

A
DISCOURSE

ON THE

Invention and Improvements

OF THE

REFLECTING TELESCOPE.

DELIVERED AT THE

Anniversary Meeting of the ROYAL SOCIETY,
November 30, 1777.

By Sir JOHN PRINGLE, Baronet,
PRESIDENT.

PUBLISHED AT THEIR REQUEST.



LONDON:

PRINTED FOR THE ROYAL SOCIETY.

MDCCLXXVIII.

DISCUSSION

ON THE

REVISION AND IMPROVEMENTS

OF THE

REFLECTING TELESCOPE

DESCRIBED AT THE

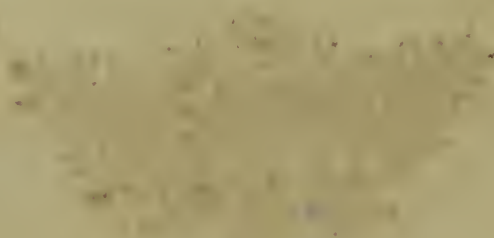
ANNUAL MEETING OF THE ROYAL SOCIETY

HOLDEN AT 1847

BY DR. JOHN HENRIE, F.R.S.

PHILADELPHIA

AND NEW YORK



1847

PRINTED BY J. B. LIPPINCOTT & CO.

PHILADELPHIA



G E N T L E M E N,

IT was with equal truth and modesty observed by our most worthy brother the Reverend Dr. BRADLEY, in his celebrated Paper concerning the apparent motion of the fixed stars and the causes of that deception, *that the great exactness with which instruments are now constructed hath enabled the astronomers of the present age to discover several changes in the position of the heavenly bodies, which, by reason of their smallness, had escaped the notice of their predecessors*^(a). And indeed it was upon this liberal principle, the embracing of every assistance which could be advantageous to their institution, that this Society, from their foundation to this day, have cherished the mechanical arts; nay, have often associated those artists that had invented or perfected instruments eminently conducive to the advancement of natural knowledge.

(a) Phil. Transf, vol. 45.

It is a merit of this kind, I would say a signal mechanical improvement, which your Council have thought proper at this time to distinguish; and they have accordingly empowered me to announce to you, on this day of your annual solemnity, that they have adjudged the prize-medal, founded on the benefaction of Sir GODFREY COPLEY, Baronet, to Mr. JOHN MUDGE of Plymouth, Fellow of this Society, on account of his valuable Paper *containing directions for making the best composition for the metals of reflecting telescopes, together with a description of the process for grinding, polishing, and giving the great speculum the true parabolic form*^(b). Nor do they doubt (conscious as they are of their zeal for the honour of the Society, and of their attention to their duty) of obtaining your wonted approbation, when they shall have laid before you the reasons which moved them to put this mark of distinction upon that communication, amidst a number of others^(c) very deserving of praise.

But before I enter upon those considerations, allow me briefly to recall to your memory some particulars concern-

(b) Phil. Transf. vol. 67. part I.

(c) The encouragement of *experimental* improvements, it may be observed, was the main object of the institution of Sir GODFREY COPLEY's medal.

ing the invention of reflecting telescopes, the subsequent improvements of these instruments, and the state in which Mr. MUDGE found them when he first set about working them to a greater perfection, than was attainable either by the methods which the artificers thought proper to divulge, or the directions that had been given by learned writers on that subject. Thus you will have under your view sufficient materials to judge of the merits of his performance, and of the equity of your Council in decreeing these honours to him.

It must be acknowledged (says Dr. SMITH in his Complete System of Optics) that Mr. JAMES GREGORY of Aberdeen was the first inventor of the reflecting telescope; but his construction is quite different from Sir ISAAC NEWTON's, and not nearly so advantageous^(d).

But, with much deference to so respectable an author, and with all regard to the fame of GREGORY, let us not forget to do justice to MERSENNUS, by acknowledging him to be the man who is entitled to the credit of having entertained the *first* thought of a reflector. A telescope with *specula* he certainly proposed to the celebrated DESCARTES many years before GREGORY's invention, though

(d) Remarks upon Art. 24.

indeed in a manner so very unsatisfactory, that DESCARTES, who had given particular attention to the improvement of the telescope, was so far from approving the proposal, that he endeavoured to convince MERSENNUS of its fallacy^(e). Dr. SMITH, it appears, had never perused the two letters of DESCARTES to MERSENNUS which briefly touch on that subject.

Again, as to his assertion *that* GREGORY'S construction was not nearly so advantageous as NEWTON'S, it may be accounted for from his having set it down early in the composition of his work, and forgetting to qualify it afterwards, when, before the publication, he had received pretty sure information to the contrary. Or perhaps he was influenced by the example of Dr. BRADLEY, who had been a most successful observer, and yet had always preferred the NEWTONIAN telescope to the other. But if long experience is allowed to be the final arbiter in such matters, we must adjudge the superiority to the latter, as that is now, and has been for several years past, the only instrument of the kind in request.

(e) *Lettres de DESCARTES*, tome 2. printed at Paris in 1657, lett. 29. and 32. See this point discussed by two learned and candid authors, M. LE ROI in the *Encyclopedie*, under the article *Telescope*; and M. MONTUCLA in *Hist. des Mathem.* tome 2. p. 643.

GREGORY, a young man of an uncommon genius, was led to the invention, in seeking to correct two imperfections of the common telescope; the first was its too great length, which made it less manageable; the second, the incorrectness of the image. Mathematicians had demonstrated, that a pencil of rays could not be collected in a single point by a spherical lens; and also, that the image transmitted by such a lens would be in some degree incurvated. These inconveniences he believed would be obviated by substituting for the object-glass a metallic speculum, of a parabolic figure, to receive the image, and to reflect it towards a small speculum of the same metal: this again was to return the image to an eye-glass placed behind the great speculum, which for that purpose was to be perforated in its centre. This construction he published in 1663, in his *Optica Promota*, a work which in every respect doth honour to the author. But as GREGORY, as he himself declares, was endowed with no mechanical dexterity, nor could find any workman capable of realizing his invention, after some fruitless attempts in that way, he was obliged to give up the pursuit: and probably, had not some new discoveries been made in light and colours, a reflecting telescope would never more have been thought of, considering

dering the difficulty of the execution, and the small advantages that could accrue from it, deduceable from the principles of optics that were then known.

But NEWTON, whose happy genius for experimental knowledge was equal to that for geometry, and who to these talents, in a supreme degree, joined patience and mechanical abilities; NEWTON, I say, thus accomplished, happily interposed, and saved this noble invention from well-nigh perishing in its infant-state. He likewise at an early period of life had applied himself to the improvement of the telescope, but imagining that GREGORY'S *specula* were neither very necessary, nor likely to be executed, he began with prosecuting the views of DESCARTES, who aimed at making a more perfect image of an object by grinding lenses, not to the figure of a sphere, but to that of one of the conic sections. Now whilst he was thus employed, three years after GREGORY'S publication, he happened to take to the examination of the colours formed by a prism, and having by the means of that simple instrument made the ever-memorable discovery of the *different refrangibility of the rays of light*, he then perceived that the errors of telescopes, arising from that cause alone, were some hundred times greater than such as were occasioned by the spherical

cal

cal figure of lentes. This circumstance forced, as it were, NEWTON to fall into GREGORY's track, and to turn his thoughts to reflectors. *The different refrangibility of the rays of light* (says he, in a letter to Mr. OLDENBURG, secretary to this Society, dated in February, 1672) *made me take reflections into consideration, and finding them regular, so that the angle of reflection of all sorts of rays was equal to the angle of incidence, I understood, that by their mediation optic instruments might be brought to any degree of perfection imaginable, provided a reflecting substance could be found which would polish as finely as glass, and reflect as much light as glass transmits, and the art of communicating to it a parabolic figure be also obtained. . . .* Amidst these thoughts I was forced from Cambridge by the intervening plague, and it was more than two years before I proceeded further^(f).

It appears then, that if NEWTON was not the first inventor of the reflecting telescope, he was the main and effectual inventor. By the force of his admirable genius he fell upon this new property of light, and thereby found that all lentes, of whatever figure, would be affected more or less with such prismatic aberrations of the rays as would be an insuperable obstacle to the perfection

(f) Phil. Transf. n. 80.

of a dioptric telescope. Here was (if I may use the similitude) a disorder inherent in the constitution of this instrument, which NEWTON, like a wise physician, penetrated into, and, by understanding the nature of the disease, was led to the remedy; one indeed that had been devised before, but for a different and a flightier ailment, and withal of such difficult composition, that the contriver of it himself had not been able to prepare it.

It was towards the end of 1668, or in the beginning of the following year, when NEWTON being thus obliged to have recourse to reflectors, and not relying on any artificer for making his *specula*, set about the work himself, and early in the year 1672 completed two small reflecting telescopes. In these he ground the great speculum into a spherical concave; not but that he approved of the parabolic form proposed by GREGORY, though he found himself unable to accomplish it. In the letter that accompanied one of these instruments which he presented to the Society, he writes, *that though he then despaired of performing that work (to wit, the parabolic figure of the great speculum) by geometrical rules, yet he doubted not but that the thing might in some measure be accomplished by mechanical devices*^(g).

(g) Phil. Transf. n. 81.

Not less did the difficulty appear to find a metallic substance that would be of a proper hardness, have the fewest pores, and receive the smoothest polish: a difficulty in truth which he deemed almost unfurmountable, when he considered that every irregularity in a reflecting surface would make the rays of light stray five or six times more out of their due course, than the like irregularities in a refracting one. In another letter, written soon after, he tells the secretary, *that he was very sensible that metal reflects less light than glass transmits; . . . but as he had found some metalline substances to be more strongly reflective than others, to polish better, and to be freer from tarnishing than others, so he hoped that there might in time be found out some substances much freer from these inconveniences than any yet known^(b)*. Meanwhile here was, as I said, another stop; and the more discouraging, as it was not, like the former, to be removed by *mechanical devices*, nor even by any chemical principle that had been discovered. That want could only be supplied by making repeated trials; nay, I may say, as it were fortuitously. NEWTON therefore laboured till he found a composition that answered in some degree, and left it to those who should come after him to find a better. The

(b) Phil. Transf. n. 82.

industry of Mr. MUDGE has been aiding to that of Sir ISAAC NEWTON; and the happy assistant of that great man has been so candid as to acknowledge, that chance did save him much trouble, by furnishing him with a metallic mixture, which he had reason to believe was fitter for the purpose than any that had been used before, either published, or concealed from the public.

NEWTON having, with his telescope, communicated to the Society a full and satisfactory account of its construction and performance, he received from your illustrious predecessors such thanks as were due to so curious and valuable a present. And HUYGENS, one of the greatest geniuses of the age, and himself a distinguished improver of the refractor, no sooner was informed by Mr. OLDENBURG of the discovery than he wrote in answer, *that it was an admirable telescope; and that Mr. NEWTON had well considered the advantage which a concave speculum had above convex glasses in collecting the parallel rays, which according to his own calculation was very great. Hence that Mr. NEWTON could give a far greater aperture to that speculum than to an object-glass of the same distance of focus, and consequently much more magnify in his way than by an ordinary telescope. Besides, that by the reflector he avoided an inconvenience inseparable*

ble

ble from object-glasses, which was the obliquity of both their surfaces, which vitiated the refraction of the rays that pass towards the sides of the glass, and did more hurt than men were aware of. Again, that by the mere reflection of the metalline speculum there were not so many rays lost as in glasses, which reflected a considerable quantity by each of their surfaces, and besides intercepted many of them by the obscurity of their matter. That the main business would be, to find a matter for this speculum that would bear as good and even a polish as glass. Lastly, he believed that Mr. NEWTON had not been without considering the advantage which a parabolic speculum would have above a spherical one in this construction; but had despaired, as he himself had done, of working other surfaces than spherical ones with due exactness⁽ⁱ⁾. HUYGENS was not satisfied with thus expressing to the Society his high approbation of the late invention, but drew up a favourable account of the new telescope, which he caused to be published in the *Journal des Scavans*, of the year 1672, and by that channel it was soon known over Europe.

But how excellent soever the contrivance was; how well soever supported and announced to the public; yet whether it was that the artists were deterred by the dif-

(i) Phil. Transf. n. 81.

difficulty and labour of the work, or that the discoveries even of a NEWTON were not to be exempted from the general fatality attending great and useful inventions, *the making a slow and vexatious progress to the authors*; the fact is, that, excepting an unsuccessful attempt which the Society made by employing an artificer to imitate the NEWTONIAN construction, but upon a larger scale, and a disguised GREGORIAN telescope, set up by CASSEGRAIN abroad as a rival to NEWTON's, and that in theory only (for it never was put in execution by the author^(k)) no reflector was heard of for nearly half a century after. But when that period was elapsed, a reflecting telescope was at last produced to the world of the NEWTONIAN construction, which the venerable author, ere yet he had finished his much distinguished course, had the satisfaction to find executed in such a manner, as left no room to fear that the invention would longer continue in obscurity.

This memorable event was owing to the genius, dexterity, and application of a gentleman of this Society, Mr. HADLEY, the inventor of the reflecting quadrant, another most valuable instrument. The two telescopes which NEWTON had made were but six inches

(k) Compare MONTUCLA, Hist. de Mathem. 2 t. p. 647.

long,

long, were held in the hand for viewing objects, and in power were compared to a six-foot refractor; whereas HADLEY'S was above five feet long, was provided with a well-contrived apparatus for managing it, and equalled in performance the famous aerial telescope of HUYGENS, of 123 feet in length. Excepting as to the manner of making the *specula*, we have in the Transactions of 1723 a complete description, with a figure, of this telescope, together with that of the machine for moving it; but, by a strange omission, NEWTON'S name is not once mentioned in that Paper, so that any person not acquainted with the history of the invention, and reading that account only, might be apt to conclude that HADLEY had been the sole contriver of it. But other Papers in the same volume, besides the minutes of the Society, clearly shew that this worthy member meant nothing less than to arrogate to himself any merit in this performance that properly belonged to NEWTON.

It is known that the same celebrated artist, after finishing two telescopes of the NEWTONIAN construction, accomplished a third in the GREGORIAN way; but, I should judge, less successfully, by Dr. SMITH'S declaring so strongly in favour of the other. Mr. HADLEY was not less communicative than he was ingenious, being ever
ready

ready to impart his lights to others; in particular we are informed, *that he spared no pains to instruct Mr. MOLYNEUX and the Reverend Dr. BRADLEY; and that when those gentlemen had made a sufficient proficiency in the art, being desirous that these telescopes should become more public, they liberally communicated to some of the principal instrument-makers of this city the knowledge they had acquired from him*^(l). Now such scholars, as it is easy to imagine, soon advanced beyond their masters, and completed reflectors by other and better methods than what had been taught them.

Certain it is, at least, that Mr. JAMES SHORT, as early as the year 1734, had signalized himself at Edinburgh by his work of this kind. The excellent MACLAURIN, my dear departed friend, wrote that year to Dr. JURIN, *that Mr. SHORT, who had begun with making glass specula, was then applying himself to improve the metallic; and that by taking care of the figure he was enabled to give them larger apertures than others had done; and that upon the whole they surpassed in perfection all that he had seen of other workmen. He added, that Mr. SHORT's telescopes were all of the GREGORIAN construction; and that he had much improved that excellent invention*^(m). This character of

(l) SMITH's Syst. of Opt. b. 3. ch. 2.

(m) Ibid. Rem. on Art. 489.

excellence Mr. SHORT maintained to the last, and with the more facility as he had been well grounded both in the geometrical and philosophical principles of optics, and upon the whole was a most intelligent person in whatever related to his profession. It was supposed he had fallen upon a method of giving the parabolic figure to his great speculum; a point of perfection that GREGORY and NEWTON had wished for, but despaired of attaining; and that HADLEY had never, as far as we know, attempted, either in his NEWTONIAN or GREGORIAN telescope. Mr. SHORT, I am well informed, said he had acquired that faculty, but never would tell by what peculiar means he effected it; so that the secret of working that configuration, whatever it was, as far as it then appeared, died with that ingenious artist.

It is Mr. MUDGE therefore who hath truly realized the expectation of Sir ISAAC NEWTON, who, above an hundred years ago, presaged that the public would one day possess a parabolic speculum, *not accomplished by mathematical rules, but by mechanical devices.*

This was a *desideratum*, but it was not the only want supplied by our worthy brother: he has taught us likewise a better composition of metals for the *specula*, how

to grind them better, and how to give them a finer polish; and this last part (namely the polish) he remarks was the most difficult and essential of the whole operation. In a word, I am of opinion, there is no optician in this great city (which hath been so long and so justly renowned for ingenious and dextrous makers of every kind of mathematical instruments) so partial to his own abilities as not to acknowledge, that however some parts of the mechanical process now disclosed might have been known before by individuals of the profession, yet that Mr. MUDGE hath opened to them all some new and important lights, and upon the whole hath greatly improved the art of making reflecting telescopes.

To enter into the detail of the *devices* (to use NEWTON's expression) by which Mr. MUDGE hath arrived at the true parabolic figure, as well as at the other perfections of this instrument, would encroach too much on your time; and I may add, would not be altogether suitable to the present occasion. I have laid before you the sum of what he hath performed, and declared to you the opinion of your Council, that without his interposition the nicety of the art was in danger of being lost; or at best of being kept in the hands of those who were not likely to make it public. The character which Mr. MUDGE bears for
 integrity.

integrity would leave us no room to doubt of his being himself persuaded, that he hath in every point brought the great speculum of reflecting telescopes to that degree of perfection which he professes; but as authors and improvers, like parents and preceptors, can rarely divest themselves of too partial a fondness for what is their own, or amended by them, it will be satisfactory for you to know, that some of our brethren, the most intelligent in these matters, have frequently discoursed with Mr. MUDGE upon this subject, have seen him at work upon the *specula*; nay, have examined two reflecting telescopes (the one of 18 inches, the other of 22) completed by him; and that they are confident he hath by no means exaggerated either what he hath recovered to the body of arts, or what he hath added to it.

Need I now set forth the merit of ascertaining and advancing the construction of the reflecting telescope, to an Audience so well apprized of its value? To you who know that of all inventions there are none so justly entitled to our admiration as those which have been fallen upon for enlarging the powers of vision; and that the discovery of optical instruments may be esteemed among the most noble as well as among the most useful gifts which the supreme Artift hath conferred on man? For all-

admirable as the eye came out of the hands of Him who made it, yet no organ of the animal frame hath He permitted so much to be assisted by human contrivance, not only for the uses and comfort of common life, but for the advancement of natural science; whether by giving form and proportion to the minute parts of bodies (as it were to the atoms of nature) imperceptible before; or by contracting space, and, as by magic art, bringing to view the grander objects of the universe, whose immense distances had either disguised their aspect, or rendered them quite invisible!

If PLINY, in regard to HIPPARCHUS, could extravagantly say, *Ausus rem Deo improbam annumerare posteris stellas!* what would that pompous historian of nature have said, had it been foretold him, that in the latter days a man would arise, who should enable posterity to enumerate more new stars than HIPPARCHUS had counted of the old; nay, who should in a manner verify the vulgar notion of their being innumerable! who should assign four Moons to Jupiter, and in our Moon (supposed by many to have a smooth and polished surface) point out higher mountains than any here below! who should in the Sun, the fountain of light, discover dark spots as broad as two quarters of the earth, and by these spots

ascertain

ascertain his motion round his axis! who by the varying *phases* of the planets should compose the shortest and plainest demonstration of the truth of that system, till then the greatest of paradoxes, which supposed the earth and planets revolved about that luminary ⁽ⁿ⁾? Yet these were but a part of the annunciations to the world of a single person, of GALILEO of unperishing memory! To him his contemporary, and rival in fame, Lord BACON ascribed the invention of the *perspicilla* (for so they called at first the telescopes) and in a figurative strain thus expressed himself concerning them: *With these (perspicilla) which GALILEO by a memorable effort of genius hath discovered, we are enabled, as with some small sailing vessels, to open and keep up a nearer commerce with the stars* ^(o).

Nor did this celestial commerce cease with the acquisitions of GALILEO, but hath been extending ever since the time that that great man first turned his glasses to the heavens. The famous KEPLER, on the first notice, embraced the discovery, and in 1611, the year following the *Sidereus Nuncius* of GALILEO, published a treatise of dioptrics, geometrically explaining the performance of

(n) GALILEI Sidereus Nuncius, *sparsim*.

(o) Quæ (perspicilla) memorabili conatu adinvenit GALILEUS, &c. Nov. Organ. 1. 2. aphor. 39.

the *perspicilla*, and proposing some proper improvements of them. Then came SNELLIUS, DESCARTES, and other celebrated geometricians abroad, who applied themselves to optics, and successfully cultivated that fruitful branch of science. But whilst at that period, in different parts of Europe, men of the first rank in mathematical studies seemed to vie with each other in promoting not only the theory of vision, but the mechanical practice of the instruments appertaining to it, and particularly the telescope; how did it happen, that in this country, in the last century, which had so auspiciously begun with the lights derived from Lord BACON and Dr. HARVEY, we should afterwards find few traces of any attempt in that way earlier than the establishment of this Society? Of this pause in the course of your philosophical discoveries, the distracted state of these kingdoms, under a long civil war, was indubitably the occasion. For no sooner had we sheathed the bloody sword and displayed the peaceful olive, than arts and sciences again sprang forth, and with so much vigour, that the advancement made in these lands, since that epoch, in optics alone, may be considered as one of the noblest exertions of the human genius. Not to contend for a general superiority in the publications here on that subject since the time that GREGORY entered first into that grand

career, to silence all competition I need but mention the *Theory of Light and Colours*; a piece so excellent for invention, for judgment in conducting experiments, and for drawing the proper conclusions from them, that had it been NEWTON's single work it would not only have done lasting honour to himself, but to the country that gave him birth. And as to the instruments, which of them, let me ask, hath not been either found out, or signally improved among you? Or what nation is there that hath embraced the arts, and doth not value itself on possessing every piece of this kind of British workmanship. The reflecting telescope I may call wholly yours, both as to the original contrivance and every step of its advancement: nay, from its revival by Mr. HADLEY to this day, a space of nearly threescore years, we have heard of no artist, out of this island, who hath been able tolerably to copy, much less to add to this splendid invention.

What acknowledgements then, GENTLEMEN, do we not owe to our worthy brother, who for above twenty years past, in the uncertain intervals of a toilsome and anxious profession, hath unbent his mind, not in the perishing recreations of the world; but in investigating, with unremitting diligence, what had been done but concealed by others, and in making many successful experiments

riments towards perfecting this inimitable instrument? A liberal account of these leisure hours he hath laid before you in his instructive Paper: a communication, I am persuaded, that will not only preserve but signalize his name in your records, among the very intelligent and ingenuous promoters of the great ends of your institution.

