The Third Book of Opticks (1704)

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<113>

THE THIRD BOOK OF OPTICKS.

G*Rimaldo* has informed us, that if a beam of the Sun's Light be let into a dark Room through a very small Hole, the shadows of things in this Light will be larger than they ought to be if the rays went on by the Bodies in streight Lines, and that these shadows have three parallel fringes, bands or ranks of coloured Light adjacent to them. But if the Hole be enlarged the fringes grow broad and run into one another, so that they cannot be distinguished. These broad shadows and fringes have been reckoned by some to proceed from the ordinary refraction of the Air, but without due examination of the matter. For the circumstances of the Phænomenon, so far as I have observed them, are as follows.

<114>

OBS. I.

I made in a piece of Lead a small Hole with a Pin, whose breadth was the 42th part of an Inch. For 21 of those Pins laid together took up the breadth of half an Inch. Through this Hole I let into my darkened Chamber a beam of the Sun's Light, and found that the shadows of Hairs, Thred, Pins, Straws, and such like slender substances placed in this beam of Light, were considerably broader than they ought to be, if the rays of Light passed on by these Bodies in right Lines. And particularly a Hair of a Man's Head, whose breadth was but the 280th part of an Inch, being held in this Light, at the distance of about twelve Feet from the Hole, did cast a shadow which at the distance of four Inches from the Hair was the sixtieth part of an Inch broad, that is, above four times broader than the Hair, and at the distance of two Feet from the Hair was about the eight and twentieth part of an Inch broad, that is, ten times broader than the Hair, and at the distance of ten Feet was the eighth part of an Inch broad, that is 35 times broader.

Nor is it material whether the Hair be incompassed with Air, or with any other pellucid substance. For I wetted a polished plate of Glass, and laid the Hair in the Water upon the Glass, and then laying another polished plate of Glass upon it, so that the Water might fill up the space between the Glasses, I held them in the aforesaid beam of Light, so that the Light might pass through them perpendicularly, and the shadow of the Hair was at the same distances as big as before. <115> The shadows of scratches made in polished plates of Glass were also much broader than they ought to be, and the Veins in polished plates of Glass did also cast the like broad shadows. And therefore the great breadth of these shadows proceeds from some other cause than the refraction of the Air.

[Image 1] Let the Circle X represent the middle of the Hair; ADG, BEH, CFI, three rays passing by one side of the Hair at several distances; KNQ, LOR, MPS, three other rays passing by the other side of the Hair at the like distances; D, E, F, and N, 0, P, the places where the rays are bent in their passage by the Hair; G, H, I, and

Q, R, S, the places where the rays fall on a Paper GQ; IS the breadth of the shadow of the Hair cast on the Paper, and TI, VS, two rays passing to the points I and S without bending when the Hair is taken away. And it's manifest that all the Light between these two rays AI and VS is bent in passing by the Hair, and turned aside from the shadow IS, because if any part of this Light were not bent it would fall on the Paper within the shadow, and there illuminate the Paper contrary to experience. And because when the Paper is at a great distance from the Hair, the shadow is broad, and therefore the rays TI and VS are at a great distance from one another, it follows that the Hair acts upon the rays of Light at a good distance in their passing by it. But the action is strongest on the rays which pass by at least distances, and grows weaker and weaker accordingly as the rays pass by at distances greater and greater, as is represented in the Scheme: For thence it comes to pass, that the shadow of the Hair is much broader in proportion to the distance of <116> the Paper from the Hair, when the Paper is nearer the Hair than when it is at a great distance from it.

OBS. II.

The shadows of all Bodies (Metals, Stones, Glass, Wood, Horn, Ice, *&c.*) in this Light were bordered with three parallel fringes or bands of coloured Light, whereof that which was contiguous to the shadow was broadest and most luminous, and that which was remotest from it was narrowest, and so faint, as not easily to be visible. It was difficult to distinguish the Colours unless when the Light fell very obliquely upon a smooth Paper, or some other smooth white Body, so as to make them appear much broader than they would otherwise do. And then the Colours were plainly visible in this order: The first or innermost fringe was violet and deep blue next the shadow, and then light blue, green, and yellow in the middle, and red without. The second fringe was almost contiguous to the first, and the third to the second, and both were blue within, and yellow and red without, but their Colours were very faint especially those of the third. The Colours therefore proceeded in this order from the shadow, violet, indico, pale blue, green, yellow, red; blue, yellow, red; pale blue, pale yellow and red. The shadows made by scratches and bubbles in polished plates of Glass were bordered with the like fringes of coloured Light. And if plates of Looking-glass sloop'd off near the edges with a Diamond-cut, be held in the same beam of Light, the Light which passes through the parallel planes of the Glass will be bordered with the like fringes of Co <117> lours where those Planes meet with the Diamond cut, and by this means there will sometimes appear four or five fringes of Colours.[Image 2] Let AB, CD represent the parallel planes of a Looking-glass, and BD the plane of the Diamond-cut, making at B a very obtuse Angle with the plane AB. And let all the Light between the rays ENI and FBM pass directly through the parallel planes of the Glass, and fall upon the Paper between I and M, and all the Light between the rays GO and HD be refracted by the oblique plane of the Diamond cut BD, and fall upon the Paper between K and L; and the Light which passes directly through the parallel planes of the Glass, and falls upon the Paper between I and M, will be bordered with three or more fringes at M.

OBS. III.

When the Hair was twelve Feet distant from the Hole, and its shadow fell obliquely upon a flat white scale of Inches and parts of an Inch placed half a Foot beyond it, and also when the shadow fell perpendicularly upon the same scale placed nine Feet beyond it; I measured the breadth of the shadow and fringes as accurately as I could, and found them in parts of an Inch as follows.

<118>

At the Distance of	*half a Foot.*	*Nine Feet.*
The breadth of the Shadow	$\frac{1}{54}$	$\frac{1}{9}$
The breadth between the middles of the brightest Light of the innermost fringes on either side the shadow	$\frac{1}{38}$ or $\frac{1}{39}$	$\frac{7}{50}$
The breadth between the middles of the brightest Light of the middlemost fringes on either side the shadow	$\frac{1}{23\frac{1}{2}}$	$\frac{4}{17}$
The breadth between the middles of the brightest Light of the outmost fringes on either side the shadow	$\frac{1}{18}$ or	$\frac{3}{10}$

	$\frac{1}{18\frac{1}{2}}$	
The distance between the middles of the brightest Light of the first and second fringes	$\frac{1}{120}$	$\frac{1}{21}$
The distance between the middles of the brightest Light of the second and third fringes	$\frac{1}{170}$	$\frac{1}{31}$
The breadth of the luminous part (green, white, yellow, and red) of the first fringe	$\frac{1}{170}$	$\frac{1}{32}$
The breadth of the darker space between the first and second fringes.	$\frac{1}{240}$	$\frac{1}{45}$
The breadth of the luminous part of the second fringe	$\frac{1}{290}$	$\frac{1}{55}$
The breadth of the darker space between the second and third fringes.	$\frac{1}{340}$	$\frac{1}{63}$

<119>

These Measures I took by letting the shadow of the Hair at half a Foot distance fall so obliquely on the scale as to appear twelve times broader than when it fell perpendicularly on it at the same distance, and setting down in this Table the twelfth part of the measures I then took.

OBS. IV.

When the shadow and fringes were cast obliquely upon a smooth white Body, and that Body was removed further and further from the Hair, the first fringe began to appear and look brighter than the rest of the Light at the distance of less than a quarter of an Inch from the Hair, and the dark line or shadow between that and the second fringe began to appear at a less distance from the Hair than that of the third part of an Inch. The second fringe began to appear at a distance from the Hair of less than half an Inch, and the shadow between that and the third fringe at a distance less than an Inch, and the third fringe at a distance less than three Inches. At greater distances they became much more sensible, but kept very nearly the same proportion of their breadths and intervals which they had at their first appearing. For the distance between the middle of the first and middle of the second fringe, was to the distance between the middle of the second and middle of the third fringe, as three to two, or ten to seven. And the last of these two distances was equal to the breadth of the bright Light or luminous part of the first fringe. And this breadth was to the breadth of the bright Light of the second fringe as seven to four, and to the dark <120> interval of the first and second fringe as three to two, and to the like dark interval between the second and third as two to one. For the breadths of the fringes seemed to be in the progression of the numbers 1, $\sqrt{\frac{1}{3}}$, $\sqrt{\frac{1}{5}}$ and their intervals to be in the same progression with them; that is, the fringes and their intervals together to be in the continual progression of the numbers 1, $\sqrt{\frac{1}{2}}, \sqrt{\frac{1}{3}}, \sqrt{\frac{1}{4}}, \sqrt{\frac{1}{5}}$, or thereabouts. And these proportions held the same very nearly at all distances from the Hair; the dark Intervals of the fringes being as broad in proportion to the fringes at their first appearance as afterwards at great distances from the Hair, though not so dark and distinct.

OBS. V.

The Sun shining into my darkened Chamber through a Hole a quarter of an Inch broad; I placed at the distance of two or three Feet from the Hole a Sheet of Past-board, which was black'd all over on both sides, and in the middle of it had a Hole about three quarters of an Inch square for the Light to pass through. And behind the Hole I fastened to the Past-board with Pitch the blade of a sharp Knife, to intercept some part of the Light which passed through the Hole. The planes of the Past-board and blade of the Knife were parallel to one another, and perpendicular to the rays. And when they were so placed that none of the Sun's Light fell on the Past-board, but all of it passed through the Hole to the Knife, and there part of it fell upon the blade of the Knife, and part of it passed by its edge: I let this part of the Light which passed by, fall on a <121> white Paper two or three Feet beyond the Knife, and there saw two streams of faint Light shoot out both ways from the beam of Light into the shadow like the tails of Comets. But because the Sun's direct Light by its brightness upon the Paper obscured these faint streams, so that I could scarce see them, I made a little Hole in the midst of the Paper for that Light to pass through and fall on a black cloth behind it; and then I saw the two streams plainly. They were like one another, and pretty nearly equal in length and breadth, and quantity of Light. Their

Light at that end next the Sun's direct Light was pretty strong for the space of about a quarter of an Inch, or half an Inch, and in all its progress from that direct Light decreased gradually till it became insensible. The whole length of either of these streams measured upon the Paper at the distance of three Feet from the Knife was about six or eight Inches; so that it subtended an Angle at the edge of the Knife of about 10 or 12, or at most 14 degrees. Yet sometimes I thought I saw it shoot three or four degrees further, but with a Light so very faint that I could scarce perceive it, and suspected it might (in some measure at least) arise from some other cause than the two streams did. For placing my Eye in that Light beyond the end of that stream which was behind the Knife, and looking towards the Knife, I could see a line of Light upon its edge, and that not only when my Eye was in the line of the streams, but also when it was without that line either towards the point of the Knife, or towards the handle. This line of Light appeared contiguous to the edge of the Knife, and was narrower than the Light of the innermost fringe, and <122> narrowest when my Eye was furthest from the direct Light, and therefore seemed to pass between the Light of that fringe and the edge of the Knife, and that which passed nearest the edge to be most bent, though not all of it.

OBS. VI.

I placed another Knife by this so that their edges might be parallel and look towards one another, and that the beam of Light might fall upon both the Knives, and some part of it pass between their edges. And when the distance of their edges was about the 400th part of an Inch the stream parted in the middle, and left a shadow between the two parts. This shadow was so black and dark that all the Light which passed between the Knives seemed to be bent, and turned aside to the one hand or to the other. And as the Knives still approached one another the shadow grew broader, and the streams shorter at their inward ends which were next the shadow, until upon the contact of the Knives the whole Light vanished leaving its place to the shadow.

And hence I gather that the Light which is least bent, and goes to the inward ends of the streams, passes by the edges of the Knives at the greatest distance, and this distance when the shadow begins to appear between the streams is about the eight-hundredth part of an Inch. And the Light which passes by the edges of the Knives at distances still less and less is more and more bent, and goes to those parts of the streams which are further and further from the direct Light, because <123> when the Knives approach one another till they touch, those parts of the streams vanish last which are furthest from the direct Light.

OBS. VII.

In the fifth Observation the fringes did not appear, but by reason of the breadth of the Hole in the Window became so broad as to run into one another, and by joyning make one continued Light in the beginning of the streams. But in the sixth, as the Knives approached one another, a little before the shadow appeared between the two streams, the fringes began to appear on the inner ends of the streams on either side of the direct Light, three on one side made by the edge of one Knife, and three on the other side made by the edge of the other Knife. They were distinctest when the Knives were placed at the greatest distance from the Hole in the Window, and still became more distinct by making the Hole less, insomuch that I could sometimes see a faint lineament of a fourth fringe beyond the three above-mentioned. And as the Knives continually approached one another, the fringes grew distincter and larger until they vanished. The outmost fringe vanished first, and the middlemost next, and the innermost last. And after they were all vanished, and the line of Light which was in the middle between them was grown very broad, enlarging it self on both sides into the streams of Light described in the fifth Observation, the above-mentioned shadow began to appear in the middle of this line, and divide it along the middle into two lines of Light, and increased until the whole <124> Light vanished. This inlargement of the fringes was so great that the rays which go to the innermost fringe seemed to be bent above twenty times more when this fringe was ready to vanish, than when one of the Knives was taken away.

And from this and the former Observation compared, I gather, that the Light of the first fringe passed by the edge of the Knife at a distance greater than the eight-hundredth part of an Inch, and the Light of the second fringe passed by the edge of the Knife at a greater distance than the Light of the first fringe did, and that of the third at a greater distance than that of the second, and that of the streams of Light described in the fifth and sixth Observations passed by the edges of the Knives at less distances than that of any of the fringes.

OBS. VIII.

I caused the edges of two Knives to be ground truly streight, and pricking their points into a board so that their edges might look towards one another, and meeting near their points contain a rectilinear Angle, I fastned their handles together with Pitch to make this Angle invariable. The distance of the edges of the Knives from one another at the distance of four Inches from the angular point, where the edges of the Knives met, was the eighth part of an Inch, and therefore the Angle contained by the edges was about 1 degr. 54'. The Knives thus fixed together I placed in a beam of the Sun's Light, let into my darkened Chamber through a Hole the 42th part of an Inch wide, at the distance <125> of ten or fifteen Feet from the Hole, and let the Light which passed between their edges fall very obliquely upon a smooth white Ruler at the distance of half an Inch, or an Inch from the Knives, and there saw the fringes made by the two edges of the Knives run along the edges of the shadows of the Knives in Lines parallel to those edges without growing sensibly broader, till they met in Angles equal to the Angle contained by the edges of the Knives, and where they met and joyned they ended without crossing one another. But if the Ruler was held at a much greater distance from the Paper, the fringes became something broader and broader as they approached one another, and after they met they crossed one another,and then became much broader than before.

Whence I gather that the distances at which the fringes pass by the Knives are not increased nor altered by the approach of the Knives, but the Angles in which the rays are there bent are much increased by that approach; and that the Knife which is nearest any ray determines which way the ray shall be bent, and the other Knife increases the bent.

OBS. IX.

When the rays fell very obliquely upon the Ruler at the distance of the third part of an Inch from the Knives, the dark line between the first and second fringe of the shadow of one Knife, and the dark line between the first and second fringe of the shadow of the other Knife met with one another, at the distance of the fifth part of an Inch from the end of the Light which passed be <126> tween the Knives at the concourse of their edges. And therefore the distance of the edges of the Knives at the meeting of these dark lines was the 160th part of an Inch. For as four Inches to the eighth part of an Inch, so is any length of the edges of the Knives measured from the point of their concourse to the distance of the edges of the Knives at the end of that length, and so is the fifth part of an Inch to the 160th part. So then the dark lines above-mentioned meet in the middle of the Light which passes between the Knives where they are distant the 160th part of an Inch, and the one half of that Light passes by the edge of one Knife at a distance not greater than the 320th part of an Inch, and falling upon the Paper makes the fringes of the shadow of that Knife, and the other half passes by the edge of the other Knife, at a distance not greater than the 320th part of an Inch, and falling upon the Paper makes the fringes of the shadow of the other Knife. But if the Paper be held at a distance from the Knives greater than the third part of an Inch, the dark lines above-mentioned meet at a greater distance than the fifth part of an Inch from the end of the Light which passed between the Knives at the concourse of their edges; and therefore the Light which falls upon the Paper where those dark lines meet passes between the Knives where their edges are distant above the 160th part of an Inch.

For at another time when the two Knives were distant eight Feet and five Inches from the little Hole in the Window, made with a small Pin as above, the Light which fell upon the Paper where the aforesaid dark lines met, passed between the Knives, where the di <127> stance between their edges was as in the following Table, when the distance of the Paper from the Knives was also as follows.

Distances of the Paper from the Knives in Inches.	*Distances between the edges of the Knives in millesimal parts of an Inch.*
$1\frac{1}{2}$.	0'012.
$3\frac{1}{3}$.	0'020.
$8\frac{2}{5}$.	0'034.
32.	0'057.
96.	0'081.

And hence I gather that the Light which makes the fringes upon the Paper is not the same Light at all distances of the Paper from the Knives, but when the Paper is held near the Knives, the fringes are made by Light which passes by the edges of the Knives at a less distance, and is more bent than when the Paper is held at a greater distance from the Knives.

OBS. X.

When the fringes of the shadows of the Knives fell perpendicularly upon a Paper at a great distance from the Knives, they were in the form of Hyperbolas, and their dimensions were as follows. Let CA, CB represent lines drawn upon the Paper parallel to the edges of the Knives, and between which all the Light would fall, if it passed between the edges of the Knives without inflexion; DE a right line drawn through C making <128> the Angles ACD, BCE, equal to one another, and terminating all the Light which falls upon the Paper from the point where the edges of the Knives meet; eis, fkt, and glv, three hyperbolical lines representing the terminus of the shadow of one of the Knives, the dark line between the first and second fringes of that shadow, and the dark line between the second and third fringes of the same shadow; xip, ykq and zlr, three other Hyperbolical lines representing the terminus of the shadow of the other Knife, the dark line between the first and second fringes of that shadow, and the dark line between the second and third fringes of the same shadow. And conceive that these three Hyperbolas are like and equal to the former three, and cross them in the points i, k, and l, and that the shadows of the Knives are terminated and distinguished from the first luminous fringes by the lines eis and xip, until the meeting and crossing of the fringes, and then those lines cross the fringes in the form of dark lines, terminating the first luminous fringes within side, and distinguishing them from another Light which begins to appear at i, and illuminates all the triangular space ipDEs comprehended by these dark lines, and the right line DE. Of these Hyperbolas one Asymptote is the line DE, and their other Asymptotes are parallel to the lines CA and CB. Let rv represent a line drawn any where upon the Paper parallel to the Asymptote DE, and let this line cross the right lines AC in m and BC in n, and the six dark hyperbolical lines in p, q, r; s, t, v; and by measuring the distances ps, qt, rv, and thence collecting the lengths of the ordinates np, nq, nr or ms, mt, mv, and doing this at several distances of the line rv, <129> from the Asymptote DE you may find as many points of these Hyperbolas as you please, and thereby know that these curve lines are Hyperbolas differing little from the conical Hyperbola. And by measuring the lines Ci, Ck, Cl, you may find other points of these Curves.

For instance, when the Knives were distant from the Hole in the Window ten Feet, and the Paper from the Knives 9 Feet, and the Angle contained by the edges of the Knives to which the Angle ACB is equal, was subtended by a chord which was to the Radius as 1 to 32, and the distance of the line rv from the Asymptote DE was half an Inch: I measured the lines ps, qt, rv, and found them 0'35, 0'65, 0'98 Inches respectively, and by adding to their halfs the line $\frac{1}{2}$ mn (which here was the 128th part of an Inch, or 0'0078 Inches) the sums np, nq, nr, were 0'1828, 0'3328, 0'4978 Inches. I measured also the distances of the brightest parts of the fringes which run between pq and st, qr and tv, and next beyond r and v, and found them 0'5, 0'8, and 1'17 Inches.

OBS. XI.

The Sun shining into my darkened Room through a small round Hole made in a plate of Lead with a slender Pin as above; I placed at the Hole a Prism to refract the Light, and form on the opposite Wall the Spectrum of Colours, described in the third Experiment of the first Book. And then I found that the Shadows of all Bodies held in the coloured Light between the Prism and the Wall, were bordered with fringes of the Colour <130> of that Light in which they were held. In the full red Light they were totally red without any sensible blue or violet, and in the deep blue Light they were totally blue without any sensible red or yellow; and so in the green Light they were totally green, excepting a little yellow and blue, which were mixed in the green Light of the Prism. And comparing the Fringes made in the several coloured Lights, I found that those made in the red Light were largest, those made in the violet were least, and those made in the green were of a middle bigness. For the fringes with which the Shadow of a Man's Hair were bordered, being measured cross the shadow at the distance of six Inches from the Hair; the distance between the middle and most luminous part of the first or innermost fringe on one side of the shadow, and that of the like fringe on the other side of the shadow, was

in the full red Light $\frac{1}{57\frac{1}{2}}$ of an Inch, and in the full violet $\frac{1}{46}$. And the like distance between the middle and most luminous parts of the second fringes on either side the shadow was in the full red Light $\frac{1}{22}$, and in the violet $\frac{1}{27}$ of an Inch. And these distances of the fringes held the same proportion at all distances from the Hair without any sensible variation.

So then the rays which made these fringes in the red Light passed by the Hair at a greater distance than those did which made the like fringes in the violet; and therefore the Hair in causing these fringes acted alike upon the red Light or least refrangible rays at a greater distance, and upon the violet or most refrangible rays at a less distance, and by those actions disposed the red Light into larger fringes, and the violet into smaller, and the Lights of intermediate Colours into fringes of <131> intermediate bignesses without changing the Colour of any sort of Light.

When therefore the Hair in the first and second of these Observations was held in the white beam of the Sun's Light, and cast a shadow which was bordered with three fringes of coloured Light, those Colours arose not from any new modifications imprest upon the rays of Light by the Hair, but only from the various inflections whereby the several sorts of rays were separated from one another, which before separation by the mixture of all their Colours, composed the white beam of the Sun's Light, but whenever separated compose Lights of the several Colours which they are originally disposed to exhibit. In this 13th Observation, where the Colours are separated before the Light passes by the Hair, the least refrangible rays, which when separated from the rest make red, were inflected at a greater distance from the Hair, so as to make three red fringes at a greater distance from the middle of the shadow of the Hair; and the most refrangible rays which when separated make violet, were inflected at a less distance from the Hair, so as to make three violet fringes at a less distance from the middle of the shadow of the Hair. And other rays of intermediate degrees of refrangibility were inflected at intermediate distances from the Hair, so as to make fringes of intermediate Colours at intermediate distances from the middle of the shadow of the Hair. And in the second Observation, where all the Colours are mixed in the white Light which passes by the Hair, these Colours are separated by the various inflexions of the rays, and the fringes which they make appear all together, and the innermost <132> fringes being contiguous make one broad fringe composed of all the Colours in due order, the violet lying on the inside of the fringe next the shadow, the red on the outside furthest from the shadow, and the blue, green and yellow, in the middle. And, in like manner, the middlemost fringes of all the Colours lying in order, and being contiguous, make another broad fringe composed of all the Colours; and the outmost fringes of all the Colours lying in order, and being contiguous, make a third broad fringe composed of all the Colours. These are the three fringes of coloured Light with which the Shadows of all Bodies are bordered in the second Observation.

When I made the foregoing Observations, I designed to repeat most of them with more care and exactness, and to make some new ones for determining the manner how the rays of Light are bent in their passage by Bodies for making the fringes of Colours with the dark lines between them. But I was then interrupted, and cannot now think of taking these things into further consideration. And since I have not finished this part of my Design, I shall conclude, with proposing only some Queries in order to a further search to be made by others.

Query 1. Do not Bodies act upon Light at a distance, and by their action bend its rays, and is not this action *(cæteris paribus)* strongest at the least distance?

Qu. 2. Do not the rays which differ in refrangibility differ also in flexibity, and are they not by their different inflexions separated from one another, so as after separation to make the Colours in the three fringes <133> above described? And after what manner are they inflected to make those fringes?

Qu. 3. Are not the rays of Light in passing by the edges and sides of Bodies, bent several times backwards and forwards, with a motion like that of an Eel? And do not the three fringes of coloured Light above-mentioned, arise from three such bendings?

Qu. 4. Do not the rays of Light which fall upon Bodies, and are reflected or refracted, begin to bend before they arrive at the Bodies; and are they not reflected, refracted and inflected by one and the same Principle, acting variously in various circumstances?

Qu. 5. Do not Bodies and Light act mutually upon one another, that is to say, Bodies upon Light in emitting, reflecting, refracting and inflecting it, and Light upon Bodies for heating them, and putting their parts into a vibrating motion wherein heat consists?

Qu. 6. Do not black Bodies conceive heat more easily from Light than those of other Colours do, by reason that the Light falling on them is not reflected outwards, but enters the Bodies, and is often reflected and refracted within them, until it be stifled and lost?

Qu. 7. Is not the strength and vigor of the action between Light and sulphureous Bodies observed above, one reason why sulphureous Bodies take fire more readily, and burn more vehemently, then other Bodies do?

Qu. 8. Do not all fixt Bodies when heated beyond a certain degree, emit Light and shine; and is not this emission performed by the vibrating motions of their parts?

<134>

Qu. 9. Is not fire a Body heated so hot as to emit Light copiously? For what else is a red hot Iron than fire? And what else is a burning Coal than red hot Wood?

Qu. 10. Is not flame a vapour, fume or exhalation heated red hot, that is, so hot as to shine? For Bodies do not flame without emitting a copious fume, and this fume burns in the flame. The *Ignis Fatuus* is a vapour shining without heat, and is there not the same difference between this vapour and flame, as between rotten Wood shining without heat and burning Coals of fire? In distilling hot Spirits, if the head of the still be taken off, the vapour which ascends out of the Still will take fire at the flame of a Candle, and turn into flame, and the flame will run along the vapour from the Candle to the Still. Some Bodies heated by motion, or fermentation, if the heat grow intense fume copiously, and if the heat be great enough the fumes will shine and become flame. Metals in fusion do not flame for want of a copious fume, except Spelter which fumes copiously, and thereby flames. All flaming Bodies, as Oyl, Tallow, Wax, Wood, fossil Coals, Pitch, Sulphur, by flaming waste and vanish into burning smoke, which smoke, if the flame be put out, is very thick and visible, and sometimes smells strongly, but in the flame loses its smell by burning, and according to the nature of the smoke the flame is of several Colours, as that of Sulphur blue, that of Copper opened with Sublimate green, that of Tallow yellow. Smoke passing through flame cannot but grow red hot, and red hot smoke can have no other appearance than that of flame.

<135>

Qu. 11. Do not great Bodies conserve their heat the longest, their parts heating one another, and may not great dense and fix'd Bodies, when heated beyond a certain degree, emit Light so copiously, as by the emission and reaction of its Light, and the reflexions and refractions of its rays within its pores to grow still hotter, till it comes to a certain period of heat, such as is that of the Sun? And are not the Sun and fix'd Stars great Earths vehemently hot, whose heat is conserved by the greatness of the Bodies, and the mutual action and reaction between them, and the Light which they emit, and whose parts are kept from fuming away, not only by their fixity, but also by the vast weight and density of the Atmospheres incumbent upon them, and very strongly compressing them, and condensing the vapours and exhalations which arise from them?

Qu. 12. Do not the rays of Light in falling upon the bottom of the Eye excite vibrations in the *Tunica retina?* Which vibrations, being propagated along the solid fibres of the optick Nerves into the Brain, cause the sense of seeing. For because dense Bodies conserve their heat a long time, and the densest Bodies conserve their heat the longest, the vibrations of their parts are of a lasting nature, and therefore may be propagated along solid fibres of uniform dense matter to a great distance, for conveying into the Brain the impressions made upon all the Organs of sense. For that motion which can continue long in one and the same part of a Body, can be propagated a long way from one part to another, supposing the Body homogeneal, so that the motion may not be reflected, refracted, interrupted or disordered by any unevenness of the Body.

<136>

*Qu.*13. Do not several sort of rays make Vibrations of several bignesses, which according to their bignesses excite sensations of several Colours, much after the manner that the vibrations of the Air, according to their

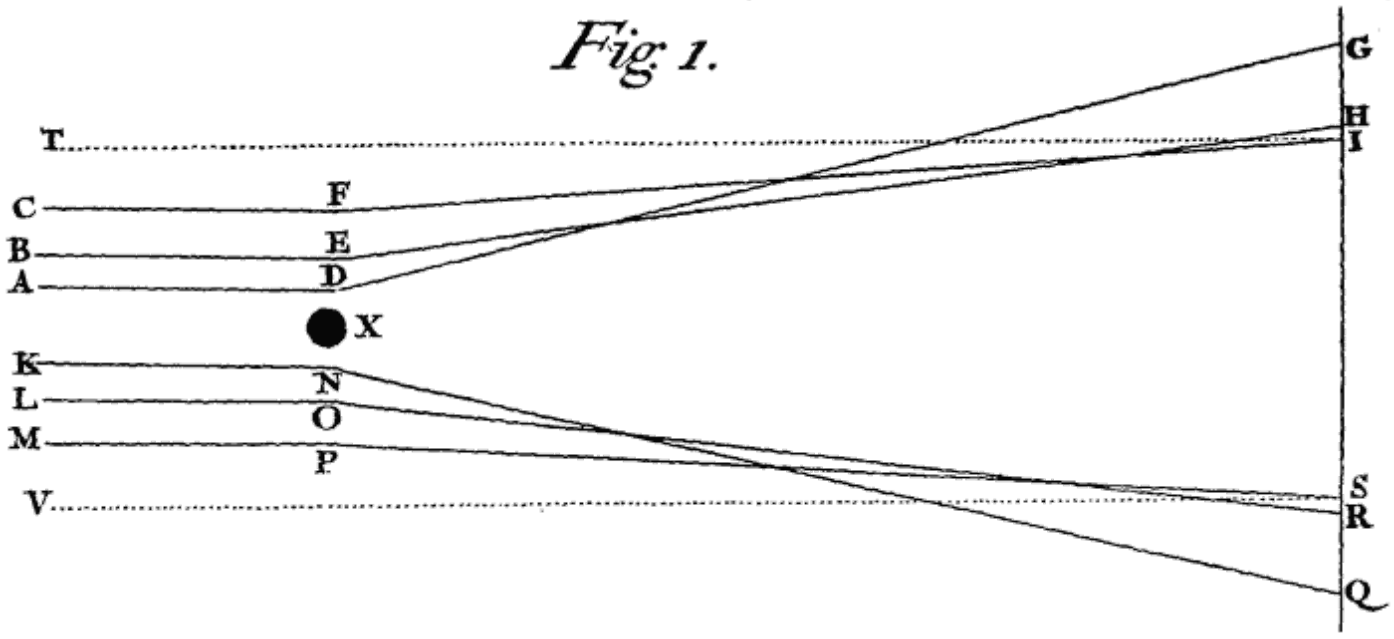
several bignesses excite sensations of several sounds? And particularly do not the most refrangible rays excite the shortest vibrations for making a sensation of deep violet, the least refrangible the largest for making a sensation of deep red, and the several intermediate sorts of rays, vibrations of several intermediate bignesses to make sensations of the several intermediate Colours?

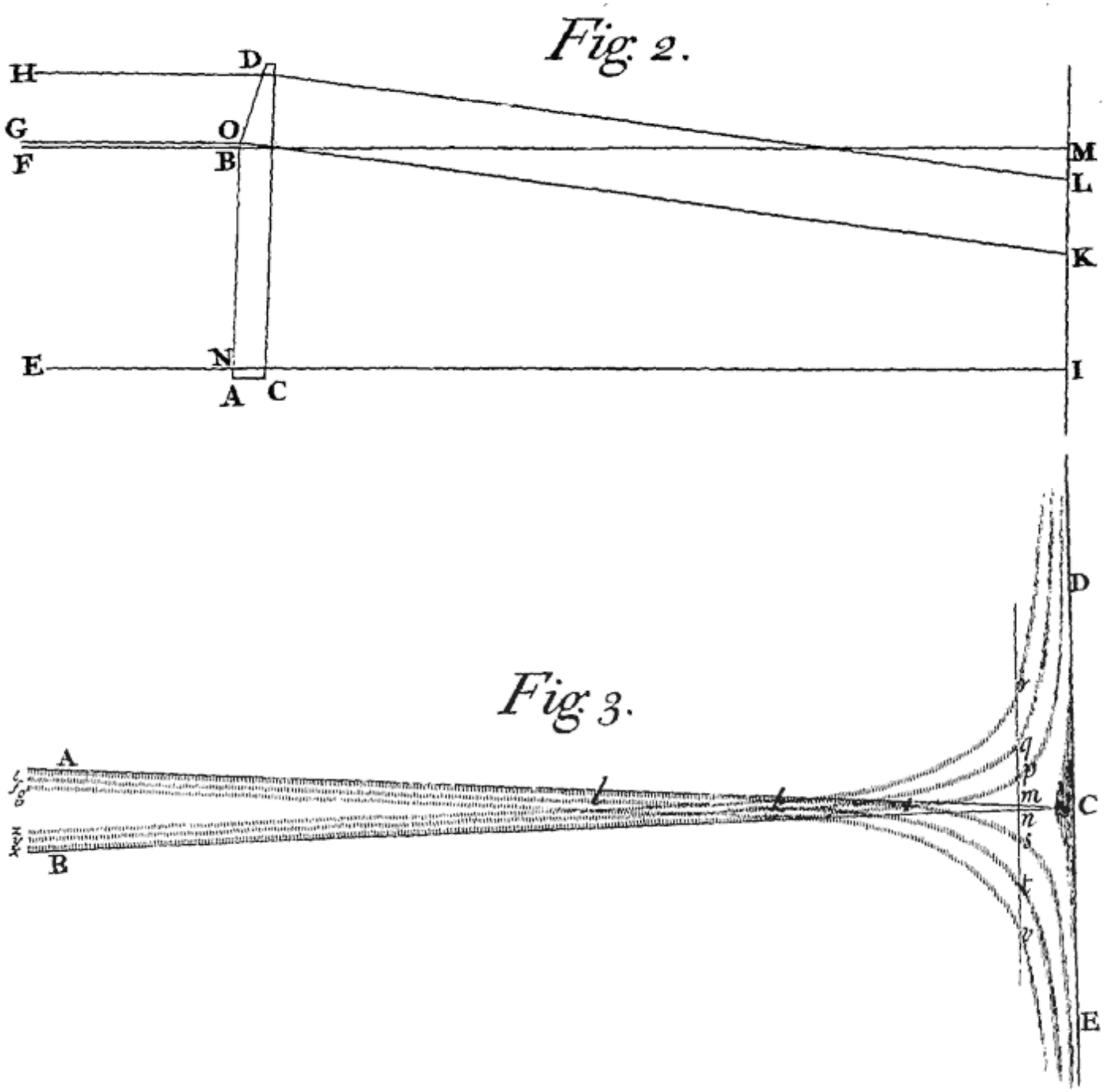
*Qu.*14. May not the harmony and discord of Colours arise from the proportions of the vibrations propagated through the fibres of the optick Nerves into the Brain, as the harmony and discord of sounds arise from the proportions of the vibrations of the Air? For some Colours are agreeable, as those of Gold and Indico, and others disagree.

Qu. 15. Are not the Species of Objects seen with both Eyes united where the optick Nerves meet before they come into the Brain, the fibres on the right side of both Nerves uniting there, and after union going thence into the Brain in the Nerve which is on the right side of the Head, and the fibres on the left side of both Nerves uniting in the same place, and after union going into the Brain in the Nerve which is on the left side of the Head, and these two Nerves meeting in the Brain in such a manner that their fibres make but one entire Species or Picture, half of which on the right side of the Sensorium comes from the right side of both Eyes through the right side of <137> both optick Nerves to the place where the Nerves meet, and from thence on the right side of the Head into the Brain, and the other half on the left side of the Sensorium comes in like manner from the left side of both Eyes. For the optick Nerves of such Animals as look the same way with both Eyes (as of Men, Dogs, Sheep, Oxen, &*c*.) meet before they come into the Brain, but the optick Nerves of such Animals as do not look the same way with both Eyes (as of Fishes and of the Chameleon) do not meet, if I am rightly informed.

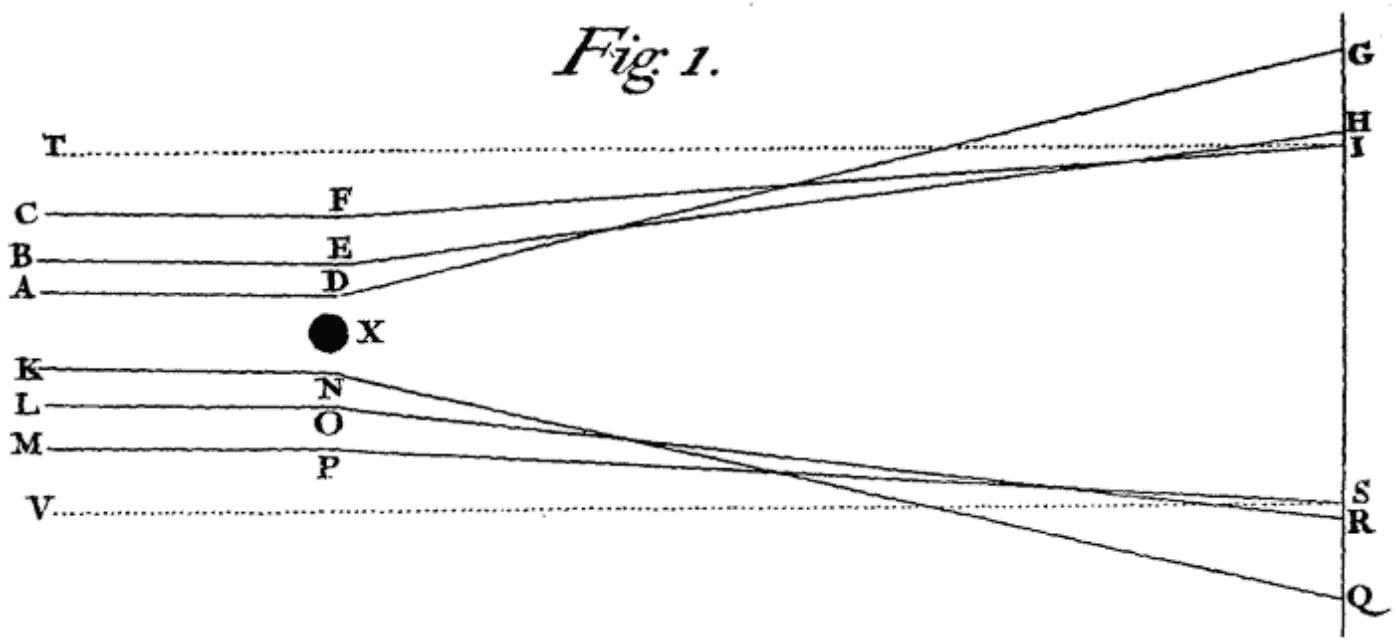
Qu. 16. When a Man in the dark presses either corner of his Eye with his Finger, and turns his Eye away from his Finger, he will see a Circle of Colours like those in the Feather of a Peacock's Tail. Do not these Colours arise from such motions excited in the bottom of the Eye by the pressure of the Finger, as at other times are excited there by Light for causing Vision? And when a Man by a stroke upon his Eye sees a Flash of Light, are not the like Motions excited in the *Retina* by the stroke?

<Book III Plate I>





[Image 1] *Fig.* 1



[Image 2] *Fig.* 2.