GEO ADDL MSS 32
(1853)

The Use of the Improved Eliptic Compass.

In Drawing. the Represantation of a Circle in Perspective.

Also

A Method of finding the true Situation, of Real Objects upon the plane of the Picture.

By

George Adams Mathematical Instrument maker to His Royal Highness the Prince of Wales.

London. March. 26. 1759

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(1854)

As the Authors on Conick Sections have cheifly kept to the Geometrical Rules of describ=
=ing an Elipsis by points, many Gentlemen have been deter'd from drawing the phases of a Solar. Eclipse &c; from the trouble of finding these points, & the former Eliptic Compasses. being confind to perticular sized Elipses, as well as to perticular Eccentricities

It was from hence that I Endeavoured to render them more Serviceable. & accord=
=ingly in July 1749 I completed one that would strike the Eliptic curve, of all Excentricities, & Sizes. within the limits of the Instrument.

By which we can readily draw every problem in the projection of the Sphere Ortho=
=graphically.

Being desirous of putting an Armilary Dialling sphere into perspective which con=
=sisted cheifly of Brass circles of a considerable thickness, which would have been attended with immense labour, could It be done by no other method but that of finding points.

Therefore I suspended my intended Drawing till some future opportunity.

and looked into several Authors on Conic Sections. and at Last into Hamiltons. Stereography, Book 3. Vol. 1. Where I found all the assistance I wanted, which was a

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Method to find the transverse Axis of the Elipse upon the picture & one point any where else in the Eliptic Curves. because I then knew very well that the Eliptic Compass would perform all the rest, but Mr Hamilton has amply suplied us with a Method of finding & limiting both the transverse & conjugate Axes.

I shall first lay down a few practical rules for the management of the Eliptical Compass. & then proceed to the problem under Consideration.

Problem. 1.

Fig. 1.

To describe an Elipse the Transverse. & Conjugate Axes being given.

Let AB, be the given transeverse, & CD the conjugate axis.

Apply the transverse axis of the Eliptic Compass, to the line AB, (the Screws of both the Sliders being first discharged,) turn the the Beam over the transverse axis AB, & slide it too & fro, until the Ink point coincides with the point A, then tighten the Screw of that Slider, which moves on the conjugate Ax, Now remove the Beam over the given conjugate Ax, CD, & make the ink point coincide with the point C. then fix the Screw of the Other Slider. now move the Ink point gently from A thro C to B. & the Semi-elipse ABC will be described. reverse.

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the compass, & describe the other half.

Problem. 2.

Thro.' any given point F, to describe an Elipse about any given trans=
Fig. 1. =verse Diameter.

Apply the Eliptic compass, as before to the given line AB. & adjust the Ink point to A. then fix the Beam by the conjugate Screw. & turn it over the given point F, Sliding it Untill the pen Coincides with F. then as in Problem 1. de=
=scribe the Elipse. ACBD.

Problem. 3.

From a given point, k, without a circle. ADBE. To draw two —
Fig. 2. Tangents & find their Chord.

From O, the center of the circle draw kO. & bisect it in f, then on center f. with Radius fO, describe the arc. d,O,e, cutting the circle in d, & e, draw kd, & ke, which will be tangents to the given circle from the point k. also draw de, thro the points of contact, & de, is the Required Chord.

Demonstration.

Draw Od, Oe, Then because kO, is the diameter of the circle k,d,O,e, (fO being its Radius)

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The angles kdO, keO, are Right (by 31.3 Eucl.) & Od, Oe being each a Radius of the Circle ADBE, and as kd, & ke, are both perpendicular to eO, & dO they are therefore Tangents to the said Circle at the points. d & e, (by 16.3. Eucl.).

Fig. 2. It has been proved that Od, & Oe, are equal (because the are radii of the same circle,) & that the angles. kdO, keO are Right. Therefore the triangles. kdO, keO, are equal & Similar, (by. 4.1 Eucl.) Consequently the sides kd, ke, must be equal, as well as the angles. dkO, ekO. likewise as the angle dke, in the Isoceles Triangle ekd, is bisected by the line kC, it also bisects de, the Chord in the point C, (by. 3. 6. Eucl.) theref.e d is perpendicular to kC.

Problem. 4.

To Find the Originals of the Axes of an Elipse formed by the Image of a Circle.

Case. 1.

Let Z. be the Original plane LM the directing line. IK the Eyes director, and ABDE a Circle on the Original plane, O, its Center.

Thro O, draw the diameter ab. perpendicular to LM, intersecting it in k, & find de, the Chord of the tangents to the Circle

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from k, (by prob. 3.) cutting ab. in C, make kY equall to, ke, or kd, & draw IY, bisect it with the perpendicular, t o, cutting LM in o. then on center o, with Radius oI, or oY, describe the Semi-circle LIYM. Cutting LM, in the points L & M, lastly from L & M, thro C draw MA, LE, terminated by the Circle in AB, DE, which are the Originals of the Axes of the Elipse, & C, the Original of its center.

Now because AB, is the Chord of the Tang=ents LA, LB, from the point L, DE, is the same from point M, and therefore LE & MA are harmonically divided by the Circle and the point C, (because the whole of LE & MA has the same proportion to Either of the Extreme parts, LD or MB, as the Other Extreme parts EC. or AC, hath to the middle part DC, or CB.)

or Otherwise

(Because the Rectangle between the Whole line, & its middle part. is Equall to the Rect=angle under the two Extreme parts.)

L & M being directing points. the Images of AB & DE, are consequently Bisected by the Image of C. Therefore AB, & DE, are the Origi=nals of the Two Axes. & C. the Original of the Center.

Again

Because the angle LIM, in the Semi-circle is Rt. (by. 31. 3. Eucl.) & IL, IM, being the directors of AB, & DE, their Images are therefore per=pendicular to Each other, consequently AB. &

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DE, being the Originals of the two Axes which are perpendicular to each other, they are therefore the originals of the axes of the Elipse.

Corolary

That diamr. a b, of a circle which is perpendicular to the directing line. is always the Original of one of the axes, of the Elipse & d e, the Chord of the tangents to the circle from k. (where the perpendicular diamr. ab meets the directing line.) is always the Original of the Other Axis (conjugate to a b).

But a b, is the only diameter of a circle whose image can be a diamr. of an Elipse upon the picture. Because being perpendicular to the picture. it must therefore vanish into the Center. & so become the transverse axis. for no other diamr. of the circle besides a b, can pass thro, C. consequently no other diamr. can be the Original of a diamr. in the Eliptic Representation.

Case. 2

If the center of the circle be in the Station line that is if k was the foot of the Eyes director then a b & de, would be the Original of the two Axes.

For ab. & de are the Originals of two conjugate diamrs. & in this position of the Circle their Images being perpendicular. must therefore be the Originals of the Axes.

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Case. 3.

If the center of the circle be in the line of Station, & the height of the Eye be equal to kY the Image of the Circle will be a Circle. because in this position the Section of the visual rays will be cut Subcontrarily.

It has been shewn when the Center is in the line of station, ab. & de are the Originals of the Axes. There only remains to Shew. that when the height of the Eye kY. & the images of ab, & de, are equal. that then the Image thereby produced will be a perfect Circle.

Demonstration.

From the properties of a circle it will hold as Ca : Ce :: Ce : Cb, also that ka : ke :: ke : kb. (by. 35 & 36. 3. Eucl.). hence Ce in the first. & ke in the Second. are mean proportionals to the other two respectively. Therefore the Image of ab, will be Equall to the Image of de, & consequently produce a Circle.

Cor.

If the height of the Eye be greater than kY. ab, will be the Original of the transverse Axis If it be less then. kY ab. will be the Originall of the conjugate Axis.

But in Both cases the Image will be an Elipse. for de, preserves its length at all heights of the Eye in the same directing plane.

Hence if the height of the Eye be greater than kY the Image of ab will be Shorter than de. but when Equall a Circle is produced.

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Problem. 5.

To find a mean proportion between two given Rt lines

By the Improved Sector.

Make the longest given line a transverse distance between. 100, & 100 on the line of lines & on the Same lines find the Number answering to the transverse measure of the Shortest line given. the measure thus found taken from the line of plans. is the mean proportion req-

Having now gone thro' the preparatory Rules I shall proceed directly to the practice upon the picture

But in the Next problem being obliged to be somewhat longer, then what is ab=solutely necessary for practize. in Order to make the demonstration clear.

I shall abbreviate it in the 7th problem.

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Problem 6.

To find the Axes of an Elipse, which is Formed by the Image of a Circle. That Diameter being given which is perpen=dicular to the plane of the Picture.

1st. Let ab be the given diamr. C the center of the picture. HC the vanishing line. CE the Distance

Fig. 3. Bisect ab. in C. which is the center of the Elipse find a mean proportion between Cb & Ca. (by prob. 5) which Sett from C to q. draw Eq. and bisect it with the perpendicular pr. cutting the Vanishing line in r. Then on center r. with radius rq. sweep the touch of an Arch. at the points s. & t. draw sq. tq parrallel to sq. draw ap.. thro' c draw fg bx, thro b, also parralel to tq. draw az, ed, thro c. & bl, then fg & de are the Indefinite Axes.

2dly Thro a, draw ik, parallel to the Vanishing line HL. cutting fg. & de produced in the points i & k. bisect il. in m, then with Radius ml, on center m, Sweep the touch of an Arch at n. on ed produced, & cn is the length of the Semi-transverse Axis. which set of from c both ways to f & g. lastly Bisect xk. in w, & with radius wk on center w sweep the touch of an Arch. on the point v, then cv is the length of the Semi-conjugate Axis, which Sett of from c, each way to e, & d,

Now by problem. 5. draw the Elipse.

ad, g, b, e. f.

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Demonstration

The given diam^r. ab. of the circle fig. 3. re=
=presents a b, in that of fig. 2, and c in fig. 3, re=
=presents C in fig 2.

Because kY in fig. 2. is a mean proportional
between ka, & kb, the Image q. in the 3^d. fig: will
be a mean proportional between Ca & Cb. Therefore
q. found as above in fig. 3. is the representation of
Y, in fig. 2.

Again. in fig. 3. as the original of ik, is per=
pendicular to the original of a b, & because the
originals of all lines which vanish into the center of the
picture. are perpendicular to it, & i k. being par=
=allel to the Vanishing line. its original is therefore
parrallel to the picture and also perpendicular
to the original of a b, which is a diam^r. of the
forming circle. it must therefore be a tangent to
the circle at the point represented by a, (by. 18 3 Eucl.)
Therefore ik, is a tangent to the Elipse at a,
formed by the Image of the Circle. & za being an
Ordinate to the axis fg. the half of fg. is a mean.
proportion between. cz. & ci, but by construction,
cl, is equal to cz. Therefore, cn, which is a
mean proportional between cl, & ci, is also a
mean proportional between ci & cz. hence
cf. & cg being made each equall to cn. will
give fg. the true length of the transeverse
axis.

In the same manner we prove that cp.
& cx being equal by construction, & cv, being a

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a mean proportion between cp. & ck, and There=
=fore cd, & ce being each made equal to cv, will
give the true determination of the Conjugate —
Axis. d e.

Corolary.

Fig. 4. If the center of the Original Circle be in the station line then the given diam.r ab, co=
=inciding with the Vertical line will be one of the axes, bisect a b. in c, by the perpendicular e d, which will be the other indefinite Axis. To determine its Extremities, we must first find the Image of the center of the Original circle by setting of on HO. the two Vanishing points of the diagonals of a Square E.1 E.2. draw E.1 b. & E.2 a. cutting each other in the point F. thro' F, draw F parallel to e d, cutting the given diameter a b. in o., the Image of the Original center.

Then find C. q. (by prob. 5.) a mean proportion between Cb, & Ca, & thro the point F, draw FC, (a tangent to the Ellipse from C.) cutting e d produced in. n, thro q, draw qr. par=
=allel to e d, cutting CF, in r. make cd & ce each equal to qr. then e d, will be the trans=
=verse Axis. Now by problem 1. describe the Ellipse. eFaDdb.

OR

e d, might have been found by a Mean proportional between cn. & cw. which is equal to qr.

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Demonstration

This differs but little from the demonstration of fig:3. for having found. kY, fig.2. in the Original & Cq on the picture fig.4. the first a mean pro=portional between ka & kb, the second the same between Ca, & Cb, produce the diameter gh, in Fig.2. till it meets the tangent ke, in t. for gh, is parallel to LM. Then the Radius Oh, will be a mean proportional between Ce, ~~~ the Semi-chord of the tangent from k, & the line Ot.

Because in fig.2. Oe. is perpendicular to kt, (by.18.3 Eucl). & the Δ^s kOe, & Ote are similar & because Ce, is perpendicular to kO, the Δ^s kOe, & OeC, are also similar (by 8.6 Eucl.) There=fore the Δ.Ote, is similar to the Δ. OeC. Consequently Ot : Oe = Oh :: Oh : Ce.

Hence, if Yr, be drawn parrallel to gh cutting kt. in r. then Yr. will be equall to Oh.

For the Δ^s, kCe, kYr. & kOt, being Similar. Ce, Yr, & Ot, have the same proportion to each other as kC, kY, & kO, but kY, being a mean proportional between kO, & kC, Therefore Yr. must be a mean proportional between Ce & Ot.

Corolary.

Fig.3 & 4 If CE & Cq. be equall the Axes ab, & ed, will also be equal, & the Image will be a perfect Circle.

If EC, be greater then Cq. ed, will be the transverse Axis, if less it will be the conjugate Axis.

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Symbols. Explained

|| .. parallel, or parallel to.

= .. equal, or equal to.

⊥ .. perpendicular, or perpendicular to

△. triangle, △ˢ, triangles.

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Problem. 7.

To describe the Image of a Circle in perspective by the Eliptic Compass.

the Practice.

Fig. 3.

Let ab, be the given diamr, which bisect in c, make Cq. a mean propor.n† betw.n Cb, & Ca, draw Eq. & bisect it with the ⊥, pr. make rs, rt = Cq. and draw sq. & thro c, draw ig, ∥, to it. also draw qt, & thro c, en ∥, to it. draw ik, ∥. HL & az, ∥. tq. a mean prop.n betw.n ci, & cz gives. cf & cg. the same between. ck, & za, gives cd, & ce. Then by prob. 5 describe the Elipse.

(†by prob 5)

If the Center of the Original circle be in the Station line.

Fig. 4.

Let ab, be the given diamr. bisect it in, c, by the ⊥ ed, set of. E.1, E.2 the Vanishing points of the diagonals of a Square, draw E.1b. & E.2a. intersecting each other in the point F, & draw Fo, ∥. ed, also draw CF, cutting ce, produced, in n, a mean propr. betw.n cn, & Fo. gives ce, & cd Then by problem 5. describe the Elipse.

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A General Theorem

If Objects are not projected upon the Picture under the same apparent angle. their originals have from the point of Station.
They cannot be represented as they appear to the Eye.

From the known principles of Astronomy and Optics. we are taught that if several Globes of the same diameter, are placed at different distances from the Eye, the nearest will be se under a greater Angle then those which are more remote, Hence the Sun, Moon, &c. appear bigger in Perihelion, than they do in their Aphelion.

So by Observing the planets Apparent diameters, at different Seasons, Astronomers compute their places in Each respective Orbit

And so likewise in perspective. If we can but limit the angle at the Eye. Subtended by a Real Object, we may as correctly mark that very same angle on the plane of the picture.

For unless the very same apparent angle be projected on the picture, which the real Object Subtends at the Eye from the point of Station. It cannot be a true representation of the Original.

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Hence from the principles of Geometry & Trigonometry we may find as many capital points upon the picture as we choose, which Shall represent the Images of real Objects under the very same angles they appear to the Eye from the Station point.

Lett a Row of Columns be Supposed Parallel to the Picture.

And the two outermost 100, feet distant from each other. — if we intend our picture should contain no more than this row of columns, & its length to be two feet, & that the distance of the Eye from the picture shall subtend with the Sides thereof an angle of Sixty degrees which is generally allowed to be the best distance.

In this Case the least distance from the Object to the point of Station cannot be less than equal to that of the Whole Row of Columns. or 100 feet, if greater the projection of the Extreme diameters, will be nearer to the Size of the Middle Column. — But if the distance of the Station point be less than 100 feet their appearance upon the picture will become more & more disagreeable as the Station approaches nearer & nearer to the Object.

Therefore. the Grand point to be settled before we begin a perspective Drawing is. The distance of the point of station. governed by the Apparent angle of the Whole groupe of Objects

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the picture is to contain. & thence to limit the horizontal length of the picture & distance of the Eye.

See fig. 5.

Let the circles I, G, H, represent a Section of three Columns, made by the horizontal plane, passing thro' the Eye at E, and PP, the horizontal line on the picture, C, its center, from the Eye at E, draw tangents to the Extremities of each circle (by. 17. 3. Eucl.) these Tangents will Express the Rays proceeding from the Eye to the real diameters of the Circles, as well as limit their apparent angles, For as the line GE is perpendicular to the plane passing thro the Axes of all the Columns. which by construction is parallel to PP, the plane of the picture, therefore the picture does intersect the Visual rays, in the very same proportion as the line IH, intersects the real Columns. — for IH is a tangent to the Circle KGQ, at the point G, to the Radius EG. because EG, is the Semi-diameter of the Circle, & IH is perpendicular to it (by. 16. 3. Eucl.). In the Same manner we prove PP, to be a tangent to the circle RCS, to the Radius EC,

Again

By the present Hypothesis the circle BA being nearer the Eye then the Other two must Subtend at the Eye a greater Angle. for the Angle BEA, contains about. 7°. 45'. & each of the Other two Angles but 6°. 45'. Therefore the

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the Aparent angle from the middle column is about one whole degree greater, than the apparent angles of either of the other two extreme columns. Also the angle dEc is equal to the angle gEh, & fEe, equal to kEi. by construction.

Therefore (by Cor. 2, Theorem, 2, Brook Taylors perspective. " The Original of a " projection may be any object, that will " produce the same cone of rays.

Hence the Originals of the projections fe, dc, may be any lines ki, or lm, gh, or no, producing the same optic Cone. but Gm, is a Tangent, to the radius EG, of the angle mEG, & Gl, is also a tangent to the same Radius. of the angle lEG. and Ce, Cf are similar tangents to the Radius EC (by construction) Therefore lm. is the difference of the tangents Gl. & Gm. so also. ef is the difference of similar Tangents Cf. Ce.

Consequently no other projection but that of ef, can be the true representation of the diameter of the column I.

We prove in the same manner, dc, to be the true representation of the Column. H.

Hence it plainly appears that if the Tangents of the apparent angles GEl, GEm, be set off upon the picture, to the radius EC, from C to l, & m. that fe, the difference of the tangents will be truly projected; for if fe, be shortned at discretion upon the picture, it will appear

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to an Eye at E, under a less angle than its Ori=
ginal lm, if longer it will be disagreeable &
preposterous. Therefore no other Image but
that of fe, can possibly represent on the picture
the true apparent angles of the two tangents
Gm, Gl, which must consequently produce the
true projection of the diamr. ki. of its Original
circle I. (By Theorem 2. p. 2. Brook Taylors
perspective. "Because if it be not the true
" representation, the light cannot come from
" the picture, to the Spectators Eye, in the same
" direction from the corresponding points of the
Original Object.

This leads me to a general rule for
finding a few Eminent points from Visible
Objects. any how situated, & thence to determine
their true Situation on the plain of the picture.

But this depends upon a Solution of the following

Problem. 8.

Fig. 6. The place of the Eye, its Distance from the picture. and a Visible point being given. To find the true situation of that point upon the picture.

As the position of a point in absolute
Space, is not to be determined but by its distance
from two, or three planes. differently Situated
to each other. Therefore I shall choose the
three planes generally used in perspective
The first, is that of the picture AB on which

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the visible points, are to be projected. the Second
Fig. 6. is the horizontal plane DF. passing thro' the Eye at E
& limiting the horizontal line HO. by its intersection
with the plane of the picture. The third is a
Vertical plane KL, passing thro the Eye at E, &
being perpendicular to both the other planes, by
its intersection with the picture. gives the Vertical
line GI.

These three planes being given in position
The Vertical & horizontal lines are given in
position upon the picture.

The Use of the Vertical plane is to distin=
=guish, what points lie to the Right & what to
the left of the Eye. the horizontal plane serves
to compare the Elevation, or Depression of objects.
relative to the Eye, & the picture receives the pro=
jections of these Objects.

On E as a center with Radius CE, describe
the Semi-circle aCb. on the horizontal plane FD,
and with the same Radius E.C, describe the Semi-
-circle eCf upon the Vertical plane KL, then
(by.16.3, Eucl.) the Vertical line IG, is a tangent
of the Circle. eCf. and the horizontal line HO, is a
tangent to the circle aCb. (by the same). now if
we can find the aparent angles that any visible
point N. makes with the horizontal & vertical planes.
its true place may be readily found upon the
picture.

Draw MN. PQ. parallel to the horizontal
plane, & QN. parallel to the Vertical plane

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draw EM, EN, EP. EQ then (by Sec. 1. B1. Chap. 3 of Mr Kirby's perspective) C q n m. will be the representation of the Original Square or oblong M N P Q. & n. the projection of the given Visible point N.

For M.E.N, is the Aparent angle under which the line MN. is seen from the Eye at E, and is the horizontal distance of the given point N. from the Vertical plane, so also the angle N E Q. is the Aparent angle, of the line N Q. & N Q, its Elevation above the horizontall plane, but ___ . m n, is the the tangent of the angle N E M. to the Radius E C. & q n. the tangent of the angle N E Q. to the same Radius. (the proof of this is omitted here being the same with that of the foregoing Theorem.).

Hence then it is evident that knowing the aparent angle, from the Vertical & horizontal planes. If we open the Sector. to the Radius of the Eyes distance from the picture, & set of the tangent of the horizontal angle from the Vertical line. and the tangent of the Vertical Angle from the horizontal line [illegible] at their intersection will be the true place, o[f] the given distant Visible point upon the [illegible]

But to find the aparent visible Angles. a Theodolite with a spirit tube & Vertic[al] Arch will be the Most Accurate.

Therefore having chose the point of Station, set up the Theodolite. & Bring the Index to the Begining of degrees. & then turn the Whole Instrument about untill the

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Hairs in the telescope are directed to that part of the prospect you intend shall be the center of the picture, here fix the limb by the Screw under the Staff head, (the Instrument being first supposed to be set level.) then the circular limb of the Instrument represents the horizontal plane. & the Vertical arch the Vertical plane. & the telescope the place of the Eye.

This being done & picture prepared by having the Vertical & horizontal line as well as the distance of the Eye from the center of the picture drawn thereon.

Turn the Index & the Telescope, to the given Visible point N. and then the degrees cut by the Index on the limb, is the apparent angle of the point N. from the Vertical Plane, and the degrees cut by the other Index on the Vertical arch is the apparent angle of the point N. from the horizontal plane.

Now open the Sector untill 45. & 45 on the tangents is equal to the distance of the Fig: 6 Eye from the picture, then take of the tangent of the horizontal angle, & set it from C to q. Upon the horizontal line from q. draw q n. perpendicular to HO. & set off the tangent of the Vertical angle from q to n. Then n. is the true situation of the given visible point N.

As the situation upon the picture of almost all Objects, may be determined by a

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Square, oblong, triangle, or circle. we need only Use the Theodolite to find the fewest points necessary, to determine either of these figures, for a house, or groupes of houses, men, trees, circles, Arches, feilds, roads, &c. may by this easy problem have their true Situation on the picture. and thence the Whole drawing Completed according to Mr Kirbys perspective Rules.

Hence by the Theodolite & Sector a large feild is opened for a farther improvement in the art of Perspective.

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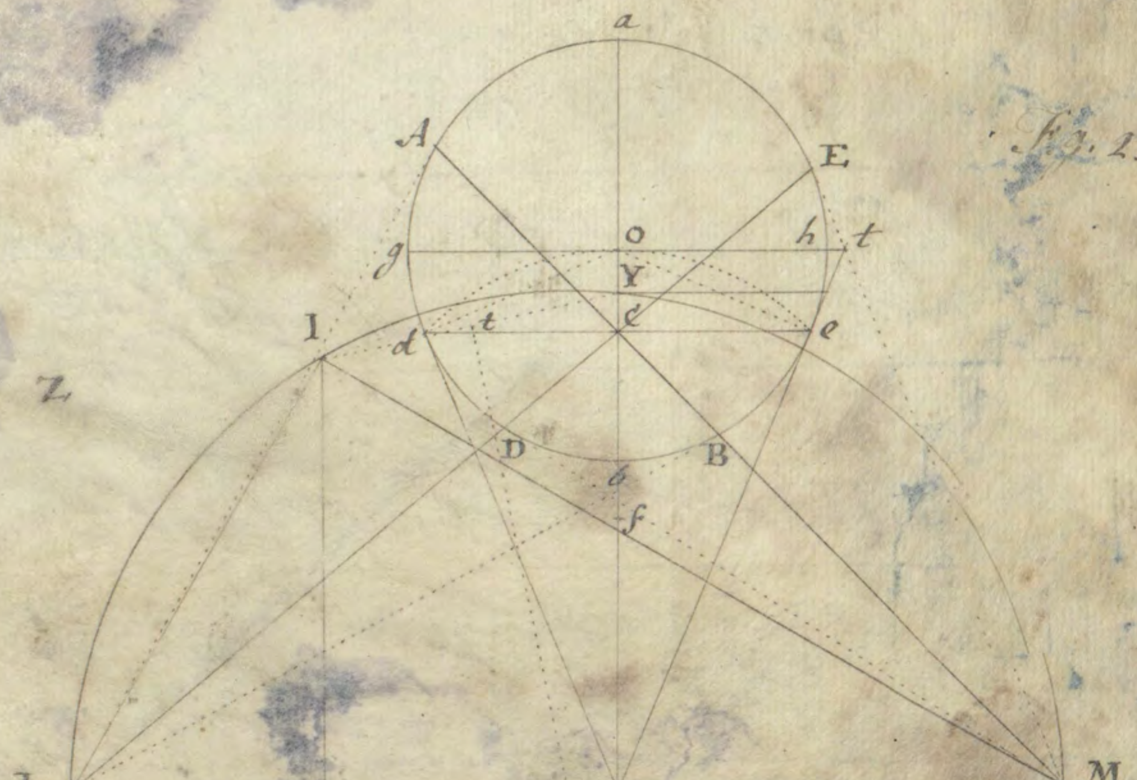

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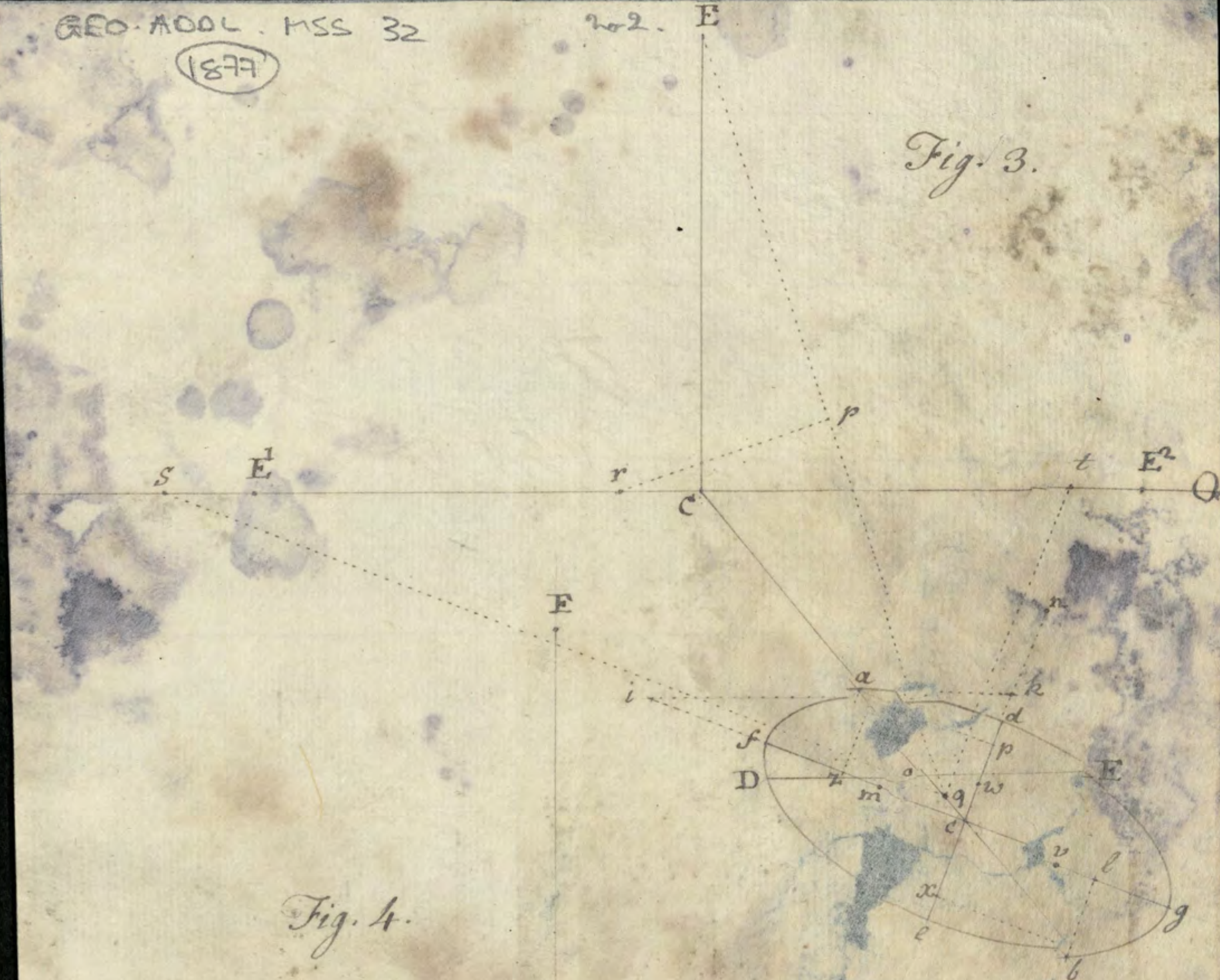

Fig. 3.

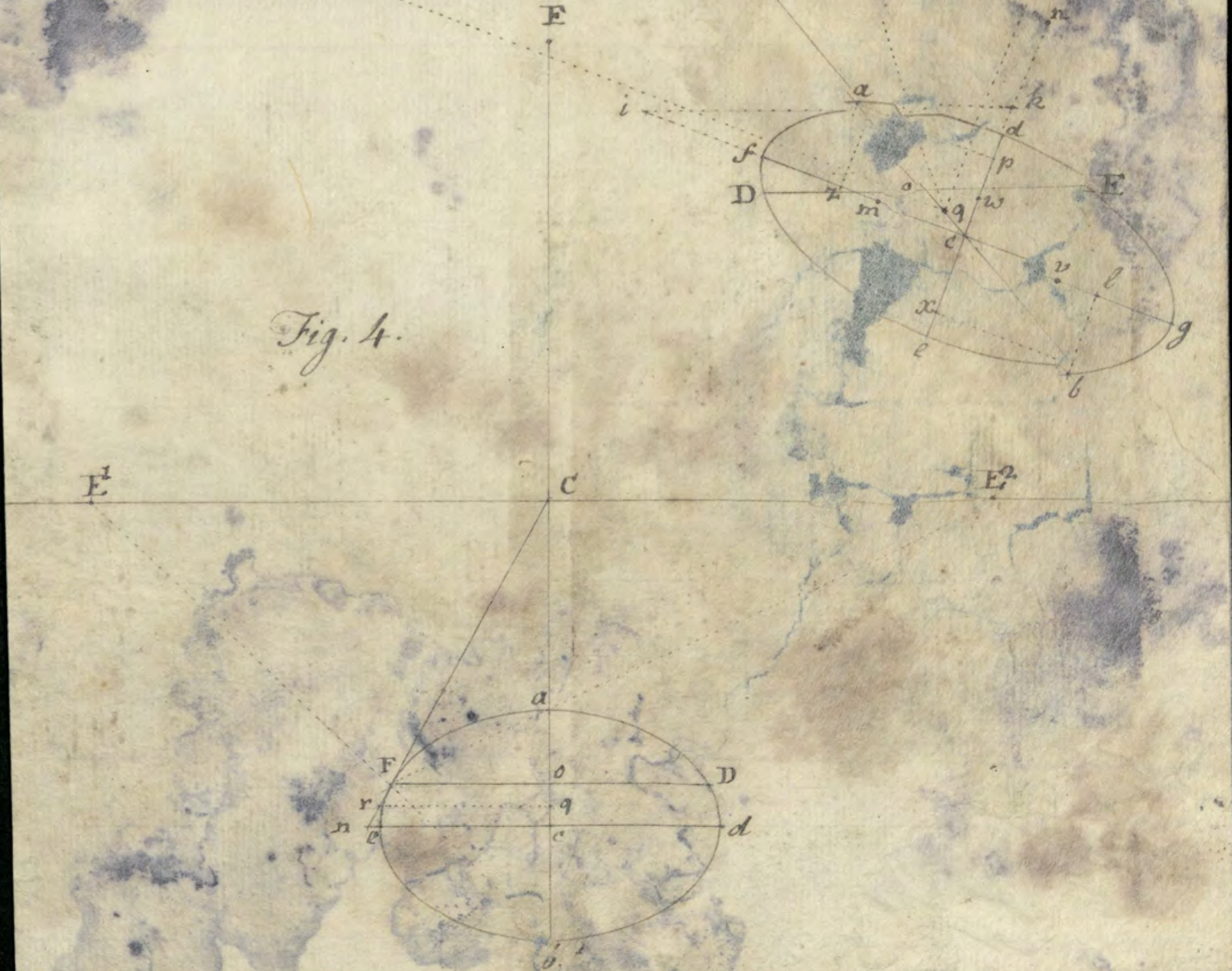

Fig. 4.

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Fig. 5.

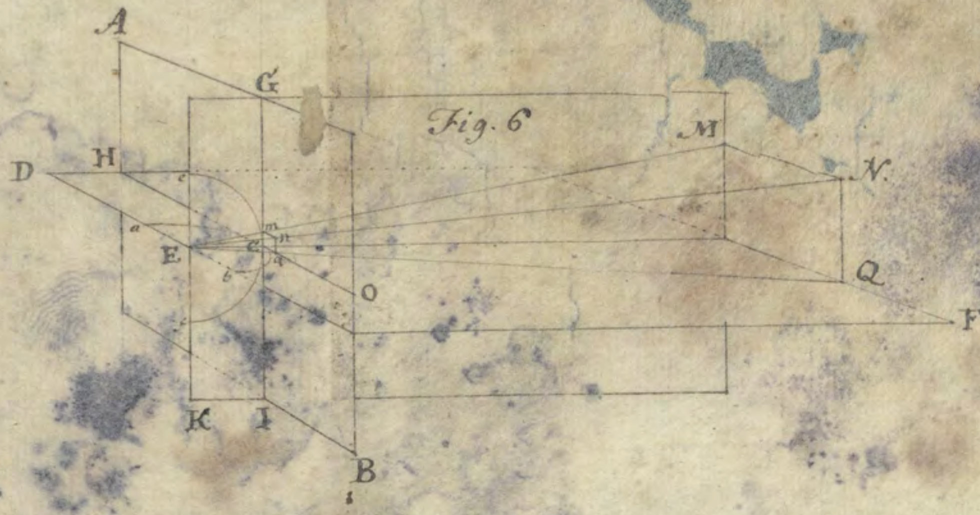

Fig. 6

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