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RDTE PROJECT NO.  
USAAVSCOM PROJECT NO. 68-30  
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**AIRWORTHINESS  
AND FLIGHT CHARACTERISTICS TEST  
PRODUCTION OH-58A HELICOPTER  
UNARMED AND ARMED WITH  
XM27E1 WEAPON SYSTEM**

**PERFORMANCE**

**FINAL REPORT**

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PROJECT ENGINEER

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PROJECT OFFICER/PILOT

**SEPTEMBER 1970**

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**US ARMY AVIATION SYSTEMS TEST ACTIVITY  
EDWARDS AIR FORCE BASE, CALIFORNIA 93523**

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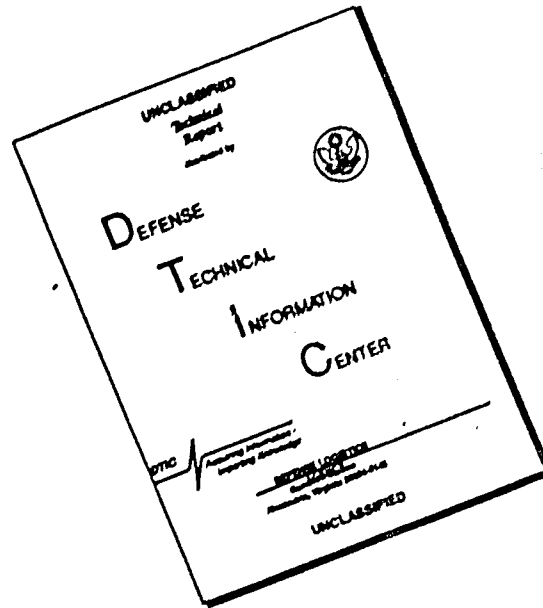
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## **ABSTRACT**

Performance tests were conducted on a production OH-58A helicopter to determine compliance with performance guarantees outlined in the detail specification and approved revisions, and also to provide information for the operator's manual. Testing was performed by the US Army Aviation Systems Test Activity, Edwards Air Force Base, California, during the period between 19 August 1969 and 13 January 1970. The testing consisted of 99 flights totaling 62.5 productive hours. The OH-58A met or exceeded all of the contractual performance guarantees. The engine inlet losses with the particle separator installed exceeded the limits of the detail specification. A single flight at cold temperatures indicated that level flight performance is significantly affected by compressibility. Although all contractual hover performance guarantees were met, the helicopter could not hover out of ground effect on a 95°F day at gross weights greater than 2930 pounds with the particle separator installed. Under moderate temperature conditions, the performance capabilities of the OH-58A are satisfactory for mission accomplishment. It is recommended that consideration be given to increasing the utility of the OH-58A by installing a more powerful engine.

## **FOREWORD**

Throughout the performance evaluation, technical support was provided under contract by the airframe manufacturer, Bell Helicopter Company, Fort Worth, Texas; and the engine manufacturer, Allison Division of General Motors Corporation, Indianapolis, Indiana. Instrumentation calibration, emergency fire fighting, scientific photography and medical support were provided by the US Air Force Flight Test Center, Edwards Air Force Base, California.

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# INTRODUCTION

## BACKGROUND

1. In 1967, the US Army Aviation Systems Test Activity (USAASTA) conducted a preliminary evaluation of a production Model 206A (JetRanger) helicopter manufactured by Bell Helicopter Company. A contract was awarded to Bell Helicopter Company in 1968 to produce for the US Army a Light Observation Helicopter (LOH) designated the OH-58A. Authority for USAASTA to conduct engineering flight tests of a production OH-58A was issued by the Project Manager, US Army Materiel Command in a test directive 7 August 1968 (ref 1, app I). Performance tests were conducted at Edwards Air Force Base, California, and at auxiliary test sites near Bakersfield and Bishop, California.

## TEST OBJECTIVES

2. The objectives of the test program were as follows:

a. To determine compliance with detail specification guarantees (ref 2, app I).

b. To provide performance data, with and without the XM27E1 armament system installed, for incorporation into the operator's manual and other publications.

## DESCRIPTION

3. The OH-58A Light Observation Helicopter employs a single main rotor and an antitorque tail rotor of the two-bladed, semirigid, teetering type. The tail rotor also has a delta-three coupling. The cockpit provides side-by-side seating for a crew of two (pilot and copilot/observer), and the cargo compartment has provisions for two passengers. Dual flight controls are provided. The cyclic and collective controls are of the hydraulically boosted, irreversible type, and the antitorque control is unboosted. The main landing gear is of the fixed, energy-absorbing skid type. The helicopter is powered by an Allison T63-A-700 free gas turbine engine with a takeoff power rating of 317 shaft horsepower (shp) under sea-level (SL), standard-day, uninstalled conditions. The main transmission has a rating of 270 shp (maximum continuous) with a takeoff power limit of 317 shp (5-minute rating). More detailed aircraft information may be found in appendix II.

4. The XM27E1 armament system consists of one XM134 high-rate 7.62 millimeter (mm) gun (GAU-2B/A) with mount, feed system and ammunition boxes, and one XM70E1 sight for pilot operation. The weapon system is mounted on the left side of the helicopter near the longitudinal center of gravity (cg). The XM134 gun is adjustable in elevation from 5 degrees above to 20 degrees below waterline zero and is operated by either the pilot or copilot/observer.

#### SCOPE OF TEST

5. The OH-58 was evaluated with respect to its guaranteed mission capabilities as defined in the detail specification. The flight restrictions and operating limitations observed during this evaluation were as specified in the Federal Aviation Administration (FAA) approved operator's manual with exceptions specifically approved by the US Army Aviation Systems Command (USAAVSCOM).

6. Performance tests were conducted in both the armed and unarmed configurations, primarily with all doors installed. In order to determine the effect of door removal on level flight performance, tests were also conducted in the armed configuration with various door combinations. Gross weight was varied from the lightest obtainable to the maximum design weight. A mission cg location at an approximate fuselage station (FS) of 107 inches was used for all tests except for two level-flight speed-power polars that were flown to determine the effect of cg change. Additional tests were conducted to determine the increase in power required for level flight with sideslip, as well as level flight at higher main rotor tip Mach numbers. One flight was conducted with the particle separator removed in order to determine the difference in engine inlet losses. All other tests were flown with the particle separator installed.

7. A total of 99 flights were conducted, consisting of 62.5 productive hours, at Edwards Air Force Base, Bakersfield, and Bishop, California.

#### METHODS OF TEST

8. Flight test methods used for data acquisition are briefly described in each subtest section of this report and also in the test plan (ref 3, app I). Appendix III outlines the reduction methods used to analyze and evaluate the data in order to determine performance capabilities and compliance with contractual guarantees. All tests were conducted under nonturbulent atmospheric conditions to preclude uncontrolled disturbances influencing the results.

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9. An OH-58A helicopter (S/N 68-16693) was equipped with sensitive, calibrated instrumentation. A detailed list of the test instrumentation is presented in appendix IV. Photographs of the cockpit and cabin instrumentation are found in appendix V. Qualitative pilot comments were used to aid in the analysis of data and to assist in the overall assessment of the performance characteristics of the OH-58A.

#### CHRONOLOGY

10. The chronology of the OH-58A test program is as follows:

|                               |            |      |
|-------------------------------|------------|------|
| Test directive issued         | 7 August   | 1968 |
| Test plan submitted (revised) | May        | 1969 |
| Test plan approved            | July       | 1969 |
| Test aircraft received        | 3 July     | 1969 |
| Tests started                 | 18 August  | 1969 |
| Calibrated engine installed   | 23 August  | 1969 |
| Tests completed               | 13 January | 1970 |
| Draft report submitted        | May        | 1970 |

## RESULTS AND DISCUSSION

### GENERAL

11. Test results indicate that the performance capabilities of the OH-58A helicopter are satisfactory for mission accomplishment under moderate temperature conditions. At cold temperatures and high advancing tip Mach numbers, compressibility effects significantly decrease the level flight performance. On a hot day (95°F), the OH-58A helicopter lacks the power available for out of ground effect (OGE) hover capability at gross weights greater than 2930 pounds. All detail specification performance guarantees were met or exceeded. Guarantee compliance was based on fuel-flow and power-available data presented in the T63-A-700 engine model specification (ref 4, app I) without the particle separator installed. This particle-separator-removed condition was a contractual agreement defined in the detail specification. Definitions of configuration I and II gross weights, which were used for all of the guarantee compliances, are summarized in table 1. Table 2 summarizes performance guarantee results at 354 rotor rpm based on the engine inlet losses without the particle separator installed.

12. The test data that are presented in appendix VI represent conditions with the particle separator installed, except for five plots which were used for guarantee compliance and are indicated by the notation "particle separator removed."

Table 1. Guarantee Gross Weights.

| Item                      | Weight (lb) | Configuration I <sup>1</sup> | Configuration II <sup>2</sup> |
|---------------------------|-------------|------------------------------|-------------------------------|
| Guaranteed empty weight   | 1586        | 1586                         | 1586                          |
| Crew of two               | 400         | 400                          | 400                           |
| Engine oil                | 10          | 10                           | 10                            |
| Removable armor           | 112         | 112                          | 112                           |
| Armor chest protectors    | 30          | 30                           | 30                            |
| Mission equipment         | 170         | 170                          | 170                           |
| XM27E1 armament system    | 106         | 0                            | 106                           |
| 2000 rounds of ammunition | 128         | 0                            | 128                           |
| Fuel                      | --          | <sup>3</sup> 443.9           | <sup>4</sup> 417.8            |
| Total gross weight        |             | 2752                         | 2960                          |

<sup>1</sup>Observation mission.

<sup>2</sup>Scout mission.

<sup>3</sup>Fuel required for a 260 nautical air mile range, sea level, standard day, particle separator removed; 10 percent of initial fuel for reserve, takeoff fuel allowance consisting of 2-minute fuel at normal rated power (conditions as defined in ref 2, app I).

<sup>4</sup>Same conditions as footnote 3 above except for a 230 nautical air mile range.

Table 2. Performance Guarantee Summary  
(Particle Separator Removed).

| Configuration I <sup>1</sup>                                             |                       |                       |
|--------------------------------------------------------------------------|-----------------------|-----------------------|
| Item                                                                     | Guaranteed            | Test Results          |
| FAA certified $V_{NE}$ <sup>2</sup> ,<br>sea level, standard day         | 120 KCAS <sup>3</sup> | 123 KCAS              |
| Power required, 110 KTAS <sup>4</sup> ,<br>sea level, standard day       | 255 shp               | 246 shp               |
| Maximum rate of climb at<br>MRP <sup>5</sup> , sea level, standard day   | 1500 fpm <sup>6</sup> | 1815 fpm              |
| Hover ceiling at MRP, OGE,<br>95°F day                                   | 2000 ft               | 2240 ft               |
| Hover ceiling at MRP, IGE <sup>7</sup> ,<br>4-foot skid height, 95°F day | 5000 ft               | 5030 ft               |
| Range at sea level, standard<br>day                                      | 260 NAMT <sup>8</sup> | 260 NAMT              |
| Endurance at sea level,<br>standard day                                  | 3.0 hrs               | 3.63 hrs              |
| Configuration II <sup>9</sup>                                            |                       |                       |
| Range at sea level, standard<br>day                                      | 230 NAMT              | 230 NAMT              |
| Hover ceiling at MRP, OGE,<br>standard day                               | 6000 ft               | 6270 ft <sup>10</sup> |

<sup>1</sup>Observation mission gross weight calculated to be 2752 pounds.

<sup>2</sup>Never exceed airspeed.

<sup>3</sup>Knots calibrated airspeed.

<sup>4</sup>Knots true airspeed.

<sup>5</sup>Military rated power.

<sup>6</sup>Feet per minute.

<sup>7</sup>In ground effect.

<sup>8</sup>Nautical air miles traveled.

<sup>9</sup>Scout mission gross weight, XM27E1 gun system installed, calculated to be 2960 pounds.

<sup>10</sup>Extrapolated from test data.

## PERFORMANCE CHARACTERISTICS

### Takeoff Performance

13. Takeoff performance tests were conducted to determine the total distance required to clear a 50-foot obstacle under conditions where the OH-58A cannot accomplish a vertical takeoff. Test results are presented in figures 2 through 5, appendix VI, and are summarized in figure 1. All takeoffs were initiated from a stabilized 2-foot hover skid height. Because of the limited time available for this evaluation, only the level acceleration takeoff method was used. This was qualitatively determined to be the optimum method for all operating conditions. Under conditions of large power margins (excess power available over power required), the climb acceleration takeoff method requires a high degree of pilot skill and proficiency inconsistent with normal operational requirements. During the takeoff tests, regardless of method, increased pilot attention was required in order to maintain the desired power setting without exceeding the maximum takeoff power (TOT) limit (749°C).

### Hover Performance

14. The hover performance capabilities of the OH-58A were evaluated IGE and OGE at various skid heights and gross weights, both in the clean (unarmed) and armed configurations. All hover performance data were collected using the free-flight method. A premeasured, weighted cord was attached to the skid to precisely determine height above the ground. The hover performance capabilities are summarized and presented in figures 6 and 7, appendix VI, as plots of hover capabilities based on gross weight, skid height and pressure altitude for various temperatures at takeoff and normal rated power. Nondimensional plots of power coefficient ( $C_p$ ) versus thrust coefficient ( $C_T$ ) are presented in figures 8 through 14 for skid heights of 2, 4, 10 and 20 feet (IGE) and 50 feet (OGE). These tests were conducted at density altitudes ranging from 235 to 10,110 feet and at gross weights from 2085 to 3055 pounds.

15. All OH-58A hover ceiling performance guarantees were exceeded. As stipulated, the model engine specification power available (without the particle separator installed) was used to determine guarantee compliance. At configuration I gross weight (2752 pounds), hot-day (95°F), OGE conditions, test data indicated a hover ceiling of 2240 feet as compared to a guarantee of 2000 feet. At the same gross weight, IGE (4-foot skid height), results indicated a hot-day (95°F) hover ceiling capability of 5030 feet as compared to a 5000-foot guarantee. In order to determine guarantee compliance for configuration II gross weight (2960 pounds) at standard-day, OGE conditions, the extrapolated portion of the faired curve was used, (fig. 14, app VI). The results indicated a hover ceiling capability of

6270 feet as compared to a guarantee of 6000 feet. Figure A summarizes hover ceiling test data as compared to the performance guarantee.

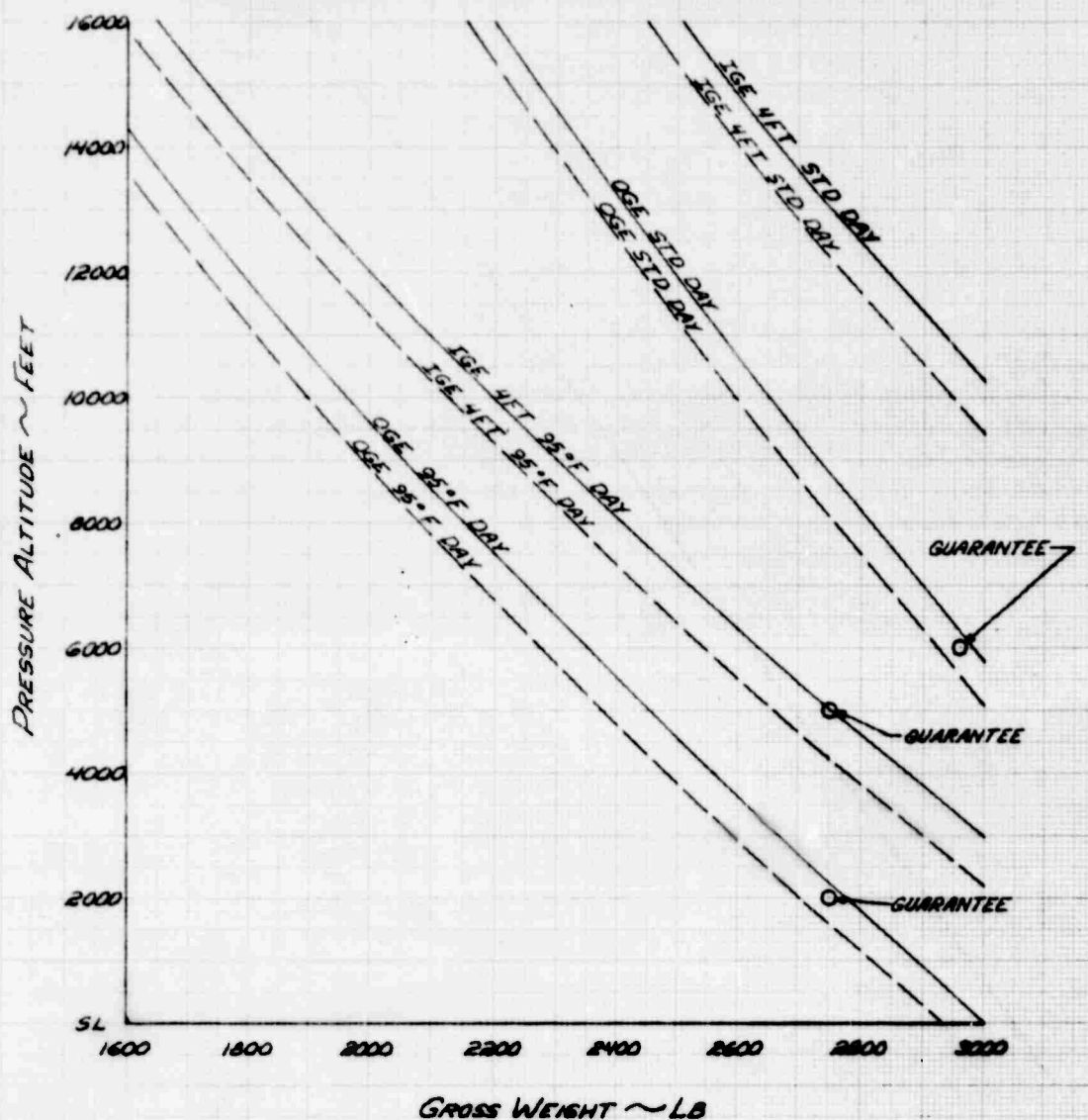
16. The hover performance of the OH-58A with the particle separator installed was adequate for mission accomplishment under moderate temperature conditions. Standard-day hover performance data indicate a sea-level capability of hovering OGE at gross weights greater than the maximum design gross weight (3000 pounds) at 354 rpm. However, on a hot day (95°F) with the particle separator installed, the OH-58A helicopter will not hover OGE at gross weights greater than 2930 pounds. Installation of the particle separator decreased the T63-A-700 engine power available by 7.5 shp at sea-level, standard-day conditions. A comparison between the hover performance with the particle separator installed and the hover performance with the particle separator removed is illustrated in figure A.

17. Since it is not a requirement of the OH-58A detail specification, the lack of a 95°F, hot-day, OGE hover capability at the configuration II gross weight could not be termed a deficiency or shortcoming of the aircraft. However, experienced test pilots who have served in Southeast Asia affirm the need for a helicopter which meets these design criteria. In combat situations, there is a requirement to maximize an aircraft's usefulness in terms of range, endurance and load-carrying capability. The OH-58A will, therefore, probably be flown in that environment at or near its maximum design gross weight of 3000 pounds and in ambient temperatures often reaching 95°F. The test results (takeoff power, model specification engine, particle separator installed, fig. A) show that at the configuration II gross weight, the OH-58A can hover IGE at pressure altitudes up to 2450 feet on a 95°F day (5100-foot density altitude). This condition will allow mission accomplishment but does not provide the safety or design margin afforded by an OGE hover capability. For a normal, safe operation, a reduced fuel load with a consequent reduction in range and endurance would be required. Considering the possibility of dirty, worn engines, inaccurate calculation of gross weight, and other factors common to an operational environment, it is recommended that the OH-58A not be flown at gross weights in excess of 2930 pounds at density altitudes higher than 2200 feet (sea level, 95°F) except in emergency tactical situations. Gross weight limitations for a range of temperature and altitude conditions should be specified in the operator's manual. Because of the temperature-limited design characteristic of the OH-58A, weight limitations are more critical at high temperature conditions than at high pressure altitudes. For increased utility, it is also recommended that consideration be given to installing a more powerful engine in the OH-58A.

**FIGURE A**  
**SUMMARY HOVER PERFORMANCE COMPARISON FOR GUARANTEE COMPLIANCE**  
**OH-58A USA SIN 68-1669.9**  
**T63-A-700 ENGINE**  
**FREE FLIGHT METHOD**  
**WINDS LESS THAN 9 KNOTS**

**NOTE:**

1. POWER AVAILABLE SPECIFICATION ENGINE OBTAINED FROM FIG. 69 APPENDIX VI.
2. HOVER CAPABILITY OBTAINED FROM FIGS 11 AND 14 APPENDIX VII.
3. SOLID LINES DENOTE WITHOUT PARTICLE SEPARATOR INSTALLED.
4. DASHED LINES DENOTE WITH PARTICLE SEPARATOR INSTALLED.



### Climb Performance

18. Continuous climbs were conducted from sea level to service ceiling to determine the OH-58A climb capabilities and compliance with the guarantees. All climbs were flown at the airspeed schedule for best rate of climb at 354 rotor rpm, and at both takeoff and maximum continuous power settings. The climb schedules were determined from level-flight data at the minimum power required for level flight on a standard day. Although the climb schedule was based on standard conditions, tests were flown with reference to pressure altitude disregarding existing ambient temperature. The data were corrected from test-day conditions to standard-day conditions and also to model specification engine power and fuel flow with the particle separator installed. No attempt was made to correct rate of climb for compressibility since the extent of this effect was not determined. Test results are presented in figures 15 through 20, appendix VI.

19. In order to make a valid comparison, flight test data were corrected to the detail specification guarantee condition. The calculated value shows that the maximum rate of climb at sea level, using takeoff power (without the particle separator installed), was approximately 1815 fpm. This exceeded the guaranteed rate of climb of 1500 fpm by 21 percent at the configuration I gross weight (2752 pounds). The computation of the compliance guarantee is summarized as follows:

| <u>Item</u>        | <u>Guarantee Condition<sup>1</sup></u> | <u>Flight Test Condition<sup>2</sup></u> |
|--------------------|----------------------------------------|------------------------------------------|
| Altitude           | SL, standard day                       | SL, standard day                         |
| Gross weight (GW)  | 2752 lb                                | 2747 lb                                  |
| Particle separator | Removed                                | Installed                                |
| Power setting      | Takeoff                                | Takeoff                                  |
| Rotor speed        | 354 rpm                                | 354 rpm                                  |

<sup>1</sup>Conditions defined in detail specification.

<sup>2</sup>Data obtained from figure 15, appendix VI.

| <u>Item</u>                                   | <u>Test Value</u>  | <u>Source</u>   |
|-----------------------------------------------|--------------------|-----------------|
| Rate of climb (R/C)                           | 1750 fpm           | Fig. 15, app VI |
| Shaft horsepower test (SHP <sub>t</sub> )     | 300 shp            | Fig. 15, app VI |
| Shaft horsepower standard (SHP <sub>s</sub> ) | 307.5 shp          | Fig. 69, app VI |
| Power correction factor (K <sub>p</sub> )     | 0.7946             | Fig. 21, app VI |
| Weight correction factor (K <sub>w</sub> )    | 0.94 at<br>2752 lb | Fig. 22, app VI |

Formulas:

$$R/C_s = R/C + \Delta R/C_p + \Delta R/C_w$$

$$\Delta R/C_p = K_p \times \frac{(SHP_s - SHP_t) \times 33,000}{GW_t}$$

$$\Delta R/C_w = K_w \times SHP_s \times 33,000 \left( \frac{1}{GW_s} - \frac{1}{GW_t} \right)$$

Computation:

$$R/C_s = 1750 + 0.7946 \frac{(307.5 - 300) \times 33,000}{2747} + 0.94 \times 307.5 \times 33,000 \times \left( \frac{1}{2752} - \frac{1}{2747} \right)$$

$$R/C_s = 1815 \text{ fpm}$$

20. The climb performance of the OH-58A with the particle separator installed was satisfactory for mission accomplishment. The maximum rates of climb (corrected for test weight variation from configuration I gross weight) for takeoff and maximum continuous power at sea level were 1744 and 1350 fpm, respectively. Under the same conditions except for changing the gross weight to that of configuration II (2960 pounds), the maximum rates of climb were 1570 and 1210 fpm, respectively. Table 3 summarizes service ceiling results at 354 rpm, with the particle separator installed, and at standard-day conditions.

Table 3. Service Ceiling Summary.

| Takeoff Gross Weight<br>(lb) | Power Setting      | Service Ceiling<br>(ft) |
|------------------------------|--------------------|-------------------------|
| 2,252                        | Takeoff            | 26,170                  |
| 2,248                        | Maximum continuous | 25,000                  |
| 2,747                        | Takeoff            | 21,800                  |
| 2,755                        | Maximum continuous | 19,500                  |
| 2,960                        | Takeoff            | 18,380                  |
| 2,965                        | Maximum continuous | 17,200                  |

21. In addition to the continuous climb tests, two series of sawtooth climbs were conducted to determine correction factors for variation in power ( $K_p$ ) and gross weight ( $K_w$ ). These factors were used to correct continuous climb data from test to standard conditions. The first series of sawtooth climbs was flown at constant gross weight and varying power. The second series was flown at a constant power and varying gross weight. The test results are presented in figures 21 and 22, appendix VI. The plots indicate that  $K_p$  is equal to 0.7946 for all conditions tested, and  $K_w$  varies as a function of gross weight.

#### Level Flight Performance

22. Tests were conducted to determine airspeed, fuel flow, and power-required relationships to define the level flight performance for combinations of external configuration, gross weight, altitude, and rotor rpm. All flights were conducted at zero sideslip except for one which was flown to determine sideslip effects. Each speed power was conducted at a constant value of gross weight divided by density ( $W/\rho$ ). This procedure necessitated an increase in altitude for successive data points as fuel was consumed. Tests were conducted

at gross weights ranging from 2180 to 3007 pounds and at density altitudes from 1150 to 15,160 feet. Nondimensional summary plots are presented in figures 23 through 25, appendix VI. Specific range summaries for sea-level, 5000- and 10,000-foot standard-day conditions (to include the effects of configuration change, cg change and sideslip), are summarized in figures 26 through 31. Individual test results are presented graphically in figures 32 through 53.

23. All level-flight performance guarantees were met or exceeded. Figure B compares guarantees to test results for  $V_{NE}$  and for power required at 110 KTAS in level flight. As determined by flight test, the power required to maintain 110 KTAS was 9 shp less than the guarantee. Using the maximum available shaft horsepower of a model specification engine (sea level, particle separator removed and measured installation losses included), a  $V_{NE}$  which was 3 knots higher than the guarantee was obtained from figure B.

**FIGURE B**  
**LEVEL FLIGHT PERFORMANCE FOR GUARANTEE COMPLIANCE**  
**OH-53A USA 9/168-16693**

|                              |                                      |
|------------------------------|--------------------------------------|
| DENSITY ALTITUDE = SEA LEVEL | CG. STATION = 107.0 IN. (FWD)        |
| GROSS WEIGHT = 2758.1 LB.    | C <sub>T</sub> = 0.002753            |
| ROTOR SPEED = 354 RPM        | CONFIGURATION = CLEAN - ALL DOORS ON |
|                              | PARTICLE SEPARATOR REMOVED           |

NOTE: 1. SHP REQUIRED OBTAINED FROM FIGS. 23 THRU 25, APPENDIX VII.  
 2. SHP AVAILABLE OBTAINED FROM FIG 69, APPENDIX VII.

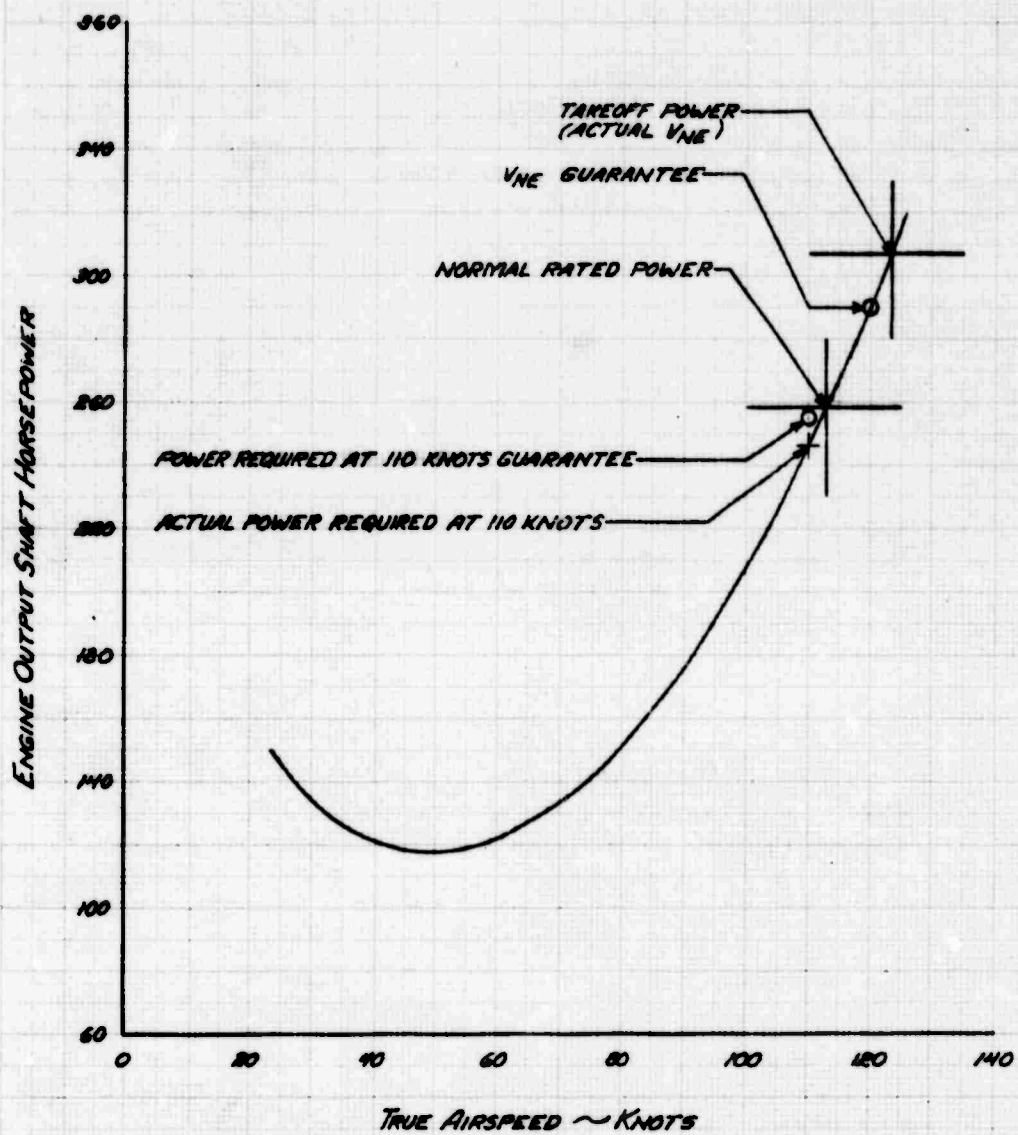


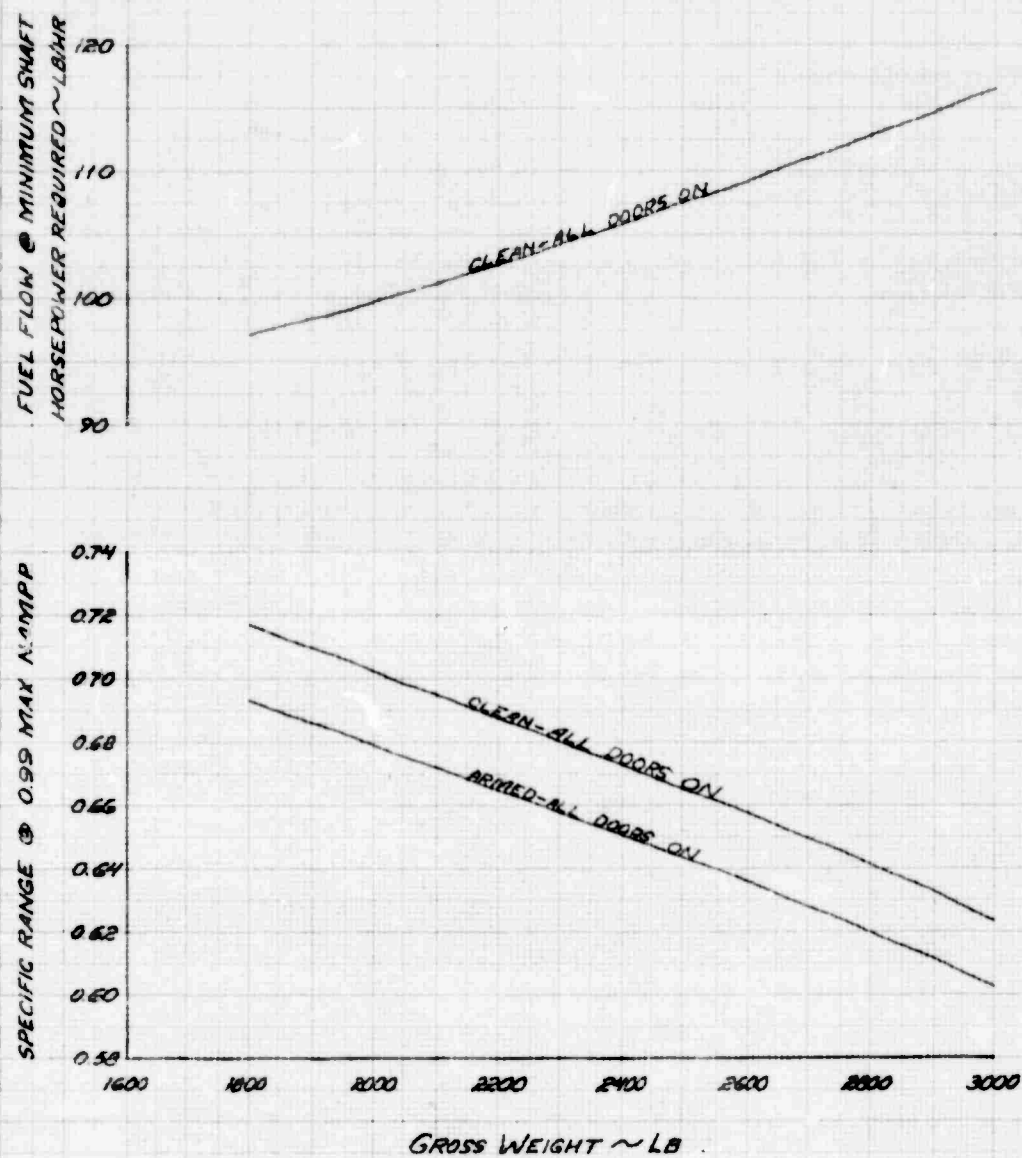
FIGURE C  
LEVEL FLIGHT RANGE AND ENDURANCE SUMMARY FOR GUARANTEE COMPLIANCE

OH-58A USA SIN 68-16693

SEA LEVEL — STANDARD DAY

354 RPM — PARTICLE SEPARATOR REMOVED

NOTE: 1. DATA DERIVED FROM FIGS. 23 THRU 25 AND 72  
APPENDIX VI



24. Using data from figure C, level-flight range guarantees for configurations I and II were computed to match the guaranteed values of 260 and 230 nautical air miles traveled, respectively. The range computations which define configuration I and II gross weights and were used to check the guarantees are summarized as follows:

| <u>Item</u>                            | <u>Configuration I<sup>1</sup></u><br><u>(lb)</u> | <u>Configuration II<sup>2</sup></u><br><u>(lb)</u> |
|----------------------------------------|---------------------------------------------------|----------------------------------------------------|
| Basic mission weight without fuel      | 2308.2                                            | 2542.2                                             |
| Fuel                                   | <u>443.9</u>                                      | <u>417.8</u>                                       |
| Mission gross weight                   | 2752.1                                            | 2960.0                                             |
| Engine start gross weight              | 2752.1                                            | 2960.0                                             |
| Warm-up (2 minute) at NRP <sup>3</sup> | <u>-6.21</u>                                      | <u>-6.21</u>                                       |
| Lift-off gross weight                  | <sup>4</sup> 2745.89                              | <sup>5</sup> 2953.79                               |
| Cruise fuel                            | <sup>6</sup> <u>-393.3</u>                        | <sup>7</sup> <u>-369.81</u>                        |
| Landing gross weight                   | <sup>8</sup> 2352.59                              | <sup>9</sup> 2583.98                               |
| Basic mission weight without fuel      | <u>-2308.2</u>                                    | <u>-2542.2</u>                                     |
| Ten-percent fuel reserve               | 44.39                                             | 41.78                                              |

<sup>1</sup>Observation mission, unarmed, all doors on, sea level, 15°C, T63-A-700 engine, JP-4 fuel, no bleed air, anti-icer off, particle separator removed, 354 rpm, cruise at 0.99 maximum NAMPP specific range.

<sup>2</sup>Same as footnote 1 above except for: scout mission, armed with XM27E1, 2000 rounds of ammunition.

<sup>3</sup>Fuel flow = 186.3 lb/hr.

<sup>4</sup>Specific range = 0.6460 NAMPP; fuel flow = 111.8 lb/hr.

<sup>5</sup>Specific range = 0.6068 NAMPP.

<sup>6</sup>Fuel required for 260 nautical air miles.

<sup>7</sup>Fuel required for 230 nautical air miles.

<sup>8</sup>Specific range = 0.6762 NAMPP; fuel flow = 105.1 lb/hr.

<sup>9</sup>Specific range = 0.6372 NAMPP.

Formula:

$$\text{Range} = \text{Average NAMPP} \times \text{cruise fuel}$$

Configuration I Calculation:

$$\text{Range} = \frac{0.6460 + 0.6762}{2} \times 393.3$$

$$\text{Range} = 260.01 \text{ nautical miles}$$

Configuration II Calculation:

$$\text{Range} = \frac{0.6068 + 0.6372}{2} \times 369.81$$

$$\text{Range} = 230.02 \text{ nautical miles}$$

25. Using figure C and the range summary of configuration I, endurance was calculated to be 3.63 hours which exceeded the guarantee of 3.0 hours by 21 percent. The computation of endurance is summarized as follows:

Formula:

$$\text{Endurance} = \frac{\text{cruise fuel}}{\text{average fuel flow}}$$

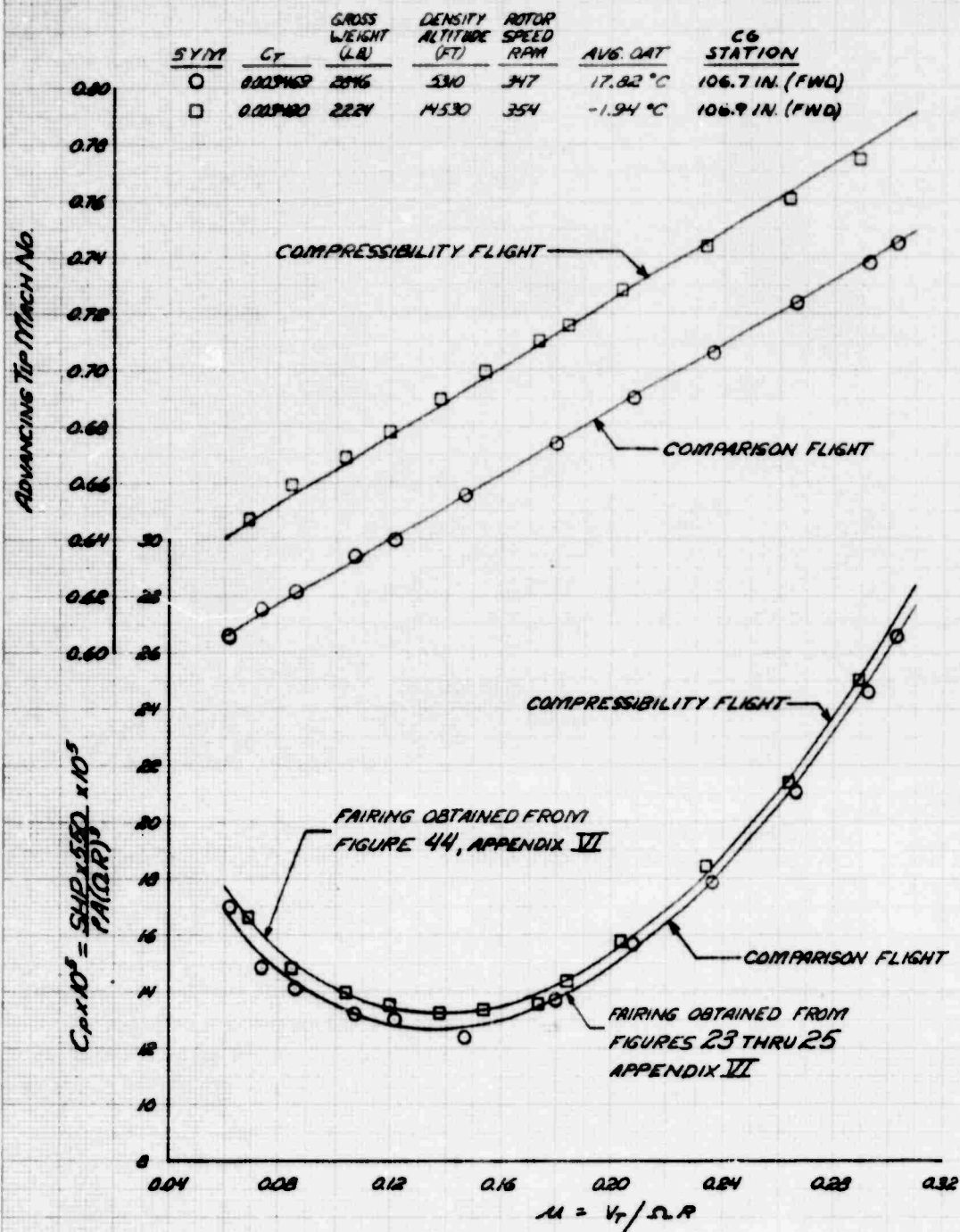
Calculation:

$$\text{Endurance} = \frac{393.3}{\frac{111.8 + 105.1}{2}}$$

$$\text{Endurance} = 3.63 \text{ hours}$$

26. The results of the level-flight performance tests of the OH-58A with the particle separator installed were satisfactory. However, compressibility may decrease level flight performance significantly. Advancing tip Mach ( $M_{Ntip}$ ), which is associated with compressibility, is mainly affected by temperature; that is, the colder the temperature, the higher the  $M_{Ntip}$ . One flight was conducted at a coefficient of thrust ( $C_T$ ) of 0.003480, at a relatively cold temperature, and higher  $M_{Ntip}$  to determine compressibility effect. The result is illustrated nondimensionally in figure D.

FIGURE D  
COMPRESSIBILITY EFFECTS ON LEVEL FLIGHT PERFORMANCE  
OH-55A USA S/N 68-16693  
CLEAN-ALL DOORS ON



27. Compared with another flight at a similar  $C_T$  as shown in figure D, the compressibility flight with the higher  $M_{Ntip}$  resulted in an increased coefficient of power ( $C_p$ ) at all airspeeds. Since the compared  $C_T$ 's were not identical, further substantiation of compressibility may be found through a comparison of figures 23 through 25, appendix IV, with figure 44. Figure 44 indicates that an average increase of 3 shp is required at airspeeds between 26 and 115 KTAS. A more detailed investigation should be conducted at cold temperatures to determine compressibility effects on the performance capability of the OH-58A.

28. The unarmed OH-58A with all doors on was defined as the clean external configuration with zero equivalent flat plate area ( $F_e$ ). Figure 29, appendix VI, illustrates that for each configuration the increased drag is uniquely constant at all  $C_T$ 's for airspeeds between 20 and 120 KTAS. Compared with the clean external configuration, the armed helicopter with the XM27E1 armament system installed and all doors on resulted in an increased  $F_e$  of 1.2 square feet. Also, the armed configuration with the cargo doors off and all doors off showed a respective increase in  $F_e$  of 2.2 and 2.8 square feet. A range performance comparison among the various configurations at 354 rpm and configuration II gross weight (2960 pounds) at sea level, standard day is summarized in table 4.

Table 4. Range Summary<sup>1</sup> at Sea Level (15°C Day).

| Configuration          | Equivalent Flat Plate Area (ft <sup>2</sup> ) | Recommended Cruise <sup>2</sup> (KTAS) | Specific Range (NAMPP) |
|------------------------|-----------------------------------------------|----------------------------------------|------------------------|
| Unarmed, all doors on  | 0                                             | 104.5                                  | 0.603                  |
| Armed, all doors on    | 1.2                                           | 101.5                                  | 0.582                  |
| Armed, cargo doors off | 2.2                                           | 99.7                                   | 0.567                  |
| Armed; all doors off   | 2.8                                           | 98.5                                   | 0.559                  |

<sup>1</sup>Fuel flow based on engine model specification with particle separator installed.

<sup>2</sup>Airspeed based on high side of 0.99 maximum NAMPP.

29. With the exception of two flights, to determine cg effects all level-flight performance tests were conducted at a mission cg (FS 107.0). As may be seen in figure 30, appendix VI, at the forward cg limit (FS 105.2) the  $F_e$  increased 1.15 square feet, while at the aft limit (FS 114.2) the  $F_e$  decreased 0.22 square feet.

30. The increase in power required with various angles of sideslip is shown in figure 31, appendix VI, and is summarized in table 5.

Table 5. Difference in Shaft Horsepower Required Versus Sideslip.

| Sideslip Angle<br>(deg) | 60 Knots<br>True<br>Airspeed<br>(shp) | 80 Knots<br>True<br>Airspeed<br>(shp) | 100 Knots<br>True<br>Airspeed<br>(shp) | 110 Knots<br>True<br>Airspeed<br>(shp) |
|-------------------------|---------------------------------------|---------------------------------------|----------------------------------------|----------------------------------------|
| 5 left                  | 0.8                                   | 4.1                                   | 9.0                                    | 12.2                                   |
| 5 right                 | 1.0                                   | 4.0                                   | 8.6                                    | 11.8                                   |
| 10 left                 | 2.8                                   | 9.5                                   | 21.7                                   | 29.2                                   |
| 10 right                | 2.4                                   | 8.2                                   | 17.2                                   | 24.1                                   |
| 15 left                 | 6.8                                   | 18.8                                  | 47.0                                   | --                                     |
| 15 right                | 4.7                                   | 15.5                                  | 40.0                                   | --                                     |

#### Autorotational Descent

31. Tests were conducted to determine the autorotational descent performance characteristics of the OH-58A. Test results were satisfactory and are presented in figures 54 through 57, appendix VI. To determine the airspeed for minimum rate of descent, a series of stabilized descents was conducted at each of the conditions listed in table 6. During each autorotational descent, rotor speed was held constant, and data were recorded at stabilized airspeeds from 30 to 80 KCAS in 10-knot increments. After the airspeed for minimum rate of descent was determined, another series of descents was conducted while maintaining constant airspeed and varying rpm from 330 to 390 in 10-rpm increments. The airspeed for maximum glide distance varied from 74.5 KCAS at 330 rpm to 81.5 KCAS at 390 rpm. The variation in horizontal glide distance over this rpm/airspeed range was less than 85 feet. It was, therefore, determined that for optimum performance an airspeed of from 74 to 78 KCAS and 360 rpm should be maintained during autorotational descents.

Table 6. Autorotational Descent Test Conditions.

| Gross Weight<br>(lb) | Rotor Speed<br>(rpm) |
|----------------------|----------------------|
| 2160                 | 330, 354, 390        |
| 2640                 | 330, 354, 390        |
| 2800                 | 330, 354, 390        |

#### Power-on Landing

32. Satisfactory power-on landing performance was qualitatively evaluated in conjunction with the takeoff tests. The OH-58A is capable of accomplishing satisfactory landings under conditions where hover capability does not exist, and no special or unique pilot techniques or additional space is required. However, under such conditions, precise control manipulations are necessary to preclude touchdown with a high sink rate.

#### MISCELLANEOUS TESTS

##### Weight and Balance

33. The test helicopter was weighed before the start of the flight test program. The weighing was accomplished in a closed hangar with electrical load cells placed under the aircraft jack points. The basic weight (empty aircraft plus trapped fuel and oil) was 1555.0 pounds, and the cg location was at FS 118.5. This weight compared very well with the contractor weight on the same aircraft which was 1557.0 pounds. The specification guaranteed weight was 1586.2 pounds. After the instrumentation was installed, the test aircraft was reweighed using the same equipment and procedure, and a gross weight of 1676.5 pounds with a cg location at FS 115.8 was recorded. Throughout this evaluation, a mission cg location at FS 107 was used for all tests with the exception of two level-flight speed-power polars to determine cg effects.

##### Engine Starts

34. The OH-58A engine starting characteristics on the ground were satisfactory utilizing either the aircraft battery or external power units. Satisfactory engine starts were accomplished at field elevations ranging from sea level to 9500 feet under varying atmospheric conditions. No tendency toward "overtemp" was experienced during this test utilizing the procedures outlined in the operator's manual, TM 55-1520-228-10 (ref 5, app I).

35. Air starts were accomplished at pressure altitudes from 4000 to 11,500 feet. During this test, the gas producer speed ( $N_1$ ) as well as the power turbine speed ( $N_2$ ) were allowed to completely coast to a stop prior to initiating the restart. Five of seven start attempts were successfully accomplished without complications. All successful air starts were similar to the ground starts with the exception that the turbine outlet temperature (TOT) was observed to be slightly higher. One start attempt resulted in an abort because of overtemp conditions, and another abort was caused by insufficient gas producer rpm to effect light off. After each abort, a successful start was accomplished after descending to a lower altitude. One air start was satisfactorily accomplished with the boost pump inoperative at a pressure altitude of 10,100 feet. Altitude loss during the air start attempts was not excessive and averaged approximately 1200 feet from throttle closure to power application in the recovery. The same procedures that were used for ground starts produced satisfactory results during the air start tests.

#### Engine Characteristics

36. Tests were conducted to determine the compressor inlet pressure ( $P_{T_2}$ ) and temperature ( $T_{T_2}$ ) characteristics, both with and without the particle separator installed. In order to compare the installed test engine to an installed model specification engine, the calibrated test engine parameters of shaft horsepower, gas producer speed, turbine outlet temperature, and fuel flow were measured during the entire test program.

37. For the purpose of the engine inlet tests, an inlet ring with three pressure and three temperature probes was installed in the engine bellmouth. The probes were placed 120 degrees apart and were manifolded into one average reading for each parameter. The pressure probes were referenced to the test boom static source system to provide a differential pressure measurement. The temperature installation system measured temperature directly. Test results are presented in figures 59 and 60, appendix VI, as plots of compressor inlet temperature rise and compressor inlet pressure ratio ( $P_{T_2}/P_a$ ) with the particle separator removed or installed versus calibrated airspeed. A comparison plot of contractor estimated losses and test data versus calibrated airspeed is presented in figure 58.

38. At zero airspeed, the particle-separator-removed configuration indicated a pressure loss of 0.3 percent and a temperature rise of  $2^\circ\text{C}$  while the installed configuration indicated a 1.5-percent pressure loss and a  $2.4^\circ\text{C}$  temperature rise. The takeoff power available at sea-level, standard-day conditions was reduced 7.5 shp by the installation of the particle separator. This represents a 2.4-percent power loss as compared to the maximum of 2.0 percent stipulated in the detail specification.

39. The detail specification estimated the compressor inlet temperature rise, at zero airspeed, to be 2.5°F for both the installed and removed particle separator conditions. Test data show a temperature rise of 4.32 and 3.60°F, respectively. The detail specification also estimated the compressor inlet pressure loss at zero airspeed to be 1.0 inches of water (H<sub>2</sub>O) with the particle separator removed, and stipulated the loss with the particle separator installed to be no greater than 4.0 inches of water. Test data show losses of 1.31 and 6.12 inches of water, respectively. All contractual performance guarantees were met; however, the test data indicated inlet losses greater than those estimated with the particle separator removed and greater than the limits set forth in the detail specification for the particle-separator-installed condition. The magnitude of the inlet pressure loss, as compared with the detail specification requirement, was not sufficient to be called a shortcoming. Table 7 summarizes the comparison of both sources.

Table 7. Engine Inlet Losses.

| Parameter        | Particle Separator Removed  |                              | Particle Separator Installed |                              |
|------------------|-----------------------------|------------------------------|------------------------------|------------------------------|
|                  | Estimated                   | Test Data                    | Estimated                    | Test Data                    |
| Pressure loss    | 1.0 in. of H <sub>2</sub> O | 1.31 in. of H <sub>2</sub> O | 4.0 in. of H <sub>2</sub> O  | 6.12 in. of H <sub>2</sub> O |
| Temperature rise | 2.5°F                       | 3.6°F                        | 2.5°F                        | 4.32°F                       |

40. Figure 61, appendix VI, illustrates the exhaust pressure loss because of the exhaust extension installation. These data, used to predict power available and fuel flow for a specification engine, were furnished by the airframe contractor.

41. The referred terms of the engine parameters were used to compare the calibrated test engine with the model specification engine. Data on referred gas producer speed, shaft horsepower, and turbine outlet temperature are presented in figures 62 and 63, appendix VI. Fuel-flow data are not presented because a problem existed in the measurement of the fuel-flow rate which was attributed to the test instrumentation.

42. The referred shaft horsepower versus referred gas producer speed (fig. 62, app VI) shows that the gas producer speed for the test engine was below the model specification. At a gas producer speed equal to 100-percent rpm, the test engine produced 10 shp less than the model specification engine. These data indicate that the test engine may

have had a dirty compressor section. In these areas, the turbine outlet temperature and the trend of fuel-flow data show that the test engine performed better than the model specification engine.

#### Pitot-Static System Calibration

43. An airspeed calibration was performed with the test aircraft utilizing the ground speed course and trailing bomb methods. Test results are presented in figures 64 through 67, appendix VI.

#### Altimeter Calibration

44. The altimeter position error was calculated utilizing data collected during airspeed calibration tests. Test results are presented in figure 68, appendix VI.

#### Problems Encountered

45. During the conduct of this evaluation, the following problems were encountered:

- a. Blow-by of oil from the main transmission oil filler cap when the system was properly serviced.

- b. Failure of the tail rotor static stop rubber washer (P/N 206-010-777-1).

- c. Failure of the linear actuator ( $N_2$ ).

- d. Malfunction of the fuel control (uncontrollable engine surge).

46. Prior to report compilation, information received from the Project Manager indicated that corrective action pertaining to these problems was being taken, and modification is being incorporated on current production aircraft.

## CONCLUSIONS

### GENERAL

47. Analysis of the test results obtained during this evaluation resulted in the following conclusions:

- a. The overall performance characteristics of the OH-58A meet or exceed the detail specification guarantees (para 11).
- b. The performance characteristics of the OH-58A are satisfactory for mission accomplishment under moderate temperature conditions (para 11).
- c. At the configuration II gross weight, the OH-58A will not hover OGE on a 95°F hot day with the particle separator installed.
- d. At the configuration II gross weight, the OH-58A cannot hover IGE on a 95°F hot day at pressure altitudes greater than 2450 feet.
- e. Except for emergency tactical use, the OH-58A should not be flown at gross weights in excess of 2930 pounds at density altitudes higher than 2200 feet.
- f. The compressor inlet losses with the particle separator installed are in excess of the detail specification requirement (para 39).
- g. Compressibility significantly affects the performance of the OH-58A at high-altitude, low-temperature conditions (para 27).

### DEFICIENCIES AND SHORTCOMINGS AFFECTING MISSION ACCOMPLISHMENT

48. During the conduct of this evaluation, no deficiencies or shortcomings were discovered.

## **RECOMMENDATIONS**

49. As a result of this evaluation, the recommendations are as follows:

a. That the performance data generated during this evaluation be incorporated into the operator's manual.

b. That limitations be placed on the use of the OH-58A at combined high-gross-weight/high-ambient-temperature conditions.

c. That consideration be given to increasing the utility of the OH-58A by installing a more powerful engine.

d. That additional engineering tests be conducted to further define compressibility effects.

## APPENDIX I. REFERENCES

1. Letter, AMCPM-LH-T, HQ, USAAVSCOM, 7 August 1968, subject: OH-58A Light Observation Helicopter Flight Test.
2. Detail Specification, Bell Helicopter Company, 206-947-031, *Light Observation Helicopter*, Revision Number R-4, 11 March 1969.
3. Test Plan, USAASTA, Project No. 68-30, *Engineering Flight Test of the Production OH-58A Helicopter, Unarmed and Armed with XM27E1 Weapons Subsystem*, May 1969.
4. Model Specification Number 803, Allison Division of General Motors Corporation, *Military Turboshaft Engine, Model T63-A-700*, 19 July 1967.
5. Operator's Manual, TM 55-1520-228-10, *Army Model OH-58A Helicopter*, 30 June 1969 with change 1 November 1969.

## APPENDIX II. GENERAL AIRCRAFT INFORMATION

### DIMENSIONS AND DESIGN DATA

#### Overall Dimensions

|                                         |                 |
|-----------------------------------------|-----------------|
| Aircraft length (rotor turning)         | 40 ft, 11.8 in. |
| Aircraft length (nose to tail skag)     | 32 ft, 2.0 in.  |
| Width (rotor turning)                   | 35 ft, 4 in.    |
| Width (rotor static)                    | 6 ft, 5.4 in.   |
| Height (over main rotor blades at rest) | 9 ft, 7.0 in.   |
| Height (top of vertical stabilizer)     | 8 ft, 1.5 in.   |

#### Main Rotor

|                           |                                |
|---------------------------|--------------------------------|
| Number of blades          | 2                              |
| Diameter                  | 35 ft, 4 in.                   |
| Blade chord (constant)    | 1.08 ft                        |
| Solidity                  | 0.0390                         |
| Blade twist angle         | -10.6 deg linear               |
| Hub precone angle         | 3.0 deg                        |
| Airfoil section thickness | 11.3%                          |
| Airfoil type              | Modified "droop-snoot" airfoil |

#### Tail Rotor

|                                                      |             |
|------------------------------------------------------|-------------|
| Number of blades                                     | 2           |
| Diameter                                             | 5 ft, 2 in. |
| Blade chord                                          | 0.4375 ft   |
| Blade twist angle                                    | 0 deg       |
| Hub precone angle                                    | 0 deg       |
| Airfoil section designation and thickness (constant) | NACA 0012.5 |

#### Control Travel

|                                               |                                 |
|-----------------------------------------------|---------------------------------|
| Cyclic stick (measured at center of grip):    |                                 |
| Longitudinal                                  | 6.0 in. fwd<br>6.0 in. aft      |
| Lateral                                       | 5.15 in. right<br>5.15 in. left |
| Collective stick (measured at center of grip) | 10.15 in.                       |
| Antitorque pedals (from neutral)              | 3.43 in. fwd<br>3.43 in. aft    |

### Gear Ratio

|                      |         |
|----------------------|---------|
| Engine to main rotor | 17.44:1 |
| Engine to tail rotor | 2.353:1 |

### Operating Limitations

|                                           |                                |
|-------------------------------------------|--------------------------------|
| Power turbine speed ( $N_2$ )             | 101 to 103%                    |
| Turbine outlet temperature (TOT)          | 693°C (cont),<br>749°C (5 min) |
| Rotor rpm (power on)                      | 347 to 354 rpm                 |
| Rotor rpm (power off)                     | 330 to 390 rpm                 |
| Maximum airspeed ( $V_{max}$ ), sea level | 120 KIAS                       |
| Torque                                    | 79 psi (cont),<br>92 psi (max) |

### Powerplant

Aircraft power is provided by an Allison T63-A-700 free gas turbine engine which has a nominal rating of 270 shp at 100-percent  $N_2$ . As installed in the OH-58A, the engine is limited by either the output shaft torque or the gas producer turbine outlet temperature. For maximum continuous operation, these limits are 249 ft-lb torque (270 shp) at 6000 rpm or 693°C TOT, whichever is reached first. The takeoff power (maximum of 5 minutes continuous operation) limits are 293 ft-lb torque (317 shp) or 749°C. The engine consists of a multistage axial-centrifugal flow compressor, a single combustion chamber, a two-stage gas producer turbine and a two-stage power turbine which supplies the output power of the engine.

### Fuel System

The helicopter fuel system incorporates a single-bladder type, self-sealing fuel cell with a total usable capacity of 73 United States gallons. The cell is located below and aft of the passenger seat. Mounted in the bottom of the cell is one boost pump, one fuel quantity transmitter, one low fuel transmitter and one fuel sump drain and defuel valve. Installed in the top of the cell is one fuel quantity transmitter, a vent line, a boost pump pressure switch and a governor return line. A fuel filler cap is located on the right side, just aft of the passenger door. The fuel shut-off valve is mounted on the right side of the aircraft above the fuel cell cavity and is manually operated.

### Electrical System

The OH-58A electrical systems consist of a 28-volt, direct current (DC) dual bus system and a 115-volt 400 Hertz alternating current (AC) system.

The DC system is normally powered by a vented 24-volt, 13-ampere-hour, nickel-cadmium battery and a starter generator. The starter generator is used to start the aircraft engine, recharge the battery and provide primary 28-volt DC power for the aircraft electrical system. During ground operations, external DC power may be connected to the aircraft through a polarized, external power receptacle located on the right side of the fuselage below the baggage compartment.

The alternating current system is powered by a 65 volt-ampere, solid state inverter. The inverter delivers 115-volt AC, 400 Hertz to the AC bus. AC power is used to energize the attitude gyro and gyro compass.

## **APPENDIX III. DATA REDUCTION METHODS**

### INTRODUCTION

1. This appendix contains the formulas used to calculate the OH-58A performance capabilities. These formulas correct test-day conditions to standard-day conditions and also provide the necessary tools with which to predict helicopter performance for various atmospheric conditions. The following performance parameters are discussed.

- a. Airspeed position error.
  - (1) Ground speed course method.
  - (2) Trailing bomb method.
- b. Altimeter position error.
- c. Shaft horsepower required.
- d. Compressor inlet characteristics.
- e. Hover.
- f. Takeoff.
- g. Climb.
- h. Level flight and specific range.
- i. Autorotation.

## GENERAL

2. The basic nondimensional, helicopter equations that were used for hover, takeoff, climb, and level-flight analyses are defined as follows:

- a. Coefficient of power ( $C_p$ ):

$$C_p = \frac{\text{SHP} \times 550}{\rho A (\Omega R)^3} \quad (1)$$

- b. Coefficient of thrust ( $C_T$ ):

$$C_T = \frac{W}{\rho A (\Omega R)^2} \quad (2)$$

- c. Airspeed ratio ( $\mu$ ):

$$\mu = \frac{V_T}{\Omega R} \quad (3)$$

where: SHP = Shaft horsepower

550 = Conversion factor (ft-lb/sec per shp)

$\rho$  = Density (slugs/ft<sup>3</sup>)

A = Main rotor disc area (ft<sup>2</sup>)

$\Omega$  = Main rotor angular velocity (radians/sec)

R = Main rotor radius (ft)

W = Aircraft gross weight (lb)

$V_T$  = True airspeed (kt)

### Airspeed Position Error

3. The airspeed position error was determined by two methods:

a. Ground speed course method:

$$\Delta V_{PC} = V_{cal_{std}} - V_{IC_{test}} \quad (4)$$

$$\Delta V_{PC} = \left[ \frac{(S \div t)_1 + (S \div t)_2}{2 (1.6889)} \times \sqrt{\sigma_{avg}} \right] - \frac{V_{IC_1} + V_{IC_2}}{2} \quad (5)$$

where:  $\Delta V_{PC}$  = Airspeed position error (kt)

$V_{cal_{std}}$  = Standard calibrated airspeed obtained from the ground speed course (kt)

$V_{IC_{test}}$  = Test system indicated airspeed corrected for instrument error (kt)

S = Course length (ft)

t = Time required to travel the course distance (sec)

$\sqrt{\sigma_{avg}}$  = Average density ratio at the average density altitude

Subscripts 1 and 2 = Reciprocal headings

1.6889 = Conversion factor (ft/sec per kt)

b. Trailing bomb method:

$$\Delta V_{PC} = V_{cal_{bomb}} - V_{IC_{test}} \quad (6)$$

where:  $\Delta V_{PC}$  = Airspeed position error (kt)

$V_{cal_{bomb}}$  = Bomb system indicated airspeed corrected for instrument error (kt)

#### Altitude Position Error

4. The altitude position error for the standard ship system was calculated by using the airspeed position error from the ship's system.

$$\Delta H_{PC} = \left\{ \frac{58.566}{\sigma_s} \left( \frac{V_{IC}}{a_{SL}} \right) \left[ 1 + 0.2 \left( \frac{V_{IC}}{a_{SL}} \right)^2 \right]^{2.5} \right\} \Delta V_{PC} \quad (7)$$

where:  $\Delta H_{PC}$  = Altitude position error (ft)

58.566 = Conversion factor

$\sigma_s$  = Standard-day air density ratio at the test indicated altitude

$V_{IC}$  = Test system indicated airspeed corrected for instrument error (kt)

$a_{SL}$  = 661.48 (kt)

$\Delta V_{PC}$  = Airspeed position error (kt) (4, 5, 6)

#### Shaft Horsepower Required

5. The shaft horsepower required was determined by the following relationship:

$$SHP = \frac{2\pi \times K_t \times GR \times N_R \times TRQ}{33,000} \quad (8)$$

where: SHP = Shaft horsepower

$K_t$  = Conversion factor to change measured engine torque pressure (psi) to ft-lb

GR = Gear ratio of the output shaft rotational speed to the main rotor rotational speed

$N_R$  = Main rotor speed (rpm)

TRQ = Engine torque pressure (psi)

33,000 = Conversion factor (ft-lb/min per shp)

### Compressor Inlet Characteristics

6. The compressor inlet temperature and pressure characteristics were determined by the following formulas:

a. Temperature rise:

$$\Delta T = CIT_{ic} - T_{a_{ic}} \quad (9)$$

where:  $\Delta T$  = Temperature difference ( $^{\circ}\text{C}$ )

$CIT_{ic}$  = Indicated compressor inlet total temperature corrected for instrument error ( $^{\circ}\text{C}$ )

$T_{a_{ic}}$  = Indicated ambient temperature corrected for instrument error ( $^{\circ}\text{C}$ )

b. Pressure ratio:

$$\frac{P_{T_2}}{P_a} = \frac{\Delta CIP_{ic}}{P_{a_c}} + 1 \quad (10)$$

where:  $P_{T_2}$  = Compressor inlet total pressure (in. of Hg)

$P_a$  = Ambient total pressure (in. of Hg)

$\Delta CIP_{ic}$  = Indicated compressor inlet pressure difference ( $P_{T_2} - P_a$ ) corrected for instrument error (in. of Hg)

$P_{a_c}$  =  $P_a$  at the indicated pressure altitude plus  $\Delta P_a$  for altitude position error using formula 7 (in. of Hg)

### Hover

7. Hover performance was determined in ground effect (IGE) and out of ground effect (OGE) by the free-flight hover technique. Formulas 1 and 2 were used to define the hover capability.

### Takeoff

8. Formulas 1, 2, and 11 were used to determine the takeoff performance.

$$\Delta C_p = \left( \text{SHP}_{\text{avail}} - \text{SHP}_{\text{req at 2 ft}} \right) \left( \frac{550}{\rho A (\Omega R)^3} \right) \quad (11)$$

where:  $\Delta C_p$  = Nondimensional factor for excess power (for each  $\Delta C_p$ , a plot was constructed to relate the distance required to clear a 50-foot obstacle and the selected climb-out airspeed over the obstacle)

$\text{SHP}_{\text{avail}}$  = Shaft horsepower available for the installed test engine at takeoff atmospheric conditions

$\text{SHP}_{\text{req at 2 ft}}$  = Shaft horsepower required for a 2-foot hover skid height at takeoff atmospheric conditions

550 = Conversion factor (ft-lb/sec per shp)

### Climb

9. The climb schedules used during this test program were determined by the airspeed for minimum power required in level flight. All climbs were flown with pressure altitude as the reference. Sawtooth climbs were flown to determine the coefficient of power correction ( $K_p$ ) and the coefficient of weight correction ( $K_w$ ).  $K_p$  and  $K_w$  were used to solve for the difference in rate of climb caused by differences in shaft horsepower and gross weight, respectively. These differences occur when the performance of an installed test engine is corrected to a model specification engine for standard-day conditions.

$$\Delta R/C_p = K_p \times \frac{\Delta SHP}{GW_t} \times 33,000 \quad (12)$$

$$\Delta R/C_w = K_w \times SHP_s \times 33,000 \left( \frac{1}{GW_s} - \frac{1}{GW_t} \right) \quad (13)$$

where:  $\Delta R/C_p$  = Rate of climb difference due to power difference (ft/min)

$K_p$  = Coefficient of power correction

$\Delta SHP$  = Difference in standard shaft horsepower available and test shaft horsepower measured

$GW_t$  = Test gross weight (lb)

$K_w$  = Coefficient of weight correction

$SHP_s$  = Standard shaft horsepower obtained from a model specification engine

$GW_s$  = Standard gross weight (lb)

$\Delta R/C_w$  = Rate of climb difference due to weight difference (ft/min)

10. The observed rate of climb was corrected to tapeline rate of climb by the equation:

$$R/C_T = \frac{dhp}{dt} \times \frac{T_t}{T_s} \quad (14)$$

where:  $R/C_T$  = Tapeline rate of climb (ft/min)

$\frac{dhp}{dt}$  = Slope of pressure altitude versus time curve at a given pressure altitude (ft/min)

$T_t$  = Test ambient air temperature at the pressure altitude at which the slope is taken ( $^{\circ}K$ )

$T_s$  = Standard ambient air temperature at the pressure altitude at which the slope is taken ( $^{\circ}K$ )

11. The standard rate of climb was finally determined by the summarized equation:

$$R/C_s = R/C_T + \Delta R/C_p + \Delta R/C_w \quad (15)$$

where:  $R/C_s$  = Final rate of climb standard (ft/min)

$R/C_T$  = Tapeline rate of climb (ft/min)

$\Delta R/C_p$  = Rate of climb difference due to power difference (ft/min)

$\Delta R/C_w$  = Rate of climb difference due to weight difference (ft/min)

#### Level Flight and Specific Range

12. Level-flight speed-power performance was determined by using equations 1, 2, and 3. Each speed power was flown at a predetermined  $C_T$  with rotor speed held constant. To maintain  $W/\rho$  approximately constant, altitude was increased as fuel was consumed.

13. Test-day level-flight power was corrected to standard-day conditions by assuming that the test-day dimensionless parameters,  $C_{p_t}$ ,  $C_{T_t}$ , and  $\mu_t$ , are independent of atmospheric conditions.

Consequently, the standard-day dimensionless parameters,  $C_{p_s}$ ,  $C_{T_s}$ , and  $\mu_s$ , are identical to  $C_{p_t}$ ,  $C_{T_t}$ , and  $\mu_t$ , respectively. A corollary to the above assumption relates:

$$\rho_s = \rho_t \left( \frac{W_s}{W_t} \right) \quad (16)$$

where:  $\rho$  = Density (slugs/ft<sup>3</sup>)

$W$  = Gross weight (lb)

Subscript  $t$  = Test day

Subscript  $s$  = Standard day

14. Equation 16 defines the standard-day density ( $\rho_s$ ) which is required for presentation of test-day data at a standard gross weight ( $W_s$ ).

15. From the definition of  $C_p$  (equation 1), the following relationship can be derived:

$$SHP_s = SHP_t \times \frac{\rho_s}{\rho_t} \quad (17)$$

16. The relationship shown by equation 17 then defines the standard-day power required for flying at the same thrust, power, and airspeed coefficients as on the test day but under standard-day conditions. Each level-flight speed-power point was corrected in this fashion to standard-day conditions at the target gross weight.

17. Specific range was calculated using the nondimensional level-flight performance curve and the specification fuel-flow characteristics:

$$NAMPP = \frac{V_T}{W_f} \quad (18)$$

where:  $NAMPP$  = Nautical air miles per pound of fuel (naut mi/lb)

$V_T$  = True airspeed (kt)

$W_f$  = Fuel flow (lb/hr)

#### Autorotation

18. The autorotational performance was determined using equation 15 except that  $R/C_T$  was re-defined as  $R/D_T$ .

$$R/D_T = \frac{dhp}{dt} \times \frac{T_t}{T_s} \quad (19)$$

where:  $R/D_T$  = Tapeline rate of descent (ft/min)

## APPENDIX IV. TEST INSTRUMENTATION

### GENERAL

The test instrumentation used during this evaluation was supplied, installed and maintained by USAASTA. Sensitive instruments were calibrated to record the following parameters:

#### Pilot/Engineer Panel

Airspeed (boom system)  
Altitude (boom system)  
Airspeed (standard system)  
Altitude (standard system)  
Outside air temperature  
Rate of climb  
Rotor speed  
Angle of sideslip  
Fuel counter  
Gas producer speed ( $N_1$ )  
Torquemeter oil pressure  
Turbine outlet temperature ( $T_{t_5}$ )  
Compressor inlet total temperature  
Compressor inlet total pressure  
Collective position indicator  
Photopanel frame counter  
Stepper motor indicator

#### Photopanel

Airspeed (boom)  
Altitude (boom)  
Outside air temperature  
Rotor speed  
Fuel counter  
Time of day  
Gas producer speed ( $N_1$ )  
Torquemeter oil pressure  
Turbine outlet temperature ( $T_{t_5}$ )  
Photopanel frame counter  
Stopwatch

## **APPENDIX V. PHOTOGRAPHS**



Photo 1. XM27E1 Armament System.

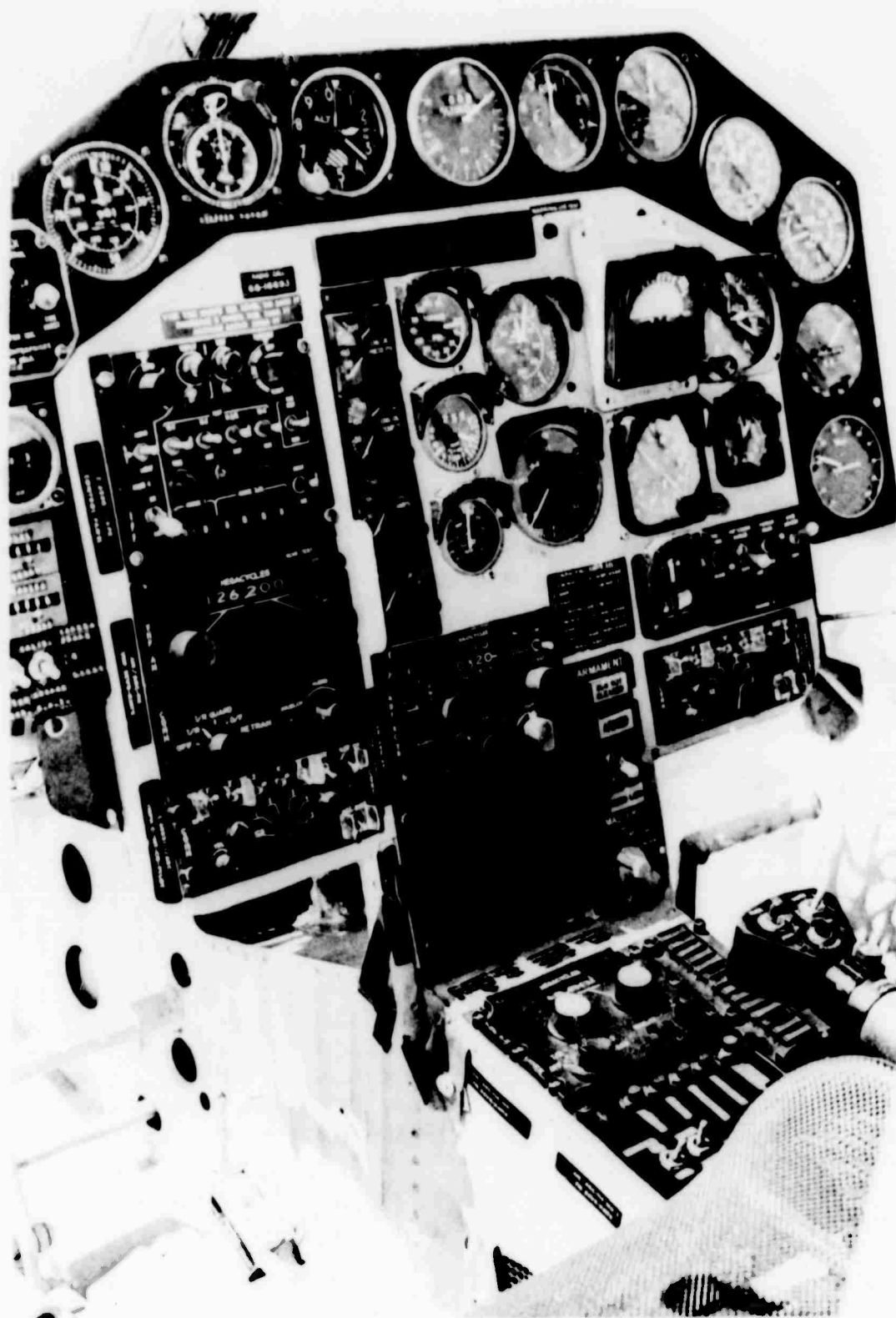


Photo 2. Cockpit Instrumentation.

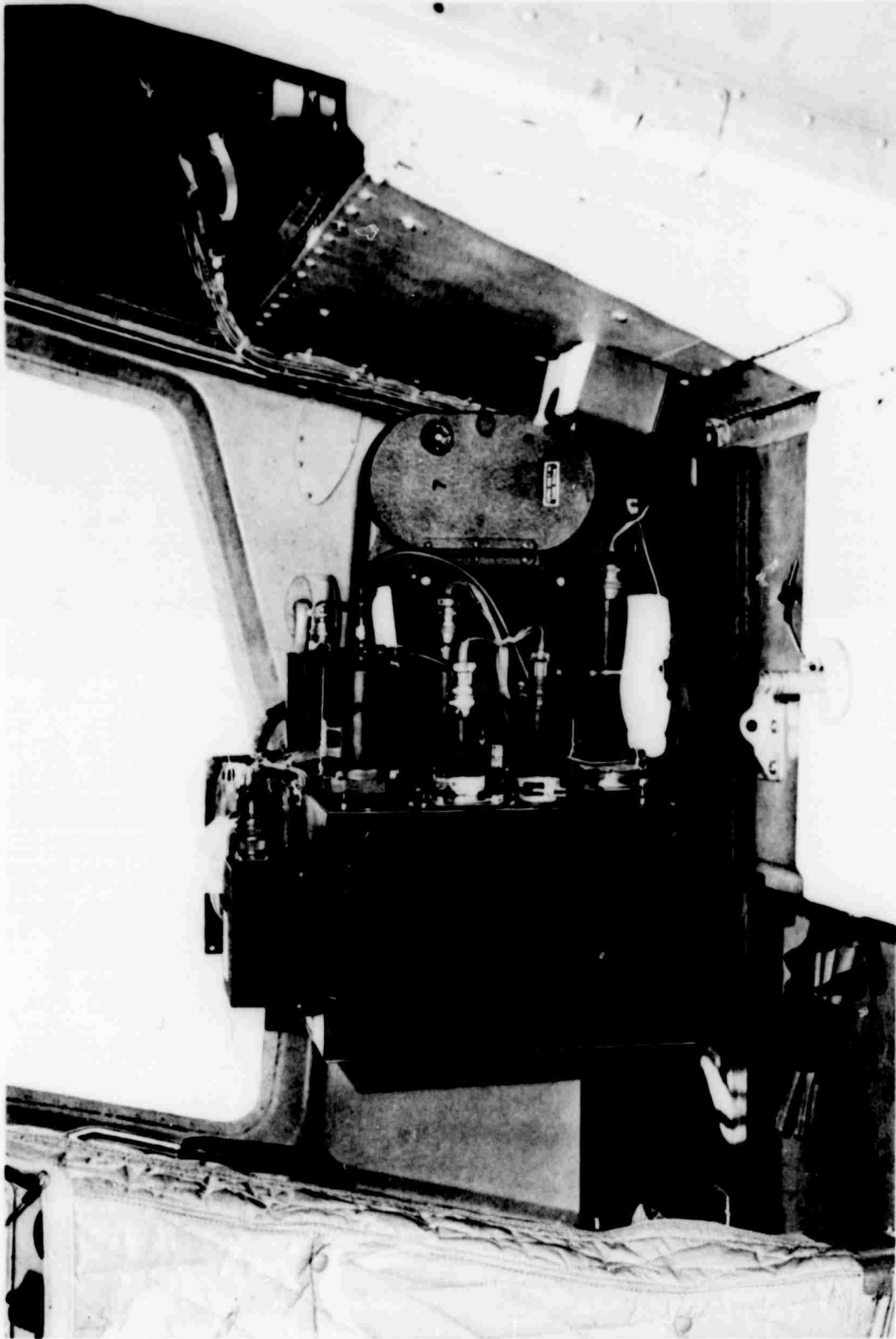


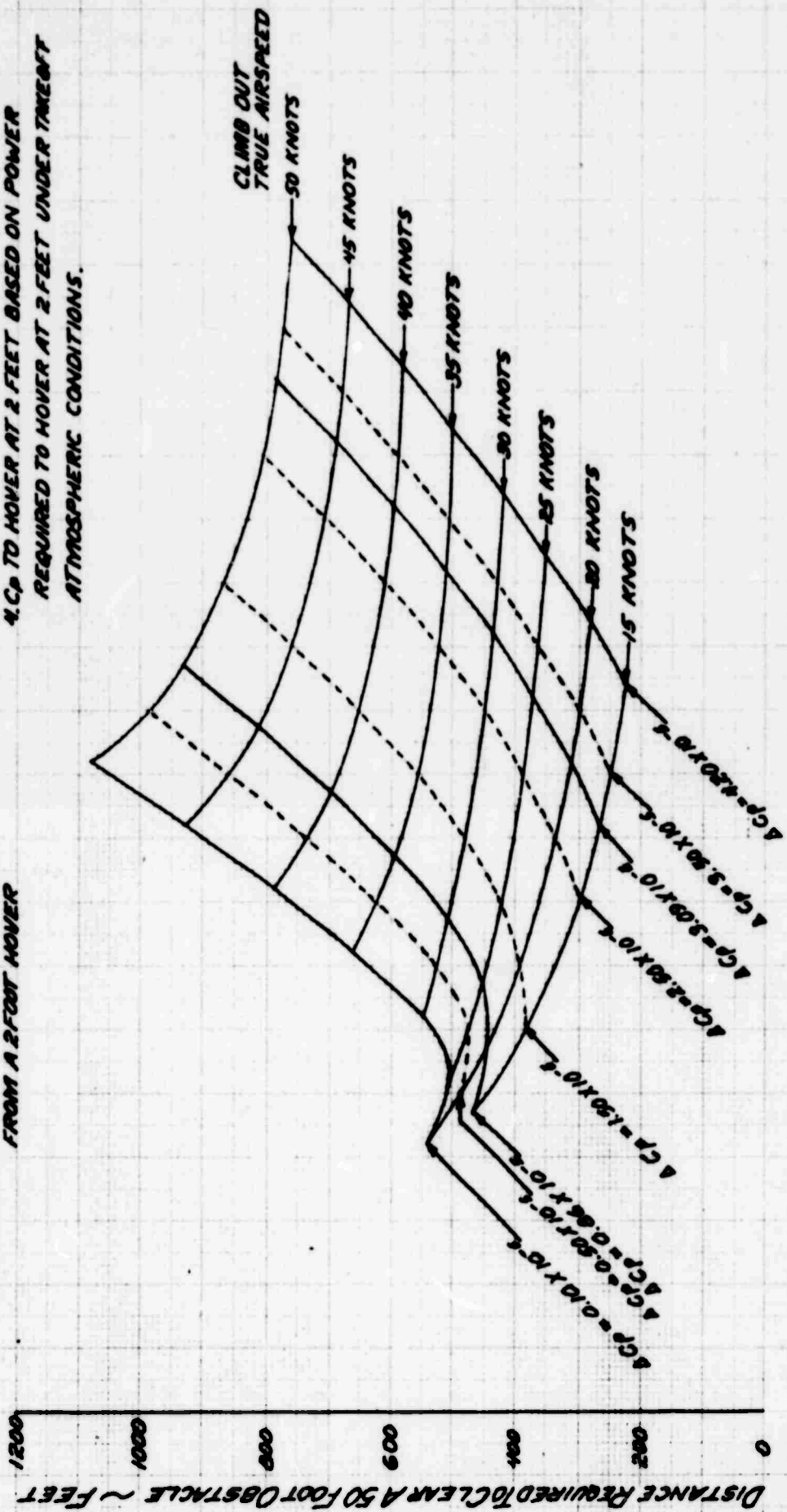
Photo 3. Photopanel Location.

## **APPENDIX VI. TEST DATA**

**FIGURE 1**  
**VARIATION OF TAKEOFF DISTANCE WITH**  
**CLIMB-OUT AIRSPEED AND  $\Delta C_p$**   
**OH-58A USA SING-MS93**

CONFIGURATION = ARMED-ALL DOORS ON  
 WIND VELOCITY < 3 KNOTS  
 ROTOR SPEED = 354 RPM  
 TECHNIQUE = LEVEL ACCELERATION  
 FROM A 2 FOOT HOVER

NOTE : 1.  $\Delta C_p$  FAIRINGS BASED ON FIGS 2 THRU 5  
 2.  $\Delta C_p = C_p$  AT TAKEOFF -  $C_p$  TO HOVER AT 2 FEET.  
 3.  $C_p$  AT TAKEOFF BASED ON POWER AVAILABLE  
 UNDER TAKEOFF ATMOSPHERIC CONDITIONS.  
 4.  $C_p$  TO HOVER AT 2 FEET BASED ON POWER  
 REQUIRED TO HOVER AT 2 FEET UNDER TAKEOFF  
 ATMOSPHERIC CONDITIONS.



**FIGURE 2**  
**TAKEOFF DISTANCE REQUIRED**  
**TO CLEAR A 50 FT OBSTACLE**  
**OH-58A USA SIN 68-16693**

ROTOR RPM = 354

GROSS WEIGHT = 2965 LB

PRESSURE ALTITUDE = 4150 FT

TECHNIQUE = LEVEL ACCELERATION  
 FROM A 2 FT HOVER

WIND VELOCITY < 3 KTS

FREE AIR TEMP = 11.9 °C

$\Delta C_p = 4.2 \times 10^{-6}$

CONFIGURATION = ARMED-ALL  
 DOORS ON

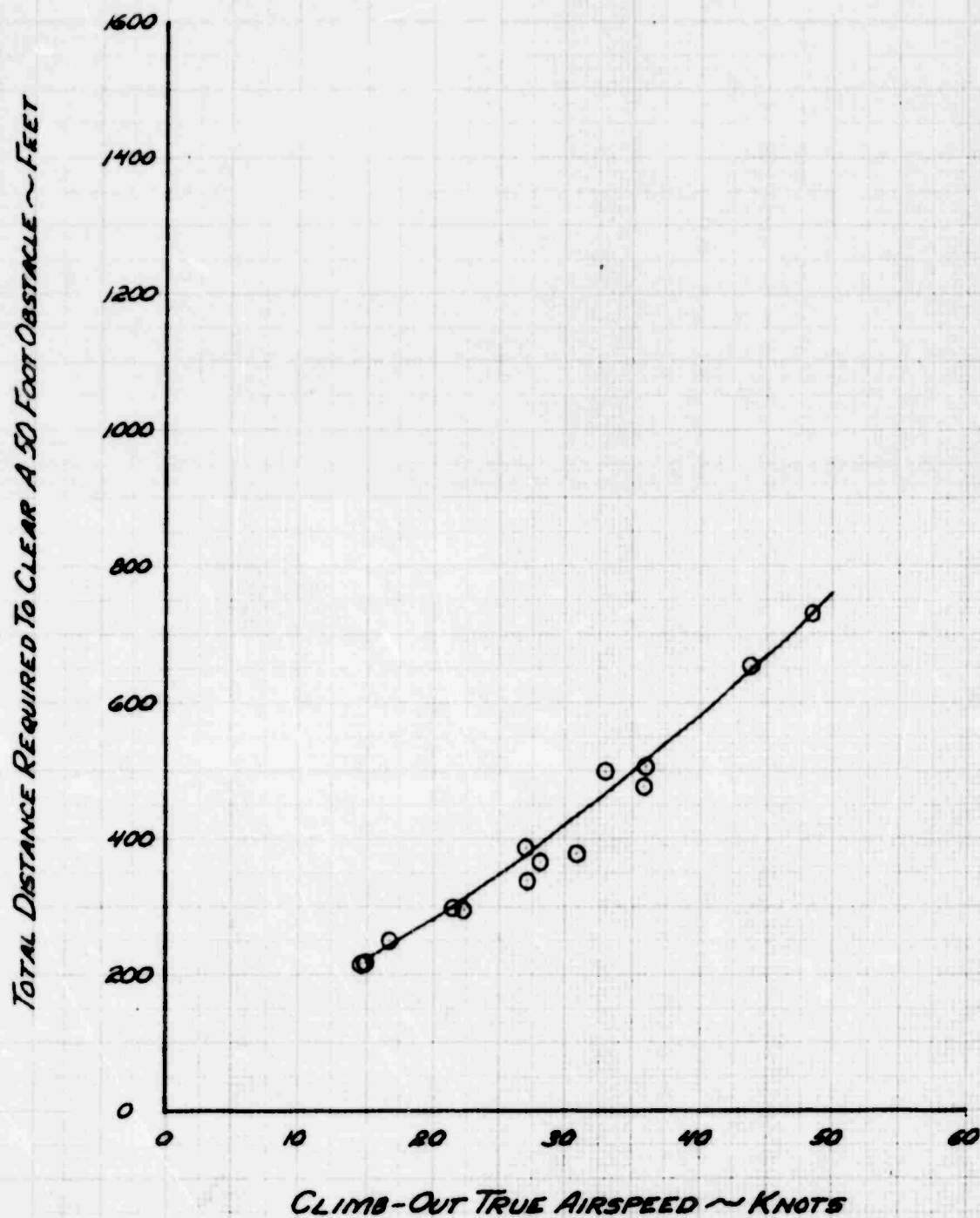
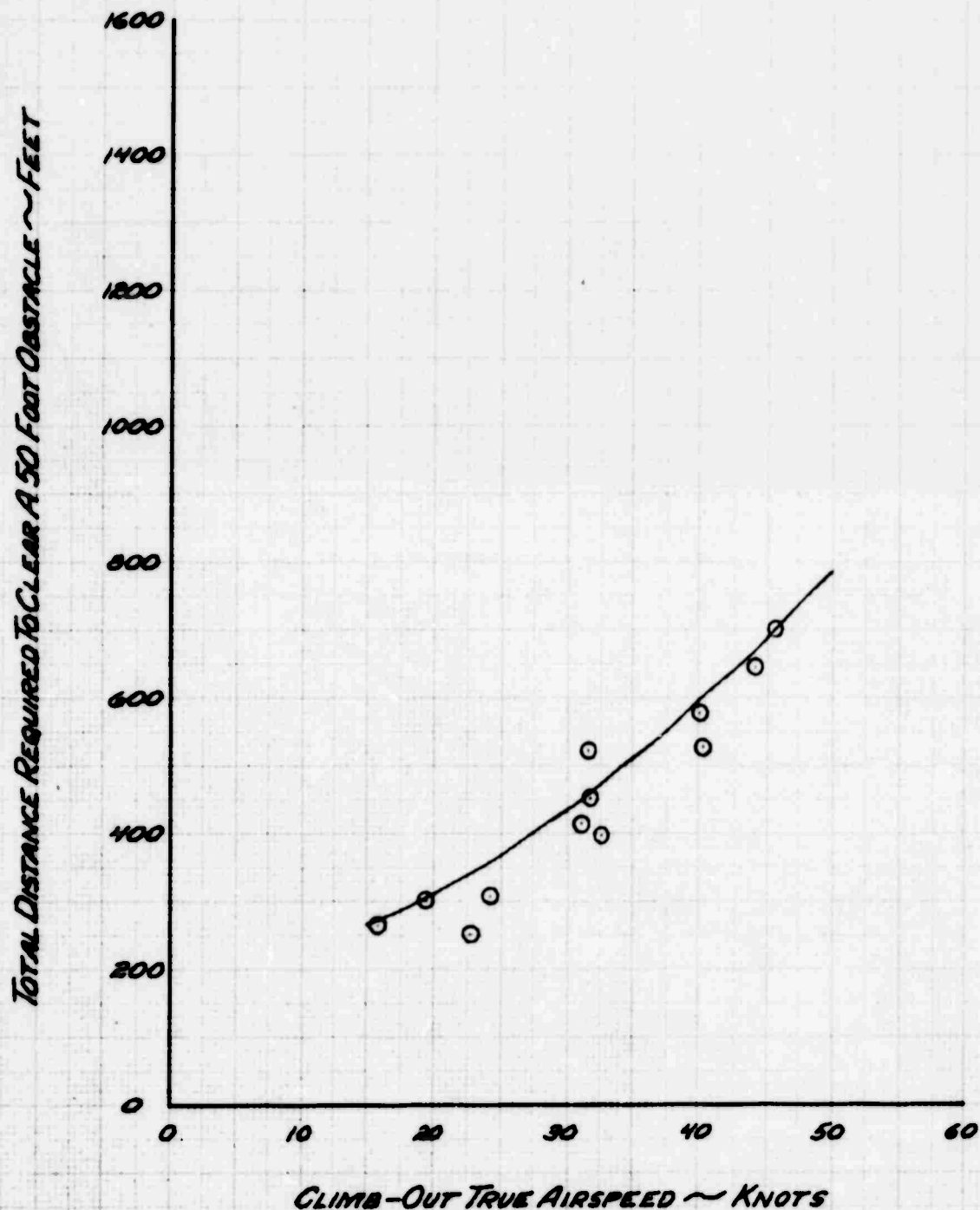


FIGURE 3  
TAKEOFF DISTANCE REQUIRED  
TO CLEAR A 50 FT. OBSTACLE  
OH-58A USA S/N 68-16693

ROTOR RPM = 354  
GROSS WEIGHT = 3030 LB  
PRESSURE ALTITUDE = 4075 FT  
TECHNIQUE = LEVEL ACCELERATION  
FROM A 2 FT. HOVER

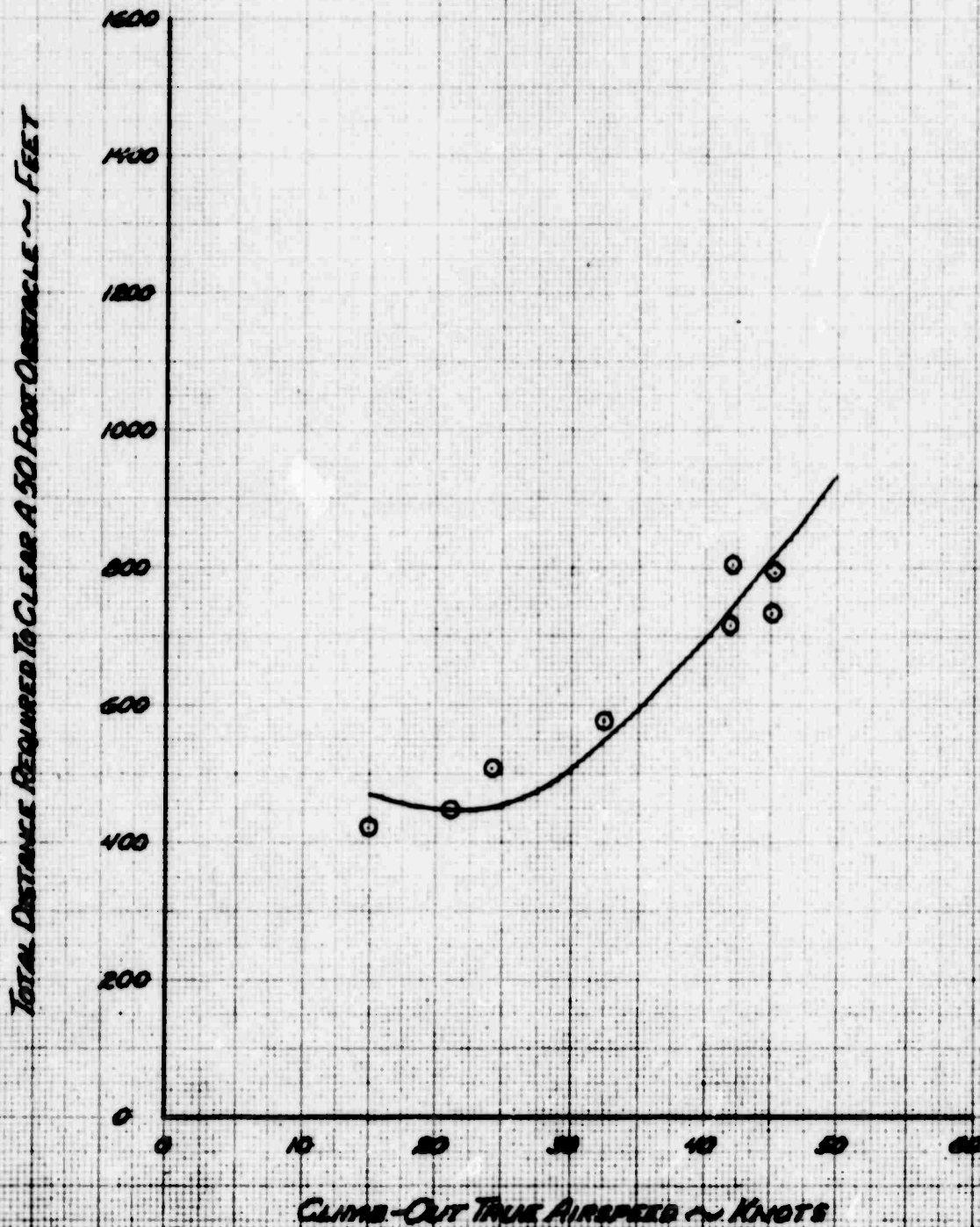
WIND VELOCITY < 3 KTS  
FREE AIR TEMP = 14.7°C  
 $\Delta C_p = 3.09 \times 10^{-5}$   
CONFIGURATION = ARMED-ALL  
DOORS ON



**FIGURE 4**  
**TAKEOFF DISTANCE REQUIRED**  
**TO CLEAR A 50 FT. OBSTACLE**  
**OH-58A USA SINCE 1969**

ROTOR RPM         $\approx 354$   
 GROSS WEIGHT     $\approx 2783$  LB  
 PRESS ALTITUDE  $\approx 8950$  FT  
 TECHNIQUE = LEVEL ACCELERATION  
                  FROM A 2 FT HOVER

WIND VELOCITY     $\leq 3$  KTS  
 FREE AIR TEMP  $\approx 0.3^\circ\text{C}$   
 $AC_P$                  $\approx 0.86 \times 10^{-4}$   
 CONFIGURATION = ARMED-ALL  
                          DOORS ON



**FIGURE 5**  
**TAKEOFF DISTANCE REQUIRED**  
**TO CLEAR A 50 FT. OBSTACLE**  
**OH-58A USA SINGLE-ENGINE**

|                   |                                           |               |                           |
|-------------------|-------------------------------------------|---------------|---------------------------|
| ROTOR RPM         | = 350                                     | WIND VELOCITY | = 13 KTS                  |
| GROSS WEIGHT      | = 2700 LB                                 | FREE AIR TEMP | = -25°C                   |
| PRESSURE ALTITUDE | = 9600 FT                                 | ACFT          | = 0.10 X 10 <sup>-4</sup> |
| TECHNIQUE         | = LEVEL ACCELERATION<br>FROM A 2 FT HOVER | CONFIGURATION | = ARMED-ALL<br>DOORS ON   |

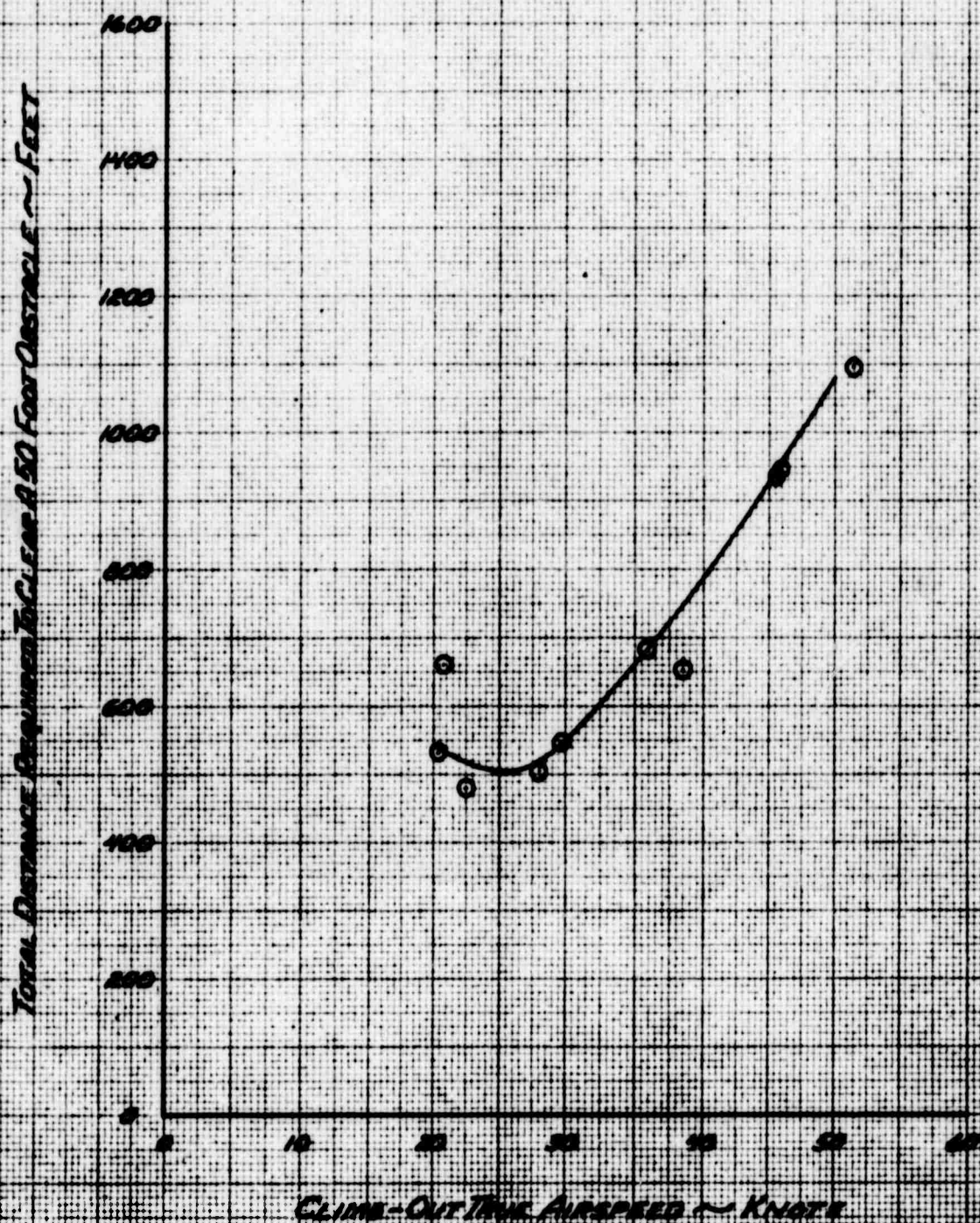


FIGURE 6  
 SUMMARY HOVERING PERFORMANCE  
 OH-58A USA SIN 68-16693  
 T63-A-700 SIN 402811  
 FREE FLIGHT METHOD  
 ROTOR SPEED = 354 RPM  
 WINDS LESS THAN 3 KNOTS  
 TAKE-OFF POWER

NOTE: CURVES DERIVED FROM FIGS. 8 THRU 14 AND 70

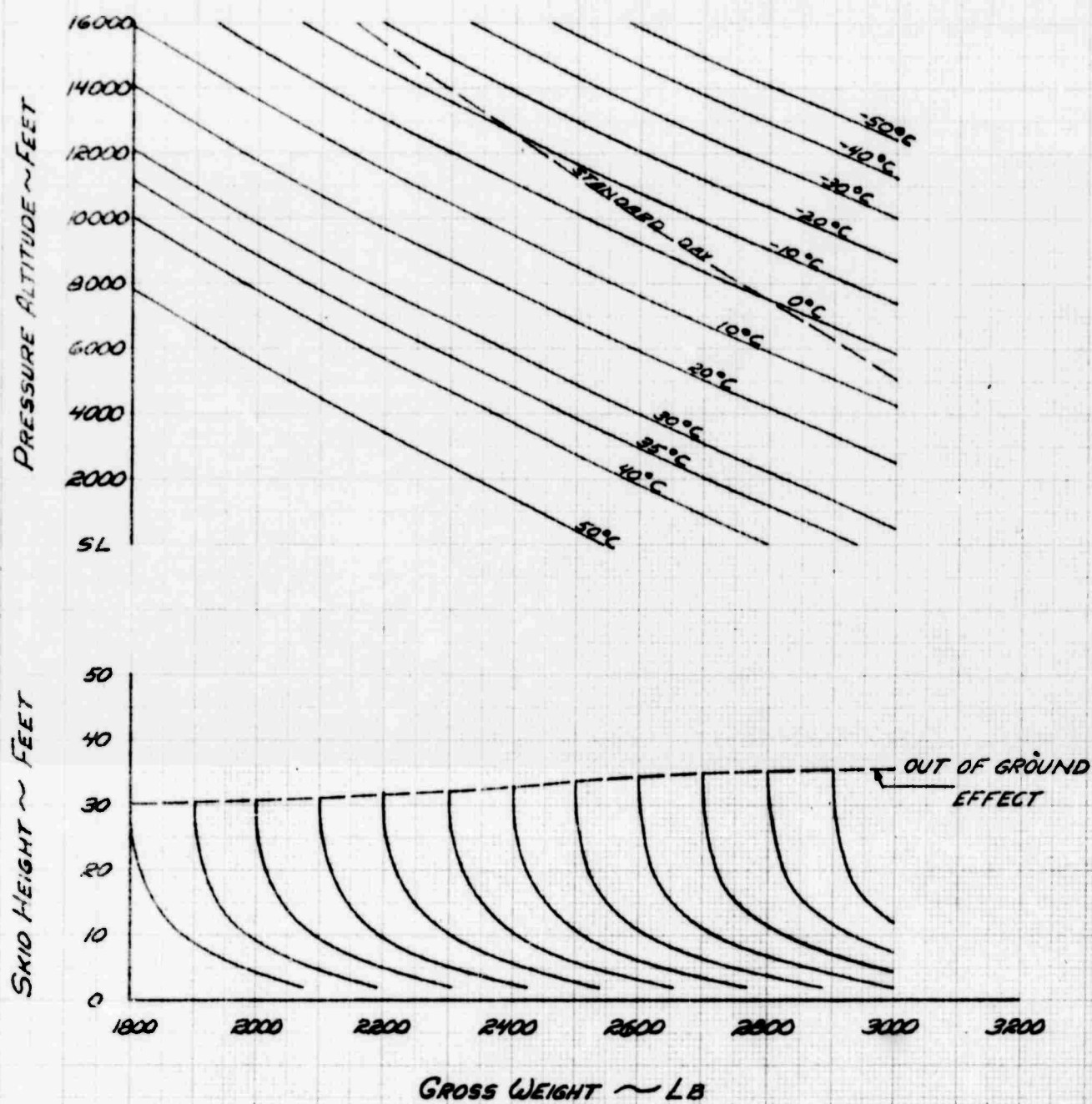


FIGURE 7  
 SUMMARY HOVERING PERFORMANCE  
 OH-58A USA S/N 68-16693  
 T63-A-700 S/N 402811  
 FREE FLIGHT METHOD  
 ROTOR SPEED = 354 RPM  
 WINDS LESS THAN 3 KNOTS  
 NORMAL RATED POWER

NOTE: CURVES DERIVED FROM FIGS. 8 THRU 14 AND 71

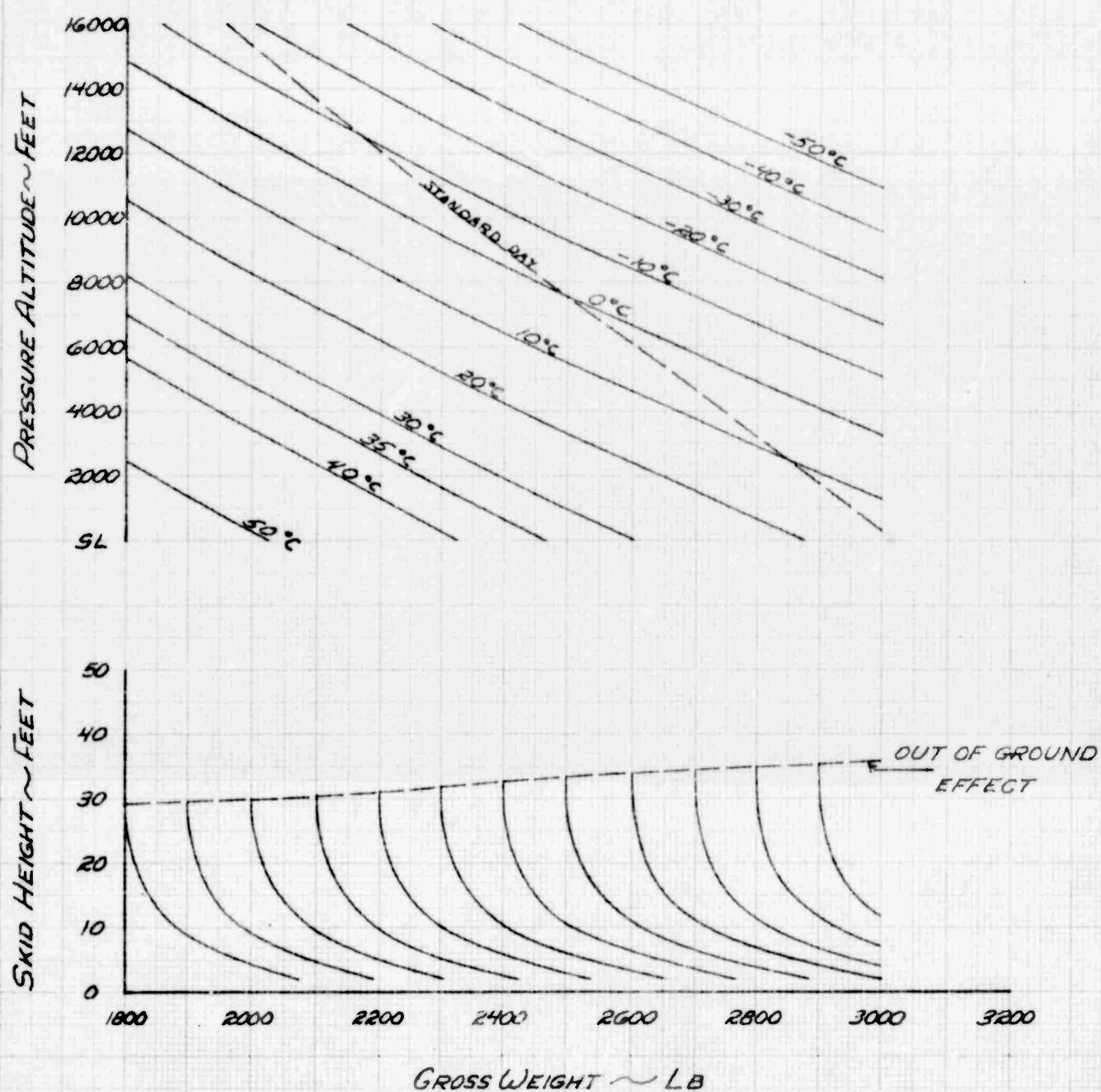


FIGURE 8  
 NON-DIMENSIONAL HOVERING PERFORMANCE  
 OH-58A USA S/N 68-16693  
 T63-A-700 S/N 402811  
 FREE FLIGHT METHOD  
 WINDS LESS THAN 3 KNOTS.

NOTE

1. DERIVED FROM FAIRED CURVES ON FIGS 9 THRU 14
2. VERTICAL DISTANCE FROM BOTTOM OF SKID TO TOP OF ROTOR MAST = 9.58 FEET.

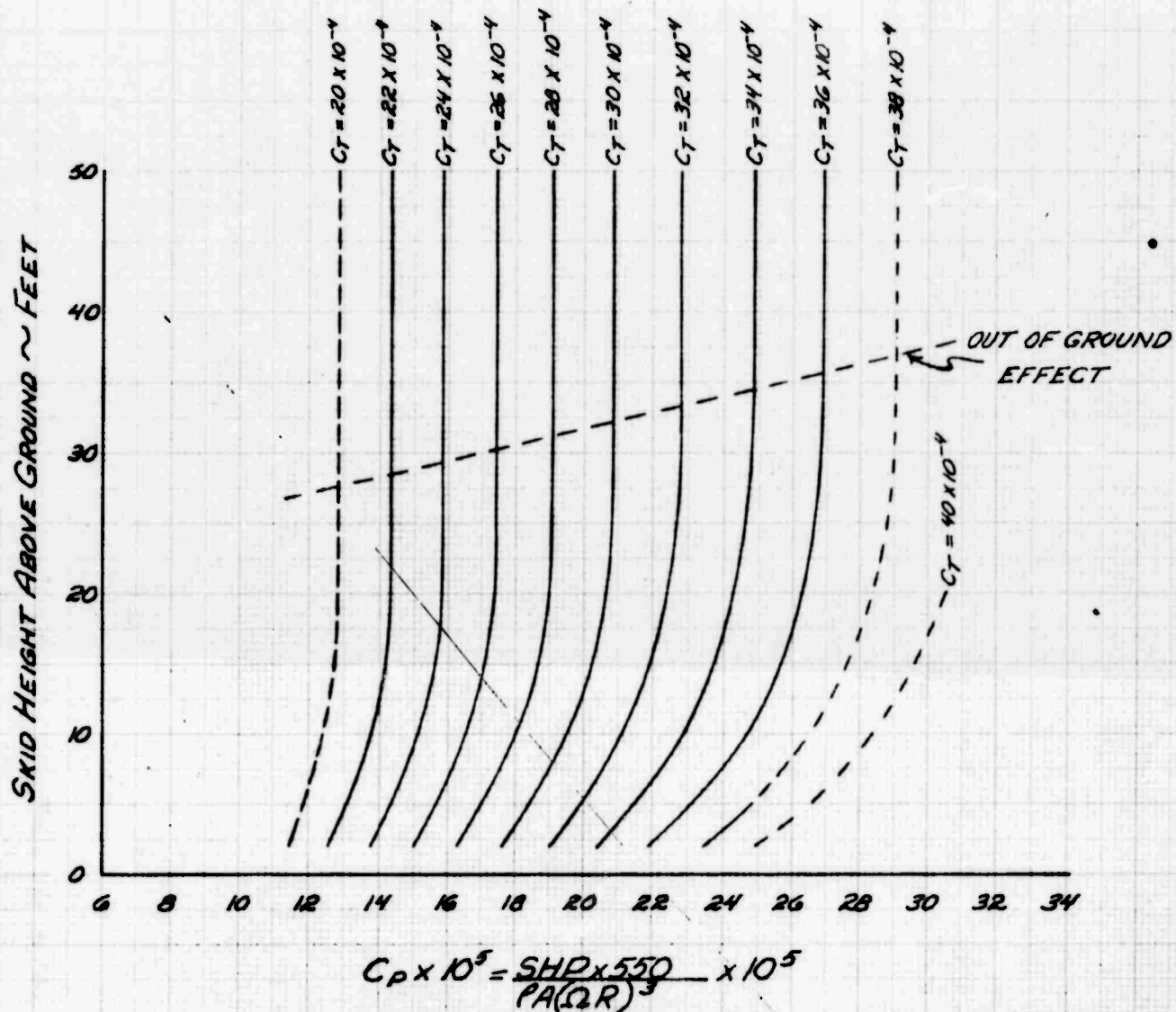
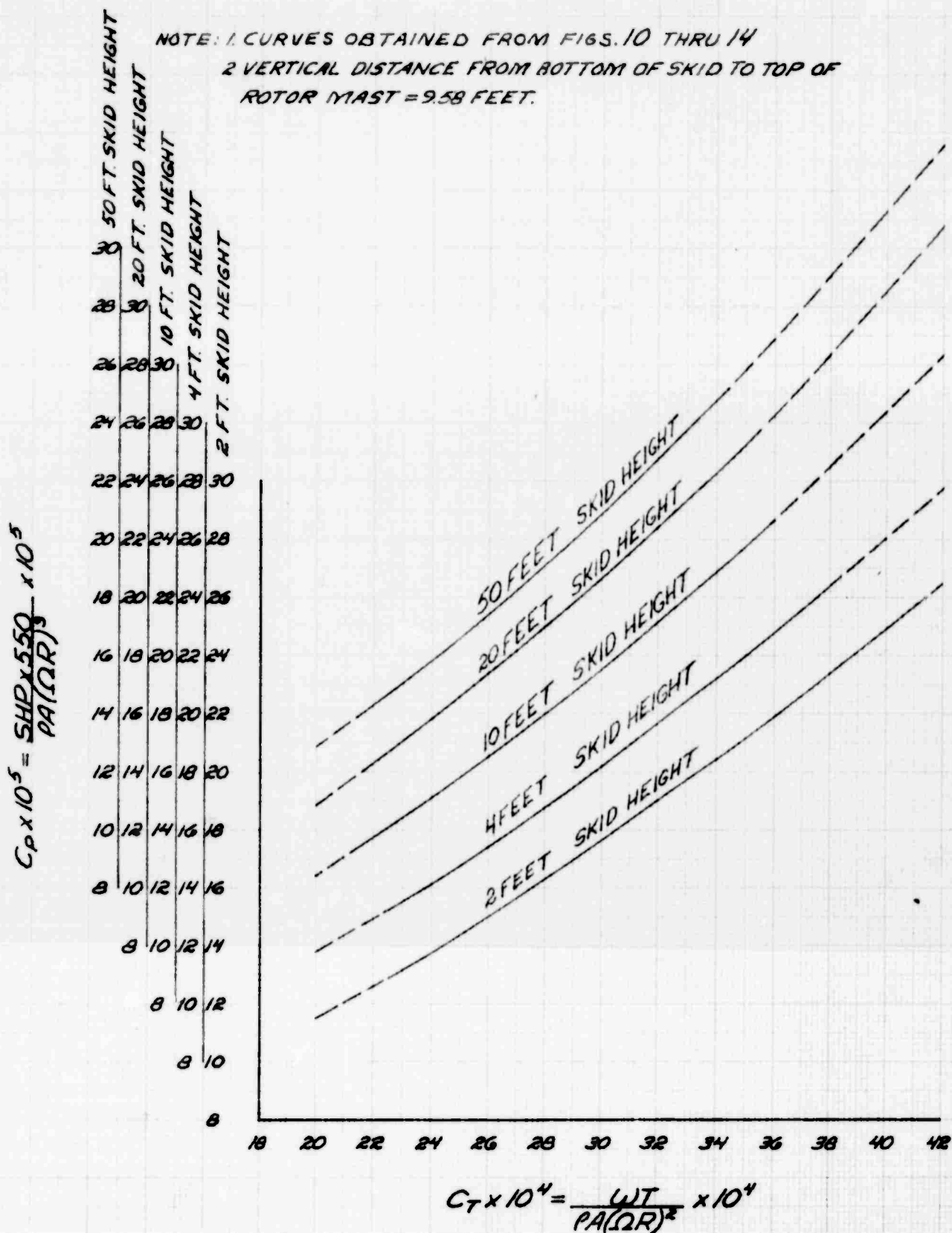


FIGURE 9  
 NON-DIMENSIONAL HOVERING PERFORMANCE  
 OH-58A USA S/N 63-16693  
 TG3-A-700 S/N 402811  
 FREE FLIGHT METHOD  
 WINDS LESS THAN 3 KNOTS

NOTE: 1. CURVES OBTAINED FROM FIGS. 10 THRU 14  
 2. VERTICAL DISTANCE FROM BOTTOM OF SKID TO TOP OF  
 ROTOR MAST = 9.58 FEET.



# **FIGURE 10** **NON-DIMENSIONAL HOVERING PERFORMANCE**

OH-58A USA S/N 68-16693

T63-A-700 S/N 402811

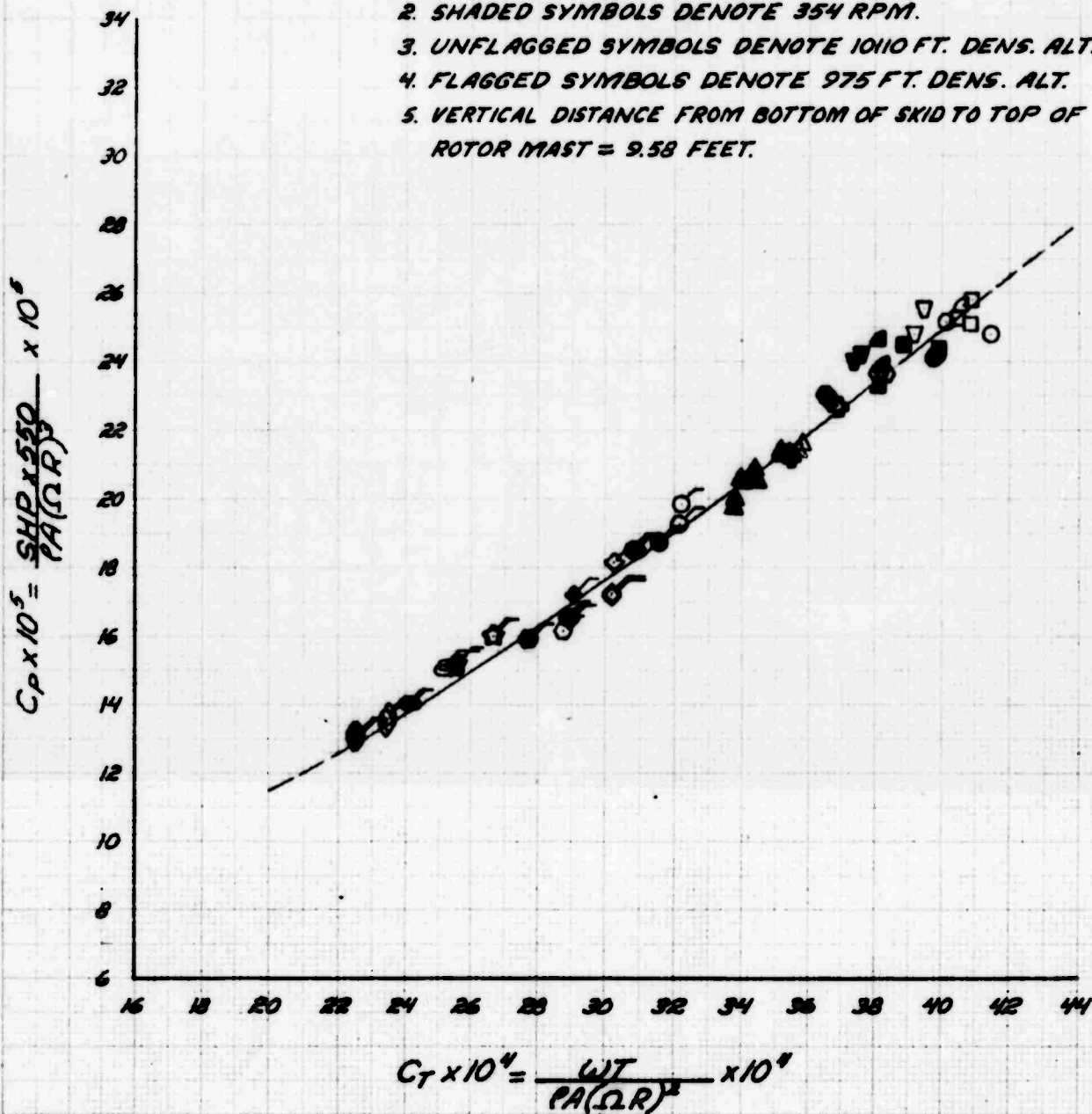
SKID HEIGHT = 2 FEET

FREE FLIGHT METHOD

WINDS LESS THAN 3 KNOTS

| <u>SYM</u> | <u>GROSS WEIGHT (LB)</u> | <u>CONFIG</u> | <u>SYM</u> | <u>GROSS WEIGHT (LB)</u> | <u>CONFIG</u> |
|------------|--------------------------|---------------|------------|--------------------------|---------------|
| ○          | 3010                     | CLEAN         | ⊕          | 2620                     | CLEAN         |
| □          | 2870                     | CLEAN         | ☆          | 2535                     | CLEAN         |
| ◇          | 2795                     | ARMED         | △          | 2515                     | ARMED         |
| ◻          | 2765                     | CLEAN         | ○          | 2340                     | CLEAN         |
| ◼          | 2765                     | ARMED         | ◊          | 2195                     | CLEAN         |
| ○          | 2715                     | CLEAN         |            |                          |               |

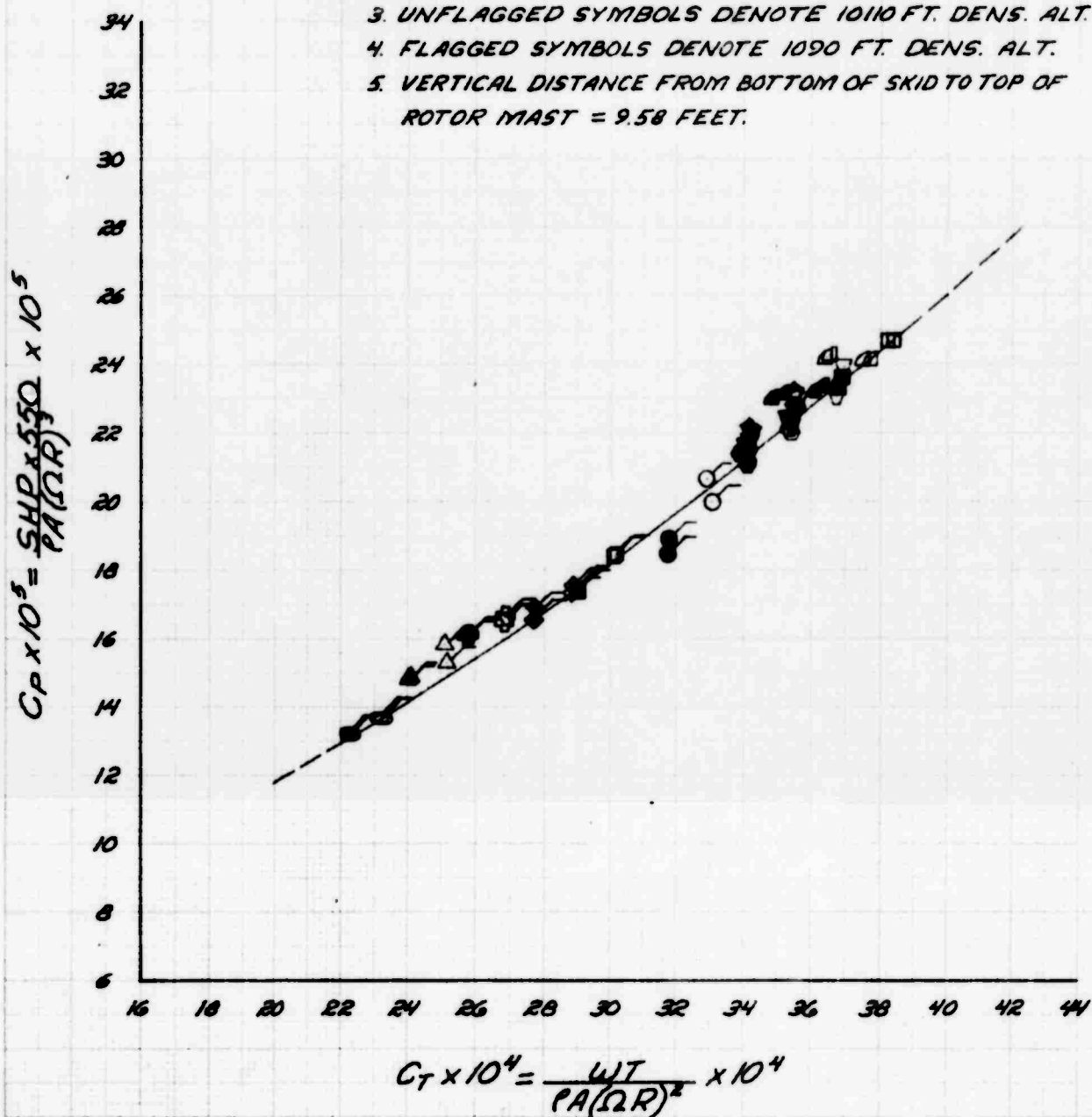
- NOTE:**
1. UNSHADED SYMBOLS DENOTE 347 RPM.
  2. SHADED SYMBOLS DENOTE 354 RPM.
  3. UNFLAGGED SYMBOLS DENOTE 10110 FT. DENS. ALT.
  4. FLAGGED SYMBOLS DENOTE 975 FT. DENS. ALT.
  5. VERTICAL DISTANCE FROM BOTTOM OF SKID TO TOP OF ROTOR MAST = 9.58 FEET.



**FIGURE 11**  
**NON-DIMENSIONAL HOVERING PERFORMANCE**  
 OH-58A USA S/N 68-16693  
 T63-A-700 S/N 402811  
 SKID HEIGHT = 4 FEET  
 FREE FLIGHT METHOD  
 WINDS LESS THAN 3 KNOTS

| <u>SYM</u> | <u>GROSS WEIGHT (LB)</u> | <u>CONFIG</u> | <u>SYM</u> | <u>GROSS WEIGHT (LB)</u> | <u>CONFIG</u> |
|------------|--------------------------|---------------|------------|--------------------------|---------------|
| ○          | 3025                     | CLEAN         | ○          | 2535                     | ARMED         |
| □          | 2790                     | ARMED         | ◊          | 2535                     | CLEAN         |
| ◇          | 2700                     | CLEAN         | ☆          | 2470                     | ARMED         |
| △          | 2640                     | ARMED         | △          | 2330                     | CLEAN         |
| ▽          | 2610                     | CLEAN         | ○          | 2185                     | CLEAN         |

NOTE: 1. UNSHADED SYMBOLS DENOTE 347 RPM.  
 2. SHADED SYMBOLS DENOTE 354 RPM.  
 3. UNFLAGGED SYMBOLS DENOTE 10110 FT. DENS. ALT.  
 4. FLAGGED SYMBOLS DENOTE 1090 FT. DENS. ALT.  
 5. VERTICAL DISTANCE FROM BOTTOM OF SKID TO TOP OF ROTOR MAST = 9.58 FEET.



**FIGURE 12**  
**NON-DIMENSIONAL HOVERING PERFORMANCE**  
 OH-58A USA S/N 68-16693  
 TG3-A-700 S/N 402811  
 SKID HEIGHT=10 FEET  
 FREE FLIGHT METHOD  
 WINDS LESS THAN 3 KNOTS

| <u>SYM</u> | <u>GROSS WEIGHT (LB)</u> | <u>CONFIG</u> | <u>SYM</u> | <u>GROSS WEIGHT (LB)</u> | <u>CONFIG</u> |
|------------|--------------------------|---------------|------------|--------------------------|---------------|
| ○          | 3055                     | CLEAN         | ◊          | 2320                     | ARMED         |
| □          | 2965                     | ARMED         | ☆          | 2320                     | CLEAN         |
| ◇          | 2815                     | ARMED         | △          | 2285                     | ARMED         |
| △          | 2710                     | CLEAN         | ○          | 2170                     | CLEAN         |
| ▽          | 2530                     | ARMED         | ○          | 2085                     | CLEAN         |
| ○          | 2530                     | CLEAN         |            |                          |               |

- NOTE: 1. UNSHADED SYMBOLS DENOTE 347 RPM.  
 2. SHADED SYMBOLS DENOTE 354 RPM.  
 3. UNFLAGGED SYMBOLS DENOTE 9975 FT. DENS. ALT.  
 4. FLAGGED SYMBOLS DENOTE 4585 FT. DENS. ALT.  
 5. SLASHED SYMBOLS DENOTE 1075 FT. DENS. ALT.  
 6. VERTICAL DISTANCE FROM BOTTOM OF SKID TO TOP OF ROTOR MAST = 9.58 FEET.

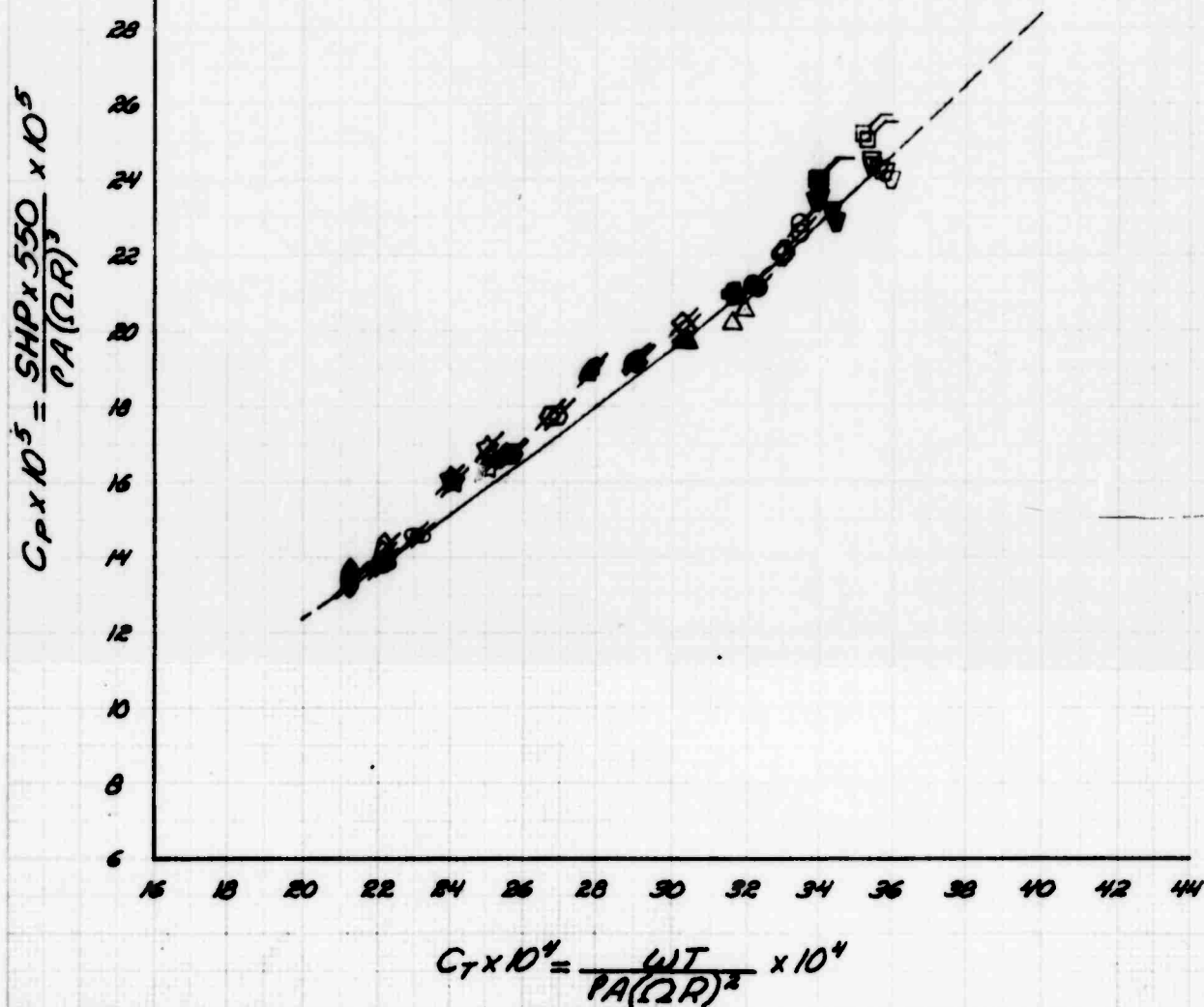
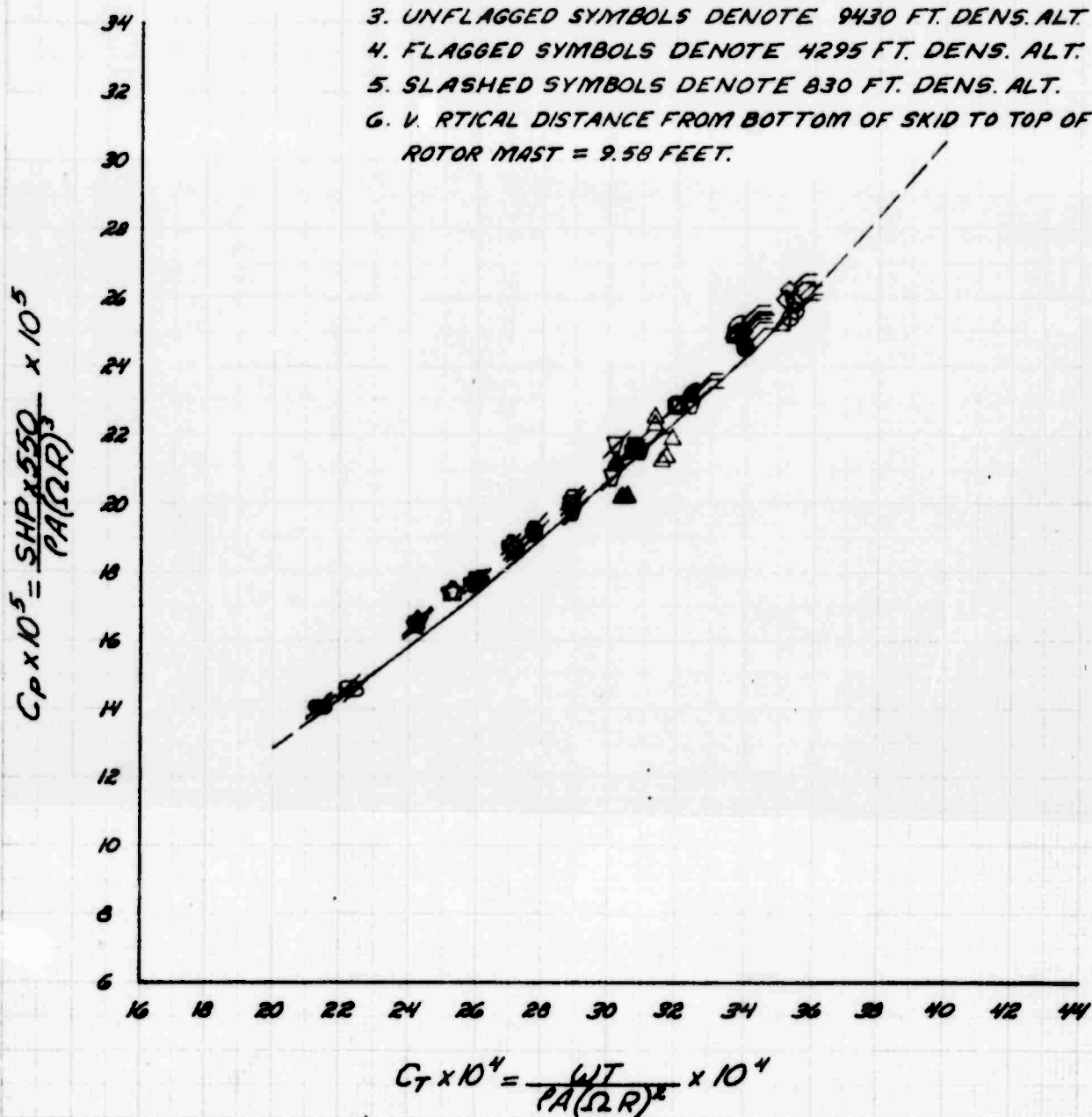


FIGURE 13  
 NON-DIMENSIONAL HOVERING PERFORMANCE  
 OH-58A USA S/N 68-16693  
 TG3-A-700 S/N 402811  
 SKID HEIGHT = 20 FEET  
 FREE FLIGHT METHOD  
 WINDS LESS THAN 3 KNOTS

| SYM | GROSS WEIGHT (LB) | CONFIG | SYM | GROSS WEIGHT (LB) | CONFIG |
|-----|-------------------|--------|-----|-------------------|--------|
| ○   | 3035              | ARMED  | ○   | 2690              | CLEAN  |
| □   | 3035              | CLEAN  | ◊   | 2555              | CLEAN  |
| ◇   | 2945              | ARMED  | ◊   | 2395              | CLEAN  |
| △   | 2875              | ARMED  | △   | 2285              | ARMED  |
| ▽   | 2795              | ARMED  | ○   | 2120              | CLEAN  |

NOTE: 1. UNSHADED SYMBOLS DENOTE 347 RPM.  
 2. SHADED SYMBOLS DENOTE 354 RPM.  
 3. UNFLAGGED SYMBOLS DENOTE 9430 FT. DENS. ALT.  
 4. FLAGGED SYMBOLS DENOTE 4295 FT. DENS. ALT.  
 5. SLASHED SYMBOLS DENOTE 830 FT. DENS. ALT.  
 6. VERTICAL DISTANCE FROM BOTTOM OF SKID TO TOP OF ROTOR MAST = 9.58 FEET.



**FIGURE 14**  
**NON-DIMENSIONAL HOVERING PERFORMANCE**  
 OH-58A USA S/N 68-16693  
 T63-A-700 S/N 40811  
 SKID HEIGHT = 50 FEET  
 FREE FLIGHT METHOD  
 WINDS LESS THAN 3 KNOTS

| <u>SYM</u> | <u>GROSS WEIGHT (LB)</u> | <u>CONFIG</u> | <u>SYM</u> | <u>GROSS WEIGHT (LB)</u> | <u>CONFIG</u> |
|------------|--------------------------|---------------|------------|--------------------------|---------------|
| ○          | 3050                     | CLEAN         | ⊗          | 2440                     | CLEAN         |
| □          | 2955                     | ARMED         | ☆          | 2405                     | CLEAN         |
| ◇          | 2690                     | ARMED         | △          | 2305                     | ARMED         |
| △          | 2665                     | CLEAN         | ○          | 2305                     | CLEAN         |
| ▽          | 2585                     | CLEAN         | ○          | 2100                     | CLEAN         |
| ○          | 2545                     | CLEAN         |            |                          |               |

- NOTE: 1. UNSHADED SYMBOLS DENOTE 347 RPM.  
 2. SHADED SYMBOLS DENOTE 354 RPM.  
 3. UNFLAGGED SYMBOLS DENOTE 9385 FT. DENS. ALT.  
 4. FLAGGED SYMBOLS DENOTE 3340 FT. DENS. ALT.  
 5. SLASHED SYMBOLS DENOTE 235 FT. DENS. ALT.  
 6. VERTICAL DISTANCE FROM BOTTOM OF SKID TO TOP OF ROTOR MAST = 9.58 FEET.

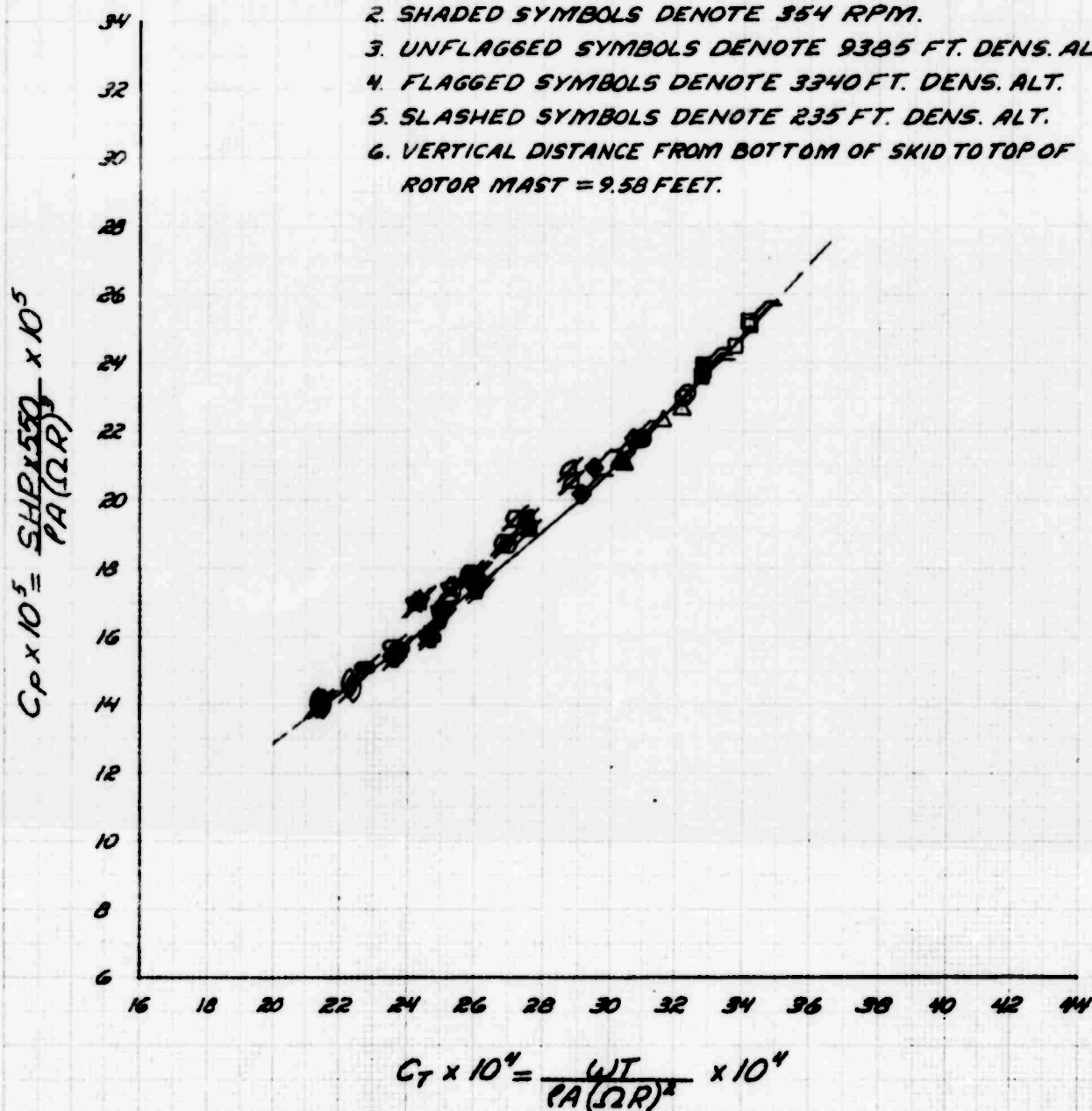


FIGURE 15  
CLIMB PERFORMANCE  
OH-58A USA S/N 68-16693  
T63-A-700 ENGINE  
TAKEOFF RATED POWER  $T_{R_0} = 1380$  HP  
STANDARD DAY

TAKEOFF GROSS WEIGHT = 2747 LB C6 = 1070 IN. (FWD) ROTOR SPEED = 354 RPM CLEAN CONFIGURATION  
SERVICE CEILING 21,800 FT  
NOTE: 1. TEST POINTS DENOTE TWO SEPARATE CLIMBS.

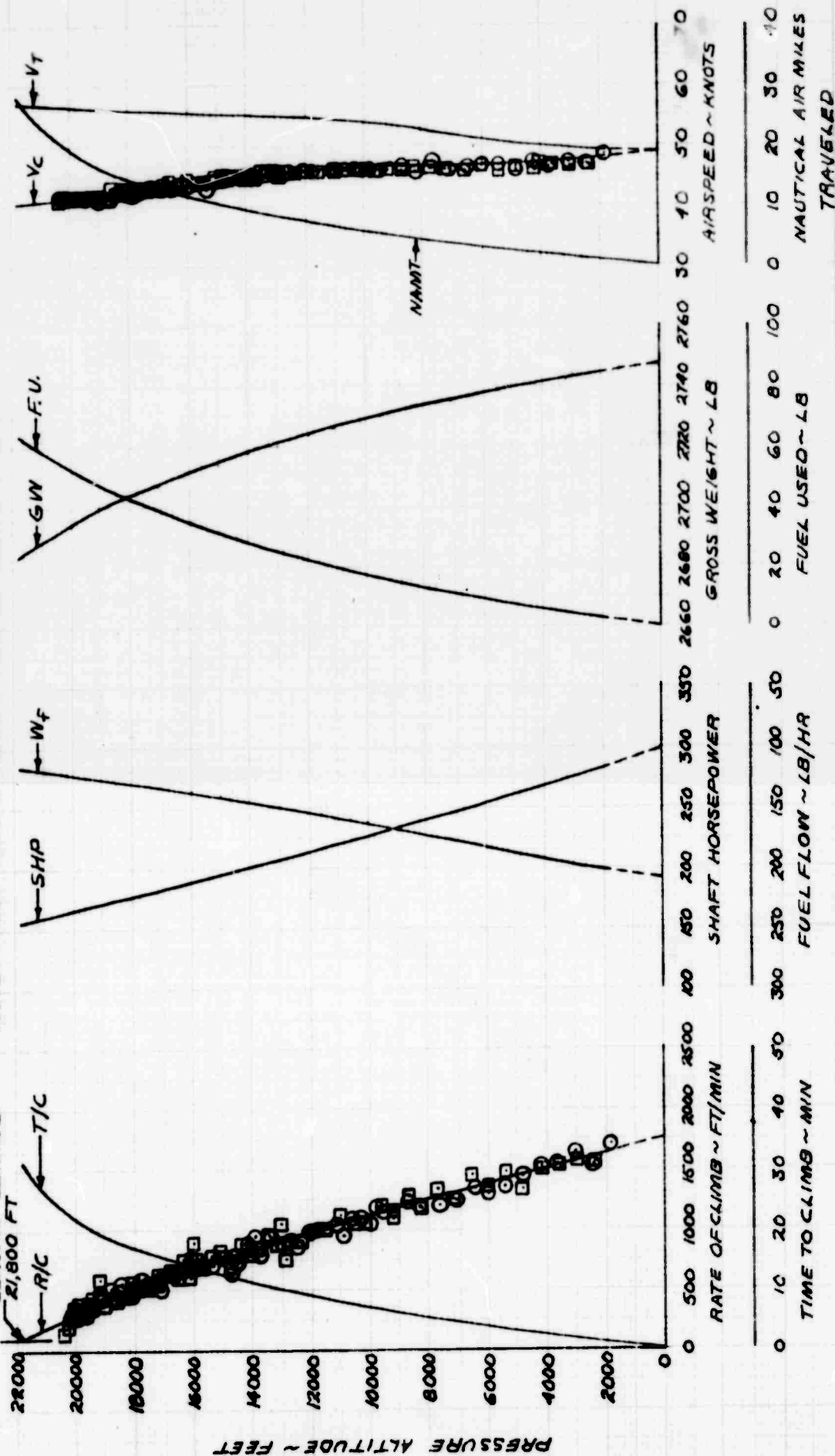


FIGURE 16A  
CLIMB PERFORMANCE  
OH-58A USA. S/N 68-16693  
T63-A-700 ENGINE  
TAKEOFF RATED POWER  $T_{TS} = 1980^{\circ}\text{F}$   
STANDARD DAY

TAKEOFF GROSS WEIGHT = 2252 LBS      ROTOR SPEED = 354 RPM  
C.G. STATION = 107.0 IN. (FWD)      CLEAN CONFIGURATION  
NOTE: 1 TEST POINTS DENOTE TWO SEPARATE CLIMBS.

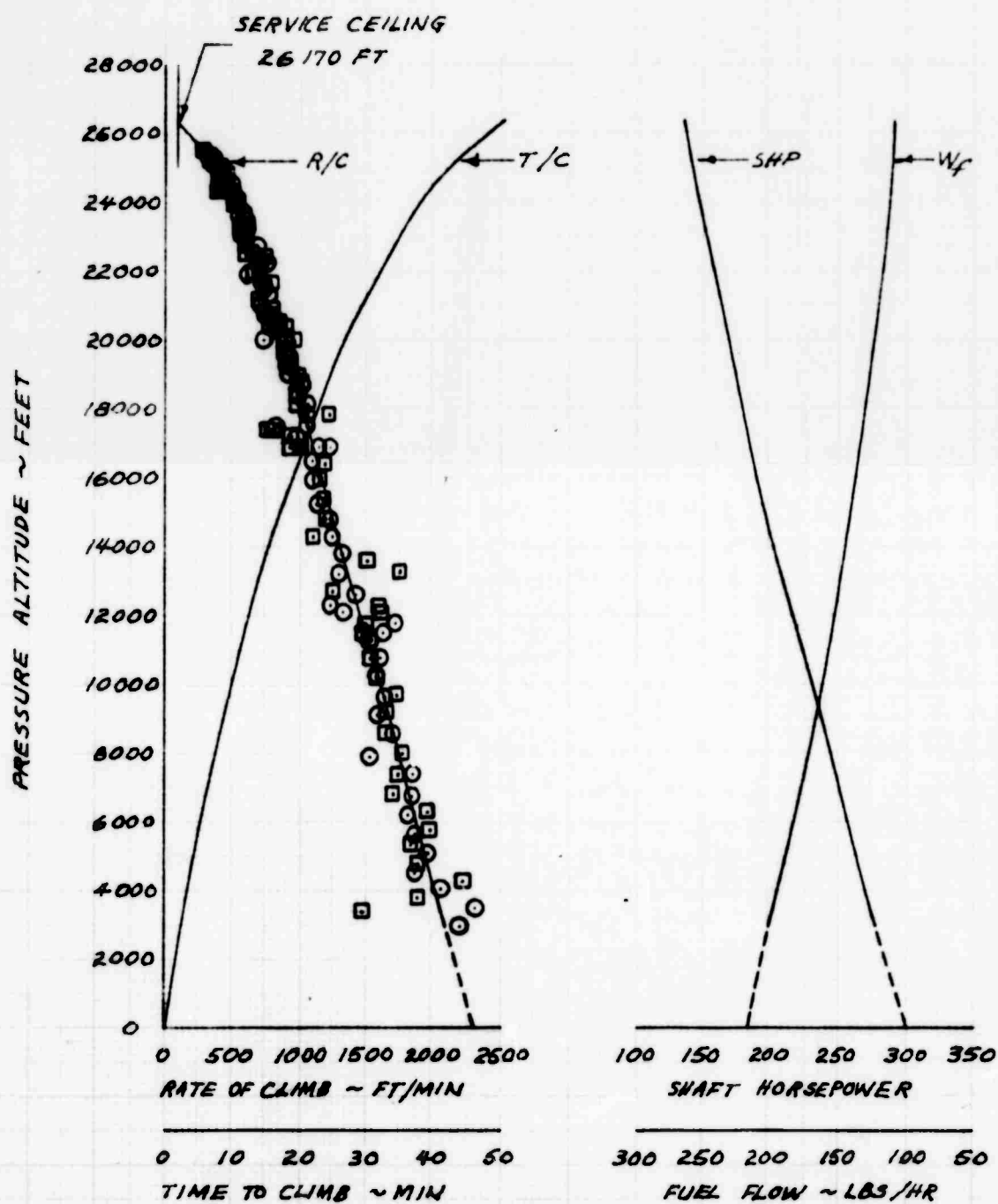


FIGURE 16B  
CLIMB PERFORMANCE (CONCLUDED)  
OH-58A USA. S/N 68-16693

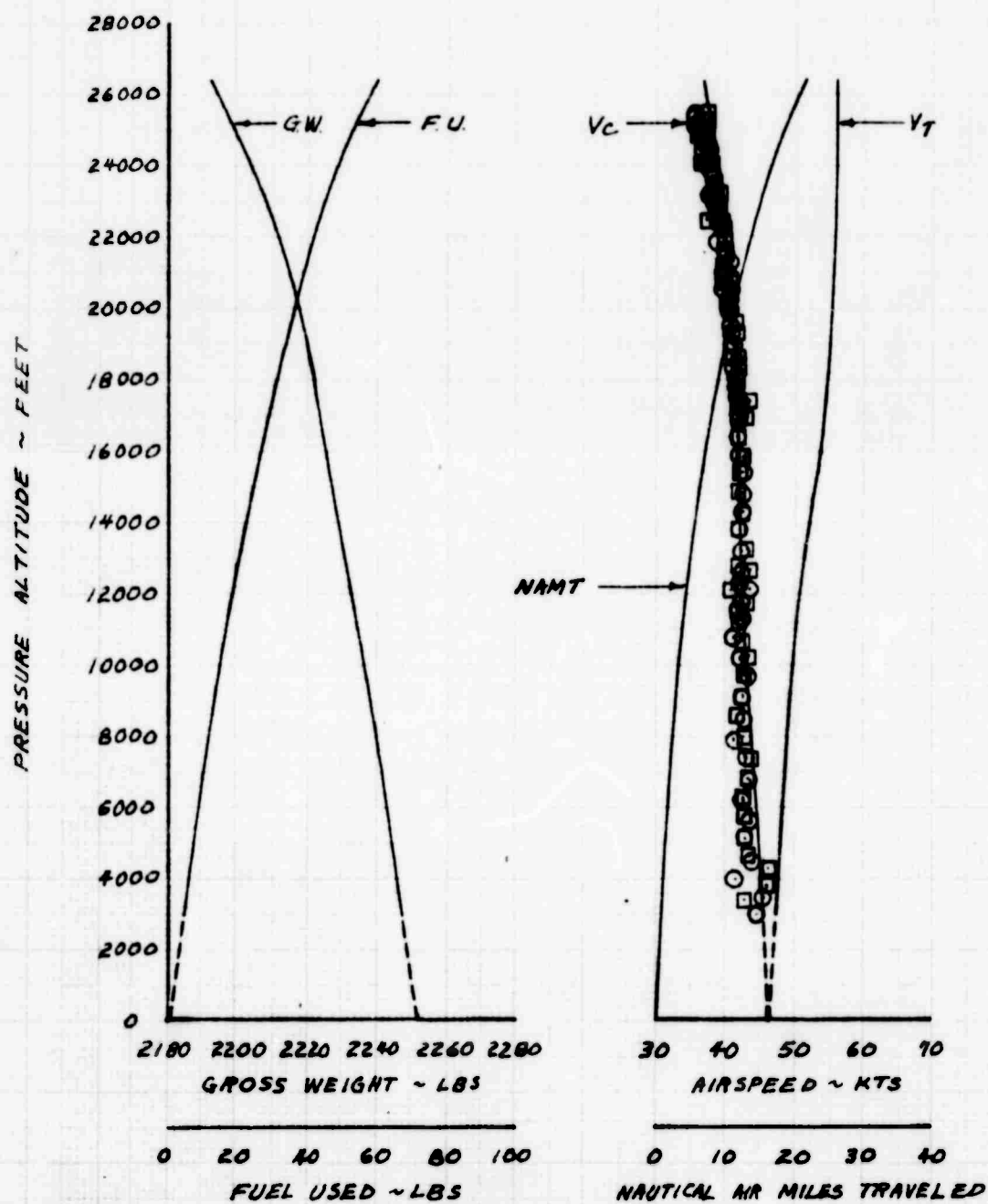


FIGURE 17

CLIMB PERFORMANCE

OH-58A U.S.A. S/N 68-16693

TC3-A-700 ENGINE

TAKEOFF RATED POWER  $T_{R5} = 1380 \text{ HP}$

STANDARD DAY

SERVICE CEILING 18380 FT TAKEOFF GROSS WEIGHT = 2960 LBS ROTOR SPEED = 354 RPM

C.G. STATION = 107.0 IN. (FWD) CLEAN CONFIGURATION

NOTE: 1. TEST POINTS DENOTE TWO SEPARATE CLIMBS

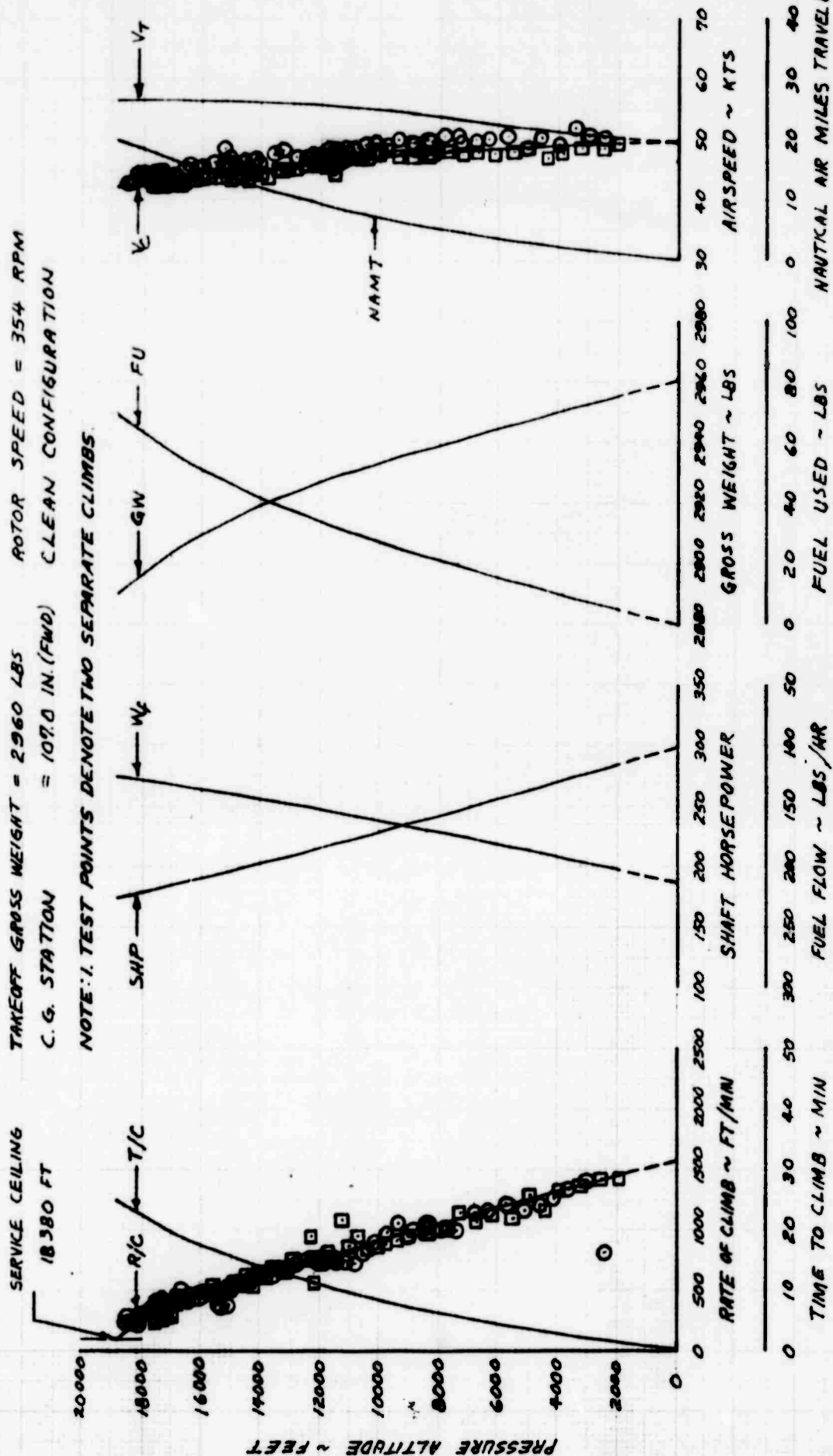


FIGURE 18

CLIMB PERFORMANCE  
OH-30A USA SING-16693  
T63-A-700 ENGINE

NORMAL RATED POWER  $T_{TS} = 1280 \text{ HP}$   
STANDARD DAY

TAKEOFF GROSS WEIGHT = 2240 LB

SERVICE CEILING

25000 FT

R/C

T/C

NOTE: 1. TEST POINTS  
DENOTE TWO  
SEPARATE  
CLIMBS.

CG = 107.0 IN. (FWD) ROTOR SPEED = 354 RPM

SHP

W<sub>r</sub>

GW

F.U.

CLEAN CONFIGURATION

V<sub>c</sub>

V<sub>t</sub>

NAMT

PRESSURE ALTITUDE ~ FEET

RATE OF CLIMB ~ FT/MIN

SHAFT HORSEPOWER

GROSS WEIGHT ~ LB

AIR SPEED ~ KNOTS

TIME TO CLIMB ~ MIN

FUEL FLOW ~ LB/HR

FUEL USED ~ LB

NAUTICAL AIR MILES  
TRAVELED

FIGURE 19  
 CLIMB PERFORMANCE  
 OH-58A USA/N68-16693  
 T63-A-700 ENGINE  
 NORMAL RATED POWER  $T_{TS} = 1280^{\circ}\text{F}$   
 STANDARD DAY

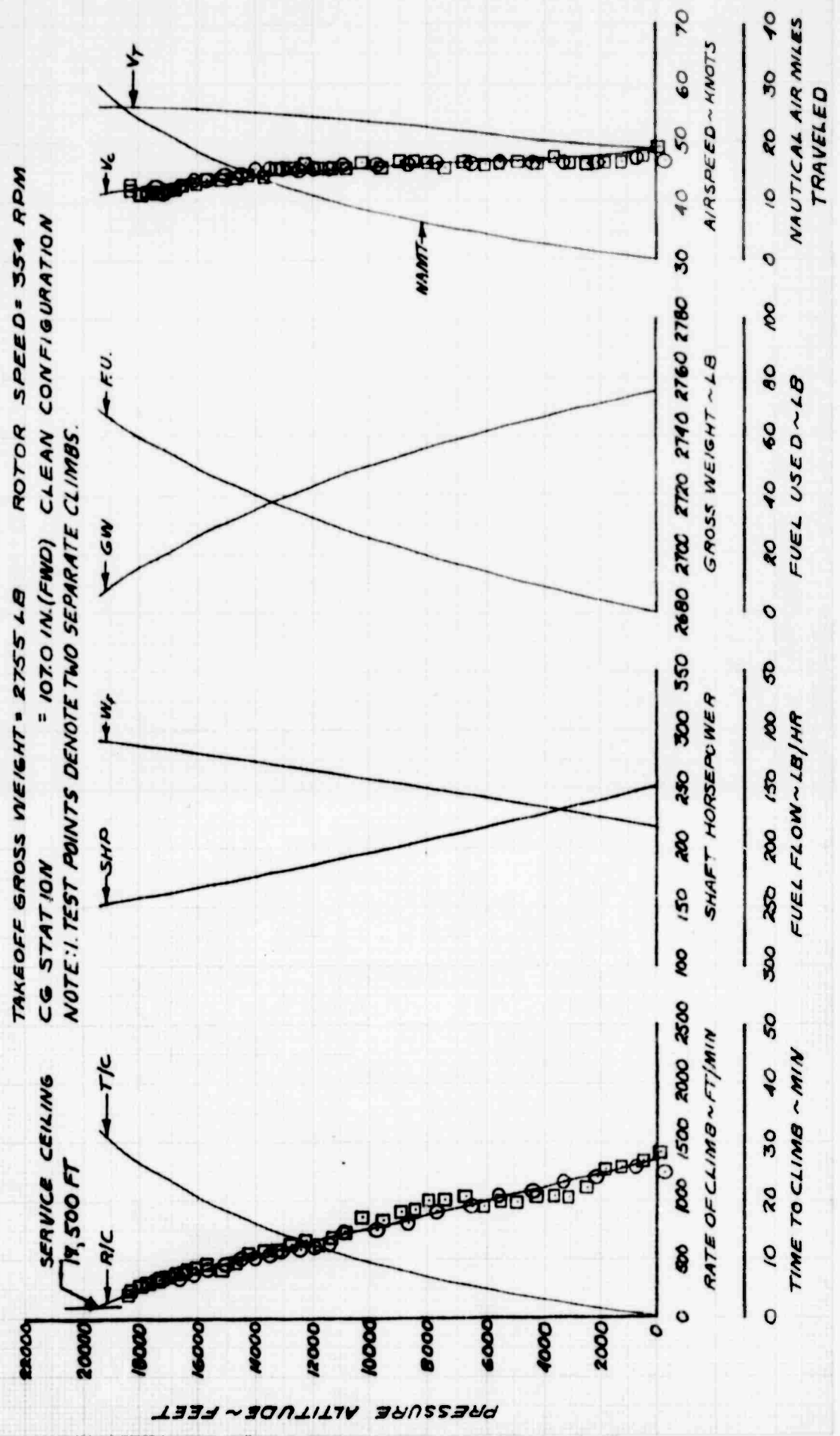


FIGURE 20  
CLIMB PERFORMANCE  
OH-58A USAF/N68-16693  
T63-A-700 ENGINE  
NORMAL RATED POWER  $TQ_c = 1280$  HP  
STANDARD DAY

TAKEOFF GROSS WEIGHT = 2765 LB ROTOR SPEED = 354 RPM  
CG STATION = 107.0 IN. (FWD) CLEAN CONFIGURATION

NOTE: 1. TEST POINTS DENOTE TWO SEPARATE CLIMBS.

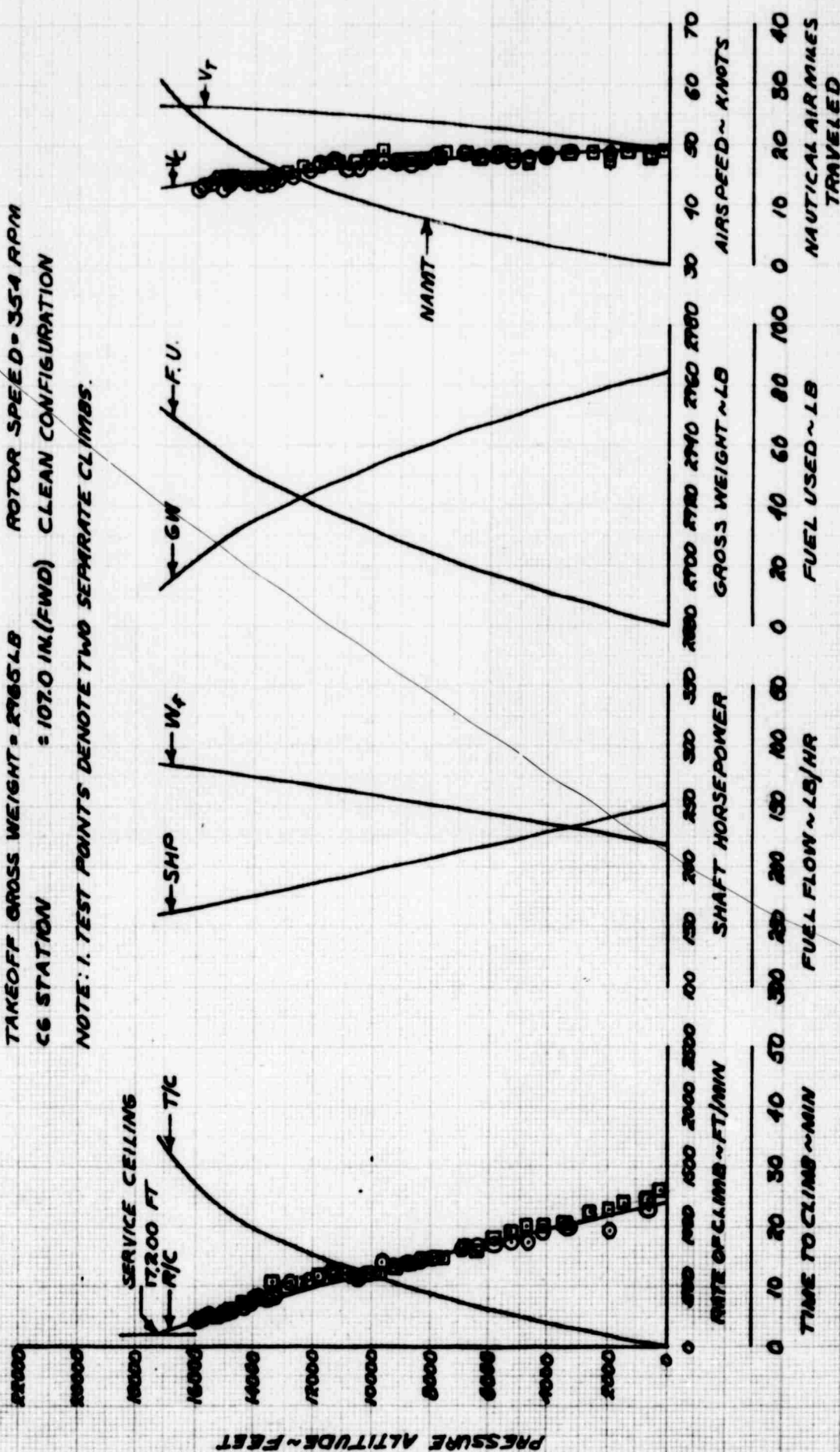


FIGURE 21  
 VARIATION IN RATE OF CLIMB  
 AS A FUNCTION OF SHAFT HORSEPOWER  
 OH-58A USA S/N 68-16693

| SYM | DENSITY<br>ALTITUDE<br>(FT) | GROSS<br>WEIGHT<br>(LB) |
|-----|-----------------------------|-------------------------|
| ○   | 4670                        | 2560                    |
| □   | 9865                        | 2560                    |

$$K_p = \frac{A R K}{85HP} \times \frac{GW}{33000}$$

$$K_p = 0.7946$$

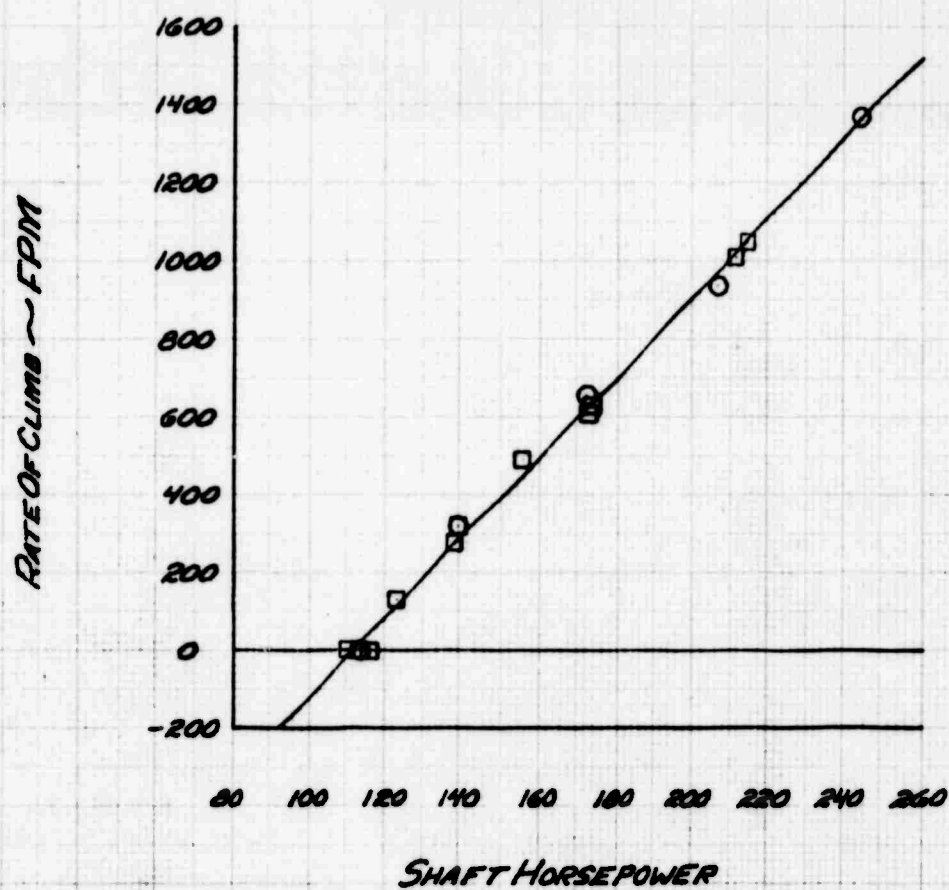


FIGURE 22  
VARIATION IN RATE OF CLIMB  
AS A FUNCTION OF GROSS WEIGHT  
OH-58A USA SIN 68-16698

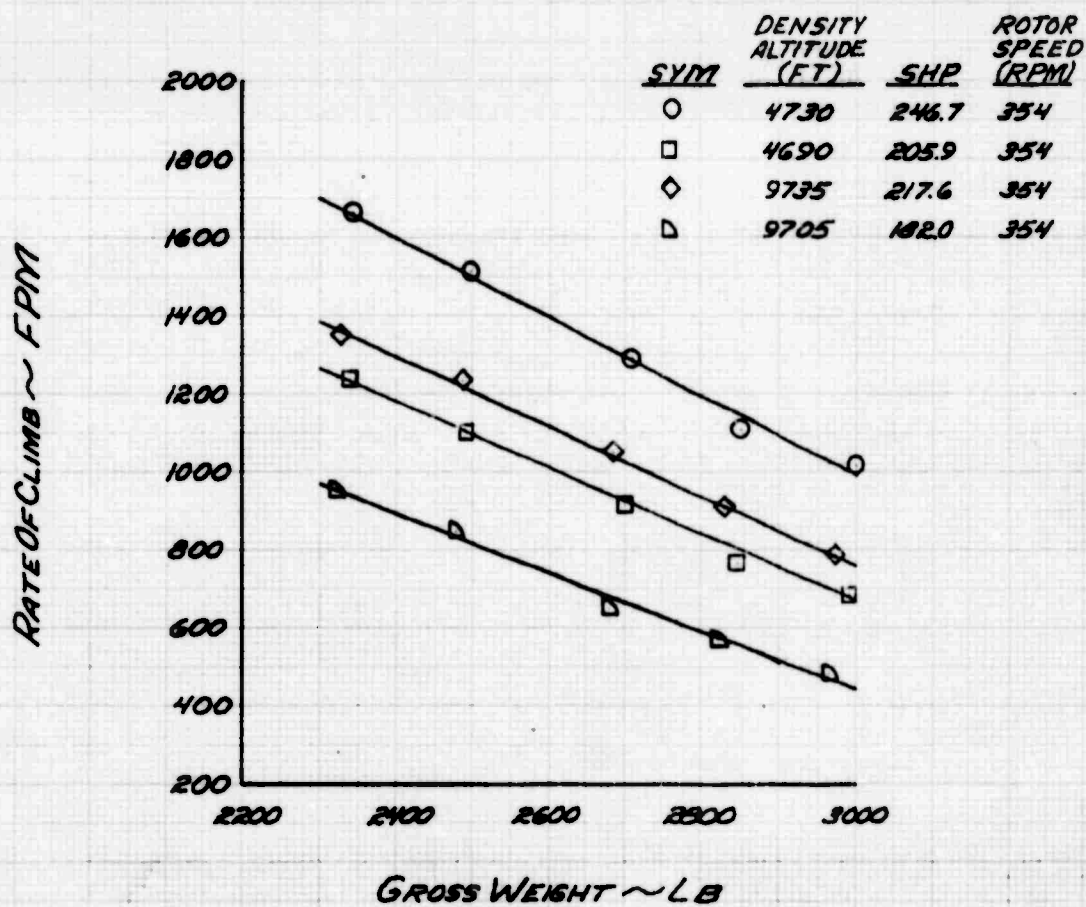
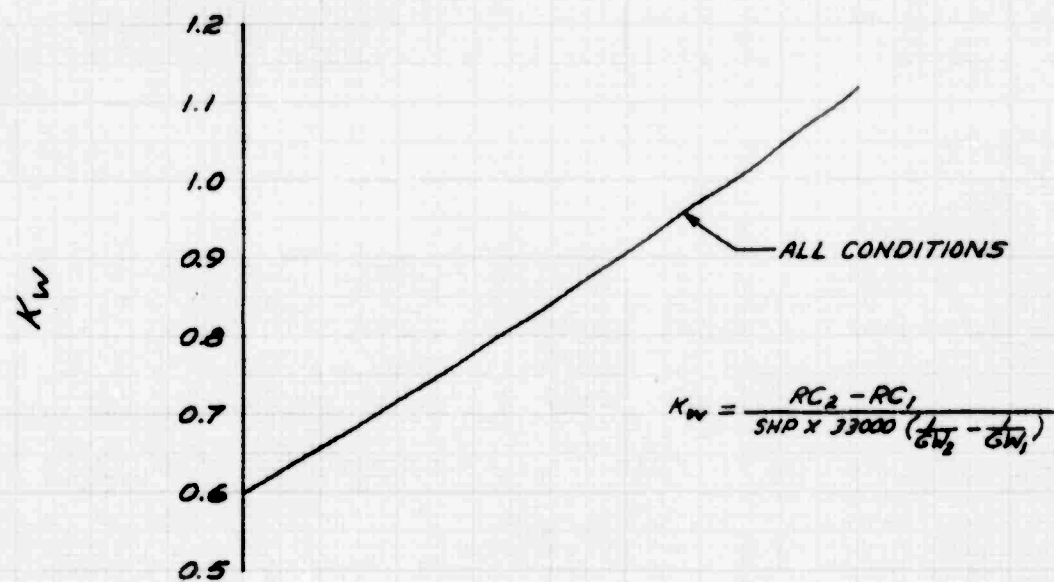


FIGURE 23  
 LEVEL FLIGHT PERFORMANCE  
 OH-58A USA SINGB-16693  
 CLEAN-ALL DOORS ON  
 CG = 107.0 IN. (FWD)

NOTE: 1. CURVES DERIVED FROM FIGS. 32 THRU 44  
 2. SHADED SYMBOLS DENOTE COMPRESSIBILITY EFFECTS.

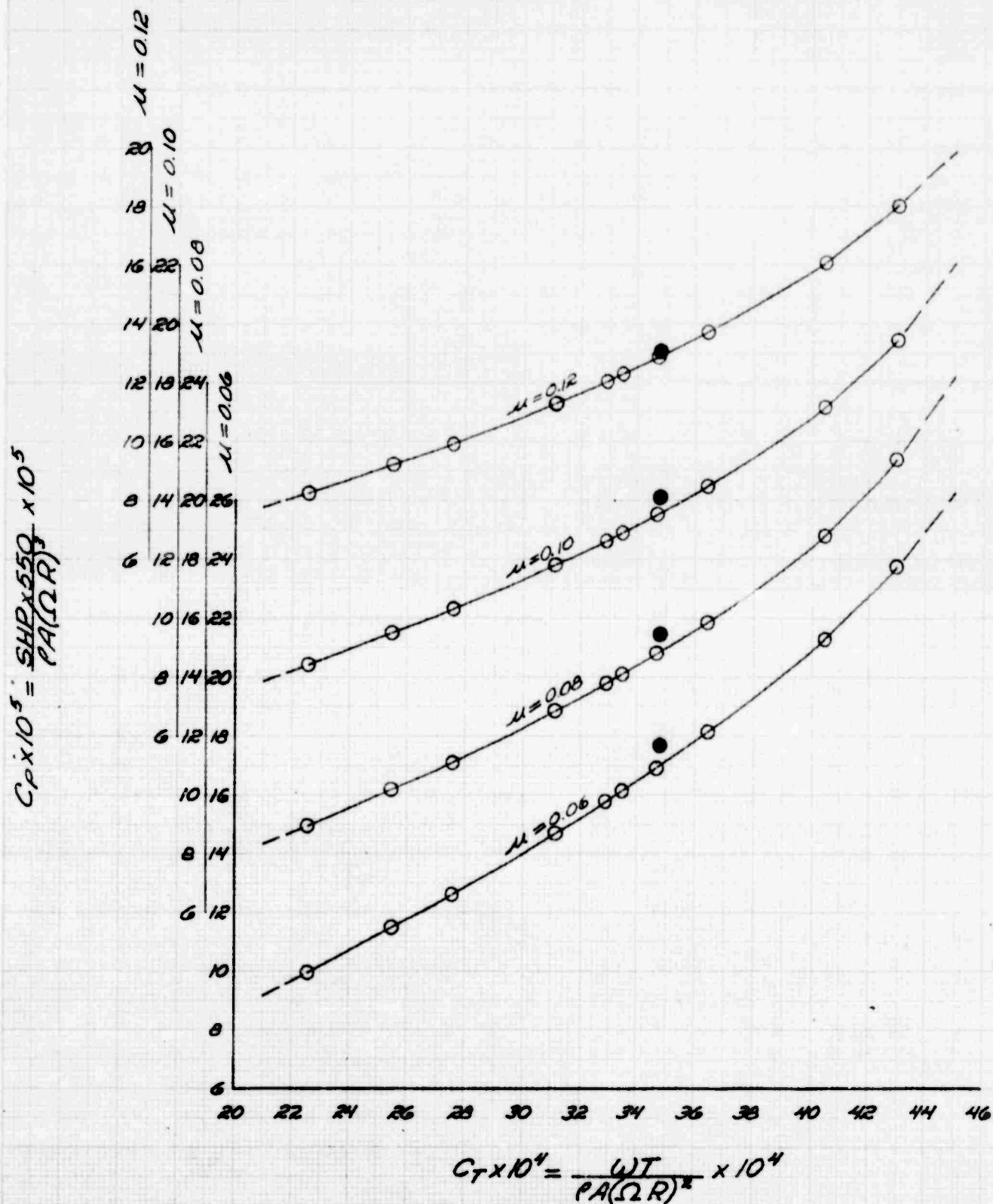


FIGURE 24  
LEVEL FLIGHT PERFORMANCE  
OH-58A USA S/N 68-16693  
CLEAN-ALL DOORS ON  
CG = 107.0 IN. (FWD)

NOTE: 1. CURVES DERIVED FROM FIGS. 32 THRU 44  
2. SHADED SYMBOLS DENOTE COMPRESSIBILITY EFFECTS.

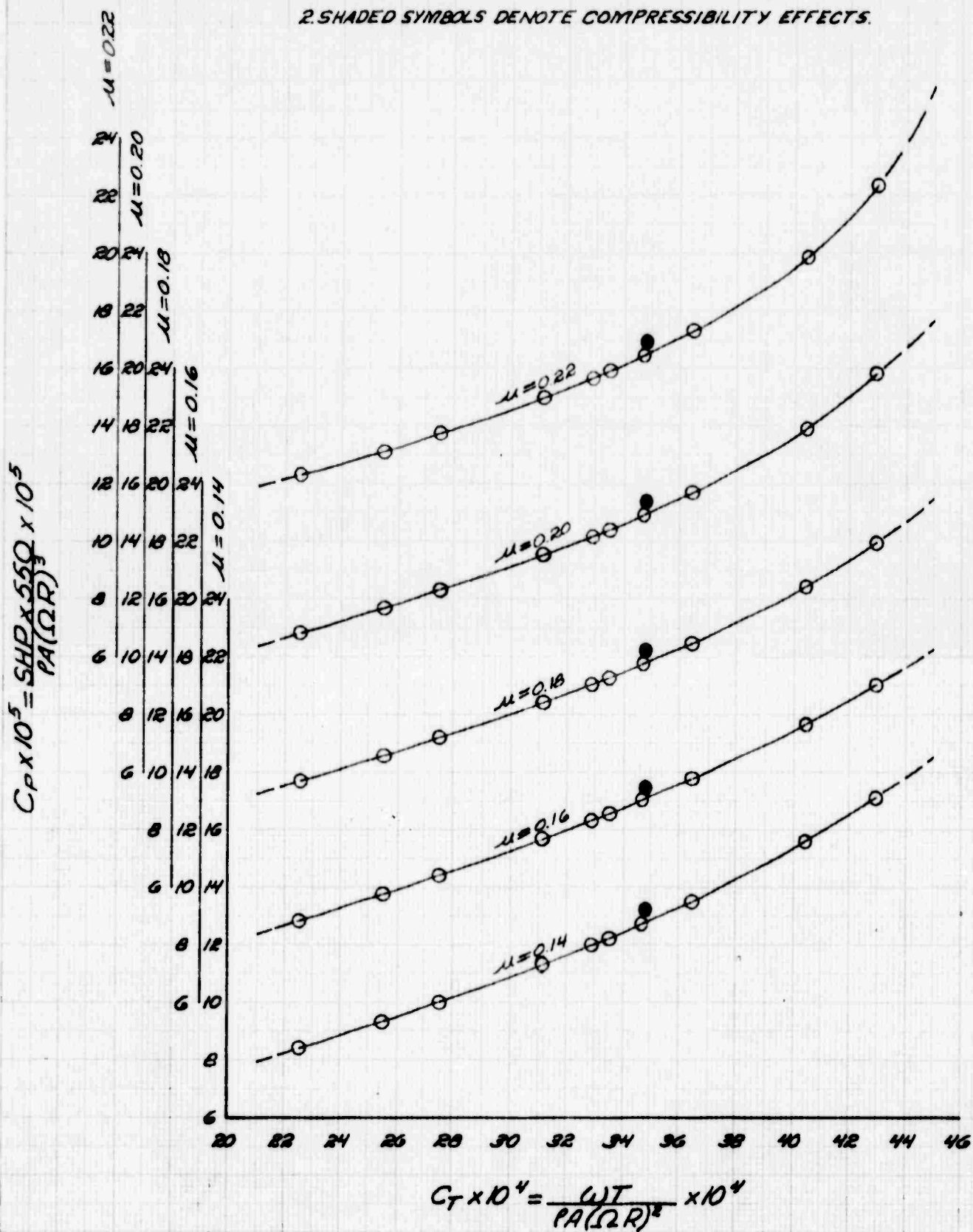


FIGURE 25  
LEVEL FLIGHT PERFORMANCE  
OH-58A USA 51668-16693  
CLEAN-ALL DOORS ON  
CG = 107.0 IN. (FWD)

NOTE: 1. CURVES DERIVED FROM FIGS. 32 THRU 44  
2. SHADED SYMBOLS DENOTE COMPRESSIBILITY EFFECTS.

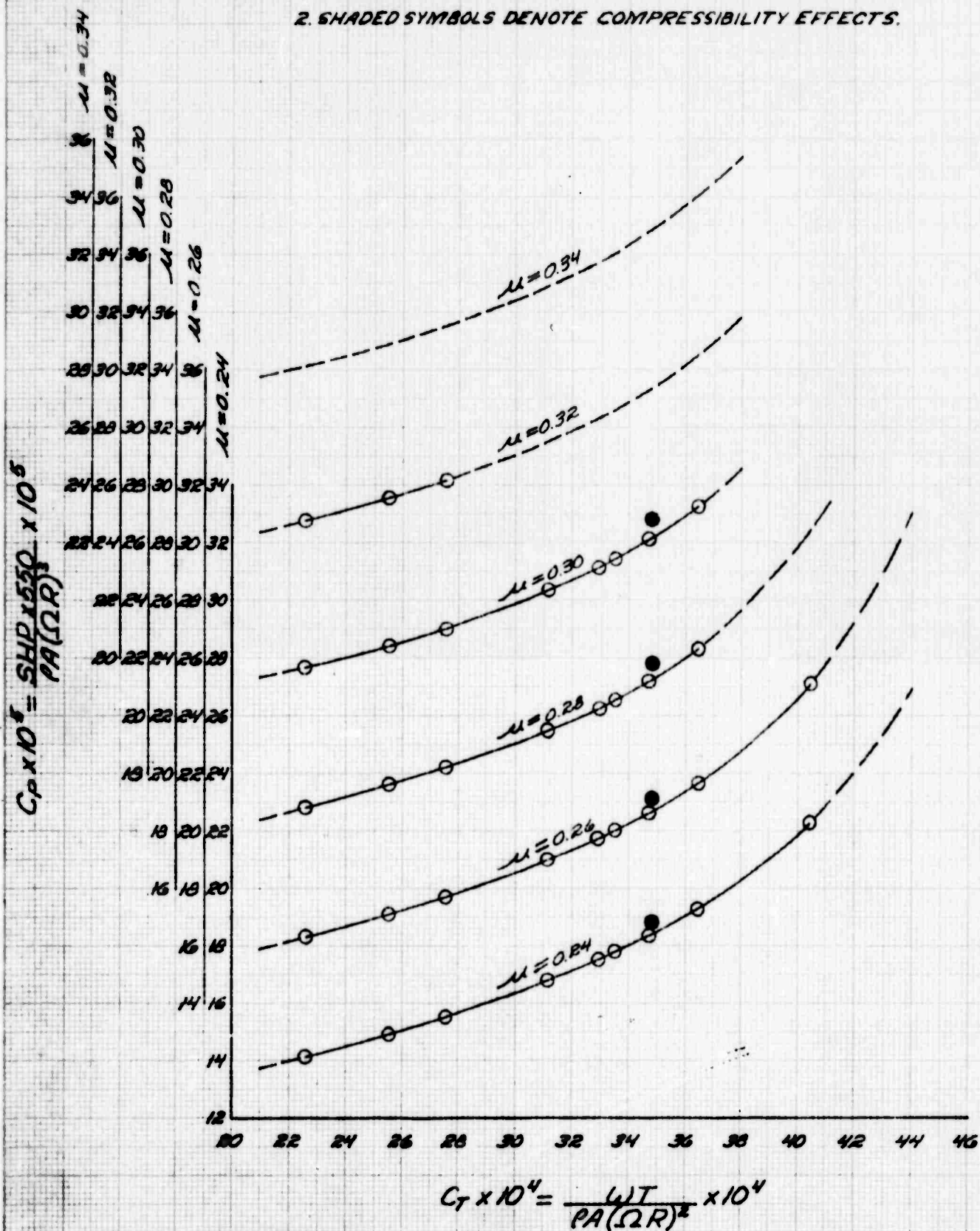


FIGURE 26  
 LEVEL FLIGHT RANGE SUMMARY  
 OH-58A USA SIN 68-16693  
 SEA LEVEL — STANDARD DAY  
 CG = 107.0 IN. (FWD)

NOTE: 1. DATA DERIVED FROM FIGURES 23 THRU 25 AND 72

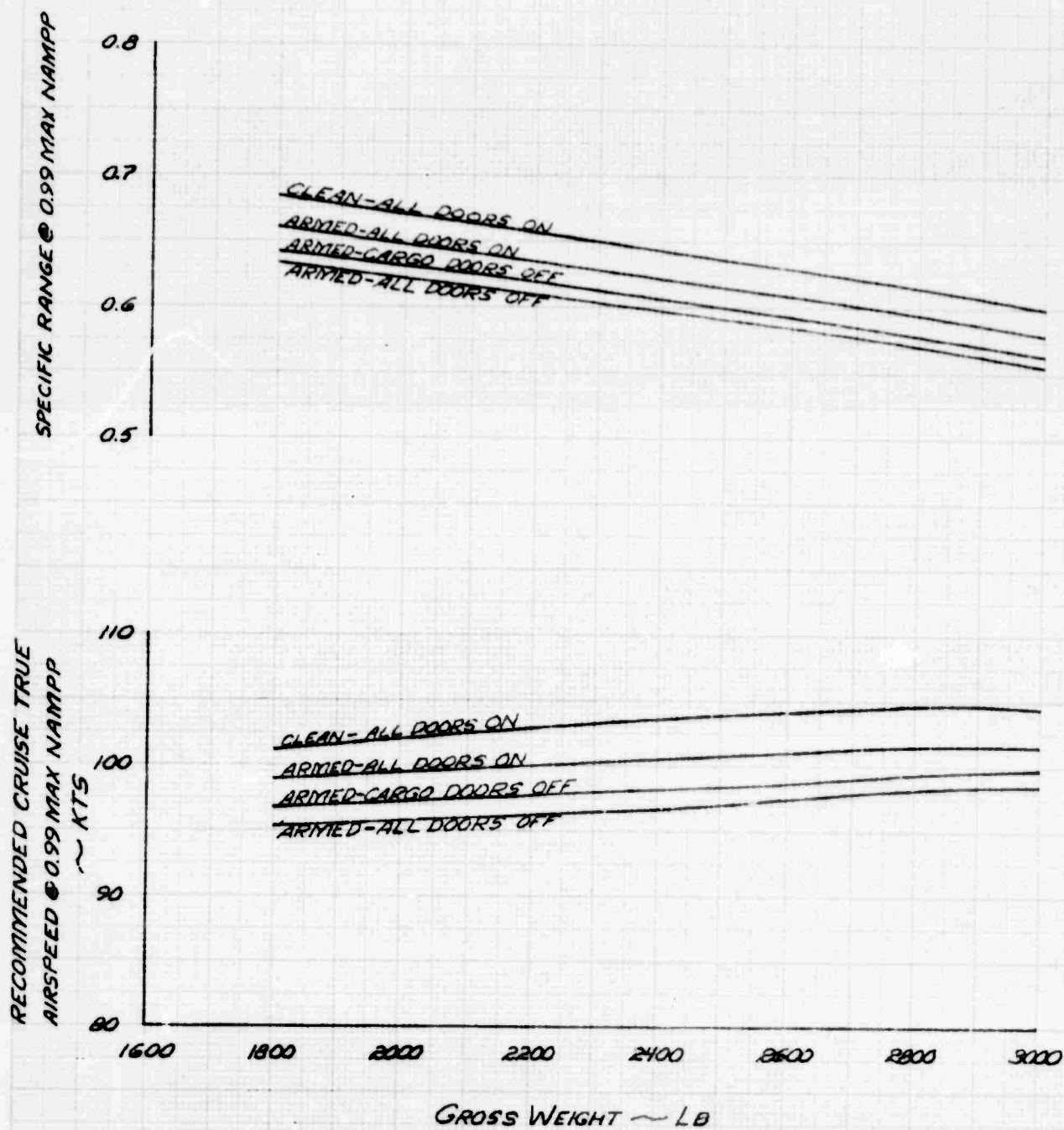


FIGURE 27  
 LEVEL FLIGHT RANGE SUMMARY  
 OH-58A USA SIN 68-16693  
 5000 FEET STANDARD DAY  
 CG = 107.0 IN. (FWD)

NOTE: 1. DATA DERIVED FROM FIGURES 23 THRU 25 AND 72  
 2. DASHED LINES DENOTE NORMAL RATED POWER LIMIT.

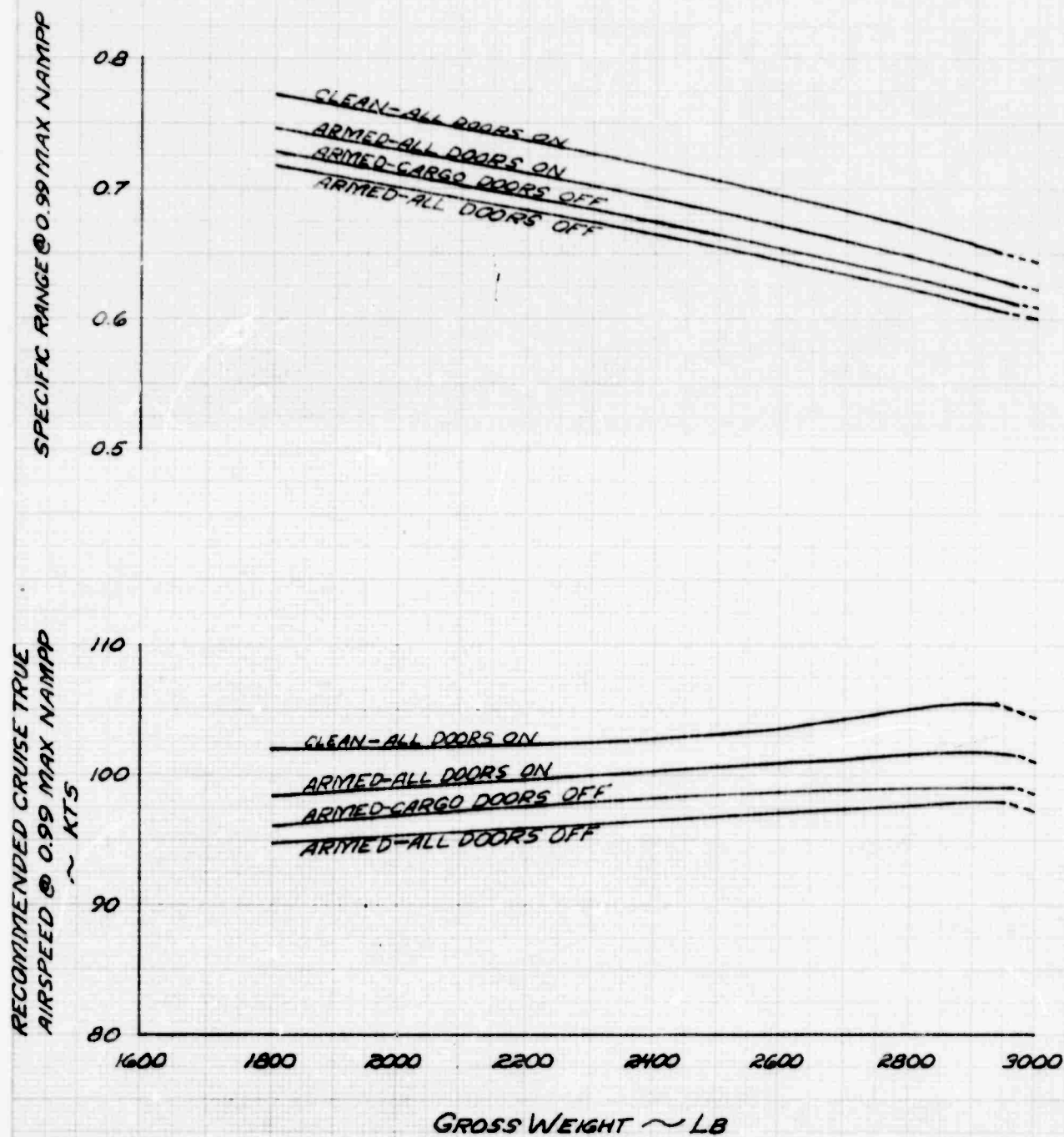


FIGURE 28  
 LEVEL FLIGHT RANGE SUMMARY  
 OH-58A USA S/N 68-16693  
 10000 FEET STANDARD DAY  
 CG = 107.0 IN. (FWD)

NOTE: 1. DATA DERIVED FROM FIGURES 23 THRU 25 AND 72  
 2. DASHED LINE DENOTES NORMAL RATED POWER LIMIT.

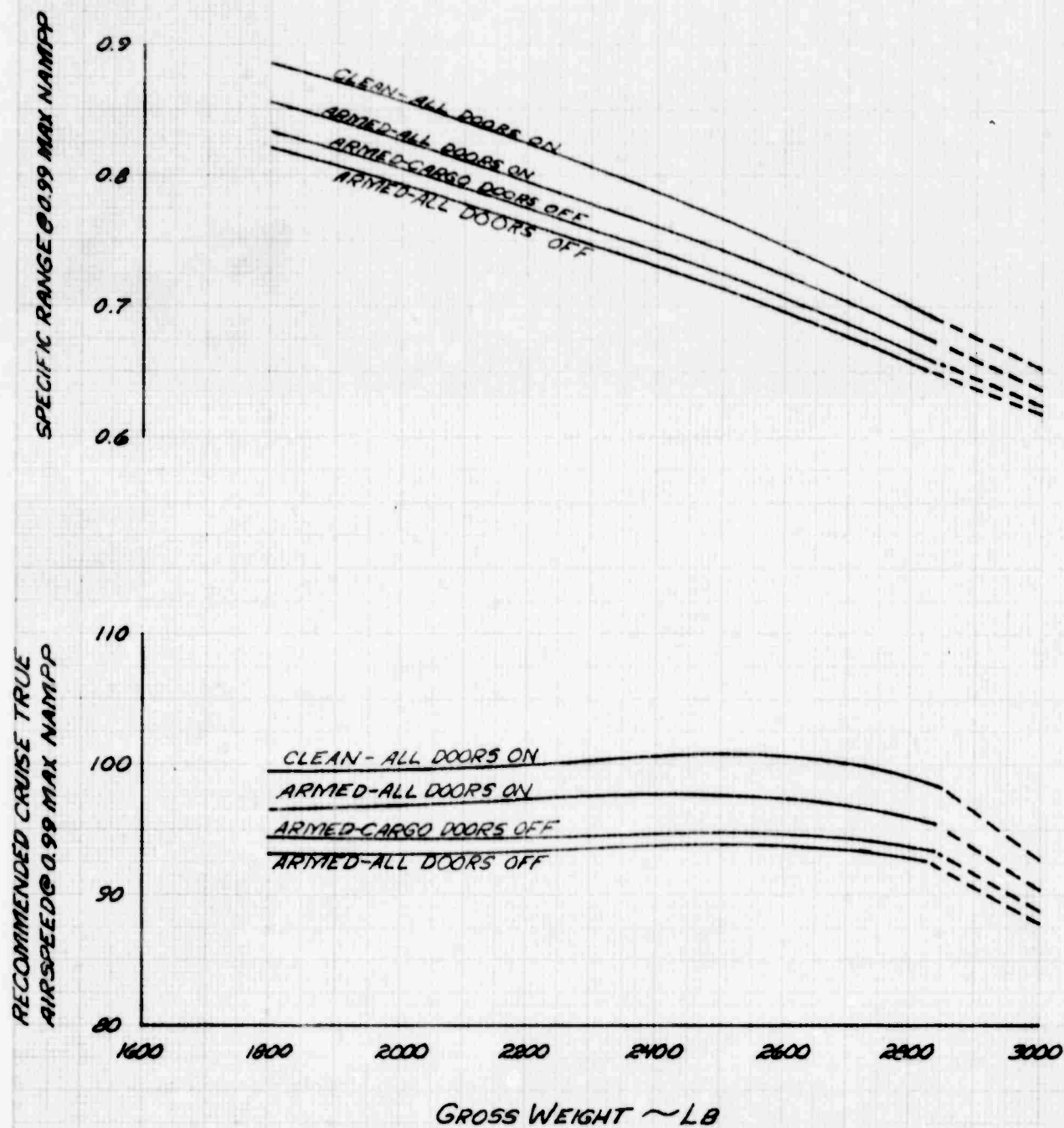
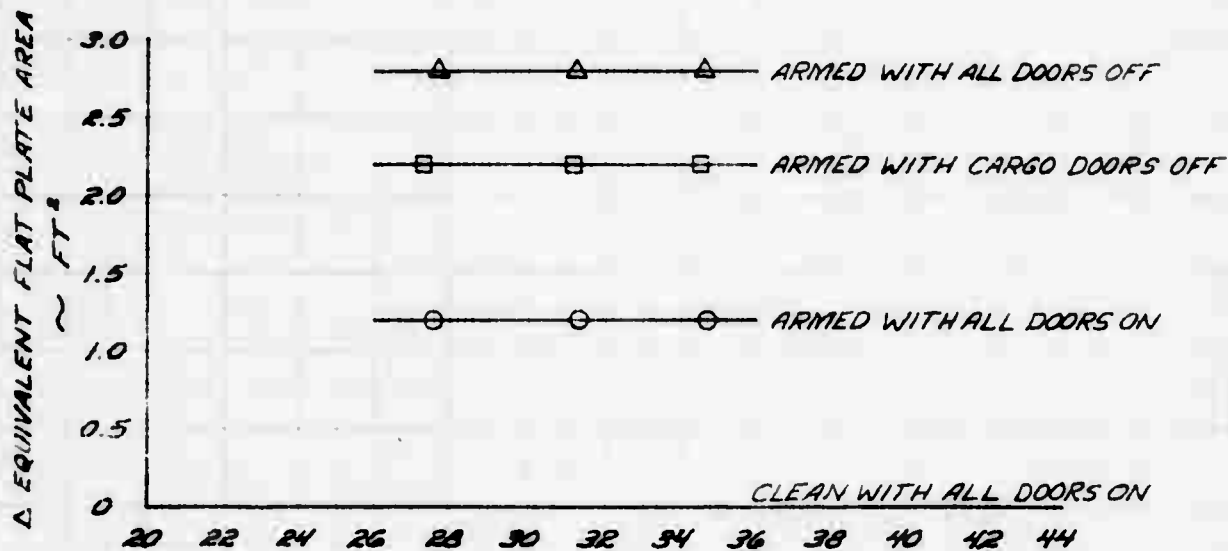
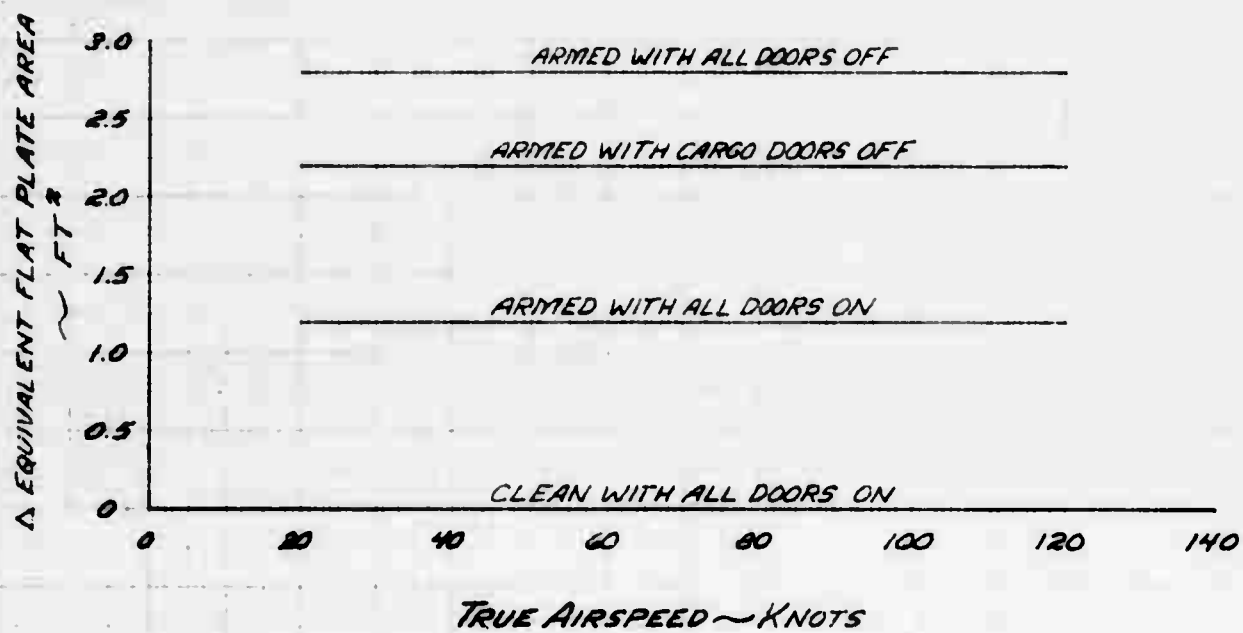


FIGURE 29  
LEVEL FLIGHT PERFORMANCE WITH CONFIGURATION CHANGE  
OH-58A USA SIN 68-16693

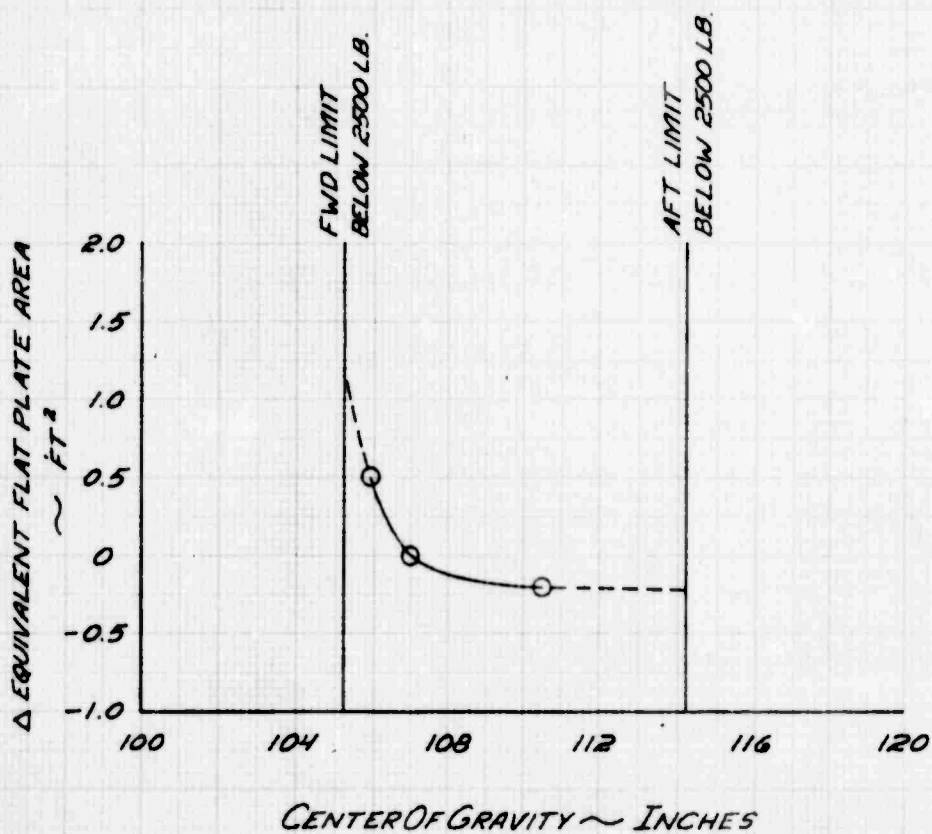
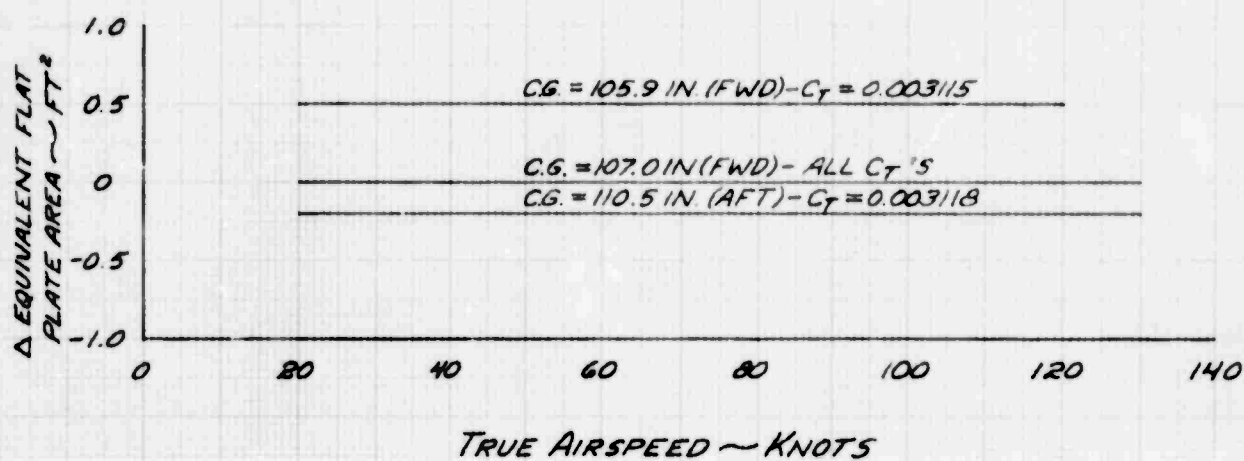
NOTE: 1. DATA OBTAINED FROM FIGURES 45 THRU 53



$$C_T \times 10^4 = \frac{WT}{PA(\Omega R)^2} \times 10^4$$

FIGURE 30  
 LEVEL FLIGHT PERFORMANCE WITH C.G. CHANGE  
 OH-58A USA SIN 68-16693  
 CLEAN-ALL DOORS ON

NOTE: 1. DATA OBTAINED FROM FIGURES 36 AND 37



# **FIGURE 31** **SIDESLIP EFFECTS ON LEVEL FLIGHT PERFORMANCE**

OH-58A USA SINGB-16693

CLEAN-ALL DOORS ON

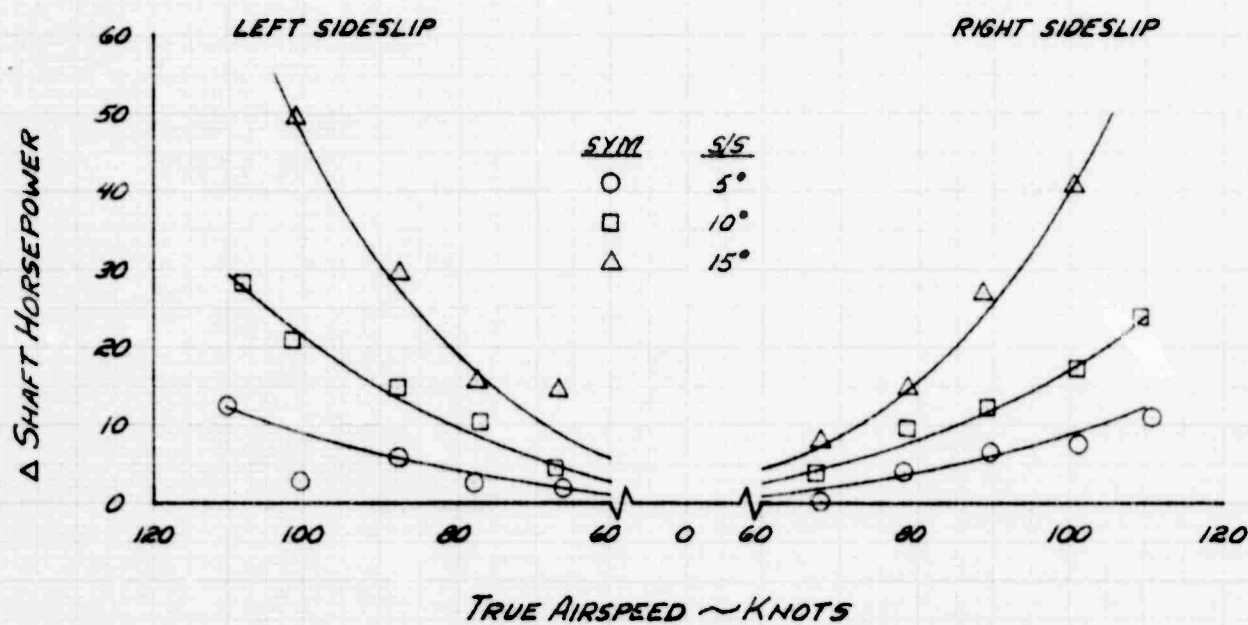
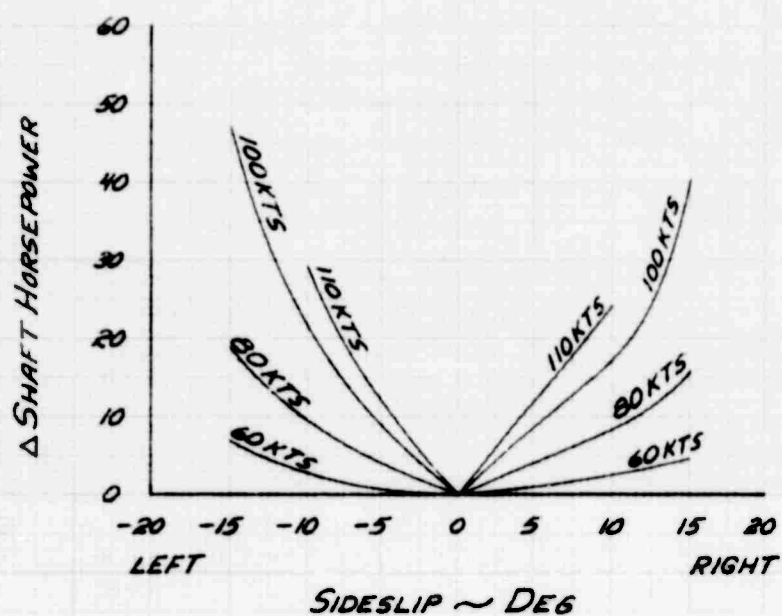
DENSITY ALTITUDE = 4700 FT.

GROSS WEIGHT = 2682 LB.

ROTOR SPEED = 354 RPM

C.G. STATION = 106.9 IN. (FWD)

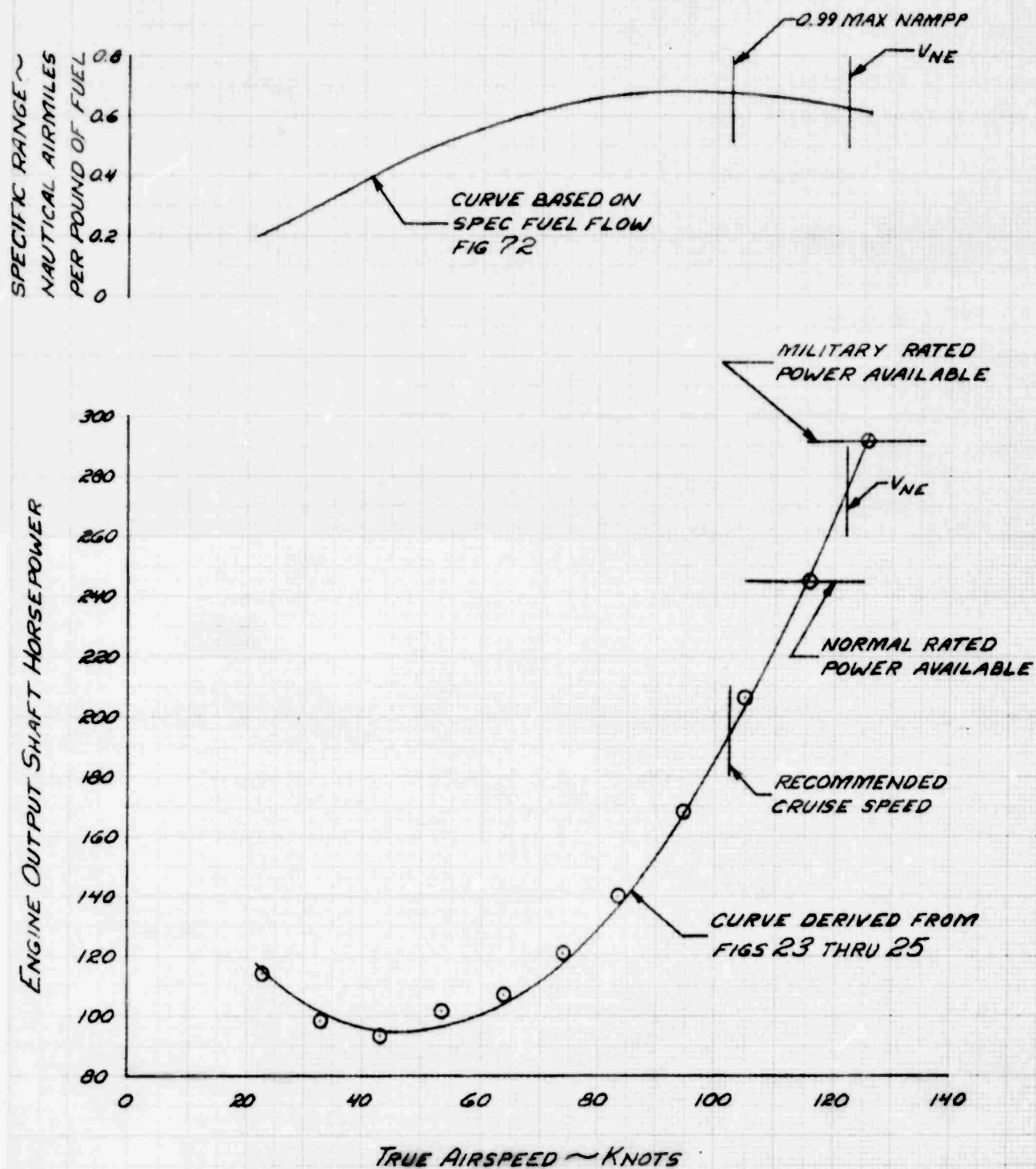
$C_T = 0.003090$



**FIGURE 32**  
**LEVEL FLIGHT PERFORMANCE**  
**OH-58A USA SINGB-16693**

DENSITY ALTITUDE = 1150 FT  
 GROSS WEIGHT = 2180 LB  
 ROTOR SPEED = 354 RPM

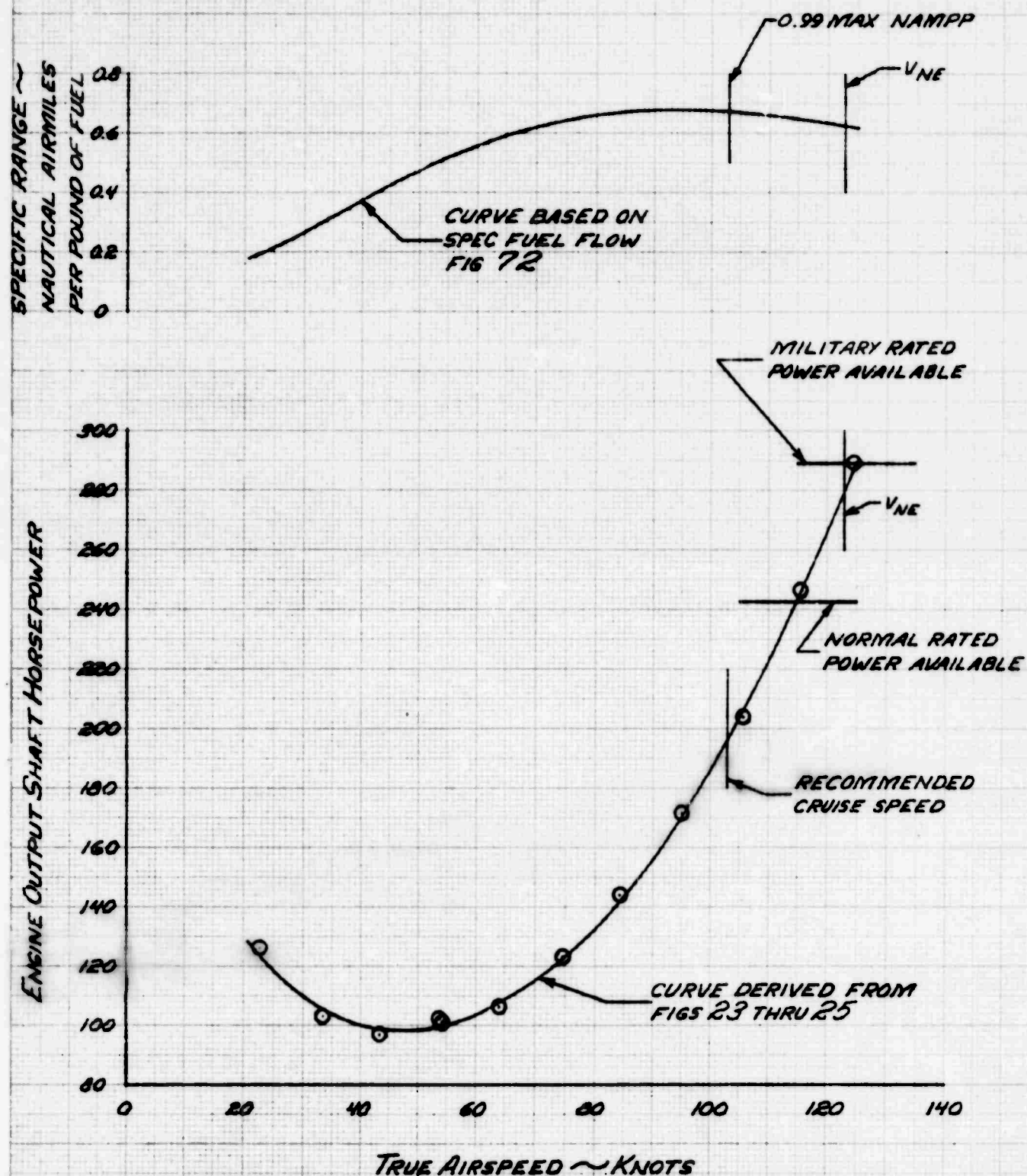
CG STATION = 107.0 IN (FWD)  
 $C_T = 0.002254$   
 CONFIGURATION = CLEAN - ALL  
 DOORS ON



**FIGURE 33**  
**LEVEL FLIGHT PERFORMANCE**  
**OH-58A USA S/N 68-16693**

DENSITY ALTITUDE = 1605 FT  
 GROSS WEIGHT = 2336 LB  
 ROTOR SPEED = 347 RPM

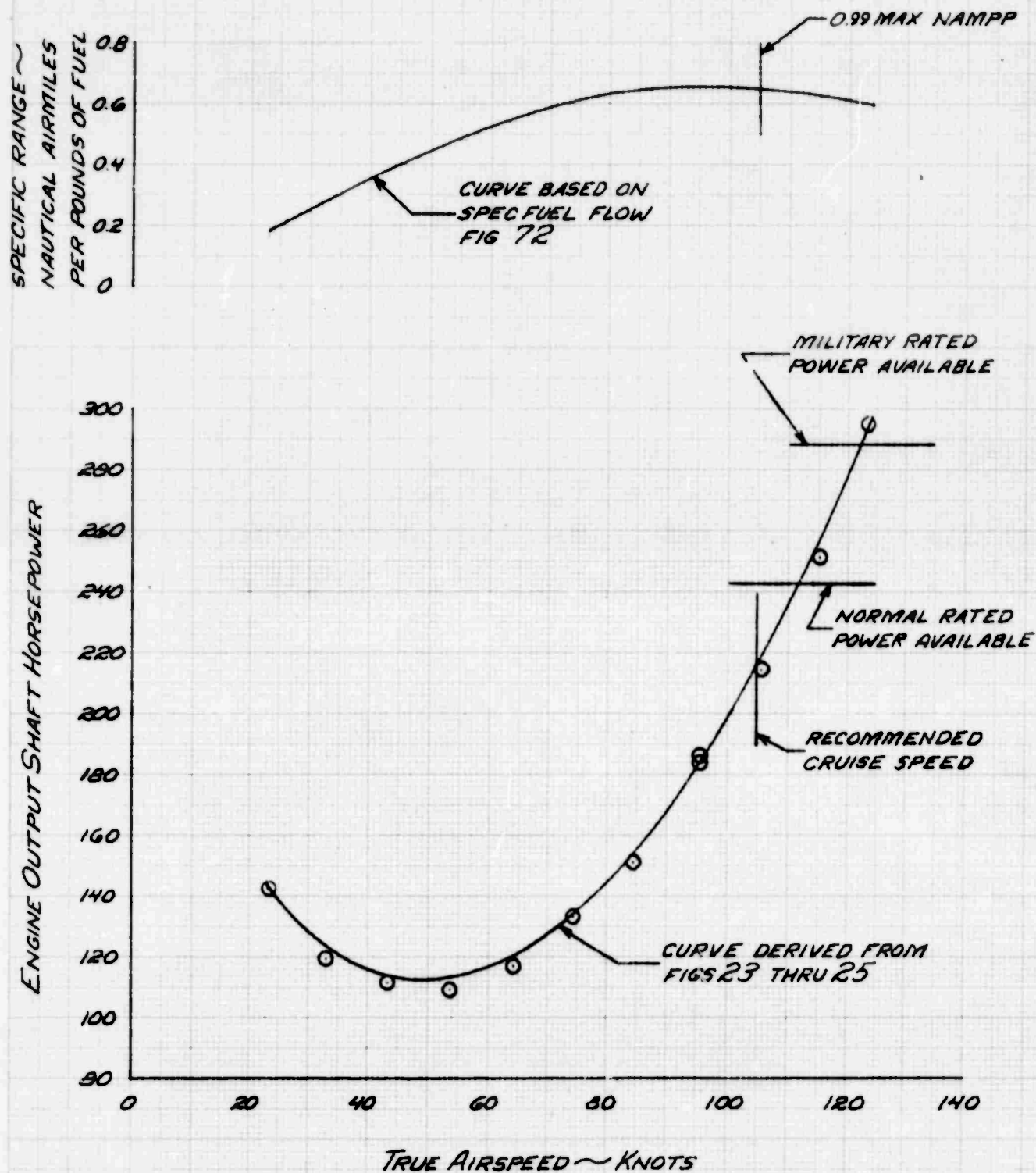
CG STATION = 107.0 IN (FWD)  
 $C_T = 0.002548$   
 CONFIGURATION = CLEAN - ALL  
 DOORS ON



**FIGURE 34**  
**LEVEL FLIGHT PERFORMANCE**  
**OH-58A USA S/N 68-16693**

DENSITY ALTITUDE = 1595 FT  
 GROSS WEIGHT = 2632 LB  
 ROTOR SPEED = 354 RPM

CG STATION = 106.9 IN (FWD)  
 $C_T = 0.002757$   
 CONFIGURATION = CLEAN - ALL  
 DOORS ON



**FIGURE 35**  
**LEVEL FLIGHT PERFORMANCE**  
**OH-58A USA S/N 68-16693**

DENSITY ALTITUDE = 4175 FT  
 GROSS WEIGHT = 2752 LB  
 ROTOR SPEED = 354 RPM

CG STATION = 107.2 IN (FWD)  
 C<sub>T</sub> = 0.003114  
 CONFIGURATION = CLEAN - ALL  
 DOORS ON

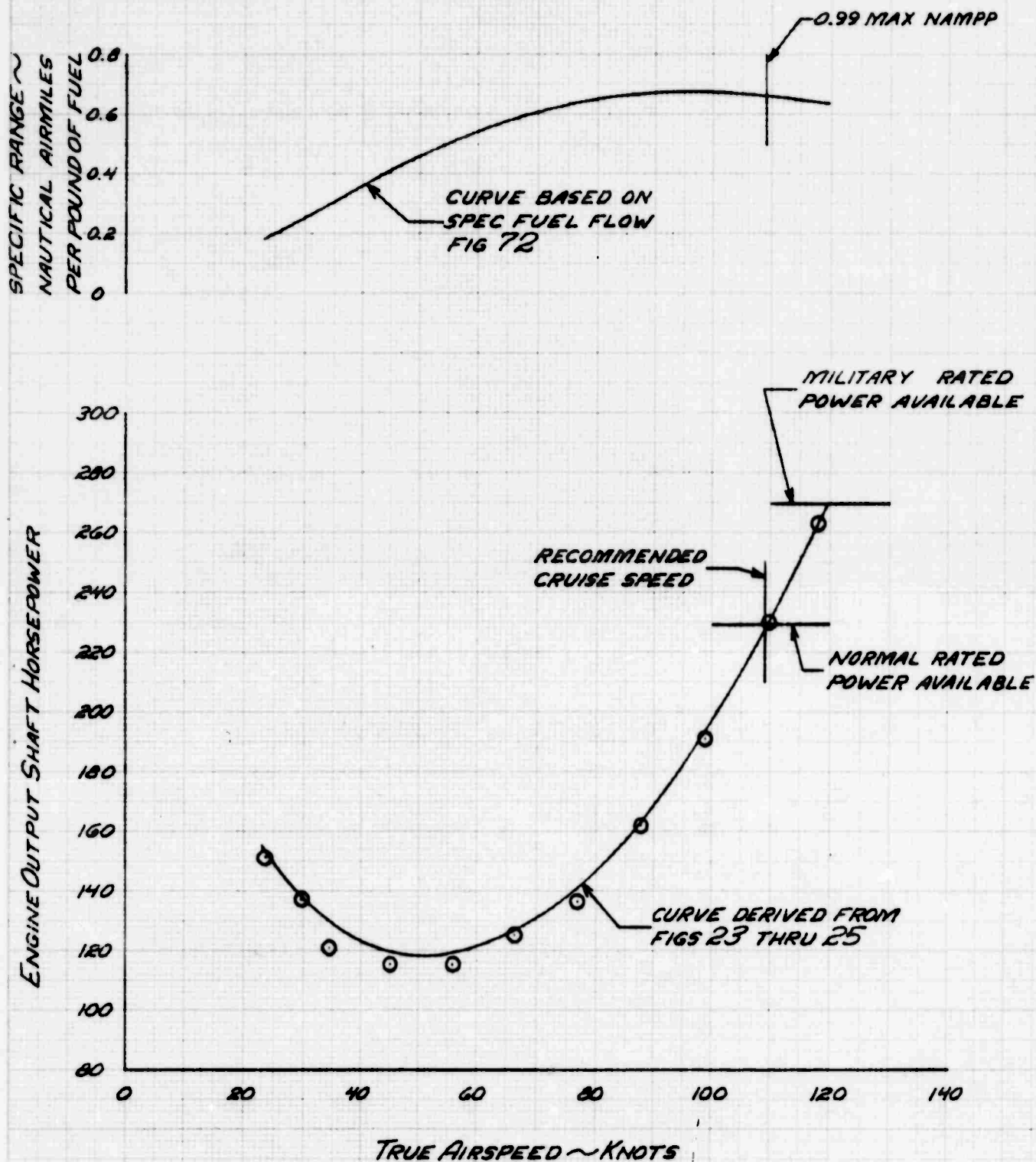
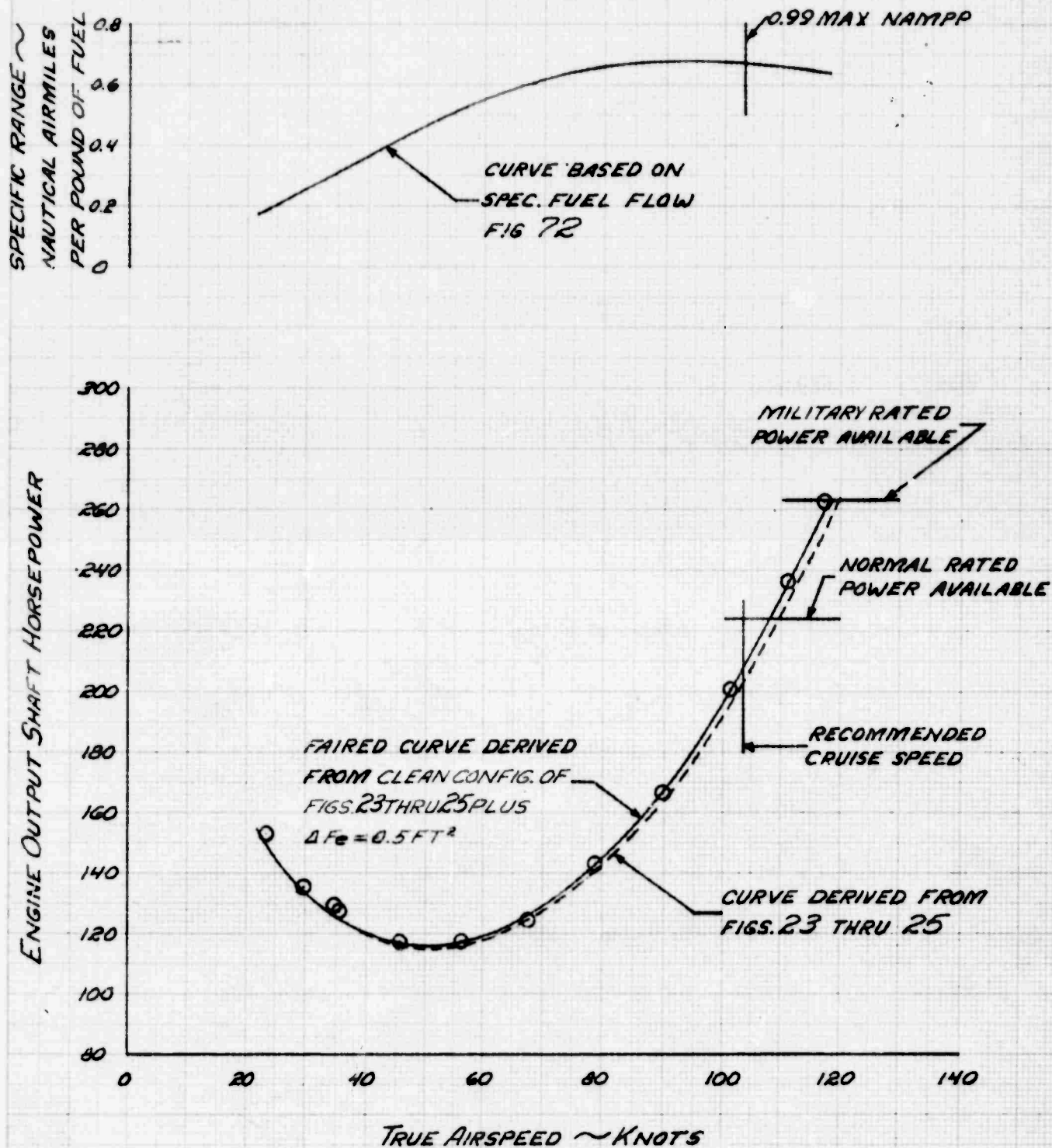


FIGURE 36  
LEVEL FLIGHT PERFORMANCE  
OH-58A USA SINGB-16693

DENSITY ALTITUDE = 5090 FT  
GROSS WEIGHT = 2678 LB  
ROTOR SPEED = 354 RPM

CG STATION = 105.9 IN (FWD)  
 $C_T = 0.003115$   
CONFIGURATION = CLEAN - ALL  
DOORS ON



**FIGURE 37**  
**LEVEL FLIGHT PERFORMANCE**  
**OH-58A USA S1N68-16693**

DENSITY ALTITUDE = 5425 FT  
 GROSS WEIGHT = 2654 LB  
 ROTOR SPEED = 354 RPM

CG STATION = 110.5 IN (AFT)  
 $C_T = 0.003118$   
 CONFIGURATION = CLEAN - ALL  
 DOORS ON

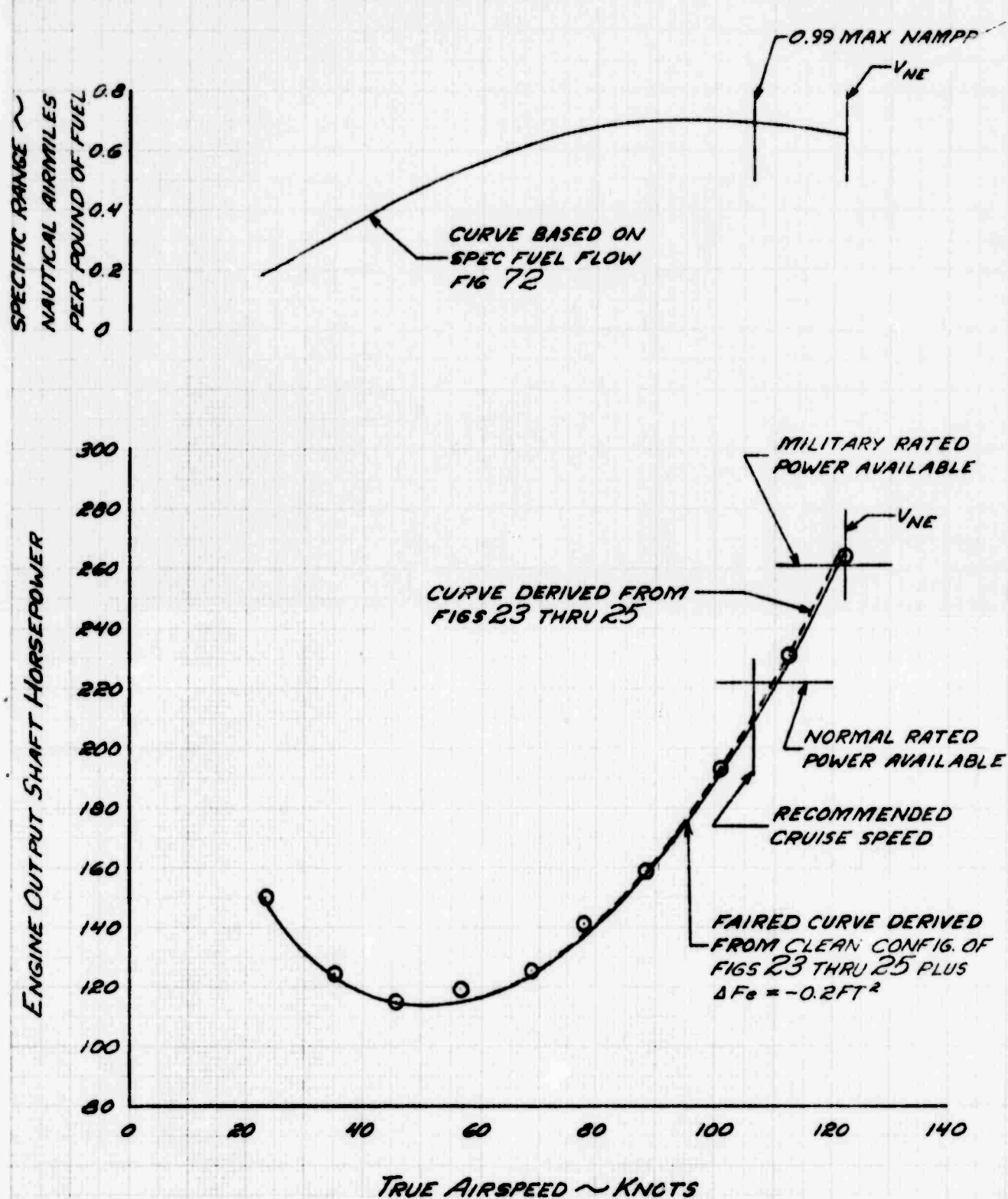


FIGURE 38  
LEVEL FLIGHT PERFORMANCE  
OH-58A USA SIN 68-16693

DENSITY ALTITUDE = 5690 FT  
GROSS WEIGHT = 2775 LB  
ROTOR SPEED = 354 RPM

CG STATION = 107.4 IN (FWD)  
 $C_T$  = 0.003288  
CONFIGURATION = CLEAN - ALL  
DOORS ON

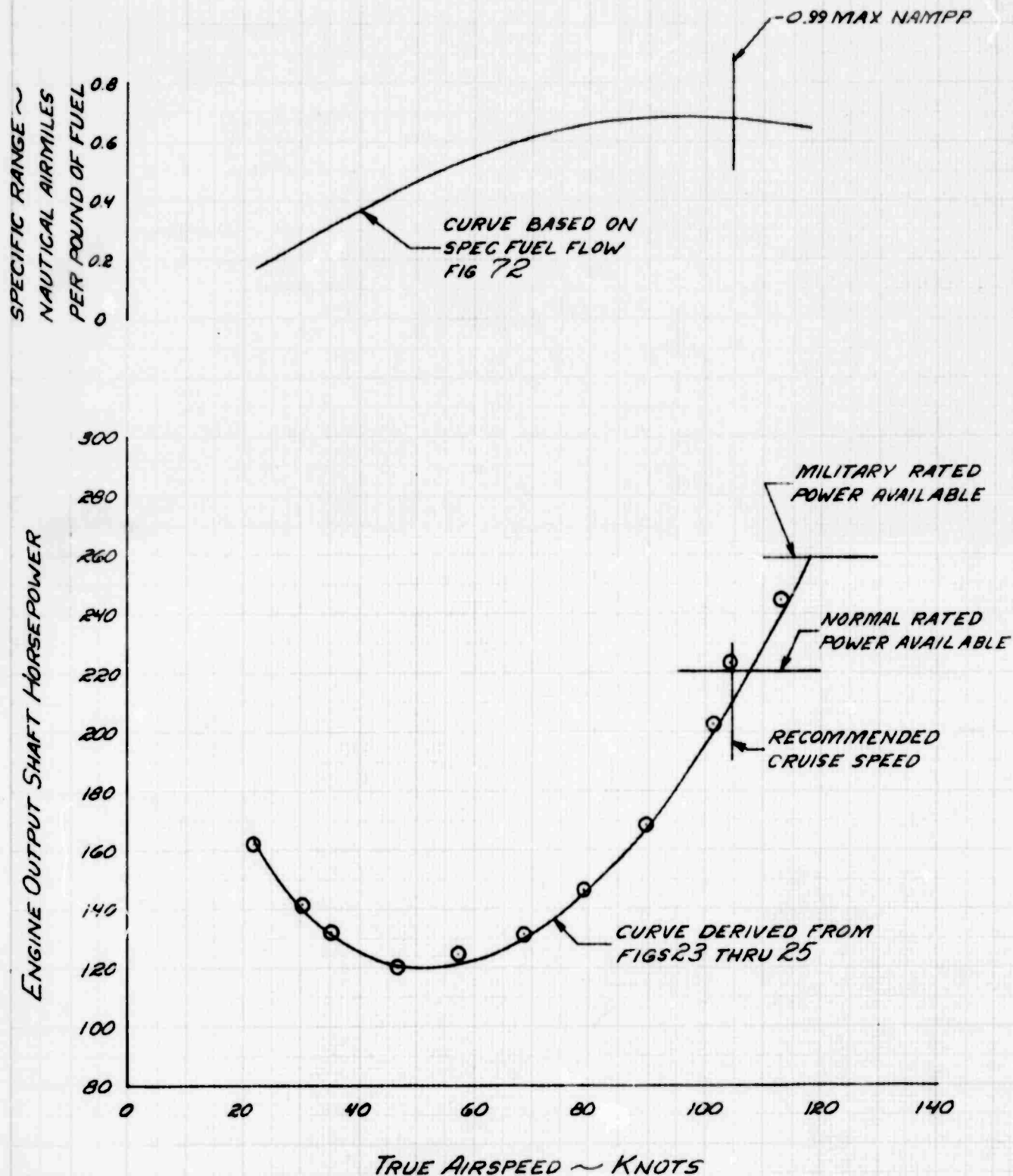


FIGURE 39  
LEVEL FLIGHT PERFORMANCE  
OH-58A USA S/N 68-16693

DENSITY ALTITUDE = 4320 FT  
GROSS WEIGHT = 2946 LB  
ROTOR SPEED = 354 RPM

CG STATION = 107.2 IN (FWD)  
C<sub>T</sub> = 0.003348  
CONFIGURATION = CLEAN-ALL  
DOORS ON

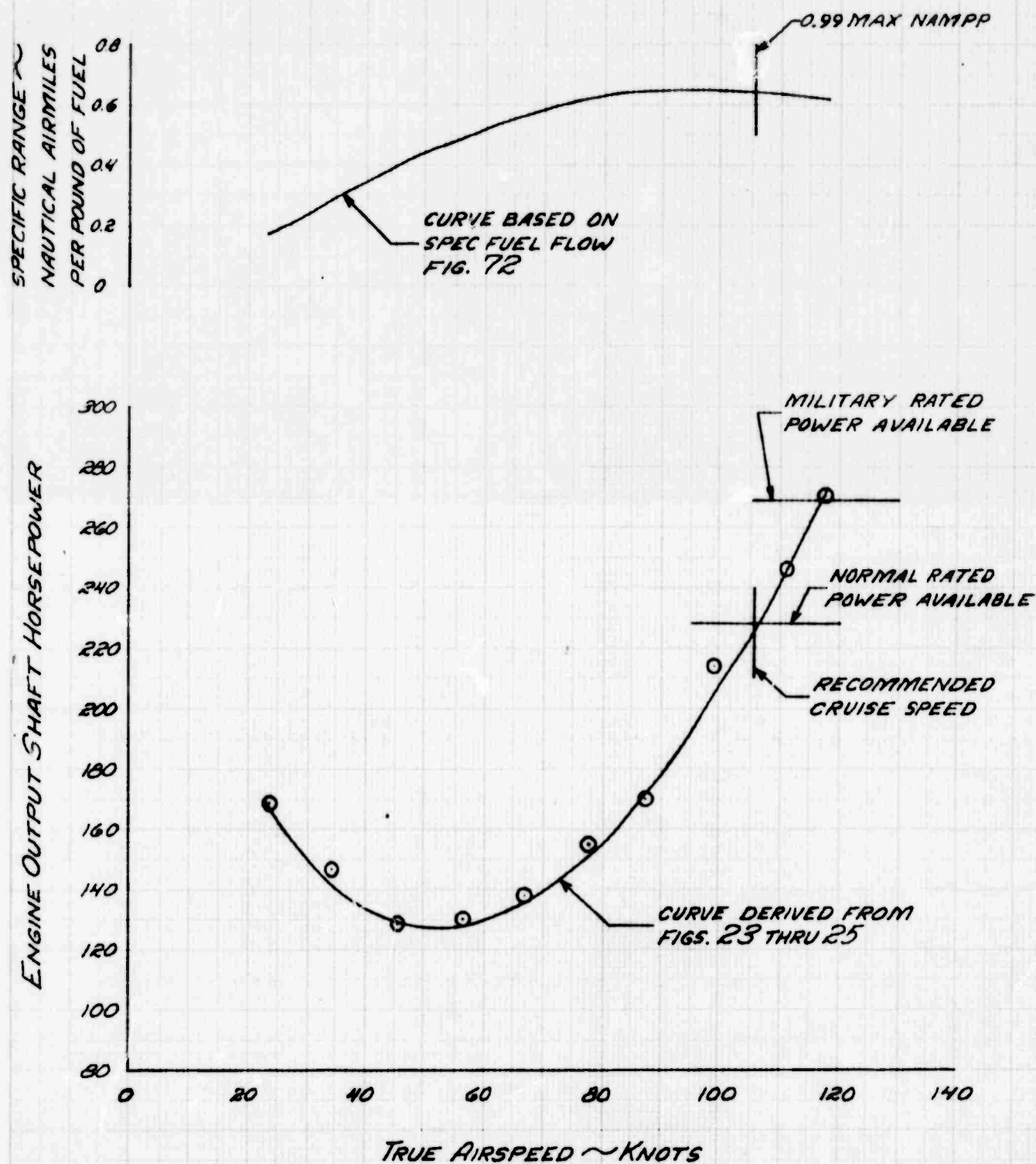
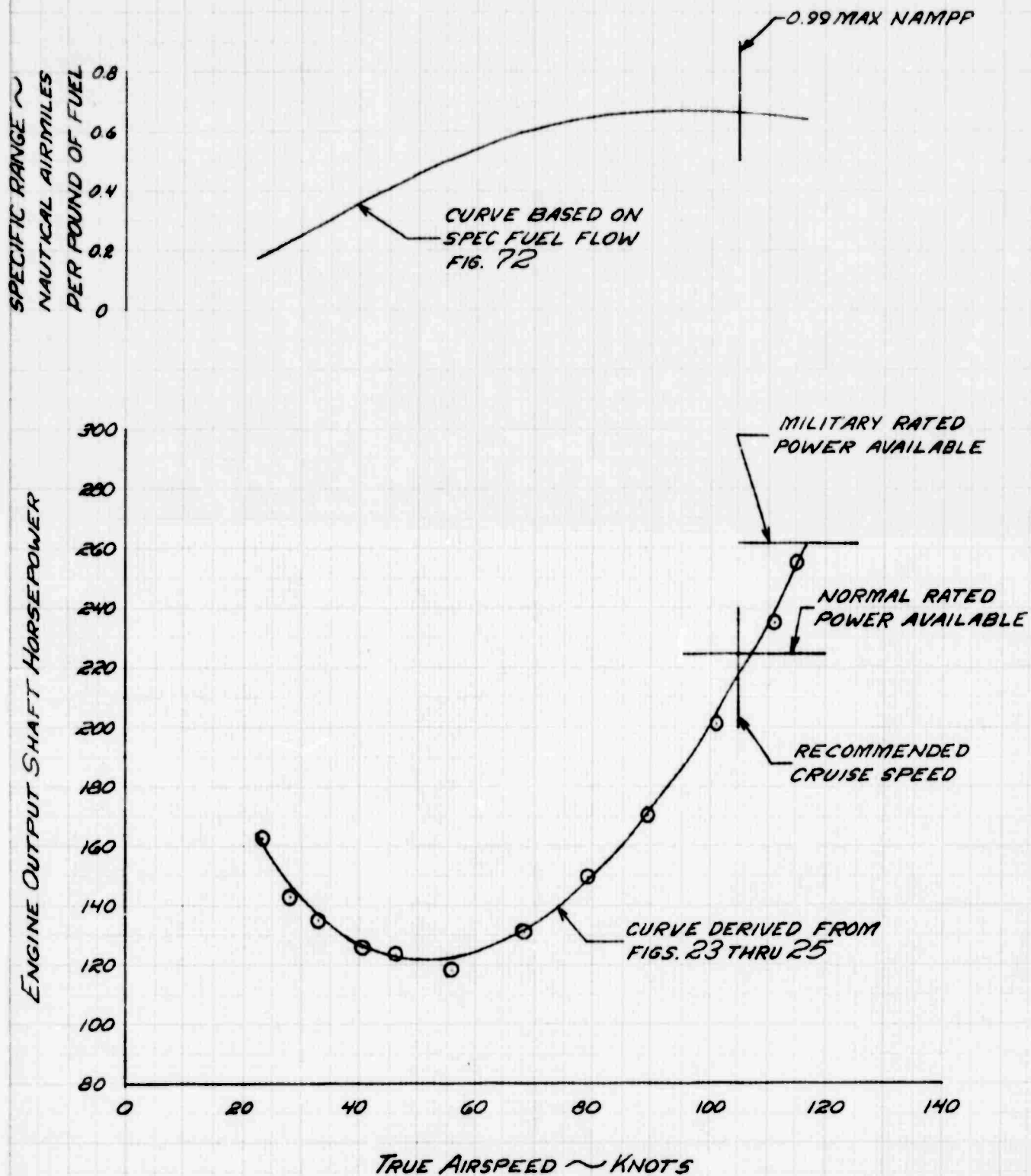


FIGURE 40  
LEVEL FLIGHT PERFORMANCE  
OH-58A USA S/N 68-16693

DENSITY ALTITUDE = 5310 FT  
GROSS WEIGHT = 2846 LB  
ROTOR SPEED = 347 RPM

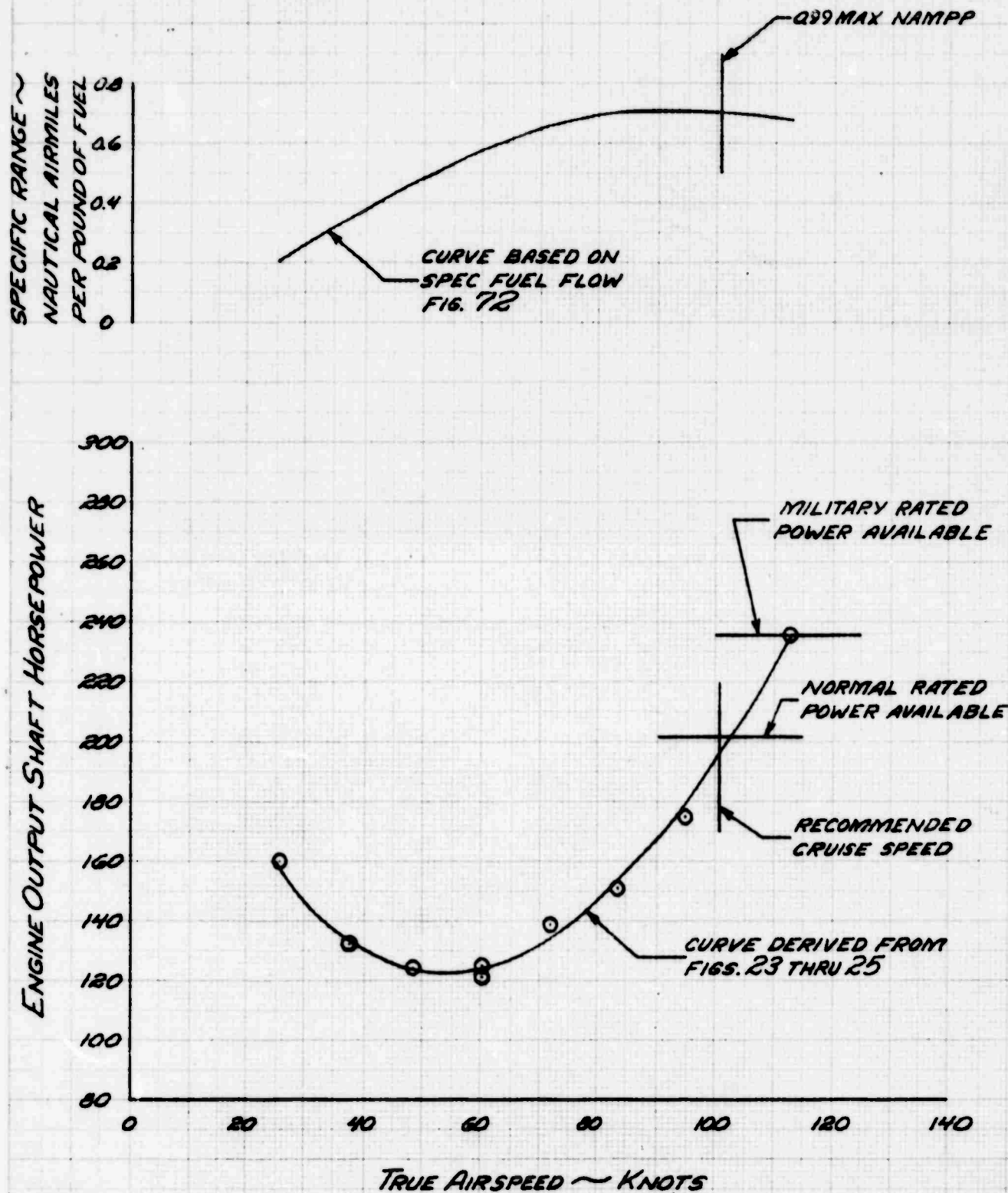
CG STATION = 106.7 IN (FWD)  
 $C_T$  = 0.003469  
CONFIGURATION = CLEAN - ALL  
DOORS ON



**FIGURE 41**  
**LEVEL FLIGHT PERFORMANCE**  
**OH-58A USA S/N 68-16693**

DENSITY ALTITUDE = 8955 FT  
 GROSS WEIGHT = 2781 LB  
 ROTOR SPEED = 354 RPM

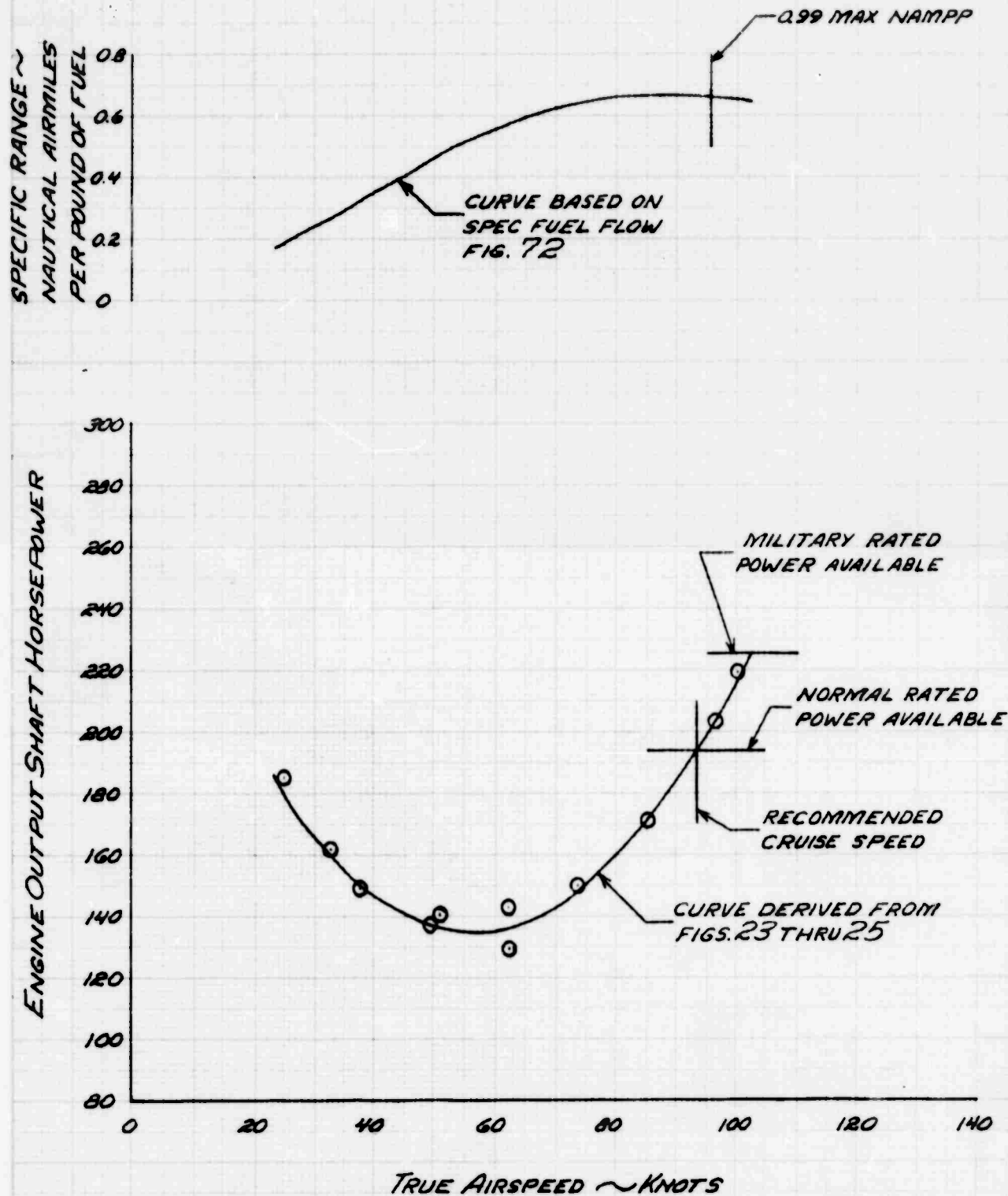
CG STATION = 107.4 IN (FWD)  
 C<sub>T</sub> = 0.003644  
 CONFIGURATION = CLEAN - ALL  
 DOORS ON



**FIGURE 42**  
**LEVEL FLIGHT PERFORMANCE**  
**OH-58A USA SINGB-16693**

DENSITY ALTITUDE = 10405 FT  
 GROSS WEIGHT = 2950 LB  
 ROTOR SPEED = 354 RPM

CG STATION = 106.8 IN (FWD)  
 C<sub>T</sub> = 0.004045  
 CONFIGURATION = CLEAN - ALL  
 DOORS ON



**FIGURE 43**  
**LEVEL FLIGHT PERFORMANCE**  
**OH-58A USA S/N 68-16693**

DENSITY ALTITUDE = 15160 FT.  
 GROSS WEIGHT = 2690 LB  
 ROTOR SPEED = 354 RPM

CG STATION = 106.9 IN (FWD)  
 $C_T = 0.004296$   
 CONFIGURATION = CLEAN-ALL  
 DOORS ON

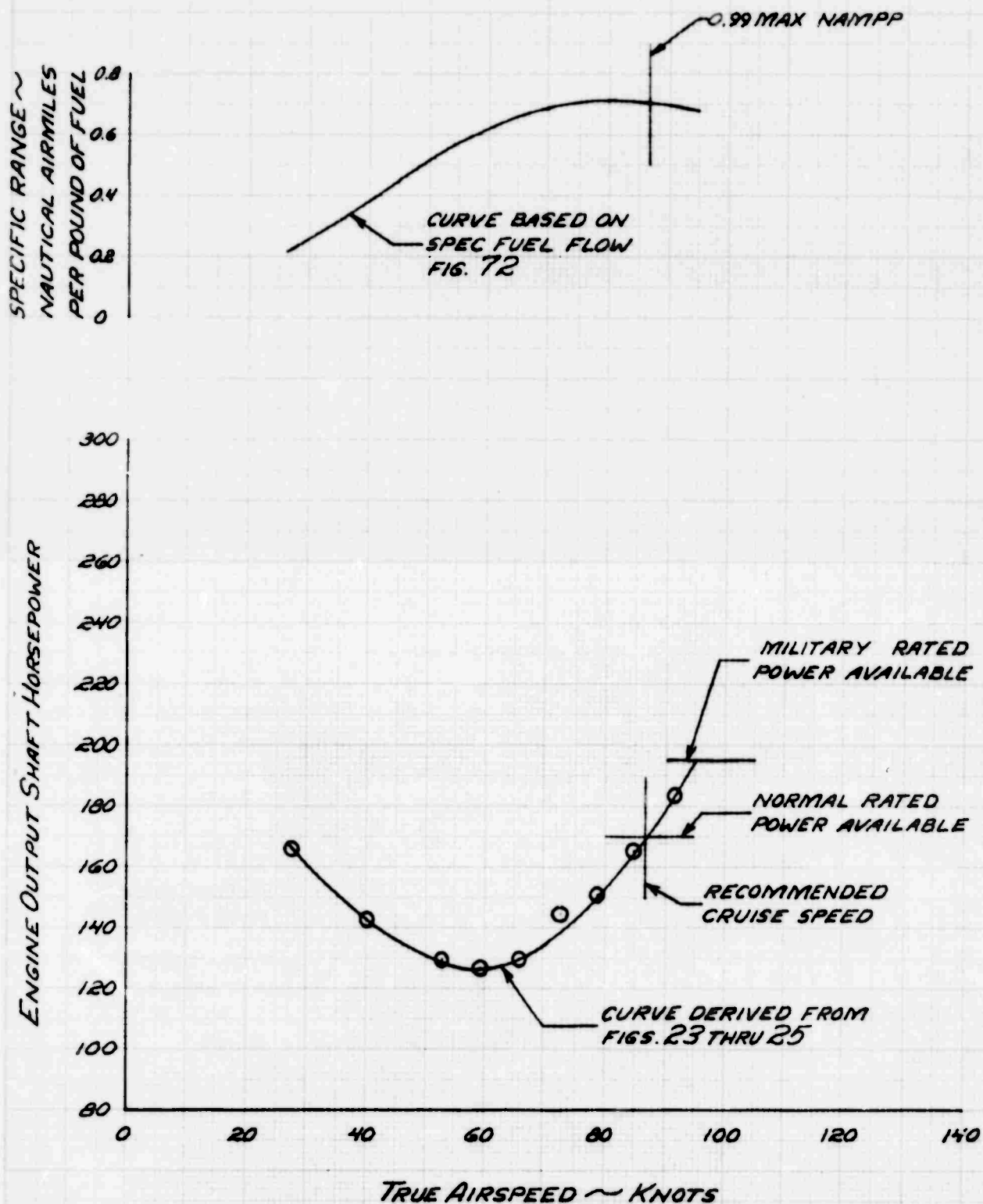
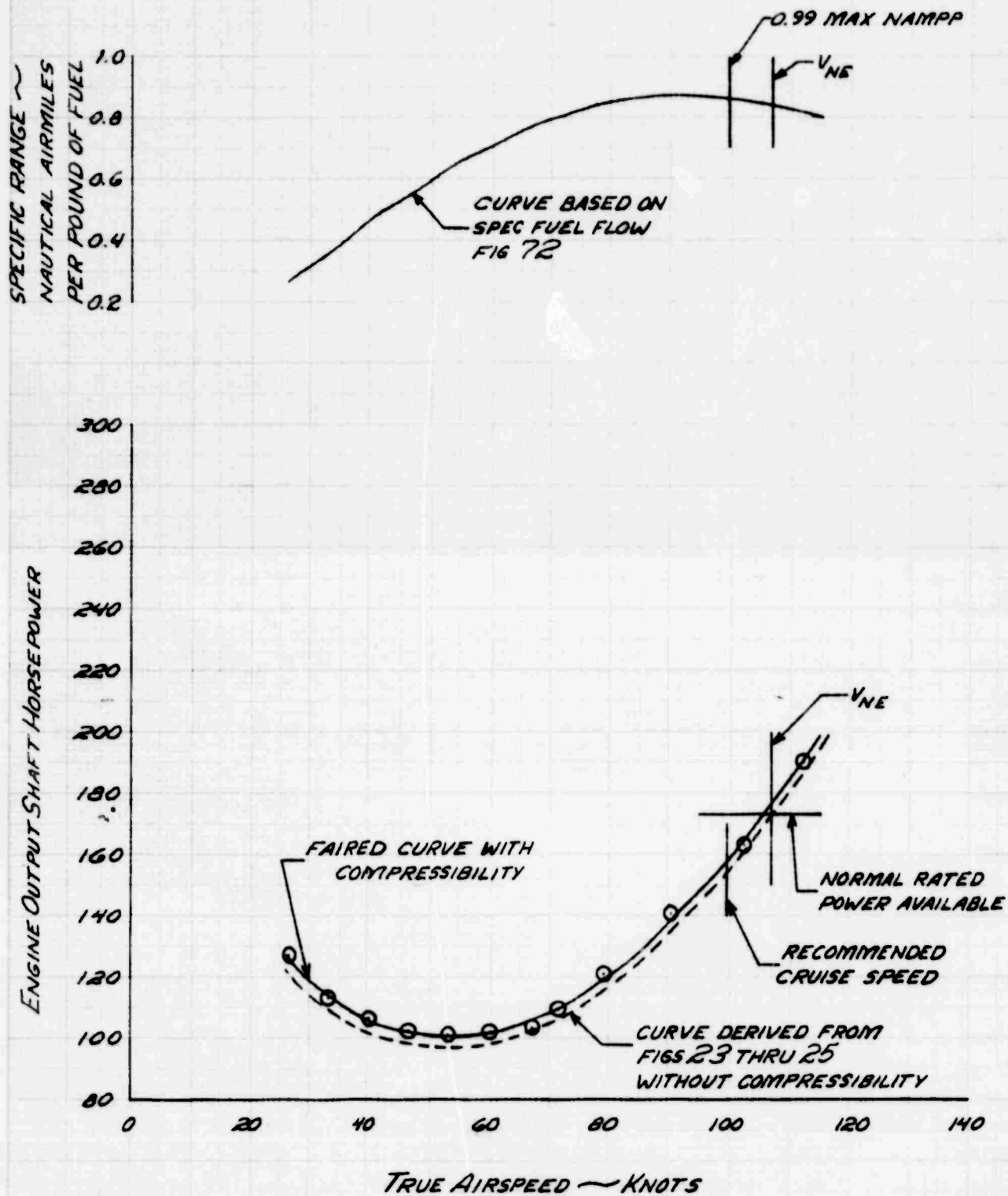


FIGURE 44  
LEVEL FLIGHT PERFORMANCE  
OH-58A USA SINGB-16683

DENSITY ALTITUDE = 14530 FT.  
GROSS WEIGHT = 2224 LB.  
ROTOR SPEED = 354 RPM

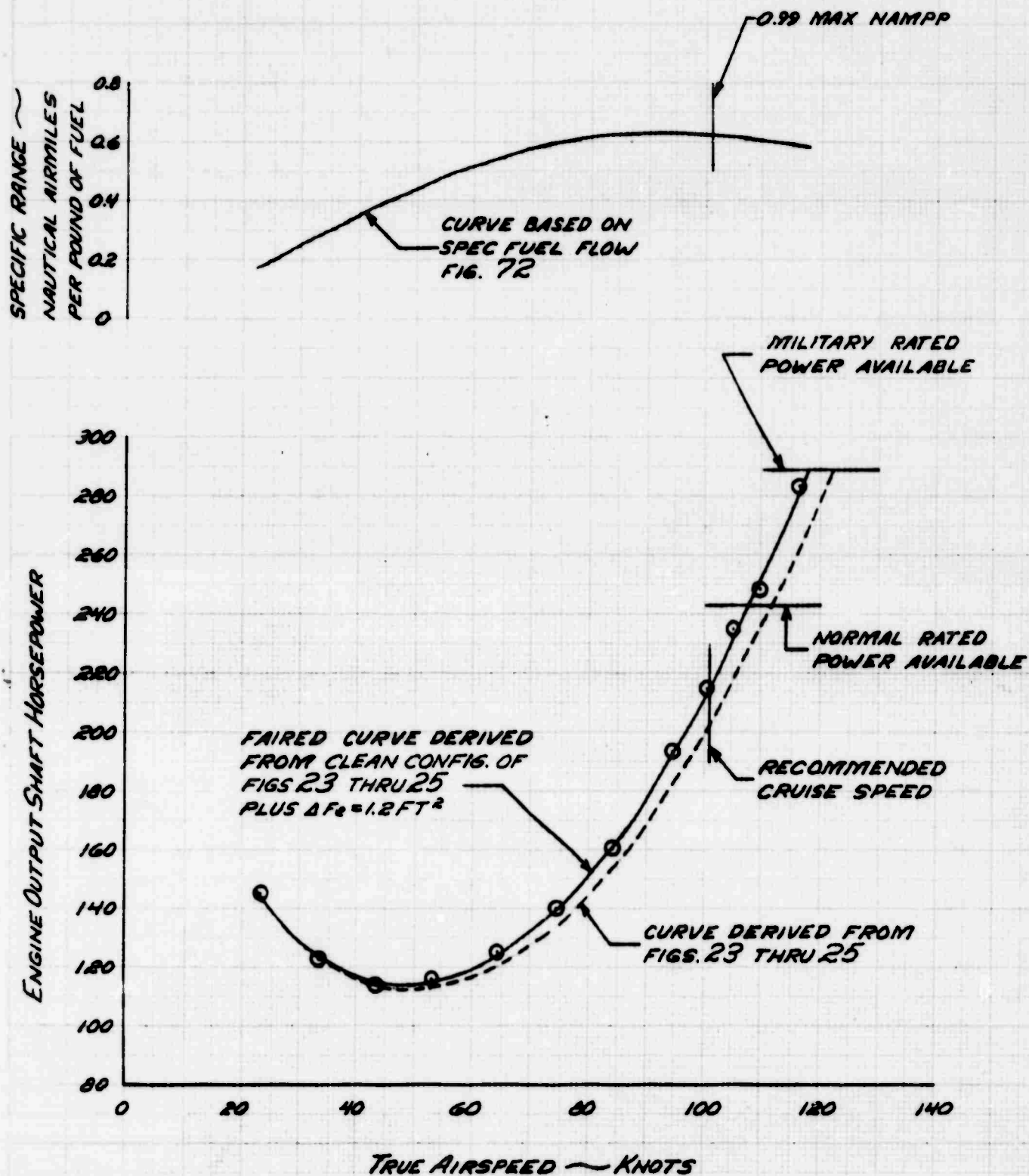
CG STATION = 106.9 IN (FWD)  
 $C_T$  = 0.003480  
CONFIGURATION = CLEAN-ALL  
DOORS ON



**FIGURE 45**  
**LEVEL FLIGHT PERFORMANCE**  
**OH-58A USA SIN 68-16693**

DENSITY ALTITUDE = 1490 FT.  
 GROSS WEIGHT = 2641 LB.  
 ROTOR SPEED = 354 RPM

CG STATION = 106.9 IN (FWD)  
 $C_T$  = 0.002758  
 CONFIGURATION = ARMED-ALL  
 DOORS ON



**FIGURE 46**  
**LEVEL FLIGHT PERFORMANCE**  
**OH-58A USA SIN 68-16693**

DENSITY ALTITUDE = 5055 FT  
 GROSS WEIGHT = 2694 LB  
 ROTOR SPEED = 354 RPM

C/G STATION = 107.0 IN (FWD)  
 $C_T = 0.003131$   
 CONFIGURATION = ARMED-ALL  
 DOORS ON

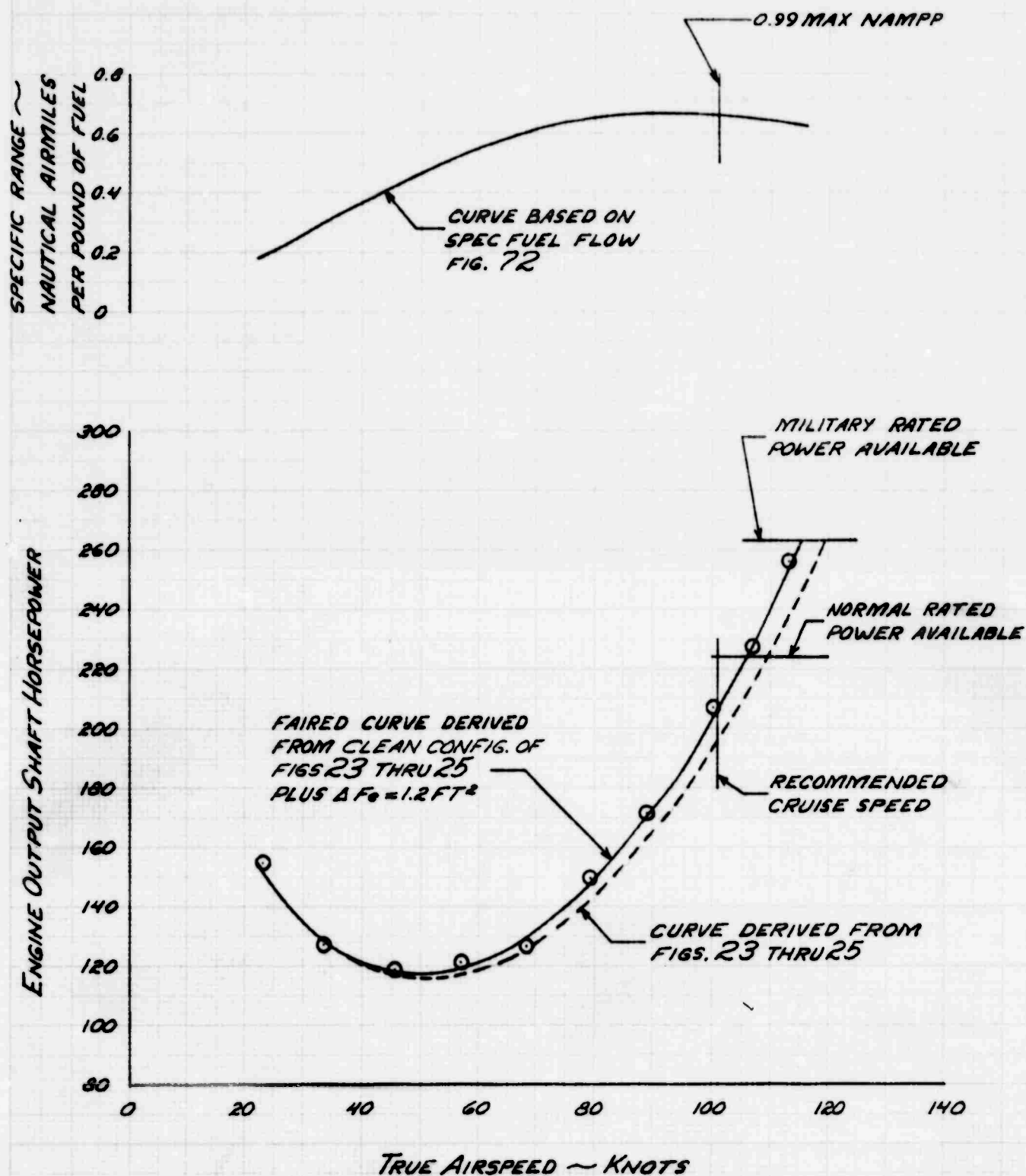
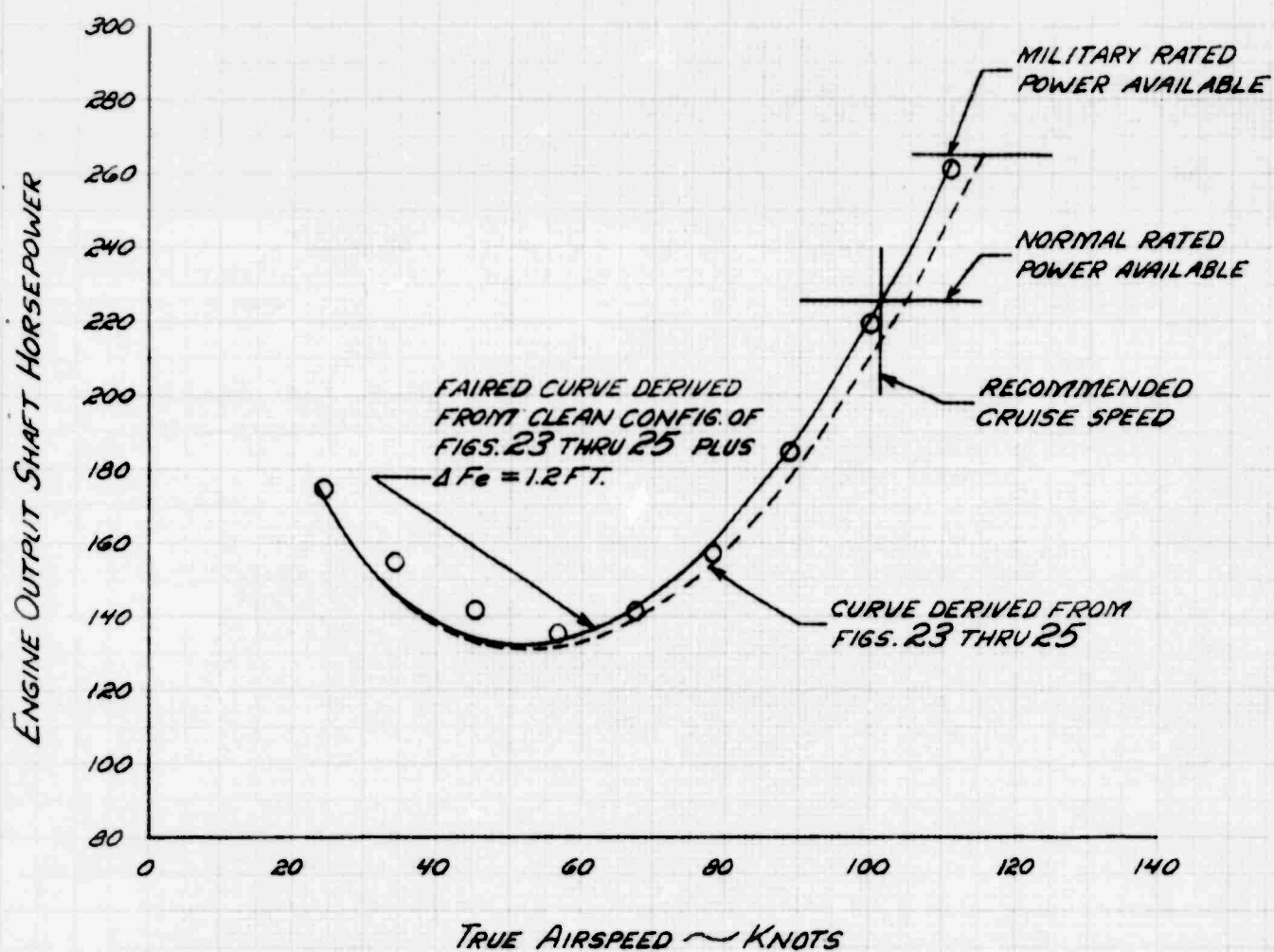
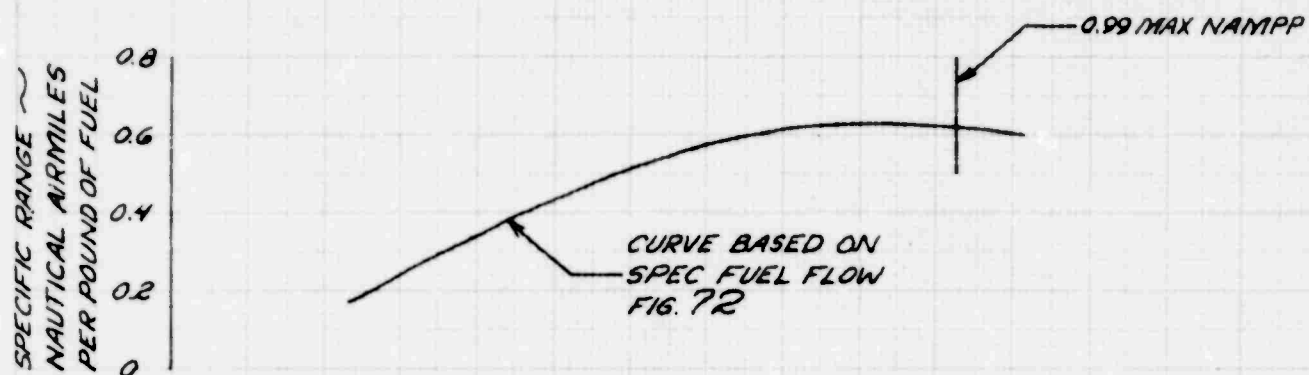


FIGURE 47  
LEVEL FLIGHT PERFORMANCE  
OH-58A USA S/N 68-16693

DENSITY ALTITUDE = 4815 FT  
GROSS WEIGHT = 3007 LB  
ROTOR SPEED = 354 RPM

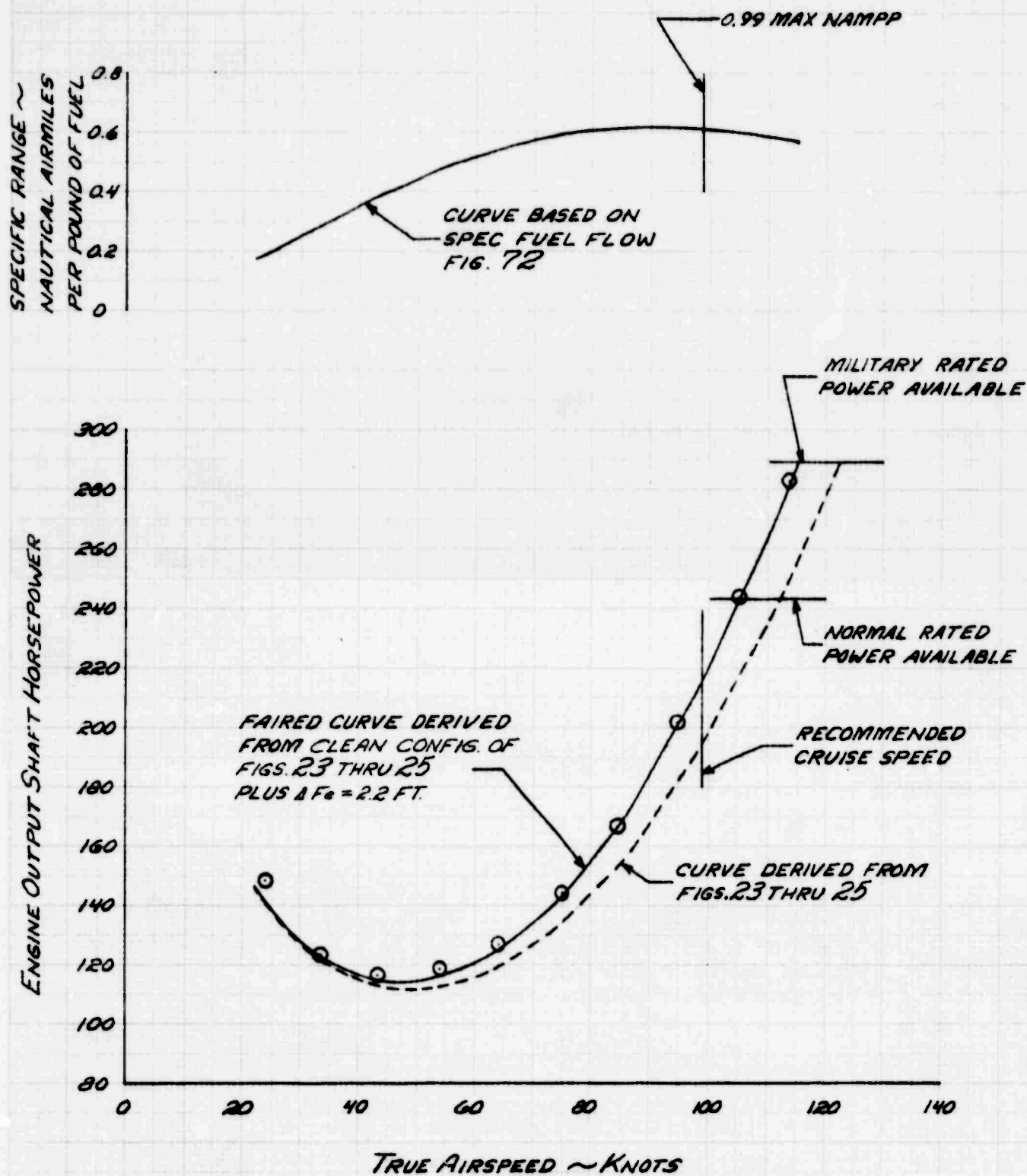
CG STATION = 107.1 IN (FWD)  
 $C_T = 0.003469$   
CONFIGURATION = ARMED - ALL  
DOORS ON



**FIGURE 48**  
**LEVEL FLIGHT PERFORMANCE**  
**OH-58A USA S/N 68-16693**

DENSITY ALTITUDE = 1495 FT  
 GROSS WEIGHT = 2616 LB  
 ROTOR RPM = 354 RPM

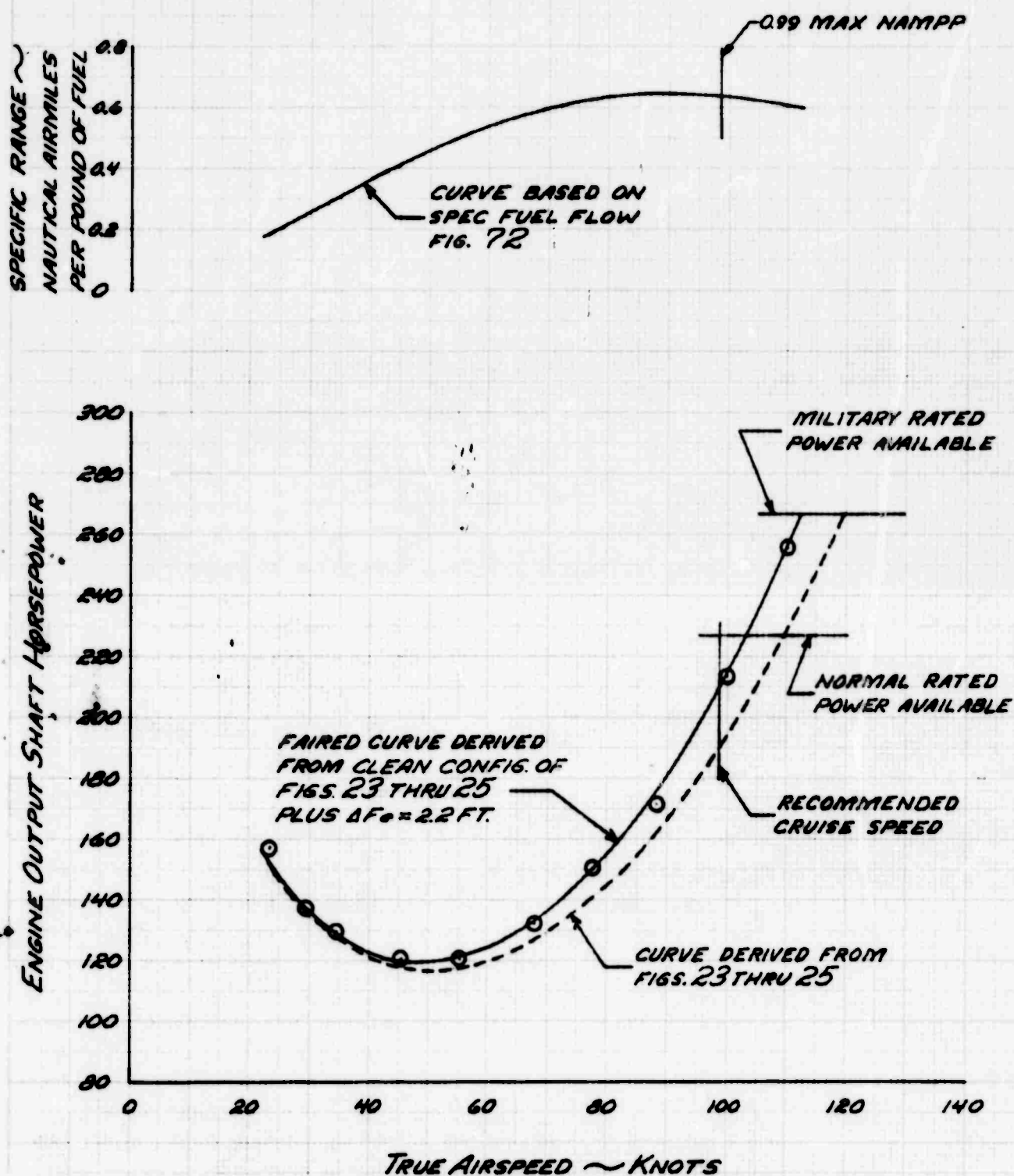
C.G. STATION = 106.8 IN. (FWD)  
 $C_T = 0.002733$   
 CONFIGURATION = ARMED-CARGO  
 DOORS OFF



**FIGURE 49**  
**LEVEL FLIGHT PERFORMANCE**  
**OH-58A USA S/N 68-16693**

DENSITY ALTITUDE = 4580 FT  
 GROSS WEIGHT = 2720 LB  
 ROTOR SPEED = 354 RPM

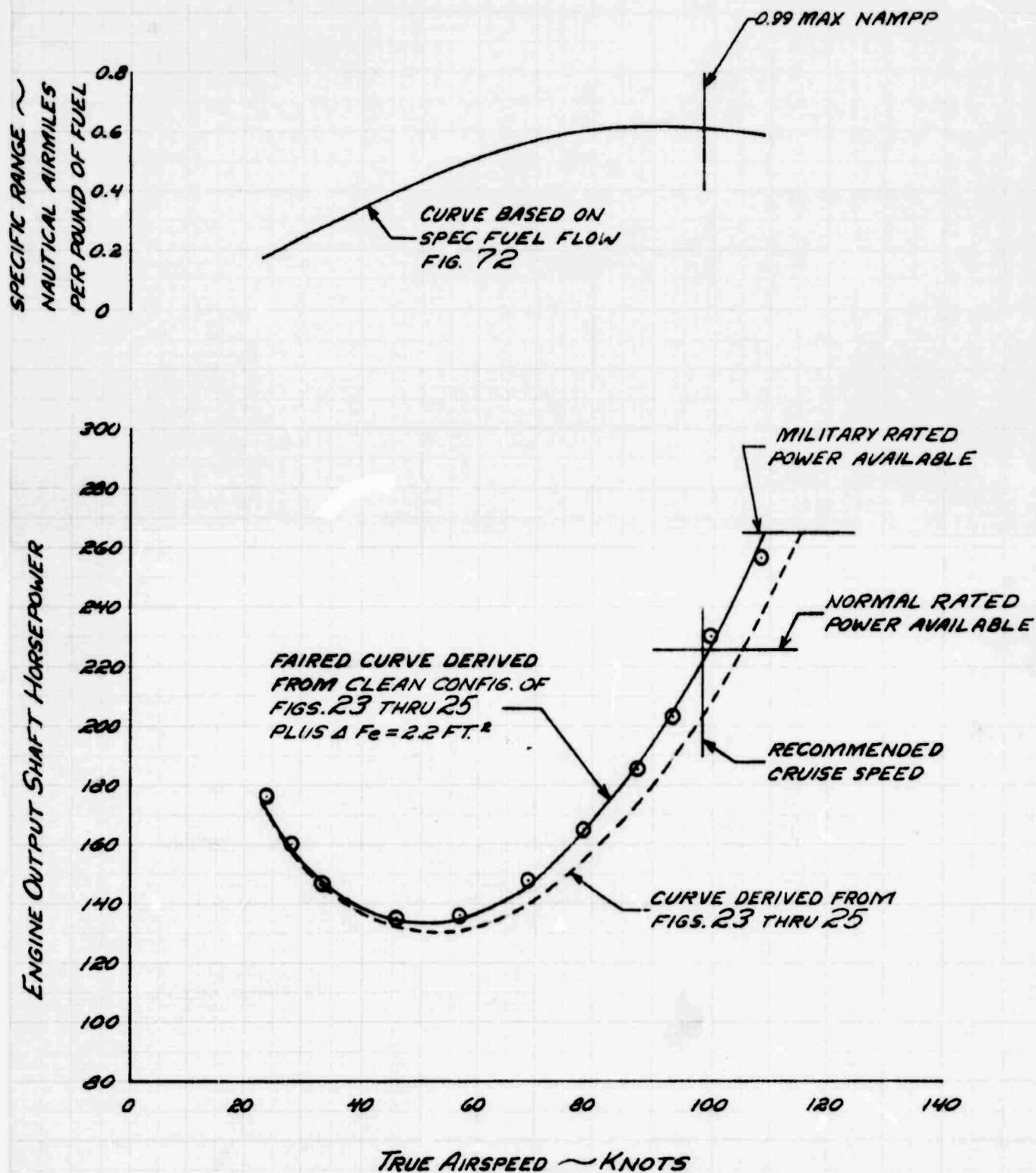
CG STATION = 107.1 IN (FWQ)  
 $C_T = 0.003115$   
 CONFIGURATION = ARMED-CARGO  
 DOORS OFF



**FIGURE 50**  
**LEVEL FLIGHT PERFORMANCE**  
**OH-58A USA S/N 68-16693**

DENSITY ALTITUDE = 4795 FT.  
 GROSS WEIGHT = 2992 LB.  
 ROTOR SPEED = 354 RPM

CG STATION = 107.0 IN (FWD)  
 $C_T = 0.003450$   
 CONFIGURATION = ARMED-CARGO  
 DOORS OFF

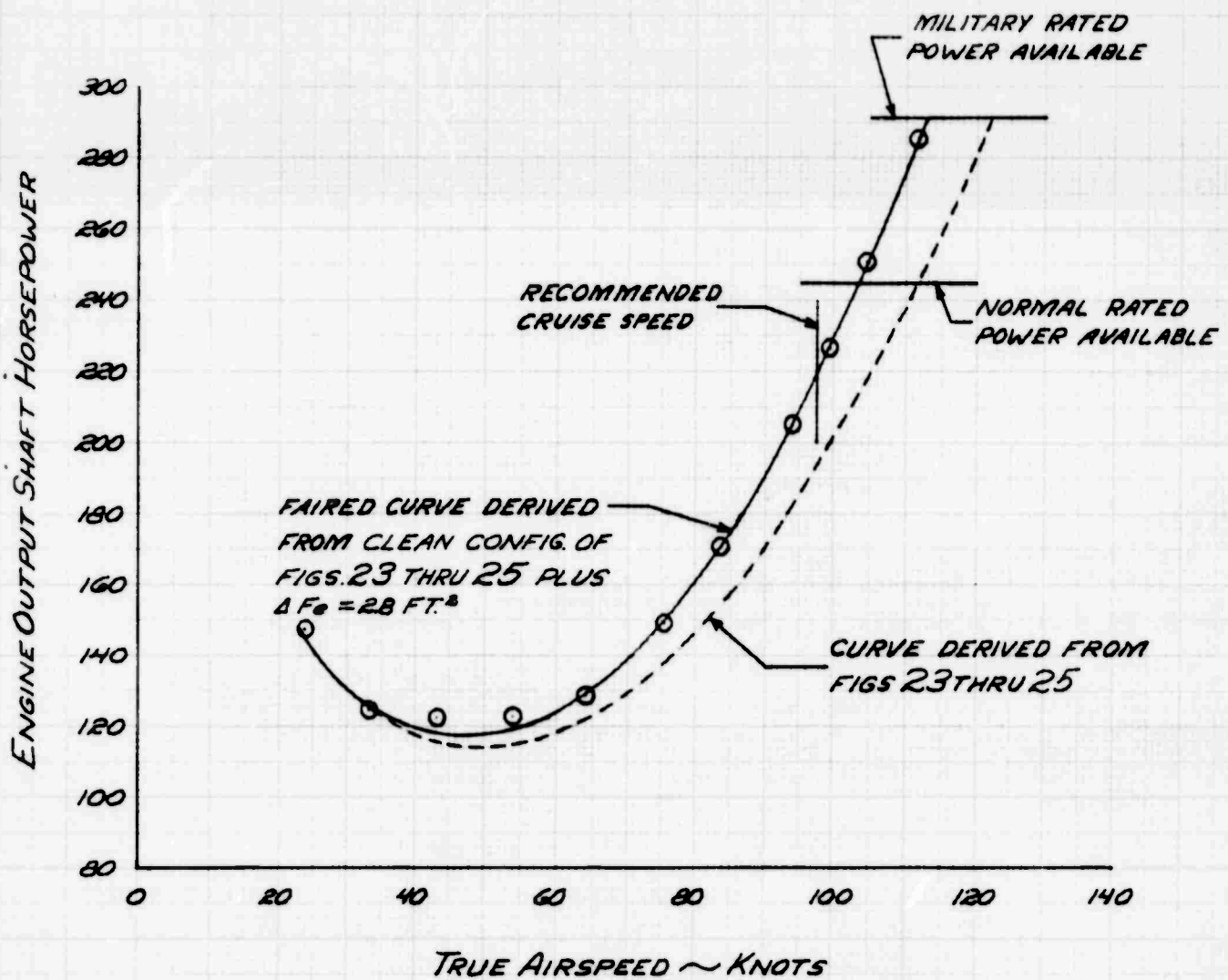
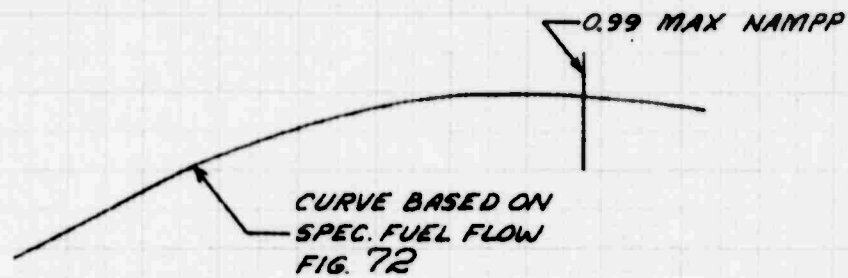


**FIGURE 51**  
**LEVEL FLIGHT PERFORMANCE**  
**OH-58A USA SIN 68-16693**

DENSITY ALTITUDE = 1195 FT  
 GROSS WEIGHT = 2671 LB  
 ROTOR SPEED = 354 RPM

CG. STATION = 107.1 IN (FWD)  
 $C_T = 0.002765$   
 CONFIGURATION = ARMED-ALL  
 DOORS OFF

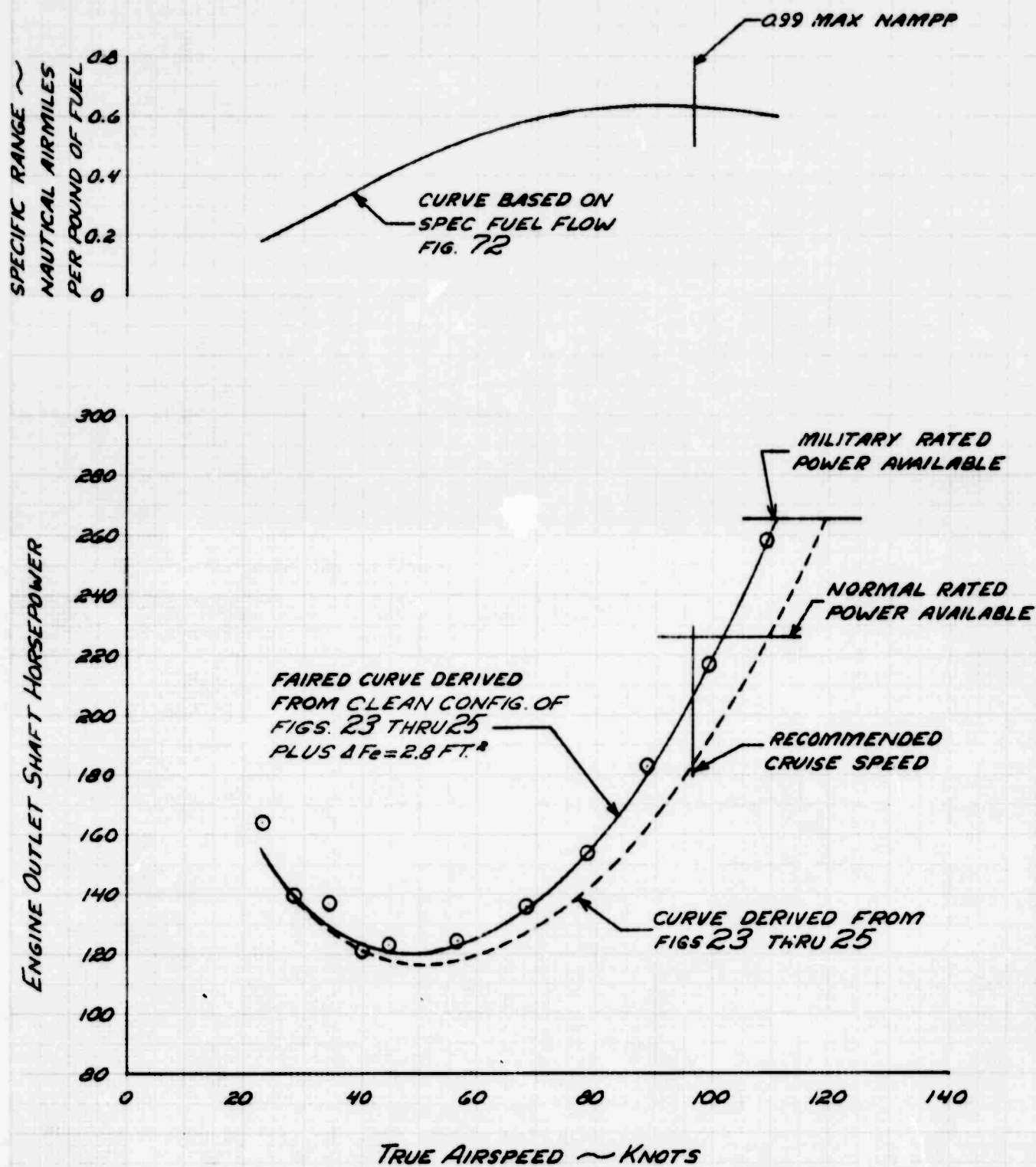
SPECIFIC RANGE ~  
 NAUTICAL AIRMILES  
 PER POUND OF FUEL



**FIGURE 52**  
**LEVEL FLIGHT PERFORMANCE**  
**OH-58A USA SIN 68-16693**

DENSITY ALTITUDE = 4740 FT  
 GROSS WEIGHT = 2713 LB  
 ROTOR SPEED = 354 RPM

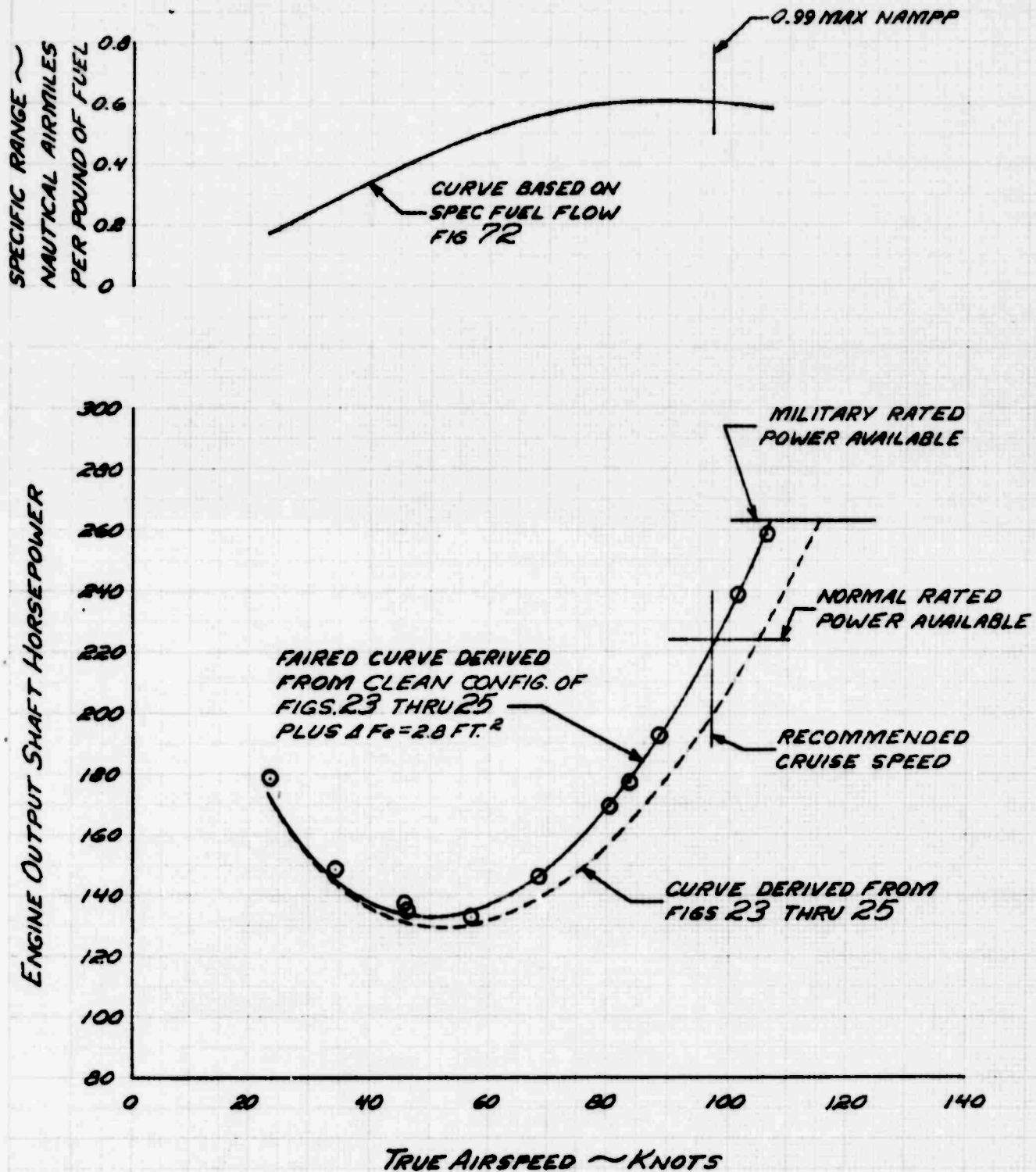
CG STATION = 107.1 IN (FWD)  
 $C_T$  = 0.003123  
 CONFIGURATION = ARMED - ALL  
 DOORS OFF



**FIGURE 53**  
**LEVEL FLIGHT PERFORMANCE**  
**OH-58A USA S/N 68-16693**

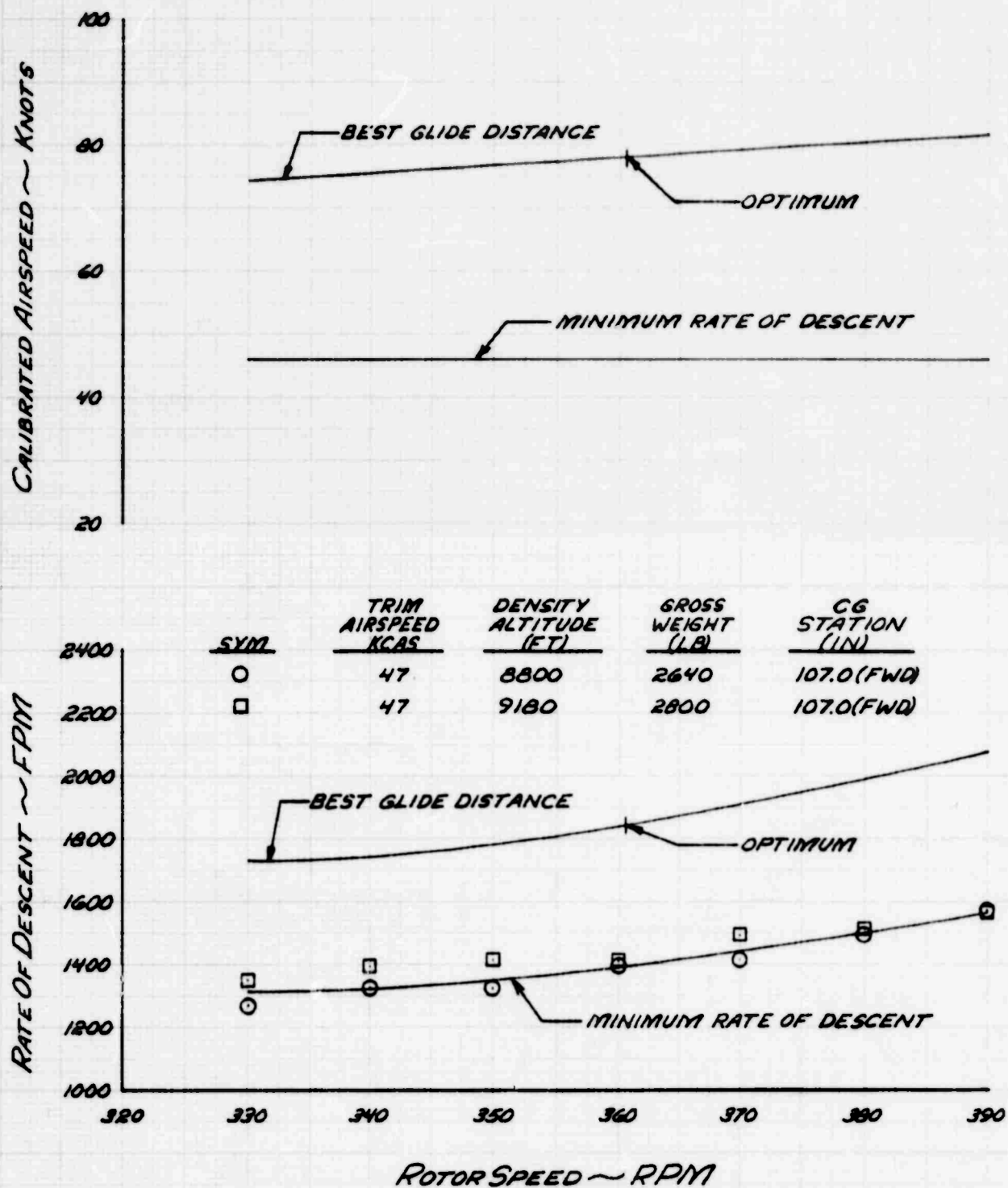
DENSITY ALTITUDE = 5070 FT  
 GROSS WEIGHT = 2977 LB  
 ROTOR SPEED = 354 RPM

CG STATION = 106.9 IN (FWD)  
 $C_T$  = 0.003460  
 CONFIGURATION = ARMED - ALL  
 DOORS OFF



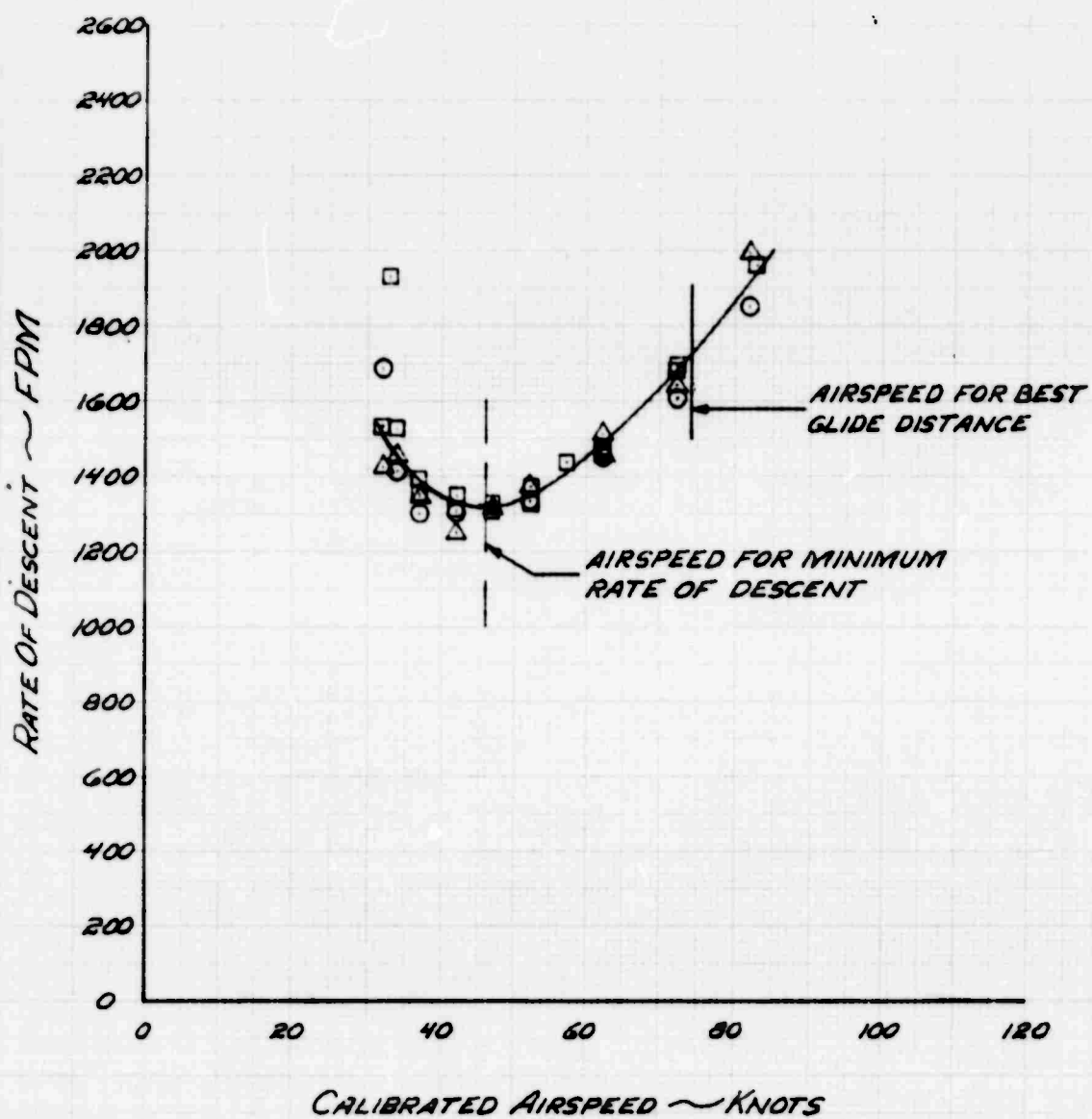
**FIGURE 54**  
**AUTOROTATIONAL DESCENTS**  
**OH-58A USA S/N 68-16693**  
**CLEAN CONFIGURATION**

NOTE: 1 CURVES OBTAINED FROM FIGS 55 THRU 57



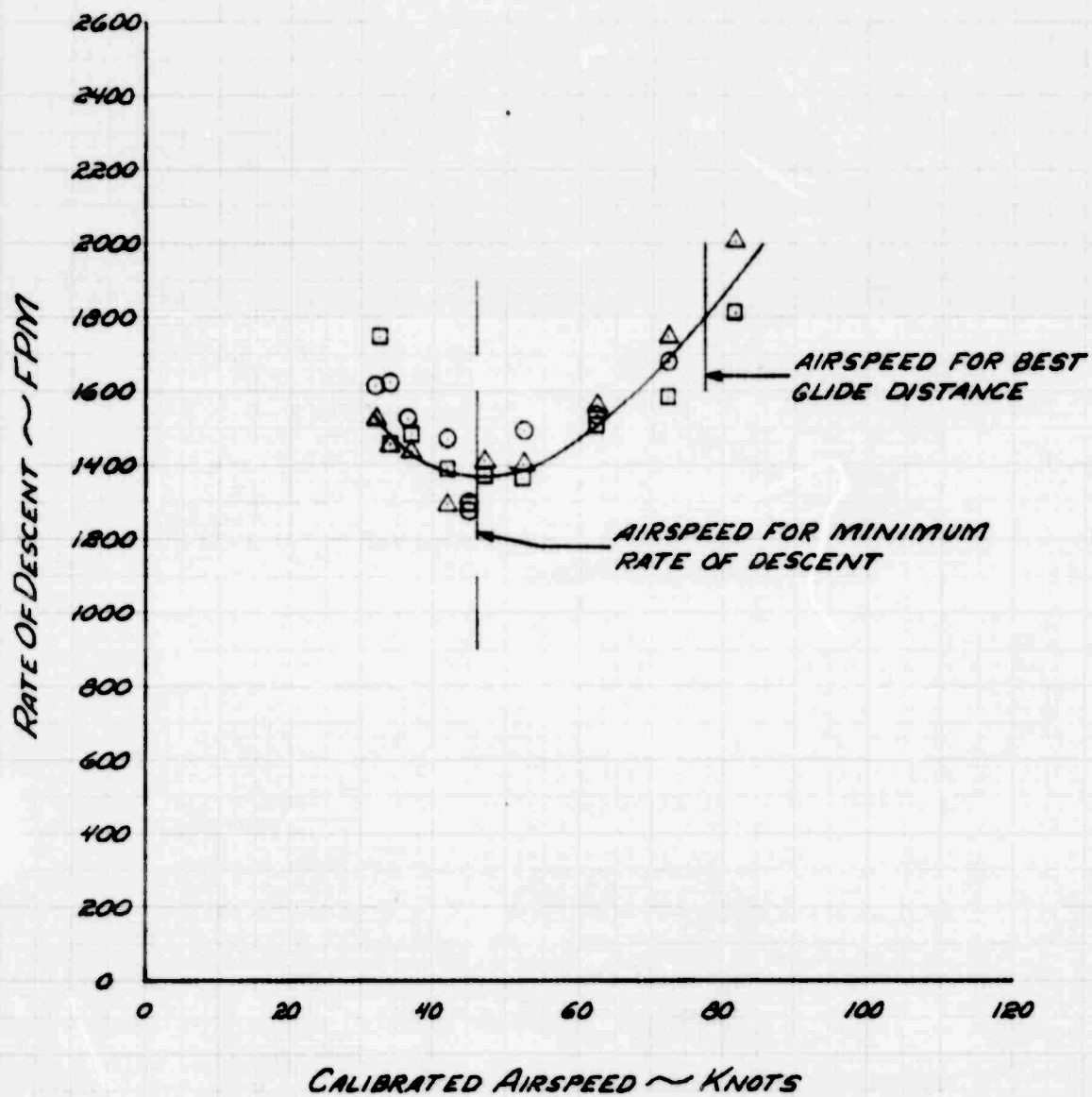
**FIGURE 55**  
**AUTOROTATIONAL DESCENTS**  
**OH-58A USA S/N 68-16693**  
**CLEAN CONFIGURATION**  
**330 RPM**

| <u><i>SYM</i></u> | <u>DENSITY<br/>ALTITUDE<br/>(FT)</u> | <u>GROSS<br/>WEIGHT<br/>(LB)</u> | <u>CG<br/>STATION<br/>(IN)</u> |
|-------------------|--------------------------------------|----------------------------------|--------------------------------|
| ○                 | 9590                                 | 2640                             | 107.0(FWD)                     |
| □                 | 8930                                 | 2800                             | 107.0(FWD)                     |
| △                 | 12150                                | 2160                             | 107.0(FWD)                     |



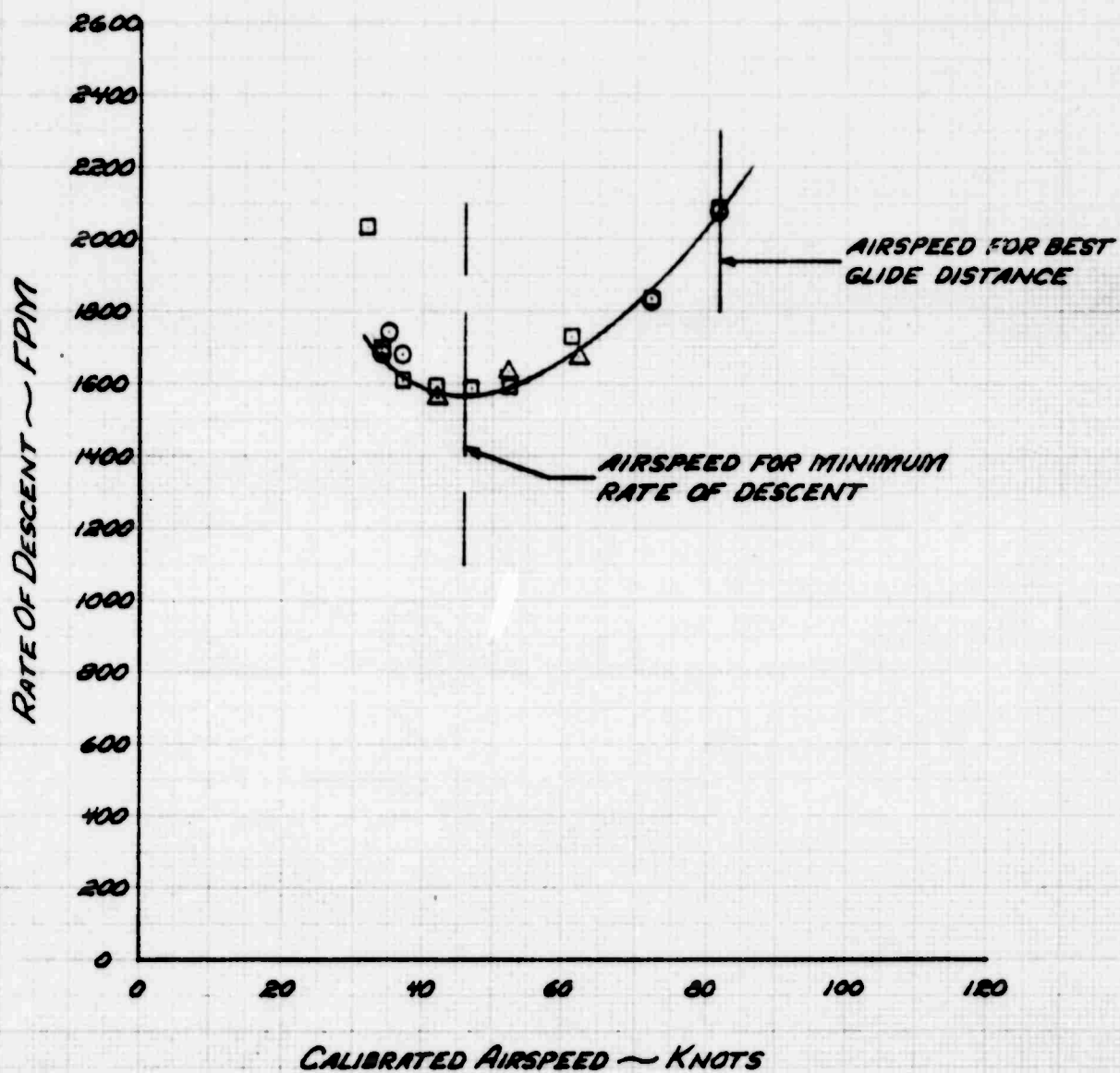
**FIGURE 56**  
**AUTOROTATIONAL DESCENTS**  
 OH-58A USA S/N 68-16693  
 CLEAN CONFIGURATION  
 354 RPM

| <u>SYM</u> | <u>DENSITY<br/>ALTITUDE<br/>(FT)</u> | <u>GROSS<br/>WEIGHT<br/>(LB)</u> | <u>CG<br/>STATION<br/>(IN)</u> |
|------------|--------------------------------------|----------------------------------|--------------------------------|
| ○          | 9195                                 | 2640                             | 107.0 (FWD)                    |
| □          | 10590                                | 2800                             | 107.0 (FWD)                    |
| △          | 12360                                | 2160                             | 107.0 (FWD)                    |

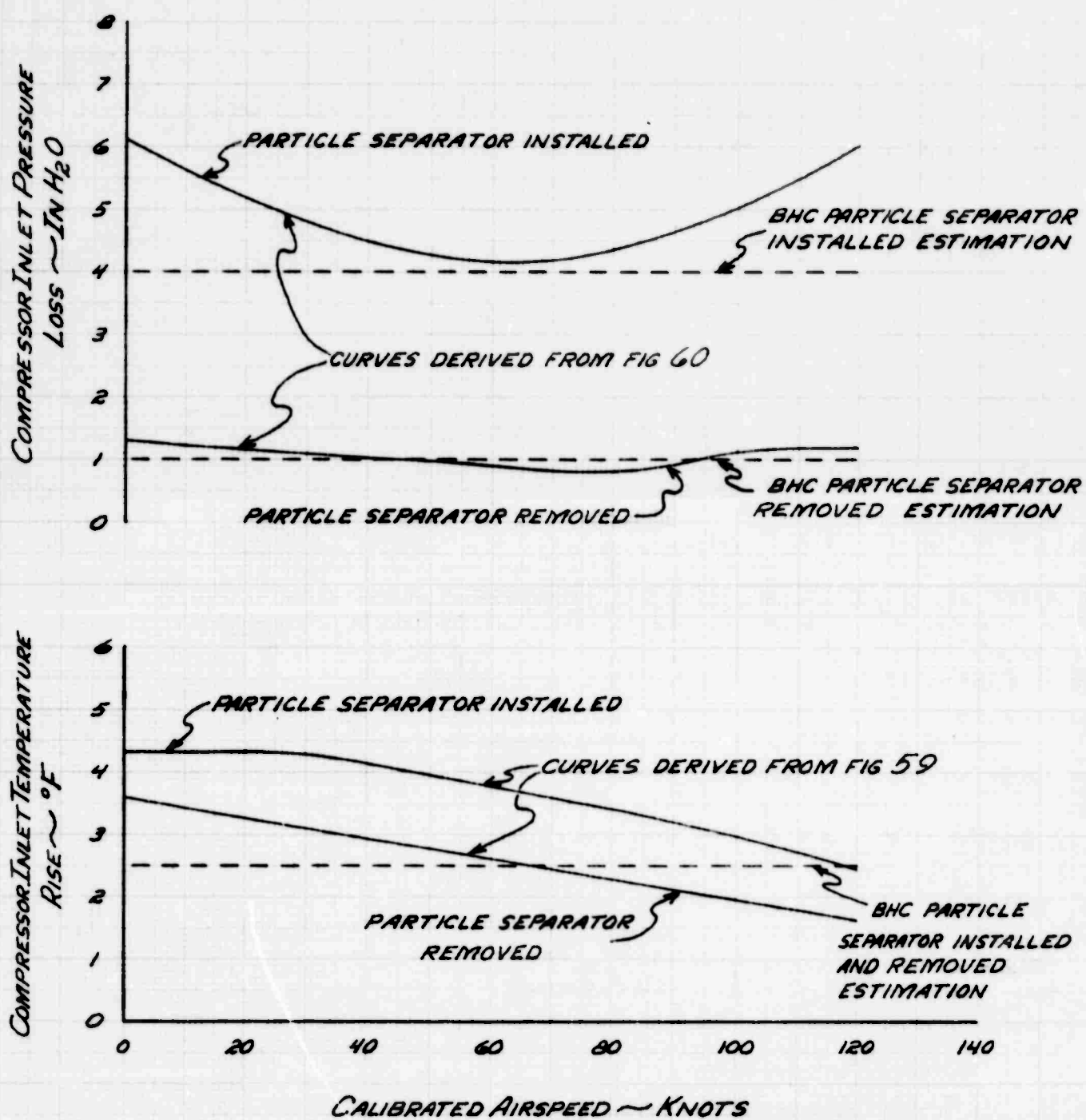


**FIGURE 57**  
**AUTOROTATIONAL DESCENTS**  
**OH-58A USA SING 16693**  
**CLEAN CONFIGURATION**  
**390 RPM**

| <u>SYM</u> | <u>DENSITY<br/>ALTITUDE<br/>FT</u> | <u>GROSS<br/>WEIGHT<br/>(LB)</u> | <u>CG<br/>STATION<br/>(IN)</u> |
|------------|------------------------------------|----------------------------------|--------------------------------|
| ○          | 13265                              | 2640                             | 107.0 (FWD)                    |
| □          | 10385                              | 2800                             | 107.0 (FWD)                    |
| △          | 12690                              | 2160                             | 107.0 (FWD)                    |

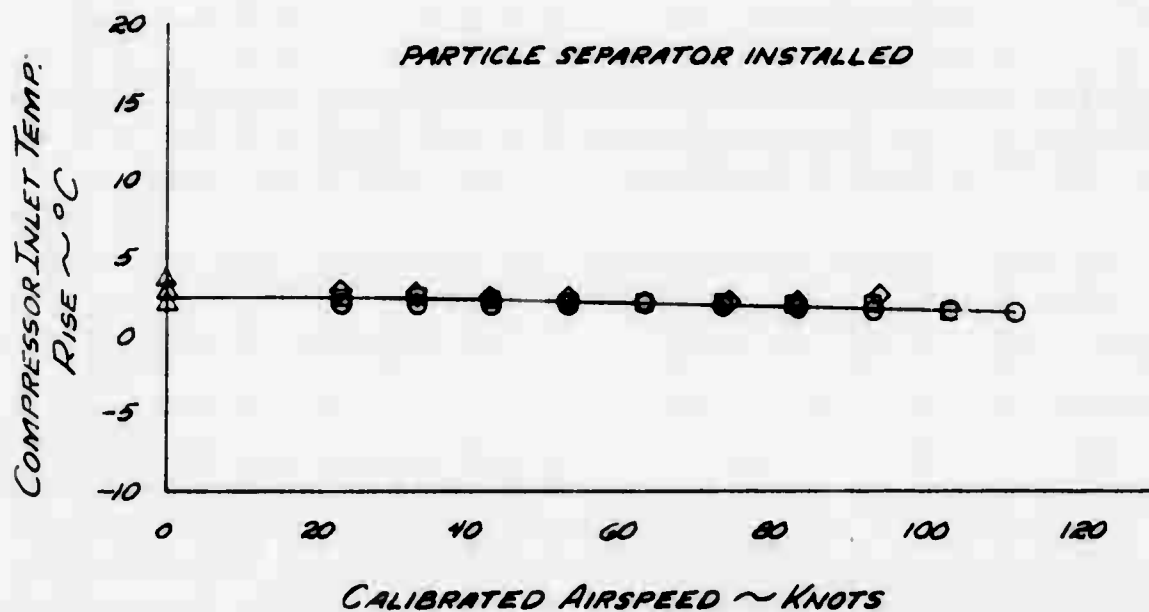
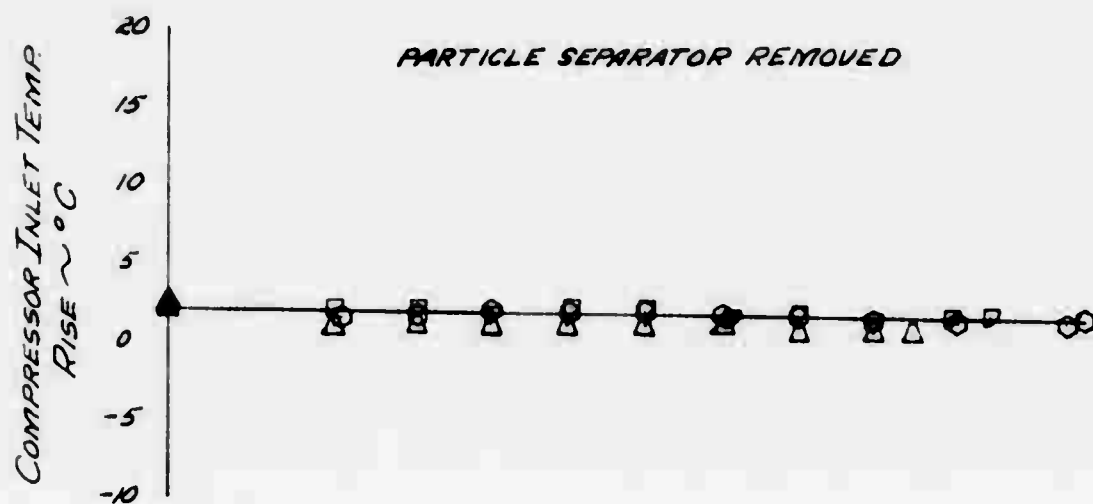


**FIGURE 58**  
**COMPRESSOR INLET CHARACTERISTIC COMPARISON**  
 OH-58A USA SIN 68-16693  
 T63-A-700 ENGINE



**FIGURE 59**  
**ENGINE INLET CHARACTERISTICS**  
 OH-58A USA S/N GB-K6699  
 T63-A-700 ENGINE

| <u>SYM</u> | <u>PRESS<br/>ALT<br/>(FT)</u> | <u>GROSS<br/>WEIGHT<br/>(LB)</u> | <u>ROTOR<br/>SPEED<br/>(RPM)</u> | <u>CG<br/>STATION</u> |
|------------|-------------------------------|----------------------------------|----------------------------------|-----------------------|
| ○          | 2995                          | 2400                             | 354                              | 107.0 (FWD)           |
| □          | 5960                          | 2400                             | 354                              | 107.0 (FWD)           |
| △          | 510                           | 2400                             | 354                              | 107.0 (FWD)           |
| ◇          | 9930                          | 2400                             | 354                              | 107.0 (FWD)           |
| ○          | 1015                          | 2400                             | 354                              | 107.0 (FWD)           |
| ▽          | 4970                          | 2400                             | 354                              | 107.0 (FWD)           |
| △          | 9955                          | 2400                             | 354                              | 107.0 (FWD)           |



**FIGURE 60**  
**ENGINE INLET CHARACTERISTICS**  
**OH-58A USA SIN 68-16623**  
**T63-A-700 ENGINE**

| <u>SYM</u> | <u>PRESS<br/>ALT<br/>(FT)</u> | <u>GROSS<br/>WEIGHT<br/>(LB)</u> | <u>ROTOR<br/>SPEED<br/>(RPM)</u> | <u>C6<br/>STATION</u> |
|------------|-------------------------------|----------------------------------|----------------------------------|-----------------------|
| ○          | 2995                          | 2400                             | 354                              | 107.0 (FWD)           |
| □          | 5960                          | 2400                             | 354                              | 107.0 (FWD)           |
| △          | 9930                          | 2400                             | 354                              | 107.0 (FWD)           |
| ◇          | 510                           | 2400                             | 354                              | 107.0 (FWD)           |
| ○          | 840                           | 2630                             | 354                              | 106.9 (FWD)           |
| ○          | 1140                          | 2180                             | 354                              | 107.0 (FWD)           |
| ○          | 1015                          | 2400                             | 354                              | 107.0 (FWD)           |
| ▽          | 4970                          | 2400                             | 354                              | 107.0 (FWD)           |
| △          | 9995                          | 2400                             | 354                              | 107.0 (FWD)           |

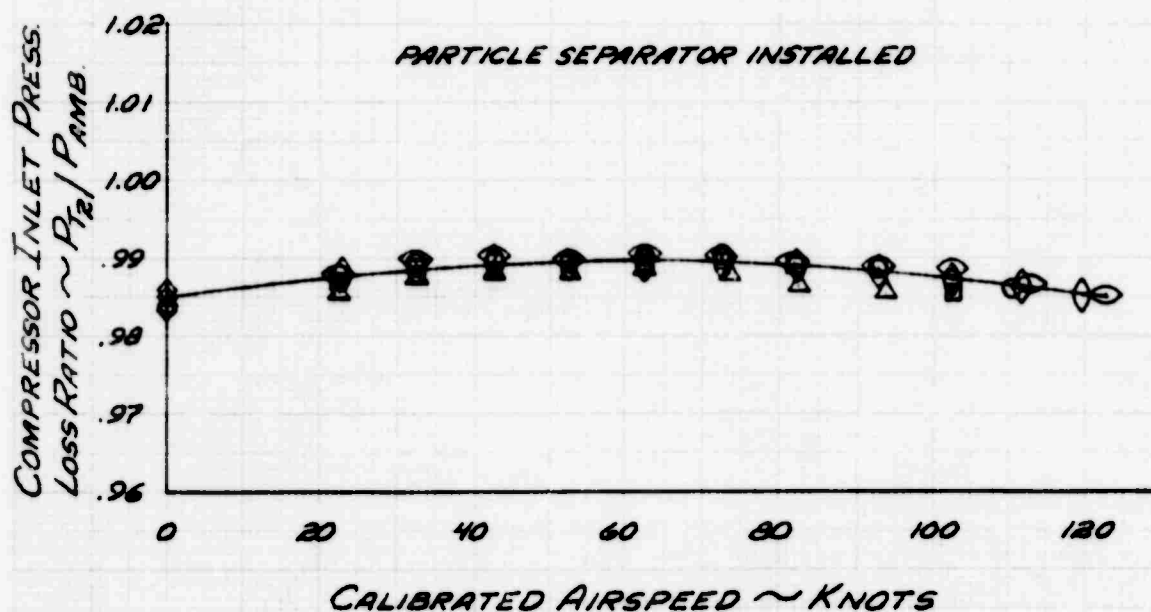
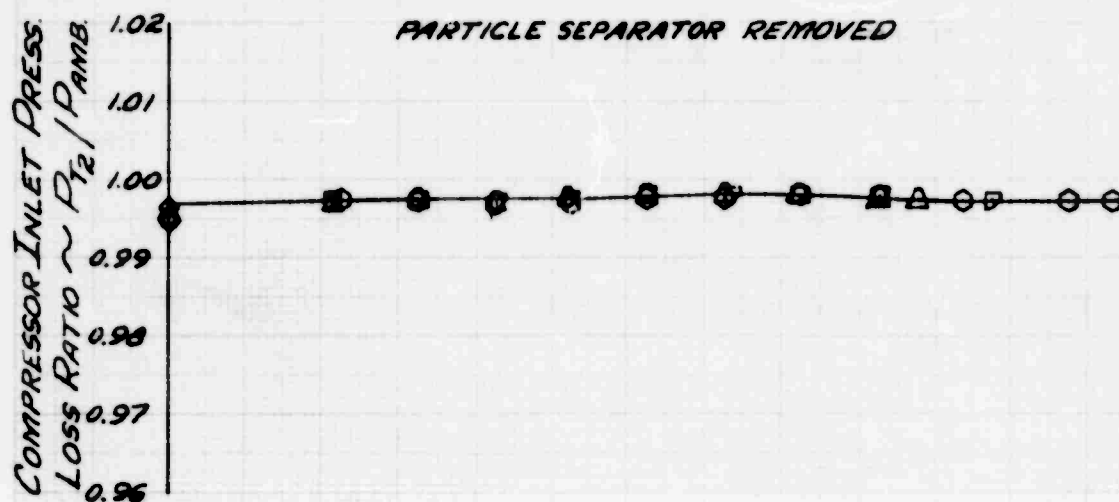


FIGURE 61  
EFFECT OF BELL EXHAUST EXTENSION  
ON T63-A-700 EXHAUST STATIC PRESSURE  
OH-58A USA SIN 68-16693

NOTE: 1. DATA FURNISHED BY BELL HELICOPTER COMPANY.

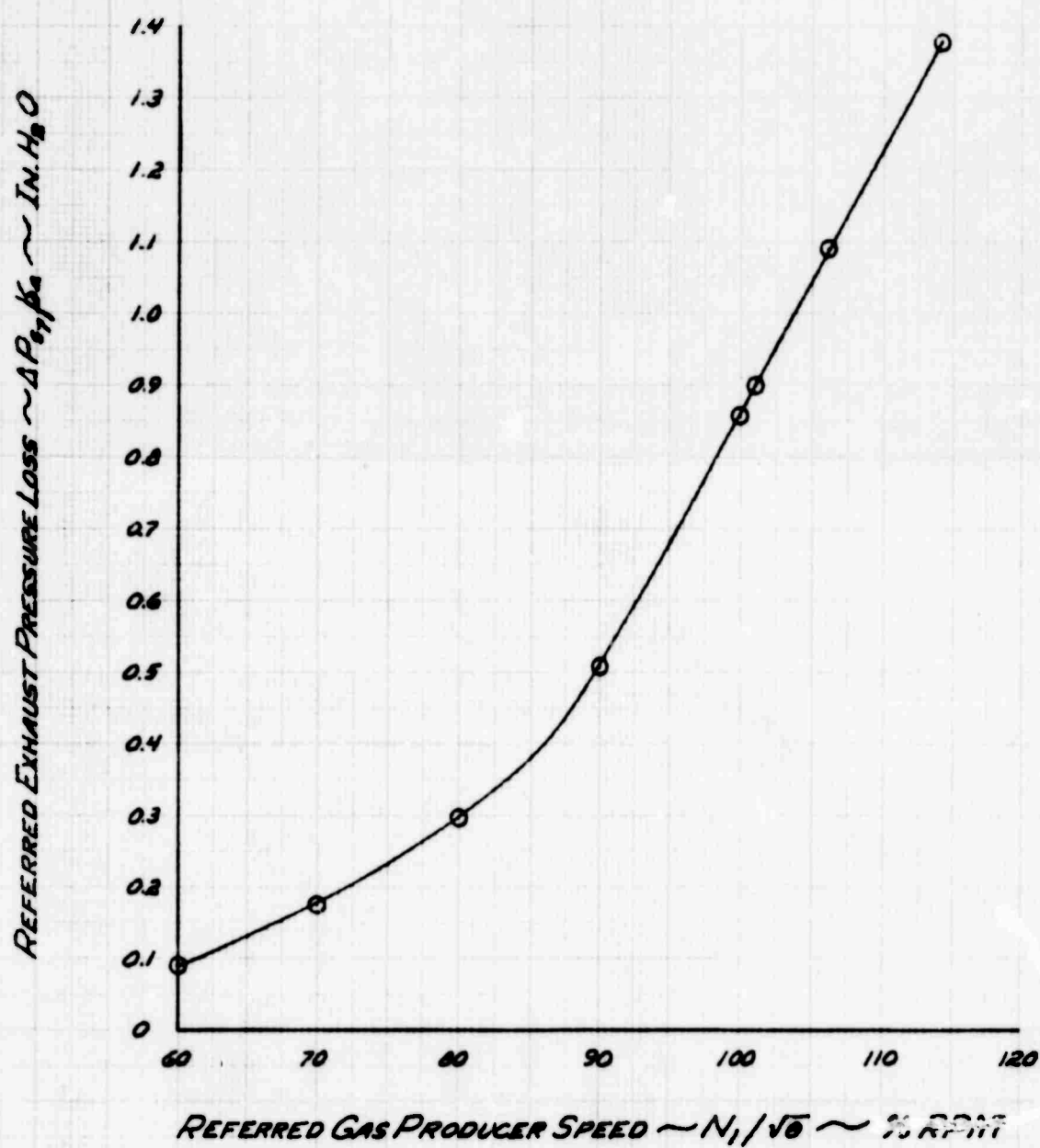


FIGURE 62  
ENGINE CHARACTERISTICS  
OH-58A USAS/N68-16693  
T63-A-700 S/N402811

NOTES:

1. SHAFT HORSEPOWER  
CORRECTION FACTOR ( $C_1$ )  
OBTAINED FROM ALLISON  
ENGINE MODEL SPECIFICATION  
803.
2.  $\delta$ ,  $\sqrt{\theta}$  AND  $C$ , BASED ON  
COMPRESSOR INLET TOTAL  
PRESSURE AND TEMPERATURE.

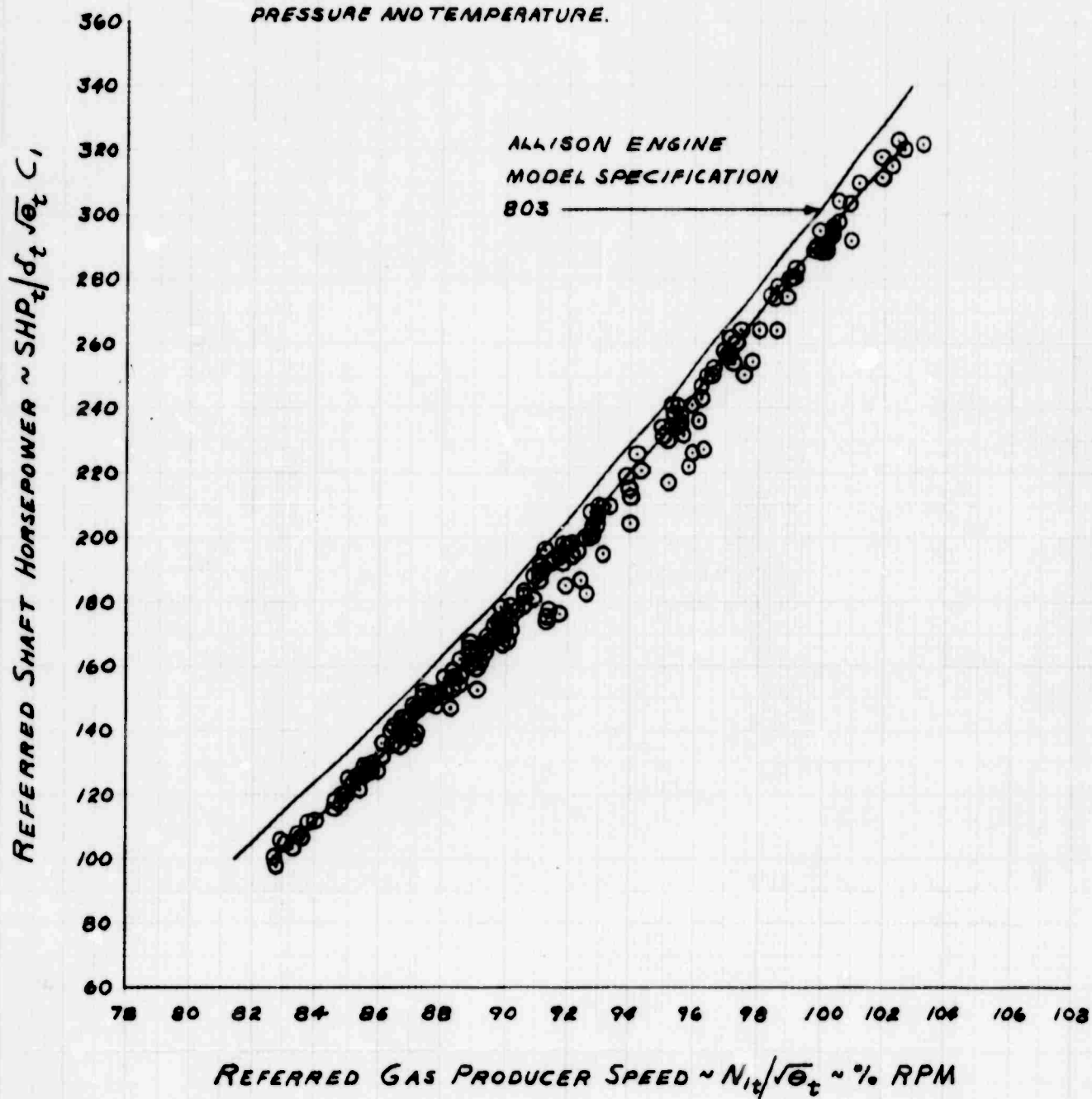
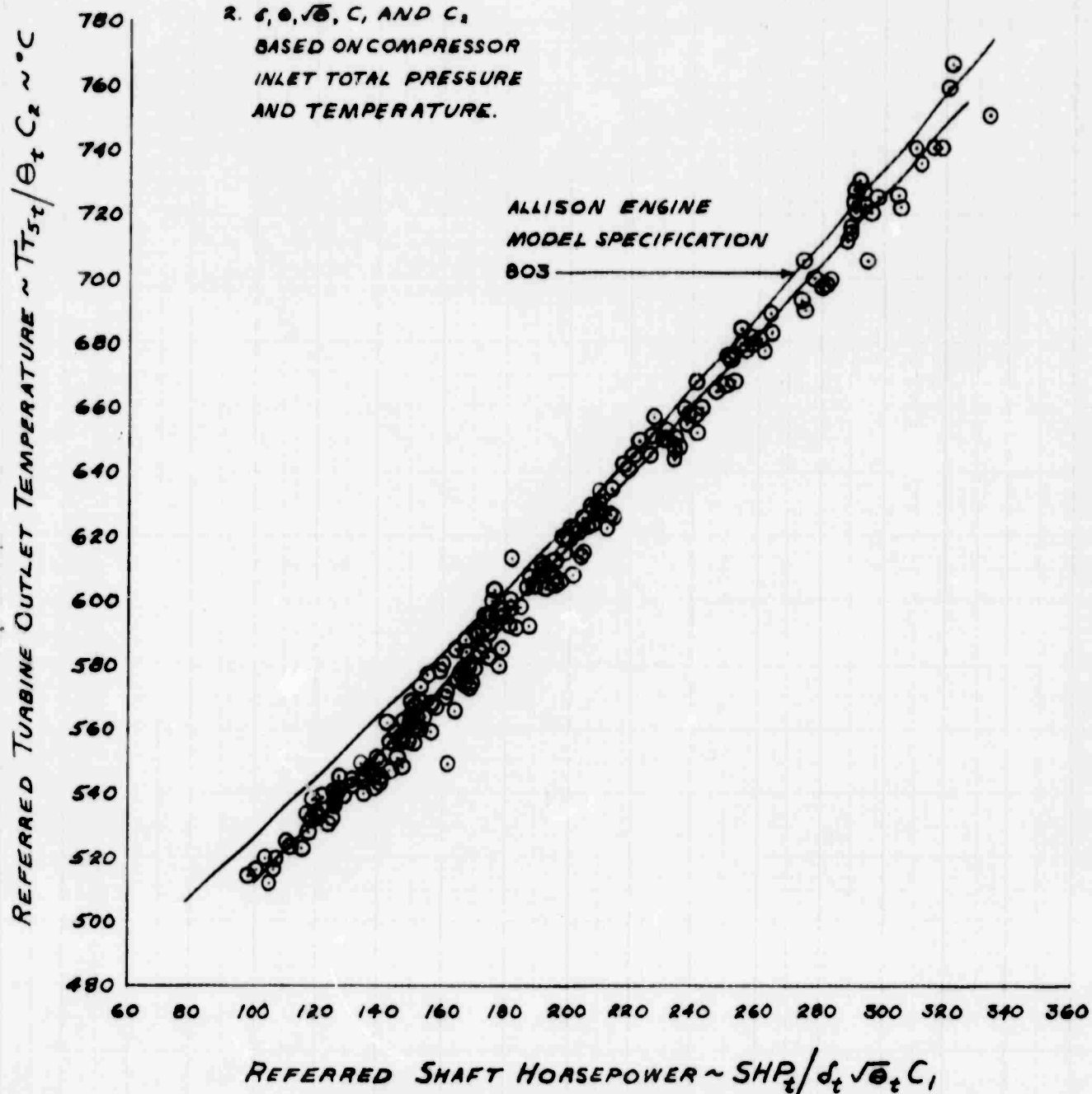


FIGURE 63  
ENGINE CHARACTERISTICS  
OH-58A USA S/N 68-16693  
T63-A-700 S/N 402811

NOTES:

1. SHAFT HORSEPOWER  
CORRECTION FACTOR ( $C_1$ )  
AND  $T_{T_2}$  CORRECTION  
FACTOR ( $C_2$ ) OBTAINED  
FROM ALLISON ENGINE  
MODEL SPECIFICATION  
803.

2.  $\delta$ ,  $\theta$ ,  $\sqrt{\theta}$ ,  $C_1$ , AND  $C_2$   
BASED ON COMPRESSOR  
INLET TOTAL PRESSURE  
AND TEMPERATURE.



**FIGURE 64**  
**AIRSPEED CALIBRATION**  
**OH-58A USA SIN 68-16693**  
**SHIPS SYSTEM IN LEVEL FLIGHT**

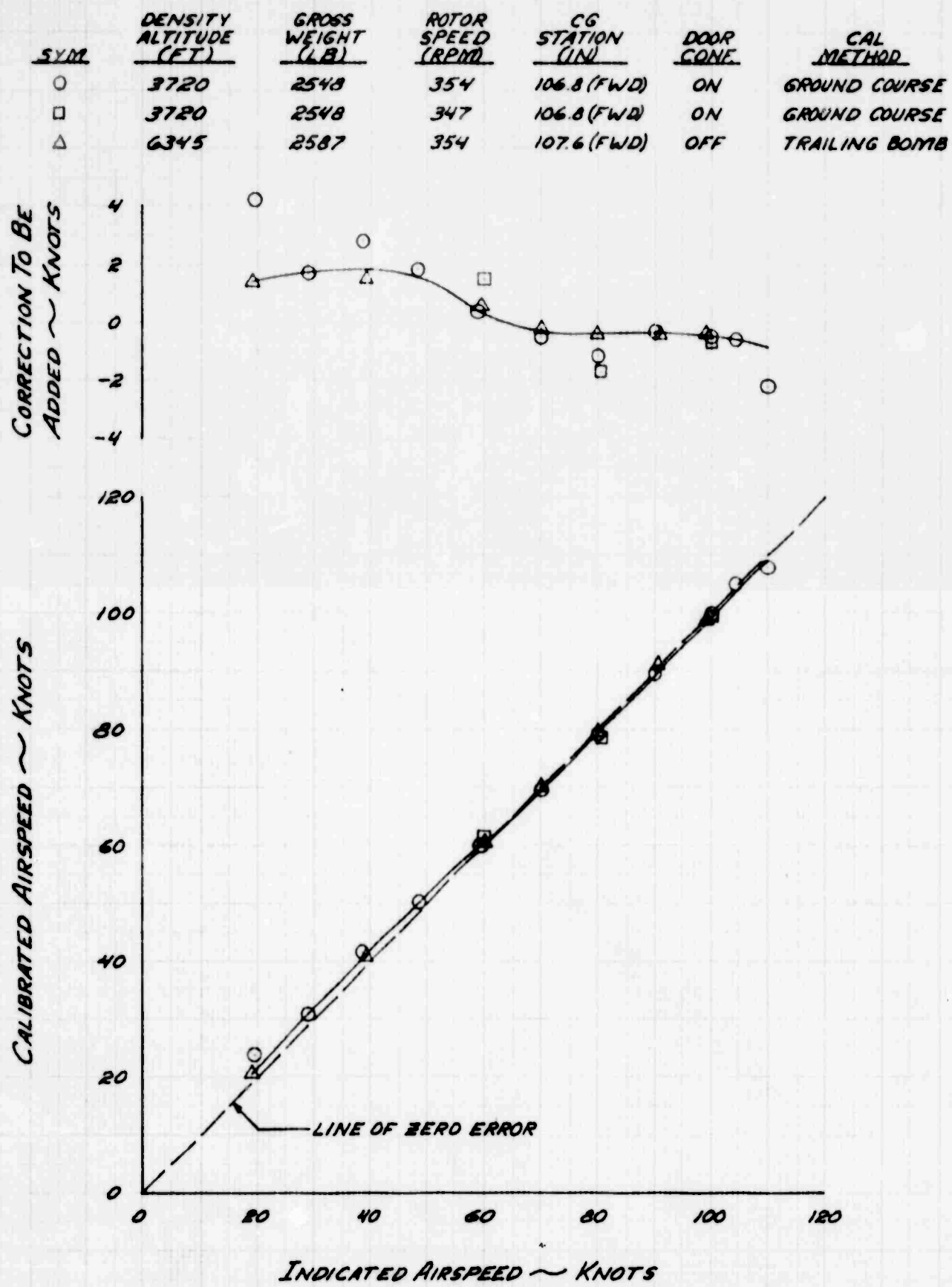


FIGURE 65  
AIRSPEED CALIBRATION  
OH-58A USA SINGB-16693  
SHIPS SYSTEM IN CLIMB  
MILITARY RATED POWER

| <u>SYM</u> | <u>DENSITY ALTITUDE (FT)</u> | <u>GROSS WEIGHT (LB)</u> | <u>ROTOR SPEED (RPM)</u> | <u>CG STATION (IN)</u> | <u>DOOR CONE</u> | <u>CAL METHOD</u> |
|------------|------------------------------|--------------------------|--------------------------|------------------------|------------------|-------------------|
| ○          | 7230                         | 2525                     | 354                      | 106.7(FWD)             | ON               | TRAILING BOMB     |
| □          | 6850                         | 2587                     | 354                      | 107.6(FWD)             | OFF              | TRAILING BOMB     |

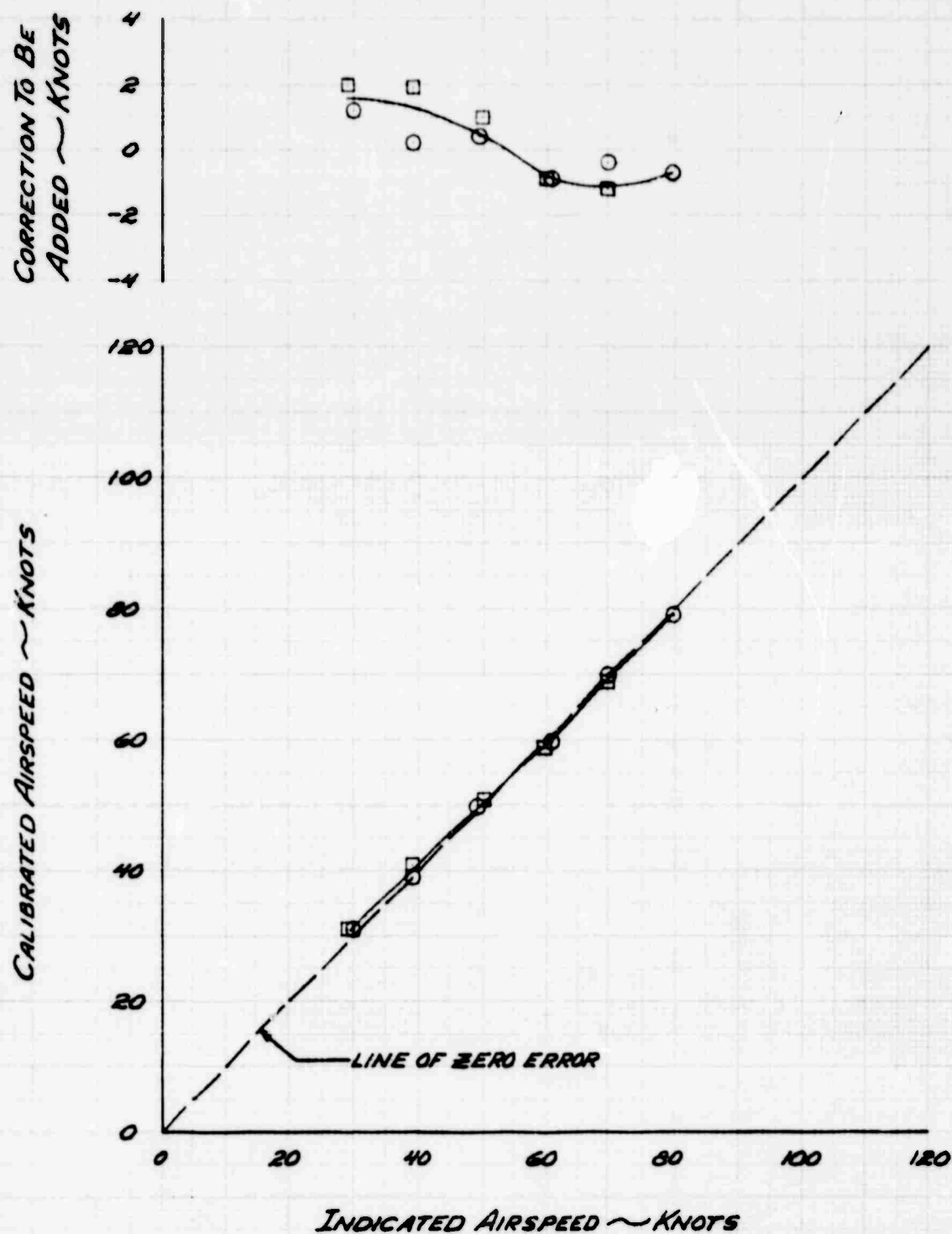


FIGURE 66  
AIRSPEED CALIBRATION  
OH-58A USA SIN 68-16693

SHIPS SYSTEM IN AUTOROTATION

| SYM | DENSITY ALTITUDE (FT) | GROSS WEIGHT (LB) | ROTOR SPEED (RPM) | CG STATION (IN) | DOOR CONF | CAL METHOD    |
|-----|-----------------------|-------------------|-------------------|-----------------|-----------|---------------|
| ○   | 7355                  | 2525              | 354               | 106.7 (FWD)     | ON        | TRAILING BOMB |
| □   | 6510                  | 2525              | 390               | 106.7 (FWD)     | ON        | TRAILING BOMB |
| △   | 7115                  | 2525              | 330               | 106.7 (FWD)     | ON        | TRAILING BOMB |
| ◻   | 7065                  | 2587              | 354               | 107.6 (FWD)     | OFF       | TRAILING BOMB |

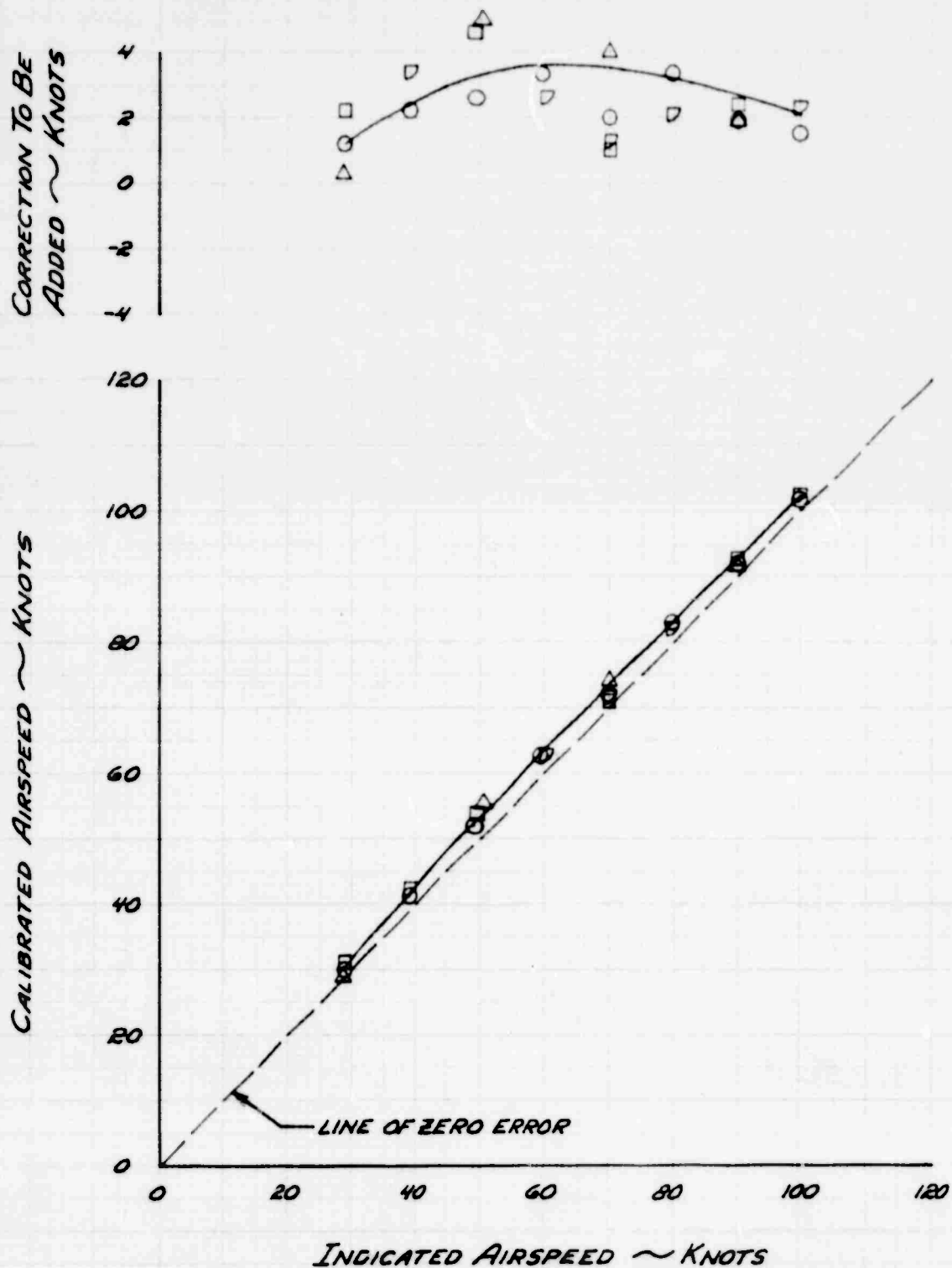
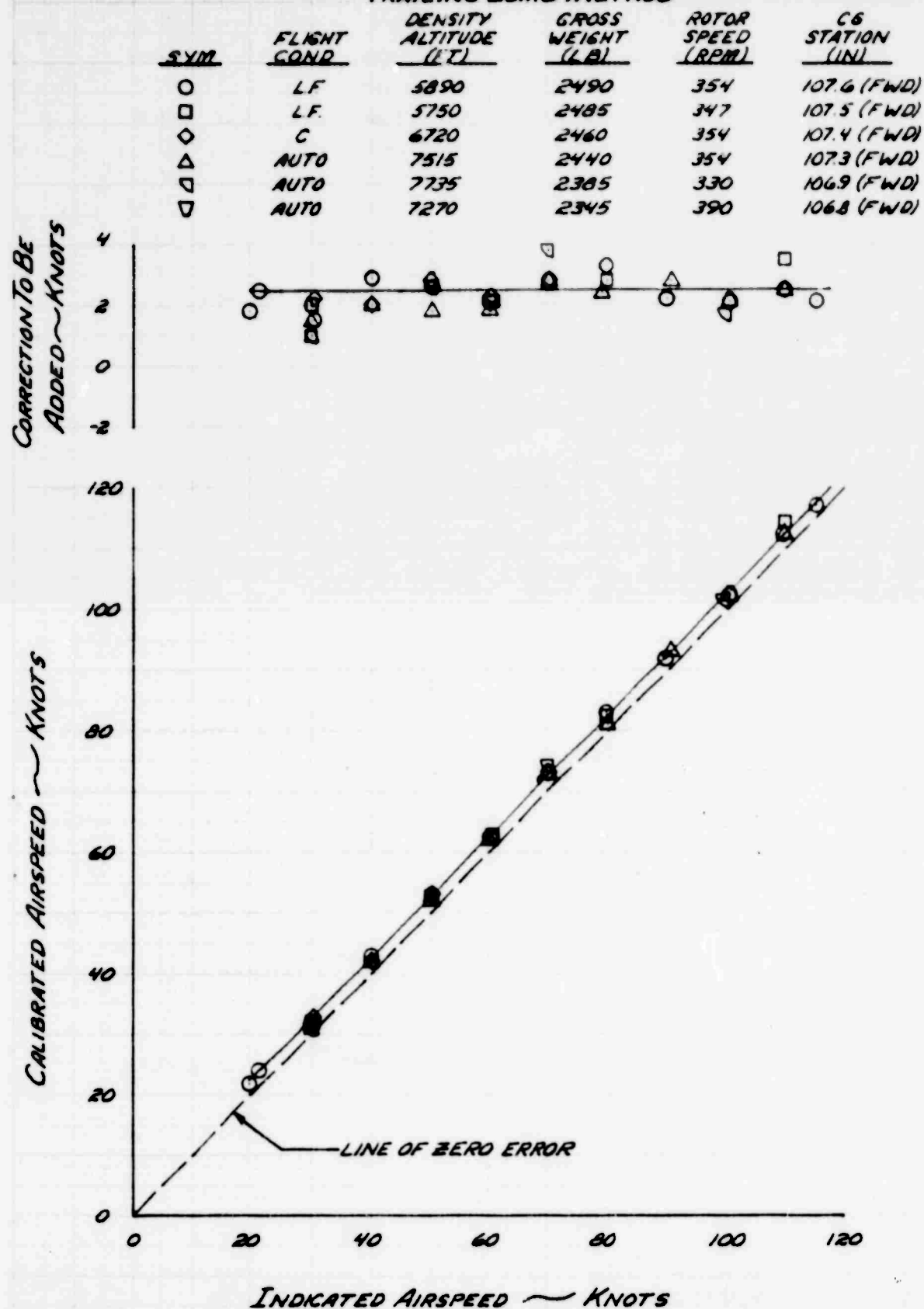


FIGURE 67  
AIRSPEED CALIBRATION  
OH-58A USA SIN 68-16693  
TEST BOOM SYSTEM  
CLEAN CONFIGURATION  
TRAILING BOMB METHOD



**FIGURE 6B**  
**ALTIMETER CALIBRATION FOR STANDARD SYSTEM**  
 OH-58A USA SIN 68-16693

| <u>SYM</u> | <u>PRESSURE ALTITUDE (FT)</u> | <u>GROSS WEIGHT (LB)</u> | <u>ROTOR SPEED (RPM)</u> | <u>CG STATION (IN)</u> | <u>DOOR CONF</u> | <u>FLT CONDTN</u> |
|------------|-------------------------------|--------------------------|--------------------------|------------------------|------------------|-------------------|
| ○          | 2650                          | 2548                     | 354                      | 106.8 (FWD)            | ON               | LEVEL             |
| ○          | 4810                          | 2525                     | 354                      | 106.7 (FWD)            | ON               | CLIMB             |
| ○          | 5110                          | 2525                     | 354                      | 106.7 (FWD)            | ON               | AUTO              |
| ○          | 4795                          | 2525                     | 330                      | 106.7 (FWD)            | ON               | AUTO              |
| △          | 2550                          | 2548                     | 347                      | 106.8 (FWD)            | ON               | LEVEL             |
| △          | 4415                          | 2525                     | 390                      | 106.7 (FWD)            | ON               | AUTO              |
| □          | 3830                          | 2587                     | 354                      | 107.6 (FWD)            | OFF              | LEVEL             |
| □          | 4370                          | 2587                     | 354                      | 107.6 (FWD)            | OFF              | CLIMB             |
| □          | 4775                          | 2587                     | 354                      | 107.6 (FWD)            | OFF              | AUTO              |

NOTE: ALTIMETER POSITION ERROR DERIVED FROM AIRSPEED POSITION  
 ERROR DATA, FIGS 64 THRU 66

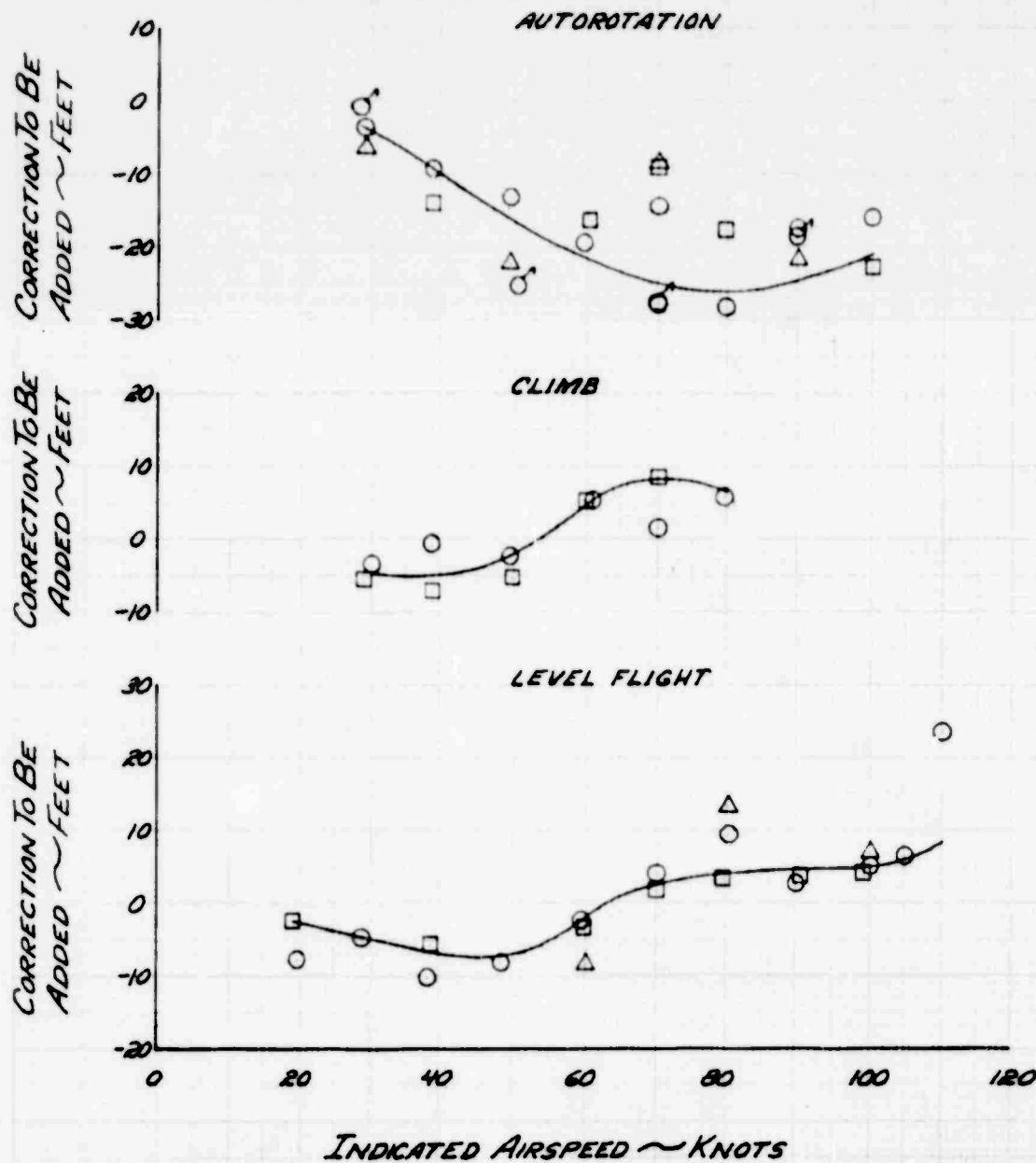


FIGURE 69  
SHAFT HORSEPOWER AVAILABLE COMPARISON  
OH-58A USA S/N 68-16693  
T63-A-700 ENGINE  
TAKEOFF RATED POWER  $T_{T_8} = 1300^\circ\text{F}$

NOTE: 1. STATIC CONDITIONS.

2. O BLEED AND ANTI-ICE OFF.

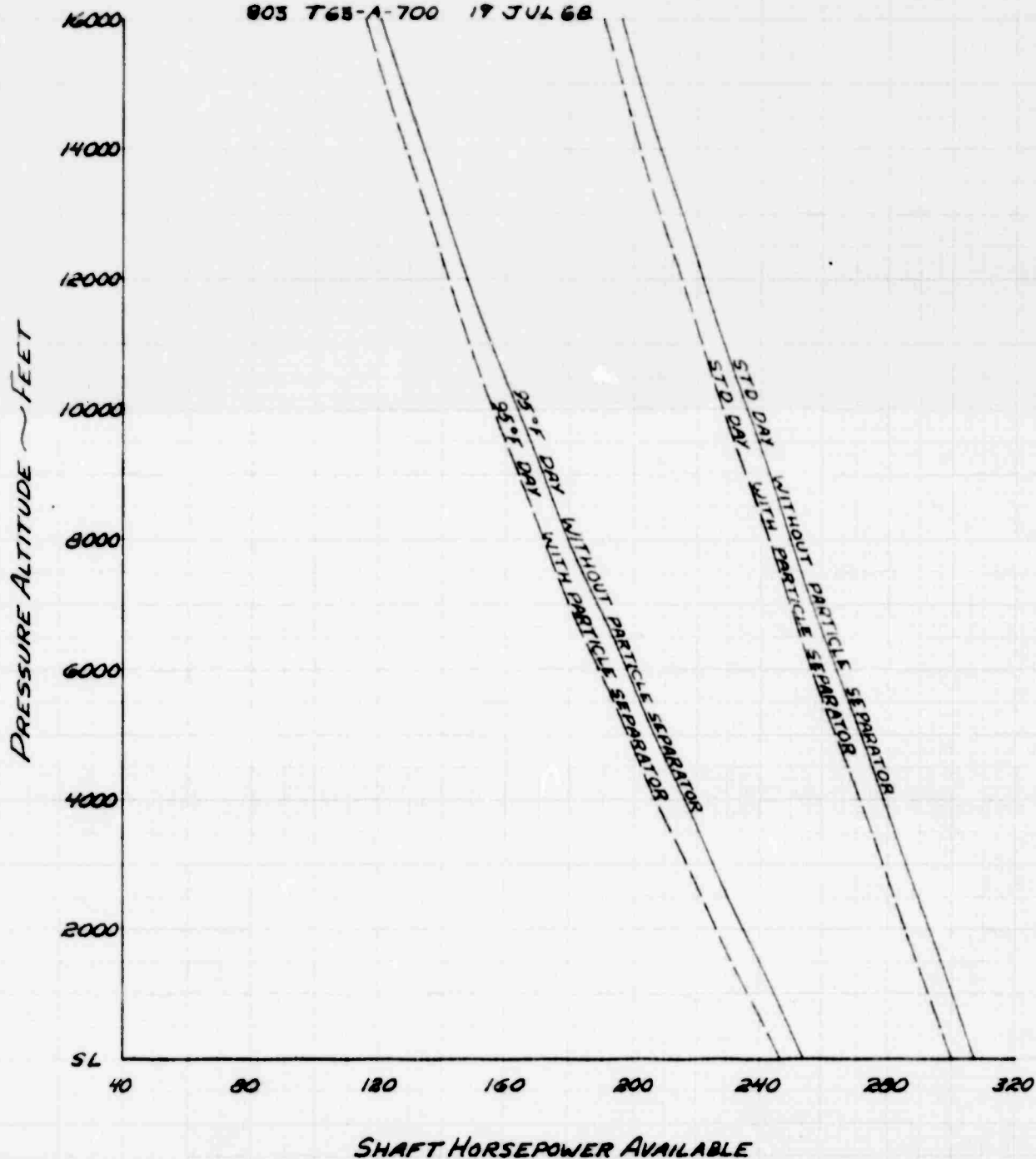
3. POWER EXTRACTED EQUALS 2.0 SHP.

4. INLET LOSSES BASED ON FIGS. 59 AND 60

5. EXHAUST PRESSURE LOSS IS 1.16 INCHES OF  $\text{H}_2\text{O}$ , FIG. 61

6. SHAFT HORSEPOWER DERIVED FROM ENGINE MODEL SPECIFICATION

803 T63-A-700 19 JUL 68



# FIGURE 70 SHAFT HORSEPOWER AVAILABLE

OH-58A USA SIN 68-16693

T63-A-700 ENGINE

TAKEOFF RATED POWER  $T_{TS} = 1380^{\circ}F$

PARTICLE SEPARATOR INSTALLED 354 RPM

NOTE: 1. STATIC CONDITIONS.

2. O BLEED AND ANTI-ICE OFF.

3. POWER EXTRACTED EQUALS 2.0 SHP.

4. INLET LOSSES BASED ON FIGS. 59 AND 60

5. EXHAUST PRESSURE LOSS IS 1.16 INCHES OF  $H_2O$ , FIG 61

6. SHAFT HORSEPOWER DERIVED FROM ENGINE MODEL SPECIFICATION

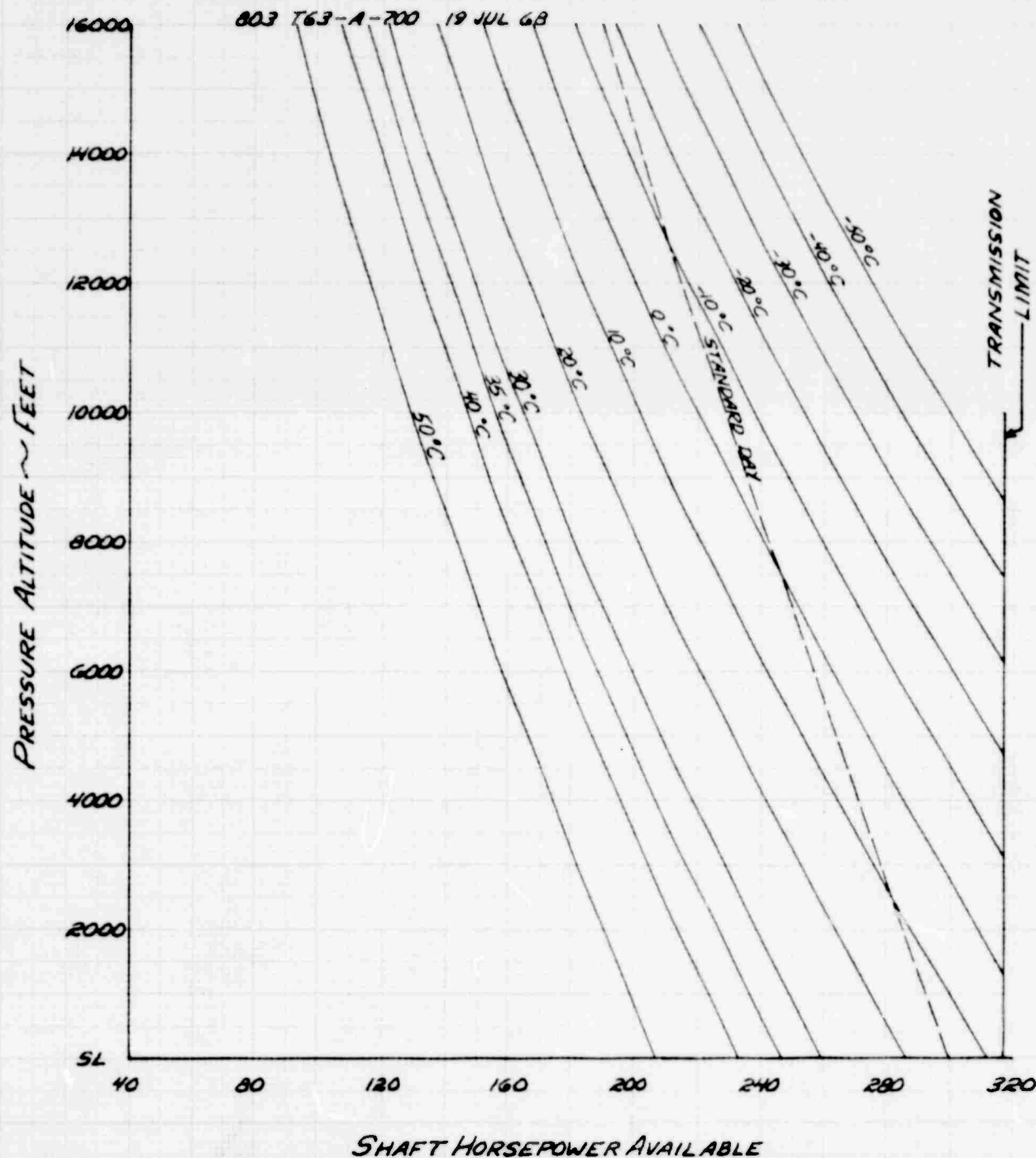


FIGURE 71  
SHAFT HORSEPOWER AVAILABLE  
OH-58A USA SIN 68-16693  
T63-A-700 ENGINE  
NORMAL RATED POWER  $T_{T5} = 1280^\circ\text{F}$   
PARTICLE SEPARATOR INSTALLED 354 RPM

NOTE: 1. STATIC CONDITIONS.

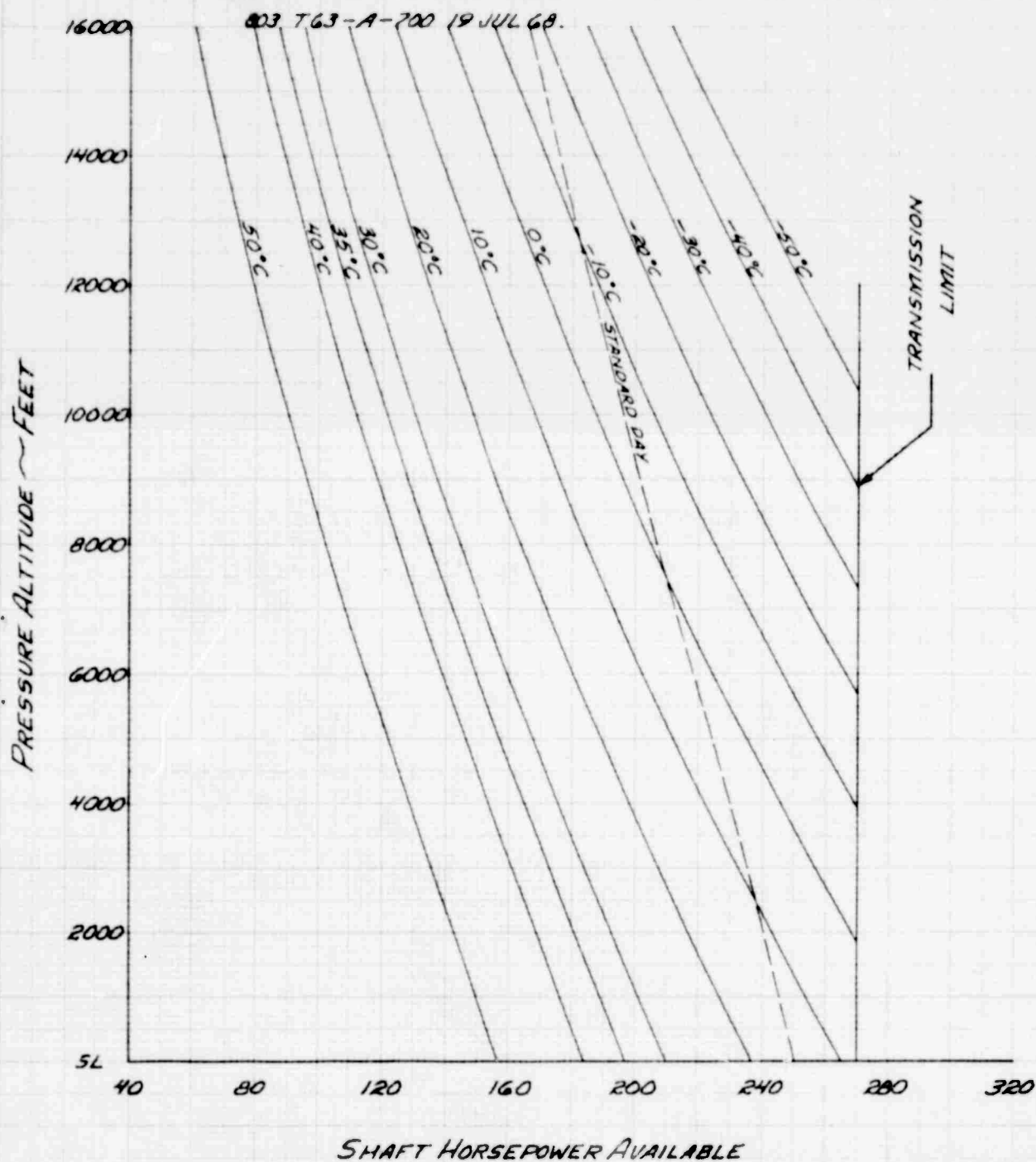
2. O BLEED AND ANTI-ICE OFF.

3. POWER EXTRACTED EQUALS 2.0 SHP.

4. INLET LOSSES BASED ON FIGS. 59 AND 60

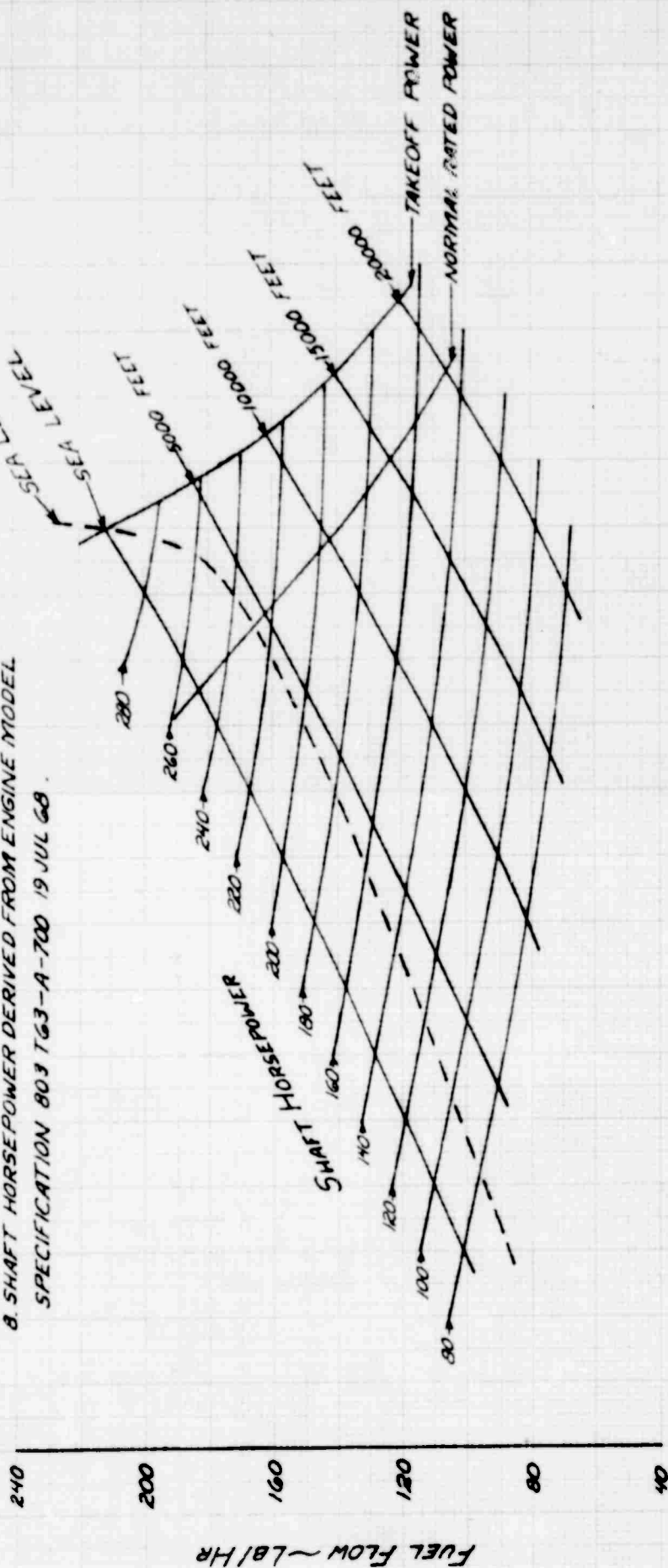
5. EXHAUST PRESSURE LOSS IS 1.16 INCHES OF  $\text{H}_2\text{O}$ , FIG. 61

6. SHAFT HORSEPOWER DERIVED FROM ENGINE MODEL SPECIFICATION



# FIGURE 72 FUEL FLOW T63-A-700 ENGINE STANDARD DAY

NOTE: 1. FUEL FLOW BASED ON ALLISON MODEL SPECIFICATION NO. 803, MODEL T63-A-700, 19 JUL 68.  
2. SOLID LINE DENOTES PARTICLE SEPARATOR INSTALLED.  
3. STATIC CONDITIONS.  
4. 0 BLEED AND ANTI-ICE OFF.  
5. POWER EXTRACTED EQUALS 2.0 SHP.  
6. INLET LOSSES BASED ON FIGS. 59 AND 60.  
7. EXHAUST PRESSURE LOSS IS 1.16 INCHES OF H<sub>2</sub>O, FIG 61.  
8. SHAFT HORSEPOWER DERIVED FROM ENGINE MODEL SPECIFICATION 803 T63-A-700 19 JUL 68.



## APPENDIX VII. SYMBOLS AND ABBREVIATIONS

| <u>SYMBOL</u>     | <u>DEFINITION</u>                                                                                                                                                  |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $\delta_a$        | Pressure ratio based on ambient condition                                                                                                                          |
| $\delta_t$        | Pressure ratio based on test condition                                                                                                                             |
| $\Delta$          | Difference in value                                                                                                                                                |
| $\Delta CIP_{ic}$ | Indicated compressor inlet pressure difference ( $P_{T_2} - P_a$ ) corrected for instrument error (in. of Hg)                                                      |
| $\Delta C_p$      | Excess power between installed test aircraft power available minus horsepower required to hover at a reference skid height; nondimensional factor for excess power |
| $\Delta H_{PC}$   | Altimeter position error                                                                                                                                           |
| $\Delta R/C_p$    | Difference in rate of climb due to power differences                                                                                                               |
| $\Delta R/C_w$    | Difference in rate of climb due to weight                                                                                                                          |
| $\Delta SHP$      | Difference in standard shaft horsepower available and test shaft horsepower measured                                                                               |
| $\Delta T$        | Temperature difference ( $^{\circ}C$ )                                                                                                                             |
| $\Delta V_{PC}$   | Airspeed position error                                                                                                                                            |
| $\mu$             | Airspeed ratio; nondimensional unit of airspeed                                                                                                                    |
| $\rho$            | Density; air density                                                                                                                                               |
| $\rho_s$          | Standard-day density                                                                                                                                               |
| $\rho_t$          | Test-day density                                                                                                                                                   |
| $\sigma$          | Density ratio                                                                                                                                                      |

| <u>SYMBOL</u>         | <u>DEFINITION</u>                                                                           |
|-----------------------|---------------------------------------------------------------------------------------------|
| $\sigma_s$            | Standard-day air density ratio at the test indicated altitude                               |
| $\sqrt{\sigma}_{avg}$ | Average density ratio at the average density altitude                                       |
| $\theta_t$            | Temperature ratio based on test condition                                                   |
| $A$                   | Main rotor disc area                                                                        |
| $a_{SL}$              | 661.48 knots                                                                                |
| $C_1$                 | Shaft horsepower correction factor                                                          |
| $C_2$                 | Gas producer and turbine outlet total temperature correction factor                         |
| $C_3$                 | Fuel-flow correction factor                                                                 |
| $C_P$                 | Power coefficient; nondimensional unit of power; coefficient of power                       |
| $C_{P_s}$             | Power coefficient based on standard condition                                               |
| $C_{P_t}$             | Power coefficient based on test condition                                                   |
| $CIT; T_{T_2}$        | Compressor inlet total temperature                                                          |
| $CIT_{ic}$            | Indicated compressor inlet total temperature corrected for instrument error ( $^{\circ}C$ ) |
| cps                   | Cycles per second                                                                           |
| $C_T$                 | Thrust coefficient; nondimensional unit of thrust or weight; coefficient of thrust          |
| $C_{T_s}$             | Thrust coefficient based on standard condition                                              |

SYMBOLDEFINITION

|                    |                                                                                                             |
|--------------------|-------------------------------------------------------------------------------------------------------------|
| $C_{T_t}$          | Thrust coefficient based on test condition                                                                  |
| $^{\circ}\text{C}$ | Degree(s) centigrade                                                                                        |
| $^{\circ}\text{F}$ | Degree(s) Fahrenheit                                                                                        |
| $^{\circ}\text{K}$ | Degree(s) Kelvin                                                                                            |
| $\frac{dhp}{dt}$   | Slope of pressure altitude versus time curve at a given pressure altitude                                   |
| $F_e$              | Equivalent flat plate area                                                                                  |
| FU                 | Fuel used                                                                                                   |
| GR                 | Gear ratio of the output shaft rotational speed to the main rotor rotational speed                          |
| GW                 | Gross weight                                                                                                |
| $GW_s$             | Standard gross weight                                                                                       |
| $GW_t$             | Test gross weight                                                                                           |
| $H_D$              | Density altitude                                                                                            |
| $H_P$              | Pressure altitude                                                                                           |
| Hz                 | Hertz                                                                                                       |
| in. of Hg          | Inches of mercury                                                                                           |
| in. of $H_2O$      | Inches of water                                                                                             |
| $K_p$              | Power correction factor; coefficient of power correction; correction factor for variation in power          |
| $K_t$              | Conversion factor to change measured engine torque pressure (psi) to ft-lb                                  |
| $K_w$              | Weight correction factor; coefficient of weight correction; correction factor for variation in gross weight |

| <u>SYMBOL</u>              | <u>DEFINITION</u>                                                                                      |
|----------------------------|--------------------------------------------------------------------------------------------------------|
| $M_{N_{tip}}$              | Advancing tip Mach; advancing tip Mach number                                                          |
| $N_1$                      | Gas producer speed                                                                                     |
| $N_{1_t}; \sqrt{\theta_t}$ | Referred gas producer speed at test condition                                                          |
| $N_2$                      | Power turbine speed                                                                                    |
| $N_R$                      | Main rotor speed                                                                                       |
| $P_a$                      | Ambient total pressure                                                                                 |
| $P_{a_c}$                  | $P_a$ at the indicated pressure altitude plus $\Delta P_a$ for altitude position error using formula 7 |
| $P_{S_7}$                  | Exhaust pressure                                                                                       |
| $P_{T_2}$                  | Compressor inlet total pressure                                                                        |
| $R$                        | Radius; main rotor radius                                                                              |
| $R/C$                      | Rate of climb                                                                                          |
| $R/C_s$                    | Standard rate of climb; final rate of climb standard                                                   |
| $R/C_T$                    | Tapeline rate of climb                                                                                 |
| $R/D$                      | Rate of descent                                                                                        |
| $R/D_T$                    | Tapeline rate of descent                                                                               |
| $S$                        | Course length                                                                                          |
| $SHP_{avail}$              | Shaft horsepower available for the installed test engine at takeoff atmospheric conditions             |
| $SHP_{req}$ at 2 ft        | Shaft horsepower required for a 2-foot hover skid height at takeoff atmospheric conditions             |

| <u>SYMBOL</u>        | <u>DEFINITION</u>                                                                     |
|----------------------|---------------------------------------------------------------------------------------|
| $\text{SHP}_s$       | Standard shaft horsepower obtained from a model specification engine                  |
| $\text{SHP}_t$       | Test shaft horsepower obtained from a model specification engine                      |
| S/N                  | Serial number                                                                         |
| S/S                  | Sideslip angle                                                                        |
| t                    | Time required to travel the course distance                                           |
| $T_{a_{ic}}$         | Indicated ambient temperature corrected for instrument error                          |
| TOP                  | Takeoff power                                                                         |
| TOT; $T_{t_2}$       | Turbine outlet temperature                                                            |
| TOT; $T_{T_5}$       | Turbine outlet total temperature                                                      |
| TRQ                  | Torque                                                                                |
| $T_t$                | Test ambient air temperature at the pressure altitude at which the slope is taken     |
| $T_{T_5} ; \theta_t$ | Referred turbine outlet total temperature                                             |
| $T_s$                | Standard ambient air temperature at the pressure altitude at which the slope is taken |
| $V_{cal}$            | Calibrated airspeed                                                                   |
| $V_{cal_{bomb}}$     | Bomb system indicated airspeed corrected for instrument error                         |
| $V_{cal_{std}}$      | Standard calibrated airspeed obtained from the ground speed course                    |
| $V_{IC}$             | Test system indicated airspeed corrected for instrument error                         |

SYMBOLDEFINITION

|                 |                                                               |
|-----------------|---------------------------------------------------------------|
| $V_{IC_{test}}$ | Test system indicated airspeed corrected for instrument error |
| $V_{NE}$        | Never exceed airspeed                                         |
| $V_T$           | True airspeed                                                 |
| $W$             | Gross weight; aircraft gross weight                           |
| $W_f$           | Fuel flow; fuel-flow rate                                     |
| $W_s$           | Standard-day gross weight                                     |
| $W_t$           | Test-day gross weight                                         |
| $W/\rho$        | Gross weight divided by density                               |

ABBREVIATIONDEFINITION

|             |                                 |
|-------------|---------------------------------|
| AC          | Alternating current             |
| AVG, avg    | Average                         |
| BHC         | Bell Helicopter Company         |
| CG, cg      | Center of gravity               |
| DC          | Direct current                  |
| deg         | Degree/degrees                  |
| FAA         | Federal Aviation Administration |
| fig., figs. | Figure, figures                 |
| fpm         | Foot/feet per minute            |
| FS          | Fuselage station                |
| ft          | Foot/feet                       |
| fwd         | Forward                         |
| GRWT, grwt  | Gross weight                    |

ABBREVIATIONDEFINITION

|          |                                      |
|----------|--------------------------------------|
| hr, hrs  | Hour, hours                          |
| in.      | Inch/inches                          |
| KCAS     | Knots calibrated airspeed            |
| KTAS     | Knots true airspeed                  |
| lb       | Pound/pounds                         |
| LOH      | Light observation helicopter         |
| MAX, max | Maximum                              |
| MIN, min | Minimum                              |
| MRP      | Military rated power                 |
| NAMPP    | Nautical air miles per pound of fuel |
| NAMT     | Nautical air miles traveled          |
| NRP      | Normal rated power                   |
| OAT      | Outside air temperature              |
| OGE      | Out of ground effect                 |
| rpm      | Revolutions per minute               |
| SHP, shp | Shaft horsepower                     |
| SL       | Sea level                            |

SUBSCRIPTDEFINITION

|     |                        |
|-----|------------------------|
| a   | Ambient                |
| s   | Standard; standard day |
| std | Standard               |
| t   | Test; test day         |
| T   | Tapeline               |
| 1   | Reciprocal heading     |
| 2   | Reciprocal heading     |

## APPENDIX VIII. DISTRIBUTION

| <u>Agency</u>                          | <u>Test<br/>Plans</u> | <u>Interim<br/>Reports</u> | <u>Final<br/>Reports</u> |
|----------------------------------------|-----------------------|----------------------------|--------------------------|
| Commanding General                     |                       |                            |                          |
| US Army Aviation Systems Command       |                       |                            |                          |
| ATTN: AMSAV-R-F                        | 5                     | 5                          | 6                        |
| AMSAV-C-A                              | -                     | -                          | 2                        |
| AMSAV-D-ZDOR                           | -                     | -                          | 2                        |
| AMSAV-D-W                              | -                     | -                          | 2                        |
| AMSAV-R-R                              | -                     | -                          | 1                        |
| PO Box 209                             |                       |                            |                          |
| St. Louis, Missouri 63166              |                       |                            |                          |
|                                        |                       |                            |                          |
| Commanding General                     |                       |                            |                          |
| US Army Materiel Command               |                       |                            |                          |
| ATTN: AMCPM-LH                         | 5                     | 1                          | 5                        |
| PO Box 209                             |                       |                            |                          |
| St. Louis, Missouri 63166              |                       |                            |                          |
|                                        |                       |                            |                          |
| Commanding General                     |                       |                            |                          |
| US Army Materiel Command               |                       |                            |                          |
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| St. Louis, Missouri 63166              |                       |                            |                          |
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| Commanding General                     |                       |                            |                          |
| US Continental Army Command            |                       |                            |                          |
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| <u>Agency</u>                                                                                            | <u>Test<br/>Plans</u> | <u>Interim<br/>Reports</u> | <u>Final<br/>Reports</u> |
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| 5. AUTHOR(S) (First name, middle initial, last name)<br>GEORGE M. YAMAKAWA, Project Engineer<br>JOSEPH C. WATTS, Project Officer/Pilot                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |  |                                                                                                                                                          |                      |
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| 13. ABSTRACT<br><br>Performance tests were conducted on a production OH-58A helicopter to determine compliance with performance guarantees outlined in the detail specification and approved revisions, and also to provide information for the operator's manual. Testing was performed by the US Army Aviation Systems Test Activity, Edwards Air Force Base, California, during the period between 19 August 1969 and 13 January 1970. The testing consisted of 99 flights totaling 62.5 productive hours. The OH-58A met or exceeded all of the contractual performance guarantees. The engine inlet loses with the particle separator installed exceeded the limits of the detail specification. A single flight at cold temperatures indicated that level flight performance is significantly affected by compressibility. Although all contractual hover performance guarantees were met, the helicopter could not hover out of ground effect on a 95°F day at gross weights greater than 2930 pounds with the particle separator installed. Under moderate temperature conditions, the performance capabilities of the OH-58A are satisfactory for mission accomplishment. It is recommended that consideration be given to increasing the utility of the OH-58A by installing a more powerful engine. |  |                                                                                                                                                          |                      |

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|-------------------------------------------------------------|--------|----|--------|----|--------|----|
|                                                             | ROLE   | WT | ROLE   | WT | ROLE   | WT |
| OH-58A helicopter<br>Performance test<br>Particle separator |        |    |        |    |        |    |

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