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NAVAL AIR MATERIAL CENTER
NAVAL BASE
PHILADELPHIA, PA.



AERONAUTICAL ENGINE LABORATORY
REPORT ON

CALIBRATION OF PRATT AND WHITNEY R-4340-20 ENGINE

ISSUED BY
NAVAL AIR EXPERIMENTAL STATION

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23 October 1950

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R E P O R T

O N

CALIBRATION OF PRATT AND WHITNEY R-4360-20 ENGINE

BY

NAVAL AIR MATERIAL CENTER
NAVAL AIR EXPERIMENTAL STATION
AERONAUTICAL ENGINE LABORATORY
PHILADELPHIA

Project TED No. NAM-PP209.

Authority - Bureau of Aeronautics Restricted Letter Aer-PP-23 23326 of
20 March 1947.

Dates of Test - FROM: 28 July 1947 TO: 15 March 1950.

Number of Pages - Text, 14; Plates, 52.

Reported by M. J. DOTSEY, Aeronautical Engineer, GS-9 Project Engineer.

J. K. TEEL, Student Aide, General, GS-4 Test Engineer.

Approved by R. H. PRICKETT, Commander, U. S. N. Superintendent.

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PLATES 52.

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OBJECT

1. The primary object of these tests was to determine the sea-level and altitude characteristics of the Pratt and Whitney Aircraft (P&WA) model R-4360-20 engine.

CONCLUSIONS

2. Calibration results indicate that the original -20 engine, No. P-726 (incorporating 6.91:1 low gear ratio and 8.31:1 high gear ratio) failed to meet the manufacturer's high gear critical altitude guarantees (see reference (d)). Engine No. P-726, after modification to incorporate an 8.90:1 high gear ratio (see references (f) and (h) and the production engine, No. P-2727, with a 9.07:1 high gear ratio (see reference (g)), satisfactorily meet the manufacturer's guaranteed ratings. The following table shows a comparison of each of the three versions of the -20 engine with the manufacturer's guaranteed ratings:

Rating	RPM	BHP	S.F.C.	Altitude - Feet			
				AEL Dynamometer			
				Mfr.	Eng. No.	Mfr.	Eng. No.
				Guar.	P-726	P-726	P-2727
						Modified	
Low Normal	2550	2650	.72	6000	6100	6500	6600
Low Military	2700	3250	.76	1500	2000	2300	2500
High Normal	2550	2300	.76	18,000	16,300	18,200	19,300
High Military	2700	2500	.84	17,000	15,400	16,500	17,300

*Specification No. N-7056-D of 3 January 1950.

3. Operation with MIL-F-5572 100/130 grade fuel was satisfactory at the manufacturer's guaranteed horsepower ratings and fuel consumption values except during high gear operation at military speed and power. The following table shows the detonation limits of engine No. P-726 (Modified to incorporate and 8.90:1 high gear ratio):

RPM	Gear	BHP*	F/A	CAT (°F)	ASFP (In.Hg.)	Alt. (Ft.)
2700	Low	3250	.099	100	60.8	0
2550	Low	2650	.078	100	50.0	0
2550	High	2300	.084	52	49.5	13,000

* Although these data were obtained on an engine having a low gear ratio of 6.91:1 and a high ratio of 8.90:1, it is believed that a sufficient margin of safety is included to achieve detonation-free operation with later production engines. Late -20 and -20W production engines have a low ratio of 6.95:1 and high ratio of 9.07:1.

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4. Mixture response runs made in both low and high gear ratios indicate that the engine is detonation-free considerably below the lean limit of the carburetor setting in the "normal" position. The following table shows the detonation limits of the engine using MIL-F-5572 (115/145) grade fuel:

RPM	Gear	BHP	F/A	CAT (°F)	ASRP (In.Hg.)	Alt. (Ft.)
2550	Low	2650	.057	(Std + 40)	57.4	S.L.
2700	Low	3250	.071	(Std + 40)	59.2	S.L.
2550	High	2300	.064	(Std + 40)	51.8	17,000
2700	High	2500	.0725	(Std + 40)	55.0	16,000

5. The Stromberg PR-100B3 carburetor, metering according to 390941-4 parts list setting, provided satisfactory mixtures for normal engine operation, acceleration, starting, and idling.

6. Overpower runs in low and high gear indicate that the engine is capable of detonation-free operation, while using 115/145 grade fuel, at the following conditions:

RPM	BHP	CAT (°F)	Gear	Alt. (Ft.)	Mixture	ASRP (In.Hg.)	F/A
2700	3350	60	Low	S.L.	Rich	63.0	.101
2800	3475	60	Low	S.L.	Rich	65.8	.1015
2700	2780	16	High	12,000	Rich	66.0	.1085

Detonation was encountered during the overpower high gear operation at the following conditions:

RPM	BHP	CAT (°F)	Gear	Alt. (Ft.)	Mixt.	ASRP (In.Hg.)	F/A	Detonation Intensity
2700	2810	17	High	11,700	Rich	65.5	.1085	Incipient
2700	2850	18	High	11,400	Rich	67.3	.1085	Light

7. A high altitude (23,000 - 26,000 ft.) surge was encountered during the calibration at speeds below 2400 rpm. The surge was traced to the method of venting the fuel discharge nozzle. The discharge nozzle was vented to altitude during altitude operation and a severe surge was encountered; however, by venting the discharge nozzle to sea-level during all altitude operation, the surge was eliminated. This condition was also encountered by the engine manufacturer and is apparently caused by the inlet air turbulence downstream of the altitude valve.

8. With the carburetor in the "normal" mixture position, the cooling air baffle pressure drop necessary to maintain the maximum cylinder head or flange temperatures specified in reference (b) was as follows:

Condition	BHP	RPM	Gear	Cooling Air Temp. - °F	Baffle Press. Drop - In. H ₂ O
Take-Off	3250	2700	Low	63	9.5
Military	3250	2700	Low	57	7.3
Normal	2650	2550	Low	66	3.4
Military	2500	2700	High	57	6.8
Normal	2300	2550	High	65	3.7
Overpower*	3340	2700	Low	54	5.6
Overpower*	3475	2800	Low	59	7.5
Overpower*	2780	2700	High	55	5.7

* Overpower runs made with "Rich" mixtures.

9. Supercharger instability was encountered in the 2200 rpm range during full throttle altitude operation, which resulted in considerable power variation.

10. Operation of the Bendix Eclipse Automatic Power Control, Type 1626, Model 2, was satisfactory. Checks at military and normal rated power (see Plates 20 to 22) indicated a hysteresis of approximately 0.5 in.hg ASRP when varying the altitude from sea level to 30,000 ft. and returning to sea level (with a constant APC setting). The hysteresis was greater (1.5 in.hg ASRP) at military power returning from 32,000 ft. to sea level.

11. Fuel conforming to the requirements of Specification MIL-F-5572, 115/145 grade, is satisfactory for use at the ratings shown in paragraph 2.

12. Engine operation with AC181 spark plugs was satisfactory at all speeds and powers.

13. The torquemeter functioned satisfactorily throughout the test. The constant of 189.4 checked dynamometer determined power results within ±2 per cent for the two engines tested (see Plate 38).

RECOMMENDATIONS

14. It is recommended that the altitude ratings of Engine No. P-2727 determined at the Aeronautical Engine Laboratory and shown in paragraph 2, rather than the values indicated in the P&NA engine specification (reference (b)) be accepted as the actual operating characteristics of the engine.

15. Operation at the guaranteed brake horsepower ratings using F&WA guaranteed fuel consumption values using 115/145 grade fuel is recommended as satisfactory.

16. Grade 100/130 fuel is recommended as satisfactory for all low gear operation; however, high gear operation should be restricted to normal rated speed and power or less.

17. The Stromberg PR-100B3 carburetor, metering according to the "normal" and "rich" mixture positions of the P.L. No. 390941-4 setting is recommended for use with this engine. Operation in the "normal" mixture position is recommended for all speeds up to and including take-off or military with 115/145 grade fuel.

18. Overpower operation with 115/145 grade fuel is recommended as satisfactory for short periods of time at the values shown in the following table if the CAT does not exceed NACA standard values:

RPM	BHP	Gear : Ratio	Alt. : (Ft.)	Mixt.	ASRP	F/A
2700	3350	Low	S.L.	Rich	63.0	.101
2800	3475	Low	S.L.	Rich	65.8	.1015
2700	2780	High	12,000	Rich	66.0	.1085

19. It is recommended that a complete investigation be made in airplane installations of the subject type engine to determine whether supercharger instability is encountered during full throttle altitude operation at 2200 rpm. See reference (c) for discussion of centrifugal supercharger performance.

20. Use of the Bendix Eclipse Automatic Power Control, Type 1626, Model 2, is recommended as satisfactory with this type engine.

21. Operation with fuel conforming to the minimum requirements of MIL-F-5572, grade 115/145, is recommended as satisfactory using either F&WA guarantee or normal mixtures.

22. On the basis of these tests AC181 spark plugs are recommended as satisfactory for use with this type engine.

23. A torquemeter constant (K) of 189.4 is recommended as satisfactory for calculation of horsepower where

$$\text{BHP} = \frac{\text{Engine RPM} \times \text{Torq. Pressure}}{K}$$

DESCRIPTION OF SUBJECT

24. Following is a list of the characteristics of the subject engine.

a. Manufacturer:

Name - Pratt and Whitney Aircraft
Location - East Hartford, Conn.

b. Model, Numbers and Ratings:

Model - P&WA R-4360-20
Type - Air-cooled, 28-cylinder, 4-row radial,
single stage, variable speed supercharger
Engine Numbers - P-726, P-726 modified and P-2727
Normal and Military Ratings - See paragraph 2.
Dive Rating - 3060 rpm

c. General Data:

Bore and stroke - 5.75 X 6.0
Cylinder arrangement - Four row radial, 7 cylinders
each row.
Master Rod Location - A7, B4, C4, and D1
Total Displacement - 4360 cu.in.
Compression Ratio - 6.70:1
Reduction Gear Ratio - 0.425:1
Torquemeter Constant - 189.4
Propeller Shaft Spline - No. 60A
Propeller and Crankshaft Rotation - Clockwise
Crankshaft Dampers - Two 3-1/2 order (front & rear)
Overall Dimensions - 54-in. diameter
102-in. length
Dry Weight of Engine Including
Carburetor, Spark Plugs, etc. - 3505 lb.
Maximum Specific Outputs (Based
on 3250 bhp Take-Off Rating) - .93 bhp/lb
- .75 bhp/cu.in.
Fuel Spec. MIL-F-5572 - Grade 115/145
Oil Spec. AN-C-8 - Grade 1100

d. Supercharger:

Number of Stages (P-2727 Engine Only) - One stage, variable speed.
Impeller Gear Ratios - Low 6.95:1 (No Slip)
- High 9.07:1 (No Slip)
Impeller Diameter - 14 in.

e. Carburetor:

Make - Stromberg
 Model - PR-100B3
 Setting Number - 390941-4
 Fuel Pressure Desired - 25 ± 1 psi
 Injector Location - Impeller

f. Ignition:

Magnetos - Bendix Scintilla D4RN-2
 Number - Seven
 Firing Order - A1, B5, C2, D6, A3, B7, C4, D1, A5, B2, C6, D3, A7, B4, C1, D5, A2, B6, C3, D7, A4, B1, C5, D2, A6, B3, C7, D4
 Ignition Timing (fixed) - 20° BTC on #D-1 Cylinder
 Spark Plugs - AC181
 Harness - Scintilla Rewireable

g. Valve Timing:

The valve timing and tappet clearances are as follows:

Intake Opens - 20° BTC
 Intake Closes - 76° ABC
 Exhaust Opens - 76° BBC
 Exhaust Closes - 20° ATC
 Intake Valve Remains Open - 276°
 Exhaust Valve Remains Open - 276°
 Valve Lift - 0.562 in.
 Overlap - 40°
 Cold Valve Adjusting Clearances -
 Intake - .030 in.
 Exhaust - .030 in.

h. Accessories:

Accessory	No. of	Type	Ratio to	Maximum	Max.	Directions
Drive	Drives		C'shaft	Continuous Torque	Static Torque	of
				lb-in	lb-in	Rotation
						*
Starter	1	IA	3.000:1	-	12,000	C.
Generator	3	IA	3.000:1	500	2200	C.
Fuel Pump	1		.800:1	50	600	C.C.
Tachometer	1	I	.500:1	7	50	C.
Tachometer	1	II	.500:1	7	50	C.
Governor	1		.956:1	125	825	C.C.

*C. - Clockwise, C.C. - Counter-clockwise

METHOD OF TEST

25. Engines Nos. P-726 and P-2727 were installed in No. 5 Dynamometer Room for conduct of a sea level and altitude calibration, as authorized by reference (a). The engine was attached to the dynamometer by means of a large, hard rubber coupling at the dynamometer end of the extension shaft and a gear-type coupling at the engine end. The engine carburetor air and exhaust were maintained at the required altitude conditions. The breather, fuel, and oil systems were maintained at or near sea level conditions. A standard complement of instruments as is normally used in this Laboratory was employed to measure temperatures, pressures, and air, fuel and oil flows.

26. Fuel conforming to the requirements of Specification MIL-F-5572, grade 115/145, and AN-O-8 (grade 1100) oil were used during all tests. The oil-in temperature and oil-out pressure were maintained at approximately 165°F and 15 psi, respectively.

27. The calibration data were obtained with engine No. P-2727, which accumulated 212 hours total running time during these tests. A Stromberg PR-100B3 carburetor with a 390941-4 parts list No. setting and a straight carburetor scoop were used for all tests. A Bendix Eclipse Automatic Power Control, Type 1626, Model 2, was employed for all calibration runs. A Lockheed Model XR60-1 airplane-type exhaust collector was used.

28. Sperry detonation-detecting units were attached to the intake rocker boxes on each of the 28 cylinders. Detonation was limited to "incipient" defined as "one or more cylinders indicating detonation at irregular intervals, none indicating a definite frequency".

29. A manual mixture control system was installed on the carburetor for obtaining desired fuel flows during mixture control and detonation-limited runs.

RESULTS AND DISCUSSION

30. The location of various plates and photographs in this report are as follows:

<u>Title</u>	<u>Plate Nos.</u>
Altitude Characteristics - Normal Mixture	1 to 5
Part Throttle Characteristics - Normal Mixtures	6 to 8
Altitude Characteristics - Rich Mixtures	9 to 12
Part Throttle Characteristics - Rich Mixtures	13 to 15
Normal and Military Critical Altitude Runs	16
Sea Level Overpower Runs	17
Altitude Overpower Runs	18 and 19
Automatic Power Control Altitude Characteristics	20 to 22
Mixture Requirement Curves (100/130 and 115/145 Fuels)	23 and 24

<u>Title</u>	<u>Plate Nos.</u>
Mixture Response Runs	25 and 26
Carburetor Characteristics	27 to 30
Correction Curves	
Carburetor Air and Mixture Temperature	31
Exhaust Back Pressure	32 and 33
Cylinder Head Temperature	34
Friction Characteristics	35 and 36
Oil Flow and Heat Rejection Characteristics	22 and 37
Torque Meter Calibration	38
Photographs of Engine Installation	39 and 40
Condition of Engine After Completion of Tests	41 to 46
General Views of the Engine	47 to 52

31. Plates 1 to 15 show the basic engine calibration in low and high gear. The bhp, SFC, altitude, manifold pressure, etc., plotted on these plates at various speeds and powers, indicate the values obtained in rich and normal mixtures using the PR-100B3 carburetor incorporating the P.L. No. 390941-4 setting (see Plates 27 and 28 inclusive). NACA Standard altitude conditions were maintained at the engine inlet and exhaust throughout the calibration. The cylinder head temperatures were maintained at the maximum allowable limits, as specified in reference (b). A Bendix Eclipse Automatic Power Control, Type 1626, Model 2, and an XR60-1 airplane-type exhaust collector were used during these tests. Calibration results indicate that the original -20 engine, No. P-726 (incorporating 6.91:1 low gear ratio and 8.31:1 high gear ratio) failed to meet the manufacturer's high gear critical altitude guarantees (see reference (d)). This engine was then returned to the manufacturer for modification, during which time the high gear ratio was changed to 8.90:1; however, due to mechanical troubles with the modified engine during subsequent qualification tests, the production engines appeared with a low ratio of 6.91:1 and a high ratio 9.07:1 (see reference (b)). Engine No. P-726 after modification and the production model engine, No. P-2727, satisfactorily meet the manufacturer's guaranteed ratings (references (f) and (g)).

32. The critical altitude performance of the engine in low and high gear at normal and military powers is shown on Plate 16. Standard altitude conditions were maintained for these runs and cylinder head and flange temperatures were maintained at the maximum allowable limits as specified in reference (b). The P&WA guaranteed specific fuel consumptions are shown on each of the curves. Additional information on criticals obtained on engine No. P-726 before and after modification, and on engine No. P-2727 is available in references (d), (f) and (g). The following table shows the values obtained in Normal (reference (j)) and Rich Mixture positions for normal rated and military rated powers with low gear supercharging:

Mixture	RPM	BHP	SFC	Altitude (Ft.)	ASRP (In.Hg)	Air Flow (lb/hr)	F/A
Normal	2550	2650	.70	6800	49	19,400	.094:
Rich	2550	2645	.73	6100	49.8	19,250	.101:
Normal	2700	3250	.75	2700	60.1	24,600	.099:
Rich	2700	3230	.77	2500	60.2	24,210	.103:
Normal	2550	2650	.65	Sea Level	50	19,000	.0905:
Rich	2550	2650	.71	Sea Level	50.7	19,500	.097:
Normal	2700	3250	.73	Sea Level	60.2	24,200	.0975:
Rich	2700	3250	.78	Sea Level	61.3	24,700	.102:

Supercharger instability was encountered at 2200 rpm during full throttle altitude operation. Two separate full throttle lines with a variation of about 240 hp could be obtained at the same altitude, engine speed, and throttle setting. This condition is believed to have been caused by the inherent static instability (see paragraphs 57 to 64, inclusive, of reference (c)) characteristics of the supercharger and may have been caused or aggravated by the test plant induction system configuration. A similar condition had been encountered on the R-1820-74W and R-3350-26W engines.

33. Plates 17, 18 and 19 show the overpower characteristics of the engine in low and high gear at sea level and altitude using NACA standard altitude conditions. These runs were made using 115/145 grade fuel with "rich" mixture as produced by the PR-100B3 carburetor. The low and high gear overpower ratings are indicated on the plates and tabulated in paragraph 6. Incipient detonation was encountered during high gear operation at the conditions indicated in the second table in paragraph 6.

34. Plates 20, 21 and 22 show the altitude characteristics of the Eclipse Automatic Power Control Unit, Type 1626, Model 2. Some hysteresis of the control was noted, especially at military speed, when the sea level setting was checked after operating up to 32,000 ft. altitude. Performance of the control was generally satisfactory.

35. Plates 23 and 24 show the minimum mixture characteristics of the engine in both low and high gear. These data indicate that the mixtures produced by the PR-100B3 carburetor with P.L. setting No. 390941-4 gave satisfactory detonation-free and stable operation in the cruise range. Included on these plates are check points using cold carburetor air temperatures, and part and full carburetor throttle.

36. Detonation characteristics of the engine in low and high gear are shown on Plates 25 and 26. Plate 25 shows the results obtained with 115/145 grade fuel, while the results obtained with 100/130 grade fuel are shown on Plate 26. Detonation characteristics are satisfactory over the entire engine speed range using 115/145 grade fuel and the present carburetor setting.

() 37. On plates 27 and 28 are plotted engine data and on plates 29 and 30 airbox characteristics of the Tn-100B3 carburetor. A comparison of the sea-level mixtures provided by this carburetor (P.L. Setting No. 390941-4) with the P&WA temporary acceptance limits indicates that it meters within the manufacturer's setting limits at sea level (reference (e)). The carburetor meters on the lean side of both the "rich" and "normal" limits.

38. Plate 31 is a correction curve for carburetor air temperature deviation from standard and correction curve for mixture temperature deviation from the plotted calibration values. These curves were derived from various runs at different powers made at constant manifold pressure and fuel-air ratio for each run and combined to give a percentage power correction.

() 39. Plates 32 and 33 show exhaust back pressure correction curves in low and high gear. Data were obtained with the cylinder inlet conditions (ASRP, mixture temperature and F/A ratio) constant throughout the run. The exhaust pressure was varied to change the P_e/P_m ratio (exhaust pressure to manifold pressure). The examples illustrated on these plates indicate the proper use of the curves.

40. Plate 34 shows the effect of cylinder head temperature on engine power. Inlet conditions to the cylinders (ASRP, F/A ratio and mixture temperature) were maintained constant throughout these runs.

41. Friction characteristics of the engine in low and high gear are shown on Plates 35 and 36. For these runs, the engine was motored by the dynamometer at approximately the same conditions as those obtained during the altitude calibration. The friction horsepower, which is the difference between indicated and brake horsepower, is the sum of the power absorbed by the supercharger, the mechanical friction of the engine, and the pumping action of the pistons. Since the engine operating temperature was not the same as it would be with the engine firing, there may be minor errors in simulating both the mechanical friction (effect of temperature upon bearing clearances, oil viscosity, etc.) and the pumping losses (because of improper valve timing due to expansion differences at lower temperatures and incorrect temperature of the air flowing through the cylinders). However, since the horsepower absorbed by the supercharger constitutes the greatest portion of the friction horsepower, the friction horsepower values plotted on these plates should be relatively accurate.

42. Plate 37 shows the oil flow and heat rejection characteristics of the engine at propeller load powers and various speeds. The limits as specified in reference (b) are shown for comparison.

43. On Plate 38 is shown a comparison of the brake horsepower output of the engine as determined by the engine torquemeter and by the dynamometer.

44. Plates 39 and 40 are views of the engine installation in No. 5 dynamometer room.

45. Plates 41 to 46 inclusive show the condition of damaged parts of engine No. P-2727 after disassembly. This engine was operated a total of 227 hours, 212 hours of which were accumulated during the calibration. After completing the calibration the engine was used for experimental carburetor tests under Project T&D No. NAM-PP3294. The carburetor test program was interrupted when sizable metal chips were found in the main sump. These chips were identified as parts of the supercharger hydraulic coupling impeller nut tab-washer, and it was decided to discontinue tests before the coupling could become completely disassembled and cause major damage to the engine rear section. Several unusual conditions were noted on disassembly of the engine which could not be explained; namely - severe and irregular wear of the high ratio supercharger intermediate pinion gear teeth (see Plate 43), and discoloration of the hydraulic coupling cover caused by excess temperatures (see Plate 41) without any evidence of metal-to-metal contact. Although the hydraulic coupling oil feed manifold assembly was cracked (see Plates 45 and 46), only the line feeding oil to the low ratio coupling was cracked and the low ratio cover did not show any evidence of overheating. The coupling assembly was returned to the engine manufacturer for study.

46. Plates 47 to 52 are general views of the engine.

REFERENCES

- a. Project Authorization - Bureau of Aeronautics Restricted letter AER-PP-23 23326 of 20 March 1947.
- b. Engine Specification - Pratt and Whitney Aircraft Specification No. N-7056-D of 3 January 1950, Model R-4360-20, -20W Engines,
- c. Supercharger Performance - Aeronautical Engine Laboratory Report No. AEL-763 - "Centrifugal Supercharger Performance".
- d. Critical Altitude Checks - Naval Air Experimental Station Restricted letter XE-1-PCP:frs F21-1(2)(4360) of 9 October 1947 - Including Preliminary Report No. 1 on Project TED No. NAM-PP209.
- e. Carburetor Metering - Naval Air Experimental Station Restricted letter XE-1-PCP:frs F21-1(2)(4360) of 20 November 1947 - Including Preliminary Report No. 2 on Project TED No. NAM-PP209.
- f. Critical Altitude Checks Engine P-726 Modified - Naval Air Experimental Station Restricted letter XE-1-WVT:frs F21-1(2)(4360) of 14 May 1948 - Including Preliminary Report No. 3 on Project TED No. NAM-PP209.
- g. Critical Altitude Checks Revised Production Engine P-2727 - Naval Air Experimental Station Restricted letter XE-1-MJD:mck F21-1(2)(4360)(104) of 26 Aug 1949 - Including Preliminary Report No. 4 on Project TED No. NAM-PP209.
- h. Engine No. P-726 Modification - Pratt and Whitney Aircraft Report PWA-731 on "Tests Conducted and Modifications Made to Improve Critical Altitude Performance and Carburetor Altitude Compensation of R-4360-20W Engine P-726."
- i. Detonation Checks 100/130 Fuel - Naval Air Experimental Station Restricted letter XE-1-MJD:mck F21-1(2)(4360)(429) of 2 February 1950 - Including Preliminary Report No. 5 on Project TED No. NAM-PP209.
- j. Calibration With Normal Mixtures - Naval Air Experimental Station Restricted letter XE-1-MDJ:cts F21-1(2)(4360)(607) of 18 May 1950 - Including Preliminary Report No. 6 on Project TED No. NAM-PP209.

ALTITUDE THOUSAND FEET

1148

**ALTITUDE CHARACTERISTICS
WITH AUTO. POWER CONTROL UNIT
"NORMAL" MIXTURES
P & W R-4360-20 ENGINE**

ENGINE NO. P-2727
AERONAUTICAL ENGINE LABORATORY
NAVAL AIR ENGINEERING STATION, PHILA. PA.
PROJECT NO. PP209 ENGINEER DOTSEY
RATIOS: COMP. 57:1, PROP. 4.25:1
IMPELLER LOW 5.95:1
HIGH 8.07:1
IGNITION - SCINTILLA 24RN-2
PLUGS - AC 181
CARB. - STRONBERG PR-KOD-1
FUEL - 115/145
OIL - LUGO
* ECLIPSE TYPE 1626, MODEL 2
** SETTING P.L. NO. 390241-4,
SER. NO. - 736152-A

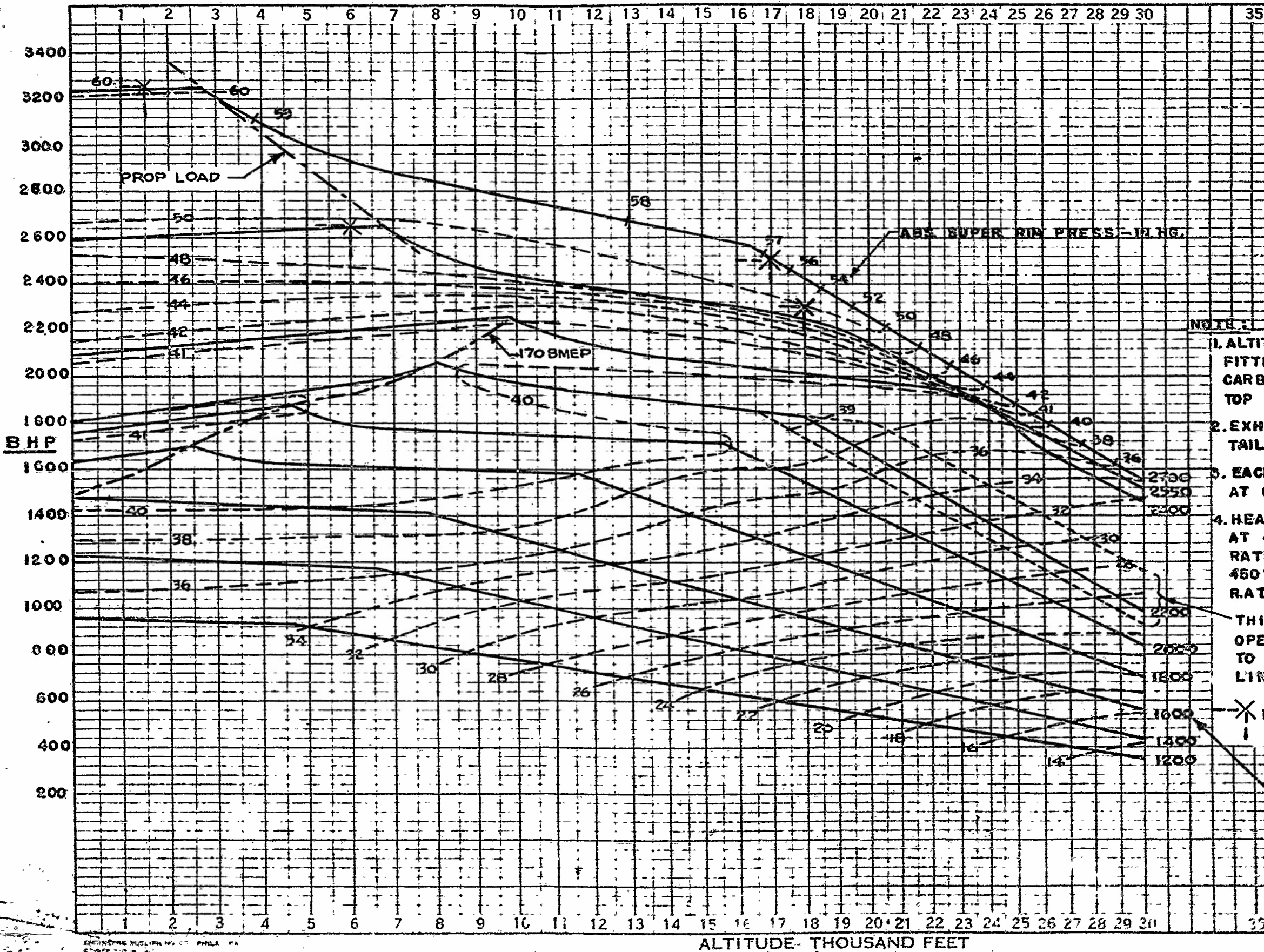
NOTE:

1. ALTITUDES MEASURED BY 2 STATIC FITTINGS ON SIDES OF STRAIGHT CARB. SCOOP 5" UPSTREAM OF CARB. TOP DECK.
2. EXHAUST ALTITUDE MEASURED ON TAIL PIPES OF R60-1 COLLECTOR.
3. EACH SPEED RUN WITH A.P.C. UNIT AT CONSTANT SETTING.
4. HEAD TEMPERATURES MAINTAINED AT 480°F (MAX. LIMIT) FOR NORMAL RATED POWER AND ABOVE; AND AT 450°F FOR POWERS BELOW NORMAL RATED.

THIS AREA INDICATES UNSTABLE OPERATING RANGE; IT WAS POSSIBLE TO OBTAIN TWO FULL THROTTLE LINES AT 2200 RPM.

X MFRS. GUAR. CRITICAL ALTITUDE

CRANKSHAFT RPM



ALTITUDE THOUSAND FEET

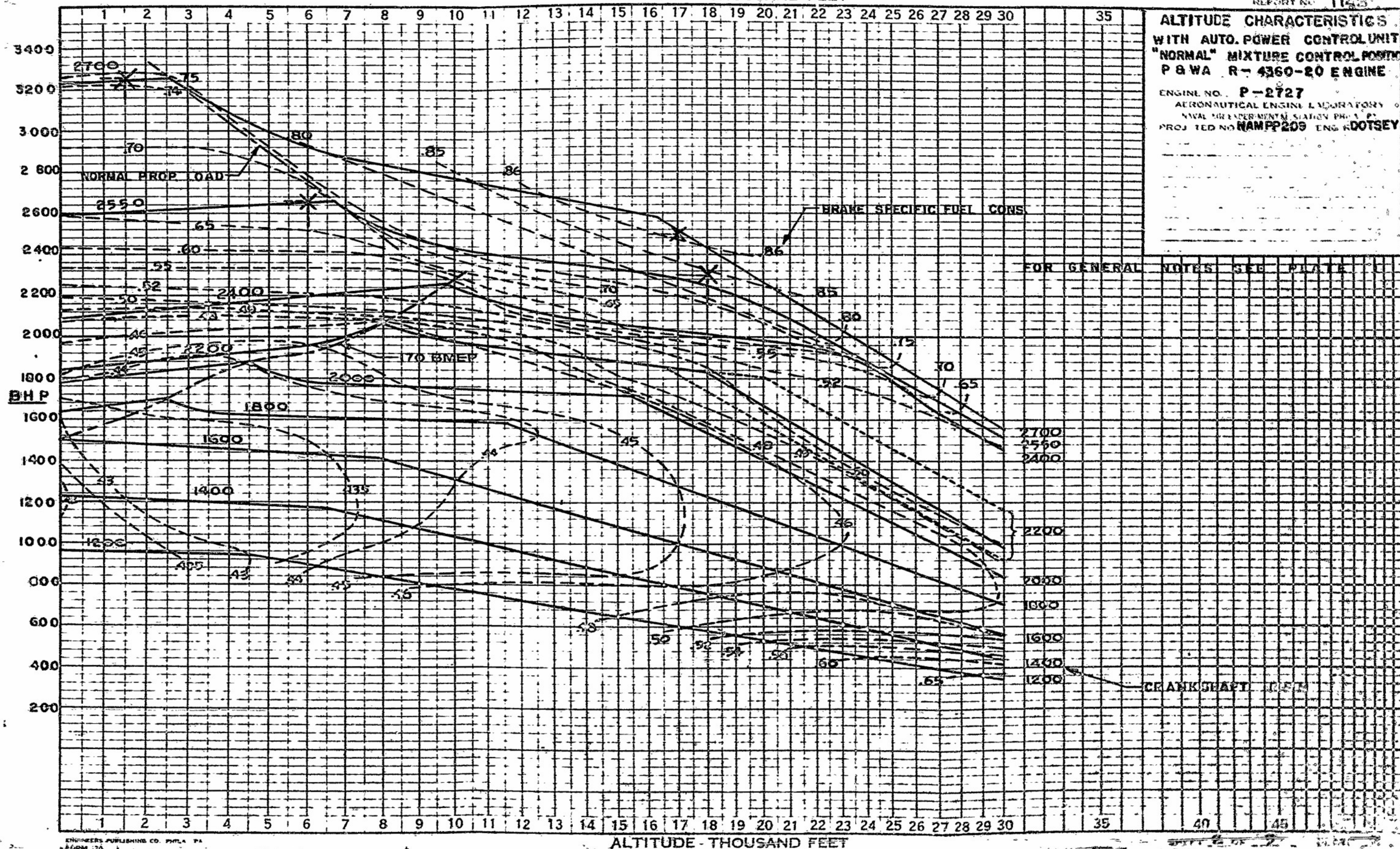
CHART 1 OF 2 PLATE 11

ALTITUDE THOUSAND FEET

REPORT NO. 1143

**ALTITUDE CHARACTERISTICS
WITH AUTO. POWER CONTROL UNIT
"NORMAL" MIXTURE CONTROL POSITION
P & WA R-4360-20 ENGINE**

ENGINE NO. P-2727
AERONAUTICAL ENGINE LABORATORY
NAVAL EXPERIMENTAL STATION, PATENT
PROJECT NO. NAMPP209 ENS. FOOTSEY



ALTITUDE THOUSAND FEET

REPORT NO. 1148

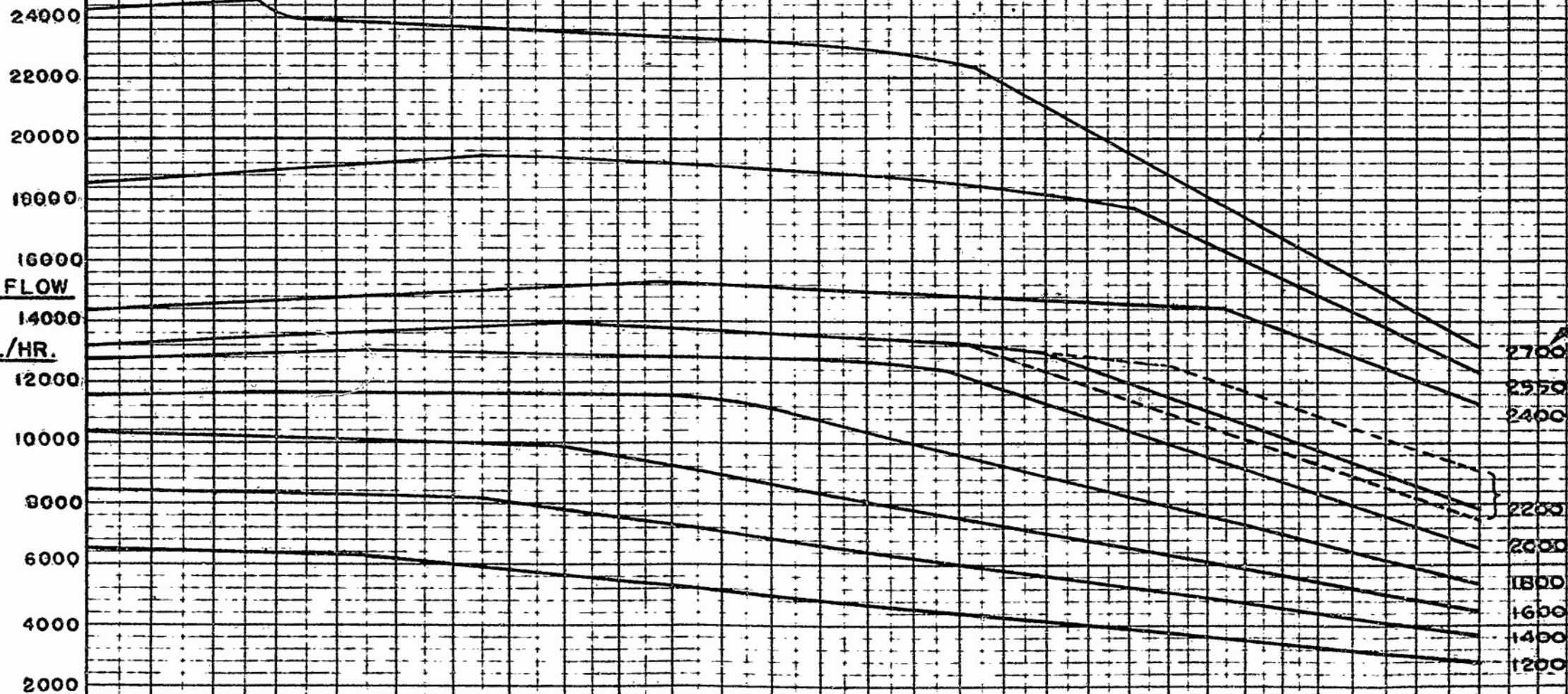
**ALTITUDE CHARACTERISTICS
WITH AUTO. POWER CONTROL UNIT
"NORMAL" MIXTURES
PWA R-4360-20 ENGINE**

ENGINE NO. P-2727
AERONAUTICAL ENGINE LABORATORY
NAVAL AIR EXPERIMENTAL STATION PHILA. PA.
PROJECTED NO. PP-209 ENG. DOTSEY

FOR GENERAL NOTES SEE PLATE 1

AIR FLOW
LB./HR.

CRANKSHAFT RPM



ALTITUDE THOUSAND FEET

PLATE 2

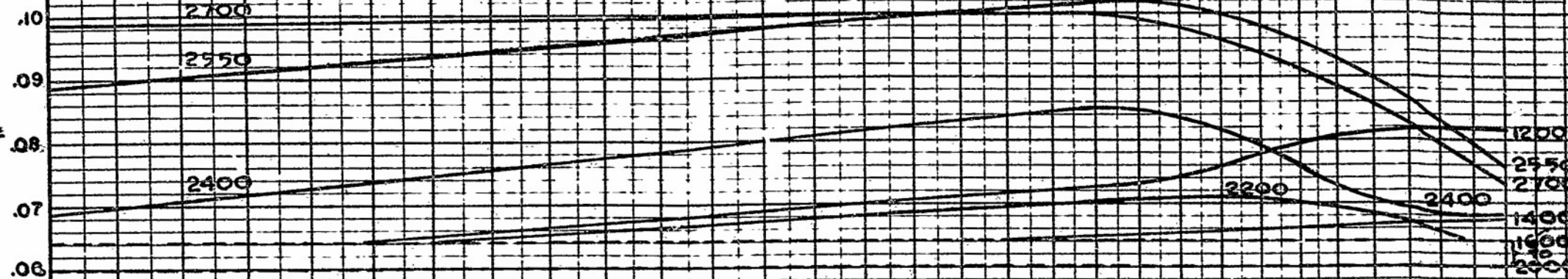
ALTITUDE-THOUSAND FEET

REPORT NO. 2100

ALTITUDE CHARACTERISTICS WITH AUTO. POWER CONTROL UNIT "NORMAL" MIXTURES P QWA R-4360-20 ENGINE

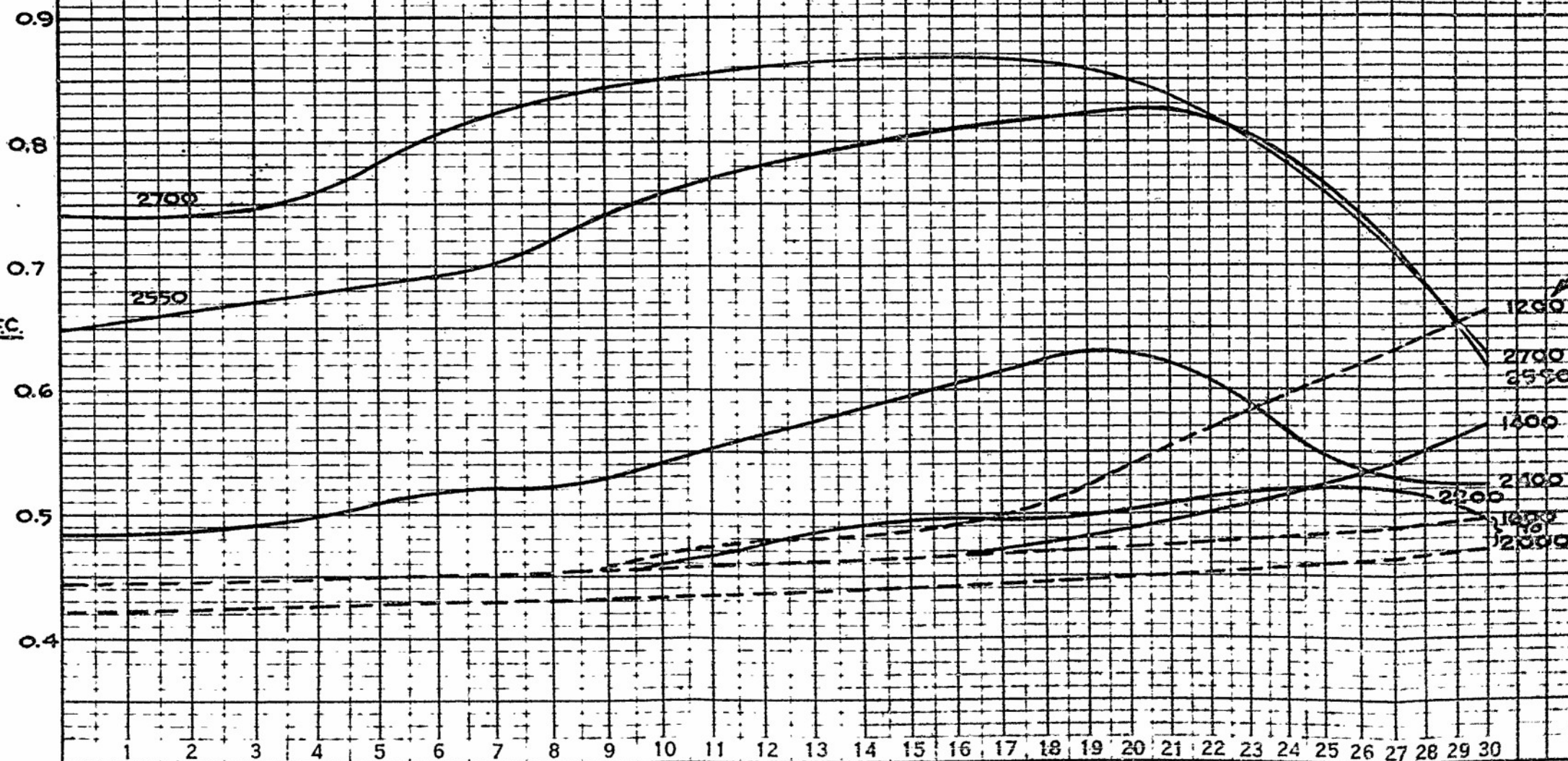
ENGINE NO. P-2727
AERONAUTICAL ENGINE LABORATORY
NAVAL AIR EXPERIMENTAL STATION PHILADELPHIA
PROJECTED NO. PP-209 ENG. DOTSEY

$\frac{P}{A}$



FOR GENERAL NOTES SEE PLATE I.

S.F.C.



ALTITUDE-THOUSAND FEET

ENGINE P-2727, Q-1, R-4360-20

PLATE 4

5

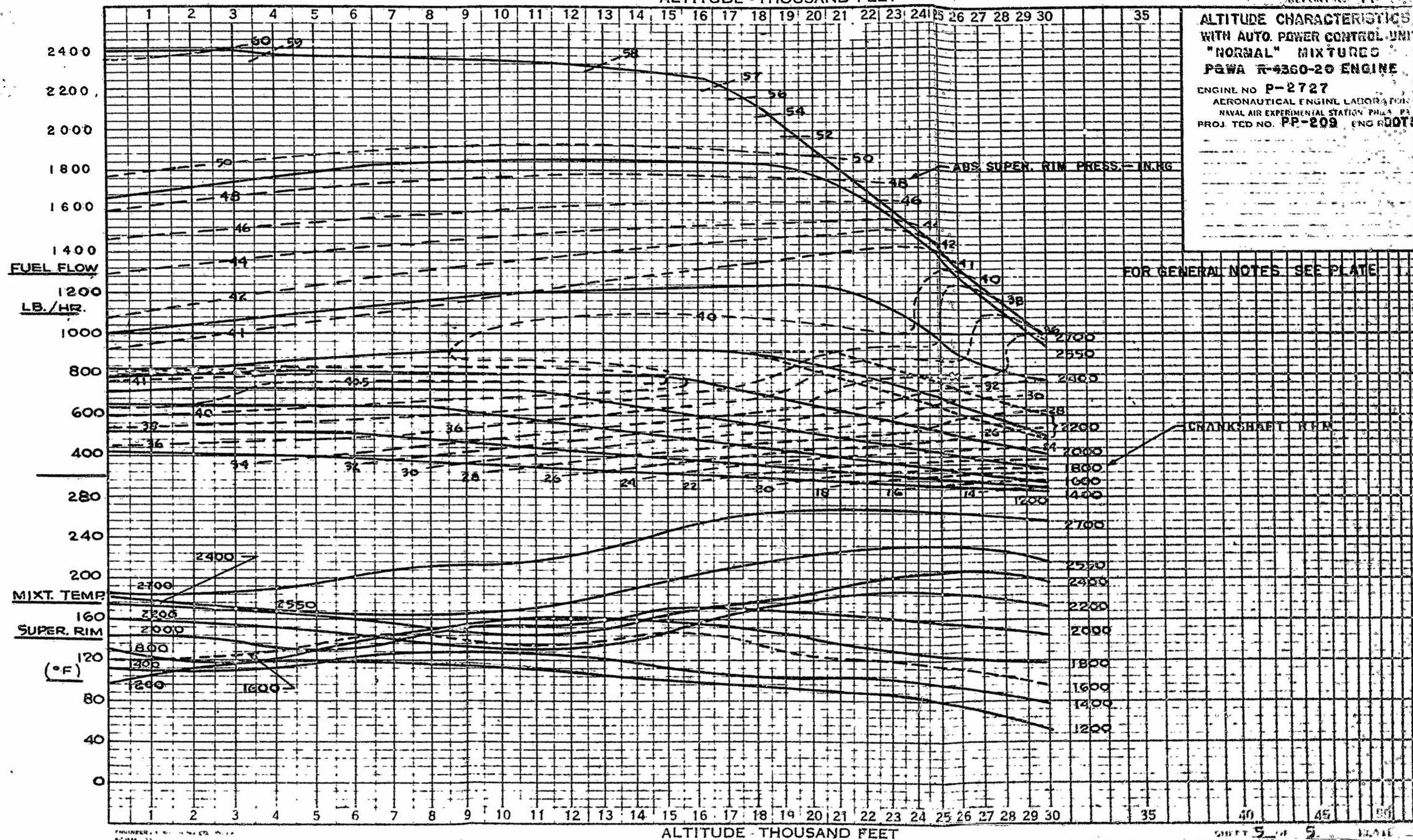
PLATE 4

ALTITUDE - THOUSAND FEET

REPORT NO. 11

ALTITUDE CHARACTERISTICS WITH AUTO. POWER CONTROL UNIT "NORMAL" MIXTURES PQWA R-4360-20 ENGINE

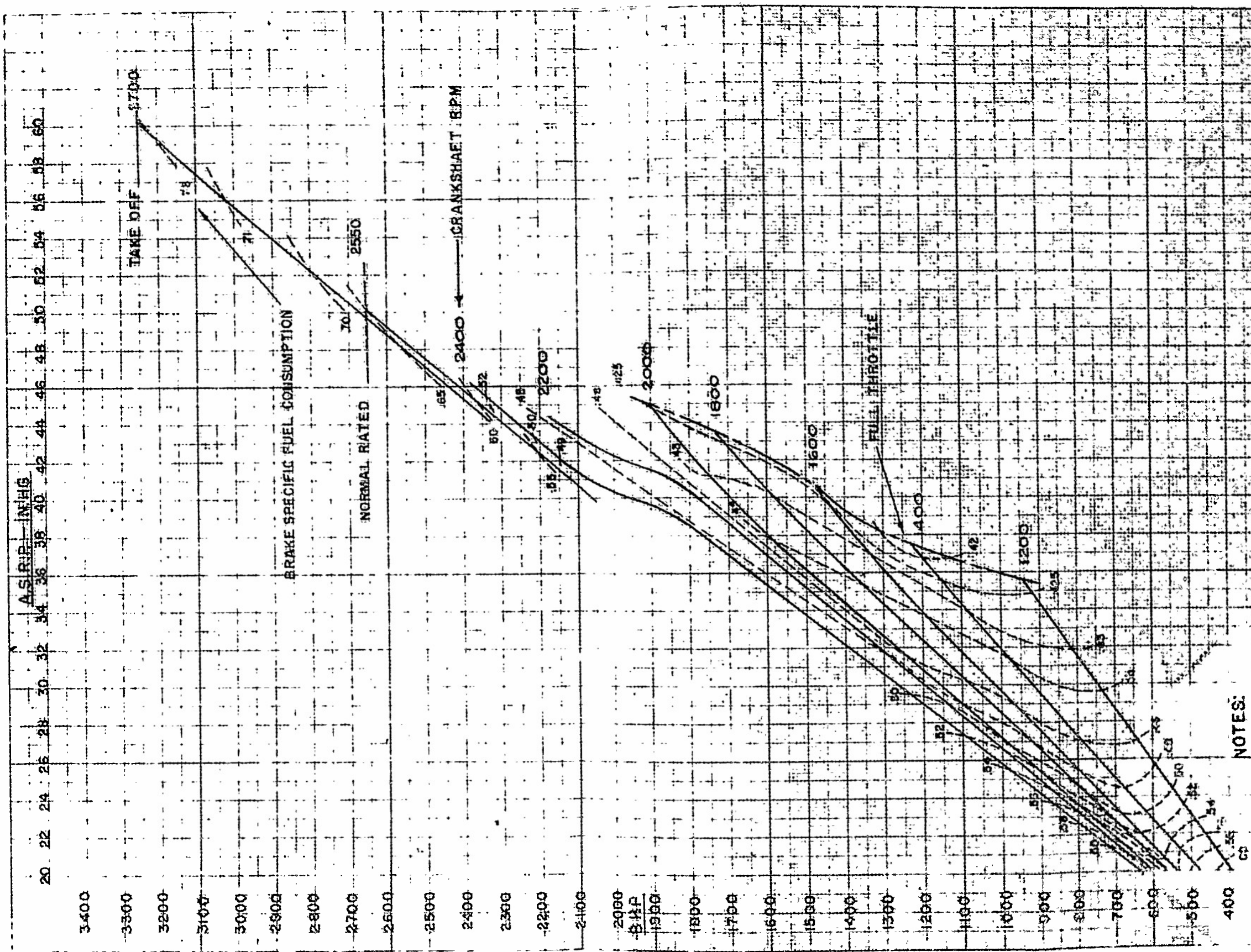
ENGINE NO P-2727
AERONAUTICAL ENGINE LABORATORY
NAVAL AIR EXPERIMENTAL STATION PHILADELPHIA
PROJECT NO. PP-209 ENG. ROOTS



ENGINEER: J. H. H. CO. 11-11-11

ALTITUDE - THOUSAND FEET

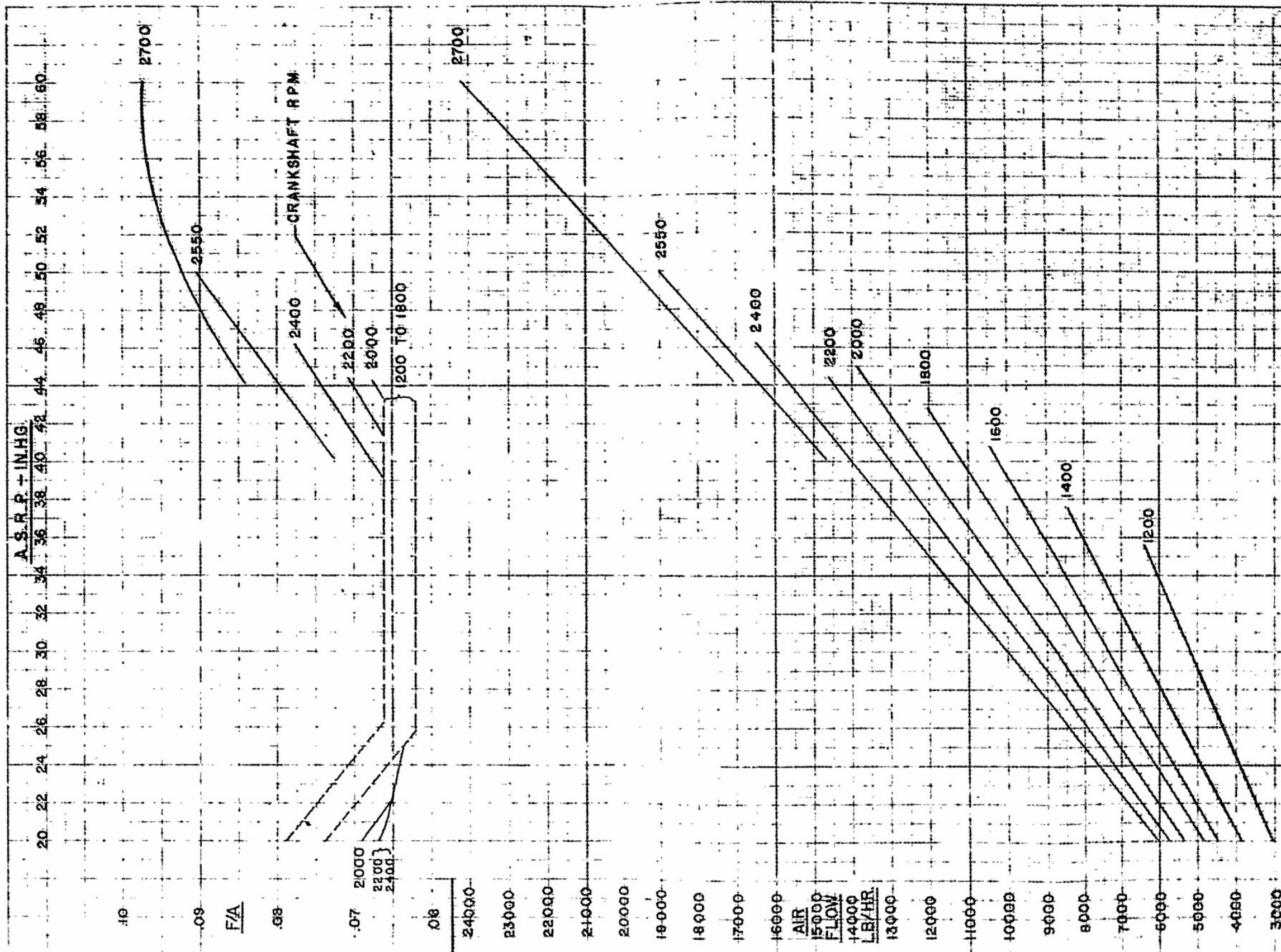
PLATE 5 OF 5



NOTES:

1. HEAD TEMPERATURES MAINTAINED AT 480°F (MAX LIMIT) AT NORMAL RATED POWER AND ABOVE, AND 450°F AT POWERS BELOW NORMAL RATED.
2. STROMBERG PR100B3 CARBURETOR SETTING NO. 3909 #1-4, SET NO. 736152 IN NORMAL MIXTURE POSITION.
3. STRAIGHT CARBURETOR SCORER.
4. X-RED TYPE EXHAUST COLLECTION.

PART THROTTLE
SEA LEVEL - CHARTS
LOW BEAR - NORMAL MIXTURE
PWA 4-1350-20 ENGINE P-2771
RAUMUTON ENGINE COMPANY
NAVAL AIR EXPERIMENTAL STATION, PALMDALE, CALIF.
FILED No. 1414-203



PLATE

7

PART THROTTLE

SEA LEVEL CHARACTERISTICS

LOW GEAR - NORMAL MIXTURE

PBWA R-4360-20 ENGINE NO. P-2727

AERONAUTICAL ENGINE LABORATORY

NAVAL AIR EXPERIMENTAL STATION, PHILADELPHIA, PA.

Revised No. NAEK PP 208 P. 201867

A.S.R.P. - IN.HG.

20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60

2400

2300

2200

2100

2000

1900

1800

1700

1600

1500

1400

1300

FUEL

FLOW

LB/HR

1000

900

800

700

600

500

400

300

200

100

0

150

140

130

120

110

100

90

80

70

60

50

40

30

20

2700

2550

2400

2200

2000

1800

1600

1400

1200

2700

2550

2400

2200

2000

1800

1600

1400

1200

PART THROTTLE

SEALEVEL CHARACTERISTICS

LOW GEAR - NORMAL MIXTURE

88WA R-4360-20 ENGINE NO. P-2727

AERONAUTICAL ENGINE LABORATORY

NAVY AIR ENGINEERING STATION PHILADELPHIA, PA.

Proj. TED No. NAM-2003 E. DOTSEY

FOR GENERAL NOTES SEE PLATE 6

PLATE 6

APL-1148

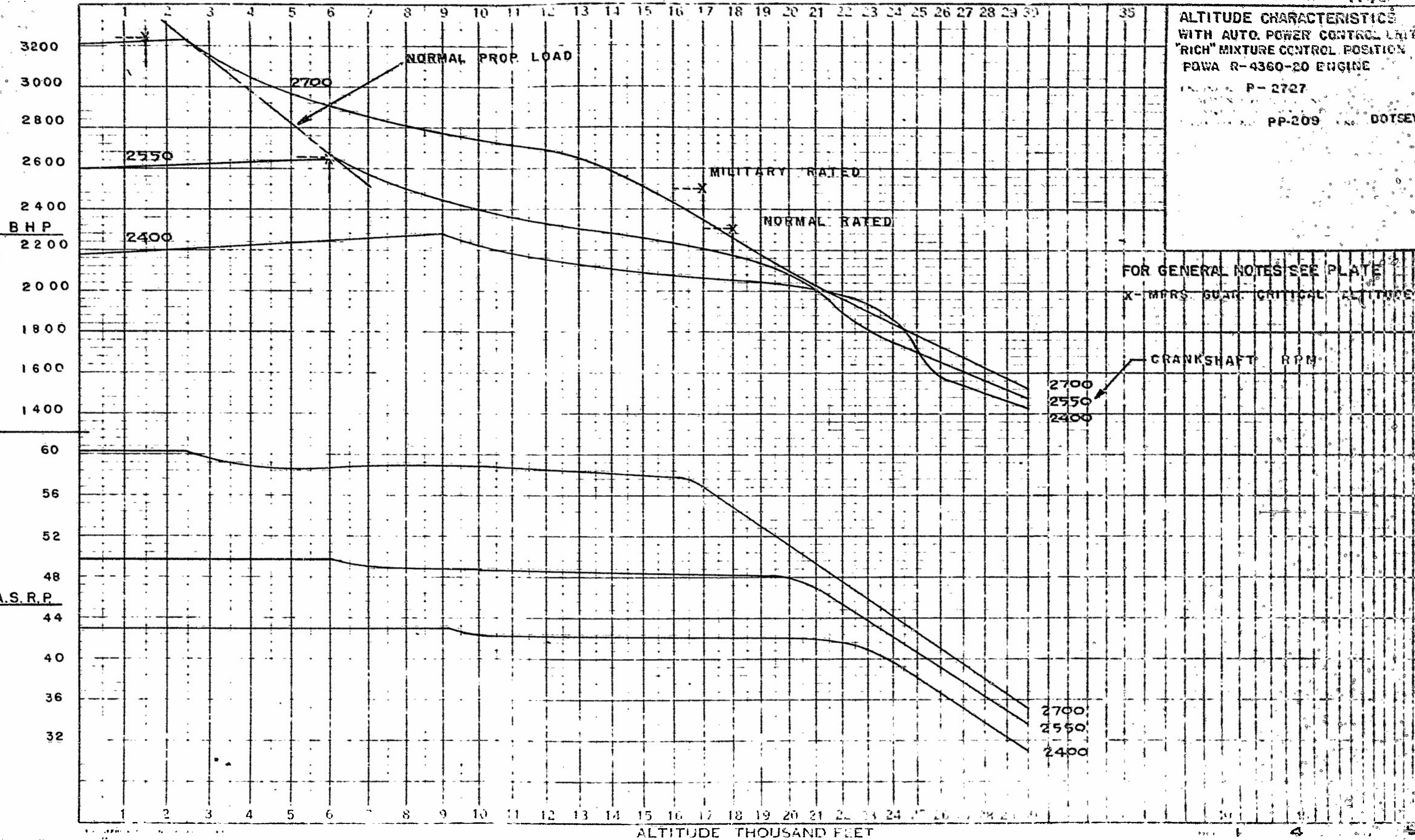
ALTITUDE THOUSAND FEET

1148

ALTITUDE CHARACTERISTICS
WITH AUTO. POWER CONTROL UNIT
"RICH" MIXTURE CONTROL POSITION
PQWA R-4360-20 ENGINE

MODEL P-2727

PP-209 DOTSEY



ALTITUDE THOUSAND FEET

ALTITUDE CHARACTERISTICS
WITH AUTO. POWER CONTROL AND
"RICH" MIXTURE CONTROL POSITION
PWA R-4360-20 ENGINE

P-2727

PP209

DOTSEY

3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
BHP

FOR GENERAL NOTES SEE PLATE 1.

CRANKSHAFT RPM

2700
2550
2400

1.0
.9
.8
S.F.C.
.7
LB/BHP-HR
.6
.5

2700
2550
2400

ALTITUDE THOUSAND FEET

2 4 10

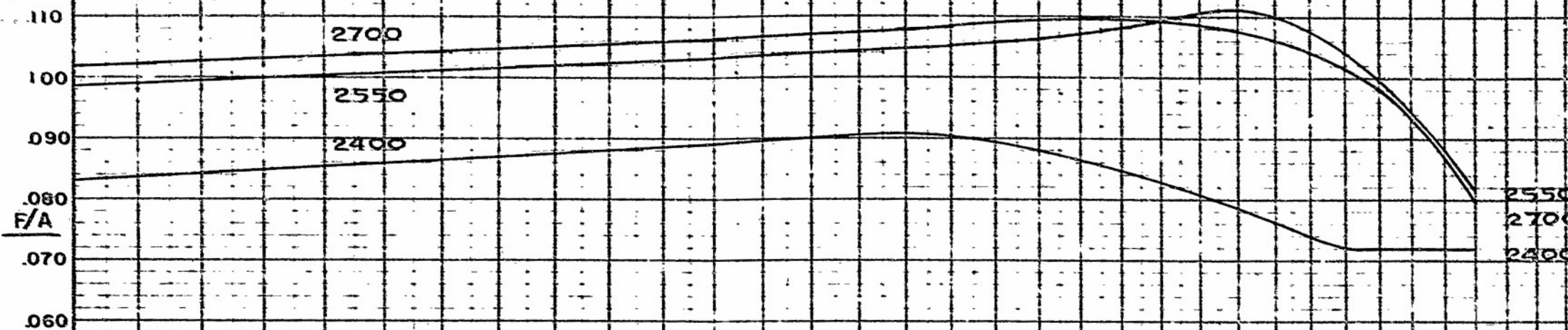
ALTITUDE THOUSAND FEET

ALTITUDE CHARACTERISTICS
WITH AUTO. POWER CONTROL UNIT
"RICH" MIXTURE CONTROL POSITION
P8WA R-4360-20 ENGINE

MODEL P-2727

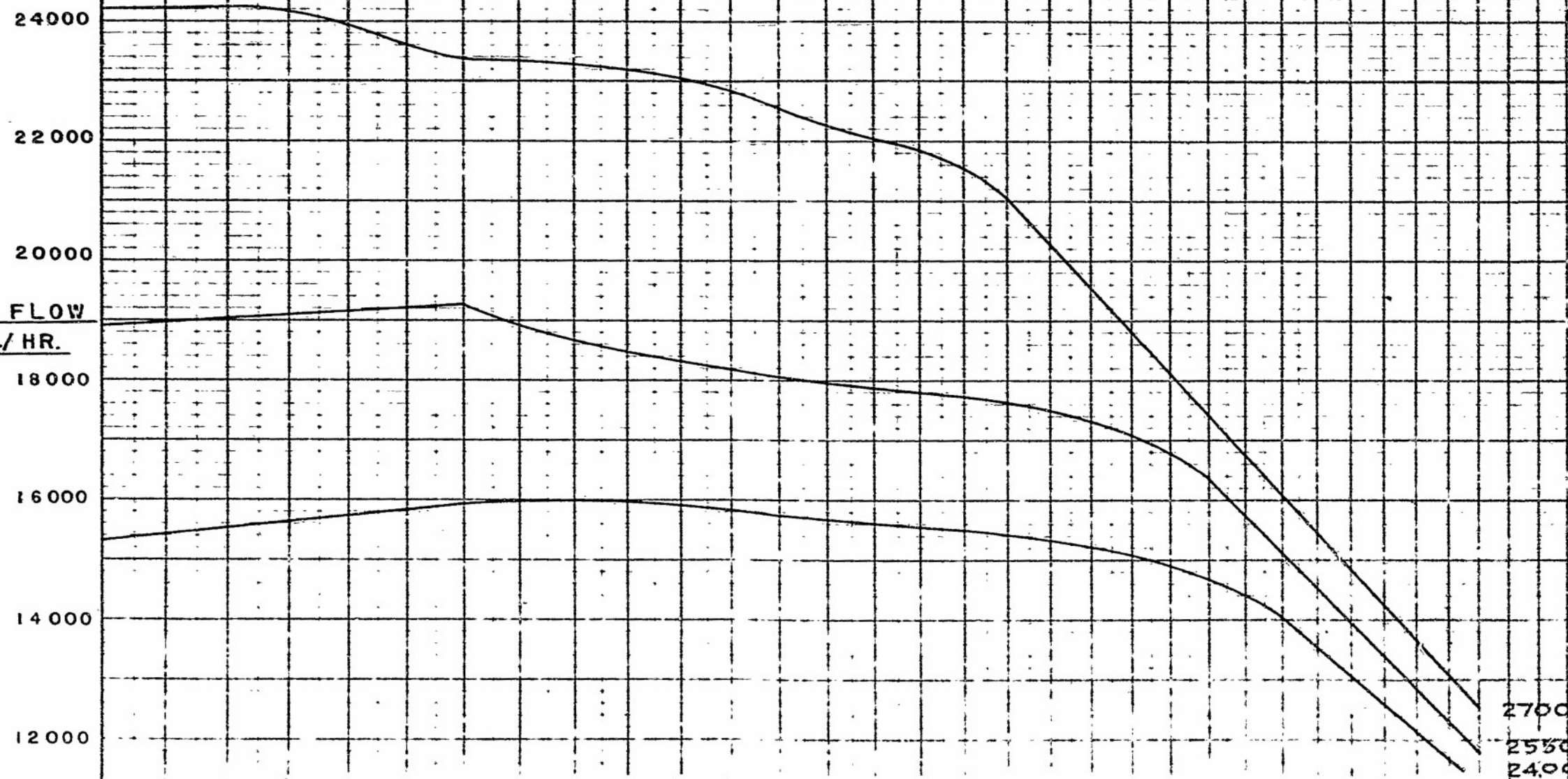
PP 209

DOTSEY



FOR GENERAL NOTES SEE PLATE 1

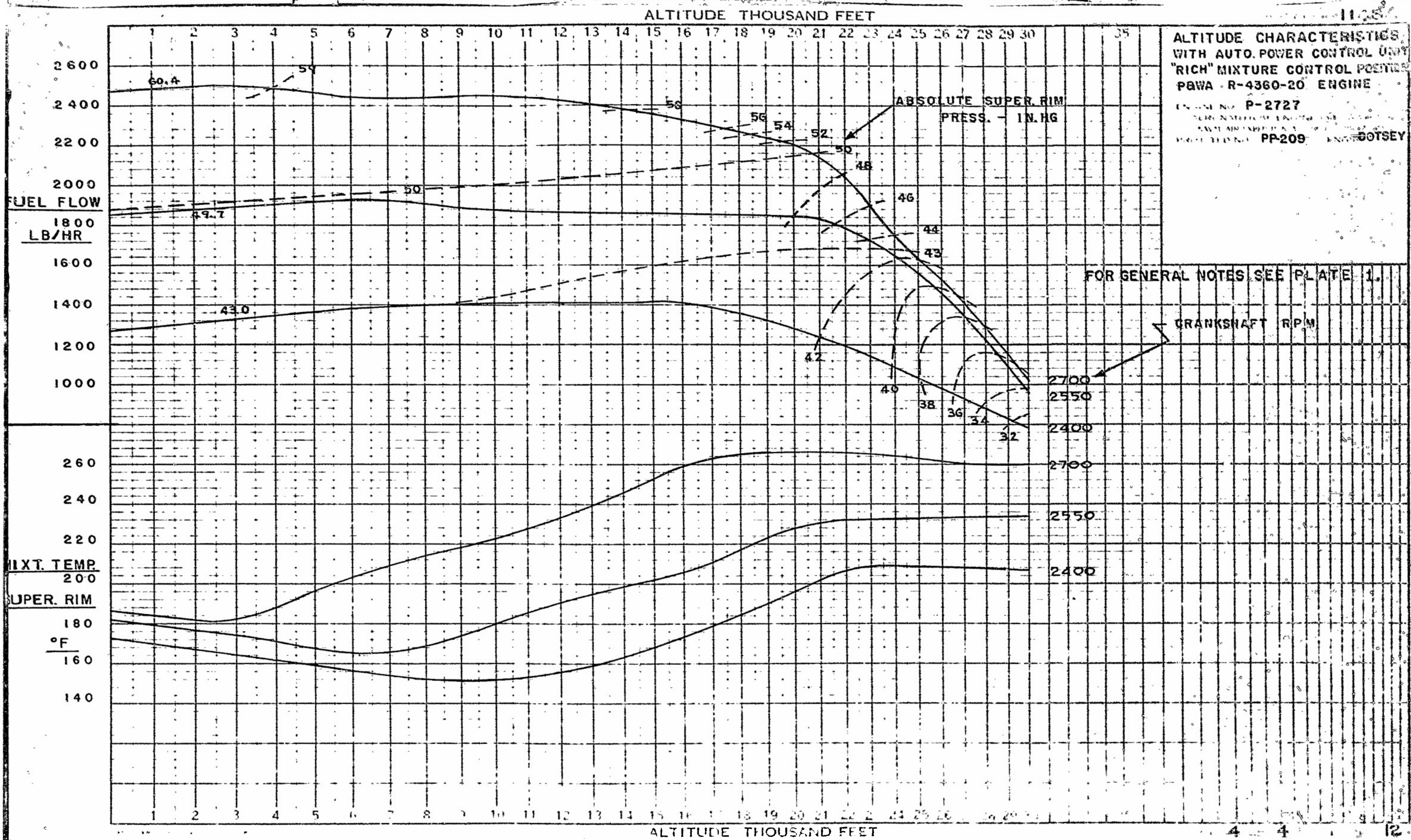
IR FLOW
LB./HR.

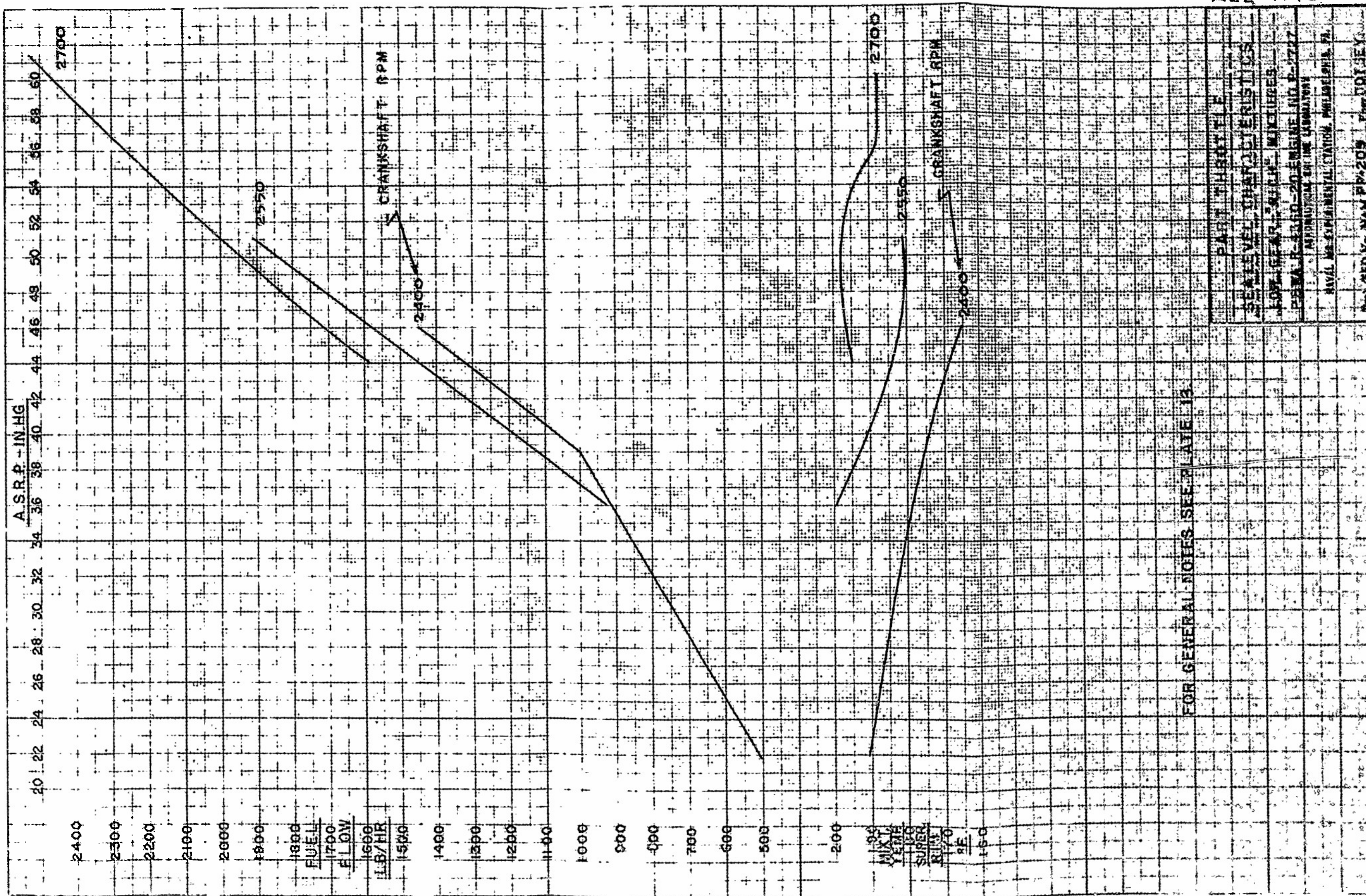


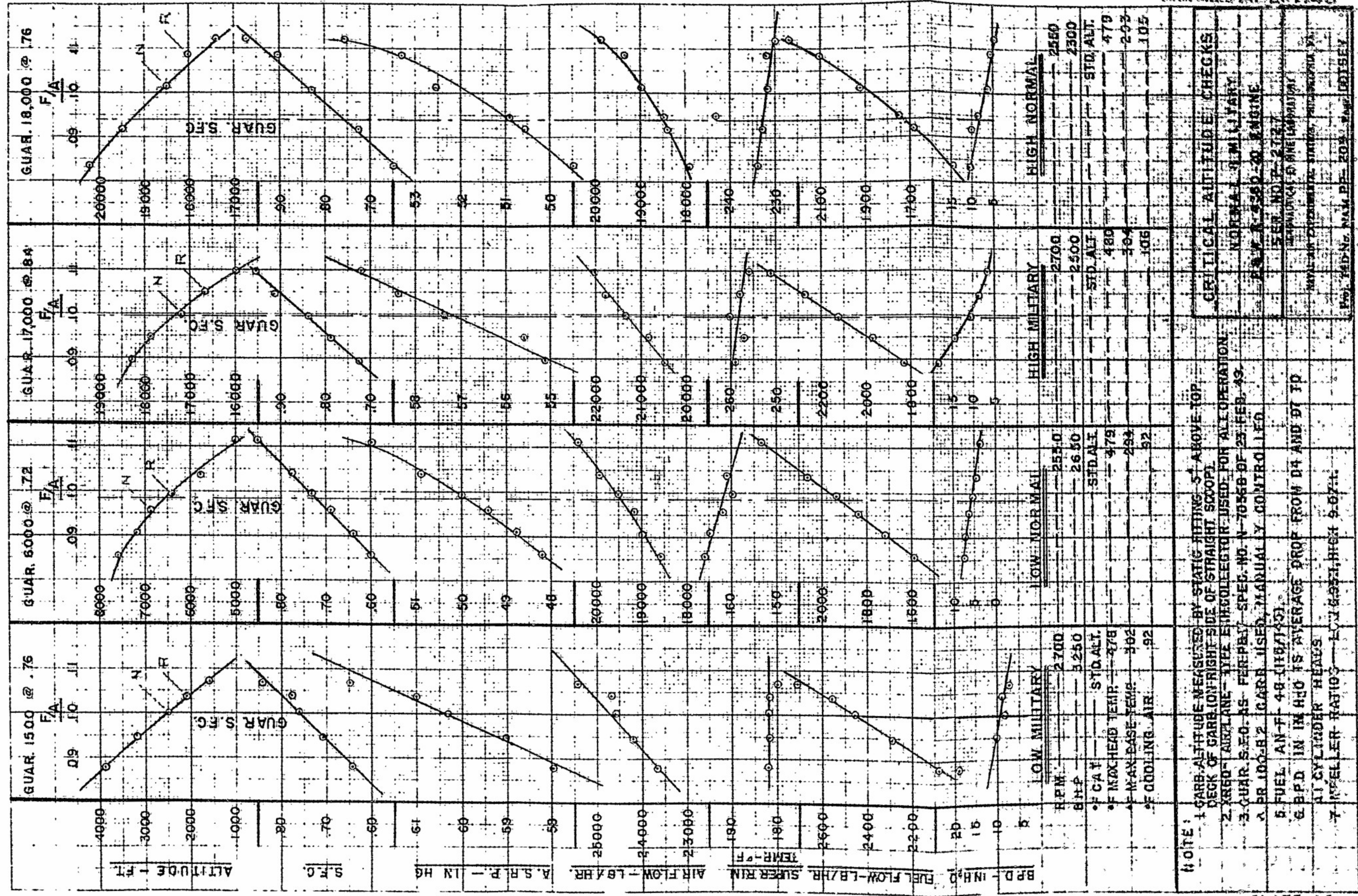
CRANKSHAFT RPM

ALTITUDE THOUSAND FEET

3 4

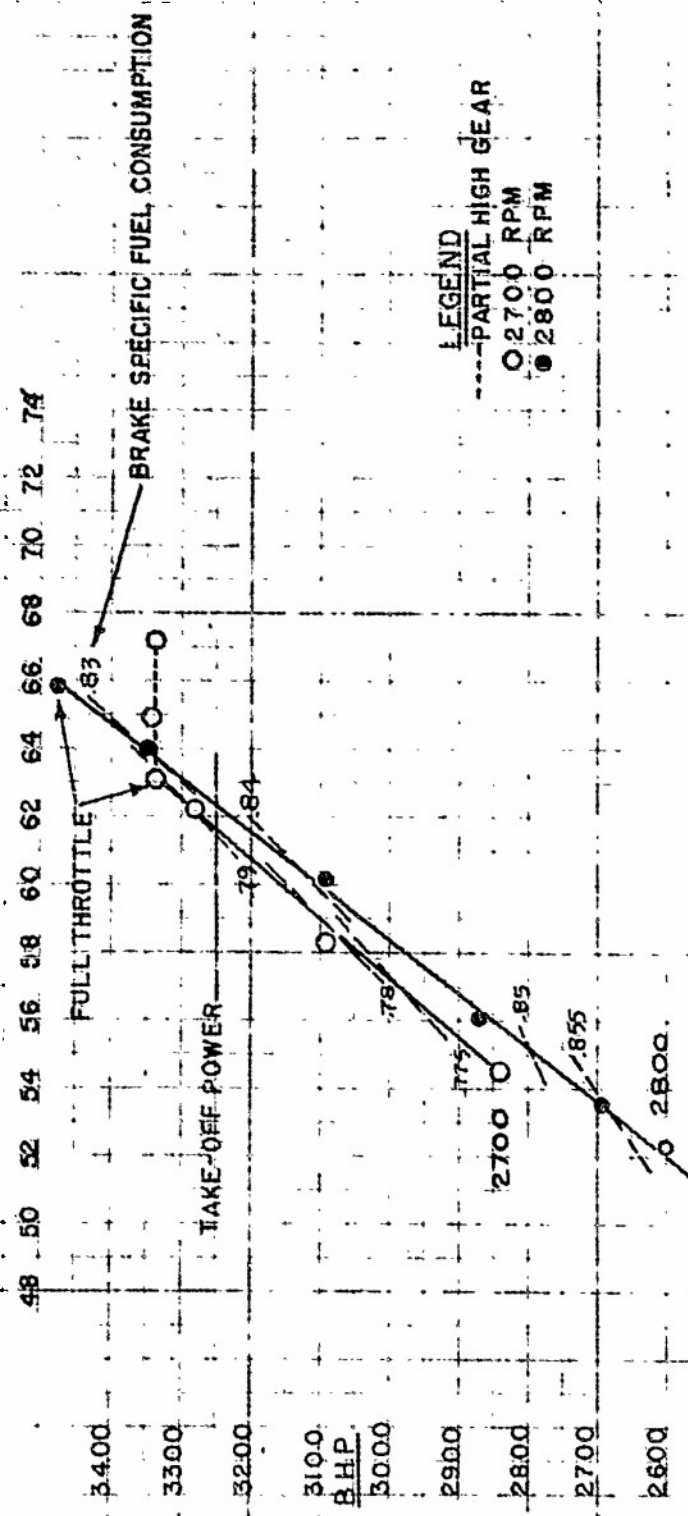




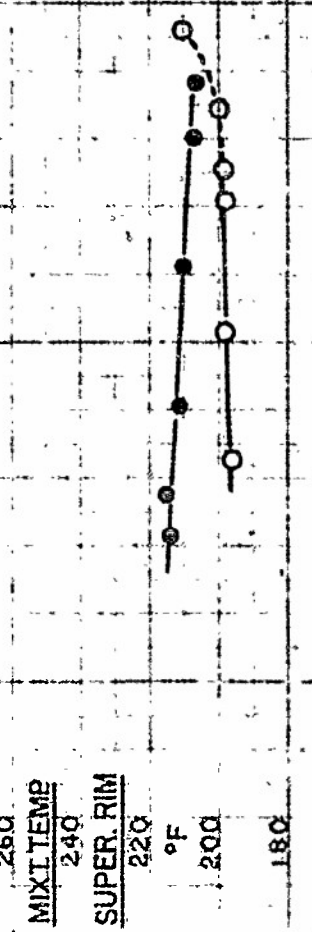
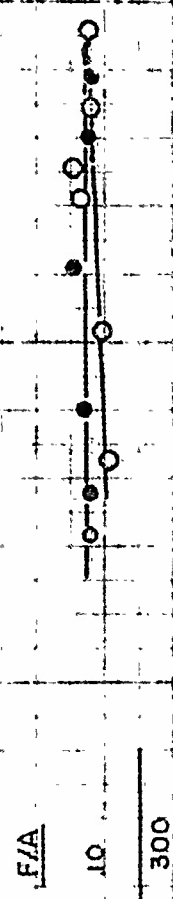
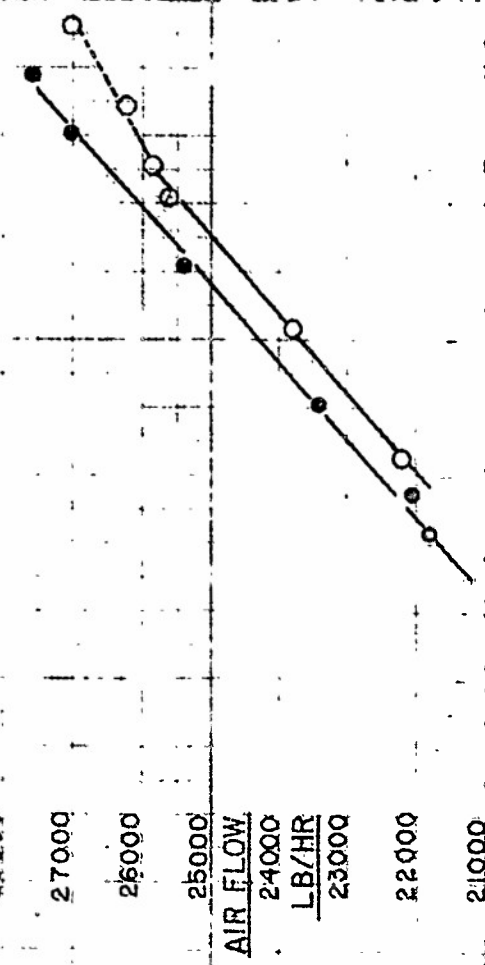


NOTE: 1. CARB. ALTITUDE MEASURED BY STATIC TYPING 5' ABOVE TOP DECK OF CARBURETOR (RIGHT SIDE OF STRAIGHT SCOOP).
2. XRGD- AIRPLANE - TYPE ENGINE (ENGINE USED FOR ALT. OPERATION).
3. GUAR. S.E.O. - 15 - PERPET - SPEC. NO. N-70558 OF 23 FEB. 49.
4. BR 100-B2 CARB. USED MANUALLY CONTROLLED.
5. FUEL AN-F-48 (118/150).
6. B.P.D. IN IN HG IS AVERAGE DROP FROM D4 AND D7 TO D1 CYLINDER HEADS.
7. COOLER RATIO - LOW 1.053, HIGH 1.071.

A.S.R.P.-IN.HG.



LEGEND
 --- PARTIAL HIGH GEAR
 O 2700 RPM
 ● 2800 RPM



- NOTES:
1. AN-F-48 (145-145) GRADE FUEL.
 2. 50°F CAT.
 3. STRAIGHT CARB. SCOP.
 4. FOR GENERAL NOTES SEE PLATE 13.

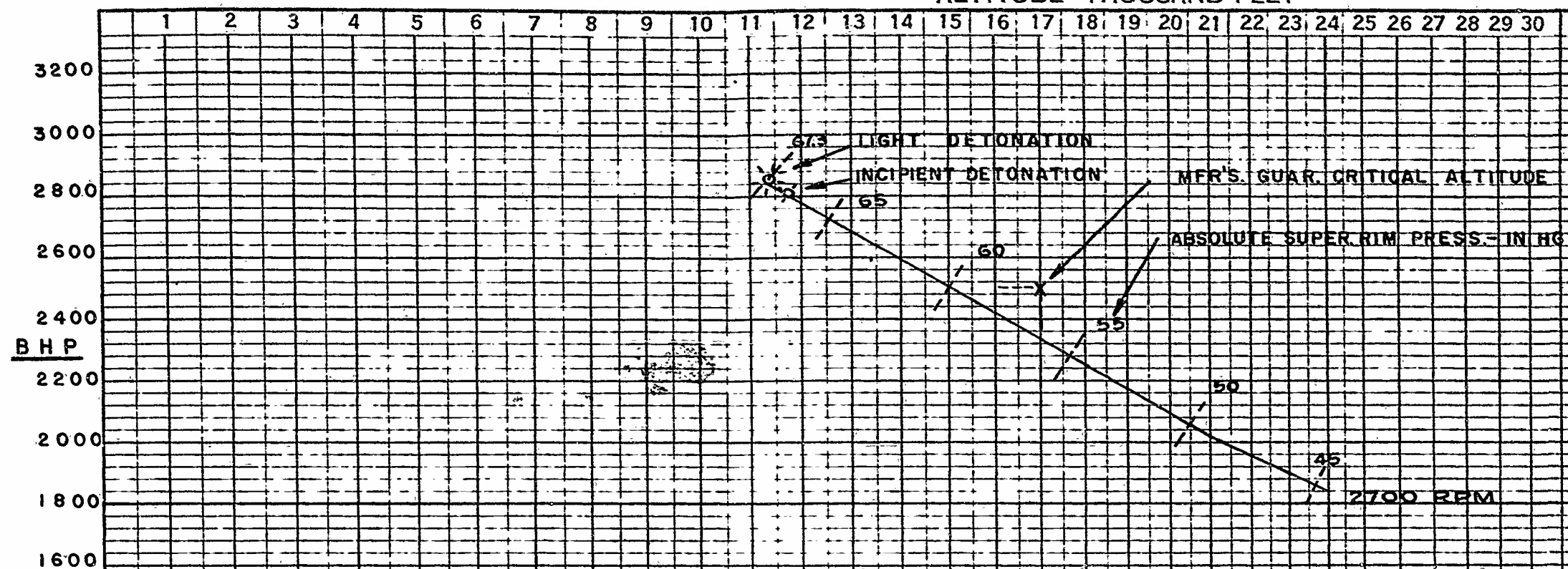
SEA LEVEL
 OVERPOWER CHARACTERISTICS
 LOW GEAR - RICH MIXTURES
 PBWA R-4380-20 ENGINE NO. P-2727
 AERONAUTICAL ENGINE LABORATORY
 NAVAL AIR EXPERIMENTAL STATION, PHILADELPHIA, PA.
 Proj. TED No. NAMPE-203 - Eng. DOIGLEY

ALTITUDE THOUSAND FEET

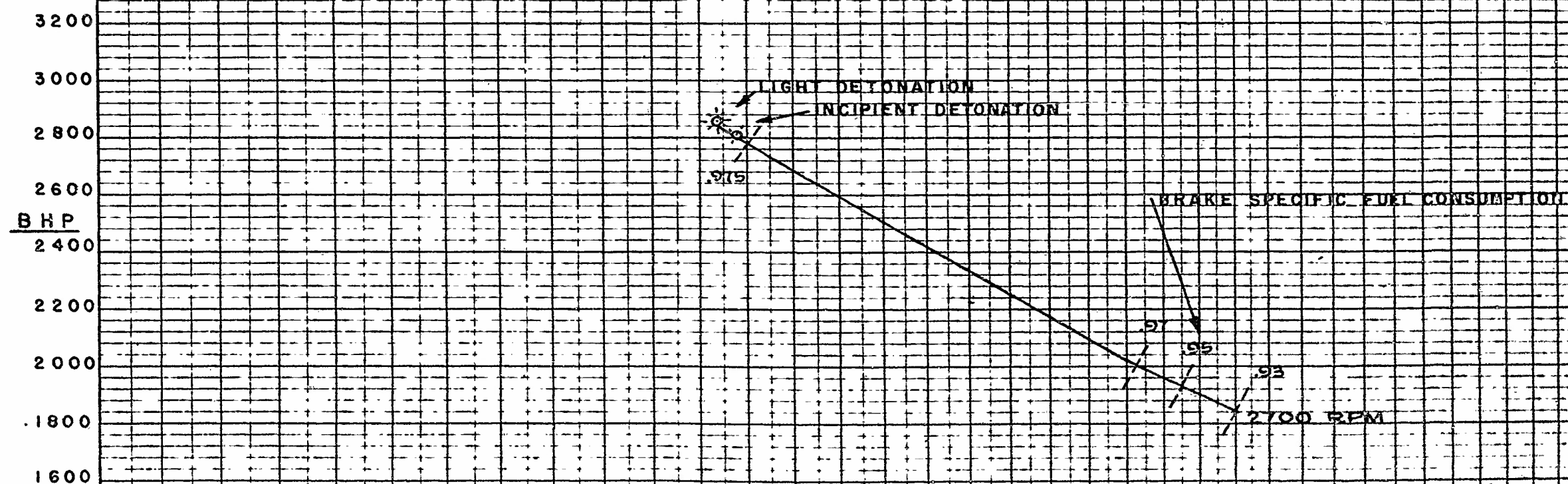
REPORT NO. 1148

**ALTITUDE CHARACTERISTICS
OVER-POWER RUNS
HIGH GEAR-"RICH" MIXTURE
P&WA R-4360-20 ENGINE**

ENGINE NO P-2727
AERONAUTICAL ENGINE LABORATORY
NAVAL AIR EXPERIMENTAL STATION, PHILADELPHIA
PROJECT NO PP209 ENGINEER JOOTSEY



FOR GENERAL NOTES SEE PLATE 1



ALTITUDE THOUSAND FEET

SHEET 1 OF 2 PLATE 1A

ALTITUDE-THOUSAND FEET

REPORT NO. 1148

ALTITUDE CHARACTERISTICS
OVER-POWER RUNS
HIGH GEAR-"RICH" MIXTURE
PWA R-4360-20 ENGINE

ENGINE NO P-2727
AERONAUTICAL ENGINE LABORATORY
NAVAL AIR EXPERIMENTAL STATION, PMA, PA
PROJ. TED NO PP209 ENG. HOOTSEY

FOR GENERAL NOTES SEE PLATE II

26000

24000

22000

AIR FLOW

20000

LB/HR

18000

16000

14000

.11

F/A

.10

290

MIXT.

TEMP

280

SUPER

RIM

270

°F

2700 RPM

ALTITUDE-THOUSAND FEET

PLATE 2 OF 2 PLATE 10

ALTITUDE THOUSAND FEET

1148

ALTITUDE CHARACTERISTICS
WITH AUTO. POWER CONTROL UNIT
"NORMAL" MIXTURE CONTROL POS.
P&WA R-4360-20 ENGINE

ENGINE NO P-2727
AERONAUTICAL ENGINE LABORATORY
NAVAL AIR EXPERIMENTAL STATION PHILA. PA.
PROJECTED NO PP209 ENG RDOTSEY

B.H.P.

ASRP

IN. HG.

FOR GENERAL NOTES SEE PLATE II

CRANKSHAFT RPM

2700
2550

LEGEND

(2700 RPM)

○ INCREASING ALTITUDE

△ DECREASING ALTITUDE

(2550 RPM)

● INCREASING ALTITUDE

+ DECREASING ALTITUDE

X HERS. GUAR. CRITICAL ALTITUDES

CRANKSHAFT RPM

2700
2550

ALTITUDE THOUSAND FEET

3 20

ALTITUDE THOUSAND FEET

REPORT NO. 1143

ALTITUDE CHARACTERISTICS
WITH AUTO. POWER CONTROL UNIT
"NORMAL" MIXTURE CONTROL POS.
PWA R-4360-20 ENGINE

ENGINE NO P-2727
AERONAUTICAL ENGINE LABORATORY
NAVAL AIR EXPERIMENTAL STATION PMA 12
PROJ. TED NO PP209 ENG R DOTSEY

AIR FLOW
LB/HR

24000
22000
20000
18000
16000
14000
12000

F/A
.100
.090
.080
.070

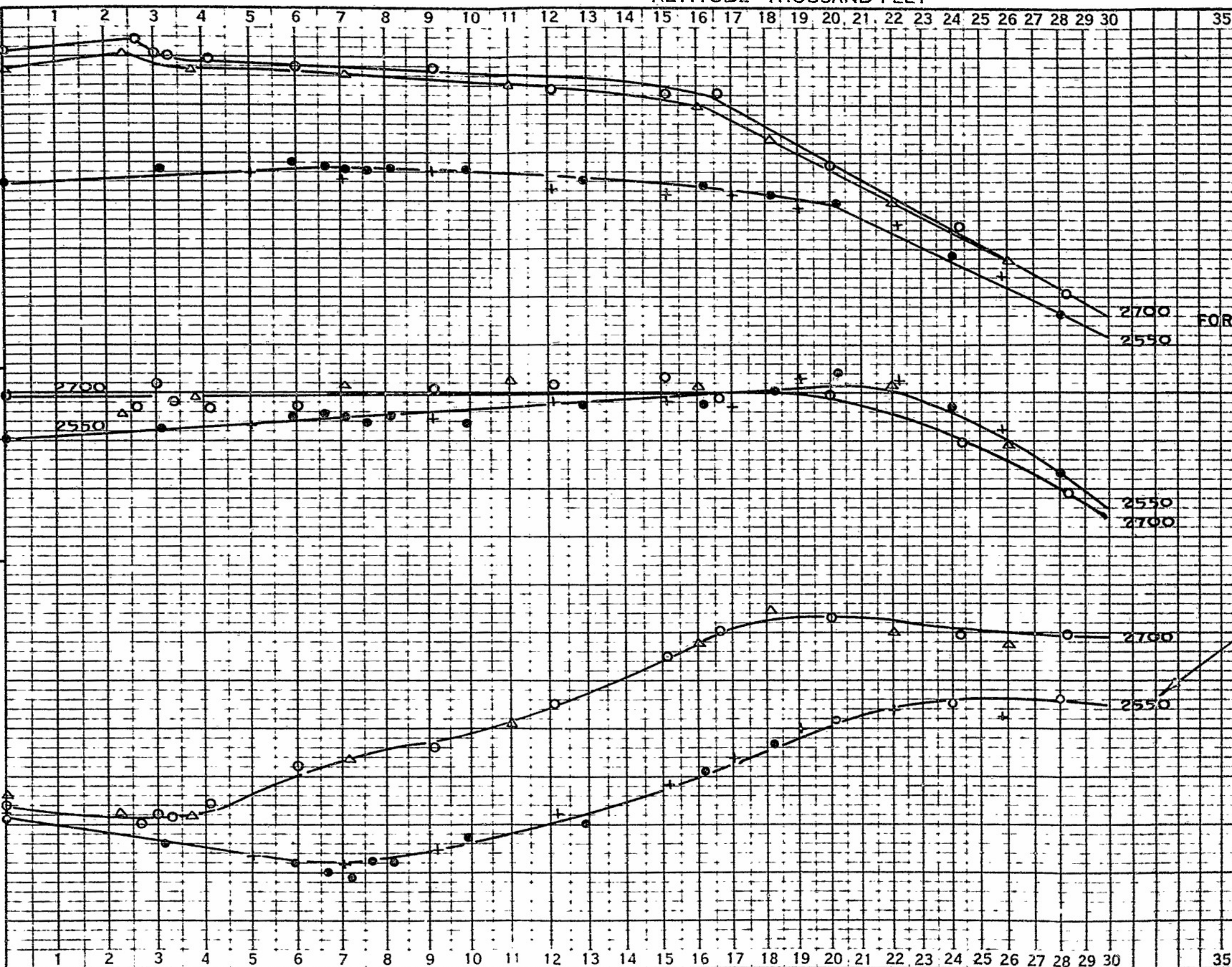
MIXT.
TEMP.
°F
280
260
240
220
200
180
160

FOR GENERAL NOTES SEE PLATE 1.

LEGEND

- (2700 RPM)
- INCREASING ALTITUDE
- △ DECREASING ALTITUDE (2550 RPM)
- INCREASING ALTITUDE
- + DECREASING ALTITUDE

CRANKSHAFT RPM



ALTITUDE-THOUSAND FEET

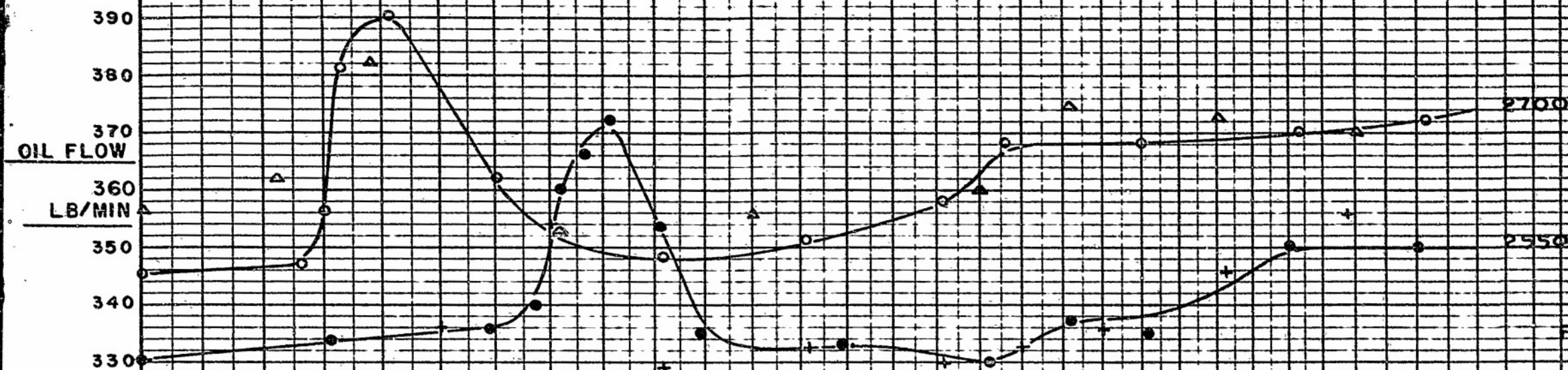
PLATE 21

ALTITUDE - THOUSAND FEET

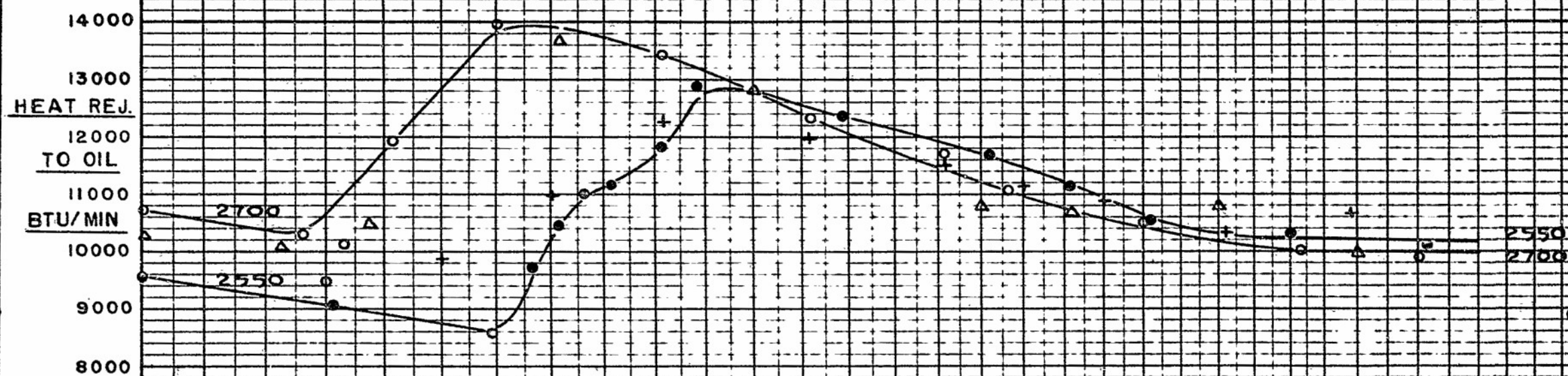
REPORT NO. 1148

ALTITUDE CHARACTERISTICS
WITH AUTO. POWER CONTROL UNIT
"NORMAL" MIXTURE CONTROL POS.
PQWA R-4360-20 ENGINE

ENGINE NO P-2727
AERONAUTICAL ENGINE LABORATORY
NAVAL AIR EXPERIMENTAL STATION, PHILA. PA.
PROJECT NO. PP209 ENGINE DOTSEY



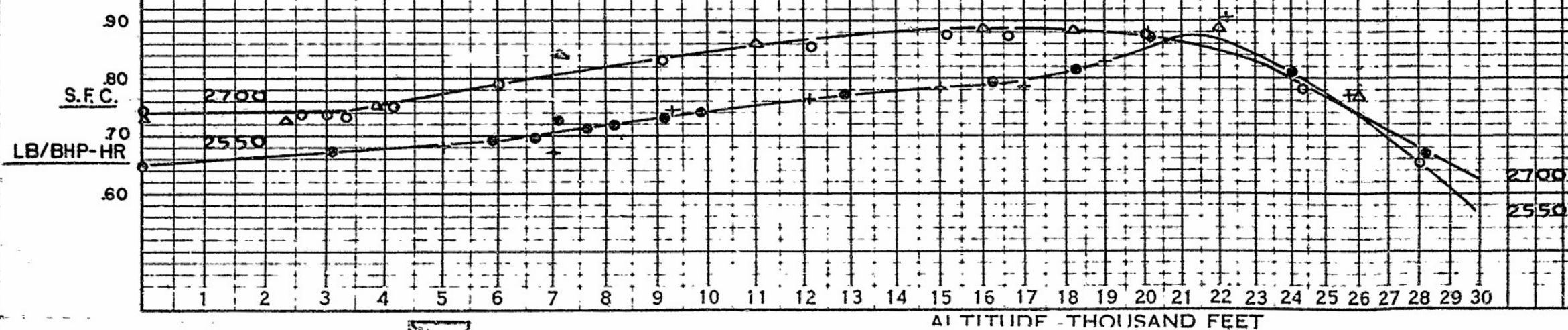
FOR GENERAL NOTES SEE PLATE 1



LEGEND

- (2700 RPM)
- (2550 RPM)
- INCREASING ALTITUDE
- △ DECREASING ALTITUDE
- INCREASING ALTITUDE
- + DECREASING ALTITUDE
- SPEC. LIMITS

	NORMAL	MILITARY
OIL IN TEMP °F	167	183
OIL FLOW - LB/MIN	400	400
HEAT REJ. TO OIL BTU/MIN	11,000	12,500

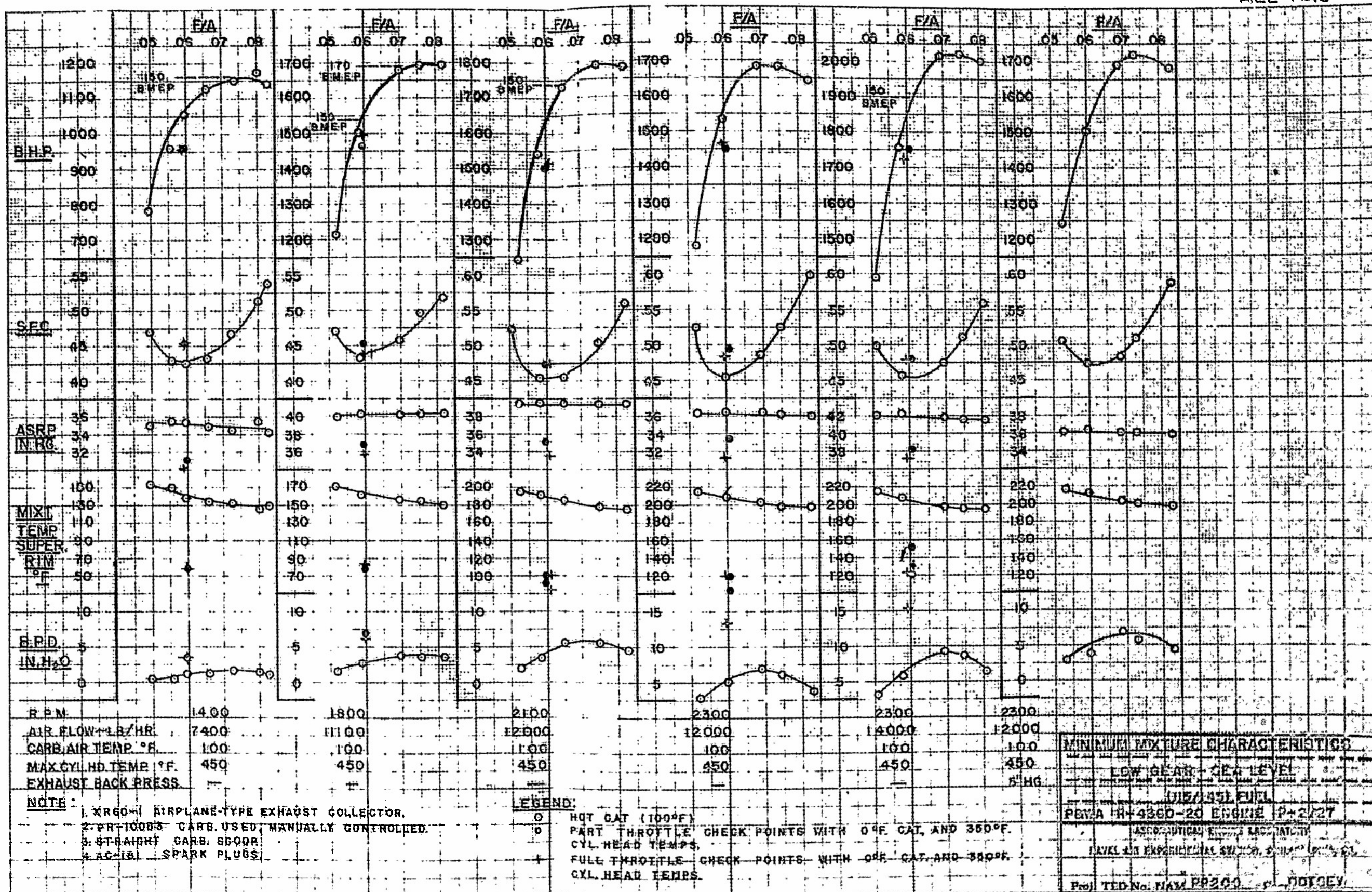


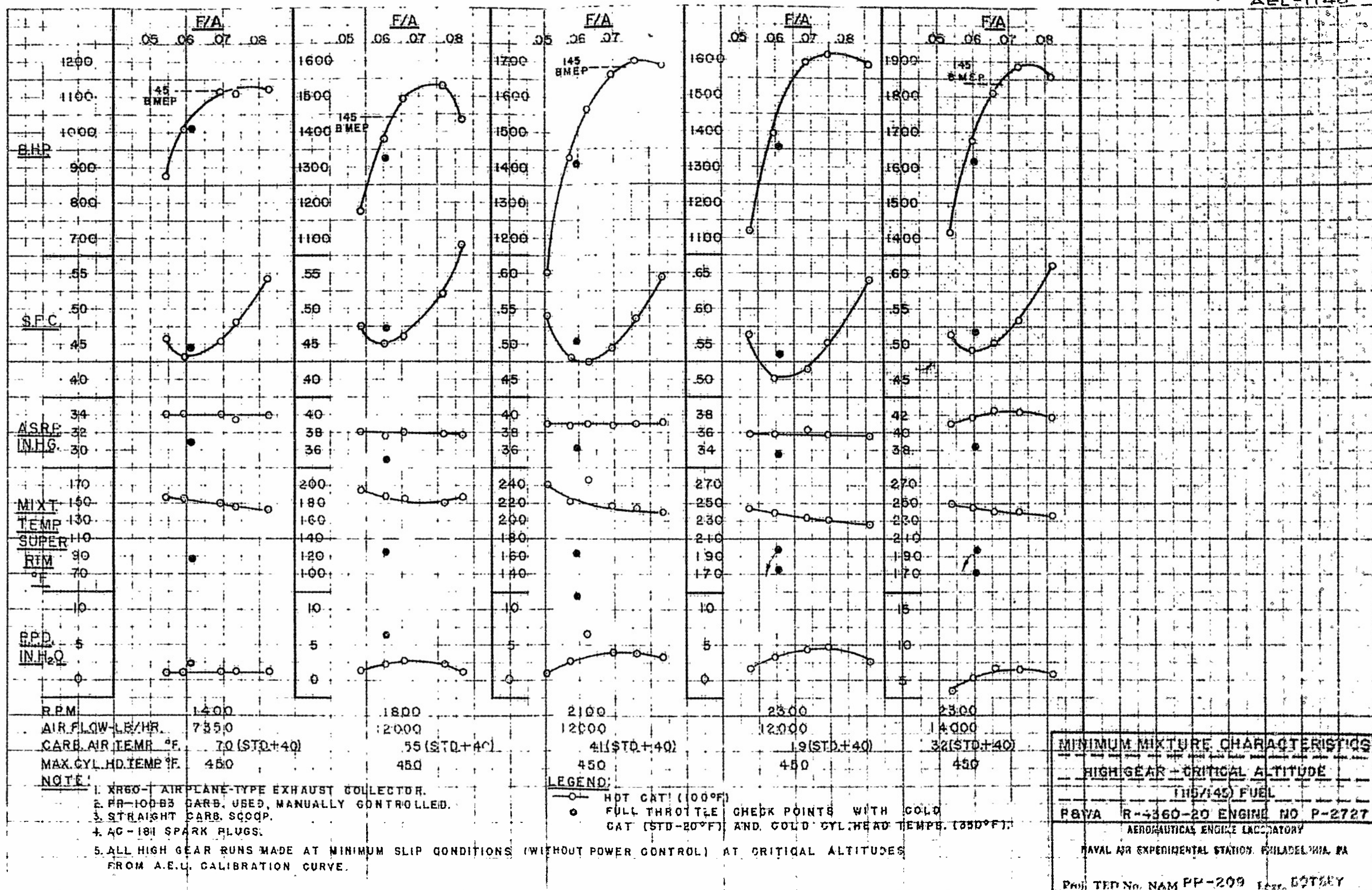
CRANKSHAFT RPM

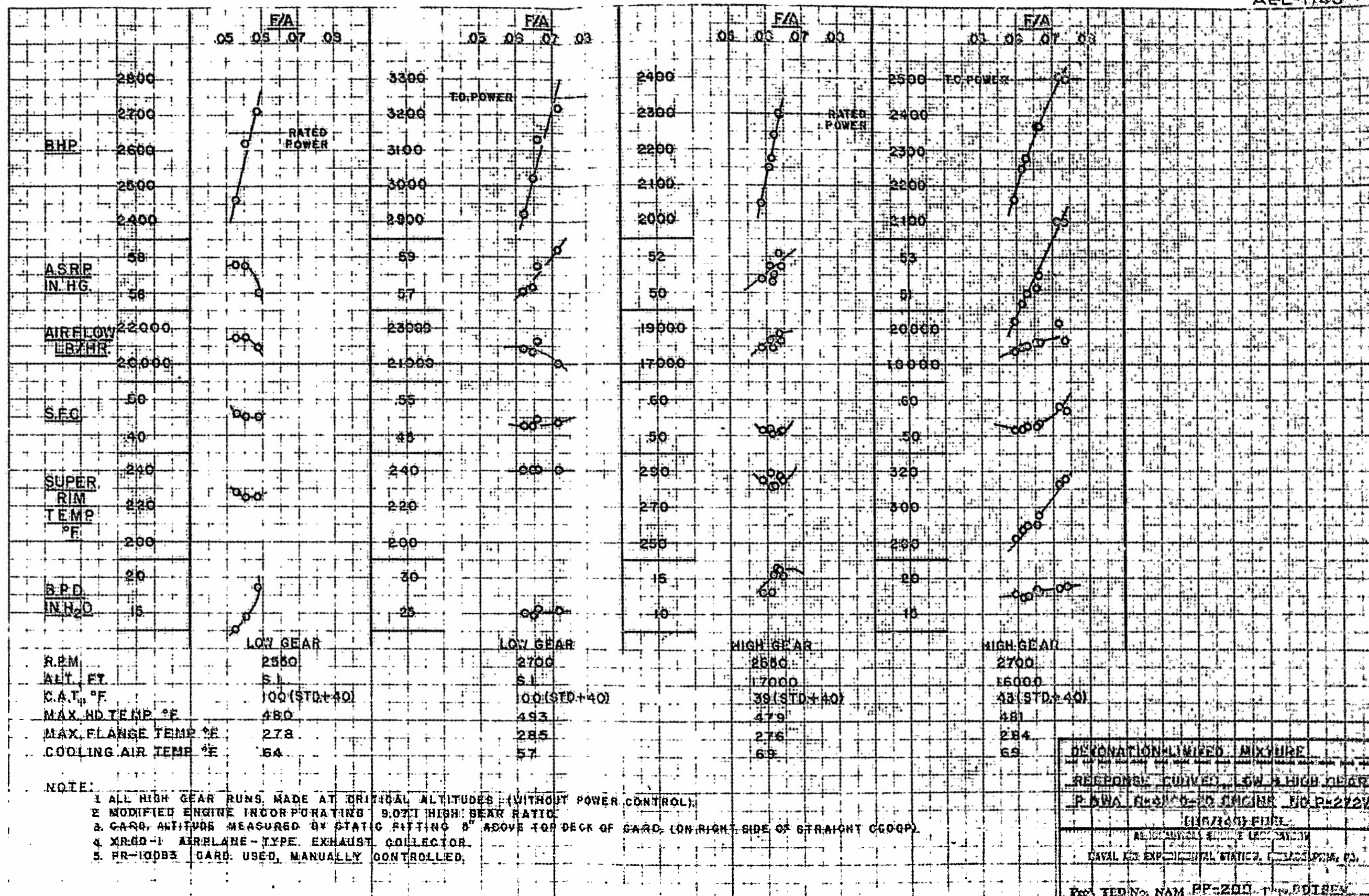
2700
2550

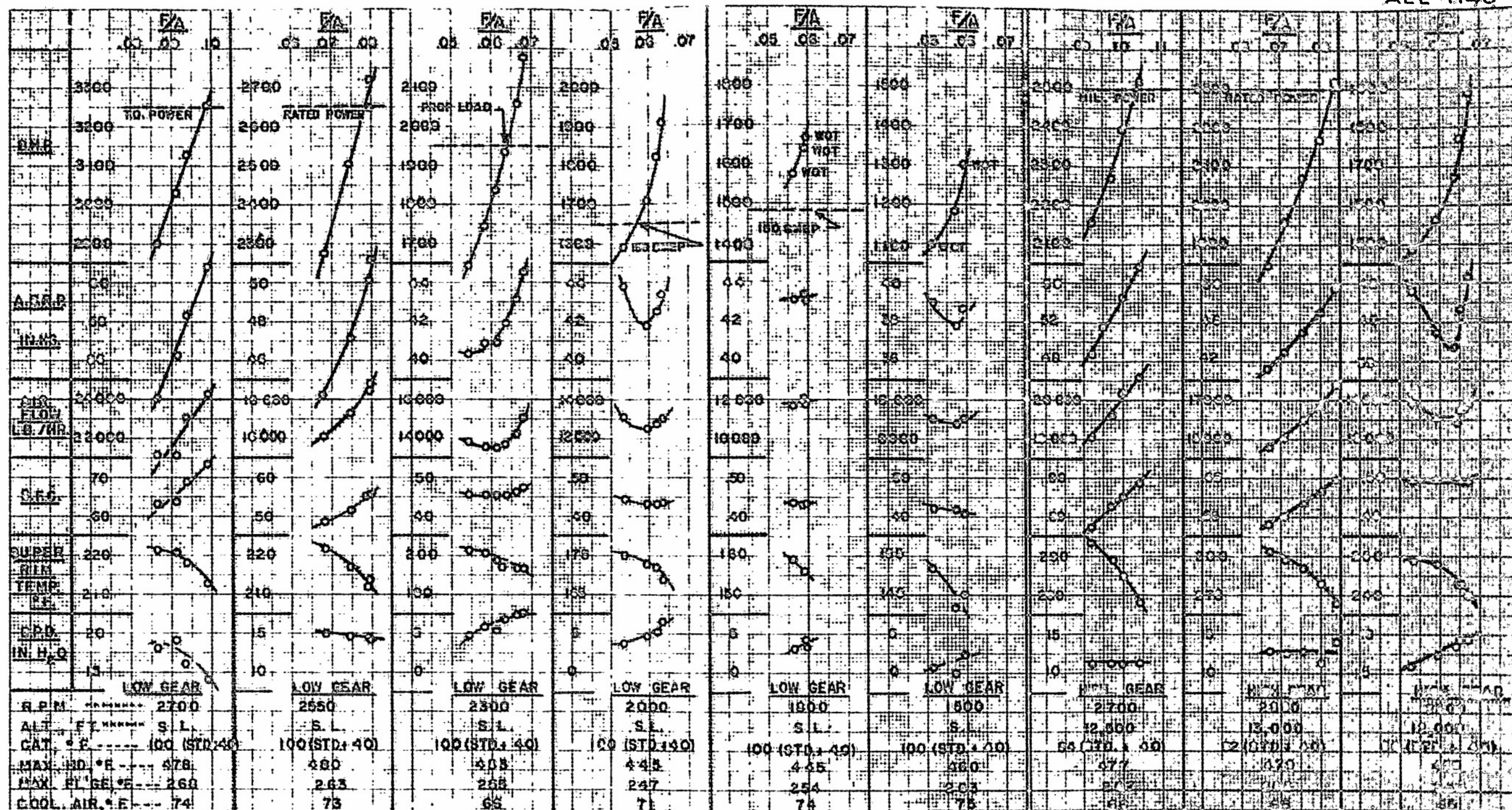
ALTITUDE - THOUSAND FEET

PLATE 22









NOTE

- ENGINE OPERATION AT 1000 AND 2000 RPM IN HIGH GEAR WERE BURGE-LIMITED BELOW 5000 FT. NO DETONATION
- ALL HIGH GEAR RUNS MADE AT MINIMUM SLIP CONDITIONS WITHOUT POWER CONTROLS AT APPROX. SHIFT ALTITUDES SELECTED FROM P.W. ESTIMATED CALIBRATION CURVE NO. INST. 7204-3.
- MODIFIED ENGINE INCORPORATING 8.90:1 HIGH RATIO, RR-CLARE IMPELLER AND 11-BLADE REDUCER.
- CARB. ALTITUDE MEASURED BY STATIC FITTING 2" ABOVE TOP EDGE OF CARB. ON RIGHT SIDE OF STRAIGHT PROOP.
- KR 60-1 AIRPLANE TYPE EXHAUST COLLECTOR.
- PR-100 BS CARB. USED, MANUALLY CONTROLLED.

DETONATION LIMITED MIXTURE

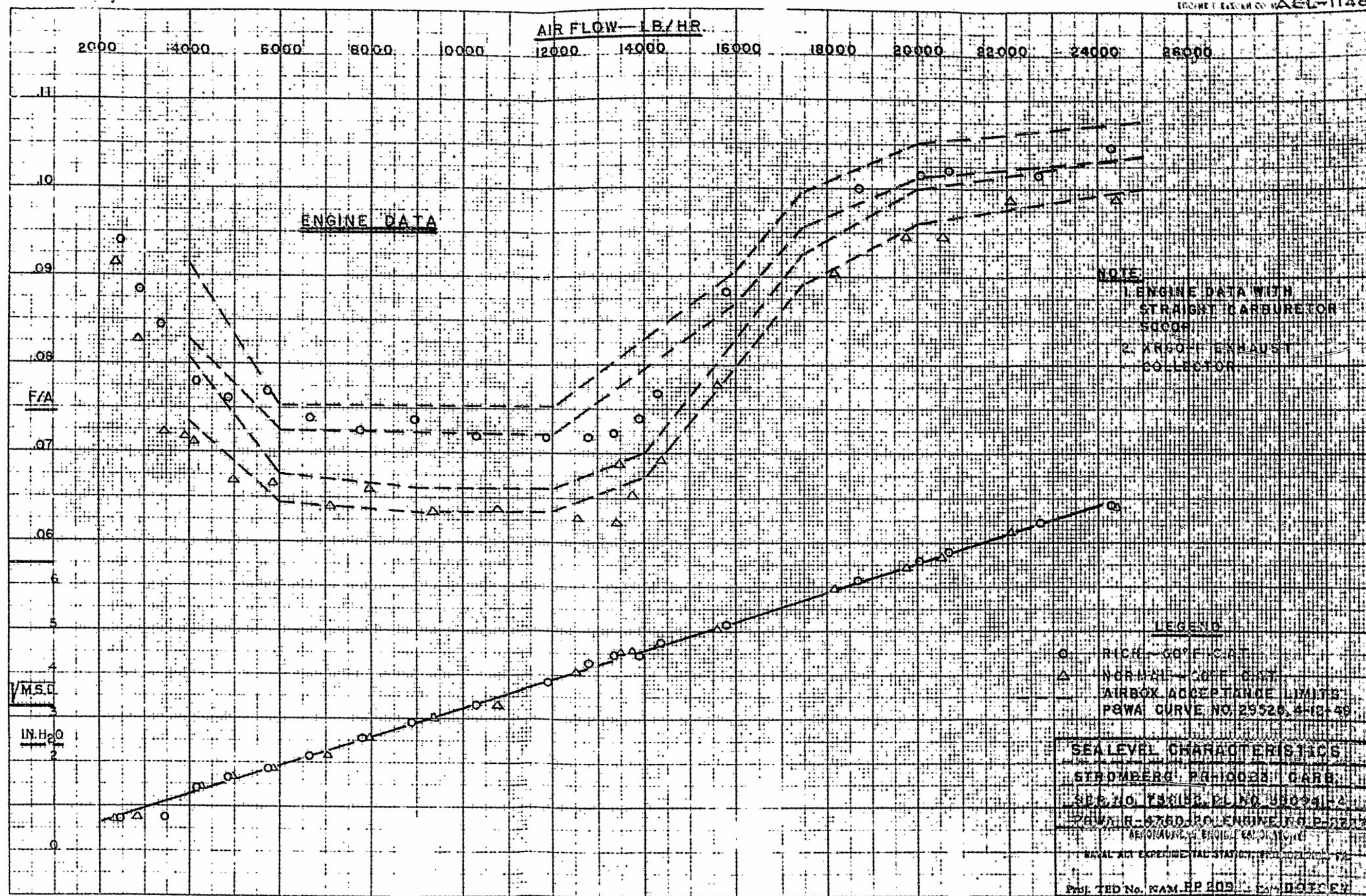
RESPONSE CURVES LOW GEAR

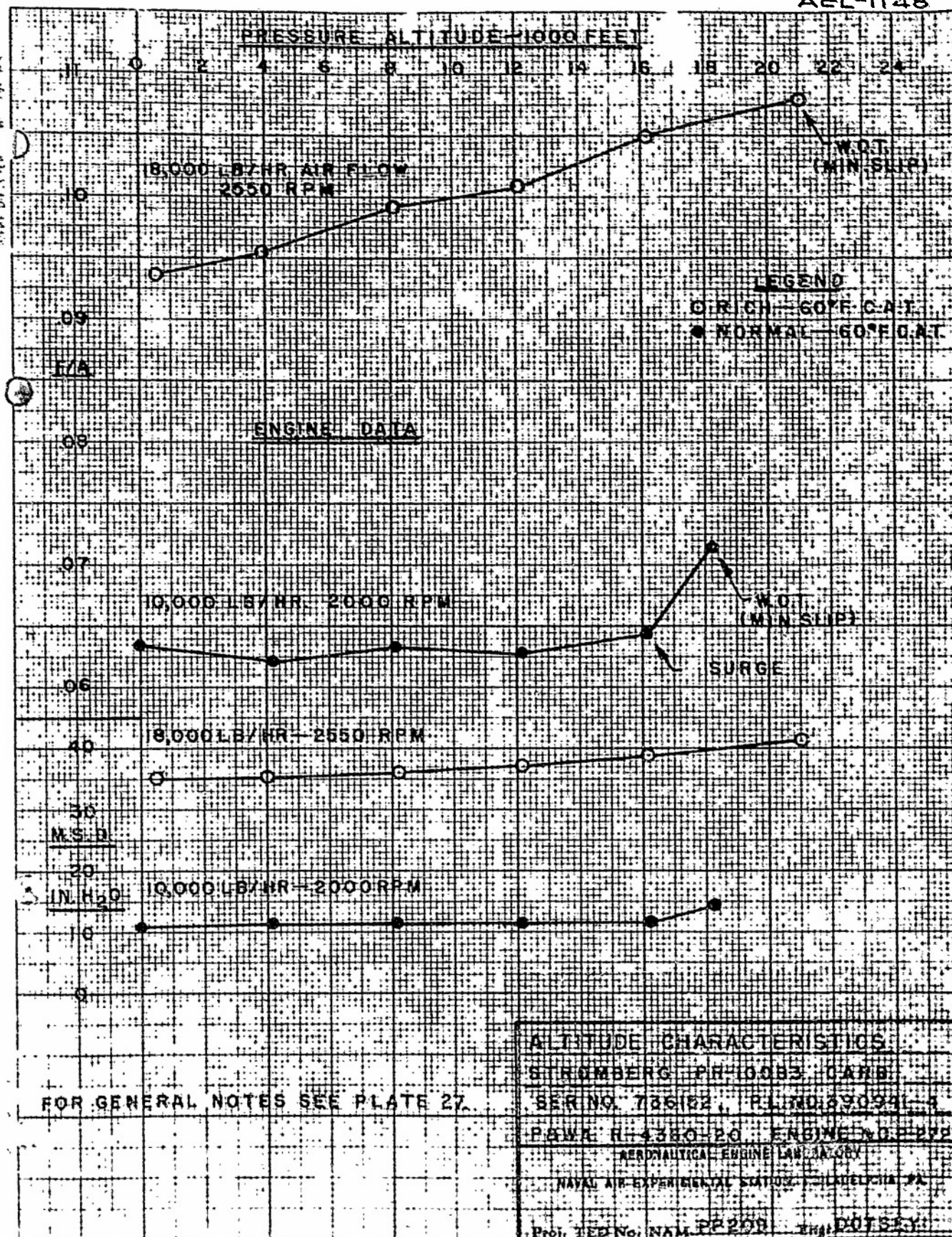
LOW GEAR 2000 RPM

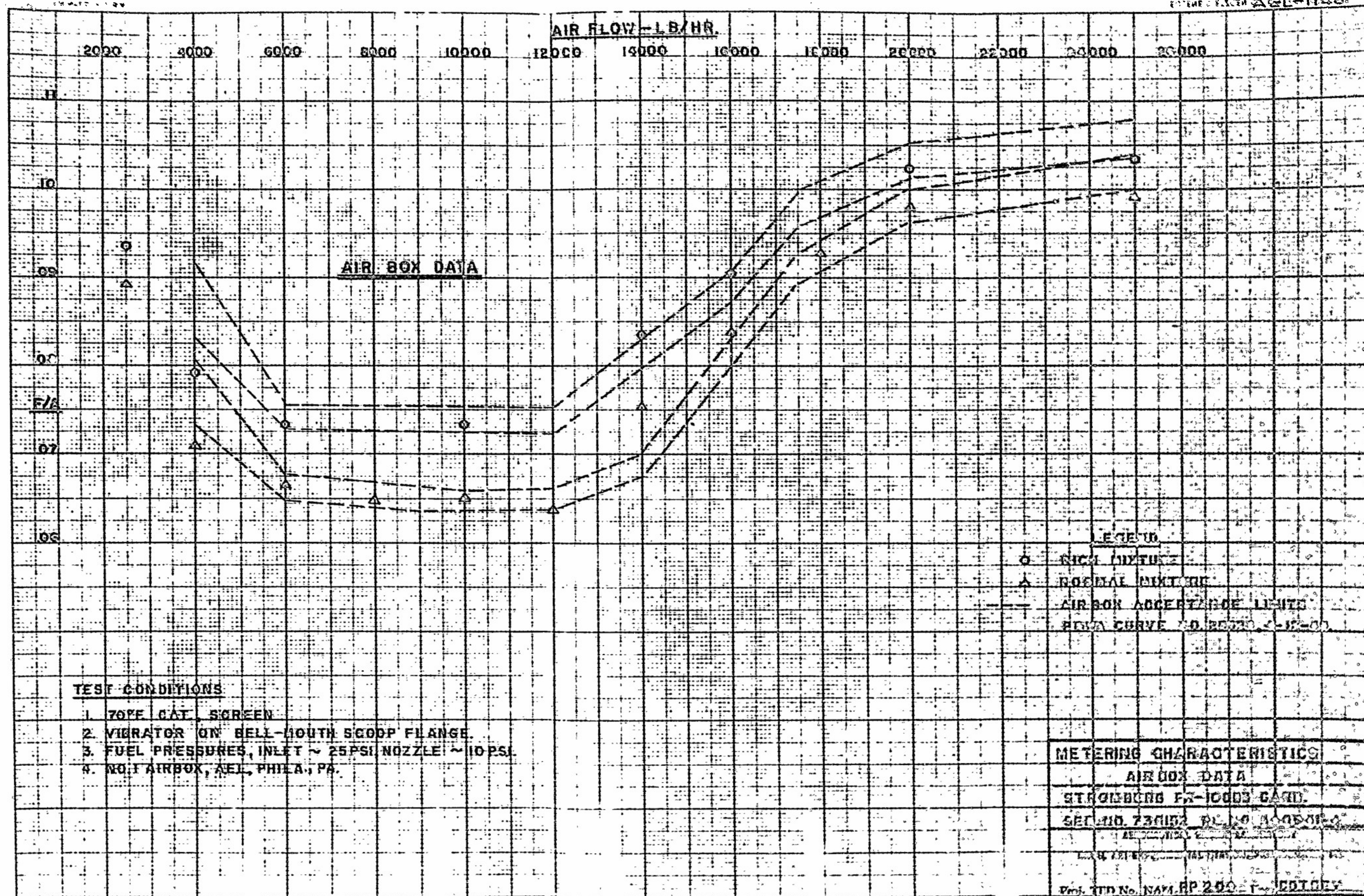
ENGINE NOT TESTED

USING GRADE 100/130 FUEL

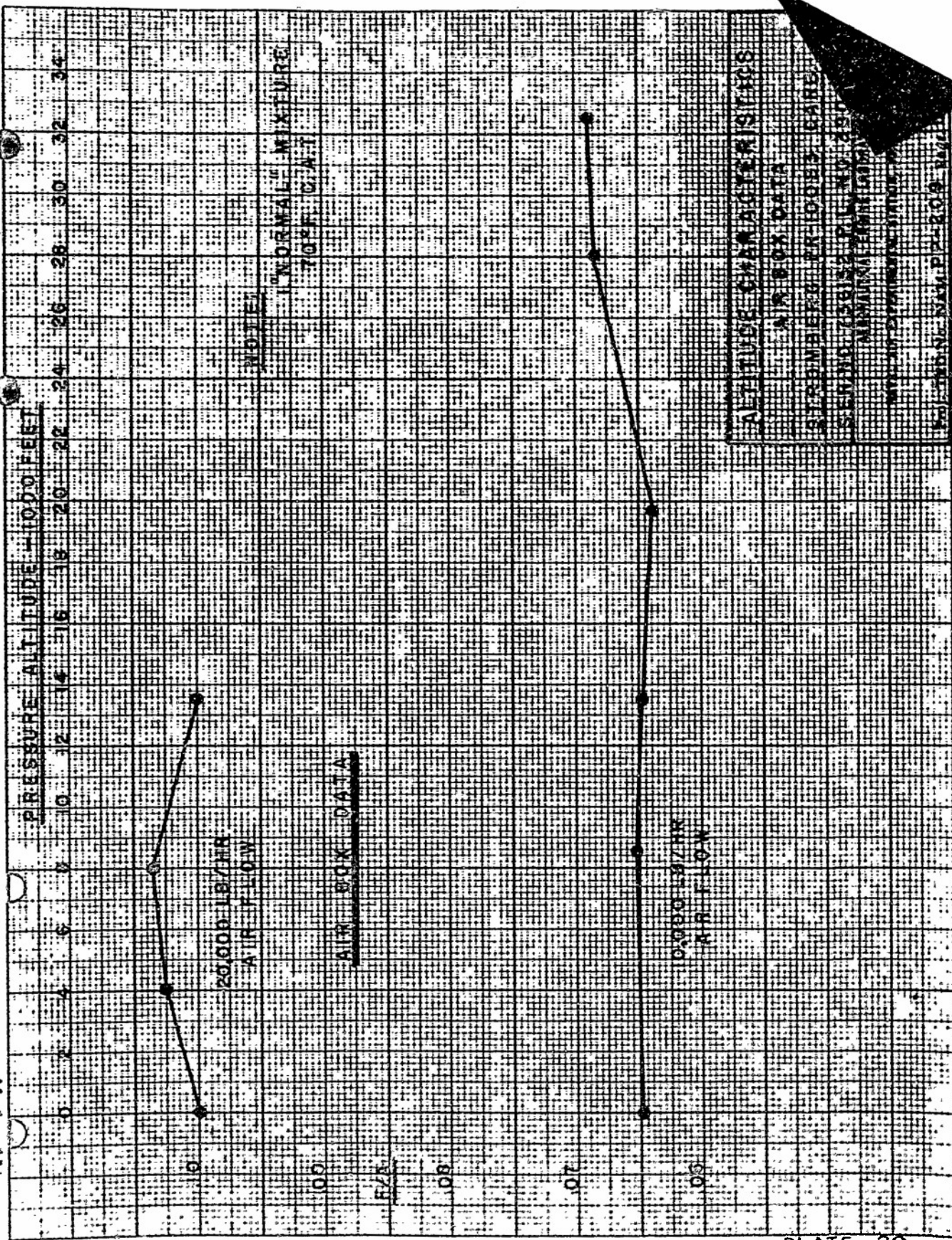
PLATE 26







LOGAR: 1.50000 4: 340 64



ALTITUDE CHARACTERISTICS

AIR BOX DATA

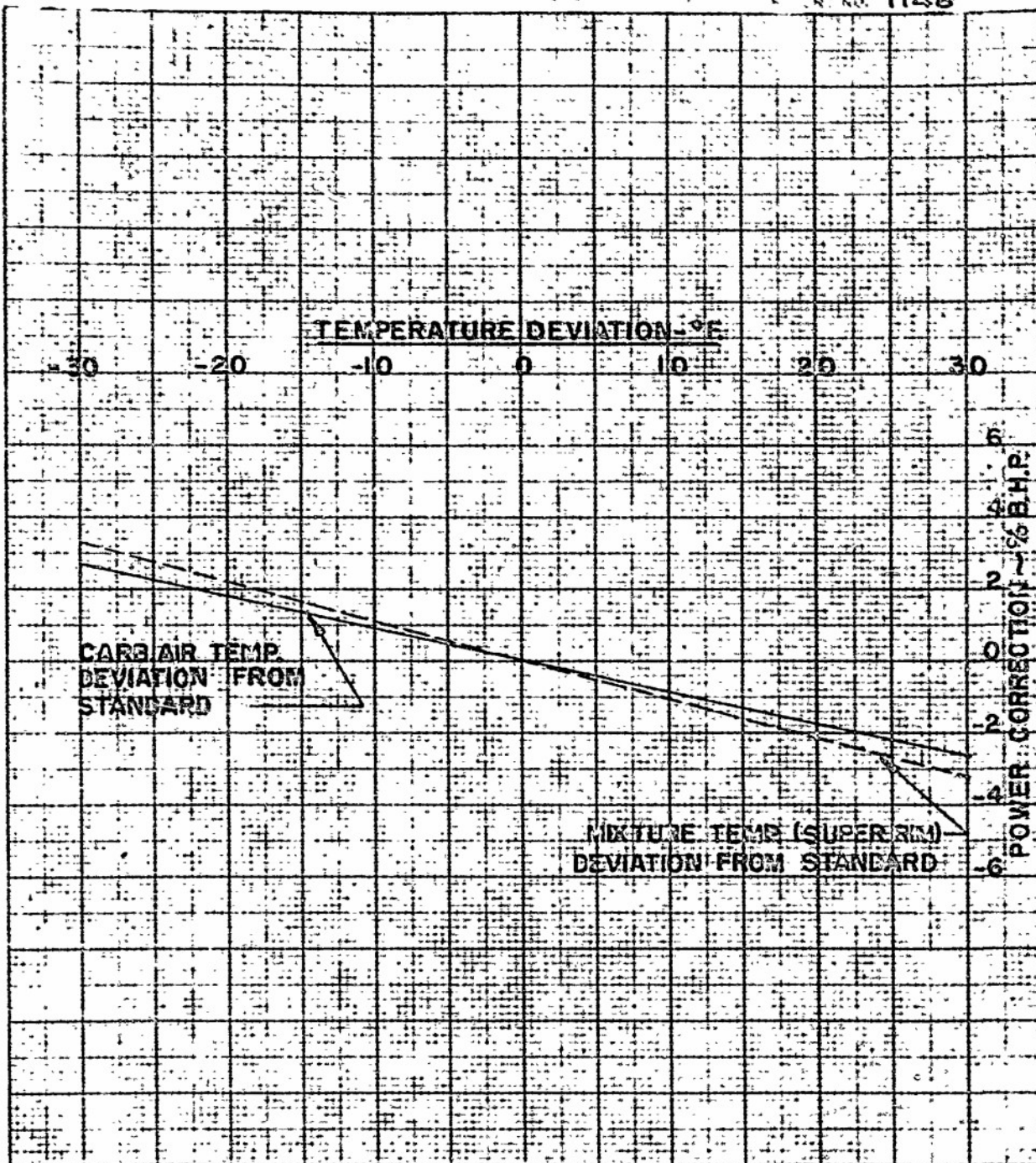
STRONBERG CR-10003 CARB

SERVO 750152 P/L NO 250

NEWARK ENGINE CO

WILSON ENGINE CO

ENGINE NAME: P-200



DATA OBTAINED FROM RUNS MADE
AT MILITARY, RATED AND CRUISE
POWERS AT SEA LEVEL AND HIGH
GEAR CRITICAL ALTITUDES.

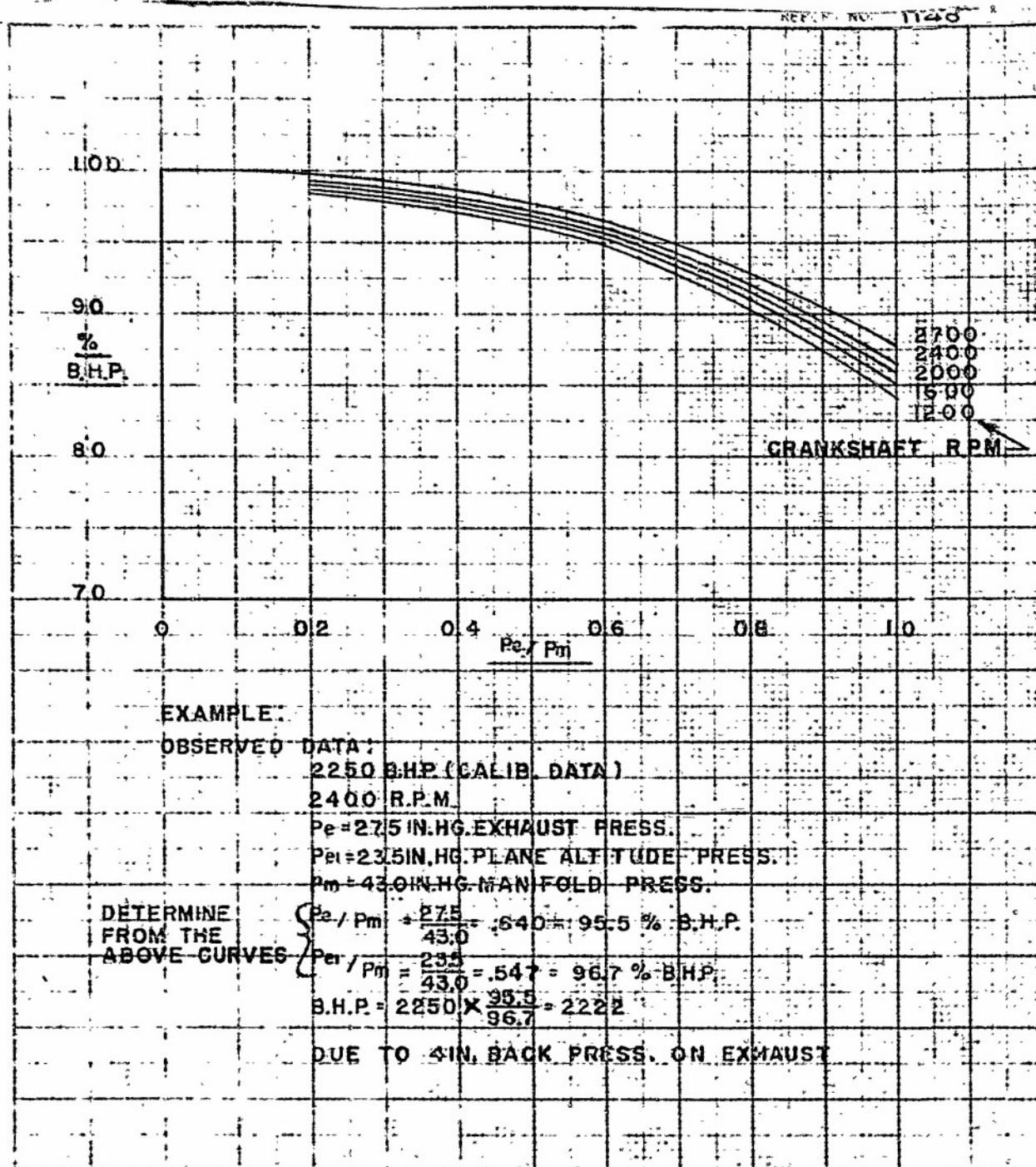
CONSTANT A-S.R.P., FUEL-AIR RATIO
AND CYLINDER HEAD TEMPERATURES.

**CARBURETOR AIR AND
MIXTURE TEMPERATURE
CORRECTION CURVES**

P & W R-4360-20 ENGINE NO. P-2727

AERONAUTICAL ENGINE LABORATORY
NAVAL AIR EXPERIMENTAL STATION PHILA PA

PROJECTED NO NAME PP-209 ENG R DOTSEY



NOTE:

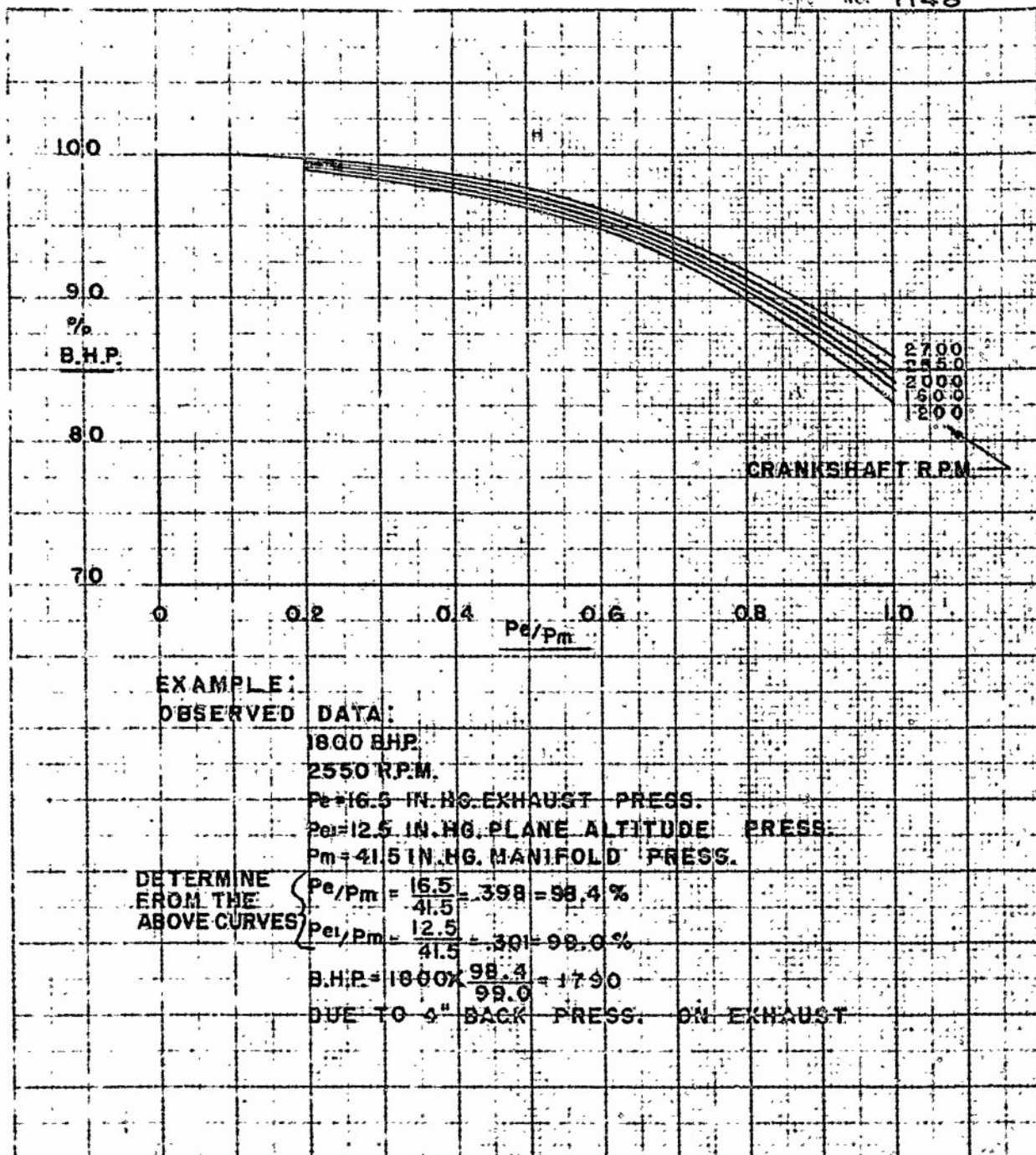
1. THIS CORRECTION FOR EXHAUST PRESS. ONLY - ADDITIONAL CORRECTION MUST BE MADE FOR MIXTURE OR CARB. AIR TEMP. VARIATION FROM CALIB. DATA.
2. RUNS MADE AT CONSTANT F/A, MIXT. TEMP. AND CYLINDER HEAD TEMP.

**EXHAUST BACK PRESSURE
CORRECTION CURVES
LOW GEAR**

P & W R-4360-20 ENG. NO. P-2727

AERONAUTICAL ENGINE LAB. REPORT
NATIONAL BUREAU OF AERONAUTICS

NAVJAG REPORT NO. 209 DOT 57

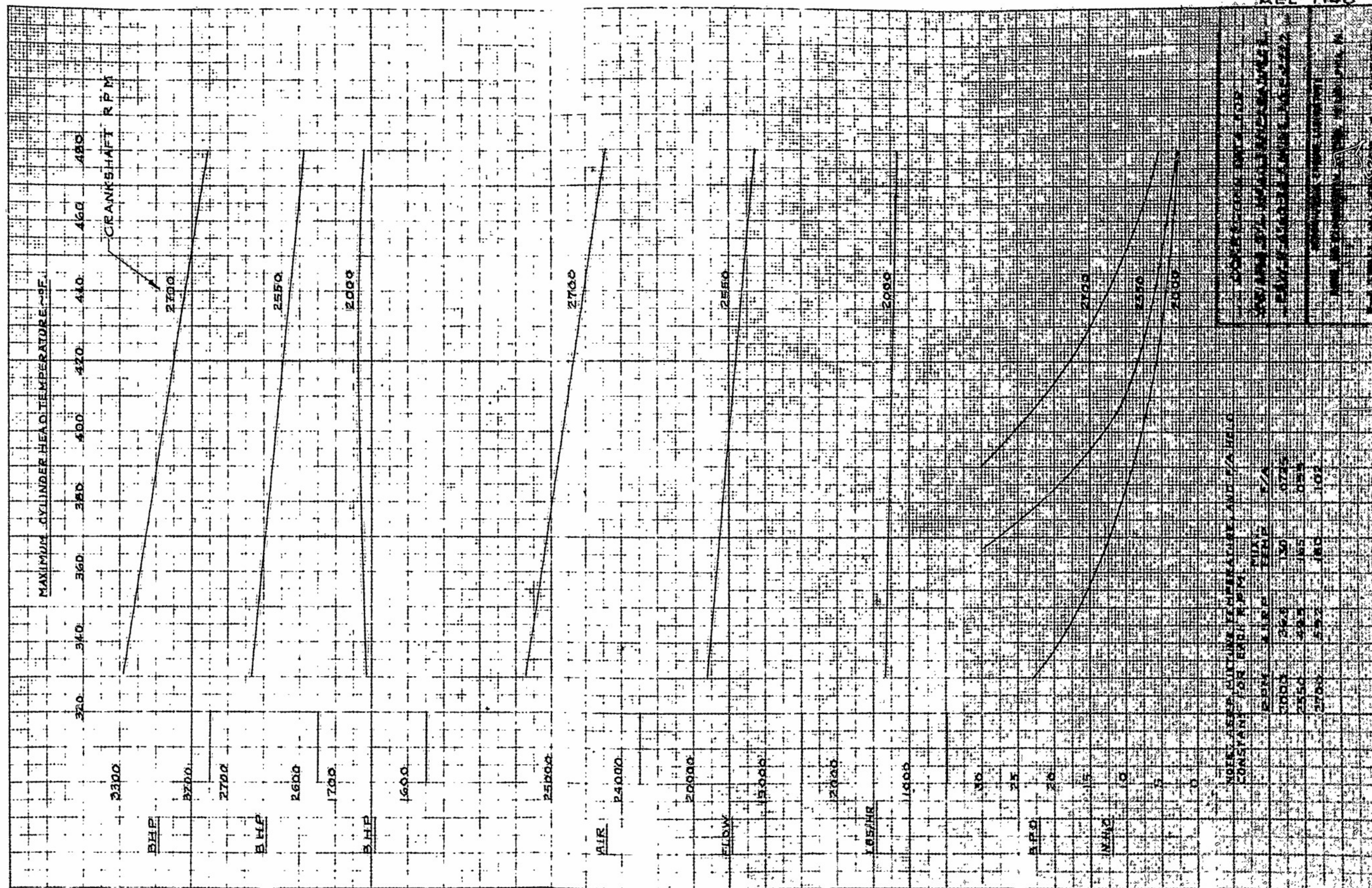
SEE PLATE 32 FOR NOTES.

EXHAUST BACK PRESSURE
CORRECTION CURVES
HIGH GEAR

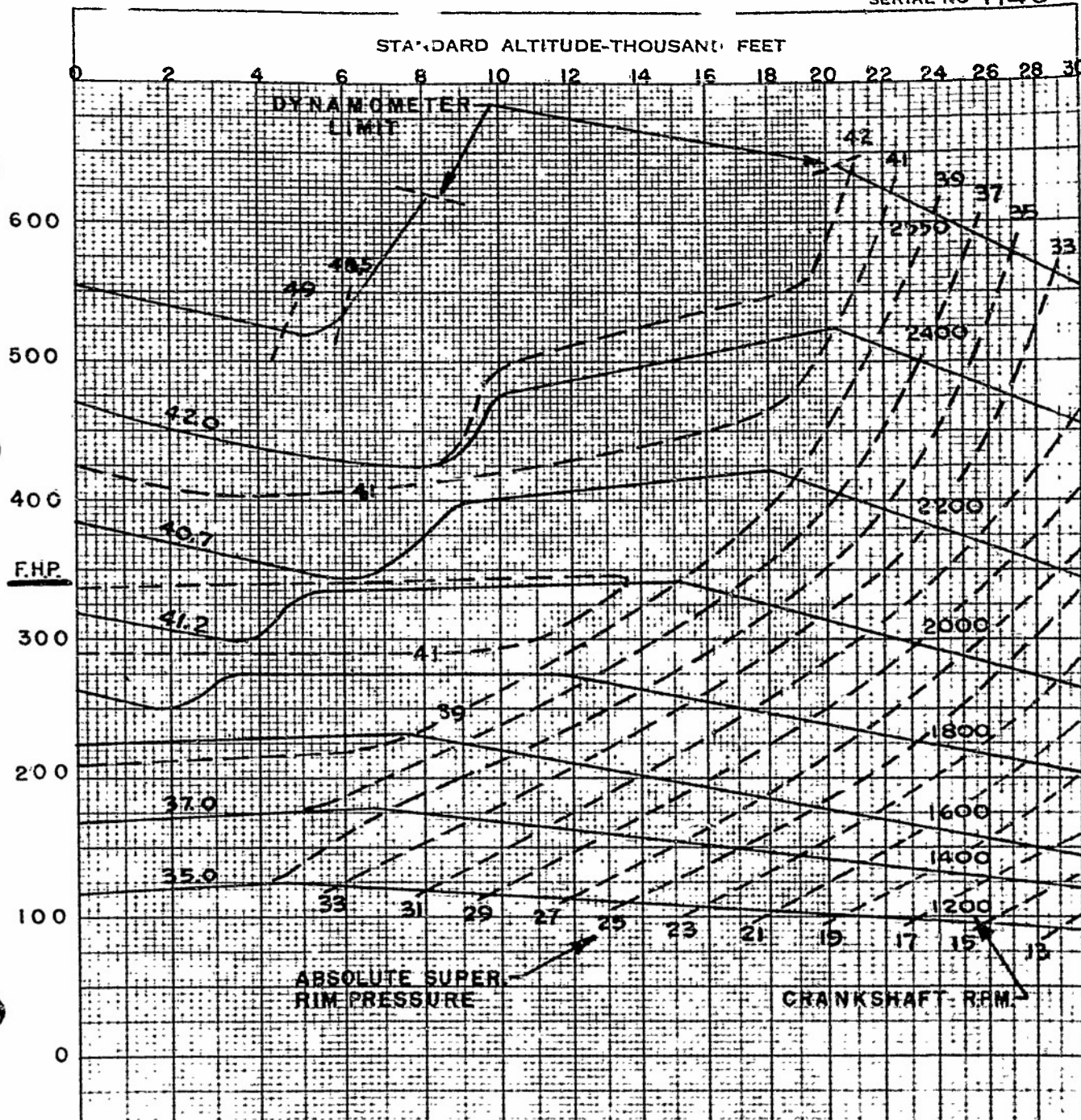
P&W R-4360-20 ENG. NO. P-2727

AERONAUTICAL ENGINE LABORATORY
NAVY AIR EXPERIMENTAL STATION, PATTERSON, CA

PROD. NO. NAMPP-209 ENR DOTSEY



SERIAL NO 1148



RATIOS COMP. 6.7:1 IMPELLER LOW 6.95:1
 CARB. PR-100B4 HIGH 9.07:1
 SPARK ADV PLUGS
 IMPELLER DIAM 14 IN.

PROP .425:1
 OIL GRADE 1120
 FUEL

TEST DATE
 AV. ROOM BAR IN HG
 AV. CARB AIR TEMP °F STD. ALTITUDE
 AV. OIL INLET TEMP °F 170
 AV. COOL AIR TEMP °F 102

TEST EQUIPMENT NO. 5 DYN. ROOM

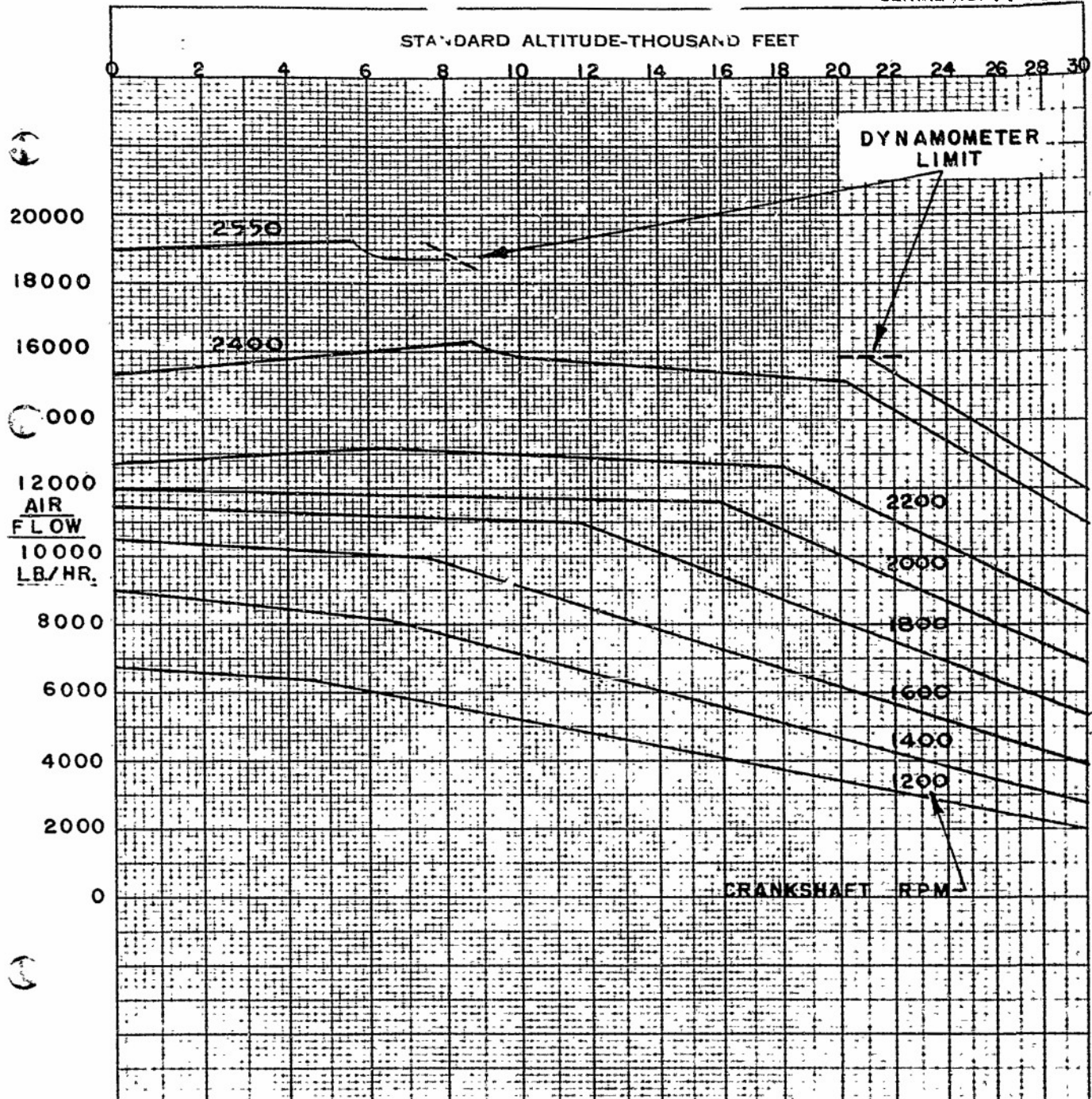
FRICITION CHARACTERISTICS

LOW & HIGH GEARS

P&WA R-4360-20 ENGINE

ENGINE BU NO MFG NO P-2727
 AERONAUTICAL ENGINE LABORATORY
 NAVAL AIRCRAFT FACTORY, PHILA. PA

PROJ PP-202NGR DOTSEY



RATIOS COMP.
CARB.
SPARK ADV.
IMPELLER DIAM.

IMPELLER
PLUGS

PROP
OIL
FUEL

FOR GENERAL DATA SEE PLATE 35.

TEST DATE

AV. ROOM BAR IN. HG.
AV. CARB. AIR TEMP °F
AV. OIL INLET TEMP °F
AV. COOL. AIR TEMP °F

TEST EQUIPMENT

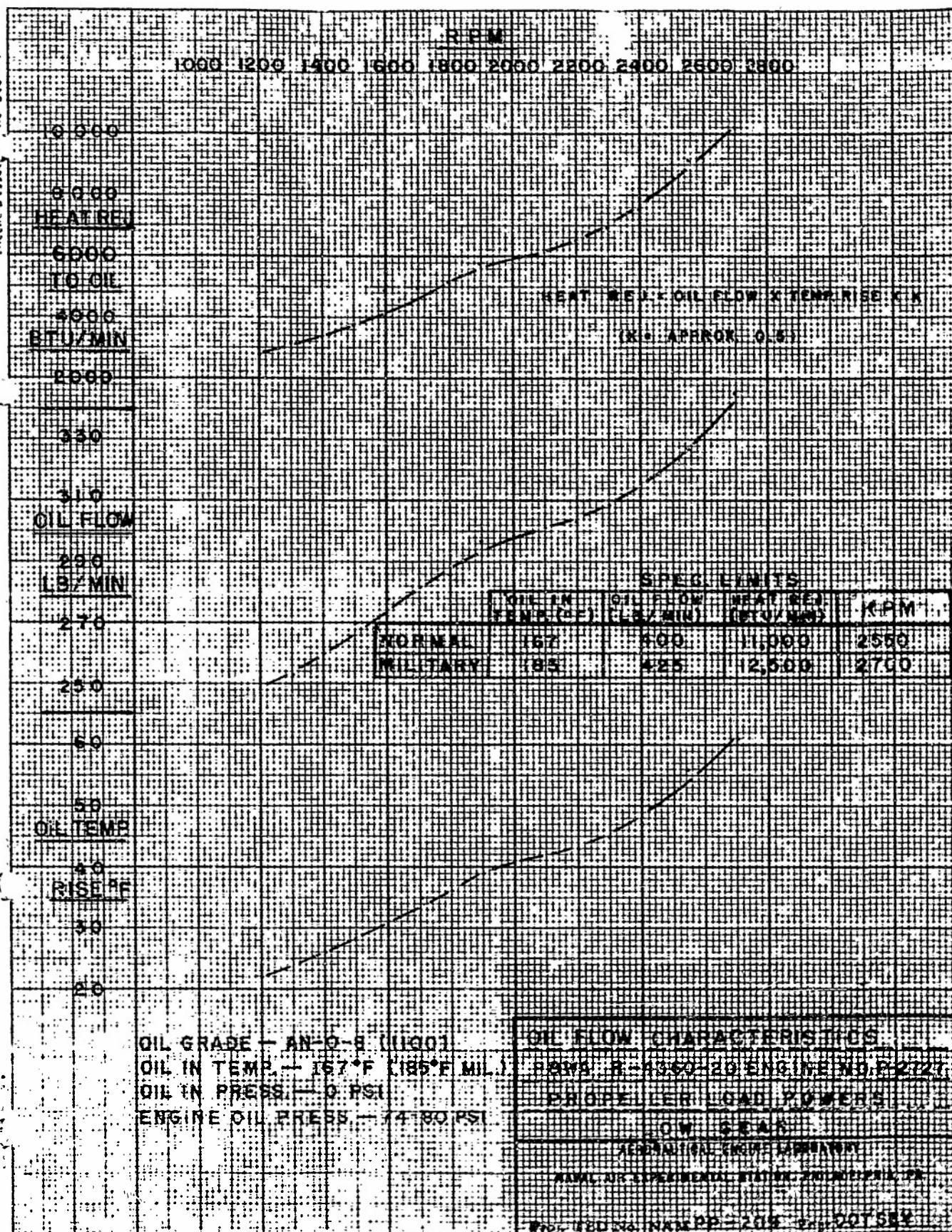
FRICTION CHARACTERISTICS

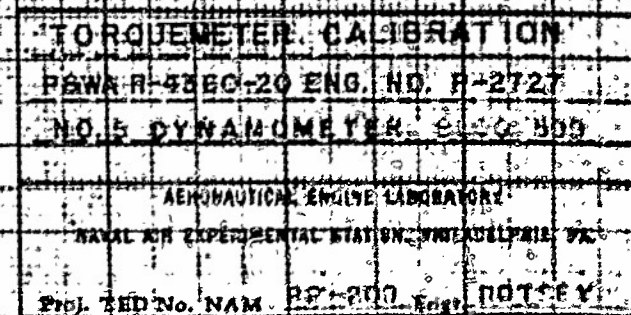
LOW & HIGH GEARS

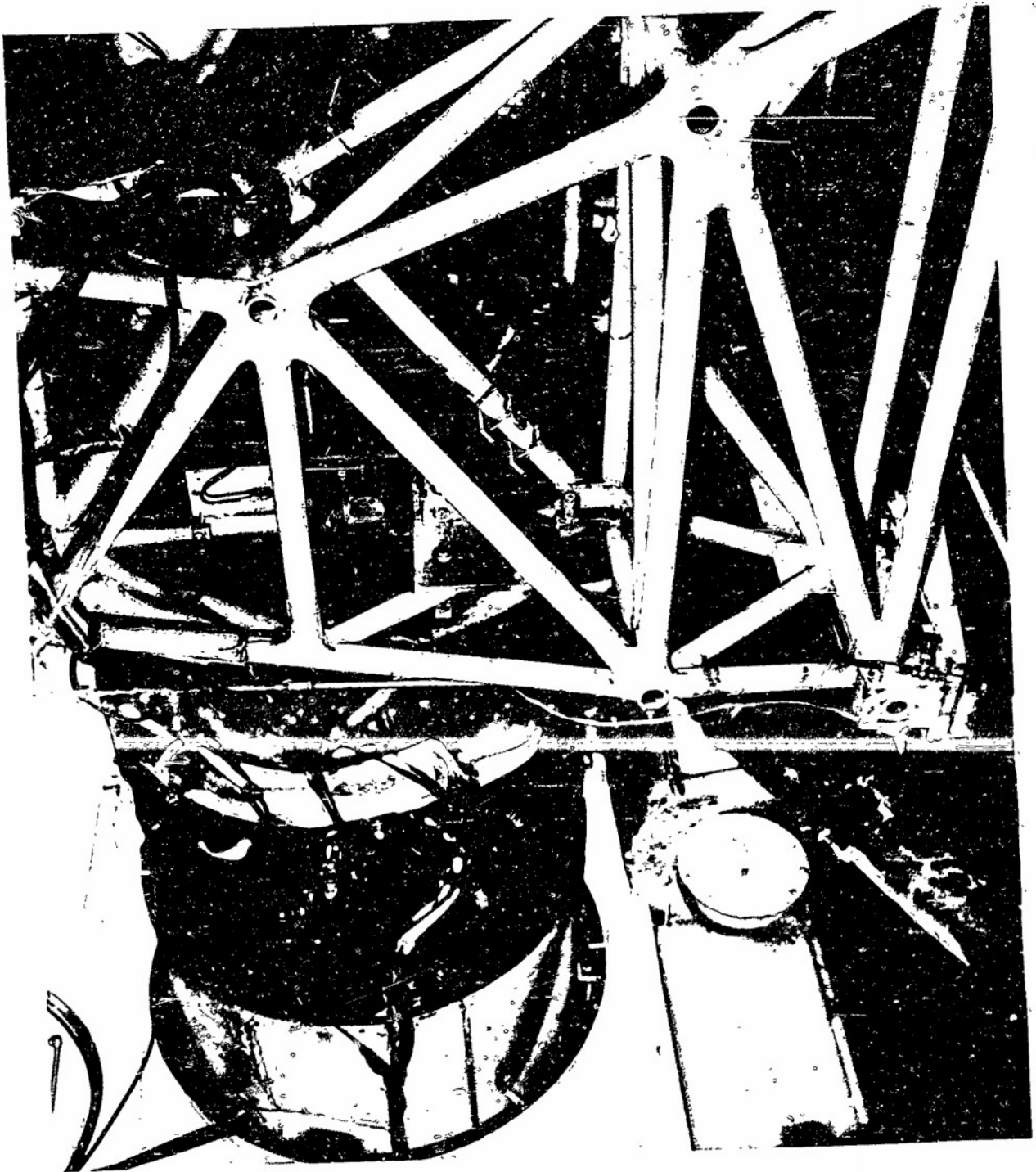
P & WA R-4360-20 ENGINE

ENGINE BU NO MFG NO P-2727
AERONAUTICAL ENGINE LABORATORY
NAVAL AIRCRAFT FACTORY PHILA PA

PROJ PP-209 ENG R DOTSEY

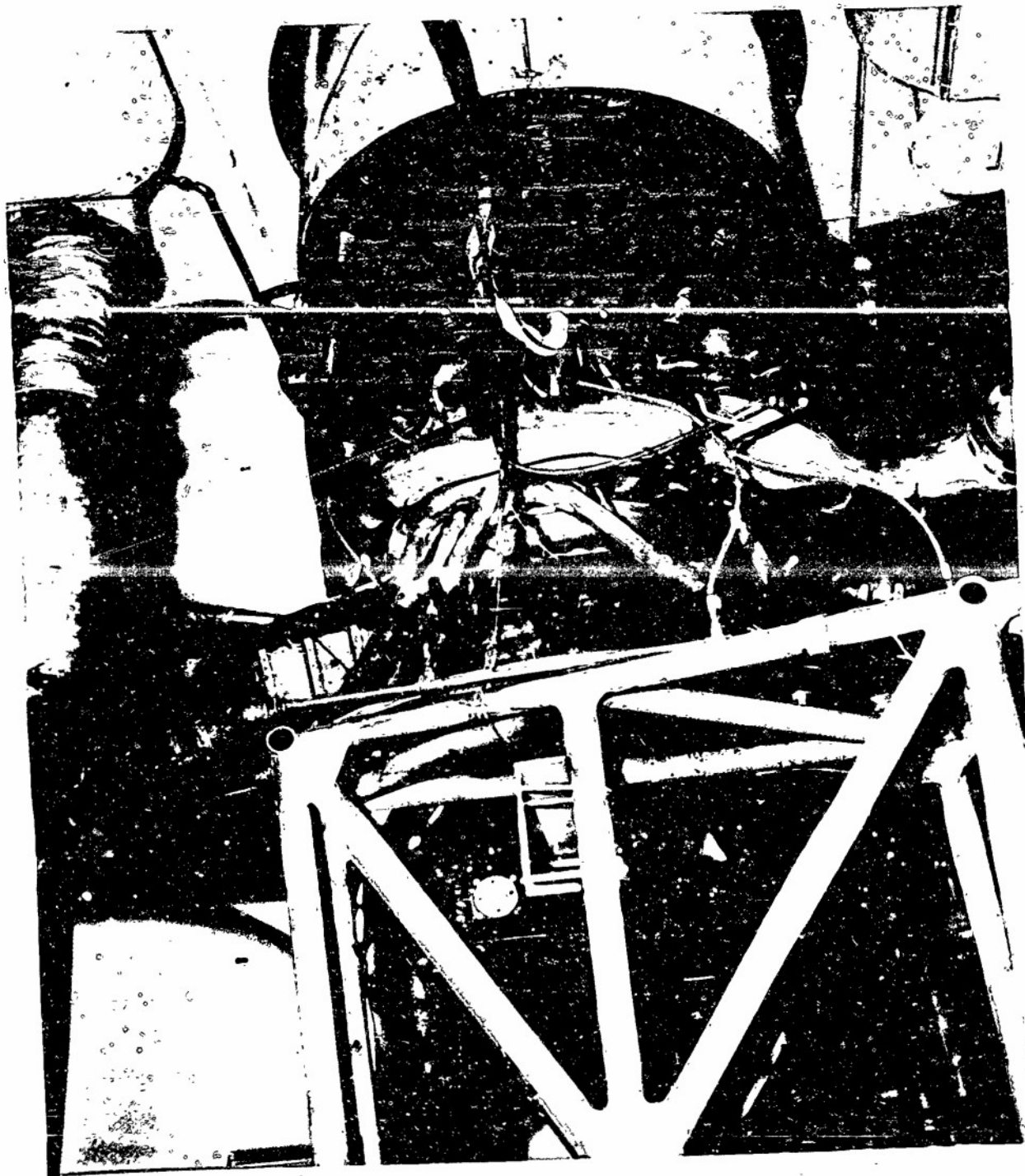






NP(3)-264950(L)-4-50
LEFT SIDE VIEW OF ENGINE INSTALLATION

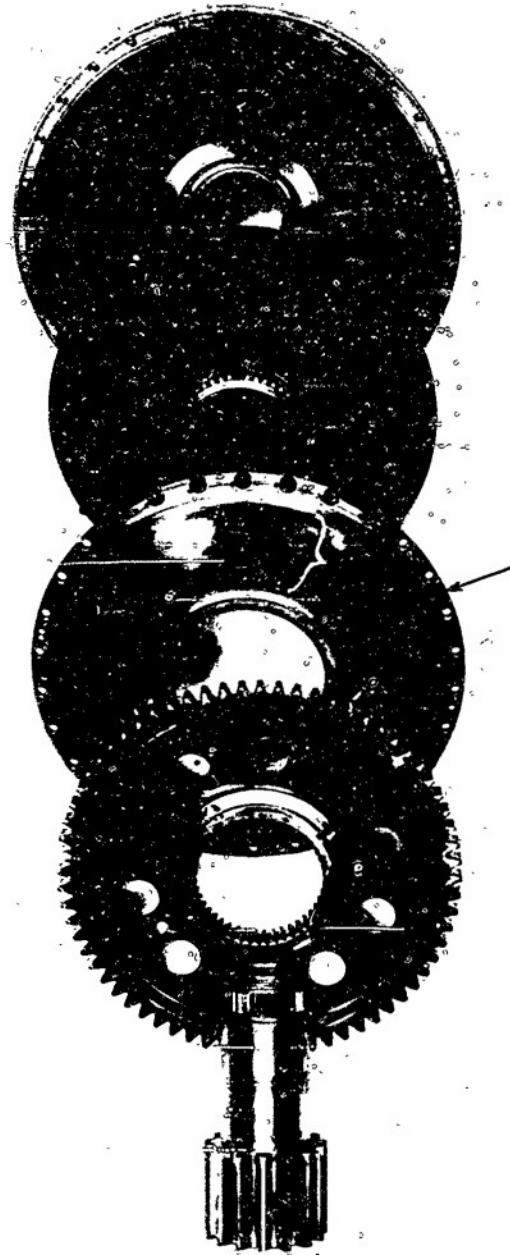
REPORT NO. AEL-1148



NP(3)-264951(L)-4-50
RIGHT SIDE VIEW OF ENGINE INSTALLATION

PLATE 40

REPORT NO. AEL-1148

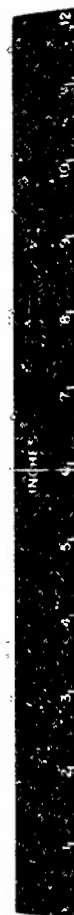
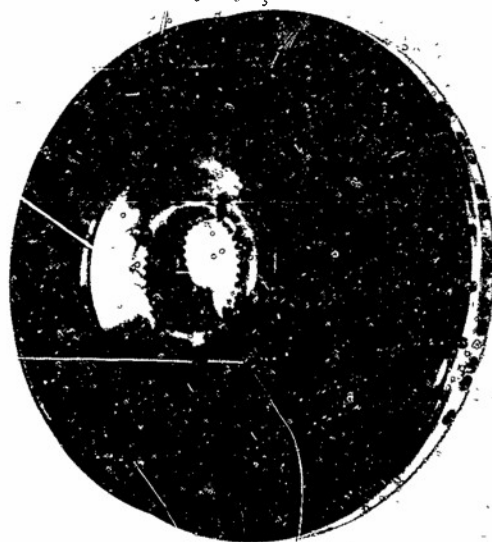


NP(3)-264376(L)-8-50

EXPLODED VIEW OF HYDRAULIC COUPLING ASSEMBLY,
HIGH GEAR - SHOWING DISCOLORATION

PLATE 41

REPORT NO. AEL-1148

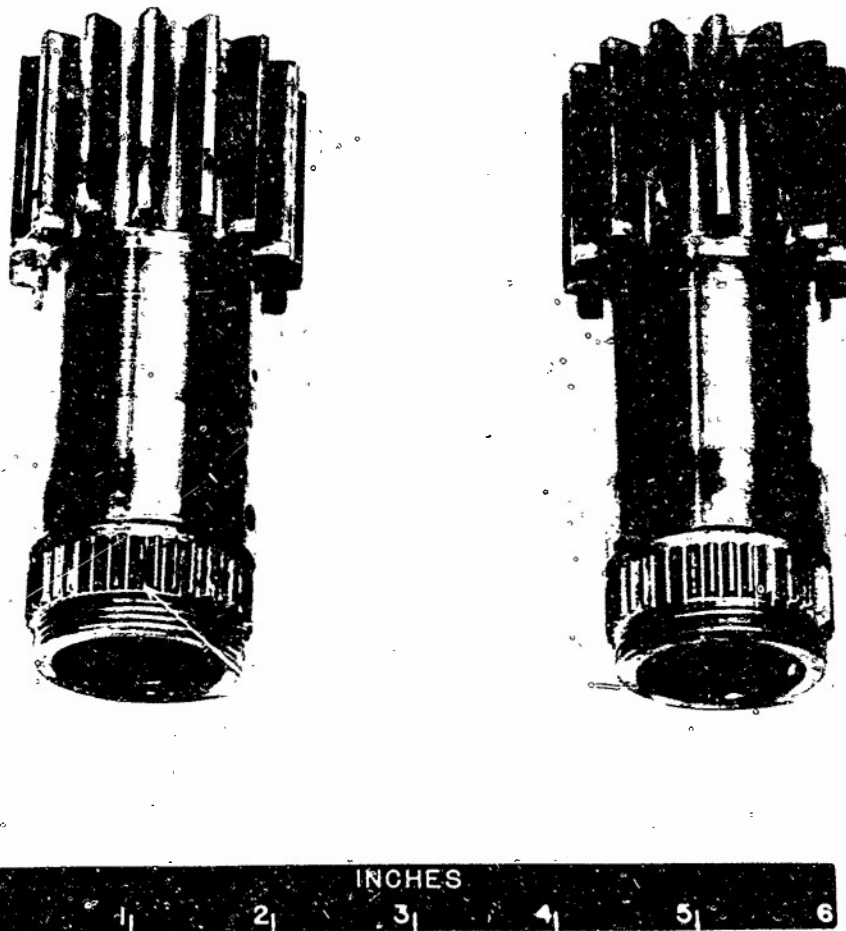


NP(3)-264378(L)-8-50

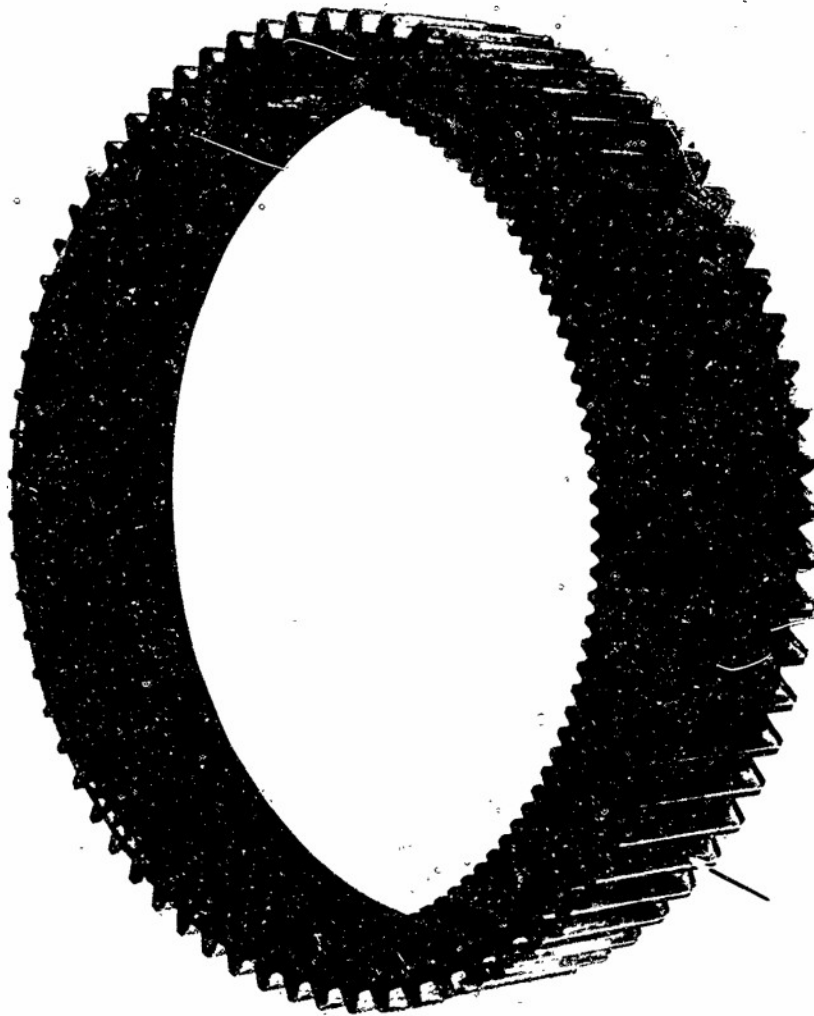
HYDRAULIC COUPLING RUNNER ASSEMBLY
SHOWING INNER SPLINE DAMAGE

PLATE 42

REPORT NO. AEL-1148



NP(3)-264377(L)-8-50
SUPERCHARGER INTERMEDIATE PINIONS, HIGH GEAR
SHOWING IRREGULAR GEAR TOOTH WEAR AND DAMAGED SPLINE PLATE 43



NP(3)-264379(L)-8-50
HYDRAULIC DAMPING SPRING DRIVE GEAR
SHOWING OUTER GEAR TOOTH WEAR

REPORT NO. AEL-1148



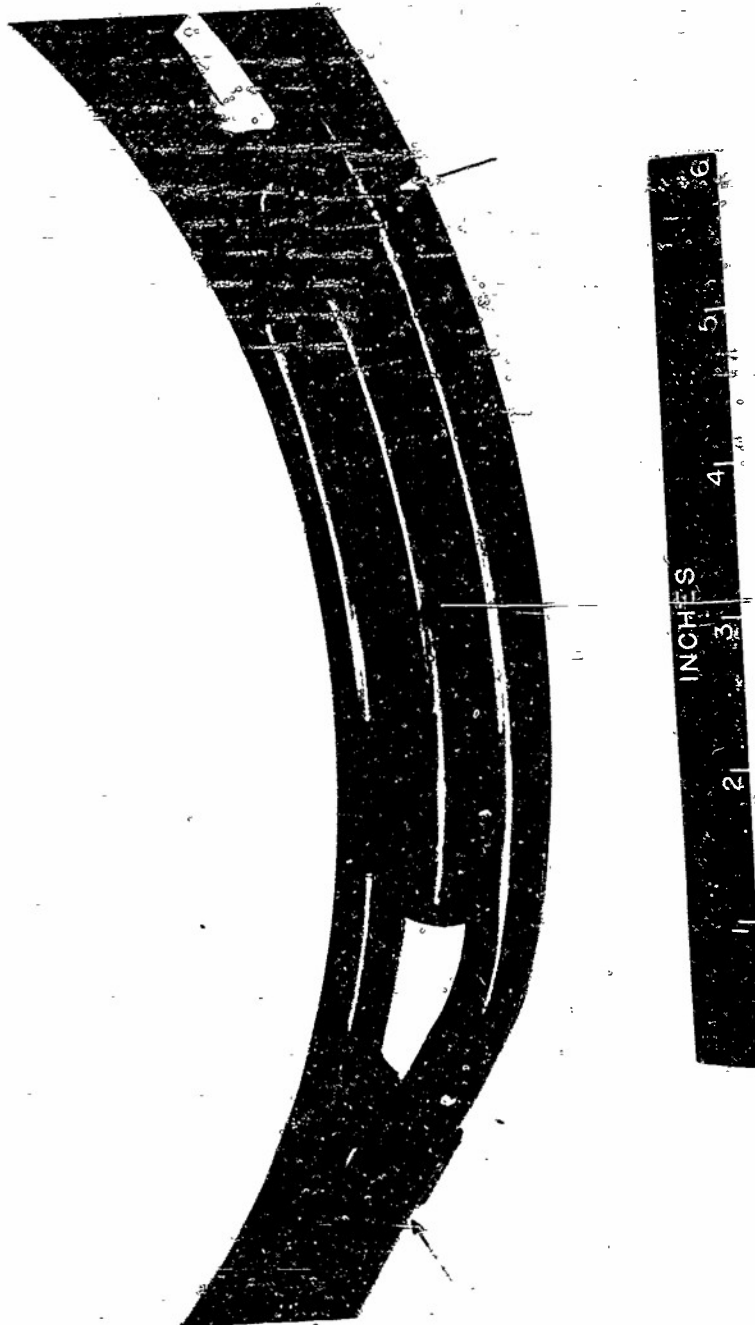
)

NP(3)-264375(L)-8-50

HYDRAULIC COUPLING OIL FEED MANIFOLD
ASSEMBLY (FRONT VIEW) SHOWING CRACKED MANIFOLD

PLATE 45

REPORT NO. AEL-1148



3
NP(3)-264374(L)-8-50

HYDRAULIC COUPLING OIL FEED MANIFOLD
ASSEMBLY (REAR VIEW) SHOWING CRACKED MANIFOLD

PLATE 46

REPORT NO. AEL-1148



NP(3)-263084(L)-4-50
3/4 LEFT FRONT VIEW R-4360-20 ENGINE

PLATE 47

REPORT NO. AEL-1148



NP(3)-208133(1)-4-50 FRONT VIEW, R-360-20 ENGINE

PLATE 41

REPORT NO. AEL-1148

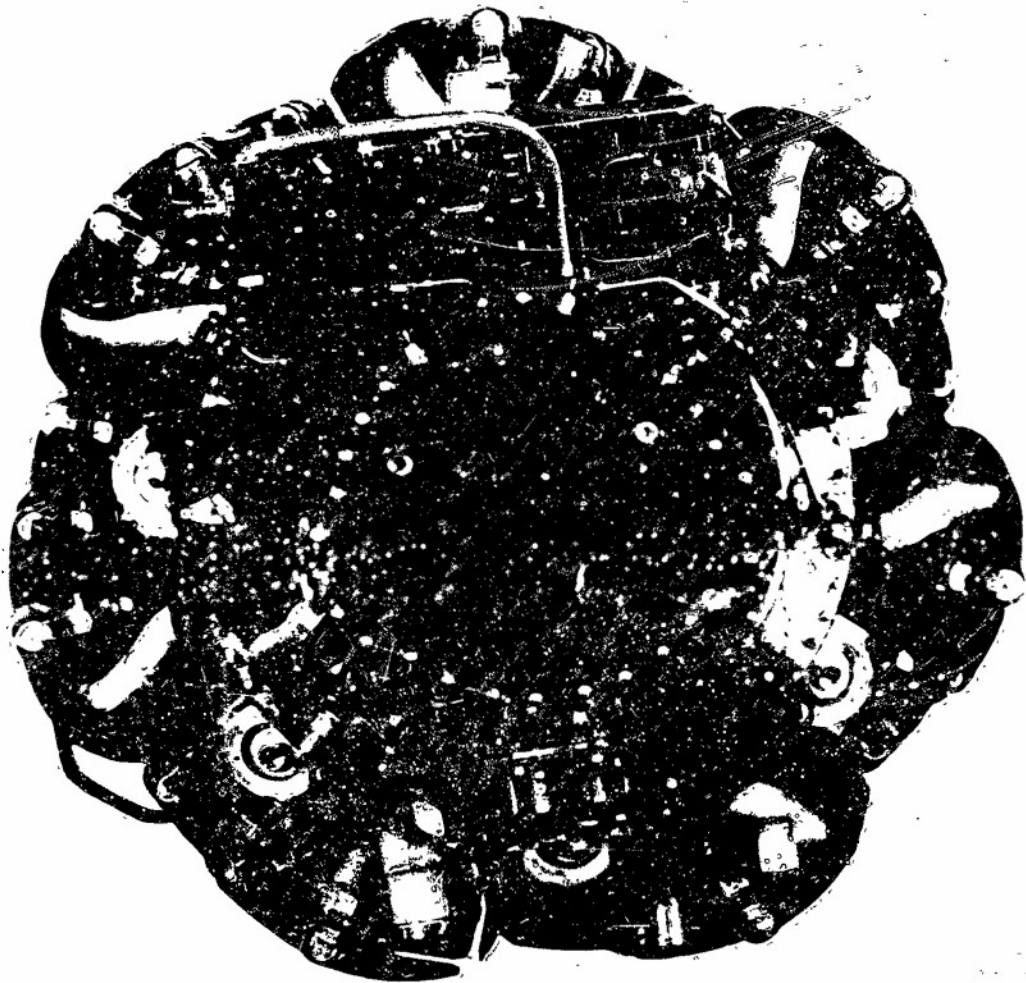


NP(3)-26303(L) 4-50

3/4 LEFT REAR VIEW, R-4360-20 ENGINE

PLATE 43

REPORT NO. AEL-1148



NP(3)-263036(L)-4-50

REAR VIEW, R-4360-20 ENGINE

PLATE 50

REPORT NO. AEL-1148

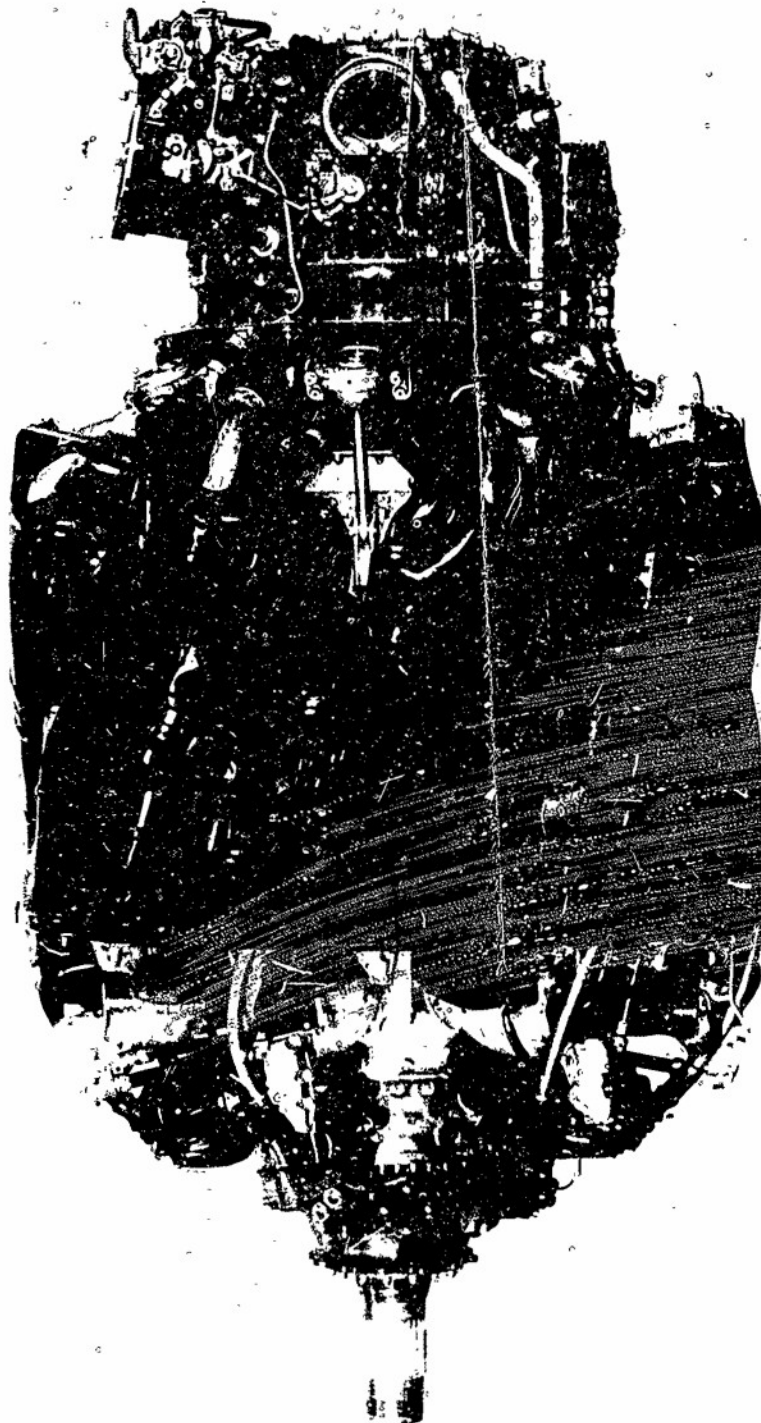


NP(3)-263088(L)-4-50

RIGHT SIDE VIEW, R-4360-20 ENGINE

PLATE 51

REPORT NO. AEL-1148



NP(3)-263087(L)-4-50

LEFT SIDE VIEW, R-4360-20 ENGINE

PLATE 52