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PRELIMINARY SPECIFICATION FOR
TURBOSUPERCHARGER

1. TYPE

- 1.01 This specification covers requirements of the Lockheed Aircraft Corporation for a turbosupercharger (G.E. W.W. 8480062 Modified) suitable for delivering supercharged air to the engine and cabin when installed with a Pratt and Whitney R4360-18 Wasp Major engine in the Lockheed Model 89-29 (Navy Model XR60-1) airplane.

2. REFERENCE

- 2.01 The current issue of Bureau of Aeronautics Specification NAVAR 8-591, "Turbosupercharger, Aircraft, General Specification", in effect on the date of issuance of a proposal under this specification, shall be used as a general guide for items not covered by this specification.
- 2.02 The provisions of this specification shall govern in the event of conflicting requirements between specifications.
- 2.03 All appendices to this specification, and drawings listed herein, are hereby made a part of this specification.

3. MATERIALS AND WORKMANSHIP

- 3.01 Materials used shall be the lightest practicable, consistent with strength and service requirements for safety, reliability, and long service life.
- 3.02 Workmanship shall conform with high grade commercial practice in the manufacture of exhaust driven turbosuperchargers for military aircraft.

4. GENERAL REQUIREMENTS

- 4.01 Dimensions, points of attachments, location of joints and contours shall conform to G.E. Drawing No. WW-8480062.
- 4.02 The turbosupercharger shall be designed for efficient operation at cruising powers to 25,000 ft. in conjunction with the single stage, single speed, supercharger model Pratt and Whitney R-4360-18 Engine. The requirements of the turbine-engine combination shall be as summarized herein.
- 4.03. The design, calibration and service tests of the supercharger shall be performed by the manufacturer, and it shall be his responsibility.
- 4.031 The manufacturer shall submit installation and detail drawings of the proposed design for review by the Lockheed Aircraft Corporation.
- 4.032 Approval of the manufacturer's design by the Lockheed Aircraft Corporation shall not relieve the manufacturer from responsibility for

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4. GENERAL REQUIREMENTS (Cont.)

- 4.032 (Cont.) - satisfactory performance or delivery of all items in conformance with the specifications.
- 4.04 Interchangeability - Practical interchangeability shall be established and maintained for all units of an item released for production under this specification.
- 4.05 Weight - The maximum dry weight of the supercharger shall be 155 pounds. The minimum weight shall be consistent with the requirements of this specification.
- 4.06 Marking
- 4.061 Each complete turbosupercharger assembly shall be provided with a suitable identification plate which shall be marked permanently and legibly with the assembly number, name of manufacturer, and date of manufacture. This identification plate shall be attached permanently to the assembly in such a location as to insure that it will remain legible throughout the service life of the supercharger assembly.
- 4.062 Each detail part and sub-assembly shall be marked permanently for identification with the same number as the drawing from which it was made. The method of marking shall not impair the strength nor shall it promote deterioration of the part.
- 4.07 Drawings and Performance Curves
- 4.071 Drawings to be furnished by the manufacturer shall consist of two vandyke sets of the necessary assembly drawings. Two vandyke sets of all changed drawings shall be furnished within 30 days following each change.
- 4.072 Estimated performance curves similar to General Electric Curves Nos. K1090561-1 (compressor) and P1090611 (turbine) shall be furnished to the Engineering Department of Lockheed Aircraft Corporation.
- 4.08 Reliability
- 4.081 The reliability of the unit is paramount and must be consistent with the requirements of commercial operation of a long range transport airplane.
- 4.09 Maintenance and Accessibility
- 4.091 Adequate provisions shall be made for the easy inspection and servicing of attachments, mechanisms, bearings, brackets, joints, fittings, etc.
- 4.092 The supercharger unit shall be designed and constructed in a manner such as to simplify inspection, maintenance and repair.

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5. DETAIL REQUIREMENTS

5.01 Performance

5.011 The turbosupercharger shall be designed for efficient operation for all cruising powers to 25,000 ft. including cabin supercharging, in conjunction with a single stage, single speed model of the Pratt and Whitney R-4360-18 Engine. The performance of the turbine-engine combination is summarized in Fig. 1 of Appendix A. Figure 2 shows the normal operating engine speeds to be used with each engine power. The following table summarizes the required critical altitudes (minimum requirements).

<u>BHP/Engine</u>	<u>Eng. RPM</u>	<u>Critical Altitude Required</u>
3000	2700	7,000 ft.
2500	2550	20,000 ft.
2100	2300	25,000 ft.
1600	2000	25,000 ft.
1100	1400	25,000 ft.
900	1200	25,000 ft.

5.012 Information necessary for the determination of the turbine and compressor performance is supplied on Figs. 3, 4, 5, and 6 of Appendix A. The turbosupercharger shall be capable of supplying the airflows and carburetor pressures corresponding to the Best Economy requirements shown on Figs. 3 and 4. The performance shall be obtained with the supercharger installed in a system, as shown on Appendix B, Fig. 7. A heat exchanger and an exhaust tail pipe nozzle are installed in series with the turbo wheel on the downstream side. Exhaust gas pressure drop data are given on Fig. 8. Intercoolers and suitable ducts are installed on the downstream side of the compressor. Estimated air pressure drop data for the intercooler and ducts are given on Fig. 5.

5.0121 Figures 3 and 4 are the information obtained from the Pratt & Whitney Aircraft Corporation at the date of this specification. It shall be the responsibility of the contractor to maintain coordination with the Pratt & Whitney Corporation relative to any changes in airflows or carburetor pressures that may arise in the development of the P & W R-4360-18 engine.

5.013 The exhaust back pressures on the engine must be kept to a minimum. For powers of 1600 BHP or below at 25,000 ft. under N.A.C.A. standard atmospheric conditions, the nozzle box pressure shall not exceed 26.5" Hg absolute. For the design condition of 3000 BHP at 7000 ft. under N.A.C.A. standard atmospheric conditions, the nozzle box pressure shall not exceed 43" Hg absolute. Both of the above conditions are with exhaust heat exchanger and tail pipe nozzle installed, including cabin air supply of 300/min. and all exhaust flow passing through heat exchanger.

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5. DETAIL REQUIREMENTS (Cont.)

5.01 Performance (Cont.)

5.014 The unit shall operate satisfactorily, meeting all conditions of this specification when supplied with exhaust from a lean mixture and at temperatures as high as $1800^{\circ} \text{ F.} \pm 50^{\circ}$.

5.02 Cooling Provisions

5.021 The design of the supercharger shall include adequate provisions for cooling of the turbine and moving parts. The air passages shall be adequately sealed so that cooling air cannot enter the exhaust stream.

5.022 A cooling cap shall be installed on the downstream side of the exhaust wheel.

5.023 Provisions for cooling the interior of the unit just ahead of the exhaust wheel shall be provided. The air passages shall be adequately sealed so that cooling air cannot enter the exhaust stream.

5.024 Exhaust back pressures as imposed on the turbo wheel by the heat exchanger and tail pipe nozzle shall not impair the operation of the unit.

5.03 Controls

5.031 A suitable waste gate and control for operation by a General Electric, G.E. No. 3GPR8A1, pressure and overspeed regulator shall be provided.

5.032 One or two tachometer generators (as required) suitable for operating a G.E. No. 3GPR8A1 regulator and a suitable speed indicator shall be installed on and furnished with the turbosupercharger.

5.04 Exhaust Wheel Inspection

5.041 Suitable provisions shall be made for the inspection of the exhaust wheel.

5.05 Mounting Provisions

5.051 Suitable connections for mounting and handling shall be provided.

5.052 The turbosupercharger shall be constructed for satisfactory operation with the axis of the shaft in any position relative to the horizontal.

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5. DETAIL REQUIREMENTS (Cont.)

5.06 Exhaust Connections

5.061 Provisions shall be made for exhaust pipe connections. One connection downstream from the turbo wheel shall be provided for the connection of a heat exchanger transition section. Two other connections shall be provided for the attachment to the exhaust collector system, and one for attaching a waste pipe.

5.062 The exhaust inlet connections shall be capable of supporting small sections of exhaust pipes fastened to ball joints weighing not more than 20# without impairing the operation or dependability of the unit.

5.063 The adaptor section from the "Z" ring to the connection to the heat exchanger transition section shall provide: (1) provisions for inspection of the turbo wheel, (2) support of the cooling cap, and (3) provisions for expansion and misalignment of the connections.

5.07 Tachometer Connection

5.071 Suitable gearing and connections for driving a tachometer generator or generators shall be provided as an integral part of the unit.

5.08 Lubricating System

5.081 The unit shall have a suitable lubricating system. This system shall be a part of the turbo assembly and shall be complete with pump, suitable oil filter (located on the pressure side of the pump), and suitable connections. This lubricating system shall be designed for use with engine oil and shall not require auxiliary oil coolers.

5.082 The lubrication system shall be designed to meet the latest requirements or recommendations of the Army Air Forces concerning Winterization.

5.083 The turbosupercharger shall perform satisfactorily when oil is applied at temperatures satisfactory for engine operation.

5.09 Stresses

5.091 The turbosupercharger shall withstand for at least one minute the gyroscopic torque imposed at the rated speed of the turbosupercharger, and at the rate of precession 0.5 radians/sec.

5.10 Protectors

5.101 Suitable protection from bucket failures shall be installed as an integral part of the unit.

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6. METHOD OF INSPECTION AND TESTS

- 6.01 The supercharger shall be subject to inspection and calibration by Lockheed Aircraft Corporation inspectors.
- 6.02 Acceptance of material or parts in course of manufacture shall not be construed as a guarantee of acceptance of the finished part or assemblies thereof.
- 6.03 Tests
- 6.031 Each turbo assembly shall be examined to determine that the design and workmanship conform to this specification.
- 6.032 Each complete turbo assembly shall be weighed accurately. The dry weight shall not exceed the weight specified herein.
- 6.033 The manufacturer shall make suitable tests of the prototype unit to prove the performance, the operating characteristics and the reliability of the unit. These tests must prove that the unit is designed in accordance with requirements of commercial operation of long range transport airplanes and will not require service overhauls more frequent than 1000 hours of flight time. The details of these tests shall be subject to further negotiation. Reports of tests shall be furnished to the Lockheed Aircraft Corporation.
- 6.04 Rejection
- 6.041 Each turbo assembly which does not fulfill the requirements of this specification shall be subject to rejection.
- 6.042 A rejected assembly may be resubmitted by the manufacturer for inspection and test, providing that it is accompanied by a statement of changes or modifications.
- 6.05 Status of Specification
- 6.051 This specification is subject to cancellation or revision.
- 6.052 No deviations from this specification shall be issued except as an amendment, which shall have the approval of the Engineering Department of the Lockheed Aircraft Corporation.
- 6.053 The data contained in this specification are "Restricted", and all Federal and Lockheed Instructions and Regulations concerning restricted data shall apply to this specification.

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APPENDIX A

- Fig. 1 Engine Brake Horsepower Versus Altitude
- Fig. 2 Engine Speed Versus Engine Brake Horsepower
- Fig. 3 Engine Air Consumption Versus Engine Brake Horsepower
- Fig. 4 Carburetor Pressure Versus Brake Horsepower
- Fig. 5 Estimated Engine Air Pressure Drop Thru Intercooler and
Ducts.
- Fig. 6 Estimated Back Pressure on Exhaust Driven Turbine Due to
Heat Exchanger and Exhaust Nozzle.

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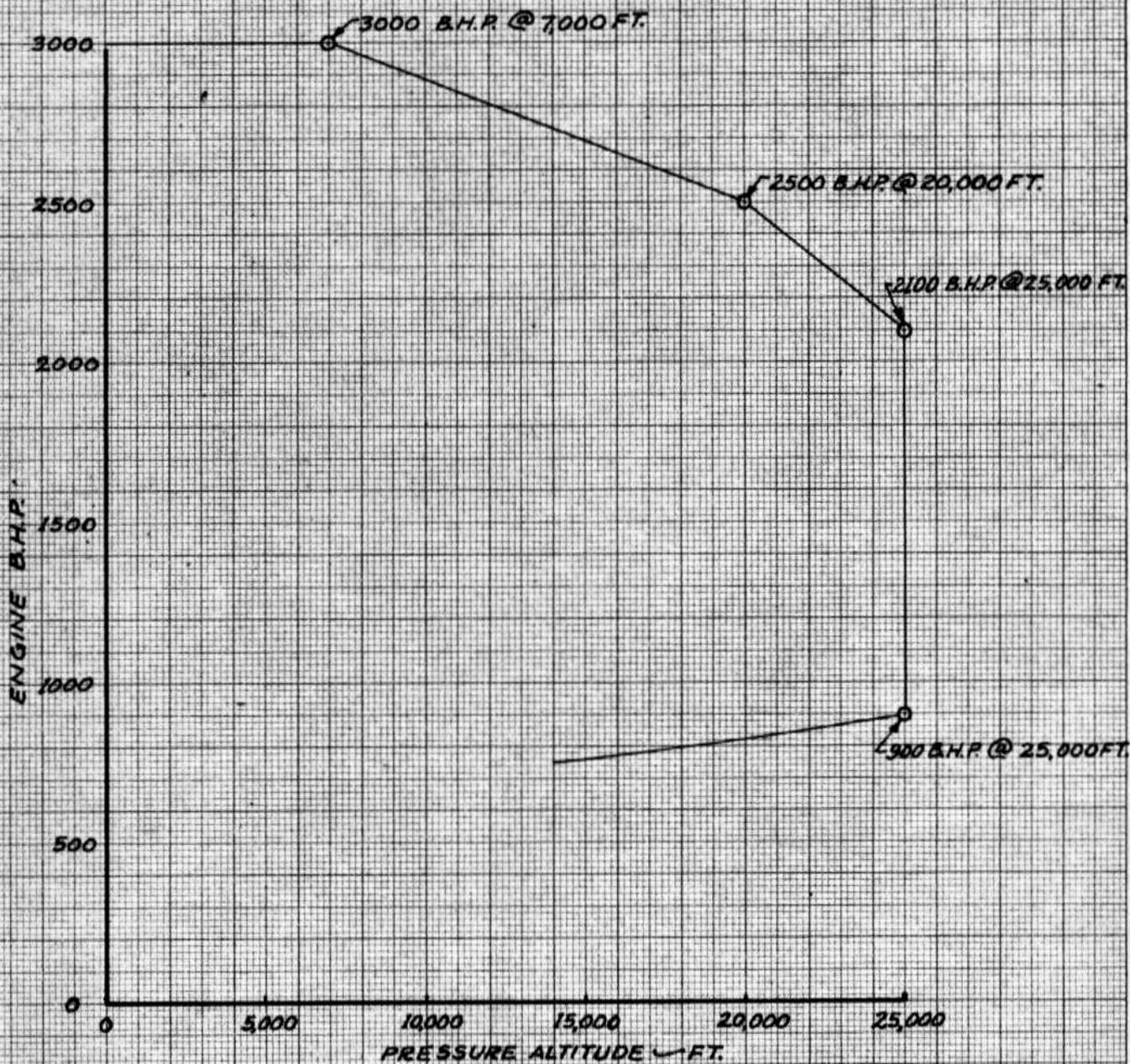
APPENDIX B

SKETCH - Fig. 7

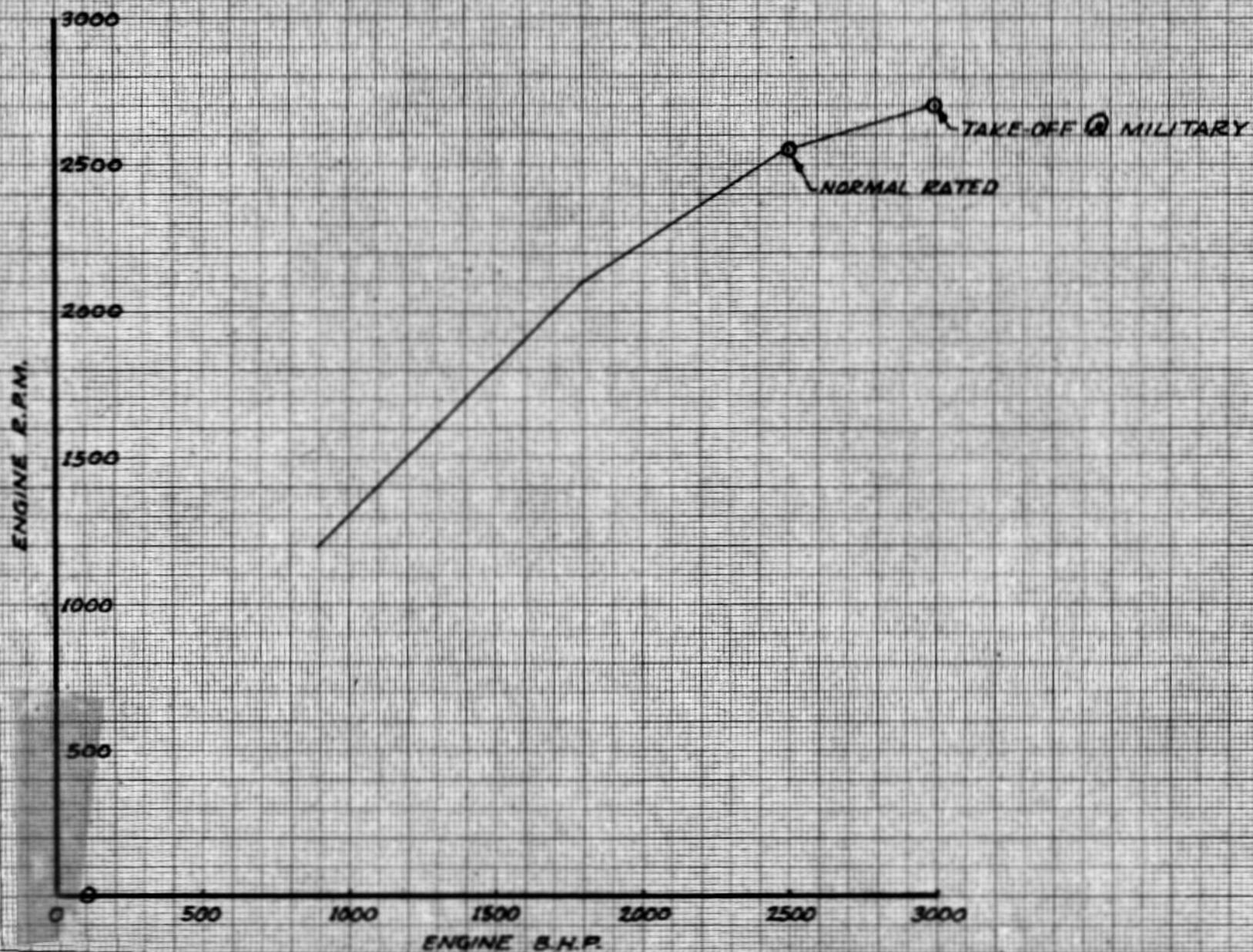
SKETCH - Fig. 8

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ENGINE BRAKE HORSEPOWER VERSUS ALTITUDE
PRATT & WHITNEY R-4360 ENGINE
REQUIRED OPERATION WITH EXHAUST TURBO-SUPERCHARGER



ENGINE SPEED VERSUS ENGINE BRAKE HORSEPOWER
- PRATT & WHITNEY R-4360 ENGINE



ENGINE AIR CONSUMPTION VERSUS ENGINE BRAKE HORSEPOWER
— PRATT & WHITNEY R-4360 ENGINE

DATA FROM:

- (1) P & W CURVE NO. 3572 (REVISED 12-7-43)
- (2) P & W CURVE T-807 (REVISED 6-26-42)

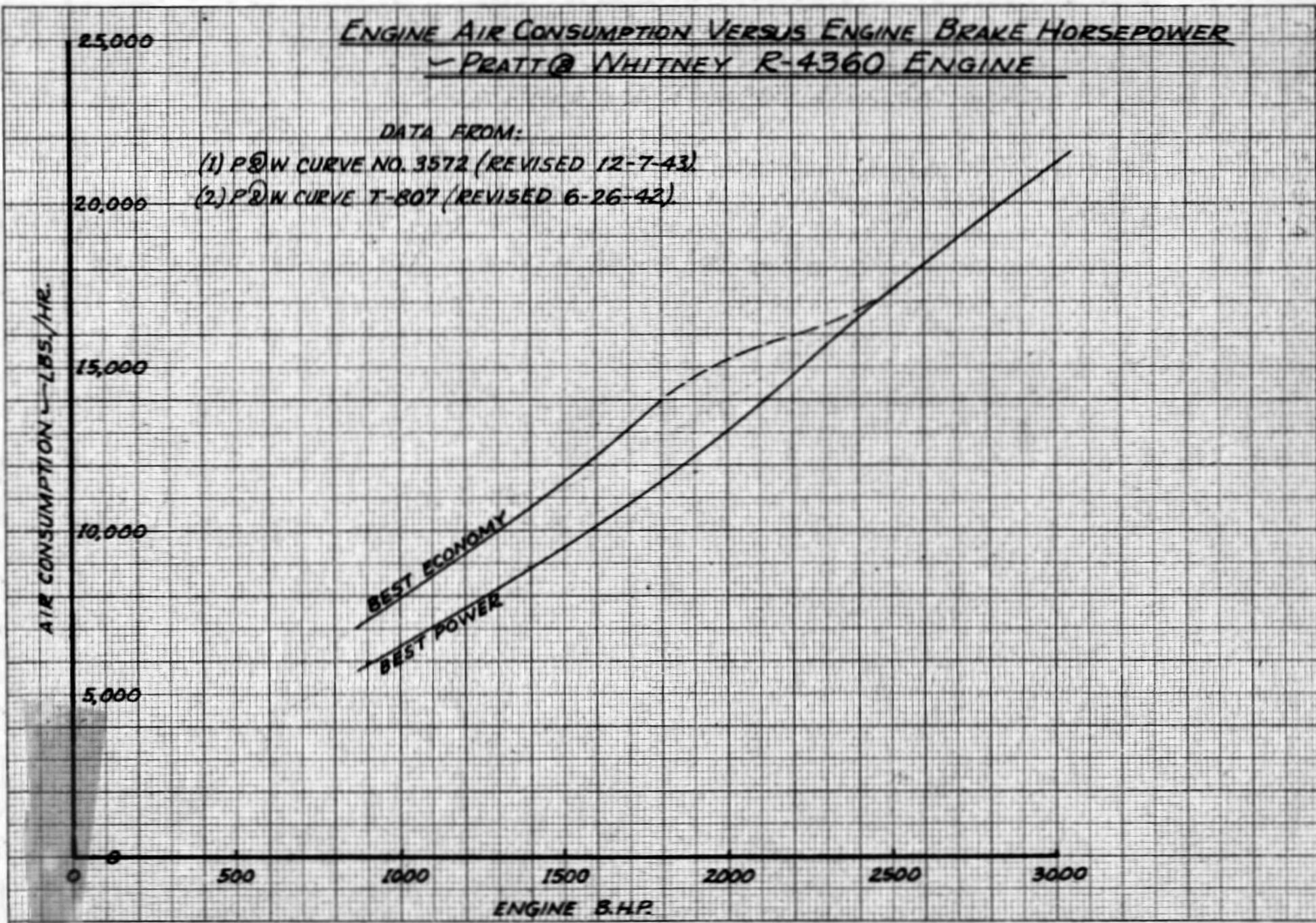
AIR CONSUMPTION — LBS./HR.

25,000
20,000
15,000
10,000
5,000

BEST ECONOMY
BEST POWER

ENGINE B.H.P.

0 500 1000 1500 2000 2500 3000



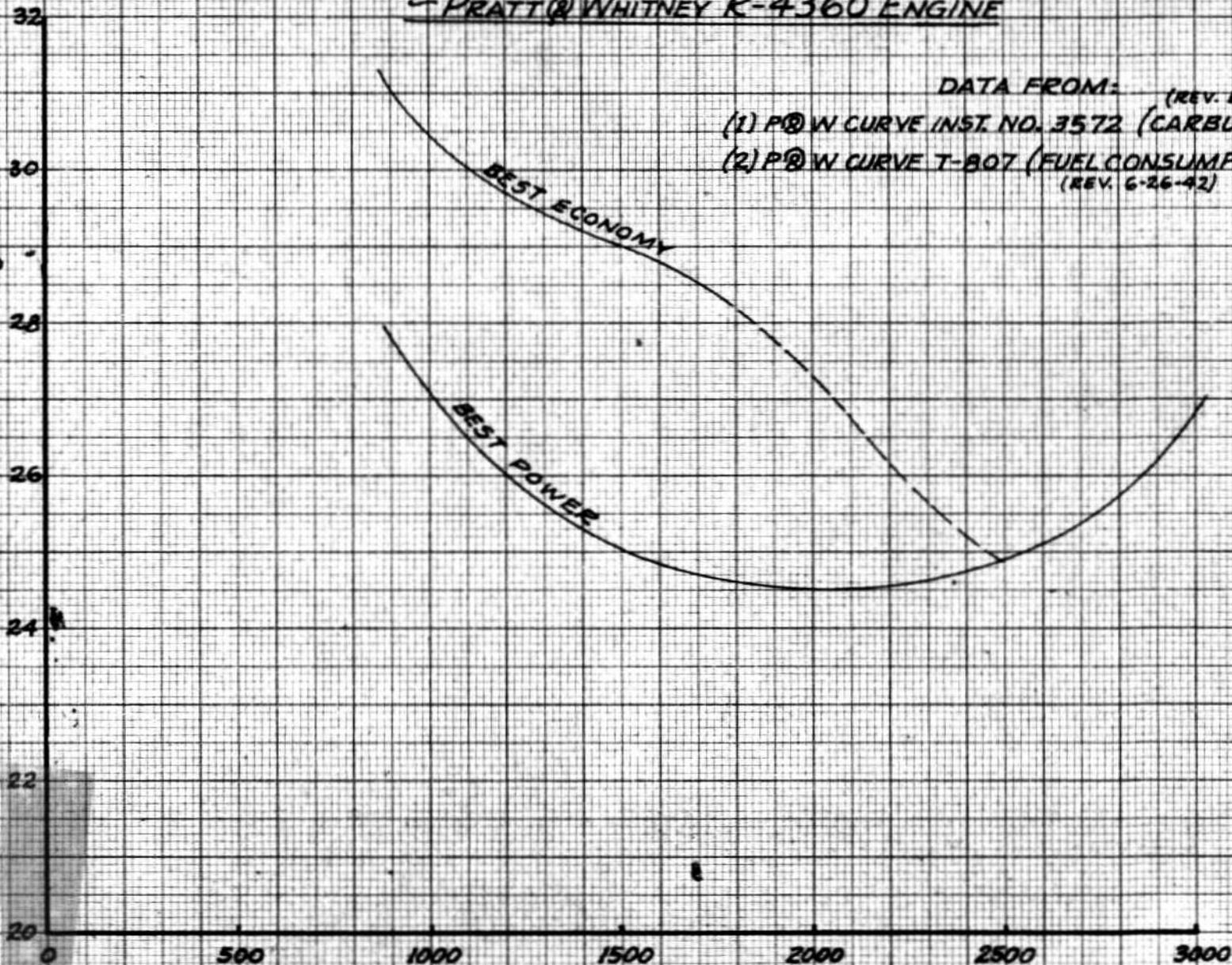
CARBURETOR PRESSURE VERSUS BRAKE HORSEPOWER
- PRATT & WHITNEY R-4360 ENGINE

DATA FROM: (REV. 12-7-43)

(1) P@W CURVE INST. NO. 3572 (CARBURETOR PRESSURE)

(2) P@W CURVE T-807 (FUEL CONSUMPTION)
(REV. 6-26-42)

CARBURETOR PRESSURE — IN. Hg



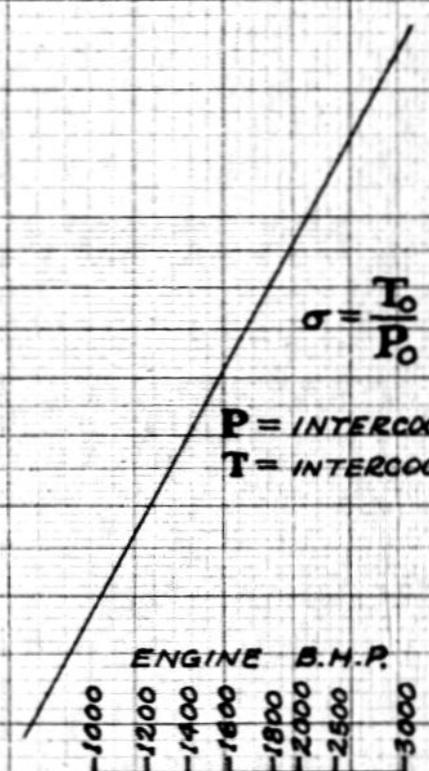
ENGINE B.H.P.

ESTIMATED ENGINE-AIR PRESSURE DROP
THRU INTERCOOLER AND DUCTS

W.W. MERRILL - A-30-43

LOCKHEED AIRCRAFT CORPORATION

AIR PRESSURE DROP - INCHES Hg



$$\Delta P = \frac{\sigma \Delta P}{\sigma}$$

$$\sigma = \frac{T_0}{P_0} \times \frac{P}{T} = \left(\frac{460 + 59}{29.92} \right) \times \frac{P}{T} = 17.35 \frac{P}{T}$$

P = INTERCOOLER INLET PRESSURE - IN. Hg ABSOLUTE.
T = INTERCOOLER INLET TEMPERATURE - °F ABSOLUTE.

ENGINE B.H.P.
 1000
 1200
 1400
 1600
 1800
 2000
 2500
 3000

ENGINE AIRFLOW - LBS./MIN.

DECLASSIFIED
 Authority NND 947020

10 20 30 40 50 60 70 80 90 100 200 300 400 500 600 700 800 1000 2 3 4

ESTIMATED BACK PRESSURE ON EXHAUST-DRIVEN TURBINE,
DUE TO HEAT EXCHANGER AND EXHAUST NOZZLE



POP. ACROSS HEAT EXCHANGER AND NOZZLE INCHES Hg

25,000 FT. ALTITUDE

TO OBTAIN APPROXIMATE BACK PRESSURE AT ALTITUDES OTHER THAN 25,000 FT., MULTIPLY ΔP SCALE READING BY RATIO OF ATMOSPHERIC PRESSURES.

$$\text{EXAMPLE: } \Delta P_{20,000} = \Delta P_{25,000} \times \frac{P_{25,000}}{P_{20,000}}$$

ENGINE B.H.P.
 1000
 1200
 1400
 1600
 1800
 2000
 2500
 3000

EXHAUST GAS FLOW - LBS./MIN.

9 10 20 30 40 50 60 70 80 90 100 200 300 400 500 600 700 800 1000 2 3 4

