observation with the greatest possible care, some 30 minutes' work was required each time. In calculating the errors, no single observation was neglected; further, no occasion arose to replace any one of the original observations by a fresh, more careful one.

As the above data show, values were obtained for all three control pictures, in spite of the very different slopes, nearly equal to the corresponding mean errors.

As the position errors determined lie roughly on the limits of accurate drawing, the transformer described here may well be designated as an appropriate instrument for high precision work.

PILOT BALLOON SLIDE RULE — MARK I.

(Communicated by the METEOROLOGICAL OFFICE, London, November 1935).

The pilot balloon slide rule, Mark I, is designed to facilitate the calculation of the horizontal distance and bearing of the balloon from the observer at any instant. From the distance and bearings at successive one minute intervals the direction and speed of travel of the balloon relative to the observer may be calculated.

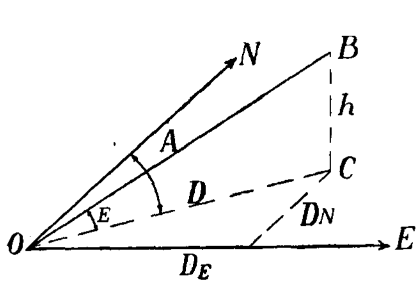


FIG. 1

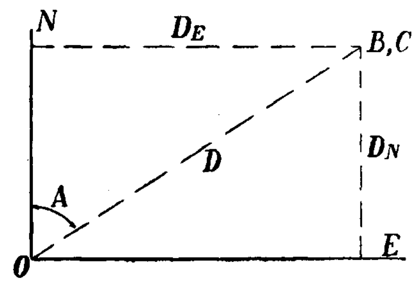


FIG. 2

THEORY.

Let O be the observer's position. ON, OE are axes drawn horizontally northwards and eastwards respectively.

Let B be the position of the balloon at any instant, and C a point in the horizontal plane NOE, vertically below the balloon.

Then $< CON, = A$, is the bearing of balloon (measured from North).

and, $< BOC, = E$, is the elevation of balloon.

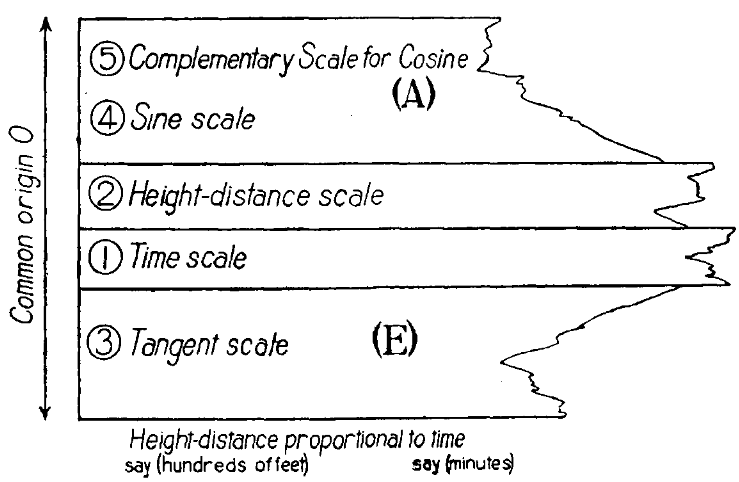


FIG. 3


PILOT BALLOON SLIDE RULE MARK I M 1234/34
COSINE SCALES
SINE SCALES
TIME SCALE
TANGENT SCALE
MAKERS NAME
DET'S. 4 & 5 FIXED WITH
2· 8 BA × 7/16" BR. CSK. SCREWS

Denote the distance of the balloon north of the observer by D_N
Denote the distance of the balloon east of the observer by D_E
Denote the height of the balloon, CB by h
Denote the distance of the ballon OC from the observer by D.

Seen in plan, Fig. 1 becomes Fig. 2.

Then

$$D = h \cot E.$$
$$D_N = D \cos A = h \cot E \cos A.$$
$$D_E = D \sin A = h \cot E \sin A.$$

These hold good whatever be the value of A if due regard is paid to the signs of $\cos A$ and $\sin A$.

The slide rule is designed to facilitate the calculation of D_N and D_E.

DESCRIPTION.

The apparatus consists of two movable scales (1) and (2) and three fixed scales (3)' (4) and (5). (See Fig. 3). Three cursors facilitate the setting for coincidence for the readings.

Scales (1) and (2) are identical; their division is that of a logarithmic scale from 1 to 1000. They provide from the same origin a length $k \log n$.

Scale (1) is the time scale; in this case n denotes for instance $n = t$ minutes.

Scale (2) is the height-distance scale, in which $h = \mu t$; or $h = t$, μ being equal to 1 for this purpose.

Scale (3) is the tangent scale, i.e. a logarithmic scale providing natural values of tangent from tan 0°.6 = (1) 047 to tan 84°.3 = (1000). This scale provides for the length $k \log \tan E°$.

Scale (4) is the sine scale, i.e. a logarithmic scale providing for the natural values of Sine from Sin 1° = (1) 745 to Sin 70° = (93) 9. It provides for a length, counting from the common origin, equal to $k \log \sin A°$.

Scale (5) is the complementary scale to the preceding, for cosine; it provides for the length $k \log \cos A°$.

PRACTICE.

The pilot balloon slide rule (Mark I) has a double slider, the two scales of which can be clamped in any position relative to each other. The double slider is used when a constant rate of ascent is assumed. The one (1) mark on the lower or time scale on the slider is set opposite to the rate of ascent in hundreds of feet per minute (usually 7) on the upper or height-distance scale on the slider. The two scales of the slider are then clamped together. (If the height of the balloon is measured at each instant the two scales of the slider should be clamped together so as to correspond exactly. The measured height of the balloon instead of the assumed height is then set opposite to the observed value of E, as described below).

On the bottom of the stock of the slide rule is marked a tangent scale for elevation (E). On the top of the stock are marked cosine and sine scales for azimuth (A).

To calculate the magnitudes of D_N and D_E corresponding with any particular minute, say the third,

(*a*) set the 3 of the lower scale of the slider opposite the observed value of E on the elevation scale.

(*b*) If the balloon is in the north-east quadrant, read off the distance on the upper scale of the slider opposite to the observed value of A on the cosine scale. This gives D_N. Similarly read off the distance opposite to the observed value of A on the sine scale. This gives D_E.

From the above description it is realised that on scale (2) quantities $k \log n$ may be read.

Operation (*a*) : pulling this scale on the righthand side alters the vector read from the common origin by a quantity $-k \log \tan E$, giving $k \log n - k \log \tan E$ from the said origin.

Again, Operation (*b*) alters the resultant vector by $+ k \log \cos A$ giving thus $k \log n - k \log \tan E + k \log \cos A$; i.e. $k \log h \cot E \cos A$, enabling the reading of D_N on scale (2).

(*c*) If the balloon is in the S.E., S.W., or N.W. quadrants, instead of A use $180^o - A$, $180^o + A$ or $360^o - A$ respectively, attaching to D_N and D_E their appropriate + or — signs as necessary.

Repeat these operations to obtain the values of DN and D_E (say D'_N and D'_E) at the fourth minute, setting the 4 on the lower scale of the slider opposite to the observed value of E at the fourth minute.

Denote by V'_N' V'_E the distances travelled north and east respectively by the balloon in the one-minute interval.

Then
$$V'_N = D._N - D_N$$
$$V'_E = D'_E - D_E$$

due regard being paid to sign.

$V'N$ and $V'E$ give the movement of the balloon relative to the ship in the one-minute interval. To obtain the true movement of the balloon in the interval, we must add to $V'N$ and $V'E$ the components of the ship's movement $(V_S)_N$ and $(V_S)_E$. These are readily obtained (in hundreds of feet per minute) if the ship's course and speed are known. The true movement of the balloon is then given by

$$V_N = V'_N + (V_S)_N$$
$$V_E = V'_E + (V_S)_E$$

If v = average speed of balloon in the minute interval under consideration we have

$$v = \sqrt{V^2_N + V^2_E}$$

If Θ = angle between track of balloon and the direction of the larger component (say V_N) we have :

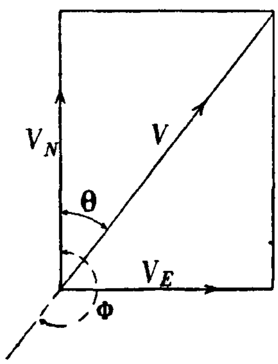


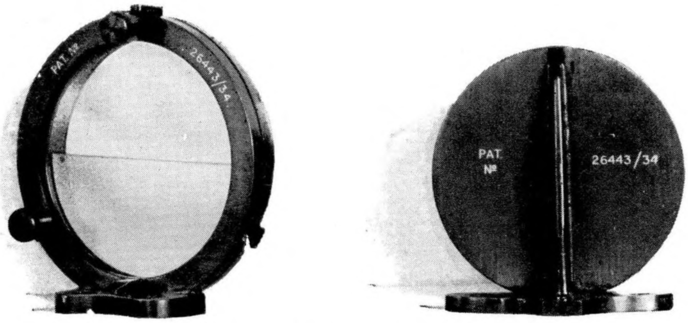
FIG. 4

$$\tan \Theta = \frac{V_E}{V_N}$$

Special tables are provided by means of which the values of v and Θ may be determined from any pair of calculated values of V_E and V_N. The *mean wind speed* in the layer of air traversed by the balloon is given by v. The wind direction, φ in this layer is determined from the value of Θ given by the tables. In Fig. 4, where V_N and V_E are both positive, the wind direction, (i.e. the direction from which the wind blows) can be seen to be given by

$$\varphi = 180 + \Theta$$

When either V_E or V_N are negative or both are negative there are different relationships between φ and Θ but in each case φ can be determined from Θ by a simple formula.



LE MIROIR ÉTANCHE DEMI-ARGENTÉ
THE HALF SILVERED WATERTIGHT MIRROR.