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FTC-TR-70-8

FTC-TR-70-8

AD894406

AFFTC

CATEGORY II PERFORMANCE AND FLYING QUALITIES TESTS OF THE HH-53C HELICOPTER

-SUPPLEMENT-

COLD WEATHER HOVER PERFORMANCE

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TECHNICAL REPORT No. 70-8

APRIL 1971

Distribution limited to U.S. Gov't. agencies only; Test and Evaluation; 28 MAY 1972. Other requests for this document must be referred to

[redacted] ASD (SDQW), Wright-Patterson AFB, Ohio 45433.

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DEPARTMENT OF THE AIR FORCE

HEADQUARTERS AERONAUTICAL SYSTEMS DIVISION (AFSC)

WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

REPLY TO ATTN OF: ASD/SDQH 5-10 (Maj Thompson/54921/cal/H-53/R&D 9-2)

SUBJECT: ASD Addendum to FTC-TR-70-8 Supplement H-53 Cold Performance

TO: Recipients of FTC-TR-70-8 Supplement

This report is a part of and should remain attached to FTC-TR-70-8 Supplement, evaluation of the H-53 "Cold Weather Hover Performance". Paragraph numbers below correspond to the recommendations in the AFFTC Technical Report.

1. Concur. However, the data obtained in this program is presented in such a form that further data analysis is an unavoidable requirement in the process of updating the flight manual. ASD/SDQH has negotiated a commercial contract to accomplish this task. All other performance data available will be reduced concurrently, to update the entire appendix simultaneously.

2. Concur with intent. With the test data available, the range of the hover chart can be extended to minus 5,000 feet density altitude. In the data analysis process, every effort will be made to extend the hover performance prediction capability, possibly as far as minus 10,000 feet density altitude. In addition, cruise data will be extended downward to the extent feasible for operations in extreme cold.

FOR THE COMMANDER

William D Eastman Jr

WILLIAM D. EASTMAN, JR., Lt Col, USAF
Chief, Helicopter Program Office
Directorate of Combat Systems
Deputy for Systems

PRIDE IN THE PAST FAITH IN THE FUTURE

FTC-TR-70-8

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[redacted] ASD (SDQH), Wright-Patterson AFB, Ohio 45433.

FOREWORD

This report presents the results of the cold weather hover performance tests of the HH-53C helicopter, USAF serial number 68-10354. Testing was conducted between 8 January and 26 February 1971 at Eielson Air Force Base, Alaska, and Fort Greeley, Alaska in conjunction with the HH-53C cold weather tests, under the authority of AFFTC Project Directive 71-24.

The authors of this report wish to express their appreciation to Mr. Edward I. Seto for his assistance with the engineering analysis.

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ABSTRACT

The cold weather hover performance tests were conducted in conjunction with the cold weather tests of the HH-53C helicopter. Interpretation of the results of this test along with previous Category II tests resulted in an adjustment to the hover performance data presented in FTC-SD-70-8. The results of this report should be used to update the Flight Manual.

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list of abbreviations and symbols

Item	Definition	Units
A	rotor disk area	ft^2
C_P	power coefficient	- - -
C_T	thrust coefficient	- - -
M_{TIP}	advancing blade tip Mach number	dimensionless
R	rotor radius	ft
SHP	shaft horsepower	$\frac{550 \text{ ft-lb}}{\text{sec}}$
W	gross weight	lb
ρ	air density	slug per ft^2
Ω	rotor angular velocity	rad per sec

INTRODUCTION

Previous HH-53C hover performance testing (FTC-TR-70-8) partially defined rotor blade compressibility and resulted in the recommendation that additional testing be conducted to more completely define this effect.

The HH-53C is a rescue-equipped, twin-engine, six-bladed, fully articulated rotor helicopter, manufactured by Sikorsky Aircraft, Division of United Aircraft Corporation, at Stratford, Connecticut. The aircraft is powered by two General Electric T64-7 engines with an uninstalled, non-flow limited, rating of 3,925 SHP at sea level standard day. Design rescue mission gross weight is 37,399 pounds with a maximum gross weight of 40,750 pounds.

TEST AND EVALUATION

Hover performance was evaluated at wheel heights of 100, 80, 47, 22 and 10 feet. Performance tests at two different M_{TIP} values were flown at all wheel heights except 80 feet. Both tethered and free flight hovering techniques were used during testing. No testing was accomplished in winds above 2 knots.

Previous data for the HH-53C (FTC-SD-70-8, reference 1) were presented without a plot of wheel height versus C_P for lines of constant C_T. In correlating the data acquired during the cold weather tests with the previously published data (FTC-SD-70-8), it was necessary to construct a crossplot combining data from both tests.

The Flight Manual's Indicated Torque Required to Hover chart (A-7) was in error. It showed torque up to 11-percent higher than was actually required. Interpretation of the results of this test along with previous Category II tests resulted in an adjustment to the hover performance curves presented in FTC-SD-70-8, figures [illegible] through [illegible], appendix I. The data presented in this report (figures 1 through 12) should be used to update the Flight Manual. (R 1)[1]

Minus 6,000 feet density altitude days were a frequent occurrence during the test program and density altitudes below minus 9,000 feet were encountered. In such cases the Indicated Torque Required To Hover chart (A-7) in the Flight Manual did not have sufficient range to be used for the conditions encountered. The range of this chart should be increased to minus 10,000 feet density altitude to provide adequate range for low-altitude, cold weather operation. (R 2)

[1]Numbers indicated as (R 1), etc., represent the corresponding recommendation numbers as tabulated in the Conclusions and Recommendations section of this report.

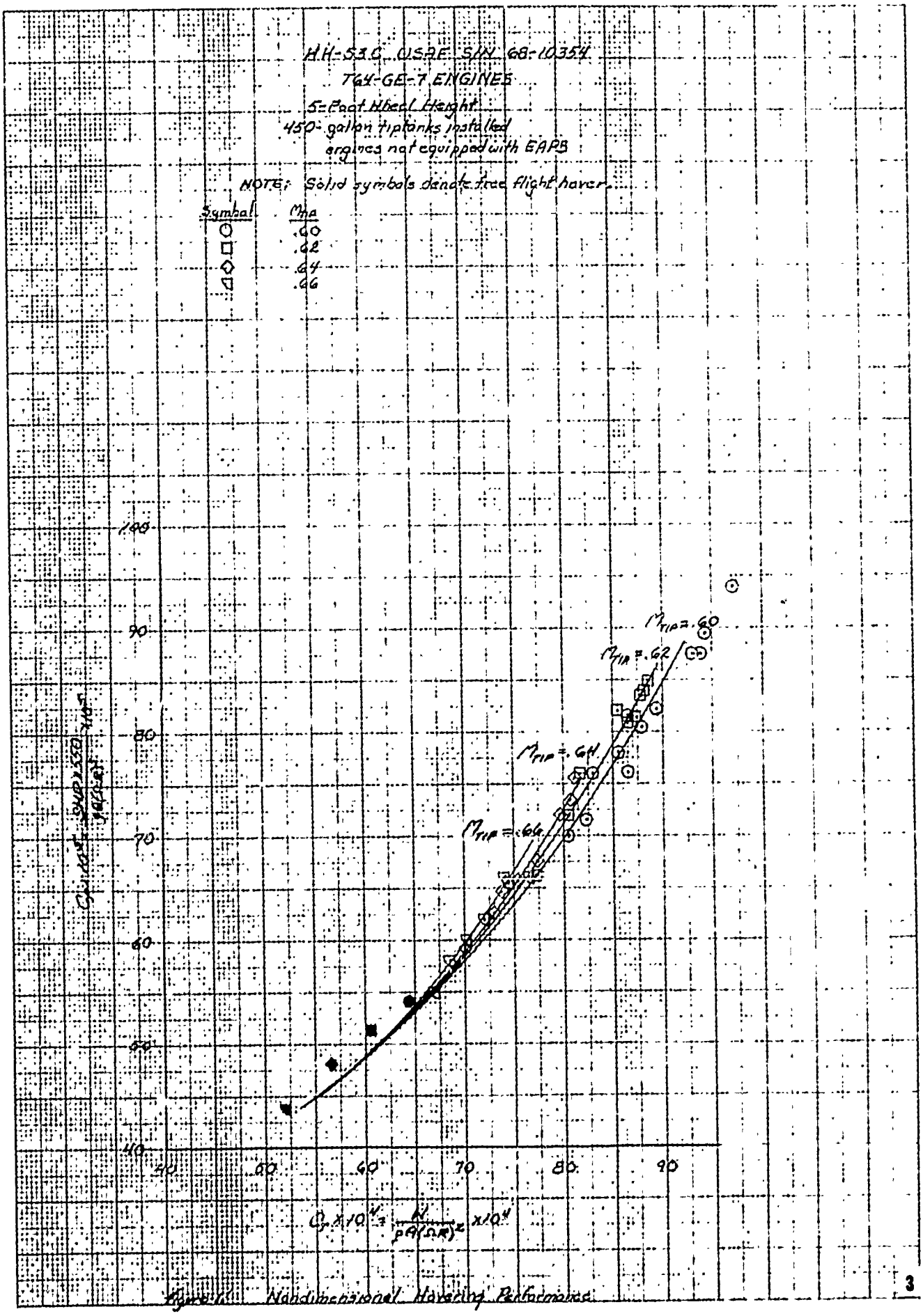


Figure 11. Nondimensional Hovering Performance

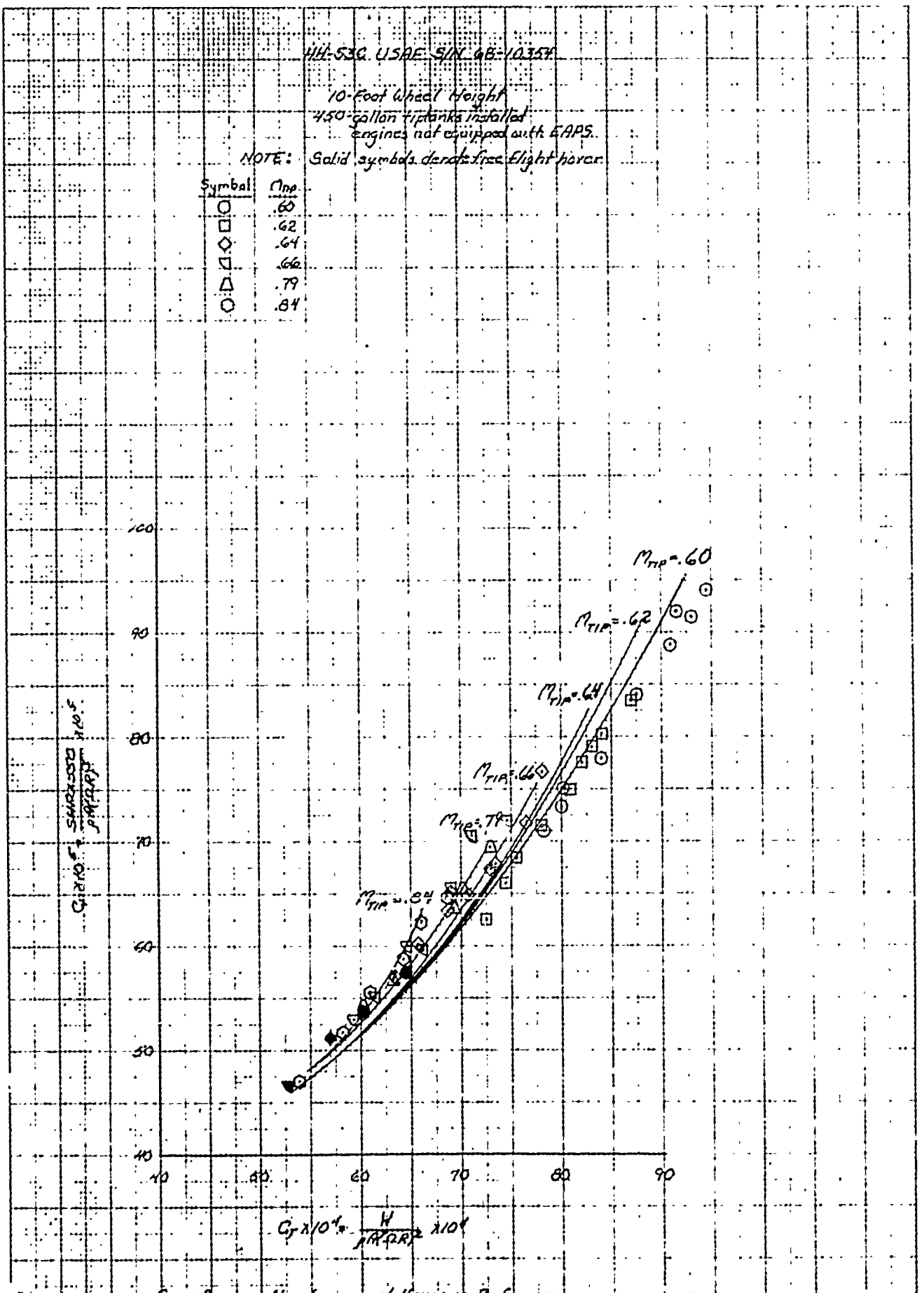


Figure 8. Nondimensional Hovering Performance

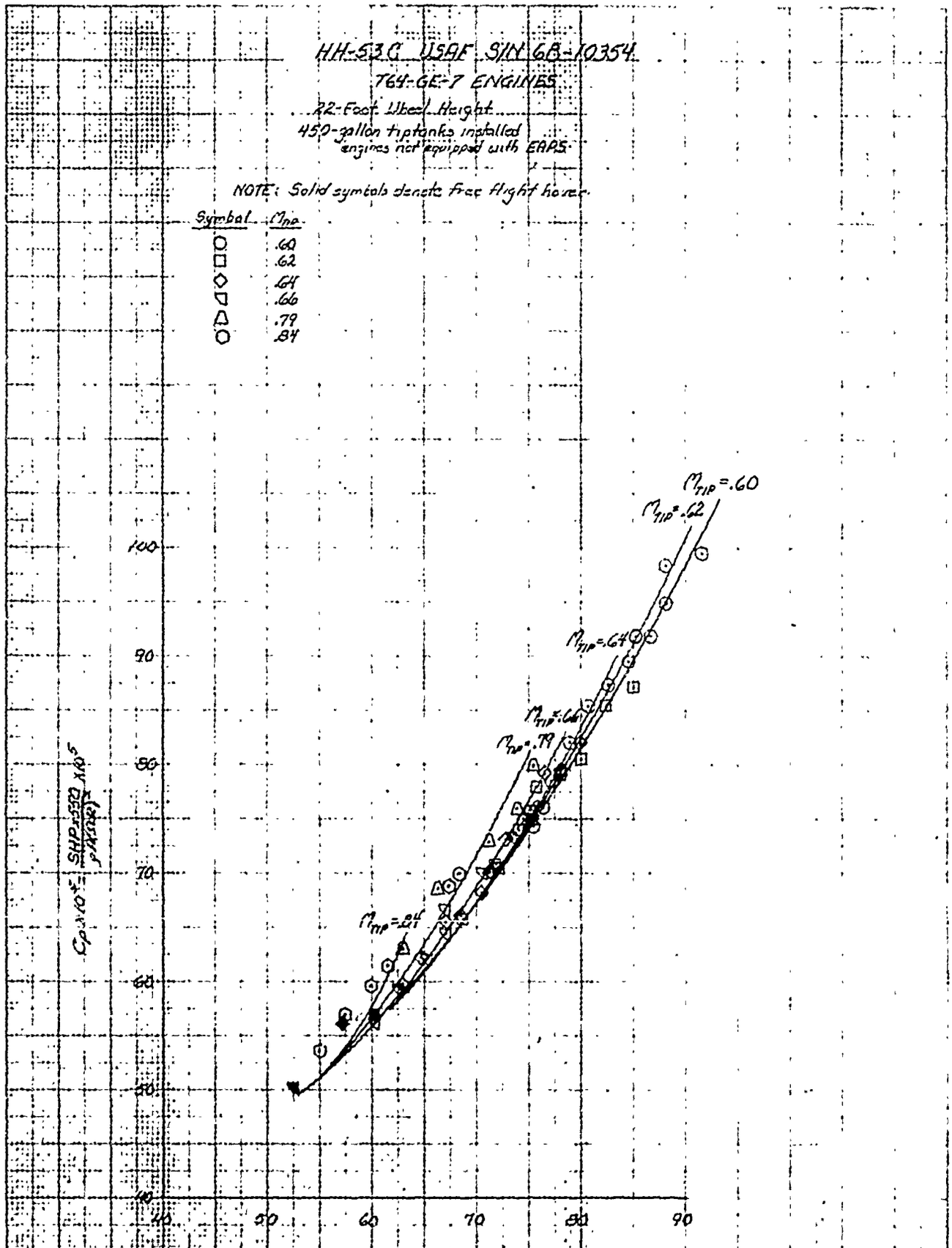


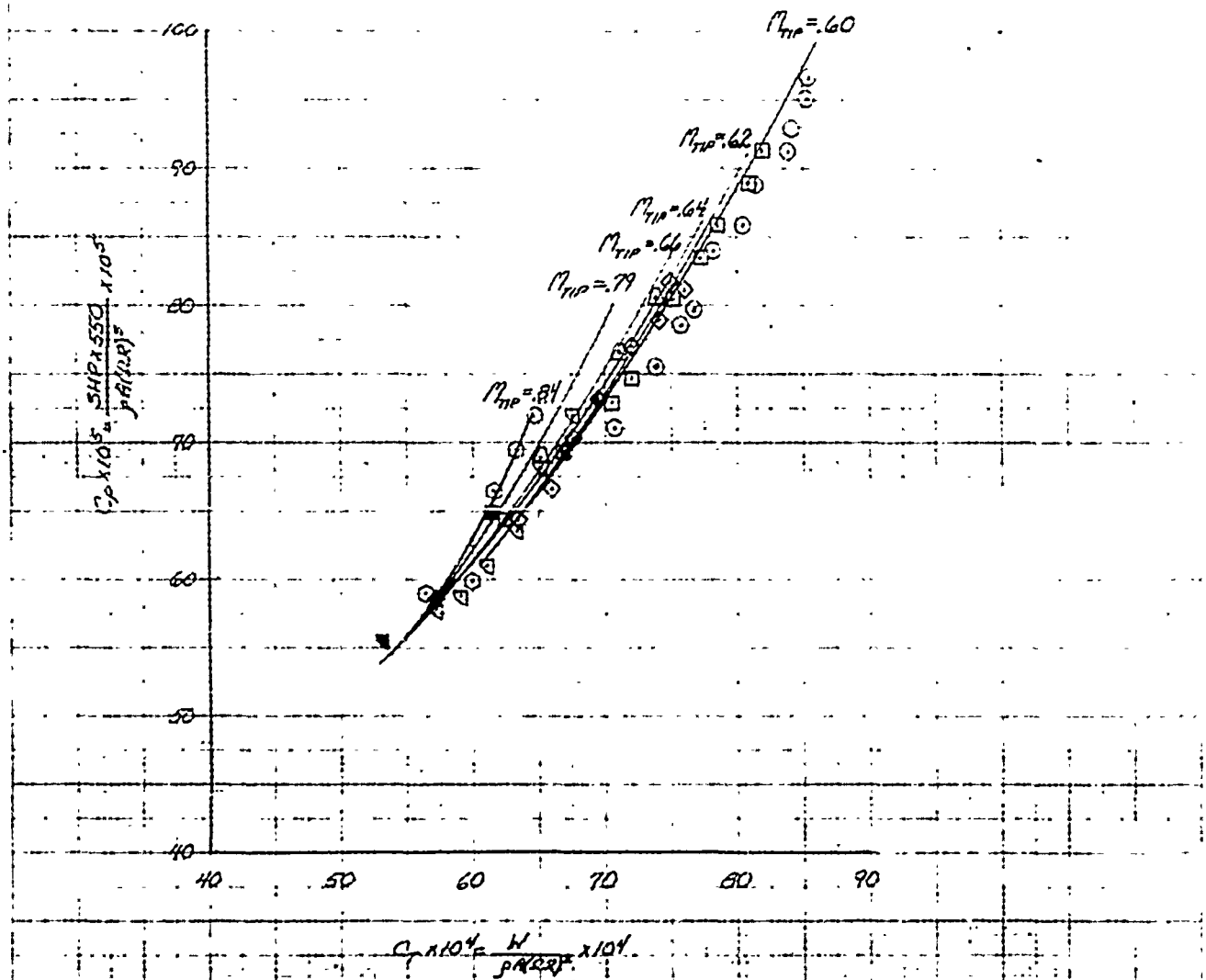
Figure 3. Nondimensional Hovering Performance

HH-53C USAF S/N 68-10534
T64-GE-7 ENGINES

47-Foot Wheel Height
450-gallon tiptanks installed
engines not equipped with EAPS

NOTE: Solid symbols denote free flight hover

Symbol	M_{TIP}
○	.60
□	.62
◇	.64
◁	.66
△	.79
⬡	.84



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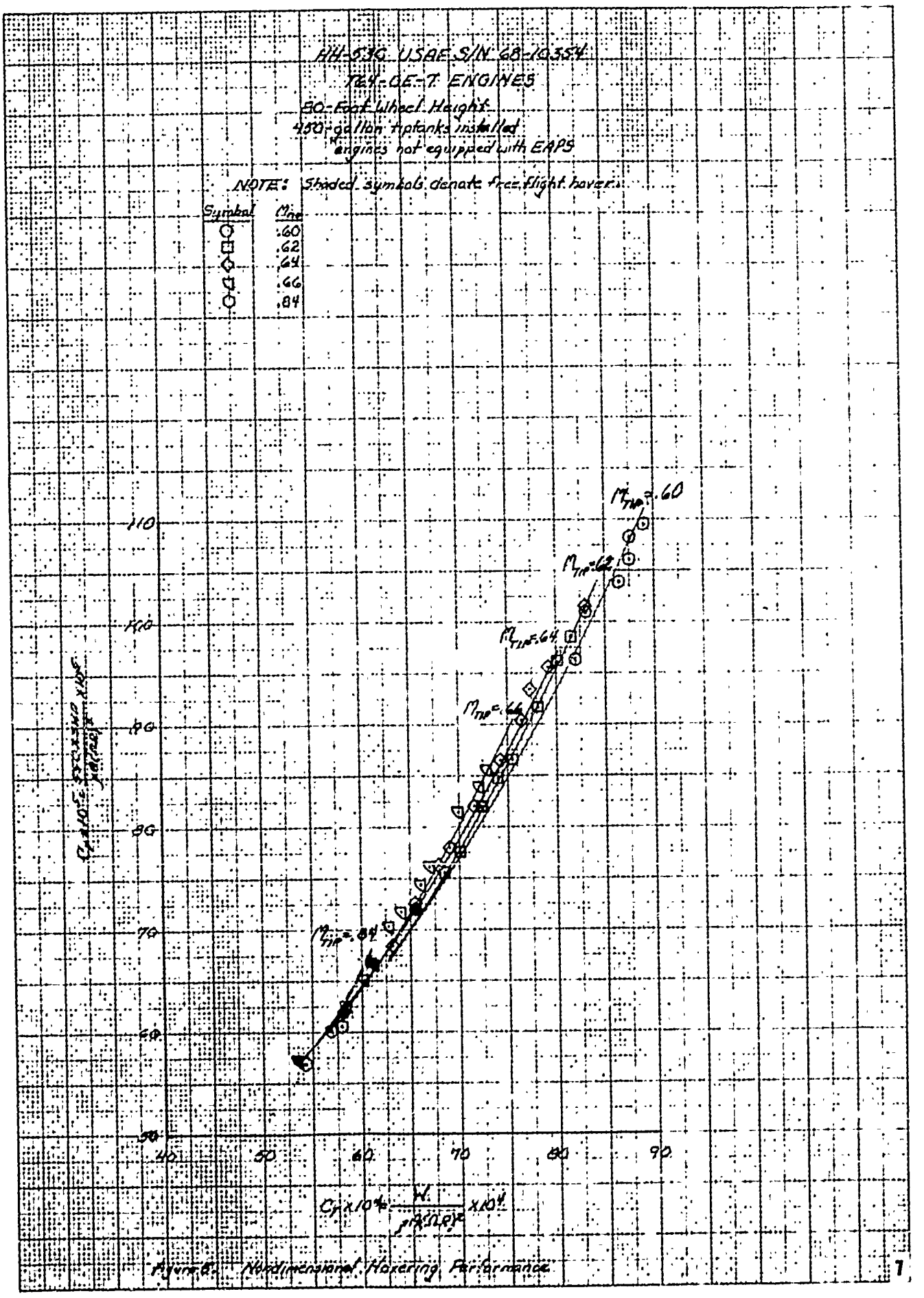


Figure 8. Nondimensional Hovering Performance

HH-53C USAF S/N 68-10354

T64-GE-7 ENGINES

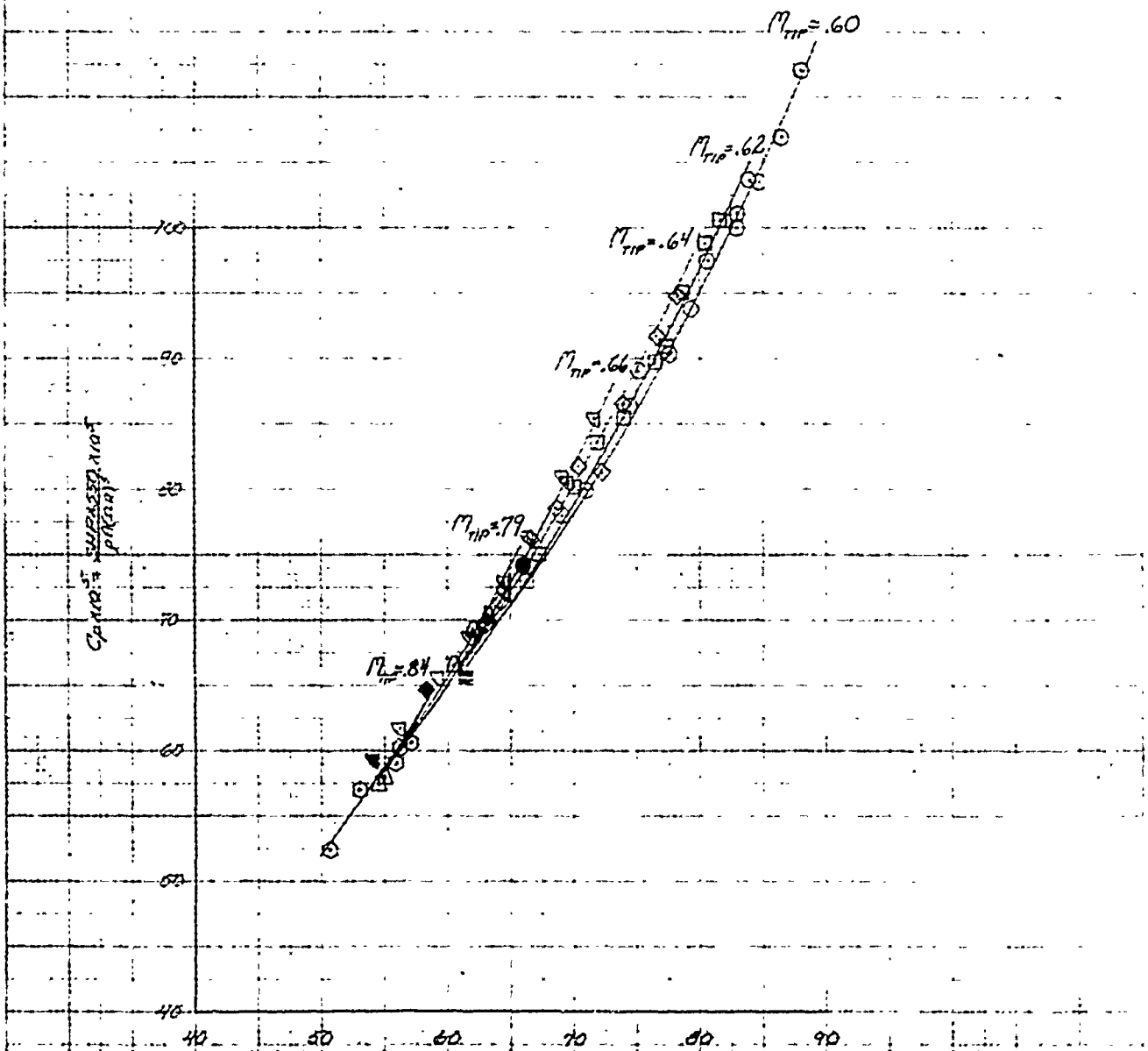
100-Foot Wheel Height

450-gallon tiptank installed

engines not equipped with EAPS

NOTE: Solid symbols denote free flight hover.

Symbol	M_{no}
○	.60
□	.62
◇	.64
▽	.66
△	.79
⬡	.84



$C_T \times 10^7 = \frac{W}{\rho(\Omega R)^2} \times 10^4$

Figure 6. Nondimensional Hovering Performance

HH-53C USAF S/N 68-10354
T64-GE-7 ENGINES
$M_{TIP} = 0.60$
NOTE: Derived from figures 1 to 6.

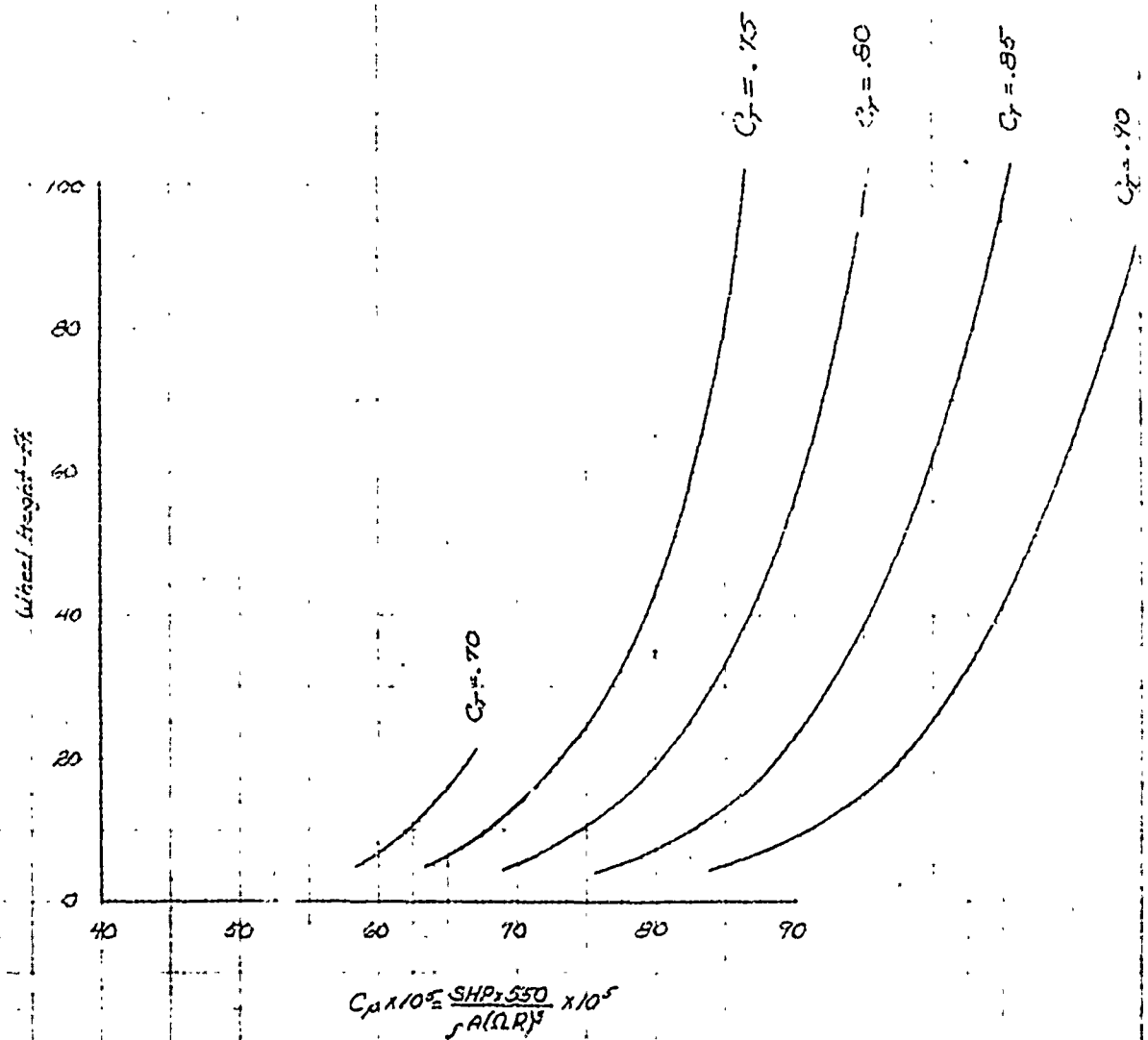


Figure 7. Hovering Performance

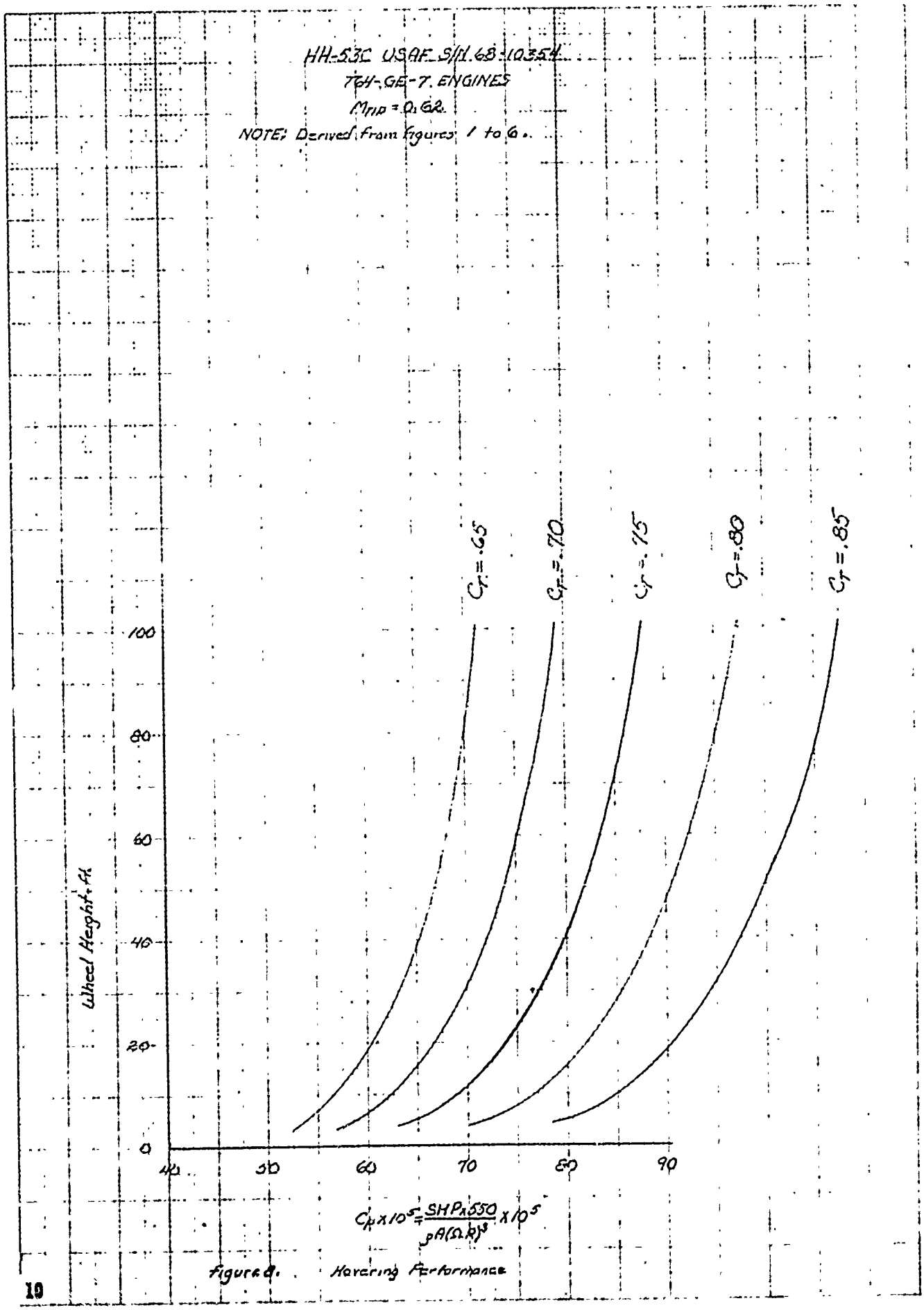


Figure 9. Hovering Performance

HH-53C USAF S/N 68-10354

T64-GE-7 ENGINES

$M_{TIP} = 0.64$

NOTE: Derived from figures 1 to 6.

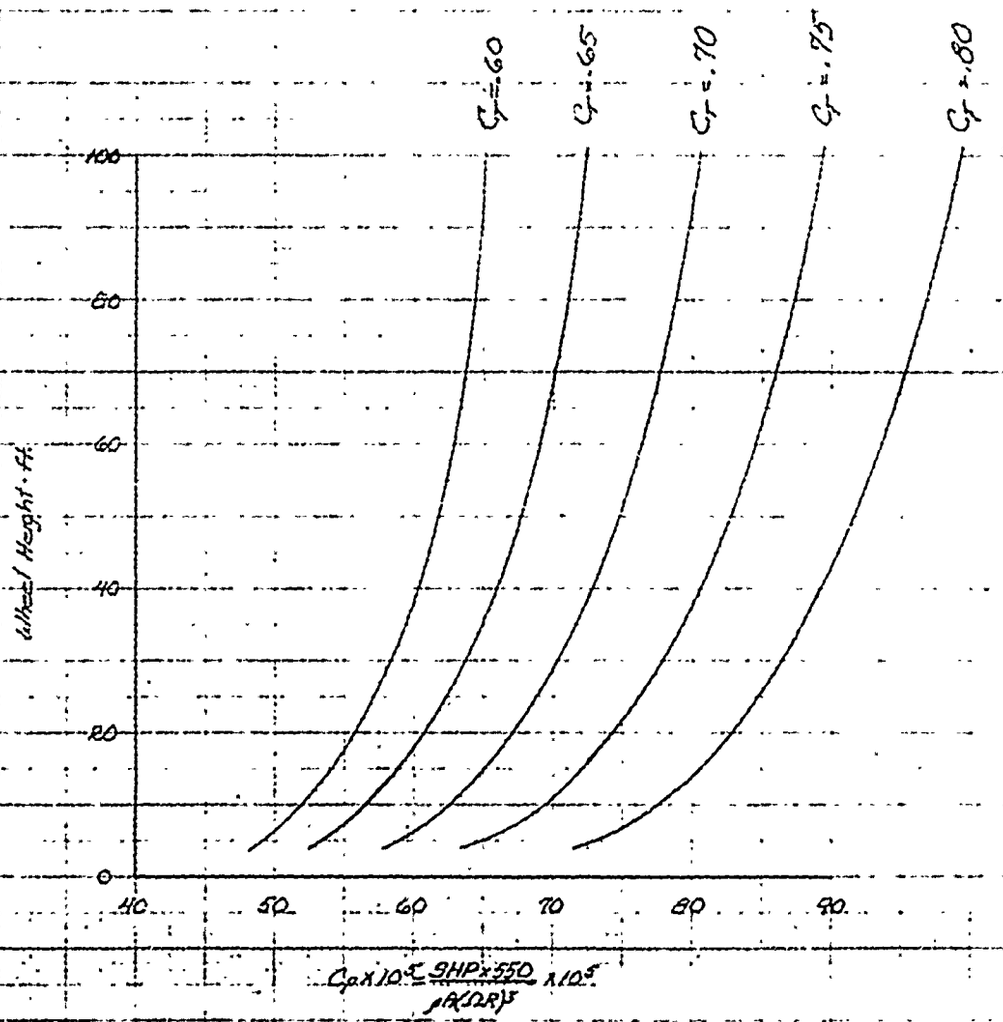


Figure 9. Hovering Performance

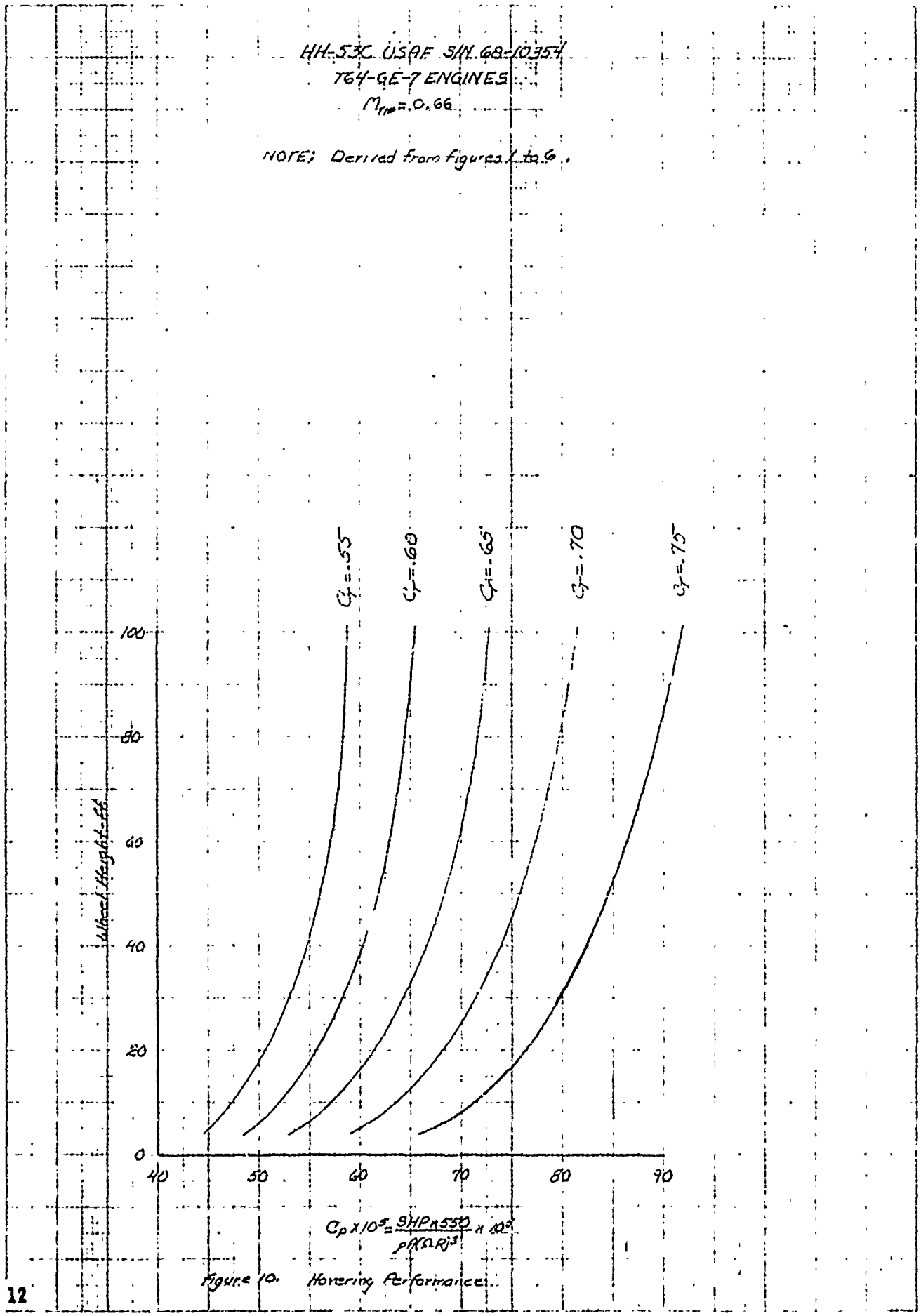


Figure 10. Hovering Performance

HH-53C USAF S/N 68-10354
T64-GE-7 ENGINES
$M_{TIP} = 0.79$

NOTE: Derived from figure 1 to 6.

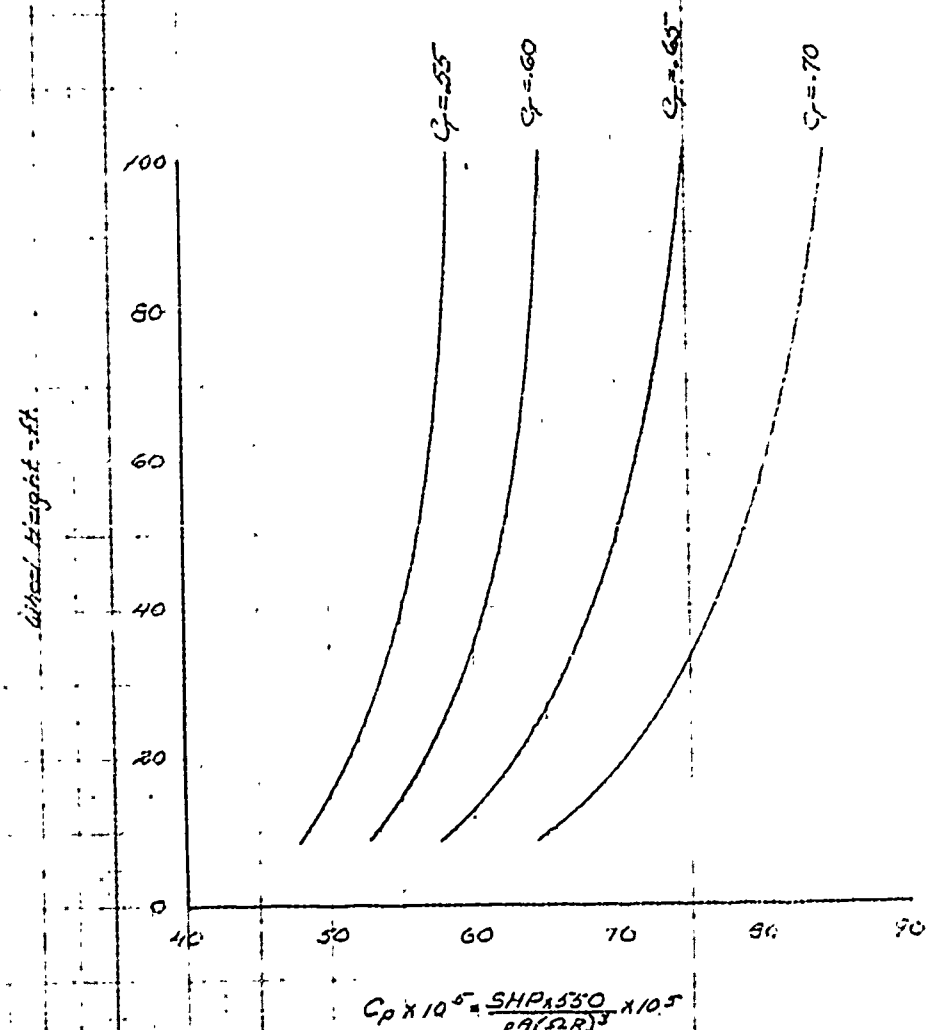


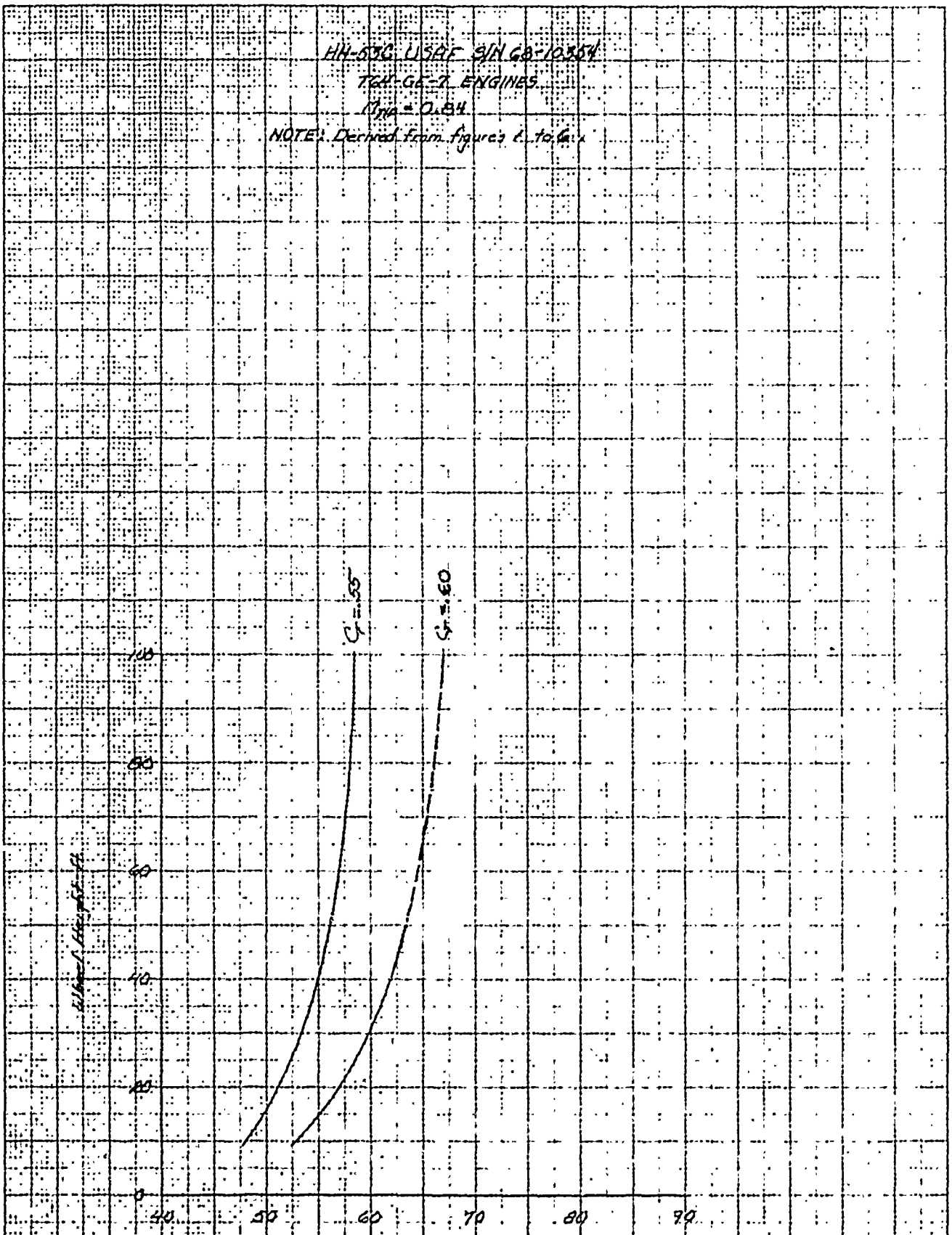
Figure 11 Hovering Performance

HH-53C USAF S/N 68-10354

T64-GE-7 ENGINES

$M_{TA} = 0.84$

NOTE: Derived from figures 1 to 6.



$$C_P \times 10^5 = \frac{SHP \times 1000}{\rho A (\Omega R)^3} \times 10^5$$

Figure 12. Hovering Performance

CONCLUSIONS AND RECOMMENDATIONS

The Flight Manual's Indicated Torque Required to Hover chart (A-7) was in error. It showed torque up to 11-percent higher than was actually required. Interpretation of the results of this test along with previous Category II tests resulted in an adjustment to the hover performance curves presented in FTC-SD-70-8, appendix I, figures 1 through 6.

1. The data presented in this report should be used to update the Flight Manual (page 2).

The Flight Manual Indicated Torque Required to Hover chart (A-7) did not have sufficient range of density altitude to define the performance of the helicopter.

2. The range of this chart should be increased to minus 10,000 feet density altitude (page 2).

REFERENCES

1. Flight Manual USAF Series HH-53B, HH-53C, and CH-53C Helicopters, T.O. 1H-53(H)B-1, 30 June 1970, Operational Supplement 31 December 1970.

2. Nasal, Timothy P., Balfe, Paul J., Major USAF, UH-1F Hover Compressibility Tests, FTC-TR-68-30, Air Force Flight Test Center, March 1969.

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4. Barbini, Wayne J., et al., Category II Performance and Flying Qualities Tests of the HH-53C Helicopter, FTC-SD-70-8, Air Force Flight Test Center, May 1970.

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The cold weather hover performance tests were conducted in conjunction with the cold weather tests of the HH-53C helicopter. Interpretation of the results of this test along with previous Category II tests resulted in an adjustment to the hover performance data presented in FTC-SD-70-8. The results of this report should be used to update the Flight Manual.

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