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TO: R. K. Lee
FROM: R. W. Dyer
SUBJECT: Rhomboid Alignment Procedure

DATE: 4 April 1968

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1. SCOPE: This procedure details the operations, accuracies, references, and establishes the sequence for the assembly and alignment of the double pivot, rhomboid arm scanner for the slide viewing system (SVS). Reference should be made to the optical specification for the rhomboid arms memos # 344-68-048 and 068.
2. DESCRIPTION: The rhomboid arm scanner consists of two parts, each of which contains two parallel mirrors in the normal rhomboid configuration. Each part (arm) is free to rotate in precise bearing which are co-axial with the optical centerline through the rhomboid mirrors. The upper arm is attached to the frame, while the lower arm is attached to the other end of the upper arm, very much in the way a human arm is configured. Each arm also contains photographic lenses and other optical elements. The arm which is nearer the film (the lower arm) can be either of two interchangeable sets of mirrors and lenses in order to accommodate different scales (magnification) of the input stimulus material. These arms shall be referred to as the high or low step, interchangeable rhomboid. The arm which is mounted to the frame contains a 10:1 zoom lens and shall be referred to as the zoom rhomboid. The main bearing at the optical bench structure is the shoulder bearing and the mirror above it is the shoulder mirror. Because the useful life of the zoom lens is expected to be limited, the zoom mount module will be prealigned as described in a separate memo.

The prime reference for the rhomboid alignment is the mechanical centerline of the shoulder bearings. Secondary references are the optical centerline in the zoom rhomboid, the centerline of the (elbow) bearing

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between the two arms, the centerline of the X-Y drive coupling and the axis which is perpendicular to the input platen. The alignment of the shoulder bearing axis to the optical centerline of the vertical optical bench structure is also critical. However, it is expected that this alignment will be maintained by careful machining and is outside the scope of this procedure.

Axial distances will be referenced to the arbitrary axial position of a special reticle located in the zoom lens focal plane, with the constraint that both the high and the low step, interchangeable arms must be "in focus" at the same input platen location. The interchangeable rhomboids will be prealigned on fixtures as described in a separate memo.

3. SUMMARY - ALIGNMENT PROCEDURE: The alignment procedure uses standard optical tooling, special fixturing and prealigned elements in order to guarantee 150 micron (.006") registration between the optical axis and coordinates on the input stimulus. The zoom lens is prealigned as a module in anticipation of future maintenance requirements. The interchangeable rhomboid arms are also prealigned in order to achieve the tight tolerances which are required for interchangeability as well as achieving the 150 micron registration.

The error budget for the 150 micron registration allows .002" error between the optical axis and the elbow bearing centerline, .002" error between the optic axis and the X-Y drive attachment point, .002" error between the optic axis and the shoulder bearing centerline, and 10 arc minute difference between the direction of the optic axis into and out of each rhomboid arm. In addition, the two interchangeable arms must have a common focus, within .003", the lenses in the arm must be centered to each other within .003", and each lens must be perpendicular to the optic axis within 15 arc minutes.

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The alignment begins at the image plane behind the zoom lens, using reference reticle which is adjusted to coincide with the centerline of the shoulder bearing within .0002". Then the mirrors in the upper arm are adjusted with special fixtures and the lenses installed. The zoom lens was prealigned so that the only adjustment is to fix the Z axis (focus) stop. The X, Y, Z, adjustments on the collimator are used to complete the alignment of the zoom rhomboid. The interchangeable rhomboid arms have also been prealigned are assembled to the zoom arm to allow adjustment of the X-Y drive connection. Any residual errors are corrected by fine adjustment of the zoom collimator and the zoom elbow mirror.

4. EQUIPMENT: The alignment procedure is based on using certain standard and special items of tooling.
 - 4.1 Surface Plate (Vendor, Cat. # TBD)
 - 4.2 Box parallel, modified to simulate actual mounting per drawing #(TBD) of the rhomboid scanner on the optical bench structure.
 - 4.3 Alignment telescope, w/right angle eyepiece, bracket for vertical mounting, (Taylor-Hobson #112/636/638 Telescope, #112/568 Eyepiece Assembly # TBD Bracket).
 - 4.4 Special target stand for defining the optical axis of the zoom rhomboid frame per drawing #TBD.
 - 4.5 Adjustable trivet, mirror and target holder per drawing #TBD.
 - 4.6 Standard, silvered alignment target (Vendor, Cat. #TBD) 2 required.
 - 4.7 Special reticle target holder for use at elbow per drawing #TBD.
 - 4.8 Separate fixture for prealigning zoom stage module per assembly #TBD.
See separate memo.

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- 4.9. Separate fixture for prealignment of interchangeable rhomboid. See separate memo.
 - 4.10. Special collimator mount with vertical pointing mirror per drawing #TBD.
 - 4.11. Alignment projection collimator.
 - 4.12. Special centering target for X-Y drive coupling.
5. INITIAL SET-UP:
- 5.1. Level surface plate to 1 arc minute.
 - 5.2. Secure box parallel to surface plate so that key axis and reference surface are square to surface plate to 1 arc minute (.0003 per inch).
 - 5.3. Adjust trivet (3.5) so that mirror surface is parallel to surface plate within 10 arc seconds (i. e., .00025 variation across 5" scan of legs) adjust height from surface to within $\pm .001$ of nominal.
 - 5.4. Adjust alignment telescope square to trivet (3.5) within 10 arc seconds.
6. ASSEMBLY AND ALIGNMENT:
- 6.1. Assemble zoom rhomboid frame, shoulder bearing, and bearing mount to the box parallel, ensuring that bearing axis is parallel to the keyway.
 - 6.2. Mount shoulder mirror mount and adjustable zoom reticle, (assembly #TBD) to the zoom rhomboid frame. Position alignment telescope and stand over the reticle, focus telescope on reticle.
 - 6.3. Rotate the zoom rhomboid frame and adjust the reticle until the center is stationary within .0002". Position alignment telescope in X, Y coordinate (do not use micrometer) so that the reticle is superimposed on the telescope reticle.

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- 6.4 Install the special target stand on the collimator lens mounting pad. Set the alignment telescope for autocollimation and adjust the shoulder mirror until the return image is within 15 arc seconds.
- 6.5 Focus on the target stand center. If required adjust the shoulder mirror mount by shimming until the centers are within .003".
- 6.6 Repeat 5.4, check 6.5.
- 6.7 Install zoom elbow mirror, remove special target stand, position trivet under elbow, and set the alignment telescope for autocollimation. Adjust the elbow mirror until the return image is within 30 arc seconds.
- 6.8 Attach special reticle target holder (3.7) to the kinematic flange on the elbow bearing, focus alignment scope. If required adjust zoom elbow mirror by shimming until the reticle appears centered within .002".
- 6.9 Repeat 6.7 and check 6.8.
- 6.10 Install prealigned zoom lens set at 50mm focal length and f/4. Position special collimator mount under elbow. Adjust the position of the zoom lens focus stop so that the projected reticle pattern is focused on the zoom reticle. Confirm focus by going through zoom range. Permanently lock the focus stop to the rhomboid base.
- 6.11 Install collimator lens, adjust focus until special reticle target is superimposed on zoom reticle. Adjust X, Y until the two reticles superimpose. Vary alignment by going through zoom. Secure the collimator adjustments.
- 6.12 Remove special target reticle. Install high power step, interchangeable arm. (Prealigned). Set the rhomboid arms to correspond to the center of the input format. Position the trivet mount under wrist mirror. Swing arm out of the way and position alignment telescope over the trivet target, adjust $\pm .0015''$. Reposition rhomboids over target and carefully adjust to

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- $\pm .0005$ alignment between the optic axis and the target by observing zoom reticle with a 10X loupe (zoom lens adjusted for maximum power).
- 6.13 Install center target in X-Y drive mounting and focus alignment telescope. Adjust X-Y drive mount until target coincides $\pm .0005$ with telescope reticle. Go through zoom range, checking for any image shifts.
- 6.14 Reposition the trivet and the optic axis at each corner of the format as in 6.12. Check the alignment by observing the X-Y drive mount target. Average any errors, install low power step and check registration, focus and zoom.
7. ERROR CALIBRATION: The residual registration errors must be calibrated after complete assembly of the slide viewing system. The calibration procedures are not a part of this procedure.

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