NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL MEMORANDUM

No. 1225

TEST REPORT ON THREE- AND SIX-COMPONENT MEASUREMENTS ON A SERIES OF TAPERED WINGS OF SMALL ASPECT RATIO

(Partial Report: Trapezoidal Wing)

By Lange/Wacke

Translation of ZWB Untersuchungen und Mitteilungen Nr. 1023/1, September 1943

NACA

Washington

May 1949

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL MEMORANDUM NO. 1225

TEST REPORT ON THREE- AND SIX-COMPONENT MEASUREMENTS ON A SERIES OF TAPERED WINGS OF SMALL ASPECT RATIO

(Partial Report: Trapezoidal Wing)*

By Lange/Wacke

The present report, which forms the first of six articles on experiments with airfoils of aspect ratio from 1 to 3 and various plan forms, deals with the three- and six-component measurements made on the trapezoidal wing series in the 2.15 × 3-meter wind tunnel of the DVL at the request of the Henschel Aircraft Company.

I. INTRODUCTION

The aerodynamic behavior of wings with aspect ratio from 1 to 3 was studied in wind-tunnel measurements, first on the wing alone, and later on the wings with fuselage.

As seen from figure 1, the sweepback constituted the principal variation. The leading edge of the wing is either curved (elliptic wing), or straight (trapezoidal and triangular wing). Common to all wings is the trailing edge perpendicular to the plane of symmetry. Since the test data serve as the aerodynamic data for the design of gliding bodies, this test series was to provide the plan form that affords a constant neutral position point for a large c_a-range.

This first partial report deals with the measurements of the trapezoidal wing series with equal aspect ratio $\Lambda = 4/3$ and equal span for varying taper (fig. 2).

II. DESCRIPTION OF MODELS

The models, of wood, were made at the scale 1:1; the surface was polished. Three different wings were used: DT 1/2, DT 1/4, and DT 1/8. The dimensions and plan forms are shown in figure 2. The wing section is the NACA airfoil 0012.

---

*"Prüfbericht über 3- und 6-Komponentenmessung an der Zuspitzungsreihe von Flügeln kleiner Streckung. Teilbericht: Trapezflügel." Zentrale für wissenschaftliches Berichtswesen der Luftfahrtforschung des Generalluftzeugmeisters (ZWB) – Berlin-Adlershof, Untersuchungen und Mitteilungen Nr. 1023/1, Sept. 15, 1943.

III. TEST PROCEDURE

The measurements were made in the 2.15 × 3 meter wind tunnel of the DVL in the usual manner on the six-component balance. (Figs. 3 and 4). To prevent the air from flowing through the wing at the two forward suspension points, the preliminary tension was provided centrally in the plane of symmetry of the wing. The dynamic pressure was $q = 100$ kilograms per meter^2, corresponding to 40 meters per second airspeed.

IV. INTERPRETATION

The forces and moments are defined by the standard DIN L 100 and measured in the aerodynamic system of axes (fig. 3). The moment reference point for all three wings lies on the wing chord at a distance of three-fourths of the mean reference chord of the wing trailing edge (fig. 2). The reference axes for the moments are defined as follows:

Rolling moment: x_e-axis = line of intersection of the vertical plane of symmetry of the body with the horizontal plane of the tunnel (positive toward wind direction)

Pitching moment: y_e-axis = transverse axis along the wing (positive in flow direction, seen from the left)

Yawing moment: z_e-axis = normal axis in wind direction (positive downward)

All moments viewed along the positive axes of rotation and for clockwise rotation are positive.

The coefficients of the forces and moments are:

A	lift, kilograms
W	drag, kilograms
Q	transverse force, kilograms
L	rolling moment, meter-kilograms
M	pitching moment, meter-kilograms
N	yawing moment, meter-kilograms
$c_a = \frac{A}{q \times F}$	lift coefficient

$c_w = \frac{W}{q \times F}$ drag coefficient

$c_q = \frac{Q}{q \times F}$ transverse force coefficient

$c_L = \frac{L}{q \times F \times \frac{b}{2}}$ rolling moment coefficient

$c_M = \frac{M}{q \times F \times l_m}$ pitching moment coefficient

$c_N = \frac{N}{q \times F \times \frac{b}{2}}$ yawing moment coefficient

Reference quantities:

$F = 0.75$ wing area, (meter^2)

$b = 1$ span, (meters)

$l_m = \frac{F}{b} = 0.75$ mean wing chord (reference chord), (meters)

$q = \frac{\rho}{2} v^2 = 100$ dynamic pressure (kilograms per meter^2)

Angles:

α angle of attack = angle between longitudinal axis along the wing and the x_e–axis at rotation about the y_e–axis

β angle of yaw = angle between the longitudinal axis in wind direction and the x_e–axis at rotation about the z_e–axis

Viewed along the positive axis of rotation at clockwise rotation the prefixes are positive. The results are tabulated in Table A.

(a) Three–Component Measurements

For each of the three wings the coefficients $c_a = f(\alpha)$, $c_a = f(c_w)$, and $c_a = f(c_M)$ are reproduced in graphs 1, 7, and 13. Increasing taper is accompanied by decreasing c_a'. Since the aspect ratio is constant, that is a consequence of increasing sweepback. The moment reference point lies in the range of $c_a = \pm 0.35$ before the chosen moment reference point and moves quickly backward at $c_a > 0.35$. The cause of it is the lift–producing transverse flow in the rear part of the wing observed in the measurements on the triangular wings. The effect of taper and sweepback is small. It causes a slight backward travel of the neutral point.

Owing to the c_a ' decrease, the drag increases with increasing taper for constant c_a, since the form drag, and especially also c_{w_i} increases at the correspondingly greater angles of attack.

The maximum lift is but little affected by the taper, but that of the sweepback on the $c_{a\ max}$ is considerably greater. While the flow on the DT 1/2 separates very suddenly, it is very gradual on the DT 1/4 and the DT 1/8. The cause must be looked for in the decreased low-pressure peaks resulting from the sweepback. The $c_{a\ max}$ shifts, for the very same reasons, toward higher values with increasing taper.

(b) Six-Component Measurements

The coefficients of the six components are represented as functions of the angle of yaw β and the angle of attack α as parameter. As one can see from the drawings, the course of the curves for the angle of attack $\alpha = 0.62^\circ$ ($c_a = 0$), $\alpha = 9^\circ$ ($c_a = 0.3$), and $\alpha = 17.5$ ($c_a = 0.6$) is true to expectations wherever for large angles of attack the significant course of the curves is frequently interrupted. This applies partly to the transverse force and to the yawing moment. The influence of the yawed flow on the lift coefficient is small. Only in the regions of maximum lift coefficient does c_a show a larger decrease with the angle of yaw. The drag also is independent of the yawed flow. It becomes smaller only for angles of attack over 27° due to the decreasing induced drag.

The transverse force with respect to the angle of yaw is largely determined by the form drag at the wing tips; $\frac{\partial c_q}{\partial \beta}$ is positive and differs very little for the three wings. At $c_a > 0.3$ the negative transverse force of the wing surface prepcnderates, $\frac{\partial c_q}{\partial \beta}$ becomes negative.

Increasing taper is accompanied by decreasing rolling moment, which is likely to be due to the changed flow around the edge.

The pitching moment is not appreciably changed by the yawed flow.

Increasing taper acts unstable on the yawing moment, since the stabilizing effect of the decreasing blunt wing tips decreases.

FURTHER REPORT OF THE SERIES

Trapezoidal Wing with Fuselage	UM 1023/2
Elliptical Wing ($\Lambda = 2 + 1$)	UM 1023/3
Elliptical Wing with Fuselage	UM 1023/4
Triangular Wing ($\Lambda = 3 + 1$)	UM 1023/5
Triangular Wing with Fuselage	UM 1023/6

A comprehensive report of the entire test data is being prepared by Voepel.

Translated by J. Vanier
National Advisory Committee
for Aeronautics

TABLE A

SURVEY OF THE THREE- AND SIX-COMPONENT MEASUREMENTS

ON THE SERIES OF TAPERED WING –

TRAPEZOIDAL WING

Symbol		Angle		Chart of curves	Table
		α°	β°		
DT 1/2	Three-component measurement	Variable	0	1	1
	Six-component measurement	0.63	Variable	2	2
	Do----------	9	---do---	3	2
	Do----------	17.5	---do---	4	3
	Do----------	26.1	---do---	5	3
	Do----------	30	---do---	6	4
DT 1/4	Three-component measurement	Variable	0	7	5
	Six-component measurement	0.62	Variable	8	6
	Do----------	9	---do---	9	6
	Do----------	17.6	---do---	10	7
	Do----------	26.2	---do---	11	7
	Do----------	33	---do---	12	8
DT 1/8	Three-component measurement	Variable	0	13	9
	Six-component measurement	0.63	Variable	14	10
	Do----------	9	---do---	15	10
	Do----------	17.5	---do---	16	11
	Do----------	26.2	---do---	17	11
	Do----------	38	---do---	18	12
Comparative curves of the three wings					
$c_a = f(\alpha)$; $c_a = f(c_w)$		Variable	0	19	
$c_a = f(c_M)$		---do---	0	20	
c_L and $c_q = f(\beta)$		$\alpha_{c_a} = 0.3$	Variable	21	
c_L and $c_q = f(\beta)$		$\alpha_{c_a} = 0.9$	---do---	22	

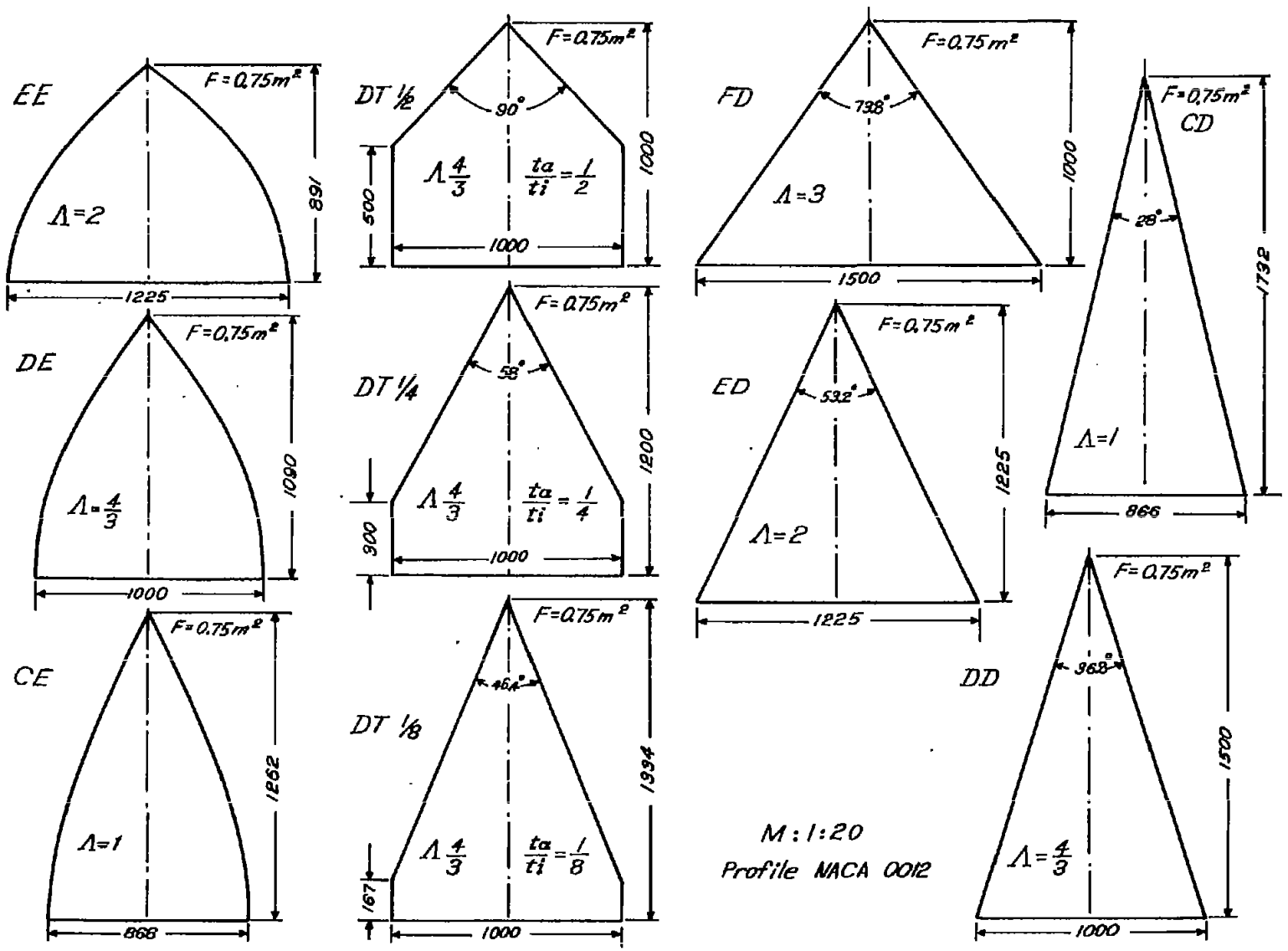
EE
F=0,75m²
Λ=2
891
1225
DE
F=0,75m²
Λ=4/3
1090
1000
CE
F=0,75m²
Λ=1
1262
868
DT 1/2
F=0,75m²
90°
Λ 4/3
ta/ti = 1/2
500
1000
1000
DT 1/4
F=0,75m²
58°
Λ 4/3
ta/ti = 1/4
300
1000
1200
DT 1/8
F=0,75m²
46,4°
Λ 4/3
ta/ti = 1/8
167
1000
1994
FD
F=0,75m²
73,8°
Λ=3
1000
1500
ED
F=0,75m²
53,2°
Λ=2
1225
1225
CD
F=0,75m²
28°
Λ=1
1732
866
DD
F=0,75m²
36,8°
Λ=4/3
1500
1000
M:1:20
Profile NACA 0012

Figure 1.

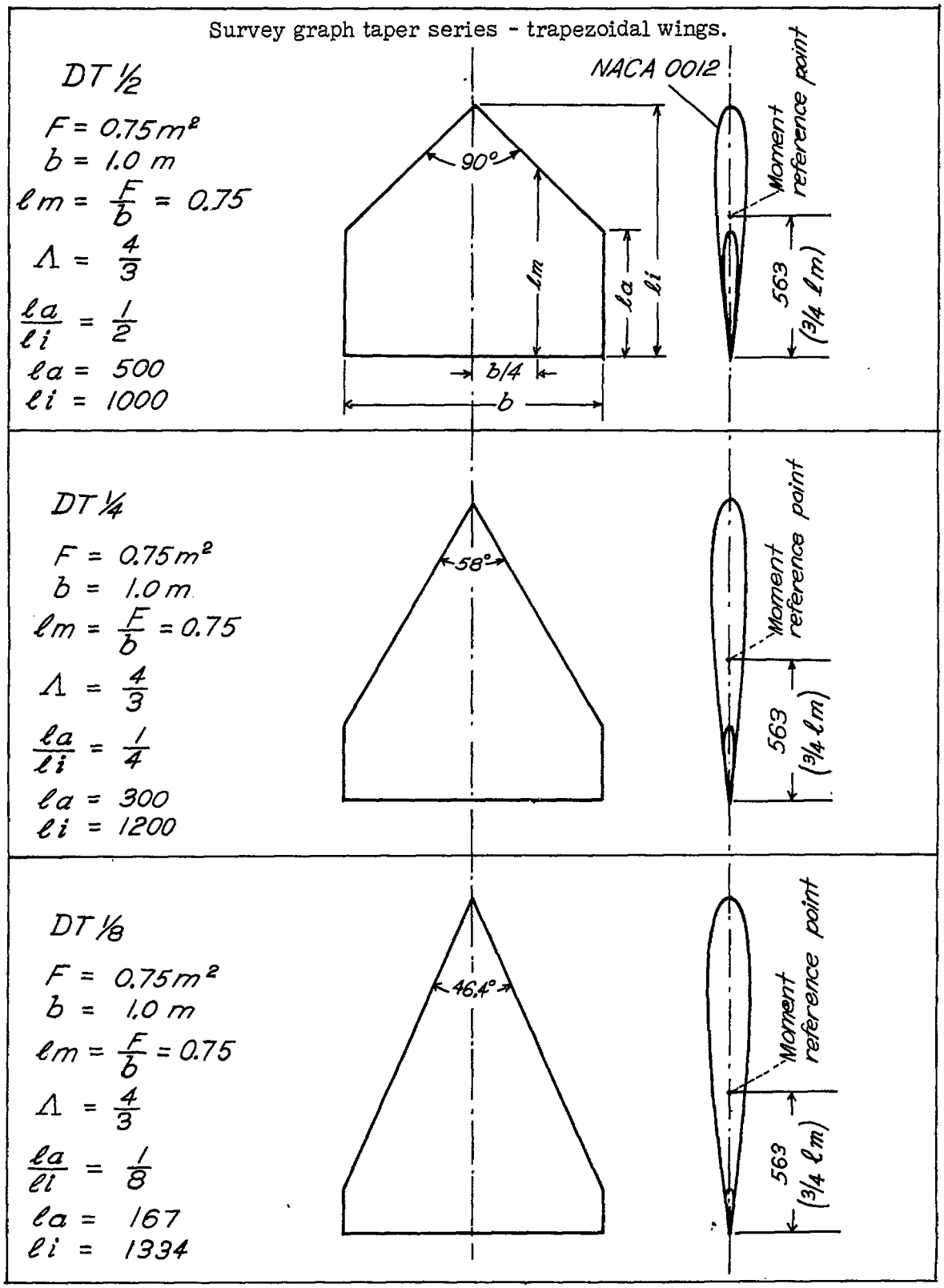
Survey graph taper series - trapezoidal wings.
DT ½
F = 0.75 m²
b = 1.0 m
ℓm = F/b = 0.75
Λ = 4/3
ℓa/ℓi = 1/2
ℓa = 500
ℓi = 1000
90°
ℓm
ℓa
ℓi
b/4
b
NACA 0012
Moment reference point
563 (¾ ℓm)
DT ¼
F = 0.75 m²
b = 1.0 m
ℓm = F/b = 0.75
Λ = 4/3
ℓa/ℓi = 1/4
ℓa = 300
ℓi = 1200
58°
Moment reference point
563 (¾ ℓm)
DT ⅛
F = 0.75 m²
b = 1.0 m
ℓm = F/b = 0.75
Λ = 4/3
ℓa/ℓi = 1/8
ℓa = 167
ℓi = 1334
46.4°
Moment reference point
563 (¾ ℓm)

Figure 2.

Suspension of the model of the series of tapered wings - trapezoidal wing - in the medium wind tunnel of DVL

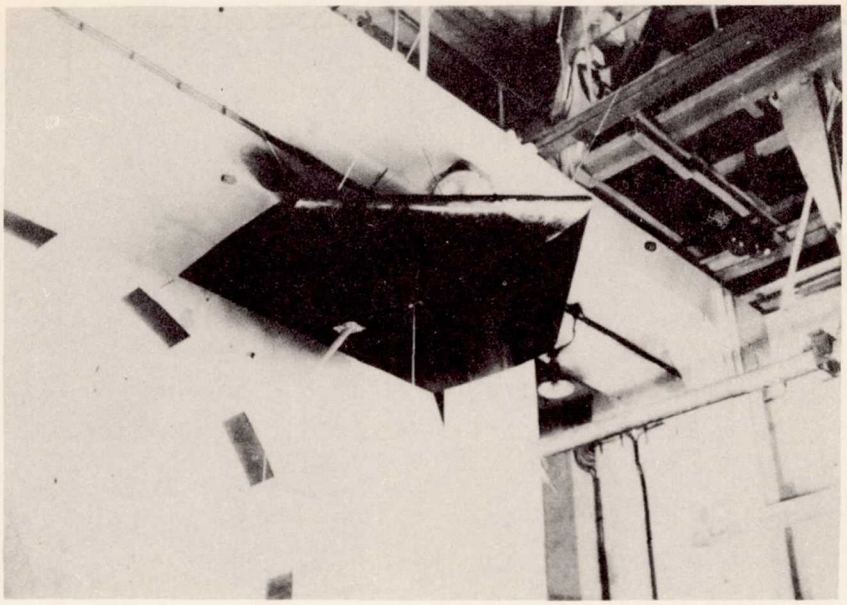

Figure 3.- DT$\frac{1}{2}$.

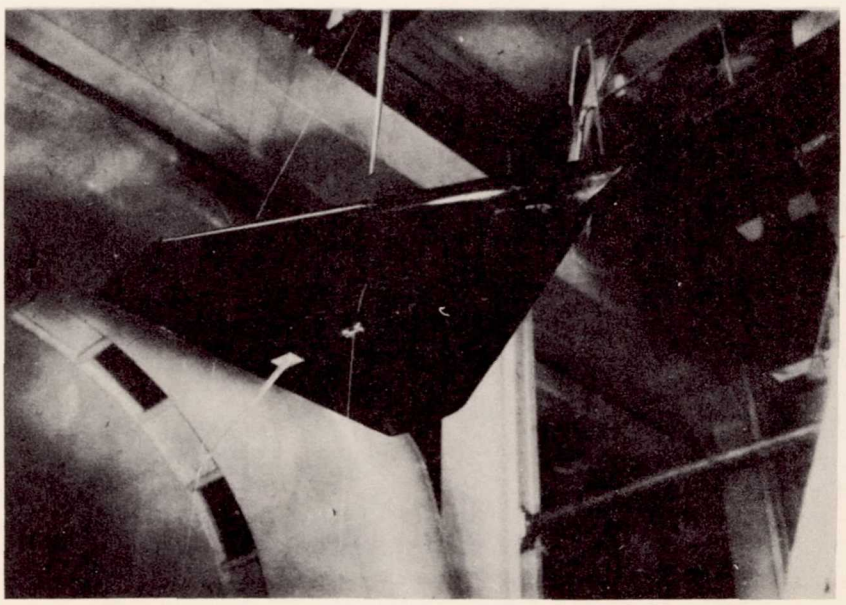

Figure 4.- DT$\frac{1}{4}$.

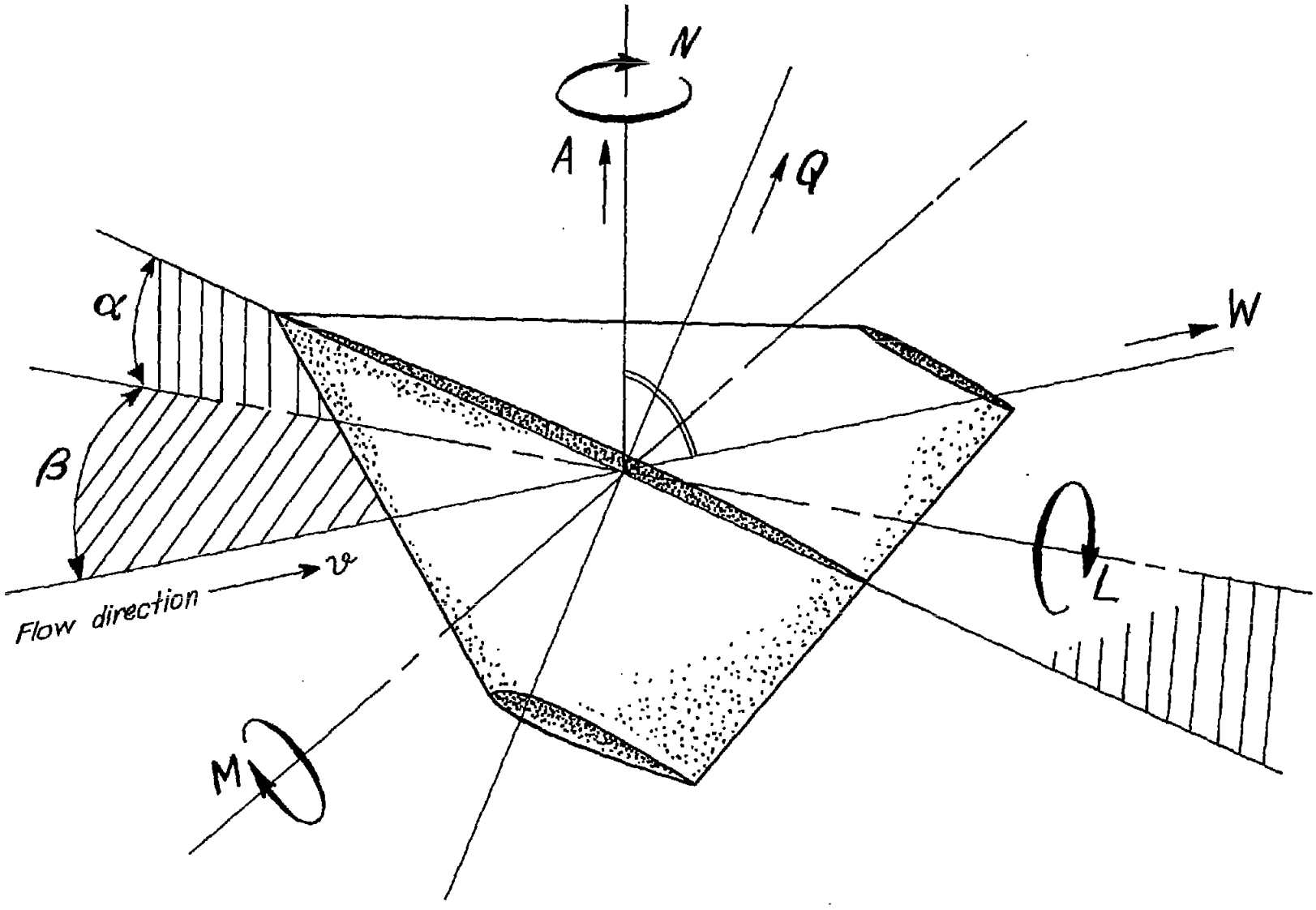

Figure 5.- System of coordinates of the six-component measurement.

THREE-COMPONENT MEASUREMENT ON A SERIES OF

TAPERED WINGS – TRAPEZOIDAL WING

TABLE NO. 1 TO CHART 1

DT 1/2

α^{o}	c_a	c_w	c_M
-5.41	-0.1895	0.0177	-0.0096
.34	.0061	.0080	.0014
6.10	.2029	.0190	.0065
11.82	.4230	.0533	.0119
17.53	.6526	.1155	.0014
23.22	.8985	.2149	-.0247
28.94	1.1240	.3433	-.0511
29.88	1.1710	.3734	-.0576
30.84	1.2020	.4961	-.0811
32.17	.9395	.5593	-.1092
35.33	.8140	.5369	-.1082
38.54	.6419	.5283	-.1078
41.55	.6341	.5548	-.1151

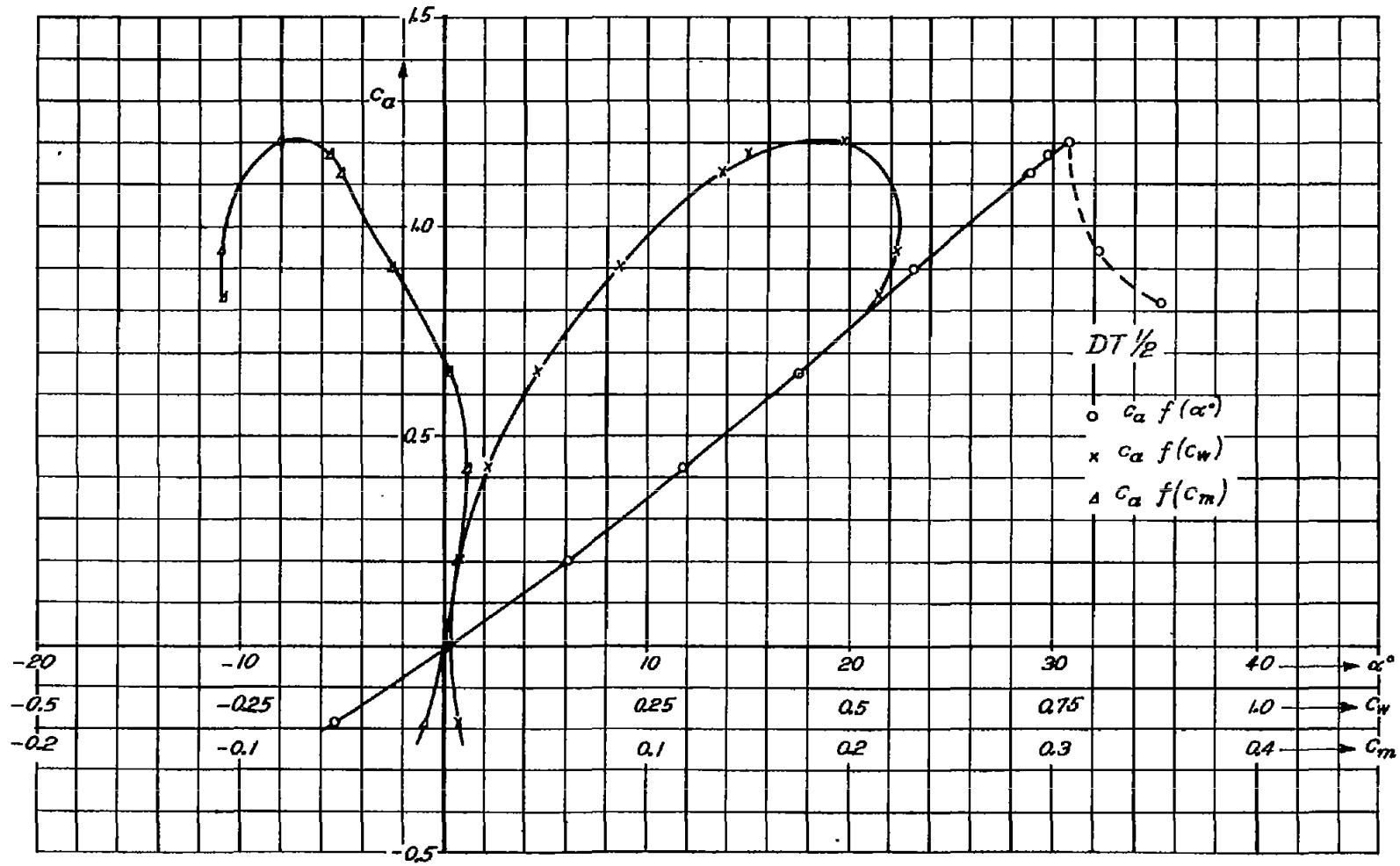

Chart 1. Three-component measurement on a series of tapered wings - trapezoidal wing.
Table 1.

SIX-COMPONENT MEASUREMENT ON A SERIES OF

TAPERED WINGS – TRAPEZOIDAL WING

TABLE NO. 2 TO CHART 2, 3

DT 1/2

$\alpha = 0.63°$

$\beta°$	c_a	c_q	c_w	c_L	c_M	c_N
–4	0.0166	–0.0033	0.0085	–0.0027	0.0016	0.0033
–2	.0158	–.0015	.0083	–.0018	.0021	.0010
0	.0152	.0003	.0080	–.0009	.0020	–.0005
2	.0152	.0022	.0084	.0003	.0023	–.0023
4	.0156	.0030	.0089	.0004	.0019	–.0036
6	.0160	.0035	.0092	.0008	.0014	–.0041
10	.0180	.0058	.0099	.0018	.0016	–.0055
15	.0185	.0087	.0103	.0027	.0013	–.0090
20	.02000	.0107	.0141	.0032	.0005	–.0106

$\alpha = 9°$

$\beta°$	c_a	c_q	c_w	c_L	c_M	c_N
–4	0.3139	–0.0047	0.0338	–0.0194	0.0126	0.0072
–2	.3144	–.0025	.0332	–.0108	.0127	.0033
0	.3142	–.0010	.0332	–.0013	.0130	–.0006
2	.3108	.0005	.0333	.0073	.0158	–.0043
4	.3119	.0002	.0335	.0162	.0129	–.0069
6	.3111	.0018	.0338	.0255	.0123	–.0098
10	.3111	.0035	.0348	.0422	.0100	–.0123
15	.3089	.0043	.0369	.0584	.0061	–.0207
20	.3000	.0047	.0387	.0728	.0021	–.0259

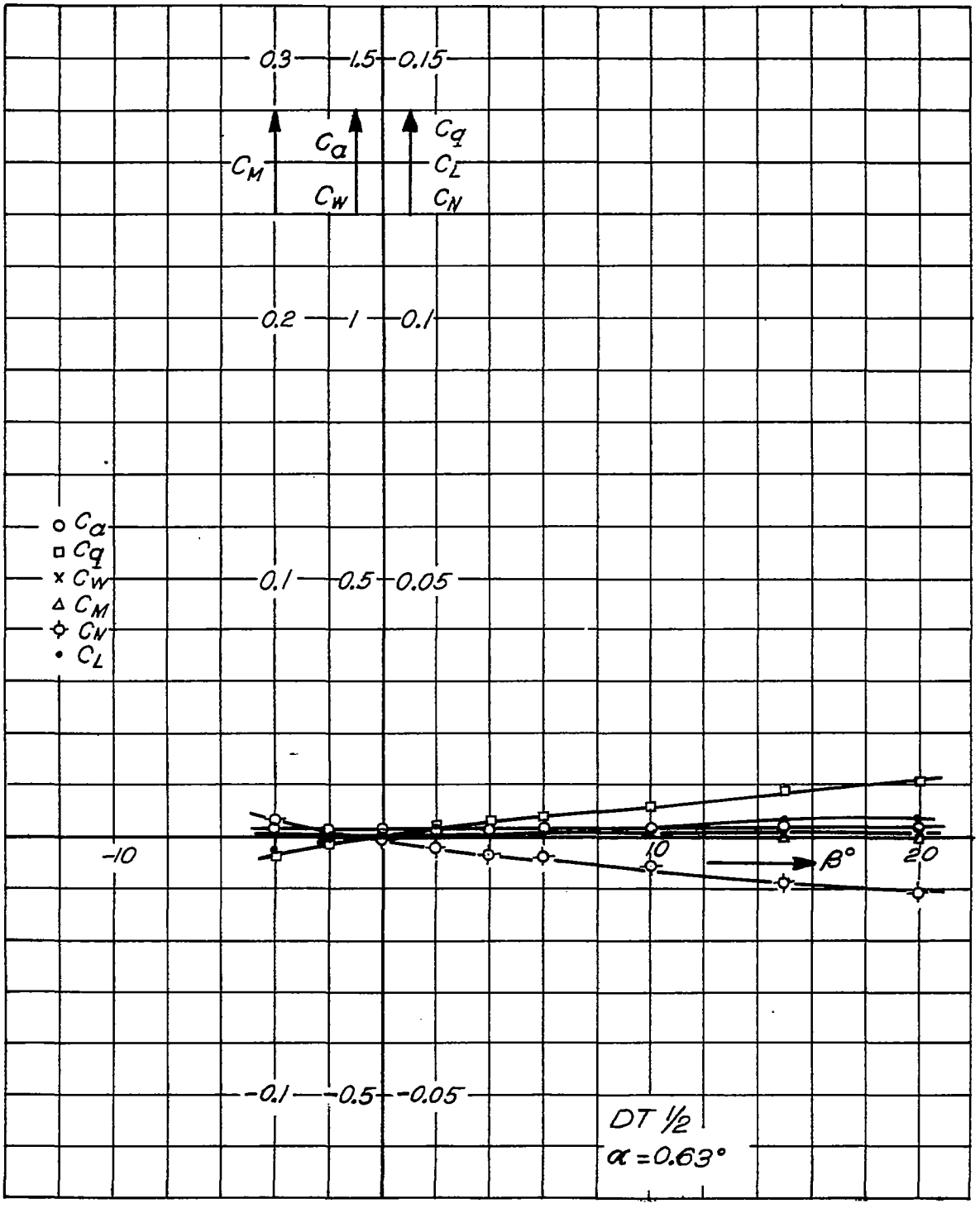

Chart 2. Six-component measurement on a series of tapered wings - Table 2. trapezoidal wing.

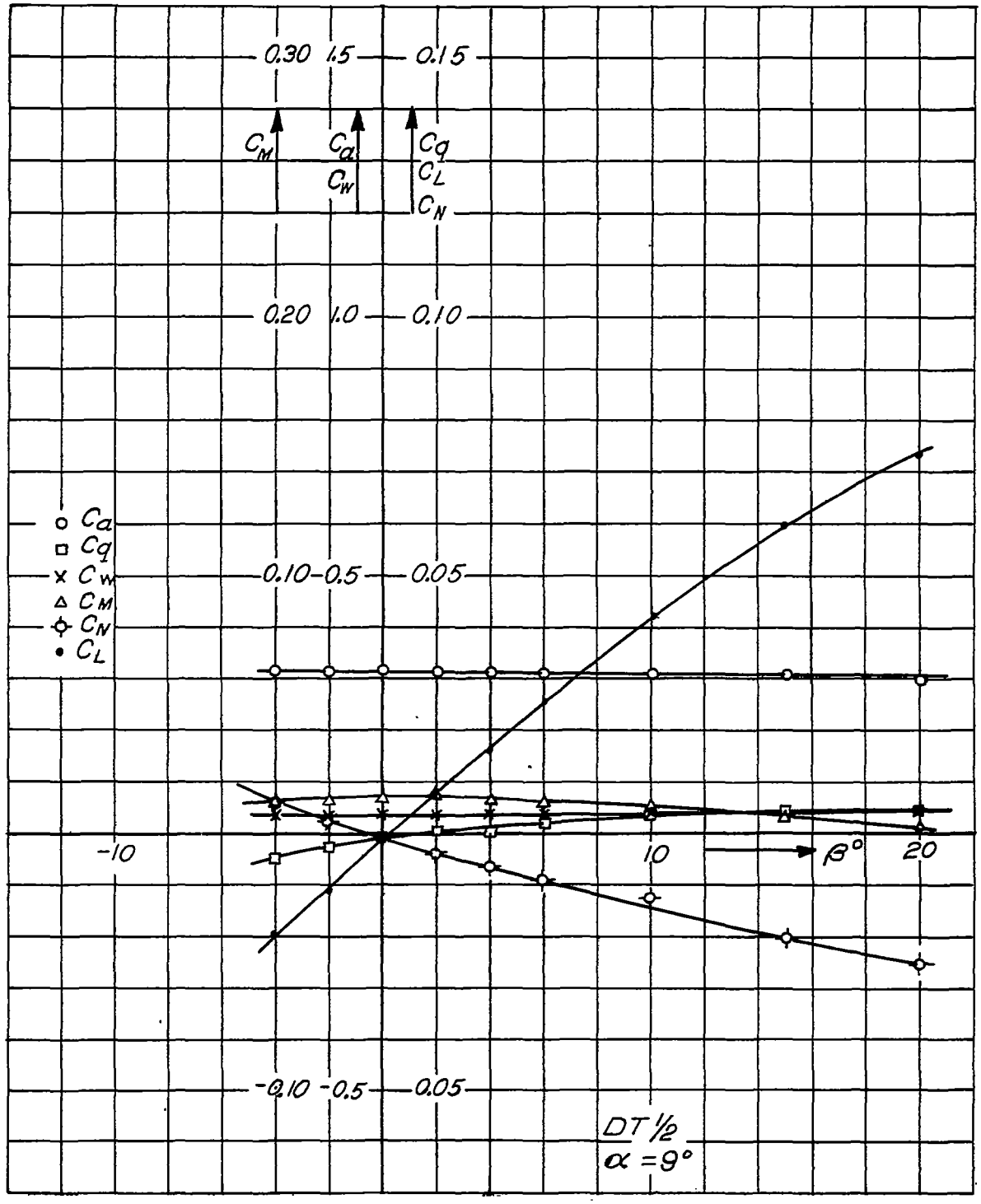

Chart 3. Six-component measurement on a series of tapered wings - Table 2. trapezoidal wing.

SIX-COMPONENT MEASUREMENT ON A SERIES OF

TAPERED WINGS – TRAPEZOIDAL WING

TABLE NO. 3 TO CHART 4, 5

DT 1/2

$\alpha = 17.5°$

$\beta°$	c_a	c_q	c_w	c_L	c_M	c_N
–4	0.6480	–0.0013	0.1154	–0.0355	0.0018	0.0158
–2	.6524	–.0018	.1156	–.0202	.0015	.0077
0	.6542	–.0023	.1157	–.0044	.0009	–.0006
2	.6526	–.0035	.1155	.0121	.0012	–.0078
4	.6500	–.0050	.1158	.0278	.0012	–.0145
6	.6452	–.0075	.1145	.0445	.0016	–.0206
10	.6389	–.0100	.1128	.0760	.0006	–.0340
15	.6239	–.0147	.1129	.1099	–.0038	–.0499
20	.6070	–.0187	.1121	.1367	–.0081	–.0623

$\alpha = 26.1°$

$\beta°$	c_a	c_q	c_w	c_L	c_M	c_N
–4	1.0200	–0.0496	0.3197	–0.0211	–0.0368	0.0548
–2	1.0500	–.0435	.3060	–.0183	–.0300	.0454
0	1.0490	–.0403	.2963	–.0065	–.0363	.0228
2	1.0460	–.0401	.2902	.0098	–.0383	.0068
4	1.0070	–.0193	.2718	.0324	–.0346	–.0231
6	1.0040	–.0288	.2697	.0517	–.0346	–.0338
10	1.0000	–.0504	.2653	.0845	–.0349	–.0508
15	.9690	–.0733	.2554	.1275	–.0394	–.0724
20	.9390	–.0812	.2475	.1643	–.0403	–.0981

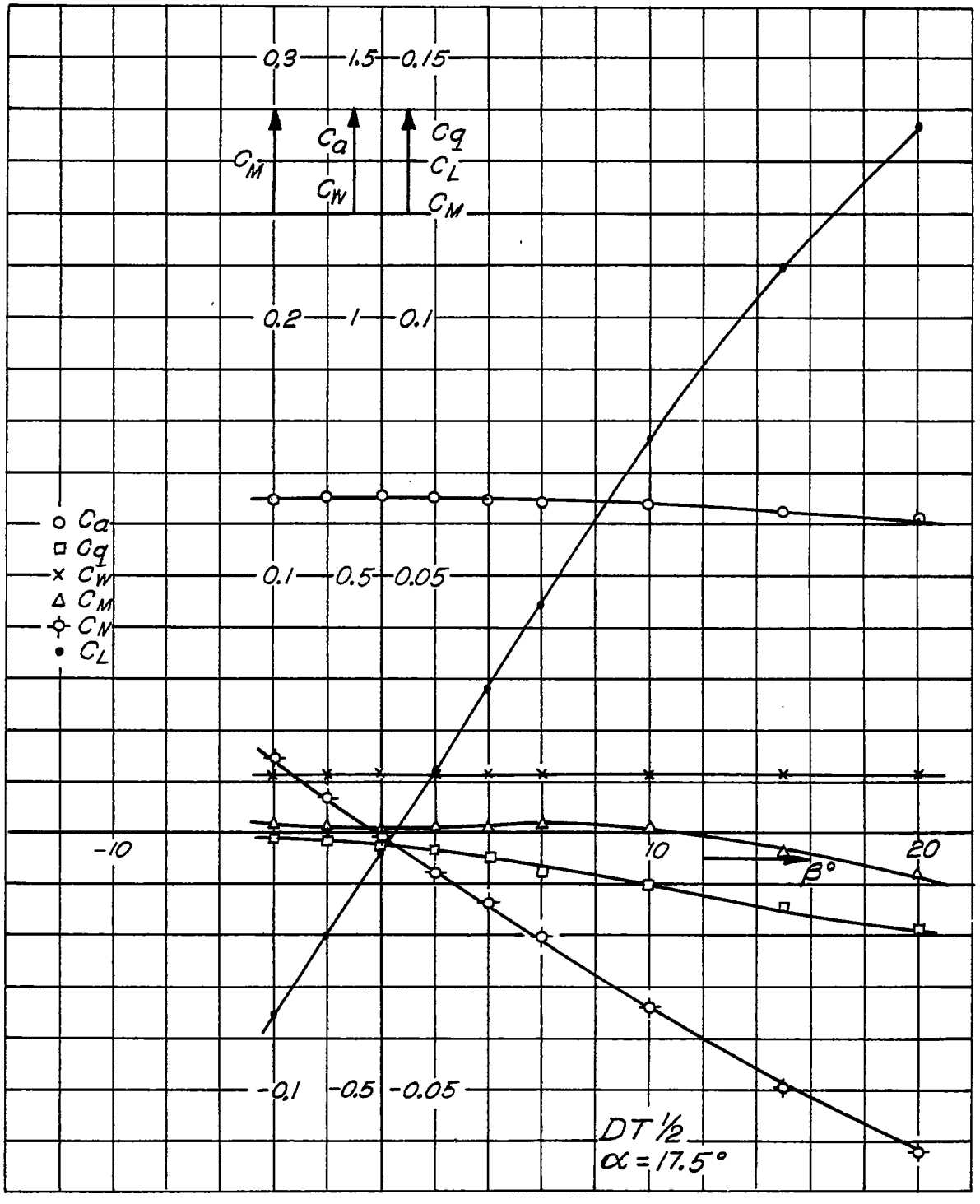

Chart 4. Six-component measurement on a series of tapered wings - Table 3. trapezoidal wing.

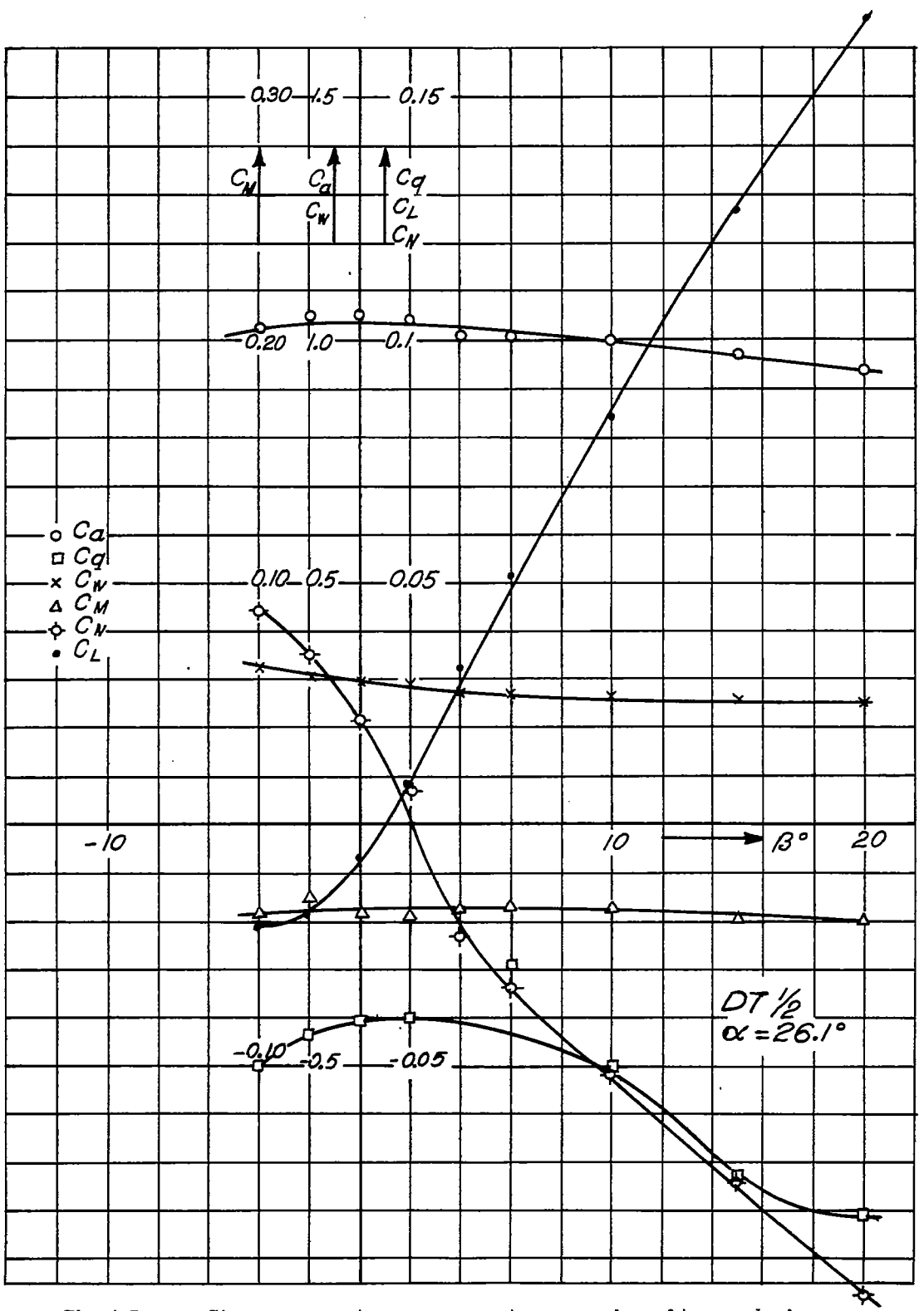

Chart 5. Six-component measurement on a series of tapered wings - trapezoidal wing.
Table 3.

SIX-COMPONENT MEASUREMENT ON A SERIES OF

TAPERED WINGS – TRAPEZOIDAL WING

TABLE NO. 4 TO CHART 6

DT 1/2

$\alpha = 30^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
–4	1.1310	–0.0187	0.5526	0.0257	–0.0932	–0.0068
–2	1.1480	–.0125	.5639	.0065	–.0944	–.0024
0	1.1590	–.0093	.5614	–.0120	–.0953	.0210
2	1.1320	–.0045	.5555	–.0333	–.0950	.0114
4	1.1130	–.0020	.5378	–.0471	–.0954	.0115
6	1.0870	.0068	.5168	–.0637	–.0937	.0158
10	1.0270	.0042	.4641	–.0594	–.0868	.0020
15	.8960	–.0023	.4227	–.0511	–.0877	–.0114
20	.7620	–.0210	.4400	–.0441	–.0999	–.0275

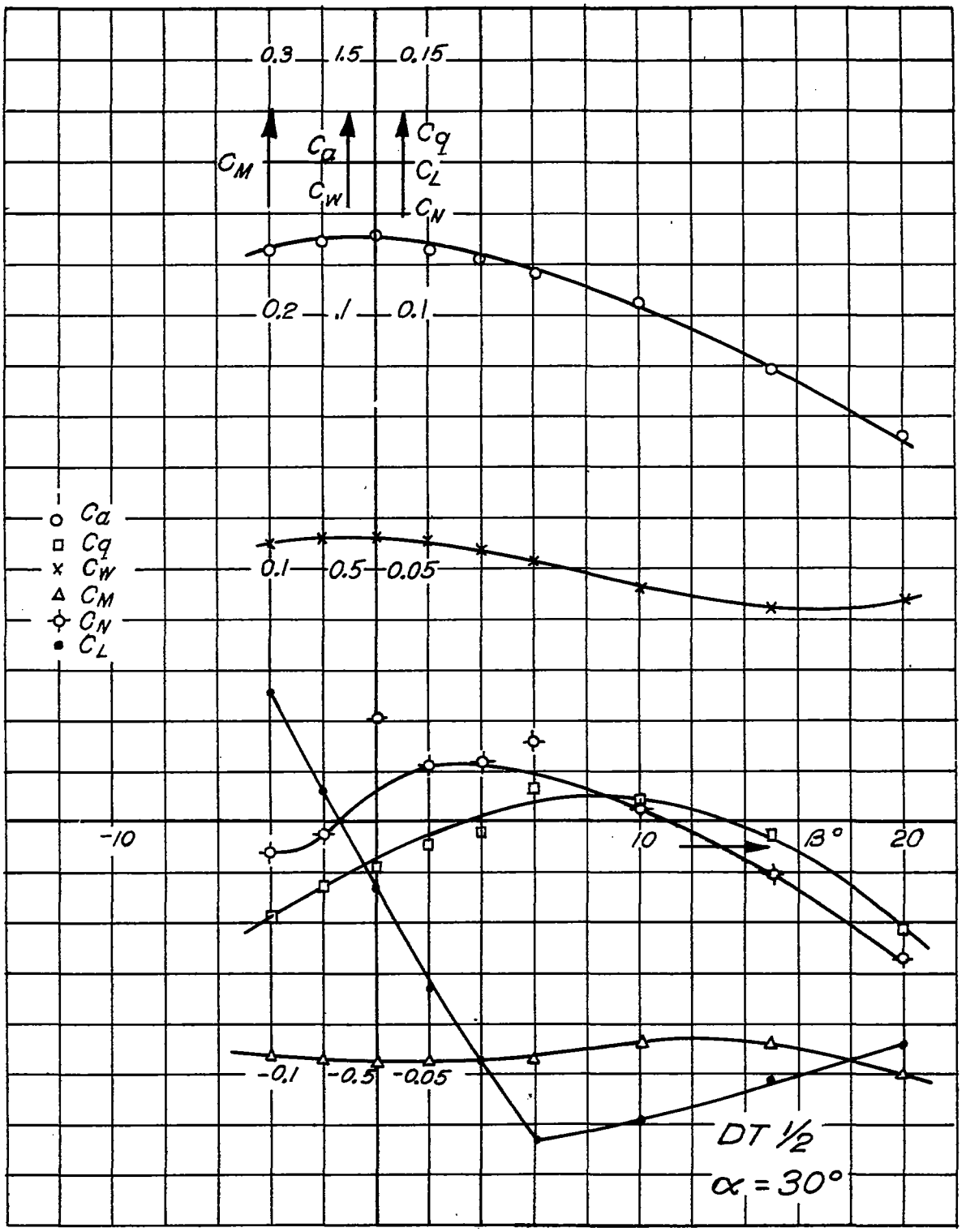

Chart 6. Six-component measurement on a series of tapered wings - trapezoidal wing.
Table 4.

THREE-COMPONENT MEASUREMENT ON A SERIES OF

TAPERED WINGS — TRAPEZOIDAL WING

TABLE NO. 5 TO CHART 7

DT 1/4

α°	c_a	c_w	c_M
-5.43	-0.1714	0.0160	-0.0076
.33	.0138	.0075	.0006
6.10	.2006	.0180	.0072
11.85	.3980	.0496	.0057
17.63	.6140	.1082	-.0098
23.26	.8670	.2169	-.0435
28.97	1.0980	.4432	-.0757
31.99	1.1660	.5582	-.0870
32.86	1.1850	.5970	-.0905
33.85	1.1950	.6319	-.0928
34.85	1.2010	.6681	-.0958
35.83	1.2130	.7075	-.1000
37.85	1.1960	.7712	-.1043
39.90	1.1540	.8178	-.1109

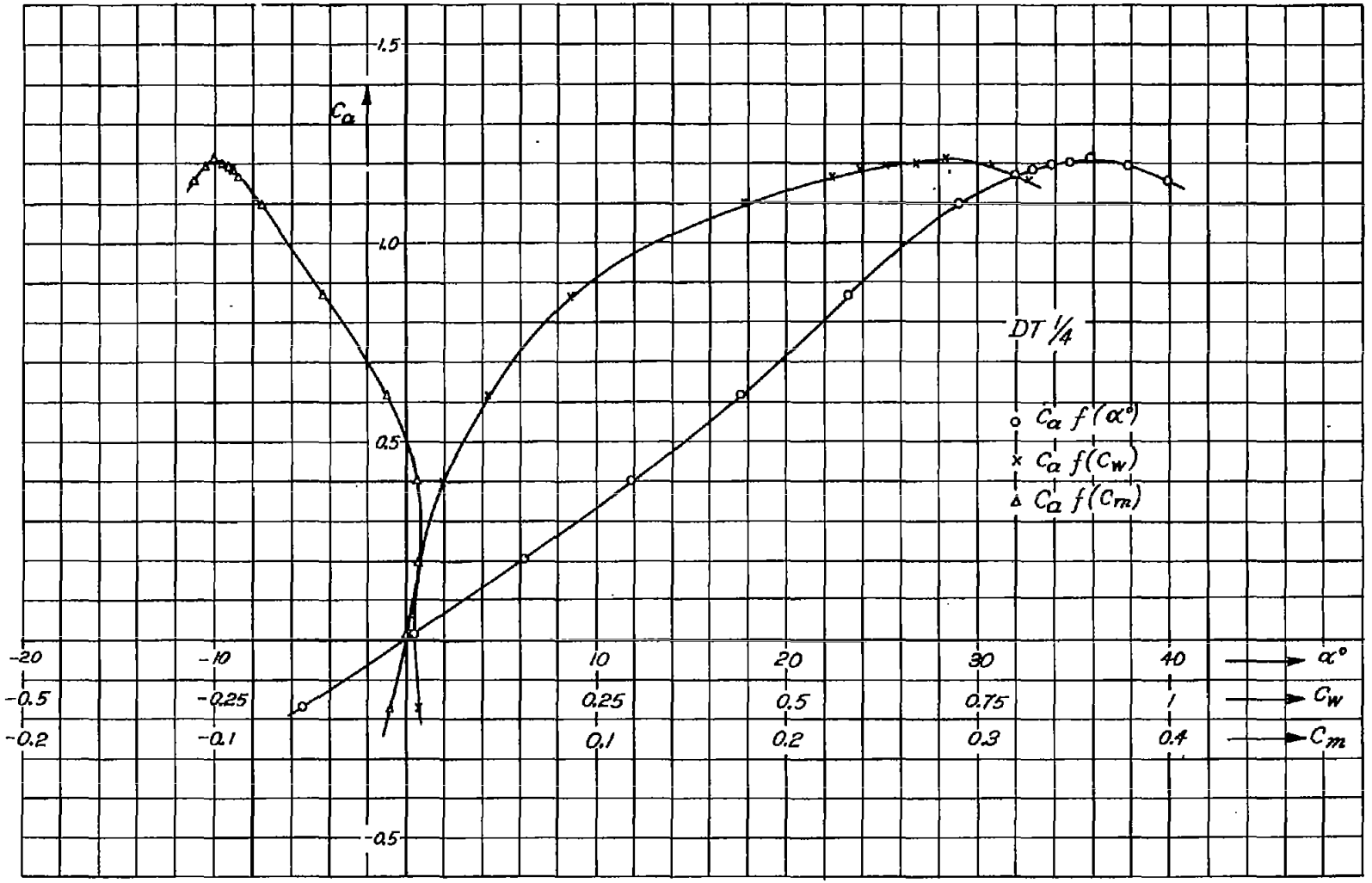

Chart 7. Three-component measurement on a series of tapered wings - trapezoidal wing.
Table 5.

SIX-COMPONENT MEASUREMENT ON A SERIES OF

TAPERED WINGS – TRAPEZOIDAL WING

TABLE NO. 6 TO CHARTS 8, 9

DT 1/4

$\alpha = 0.62^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
–4	0.0243	–0.0035	0.0085	–0.0004	0.0007	0.0018
–2	.0242	–.0028	.0088	.0005	.0002	.0023
0	.0228	–.0017	.0089	.0019	.0006	.0006
2	.0229	.0007	.0090	.0028	.0010	.0001
4	.0238	.0025	.0092	.0032	.0006	–.0020
6	.0248	.0030	.0095	.0028	.0000	.0004
10	.0237	.0032	.0103	.0038	–.0005	–.0000
15	.0250	.0065	.0114	.0051	.0004	.0005
20	.0251	.0090	.0135	.0056	.0000	.0004

$\alpha = 9^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
–4	0.2945	–0.0032	0.0319	–0.0150	0.0080	0.0047
–2	.2965	–.0028	.0315	–.0080	.0081	.0035
0	.2960	–.0023	.0313	.0015	.0085	.0015
2	.2970	–.0003	.0316	.0120	.0082	–.0020
4	.2980	.0008	.0320	.0203	.0071	–.0049
6	.2965	.0007	.0322	.0286	.0066	–.0056
10	.2935	.0015	.0327	.0457	.0059	–.0091
15	.2850	.0032	.0332	.0631	.0035	–.0119
20	.2605	.0050	.0343	.0771	.0041	–.0143

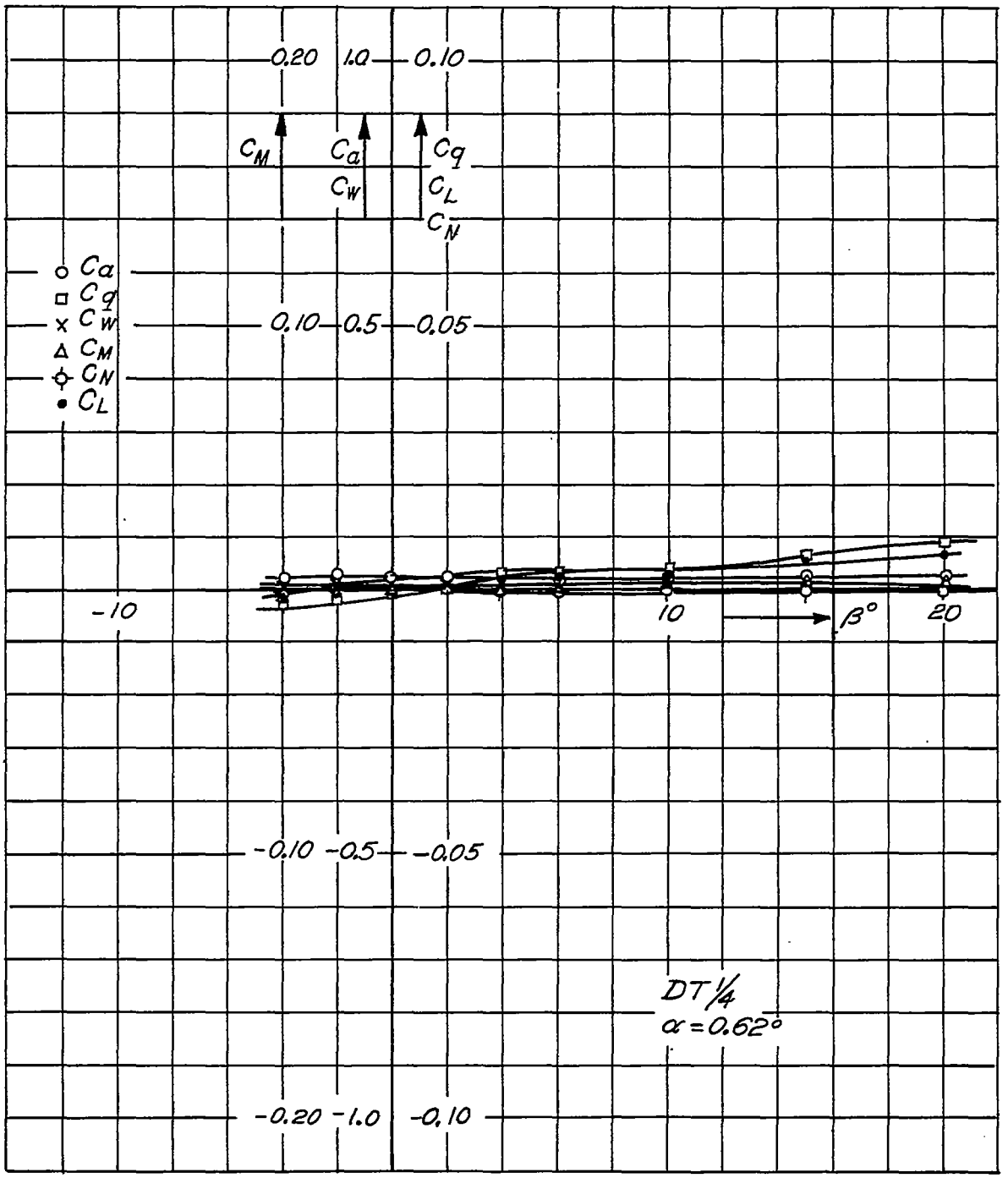

Chart 8. Six-component measurement on a series of tapered wings - trapezoidal wing.
Table 6.

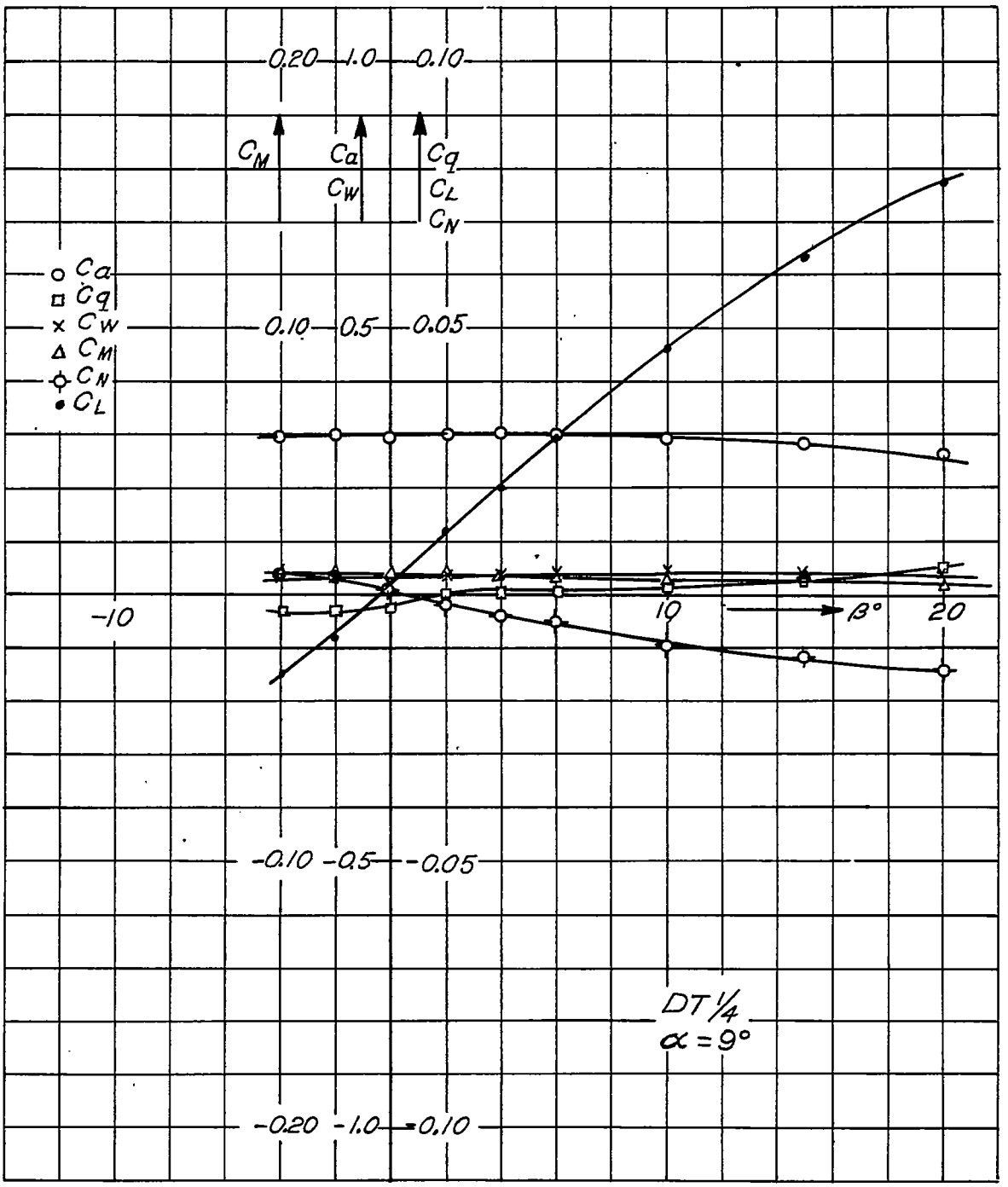

Chart 9. Six-component measurement on a series of tapered wings - trapezoidal wing.
Table 6.

SIX-COMPONENT MEASUREMENT ON A SERIES OF

TAPERED WINGS – TRAPEZOIDAL WING

TABLE NO. 7 TO CHARTS 10, 11

DT 1/4

$\alpha = 17.6^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
–4	0.6110	0.0022	0.1083	–0.0226	–0.0097	0.0097
–2	.6130	–.0008	.1085	–.0092	–.0100	.0058
0	.6140	–.0037	.1078	.0046	–.0105	.0011
2	.6150	–.0059	.1090	.0179	–.0105	–.0037
4	.6160	–.0102	.1095	.0297	–.0113	–.0079
6	.6170	–.0157	.1111	.0420	–.0124	–.0080
10	.6020	–.0152	.1071	.0680	–.0114	–.0209
15	.5850	–.0221	.1050	.1008	–.0136	–.0288
20	.5730	–.0326	.1062	.1273	–.0185	–.0304

$\alpha = 26.2^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
–4	0.9860	–0.0162	0.3226	–0.0105	–0.0616	0.0209
–2	.9990	–.0062	.3222	–.0048	–.0644	.0092
0	1.0000	.0007	.3201	.0020	–.0650	–.0022
2	.9990	.0023	.3222	.0088	–.0650	–.0123
4	.9950	.0045	.3273	.0157	–.0642	–.0213
6	.9840	.0037	.3318	.0230	–.0622	–.0266
10	.9450	.0018	.3351	.0282	–.0572	–.0280
15	.8730	.0052	.3256	.0411	–.0539	–.0294
20	.8020	–.0167	.3137	.0515	–.0486	–.0205

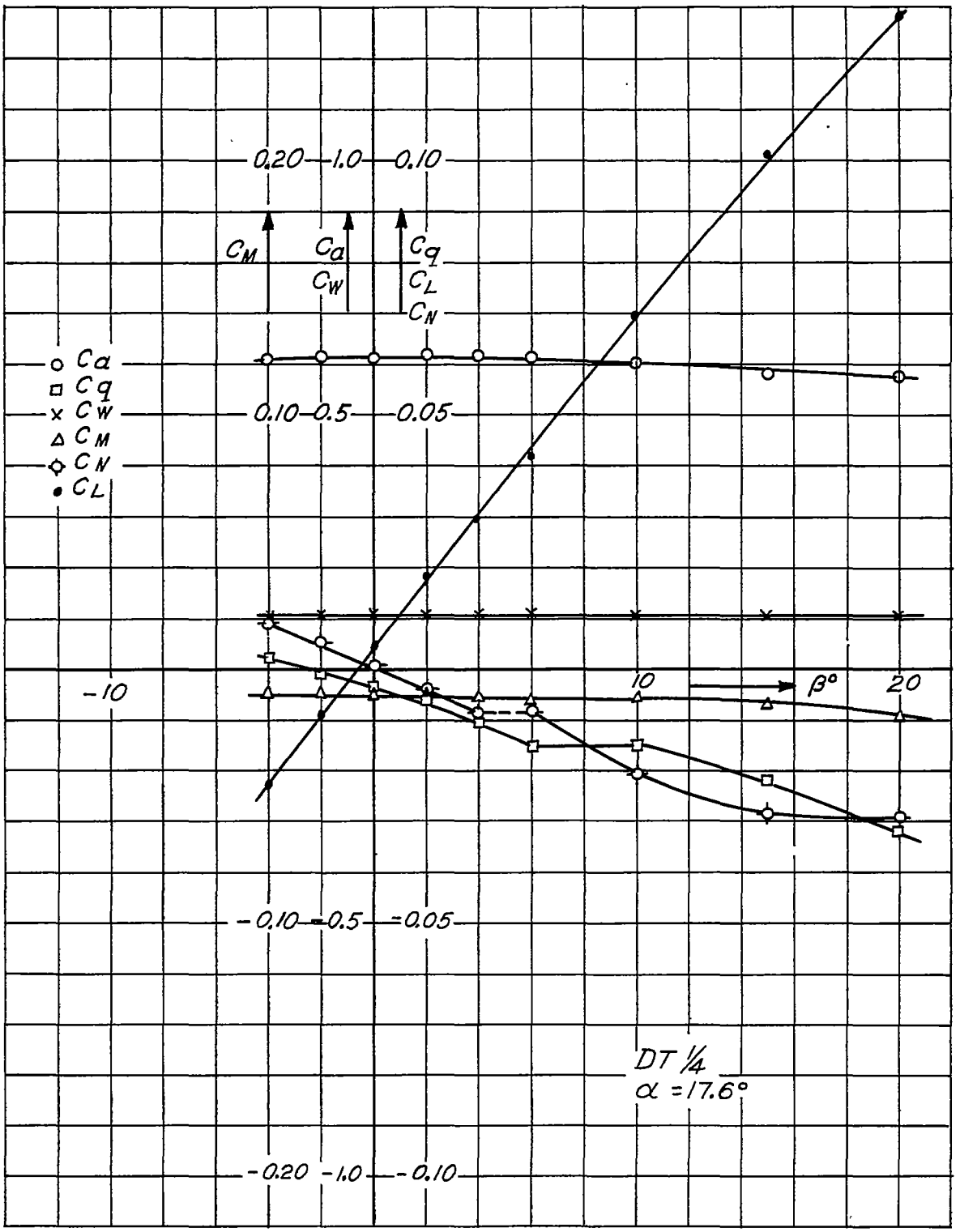

Chart 10. Six-component measurement on a series of tapered wings - trapezoidal wing.
Table 7.

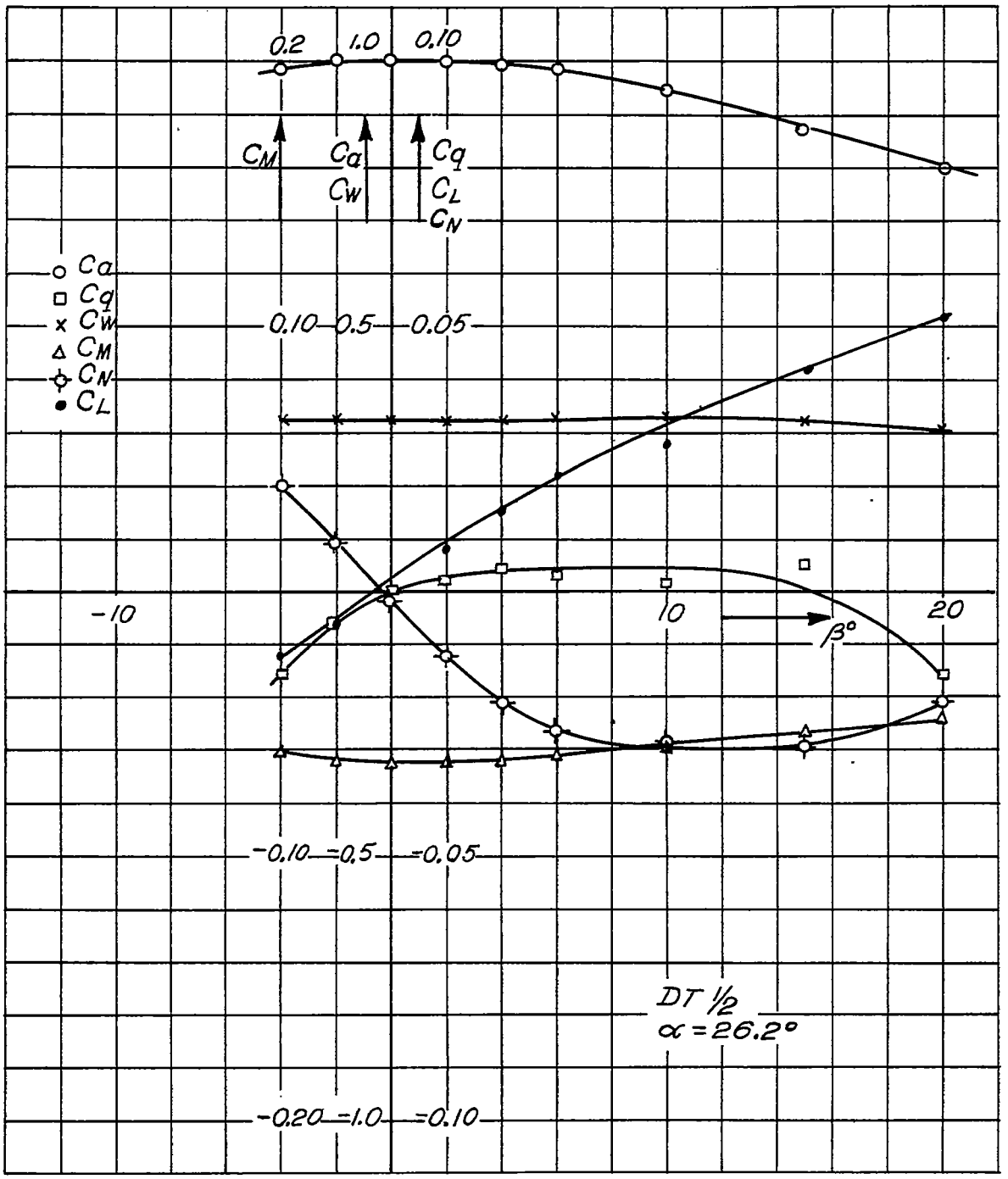

Chart 11. Six-component measurement on a series of tapered wings - Table 7. trapezoidal wing.

SIX-COMPONENT MEASUREMENT ON A SERIES OF

TAPERED WINGS – TRAPEZOIDAL WING

TABLE NO. 8 TO CHART 12

DT 1/4

$\alpha = 33^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
-4	1.1950	0.0022	0.5978	-0.0015	-0.0933	0.0112
-2	1.2010	.0025	.5996	.0014	-.0940	.0055
0	1.2070	.0017	.5990	.0019	-.0944	.0004
2	1.2060	.0017	.5964	.0055	-.0947	-.0045
4	1.2000	.0032	.5945	.0066	-.0966	-.0107
6	1.1900	.0013	.5931	.0074	-.0951	-.0169
10	1.1450	-.0122	.5901	.0115	-.0906	-.0161
15	1.0600	-.0042	.5460	.0154	-.0882	-.0236
20	.9800	-.0280	.5138	.0364	-.0820	-.0321

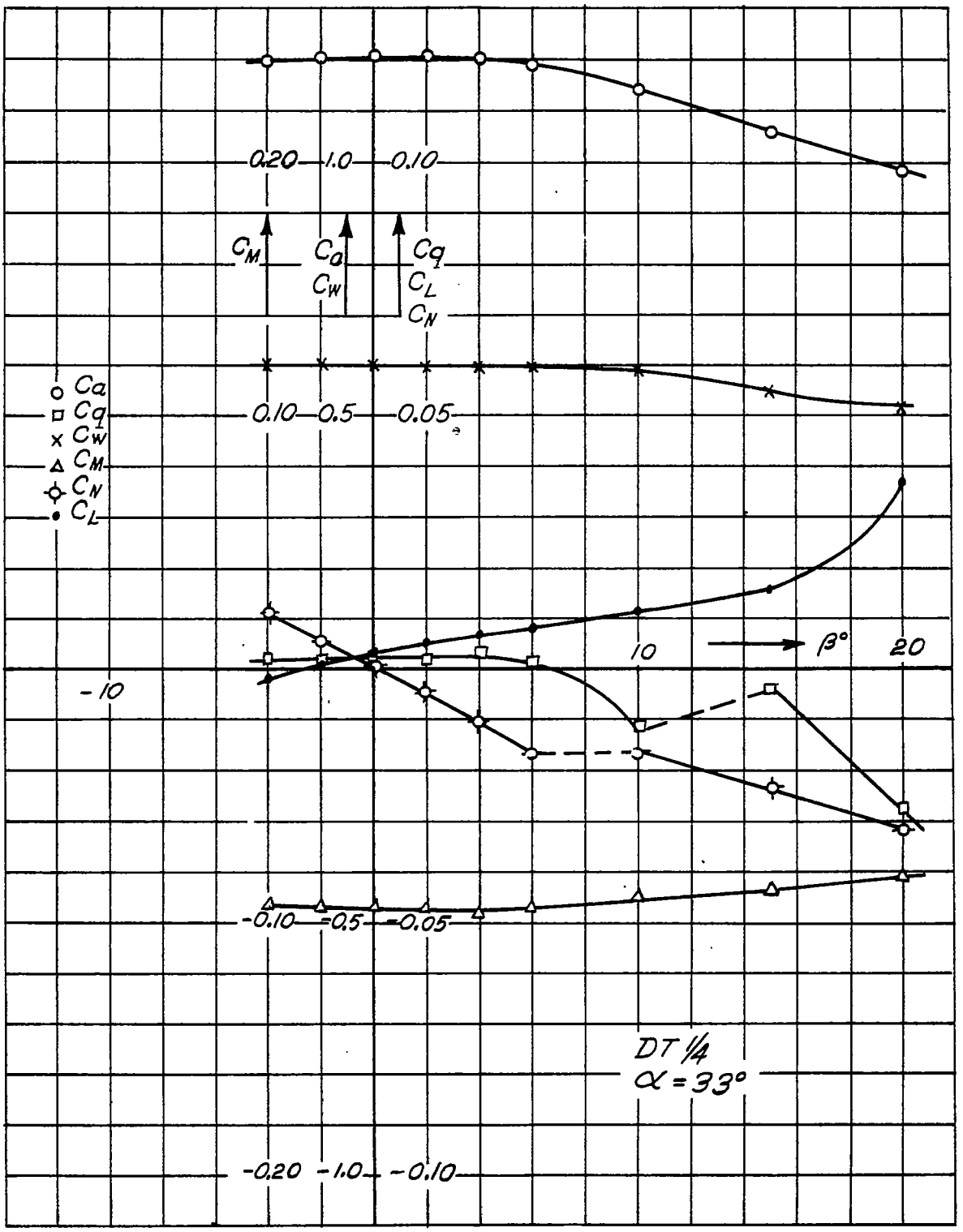

Chart 12. Six-component measurement on a series of tapered wings - Table 8. trapezoidal wing.

THREE-COMPONENT MEASUREMENT ON A SERIES OF

TAPERED WINGS – TRAPEZOIDAL WING

TABLE NO. 9 TO CHART 13

DT 1/8°

α°	c_a	c_w	c_M
-5.87	-0.1703	0.0167	-0.0061
.34	.0057	.0074	.0013
6.12	.1856	.0168	.0086
11.89	.3691	.0449	.0068
17.86	.5809	.1027	-.0107
23.37	.7942	.2241	-.0409
29.11	.9840	.3712	-.0598
32.09	1.0522	.4677	-.0673
34.93	1.1239	.5418	-.0785
37.91	1.1492	.6022	-.0831

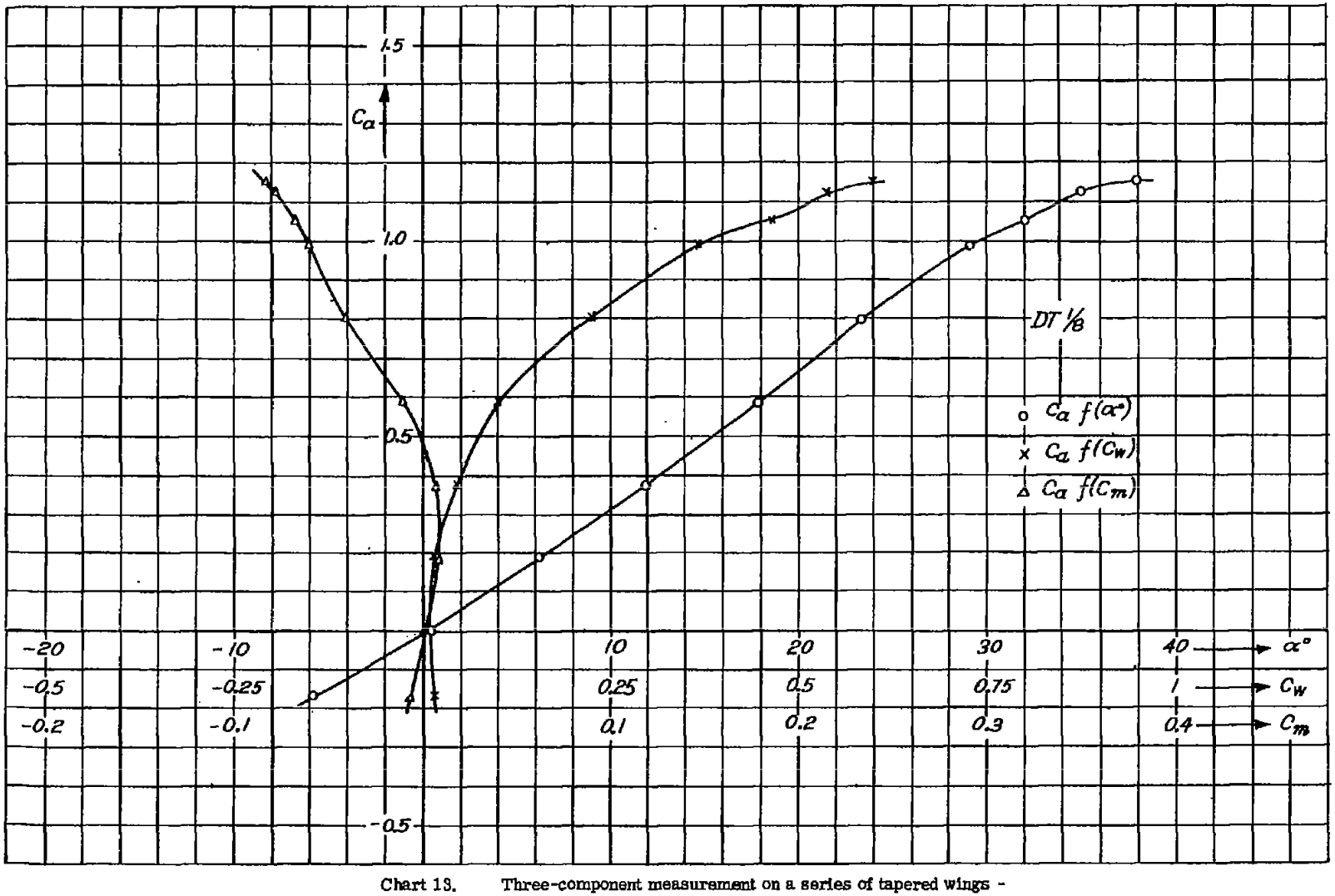

Chart 13. Three-component measurement on a series of tapered wings - trapezoidal wing.
Table 9.

SIX-COMPONENT MEASUREMENT ON A SERIES OF

TAPERED WINGS – TRAPEZOIDAL WING

TABLE NO. 10 TO CHARTS 14, 15

DT 1/8

$\alpha = 0.63°$

$\beta°$	c_a	c_q	c_w	c_L	c_M	c_N
–4	0.0152	–0.0030	0.0088	–0.0000	0.0017	0.0000
–2	.0145	–.0023	.0086	–.0000	.0019	.0012
0	.0138	–.0013	.0073	.0005	.0019	.0013
2	.0152	.0007	.0078	.0018	.0017	.0002
4	.0153	.0027	.0079	.0023	.0015	.0002
6	.0146	.0037	.0090	.0029	.0015	–.0007
10	.0145	.0045	.0098	.0034	.0016	.0034
15	.0146	.0075	.0110	.0063	.0017	.0064
20	.0135	.0105	.0130	.0068	.0014	.0100

$\alpha = 9°$

$\beta°$	c_a	c_q	c_w	c_L	c_M	c_N
–4	0.2790	–0.0030	0.0288	–0.0160	0.0078	0.0032
–2	.2780	–.0033	.0283	–.0081	.0096	.0031
0	.2780	–.0020	.0278	.0006	.0094	.0002
2	.2780	.0000	.0283	.0088	.0095	–.0013
4	.2793	.0010	.0288	.0176	.0079	–.0032
6	.2760	.0010	.0293	.0264	.0075	–.0039
10	.2725	.0018	.0298	.0416	.0063	–.0034
15	.2660	.0032	.0584	.0587	.0038	–.0025
20	.2555	.0045	.0728	.0720	.0014	–.0000

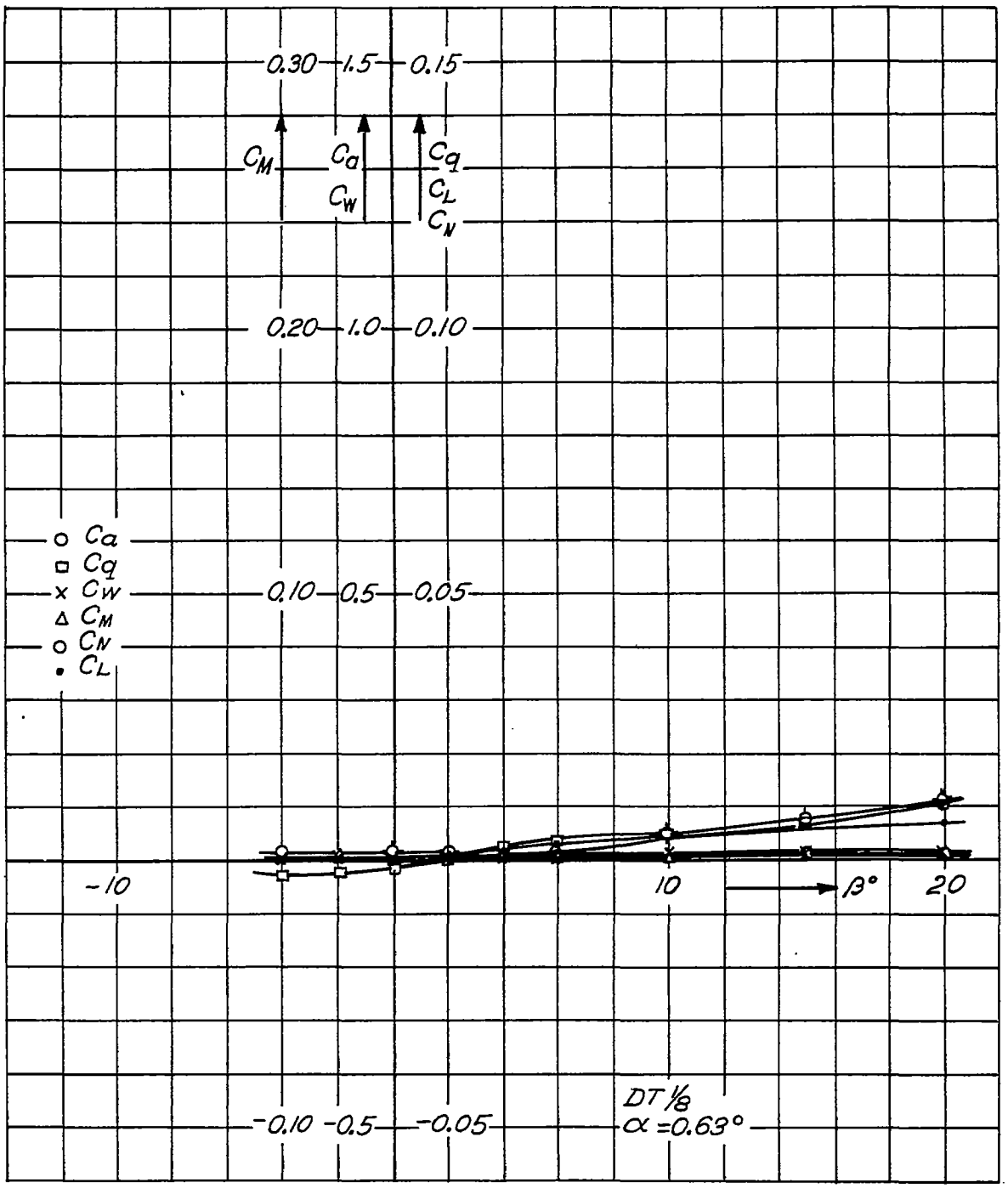

Chart 14. Six-component measurement on a series of tapered wings - trapezoidal wing.
Table 10.

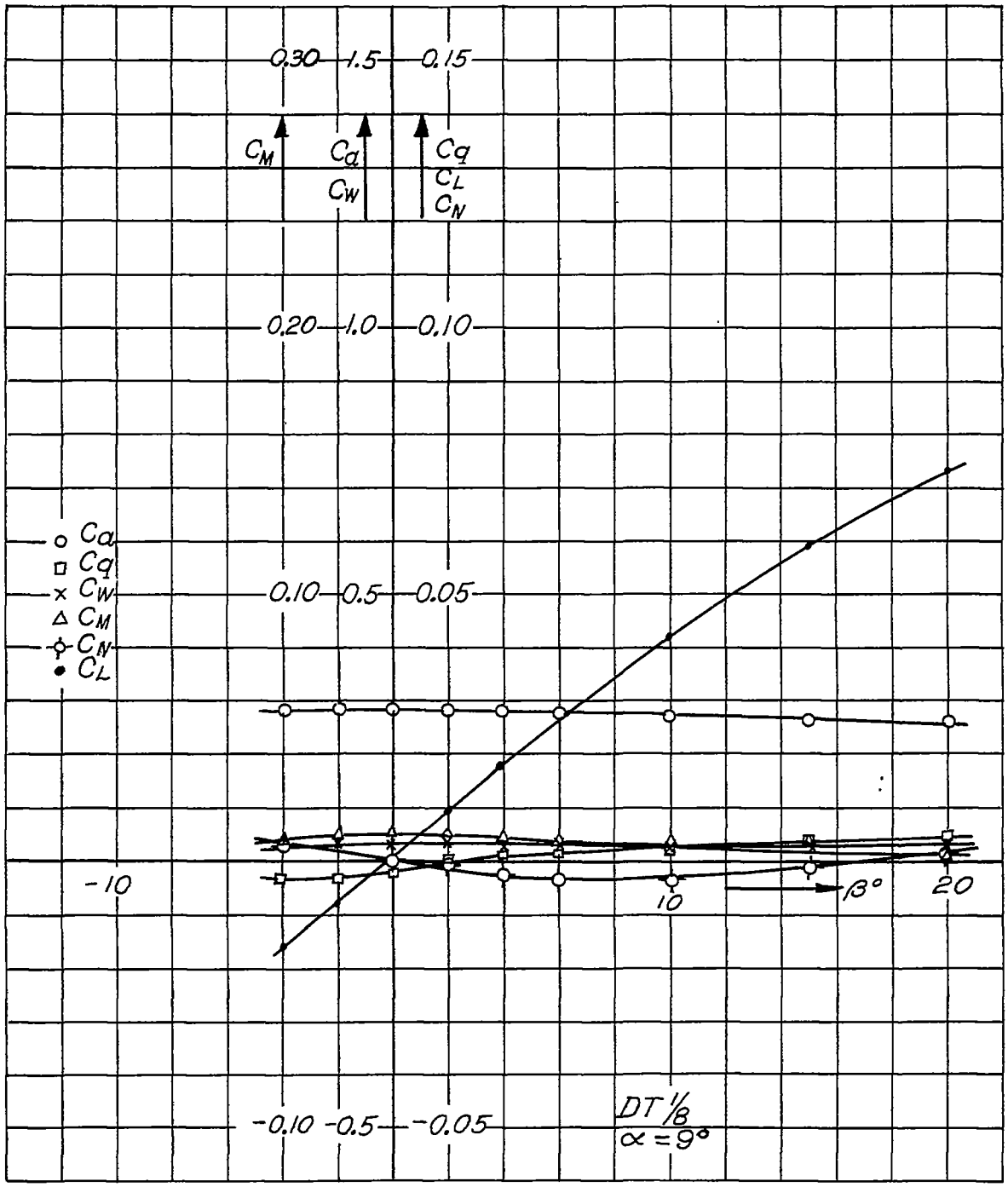

Chart 15. Six-component measurement on a series of tapered wings -
Table 10. trapezoidal wing.

SIX-COMPONENT MEASUREMENT ON A SERIES OF

TAPERED WINGS – TRAPEZOIDAL WING

TABLE NO. 11 TO CHARTS 16, 17

DT 1/8

$\alpha = 17.5°$

$\beta°$	c_a	c_q	c_w	c_L	c_M	c_N
–4	0.5800	0.0057	0.1029	–0.0250	–0.0101	0.0026
–2	.5800	.0017	.1029	–.0104	–.0100	.0017
0	.5810	–.0037	.1029	.0027	–.0096	.0004
2	.5808	–.0073	.1029	.0144	–.0100	–.0009
4	.5808	–.0106	.1031	.0259	–.0106	–.0018
6	.5780	–.0133	.1040	.0375	–.0112	–.0032
10	.5740	–.0232	.1062	.0620	–.0123	–.0021
15	.5580	–.0302	.1043	.0962	–.0134	–.0050
20	.5290	–.0312	.1000	.1258	–.0143	–.0089

$\alpha = 26.2°$

$\beta°$	c_a	c_q	c_w	c_L	c_M	c_N
–4	0.8920	0.0090	0.2859	–0.0192	–0.0499	0.0102
–2	.8940	–.0017	.2879	–.0079	–.0504	.0078
0	.8940	–.0073	.2769	.0016	–.0494	.0011
2	.8920	–.0147	.2849	.0105	–.0496	–.0022
4	.8880	–.0226	.2835	.0237	–.0490	–.0073
6	.8840	–.0313	.2807	.0369	–.0487	–.0104
10	.8580	–.0142	.2989	.0475	–.0409	–.0346
15	.8370	–.0265	.3047	.0617	–.0427	–.0370
20	.7660	–.0335	.3017	.0821	–.0411	.0338

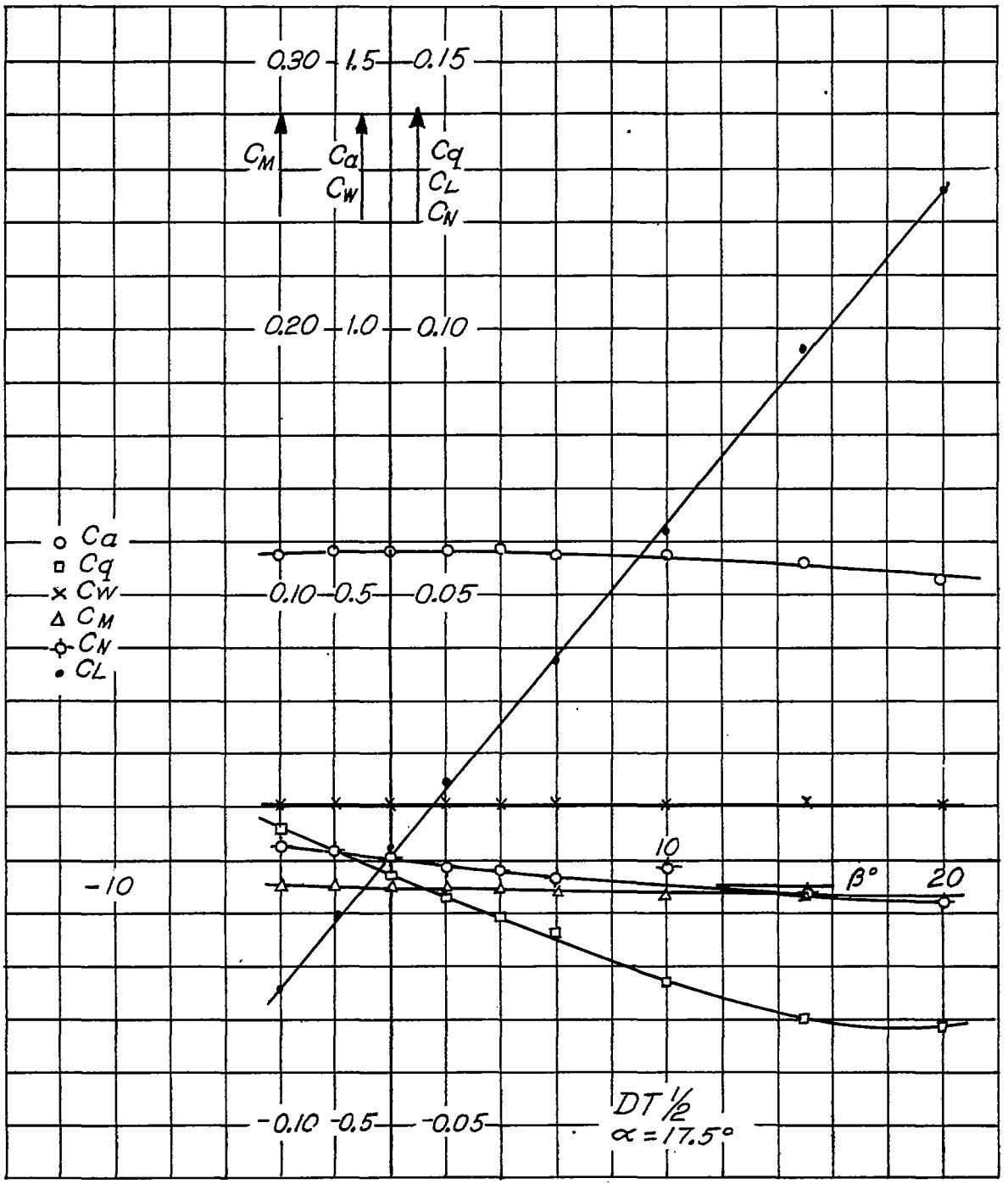

Chart 16. Six-component measurement on a series of tapered wings - trapezoidal wing.
Table 11.

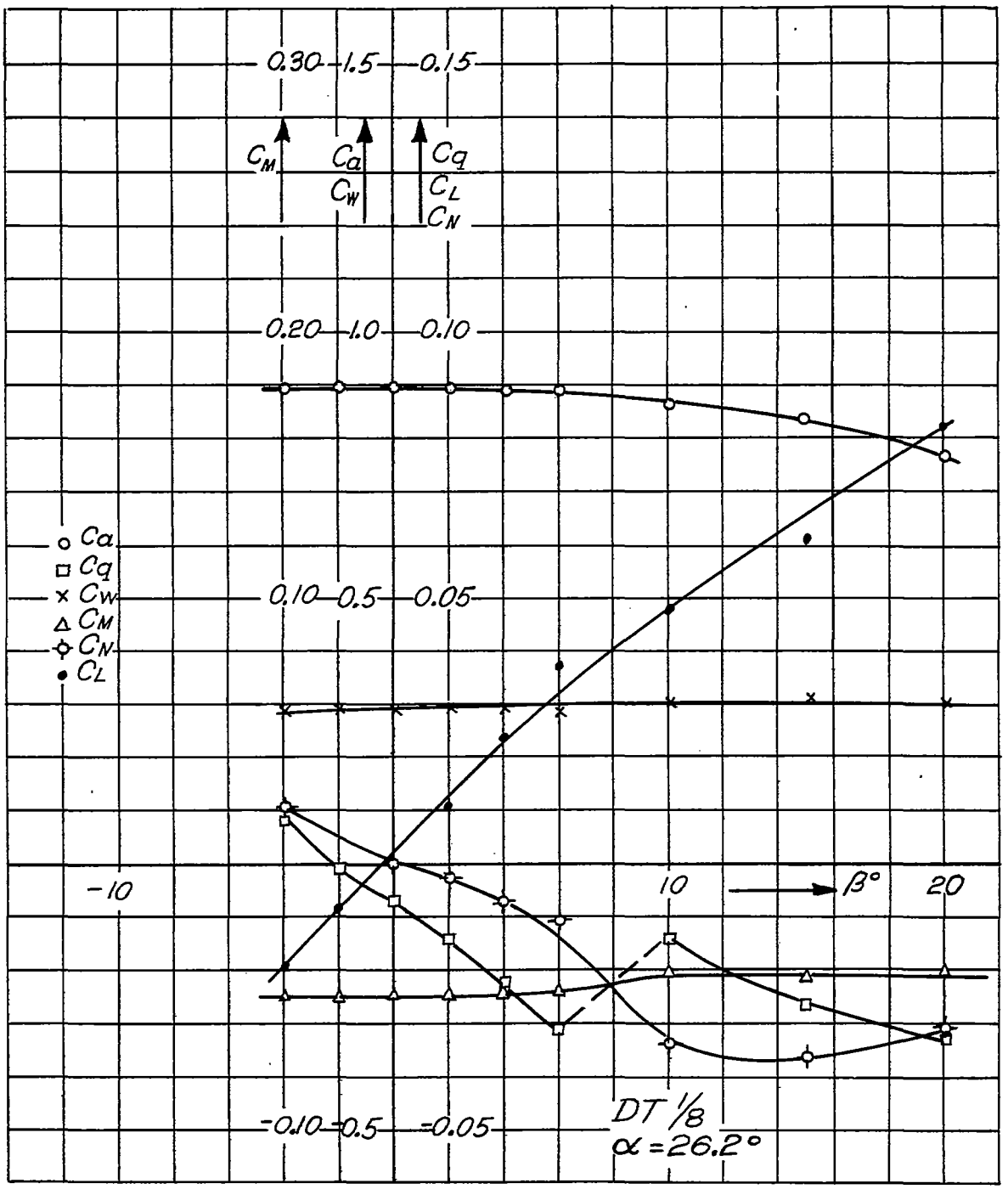

Chart 17. Six-component measurement on a series of tapered wings - trapezoidal wing.
Table 11.

SIX-COMPONENT MEASUREMENT ON A SERIES OF

TAPERED WINGS – TRAPEZOIDAL WING

TABLE NO. 12 TO CHART 18

DT 1/8

$\alpha = 38^\circ$

β°	c_a	c_q	c_w	c_L	c_M	c_N
–4	1.1850	0.0000	0.7014	–0.0118	–0.0912	0.0118
–2	1.1890	–.0043	.6942	–.0047	–.0940	.0079
0	1.1860	–.0080	.6897	–.0001	–.0944	.0033
2	1.1790	–.0137	.6884	.0022	–.0927	–.0016
4	1.1700	–.0227	.6887	.0058	–.0903	–.0055
6	1.1540	–.0333	.6846	.0132	–.0866	–.0069
10	1.1190	–.0378	.6726	.0276	–.0825	–.0154
15	1.0580	–.0628	.6485	.0536	–.0722	–.0198
20	.9440	–.0588	.6127	.0496	–.0800	.0066

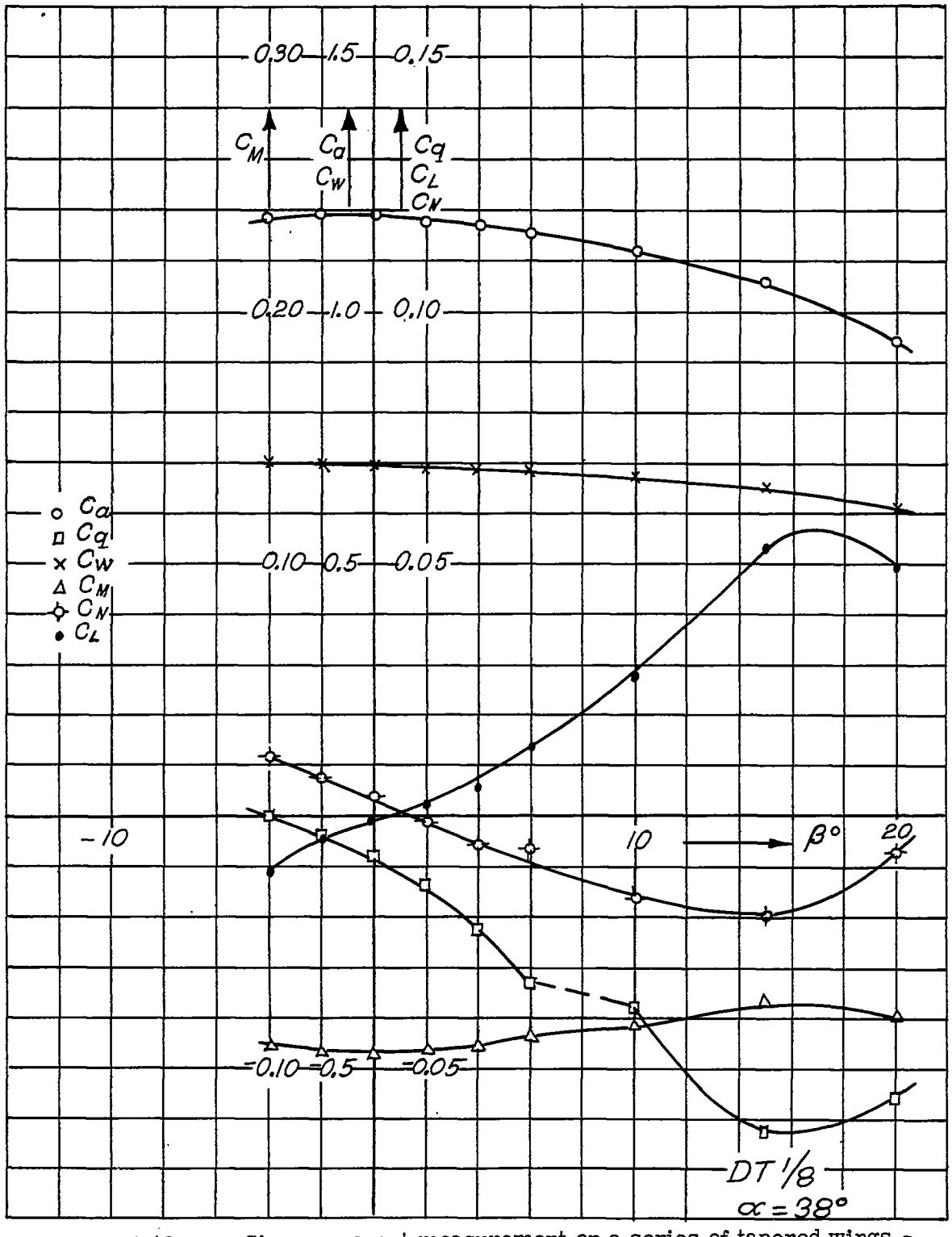

Chart 18. Six-component measurement on a series of tapered wings - trapezoidal wing.
Table 12.

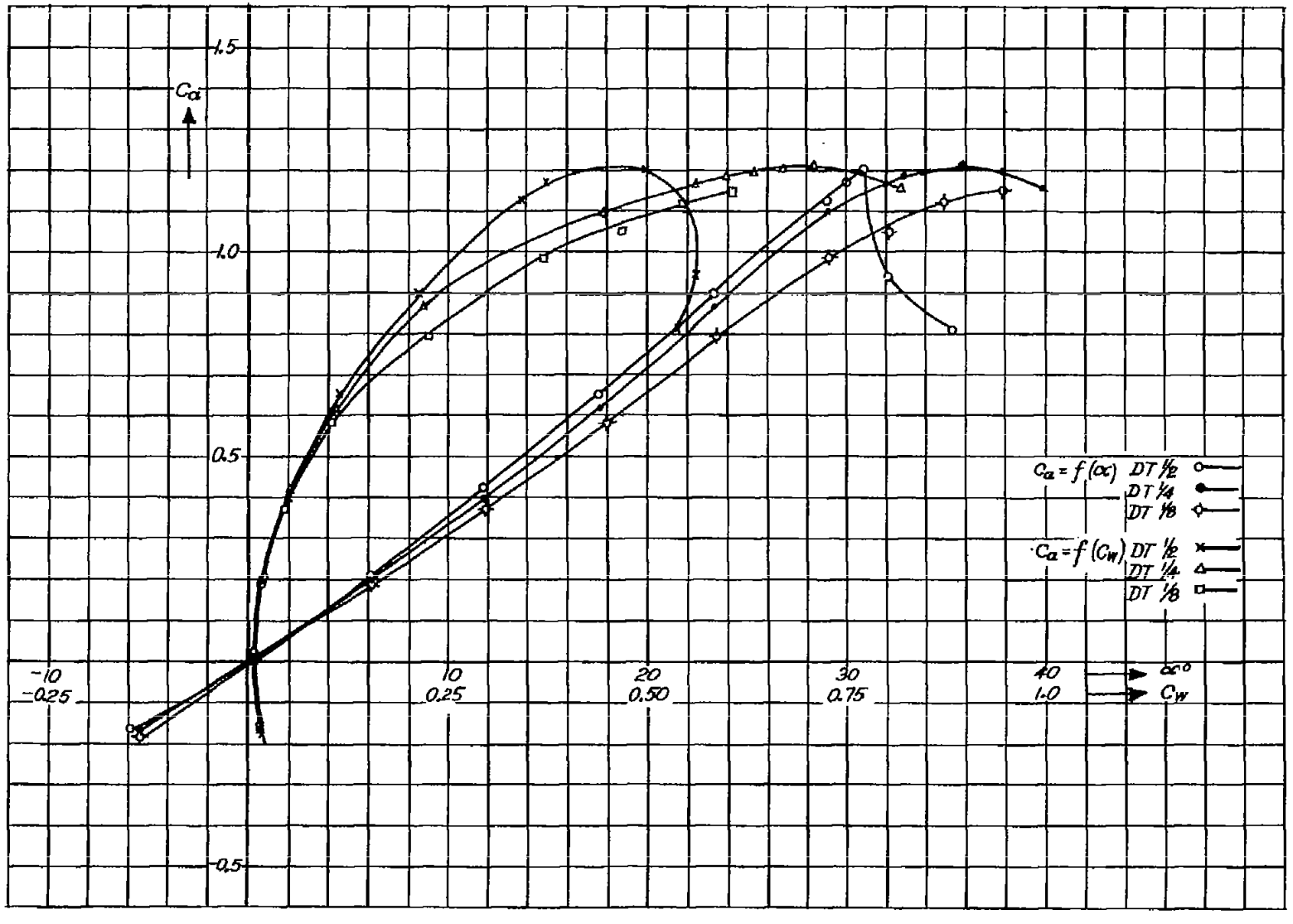

Chart 19.- $c_a = f(\alpha)$ and $c_a = f(c_w)$ curves of trapezoidal wing series.

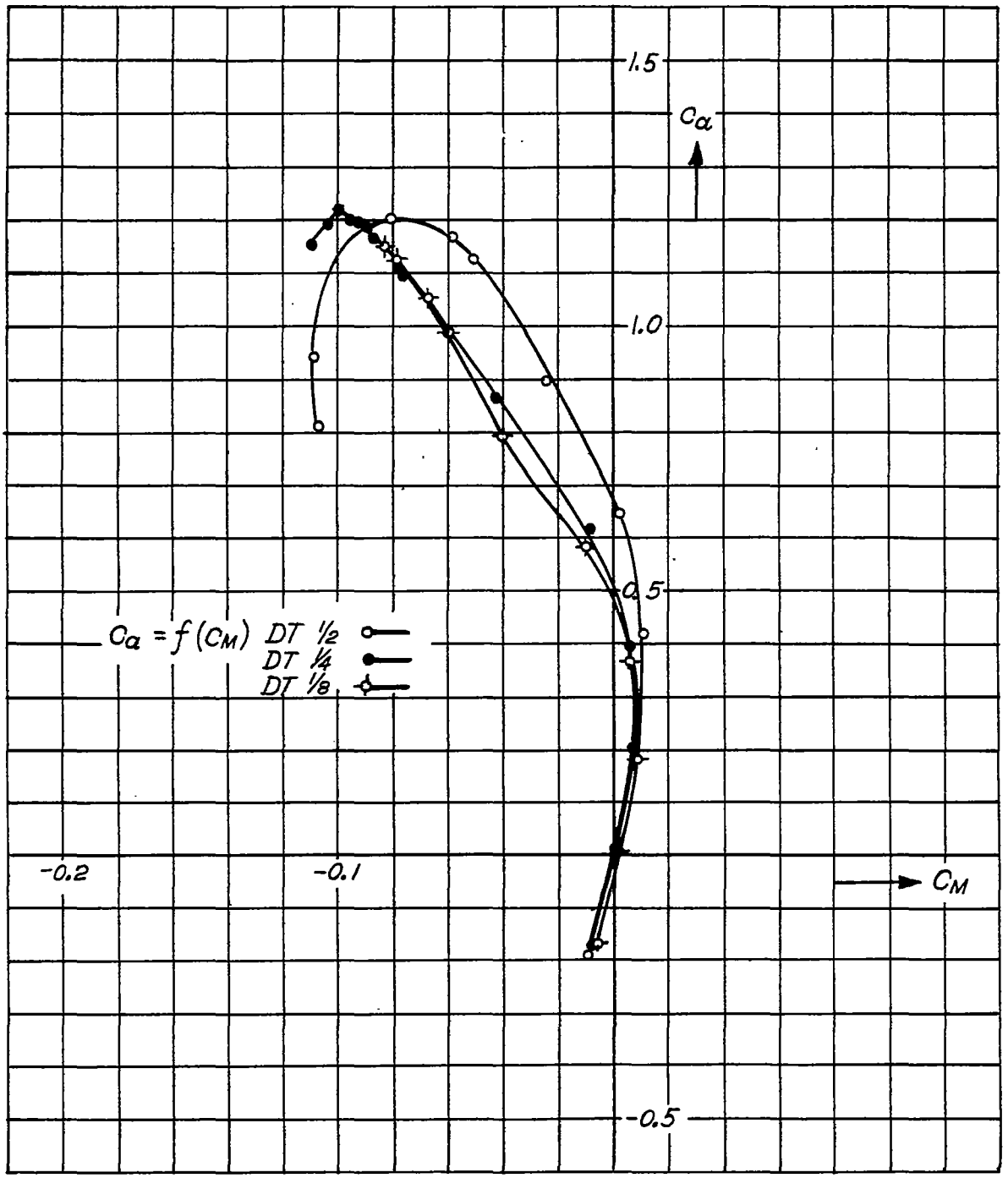

Chart 20.- $c_a = f(c_M)$ curves of trapezoidal wing series.

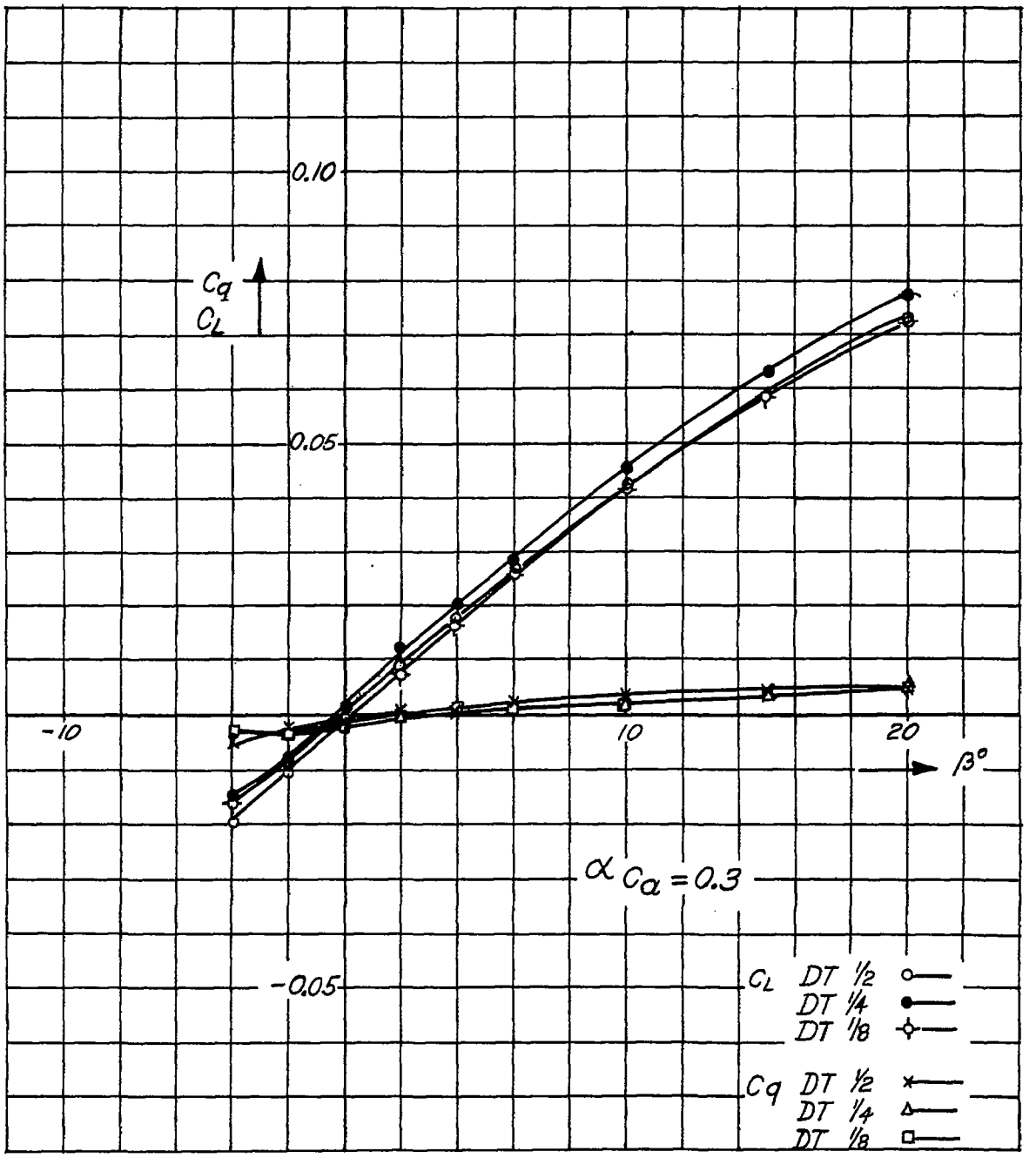

Chart 21.- c_L and c_q curves of trapezoidal wing series.

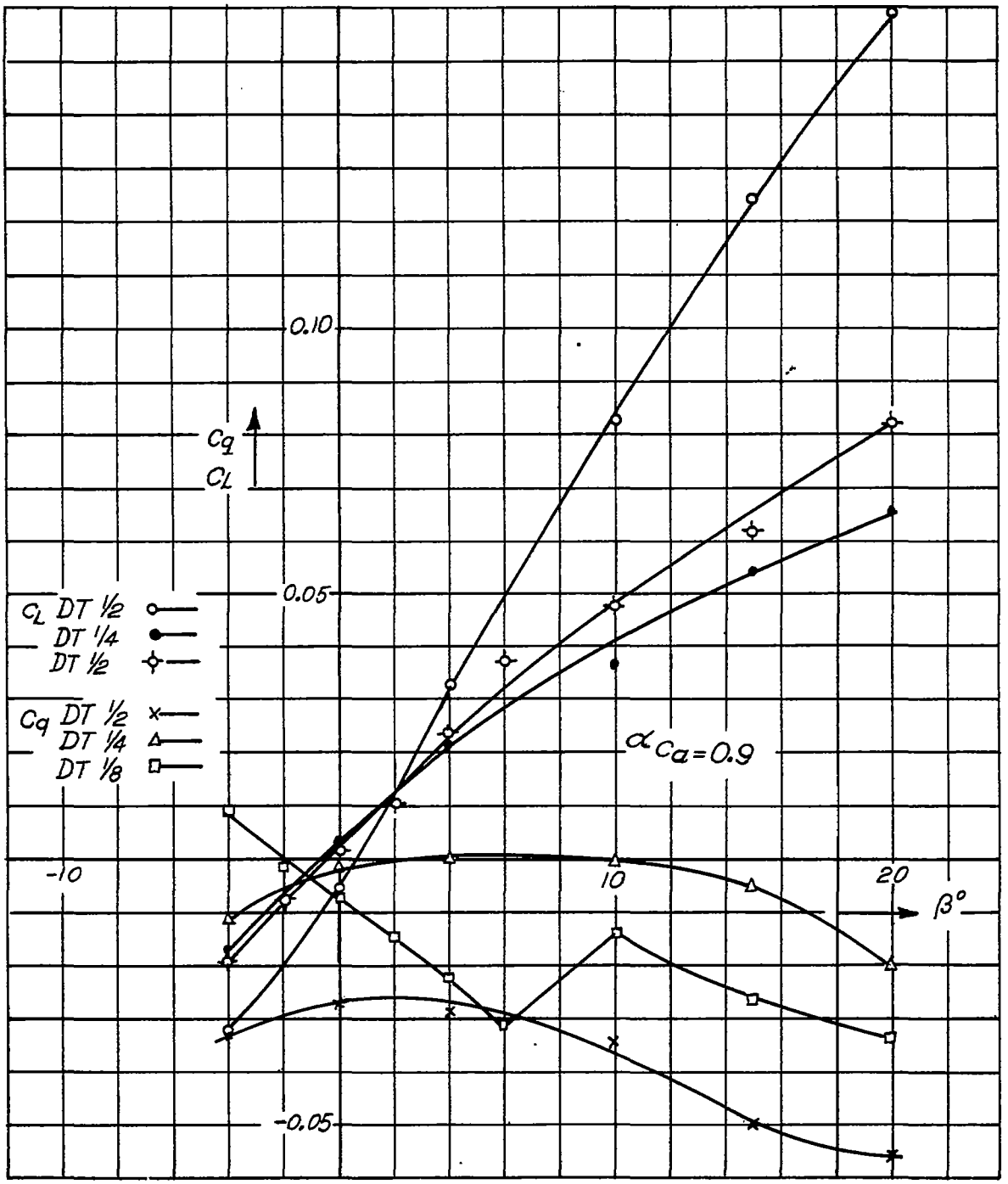

Chart 22.- c_L and c_q curves of trapezoidal wing series.