Set pointer $L$ to the declination by sliding and turning the inner cylinder secured to the top end cap of the slide rule,

Set pointer $S$ to the Hour Angle $H$ by turning and sliding the outer cylinder.

Read off the value of $y$ by the pointer $L$. As two figures (supplementary) are shown to each mark on the scales it is necessary to remember that $y$ is greater or less than 90° according to whether $H$ was greater or less than 90°.

Next form $Y$ from $y$ and $c$, the co-latitude, adding $y$ to $c$ if the declination and latitude are of the same name and subtracting if they are of opposite names.

The Azimuth $A$ is now found from the Slide Rule by setting the pointer $S$ to $y$, then the pointer $L$ to the hour angle $H$, the pointer $S$ to the value of $Y$, and then reading off the azimuth from the pointer $L$. Here again we have the rule that $A$ is greater or less than 90° according to whether $Y$ is greater or less than 90°. The Azimuth is noted for future use and the altitude found from the Slide Rule by a third series of settings.

Set pointer $S$ to the Azimuth $A$, pointer $L$ to the value of $Y$, return pointer $S$ to zero, and read off the altitude by pointer $L$.

The calculation is now complete, having found both Azimuth and Altitude.

As described in the Theory of the Method, the calculation can be checked by re-working with the declination and latitude interchanged, in which case the new azimuth is to be rejected but the altitude will be correct.

*The Observed Altitude*

Before the observed altitude can be compared with the calculated altitude, it must be corrected for Dip of the Horizon (height of eye), Refraction, semi-diameter, and Paral lax, and this is done either by the usual nautical tables or by the auxiliary tables found on the slide rule; while the latter are sufficiently accurate for aircraft observations, for marine work the nautical tables are to be preferred.

Here it is essential to note that if the observations were made with a bubble or artificial horizon, then the corrections for Height of Eye (Dip) and semi-diameter must not be applied.

The Azimuth and the difference of the calculated and corrected observed altitudes are now used to draw the position line.

*Calculation of Great Circle Courses*

Reference to the figure shows at once that the Slide Rule can be used to calculate Great Circle Courses by the following method :-

The latitude and longitude of the point of departure are used in place of the Dead Reckoning Position.

The latitude of the point of arrival is used instead of the declination.

The difference of the longitude $S$ is used for the Hour Angle.

The Azimuth so found is the Initial Great Circle Course, and the altitude found is the length of the Great Circle Course which, when reduced to minutes of arc, is the length in Geographical Miles.

## NOTE ON THE INTERNAL READING MICROSCOPE FITTED TO AZIMUTH CIRCLE N° 13.

COMMUNICATED* BY THE INSTRUMENT SECTION OF THE ARMY GEOGRAPHICAL SERVICE, PARIS.

For taking exact readings of graduated circles it is usual to make use of microscopes fitted with micrometer eyepieces.

In this case, the eyepiece bears a reticle in the plane of the image of the division. The lines of the reticle can be made to coincide with this image of the division by a translatory motion governed by a micrometer screw.

(*) *In French.*

It is with this screw that the displacement, and so the position of the microscope with respect to the division, is measured.

In an effort to improve the results and to remedy the defects in the screws, we have tried replacing this mechanical procedure by optical methods.

In 1923, the Optical Laboratory of the Army Geographical Service, having to design a circle for the Artillery Control Sections, conceived a microscope based on a new principle (see Fig. 1).

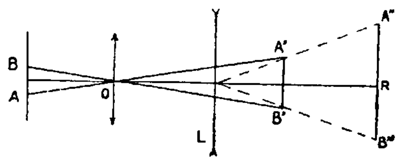


Fig. 1

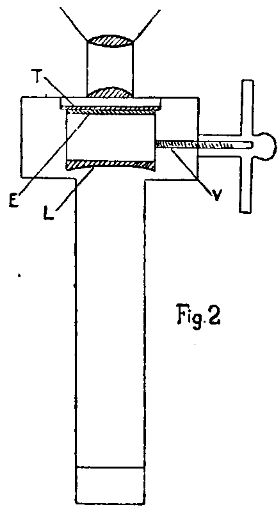


Fig. 2

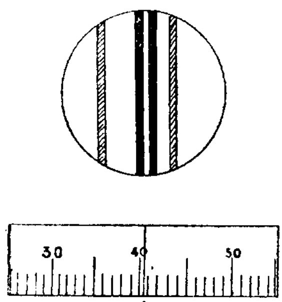


Fig. 3

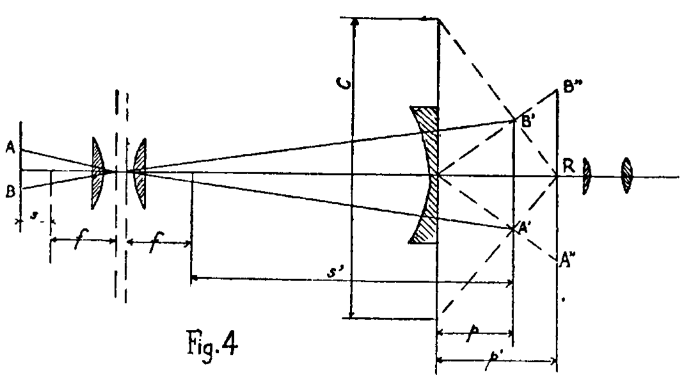


Fig. 4

The object-glass $O$ is placed before the division $AB$, forming an image of the latter at $A'B'$; before the image is formed at $A'B'$ a dispersion lens $L$ is interposed, which transports the image $A'B'$ to $A"B"$.

In the plane of this image $A"B"$ is a fixed mark $R$; the image and the mark are seen through an eyepiece. To find the position of the mark with respect to the division, the lens $L$ is moved in its own plane until $A"$ coincides with $R$, the displacement of $L$ is measured by means of a micrometer screw, and the respective positions of the microscope and the division are thus determined.

Recourse is still had to measurement by a screw, but it must be noticed that a slight displacement of the image $A"$ represents a large displacement of $L$, which enables good results to be obtained without requiring great precision in the screw.

Borrowing the idea contained in this design, the Instrument Section of the Geographical Service, having to fit out various geodetic appliances, got the firm of SECRETAN to produce a microscope which also comprises displacement of the image by an internal dispersion lens. But with a view to entirely eliminating measurement by screw, the lens is actuated by some means (cam or screw) and its displacement is read on a divided scale moving with it.

Fig. 2 shows this microscope.

The dispersion lens *L*, actuated by the screw *V*, carries with it the strip *E* on which is a scale divided into one hundred parts. The strip *E* is sufficiently narrow to hide only a part of the field.

In a plane very near that of the scale is a fixed frame *T* holding two windows fitted with indices; in one window the scale is seen, in the other, the image of the division; and the position of the scale is read after bringing the image of the division against its index.

Fig. 3 shows the appearance of the frame as seen through the eyepiece.

Fig. 4 shows the path of the rays in the microscope.

The characteristics of the microscope are as follows:

- focal length of objective........................ $f = 19$ mm.
- focal length of dispersion lens................ $F = 60$ mm.
- distance apart of two lines of the reticle. $d = 0.17279$ mm.

Referring to Fig. 4 we have the following formulae:

$$ss' = f^2.$$

Denoting the length $A'B'$ by $d'$, we have:

$$\frac{d'}{d} = \frac{f + s'}{f + s}.$$

Also,

$$\frac{-1}{p} + \frac{1}{p'} = \frac{-1}{F}.$$

Denoting by $C$ the total displacement to be applied to the dispersion lens to bring the images $A''$ and $B''$ in turn on to the mark $R$, i. e. the maximum displacement necessary, we have:

$$\frac{C}{d'} = \frac{p'}{p' - p},$$

whence

$$C = \frac{d \times f \times F}{p \times s}.$$

In the present case, $p = 8.57$,
whence

$$C = 5 \text{ mm}.$$

On trial, readings taken with this microscope have been shown to be more stable than readings taken with the screw microscope.

The following table contains the results obtained in twenty measurements of the same angle from twenty different points of origin. The first ten measurements were made by an observer using the supplementary microscope of the eyepiece. (*) The ten following measurements were made by an observer using the plain eyepiece.

---

(*) *The large azimuth circles of the Army Geographical Service actually include among the accessories a small microscope of rather low power which may be substituted for the ordinary eyepiece of the measuring microscopes; it is chiefly used for ensuring correct adjustment of the focus of these latter microscopes.*

During the course of these measurements, the work was done with different departures with respect to the divisions, in order to show up the irregularities of the microscopes if such existed.

| *Origin.* | *Angle.* | *Discrepancy.* |
|---|---|---|
| 0 | 10G 03 49.2 | 1.5 |
| 10 | 47.8 | 2.9 |
| 20 | 46.8 | 3.9 |
| 30 | 49.4 | 1.3 |
| 40 | 49.7 | 1.0 |
| 50 | 50.5 | 0.2 |
| 60 | 48.6 | 2.1 |
| 70 | 54.1 | 4.6 |
| 80 | 53.4 | 3.3 |
| 90 | 52.4 | 1.7 |
| 100 | 55.8 | 5.1 |
| 110 | 47.1 | 3.6 |
| 120 | 51.4 | 0.7 |
| 130 | 45.8 | 4.9 |
| 140 | 55.4 | 4.7 |
| 150 | 48.4 | 2.3 |
| 160 | 54.7 | 4.0 |
| 170 | 47.4 | 3.3 |
| 180 | 54.4 | 3.7 |
| 190 | 52.4 | 1.7 |

Value of the angle : 10G 03 50.7

# AN OPTICAL DEVICE TO AID IN MAPPING FROM PHOTOGRAPHS

by

O. M. MILLER, American Geographical Society

(Extract from the *Journal of the Optical Society of America*, Vol. 25, No. 6, Washington, June 1935).

The operation of the single eyepiece oblique plotter which is being used at the American Geographical Society (1) enables level features, such as coastlines, to be drawn directly in plan from their perspective images appearing on high oblique photographs, that is to say, those taken with the camera axis pointing more nearly horizontal than vertical. Where the ground is not flat, the instrument can be operated to obtain the positions of points both in plan and in elevation by plotting the intersection of corresponding perspective rays from two photographs.

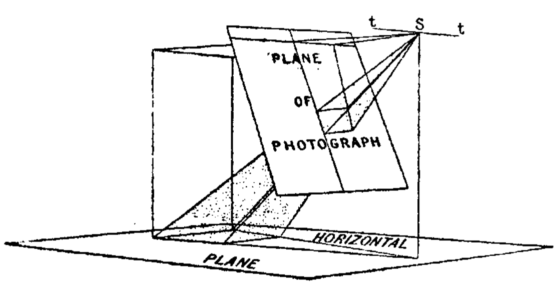


Fig. 1

(1) *The instrument has been built by the Mann Instrument Company.*