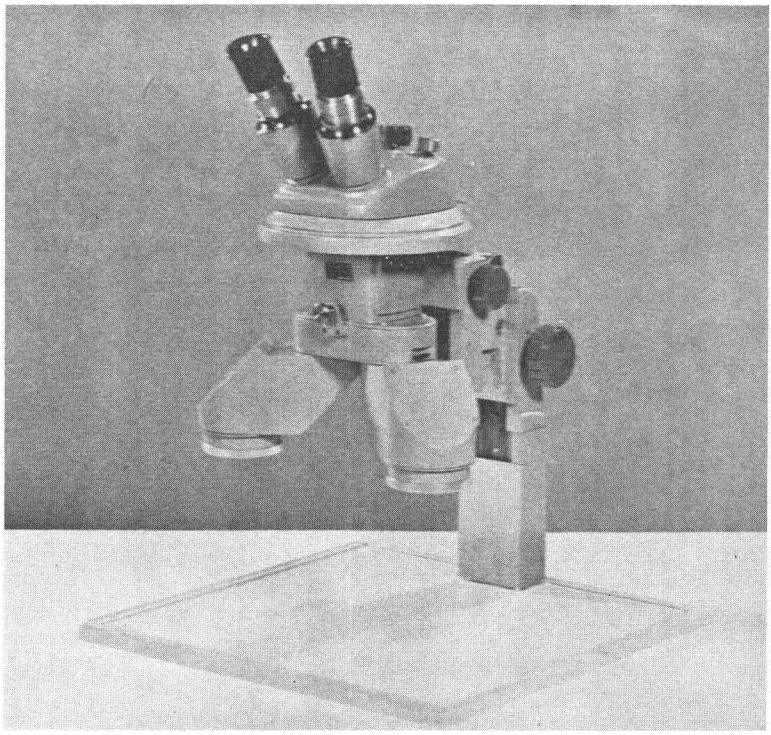

FRONTISPIECE. Zoom 95 Stereoscope (See text, page 825).

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Three new versatile stereoscopes for viewing aerial photographs have recently been developed by Bausch & Lomb

Stereoscopes with High Performance

INTRODUCTION

THE AVAILABILITY of instrumentation for the stereoscopic analysis of aerial photographs has been characterized by the existence of notable gaps. In particular, instruments have been needed with high optical performance and continuous magnification change. Bausch & Lomb recently developed three such instruments known as the Zoom 95 Stereoscope, the High Power Stereoviewer, and the Versatile Stereoscope. The approach was to incorporate microscope zoom systems into the design of the stereoscopes.

A paper by J. R. Benford entitled, "Recent

* Presented at the Annual Convention of the American Society of Photogrammetry, Washington, D. C., March 1965.

Microscope Developments at Bausch & Lomb" (*Applied Optics*, Vol. 3, No. 9, September 1964) describes the zoom systems of the StereoZoom Microscope and the Dynazoom Laboratory Microscope. This paper in particular describes the motion of the cams that control the lens motion.

Zoom 95 Stereoscope

The Zoom 95 Stereoscope was developed as an instrument needed for viewing 9×9 inch photographs in stereo over a wide range of magnifications and conjugate image separations. The Zoom 95 Stereoscope is based on the design of the Zoom 70 Stereoscope which in turn utilizes the design of the StereoZoom Microscope. The Zoom 70 was designed for viewing in stereo photography in 70 mm. film and some 35 mm. and 5-inch film. The rhomboid arms have a separation range from 30 mm. to 105 mm. and the magnification range is from 7× to 60× with an interchange of 10× and 20× eyepieces. An instrument capable of viewing 9×9 inch photographs with up to 80 per cent overlap and a one-half inch margin between frames must have a maximum rhomboid separation of at least $7\frac{3}{4}$ inches. Larger rhomboids required a longer optical path. This was achieved by replacing the lower lens of the Zoom system with one having a longer focal length. The resulting overall magnification and resolution are lower but this is compatible with the application to most 9×9-inch photography which in general has lower resolution than 70 mm. photography. The angular field of view presented to the eye remains the same as in the Zoom 70. Therefore, the real field of view on the photograph is proportionally larger with the lower magnification. Figure 1a shows the optical system of the Zoom 70 and Figure 1b shows the optical system of the Zoom 95. The Zoom 95 uses a mirror-type rhomboid arm rather than the rhomboid prism as used in the Zoom 70.

A newer development with the Zoom 95 is optical image rotation. This has been achieved by replacing the mirror-type erecting system in the eyepieces with an Amici-Dove-Pechan prism combination. The optical arrangement is shown in Figure 2.

The Pechan prism was chosen because it will function in convergent light without the introduction of astigmatism into the system. The original Porro system had four reflections, and it is necessary to maintain an even number of reflections. Since the Pechan has five and the Dove one, the other prism must have two reflections; therefore, a roof prism

Abstract: *Three instruments have recently been developed by Bausch & Lomb to fill some gaps in existing instrumentation for the stereoscopic viewing of aerial photographs. These are: the Zoom 95 Stereoscope, the High Power Stereoviewer and the Versatile Stereoscope. The Zoom 95 Stereoscope is a descendant of the Zoom 70 Stereoscope, and is suitable for viewing normal overlap 9×9-inch photography. The High Power Stereoviewer consists of two Dynazoom Laboratory Microscopes coupled with an optical relay system for stereo viewing. It allows the use of the high resolution capabilities of laboratory microscope objectives. The Versatile Stereoscope incorporates the zoom system of the Zoom 70 Stereoscope, the image rotation system of the Zoom 95 and three interchangeable rhomboid arms containing optical relay lens systems. This allows the instrument to be used over a wide magnification range with 70 mm., 5-inch and $9\frac{1}{2}$-inch film.*

Walter R. Ambrose

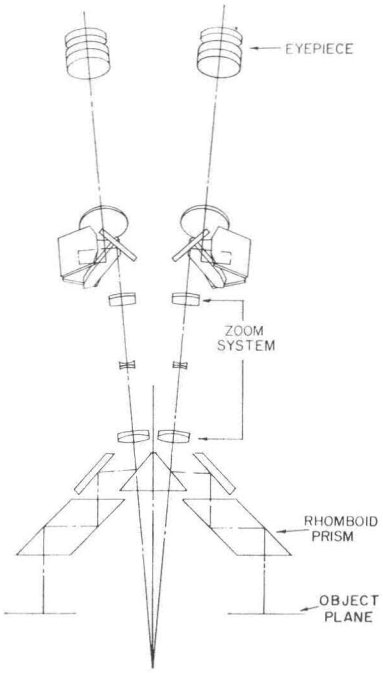

FIG. 1a. Zoom 70 Optical System.

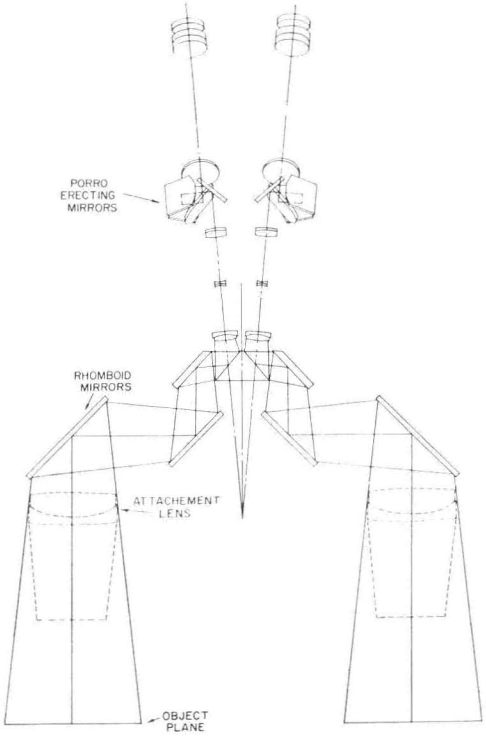

FIG. 1b. Zoom 95 Optical System.

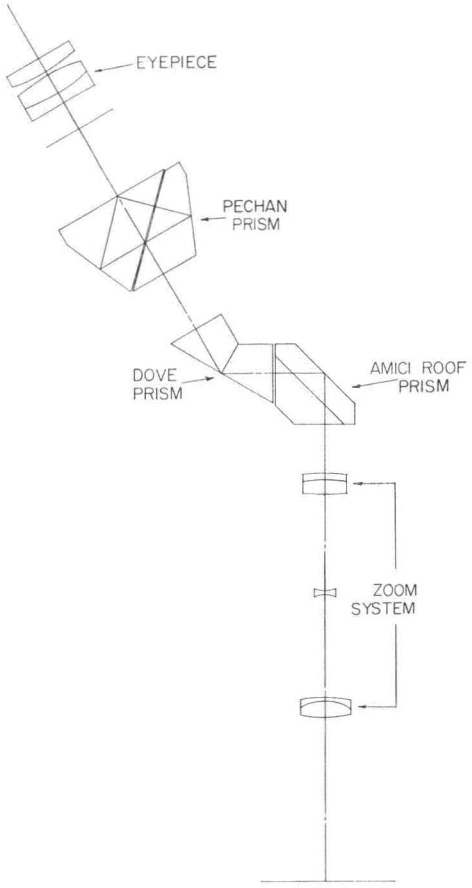

FIG. 2. Image Rotation Optical System.

was chosen rather than a simple right angle prism. Prisms are used rather than mirrors because the optical path through glass is greater than the equivalent air path. The Pechan prism, with its five reflections, requires a considerable amount of optical path and just enough was "squeezed" out of the other prisms by being glass rather than air. The image rotation feature is of sufficient complexity that it must be part of the instrument when originally manufactured. The same optical image rotation feature is now available in the Zoom 70.

The latest addition to the Zoom 95 is a 2× attachment lens. This lens may be readily attached and detached, thus extending the magnification range to 2.5× through 40× with an interchange of eyepieces. The working distance is decreased by attaching the lens, therefore, refocusing is necessary.

The attachment lens almost doubles the resolution of the system because it increased the numerical aperture (N.A.) of the objec-

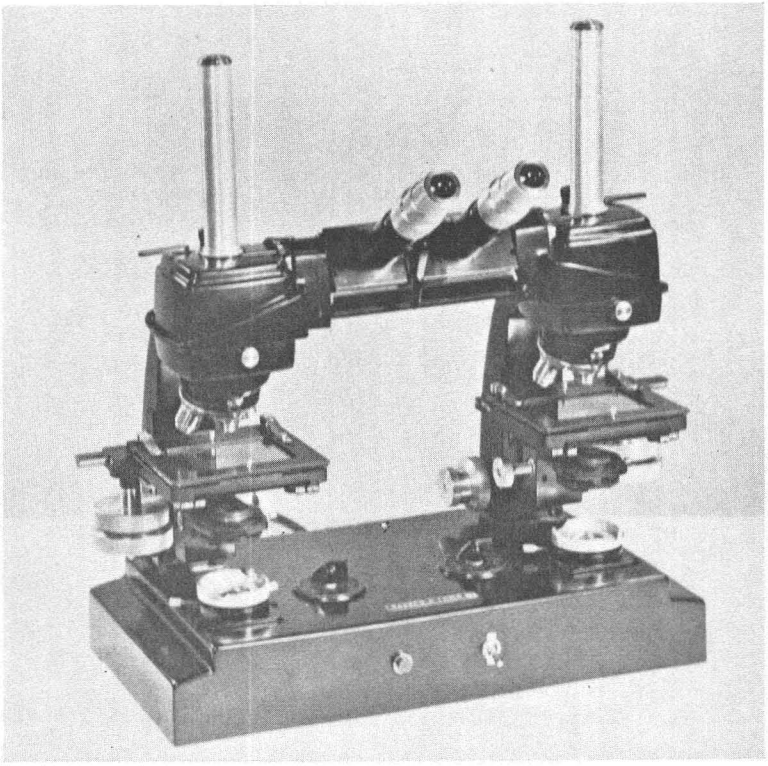

FIG. 3. High Power Stereoviewer.

tive. Interchanging eyepieces to increase the magnification does not usually increase the resolution of the system because the N.A. is not affected. The Frontispiece shows the Zoom 95 Stereoscope with Image Rotation and the 2× Attachment Lens.

HIGH POWER STEREOVIEWER

The requirements that brought about the development of the High Power Stereoviewer were for an instrument that would view very high resolution photography on 70 mm.×100 mm. film chips. The high resolution and limited film size made this an appropriate task for a high quality laboratory microscope. The Dynazoom Microscope has the additional feature of a 1× to 2× zoom system, so that, with interchange of objectives, there is a continuously variable magnification range. By interchanging the eyepieces and objectives, the magnification range is altered from 13× to 200×. A Stereoviewer was made by coupling two microscopes and directing the images from the two photographs to a pair of eyepieces. In each optical path a Pechan prism is used for image rotation. As in the instance of the Zoom 95, this requires the use of an Amici (roof) prism in place of a right-angle prism to provide an even number of reflections. The 1× relay lens is used to bring the image to the focal plane of the eyepiece. The Amici prism is movable so that a photomicrographic camera may be used for making an enlarged print of the area under study.

The standard microscope stand was modified to have larger knobs for X and Y scanning, a frame for holding the film chip flat, and a single base for the two arms. Figure 3 shows the High Power Stereoviewer.

VERSATILE STEREOSCOPE

The Versatile Stereoscope was developed under a contract with the United States Navy Bureau of Naval Weapons. It is "Versatile" because it does almost everything that the Zoom 70, Zoom 95 and the High Power Stereoviewer can do, all in one instrument. It can be used to view 70 mm., 5 inch and $9\frac{1}{2}$-inch photography in stereo, either on a single roll or two rolls side-by-side, over a continuous magnification range of 3× to 120×. The design approach was to use the zoom system of the StereoZoom Microscope and three interchangeable rhomboid arms each con-

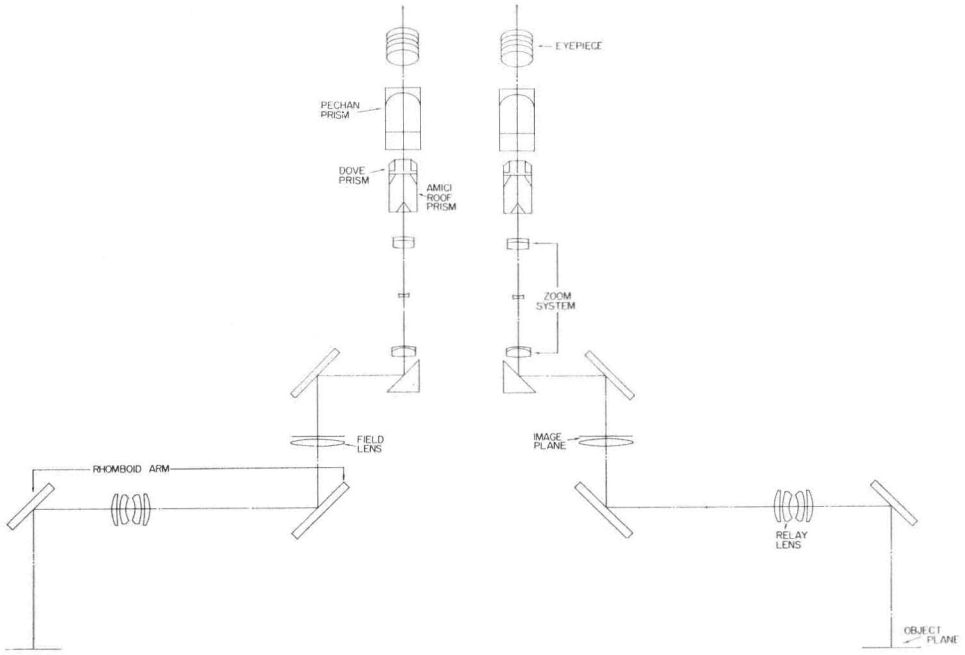

FIG. 4. Versatile Stereoscope Optical System.

taining a different relay lens. By interchanging relay lenses the N.A., and consequently the resolution, may be kept compatible with the magnification. The microscope pod has a .7× to 3× magnification, and only the 10× eyepieces are used. The three relay lenses used are .43×, 1× and 4×. The image rotation system from the Zoom 95 was also used.

One problem encountered previously on the Zoom 70 was that the convergence of the optical system of the StereoZoom Microscope made it awkward to mount the mirror system because the space below the pod where the optical bundles did not overlap was limited.

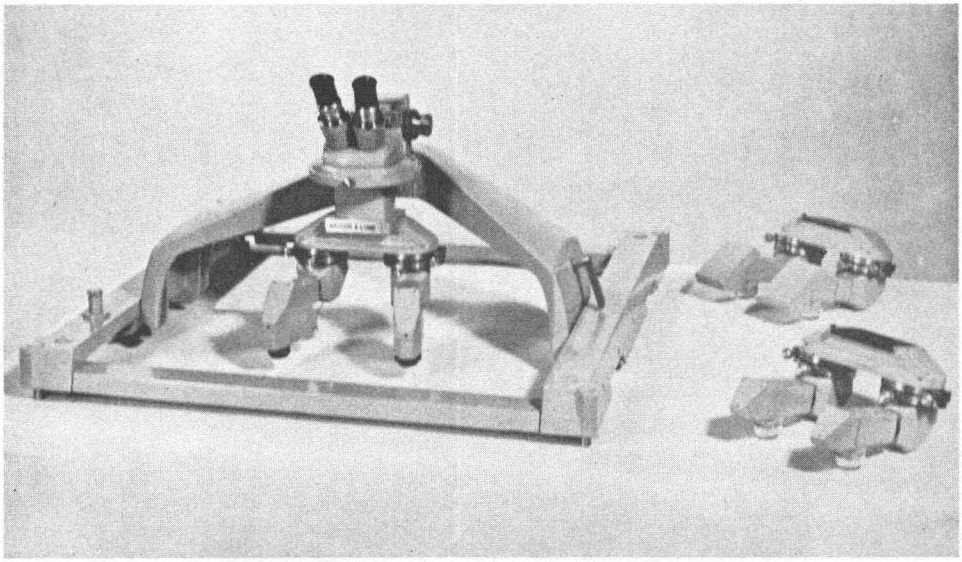

FIG. 5. Versatile Stereoscope.

This was overcome on the Versatile Stereoscope by mounting the optical paths parallel. Of couse, this precludes the use of the pod as a Stereomicroscope as is done with the Zoom 70 without special adaptation. Figure 4 shows the optical arrangement with the 1× relay and Figure 5 shows the assembled instrument.

The relay lenses in the rhomboid arms allow the arms to be long enough to view the $9\frac{1}{2}$-inch film. The maximum rhomboid arm separation is over 400 mm. and the minimum separation is 38 mm., except that for the .43× relay with its larger field of view, the minimum separation is 74 mm.

Summary

The Zoom 95 Stereoscope was developed for viewing in stereo $9\frac{1}{2}$-inch and 5-inch photography. It has a continuous magnification range of 2.5× to 40×, using the 2× attachment lens and 10× and 20× eyepieces, and rhomboid separations of 3 inches to $7\frac{3}{4}$ inches. It is avalable with optical image rotation for viewing uncut film which has differential crab between the stereo pairs. The High Power Stereoviewer is for viewing in stereo 70 mm. ×100 mm. cut film at magnifications of 13× to 200×. It has optical image rotation. The Versatile Stereoscope was developed for viewing in stereo, photographs on film from 70 mm to $9\frac{1}{2}$ inches. The magnification range, by interchanging three rhomboid arms, is 3× to 120×. The maximum rhomboid separation is over 400 mm. and the minimum separation is 74 mm. at 3 to 12.9×, 38 mm. at 7× to 120×. This instrument also has optical image rotation.