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COMMUNICATED BY THE PRINCIPAL DIRECTOR OF SCIENTIFIC RESEARCH (AIR), MINISTRY OF SUPPLY

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Summary.—This note contains the results of tests made in the Royal Aircraft Establishment 24-ft. tunnel on the Rotol hydulignum propeller RA.10046 designed for the Spitfire IX aircraft. The overall thrust and torque measurements have been analysed to give mean lift-drag data, and these have been compared with those for other propellers. When account is taken of the comparative root thickness and pitch distributions, it is shown that in general, the present results confirm conclusions from earlier analyses particularly as to the large influence of root thickness on the start of the stall. The blade has however a higher $C_{D\,min.}$ at low Mach number than was expected. For the take off condition on the Spitfire IX, the propeller gives almost 25 per cent. more thrust than does the corresponding Rotol metal design.[3] Part of this increase results from the 15 per cent. greater solidity of the wooden propeller.

1. *Introduction*.—Previous notes[1, 2, 3] have given the results of tests in the Royal Aircraft Establishment 24-ft. tunnel on various propellers designed for Spitfire aircraft. The present note continues the series by giving the results for a Rotol hydulignum propeller designed for the Spitfire IX. The results have been analysed to give mean $C_D - C_L$ data and these are compared with those derived[3, 4, 5] from the test results for the previous propellers.

2. *Details of Propeller and Range of Tests*.—The propeller tested was a two-bladed version of the Rotol compressed wood design. This propeller is of 10·75-ft. diameter, has a solidity per blade of 0·0338 and is 9·3 per cent. thick at the 0·7 radius. Over most of its length the section shape is Clark Y. The thickness distribution, plan form and pitch distribution are shown in Fig. 1. The thickness and pitch distributions are compared in Figs. 2 and 3 with those of other propellers previously tested in the 24-ft. tunnel.

The propeller was tested at four pitch settings 10·1 deg., 15·1 deg., 22 deg., and 27 deg. at 0·7 radius. For the two lower settings, measurements of overall thrust and torque were made for minimum tunnel speed and also for values of advance ratio (J) of 0·2, 0·3, 0·4, 0·5, 0·6 approximately for a range of tip speeds up to the speed of sound. At the two higher pitch settings, the tests had to be restricted owing to the severe flutter of the blades particularly at incidences corresponding to the beginning of the stall. Strain gauge measurements[6] were made by S.M.E. Department, R.A.E. to determine the limiting safe r.p.m. at these incidences under tunnel conditions. As a result, it was not considered possible to exceed safely a tip Mach number of about 0·7 (N = 1,400 r.p.m.) at 22 deg. or 0·6 (N = 1,200 r.p.m.) at 27 deg. Also, the tip Mach number of 0·7 at 22 deg. could only be achieved at tunnel speeds equal to or greater than 120 ft./sec.

* R.A.E. Technical Note No. Aero. 1780, received 13th June, 1946.

The strain-gauge measurements had to be made on the propeller without spinner. To produce a consistent set of performance data, it was considered essential to run with the spinner fitted, hence the two sets of measurements were not made simultaneously.

The above range of tests corresponds to a variation of mean blade incidence from -3 deg. up to 16 deg. at low Mach number and up to about 4 deg. at tip Mach number greater than $0 \cdot 6$ (*see* Fig. 5).

3. *Results of Tests.*—The results have been reduced to the usual coefficients, details of which are given in the list of symbols. The propulsive thrusts are derived by the formula

$$T_p = (T - R) + R_0$$

where
T_p Propulsive thrust
T " free air " thrust,
R_0 drag of nacelle and pylon without a propeller,
R drag of nacelle and pylon with propeller running,
$T - R$ tunnel balance reading.

This propeller in its original four-bladed form has to absorb the take-off power (1,375 H.P.) of a Merlin 61 engine while running at 1,430 r.p.m. (propeller). It can be deduced from the experimental results that the two-bladed propeller will absorb half the above power i.e. 687 H.P. giving a thrust of $2 \cdot 77$ lb./H.P. at a mean take-off speed of 75 m.p.h. The considerable improvement over the performance of the metal propeller[3] for the Spitfire IX which only gave $2 \cdot 24$ lb./H.P. thrust at 70 m.p.h. is principally due to the 15 per cent. greater solidity and the increased thickness ratio both of which delay the stall to a higher power absorption.

4. *Analysis of Results.*—The results have been analysed by Lock's single-radius method (R. & M. 1849[7]) into $C_D - C_L$ polar curves (Fig. 4) and C_L against α curves (Fig. 5) (up to tip Mach numbers of $1 \cdot 0$ at low incidence and $0 \cdot 6$ at the stall and beyond). The scatter of the experimental results is indicated in the figures which include both the actual points from the analysis and also mean curves. As in Ref. 5 it was found that for values of C_L corresponding to the beginning of the stall, there was a certain discrepancy between the results from two different pitch settings. This was more marked on the C_D against C_L curves than on the C_L against α curves, but it was possible to draw satisfactory mean curves in both cases. The general features of the curves were as expected: a rise in C_D with Mach number at moderate C_L values but an increase in stalling C_L with Mach number. Other features to be noted are the high values of $C_{D\,\mathrm{min.}}$ even at low Mach number (*see also* section 5.1), and the fact that $C_{D\,\mathrm{min.}}$ occurs at an increased C_L at high Mach numbers (i.e. $C_L = 0 \cdot 46$ at $M_T = 0 \cdot 5$ and $C_L = 0 \cdot 62$ for $M_T = 0 \cdot 9$).

5. *Comparison with Other Data.*—Figs. 6 and 7 compare the C_D against C_L curves for tip Mach numbers of $0 \cdot 5$ and $0 \cdot 9$ respectively for the five different propellers whose thickness and pitch distributions are plotted in Figs. 2, 3. For ease of reference in the following discussion, the propellers are listed here:

I R.A.E. wooden propellers[4], $(t/c)_{0 \cdot 7} = 12 \cdot 5$ per cent.

II Rotol hydulignum propeller of present note, $(t/c)_{0 \cdot 7} = 9 \cdot 3$ per cent.

III de Havilland standard Spitfire I propeller[4,5] $(t/c)_{0 \cdot 7} = 7 \cdot 6$ per cent.

IV Rotol metal propeller,[3] $(t/c)_{0 \cdot 7} = 7 \cdot 1$ per cent.

V Thinned version of III, $(t/c)_{0 \cdot 7} = 6$ per cent.

It is clear from Figs. 6 and 7 that for neither low nor high Mach number, is it possible to consider the thickness ratio at $0 \cdot 7$ radius as the only important criterion. This conclusion is particularly true, when applied to behaviour at the stall.

The plan forms of the five blades can be treated as reasonably similar except for the fact that blades III and V have thicker roots with smaller chords than the other blades. (An increase in the blade chords by a proportionate amount at all radii is allowed for by the single radius method.) The differences in the C_D against C_L curves for the various designs must therefore be principally correlated with the thickness and pitch distributions.

5.1. *Comparison at Low Mach Number.*—5.11. *Below the Stall.*—From Fig. 6 which compares the C_D against C_L polars for low Mach number, it can be seen that $C_{D\,\text{min.}}$ occurs at a higher value of C_L for the thicker sections and that except for the propeller considered in this note, $C_{D\,\text{min.}}$ itself increases steadily with thickness ratio. The exception follows from the fact that $C_{D\,\text{min.}} = 0{\cdot}023$ for the present propeller (II) but only $0{\cdot}020$ for the much thicker R.A.E. wooden propellers (I). Since $C_{D\,\text{min.}}$ for the latter propeller occurs at the extreme lower end of the incidence range covered, it is possible that the $0{\cdot}020$ value is not very accurate. The shape of the curves of Fig. 6 for propellers I, II suggests the difference is one of profile drag and hence it is unlikely that the differing pitch distributions of the propellers (which would affect their relative induced drags) is the cause.

5.12. *Stalling Behaviour.*—The stalling C_L is very dependent on the thickness and pitch distributions at the roots. The following double comparison is of interest, where the stalling C_L is defined as the value of C_L when C_D has risen to $0{\cdot}1$.

Blade Design	$(t/c)_{0\cdot3R}$	$(t/c)_{0\cdot7R}$	$\theta_{0\cdot3R} - \theta_{0\cdot7R}$	C_L for $C_D = 0{\cdot}1$
	per cent.	per cent.	deg.	
II	21·3	9·3	19·8	1·155
IV	21·3	7·1	15·5	0·99
III	36	7·6	18·4	1·155
V	34·7	6	18·4	0·97

Since blade IV has a smaller value of $(\theta_{0\cdot3} - \theta_{0\cdot7})$ than blade II, it will operate with its root sections at a lower incidence. Hence it can be expected that if blade IV had had the same pitch distribution as blade II, the value of C_L for $C_D = 0{\cdot}1$ would have been less than $0{\cdot}99$. The results of the above table would then be roughly consistent if it were assumed that

(i) an increase in $(t/c)_{0\cdot7}$ of 1 per cent. increases the mean stalling* C_L by about $0{\cdot}1$ (assuming *no* difference in $(t/c)_{0\cdot3}$ or in $(\theta_{0\cdot3} - \theta_{0\cdot7})$),

(ii) the difference in pitch distributions of II and IV accounted for a difference in mean stalling* C_L of about $0{\cdot}06$.

Further by comparing III and IV and using both assumptions (i) and (ii) above, it follows that a drop in mean stalling C_L of about $0{\cdot}15$ results from thinning the root sections such that the blade is 30 per cent. thick at $r/R = 0{\cdot}24$ (blade IV) instead of $r/R = 0{\cdot}32$ (blade III).

Finally it should be noted that for very high incidences and C_D values, the thinnest blade may ultimately give the best C_L value. This is discussed in Ref. 5 but the tests on propeller II described here did not extend to this range.

* Mean stalling C_L is here taken to imply mean C_L corresponding to mean $C_D = 0{\cdot}1$.

5.2. *Comparison of Mach Number Effects* (Fig. 7).—The change in performance resulting from an increase in tip Mach number from $0 \cdot 5$ to $0 \cdot 9$ is given in the following table :

Design	Increase in $C_{D\,min.}$	Increase in C_L for $C_D = 0 \cdot 1$
I	$0 \cdot 019$	$-0 \cdot 34$
II	$0 \cdot 012$	$0 \cdot 025$
III	$0 \cdot 007$	$-0 \cdot 01$
IV	$0 \cdot 004$	0
V	$0 \cdot 002$	0

It will be seen that the effect on $C_{D\,min.}$ increases steadily with blade thickness. Also, for thin blades, Mach number effects on the stall are negligible (though as shown by Monaghan[5], when the blades are badly stalled i.e. for mean C_D values of $0 \cdot 2$ or more, there is a definite fall in C_L* with Mach number). Since under tunnel operating conditions it is only the outer half of the blades that suffer appreciable compressibility effects, it would not be expected that the form of the inner parts of the blades would have much influence on Mach number effects. However, it appears that there is an increase in $C_{L\,max.}$ with Mach number for the relatively thin root sections of blade II of the present note. As can be seen from Fig. 4, the condition $C_D = 0 \cdot 1$ corresponds to the highest incidence reached for $M_T = 0 \cdot 9$ for propeller II in the tunnel tests and therefore too much reliance should not be placed on the above conclusion.

6. *Conclusions from Analysis.*—1. At low Mach number, for the hydulignum propeller (II) considered in this note, mean $C_{D\,min.} = 0 \cdot 023$ (which is unexpectedly high) and C_D has risen to $0 \cdot 1$ for $C_L = 1 \cdot 15_5$.

2. The results at low Mach number can be considered to be roughly consistent with those on propellers previously tested.

3. By comparison with other Spitfire propellers tested, it appears that

(*a*) an increase in $(t/c)_{0 \cdot 7}$ of 2 per cent. with no change in root thickness gives an increase in mean stalling $C_{L\,max.}$ (for $C_D = 0 \cdot 1$) of about $0 \cdot 2$,

(*b*) an increase in $(\theta_{0 \cdot 3} - \theta_{0 \cdot 7})$ of 3 deg. may result in a loss in mean stalling C_L of about $0 \cdot 04$.

(*c*) a thinning of the roots such that a 30 per cent. thick section is produced at $r/R = 0 \cdot 24$ instead of $0 \cdot 32$ with no change in outboard t/c reduces mean stalling $C_{L\,max.}$ by about $0 \cdot 15$; this shows the importance of the root thickness distribution.

4. An increase in tip Mach number from $0 \cdot 5$ to $0 \cdot 9$ increases $C_{D\,min.}$ for this propeller (II) from $0 \cdot 023$ to $0 \cdot 035$ and increases C_L for $C_D = 0 \cdot 1$ from $1 \cdot 15_5$ to $1 \cdot 18$. These figures are in general agreement with expectations.

*For given C_D.

LIST OF SYMBOLS

D	propeller diameter
n	propeller rotational speed (revs./sec.)
V	forward speed
ρ	air density
K_T	Propulsive thrust coefficient $\dfrac{\text{(Propulsive Thrust } (T_p)}{\rho n^2 D^4}$
K_Q	Torque coefficient $\dfrac{\text{Torque}}{\rho n^2 D^5}$
J	Advance ratio $\dfrac{V}{nD}$
η	Propulsive efficiency $\dfrac{J}{2\pi}\dfrac{K_T}{K_Q}$
M_T	Tip Mach number $\dfrac{\text{Resultant tip speed}}{\text{Speed of sound}}$

REFERENCES

No.	*Author*	*Title, etc.*
1	Diprose	Effect of Compressibility on the Performance of Propellers. Preliminary Tables of 24-ft. Wind Tunnel Results. R.A.E. Tech. Note No. Aero.977. A.R.C. 6078. June, 1942. (To be published.)
2	Monaghan..	Effect of Compressibility on the Performance of Propellers. Tables of 24-ft. Wind Tunnel Results (4th series). R.A.E. Tech. Note. No. Aero. 1607. A.R.C. 8556. February, 1945. (To be published.)
3	Haines and Chater	24-ft. Tunnel Tests on a Rotol Metal Spitfire Propeller. Test Results and Data for Single-Radius Calculations. R.A.E. Tech. Note No. Aero. 1728. A.R.C. 9378. November, 1945. (Unpublished).
4	Haines	A Comparison of Aerofoil Data for use in Single-Radius Propeller Performance Calculations. R. & M. 2188. January, 1947.
5	Monaghan..	The Performance of Stalled Propellers. Results and analysis of some 24-ft. Tunnel Tests. R. & M. 2340. March, 1946.
6	Sterne, Ewing and Kettlewell ..	Wind Tunnel Tests of a Fluttering Propeller. Strain Gauge Investigation of Propeller Flutter. R. & M. 2472. January, 1947.
7	Lock	A Graphical Method of Calculating the Performance of an Airscrew. R. & M. 1849. August, 1938.

TABLE 1

Propeller 34

Number of blades = 2 Diameter = 10·75 ft.

$\theta_{0\cdot7}$ = 10·1 deg.

J	M_T	K_Q	K_T	η
0·170	0·500	0·00343	0·0532	0·421
0·157	0·624	0·00367$_5$	0·0574	0·390
0·155	0·750	0·00399	0·0620	0·384
0·203	0·558	0·00343	0·0500	0·471
0·197	0·709	0·00383	0·0542	0·445
0·198	0·826	0·00409	0·0575	0·445
0·201	0·847	0·00417	0·0569	0·436
0·196	0·906	0·00445	0·0584	0·411
0·199	0·951	0·00461	0·0559	0·386
0·200	0·984	0·00475	0·0548	0·369
0·302	0·372	0·00300	0·0354	0·585
0·299	0·567	0·00316	0·0344	0·520
0·301	0·658	0·00326	0·0353	0·518
0·300	0·755	0·00334	0·0347	0·497
0·299	0·808	0·00382	0·0348	0·434
0·301	0·849	0·00352	0·0341$_5$	0·465
0·299	0·900	0·00364	0·0333	0·437
0·300	0·944	0·00380	0·0317	0·399
0·299	0·987	0·00397	0·0303	0·364
0·400	0·426	0·00238	0·0176	0·486
0·400	0·569	0·00253	0·0158	0·398
0·399	0·640	0·00257	0·0153	0·380
0·400	0·710	0·00261	0·0146	0·355
0·399	0·783	0·00269	0·0135$_5$	0·321
0·400	0·856	0·00283	0·0130	0·292
0·400	0·928	0·00303	0·0098	0·207
0·399	0·949	0·00309	0·0061	0·126
0·398	0·974	0·00315	0·0049	0·098
0·401	0·997	0·00313	0·0042	0·092
0·499	0·453	0·00164	−0·0004	—
0·499	0·514	0·00165	−0·0015$_5$	—
0·500	0·570	0·00171	−0·0023	—
0·498	0·629	0·00172	−0·0032	—
0·499	0·687	0·00175	−0·0039	—
0·502	0·745	0·00183	−0·0041	—
0·501	0·799	0·00183	−0·0056	—
0·500	0·859	0·00192	−0·0070	—
0·500	0·903	0·00202	−0·0089	—
0·498	0·944	0·00217	−0·0115	—
0·500	0·972	0·00214	−0·0261	—
0·498	1·002	0·00218	−0·0297$_5$	—
0·599	0·479	0·00073	−0·0203	—
0·602	0·576	0·00068	−0·0225	—
0·600	0·624	0·00075	−0·0220	—
0·602	0·670	0·00072	−0·0227$_5$	—
0·602	0·718	0·00074	−0·0228	—
0·601	0·763	0·00085	−0·0368	—
0. 600	0·814	0·00114	−0·0374	—
0·600	0·838	0·00091	−0·0377	—

TABLE 2

Number of blades = 2 Diameter = 10·75 ft.

$\theta_{0\cdot7}$ = 15·1 deg.

J	M_T	K_Q	K_T	η
0·199	0·706	0·00729	0·0942	0·410
0·200	0·844	0·01095	0·1142	0·332
0·200	0·903	0·01156	0·1137	0·309
0·198	0·948	0·01135	0·1101	0·308
0·199	0·982	0·01111	0·1075	0·307
0·307	0·371	0·00553	0·0670	0·592
0·299	0·565	0·00613	0·0728	0·568
0·300	0·655	0·00651	0·0760$_5$	0·560
0·301	0·751	0·00702	0·0810	0·552
0·298	0·806	0·00716	0·0877	0·580
0·300	0·846	0·00814	0·0930	0·546
0·297	0·894	0·00914	0·0948$_5$	0·492
0·300	0·938	0·00948	0·0922	0·466
0·298	0·984	0·00916	0·0868$_5$	0·450
0·399	0·425	0·00508	0·0550	0·690
0·399	0·566	0·00544	0·0574	0·660
0·399	0·637	0·00570	0·0607	0·662
0·399	0·706	0·00598	0·0619	0·658
0·404	0·779	0·00631	0·0644	0·658
0·400	0·850	0·00676	0·0679$_5$	0·642
0·400	0·923	0·00698	0·0658$_5$	0·603
0·399	0·946	0·00695	0·0630	0·577
0·400	0·991	0·00685	0·0578	0·539
0·499	0·456	0·00441	0·0400	0·722
0·500	0·512	0·00444	0·0397	0·712
0·499	0·568	0·00459	0·0410	0·710
0·506	0·625	0·00461	0·0408	0·713
0·500	0·685	0·00475	0·0413	0·692
0·502	0·738	0·00473	0·0407	0·688
0·500	0·794	0·00483	0·0408	0·674
0·502	0·851	0·00487	0·0399	0·655
0·501	0·904	0·00492	0·0362	0·588
0·498	0·940	0·00496	0·0334	0·536
0·495	0·969	0·00492	0·0301$_5$	0·488
0·492	0·997	0·00498	0·0303	0·485
0·598	0·477	0·00317	0·0223	0·673
0·598	0·574	0·00322	0·0210	0·624
0·600	0·620	0·00318	0·0200	0·603
0·600	0·667	0·00317	0·0192	0·579
0·602	0·714	0·00317	0·0182	0·553
0·599	0·761	0·00317	0·0177	0·534
0·600	0·811	0·00324	0·0151$_5$	0·447
0·588	0·834	0·00328	0·0149$_5$	0·433
0·591	0·859	0·00335	0·0161	0·458

TABLE 3

Number of blades = 2 Diameter = 10·75 ft.

$\theta_{0\cdot 7}$ = 22 deg.

J	M_T	K_Q	K_T	η
0·232	0·403	0·01078	0·1097	0·376
0·414	0·406	0·01020	0·0954	0·617
0·552	0·409	0·00960	0·0791	0·727
0·690	0·412	0·00807	0·0583	0·795
0·828	0·415	0·00563	0·0341	0·798
0·969	0·420	0·00255	0·0110	0·665
0·213	0·502	0·01169	0·1111	0·323
0·333	0·504	0·01130	0·1066	0·500
0·444	0·506	0·01077	0·0959	0·631
0·553	0·508	0·01008	0·0821	0·718
0·666	0·511	0·00875	0·0636	0·772
0·776	0·516	0·00680	0·0441	0·803
0·883	0·519	0·00452	0·0253	0·787
0·942	0·521	0·00319	0·0136	0·642
0·210	0·599	0·01291	0·1101	0·286
0·278	0·600	0·01252	0·1108	0·391
0·371	0·603	0·01218	0·1072	0·520
0·464	0·605	0·01160	0·0984	0·628
0·556	0·606	0·01086	0·0860	0·703
0·649	0·609	0·00950	0·0694	0·755
0·739	0·614	0·00787	0·0524	0·784
0·788	0·615	0·00678	0·0428	0·792
0·447	0·705	0·01292	0·1036	0·609
0·556	0·708	0·01194	0·0922	0·684
0·634	0·711	0·01056	0·0770	0·737
0·676	0·713	0·00971	0·0682	0·760

TABLE 4

Number of blades = 2 Diameter = 10·75 ft.

$\theta_{0\cdot 7}$ = 27 deg.

J	M_T	K_Q	K_T	η
0·239	0·403	0·01693	0·1130	0·255
0·413	0·405	0·01505	0·1118	0·489
0·555	0·408	0·01460	0·1064	0·645
0·690	0·411	0·01369	0·0926	0·746
0·830	0·414	0·01185	0·0715	0·798
0·971	0·419	0·00940	0·0509	0·839
1·109	0·423	0·00608	0·0287	0·835
1·185	0·428	0·00368	0·0159	0·819
0·225	0·505	0·01810	0·1155	0·229
0·332	0·506	0·01688	0·1141	0·359
0·444	0·508	0·01588	0·1125	0·502
0·554	0·510	0·01552	0·1090	0·620
0·668	0·515	0·01481	0·0989	0·710
0·780	0·517	0·01347	0·0834	0·770
0·219	0·603	0·01914	0·1150	0·211
0·278	0·604	0·01875	0·1144	0·270
0·372	0·605	0·01765	0·1129	0·380
0·464	0·608	0·01690	0·1116	0·490
0·558	0·610	0·01670	0·1107	0·591
0·650	0·613	0·01618	0·1049	0·673
0·742	0·616	0·01500	0·0932	0·737

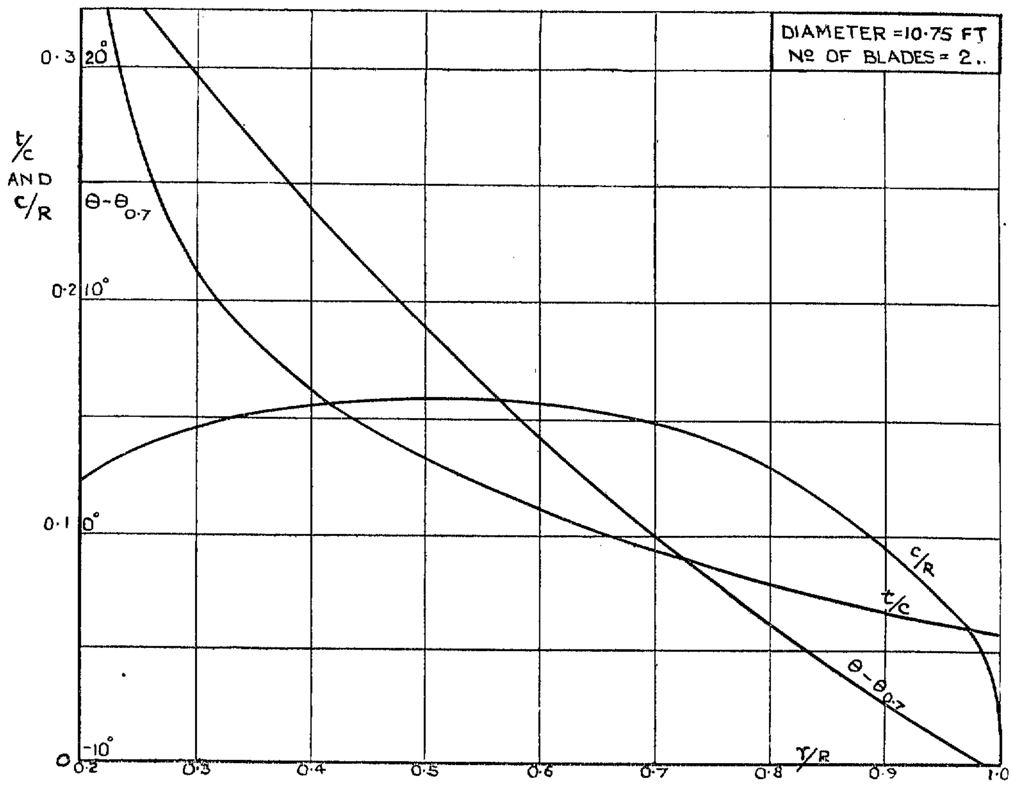

FIG. 1. Dimensions of Rotol Hydulignum Propeller for Spitfire IX Drg. No. R.A. 10046.

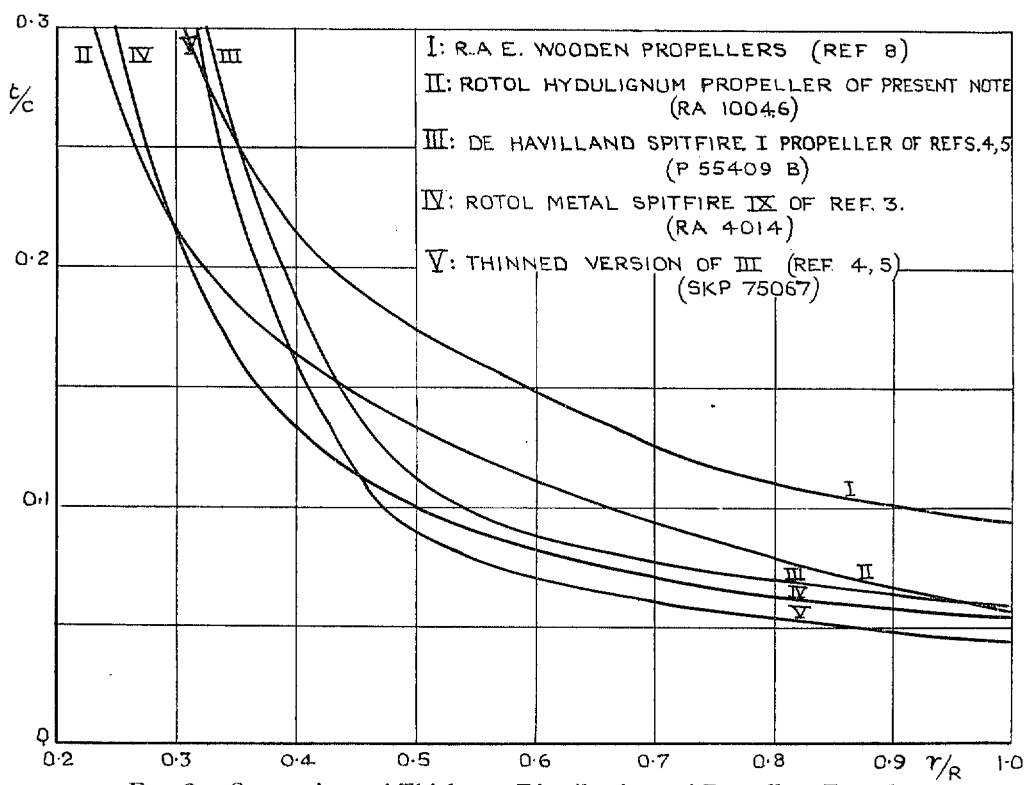

FIG. 2. Comparison of Thickness Distributions of Propellers Tested.

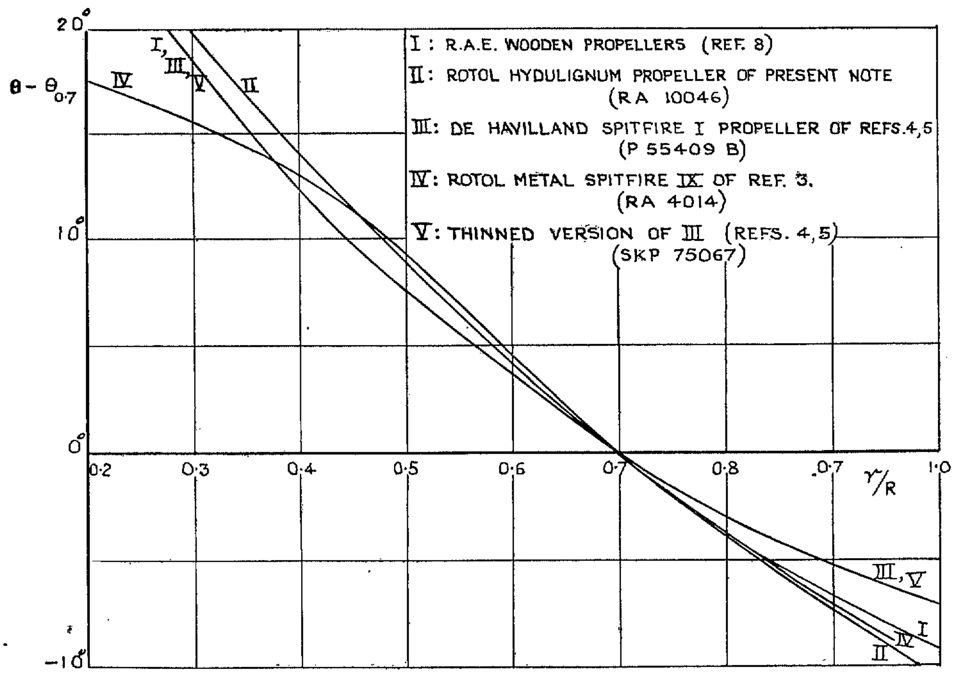

FIG. 3. Comparison of Pitch Distributions of Propellers Tested.

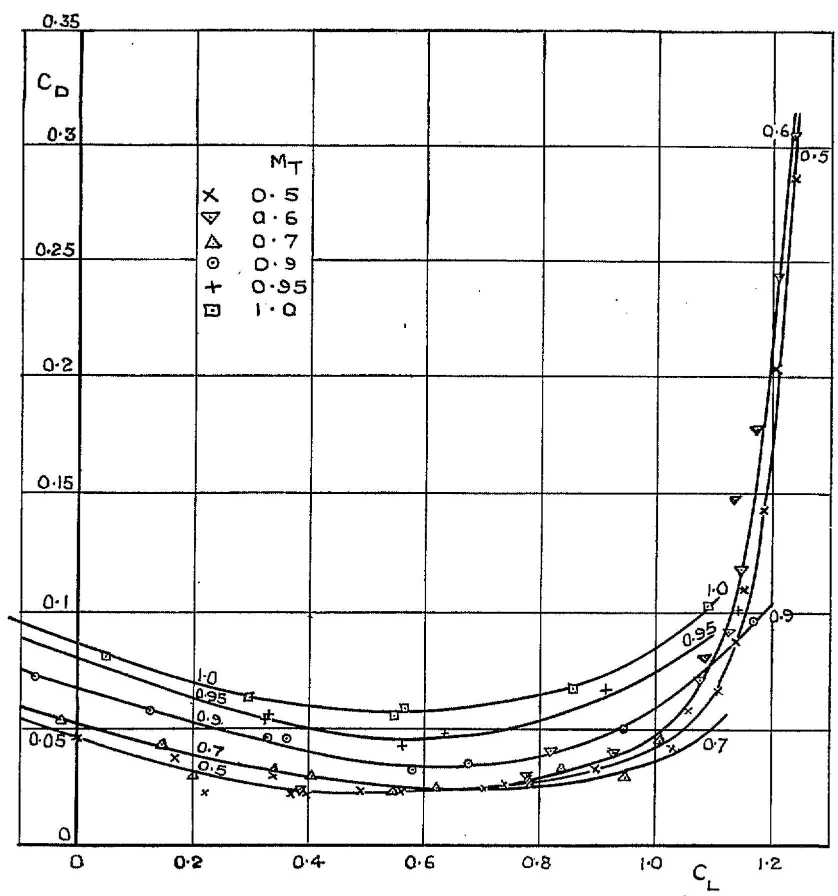

FIG. 4. C_D against C_L Polars at Constant M_T—$(t/c)_{0\cdot 7} = 9\cdot 3$ per cent.

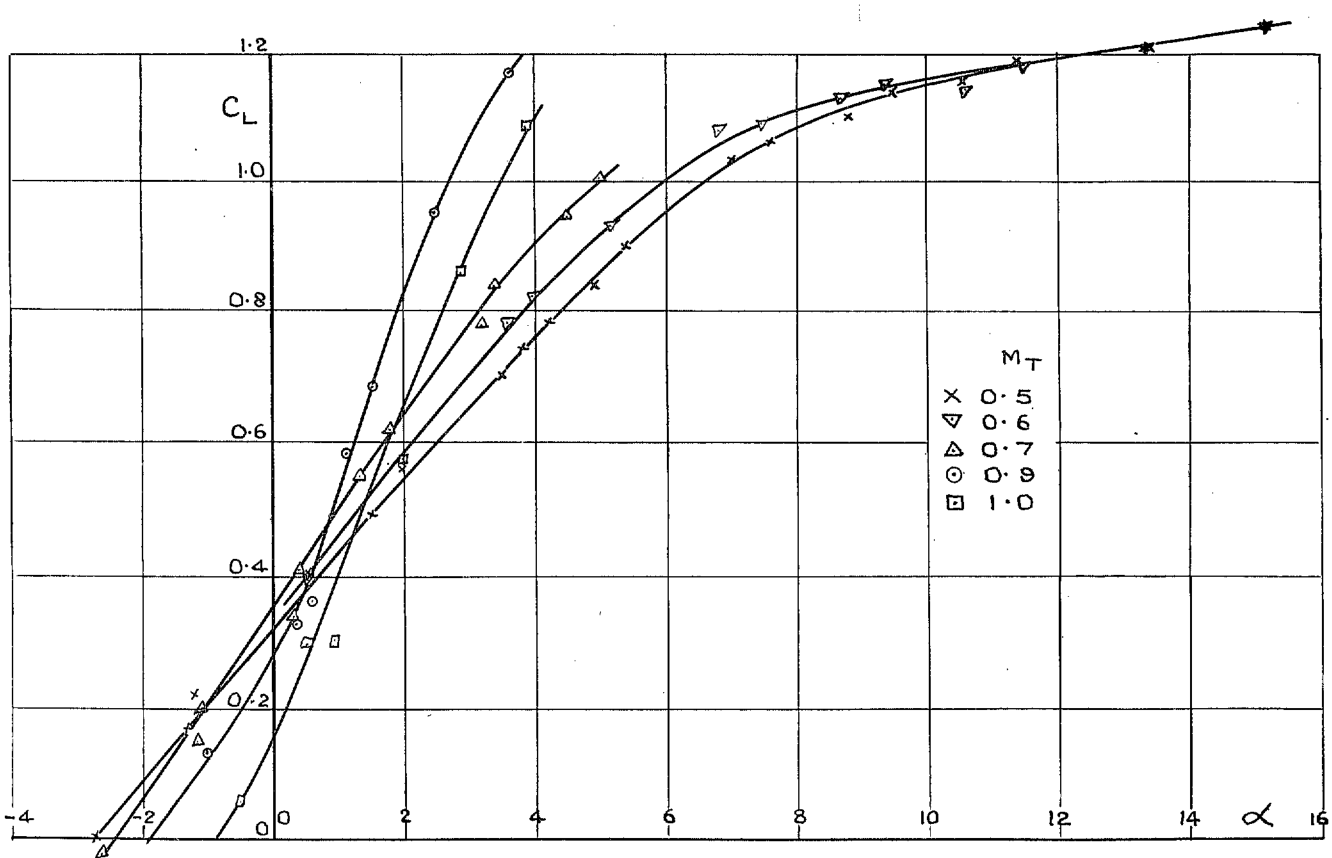

FIG. 5. C_L against α at Constant M_T—$(t/c)_{0\cdot 7} = 9\cdot 3$ per cent.

(88916) Wt. 13/806 K5 2/50 Hw.

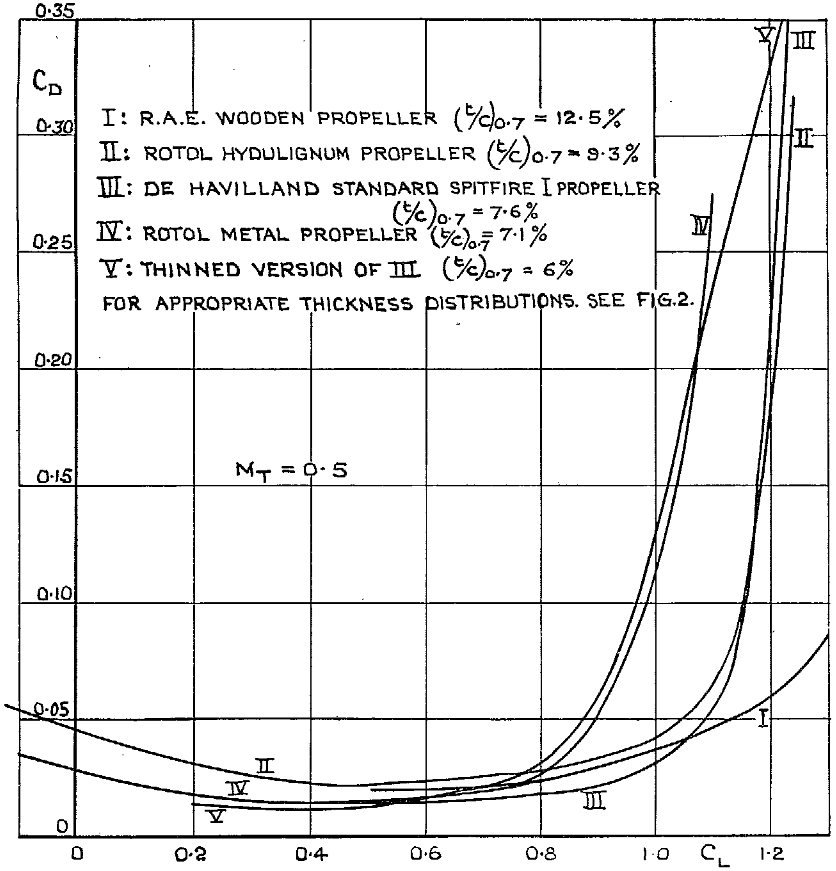

FIG. 6. Comparison of C_D against C_L Polars at Low Mach Number for Different Propellers.

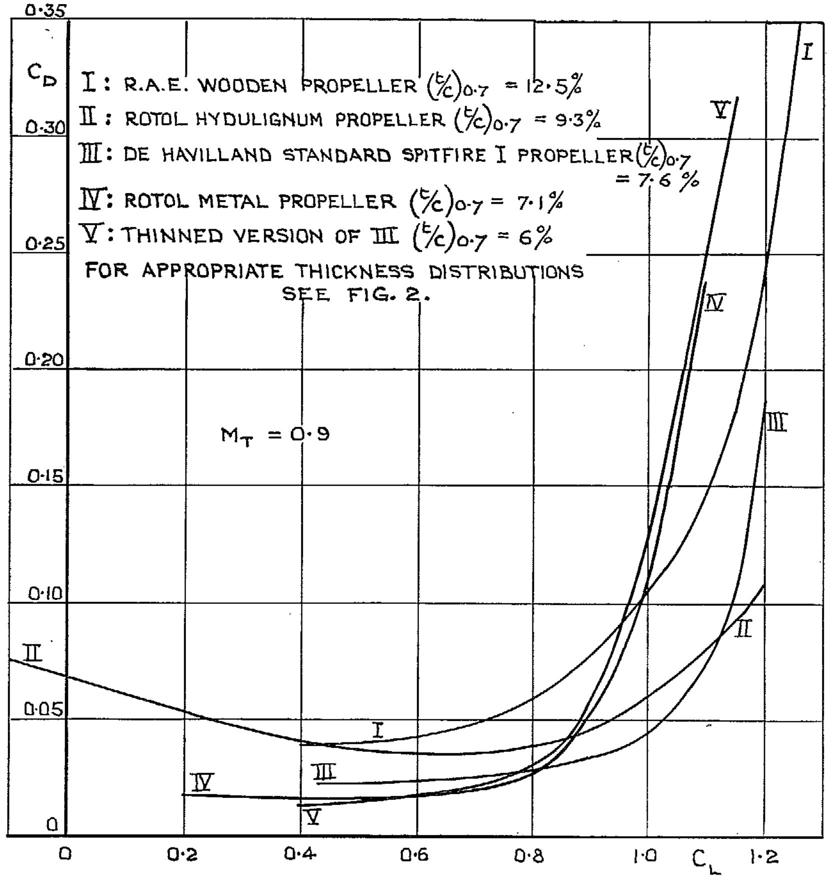

FIG. 7. Comparison of C_D against C_L Polars at High Mach Number for Different Propellers.

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