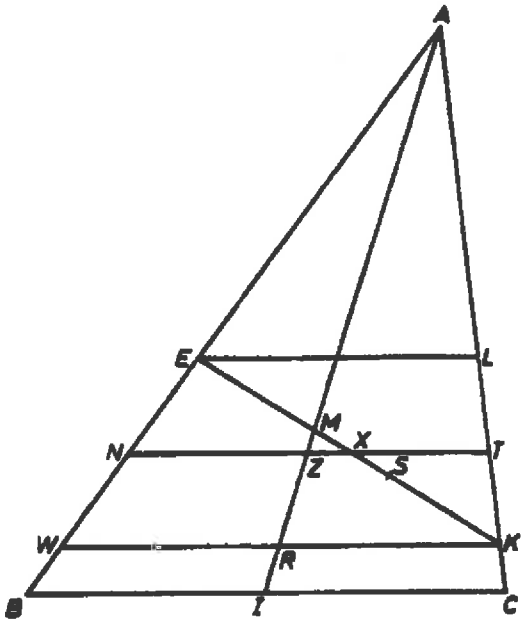
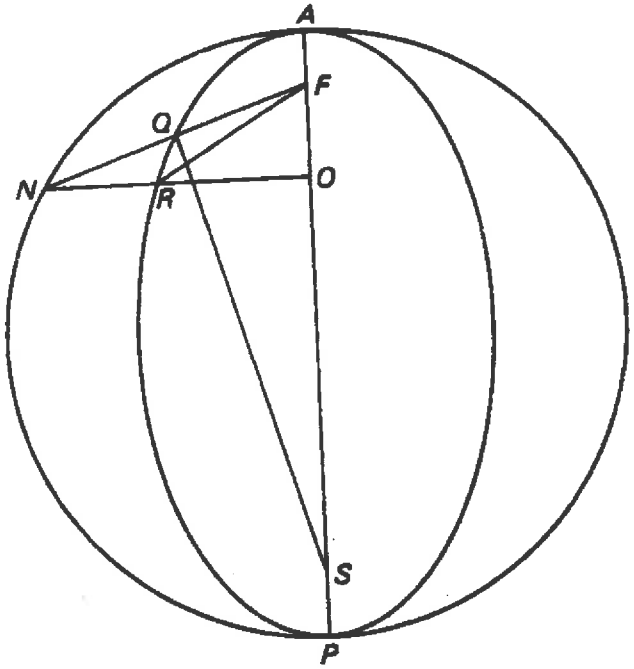


Boulliau's Conc - 1645

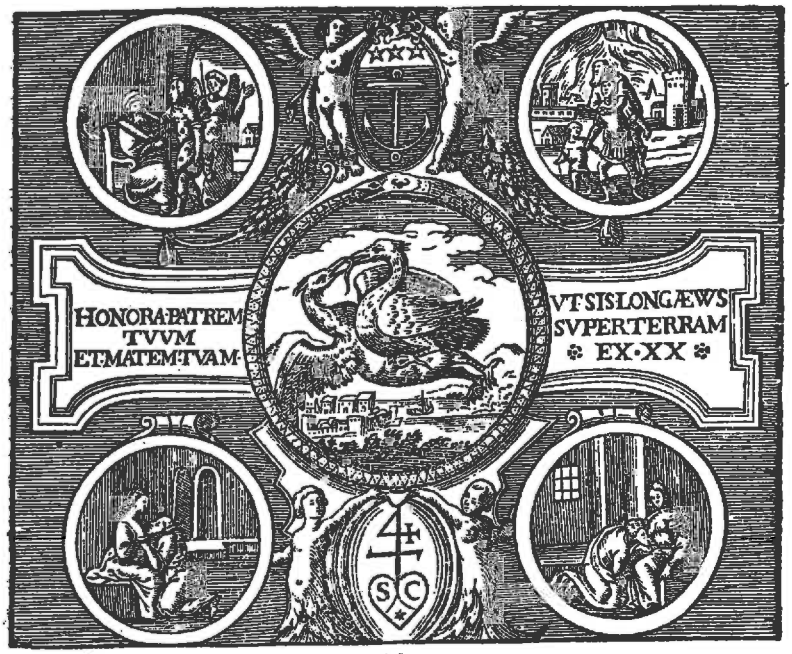


Boulliau's 1657 Method for Obtaining True Anomaly from Mean Anomaly

ISMAELIS BVLLIALDI ASTRONOMIÆ PHILOLAICÆ FVNDAMENTA clarius explicata, & asserta.

ADVERSVS

Clarissimi Viri SETHI WARDI *Oxoniensis Professoris impugnationem.*



PARISIIS,
Apud SEBASTIANVM CRAMOISY, Regis & Reginæ Architypographi,
ET
GABRIELEM CRAMOISY, viâ Iacobæâ, sub Ciconiis.

M. DC. LVII.
CVM PRIVILEGIO REGIS.

HARMONICON COELESTE:

OR,

The Cœleſtiall Harmony of the

VISIBLE WORLD:

CONTEINING,

An abſolute and entire Piece of

ASTRONOMIE.

WHEREIN

Is ſuccinctly handled the *Trigonometricall* Part, generally Propounded, and particularly Applyed in all Queſtions tending to the *DIURNALL MOTION.*

Eſpecially reſpecting, and truly ſubſervient to the main Doctrine of the Second Motions of the *Luminaries* and the other *Planets*: Together with their Affections as ECLIPSES, &c.

Grounded upon the moſt *Rationall Hypotheſis* yet Conſtituted, and compared with the beſt Obſervations that are Extant, eſpecially thoſe of TYCHO BRAHE, and other more Modern *OBSERVATORS.*

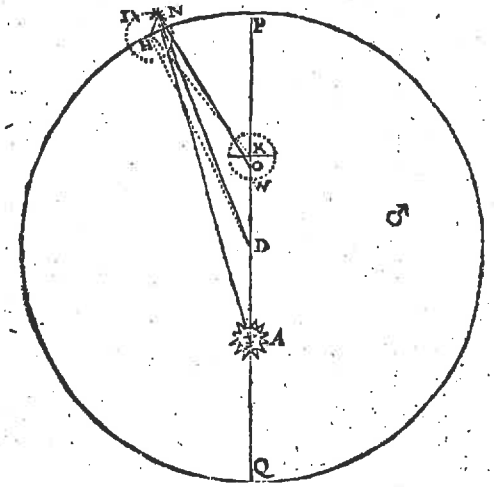
Fitted to the *Meridian* of the moſt Famous and Ancient *Metropolis* LONDON, and principally intended for our Engliſh Nation, and commended as uſefull to all *Scholers, Aſtronomers, Aſtrologers, Divines, Phyſitians, Hiſtoriographers, Polititians,* and *Poets*, &c.

By VINCENT WING. *Philomathemat.*

Quum reſpicio Cœlos tuos, opus digitorum tuorum; Lunam & Stellas quas ſtatuiſti: quid eſt mortalis, quòd memor ſis ejus? aut filius hominis, quòd viſites eum? Pſal 8.4,5.

LONDON:
Printed by ROBERT LEYBOURN, for the Company of STATIONERS, 1651.

First Figure of Mars.



In this Diagram I number the Anomalie of ♂ from P to H 6ᵈ 7′ 40″, whoſe Complement 173ᵈ 52′ 20″, is the angle D X H, which given with the Side D H 152040, and the Side D X 14105, the angle D H X will be 34′ 3″.

Side D H 152040,			5,181958
Sine of the angle D X H 173ᵈ 52′ 20″;			9,028352
Side D X 14105,			4,149373
Sine of the angle D H X 34′ 3″.			7,995767
Simple Anomalie P X H,	6ᵈ	7′	40″
Angle D H X Subſtr.		34	3
Anomalie æquated P D H.	5	33	37
Motion of the Epicycle I H N.	11	7	14

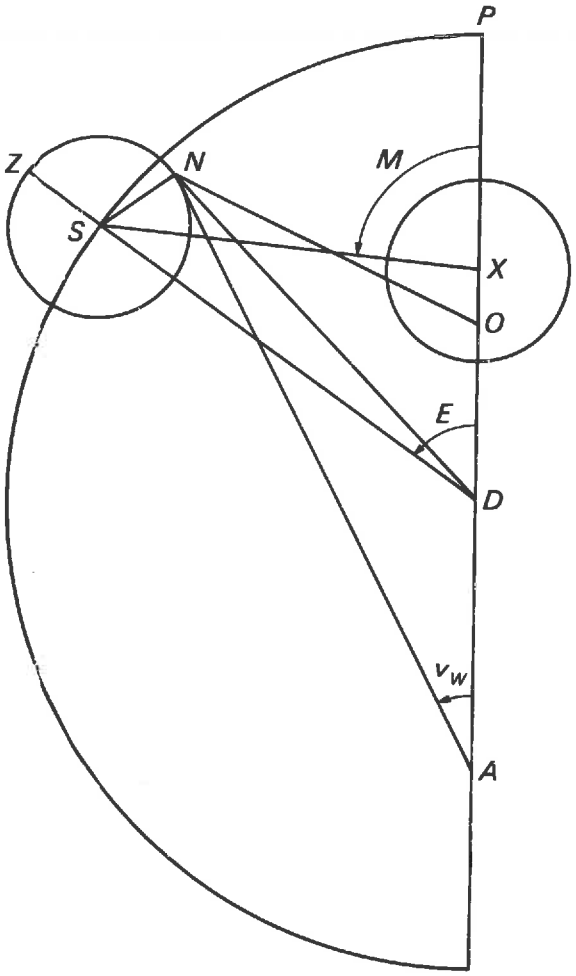
In the Triangle D H N.

Summe of D H and D N 152500,			5,183270
Difference 151580;			5,180642
Tangent of 5ᵈ 33′ 37″,			8,988343
Tangent of 5 31 37.			8,985715
Aggregate 11 5 14. *viz.* Angle H N D,			
Difference 2 0 *viz.* Angle H D N,			
Sine of the angle H N D 11ᵈ 5′ 14″,			5,283985
Side D H 152040;			5,181958
Sine of the angle D H N 168ᵈ 52′ 46″,			9,285274
Side D N 152492:			5,183247

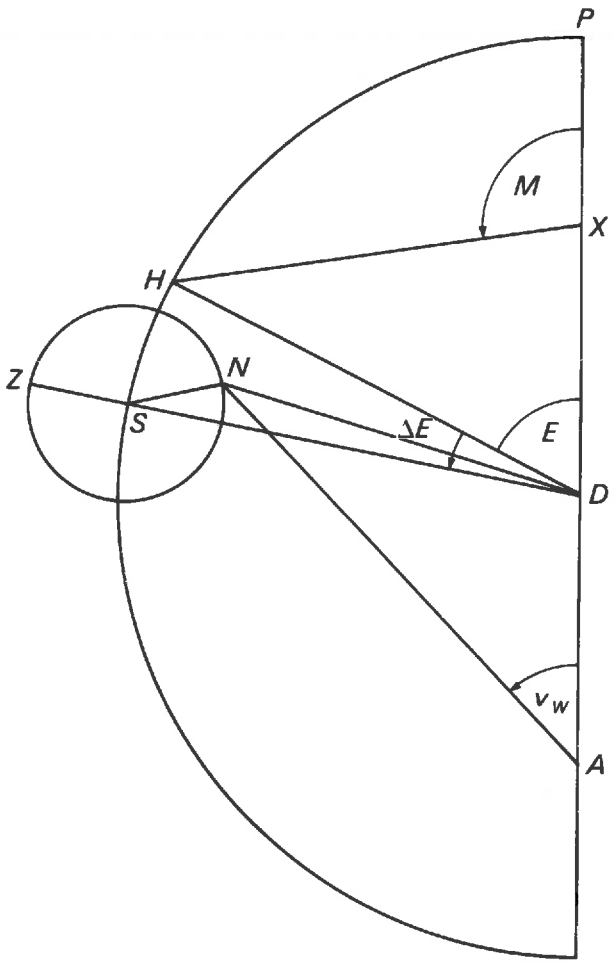
	D	′	″
Anomalie æquated P D H.	5	33	37
Angle H D N Subſtr.		2	0
Anomalie Co-æquated P D N.	5	31	37.

In the former Diagram ♂ is Supra-Diacentron, therefore I number the motion of the Epicycle 11ᵈ 7′ 14″ in the nether part of the Equant from X to O, then I ſay,

As



10.6. Vincent Wing's procedure, in his *Harmonicon coeleste* of 1651, for deriving true anomaly (v_W) from mean anomaly (M).



10.7. Wing's improved procedure, in his *Astronomia instaurata* of 1656 and his *Astronomia Britannica* of 1669, for deriving true anomaly (v_W) from mean anomaly (M).

newly devised by the Authour, wherein is plainly and succinctly delivered . . . how to calculate the Motions of all the Planets Trigonometrically, wherein I much dissent from all other Authours that have treated hereof in other Languages, and have delivered the same more methodically for practice, than any hath done before me . . . .

Wing's new procedure is in fact a modification of Boulliau's. In Figure 10.6 the ellipse is produced by an epicycle of radius $\frac{1}{4}e^2$ moving on a circle of radius $1-\frac{1}{4}e^2$; M is the mean anomaly, and E the "equated anomaly", determined by the relation $\sin(M-E)=e \sin M/(1-\frac{1}{4}e^2)$. The angle ZSN of epicyclic motion is $2E$. The eccentricity $DX=AD=e$ is varied by subtracting a sinusoidal term $XO=\frac{1}{4}e^2 \sin 2E$, and the total equation of centre is given by $\angle OND+\angle DNA$. The resulting true anomaly v_W can be shown to differ from the Keplerian value by

$$v_K - v_W = \tfrac{1}{4}e^2 \sin 2M - \tfrac{1}{4}e^2 \sin M \sin 2M - 2e^3 \sin M + \tfrac{8}{3}e^3 \sin^3 M - \tfrac{1}{2}e^3 \sin^4 M.$$

In the case of Mars, this error rises to 5′ in the second quadrant of anomaly.

By the time Wing published his *Astronomia instaurata* in 1656, he had detected the error in this theory by comparing it with acronychal observations of Mars. Moreover, he had found a way of eliminating most of this error; it consisted in adding to the angle E a correction term equal to $k \sin 2E$, where k was to be determined empirically. The value of k should be about $\frac{1}{2}e^2$; in the case of Mars, Wing in his calculation takes it to be $14' 55'' \approx \frac{1}{2}e^2+\frac{2}{3}e^4$. The new theory, which is also that of the *Astronomia Britannica* of 1669, is represented in Figure 10.7. Once again the radius DS of the deferent is $\frac{1}{2}(1+\sqrt{(1-e^2)}) \approx 1-\frac{1}{4}e^2-\frac{1}{16}e^4$, so that the radius SN of the epicycle is $\frac{1}{4}e^2+\frac{1}{16}e^4$, while, with $\angle PDH=E$, $\angle HDS=(\frac{1}{2}e^2+\frac{2}{3}e^4) \sin 2E$; and the

ASTRONOMIA BRITANNICA:

IN QUA

Per Novam, Concinnioremq; Methodum, hi quinq; Tractatus traduntur.

I. *LOGISTICA ASTRONOMICA*, quæ continet Doctrinam Fractionum Aſtronomicarum integram, tùm in Numeris Naturalibus, tùm Artificialibus.

II. *TRIGONOMETRIA*, ſeu Doctrina Triangulorum, (Analytica & Practica) quæ comprehendit Dimenſionem omnium Trigonorum, tàm Planorum, quàm Sphæricorum, cujus ope, Dimenſiones Cœli, Terræ, univerſiq; Mundi Orbis (modo mirabili) dignoſcantur.

III. *DOCTRINA SPHÆRICA*, quæ exhibet Longitudines, Latitudines, Declinationes, Aſcenſiones, Ortus, Occaſus, Intercapedines, Parallaxeſq; ſingulorum Planetarum ad cujuſlibet Sphæræ poſitum, & quo pacto Figuræ Cœleſtes erigi poſſint.

IV. *THEORIA PLANETARUM*, quæ Novâ, accuratâq; Methodo ſuper Hypotheſi *Copernicanâ*, veros Motus & Configurationes omnium Planetarum computare docet.

V. *TABULÆ NOVÆ ASTRONOMICÆ*, ex quibus Singulorum Planetarum Motus, & Luminarium Eclipſes, mirâ promptitudine colligantur.

Congruentes cum Obſervationibus accuratiſſimis Nobilis *TYCHONIS BRAHÆI.*

Cui acceſſit Obſervationum Aſtronomicarum *Synopſis Compendiaria*, ex quâ *Aſtronomiæ Britannicæ* certitudo affatim eluceſcit.

Opus exoptatum, non modò Aſtronomis, Aſtrologis, ſed & Theologis, Hiſtoriographis, Nautis, Medicis & Poetis, perutile & jucundum.

Cui additur Poſtſcriptum de *Refractione.*

Authore *VINCENTIO WING*, Mathem.

LONDINI,

Typis *Johannis Macock*, Impenſis *Georgii Sawbridge*, proſtantq; venales apud locum vulgò Clerkenwel-Green dictum. 1669.