NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

REPORT No. 643

THE AERODYNAMIC CHARACTERISTICS OF FOUR FULL-SCALE PROPELLERS HAVING DIFFERENT PLAN FORMS

By EDWIN P. HARTMAN and DAVID BIERMANN

1938

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AERONAUTIC SYMBOLS

1. FUNDAMENTAL AND DERIVED UNITS

	Symbol	Metric		English	
		Unit	Abbreviation	Unit	Abbreviation
Length	l	meter	m	foot (or mile)	ft. (or mi.)
Time	t	second	s	second (or hour)	sec. (or hr.)
Force	F	weight of 1 kilogram	kg	weight of 1 pound	lb.
Power	P	horsepower (metric)		horsepower	hp.
Speed	V	kilometers per hour	k.p.h.	miles per hour	m.p.h.
		meters per second	m.p.s.	feet per second	f.p.s.

2. GENERAL SYMBOLS

W, Weight $=mg$

g, Standard acceleration of gravity $=9.80665$ m/s² or 32.1740 ft./sec.²

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

I, Moment of inertia $=mk^2$. (Indicate axis of radius of gyration k by proper subscript.)

μ, Coefficient of viscosity

ν, Kinematic viscosity

ρ, Density (mass per unit volume)

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

Specific weight of "standard" air, 1.2255 kg/m^3 or 0.07651 lb./cu. ft.

3. AERODYNAMIC SYMBOLS

S, Area

S_w, Area of wing

G, Gap

b, Span

c, Chord

$\frac{b^2}{S}$, Aspect ratio

V, True air speed

q, Dynamic pressure $=\frac{1}{2}\rho V^2$

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

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

D_0, Profile drag, absolute coefficient $C_{D_0}=\frac{D_0}{qS}$

D_i, Induced drag, absolute coefficient $C_{D_i}=\frac{D_i}{qS}$

D_p, Parasite drag, absolute coefficient $C_{D_p}=\frac{D_p}{qS}$

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

R, Resultant force

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

i_t, Angle of stabilizer setting (relative to thrust line)

Q, Resultant moment

Ω, Resultant angular velocity

$\rho\frac{Vl}{\mu}$, Reynolds Number, where l is a linear dimension (e.g., for a model airfoil 3 in. chord, 100 m.p.h. normal pressure at 15° C., the corresponding number is 234,000; or for a model of 10 cm chord, 40 m.p.s., the corresponding number is 274,000)

C_p, Center-of-pressure coefficient (ratio of distance of c.p. from leading edge to chord length)

α, Angle of attack

ϵ, Angle of downwash

α_0, Angle of attack, infinite aspect ratio

α_i, Angle of attack, induced

α_a, Angle of attack, absolute (measured from zero-lift position)

γ, Flight-path angle

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By Edwin P. Hartman and David Biermann

SUMMARY

Tests were made of four propellers, with diameters of 10 feet, having different blade plan forms. One propeller (Navy design No. 5868–R6) was of the usual present-day type and was used as a basis of comparison for the other three, which had unusual plan forms distinguished by the inward (toward the hub) location of the sections having the greatest blade width.

It was found that propellers with points of maximum blade width occurring closer to the hub than on the present-day type of blade had higher peak efficiencies but lower take-off efficiencies. This result was found true for a "clean" liquid-cooled engine installation. It appears that some modification could be made to present plan forms which would produce propellers having more satisfactory aerodynamic qualities.

The propellers with the inward location of the points of maximum blade width had lower thrust and power coefficients and stalled earlier than the present-day type.

INTRODUCTION

One of the variables in propeller design that has received but a small amount of attention in the past is the distribution of area along the blade. Early propellers that were designed with ease of manufacture in mind had blades of constant width and square-cut tips. It is a little surprising, perhaps, to find that propellers with such simple plan forms have but little less efficiency than ones of the usual tapered plan form (reference 1). The insensitivity of efficiency to changes in plan form may provide a reason why plan form has been neglected as a subject of research.

It is probable that the trend of evolution of the propeller plan form has been dictated largely by structural rather than aerodynamic considerations. This probability appears definitely true for the inner third of the present-day type propeller, where the nearly circular sections show almost no effects of aerodynamic influence in design.

The cooling of radial engines has been taken into consideration as a factor in the design of certain special propellers of recent manufacture. In the design of these propellers the blade width has been made larger at the inner stations on the radius where the added slipstream velocity will aid in cooling the engine. Another possible reason for increasing the blade area on the inner half of the blade at the expense of the outer half is that modern propeller theory (reference 2) indicates some advantage in at least part of the normal operating range for a propeller so designed. The theory shows that the optimum distribution of circulation along the blade is such that the maximum value of circulation is reached at the 0.2 radius and then decreases almost linearly to zero at both hub and tip.

It appears that airplane and propeller designs are reaching a stage of development in which even small increases in operating efficiency are of great importance; the factor of blade plan form should therefore not be neglected in future research.

The present report is not expected to advance the state of knowledge concerning the effect of changes in plan form to any large extent because the data taken were not the result of a planned program to study this effect. Its main purpose is to present propeller data for four full-scale propellers of Navy design, three of which have somewhat unusual plan forms and the other one has a normal (usual present-day type) plan form. These data may give some clue as to what may be expected from fundamental changes in blade plan form. The four propellers had been tested as an incidental part of a rather extensive propeller-research program conducted by the N. A. C. A. during 1937. They all have the same diameter (10 feet) and airfoil section (R. A. F. 6) and three of the four have approximately the same blade area. There is some variation in thickness ratio but probably not enough to have a very large effect on the results.

APPARATUS AND METHODS

The tests were made in the N. A. C. A. 20-foot wind tunnel, which is described in reference 3. Since publication of reference 3, the original balance system and Diesel power plant have been replaced by semiautomatic recording balances and by an 1,800-horsepower electric motor. The tunnel is capable of a speed of 115 miles per hour with the test propeller running.

The propellers were turned by a 600-horsepower Curtiss Conqueror engine having a rated speed of 2,450 r. p. m. and a gear ratio of 7:5. The engine was enclosed in a liquid-cooled engine nacelle of oval cross section having over-all dimensions as follows: length 126 inches, height 46 inches, width 38 inches. A photograph of the test set-up is shown in figure 1. The engine was mounted in a cradle-type torque dynamometer and was free to rotate about an axis along its side and parallel to its crankshaft. The torque reaction was transmitted through a compression strut to the lever mechanism of a recording balance on the test-chamber floor.

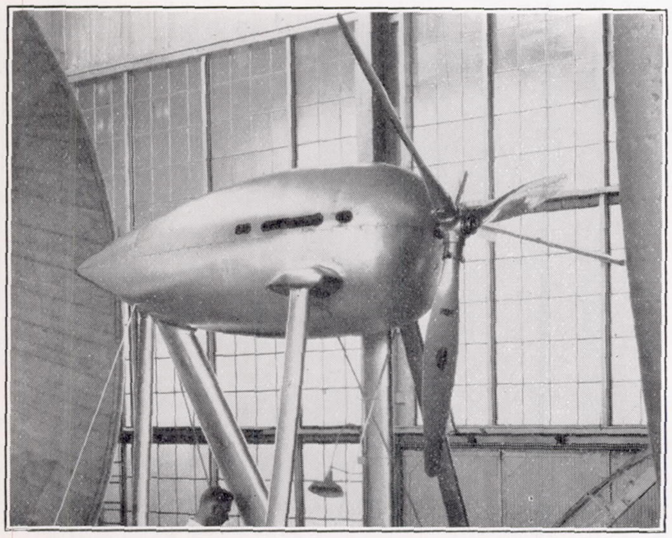


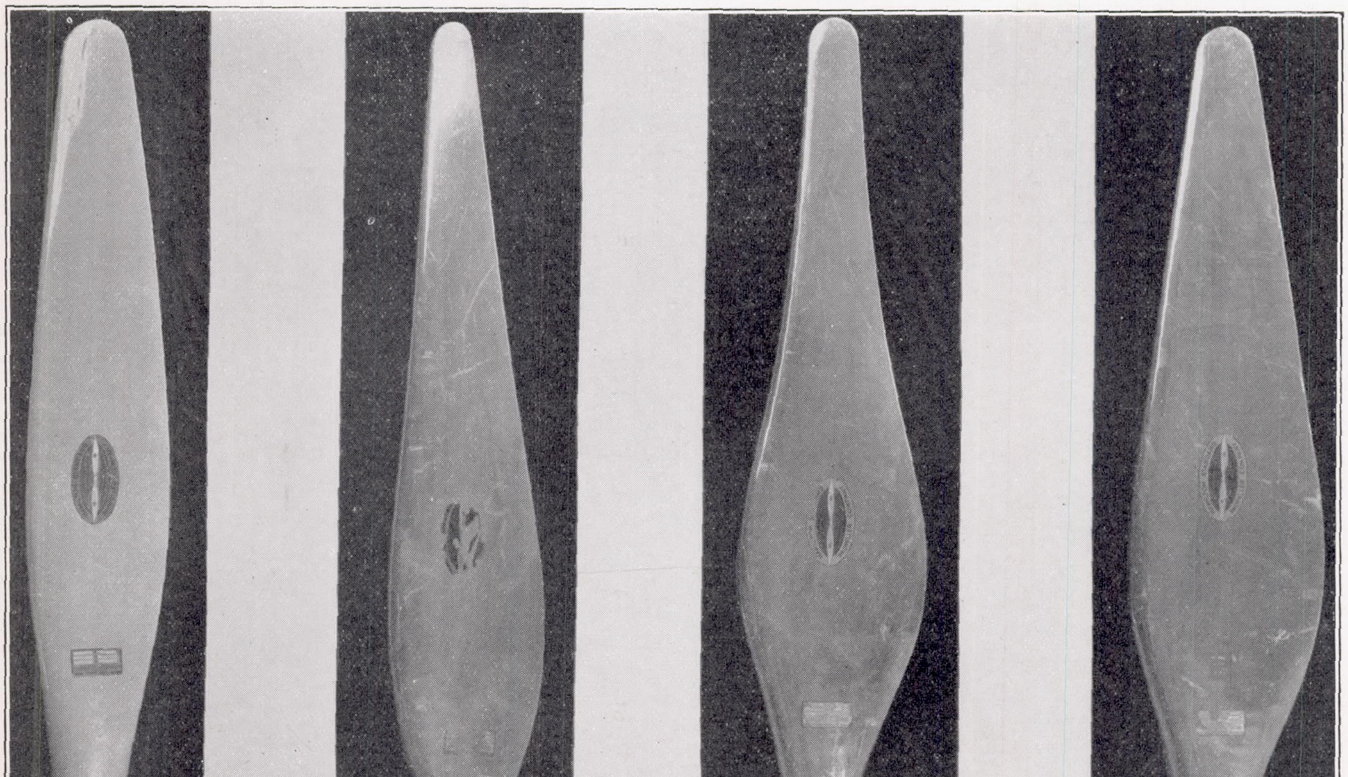
FIGURE 1.—Test set-up. (The photograph shows a 3-blade propeller instead of the 2-blade propeller actually tested.)

The thrust and torque forces were simultaneously measured on recording balances and the engine revolution speed was read from the dial of a calibrated electric tachometer.

The four propellers tested are of Navy design, and each is 10 feet in diameter and has two blades. A photograph of the propeller blades is shown in figure 2 and the blade-form curves are given in figure 3. A list of the principal characteristics of the four propellers is given in the following table.

Propeller drawing No.	Diameter (ft.)	Airfoil section	Maximum width (in.)	Position of maximum width (r/R)	Relative blade area	Blade width at $0.75R$ (in.)	Thickness ratio at $0.75R$ (h/b)
5868-R6 [a]	10	R. A. F. 6	9.15	0.51	1.00	7.40	0.090
5649	10	R. A. F. 6	10.03	.38	.97	5.47	.083
5923G	10	R. A. F. 6	11.70	.42	1.03	5.34	.105
5924H	10	R. A. F. 6	12.30	.45	1.21	7.76	.064

[a] Normal plan form.



5868-R6. 5649. 5923G. 5924H.

FIGURE 2.—Propeller blades tested.

The general method employed in making the tests was as follows: The engine speed was held constant at 1,000 r. p. m. and the tunnel speed was increased by steps to top speed (115 miles per hour with propeller operating). The tunnel speed was then held approximately constant at 115 miles per hour and the engine

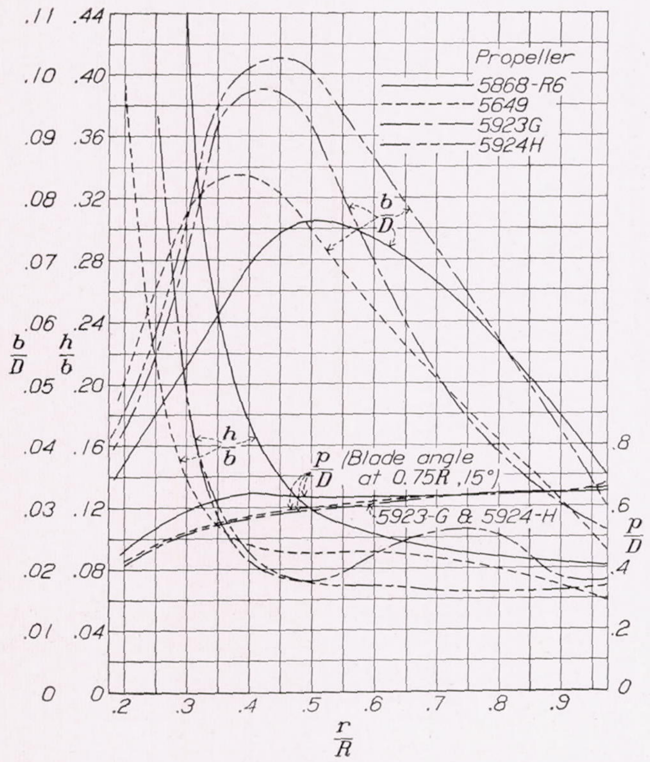


FIGURE 3.—Blade-form curves for propellers 5923G, 5924H, 5649, and 5868-R6. D, diameter; R, radius to the tip; r, station radius; b, section chord; h, section thickness; p, geometric pitch.

speed reduced by steps until the V/nD for zero thrust and power was reached. The maximum tip speeds for the tests were below the values where the efficiency is measurably affected by compressibility. The propellers were tested at three blade angles, 15°, 25°, and 35° at the 0.75 radius.

RESULTS AND DISCUSSION

The coefficient forms used in presenting the data are as follows:

$$C_T=T_e/\rho n^2D^4;\ C_P=P/\rho n^3D^5;\ C_s=\sqrt[5]{\frac{\rho V^5}{n^2P}};\ \eta=\frac{C_T}{C_P}\times\frac{V}{nD}$$

where

C_T is the thrust coefficient.
C_P, power coefficient.
C_s, speed-power coefficient.
η, propulsive efficiency.
$T_e=T-\Delta D$, effective thrust.
T, thrust of propeller (tension in propeller shaft), pounds.
ΔD, change in drag of airplane or body due to slipstream, pounds.

n, propeller revolution speed, r. p. s.
P, engine power, foot-pounds per second.
ρ, mass density of air, slugs per cubic foot.
V, air speed, feet per second.
D, propeller diameter, feet.

The basic data are given in figures 4, 5, 6, and 7, where C_T, C_P, and η are plotted against V/nD. These data are also given in table I, available on request from the National Advisory Committee for Aeronautics. The portion drawn with a broken line has been extrapolated, as a V/nD of 0.25 is about the lowest obtainable in the tunnel for a full-scale propeller.

A more convenient comparison of the characteristics of the four propellers is given in figures 8 and 9. In figure 8 are plotted thrust coefficients and efficiencies for the four propellers at a blade-angle setting of 25°. Figure 9 presents the corresponding power coefficients for the same propellers. Large differences in the thrust and power coefficients will be noted. The two propellers with narrow outer (toward tips) portions reach C_T values of only 0.10 and 0.103, whereas the two with normal-width outer portions reach the usual 0.12, or thereabouts. A corresponding difference in the power coefficients is also noted, though here the C_P curve for propeller 5924H rises far above the curve for 5868–R6 at low values of V/nD and results in lower efficiencies in this range for propeller 5924H.

In general, the blades with greater areas near the hub stall earlier than propeller 5868–R6 with the usual area distribution. The V/nD for zero thrust is somewhat greater for propeller 5868–R6 than for the other propellers, which may possibly be explained by the fact that the pitch distribution over the inner portion of the blade is different for propeller 5868–R6 than for the other three propellers. (See fig. 3.)

The differences in peak efficiency are surprisingly large and it is interesting to note that the peak for the propeller with the usual present-day distribution of area is the lowest. The differences in peak efficiency of the four propellers are more clearly shown in figure 10, where the envelopes of their efficiency curves are plotted against V/nD. On the basis of peak efficiency, the order of merit of the four propellers is as follows: 5649, 5924H, 5923G, and 5868–R6. The accuracy of the tests was such that the efficiency might vary 1 percent on repeat tests so that the relative merit of the propellers must be judged with this fact in mind. The efficiency-curve envelope of propeller 5649 averages more than 3 percent higher than propeller 5868–R6. Propeller 5649 is the one with its maximum width closest to the hub. From the point of greatest width the blade tapers evenly to a fairly narrow tip. (See fig. 2.) It is probable that the differences in efficiency indicated in figure 10 are largely due to the differences in plan form. It should be pointed out, however, that the differences in thickness ratios undoubtedly have some effect. Propeller 5923G has a greater thickness ratio at the threequarters radius than the normal, present-day type, propeller 5868–R6; propellers 5649 and 5924H have lesser thickness ratios than propeller 5868–R6. From a study of the data on the effect of blade thickness given

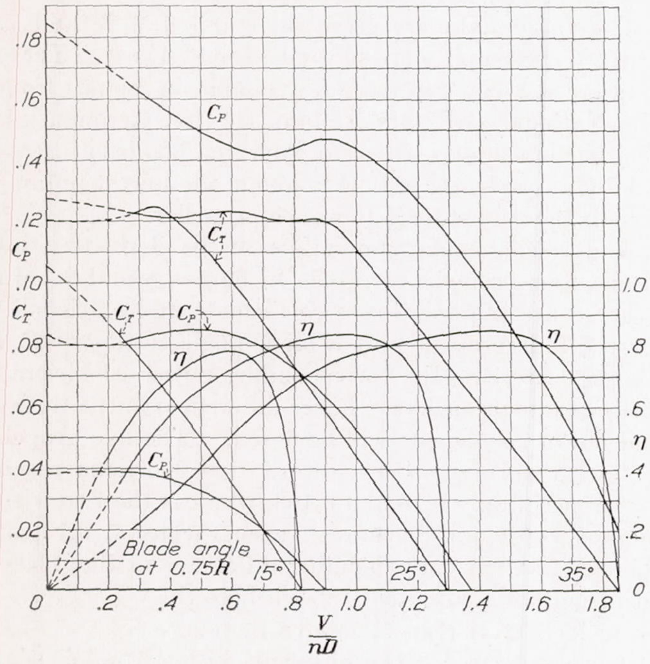


FIGURE 4.—Coefficient curves for propeller 5868–R6.

in reference 4, it does not seem probable that the differences in thickness ratio between propellers 5868–R6 and 5924H could account for more than one-half of the difference in efficiency between them. The difference

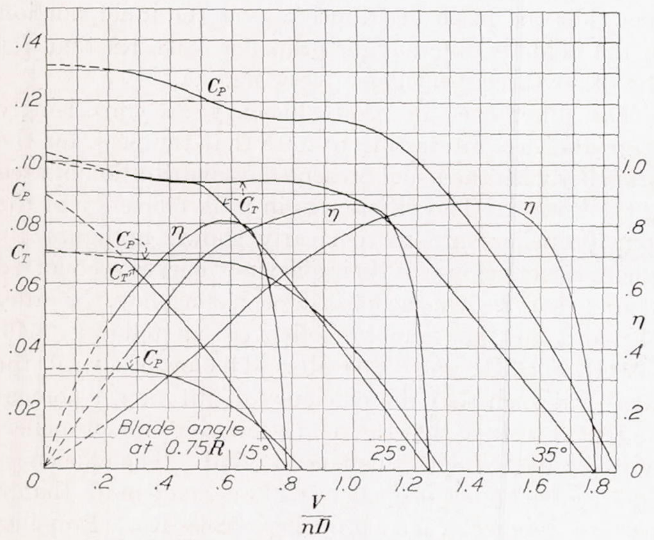


FIGURE 5.—Coefficient curves for propeller 5649.

in thickness ratio between propellers 5868–R6 and 5649 should have a negligible effect. The improvement in efficiency due to moving the blade area toward the hub seems to agree with theory, as mentioned earlier. Another probable cause for this improvement in efficiency lies in the elimination of a large part of the long cylindrical shank. The cylindrical shank adds greatly to the parasite drag of the propeller and reduces the efficiency by an amount that increases with design air speed. The reduction in efficiency may be several percent at high design speed.

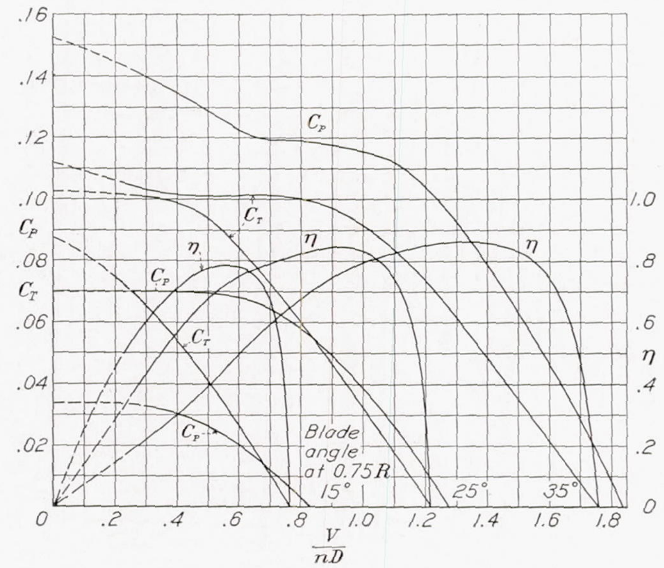


FIGURE 6.—Coefficient curves for propeller 5923G.

From practical considerations, it is usually better to compare propellers on the basis of constant C_s because

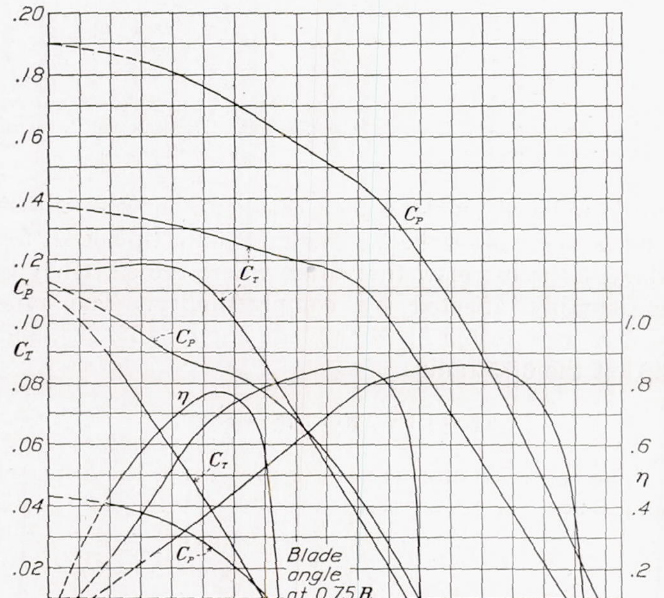


FIGURE 7.—Coefficient curves for propeller 5924H.

this coefficient represents actual design conditions. Figures 11, 12, 13, and 14 have been included for the use of readers who wish to make further comparisons on the C_s basis. The blade-angle intervals are too great for an accurate use of the chart but a linear interpolation along the line of "maximum efficiency for C_s" should give results not greatly in error.

The envelopes of the efficiency curves were taken from figures 11 to 14 and plotted against the design coefficient C_s in figure 15. The curves give the efficiency for any given set of design conditions, i. e., engine power, engine speed, air speed, and air density. The order of merit of the four propellers remains unchanged and the difference in efficiency between 5649 and 5868–R6 is still about 3 percent.

The comparison of the take-off qualities of the propellers does not present such an easy problem as the comparison of peak efficiencies because the two usual methods of comparison, both of which are reasonable methods, sometimes give contrary results. Comparisons will therefore be made by both methods, which are described as follows:

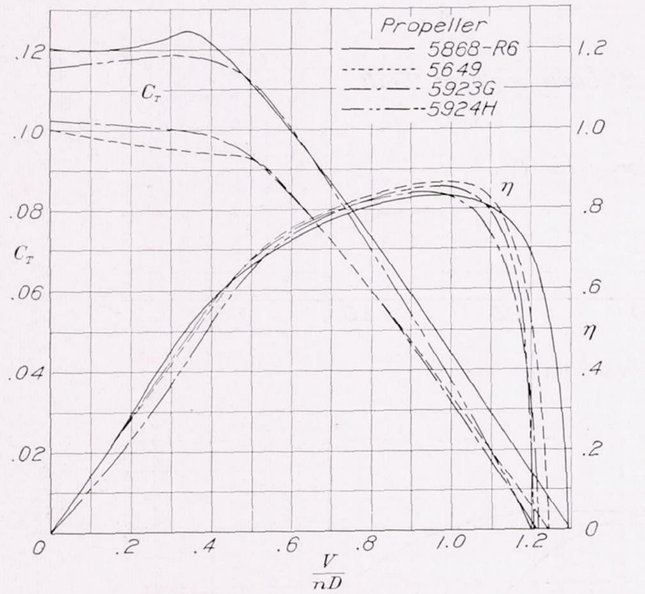


FIGURE 8.—Comparison of thrust coefficients and efficiencies for four propellers. Blade angle, 25° at 0.75R.

The first method is a comparison of a group of propellers the diameters of which are the values that have been obtained by the usual methods of selection from C_s charts. They are the diameters that will give maximum efficiency for the particular design condition chosen, i. e., for cruising or high speed. A group of propellers with different power-absorption characteristics will have different design diameters, a fact that greatly influences take-off comparisons.

The second method of take-off comparison assumes that some condition of design fixes the diameter. The fixed diameter may not be the one giving maximum efficiency for the design conditions, but the deviation from the maximum efficiency will probably be small. This method usually favors the propeller with the highest power absorption and the one that has the latest and least severe stall.

In the comparison of the take-off qualities of the present four propellers, the thrust throughout the take-off and climbing range was calculated for a representative airplane equipped with each of the four propellers. The airplane was assumed to be a light, two-engine transport airplane having the following design characteristics: high speed, 220 miles per hour; engines (2) rated at 550 horsepower at 1,750 (propeller) r. p. m. Both methods of comparison, as previously described, were used. In the first case, the propellers were selected from the design charts in figures 11, 12, 13, and 14 for the high-speed conditions. The diameters selected varied from 9.9 to 10.42 feet.

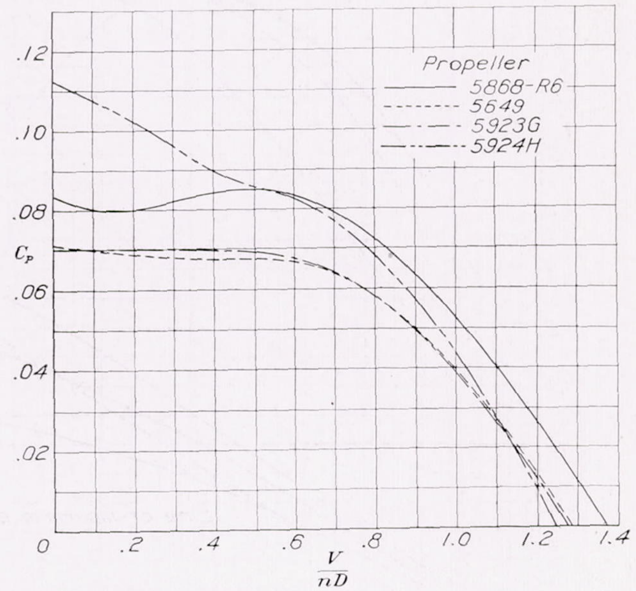


FIGURE 9.—Comparison of power coefficients for four propellers. Blade angle, 25° at 0.75R.

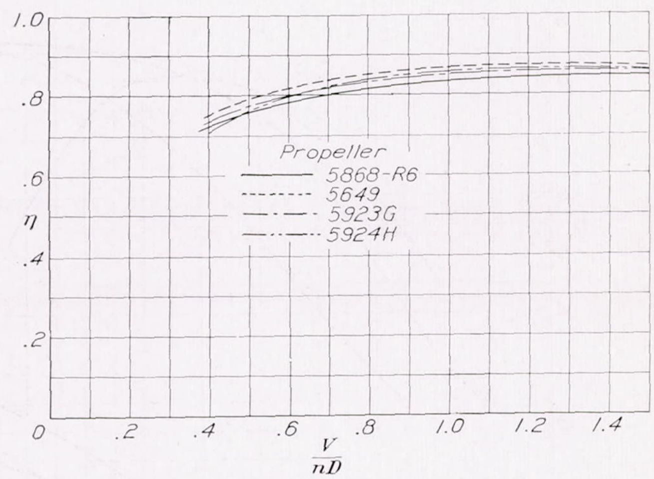


FIGURE 10.—Comparison of efficiency-curve envelopes for four propellers.

In the second case, the diameters were all taken as 10.2 feet and the difference in high-speed efficiency for the two cases was almost negligible. The results of these comparisons are shown in figures 16 and 17. In both cases, the propeller with normal, present-day plan form (5868–R6) was best for take-off, though in figure 16 it appears but little better than 5649 and not so

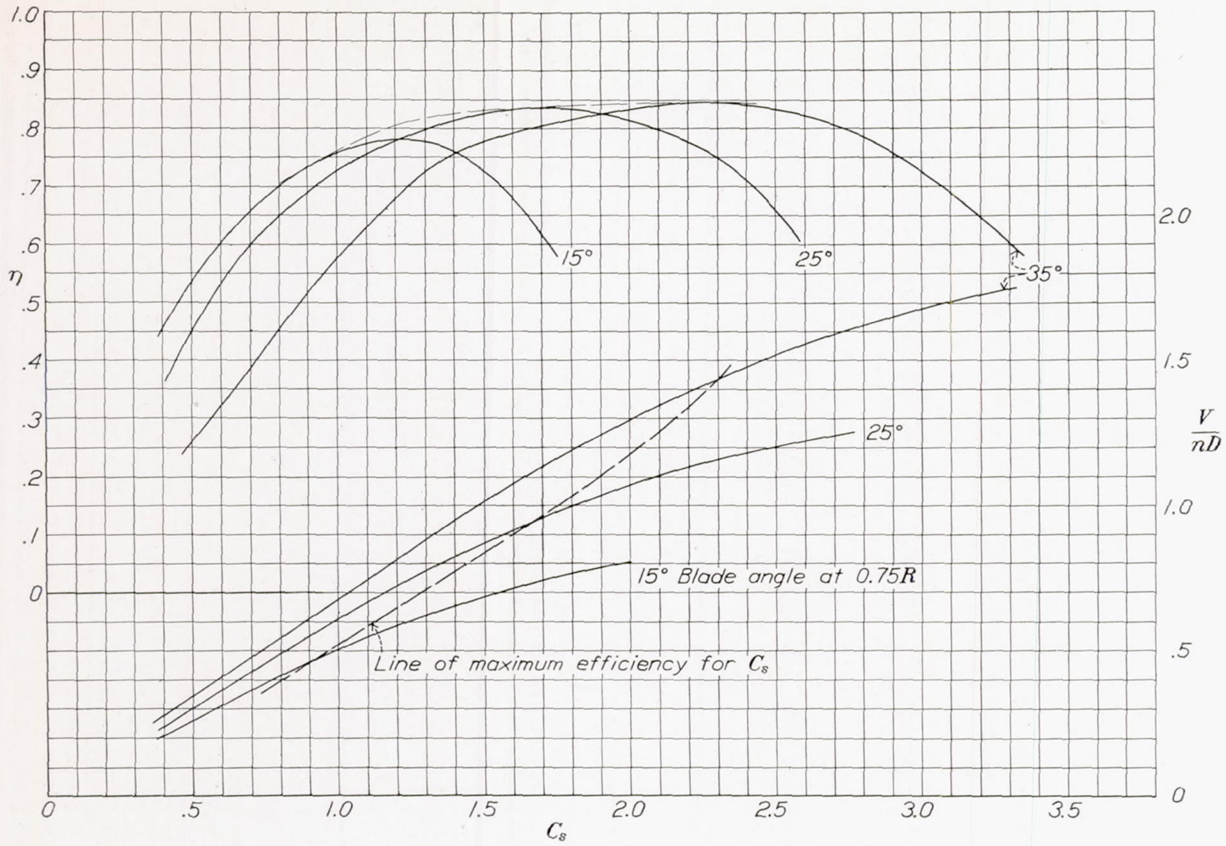


FIGURE 11.—Design chart for propeller 5868-R6.

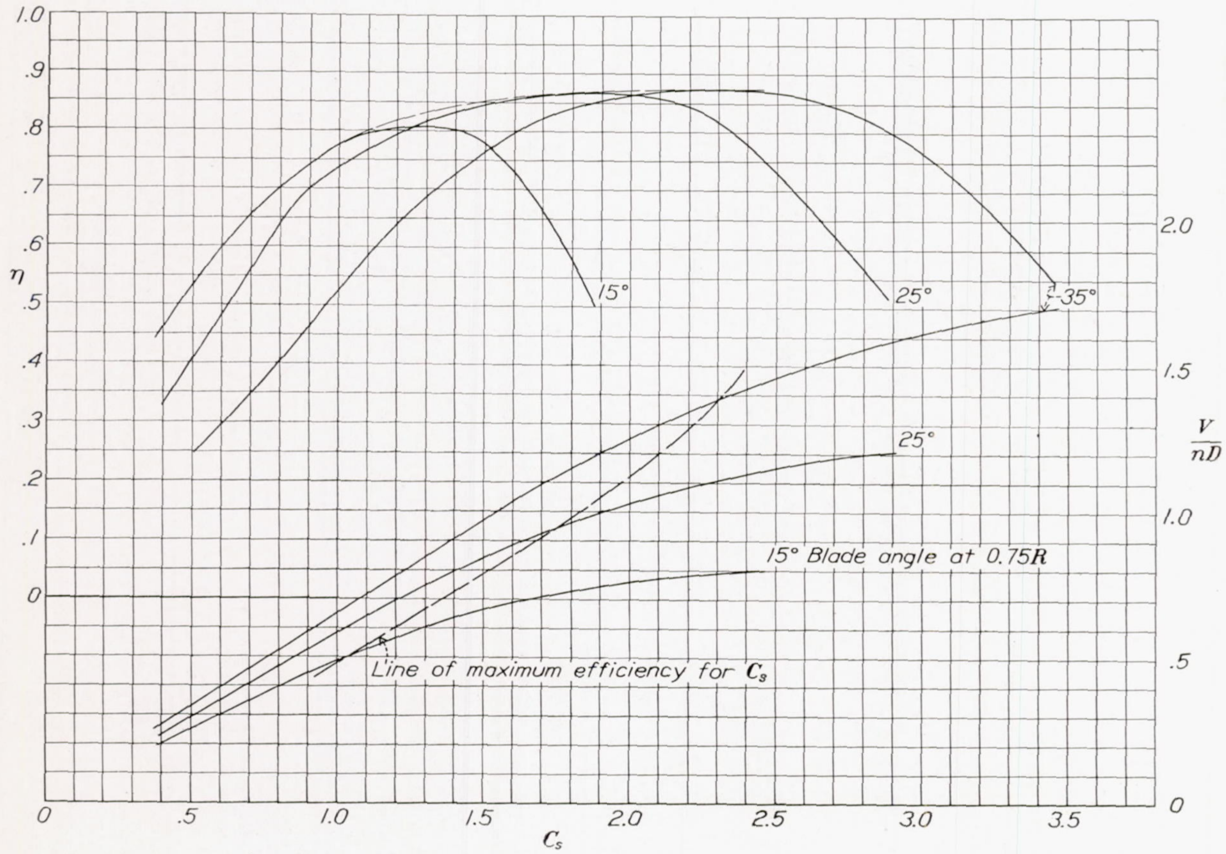


FIGURE 12.—Design chart for propeller 5649.

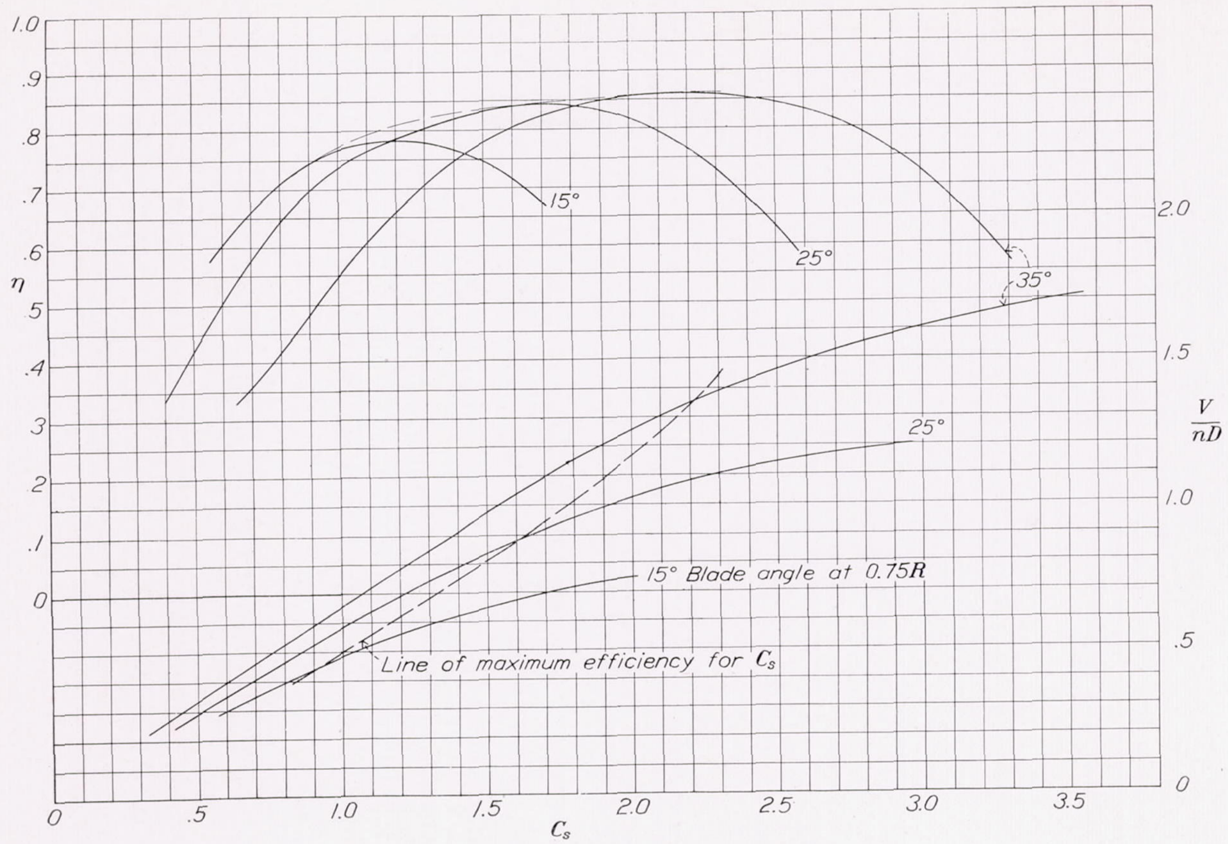


FIGURE 13.—Design chart for propeller 5923G.

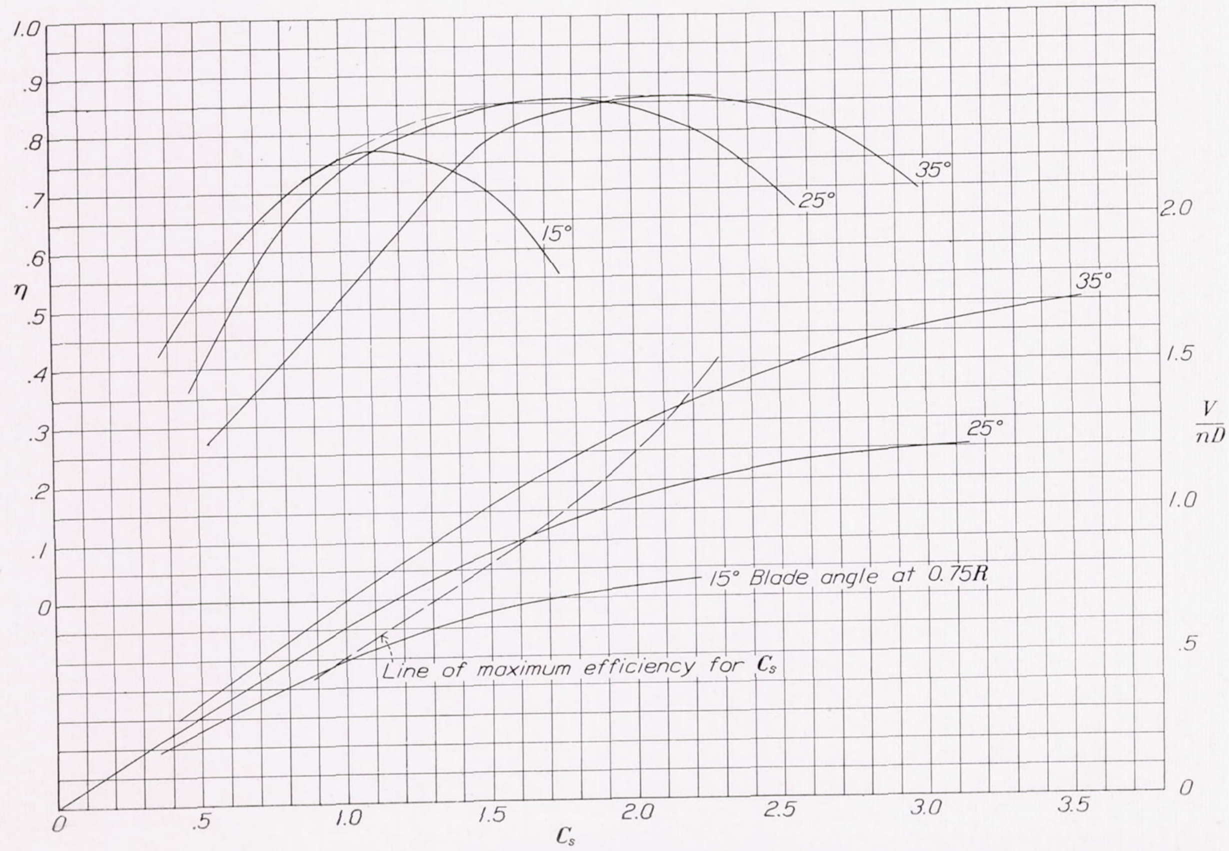


FIGURE 14.—Design chart for propeller 5924H.

good in the climbing range as 5649. In the constant-diameter comparison (fig. 17) propeller 5868–R6 is considerably better than propeller 5649 in the take-off range but equal in climb. Propeller 5924H holds up well in both cases; whereas, propeller 5923G is fairly poor in both cases. In both cases the thrust was calculated by the method given in reference 5.

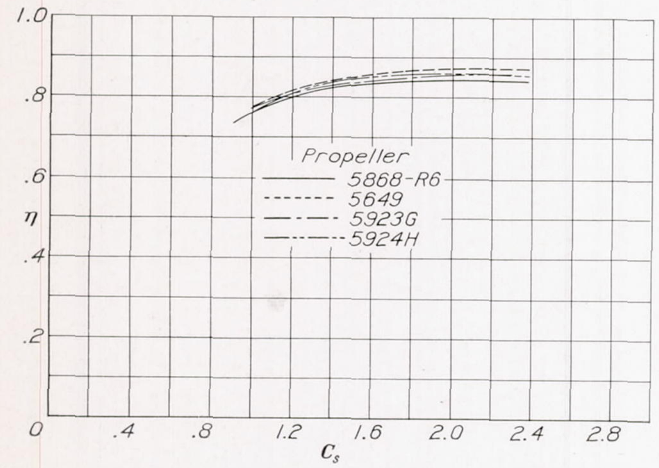


FIGURE 15.—Comparison of efficiency-curve envelopes for four propellers.

Differences in thrust that occur at speeds from 0 to 25 miles per hour have an almost negligible effect on the take-off distance as shown in reference 6. In this reference it is shown that the value of thrust most representative of the entire take-off occurs at a speed equal to 0.7 the take-off air speed. For the present example, this speed will lie somewhere between 40 and 45 miles per hour.

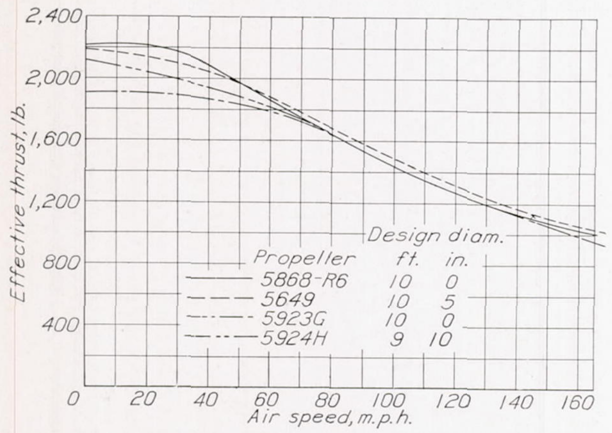


FIGURE 16.—Propeller thrust for example airplane, 2-blade constant-speed propeller. Design conditions: air speed, 220 m. p. h.; b. hp., 550 (each engine); propeller speed, 1,750 r. p. m.

The following table presents a summary of the high-speed and take-off comparisons for the example airplane. Although the results are for only one example, they are probably representative of many others and therefore give a fairly general comparison of the four propellers tested. The table presents ratios of the peak efficiencies of the various propellers relative to the peak efficiency for the normal propeller. The take-off efficiency ratio, also given in the table, is the ratio of the propeller thrust of the various propellers to the propeller thrust of the normal propeller at an air speed of 40 miles per hour.

Propeller drawing No.	High-speed efficiency ratio	Take-off efficiency ratio	
		Design diameter	Constant diameter
5868–R6 [a]	1.000	1.000	1.000
5649	1.033	.978	.895
5923G	1.016	.895	.914
5924H	1.022	.933	.982

[a] Normal propeller.

The propeller a designer should choose will depend, to a large extent, upon his particular design problem; so little discussion on this subject is worth while. Propeller 5924H seems to hold up well in all comparisons

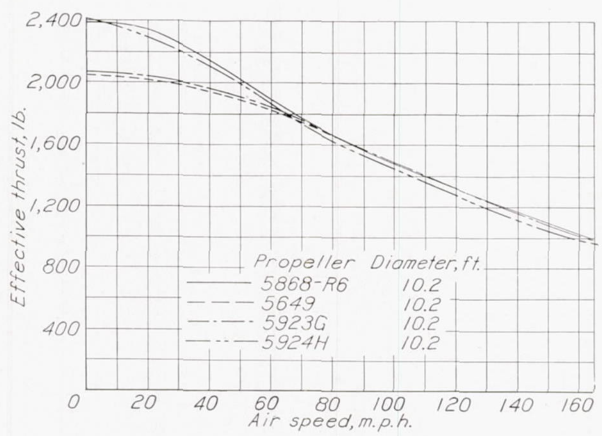


FIGURE 17.—Propeller thrust for example airplane, 2-blade constant-speed propeller. Design conditions: air speed, 220 m. p. h.; b. hp., 550 (each engine); propeller speed, 1,750 r. p. m.

whereas the others are good in one and poor in another. It is possible that, in many cases, it would be worth while to accept the 2 to 10 percent loss in take-off efficiency of propeller 5649 in order to gain its 3-percent better peak efficiency. It is also possible that the design of propeller 5649 could be improved for take-off without serious loss in peak efficiency by increasing the width near the tip but leaving the point of maximum width at its present location, $0.38R$. There seems to be a distinct advantage in having a considerable width on the inner (toward the hub) sections.

It must be remembered that these data and this discussion refer only to a clean liquid-cooled engine installation. It is quite possible that somewhat different results would be obtained with an air-cooled engine nacelle, for the added slipstream of the propellers with wide inner sections would add to the interference and drag of the nacelle but might possibly result in better engine cooling.

CONCLUSIONS

1. The peak efficiencies of propellers having present-day plan forms similar to Navy propeller 5868–R6 can possibly be improved by a change in design that will put more of the blade area in the inner half of the blade and will move the section having greatest width closer to the hub than its present location. The results of the tests show this conclusion to be true for a "clean" liquid-cooled engine installation.

2. For the propellers tested, the increase in peak efficiency due to this change in plan form is paid for in terms of a lower take-off efficiency. It is probable, however, that some compromise can be made to give more generally satisfactory results than propellers having present-day plan forms.

3. Shifting area from the outer to the inner half of a propeller blade caused an earlier stall, decreased the thrust and torque coefficients, and also slightly decreased the efficiency in the take-off range.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., *November 2, 1937.*

REFERENCES

1. Durand, W. F., and Lesley, E. P.: Experimental Research on Air Propellers, V. T. R. No. 141, N. A. C. A., 1922.
2. Glauert, H.: Airplane Propellers. Aerodynamic Theory, W. F. Durand, ed., vol. IV, div. L., Julius Springer (Berlin), 1935, p. 260.
3. Weick, Fred E., and Wood, Donald H.: The 20-Foot Propeller Research Tunnel of the National Advisory Committee for Aeronautics. T. R. No. 300, N. A. C. A., 1928.
4. Freeman, Hugh B.: Comparison of Full-Scale Propellers Having R. A. F.–6 and Clark Y Airfoil Sections. T. R. No. 378, N. A. C. A., 1931.
5. Hartman, Edwin P., and Biermann, David: The Aerodynamic Characteristics of Full-Scale Propellers Having 2, 3, and 4 Blades of Clark Y and R. A. F. 6 Airfoil Sections. T. R. No. 640, N. A. C. A., 1938.
6. Hartman, Edwin P.: Considerations of the Take-Off Problem. T. N. No. 557, N. A. C. A., 1936.

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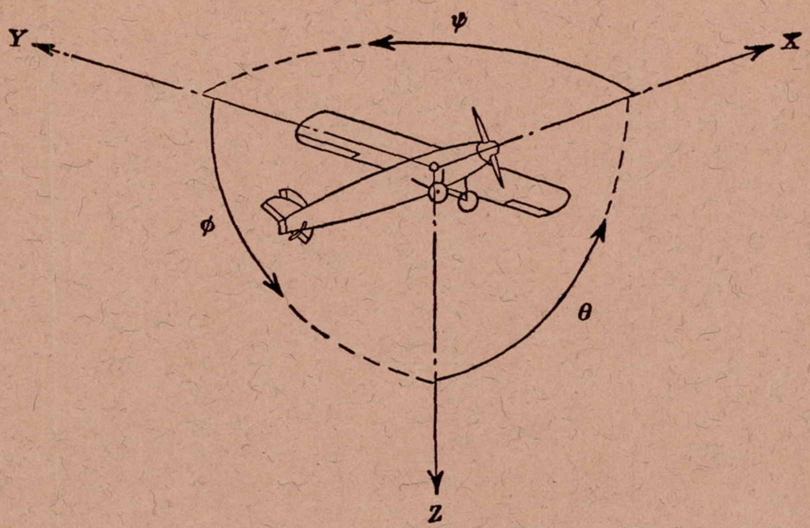

Positive directions of axes and angles (forces and moments) are shown by arrows

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

$C_l=\frac{L}{qbS}$ (rolling) $C_m=\frac{M}{qcS}$ (pitching) $C_n=\frac{N}{qbS}$ (yawing)

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

4. PROPELLER SYMBOLS

D, Diameter

p, Geometric pitch

p/D, Pitch ratio

V', Inflow velocity

V_s, Slipstream velocity

T, Thrust, absolute coefficient $C_T=\frac{T}{\rho n^2 D^4}$

Q, Torque, absolute coefficient $C_Q=\frac{Q}{\rho n^2 D^5}$

P, Power, absolute coefficient $C_P=\frac{P}{\rho n^3 D^5}$

C_s, Speed-power coefficient$=\sqrt[5]{\frac{\rho V^5}{Pn^2}}$

η, Efficiency

n, Revolutions per second, r.p.s.

Φ, Effective helix angle$=\tan^{-1}\left(\frac{V}{2\pi rn}\right)$

5. NUMERICAL RELATIONS

1 hp.=76.04 kg-m/s=550 ft-lb./sec.

1 metric horsepower=1.0132 hp.

1 m.p.h.=0.4470 m.p.s.

1 m.p.s.=2.2369 m.p.h.

1 lb.=0.4536 kg.

1 kg=2.2046 lb.

1 mi.=1,609.35 m=5,280 ft.

1 m=3.2808 ft.