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TECHNICAL NOTES

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No. 299

THE EFFECT OF FILLETS BETWEEN WINGS AND FUSELAGE ON THE DRAG AND PROPULSIVE EFFICIENCY OF AN AIRPLANE

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THE EFFECT OF FILLETS BETWEEN WINGS AND FUSELAGE ON THE DRAG AND PROPULSIVE EFFICIENCY OF AN AIRPLANE.

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Summary

This note describes tests made to determine the effect of fillets between wings and fuselage on the drag and propulsive efficiency of a high-wing cabin monoplane. The tests were made in the 20-foot Propeller Research Tunnel of the National Advisory Committee for Aeronautics. It was found that at 100 M.P.H., the drag was reduced 2.0 lb. by the use of fillets of 6-inch radius and 5.1 lb. by the use of fillets of 12-inch radius. There is a small increase in propulsive efficiency due to the use of the larger fillets.

Introduction

On May 15, 1928, at the Third Annual Engineering Research Conference at Langley Field, Virginia, it was suggested by Mr. Charles Ward Hall that, in connection with a general investigation of mutual interference of airplane parts, the effect of fillets between wings and fuselages be determined. The present tests were made on a cabin type monoplane which had been mounted in the Propeller Research Tunnel for cowling tests in connection with another research. The effect of the fillets on the drag and propulsive efficiency was determined. The tests should be regarded as preliminary and the results applicable only to this particular airplane type.

T e s t s

The Propeller Research Tunnel, which is of the open-throat type, 20 ft. in diameter, and capable of producing an air speed of 110 M.P.H. is fully described in Reference 1.

The airplane used was of the cabin type high-wing monoplane with stub wing. The wing, having a Göttingen 398 profile, was of 7 ft. chord and 16 ft. span. The chord of the wing was set parallel to the thrust line of the airplane, which in turn was parallel to the air stream. Figure 1 is a view of the set-up with no fillets. Fillets of 6-inch and 12-inch radius were made to fair the lower surface of the wing into the fuselage. These are shown in Figures 2, 3, and 4.

With the propeller removed, drag tests of the airplane with and without fillets were made. After each of these tests the propeller was replaced and a power test was made in order to determine the propulsive efficiency. The propeller used in these tests was made in accordance with Navy drawing No. 4412 (Reference 2), and was of the aluminum alloy adjustable pitch type, 9 ft. in diameter. The blade angle was set to 15° at the 42-inch radius.

Results and Discussion

Figure 5 shows curves of the observed drag readings (including the drag of the supports) plotted against dynamic pressure. This figure also shows the approximate support drag which has been determined from previous tests. As may be seen on the curves, there is a variation in the value of D/q with velocity which indicates the existence of scale effect. The data taken at 100 M.P.H. were averaged and are tabulated below.

Condition	Average D/q at 100 M.P.H.	Total drag D lb., q equiv. to 100 M.P.H.	Reduction in drag, lb.	Equivalent flat plate area, sq.ft.
With no fillets	10.90	279	-	8.72
With 6-inch fillets	10.82	277	2	8.65
With 12-inch fillets	10.70	273.9	5.1	8.55

Where D = total drag in pounds

q = dynamic pressure in lb. per sq.ft. = $\frac{1}{2} \rho V^2$.

It may be seen that with a high-wing cabin monoplane of this type, assuming it to have a total drag of 300 lb. at 100 M.P.H., the total drag could be reduced by 2 lb. or about .7 per cent by the use of 6-inch fillets, and 5.1 lb. or 1.7 per cent by the use of 12-inch fillets.

Figures 6, 7, and 8 are curves showing propulsive characteristics obtained with the different fillets in place, and Figure 9 shows the curves of the three conditions superimposed for comparison. From these curves it appears that there is an increase in efficiency of about 1 per cent due to the use of 12-inch fillets.

The percentage reduction in drag and the increase in propulsive efficiency, due to the use of fillets, appears small; but as airplane design progresses, and the total drag is reduced, the use of fillets may become more important.

Bibliography

Reference 1. Weick, Fred E. and Wood, Donald H.: The Twenty-Foot Propeller Research Tunnel of the National Advisory Committee for Aeronautics. N.A.C.A. Technical Report No. 300. (1928)

Reference 2. Weick, Fred E.: Full Scale Wind Tunnel Tests of a Series of Metal Propellers on a VE-7 Airplane. N.A.C.A. Technical Report No. 306. (1928)

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., August 17, 1928.

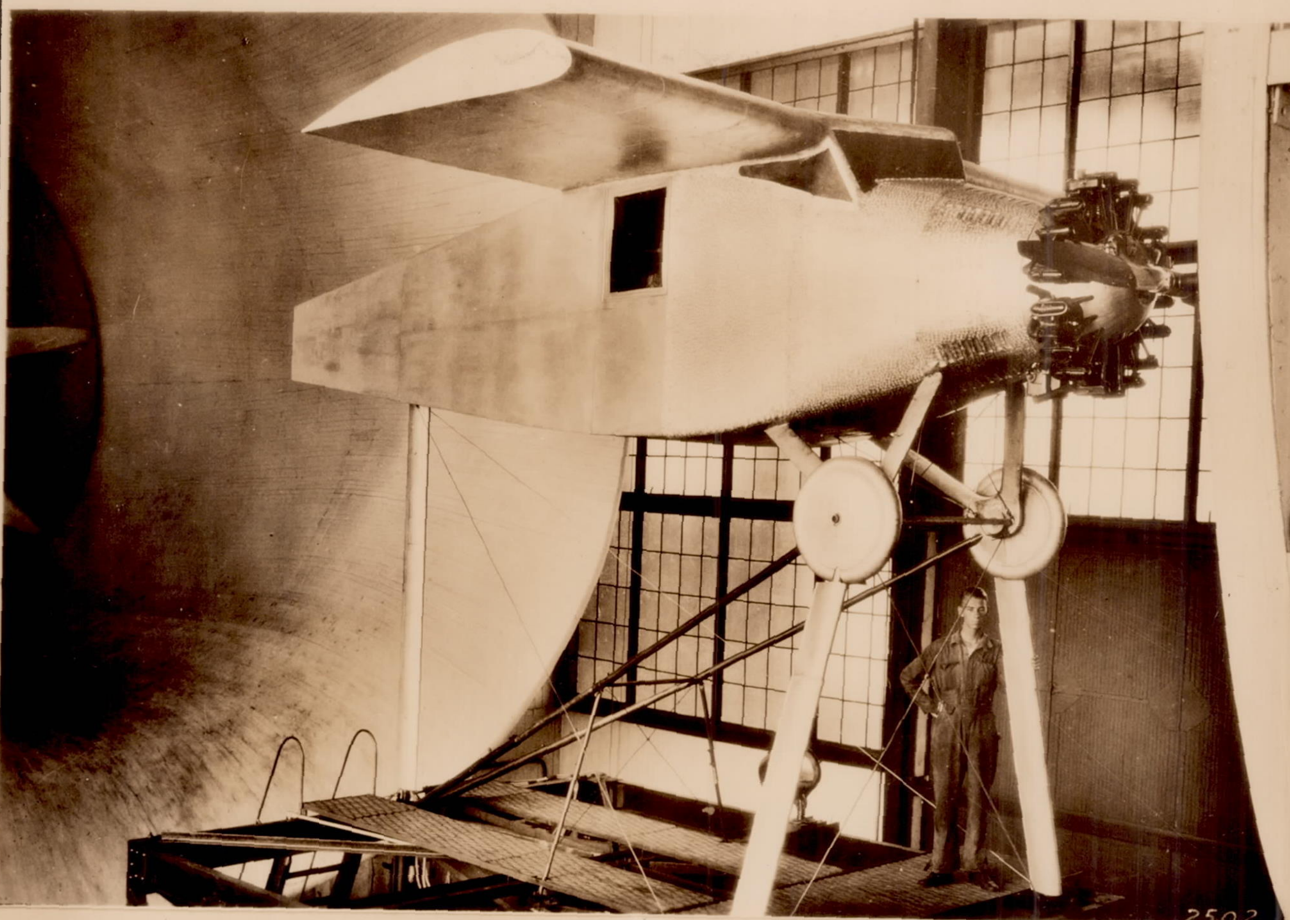


Fig. 1 Cabin monoplane without fillets mounted for test.

Fig. 2 Side view showing 6" fillets.

Fig. 3 Side view showing 12" fillets.

Fig. 4 Rear view showing 12" fillets.

N.A.C.A- #2785.

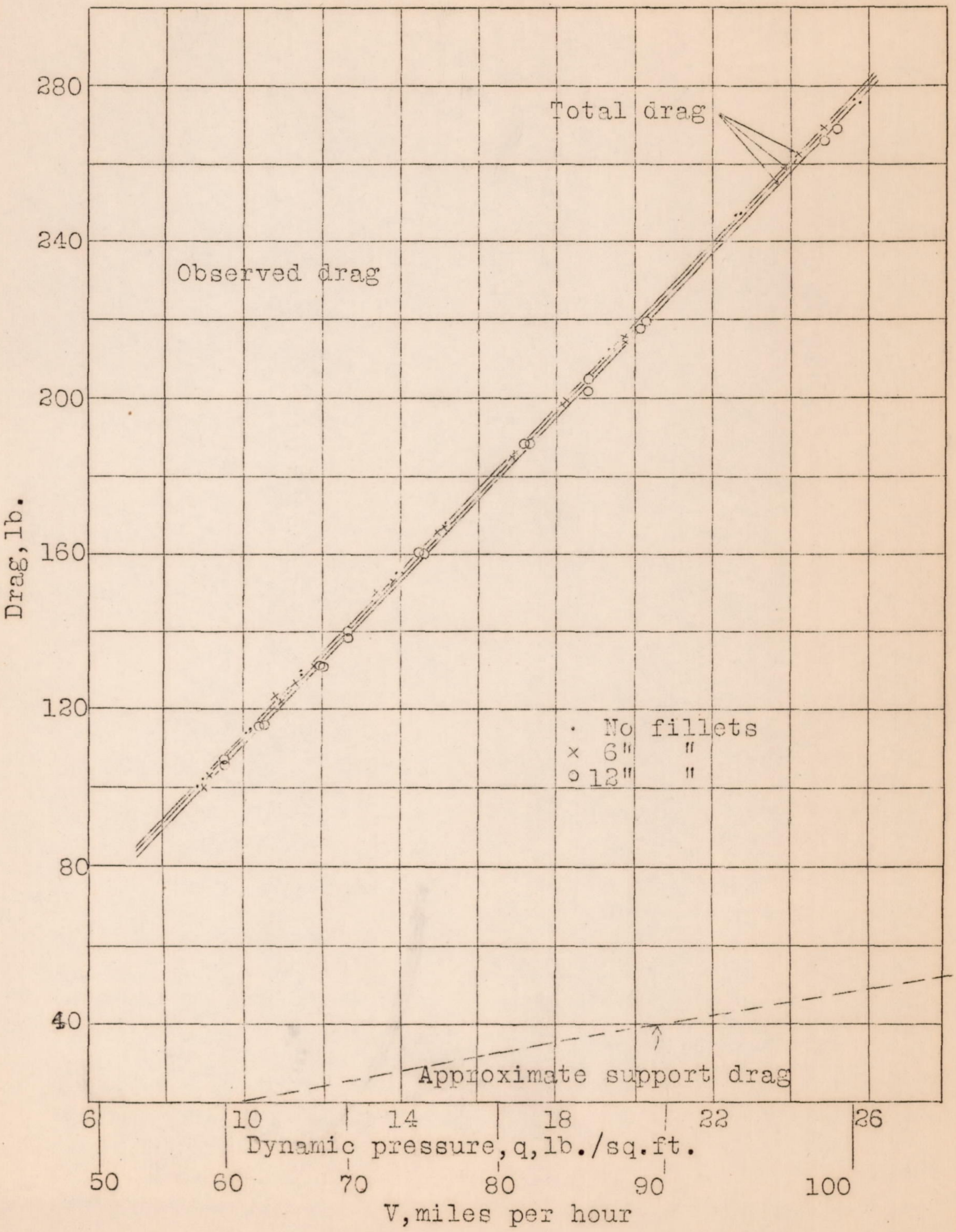

Drag, lb.
280
240
200
160
120
80
40
Total drag
Observed drag
· No fillets
× 6" "
○ 12" "
Approximate support drag
6
10
14
18
22
26
Dynamic pressure, q, lb./sq.ft.
50
60
70
80
90
100
V, miles per hour

Fig.5

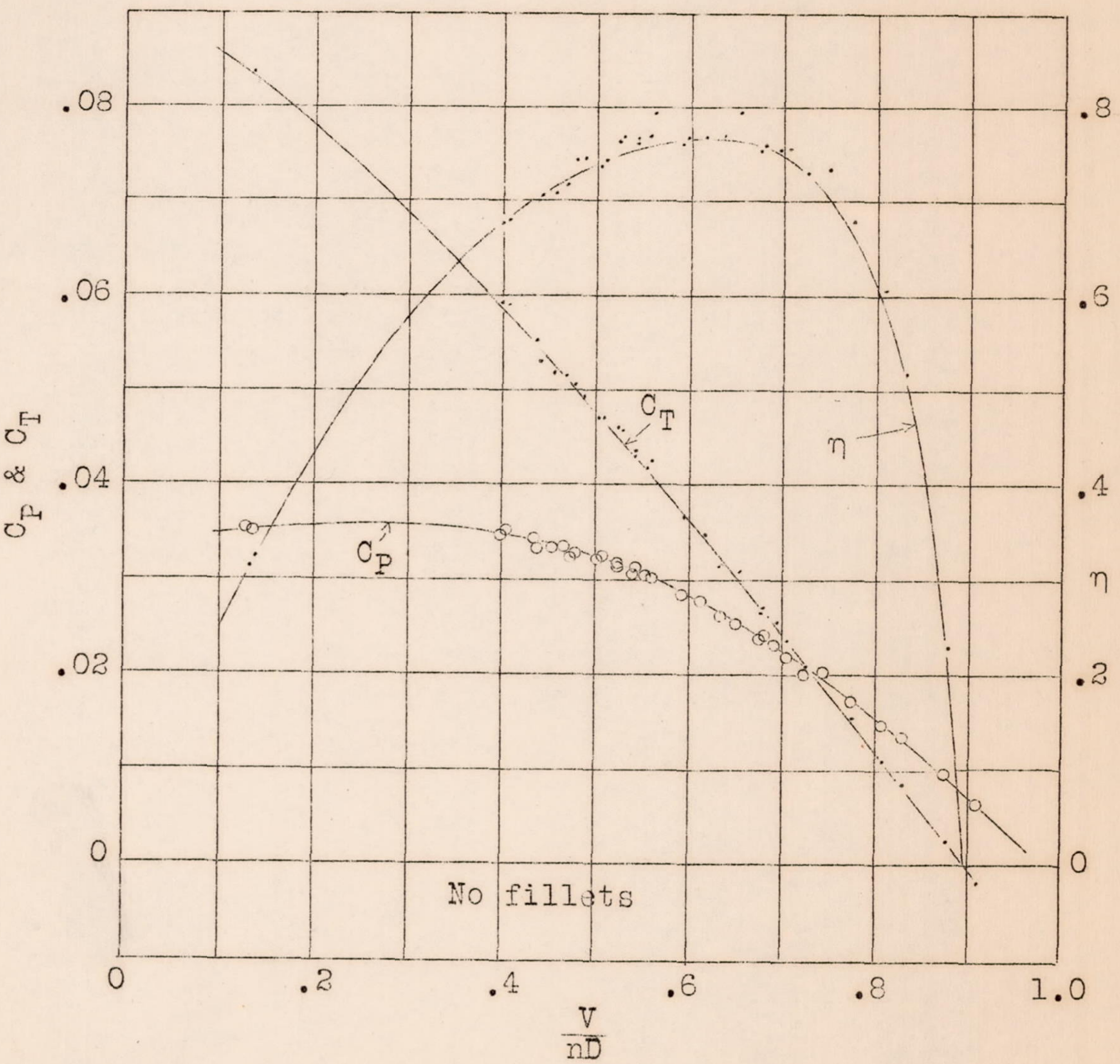


Fig.6 Propulsive characteristics, $C_T = \dfrac{T}{\rho n^2 D^4}$, $C_P = \dfrac{P}{\rho n^3 D^5}$, $\eta = \dfrac{C_T}{C_P} \times \dfrac{V}{nD}$

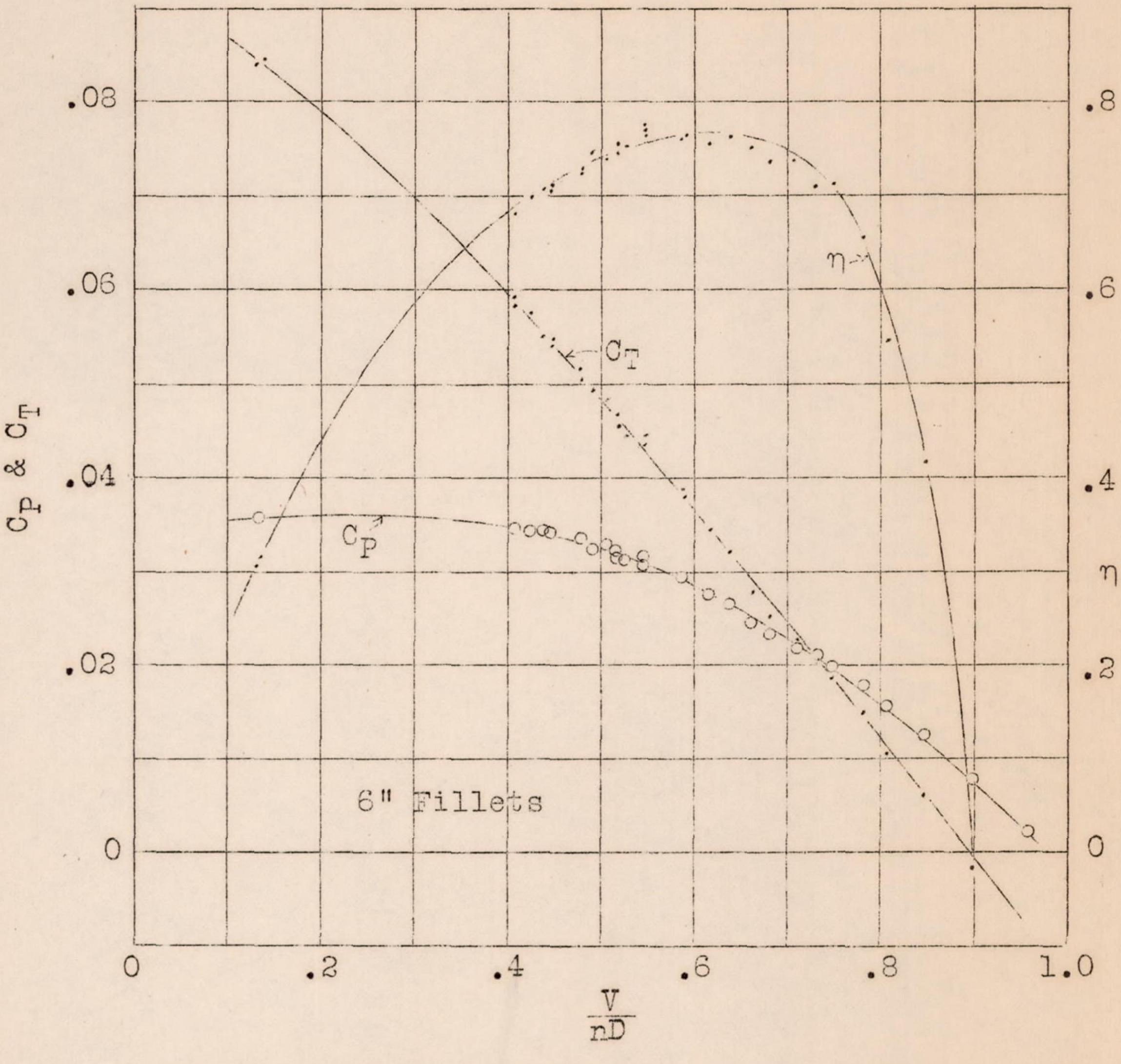


Fig.7 Propulsive characteristics, $C_T = \frac{T}{\rho n^2 D^4}$, $C_P = \frac{P}{\rho n^3 D^5}$, $\eta = \frac{C_T}{C_P} \times \frac{V}{nD}$

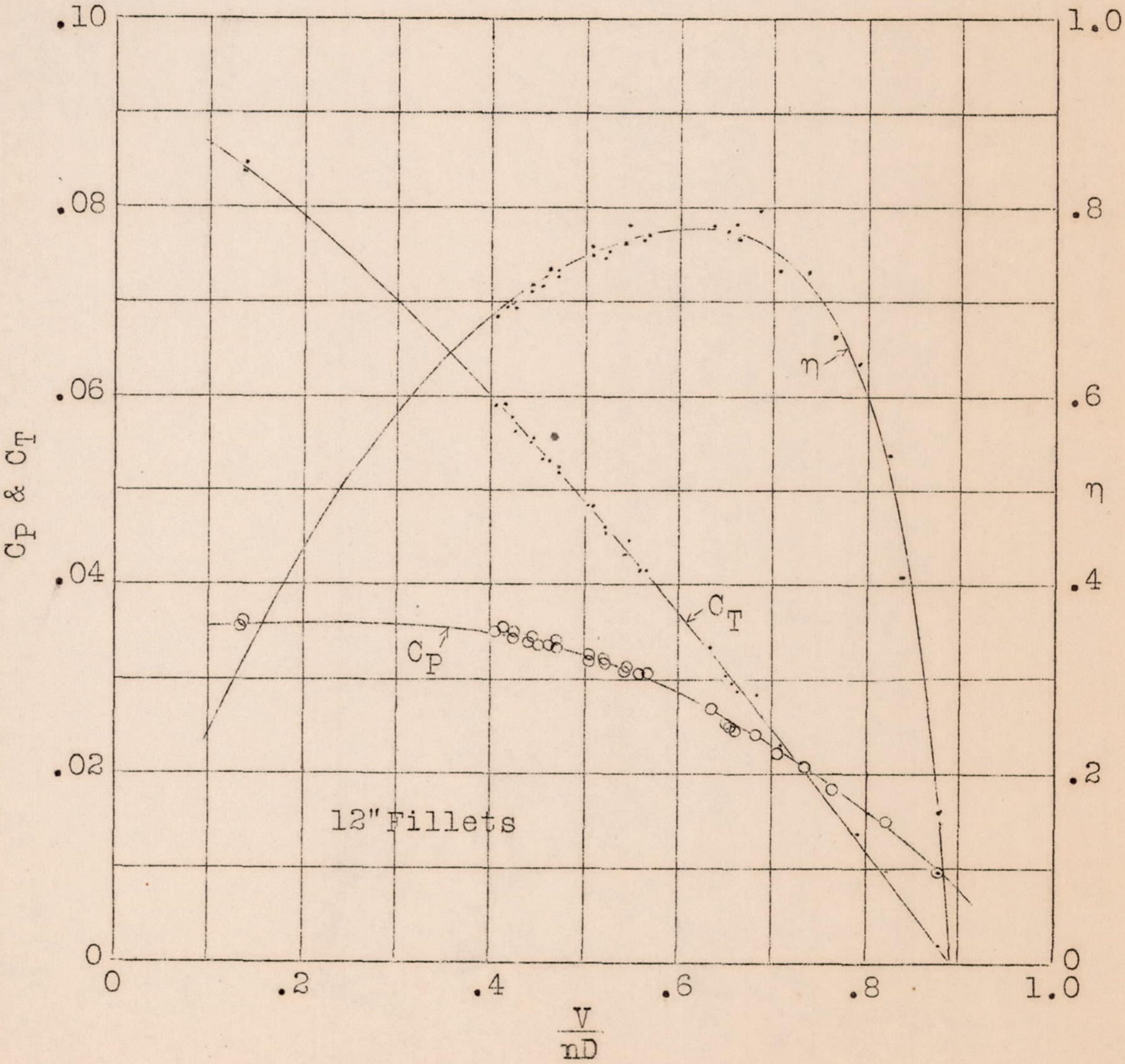
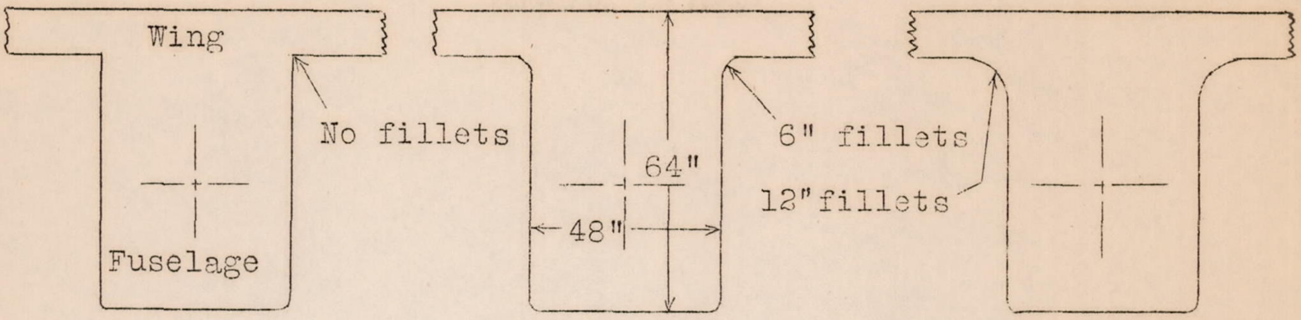


Fig.8 Propulsive characteristics, $C_T = \frac{T}{\rho n^2 D^4}$, $C_P = \frac{P}{\rho n^3 D^5}$, $\eta = \frac{C_T}{C_P} \times \frac{V}{nD}$



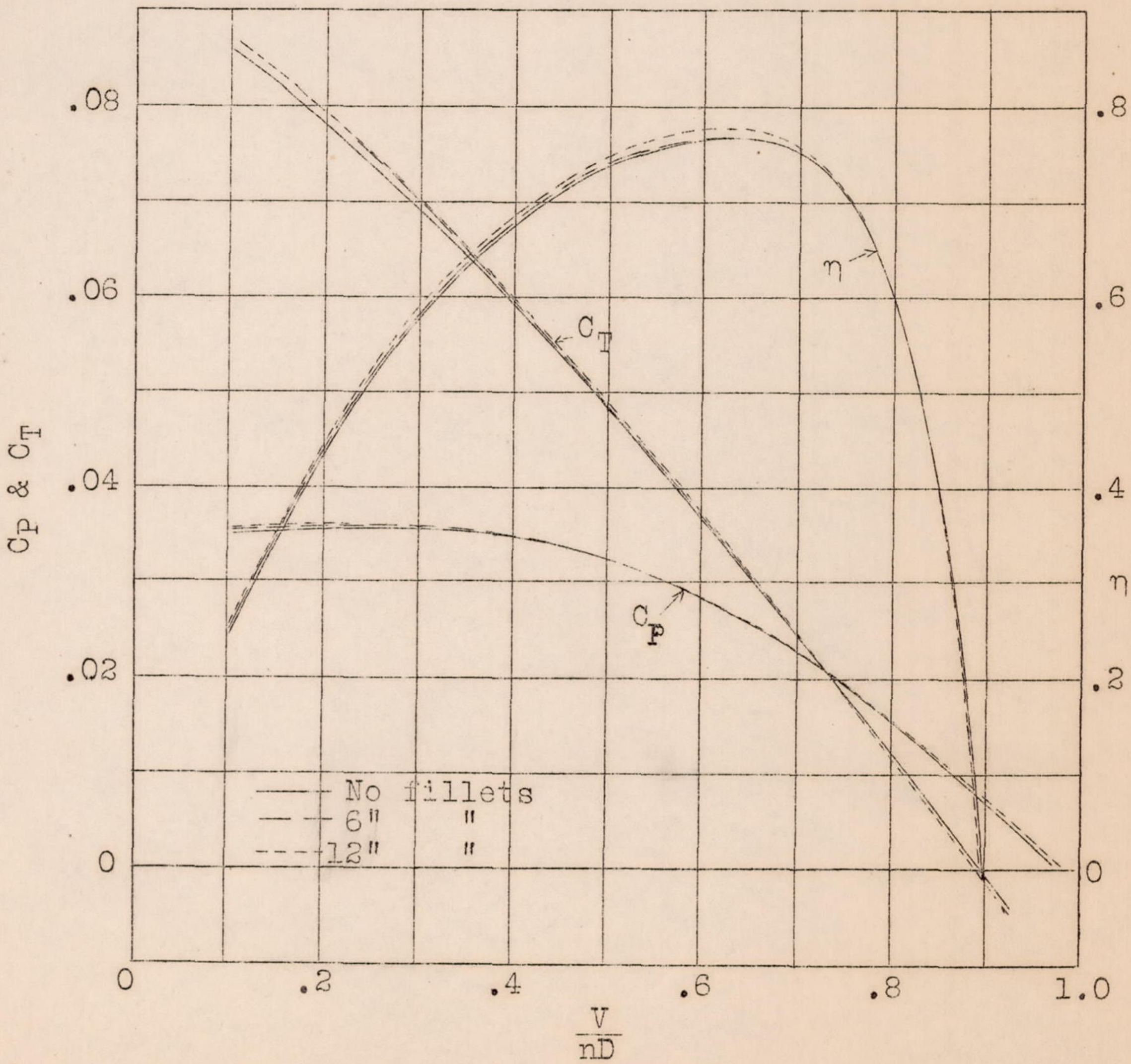


Fig.9 Propulsive characteristics, $C_T = \frac{T}{\rho n^2 D^4}$, $C_P = \frac{P}{\rho n^3 D^5}$

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