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U. S. ARMY

TRANSPORTATION RESEARCH COMMAND
FORT EUSTIS, VIRGINIA

(6) **PRELIMINARY FLIGHT TEST DATA.**

UH-1B HIGH PERFORMANCE HELICOPTER WITH AUXILIARY PROPULSION,

(11) February 1964, (12) 29p.

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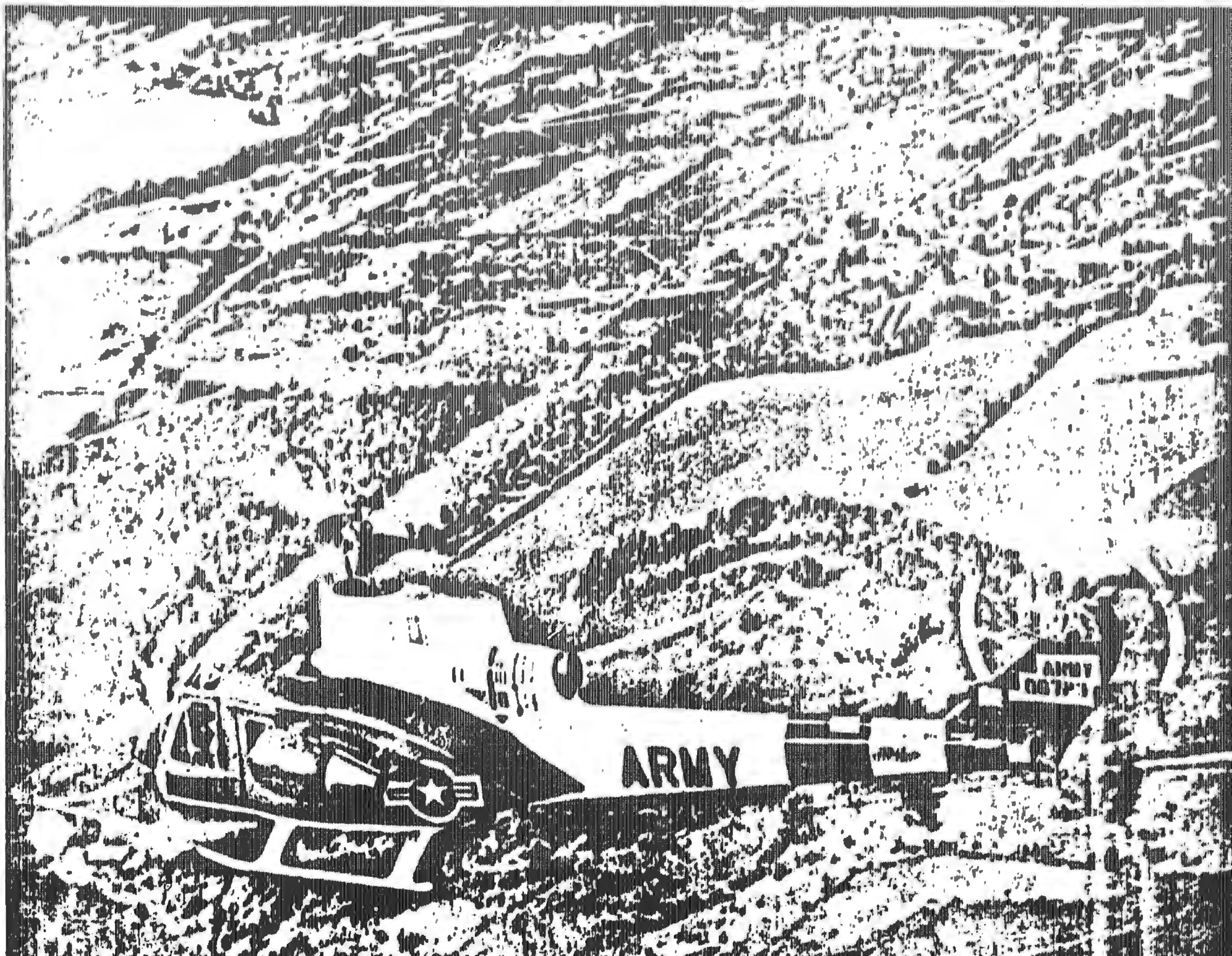
The information contained herein has been reproduced to disseminate to Government and industry, as rapidly as possible, current data vital to Army rotary-wing progress and objectives. In this respect, it is emphasized that the data, although measured flight data, are preliminary, therefore the contents of this document are subject to revision.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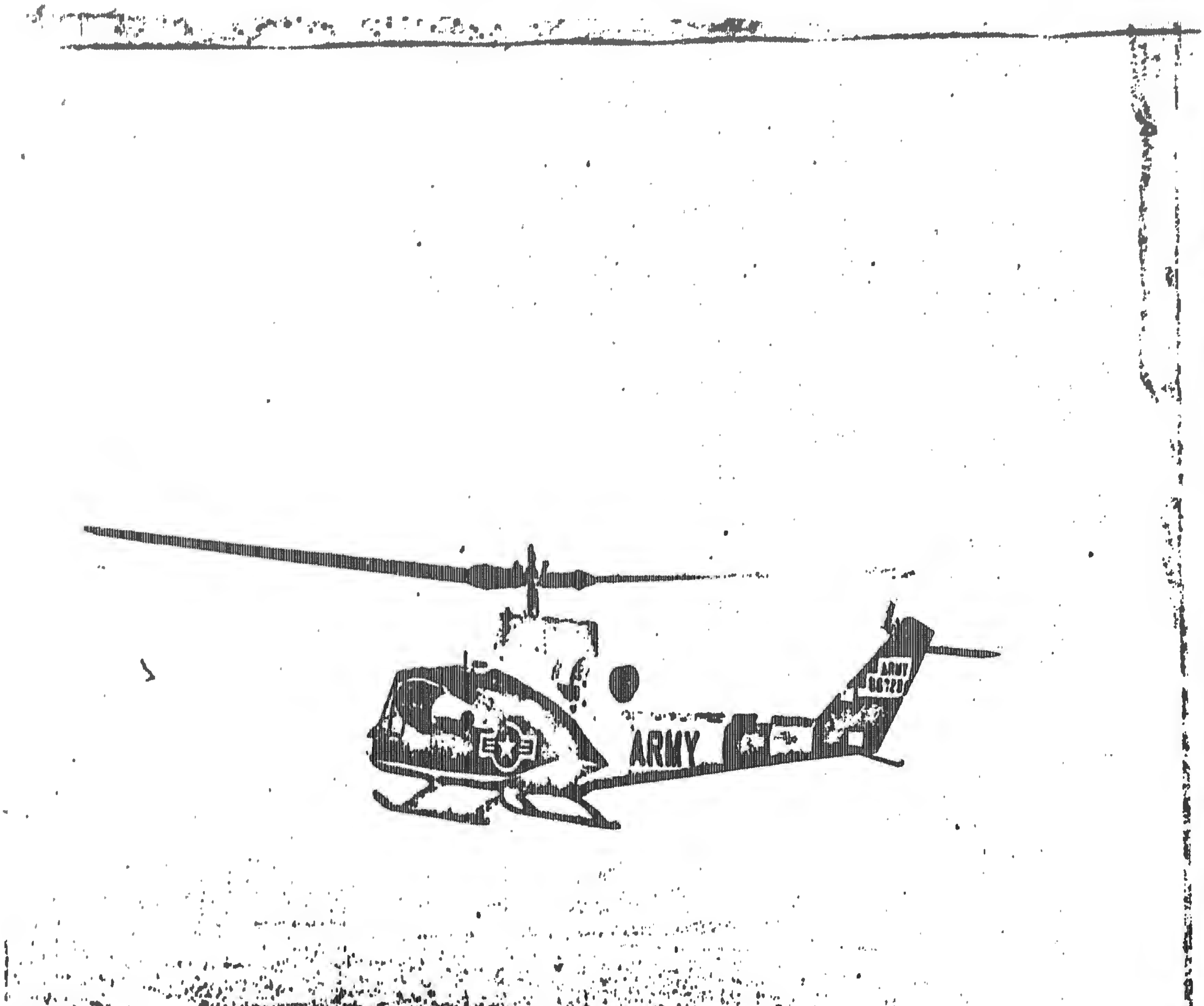
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Section 1 - The following pages present some of the previous flight test results achieved with the high performance UH-1B helicopter operating as a pure helicopter and in a winged configuration.

Figure 1

Summary of High Performance Helicopter Flight Test Results

Note: HPH 2-Bladed is with Standard UH-1B Rotor.

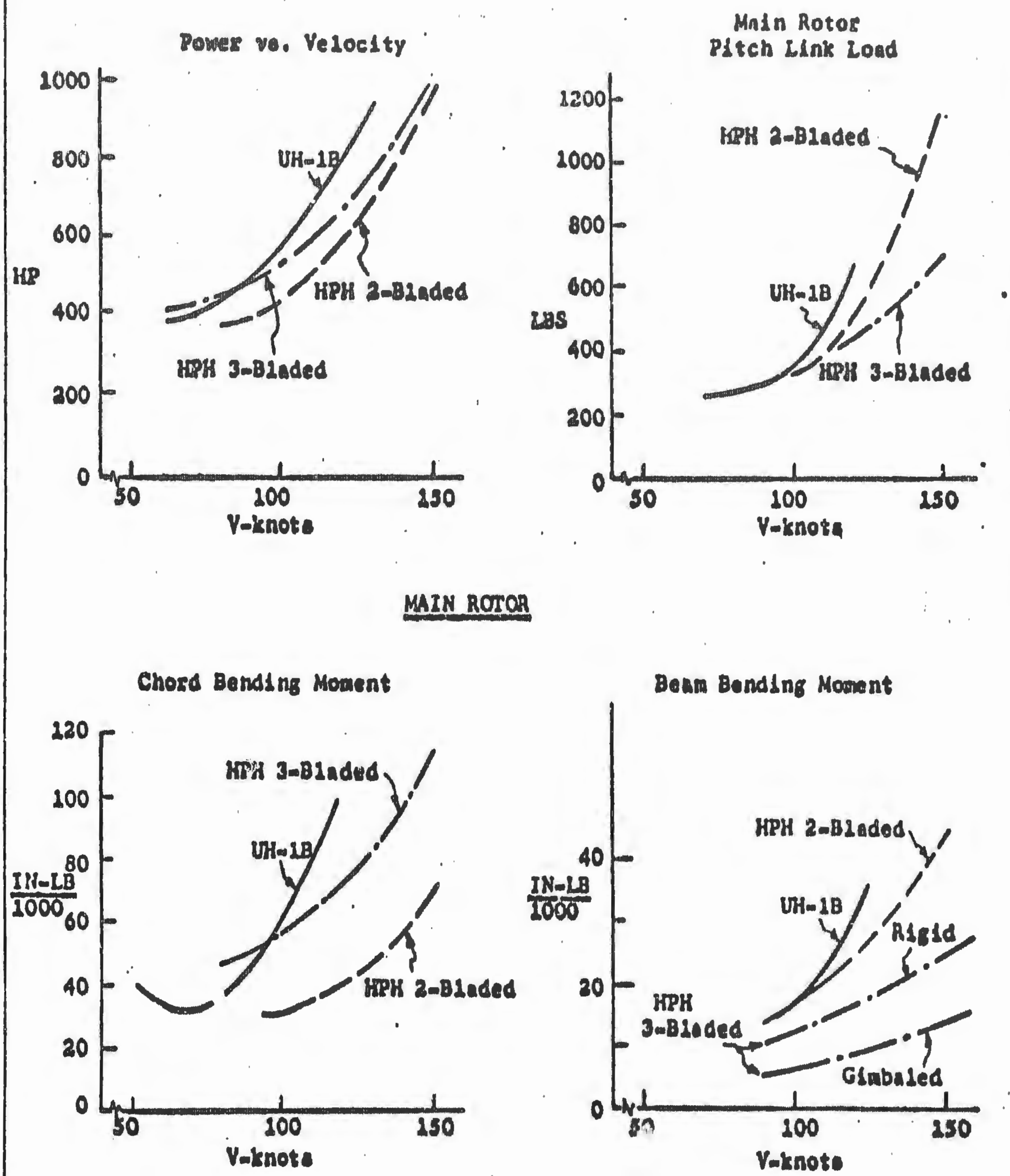
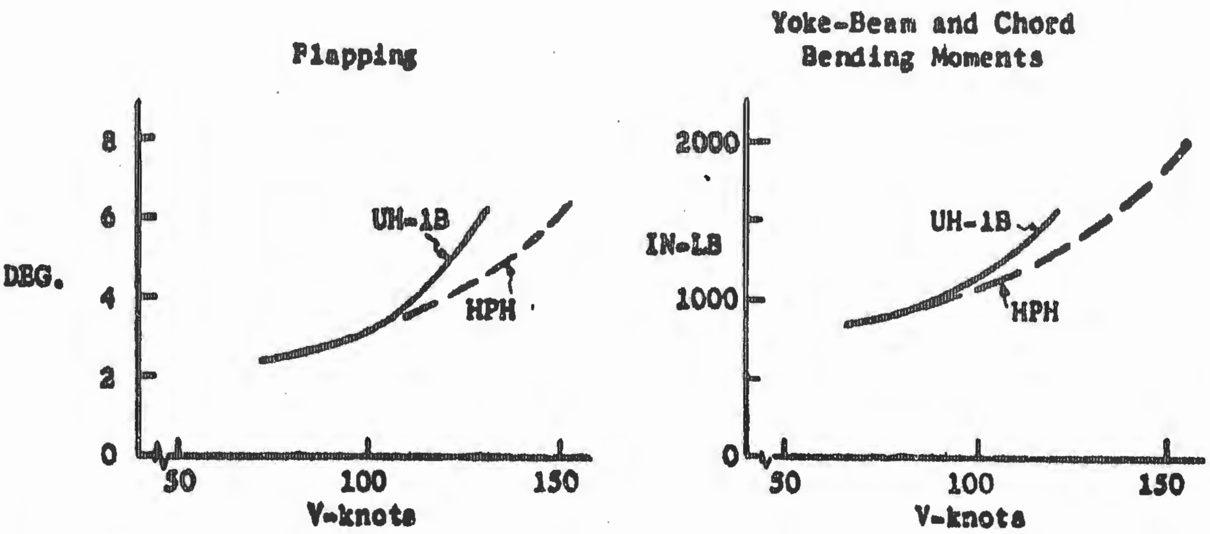


Figure 2

Summary of High Performance Helicopter
Flight Test Results

TAIL ROTOR



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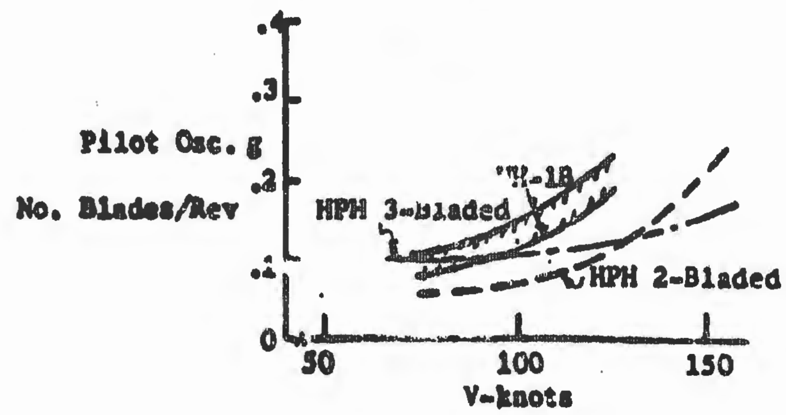
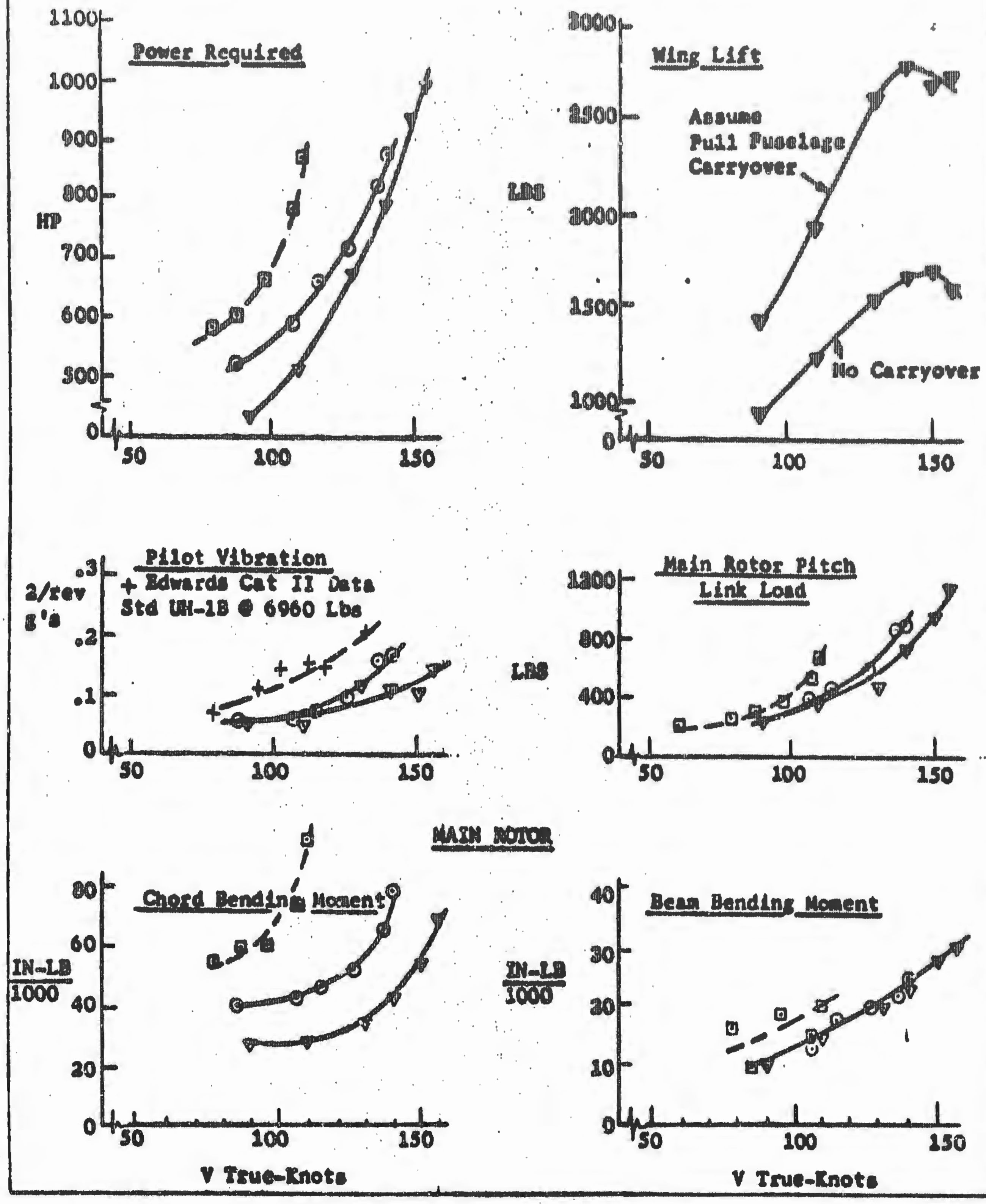


FIGURE 3

Effects of Wings on the High Performance Helicopter

⊡ Flt 303 Standard UH-1B, GW/σ' = 7580 Pounds
⊙ Flt 521 HPH, No Wing GW/σ' = 7400 Pounds
▽ Flt 524 HPH, With Wing GW/σ' = 7880 Pounds



Section 2 - The following pages present some of the preliminary data and interpretation on flights of the high performance helicopter with auxiliary propulsion. The auxiliary propulsion consists of two (2) J69-T-9 turbine engines rated at 920 pounds thrust each.

FLIGHT LOG FOR HPH - AUXILIARY PROPULSION

Flight 533 through 547 — Exploratory flight tests

Flight 548A — Performance - 2-Bladed Rotor, 4° Yoke, Bar

1. Cold Jets - 50-140 knots V_{true}, 6° Pylon

Flight 548B — [illegible] Bladed Rotor, 4° Yoke, Bar

1. 75% Jet rpm - 103-160 knots V_{true}, 6° Pylon
2. 80% Jet rpm - 125.5-163.5 knots V_{true}, 6° Pylon

Flight 549 — Performance - 2-Bladed Rotor, 4° Yoke, Bar

1. 98% Jet rpm - 147-166 V_{true} 6° Pylon
2. 75% Jet rpm - 142-1[illegible] V_{true}, 5°, 6°, 7° Pylon

Flight 550,551, and 552 — 3-Bladed Rotor Evaluation

Flight 553A — 2-Bladed Rotor, 2-3/4° Yoke, No Bar, Shakedown

Flight 553B — 2-Bladed Rotor, 2-3/4° Yoke, No.Bar, Performance

1. Cold Jets - 99-141 knots V_{true}, 6° Pylon

Flight 553C-2B — 2-Bladed Rotor, 2-3/4° Yoke, No Bar, Performance

1. 90%-95%-97% Jet rpm - 136-173 knots V_{true}, 6° Pylon

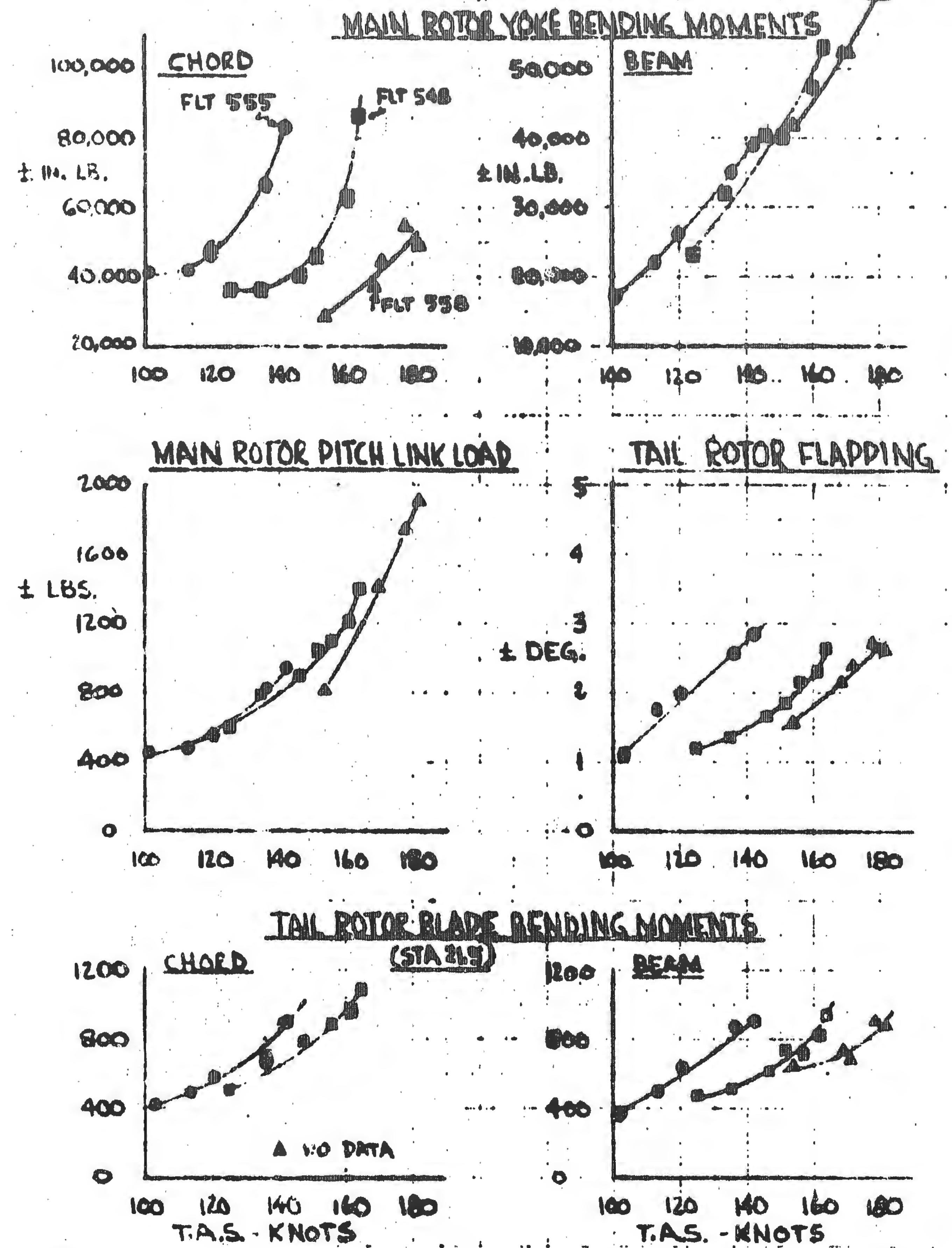
Flight 555 — 2-Bladed Rotor, 2-3/4° Yoke, No Bar, Performance, Stab

1. Idle Jets
2. Cold Jets

Flight 556, 557 — T/R Shakedown and Fuselage Attitude vs. Horsepower

Flight 558 — High Speed Performance to 182 knots

FIG. 4 HIGH PERFORMANCE HELICOPTER - AUXILIARY PROPULSION CONFIGURATION
APPROX GROSS WEIGHT 8200 LB., ● = COLD JETS, ■ ≈ 650 LB THRUST, ▲ ≈ 1600 LB THRUST



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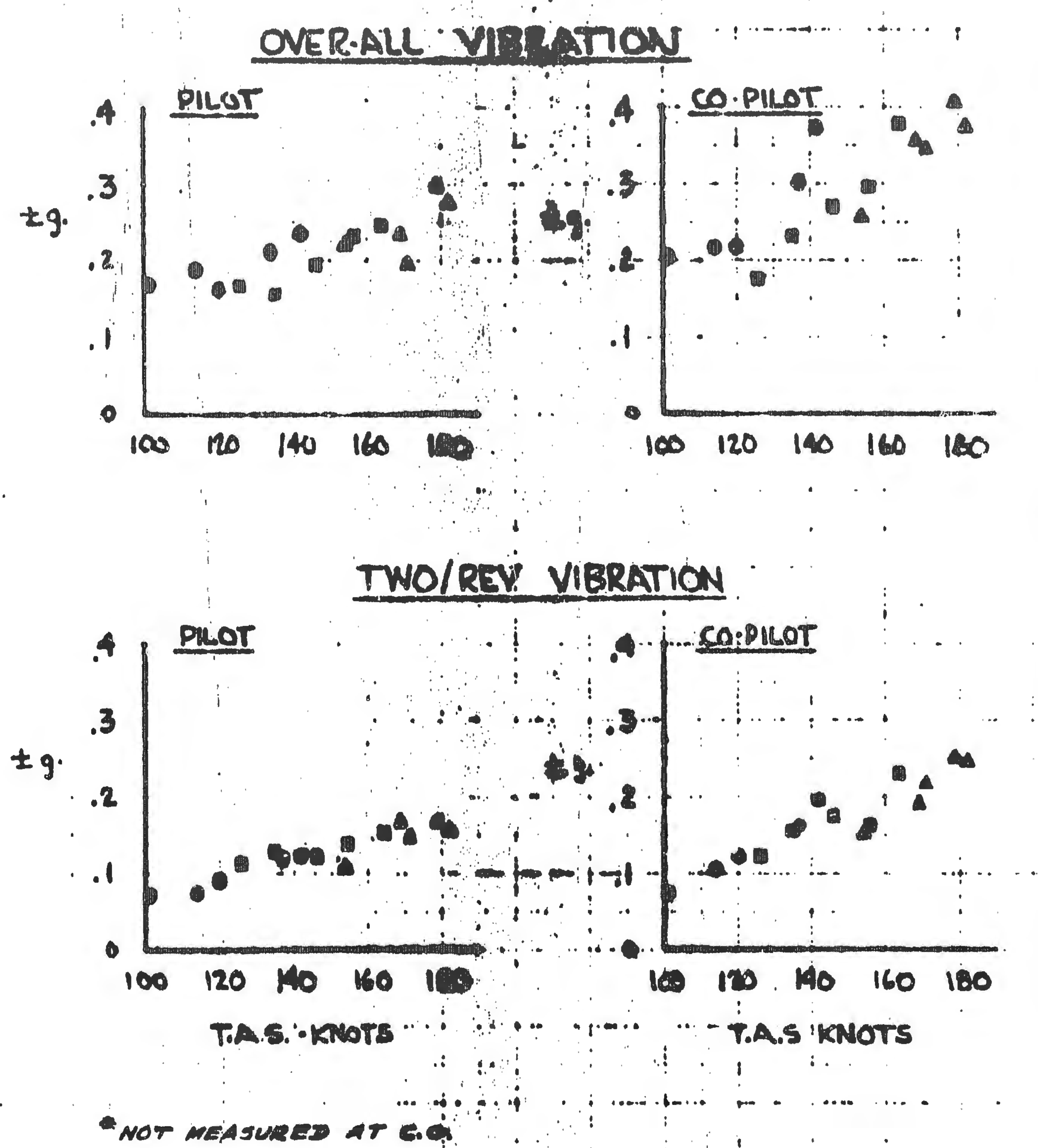
5 HIGH PERFORMANCE HELICOPTER-AUXILIARY PROPULSION CONFIGURATION

APPROX. GROSS WEIGHT = 8100 LBS.

● = COLD JETS FLT 555
■ = 650 LBS THRUST FLT 548
▲ = 1800 LBS THRUST FLT 558



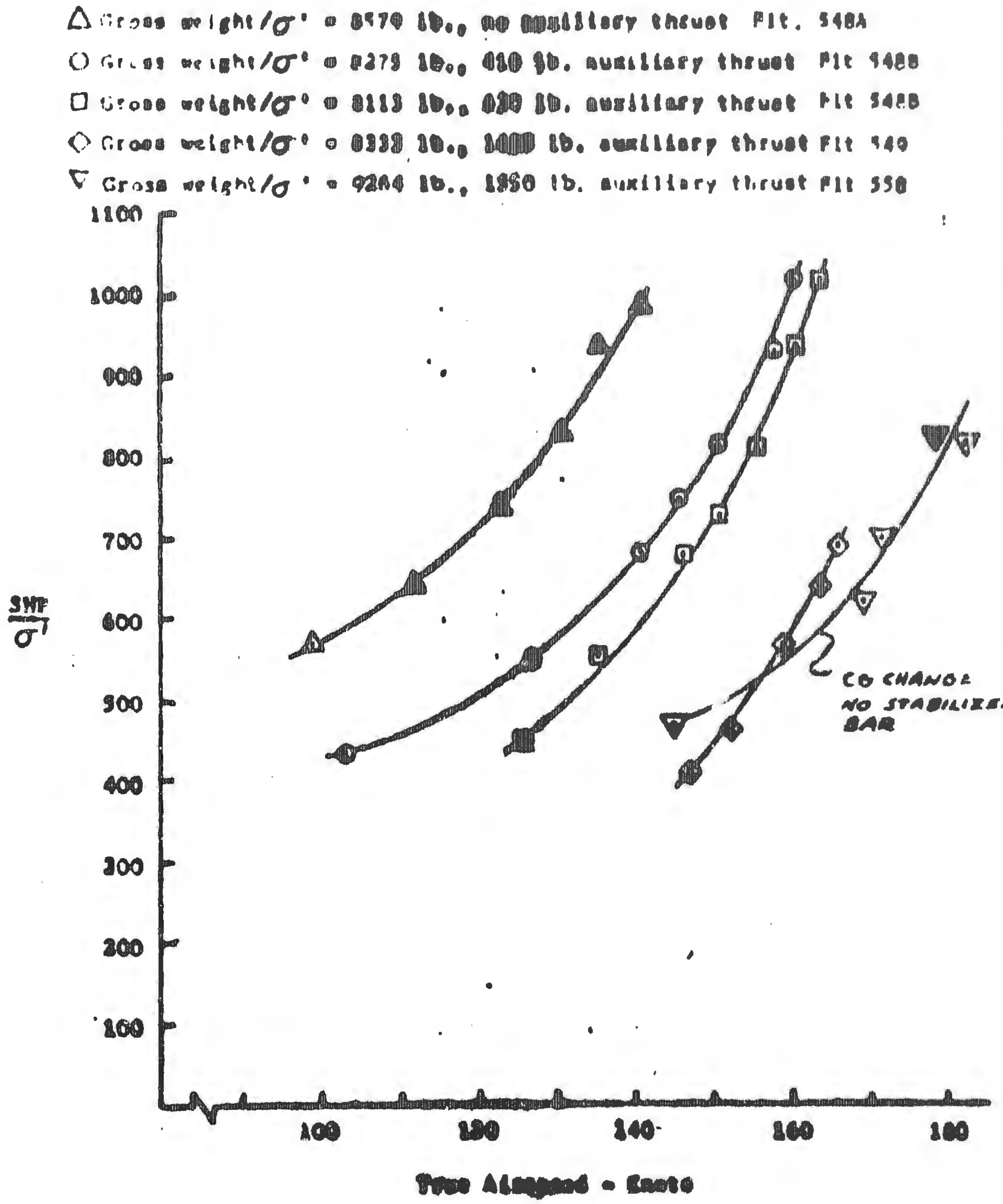


FIGURE 6. Power Required For Various Levels of Thrust

1. All flights except 550 are with stabilizer bar installed.

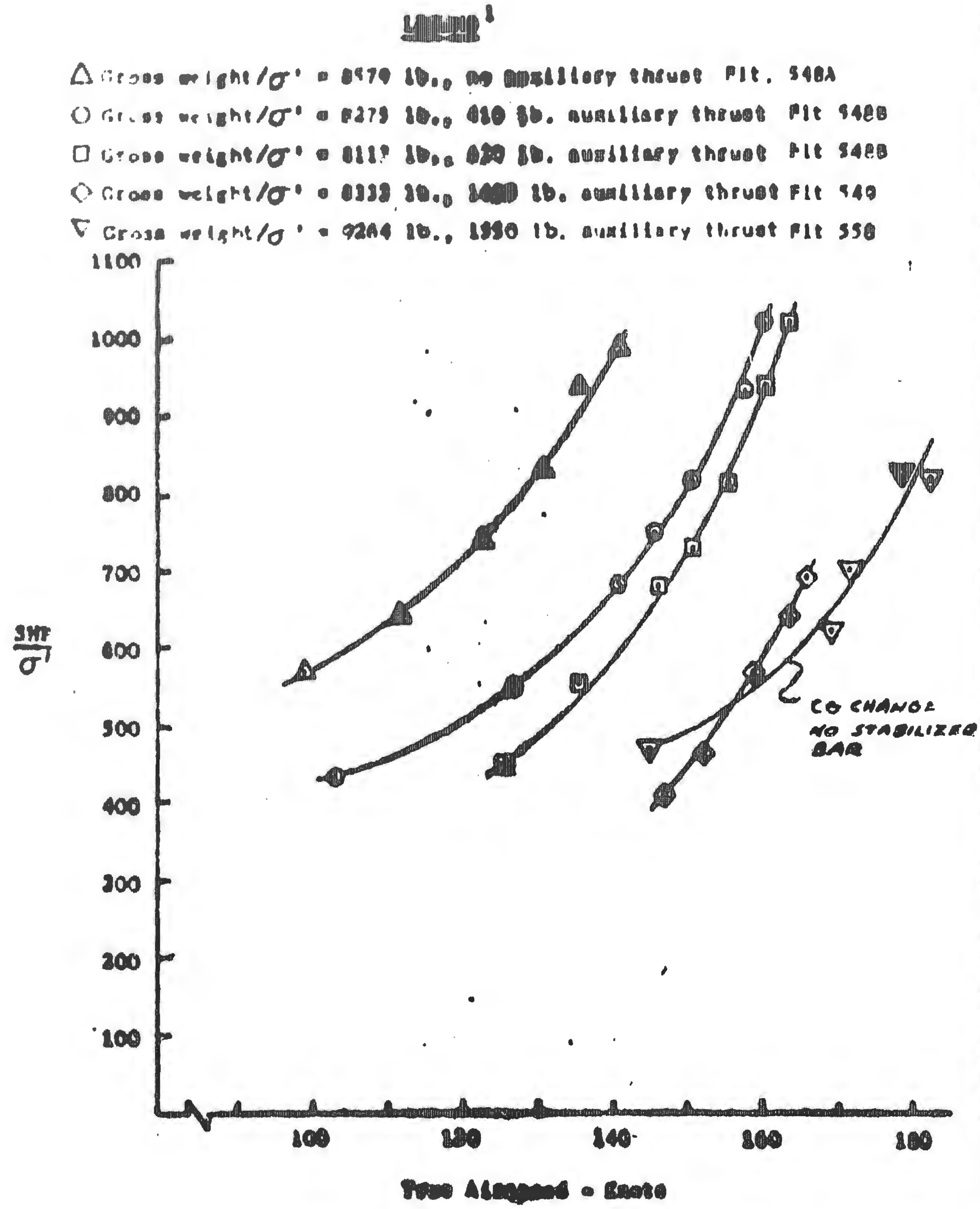


FIGURE 6. Power Required For Various Levels of Thrust

1. All flights except 558 are with stabilizer bar installed.

FIG. ? FUSELAGE PITCH ATTITUDE vs VELOCITY FOR VARIOUS THRUST LEVELS

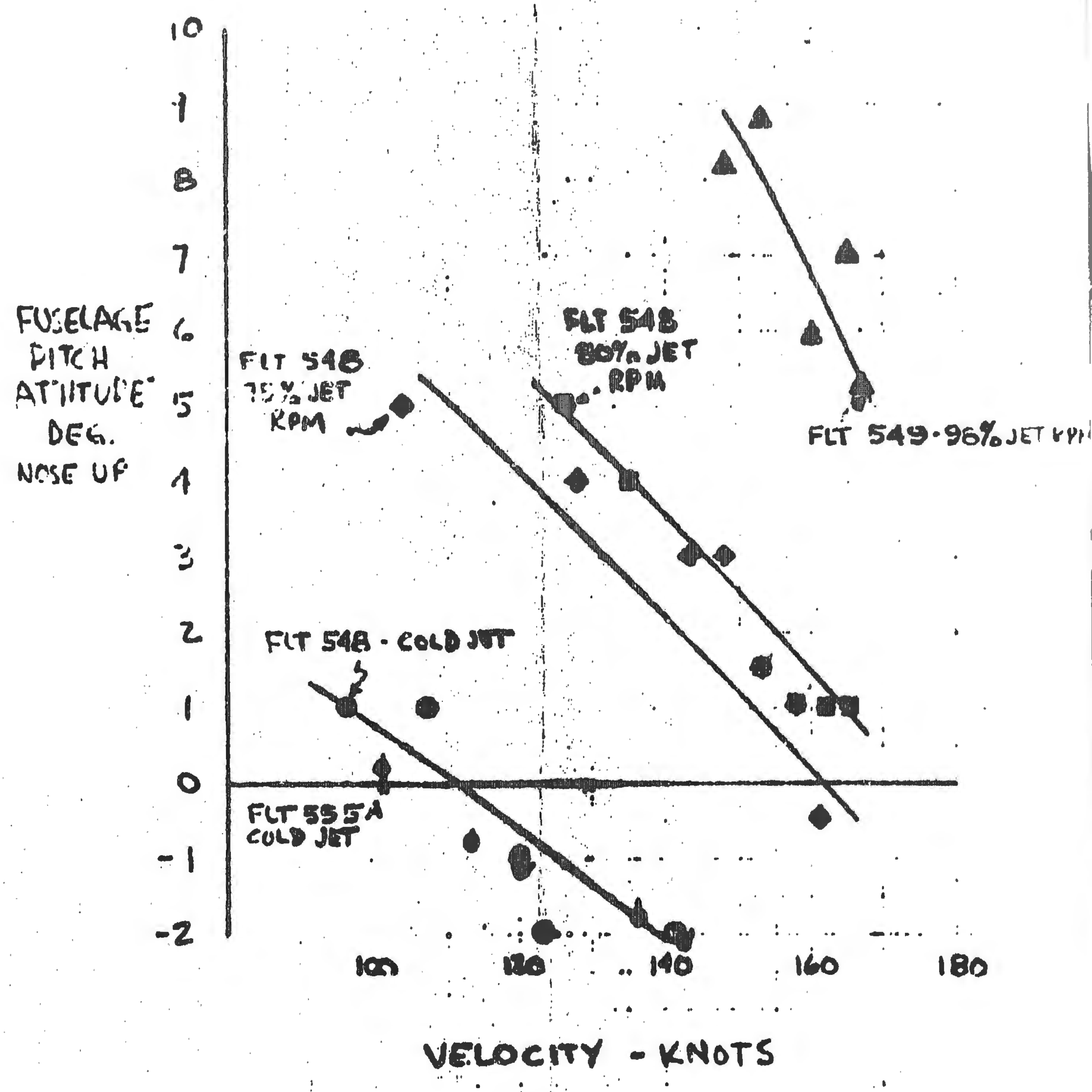


FIG 8 - INFLUENCE OF FUSELAGE ATTITUDE
AT 140 KTS. AND 650 LBS. JET THRUST

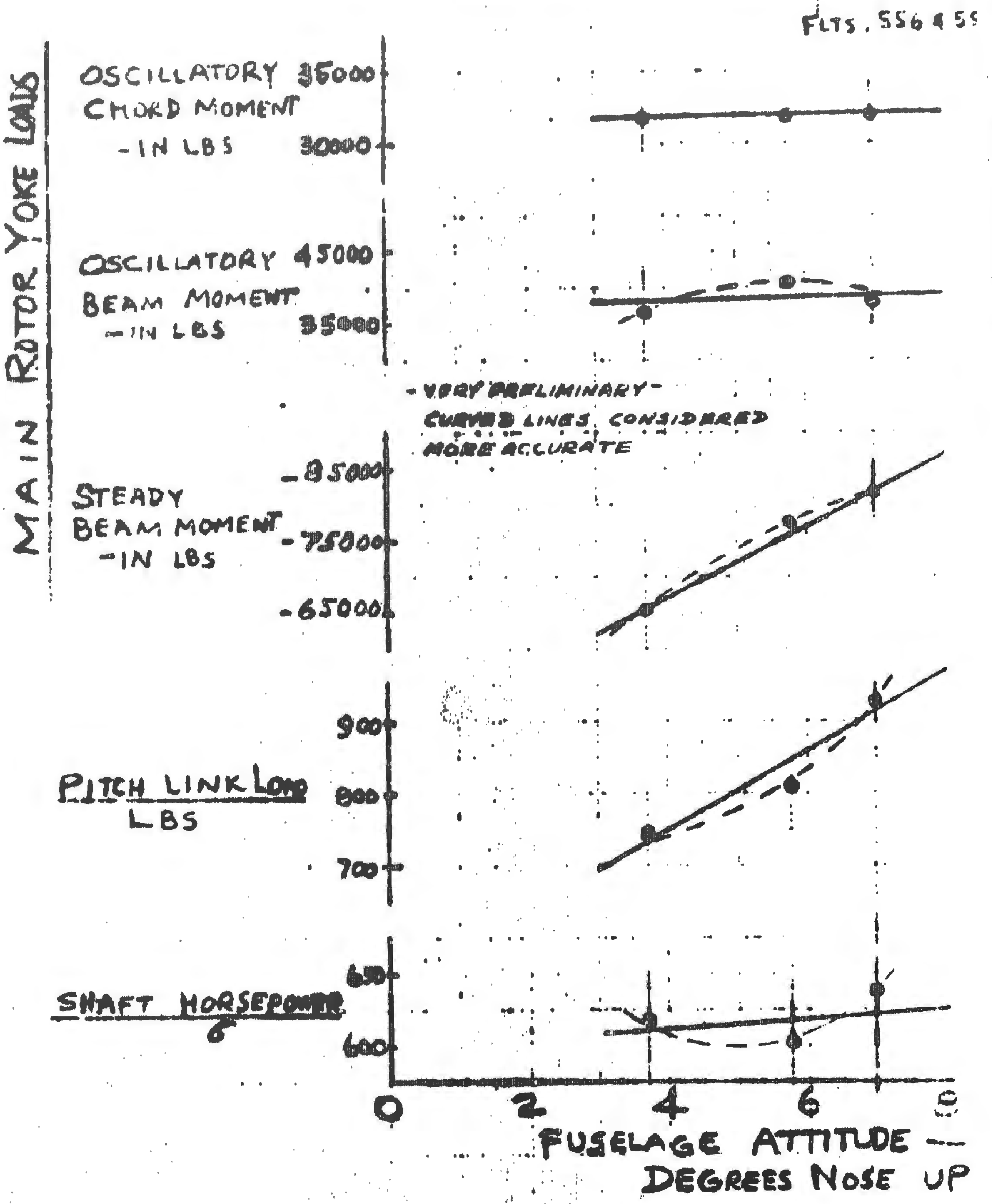
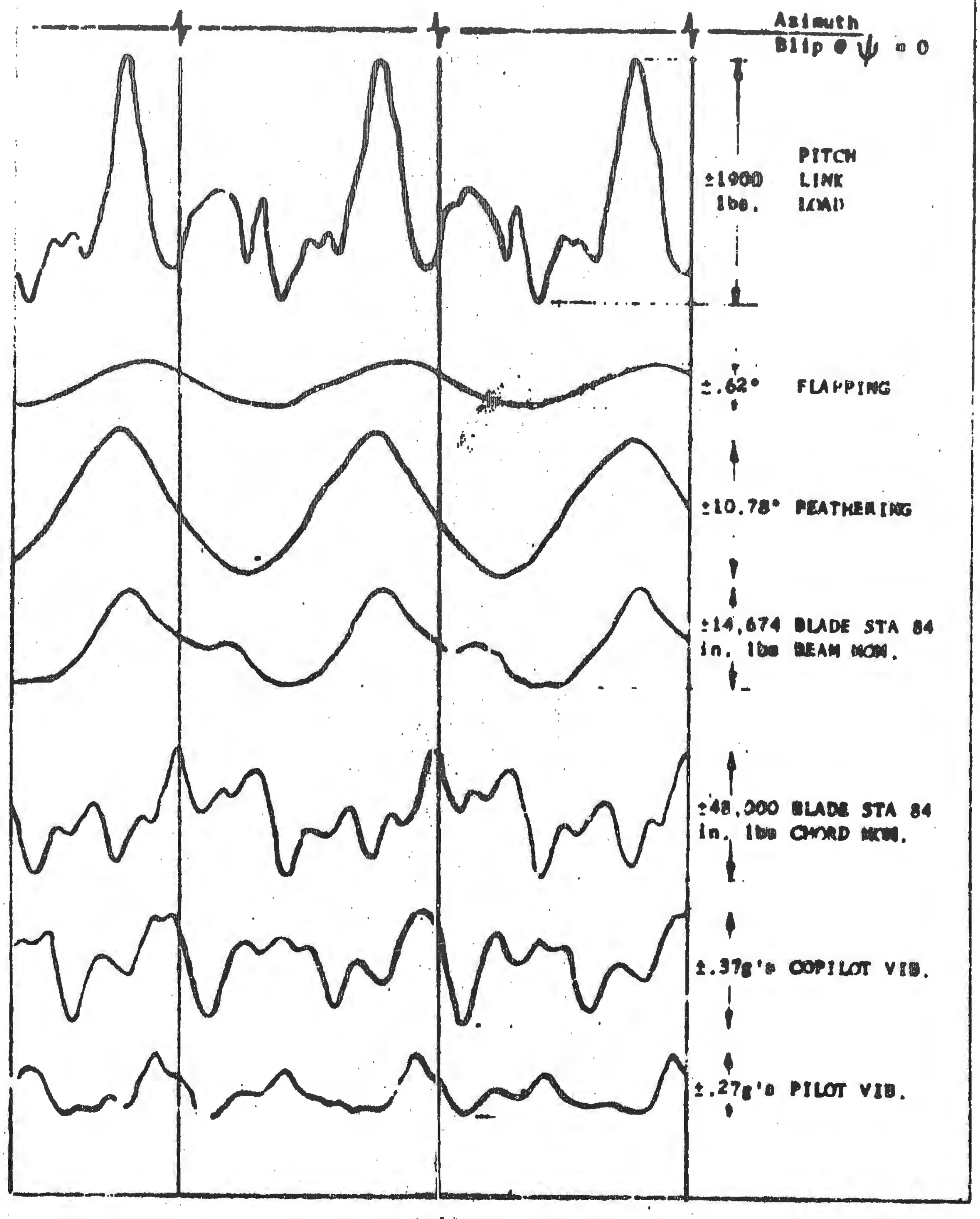


FIG. 9 — HPH OSCILLOGRAPH TRACES AT 182 KTS. TRUE AIRSPEED

FLIGHT NO. 568 GW/σ = 9100 LBS.



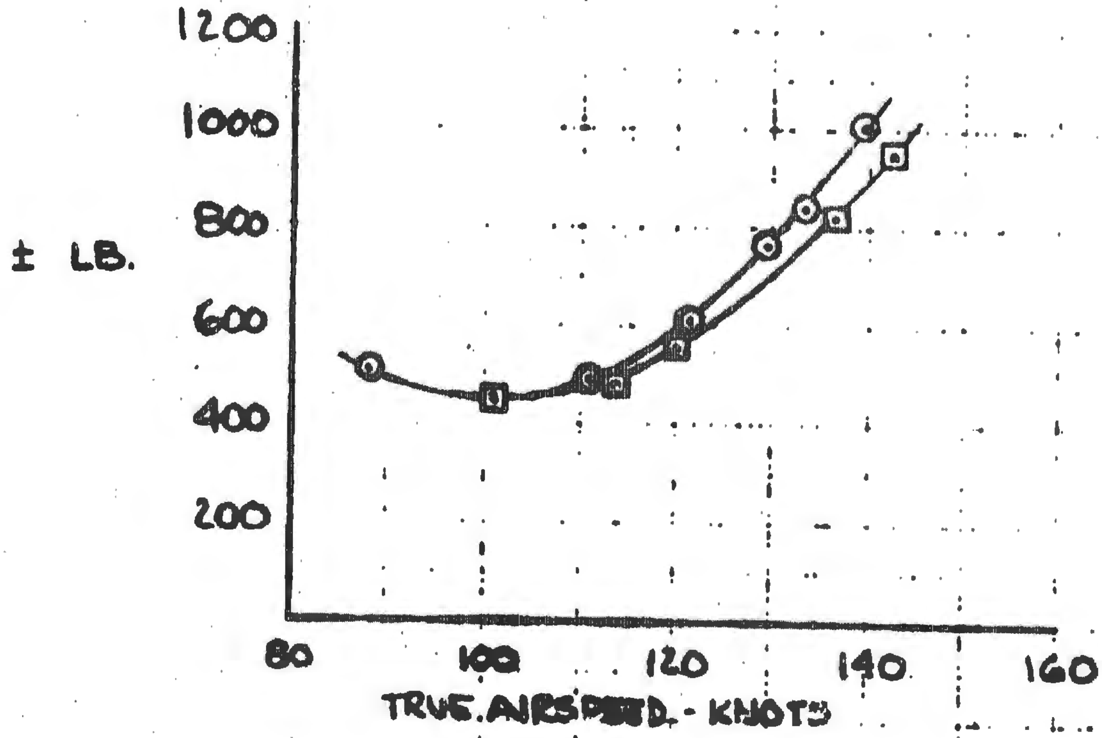
EFFECT OF YOKE PRECONE ON CONTROL LOAD

OSC. PITCH LINK LOAD vs VELOCITY

○ 4° PRECONE · G.W. · 7748 LB, C.G. 128.68 FLT 546

□ 2¾° PRECONE · G.W. 8096 LB C.G. 128.25 FLT 555

AUX. PROPULSION CONFIGURATION · NO STABILIZER BAR-COLD JET



PRELIMINARY DRAG ESTIMATE

Net Drag

Based on comparison of Flights 468A (Pg. 57) and 548A, the net Δf (Basic Aircraft and with Cold Jets, et al) for several airspeeds are:

V, Knots	Net Δf, square feet
100	3.5
120	3.2
140	3.12

ESTIMATED DRAG BREAKDOWN (120-140 Knots)

ITEM	Δf SQ. FT.	REF.
Blade Cuff	-1.0	8025- 99-012
3 Elevator Installation	.2	Est.
(Aft Elevator + Cable on Std)	-	
Jet Engines Installation	2.9	Est.
Basic		
Induced (for condition considered*)	1.1	Est.
Interference	.3	Est.
Net Drag Increment	3.5	

*Induced drag of Jet-Pylon-Fuselage is estimated to be equivalent to 750 lbs lift for each 10,000 in. lbs, blade beam, moment change. This with an assumed L/D = 6 gives an approximation to the induced drag. At 160 Knots with 98% rpm on jets, the induced drag on this basis is 6.7 square feet.

Ref: Figure 11, page 18

The steady component of main rotor yoke beam bending moment is indicative of lift the rotor is producing. The yoke beam bending moment and corresponding fuselage attitude for level flight are plotted on figure 11 versus true airspeed.

The data on figure 11 show that as jet thrust increases, the helicopter flies more nose up. The bending moment data go more negative as the nose comes up, indicating a reduction in rotor lift.

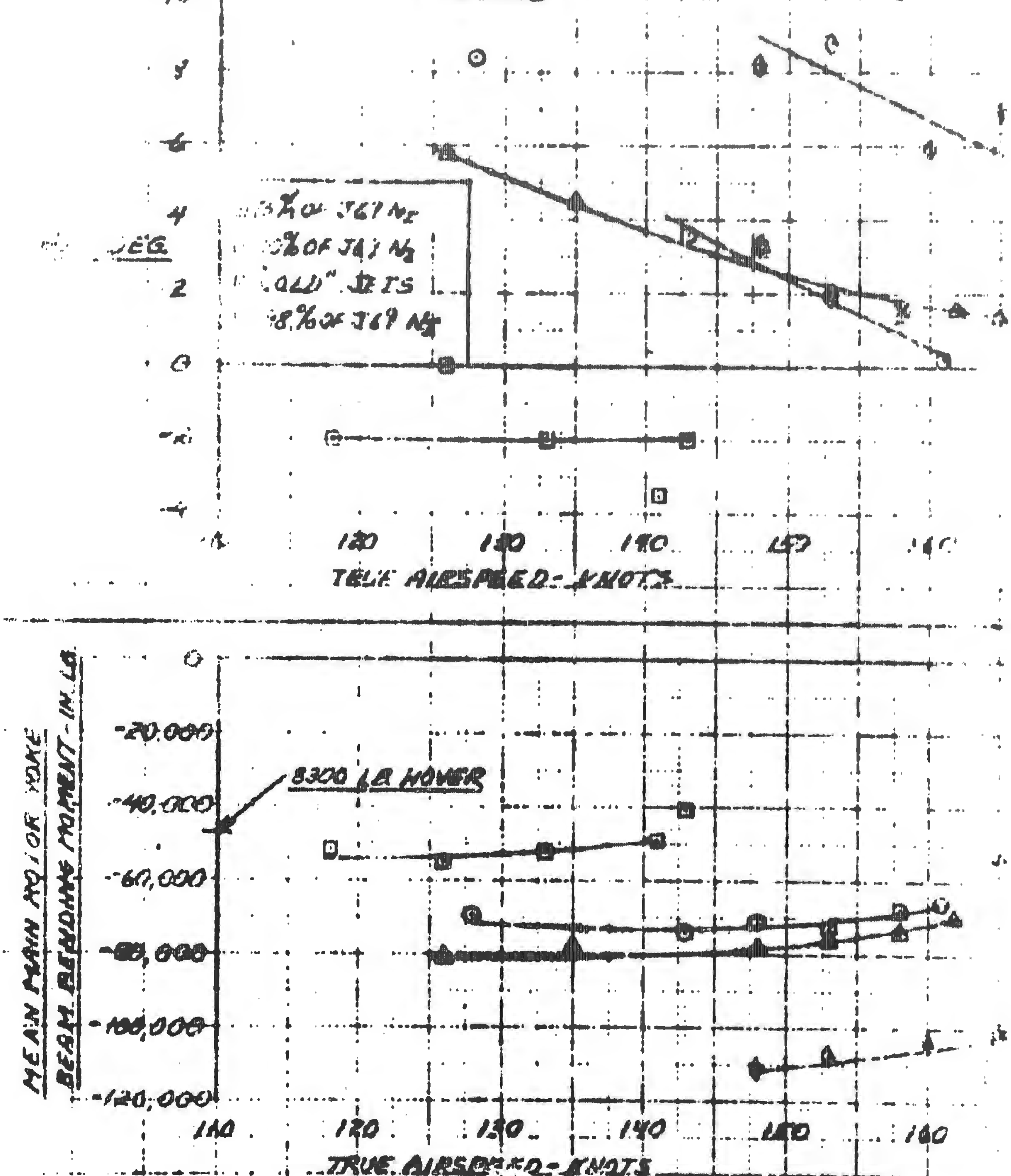
The reduction in rotor lift indicated by the bending moment change when fuselage attitude is increased is due to change in elevator load, lift on the fuselage-nacelle-fairing combination and to the vertical component of jet thrust.

STEADY COMPONENT OF MAIN ROTOR YOKE BEAM BENDING MOMENT AND FUSELAGE ATTITUDE VS. TRUE AIRSPEED

- LEVEL FLIGHT

- GW=8300 LBS

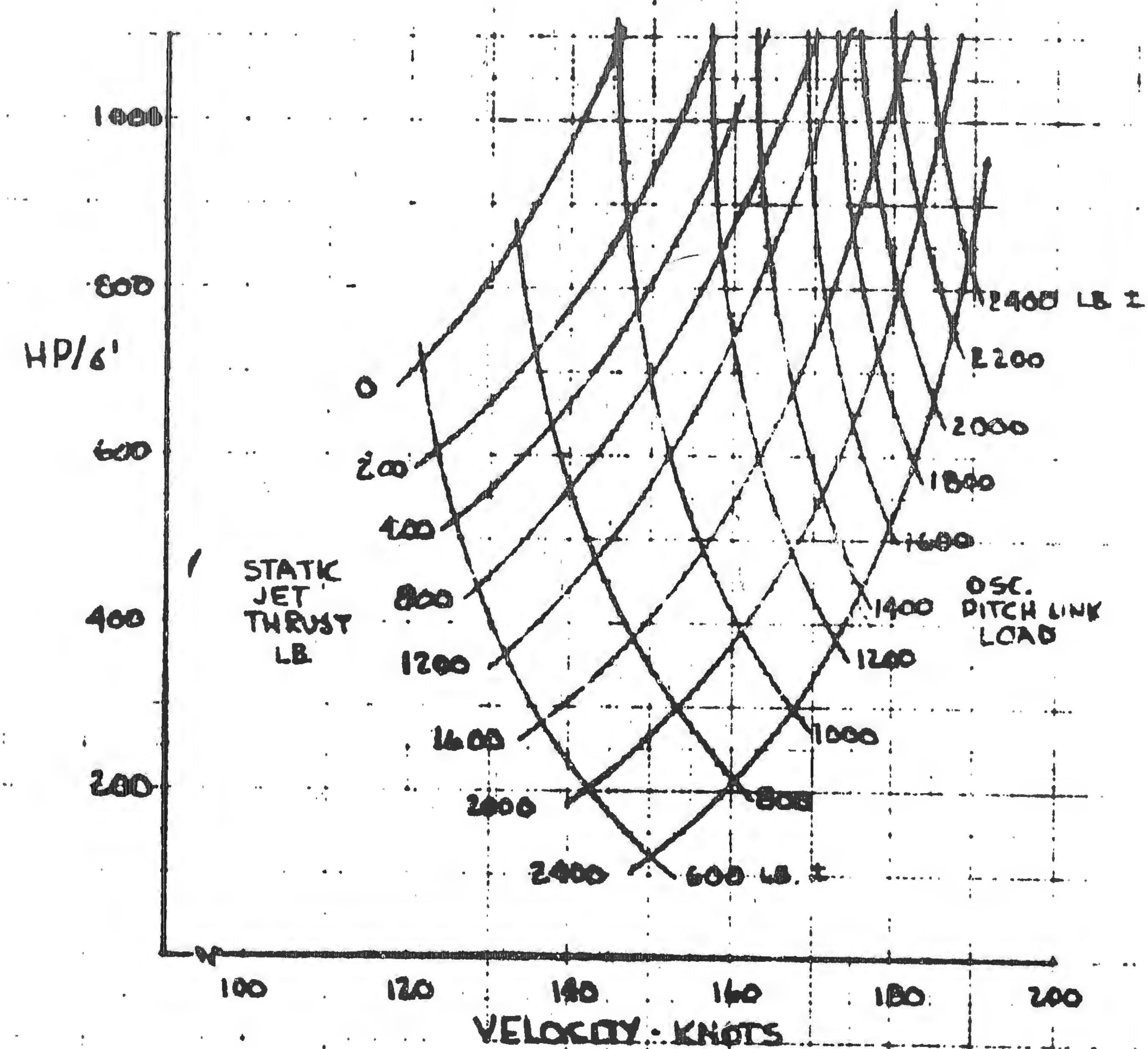
- 4° PRECONE



CONSERVATIVE WORKING

Estimated oscillatory pitch link loads versus airspeed for various combinations of auxiliary propulsion and shaft horsepower.

Approximately 8200 Lbs. Gross Weight



NOTE: Data shown are conservative & used for planning maximum performance flight.

Data based on Flights 548, 549, and 553

[redacted]

Section 3 - The following pages present some of the problems encountered in testing of the auxiliary engine configuration. These problems were not monumental and were not detrimental to the technical achievement of the flight test program. However, it is felt that exposition of the encounter and subsequent resolution of these problems is vital to all compound helicopter efforts in light of the technical interrelationship of rotary wing aircraft and the nature of research flight test programs.

PROBLEMS ENCOUNTERED

General Problems

Cooling Jet Engines in Hovering - Jet engine nacelles temperature exceeded limits during tiedown and hovering checks. Ejector cooling system designed, fabricated, and installed. Problem corrected.

Interference Drag - Interference between jet nacelles and fuselage resulted in Δ drag of about 3-4 sq. ft. New engine pylon fairing designed, fabricated, and installed. Problem corrected.

Jet Engine Resonance at 2 and 4/Rev - Response characteristics of jet engine installation resulted in near resonant conditions at 2 and 4/rev. A reinforcing strut between wing support and engine support together with the new fairing structure corrected the problem.

Problems With Two-Bladed Rotor

Pylon Rock - Lateral pylon rock encountered. Lateral damper installation designed, fabricated, and installed. Problem corrected sufficiently to allow program to continue. Incipient pylon rock still exists. Controls coupling parts to provide rotor damping fabricated not tested.

Stability and Controllability - Stability problem encountered due to elevator location. Pin mounted elevator designed, fabricated, and installed. Major improvement; however, additional elevator area required for stability and coupled elevator required for acceptable controllability in autorotation. Standard B elevator installed in tail boom location. Cable used to reduce elevator loads. Problem corrected; however, a single elevator controllable configuration located on fin just under tail rotor or at standard station over tail rotor drive shaft is needed. Preliminary design accomplished.

High Control Loads - High controls loads encountered. Critical component remade out of steel. Low precone yoke installed to reduce controls loads. Flights continued. Critical belts replaced after each flight. Required changes to eliminate this problem designed and in work. Flap on inboard section of blade designed and constructed. Low twist blades being considered.

Tail Rotor - Tail rotor changed due to high beamwise loads.

Weather - Numerous delays encountered due to weather. Due to the critical nature of the testing to establish stability and control and explore new regions, tests had to be conducted in smooth air. This normally limited flying time to the first few hours after dawn.

The weather requirements were particularly severe as low temperature could result in extremely high Mach number on advancing blade at anticipated maximum speed condition (.989). Mach number effects could increase control loads. Maximum performance flight delayed over a week due to this.

. Elevator Installation - Two elevator panels were destroyed and the flights program delayed when in the course of changing configurations, the tubular spars galled and seized in the support casting mounted in the tail boom. The parts had to cut apart to be removed. Due to the numerous configuration changes and frequent disassembly for inspection in research, problems of this type are to be expected.

Problems With Three-Bladed Rigid Rotor

While awaiting new controls part, the three-bladed rigid rotor was installed. Rotor and Controls loads were found to be acceptable; however, it was found that an aft c.g. was required for vibration reasons and a forward c.g. was required for stability reasons. The reduced angle of attack stability of the rigid rotor made the stability problem mor severe than with the flapping rotor. To correct these problems wou have required a new elevator configuration (similar to the one s) mentioned for the two-bladed rotor), shake tests and rework to readjust the fuselage response, and about a month's additional flight tests. At this point, the two-bladed rotor was reinstalled and the program continued.

Routine Type Problems Encountered

1. Jet engine electrical wiring reworked and rerouted.

2. Throttle system reworked, strengthened, and moved to better location.

3. Tail pipe temperature indicator was found to be defective.

4. Delay in getting fuel pressure indicator from GFE.

5. A special thermocouple probe had to be made for calibration of the EGT system.

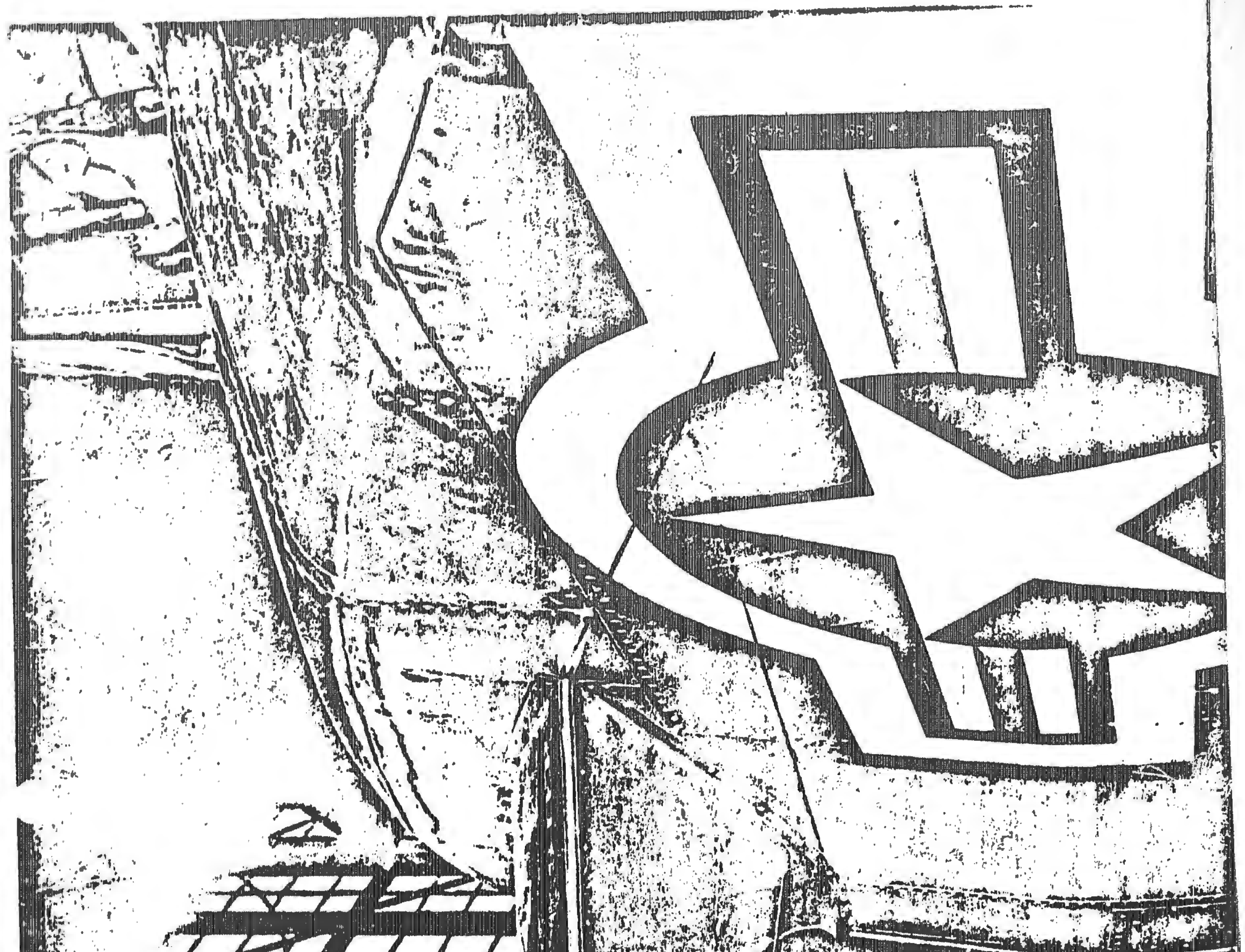
6. Preventative maintenance on instrumentation and ship during buildup.

7. Fuel line replaced due to faulty installation.

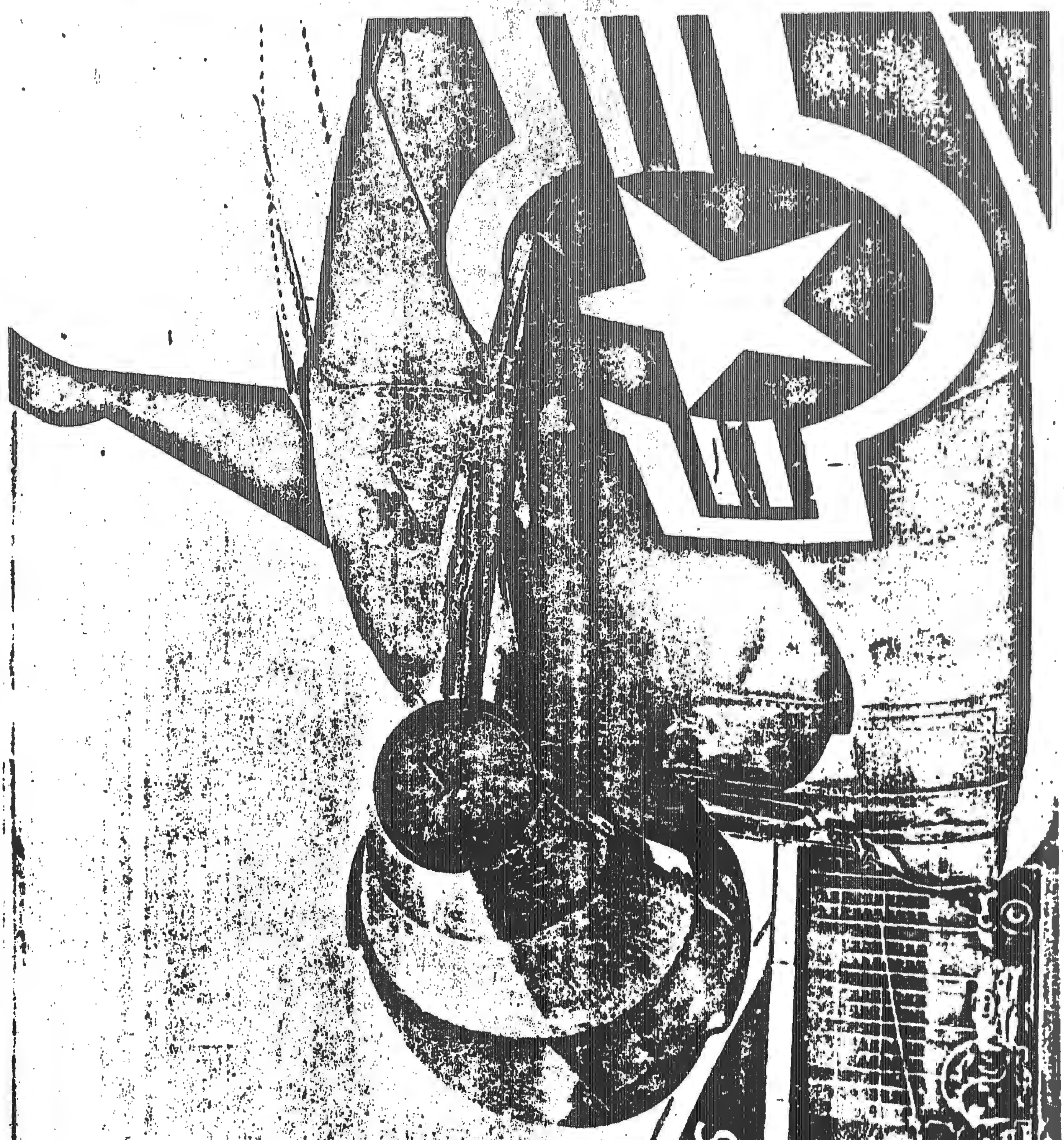
8. Miscellaneous components such as fuel boost pressure pump required reworking.

9. High frequency required shake test to isolate and correct.

10. Some of the stability and control and high load problems which were encountered had been anticipated; however, they were much more severe than expected.



BEFORE MODIFICATION



AFTER MODIFICATION

Vibration of Jet Engine Support Structure

Flight tests of the high performance helicopter with auxiliary engines showed that severe 2/rev and 4/rev vibrations of the left engine occurred. A mechanical shaker was attached to the cabin floor aft of the co-pilot's seat and the helicopter was excited from 8-23 cps.

Several conditions were checked to determine the effect of various mounting conditions. All cowling was removed and a vibration damper installed on the forward engine mount inside the cabin. This was the flight condition of most severe vibration level. Several other conditions with forward supports disconnected were checked for effect on the 2/rev response. Results indicated that vibration level could not be decreased significantly by simply softening the forward mounting.

With damper installed, torsional vibration of the engine near both the 2/rev and 4/rev range were pronounced and the amplication was relatively high. Small amounts of excitation excited a relatively large amount of engine vibration. Removal of damper resulted in an increase in resonant frequency of the first torsional mode to the upper range of 2/rev. Substitution of a stiff brace for the damper raised the first torsional mode well above the 2/rev range but the second torsional mode occurred at the upper range of 4/rev. Addition of engine to fuselage cowling had a noticeable effect on the amplitude of vibration. Less amplitude was noted with the cowling in place.

Since numerous resonance modes of the mounting system occur in the 2/rev range, difficulty would be encountered in softening or stiffening the mounting system sufficiently to isolate the frequencies to either above or below this range. Addition of the engine-fuselage cowling reduced the amplication of the vibration significantly to permit continued flight tests.

ADVANCING TIP MACH NUMBER 44 FT. ROTOR