Discussion of Rhomboid Arm Motion

Attachment C

NPIC/TSG/ESD/TEB-125/71
1 September 1971

MEMORANDUM FOR THE RECORD

SUBJECT : Investigation of Rhomboid Arm Motion

REFERENCES: 1) IEG/OD/TPB-130/71, dated 29 July 1971
2) TSG/ESD/TEB-115/71, dated 10 August 1971

1. In response to a request by IEG/OD/TPB (Ref. 1), ESD has investigated possible causes of inability to focus [redacted] Zoom 240 Mod 28 system rhomboids using 2X objective lenses. Reference 2, which treated table alignment procedures, was intended to reduce the potential problem. This memorandum discusses another aspect of the 1540/Mod 28 system which is a contributing factor.

2. It had been conjectured that part of the problem stated in Reference 1 could be caused by the non-parallel, non-planar swing of rhomboid arms. In order to test this, ESD had to purchase a surface plate to use as a base for these measurements. The plate purchased was 12" x 18" granite, with a surface flatness tolerance of ±0.0001 inches.

3. An optics mount was found in ESD/EPB's parts stock which could be mounted over the surface plate. This mount is identical in mount/pod interface to that used on the [redacted] MLT 1540. The mount was firmly fixed on the surface plate, braced so that the weight of the optics would not move it in any manner. The surface of the mount on which the optics pod rests was aligned parallel to the surface plate within 0.001 inches Total Indicating Reading. This is the equivalent to a collimation error of less than 1 minute of arc.

4. Two pods were then placed on this mount one at a time. Fourteen arms were mounted on the left side of each of the pods. The variations in distance from position 1 at positions 2 and 3 were checked with each pod and rhomboid. These measurements and a drawing of the set-up are shown in Attachment 1.

SUBJECT: Investigation of Rhomboid Arm Motion

5. The following information should be noted.

a. The rhomboids were placed on the pods in the same way that a PI would mount them. That is, no attempt was made to align the three-point mount on the rhomboid to that of the pod to minimize excursions of swing. It is possible to reduce the excursion by approximately 10% by determining whether the position 3 distance (see attachment) was plus or minus, and compensating for this at the time of mounting the rhomboid.

b. Rhomboids were placed on parallel bars, divorced from the pod, and the swing of the rhomboid arms alone were checked. Two rhomboids, 101LA and 716WF, were checked in this manner. 101LA showed a total deviation of only 0.0005 inches for 180° of rotation in this test. 716WF, which had deviated by as much as 0.062 inches when mounted on pod 296BF, showed only a 0.0002 inch deviation when not on the pod.

6. The conclusion to be drawn from these tests is that rhomboid mounting hardware is critical. The rhomboid is positioned by a dowel pin on the slide mating with a slot on the rhomboid arm itself. A total cumulative tolerance in four critical areas - dowel diameter, dowel positioning, slot width, slot position - of 0.0005 inches will result in an angular deviation from parallel of approximately 19 minutes of arc for the rhomboid arm. It is entirely possible that the prism problem noted in Reference 2 does not exist; i.e., the symptoms noted are caused by rhomboid swing, not by prism deviations.

7. This problem might be alleviated by two methods, both of which involve a redesign of the rhomboid/pod system.

a. Greater focus range could possibly be built into the rhomboid arm, enabling refocus of objectives even with gross deviations from parallel swing.

b. Tighter tolerances on the positioning hardware would provide a more nearly parallel swing of rhomboids without redesign of optics. However, the geometry of

the system is such that a deviation of 0.001 inch in positioning at the dowel will cause an angular deviation in excess of 3 minutes of arc along the rhomboid arm at position 1 (See Attachment). This is a height differential of 0.008 inches from position 1 to position 3.

8. Unfortunately, there are other areas on the power pod and rhomboid system which affect the swing of the rhomboid. If we assume that the mounting ring is perfectly aligned to the viewing surface, then, in order to have the rhomboids swing in a perfectly parallel path, the following mechanical statements apply.

a. The surface on the power pod which interfaces with the mounting pod must be perfectly flat.

b. The dovetail slide must be positioned in a horizontal plane perfectly parallel to the mounting ring.

c. The vertical surfaces on the slide to which the rhomboids butt must be perfectly parallel to each other and perfectly normal (i.e., at 90° exactly) to the plane of the mounting ring.

d. The rhomboids must mount on the slide so that a line through the center of the rhomboid movement bearings is perfectly normal to the mounting ring plane.

9. The conditions stated in section 8 do not all have to be satisfied. Section 8d, if satisfied, will provide that the rhomboids swing in a plane parallel to the viewing surface. But interchangeable parts cannot be specified in that way.

a. The rhomboid bearing is probably tied to the dowel slot and slide mating surface, with some tolerance.

b. The rhomboid mating surface and the position of the dowel are probably tied to the dovetail slide surfaces and rhomboid prism centerline, with some tolerance.

SUBJECT: Investigation of Rhomboid Arm Motion

c. The dovetail slide surfaces are probably tied to the pod mounting surface, again with some tolerance.

10. The situation found in the optics today, is that, generally, the 0.056 inch focus adjustment found in the 2X rhomboid system is adequate for PI use with the 1540 system. However, if an attempt is made to use optics with less focus accomodation, major redesign of the mechanical parts supporting the optics will be necessary. It has been stated that 3X objective lenses currently under consideration will contain focus accommodation of about 0.075 inches.

[redacted] 25X

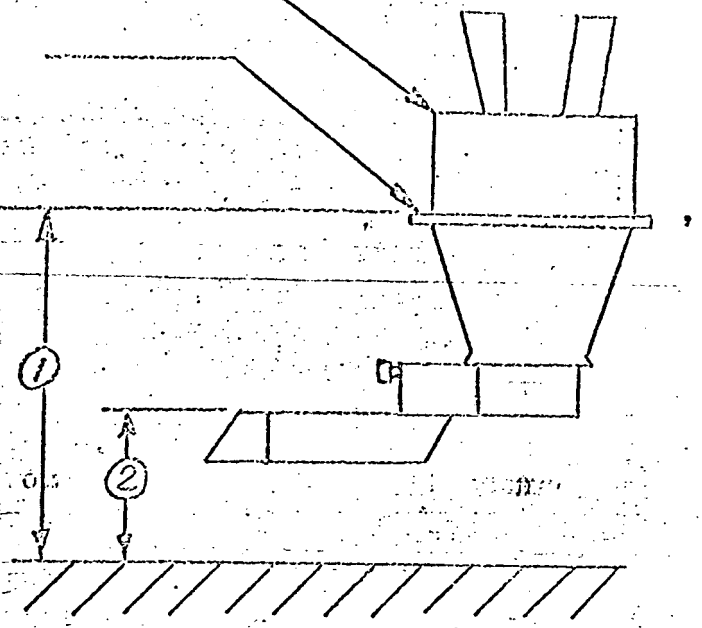
Test Engineer
TEB/ESD/TSG/NPIC

Distribution:
Original & 1 - NPIC/TSG/ESD/TEB (Chrono [redacted] 25X
1 - NPIC/TSG/ESD/EPB
1 - NPIC/TSG/RED
1 - DIA/DI-8 [redacted] 25X

5X1

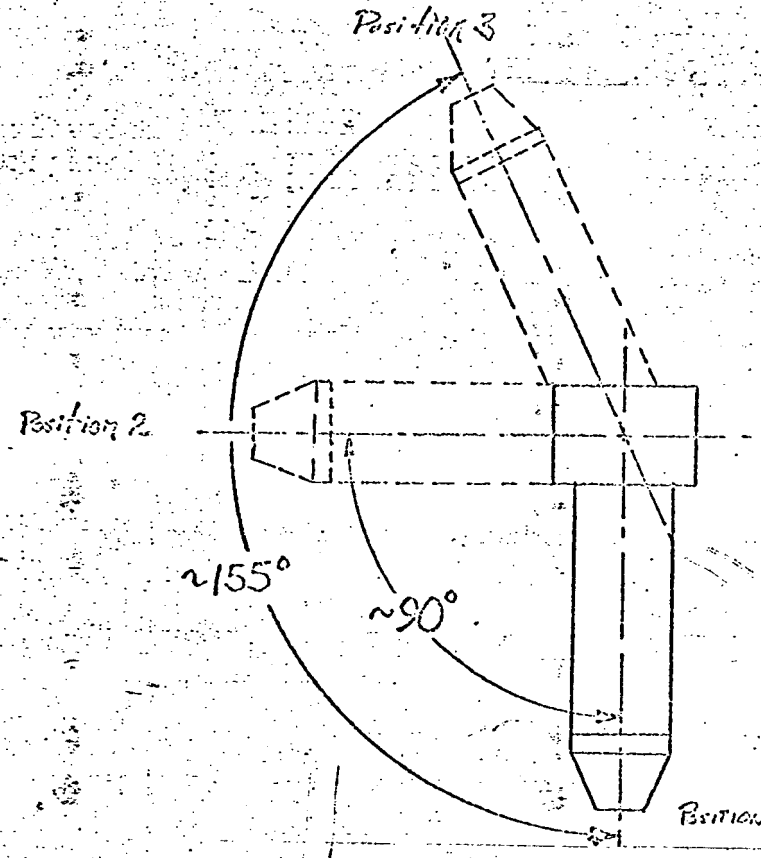
5X1

Optical Pod Mount



① The Pod Mount was set up over the surface plate with this distance indicated to 0.0001" TIR over the Pod Mount Surface.

② The variations in this distance were noted at the positions shown below.



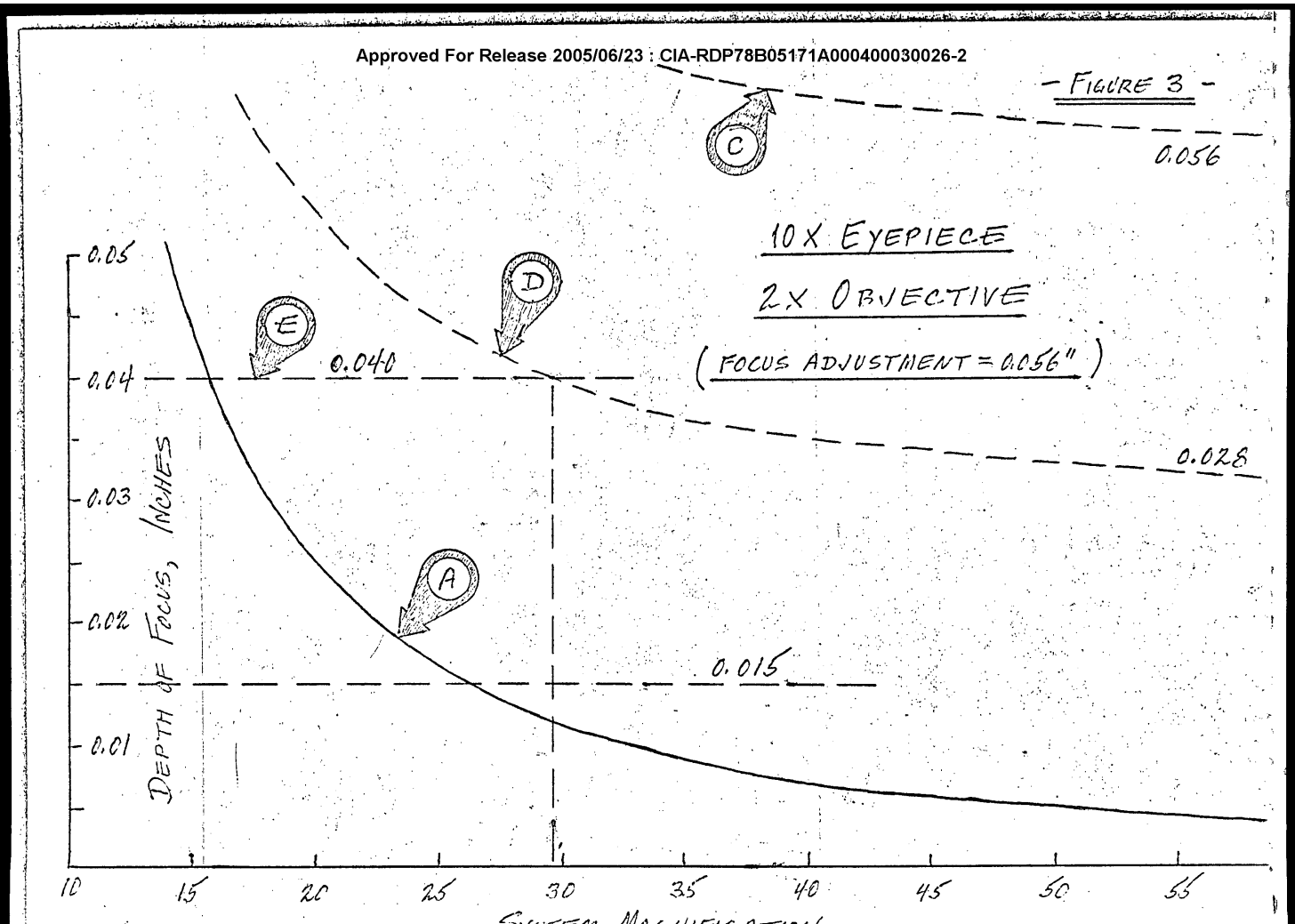
ATTACHMENT 1

The decimal numbers in the position 1 column are used for reference only. The difference between the position 1 numbers is relevant since it shows a change in the objective's distance from the surface from one to another.

	Position 1 (reference)		Variation from Position 1			
			Position 2		Position 3	
Humboid Serial	Pod 296 BF	Pod 277 BF	Pod 296 BF	Pod 277 BF	Pod 296 BF	Pod 277 BF
1197 E	+.097	.846	+.004	-.015	+.008	-.025
598 LA	.113	.848	-.028	-.027	-.040	-.038
586 LA	.102	.844	-.021	-.025	-.036	-.039
119 LA	.097	.838	-.024	-.025	-.033	-.034
160 LA (1)	.119	.855	-.032	-.028	-.056	-.048
284 LA (1)	.107	.849	-.002	-.004	-.002	-.004
*524 NF	.085	.825	+.013	+.003	+.023	+.011
*724 NF	.092	.833	+.015	+.006	+.026	+.012
*501 NF	.073	.821	+.019	+.012	+.034	+.053
*716 NF	.056	.805	+.033	+.024	+.062	+.047
*3821 BF	.085	.829	+.005	-.004	+.007	-.006
*7901 NF	.085	.816	+.015	+.018	+.029	+.034
*722 NF	.090	.818	+.018	+.024	+.028	+.036
*101 LA	.097	.840	-.002	-.006	-.002	-.007

* New arms, never used by PI's.

(1) Denotes part sent to EPB/ESD with notation "Can't focus @ 2x"



The TEB memo 125/71 clearly indicates that the rhomboid arms do not rotate in a plane parallel to the viewing surfaces of the light table. This non-planar rotation, in the fourteen rhomboid arms investigated, ranged from 0.002 inch to 0.062 inch. The 0.002 inch difference is probably of little or no significance at any magnification within the range being considered. The 0.062 inch difference is of considerable significance.

Assume a non-planar rotational difference of 0.025 inch. This, added to the maximum allowable non-parallelism of the table viewing surfaces of 0.015 inch, amounts to a total error of 0.040 inch. This has been drawn on the attached depth of focus curve for the 10X eyepiece and 2X objective lens as line "B". The intersection of curve "A" and line "B" indicates that at a total magnification of about 16X the depth of focus is sufficient to accommodate the error of 0.040 inch. Up to at least this magnification the system is capable of scanning throughout the viewing surfaces of the light table regardless of the rotational positioning of the rhomboid arms.

The intersection of curve "D" and line "E" indicates that up to a total magnification of about 30X there is sufficient focus adjustment available in one rhomboid arm to accommodate the 0.040 inch error regardless of the rotational positioning of the rhomboid arms. Between 16X and 30X, scanning will probably be possible over only very limited areas of the viewing surfaces without refocus, and repeated refocusing will be required as the optics are moved over the viewing surfaces. Beyond 30X, repeated refocusing of both rhomboid arms will be required. However, the fact that line "E" does not intersect curve "C" anywhere within the system magnification available with this combination of 10X eyepiece and 2X objectives indicates that sufficient focus adjustment is available in both rhomboid arms to accommodate the 0.040 inch error.

Inspection of the data in TEB memo 125/71 indicates a random non-planar error in rotation of the various rhomboid arms. The exact cause is unknown at this time although TEB memo 125/71 indicates several possible causes that are suspect. [redacted] has instigated an extensive study of the problem, the results of which should be available late in October.

25X1