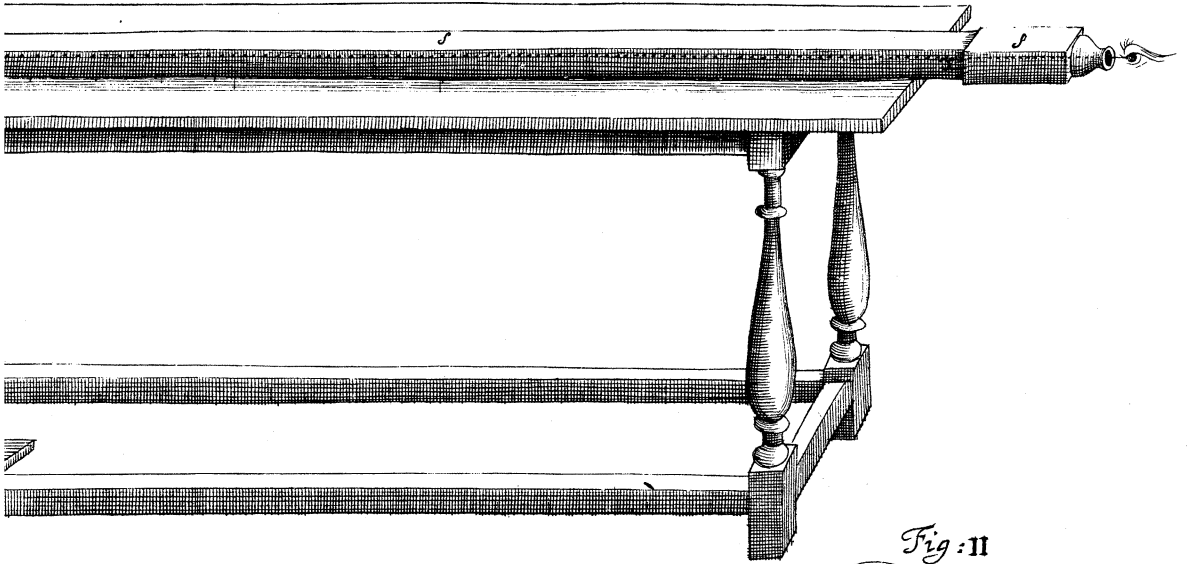
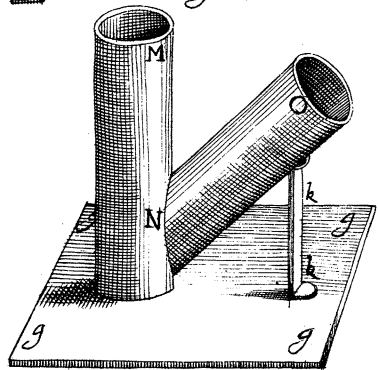


III



*Fig : II*



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# PHILOSOPHICAL TRANSACTIONS.

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For the Month of *October*, 1699.

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I. *An Experiment of the Refraction of the Air made at the Command of the Royal Society, Mar. 28. 1699. By J. Lowthorp. A. M.*

**W**E took a Cylinder of Cast-Brass Fig. I. ABCD; and cut one end of it CD perpendicular to the Axis *ax*, the other end AB enclin'd to it at an Angle of about  $27^{\circ} 30'$ . and therefore the Perpendicular to this enclining plain, *pc*, and the Axis of the Cylinder *ax* comprehended an Angle *pca* of about  $62^{\circ} 30d$ . These ends were groun'd very true upon a Glass-Grinder's Brass-Tool, and each of them was compass about with a narrow Ferule of thin Brass *bbbb*. Into the upper side of the Cylinder at E was solder'd the Brass pipe EF, and into the under side at G the other Brass pipe GH; the former of these Pipes being about 3 inches long and the late 6 inches. Upon the plate *ddd* were fixt two other plates LL Perpendicular to it and parallel to each other. Each of these two plates had an Arch of a Circle (equal to the Circumference of the Cylinder) cut out of its upper Edge, so that when the pipe GH was let through a hole near the middle of the plate *ddd*, the Cylinder fell into the Arches; and being

E e e

fasten'd

fasten'd there with Soder, the Axis *ax* laid Parallel to the Plate *ddd* and about an inch and half above it. The Perpendicular End of the Cylinder *DC* was clos'd with an Object Glass of a 76<sup>th</sup>. Foot Telescope, *oo*; and the other End *AB*, with a well polish'd flat Glass *ff*; which was carefully chosen to transmit the Object distinct enough notwithstanding its Obliquity to the Visual Rays. The Ferules were well fill'd with Cement round about the Edges of the Glass, and they laid flat and every where toucht the smooth Ends of the Cylinder, that they might firmly resist the pressure of the Excluded Air.

Instead of a Cistern (as in the Torricellian Experiment) we made use of the Inverted Siphon of Brass Fig. II. *MNO*, soder'd to the Plate *ggg*. One of the sides *MN* stood Perpendicular to the plate, and the other side *NO* Enclin'd to it, and was supported near the upper End *O* with a little prop *kk*.

We then plac'd the Cylinder (as in Fig. III.) upon a Table which was well fasten'd to a firm Flore; The pipe *GH* was let through a Hole, and the Axis laid almost parallel to the sides of the Table, and the Plate *ddd* was nail'd down to it. The Tube of the Telescope *ff* with the Eye glass was apply'd to the Object Glass, and a Hair fixt within it at the common Focus of both glasses in the Axis of the Cylinder continu'd, *x*. Upon the floore (under the Cylinder) we nail'd the plate *ggg* with the inverted Siphon upon it, and join'd *M* to *H* by the Infection of the Glass Tube *T*. The joints were very carefully clos'd with Cement: And then they were cover'd over with pieces of a bladder and wrapt hard with strong thread. There was also a bladder ty'd below each joint at *m*, and when it was fill'd with Water it was ty'd above it at *n*; So that no Air could come to the Cement or insinuate it self through it's pores or fissures if any happen'd to be left unclos'd.

It is not (I think) an unnecessary trouble, that in this account of the Apparatus I have mention'd so many minute Circumstances, for we found it difficult enough to exclude the Air, and almost Impossible to discover the very little holes through which so subtil a fluid would freely enter and possess the spaces deserted by the subsiding Mercury. But with all this precaution the experiment succeeded at last, as I wisht, after this manner.

We plac'd the Object *a* (which was a black thread sliding in a little frame over a piece of white paper) in the Axis of the Cylinder *ax* continu'd to it; We fill'd the Pipes and Cylinder

linder with Mercury; and having stop't the uppermost Pipe at F with the little Iron stopple K and clos'd it at the other joints, we let the Mercury run out gently at O into the bladder *v*, till it remain'd suspended at the usual height (as in the Barometre) leaving the space above it between the glasses *oo* and *ff* void of Air. We then found the Object, which before appear'd in the Axis at *x*, rais'd considerably above it, and we reduc'd it to appear at *x* by removing it from *a* to *x*. The Axis therefore, of the visual Ray *xx* (which was also the Axis of the Cylinder) *xa*, falling Perpendicularly on the void space in the Cylinder pass't through it without any Refraction: But emerging obliquely into the Air, it was Refracted towards the Perpendicular *pc*, and there receiv'd a new direction to *x*. And therefore the space *ax* subtended the Angle of Refraction *acx*; which we measur'd and found as follows.

The height of the Object above the Axis } inches dephs  
of visual Ray *ax* the unrefracted — } 0, 425

The Distance of the Object from the Refracting }  
Plain, &c. about 51 feet or } 612

Therefore the Angle of Refraction *acx* was 0. 2'. 23'

The Angle of Emerfion *pcx* (by the construction }  
of the Cylinder) was } 62. 30.

Therefore the Angle of Incidence *pcx* = }  
(= *pcx* + *acx*) was } 62. 27. 37.

And therefore univerfally (according  
to the known Laws of Refraction)

The fines of the Angles of Incidence being 100000

The fines of the Angles of Emerfion are 100036

And the Refractive Power of the Dense Air 36

By the Refractive Power of a Pellucid body I mean that Properly in it whereby the Oblique Rays of Light are diverted from their direct Course; and which is measur'd by the Proportional Differences always Observ'd between the fines of the Angles of Incidence and Emerfion.

This Property is not always proportional to the Density (at least not to the Gravity) of the Refracting Medium. For the Refractive power of Glass to that of Water is as 55. to 34. whereas its Gravity is as 87. to 34; that is, the squares of their Refractive Powers are (very near) as their respective Gravities. And there are some fluids which the lighter than Water  
yet

yet have a Greater Power of Refraction ; thus the Refractive Power of Spirit of Wine ( according to Dr. *Hook's* Experiments ) *Microg.* p. 220 ) is to that of Water as 36 to 33 and it's Gravity reciprocally as 33 to 36 or  $36\frac{1}{2}$ . But the Refractive Powers of Air and Water seem to observe the simple Proportion of their Gravities, directly ; as I have compar'd them in the following Table. The Numbers there Expressing the Refraction of Water are taken from the mean of \*9 Observations at so many several Angles of Incidence made *Jan. 25. 1648* by Mr. *Gascoigne* the Ingenious Fire Inventor of the Micrometer, and the ways of measuring Angles by Telescopes and those of Air are produc'd by the Experiment above related, &c.

*\* I am Indebted for them to Mr. Flamsteed, who had cover'd them with his Observations, and several passages relating to them, from his Letters to Mr. Crabtree which were happily preserv'd in the time of our Civil War by Sr. Jonas Moor and Mr. Christopher Towneley ; and are now in the Hands of Mr. Richard Towneley of Towneley in Lancashire, by whom they were imparted to him.*

	<i>Water.</i>	<i>Air.</i>
The ( assum'd ) sines of the Angles of Incidence through	} 100000	} 100000
The sines of the correspondent Angles of Emerision out of		
The Refractive power of	} 34400	} 36
The Specifick Gravity ( if as 900 to 1 ) at the time of the Experiment ) of or ( if as 850 to 1 ) of		
	} 34400	} 38 40

From hence it seems very probable that their Respective Densities and Refractive Powers are in a just simple proportion: And if this should be confirm'd by succeeding Experiments made at different Angles of Incidence and with Cylinders continuing Exhausted through several Changes of the Air it would be more than probable that the Refractive Powers of the Atmosphere are every where, at all heights above the Earth, proportional to it's Densities and Expansions. And here it would be no difficult matter to trace the Light through it, thereby to terminate the shadow of the Earth ; and ( together with proper Expedients for measuring the Quantity of Light Illuminating an Opaque Body ) to Examin at what distances the Moon must be from the Earth to suffer Eclipses of the Observ'd Duration. This Limitation is considerable enough in Astronomy, abundantly to recompense the trouble of Prosecuting such a New Experiment.

