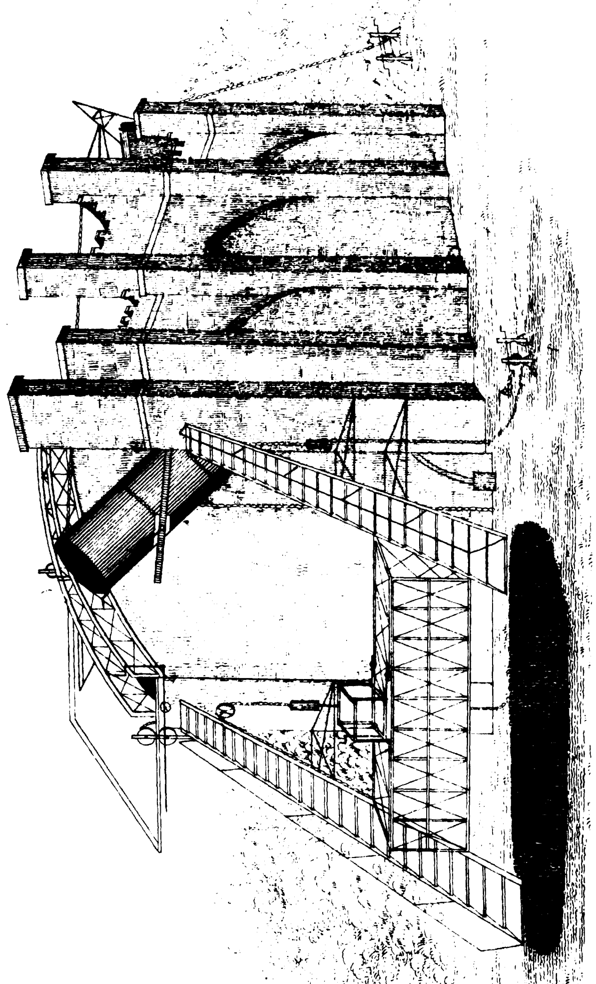


*The Monster Telescope.*

THE

# MONSTER TELESCOPES,

ERECTED BY

## THE EARL OF ROSSE, PARSONSTOWN,

WITH AN ACCOUNT OF THE

## MANUFACTURE OF THE SPECULA,

AND FULL DESCRIPTIONS OF ALL

## THE MACHINERY

CONNECTED WITH THESE INSTRUMENTS.

Illustrated by Engravings.

PARSONSTOWN
SHEILDS AND SON, CUMBERLAND-SQUARE.
LONDON: DUNCAN AND MALCOLM, PATERNOSTER-ROW.
DUBLIN: JOHN CUMMING.
MDCCCXLIV.

SHEILDS AND SON, PRINTERS, PARSONSTOWN.

# PREFACE.

To satisfy a curiosity that is naturally excited by any thing new, great, or uncommon, I tried to obtain all the information I could, connected with the Telescopes I endeavour to describe. To gratify a similar feeling in others, more remote from my opportunities of looking on, I venture to publish an account of what I have seen.

As I am hardy enough to do so without any assistance from, or even the cognizance of the noble projector of those instruments, whose liberality in diffusing his knowledge and wish for its promotion, leave me no uneasiness on this point, so I do not expect to give that information which men of deep research or mathematically close enquiry would desire. There are some particulars which might, perhaps, be more enlarged upon with advantage, but it has been my aim to place before the general reader such an account as will make the manufacture of the Specula, and the mechanism of the Telescopes, as plainly understood as could be expected, without entering with too much tediousness into minute details. I have been as explicit as possible in the history of the compound three foot Speculum, knowing that individuals whose inclination would lead them to construct Specula on a large scale, without possessing the pecuniary advantages of Lord Rosse, will be naturally led to adopt a course the most manageable and economical, and one which does not appear to be the less certain of success. I have added illustrations of every part which is at all complicated, and where I thought they could be likely to assist the text, and trust that the endeavour I have made to enable my subject to be understood, will satisfy the desire of the public to understand it.

THE AUTHOR.

*Parsonstown, September* 28, 1844.

# CONTENTS.

# PART I.

Having satisfied himself by experiments with lenses, that the Refracting Telescope could not be much improved, Lord Rosse turned his attention to reflectors; and as the first object of experimentors had always been to increase the magnifying power and light by the construction of as large a mirror as possible; so was it to this point that his Lordship's attention was also directed.

Previous to his experiments, there had not been any instrument constructed, with the exception of Sir W. Herschell's, which had given an opportunity of sufficiently well enjoying the advantage of the Reflecting Telescope; and even of this it has been lately stated,* that it possessed but little, if any, practical superiority over others of smaller size.

* Vide. Dr. Robinson's speech at the Cork meeting of the British Association, 1843.

Since Newton manufactured his Specula until the present day, there have been several opinions, both as to the metals to be employed in their construction, and the quantities in which they should be mixed—some have recommended various proportions of tin and copper; some have added arsenic; some silver; some antimony; and others, the three together—the general aim of all the operators being to increase the whiteness, and to diminish the porosity and brittleness of the compound: for the last named property has destroyed a much greater number of Specula, than it has allowed to be completed—it is the "asses' bridge," over which few have been fortunate enough to travel. The compound metal is exceedingly brittle, and requires the most cautious and well regulated cooling, after having been cast, to ensure its ultimate success; the very operation of grinding—by the heat the friction produces—having often destroyed the labour of many weeks. The grinding of Specula used to be performed by the hand, no machinery having been deemed sufficiently exact; the tool, on which they were shaped, being turned to the required form, and covered with coarse emery and water, they were ground on it to the necessary figure, and



afterwards polished by means of putty or oxide of tin, spread on pitch, as a covering to the same tool in the place of the emery. To grind a Speculum of six or eight inches in diameter, was a work of no ordinary labour; and such an one used to be considered of great size. Mr. Ramage's Reflecting Telescope—the mirror of which is fifteen inches in diameter, with a focal distance of twenty-five feet, was, till lately, the largest in use. Sir J. Herschell's, which stands in the place of his father's large one, has a Speculum eighteen inches in diameter, and a focal distance of twenty-five feet. With the difficulties of the undertaking, and the small success of his predecessors, Lord Rosse was fully acquainted, but he set about the work with a zeal that was a presage of his triumph. It is, perhaps, unnecessary to state, how fitted his Lordship is in every way, to accomplish a work, which requires the combination of so many qualities; talent to devise—patience to bear disappointment—perseverance—profound mathematical knowledge—mechanical skill—uninterupted leisure from other pursuits; and yet, these would not have been sufficient, if a great command of money had not been added. Fortunately, the world has seen them all combined, and their application to the highest branch of scientific enquiry. The fact of the great Telescope alone having cost certainly, not less than twelve thousand pounds, shows how few individuals could have successfully brought so large an instrument to a happy conclusion; and if to this be added the money expended on the Telescope with the Speculum three feet in diameter, and the various sums laid out in experimenting, we will see what a splendid offering has been made at the shrine of science, by one of her most devoted admirers.

After many trials, as to what combination of metals was most useful for Specula, both as regarded whiteness, porosity, and hardness, Lord Rosse found that copper and tin, united very nearly in their atomic proportions, viz:—copper, 126-4 parts, to tin 58-9 parts, was the best. This compound, which is of admirable lustre and hardness, and has a specific gravity of 8-8, he has used with both the small and large Specula, and he finds it to preserve its lustre with more splendor, and to be more free from pores than any other with which he is acquainted. Having ascertained the proportion to be used, he set about the casting of the



Speculum. The difficulties attending this process were such, that instead of having the Reflector, which was to be three feet in diameter, in one piece, he tried the expedient of casting it in sixteen separate portions: the Mirror, when entire, presenting the form and appearance of figure 1. When cast,

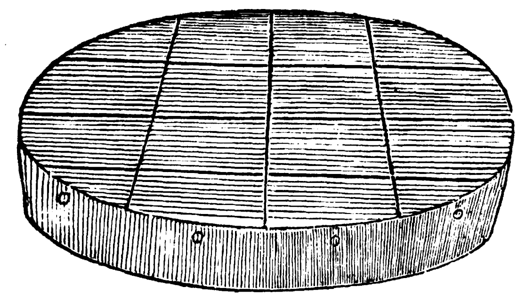


Fig. 1.

the pieces were fixed on a bed composed of zinc and copper —a species of brass, mixed in the proportion, copper 2-75, zinc 1—which expanded in the same degree by heat, as the pieces of the Speculum themselves; they were then ground, as one body, to a true surface, and, when polished, were found to answer remarkably well. The particulars in the manufacture of this compound Speculum requiring attention; are, First.—The method employed to find the quantity of zinc and copper which would, when mixed, expand in the same degree, as the Speculum itself. Secondly.—The form into which the brass was made. Thirdly.—The manner in which the Speculum was joined to the bed. Fourthly.—The method in which the pieces were cast. And Fifthly.—The grinding and polishing.

In order to find the proportion of the zinc and copper, a bar of the Speculum metal, fifteen inches long, and one and a quarter thick, was joined accurately, to a bar of the brass of the same length, but only three-quarters of an inch thick; they were then placed in a vessel of water, whose temperature was lowered to 32 degrees F. and a fine hair line drawn evenly and continuously across both; the temperâture of the water was then raised to 212 degrees, and, during the expansion, the line was examined with a microscope; when it remained perfectly strait across both Speculum metal and brass, it was evident that they had equally expanded, and that the desired compound had been attained. There was much difficulty experienced in the melting of the brass, as the zinc being volatile, it was in less quantity after this operation than before it, and the loss it sustained was not



always the same. After many endeavours to remedy this defect, it was found that a certain result was obtained, by spreading over the metal a layer of powdered charcoal, two inches in thickness; the loss sustained was always, in this case, constant, and amounted to $\frac{1}{180}$th of the zinc employed.

The bed was cast in eight pieces, each being of the shape of figure 2, which is seen in reverse. The depth of the bed

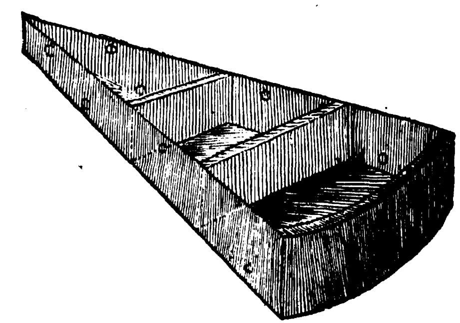


Fig. 2.

was five inches and a-half, and it weighed four hundred and fifty pounds. The eight portions were soldered together along the sides, and iron bolts used to secure the joinings more perfectly. However, it was found, when the Speculum was fastened on, that the joints had given in different places, as was evident by the effects produced in using the Telescope. The Speculum was therefore, taken off, and the following device, technically termed "burning," was had recourse to. The entire brass work was imbedded in sand, and covered to the depth of three inches. Down to the centre was bored a hole, one inch and a-half in diameter; and into this, from a height of ten inches, was poured a stream of melted brass, similar in composition to that of which the bed was composed, till forty-five pounds had overflowed the surface of the sand. This operation was repeated in thirty-four different places on the combined edges of the portions of the brass bed. The constant heat kept up by the stream on these parts, fused the metal, which contracted on cooling, and united them perfectly in these situations. The other surface of the bed was attempted to be managed in the same way, but the process failed here; some of the brass was therefore chiselled out of the necessary points, and more melted in, which contracted when cool, and fully answered the desired end.

When it was found that the joinings were now secure, the Speculum metal and bed were again soldered together;



this, however, was no easy matter, and gave rise at first to much annoyance and loss of time. It was attempted to solder them by tinning the brass bed, and placing the Speculum on this with resin interposed, then raising the temperature, and using slight pressure when the tin and resin were fused. However, the latter becoming decomposed during the elevation of the temperature effectually prevented any union taking place.—Sal Ammoniac was tried with no better success. The process was therefore modified, and the junction of the metals was accomplished in the following manner.

The pieces of the Speculum metal being ground by the hand to fit the brass bed, they were scraped on one side with hard steel chisels, no spot being left untouched, and made perfectly dry—the brass was also scraped and tinned, and all the resin washed off with turpentine, and afterwards, with soap and water. The Speculum was then laid on the brass, and both were placed in an oven with an iron bottom, and supported on bricks. When the tin was fused, which was effected in eight hours, by a gradually raised temperature, melted resin and tin were poured in between the plates, and they were moved gently backwards and forwards. The fire was withdrawn when the tin commenced acting on the Speculum, and the pieces being settled into the places where they were to remain, $\frac{1}{20}$th of an inch apart, all was allowed to cool gradually, and in five days it was ready to be ground.

The casting of a Speculum, and its preservation from breaking when cooling, has always been found a matter of the greatest difficulty. The compound is so exceedingly brittle that any sudden change of temperature is likely to destroy it; and it requires to be so free from pores, that unless great care is taken to give exit to all the air contained in the melted metal before setting, it is rendered useless. In casting the pieces of the compound Speculum, Lord Rosse first tried the plan recommended by Mr. Edwards, making the mould in sand, but the Speculum was almost always full of flaws, and generally flew in pieces when setting; on attempting to put the parts together again, it was found that they no longer fitted in their places. It was evident, from this circumstance, that they must have undergone some great strain; and it was judged that this had been produced by the unequal cooling of the different portions



—the edges becoming solid first, left the centre fluid, and this being, when about to set, unable to contract, was strained when no longer ductile. The failures in this way were so frequent, that another plan was tried, which was this:—A number of equidistant plates of iron were placed in a crucible with the fluid Speculum metal, under the idea that it would be divided, when solid, into an equal number of Specula. But this plan had no success at all; the plates were always full of flaws.

The next attempt was much more encouraging; a block of the Speculum metal was cut into plates by a circular sawing machine, the blades of which were of soft iron, kept constantly wetted with emery and water. This process gave pieces that were entirely free from flaws; however, the texture was not perfectly uniform throughout, for, near the circumference, the arrangement of the particles was not just the same as in the other parts, so that it was feared that a good Speculum would not be formed. It has, however, never been sufficiently well tried; another method having been discovered before this was fairly tested. This process which has deservedly stamped Lord Rosse's name with celebrity, and reduced the casting of Specula to a certainty, is, perhaps, the most deserving of praise of all his Lordship's works. The simplicity of the contrivance, probably at first sight, makes it appear a result of no great wonder: but, like the plan pursued by Columbus, to make the egg stand, it is only easy when known. It has been stated, that the chief conditions, so hard to be attained in the manufacture of Specula; are, First—Certainty of not breaking in cooling; and, Secondly—a freedom from pores, if it has been so fortunate as to escape the first. Now we saw that the mould of sand did not fulfil the first intention, from the unequal contraction the metal suffered when cooling; on this account a mould was made of cast iron, in the hope that its high conducting power would lower the temperature of the bottom portions of the fluid metal first, and, abstracting the heat much more quickly than it could escape from the surface, it would cool the metal gradually towards the top, and, in this manner, prevent any part of it being strained. In order to keep the under surface of the mould at a low temperature, a jet of cold water was made to play on it



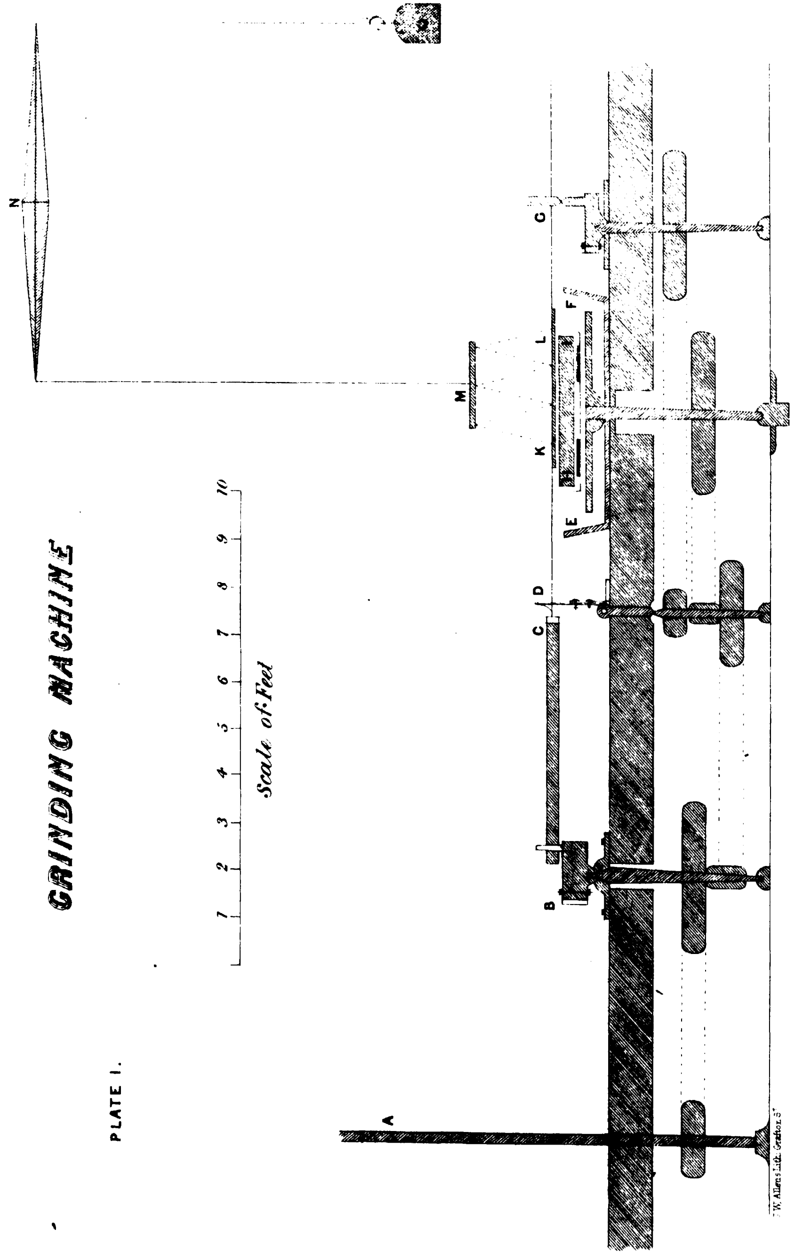
while the Speculum metal was cooling; but, unfortunately, the cold water almost always cracked the mould, and, of course, the casting was destroyed when this occurred before solidity had taken place. This plan was therefore, also, unsuccessful. It was then attempted to procure a perfect casting, by making a mould having the sides of sand and the bottom of iron, and using no jet of cold water. This was so far successful, that it answered the purpose for which it was intended; that is, cooling the metal gradually from the bottom, and preventing any flaws or breaking; but the air, not having the porous sand beneath to give it exit, lodged between the mould and the iron bottom, and formed large holes which rendered it useless. Now the great object to be attained was, to find some way of allowing the air to escape, but still to retain the iron bottom. In effecting this consists the great improvement in casting Specula, without which, the magnificent instruments Lord Rosse now possesses would never have been in existence.

Instead of the bottom of the mould being of solid cast iron, it was made by binding together tightly layers of hoop-iron, and turning the required shape on them edgewise. This mould fulfilled all the requisite intentions. The iron shape conducted the heat away through the bottom, and cooled the metal towards the top in infinitely small layers, while the interstices, though close enough to prevent the metal escaping, were sufficiently open to allow the air to penetrate. The next casting was perfect, and in all succeeding trials the results have continued to be successful. The shape requires to be perfectly dry before being used, and is heated to 212 degrees F. without impairing its cooling power. It must be of sufficient thickness to conduct rapidly; never being thinner than the Speculum to be cast. The metal entered the mould by the side, as rapidly as possible; and, before being cast, was heated until, when stirred with a wooden pole, the carbon reduced the oxide on the top, and produced a clear and brilliant surface. Immediately, on becoming solid, it was removed to an annealing oven, and cooled slowly. A plate nine inches in diameter, requires three or four days to anneal. We will here notice a circumstance worthy the attention of those who may be in future engaged in a similar attempt to his Lordship's.—In melting the metal it was found that,



when fluid, it oozed through the bottom of the cast iron crucible employed to contain it. The imperfect part was cut out, and the hole stopped by a wrought iron screw. This, however, was ineffectual, as other parts of the bottom were alike defective; and, it having been discovered that the porosity of the crucible resulted from the fact of its being cast with the face downwards, which caused the small bubbles of air to lodge in the then highest part, Lord Rosse had some cast in a contrary direction in his own laboratory, and obtained vessels perfectly secure and staunch.

In the melting of the metal, turf fires were found sufficiently good, without being strong enough to endanger the crucibles, and they were more steady than those produced by coke. The process by which the plates were soldered to the brass bed has been already described; and to complete the history of the compound Speculum, we have now to notice the grinding and polishing. Before this, however, we may remark that the porous iron bed above described, gave, in so many trials, such perfect results, that a Speculum, three feet in diameter, was cast in one piece, and went through all the steps of casting, cooling, &c. with success. There was no difference in the manipulation of this and the compound Speculum, except, of course, that it did not require any brass bed to be soldered to; it was cast in an open mould, and was allowed time in proportion to its size to anneal. It is this three foot Speculum that is at present in the Telescope erected in his Lordship's lawn; the machinery of which will be described further on. It was not, however, chosen for this situation on account of its superiority over the compound Speculum, as there could be scarcely any difference found to exist between them: there is, however, a slight diffraction of light, caused by the edges of the pieces of the latter, but it does not interfere to such a degree with its performance as to be taken into account. The processes of grinding and polishing were precisely similar in the case of each, and the machinery was the same. We premise that the moving power employed was a steam engine of three horse power, which was also made use of for many of the other processes connected with the manufacture: one horse power is sufficient for grinding. The several parts of the ma-






chinery are connected by bands of leather in place of toothed wheels, which would be more liable to accident.

Specula used before the existence of these we are describing, to be polished with the hand, and were subject to the greatest uncertainty of result. The shape on which they were worked was placed on a support, so that the manipulator might move round it. The Speculum was then ground down by rubbing it backward and forward, and, at the same time, getting a sort of circular motion from the movements of the operator round the support. The process was laborious, and not to be depended on. The velocity with which the hand moved varied constantly—the temperature was never regulated, and the pressure on the several parts of the surface was not the same.

In order to get rid of these defects, and, if possible, to produce a surer and better result, Lord Rosse invented his machine for grinding. A sketch of this is seen in plate 1, copied from the Philosophical Transactions for 1840.—A is a shaft connected with the Steam Engine; B an eccentric adjustable by a screw-bolt to any given length, from 0, to eighteen inches; C a joint; D a guide; E F a cistern for water, in which the Speculum revolves; G another eccentric adjustable, like the first, to any length of stroke, from 0, to eighteen inches. The bar D G passes through a slit, and therefore the pin at G necessarily turns on its axis at the same time, as the eccentric H I is the Speculum in its box, immersed in water to within an inch of its surface, and K L the polisher, which is of cast iron, and weighs about two hundred and a-half. M is a round disk of wood, connected with the polisher, by strings hooked to it in six places, each two-third of the radius from its centre. At M there is a swivel and hook, to which a rope is attached; connecting the whole with the lever N, so that the polisher presses on the Speculum, with a force equal to the difference between its own weight and that of the counterpoise O.

The Polisher is connected with the machinery, by means of a large ring of iron, which loosely encircles it, ending in the bars which run through G and D. The wheel work underneath the table, shows the manner in which the polishing goes on. Instead of either the Speculum or the polisher



being stationary, both move with a regulated speed; the ring of the polisher, and therefore the polisher itself, has a transverse and a longitudinal motion; it makes eighty strokes in the minute, and twenty-four strokes and a-half backward and forward, for every revolution of the mirror, and at the same time, $1\frac{72}{100}$ strokes in the transverse direction. The extent of the latter is, $\frac{27}{100}$ of the diameter of the Speculum. The polisher has another motion independent of the ring, for at the turn of the eccentric, being for a little time free, it is carried for a short distance round, lying on the Speculum. In this way, it makes one revolution for every fifteen of the mirror. The peculiarities of this mechanism, are, 1st. the mechanism itself, as before this was used it was not thought possible to grind by machinery,—2nd. placing the Speculum with the face upward,—3rd. regulating the temperature, by having it immersed in water, which is usually at 55 degrees F.—4th. regulating the pressure, and velocity. The pressure allowed to be exerted on a three-foot Speculum, is ten pounds. The improvements effected in grinding and polishing mirrors by this machine are wonderfully great; and like all the other improvements invented by Lord

Rosse, are the result of close calculation and observation. We are indebted to his powers of reasoning for all his works, and have to thank the blind goddess, Chance, for none. She is indeed so little enamoured of his Lordship that when she visits him at all, which is seldom, she appears in the shape of failure.

The following quotation from Lord Rosse's publication, in the Philosophical Transactions, will enable us to understand the theory of the Machine:—"Having observed that when the extent of the motions of the polishing machine were in certain proportions to the diameter of the Speculum, its focal length gradually and regularly increased, that fact suggested another mode of working an approximate parabolic figure. If we suppose a spherical surface, under the operation of grinding and polishing, gradually to change into one of longer radius, it is very evident that, during that change, at no one instant of time will it be actually spherical and the abrasion of the metal will be more rapid at each point as it is more distant from the centre of the *face*. When, however, the focal length neither increases nor diminishes, the abrasion will become uniform over the whole



surface producing a spherical figure. According, however, as the focal length (the actual average amount of abrasion during a given time being given) increases more or less rapidly, the nature of the curve will vary, and we might conceive it possible, having it in one power completely to control the rate at which the focal length increases, so to proportion the rate of that increase, as to produce a surface approximating to that of the paraboloid. Of course the chances against obtaining an exact paraboloid are infinitely great, as an infinite number of curves may pass between the parabola and its circle of curvature, and it is vain to look for a guide in searching for the proper one in calculations founded on the principles of exact science, as the effect of friction in polishing is not conformable to any known law; still from a number of experiments it might be possible to deduce an empirical formula practically valuable: this I have endeavoured to accomplish."

The grinding of the Speculum to the proper figure then depends on the relative velocities of the different parts, as before stated. The substance made use of to wear down the surface was emery and water; a constant supply of these was kept between the grinder and the Speculum. The Grinder is made of cast iron, with grooves cut lengthways, across, and circularly, on its face; there are twenty-five grooves, crossed by as many more, which are quarter of an inch wide, and half an inch deep. The circular grooves, of which there are thirteen concentric with the polisher, are three-eighths of an inch deep, and quarter of an inch wide. The polisher and speculum have a mutual action on each other; in a few hours, by the help of the emery and water, they are both ground truly circular, whatever might have been their previous defects. The grinding is continued until the required form of surface is produced, and this is ascertained in the following manner. There is a high tower over the house in which the Speculum is ground, on the top of this is fixed a pole, to which is attached the dial of a watch; there are trap doors which open, and, by means of a temporary eye-piece, at the calculated distance, allow the figure of the dial to be seen in the Speculum brought to a slight polish. If the dots on the dial are not sufficiently well defined the grinding is continued; but if it works satisfactorily, the polishing is



commenced. This process, like the others, was in the beginning attended with much difficulty and annoyance. To polish Specula, the same tool which grinds them is covered with a layer of pitch, and on this is spread either putty or oxide of tin, as used by Newton, or oxide of iron, commonly called rouge, as used by Lord Rosse.

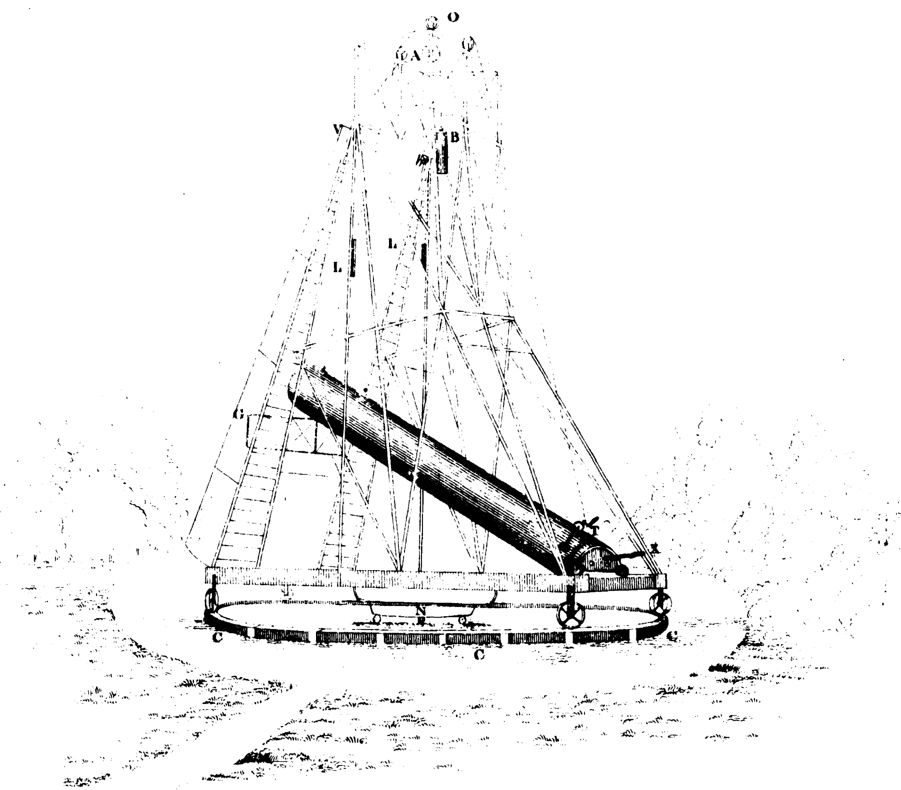
Now, in trying to polish the three foot Speculum it was found that the pitch, which should be spread in a thin layer and very evenly over the surface, collected the abraded matter in some places more than in others, and of course, lost its required shape.

If the pitch expanded laterally, so as to fit itself again to the Speculum, all would have gone on well; but, unfortunately, this could not take place unless the layer was made a great deal thicker than it could be satisfactorily used. In polishing small mirrors a thin layer could expand sufficiently laterally, on account of the small extent of its surface; but experience proved that the thickness of the layer should increase with the size of the Speculum, until, setting out from the depth of half-a-crown, which is requisite for a very small mirror, it would come to an unmanageable size before it reached that sufficient for one three feet in diameter. In order to get over this difficulty, and make room for the pitch to expand without increasing its thickness, it was cut into grooves along the surface with decided advantage, but the furrows filled up in a short time again, and it became, of course, as it was in the beginning, and the same impediment occurred. When this failed it was thought that if the polisher itself was cut into grooves it must have the desired effect, and the result proved the conjecture to be correct. The pitch might then be reduced to a very thin layer, being in the condition of a number of very small polishers united together, and the lateral expansion being allowed for, without danger of filling up the grooves, the polishing proceeded in a most satisfactory manner. However, it was not yet perfect. It requires for the production of a true surface, that the pitch should always be in general contact with the Speculum, and it should be as hard as possible, consistent with allowing the rouge to imbed itself in it. The first condition is easily satisfied, by the grooves above described, provided the pitch be



soft enough to expand; but if this be the case, it would be too soft for producing the true surface; therefore, to allow of the expansion, and at the same time, have the pitch very hard, Lord Rosse first spread over the tool a layer of soft, and then one of hard resin—which he preferred to pitch, on account of the gritty impurities of the latter—and combined both qualities in one. The manner in which the resin was prepared to be substituted for pitch was this: a large quantity was melted, and spirits of turpentine, about one-fifth of its weight, was poured in, and both well mixed together; —an iron rod dipped into this mixture, brought up a little, and allowed its temper to be tried;—after being cooled in water at 55 degrees, if the thumb nail made a slight but well marked impression the materials were mixed in proper proportions. This was then divided into two parts, so as to make the hard and the soft layer. For the first, quarter the quantity of wheaten flour was mixed with one part, and boiled until the water of the flour was expelled, and the mixture became clear—some of the turpentine was also driven off. There was then added an equal quantity of resin. This was sufficiently hard for the upper layer. The flour increases

PLATE II.




*The Machinery of the Telescope with the 3 Foot Speculum*



to which the resin was regulated at first. The length of time required for polishing was six hours. When this was completed it was supported on an equilibrium bed; that is, three iron plates, each being one-third of a circular area, which joined together made up a disc of the same size as the Speculum itself; these rest in the Speculum box on points at their centres of gravity, so that no flexure of the wood can affect the mirror. Plate 2 is a sketch of the machinery by which the Telescope is suspended and worked. The tube is twenty-six feet long;—the focal distance of the Speculum being twenty-five—the whole machinery is supported on four wheels, which run on the iron circle C C C. This circle is thirty feet in diameter, and is graduated and marked with the cardinal points. The pivot on which the machinery turns ,passes through a beam of wood, N which is fastened to the under part of the large cross beam. It is about four inches from the ground; through one end run two screws, which by being turned have, when pressed downwards, a tendency to raise the beam at that end; there is a lever imbedded in the earth with its long arm loaded, the short one pressing up against the other end of the beam N, so that the whole machinery is counterpoised to any required extent, and the weight on the wheels which run on the circle is reduced to such a degree that the instrument can be turned round to any position with the greatest ease. Across the end of the tube is fixed an axle, P, to which a small wheel is attached on either side, these run along a railway when the tube is elevated or depressed. The tube itself is counterpoised by the weight B hanging over the pulley A. In order to raise or depress it, a small wheel and axle T is fixed to one end, a rope runs from this over the top wheel O, and is joined to the other end; when the rope is wound round the axle, of course, the free end of the Telescope is raised. Instead, however, of the rope ending at the free extremity by being fixed immediately to the tube, it meets and is fastened to a smaller rope which runs through a pulley on the end of it; one extremity of this small rope is fastened to the tube, and is as it were a continuation of the large one; the other extremity is wound round a small wheel and axle which is situated near the eye-piece, so



that the observer is able, by shortening or lengthening this, to raise or depress the tube for short distances. The gallery G is supported on the step of the ladder by a catch, and is counterpoised by the weights L L hanging over the pulleys V V. It is of course, raised and lowered with the tube. X is a lever attached to the Speculum box for opening it: a vessel of lime is kept in the box for absorbing all the moisture which might tarnish the mirror. The working of this instrument is most satisfactory; the double stars are delineated with great brilliancy and some of the Nebulœ have been resolved in a more perfect manner than had previously been accomplished by any other Telescope. The great difference of appearance which these Nebulœ present when viewed in this instrument compared with the published plates of Sir J. Herschell is quite conclusive as to its great superiority. It certainly was the finest instrument in the world until it was surpassed and even thrown into comparative insignificance by the Speculum, six feet in diameter, which has arrived at the bounds beyond which the laws of matter forbid human ingenuity to pass, and marks one spot in the circumference of that great circle that defines our powers, which is so seldom reached, and for that reason so little known.

## PART II.

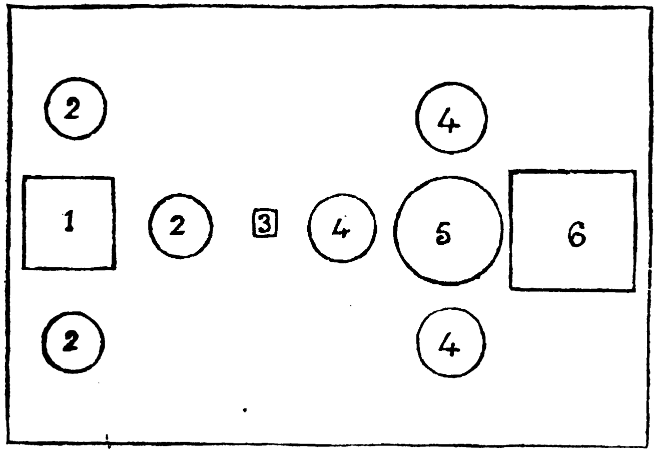
In the account of the three-foot Speculum which Lord Rosse published in the Philosophical Transactions for 1840, he speaks of the possibility of one six feet in diameter being cast. It might at that time have been considered as little less than a chimera by those who were not sufficiently acquainted with the experiments that had been made in his Lordship's laboratory, and there were not wanting some who denied altogether the practicability of the design. Various reasons were given why the attempt should be a failure, and many calculations entered into to prove the little benefit to be derived even supposing a perfect casting were obtained.—But fortunately others thought differently; the idea had no sooner occurred to Lord Rosse than he determined to put it to the test, and we may say, without flattery, that no absurdity was likely to occupy a mind like his. The attempt has been made, and the result is perfect success.

As yet we cannot say how far it may advance our knowledge of the celestial spheres, or help us to understand more fully the mechanism of the universe; but this at all events is certain, that be the advantage great or small, it is the last step that can be taken to enlarge our acquaintance with those distant bodies, and all that is ever likely to be brought before us will now be seen. But although we cannot hope to know more than will be revealed to us by this instrument, we may anticipate a great addition to our present knowledge, and perhaps it may be the means of rendering us as familiar with the secrets of the starry heavens as our finite intellects are capable of understanding.

To describe the processes by which this six foot Speculum was manufactured, would be repeating nearly what we have already said of that, three feet in diameter. The composition of the metal and the manipulation of the casting,



grinding, polishing and annealing, were the same, except of course on a larger scale, and the only alteration which took place was in consequence of its greater size. The foundry however in which the manufacture took place, was constructed expressly for the purpose. There was a chimney built from the ground, six yards high, and five and a-half square at the base, tapering to four feet at the top: it was rectangular. At each of three of its sides communicating with it by a flue, was sunk a furnace eight feet deep, (not including the ashpit, which was two,) and five and a-half feet square, with a circular opening four feet in diameter; they were lined with brick. About seven feet from the chimney was erected a large crane with the necessary tackle for elevating and carrying the crucibles from the furnace to the mould, which was placed in a line with the chimney and crane, and had three iron baskets supported on pivots hung round it. Four feet further on in the same line was the annealing oven—Figure 3 is a ground plan of the whole,—1 is the chimney; 2 2 2 the furnaces; 3 the crane; 4 4 4 the iron baskets; 5 the mould, and 6 the oven. The crucibles which contained the metal, were each two feet in diameter, two and a-half feet deep, and together weighed one ton and a-half; they were of cast-iron, and made to fit the baskets at




[The oven is placed too near the mould in the Figure.]

**Fig. 3.**

the side of the mould; these baskets were hung on wooden uprights on pivots; to one of these on each side, was attached a lever, by depressing which it might be turned over, and the contents of the crucible poured into the mould. It has already been described how the bottom of the mould is made, by packing together layers of hoop-iron, on which the certainty of the safety of the



Speculum depends. This bottom, which is six feet in diameter, and five inches and a-half thick, was made perfectly horizontal, by means of spirit levels, and was surrounded by a wooden frame; a wooden pattern, the exact size of the Speculum, being placed on the iron, sand was well packed between it and the frame, and the pattern was removed. Each of the crucibles containing the melted metal was then placed in its basket, and every thing being ready for discharging their contents, they were at the same instant turned over, and the mould being filled, the metal in a short time safely set into the required figure. While it was red hot, and scarcely solid, the frame work was removed, and an iron ring connected with a bar which passed through the oven, being placed round it, it was drawn in by means of a capstan at the other side, on a railroad, when, charcoal being lighted in the oven and turf fires underneath it, all the openings were built up and it was left for sixteen weeks to anneal. It was cast on the 13th of April, 1842, at 9 o'Clock in the evening. The crucibles were ten hours heating in the furnaces before the metal was introduced, which in about ten hours more was sufficiently fluid to be poured. When the oven was opened the Speculum was found as perfect as when it entered it. It was then removed to the grinding machine, where it underwent that process, and afterwards was polished without any accident having occurred. It weighed three tons, and lost about one-eighth of an inch in grinding. Lord Rosse has since cast another Speculum of the same diameter, four tons in weight. He can now, with perfect confidence, undertake any casting, so great an improvement has the form of mould which he has invented proved. This Speculum was placed on an equilibrium bed, in the same manner as the smaller one; it is, however, composed of nine pieces instead of three, resting on points at their centres of gravity; the pieces were lined with pitch and felt before the Speculum was placed on them. The Speculum box is also lined with felt, and pitched; this prevents any sudden change of temperature affecting the Speculum, by means of the bad conducting power of the substances employed. A vessel of lime is kept in connexion with the Speculum box to absorb the moisture, which otherwise might injure the mirror.



The Frontispiece is a perspective view of the machinery, by which the great Telescope is worked. The tube is fifty-six feet long, including the Speculum box, and is made of deal, one inch thick, hooped with iron. On the inside, at intervals of eight feet, there are rings of iron three inches in depth, and one inch broad, for the purpose of strengthening the sides. The diameter of the tube is seven feet. It is fixed to mason work, in the ground, by a large universal hinge which allows it to turn in all directions. At each side of it, at twelve feet distance, a wall is built which is seventy-two feet long, forty-eight feet high on the outer side, and fifty-six on the inner; the walls are thus twenty-four feet apart, and they lie exactly in the meridional line. The fixed end of the Telescope is in the centre of the enclosed space, and the free end turns round to either extremity, looking north or south as required. When directed to the south, the tube may be lowered till it becomes almost horizontal, but when pointed to the north it only falls until it is parallel with the earth's axis, pointing then to the pole of the heavens; a lower position would be useless, for as all celestial objects circumscribe that point, they will come into view above and about it. Its lateral movements take place only from wall to wall, and this commands a view for half-an-hour at each side of the meridian. With so large an instrument the most favourable circumstances must be combined, to allow of its being used with success; and as all bodies in the heavens are seen more perfectly when on or near the meridian, it was thought quite sufficient to have them for one hour in the field of view in their most manageable situation, and as they must also of course pass the meridian, nothing is lost by this limited range of the Telescope. There is a chain connected with that part of the tube which is uppermost when it points to the south, that runs over a pulley in a truss-beam at the northern end of the wall, and is wound round an axle on the ground. This elevates and turns the tube to the north. A beam of wood, twenty-five feet long, is hinged at one end to the mason work, which supports the large universal joint on which the tube moves; this is loaded at the other end by a weight, and from that is joined to the tube by a chain thirty-five feet long. It is so managed that when



the tube has reached its perpendicular position, the weight which is on a cross-beam is at its fullest extent from the tube, and as the tube continues to move towards the north this weight is raised, forming an angle with the horizon. From each side of the tube runs a chain, which passes round a pulley fastened to the wall, but which can turn on a pivot to suit itself to the different situations of the tube; the chain then runs under another pulley which is stationary, and ends by suspending a weight, which is thus a counterpoise to the tube. This weight on either side is also fastened to a chain, which hangs from a truss-beam at the northern extremity of the wall: when the tube is pointed towards the south, the weights hang on the chains which run from its sides over the pulleys, and so have a tendency to elevate it; but as it reaches the perpendicular, these weights are prevented sinking down in a straight line by the other chains which are fixed to the beam, and which, always continuing the same length, draw them out towards the extremity of the wall until they hang altogether on themselves, and exert no force at all on the chains which are connected with the tube: when this passes the perpendicular towards the north, the weights are again drawn back, and begin once more to counterpoise it.

Plate 3 will explain more clearly the different parts we have been attempting to describe. It is a view of the inside of the eastern wall, with all the machinery seen in section. A is the mason work in the ground; B the universal joint, which allows the tube to turn in all directions; C the speculum in its box; D the tube; E the eye-piece; F the moveable pulley; G the fixed one; H the chain from the side of the tube; I the chain from the beam; K the counterpoise; L the lever; M the chain connecting it with the tube; Z the chain which passes from the tube to the windlass over a pulley on a truss-beam, which runs from W to the same situation in the opposite wall—the pulley is not seen; X is a rail-road on which the Speculum is drawn either to or from its box—part is cut away to show the counterpoise. The dotted line, a, represents the course of the weight R as the tube rises or falls; it is a segment of a circle of which the chain I is the radius.

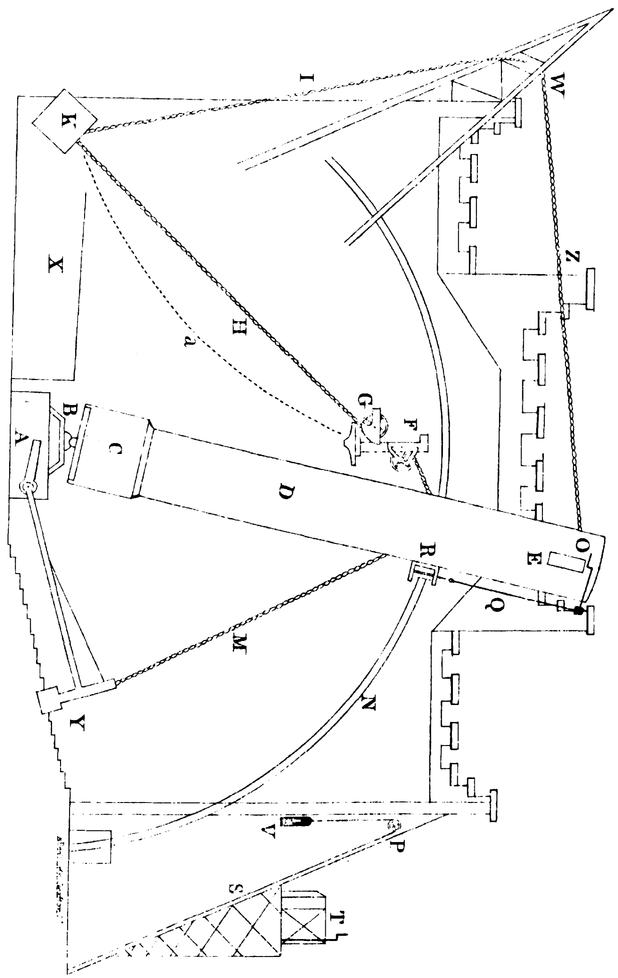



PLATE 3.

With a little attention to these several points, the working of the machinery, we think, will be easily comprehended. The weight on the lever L sinks only fifteen feet under the horizontal position, it then rests on the ground, and is, of course, no load on the tube, which is, when this happens, 30° above the horizon. Below this point the tube is sufficiently heavy to descend when the windlass unrolls the chain. Then suppose the tube makes the angle of 30° with the horizon, and that it is required to elevate it, the windlass is turned, and the chain being shortened, the desired effect is produced; but the labour of this would be immense, if the counterpoise K did not assist: this nearly balancing the tube, leaves but little exertion to be made at the windlass. However, the weight of the tube according as it ascends, is gradually becoming less and less, until it produces no strain at all on the windlass when it is quite upright. This must evidently be the case from the first principles of mechanics; for making the tube a lever, the length of its arm continually decreases as it approaches the perpendicular: therefore, if the counterpoise continued the same weight on the tube towards the end as it was in the commencement of the ascent, it would be too heavy, and would keep it in its perpendicular position. In fact, the counterpoise must become lighter as gradually and as evenly as the tube itself, in order to continue to be just the same support to it all through its movement. The plan adopted to effect this is beautifully simple: a weight hanging freely in a perpendicular direction, exerts its greatest force on the suspending point; if it be moved from the perpendicular, as much power as is required to effect this, is taken off from the same point; as will be evident to any person pushing aside a hanging body, he must supply a certain degree of force to keep it out of its perpendicular position; and this might be mathematically proved to amount to exactly the degree of weight that is taken off the point from which the body hangs. Now, from Plate 3 it will be at once seen, how, when the tube is ascending and loosing its weight, also lengthening the chain H, that on account of the chain I, whose length is always constant, the counterpoise K is moving from the perpendicular position under G. and, therefore, loos-



ing its power on the tube, and approaching the perpendicular under W, and for this reason, transferring all its weight to the fixed chain I: when the tube passes the perpendicular, the chain H is again shortened, and the counterpoise begins once more to draw it back, so that the action of this tends to keep the tube always upright to whatever side it may point, and its power is always equal to the varying weight. Under these circumstances we see how easily and evenly the windlass can elevate the Telescope, and turn it to the north; but when it arrives there it must be brought back again; and this is accomplished by the lever L. As we have seen that the action of the tube and counterpoise is so regulated, that, in all positions the weights although always changing are equal to one another, so must the weight of the lever vary with its position in order to be a perfect balance on the tube; and this it evidently does. We said that when the tube was perpendicular, the weight on the lever is most effective; for it is at the farthest distance it can be from the support; it therefore, pulls down the tube when the windlass is unrolled; but we saw that the tube as it descends increases its weight; so that if the lever continued acting with the same power with which it commenced, the weight of both would be constantly increasing: this is prevented by the lever loosing its force as it falls; for the weight thereby, of course, approaches the support and cannot be so active: but the approach to the support by its descent is so regulated to the increasing distance of the end of the tube in *its* descent by the chain M, that in the same degree as the latter gains weight the former looses it; and in this manner there is a constant equilibrium kept up between them. When the tube reaches within 30° of the horizon the lever rests on the ground, and the tube is thence able to descend by its own weight. When the tube points to the north, the lever is elevated above the horizon, and has not, of course, so much power as when it coincided with it; but it is in this case helped by the counterpoise K, which always tends to bring the tube to the perpendicular. This continues to help it until it becomes itself sufficiently able, from its horizontal position, to do all the work; it then commences opposing it, but it now



has the help of the increasing weight of the tube itself, and so all the parts are elegantly blended into one another with the most perfect concord and efficiency.

We have only yet described how the tube is elevated and depressed. The manner in which it is moved from side to side is this: there is a cast iron circle fixed to the eastern wall, marked N in Plate 3; from this nearly to the other wall there runs a wooden pole, about three inches by two in depth and breadth, through an iron bed R, which is fastened to the tube. On the face of this is a rachet in which plays a wheel connected with the rod Q. The handle O is terminated by an endless screw, which works into a toothed wheel on the top of the rod Q; therefore, it is evident, that by turning the handle O the rod Q is also turned; this makes the wheel at R work on the rachet, and as the end of this rachet is fixed to the iron circle N, the tube must move either to or from it, according to the direction in which the handle is made to revolve. This is done with the greatest ease by the observer. The end of the rachet connected with the iron circle moves along it as the tube is elevated or depressed. There is a universal joint at Q, which allows the wheel and rachet to be used with great freedom, as it prevents any stiffness in the rod. By these contrivances the Telescope can be moved in any direction, and it is admirable with what very little effort it can be adjusted to any required place. It is kept quite firmly fixed in any situation by the rachet and wheel—not the least tremor being perceptible in its working. It is fitted up in a temporary way to be used as a transit instrument; for the piece of wood which stretches from wall to wall, along which the rachet runs, is graduated so as to mark right ascensions, and there is fixed to the Speculum box a quadrant with a moveable radius, along the upper surface of which is a spirit level; this being made horizontal, shows the angle at which the Telescope is placed and points out the declination. The scale for giving the right ascension is marked to lengths of a minute at the equator, which is 2-22 inches.

We will now show how the observer is to follow the tube, and be able to make use of it in all its different situations. The perspective view will enable the reader to comprehend the general plan. The gallery which



stretches from ladder to ladder in front, is moved up and down with the Telescope; it is counterpoised by the weights which hang on the wall; a chain passes from each weight under ground, and being joined together, end at the windlass at the side of the wall. This raises and lowers the gallery, by means of which the observer follows the tube as far as the ladders allow him. In Plate 3 the gallery and box are seen in section. S is the gallery; T the box; V the counterpoise hanging over the pulley by the chain which runs under ground to meet that from the opposite side and be continued to the windlass. On a railing on the top of this gallery is the box in which the observer is situated; one of the wheels on which it runs, that on the right hand corner, is toothed on the side; into this plays a smaller one, which is turned by a handle which reaches as high as the top of the side of the box, and this moves it from end to end of the gallery. The ease with which the observer can wheel himself, and as many as can stand in the box, is surprising. It requires no more effort than would be necessary to lift a pound weight from the ground. However the wheels being so regulated as to need so small an exertion to produce effect, of course lose in velocity what they gain in power: but a slow motion is all that is required.

In order to keep up to the tube in its progress when it passes the height to which the ladders rise, the galleries on the western wall are constructed; they may be entered either by a stairs on the outside of the wall, or directly from the box on the ladder when this is at its greatest height. Nothing would be simpler than to construct a gallery extending along the top of the wall from end to end, but the Telescope having to move twenty-four feet from it, and the galleries having to follow, made the consideration of the method to be adopted a matter of some moment. The plan pursued is this: there are three galleries, which, when joined together, make up a segment of the circle which the tube in its motion describes; therefore, by walking along this, the observer follows the tube from south to north. The middle gallery is twenty-six feet long, and the side ones twenty each. One is seen in Figure 4. A is the gallery; B is a paralelogram, formed by wooden beams thirty-two feet long, more than sufficient



to reach from wall to wall; on the top and bottom of the side beams is an iron rail for the purpose of allowing them to run easily between the wheels C C; when it is

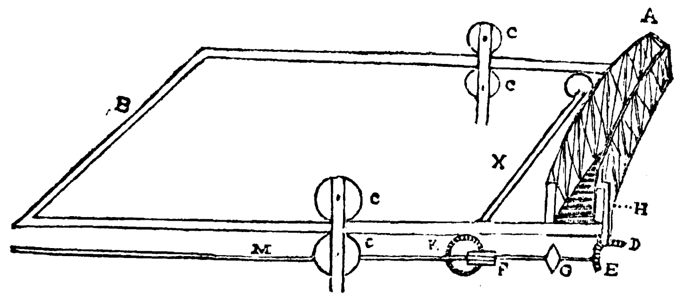



Fig. 4.

required to move the gallery, the handle H is turned; this, by means of the wheel D working in E, turns the tooth wheel F, which makes K revolve. K is connected by the axle X, with a similar wheel at the opposite side, which is thus made revolve also. In each axle of the side galleries there are two universal joints, which allow the wheels to remain perpendicular while the axle is inclined; the pressure exerted on these wheels prevent them moving without at the same time carrying the galleries backward or forward according to the direction in which the handle turns. The wheels C C revolve as the beams pass between them. They are not connected with the handle, but are merely friction wheels, and they keep the gallery in its proper place, preventing it overbalancing when brought out from the wall. Before being used the galleries were wheeled out to their fullest extent, and loaded with a weight equal to that of twelve men,—which number each gallery can contain,—and were found perfectly secure and steady. The spring F on the rod M makes the galleries move with much more smoothness than they could do without it; when the handle is turned to bring them from the wall, the spring is first stretched and makes half a round, the gallery moving as far as the spring expands; the spring then closes, and brings on the iron rod with it through the wheel F; this is repeated, and the motion is scarcely felt, at the same time that it is quick enough for all its purposes; and the gallery when fully loaded might be moved by the hand of a child. The three galleries are managed in the same way, and answer their end exceedingly well. The magnifying power of the Speculum is so great, that objects pass from the field



of view in a very short time, so that it is necessary to follow them by moving the Telescope in their direction; this is for the present accomplished by turning the handle H; it allows them to be examined for some time. But there is intended to be machinery connected with the tube and galleries which will give an automaton movement to all, so that the Telescope may be used as an equitorial: as yet there is no appearance of this, but we believe, that before a twelvemonth it will be completed. There is no other machinery at present connected with the Telescope. All the purposes are fulfilled amply, by what has been already spoken of; the mechanism is exceedingly simple, and uncomplicated, at the same time that it combines the most perfect arrangement and efficient working of the several parts. The entire is well conceived; and the plan has been carried into effect in a very substantial manner. All the works are of the strongest and safest kind; every part that sustains any weight, or to which any strain is applied, is at least, doubly equal to its task, without appearing cumbrous or out of proportion. All the iron work was cast in Lord Rosse's laboratory, by men instructed by himself; and every part of the machinery of every description, was made under his own eye, by the artizans in his own neighbourhood. There did not a single accident, except one of a trifling nature, occur during the whole proceeding; and the entire design, just as it was planned before being commenced, has been brought, without any material alteration, to a safe and successful termination. The Telescope has been used, and, although under unfavorable circumstances, it promises extraordinary results. The first and most startling proof of its superiority consists in the great quantity of light that is present, even when using eye-glasses of very high magnifying powers. The great difference in this respect between it and the three foot Speculum is most apparent: many appearances before invisible in the moon, have been seen, but of course, not yet examined. Lord Rosse hopes, we believe, to accomplish wonders with the Nebulœ and double stars. The Speculum has already exceeded his expectations; and there is not, we are sure, a single individual who will not be delighted to hear so; not so much at first for the great advance it will give to



Astronomy, and the triumph it secures for Science and mechanical skill, but for the sake of the ingenious contriver himself, whose unwearied perseverance and high talents richly deserve it. With a rank and fortune, and every circumstance that usually unfit men for scientific pursuits, especially for their practical details, if he only encouraged those undertakings in others he would merit our praise; but when we see him, without loosing sight of the duties of his station in society, give up so much time and expend so much money on those pursuits himself, and render not only his name illustrious but his rank more honorable, we must feel sympathy in his successes, and be rejoiced that he has obtained from all quarters the very highest and most flattering encomiums, and that he can now enjoy in the use of his Telescope, the well earned fruits of all his previous labours.

THE END.