coordinates. Thus, for instance, the star *r* is related to *l*, *e* and *s*. In the three triangles formed in this way, the angle at *r* is found respectively *l r e*=91° 24′, *l r s*=137° 54′, *s r e*=130° 42′. Hence it is evident that the nearly right-angular intersection of the two sides *l r* and *r e* in the triangle *l r e*, must give the best combination for the deduction of the position of *r*. The relation of *l* and *e* to another and to *a* being previously established, the coordinates of *r* to *a* were deduced from the resolution of the triangle *l r e*. The difference of these coordinates from the corresponding previously fixed coordinates of *s* with regard to *a*, gave the angle of position of *r* from *s* by calculation =258° 37′. This calculated angle, compared with the directly observed position =258° 18′, shows a difference of only 19′, and bears, therefore, a very satisfying testimony to the exactness of the deduced position of *r*. The same proceeding having been followed in all other cases, where control observations had been made, I have got the conviction that the probable error in any of the following coordinates will be considerably inferior to one second of space. It will be comparatively smaller for the brighter stars, but somewhat greater for the very faint objects.

Calculated Coordinates of the Observed Stars with regard to *a*.

| | X. | Y. |
|---|---|---|
| | ″ | ″ |
| *q* | − 97·6 | − 20·9 |
| *a′* | − 12·3 | − 57·2 |
| *b* | + 21·6 | +199·7 |
| *o* | + 49·6 | +144·0 |
| *p* | + 60·6 | + 57·9 |
| *d* | +152·5 | + 12·8 |
| *e* | +172·5 | + 98·8 |
| *g* | +174·3 | +191·5 |
| *f* | +174·6 | +142·2 |
| *k* | +186·8 | −121·0 |
| *n* | +224·9 | −184·7 |
| *m* | +225·0 | −164·3 |
| *i* | +238·2 | + 71·5 |
| *h* | +251·1 | +101·7 |
| *z* | +279·6 | −199·7 |
| *b′* | +308·3 | +186·3 |
| *w* | +317·7 | −102·0 |
| *c* | +321·1 | + 62·8 |
| *y* | +321·8 | −219·5 |
| *l* | +332·4 | −162·2 |
| *t* | +347·8 | −128·9 |
| *v* | +390·7 | −161·7 |
| *r* | +396·9 | − 74·0 |
| *u* | +402·4 | −200·8 |
| *x* | +442·0 | −148·5 |
| *s* | +555·8 | − 42·0 |

(Signed) OTTO STRUVE.

*Pulkova, Feb.* 4, 1852.]

[*Observations of Stars in the Spiral Nebula.* H. 1622.

The spiral form of this nebula is very distinctly seen in the Pulkova refractor. Unfortunately in the month of March, the best season for the observation of this object, the sky was constantly cloudy; so that I could only get three nights' observations in the months of April and May, when the twilight did not cease for the whole night. It must be attributed to this unfavourable circumstance that the following list of determinations is not so complete as it probably would have been without the twilight. The observations have been made alternately with powers of 138 and 207.

Observations.

| Date. | Object. | Magnitude. | Ang. Pos. | No. of measures. | Distance. | No. of measures. |
|---|---|---|---|---|---|---|
| 1851, April 7. | N *n* | .............. | 14° 55′ | 5 | 267″·1 | 4 |
| | N *a* | *a* =(11) | 229 24 | 3 | 88·0 | 3 |
| | N *b* | *b* =(11.12) | 109 12 | 3 | 242·6 | 3 |
| | *a b* | .............. | 93 42 | 3 | 298·6 | 3 |
| April 28. | *a b* | .............. | 94 23 | 3 | 300·8 | 4 |
| | N *a* | .............. | 228 36 | 4 | | |
| | N *b* | .............. | 108 54 | 4 | | |
| | *n a* | .............. | 203 42 | 3 | | |
| | *n b* | .............. | 153 30 | 3 | | |
| | *a d* | *d* =(12.13) | 323 51 | 3 | | |
| | N *d* | .............. | 277 27 | 3 | | |
| | *a e* | *e* =(13) | 112 13 | 3 | | |
| | N *e* | .............. | 161 56 | 3 | | |
| | N *f* | *f* =(12.13) | 309 18 | 3 | | |
| | *nf* | .............. | 237 31 | 3 | | |
| | *af* | .............. | 335 23 | 3 | | |
| | *a g* | *g* =(12.13) | 215 17 | 3 | 115·5 | 4 |
| | *a h* | *h* =(12.13) | 193 29 | 3 | | |
| | *g h* | .............. | 87 5 | 3 | | |
| May 3. | N *k* | *k* =(13.14) | 51 47 | 3 | | |
| | *n k* | .............. | 173 29 | 4 | | |
| | *b k* | .............. | 317 23 | 3 | | |
| | *b l* | *l* =(11.12) | 27 20 | 4 | | |
| | *n l* | .............. | 83 17 | 4 | 355·2 | 4 |
| | *a e* | .............. | 112 56 | 4 | | |
| | N *e* | .............. | 161 39 | 3 | | |
| | *a m* | *m* =(12.13) | 172 43 | 5 | | |
| | N *m* | .............. | 190 44 | 4 | | |
| | *b m* | .............. | 238 50 | 4 | | |
| | N *a* | .............. | 229 12 | 4 | 87·0 | 3 |
| | N *n* | .............. | 14 47 | 4 | 264·2 | 3 |

The results of these measures were deduced in this way, that I first fixed the relations between the four principal objects, namely, the centres of the two nebulæ N and *n*, and the two brightest stars *a*, *b*. In the triangle N *a b*, all distances and directions have been measured It is therefore over-determined, and the definite relations had to be deduced by the calculus of compensation. This calculus gives—

| | Ang. Pos. | Distance. |
|---|---|---|
| N *a* | 229° 26′ | 88″·57 |
| N *b* | 108 54 | 243·63 |
| *a b* | 94 6 | 298·55 |

To these relations must be added the mean value of the two observed relations N $n$ (April 7, May 3) which gives N $n$ ang. pos. $=14^\circ\ 51'$, distance $=265''\cdot65$.

These relations between the four principal objects form the base from which the places of the other stars are deduced by resolutions of the triangles formed by the observed directions. The following Table contains the results of my calculations. It gives the places of all observed objects with regard to N, the apparent centre of the greater nebula, and that of the star $g$ to $h$.

| | Ang. Pos. | Distance. |
|---|---|---|
| | ° ′ | ″ |
| N $n$ | 14 51 | 265·65 |
| N $a$ | 229 26 | 88·57 |
| N $b$ | 108 54 | 243·63 |
| N $d$ | 277 27 | 121·9 |
| N $e$ | 161 47 | 104·4 |
| N $f$ | 309 2 | 189·9 |
| N $h$ | 210 51 | 174·2 |
| N $g$ | 221 25 | 202·6 |
| N $k$ | 51 47 | 115·1 |
| N $l$ | 54 48 | 518·0 |
| N $m$ | 190 24 | 250·0 |
| $h\,g$ | 267 5 | 44·7 |

Our observations contain several controls, by which it is proved that the deduced places of the stars, with regard to N, might be judged all exact within 2″. This exactness must be regarded as very satisfactory, if we consider the extreme faintness of the observed objects. I estimate a star to be of the 14th magnitude if it is more suspected than distinctly seen in a dark night. Hence it follows that the greater part of the stars in our list are close to the extremity of measureableness in the Pulkova refractor. Another cause which troubles the agreement of results is the indistinctness of the centre of the greater nebula N. The centre of the small nebula $n$ is much more distinct: all observations of the dimensions of the nebula, or of knots in it, have been omitted by me, as they can be observed with much more accuracy by Lord ROSSE's powerful telescope.

The Earl of ROSSE communicated to me the following relations of sixteen objects in the nebula, as observed through his telescope. I add to that list the differences of our measures (S—R) for the objects which appear to be identical.

| Designation by Lord Rosse. | Designation by O. Struve. | Ang. Pos. | S−R. | Distance. | S−R. |
|---|---|---|---|---|---|
| N *n* | N *n* | 16° 34′ | −1° 43′ | 4′ 22″·2 | + 3″·4 |
| N 1 | N *k* | 52 4 | −0 17 | 2 6·6 | −11·5 |
| N 2 | ......... | 54 0 | ......... | 5 0·0 | |
| N 3 | ......... | 104 20 | ......... | 2 45·6 | |
| N 4 | N *b* | 111 57 | −3 3 | 4 3·6 | 0·0 |
| N 5 | N *e* | 165 35 | −3 48 | 1 43·2 | + 1·2 |
| N 6 | N *m* | 191 42 | −1 18 | 3 54·0 | +16·0 |
| N 7 | N *h* | 211 2 | −0 11 | 2 36·6 | +17·6 |
| 7, 8 | *h g* | 270 42 | −3 37 | 0 34·8 | + 9·9 |
| N 9 | N *a* | 231 32 | −2 6 | 1 23·4 | + 5·2 |
| 9, 10 | ......... | 197 57 | ......... | 0 27·0 | |
| N 11 | N *d* | 279 21 | −1 54 | 1 49·8 | +12·1 |
| 11, 12 | ......... | 225 27 | ......... | 0 12·6 | |
| N 13 | ......... | 281 37 | ......... | 3 51·0 | |
| 14, 15 | ......... | 297 15 | | | |
| N 15 | N *f* | 310 34 | −1 32 | 2 55·8 | +14·1 |

From this comparison it is evident that all angles measured by Lord Rosse are too great. The mean value of the correction, 1° 57′, corresponds to a linear distance of −4″·7. The distances appear to be generally too small. The mean value of the differences is +6″·8. Perhaps Lord Rosse's star 2 is identical with my *l*; but in that case, Lord Rosse's distance N 2 must be an error of writing. At the distance of 5′ from N I could not see the least trace of a star in the indicated direction. In my copy of Lord Rosse's diagram the star 2 is placed at a distance of about 8′, corresponding with my observations; 10 appears to me only as a knot of the nebula, and has therefore not been measured by me. About the stars 3, 12, 13, and 14 there is no notice given in my journal. Perhaps they might be seen and measured with our refractor. The next spring I intend to repeat and to complete the series of observations, and to decide on the visibility of the not yet noticed stars.

(Signed) Otto Struve.

(Dated) *Pulkova, June* 2, 1851.]

In forming some estimate of the degree of reliance to be placed on the micrometrical measurements in this paper, we have taken advantage of the information so obligingly communicated by M. O. Struve.

As to the measures of distance, they accord with Struve's as closely perhaps as could be expected. We measure with bars instead of lines, and without illumination, that we may the better see the faint details of the outlying portions of the nebulæ; besides, we do not employ clockwork to move the telescope. Our measures of *stars* cannot therefore in accuracy compete with Struve's, but they are quite sufficient for giving precision to the drawings. As to the angles of position, the same remarks apply, with this addition, that we refer our measurements to the horizon, and reduce them to the equator. Our zero is therefore obtained from the spirit-level, which saves time, to us a great object. We proceed in this way: the level is made horizontal and read off: each measure + or − this quantity will be the distance from the horizon, provided the telescope is on the meridian. When the measures are not taken on the meridian, but a little before or after it, there will be an error in all positions except at the equator. There will be an error owing to two causes, one the error of the zero, the level having been read off the meridian; the other the error in the reading of the position-circle, owing to the action of the universal joint which carries the telescope. The transverse axis of this joint restrains the movement of the telescope round the line of collimation as it approaches or recedes from the meridian; and consequently the plane of the position-circle, except at the equator, does not pass through the pole. The sum of the errors in each case could easily have been computed and allowed for in the reductions, had the distance from the meridian been taken simultaneously with the measurements, but this would have taken much time.

The measurements in the Dumb-bell accord pretty closely with STRUVE'S, and may, I think, be taken as a fair average of the work.

As to H. 1622, the comparison of STRUVE'S measures with those of the two STONEYS will give more than a probable amount of error at 42° N.P.D, because the stars are numerous, and some measures therefore were taken at a considerable distance from the meridian.

I have not seen the Dumb-bell since STRUVE'S letter, having been from home when it was within reach; and no attempt has been made to ascertain the largest number of stars visible in it. No stars have been inserted in the sketch which have not been measured: very many more were distinctly seen. The number of stars visible in this nebula depends even more upon magnifying power and distinctness than aperture; high powers obliterate the faint nebulous details.

The only additional information as to the limits of the nebula which has been obtained since Mr. B. STONEY'S drawing was made is contained in the following entry:—August 29th, 1854, observed by Dr. ROBINSON and Mr. J. STONEY. Mr. STONEY says, "Both Dr. ROBINSON and I agreed that the band of faint nebulosity extended further down than in my brother's drawing. My brother and I had formed the same opinion on a previous occasion."

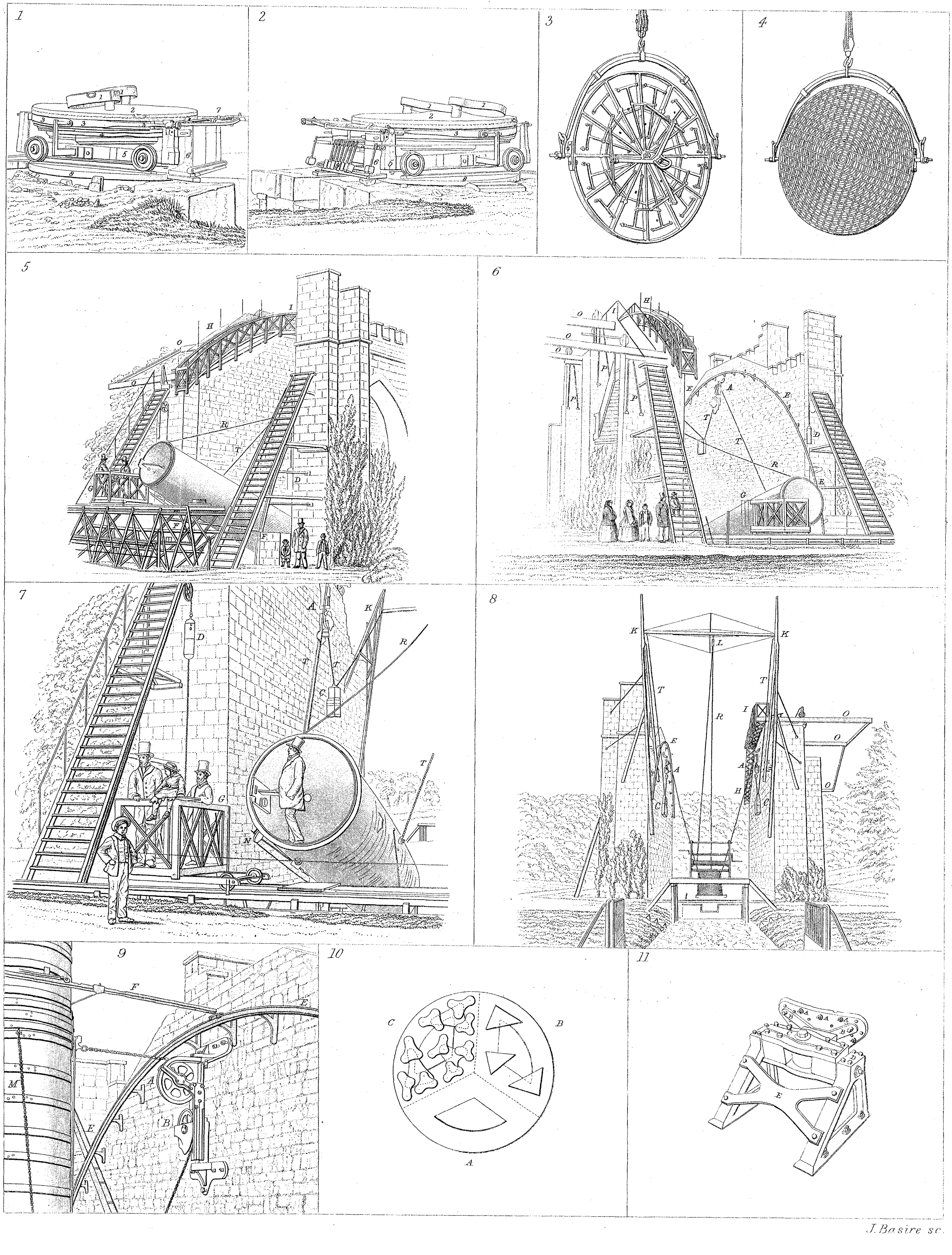
In the observations a silver speculum is sometimes mentioned: we have employed silver occasionally for the second reflexion in this way. First, a *thin* deposit on glass by LIEBIG'S process. This, even when fresh, reflects but little more light than speculum-metal. Second, a *thick* deposit on glass, by the grape-sugar or tartaric-acid process, transferred to brass by a thin film of shell-lac: this reflects much more light; but the manipulation is rather difficult, and the surface is not very durable. Third, a surface of standard silver, polished by mechanical means. Fourth, parallel glass, silvered by the grape-sugar process; this of course is durable, but very inferior to the uncovered silver in light and in definition. These substitutes for speculum-metal have only been occasionally used, and for special purposes.

List of Nebulæ not found.

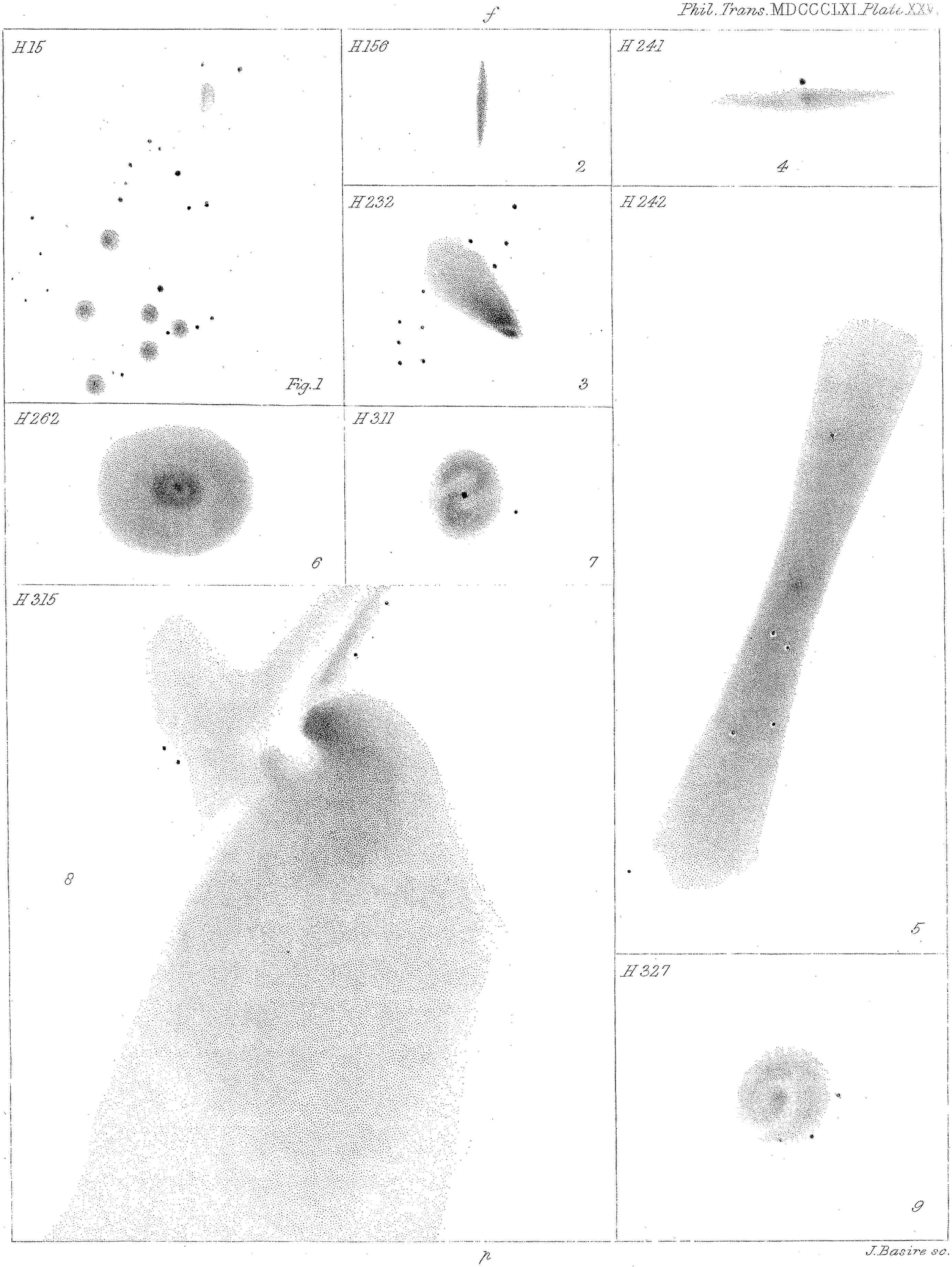
| Number in Herschel's Catalogue. | Number of times looked for. | Observations. | Number in Herschel's Catalogue. | Number of times looked for. | Observations. |
|---|---|---|---|---|---|
| 57 | 1 | | 672 | 1 | |
| 162 | 8 | | 706 | 6 | |
| 184 | 1 | | 745 | 1 | |
| 206 | 1 | | 828 | 1 | |
| 281 | 1 | | 1307 | 1 | |
| 284 | 2 | One night passing clouds. | 1485 | 2 | Once sky hazy. |
| 314 | 1 | Clouds passing. | 1535 | 1 | Clouds passing. |
| 333 | 1 | | 1832 | 1 | |
| 343 | 7 | | 1948 | 1 | |
| 356 | 4 | Twice, a slight milkiness suspected. | 1974 | 1 | |
| | | | 2062 | 1 | |
| 401 | 9 | | 2073 | 2 | |
| 468 | 5 | No nebulosity seen. | 2113 | 2 | |
| 546, 577 | 1 | | 2133 | 4 | |
| | | | 2137 | 1 | |
| 578 | 1 | | 2148 | 3 | Once clouds passing. |
| 590 | 1 | | 2250 | 4 | |
| 669 | 1 | | 2302 | 2 | |

This is not to be considered as a list of missing nebulæ, but merely of objects which were not found in the ordinary course of observing, and to which therefore it is desirable that attention should be directed. They have not been looked for since this list was made out.

The engravings of the Nebulæ are extremely faithful: there is, however, a slight inaccuracy which it is necessary to notice, and for which we are to blame, not the engraver. Many of the principal stars are too large. The error arose in this way. The stars were inserted in common, not Indian ink, and, the drawings during their transmission by post becoming slightly damp, the ink made its way into the paper, the dots in some cases becoming small blots. In a few instances it was necessary to set this right to prevent misconception, and some alteration was in consequence made in the Plates; but as to the remainder, we thought it sufficient to state the fact generally, that many of the principal stars were somewhat too large. This remark applies especially to figures 1 and 3, Plate XXV., and to figures 24, 28, 29, 30, 34, Plate XXVIII.



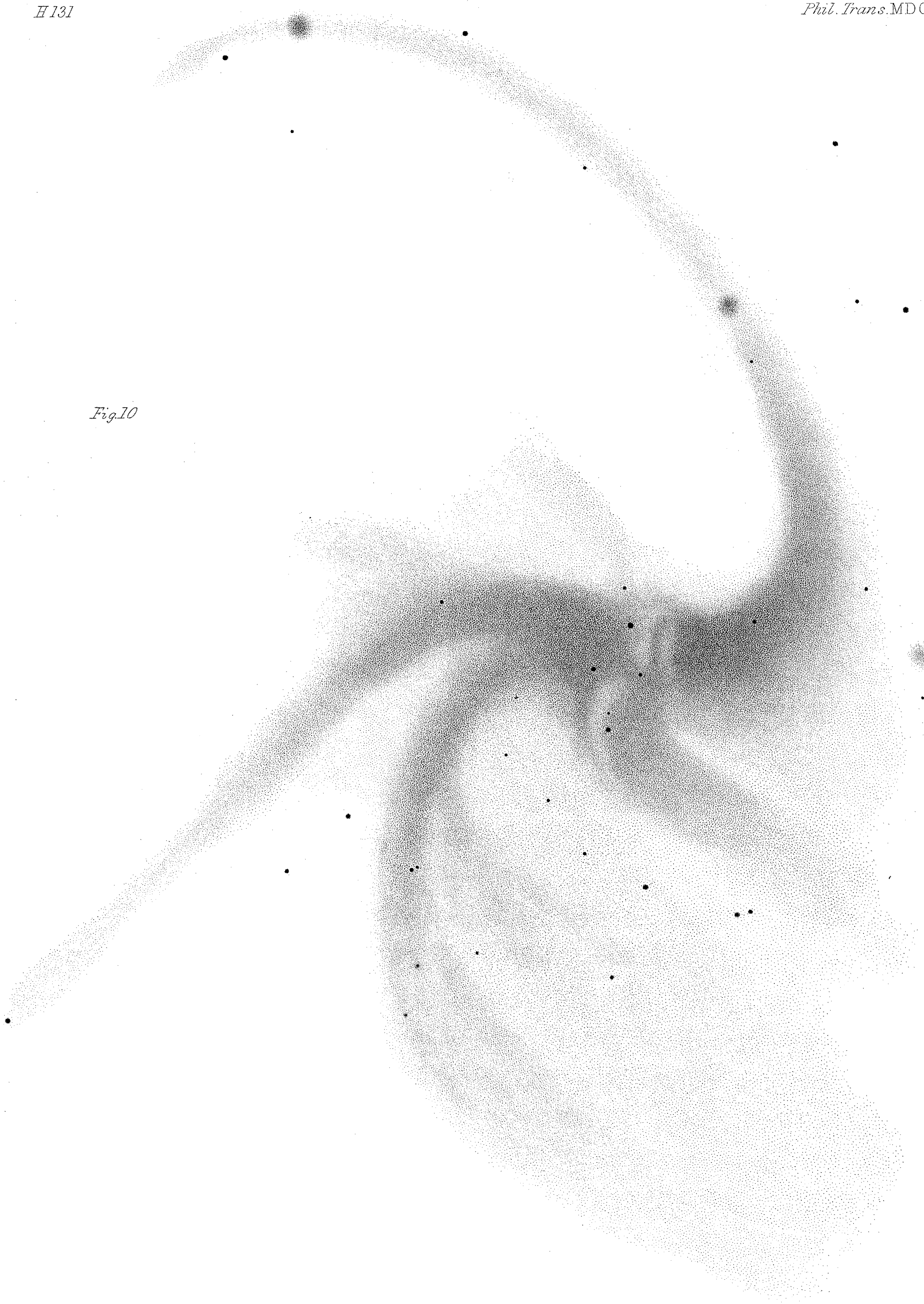

J. Basire sc.




J. Basire sc.

Phil. Trans. MDCCCLXI. Plate XXV.I

Fig. 10



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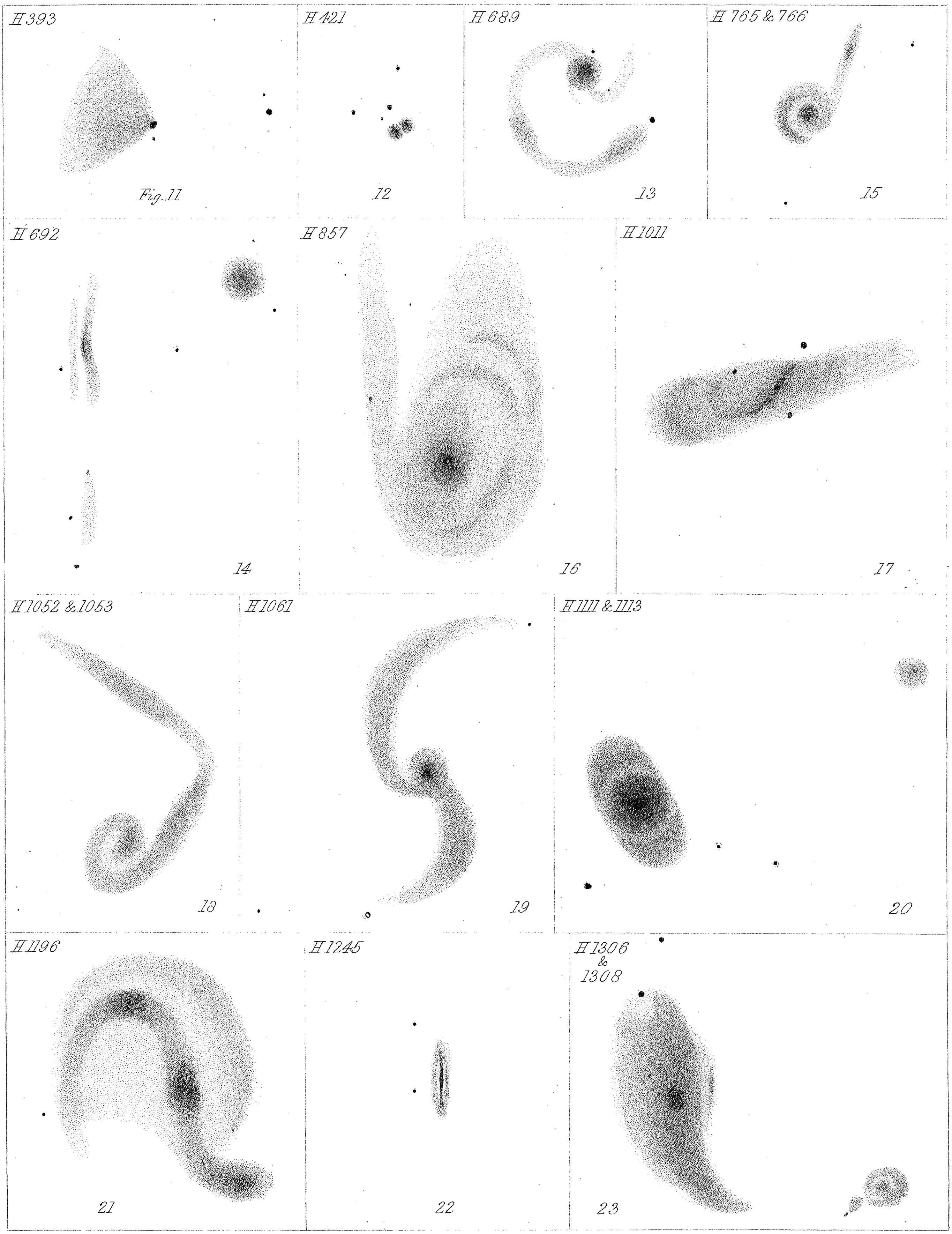

H 393
Fig. 11
H 421
12
H 689
13
H 765 & 766
15
H 692
14
H 857
16
H 1011
17
H 1052 & 1053
18
H 1061
19
H 1111 & 1113
20
H 1196
21
H 1245
22
H 1306
&
1308
23

J. Basire sc.

H 1337

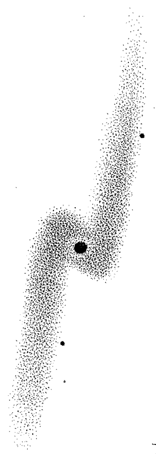
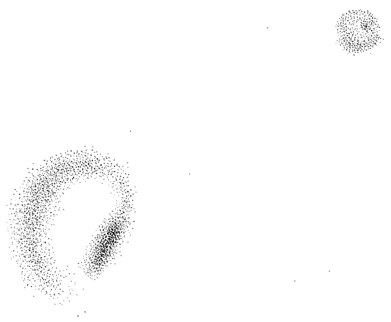


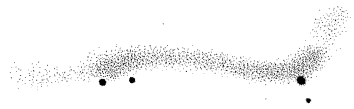
Fig 24

H 1385



25

H 1414 & 15

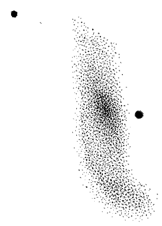


26

H 1441

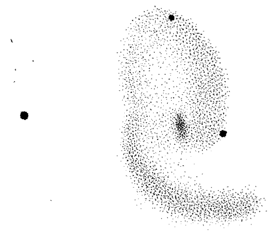
27

H 1589



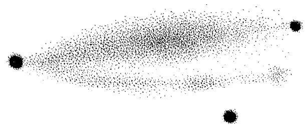
28

H 1650



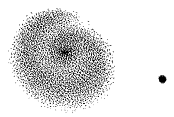
29

H 1713



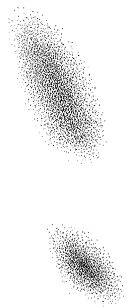
30

H 1946



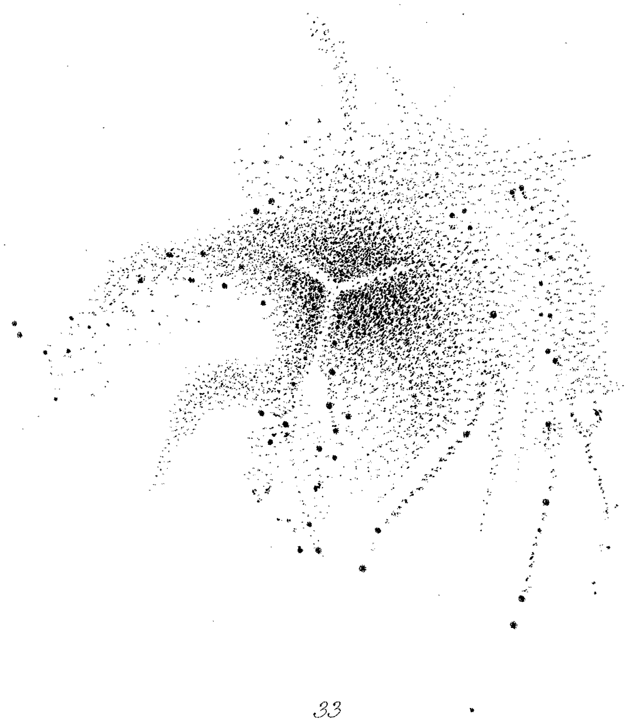
32

H 1905



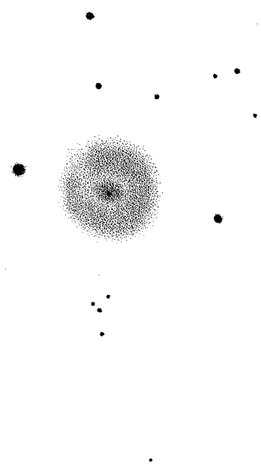
31

H 1968



33

H 2075



34

J. Basire sc.

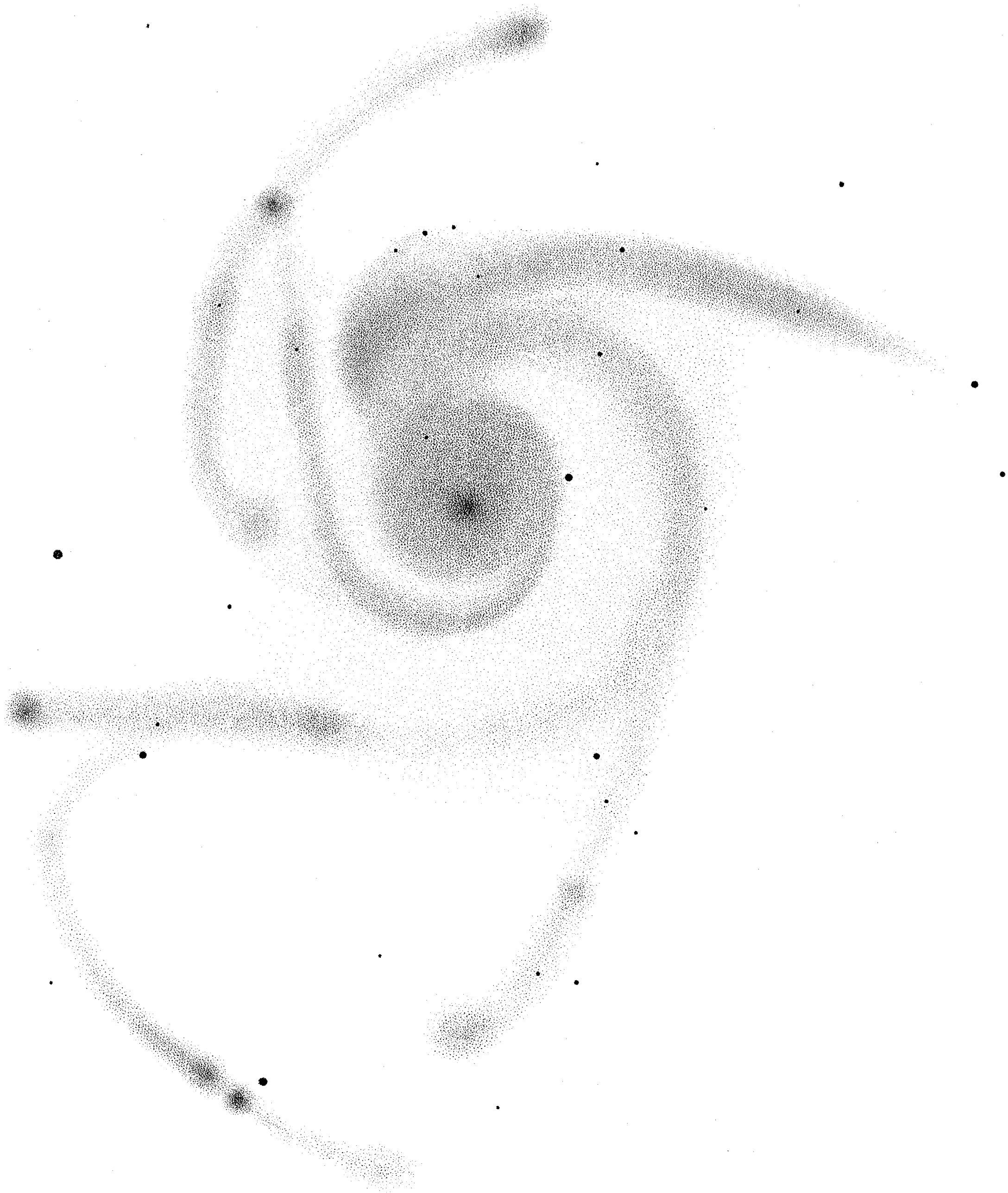


Fig 35

J. Basire sc.

H 2084

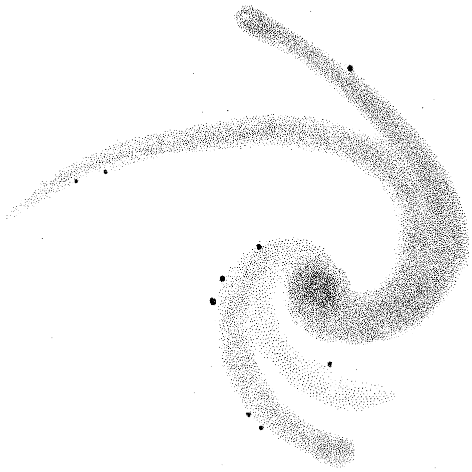
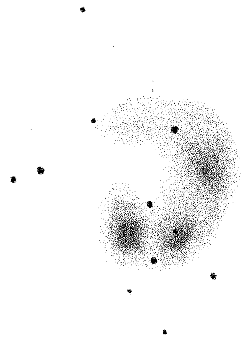


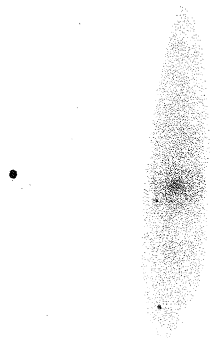
Fig. 36

H 2099



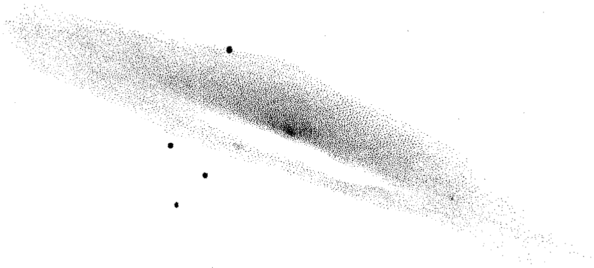
37

H 2139



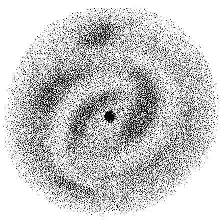
38

H 2172



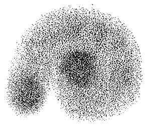
39

H 2241



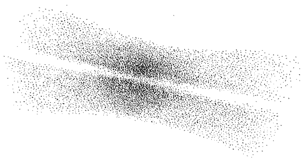
40

H 2245



41

H 2297



42

J. Basire sc

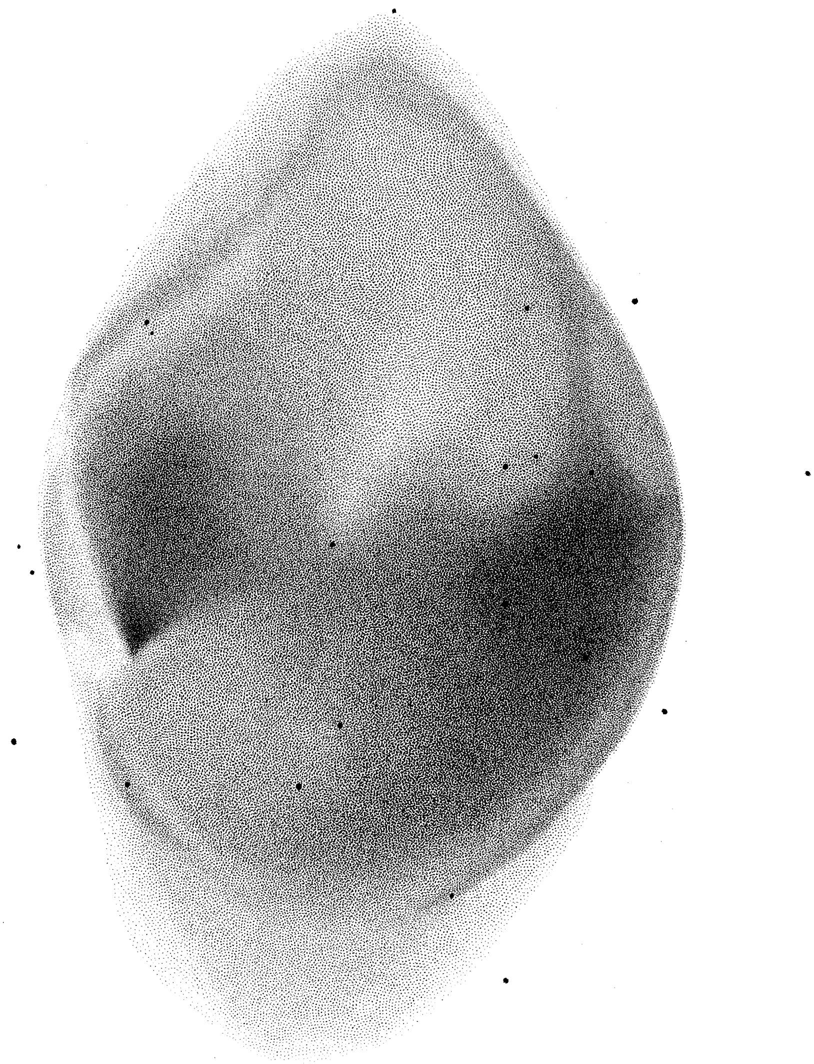


Fig. 43

J. Basire sc.