

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 giving 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 *Glas* without *Veins*, and other faults, nor to get such, as are thick enough without *Blebb*s; 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 *Middle*, 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 steadiness, that is required, especially, for any considerable length of time.

Having premised this, he discourses upon Mr. *Hook*'s 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 surpris'd when he saw the *Micrography* of Mr. *Hook*, and found there, that his *Engine* was published upon a *new 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 steady and firm, as is requisite for the not swerving 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 Glas, 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 Glas would have less *Convexity*, and consequently, less difference from a Glas perfectly plain, than the 7. or 8. part of a Line. And then he leaveth it to be judged, whether a Glas of such a Length being found, we ought to hope, that a *Turn* can be firm enough to keep such a piece of Glas in the same Inclination, so that a *Mandril* do not recede some Minutes from it: and, though even the Glas 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 Glas is worn. All which particulars, he conceives to be very hard in the practice; not to mention, that the weight of the Glas, 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 *Glas* 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 *Glas* are not equally worn away, &c. What then, *saith he*, would becom of a *Glas* 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 *Glas* of 5 feet *Aperture* would have but 4 minuts, and the curvity of it would be less than the ~~hundred~~^{eight} part of a *Line*.

But, *saith he*, let us consider, only a *Glas* 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 *Glas* only of that Length. A *Glas* 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 *Glas*s, the *Inclination*, which the *Axis*, or *Mandril*, that bears his *Glas*s, should have, should be but 16 minuts, and the *Curvity* of the *Glas*s 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 *Glas* of 300 foot should bear an *Eye-glas* 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 *Glas*s (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 (*saiſt 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*, where-with 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 (*saiſt he*) have by trial 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 inconveniences 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 *Mandrill* must pass, where the *Ring* is to be fastned; and the *Mandrill* 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 compos'd. 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 *Sorus* 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*, compos'd 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 $22\frac{1}{2}$ Lines *French*) although he (Mr. *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 smallness 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?