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NACA TN 3482

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL NOTE 3482

SUPPLEMENTARY CHARTS FOR ESTIMATING PERFORMANCE OF HIGH-PERFORMANCE HELICOPTERS

By Robert J. Tapscott and Alfred Gessow

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Langley Field, Va.

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SUPPLEMENTARY CHARTS FOR ESTIMATING PERFORMANCE OF HIGH-PERFORMANCE HELICOPTERS

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SUMMARY

Charts published in NACA TN 3323 for estimating the performance of high-performance helicopters were applicable to rotors having hinged rectangular blades with a linear twist of -8°. Supplementary charts are presented herein covering twists of 0° and -16°.

INTRODUCTION

Charts for estimating the performance of high-performance helicopters were published in reference 1. Those charts are applicable to rotors having hinged rectangular blades with a linear twist of -8°. Although the effect of blade twist on the rotor profile-drag power is not very significant at certain flight conditions, differences in profile-drag power between blades of different twist can become appreciable at other flight conditions, particularly at high tip-speed ratios. Accordingly, charts similar to those of reference 1 were prepared, covering twists of 0° and -16°, and are presented herein.

SYMBOLS

a — slope of curve of section lift coefficient against angle of attack per radian (assumed equal herein to 5.73)

b — number of blades per rotor

C_P — rotor-shaft power coefficient, $\dfrac{P}{\pi R^2 \rho (\Omega R)^3}$

C_{P_o} — rotor-shaft profile power coefficient

C_T rotor thrust coefficient, $\frac{T}{\pi R^2 \rho (\Omega R)^2}$

c blade section chord, ft

c_e equivalent blade chord (weighted on thrust basis),

$$\frac{\int_0^R cr^2 dr}{\int_0^R r^2 dr}, \text{ ft}$$

P rotor-shaft power, ft-lb/sec

R blade radius measured from center of rotation, ft

r radial distance from center of rotation to blade element, ft

T rotor thrust, lb

V true airspeed of helicopter along flight path, fps

v induced velocity at rotor (always positive), fps

x ratio of blade-element radius to rotor-blade radius, r/R

α rotor angle of attack; angle between axis of no feathering (that is, axis about which there is no cyclic-pitch change) and plane perpendicular to flight path, positive when axis is inclined rearward, deg

$\alpha_{(x)(\psi)}$ blade-element angle of attack at any radial position x and at any blade azimuth angle ψ, deg; for example, $\alpha_{(1.0)(270^\circ)}$ is blade-element angle of attack at tip of retreating blade at 270° azimuth position

$\alpha_{\left(u_T=0.4\right)(270^\circ)}$ blade-element angle of attack at radius at which tangential velocity u_T equals 0.4 tip speed and at 270° azimuth position, deg

$\theta_{.75}$ blade-section pitch angle at 0.75 radius; angle between line of zero lift of blade section and plane perpendicular to axis of no feathering, deg

λ	inflow ratio, $\frac{V \sin \alpha - v}{\Omega R}$
μ	tip-speed ratio, $\frac{V \cos \alpha}{\Omega R}$
ρ	mass density of air, slugs/cu ft
σ	rotor solidity, $bc_e/\pi R$
ψ	blade azimuth angle measured from downwind position in direction of rotation, deg
Ω	rotor angular velocity, radians/sec

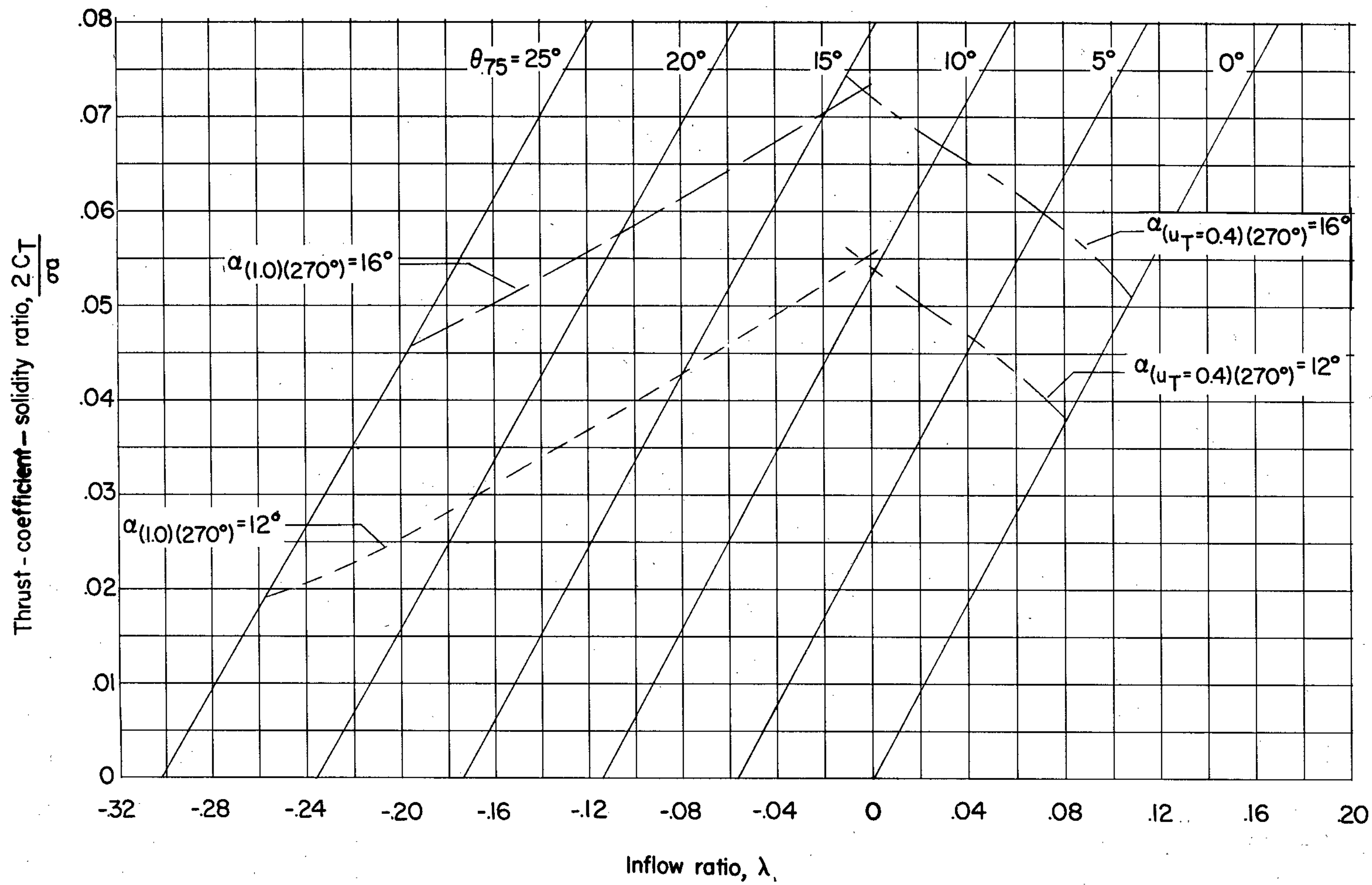
PERFORMANCE CHARTS

Charts giving the relation between thrust-coefficient—solidity ratio, inflow ratio, and pitch angle at the three-quarter radius for tip-speed ratios ranging from 0.05 to 0.50 are presented in figures 1 and 2 for blade twists of 0° and -16°, respectively. Corresponding charts relating profile power, total shaft power, thrust coefficient, and pitch angle for specified values of tip-speed ratio are given in figures 3 and 4 for blade twists of 0° and -16°, respectively. These charts were computed and used in the same way as those of reference 1 and are subject to the same limitations.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., June 8, 1955.

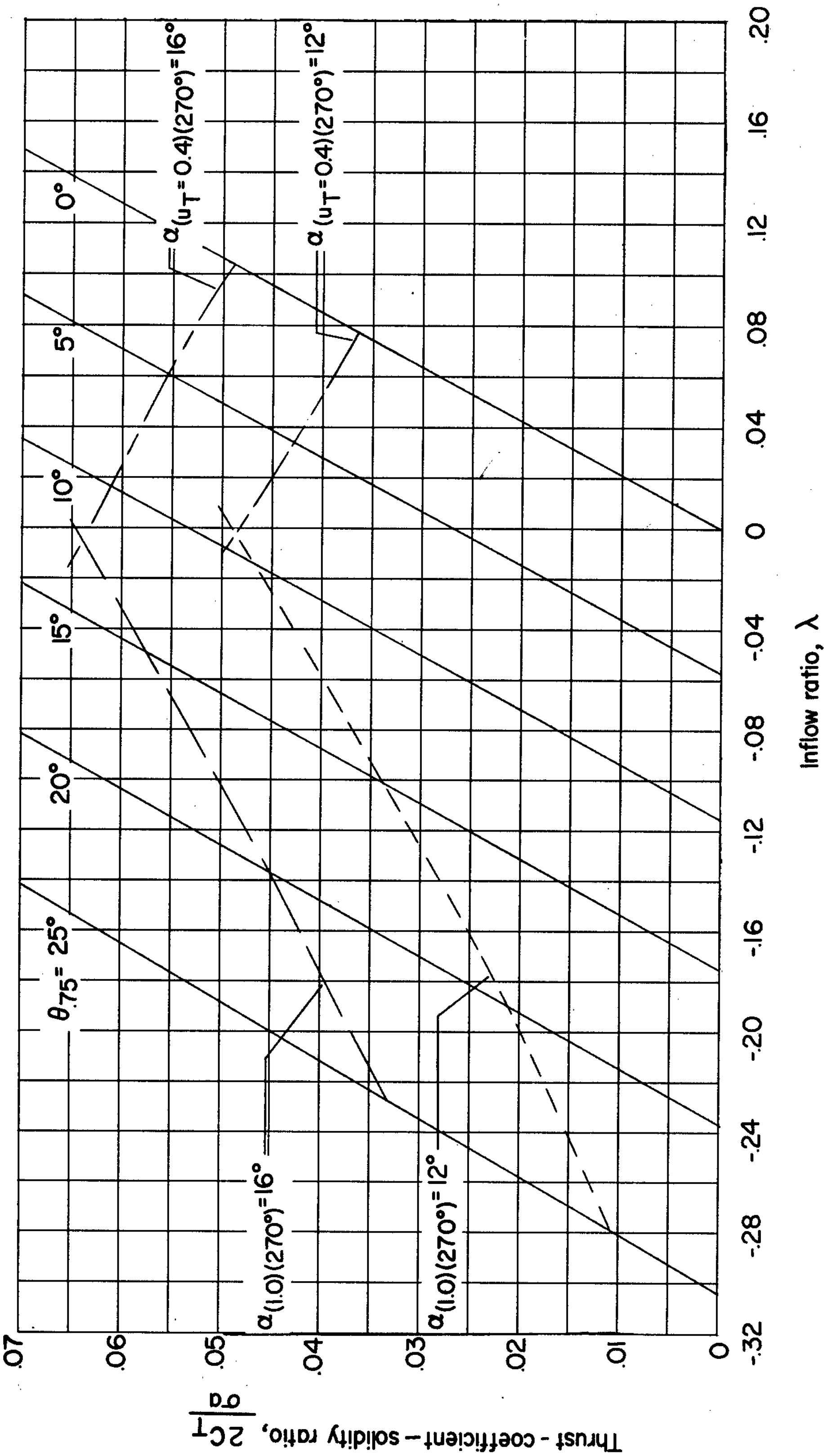
REFERENCE

1. Gessow, Alfred, and Tapscott, Robert J.: Charts for Estimating Performance of High-Performance Helicopters. NACA TN 3323, 1955.



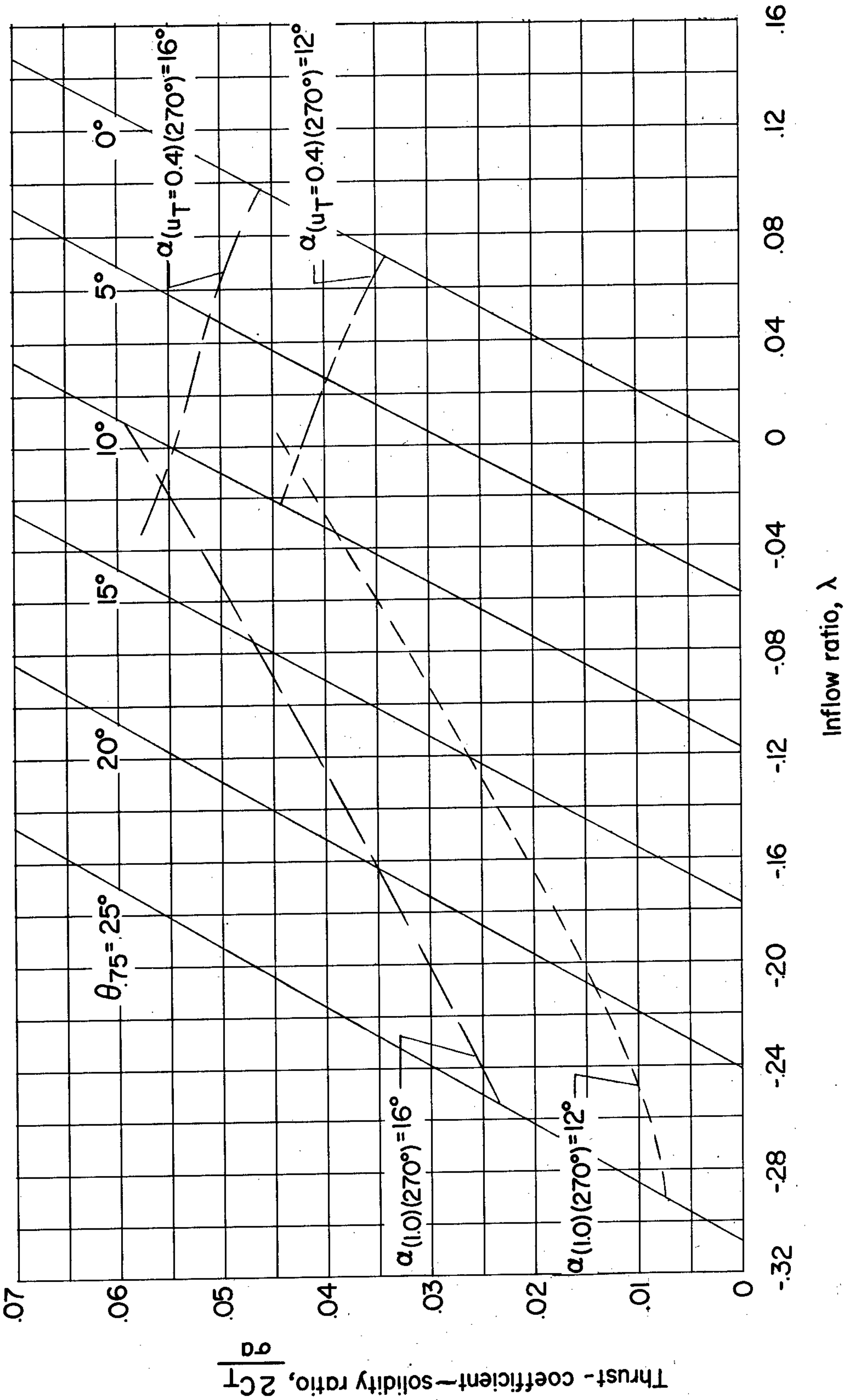
(a) $\mu = 0.05$.

Figure 1.- Thrust-coefficient—solidity ratio as a function of inflow ratio and pitch angle for blades having 0° twist.



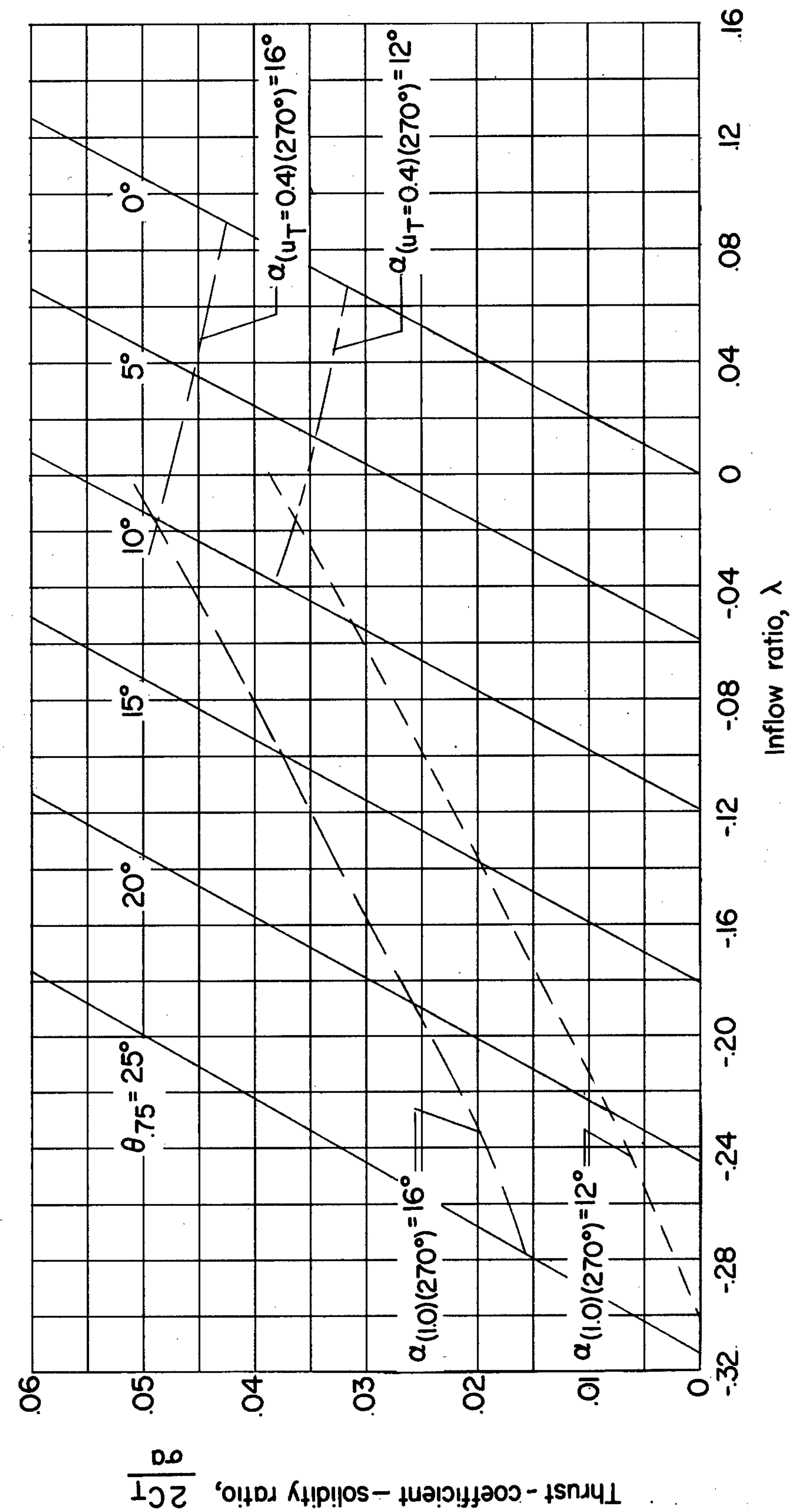
(b) μ = 0.10.

Figure 1.- Continued.



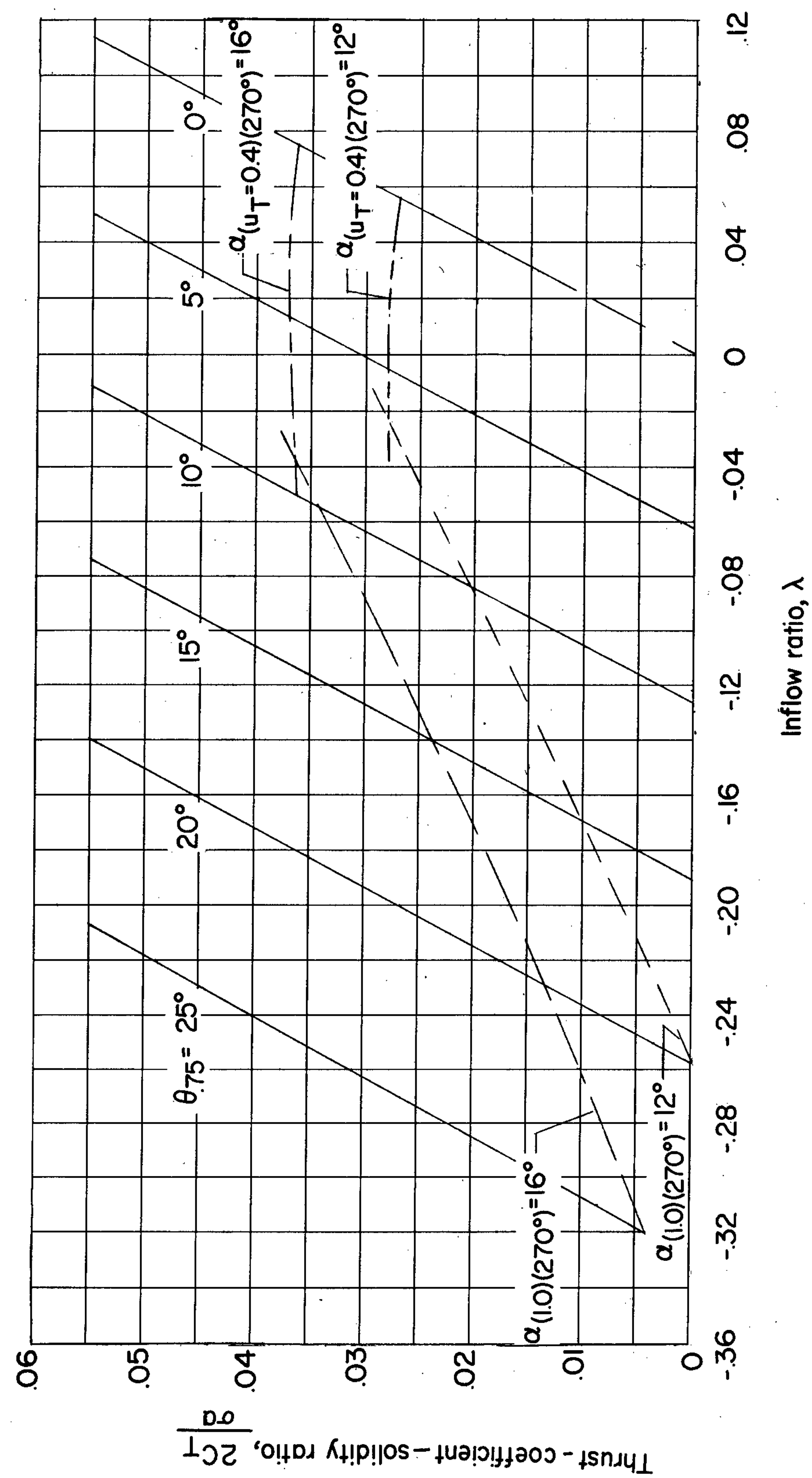
(c) $\mu = 0.15$.

Figure 1.- Continued.



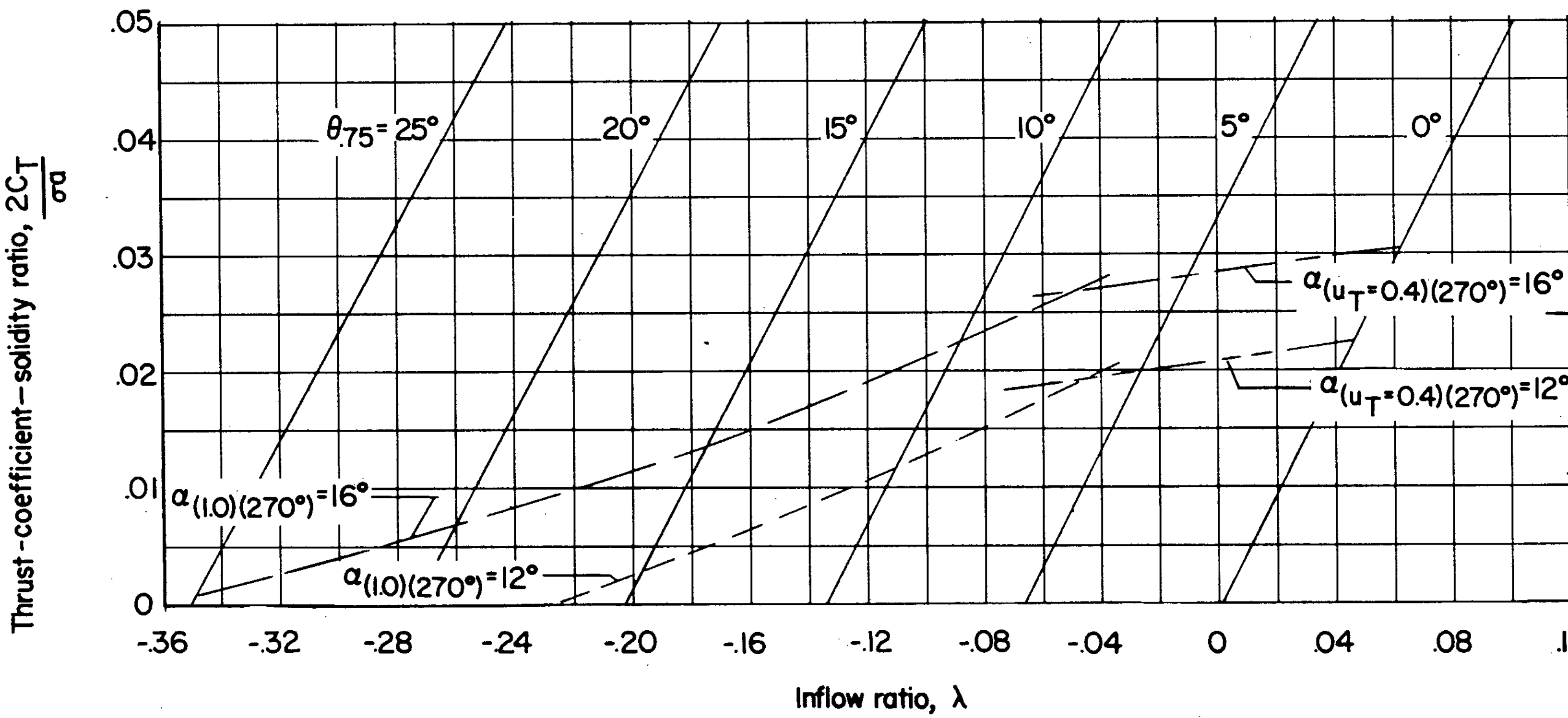
(d) μ = 0.20.

Figure 1.- Continued.



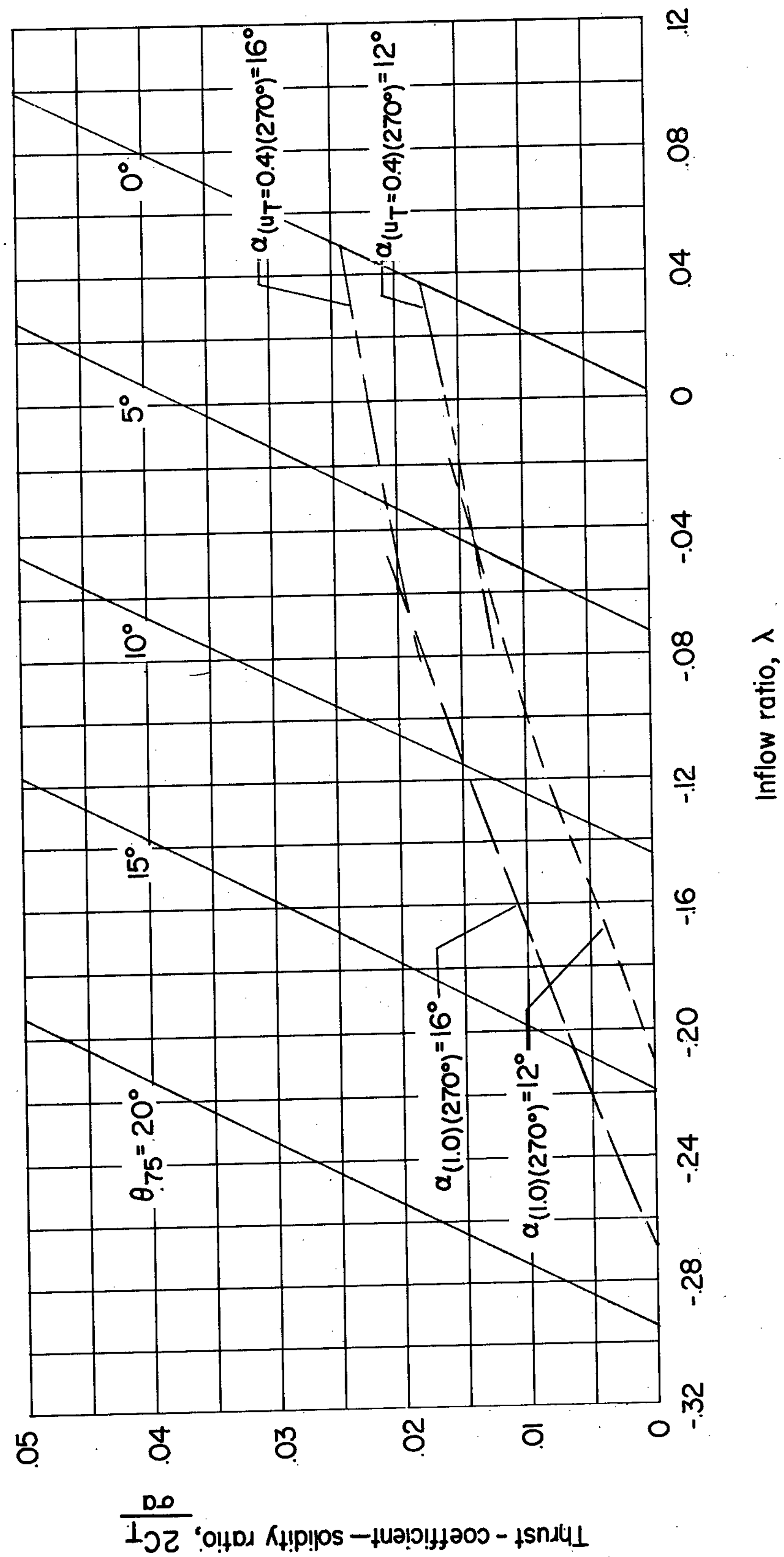
(e) $\mu = 0.30$.

Figure 1.- Continued.



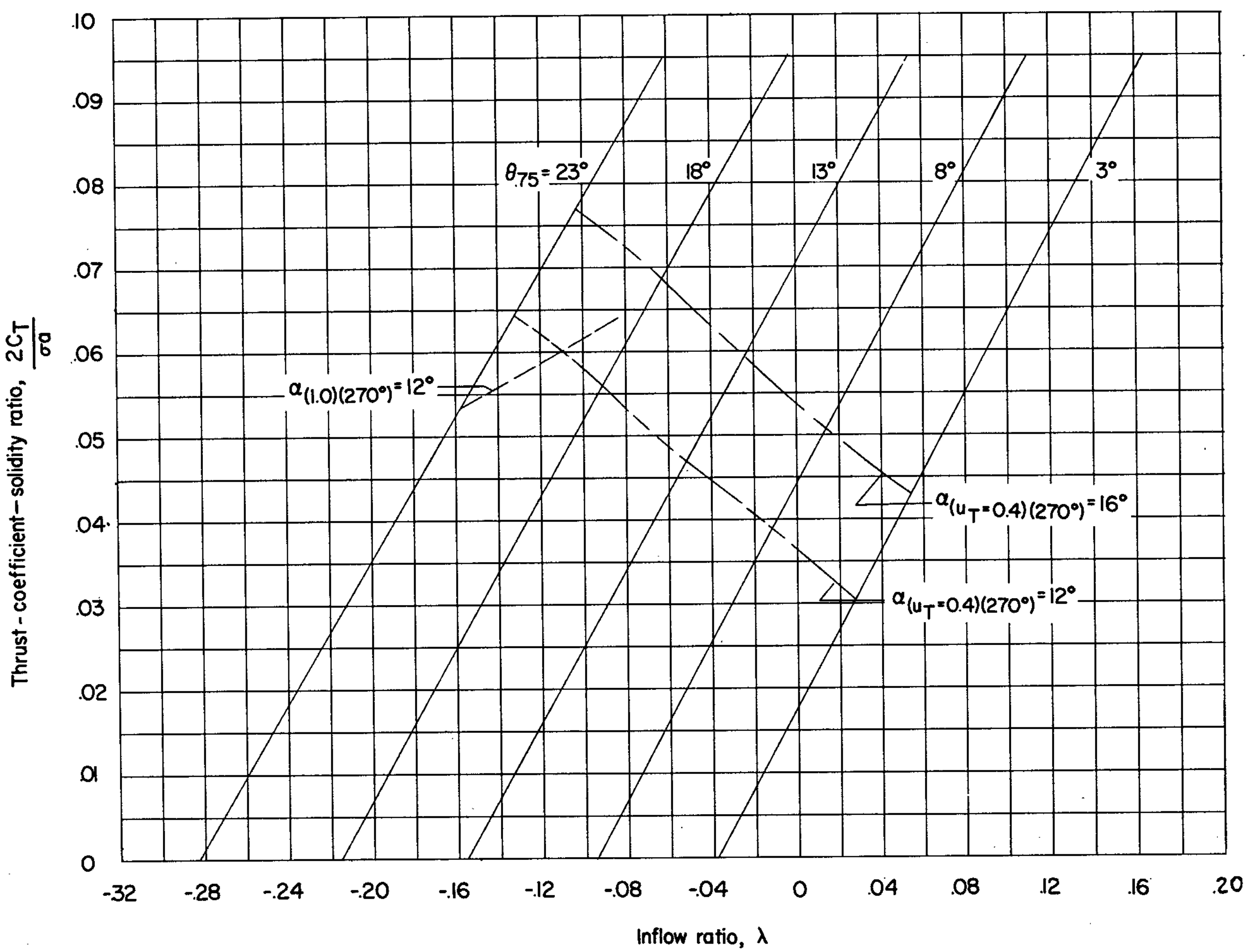
(f) $\mu = 0.40$.

Figure 1.- Continued.



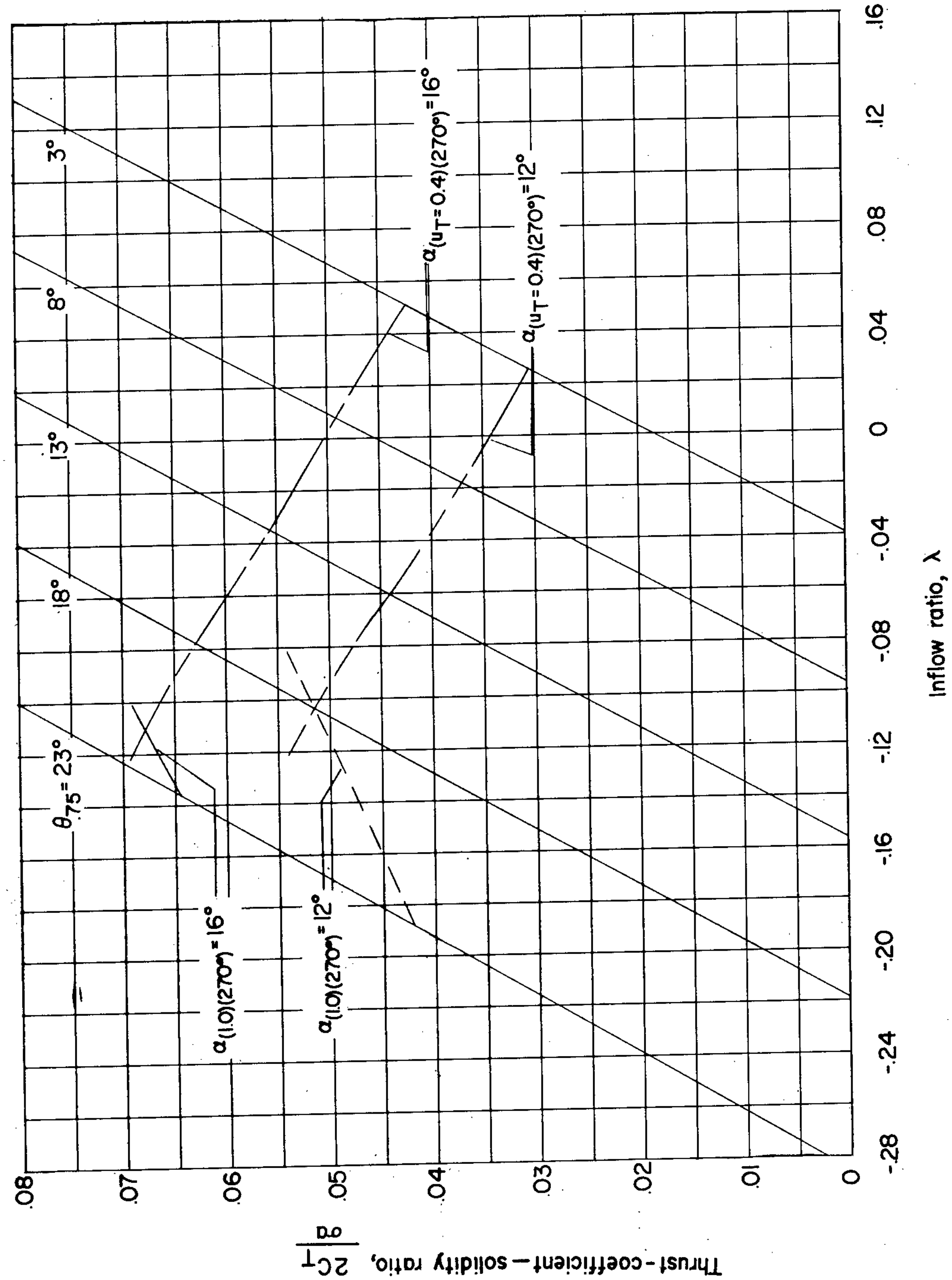
(g) $\mu = 0.50$.

Figure 1.- Concluded.



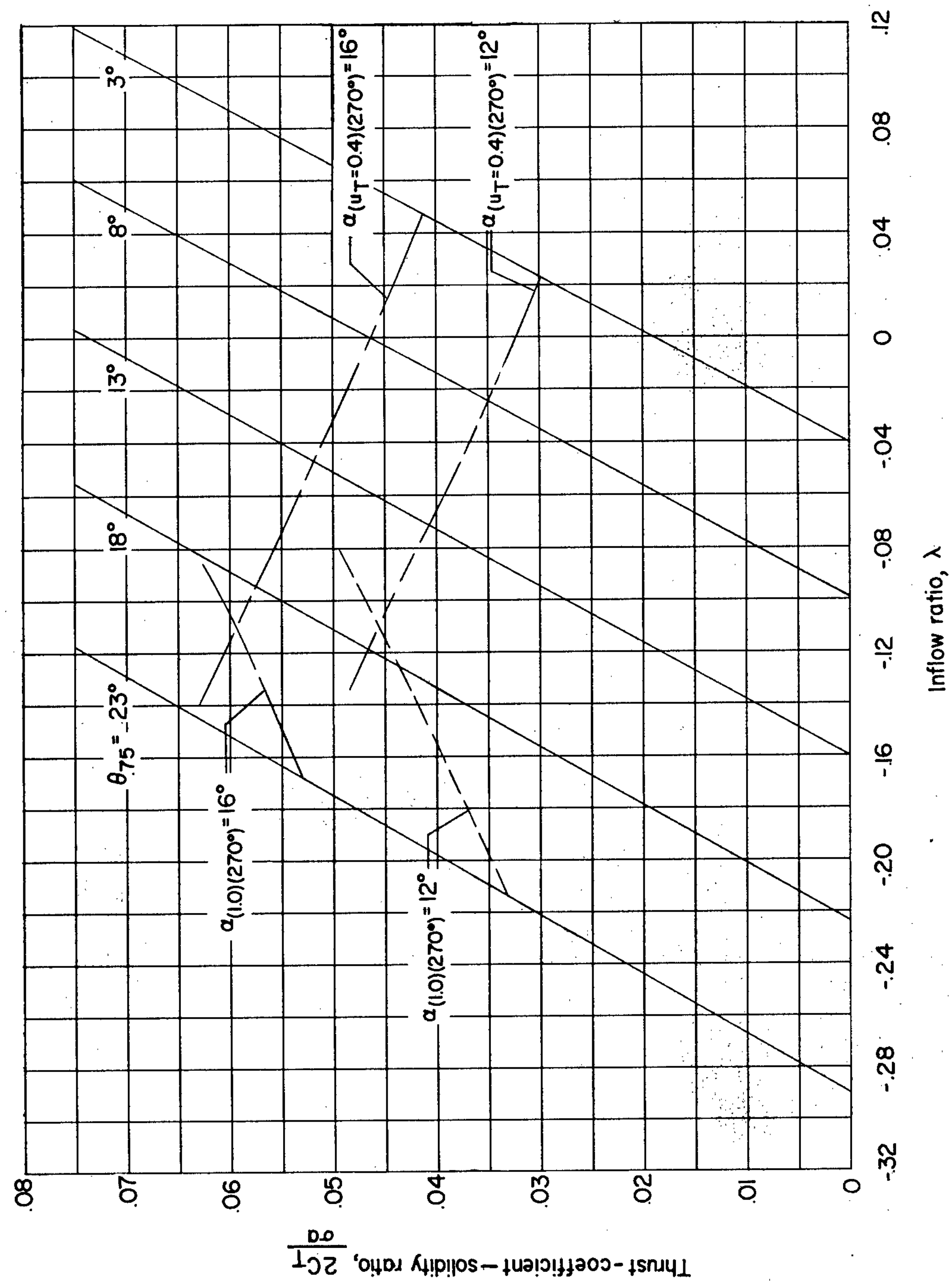
(a) $\mu = 0.05$.

Figure 2.- Thrust-coefficient—solidity ratio as a function of inflow ratio and pitch angle for blades having -16° twist.



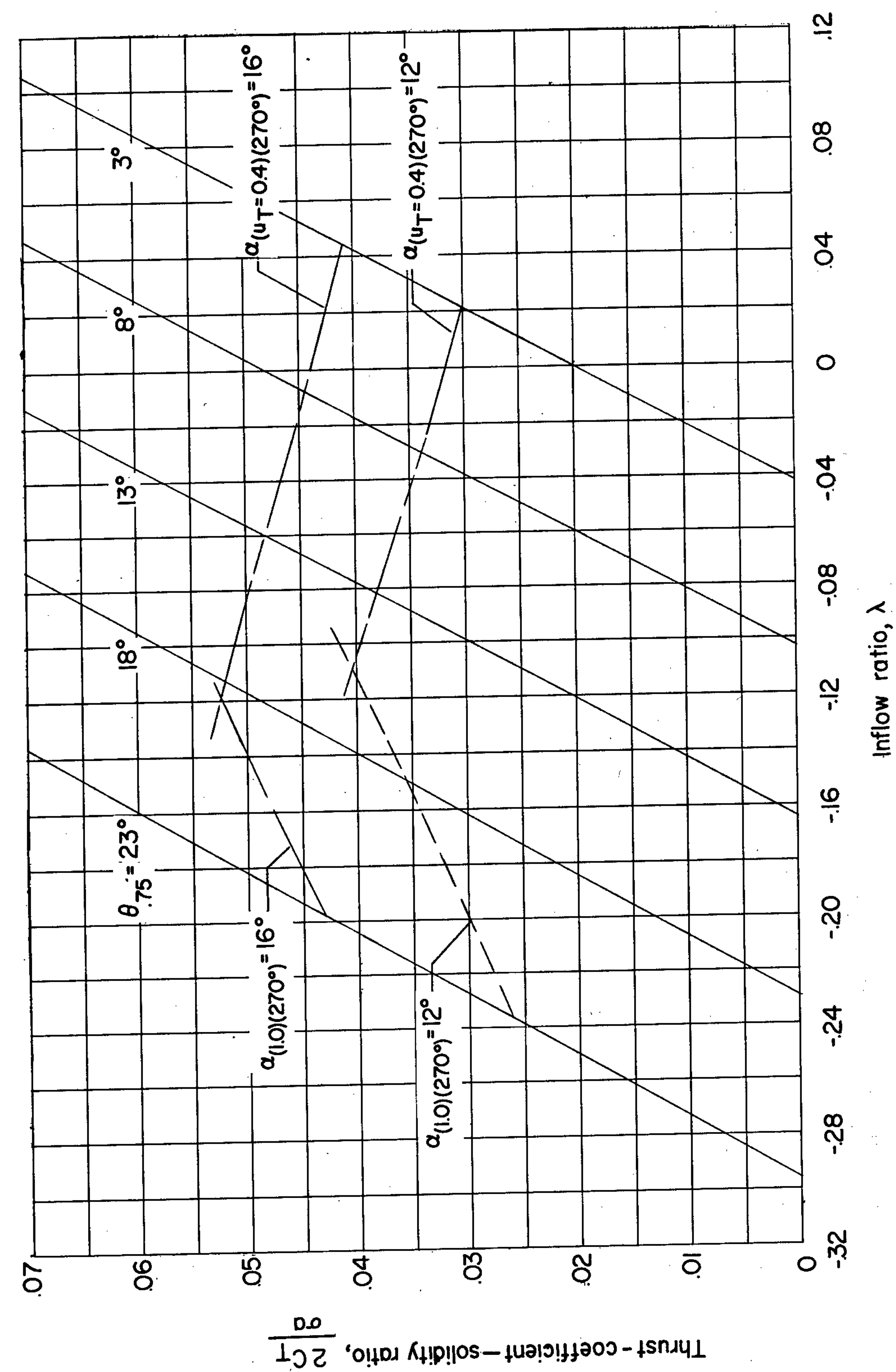
(b) $\mu = 0.10$.

Figure 2.- Continued.



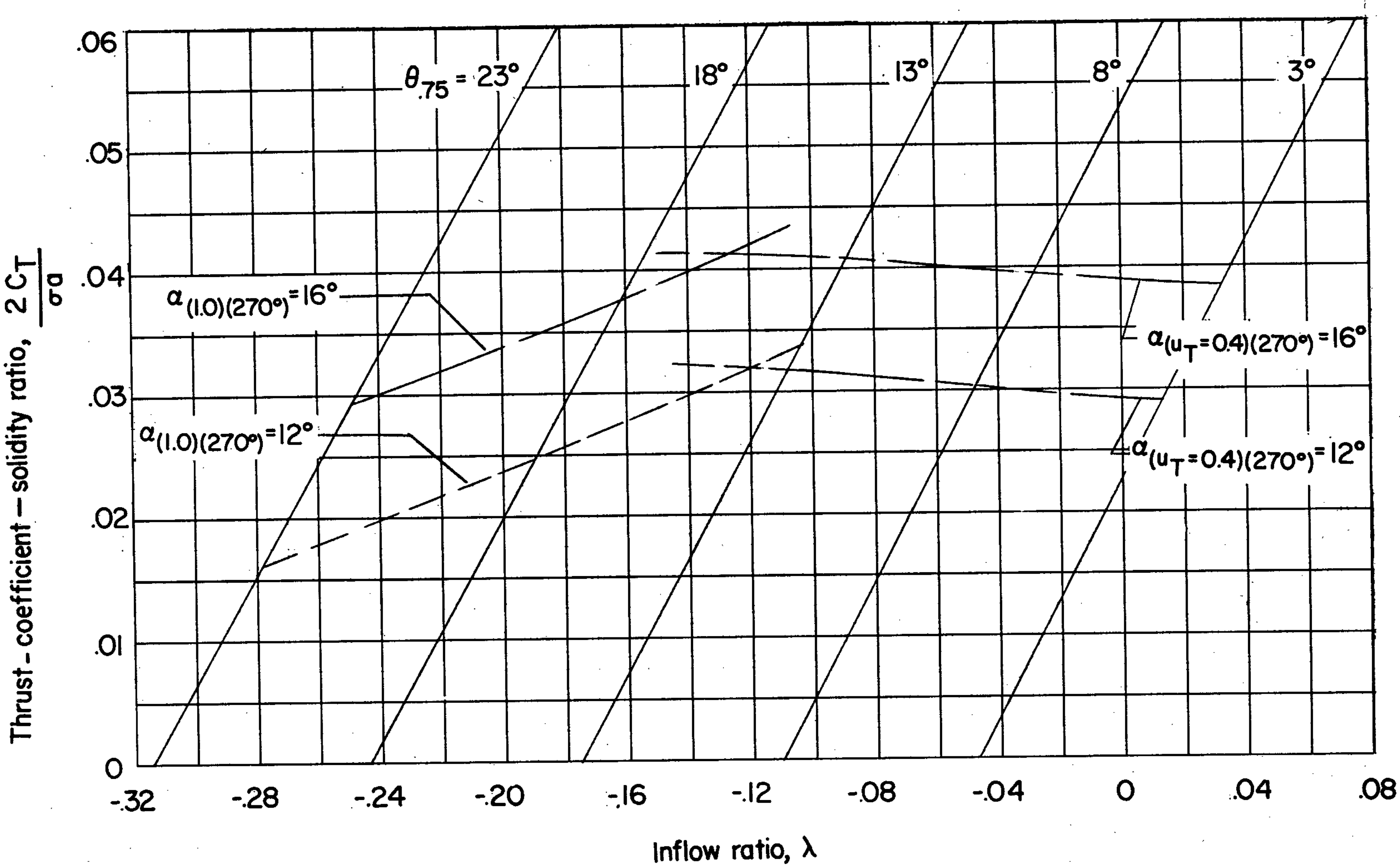
(c) $\mu = 0.15$.

Figure 2.- Continued.



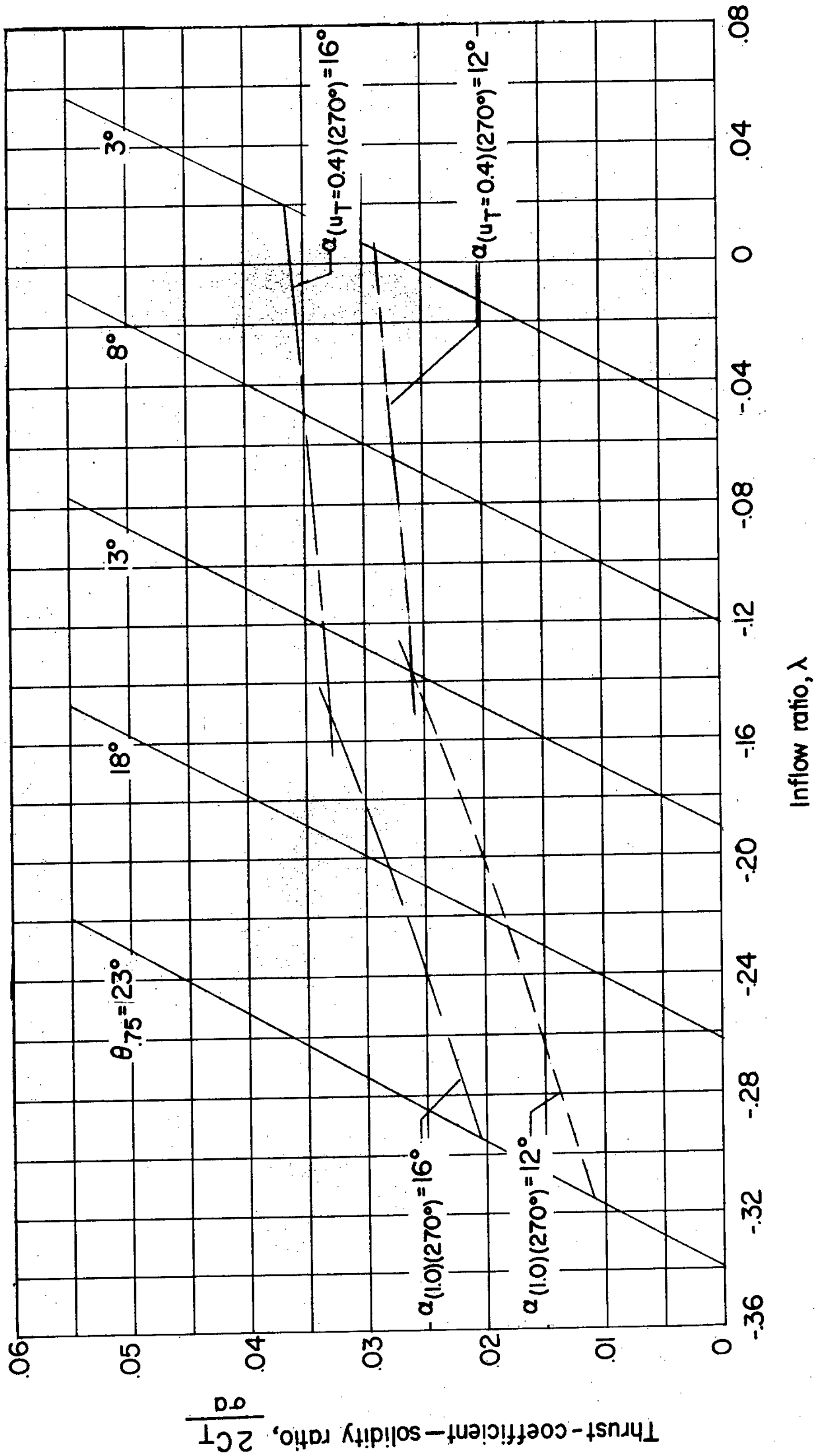
(d) $\mu = 0.20$.

Figure 2.- Continued.



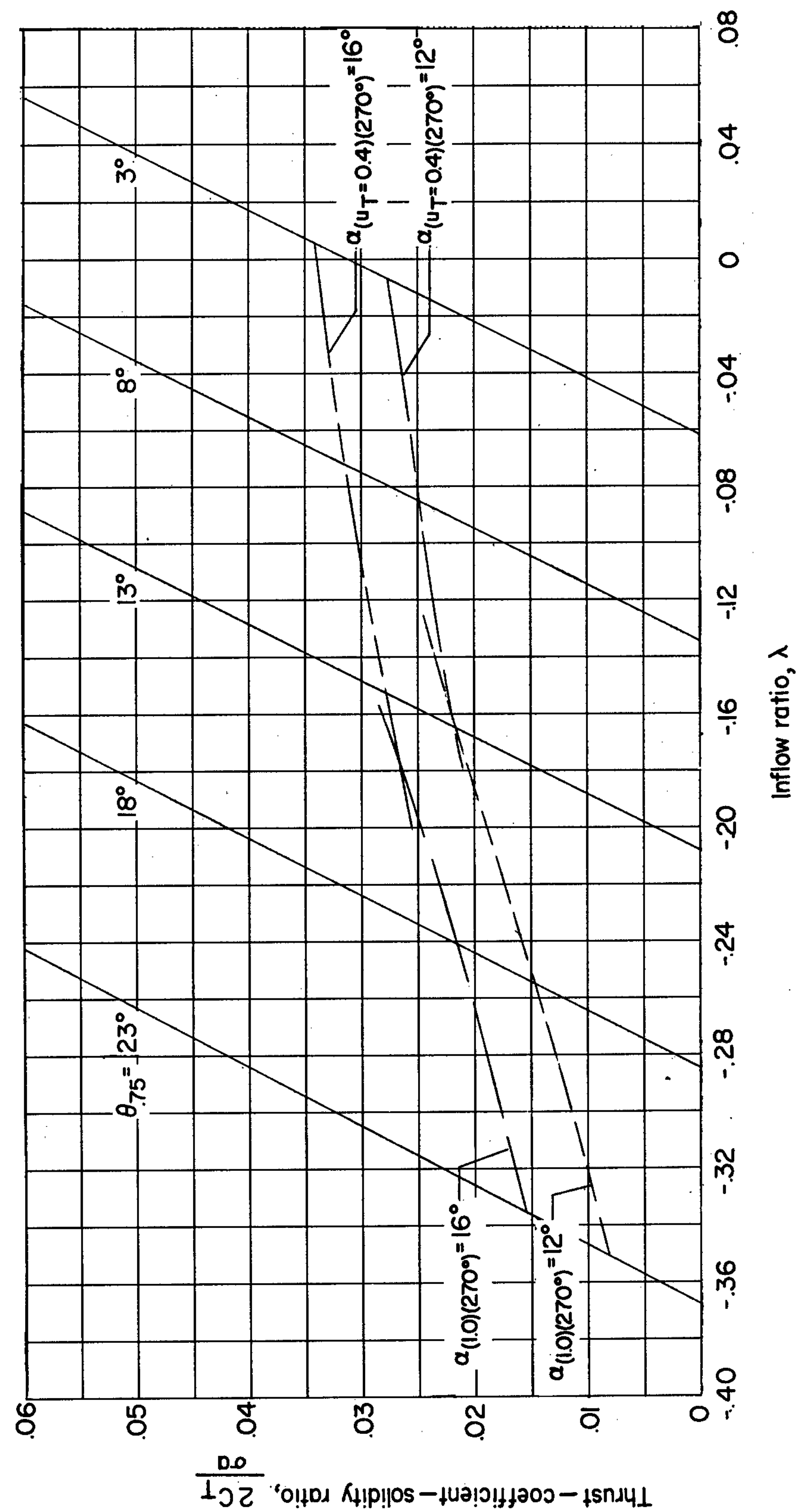
(e) $\mu = 0.30$.

Figure 2.- Continued.



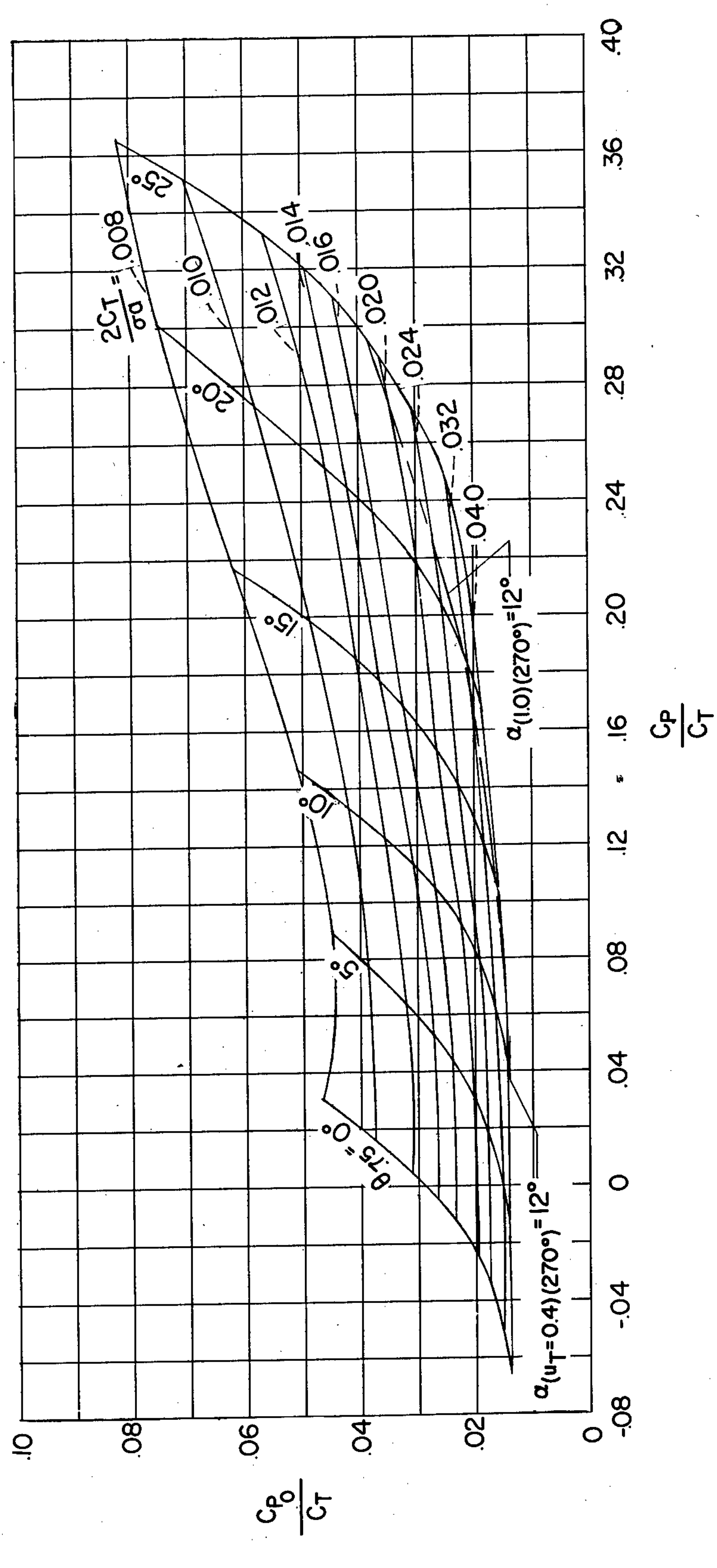
(f) $\mu = 0.40$.

Figure 2.- Continued.



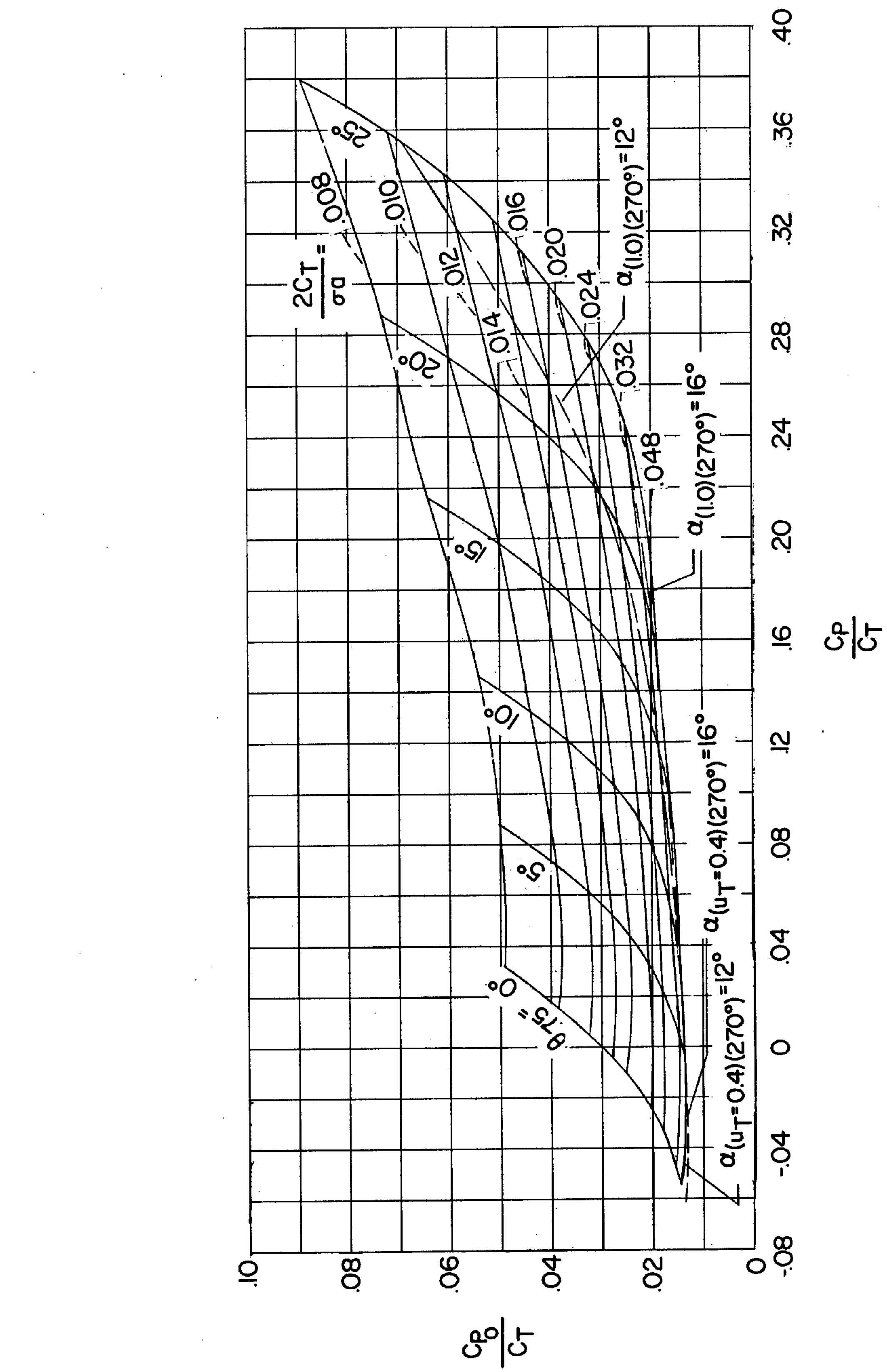
(g) μ = 0.50.

Figure 2.- Concluded.



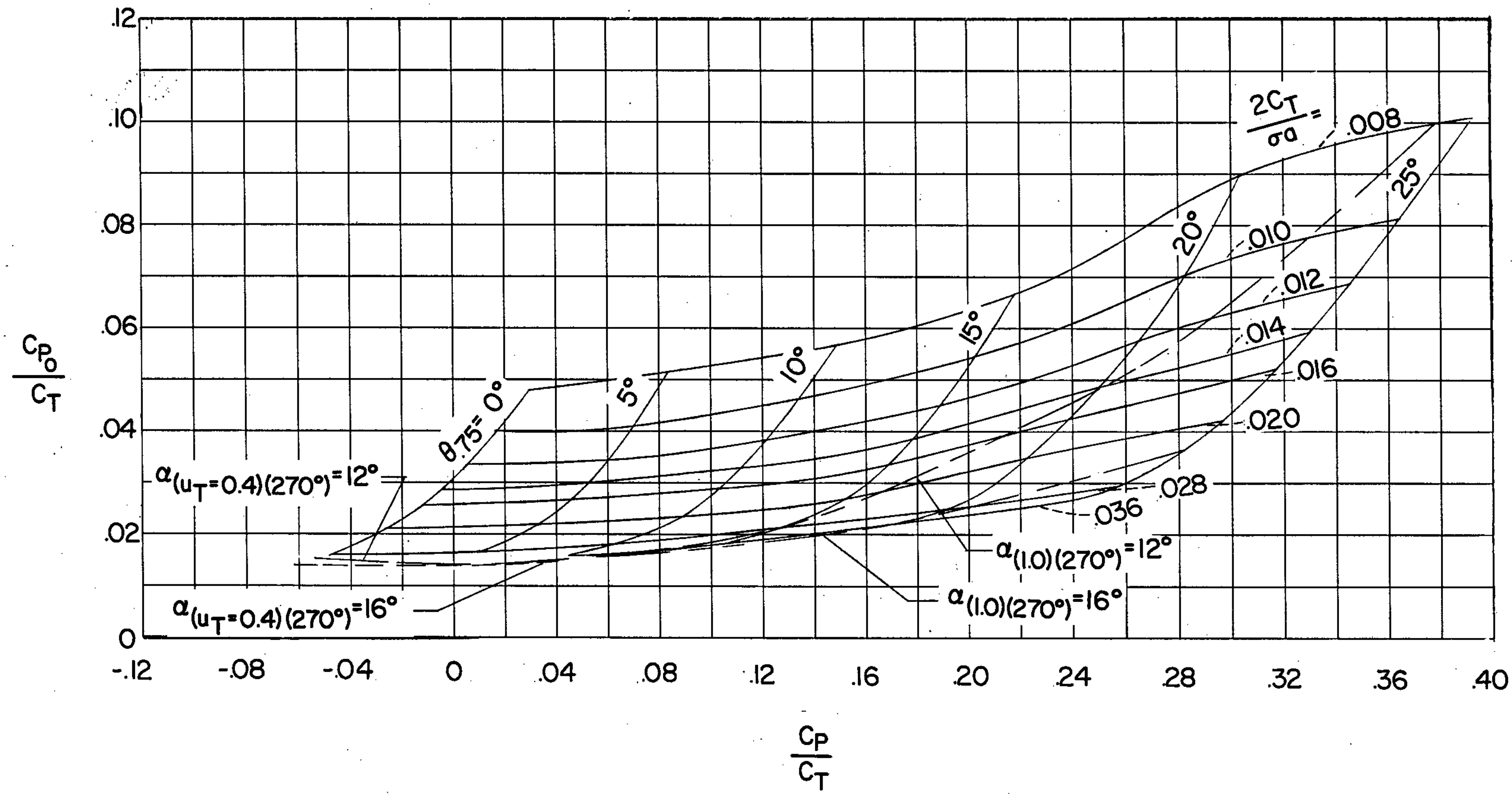
(a) μ = 0.05.

Figure 3.- Profile-drag—thrust ratio for blades having 0° twist.



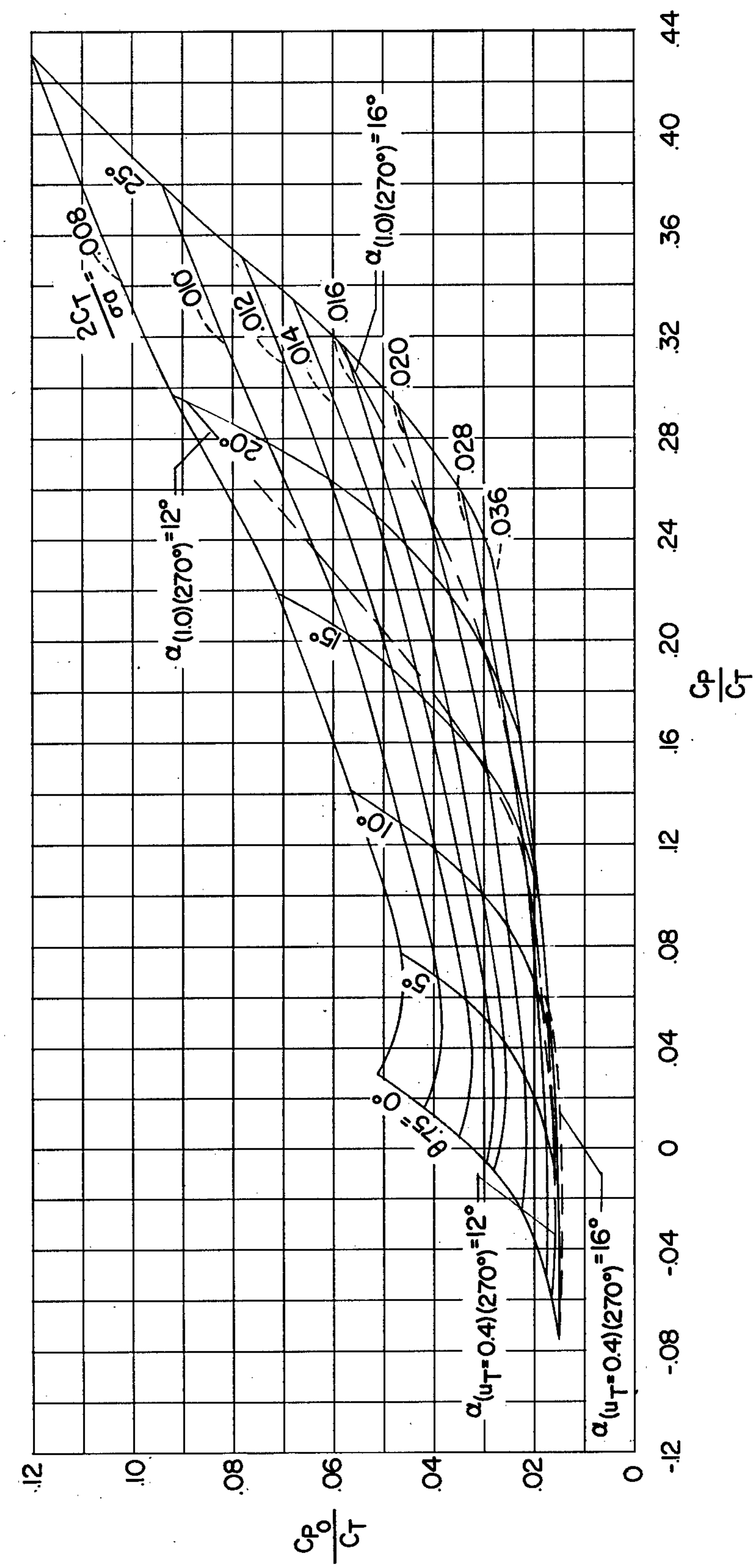
(b) μ = 0.10.

Figure 3.- Continued.



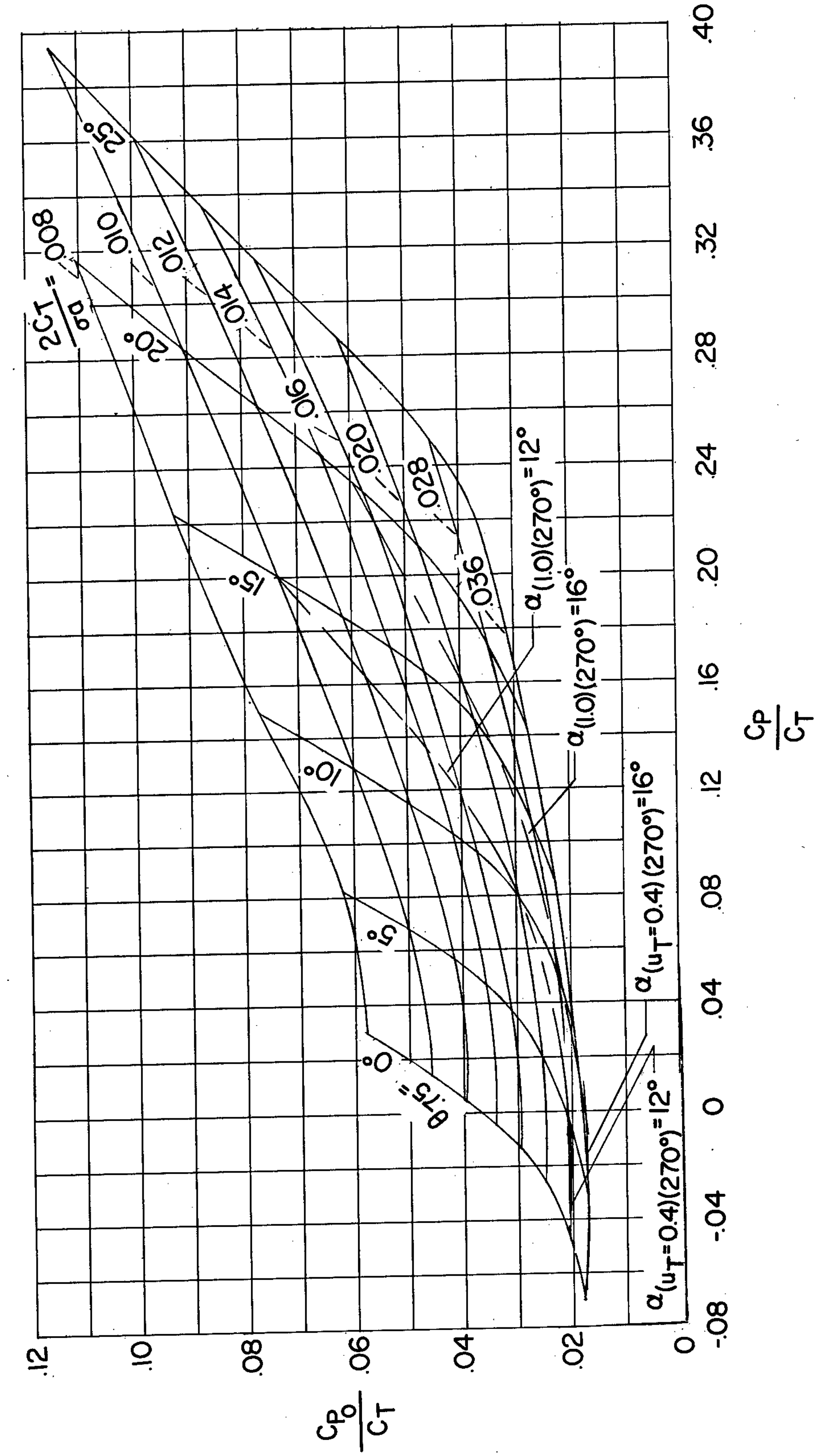
(c) $\mu = 0.15$.

Figure 3.- Continued.



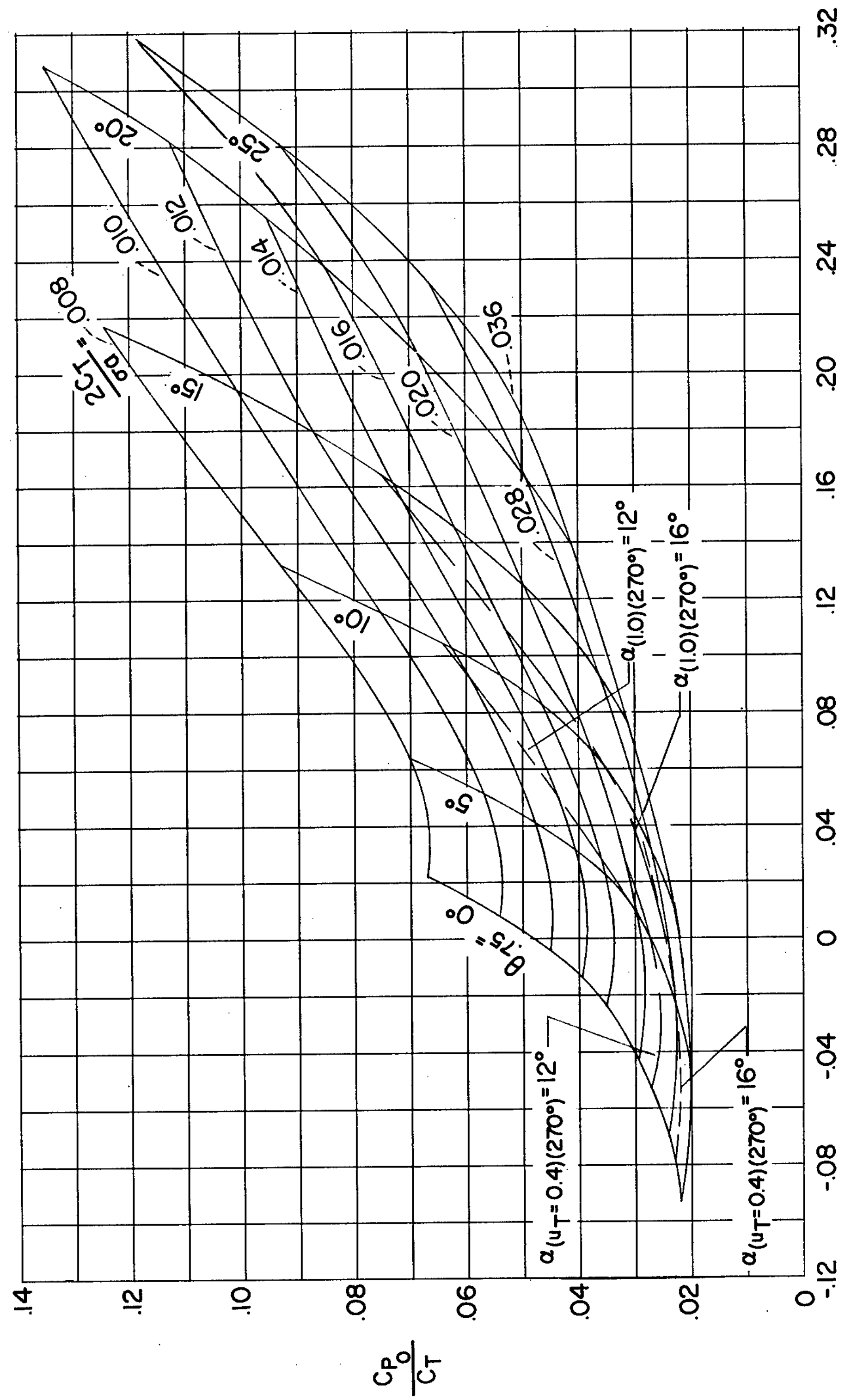
(d) $\mu = 0.20$.

Figure 3.- Continued.



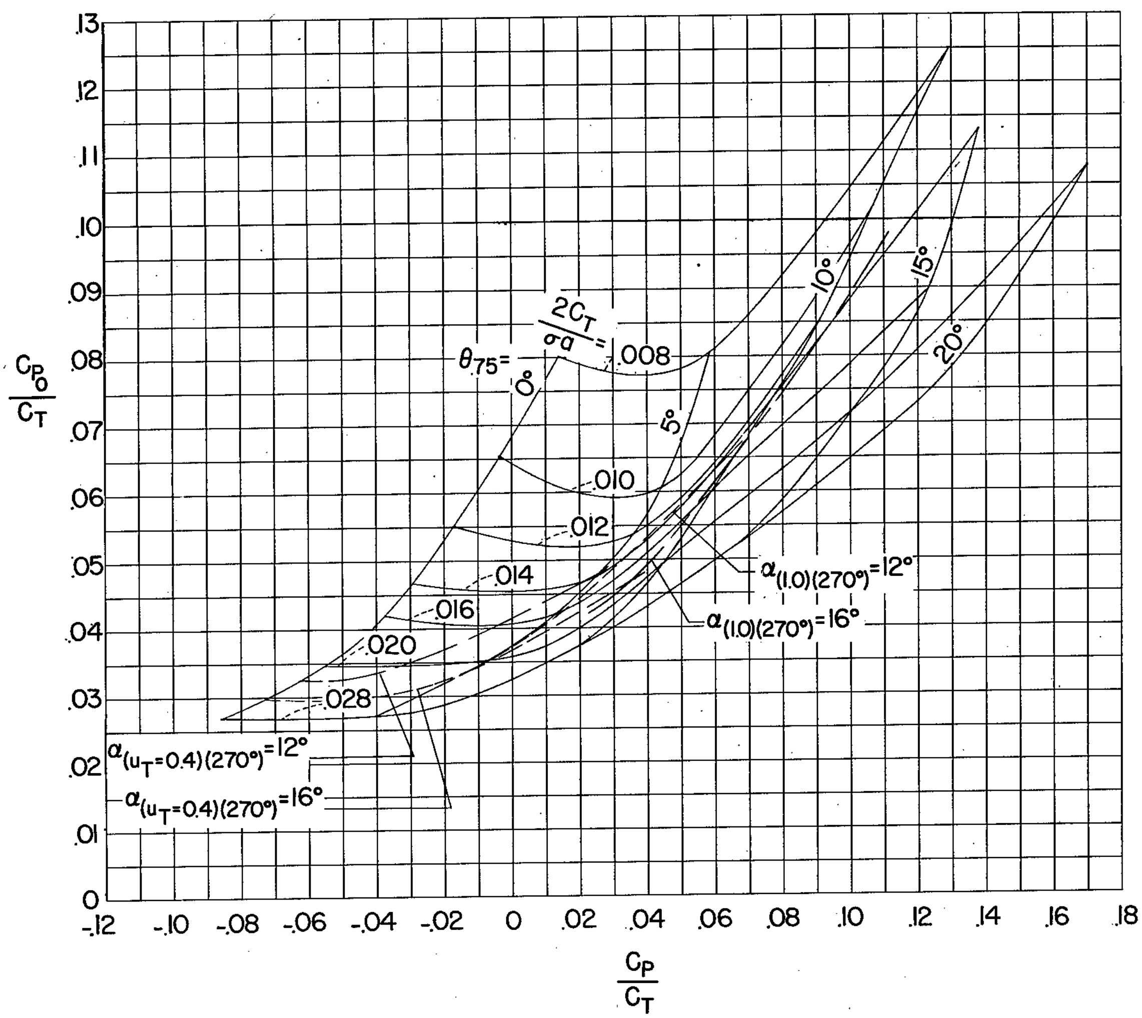
(e) $\mu = 0.30$.

Figure 3.- Continued.



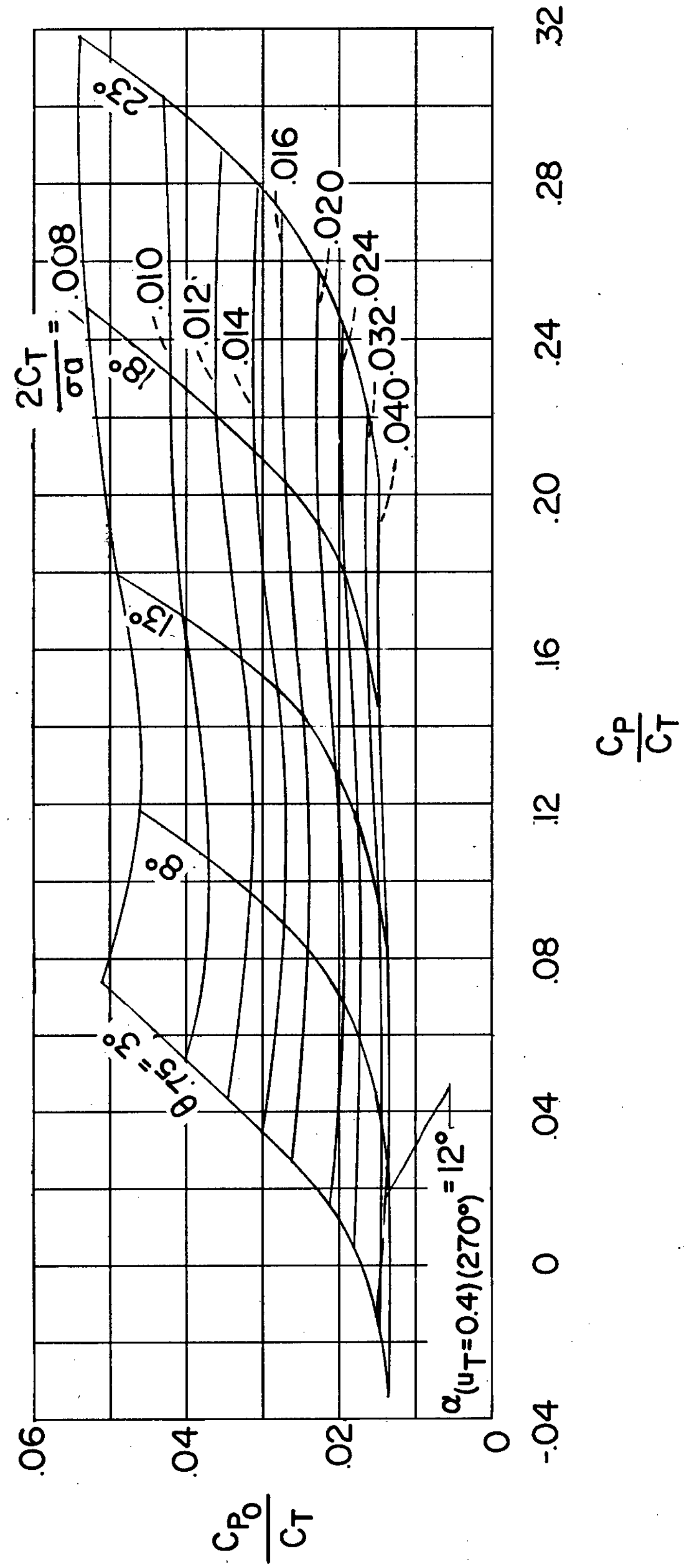
(f) $\mu = 0.40$.

Figure 3.- Continued.



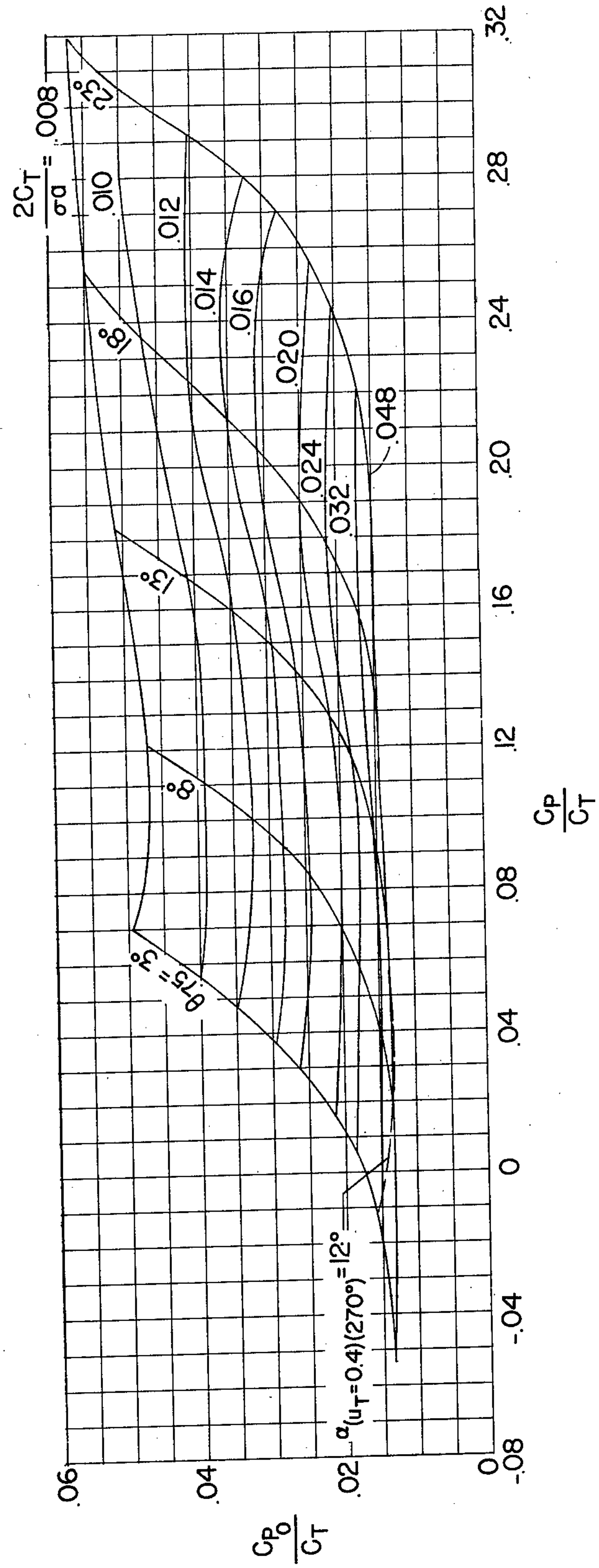
(g) $\mu = 0.50$.

Figure 3.- Concluded.



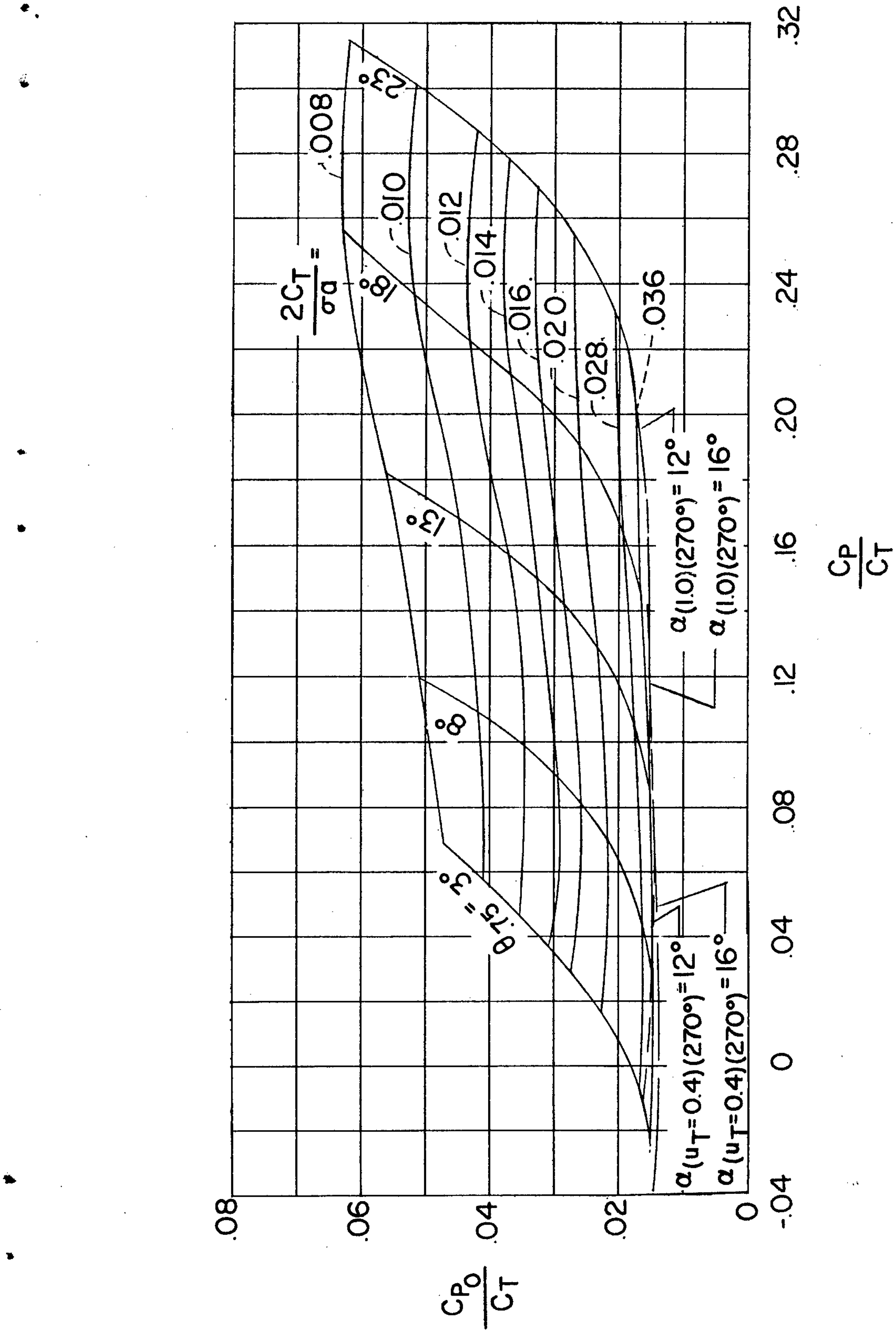
(a) $\mu = 0.05$.

Figure 4.- Profile-drag—thrust ratio for blades having -16° twist.



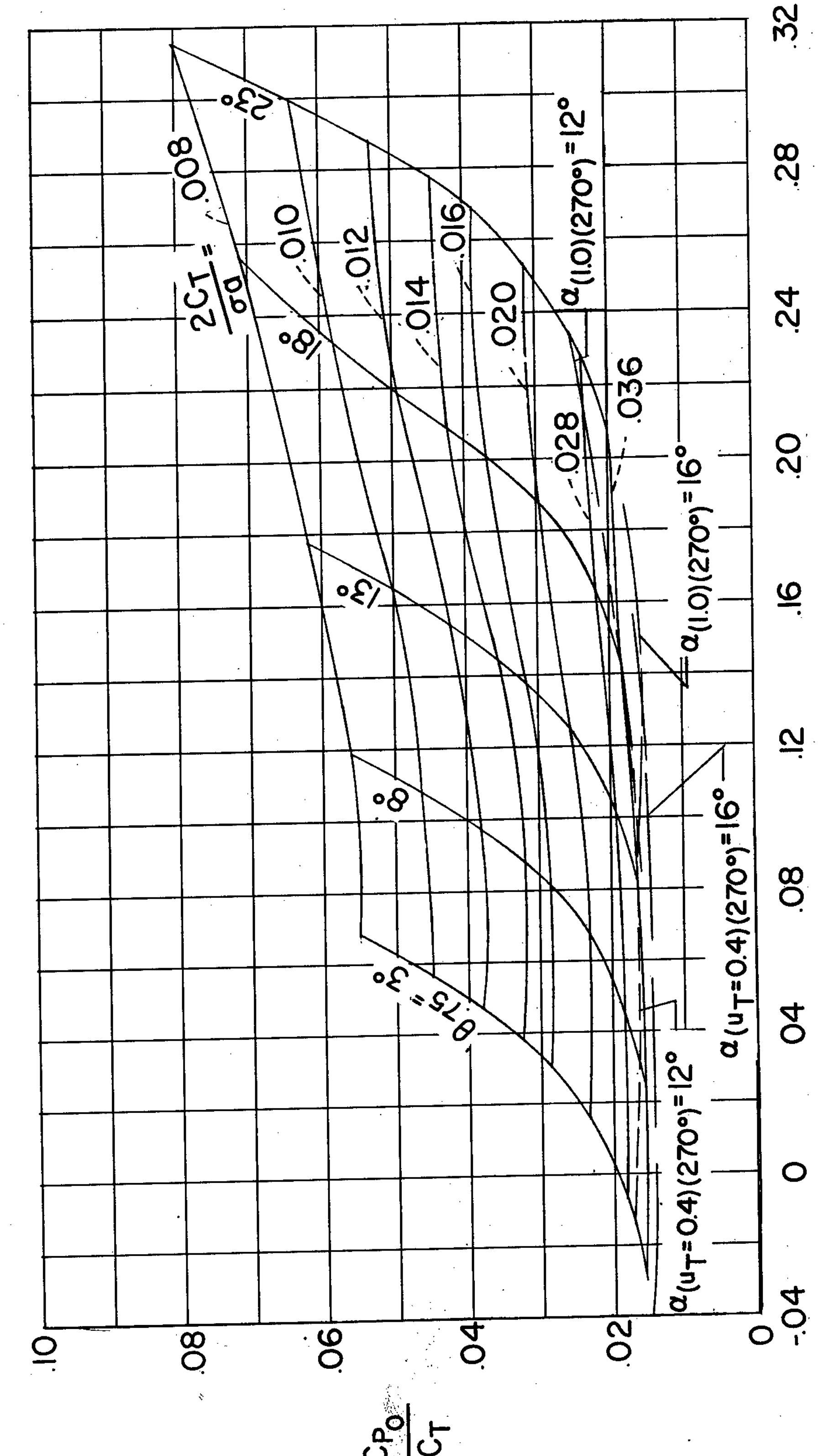
(b) $\mu = 0.10$.

Figure 4.- Continued.



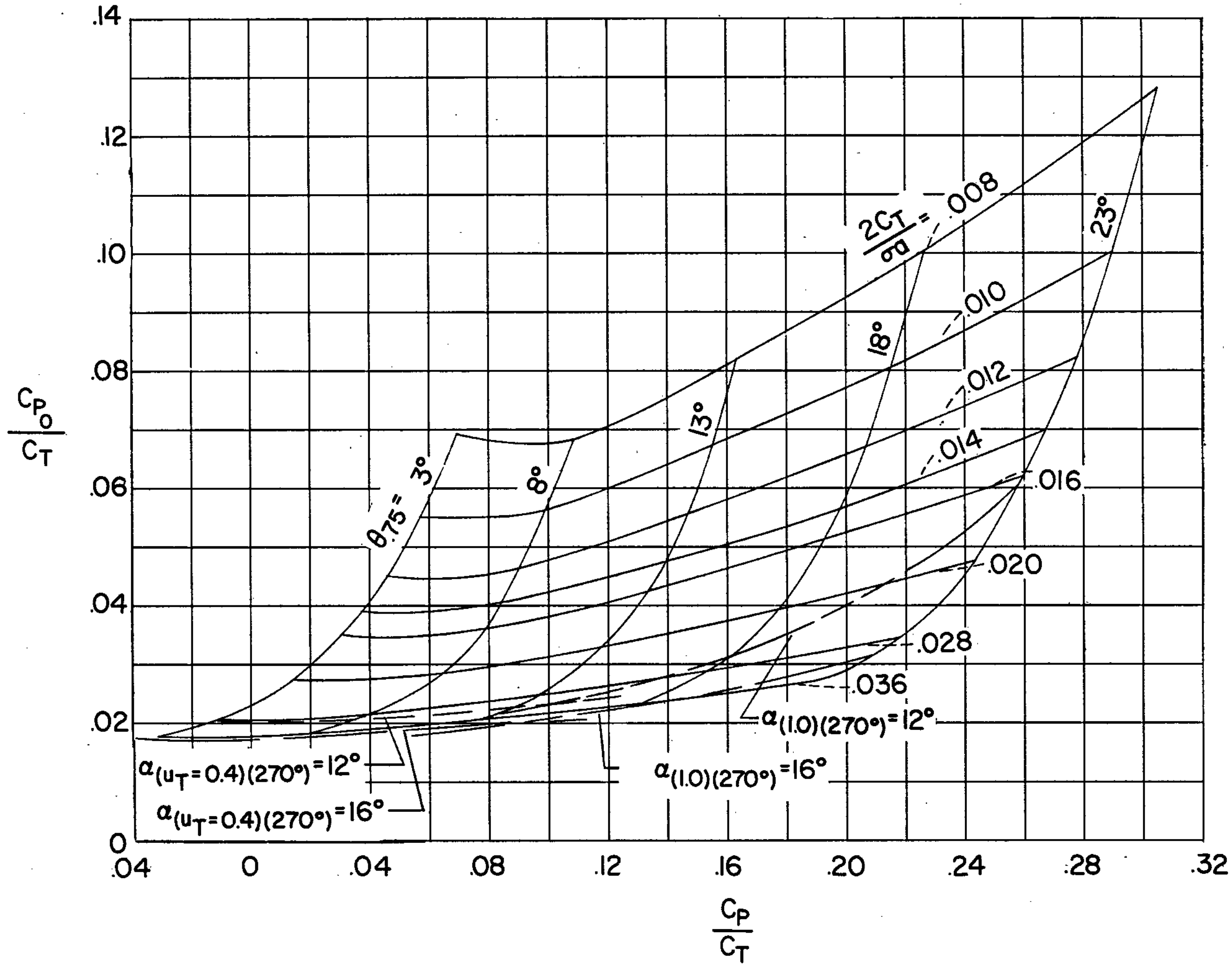
(c) $\mu = 0.15$.

Figure 4.- Continued.



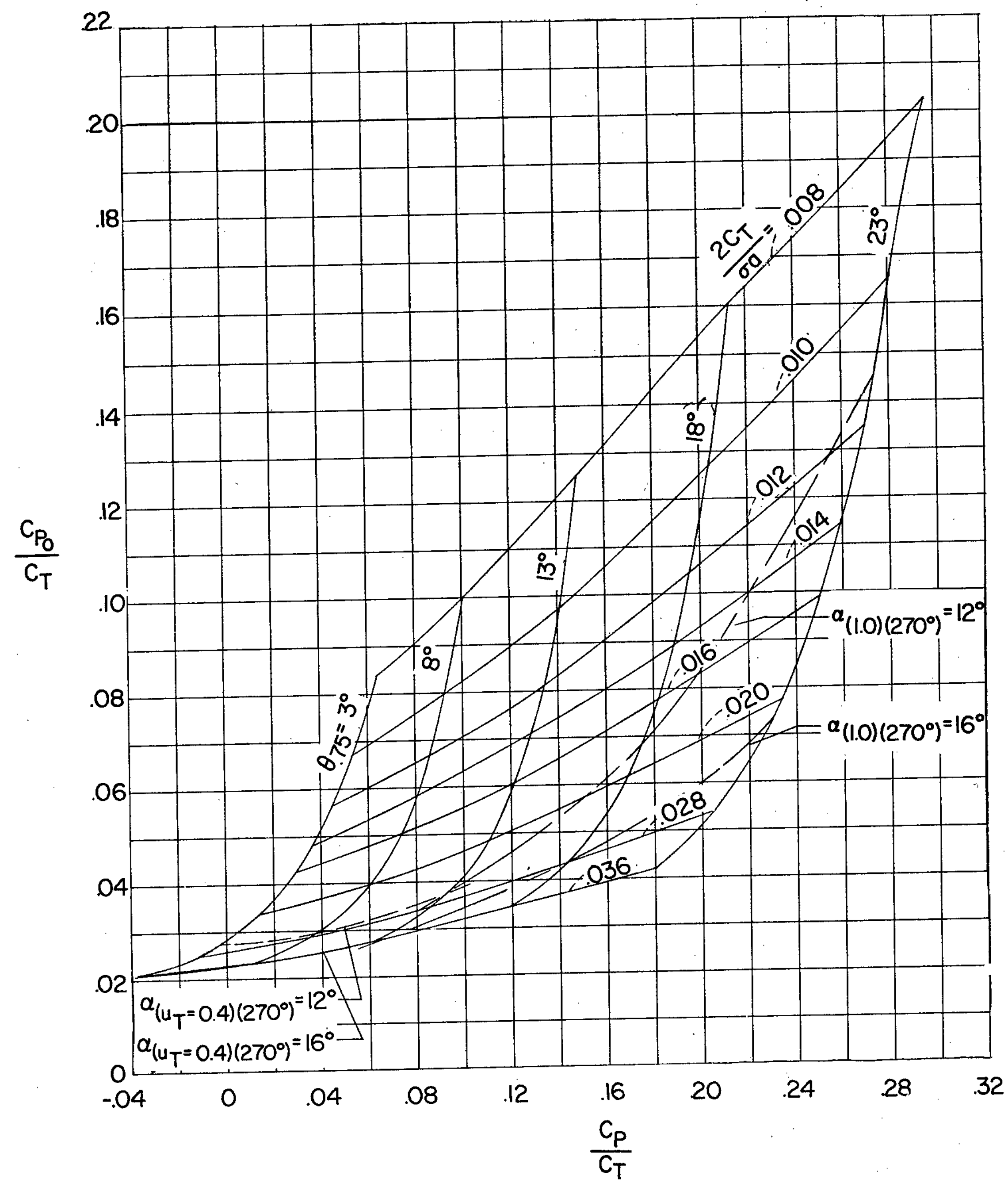
(d) $\mu = 0.20$.

Figure 4.- Continued.



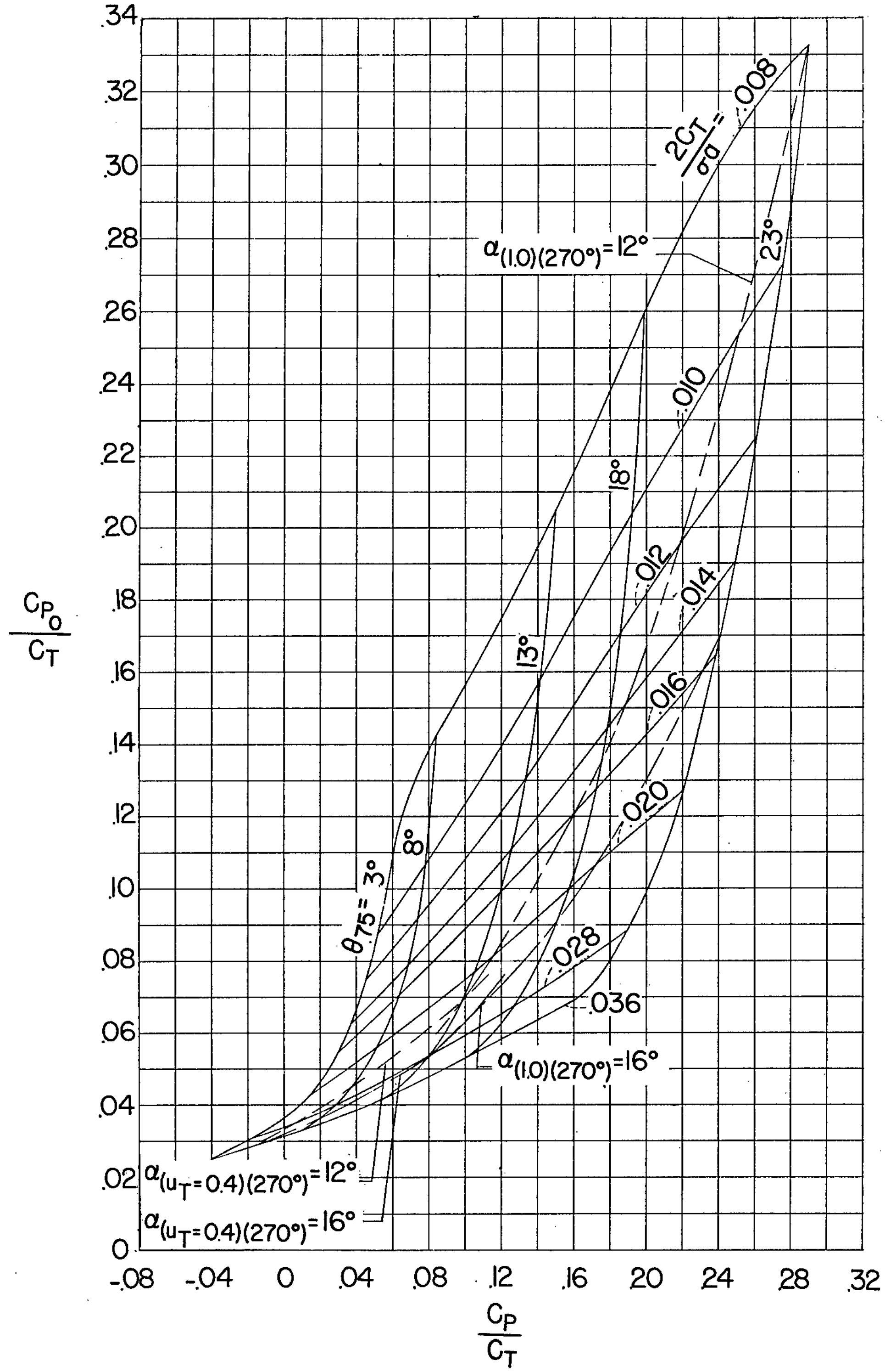
(e) $\mu = 0.30$.

Figure 4.- Continued.



(f) $\mu = 0.40$.

Figure 4.- Continued.



(g) $\mu = 0.50$.

Figure 4.- Concluded.

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Charts published in NACA TN 3323 for estimating the performance of high-performance helicopters were applicable to rotors having hinged rectangular blades with a linear twist of -8°. Supplementary charts are presented herein covering twists of 0° and -16°.

Copies obtainable from NACA, Washington

1. Wings, Rotating - Theory (1.6.1)
2. Autogiros (1.7.3.1)
3. Helicopters (1.7.3.2)
I. Tapscott, Robert J.
II. Gessow, Alfred
III. NACA TN 3482

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