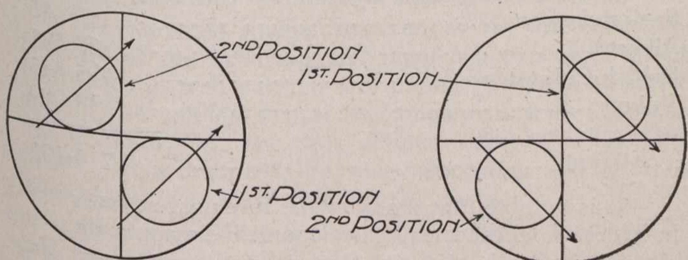
OBSERVATION OF THE SUN FOR AZIMUTH.

By J. A. Macdonald, Ottawa, Ont.

STAR observations require a clear sky. They may be prevented by smoke, haze or light clouds, although the sun may be quite visible. It may, therefore, happen that the observation of the sun will be the only method available for the determination of azimuth. The method may not be quite as accurate as with Polaris, and involves considerable calculation. The writer has made use of solar observations almost invariably in railway and land survey and other work, and finds it quite satisfactory. The method here described will be found to eliminate inaccuracies as much as possible.

The observation is made first with the vertical circle in one position, to the right of the observer, for instance, and next with the circle to the left, after reversing the telescope and turning the upper plate 180°. In the first position of the instrument, the image of the sun is brought into the angle formed by two of the threads in the telescope, so as to be tangent to both at the same time. The same process is repeated with the instrument in the second position, but with the sun's image in the opposite angle. (Figs. 1 and 2.) In order to bring both threads tangent



Observation of the Sun (left) in the Forenoon; (right) in the Afternoon, with an Erecting Eyepiece.

to the sun's limb at the same time, the sun's image must be so placed as to move towards one thread while going away from the other. The former thread is kept tangent to the limb by the proper slow-motion screw until both threads are tangent together. In the opposite angle of the threads the same process is repeated with the other slow-motion screw. Fig. 1 shows how the sun's image appears in the forenoon with an erecting eyepiece. In the upper left angle of the threads, the sun's image moves away from the horizontal thread and towards the vertical thread; the latter is kept tangent by the slow-motion screw of the upper plate. In the lower right angle of the threads, the sun's image moves away from the vertical thread and towards the horizontal thread, the latter being kept tangent by the slow-motion screw of the vertical circle. Fig. 2 shows how the discs would be placed in the afternoon.

The observation is easy enough if made methodically, otherwise there is a risk of not placing the images in opposite angles, which would entirely vitiate the result. The following rules, if followed, will prevent mistakes:

(1) Always commence with the sun on the right of the vertical thread and impinging upon it. Above the horizontal thread in the forenoon, and below in the afternoon.

(2) Always commence by following the sun with the slow-motion screw of the vertical circle.

(3) Place the sun on the left of the vertical thread and impinging upon the horizontal thread; below in the forenoon and above in the afternoon.

(4) Follow the sun with the slow-motion screw of the upper plate.

The reading of the horizontal circle on the reference object, generally a line picket, must be taken in both positions of the instrument, and the approximate time of observation noted. The best time for observation is when the sun is near the prime vertical; that is, say, nearly due east and west.

The following formula may be used for calculation:

$$\cos \frac{Az}{2} = \sqrt{\cos S \cos (S-P) \sec. L \sec. h}$$

$$\text{where } S = \frac{h + L + P}{2}$$

h being the true altitude of the sun, L the latitude, P the sun's polar distance on $Az.$, the azimuth. Reckoning the bearing from 0° to 360° and from the north point through east, south and west. $Az.$ is the bearing in the forenoon and 360° minus the bearing in the afternoon.

Below is an example of an observation taken in the forenoon, (H.C.R. denoting horizontal circle reading):

Date—June 15, 7.20 a.m.

Place—Longitude 6 h. 57 m.; latitude. 51° 26′ 45″.

Face.	Sun's altitude.	H.C.R. in sun.	H.C.R. on line.
Right ...	30° 09′	175° 43′ 00″	176° 39′ 00″
Left ...	30° 15′	176° 51′ 00″	176° 40′ 00″
Mean ..	30° 12′	176° 17′ 00″	176° 39′ 30″

Greenwich time.

Local time =	June 14	19 h.	20 m.
Longitude -	- +	6	57
Greenwich time	-	2 h.	17 m.

Correction for Altitude.

Obs. altitude	= 30° 12′ 00″
Refraction	= —1′ 40″
Difference	= 30° 10′ 20″
Paralax	= + 8″
h - - -	= 30° 10′ 28″

Sun's Polar Distance

Decl. at 0 h.	= 23° 20′ 16″ N.
Var. for 2 h. 17 m.	= +14
Decl. at 2 h. 17 m.	= 23° 20′ 30″
P - -	= 66° 39′ 30″

h = 30° 10′ 28″ sec h = 0.06324
L = 51° 26′ 45″ sec L = 0.20533
P = 66° 39′ 30″ cos $(S-P)$ = 9.99629

$2S$ = 148° 16′ 43″
S = 74° 08′ 21″
$S-P$ = 70° 28′ 51″

$$\cos^2 \frac{Az}{2} = 19.70150$$

$$\cos \frac{Az}{2} = 9.85075$$

$$\frac{Az}{2} = 44° \ 50' \ 00''$$