A SPHERICAL SUNDIAL HAVING THE GNOMON INCLINED AT THE WRONG ANGLE

Fig. 1 - VIEW LOOKING FROM WEST

to scale for a sun LHA of 45 degrees and sun dec. of +10 degrees

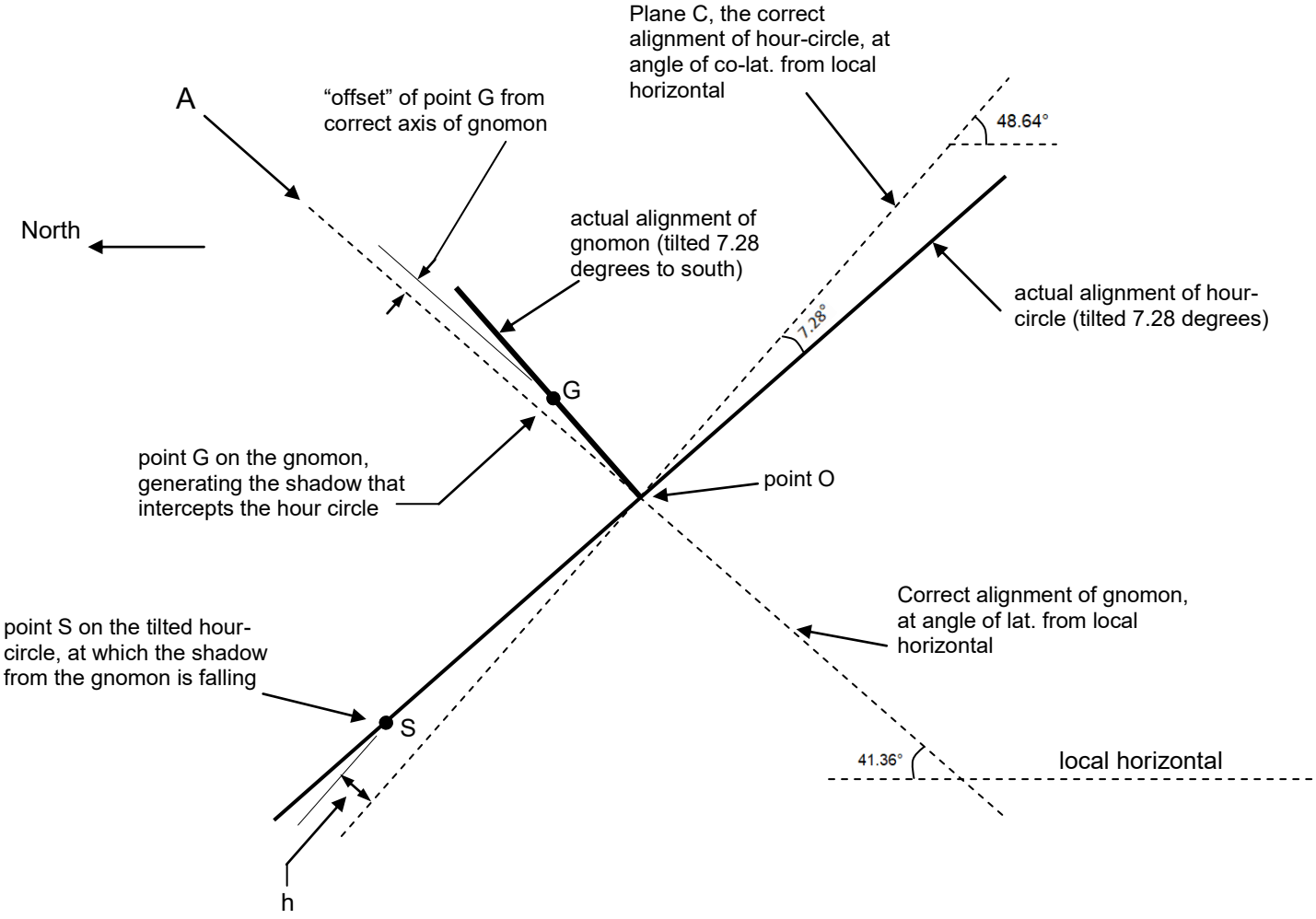
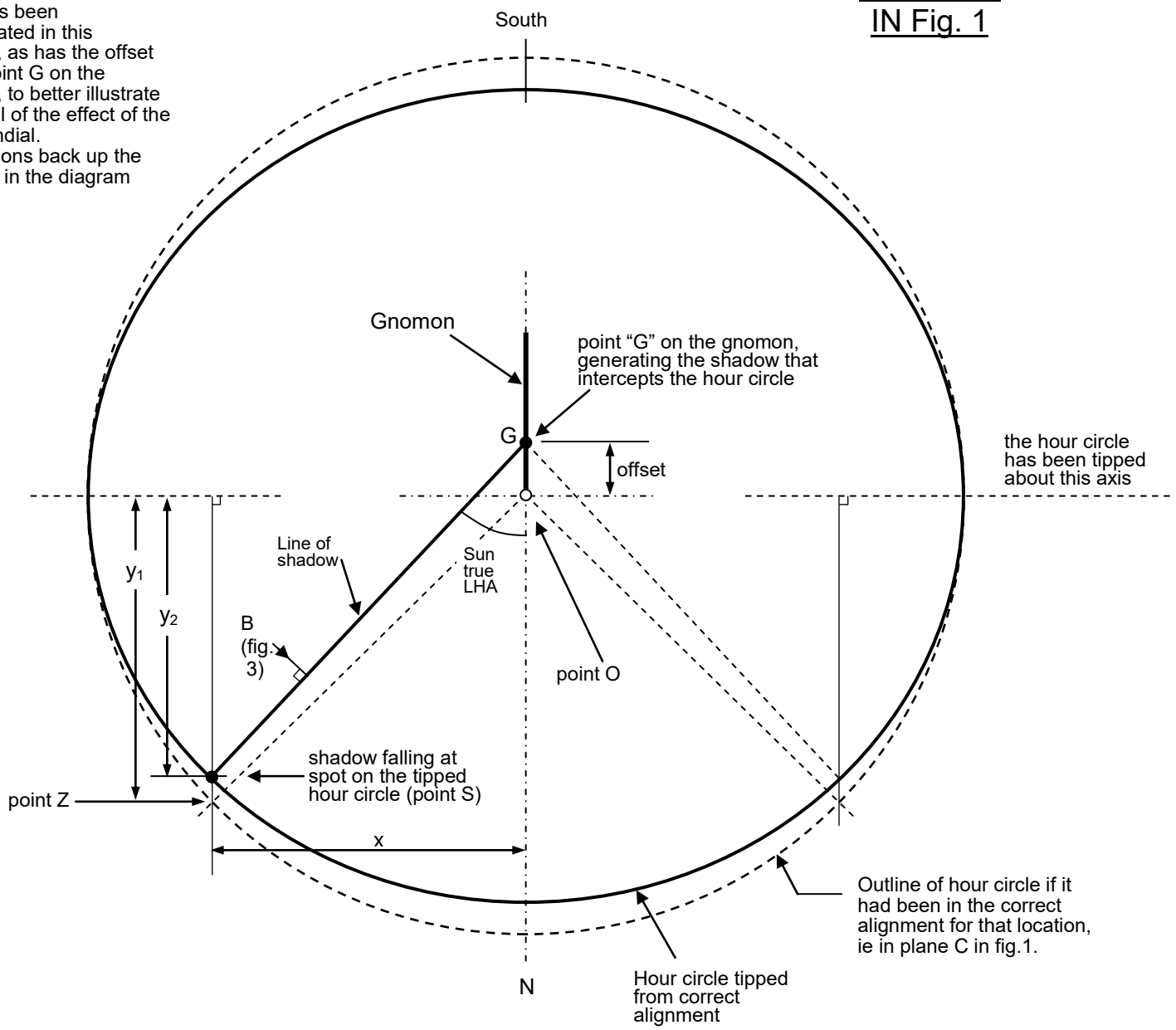


Fig. 2 - VIEW FROM "A" IN Fig. 1

The angle of tilt of the hour circle has been exaggerated in this diagram, as has the offset of the point G on the gnomon, to better illustrate the detail of the effect of the tilted sundial. Calculations back up the principle in the diagram



Effect of the tilted sundial

In the above diagram, the time marked on the tilted hour circle at the shadow spot, point S, is the same time as marked on the non-tilted hour circle at point Z.

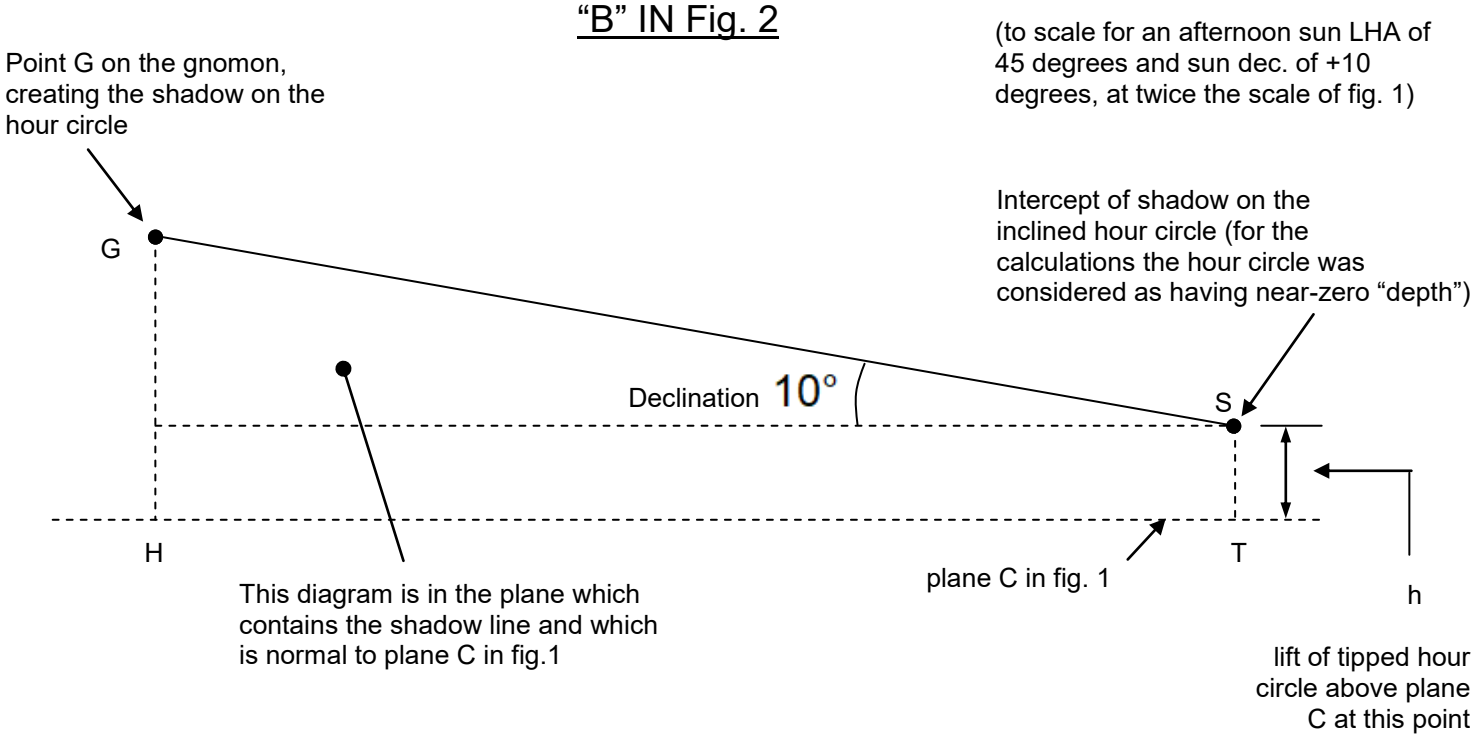
In calculations, which were for some (positive) sun declinations, the offset distance of the spot (point G) on the gnomon was always greater than the distance between points S and Z, ie the offset was > (y_1 - y_2). In the afternoons, angle NOZ is greater than angle NGS. Therefore in the afternoons when the sun has a positive declination, it appears that the tilted sundial shows a later time than if it was not tilted. This agrees with results from the Sawyer formula that Geoff Hitchcox found.

It appears from fig. 2 that the sundial error is reversed in the morning. When the sun has a positive declination, the tilted sundial shows an earlier time in the morning than if it was not tilted.

The Sawyer formula indicates that negative sun declinations have an effect on both the sign (and to a small extent the magnitude) of the sundial errors, as compared to positive sun declinations. These have been plotted on the attached graph (page 4).

The notes above and the diagrams relate to a dial in the Northern hemisphere.

Fig. 3 - VIEW FROM "B" IN Fig. 2



Iterative calculations

The notes below are superfluous now that the Sawyer formula is available and far more convenient to use, but are here to touch on how the diagrams were used to find the sundial errors.

Some calculations were done to calculate the sundial errors. which were shown in the graph posted on 11 June 2024. These calculations were iterative as I was unable to derive a formula for calculating the error directly. These iterative calculations were based on the diagrams, figures 1 to 3. This calculation method was used for some combinations of LHA and (positive only) declinations,
For a given LHA and declination, an initial value of the offset was guessed at and the parameters worked through in Excel to come to a new figure for the offset, the process being repeated until a final figure for the offset had been reached. The LHA indicated by the sundial, for that LHA/dec combination, was calculated from the final values of the parameters.

For cases of positive declinations, the erroneous LHA indicated by the misaligned sundial was $\text{Tan}^{-1}\left[\dfrac{\text{final x value}}{\left(\dfrac{\text{final } y_2 \text{ value}}{\cos 7.28 \text{ here}}\right)}\right]$

which equates to $\text{Tan}^{-1}\left[\dfrac{\text{final x value}}{\text{final } y_1 \text{ value}}\right]$

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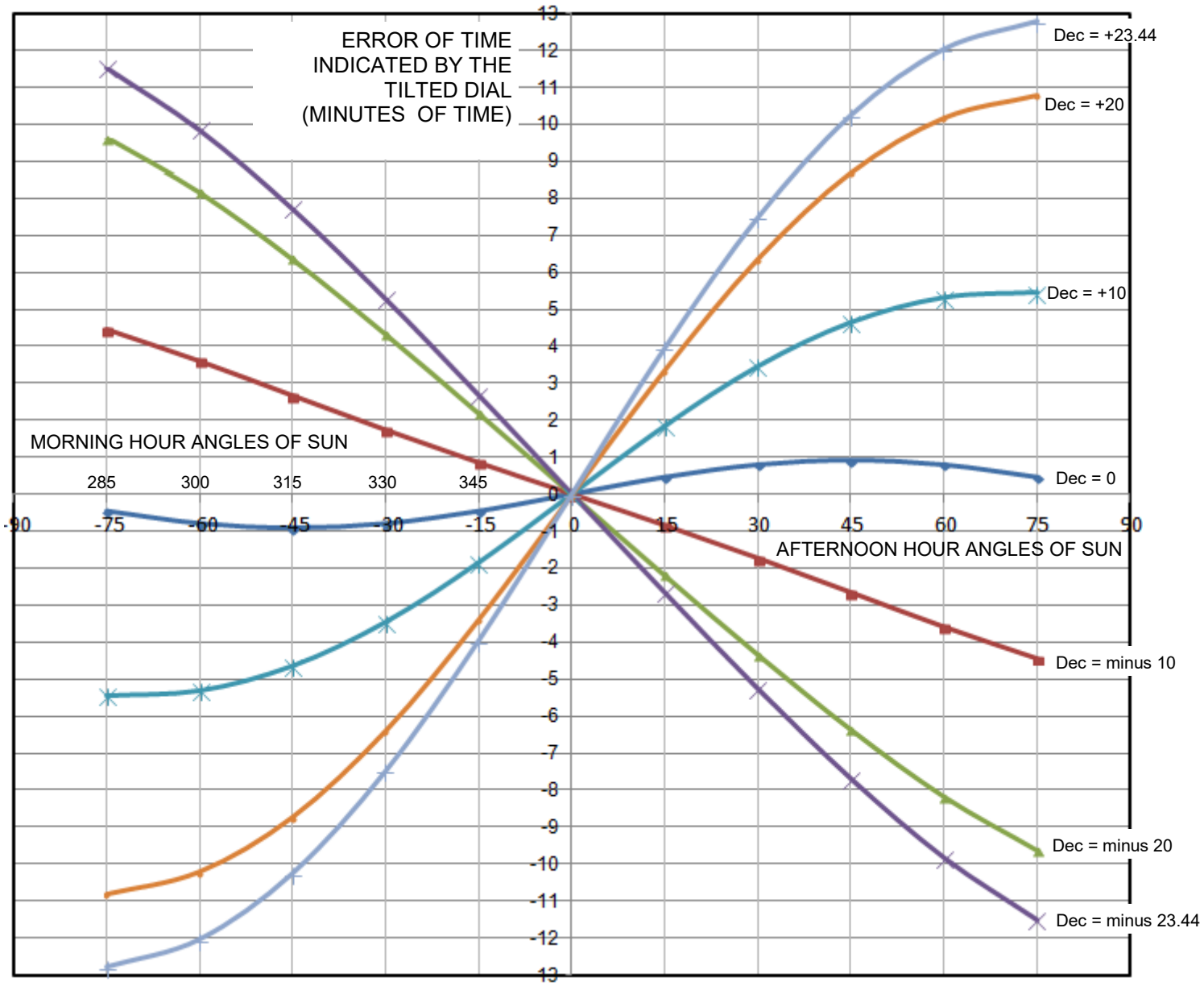

TIME ERRORS IN A SPHERICAL SUNDIAL FROM THE GNOMON BEING INCLINED AT AN ANGLE OF 48.64 DEGREES FROM THE HORIZONTAL ON A DIAL LOCATED AT LATITUDE 41.36 NORTH (ERROR FIGURES OBTAINED FROM SAWYER FORMULA).

POSITIVE FIGURES FOR ERRORS ARE THE TILTED DIAL INDICATING A LATER TIME THAN A CORRECTLY-ALIGNED DIAL,

NEGATIVE FIGURES ARE THE TILTED DIAL INDICATING AN EARLIER TIME.

(assumed the hour-circle is tilted as well as the gnomon and the dial is in the Northern hemisphere)

Acknowledgements : Points on the graph are obtained from the formula by Fred Sawyer, which Geoff Hitchcox located (Geoff's posting of 13 June 2024),