NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

REPORT No. 292

CHARACTERISTICS OF FIVE PROPELLERS IN FLIGHT

By J. W. CROWLEY, Jr., and R. E. MIXSON

REPRINT OF REPORT No. 292, ORIGINALLY PUBLISHED NOVEMBER, 1928

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AERONAUTICAL SYMBOLS

1. FUNDAMENTAL AND DERIVED UNITS

	Symbol	Metric		English	
		Unit	Symbol	Unit	Symbol
Length	l	meter	m	foot (or mile)	ft. (or mi.)
Time	t	second	sec	second (or hour)	sec. (or hr.)
Force	F	weight of one kilogram	kg	weight of one pound	lb.
Power	P	kg/m/sec		horsepower	HP.
Speed		km/hr		mi./hr	M. P. H.
		m/sec		ft./sec	f. p. s.

2. GENERAL SYMBOLS, ETC.

W, Weight, $=mg$

g, Standard acceleration of gravity $=9.80665$ m/sec.$^2=32.1740$ ft./sec.^{2}

m, Mass, $=\frac{W}{g}$

ρ, Density (mass per unit volume).

Standard density of dry air, 0.12497 (kg-m^{-4} sec.^{2}) at 15° C and 760 mm $=0.002378$ (lb.-ft.$^{-4}$ sec.^{2}).

Specific weight of "standard" air, 1.2255 kg/m$^3=0.07651$ lb./ft.^{3}

mk^2, Moment of inertia (indicate axis of the radius of gyration, k, by proper subscript).

S, Area.

S_w, Wing area, etc.

G, Gap.

b, Span.

c, Chord length.

b/c, Aspect ratio.

f, Distance from $c.\ g.$ to elevator hinge.

μ, Coefficient of viscosity.

3. AERODYNAMICAL SYMBOLS

V, True air speed.

q, Dynamic (or impact) pressure $=\frac{1}{2}\rho V^2$

L, Lift, absolute coefficient $C_L=\frac{L}{qS}$

D, Drag, absolute coefficient $C_D=\frac{D}{qS}$

C, Cross-wind force, absolute coefficient $C_C=\frac{C}{qS}$

R, Resultant force. (Note that these coefficients are twice as large as the old coefficients L_C, D_C.)

i_w Angle of setting of wings (relative to thrust line).

i_t, Angle of stabilizer setting with reference to thrust line.

γ, Dihedral angle.

$\rho\frac{Vl}{\mu}$, Reynolds Number, where l is a linear dimension.

e. g., for a model airfoil 3 in. chord, 100 mi./hr. normal pressure, 0° C: 255,000 and at 15° C., 230,000;

or for a model of 10 cm chord 40 m/sec, corresponding numbers are 299,000 and 270,000.

C_p, Center of pressure coefficient (ratio of distance of $C.\ P.$ from leading edge to chord length).

β, Angle of stabilizer setting with reference to lower wing, $=(i_t-i_w)$.

α, Angle of attack.

ϵ, Angle of downwash.

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

NAVY BUILDING, WASHINGTON, D. C.

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SUMMARY

This investigation was made by the National Advisory Committee for Aeronautics at Langley Field for the purpose of determining the characteristics of five full-scale propellers in flight. The equipment consisted of five propellers in conjunction with a VE-7 airplane and a Wright E-2 engine. The propellers were of the same diameter and aspect ratio. Four of them differed uniformly in thickness and pitch and the fifth propeller was identical with one of the other four with the exception of a change of the airfoil section. The propeller efficiencies measured in flight are found to be consistently lower than those obtained in model tests. It is probable that this is mainly a result of the higher tip speeds used in the full-scale tests. The results show also that because of differences in propeller deflections it is difficult to obtain accurate comparisons of propeller characteristics. From this it is concluded that for accurate comparisons it is necessary to know the propeller pitch angles under actual operating conditions.

INTRODUCTION

While there are considerable propeller data available from tests of model propellers, there is comparatively little available from tests of full-scale propellers under flight conditions, and consequently there is insufficient information from which the scale effect of model propeller tests can be determined. One comparison between the results of model and full-scale propeller tests is given in N. A. C. A. Technical Report No. 220 (Reference 1), and the British Advisory Committee for Aeronautics has published the results of full-scale propeller tests in a number of reports. The present research was conducted to provide additional data on the characteristics of full-scale propellers in flight.

The method used in this investigation was similar to that described in N. A. C. A. Technical Report No. 220, and consisted essentially of two parts: (1) The measurement of the lift and drag characteristics of a VE–7 airplane by means of glide tests, and (2) the determination of the propeller characteristics by means of full-throttle power flights with a calibrated engine. The propellers tested were all of wood, were of the standard Navy plan form, and were of the same diameter and blade width. Four differed uniformly in thickness and pitch and the fifth, while similar to one of the four, differed in that the airfoil sections were altered. One of the propellers was the exact duplicate of a propeller of the series reported on in N. A. C. A. Technical Report No. 220.

APPARATUS

Test propellers.—Drawings of the propellers tested are shown in Figures 1–5, and the main dimensions are tabulated in Table I. They were all of the standard Navy plan form, 8 feet 2 inches in diameter, and with an aspect ratio of 6. They were made of birch in the usual laminated construction and were covered with cotton fabric. No metal tipping was used. The blade angles were measured before and after the tests and in each case were found to be within the tolerance allowed by the Navy specifications with only a very slight change

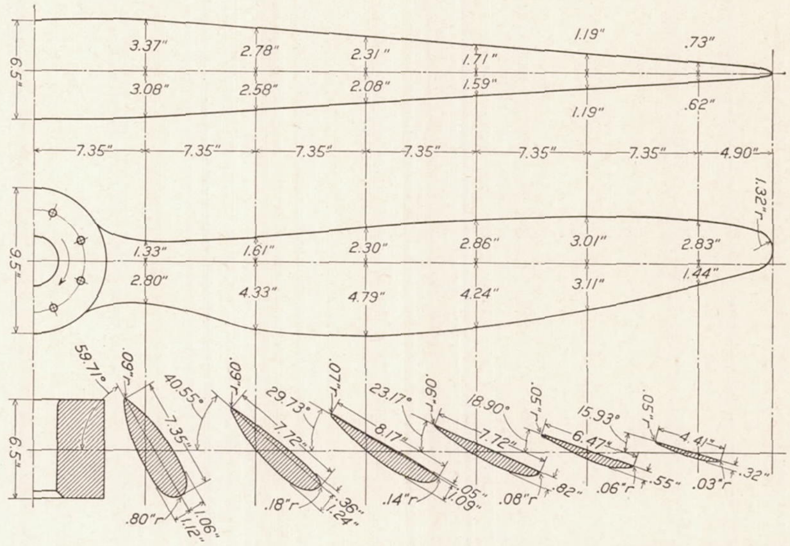

FIG. 1.—Propeller 3712. Diameter, 8′ 2″; pitch, 6′ 7″; aspect ratio, 6; camber, 8

between the measurements before and after. The measured pitches and thickness ratios of the propellers are given below. Thickness ratio as used herein is the ratio of the thickness of the propeller used to the thickness of the standard Navy propeller:

Propeller	T. R.	Mean geometrical pitch	
		ft.	*in.*
3712	0.8	6	7.1
3713	1.0	6	2.0
3714	1.2	5	8.8
3715	1.4	5	3.3
3872	1.2	5	8.7

Propeller 3714 is a duplicate of propeller I of the series of propellers reported on in N. A. C. A. Technical Report No. 220. Propeller 3872 is similar to 3714 except that an experimental airfoil section based on the Göttingen 398 was used in place of the standard Navy section.

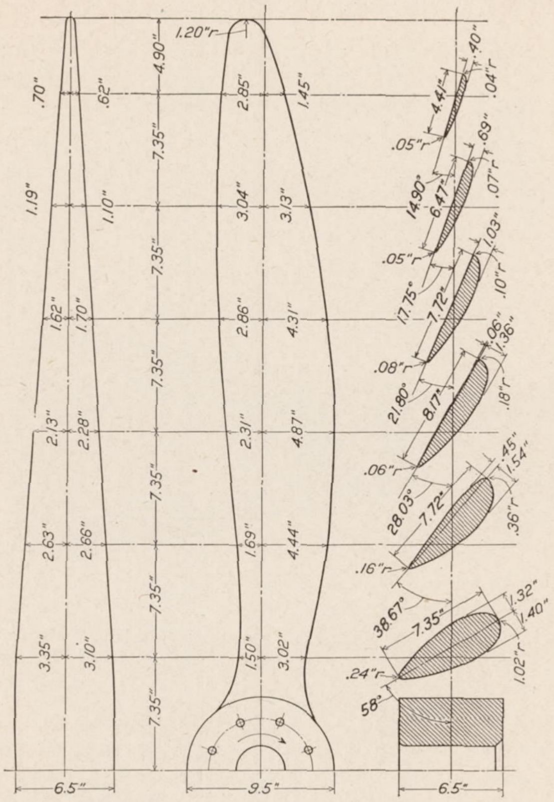

FIG. 2.—Propeller 3713. Diameter, 8′ 2″; pitch 6′ 1.8″; aspect ratio, 6; camber, 1.0

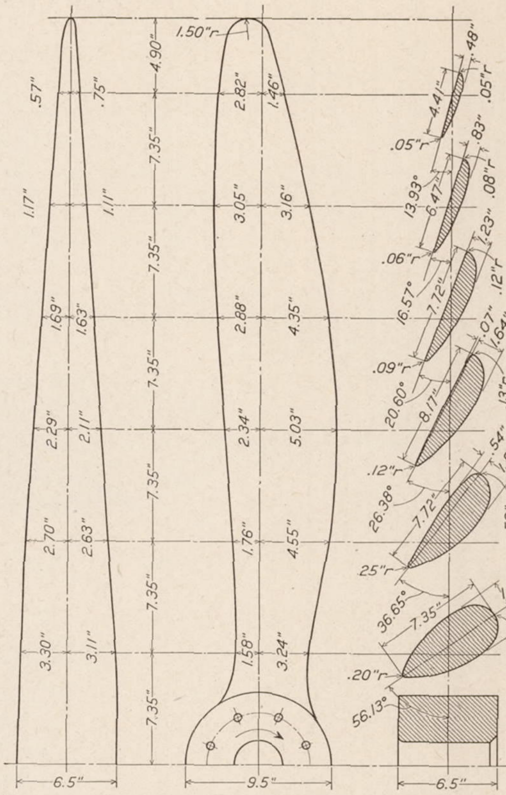

FIG. 3.—Propeller 3714. Diameter, 8′ 2″; pitch, 5′ 8.6″; aspect ratio, 6; camber, 1.2

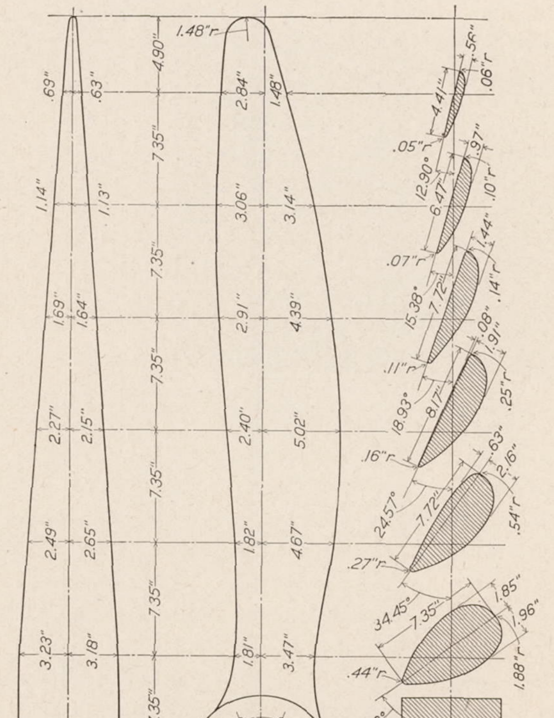

FIG. 4.—Propeller 3715. Diameter, 8′ 2″; pitch 5′ 3.4″; aspect ratio, 6; camber, 1.4

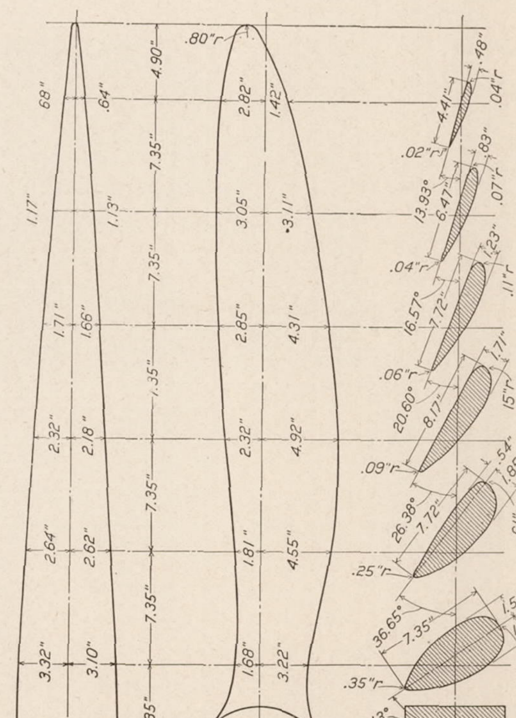

FIG. 5.—Propeller 3872. Diameter, 8′ 2″; pitch, 5′ 8.6″; aspect ratio, 6; camber, 1.2

Instruments.—The following special-test instruments were used:

(1) N. A. C. A. Flight Path Angle and Air-Speed Recorder. This instrument was developed especially for these tests for measuring continuously for a period of time, the angle of the flight path relative to the horizontal and the air speed along the flight path. Briefly, it consists of a streamlined case with stabilizing tail surfaces and a Pitot static tube in the nose. (Fig. 6.) In the case is inclosed an oil-damped pendulum, a diaphragm type air-speed measuring unit, and a film drum rotated by an electric motor. In operation the instrument is lowered approximately 50 feet below the airplane, where it takes up a path through the air parallel to that of the airplane. The inclination of the instrument, due to an inclined flight path, is recorded by

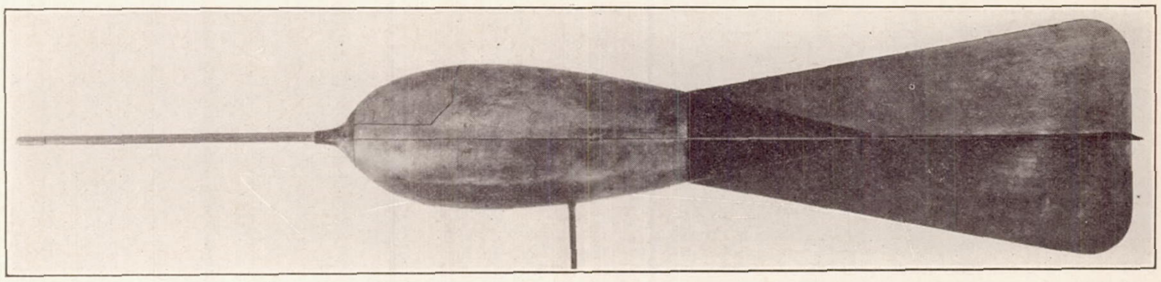

FIG. 6.—The N. A. C. A. flight path angle and air-speed recorder

means of the pendulum and the air speed is recorded by the differential pressure given by the Pitot static tube. A complete description of the instrument is given in Reference 2. A record taken of a series of glides is shown in Figure 6 (*a*).

(2) N. A. C. A. Recording Altimeter and Pendulum Inclinometer. This instrument, mounted in the airplane, was used for measuring the change of altitude with time and the attitude of the airplane. It consists of an aneroid mechanism and an oil-damped pendulum incorporated in the standard photographic recording type of instrument used by the National

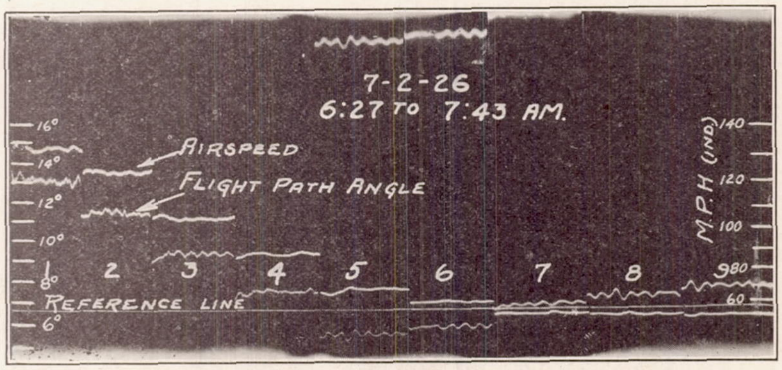

FIG. 6a.—Typical record of the N. A. C. A. flight path angle and air-speed recorder

Advisory Committee for Aeronautics. The altimeter readings together with air speed were used as a check upon the flight path angle measured by the flight path angle recorder. The inclinometer readings were used in conjunction with the flight path angle for determining the angle of attack of the airplane.

(3) Revolution Counter. A revolution counter, connected to the cam shaft by a mechanical clutch was used in conjunction with a stop watch to determine the engine speed. The readings were taken by an observer.

(4) Thermometers. Indicating distance thermometers were used to measure the strut and carburetor air intake temperatures. These readings were taken throughout each test by an observer.

ENGINE CALIBRATION

The engine was calibrated on an electric cradle dynamometer before and after the power flight tests. The results of these calibrations are shown in Figure 7. To prevent detonation during the calibration a fuel of 20 per cent benzol and 80 per cent gasoline (by volume) was used. As the flight tests were all made at altitudes above 1,000 feet, it was assumed that no detonation would occur during the tests and consequently straight gasoline used in the flight tests would be comparable, for the power developed, to the fuel mixture used in calibration. This assumption has been verified by laboratory and flight tests. In addition to the calibrations before and after the tests the power was checked at intervals during the tests by using the standing R. P. M. at full throttle with propeller 3714 as an index of the condition of the engine. This was never different by more than 20 R. P. M., which was the limit of accuracy of the tachometer used. It will be noted that the maximum difference between the calibrations before and after the tests is approximately 3 per cent. This difference is probably negligible, but to make certain of the power developed in flight the engine was assumed to have deteriorated

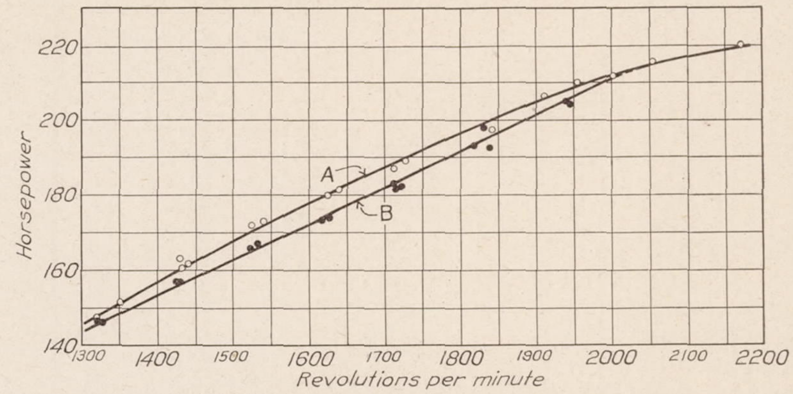

FIG. 7.—Calibration of Wright E-2 engine, reduced to standard air. Fuel: 20 per cent benzol, 80 per cent gasoline. Curve A, July 13, 1926. Curve B, September 21, 1926

progressively during the flight tests, and the power used for calculations of any particular flight was taken from the calibrations at a point between the two curves corresponding to the time the engine had been in operation.

FLIGHT TESTS

The flight tests were conducted in two parts: (1) Glide tests to determine the lift and drag of the airplane; and (2) full throttle power flights with a calibrated engine to determine the propeller characteristics.

The glide tests were conducted with propeller 3714 operating at approximately the V/nD for zero thrust. This value of V/nD was previously determined from model tests of a 3-foot propeller mounted on a model of the *VE–7* airplane. (Reference 1.) Glides were started at about 3,000 feet and the records were taken for a period of three-fourths minute after the airplane had reached a steady condition in glide. The range of speed covered was from 50 to 140 M. P. H. In the glide tests the following data were obtained from the instrument records: Flight path angle, true air speed, angle of attack, and engine R. P. M.

The power flights consisted of full throttle runs at air speeds of 50 to 135 M. P. H. with each propeller. The flights were climbing, level, or diving, as determined by the air speed. Corresponding data were obtained as in the glide tests with the addition of the carburetor air intake temperature.

REDUCTION OF DATA

Glide tests.—From the flight data obtained in the glide tests the lift and drag characteristics were determined. The essential observed and computed data for this determination are given in Table II. Lift is taken as $W \cos\gamma$, where γ is the angle of the flight path, and the apparent drag is equal and opposite in sign to $W \sin\gamma$. True drag is apparent drag plus thrust, and the thrust is determined from the thrust coefficient of a model propeller for the value of V/nD attained in the flight tests. While the glide tests were supposedly conducted with the propeller operating at the V/nD for zero thrust (0.972), this V/nD was seldom exactly realized. It was, therefore, necessary to correct the apparent drag for thrust as mentioned above.

The final coefficients C_L and C_D, plotted as a polar diagram, are given in Figure 8, and C_L versus angle of attack is shown in Figure 9. C_L and C_D are $\frac{L}{\frac{1}{2}\rho V^2 S}$ and $\frac{D}{\frac{1}{2}\rho V^2 S}$ respectively, where S is 284.5 square feet.

Power flights.—From the data obtained in the power flights the propeller characteristics were determined. The essential data for this determination are given in Table II. Lift,

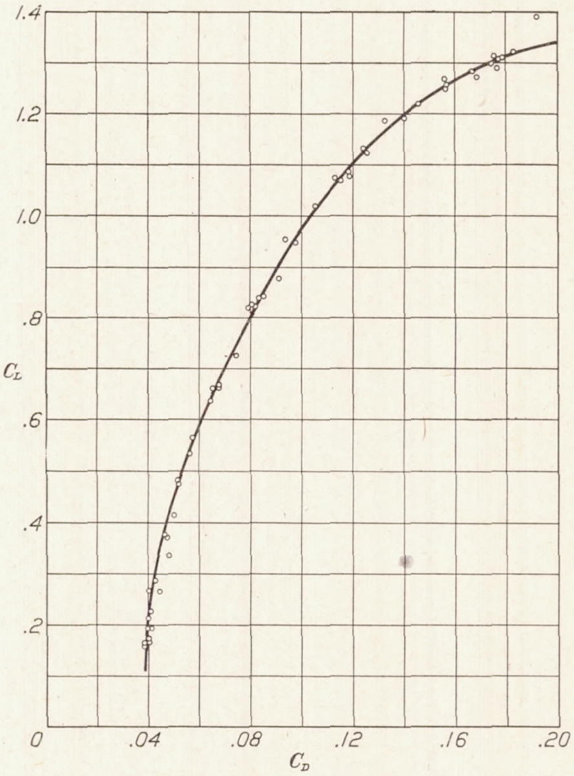

FIG. 8.—Polar diagram of Vought E-7 airplane

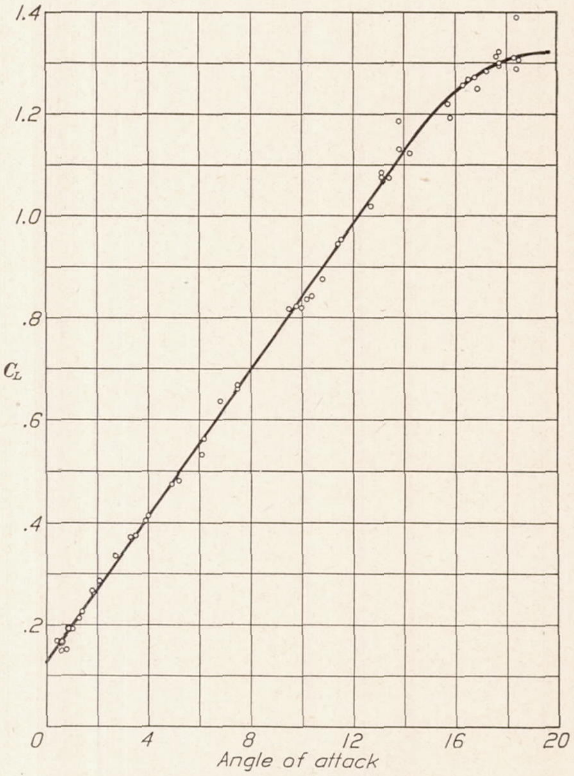

FIG. 9.—Lift characteristics of Vought E-7 airplane

drag, and thrust were determined as follows: A tentative lift, $L' = W \cos\gamma$, was assumed, thus neglecting the lift component of propeller thrust. A tentative lift coefficient C_L' was computed from L'. A corresponding C_D' was read from Figure 8 and a tentative angle of attack from Figure 9. A tentative drag D' was computed from C_D'. A tentative thrust T', equal to $D' + W \sin\gamma$ was then deduced. A second approximation of lift was then determined by deducting $T' \sin\theta$, the lift component of tentative thrust, from the tentative lift (where θ is the angle the propeller axis makes with the flight path). From this second approximation of lift a new lift coefficient, angle of attack, drag coefficient, and drag were derived. A second approximation of thrust was determined, as before, by adding $W \sin\gamma$ to the drag. A third approximation was found to be unnecessary since it differed only slightly from the second. The lift and drag of Table II are, therefore, the second approximations, the angle of attack is that read from Figure 9 for the lift coefficient derived from the second approximation of lift, and the thrust is the second approximation of drag plus $W \sin\gamma$. This method was used rather than working directly from the angle of attack measured in flight since the inclinometer records, from which the angle of attack is determined, were not satisfactory in the power flights.

Horsepower was determined from the calibration curves of Figure 7. As previously mentioned, it was assumed that the engine deteriorated progressively with time of operation and that for any flight between the dates of engine calibrations the engine power would be represented by a calibration curve between curves A and B of Figure 7, its distance from A depending on the time of engine operation. The horsepower for standard conditions was thus determined. The horsepower developed under the conditions of flight was derived from this through the relation, $\text{HP} = C\frac{p}{\sqrt{T}}$, where p is the barometric pressure, T is the absolute carburetor air intake temperature, and C is a constant.

The coefficients C_T, C_P, and η were plotted against V/nD, where

$$C_T = \frac{\text{Thrust}}{\rho n^2 D^4}$$

$$C_P = \frac{\text{Power}}{\rho n^3 D^5}$$

$$\eta = \frac{\text{thrust} \times \text{velocity}}{\text{power}}$$

$$\eta = \frac{C_T}{C_P} \frac{V}{nD}$$

In general the probable error of C_P is likely to be greater than that of C_T. This is because the power measurements are all based on the assumption that the engine consistently developed the same power in flight as on the calibrating stand, and, while previous tests have shown this assumption to be justified, it was not possible to verify it in these tests by actual measurement of the power in flight. Any future tests of this character should include direct measurement of power as a part of the flight tests.

RESULTS

The results of the propeller tests are given in curve and tabular form in Figures 10 to 14 and Tables III and IV, respectively. The experimental points from which Figures 10 to 14 were plotted, are given in Table III. Table IV gives the values of C_T, C_P, and η taken from the faired curves of Figures 10 to 14.

The performance of the Vought VE–7 airplane with the different propellers tested is shown in Figures 18 to 22. These figures are derived from the power flight tests by means of the polar diagram (fig. 8), the engine calibration (fig. 7), and the propeller characteristics (figs. 10 to 14).

DISCUSSION

The lift and drag characteristics of the VE–7 determined in these tests differed considerably from those obtained on the same airplane in the tests reported in N. A. C. A. Report No. 220. (Reference 1.) It was expected that a difference would exist since the airplane was newly covered for the present tests while the condition of the fabric was poor in the previous ones. However, the difference obtained was larger than expected and this led to a very careful rechecking of the lift and drag determinations. Suspecting a possible error in the flight path angle measurements due to effect of down wash on the flight path angle recorder, an investigation was made with the recorder suspended 100 feet below the airplane and consequently quite definitely away from down wash effects. No measureable difference was found between the 50 and 100 feet suspension. As a further check the flight path was determined independently by use of the altimeter and air-speed readings and an excellent agreement was obtained with the flight path

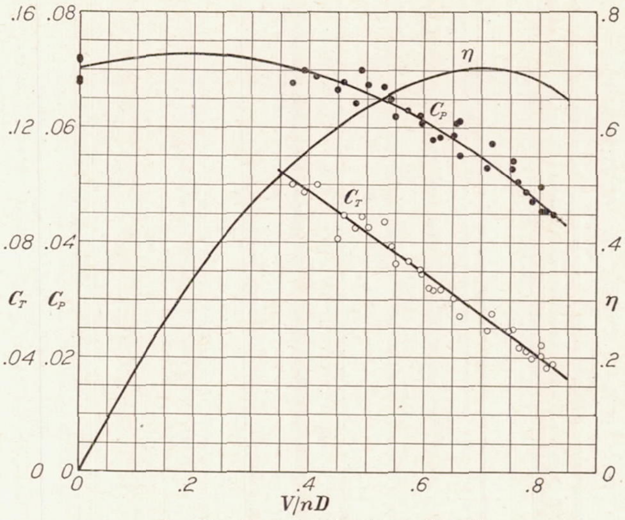

FIG. 10.—Characteristics of propeller 3712

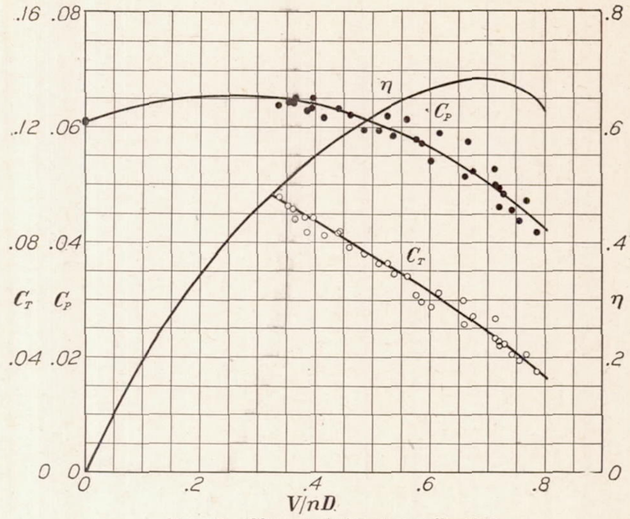

FIG. 11.—Characteristics of propeller 3713

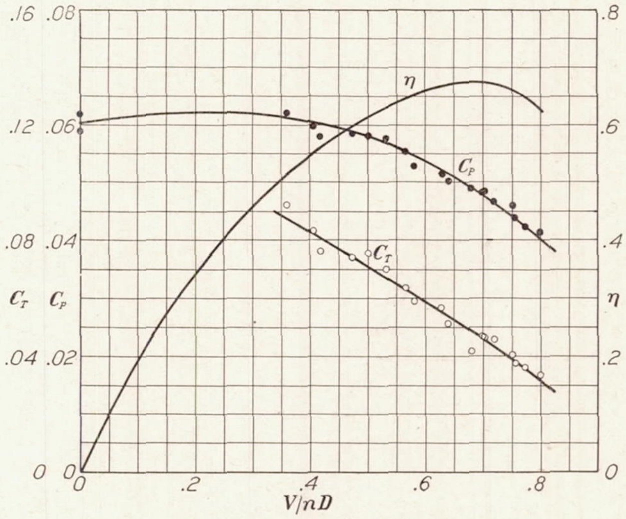

FIG. 12.—Characteristics of propeller 3714

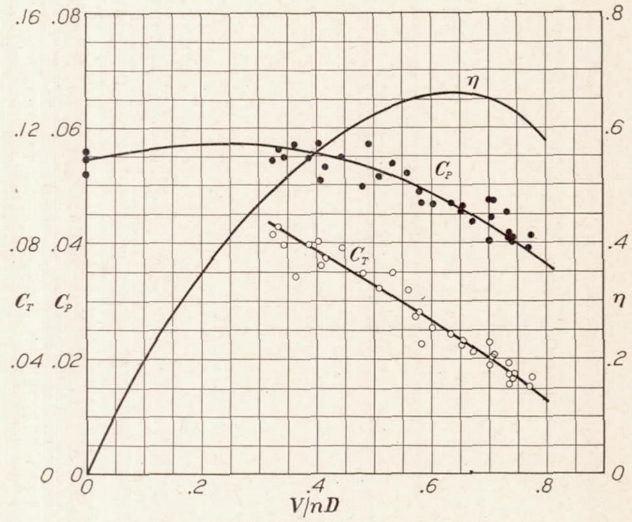

FIG. 13.—Characteristics of propeller 3715

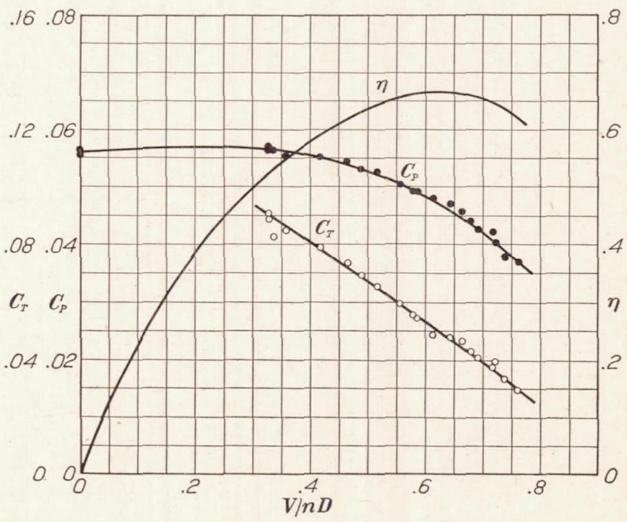

FIG. 14.—Characteristics of propeller 3872

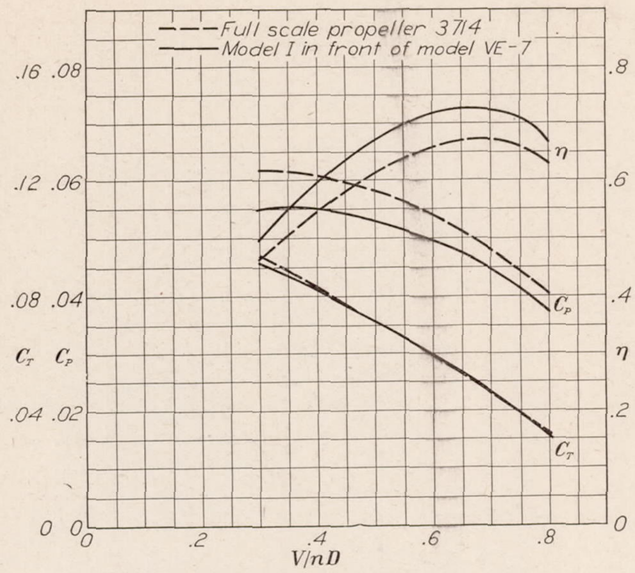

FIG. 15.—A comparison of Model I with full-scale propeller 3714

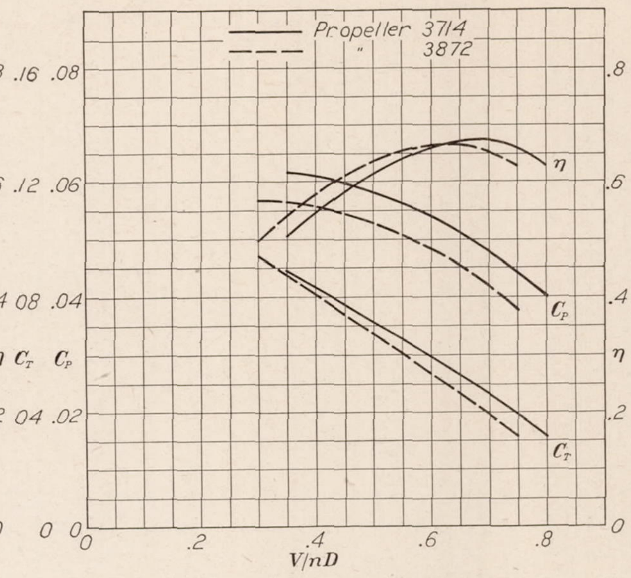

FIG. 17.—A comparison of propellers 3714 and 3872

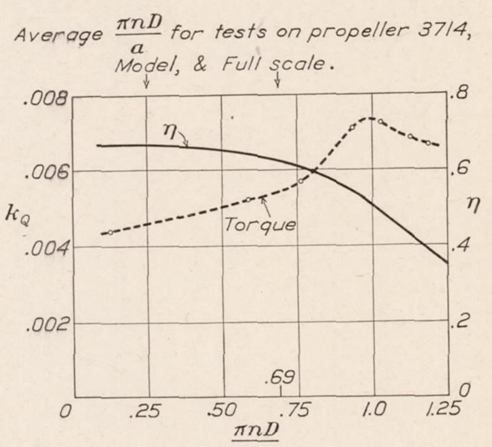

FIG. 16.—The effect of tip speed on efficiency and torque

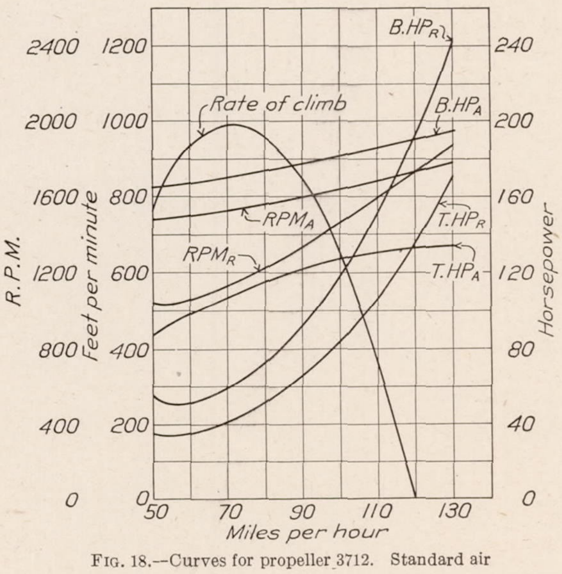

FIG. 18.—Curves for propeller 3712. Standard air

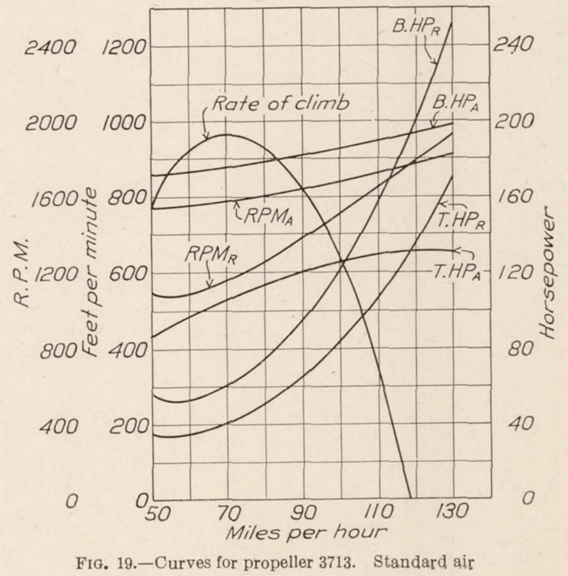

FIG. 19.—Curves for propeller 3713. Standard air

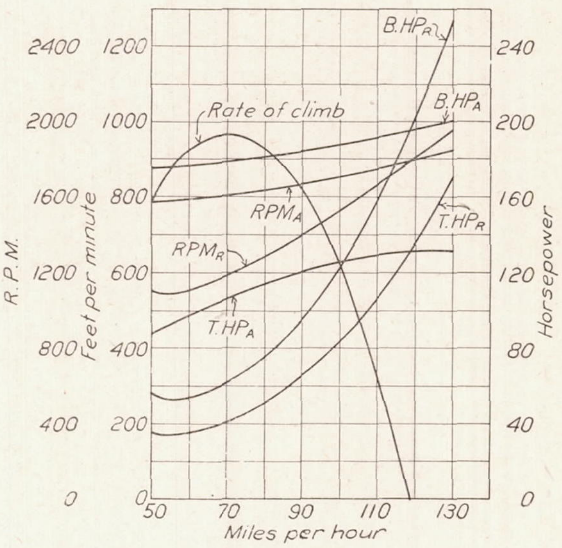

FIG. 20.—Curves for propeller 3714. Standard air

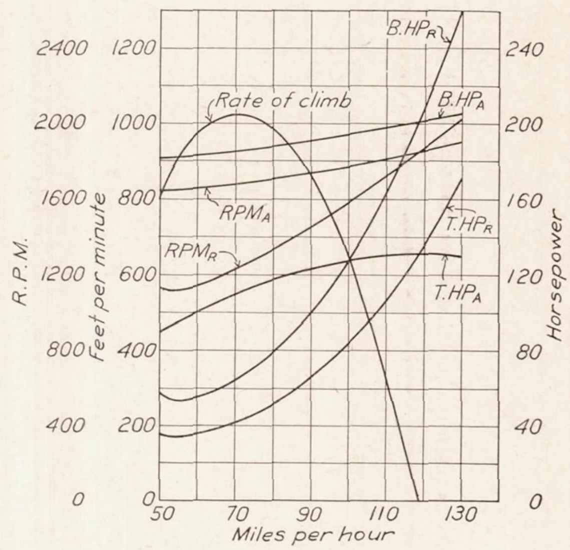

FIG. 21.—Curves for propeller 3715. Standard air

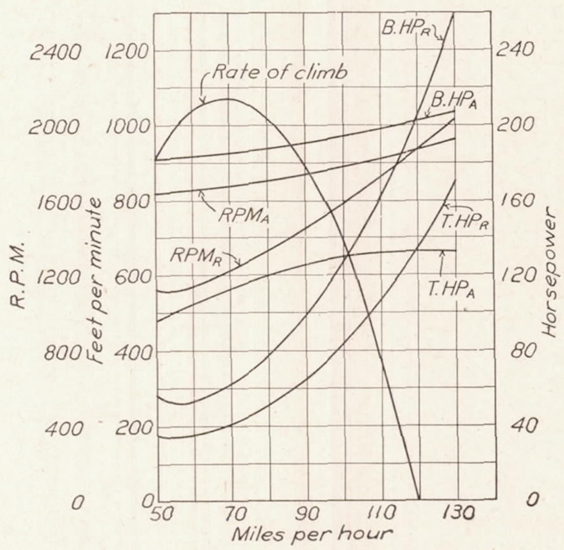

FIG. 22.—Curves for propeller 3872. Standard air

measured by the flight path angle recorder. Nearly all the gliding flights were made in the early morning hours in extremely smooth and steady air conditions. As a consequence of the care and the number of measurements made it is reasonably certain that the faired lift and drag curves are accurate to within $\pm 1\frac{1}{2}$ per cent.

The most striking results of the propeller tests were the low efficiencies obtained. As will be noted in Figures 10 to 14, the efficiency in no case exceeded 71 per cent, while estimates based on model results would have been at least 4 or 5 per cent larger. A wind-tunnel test of a 3-foot model of propeller 3714 was made previously at Leland Stanford University (Reference 1) and the results of this test are shown in Figure 15, together with the full-scale flight results. These curves show a change of approximately 5 per cent in efficiency between the flight and model results that is due to a greater power absorbed in the former. This difference is believed to be attributable mainly to the different tip velocities used in the two experiments. It is known that an increase of tip speed, within the limits reached in these flight tests, produces a considerable increase in the power absorbed and a small increase in the thrust developed, with a consequent decrease in efficiency. To illustrate this quantitatively, a curve taken from R. & M. No. 884 (Reference 3) is reproduced (fig. 16) on which are shown the average values of $\frac{\pi n D}{a}$ (where a is the velocity of sound) for both the flight and model tests of propeller 3714. This figure shows a decrease of efficiency of the same order as shown in Figure 15. There is a difference between the two, however, that is at present unaccounted for in that the results of Figure 16 indicate a definite although small change of thrust with tip speed while Figure 15 shows no change of thrust.

In addition to different tip speeds, the flight tests differ from the model tests in that the propellers in flight are always operating at some degree of yaw while the model propellers are operating at zero yaw. There is comparatively little known of the effect of yaw on propeller characteristics, but such data as are available indicate that very little effect should occur within the usual operating range of angles.

Propellers 3714 and 3872 are similar except for the change in airfoil sections and are plotted together for comparison in Figure 17. The section used in propeller 3872, having a better L/D ratio, was expected to increase the propeller efficiency for the same power absorbed. Actually, as will be noted, the efficiency was improved at the higher slips but the power absorbed was decreased. This was probably occasioned by a difference in deflection between the two propellers, which is entirely possible, particularly inasmuch as propeller 3872 was constructed at a later date than 3714 and could differ considerably in the material used. The data indicate that in operation the pitch of propeller 3872 was less than that of propeller 3714, since the maximum efficiency was lower, the efficiency at high slips was greater, and the power absorbed was less. From this it appears that an accurate comparison of propeller characteristics is not possible unless the pitch angles under operating conditions are known.

Figures 18 to 22 have been included to illustrate the effect of the various propellers tested on the performance of the VE-7 airplane. There is no great difference in the rate of climb with any of the propellers. The largest maximum rate of climb, obtained with propeller 3872, was only 110 feet per minute greater than the smallest maximum rate of climb, with propellers 3713 and 3714.

CONCLUSIONS

It appears probable that propellers in flight operate at lower efficiencies than the usual model tests indicate, mainly because of the higher tip speeds encountered in flight. It is concluded that accurate comparison of propeller characteristics is not feasible unless the pitch angles under operating conditions are known, which makes the measurement of blade twist necessary. Additional research should be conducted on the effect of tip velocity on propeller characteristics and also on the effects of yaw on the same. Future propeller tests in flight should include direct measurement of power absorbed.

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National Advisory Committee for Aeronautics,
Langley Field, Va., *November 8, 1927.*

Table I

SECTION ORDINATES FOR PROPELLER 3712

[All ordinates in inches. Stations in per cent of chord]

Radius	7. 35″		14. 70″		22. 05″		29. 40″	36. 75″	44. 10″
Chord	7. 35″		7. 72″		8. 17″		7. 72″	6. 47″	4. 41″
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Upper	Upper
Leading-edge radius	0. 80		0. 28		0. 14		0. 08	0. 06	0. 03
2. 5	. 46	. 43	. 51	. 15	. 45	. 02	. 34	. 23	. 13
5	. 66	. 63	. 73	. 21	. 64	. 03	. 48	. 32	. 19
10	. 89	. 84	. 98	. 28	. 86	. 04	. 65	. 43	. 25
20	1. 06	1. 01	1. 18	. 34	1. 04	. 05	. 78	. 52	. 30
30	1. 12	1. 06	1. 24	. 36	1. 09	. 05	. 82	. 55	. 32
40	1. 11	1. 05	1. 23	. 36	1. 08	. 05	. 81	. 54	. 32
50	1. 06	1. 01	1. 18	. 34	1. 04	. 05	. 78	. 52	. 30
60	. 97	. 92	1. 08	. 31	. 95	. 04	. 77	. 48	. 28
70	. 83	. 78	. 92	. 27	. 81	. 04	. 61	. 41	. 24
80	. 62	. 59	. 69	. 20	. 61	. 03	. 46	. 31	. 20
90	. 39	. 37	. 43	. 13	. 38	. 02	. 29	. 21	. 16
Trailing-edge radius	. 09		. 09		. 07		. 06	. 05	. 05

SECTION ORDINATES FOR PROPELLER 3713

Leading-edge radius	1. 02		0. 36		0. 18		0. 10	0. 07	0. 04
2.5	. 57	. 54	. 63	. 18	. 56	. 02	. 42	. 28	. 16
5	. 83	. 78	. 91	. 27	. 80	. 04	. 61	. 41	. 24
10	1. 11	1. 04	1. 22	. 36	1. 07	. 05	. 81	. 55	. 32
20	1. 33	1. 25	1. 46	. 43	1. 29	. 06	. 98	. 66	. 38
30	1. 40	1. 32	1. 54	. 45	1. 36	. 06	1. 03	. 69	. 40
40	1. 39	1. 31	1. 53	. 45	1. 35	. 06	1. 02	. 68	. 40
50	1. 33	1. 25	1. 46	. 43	1. 29	. 06	. 98	. 66	. 38
60	1. 22	1. 15	1. 34	. 39	1. 18	. 05	. 90	. 60	. 35
70	1. 04	. 98	1. 14	. 33	1. 01	. 04	. 76	. 51	. 30
80	. 78	. 74	. 86	. 25	. 76	. 03	. 58	. 39	. 24
90	. 49	. 46	. 54	. 16	. 48	. 02	. 36	. 25	. 17
Trailing-edge radius	. 24		. 16		. 08		. 08	. 05	. 05

TABLE I—Continued

SECTION ORDINATES FOR PROPELLER 3714

Radius	7. 35″		14. 70″		22. 05″		29. 40″	36. 75″	44. 10″
Chord	7. 35″		7. 72″		8. 17″		7. 72″	6. 47″	4. 41″
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Upper	Upper
Leading edge radius	1. 44		0. 68		0. 28		0. 12	0. 08	0. 05
2.5	. 69	. 65	. 76	. 22	. 67	. 03	. 50	. 34	. 20
5	. 99	. 94	1. 09	. 32	. 97	. 04	. 73	. 49	. 28
10	1. 33	1. 26	1. 46	. 43	1. 30	. 06	. 97	. 66	. 38
20	1. 60	1. 51	1. 76	. 51	1. 56	. 07	1. 17	. 79	. 46
30	1. 68	1. 59	1. 85	. 54	1. 64	. 07	1. 23	. 83	. 48
40	1. 66	1. 57	1. 83	. 53	1. 62	. 07	1. 22	. 82	. 48
50	1. 60	1. 51	1. 76	. 51	1. 56	. 07	1. 17	. 79	. 46
60	1. 46	1. 38	1. 61	. 47	1. 43	. 06	1. 07	. 72	. 42
70	1. 24	1. 18	1. 37	. 40	1. 21	. 05	. 91	. 61	. 36
80	. 94	. 89	1. 04	. 30	. 92	. 04	. 69	. 46	. 28
90	. 59	. 56	. 65	. 19	. 57	. 02	. 43	. 29	. 20
Trailing edge radius	. 20		. 16		. 12		. 09	. 06	. 05

SECTION ORDINATES FOR PROPELLER 3715

Leading edge radius	1. 78		0. 64		0. 20		0. 14	0. 10	0. 06
2.5	. 80	. 76	. 89	. 26	. 78	. 03	. 59	. 40	. 23
5	1. 16	1. 07	1. 28	. 37	1. 13	. 05	. 85	. 57	. 33
10	1. 55	1. 46	1. 71	. 50	1. 51	. 06	1. 14	. 77	. 41
20	1. 86	1. 76	2. 05	. 60	1. 81	. 08	1. 37	. 92	. 53
30	1. 96	1. 85	2. 16	. 63	1. 91	. 08	1. 44	. 97	. 56
40	1. 94	1. 83	2. 14	. 62	1. 89	. 08	1. 43	. 96	. 55
50	1. 86	1. 76	2. 05	. 60	1. 81	. 08	1. 37	. 92	. 53
60	1. 71	1. 61	1. 88	. 55	1. 66	. 07	1. 25	. 84	. 49
70	1. 45	1. 37	1. 60	. 47	1. 41	. 06	1. 07	. 72	. 41
80	1. 10	1. 04	1. 21	. 35	1. 07	. 04	. 81	. 54	. 31
90	. 69	. 65	. 76	. 22	. 67	. 03	. 50	. 34	. 20
Trailing edge radius	. 28		. 22		. 16		. 11	. 07	. 05

SECTION ORDINATES FOR PROPELLER 3872

Radius	7. 35″		14. 70″		22. 05″		29. 40″		36. 75″		44. 10″	
Chord	7. 35″		7. 72″		8. 17″		7. 72″		6. 47″		4. 41″	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Leading edge radius	1. 48		0. 58		0. 15		0. 11		0. 07		0. 04	
2.5	. 69	. 65	. 76	. 22	. 92	. 15	. 66	. 11	. 45	. 07	. 26	. 04
5	. 99	. 94	1. 09	. 32	1. 15	. 09	. 82	. 06	. 56	. 04	. 32	. 02
10	1. 33	1. 26	1. 46	. 43	1. 40	. 02	1. 01	. 01	. 68	. 01	. 39	------
20	1. 60	1. 51	1. 76	. 51	1. 66	------	1. 19	------	. 81	------	. 47	------
30	1. 68	1. 59	1. 85	. 54	1. 71	------	1. 23	------	. 83	------	. 48	------
40	1. 66	1. 57	1. 83	. 53	1. 66	------	1. 19	------	. 81	------	. 47	------
50	1. 60	1. 51	1. 76	. 51	1. 54	------	1. 11	------	. 75	------	. 43	------
60	1. 46	1. 38	1. 61	. 47	1. 33	------	. 96	------	. 65	------	. 37	------
70	1. 24	1. 18	1. 37	. 40	1. 09	------	. 79	------	. 53	------	. 31	------
80	. 94	. 89	1. 04	. 30	. 82	------	. 59	------	. 40	------	. 23	------
90	. 59	. 56	. 65	. 19	. 51	------	. 37	------	. 25	------	. 14	------
Trailing edge radius	. 20		. 14		. 09		. 06		. 04		. 02	

TABLE II

GLIDE TEST DATA

Flight and run No.	Angle of flight path γ	Angle of wing	Angle of attack α	Weight	Lift	Apparent drag	$1/2 \rho V^2$	Specific weight	Velocity	R. P. M.	$\frac{V}{nD}$	Thrust	True drag	C_L	C_D
								Lb./cu. ft.	Ft./sec.						
1–2	−6. 1	−1. 2	4. 9	2, 208	2, 196	234. 3	16. 22	0. 0680	124. 0	950	0. 959	5. 8	240. 1	0. 475	0. 0520
1–3	−5. 8	1. 4	7. 2	2, 203	2, 192	222. 5	13. 67	. 0677	114. 0	857	. 970	. 9	223. 6	. 564	. 0575
1–5	−5. 7	4. 3	10. 0	2, 193	2, 184	217. 9	9. 36	. 0670	94. 8	693	. 998	−6. 2	211. 7	. 820	. 0795
1–6	−6. 1	----------	--------	2, 188	2, 176	232. 1	8. 07	. 0675	87. 6	640	1. 005	−6. 7	225. 1	. 948	. 0983
1–8	−5. 2	----------	--------	2, 178	2, 169	197. 3	11. 51	. 0676	104. 7	851	. 904	16. 1	213. 4	. 662	. 0652
1–9	−5. 9	----------	--------	2, 173	2, 161	223. 1	8. 43	. 0674	89. 6	676	. 973	0	223. 1	. 726	. 0749
4–1	−6. 4	7. 4	13. 8	2, 213	2, 198	246. 5	6. 50	. 0668	79. 2	594	. 979	−. 8	245. 7	1. 187	. 1327
4–2	−6. 5	6. 6	13. 1	2, 208	2, 191	249. 9	7. 08	. 0671	82. 3	580	1. 041	−11. 3	230. 6	1. 088	. 1184
4–3	−6. 2	5. 3	11. 5	2, 203	2, 190	238. 0	8. 07	. 0671	87. 9	618	1. 042	−13. 3	214. 7	. 954	. 0935
4–4	−6. 0	3. 8	9. 8	2, 198	2, 186	229. 7	9. 32	. 0672	94. 4	662	1. 046	−15. 7	214. 0	. 824	. 0807
4–5	−6. 5	7. 3	13. 8	2, 193	2, 178	248. 2	6. 76	. 0680	80. 1	573	1. 026	−8. 8	239. 4	1. 131	. 1244
4–6	−6. 3	6. 8	13. 1	2, 188	2, 173	240. 0	7. 08	. 0684	81. 6	614	. 976	−. 7	239. 3	1. 078	. 1187
4–7	−5. 9	5. 5	11. 4	2, 183	2, 171	224. 4	8. 07	. 0672	87. 9	652	. 989	−3. 4	221. 0	. 946	. 0963
4–8	−6. 5	7. 7	14. 2	2, 178	2, 163	246. 4	6. 76	. 0672	80. 4	583	1. 002	−5. 1	241. 3	1. 124	. 1254
4–9	−6. 1	6. 6	12. 7	2, 173	2, 160	230. 8	7. 44	. 0677	84. 3	612	1. 011	−7. 1	223. 7	1. 020	. 1056
5–1	−14. 3	−13. 7	. 6	2, 213	2, 145	547. 0	47. 40	. 0703	208. 6	1, 539	. 995	−27. 6	519. 4	. 158	. 0385
5–3	−11. 0	−9. 6	1. 4	2, 203	2, 161	420. 5	33. 54	. 0691	176. 7	1, 295	1. 003	−27. 4	393. 1	. 226	. 0412
5–4	−8. 5	−6. 4	2. 1	2, 198	2, 172	324. 9	26. 61	. 0685	158. 2	1, 196	. 972	0	324. 9	. 287	. 0430
5–5	−7. 3	−4. 0	3. 3	2, 193	2, 174	278. 5	20. 53	. 0665	141. 0	1, 059	. 970	−1. 4	277. 1	372	. 0475
5–6	−6. 4	−1. 2	5. 2	2, 188	2, 173	243. 9	15. 86	. 0660	124. 3	916	. 996	−9. 5	234. 4	. 482	. 0519
5–7	−6. 1	1. 4	7. 5	2, 183	2, 170	232. 7	11. 44	. 0660	105. 6	766	1. 013	−11. 5	221. 2	. 667	. 0680
5–8	−5. 8	5. 0	10. 8	2, 178	2, 167	225. 4	8. 69	. 0663	91. 8	710	. 950	5. 4	214. 6	. 877	. 0912
6–1	−13. 2	−12. 8	. 4	2, 213	2, 160	506. 0	44. 40	. 0692	203. 0	1, 536	. 968	4. 1	510. 1	. 171	. 0403
6–2	−11. 8	−10. 8	1. 0	2, 208	2, 155	452. 0	39. 00	. 0692	190. 5	1, 448	. 967	3. 9	455. 9	. 194	. 0411
6–3	−10. 8	−9. 5	1. 3	2, 203	2, 160	413. 0	35. 60	. 0680	183. 5	1, 376	. 980	−7. 1	405. 9	. 213	. 0400
6–4	−8. 3	−6. 5	1. 8	2, 198	2, 170	317. 0	28. 70	. 0676	165. 0	1, 282	. 958	11. 3	328. 3	. 266	. 0402
6–5	−7. 7	−5. 0	2. 7	2, 193	2, 175	294. 0	23. 50	. 0682	149. 0	1, 172	. 932	27. 2	321. 2	. 336	. 0481
6–6	−6. 8	−2. 8	4. 0	2, 188	2, 170	259. 0	18. 45	. 0670	133. 0	1, 014	. 962	4. 8	263. 8	. 414	. 0504
6–7	−5. 6	. 5	6. 1	2, 183	2, 170	213. 0	14. 30	. 0660	118. 0	936	. 930	17. 1	230. 1	. 533	. 0565
6–8	−4. 9	2. 6	7. 5	2, 178	2, 170	185. 5	11. 45	. 0660	105. 8	888	. 873	36. 6	222. 1	. 665	. 0680
6–9	−7. 7	10. 7	18. 4	2, 173	2, 160	291. 0	5. 46	. 0675	72. 2	562	. 932	6. 3	297. 3	1. 390	. 1920
7–3	−11. 4	−10. 4	1. 0	2, 203	2, 159	435. 2	39. 10	. 0678	192. 8	1, 478	. 958	15. 6	450. 8	. 194	. 0405
7–4	−7. 9	10. 5	18. 4	2, 198	2, 178	302. 0	5. 93	. 0661	76. 0	559	. 998	−3. 9	298. 1	1. 290	. 1767
7–5	−7. 3	10. 3	17. 6	2, 193	2, 176	278. 5	5. 82	. 0701	73. 1	594	. 904	12. 0	290. 5	1. 314	. 1755
7–6	−6. 4	9. 4	15. 8	2, 188	2, 175	243. 8	6. 40	. 0688	77. 4	642	. 885	17. 6	255. 8	1. 194	. 1404
7–7	−6. 0	7. 2	13. 2	2, 183	2, 171	227. 9	7. 13	. 0661	83. 3	652	. 948	7. 1	235. 0	1. 070	. 1158
7–8	−5. 8	4. 6	10. 4	2, 178	2, 168	220. 0	9. 05	. 0656	94. 2	710	. 974	−. 5	219. 5	. 842	. 0852
7–9	−6. 6	9. 9	16. 5	2, 173	2, 159	249. 5	5. 98	. 0663	76. 2	638	. 888	15. 9	265. 4	1. 269	. 1560
8–1	−13. 1	−12. 5	. 6	2, 213	2, 150	502. 0	45. 10	. 0698	204. 0	1, 564	. 958	18. 1	520. 1	. 167	. 0406
8–2	−11. 4	−10. 5	. 9	2, 208	2, 165	436. 5	39. 15	. 0692	190. 8	1, 452	. 964	7. 8	444. 3	. 194	. 0399
8–3	−9. 4	−7. 6	1. 8	2, 203	2, 170	360. 0	28. 62	. 0686	163. 7	1, 230	. 975	2. 9	362. 9	. 266	. 0447
8–4	−7. 5	−4. 0	3. 5	2, 198	2, 175	287. 0	20. 30	. 0684	138. 2	1, 010	1. 006	−14. 9	272. 1	. 376	. 0488
8–5	−5. 6	1. 2	6. 8	2, 193	2, 182	213. 4	12. 07	. 0658	108. 8	840	. 950	7. 2	220. 6	. 637	. 0644
8–6	−5. 8	4 4	10. 2	2, 188	2, 170	221. 2	9. 12	. 0658	94. 3	696	. 994	−5. 1	216. 1	. 838	. 834

8–7	−6. 8	8. 9	15. 7	2, 183	2, 165	258. 6	6. 25	. 0656	78. 2	592	. 970	−. 4	258. 2	1. 212	. 1455
8–8	−7. 2	9. 6	16. 8	2, 178	2, 160	275. 0	6. 09	. 0666	76. 6	564	. 996	−3. 6	271. 4	1. 249	. 1569
8–9	−7. 6	10. 7	18. 3	2, 173	2, 155	287. 7	5. 83	. 0689	73. 8	584	. 928	7. 4	295. 1	1. 301	. 1783
9–1	−7. 7	10. 7	18. 4	2, 213	2, 193	296. 7	5. 83	. 0678	74. 4	588	. 930	7. 2	303. 9	1. 321	. 1830
9–2	−7. 6	10. 1	17. 7	2, 208	2, 189	292. 0	5. 93	. 0678	75. 1	576	. 958	2. 4	294. 4	1. 296	. 1744
9–3	−7. 3	9. 4	16. 7	2, 203	2, 184	279. 8	6. 04	. 0683	76. 0	608	. 918	9. 6	289. 4	1. 271	. 1684
9–4	−6. 0	7. 4	13. 4	2, 198	2, 184	229. 8	7. 13	. 0673	82. 6	656	. 925	9. 9	239. 7	1. 076	. 1131
9–5	−5. 8	3. 7	9. 5	2, 193	2, 182	221. 6	9. 31	. 0680	93. 9	696	. 990	−4. 3	217. 3	. 824	. 0821
9–6	−7. 3	11. 2	18. 5	2, 188	2, 170	278. 0	5. 83	. 0701	73. 2	608	. 884	16. 3	294. 3	1. 307	. 1773
9–7	−6. 9	10. 3	17. 2	2, 183	2, 169	262. 3	5. 93	. 0680	74. 9	630	. 873	19. 1	281. 4	1. 285	. 1666
9–8	−7. 0	9. 3	16. 3	2, 178	2, 162	265. 3	6. 04	. 0678	75. 7	588	. 946	4. 4	269. 7	1. 259	. 1569
9–9	−7. 7	10. 0	17. 7	2, 173	2, 153	291. 2	5. 83	. 0685	74. 0	554	. 981	−1. 3	289. 9	1. 298	. 1745

Table III

POWER FLIGHT DATA

PROPELLER 3712

Flight and run No.	Specific weight	Velocity	R. P. M.	Angle of Flight path γ	Angle of attack α	W	L	D	T	HP	$\frac{V}{nD}$	C_T	C_P	η
	Lb./cu. ft.	*Ft./sec.*												
1–1	0. 0698	100. 4	1, 500	8. 3	8. 1	2, 213	2, 132	214. 5	534. 3	155. 7	0. 492	0. 0890	0. 0701	0. 626
1–3	. 0700	192. 2	1, 756	−2. 3	. 9	2, 203	2, 207	455. 0	367. 4	178. 1	. 804	. 0444	. 0497	. 720
1–4	. 0693	85. 2	1, 510	10. 4	12. 0	2, 198	2, 056	208. 0	605. 0	155. 6	. 414	. 1000	. 0690	. 601
1–5	. 0688	114. 7	1, 552	7. 2	5. 8	2, 193	2, 120	222. 8	498. 3	158. 0	. 543	. 0784	. 0649	. 656
1–6	. 0694	206. 8	1, 842	−4. 7	. 5	2, 188	2, 189	517. 5	338. 3	183. 1	. 825	. 0374	. 0447	. 692
1–7	. 0707	175. 5	1, 710	0. 0	1. 4	2, 183	2, 187	389. 4	389. 4	176. 1	. 754	. 0491	. 0527	. 703
1–8	. 0692	129. 2	1, 594	5. 7	4. 2	2, 178	2, 150	249. 3	465. 4	162. 5	. 596	. 0690	. 0606	. 678
1–9	. 0690	144. 5	1, 630	3. 8	3. 0	2, 173	2, 161	282. 9	426. 9	165. 3	. 652	. 0608	. 0586	. 676
2–1	. 0700	94. 1	1, 535	7. 8	9. 4	2, 213	2, 125	212. 2	512. 2	159. 2	. 450	. 0812	. 0665	. 550
2–2	. 0690	104. 5	1, 524	8. 0	7. 4	2, 208	2, 138	216. 3	523. 5	155. 6	. 504	. 0851	. 0674	. 636
2–3	. 0692	76. 8	1, 520	10. 2	15. 2	2, 203	2, 023	224. 1	614. 5	156. 0	. 372	. 1001	. 0678	. 547
2–7	. 0695	122. 6	1, 577	6. 5	4. 8	2, 183	2, 146	238. 0	485. 1	161. 7	. 572	. 0730	. 0628	. 664
2–8	. 0699	139. 6	1, 633	4. 8	3. 4	2, 178	2, 160	272. 1	454. 5	167. 6	. 629	. 0637	. 0583	. 686
2–9	. 0704	199. 8	1, 828	−3. 5	. 7	2, 173	2, 176	498. 0	365. 4	184. 6	. 804	. 0407	. 0455	. 720
2–10	. 0765	0	1, 504	---------	---------	---------	---------	---------	---------	164. 7	0	---------	. 0718	---------
14–3	. 0702	179. 1	1, 724	−1. 4	1. 3	2, 203	2, 204	402. 2	348. 4	171. 3	. 764	. 0437	. 0505	. 661
14–4	. 0701	149. 4	1, 656	2. 6	2. 7	2, 198	2, 190	301. 2	400. 9	165. 5	. 663	. 0545	. 0551	. 656
14–5	. 0681	100. 6	1, 536	8. 2	8. 1	2, 193	2, 114	211. 6	524. 5	150. 3	. 481	. 0850	. 0642	. 637
14–6	. 0677	135. 1	1, 612	4. 4	3. 8	2, 188	2, 168	258. 8	426. 6	155. 3	. 616	. 0632	. 0579	. 674
14–7	. 0693	190. 7	1, 780	−2. 9	. 9	2, 183	2, 186	444. 4	334. 0	173. 2	. 788	. 0399	. 0471	. 668
14–8	. 0691	117. 1	1, 564	6. 4	5. 5	2, 178	2, 135	227. 8	470. 4	154. 4	. 550	. 0726	. 0618	. 647
14–9	. 0691	163. 3	1, 688	1. 0	1. 9	2, 173	2, 173	332. 5	370. 4	166. 3	. 711	. 0491	. 0529	. 660
14–10	. 0703	130. 6	1, 580	4. 7	3. 9	2, 168	2, 147	254. 0	431. 7	158. 9	. 608	. 0643	. 0607	. 643
14–11	. 0765	0	1, 480	---------	---------	---------	---------	---------	---------	158. 9	0	---------	. 0678	---------
15–1	. 0682	94. 3	1, 504	8. 2	9. 6	2, 213	2, 119	212. 0	527. 8	148. 8	. 461	. 0893	. 0679	. 606
15–2	. 0688	171. 5	1, 668	−0. 1	1. 7	2, 208	2, 210	367. 8	364. 0	162. 9	. 756	. 0497	. 0541	. 695
15–3	. 0675	79. 1	1, 489	8. 8	14. 5	2, 203	2, 012	216. 6	553. 6	145. 8	. 392	. 0972	. 0701	. 543
15–4	. 0689	185. 3	1, 748	−2. 0	1. 2	2, 198	2, 204	417. 0	340. 2	169. 5	. 778	. 0421	. 0487	. 673
15–5	. 0682	108. 6	1, 504	7. 2	6. 8	2, 193	2, 135	217. 1	492. 1	146. 8	. 531	. 0873	. 0671	. 660
15–6	. 0683	200. 0	1, 808	−4. 5	. 7	2, 188	2, 188	481. 0	309. 4	173. 3	. 813	. 0362	. 0455	. 647
15–7	. 0682	126. 5	1, 564	5. 5	4. 5	2, 183	2, 152	242. 1	451. 3	152. 7	. 594	. 0706	. 0620	. 677
15–8	. 0679	158. 9	1, 624	1. 5	2. 2	2, 178	2, 177	320. 7	377. 7	157. 1	. 719	. 0552	. 0571	. 696
15–10	. 0670	142. 4	1, 581	3. 4	3. 3	2, 168	2, 155	272. 4	401. 0	153. 0	. 662	. 0626	. 0612	. 677
15–11	. 0765	0	1, 482	---------	---------	---------	---------	---------	---------	158. 9	0	---------	. 0683	---------

3–1	0. 0693	94. 5	1, 564	8. 6	9. 4	2, 213	2, 114	210. 5	541. 5	158. 8	0. 444	0. 0834	0. 0632	0. 586
3–2	. 0694	157. 0	1, 704	2. 5	2. 3	2, 208	2, 204	324. 6	420. 8	169. 8	. 676	. 0544	. 0522	. 705
3–3	. 0705	186. 0	1, 772	−2. 0	1. 1	2, 203	2, 208	431. 5	354. 6	177. 2	. 769	. 0411	. 0472	. 670
3–5	. 0692	172. 5	1, 752	0	1. 3	2, 193	2, 198	370. 0	370. 0	173. 7	. 721	. 0456	. 0494	. 666
3–6	. 0695	80. 6	1, 545	8. 8	13. 3	2, 188	2, 154	231. 6	566. 1	156. 8	. 383	. 0888	. 0645	. 527
3–8	. 0727	120. 5	1, 578	6. 2	4. 7	2, 178	2, 143	238. 1	473. 0	166. 0	. 561	. 0682	. 0614	. 623
3–9	. 0725	135. 0	1, 605	4. 8	3. 4	2, 173	2, 154	269. 0	450. 5	167. 7	. 617	. 0627	. 0589	. 657
4–1	. 0711	99. 0	1, 576	8. 2	8. 1	2, 213	2, 132	213. 8	529. 6	162. 6	. 461	. 0782	. 0621	. 581
4–2	. 0712	82. 3	1, 564	9. 0	12. 5	2, 208	2, 076	213. 2	558. 4	161. 6	. 387	. 0838	. 0628	. 516
4–3	. 0714	174. 9	1, 764	−. 4	1. 4	2, 203	2, 207	392. 5	377. 3	178. 9	. 729	. 0443	. 0484	. 669
4–4	. 0702	76. 6	1, 550	9. 7	14. 8	2, 198	2, 028	222. 5	593. 0	158. 3	. 363	. 0916	. 0641	. 519
4–6	. 0725	113. 0	1, 576	7. 3	5. 7	2, 188	2, 137	225. 4	503. 4	166. 2	. 527	. 0729	. 0621	. 619
4–7	. 0714	146. 4	1, 632	3. 7	2. 7	2, 183	2, 174	296. 2	437. 0	168. 5	. 659	. 0600	. 0575	. 688
4–8	. 0708	165. 3	1, 700	1. 7	1. 8	2, 178	2, 175	353. 0	417. 6	172. 8	. 715	. 0534	. 0527	. 725
4–9	. 0717	127. 8	1, 628	5. 3	4. 1	2, 173	2, 146	250. 2	451. 1	169. 3	. 577	. 0619	. 0578	. 616
4–10	. 0702	76. 6	1, 536	9. 0	14. 7	2, 168	2, 013	220. 5	559. 5	157. 0	. 366	. 0881	. 0652	. 495
4–11	. 0765	0	1, 582	---------	---------	---------	---------	---------	---------	173. 8	0	---------	. 0607	---------
5–1	. 0710	90. 1	1, 588	9. 2	10. 2	2, 213	2, 104	211. 4	565. 4	165. 6	. 417	. 0824	. 0617	. 557
5–2	. 0702	169. 8	1, 748	. 4	1. 7	2, 208	2, 206	367. 0	382. 2	176. 8	. 714	. 0465	. 0498	. 665
5–3	. 0705	137. 9	1, 680	4. 4	3. 4	2, 203	2, 185	272. 0	441. 0	171. 1	. 603	. 0578	. 0541	. 644
5–4	. 0714	184. 0	1, 820	−1. 4	1. 1	2, 198	2, 202	425. 0	371. 4	184. 7	. 743	. 0410	. 0455	. 669
5–5	. 0715	106. 1	1, 604	8. 4	6. 8	2, 193	2, 125	216. 4	537. 0	167. 2	. 486	. 0761	. 0595	. 622
5–7	. 0724	119. 1	1, 628	7. 1	4. 9	2, 183	2, 135	236. 4	506. 4	172. 2	. 538	. 0690	. 0585	. 634
5–9	. 0682	75. 5	1, 569	9. 7	16. 0	2, 173	2, 010	229. 0	595. 1	159. 5	. 354	. 0928	. 0643	. 511
5–10	. 0673	155. 8	1, 733	2. 4	2. 4	2, 168	2, 163	310. 0	400. 8	170. 7	. 661	. 0518	. 0515	. 665
5–11	. 0765	0	1, 576	---------	---------	---------	---------	---------	---------	173. 4	0	---------	. 0610	---------
6–1	. 0716	94. 2	1, 568	9. 1	9. 1	2, 213	2, 104	210. 6	560. 6	164. 7	. 442	. 0831	. 0632	. 581
6–3	. 0714	190. 7	1, 852	−2. 4	. 9	2, 203	2, 195	457. 0	365. 0	187. 8	. 757	. 0389	. 0438	. 672
6–4	. 0709	131. 0	1, 644	4. 6	3. 9	2, 198	2, 176	257. 8	435. 5	169. 5	. 586	. 0593	. 0571	. 598
6–5	. 0727	203. 0	1, 896	−4. 5	. 4	2, 193	2, 177	523. 0	351. 0	194. 1	. 787	. 0350	. 0418	. 666
6–6	. 0713	112. 8	1, 620	7. 8	5. 8	2, 188	2, 134	224. 3	521. 3	169. 6	. 512	. 0729	. 0594	. 627
6–7	. 0712	177. 7	1, 812	−. 4	1. 3	2, 183	2, 178	402. 0	386. 8	184. 5	. 721	. 0431	. 0461	. 675
6–8	. 0703	83. 8	1, 548	9. 6	12. 0	2, 178	2, 046	208. 2	571. 2	159. 8	. 398	. 0887	. 0651	. 542
6–9	. 0696	71. 5	1, 552	10. 2	20. 0	2, 173	1, 923	230. 2	615. 2	158. 9	. 338	. 0956	. 0638	. 506

TABLE III—Continued

POWER FLIGHT DATA—Continued

PROPELLER 3714

Flight and run No.	Specific weight	Velocity	R. P. M.	Angle of Flight path γ	Angle of attack α	W	L	D	T	HP	$\frac{V}{nD}$	C_T	C_P	η
	Lb./cu. ft.	*Ft./sec.*												
8- 1	0. 0710	104. 7	1, 624	8. 1	7. 2	2, 213	2, 143	218. 0	530. 0	168. 0	0. 474	0. 0740	0. 0586	0. 599
8- 3	. 0698	185. 4	1, 812	−1. 7	1. 1	2, 203	2, 207	421. 0	356. 0	180. 2	752	. 0406	. 0460	. 664
8- 4	. 0692	88. 6	1, 604	9. 4	11. 0	2, 198	2, 079	209. 4	568. 0	161. 1	. 406	. 0833	. 0598	. 565
8- 5	. 0707	197. 2	1, 872	−3. 7	. 7	2, 193	2, 181	483. 5	342. 0	185. 5	. 774	. 0360	. 0432	. 659
8- 6	. 0709	168. 5	1, 772	. 9	1. 7	2, 188	2, 190	365. 0	399. 4	179. 7	. 699	. 0469	. 0483	. 679
8- 7	. 0705	134. 7	1, 700	5. 2	3. 6	2, 183	2, 161	263. 3	461. 1	172. 8	. 582	. 0590	. 0528	. 651
8- 8	. 0702	150. 4	1, 728	2. 9	2. 5	2, 178	2, 168	306. 5	416. 6	174. 2	. 640	. 0511	. 0502	. 652
8- 9	. 0688	118. 3	1, 632	6. 9	4. 4	2, 173	2, 177	231. 8	492. 8	163. 4	. 532	. 0702	. 0578	. 647
8-10	. 0690	168. 7	1, 768	. 7	1. 7	2, 168	2, 170	356. 0	382. 5	174. 2	. 702	. 0465	. 0485	. 673
8-11	. 0765	0	1, 564	---------	---------	---------	---------	---------	---------	169. 2	0	---------	. 0620	---------
9- 1	. 0715	92. 1	1, 620	8. 7	9. 6	2, 213	2, 115	211. 8	546. 5	166. 7	. 418	. 0761	. 0580	. 548
9- 2	. 0700	190. 6	1, 852	−2. 8	. 9	2, 208	2, 211	450. 4	342. 7	184. 4	. 756	. 0377	. 0437	. 651
9- 3	. 0696	110. 0	1, 616	7. 9	6. 4	2, 203	2, 142	220. 0	522. 9	160. 8	. 501	. 0753	. 0582	. 648
9- 4	. 0699	176. 0	1, 800	−. 5	1. 4	2, 198	2, 202	390. 3	371. 1	179. 9	. 719	. 0428	. 0467	. 660
9- 5	. 0696	145. 3	1, 696	3. 9	2. 9	2, 193	2, 180	287. 5	436. 6	168. 4	. 629	. 0568	. 0515	. 693
9- 7	. 0689	206. 8	1, 900	−5. 1	. 5	2, 183	2, 182	512. 0	318. 0	183. 9	. 800	. 0335	. 0414	. 648
9- 8	. 0690	127. 8	1, 652	5. 8	4. 3	2, 178	2, 149	246. 0	466. 0	164. 7	. 566	. 0638	. 0554	. 652
9- 9	. 0684	79. 1	1, 612	10. 0	15. 0	2, 173	2, 000	219. 6	596. 9	160. 2	. 360	. 0923	. 0623	. 457
9-10	. 0681	163. 4	1, 767	1. 4	2. 0	2, 168	2, 168	335. 4	340. 7	173. 8	. 680	. 0419	. 0490	. 581
9-11	. 0765	0	1, 604	---------	---------	---------	---------	---------	---------	172. 8	0	---------	. 0590	---------

10- 1	0. 0706	89. 6	1, 624	9. 5	10. 4	2, 213	2, 100	210. 9	576. 2	165. 0	0. 405	0. 0804	0. 0574	0. 567
10- 2	. 0704	169. 5	1, 784	. 6	1. 7	2, 208	2, 206	367. 2	390. 6	178. 5	. 700	. 0455	. 0474	. 673
10- 3	. 0690	75. 0	1, 648	10. 0	16. 5	2, 203	2, 005	230. 2	612. 8	163. 9	. 335	. 0857	. 0562	. 511
10- 4	. 0688	101. 0	1, 664	9. 3	8. 1	2, 198	2, 109	211. 8	567. 3	163. 3	. 446	. 0782	. 0549	. 635
10- 5	. 0682	121. 0	1, 668	7. 3	5. 1	2, 193	2, 147	233. 2	512. 0	162. 3	. 533	. 0699	. 0538	. 693
10- 6	. 0698	184. 0	1, 844	−1. 7	1. 1	2, 188	2, 191	416. 4	351. 1	187. 5	. 733	. 0385	. 0452	. 623
10- 7	. 0702	136. 0	1, 748	4. 9	3. 6	2, 183	2, 162	262. 9	449. 2	173. 9	. 572	. 0546	. 0491	. 636
10- 8	. 0703	200. 0	1, 896	−4. 4	. 7	2, 178	2, 177	497. 1	329. 8	187. 4	. 775	. 0338	. 0412	. 637
10- 9	. 0708	140. 0	1, 764	2. 9	3. 0	2, 173	2, 167	282. 5	392. 0	176. 4	. 583	. 0452	. 0468	. 564
10-10	. 0765	0	1, 640	--------	--------	--------	--------	--------	--------	177. 4	0	--------	. 0561	--------
11- 1	. 0709	94. 2	1, 696	9. 2	9. 2	2, 213	2, 111	211. 3	564. 9	166. 4	. 408	. 0723	. 0509	. 580
11- 2	. 0709	189. 7	1, 896	−3. 8	. 9	2, 208	2, 205	454. 0	307. 7	188. 7	. 735	. 0312	. 0409	. 561
11- 3	. 0712	109. 8	1, 676	8. 2	6. 3	2, 203	2, 139	220. 7	534. 8	157. 5	. 481	. 0698	. 0498	. 675
11- 4	. 0712	175. 2	1, 828	−. 6	1. 4	2, 198	2, 202	394. 0	371. 0	182. 3	. 705	. 0408	. 0444	. 648
11- 5	. 0706	81. 5	1, 648	10. 2	12. 8	2, 193	2, 063	213. 8	502. 2	167. 8	. 364	. 0685	. 0571	. 443
11- 7	. 0682	130. 1	1, 708	6. 2	4. 2	2, 183	2, 152	249. 7	485. 5	166. 7	. 560	. 0638	. 0520	. 687
11- 8	. 0697	160. 4	1, 800	1. 8	2. 1	2, 178	2, 177	332. 5	400. 9	177. 8	. 655	. 0463	. 0464	. 653
11- 9	. 0695	192. 5	1, 904	−3. 1	. 9	2, 173	2, 176	453. 0	335. 5	185. 7	. 743	. 0348	. 0410	. 630
11-10	. 0765	0	1, 668	--------	--------	--------	--------	--------	--------	179. 2	0	--------	. 0545	--------
12- 1	. 0708	88. 4	1, 676	10. 2	10. 7	2, 213	2, 087	210. 1	603. 3	172. 1	. 388	. 0795	. 0548	. 563
12- 2	. 0710	170. 1	1, 860	. 7	1. 7	2, 208	2, 210	369. 8	397. 2	188. 0	. 672	. 0423	. 0437	. 651
12- 3	. 0705	74. 2	1, 680	10. 6	16. 5	2, 203	2, 000	227. 0	631. 8	171. 8	. 325	. 0830	. 0544	. 496
12-4	. 0712	183. 2	1, 916	−1. 1	1. 1	2, 198	2, 204	422. 3	380. 0	191. 0	. 702	. 0378	. 0403	. 658
12-6	. 0716	193. 8	1, 920	−3. 5	. 8	2, 193	2, 197	475. 0	341. 2	192. 1	. 742	. 0336	. 0401	. 622
12-7	. 0709	119. 2	1, 712	7. 4	5. 1	2, 188	2, 140	235. 1	517. 5	174. 3	. 510	. 0648	. 0515	. 642
12-9	. 0687	154. 0	1, 784	2. 5	2. 4	2, 178	2, 167	310. 9	405. 8	173. 1	. 635	. 0484	. 0468	. 656
12-10	. 0682	138. 0	1, 752	4. 8	3. 5	2, 173	2, 153	265. 7	447. 0	169. 0	. 579	. 0560	. 0489	. 663
12-11	. 0765	0	1, 648	--------	--------	--------	--------	--------	--------	178. 4	0	--------	. 0559	--------
13-1	. 0695	95. 2	1, 676	9. 0	9. 2	2, 213	2, 115	211. 7	557. 8	168. 6	. 417	. 0746	. 0532	. 572
13-2	. 0696	176. 1	1, 828	−. 6	1. 4	2, 208	2, 204	391. 8	368. 7	191. 4	. 708	. 0413	. 0474	. 616
13-4	. 0712	203. 3	1, 940	−5. 3	. 5	2, 198	2, 180	514. 0	311. 0	192. 5	. 770	. 0302	. 0391	. 596
13-6	. 0710	161. 2	1, 816	1. 5	2. 0	2, 188	2, 187	340. 5	397. 8	182. 0	. 652	. 0448	. 0453	. 641
13-7	. 0690	147. 0	1, 792	3. 6	2. 8	2, 183	2, 173	294. 2	431. 2	175. 3	. 603	. 0508	. 0467	. 656
13-9	. 0695	191. 5	1, 912	−3. 0	. 9	2, 173	2, 164	450. 0	336. 3	192. 1	. 736	. 0345	. 0418	. 607
13-10	. 0682	78. 4	1, 668	9. 5	14. 4	2, 168	2, 011	217. 1	574. 9	163. 8	. 345	. 0792	. 0549	. 491
13-11	. 0765	0	1, 700	--------	--------	--------	--------	--------	--------	182. 1	0	--------	. 0519	--------

TABLE III—Continued

POWER FLIGHT DATA—Continued

PROPELLER 3872

Flight and run No.	Specific weight	Velocity	R. P. M.	Angle of Flight path γ	Angle of attack α	W	L	D	T	HP	$\frac{V}{nD}$	C_T	C_P	η
	Lb./cu. ft.	*Ft./sec.*												
16–1	0.0685	75.4	1,640	9.2	16.6	2,213	2,007	228.5	582.0	161.1	0.337	0.0825	0.0563	0.494
16–2	.0683	183.5	1,880	−1.4	1.2	2,208	2,211	409.0	345.1	179.9	.717	.0374	.0421	.637
16–3	.0677	72.5	1,624	9.6	20.4	2,203	2,022	259.7	627.0	157.5	.328	.0909	.0570	.523
16–4	.0678	170.5	1,844	.5	1.8	2,198	2,198	359.7	379.0	176.5	.679	.0429	.0439	.663
16–5	.0673	105.7	1,668	8.2	7.2	2,193	2,122	214.9	527.7	160.8	.465	.0736	.0545	.629
16–6	.0694	197.6	1,968	−3.6	.6	2,188	2,192	477.5	340.1	188.4	.738	.0331	.0377	.646
16–7	.0687	118.8	1,688	6.8	5.3	2,183	2,140	230.2	488.6	164.2	.517	.0651	.0526	.640
16–8	.0669	137.1	1,740	4.5	2.7	2,178	2,166	261.7	432.7	164.0	.579	.0557	.0492	.655
16–9	.0664	155.7	1,780	2.1	2.5	2,173	2,169	306.2	386.0	166.1	.643	.0479	.0471	.654
16–10	.0653	138.7	1,740	4.0	2.7	2,168	2,156	261.0	412.2	159.7	.586	.0544	.0491	.650
16–11	.0765	0	1,624	---	---	---	---	---	---	172.5	0	---	.0564	---
17–1	.0695	93.5	1,644	9.3	9.6	2,213	2,107	209.8	567.5	161.0	.418	.0790	.0553	.597
17–2	.0695	174.7	1,856	−.3	1.5	2,208	2,211	384.0	372.5	177.9	.692	.0407	.0425	.663
17–3	.0681	80.6	1,652	10.0	13.8	2,203	2,044	216.7	599.4	160.0	.359	.0845	.0553	.549
17–4	.0690	188.2	1,916	−2.2	1.1	2,198	2,204	429.0	383.0	184.1	.722	.0394	.0401	.709
17–5	.0676	112.0	1,684	7.5	6.4	2,193	2,133	220.2	506.4	161.0	.489	.0693	.0531	.638
17–6	.0677	162.8	1,800	1.5	2.1	2,188	2,187	333.0	390.3	170.7	.664	.0465	.0475	.675
17–7	.0669	130.0	1,720	5.4	4.3	2,183	2,154	246.1	451.5	161.8	.555	.0595	.0503	.655
17–8	.0674	205.8	1,988	−5.3	.6	2,178	2,181	501.0	300.0	184.8	.761	.0295	.0369	.607
17–9	.0676	147.3	1,764	2.8	2.9	2,173	2,165	286.1	329.3	167.6	.614	.0488	.0479	.625
17–10	.0674	72.9	1,626	10.0	19.6	2,168	1,926	229.1	605.6	155.3	.329	.0884	.0565	.515
17–11	.0765	0	1,636	---	---	---	---	---	---	171.9	0	---	.0554	---

TABLE IV

VALUES FROM THE FAIRED CURVES OF FIGURES 10 TO 14

PROPELLER 3712

$\frac{V}{nD}$	C_T	C_P	η
0.35	0.1047	0.0711	0.516
.40	.0980	.0698	.559
.45	.0910	.0682	.599
.50	.0839	.0662	.632
.55	.0768	.0638	.662
.60	.0696	.0611	.684
.65	.0623	.0583	.698
.70	.0551	.0547	.705
.75	.0478	.0510	.700
.80	.0402	.0420	.683

PROPELLER 3713

$\frac{V}{nD}$	C_T	C_P	η
0.35	0.0936	0.0648	0.507
.40	.0876	.0639	.548
.45	.0817	.0627	.586
.50	.0754	.0610	.619
.55	.0692	.0590	.646
.60	.0637	.0565	.667
.65	.0561	.0536	.680
.70	.0490	.0503	.684
.75	.0418	.0467	.671
.80	.0335	.0425	.632

PROPELLER 3714

$\frac{V}{nD}$	C_T	C_P	η
0.35	0.0889	0.0615	0.506
.40	.0829	.0607	.546
.45	.0771	.0597	.583
.50	.0710	.0582	.613
.55	.0652	.0561	.639
.60	.0590	.0538	.660
.65	.0528	.0511	.671
.70	.0459	.0478	.674
.75	.0391	.0442	.662
.80	.0316	.0402	.627

PROPELLER 3715

$\frac{V}{nD}$	C_T	C_P	η
0.35	0.0836	0.0564	0.516
.40	.0777	.0556	.556
.45	.0716	.0543	.592
.50	.0657	.0528	.622
.55	.0596	.0509	.644
.60	.0534	.0487	.657
.65	.0472	.0466	.661
.70	.0403	.0431	.652
.75	.0332	.0398	.625
.80	.0258	.0363	.578

PROPELLER 3872

$\frac{V}{nD}$	C_T	C_P	η
0.30	0.0940	0.0567	0.497
.35	.0872	.0563	.541
.40	.0806	.0555	.578
.45	.0739	.0543	.609
.50	.0670	.0527	.636
.55	.0601	.0507	.654
.60	.0532	.0483	.664
.65	.0462	.0453	.665
.70	.0391	.0418	.653
.75	.0315	.0379	.627

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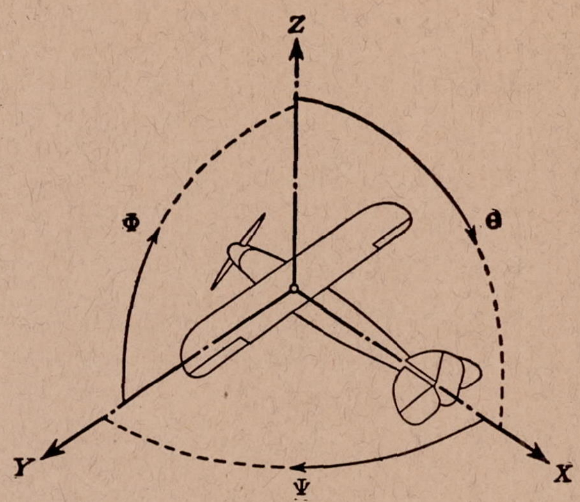

Positive directions of axes and angles (forces and moments) are shown by arrows

Axis		Force (parallel to axis) symbol	Moment about axis			Angle		Velocities	
Designation	Symbol		Designation	Symbol	Positive direction	Designation	Symbol	Linear (component along axis)	Angular
Longitudinal	X	X	rolling	L	$Y \longrightarrow Z$	roll	Φ	u	p
Lateral	Y	Y	pitching	M	$Z \longrightarrow X$	pitch	Θ	v	q
Normal	Z	Z	yawing	N	$X \longrightarrow Y$	yaw	Ψ	w	r

Absolute coefficients of moment

$$C_L=\frac{L}{qbS} \quad C_M=\frac{M}{qcS} \quad C_N=\frac{N}{qfS}$$

Angle of set of control surface (relative to neutral position), δ. (Indicate surface by proper subscript.)

4. PROPELLER SYMBOLS

D, Diameter.
p_e, Effective pitch
p_g, Mean geometric pitch.
p_s, Standard pitch.
p_t, Zero thrust.
p_q, Zero torque.
p/D, Pitch ratio.
V', Inflow velocity.
V_s, Slip stream velocity.

T, Thrust.
Q, Torque.
P, Power.
(If "coefficients" are introduced all units used must be consistent.)
η, Efficiency $= T\,V/P$.
n, Revolutions per sec., r. p. s.
N, Revolutions per minute., R. P. M.
Φ, Effective helix angle $=\tan^{-1}\left(\frac{V}{2\pi rn}\right)$

5. NUMERICAL RELATIONS

1 HP = 76.04 kg/m/sec. = 550 lb./ft./sec.
1 kg/m/sec. = 0.01315 HP.
1 mi./hr. = 0.44704 m/sec.
1 m/sec. = 2.23693 mi./hr.

1 lb. = 0.4535924277 kg.
1 kg = 2.2046224 lb.
1 mi. = 1609.35 m = 5280 ft.
1 m = 3.2808333 ft.