TECHNICAL NOTES

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

No. 118

F-5-L BOAT SEAPLANE - PERFORMANCE CHARACTERISTICS.

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This Note is the second of a series on performance of Service Naval Aircraft. In general, the outline is quite similar to that followed in A.T.N. No. 215 (N9H Performance), although certain changes have been found necessary in determining cruising speeds. The performance curves given in Figs. 5, 6, and 7 represent more or less ideal conditions and will hardly be attained except by an exceptional pilot with an airplane in good shape. Experience has shown, however, that service deviations from the ideal values should not be excessive and that the ideal conditions may be used as a guide in obtaining the best performance.

An explanation of the "stalling speed" is necessary. In most cases this will be considerably lower than the "landing speed," chiefly because of the lack of control at the attitude required to obtain the slowest possible speed. The values of "probable landing speed" include the effect of those factors tending to increase the speed on a landing.

Wing Characteristics.

Characteristic curves for the RAF-6 airfoil and F-5-L wings are plotted on Fig. 1. The absolute lift and drag coefficients C_L and C_D are defined by the relations:

*Originally prepared as A.T.N. #221, Bureau of Aeronautics, Navy Department.

$$\text{Lift} = C_L\ (1/2\ PV^2)\ S$$

$$\text{Drag} = C_D\ (1/2\ PV^2)\ S$$

where S is the wing area, V the velocity and P the mass density of the air. These equations hold true and the coefficients C_L and C_D have the same value in any consistent system of units. It should be noted that P is the mass-density of the air, that is, the weight per unit volume divided by the acceleration of gravity. For force in lbs., area in sq.ft., and velocity in ft/sec., P = .00237 for standard air; or for force in lbs., area in sq.ft., and velocity in mi/hr., P = .0051 for standard air. The variation of P with altitude may be obtained from the curves given in Aircraft Design Data, Vol. I.

<u>Resistance and Velocity.</u>

A summation of the parasite resistance for all parts except the hull of the F-5-L seaplane gives R_p = 812 lbs. at 70 mi/hr.; 334 lbs. of this is in the slip stream and the remainder, 478 lbs. is clear of the slip stream. These resistances vary as the square of the velocity so that at any velocity V, (mi/hr) the total parasite resistance (except the hull) is

$$R_p = F.R_1 \left(\frac{V}{70}\right)^2 + R_2 \left(\frac{V}{70}\right)^2$$

$$= (334\ F + 478) \left(\frac{V}{70}\right)^2$$

where F is the factor which corrects for the increased velocity in the slip stream.

The resistance of the hull was obtained from a wind tunnel test on a model at the Washington Navy Yard.

The wing resistance is obtained from the equation

$$R^W = C_D \left(\frac{1}{2} PV^2\right) \quad (S_1 + S_{2.F})$$

where S_1 is the wing area clear of the slip stream (1297 sq.ft.), S_2 the wing area in the slip stream (100 sq.ft.) and F the slip stream factor.

The velocity at each angle of attack depends upon the corresponding value of C_L, the apparent weight and the effective area, i.e.,

$$V = \sqrt{\frac{W_a}{C_L \cdot \frac{P}{2} \cdot S_e}}$$

The apparent weight is the actual weight less the lift of the hull and tail surfaces. The effective area is the term $(S_1 + S_2 F)$ used in finding the wing drag.

Wing, parasite, and total resistance, and angles of attack are plotted for full load condition (13600 lbs.) in Fig. 2.

Engine and Propeller Characteristics.

The maximum BHP for the standard low compression Liberty 12 engine is given in Fig. 3. The propeller load curve for throttled conditions is obtained from the relation

$$(BHP/BHP_o) = (N/N_o)^3$$

where N is the RPM. The fuel consumption under throttled conditions is based on tests considered to be representative.

The efficiency curve for an average F-5-L propeller is given in Fig. 4.

Power Chart and Indicated Performance.

The Effective Horsepower, EHP, required for horizontal flight at any air speed V is determined by the corresponding total resistance R_T, i.e.,

$$EHP = \frac{R_T \cdot V}{375}$$

where V is in mi/hr. and R_T is in lbs.

The maximum HP available at any speed is determined by the engine BHP and the propeller efficiency at the corresponding RPM.

Curves of EHP required for full load of 13600 lbs. and for light load of 11000 lbs. are plotted with the curve of HP available on Fig. 5. The intersections of these curves indicate a maximum speed of 83.6 mi/hr (72.5 K) for the full load condition and 85.3 mi/hr. (74.0 K) for the light load condition.

The difference between the EHP required and the HP available, at any speed, is the excess HP available for climb at that speed. The best climbing speed corresponds to the maximum excess HP. For full load maximum excess HP is 160 at 57 mi/hr. (49.4 K), corresponding to an initial rate of climb of

$$V = \frac{33000 \cdot 160}{13600} = 390 \text{ ft/min.}$$

For light load the maximum excess HP is 215 at 54 mi/hr. (46.8 K), corresponding to an initial rate of climb of

$$V = \frac{33000 \cdot 215}{11000} = 640 \text{ ft/min.}$$

The <u>absolute ceiling</u> is determined by the maximum value of the ratio

R = Maximum HP available/HP required.

For full load R = 1.61 which indicates an absolute ceiling of 9200 ft; for light load R = 2.06 which indicates an absolute ceiling of 14000 ft. The actual absolute ceiling will fall somewhere between these values. Starting out with full load the climb should be as plotted on Fig. 6, up to an altitude of approximately 8000 ft. Above this altitude the climb depends largely on the total weight and is therefore indeterminate. For full load, the <u>service ceiling</u>, i.e. the altitude at which the rate of climb is 100 ft/min., is 6800 ft. The time of climb to any altitude less than 7000 ft. is given by the curve on Fig. 6.

Rate of climb and ceiling are much influenced by small changes in power and weight, and the values given may appear optimistic when compared with service performance obtained under unfavorable conditions.

<u>Cruising Performance.</u>

The usual method of determining cruising speeds is to draw a tangent to the curve of HP required (See Fig. 5) from a point on the velocity axis so taken as to allow for wind velocity. This gives the true cruising speed only in case the fuel consumption and propeller efficiency remain constant. For the F-5-L seaplane it is necessary to calculate for each speed the fuel consumption in lbs/hr. from the corresponding propeller efficiency, HP required and specific fuel consumption. The resulting curves, plotted on Fig. 7, are to be used, instead of the HP required curves, in obtaining cruising speeds.

Cruising speeds for both full load and light load are plotted against wind velocity in Fig. 8.

Calculated Performance.

Full Load 13600 lbs.

Stalling speed - Power on	48 mi/hr	(41.6 K)
Probable landing speed,- Power off	54.0 mi/hr	(46.8 K)
High speed	83.6 "	(72.5 K)
Speed at best climb	57.0 "	(49.4 K)
Cruising speed (still air)	66.3 "	(57.6 K)
Absolute ceiling	9200 ft.	
Service ceiling	6800 ft.	
Initial rate of climb	390 ft/min.	
Climb in 10 minutes	3200 ft.	

Light Load 11000 lbs.

Stalling speed - Power on	43.3 mi/hr (37.6 K)
Probable landing speed - Power off	48.5 " (42.0 K)
High speed	85.3 " (74.0 K)
Speed at best climb	54.0 " (46.8 K)
Cruising speed (still air)	56.0 " (48.5 K)
Absolute ceiling	14000 ft.
Service ceiling	11800 "
Initial rate of climb	640 ft/min.
Climb in 10 minutes	5100 ft.

F-5-L Boat Seaplane.

Length over-all	49' 3-11/16"
Height over-all	18' 9-1/4"
Span: Upper wing	103' 9-1/4"
Lower wing	74' 3-7/8"
Chord - Both wings	8' 0"
Gap	8' 10"
Stagger	0' 0"
Wing curve	RAF-6
Dihedral	1-1/2°
Upper wings (including ailerons)	851 sq.ft.
Lower wings	546 "
Total wing area	1397 "
Ailerons (2) each	59.5 "
Stabilizer	121

Elevators	55
Fin	54.0
Rudder	33.0
Non-skid fins, total	31.0
Engines (2) Liberty 12	360 BHP at 1500 RPM
Propeller	10' 6" diameter 5' 6" pitch

Weight -	Dead load	9720 lbs.
	Fuel, gas and oil	2880 "
	Total useful load	3880 "
	Gross load	13600 "

Lbs. per sq.ft.	9.73
Lbs. per BHP	18.8

C.G. location (approximate) 2' 10" aft of leading edge of lower wing and 3' 3" below thrust line. Angle of wing chord to thrust line +4°; angle of stabilizer to thrust line +2°.

	Full load Calculated	Actual
High speed	72.5 K	73.0 K #
Low speed	42-47 K	43 K #
Climb in 10 minutes	3200 ft.	2600 ft #
Absolute ceiling	9200 ft.	9000 approx.
Service ceiling	6800 ft.	6200 "
(San Diego claims 12000 ft absolute ceiling)		Estimated from clim.
Cruising speed (calm)	57.6 K	56-58 K #
Initial rate of climb	390 ft/min.	320 approx. #

All climb data in files are inconsistent - tests are rather loosely conducted. The figures marked # have actually been obtained with load of 13600 lbs.

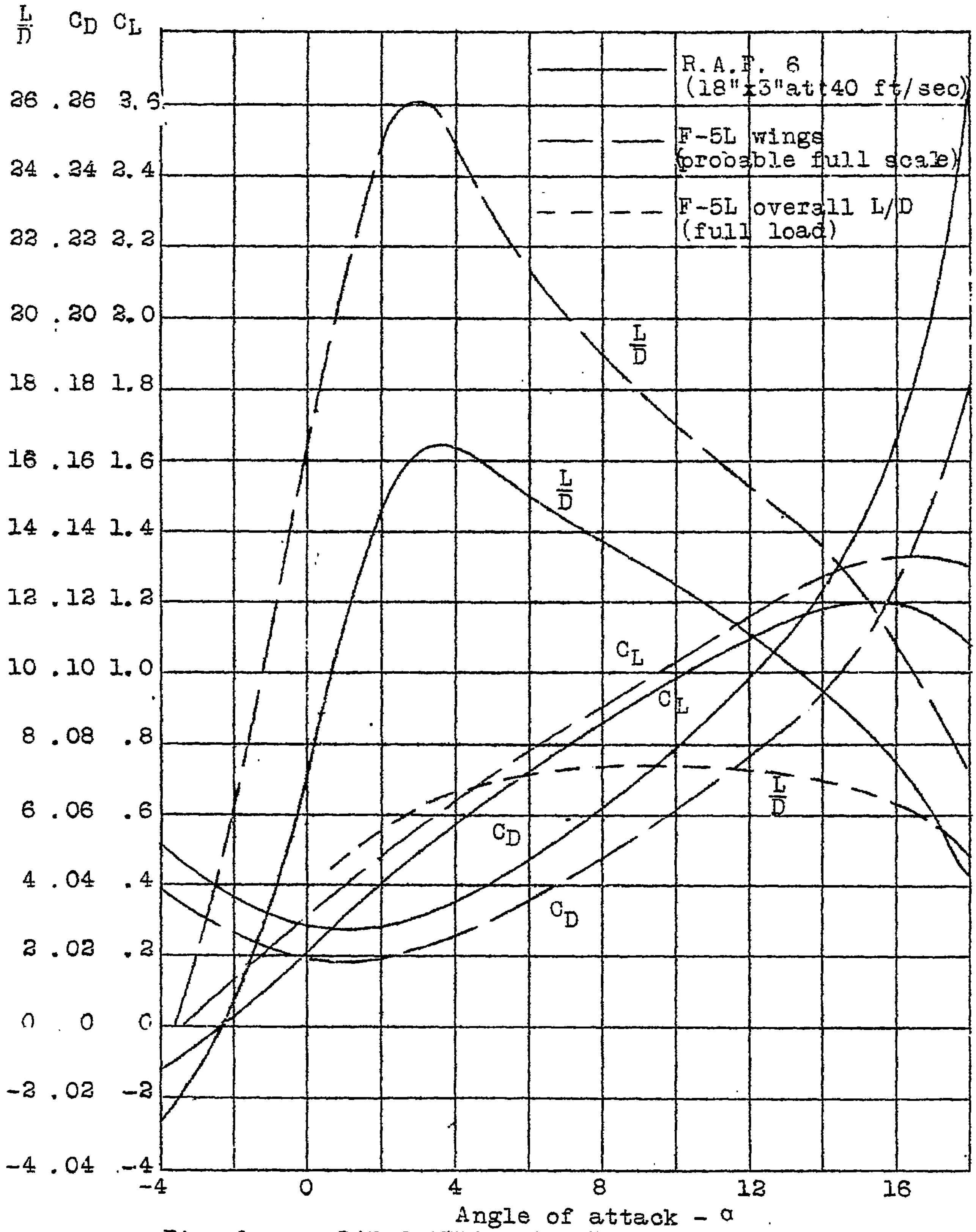

Fig. 1. RAF-6 AEROFOIL AND F-5L WINGS.

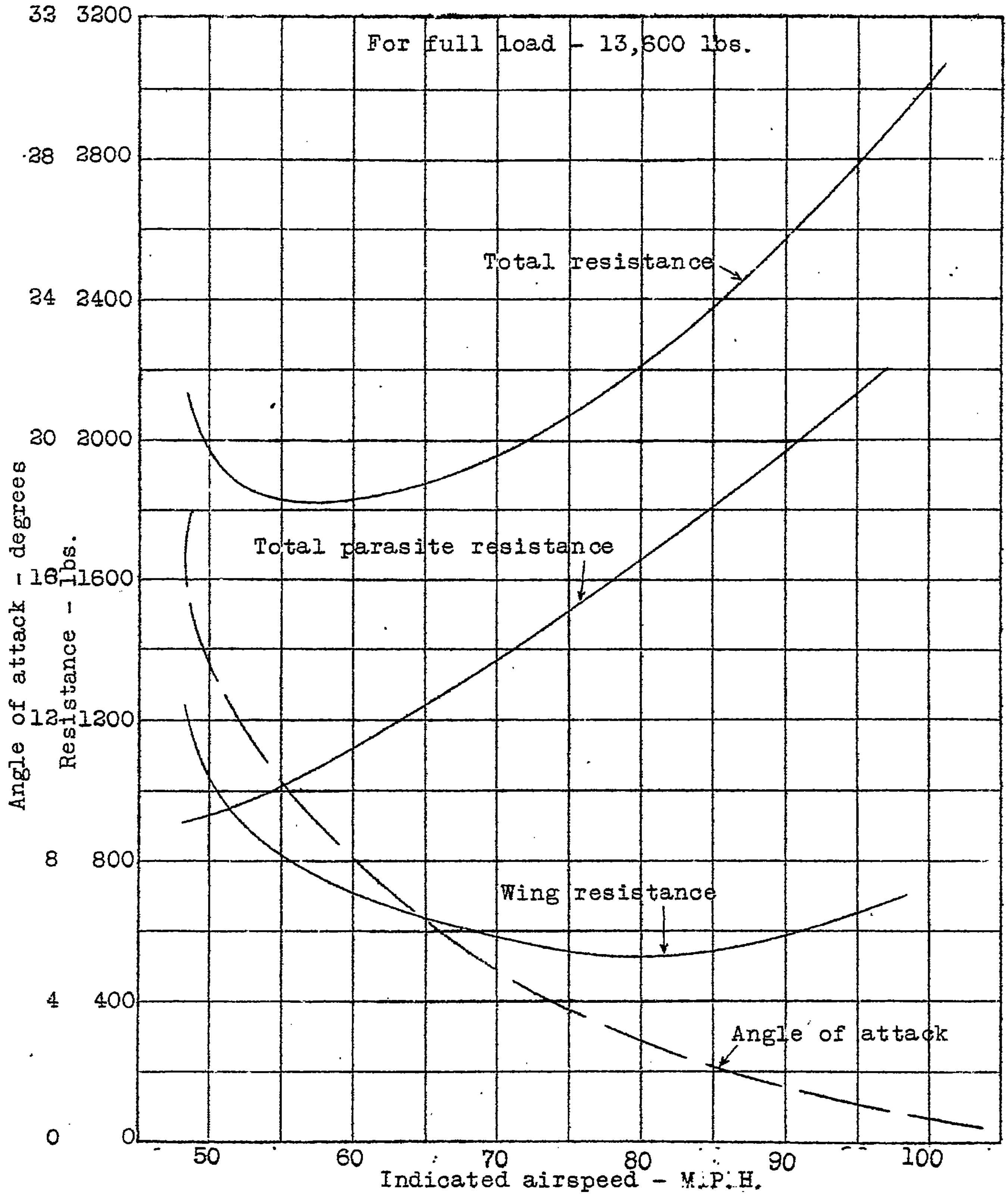

Fig. 2. F-5L BOAT SEAPLANE

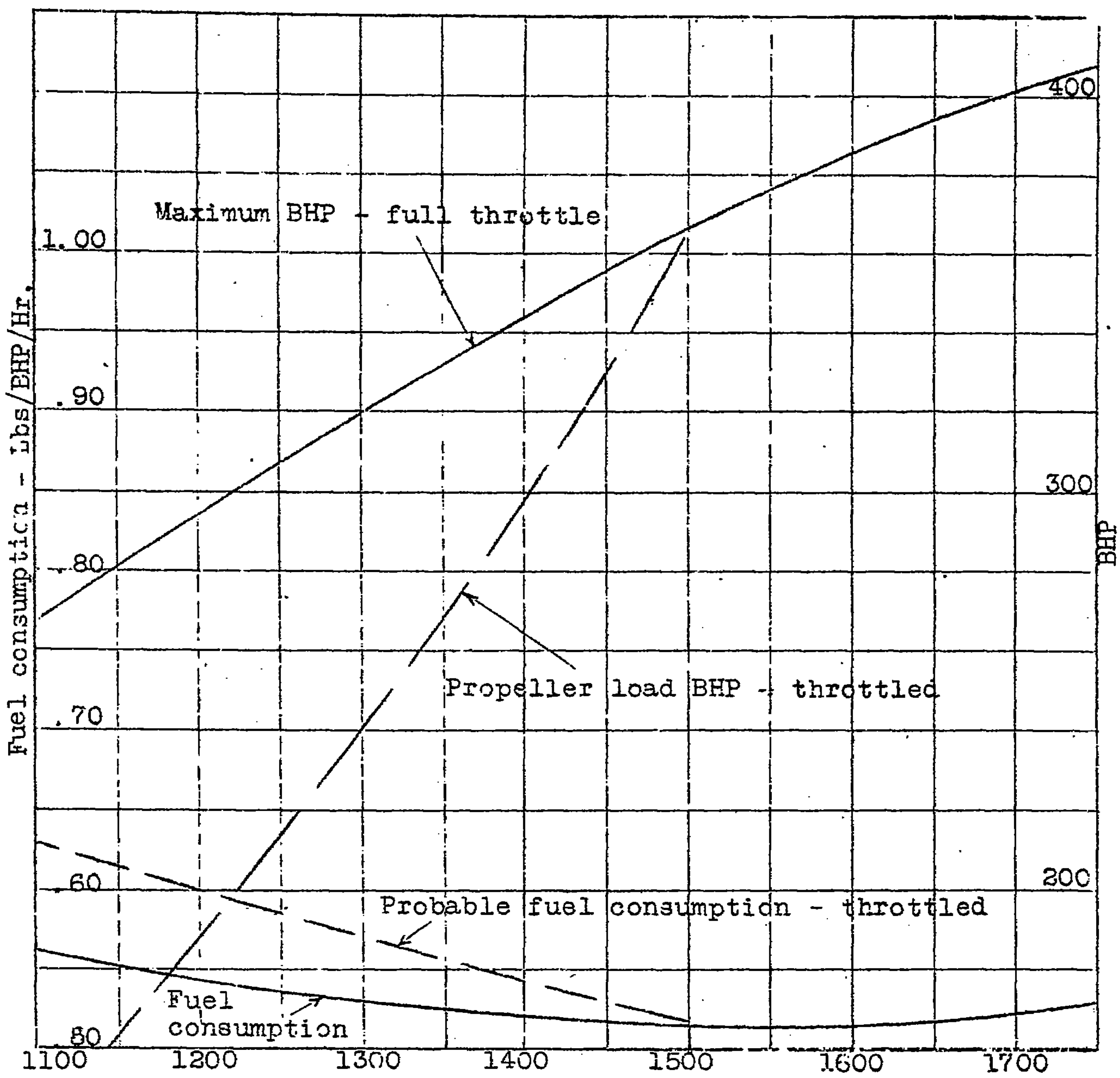

Fig. 3. LIBERTY "12" ENGINE - LOW COMPRESSION.

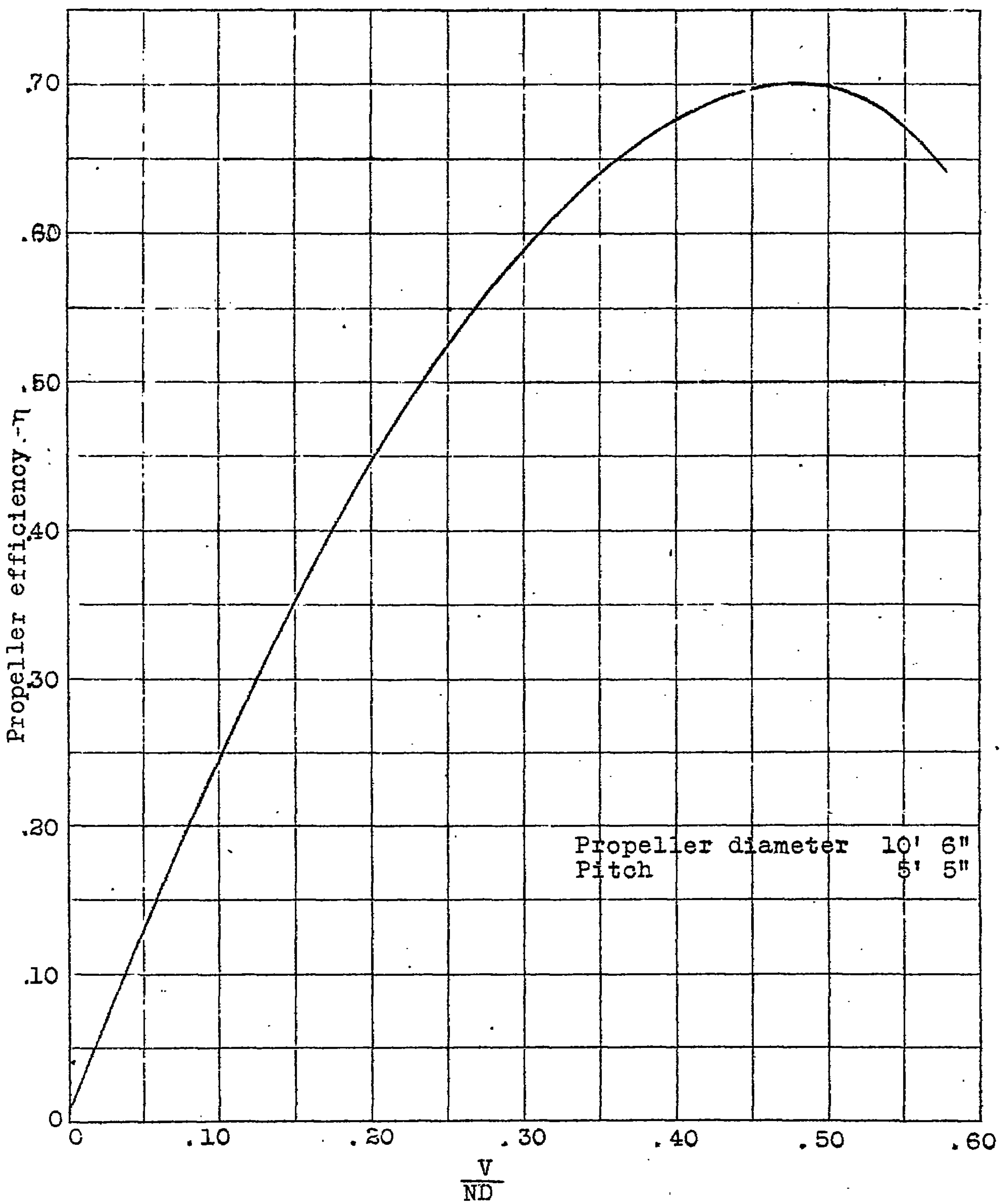

Fig 4. PROPELLER EFFICIENCY F-5 L BOAT SEAPLANE

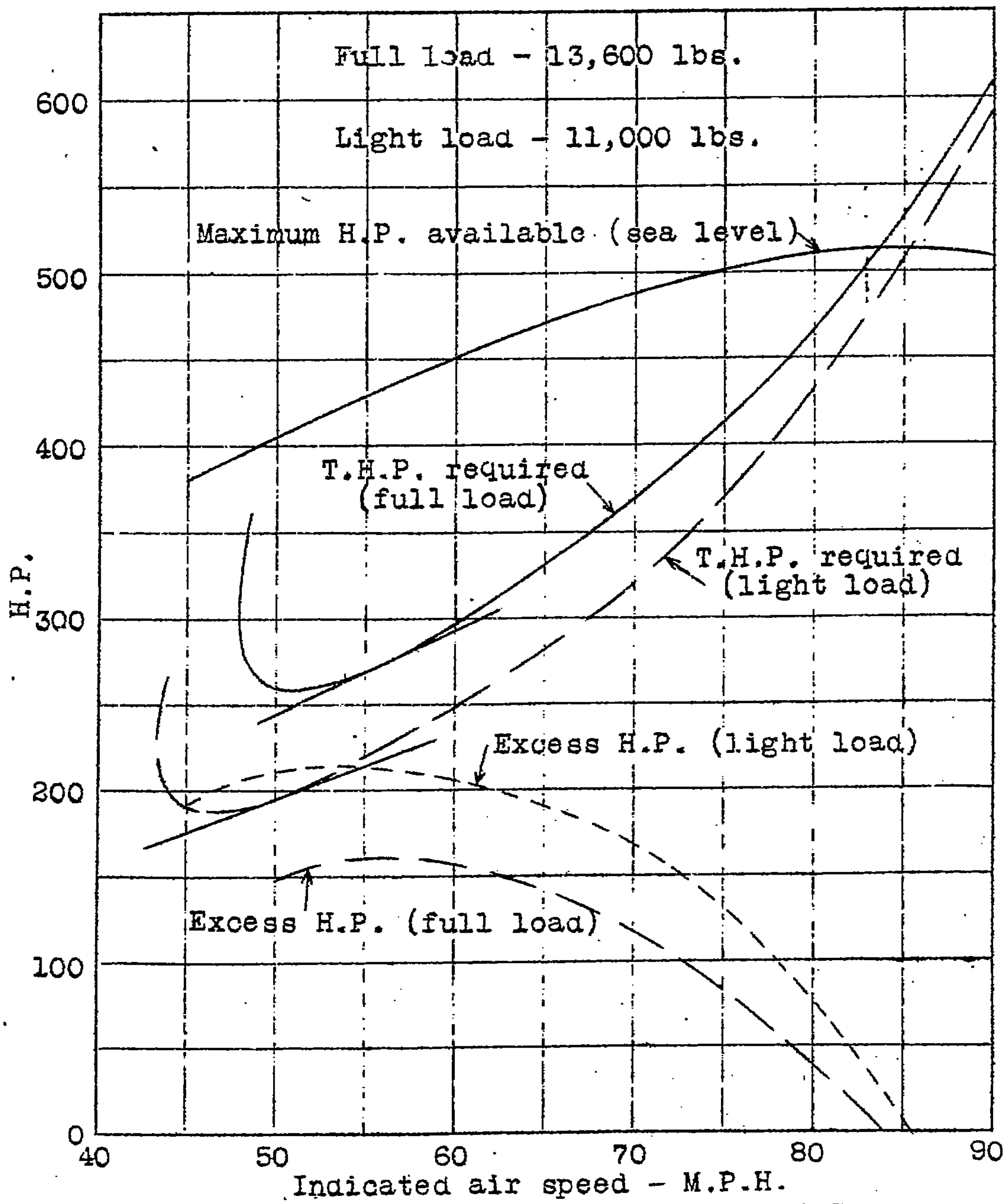

Fig.5 F-5L BOAT SEAPLANE PERFORMANCE CURVES

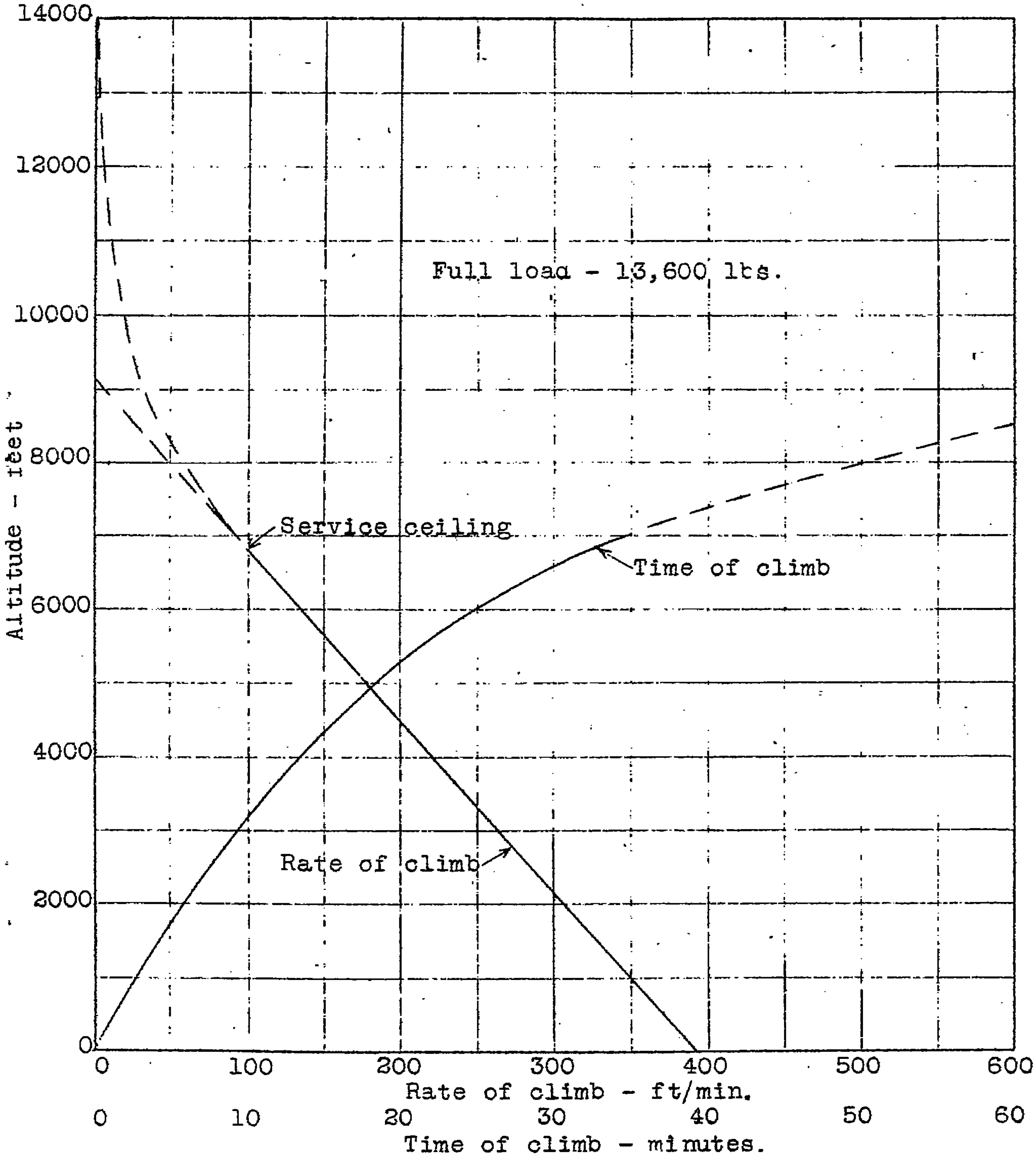

Fig. 6. F-5L BOAT SEAPLANE - PERFORMANCE

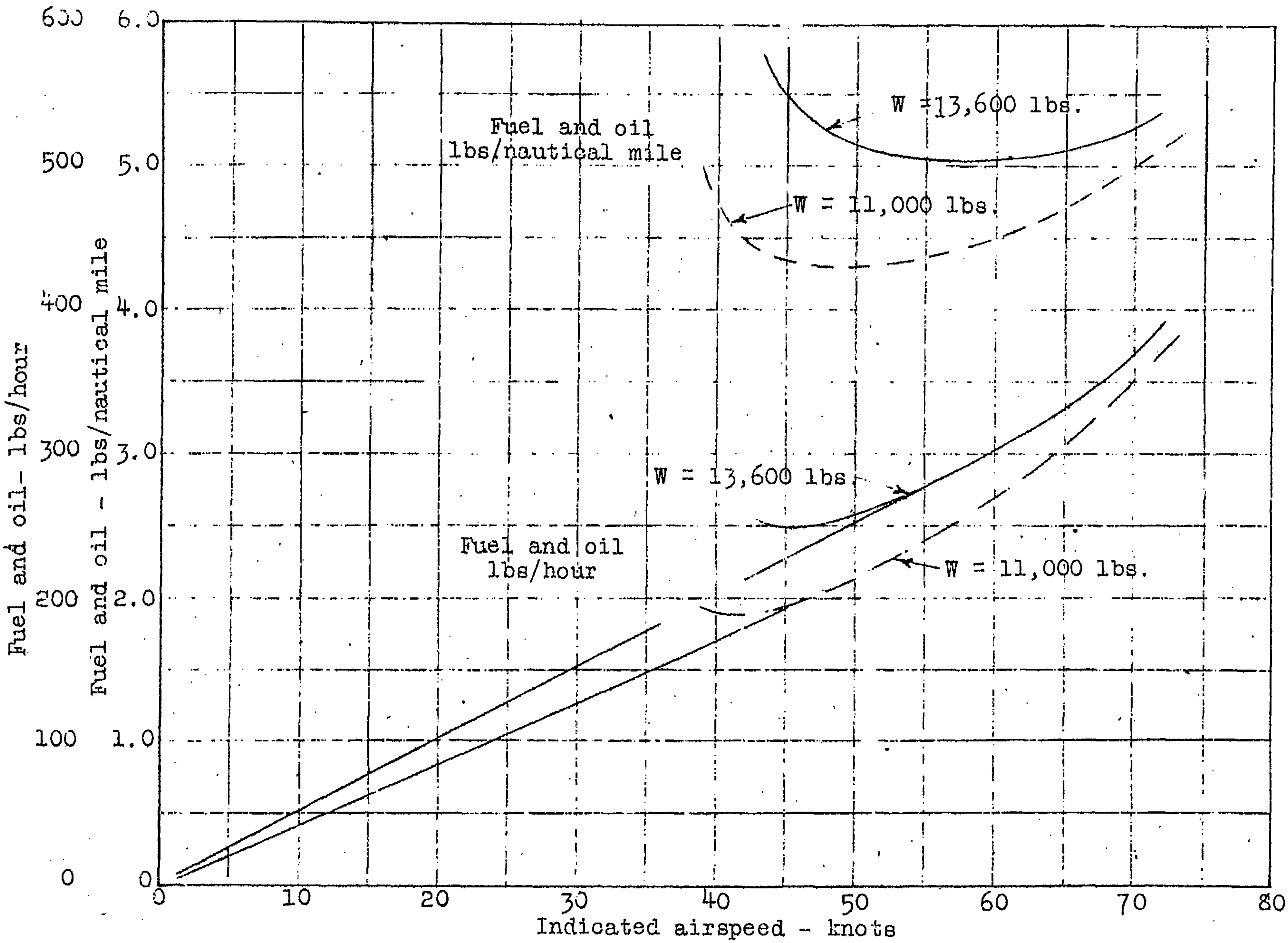

Fig. 7

F-5L BOAT SEAPLANE - FUEL CONSUMPTION

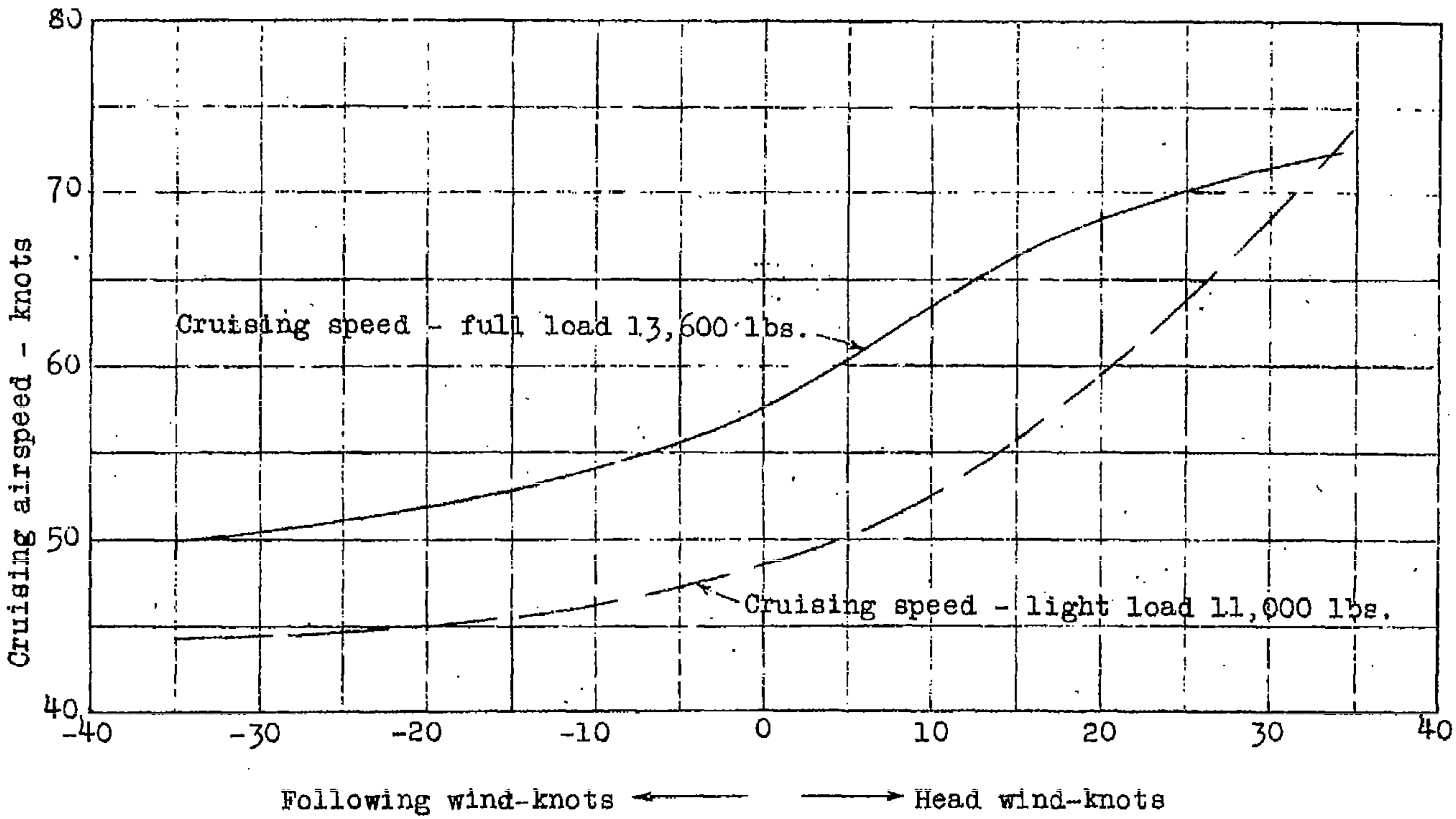

Fig. 8. F-5L BOAT SEAPLANE - CRUISING SPEEDS