Conſiderations of Monſieur Auzout *upon Mr.* Hook's *New Inſtrument for Grinding of* Optick-Glaſſes.

In the above-mentioned *French* Tract, there are, beſides ſeveral other particulars, to be repreſented in due place, contained ſome *Conſiderations* of Monſieur *Auzout* upon Mr. *Hook*'s New *Engine* for grinding *Optick-Glaſſes*. Where he premiſes in *General* his thoughts touching the working of *Great* Optick-Glaſſes, and that by the help of a *Turn lathe*; affirming firſt of all, that not only the *Engin* is to be conſidered for giveing the *Figure*, but the *Matter* alſo, which ought to be brought to greater perfection, than it hath been hitherto. For, he finds it not ſo eaſie (at leaſt, *where he is*) to procure *Great* pieces of Glaſs without *Veins*, and other faults, nor to get ſuch, as are thick enough without *Blebbs*; which, if they be not, they will yield to the preſſure and weight, either when they are fitted to the *Cement*, or wrought.

Secondly, He finds it difficult to work theſe *Great* Glaſſes of the *ſame* thickneſs, which yet is very neceſſary, becauſe, that the leaſt difference in *Figures* ſo little *convex*, can put the *Center* out of the *Midle*, 2 or 3 *Inches*; and if they be wrought in *Moulds*, the length of time, which is required to wear and to ſmooth them, may ſpoil the beſt *Mould*, before they be finiſhed. Beſides, that the ſtrength of Man is ſo limited, that he is unable to work Glaſſes beyond a certain bigneſs, ſo as to finiſh and poliſh them all over ſo well, as *ſmall* Glaſſes; whereas yet, the bigger they are, the more compleat they ought to be: And if any weight or Engine be uſed to ſupply ſtrength, there is then danger of an unequal preſſure, and of wearing away the Engine; In the mean time, the preciſeneſs and delicateneſs is greater,

greater than can eaſily be imagined. Wherefore he could never, having ſome experience of this preciſeneſs, conceive, that a *Turn-lathe*, wherein muſt be two different, and in ſome manner contrary motions, can move with that exactneſs and ſteddineſs, that is required, eſpecially, for any conſiderable length of time.

Having premiſed this, he diſcourſes upon Mr. *Hook* his *Turne*, intimating firſt of all, that he was impatient to know what kind of *Turne* this was, imagining, that it had been tried, and had ſucceeded, as coming from a Society that profeſſeth, they publiſh nothing but what hath been maturely examin'd. But that he was much ſurpriſed when he ſaw the *Micrography* of Mr. *Hook*, and found there, that his *Engine* was publiſhed upon a *meer Theory*, without having made any Experiment, though that might have been made with little charge and great ſpeed; expence of Money and Time being the onely thing, that can excuſe thoſe who in matter of *Engines* impart their inventions to the publick, without having tried them, to excite others to make trial thereof.

Whereupon he propoſes ſome difficulties, to give the *Inventor* occaſion to find a way to remove them. He affirms therefore, that though it be true in the *Theory*, that a *Circle*, whoſe *Plain* is inclined to the *Axis* of the *Sphere* by an *Angle*, whereof half the *Diameter* is the *Sine*, and which touches the *Sphere* in its *Pole*, will touch in all its parts a *ſpherical Surface*, that ſhall turn upon that *Axe*. But that it is true alſo, that that muſt be but a *Mathematical Circle*, and without *Breadth*, and which preciſely touches the Body in its middle: Whereas in the practice, a *Circle* capable to keep Sand and Putty, muſt be of ſome *breadth*; and he knows not whether we can find ſuch a dexterity of keeping ſo much of it, and for ſo long a time, as needs, upon the Brim of a *Ring* that is half an Inch broad. He adds, that it is very difficult to contrive, that the middle of the Glaſs do always preciſely anſwer to the Brim of this *Ring*, ſeeing that the poſition of the Glaſs does always change a little in reſpect of the *Ring*, in proportion as 'tis worn, and as it muſt be preſſed becauſe of its inclination. He believes it alſo very hard, to give to the *Axis* or to the *Mandril*, which holds the Glaſs, that little

Inclination,

Inclination, that would be neceſſary for great Glaſſes, and to make the two *Mandrils* to have one and the ſame *Plain*, as is neceſſary. And, having done all this, he perſuades himſelf, that it is exceeding difficult, if not impoſſible, for two contrary motions, where ſo many pieces are, to reſt for a long time ſteddy and firm, as is requiſite for the not ſwarving from it a hair's thickneſs, ſince leſs than that can change all.

He goes on, and, ſeeing that this *Inventor* ſpeaks of Glaſſes of a thouſand, & ten thouſand foot, which he ſuppoſed not impoſſible to be made by this *Engine*, diſcourſes of what is neceſſary for the making Glaſſes of ſuch bigneſs; which he believes this *Inventor* may perhaps not have thought of. Wherefore he affirms, that if the *Table*, made by himſelf for the *Apertures* of Glaſſes (which is that, that is above delivered) be continued unto a thouſand feet, by taking always the *Subduplicate proportion* of *Lengths*, it will be found, that for pretty good ones, the *Aperture* muſt be of 15. Inches; for good ones, more than 18. and for ſuch as are excellent, more than 21. Inches: whence it may be judged, what piece of Glaſs, and of what thickneſs it muſt be, to reſiſt the working. But he proceeds to ſpeak of the *Inclination*, which the *Mandril* muſt have upon the *Plain* of the *Ring*, when the *Ring* ſhould have 10. or 12 Inches; and finds, that it would make but 6 or 7. minutes of inclination, and that a Glaſs would have leſs *Convexity*, and conſequently, leſs difference from a Glaſs perfectly plain, than the 7. or 8. part of a Line. And then he leaveth it to be judged, whether a Glaſs of ſuch a Length being found, we ought to hope, that a *Turn* can be firm enough to keep ſuch a piece of Glaſs in the ſame Inclination, ſo that a *Mandril* do not recede ſome Minutes from it: and, though even the Glaſs could be faſtned perfectly perpendicular to the *Mandril*, that theſe two *Mandrils* could be put in one and the ſame place, & that that little Inclination, which is requiſite, could be given, and the *Mandril* be continued to be preſſed in that ſame *Inclination*, according as the Glaſs is worn. All which particulars, he conceives to be very hard in the practice; not to mention, that the weight of the Glaſs, that ſhould be inclined to the *Horizon*, as 'tis repreſented by Mr. *Hook*, would make it ſlide upon the *Cement*, and ſo chance

change the *Center*; and that the Glaſs is not preſſed at the ſame time by the *Ring* but in one part on the ſide, *vid.* about a fourth; and that the parts of the Glaſs are not equally worn away, *&c.* What then, *ſaith he*, would becom of a Glaſs of 10000 feet, which, according to the ſaid Table, would have more than four feet, or four feet and nine inches, or five feet, ſeven inches *Aperture*, and of which the *Ring*, though it were two feet nine inches, would have but one minut of *Inclination*, and the Glaſs of 5 feet *Aperture* would have but 4 minuts, and the curvity of it would be leſs than the hundred part of a Line.

But, *ſaith he*, let us conſider, only a Glaſs of 300 foot, to ſee, what is to be hoped of that, and to know at leaſt the difficulty, to be met with in making a Glaſs only of that Length. A Glaſs then of 300 foot, according to his Table, muſt have more than 8 inches *Aperture*, which maketh but 16 minuts of its *Circle*, and it ſhould have more than 11 inches, if it be an excellent one. If Mr. *Hook* (adds he) did uſe but his *Ring* of 6 inches, which he would uſe from twelve to an hundred foot Glaſs, the *Inclination*, which the *Axis*, or *Mandril*, that bears his Glaſs, ſhould have, ſhould be but 16 minuts, and the *Curvity* of the Glaſs would be leſs than the eighth part of a Line, and if he ſhould uſe a bigger, the *Inclination* would be proportionable.

Whence it may be judged (continues he) that we are yet very far from ſeeing *Animals &c.* in the *Moon*, as Monſieur *Des Cartes* gave hope, and Mr. *Hook* deſpairs not of. For, he believes by what he knows of *Teleſcopes*, that we are not to look for any above 300 or 400 foot at moſt; and he fears, that neither *Matter* nor *Art* will go even ſo far.

When therefore (*ſaith he*) a Glaſs of 300 foot ſhould bear an Eye-glaſs of 6 inches (which would appear wonderful) it would magnifie but 600. times in *Diameter*, that is, 360000 times in *Surface*: but ſuppoſe, that ſuch could be made, as would magnifie a 1000 times in *Diameter*, and 1000000. of times in *Surface*, admitting there were but 60000 leagues from the *Earth* to the *Moon*, and that the ſmalneſs of the *Aperture* of the Glaſſes (which yet would diminiſh the Light more than 36 times), and the obſtacle of the Air were not conſidered, we ſhould not

ſee

ſee the *Moon*, but as if we were a 100, or at leaſt, 60. leagues diſtant from her without a Glaſs. He here wiſhes, that thoſe that promiſe to make us ſee *Animals* and *Plants* in the Moon, had thought on what our naked Eyes can make us diſcern of ſuch Objects, only at 10 or 12 leagues diſtance.

But this he would not have underſtood as a diſcouragement from ſearching with all care and earneſtneſs after the means of making long *Teleſcopes*, or of facilitating the working thereof; but only as an Advertiſement to thoſe, who light upon the *Theory* of any *Engine*, not to expoſe it preſently as poſſible and uſeful, before they have tried it, or if it have ſucceeded in ſmall, not to endeavour to perſuade, that it will alſo ſucceed in great.

As it may happen (*ſaith he*) that the Engin of Mr. *Hook* may, by uſing all neceſſary precautions, ſucceed in the making of *Eye-Glaſſes*, or *ſmall* Optick-Glaſſes, but not in making *great* ones; as we ſee, that an inſtrument compoſed of two Rulers, wherewith are traced Portions of Circles, ſucceeds well enough in *ſmall*, but when there is no more than half a Line, a quarter of a Line, or leſs convexity, it will be no longer juſt at all, as he tells us to have made the proof of it in Circles drawn by the means of one of theſe Inſtruments, made by one of the beſt Workmen in his time, who, whilſt he lived, eſteemed them above price, although they be not juſt; as others and my ſelf (*ſaith he*) have by tryal found, when we endeavoured to make *Moulds* by their means, & as thoſe, who by the like Inſtrument laboured to trace portions of Circles of 80 or 100 foot, *&c. Diameter*, can atteſt.

But, notwithſtanding all this, he hath thought upon two or three things, which he thinks may remedy ſome inconveniencies of Mr. *Hook* his *Turn*. The *firſt* is, to invert the Glaſs, and to put it under the *Ring*, that ſo not only the Glaſs may be placed more *Horizontally*, and not ſlide upon the *Cement*, but that the *Sand* alſo, and the *Putty* may ſtay upon the Glaſs.

The *other* is, that there muſt be two *Poppetheads*, into which the *Mandril* muſt paſs, where the *Ring* is to be faſtned; and the *Mandril* muſt be perfectly *Cylindrical*, that ſo it may advance upon the Glaſs as it wears away by the means of its weight, or by the means of a ſpring, preſſing it, without wrigling from one place to another, as it would preſently happen in the faſhion,

as the *Turn* is compoſed. For, when the Glaſſes do wear, eſpecially when they are very *convex*, it cannot be otherwiſe, but the *Mandril* will play and wrigle, before the *Sorue* be made firm.

But he doubts, whether all can be remedied, which he leavs to the induſtry of Mr. *Hook*, conſidering what he ſaith in the *Preface* of his *Micrography*, touching a Method, he knows, of finding out as much in *Mechanicks*, as can be found in *Geometry* by *Algebra*.

Beſides this, he taketh notice, that moſt of thoſe that medle with *Optick-Glaſſes*, give them not as much *Aperture*, nor charge them ſo deep as they ought. And he inſtances in the *Teleſcope*, which His *Majeſty* of *Great Britain* preſented the *Duke* of *Orleans* with, *videl.* that it did bear but 2 inches, and 9 lines *French*, for its greateſt *Aperture*, though there be 5 or 6 leſſer *Apertures*, of which it ſeems (*ſaith he*) the Artificer would have thoſe, that uſe it, ſerve themſelves more ordinarily, than of the greateſt; which conveys but almoſt half as many Rays as it ſhould do, according to his Calculation, which is, as 9 to 16; Whereas, according to his *Table* of *Apertures*, an excellent 35 foot *Teleſcope* ſhould bear 4 inches *Aperture* in proportion to *excellent* ſmall ones. He notes alſo, that the Eye-glaſs of the ſaid *Teleſcope*, compoſed of 2 Glaſſes, hath no more effect, when it is moſt charged, than a Glaſs of $4\frac{1}{2}$ inches; which makes it magnifie not a 100 times. And he finds by Mr. *Hook*, that he eſteems a *Teleſcope* made in *London* of 60 feet, (which amount to about 57 feet of *France*, the foot of *France* being to that of *England* as about 15 to 16) becauſe it can bear at leaſt 3 *Engliſh* inches *Aperture*, and that there are few of 30 feet, that can bear more than 2 inches, (which is but $22\frac{1}{12}$ Lines *French*) although he (M. *Auzout*) gives no leſs *Aperture*. than ſo, to a 15 foot-*Teleſcope*, and his of 21 feet hath ordinarily 2 Inches, 4 Lines, or 2 inches, 6 Lines *Aperture*.

This Diſcourſe he Concludeth with exhorting thoſe, that work *Optick-Glaſſes*, to endeavor to make them ſuch, that they may bear great *Apertures* and deep Eye-glaſſes; ſeeing it is not the length that gives eſteem to *Teleſcopes*; but on the contrary renders them leſs eſtimable, by reaſon of the trouble accompanying

panying them, if they perform no more, than ſhorter ones. Where, by the by, he takes notice, that he knows not yet, what *Aperture* Signor *Campani* gives to his Glaſſes, ſeeing he hath as yet ſignified nothing of it; but that the ſmall one, ſent by him to Cardinal *Antonio*, hath no more *Aperture*, than ordinary ones ought to have.

He promiſes withall, that he will explicate this way in his *Treatiſe of the uſefulneſs of Teleſcopes*, where he intends to aſſign the Bigneſs of the *Diameter* of all the *Planets*, and their proportion to that of the *Sun*; as alſo, that of the *Stars*, which he eſteems yet much leſs, than all thoſe have done, that have written of it hitherto; not believing, that the *Great Dog*, which appears to be the faireſt Star of the *Firmament*, hath 2 *Seconds* in *Diameter*, nor that thoſe, which are counted of the ſixth Magnitude, have 20 *thirds*; nor thinking, that all the Stars, that are in the *Firmament*, do enlighten the Earth as much as a Luminous Body of 20 *ſeconds* in *Diameter* would do, or, becauſe there is but one half of them at the ſame time above our *Horizon*, as a Body of 14 *ſeconds* in *Diameter*; and as the 18432th part of the *Sun* would enlighten us, or as the *Sun* would do, if we were 14 times more diſtant from it, than *Saturn*, and 137 times further, than the Earth: Which, *he ſaith*, would not be credible, if he did not endeavor to evince it both by *Experience* and *Reaſon*. And he doubts not, but that *Venus*, although ſhe ſends us no Light but what is reflected, does ſometimes enlighten the *Earth* more, than all the Stars together. Yet he would not have us imagine, from what he hath ſpoken of the ſmalneſs of the Stars, that *Teleſcopes* do not magnifie them by reaſon of their great diſtance, as they do *Planets*; for this he judgeth a Vulgar Error, to be renounced. *Teleſcopes* magnifie the *Stars* (*ſaith he*) as much in proportion, as they do all other Bodies, ſeeing that the demonſtration of their magnifying is made even upon *Parallel* rays, which do ſuppoſe an infinite diſtance; though the Stars have none ſuch: And if the *Teleſcopes* did not magnifie the Stars, how could they make us ſee ſome of the *fiftieth*, and it may be ſome of the *hundreth*, and *two hundreth* Magnitude, as they do, and as they would ſhew yet much leſſer ones, if they did magnifie more?