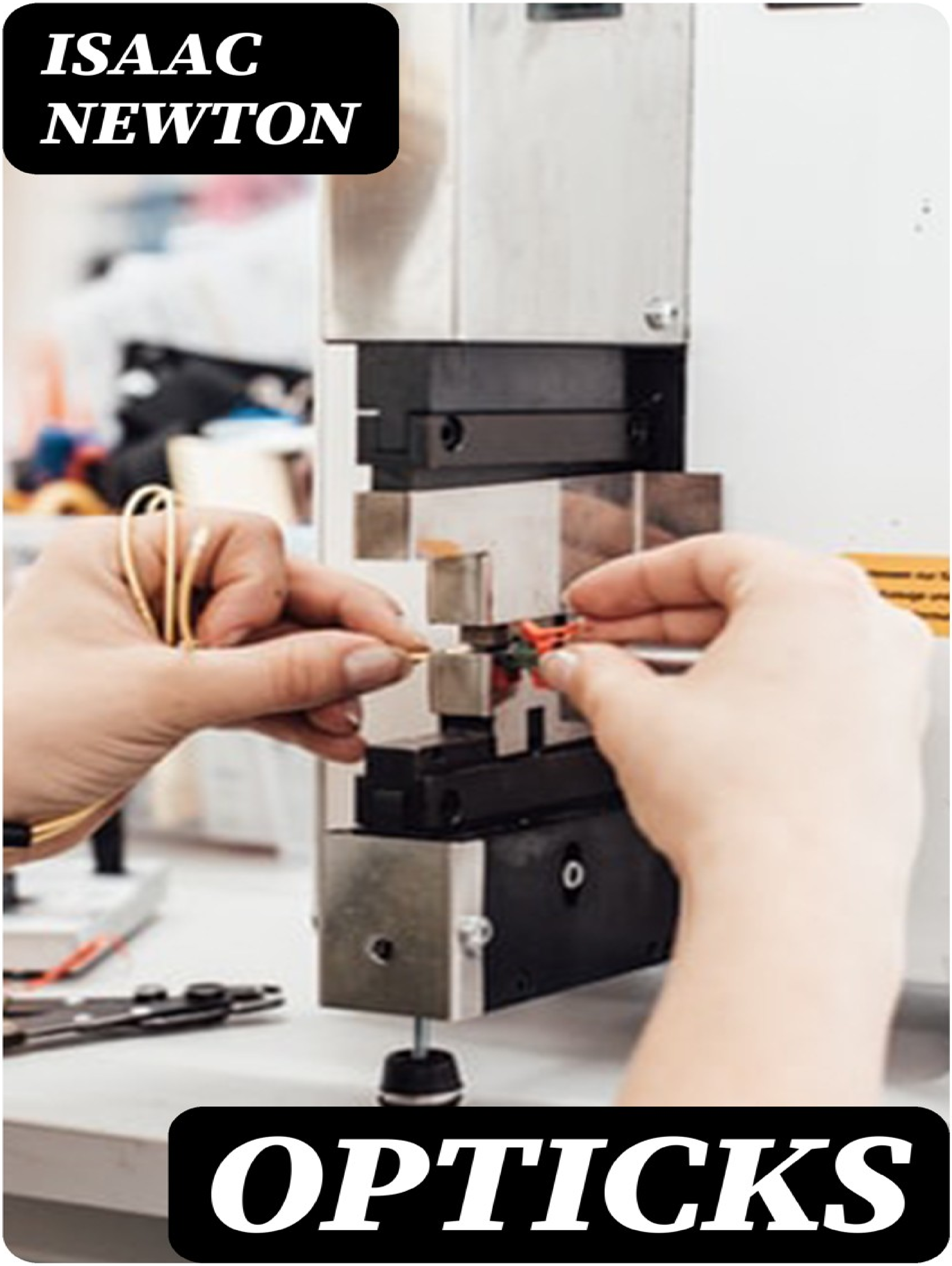
ISAAC NEWTON



# OPTICKS

**Isaac Newton**

# Opticks

## Or, A Treatise of the Reflections, Refractions, Inflections, and Colours of Light

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# THE FIRST BOOK OF OPTICKS

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# PART I.

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My Design in this Book is not to explain the Properties of Light by Hypotheses, but to propose and prove them by Reason and Experiments: In order to which I shall premise the following Definitions and Axioms.

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## DEFINITIONS

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## DEFIN. I.

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*By the Rays of Light I understand its least Parts, and those as well Successive in the same Lines, as Contemporary in several Lines.* For it is manifest that Light consists of Parts, both Successive and Contemporary; because in the same place you may stop that which comes one moment, and let pass that which comes presently after; and in the same time you may stop it in any one place, and let it pass in any other. For that part of Light which is stopp'd cannot be the same with that which is let pass. The least Light or part of Light, which may be stopp'd alone without the rest of the Light, or propagated alone, or do or suffer any thing alone, which the rest of the Light doth not or suffers not, I call a Ray of Light.

## DEFIN. II.

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*Refrangibility of the Rays of Light, is their Disposition to be refracted or turned out of their Way in passing out of one transparent Body or Medium into another. And a greater or less Refrangibility of Rays, is their Disposition to be turned more or less out of their Way in like Incidences on the same Medium.* Mathematicians usually consider the Rays of Light to be Lines reaching from the luminous Body to the Body illuminated, and the refraction of those Rays to be the bending or breaking of those lines in their passing out of one Medium into another. And thus may Rays and Refractions be considered, if Light be propagated in an instant. But by an Argument taken from the Æquations of the times of the Eclipses of *Jupiter's Satellites*, it seems that Light is propagated in time, spending in its passage from the Sun to us about seven Minutes of time: And therefore I have chosen to define Rays and Refractions in such general terms as may agree to Light in both cases.

## DEFIN. III.

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*Reflexibility of Rays, is their Disposition to be reflected or turned back into the same Medium from any other Medium upon whose Surface they fall. And Rays are more or less reflexible, which are turned back more or less easily.* As if Light pass out of a Glass into Air, and by being inclined more and more to the common Surface of the Glass and Air, begins at length to be totally reflected by that Surface; those sorts of Rays which at like Incidences are reflected most copiously, or by inclining the Rays begin soonest to be totally reflected, are most reflexible.

## DEFIN. IV.

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The Angle of Incidence is that Angle, which the Line described by the incident Ray contains with the Perpendicular to the reflecting or refracting Surface at the Point of Incidence.

## DEFIN. V.

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The Angle of Reflexion or Refraction, is the Angle which the line described by the reflected or refracted Ray containeth with the Perpendicular to the reflecting or refracting Surface at the Point of Incidence.

## DEFIN. VI.

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*The Sines of Incidence, Reflexion, and Refraction, are the Sines of the Angles of Incidence, Reflexion, and Refraction.*

## DEFIN. VII

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*The Light whose Rays are all alike Refrangible, I call Simple, Homogeneal and Similar; and that whose Rays are some more Refrangible than others, I call Compound, Heterogeneal and Dissimilar.* The former Light I call

Homogeneal, not because I would affirm it so in all respects, but because the Rays which agree in Refrangibility, agree at least in all those their other Properties which I consider in the following Discourse.

## DEFIN. VIII.

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*The Colours of Homogeneal Lights, I call Primary, Homogeneal and Simple; and those of Heterogeneal Lights, Heterogeneal and Compound.* For these are always compounded of the colours of Homogeneal Lights; as will appear in the following Discourse.

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## AXIOMS.

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## AX. I.

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The Angles of Reflexion and Refraction, lie in one and the same Plane with the Angle of Incidence.

## AX. II.

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The Angle of Reflexion is equal to the Angle of Incidence.

## AX. III.

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If the refracted Ray be returned directly back to the Point of Incidence, it shall be refracted into the Line before described by the incident Ray.

## AX. IV.

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Refraction out of the rarer Medium into the denser, is made towards the Perpendicular; that is, so that the Angle of Refraction be less than the Angle of Incidence.

## AX. V.

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The Sine of Incidence is either accurately or very nearly in a given Ratio to the Sine of Refraction.

Whence if that Proportion be known in any one Inclination of the incident Ray, 'tis known in all the Inclinations, and thereby the Refraction in all cases of Incidence on the same refracting Body may be determined. Thus if the Refraction be made out of Air into Water, the Sine of Incidence of the red Light is to the Sine of its Refraction as 4 to 3. If out of Air into Glass, the Sines are as 17 to 11. In Light of other Colours the Sines have other Proportions: but the difference is so little that it need seldom be considered.

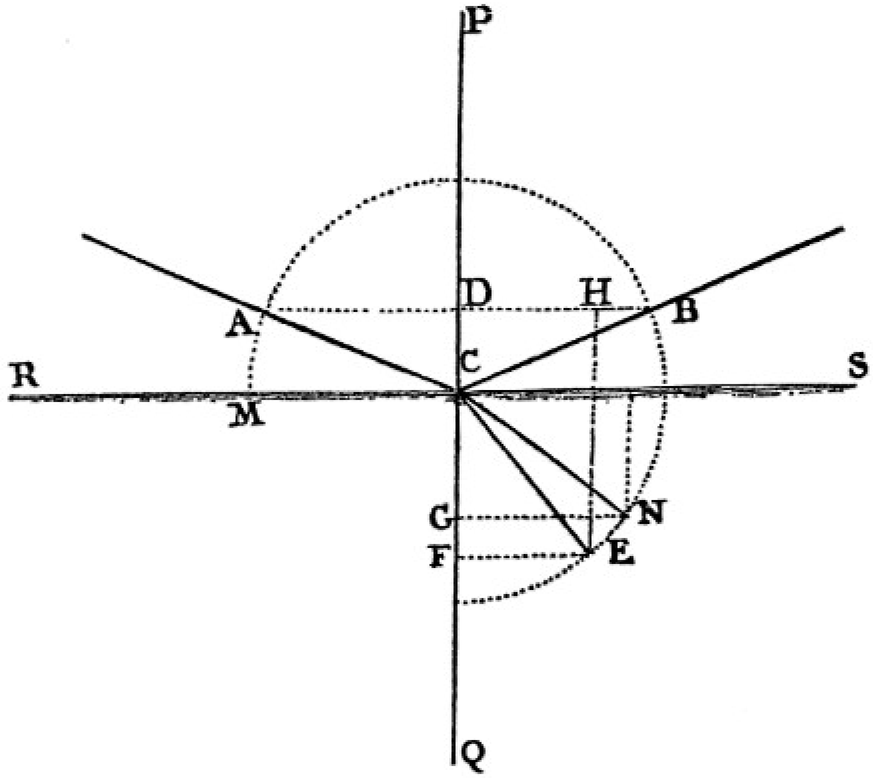

Fig. 1

Suppose therefore, that RS [in *Fig.* 1.] represents the Surface of stagnating Water, and that C is the point of Incidence in which any Ray coming in the Air from A in the Line AC is reflected or refracted, and I would know whither this Ray shall go after Reflexion or Refraction: I erect upon the Surface of the Water from the point of Incidence the Perpendicular CP and produce it downwards to Q, and conclude by the first Axiom, that the Ray after Reflexion and Refraction, shall be found somewhere in the Plane of the Angle of Incidence ACP produced. I let fall therefore upon the Perpendicular CP the Sine of Incidence AD; and if the reflected Ray be desired, I produce AD to B so that DB be equal to AD, and draw CB. For this Line CB shall be the reflected Ray; the Angle of Reflexion BCP and its Sine BD being equal to the Angle and Sine of Incidence, as they ought to be by the second Axiom, But if the refracted Ray be desired, I produce AD to H, so that DH may be to AD as the Sine of Refraction to the Sine of Incidence, that is, (if the Light be red) as 3 to 4; and about the Center C and in the Plane ACP with the Radius CA describing a Circle ABE, I draw a parallel to the Perpendicular CPQ, the Line HE cutting the Circumference in E, and joining CE, this Line CE shall be the Line of the refracted Ray. For if EF be let fall perpendicularly on the Line PQ, this Line EF shall be the Sine of Refraction of the Ray CE, the Angle of Refraction being ECQ; and this Sine EF is equal to DH, and consequently in Proportion to the Sine of Incidence AD as 3 to 4.

In like manner, if there be a Prism of Glass (that is, a Glass bounded with two Equal and Parallel Triangular ends, and three plain and well polished Sides, which meet in three Parallel Lines running from the three Angles of one end to the three Angles of the other end) and if the Refraction of the Light in passing cross this Prism be desired: Let ACB [in *Fig.* 2.] represent a Plane cutting this Prism transversly to its three Parallel lines or edges there where the Light passeth through it, and let DE be the Ray incident upon the first side of the Prism AC where the Light goes into the Glass; and by putting the Proportion of the Sine of Incidence to the Sine of Refraction as 17 to 11 find EF the first refracted Ray. Then taking this Ray for the Incident Ray upon the second side of the Glass BC where the Light goes out, find the next refracted Ray FG by putting the Proportion of the Sine of Incidence to the Sine of Refraction as 11 to 17. For if the Sine of Incidence out of Air into Glass be to the Sine of Refraction as 17 to 11, the Sine of Incidence out of Glass into Air must on the contrary be to the Sine of Refraction as 11 to 17, by the third Axiom.

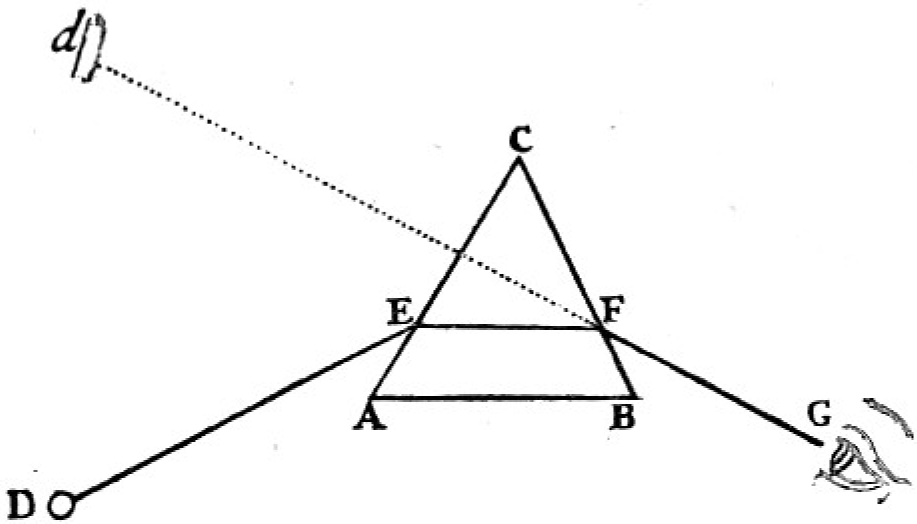


Fig. 2.

Much after the same manner, if ACBD [in *Fig.* 3.] represent a Glass spherically convex on both sides (usually called a *Lens*, such as is a Burning-glass, or Spectacle-glass, or an Object-glass of a Telescope) and it be required to know how Light falling upon it from any lucid point Q shall be refracted, let QM represent a Ray falling upon any point M of its first spherical Surface ACB, and by erecting a Perpendicular to the Glass at the point M, find the first refracted Ray MN by the Proportion of the Sines 17 to 11. Let that Ray in going out of the Glass be incident upon N, and then find the second refracted Ray N*q* by the Proportion of the Sines 11 to 17. And after the same manner may the Refraction be found when the Lens is convex on one side and plane or concave on the other, or concave on both sides.

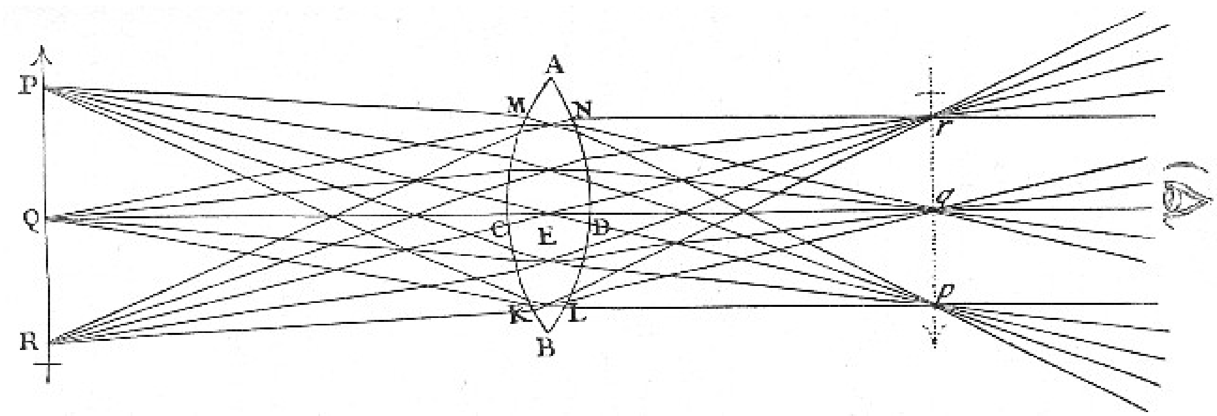

Fig. 3.

# AX. VI.

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Homogeneal Rays which flow from several Points of any Object, and fall perpendicularly or almost perpendicularly on any reflecting or refracting Plane or spherical Surface, shall afterwards diverge from so many other Points, or be parallel to so many other Lines, or converge to so many other Points, either accurately or without any sensible Error. And the same thing will happen, if the Rays be reflected or refracted successively by two or three or more Plane or Spherical Surfaces.

The Point from which Rays diverge or to which they converge may be called their *Focus*. And the Focus of the incident Rays being given, that of the reflected or refracted ones may be found by finding the Refraction of any two Rays, as above; or more readily thus.

*Cas.* 1. Let ACB [in *Fig.* 4.] be a reflecting or refracting Plane, and Q the Focus of the incident Rays, and Q*q*C a Perpendicular to that Plane. And if this Perpendicular be produced to *q*, so that *q*C be equal to QC, the Point *q* shall be the Focus of the reflected Rays: Or if *q*C be taken on the same side of the Plane with QC, and in proportion to QC as the Sine of Incidence to the Sine of Refraction, the Point *q* shall be the Focus of the refracted Rays.

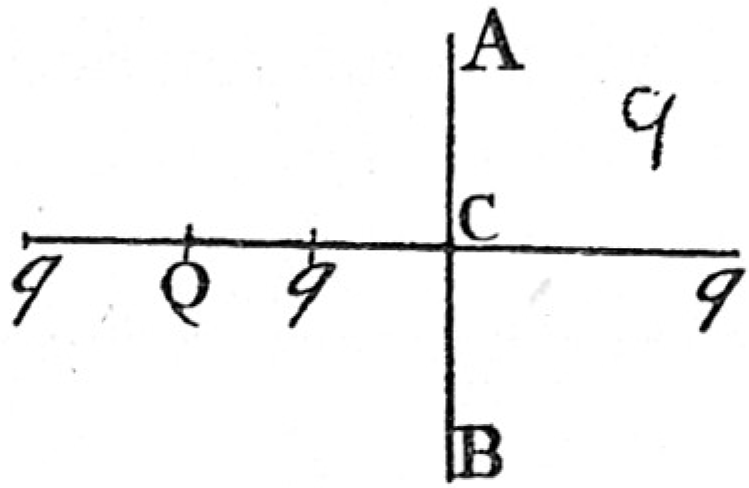


Fig. 4.

*Cas.* 2. Let ACB [in *Fig.* 5.] be the reflecting Surface of any Sphere whose Centre is E. Bisect any Radius thereof, (suppose EC) in T, and if in that Radius on the same side the Point T you take the Points Q and *q*, so that TQ, TE, and T*q*, be continual Proportionals, and the Point Q be the Focus of the incident Rays, the Point *q* shall be the Focus of the reflected ones.

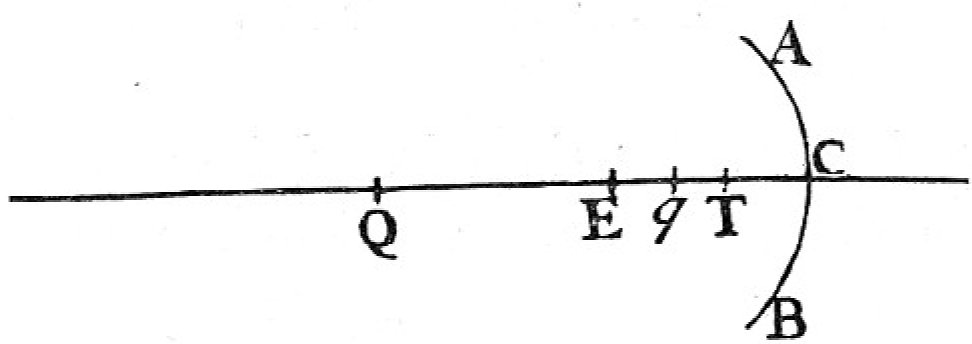


Fig. 5.

*Cas.* 3. Let ACB [in *Fig.* 6.] be the refracting Surface of any Sphere whose Centre is E. In any Radius thereof EC produced both ways take ET and C*t* equal to one another and severally in such Proportion to that Radius as the lesser of the Sines of Incidence and Refraction hath to the difference of those Sines. And then if in the same Line you find any two Points Q and *q*, so that TQ be to ET as E*t* to *tq*, taking *tq* the contrary way from *t* which TQ lieth from T, and if the Point Q be the Focus of any incident Rays, the Point *q* shall be the Focus of the refracted ones.

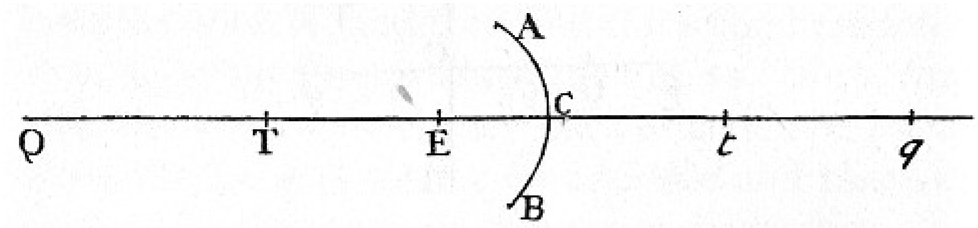


Fig. 6.

And by the same means the Focus of the Rays after two or more Reflexions or Refractions may be found.

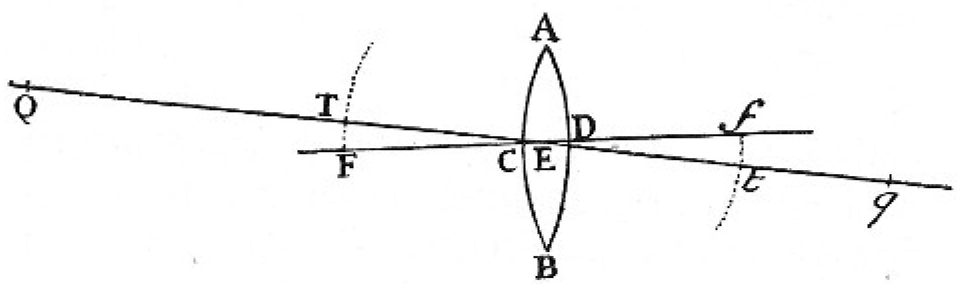


Fig. 7.

*Cas.* 4. Let ACBD [in *Fig.* 7.] be any refracting Lens, spherically Convex or Concave or Plane on either side, and let CD be its Axis (that is, the Line which cuts both its Surfaces perpendicularly, and passes through the Centres of the Spheres,) and in this Axis produced let F and *f* be the Foci of the refracted Rays found as above, when the incident Rays on both sides the Lens are parallel to the same Axis; and upon the Diameter F*f* bisected in E, describe a Circle. Suppose now that any Point Q be the Focus of any incident Rays. Draw QE cutting the said Circle in T and *t*, and therein take *tq* in such proportion to *t*E as *t*E or TE hath to TQ. Let *tq* lie the contrary way from *t* which TQ doth from T, and *q* shall be the Focus of the refracted Rays without any sensible

Error, provided the Point Q be not so remote from the Axis, nor the Lens so broad as to make any of the Rays fall too obliquely on the refracting Surfaces.[A]

And by the like Operations may the reflecting or refracting Surfaces be found when the two Foci are given, and thereby a Lens be formed, which shall make the Rays flow towards or from what Place you please.[B]

So then the Meaning of this Axiom is, that if Rays fall upon any Plane or Spherical Surface or Lens, and before their Incidence flow from or towards any Point Q, they shall after Reflexion or Refraction flow from or towards the Point *q* found by the foregoing Rules. And if the incident Rays flow from or towards several points Q, the reflected or refracted Rays shall flow from or towards so many other Points *q* found by the same Rules. Whether the reflected and refracted Rays flow from or towards the Point *q* is easily known by the situation of that Point. For if that Point be on the same side of the reflecting or refracting Surface or Lens with the Point Q, and the incident Rays flow from the Point Q, the reflected flow towards the Point *q* and the refracted from it; and if the incident Rays flow towards Q, the reflected flow from *q*, and the refracted towards it. And the contrary happens when *q* is on the other side of the Surface.

## AX. VII.

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Wherever the Rays which come from all the Points of any Object meet again in so many Points after they have been made to converge by Reflection or Refraction, there they will make a Picture of the Object upon any white Body on which they fall.

So if PR [in *Fig.* 3.] represent any Object without Doors, and AB be a Lens placed at a hole in the Window-shut of a dark Chamber, whereby the Rays that come from any Point Q of that Object are made to converge and meet again in the Point *q*; and if a Sheet of white Paper be held at *q* for the Light there to fall upon it, the Picture of that Object PR will appear upon the Paper in its proper shape and Colours. For as the Light which comes from the Point Q goes to the Point *q*, so the Light which comes from other Points P and R of the Object, will go to so many other correspondent Points *p* and *r* (as is manifest by the sixth Axiom;) so that every Point of the Object shall illuminate a correspondent Point of the Picture, and thereby make a Picture like the Object in Shape and Colour, this only excepted, that the Picture shall be inverted. And this is the Reason of that vulgar Experiment of casting the Species of Objects from abroad upon a Wall or Sheet of white Paper in a dark Room.

In like manner, when a Man views any Object PQR, [in *Fig.* 8.] the Light which comes from the several Points of the Object is so refracted by the transparent skins and humours of the Eye, (that is, by the outward coat EFG, called the *Tunica Cornea*, and by the crystalline humour AB which is beyond the Pupil *mk*) as to converge and meet again in so many Points in the bottom of the Eye, and there to paint the Picture of the Object upon that skin (called the *Tunica Retina*) with which the bottom of the Eye is covered. For Anatomists, when they have taken off from the bottom of the Eye that outward and most thick Coat called the *Dura*

*Mater*, can then see through the thinner Coats, the Pictures of Objects lively painted thereon. And these Pictures, propagated by Motion along the Fibres of the Optick Nerves into the Brain, are the cause of Vision. For accordingly as these Pictures are perfect or imperfect, the Object is seen perfectly or imperfectly. If the Eye be tinged with any colour (as in the Disease of the *Jaundice*) so as to tinge the Pictures in the bottom of the Eye with that Colour, then all Objects appear tinged with the same Colour. If the Humours of the Eye by old Age decay, so as by shrinking to make the *Cornea* and Coat of the *Crystalline Humour* grow flatter than before, the Light will not be refracted enough, and for want of a sufficient Refraction will not converge to the bottom of the Eye but to some place beyond it, and by consequence paint in the bottom of the Eye a confused Picture, and according to the Indistinctness of this Picture the Object will appear confused. This is the reason of the decay of sight in old Men, and shews why their Sight is mended by Spectacles. For those Convex glasses supply the defect of plumpness in the Eye, and by increasing the Refraction make the Rays converge sooner, so as to convene distinctly at the bottom of the Eye if the Glass have a due degree of convexity. And the contrary happens in short-sighted Men whose Eyes are too plump. For the Refraction being now too great, the Rays converge and convene in the Eyes before they come at the bottom; and therefore the Picture made in the bottom and the Vision caused thereby will not be distinct, unless the Object be brought so near the Eye as that the place where the converging Rays convene may be removed to the bottom, or that the plumpness of the Eye be taken off and the Refractions diminished by a Concave-glass of a due degree of Concavity, or lastly that by Age the Eye grow flatter till it come to a due Figure: For short-sighted Men see remote Objects best in Old Age, and therefore they are accounted to have the most lasting Eyes.

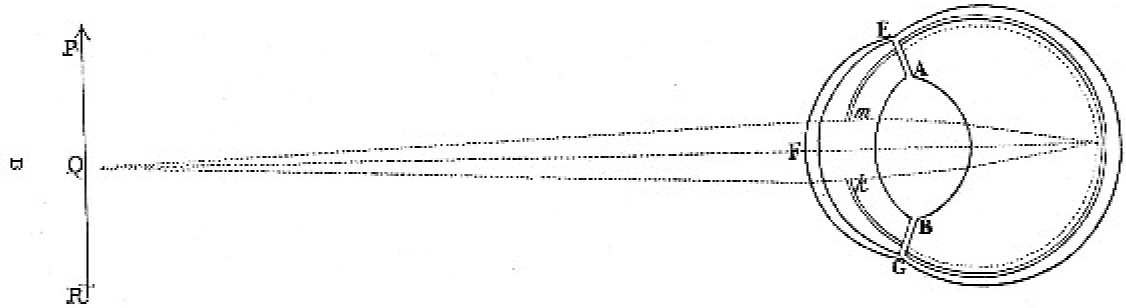

Fig. 8.

# AX. VIII.

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An Object seen by Reflexion or Refraction, appears in that place from whence the Rays after their last Reflexion or Refraction diverge in falling on the Spectator's Eye.

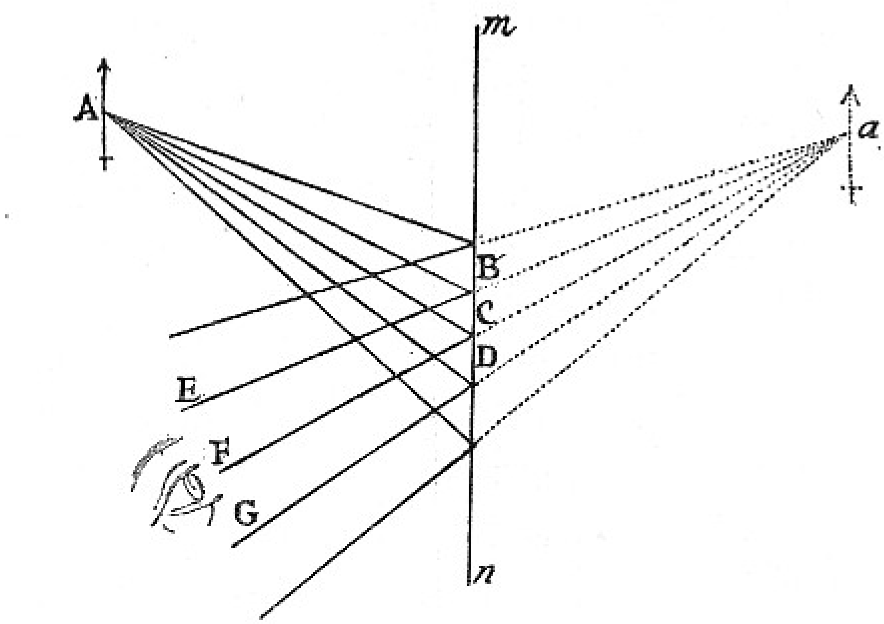

Fig. 9.

If the Object A [in Fig. 9.] be seen by Reflexion of a Looking-glass *mn*, it shall appear, not in its proper place A, but behind the Glass at *a*, from whence any Rays AB, AC, AD, which flow from one and the same Point of the Object, do after their Reflexion made in the Points B, C, D, diverge in going from the Glass to E, F, G, where they are incident on the Spectator's Eyes. For these Rays do make the same Picture in the bottom of the Eyes as if they had come from the Object really placed at *a* without the Interposition of the Looking-glass; and all Vision is made according to the place and shape of that Picture.

In like manner the Object D [in Fig. 2.] seen through a Prism, appears not in its proper place D, but is thence translated to some other place *d* situated in the last refracted Ray FG drawn backward from F to *d*.

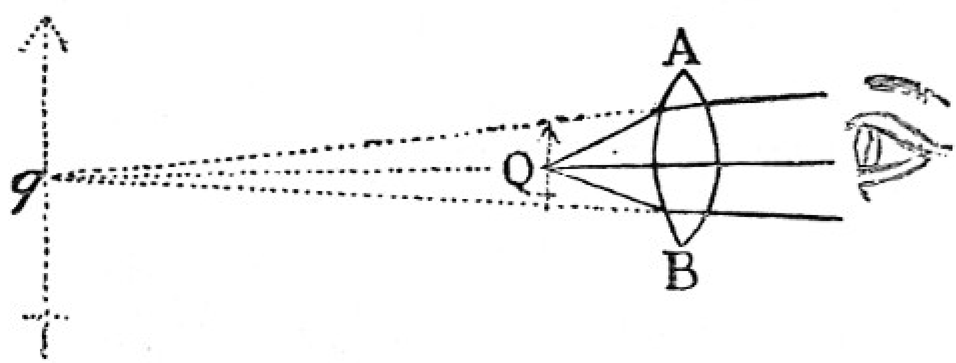


Fig. 10.

And so the Object Q [in Fig. 10.] seen through the Lens AB, appears at the place *q* from whence the Rays diverge in passing from the Lens to the Eye. Now it is to be noted, that the Image of the Object at *q* is so much bigger or lesser than the Object it self at Q, as the distance of the Image at *q* from the Lens AB is bigger or less than the distance of the Object at Q from the same Lens. And if the Object be seen through two or more such Convex or Concave-glasses, every

Glass shall make a new Image, and the Object shall appear in the place of the bigness of the last Image. Which consideration unfolds the Theory of Microscopes and Telescopes. For that Theory consists in almost nothing else than the describing such Glasses as shall make the last Image of any Object as distinct and large and luminous as it can conveniently be made.

I have now given in Axioms and their Explications the sum of what hath hitherto been treated of in Opticks. For what hath been generally agreed on I content my self to assume under the notion of Principles, in order to what I have farther to write. And this may suffice for an Introduction to Readers of quick Wit and good Understanding not yet versed in Opticks: Although those who are already acquainted with this Science, and have handled Glasses, will more readily apprehend what followeth.

# Footnote

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[A] In our Author's *Lectiones Opticæ*, Part I. Sect. IV. Prop 29, 30, there is an elegant Method of determining these *Foci*; not only in spherical Surfaces, but likewise in any other curved Figure whatever: And in Prop. 32, 33, the same thing is done for any Ray lying out of the Axis.

[B] *Ibid.* Prop. 34.

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# PROPOSITIONS.

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## *PROP.* I. Theor. I.

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Lights which differ in Colour, differ also in Degrees of Refrangibility.

The Proof by Experiments.

*Exper.* 1. I took a black oblong stiff Paper terminated by Parallel Sides, and with a Perpendicular right Line drawn cross from one Side to the other, distinguished it into two equal Parts. One of these parts I painted with a red colour and the other with a blue. The Paper was very black, and the Colours intense and thickly laid on, that the Phænomenon might be more conspicuous. This Paper I view'd through a Prism of solid Glass, whose two Sides through which the Light passed to the Eye were plane and well polished, and contained an Angle of about sixty degrees; which Angle I call the refracting Angle of the Prism. And whilst I view'd it, I held it and the Prism before a Window in such manner that the Sides of the Paper were parallel to the Prism, and both those Sides and the Prism were parallel to the Horizon, and the cross Line was also parallel to it: and that the Light which fell from the Window upon the Paper made an Angle with the Paper, equal to that Angle which was made with the same Paper by the Light reflected from it to the Eye. Beyond the Prism was the Wall of the Chamber under the Window covered over with black Cloth, and the Cloth was involved in Darkness that no Light might be reflected from thence, which in passing by the Edges of the Paper to the Eye, might mingle itself with the

Light of the Paper, and obscure the Phænomenon thereof. These things being thus ordered, I found that if the refracting Angle of the Prism be turned upwards, so that the Paper may seem to be lifted upwards by the Refraction, its blue half will be lifted higher by the Refraction than its red half. But if the refracting Angle of the Prism be turned downward, so that the Paper may seem to be carried lower by the Refraction, its blue half will be carried something lower thereby than its red half. Wherefore in both Cases the Light which comes from the blue half of the Paper through the Prism to the Eye, does in like Circumstances suffer a greater Refraction than the Light which comes from the red half, and by consequence is more refrangible.

*Illustration.* In the eleventh Figure, MN represents the Window, and DE the Paper terminated with parallel Sides DJ and HE, and by the transverse Line FG distinguished into two halfs, the one DG of an intensely blue Colour, the other FE of an intensely red. And BAC*cab* represents the Prism whose refracting Planes AB*ba* and AC*ca* meet in the Edge of the refracting Angle A*a*. This Edge A*a* being upward, is parallel both to the Horizon, and to the Parallel-Edges of the Paper DJ and HE, and the transverse Line FG is perpendicular to the Plane of the Window. And *de* represents the Image of the Paper seen by Refraction upwards in such manner, that the blue half DG is carried higher to *dg* than the red half FE is to *fe*, and therefore suffers a greater Refraction. If the Edge of the refracting Angle be turned downward, the Image of the Paper will be refracted downward; suppose to δε, and the blue half will be refracted lower to δγ than the red half is to πε.

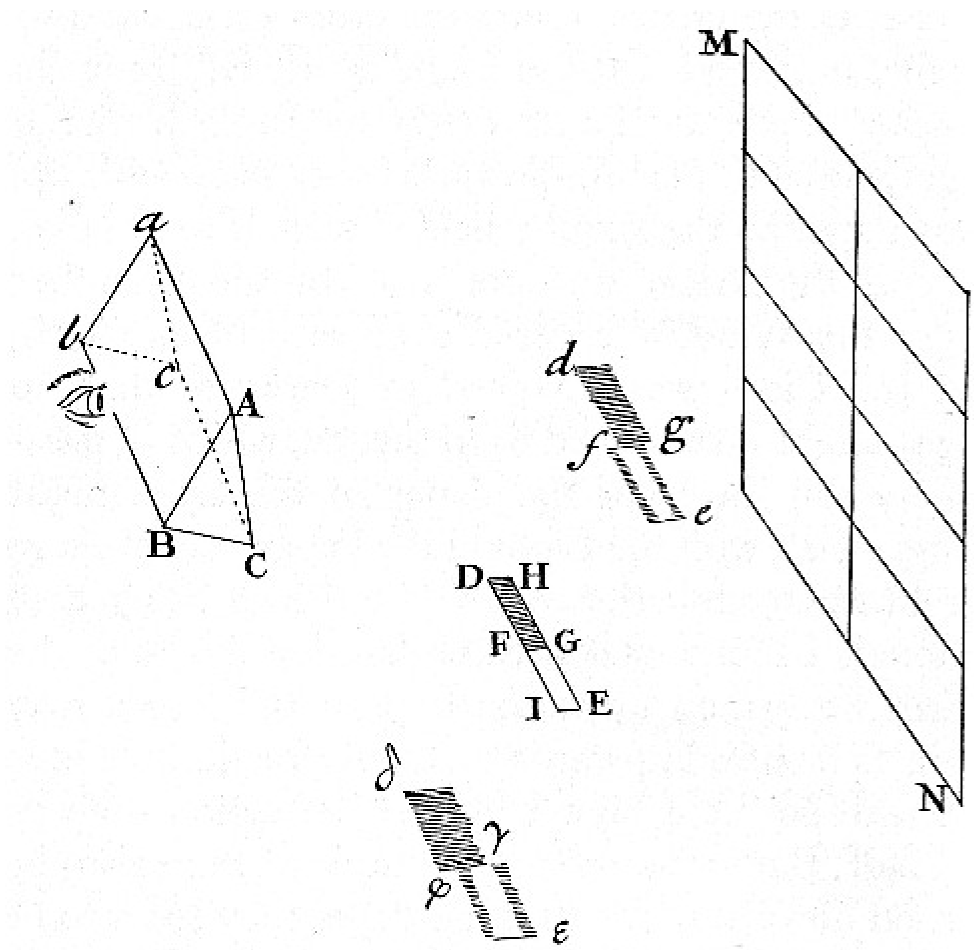


Fig. 11.

*Exper.* 2. About the aforesaid Paper, whose two halfs were painted over with red and blue, and which was stiff like thin Pasteboard, I lapped several times a slender Thred of very black Silk, in such manner that the several parts of the Thred might appear upon the Colours like so many black Lines drawn over them, or like long and slender dark Shadows cast upon them. I might have drawn black Lines with a Pen, but the Threds were smaller and better defined. This Paper thus coloured and lined I set against a Wall perpendicularly to the Horizon, so that one of the Colours might stand to the Right Hand, and the other to the Left. Close before the Paper, at the Confine of the Colours below, I placed a Candle to illuminate the Paper strongly: For the

Experiment was tried in the Night. The Flame of the Candle reached up to the lower edge of the Paper, or a very little higher. Then at the distance of six Feet, and one or two Inches from the Paper upon the Floor I erected a Glass Lens four Inches and a quarter broad, which might collect the Rays coming from the several Points of the Paper, and make them converge towards so many other Points at the same distance of six Feet, and one or two Inches on the other side of the Lens, and so form the Image of the coloured Paper upon a white Paper placed there, after the same manner that a Lens at a Hole in a Window casts the Images of Objects abroad upon a Sheet of white Paper in a dark Room. The aforesaid white Paper, erected perpendicular to the Horizon, and to the Rays which fell upon it from the Lens, I moved sometimes towards the Lens, sometimes from it, to find the Places where the Images of the blue and red Parts of the coloured Paper appeared most distinct. Those Places I easily knew by the Images of the black Lines which I had made by winding the Silk about the Paper. For the Images of those fine and slender Lines (which by reason of their Blackness were like Shadows on the Colours) were confused and scarce visible, unless when the Colours on either side of each Line were terminated most distinctly, Noting therefore, as diligently as I could, the Places where the Images of the red and blue halfs of the coloured Paper appeared most distinct, I found that where the red half of the Paper appeared distinct, the blue half appeared confused, so that the black Lines drawn upon it could scarce be seen; and on the contrary, where the blue half appeared most distinct, the red half appeared confused, so that the black Lines upon it were scarce visible. And between the two Places where these Images appeared distinct there was the distance of an Inch and a half; the distance of the white Paper from the Lens, when the Image of the red half of the coloured Paper appeared most distinct, being greater by an Inch and an half than the distance of the same white Paper from the Lens, when the Image of the blue half appeared most distinct. In like Incidences therefore of the blue and red upon the Lens, the blue was refracted more by the Lens than the red, so as to converge sooner by an Inch and a half, and therefore is more refrangible.

*Illustration.* In the twelfth Figure (p. 27), DE signifies the coloured Paper, DG the blue half, FE the red half, MN the Lens, HJ the white Paper in that Place where the red half with its black Lines appeared distinct, and *hi* the same Paper in that Place where the blue half appeared distinct. The Place *hi* was nearer to the Lens MN than the Place HJ by an Inch and an half.

*Scholium.* The same Things succeed, notwithstanding that some of the Circumstances be varied; as in the first Experiment when the Prism and Paper are any ways inclined to the Horizon, and in both when coloured Lines are drawn upon very black Paper. But in the Description of these Experiments, I have set down such Circumstances, by which either the Phænomenon might be render'd more conspicuous, or a Novice might more easily try them, or by which I did try them only. The same Thing, I have often done in the following Experiments: Concerning all which, this one Admonition may suffice. Now from these Experiments it follows not, that all the Light of the blue is more refrangible than all the Light of the red: For both Lights are mixed of Rays differently refrangible, so that in the red there are some Rays not less refrangible than those of the blue, and in the blue there are some Rays not more refrangible than those of the red: But these Rays, in proportion to the whole Light, are but few, and serve to diminish the Event of the Experiment, but are not able to destroy it. For, if the red and blue Colours were more dilute and weak, the distance of the Images would be less than an Inch and a half; and if they were more intense and full, that distance would be greater, as will appear hereafter. These Experiments may suffice for the Colours of Natural Bodies. For in the Colours made by the Refraction of Prisms, this Proposition will appear by the Experiments which are now to follow in the next Proposition.

## ***PROP.*** **II. THEOR. II.**

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The Light of the Sun consists of Rays differently Refrangible.

The PROOF by Experiments.

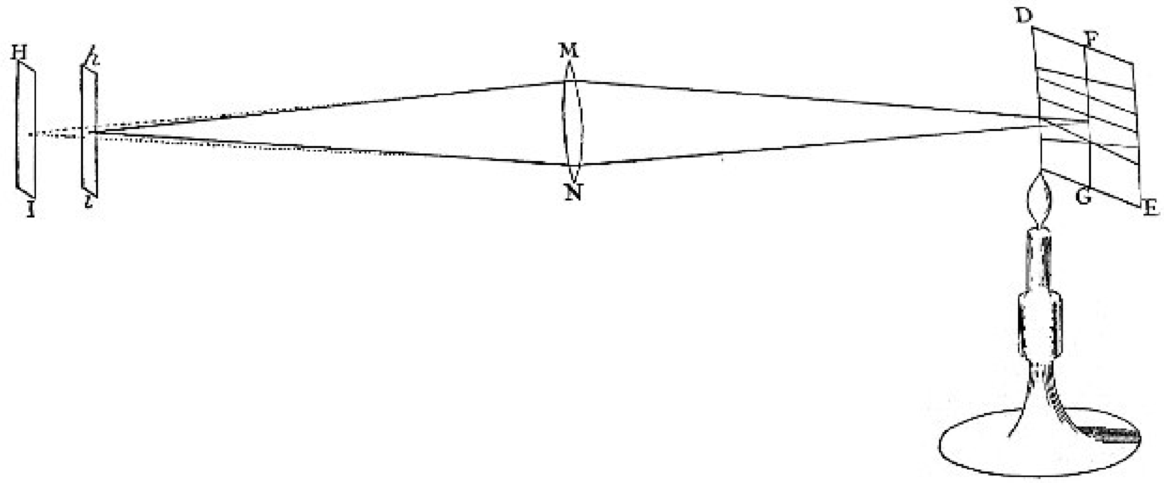

Fig. 12.

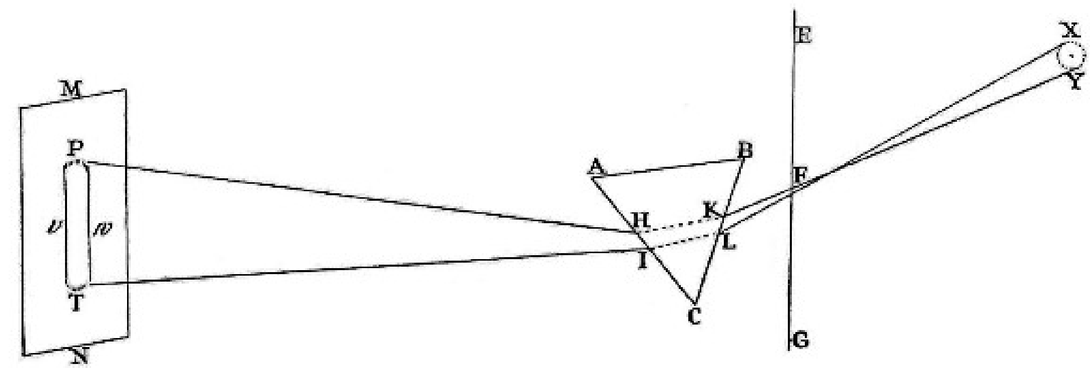

Fig. 13.

*Exper.* 3.

In a very dark Chamber, at a round Hole, about one third Part of an Inch broad, made in the Shut of a Window, I placed a Glass Prism, whereby the Beam of the Sun's Light, which came in at that Hole, might be refracted upwards toward the opposite Wall of the Chamber, and there form a colour'd Image of the Sun. The Axis of the Prism (that is, the Line passing through the middle of the Prism from one end of it to the other end parallel to the edge of the Refracting Angle) was in this and the following Experiments perpendicular to the incident Rays. About this Axis I turned the Prism slowly, and saw the refracted Light on the Wall, or coloured Image of the Sun, first to descend, and then to