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DIRECTIONS

FOR MAKING

AN UNIVERSAL MERIDIAN DIAL,

CAPABLE OF

BEING SET TO ANY LATITUDE;

WHICH SHALL GIVE

THE *MEAN SOLAR TIME* OF NOON, BY INSPECTION,

WITHOUT ANY CALCULATION WHATSOEVER.

BY

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Directions for making an Universal Meridian Dial, capable of being set to any Latitude; which shall give the Mean Solar Time *of Noon, by Inspection, without any Calculation whatsoever.*

The Author, having done his duty by communicating his idea first to that Society of which he has been during many years not an idle member, hopes they will not think it any reflection upon the decision of their Council, who did not think proper to publish his paper in their Transactions, if he now takes another method of making it known; in a form perhaps better suited to those who may choose to construct such dials; since he must confess, that he still apprehends they may be acceptable to the public.

The Principle upon which they are formed, is this.

As a ray of the sun, being let through a small hole into a dark room, gives his image on the floor; and if a *strait line* be drawn truly in the meridian from beneath that hole, the centre of the image when cut by that line, shews *apparent* noon; so it was considered, that if a *curve* were drawn at a proper distance on each side of that line, according to the equation of time and latitude of the place, the centre of the sun's image crossing that curve might shew the *mean* time of noon, and continue true throughout the year. For since what is called the equation of time, arises principally from the variation of the sun's apparent motion in the ecliptic, together with the obliquity of the ecliptic to the equator; both of which depend upon his longitude or place in the ecliptic; and since his declination depends upon the same too; whatever be the sun's declination ascending or descending, the equation of time would very nearly correspond with it: and this would hold good for half a century at least, without any sensible difference. On this idea a meridian curve has been formed, and found to answer: and from it the following dial was contrived, on a more general plan; whose construction it is apprehended will easily be understood.

A Table, here subjoined, was first made of the equation of time at each degree of the sun's declination according to his longitude; in which, the middle column contains the sun's declination north or south; the next adjoining on each side, the sun's longitude: next to them are the respective equations of time; and the outermost columns contain those equations converted into degrees, and corrected by the cosine of the sun's declination.

This table being provided, it will be found most convenient to lay down a Plan for general use, thus. On a metal plate, or a sheet of fine pasteboard, draw a strait line. In the middle of that line, raise a pendicular, of the length you choose for the size of your dial. Twelve inches seems to be a most convenient one. With that length as radius, either by calculation or with a sector and compasses, lay off the tangent of every degree along the original line, from each side of the middle, till you come to 23° 28′ 15″, whose tangent must be laid down upon it likewise. The middle point is here intended to correspond with the equinoxes, while each of the others answers to a degree of declination north or south.

You are then, with the same radius as before, to lay off, for the equation of time, the tangents of so many degrees, minutes, and seconds, at right angles on either side of the line at the centre of it, as you find in the outermost columns of the table at the equinoxes: laying that which you find + in the table, on what you design for the western side of your meridian line, which will be for March; and the equation marked —, on the eastern side, for September; and making a dot at each. In the same manner you proceed at each degree of declination; taking the secant of that degree (or the distance from the farther end of the perpendicular, to the end of the tangent of that degree) for your radius; and laying off its respective equation from the table accordingly, at right angles to the meridian line; and marking its place by a dot. Through these dots, you then draw the curve formed by them; and mark the months, in which the curve on the one or the other side of the meridian is to be observed.

This laying down on your plan, requires to be executed with great care; because it is the foundation of the whole. But, when it is once done, the points are easily transferred from it, to any number of dials of the same radius.

In order to draw the curve with a steady hand, it will be found convenient, to form a pair of Rules suited to the curve of each half year from solstice to solstice; by which, after laying down a few of the principal points, and placing the rules carefully, you strike each half of the curve on the dial itself with ease.

With these data, for a dial of 12 inches radius, provide a box in the form of an equilateral triangle, each of whose sides are $14\frac{1}{2}$ inches clear within, and about 5 inches broad. On one of them paste a paper perfectly smooth. Let the angle opposite to this side be cut so far down as to receive a brass plate, whose inner surface may be exactly 12 inches from the centre of the paper opposed to it. In the middle of that brass plate, let there be a very small hole, just to admit a ray of light (chamfered all round, to an angle of 60 degrees at least, so as to be very thin at the edge next to the inner surface of the brass) and mark the point on the paper, at which the hole is exactly at right angles opposite to the surface; which, if your work be true, will be in the centre of your paper. Through that point, draw a strait line on the paper for a meridian line, parallel to the triangular sides; and cross it at that point, with another at right angles, for an equinoctial line. On the meridian line, transfer from your original plan, so many of the dots for declination as you see proper; and, on the equinoctial, the equations at the equinoxes. Transfer likewise the dots for the equation at each solstice; and so many of the intermediate equations, as may be necessary for being certain of laying your rules properly. Then with a steel pen, strike the curves; and insert the months in their respective places; but at such a distance from the line itself, as to be clear of the sun's image when it is near the curve.

These things will require to be done before the box is finally put together, that they may be done with accuracy. And therefore it will be found most convenient to have that side fixed with screws. Another of the sides (viz. that nearest to the winter solstice, according as it is intended for north or south latitude) must be made to open about $\frac{2}{3}$ of its length; with a rule-joint and cheeks like the lid of a small camera obscura, to keep off false light, and enable you to see the image within.

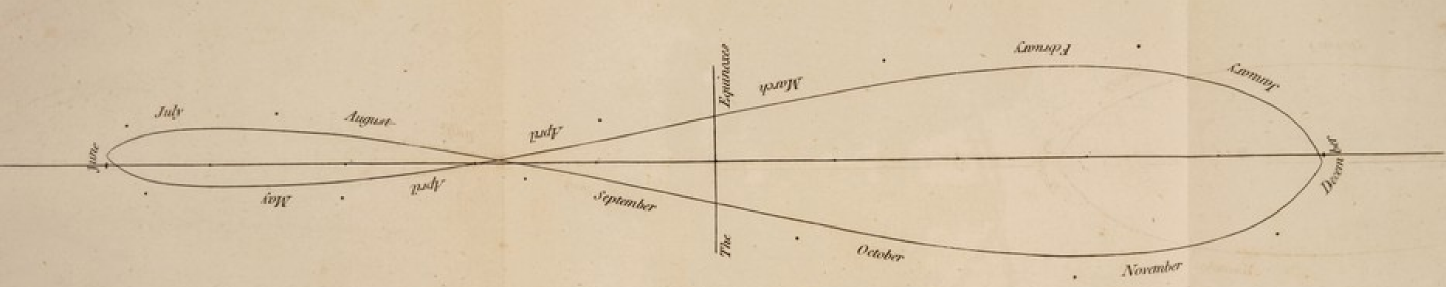
Additions may be made to it, for elegance, or difference of adjustment; but this is the whole of the instrument: which, if carefully constructed, and once rightly fixed in the meridian, inclined properly according to the latitude of the place (or fitted on a frame, so as to be applied occasionally to a window) will, throughout the year, give the *mean solar time* of noon, far more accurately than any sun-dial of the usual construction. On this account it is made public: because it should seem it might be convenient in most country places. For it requires no skill in the observer, but merely to see, that his clock or watch point to 12, or to set them to that hour, when the centre of the sun's image is upon the curve line belonging to that month. At present it is not uncommon to find the clocks in two adjoining parishes, differing nearly half an hour from each other; because so few persons understand rightly the nature of the equation of time, or how to regulate their clocks by a common sun-dial.

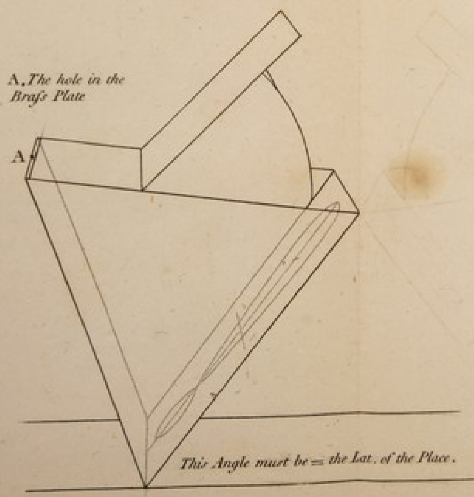
N. B. The directions above given, contain the principle, and best method of making these dials. But if any person chooses to make use of an *impression* from the copper plate, which accompanies this paper, he must reduce the radius (or perpendicular distance between the hole in the brass plate and the surface of the paper) according to the proportion of its shrinking; that is, after it is pasted on the board and dry, he must consider the whole length of the curve as 0,8684 parts, of which the radius must contain 1,0000.

Equation ± W./E. in Deg. corrected.	Equation ± W./E. in Time.	Sun's Long.	Sun's Decl. N.	Sun's Long.	Equation ± W./E. in Time.	Equation ± W./E. in Deg. corrected.	Equation ± W./E. in Deg. corrected.	Equation ± W./E. in Time.	Sun's Long.	Sun's Decl. S.	Sun's Long.	Equation ± W./E. in Time.	Equation ± W./E. in Deg. corrected.
° ′ ″	′ ″	S. ° ′	° ′ ″	S. ° ′	′ ″	° ′ ″	° ′ ″	′ ″	S. ° ′	° ′ ″	S. ° ′	′ ″	° ′ ″
+0 16 44	+ 1 13	3 0 0	23 28 15	2 30 0	+ 1 13	+0 16 44	−1 54 15	− 7 37	6 0 0	0 0 0	11 30 0	+ 7 36	+1 54 0
49 29	3 35	11 0	23	19 0	− 1 12	− 16 34	2 7 14	8 29	2 32	1	27 28	8 22	2 5 29
1 10 28	5 4	19 50	22	10 10	2 46	38 29	2 19 55	9 20	5 2	2	24 58	9 8	2 16 57
1 20 4	5 43	3 25 51	21	2 4 9	3 32	49 29	2 32 18	10 10	7 35	3	22 25	9 50	2 27 19
1 24 19	5 59	4 0 40	20	1 29 20	3 54	54 59	2 44 22	10 59	10 5	4	19 55	10 33	2 37 53
1 25 34	6 2	5 15	19	24 45	4 2	57 12	2 55 35	11 45	12 40	5	17 20	11 11	2 47 5
1 23 56	5 53	9 5	18	20 55	3 59	56 50	3 6 15	12 29	15 15	6	14 45	11 49	2 56 18
1 20 5	5 35	12 45	17	17 15	3 48	54 31	3 16 3	13 10	17 50	7	12 10	12 25	3 4 57
1 14 5	5 9	16 9	16	13 51	3 31	50 42	3 25 31	13 50	20 29	8	9 31	12 57	3 12 41
1 7 22	4 39	19 29	15	10 31	3 5	44 40	3 33 7	14 23	23 3	9	6 57	13 25	3 18 45
1 0 49	4 5	22 35	14	7 25	2 38	38 19	3 40 8	14 54	25 51	10	4 9	13 51	3 24 35
50 25	3 27	25 36	13	4 24	2 6	30 42	3 46 2	15 21	6 28 29	11	11 1 21	14 11	3 28 51
40 21	2 45	4 28 30	12	1 1 30	1 29	21 46	3 50 53	15 44	7 1 30	12	10 28 30	14 27	3 32 1
29 12	1 59	5 1 21	11	0 28 29	0 48	11 48	3 53 51	16 0	4 24	13	25 36	14 38	3 34 17
17 44	1 12	4 9	10	25 51	− 0 10	− 2 28	3 55 26	16 11	7 25	14	22 35	14 42	3 33 57
+ 5 26	+ 0 22	6 57	9	23 3	+ 0 34	+ 8 24	3 55 14	16 14	10 31	15	19 29	14 40	3 32 31
− 6 41	− 0 27	9 31	8	20 29	1 16	18 49	3 52 53	16 9	13 51	16	16 9	14 28	3 28 38
19 36	1 19	12 10	7	17 50	2 3	30 31	3 48 18	15 54	17 15	17	12 45	14 8	3 22 46
32 49	2 12	14 45	6	15 15	2 49	42 1	3 40 27	15 27	20 55	18	9 5	13 37	3 14 27
46 34	3 7	17 20	5	12 40	3 38	54 18	3 29 45	14 47	24 45	19	5 15	12 51	3 2 17
59 51	4 0	19 55	4	10 5	4 25	1 6 6	3 13 50	13 45	7 29 20	20	10 0 40	11 40	2 44 28
1 13 37	4 55	22 25	3	7 35	5 15	1 18 38	2 53 0	12 21	8 4 9	21	9 25 51	10 10	2 22 24
1 27 27	5 50	24 58	2	5 2	6 1	1 30 11	2 22 20	10 14	10 10	22	19 50	7 57	1 50 34
1 40 44	6 43	27 28	1	2 32	6 50	1 42 29	1 22 51	6 0	19 0	23	11 0	+ 4 8	+ 57 10
−1 54 15	− 7 37	5 30 0	0	0 0 0	+ 7 36	+1 54 0	− 16 30	− 1 12	8 30 0	23 28′ 15″	9 0 0	− 1 12	− 16 30

THE EQUINOXES.

The Form and Size of the Curve for a Meridian Dial of one foot Radius.





It should be observed, that notwithstanding the Curve is laid down accurately on the Plate, it will err a little in the impression, from the unavoidable shrinking of the paper.

If an impression itself be used, it will be necessary, after it is pasted on the board & dry, to consider the length of each half from the Equinoxes, as 0.4342 parts (or the whole length as 0.8684) of which the Radius, or the distance from the hole in the Plate to the surface of the board must contain 1.0000