U.S. ARMY

TEST & EVALUATION COMMAND

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USATECOM PROJECT NO. 4-3-0150-10

FINAL REPORT of ENGINEERING TEST of THE YT53-L-13 ENGINE INSTALLED IN THE UH-1D HELICOPTER

MARCH 1965

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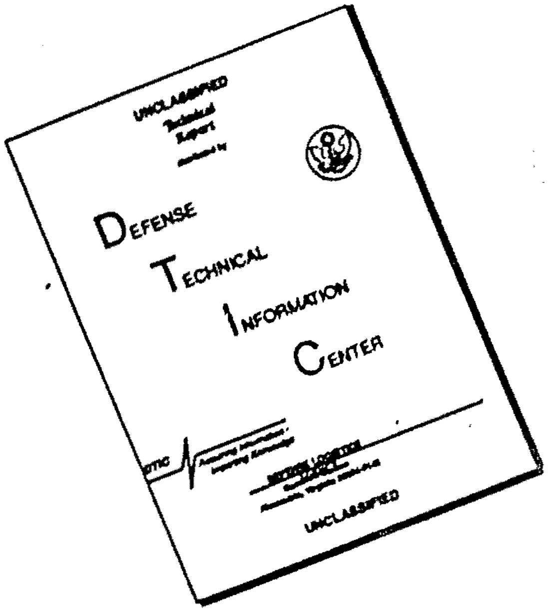

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U.S. ARMY AVIATION TEST ACTIVITY

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FINAL REPORT of ENGINEERING TEST of THE YT53-L-13 ENGINE INSTALLED IN THE UH-1D HELICOPTER

USATECOM PROJECT NO.4-3-0150-10

USAATA PROJECT NO.64-20-1

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AUTHENTICATED BY:

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Lieutenant Colonel, TC
Commanding

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ABSTRACT

Limited engineering tests were conducted to determine the performance characteristics of the YT53-L-13 gas turbine engine installed in the UH-1D helicopter. The tests were also conducted to determine the approximate additional performance available from a UH-1D when equipped with the YT53-L-13 engine.

The US Army Aviation Test Board (USAAVNTBD) was designated as Executive Test Agency, responsible for conduct of the limited Phase E evaluation and the US Army Aviation Test Activity (USAAVNTA) was designated as Participating Test Authority, responsible for conduct of the engineering tests.

Engineering flight tests were conducted by USAAVNTA at the Contractor's facility in Fort Worth, Texas, during the period 19 January through 28 January 1965. A total productive test time of 7.9 hours was flown.

Specific fuel consumption characteristics were found to be higher than those presented in the Engine Model Specification.

Engine characteristics were found to be generally satisfactory during climb and level flight tests. The engine critical altitude (altitude at which maximum power cannot be maintained) was found to be 12,000 feet at standard-day conditions.

The climb tests, which were conducted at takeoff gross weights of 8600 and 9500 pounds, showed a decrease of rate of climb from predicted values, at approximately 7000 and 5000 feet, respectively. This decrease in climb performance was due to a deterioration of the rotor characteristics, since the engine was capable of delivering full power up to 12,000 feet.

1 General

1.1 REFERENCES

a. Letter, Bell Helicopter Company, 11 April 1963, subject: "Proposal for the Installation and Test of a Lycoming LTCIK-3 Alternate Engine for the UH-1D."

b. Letter, Bell Helicopter Company, 2 May 1963, subject: "UH-1D Alternate Engine Proposal - Twin Turbine Continental T-72."

c. Letter, AMCPM-IR, Headquarters, US Army Materiel Command, 29 July 1963, subject; "Evaluation of Alternate Engine Installation in the UH-1D Helicopter," with 1st Indorsement, AMSTE-BG, Headquarters, US Army Test and Evaluation Command, 28 August 1963.

d. Message, Unclas 10-1015, AMCPM-IR, Headquarters, US Army Materiel Command, 4 October 1963.

e. Plan of Test, USATECOM Project No. 4-4-0150-10, "Evaluation of Alternate Engine Installation in the UH-1D Helicopter," US Army Aviation Test Board, undated.

f. Letter, AMCPM-IR-T, Headquarters, US Army Materiel Command 8 July 1964, subject: "USATECOM Plan of Test, Project No. 4-3-0150-10, Evaluation of Alternate Engine Installation in the UH-1D Helicopter," undated, with 1st Indorsement, AMSTE-BG, Headquarters, US Army Test and Evaluation Command, 20 August 1964.

g. Letter, STEBG-TPAC, US Army Aviation Test Board, 24 September 1964, subject:"Change to Evaluation of Alternate Engine Installation Plan of Test for UH-1D Helicopter," USATECOM Project No. 4-4-0150-10.

h. Letter, STEAV-P, US Army Aviation Test Activity, 18 September 1964, subject:"Engineering Plan of Test of the LTCIK-4 Engine Installed in the UH-1D Helicopter, USATECOM Project No. 4-3-0150-10," with Inclosure 1,"USATECOM Project No. 4-3-0150-10, Engineering Plan of Test of the LTCIK-4 Engine Installed in the UH-1D Helicopter," September 1964.

i. Letter, STEAV-PO, US Army Aviation Test Activity, 3 November 1964, subject:"Evaluation of the Alternate Engine Installation Using the T-72 Engine Installed in the UH-1D, USATECOM Project No. 4-3-0150-10."

j. Letter, AMCPM-IR-T, Headquarters, US Army Materiel Command, 28 December 1964, subject:"USATECOM Plan of Test, Project No. 4-3-0150-10. Engineering Plan of Test of the LTCIK-4 Engine Installed in the UH-1D Helicopter," with 1st Indorsement, AMSTE-BG, Headquarters, US Army Test and Evaluation Command, 13 January 1965.

k. FTC-TDR-64-27, "Category II Performance Tests of the YHU-1D with a 48-Foot Rotor," US Air Force Flight Test Center, November 1964.

l. Model Specification,YT-53-L-13,"Shaft Turbine Engine (Lycoming Model LTCIK-4),"Specification Number 104.24-A, 1 August 1963.

1.2 AUTHORITY

Letter, AMCPM-IR-T, Headquarters, US Army Materiel Command, 8 July 1964, subject: "USATECOM Plan of Test, Project No. 4-3-0150-10, Evaluation of Alternate Engine Installation in the UH-1D Helicopter," undated, with 1st Indorsement, AMSTE-BG, Headquarters, US Army Test and Evaluation Command, 20 August 1964

1.3 OBJECTIVE

The objective of this limited test was to determine the performance characteristics of the YT53-L-13 engine installed in the UH-1D helicopter.

1.4 RESPONSIBILITIES

1.4.1 The US Army Aviation Test Board (USAAVNTBD) was assigned responsibility for coordinating the test plan preparation, executing the limited serviceability testing, and coordinating the test reporting.

1.4.2 The US Army Aviation Test Activity (USAAVNTA) was assigned responsibility for coordinating the planning and reporting of the engineering portion of the test with USAAVNTBD and executing this portion of the test.

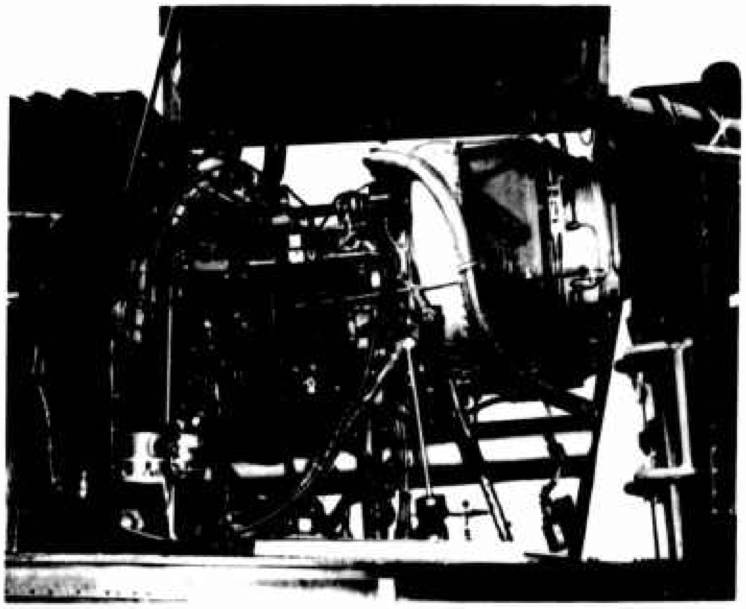
1.5 DESCRIPTION OF MATERIEL

The TY53-L-13 is a turbine engine rated at 1400 thermodynamic/1100 shaft horsepower. The engine has the same physical envelope and is interchangeable with the T53-L-11 engine currently installed in the UH-1D helicopter.

The YT53-L-13 engine performance ratings were changed during the test period. The following table presents a list of the performance ratings at sea level static conditions as revised from the original Engine Model Specification (Reference 1.1.1):

Ratings	Shaft Horsepower (shp)	Specific Fuel Consumption lb/shp/hr	Measured Rated Exhaust Gas Temperature °C
Military (30 min)	1400	0.580	593
Normal Rated	1250	0.590	567

PHOTO NO. 1
YT53-L-13 ENGINE



The test aircraft was a UH-1D helicopter with a 48-foot rotor. Sensitive instruments were installed on the pilot's and copilot's instrument panels. The test pitot-static system was attached to a 7-foot boom that was mounted on the nose of the aircraft.

PHOTO NO. 2 - UH-1D

1.6 BACKGROUND

1.6.1 The Army has a continuing requirement to attain the optimum potential from all equipment in the inventory. The ultimate usefulness of the UH-1D helicopter could be enhanced by an improvement in the hovering and climb capabilities.

1.6.2 In April and May 1963, Bell Helicopter Company submitted proposals to install and evaluate a YT53-L-13 as an alternate power plant for the UH-1D helicopter. The power plant manufacturer's test data indicated that the UH-1D hovering capability, climb performance, acceleration, and/or throttle response would be improved with the alternate power package.

1.6.3 The Iroquois Project Manager (AMCPM-IR-T) requested that the US Army Test and Evaluation Command accomplish engineering tests to meet the objectives previously stated.

1.7 FINDINGS

1.7.1 ENGINE STARTING CHARACTERISTICS

It was necessary to start the test engine in two phases to avoid excessive exhaust gas temperatures (EGT). Previous models had been started in a single phase.

1.7.1.1 First Phase

The first phase of the two-phase engine start consisted of the following:

a. The throttle was positioned at a point approximately 3/4 of the travel from full-off to the solenoid-operated idle detent.

b. The starter trigger switch was engaged, a light-off was observed and the start fuel was turned off at 20 percent gas producer (N_1) rpm. (Start fuel had been turned off at 25 percent N_1 in the single-phase start of previous models.)

c. The starter trigger switch was released at 45 percent N_1. (The starter trigger switch had been released at 35-42 percent in previous models.)

On completion of this first phase and without throttle manipulation, rpm stabilized at approximately 45 percent N_1. Elapsed times for this phase varied from 30 seconds for a cold engine to 20 seconds for a warm engine. Maximum observed EGT's were 460 degrees Centigrade (C) (cold engine) and 500 degrees C (warm engine). These EGT's were well below the limit of 649 degrees C. (EGT's of 650 to 760 degrees C were permitted for 5 seconds.)

1.7.1.2 Second Phase

In the second phase of the two-phase engine start, the throttle was advanced from its initial position (45 percent N_1) to the idle detent (67 percent N_1). Acceleration times and peak EGT's depended on technique. Abrupt throttle movement resulted in rapid acceleration and peak EGT's near the limit. Careful throttle handling resulted in acceleration times of 30 to 45 seconds and peak EGT's of 500 to 550 degrees C. All engine starts were performed in relatively cool ambient temperatures between 25 and 70 degrees Fahrenheit (F) and with external power.

Typical engine readings with the throttle at the solenoid-operated idle detent were as follows:

N_1	66.8 %
N_2	4200 rpm
Torque	6 psi
Engine Oil Pressure	73 psi
Transmission Oil Pressure	50 psi

1.7.2 ENGINE ACCELERATION CHARACTERISTICS

1.7.2.1 Engine Acceleration Characteristics - Ground

Typical engine readings at flat pitch and full throttle were as follows:

N_1	82.2 %
N_2	6600 rpm (Selected by governor)
EGT	500° C
Torque	12.5 psi

Three to four seconds were required to accelerate to these values from those presented in Paragraph 1.7.1

1.7.2.2 Engine Acceleration Characteristics - Airborne

Response during power recovery from autorotation (near flat pitch) was satisfactorily rapid with needles joining coincidentally with throttle movement. The rate at which N_1 rpm increased during full-throttle collective application was rapid and satisfactorily uniform below 10,000 feet. At higher altitudes, acceleration through the rpm range from 80 to 88 percent was noticeably slower than at lower and higher rpm's but was acceptable.

PHOTO NO. 3 - PHOTO RECORDER

1.7.3 BLEED BAND OPERATION

The increased compressor ratio of the YT53-L-13 engine has made the operation of the compressor air bleed system more important than that used on previous models. The requirement for precise bleed scheduling has resulted in abrupt opening and closing of the bleed band; this, in turn, has resulted in abrupt changes in power. In the test installation, the sudden directional input that accompanied the power change was particularly noticeable under the following flight conditions:

a. Power Recovery from Practice Autorotation

An abrupt but controllable right yaw occurred as collective was applied to stop the descent.

b. Light-Weight, Low-Speed (20 to 50 knots indicated airspeed (KIAS)) Level Flight

Small but abrupt yaw inputs occasionally accompanied small changes in collective.

c. Air Taxiing at Light Weights in Light Turbulence

The collective changes made

necessary by wind and turbulence caused bleed band actuation and directional deviation that tended to make precise control of heading and height more difficult.

1.7.4 EMERGENCY FUEL CONTROL OPERATION

When emergency fuel control was used, engine readings with the throttle at the idle detent were as follows:

N_1	45.4 %
N_2	2550 rpm
EGT	440° C
Torque	2 psi

When emergency fuel control was used, throttle sensitivity during hovering and transitioning to forward cruising flight did not appear to differ from that of previous models and was acceptable.

1.7.5 TORQUEMETER

Because the YT53-L-13 has over 25 percent more power at sea-level standard-day conditions than the transmission can absorb, it is capable of providing transmission limit torque over a much wider range of ambient temperatures and operating altitudes. Thus, with this engine, pilots will refer to the torquemeter as their primary power-limiting instrument on a much greater proportion of flights. The instrument's inadequate size and poor readability will, therefore, have much more operational significance. A larger and more readable instrument should be furnished as standard aircraft equipment.

1.7.6 HOVERING

Installation of the YT53-L-13 engine in the UH-1D caused the out-of-ground-effect (OGE) hovering ceiling to be increased by an average of 1200 feet. Under sea-level, standard-day conditions, the UH-1D equipped with the YT53-L-13 engine could hover OGE at a gross weight of 10,000 pounds, and in-ground-effect (IGE) (2-foot skid height) at a gross weight of 11,800 pounds. The UH-1D hovering data for IGE and OGE conditions were not available, without extrapolation, to allow calculation of hovering ceilings under standard-day conditions above 8000 feet.

1.7.7 CLIMBS

The installation of the YT53-L-13 engine increased the overall climb performance of the UH-1D over that previously obtained from the T53-L-9 engine.

The climb tests, which were conducted at takeoff gross weights of 8600 pounds and 9500 pounds, showed a decrease of rate of climb from predicted values, at approximately 7000 and 5000 feet, respectively. This decrease in climb performance was due to a deterioration of the rotor characteristics since the engine was capable of delivering full power up to 12,000 feet.

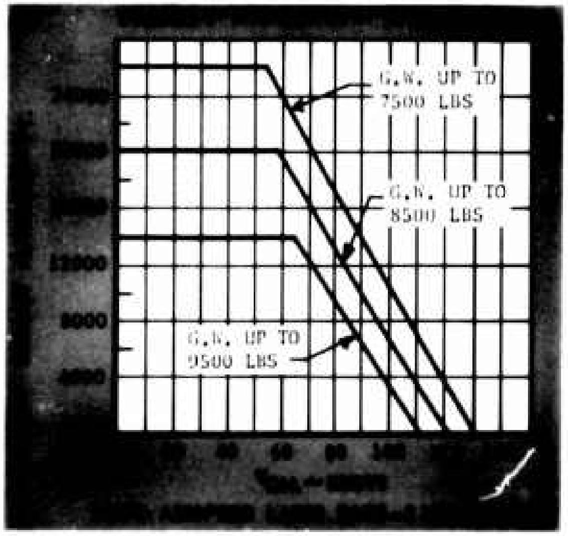
The service ceilings (altitudes at which the rate of climb is 100 feet per minute) were found to be 24,000 feet at a climb-start weight of 7000 pounds; 18,500 feet at a climb-start weight of 8600 pounds; and 15,400 feet at a climb-start weight of 9500 pounds. All climbs were corrected to the airframe manufacturer's recommended continuous torque limit of 926 foot-pounds, which is equivalent to 1160 shaft horsepower (shp) at sea-level standard-day conditions and a transmission input of 6600 rpm.

All climbs were corrected to

the maximum power available on a standard day. This power available was based on the engine contractor's temperature bias curve. A limited amount of data from the 7000-pound climbs showed a decrease of approximately 20 percent from the contractor's curve. This deviation would cause a decrease in maximum power available and, hence, a decrease in service ceiling.

1.7.8 LEVEL FLIGHT

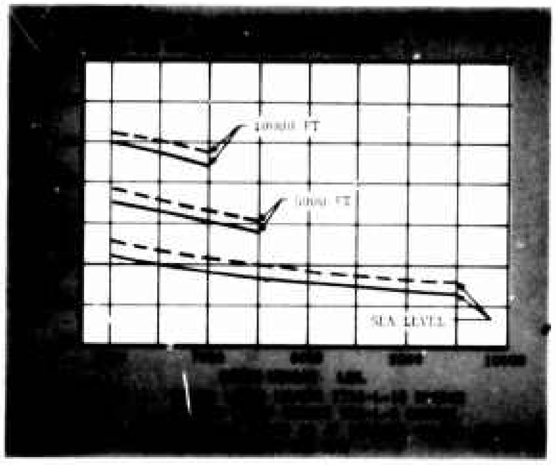
The limit airspeed flown during this test is shown in Figure 1. The airspeed envelope was furnished by the airframe manufacturer prior to the tests.



For the conditions flown, the power-required data showed good agreement with that obtained in the "Category - Type II Performance Tests of the YHU-1D with a 48-Foot Rotor" (Reference 1.1.k).

Specific range calculations were performed using the power-required data from Reference 1.1.k and the fuel-flow characteristics presented in Figure 16, Section 3, Appendix I. The recommended cruise airspeed was determined at the optimum specific range.

A comparison of the aircraft's specific range with the YT53-L-13 and the T53-L-9 engine installations is presented in Figure 2. The specific range of the YT53-L-13 was decreased by approximately 2.5 percent at sea level and 5000 feet. The specific range was decreased by approximately 2 percent at 10,000 feet. At 5000 and 10,000 feet, specific range was determined for gross weights ranging from 6000 to 8000 pounds and 6000 to 7000 pounds, respectively. The optimum specific range could not be obtained above these weights and altitudes because of airspeed limits.



A comparison of referred fuel flow versus referred shp for the YT53-L-13 and the T53-L-9 engines, Figure 16, Section 3, Appendix I, showed that at sea-level standard-day conditions the fuel flow of the YT53-L-13 engine was increased significantly when the bleed band was programmed to be in the open position at N_1 speeds less than approximately 86 percent. While the bleed band was in the open position, the engine air flow was decreased and the fuel flow and EGT's were increased.

1.8

1.8.1 The YT53-L-13 engine was found to be acceptable for installation in the UH-1D helicopter.

1.8.2 The YT53-L-13 engine installed in the UH-1D improved the following performance characteristics of the helicopter:

a. At gross weights from 6000 pounds to 8500 pounds, the OGE hover ceiling was increased by an average of 1200 feet on a 95-degree F day.

b. The OGE hover ceiling at 9500 pounds was increased from 1000 feet to 5600 feet on a standard day.

c. The standard-day climb service ceiling was increased by 4000 feet at a takeoff gross weight of 9500 pounds.

1.8.3 The YT53-L-13 engine installed in the UH-1D reduced the specific range of the helicopter under sea-level standard-day conditions.

1.9

a. The fuel-flow characteristics of the YT53-L-13 engine should be improved so that they are comparable to fuel-flow characteristics of the T53-L-9 engine. (Paragraph 1.7.8)

b. The engine fuel control should be modified to eliminate the directional control inputs, which are caused by the bleed band operation, so that the bleed band is actuated at a lower N_1 speed. (Paragraph 1.7.8)

c. Further tests should be conducted on the UH-1D to determine any detrimental effects of altitude performance resulting from the higher installed power. (Paragraph 1.7.8)

2 DETAILS and RESULTS of SUB-TESTS

2.0 INTRODUCTION

Engineering flight tests were conducted to determine the limited performance characteristics of the YT53-L-13 engine installed on the UH-1D helicopter by USAAVNTA, at the contractor's facility in Fort Worth, Texas. Thirteen flights were conducted for 7.9 productive flight hours. These tests were accomplished during the period 19 January through 28 January 1965.

These tests were conducted in non-turbulent air so that accurate performance data could be obtained. Test data were hand-recorded from sensitive instruments or recorded automatically from a photo panel.

2.1 CLIMBS

2.1.1 OBJECTIVE

Climb tests were conducted to determine the performance during climbing flight and the service ceiling at the best climb airspeed.

2.1.2 METHOD

Continuous climb performance tests were conducted from sea level to service ceiling at three gross weights. Power used for these climb tests was 1160 shp, which corresponded to the airframe contractor's maximum torque limit of 926-foot-pounds at 6600 engine rpm up to the engine critical altitude. Above critical altitude, the power used was that which corresponded to the N_1 "Topping" limit as defined by the engine contractor's temperature bias curve.

2.1.3 RESULTS

Test results are presented graphically in Figures 3 through 5, Section 3, Appendix I.

2.1.4 ANALYSIS

Presented in Paragraph 1.7.7 (Findings).

2.2 LEVEL FLIGHT

2.2.1 OBJECTIVE

Tests were conducted in level flight to determine range, endurance, and increase in maximum airspeed as a result of the YT53-L-13 engine installation in the UH-1D.

2.2.2 METHOD

Speed-power tests were conducted at various conditions of altitude, gross weight, and rotor speed. Each speed-power was flown at a constant value of gross weight/ρ. This required increasing altitude as fuel was consumed. During the tests, data were recorded in stabilized level flight at various airspeeds throughout the allowable speed range at approximately 10-knot increments to define adequately the power-required characteristics. In addition to basic power parameters, fuel-flow data were recorded.

2.2.3 RESULTS

Test results are presented graphically in Figures 7 through 11, Section 3, Appendix I.

2.2.4 ANALYSIS

Presented in Paragraph 1.7.8 (Findings).

2.3 AIRSPEED CALIBRATION

2.3.1 OBJECTIVE

The objective of this test was to determine the position error of the test airspeed system.

2.3.2 METHOD

The calibrated trailing bomb was used to obtain airspeed calibration of the test system. The airspeed from the trailing bomb was compared to the test airspeed system while the aircraft was flown in stabilized level flight.

2.3.3 RESULTS

Test results are presented graphically in Figure 12, Section 3, Appendix I.

2.3.4 ANALYSIS

The test airspeed had a position error of +3.5 KIAS.

SECTION 3

Appendices

APPENDIX I

Test Data

FIGURE No 1

HOVERING CEILING OUT OF GROUND EFFECT

UH-1D USA S/N 62-2106

48-FOOT ROTOR

ROTOR SPEED = 324 RPM

NOTES

1. DASHED CURVES DERIVED FROM FTC-TDR-64-27 (T53-L-9 ENGINE)
2. SOLID LINES BASED ON 60 FT. HOVER DATA IN FTC-TDR-64-27 AND FIG.
3. MAX ALLOWABLE GROSS WT. = 9500 LBS

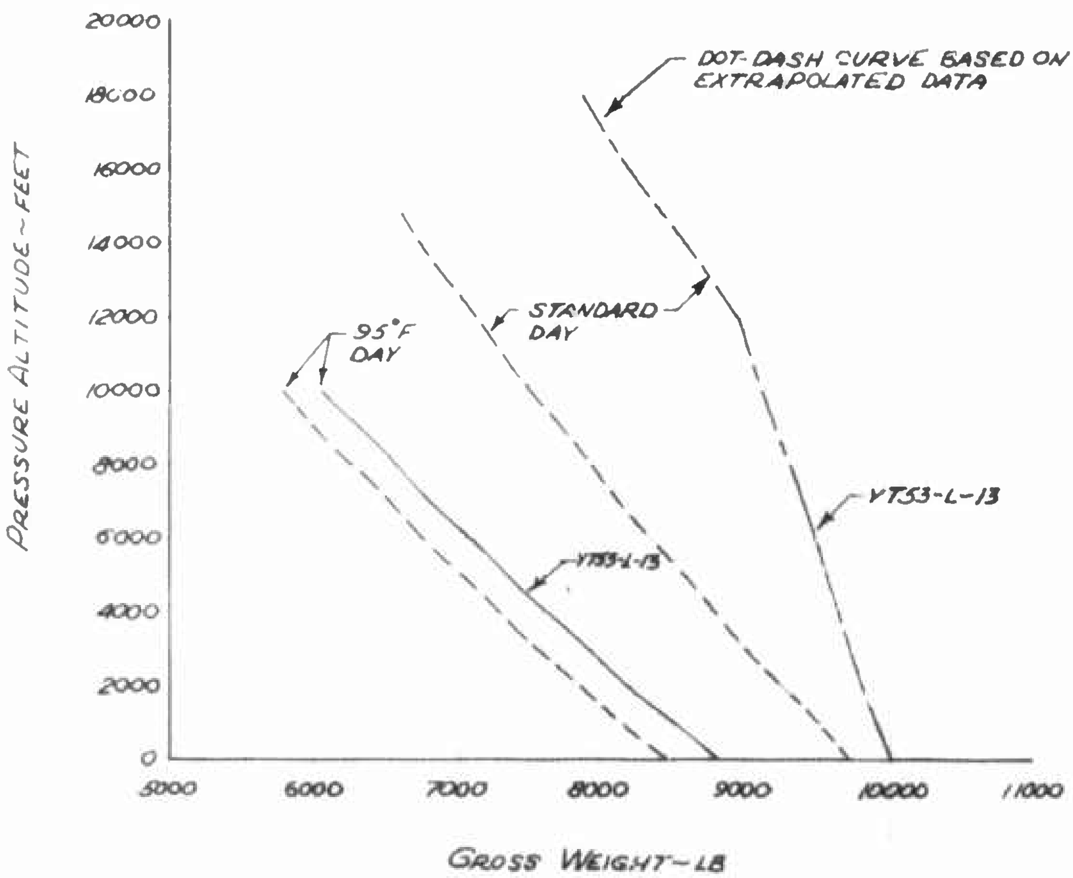


FIGURE NO 2

HOVERING CEILING IN GROUND EFFECT

UH-1D USA S/N 62-2106

48-FOOT ROTOR

STANDARD DAY

ROTOR SPEED = 324 RPM

NOTES:

1. DASHED CURVE DERIVED FROM FTC-TDR-64-27 (T53-L-9)
2. SOLID CURVE BASED ON 2 FT. HOVER DATA IN FTC-TDR-64-27 AND FIG.
3. MAX ALLOWABLE GROSS WT = 9500 LBS.

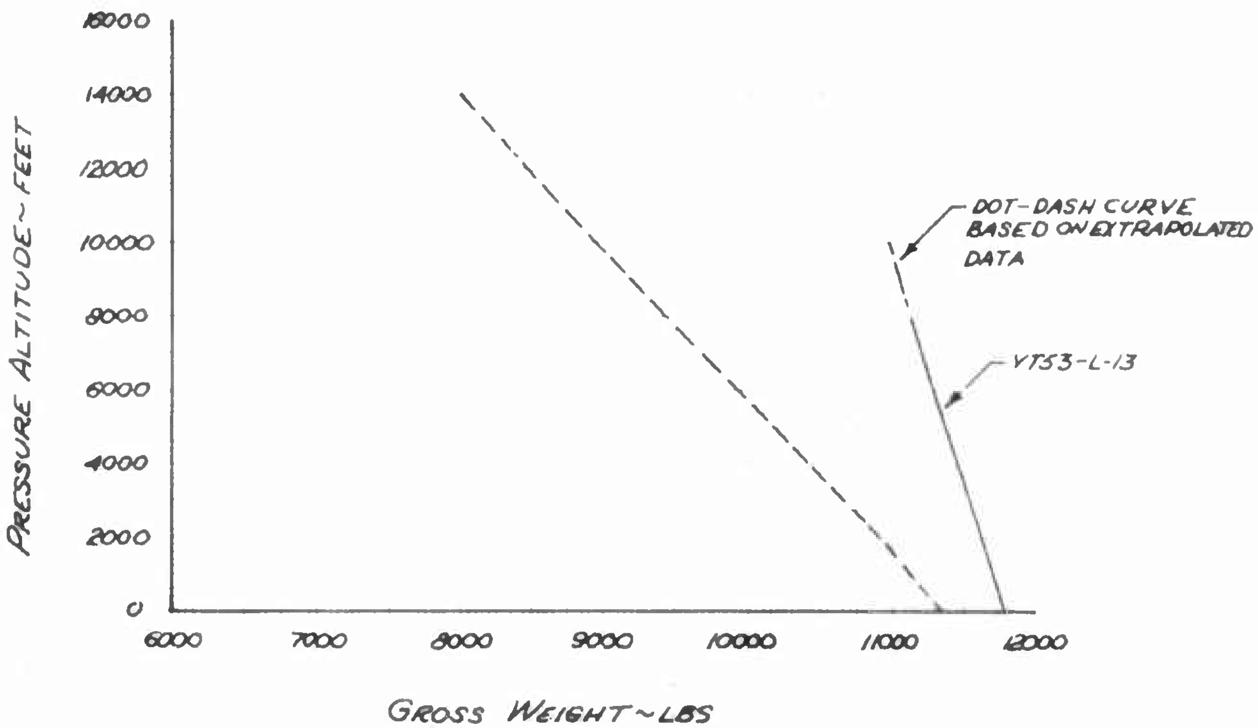


FIGURE NO 3
CLIMB PERFORMANCE
UH-1D USA S/N 62-2106
48-FOOT ROTOR YT53-L-13 ENGINE
GROSS WEIGHT - 7000 LBS CG STATION - 136.5 (MID)
ROTOR RPM - 324 STANDARD DAY

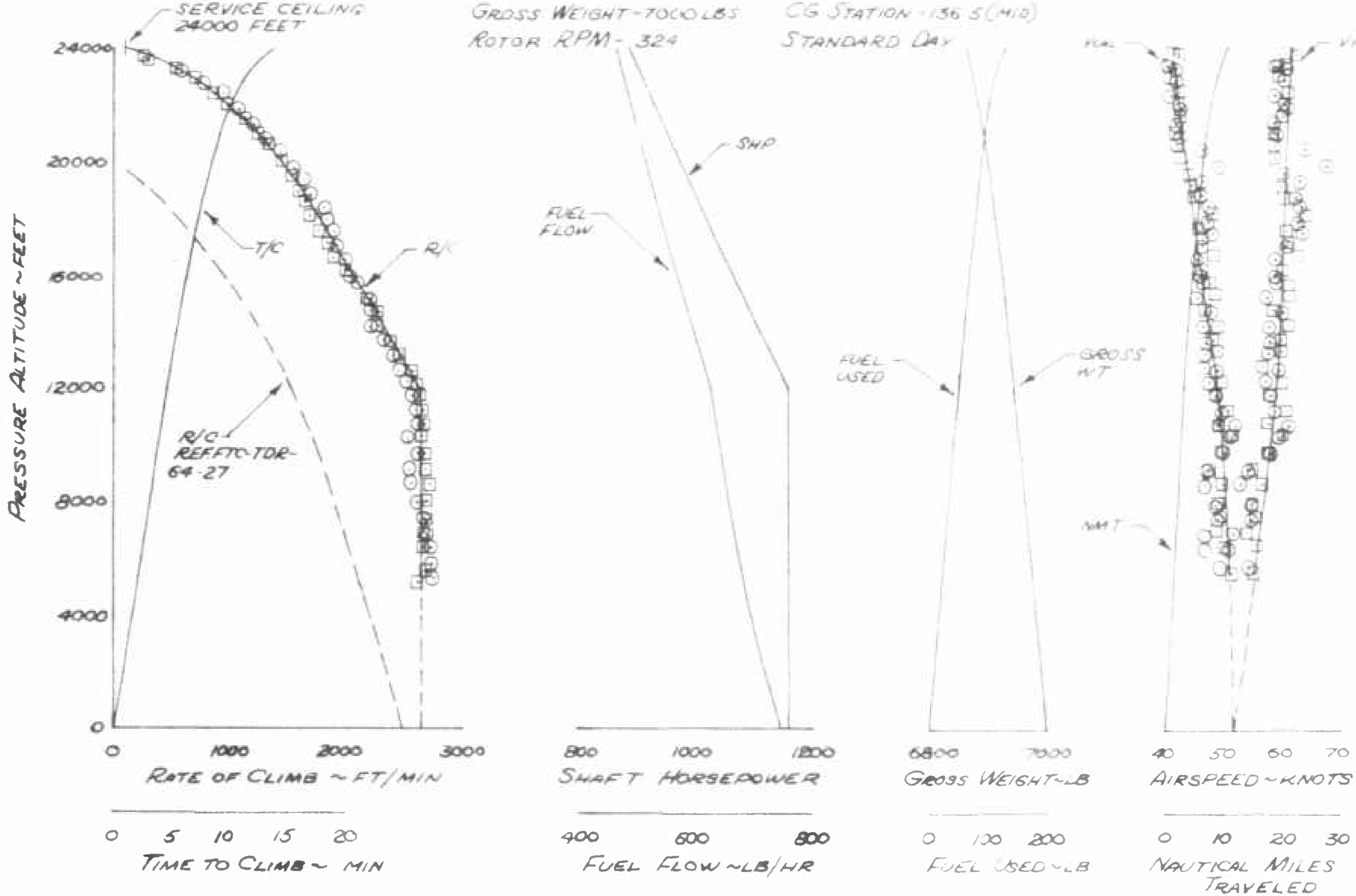


Figure No 4
Climb Performance
UH-1D USA S/N 62-2106
48-Foot Rotor
Gross Weight - 8600 LBS
Rotor RPM - 324
CG Station - 136.5 (MID)
Standard Day
YT53-L-13 Engine

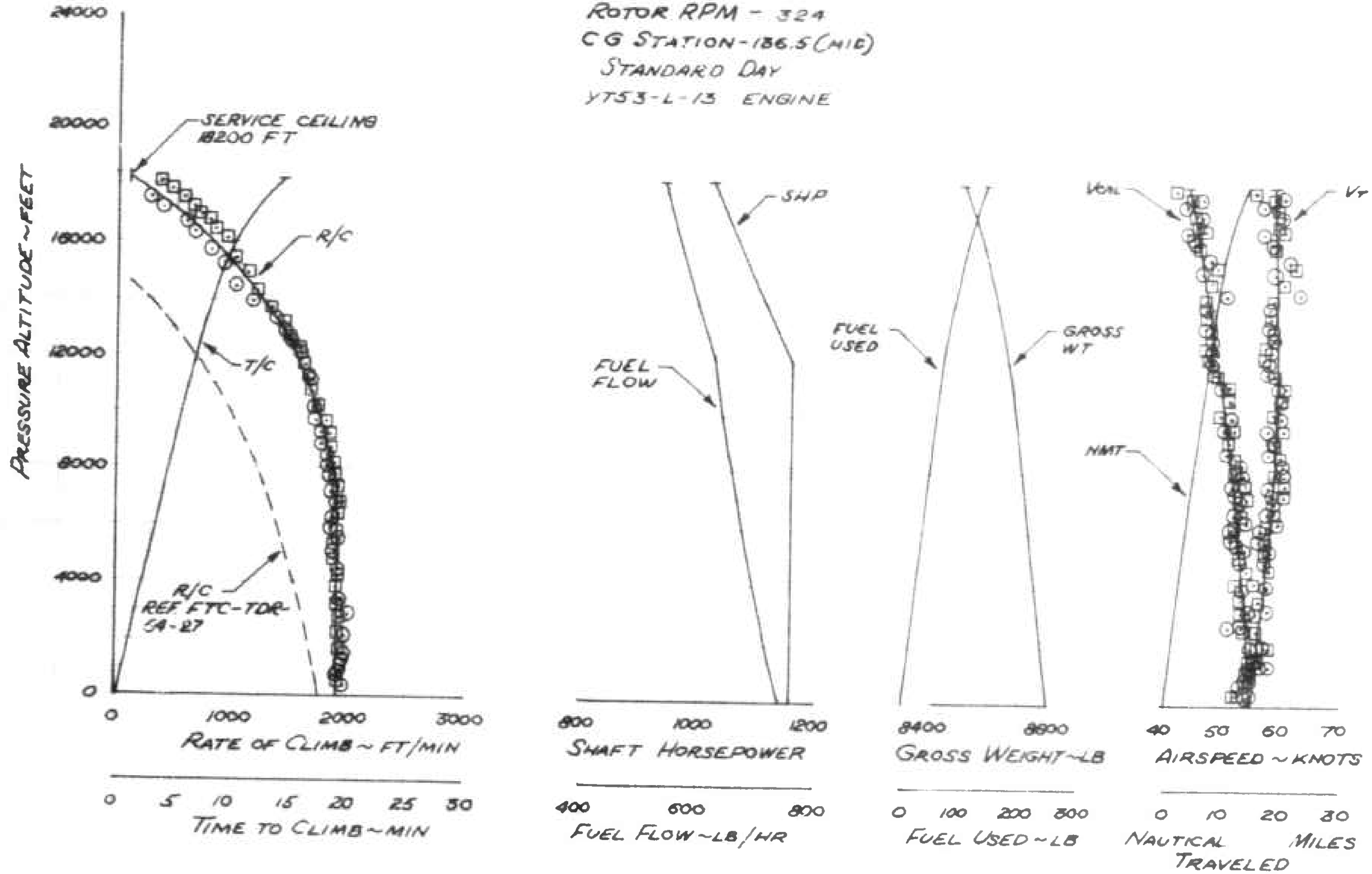


FIGURE NO 5
CLIMB PERFORMANCE
UH-1D USA S/N 62-2106
48-FOOT ROTOR
GROSS WEIGHT - 9500 LBS
ROTOR RPM -
CG STATION - 136.5 (MID)
STANDARD DAY
YT53-L-13 ENGINE

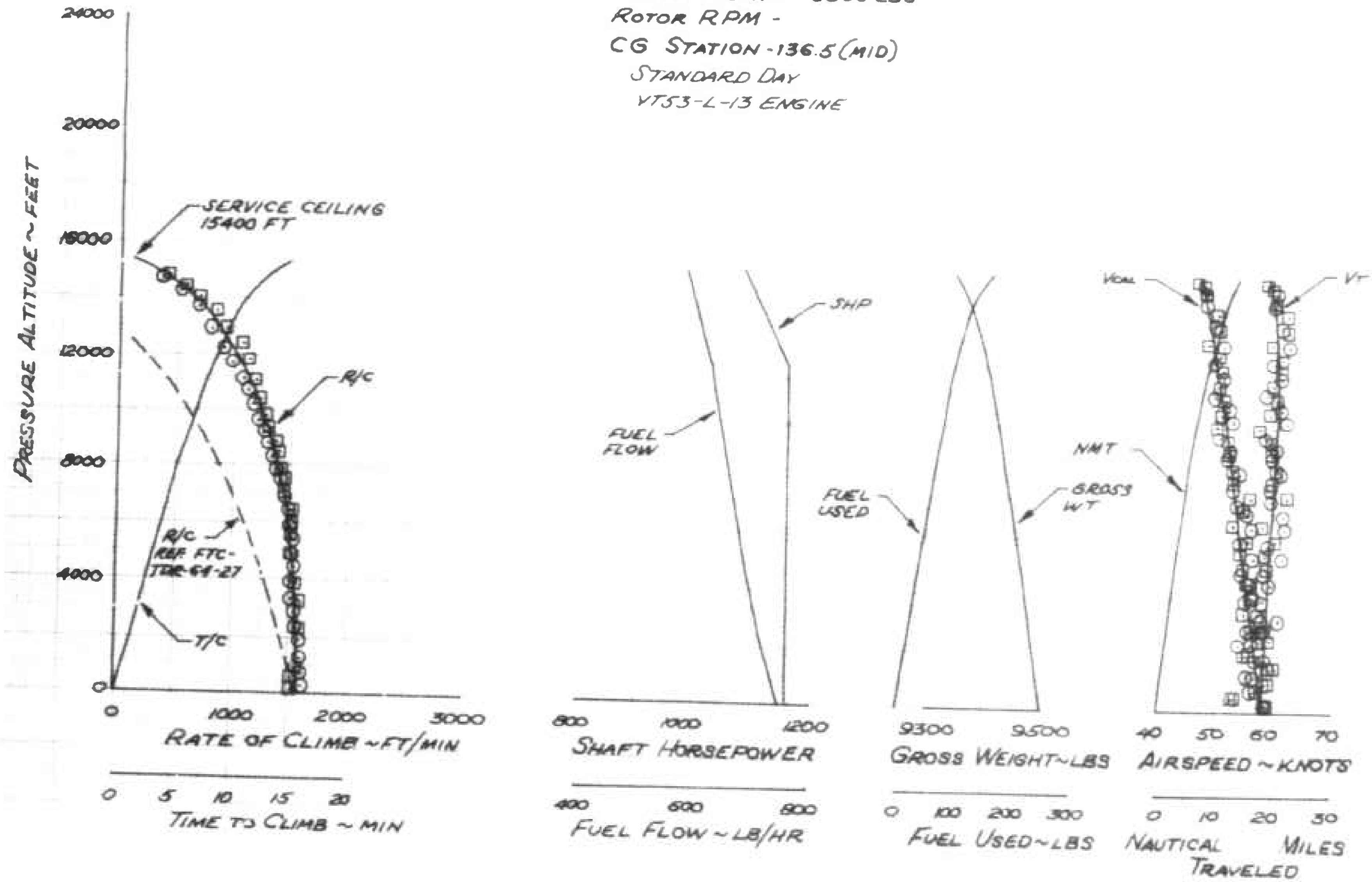


FIGURE No 6
LEVEL FLIGHT RANGE SUMMARY
UH-1D USA S/N 62-2106
48-FOOT ROTOR
ROTOR SPEED = 314 RPM
STANDARD DAY

NOTES:
1. SOLID LINES DENOTE YT53-L-13 ENGINE
2. DASHED LINES DENOTE T53-L-9 ENGINE
3. SPECIFIC RANGE IS AT OPTIMUM CRUISE AIRSPEED.
4. ROTOR SPEED = 314 RPM

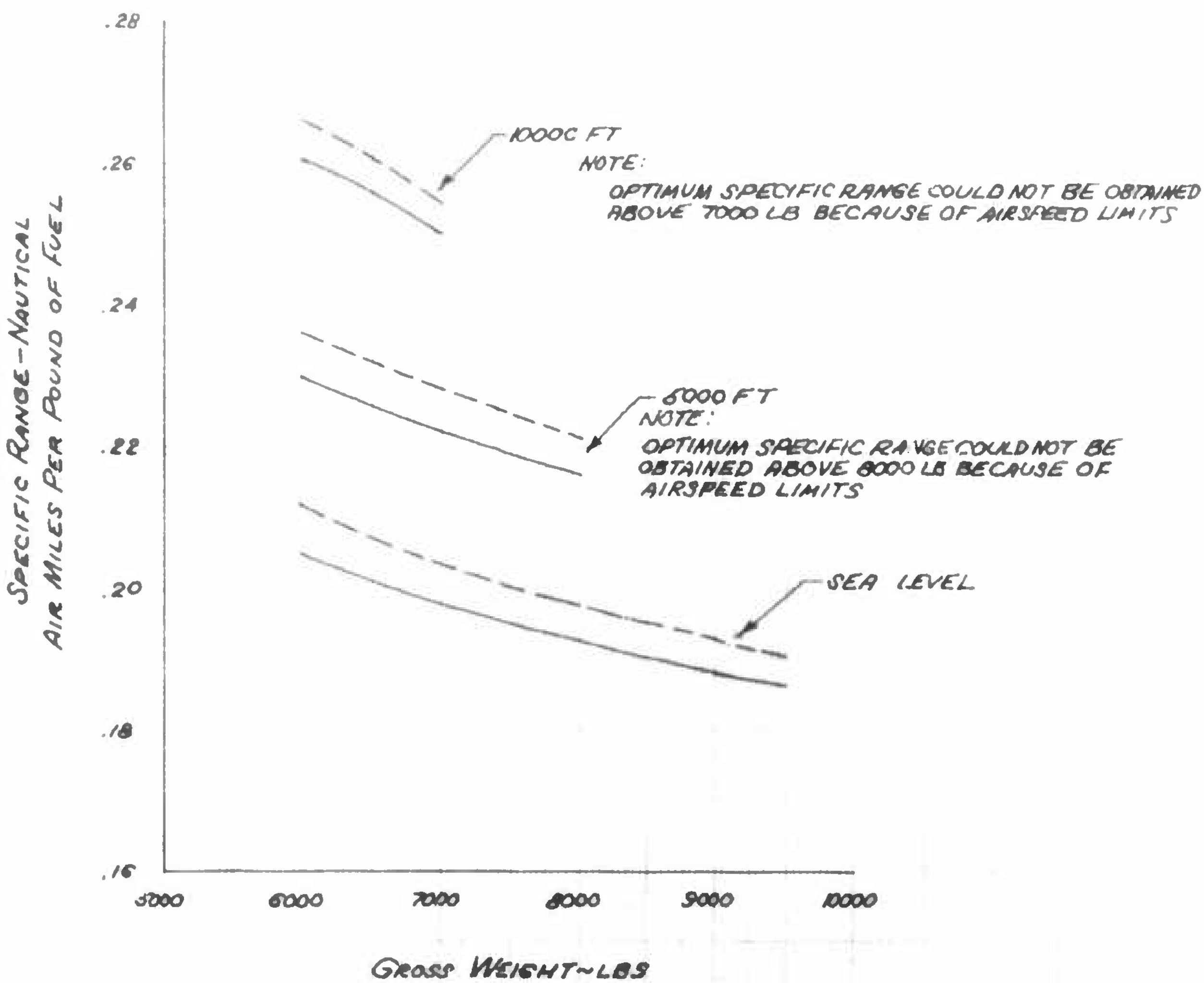


FIGURE No 7
LEVEL FLIGHT PERFORMANCE
UH-1D USA S/N 62-2106
48-FOOT ROTOR

GROSS WEIGHT	6450 LBS
ALTITUDE	2050 FT
ROTOR RPM	322
C_T	.002450
CG STATION	136.5 (MID)

YT53-L-13 ENGINE

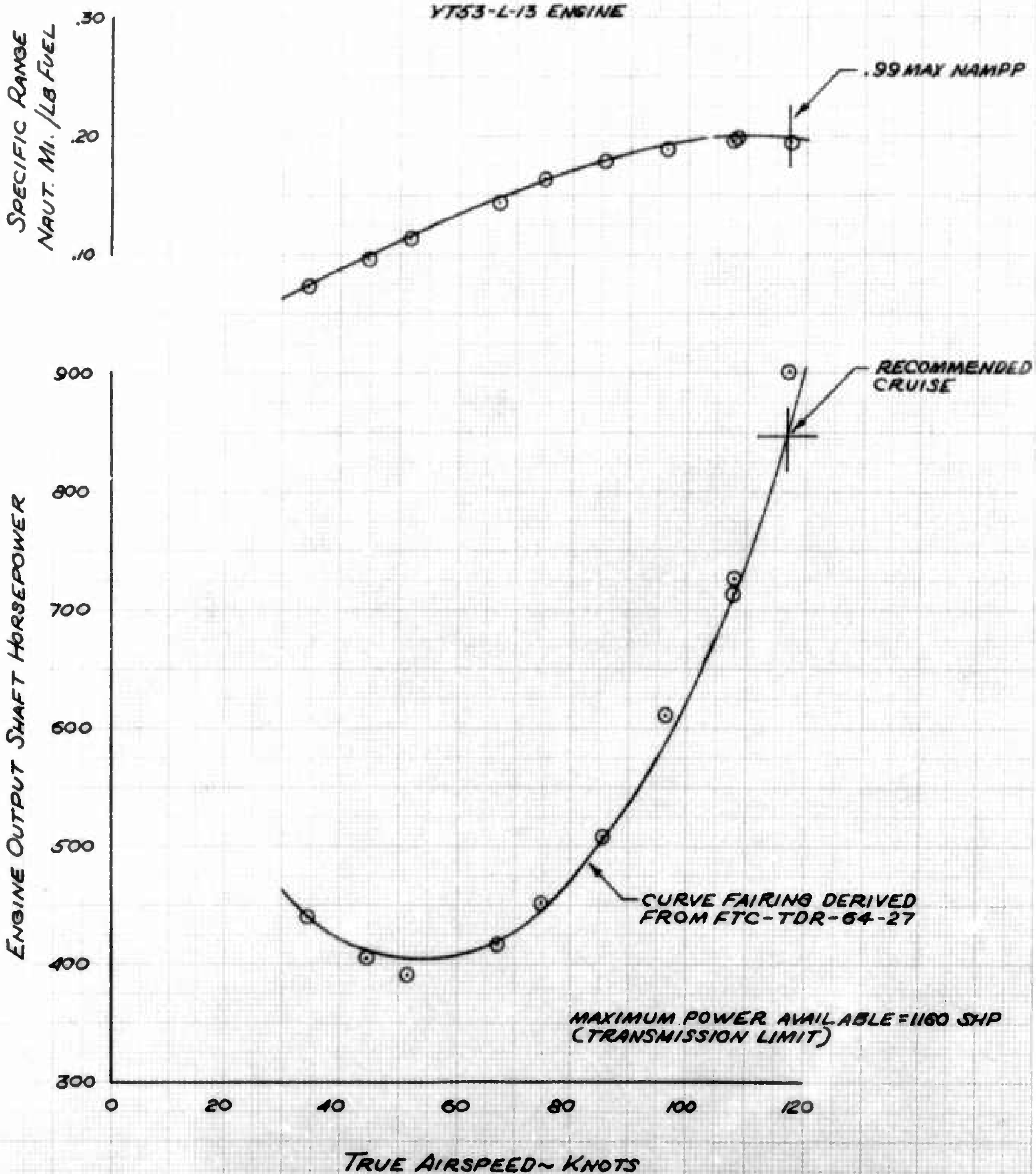
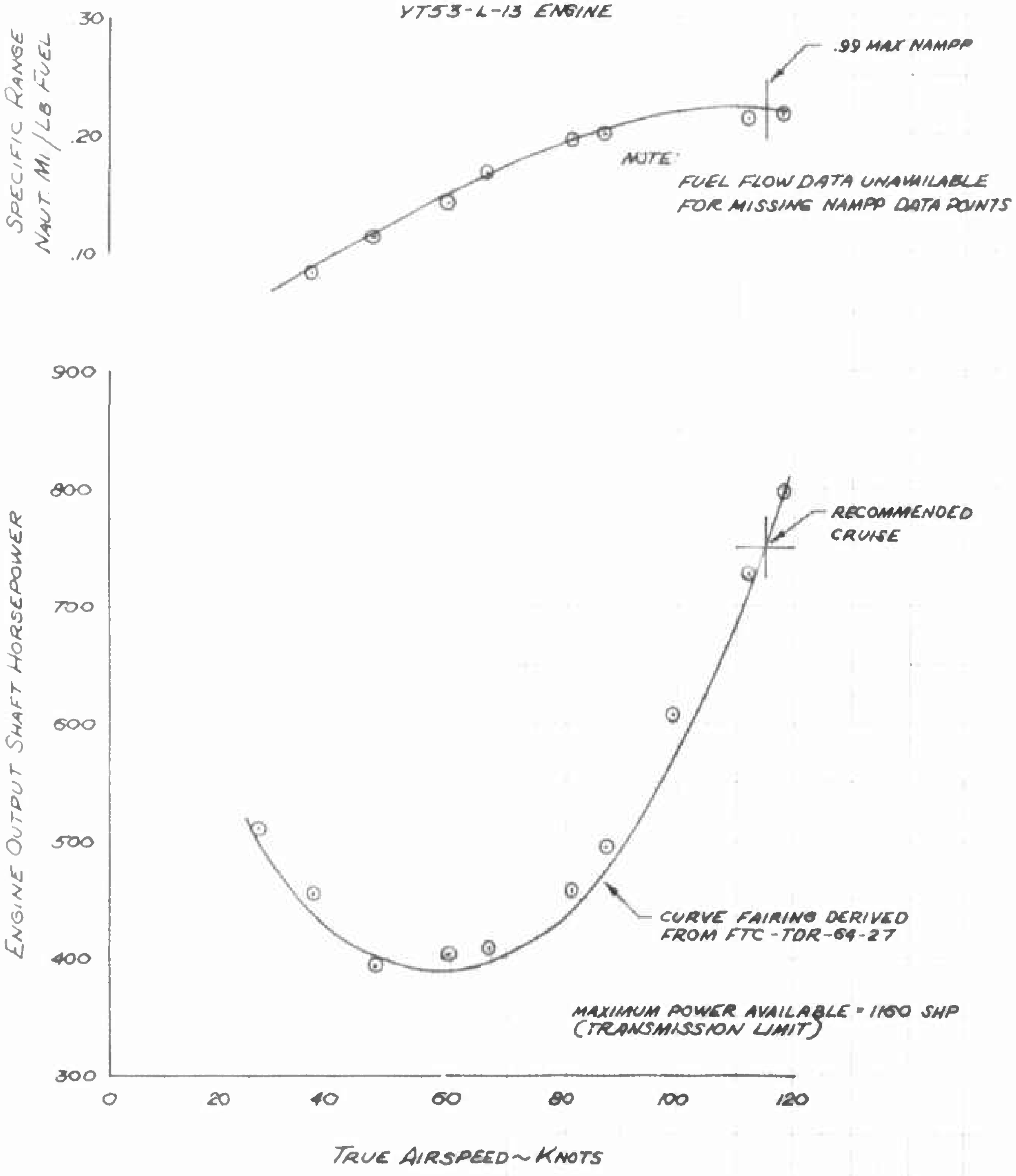


FIGURE NO 8
LEVEL FLIGHT PERFORMANCE
UH-1D USA S/N 62-2106
48-FOOT ROTOR

GROSS WEIGHT	6440 LB
ALTITUDE	5400 FT
ROTOR RPM	322
CT	.002700
CG STATION	136.5 (MID)

YT53-L-13 ENGINE



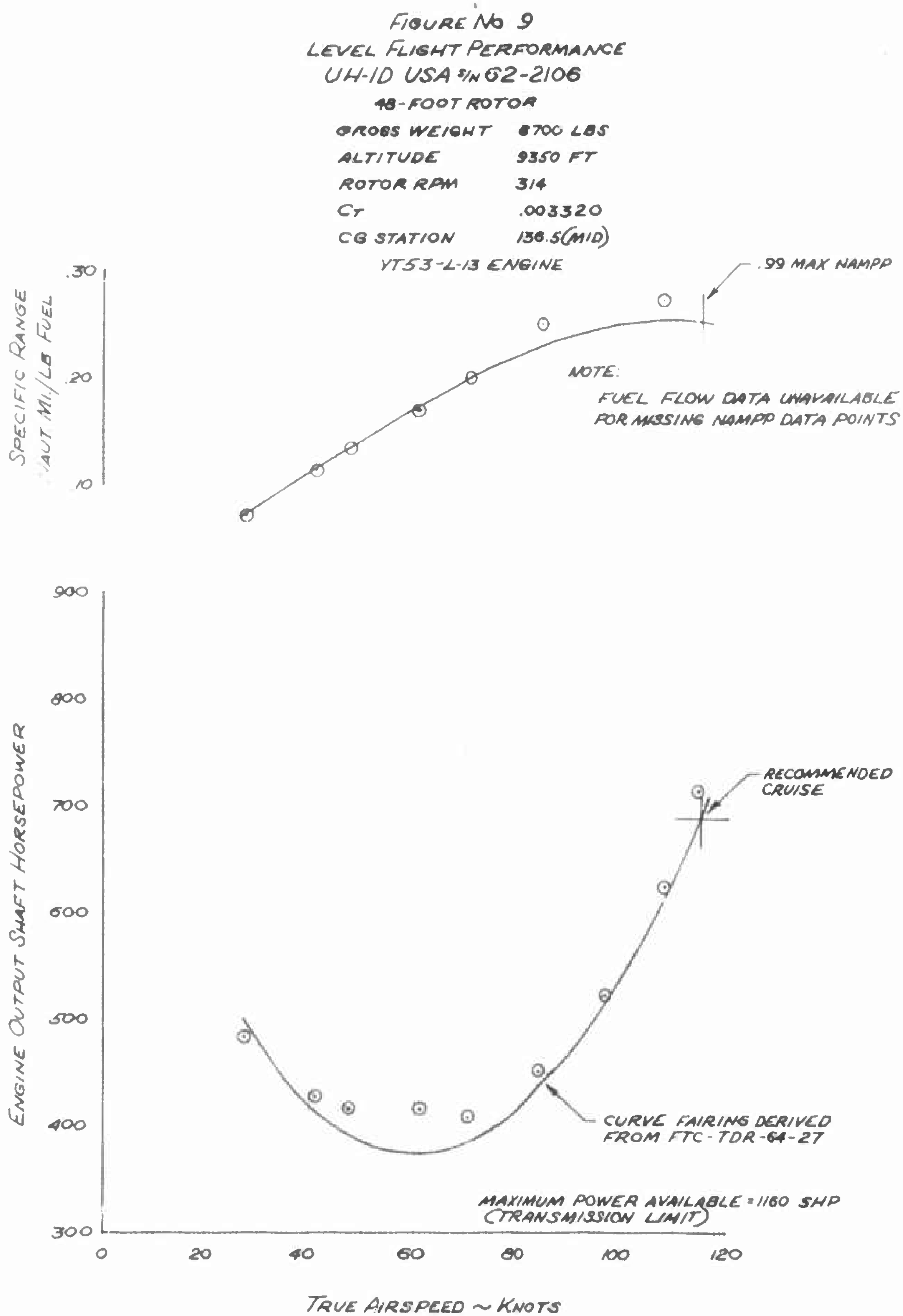
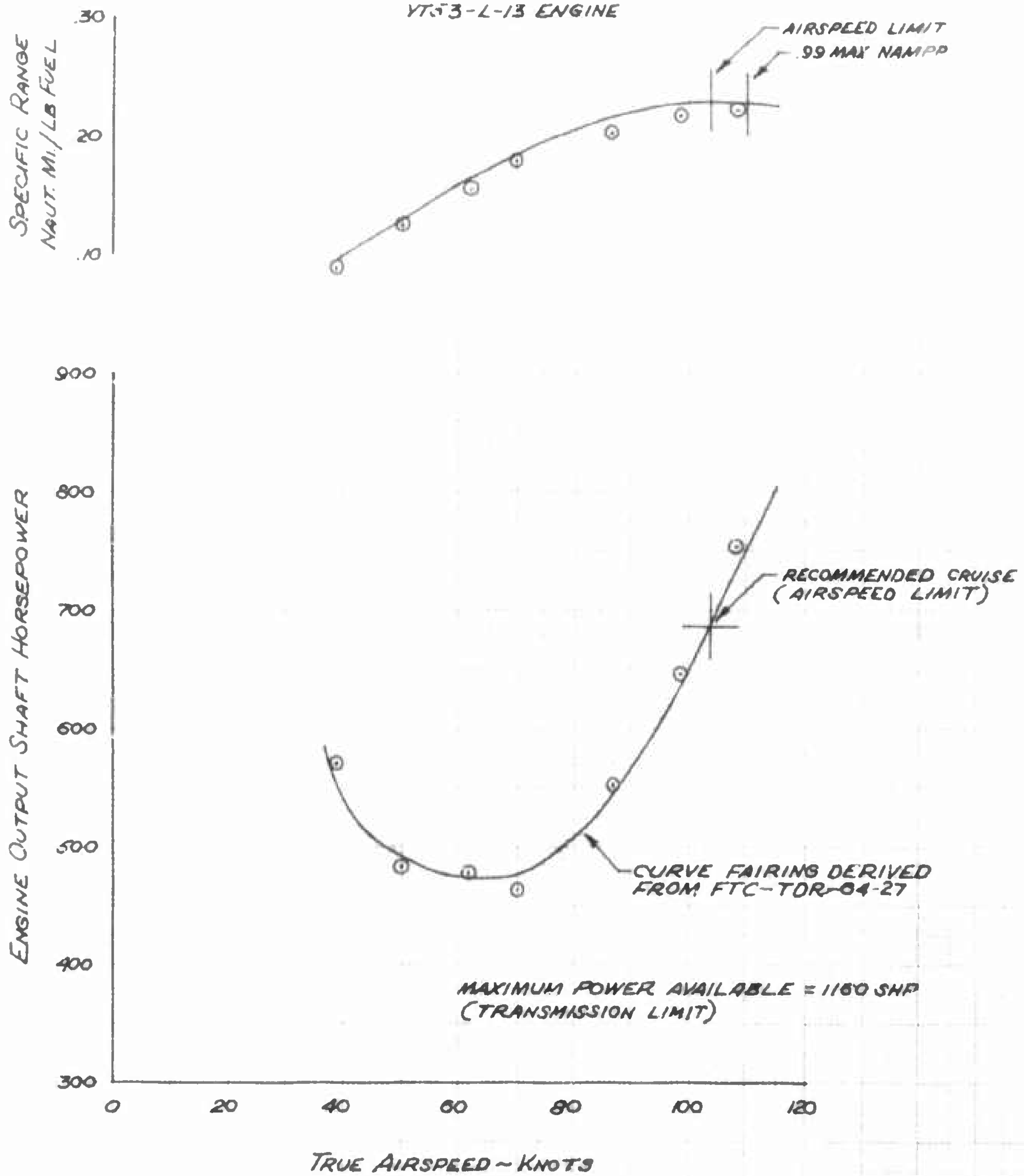


FIGURE No 9
LEVEL FLIGHT PERFORMANCE
UH-1D USA S/N 62-2106
48-FOOT ROTOR
GROSS WEIGHT 8700 LBS
ALTITUDE 9350 FT
ROTOR RPM 314
C_T .003320
CG STATION 136.5(MID)
YT53-L-13 ENGINE
.99 MAX NAMPP
NOTE:
FUEL FLOW DATA UNAVAILABLE FOR MISSING NAMPP DATA POINTS
SPECIFIC RANGE NAUT MI/LB FUEL
.30
.20
.10
900
800
700
600
500
400
300
ENGINE OUTPUT SHAFT HORSEPOWER
RECOMMENDED CRUISE
CURVE FAIRING DERIVED FROM FTC-TDR-64-27
MAXIMUM POWER AVAILABLE = 1160 SHP (TRANSMISSION LIMIT)
0
20
40
60
80
100
120
TRUE AIRSPEED ~ KNOTS

FIGURE No 10
LEVEL FLIGHT PERFORMANCE
UH-1D USA S/N 62-2106
48-FOOT ROTOR

GROSS WEIGHT	8040 LBS
ALTITUDE	9650 LBS
ROTOR RPM	322
C_T	.003824
CG STATION	136.5 (MID)

YT53-L-13 ENGINE



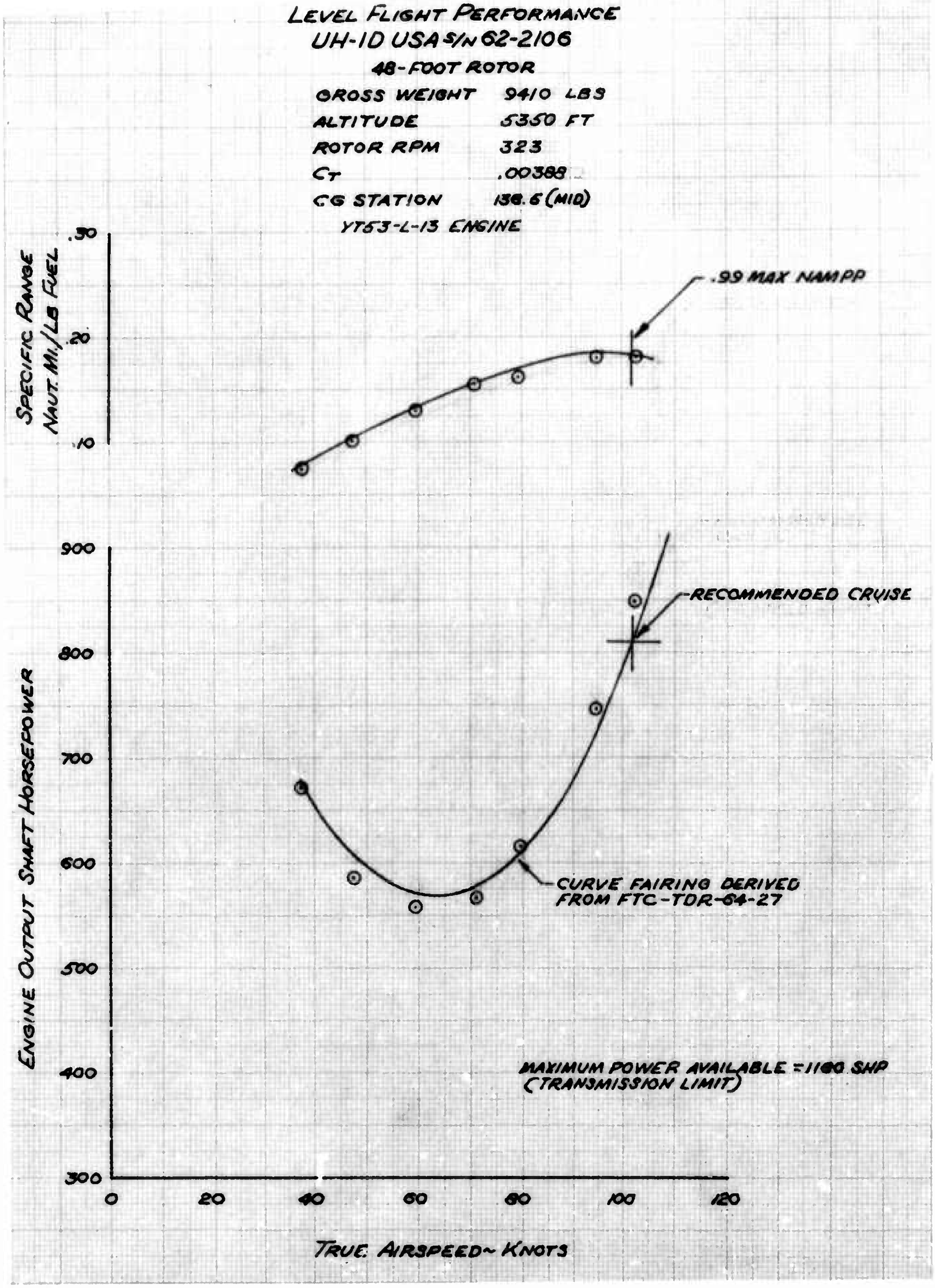

LEVEL FLIGHT PERFORMANCE
UH-1D USA S/N 62-2106
48-FOOT ROTOR
GROSS WEIGHT 9410 LBS
ALTITUDE 5350 FT
ROTOR RPM 323
CT .00388
CG STATION 138.6 (MID)
YT53-L-13 ENGINE
SPECIFIC RANGE NAUT. MI./LB FUEL
.30
.20
.10
.99 MAX NAMPP
ENGINE OUTPUT SHAFT HORSEPOWER
900
800
700
600
500
400
300
RECOMMENDED CRUISE
CURVE FAIRING DERIVED FROM FTC-TDR-64-27
MAXIMUM POWER AVAILABLE = 1100 SHP (TRANSMISSION LIMIT)
0
20
40
60
80
100
120
TRUE AIRSPEED ~ KNOTS

FIGURE No 12
AIRSPEED CALIBRATION
UH-1D USA S/N 62-2106
48-FOOT ROTOR
TRAILING BOMB METHOD
BOOM SYSTEM
GROSS WT 6500 LBS
ROTOR RPM 324
CG STATION 136.5 (MID)

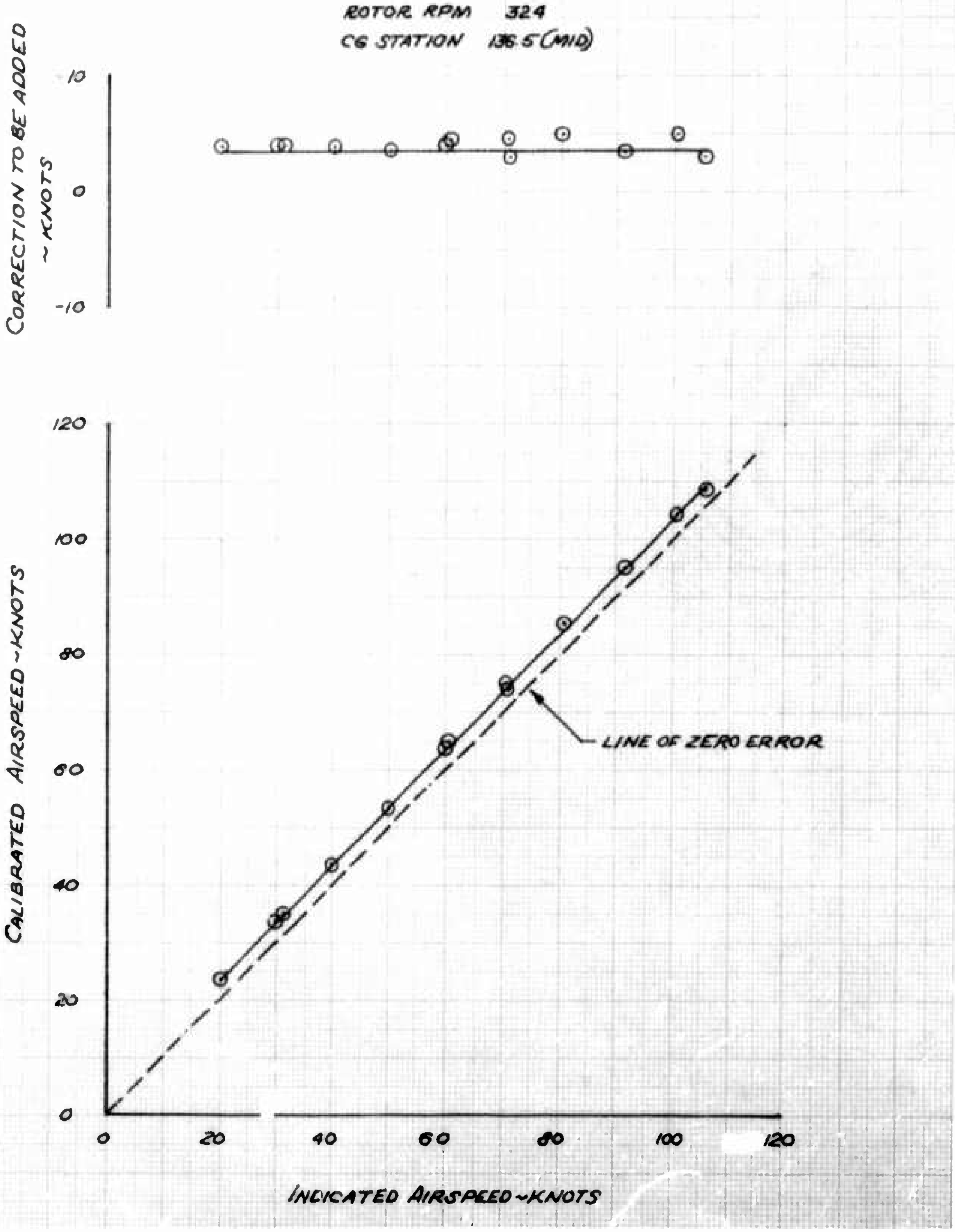


FIGURE No 13

DEVIATION IN REGULATED GAS PRODUCER SPEED
WITH COMPRESSOR INLET TOTAL TEMPERATURE
TEMPERATURE BIAS CURVE
YT-53-L-13 S/N LYC 3

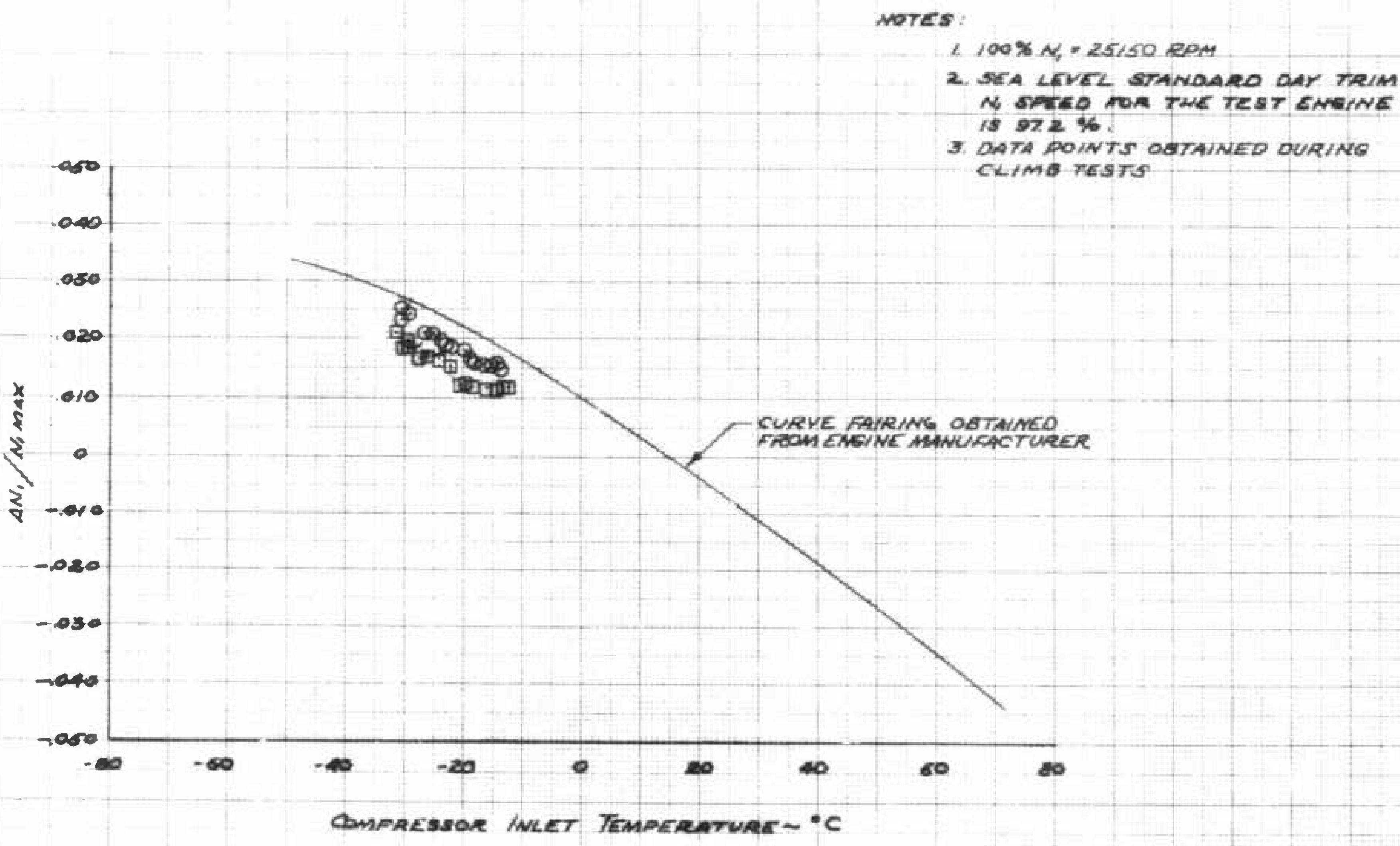


FIGURE NO 14
SHAFT HORSEPOWER AVAILABLE
UH-1D USA S/N 62-2106
48-FOOT ROTOR
YT53-L-13 S/N LYC 3

NOTES:

1. BASED ON COMPRESSOR INLET TEMPERATURE = AMBIENT AIR TEMPERATURE + 0.5 °C
2. BASED ON INLET RECOVERY OF .9966 (P_2/P_A = .9966)
3. LIMIT N_I VARIES WITH TEMPERATURE ACCORDING TO CONTRACTOR BIAS CURVE BUT NOT TO EXCEED 97.2% N_I
4. SHP DETERMINED FROM CURVE OF SHP/$\delta\sqrt{\theta}$ VS $N_I/\sqrt{\theta}$ AS OBTAINED FROM FLIGHT TEST DATA.

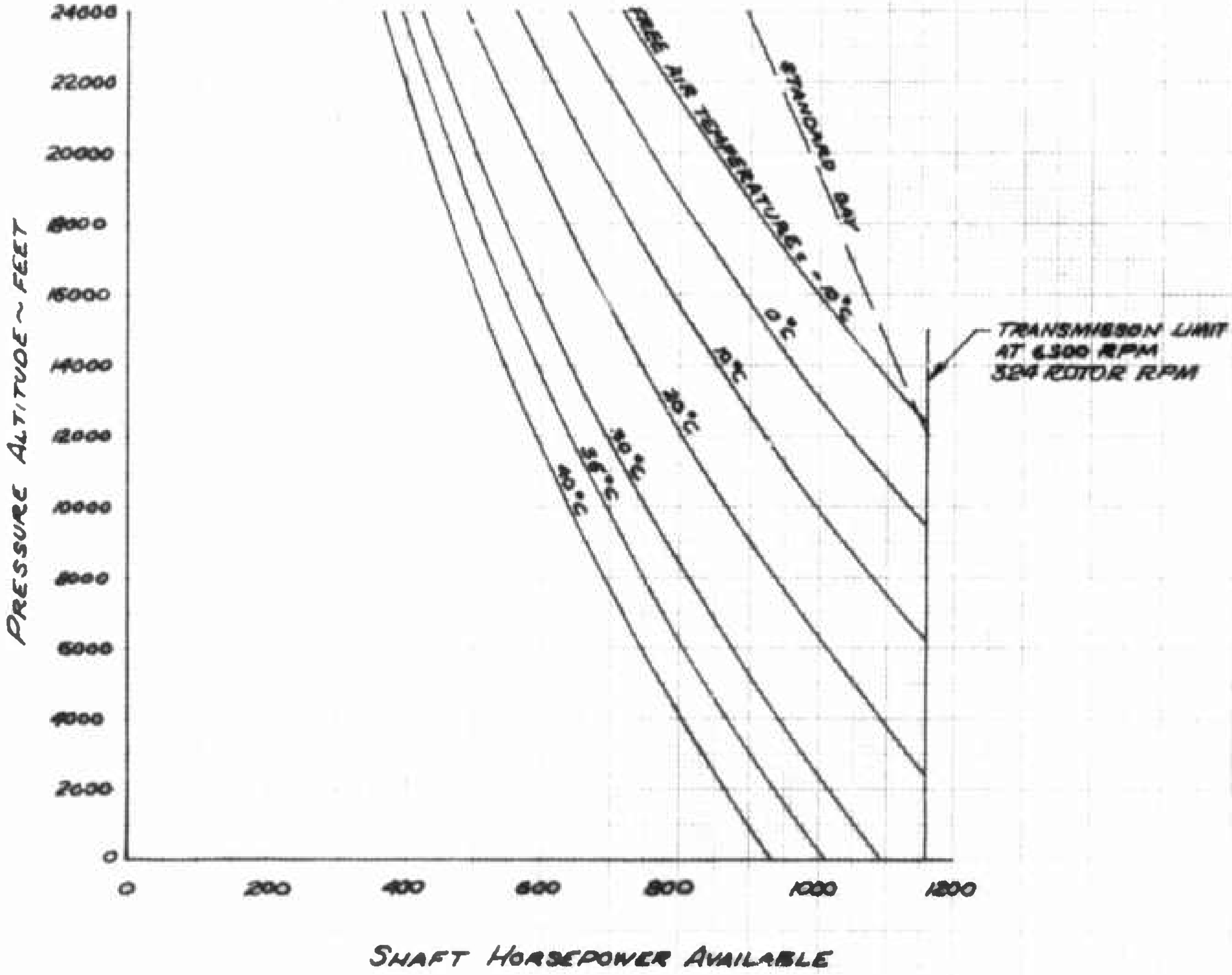


FIGURE NO 15
ENGINE CHARACTERISTICS
UH-1D USA S/N 62-2106
48-FOOT ROTOR
YT53-L-13 S/N LYC 3

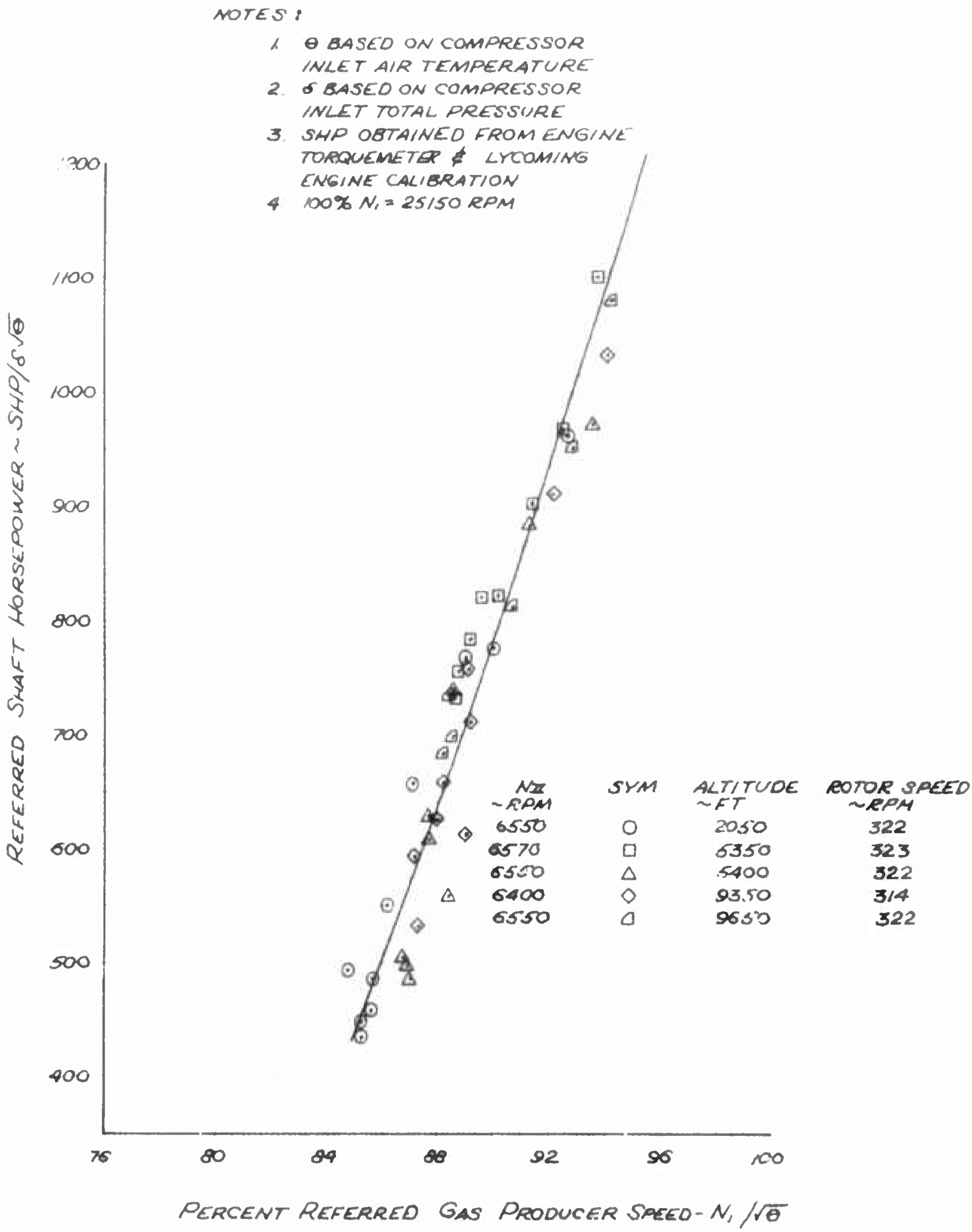


FIGURE NO 16
ENGINE CHARACTERISTICS
UH-1D USA S/N 62-2106
48-FOOT ROTOR
YT53-L-13 S/N LYC 3

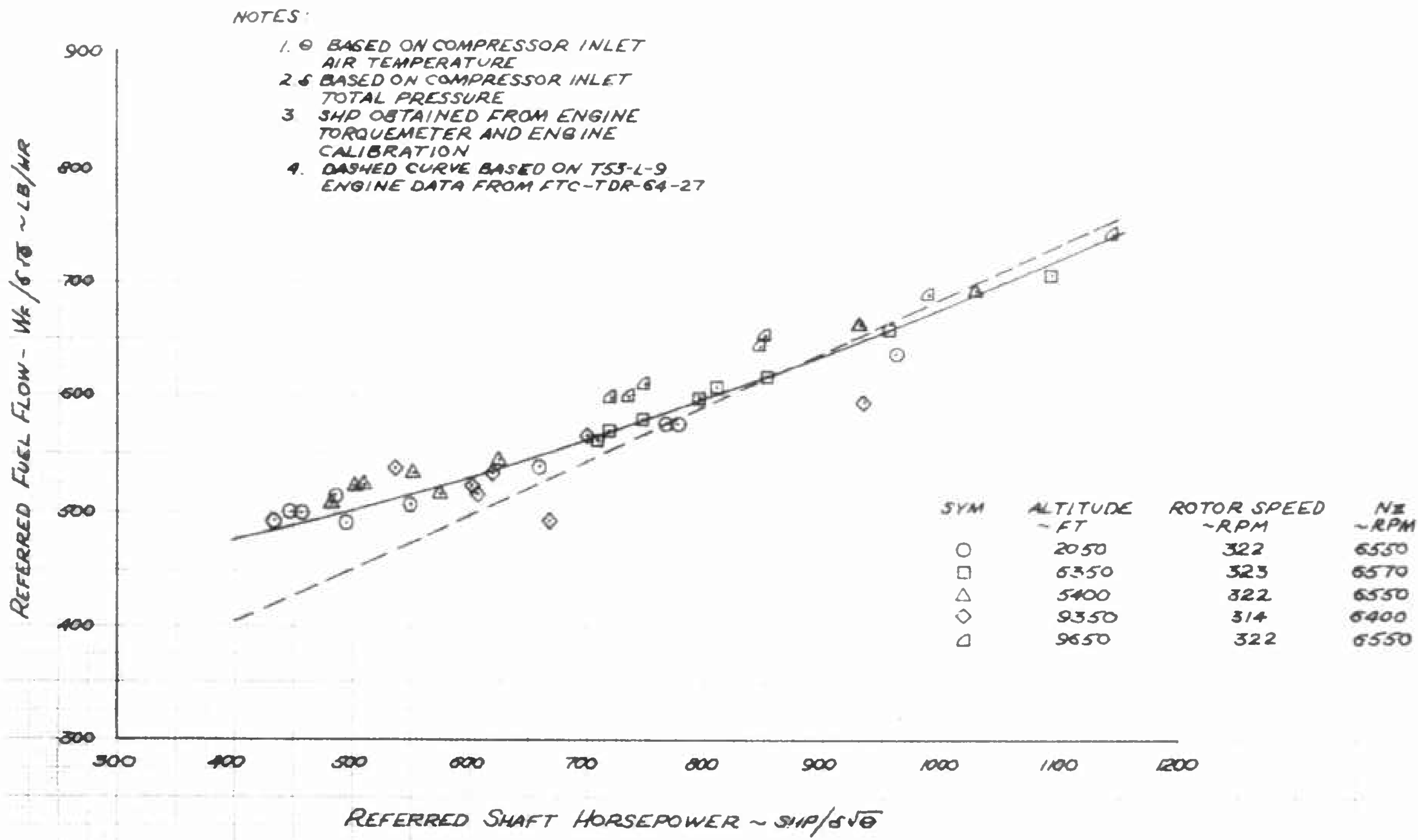


FIGURE No 17
ENGINE CHARACTERISTICS
UH-1D USA S/N 62-2106
48-FOOT ROTOR
YT53-L-13 S/N LYC 3

NOTES
1. θ BASED ON COMPRESSOR INLET TEMPERATURE
2. 100% N_1 = 25150 RPM

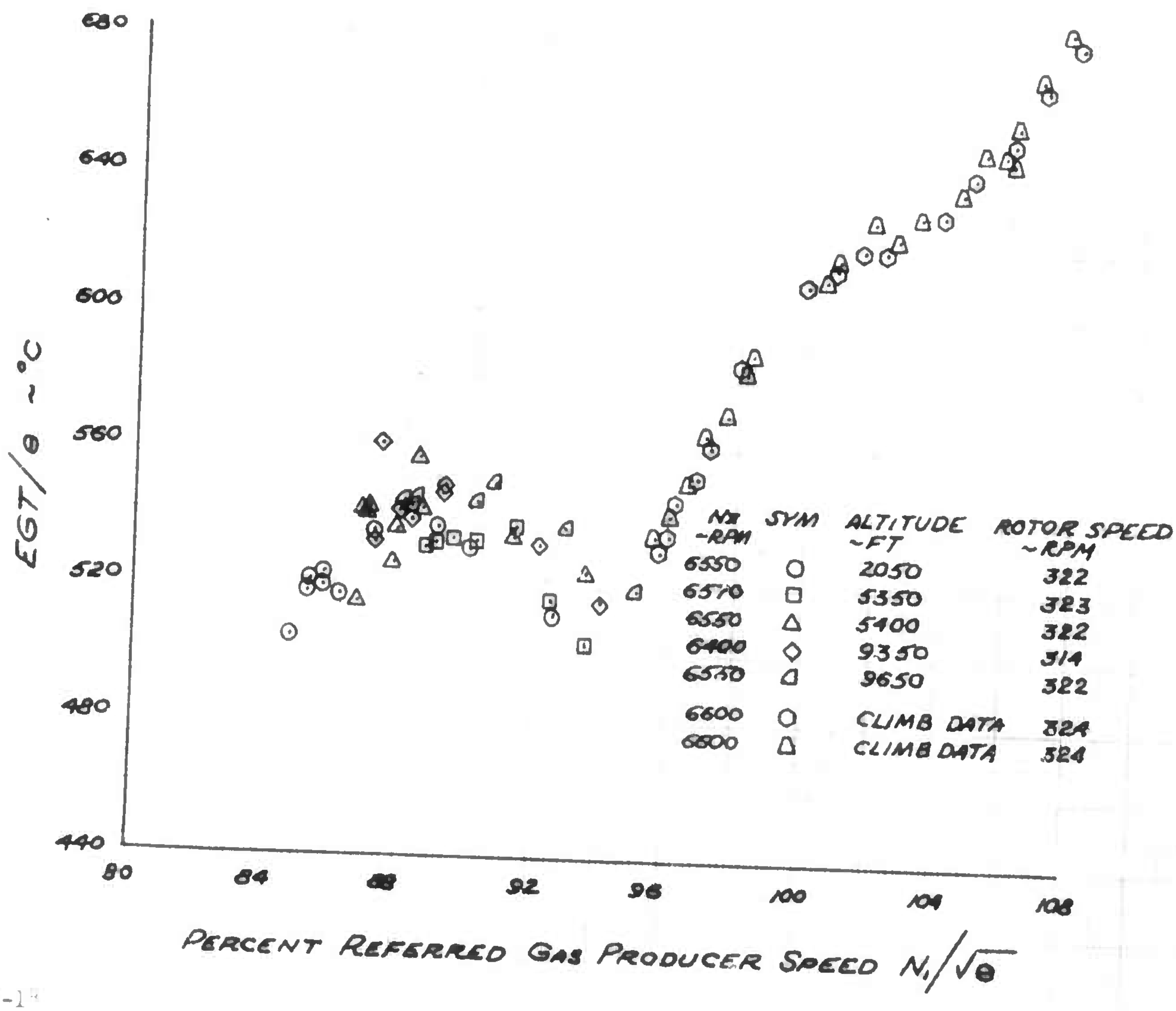


FIGURE No 18
ENGINE INLET CHARACTERISTICS
UH-1D USA S/N 62-2106
48-FOOT ROTOR
YT53-L-13 S/N LYC 3

SYM	ALTITUDE ~FT	ROTOR SPEED ~RPM
○	2050	322
□	5350	323
△	5400	322
◇	9350	314
◁	9650	322

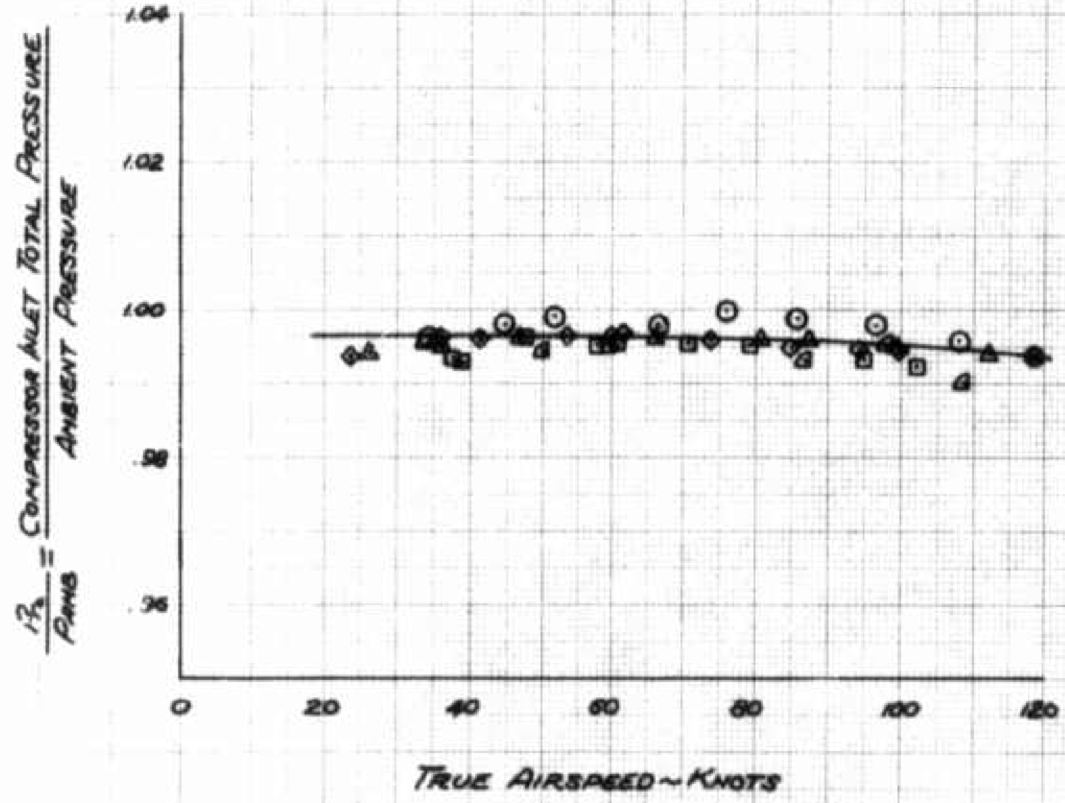


FIGURE NO 19
ENGINE INLET CHARACTERISTICS
UH-1D USA S/N 62-2106
48-FOOT ROTOR
YT53-L-13 S/N LYC 3

SYM	ALTITUDE ~FT	ROTOR SPEED ~RPM
○	2060	322
□	5850	323
△	6400	322
◇	9350	314
◢	9650	322

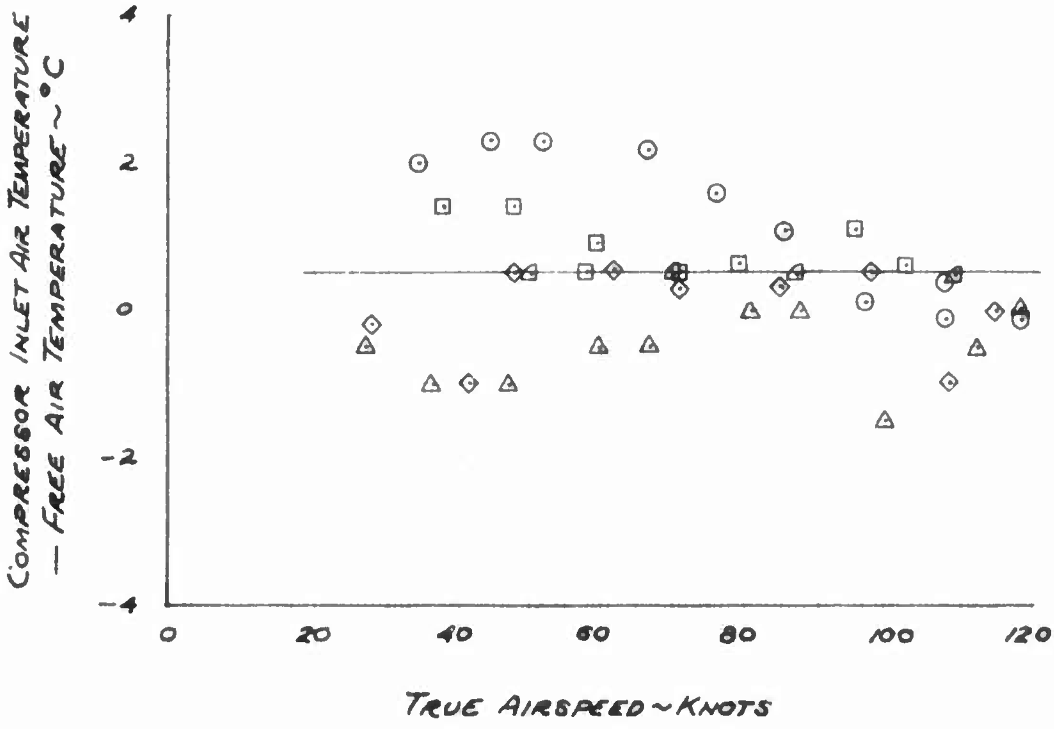


FIGURE NO 20

ENGINE CHARACTERISTICS

UH-1D USA S/N 62-2106

48-FOOT ROTOR

YT53-L-13 S/N LYC 3

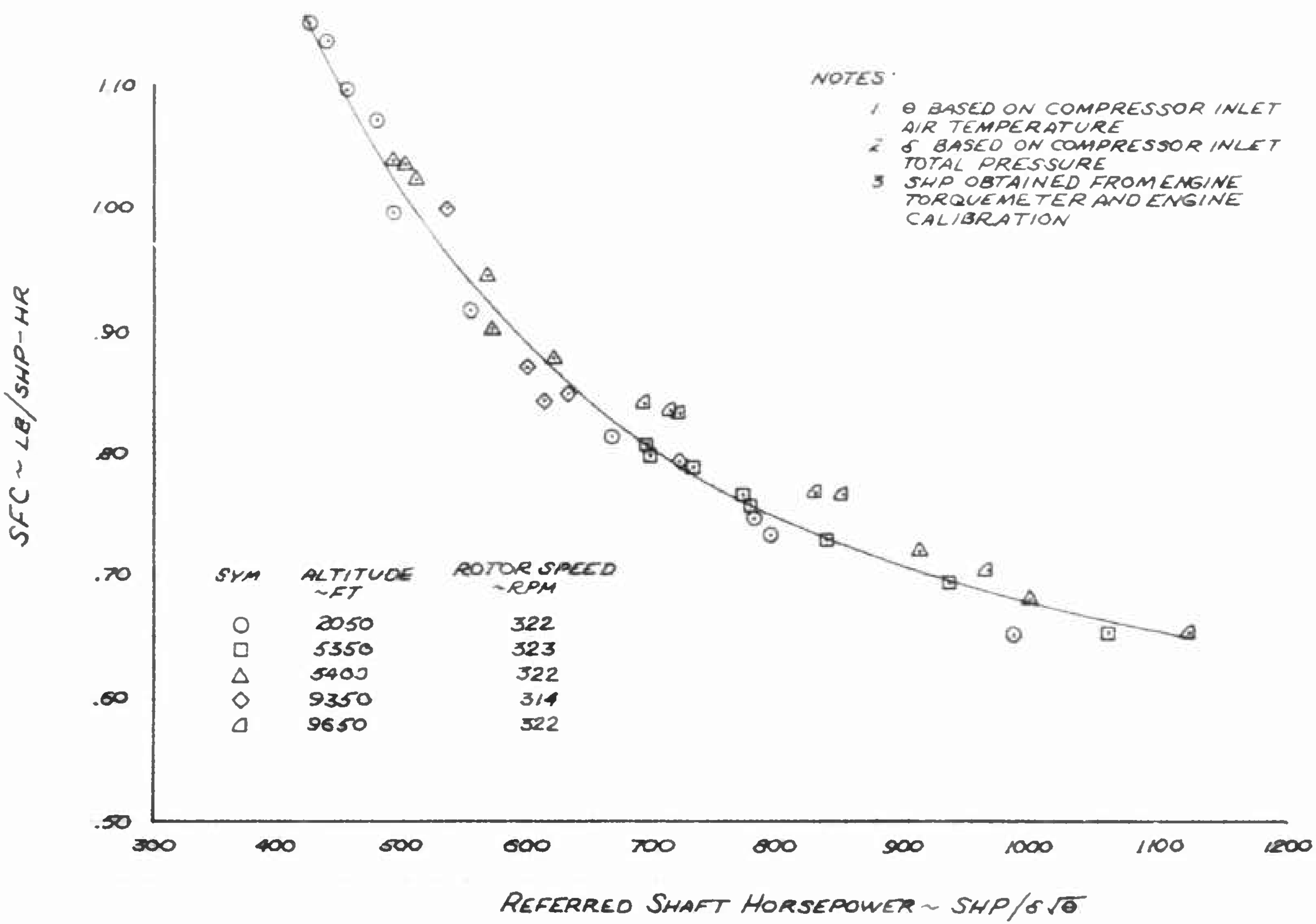
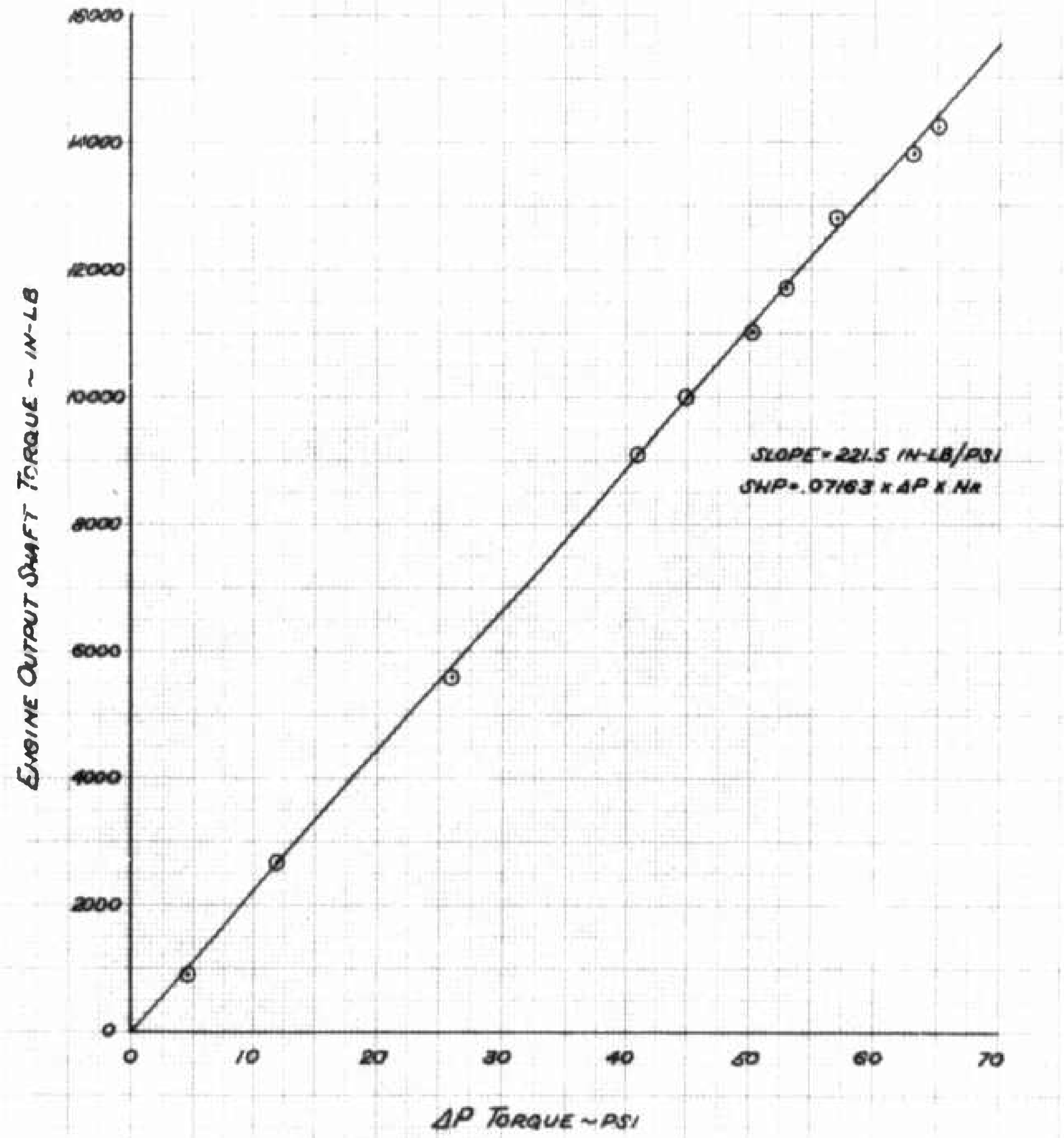


FIGURE No 21
ENGINE CHARACTERISTICS
YT53-L-13 SN LYC3
BASED ON ENGINE TEST STAND CALIBRATION



II

GENERAL ENGINE INFORMATION

1. ENGINE DESCRIPTION

The YT53-L-13 engine, rated at 1400 shp, is a successor to the T53-L-11 engine. The additional power has been achieved with no change in the basic T53-L-11 engine envelope mounting and connection points and with a 6 percent increase in basic engine weight.

The performance gain is accomplished thermodynamically by the mechanical integration of a modified axial compressor, a two-stage compressor turbine, and a two-stage power turbine into the T53-L-11 engine configuration.

Replacement of the first two compressor stators and changing of the first two stages of compressor rotor blades and disks results in an approximately 20 percent increase in mass air flow through the engine. This is accomplished without the use of inlet guide vanes.

An inlet flow fence, located on the outer wall of the inlet housing in the area of the previously used inlet guide vanes, provides the desired inlet conditions for the transonic compressor during acceleration at low speeds. At compressor speeds up to 70 percent, the fence is in the extended position as shown in Figure 3. Above 70 percent, the flow fence is retracted into the outer wall of the inlet housing. Similar to a piston ring, the circumference of the flow fence is changed by the action of a piston actuator powered by compressor discharge pressure.

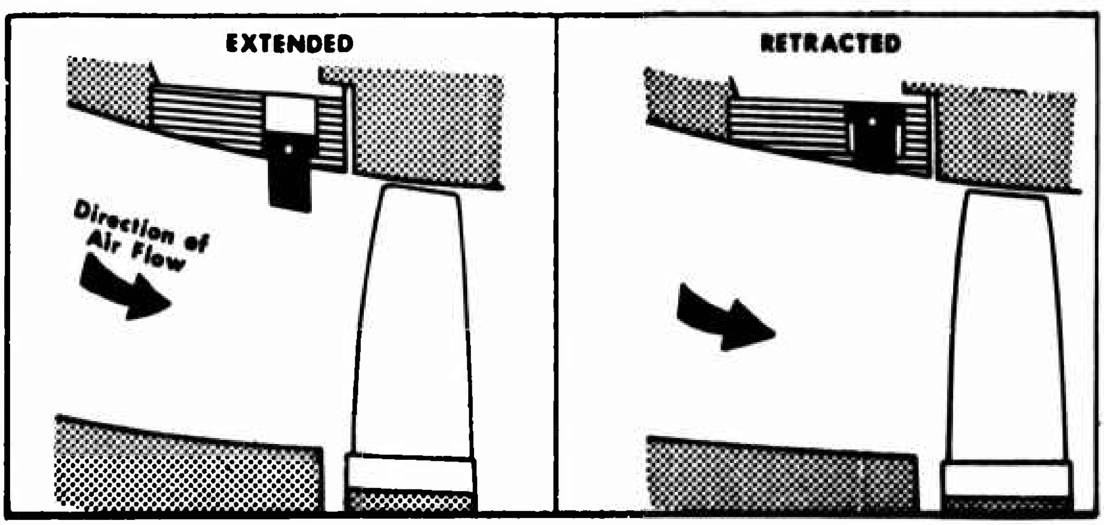


FIG. 3 ,COMRESSOR INLET FLOW FENCE

The specification for this engine allows the use of JP-4 or JP-5 type fuel for satisfactory operation throughout the engine's operating envelope. During this program, JP-4 fuel was used.

2. POWER CONTROL SYSTEM

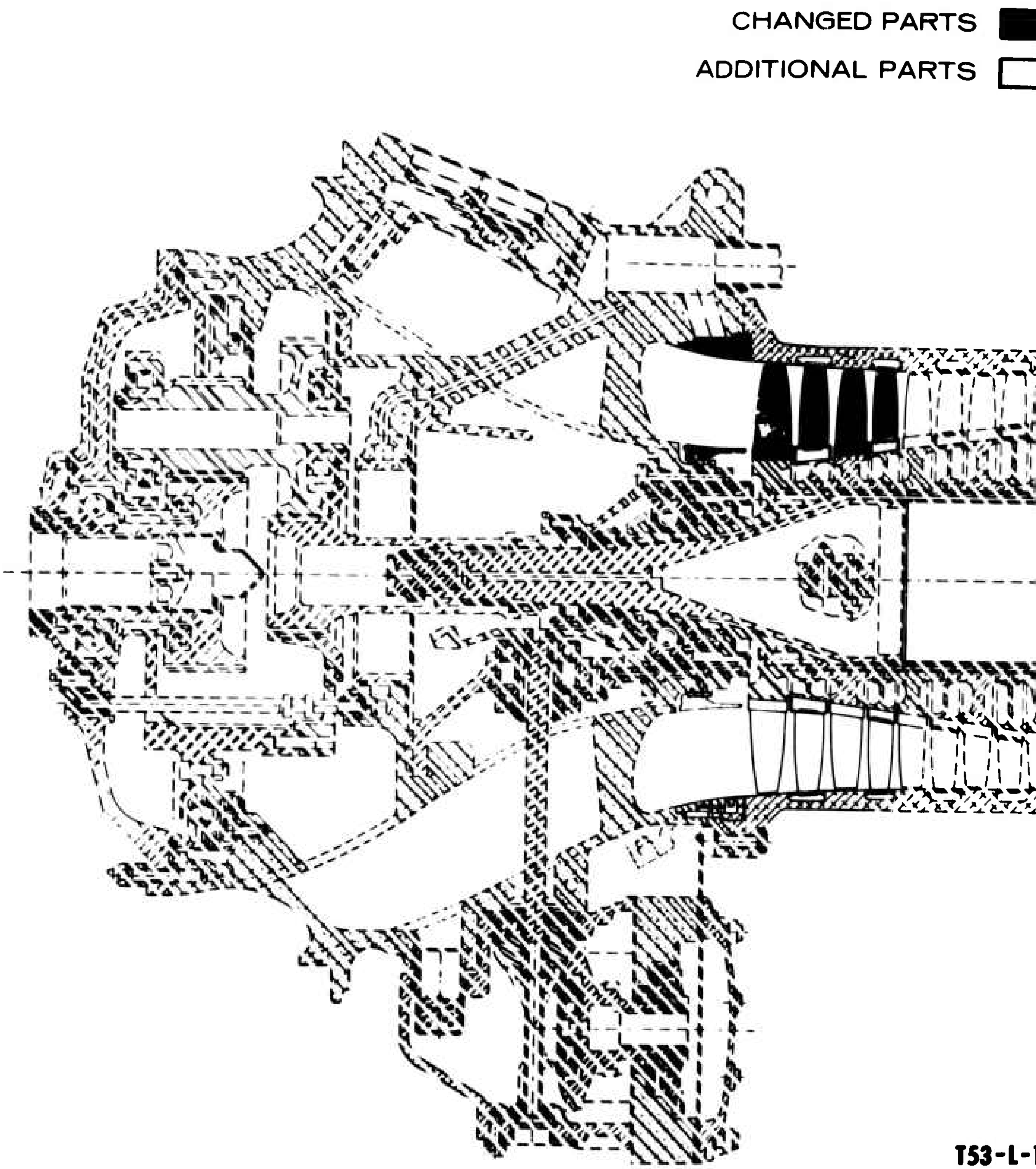
The fuel control for the YT53-L-13 engine is a hydro-mechanical type of fuel control. It consists of the following main units:

a. Dual-element fuel pump
b. Gas producer speed governor
c. Power turbine speed topping governor
d. Acceleration and deceleration control
e. Fuel shut-off valve
f. Transient air bleed control

An air bleed control is incorporated within the control to provide for opening and closing the compressor interstage air bleed in response to the following signals present in the power control:

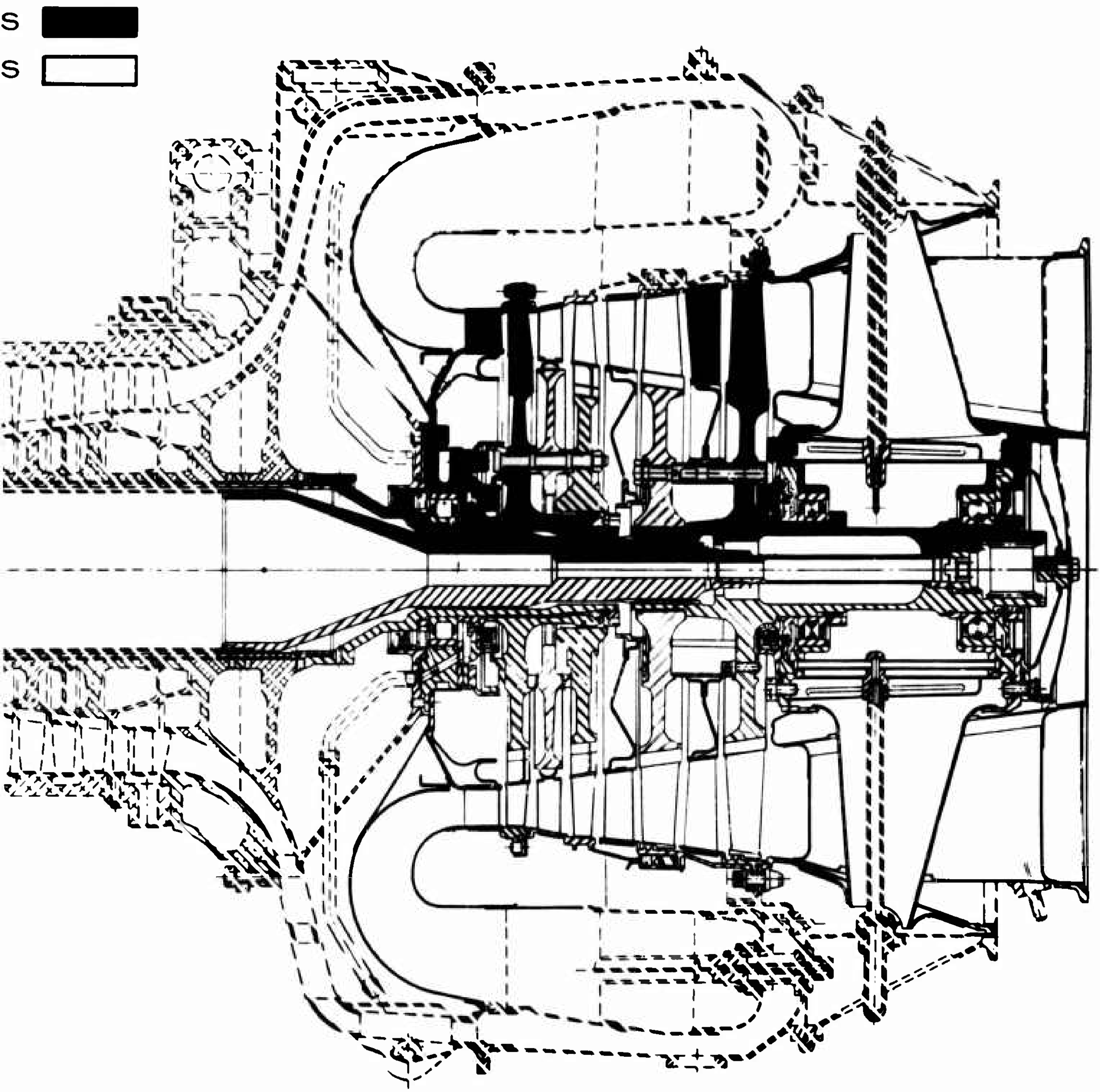
a. Gas producer speed
b. Compressor inlet air temperature
c. Fuel flow

The fuel control is designed to be operated either automatically or in an emergency mode. In the emergency position, fuel flow is terminated to the main metering valve and is routed to the manual (emergency) metering and dump valve assembly. While in the emergency mode, fuel flow to the engine is controlled by the position of the manual metering valve, which is directly connected to the power lever (twist grip). During the emergency operation, there is no automatic control of fuel flow during acceleration and deceleration; thus, EGT and schedule must be pilot-monitored.



T53-L-1

(SHOWING CHANGES AS



T53-L-13 ENGINE

GES AS COMPARED TO T53-L-11)

2

APPENDIX III

SYMBOLS and ABBREVIATIONS

Symbol	Definition	Unit
TAS (V_t)	True Airspeed	Knots
CAS (V_c) (V_{cal})	Calibrated Airspeed	Knots
K (Kt)	Knots	Knots
IAS	Indicated Airspeed	Knots
V_{max}	Maximum Airspeed Attainable	Knots
OGE	Out of Ground Effect	-
IGE	In Ground Effect	-
C.G.	Center of Gravity	Inches
GW	Gross Weight	Pounds
RPM/rpm	Revolutions per Minute	-
°C	Degrees Centigrade	Degrees
°F	Degrees Fahrenheit	Degrees
SHP	Shaft Horsepower	-
R/C	Rate of Climb	Feet per Minute
T/C	Time to Climb	Minutes
C_T	Thrust Coefficient	-
NMT	Nautical Miles Traveled	-
NAMPP	Nautical Miles Per Pound of Fuel	-
N_1	Gas Producer Speed	Percent rpm
N_2	Power Turbine Speed	Percent rpm
N_R	Rotor Speed	rpm
EGT	Exhaust Gas Temperature	Degrees
ρ	Air Mass Density	$\frac{Lb\text{-}sec^2}{Ft^4}$

APPENDIX IV COORDINATION

Coordination has been effected with the U. S. Army Aviation Test Board and the Bell Helicopter Company.