poor tracking and out-of-contact. As a result, the aerial photographer, whether engaged in reconnaissance or in map making, can now make his compromise between quality and economy at a much higher level of each. The immediate boon to "flying contractors" in making index prints, and to the military for routine reconnaissance and negative duplication for mass dissemination, are both obvious applications. A less obvious, and less immediate boon to the photogrammetrist will be the eventual high-speed production of positive transparencies on a stable base film—suitable for use in yet-to-be designed plotting devices—saving the glass for lenses.

References

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Wide-Angle Convergent Photography with Angles of Convergence of 27 Degrees (30^g) or 40 Degrees (44.5^g)

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In order to further increase the economy of the photogrammetric procedure as applied to small-scale maps, the method of normal-angle *convergent photography* used in Europe was adapted in the United States to *wide-angle cameras.* With the purpose of obtaining a large base-ratio required for an increase in the stereoscopic setting accuracy, an *angle of convergence* of 40° (44.5^g) was selected for a camera unit composed of two Metrogon Cameras. An investigation of other angles of convergence revealed the surprising fact that in practically all cases more favorable conditions will be encountered, if a smaller angle of convergence is selected, such as for instance 30^g as has proved appropriate for normal-angle convergent photography. Let us therefore compare a few data on these two types of photography:

1. Photography with an Angle of Convergence of 44.5^g Corresponding to Figure 1b

a) In the case of 44.5^g-convergent photography the exposure interval is so selected that one stereoscopic pair of photographs taken from two different air stations will have an overlap area of exactly 100% (see Figure 1b). This will make the *base ratio* $b:h$ extremely large, viz. 1.24. A large number of measurements* has revealed that the vertical setting accuracy does not increase lineally with the base ratio; this means that only a slight increase in setting accuracy will be found beyond a ratio of $b:h=1.0$ (Figure 3). Under extreme base ratios, however, and especially in mountainous terrain *physiological* difficulties may be encountered in the stereoscopic setting; these are based on the fact that the object is observed from two sides or under largely differing angles-of-view which, in the case of mountainous terrain, may even be parallel to the inclination of the terrain.

b) The angles ν under which picture detail

* See: *Bildmessung und Luftbildwesen, 1956.* W. A. Brucklacher: "A Consideration of the Use of the 2×RMK 21/18 Convergent Camera of Zeiss-Aerotopograph."

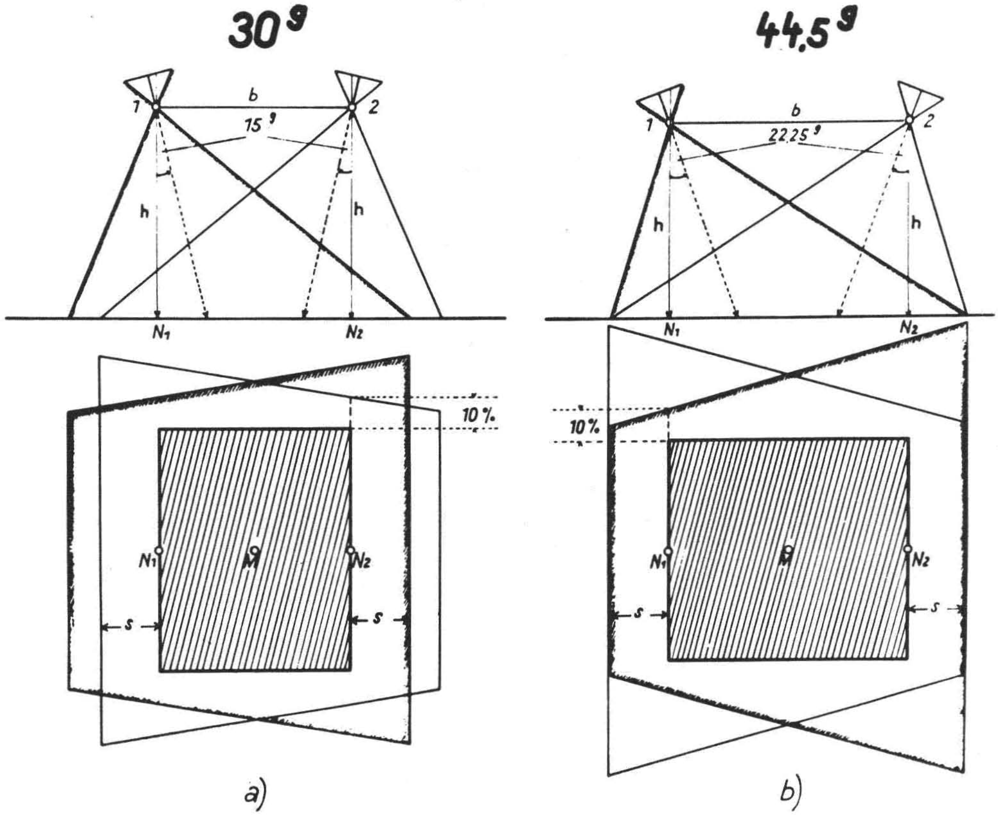

FIG. 1

is seen in the corners of the useful model area, are very small, viz. 40.5g. As a consequence, considerable *dead spaces* are encountered.

c) The *angles* γ under which *homologous rays* intersect, vary considerably within the useful model, viz. up to 18g. This impairs the homogeneity of observation and also of measurement within the model area.

d) On account of the extremely large *angles* of *convergence* of the bundle of taking rays, the plotting range of some plotters is restricted as regards the *choice* of *the plotting scale* and the *range* of *elevation*. Consequently, it is at least very difficult to use such photography on a universal basis.

2. PHOTOGRAPHY WITH ANGLES OF CONVERGENCE OF 30g CORRESPONDING TO FIGURE 2A

a) In 30g convergent photography a 100% overlap in stereoscopic picture pairs taken from two different air stations has now been abandoned. The exposure interval was so selected that the safety margin "*s*" is as large as in 44.5g convergent photography (see Figures 1a and 1b). The resulting *base-ratio* will then be

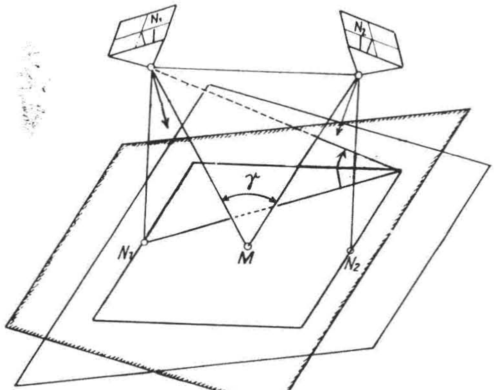

FIG. 2

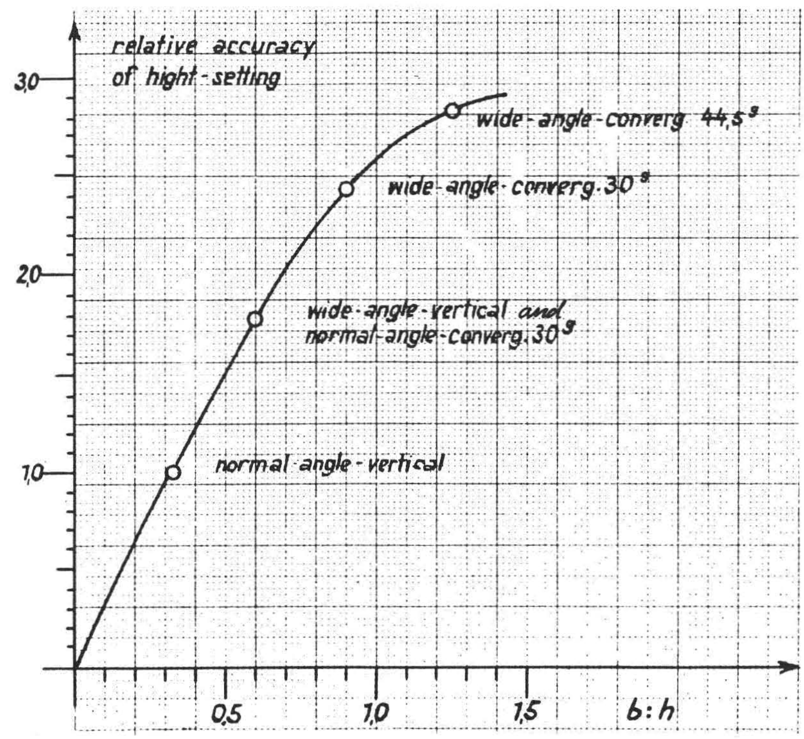

FIG. 3

$b:h=0.94$.[1] This value lies between the base-ratio of standard vertical wide-angle photography and the extreme base-ratio of 44.5^g convergent photography. Consequently, the physiological conditions are greatly improved.

b) The model is observed under considerably *steeper angles of view*. In the corners of the photo, the angle ν is still 47^g! As a result, the terrain is viewed under much more favorable conditions and the dead spaces are about 30% smaller than in 44.5^g convergent photography.

c) The angles γ of homologous rays vary in the model only by 30^g. Consequently, the physiological conditions and the homogeneity in plotting are improved.

d) The fact that the angle of convergence is by 14.5^g smaller than in 44.5^g convergent photography makes it possible to use the *setting ranges* of the existing types of plotting instruments more extensively.

e) At the same photo-scale in the center of the model, the new *stereoscopic surface* is about 10% smaller in 30^g convergent photography than in 44.5^g convergent photography. However, the *strips are approximately* 10% *wider*, so that the number of flight strips will be reduced in the case of 30^g convergent photography. As a result, 30^g convergent photography *is not in any way less economic* than $44\ 5^g$ convergent photography. (See Table 1)

Summarizing, it may be said that 30^g convergent photography has a number of *considerable advantages* over 44.5^g convergent photography without any loss in economy. In the interest of an extensive use of this procedure, it therefore seems indicated to adapt *wide-angle convergent photography* to an *angle of convergence of* 30^g. A conversion from 44.5^g to an angle of convergence of 30^g should not present any difficulty for the Balplex Plotter used in the United States for the plotting of convergent photography. In all other types of plotting instruments, however, a far better utilization of plotting ranges would be the result.

[1] Such photographs can be obtained in the simplest way by using the IRU universal intervalometer made by ZEISS-AEROTOPOGRAPH. With this instrument the scale at the control button for the overlap ratio can also be supplied with "base-ratio $b:h$" division instead of "% overlap." In our particular case, the required value of 0.94 can then be directly set, so that the correct cycling speed can be automatically guaranteed.

TABLE 1

LIST OF DATA FOR 30^g AND 44.5^g CONVERGENT PHOTOGRAPHY BASED UPON A PHOTO-SCALE IN THE MODEL CENTER OF 1:50,000

	30^g Convergent Photography	*44.5^g Convergent Photography*
Picture size *Focal-length*	9″×9″ (23×23 cm.) 6″ (15 cm.)	9″×9″ (23×23 cm.) 6″ (15 cm.)
Flying Height h *Base b* *Base-ratio b:h*	23,200 ft. (7,100 m.) 4.16 miles (6.7 km.) 0.94	21,800 ft. (6,650 m.) 5.1 miles (8.2 km.) 1.24
Width of Flight Strip	5.15 miles (8.7 km.)	4.65 miles (7.5 km.)
Useful Model Area	21.2 miles² (55 km.²)	23.6 miles² (61 km.²)
Angle of View ν in Model Corner	47^g	40.3^g
Dead Spaces in Model Corner	$1.09 \cdot \Delta h$	$1.35 \cdot \Delta h$
Maximum Angle γ of Homologous Rays	56^g	70^g
Variation of γ over Entire Model	13^g	18^g

*Universal Photogrammetric Electronic Rectifier**

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ABSTRACT: *An electronic line scanning machine is described which will line scan an oblique aerial photograph and produce a rectified print automatically. The machine incorporates optical-mechanical scanning and reproduces by means of an ultrasonic light modulator. The rectifier will handle camera formats up to 9″×18″, focal lengths from 3″ to 100″ and tilt angles up to 80 degrees. Scanning is done at 500 lines per minute.*

The basic theory of line scanning for aerial image rectification is discussed and the development of the equations for the computer required for the machine is given.

FOR many years various progressive individuals involved in the rectification of oblique aerial photographs have considered an electronic line scanning technique for the rectification of such photographs. In this technique each elemental area in the oblique photograph would be scanned point by point as a series of lines and each line would be reproduced with dimensions distorted according to the mathematical relationship

* Acting for the authors, this paper was read at the Society's 24th Annual Meeting by Mr. John Freda of the Rome Air Development Center.