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PRODUCT-IMPROVEMENT TEST OF OH-6A ROTOR BLADES WITH INCREASED T--ETC(U)
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DEPARTMENT OF THE ARMY
UNITED STATES ARMY AVIATION TEST BOARD
Fort Rucker, Alabama 36360

STEBG-TD

DEC 4 - 1968

SUBJECT: Final Report of Product-Improvement Test of OH-6A Rotor Blades with Increased Twist and Contour Tolerances, USATECOM [redacted]-4-6-0251-18

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1. REFERENCES

a. Letter, AMCPM-LH-T, Headquarters, US Army Materiel Command, 16 July 1968, subject: "Test of OH-6A Rotor Blades with Increased Twist and Contour Tolerances," with 1st Indorsement, AMSTE-BG, Headquarters, US Army Test and Evaluation Command, 12 August 1968.

b. Telephone conversation between Colonel Mahone, Cayuse Project Manager; LTC DeLoach, USAAVNTBD; and Mr. Don Conley, USATECOM, 8 October 1968, subject: "Test of OH-6A Rotor Blades with Increased Twist and Contour Tolerances."

c. Message, STEBG-TD-A 10-35, US Army Aviation Test Board, 24 October 1968, subject: "Test of OH-6A Rotor Blades with Increased Twist and Contour Tolerances."

2. BACKGROUND

Operational requirements in Vietnam have created a critical shortage of OH-6A rotor blades. The aircraft manufacturer, working with the LOH Project Manager, presented an Engineering Change Proposal for OH-6A HELICOPTERS. to increase the parameters of the main-rotor blade tolerances. On 12 August 1968 the US Army Test and Evaluation Command directed the US Army Aviation Test Board (USAAVNTBD) to conduct a product-improvement test of OH-6A rotor blades with increased twist and → cont

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contour thickness tolerances (reference 1a). The test hardware was delivered on 14 October 1968.

3. DESCRIPTION OF MATERIEL

The test blades are similar to standard blades with respect to appearance, weight, and dimensions; however, they are allowed a greater tolerance in twist and contour thickness. The blades are pretracked by the manufacturer using a master blade. Pitch-change link dimensions are stencilled on each blade and are used in lieu of nominal settings contained in the technical manual. Tolerance deviations for the blades tested are listed in inclosure 1.

4. SCOPE

This Category II product-improvement test was conducted at Fort Rucker, Alabama, during the period 14 October through 19 November 1968. The test items were installed on OH-6A Helicopter, S/N 65-12921, by USAAVNTBD personnel. Fifteen subtests were conducted with various combinations of out-of-tolerance blades and standard blades. (See inclosure 2.)

5. OBJECTIVES

a. To determine the time required to track the main-rotor system of the OH-6A with combinations of the test items and standard main-rotor blades installed.

b. To qualitatively evaluate the performance of the OH-6A with various blade combinations.

6. SUMMARY OF RESULTS

a. Average tracking time for each blade combination was 1 hour and 54 minutes. The time required for tracking each combination is listed in inclosure 3.

b. An average of 17 adjustments per tracking operation was made.

c. Final track adjustment and performance data for each subtest are contained in inclosure 3.

d. Accurate trim tab or pitch change link adjustments were not possible with existing tools. Locally manufactured tools (figures 1 and 2, inclosure 4) were used during the test.

e. Test data indicate that, unless a compatible relationship is obtained between the pitch-change link length and the high-r.p.m.-trim-tab setting, vibration will be encountered in the cyclic stick and/or the airframe. Pretracked blades have this ideal relationship by being tracked with a master blade.

f. Out-of-tolerance blades were difficult to track and required excessive time when trim tabs were zeroed and pitch-change links adjusted to the nominal setting specified in Technical Manual 55-1520-214-20.

g. Pitch-change-link stencil errors previously reported (reference 1c) were evaluated throughout the remainder of the test and were not considered a problem when it was known which strap pack the blade was installed on during pretracking. This error was indicated during low r.p.m. track, and pitch-change link adjustments could be made to correct the condition.

h. Difficulties were encountered tracking the high-time standard blades. These blades were tracked using the locally developed procedure described in subtest number 15. (See inclosure 2.)

7. CONCLUSIONS

a. The time required to track out-of-tolerance blades is not excessive in comparison with that for standard blades, provided the out-of-tolerance blades are pretracked.

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b. Aircraft performance is not adversely affected by the out-of-tolerance blades.

c. Out-of-tolerance blades require excessive time for tracking when trim tabs are set to nominal dimensions.

8. RECOMMENDATIONS

a. Pretracked out-of-tolerance blades be adopted for use on the OH-6A Helicopter.

b. The pretrack stencil be revised to include pitch-change link dimensions, r.p.m. trim tab settings, and the strap pack on which the blade was installed during pretrack.

c. Tools suitable for accurate adjustment of trim tabs and pitch-change links be provided to units equipped with the OH-6A.

d. Further product-improvement testing be conducted to determine whether the locally developed tracking procedures can be used on out-of-tolerance blades.

FOR THE PRESIDENT:

A. J. Montcalmo

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as

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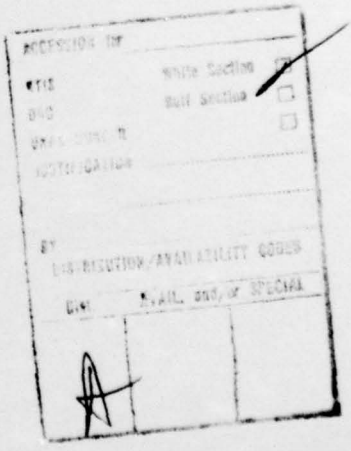

OUT OF TOLERANCE BLADES

TOLERANCE DEVIATION

Blade S/N	ECP	Inboard Twist (5^{o} 30' $\pm$ 1^{o} 0')	Outboard Twist (2^{o} $\pm$ 45')	Contour Thickness (+.160 -.250)
58-4276	511642	6^{o} 25'		
58-4512	511642	4^{o} 18'		
58-1587	511677		1^{o} 14'	
58-4854	511677		2^{o} 46'	
58-4022	511685			-0.246
58-4388	511685			+0.156

INCLOSURE 1

1. Subtest No. 1

a. Blade Configuration: Standard blades with zero trim tab settings and nominal pitch-change link settings.

b. Analysis: The standard blades were used as a baseline for comparison with test blades. Vibration level of the aircraft was acceptable.

2. Subtest No. 2

a. Blade Configuration: One out-of-tolerance (thickness) blade and three standard blades. The test blade, S/N 58-4388, was installed on the lower strap pack and was the red blade.

b. Analysis: This pretracked blade was installed and flown without tracking adjustments. Maximum out-of-track condition was 3/8 inch at 120 knots; however, vibration level of the aircraft was acceptable. There was a slight lateral vibration which was attributed to one new blade combined with three high-time blades. This combination of blades caused a slight lateral feedback force in the cyclic control stick.

3. Subtest No. 3

a. Blade Configuration: One out-of-tolerance (thickness) blade and three standard blades. The test blade, S/N 58-4022, was installed on the lower strap pack and was the red blade.

b. Analysis: This pretracked blade was installed and flown without tracking adjustments. Lateral vibration, attributed to one new blade and three used blades, was present but was considered acceptable. No lateral feedback was felt with this combination of blades.

4. Subtest No. 4

a. Blade Configuration: One out-of-tolerance (outboard twist) blade and three standard blades. The test blade, S/N 58-1587, was installed on the lower strap pack and was the red blade.

b. Analysis: This pretracked blade was installed and flown with low r.p.m. track adjustment required on one of the standard blades. The previously reported lateral vibration was felt; however, overall vibration level was acceptable. A slight lateral feedback was present in the cyclic stick.

INCLOSURE 2

5. Subtest No. 5

a. Blade Configuration: One out-of-tolerance (outboard twist) blade and three standard blades. The test blade, S/N 58-4854, was installed on the upper strap pack and was the yellow blade.

b. Analysis: This blade, unlike blades installed on the lower strap pack, required a pitch-change link adjustment. This was attributed to the fact that the blades were pretracked on the lower strap pack with a nominal 0.250 inch added to the stencilled pitch-change link dimension for the upper strap pack. This difference in pitch-change link length is apparently affected by the rotor system and therefore a fixed difference is not accurate. The pretrack data stencil should specify which strap pack was used and that the pitch-change link may require adjustment when the blade is installed on the other strap pack. This combination of blades induced a slight lateral feedback in the cyclic control stick.

6. Subtest No. 6

a. Blade Configuration: One out-of-tolerance (inboard twist) blade and three standard blades. The test blade, S/N 58-4512, was installed on the upper strap pack and was the yellow blade.

b. Analysis: This combination of blades induced moderate cyclic feedback; however, the overall vibration level in the aircraft was acceptable.

7. Subtest No. 7

a. Blade Configuration: One out-of-tolerance (inboard twist) and three standard blades. The test blade, S/N 58-4276, was installed on the upper strap pack and was the yellow blade.

b. Analysis: Overall vibration level with this combination of blades was acceptable.

8. Subtest No. 8

a. Blade Configuration: One new production blade and three standard blades. The new blade was installed on the upper strap pack and was the green blade.

b. Analysis: This test was conducted to provide a comparison time.

9. Subtest No. 9

a. Blade Configuration: Two adjacent standard blades and two adjacent blades with increased inboard twist tolerance. The blade with minimum inboard twist led the blade with maximum twist and was installed on the upper strap pack. The test blades, S/N 58-4512 and 58-4276, were yellow and white, respectively.

b. Analysis: Vibration level with this combination was acceptable.

10. Subtest No. 10

a. Blade Configuration: Two adjacent standard blades and two adjacent blades with increased outboard twist tolerance. The blade with minimum outboard twist led blade with maximum twist and was installed on the upper strap pack. The test blades, S/N 58-1587 and 58-4854, were yellow and white, respectively.

b. Analysis: Vibration level with this combination was acceptable.

11. Subtest No. 11

a. Blade Configuration: Two adjacent standard blades and two adjacent blades with increased thickness tolerance. The blade with maximum thickness led the blade with minimum thickness and was installed on the upper strap pack. The test blades, S/N 58-4022 and 58-4388, were yellow and white, respectively.

b. Analysis: Man-hours required for tracking this blade configuration were high due to the requirement for re-zeroing standard blades. The blades could not be tracked at high speed. When high-speed adjustments were made, low-speed track was affected. These problems have been encountered with high-operating-time blades. It is felt that repeated tracking adjustments induce instability into the blades; therefore, the trim tabs should be zeroed after two or three major tracking operations have been performed. As indicated in Subtest No. 14, re-zeroing the blades should be back to the pretracked settings stencilled on the blade. Test results indicate a definite relationship between pitch-change-link length and high-r.p.m.-trim-tab setting. The rotor system may be tracked if this relationship is not

completely compatible, but the vibration level is higher than when this relationship is compatible. The cyclic stick feedback appears to be present when this relationship is not compatible.

12. Subtest No. 12

a. Blade Configuration: Two adjacent blades with increased thickness tolerance and two adjacent blades with increased outboard twist. The thick blade led the thin and was on the upper strap pack. The blades, S/N 58-4388 and 58-4022, were red and green, respectively.

b. Analysis: Four pretracked rotor blades provided a smooth rotor system. This was attributed to the fact that each pitch-change link and r.p.m. trim tab were ideally related. (See Subtest No. 11.)

13. Subtest No. 13

a. Blade Configuration: Two adjacent blades with increased inboard twist and two adjacent blades with increased outboard twist tolerances. The blade with minimum inboard twist led the blade with maximum inboard twist and was installed on the upper strap pack. These blades, S/N 58-4512 and 58-4276, were yellow and white, respectively. The blade with minimum outboard twist led the blade with maximum outboard twist and was installed on the upper strap pack. These blades, S/N 58-4587 and 58-4854, were green and red, respectively.

b. Analysis: Four pretracked rotor blades provided a smooth rotor system. This was attributed to the fact that each pitch-change link and r.p.m. trim tab were ideally related.

14. Subtest No. 14

a. Blade Configuration: Blades installed for Subtest No. 13 with zeroed trim tabs and nominal pitch-change links.

b. Analysis: After expenditure of 12 man-hours, this subtest was terminated. Difficulties encountered were: adverse effects of high-speed trim-tab adjustments on ground track and low-speed track, excessive airframe vibration, and excessive cyclic control feedback.

15. Subtest No. 15

a. Blade Configuration: Standard high-operating-time blades.

b. Analysis: The high-time standard blades were difficult and time consuming to track, exhibiting the same adverse effects as the blades in Subtest No. 14. This problem was resolved by tracking the blades on two levels separated by the difference in their respective strap pack levels. The results indicate that this tracking method will reduce both tracking difficulty and aircraft vibration levels.

INCLOSURE 3

	TIME REQUIRED (MINUTES)					NUMBER OF ADJUSTMENTS			PERFORMANCE											
												60 KNOTS			80 KNOTS			100 KNOTS		
Subtest	Low R.P.M.	High R.P.M.	Hover Verification	High Speed	Total	Low R.P.M.	High R.P.M.	Speed Track	Density Altitude (ft.)	Altitude m.s.l. (ft.)	N_2 R.P.M. (%)	N_1 (%)	TOT (°C.)	Torque (p.s.i.)	N_1 (%)	TOT (°C.)	Torque (p.s.i.)	N_1 (%)	TOT (°C.)	Torque (p.s.i.)
1	65	40	2	105	210	10	8	10	+1,075	500	100	90	585	47	92	605	53	94	615	61
2	2	2	2	11	15	0	0	0	+1,075	500	100	89	580	46	91	600	52	93	610	60
3	2	2	2	36	40	0	0	4	+1,275	500	100	90	580	48	92	610	56	95	620	62
4	15	2	2	75	90	1	0	8	+1,425	500	100	88	580	43	91	600	55	93	610	59
5	20	20	2	100	120	2	3	6	+2,100	500	100	89	590	45	92	605	55	93	610	62
6	15	20	2	30	65	3	2	4	+1,350	500	100	89	590	46	92	605	53	94	615	60
7	15	15	2	35	65	2	2	3	+50	500	100	90	580	50	91	600	55	92	605	58
8	20	20	2	65	105	3	5	12	+1,900	500	100	88	565	40	91	600	51	93	610	58
9	15	2	2	45	60	2	0	6	+625	500	100	89	575	46	90	595	53	92	610	60
10	30	30	2	105	165	5	4	14	+350	500	100	88	595	46	90	580	50	92	605	60
11	30	20	2	220	270	5*	13*	21*	+850	500	100	87	550	45	89	575	52	91	605	60
12	20	15	2	130	165	7	3	21	+625	500	100	87	560	44	90	580	52	92	600	62
13	20	20	2	110	150	6	9	12	+1,150	500	100	89	580	48	91	600	55	95	620	60

*Rezero standard blades.

Final Track Adjustments

	Subtest No. 1	Subtest No. 2	Subtest No. 3	Subtest No. 4	Subtest No. 5	Subtest No. 6	Subtest No. 7	Subtest No. 8	Subtest No. 9	Subtest No. 10	Subtest No. 11	Subtest No. 12	Subtest No. 13
Green pitch link	U1/2	U1/2	U1/2	U1/2	U1/2	U1/2	U1/2	U3	U3	U1 1/2	D1	D2	D1/4
Red pitch link	U1 1/2	SL	SL	SL	U1/2	U1/2	U1/2	U1/2	D1/2	D2	D1	U5	U4 3/4
Yellow pitch link	U1 1/2	U1 1/2	U1 1/2	U2 1/4	U4*	U5*	U1*	U4	U5*	U1*	U1*	SL	SL
White pitch link	N	N	N	N	N	D1	D3	D3	SL	SL	SL	U1/2*	U1/2*
Green r.p.m. tab	U1	U1	U1	U1	U1	U1	U1	D2 1/2	D2 1/2	D2 1/2	U4	U1/2	U2 1/2
Green 0-50 knots tab	D2	D2	D2	D1 1/2	D1 1/2	D1 1/2	D1 1/2	U1	U1	U1	U1	0	D1 1/2
Green 50-100 knots tab	D2	D2	D2	D1 1/2	D1 1/2	D1 1/2	D1 1/2	U1 1/2	U1/2	D1/2	0	0	U1/2
Green 100-120 knots tab	D2	D2	D2	D2	D2 1/2	D3	D3	D3	D3 1/2	D5	U1 1/2	U1 1/2	0
Red r.p.m. tab	D3 1/2	PS	PS	PS	D2	D2 1/2	D2 1/2	D2 1/2	D2 1/2	D4	D3 1/2	U2 1/2*	PS
Red 0-50 knots tab	0	0	U2 1/2	U5	D5	D5	D5	D4	D4	D3 1/2	D1/2	U1 1/2	D4 1/2
Red 50-100 knots tab	0	0	U2 1/2	U5	D5	D5	D5	D4	D4	D3 1/2	D1	U1 1/2	D4 1/2

*Above pretracked r.p.m. tab setting.

	Subtest No. 1	Subtest No. 2	Subtest No. 3	Subtest No. 4	Subtest No. 5	Subtest No. 6	Subtest No. 7	Subtest No. 8	Subtest No. 9	Subtest No. 10	Subtest No. 11	Subtest No. 12	Subtest No. 13
Red 100-120 knots tab	0	0	U4 1/2	U1	0	0	0	0	U1/4	U3/4	D1/2	U2 1/2	0
Yellow r.p.m. tab	D2	D2	D2	D2	U2*	U1/2*	U1/2	U1 1/4	U1/2*	U2 1/2*	PS	PS	PS
Yellow 0-50 knots tab	D2	D2	D2	D3 1/2	U1	U2	U1/4	D2	U3/4	D1/2	0	U1/2	U1/2
Yellow 50-100 knots tab	D2	D2	D2	D3 1/2	U1	U2	U1/4	D2	U3/4	D2	0	U1	U1/2
Yellow 100-120 knots tab	0	0	0	0	U1/2	0	0	U1	0	D2	D1	D2 1/2	U1/2
White r.p.m. tab	U1/2	U1/2	U1/2	U1/2	0	0	0	0	U1/2*	PS	U2*	U1 1/2*	0
White 0-50 knots tab	0	0	U1 1/2	U1 1/2	U2 1/2	U3 1/2	U4	U5	U4 1/2	U6	U2 1/2	U2	D4 1/2
White 50-100 knots tab	0	0	U1 1/2	U1 1/2	U2 1/2	U3 1/2	U4	U5	U4 1/2	U6	U2 1/2	U2	D4
White 100-120 knots tab	U2	U2	U2	U2	U4	U5	U5	U5	U5	U1	U4 1/2	U5	D1/2

*Above pretracked r.p.m. tab setting.

Legend

D - Down
U - Up
N - Nominal length
SL - Stencilled length
PS - Pretrack setting

Note

Pitch link adjustments are measured in turn buckle nut flats.
Trim tab settings are measured in degrees above and below zero.

PHOTOGRAPHS

INCLOSURE 4

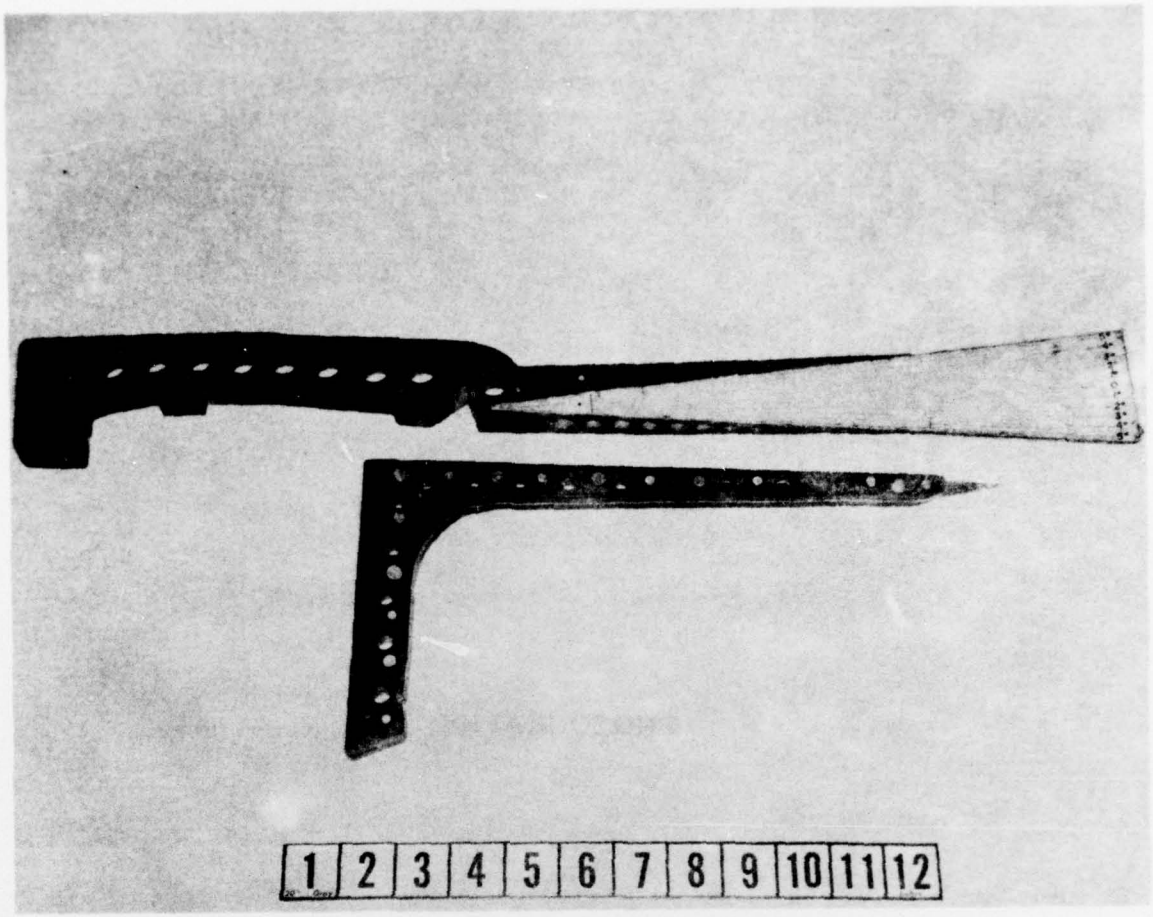

Figure 1.

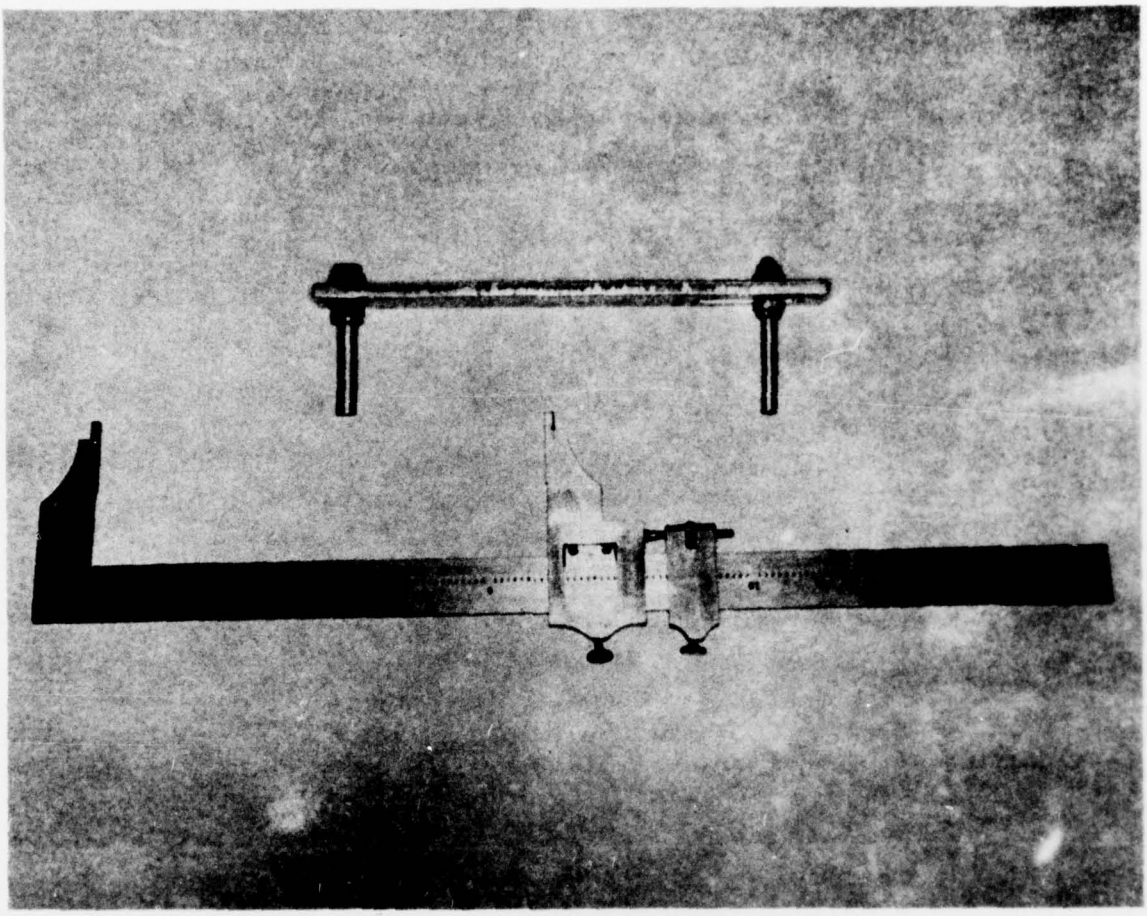

Figure 2.