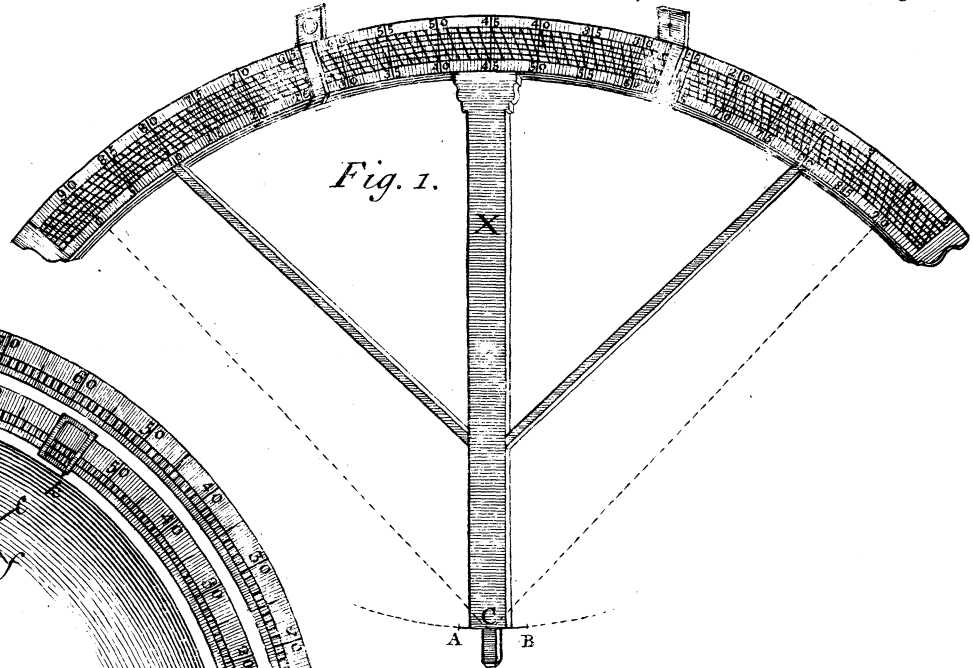
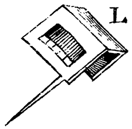


Fig. 1.



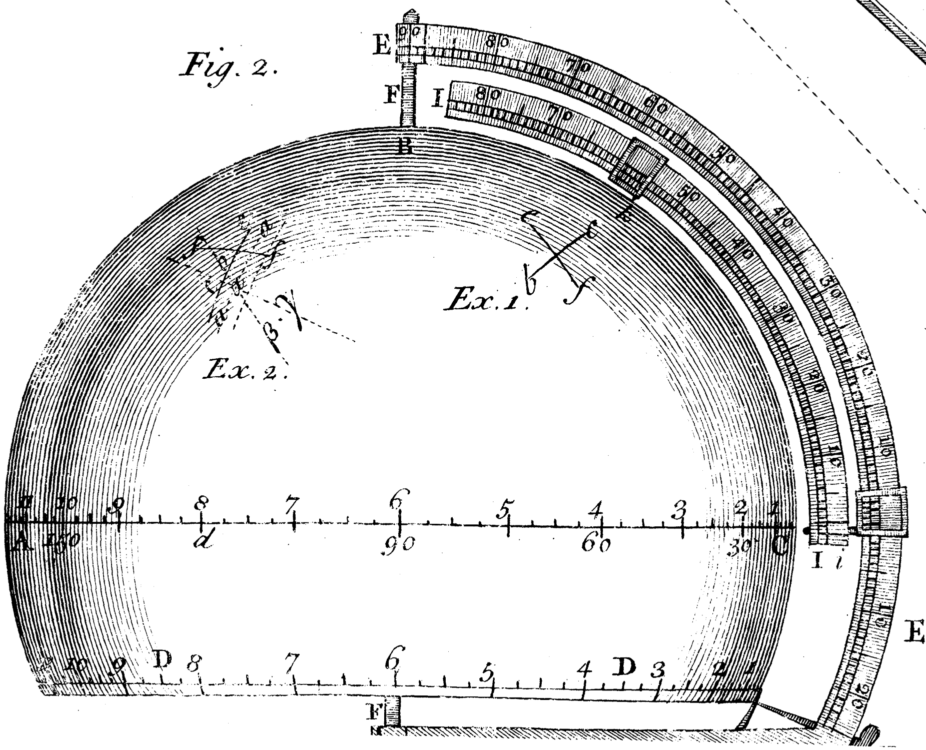


Fig. 2.

any thing that might contribute to a publick Benefit, and to do ſome juſtice to Merit, could induce me, I ſhall only requeſt that what I have here offered may be conſtrued by that Intention.

Philad. 28th of *June*, 1734.

J. LOGAN.

Note, That the Radius of the Quadrant being divided into 20 equal Parts, the Center x (in *Fig.* 1.) of the Curvature of the Horizon-Vane (A B) muſt be 12 $\frac{8}{10}$ of thoſe Parts from the Center (C) of the Quadrant. The Breadth (A B or *g h*) of that Vane ſhould be $\frac{1}{10}$ of the whole Radius, that is, $\frac{1}{20}$ on each Side of the Center (C).

IV. *The Deſcription and Uſe of an Inſtrument for taking the Latitude of a Place at any time of the Day; by Mr.* Richard Graham, *F. R. S.*

THE neceſſity of finding the Latitude, a Ship is in, is too well known to be inſiſted on: Frequent opportunities of obſerving the Latitude muſt conſequently

consequently be of very great Advantage to Navigation. The Method usually practised, is by taking the Sun or Stars Meridian Altitude or Zenith Distance: In this Case, if the Sun does not shine but for some small Time only, before Noon and after, though it be clear all the rest of the Day, it is of no use for this Purpose. Mr. *Fatio, F.R.S.* (in the Year 1728) proposed a Method for finding the Latitude, from two or more Observations of the Sun (or Stars) at any Time, the Distance of the said Observations in Time, being given by a Watch; but as his Method requires a vast Number of Computations, and a great deal of Skill in Spherical Trigonometry, it has very seldom been made use of, and never but by good Mathematicians. The Instrument here described will answer the same End, and has these Advantages; *viz.*

1st, It may be very easily understood by Seamen.
2dly, It immediately shews the Latitude of the Place.
3dly, It gives the Time of Day at Sea when no other Instrument can.
4thly, It may be made as large, and consequently as accurate as is desired.

A Description of the Instrument. See *Fig.* 2.

A B C represents part of the Hemisphere of a large Globe (half the Globe, and the Part below the Tropick are cut off, that it may take up the less room.) A C, half the Equator, divided into 12 Hours above, and 180 Degrees below, and subdivided into Minutes, as is likewiſe the lower Tropick D D. EE, a moveable graduated Meridian, turning on the Axis F F. G an Index to fix it (by the means of the Screw H) to any Hour. I *i* I, a circular Beam-compaſs, the Center I *i* to be fixed on the Meridian to any Degree and Minute of Declination, by the Method commonly called *Nonius's* Diviſions: *k* the Point for drawing Arches, which is likewiſe fixed to any Degree and Minute by the ſame Method. As the Meridian is at ſome Diſtance from the Globe, L is a piece of Braſs to fix on the Meridian, marked with *Nonius's* Diviſions, with a Point reaching down to the Interſection of the Arches, by which means the Diſtance of the ſaid Interſection from the Equator, or its Latitude is found. The Degrees and Minutes may likewiſe be ſhewn by diagonal Lines.

The Uſe of the Inſtrument.

I. PROPOSITION.

From two Obſervations of the Height of the Sun, the Diſtance of the ſaid Obſervations in Time, being given by a Watch, as likewiſe the Declination of the Sun; to find the Latitude of the Place, and Hour of the Day.

I. *When the Ship is at Reſt, that is, at Anchor, or in a Calm, ſo as to have little or no progreſſive Motion.*

Caſe I.

Case 1. Suppose the Sun in the Equator, on the Day of Observation: Fix the Center of the Beam-compass at o Degree (or at the Equator,) and move the Point *k* to the Zenith Distance (the Complement of the Altitude, taken by the usual Instruments,) and from any Hour, as from C, describe an Arch of a Circle with the said Point, as *bc* (*Ex.* 1.) Suppose eight Hours after, by your Watch, you have another Observation; move the Meridian eight Hours farther, to *d*, and fix it there; and with the Zenith Distance then observed, describe another Arch as *e f*, the Point where it cuts the former is the Place of Observation, and its Distance taken on the Meridian from the Equator shews its Latitude; and the Minutes reckoned on the Equator from the Meridian to C and *d* (the Times of Observation) shew what those Hours were.

Case 2. When the Sun has Declination: Fix the Center of the Beam-compass on the Meridian, to the proper Degree of Declination for the Day of Observation, and proceed as before.

Case, 3. If the Observations are at a greater Distance than twelve Hours, but in the same Day: Make use of the Complement to twenty-four Hours of the Distance in Time, and take the Declination on the contrary, or lower side of the Equator; and instead of the Zenith Distances, take the Nadir Distances or Altitudes increased by ninety Degrees.

Thus

Thus you will find the Latitude, and Time of each Obſervation from Midnight. In this Caſe the Beam-compaſs muſt extend to more than 90 Degrees.

Caſe 4. If the Obſervations are more than a Day aſunder; as for Inſtance a Day and two Hours (26 Hours:) Place the Centre of the Beam-compaſs two Hours farther than it was the Day before; but in different Declinations, according to the Table of Declination for the ſeveral Days.

Caſe 5. When the Obſervations are made by a Star: The Center of the Beam-compaſs muſt be ſet to the Declination of the Star; then proceed as before. To find the Hour in this Caſe, the right Aſcenſion muſt be likewiſe given.

Scholium. The ſame Method may be uſeful at Land, when no Meridian Obſervation offers.

II. *The Ship in Motion.*

Caſe 1. Suppoſe the Sun in the Equator: The Diſtance between the two Obſervations eight Hours, as before, and the Arch *a a a* (*Ex*. 2.) deſcrib'd by the Zenith Diſtance of the firſt Obſervation, from the Center C; and the Angle *c a b*, 40 Degrees, is the Angle between the Ship's way, and the Azimuth of the Sun continued, (given by the Azimuth Compaſs;) and that during the eight Hours, the Ship has made one Degree, or 60 Minutes from *a* to *b*, or from the Sun; then,

then, as Radius is to the Cosine of *c a b* 40 Degrees, so is *a b* 60 Minutes to *a c* 46 Minutes; add 46 Minutes to the Zenith Distance C *a*; and with *k*, the Point of the Beam-compass set at that Distance, describe the Arch *c b e*; then with the Zenith Distance of the last Observation, whose Center is *d*, draw the Arch *f f*; the Point where it cuts the Arch *c b e*, is the Place where the Ship was last; and its Distance taken on the Meridian from the Equator shews its Latitude; the Minutes reckoned on the Equator from the Meridian to *d* (the Time of the last Observation) shew the Hour, or its Distance from 12 o' Clock.

Case 2. If the Ship had sailed from *a* to β or towards the Sun: The Cosine of the Angle $\beta\, a\, \gamma$, or of the Angle between the Ship's Way and the Sun, must be substracted from the Zenith Distance of the first Observation.

N. B. Only the two Arches *c b e*, *f f*, are to be drawn on the Globe, the rest being added here, to shew the Reason of the Construction.

Case 3. To find the Latitude of the first Place: From the Equator, with a pair of Compasses, take the Distance sailed 60 Minutes, and with one Foot in the Intersection of the Arches *b e*, *f f*, the Place found before, put the other in the Arch *a a a*, the Zenith Distance of the first Observation, and in this Instance, on the left Hand of the Azimuth of the Sun, this is the Place sought; and its Distance ta-

ken

ken on the Meridian from the Equator, ſhews the Latitude; and the Minutes reckoned on the Equator from the Meridian to C, the Time of the firſt Obſervation, ſhew the Hour.

The Interval in Time or Degree between the two Places, ſhewn by the Index G, is the Difference of Longitude.

N. B. Thoſe Obſervations are beſt, whoſe Arches croſs each other almoſt at right Angles.

II. PROPOSITION.

The Zenith Diſtances of two Stars, obſerved at the ſame Time, their Declination, and right Aſcenſion being known; to find the Latitude of the Place of Obſervation.

Fix the Center of the Beam-compaſs to the Declination of either of the Stars, and with the Zenith Diſtance of that Star deſcribe an Arch; move the Meridian as many Hours farther as is the Difference of right Aſcenſion of the other Star; and fix the Center of the Beam-compaſs to the Declination of it; and with its Zenith Diſtance croſs the firſt Arch: The Interſection ſhews the Latitude of the Place of Obſervation; and alſo the Diſtance of the right Aſcenſion of the Zenith from that of either of the Stars, by which means the Hour may be known.

If a Celeſtial Globe is made uſe of, then place the Center of the Beam-compaſs over the ſeveral Stars.

The

The Latitude and Hour being given, the Variation of the Compaſs is eaſily known.

N. B. In order to draw Arches on the Globe; rub ſome black Lead powdered on a piece of Paper; lay the Side which is black'd next the Globe, where you imagine the Interſection of the Arches will be: Then draw them on the clean Side with the Point of the Beam-compaſs, and they will appear on the Globe; and if the Globe is well varniſhed, they may be rubbed out with Bread, or waſhed out with Water.

As Altitudes at Sea are now readily taken, with great Exactneſs, by the Quadrant invented by *John Hadley*, Eſq; V. P. R. S. and as the ſaid Altitudes are the Principles on which the Operations above deſcribed are founded; the previous Uſe of that Quadrant cannot but be of the utmoſt Importance to thoſe who ſhall have Occaſion for this Inſtrument.

The Deſcription and Uſe of this Inſtrument was laid before the *Royal Society Dec.* 9. 1731; but as I knew Mr. *Reid* was contriving one for the ſame Purpoſe, I delay'd making mine Publick. His Method not yet appearing in Print, I have thought proper to communicate my own (eſpecially as 'tis now improv'd) conceiving it may be of ſome Advantage to Navigation.