A tag label should be tied to the bottle, giving the name of the ship and the date; both of these should be given on every label. The depth, time, position and temperature should also be entered on the label, or they may be entered in the return and some identifying mark made on the label. The number of the thermometer should also be given in the return.

6. *General Notes :*

(*a*) *Caution.* If the bottle is lowered closed it will collapse under the pressure.

(*b*) The frame may be lengthened downwards by removing the lock nuts at the bottom, if provided (they are not shown in the diagram), and fixing on the metal extension pieces and sinker provided. This is often useful in a strong current.

(*c*) The working parts should be kept *lightly* oiled, but no oil or grease should be allowed to get on to the washers or the inside cylinders.

(*d*) When the bottle is not in use the springs in the guides should be thrown out of action.

(*e*) In case of need a "surface thermometer" may be used in the water bottle, but the results are not satisfactory and the thermometer may collapse.

(*f*) The bottle will not hold its temperature with certainty for more than six minutes and it should not be used if the time between the beginning of heaving in and reading the temperature is more than this.

(*g*) The water in the bottle and the material of which the bottle is made are decompressed and cooled by expansion as they are brought up. It is not possible to calculate the correction for the bottle accurately if the depth is great, and the bottle should therefore not be used at depths greater than 500 fathoms. At 500 fathoms and at high temperatures the correction is considerable, 0.2° in the Red Sea.

All corrections are applied at the Admiralty.

(*h*) In the absence of other instructions, observations should be made at the following standard depths: surface, 5, 10, 20, 30, 50, 75, 100, 150, 200, 300, 500, 750 and 1,000 metres.

(*j*) The bottle weighs about 26 lbs.

7. *Surface Observations.* Surface observations should be made as near in time to the 5 m. observation as circumstances allow.

If the state of the sea permits, the surface observations are made with the water bottle. Care should be taken that the bottle is completely under the surface when it is closed, so that it is full of water. The temperature observation is useless unless the bottle is full.

In rough weather a bucket may be used for the surface observation. It may be made of pulp, wood, metal or leather, but not of canvas. The evaporation and cooling from the surface of a canvas bucket are large, especially in a wind, so that the temperature observed is too low and the salinity too high.

To make a surface observation, rinse the bucket well over the side, draw it full of water, put one of the surface thermometers supplied into it and stir it about for a quarter of a minute and then read the temperature to the nearest tenth of a degree, *keeping the bulb still in the water.* If the bulb is removed from the water the observation is *quite useless.*

The same bucket of water may be used for bottling off a sample if the bucket is large and there has been no delay which may have allowed evaporation. Otherwise the bucket should be rinsed and filled again. The glass bottle should be rinsed twice before filling and a small air space should be left. Care should be taken that the stopper sits straight.

ON A NEW APPARATUS FOR TRANSFORMATION BY DRAWING.

by

PROF. Dr. A. BUCHHOLTZ.

(Extract from *Bildmessung und Luftbildwesen*, Liebenwerda, 1935, Heft 3, p. 141).

Within recent times various types of apparatus have been proposed for transformation by drawing — i.e. instruments for drawing maps from the optically produced projection of air photographs. In comparison with the optical photographic rectifying appliances in normal use, these transformers have certain disadvantages inherent in their nature against which however must be weighed certain advantages which should not be underestimated. It depends on circumstances whether the verdict should be given in favour of this one or that.

The essential disadvantage of transformers lies in their lesser quantitative output as compared with rectifying appliances. But they have the compensating merit that in many cases the use of a transformer makes it possible to avoid troublesome peculiarities of optical-photographic rectification (superfluous details in the plane of the air photograph) and certain not inconsiderable sources of error in this process (distortion of the photographic paper). Besides, the simpler construction and correspondingly lower price of the transformer are important advantages which are far from negligible.

We shall now describe the transformer constructed to the author's specification by the *Ottico Meccanica Italiana* of Rome, which, considering its proportionately simpler arrangement and moderate price, is capable of satisfying fairly high requirements of accuracy.

As is well known, in aero-photogrammetrical work by the rectification process large differences in the height of the ground are a source of very considerable error. If in the case of uneven ground, use of the rectification process is generally decided upon, yet this will only be done when one can be satified with a result of moderate accuracy. Under such conditions, naturally, the inaccuracies peculiar to the rectification process itself are of more or less secondary importance. And thus, less elbaorate, and consequently cheaper, rectifying instruments or transformers also become of interest.

It is quite another matter when one is concerned simultaneously with high requirements of precision and with ground where the differences of height are so small that in the application of the rectification process they do not enter into one's calculations as sources of error, or at least play no predominant part. Under these conditions the accuracy depends really on the precision with which are carried out both the optical transformation of the perspective of the original into the perspective of a vertical photograph, and the drawing of a map from the transformed image. Certainly, in the case of flat ground, the rectification process produces results capable of satisfying very high requirements of accuracy, but only, of course, if appliances are used which work impeccably from the point of view of perspective. In the circumstances which we have indicated here, one's choice must fall on a precise transformer, particularly when dealing with occasional work of small extent, observing that, in this case, the great quantitative output of a precise rectifying apparatus cannot be sufficiently exploited to provide an adequate return for the high purchase price.

The transformer now under consideration is so arranged that, on the principle of the camera lucida, the virtual image of the original negative, produced by a semi-transparent mirror, is projected on to a drawing plane.

The centre of projection is arranged in the "projection system", which contains, *inter alia*, the above-mentioned mirror and the original negative, in such a way that the projecting pencil of rays corresponds exactly to that engendered by the original view at the time of exposure. The projection system is so placed that the orientation of the projected pencil of rays, with respect to the drawing plane, corresponds to the tilt and swing of the original view. Under these conditions, the subjective optical projection of the reflected image is thus identical with the perspectively correct rectification of the prototype and the important details can be drawn in directly on the drawing plane. The scale of rectification is determined by the distance of the centre of projection from the drawing plane, and can consequently be adjusted by raising or lowering the projection system.

With respect to the scale of the subjective projection, the following should be noted: If it differs from the mean scale of the original, it will happen that the reflected image giving the direction for the projecting pencil of rays is formed outside the drawing plane. This results in certain difficulties of accommodation when drawing on the drawing plane. These may none the less be eliminated by inserting suitable lenses; these lenses must naturally be so arranged that they influence only the rays of light arriving at the observer's eye from the drawing plane or only those arriving from the original. As the ancillary lens must not therefore be between the eye and the mirror, an arrangement of this nature must be expected to have a certain unfavourable influence on the accuracy. Furthermore, it must not be forgotten that slight displacements of the eye-point with respect to its theoretically required position, which are hardly avoidable in practice, occasion corresponding errors of rectification, and that these errors, for a known erroneous position of the eye-point, become greater as the distance of the reflected image from the drawing plane increases.

The disadvantages in question can be overcome, or at least kept within manageable bounds, by adjusting the apparatus in such a way that the principal point of the reflected image always falls, at least approximately, in the drawing plane. This means of course that a free choice of the scale of projection must be renounced in that, with such an arrangement, the projection will be held to the mean scale of the original. In this case, however, there is a remedy, in that one can alter the scale of the reflected image projected on to the drawing plane by means of a suitably adjusted pantograph.

With regard to the fact that the adjustment is made as a rule by the control points, it seems further desirable that a change of tilt of the projection system should not displace the subjective projection of the principal point on the drawing plane. This is attended to by making the tilt of the projection system occur about an axis lying in the drawing plane and passing through the point of intersection of this plane with the axis of the projecting pencil of rays defined by the principal point of the reflected image.

The first model of transformer designed in accordance with the general principles expounded here was already constructed — rather roughly and of wood — some years ago, by the Geodetic Institute of the University of Latvia (*)

The projection system of this instrument consists of a chamber G (Fig. 1) comprising the following elements:

1. The plate-carrier B for holding the original negative N;
2. The electric lamp L;
3. The semi-transparent mirror S;
4. The small round aperture O' determining the centre of projection;
5. The compensating plate K.

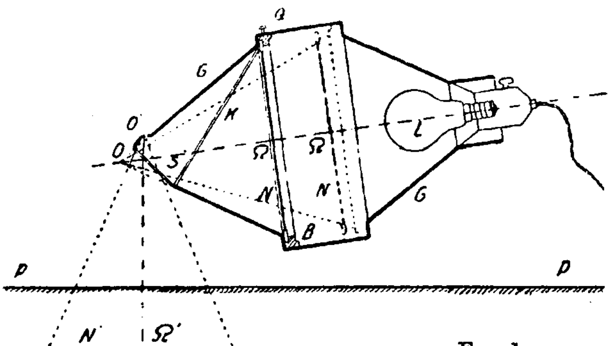

FIG. 1

By means of the milled head Q, the original negative N in its holder can be swung at will round its principal point Ω. The axis of the projection system perpendicular to the plane N is defined by the principal point Ω and the conjugated optical point O of the centre of projection O' with respect to the mirror S. The corresponding axis of the projecting pencil of rays passes through the centre of projection O' and the point Ω' which corresponds in the reflected image N' to the principal point Ω of the original negative. The distance $O'\Omega' = O\Omega$ may be made equal to the focal length of the camera lens by moving the plate-holder B in the chamber G in the direction of the axis $O\Omega$. The projecting pencil of rays defined by O' and N' is then identical with that engendered by the taking of the original photograph.

In default of a proper semi-transparent mirror we used for this purpose an unsilvered transparent coloured glass plate. By strongly illuminating the original negative, a glass plate of this nature produces a well observable reflected image. The secondary reflected image formed on the rear surface of the glass plate is eliminated by the colour-filtering effect of the plate.

The light rays coming from the drawing plane P to the centre of projection O' undergo certain parallel displacements while going through the plane-parallel plate. To avoid errors of rectification arising from this fact, it is necessary to make the pencil of

(*) *A. Buchholtz:* Entzerrung mit graphischer Kartierung aus dem Spiegelbild des Originalnegativs. *Oesterr. Z. Vermess.-Wes.* 1933, *No.* 6.

rays determined by the original negative N and the point O undergo corresponding parallel displacements. With this object, the compensating plate K has been inserted in the chamber between the plate-holder and the mirror. The orientation of this plate in the pencil of rays from the original negative corresponds to that of the mirror S in the projecting pencil of rays; its thickness corresponds to that of the mirror.

To allow for swing, the original negative in its holder must be so oriented by means of the milled head Q that the horizon trace be made parallel to the drawing plane.

Further, the projection system must be inclined relative to the drawing plane in proportion to the slope of the original picture. To this effect the chamber G (Fig. 2) is slung in the cradle R whose trunnions Z' run in arciform slots F' in the chassis T standing on the drawing plane. By moving the cradle R in the slots F', the projection system or projecting pencil of rays tilts about an imaginary axis which is parallel to the plane of the original and passes, in the drawing plane P, through the point of intersection of the latter with the axis of the projecting pencil of rays $O' \Omega'$.

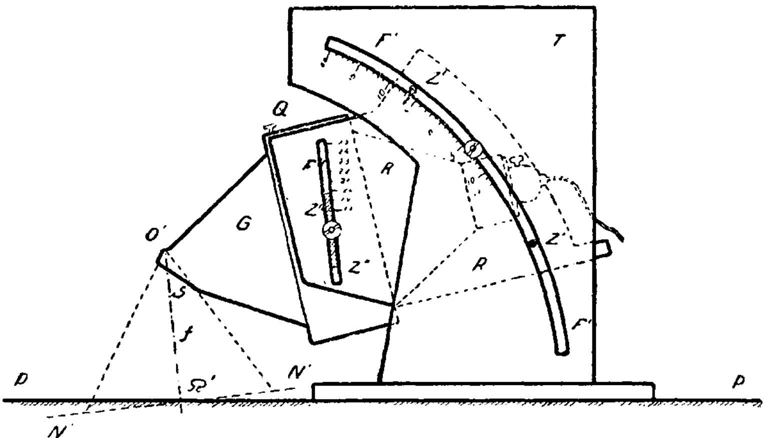

FIG. 2

The reflected image N' should fall with its principal point Ω' roughly in the drawing plane P; in other words, the subjective projection of the reflected image on the drawing plane should be roughly on the mean scale of the original negative. This adjustment to scale is performed by moving the chamber G through the cradle R in the direction of the axis of the projecting pencil of rays. With this object the cradle R has been provided with slots F'' in which the trunnions Z'' of the chamber G slide. By means of this arrangement, the distance, measured along the axis of projection, between the centre of projection and the drawing plane can be adjusted in such a way as to be equal to $O\,\Omega = f$, where f denotes the focal length of the camera lens. Then Ω' falls in the drawing plane and remains fixed in position during tilting of the projection system. Also the scale of the subjective projection at its principal point is not influenced by tilting the projection system.

Along the slot F' is a scale on which the slope of the original can be read directly. There is a second scale along the slot F''. On it is read the distance of the centre of projection O' from the drawing plane P, measured in the sense of the axis of projection $O' \Omega'$.

The capabilities of this model are defined by the following data:

Size of the original negative: up to 18×13 cms.
Focal length of the camera lens: 18 to 25 cms.
Slope: up to 20°.

Figure 3 is a view of the first model.

The second model, made of metal by the *Ottico Meccanica Italiana* (Figs. 4 & 5) is not very different from the first model in its general lay-out, but is greatly improved in its optical and mechanical details.

The coloured glass plate of the first model is replaced by a small right-angled triangular prism, the hypotenuse side of which is provided with semi-transparent silvering. This prism is so mounted in the projection system that the geometric centre of the semi-

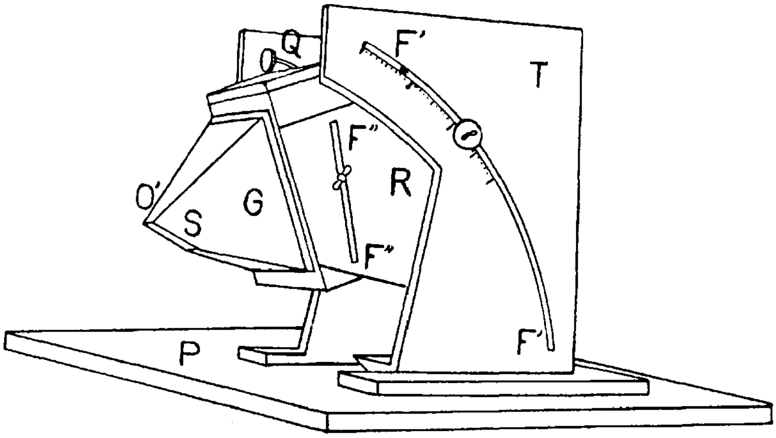

FIG. 3

transparent mirror falls at the centre of projection of the original negative and determines at the same time the vertex of the pencil of rays of the subjective projection. Under this prism is a second one, identical except that it is unsilvered, attached directly on hypotenuse side to the semi-transparent reflecting face of the first prism. This second prism fulfils the same functions as the compensating plate of the first model, which, in consequence, is no longer required.

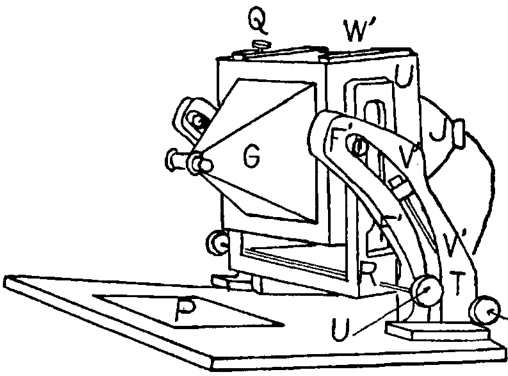

FIG. 4

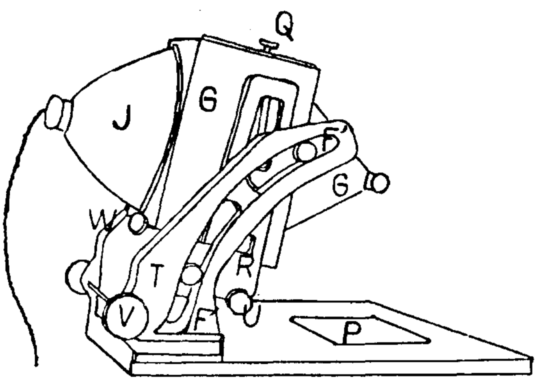

FIG. 5

In its initial form, in which the second model was to be seen at the Exhibition of Photogrammetry in Paris, there was a small observing periscope above the prisms in question, with magnification × 1 and a field of view of about 40°. This periscope was eliminated afterwards, as it appeared more practical to observe directly with the naked eye. Instead of the periscope, a cover was fitted above the prisms with a round peep-hole, carrying a plane-parallel glass, through which observations are made with the naked eye. Since, as we have already said, the reflected image and the drawing plane are roughly at the same distance from the mirror, i.e. from the eye of the observer, and since this distance, for its part, in conformity with the focal length of the camera lens, is set between 18 and 25 cms., an eye with normal sight needs no special optical assistance for observing. Short- or long-sighted observers would find it advisable, instead of using ordinary spectacles which may hinder observation, to replace the plane-parallel glass in the peep-hole by a suitable eyeglass lens.

The lighting arrangements have been substantially improved through the rear portion of the projection system having been fashioned in the form of a parabolic reflector *J* at the focus of which has been placed a small (12 volt) electric lamp serving as source of light.

With regard to the mechanical part, suitable screws or simple mechanisms have been provided for applying the necessary movements for the adjustment of the instrument.

As in the first model, the plate-holder is fitted with a toothed edge, in which the driving screw *Q* engages, for swinging the original negative. This screw may be disengaged from the rack by pressing it sideways, enabling larger swings to be applied more quickly by hand.

The distance of the original negative from the centre of projection, in correlation with the focal length of the camera lens, is adjusted by moving the plate-holder in the chamber *G* by means of the screw *W* (Fig. 5). The resulting setting of the plate-holder can be read on the corresponding scale *W'* (Fig. 4).

As has already been stated, the distance of the centre of projection from the drawing plane, reckoned along the axis of projection, must be about equal to the focal length of the camera lens, so that the principal point of the reflected image may fall in the neighbourhood of the drawing plane. The movement of the projection system *G* in the cradle *R*, necessary for this purpose, is applied through the screw *U*, and the distance of the centre of projection from the projection of the principal point of the reflected image on the drawing plane *P* is read on the scale *U'*.

The setting of the slope, i.e. the corresponding tilt of the cradle *R* or of the projection system *G* carried by it, is performed with the aid of a special mechanism actuated by the screw *V*. The slope set can be read on the scale *V'*.

The chassis *T* bearing the curved slot *F'* for the tilting of the projection system is screwed directly on to a drawing table, of which the surface *P* then plays the part of the plane of projection or drawing plane; this facilitates the adjustment of the map by means of a pantograph which is sometimes necessary.

On the subject of adjusting the apparatus by the control points, and of mapping from the subjective optical projection, the following should be noted:

The plan of the control points is prepared on a more or less rounded off mean scale of the prototype determined beforehand. Then the distance of the original negative in the plate-holder, from the centre of projection, is regulated by means of the screw — to correspond with the focal length of the camera lens. If necessary, the plane-parallel sheet of glass in the peep-hole will also be replaced by a lens suited to the observer's eye-sight.

After the plan of the control points has been registered on the drawing plane and the lighting of the original negative and of the drawing plane regulated, the adjustment proper can be begun. This is done in the usual way, i.e. by sliding the plan of the control points over the drawing plane and adjusting the scale of the subjective projection as well as the tilt and swing of the reflected image, by means of the corresponding screws *U*, *V* and *Q*, until the required coincidence between the projection and the plan of the control points is obtained.

The graphic mapping from the optical projection is done either directly or by means of a pantograph, according to whether the scale of the projection corresponds roughly with, or differs considerably from, the mean scale of the original.

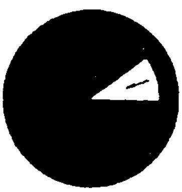

FIG. 6

In the practical trials carried out with the instrument, it was observed that a bright drawing plane as background for the optical projection is a disadvantage in this sense that it makes a glare to some extent over the reflected image, with the result that the latter stands out less well. In this connection more favourable conditions for observation are obtained by using a black sheet with a white wedge-shaped mark (Fig. 6) free to move about the drawing plane, so that the point of the drawing pencil can pass through a small hole at the apex of the mark. Nevertheless such an arrangement can only be considered a makeshift. We intend, therefore, to add to the instrument, for mapping purposes, a small black screen, with a white wedge-shaped mark lighted from below by a small electric lamp, under the apex of which will be a pin extending down to the drawing plane. When mapping by means of a pantograph, a similar screen with a mark can be mounted directly on the guiding point of the latter. As the mapping mark in question does not fall in the drawing plane proper, i.e. on the plan of control points used in the adjustment, one is obliged, after the resulting adjustment, to raise the whole instrument perpendicularly to the drawing plane by the amount of the distance of the mark from this plane. This operation is performed by means of an appropriate accessory, all the more easily in that it consists of a displacement parallel to the instrument by a constant quantity independent of the orientation of the original.

For the rest, the instrument in its present form has been proved to answer the purposes for which it was designed, so that further important modifications do not appear necessary.

Its scope of use corresponds to that of the first model, with the exception of the adjustment for slope which is limited to 15° for constructional reasons.

Let us recall once more that observation with the naked eye presents no special difficulties. The field of view embraces, for a given position of the eye, about half of the entire image. But as a trifling displacement of the eye suffices to bring the other parts of the plane of the image also into the field of vision, the observer has a sufficiently extended view over the whole of the image, which is of importance when adjusting by the control points.

As we are concerned here with a transformer intended to execute precise rectification work, the tests of accuracy undertaken with it, and their results, are worth stating.

To exclude as far as possible external sources of error independent of the transformer itself, when determining the position of given points in the original, three special control pictures were taken, with a good camera, of a perfectly plane "artificial ground", with slopes of 3°, 8° and 13°. The "artificial ground" consisted of a sheet of drawing paper stretched on a drawing board, and bearing 55 very clearly marked points, the co-ordinates of which were measured with the greatest care. The photographs 18 × 13 cms. in size, and with a principal distance of 21.6 cms., were so arranged that the points, very regularly distributed over the whole plane of the image, extended almost to its edges.

On each of these pictures, all the 55 points were plotted with the transformer under test, on the rounded-off scale of the original (1:6), four points being used each time as control points. On the plans of position thus obtained, the co-ordinates of all the 55 points were repeatedly measured with accuracy; these co-ordinates were transformed by FELDER's method, so that, using the principle of the method of least squares, the control points came into the most favourable concordance with the corresponding co-ordinates determined on the "ground". From the differences remaining after this, between the transformed x and y co-ordinates measured on the plan and the corresponding co-ordinates determined on the "ground", the mean errors of co-ordinates, m_x and m_y, were calculated for each control picture and the corresponding error of position, m_p, of a point was plotted with the instrument.

It should be noted on this subject that in addition to the 55 points already quoted, four marks determining the axes of the selected system of co-ordinates had also been drawn on the "artificial ground", these being reproduced in all the control pictures. When measuring the co-ordinates on the plans of position obtained with the transformer, the co-ordinates were likewise plotted on the axis system determined by the selected marks. Consequently, as corresponding systems of co-ordinates were utilised on the plan and on the "ground", the co-ordinates measured on the plan and on the "ground" should theoretically be in agreement, even without first transforming the former. Thus, one should theoretically find, for the transformation elements A and B (*), the values 1 and 0. With regard to this, in order to provide fuller characteristics of the results with regard to precision, we show below, for each control picture, the elements of transformation A and B in addition to the mean errors m_x, m_y and m_p.

For control picture No. 1 (slope 3°) : $A = 1.00202$, $B = 0.00159$,
$m_x = \pm 0.13$ mm., $m_y = \pm 0.12$ mm., $m_p = \pm 0.18$ mm.

For control picture No. 2 (slope 8°) : $A = 1.00011$, $B = 0.00112$,
$m_x = \pm 0.14$ mm., $m_y = \pm 0.11$ mm., $m_p = \pm 0.18$ mm.

For control picture No. 3 (slope 13°) : $A = 1.00353$, $B = 0.00003$,
$m_x = \pm 0.14$ mm., $m_y = \pm 0.12$ mm., $m_p = \pm 0.18$ mm.

Let us once again recall that for each control picture the plotting of all the 55 points and of the four axis marks was done in a single operation, and that in making the

(*) *A. Buchholtz*, Uber einige Probleme der Radialtriangulation. *Acta Universitatis Latviensis, Serie d. Ingenieur-Fakultät I/6, Riga* 1932.

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.

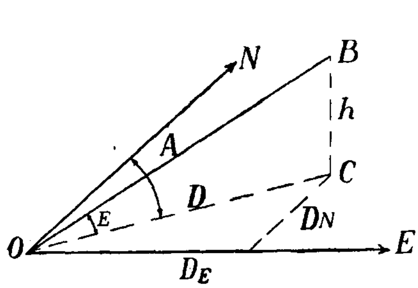

FIG. 1

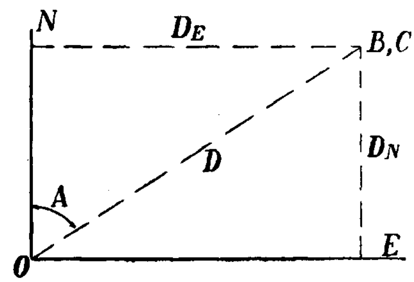

FIG. 2

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.

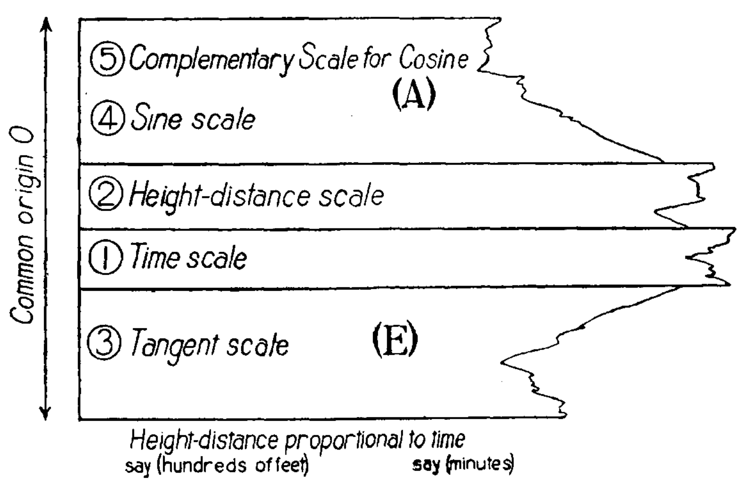

FIG. 3