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PERFORMANCE TESTS OF A MARS-MODIFIED HH-53C HELICOPTER

AFFTC

TIMOTHY P. NASAL
Project Engineer

CHARLES R. DUNN
Major, USAF
Project Pilot

TECHNICAL REPORT No. 73-42
OCTOBER 1973

Distribution limited to U.S. Government agencies only (Test and Evaluation), September 1973. Other requests for this document must be referred to ASD/SDQH, Wright-Patterson AFB, Ohio 45433.

AIR FORCE FLIGHT TEST CENTER
EDWARDS AIR FORCE BASE, CALIFORNIA
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE

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FOREWORD

The tests were conducted at Edwards AFB between 1 November 1972 and 11 August 1973 under the authority of AFFTC Project Directive 72-126, dated 18 April 1972. The test aircraft was HH-53C USAF S/N 67-14993.

The authors of this report wish to express their appreciation to the helicopter pilots of the 6512th and 6514th Test Squadrons for their assistance in the flying portion of this program, to Sergeant Gary L. Snitily for his support in the engineering aspects of the program, and to Mr. John Raccasi of Sikorsky Aircraft for his efforts in the areas of technical support and program liaison.

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ABSTRACT

This report presents the results of tests to determine the performance characteristics of a MARS (Mid Air Retrieval System) -modified HH-53C helicopter in the clean loading and with the AQM-34L, AQM-34R and AQM-91A drones in tow. No unusual handling qualities were noted when smooth, coordinated flight techniques were used. Hover performance with the AQM-91A drone in tow was unchanged from that of the clean MARS-modified HH-53C when hovering in ground effect. Power required to hover out of ground effect was increased four to six percent by the effects of the AQM-91A in tow. Level flight performance comparisons between the clean MARS-configured HH-53C and the same aircraft with each of the drones in tow revealed a decrease in average maximum nautical air miles per pound of fuel of approximately 12 percent with the AQM-34L drone, 13 percent with the AQM-34R drone, and 34 percent with the AQM-91A drone.

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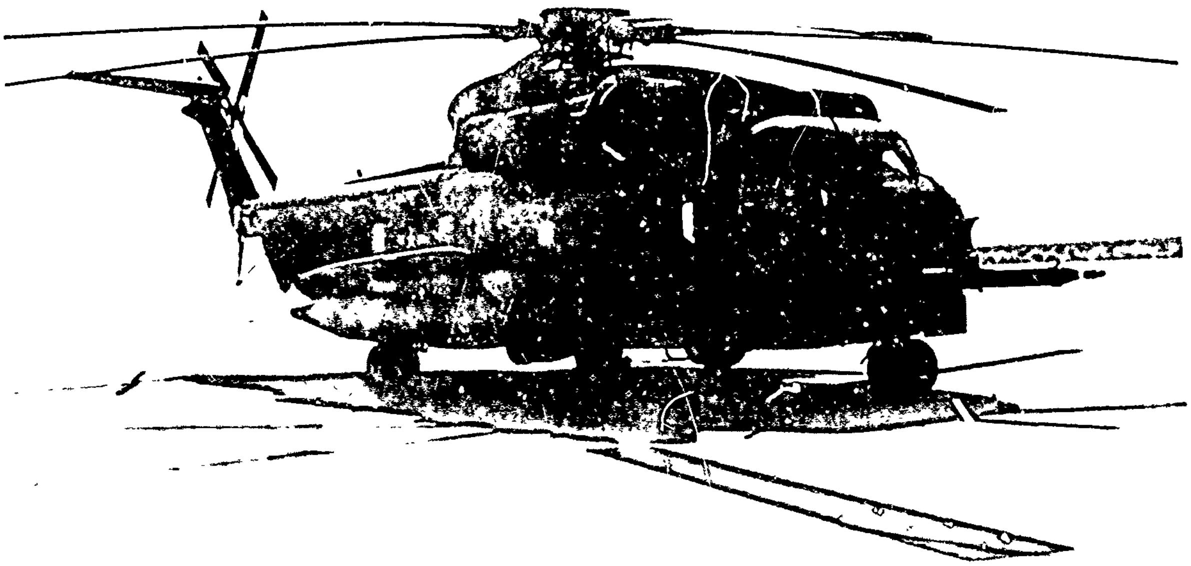
Item	Definition	Units
A	rotor disk area	ft^2
AFCS	automatic flight control system	- - -
C	centigrade or Celsius	- -
C_P	power coefficient	dimensionless
C_T	thrust coefficient	dimensionless
FAT	free air temperature (t_a, ambient air temperature)	deg C
GW	gross weight	lb
IGE	in ground effect	- - -
K	Kelvin	- - -
KIAS	knots indicated airspeed (corrected for instrument error - not corrected for position error)	kt
M_{TIP}	advancing blade tip Mach number	dimensionless
NAMPP	nautical air miles per pound of fuel	- - -
N_R	main rotor speed	rpm
N_g	gas producer speed	rpm
OGE	out of ground effect	- - -
P_a	atmospheric or ambient pressure	in. Hg
R	rotor radius	ft
SHP	shaft horsepower	$\frac{550 \text{ ft-lb}}{\text{sec}}$
SL	sea level	- - -
T_a	ambient or atmospheric temperature	deg K
V	velocity (used in general terms)	kt
V_E	equivalent airspeed	kt
V_{NE}	indicated airspeed never to exceed	kt
ΔV_{pc}	correction for airspeed position error	kt
W_f	fuel flow	lb per hr
δ_a	ambient pressure ratio ($= \frac{P_a}{29.92}$)	dimensionless
Δ	incremental change to a parameter	variable
θ_a	ambient temperature ratio ($= \frac{T_a}{288.16}$)	dimensionless
μ	rotor advance ratio	dimensionless
Ω	rotor angular velocity	rad per sec

Subscripts

a	ambient
t	test day conditions or total



INTRODUCTION

GENERAL

Impetus for the performance testing documented in this report was provided by a requirement to supply the Strategic Air Command with a fully qualified system capable of mid-air retrieval of relatively heavy vehicles. The HH-53C helicopter will provide increased operational capability over the CH-3E helicopters currently in use. It is equipped with an 80H series winch from All-American Industries which is an improved model of existing equipment. Efforts to qualify this retrieval system include development and testing of the winch itself, a load survey to determine the effects of retrieving various packages on the dynamic components of the winch and helicopter, and the definition of the performance characteristics of the HH-53C helicopter with each of several representative drones in tow.

This report covers testing conducted at the Air Force Flight Test Center, Edwards AFB, California, between 1 November 1972 and 11 August 1973. The test aircraft, HH-53C USAF S/N 67-14993, accumulated 82.4 test hours during 67 test missions. Further programmed hover tests were cancelled through mutual agreement between the Systems Program Office and the AFFTC.

TEST AIRCRAFT

The test aircraft was equipped with a Mid-Air Retrieval System (MARS) that provided the capability to engage and retrieve a variety of objects descending by parachute. The MARS modification consisted of a Model 80H constant-tension, energy-absorbing winch (manufactured by All-American Industries, Inc., Wilmington, Delaware), winch line, winch hydraulic module, trough, center of gravity roller, fairlead, roller assembly, control panels, pole mounts, recovery poles, recovery loop assembly, and breakaway line. The winch, trough and associated equipment were mounted on a pallet in the cargo compartment near the aircraft cg, and the pole mount assembly was mounted on a pallet at the aft end of the cargo compartment. The winch consisted of a drum that paid out and reeled in the winch cable until the object was in the stowed position beneath the helicopter. Figure 1 depicts a typical level flight configuration with a drone in tow. The winch was designed to provide controlled line tension during the payout operation. External modifications to the aircraft consisted of removing the rear cargo ramp and installing a fairlead assembly on the underside of the aircraft, approximately 37 inches aft of the cargo hook. Hydraulic power requirements were supplied by the aircraft utility hydraulic system, which was modified through the addition of three quarts of hydraulic fluid and a heat exchanger. An emergency cable release mechanism was incorporated in the modification. It consisted of an explosive cartridge to sever the winch cable and activation buttons on the pilot's and copilot's cyclic stick grips, on the winch control panel, and in the winch trough. Figures 2 through 4 depict the winch installation. Further information regarding the winch installation may be obtained from the HH-53C MARS Partial Flight Manual, reference 1.

DRONES

Three test drones were employed during the performance tests. In order of increasing size, they were: the AQM-34L (figures 5 and 6), AQM-34R (figures 7 and 8) and AQM-91A (figures 9 and 10). Details of specific drone dimensions, weights, power plant specifications, and missions are presently classified and not included in this report. Level flight tests were accomplished with a six-foot diameter stabilization chute attached to the drone. A stabilization chute was not used during hover tests with the drones in tow. The clean loading referred to in this report consisted of the basic MARS-modified HH-53C with the rear cargo ramp removed and winch installed. All tests with a drone in tow were conducted with the drone in the stowed position. For the purposes of this report, "in tow" and "in the stowed position" are synonymous.

Figure 1 Typical Level Flight Configuration

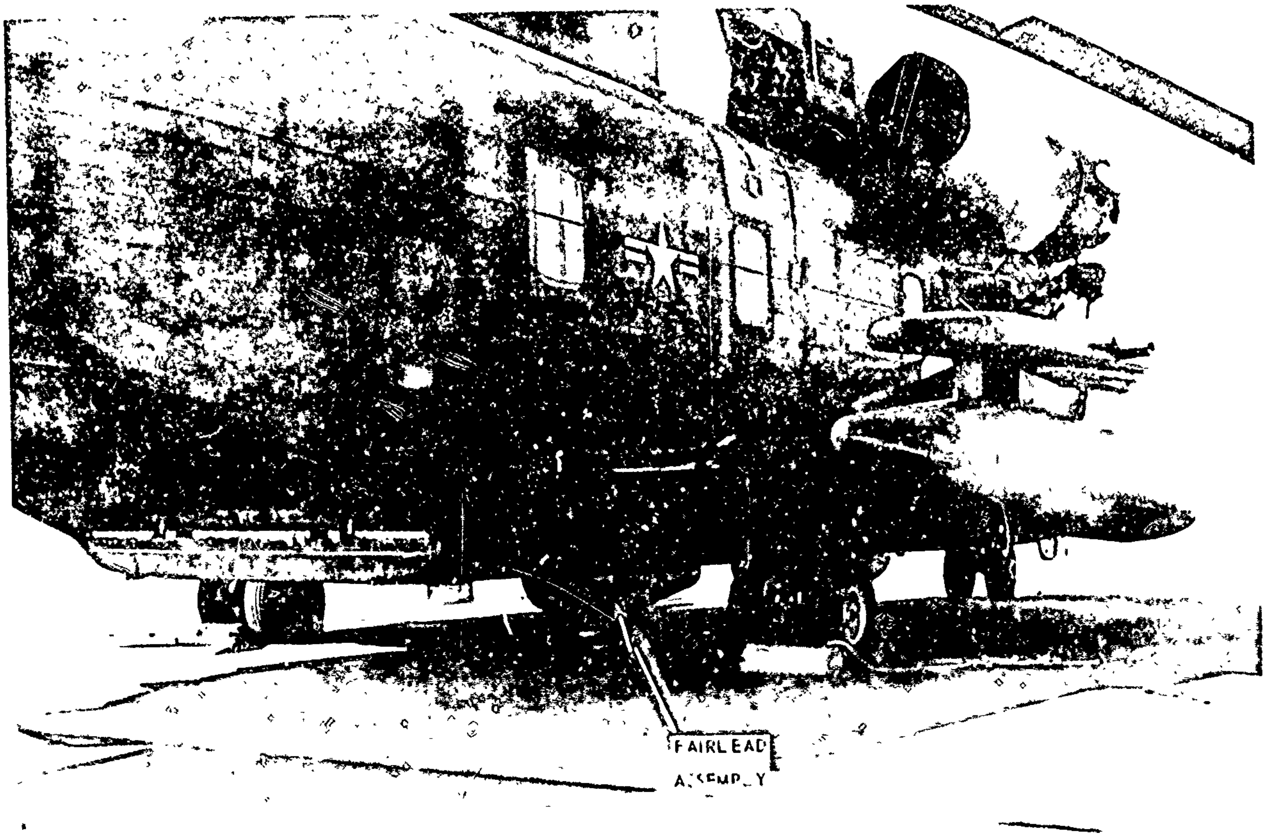


Figure 2 MARS Modification

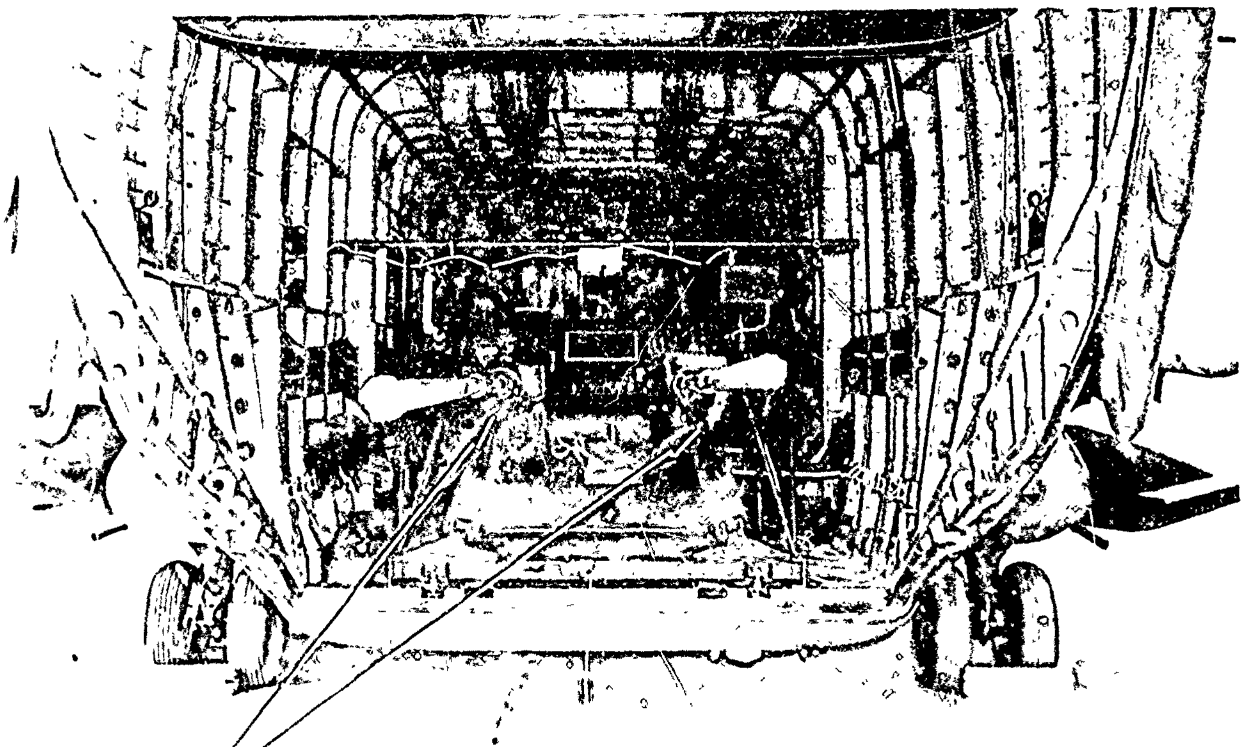


Figure 3 MARS Modification

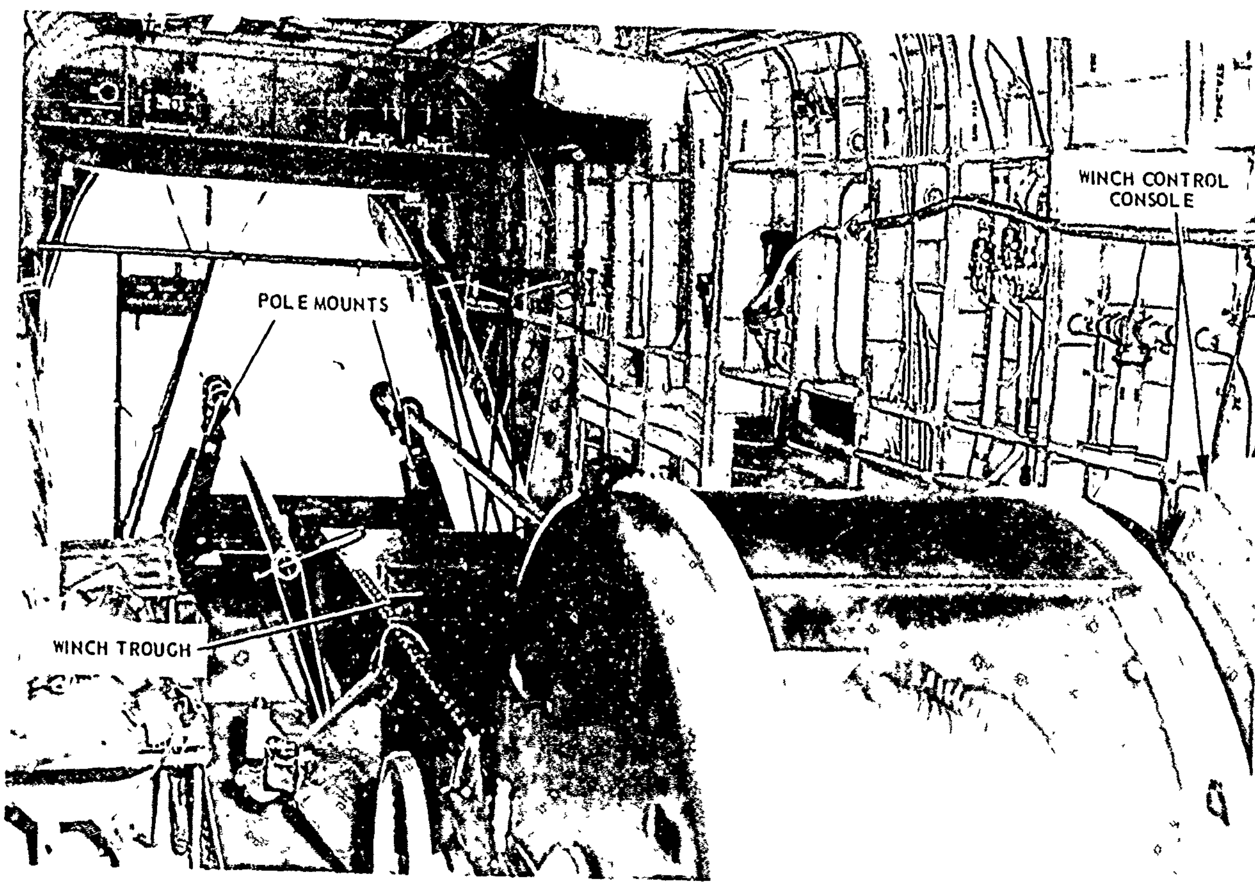


Figure 4 MARS Modification

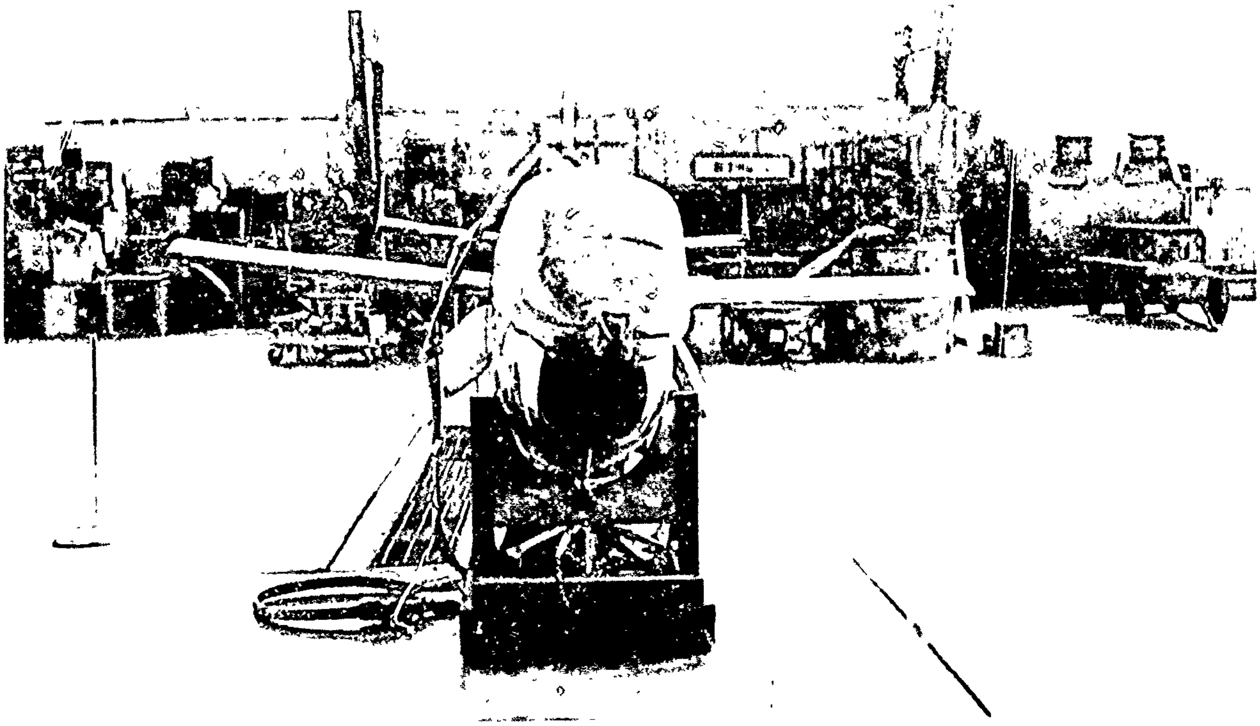


Figure 5 AQM-34L Front View

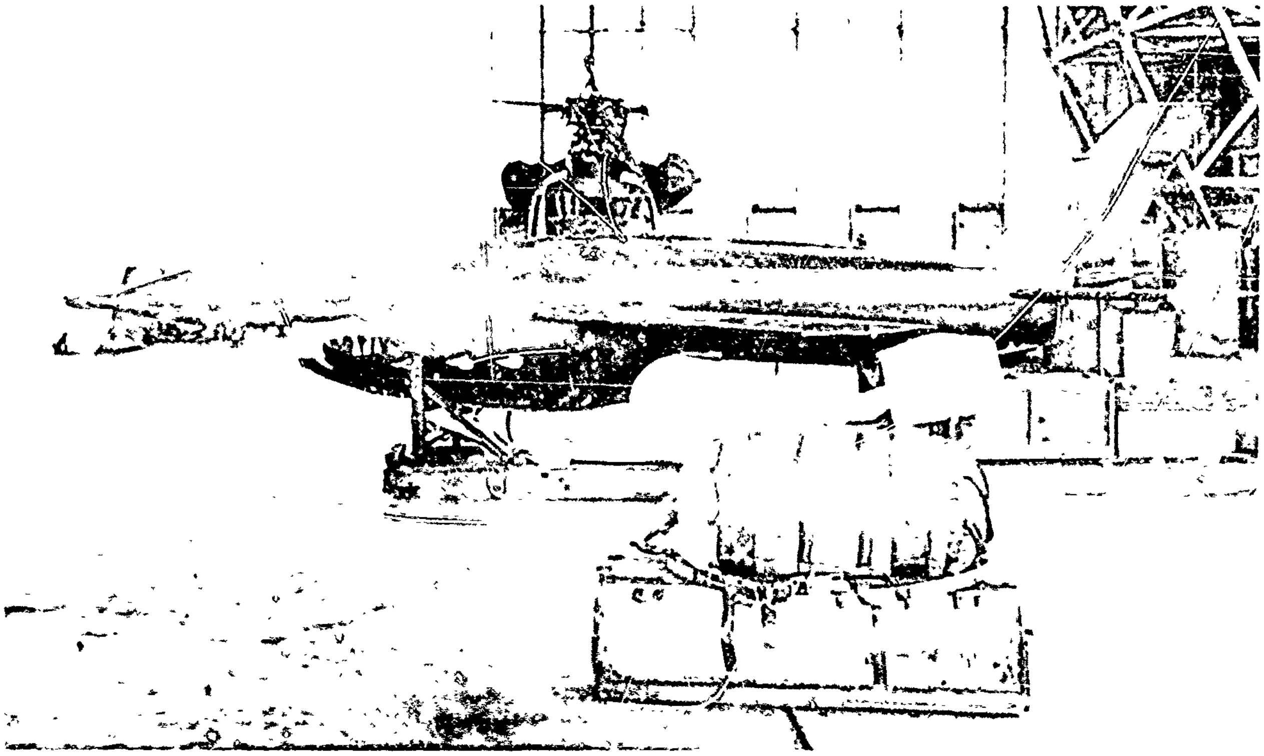


Figure 6   AQM-34L Side View

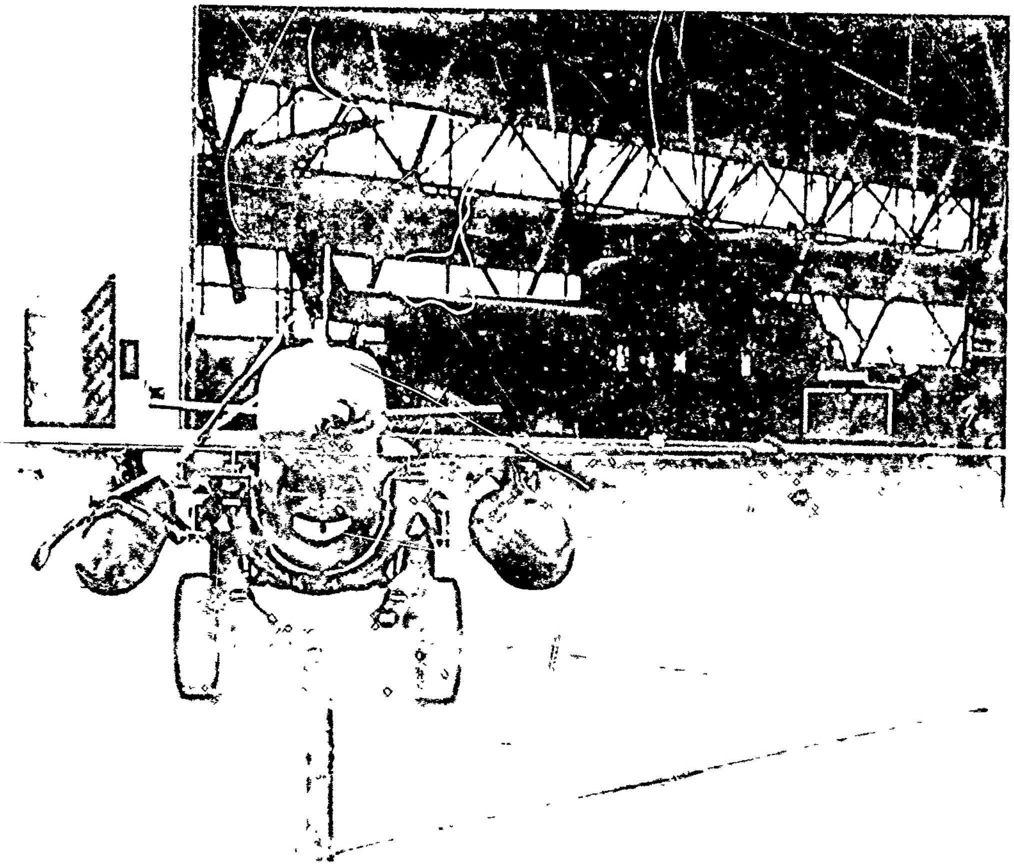


Figure 7 AQM-34R Front View

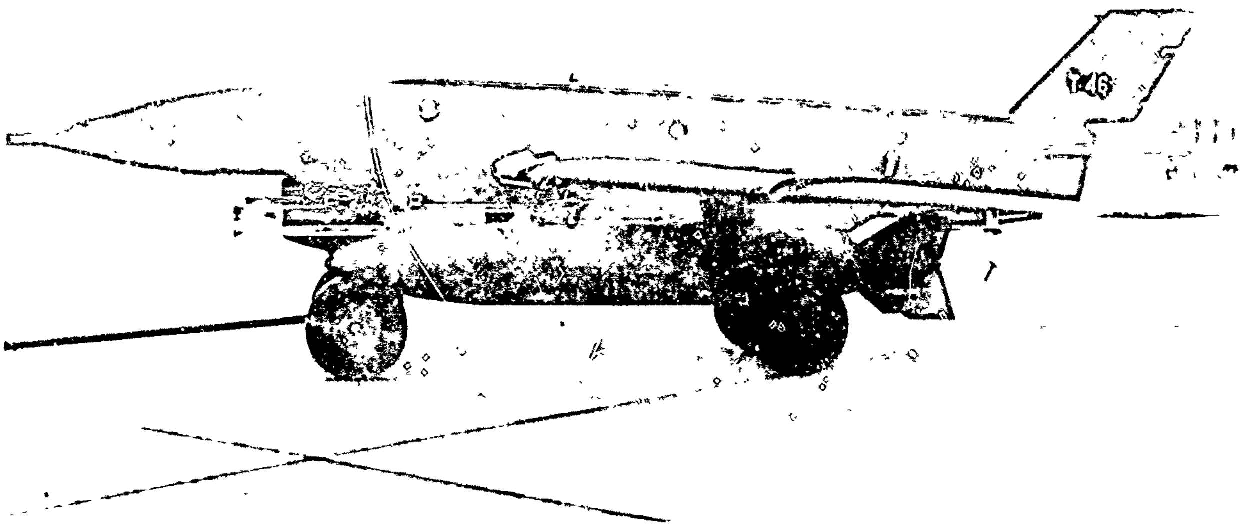


Figure 8 AQM-34R Side View

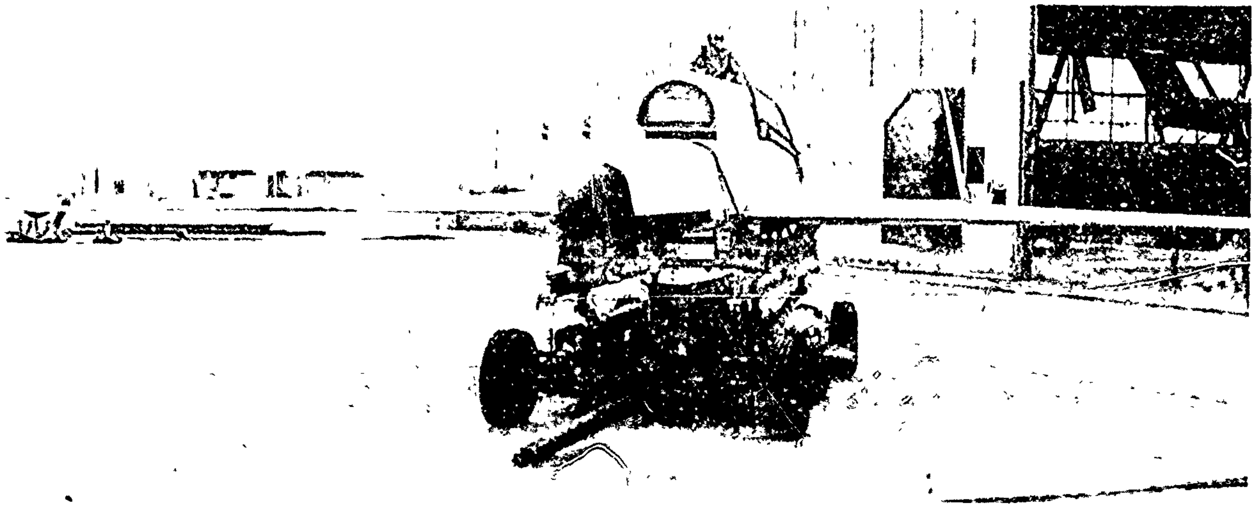


Figure 9 AQM-91A Front View

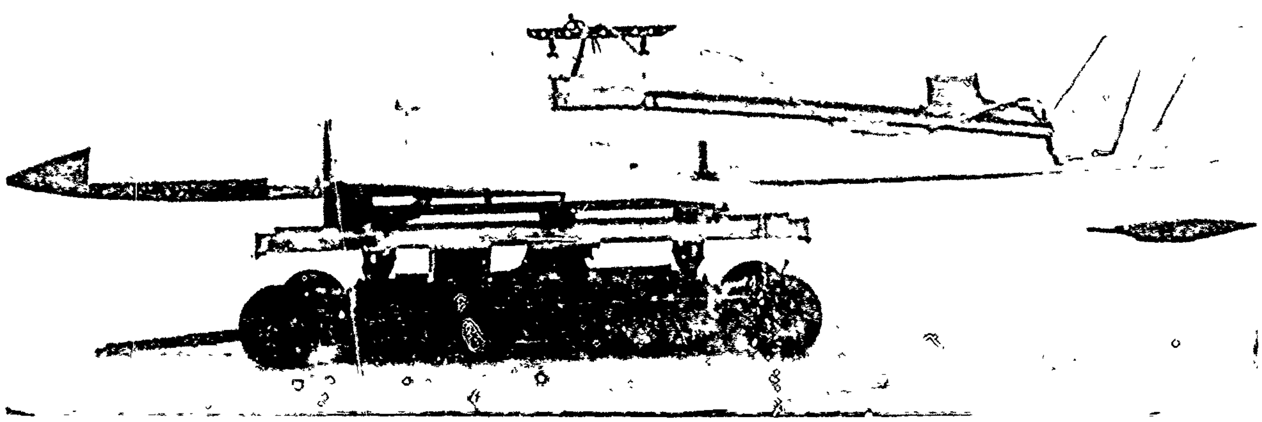


Figure 10 AQM-91A Side View

TEST AND EVALUATION

FLYING QUALITIES AND HANDLING TECHNIQUES

General

Airlift, including takeoff, climb, level flight and docking, of all drones tested presented no abnormal problems when smooth, coordinated flight techniques were employed. Abrupt or rapid attitude changes produced drone lateral and longitudinal oscillations during level flight. Oscillations caused by pilot technique or external disturbances were effectively damped by maintaining a stable aircraft attitude and/or reducing airspeed. A high-frequency vibration was induced in the cockpit and airframe when towing drones at conditions of high airspeed, power, and rotor speed. Decreasing airspeed or rotor speed eliminated these objectionable vibrations. These vibrations were not present during the clean loading tests, which were conducted without the winch installed.

The automatic flight control system (AFCS) pitch attitude hold function has a limited range of authority. A CG TRIM control is provided to reposition the range of AFCS authority and thus ensure that the AFCS has maximum authority regardless of any necessary cyclic stick movements. Throughout testing with the AQM-34L and AQM-34R drones in tow, it was noted that during flight at high airspeeds (above 110 KIAS) CG TRIM adjustments were necessary to retain AFCS pitch hold capability. The following NOTE should be included in the Partial Flight Manual for MARS-configured HH-53C helicopters: **(R 1)**[1]

NOTE

> When towing drones at high airspeeds (above 110 KIAS) CG TRIM adjustments will be necessary to retain AFCS pitch attitude hold capability.

Both the AQM-34L and AQM-91A drones were successfully towed without stabilization chutes. However, under these conditions, drone oscillations were more easily induced by the pilot or outside disturbances and were slower to subside after corrective action had been initiated. When available, stabilization chutes should be employed for drone towing. **(R 2)**

Takeoff

All drones tested were airlifted from a ground position. Takeoffs were accomplished with minimum time spent in the hover and a smooth, gradual increase in airspeed and altitude. This technique minimized drone oscillations and subsequent fouling of the AQM-34L and AQM-34R stabilization chutes. The AQM-91A was equipped with a stabilization chute that could be deployed in flight from within the helicopter cargo section. The chute was most effectively deployed after sufficient forward airspeed had been attained to allow the drone to become approximately aligned with

[1] Boldface numerals preceded by an R correspond to the recommendation numbers tabulated in the Conclusions and Recommendations section of this report.

the flight path. A substantial charge of static electricity quickly built up on the drone, making it necessary to use a grounding device between the chute deployment ring on the riser holding the drone and the aircraft frame. The AQM-34R and AQM-34L drone stabilization chutes were extended behind the drone and ballasted to prevent inflation and fouling prior to lift-off. Fouling of the chute immediately after takeoff was minimized by aligning the drone and chute with the intended aircraft takeoff direction. Once the stabilization chute was properly deployed, the increasing airspeed resulted in the drone aligning with the helicopter and drone oscillations quickly subsiding.

Level Flight

Level flight with the AQM-34L drone was airspeed-limited by maximum collective pitch, turbine inlet temperature, and pilot comfort. Above approximately 120 KIAS, the AQM-34R drone tended to oscillate both longitudinally and laterally. This tendency to oscillate became the limiting factor on forward airspeed with the AQM-34R drone in tow. Under conditions of high forward airspeed and high rotor speed (above 103 percent) a strong high-frequency vibration occurred in the cockpit and airframe. The vibration was eliminated by reducing airspeed and rotor speed. The winch brake was able to hold the loads induced by the drones during all testing with the AQM-34L and AQM-34R drones.

When towing the AQM-91A drone, forward airspeed was limited by the winch cable load, which exceeded the ability of the winch brake to hold the drone in the stowed position. The airspeed at which uncommanded reel-out occurred varied with winch brake condition, aircraft power applied (rotor wash effects), and flight attitude of the drone (drag effects). Level flight conditions at which uncommanded reel-out occurred varied from 70 KIAS and 6,600 pounds cable tension to 77 KIAS and 8,500 pounds cable tension. Uncommanded reel-out usually occurred when winch cable tension reached approximately 8,500 pounds. During climbs this 8,500-pound cable tension occurred at lower airspeeds, dependent on power setting. When operating at high rotor speeds and high forward airspeeds with the AQM-91A drone in tow, the high-frequency vibration in the cockpit and airframe was noted again.

Turns and Descents

The aircraft was maneuvered in level flight with each of the three drones in tow throughout the attainable airspeed envelopes with as much as 30 degrees of aircraft bank angle. Flight at rates of descent up to 1,500 feet per minute was also accomplished with each drone. No abnormal flight characteristics were noted when smooth, coordinated flight techniques were used.

Approach and Landing

Final approaches were executed shallower than normal, with a gradual decrease in airspeed to minimize attitude changes just prior to establishing a hover. Because the drones were suspended well below the aircraft (18 to 23 feet), a high hover was established at 40 to 50 feet above ground. Setting the radar altimeter to 50 feet was a useful pilot cue. After decelerating to below translational lift speed, all three drones began oscillating, particularly in yaw. Once the hover had been stabilized, the aircraft was lowered at a constant, moderate rate until the drone was firmly on the ground. This minimized the probability of damage to the drone wing tips caused by drone roll oscillations.

Emergency Cable Release

An emergency cable cutter was incorporated in the MARS winch package. The device was an explosive cartridge electrically activated by a button on both the pilot's and copilot's cyclic control sticks. Figure 11 shows the cyclic control stick grip and the location of the cable release button. This release button is in the same position as the trim release button on H-1 series helicopters. Pilots who have flown H-1 series helicopters may have a tendency to press the cable release button while intending to release the cyclic trim. One such inadvertent cable release occurred during the performance tests. Fortunately, the drone was on the ground at the time. However, the potential for a more serious consequence exists. If possible, the cyclic stick cable release button should be moved to another location on the cyclic stick. If this is impractical, the cable release button should have a guard installed to prevent inadvertent cable release. (R 3)

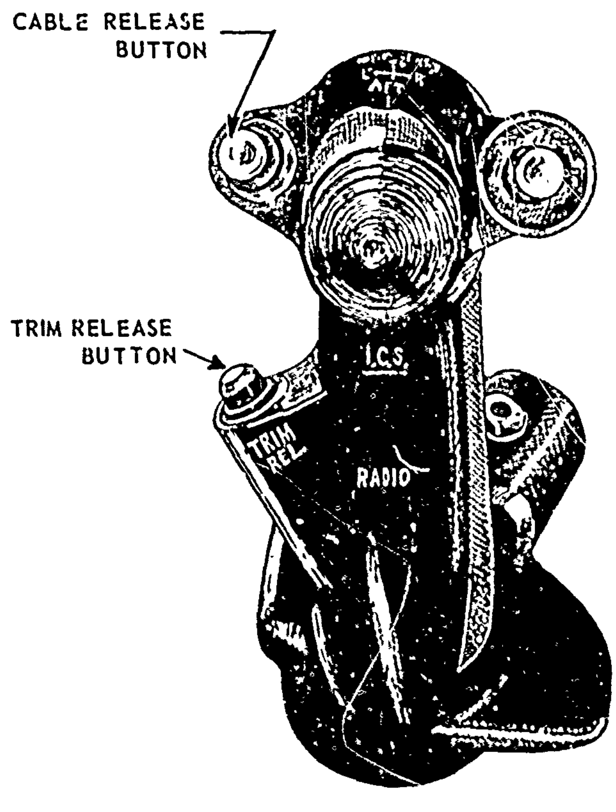


Figure 11 Cyclic Stick Grip

PERFORMANCE

Pitot-Static System Calibration

The position error of the standard pitot-static system was determined in level flight by the ground speed course method and in a descent using a trailing "bomb" (pitot-static source). The results of these tests are presented in figure 3, appendix I.

The airspeed position error during level flight agreed with previous airspeed calibrations accomplished on an HH-53B helicopter with engine air particle separators (EAPS) installed (reference 2). The HH-53B and HH-53C helicopters were considered identical for the purposes of this airspeed calibration. The Flight Manual did not contain airspeed calibration data with the engine air particle separators installed.

The standard airspeed system was also calibrated during descents for a rate of descent of approximately 1,000 feet per minute. The intent was to simulate conditions present during an approach to an engagement chute for a typical MARS recovery. The standard system was compared to a calibrated pitot-static source trailing from a cable attached to the rear of the cargo ramp. Results of this test are also presented in figure 3, appendix I.

The level flight airspeed calibration was repeated with the AQM-91A drone in tow for airspeeds up to approximately 70 KTAS. No significant differences were noted between the basic MARS-configured aircraft and the aircraft with the AQM-91A drone in tow. Results of this test are also presented in figure 3, appendix I.

Hover Performance

Hovering performance data were obtained during tethered and free-flight hover at an approximate pressure altitude of 2,200 feet for wheel heights of 30, 50, and 100 feet in less than three knots of wind. Two aircraft loadings were tested; the basic MARS-configured aircraft, and the basic aircraft with the AQM-91A drone in tow. The hovering performance data are presented in non-dimensional form in figures 7 through 12, appendix I. Tables I and II, appendix I, present a summary of hover test conditions.

The power required to hover data from these tests with the clean loading were compared to previously acquired data presented in references 5 and 6. The data from these tests agreed within three percent (lower) of the data in the above-mentioned references.

Power required to hover was compared for the loadings tested. During in-ground effect (IGE) hover (30 and 50-foot wheel heights) the clean aircraft and the aircraft with drone in tow exhibited no significant differences in power required for a given gross weight and referred rotor speed. During out-of-ground effect (OGE) hover (100-foot wheel height), aerodynamic loads on the AQM-91A drone caused an increase in power required of approximately five units of power coefficient (C_p) over the power required by the clean aircraft. This corresponds to an increase in power required to hover varying from four to six percent, depending on specific flight conditions. Effects of the aerodynamic loads on the drone on power required to hover are presented in figures 4 through 6, appendix I. A more detailed analysis of these three comparison plots is presented in the Hover section of appendix I of this report. If the AQM-91A drone is expected to become an operational vehicle, the following NOTE should be added to the Flight Manual for MARS-modified HH-53C helicopters: (R 4)

NOTE

> When hovering in ground effect with the AQM-91A drone in tow, power required to hover will be unchanged from that of the clean MARS-modified HH-53C helicopter. However, when hovering out of ground effect with the AQM-91A drone in tow, power required to hover will be increased approximately six percent over that of the clean MARS-modified HH-53C helicopter.

Additional planned hover tests with the AQM-34L and AQM-34R drones in tow were cancelled due to persistent adverse weather conditions and non-availability of the test aircraft. Based on results of the hover tests conducted with the AQM-91A drone in tow, it appears that the AQM-34L and AQM-34R drones will also have no significant effect on power required to hover in ground effect and that power required to hover out of ground effect will be increased a maximum of five percent over the power required in the clean loading.

Level Flight Performance

Level flight performance tests were conducted to determine power required and specific range (nautical air miles per pound of fuel, NAMPP) for various gross weights, altitudes and rotor speeds. The tests were conducted with controlled advancing blade tip Mach numbers in order to define compressibility effects on power required. Tests were conducted with the following four loadings: basic MARS-configured aircraft, with the AQM-34L drone in tow, with the AQM-34R drone in tow, and with the AQM-91A drone in tow. Results of these tests are presented in figures 13 through 40, appendix I, figures 41 through 62, appendix I, figures 63 through 82, appendix I, and figures 83 through 107, appendix I, respectively.

A comparison of the test results from each loading was made using the basic MARS-modified HH-53C data in this report as the standard for comparison. Aerodynamic effects of the AQM-34L drone reduced the average maximum test NAMPP by approximately 12 percent. The effects of the AQM-34R drone resulted in a decrease in average maximum NAMPP of approximately 13 percent, while the AQM-91A drone reduced the average maximum NAMPP by approximately 34 percent. The level flight performance data contained in this report should be included in the Partial Flight Manual for MARS-modified HH-53C helicopters. (R 5)

It was noted during testing with the AQM-91A drone in tow that the maximum airspeed attainable (limited by the ability of the winch brake to hold the load on the winch cable) was usually below the airspeed at which maximum NAMPP would be obtained. As airspeed was increased, the rate of increase of aerodynamic loads on the AQM-91A drone was more rapid than that observed with the smaller drones. This was apparently a result of the nosedown flight attitude of the drone as it hung in the support risers. If the AQM-91A, or similar drone are to be towed, consideration should be given to reducing the drone nosedown flight attitude, thus reducing the rate of load increase on the winch cable as airspeed is increased. This should allow higher airspeeds during towing and should increase the maximum NAMPP attainable for most flight conditions. (R 6)

Winch cable loads with a drone in tow were not limiting factors with the AQM-34L and AQM-34R drones. Forward airspeed with the AQM-34L drone in tow was limited by full up collective control or by maximum allowable turbine inlet temperature. Forward airspeed with the AQM-34R drone in tow was limited by the tendency of the drone to oscillate at high forward speeds (above 120 KIAS). Tables III through VI, appendix I, present a listing of level flight conditions tested during this program.

Engine Characteristics

The engines utilized during the test program were not specially calibrated and had a limited amount of special instrumentation. Fuel flow, gas generator speed, power turbine speed, and engine output torque were the only parameters recorded.

Engine parameters were referred to ambient conditions and plotted in the form of referred shaft horsepower versus referred gas generator speed and referred fuel flow versus referred gas generator speed. These results are presented in figures 108 through 111, appendix I. In addition, these data were used to construct a plot of referred shaft horsepower versus referred fuel flow for each engine. These plots, presented in figures 112 and 113, appendix I, were used to compare the test engines with the T64-GE-7 engine specification (reference 3). Fairings derived from this specification are also presented on figures 112 and 113, appendix I. The results of the comparison indicated that the test engines' shaft horsepower - fuel flow characteristics were representative of the T64-GE-7 engines.

CONCLUSIONS AND RECOMMENDATIONS

Drone airlift, including takeoff, climb, level flight, descent, and docking, presented no abnormal problems when smooth, coordinated flight techniques were employed. Drone oscillations during level flight were effectively damped by maintaining a stable aircraft attitude and/or reducing airspeed. When hovering with the AQM-91A drone in tow, power required to hover in ground effect did not change from the power required with the clean loading, but power required to hover out of ground effect was increased four to six percent above power required for the clean loading. Using the MARS-configured HH-53C as a standard, the presence of the drones in tow produced the following approximate decreases in average maximum NAMPP: AQM-34L - 12 percent; AQM-34R - 13 percent; AQM-91A - 34 percent.

A high-frequency vibration was induced in the cockpit and airframe when towing drones at conditions of high airspeed, power, and rotor speed. These objectionable vibrations were eliminated by decreasing airspeed or rotor speed. The vibrations appeared to be the result of drone/winch/airframe interactions.

Throughout the testing, it was necessary to make CG TRIM adjustments at high airspeeds (above 110 KIAS) to retain the automatic flight control system (AFCS) pitch attitude hold function.

1. The following NOTE should be added to the Flight Manual for MARS-configured HH-53C helicopters (page 11):

NOTE

> When towing drones at high airspeeds (above 110 KIAS), CG TRIM adjustments will be necessary to retain the AFCS pitch attitude hold capability.

While both the AQM-34L and AQM-34R drones were successfully towed without stabilization chutes, drone oscillations under these conditions were easily induced and slow to subside after corrective action.

2. When available, a stabilization chute should be employed for drone towing (page 11).

Takeoffs with a drone in tow were best accomplished by spending a minimum amount of time in a hover and effecting a smooth, gradual increase in airspeed and altitude.

An inadvertent release of the winch cable focused attention on the fact that the cyclic stick emergency cable cutter button was located in the same position as the cyclic trim stick release button on H-1 series helicopters.

3. If possible, the emergency cable release button should be moved to another location on the cyclic stick. If this is impractical, the emergency cable release button should have a guard installed to prevent inadvertent cable release (page 13).

The position error of the standard pitot-static system agreed with previously acquired data (reference 2). No significant differences were noted between the basic MARS-modified HH-53C and the HH-53C with the AQM-91A drone in tow.

The power required to hover data from the tests with the clean loading agreed within three percent (lower) of previously acquired data presented in references 5 and 6.

The presence of the AQM-91A drone in tow did not appreciably affect power required for hover in ground effect, but increased power required to hover out of ground effect approximately four to six percent.

4. If the AQM-91A drone is expected to become an operational vehicle, the following NOTE should be added to the Flight Manual for MARS-modified HH-53C helicopters (page 15):

NOTE

When hovering in ground effect with the AQM-91A drone in tow, power required will be unchanged from the clean MARS-modified HH-53C helicopter. However, when hovering out of ground effect with the AQM-91A drone in tow, power required to hover will be increased approxiately six percent over the clean MARS-modified HH-53C helicopter.

Based on results of the hover tests with the AQM-91A drone in tow, it appears that the AQM-34L and AQM-34R drones will also have no significant effect on power required to hover in ground effect, and that power required to hover out of ground effect will be increased a maximum of five percent over the power required in the clean loading.

The level flight performance data contained in this report are representative of a MARS-modified HH-53C helicopter with an AQM-34L, and AQM-34R, or an AQM-91A drone in tow.

5. The level flight performance data included in this report should be included in the Partial Flight Manual for MARS-modified HH-53C helicopters (page 15).

The nosedown flight attitude of the AQM-91A drone caused a rapid increase in winch load as airspeed increased and limited the maximum attainable airspeed and NAMPP below what could be expected.

6. If the AQM-91A, or similar drones, are to be towed, consideration should be given to reducing the drone nosedown flight attitude, thus reducing the rate of load increase on the winch cable as airspeed is increased. This should allow higher airspeeds during towing and should increase the maximum NAMPP available for most flight conditions (page 16).

Winch cable loads were not a limiting factor when towing the AQM-34L and AQM-34R drones. Maximum attainable forward airspeed while towing the AQM-34L drone was limited by full up collective control, maximum turbine inlet temperature, or pilot comfort. Maximum attainable forward airspeed with the AQM-34R drone in tow was limited by the tendency of the drone to oscillate at high forward airspeeds (above 120 KIAS).

APPENDIX I
TEST TECHNIQUES, DATA ANALYSIS METHODS, AND TEST DATA

GENERAL

Dimensional analysis of the major factors affecting helicopter performance yielded the variables used to present performance data. These dimensionless variables are as follows:

$$C_P = \frac{SHP \times 550}{\rho A (\Omega R)^3} = K_2 \left[\frac{SHP}{\delta_a \sqrt{\theta_a}}\right]\left[\frac{1}{N_R/\sqrt{\theta_a}}\right]^3$$

$$C_T = \frac{GW}{\rho A (\Omega R)^2} = K_1 \left[\frac{GW}{\delta_a}\right]\left[\frac{1}{N_R/\sqrt{\theta_a}}\right]^2$$

$$M_{TIP} = \frac{V_t + 0.592\ (\Omega R)}{38.967\sqrt{T_a}} = K_3 \left[\frac{N_R}{\sqrt{\theta_a}}\right](1 + \mu)$$

$$\mu = \frac{V_t}{\Omega R} = K_4 \left[\frac{1}{N_R/\sqrt{\theta_a}}\right]\left[\frac{V_c}{\sqrt{\delta_a}}\right]$$

Notes:

1. Constants K_1 through K_4 are related to specific rotor systems and are as follows for the HH-53C:

   $K_1 = 12{,}211.87223/(R)^4 = 0.0071705$

   $K_2 = 64{,}138{,}149/(R)^5 = 1.0425$

   $K_3 = 0.00009373\ (R) = 0.00338599$

   $K_4 = 9.5492857/(R) = 0.26434$ (for V_c in knots)

2. For the test airspeeds encountered, it was assumed that $V_c = V_e = V_t\sqrt{\sigma}$, i.e., ΔV_c (compressibility correction to calibrated airspeed) = 0.

PITOT-STATIC SYSTEM CALIBRATION

Tests were conducted to determine the position error of the standard pitot-static system. The ground speed course method was used for level flight tests of the basic MARS-modified HH-53C (clean loading) and with the AQM-91A drone in tow. The standard pitot-static system was also calibrated during descents at approximately 1,000 feet per minute rate of descent for the clean loading. A trailing bomb (calibrated pitot-static source) was trailed behind the aircraft on a 50-foot cable attached to the aft end of the cargo compartment. The trailing bomb was used as a calibration standard, against which the standard pitot-static system was calibrated. Results of the airspeed calibration tests are presented in figure 3, appendix I.

HOVER

Hover tests were conducted using aim referred rotor speeds ($N_R/\sqrt{\theta_a}$) of 175, 185, and 195 rpm. This technique required that rotor speed be varied with ambient temperature to maintain a constant main rotor blade tip Mach number. All hover tests were conducted in less than three knots of wind.

Hover tests with the clean aircraft were conducted at wheel heights of 30, 50 and 100 feet. The primary test technique was tethered hover. Several test conditions were repeated using the free flight hover test technique; data acquired by the two techniques showed excellent agreement.

During the tethered hover tests, the helicopter was tethered to the ground with a cable and load cell. Using this equipment, a large range of thrust coefficients could be obtained by varying the rotor thrust to provide a range of cable tensions (as read from the load cell) to simulate increases in vehicle gross weight. This vehicle gross weight was computed as helicopter gross weight plus cable weight, load cell weight, and cable tension. Results of the clean aircraft hover tests are presented in figures 7 through 9, appendix I.

Hover tests with the AQM-91A drone in the stowed position (approximately 23 feet below the helicopter) were conducted using the free-flight hover test technique. Lead ballast was used to vary aircraft gross weight.

Free-flight hover tests were conducted using a "hover pole" to position the helicopter at a specific height, stationary over a point on the ground. This hover pole consists of two concentric tubes, a gimbal mount, a reference plate, a sighting fence, bungee cord, connecting cable, mounting bracket, and an anchor weight. The hover pole arrangement is depicted in figure 1, this appendix. The center tube is restrained by a bungee cord and a physical stop, but is free to move up and down (within limits) within the outer tube. This outer tube is mounted to the gimbal assembly which allows both tubes to tilt in all directions. The outer gimbal mount is rigidly attached to a bracket which in turn was mounted to a support bracket on the aircraft's refueling probe. The reference plate and sighting fence are mounted to the outer tube. A cable is attached to the lower end of the inner tube and to the anchor weight on the ground.

As the helicopter established a hover near the intended height, tension on the cable (provided by the anchor) caused the center tube to be fixed vertically. As the helicopter moved vertically, the outer tube and the remainder of the assembly moved up and down with respect to the inner tube. As the pilot viewed the center tube, his task was to align the sighting fence with a predetermined mark on the center pole. This established the correct height above ground. The gimbal suspension allowed the poles and the reference plate to tilt when the hover pole was not directly over the anchor. The pilot would "fly" the plate to a level attitude, thus assuring himself that he was over the intended point and was not drifting.

During the hover tests with the AQM-91A drone in tow, a stabilization chute was not used. A restraining line, attached to the aft end of the drone and manipulated by ground personnel, was used to prevent the drone from rotating beneath the helicopter (figure 2, this appendix). Results of the hover tests with the AQM-91A drone in tow are presented in figures 10 through 12, appendix I.

During OGE hover tests, aerodynamic loads acting on the drone increased the winch cable load above the static gross weight of the drone. This resulted in a higher power required to hover than was predicted from data from tests using the clean loading at a gross weight equal to the static weight of the drone and helicopter. Since the data presented in figures 10 through 12, appendix I, were computed using the "effective weight" of the drone (including drone aerodynamic loads and equal to winch cable load), the fairings on these plots are identical with the fairings through the data for the clean loading (figures 7 through 9, appendix I). This is to be expected when using a nondimensional analysis; if there were no interference effects with the rotors, a change in C_T (caused by aerodynamic loads on the drone) would require a compensating change in C_P to maintain the hover.

In order to isolate the effects of aerodynamic loads on the drone, figures 4 through 6, appendix I, were constructed. Thrust coefficient (C_T) was computed in two ways on this plot. The tailed symbols represent thrust coefficients computed using the helicopter gross weight plus drone weight. The untailed symbols represent thrust coefficients computed using helicopter gross weight, drone weight, and aerodynamic loads on the drone. These last two items were equal to winch cable load. The difference in C_T between the two fairings at a given referred rotor speed was caused by the net aerodynamic loads on the drone. Table I, appendix I, presents the conditions in which the clean loading was tested, while table II, appendix I, lists the conditions in which the helicopter with the AQM-91A drone in tow was tested.

LEVEL FLIGHT

Level flight performance tests were conducted to determine power required, range, and compressibility effects for the MARS-configured HH-53C and to determine the changes in these parameters caused by towing the AQM-34L, AQM-34R, and AQM-91A drones. All level flights tests with a drone in tow were conducted with a 6-foot diameter, ribless guide chute attached to the drone and trailing approximately 12 feet behind the drone.

Level flight tests with the clean loading were conducted at predetermined values of C_T and referred rotor speed ($N_R/\sqrt{\theta_a}$) by maintaining a constant ratio of referred gross weight (GW/δ_a). This required increasing pressure altitude as fuel was consumed and adjusting the rotor speed as ambient temperature varied. The indicated ambient temperature data were corrected for adiabatic temperature rise created by the aircraft's forward velocity. The test conditions flown are presented in table III, appendix I, for the clean loading.

The level flight data were converted to nondimensional terms and plotted as C_P versus μ for constant C_T and referred rotor speed. These plots are presented in figures 25 through 40, appendix I. Data from these plots were used to construct plots of C_p versus C_T at a constant μ with lines of constant referred rotor speed (figures 18 through 24, appendix I). Two additional plots were constructed as an aid in analyzing the power requirements; C_p versus $N_R/\sqrt{\theta_a}$ at a constant rotor advance ratio (μ) with lines of varying C_T, and C_p versus $N_R/\sqrt{\theta_a}$ at a constant C_T with lines of varying μ. These latter two sets of plots were used to help generate the summary or "carpet" plots presented in figures 13 through 17, appendix I. The fairings for power required on figures 25 through 40, appendix I, can be derived from these carpet plots.

Level flight performance tests with the AQM-34L drone were conducted and analyzed in the same manner as with the clean loading. Results of these tests are presented in individual flight plots (figures 52 through 62, appendix I), summary plots (figures 46 through 51, appendix I) and "carpet" plots (figures 41 through 45, appendix I). Average values of C_T for the level flight performance tests with the AQM-34L drone in tow were computed using helicopter gross weight and drone weight. This is equivalent to the C_T computed with no knowledge of the variation of the aerodynamic load on the drone with airspeed. Computing C_T in this manner makes it possible to use the summary and carpet plots (figures 46 through 51, appendix I, and figures 41 through 45, appendix I, respectively) to determine actual power required knowing only aircraft gross weight, drone weight, and the proposed flight conditions (airspeed, altitude, outside air temperature, and rotor speed). The aerodynamic loads on the drone are presented [(cable load minus drone weight) versus μ] on the individual flight plots. This makes it possible to compute the actual C_T (including drone aerodynamic loads) which produced the power required for a given test condition. Level flight performance data with the AQM-34R and AQM-91A drones in tow are presented in the same manner as described above for data with the AQM-34L drone in tow. Individual flight data plots with the AQM-34R drone in tow are presented in figures 73 through 82, appendix I; the summary plots in figures 68 through 72, appendix I; the "carpet" plots in figures 63 through 67, appendix I. Individual flight data plots with the AQM-91A drone in tow are presented in figures 93 through 107, appendix I; the summary plots in figures 88 through 92, appendix I; and the "carpet" plots in figures 83 through 87, appendix I. Summaries of level flight test conditions with drones in tow are presented in tables IV, V and VI, appendix I, for the AQM-34L, AQM-34R and AQM-91A drones, respectively.

Due to the arrangement of the harness supporting each drone, the "stowed" position of the AQM-34L and AQM-34R drones was approximately 18 feet below the helicopter, while the "stowed" position of the AQM-91A drone was approximately 23 feet below the helicopter.

Specific range (NAMPP) was computed using the following equation:

$$NAMPP = \frac{V_{t_t}}{W_{f_t}}$$

where

V_{t_t} = test day true airspeed in knots

W_{f_t} = test day fuel flow in lb/hr

Fairings for the NAMPP data were computed using the equation above, where W_{f_t} was obtained from referred fuel flow ($W_f/\delta_a\sqrt{\theta_a}$) and referred shaft horsepower presented in figures 112 and 113, appendix I.

POWER DETERMINATION

The HH-53C uses an electronic torque monitoring system to measure the torque applied by each engine to the main transmission. The torque sensing system is located at the input from each engine section to the nose gear box. The system was designed to measure the "twist" of the shaft connecting the engine and nose gearbox.

The shaft assembly consists of a central power-transmitting shaft and an outer, concentric sleeve which is attached to the shaft only at the driven end. At the "free" end, the sleeve is free to rotate with respect to the shaft. At this end of the sleeve, and integral with it, is a multi-tooth wheel. Next to it, and integral with the power-transmitting shaft, is another wheel having the same number of teeth. The teeth of the two shafts were machined to be axially aligned at zero torque. As torque is applied to the shaft, the shaft twists proportionately; the relative axial alignment of the two sets of teeth changes proportionately with applied torque.

The torque pickup is mounted on the shaft housing and consists of a dual, variable-reluctance generator assembly and a temperature-sensitive resistance (thermistor). One generator is positioned over the sleeve wheel, and the other is positioned over the shaft wheel. As the shaft and sleeve teeth and slots rotate past the generator poles, the magnetic flux alternately accumulates and decays, generating two alternating voltages. The phase difference between the two alternating voltages depends upon the axial alignment of the two sets of teeth and the alignment of the poles of the generator assemblies. The frequency of the alternating voltages is directly proportional to power turbine speed and to the number of teeth on each wheel. Therefore, since axial alignment of the teeth changes proportionately with shaft torque, the phase difference between the two voltages changes proportionately with applied torque. Since shaft modulus varies with temperature, the proportionality constant (change in phase difference per unit of torque) also varies with temperature. The thermistor provides a resistance which varies with pickup temperature. When properly related to shaft temperature, the thermistor provides a means to make corrections in the rate-of-change of phase difference versus torque as temperature changes. Each shaft was calibrated on a static torquing fixture to determine its torsional spring rate. When properly converted to electrical parameters, this torsional spring rate is used in calculating standard inputs during the torque system (electrical) calibrations. A torque reading of 100 percent corresponded to 3,200 shaft horsepower at 100 percent rotor speed (184.7 rpm). Test shaft horsepower was determined from inflight torquemeter readings and rotor speed using the following equation:

$$\frac{SHP}{Engine} = \frac{(1,235)\left(\frac{\%\ torque}{100}\right)(13,600)\left(\frac{\%\ rotor\ rpm}{100}\right)}{5,252}$$

ENGINE CHARACTERISTICS

The absence of engine inlet instrumentation made it necessary to generalize output shaft horsepower, fuel flow, and gas generator turbine speed according to the following relationships:

$$\frac{SHP}{\delta_a\sqrt{\theta_a}} \quad \text{versus} \quad \frac{N_g}{\sqrt{\theta_a}}$$

$$\frac{W_f}{\delta_a\sqrt{\theta_a}} \quad \text{versus} \quad \frac{N_g}{\sqrt{\vartheta_a}}$$

$$\frac{SHP}{\delta_a\sqrt{\theta_a}} \quad \text{versus} \quad \frac{W_f}{\delta_a\sqrt{\theta_a}}$$

The engine characteristics data are presented in figures 108 through 113, appendix I. A comparison was made between the T64-GE-7 engine specification (reference 3) and the engines installed in the test aircraft. Fairings of specification predicted engine performance are presented in figures 112 and 113, appendix I.

Table I

SUMMARY OF HOVER TEST CONDITIONS

(Clean)

	$N_R/\sqrt{\theta_a}$ = 177.5 rpm		$N_R/\sqrt{\theta_a}$ = 188.5 rpm		$N_R/\sqrt{\theta_a}$ = 197.5 rpm	
Wheel Height (ft)	Pressure Altitude (ft)	Free Air Temperature (deg C)	Pressure Altitude (ft)	Free Air Temperature (deg C)	Pressure Altitude (ft)	Free Air Temperature (deg C)
30	2,270	13.5	2,175	5.0	2,170	5.0
50	2,305	14.5	2,200	5.0	2,205	5.0
	- - -	- - -	1,965	-4.5	1,970	-4.0
	- - -	- - -	2,050	5.0	2,050	4.0
100	2,340	15.5	1,950	0.0	1,940	-1.0
	- - -	- - -	2,025	-4.5	2,040	-4.5
	- - -	- - -	2,150	4.0	2,150	4.5

Table II

SUMMARY OF HOVER TEST CONDITIONS

(With AQM-91A Drone)

	$N_R/\sqrt{\theta_a}$ = 178.9 rpm		$N_R/\sqrt{\theta_a}$ = 189.2 rpm		$N_R/\sqrt{\theta_a}$ = 196.9 rpm	
Wheel Height (ft)	Pressure Altitude (ft)	Free Air Temperature (deg C)	Pressure Altitude (ft)	Free Air Temperature (deg C)	Pressure Altitude (ft)	Free Air Temperature (deg C)
30	2,005	4.0	2,010	4.0	2,020	2.0
	2,225	18.0	2,225	18.0	- - -	- - -
	2,220	18.5	2,215	18.5	- - -	- - -
	2,165	17.0	2,170	17.0	- - -	- - -
50	2,045	4.5	2,040	4.5	2,065	2.0
	2,265	18.5	2,265	18.5	- - -	- - -
	2,220	17.0	2,215	17.0	- - -	- - -
100	2,330	19.0	2,125	2.0	2,120	2.5
	2,290	16.5	2,320	19.0	- - -	- - -
	2,255	18.5	2,275	17.0	- - -	- - -

Table III

SUMMARY OF LEVEL FLIGHT TEST CONDITIONS

(Clean)

Flight No.	$C_T \times 10^4$	$N_R/\sqrt{\theta_a}$ (rpm)	GW/δ_a (lb)	Pressure Altitude (ft)	Free Air Temperature (deg C)	Average Gross Weight (lb)
6	88.01	188.9	43,860	4,400	-5.0	37,320
7	108.71	185.2	52,000	8,800	-4.5	37,460
8	99.74	193.2	51,930	8,950	-3.5	37,190
9	99.27	183.5	46,670	5,800	2.0	37,680
10	78.79	192.2	40,590	6,000	5.5	32,530
16.1	89.56	192.5	46,280	7,550	4.5	34,970
16.2	77.65	188.3	38,370	3,700	3.0	33,510
19.1	87.39	164.7	41,540	4,450	1.0	35,280
19.2	99.41	188.3	48,840	10,150	-7.0	33,390
20	76.48	185.0	36,520	3,550	4.5	32,070
22.1	102.62	195.3	54,970	8,250	0.0	40,440
22.2	112.46	187.1	54,980	9,200	-0.5	39,000
23.1	114.50	195.5	61,000	11,000	-3.5	40,350
23.2	113.07	191.7	57,930	10,750	-4.0	38,690
26.1	90.99	196.0	48,770	8,200	0.5	35,950
26.2	79.68	196.1	42,760	5,700	4.0	34,660

Table IV

SUMMARY OF LEVEL FLIGHT TEST CONDITIONS

(With AQM-34L Drone)

Flight No.	$C_T \times 10^4$	$N_R/\sqrt{\theta_a}$ (rpm)	GW/δ_a (lb)	Pressure Altitude (ft)	Free Air Temperature (deg C)	Average Gross Weight (lb)
39	78.39	192.5	40,440	4,900	7.0	33,780
40	89.70	192.4	46,080	6,950	2.0	35,620
42.1	88.90	188.2	43,960	4,900	10.0	36,710
42.2	80.24	195.3	43,160	5,000	10.5	35,910
44.1	113.45	196.4	60,940	12,750	-0.5	37,630
44.2	110.59	188.9	55,530	11,000	2.0	36,730
45	87.03	185.1	41,590	5,200	15.0	34,340
46	110.80	193.5	57,880	11,350	4.5	37,760
47.1	107.90	186.0	52,040	9,600	7.5	36,340
47.2	90.99	196.4	49,440	8,850	9.0	35,540
53	77.21	189.0	38,270	3,700	18.5	33,570

Table V

SUMMARY OF LEVEL FLIGHT TEST CONDITIONS

(With AQM-34R Drone)

Flight No.	$C_T \times 10^4$	$N_R/\sqrt{\theta_a}$ (rpm)	GW/δ_a (lb)	Pressure Altitude (ft)	Free Air Temperature (deg C)	Average Gross Weight (lb)
55	85.75	186.0	41,370	3,550	24.5	36,330
56.1	87.84	188.8	43,670	5,100	17.0	36,200
56.2	90.83	196.1	48,720	8,650	12.0	35,300
58.1	78.17	193.4	40,780	4,300	18.0	34,830
58.2	81.56	187.8	40,120	4,800	18.0	33,630
59	87.98	194.2	46,280	7,900	12.5	34,500
60.1	108.94	190.0	54,850	8,670	12.0	39,700
60.2	108.17	186.1	52,250	8,070	13.0	38,700
61.1	113.06	196.7	61,010	11,475	6.0	39,600
61.2	109.88	194.5	57,980	10,700	9.0	38,800

Table VI

SUMMARY OF LEVEL FLIGHT TEST CONDITIONS

(With AQM-91A Drone)

Flight No.	$C_T \times 10^4$	$N_R/\sqrt{\theta_a}$ (rpm)	GW/δ_a (lb)	Pressure Altitude (ft)	Free Air Temperature (deg C)	Average Gross Weight (lb)
30	88.05	189.5	44,150	5,950	8.5	35,440
31.1	108.08	185.6	51,860	8,750	3.0	37,430
31.2	80.17	195.5	42,780	4,450	13.0	36,330
32.1	100.43	192.9	52,220	8,800	4.5	37,610
32.2	97.89	185.2	46,740	6,600	10.0	36,610
34.1	99.22	188.7	49,360	7,300	9.5	37,650
34.2	94.67	196.7	49,360	7,650	8.5	37,150
35	87.10	185.2	41,640	4,400	16.5	35,430
36.1	110.22	188.9	54,840	10,300	1.0	37,270
36.2	102.79	195.5	54,840	11,000	-0.5	36,270
37.1	78.02	192.9	40,450	3,100	15.5	36,120
37.2	77.60	188.5	39,540	2,900	14.5	35,570
38.1	111.85	192.7	58,010	11,500	-1.5	37,630
38.2	114.47	195.5	60,980	13,650	-7.5	36,330
43	88.53	193.4	46,180	5,650	9.5	37,500

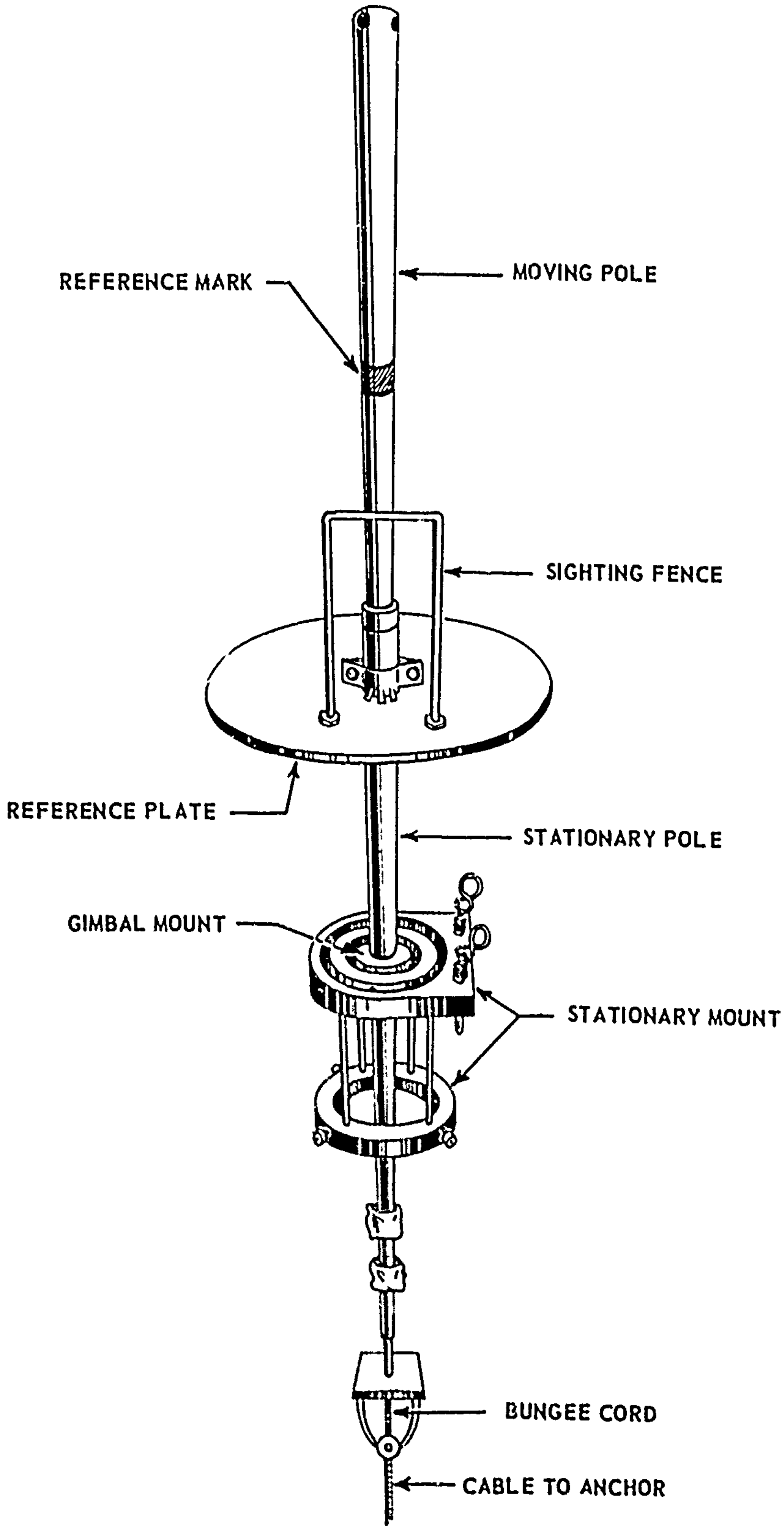


Figure 1 Hover Pole

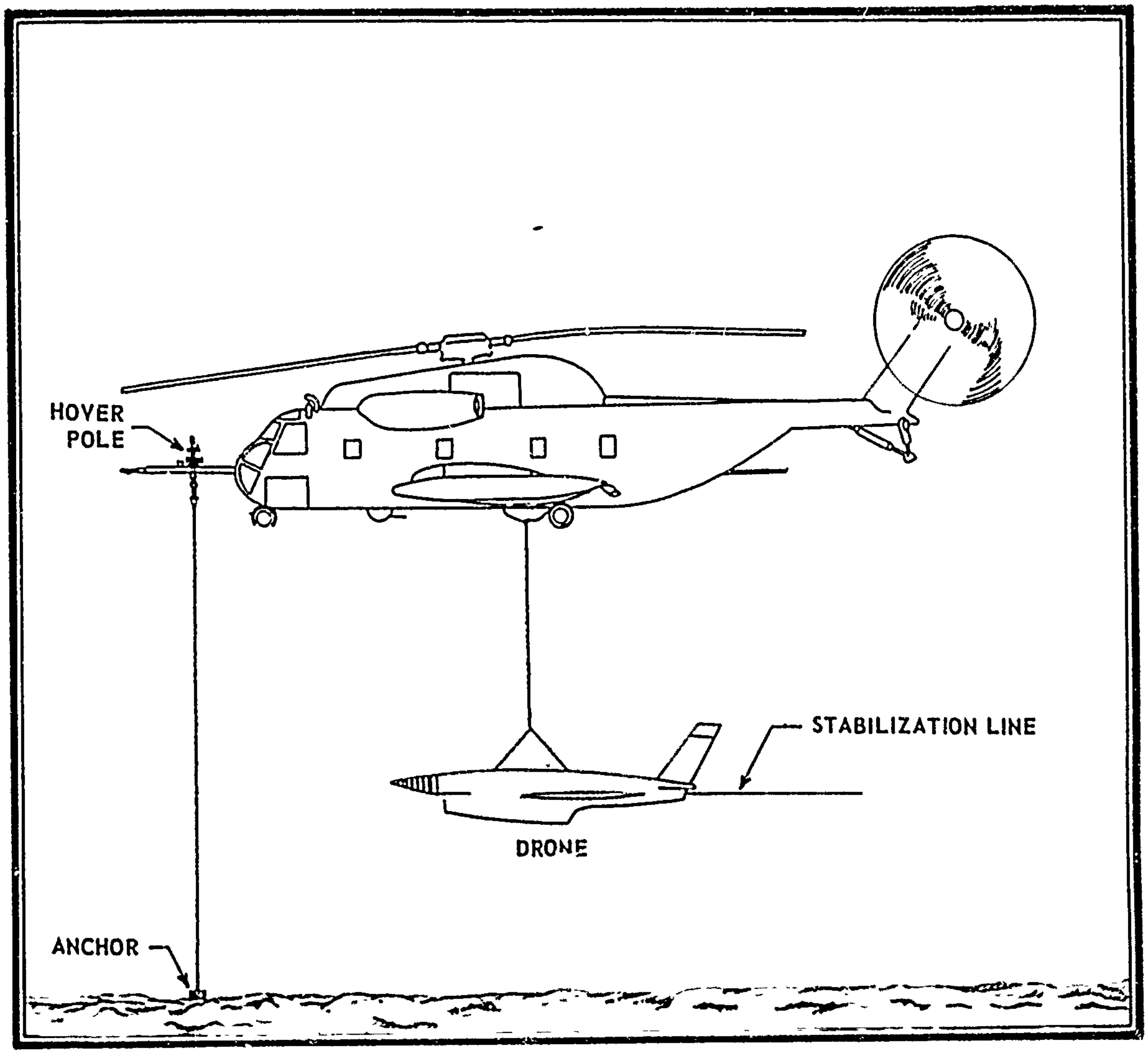


Figure 2 Hover Test Technique with Drone in Tow

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES - EAPS INSTALLED
MARS PERFORMANCE

NOTES: 1. MARS CONFIGURED, TWO 450-GALLON AUXILIARY FUEL TANKS INSTALLED, EXTERNAL RESCUE HOIST
2. LEVEL FLIGHT DATA OBTAINED USING GROUND SPEED COURSE TEST METHOD
3. DESCENT DATA OBTAINED USING TRAILING BOMB TEST METHOD, AVERAGE RATE OF DESCENT 1,000 FEET PER MINUTE

SYMBOL	AVG. G.W. (LB)	AVG. ALT. (FT)	AVG. FAT (DEG. C)	AVG. ROTOR SPEED (rpm)	AVG. C.G. (IN.)	CONDITION	DRONE
○	36,200.	2,380.	7.0	194.0	339.	LEVEL FLT.	NONE
□	36,600.	2,450.	17.5	191.5	337.	LEVEL FLT.	AQM-91A
△	34,500.	7,970.	17.0	192.3	335.	DESCENT	NONE

STANDARD PITOT-STATIC SYSTEM

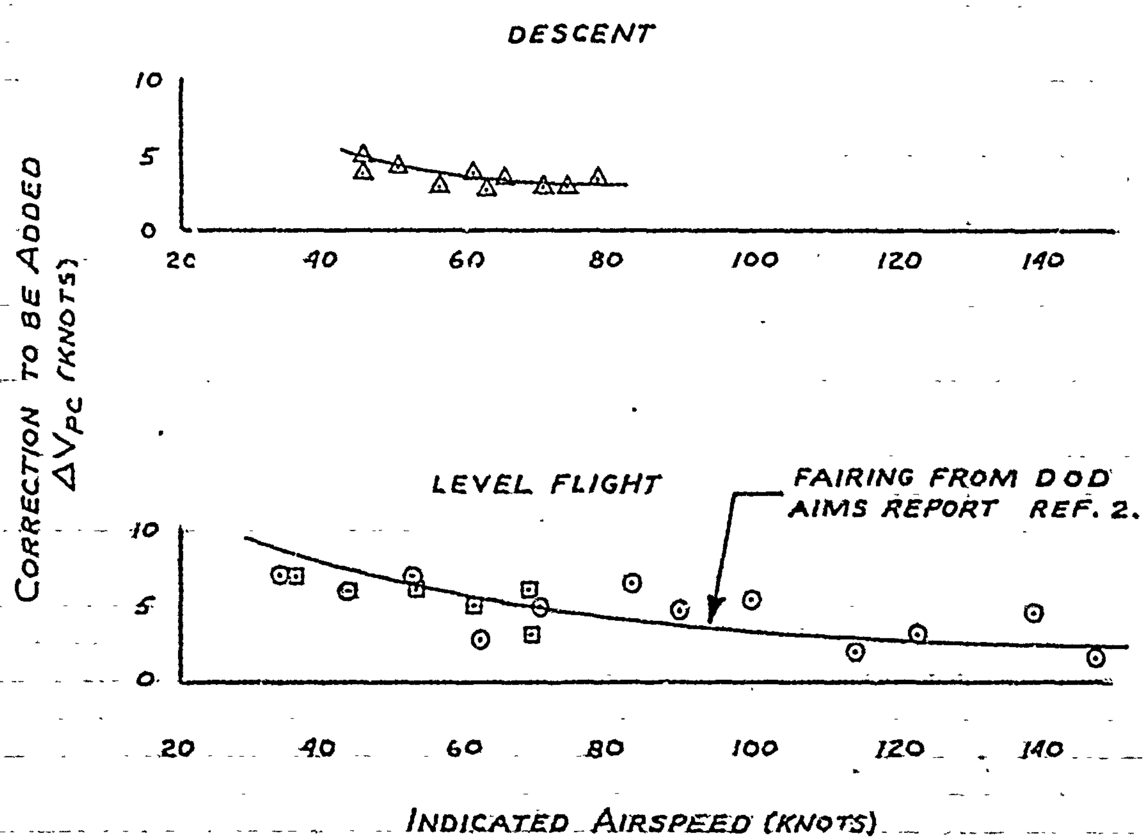


FIGURE 3. AIRSPEED CALIBRATION

HH-53C USAF S/N 67-14993

T64-GE-7 ENGINES ~ EAPS INSTALLED

MARS PERFORMANCE

NOTES: 1. MARS-CONFIGURED, TWO 450-GAL AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-91A DRONE IN STOWED POSITION.

2. DATA OBTAINED IN FREE-FLIGHT AND LESS THAN THREE KNOTS OF WIND.

3. DISTANCE FROM CENTER OF WHEEL TO CENTER OF ROTOR HUB = 17 FT. 5 IN.

4. TAILED SYMBOLS DENOTE DATA COMPUTED USING AIRCRAFT GROSS WEIGHT AND DRONE STATIC WEIGHT TO COMPUTE C_T; UNTAILED SYMBOLS DENOTE DATA COMPUTED USING AIRCRAFT GROSS WEIGHT AND DRONE EFFECTIVE (IN-FLIGHT) WEIGHT.

SYM	AVG. $N_R/\sqrt{\theta_0}$ (r.p.m)	AVG. ROTOR SPEED (r.p.m)	AVG. M_{TIP} (ADV. BLADE)	AVG. PRESSURE ALTITUDE (FT.)	AVG. FREE AIR TEMP (DEG. C)
○	179.0	179.2	0.606	2,775	15.5
□	189.3	189.6	0.641	2,170	15.5
△	196.8	192.4	0.666	2,020	2.5

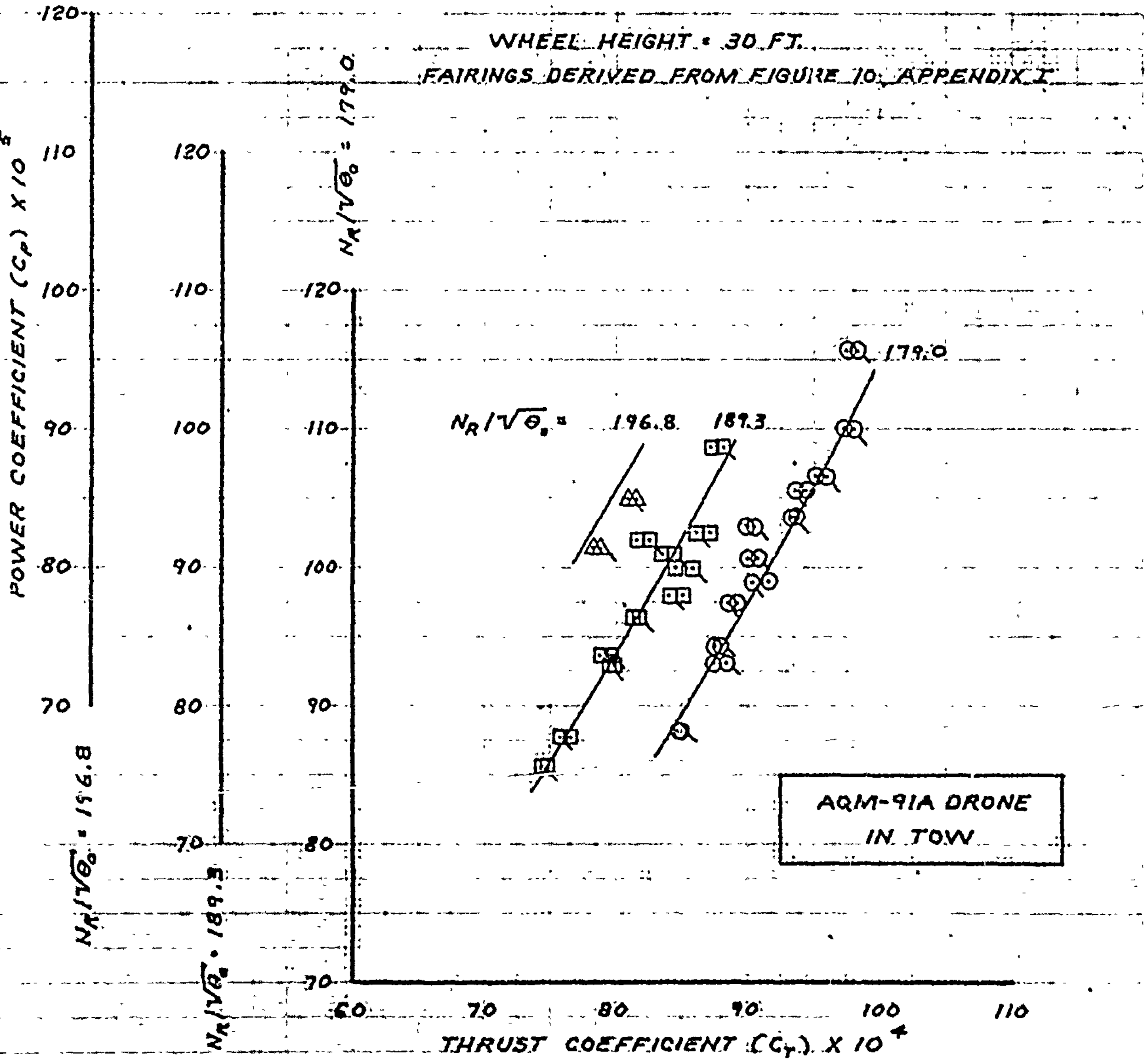


FIGURE 4. NONDIMESIONAL HOVER PERFORMANCE

HH-53C USAF S/N 67-14993

T64-GE-7 ENGINES~EAPS INSTALLED

MARS PERFORMANCE

NOTES: 1. MARS-CONFIGURED, TWO 450-GAL AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-91A DRONE IN STOWED POSITION.

2. DATA OBTAINED IN FREE-FLIGHT AND LESS THAN THREE KNOTS OF WIND.

3. DISTANCE FROM CENTER OF WHEEL TO CENTER OF ROTOR HUB = 17 FT. 5 IN.

4. TAILED SYMBOLS DENOTE DATA COMPUTED USING AIRCRAFT GROSS WEIGHT AND DRONE STATIC WEIGHT TO COMPUTE C_T; UNTAILED SYMBOLS DENOTE DATA COMPUTED USING AIRCRAFT GROSS WEIGHT AND DRONE EFFECTIVE (IN-FLIGHT) WEIGHT.

SYM	AVG. $N_R/\sqrt{\theta_a}$ (rpm)	AVG. ROTOR SPEED (rpm)	AVG. M_{TIP} (ADV. BLADE)	AVG. PRESSURE ALTITUDE (FT.)	AVG. FREE AIR TEMP (DEG C)
⊙	179.1	178.9	0.606	2,190	14.5
⊡	189.1	188.7	0.641	2,180	14.0
△	197.5	193.1	0.669	2,065	2.5

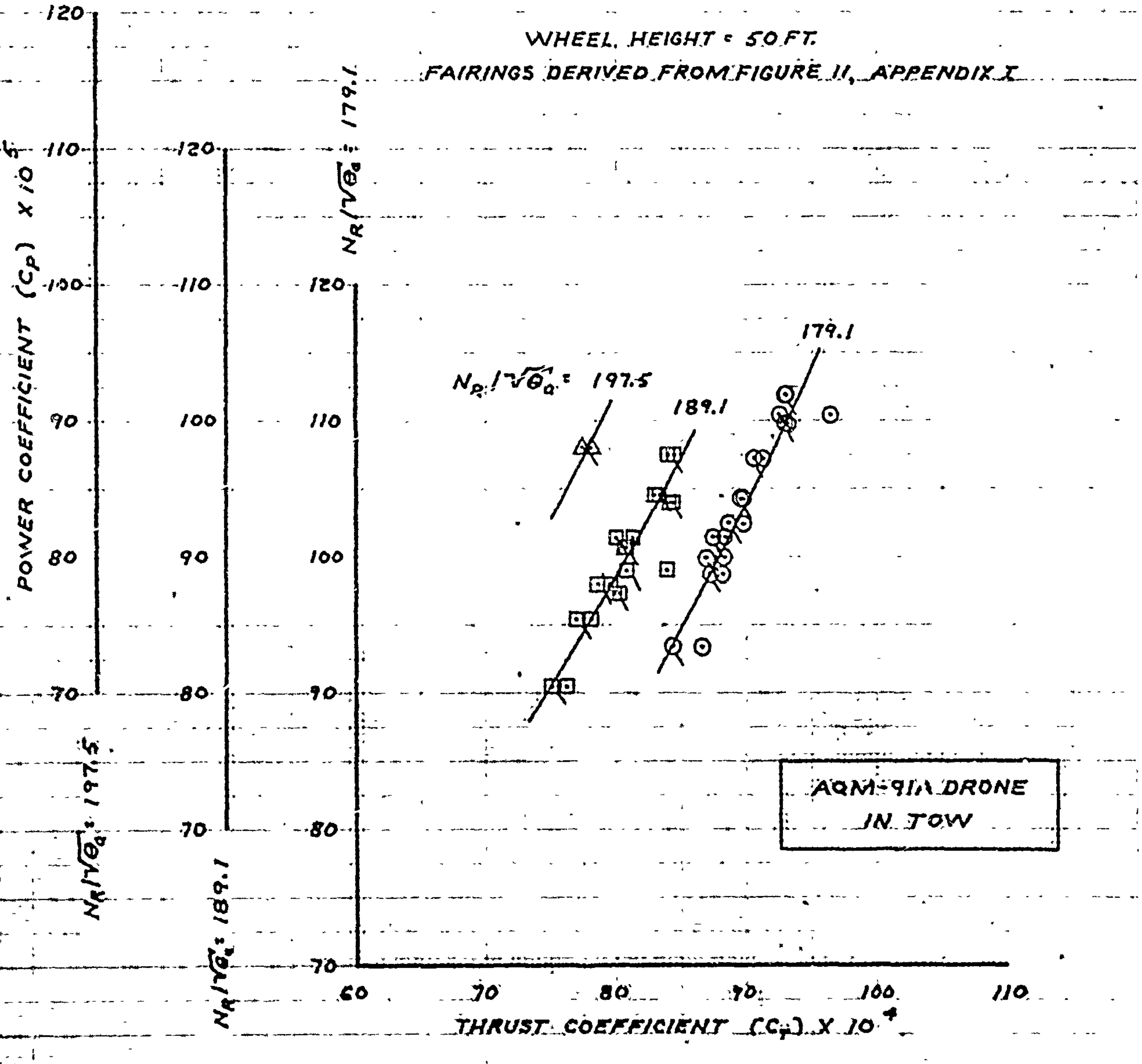


FIGURE 5. NONDIMENSIONAL HOVER PERFORMANCE

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES - EAPS INSTALLED
MARS PERFORMANCE

NOTES: 1. MARS-CONFIGURED, TWO 450-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-91A DRONE IN STOWED POSITION.
2. DATA OBTAINED IN FREE FLIGHT AND LESS THAN THREE KNOTS OF WIND.
3. DISTANCE FROM CENTER OF WHEEL TO CENTER OF ROTOR HUB = 17 FT 5 IN.
4. TAILED SYMBOLS DENOTE DATA COMPUTED USING AIRCRAFT GROSS WEIGHT AND DRONE STATIC WEIGHT TO COMPUTE C_T; UNTAILED SYMBOLS DENOTE DATA COMPUTED USING AIRCRAFT GROSS WEIGHT AND DRONE EFFECTIVE (IN-FLIGHT) WEIGHT.

SYM	AVG. $N_R/\sqrt{\theta_a}$ (RPM)	AVG. ROTOR SPEED (RPM)	AVG. M_{TIP} (ADV. BLADE)	AVG. PRESSURE ALTITUDE (FT)	AVG. FREE AIR TEMP. (DEG C)
○	178.5	179.3	0.604	2,300	18.0
□	189.1	189.4	0.641	2,270	16.0
△	196.5	192.4	0.665	2,120	2.5

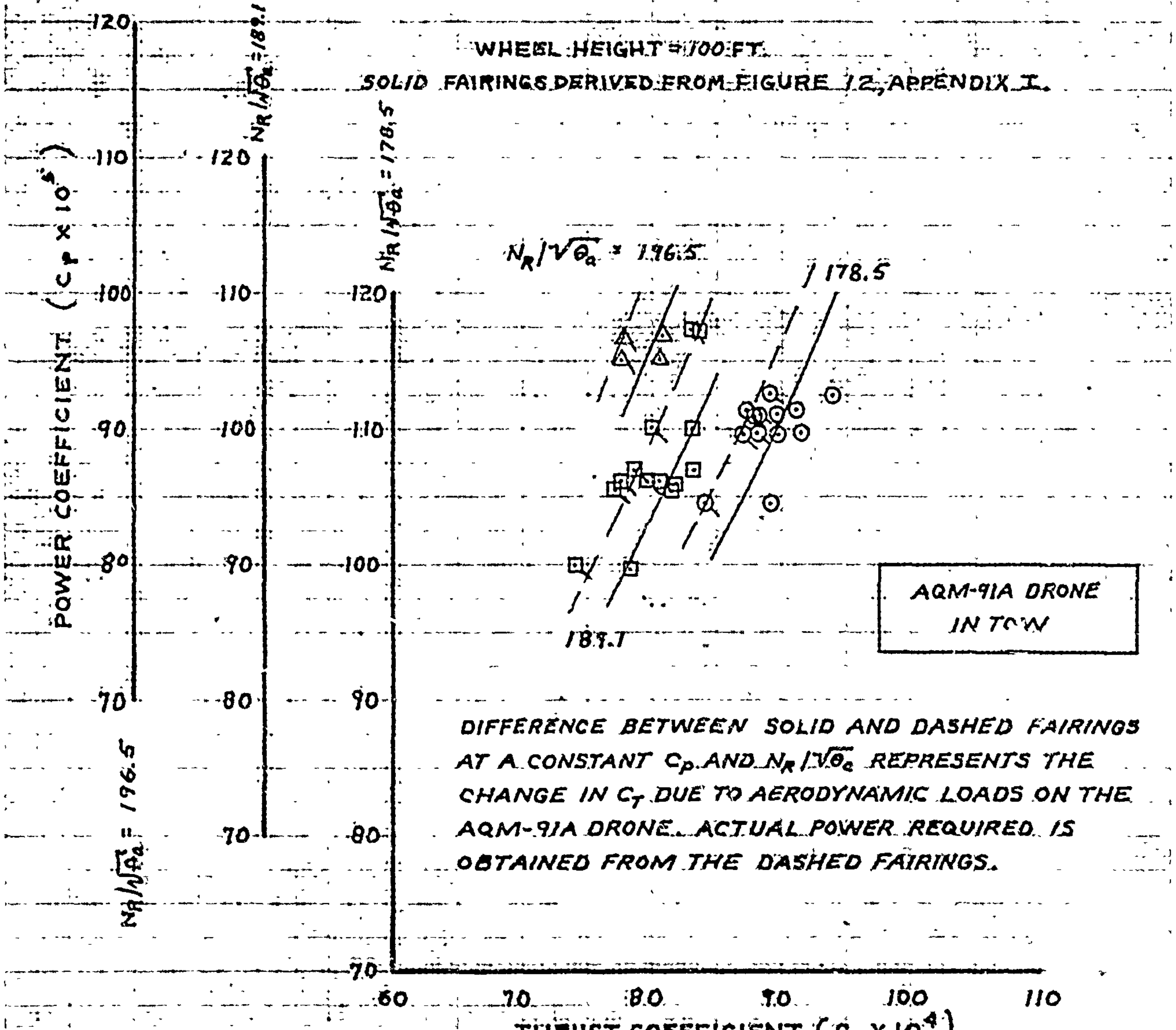


FIGURE 6. NONDIMENSIONAL HOVER PERFORMANCE

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE
WHEEL HEIGHT = 30 FT.

NOTES: 1. MARS-CONFIGURED, TWO 450-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.
2. DATA FLOWN IN LESS THAN THREE KNOTS OF WIND.
3. DISTANCE FROM CENTER OF WHEEL TO CENTER OF ROTOR HUB EQUALS 17 FT. 5 IN.
4. SOLID SYMBOLS DENOTE FREE-FLIGHT HOVER; OPEN SYMBOLS, TETHERED HOVER.

SYM	AVG. $N_R/\sqrt{\theta_a}$ (rpm)	AVG. ROTOR SPEED (rpm)	AVG. M_{TIP} (ADV. BLADE)	AVG. PRESSURE ALTITUDE (FT.)	AVG. FREE AIR TEMP (DEG. C)
⊙	177.7	177.2	0.601	2,270	13.5
⊡	188.5	185.0	0.638	2,180	5.5
△	198.0	194.0	0.669	2,170	5.0

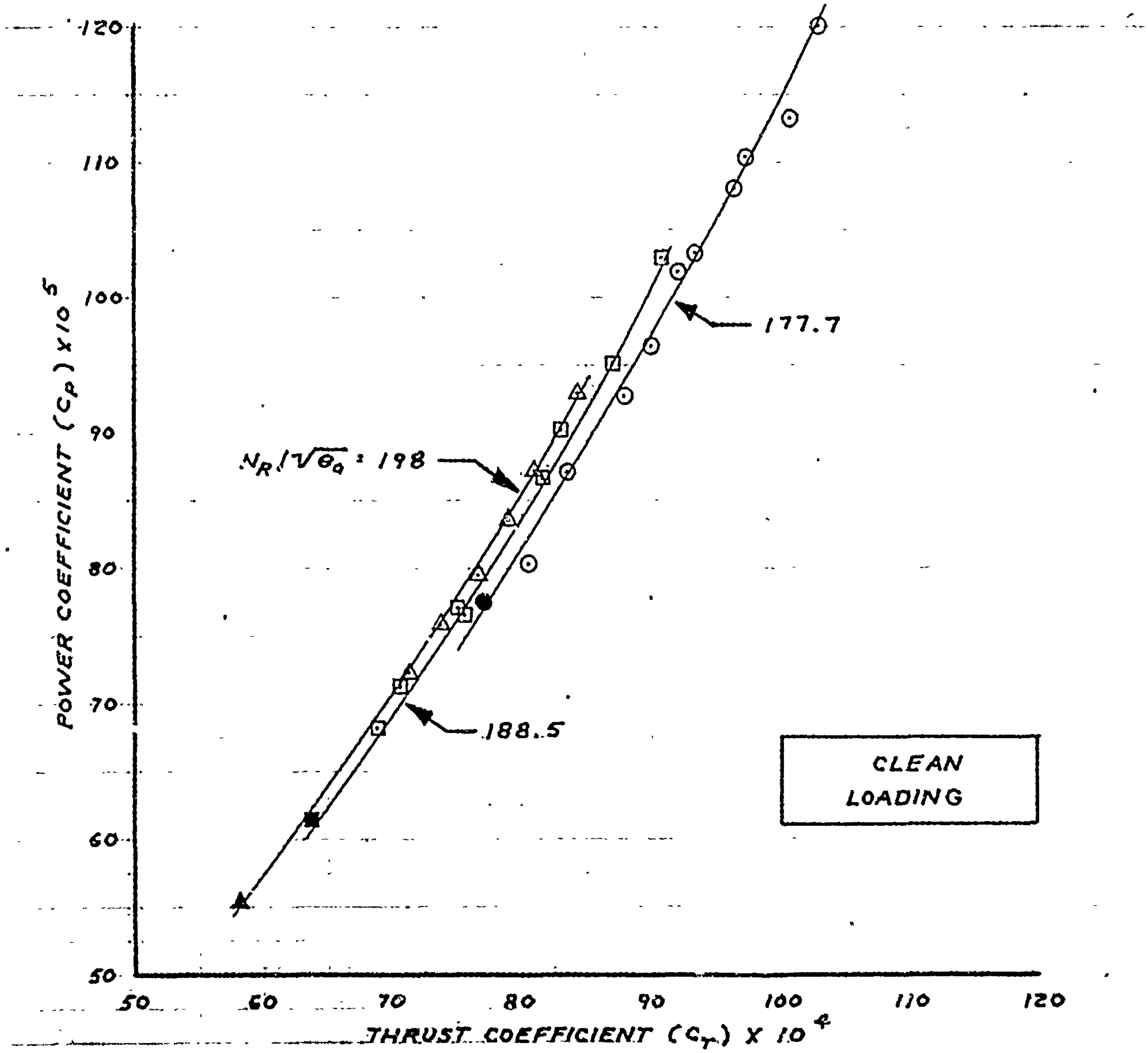


FIGURE 7. NONDIMENSIONAL HOVERING PERFORMANCE

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES - EAPS INSTALLED
MARS PERFORMANCE
WHEEL HEIGHT = 50 FT.

NOTES: 1. MAR-CONFIGURED, TWO 450-GAL AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.
2. DATA FLOWN IN LESS THAN THREE KNOTS OF WIND.
3. DISTANCE FROM CENTER OF WHEEL TO CENTER OF ROTOR HUB EQUALS 17 FT 5 IN.
4. SOLID SYMBOLS DENOTE FREE-FLIGHT HOVER; OPEN SYMBOLS TETHERED HOVER.

SYM	AVG. $N_R/\sqrt{\theta_a}$ (rpm)	AVG. ROTOR SPEED (rpm)	AVG. M_{TIP} (ADV. BLADE)	AVG. PRESSURE ALTITUDE (FT.)	AVG. FREE AIR TEMP. (DEG. C)
○	177.5	177.3	0.601	2,310	14.5
□	188.6	185.2	0.639	2,200	5.0
△	197.5	194.1	0.669	2,200	5.0

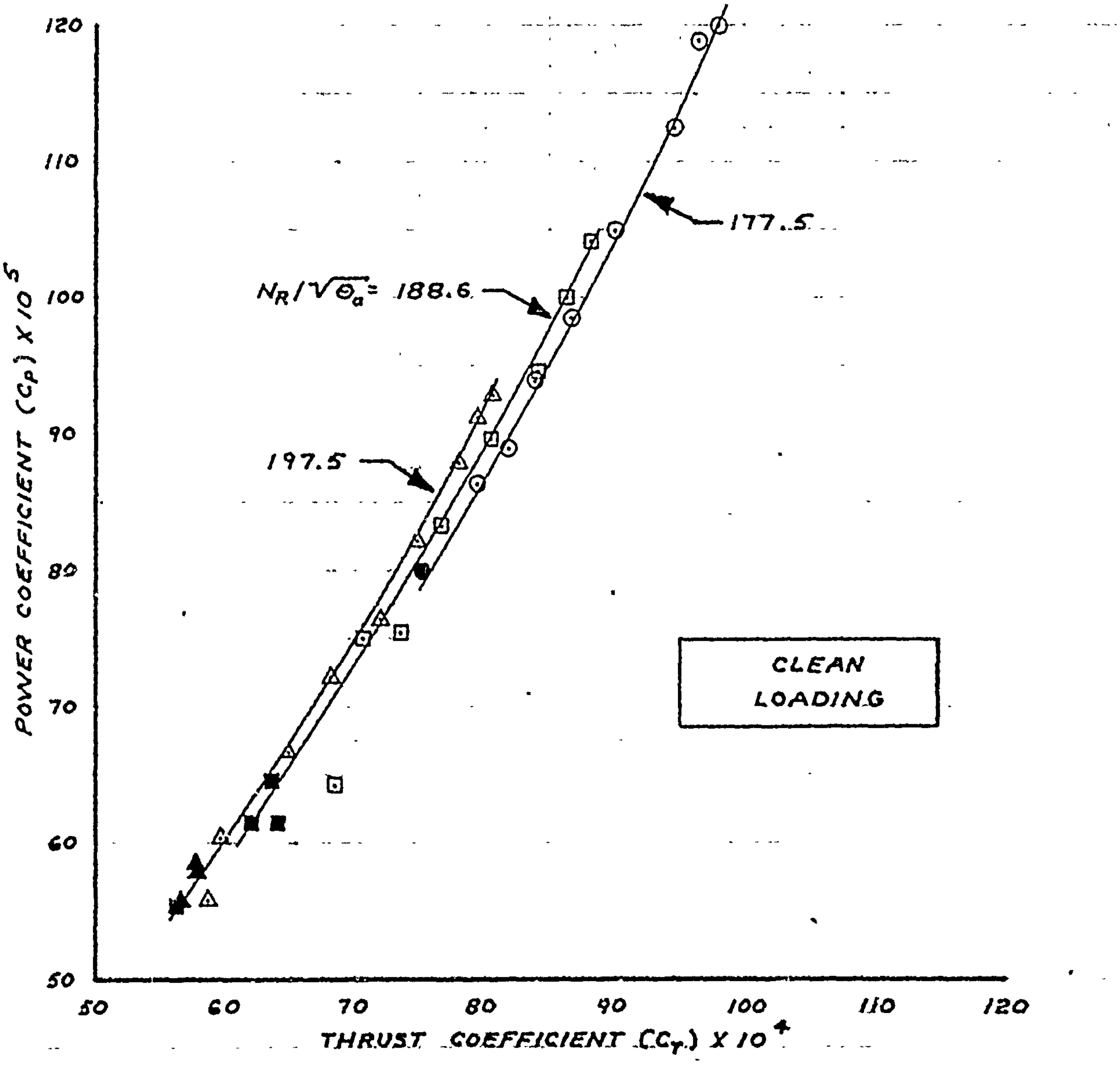


FIGURE 8. NONDIMENSIONAL HOVERING PERFORMANCE

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE
WHEEL HEIGHT = 100 FT.

NOTES: 1. MARS-CONFIGURED, TWO 450-GAL AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.
2. DATA FLOWN IN LESS THAN THREE KNOTS OF WIND.
3. DISTANCE FROM CENTER OF WHEEL TO CENTER OF ROTOR HUB EQUALS 17 FT. 5 IN.
4. SOLID SYMBOLS DENOTE FREE-FLIGHT HOVER; OPEN SYMBOLS TETHERED HOVER.

SYM	AVG. $N_R/\sqrt{\theta_a}$ (r.p.m)	AVG. ROTOR SPEED (r.p.m)	AVG. M_{TIP} (ADV. BLADE)	AVG. PRESSURE ALTITUDE (FT.)	AVG. FREE AIR TEMP. (DEG.C)
○	177.5	177.7	0.601	2,340	15.5
□	188.2	183.2	0.637	1,950	0.0
△	197.3	190.4	0.668	2,040	-4.5

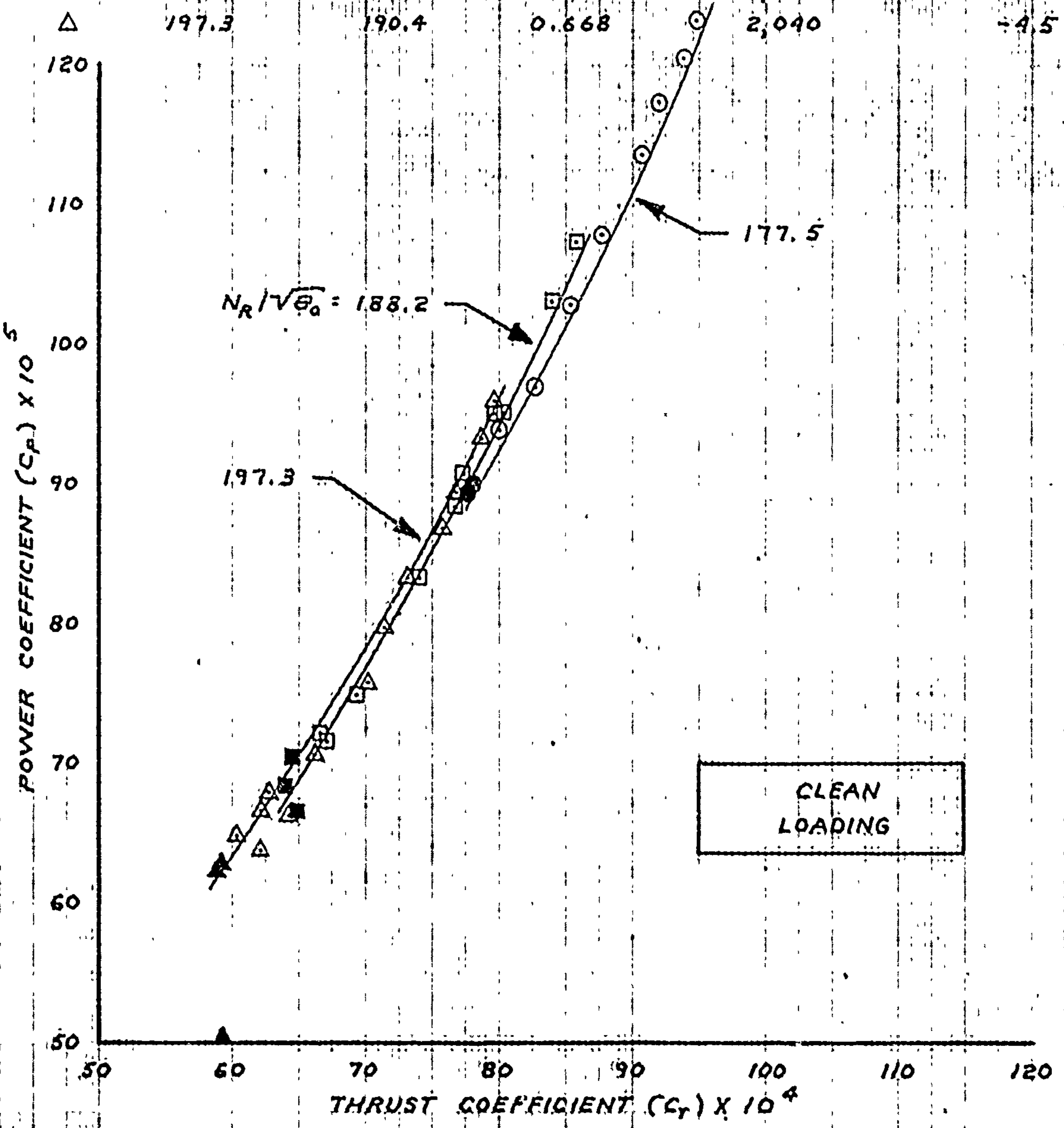


FIGURE 9. NONDIMENSIONAL HOVERING PERFORMANCE

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE
WHEEL HEIGHT = 30 FT.

NOTES: 1. MARS-CONFIGURED, TWO 450-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.
2. DATA FLOWN IN LESS THAN THREE KNOTS OF WIND.
3. DISTANCE FROM CENTER OF WHEEL TO CENTER OF ROTOR HUB EQUALS 17 FT. 5 IN.
4. DATA OBTAINED USING FREE-FLIGHT HOVER TECHNIQUE.

SYM	AVG. $N_R/\sqrt{\theta_a}$ (rpm)	AVG. ROTOR SPEED (rpm)	AVG. M_{TIP} (ADV. BLADE)	AVG. PRESSURE ALTITUDE (FT.)	AVG. FREE AIR TEMP. (DEG. C)
⊙	179.0	179.2	0.606	2,175	15.5
⊡	189.3	189.5	0.641	2,170	15.5
△	196.8	192.4	0.666	2,020	2.5

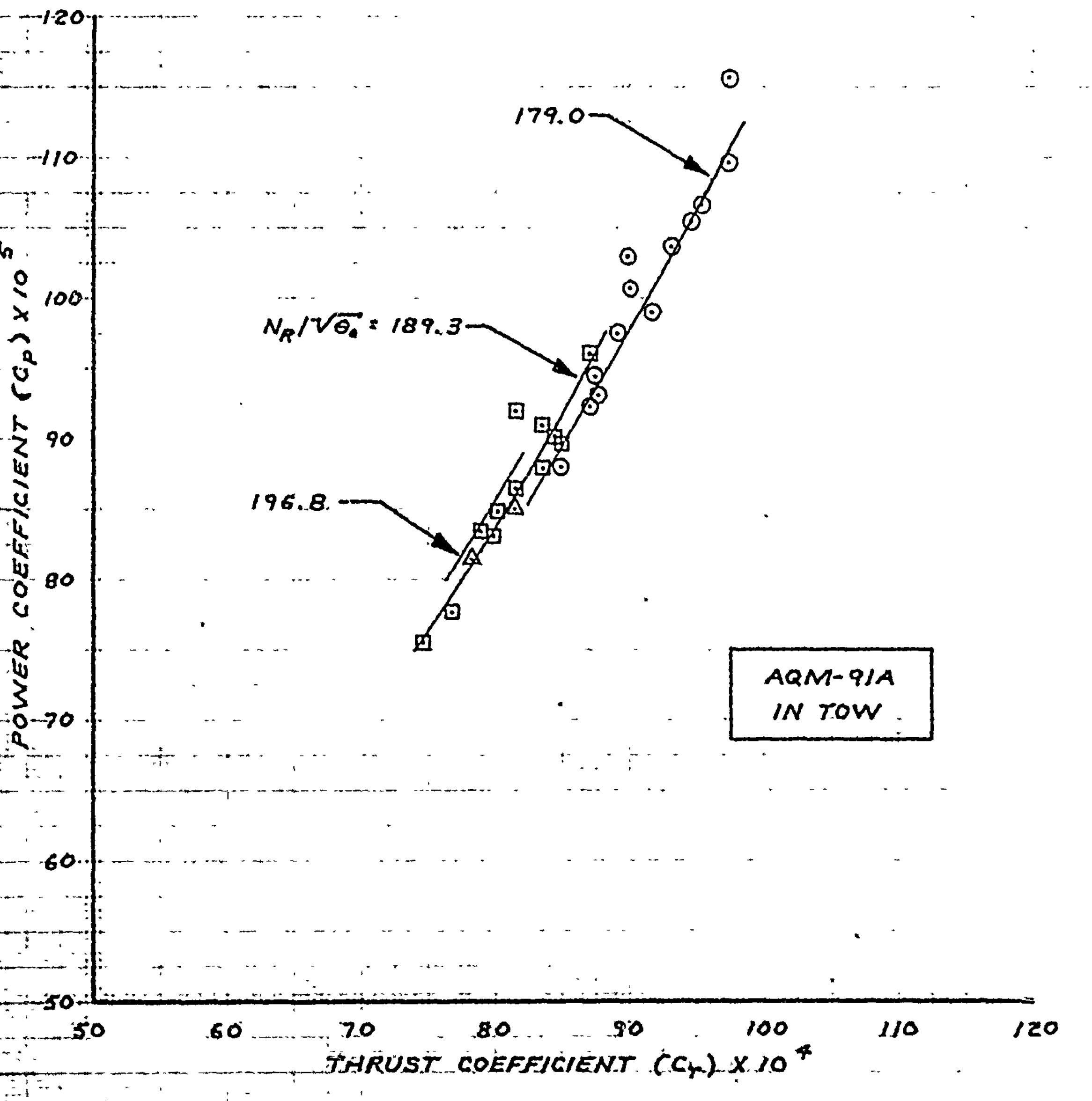


FIGURE 10. NONDIMENSIONAL HOVERING PERFORMANCE (AQM-91A)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES - EAPS INSTALLED
MARS PERFORMANCE
WHEEL HEIGHT = 50 FT.

NOTES: 1. MARS-CONFIGURED, TWO 450-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.
2. DATA FLOWN IN LESS THAN THREE KNOTS OF WIND.
3. DISTANCE FROM CENTER OF WHEEL TO CENTER OF ROTOR HUB EQUALS 17 FT. 5 IN.
4. DATA OBTAINED USING FREE-FLIGHT HOVER TECHNIQUE.

SYM	AVG. $N_R/\sqrt{\theta_a}$ (r.p.m.)	AVG. ROTOR SPEED (r.p.m.)	AVG. M_{TIP} (ADV. BLADE)	AVG. PRESSURE ALTITUDE (FT.)	AVG. FREE AIR TEMP (DEG. C)
○	179.1	178.9	0.606	2,190	14.5
□	189.1	188.7	0.640	2,180	14.0
△	197.5	193.1	0.669	2,065	2.5

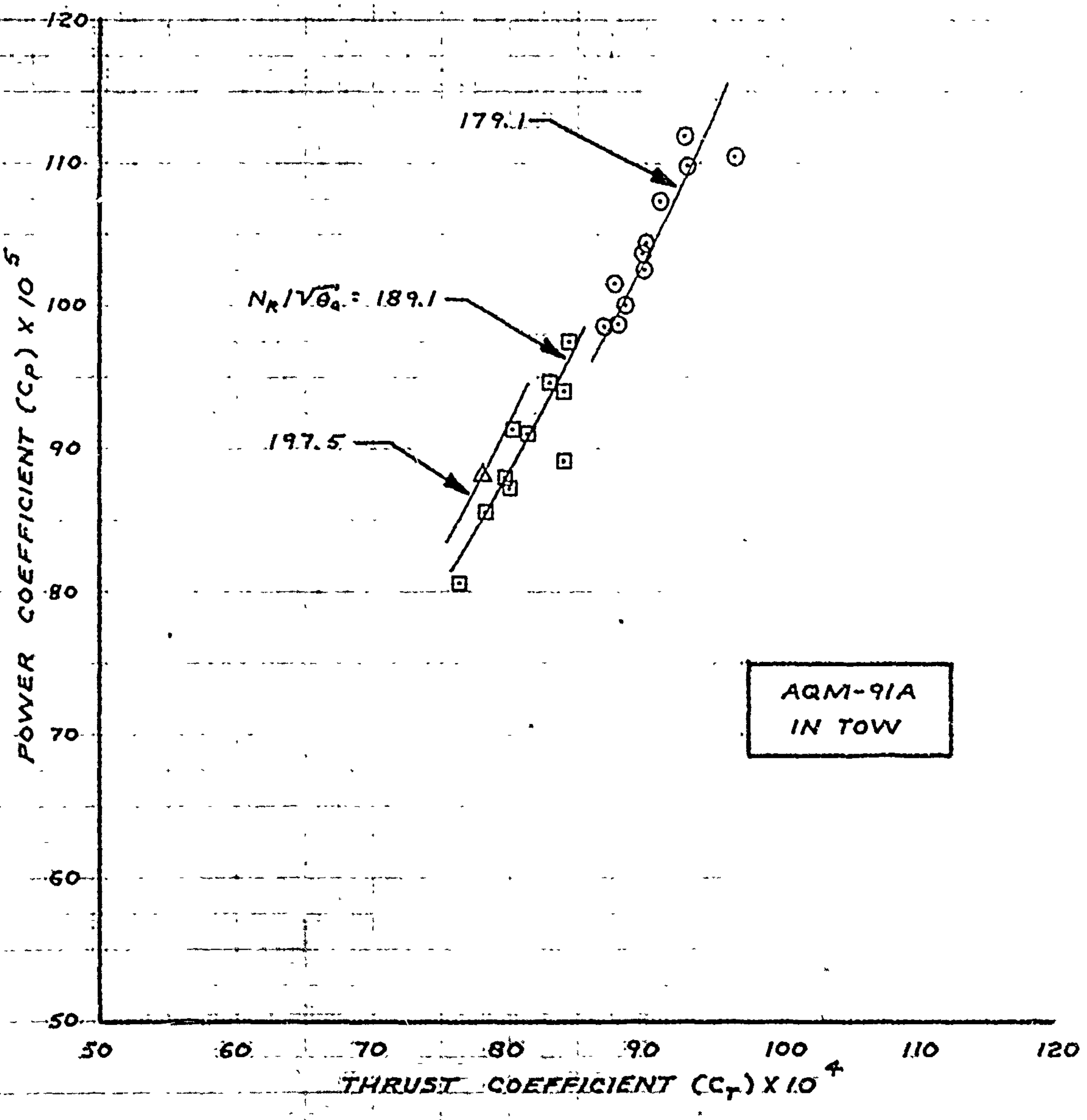


FIGURE 11. NONDIMENSIONAL HOVERING PERFORMANCE (AQM-91A)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES - EAPS INSTALLED
MARS PERFORMANCE
WHEEL HEIGHT = 100 FT.

NOTES: 1. MARS-CONFIGURED, TWO 450-GAL AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.
2. DATA FLOWN IN LESS THAN THREE KNOTS OF WIND.
3. DISTANCE FROM CENTER OF WHEEL TO CENTER OF ROTOR HUB EQUALS 17 FT 5 IN.
4. DATA OBTAINED USING FREE-FLIGHT HOVER TECHNIQUE.

SYM	AVG. $N_R/\sqrt{\theta_a}$ (RPM)	AVG. ROTOR SPEED (RPM)	AVG. M_{TIP} (ADV. BLADE)	AVG. PRESSURE ALTITUDE (FT.)	AVG. FREE AIR TEMP. (DEG. C)
○	178.5	179.3	0.604	2,300	18.0
□	189.1	189.4	0.641	2,270	16.0
△	196.5	192.4	0.665	2,120	2.5

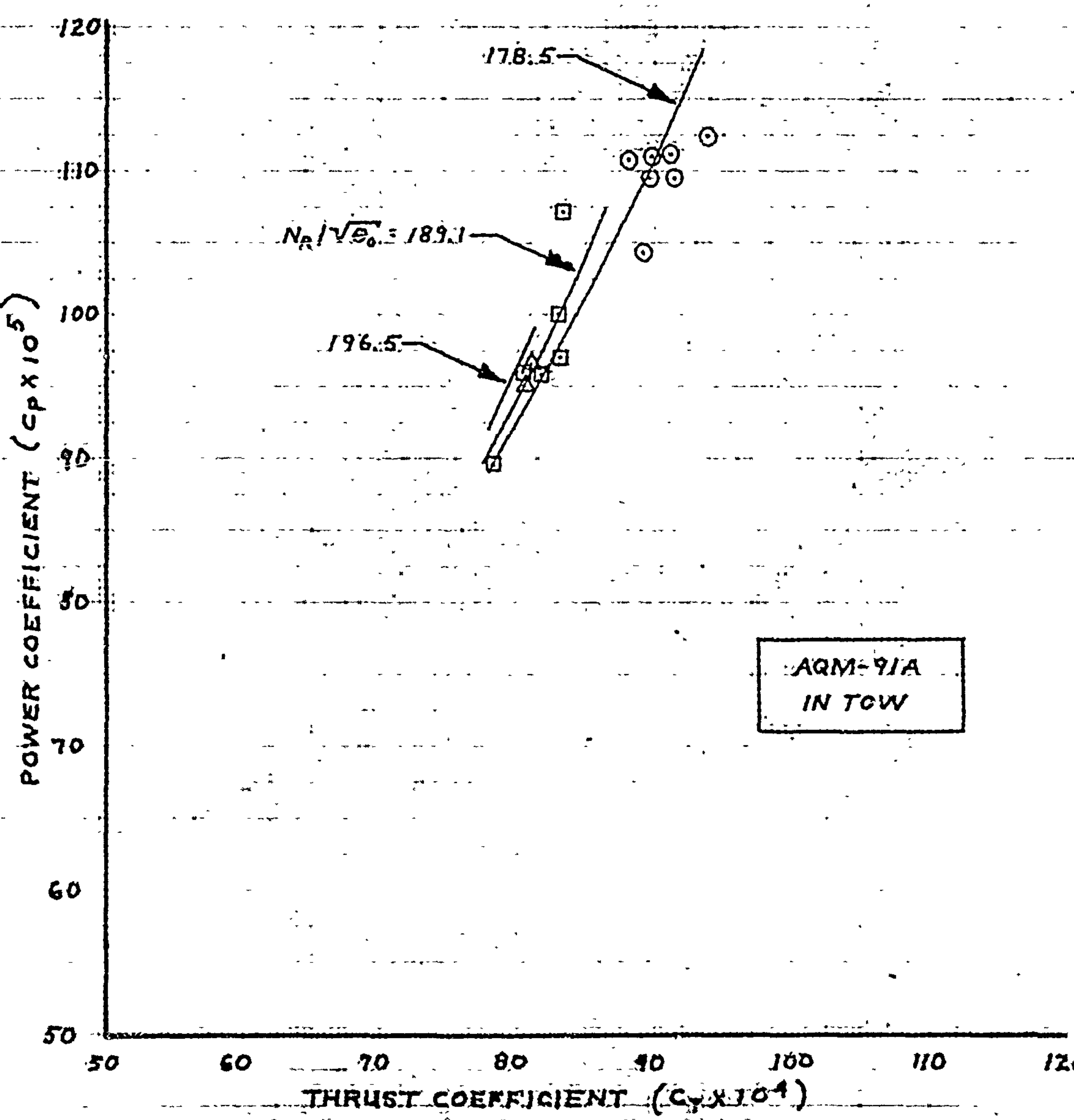


FIGURE 12 NONDIMENSIONAL HOVERING PERFORMANCE (AQM-91A)

HH-53C USAF S/N 67-14993
TG4-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 18 THROUGH 24, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.

$C_T = 0.0080$

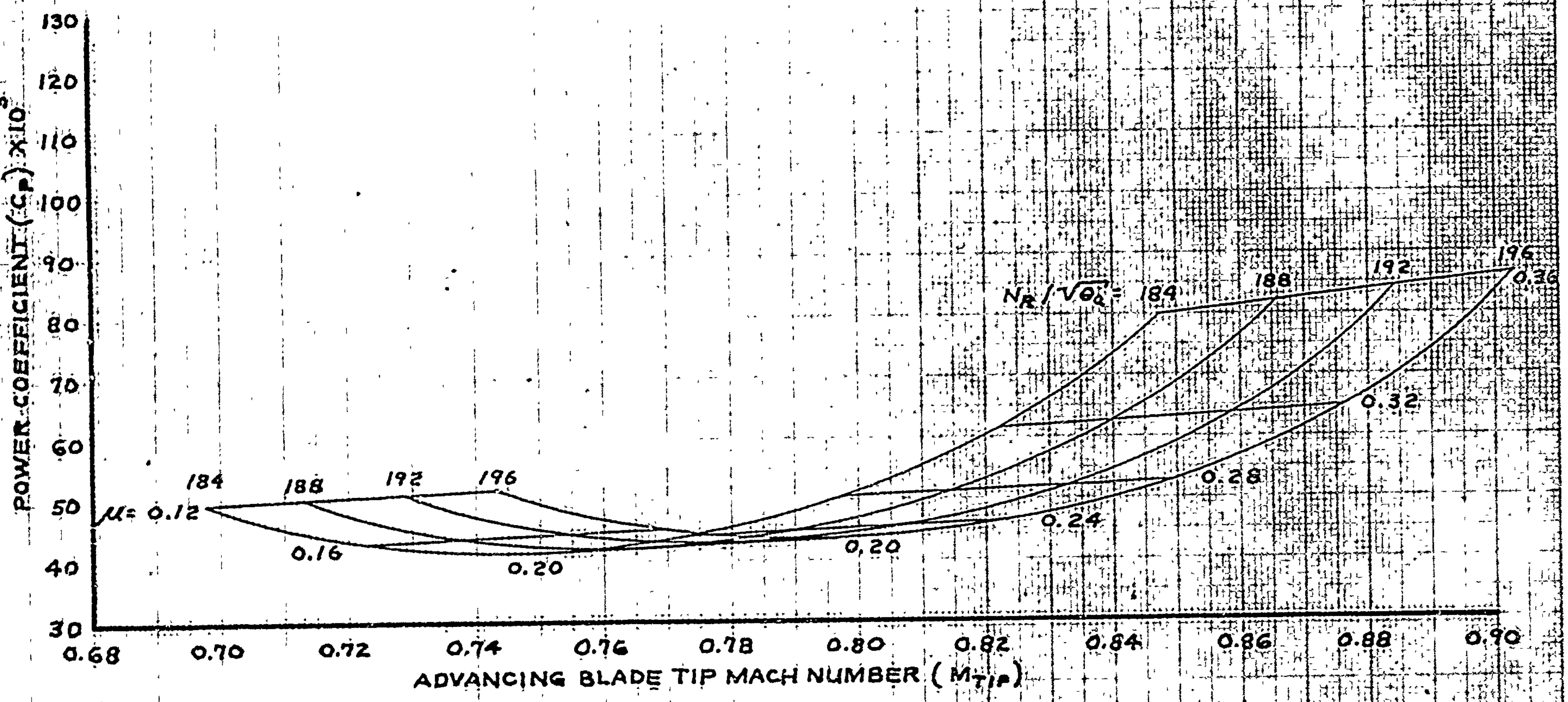


FIGURE 13 .LEVEL FLIGHT PERFORMANCE SUMMARY (CLEAN)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 18 THROUGH 24, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.

$C_T = 0.0090$

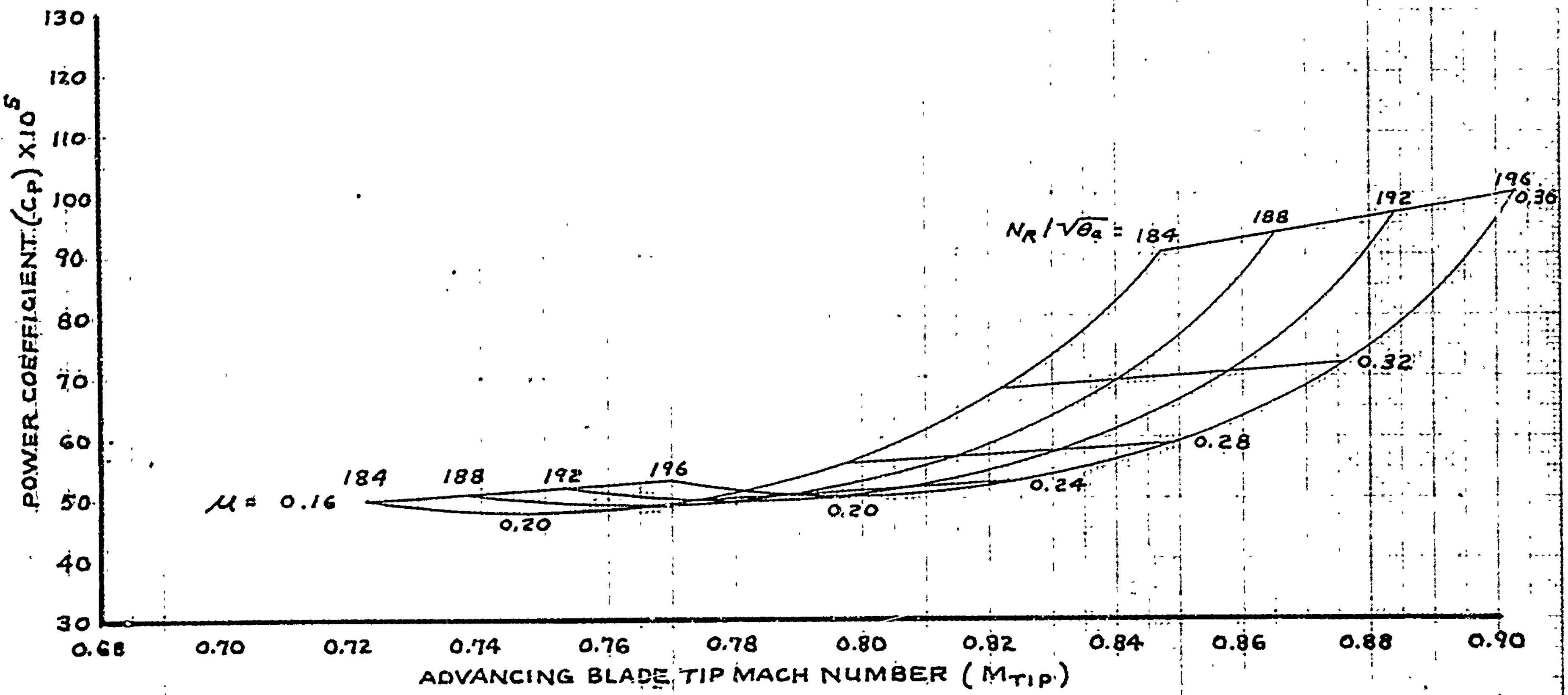


FIGURE 14. LEVEL FLIGHT PERFORMANCE SUMMARY (CLEAN)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 18 THROUGH 24, APPENDIX I.
2. MARS-MODIFIED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.

$C_T = 0.0100$

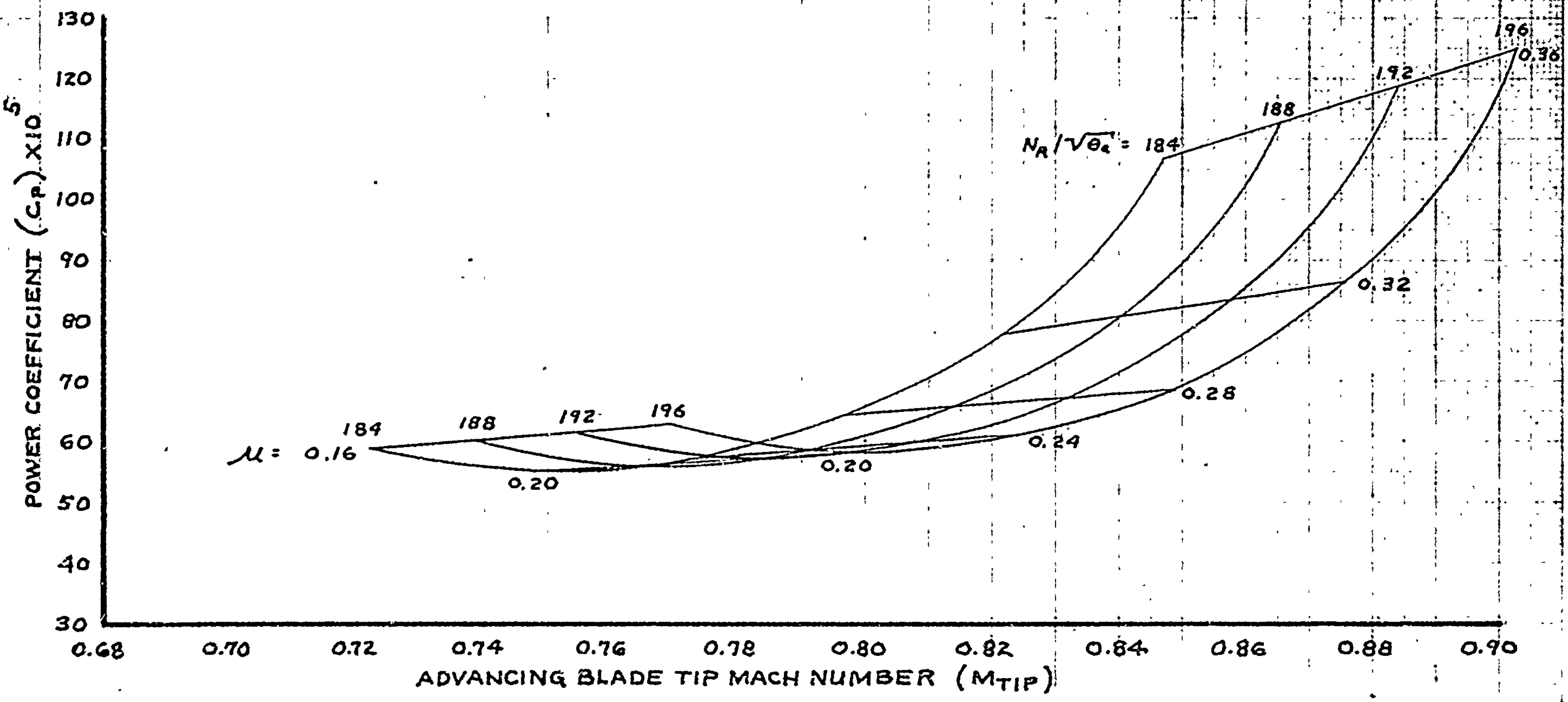


FIGURE 15. LEVEL FLIGHT PERFORMANCE SUMMARY (CLEAN)

HH-53C USAF S/N 67-14993

T64-GE-7 ENGINES ~ EAPS INSTALLED

MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 18 THROUGH 24, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.

$C_T = 0.0110$

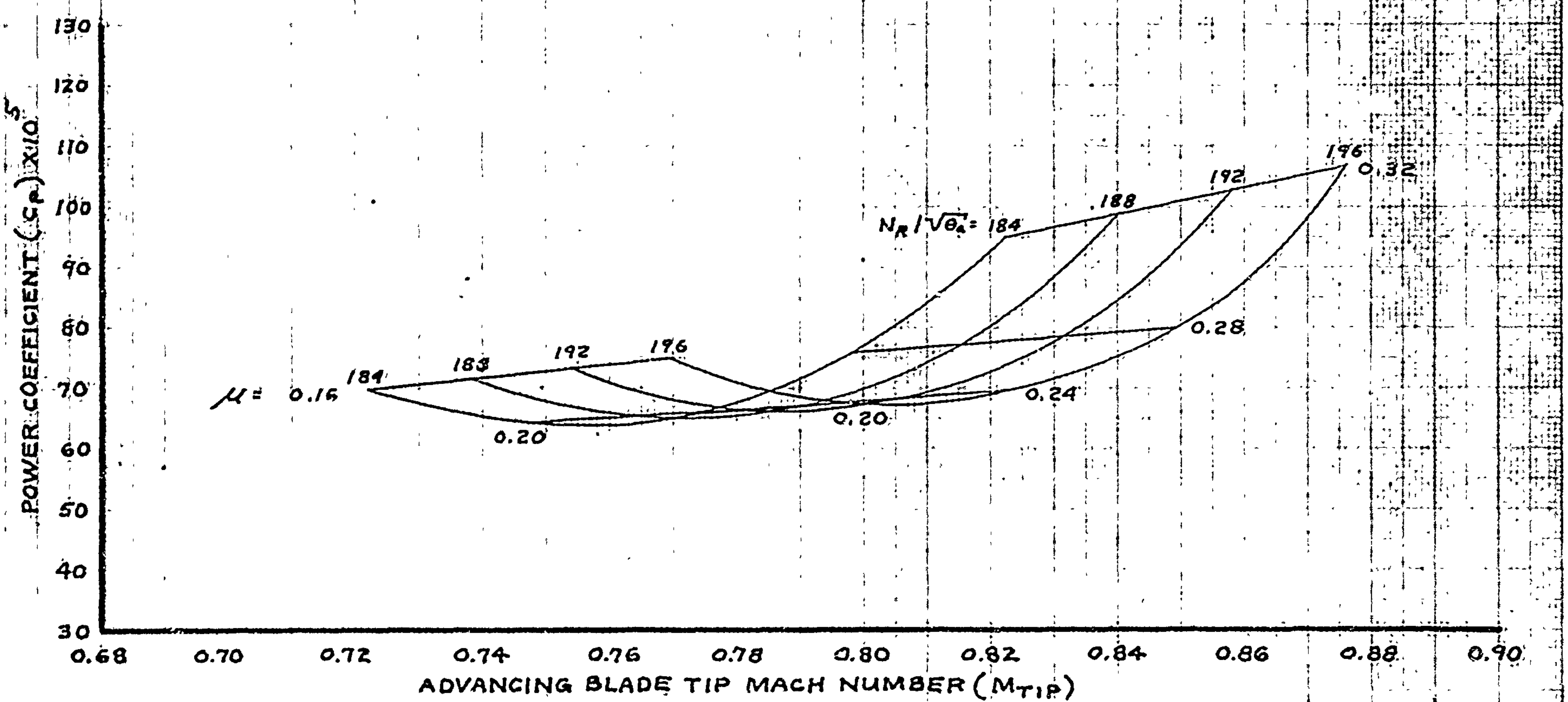


FIGURE 16. LEVEL FLIGHT PERFORMANCE SUMMARY (CLEAN)

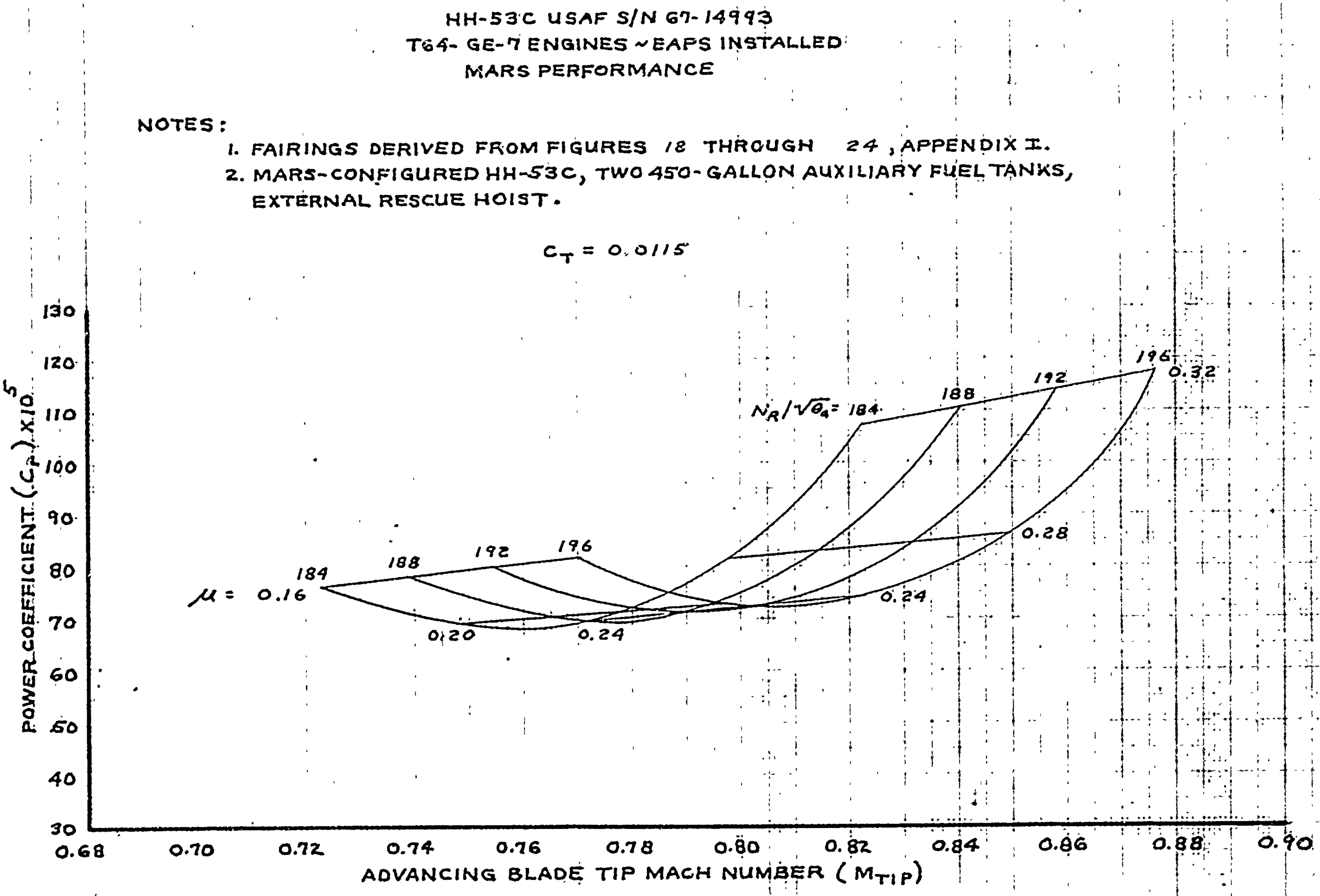


FIGURE 17. LEVEL FLIGHT PERFORMANCE SUMMARY (CLEAN)

HH-53C USAF S/N 67-14993

T64-GE-7 ENGINES - EAPS INSTALLED

MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 25 THROUGH 40, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.

$\mu = 0.12$

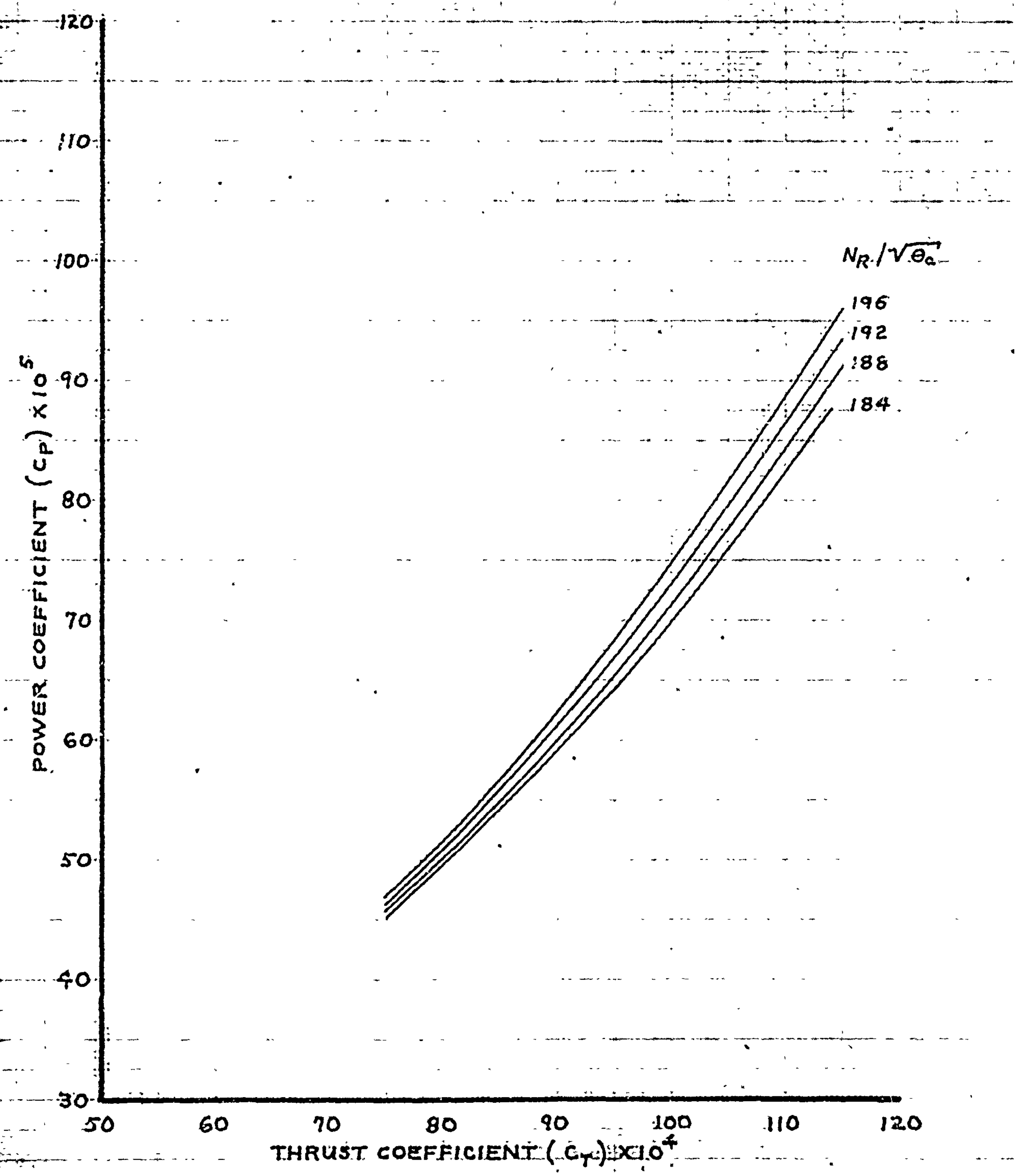


FIGURE 18 . LEVEL FLIGHT PERFORMANCE SUMMARY (CLEAN)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES - EAPS INSTALLED
MARS PERFORMANCE

NOTES:
1. FAIRINGS DERIVED FROM FIGURES 25 THROUGH 40, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.

$\mu = 0.16$

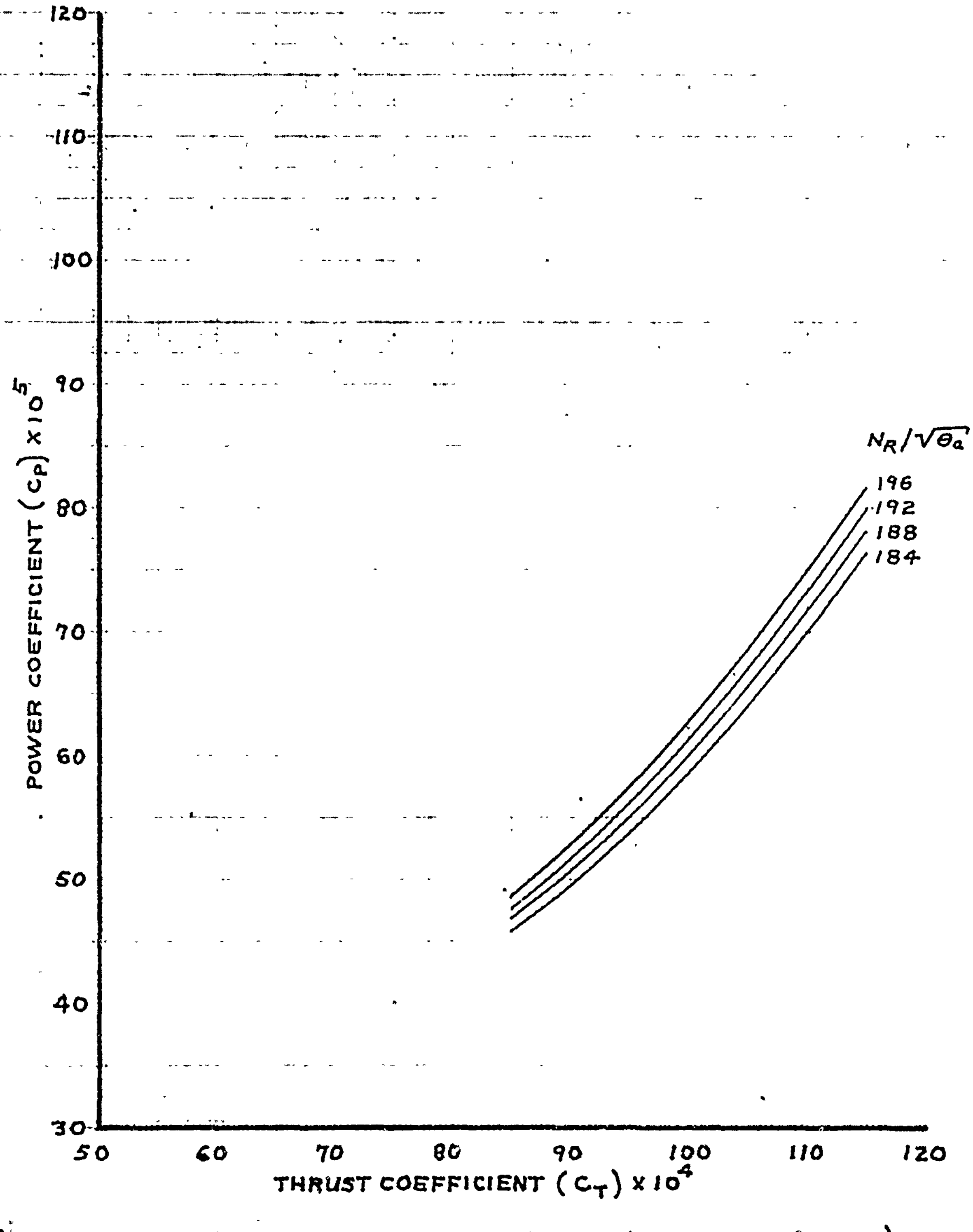


FIGURE 19. LEVEL FLIGHT PERFORMANCE SUMMARY (CLEAN)

HH-53C USAF S/N 67-14993

T64-GE-7 ENGINES - EAPS INSTALLED

MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 25 THROUGH 40, APPENDIX I.
2. MARS CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.

$\mu = 0.20$

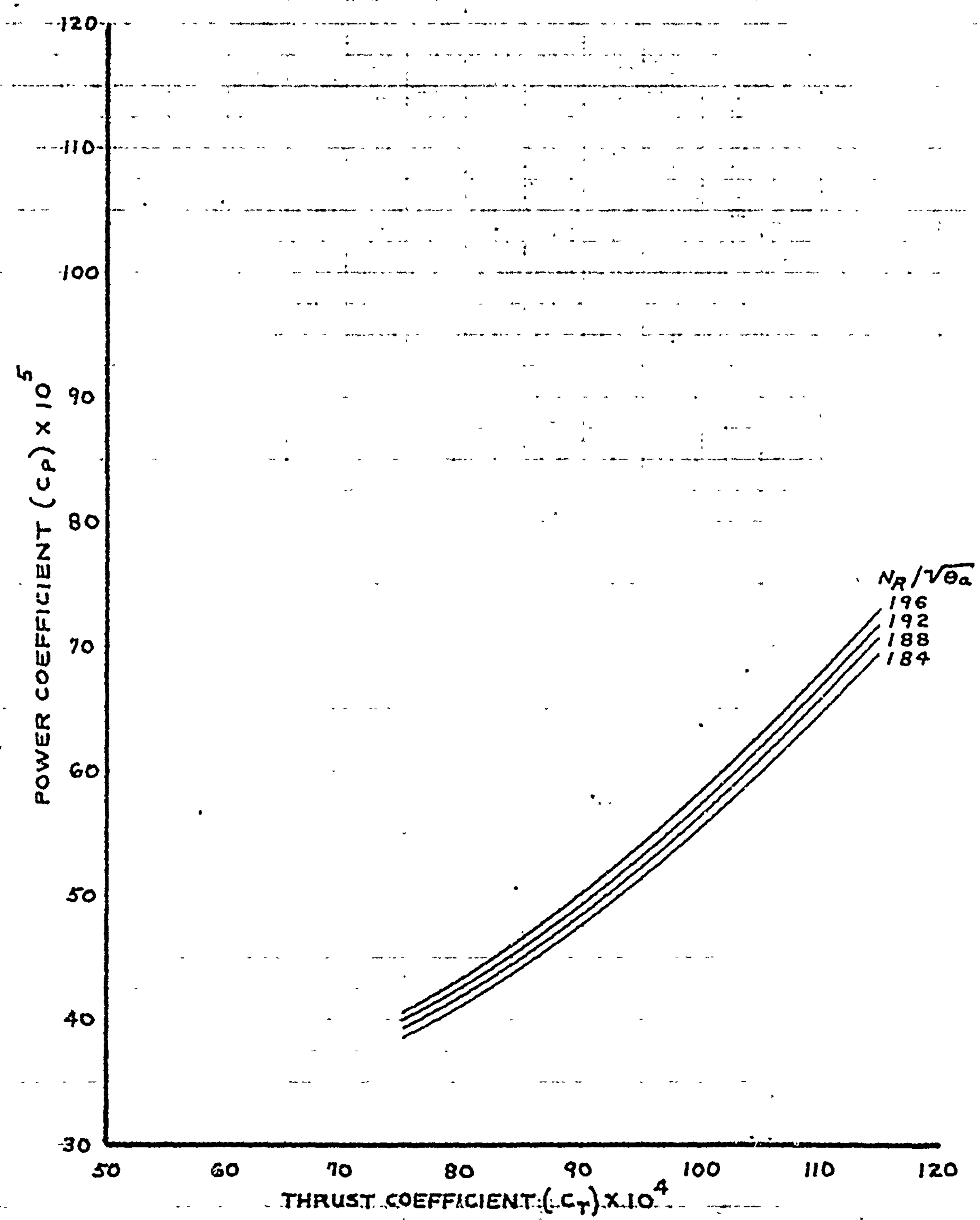


FIGURE 20. LEVEL FLIGHT PERFORMANCE SUMMARY (CLEAN)

HH-53C USAF S/N 67-14993

T64-GE-7 ENGINES EAPS INSTALLED

MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 25 THROUGH 40, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.

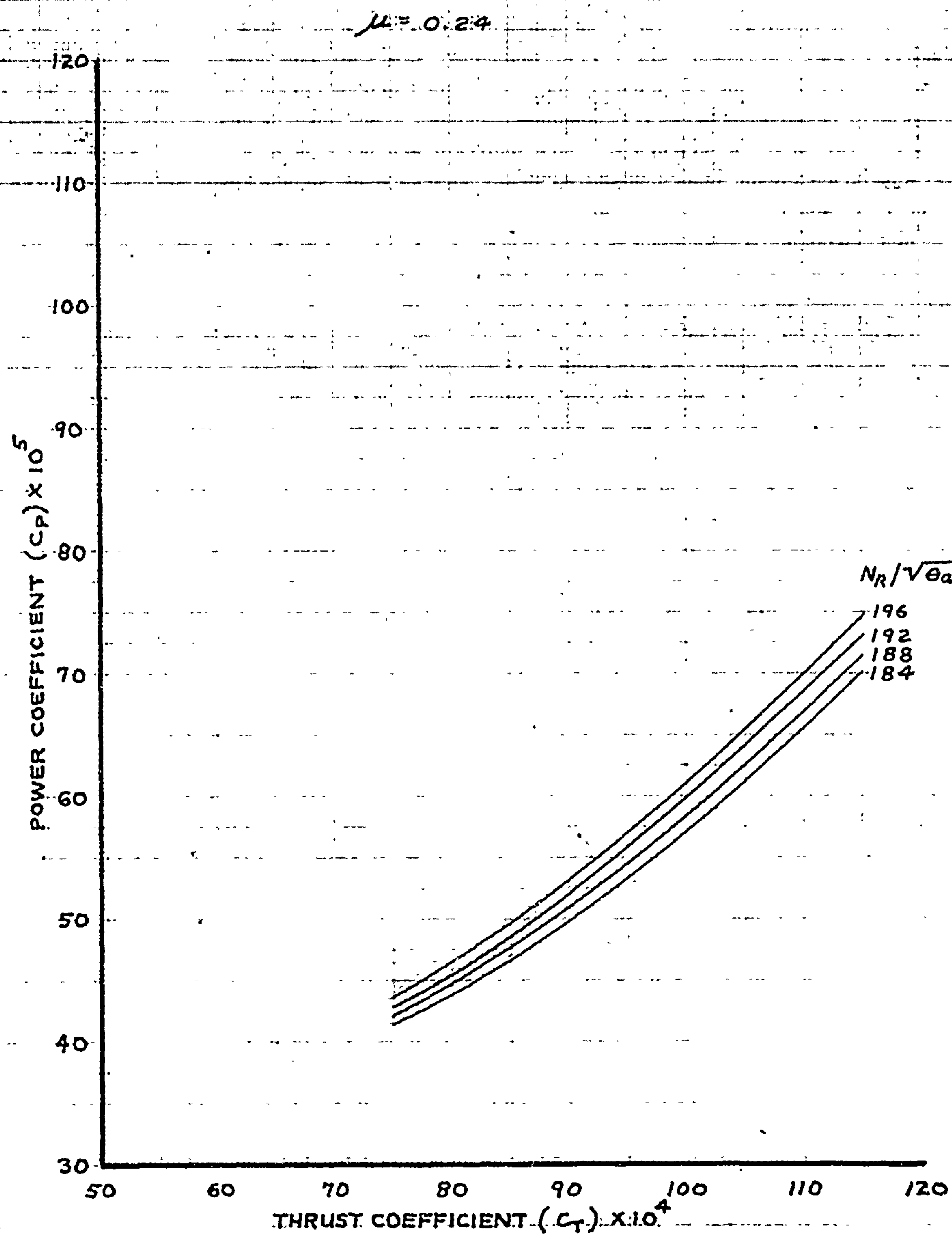


FIGURE 21. LEVEL FLIGHT PERFORMANCE SUMMARY (CLEAN)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES - EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 25 THROUGH 40, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.

$\mu = 0.28$

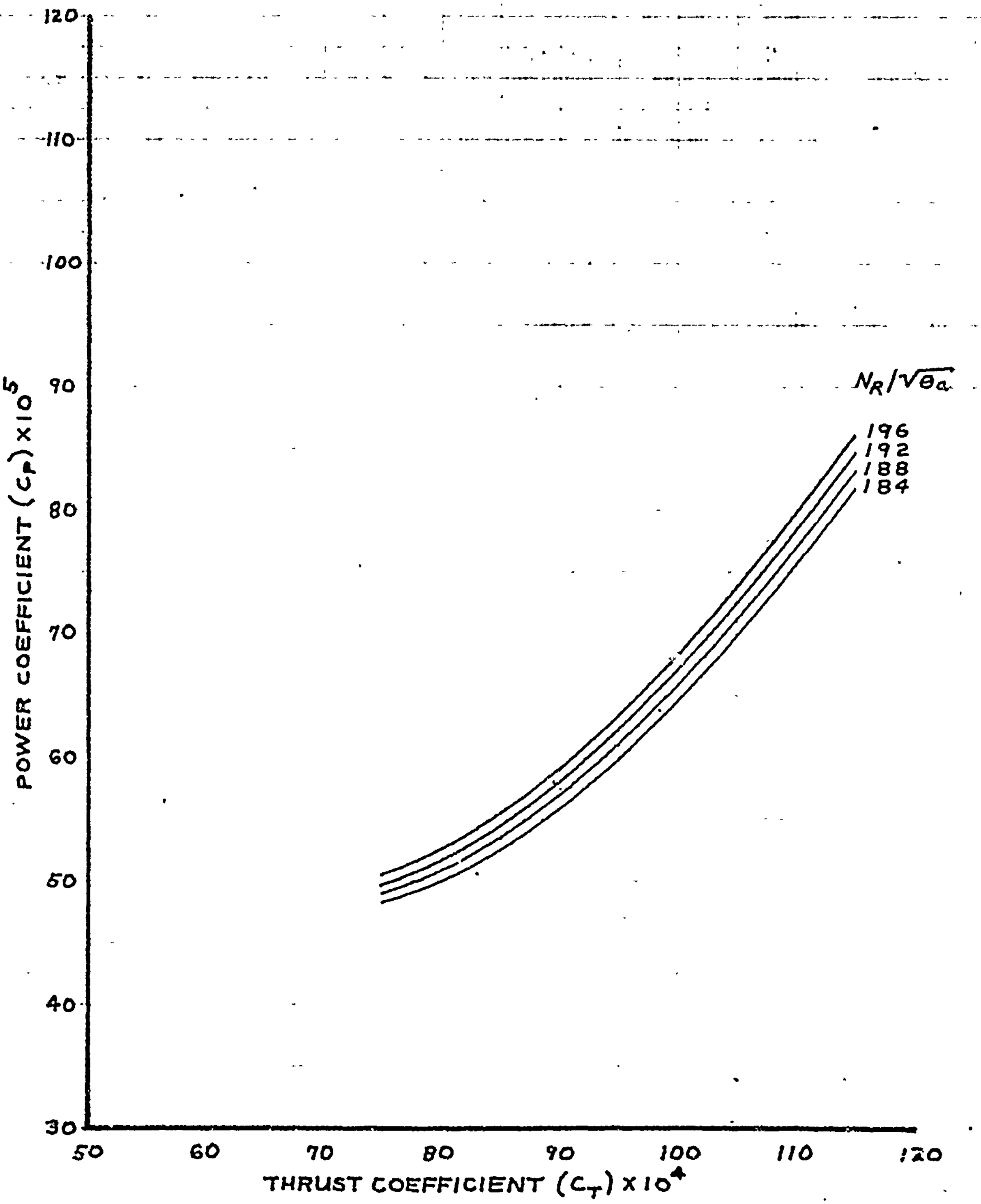


FIGURE 22. LEVEL FLIGHT PERFORMANCE SUMMARY (CLEAN)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES - EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 25 THROUGH 40, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.

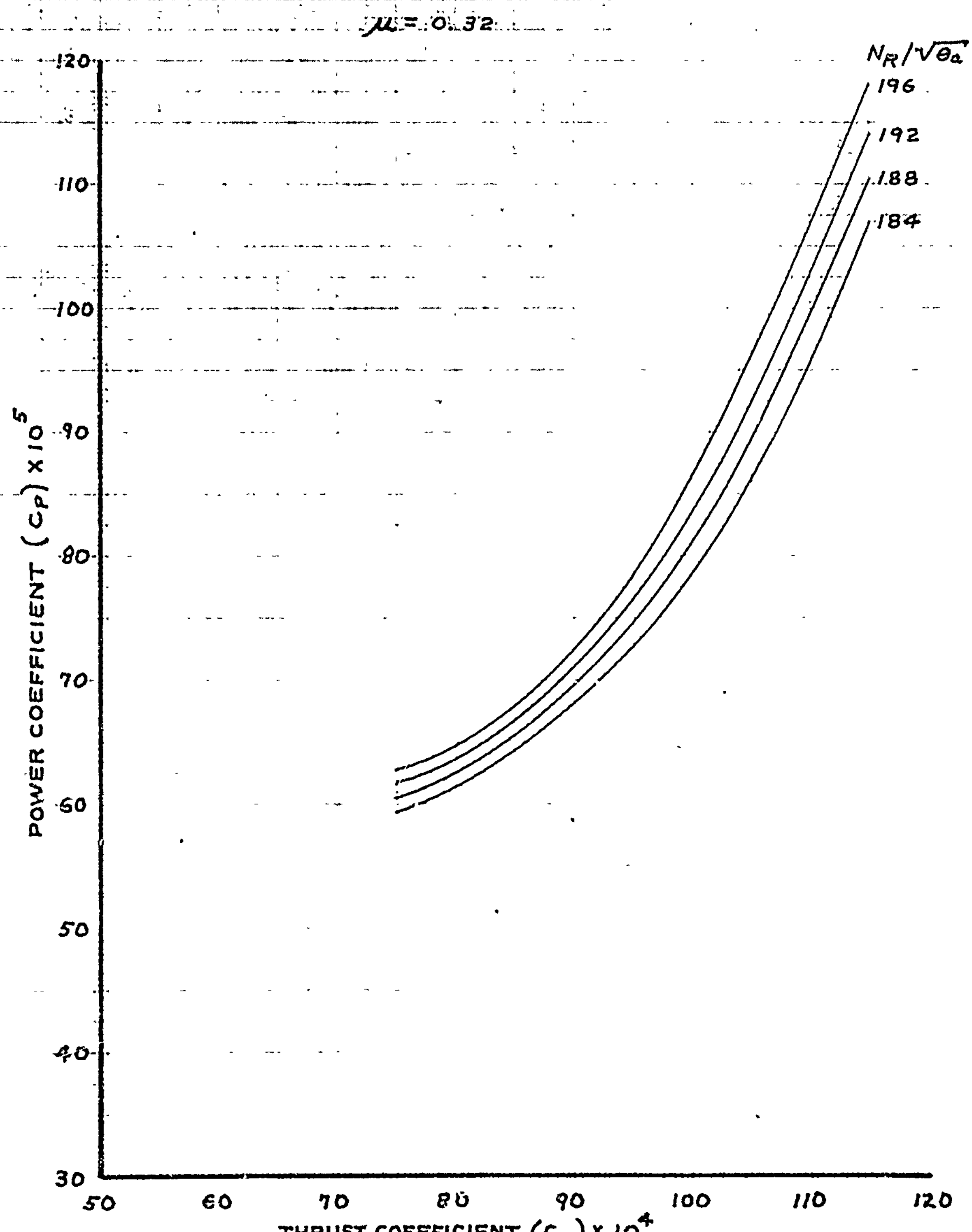


FIGURE 23. LEVEL FLIGHT PERFORMANCE SUMMARY (CLEAN)

HH-53C USAF S/N 67-14993

T64-GE-7 ENGINES - EAPS INSTALLED

MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 25 THROUGH 40, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.

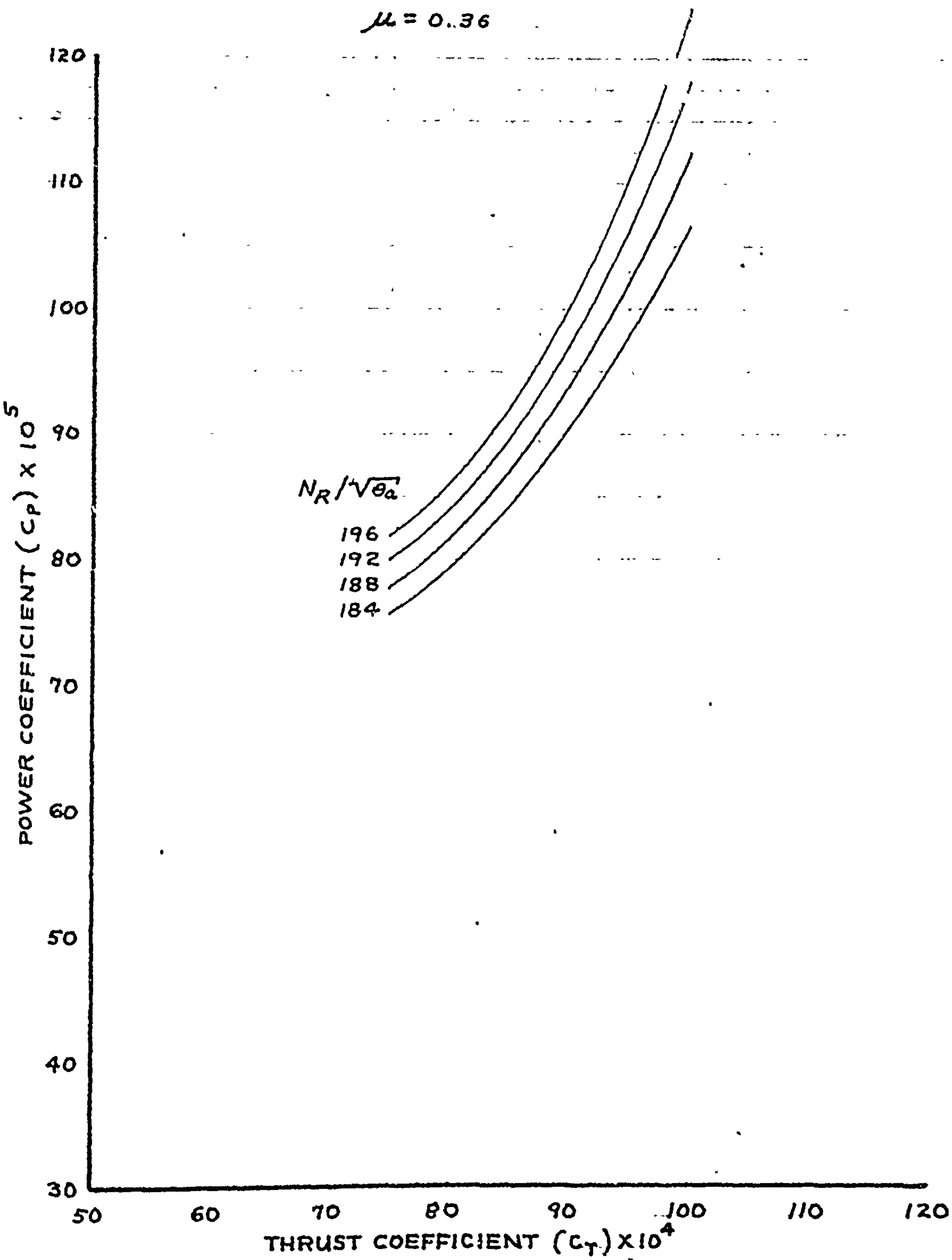


FIGURE 24. LEVEL FLIGHT PERFORMANCE SUMMARY (CLEAN)

HH-53C USAF S/N 67-
T64-GE-7 ENGINES ~ EAPS
MARS PERFORMAN

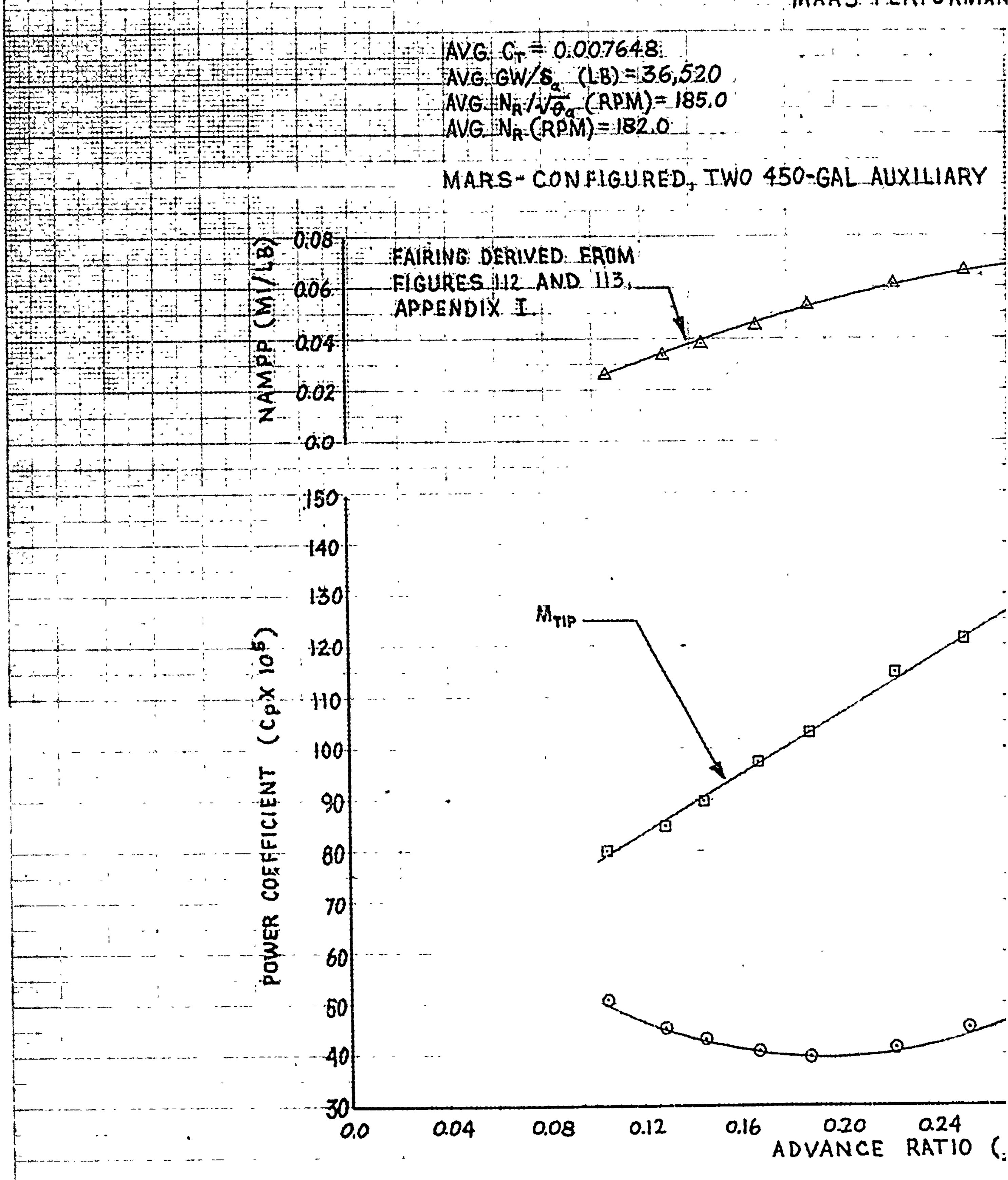
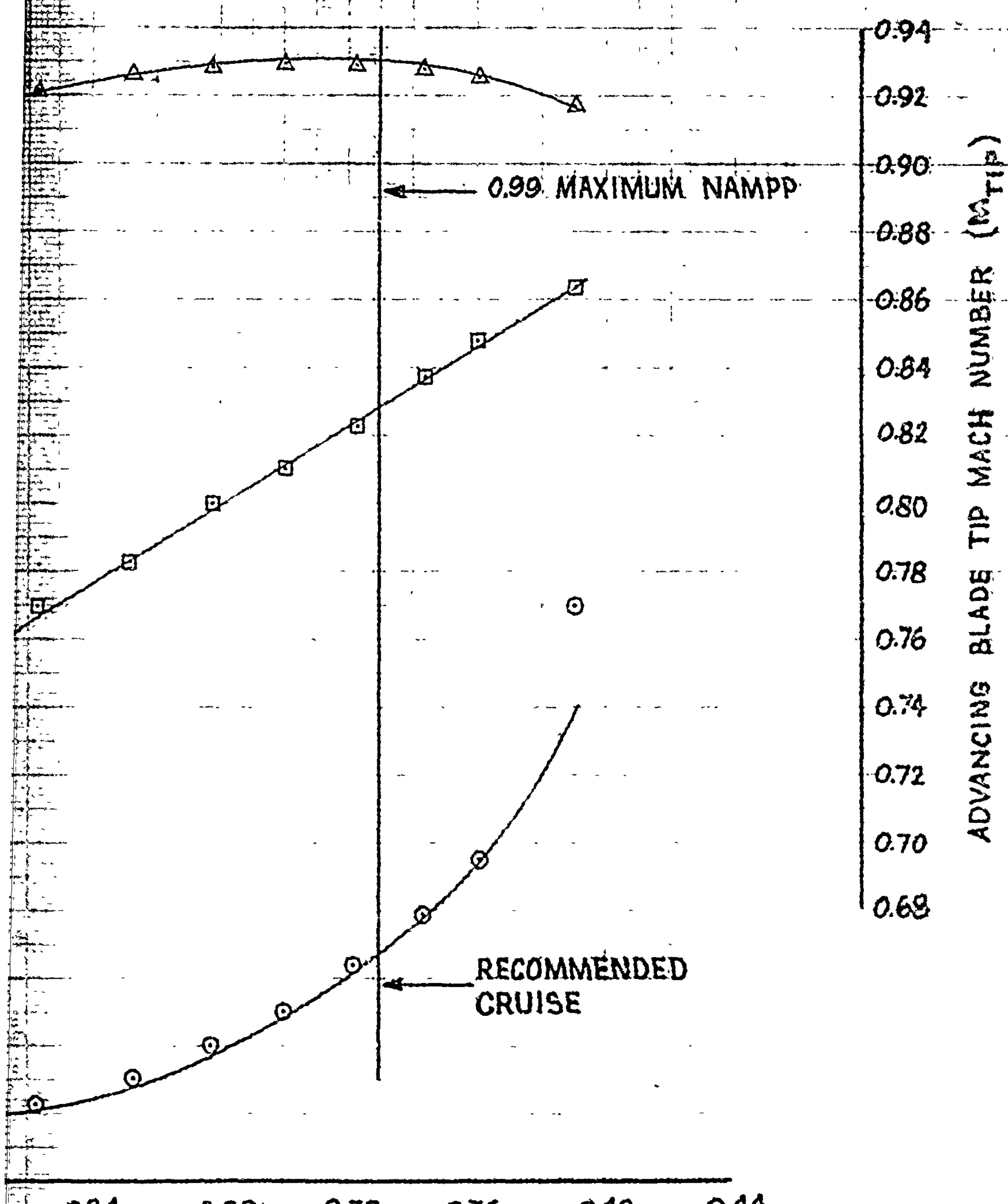


FIGURE 25 NONDIMENSIONAL LEVEL FL

AF S/N 67-14993
INES ~ EAPS INSTALLED
ERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 3,550
AVG. FREE AIR TEMP (DEG C) = 4.5
AVG. GROSS WEIGHT (LB) = 32,070
AVG. CG LOCATION (STA) = 336.1

UXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.



E LEVEL FLIGHT PERFORMANCE (CLEAN)

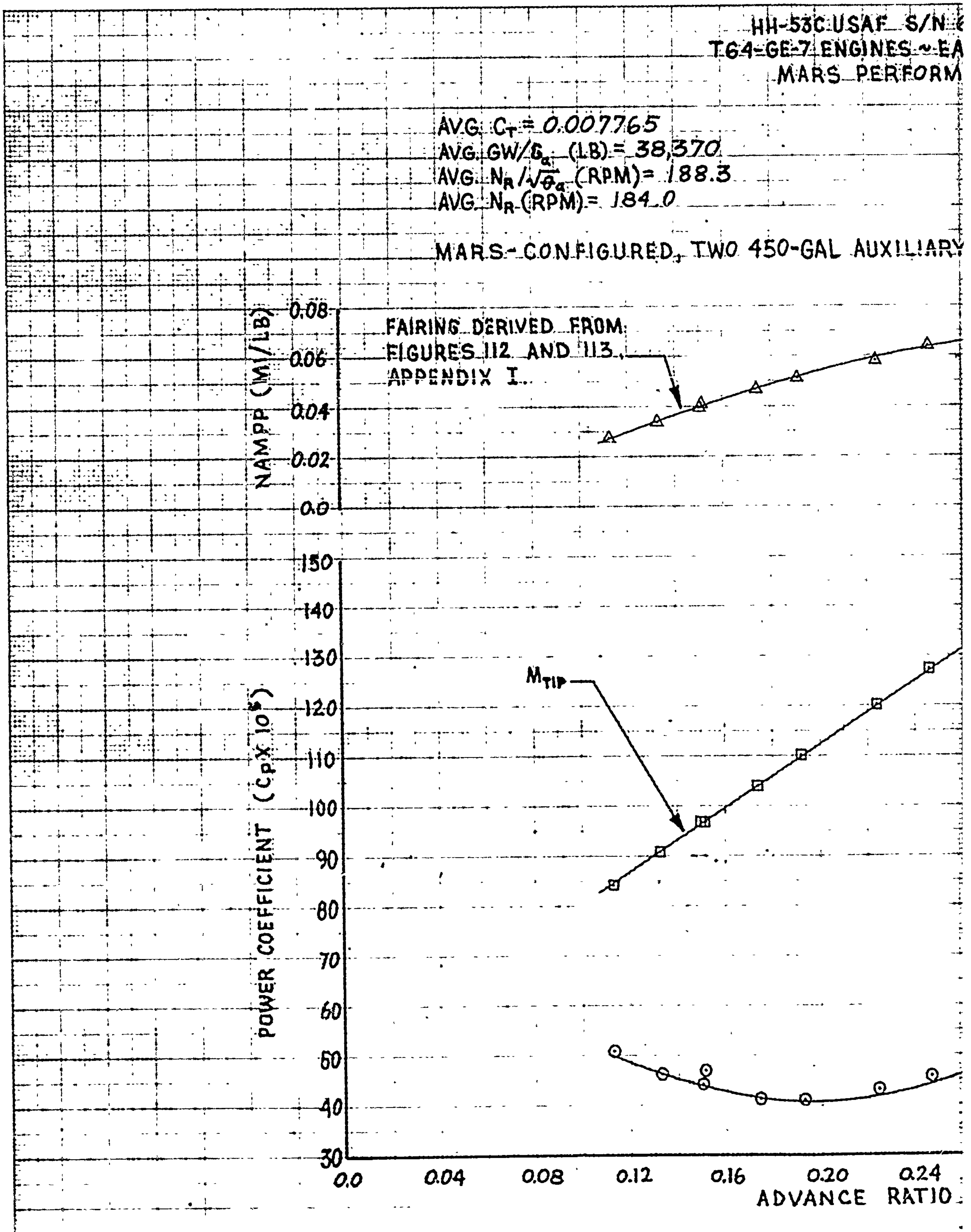
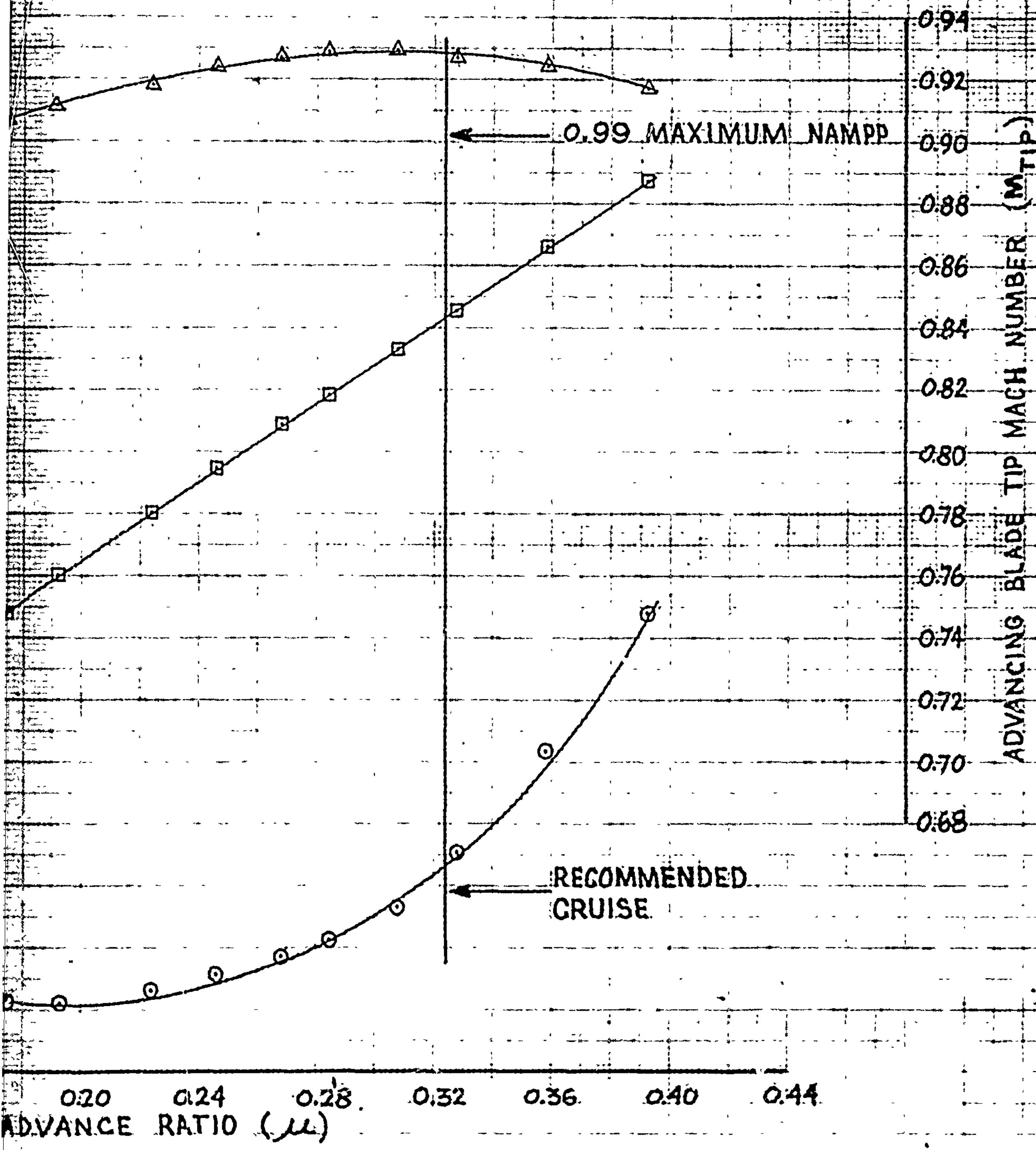


FIGURE 26 NONDIMENSIONAL LEVEL F

HH-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 3,700
AVG. FREE AIR TEMP (DEG C) = 3.0
AVG. GROSS WEIGHT (LB) = 33,510
AVG. CG LOCATION (STA) = 339.4

150-GAL AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST



NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE (CLEAN)

HH-53C USAF S/N 67
T64-GE-7 ENGINES ~ EAP
MARS PERFORMAI

AVG. C_T = 0.007879
AVG. GW/δ_a (LB) = 40,590
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 192.2
AVG. N_R (RPM) = 189.0

MARS-CONFIGURED, TWO 450-GAL AUXILIARY

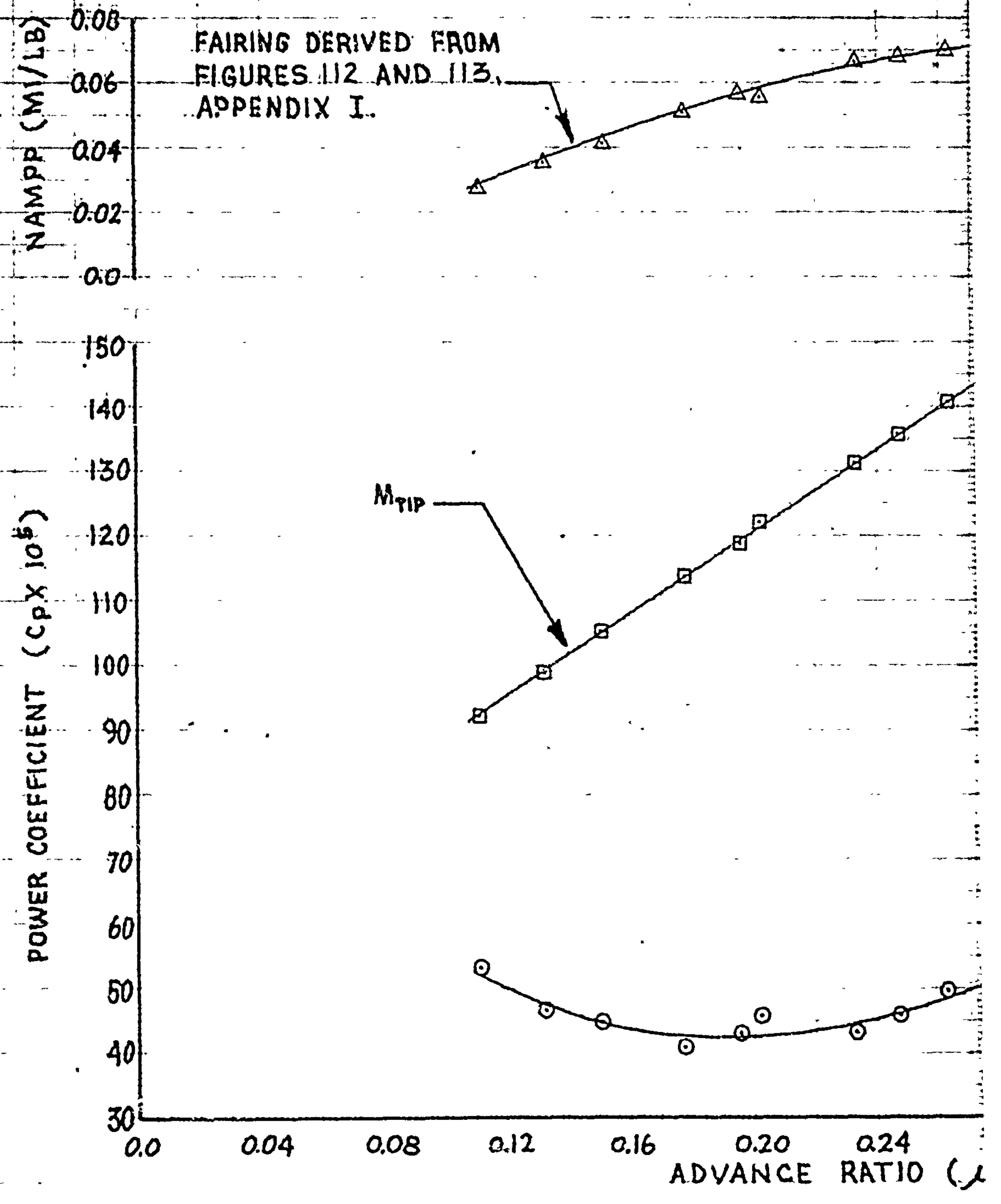
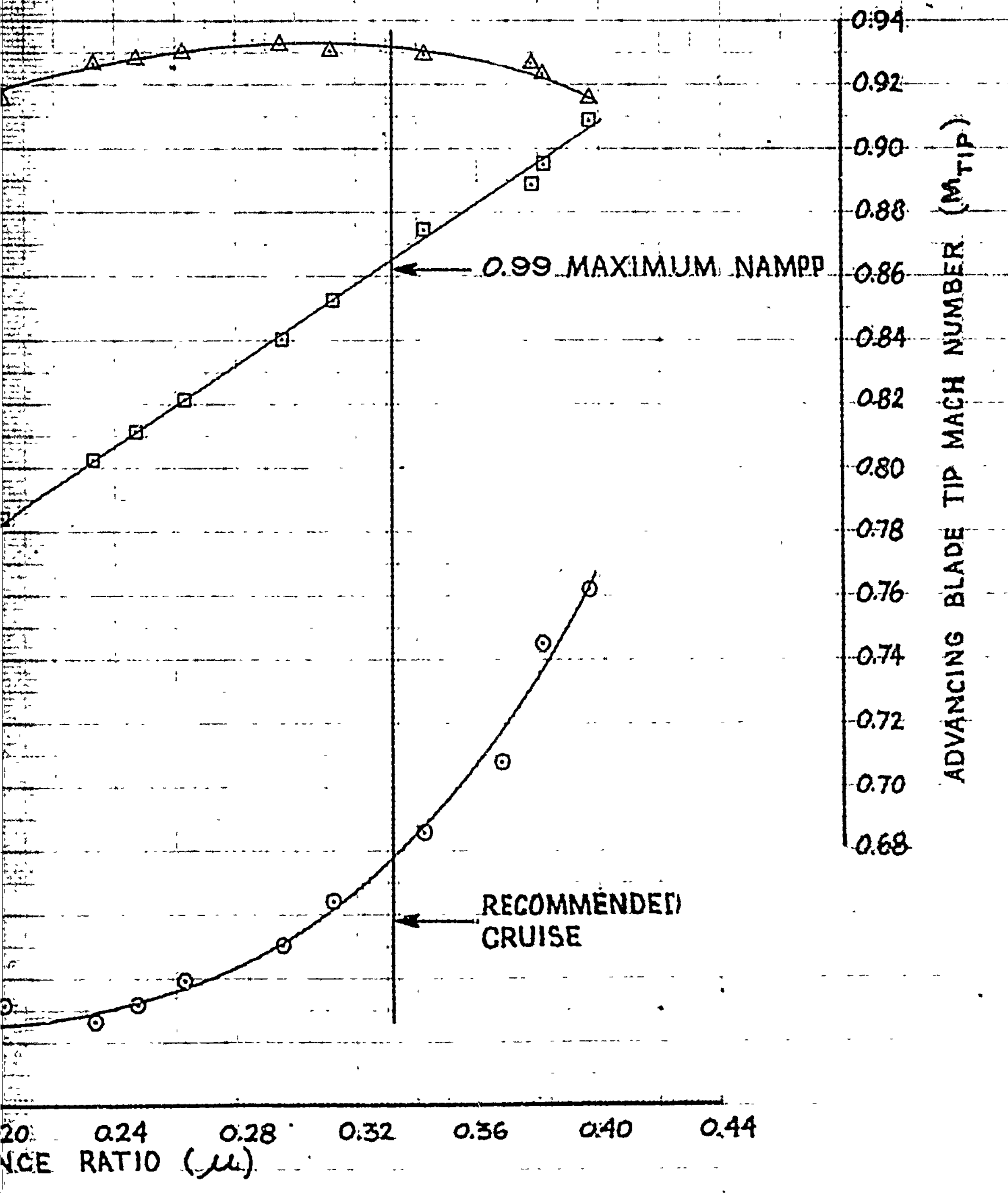


FIGURE 27 NONDIMENSIONAL LEVEL FLIG

USAF S/N 67- 4993
ENGINES ~ EAPS INSTALLED
S PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 6,000
AVG. FREE AIR TEMP (DEG. C) = 5.5
AVG. GROSS WEIGHT (LB) = 32,530
AVG. CG LOCATION (STA) = 333.9

L AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.



NAL LEVEL FLIGHT PERFORMANCE (CLEAN)

HH-53C USAF S/N 6
T64-GE-7 ENGINES ~ EA
MARS PERFORMA

AVG. C_T = 0.007968
AVG. GW/δ_a (LB) = 42,760
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 196.1
AVG. N_R (RPM) = 192.0

MARS-CONFIGURED, TWO 450-GAL AUXILIARY

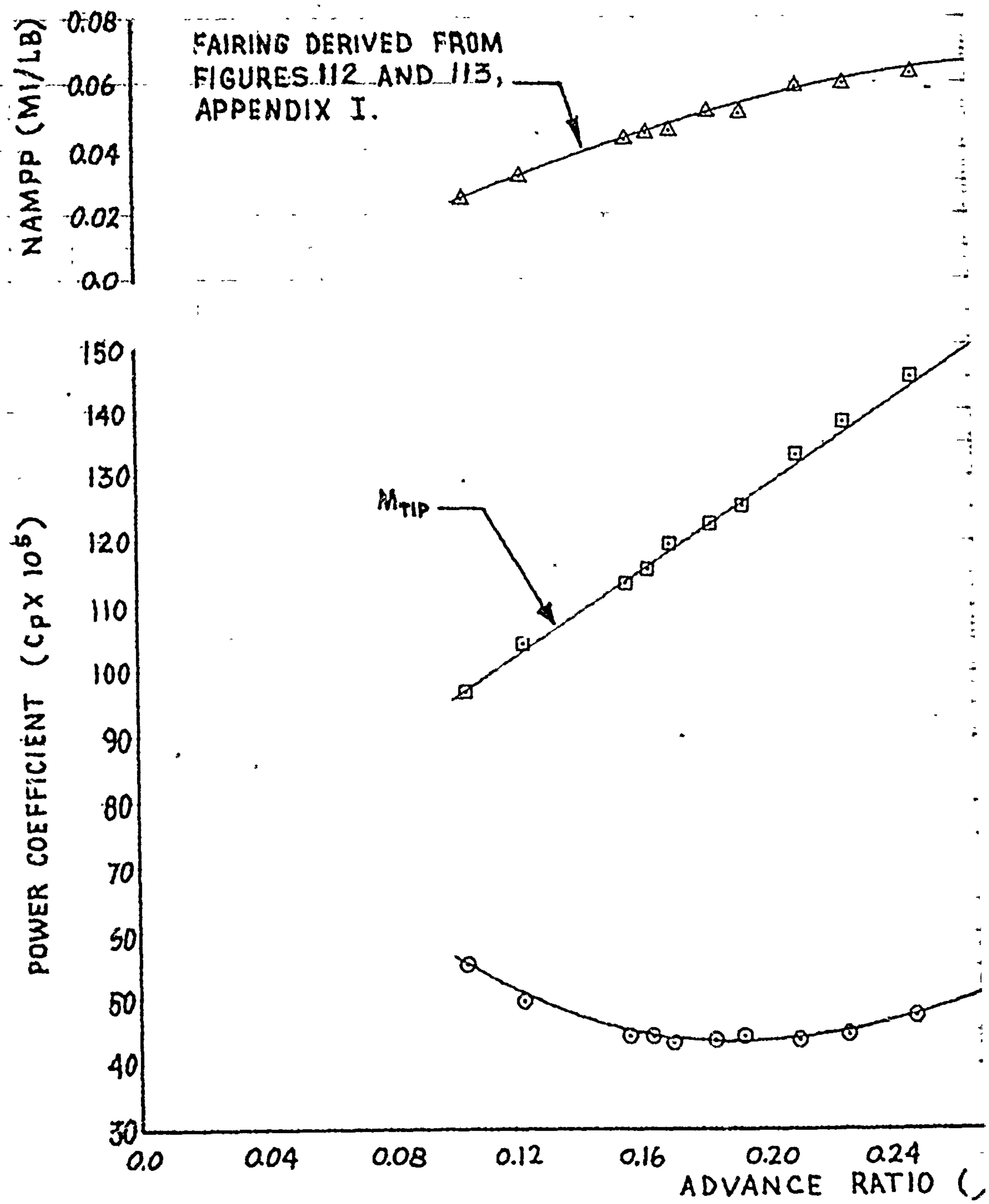
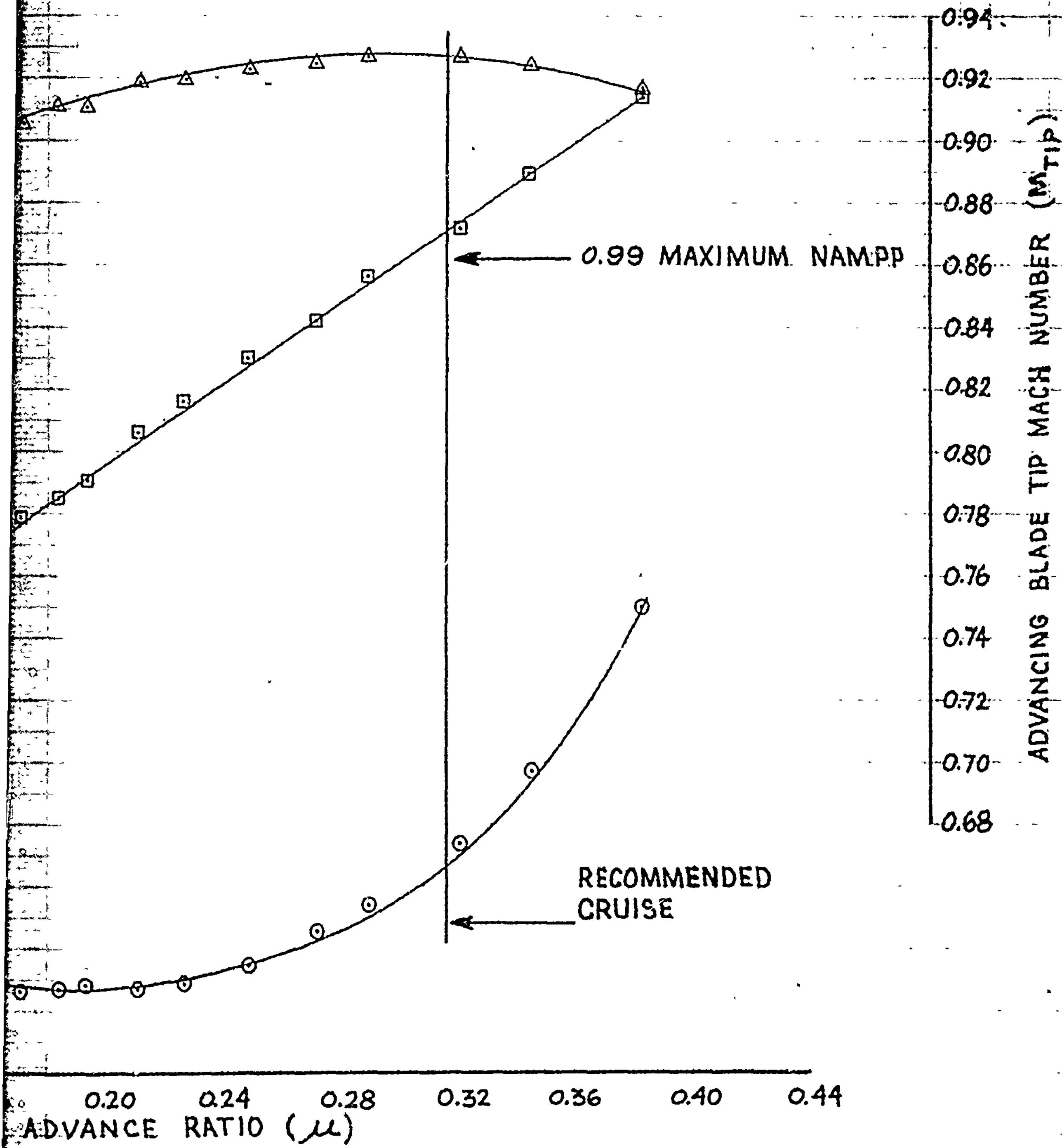


FIGURE 28 NONDIMENSIONAL LEVEL FLI

HH-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 5,700
AVG. FREE AIR TEMP. (DEG. C) = 4.0
AVG. GROSS WEIGHT (LB) = 34,660
AVG. CG LOCATION (STA) = 336.7

450-GAL AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.



MENSIONAL LEVEL FLIGHT PERFORMANCE (CLEAN)

HH-53C USAF S/N 67
T64-GE-7 ENGINES ~ EAP
MARS PERFORMA

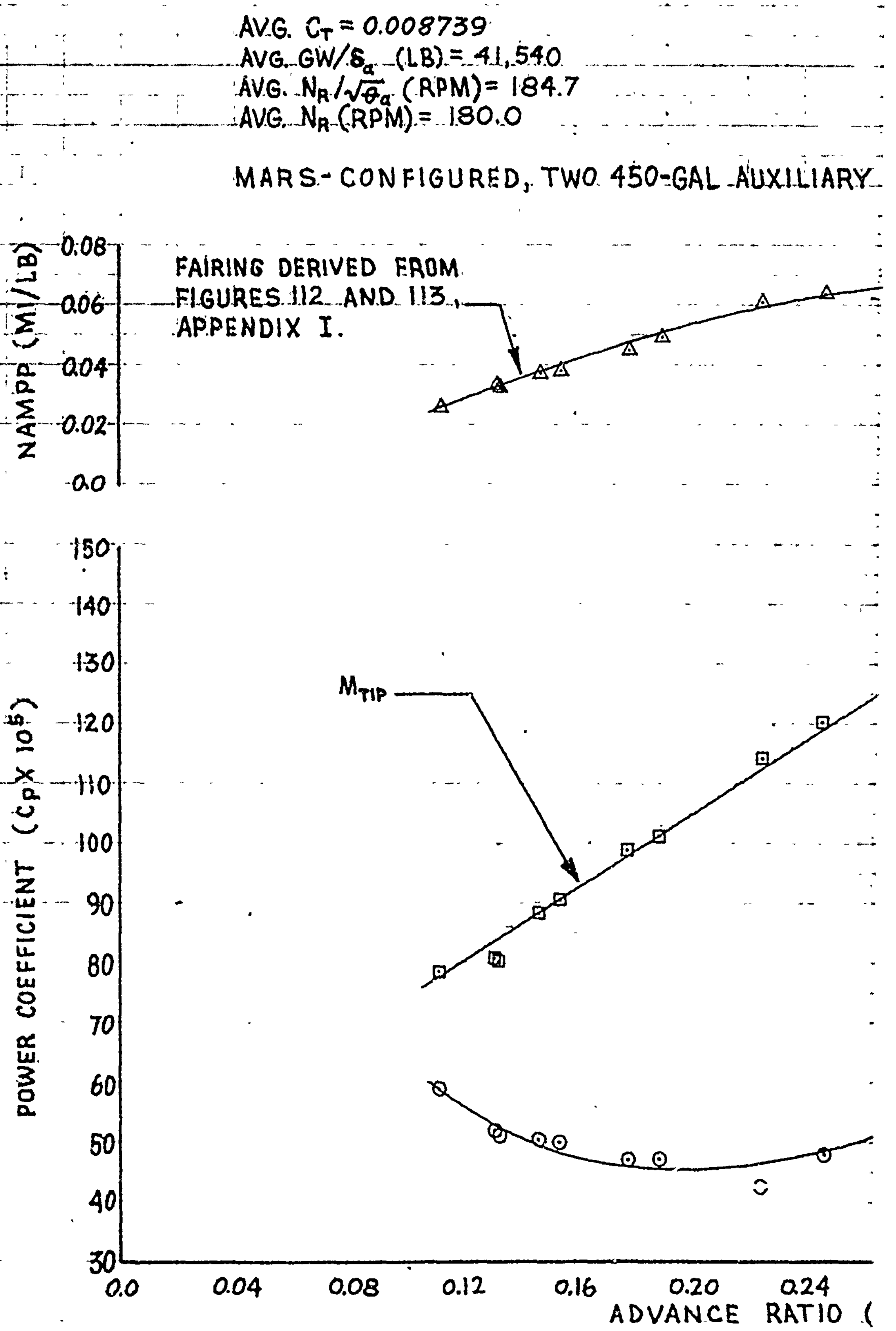
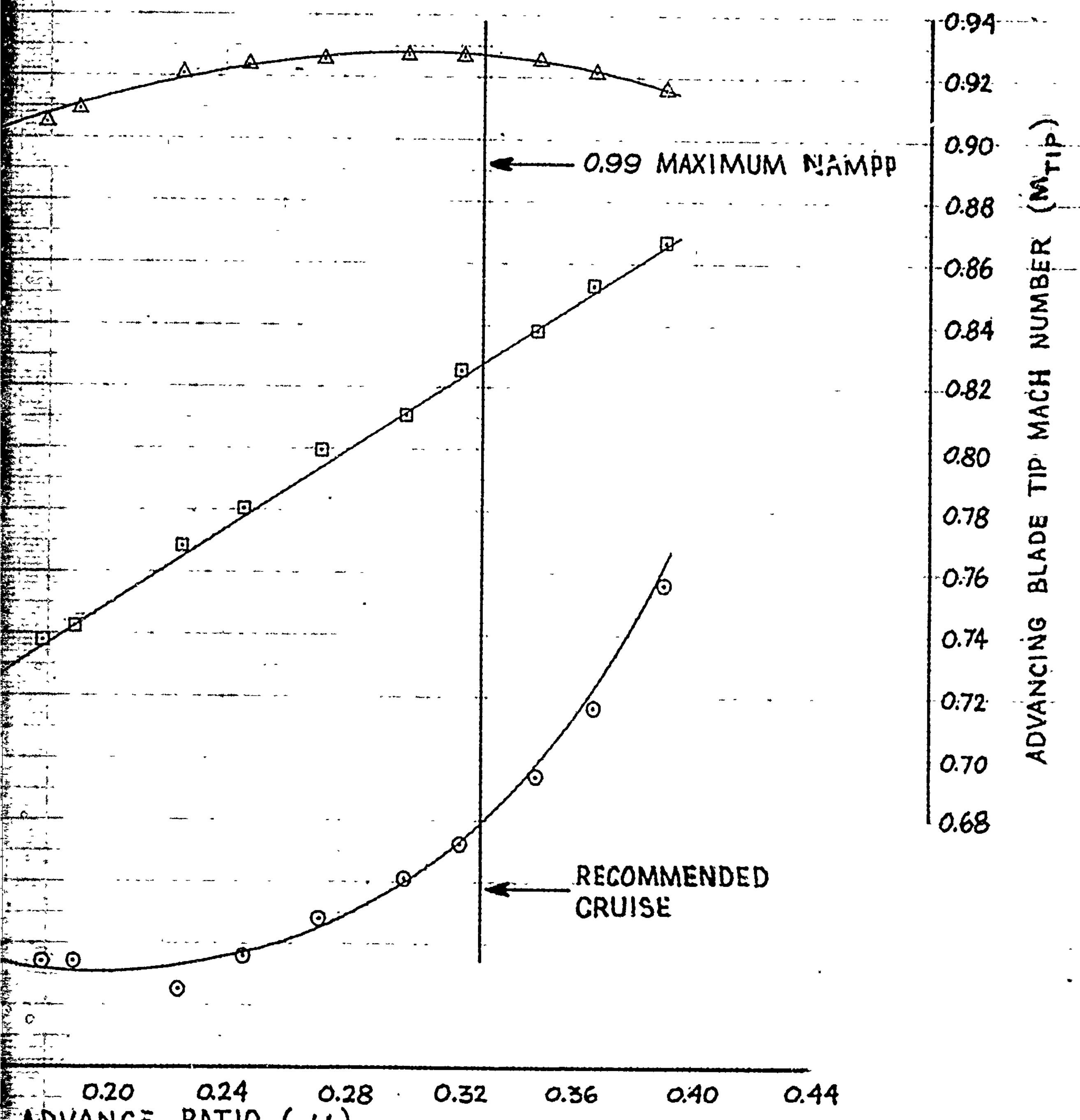


FIGURE 29 NONDIMENSIONAL LEVEL FL

HH-53C USAF S/N 67-14993
64-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 4,450
AVG. FREE AIR TEMP (DEG C) = 1.0
AVG. GROSS WEIGHT (LB) = 35,280
AVG. CG LOCATION (STA) = 339.1

450-GAL AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.



ENSIONAL LEVEL FLIGHT PERFORMANCE (CLEAN)

HH-53C USAF S/N
T64-GE-7 ENGINES ~
MARS PERFOR

AVG. C_T = 0.008801
AVG. GW/δ_a (LB) = 43,860
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 188.9
AVG. N_R (RPM) = 182.0

MARS-CONFIGURED, TWO 450-GAL AUXILIAR

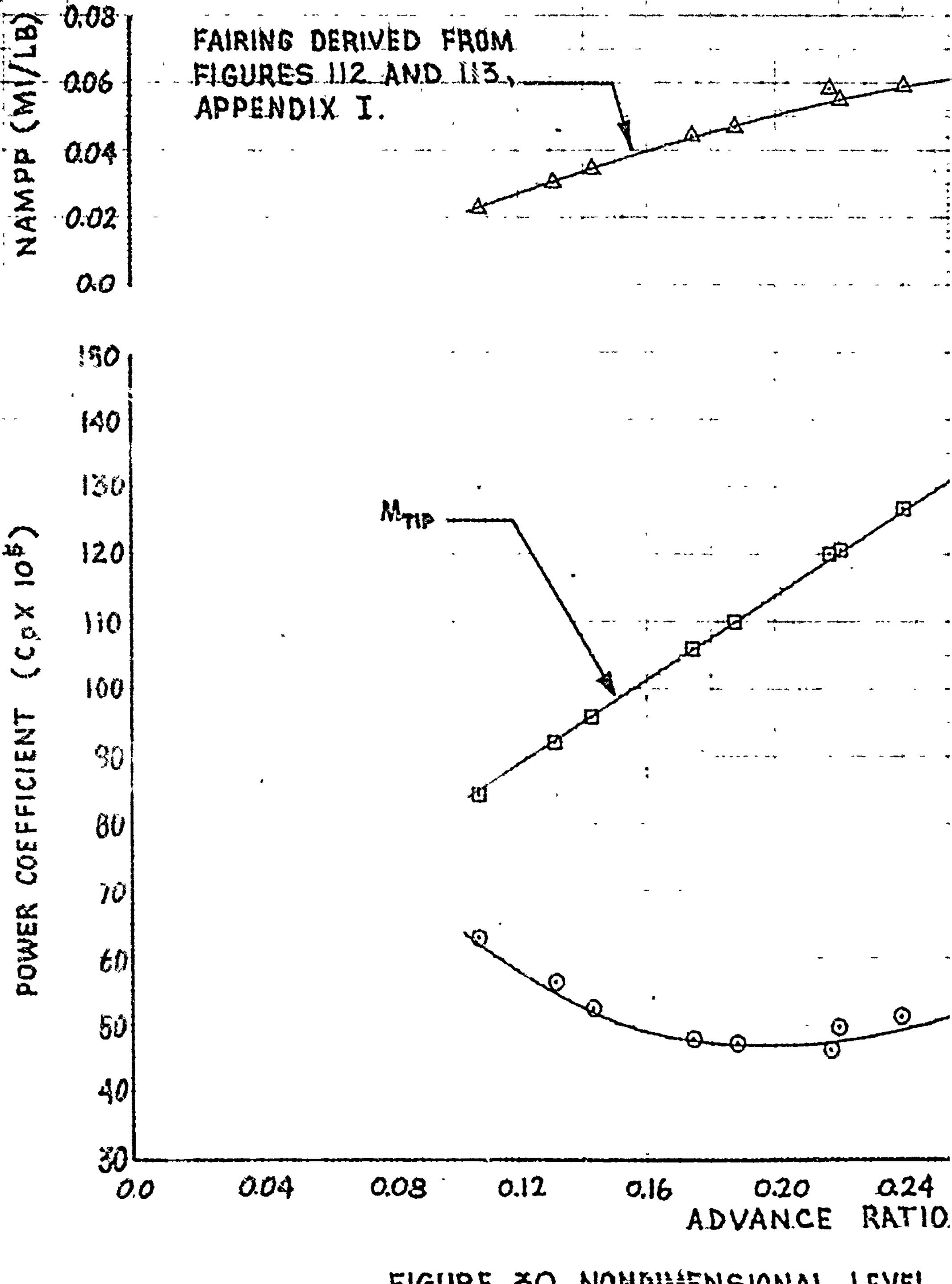
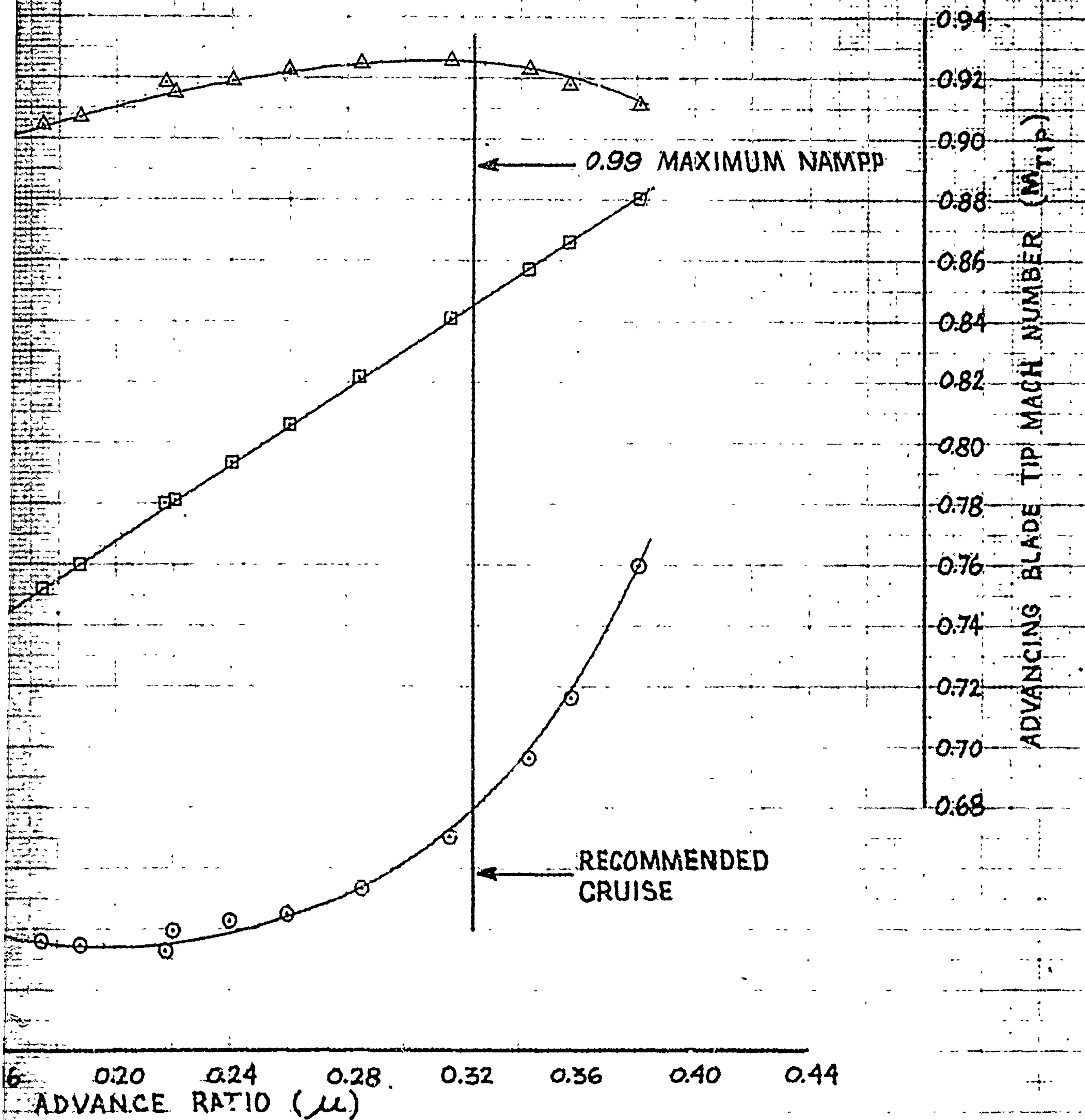


FIGURE 30 NONDIMENSIONAL LEVEL

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 4,400
AVG. FREE AIR TEMP (DEG. C) = -5.0
AVG. GROSS WEIGHT (LB) = 37,320
AVG. CG LOCATION (STA) = 338.9

450-GAL AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST



DIMENSIONAL LEVEL FLIGHT PERFORMANCE (CLEAN)

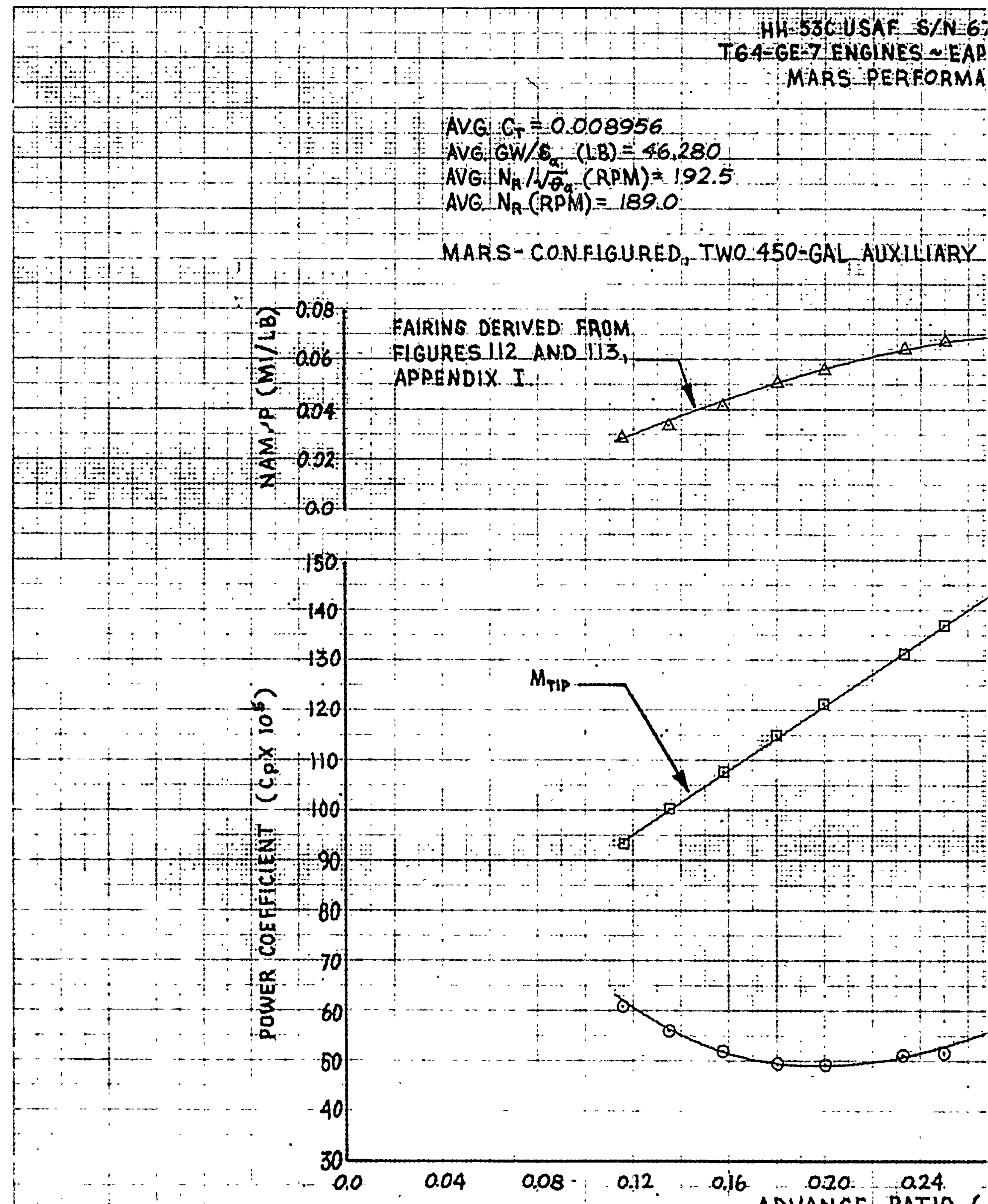
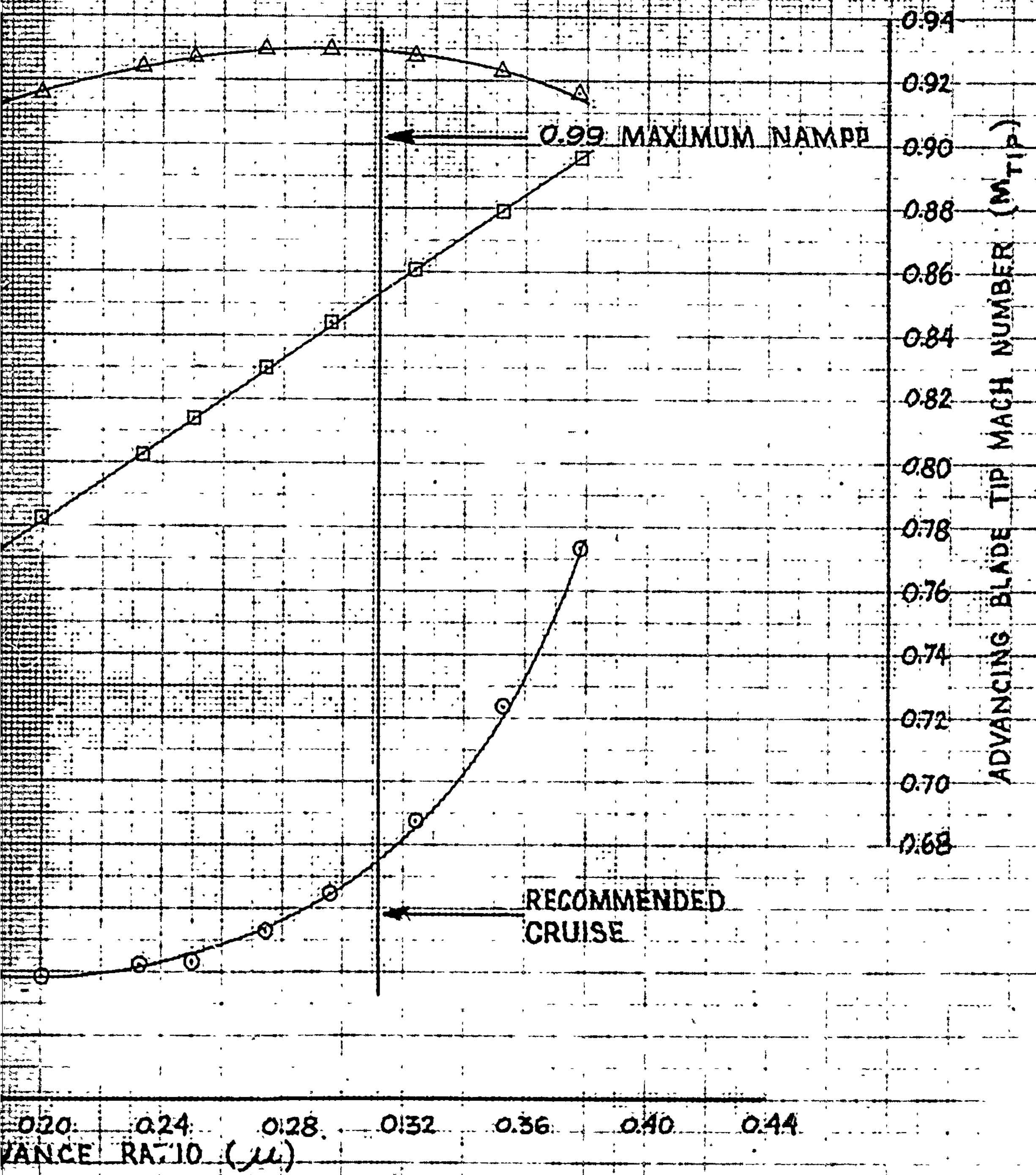


FIGURE 31 NONDIMENSIONAL LEVEL FL

-53C USAF S/N 67-14993
-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG PRESSURE ALTITUDE (FT) = 7,550
AVG FREE AIR TEMP (DEG C) = 4.5
AVG GROSS WEIGHT (LB) = 34,970
AVG CG LOCATION (STA) = 338.8

-GAL AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST



IONAL LEVEL FLIGHT PERFORMANCE (CLEAN)

2

HH-53C USAF S/N
T64-GE-7 ENGINES ~ E
MARS PERFORM

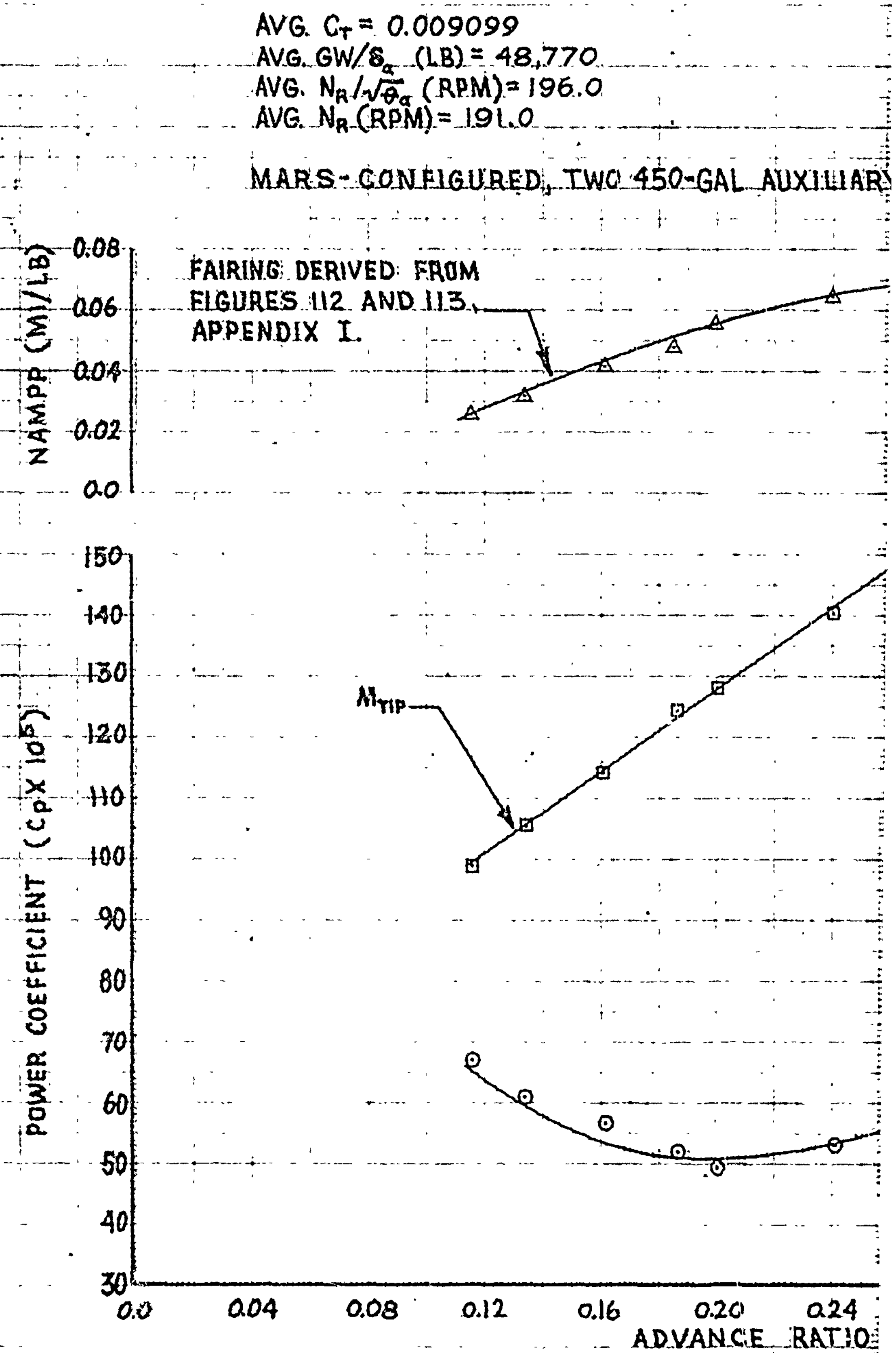
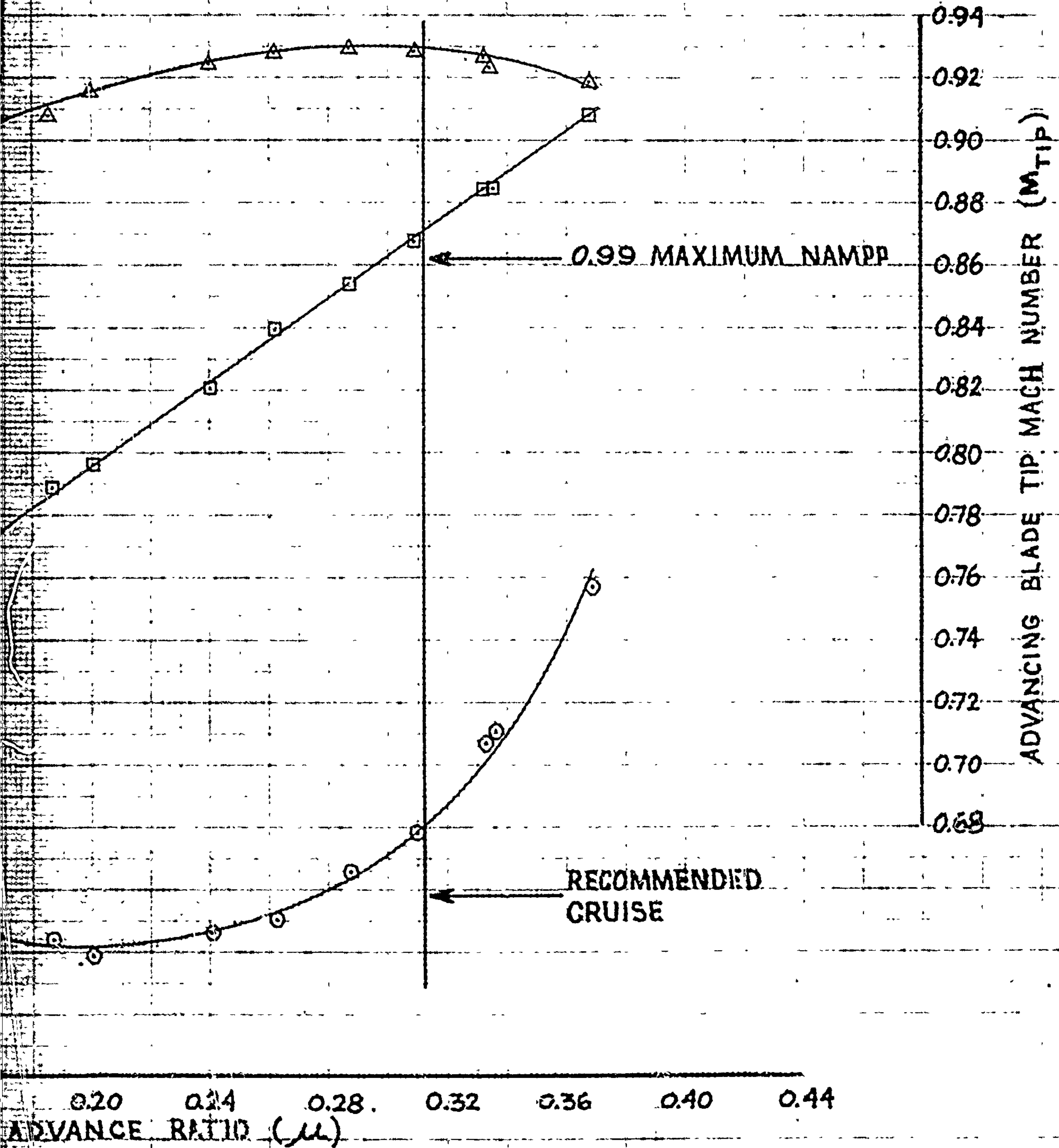


FIGURE 32 NONDIMENSIONAL LEVEL

HH-53C USAF S/N 67-14993
-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 8,200
AVG. FREE AIR TEMP (DEG. C) = 0.5
AVG. GROSS WEIGHT (LB) = 35,950
AVG. CG LOCATION (STA) = 338.8

450-GAL AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.



ENSIONAL LEVEL FLIGHT PERFORMANCE (CLEAN)

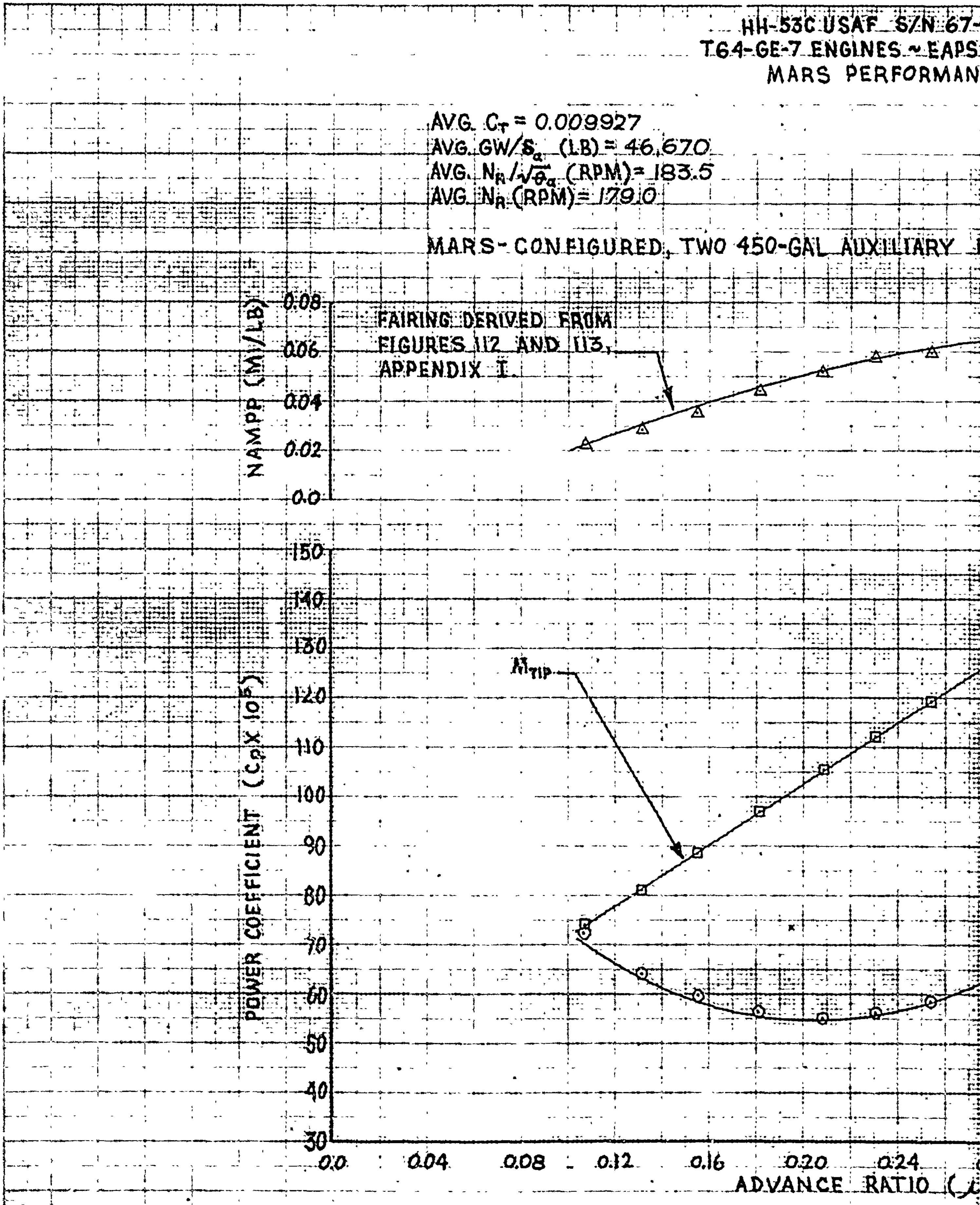
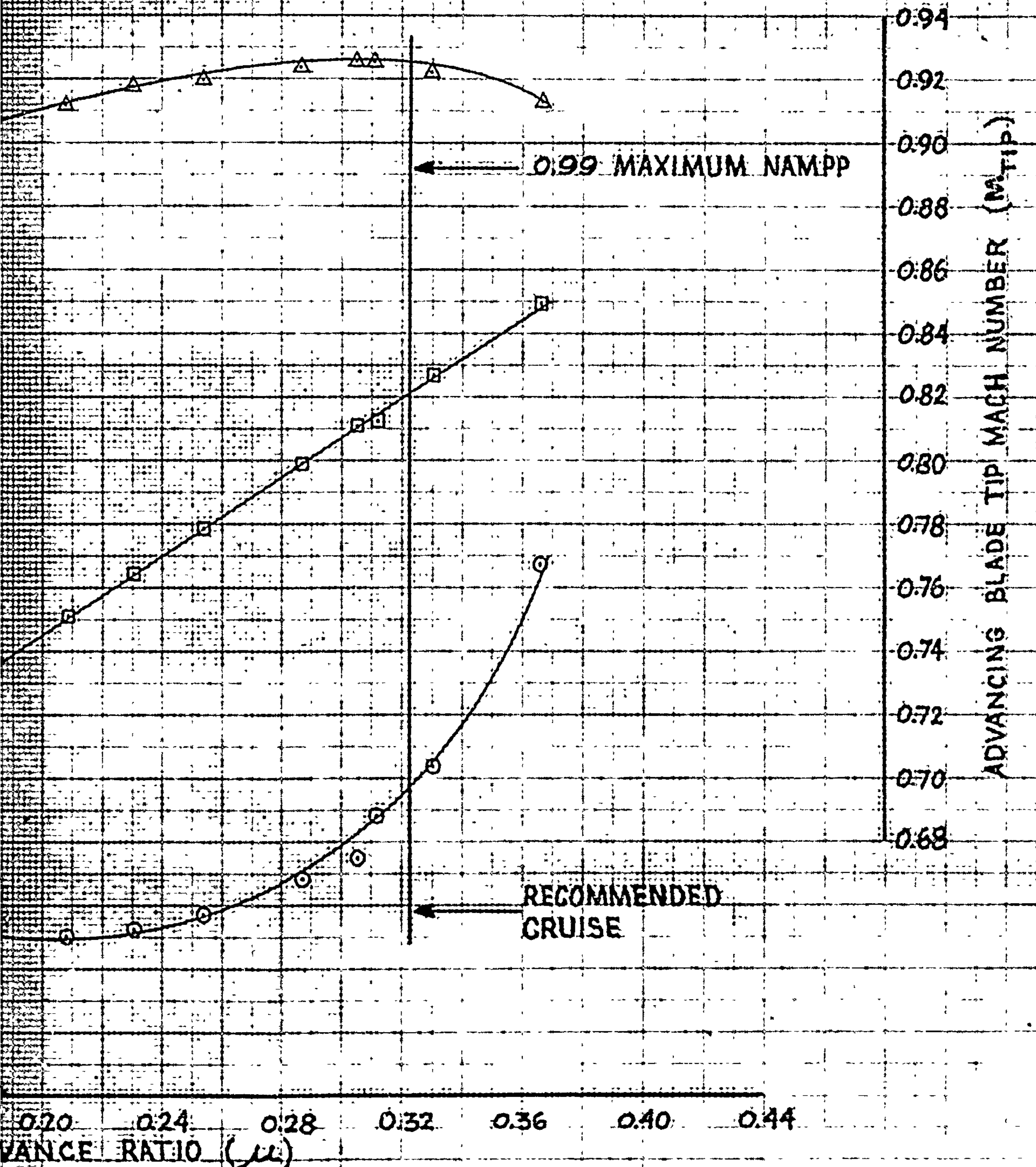


FIGURE 33 NONDIMENSIONAL LEVEL FLIG

53C USAF S/N 67-14993
E-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 5,800
AVG. FREE AIR TEMP (DEG C) = 2.0
AVG. GROSS WEIGHT (LB) = 37,680
AVG. CG LOCATION (STA) = 338.5

-GAL AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST



SIONAL LEVEL FLIGHT PERFORMANCE (CLEAN)

HH-53C USAF S/N 6
T64-GE-7 ENGINES ~ EA
MARS PERFORM

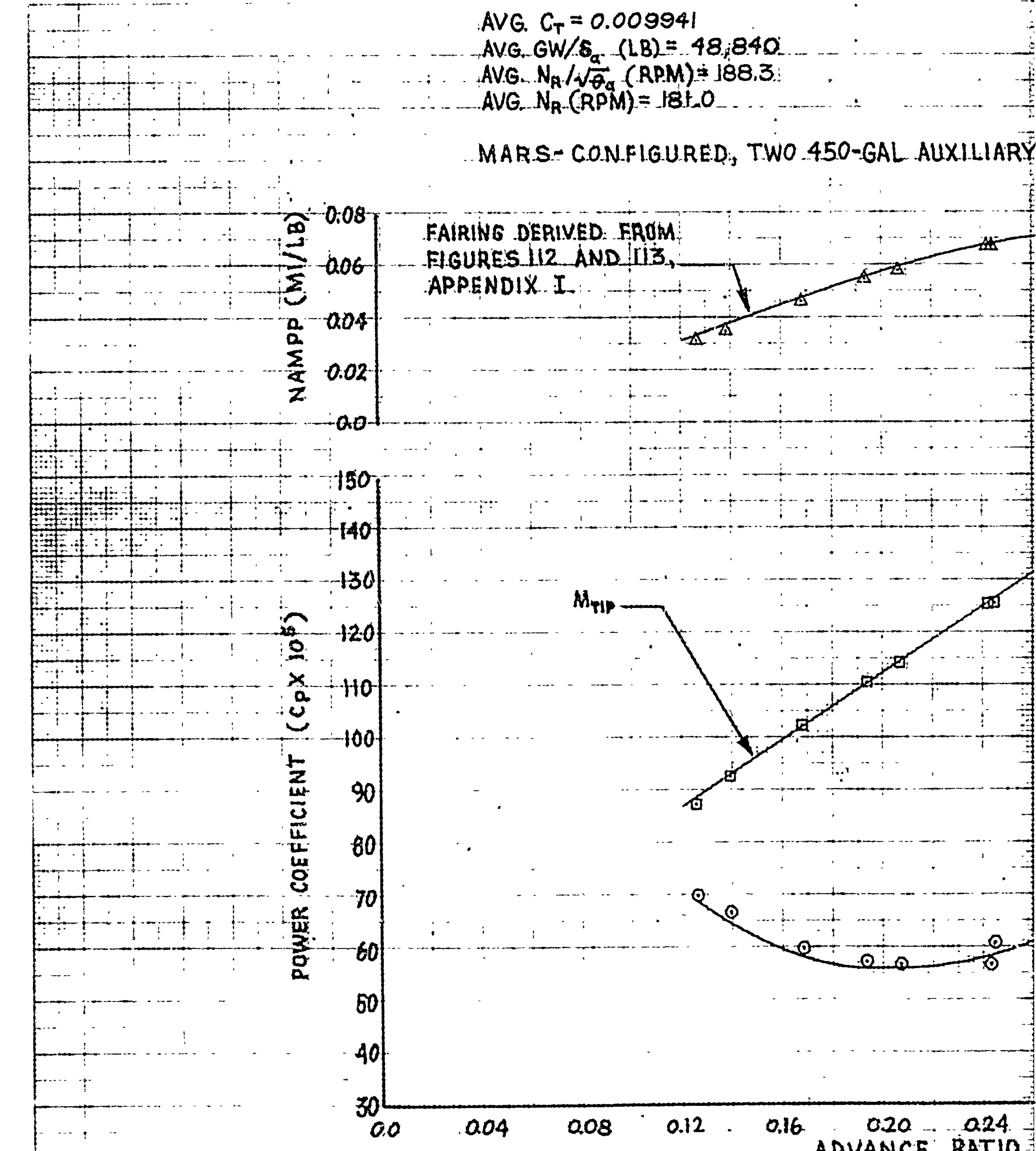
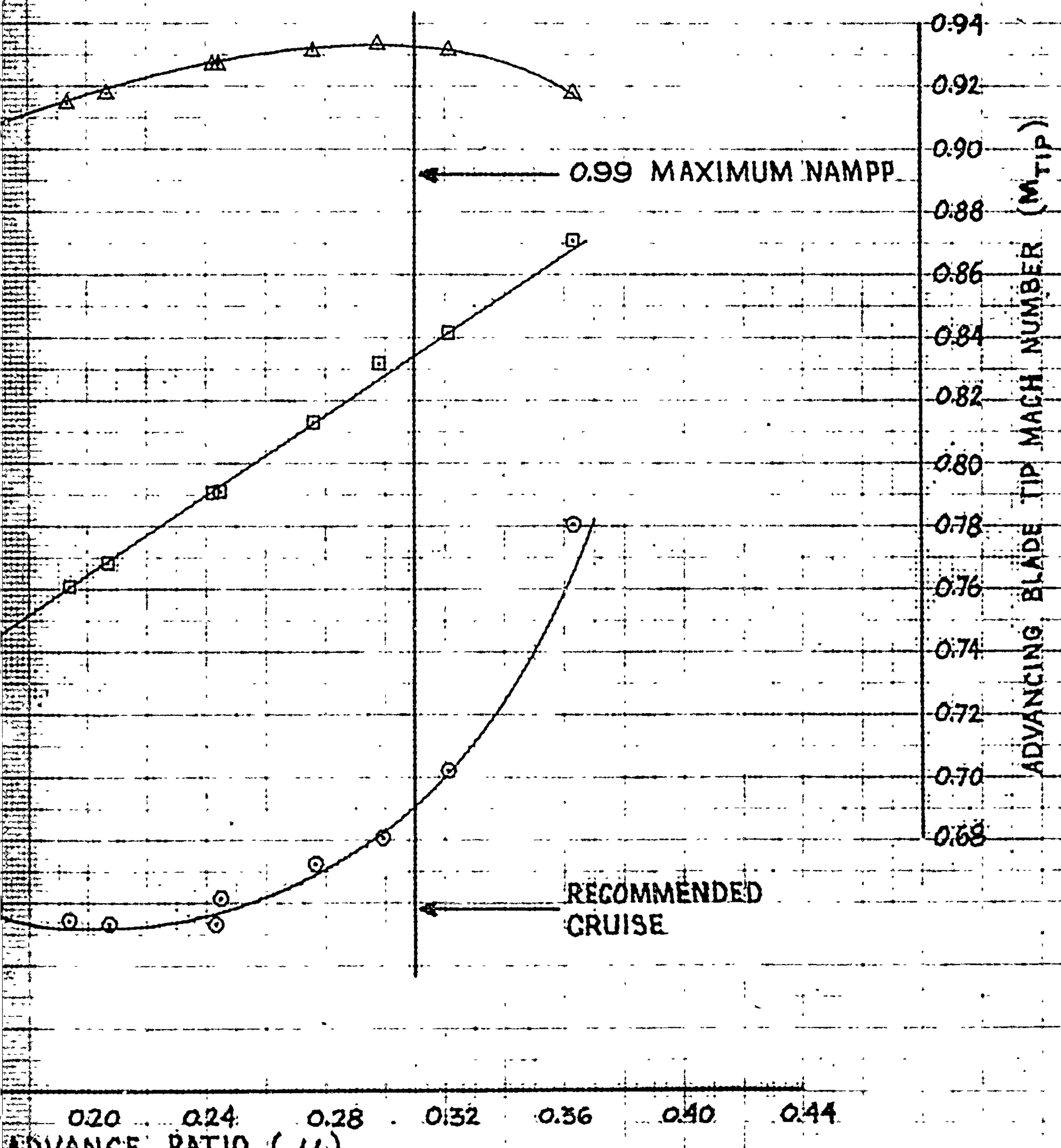


FIGURE 34 NONDIMENSIONAL LEVEL F

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 10,150
AVG. FREE AIR TEMP. (DEG. C) = -7.0
AVG. GROSS WEIGHT (LB) = 33,390
AVG. CG LOCATION (STA) = 334.5

450-GAL AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.



ENSIONAL LEVEL FLIGHT PERFORMANCE (CLEAN)

HH-53C USAF S/N 67-
T64-GE-7 ENGINES ~ EAPS
MARS PERFORMAN

AVG. C_T = 0.009974
AVG. GW/δ_a (LB) = 51,930
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 193.2
AVG. N_R (RPM) = 187.0

MARS-CONFIGURED, TWO 450-GAL AUXILIARY

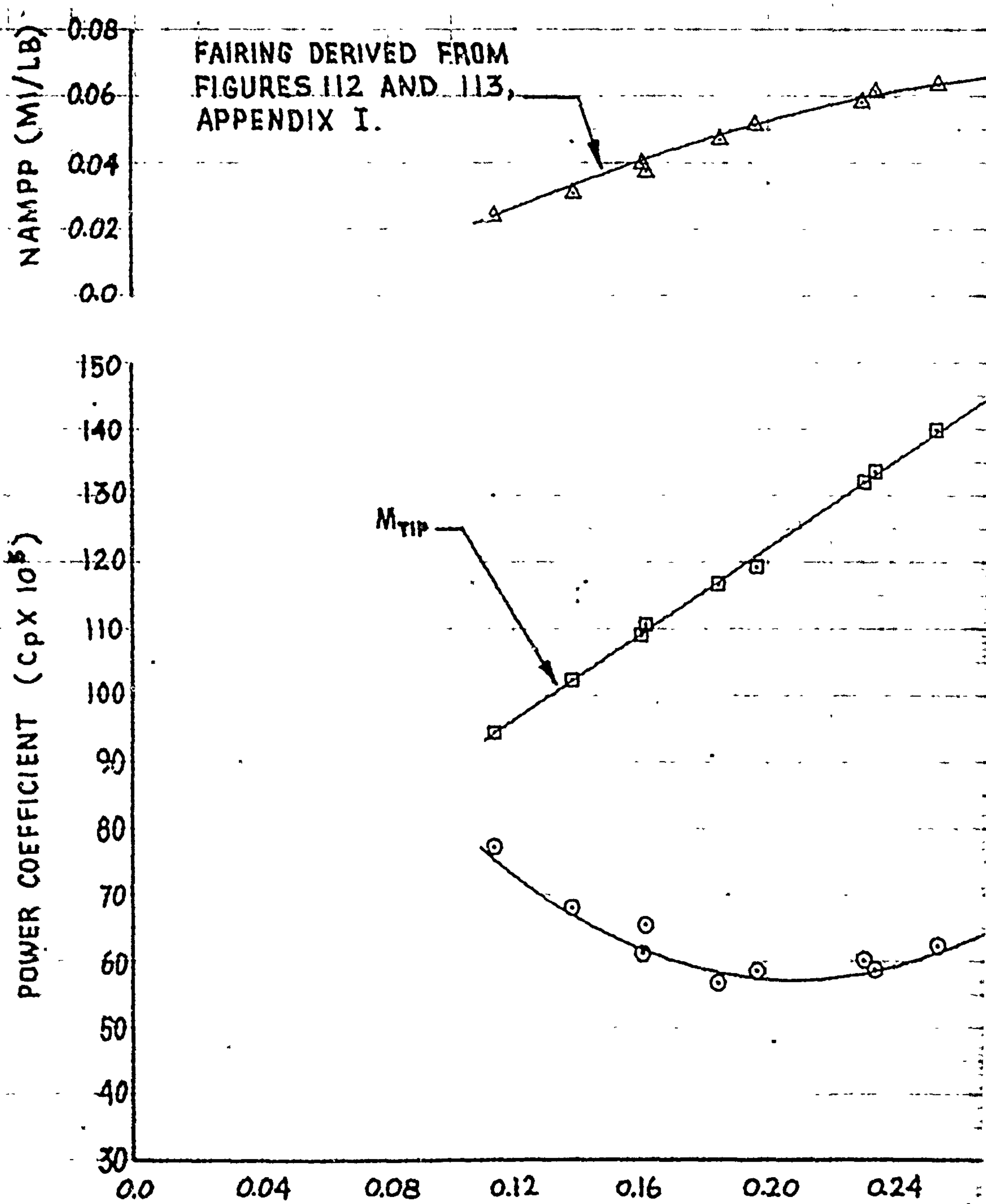
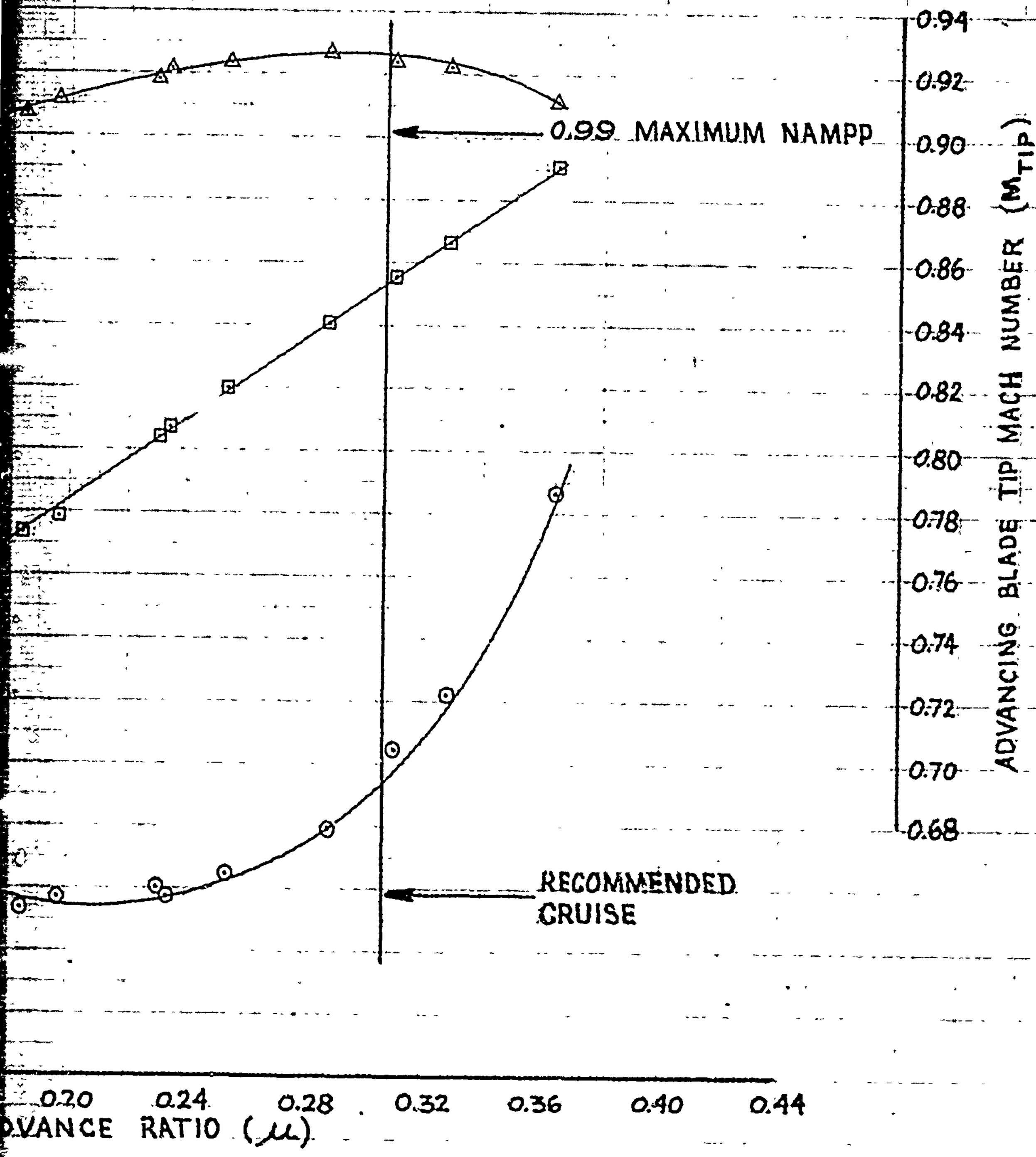


FIGURE 35 NONDIMENSIONAL LEVEL FLI

H-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 8,950
AVG. FREE AIR TEMP (DEG C) = -3.5
AVG. GROSS WEIGHT (LB) = 37,190
AVG. CG LOCATION (STA) = 337.9

50-GAL AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.



...SIONAL LEVEL FLIGHT PERFORMANCE (CLEAN)

2

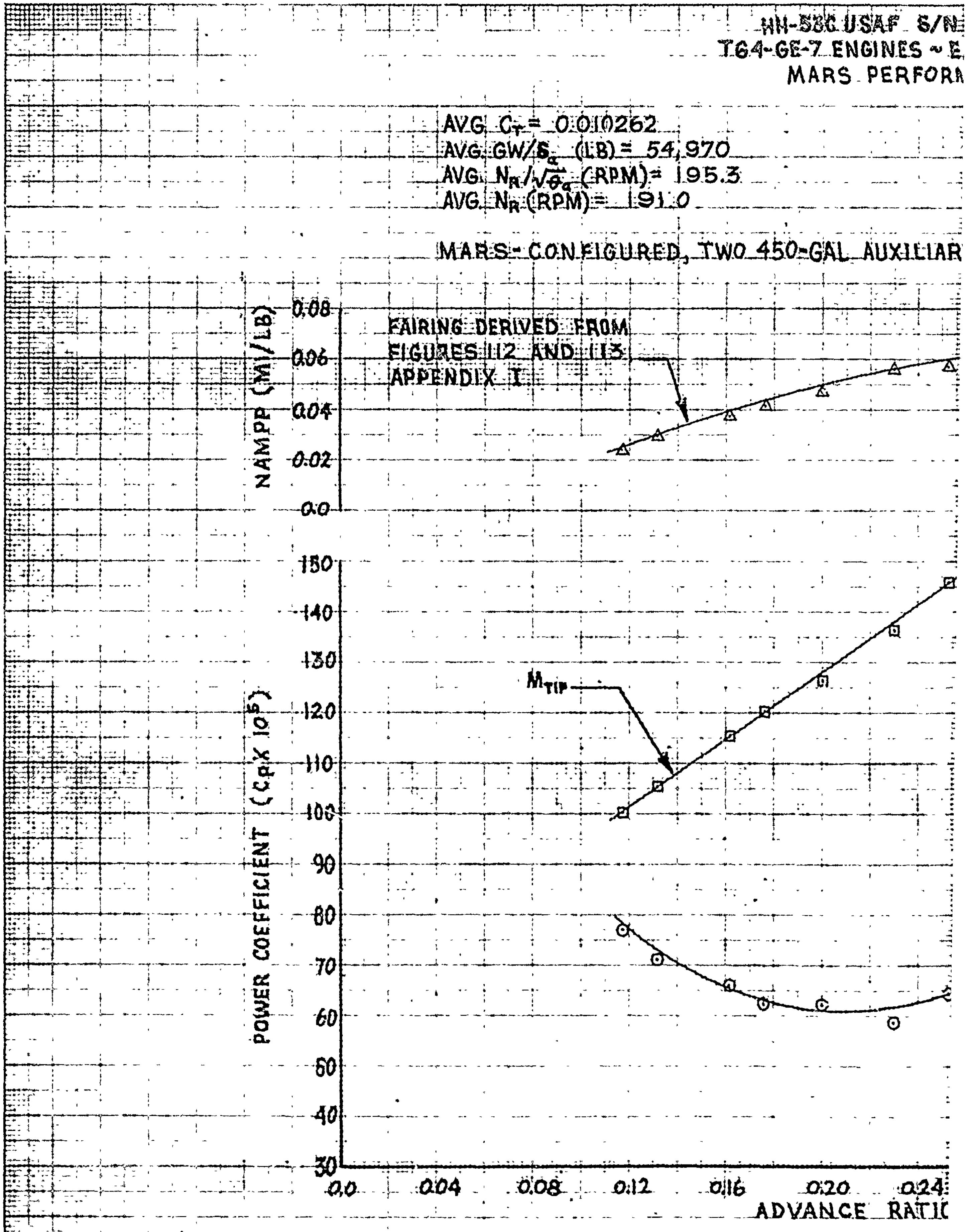
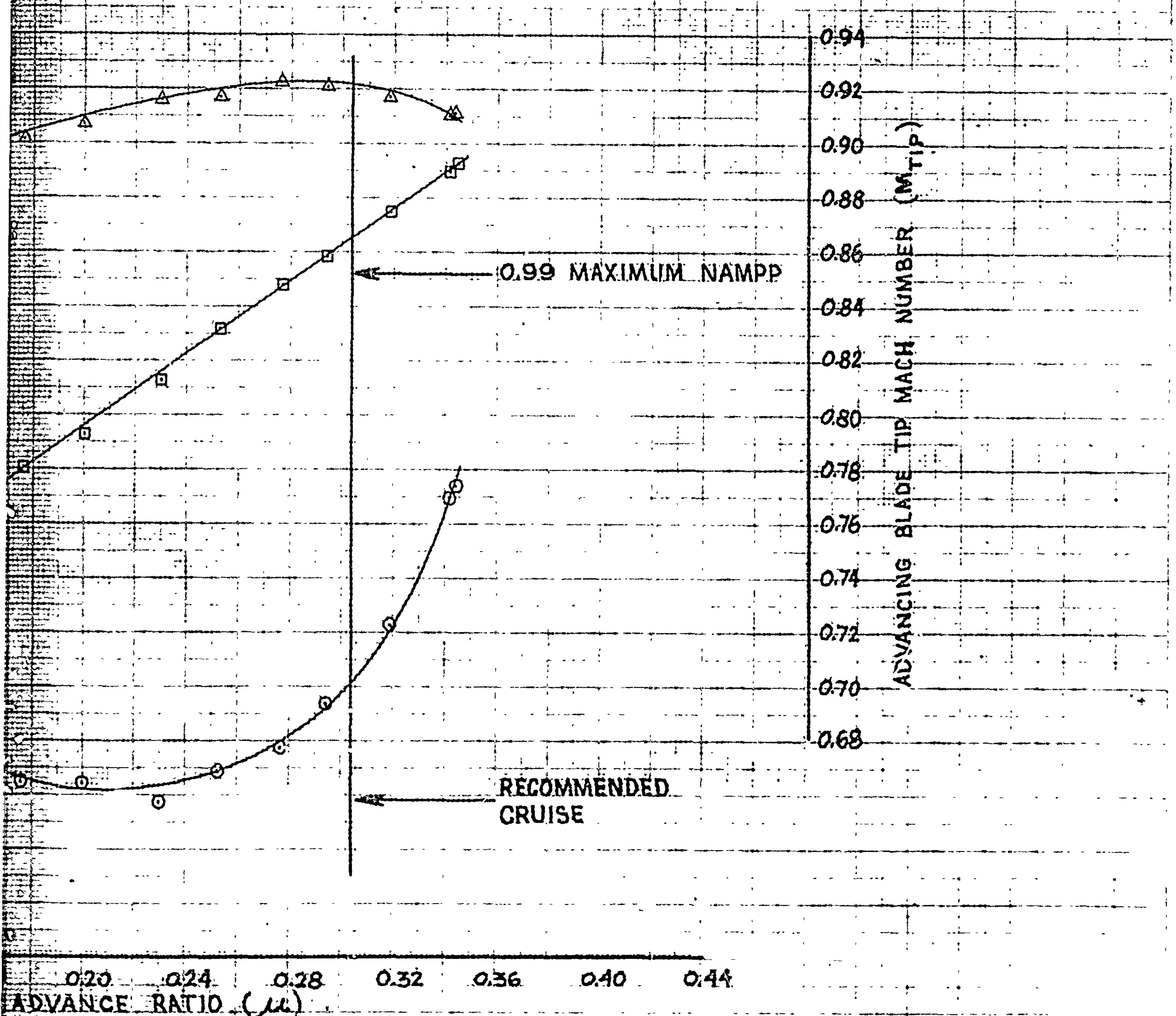


FIGURE 36 NONDIMENSIONAL LEVEL

HH-53C USAF S/N 67-14993
-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 8,250
AVG. FREE AIR TEMP (DEG. C) = 0.0
AVG. GROSS WEIGHT (LB) = 40,440
AVG. CG LOCATION (STA) = 337.8

450-GAL AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.



ENSIONAL LEVEL FLIGHT PERFORMANCE (CLEAN)

HH-53C USAF S/N 6
T64-GE-7 ENGINES ~ EA
MARS PERFORM

AVG. C_T = 0.010871
AVG. GW/δ_a (LB) = 52,000
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 185.2
AVG. N_R (RPM) = 179.0

MARS-CONFIGURED, TWO 450-GAL AUXILIARY

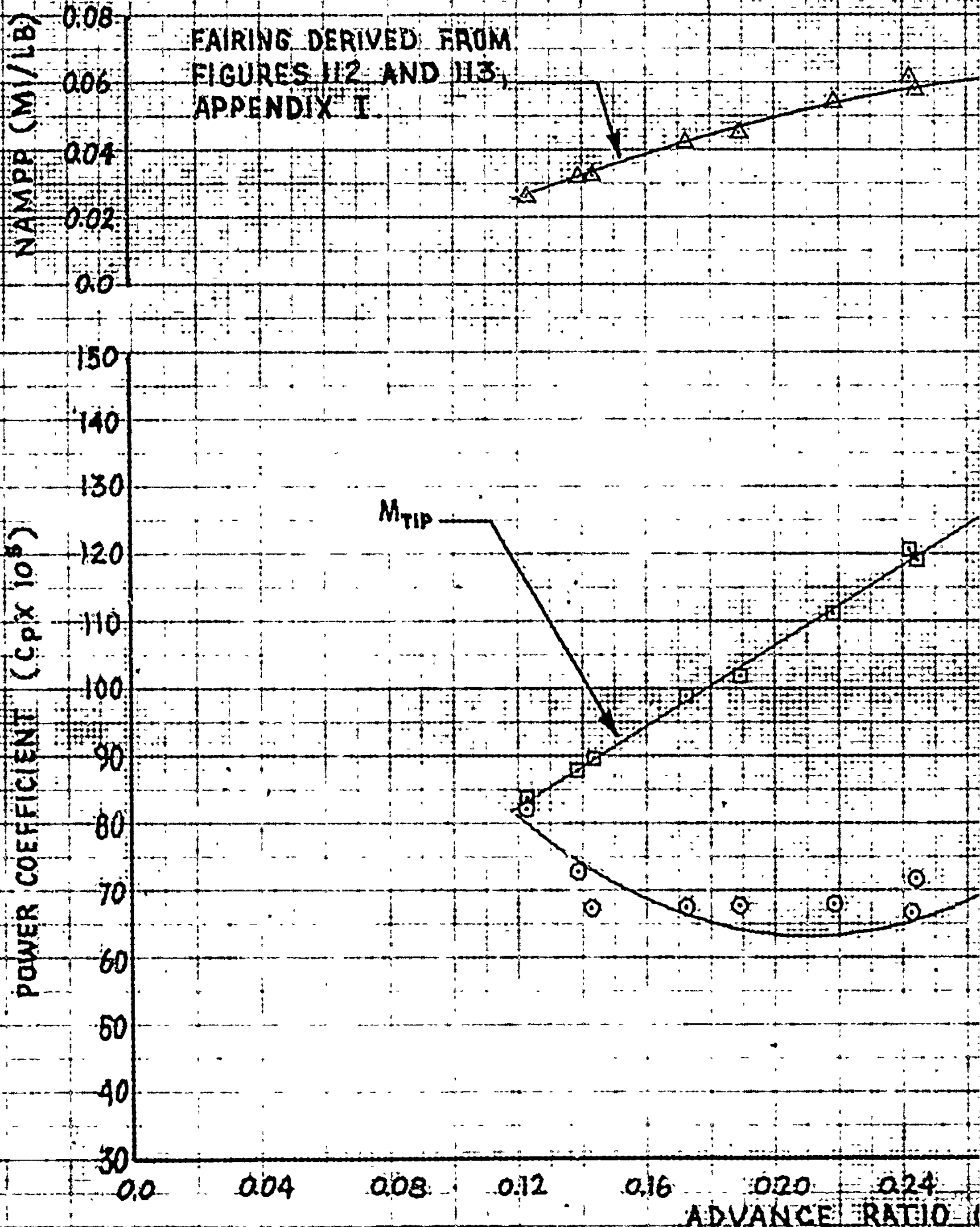
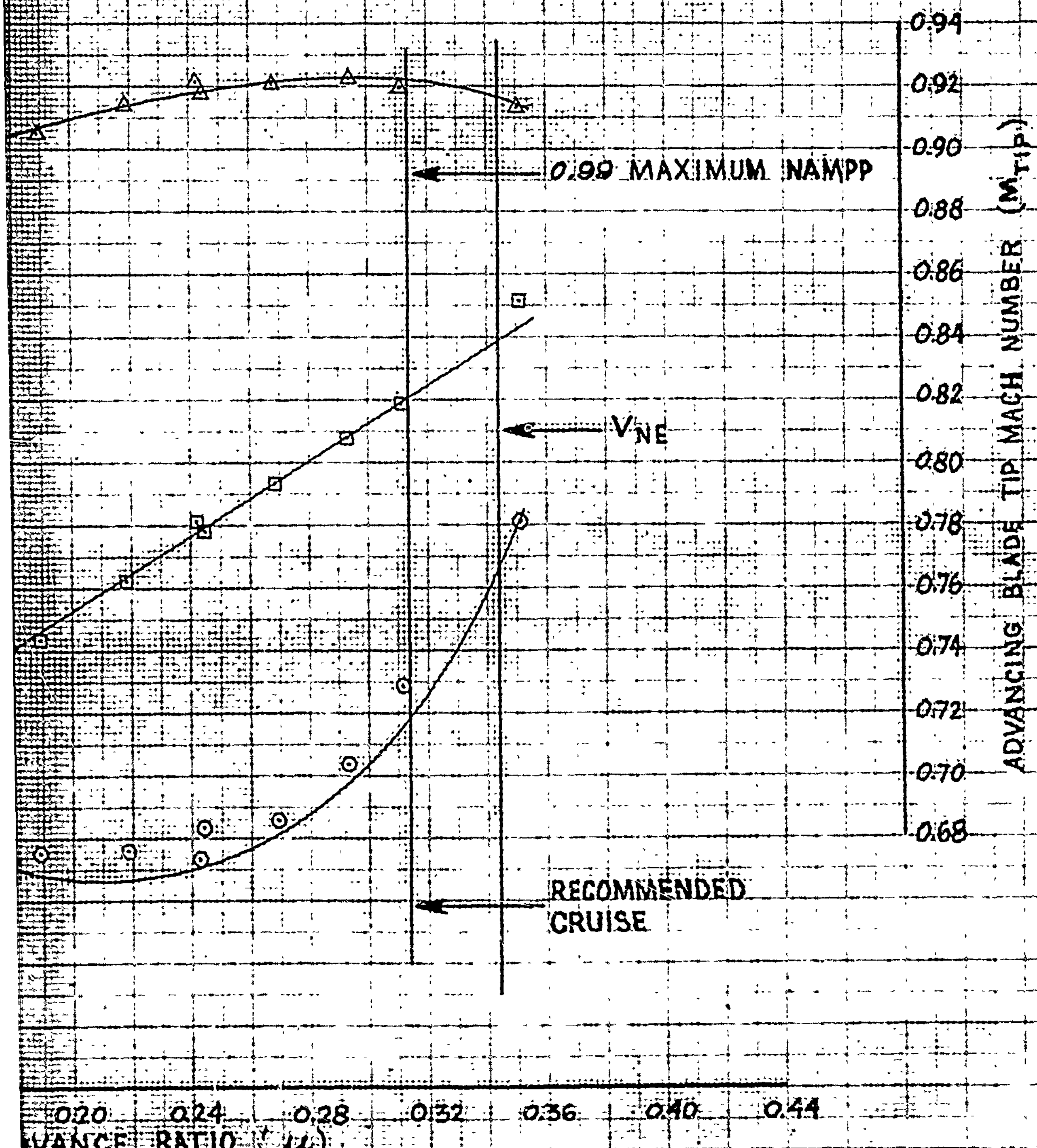


FIGURE 57 NONDIMENSIONAL LEVEL FI

HH-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 8,800
AVG. FREE AIR TEMP (DEG. C) = -4.5
AVG. GROSS WEIGHT (LB) = 37,460
AVG. CG LOCATION (STA) = 340.6

50-GAL AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.



...SIONAL LEVEL FLIGHT PERFORMANCE (CLEAN)

2

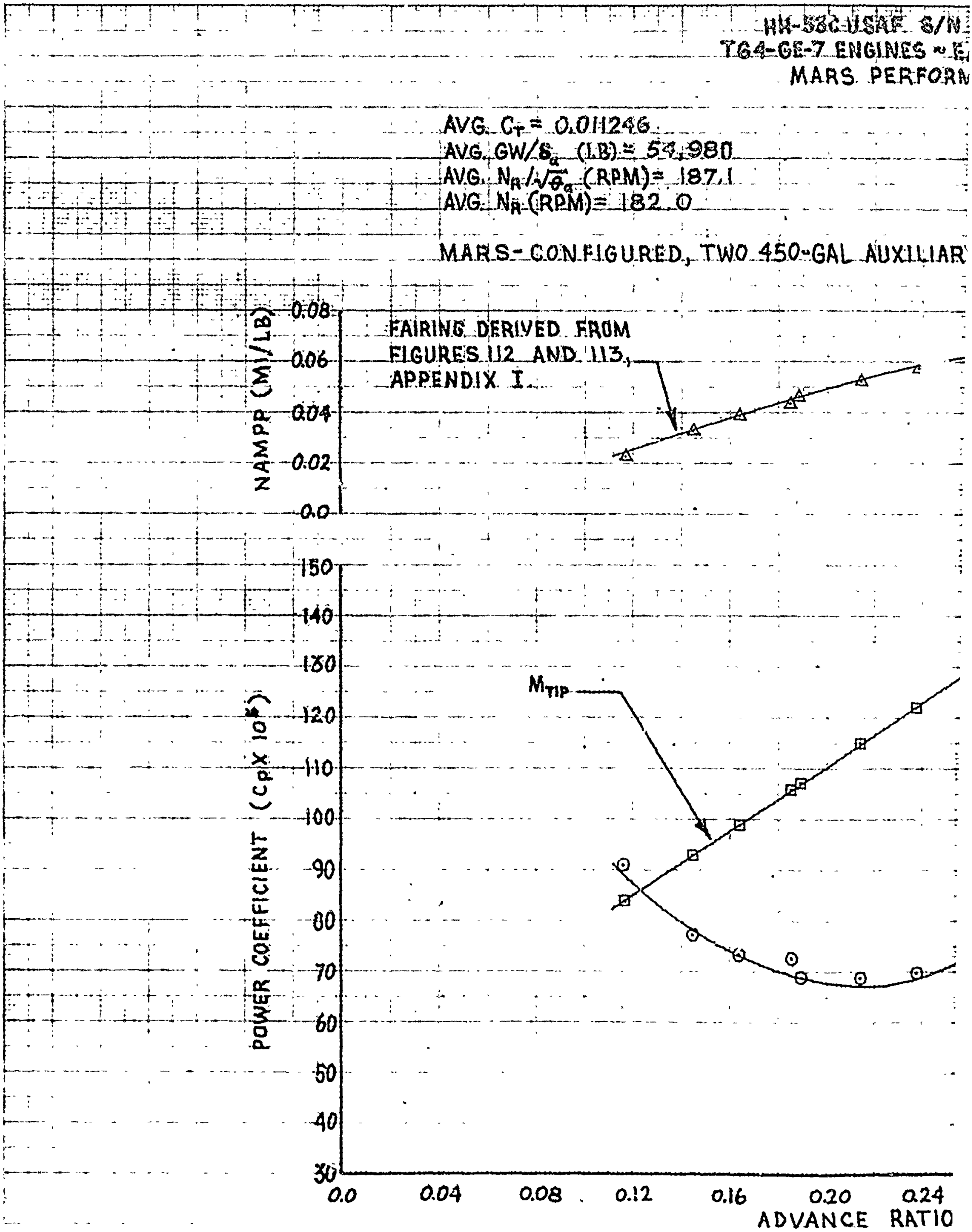
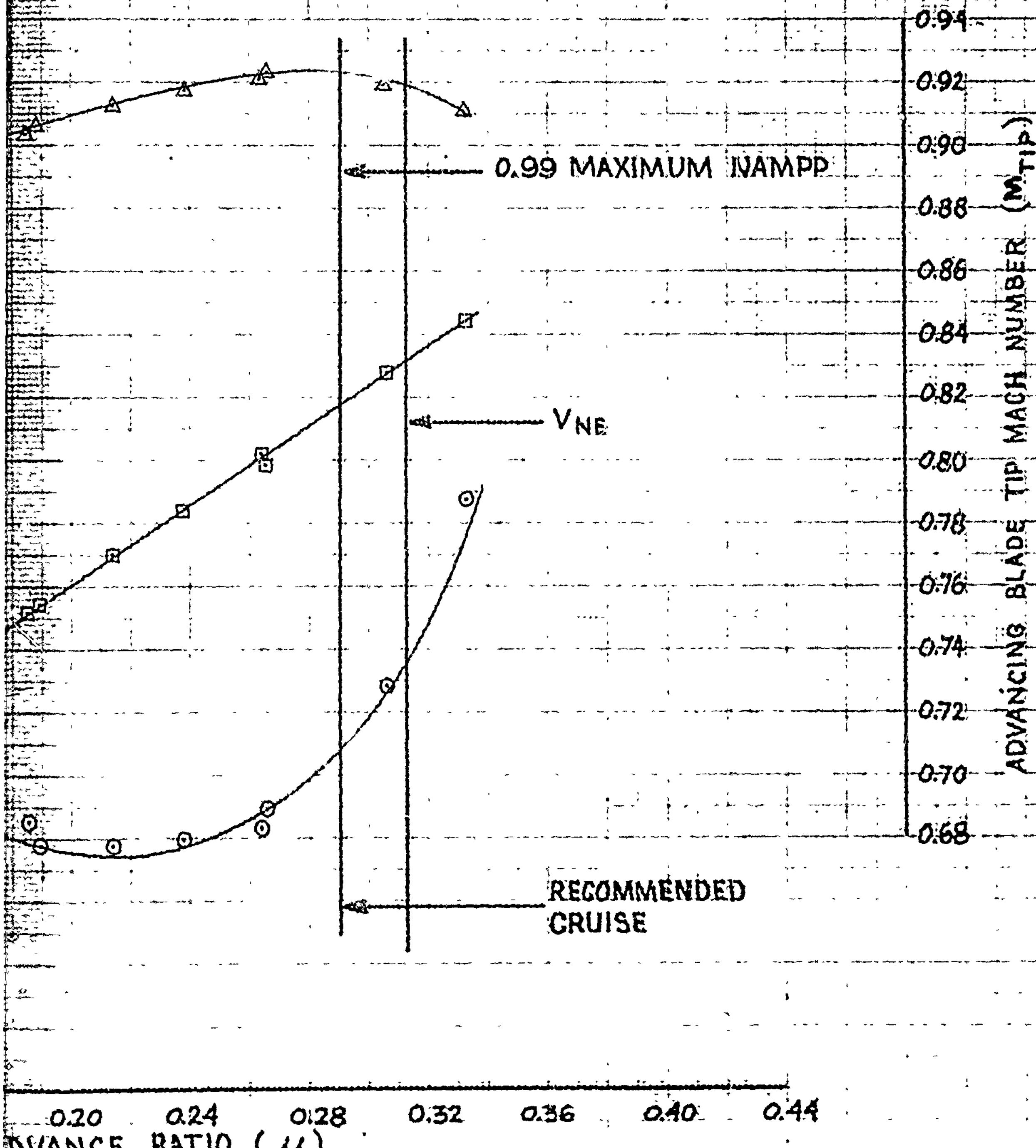


FIGURE 38. NONDIMENSIONAL LEVEL

H-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 9,200
AVG. FREE AIR TEMP (DEG. C) = -0.5
AVG. GROSS WEIGHT (LB) = 39,000
AVG. CG LOCATION (STA) = 336.6

50-GAL AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST



NSIONAL LEVEL FLIGHT PERFORMANCE (CLEAN)

HH-53C USAF S/N 67
T64-GE-7 ENGINES ~ EAPS
MARS PERFORMAN

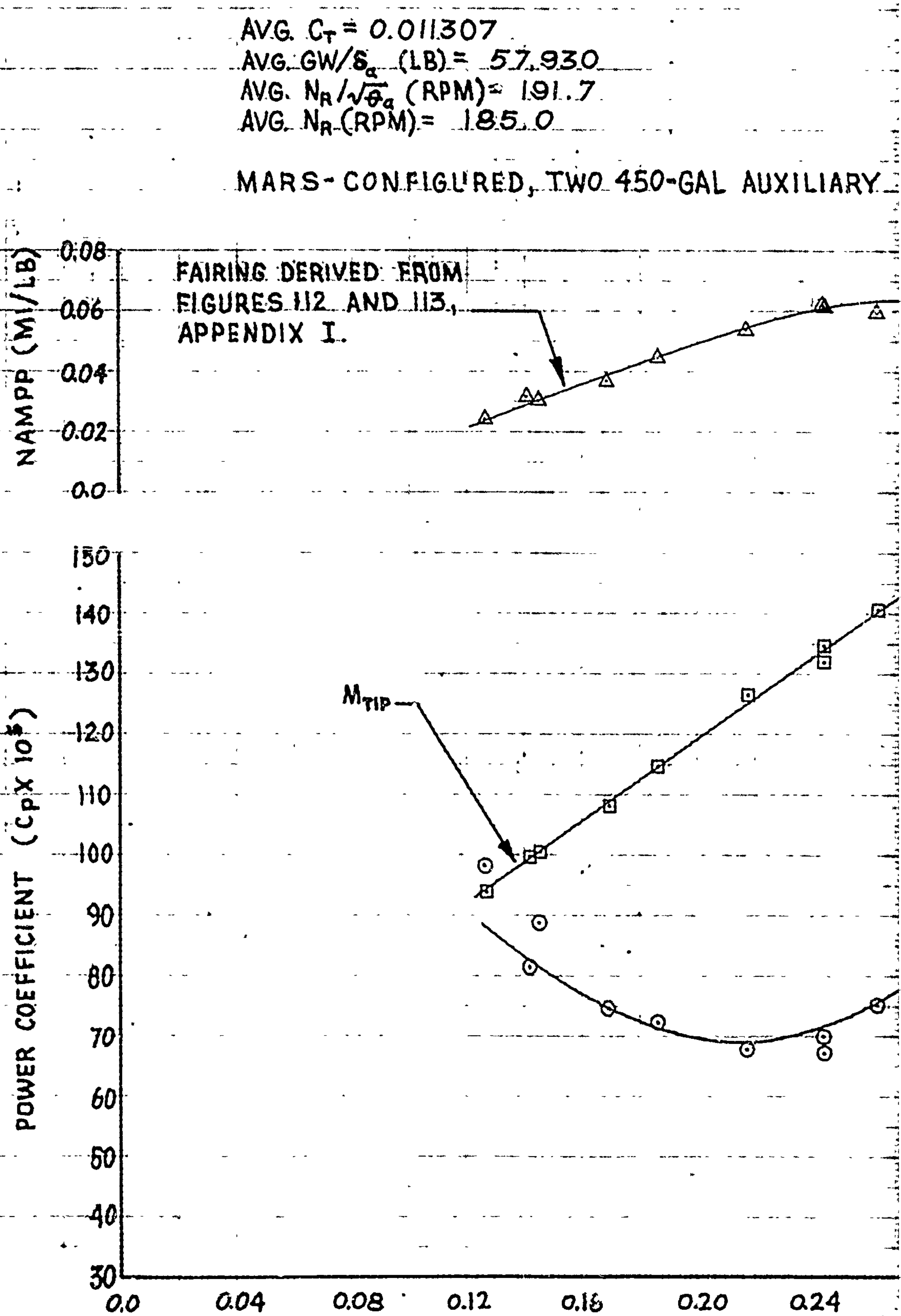
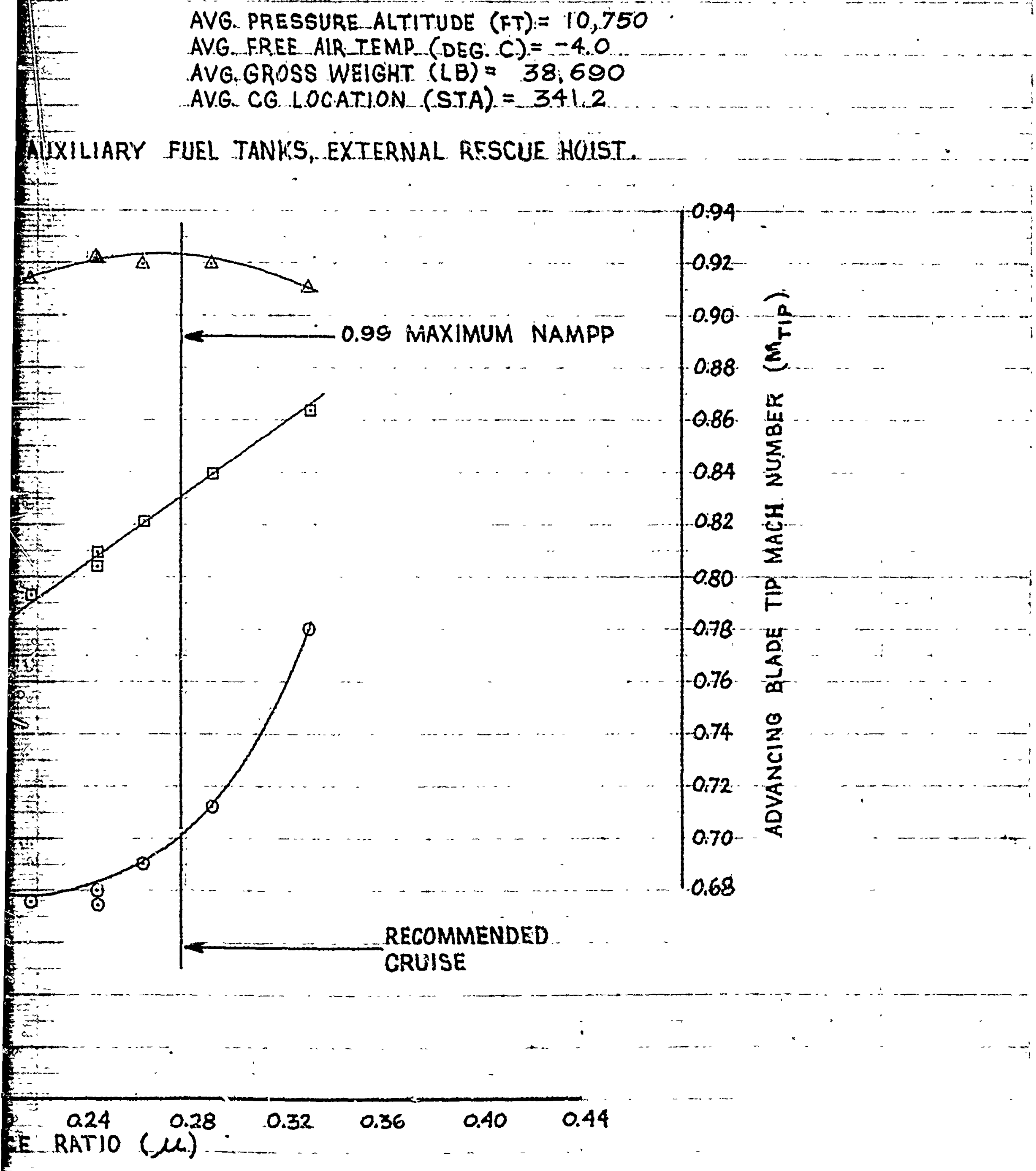


FIGURE 39 NONDIMENSIONAL LEVEL FLI

SAF S/N 67-14993
GINES ~ EAPS INSTALLED
PERFORMANCE



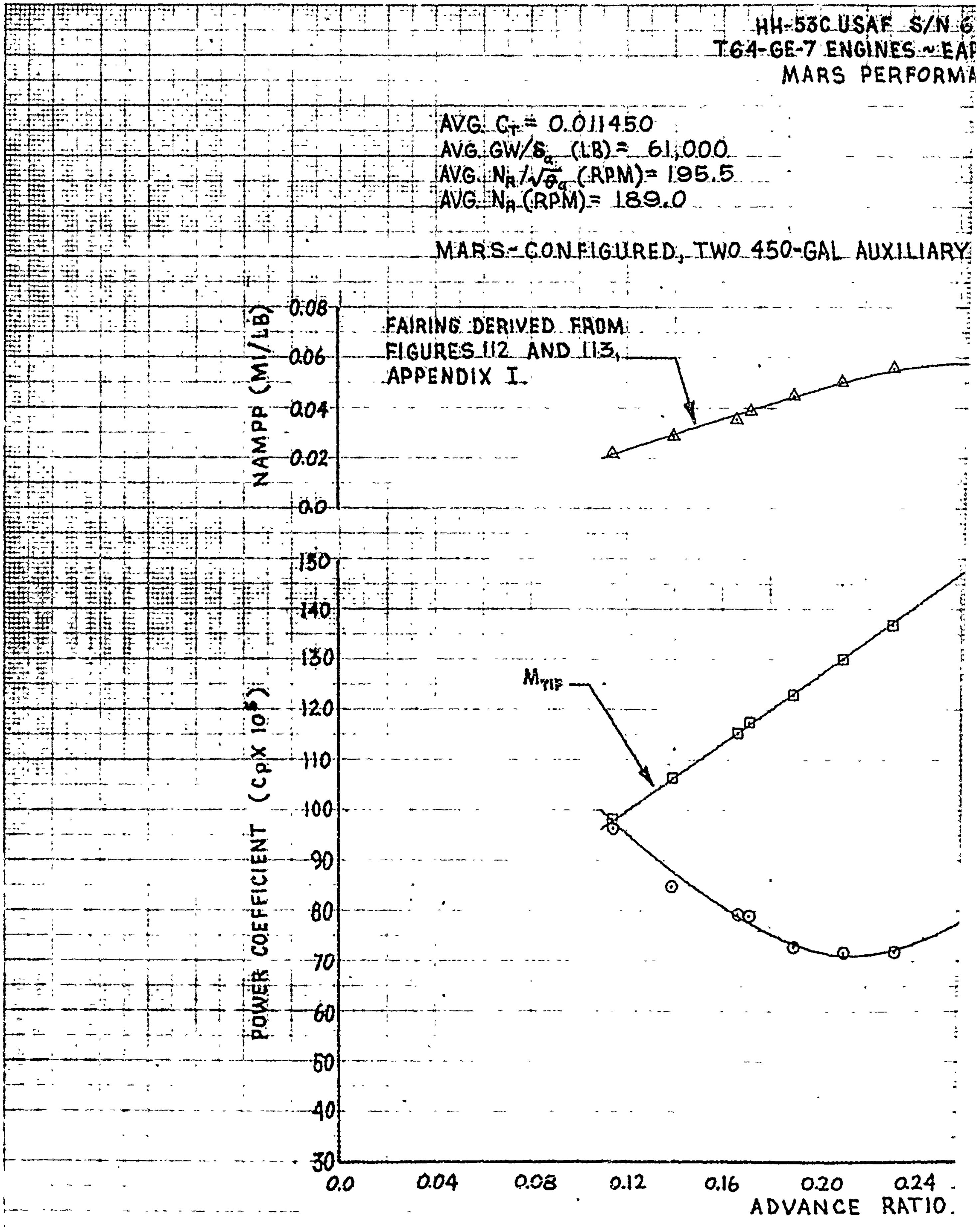
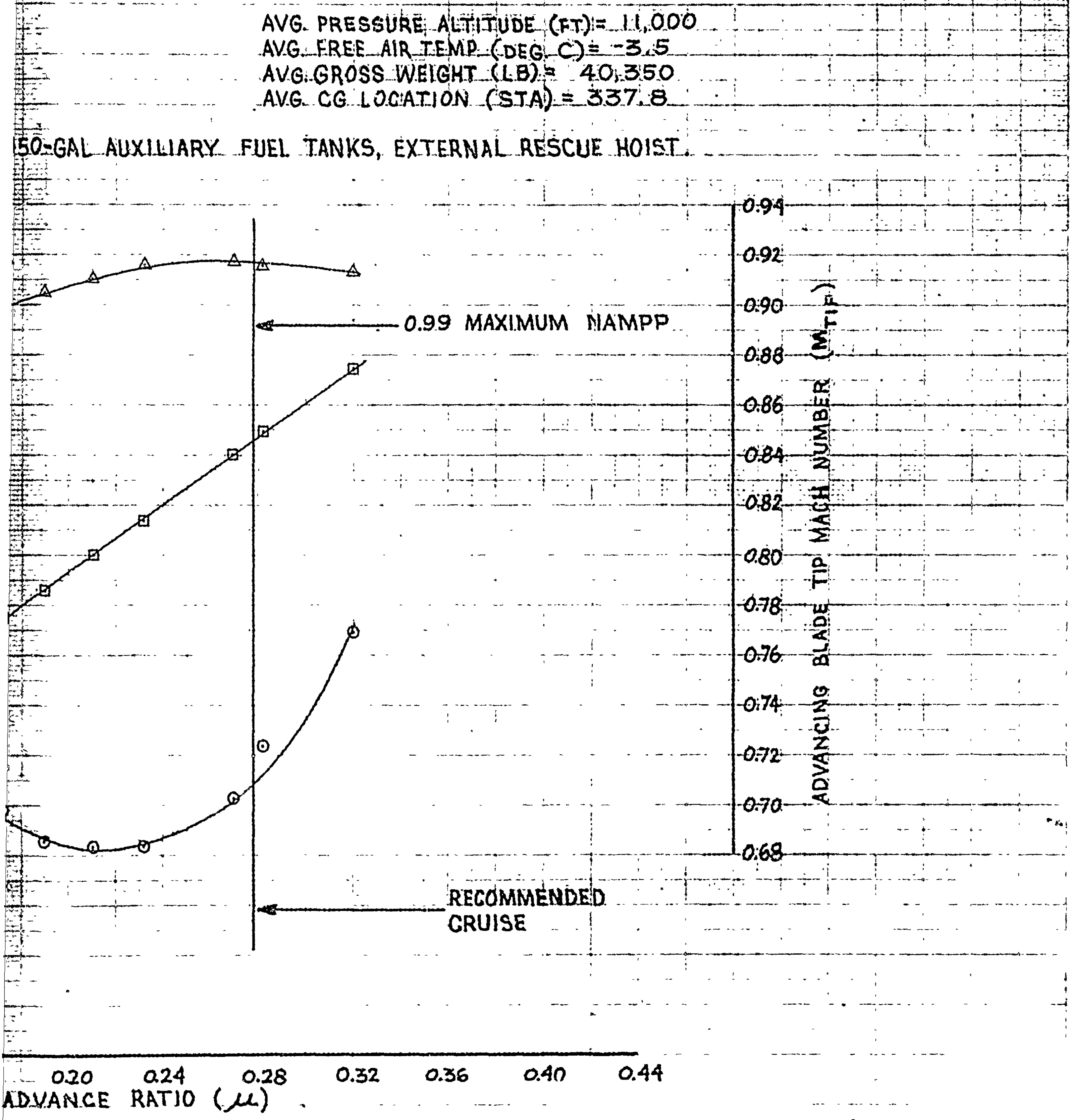


FIGURE 40 NONDIMENSIONAL LEVEL

HH-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE



ENSIONAL LEVEL FLIGHT PERFORMANCE (CLEAN)

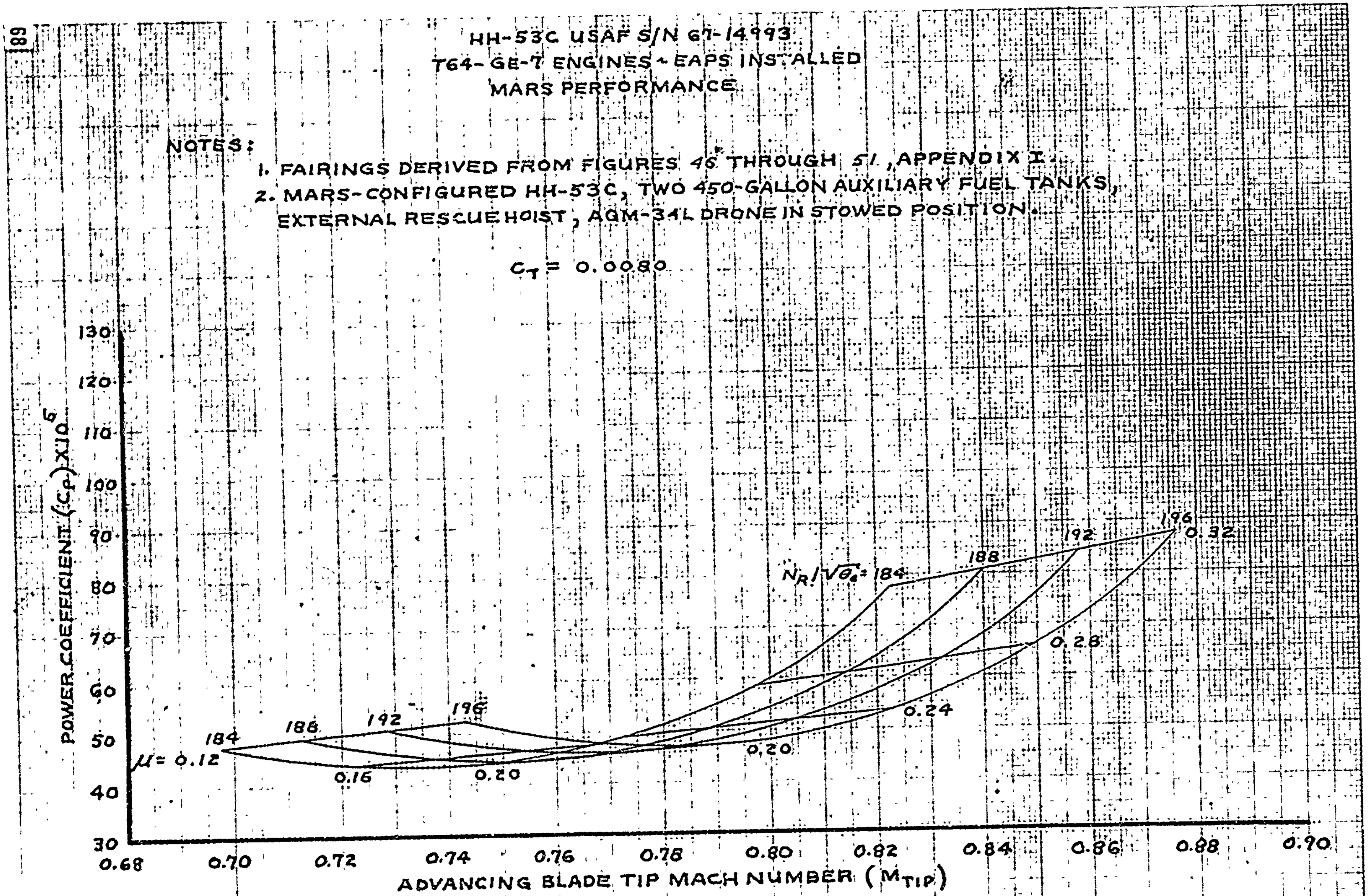


FIGURE 41. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-34L)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES - EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 46 THROUGH 51, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AGM-34L DRONE IN STOWED POSITION.

$C_T = 0.0090$

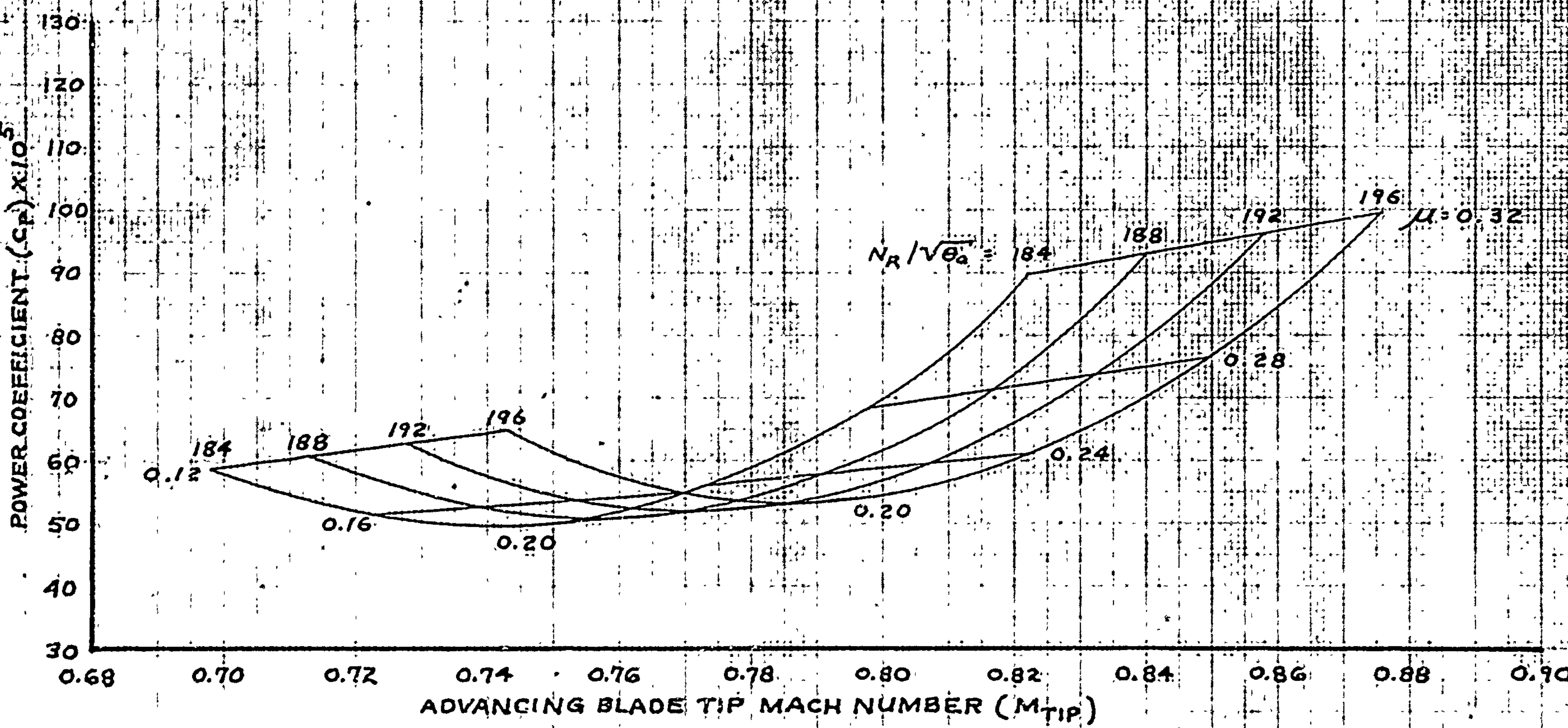


FIGURE 42. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-34L)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 46 THROUGH 51, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-34L DRONE IN STOWED POSITION.

$C_T = 0.0100$

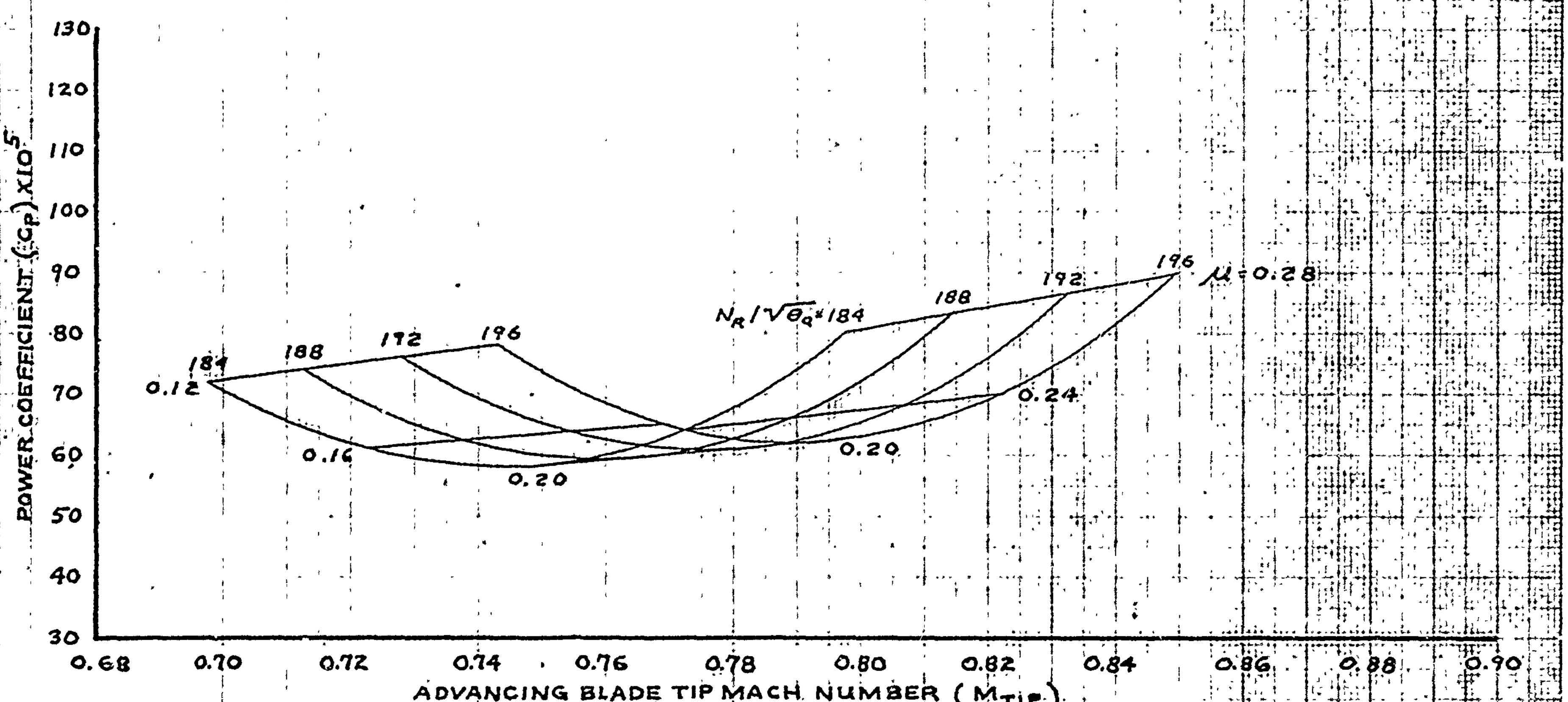


FIGURE 43. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-34L)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 46 THROUGH 51, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-34L DRONE IN STOWED POSITION.

$C_T = 0.0110$

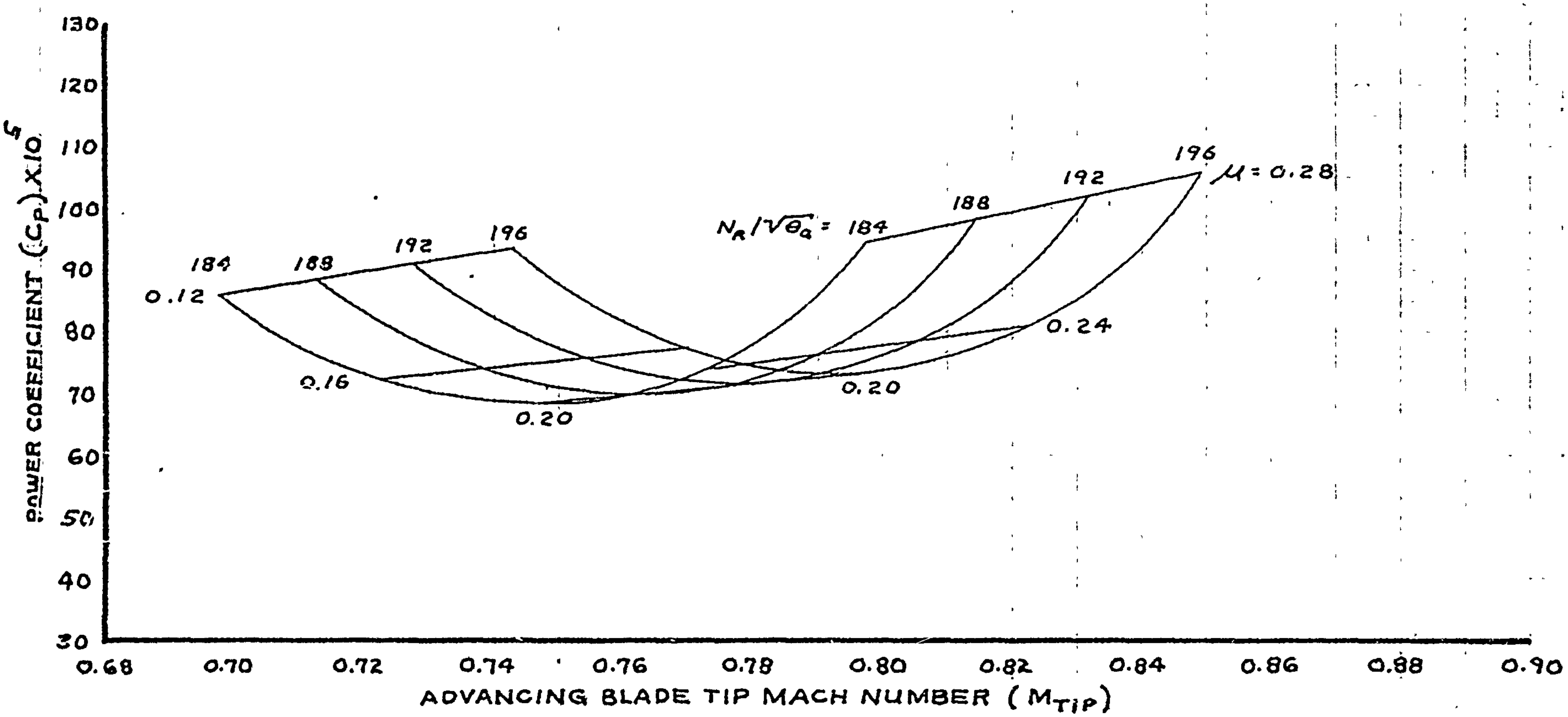


FIGURE 44. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-34L)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 46 THROUGH 51, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-34L DRONE IN STOWED POSITION.

$C_T = 0.0115$

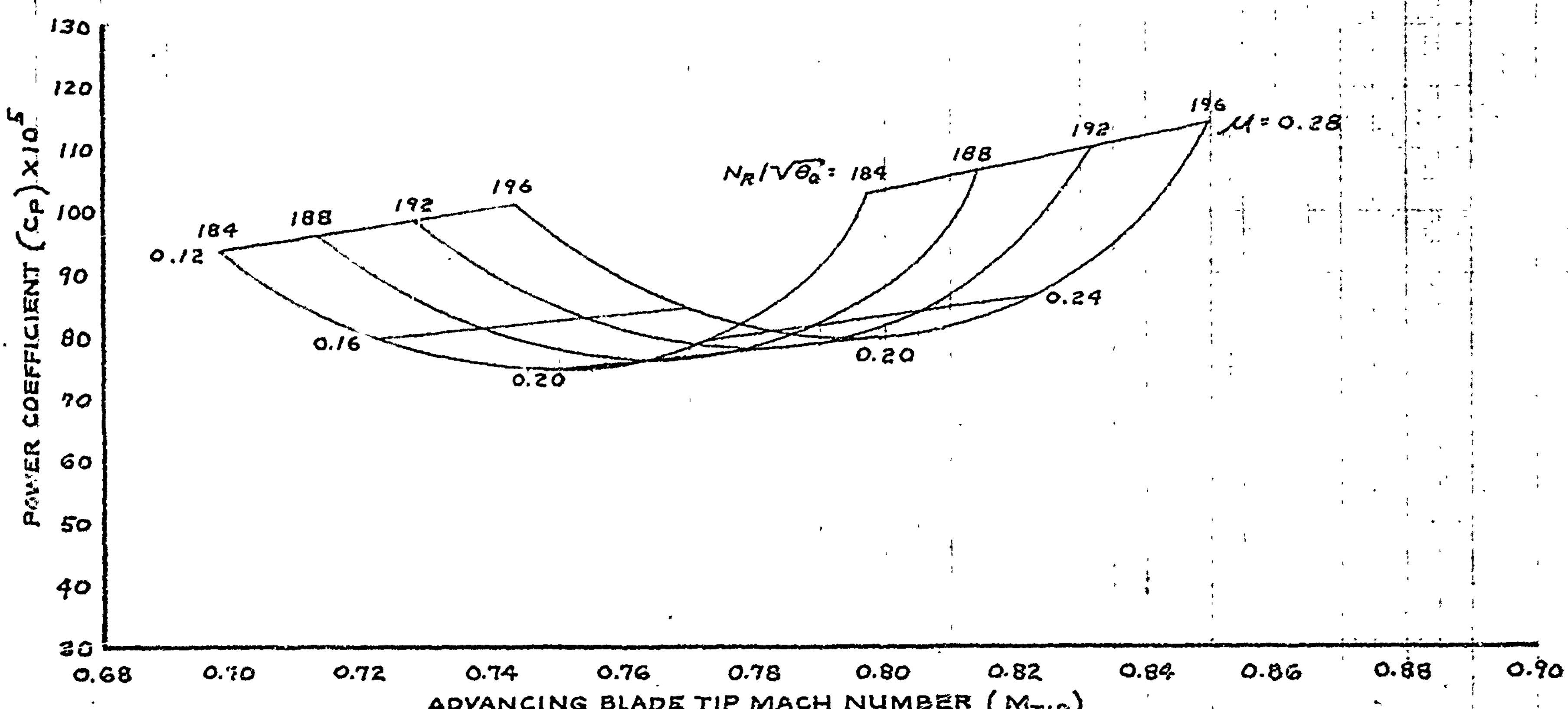


FIGURE 45. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-34L)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES - EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 52 THROUGH 62, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-34L DRONE IN STOWED POSITION.

$\mu = 0.12$

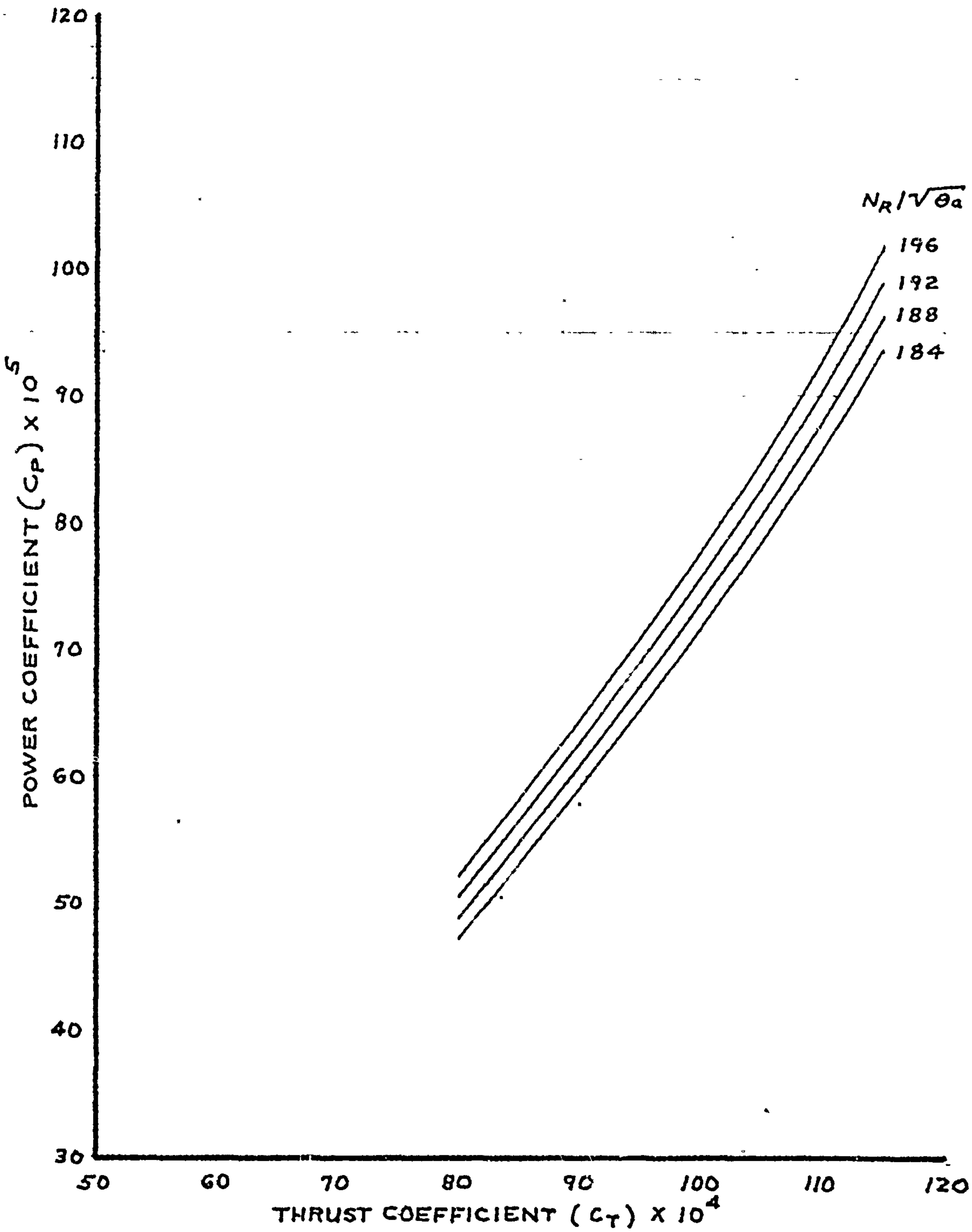


FIGURE 46. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-34L)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES - EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 52 THROUGH 62, APPENDIX I.
2. MARS CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-34L DRONE IN STOWED POSITION.

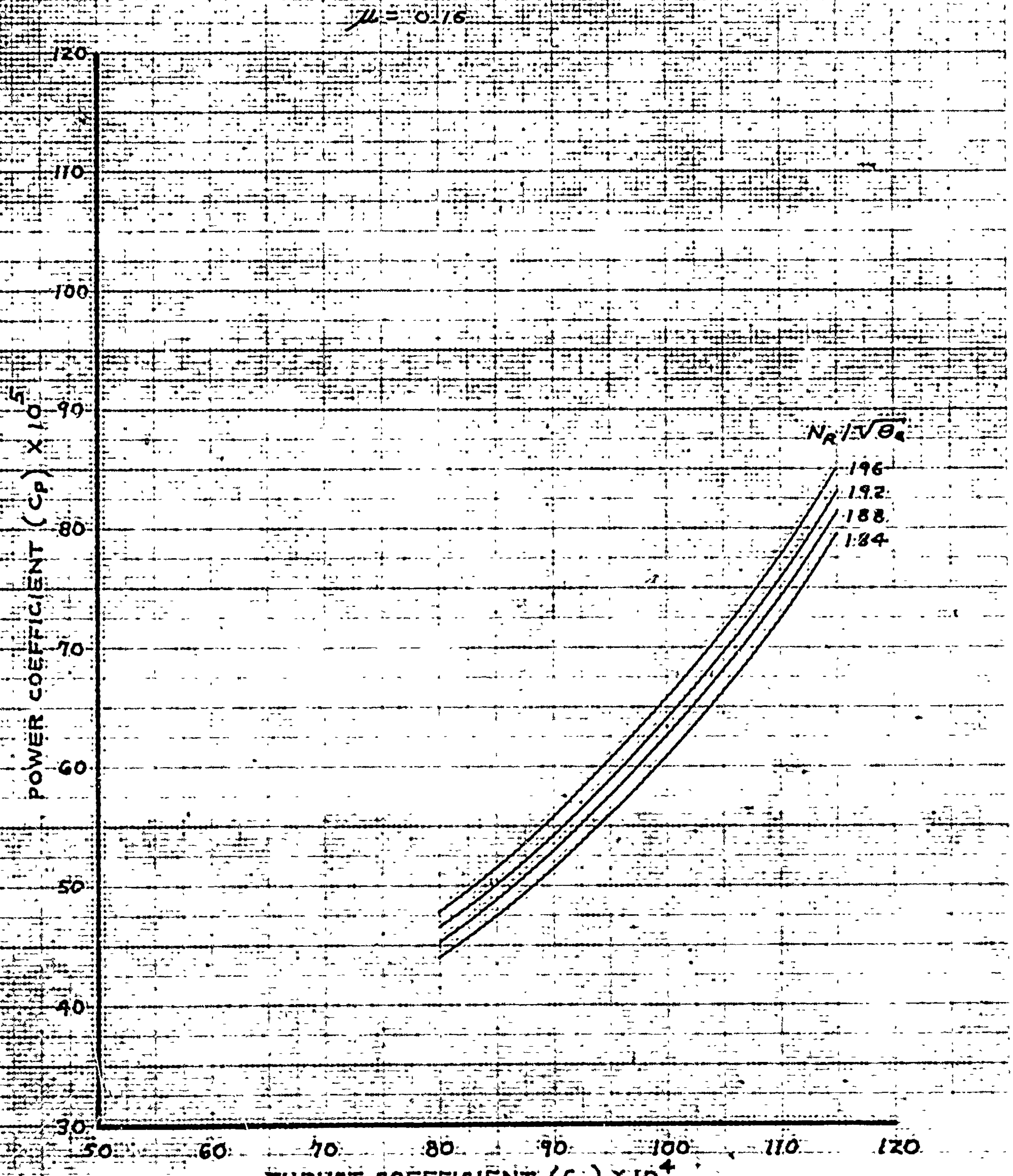


FIGURE 47 LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-34L)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES - EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 52 THROUGH 62, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-34L DRONE IN STOWED POSITION.

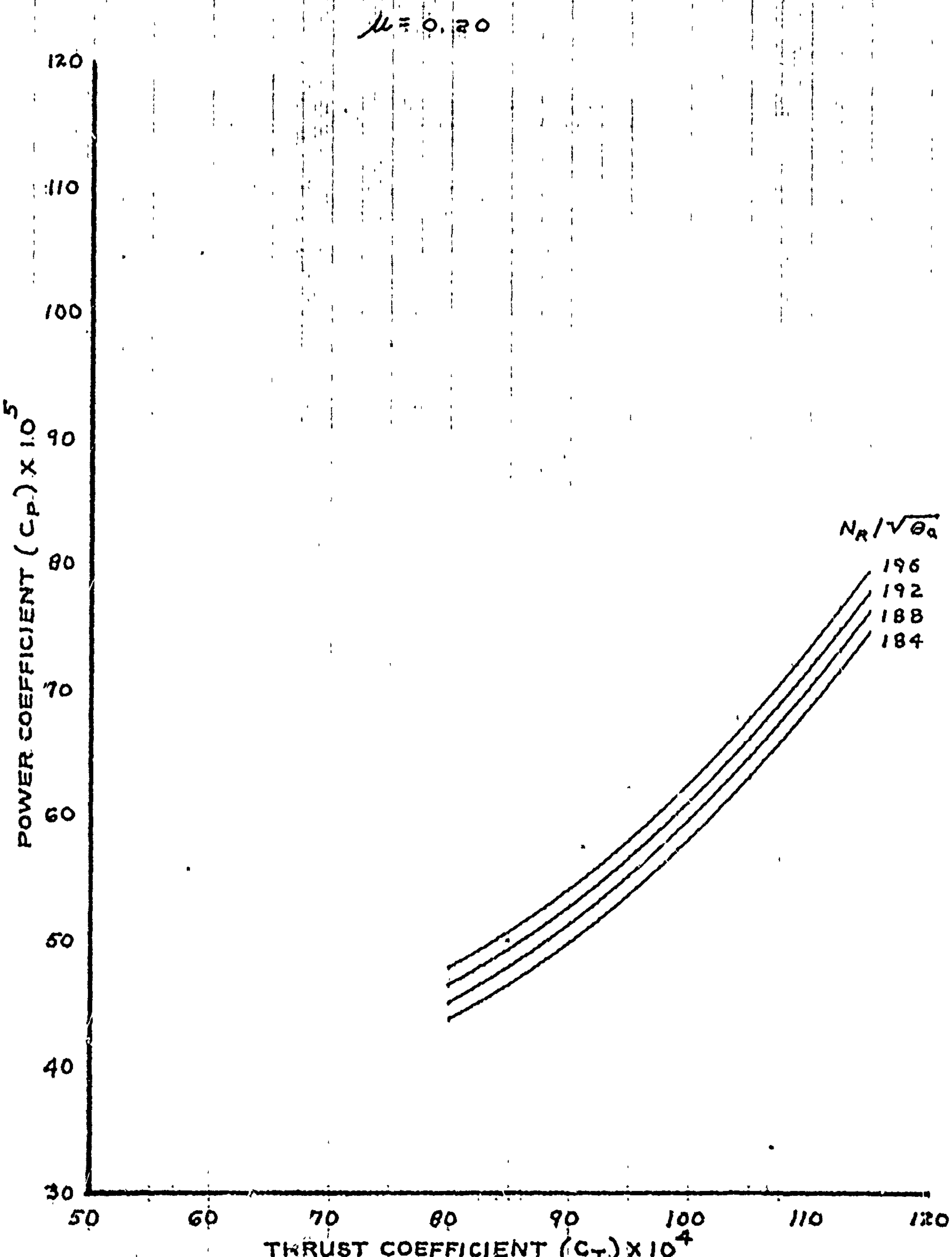


FIGURE 48. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-34L)

HH-53C USAF S/N 67-14993

T64-GE-7 ENGINES - EAPS INSTALLED

MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 52 THROUGH 62, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-34L DRONE IN STOWED POSITION.

$\mu = 0.24$

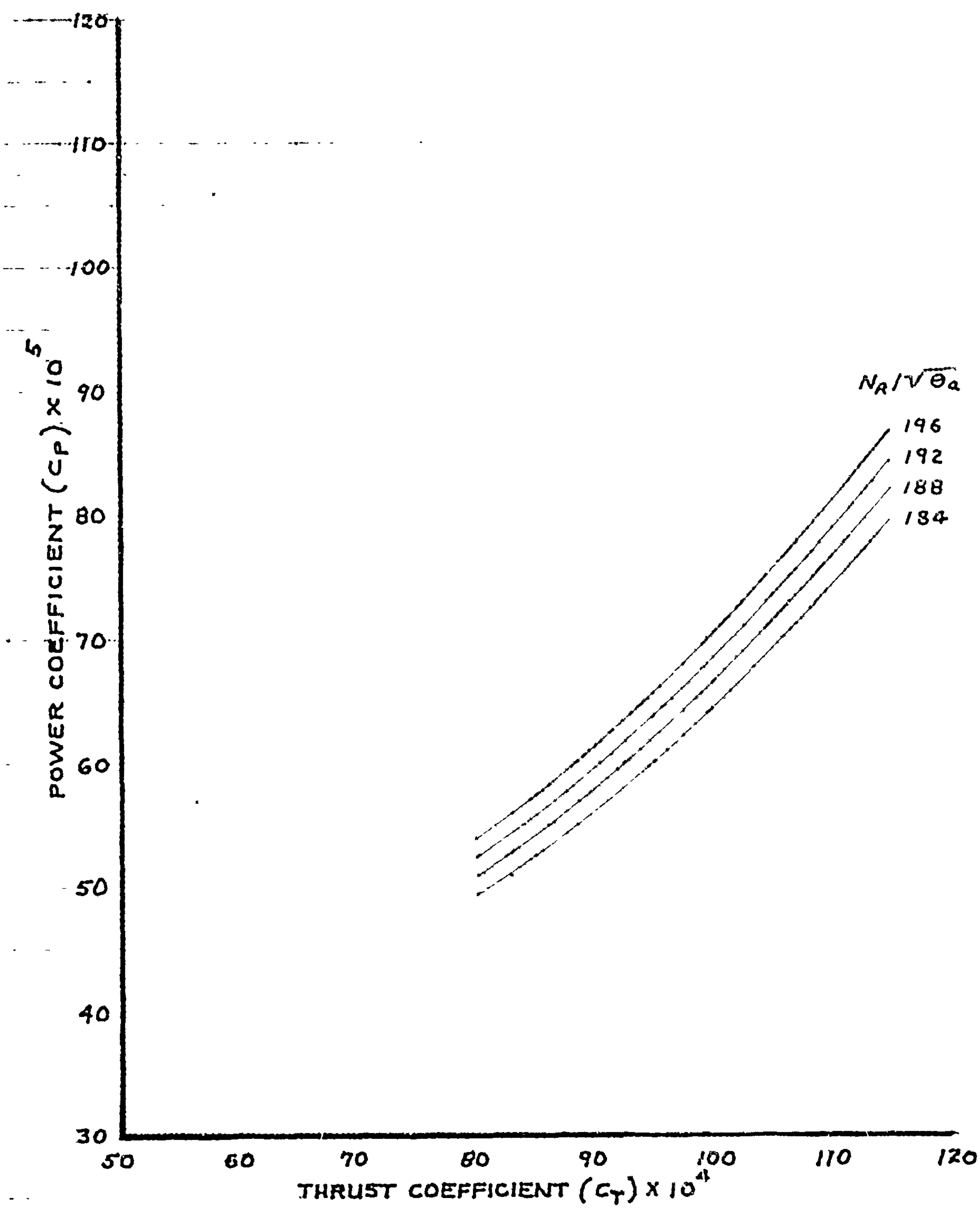


FIGURE 49. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-34L)

HH-53C USAF S/N 67-14993

T64-GE-7 ENGINES - EAPS INSTALLED

MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 52 THROUGH 62, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-34L DRONE IN STOWED POSITION.

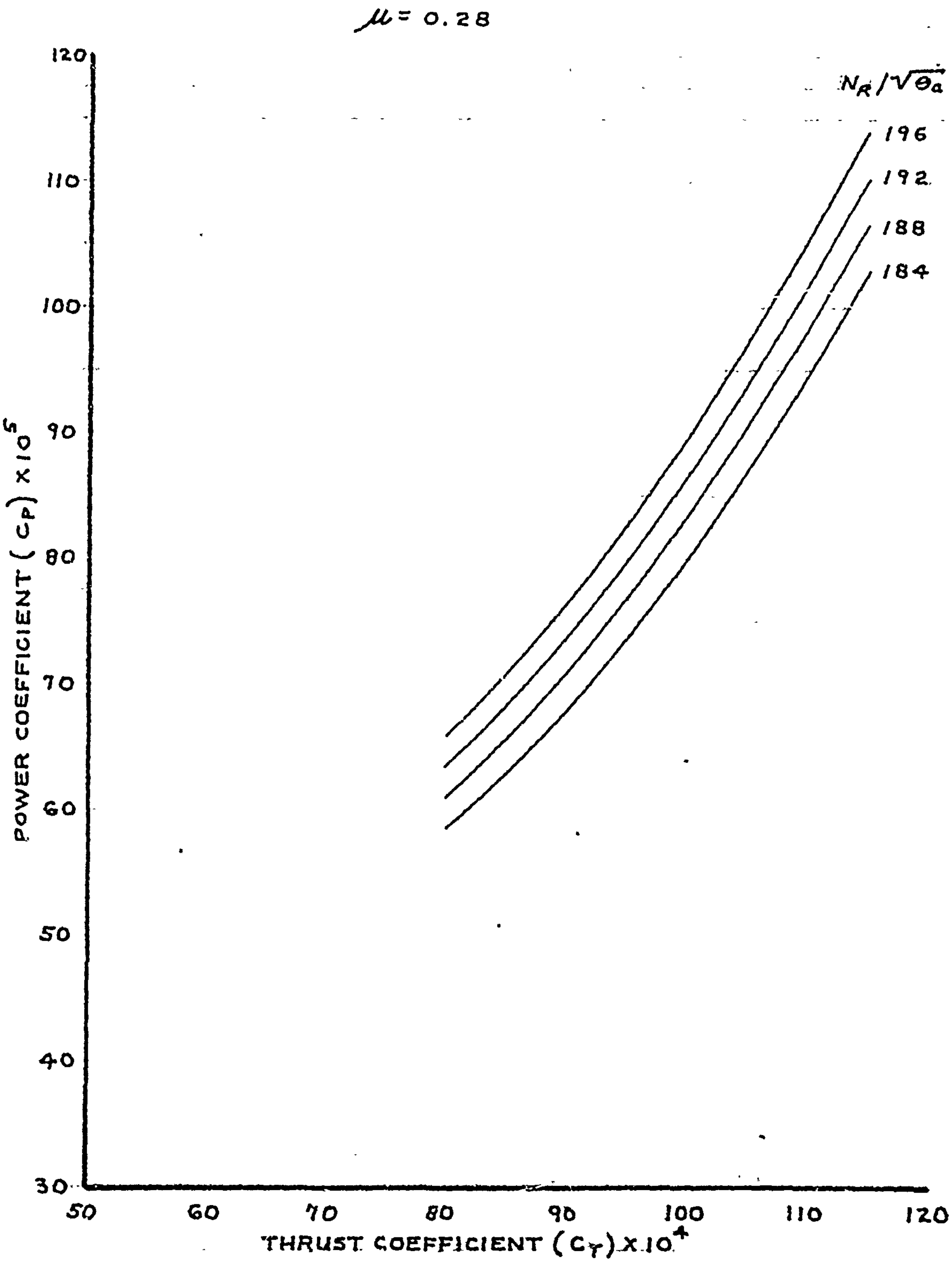


FIGURE 50. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-34L)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES - EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 52 THROUGH 62, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-34L DRONE IN STOWED POSITION.

$\mu = 0.32$

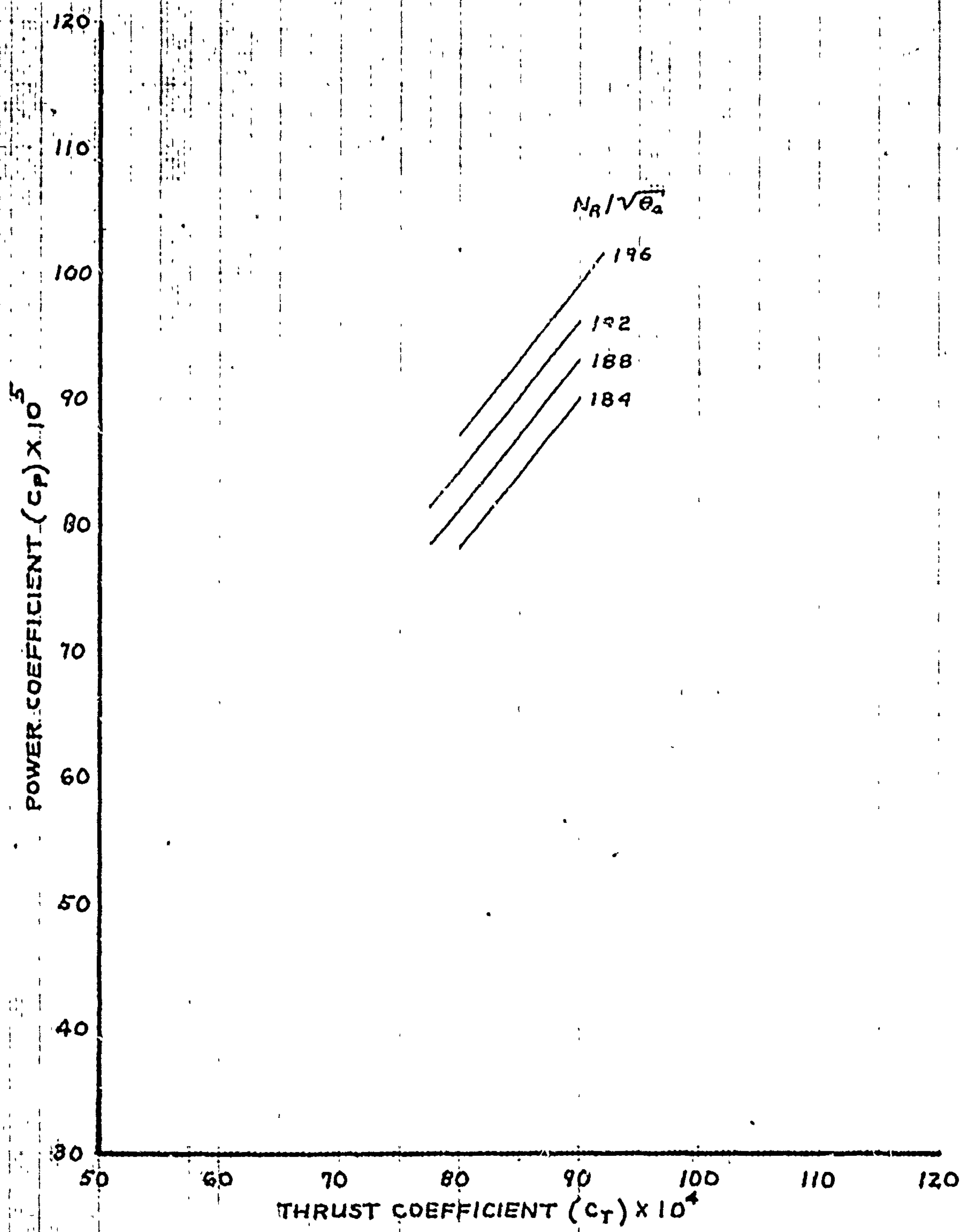


FIGURE 51. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-34L)

HH-53C USAF S/N 6
T64-GE-7 ENGINES ~ EAP
MARS PERFORM

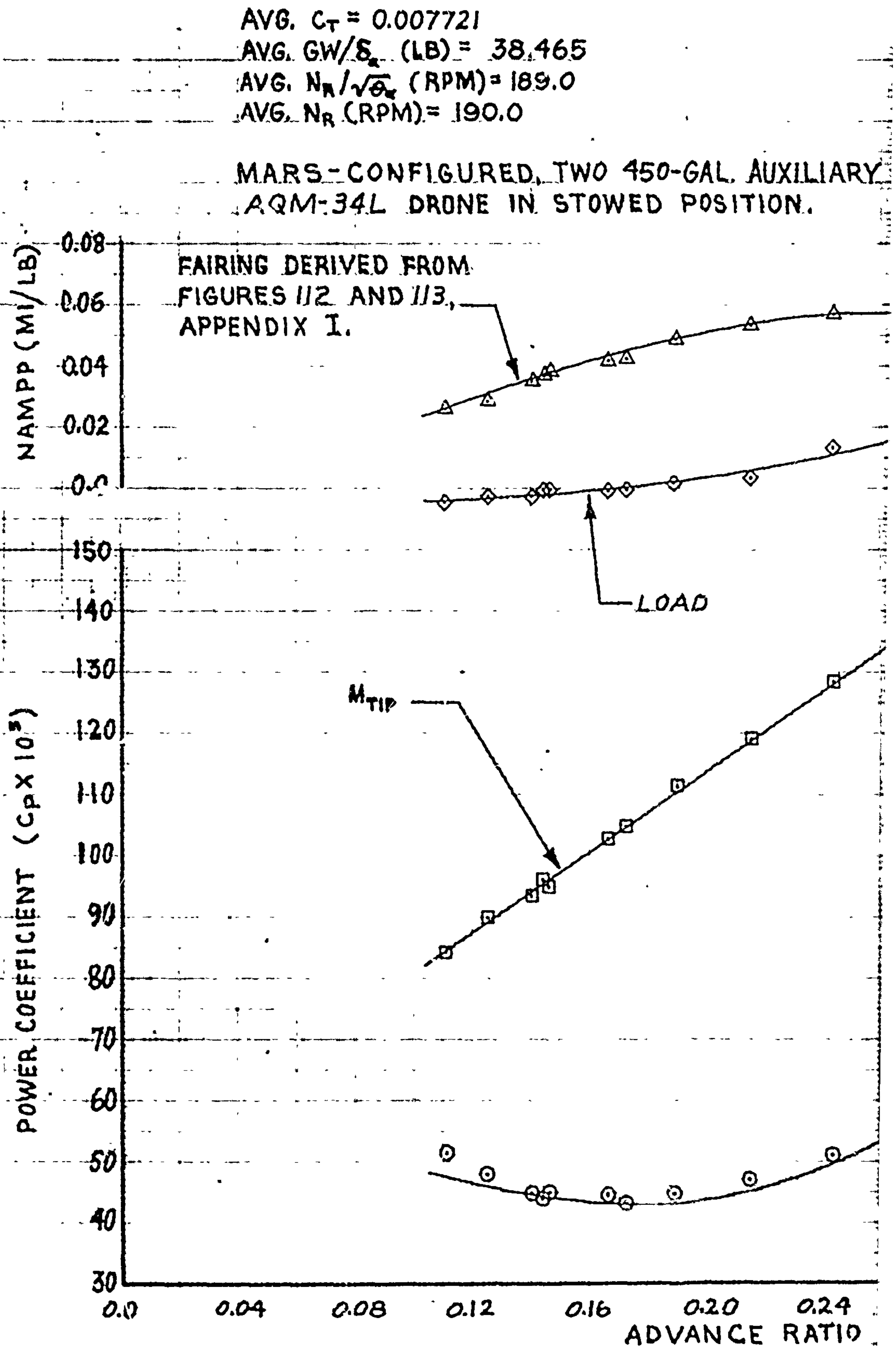
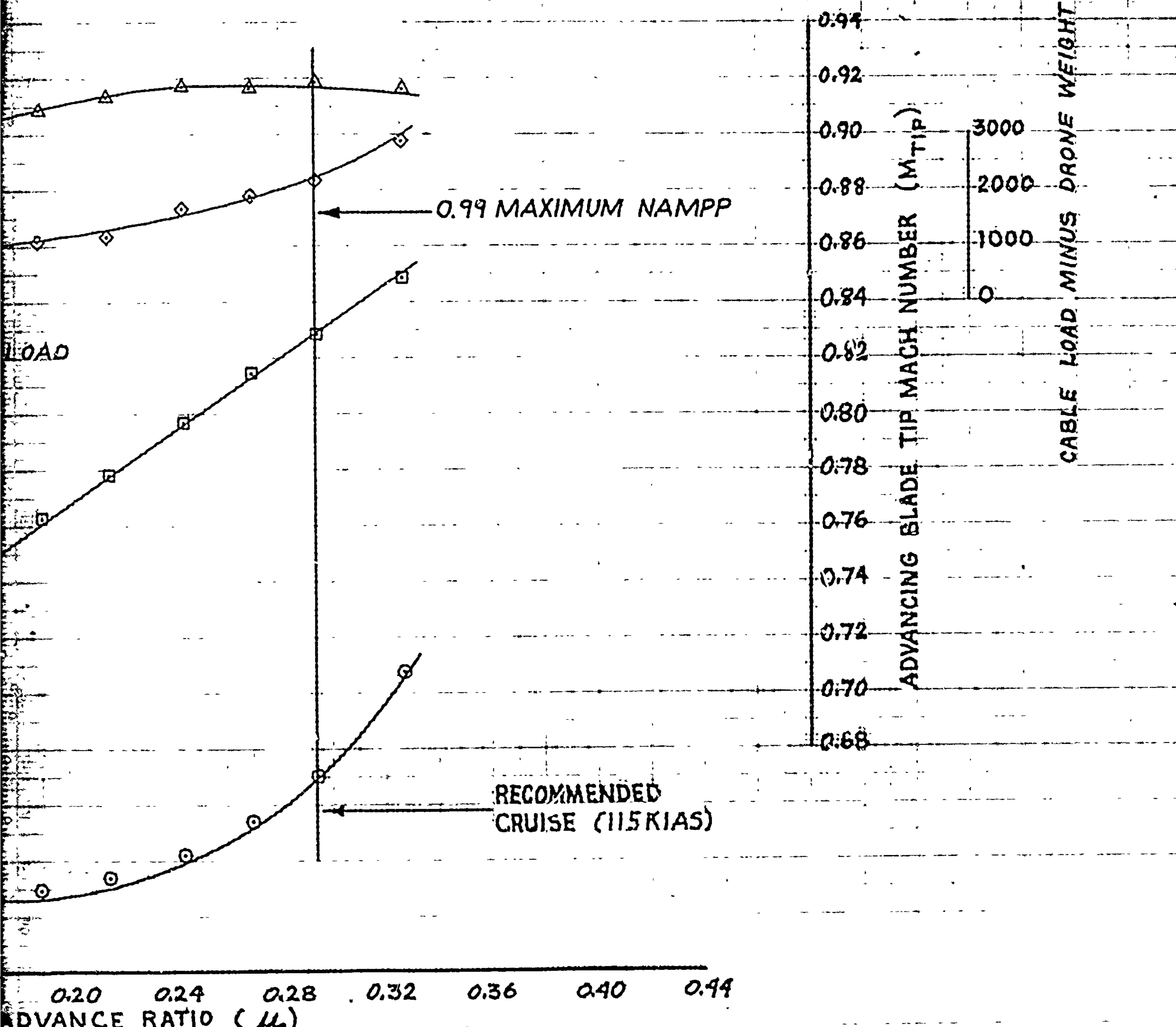


FIGURE 52. NONDIMENSIONAL LEVEL F

H-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 3,685
AVG. FREE AIR TEMP. (DEG. C) = 18.5
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 33,620
AVG. CG LOCATION (STA) = 336.2

50-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
D POSITION.



ENSIONAL LEVEL FLIGHT PERFORMANCE (AQM-34L)

2

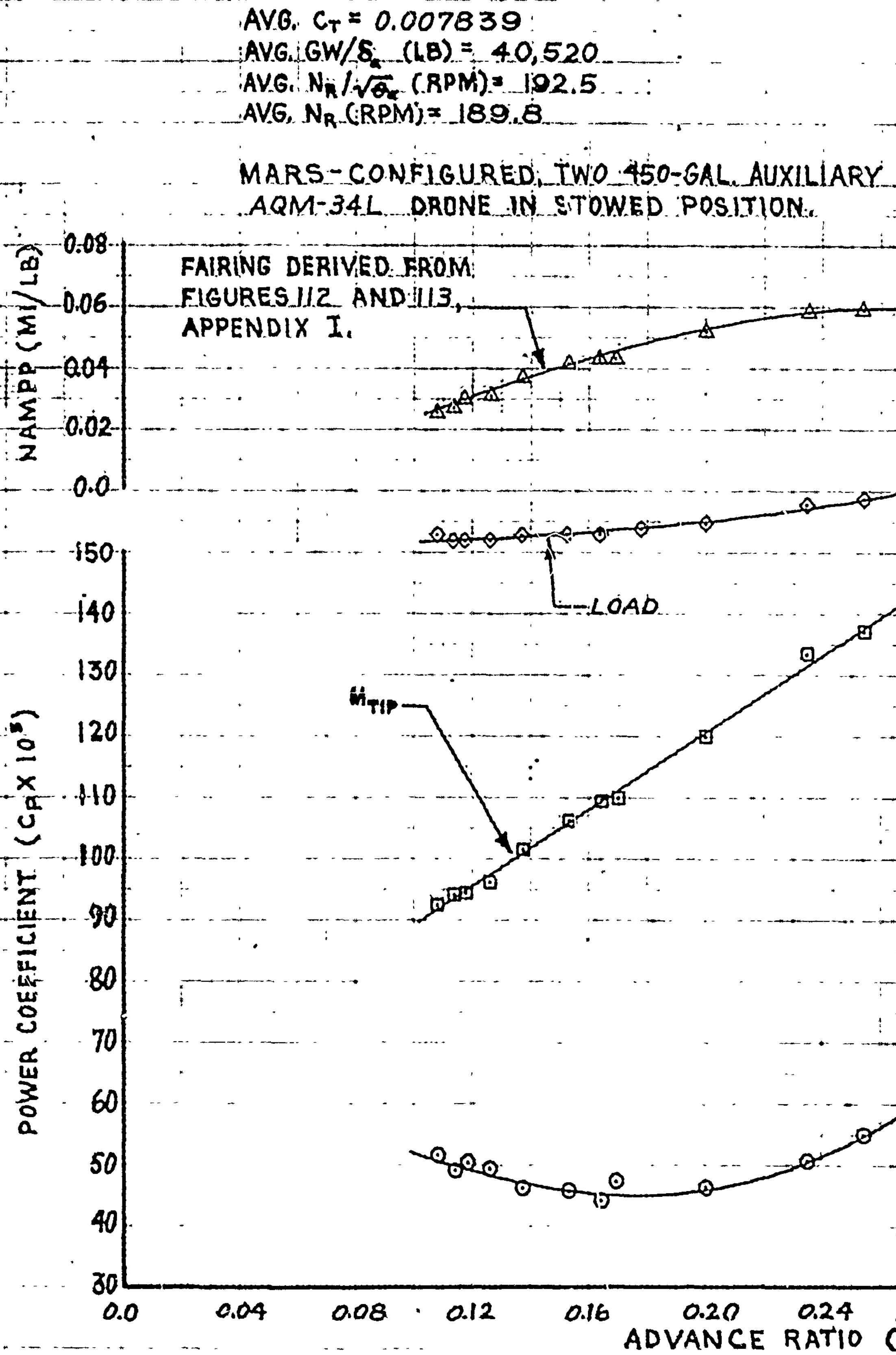
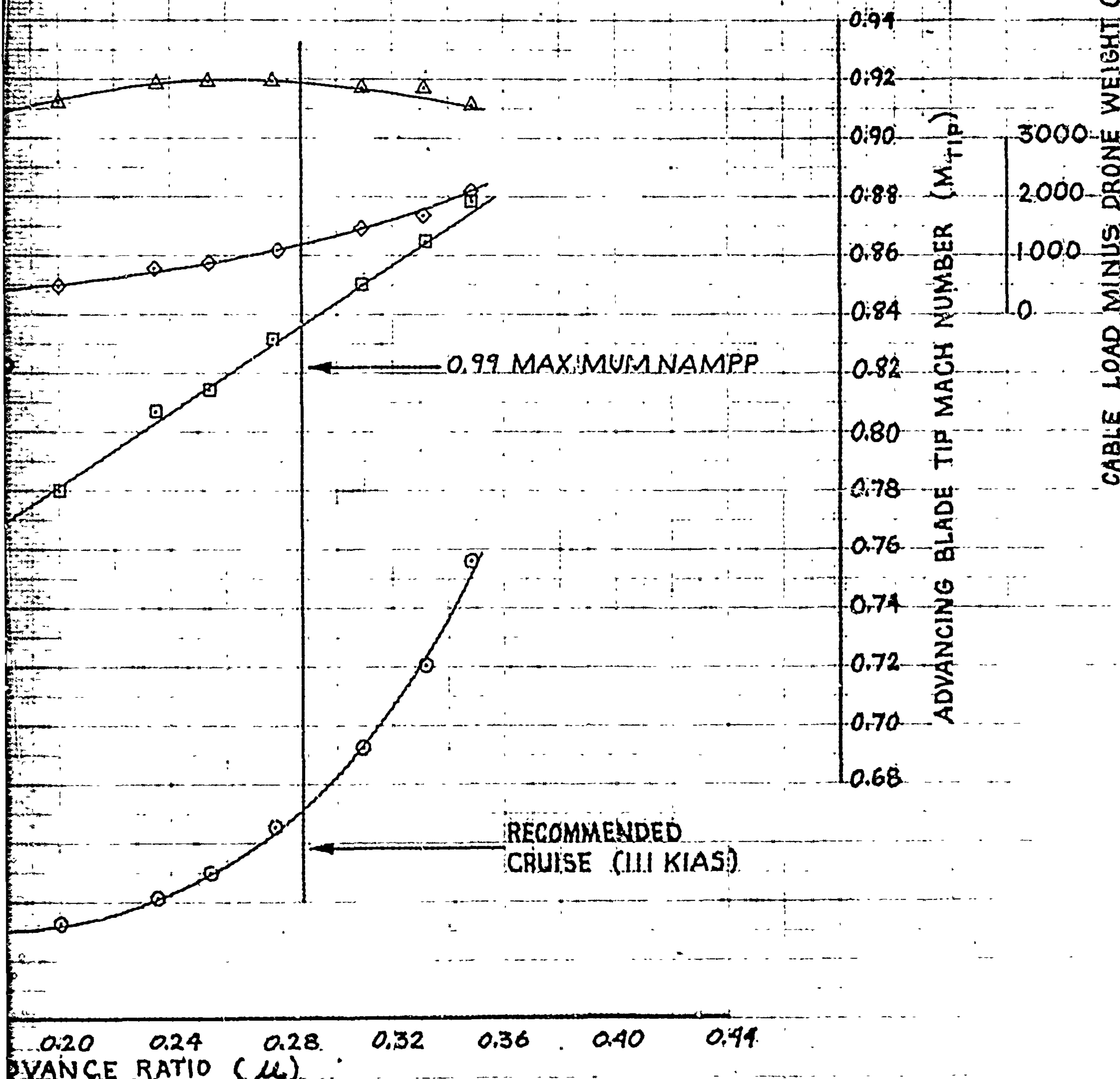


FIGURE 53. NONDIMENSIONAL LEVEL FLI

-53C USAF S/N 67-14993
E-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 4,910
AVG. FREE AIR TEMP. (DEG. C) = 7.0
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 33,830
AVG. CG LOCATION (STA) = 336.2

0-GAL AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
D POSITION.



SIONAL LEVEL FLIGHT PERFORMANCE (AQM-34L)

HH-53C USAF S/N 6
T64-GE-7 ENGINES ~ EAF
MARS PERFORM

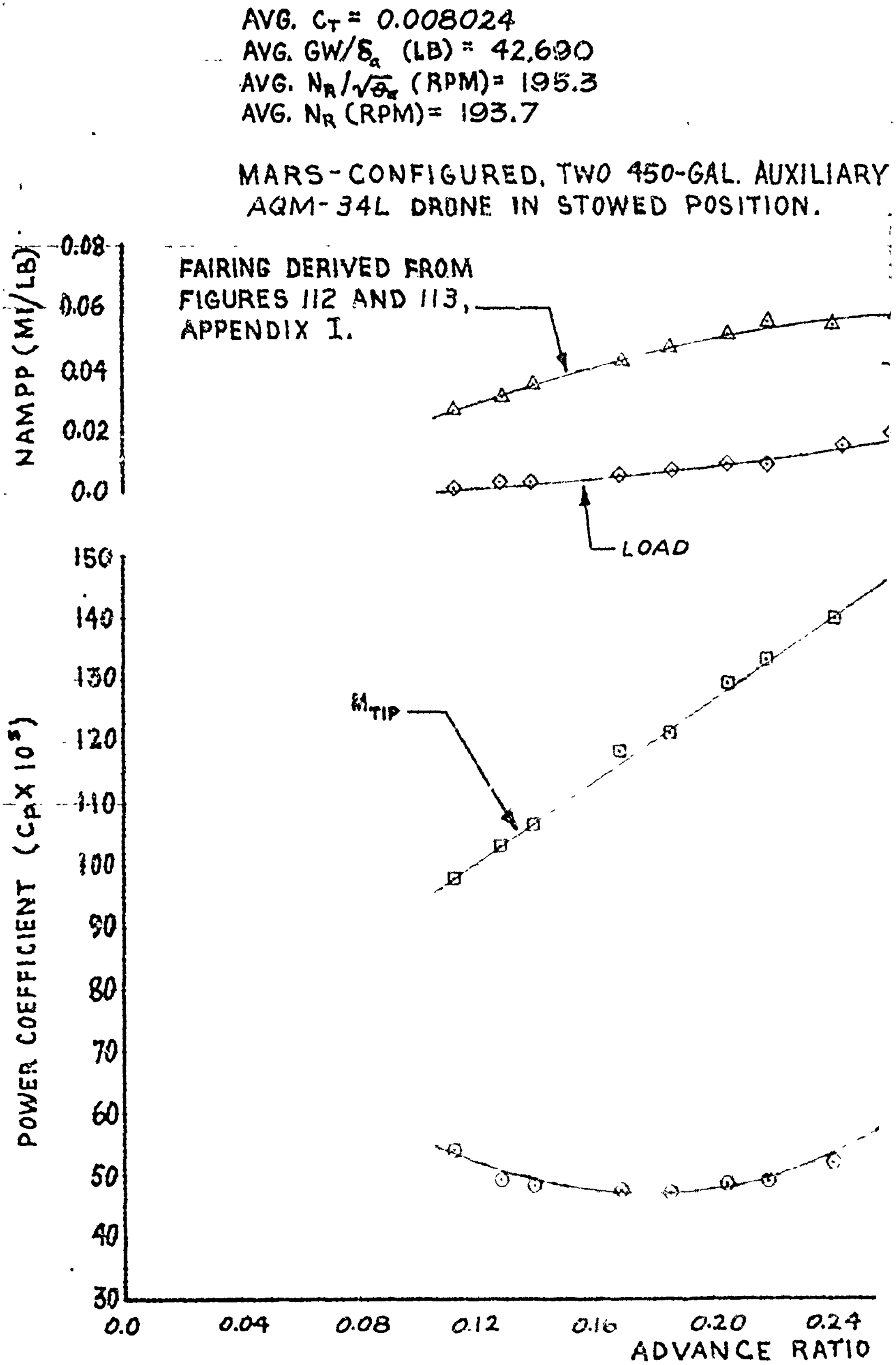
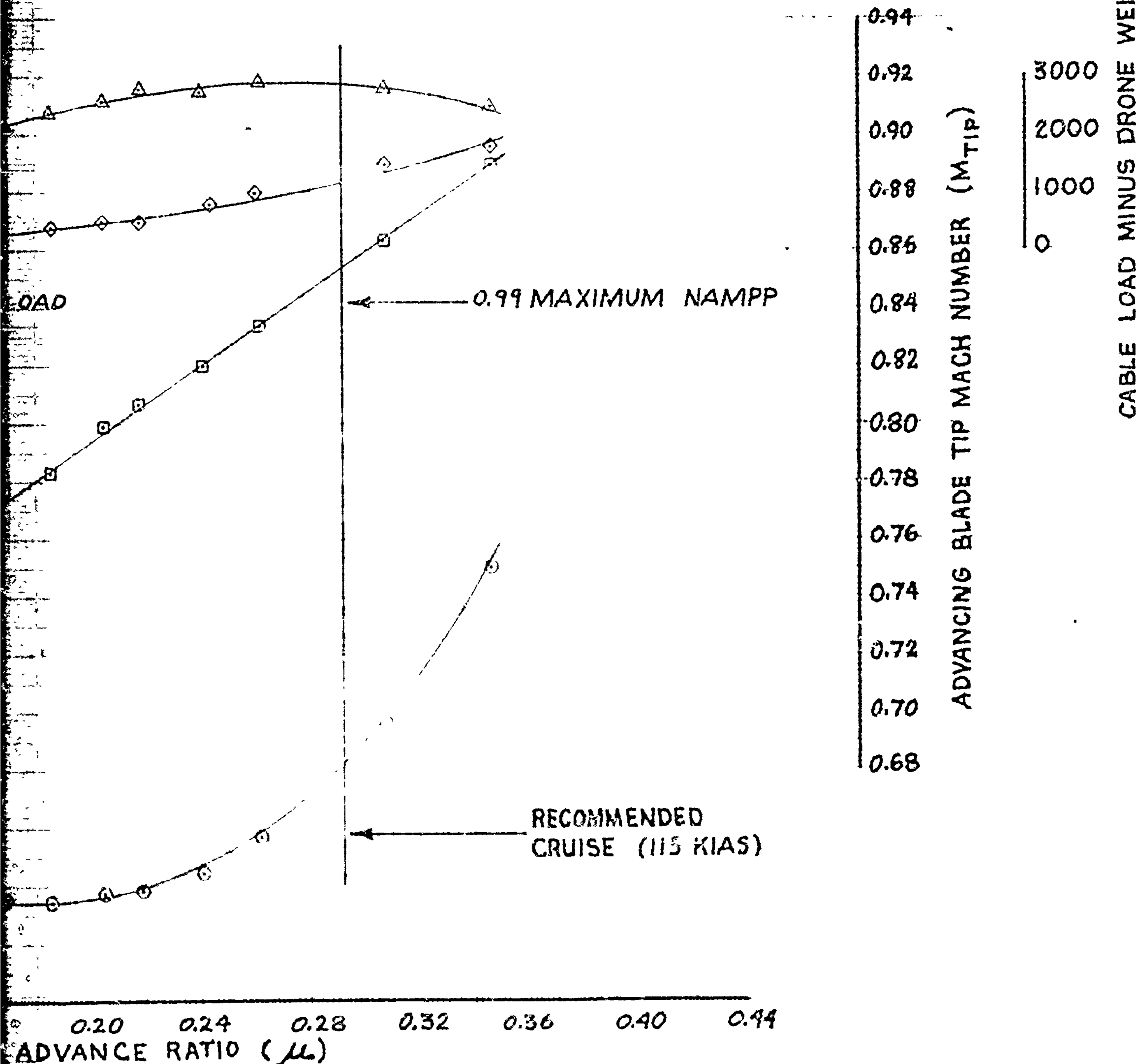


FIGURE 54. NONDIMENSIONAL LEVEL I

HH-53C USAF S/N 67-14993
-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 5,020
AVG. FREE AIR TEMP. (DEG. C) = 10.5
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 35,490
AVG. CG LOCATION (STA) = 336.2

150-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
ED POSITION.



ENSIONAL LEVEL FLIGHT PERFORMANCE (AQM-34L)

HH-53C USAF S/N 6
T64-GE-7 ENGINES ~ EAP
MARS PERFORMA

AVG. C_T = 0.008703
AVG. GW/δ_a (LB) = 41,590
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 185.1
AVG. N_R (RPM) = 185.1

MARS-CONFIGURED, TWO 450-GAL. AUXILIARY
AQM-34L DRONE IN STOWED POSITION.

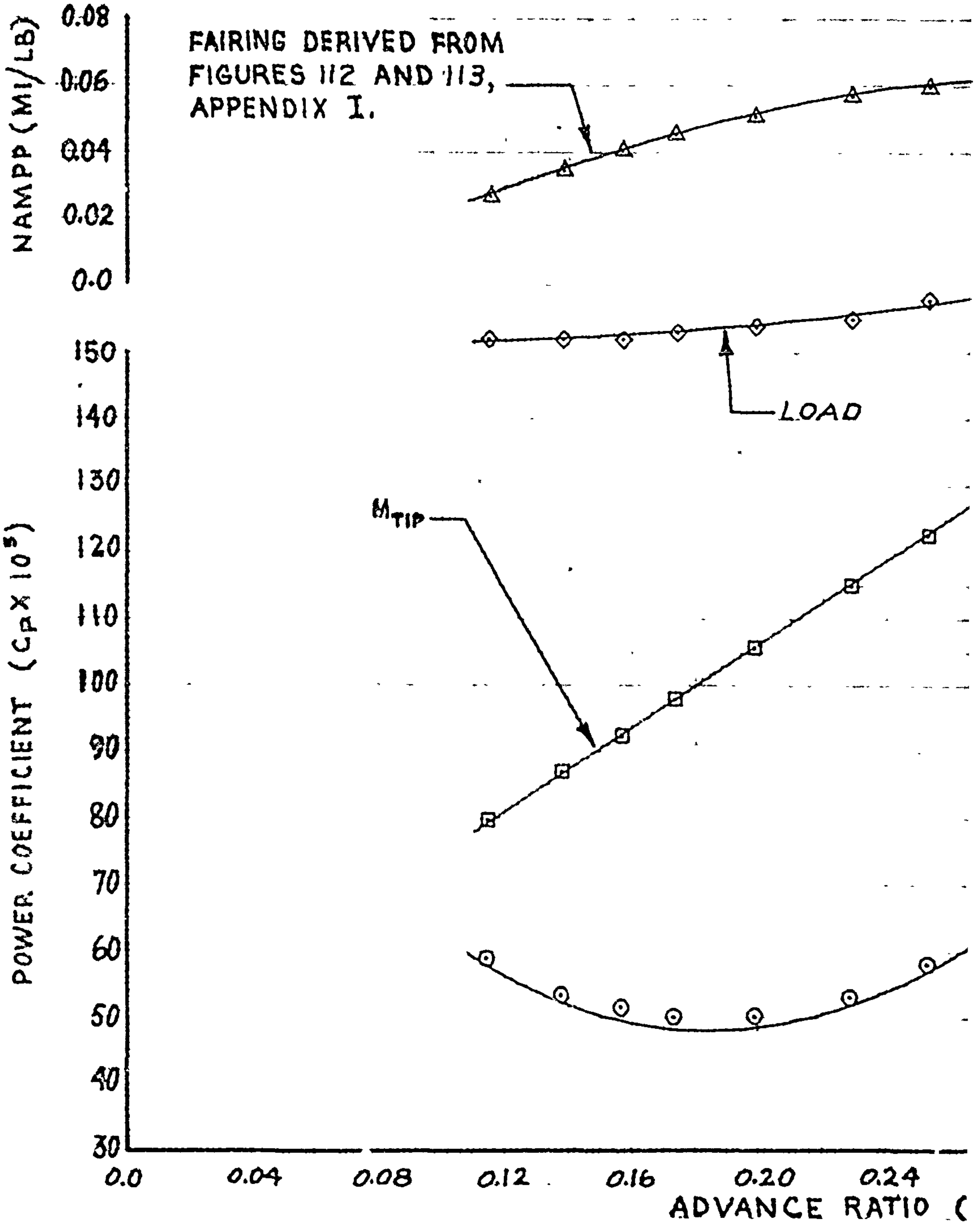
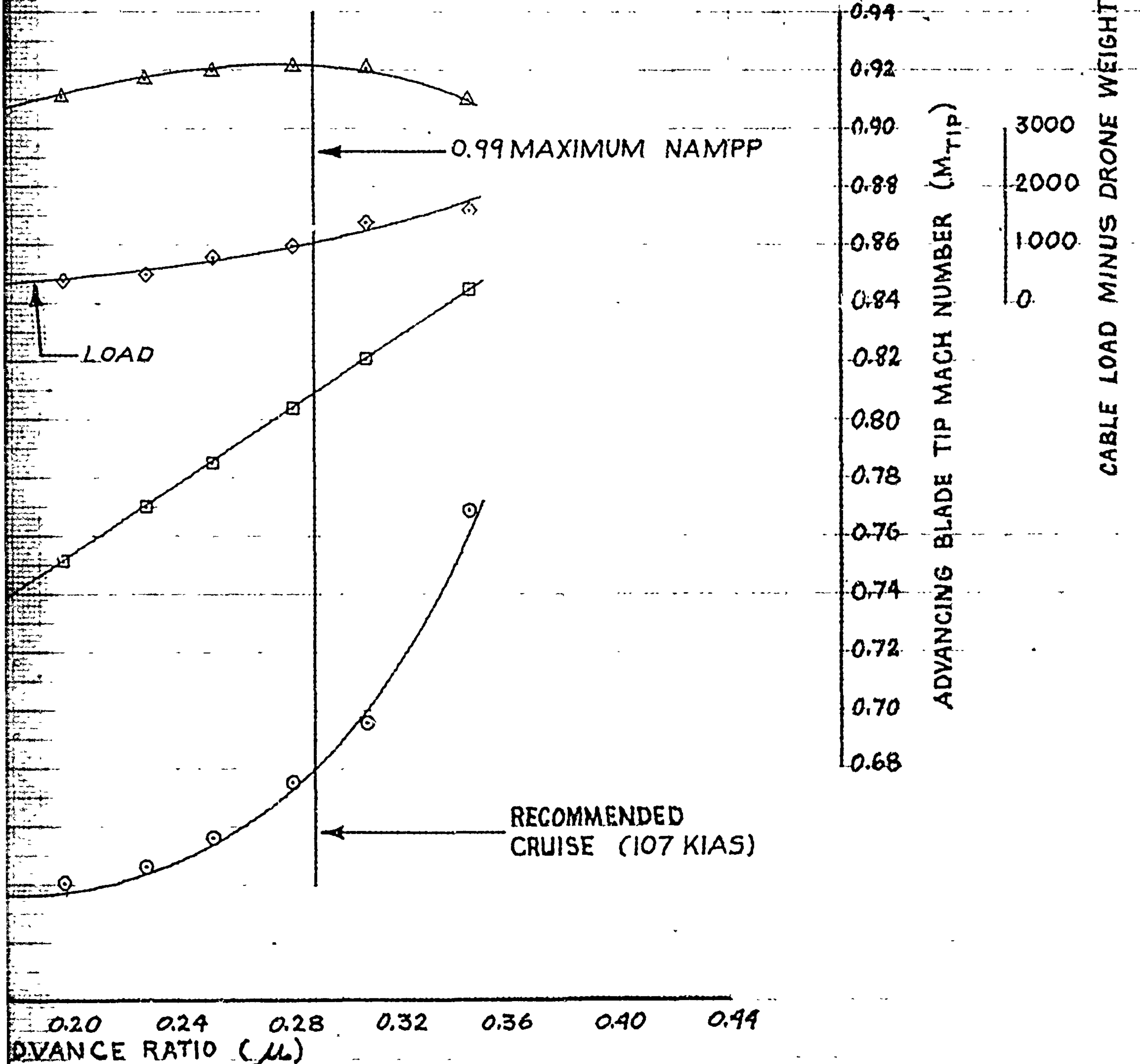


FIGURE 55. NONDIMENSIONAL LEVEL FLI

H-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 5,220
AVG. FREE AIR TEMP. (DEG. C) = 15.0
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 34,320
AVG. CG LOCATION (STA) = 336.3

50-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
D POSITION.



NSIONAL LEVEL FLIGHT PERFORMANCE (AQM-34L)

HH-53C USAF S/N
T64-GE-7 ENGINES ~ EA
MARS PERFORM

AVG. C_T = 0.008890
AVG. GW/δ_a (LB) = 43,920
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 188.2
AVG. N_R (RPM) = 186.6

MARS-CONFIGURED, TWO 450-GAL. AUXILIARY
AQM-34L DRONE IN STOWED POSITION.

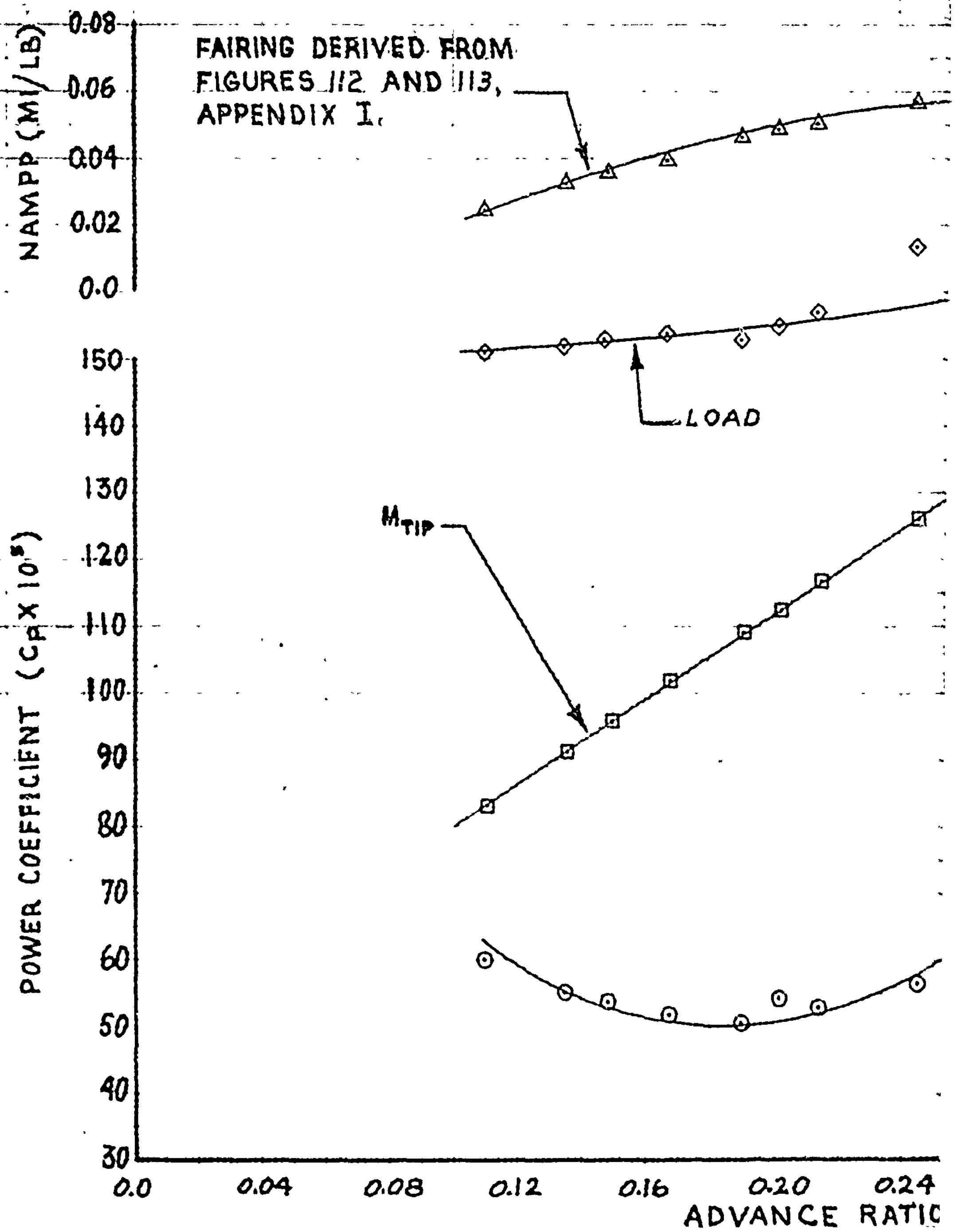
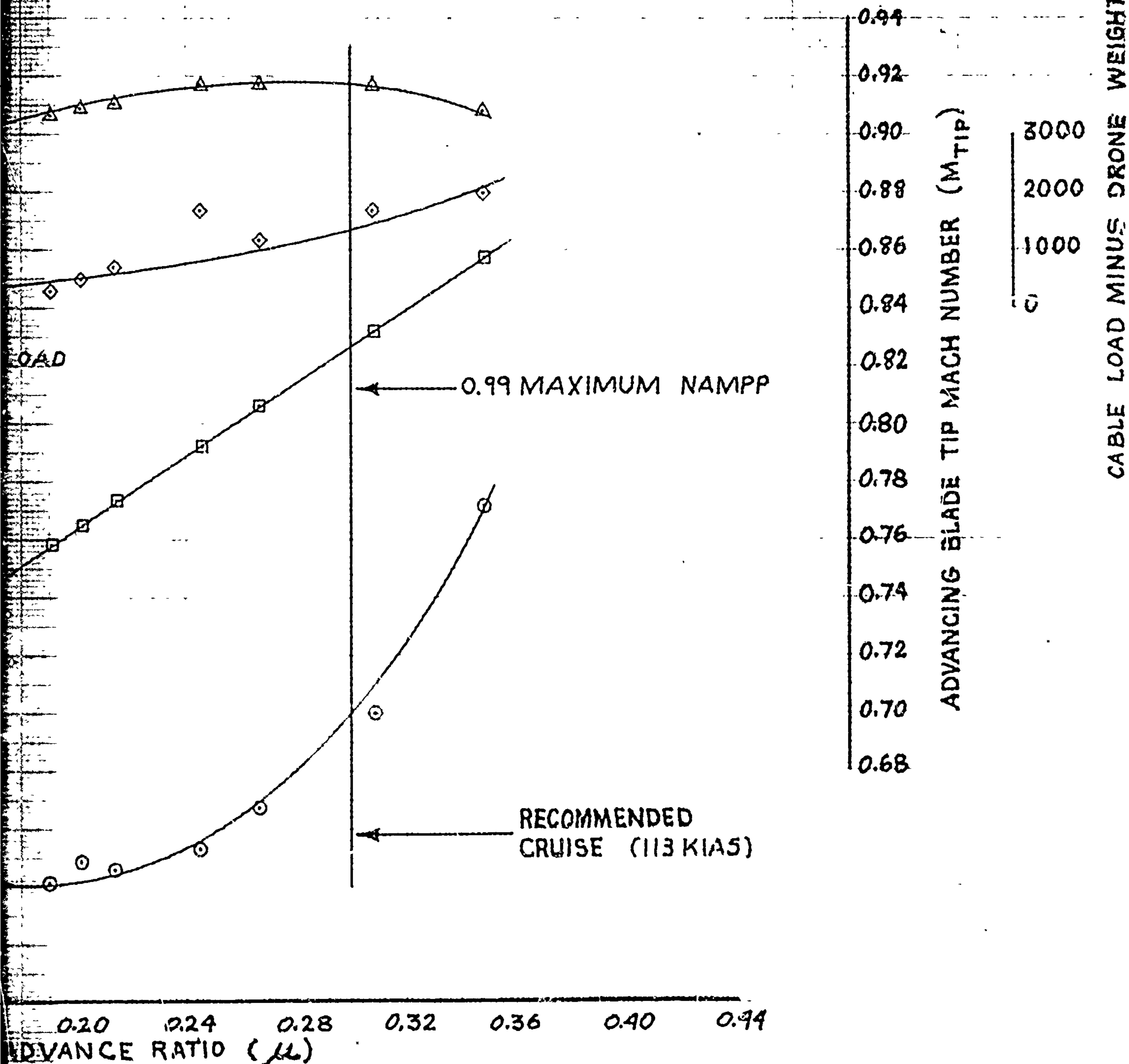


FIGURE 56. NONDIMENSIONAL LEVEL

HH-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 4,920
AVG. FREE AIR TEMP. (DEG. C) = 10.0
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 36,650
AVG. CG LOCATION (STA) = 335.6

50-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
D POSITION.



ENSIONAL LEVEL FLIGHT PERFORMANCE (AQM-34L)

HH-53C USAF S/N 67-
T64-GE-7 ENGINES ~ EAPS
MARS PERFORMAN

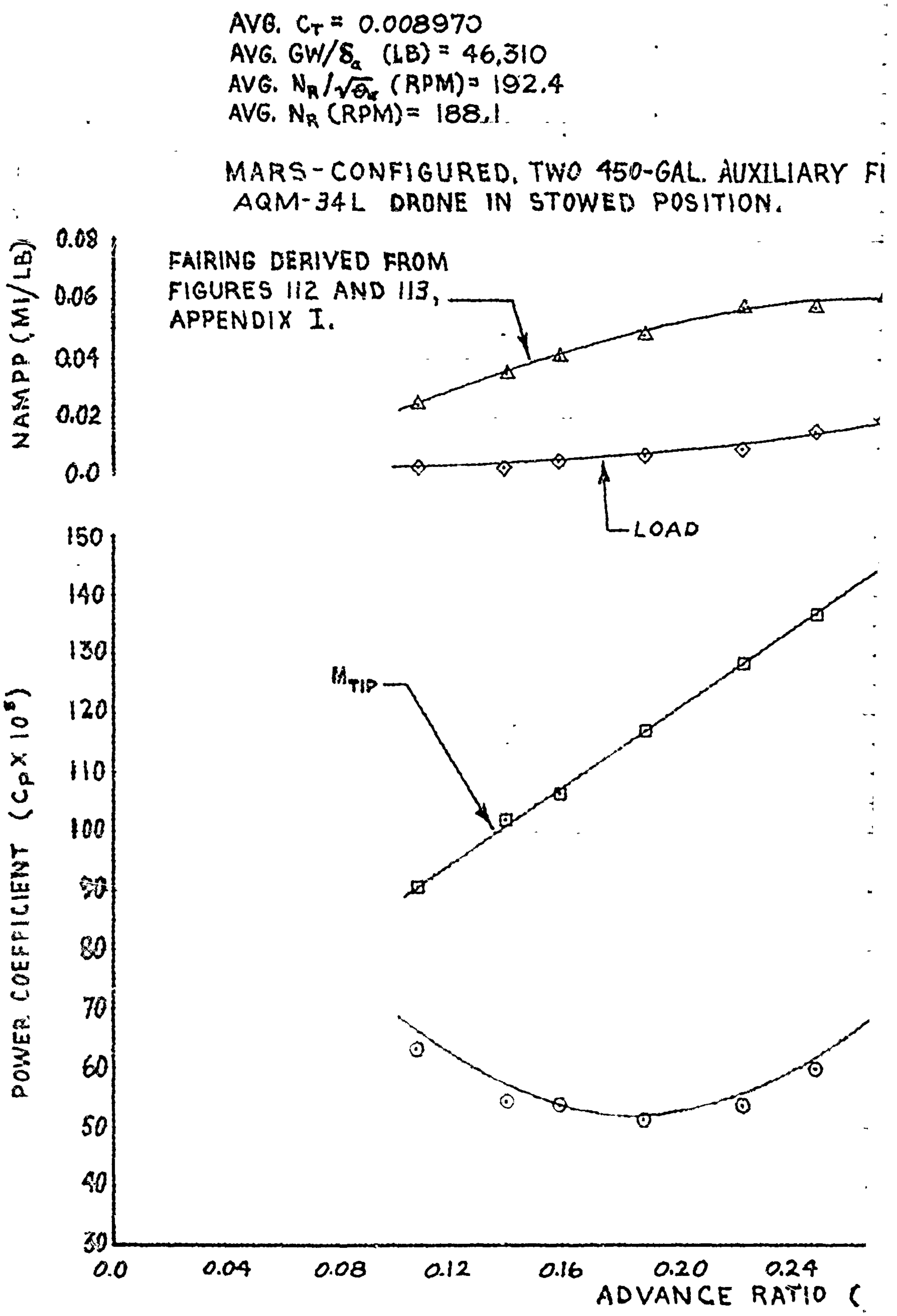
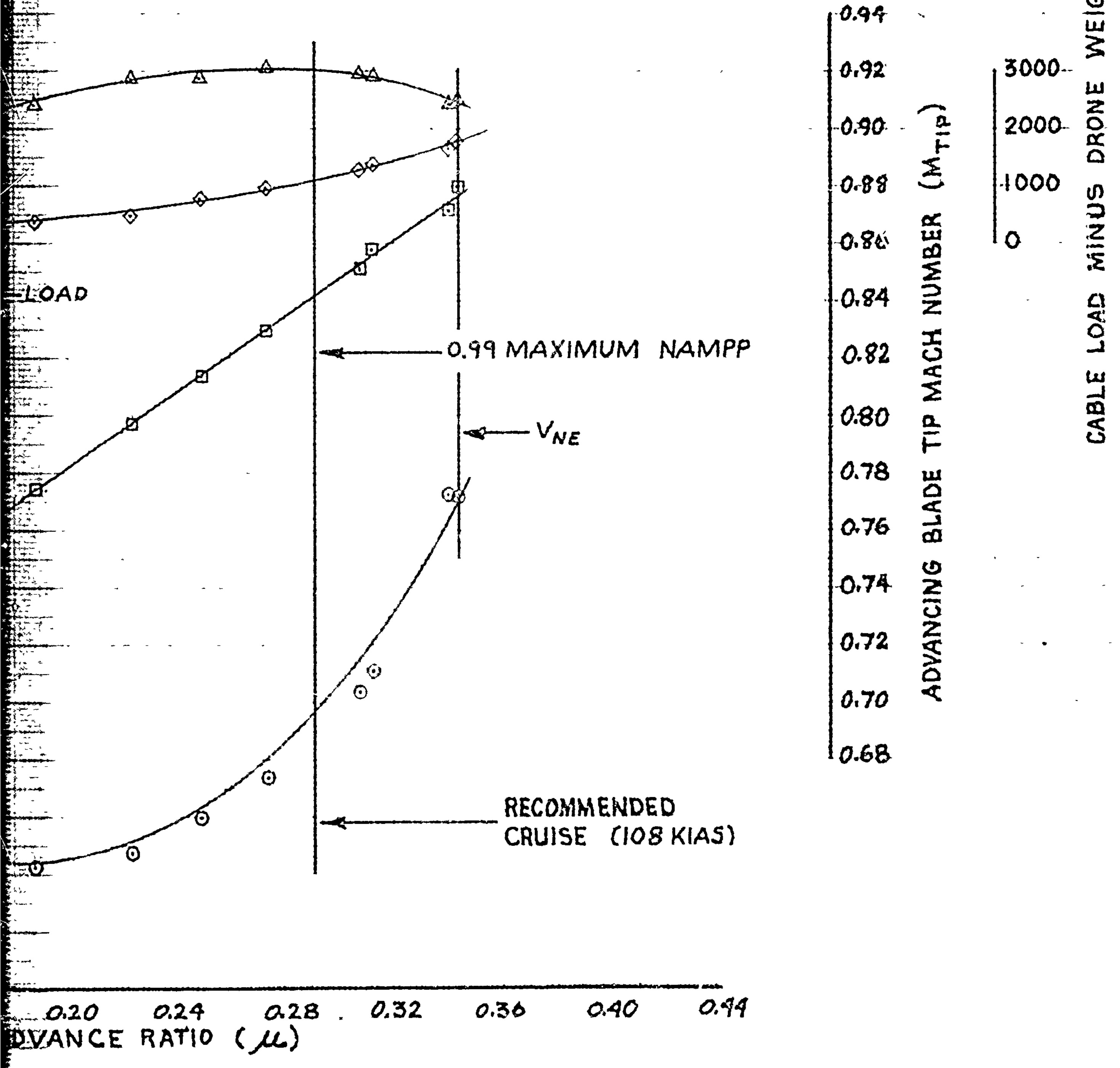


FIGURE 57. NONDIMENSIONAL LEVEL FLI

H-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
EMARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 6,930
AVG. FREE AIR TEMP. (DEG. C) = 2.0
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 35,830
AVG. CG LOCATION (STA) = 336.2

50-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
D POSITION.



NSIONAL LEVEL FLIGHT PERFORMANCE (AQM-34L)

HH-53C USAF S/N. 6
T64 GE-7 ENGINES ~ EA
MARS PERFORM

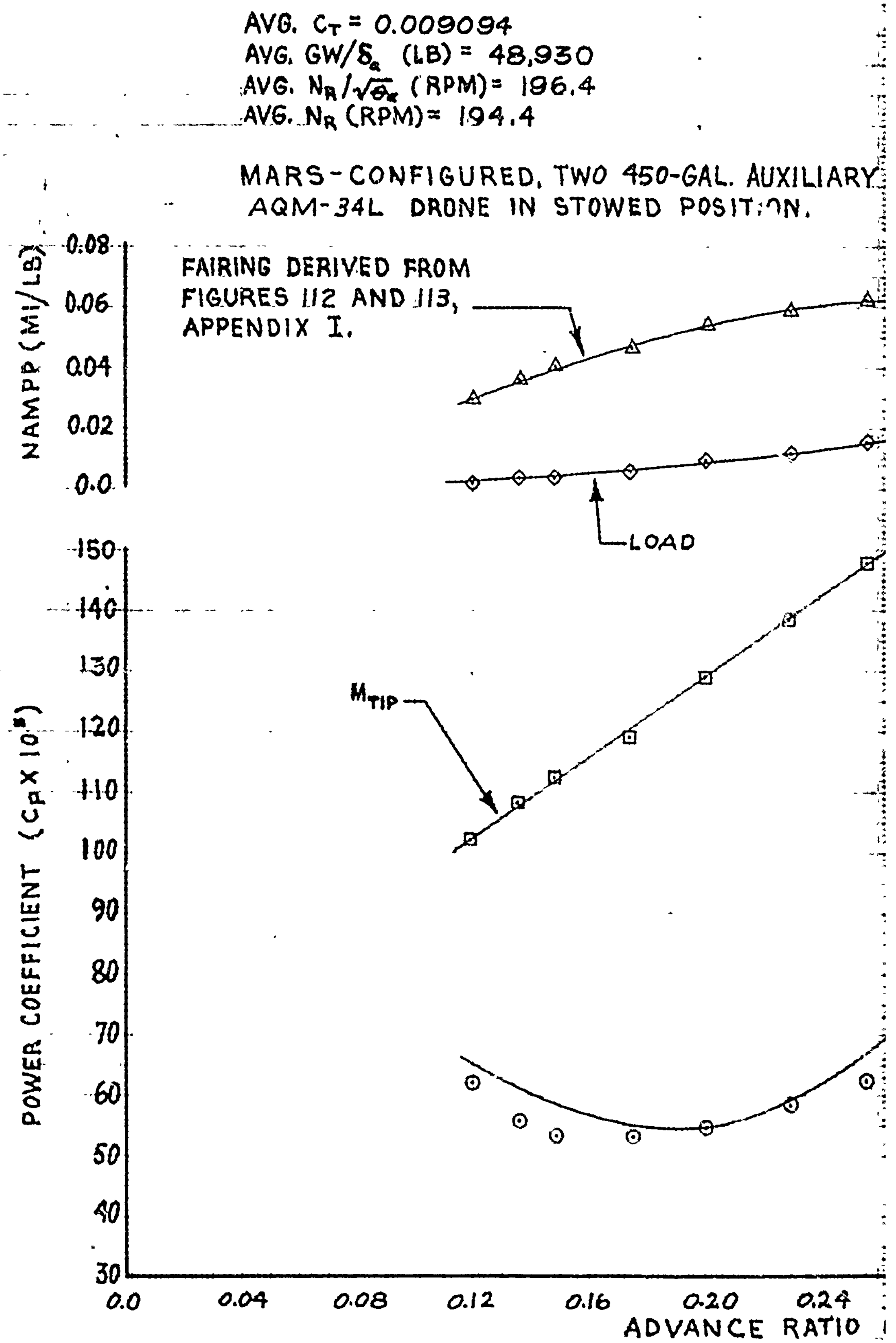
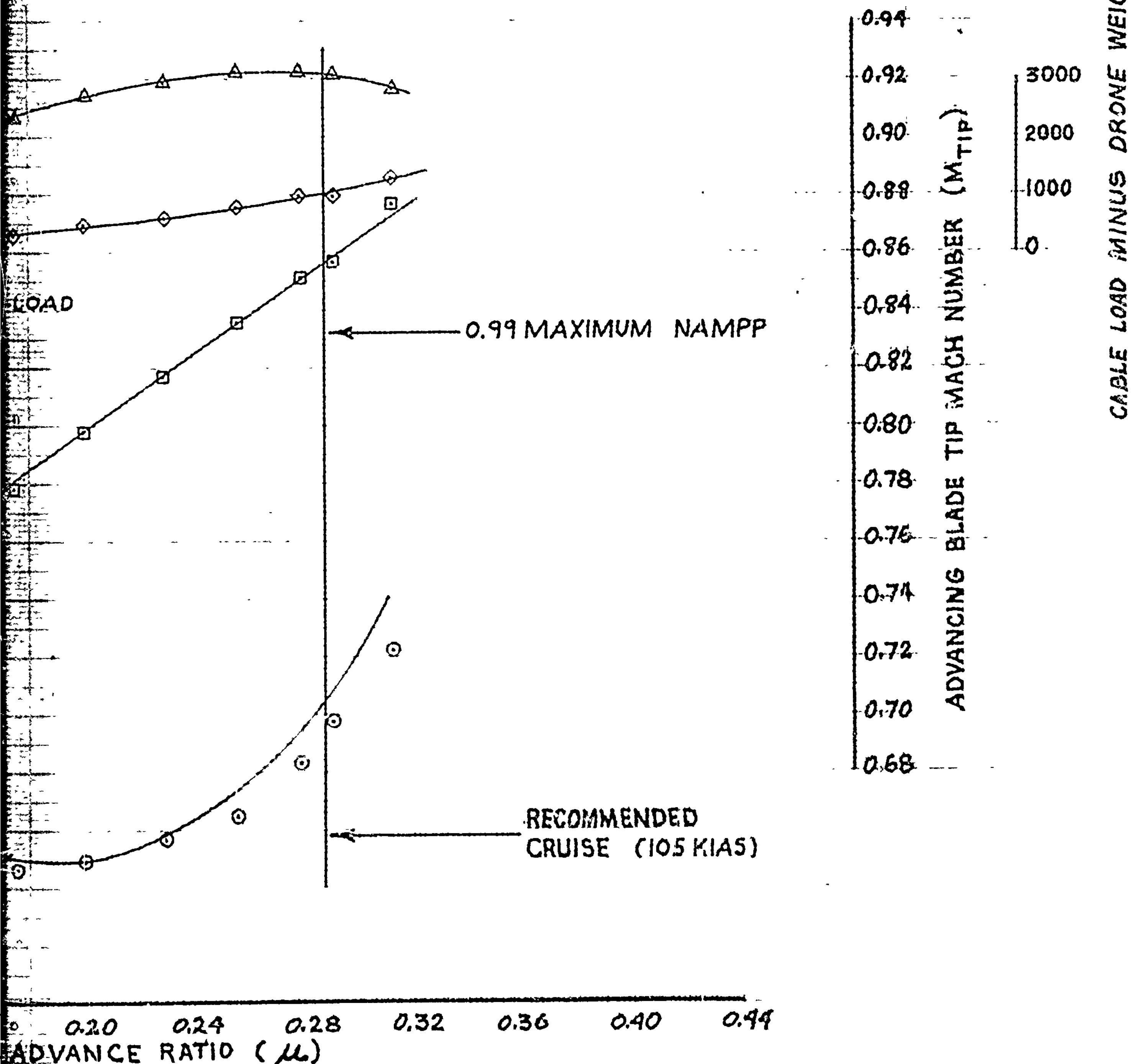


FIGURE 58. NONDIMENSIONAL LEVEL FL

HH-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 8,860
AVG. FREE AIR TEMP. (DEG. C) = 9.0
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 35,160
AVG. CG LOCATION (STA) = 336.2

450-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
ED POSITION.



ENSIONAL LEVEL FLIGHT PERFORMANCE (AQM-34L)

HH-53C USAF S/N 67
T64-GE-7 ENGINES ~ EAPS
MARS PERFORMA

AVG. C_T = 0.01079
AVG. GW/δ_a (LB) = 52,080
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 186.0
AVG. N_R (RPM) = 183.5

MARS-CONFIGURED, TWO 450-GAL. AUXILIARY
AQM-34L DRONE IN STOWED POSITION.

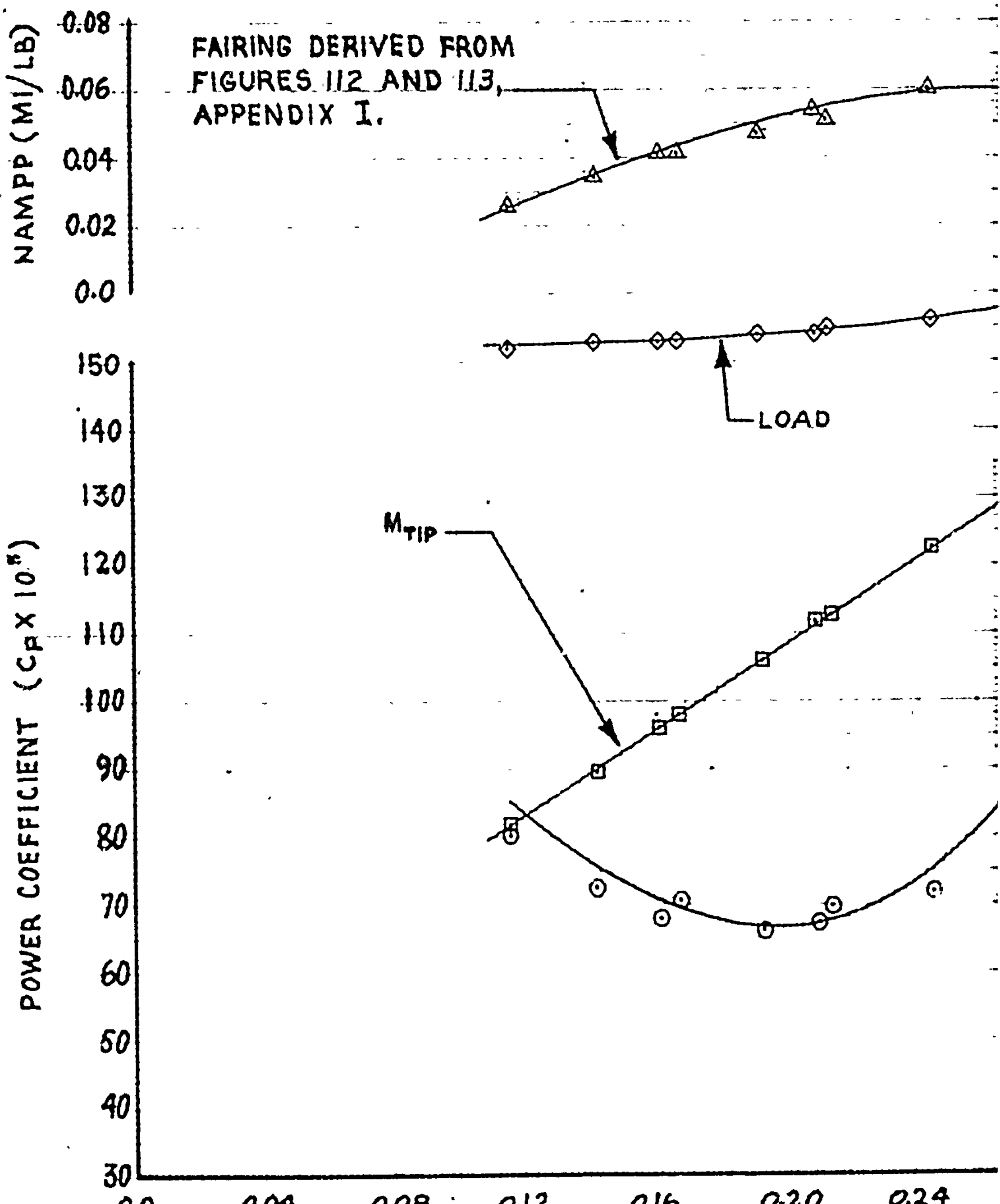
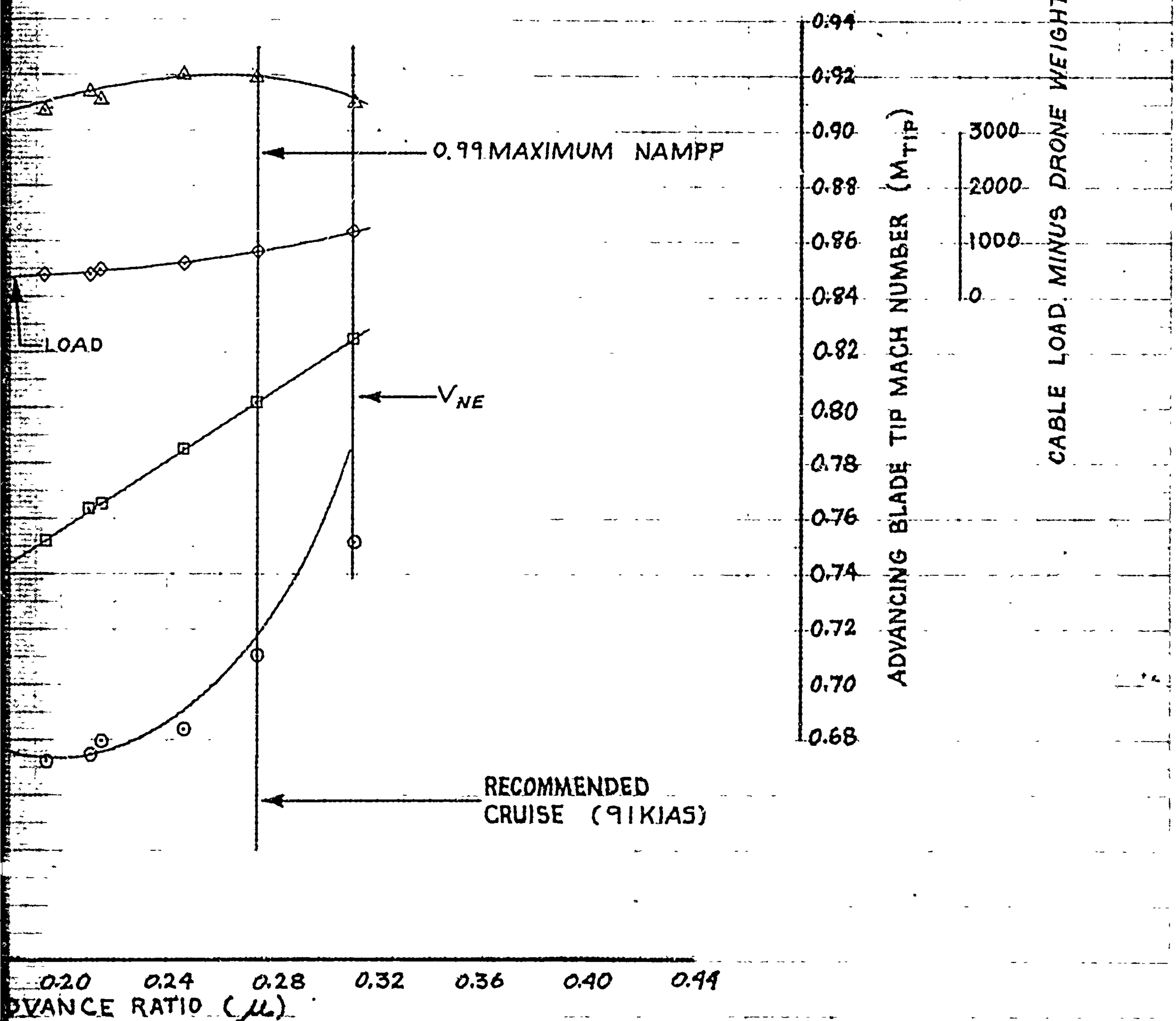


FIGURE 59. NONDIMENSIONAL LEVEL FL

H-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 9,620
AVG. FREE AIR TEMP. (DEG. C) = 7.5
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 36,340
AVG. CG LOCATION (STA) = 335.6

50-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
D POSITION.



NSIONAL LEVEL FLIGHT PERFORMANCE (AQM-34L)

2

HH-53C USAF S/N 6
T64-GE-7 ENGINES ~ EAF
MARS PERFORM

AVG. C_T = 0.011059
AVG. GW/δ_a (LB) = 55,040
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 188.9
AVG. N_R (RPM) = 184.6

MARS-CONFIGURED, TWO 450-GAL. AUXILIARY
AQM-34L DRONE IN STOWED POSITION.

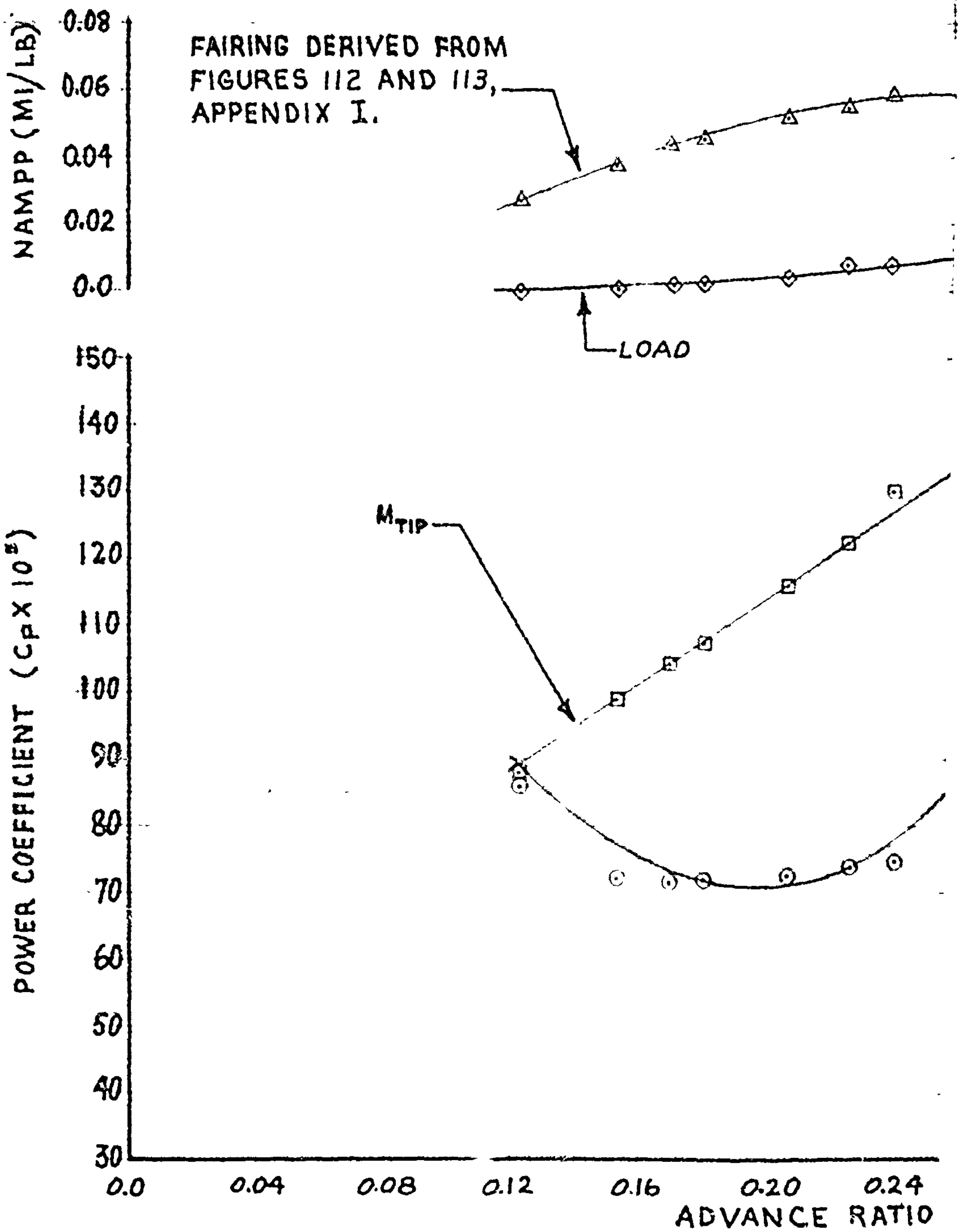
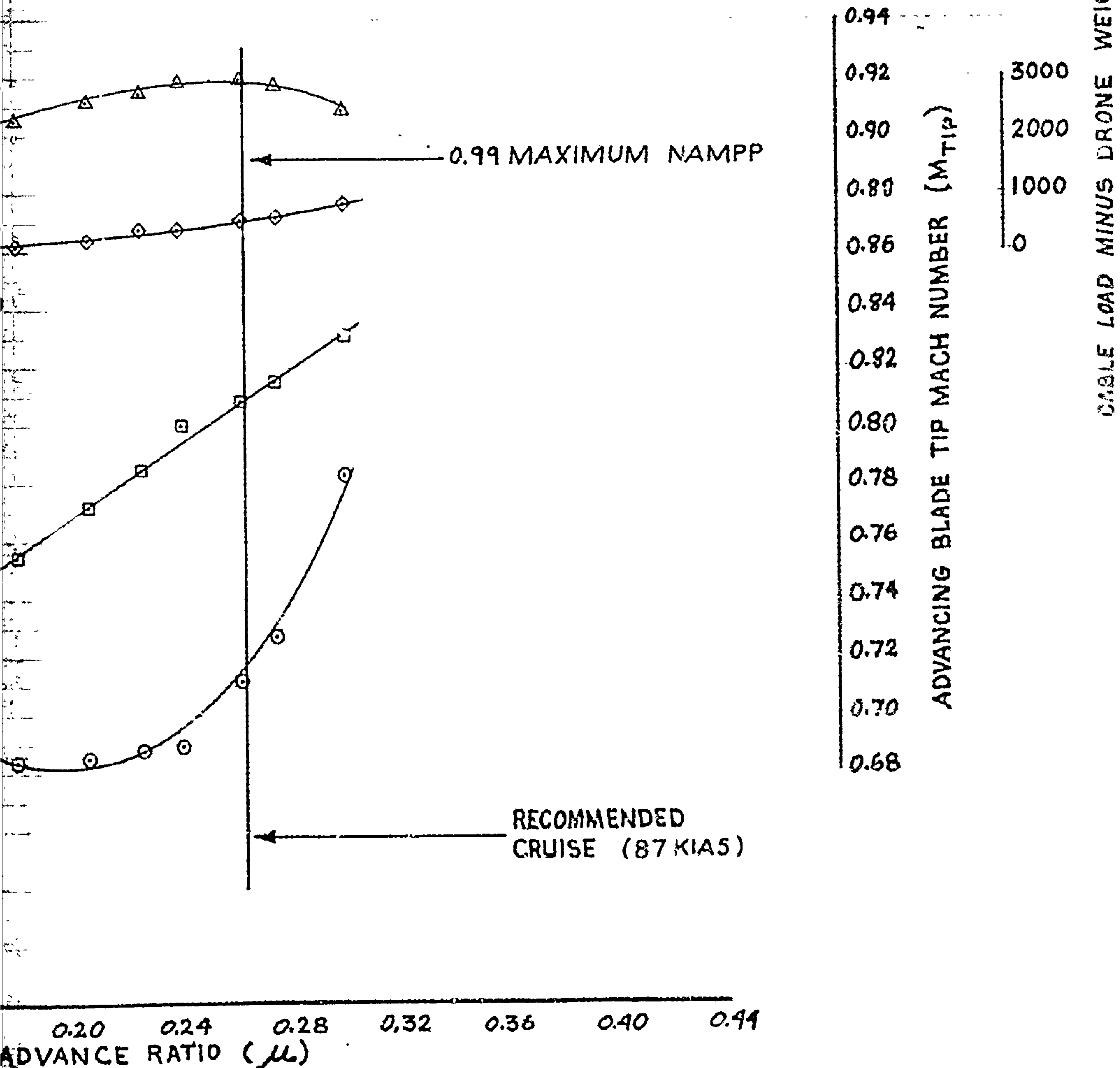


FIGURE 60. NONDIMENSIONAL LEVEL

H-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 11,020
AVG. FREE AIR TEMP. (DEG. C) = 2.0
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 36,380
AVG. CG LOCATION (STA) = 337.4

50-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
D POSITION.



ENSIONAL LEVEL FLIGHT PERFORMANCE (AQM-34L)

HH-53C USAF S/N 67-
T64-GE-7 ENGINES ~ EAPS
MARS PERFORMAN

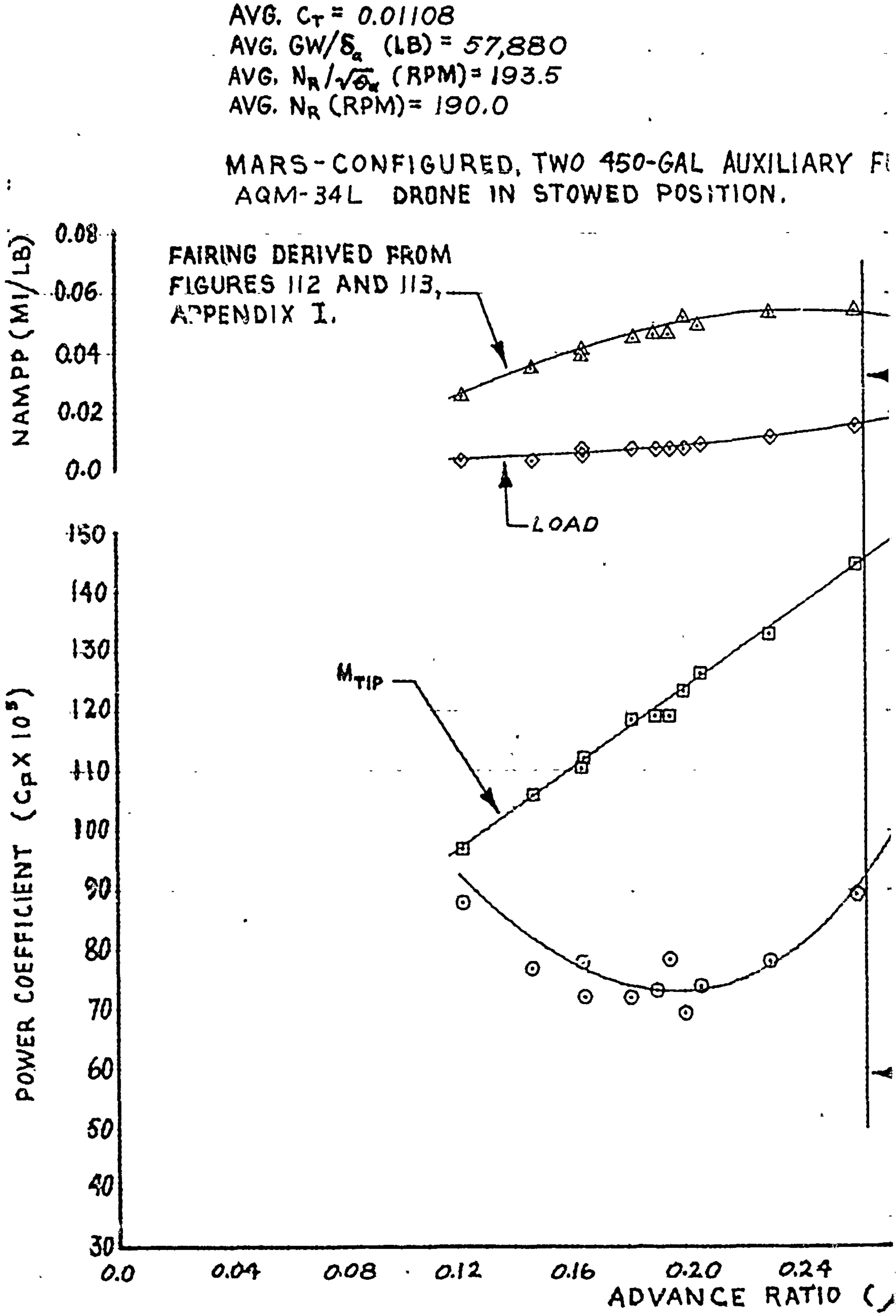
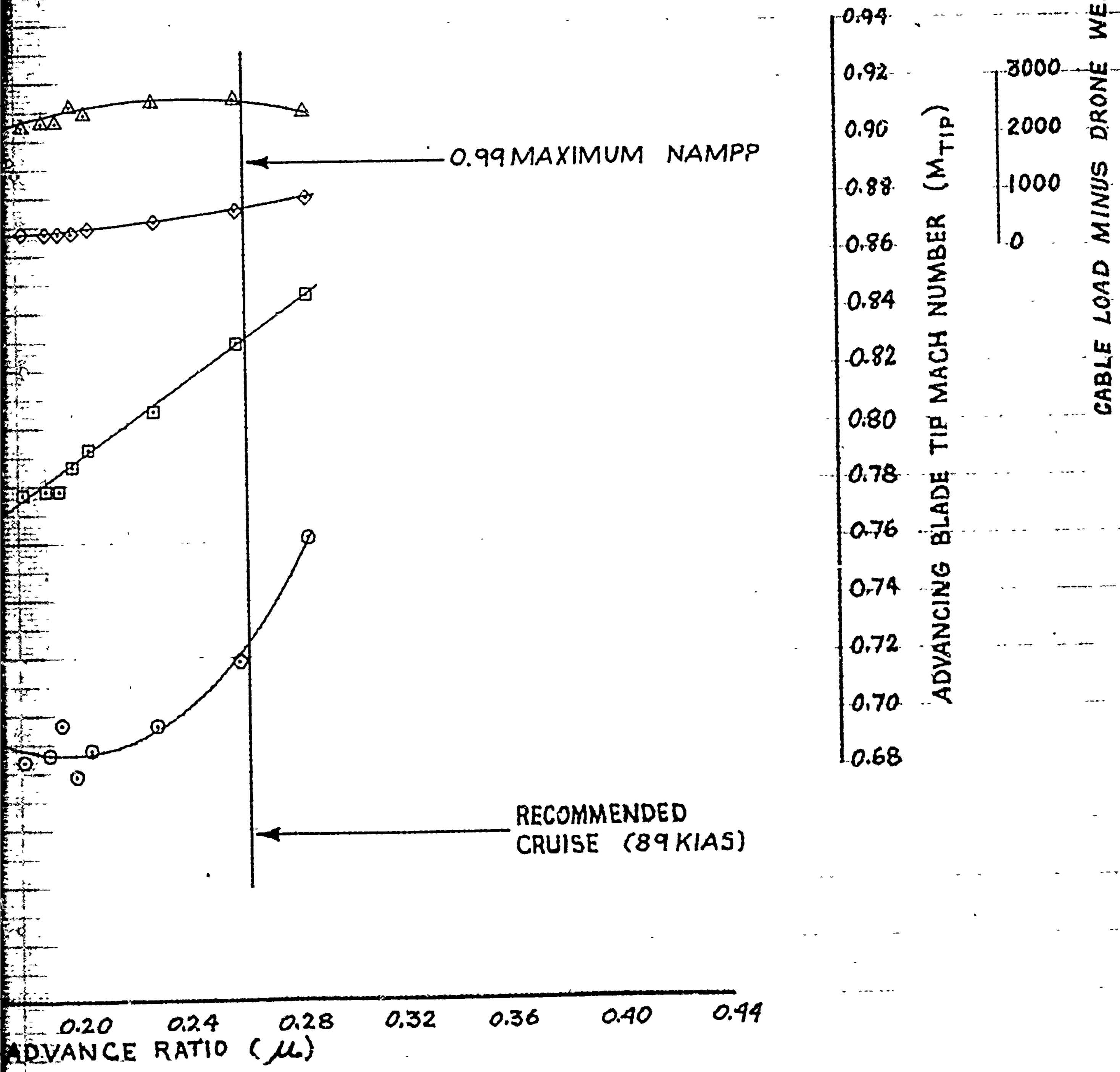


FIGURE 61. NONDIMENSIONAL LEVEL FLIG

H-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 11,350
AVG. FREE AIR TEMP. (DEG. C) = 4.5
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 37,760
AVG. CG LOCATION (STA) = 335.8

50-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
D POSITION.



ENSIONAL LEVEL FLIGHT PERFORMANCE (AQM-34L)

HH-53C USAF S/N
T64-GE-7 ENGINES ~ E
MARS PERFOR

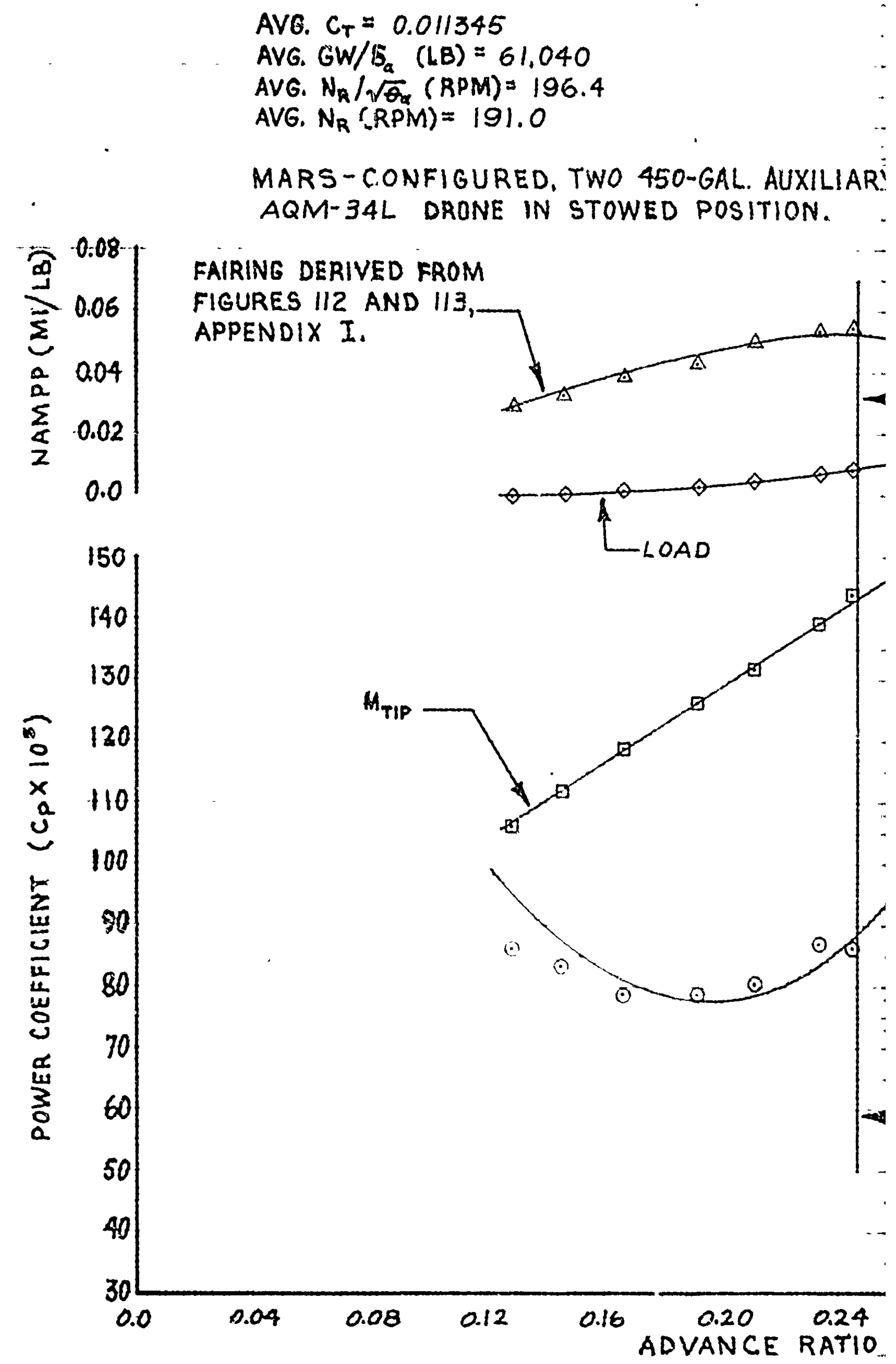
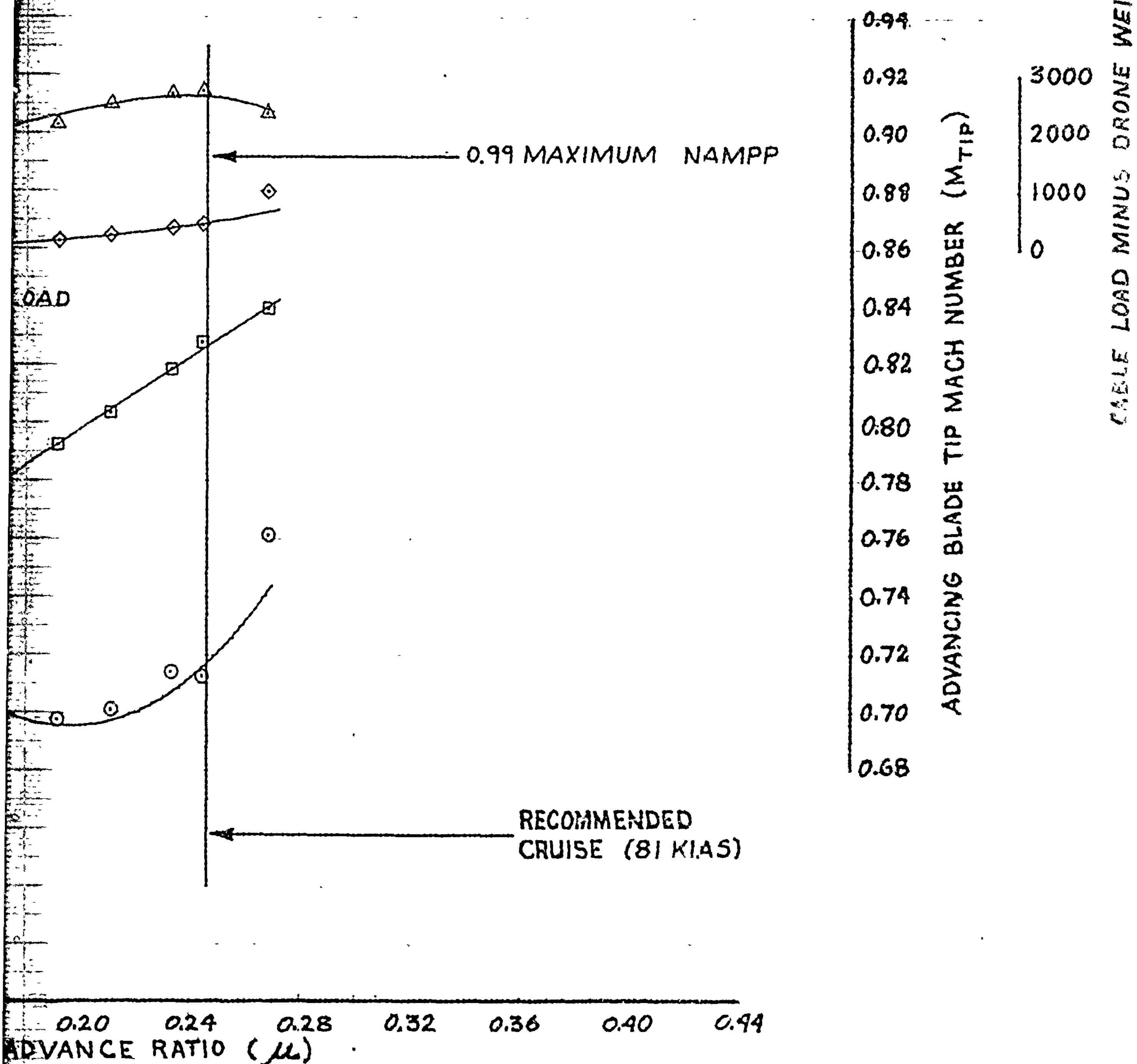


FIGURE 62. NONDIMENSIONAL LEVEL

H-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 12,740
AVG. FREE AIR TEMP. (DEG. C) = -0.5
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 37,700
AVG. CG LOCATION (STA) = 335.8

50-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
D POSITION.



ENSIONAL LEVEL FLIGHT PERFORMANCE (AQM-34L)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 68 THROUGH 72, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-34R DRONE IN STOWED POSITION.

$C_T = 0.0080$

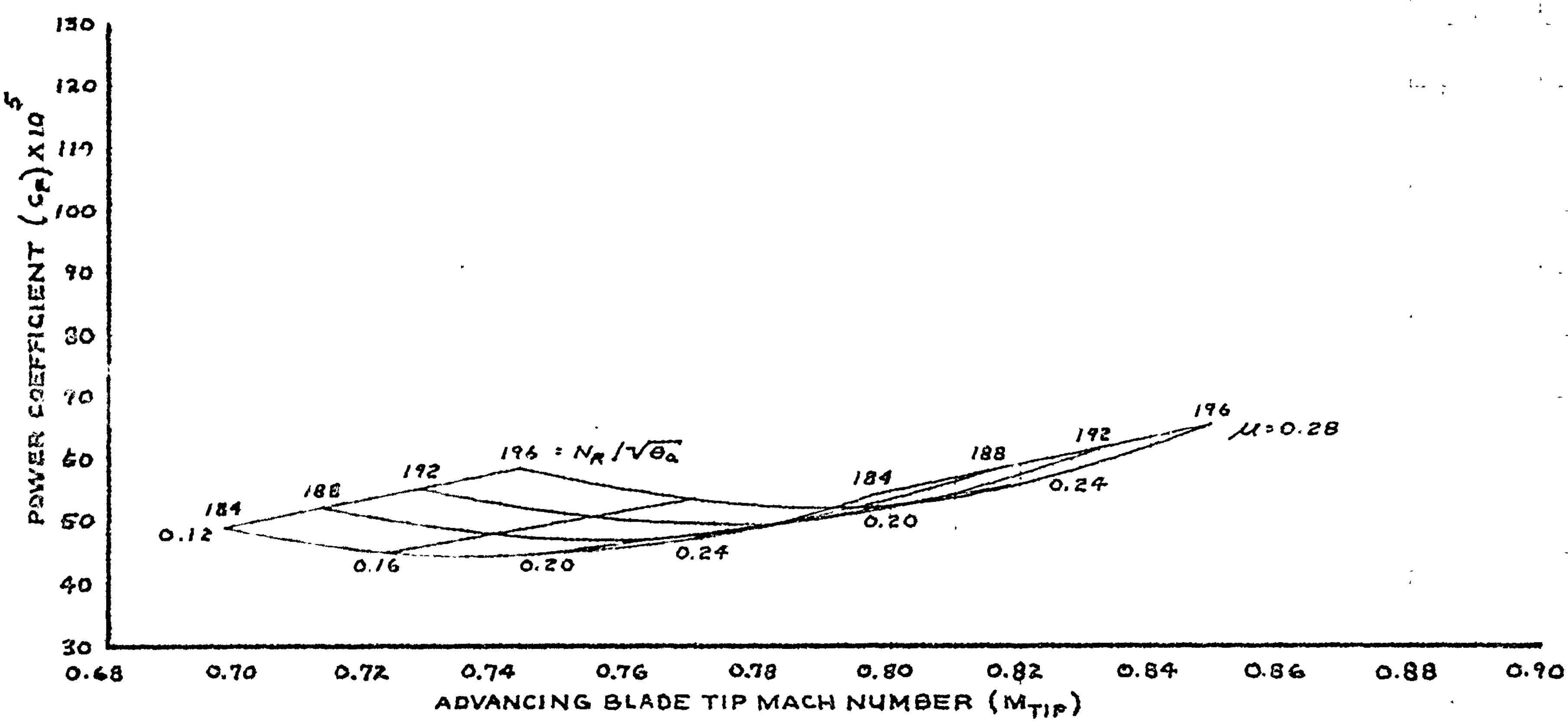


FIGURE 63. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-34R)

HH-53C USAF S/N 67-14993
T64- GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 68 THROUGH 72, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-34R DRONE IN STOWED POSITION.

$C_T = 0.0090$

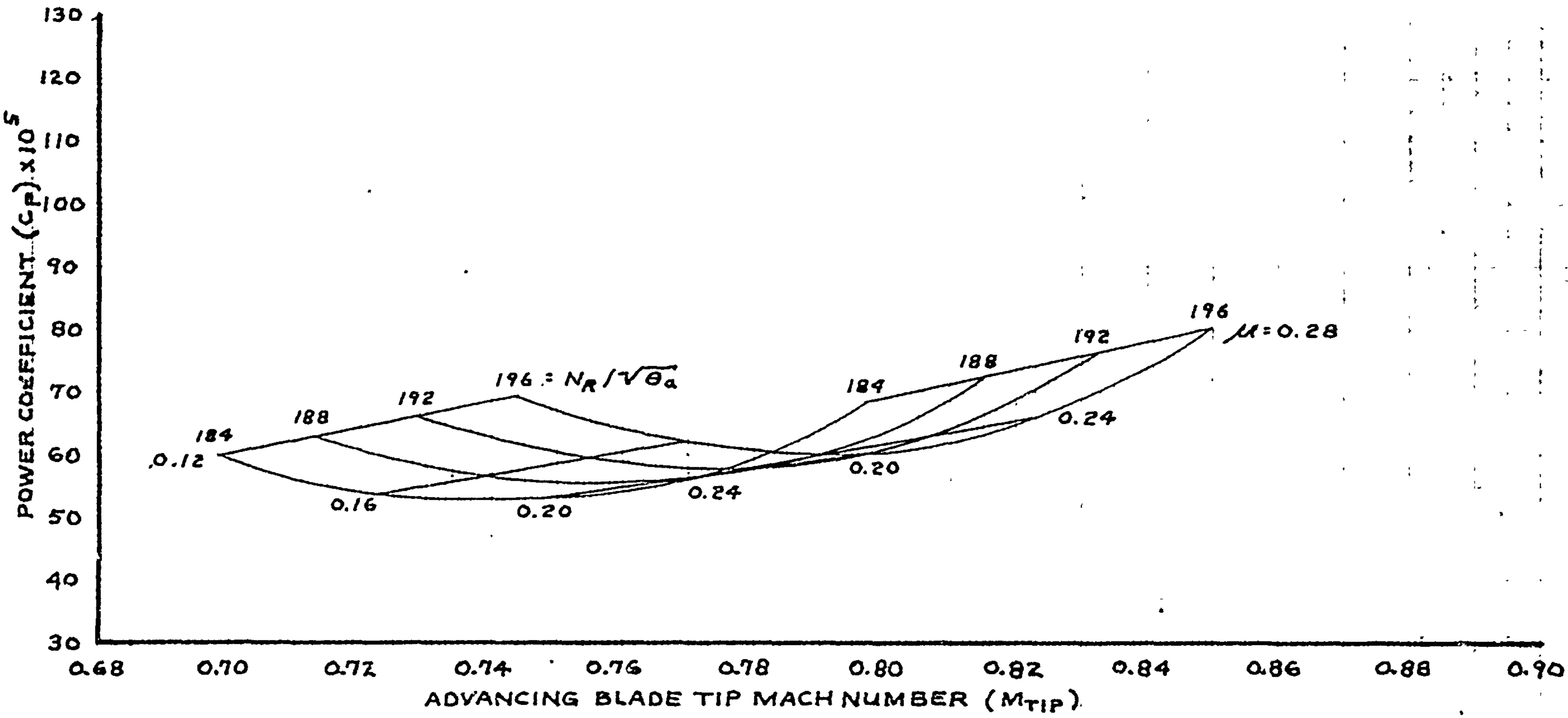


FIGURE 64. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-34R)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 68 THROUGH 72, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-34R DRONE IN STOWED POSITION.

$C_T = 0.0100$

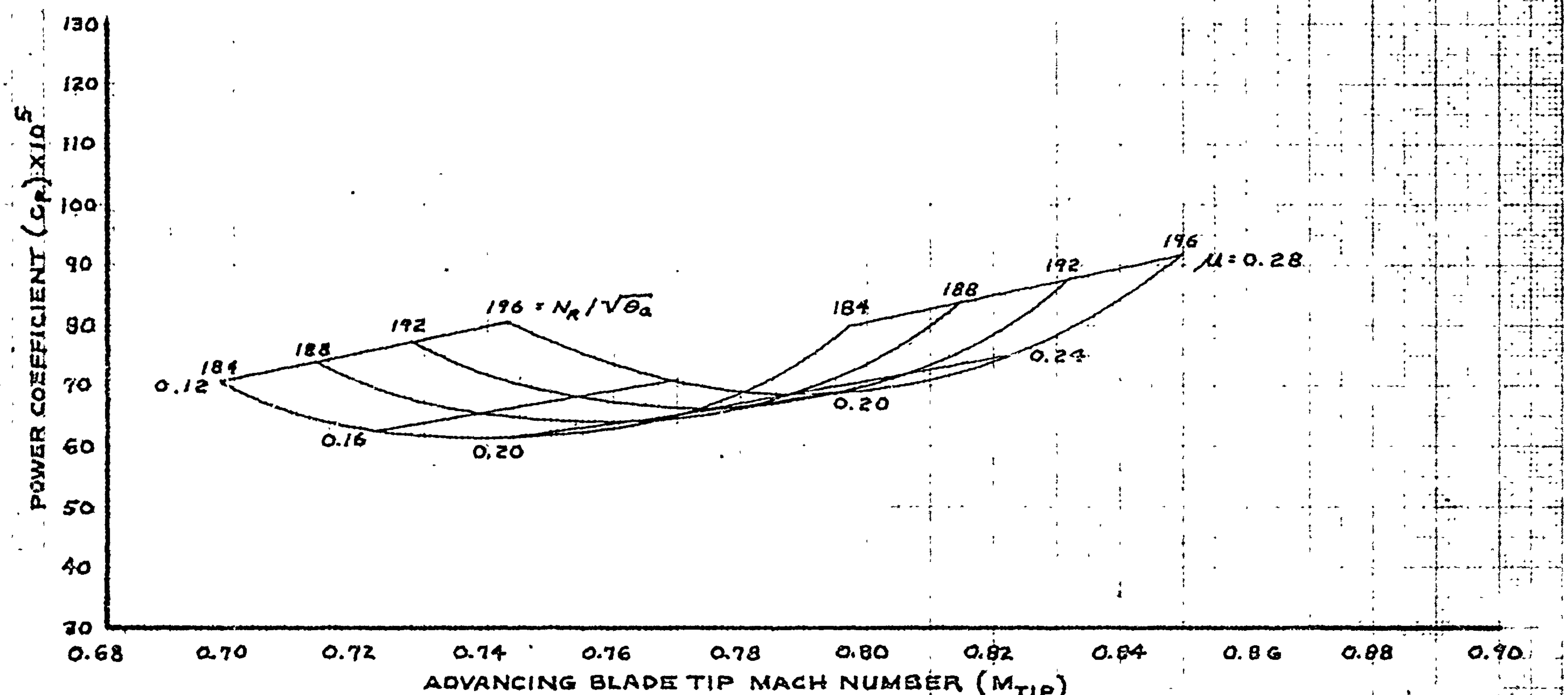


FIGURE 65. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-34R)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 68 THROUGH 72, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-34R DRONE IN STOWED POSITION.

$C_T = 0.0110$

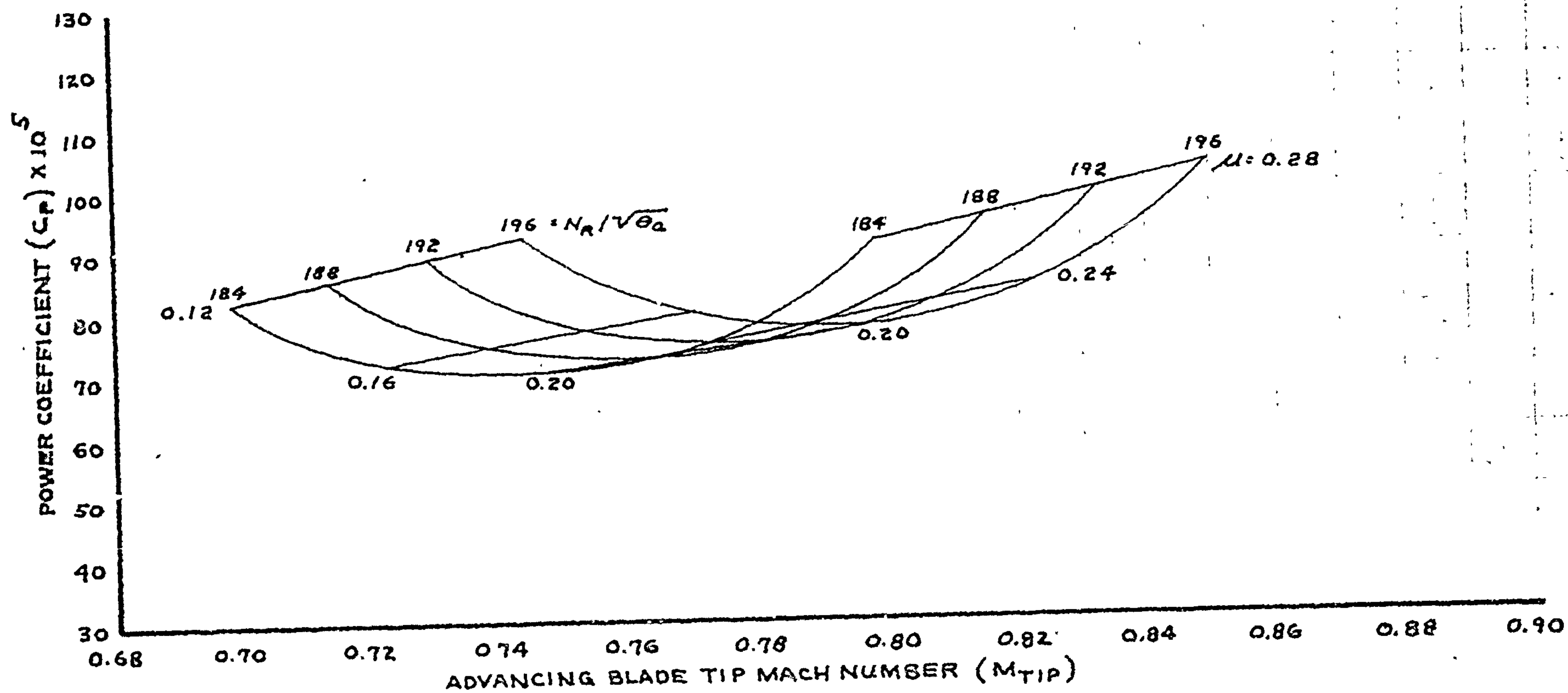


FIGURE 60. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-34R)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 68 THROUGH 72, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-34R DRONE IN STOWED POSITION.

$C_T = 0.0115$

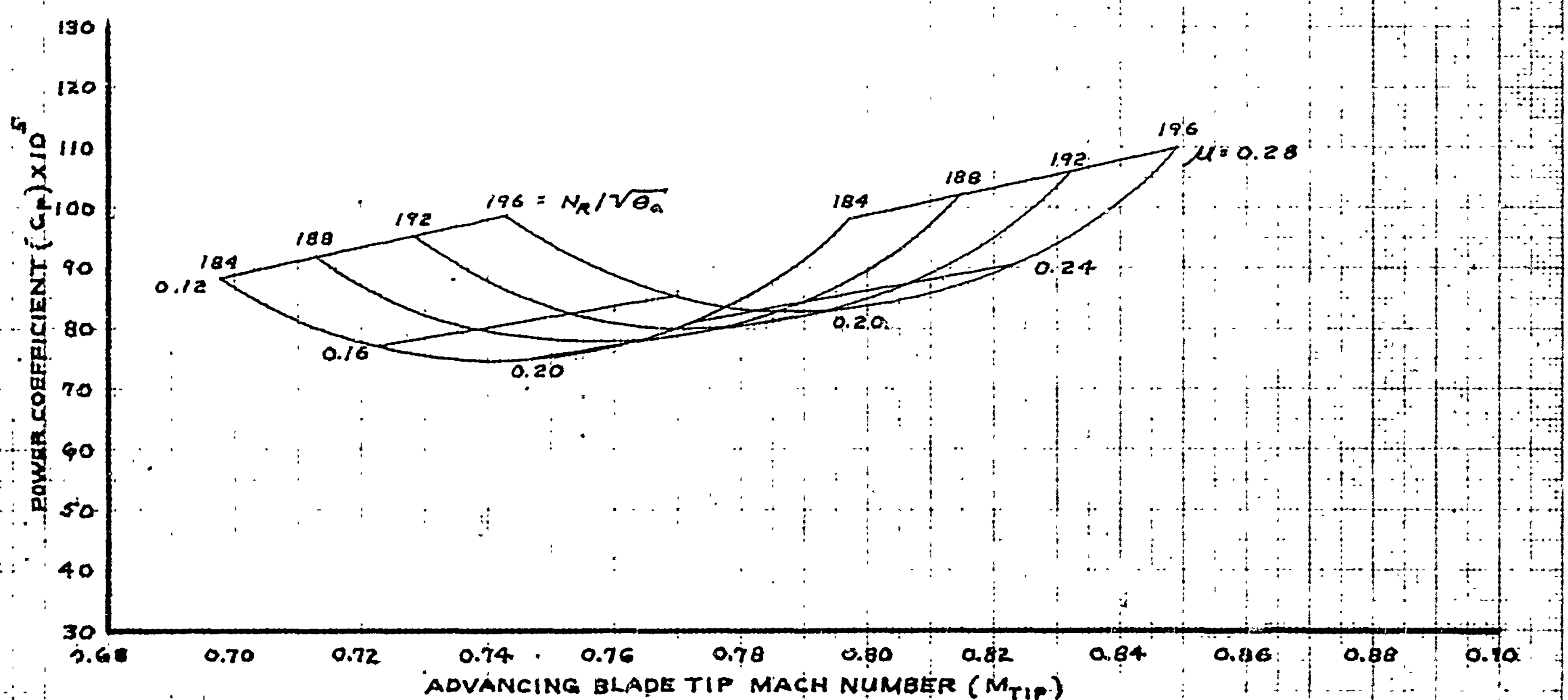


FIGURE 67. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-34R)

HH-53C USAF S/N 67-14993

T64-GE-7 ENGINES - EAPS INSTALLED

MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 73 THROUGH 82, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-34R DRONE IN STOWED POSITION.

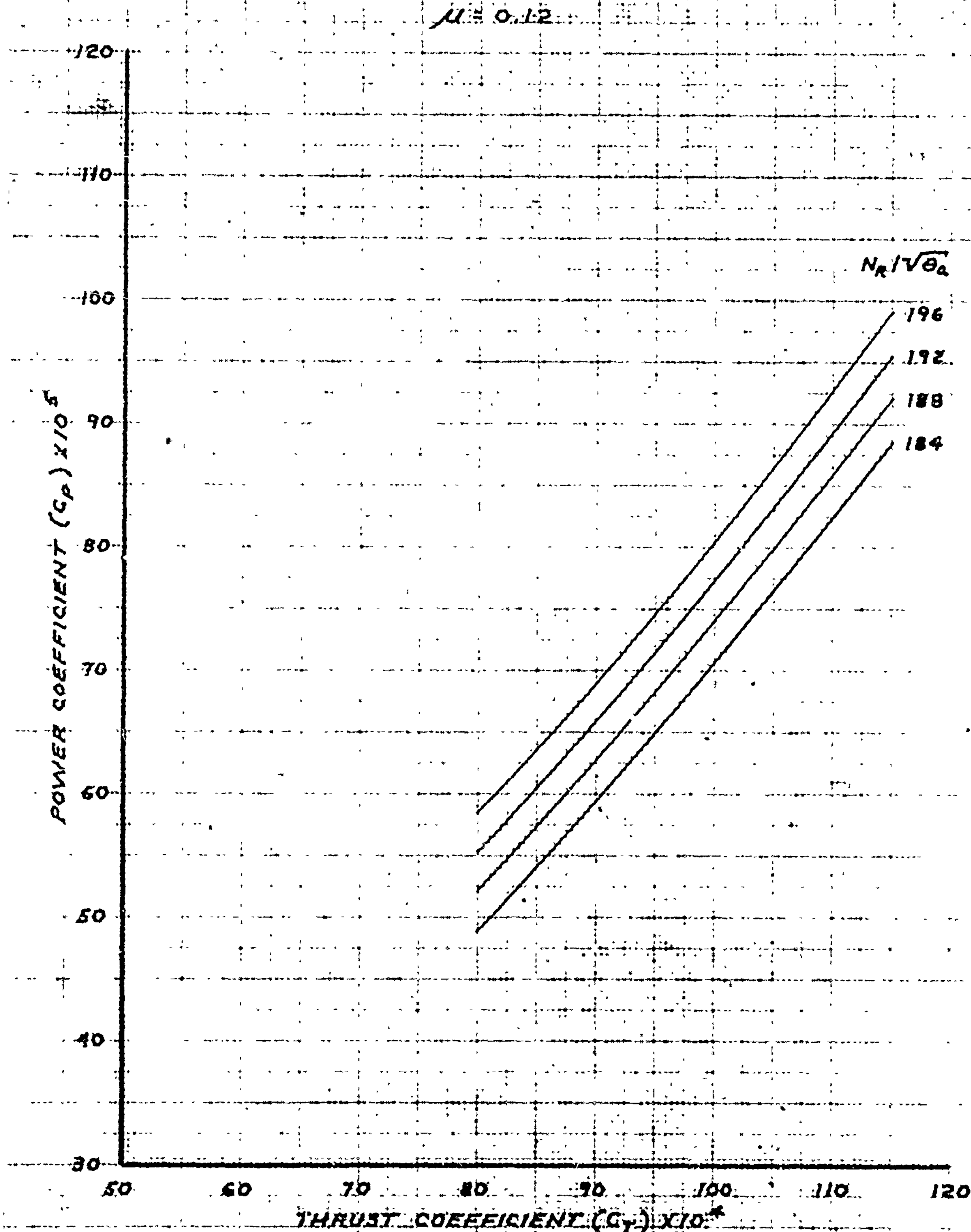


FIGURE 68. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-34R)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 73 THROUGH 82, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-34R DRONE IN STOWED POSITION.

$\mu = 0.16$

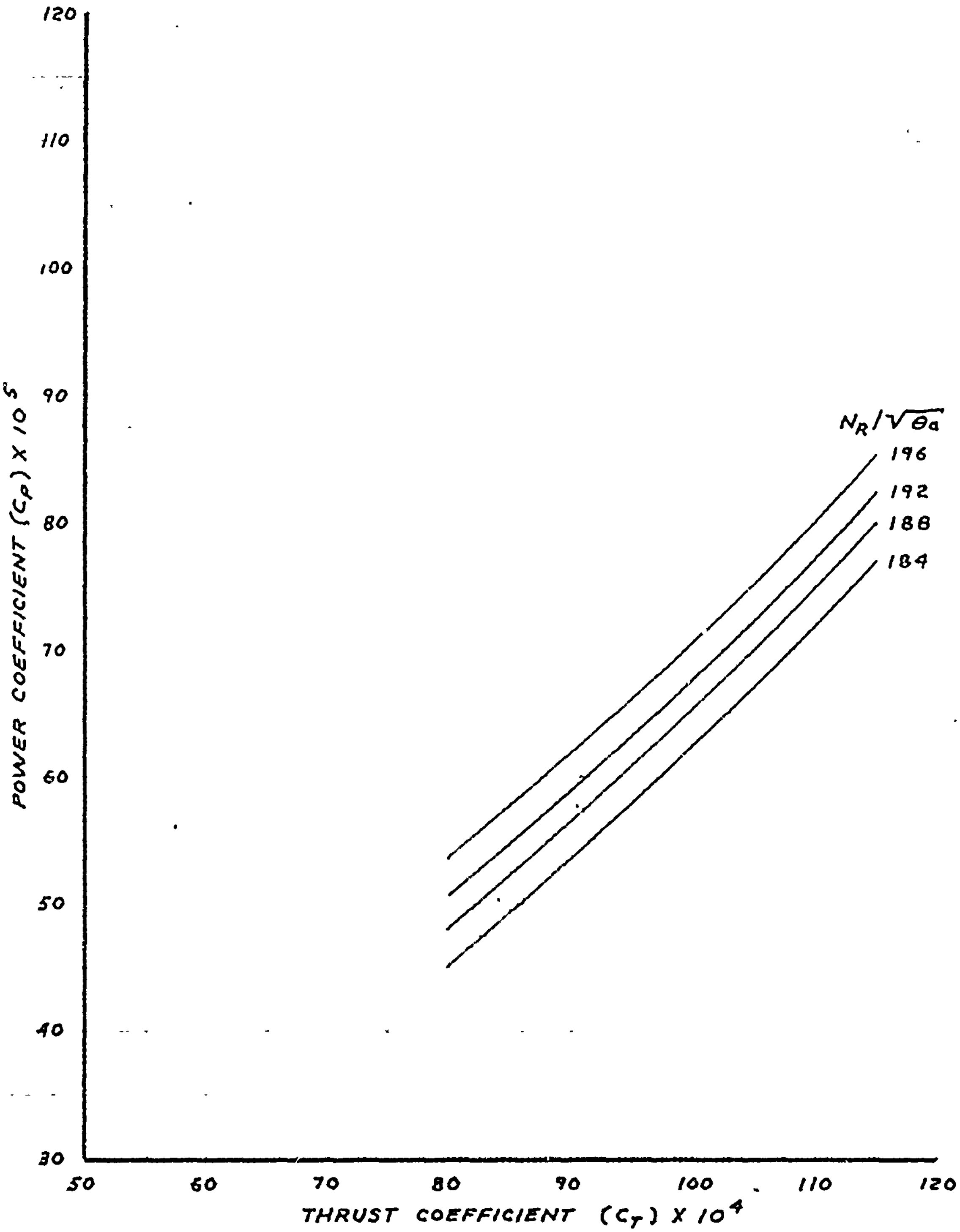


FIGURE 69. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-34R)

HH-53C USAF S/N 67-14993

T64-GE-7 ENGINES ~ EAPS INSTALLED

MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 73 THROUGH 82, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-34R DRONE IN STOWED POSITION.

$\mu = 0.20$

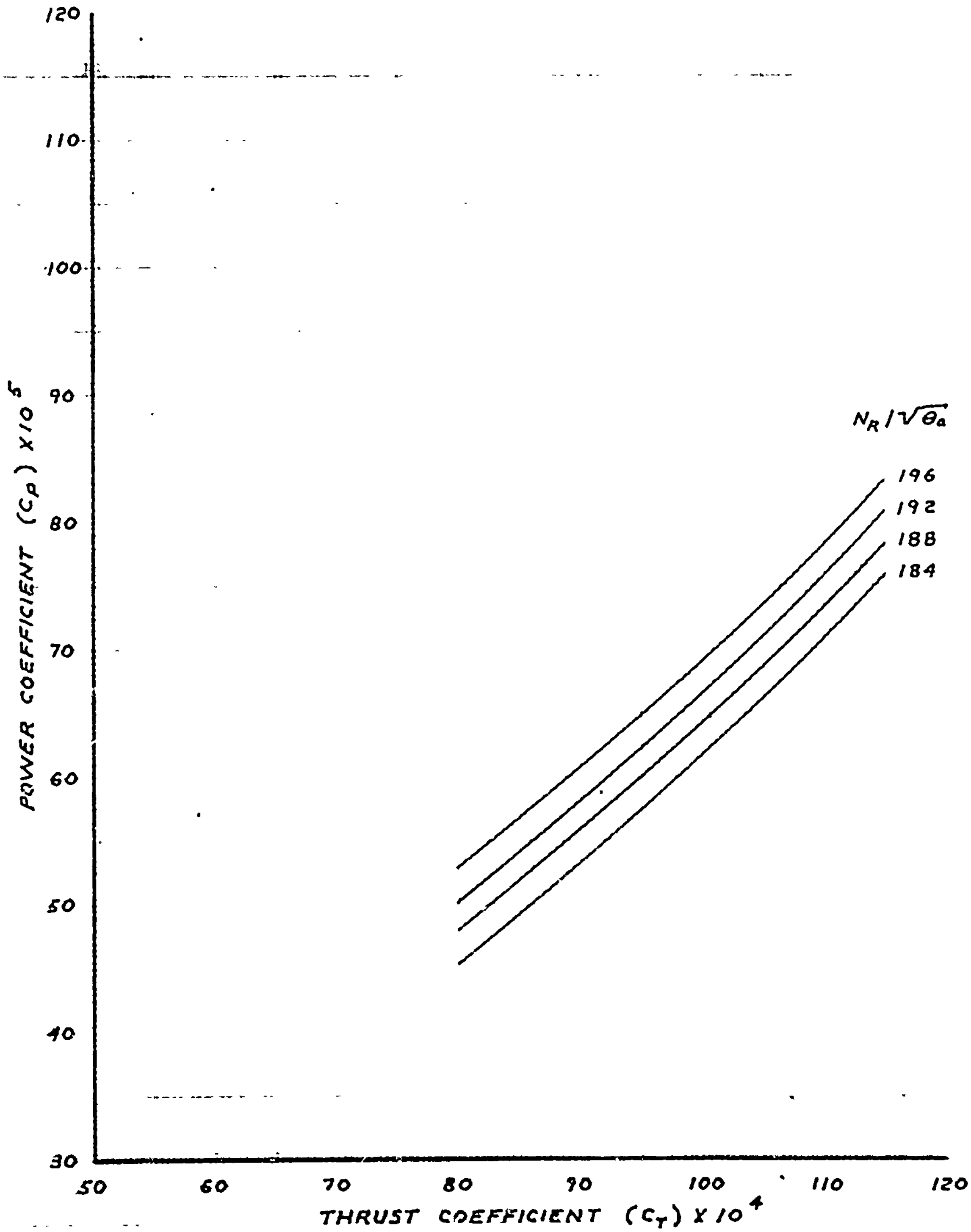


FIGURE 70. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-34R)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 73 THROUGH 82, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-34R DRONE IN STOWED POSITION.

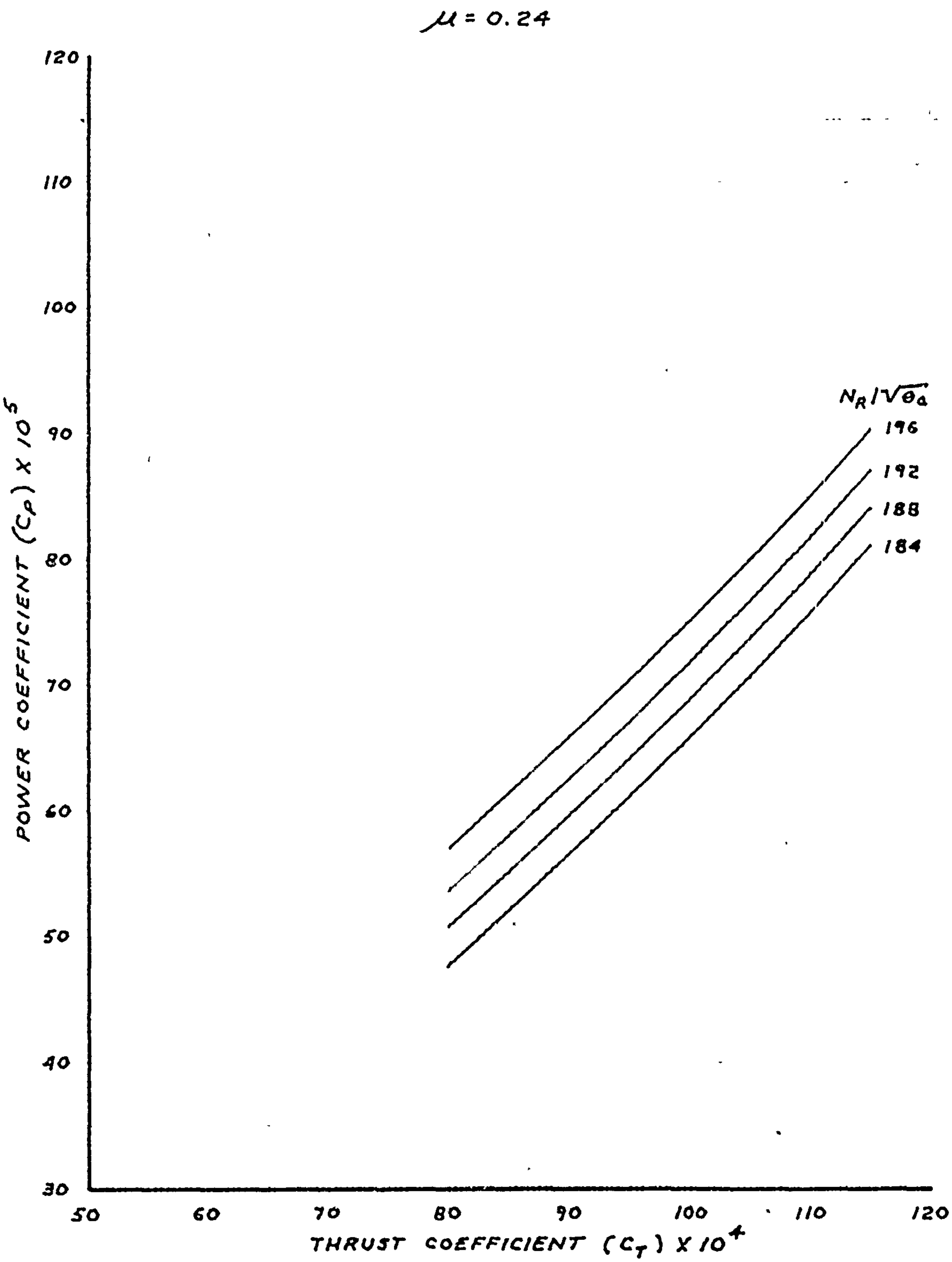


FIGURE 71. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-34R)

HH-53C USAF S/N 67-14993

T64-GE-7 ENGINES~EAPS INSTALLED

MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 73 THROUGH 82, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-34R DRONE IN STOWED POSITION.

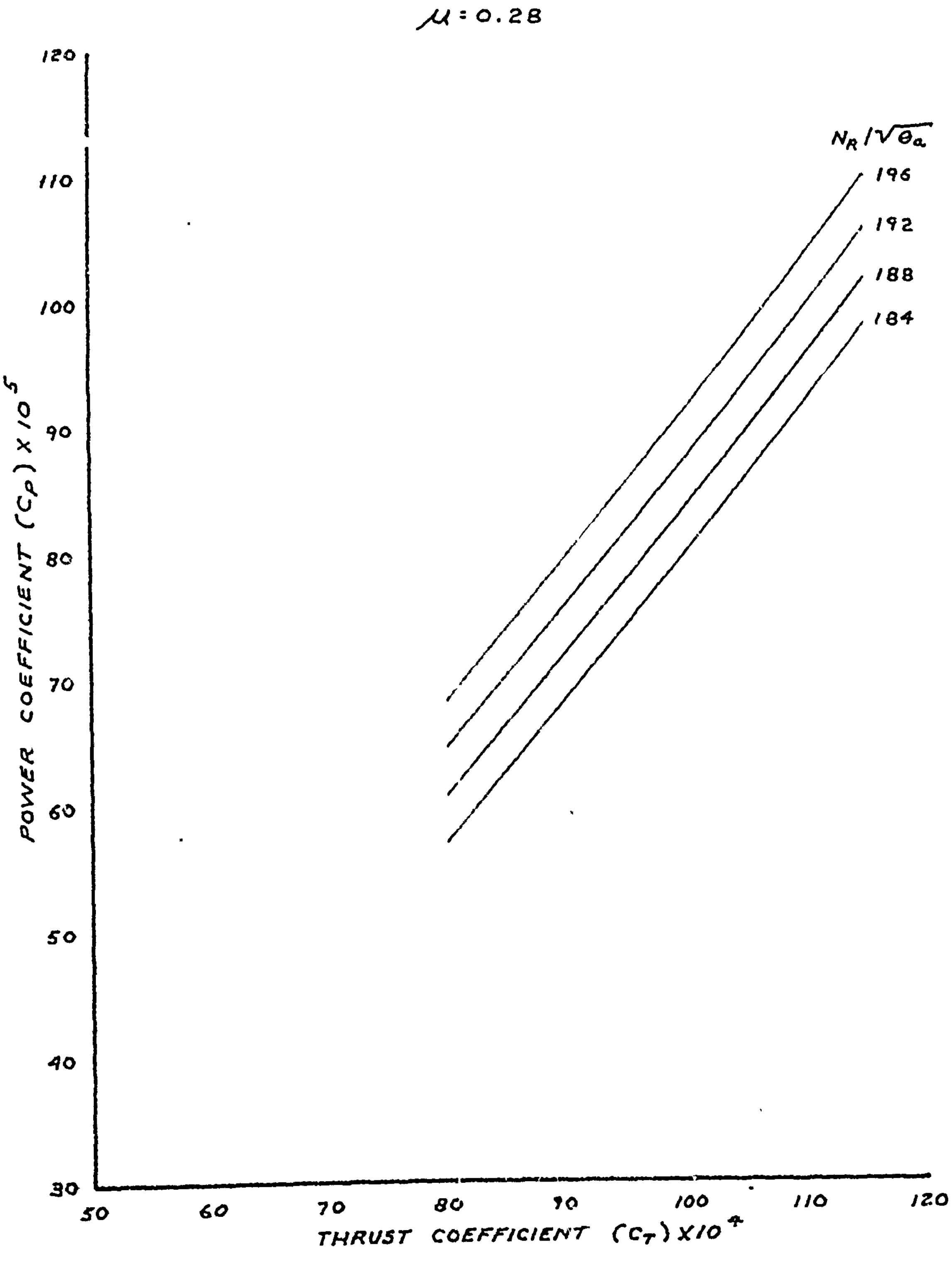


FIGURE 72. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-34R)

HH-53C USAF S/N 67-
T64-GE-7 ENGINES ~ EAPS
MARS PERFORMAN

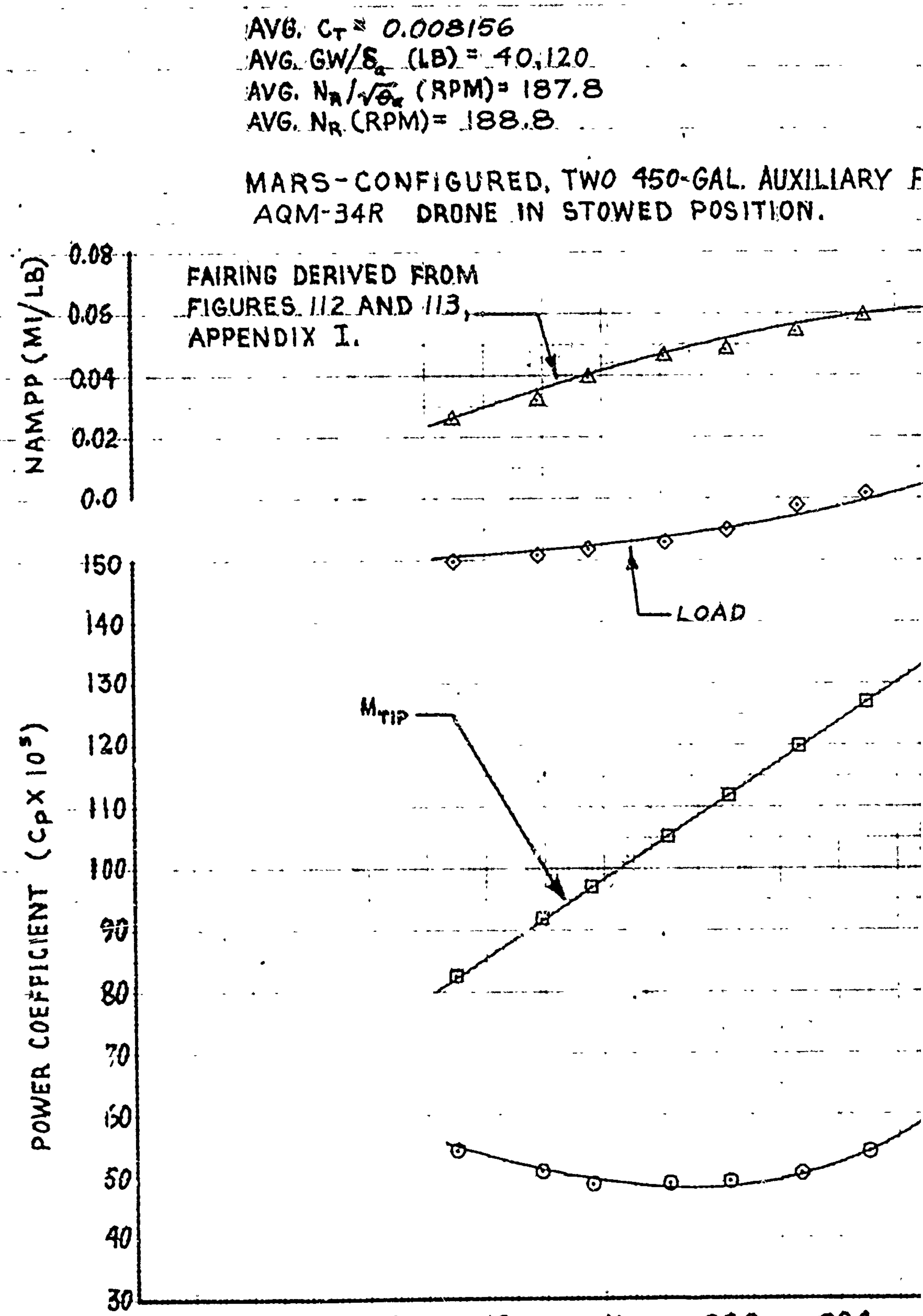
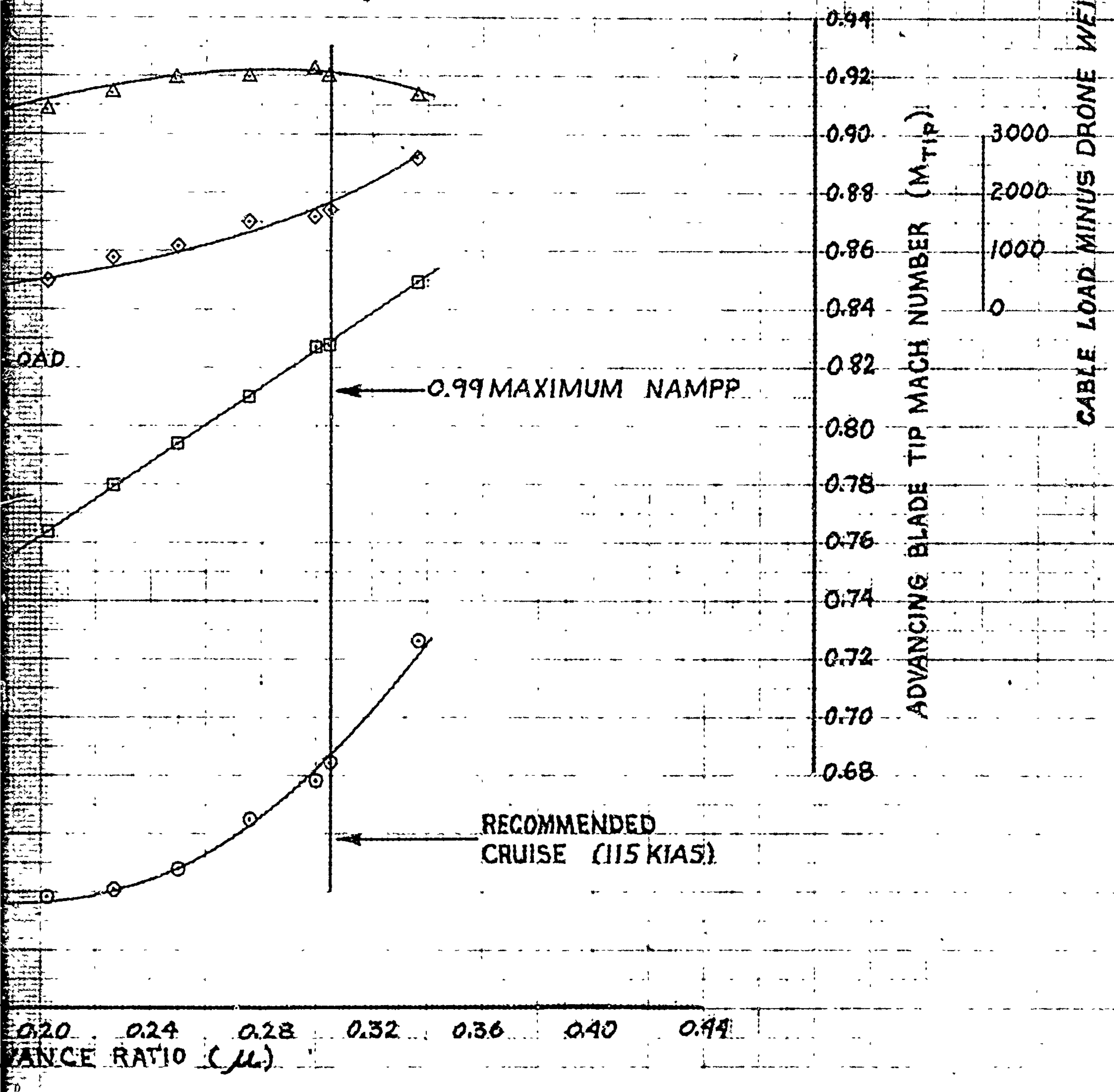


FIGURE 73. NONDIMENSIONAL LEVEL FLI

35C USAF S/N 67-14993
57 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 4,800
AVG. FREE AIR TEMP. (DEG. C) = 18.0
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 33,630
AVG. CG LOCATION (STA) = 337.3

GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
POSITION.



IONAL LEVEL FLIGHT PERFORMANCE (AQM-34R)

HH-53C USAF S/N.
T64-GE-7 ENGINES ~ E
MARS PERFOR

AVG. C_T = 0.007817
AVG. GW/δ_a (LB) = 40,780
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 193.4
AVG. N_R (RPM) = 194.4

MARS-CONFIGURED, TWO 450-GAL. AUXILIAR
AQM-34R DRONE IN STOWED POSITION.

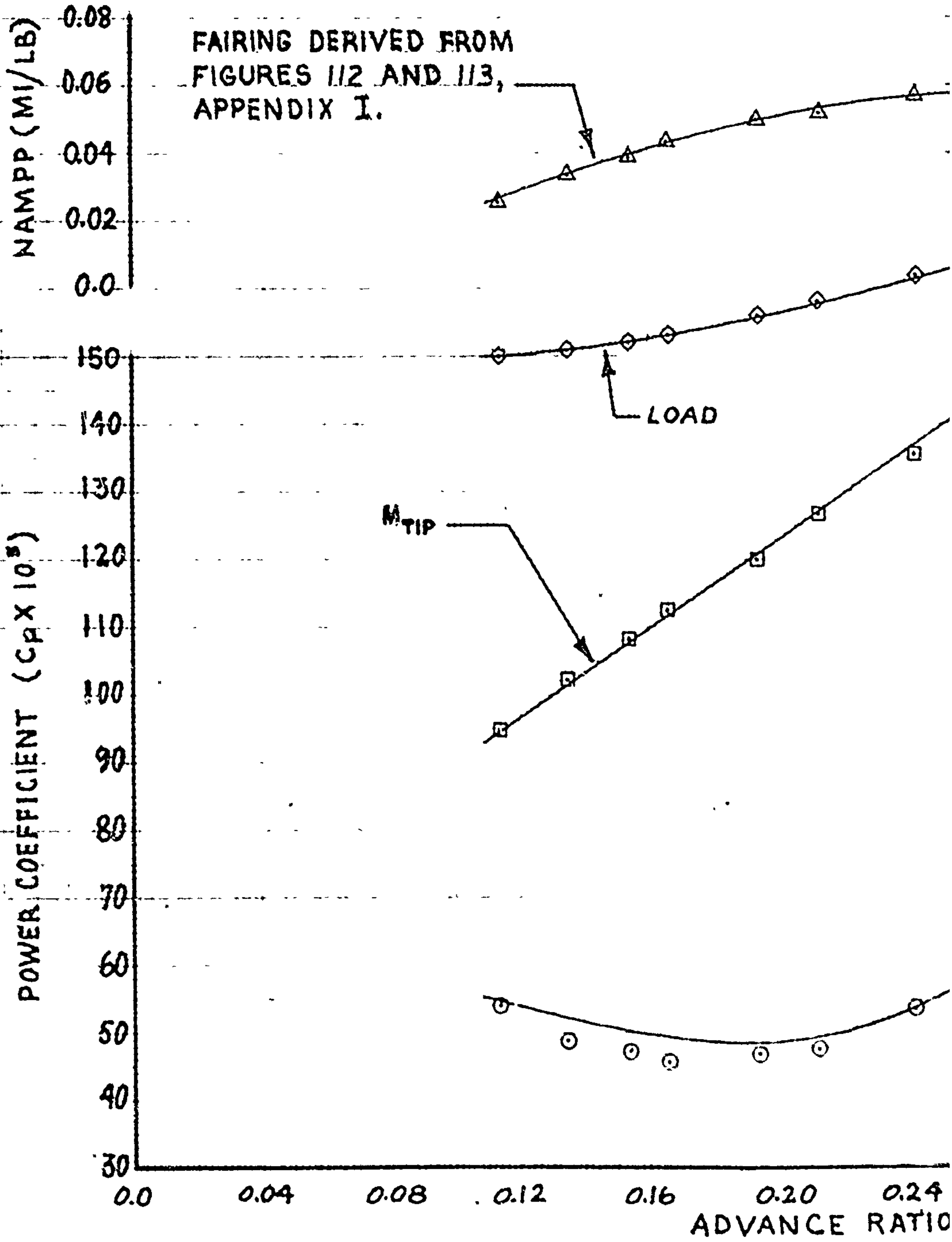
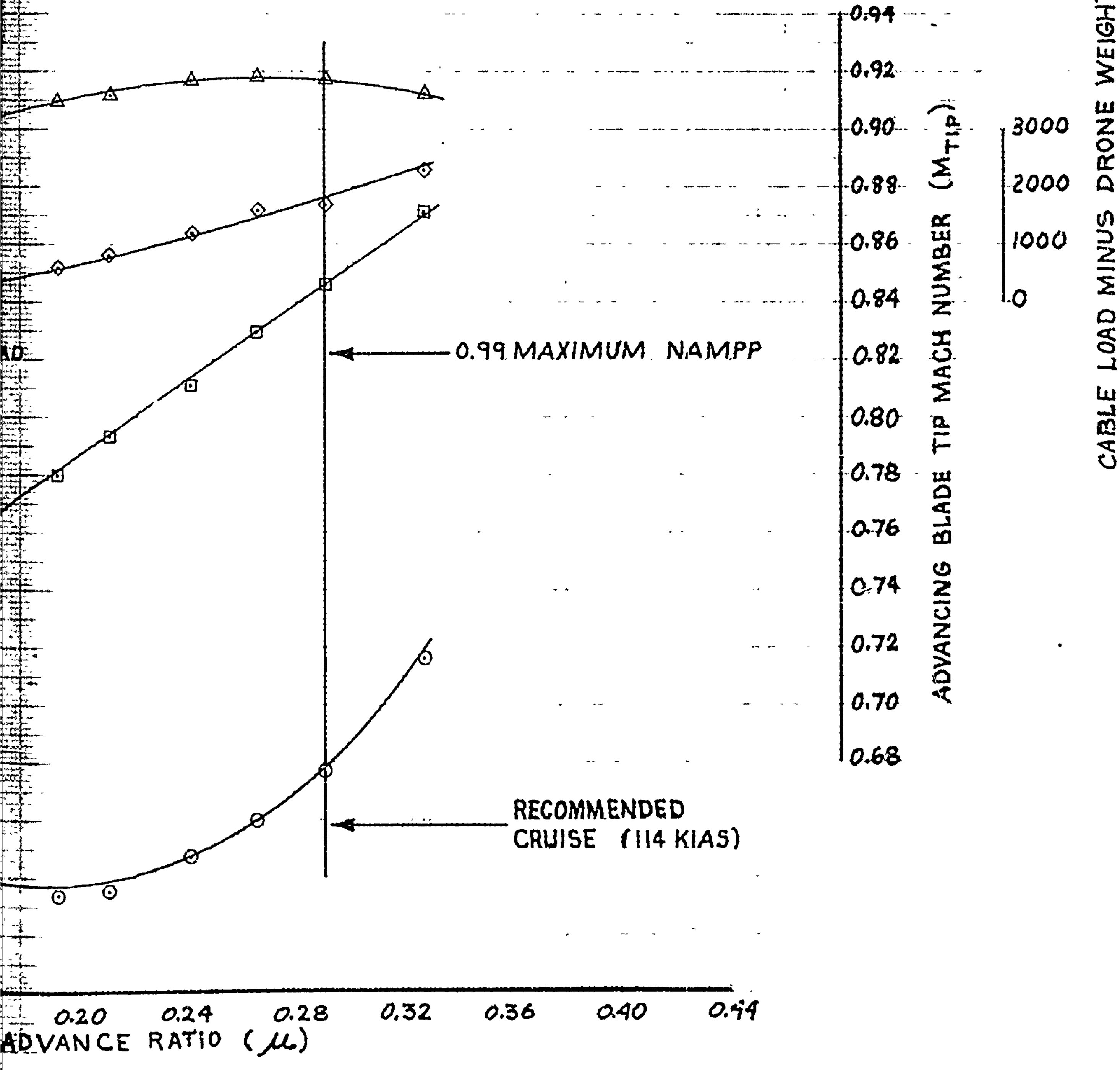


FIGURE 74. NONDIMENSIONAL LEVEL

HH-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 4,300
AVG. FREE AIR TEMP. (DEG. C) = 18.0
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 34,830
AVG. CG LOCATION (STA) = 337.5

450-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
ED POSITION.



ENSIONAL LEVEL FLIGHT PERFORMANCE (AQM-34R)

HH-53C USAF S/N 67-1
T64-GE-7 ENGINES ~ EAPS I
MARS PERFORMANC

AVG. C_T = 0.008574
AVG. GW/δ_a (LB) = 41,370
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 186.0
AVG. N_R (RPM) = 189.0

MARS-CONFIGURED, TWO 450-GAL. AUXILIARY FUE
AQM-34R DRONE IN STOWED POSITION.

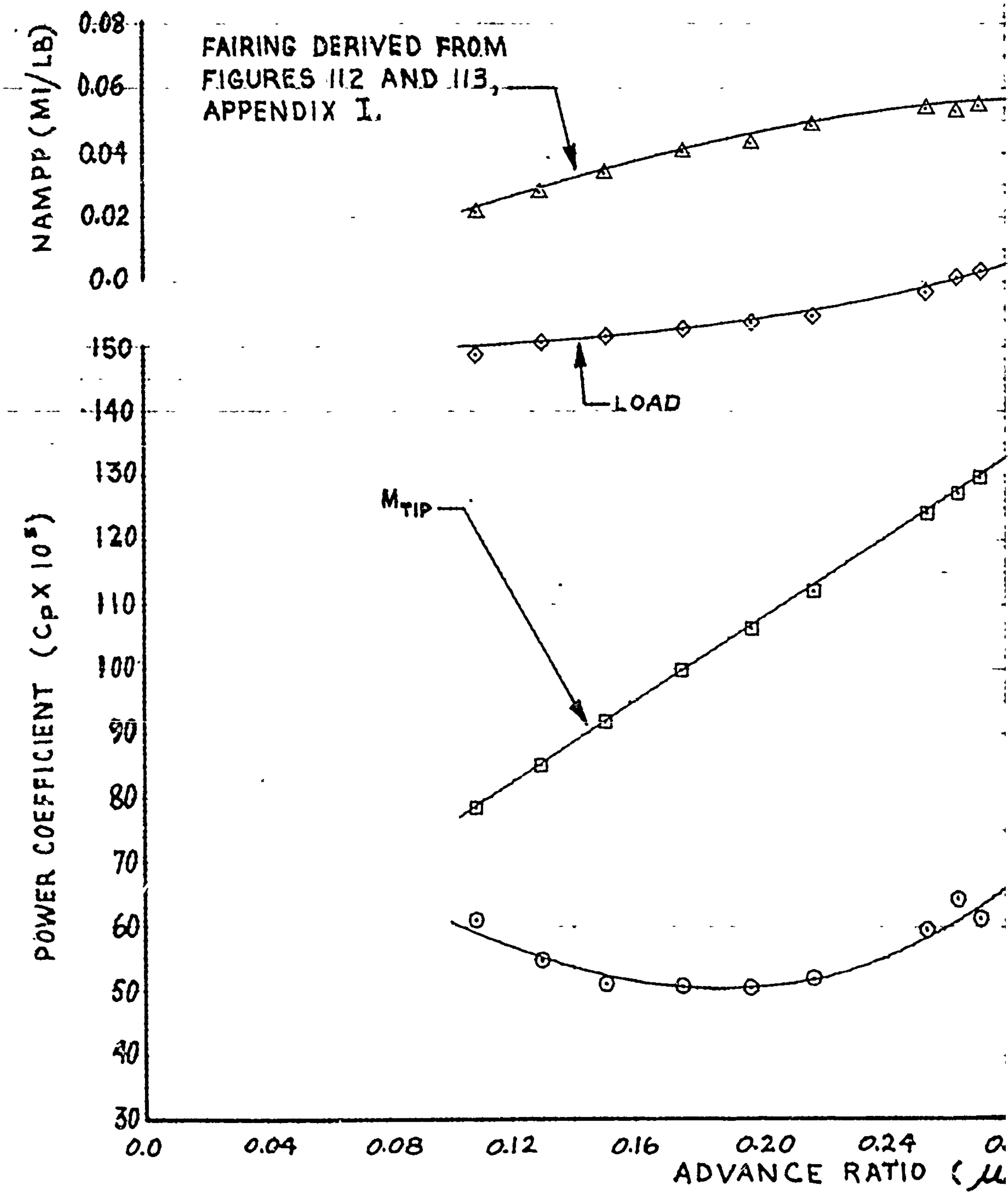
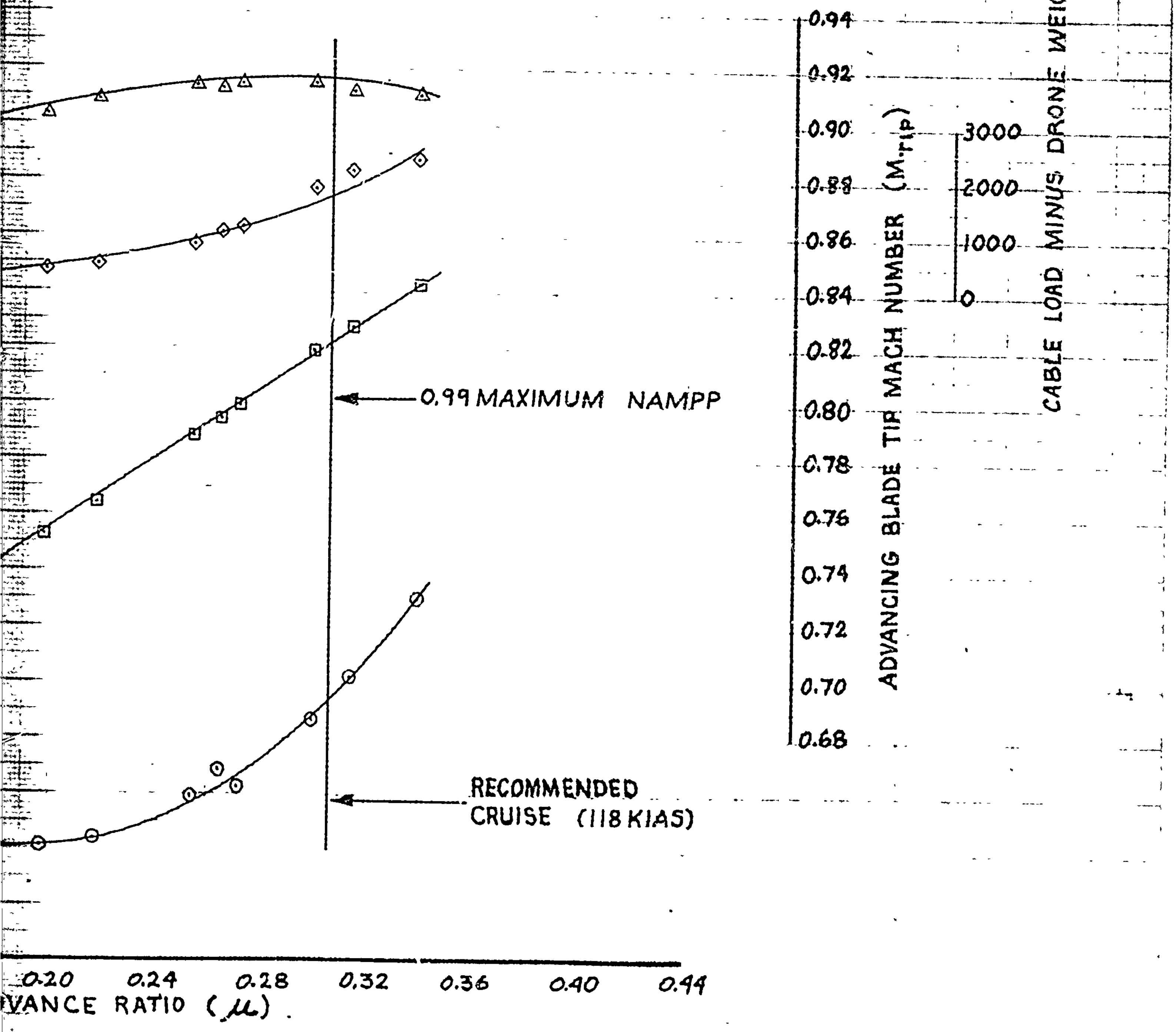


FIGURE 75. NONDIMENSIONAL LEVEL FLIGHT

H-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 3,550
AVG. FREE AIR TEMP. (DEG. C) = 24.5
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 36,330
AVG. CG LOCATION (STA) = 338.2

50-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
D POSITION.



SIONAL LEVEL FLIGHT PERFORMANCE (AQM-34R)

HH-53C USAF S/N 6
T64-GE-7 ENGINES ~ EA
MARS PERFORM

AVG. C_T = 0.008784
AVG. GW/δ_a (LB) = 43,670
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 188.8
AVG. N_R (RPM) = 189.4

MARS-CONFIGURED, TWO 450-GAL. AUXILIARY
AQM-34R DRONE IN STOWED POSITION.

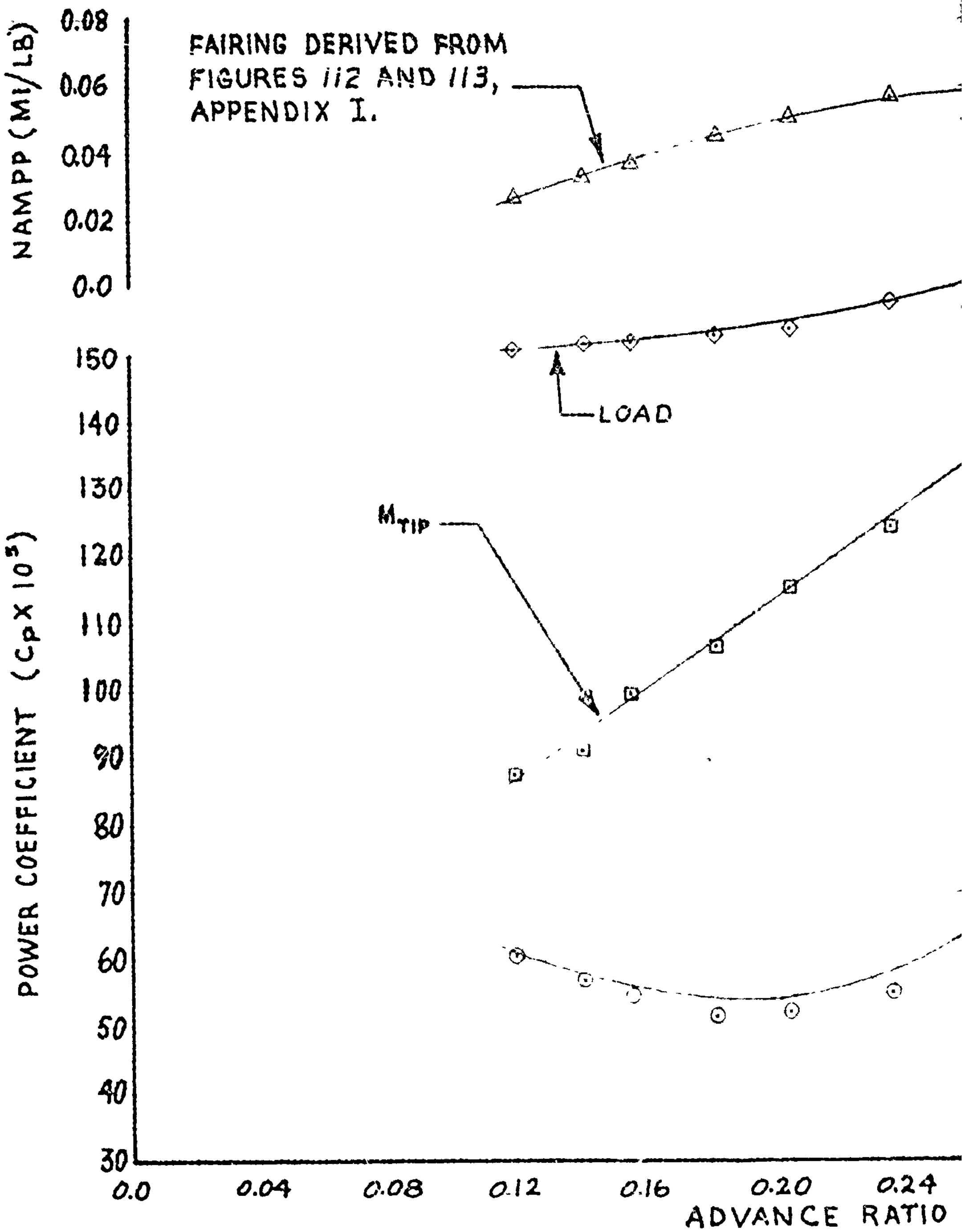
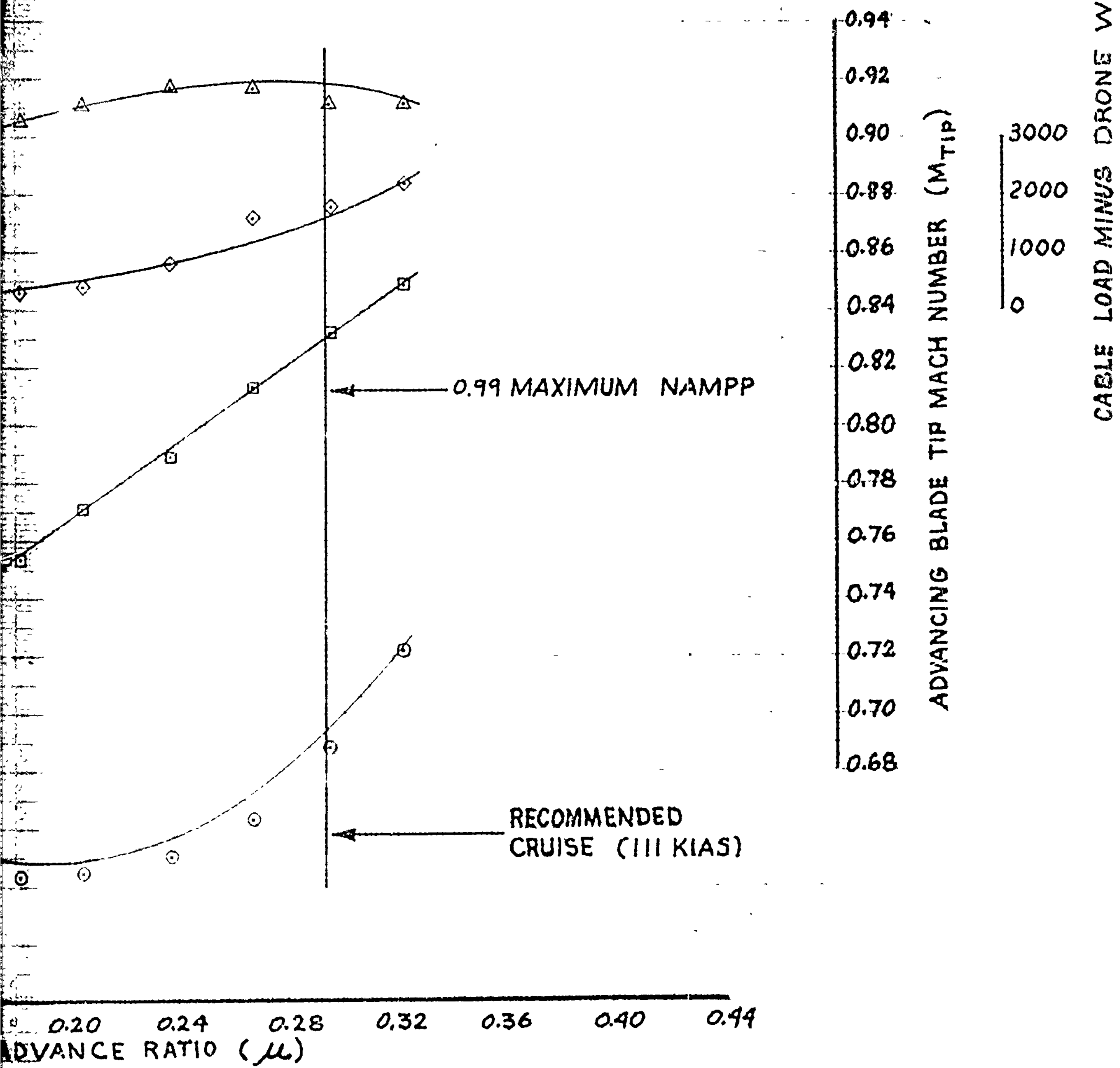


FIGURE 76. NONDIMENSIONAL LEVEL F

H-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 5,100
AVG. FREE AIR TEMP. (DEG. C) = 17.0
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 36,200
AVG. CG LOCATION (STA) = 339.3

50-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST.
D POSITION.



NSIONAL LEVEL FLIGHT PERFORMANCE (AQM-34R)

HH-53C USAF S/N 67-
T64-GE-7 ENGINES ~ EAPS
MARS PERFORMANC

AVG. C_T = 0.008798
AVG. GW/δ_a (LB) = 46,280
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 194.2
AVG. N_R (RPM) = 193.4

MARS-CONFIGURED, TWO 450-GAL. AUXILIARY FU
AQM-34R DRONE IN STOWED POSITION.

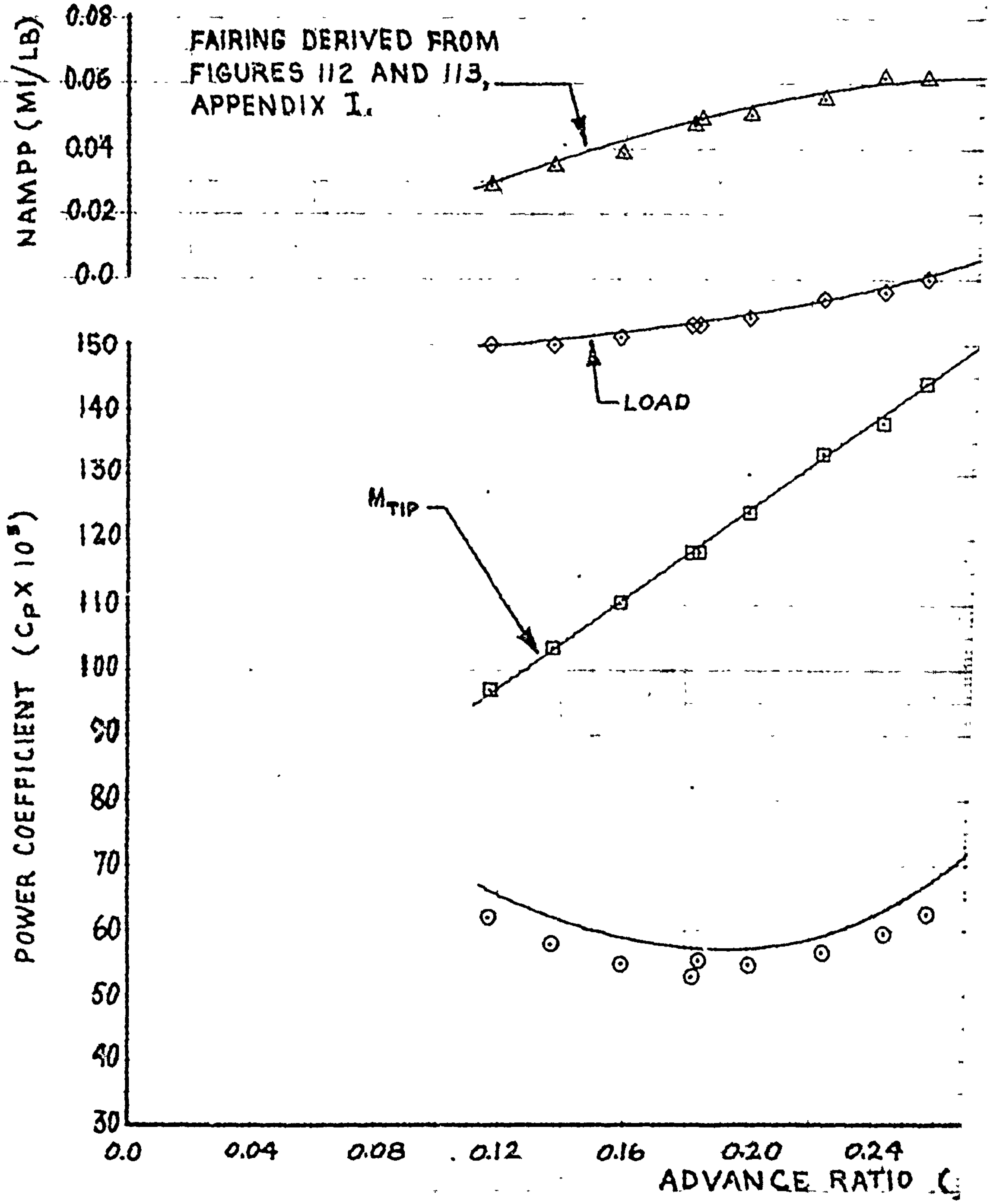
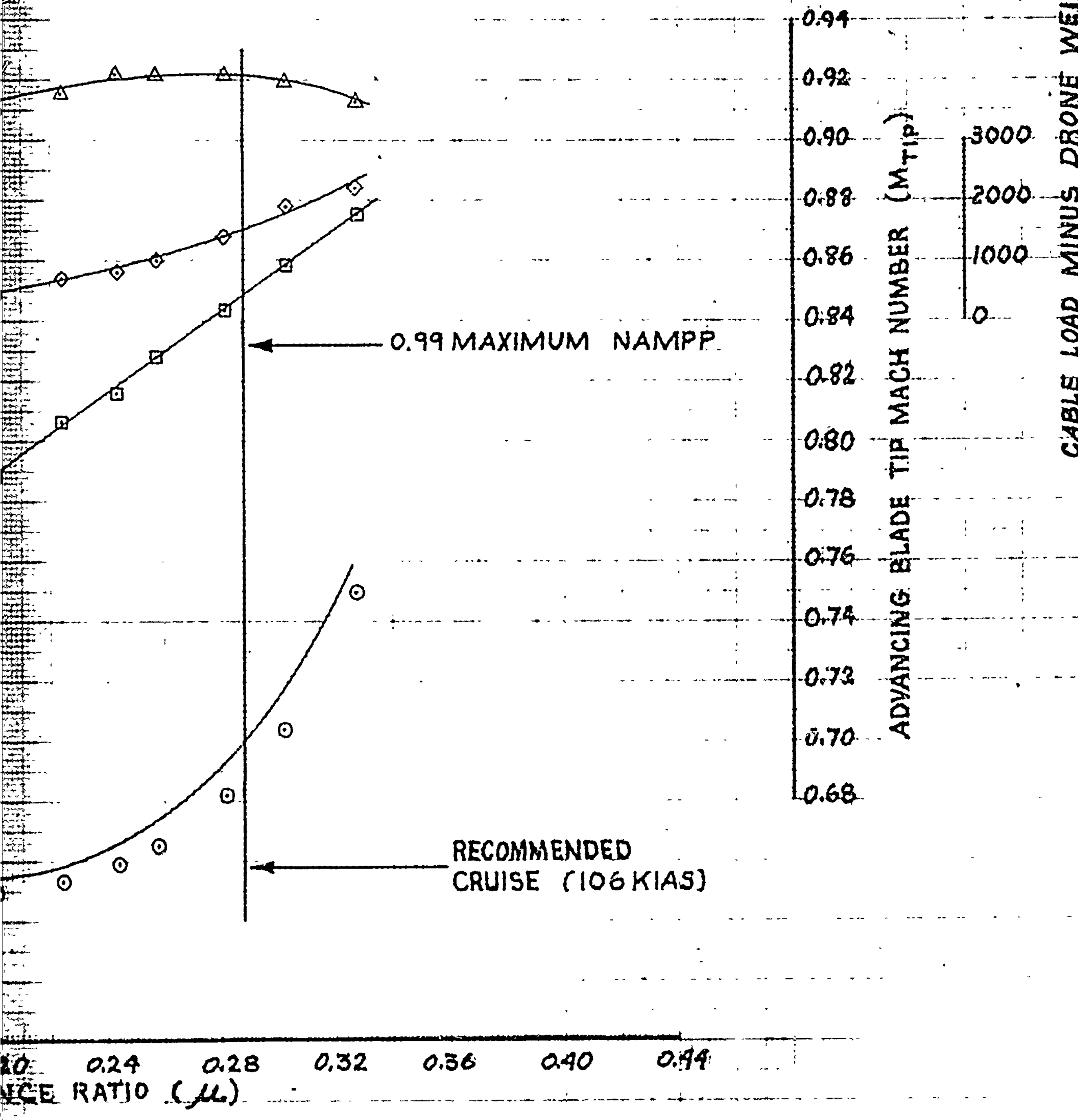


FIGURE 77. NONDIMENSIONAL LEVEL FLIG

USAF S/N 67-14993
NGINES ~ EAPS INSTALLED
S PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 7,900
AVG. FREE AIR TEMP. (DEG. C) = 12.5
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 34,500
AVG. CG LOCATION (STA) = 339.9

L AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
SITION.



AL LEVEL FLIGHT PERFORMANCE (AQM-34R)

HH-53C USAF S/N 67
T64-GE-7 ENGINES ~ EAPS
MARS PERFORMA

AVG. C_T = 0.009083
AVG. GW/δ_a (LB) = 48,720
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 196.1
AVG. N_R (RPM) = 195.1

MARS-CONFIGURED, TWO 450-GAL. AUXILIAR
AQM-34R DRONE IN STOWED POSITION.

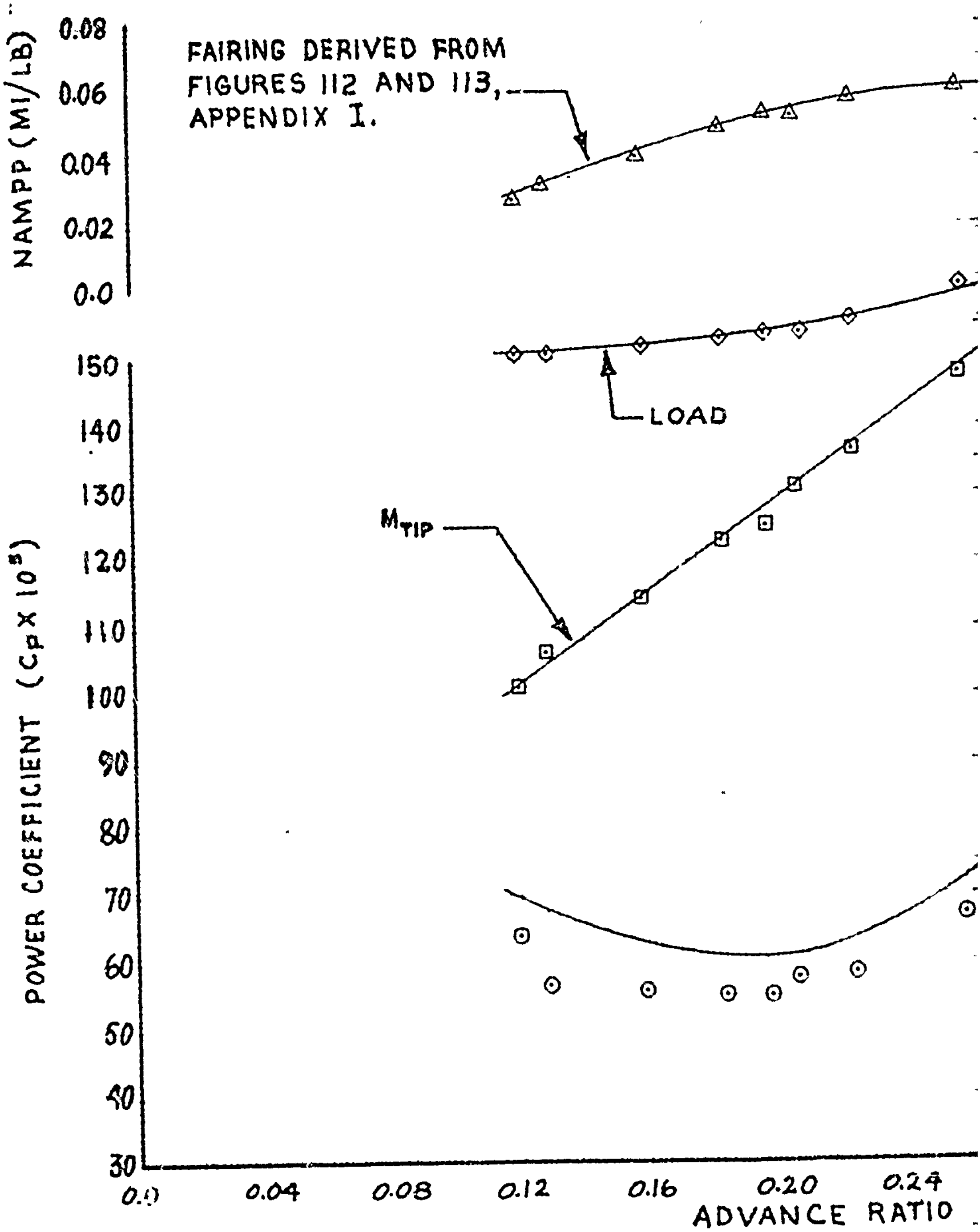
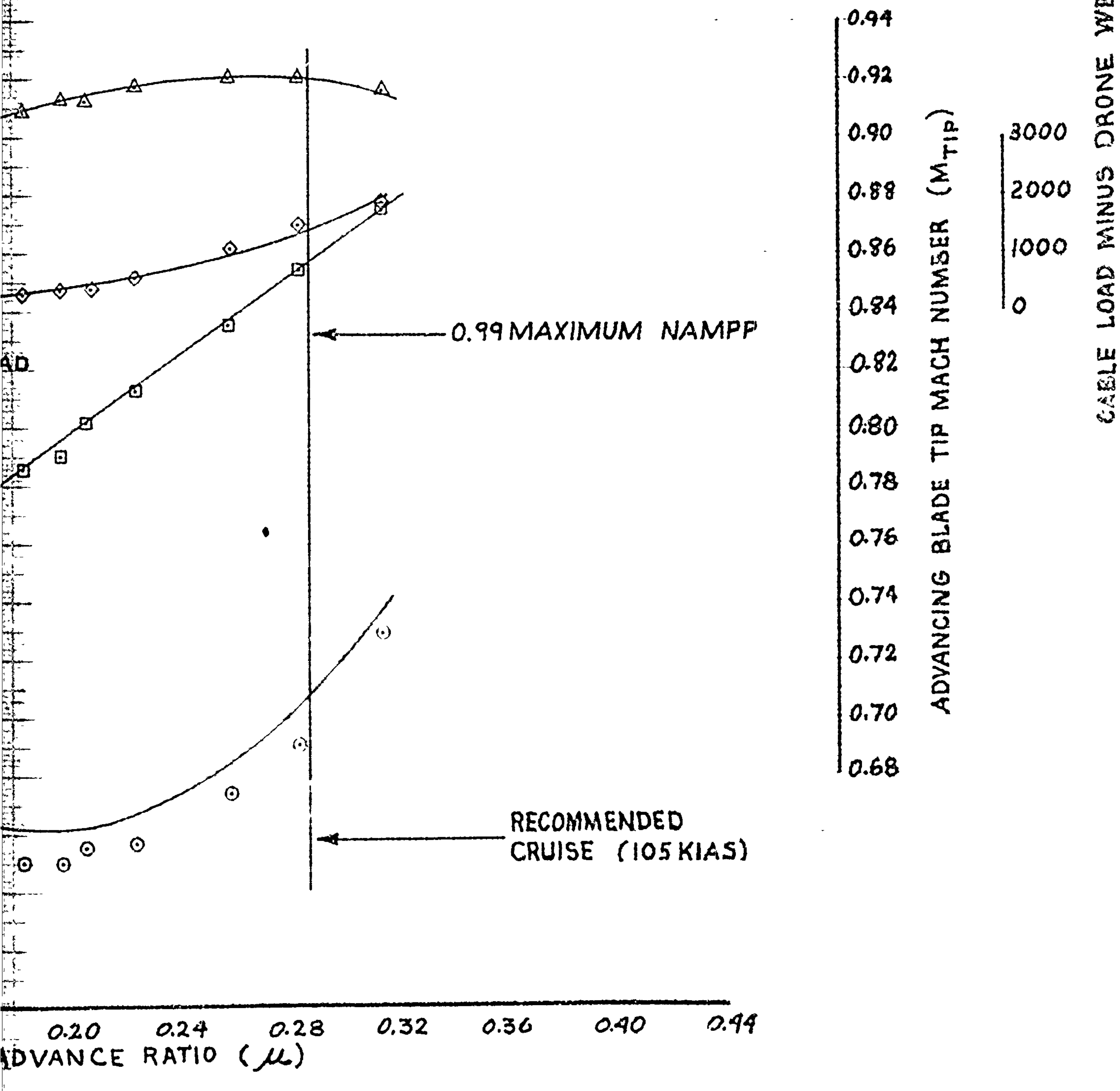


FIGURE 78. NONDIMENSIONAL LEVEL FL

H-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MAARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 8,650
AVG. FREE AIR TEMP. (DEG. C) = 12.0
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 35,300
AVG. CG LOCATION (STA) = 339.9

50-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
D POSITION.



ENSIONAL LEVEL FLIGHT PERFORMANCE (AQM-34R)

2

HH-53C USAF S/N 67-[
T64-GE-7 ENGINES ~ EAPS I
MARS PERFORMANC

AVG. C_T = 0.010817
AVG. GW/δ_a (LB) = 52,250
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 186.1
AVG. N_R (RPM) = 185.5

MARS-CONFIGURED, TWO 450-GAL. AUXILIARY FU
AQM-34R DRONE IN STOWED POSITION.

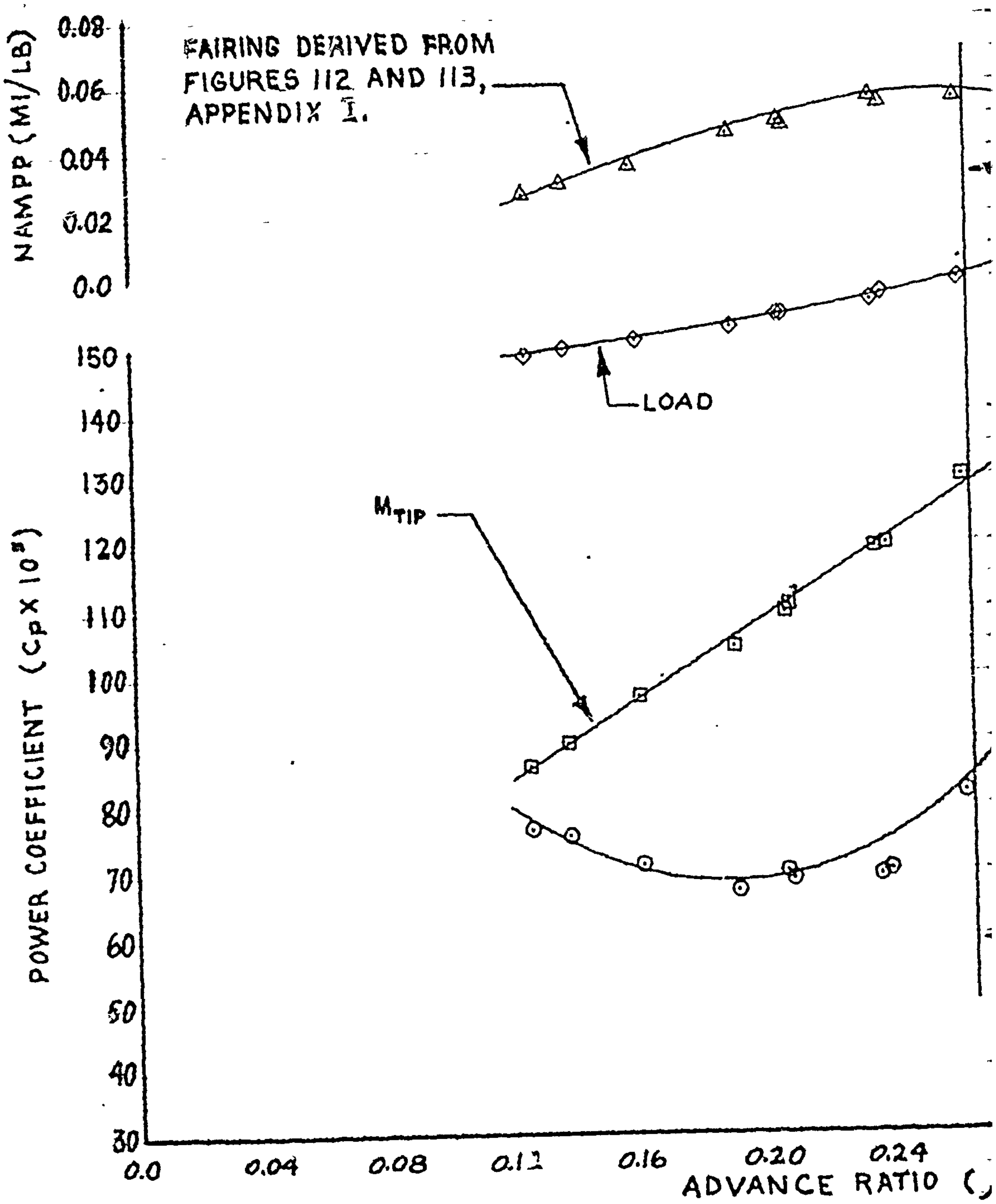
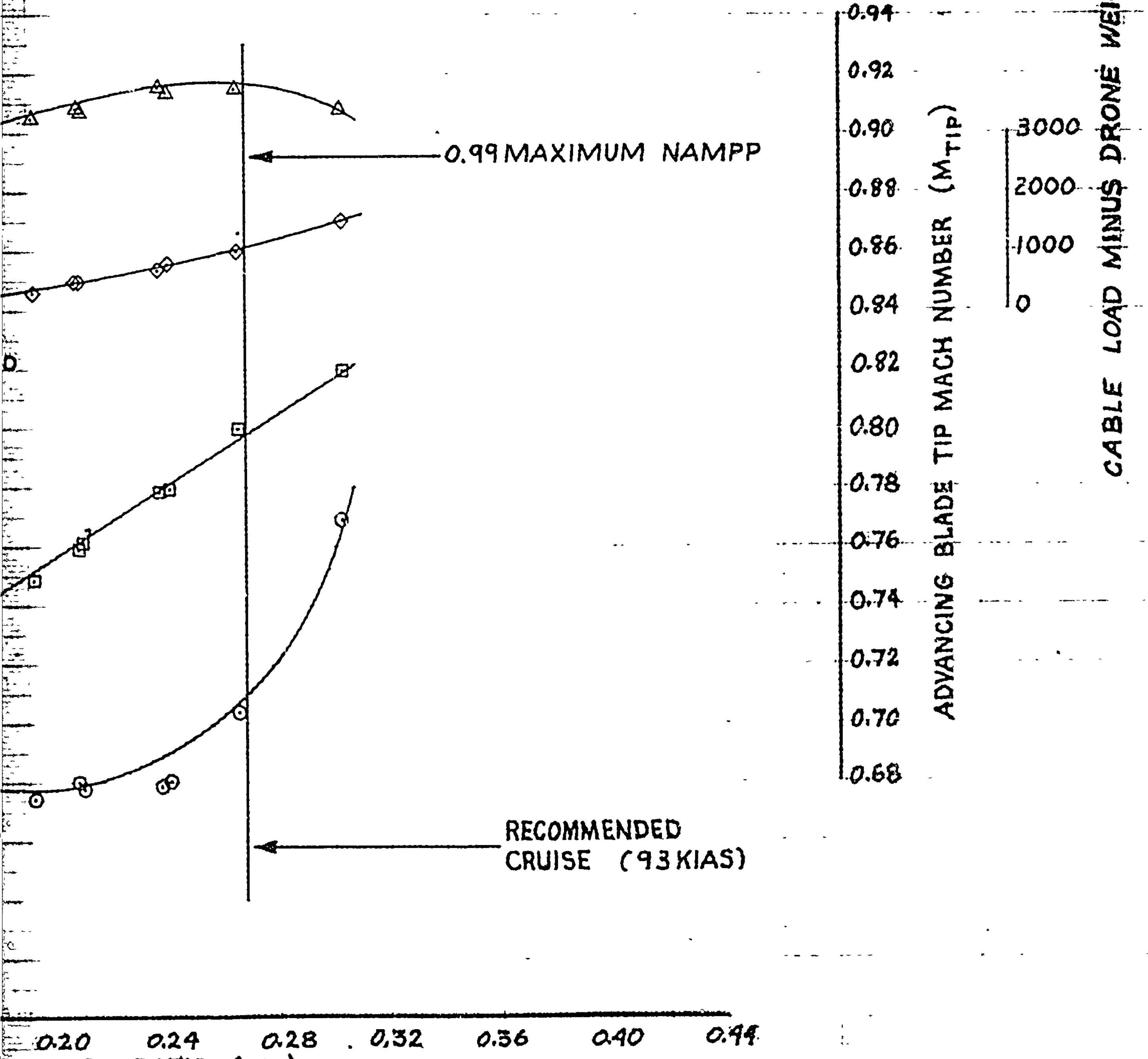


FIGURE 79. NONDIMENSIONAL LEVEL FLIG

-53C USAF S/N 67-14993
F-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 8,070
AVG. FREE AIR TEMP. (DEG. C) = 13.0
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 38,700
AVG. CG LOCATION (STA) = 338.7

0-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
D POSITION.



NSIONAL LEVEL FLIGHT PERFORMANCE (AQM-34R)

HH-53C USAF S/N 6
T64-GE-7 ENGINES ~ EAP
MARS PERFORM

AVG. C_T = 0.010894
AVG. GW/δ_a (LB) = 54,850
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 190.0
AVG. N_R (RPM) = 189.1

MARS-CONFIGURED, TWO 450-GAL. AUXILIARY
AQM-34R DRONE IN STOWED POSITION.

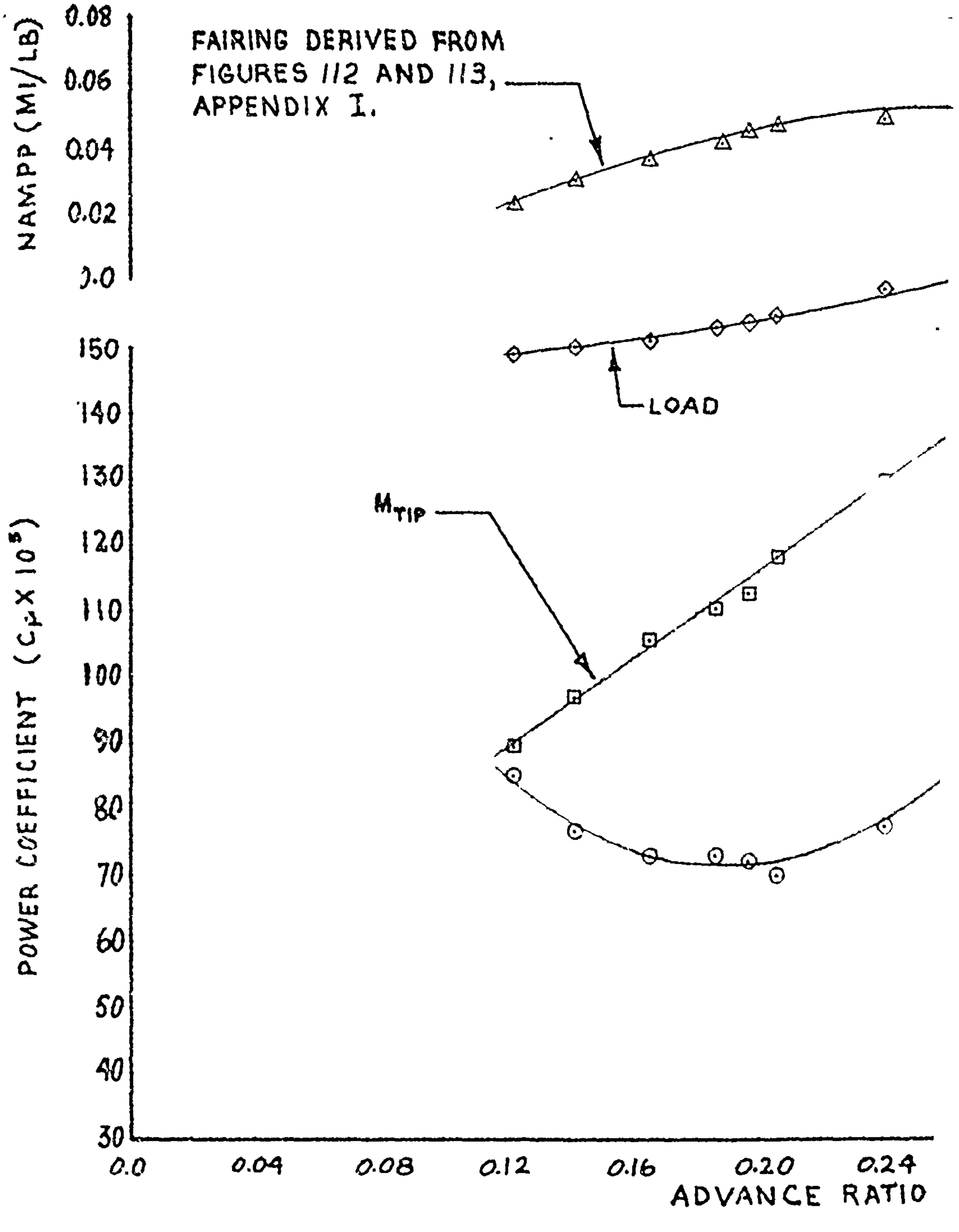
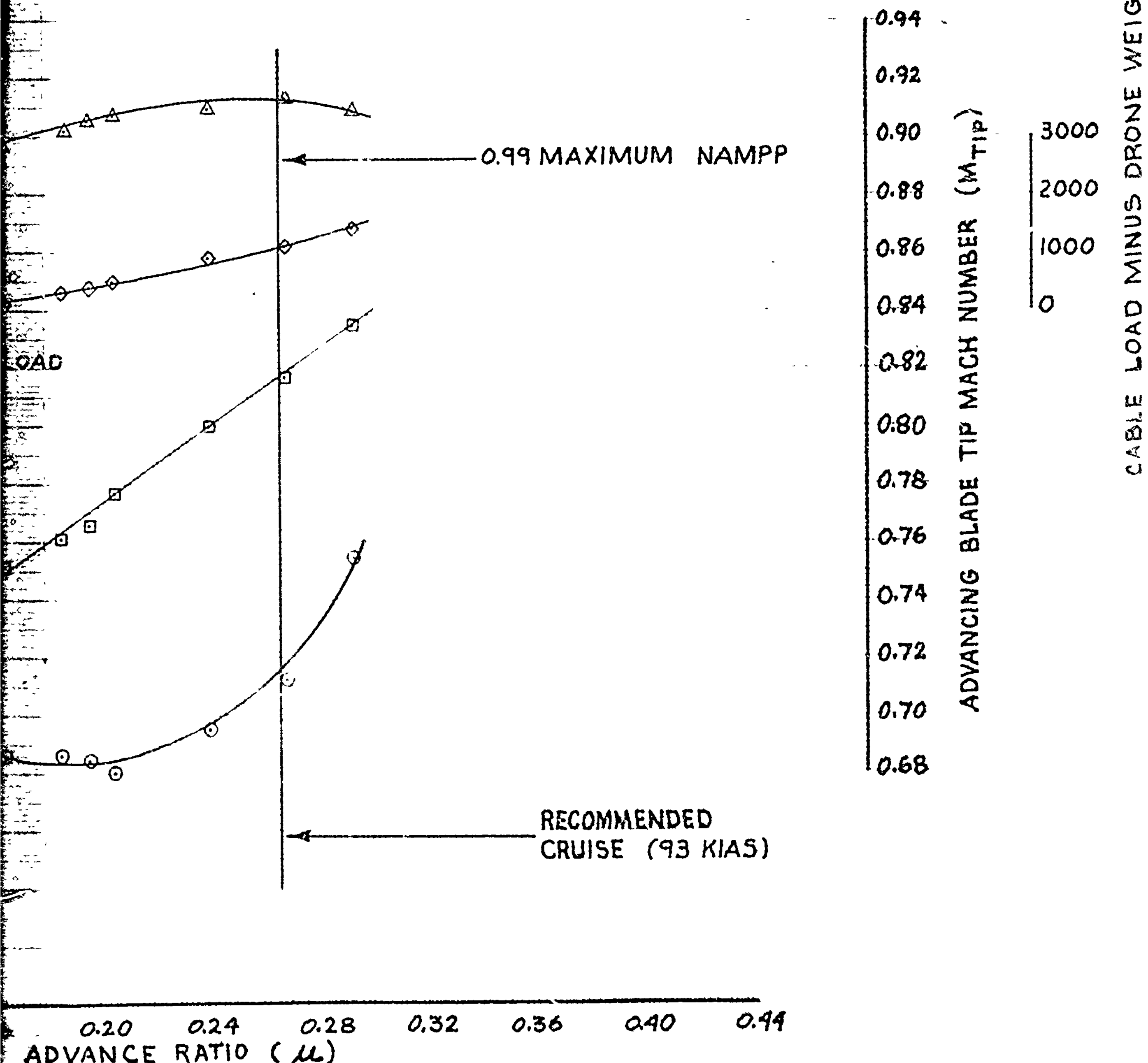


FIGURE 80. NONDIMENSIONAL LEVEL

HH-53C USAF S/N 67-14993
4-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 8,670
AVG. FREE AIR TEMP. (DEG. C) = 12.0
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 39,700
AVG. CG LOCATION (STA) = 339.5

450-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
VED POSITION.



MENSIONAL LEVEL FLIGHT PERFORMANCE (AQM-34R)

AVG. C_T = 0.00988
AVG. GW/δ_a (LB) = 57,980
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 194.5
AVG. N_R (RPM) = 192.4

MARS-CONFIGURED, TWO 450-GAL. AUXILIARY
AQM-34R DRONE IN STOWED POSITION.

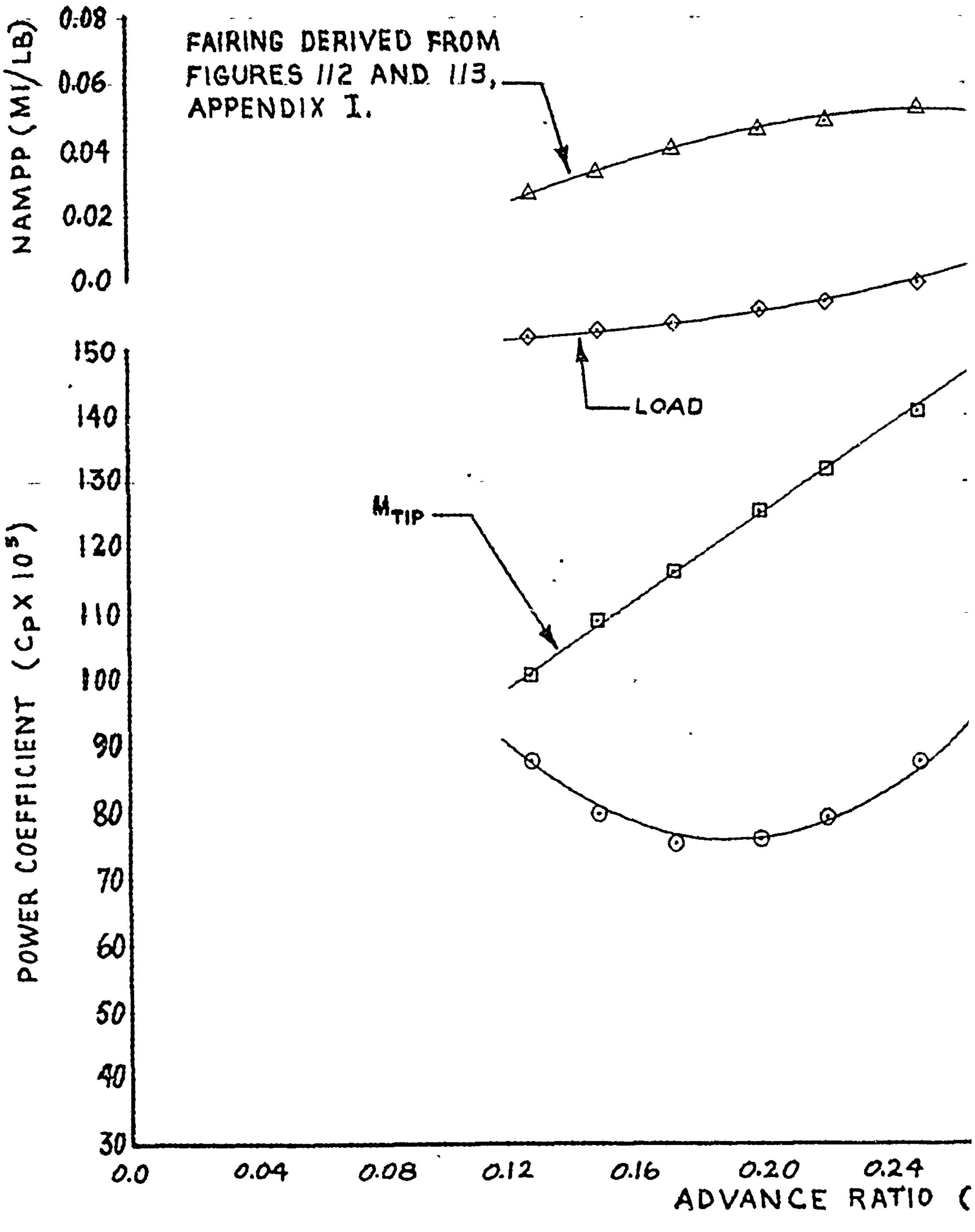
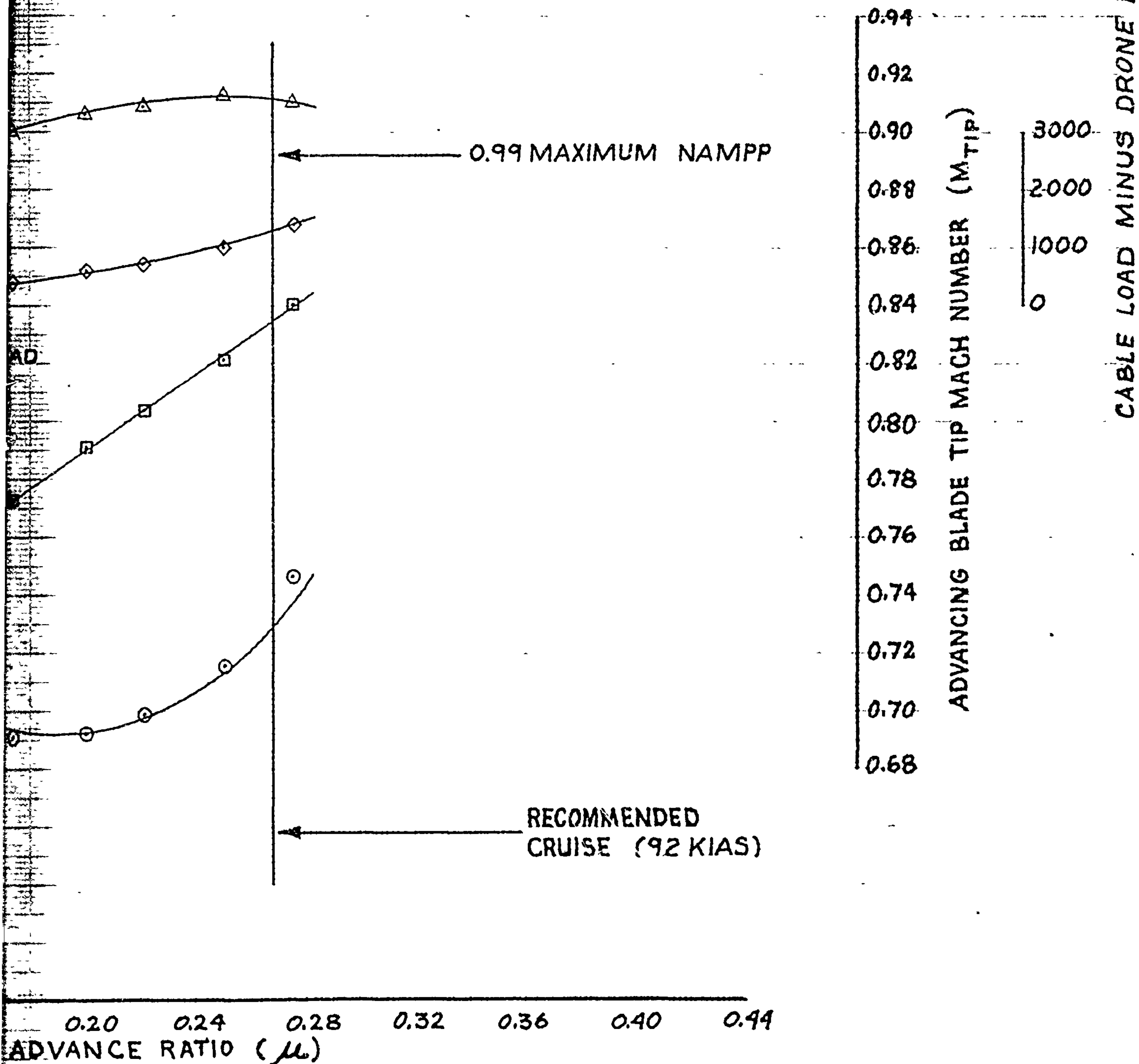


FIGURE 81. NONDIMENSIONAL LEVEL FL

HH-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 10,700
AVG. FREE AIR TEMP. (DEG. C) = 9.0
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 38,800
AVG. CG LOCATION (STA) = 339.6

50-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
ED POSITION.



ENSIONAL LEVEL FLIGHT PERFORMANCE (AQM-34R)

HH-53C USAF S
T64-GE-7 ENGINES ·
MARS PERF

AVG. C_T = 0.011306
AVG. GW/δ_a (LB) = 61,010
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 196.7
AVG. N_R (RPM) = 194.3

MARS-CONFIGURED, TWO 450-GAL. AUXILI
AQM-34R DRONE IN STOWED POSITION.

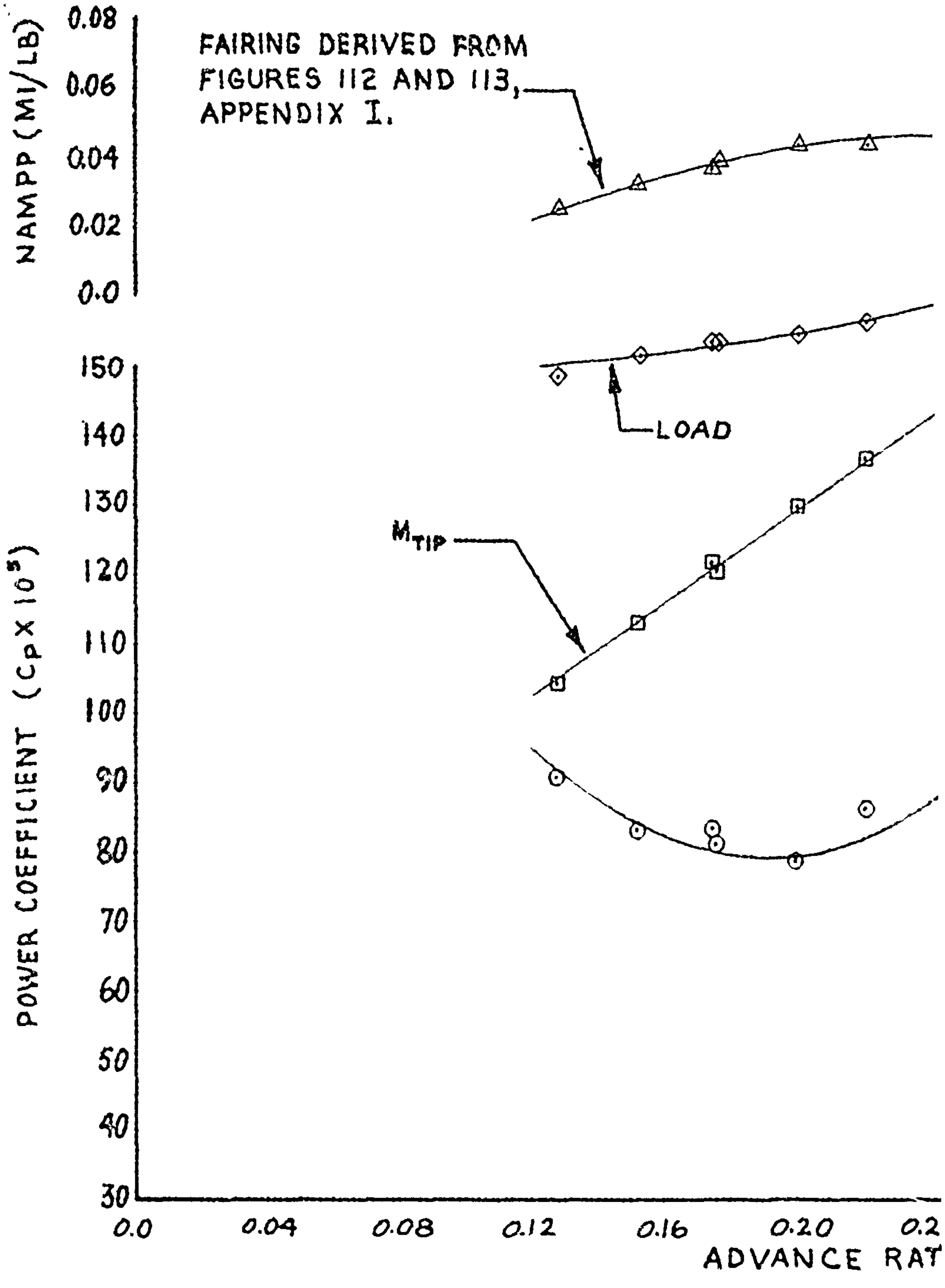
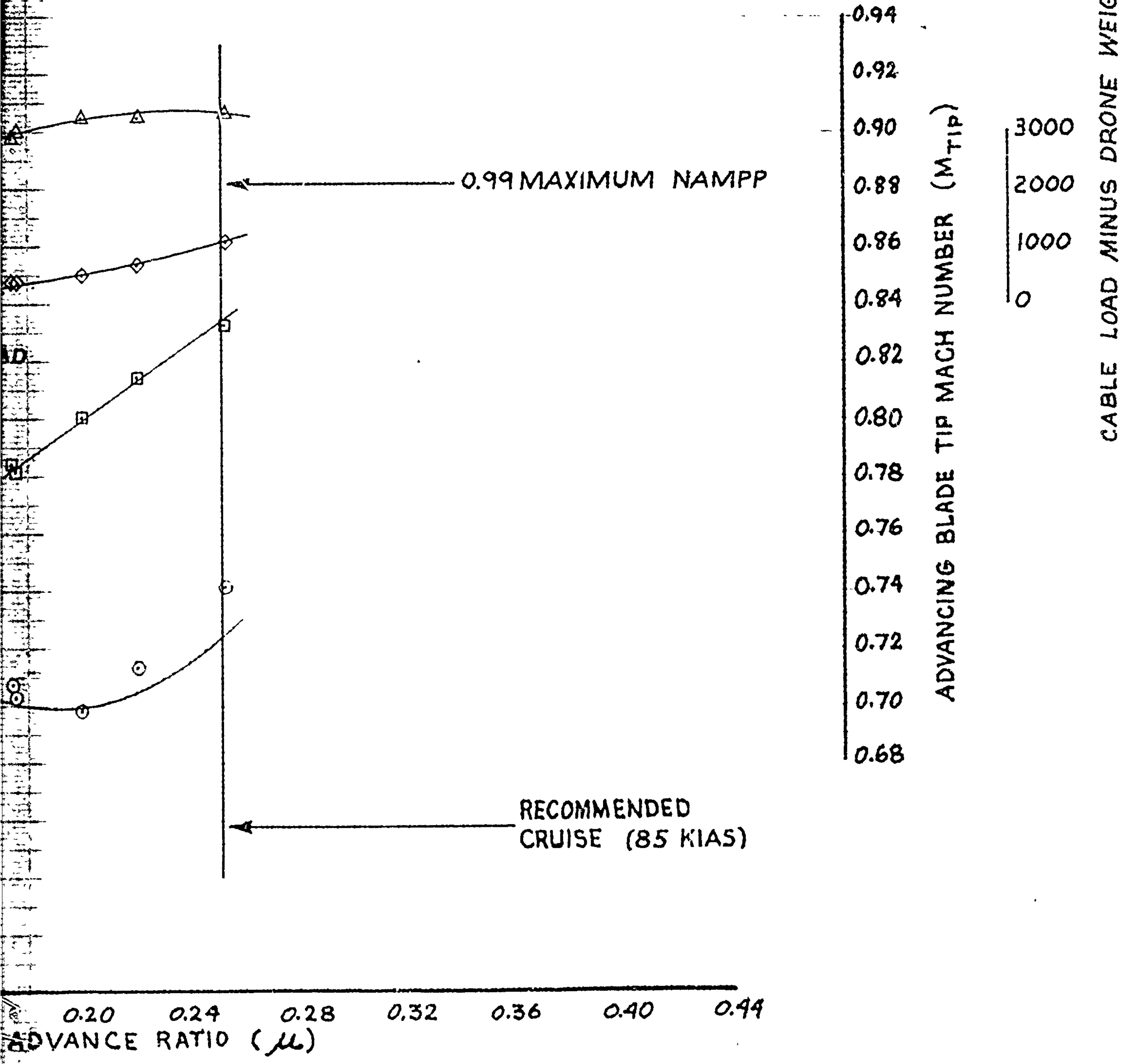


FIGURE 82. NONDIMENSIONAL LEVE

HH-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 11,475
AVG. FREE AIR TEMP. (DEG. C) = 8.0
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 39,600
AVG. CG LOCATION (STA) = 339.5

450-GAL AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
ED POSITION.



ENSIONAL LEVEL FLIGHT PERFORMANCE (AQM-34R)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 88 THROUGH 92, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-91A DRONE IN STOWED POSITION.

$C_T = 0.0080$

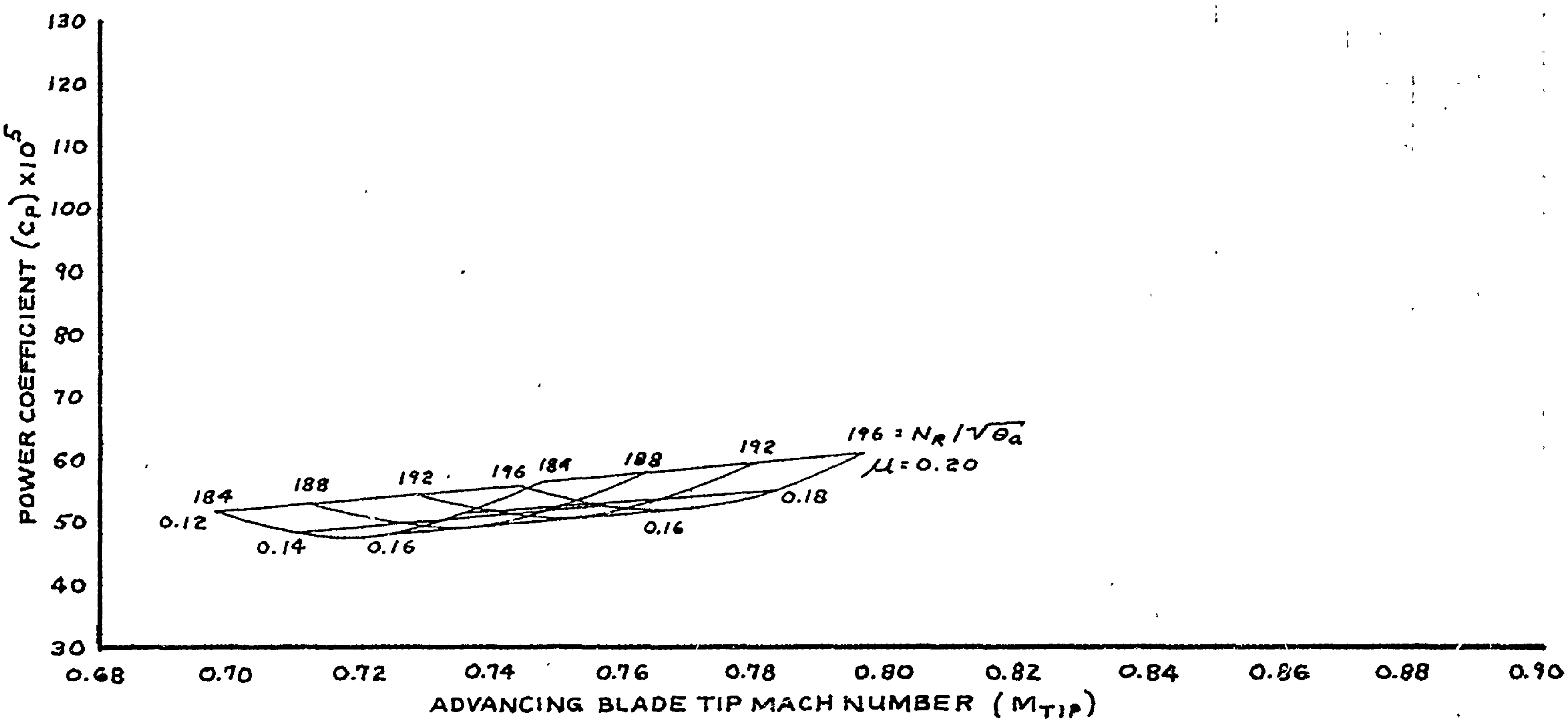


FIGURE 83. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-91A)

HH-53C USAF S/N 67-14993
TG4-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 88 THROUGH 92, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-91A DRONE IN STOWED POSITION.

$C_T = 0.0090$

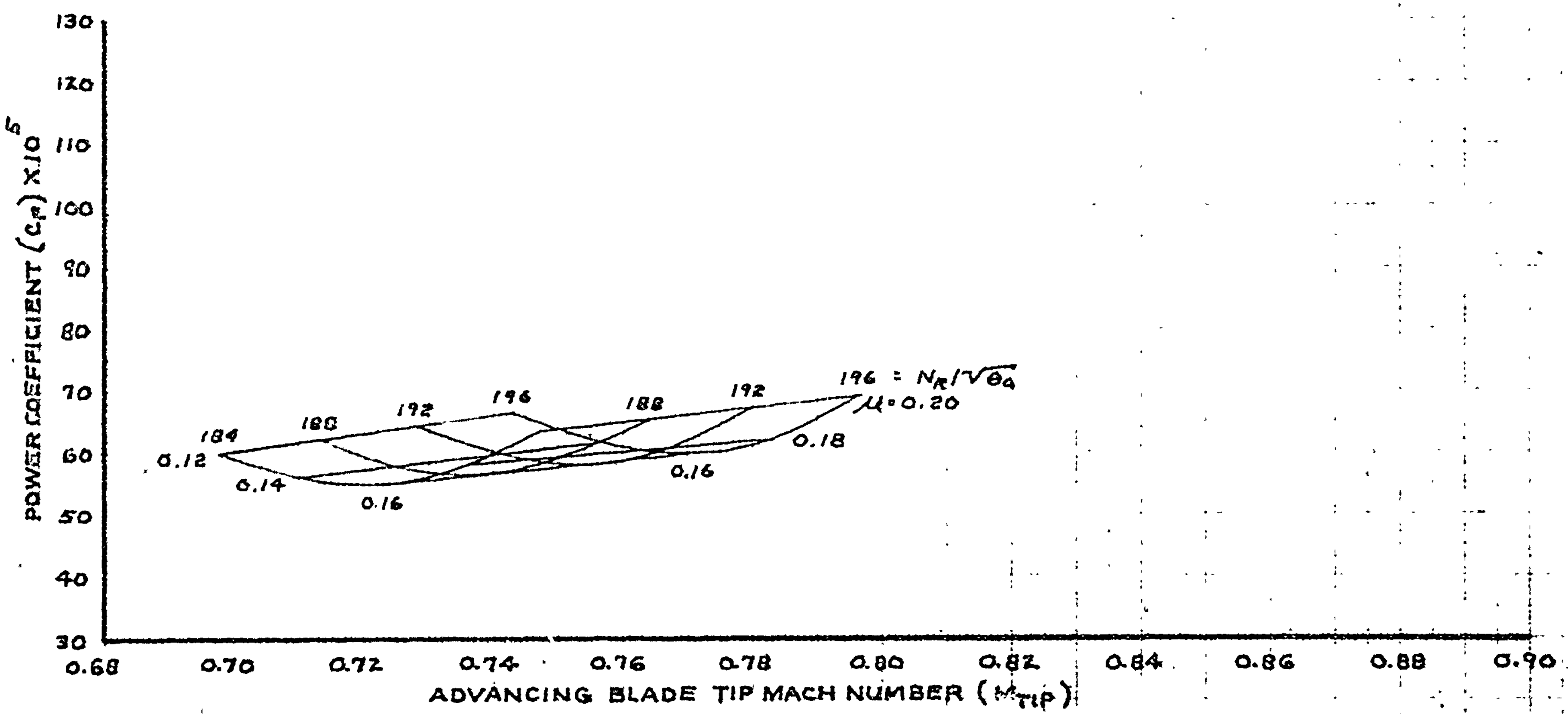


FIGURE 84 . LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-91A)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 88 THROUGH 92, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-91A DRONE IN STOWED POSITION.

$C_T = 0.0100$

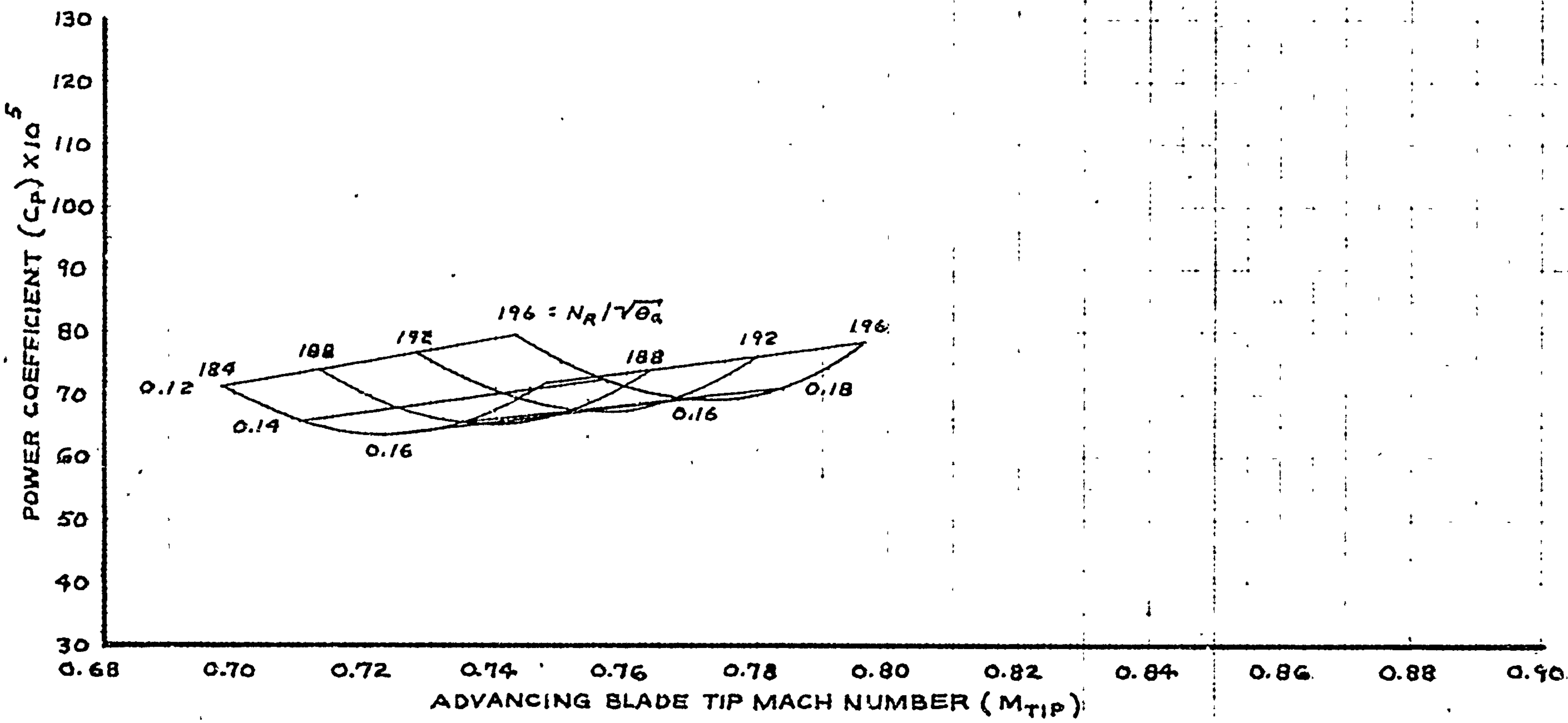


FIGURE 85. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-91A)

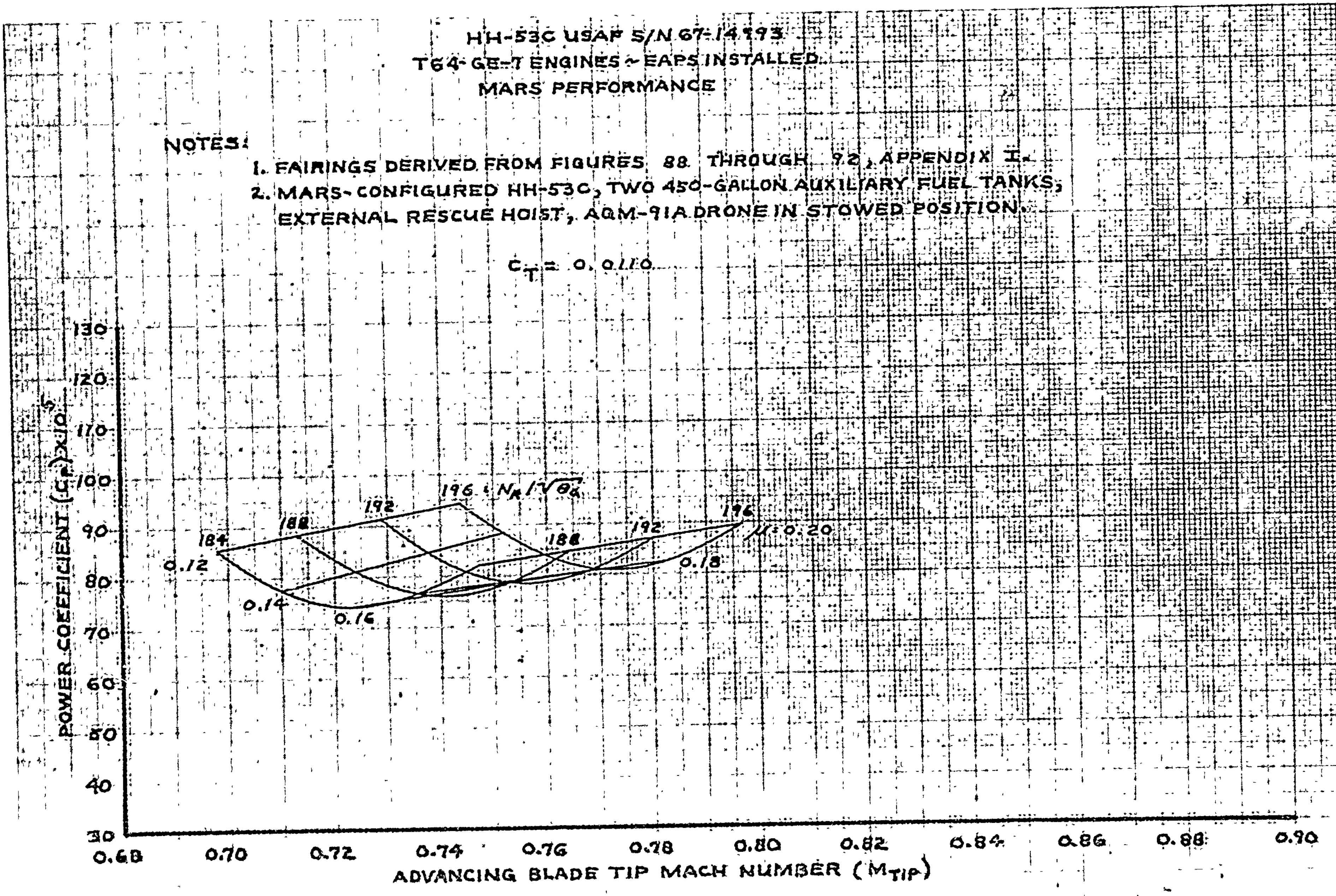


FIGURE 86. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-91A)

HH-53C USAF S/N 67-14993
T64-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 88 THROUGH 92, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-91A DRONE IN STOWED POSITION.

$C_T = 0.0115$

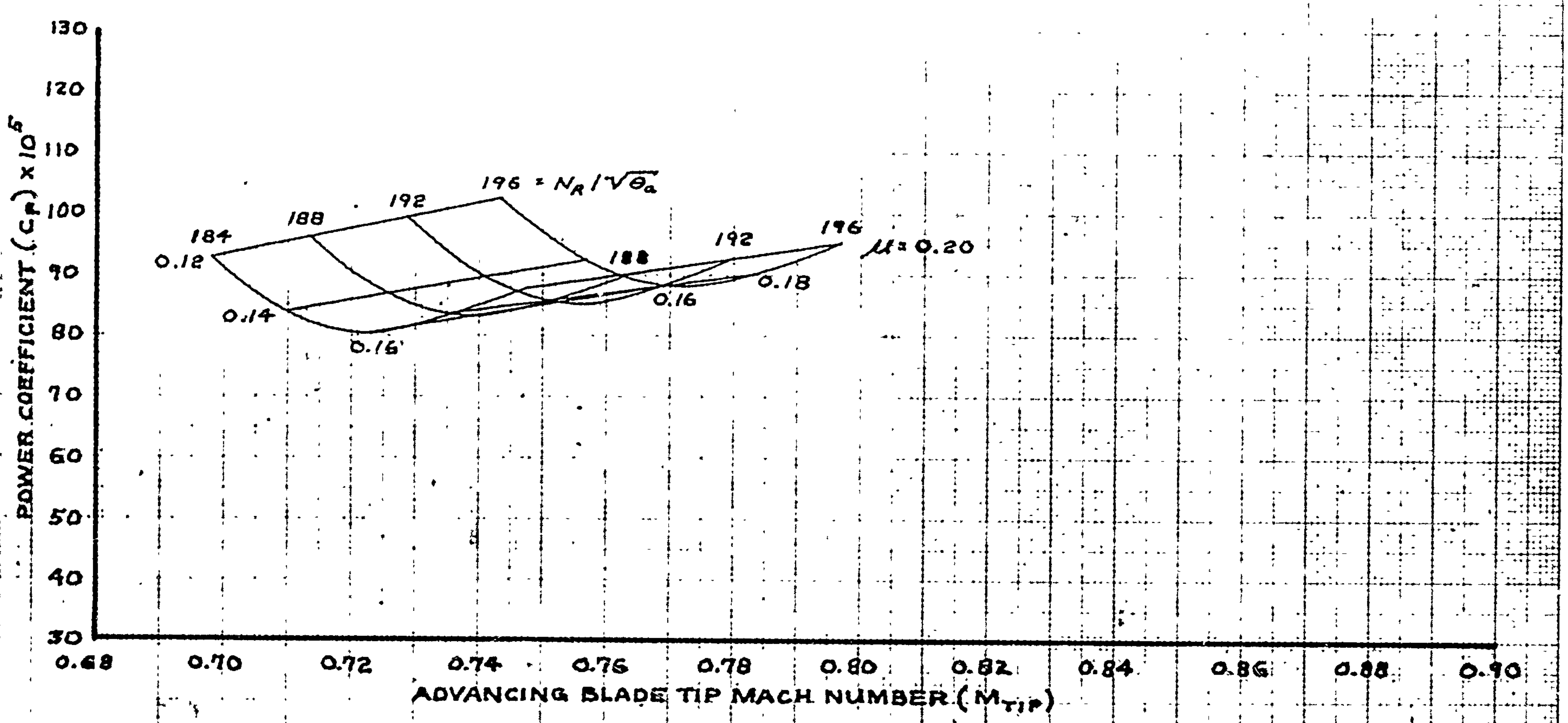


FIGURE 87 - LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-91A)

HH-53C USAF S/N 67-14993

T64-GE-7 ENGINES - EAPS INSTALLED

MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 93 THROUGH 107, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-91A DRONE IN STOWED POSITION.

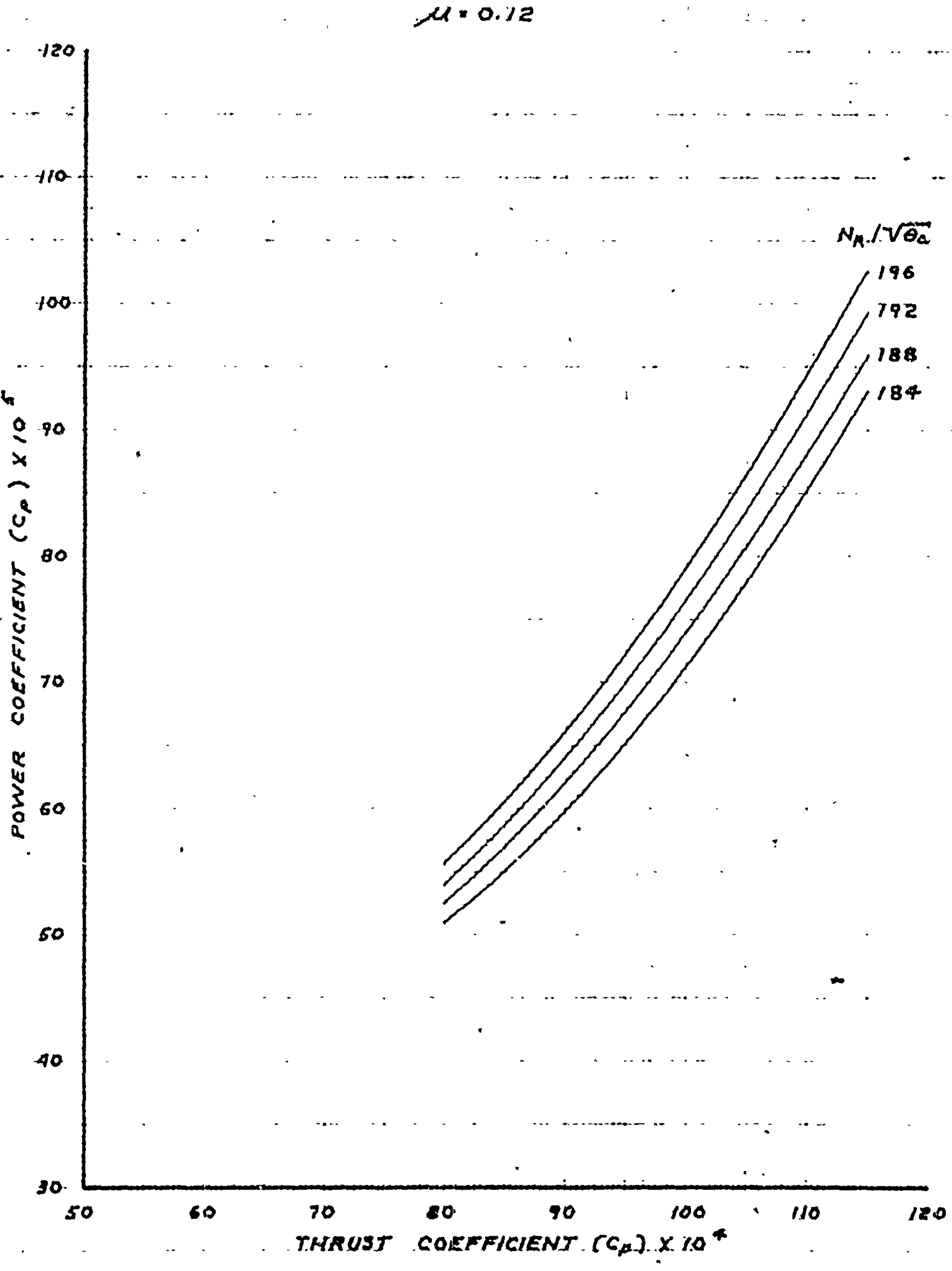


FIGURE 88. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-91A)

HH-53C USAF S/N 67-14993

T64-GE-7 ENGINE - EAPS INSTALLED

MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 93 THROUGH 107, APPENDIX I.

2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-91A DRONE IN STOWED POSITION.

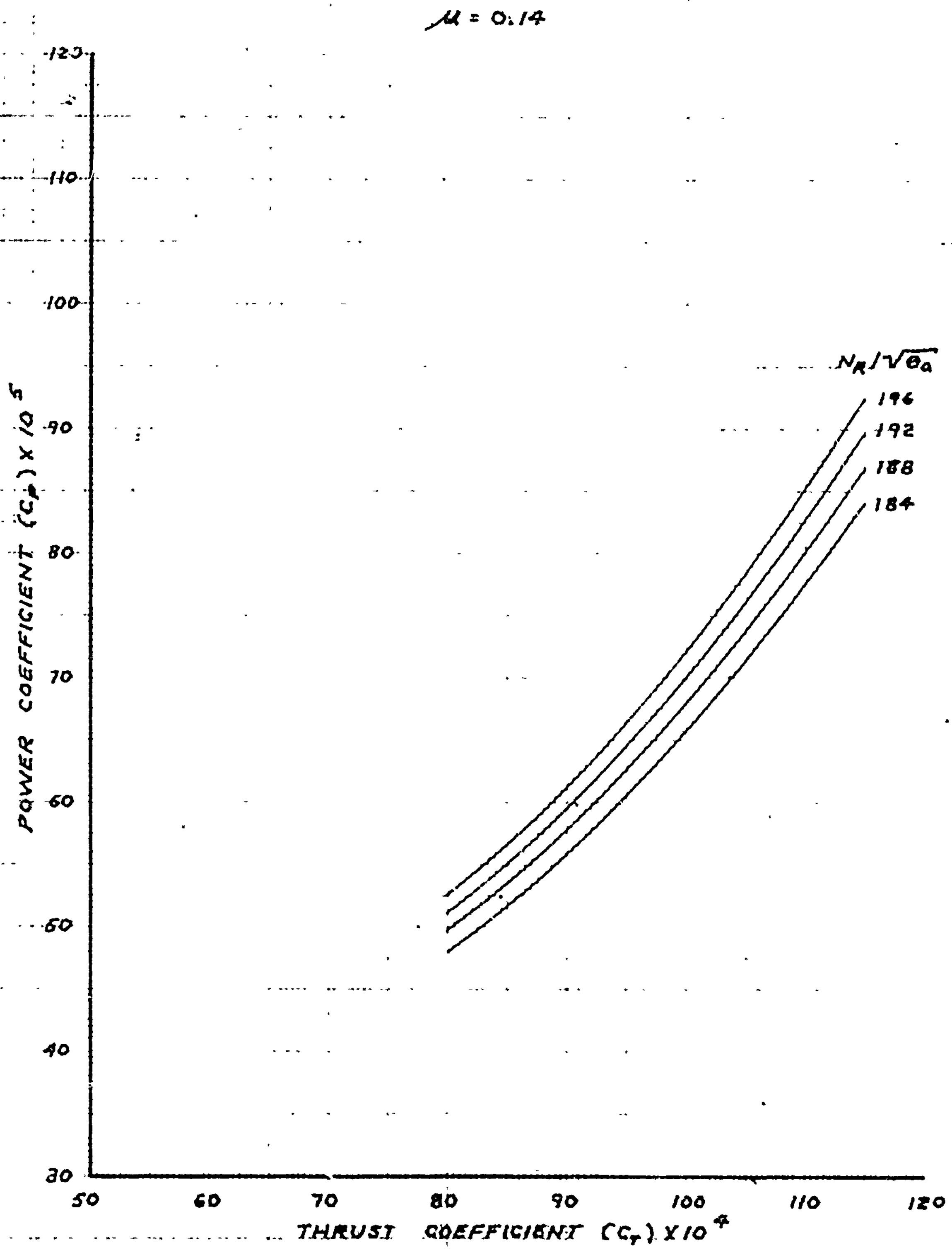


FIGURE 89. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-91A)

HH-53C USAF S/N 67-14993

T64-GE-7 ENGINES—EAPS INSTALLED

MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 93 THROUGH 107, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-91A DRONE IN STOWED POSITION.

$\mu = 0.16$

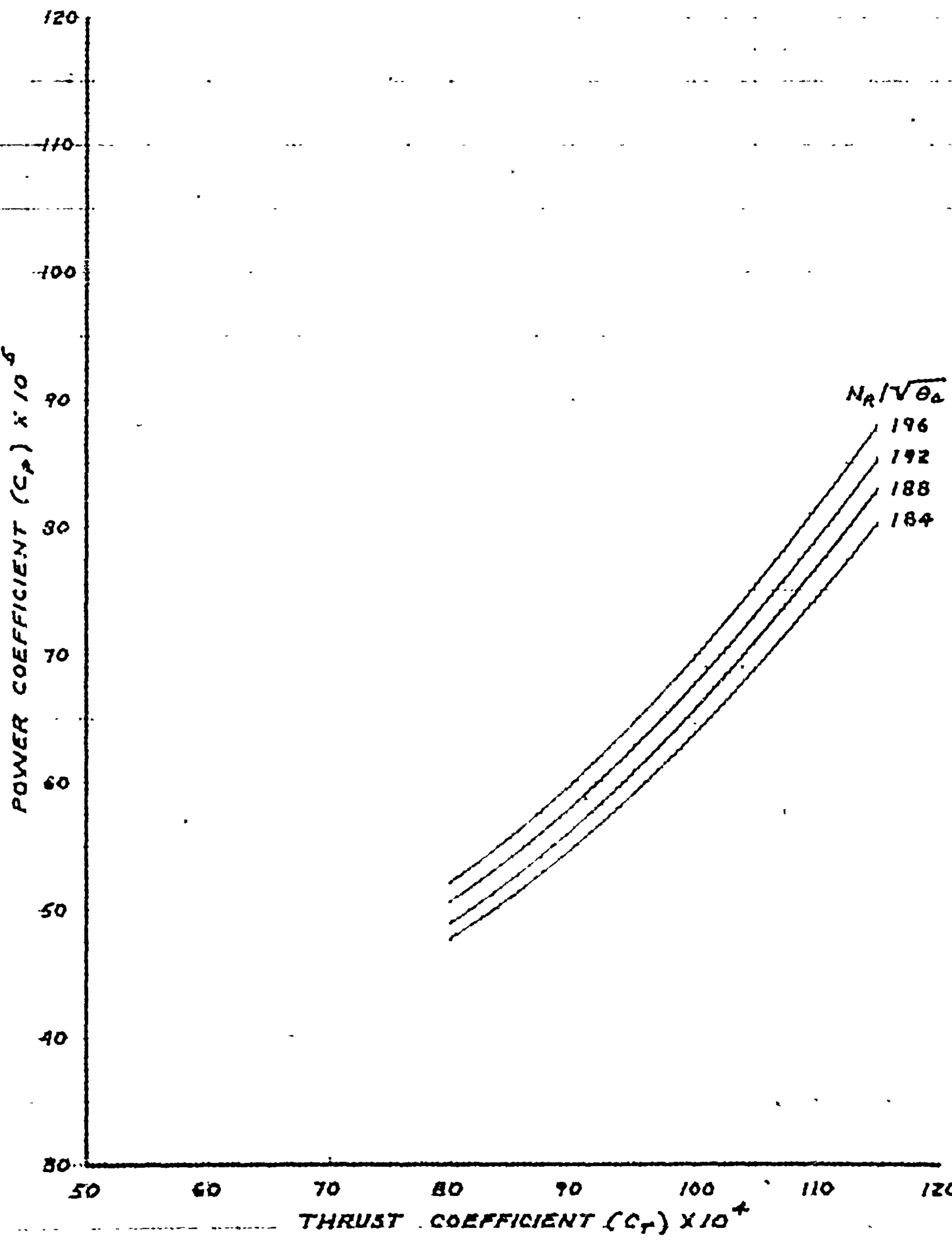


FIGURE 90. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-91A)

HH-53C USAF S/N 67-14993

T64-GE-7 ENGINES + EAPS INSTALLED

MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 93 THROUGH 107, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-91A DRONE IN STOWED POSITION.

$\mu = 0.18$

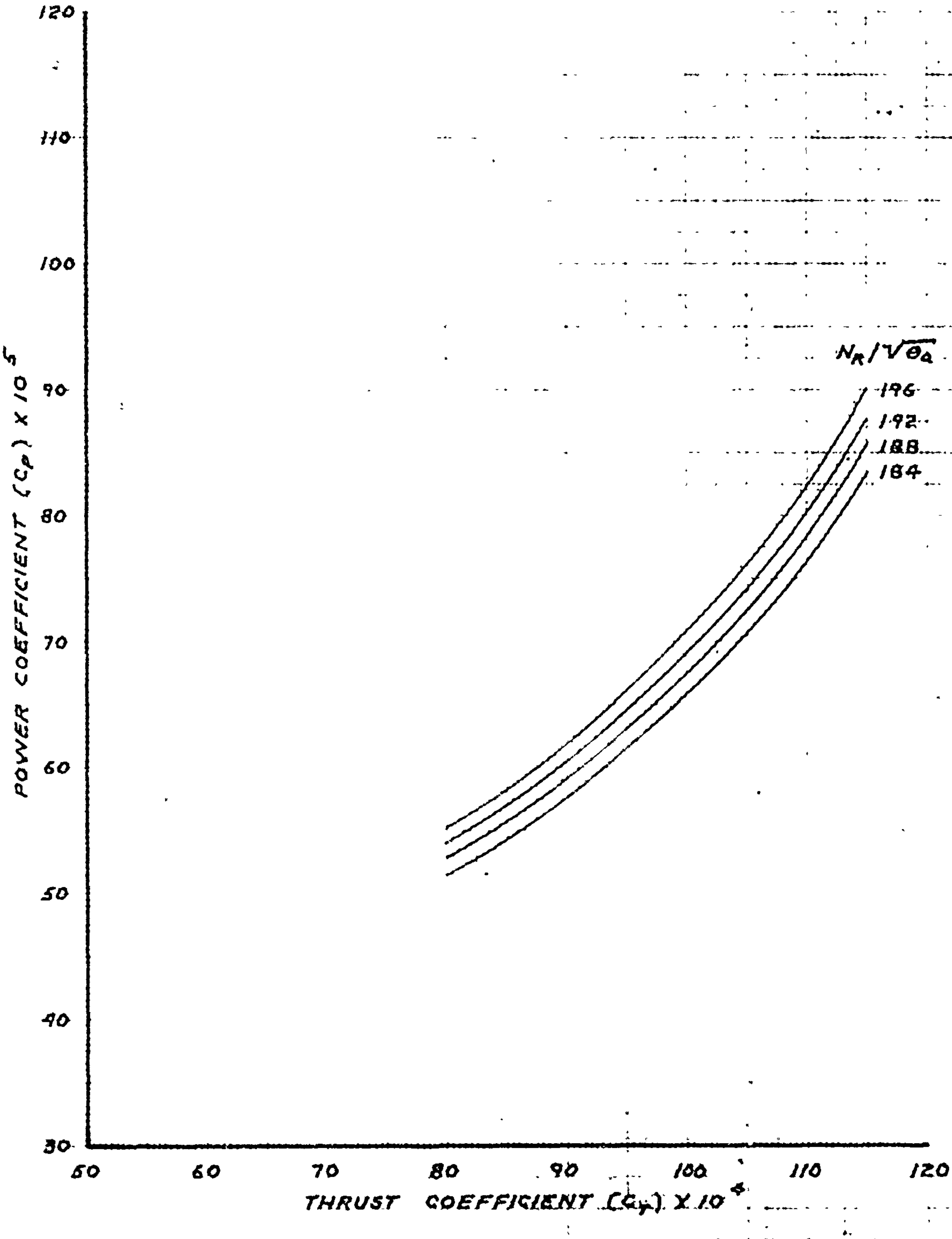


FIGURE 91. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-91A)

HH-53C USAF S/N 67-14993

T64-GE-7 ENGINES ~ EAPS INSTALLED

MARS PERFORMANCE

NOTES:

1. FAIRINGS DERIVED FROM FIGURES 93 THROUGH 107, APPENDIX I.
2. MARS-CONFIGURED HH-53C, TWO 450-GALLON AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST, AQM-91A DRONE IN STOWED POSITION.

$\mu = 0.20$

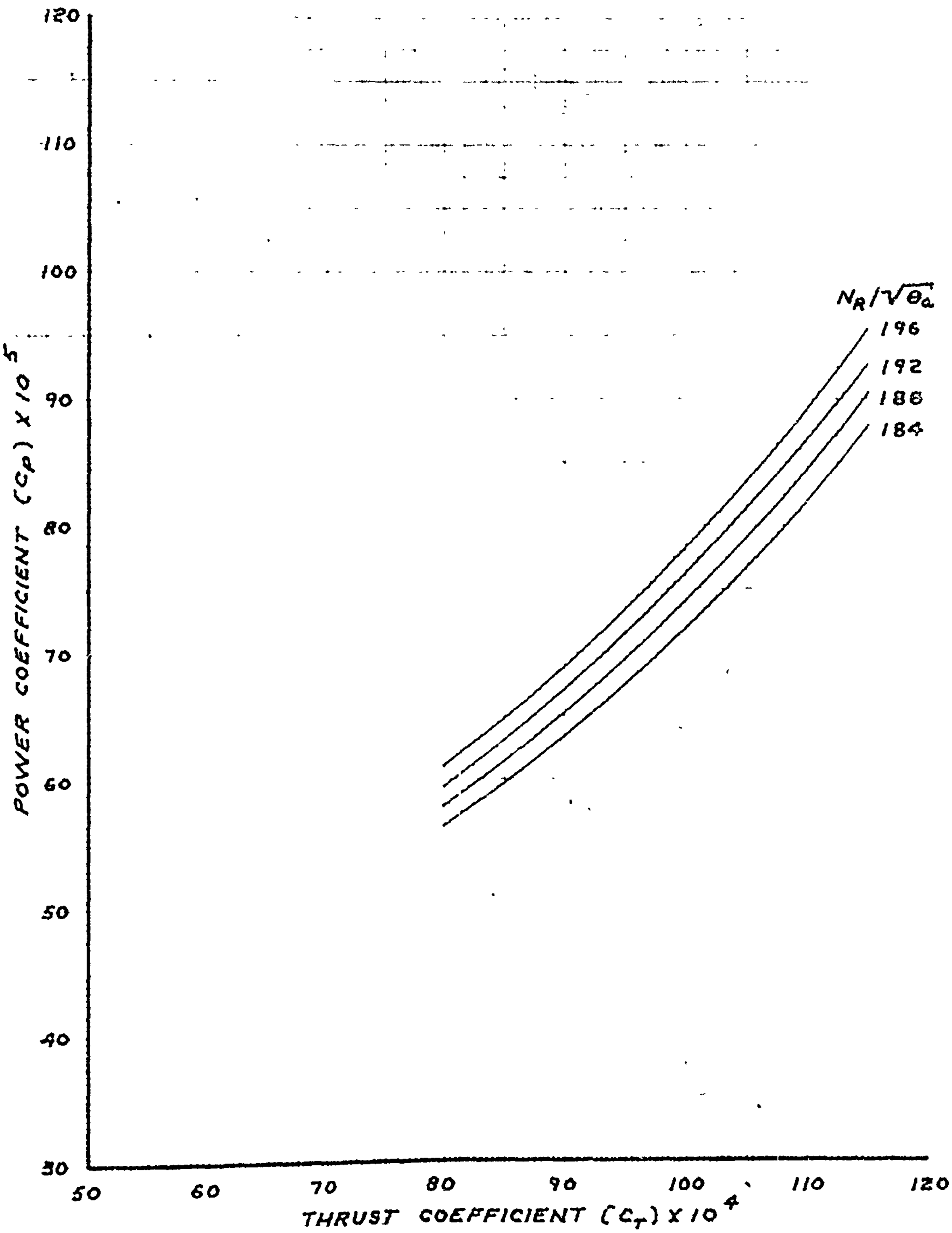


FIGURE 92. LEVEL FLIGHT PERFORMANCE SUMMARY (AQM-91A)

HH-53C USAF S/N 67-
T64-GE-7 ENGINES ~ EAPS
MARS PERFORMANC

AVG. C_T = 0.007760
AVG. GW/δ_a (LB) = 38,460
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 188.5
AVG. N_R (RPM) = 188.3

MARS-CONFIGURED, TWO 450-GAL. AUXILIARY FU
AQM-91A DRONE IN STOWED POSITION.

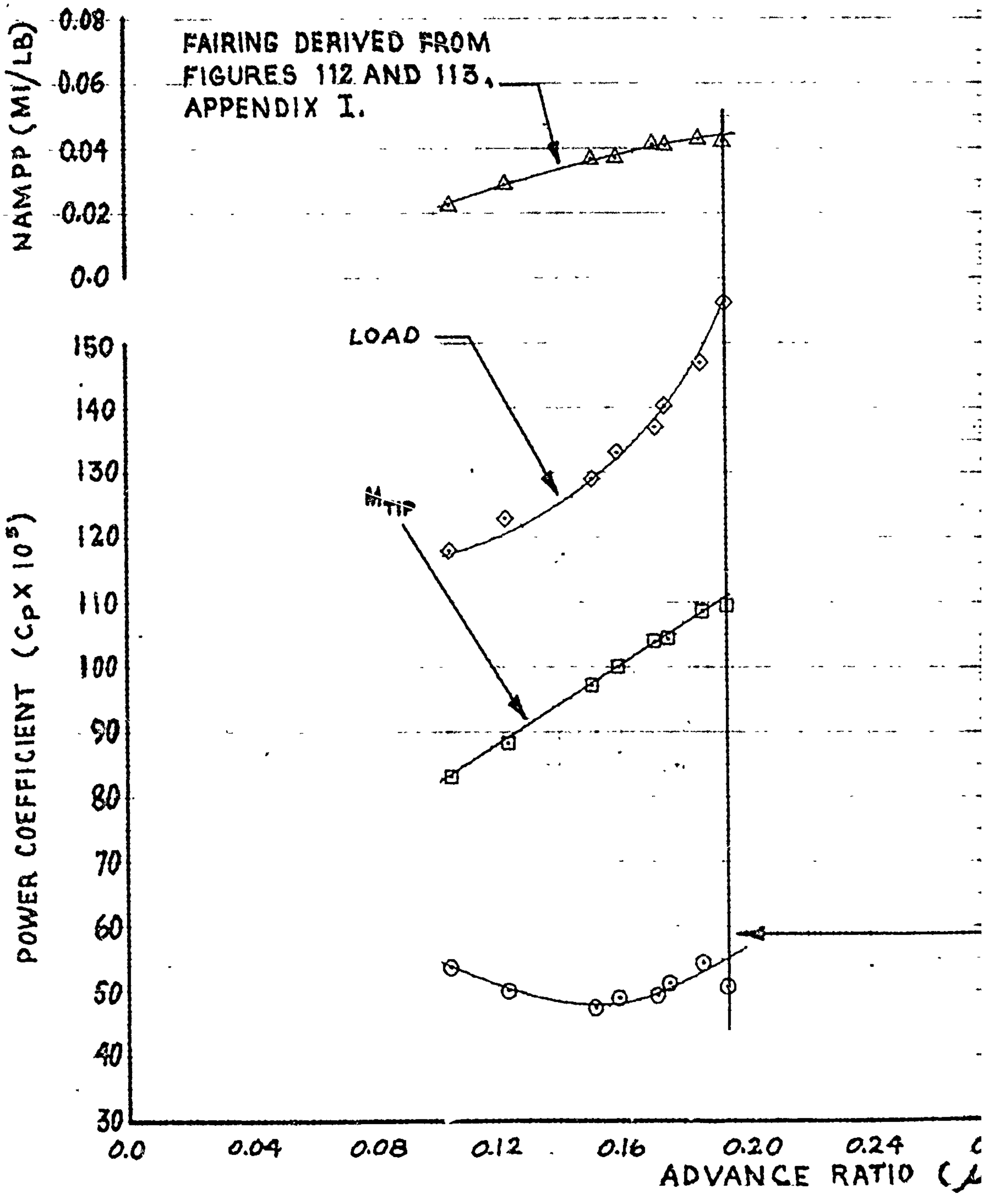
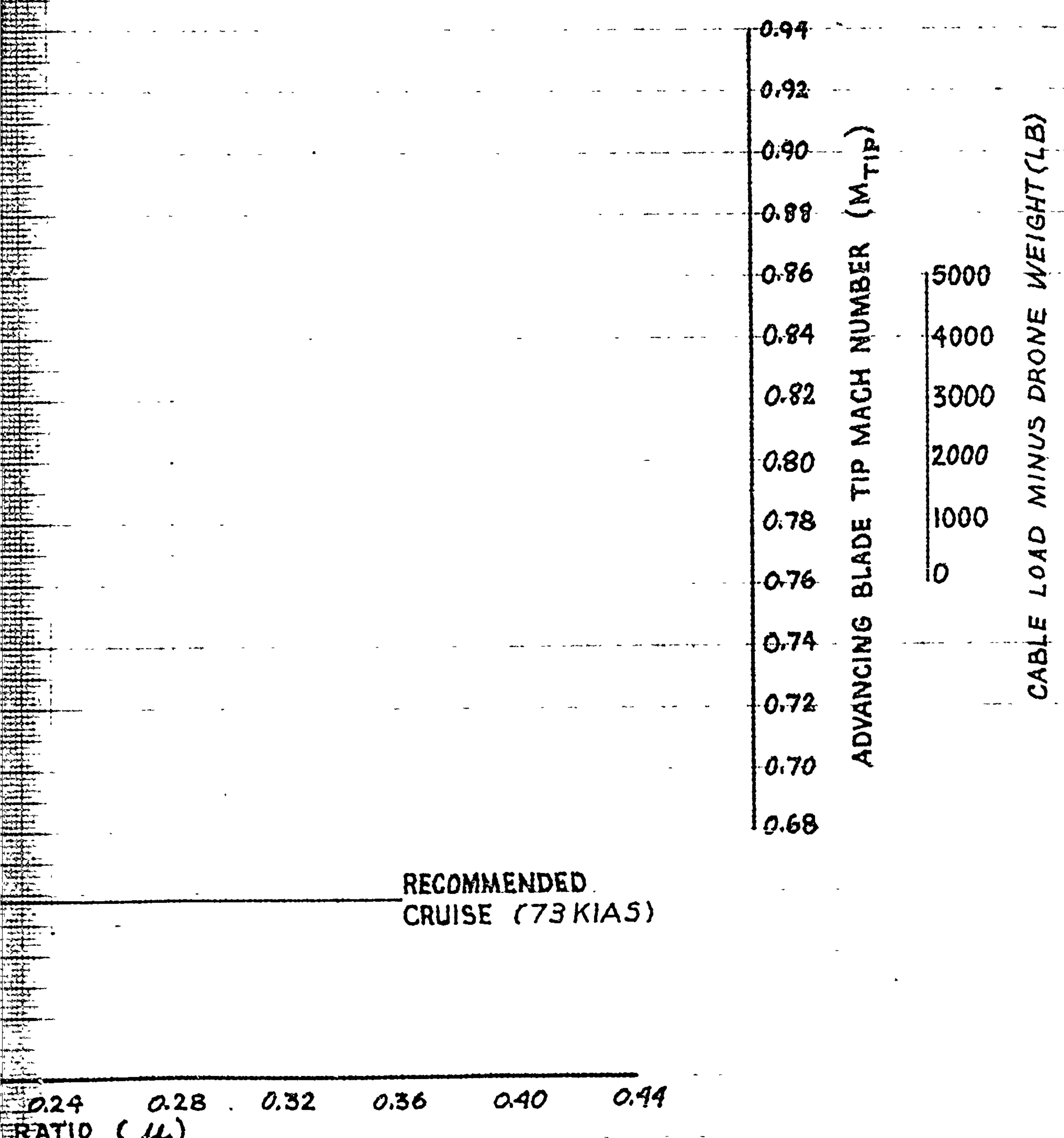


FIGURE 93 NONDIMENSIONAL LEVEL FLIGH

S/N 67-14993
S ~ EAPS INSTALLED
RFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 2,890
AVG. FREE AIR TEMP. (DEG. C) = 14.5
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 34,610
AVG. C.G. LOCATION (STA) = 338.8

XILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
IN.



LEVEL FLIGHT PERFORMANCE (AQM-91A)

HH-53C USAF S/N 67
T64-GE-7 ENGINES ~ EAPS
MARS PERFORMA

AVG. C_T = 0.007802
AVG. GW/δ_a (LB) = 40,450
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 192.9
AVG. N_R (RPM) = 193.1

MARS-CONFIGURED, TWO 450-GAL. AUXILIARY
AQM-91A DRONE IN STOWED POSITION.

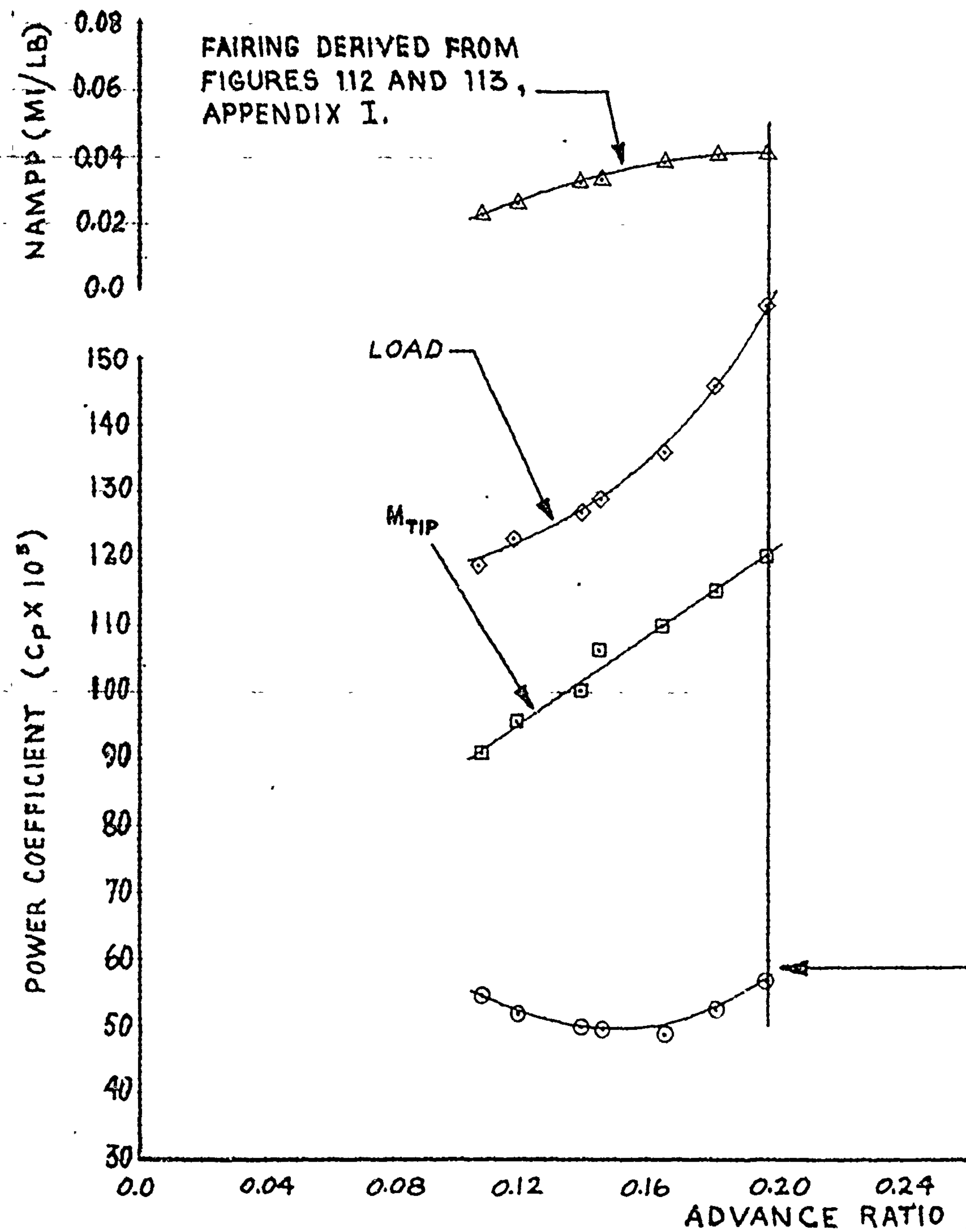
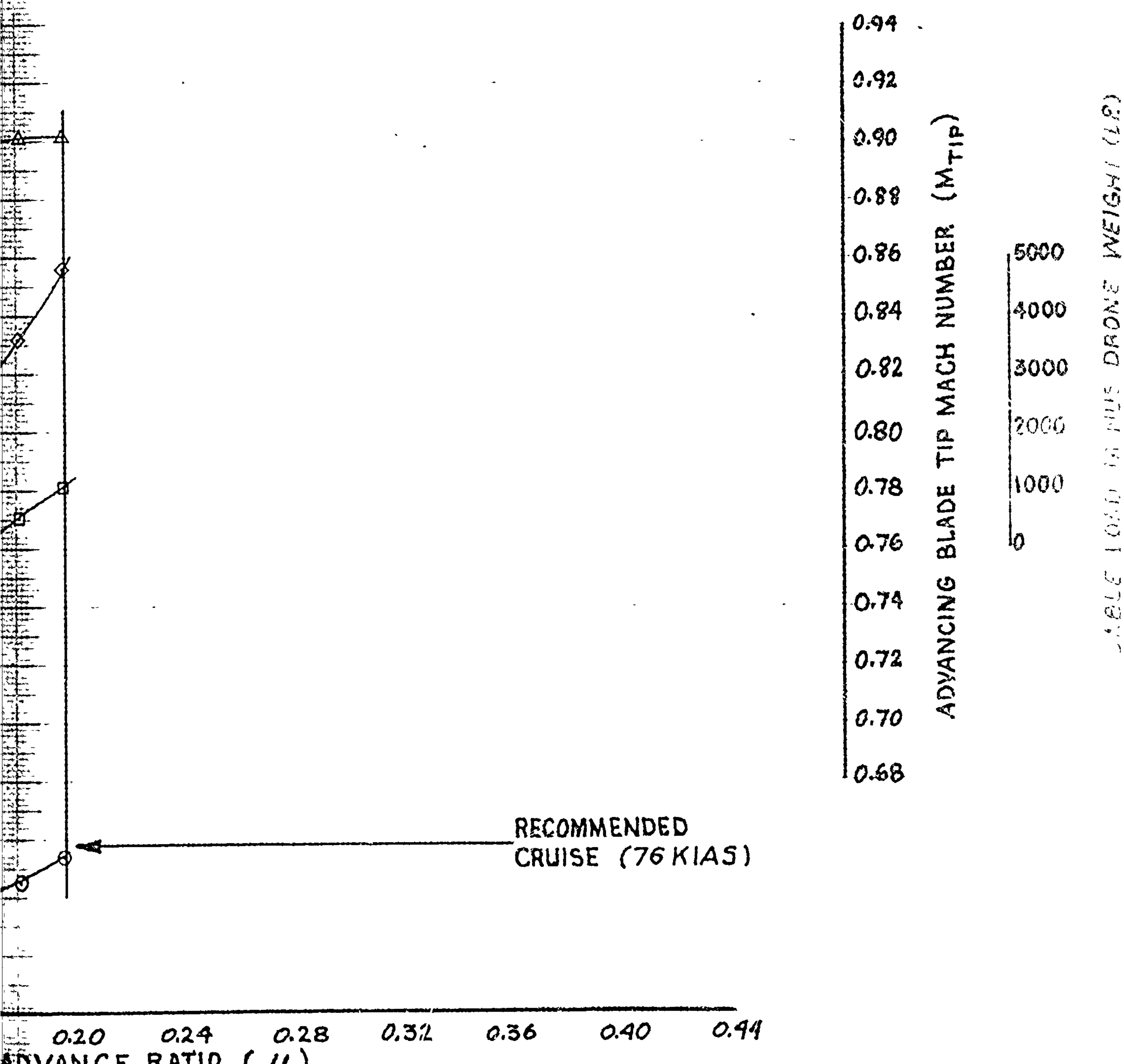


FIGURE 94 NONDIMENSIONAL LEVEL FL

H-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 3,090
AVG. FREE AIR TEMP. (DEG. C) = 15.5
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 36,170
AVG. CG LOCATION (STA) = 338.9

150-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
ED POSITION.



ENSIONAL LEVEL FLIGHT PERFORMANCE (AQM-91A)

HH-53C USAF S/N 67
T64-GE-7 ENGINES ~ EAPS
MARS PERFORMA

AVG. C_T = 0.008017
AVG. GW/δ_a (LB) = 42,740
AVG. $N_R/\sqrt{\theta_\alpha}$ (RPM) = 195.5
AVG. N_R (RPM) = 194.9

MARS-CONFIGURED, TWO 450-GAL. AUXILIARY
AQM-91A DRONE IN STOWED POSITION.

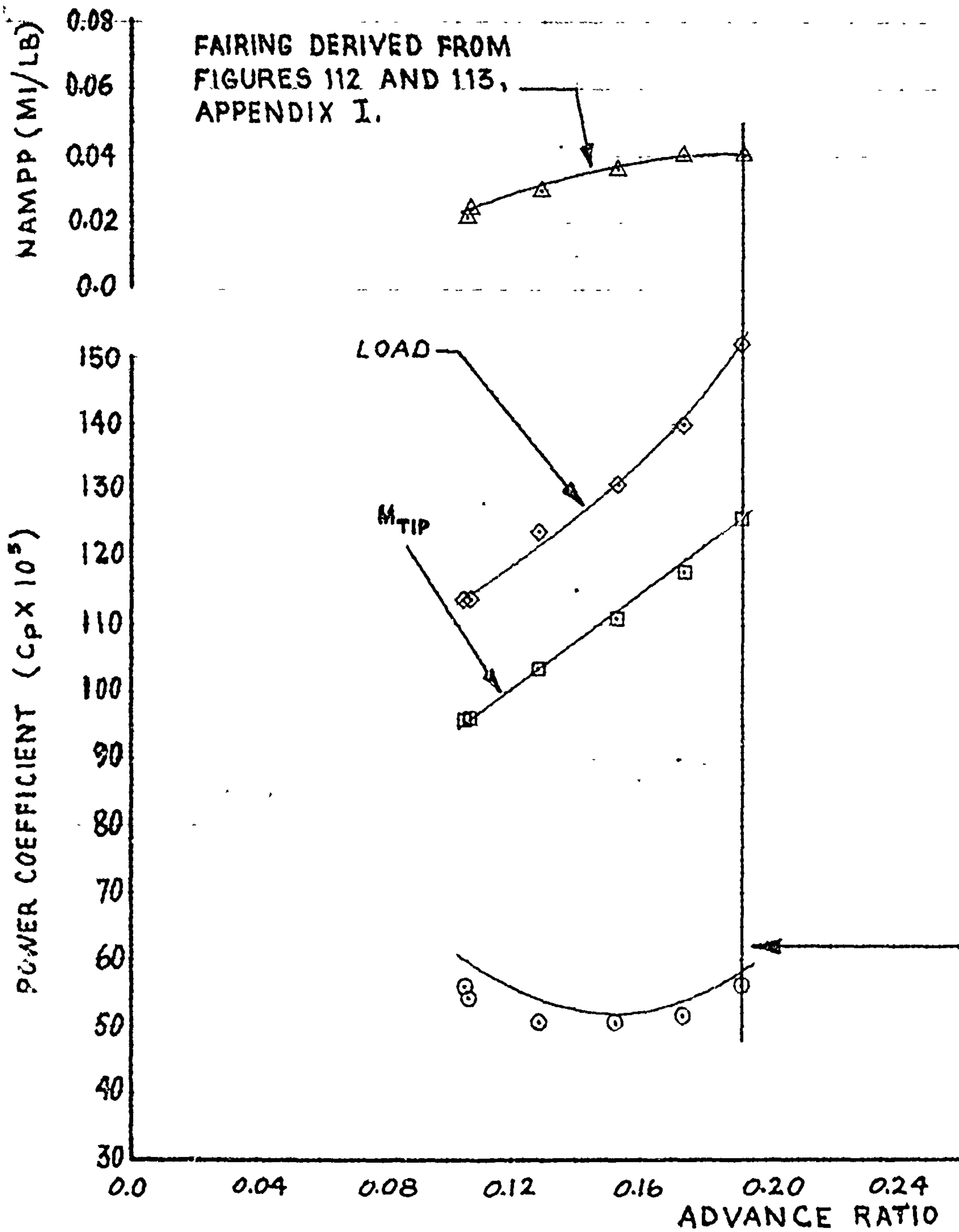
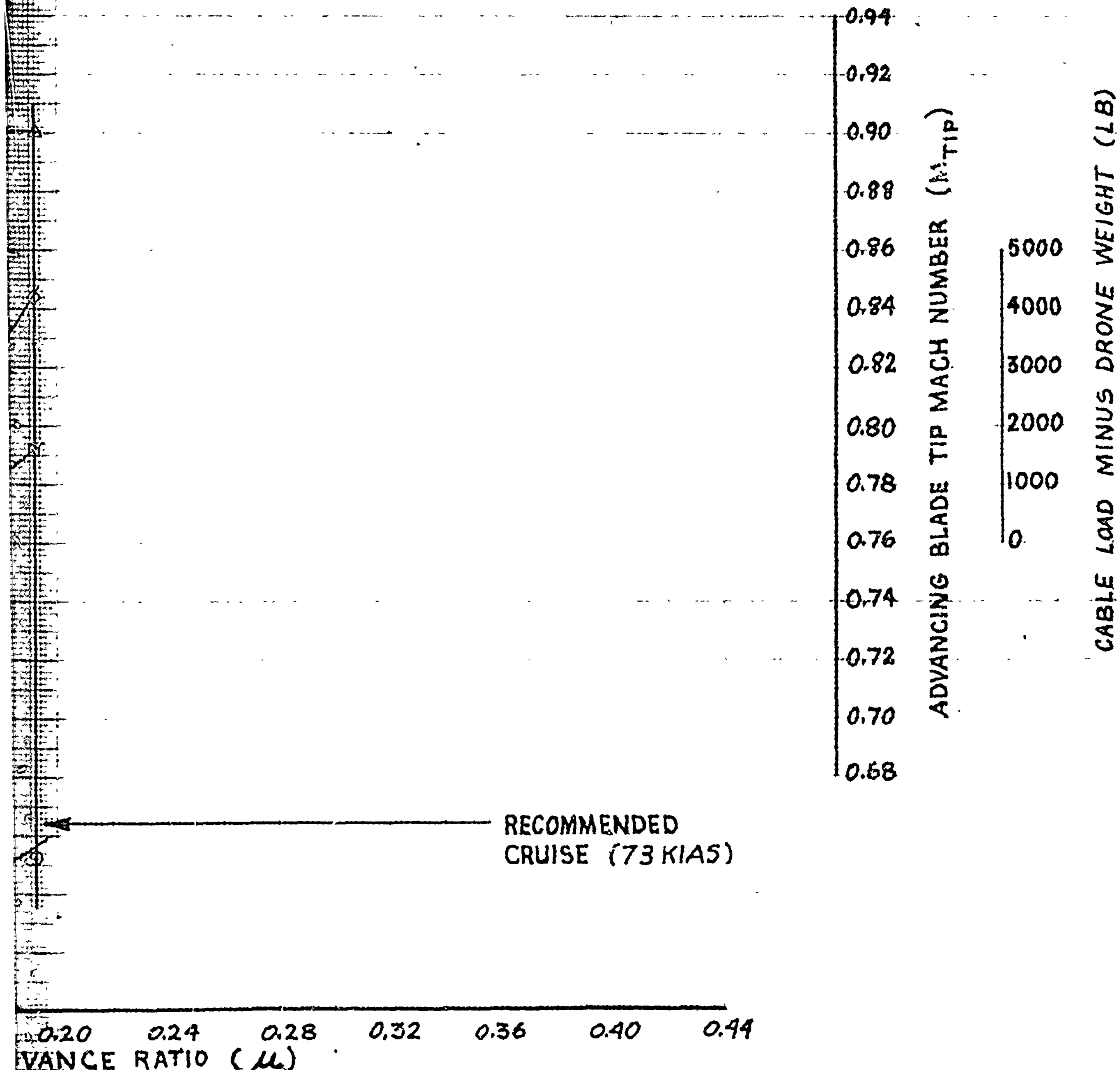


FIGURE 95 NONDIMENSIONAL LEVEL FL

-53C USAF S/N 67-14993
E-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 4,430
AVG. FREE AIR TEMP. (DEG. C) = 13.0
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 36,320
AVG. C.G LOCATION (STA) = 338.5

0-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
POSITION.



SIONAL LEVEL FLIGHT PERFORMANCE (AQM-91A)

HH-53C USAF S/N
T64-GE-7 ENGINES ~ E
MARS PERFOR

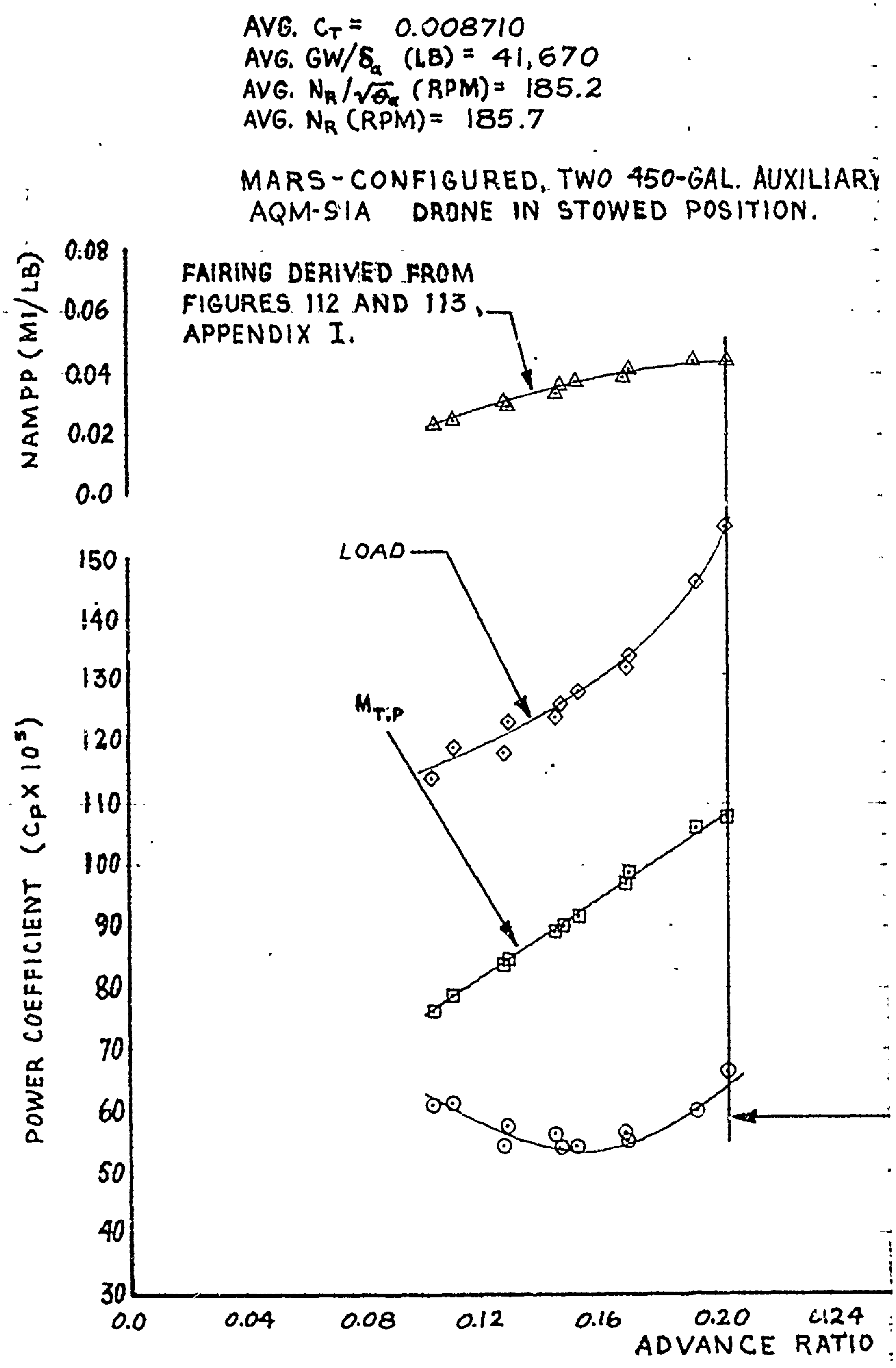
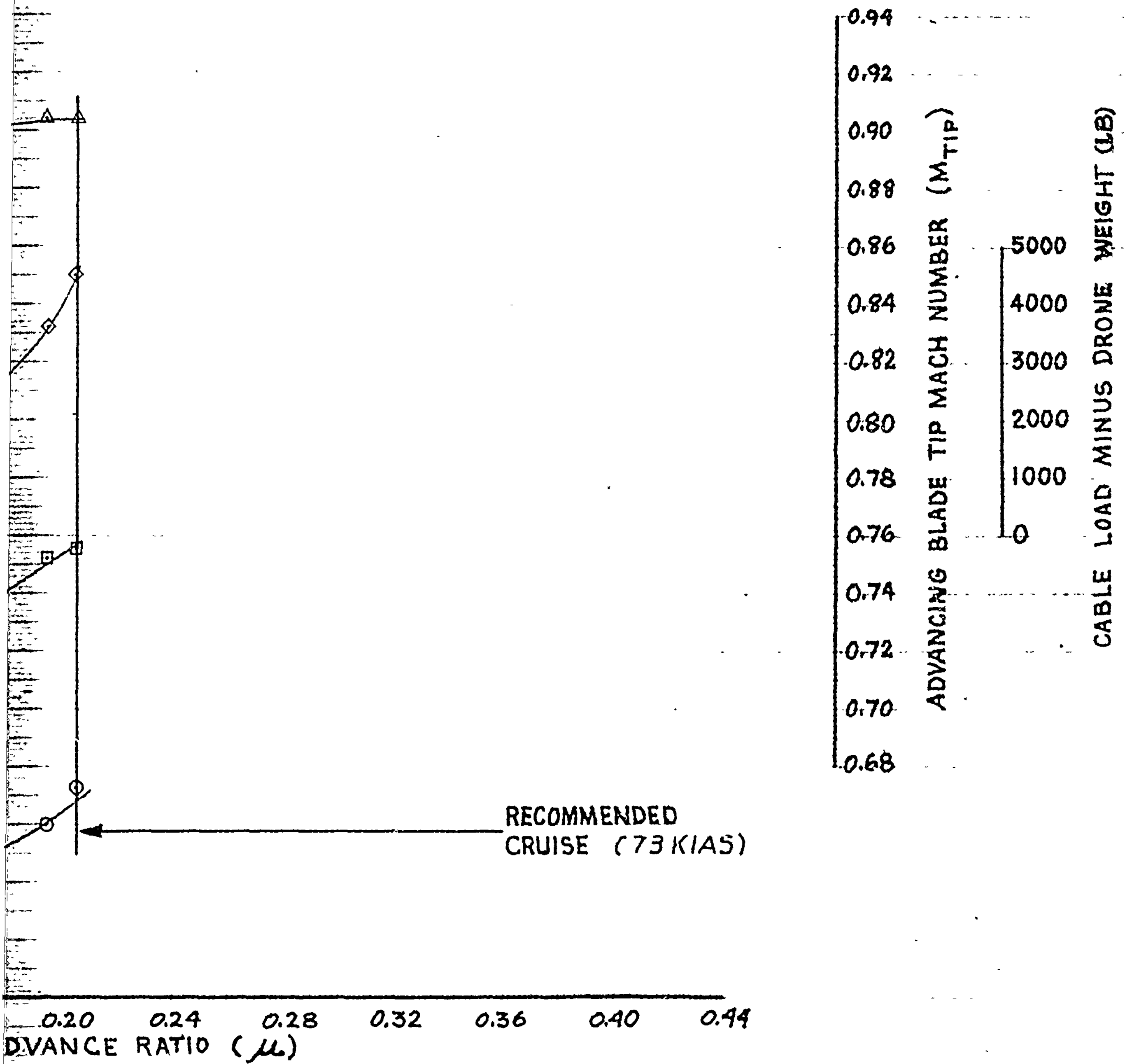


FIGURE 96 NONDIMENSIONAL LEVEL F

E-53C USAF S/N 67-14993
E-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 4,400
AVG. FREE AIR TEMP. (DEG. C) = 16.5
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 35,460
AVG. CG LOCATION (STA) = 337.2

0-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
D POSITION.



NSIONAL LEVEL FLIGHT PERFORMANCE (AQM-91A)

HH-53C USAF S/N 6
T64-GE-7 ENGINES ~ EAP
MARS PERFORMA

AVG. C_T = 0.008805
AVG. GW/δ_a (LB) = 44,150
AVG. $N_R/\sqrt{\theta_\alpha}$ (RPM) = 189.5
AVG. N_R (RPM) = 187.0

MARS-CONFIGURED, TWO 450-GAL. AUXILIARY
AQM-91A DRONE IN STOWED POSITION.

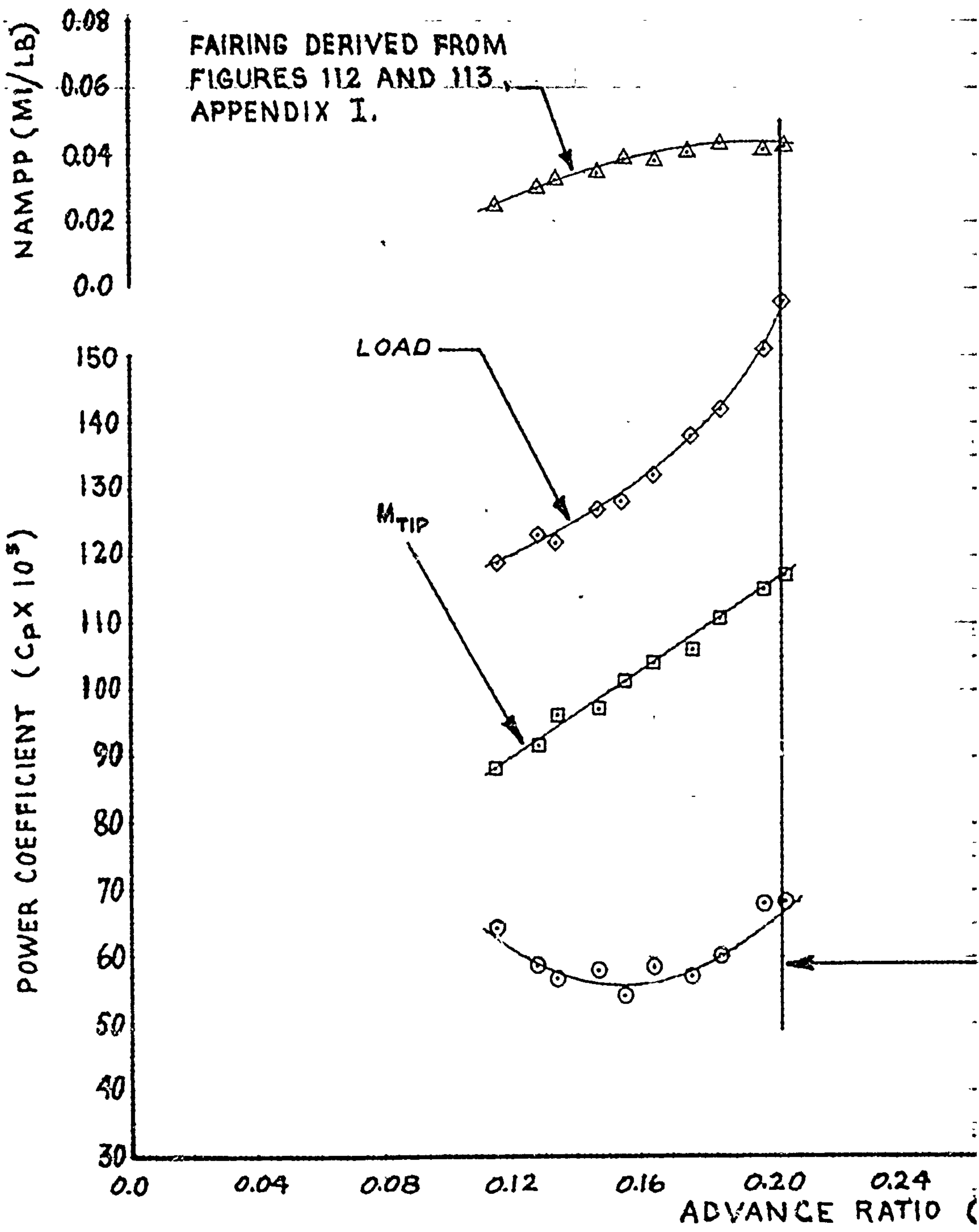
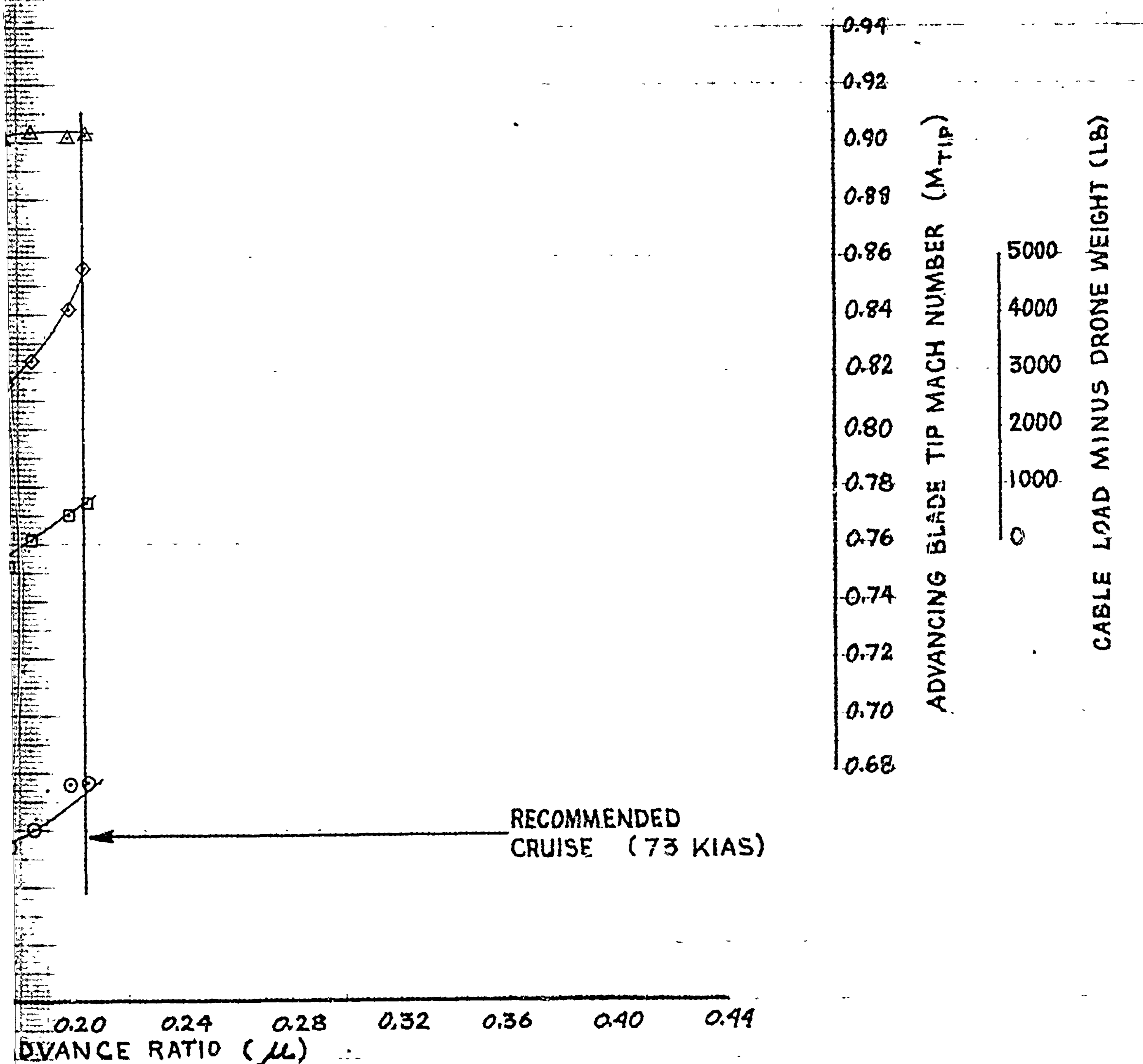


FIGURE 97 NONDIMENSIONAL LEVEL FLI

H-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 5,970
AVG. FREE AIR TEMP. (DEG. C) = 8.5
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 35,380
AVG. CG LOCATION (STA) = 337.8

50-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
ED POSITION.



NSIONAL LEVEL FLIGHT PERFORMANCE (AQM-91A)

HH-53C USAF S/N 67
T64-GE-7 ENGINES ~ EAPS
MARS PERFORMA

AVG. C_T = 0.008853
AVG. GW/δ_a (LB) = 46,180
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 193.4
AVG. N_R (RPM) = 191.5

MARS-CONFIGURED, TWO 450-GAL. AUXILIARY F
AQM-91A DRONE IN STOWED POSITION.

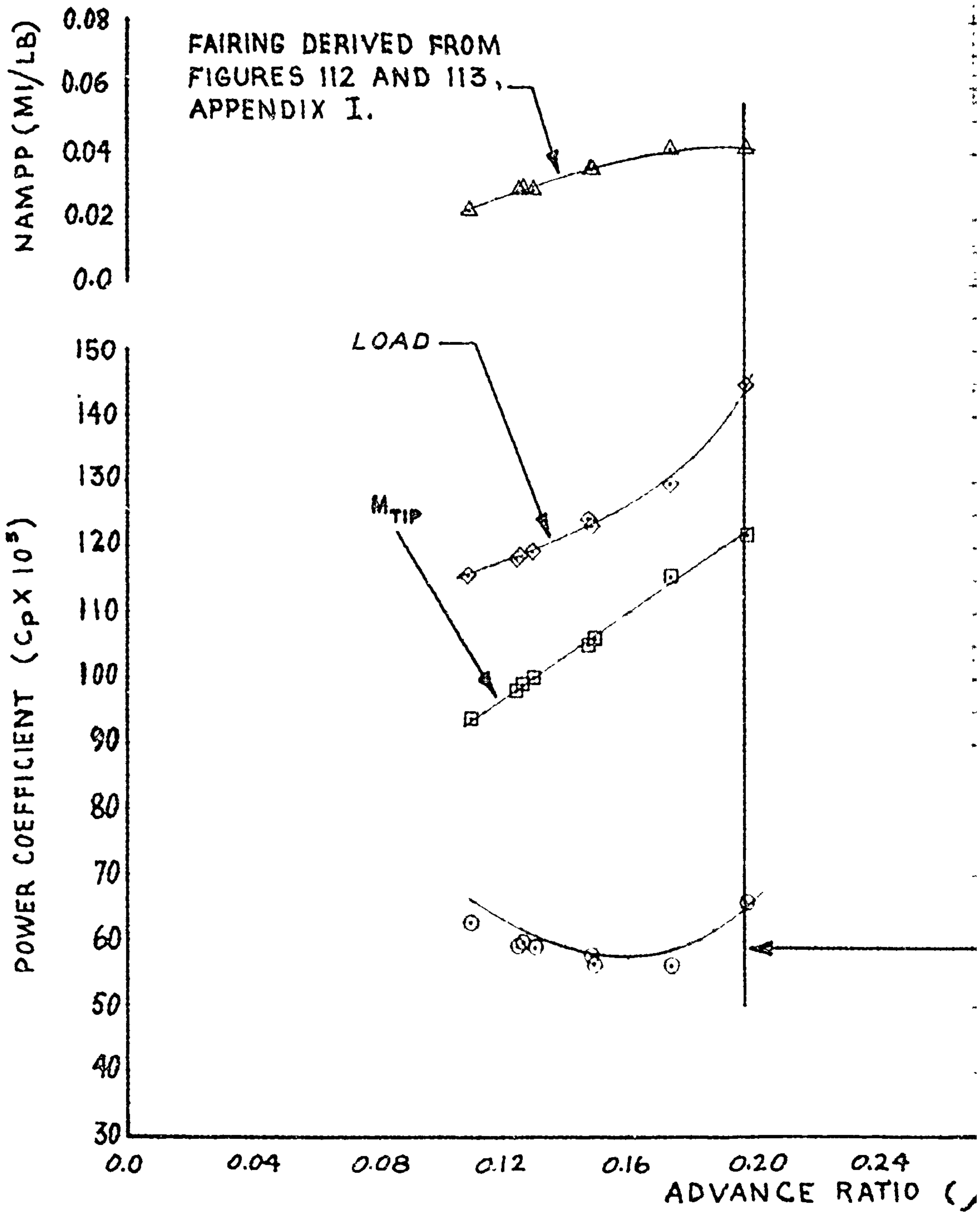
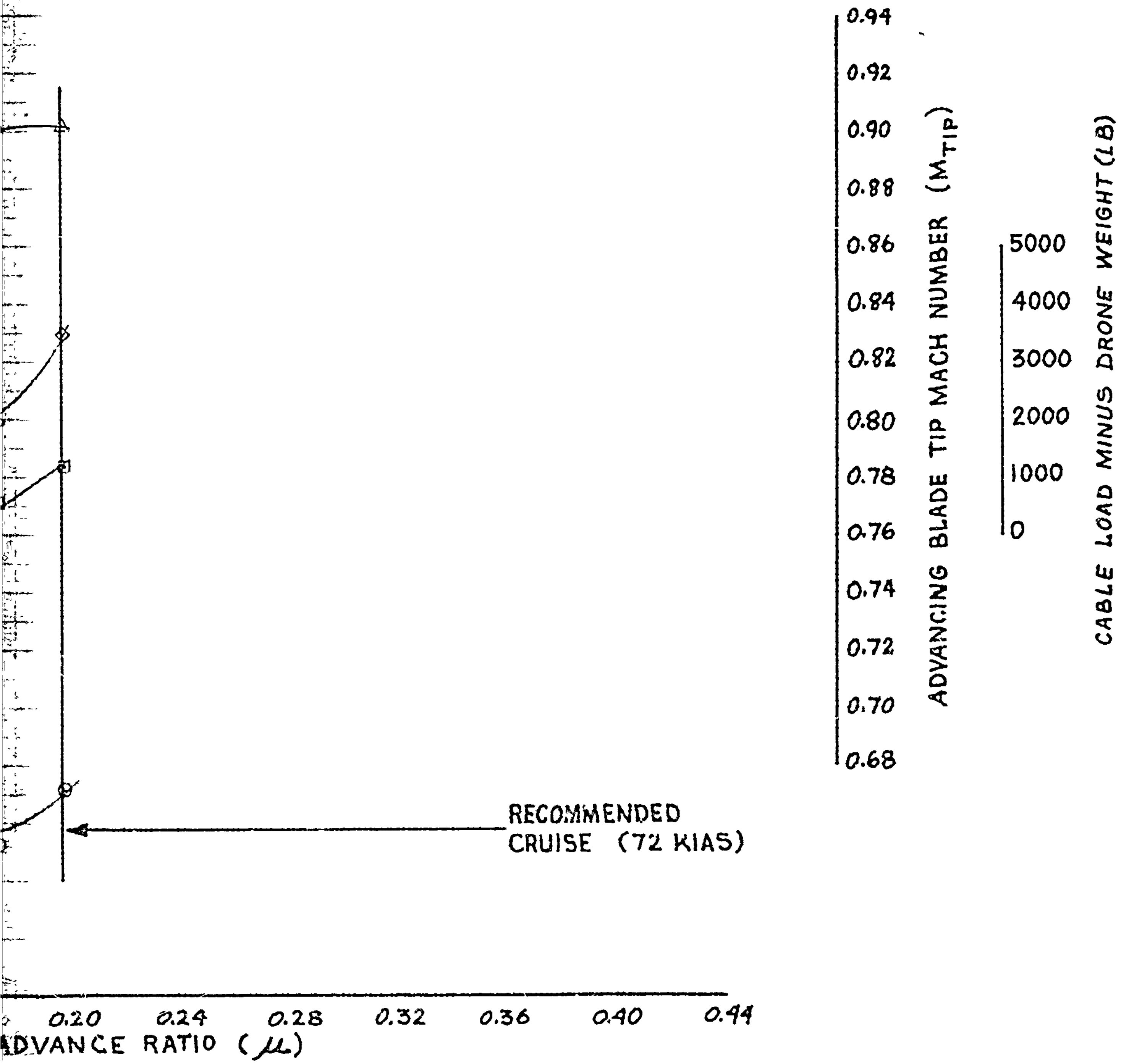


FIGURE 98 NONDIMENSIONAL LEVEL FLIG

IH-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 5,650
AVG. FREE AIR TEMP. (DEG. C) = 9.5
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 37,500
AVG. CG LOCATION (STA) = 337.6

150-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
ED POSITION.



ENSIONAL LEVEL FLIGHT PERFORMANCE (AQM-91A)

AVG. C_T = 0.009467
AVG. GW/δ_a (LB) = 48,820
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 196.7
AVG. N_R (RPM) = 194.4

MARS-CONFIGURED, TWO 450-GAL. AUXILIARY F
AQM-91A DRONE IN STOWED POSITION.

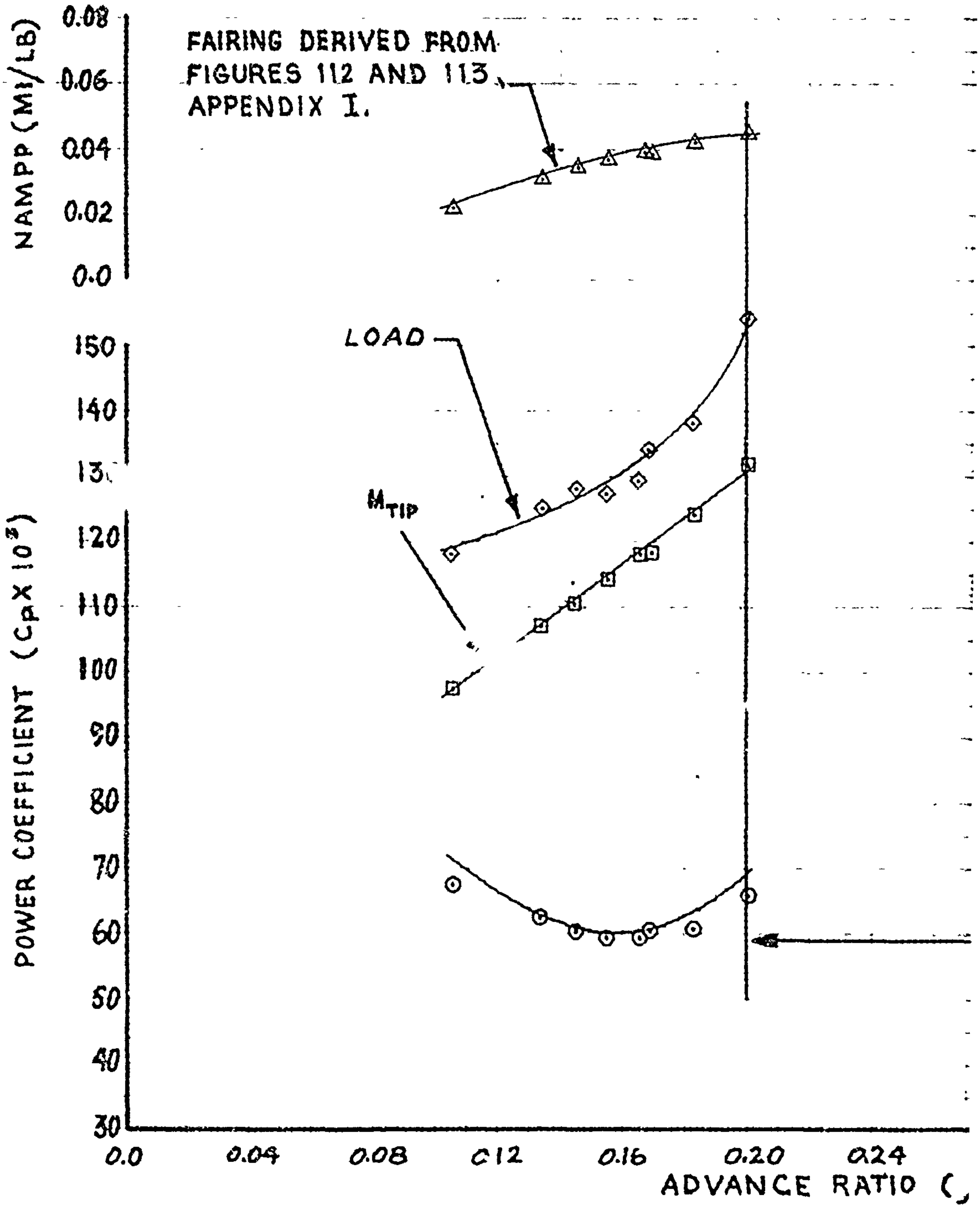
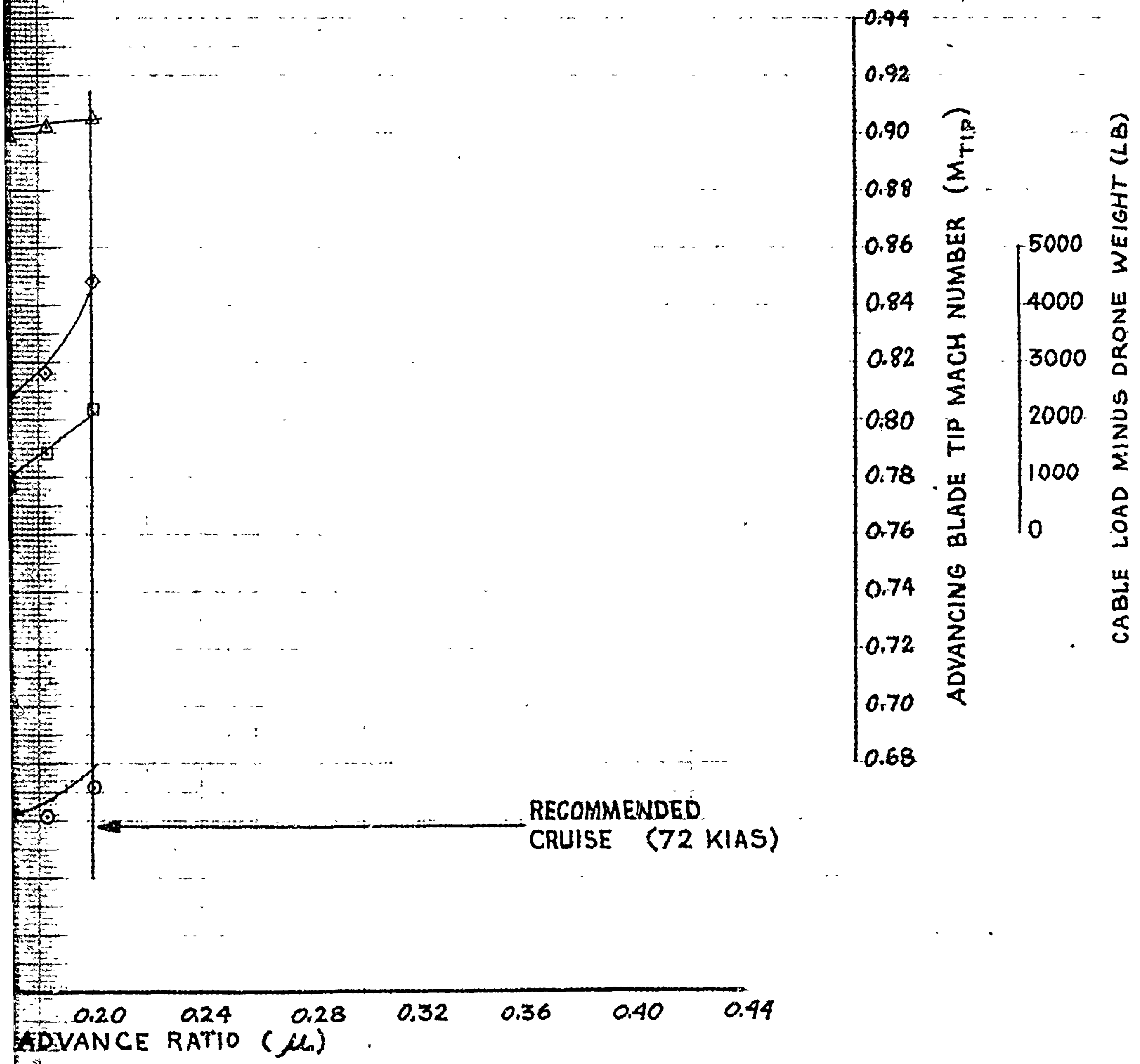


FIGURE 99 NONDIMENSIONAL LEVEL FLIG

HH-53C USAF S/N 67-14993
-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 7,650
AVG. FREE AIR TEMP. (DEG. C.) = 8.5
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 36,750
AVG. CG LOCATION (STA) = 338.1

450-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
ED POSITION.



ENSIONAL LEVEL FLIGHT PERFORMANCE (AQM-91A)

HH-53C USAF S/N 67
T64-GE-7 ENGINES ~ EAPS
MARS PERFORMA

AVG. C_T = 0.009789
AVG. GW/δ_a (LB) = 46,830
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 185.2
AVG. N_R (RPM) = 183.5

MARS-CONFIGURED, TWO 450-GAL. AUXILIARY F
AQM-91A DRONE IN STOWED POSITION.

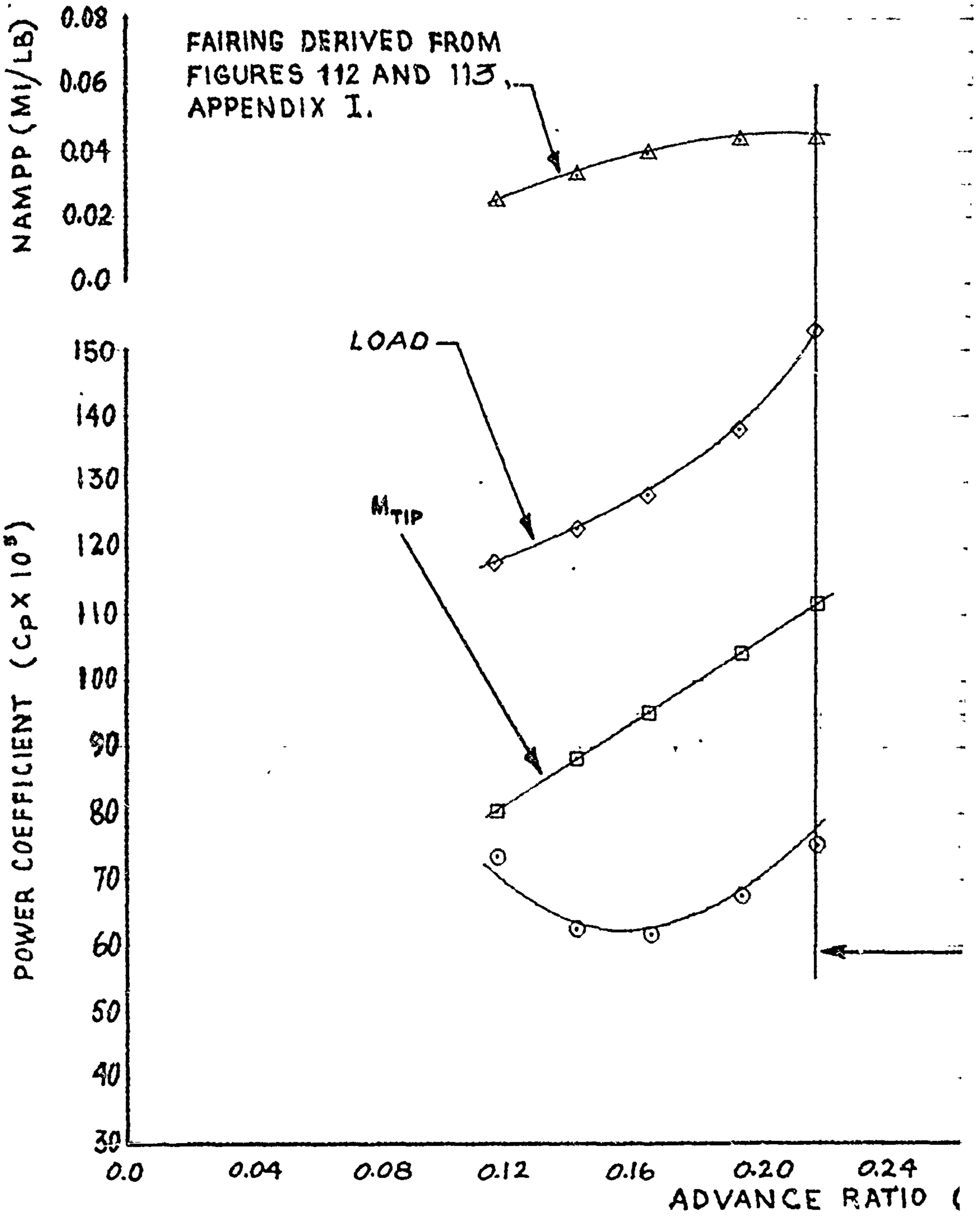
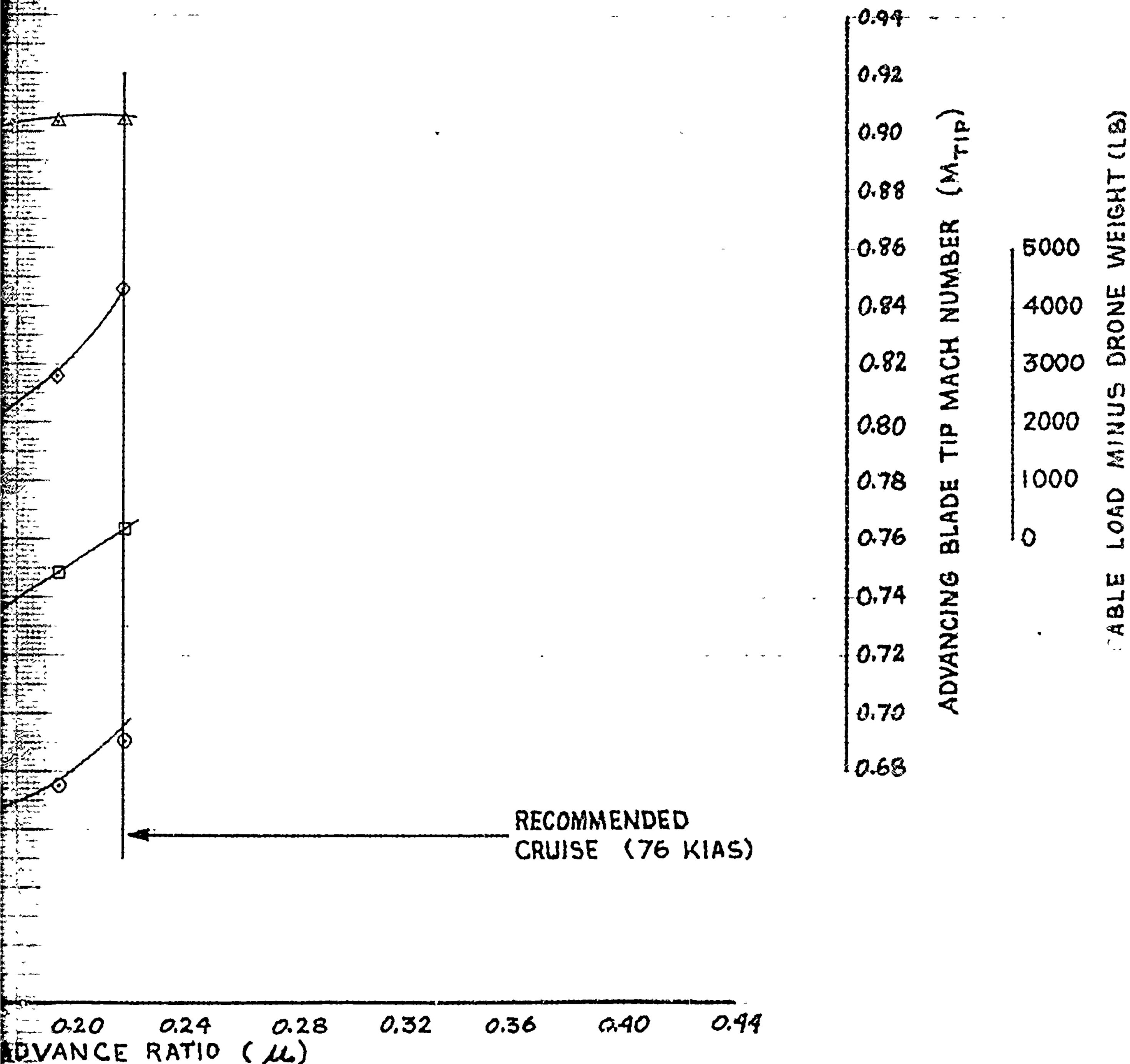


FIGURE 100 NONDIMENSIONAL LEVEL FL

HH-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 6,620
AVG. FREE AIR TEMP. (DEG. C) = 10.0
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 36,660
AVG. CG LOCATION (STA) = 340.5

50-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
D POSITION.



NSIONAL LEVEL FLIGHT PERFORMANCE (AQM-91A)

HH-53C USAF S/N 67-
T64-GE-7 ENGINES ~ EAPS
MARS PERFORMANC

AVG. C_T = 0.009922
AVG. GW/δ_a (LB) = 49,280
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 188.7
AVG. N_R (RPM) = 186.8

MARS-CONFIGURED, TWO 450-GAL. AUXILIARY FU
AQM-91A DRONE IN STOWED POSITION.

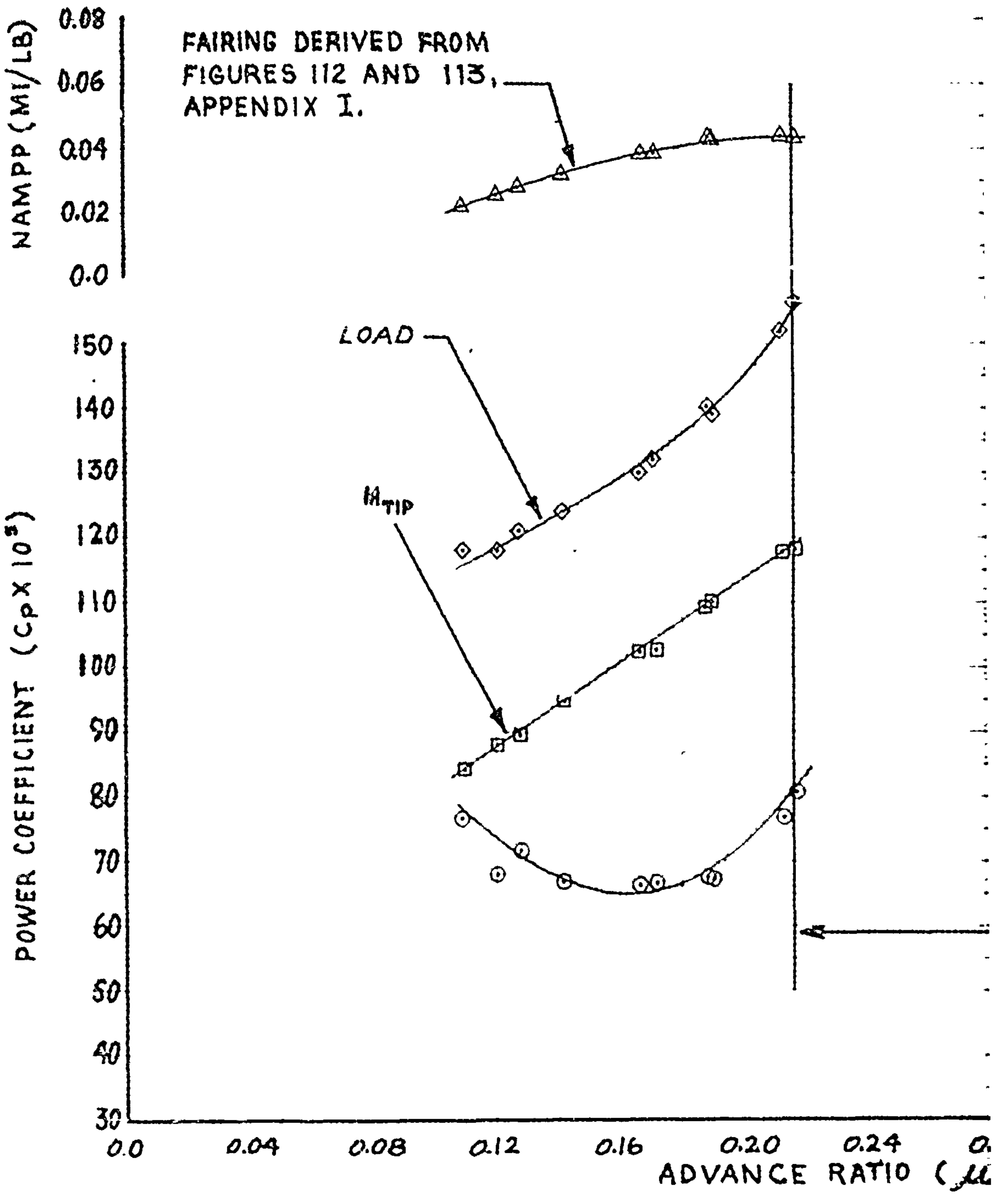
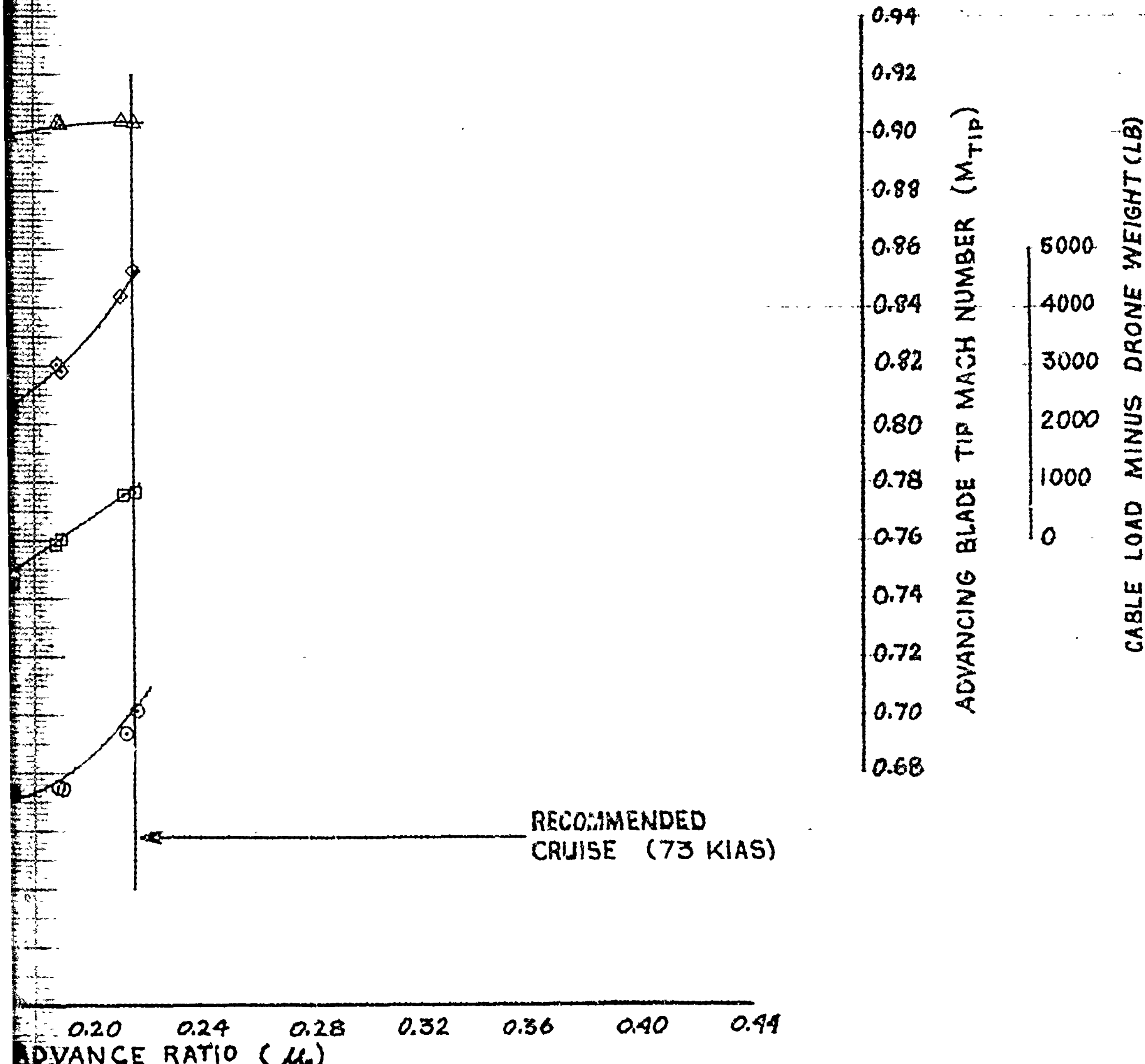


FIGURE 101 NONDIMENSIONAL LEVEL FLIGH

HH-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 7,300
AVG. FREE AIR TEMP. (DEG. C) = 9.5
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 37,590
AVG. CG LOCATION (STA) = 337.7

450-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
ED POSITION.



ENSIONAL LEVEL FLIGHT PERFORMANCE (AQM-91A)

HH-53C USAF S/N 6
T64-GE-7 ENGINES ~ EA
MARS PERFORM

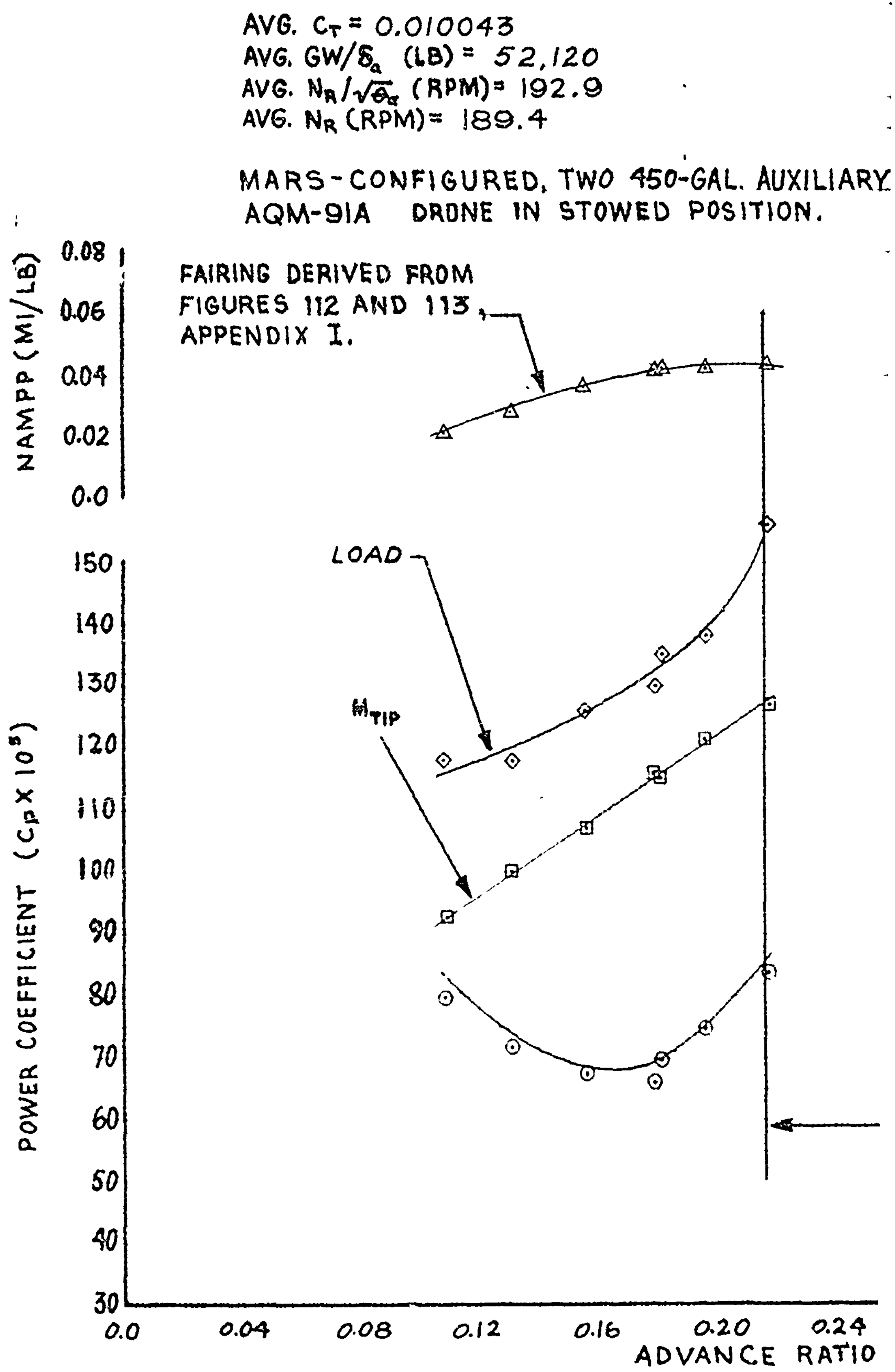
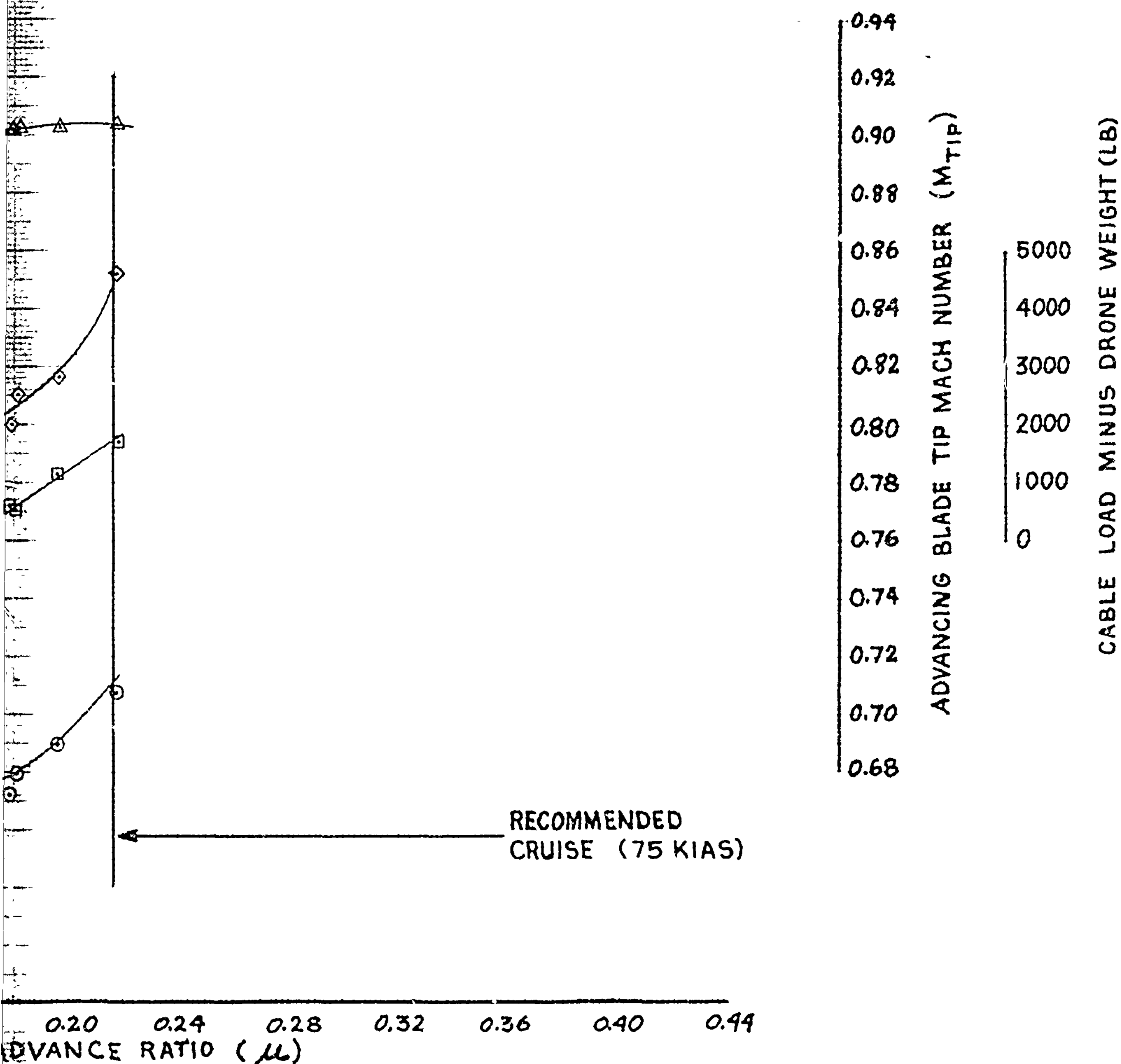


FIGURE 10.2 NONDIMENSIONAL LEVEL

H-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 8,800
AVG. FREE AIR TEMP. (DEG. C) = 4.5
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 37,550
AVG. CG LOCATION (STA) = 339.7

50-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
D POSITION.



NSIONAL LEVEL FLIGHT PERFORMANCE (AQM-91A)

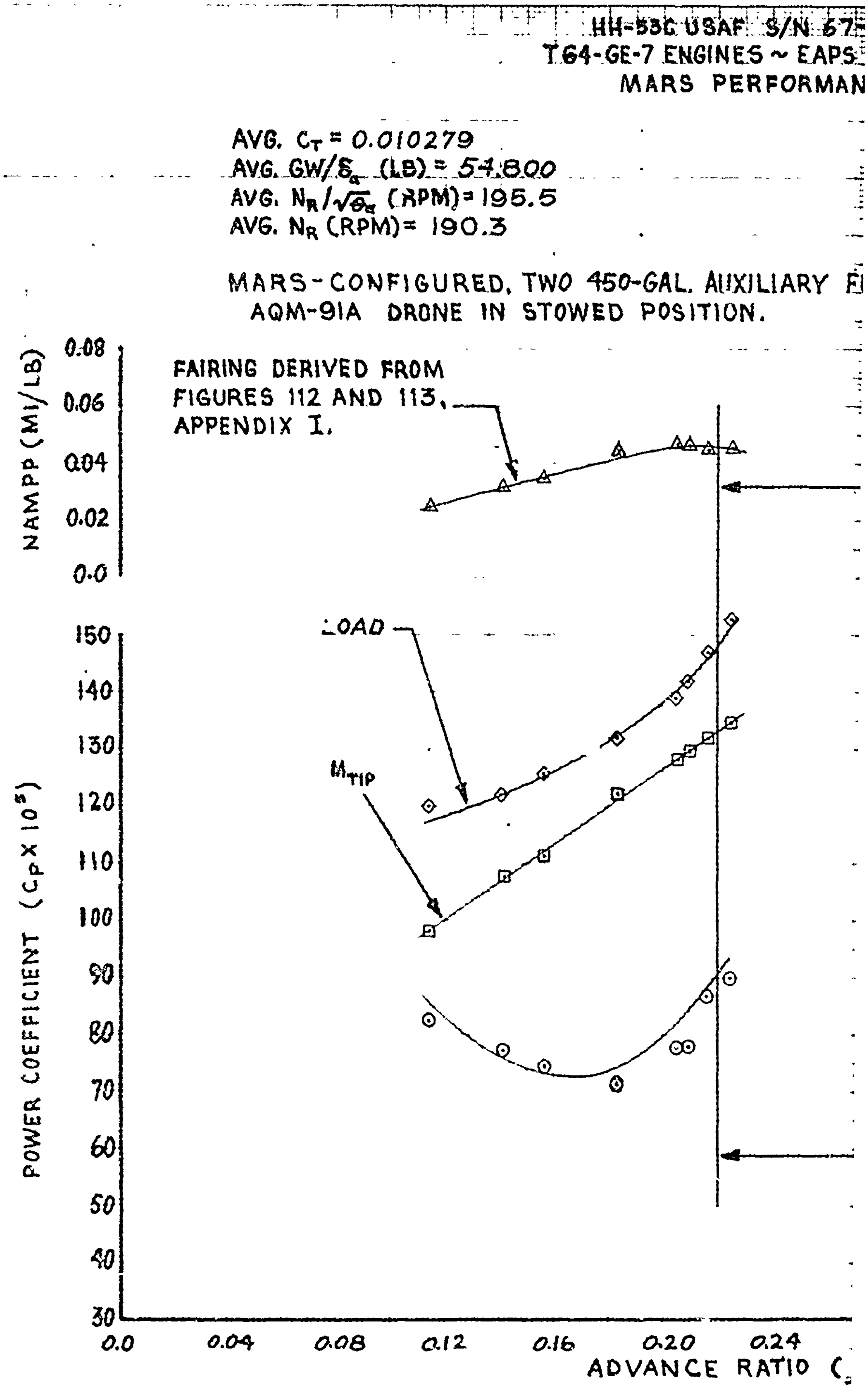
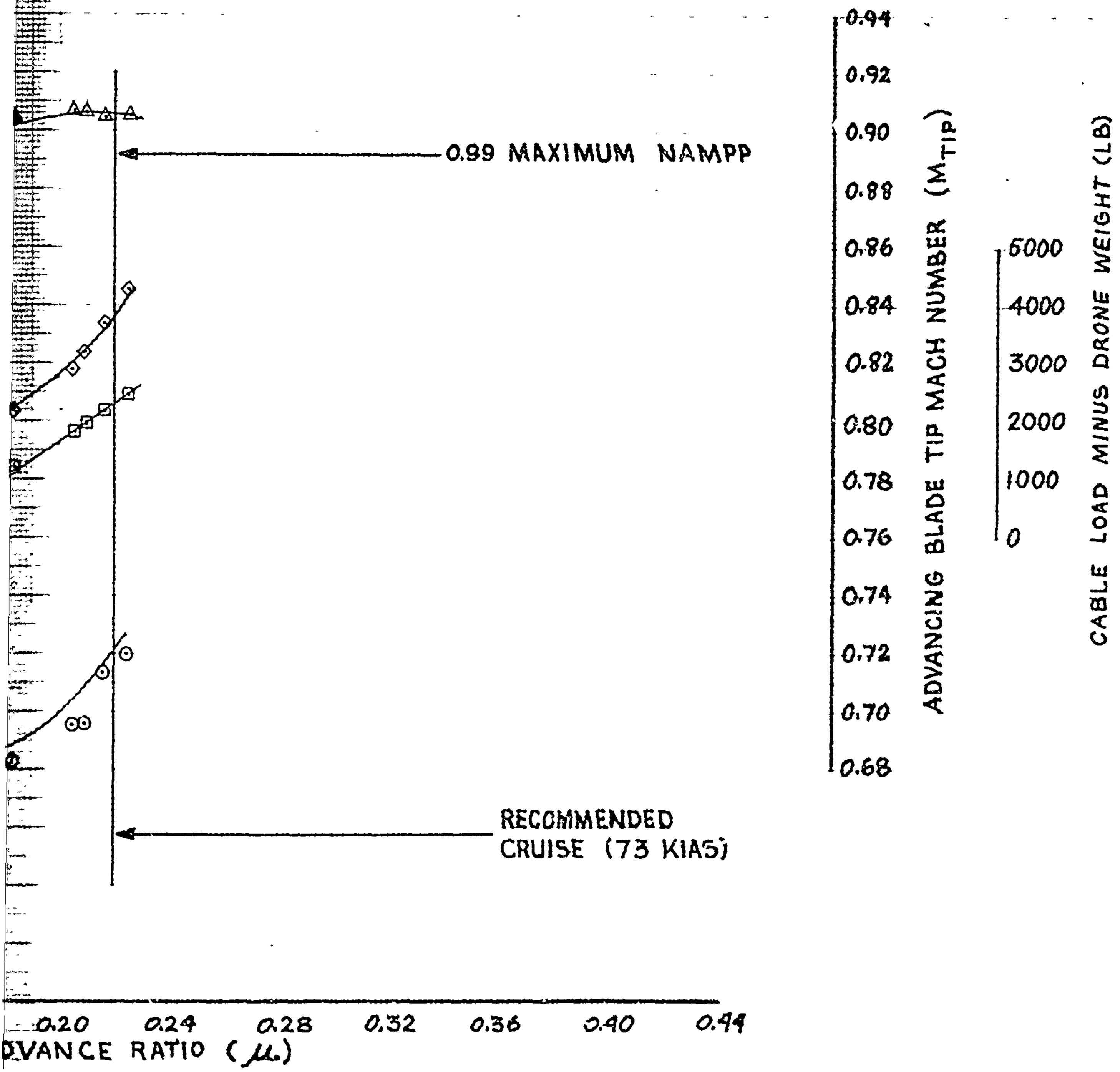


FIGURE 103 NONDIMENSIONAL LEVEL FLIG

-53C USAF S/N 67-14993
E-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 11,020
AVG. FREE AIR TEMP. (DEG. C) = -0.5
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 36,220
AVG. CG LOCATION (STA) = 337.2

0-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
) POSITION.



NSIONAL LEVEL FLIGHT PERFORMANCE (AQM-91A)

HH-53C USAF S/N 67

T64-GE-7 ENGINES ~ EAPS

MARS PERFORMAN

AVG. C_T = 0.010808

AVG. GW/δ_a (LB) = 51,925

AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 185.6

AVG. N_R (RPM) = 181.8

MARS-CONFIGURED, TWO 450-GAL. AUXILIARY F

AQM-91A DRONE IN STOWED POSITION.

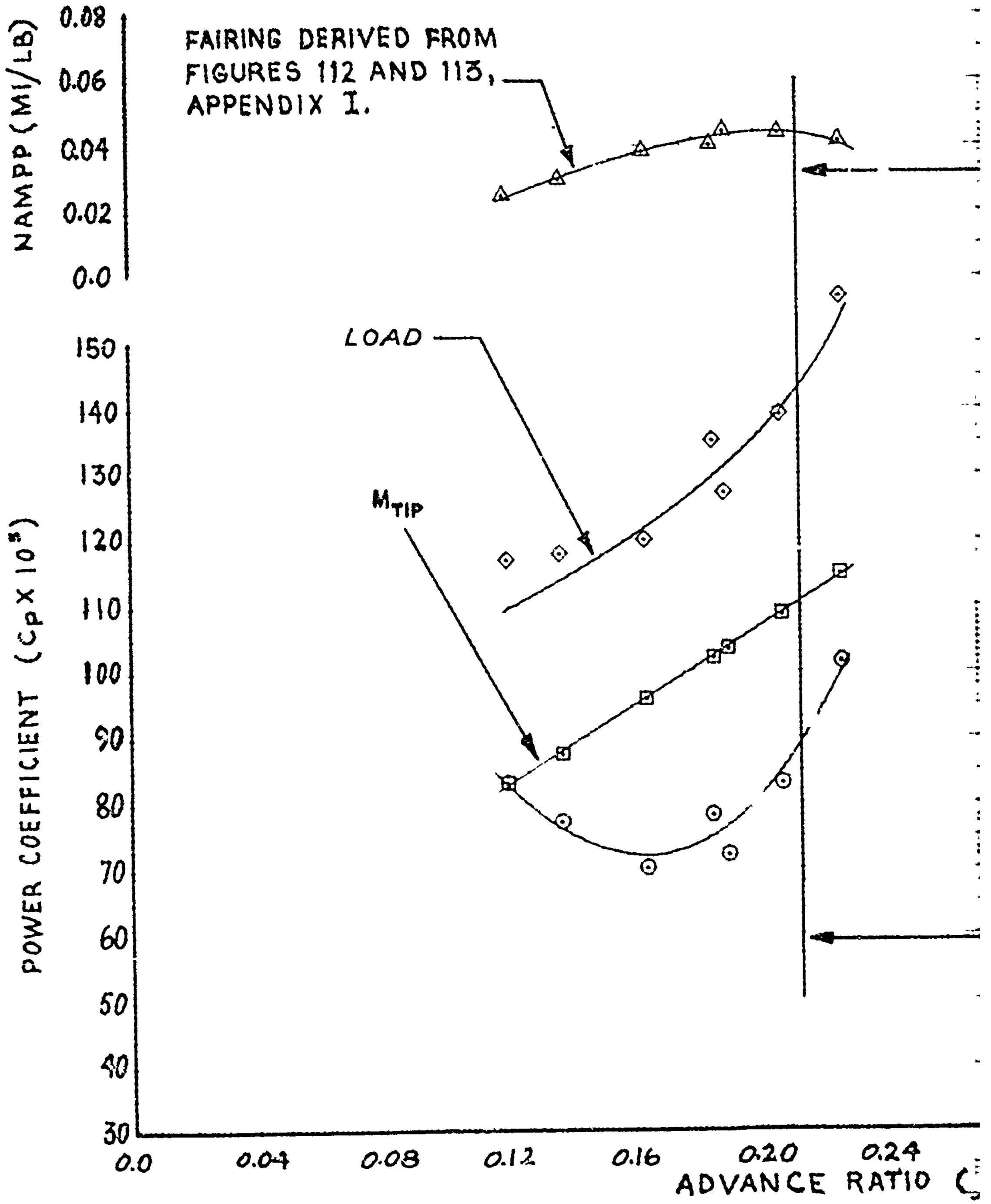
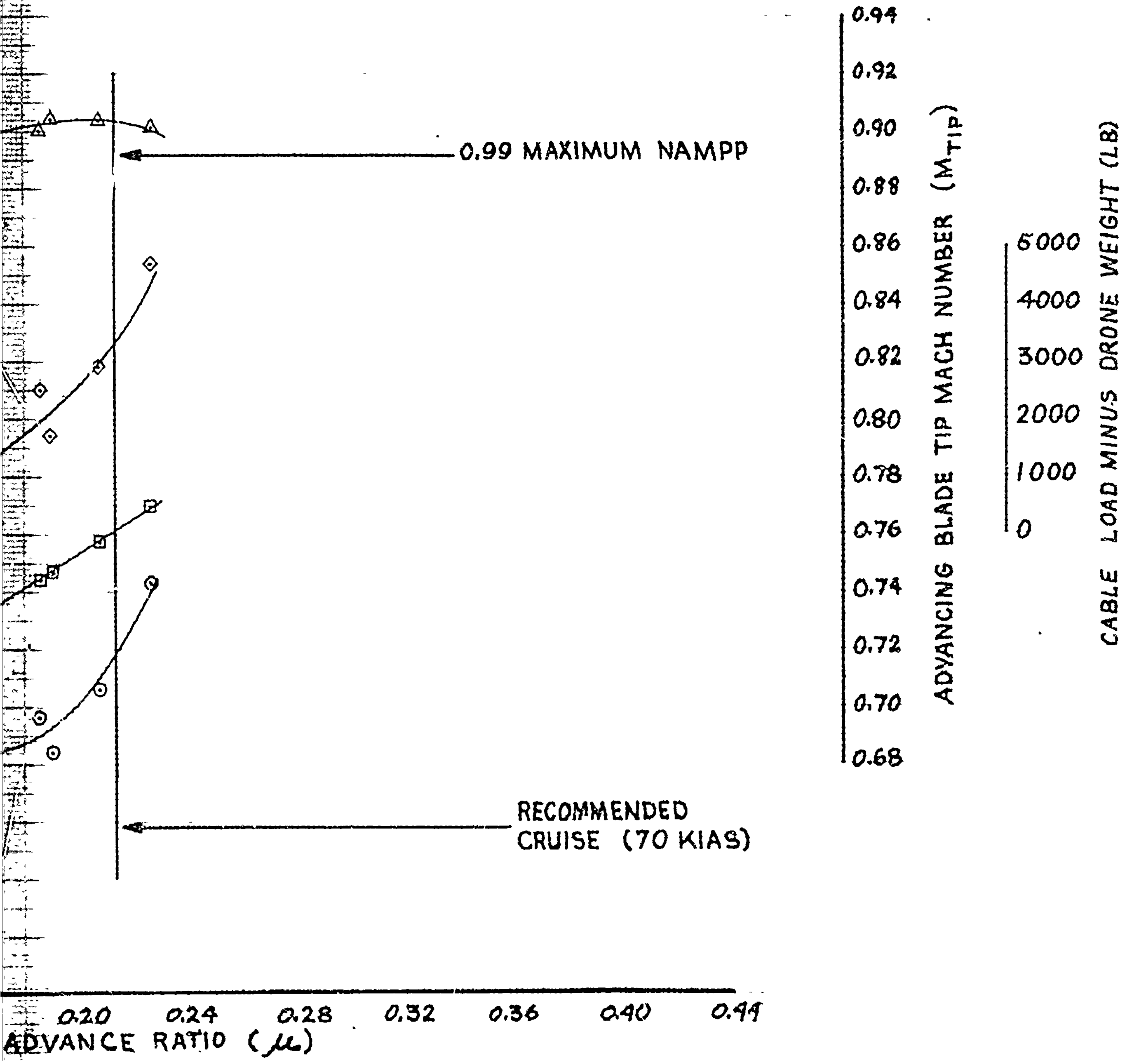


FIGURE 104 NONDIMENSIONAL LEVEL FLIG

HH-53C USAF S/N 67-14993
GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 8,760
AVG. FREE AIR TEMP. (DEG. C) = 3.0
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 37,460
AVG. CG LOCATION (STA) = 337.8

450-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
ED POSITION.



ENSIONAL LEVEL FLIGHT PERFORMANCE (AQM-91A)

HH-53C USAF S/N 67
T64-GE-7 ENGINES ~ EAPS
MARS PERFORMAN

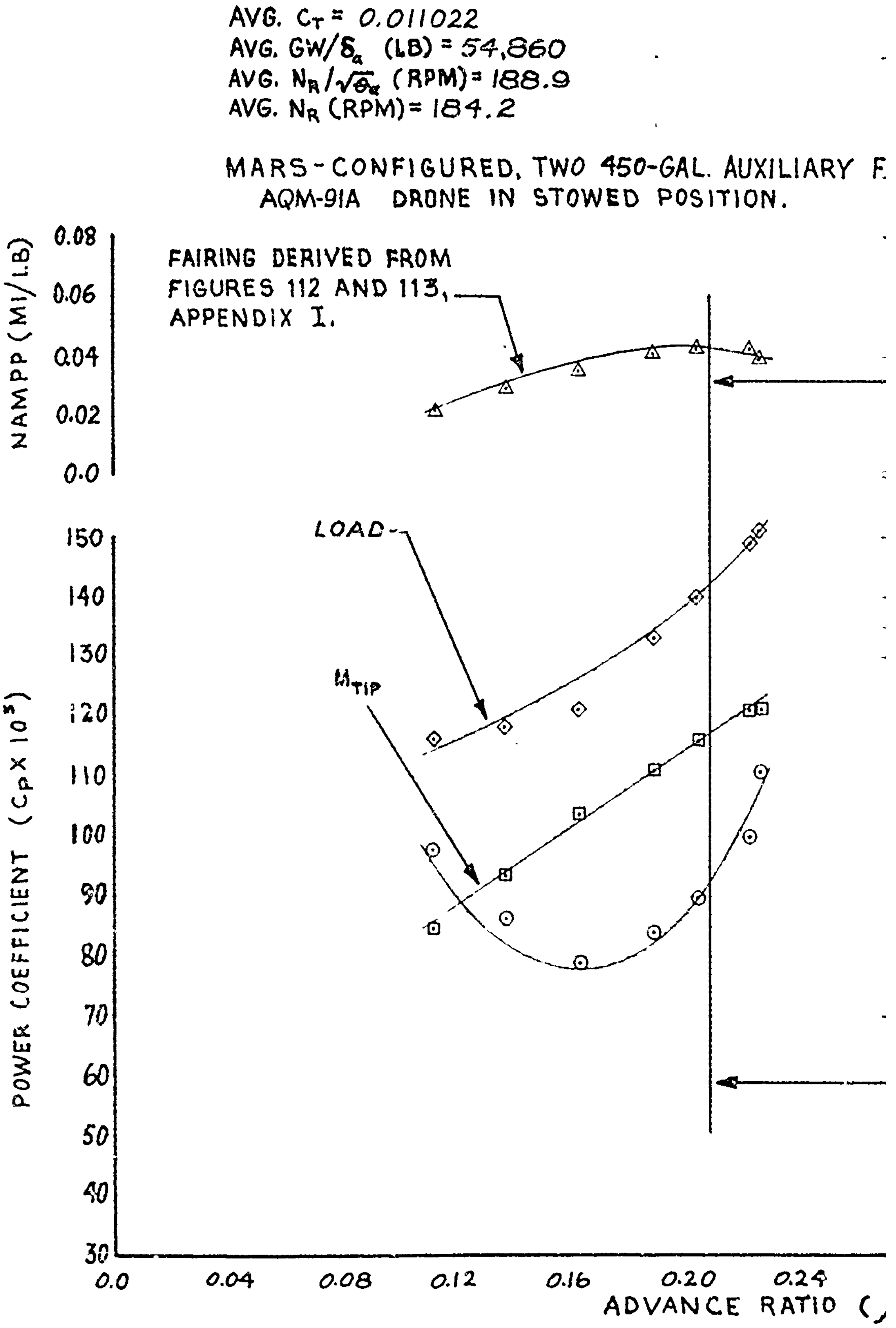
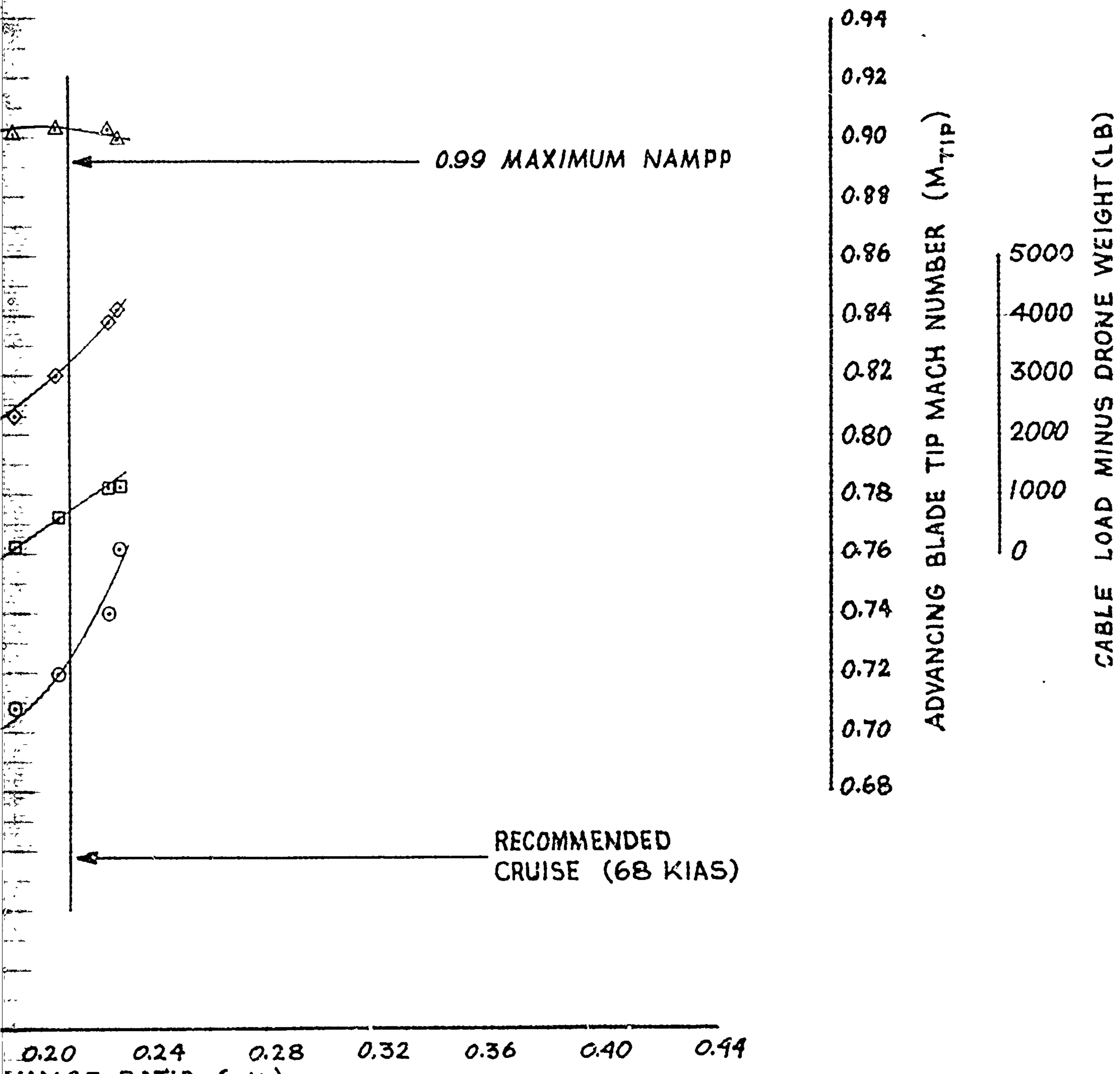


FIGURE 105 NONDIMENSIONAL LEVEL FLIG

-53C USAF S/N 67-14993
-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 10,300
AVG. FREE AIR TEMP. (DEG. C) = 1.0
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 37,290
AVG. CG LOCATION (STA) = 336.7

-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
POSITION.



SIONAL LEVEL FLIGHT PERFORMANCE (AQM-91A)

HH-53C USAF S/N
T64-GE-7 ENGINES ~ E
MARS PERFOR

AVG. C_T = 0.011185
AVG. GW/δ_a (LB) = 57,930
AVG. $N_R/\sqrt{\theta_a}$ (RPM) = 192.7
AVG. N_R (RPM) = 187.0

MARS-CONFIGURED, TWO 450-GAL. AUXILIAR
AQM-91A DRONE IN STOWED POSITION.

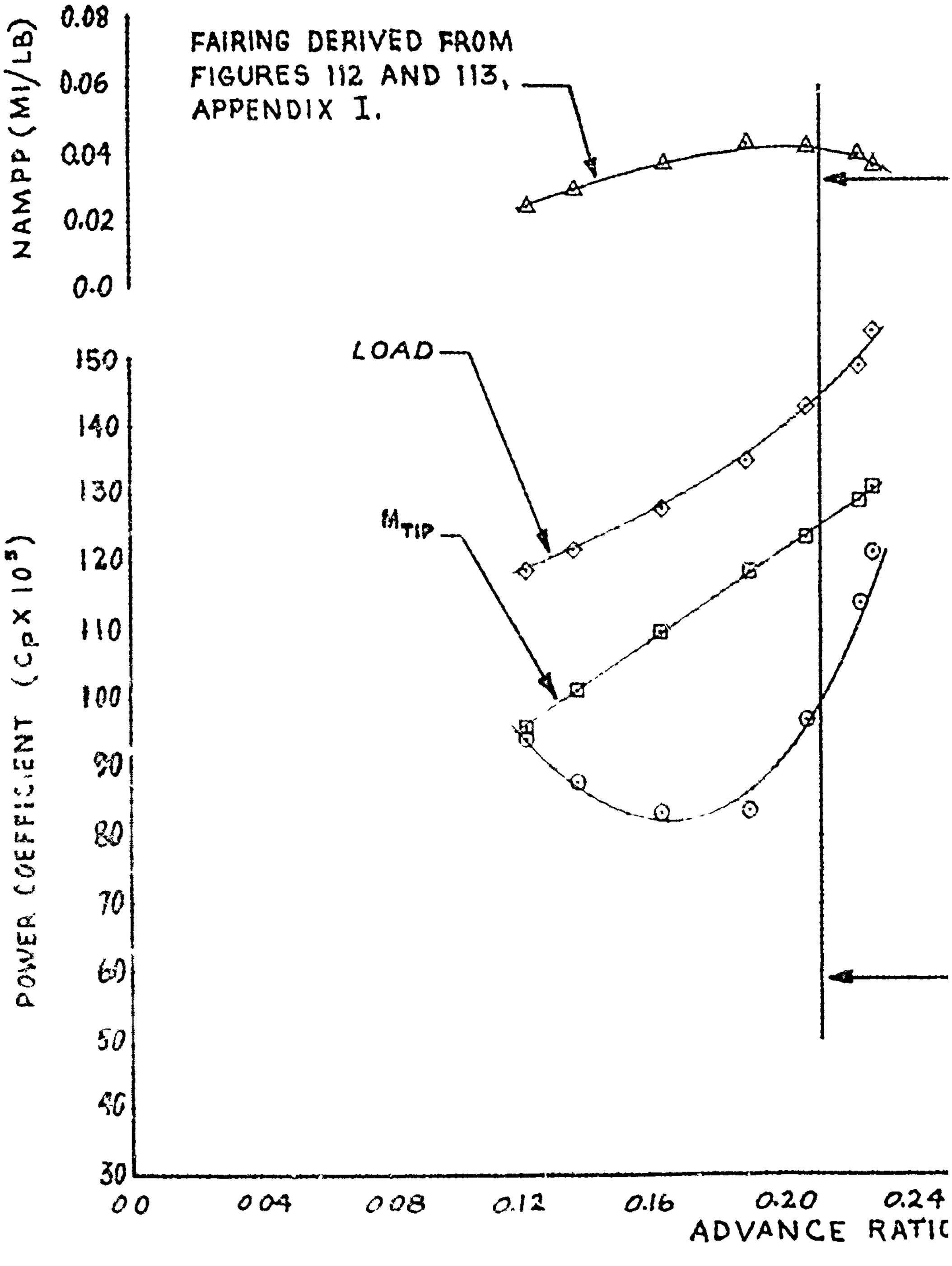
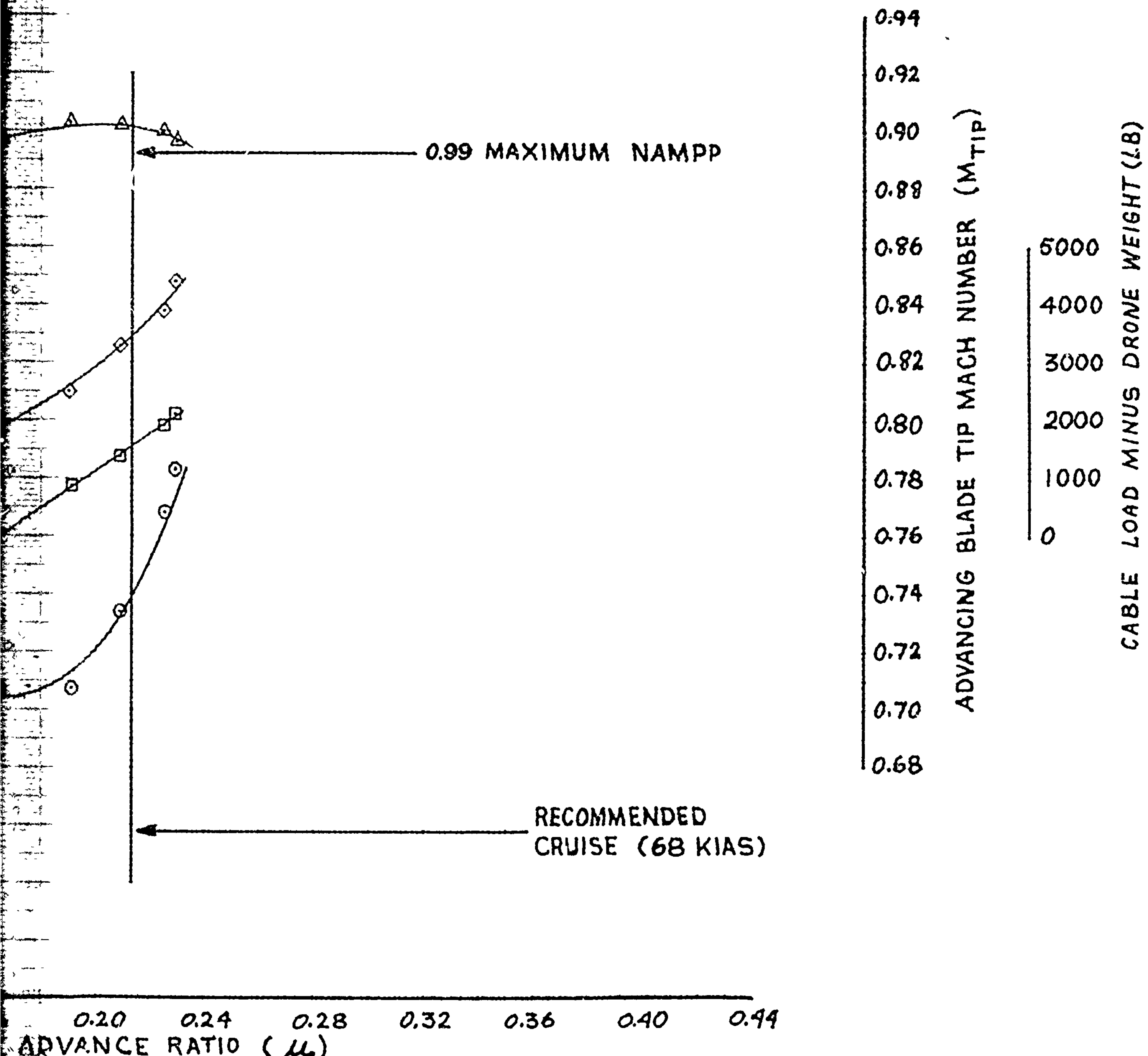


FIGURE 106 NONDIMENSIONAL LEVEL

HH-53C USAF S/N 67-14993
T-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 11,520
AVG. FREE AIR TEMP. (DEG. C) = -1.5
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 37,550
AVG. CG LOCATION (STA) = 337.9

450-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
WED POSITION.



MENSIONAL LEVEL FLIGHT PERFORMANCE (AQM-91A)

HH-55C USAF S/N 67- I
T64-GE-7 ENGINES ~ EAPS I
MARS PERFORMANC

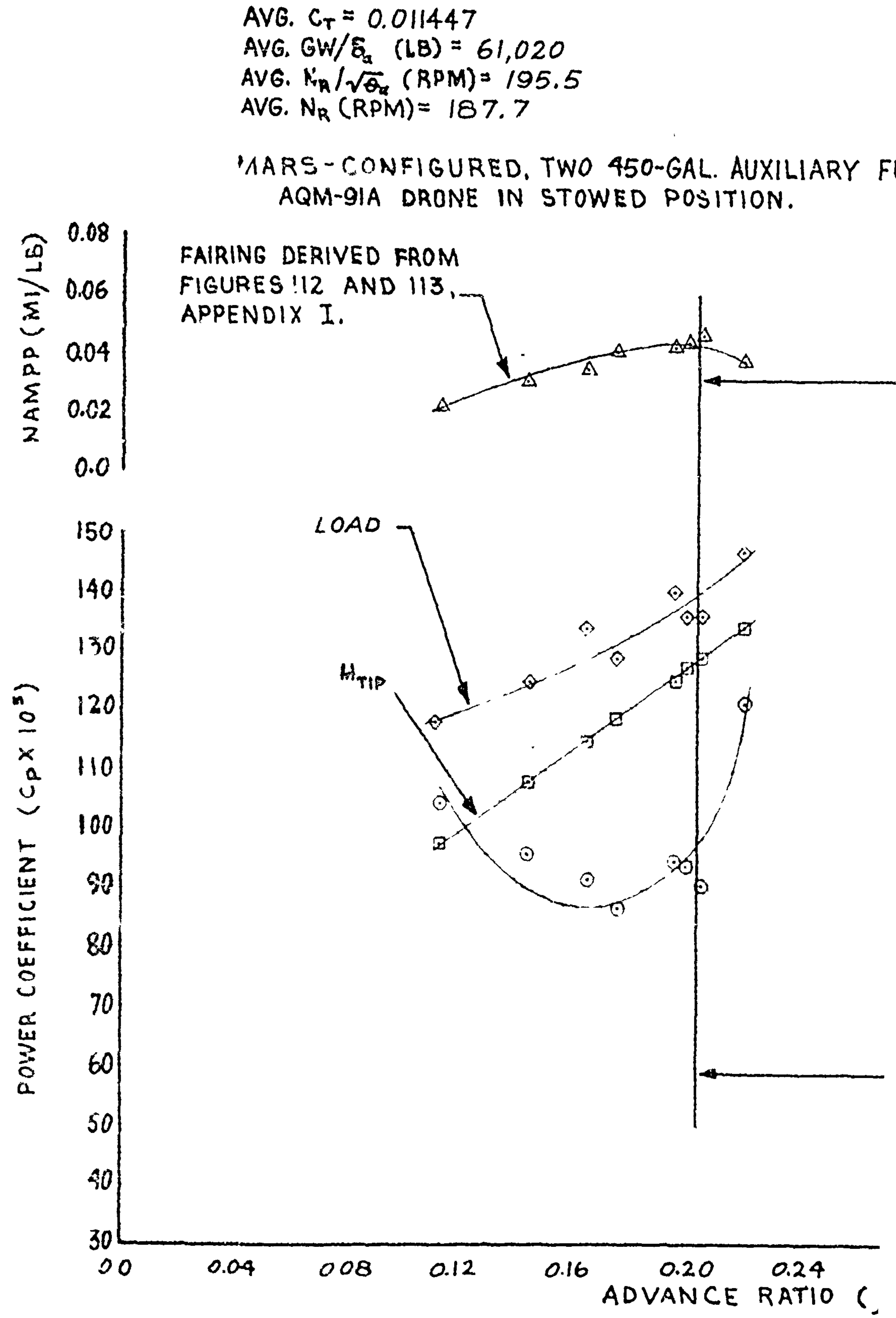
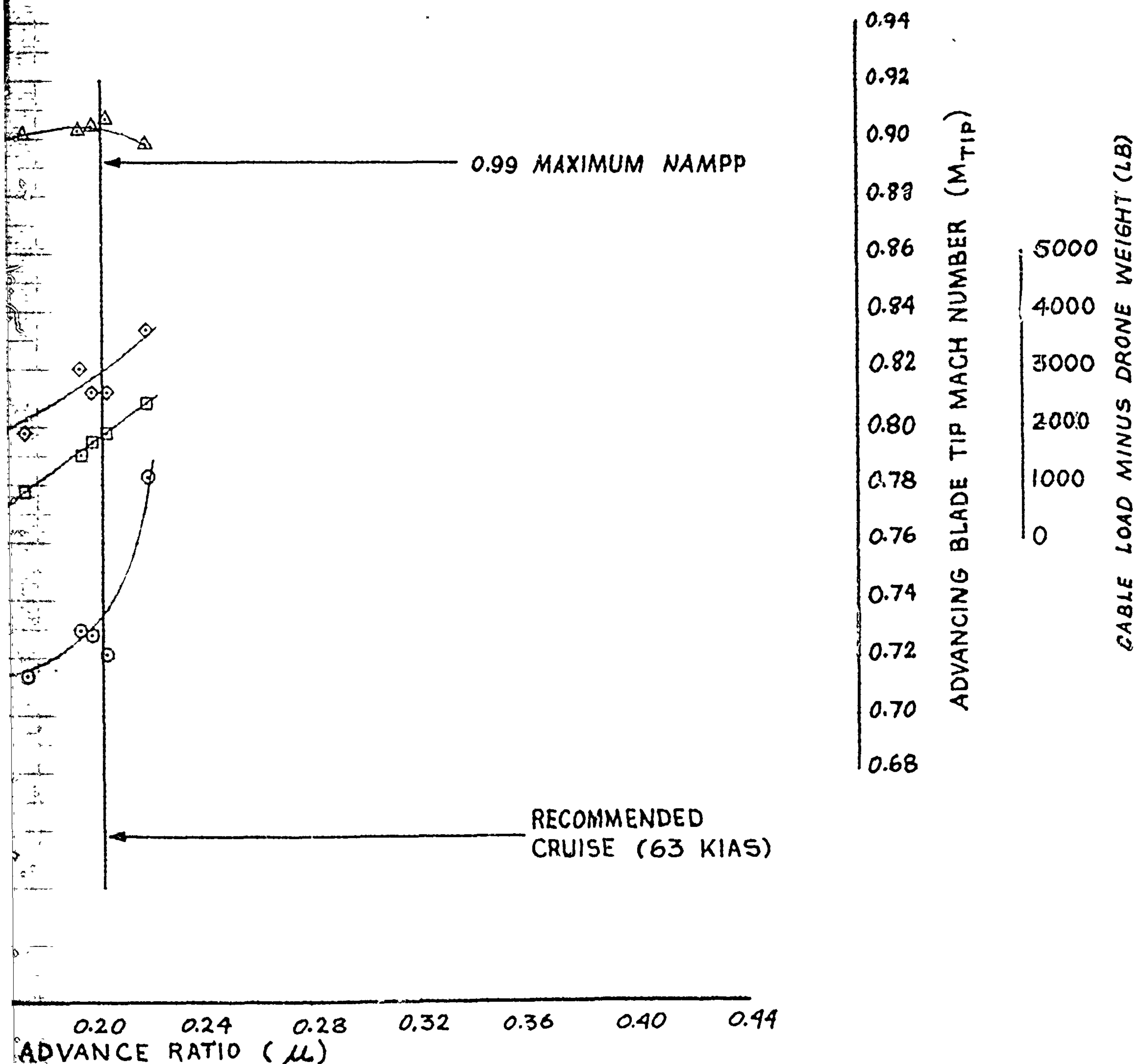


FIGURE 107 NONDIMENSIONAL LEVEL FLIG

HH-53C USAF S/N 67-14993
-GE-7 ENGINES ~ EAPS INSTALLED
MARS PERFORMANCE

AVG. PRESSURE ALTITUDE (FT) = 13,650
AVG. FREE AIR TEMP. (DEG. C) = -7.5
AVG. GROSS WEIGHT INCLUDING DRONE (LB) = 36,350
AVG. CG LOCATION (STA) = 338.7

450-GAL. AUXILIARY FUEL TANKS, EXTERNAL RESCUE HOIST,
ED POSITION.



ENSIONAL LEVEL FLIGHT PERFORMANCE (AQM-91A)

2

HH-53C USAF S/N 67-14993

T64-GE-7 Engines - EAPS Installed

MARS Performance

Notes:
1. Left engine S/N 261005.
2. One hundred percent N_g = 18,230 rpm.
3. Temperature ratio computed using ambient air temperature.
4. Pressure ratio computed using ambient air pressure.

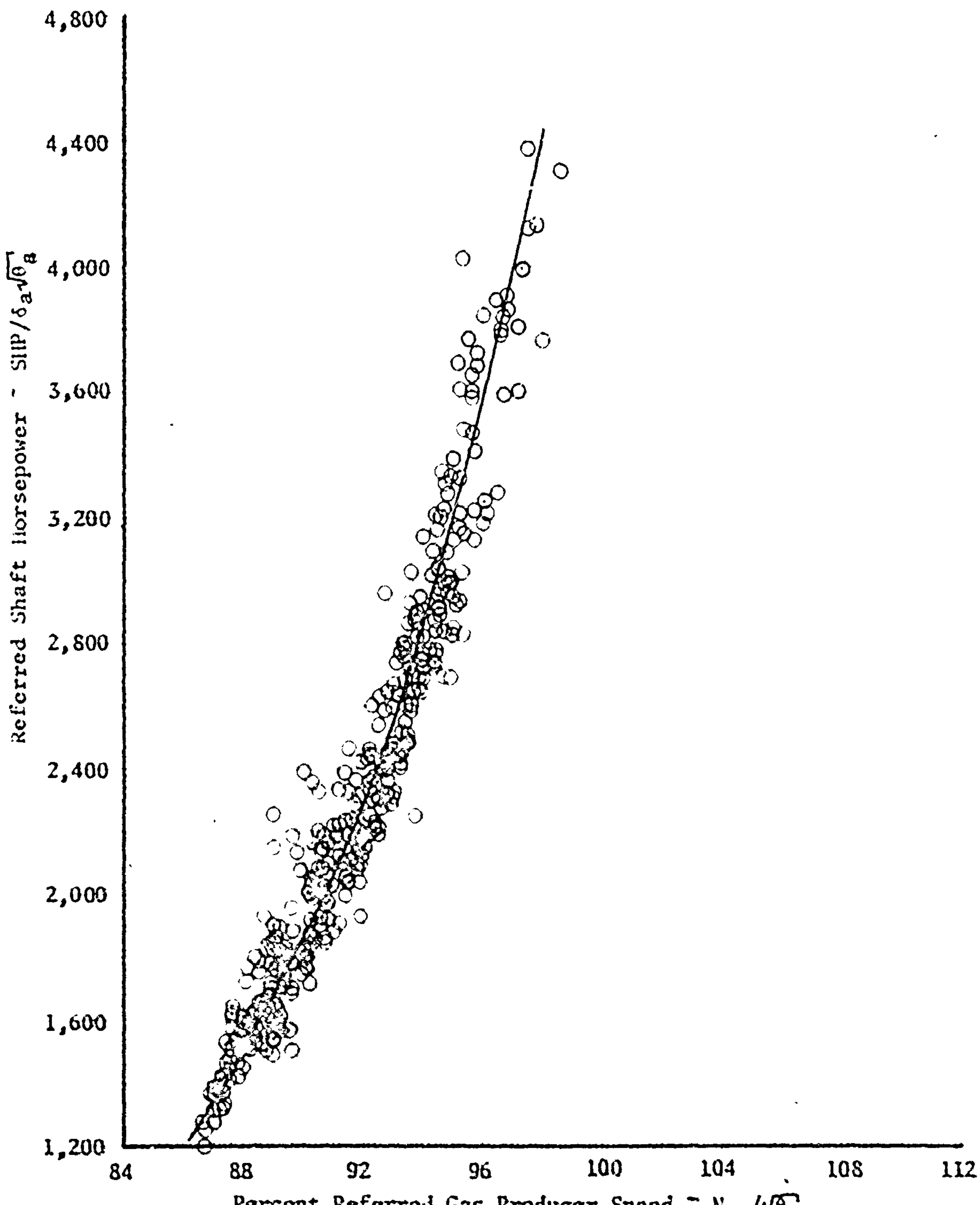


Figure 108. Engine Characteristics

HH-53C USAF S/N 67-14993
T64-GE-7 Engines - EAPS Installed
MARS Performance

Notes: 1. Left engine S/N 261005.
2. One hundred percent N_g = 18,230 rpm.
3. Temperature ratio computed using ambient air temperature.
4. Pressure ratio computed using ambient air pressure.

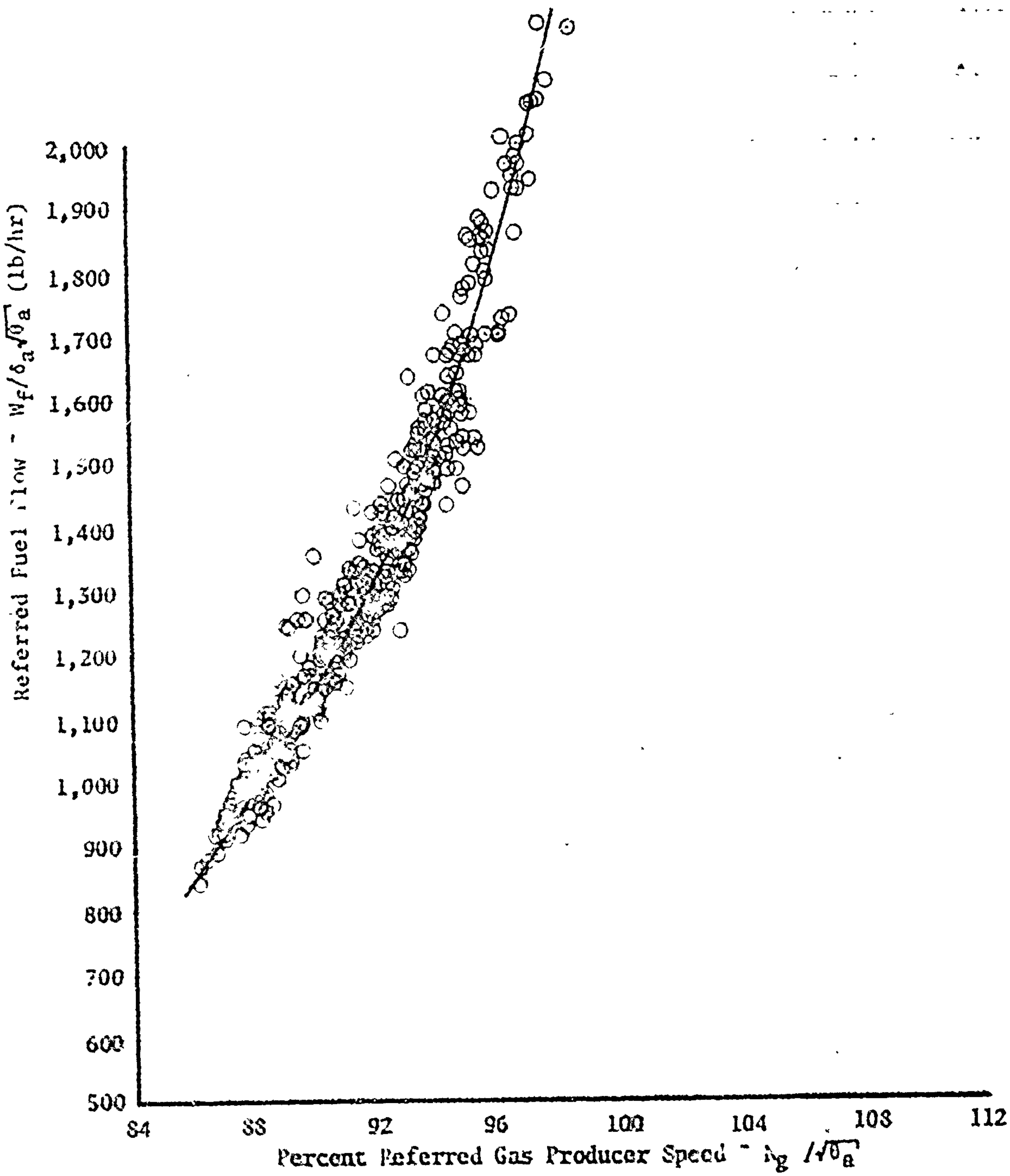


Figure 109. Engine Characteristics

HH-53C USAF S/N 67-14993
T64-GE-7 Engines - EAPS Installed
MARS Performance

Notes: 1. Right engine S/N 261006.
2. One hundred percent N_g = 18,230 rpm.
3. Temperature ratio computed using ambient air temperature.
4. Pressure ratio computed using ambient air pressure.

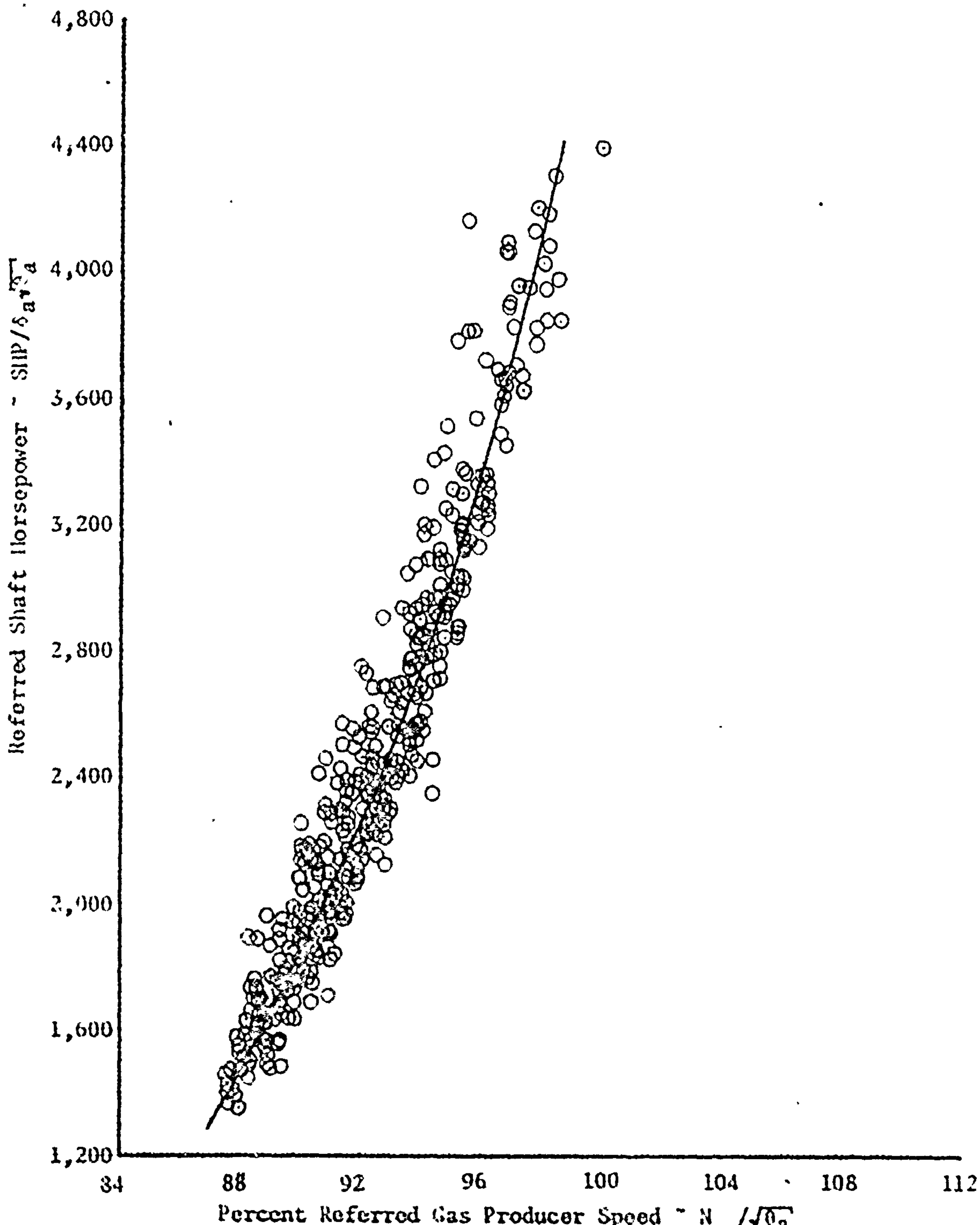


Figure 110. Engine Characteristics

HH-53C USAF S/N 67-14993
T64-GE-7 Engines - EAPS Installed
MARS Performance

Notes: 1. Right engine S/N 261006.
2. One hundred percent N_g = 18,230 rpm.
3. Temperature ratio computed using ambient air temperature.
4. Pressure ratio computed using ambient air pressure.

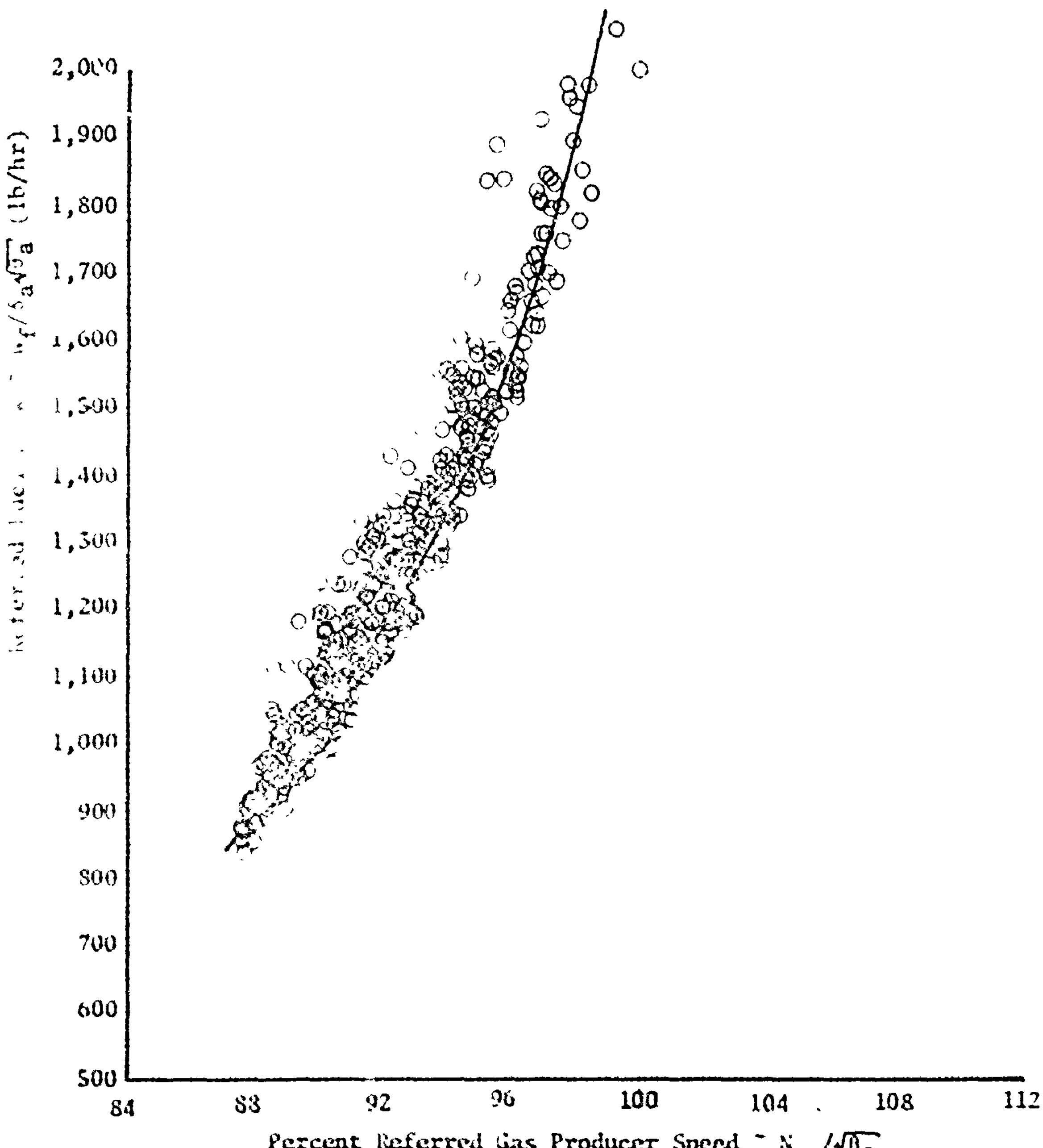


Figure 111. Engine Characteristics

HH-53C USAF S/N 67-14993
T64-GE-7 Engines - EAPS Installed
MARS Performance

Notes:
1. Left engine S/N 261005.
2. Temperature ratio computed using ambient air temperature.
3. Pressure ratio computed using ambient air pressure.
4. Solid fairing derived from figures 108 and 109, Appendix I.

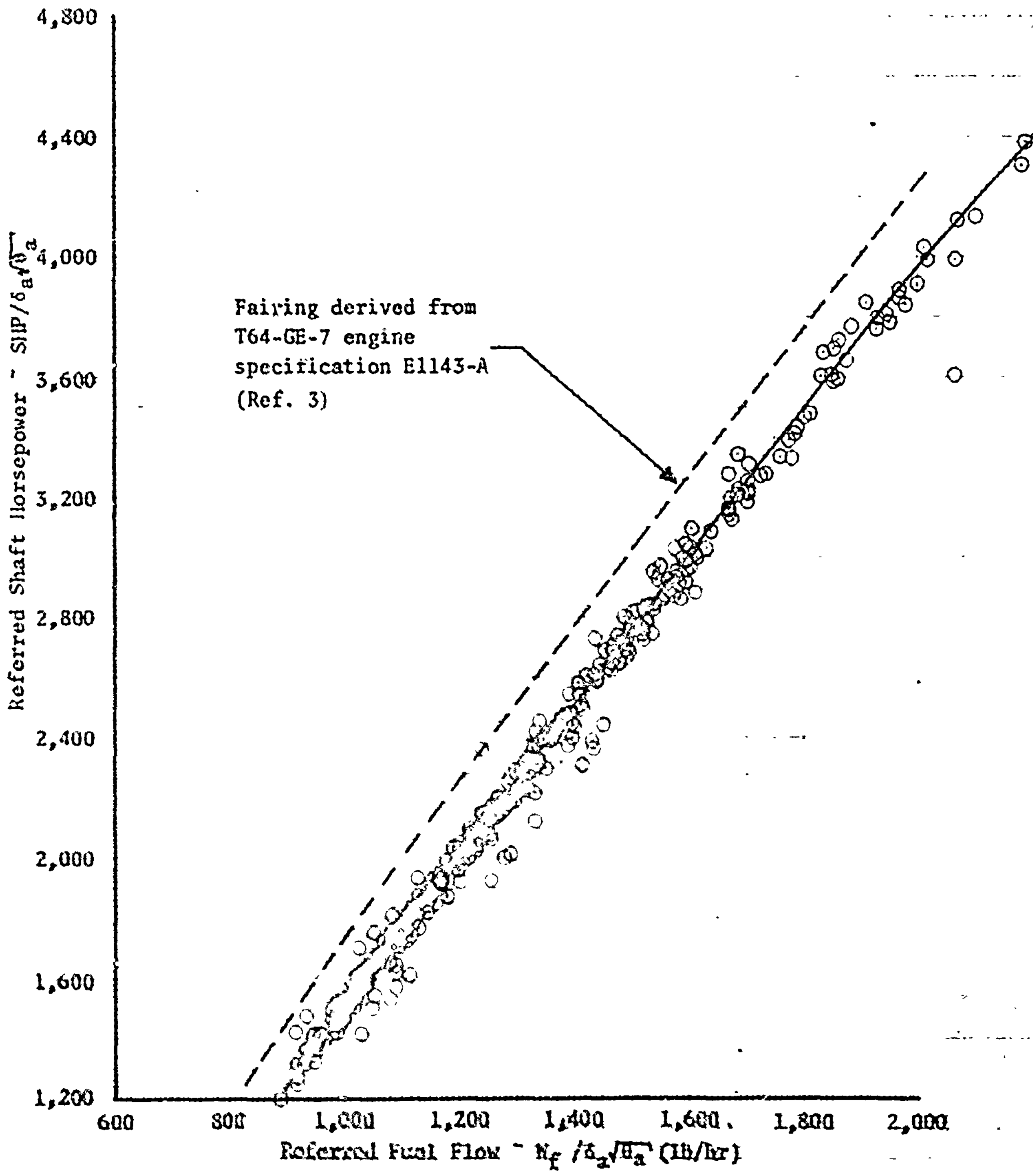


Figure 112. Engine Characteristics

HH-53C USAF S/N 67-14993
T64-GE-7 Engines - EAPS Installed
MARS Performance

Notes: 1. Right engine S/N 261006.
2. Temperature ratio computed using ambient air temperature.
3. Pressure ratio computed using ambient air pressure.
4. Solid fairing derived from figures 110 and 111, Appendix I.

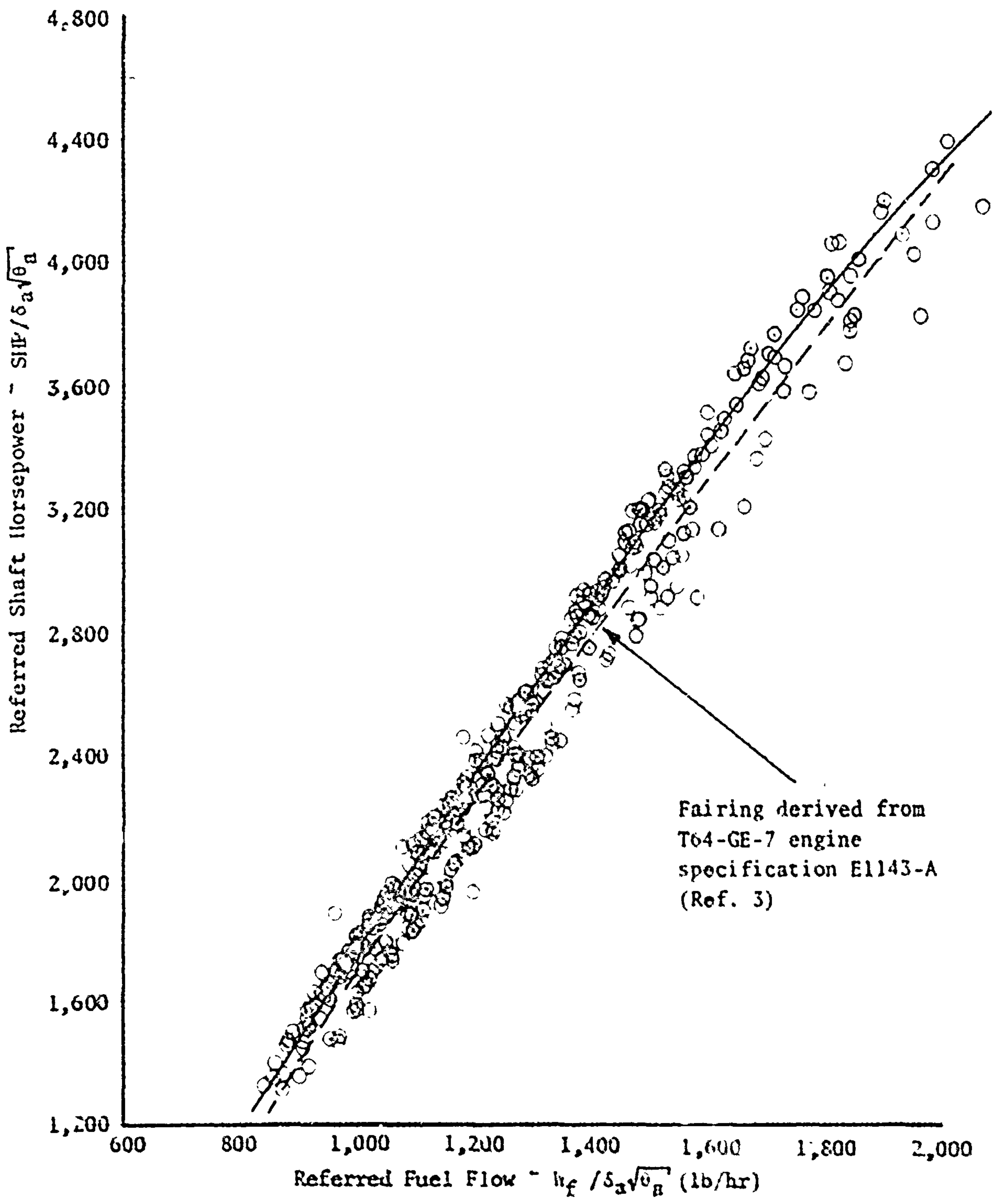


Figure 113. Engine Characteristics

APPENDIX II
GENERAL AIRCRAFT INFORMATION

DESIGN DATA

Overall Dimensions

Aircraft length (rotors turning)	88 ft 6 in.
Height (to top of turning tail rotor)	24 ft 11 in.
Height (to top of rotor crown)	17 ft 1.4 in.
Aircraft width (main rotor blades removed)	16 ft 6 in.
Main landing gear tread	13 ft 0 in.

Main Rotor

Number of blades	6
Rotor diameter	72 ft 3 in.
Rotor disc area	4071.5 sq ft
Blade chord	2 ft 2 in.
Blade airfoil	NACA 0011 Modified
Effective solidity ratio	0.115
Clearance above ground (static)	10 ft 4 in.
Angle of incidence in neutral (all blades)	17° 15 min.

Tail Rotor

Number of blades	4
Diameter	16 ft 0 in.
Rotor disc area	201.1 sq ft
Blade chord	1 ft 3.4 in.
Blade airfoil	NACA 0012
Solidity ratio	0.16
Clearance above ground	8 ft 9 in.

Main Rotor Speeds

Power on design maximum (normal operation)	105% (193.9 rpm)
Power on design minimum (normal operation)	95% (175.5 rpm)
Power off design maximum	125% (231 rpm)

Gear Ratios

Engine power turbine speed to engine output shaft	2.2580:1
Main gear box speed to main rotor speed	32.5567:1
Tail rotor speed to main rotor speed	4.2810:1

Limit Flight Load Factors

Positive maneuver loads (g's)	
35,500 lb (zero airspeed)	+2.5
35,500 lb (0 - 60 kt)	linear +2.5 to 3.0
35,500 lb (greater than 60 kt)	3.0
42,000 lb	2.1
Negative maneuver loads (g's)	
42,000 lb	-0.5

Design Maximum Airspeeds

Level flight (40,750 lb)	170 KIAS or 0.94 blade tip Mach
Level flight (42,000 lb)	158 KIAS or 0.94 blade tip Mach
Sideward	35 kt
Rearward	30 kt
External loads	150 KIAS
Landing gear actuation	140 KIAS
Landing gear extended	170 KIAS

ROTOR SYSTEMS

The main rotor is a six-bladed, fully-articulated rotor. The main rotor head is mounted directly to the output shaft of the main gear box and consists of a hub assembly and a swashplate assembly.

The hub assembly, consisting of six sleeve-spindle assemblies and six hydraulic dampers, is splined to the main rotor drive shaft. The main rotor blades are attached to the sleeve-spindle assemblies which permit each blade to flap vertically, hunt horizontally, and rotate about their spanwise axis. The hydraulic dampers minimize the hunting movement of the blades about the vertical hinges as they rotate, prevent shock to the blades when the rotor head is started or stopped, and position the blades against the stops after rotor shut down.

The swashplate assembly consists of a rotating upper swashplate and a stationary lower swashplate. The upper swashplate is driven by the main rotor hub assembly. The lower swashplate is secured to the main gear box by a scissor assembly to prevent rotation. The swashplates are mounted on a ballring and socket assembly which keeps them parallel at all times. However, they can be simultaneously tilted, raised, or lowered by the flight control system connected to arms on the lower swashplate. Cyclic or collective pitch changes introduced at the lower swashplate are transmitted to the blades by linkage on the upper swashplate.

The tail rotor assembly consists of the tail rotor hub assembly, sleeve and spindle, pitch-changing mechanism, and four tail rotor blades. The tail rotor hub assembly is mounted on the upper end of the pylon and is splined to and driven by the horizontal output shaft of the tail gear box. The tail rotor blades are attached to the sleeve and spindle assembly and flapping hinges, which allows them to flap and rotate about their spanwise axis for pitch variation. Anti-flap pins prevent flapping at low rpm and when the blades are stopped.

POWER PLANT

The aircraft is powered by two General Electric T64-GE-7 turboshaft engines, each of which has an uninstalled rating of 3,925 SHP at sea level standard day conditions. The engines are located one on each side of the upper outboard fuselage. The basic engine consists of a torque sensor shaft and housing, compressor section, combustion section, and turbine section.

The torque sensor shaft and housing transmits engine power to the nose gear box. The shaft assembly is used for torque measuring purposes.

The compressor section consists of the compressor rotor assembly and the compressor stator. The main purpose of the compressor section is to compress air for combustion and provide bleed air.

The combustion section consists of a combustion chamber and frame, combustion liner, fourteenth stage compressor and exit guide vanes, and the combustion air deflector. The combustion chamber has fuel nozzles and two ignitor plugs. The combustion liner has perforated inner and outer shells to provide airflow for liner cooling, combustion, and dilution of combustion products to maintain required engine temperature.

The turbine section contains the gas generator and power turbines, which are not mechanically coupled. The gas generator turbine rotor receives hot combustion chamber gases and extracts the power necessary to drive the compressor. The remainder of that power is used to drive the power turbine which provides power output. Power turbine speed can be regulated independent of power output. This allows the pilot to set a desired power turbine speed with the engine throttles. The power turbine speed governor will set the gas generator speed at a level necessary to maintain the power turbine speed and provide a constant main rotor speed.

Each engine has an engine air particle separator which is designed to remove sand, dust, and foreign particles in the engine inlet air, exhaust these particles, and allow clean air to enter the engine. The separators are located in front of and along the outboard side of the engine air inlet duct.

WEIGHT AND BALANCE

The operating weight of the MARS-modified test aircraft, measured with full oil, full hydraulic fluid, trapped fuel, and test instrumentation installed was 28,233 pounds. The cg for this condition was at fuselage station 338. The allowable cg range was between fuselage stations 328 and 352. The maximum allowable gross weight was 42,000 pounds.

AIRSPEED LIMITATIONS

The design maximum allowable airspeed (equal to the never-exceed airspeed, V_{NE}) was limited to the lowest value of the following: 170 KIAS; the maximum allowable airspeed as limited by retreating blade stall; or the maximum allowable airspeed as limited by advancing blade tip Mach number. These latter two limits are derived from charts in the Flight Manual (reference 4). These charts are presented as figures 1 and 2 of this appendix. Figure 1 presents the limits on maximum airspeed defined by retreating blade stall as a function of pressure altitude, outside air temperature, rotor speed, gross weight, and indicated airspeed. Figure 2 presents the limits on maximum airspeed defined by advancing blade tip Mach number as a function of gross weight, outside air temperature, rotor speed, and indicated airspeed.

SPECIAL INSTRUMENTATION

Special instrumentation for the test program was principally furnished by the AFFTC with some equipment being provided by Sikorsky Aircraft. The installation was performed at Edwards AFB by Sikorsky Aircraft personnel.

Photos of the instrumentation installation are presented in figures 3 through 5. A list of test instrumentation is also provided in this appendix.

TEST INSTRUMENTATION LIST

Parameter	Range	Calibration Increment
Engine Torque (No. 1 and No. 2)	0-130 percent	10 percent
Airspeed	0-170 kt	10 kt
Altitude	0-20,000 ft	500 ft from 0 to 5,000 ft 1,000 ft from 5,000 to 20,000 ft
Rotor Speed	0-200 rpm	2 rpm from 174 to 200 rpm
Load Cell	0-16,000 lb	800 lb
Engine Fuel Temperature (No. 1 and No. 2)	-45 to +55 deg C	5 deg C
Gas Generator Speed (No. 1 and No. 2)	70 to 105 percent	3 percent
Outside Air Temperature	-40 to +90 deg C	10 deg C
Power Turbine Speed (No. 1 and No. 2)	0 to 110 percent	5 percent from 0 to 80 percent 2 percent from 80 to 110 percent
Fuel Counters (No. 1 and No. 2)	0 to 59,999 counts	16 counts = 1 gallon
Instantaneous Vertical Speed Indicator	0 to 3,000 feet per minute (dive)	500 feet per minute

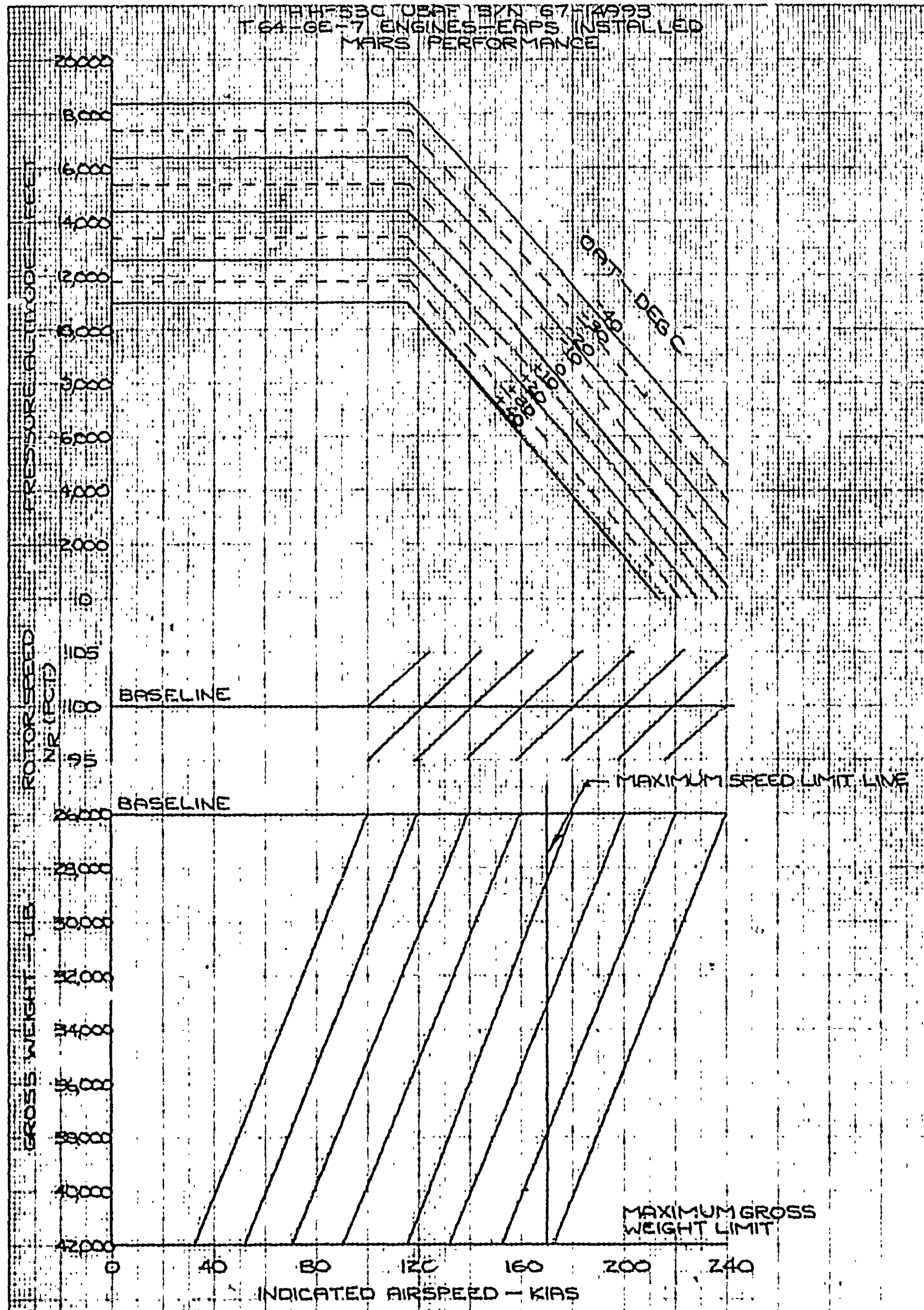


FIGURE 1. MAXIMUM AIRSPEED AS LIMITED BY BLADE STALL

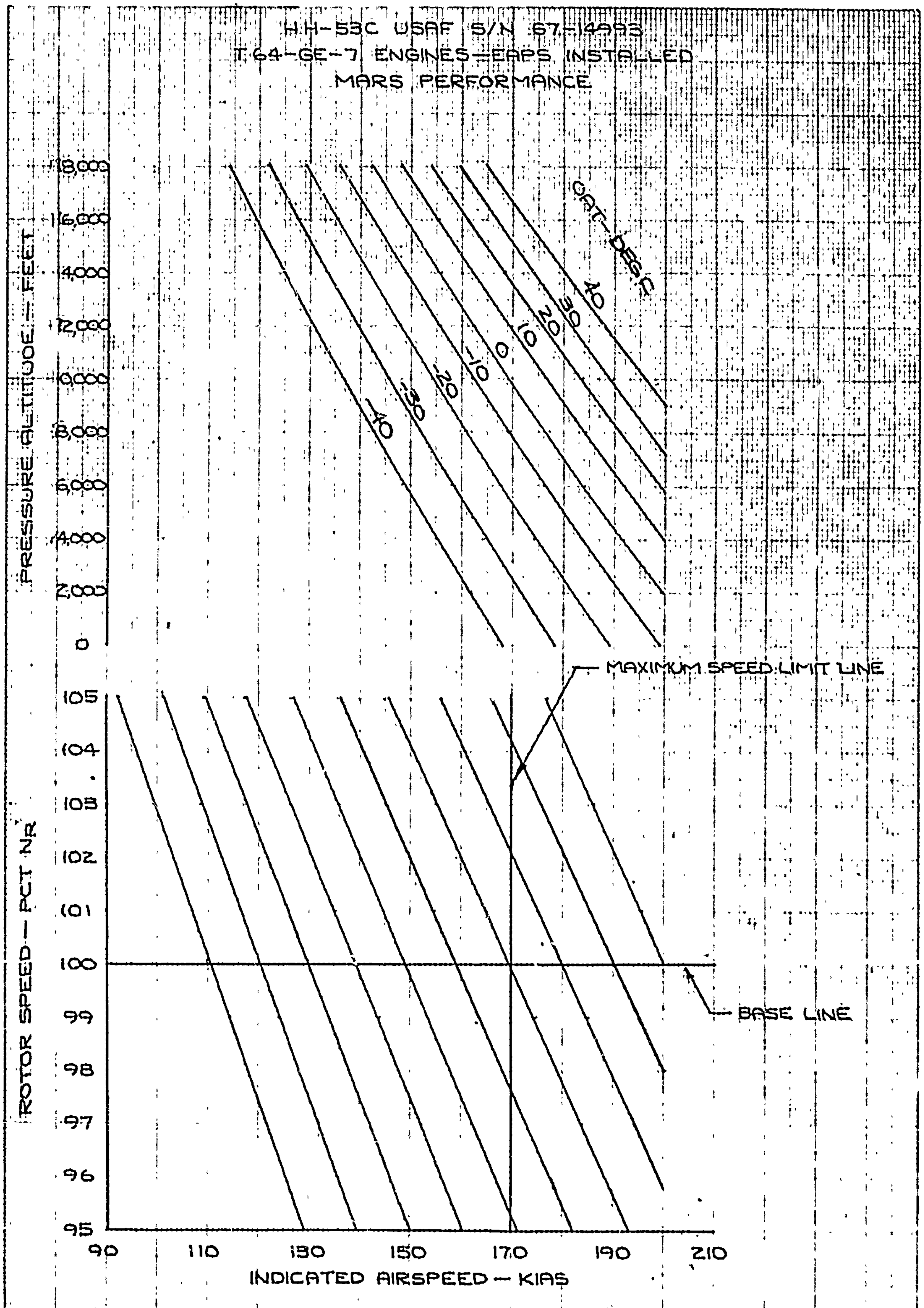


FIGURE 2. MAXIMUM AIRSPEED AS LIMITED BY M_{TIP}

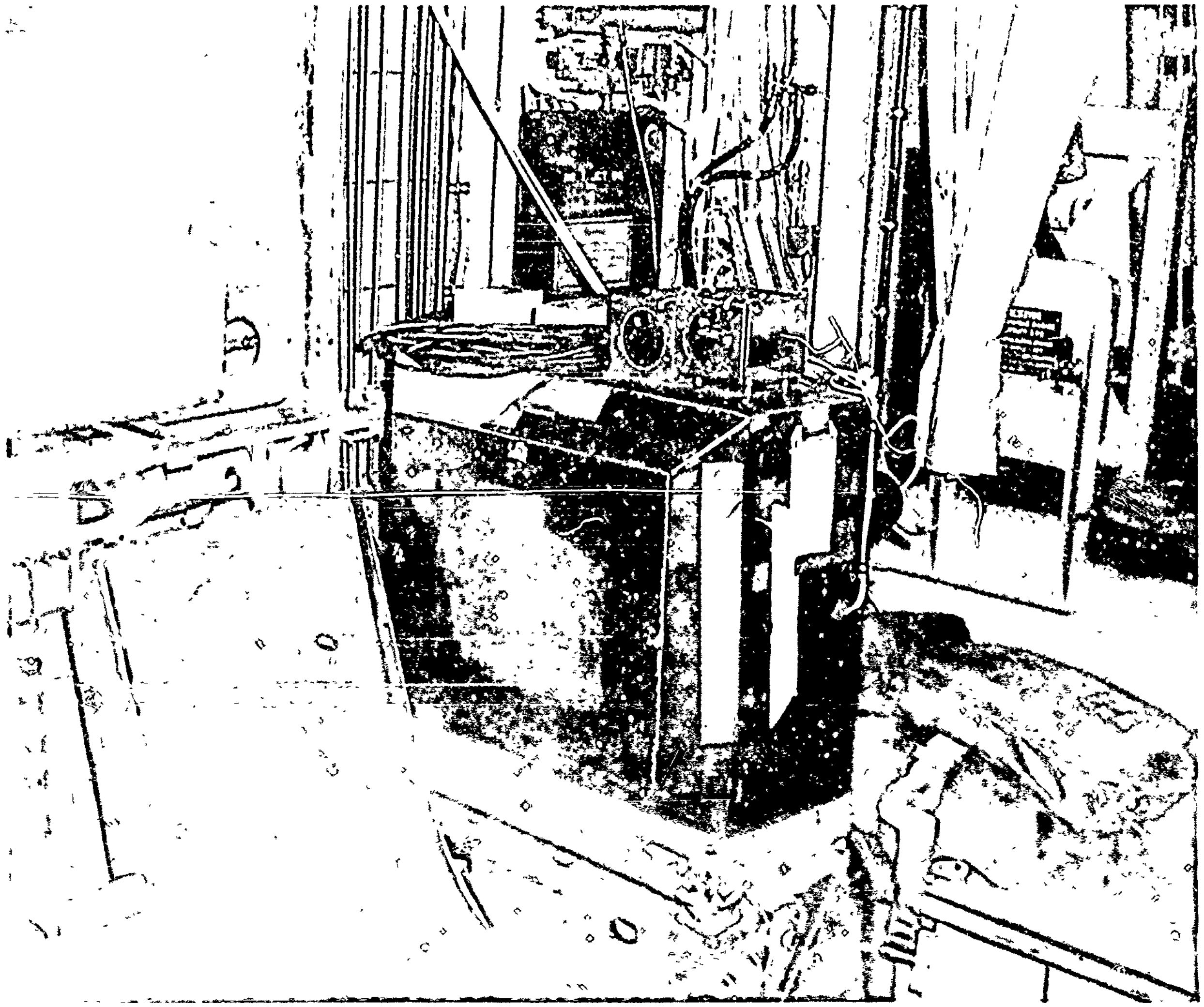


Figure 3 Instrumentation Installation

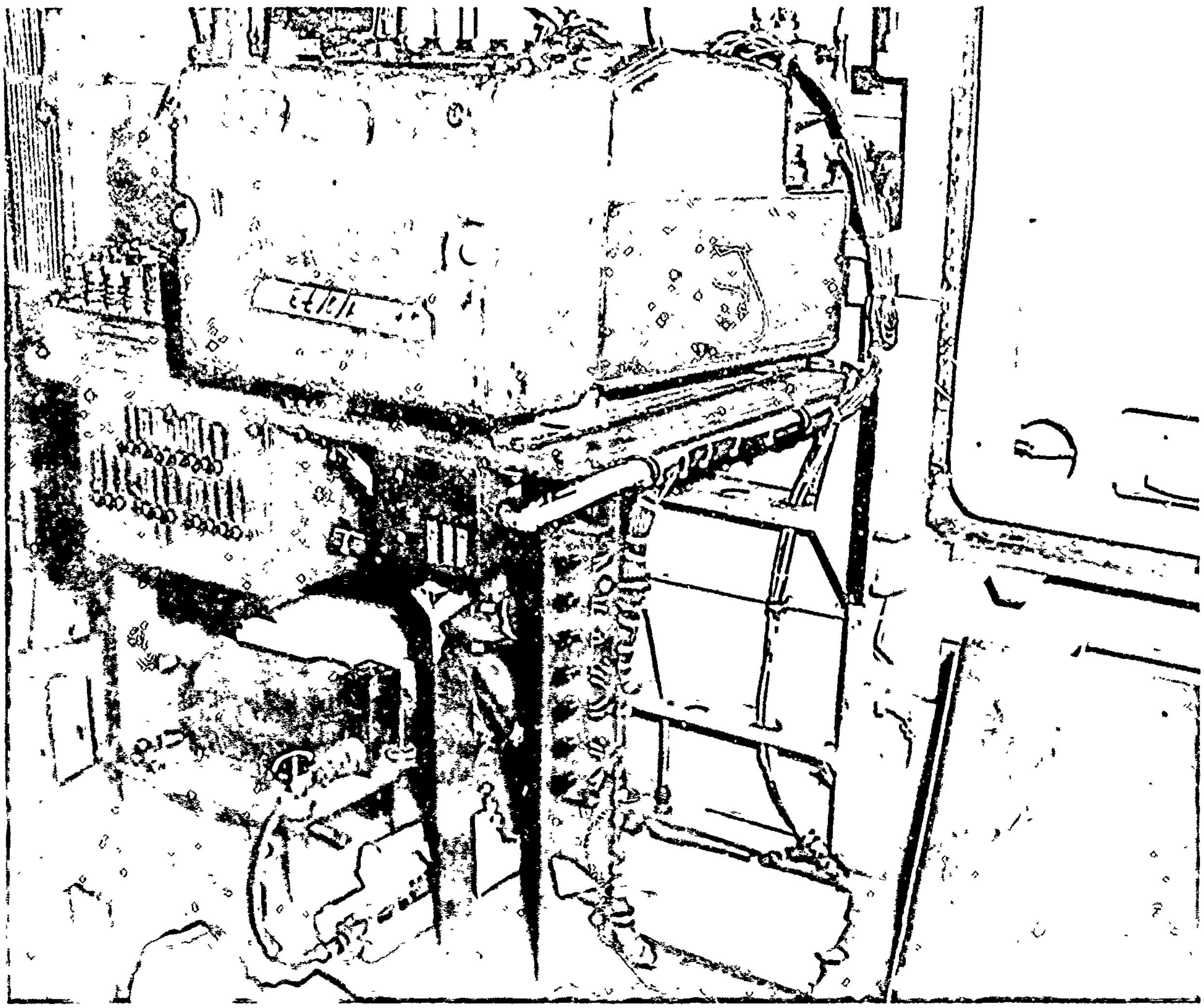


Figure 4 Instrumentation Installation

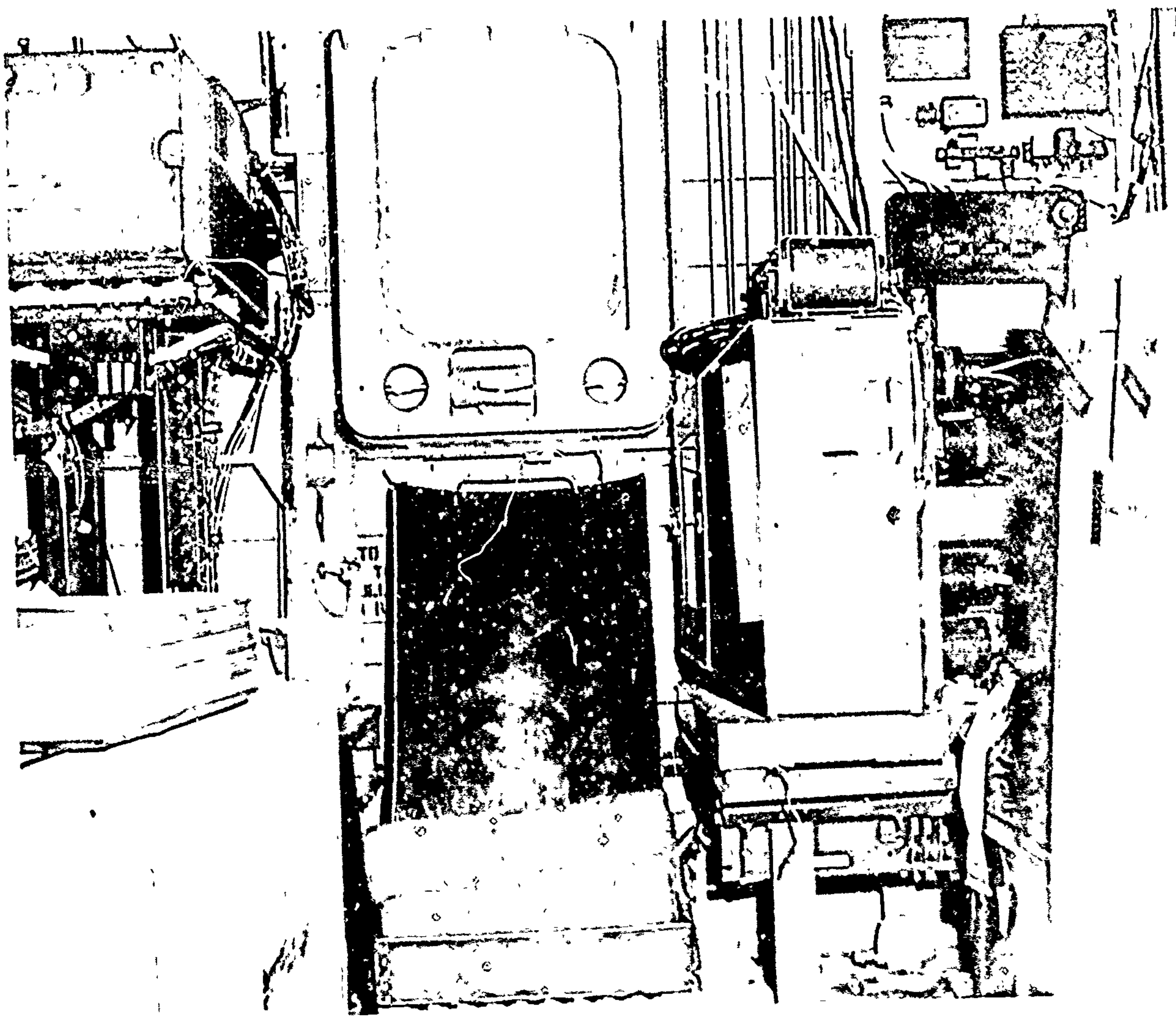


Figure 5 Instrumentation Installation

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13. ABSTRACT

This report presents the results of tests to determine the performance characteristics of a MARS (Mid Air Retrieval System) -modified HH-53C helicopter in the clean loading and with the AQM-34L, AQM-34R and AQM-91A drones in tow. No unusual handling qualities were noted when smooth, coordinated flight techniques were used. Hover performance with the AQM-91A drone in tow was unchanged from that of the clean MARS-modified HH-53C when hovering in ground effect. Power required to hover out of ground effect was increased four to six percent by the effects of the AQM-91A in tow. Level flight performance comparisons between the clean MARS-configured HH-53C and the same aircraft with each of the drones in tow revealed a decrease in average maximum nautical air miles per pound of fuel of approximately 12 percent with the AQM-34L drone, 13 percent with the AQM-34R drone, and 34 percent with the AQM-91A drone.

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