XIV. *A Paper to obviate some Doubts concerning the great Magnifying Powers used. By Mr.* Herschel, *F. R. S.*

TO SIR JOSEPH BANKS, BART. P. R. S.

SIR,

I HAVE the honour of laying before you the result of a set of measures I have taken in order to ascertain once more the powers of my Newtonian seven-feet reflector. The method I have formerly used, and which I still prefer to that which I have now been obliged to practise, requires very fine weather and a strong sun-shiny day; but my impatience to answer the requests of Sir JOSEPH BANKS would not permit me to wait for so precarious an opportunity at this season of the year. The difference in all the powers, as far as 2010, will be found to be in favour of those I have mentioned; and, I believe, a much greater concurrence could not well be expected, where

different

different methods of afcertaining them are ufed. The varia-
tion in the two higheft powers is more confiderable than I was
aware of; but ftill may eafily be fhewn to be a neceffary confe-
quence of the difference in the methods. However, if upon
comparing together the methods it fhould be thought, that the
power 5786 is nearer the truth than 6450, I fhall readily join
to correct that number. The manner in which I have now
determined the powers is as follows: I took one of the eye
lenfes which magnifies leaft, and meafured its folar focus by
the fun's rays as exactly as I could five times, which proved to be
1.01, 1.04, 1.09, 1.01, 1.05, in half-inch meafure, a mean of
which is 1.04. The fidereal focus of my feven-feet fpeculum
is 170.4 in the fame meafure. Thence, dividing 170.4 by
1.04 we find that the telefcope will magnify 163.8 times when
that lens is ufed. This power being found, I applied the fame
lens as a fingle microfcope to view with it a certain object,
which was a drawn brafs wire faftened fo as not to turn upon
its axis or change its pofition; for thefe wires are feldom per-
fectly round, or of an even fize, and it is therefore neceffary to
ufe this precaution to prevent errors: then, with a fine pair
of compaffes, I took four independent meafures of the image
of the brafs wire, which was thrown upon a fheet of paper
exactly 8½ inches from the lens, the eye being always as clofe
to the lens as poffible. I viewed the fame wire, exactly in the
fame manner, with every one of the lenfes, and meafured the
pictures upon the paper. When I came to the higher powers
the wire was exchanged for another 4.37 times thinner than
the former, as determined by comparing the proportion of their
images 54 to 235¾, taken by the fame lens.

When the images of thefe wires are obtained, the power of
the telefcope, with every one of the lenfes, becomes known
by

by one plain analogy : *viz.* as the image of the wire by the firft lens (77¾) is to the power it gives to the telefcope (163.8), fo is the image of the wire by the fecond lens (119) to the power it will give to the fame telefcope (250.7). The particulars of all the meafures are as follows :

Powers as they have been called in my papers.	Images of a wire thrown upon a paper in hundredths of half inches.				A mean of the four meafures.	Powers as they come out by this method.
146	77	78	78	78	77¾	$163.86 = \frac{170.4}{1.04}$
227	119	119	119	119	119	250.7
278	143	143	144	143	143¼	301.8
460 {	236	236	235	236	235¾ }	496.7
	Smaller wire.					
	53	54	55	54	54	
754	83	85	84	85	84¼	775.1
932	107	107	107	108	107¼	986.7
1159	128	128	129	128	128¼	1179.9
1536	An excellent lens, loft about eight months ago.					
2010	236	236	238	336	236½	2175.8
3168	281	283	281	280	281¼	2585.5
6450	635	625	630	626	629	5786.8

I beg leave, Sir, now to give a fhort defcription of the method I have formerly ufed to determine thefe powers. In the year 1776 I erected a mark of white paper, exactly half an inch in diameter, which I viewed with my telefcope at the greateft convenient diftance with one of the leaft magnifiers. An affiftant was placed at rectangles in a field, at the fame diftance

from

from my eye as the object from the great speculum of the telescope. Upon a pole erected there I viewed the magnified image of the half inch, and the assistant marked it by my direction; this being measured gave the power of the instrument at once. The power thus obtained was corrected by theory, to reduce it to what it would be upon infinitely distant objects. The powers of the rest of the lenses I deduced from this by a *Camera-eye-piece*, which I made for that purpose. ABCD (fig. 1.) represents a perpendicular section of it. The end A screws into the telescope. Upon the end B may be screwed any of the common single-lens eye-pieces. *lmn* is a small oval plane speculum, adjusted to an angle of 45° by three screws, two whereof appear at *op*. When the observer looks in at B, he may see the object projected upon a sheet of paper on a table placed under the Camera-piece, and measure its picture *a*, *b*, as in fig. 2. The power of one lens therefore being known, that of the rest was also found by comparing the measures of the projected images.

It may not be amiss to mention some of the advantages and inconveniencies attending each of these methods. When we take the focus of an eye-lens, which the first method requires, we are liable to a pretty considerable uncertainty, and in very small lenses it is not to be done at all. Moreover, in calculating the power by that focus no account is made of the aberration which takes place in all specula and lenses, and increases the image, so that we rather find out how much the telescope *should* magnify than how much it really *does* magnify; but in determining the power by an experiment we avoid these difficulties.

On the other hand, when the power is very great, the latter method becomes inconvenient, both on account of want of

light

light in the object, and a very confiderable aberration which takes place, and makes the picture too indiftinct to be very accurate in the meafure, and of courfe larger than it ought to be; and this will account for the excefs in the meafures of my two largeft powers. However, when I employed 6450 upon the diameter of α Lyræ, I incline to think the method I had ufed when I determined that power, ought to be preferred, becaufe my Lamp-micrometer gives the meafure of an object as it appears in the telefcope, and therefore this aberration is included, and fhould be taken into confideration.

To prevent any miftakes, I wifh to mention again, that I have all along proceeded *experimentally* in the ufe of my powers, and that I do not mean to fay I have ufed 6450 (or 5786) upon the planets, or even upon double ftars; every power I have mentioned is to be underftood as having been ufed juft as it is related; but farther inferences ought not as yet to be drawn. For inftance, my obfervations on ε Bootis mention that I have viewed that ftar with 2010 (or as in the above table with 2175) extremely diftinct; but upon feveral other celeftial objects I have found this power of no fervice. Many plaufible fuggeftions have already occurred to account for thefe appearances; but I wait till farther experiments fhall have furnifhed me with more materials to reafon upon. The ufe of high powers is a new and untrodden path, and in this attempt variety of new phænomena may be expected, therefore I wifh not to be in a hafte to make general conclufions. I fhall not fail to purfue this fubject, and hope foon to be able to attack the celeftial bodies with a ftill ftronger armament, which is now preparing.

It remains now only for me to make the moſt ſincere acknowledgement for the favours you have ſhewn to me, and to ſay that I ſhall ever remain, with equal reſpect and gratitude,

S I R, your moſt obedient, &c.

P. S. Dr. WATSON junior has done me the favour ſeparately to examine and meaſure the powers of my teleſcope; and placing the greateſt confidence in his accuracy, I rely on his meaſures at leaſt as much as my own.

B

C

Fig. 1.

A

m

n

o   D   *p*

B

Fig. 2.

a   *b*