THE DUOSCOPE*

H. E. Seely
Dominion Forest Service, Lands, Parks and Forests Branch
Department of Mines and Resources

FIGURE NO. 1 shows the latest model of the duoscope, an instrument developed by the Dominion Forest Service, Lands, Parks and Forests Branch, Department of Mines and Resources, Ottawa, for the transfer of details from air photograph direct to map. It will be noted that the lines of sight of the eyes are directed separately so that one eye sees the map while the other eye views the photograph. When plotting is done in these circumstances the reduction or enlargement of scale is in the ratio of the relative lengths of the lines of sight of the eyes. The desired ratio may be secured by moving the large single mirrors along the bars, fine adjustment being secured by rack and pinion. (See Figure No. 2.)

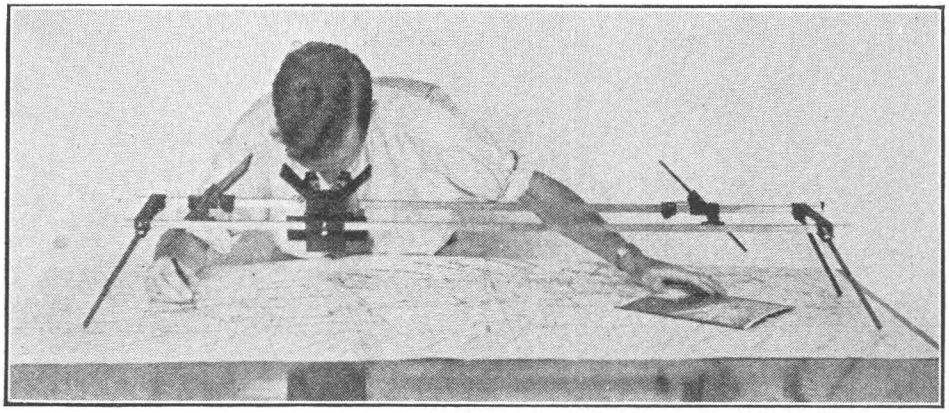

FIG. 1.

The first models were equipped only with simple lenses and required several days of eye-training. Errors up to one-twentieth of an inch continued to occur. Some difficulty was experienced where control features, such as streams and roads, were not plentiful. These disadvantages have been overcome by means of a binocular attachment as shown in Figure No. 2. The eyesight is aided and controlled by fusion markings in the form of reticles placed in the focal planes of the eyepieces. Incidentally, an operator whose weak or defective eyesight handicaps him when using simple lenses, may sometimes secure acceptable results with the binocular attachment. On the other hand, in cases where a high standard of accuracy is not required, an experienced operator may prefer to use the simple lenses because they permit greater flexibility and freedom of plotting.

The duoscope is based on scientific principles, and the accuracy of results is governed by the amount of care taken in its adjustments and the degree of refinement of the optical appliances used in its construction. It is of course necessary for the operator to familiarize himself with the functioning of the in-

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strument. As with a stereoscope, good binocular vision is required. Nearsightedness or farsightedness is not a disadvantage since the eyepieces may be adjusted to compensate therefor and the operator may then dispense with spectacles.

The duoscope shown will accommodate reductions to one-third of the scale and enlargements to twice the scale of the photograph. A much greater range could be secured by the addition of certain simple accessories, such as an eyepiece of higher magnification in the right-hand telescope. Provision is made for altering the angle of the large mirrors in order to overcome variations of scale in the air photograph resulting from tilt of the camera axis or from differences of elevation in the surface of the ground. In the construction of the instrument, no difficulty was encountered in securing adequate fields of view of both photograph and map. In this connection it may be mentioned that the telescopes are of approximately unity magnification. The reticle lines are so fine as to offer no material obstacle to clear vision.

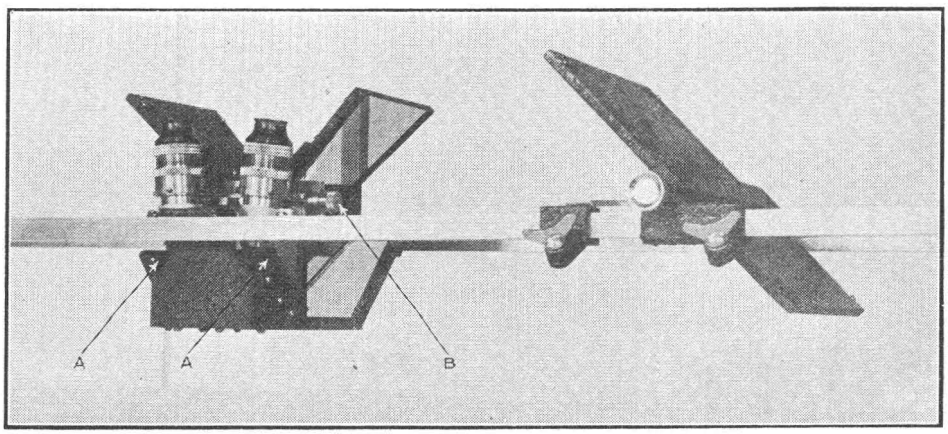

FIG. 2.

The duoscope is readily portable, as it may be demounted and all its parts, except the long bars, fitted into a case. (Figure No. 3.) The total weight, inclusive of case and bars, is twenty-five pounds. First surface "chroluminum" mirrors are used to avoid double reflection.

Three of the adjustments of the duoscope are of a fixed character and require no alteration in ordinary circumstances. One of them establishes the line of collimation of the telescopes, one sets the inclination of the telescopes, which is 5 degrees inward; and the third fixes the angle of the small mirrors situated just underneath the telescopes (See "A", Figure No. 2). However, there is a fourth adjustment, which must be used whenever there is a change of operators, and is necessitated by variations in individual vision. This adjustment, which involves the testing of the telescopes as a pair, is made as follows:

First adjust the telescopes individually, bringing the reticle into sharp focus and eliminating parallax. Select two sheets of paper on which are lines of fine print and place them under the instrument so that one line of print is seen by the left eye while the other line appears to the right eye to be just above the left-hand line of print. Adjust the interocular distance very carefully by means of the milled head (See "B", Figure No. 2), and look into the binoculars, using both eyes in the normal way. It is probable that a lack of adjustment will be evident in spite of the fact that the telescopes have already been adjusted

individually. While sighting with both eyes, adjust one of the eyepieces until both of the reticles and both of the lines of print are seen distinctly. Rotate the telescopes until the reticle lines are at 90 degrees to the eye-base, in which orientation they will be sensitive to any lack of sympathy between the accommodation and convergence of the eyes. If the reticles now appear overlapping or separated, turn both the eyepieces as nearly an equal amount as possible until easy fusion is secured. If for any reason fusion is not readily obtainable, make a slight alteration symmetrically in the angles of inclination of the telescopes, adjusting the bearings that are situated where the telescopes are attached to the rest of the instrument. Finally orient the reticles at about 45 de-

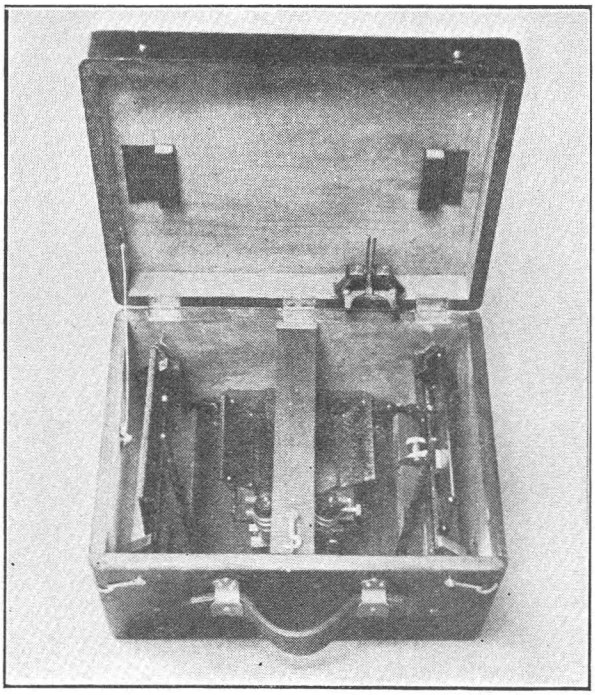

FIG. 3.

grees from the eye-base, in which orientation they will hold their fusion most tenaciously.

The above adjustment complies with the necessity for maintaining sympathy between the convergence and the accommodation of the eyes.

Readers who have had experience with binocular instruments may be able to explain the following unexpected development relating to the optics of this instrument. While, in theory, the telescopes could have been set vertically, in practice the operator could not hold the reticles in proper fusion unless the telescopes were inclined inward, even though the eyepieces were adjusted to infinite focus. The situation is different in a stereoscopic pair of photographs, where the fused photographic detail serves to control the convergence of the eyes. A point that was borne out, during the course of the tests, was that the reticles, consisting of a network of squares, are in the best orientation for testing purposes when they are at 90 degrees from the eye-base, but for the desired tenacity of fusion when the instrument is in use, 45 degrees is the optimum.

When an opportunity arises, the application of the new model to low (steep) oblique photographs will be tested. A device has been added to the right-hand mirror which allows it to be rotated sufficiently to provide visual rectification of a low oblique. It is possible, however, that to a considerable extent point-by-point plotting will be necessary, requiring the use of a single small fusion mark rather than a whole grid. Incidentally, it may be stated that magnification greater than unity would introduce a theoretical error in the plotting of obliques, though not in verticals.

The duoscope may be said to resemble the stereoscope but is actually more comprehensive, and the use of the stereoscope may be considered as a special application of the duoscope. At a certain setting the duoscope will serve as a stereoscope.

Among possibilities that have suggested themselves are the use of the duoscope for stereoscopic contouring or for the transfer of photo control points. Also it has been found that, when suitably modified, the duoscope may be used in the field to make sketches of the landscape, in perfectly true perspective.

The telescopes contain merely the essential eyepiece and object-glass, with no prisms or extra lens. Since only stock lenses were used, no great expense was incurred. An erect and non-reversed image is secured by the aid of the central mirror assembly (Figure No. 2). In passing through this assembly the line of sight is reflected three times, eventually being directed laterally towards the large single mirrors.

It has been found that there is an optimum degree of illumination of the photograph as compared with that of the map. An iris diaphragm inserted in one of the telescopes might be used to advantage for balancing the illumination.

Through the kindness of the Dominion Astronomer, the telescopes and their carriage were constructed in the machine shop of the Dominion Observatory, Surveys and Engineering Branch, Department of Mines and Resources. The remainder of the instrument was built by a local firm.

Summarizing, the duoscope has the following advantages:—

1. Allows the photograph to appear superposed and properly adjusted on the map, permitting direct transfer and preventing errors by making possible a simultaneous and natural observation of the photograph and the actual map sheet. The consequent simplicity of operation results in a great acceleration in the rate of plotting.
2. Provides unimpaired images of both photograph and map, due to the full strength of the view obtained by each eye.
3. Permits ease of manipulation of the photographs and remains mobile after being set up for use.
4. Is particularly applicable to tilted photographs because of its greater depth of focus.
5. Will serve as a stereoscope.
6. Is light, compact, portable and does not require special artificial lighting. It is therefore adapted to use in the field, or in places where electric current is not available.
7. Sells at a comparatively low price.