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An Investigation of Tip Planform Influence on the Aerodynamic Load Characteristics of a Semi-Span, Unswept Wing and Wing-Tip

Johannes M. van Aken

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An Investigation of Tip Planform Influence on the Aerodynamic Load Characteristics of a Semi-Span, Unswept Wing and Wing-Tip

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ABSTRACT

An experimental investigation to determine the aerodynamic load characteristics of a series of wing tips, varying in size and planform, on a semi-span wing was conducted in the NASA Ames 7- by 10-foot Low Speed Wind Tunnel at a Mach number of 0.178, and a Reynolds number of 0.867 million based upon an aerodynamic chord of 0.209 meters. The wing had a V23010-1.58 airfoil section. The wing tip could be indexed from -5° to $+5^{\circ}$ in pitch angle relative to the wing inboard section. Aerodynamic loading of both wing and wing tip are presented in tables and in graphs.

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LIST OF SYMBOLS

Symbol	Description
AR	wing aspect ratio, $2b^2/S$
b_t	tip span, m
b_w	wing span, m
c_t	tip chord, m
c_w	wing chord, m
C_{D_t}, CDT	tip drag coefficient, (tip drag)/qS_t, positive towards tip trailing edge
C_{D_w}, CDW	wing drag coefficient, (wing drag)/qS_w, positive towards wing trailing edge
C_{L_t}, CLT	tip lift coefficient, (tip lift)/qS_t, positive towards tip upper-surface
C_{L_w}, CLW	wing lift coefficient, (wing lift)/qS_w, positive towards wing upper-surface
C_{ℓ_t}, CLLT	tip rolling moment coefficient, (tip rolling moment)/$qS_t b_t$, positive towards tip root
C_{ℓ_w}, CLLW	wing rolling moment coefficient, (wing rolling moment)/$qS_w b_w$, positive towards wing root
C_{M_t}, CMT	tip pitching moment coefficient, (tip pitching moment)/$qS_t c_t$, positive tip trailing edge down
C_{M_w}, CMW	wing pitching moment coefficient, (wing pitching moment)/$qS_w c_w$, positive wing trailing edge down
C_{n_t}, CLNT	tip yawing moment coefficient, (tip yawing moment)/$qS_t b_t$, positive tip forward
C_{n_w}, CLNW	wing yawing moment coefficient, (wing yawing moment)/$qS_w b_w$, positive wing-tip forward
C_{Y_t}, CYT	tip side force coefficient, (tip side force)/qS_t, positive tip up

LIST OF SYMBOLS (Continued)

Symbol	Description
C_{Y_w}, CYW	wing side force coefficient, (wing side force)/qS_w, positive wing-tip up
q	dynamic pressure = $\frac{1}{2}\rho V_\infty^2$, Pa
S_t	projected tip area, m^2
S_w	projected wing area, m^2
V_∞	free-stream velocity, m/s
α_t, ALFT	tip angle of attack, deg
α_w, ALFW	wing angle of attack, deg
Δi, DELTA I	tip incidence angle, deg, positive tip-nose up
λ_t	taper ratio of tip outboard section
$\Lambda_{t_{c/4}}$	quarter chord sweep angle of tip outboard section, deg
ρ	air density, kg/m^3

Subscripts	
t, T	tip
w, W	wing

LIST OF ACRONYMS

CRINC	The University of Kansas Center for Research, Inc.
NASA	National Aeronautics and Space Administration
ONERA	Office National d'Etudes et de Recherches Aerospatiales
TM	Technical Memorandum

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1. INTRODUCTION

Because the tip has a strong influence on the overall rotor performance and load characteristics, the rotor blade-tip region has received considerable attention lately. Most researchers have concentrated on planform, airfoil section and thickness, and spanwise droop to achieve their particular objectives. A new rotor configuration, the Free Tip Rotor, which can include all the above features, has been devised to improve rotor performance by improving aerodynamic efficiency of the tip. The Free-Tip, which was first presented in Reference 1, is self-adjusting in pitch with respect to the rest of the rotor blade. With this ability, the resulting pitch motion is expected to generate a more uniform airload distribution around the azimuth. To be able to evaluate the Free Tip Rotor concept it is important to have detailed information concerning the tip aerodynamics. Both lifting and non-lifting rotors as well as semi-span wings have been tested in the past. However, emphasis has mainly been on the chord-wise pressure distribution near the tip, and/or on the influence of the tip shape on the total performance of the wing or rotor (see References 2 to 7). For the evaluation of the Free Tip, knowledge about the total aerodynamic loading of the tip itself is important.

The present investigation considers a semi-span wing, equipped with a interchangeable tip, which was varied in planform and size. Total wing aerodynamic loading was obtained from the wind tunnel scale system. The wing tip was mounted on a separate six-component strain gauge balance, which provided the aerodynamic loads on the tip. The tests were accomplished in the NASA Ames 7- by 10-foot Wind Tunnel at a Mach number of 0.178. This report presents the aerodynamic load characteristics of the wing and of the tip with the tip at several incidence angles relative to the wing inboard section.

2. EXPERIMENTAL APPARATUS AND PROCEDURES

2.1. Test Facility

This investigation was conducted in the NASA Ames 7- by 10-foot Low Speed Wind Tunnel, which is of the closed throat, single return design with the return passage at atmospheric pressure. Tip aerodynamic forces and moments were measured by means of a 0.019 meters (0.75 inches) diameter, six-component internal strain gauge balance, installed at the 1/4 chord point location of the inboard section of the wing. Total wing aerodynamic forces and moments were measured using the tunnel's external scale system. A rectangular gound board was used to bring the semi-span wing out of the tunnel floor boundary layer.

2.2. Model Description

The wing tested represents a left wing configuration and has a V23010-1.58 airfoil section. The profile coordinates are presented in Table 1.

The wing chord line is defined as the dividing line of the trailing edge angle as shown in Figure 1. The wing angle of attack is defined as the angle between the chord line at the 0.673 meters (26.5 inches) span location and the free stream velocity (see Figures 1 and 2).

The wing was built up with a number of functional parts which are shown in Figure 2a and described below in detail. Figure 2b defines the positive direction of the forces, moments, and angular displacements.

The wing inboard section consisted of three parts: wing root section, balance adapter, and airfoil spacer.

Wing Root Section.- the root section of the semi-span wing consisted of an unswept, rectangular section with a span of 0.699 meters (27.5 inches) and with a chord of 0.209 meters (8.23 inches). The wing root section had a geometric twist as given in Table 2.

Balance Adapter.- the 0.019 meters (0.75 inches) diameter, 0.118 meters (4.65 inches) long, six-component strain gauge balance was mounted into a 0.051 meters (2.0 inches) span airfoil adapter with a chord of 0.209 meters (8.23 inches). The balance ground was installed into the adapter at the quarter chord point location with the balance axis running in spanwise direction. The balance normal force gauges were perpendicular to the wing inboard section chord. The balance adapter could be mounted directly onto the wing inboard section, or onto an airfoil spacer, which then in turn would be mounted onto the wing inboard section.

Airfoil Spacers.- two airfoil spacers of 0.209 meters (8.23 inches) chord and of span lengths of 0.064 and 0.163 meters (2.52 and 6.42 inches) were available to be mounted between the balance adapter and the wing inboard section. Using these spacers it was possible to increase the wing semi-span with a given tip, or to maintain the same semi-wing span when testing different size tip spans.

The wing outboard section, or metric tip, consisted of two parts: the balance holder, and the tip outboard section. The total tip, consisting of the balance holder and an outboard tip section, could be indexed in pitch angle relative to the wing inboard section. Pitch rotation occurs around the strain gauge balance.

Balance Holder.- a 0.150 meters (5.91 inches) span airfoil section with a chord of 0.209 meters (8.23 inches), containing the balance and the tip pitch angle indexing mechanism.

Tip Outboard Section.- several tip outboard sections, containing various amount of sweep and/or taper were available (see Table 3). The selected tip outboard section could be rigidly attached to the balance holder.

2.3. Model Configurations

A total of 10 model configurations were tested. Sketches and dimensions of the various configurations are provided in Figure 3 and Table 3.

2.4. Test Conditions

Measurements were taken at a dynamic pressure of approximately 2250 Pa. (47 psf), corresponding to a Mach number of 0.178, and a Reynolds number of 0.807 million based upon the aerodynamic chord of 0.209 meters (8.23 inches). The wing-angle of attack varied from -8° to $+20^{\circ}$. The available tip pitch incidence angle settings were -5, -2, 0, +3, and +5 degrees, relative to the wing inboard section.

2.5. Corrections

The tip-angle of attack, equal to the wing-angle of attack plus the tip pitch incidence angle was corrected for the deformation of the balance and the tip indexing mechanism due to aerodynamic loading. Tip and total wing data were corrected for static loads and tunnel wall effects. The various corrections applied to the test data are discussed in more detail in the Appendix.

2.6. Accuracies

The following table lists the accuracy of the data taken in terms of the non-dimensionalized wing and tip aerodynamic coefficients.

	Wing	Tip
C_L	0.006	0.005
C_D	0.001	0.003
C_M	0.02	0.0005
C_Y	0.015	0.001
C_ℓ	0.02	0.001
C_n	0.004	0.005
α	0.1^{o}	0.1^{o}

As can be seen the accuracy on wing side force and wing pitching moment is very low and was of the same order of magnitude as the experienced force and moment. Therefore, these data have not been included in this report.

3. PRESENTATION OF RESULTS

The results of this investigation are presented in both table and graph form. Tables 4 through 13 present the non-dimensional aerodynamic coefficients C_L, C_D, etc. for both the semi-span wing and for the tip section for the ten configurations tested. The wing and tip forces and moments were non-dimensionalized in the standard fashion, using the dimensions for the wing and for the tip given in Table 3. The moment center of the total wing is located at the quarter chord point of the wing root. The moment center for the tip is the tip root quarter chord point location.

Figures 4 through 13 show the wing and tip aerodynamic coefficients for the ten configurations in graph-form. The influence of the tip pitch incidence angle is shown in these figures. In addition, comparison plots are presented in Figures 14 through 21, showing the influence of wing aspect ratio, tip-span, tip-sweep, and tip-taper.

4. DISCUSSION OF RESULTS

Wing aerodynamic load characteristics were not appreciably affected by the tip configurations involving straight taper and a wing aspect ratio change from 8.63 to 10.18. The tip configurations, which appreciably impacted the wing loads were tip incidence angle and tip sweep. The impact of the various tip configurations on the wing aerodynamic load characteristics and the tip aerodynamic load characteristics will be discussed below under the appropriate headings.

4.1. Effect of Tip Incidence

The effect of deflecting the metric tip around the tip balance at the 1/4 chord line is shown in Figures 5, 6, 7, 9, 11, and 12 for configurations 2, 3, 4, 6, 8, and 9, respectively. Tip deflection or tip (pitch) incidence angle is defined positive if the trailing edge is down.

Wing Characteristics: A positive change in tip incidence angle causes an increase in the C_{L_w}-level at a given wing angle of attack. No appreciable change in $dC_{L_w}/d\alpha_w$ is observed.

Positive and negative tip incidence changes cause respective changes in wing drag at low wing lift levels, except for configuration 4, the large rectangular tip, and configuration 8, the unswept, 0.3 tapered tip, where the wing drag is always increased with tip deflection. At high wing lift levels the wing drag always increases with tip deflection.

Positive tip incidence causes a slight increase in wing rolling moment at given wing lift levels, while reducing the positive slope dC_{ℓ_w}/dC_{L_w}. Negative tip incidence shows either negligible effect or a slight decrease in the wing rolling moment at constant lift.

A non-consistent effect between configurations on the wing yawing moment due to tip deflection is observed. Positive tip incidence causes a more negative yawing moment C_{n_w} at positive lift levels for configurations 3, 4, 6, and 8, but a less negative C_{n_w} for configuration 2 (small rectangular tip) and configuration 9 (35 degrees swept, 0.3 tapered tip). Negative tip incidence causes a smaller change in C_{n_w} than an equivalent positive tip incidence angle would cause, as was the case with the wing rolling moment. Negative tip incidence tends to give more negative yawing moments at constant lift levels, except for configurations 4 and 9, where less negative C_{n_w} values are observed. In general, tip deflection in either direction tends to reduce the negative slope of dC_{n_w}/dC_{L_w}, resulting in a flatter $C_{n_w} - C_{Lw}$ behavior around zero lift.

Tip Characteristics: The effect of tip incidence on $dC_{L_t}/d\alpha_t$ is negligible. However, a positive tip incidence decreases the lift at a given tip angle of attack (see tables). This is caused by a decrease in carry-over lift to the tip from the inboard section of the wing, which is at a lower angle of attack in order to compensate for the tip incidence angle.

A positive tip incidence causes an increase in tip drag at positive tip lift levels, while decreasing the drag at negative tip lift levels. It appears that positive tip incidence shifts the lift-drag parabola down.

Tip incidence shows negligible effect on the tip pitching moment if the tip is swept (see Figure 12). For the unswept tips a positive tip incidence causes the tip pitching moment to be less negative. The pitching moment-lift slope dC_{M_t}/dC_{L_t} at zero lift becomes more positive with either a positive or negative tip incidence angle. At higher lift levels ($C_{L_t} > 0.3$) tip incidence causes a more negative dC_{M_t}/dC_{L_t}, resulting in more negative tip pitching moments at lift levels near stall than for the $\Delta i = 0°$ case. This could be caused by flow disturbance near the wing-tip gap.

No effects of the tip incidence on the tip rolling moment are observed.

A positive tip incidence causes a more negative tip yawing moment at positive constant tip lift levels and vice versa for negative lift levels.

4.2. Effect of Tip Span

Figure 14 shows the effect of increasing the metric tip span of a rectangular tip, while keeping the semi-span wing span basically constant. This is accomplished through the use of the airfoil spacers, discussed in Section 2. As was expected, no noticeable effects are seen on the wing aerodynamic load characteristics.

Tip Characteristics: The tip lift curve slope $dC_{L_t}/d\alpha_t$ increases with an increase in tip span. No change in alpha-zero-lift is seen.

The smaller span tip shows higher tip drag values at given tip lift.

The smaller span tip has a larger nose down pitching moment then the larger tips at moderate and high tip lift levels.

No noticeable effect of tip span is observed on the tip rolling moment.

A slightly more negative tip yawing moment is seen with an increase in tip span.

The above described tip aerodynamic behavior can be explained by three-dimensional effects. As the wing span is held constant it can be assumed that the development of the wing tip vortex is the same for the three metric tip span cases, i.e. the vortex influences the same net tip area. The vortex causes a higher loading near the tip trailing edge resulting in a local nose down pitching moment, a lower local lift level, and increased local drag (see References 5, 6, and 7). Although the area effected by the tip vortex stays the same, this area forms a smaller percentage of the metric tip area when increasing the metric tip span. Thus, less influence of the three-dimensional tip effects is seen for the large tip span with the corresponding increase in reference area and length used for non-dimensionalizing.

4.3. Effect of Straight Tip Taper

The effect of straight tip taper can be seen in Figure 16.

Wing Characteristics: Tapering the tip outboard section has negligible effect on $dC_{L_w}/d\alpha_w$ and on alpha-zero-lift.

At low wing levels ($C_{L_w} < 0.2$) the 0.6 tapered tip shows slightly less wing drag, while the 0.3 tapered tip shows slightly higher drag compared to the rectangular tip configuration. However, at higher wing lift levels the tapering reduces the wing drag. This is probably due to a reduced tip vortex due to the tapering of the tip section.

Tapering has little effect on the wing rolling moment. Only the 0.3 tapered tip configuration shows slightly reduced rolling moment levels.

Tapering the tip causes the wing yawing moment to become more negative. Only for the 0.3 tapered tip at high lift levels near stall is a reduction of wing yawing moment observed.

Tip Characteristics: Tapering the outboard section of the tip increases the tip lift curve slope $dC_{L_t}/d\alpha_t$ slightly and shows more nonlinearity.

A slight increase in tip drag is observed at low tip lift levels ($C_{L_t} < 0.35$) due to tapering the tip. At higher lift levels ($C_{L_t} > 0.6$) a significant decrease in tip drag is seen. The effects are increased with increased taper. As noted above, this is probable due to the reduction in tip vortex strength with tip taper.

Increased taper causes a less negative dC_{M_t}/dC_{L_t}, while increasing the linearity of the tip pitching moment behavior as function of tip lift.

Tapering the tip causes a decrease in dC_{ℓ_t}/dC_{L_t}.

Tip taper causes a less negative yawing moment at a given C_{L_t}, resulting in a flatter $C_{n_t} - C_{L_t}$ behavior for the tapered tips.

4.4. Effect of Tip Sweep

The effect of outboard tip sweep on the aerodynamic load characteristics of both the wing and the metric tip can be seen in Figures 17, 18, and 19. The general effects of sweep are summarized here.

Wing Characteristics: The wing lift curve slope $dC_{L_w}/d\alpha_w$ is slightly reduced by tip sweep.

Tip sweep has little effect on the wing drag in case of the rectangular tip configuration. 30^o tip sweep on the 0.6 tapered tip causes an increase in wing drag at constant wing lift levels. A slight decrease in wing drag is observed due to 35^o sweep on the 0.3 tapered tip.

Tip sweep has little effect on the wing rolling moment.

Sweeping the tip outboard section has little effect on the wing yawing moment.

Tip Characteristics: Sweep on the outboard tip section reduces the tip lift curve slope $dC_{L_t}/d\alpha_t$.

The tip drag coefficient C_{D_t} is slightly increased by sweep for the rectangular tip and the 0.6 tapered tip, while being reduced for the 0.3 tapered tip at low tip lift levels ($C_{L_t} < 0.3$). At higher lift levels ($C_{L_t} > 0.3$) the effect of tip sweep on tip drag is negligible.

As could be expected, the tip dC_{M_t}/dC_{L_t} becomes much more negative by sweeping the tip. This is caused by the aft motion of the tip's aerodynamic center with tip-sweep relative to the tip root 1/4 chord point. Thus, an offset exist between the tip's aerodynamic center and the tip's moment center. This offset increases with increased tip sweep.

The effect of tip sweep on the tip rolling moment is negligible.

The tip yawing moment is less negative at given tip lift levels due to tip sweep. Also dC_{n_t}/dC_{L_t} is reduced by sweeping the tip. This is probably due to the fact that the tip vortex has less influence on the tip inboard section in case of the swept tip.

4.5. Effect of Tip Leading Edge Droop

The effect of tip leading edge droop on the wing and tip aerodynamic load characteristics of a wing with a 0.3 tapered, 35^o swept tip is shown in Figure 20.

Wing Characteristics: Negligible effect of tip leading edge droop is seen on the wing lift.

At low lift levels the drooped configuration shows slightly more wing drag. Only at $0.4 < C_{L_w} < 0.7$ is a slight decrease in wing drag observed. This might be the area where the tip leading edge droop is effective.

A slight decrease in wing rolling moment due to tip droop is seen.

More negative wing yawing moment at negative wing lift levels and slightly less negative yawing moment at $C_{L_w} > 0.6$ is observed with the drooped tip configuration.

Tip Characterictics: Little effect of tip droop is seen on the tip lift coefficient.

The drooped tip configuration always shows more tip drag, especially at low tip lift levels. At low tip angles of attack or low lift levels the airflow sees a very blunt tip leading edge, resulting in the high tip drag that is observed.

A more negative tip pitching moment as well as a more negative dC_{M_t}/dC_{L_t} is observed with the tip droop.

No effect of tip droop on the tip rolling moment is seen.

Droop always causes more negative tip yawing moments.

4.6. Effect of Tip-Gap-Sealing

The effect of sealing the gap at $\Delta i = 0^o$ between the wing inboard section and the metric tip is shown in Figure 21. Two methods were used to seal the tip gap: grease was inserted in the gap, which should not influence the tip balance measurements to any large extent (except possible tip side force and yawing moment). The second method was to tape the gap, providing a physical connection between the tip and the wing inboard section. In the latter case only wing data is reported.

Wing Characteristics: The wing lift curve slope $dC_{L_w}/d\alpha_w$ is slighltly reduced by sealing the tip gap. Applying grease to the tip gap causes the largest reduction. More non-linearity is also observed with a sealed gap.

Sealing the tip gap has little effect on the wing drag.

Tip gap sealing reduces the wing rolling moment slightly.

Sealing the tip gap provides slightly more negative wing yawing moment at low lift levels. Taping the gap causes less negative wing yawing moment at high wing lift, while greasing the gap gives more negative yawing moment here.

Tip Characteristics: The effect of gap sealing is very small on the tip lift. Slightly lower lift is seen at high angles of attack ($\alpha_t > 10^o$) for the sealed tip gap case.

Gap sealing causes a slighlty more negative tip pitching moment. The above effect could be caused by the fact that the grease prevents the equilization of lower and upper surface pressures through the gap.

No effect of gap sealing on tip rolling moment is observed.

4.7. Wing versus Tip Characteristics

If a comparison is made between wing aerodynamic characteristics and tip aerodynamic characteristics the following difference can be observed. It should be noted that all the observations here concern the undeflected tip.

The wing lift curve slope for the 8.63 aspect ratio wing equals 0.075/deg. For the 10.18 aspect ratio wing configurations $dC_{L_w}/d\alpha_w$ varied from 0.076 to 0.083/deg. The tip lift curve slope is function of tip span and varied from 0.054 to 0.065/deg for the 0.149m to 0.312m span, rectangular tips, respectively. Tip tapering and sweep gave a variation in $dC_{L_t}/d\alpha_t$ from 0.062 to 0.071/deg. Thus, $dC_{L_t}/d\alpha_t$ varied form $0.68 dC_{L_w}/d\alpha_w$ for the small tip to $0.87 dC_{L_w}/d\alpha_w$ for the 0.6 tapered tip. In general, the tip alpha-zero-lift was slightly higher than the wing alpha-zero-lift (approximately 0.5°). This difference could be caused by the wing twist at the wing inboard section (see Table 2).

The wing minimum drag coefficient is approximately 0.008 for most configurations. Tip minimum drag is 25 to 50 % higher at 0.010 to 0.012. Overall, the tip drag is about 120 % greater than the wing drag for the small span tip at the same lift levels. The large rectangular tip shows 100 % higher tip drag coefficients compared to the total wing. Tapering and sweep reduce this tip drag coefficient difference to about 80 % of that of the wing. The wing drag bucket occurs at about 2.0 to 2.5 degrees angle of attack, while that for the tip is at about $-0.5°$ to $1.0°$.

The wing shows rougly 8 to 10 % higher rolling moment coefficients than the tip at the same lift levels. However, $dC_{\ell_w}/d\alpha_w$ is approximately 35 % higher than $dC_{\ell_t}/d\alpha_t$, indicating that to obtain the same rolling moment coefficient the tip has to be at a much higher angle of attack than the total wing. This illustrates the three dimensional tip effects causing reduced loadings near the wing tip.

At a given lift level the tip section, in general, shows approximately 12 % more negative yawing moments than the wing. This is directly related to the higher drag coefficients on the tip as compared to the wing.

5. CONCLUSIONS

A semi-span wing with a metric tip was tested at a Mach number of 0.178 (q = 2250 Pa). Various tip planforms, having tip sweep, taper, and droop were tested. Both total-wing and tip aerodynamic forces and moments were measured. The following general conclusions can be made.

1. The effects of the various tip planform changes on the wing aerodynamic load characteristics were in general small. The largest effect was seen with the tip sweep.

2. It was found that the tip aerodynamic load characteristics were essentially the same for the 8.63 and the 10.18 aspect ratio wings.

3. Both tip taper and sweep influenced the tip aerodynamic load characteristics. Tip sweep caused a large increase in tip pitching moment.

4. Tip leading edge droop caused high tip drag without increasing the tip lift and pitching moment significantly compared to the non-drooped configuration.

5. Sealing the tip gap at $\Delta i = 0^{\circ}$ had little effect on both the wing and the tip aerodynamic characteristics.

6. It was found that the tip lift curve slope $dC_{L_t}/d\alpha_t$ at $\Delta i = 0^{\circ}$ amounted to 68 to 87 % of that of the wing lift curve slope $dC_{L_w}/d\alpha_w$. The lower value was observed for the small span tip.

7. It was observed that the tip minimum drag coefficient was from 25 to 50 % higher than the wing minimum drag coefficient for the various tested configurations at $\Delta i = 0^{\circ}$.

8. At corresponding tip and wing lift coefficients above 0.3 the tip C_{D_t} was from 100 to 120 % higher than the wing C_{D_w} for a rectangular tip at $\Delta i = 0^{\circ}$. Tapering and/or sweeping the tip reduces this difference between C_{D_t} and C_{D_w}. A minimum difference of 80 % was obtained for configuration 7 (the 0.6 tapered, 30° swept tip).

6. REFERENCES

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x/c	y_u/c	y_z/c
0.0	-0.0225	-.0225
0.005	-0.0078	-0.0329
0.01	-0.0024	-0.0362
0.015	0.0019	-0.0378
0.025	0.0096	-0.0394
0.035	0.0155	-0.0404
0.047	0.0214	-0.0412
0.06	0.0265	-0.042
0.08	0.0327	-0.0434
0.11	0.0396	-0.0449
0.15	0.0455	-0.0471
0.19	0.0489	-0.0494
0.23	0.0499	-0.0513
0.27	0.0499	-0.0522
0.31	0.0497	-0.05215
0.35	0.049	-0.0517
0.39	0.048	-0.0505
0.43	0.0465	-0.0487
0.47	0.0446	-0.0468
0.51	0.0424	-0.044
0.55	0.0397	-0.0412
0.59	0.0369	-0.038
0.63	0.0336	-0.0346
0.67	0.0301	-0.0308
0.71	0.0263	-0.0269
0.75	0.0223	-0.0226
0.79	0.0181	-0.0182
0.83	0.0137	-0.0136
0.87	0.0093	-0.0093
0.91	0.0056	-0.0057
0.945	0.0028	-.0031
0.96	0.00235	-0.00235
1.0	0.00235	-0.00235

Table 1.- Airfoil Coordinates for $V23010 - 1.58$ Airfoil

Spanwise Location $y/_{(b/2)}$	Twist deg.
0.000	-0.432
0.049	-0.360
0.104	-0.287
0.131	-0.253
0.155	-0.222
0.213	-0.165
0.268	-0.116
0.322	-0.075
0.377	-0.042
0.404	-0.028
0.431	-0.017
0.486	0.000
0.541	0.009
0.595	-0.010
0.650	0.003
0.664	0.000
0.712	0.000
1.000	0.000

Note: b/2 = 1.045 meters (3.484 feet)

Table 2.- Wing Geometric Twist Distribution.

Conf.	Tip	WING						TIP							
		c_w		b_w		S_w		c_t		b_t		S_t		$\Lambda_{c/4}$	λ_t
	No.	m	ft	m	ft	m^2	ft^2	m	ft	m	ft	m^2	ft^2	deg	
1	1	0.209	0.684	0.900	2.953	0.1877	2.020	0.209	0.684	0.149	0.490	0.0311	0.335	0.	1.0
2	1	0.209	0.684	1.064	3.484	0.2214	2.383	0.209	0.684	0.149	0.490	0.0311	0.335	0.	1.0
3	8	0.209	0.684	1.045	3.427	0.2187	2.344	0.209	0.684	0.233	0.766	0.0487	0.524	0.	1.0
4	2	0.209	0.684	1.062	3.484	0.2214	2.383	0.209	0.684	0.312	1.023	0.0650	0.700	0.	1.0
5	3	0.209	0.684	1.062	3.484	0.2214	2.383	0.209	0.684	0.312	1.023	0.0650	0.700	20.	1.0
6	5	0.202	0.663	1.062	3.484	0.2146	2.310	0.187	0.614	0.312	1.023	0.0583	0.628	0.	1.0
7	4	0.202	0.663	1.062	3.484	0.2146	2.310	0.187	0.614	0.312	1.023	0.0583	0.628	30.	0.6
8	6	0.197	0.647	1.062	3.484	0.2094	2.254	0.170	0.559	0.312	1.023	0.0531	0.572	0.	0.3
9	7	0.197	0.647	1.062	3.484	0.2094	2.254	0.170	0.559	0.312	1.023	0.0531	0.572	35.	0.3
10	9	0.197	0.647	1.062	3.484	0.2094	2.254	0.170	0.559	0.312	1.023	0.0531	0.572	35.	0.3

Configuration 10 has a 20^o leading edge droop over the outboard 0.081m (0.267 ft) of Tip 9.

Table 3.- Geometric Information for Wing-Tip Configurations 1 through 10.

Run 43 Tip No 1 Tip Incidence Angle = 0.0°

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	0.2	0.006	0.00	0.02	-0.007	0.012	0.006	-0.01	0.00	-0.007	-0.008
3	-6.1	-5.8	0.046	-0.44	-0.21	-0.044	0.031	-0.002	-0.32	-0.15	-0.009	-0.013
4	-4.1	-3.8	0.034	-0.34	-0.09	-0.009	0.023	0.001	-0.22	-0.10	-0.010	-0.010
6	-2.0	-1.8	0.014	-0.16	-0.04	-0.007	0.016	0.004	-0.12	-0.05	-0.009	-0.009
7	0.0	0.2	0.009	-0.05	0.06	-0.009	0.013	0.005	-0.01	-0.01	-0.007	-0.009
8	2.0	2.2	0.005	0.12	0.11	-0.012	0.015	0.004	0.09	0.04	-0.004	-0.009
9	4.1	4.2	0.007	0.29	0.17	-0.009	0.018	0.004	0.19	0.08	-0.003	-0.010
10	6.1	6.2	0.012	0.45	0.25	-0.015	0.026	0.002	0.30	0.13	-0.004	-0.011
12	8.2	8.2	0.022	0.63	0.28	-0.019	0.039	-0.001	0.42	0.19	-0.009	-0.015
13	10.2	10.2	0.035	0.75	0.40	-0.033	0.058	-0.007	0.54	0.25	-0.014	-0.021
14	12.2	12.2	0.055	0.90	0.47	-0.041	0.081	-0.015	0.65	0.31	-0.021	-0.029
16	14.3	14.2	0.073	1.06	0.48	-0.057	0.109	-0.026	0.78	0.37	-0.030	-0.040
17	16.3	16.2	0.099	1.16	0.55	-0.050	0.140	-0.038	0.88	0.43	-0.039	-0.053
19	18.3	18.2	0.148	1.07	0.59	-0.087	0.173	-0.049	0.96	0.47	-0.046	-0.069
20	20.2	20.3	0.191	1.01	0.54	-0.112	0.214	-0.062	1.03	0.51	-0.057	-0.089
21	22.2	22.3	0.283	0.79	0.50	-0.149	0.292	-0.068	1.04	0.51	-0.102	-0.127
22	0.0	0.2	0.008	0.00	0.03	-0.039	0.013	0.005	0.00	0.00	-0.007	-0.009
23	0.0	0.2	0.006	-0.02	0.02	-0.040	0.013	0.005	-0.01	-0.01	-0.007	-0.009

Table 4 .- Non-Dimensional Aerodynamic Coefficients for Configuration 1: Aspect Ratio 8.63 Wing with a 0.149m Span Rectangular Tip.

Run 13 Tip No 1 Tip Incidence Angle = -5.0^o

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
3	0.0	-4.8	0.007	0.00	-0.01	-0.031	0.019	0.006	-0.10	-0.05	-0.012	-0.011
4	-6.1	-10.8	0.061	-0.48	-0.23	-0.039	0.077	-0.011	-0.41	-0.20	-0.004	-0.030
6	-4.1	-8.8	0.041	-0.36	-0.17	-0.016	0.043	-0.004	-0.33	-0.15	-0.011	-0.017
7	-2.1	-6.8	0.021	-0.22	-0.05	0.002	0.026	0.001	-0.21	-0.10	-0.012	-0.012
8	0.0	-4.8	0.013	-0.04	0.02	-0.005	0.018	0.005	-0.11	-0.05	-0.011	-0.010
10	4.1	-0.8	0.006	0.30	0.17	-0.015	0.013	0.009	0.10	0.04	-0.008	-0.010
11	6.1	1.2	0.013	0.48	0.21	-0.012	0.014	0.008	0.20	0.09	-0.005	-0.009
12	8.2	3.2	0.019	0.62	0.31	-0.022	0.020	0.008	0.32	0.14	-0.006	-0.010
13	10.2	5.2	0.030	0.78	0.39	-0.028	0.032	0.004	0.44	0.20	-0.009	-0.014
14	12.3	7.2	0.047	0.91	0.47	-0.037	0.047	-0.004	0.56	0.25	-0.014	-0.019
15	14.3	9.2	0.062	1.05	0.53	-0.047	0.066	-0.013	0.67	0.31	-0.019	-0.026
16	15.3	10.2	0.078	1.14	0.55	-0.051	0.077	-0.020	0.73	0.34	-0.022	-0.030
17	16.3	11.2	0.093	1.11	0.57	-0.065	0.092	-0.027	0.79	0.37	-0.025	-0.036
18	17.3	12.2	0.118	1.12	0.56	-0.075	0.105	-0.033	0.83	0.39	-0.028	-0.042
19	18.3	13.2	0.142	1.09	0.56	-0.086	0.117	-0.038	0.86	0.41	-0.031	-0.047
20	0.0	-4.8	0.008	0.03	-0.02	-0.028	0.017	0.006	-0.10	-0.05	-0.011	-0.010
21	0.0	-4.8	0.007	0.00	-0.02	-0.032	0.017	0.006	-0.10	-0.05	-0.012	-0.010

Run 12 Tip No 1 Tip Incidence Angle = -2.0^o

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
7	0.0	-1.8	0.006	0.02	-0.02	-0.037	0.014	0.007	-0.09	-0.04	-0.013	-0.010
8	-6.1	-7.8	0.064	-0.28	-0.41	-0.048	0.076	-0.010	-0.43	-0.20	-0.007	-0.029
9	-4.1	-5.8	0.042	-0.38	-0.15	-0.021	0.040	-0.004	-0.34	-0.16	-0.012	-0.016
10	-2.1	-3.8	0.022	-0.21	-0.10	-0.008	0.025	0.002	-0.22	-0.10	-0.013	-0.012
11	0.0	-1.8	0.014	-0.05	0.00	-0.014	0.017	0.006	-0.10	-0.05	-0.013	-0.011
12	2.0	0.2	0.014	0.14	0.08	-0.008	0.014	0.007	0.00	0.00	-0.010	-0.010
13	4.1	2.2	0.012	0.29	0.18	-0.009	0.012	0.008	0.12	0.05	-0.008	-0.009
14	6.1	4.2	0.016	0.52	0.22	-0.019	0.016	0.008	0.23	0.10	-0.006	-0.010
15	8.2	6.2	0.023	0.66	0.34	-0.024	0.024	0.006	0.35	0.16	-0.007	-0.012
16	10.2	8.2	0.034	0.83	0.40	-0.026	0.035	0.000	0.47	0.21	-0.011	-0.015
17	12.3	10.2	0.054	1.01	0.48	-0.040	0.054	-0.007	0.60	0.28	-0.016	-0.022
18	14.3	12.2	0.070	1.15	0.56	-0.052	0.073	-0.018	0.73	0.34	-0.022	-0.029
19	15.3	13.2	0.086	1.15	0.66	-0.060	0.088	-0.027	0.81	0.38	-0.026	-0.034
20	0.0	-1.8	0.012	0.14	-0.13	-0.041	0.017	0.006	-0.11	-0.05	-0.013	-0.010

Table 5 .- Non-Dimensional Aerodynamic Coefficients for Configuration 2: Aspect Ratio 10.19 Wing with a $0.149m$ Span Rectangular Tip.

Run 16 Tip No 1 Tip Incidence Angle = 0.0°

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	0.2	0.005	0.02	0.01	-0.034	0.011	0.006	-0.01	0.00	-0.005	-0.008
3	-6.1	-5.8	0.054	-0.47	-0.21	-0.037	0.033	0.000	-0.33	-0.15	-0.007	-0.014
4	-6.1	-5.8	0.056	-0.46	-0.20	-0.032	0.033	0.000	-0.34	-0.15	-0.007	-0.014
5	-6.1	-5.8	0.054	-0.46	-0.22	-0.034	0.033	0.000	-0.33	-0.15	-0.008	-0.014
6	-4.1	-3.8	0.034	-0.32	-0.14	-0.011	0.022	0.003	-0.23	-0.10	-0.008	-0.011
7	-2.1	-1.8	0.021	-0.18	-0.06	0.002	0.017	0.005	-0.13	-0.06	-0.007	-0.009
8	0.0	0.2	0.011	-0.01	0.01	-0.011	0.014	0.006	-0.03	-0.01	-0.006	-0.008
9	2.0	2.2	0.003	0.15	0.10	-0.012	0.014	0.005	0.08	0.03	-0.004	-0.008
10	4.1	4.2	0.007	0.31	0.17	-0.013	0.017	0.004	0.20	0.09	-0.002	-0.009
11	6.1	6.2	0.014	0.49	0.25	-0.016	0.024	0.002	0.31	0.14	-0.003	-0.011
12	8.2	8.2	0.021	0.66	0.32	-0.022	0.036	-0.002	0.41	0.19	-0.007	-0.014
13	10.2	10.2	0.035	0.81	0.41	-0.028	0.053	-0.009	0.54	0.25	-0.012	-0.020
14	12.3	12.2	0.052	0.95	0.46	-0.038	0.073	-0.019	0.65	0.31	-0.018	-0.028
15	14.3	14.2	0.067	1.06	0.57	-0.055	0.100	-0.031	0.77	0.37	-0.025	-0.039
17	14.3	14.2	0.070	1.08	0.53	-0.049	0.098	-0.031	0.76	0.37	-0.025	-0.038
18	15.3	15.2	0.084	1.12	0.60	-0.054	0.113	-0.038	0.84	0.40	-0.030	-0.045
19	0.0	0.2	0.007	0.08	-0.04	-0.035	0.012	0.006	-0.02	-0.01	-0.006	-0.008
20	0.0	0.2	0.008	0.03	0.01	-0.029	0.011	0.006	-0.01	-0.01	-0.006	-0.007

Run 14 Tip No 1 Tip Incidence Angle = 3.0°

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	3.2	0.007	0.04	0.03	-0.033	0.011	0.006	0.07	0.03	-0.001	-0.008
3	-8.2	-4.8	0.102	-0.53	-0.28	-0.053	0.035	0.006	-0.36	-0.16	-0.004	-0.015
4	-6.1	-2.8	0.064	-0.51	-0.18	-0.023	0.024	0.007	-0.27	-0.12	-0.006	-0.011
5	-4.1	-0.8	0.035	-0.31	-0.12	0.001	0.017	0.007	-0.16	-0.07	-0.005	-0.009
6	-2.0	1.2	0.017	-0.17	-0.05	-0.004	0.014	0.007	-0.05	-0.02	-0.003	-0.008
7	0.0	3.2	0.012	0.01	0.02	-0.004	0.014	0.005	0.05	0.03	0.000	-0.008
8	2.0	5.0	0.009	0.17	0.11	-0.009	0.018	0.003	0.16	0.08	0.002	-0.009
10	6.1	9.2	0.016	0.51	0.25	-0.016	0.038	-0.006	0.38	0.18	-0.003	-0.015
11	8.2	11.2	0.028	0.68	0.34	-0.021	0.056	-0.013	0.51	0.24	-0.009	-0.021
12	10.2	13.2	0.040	0.85	0.41	-0.034	0.077	-0.023	0.64	0.30	-0.015	-0.029
13	12.3	15.2	0.057	1.01	0.50	-0.037	0.105	-0.037	0.77	0.37	-0.023	-0.040
14	12.3	15.2	0.060	1.02	0.48	-0.039	0.104	-0.035	0.75	0.36	-0.022	-0.040
15	13.3	16.2	0.065	1.04	0.54	-0.051	0.117	-0.043	0.83	0.40	-0.028	-0.046
16	14.3	17.2	0.073	1.04	0.63	-0.048	0.132	-0.049	0.87	0.43	-0.031	-0.053
17	15.3	18.2	0.088	1.12	0.62	-0.056	0.148	-0.055	0.91	0.45	-0.035	-0.061
18	4.1	7.0	0.007	0.35	0.19	-0.035	0.024	-0.001	0.29	0.13	0.000	-0.010
19	0.0	3.2	0.008	0.04	0.02	-0.036	0.012	0.006	0.06	0.03	0.000	-0.008

Table 5.- Continued.

Run 15 Tip No 1 Tip Incidence Angle = 5.0°

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
3	-0.3	5.0	0.013	-1.09	0.88	-0.031	0.014	0.005	0.11	0.05	0.003	-0.008
4	-10.1	-5.0	0.136	-0.34	-0.40	-0.062	0.042	0.009	-0.39	-0.17	0.000	-0.020
5	-10.1	-4.8	0.140	-0.47	-0.31	-0.058	0.042	0.009	-0.39	-0.17	-0.001	-0.020
6	-10.1	-4.8	0.140	-0.51	-0.27	-0.050	0.043	0.009	-0.39	-0.17	0.000	-0.020
7	-10.2	-5.0	0.135	-0.53	-0.26	-0.057	0.043	0.009	-0.39	-0.17	0.000	-0.020
8	-8.2	-2.8	0.110	-0.55	-0.25	-0.029	0.027	0.010	-0.31	-0.13	-0.005	-0.013
9	-6.1	-0.8	0.062	-0.48	-0.17	-0.018	0.018	0.011	-0.22	-0.09	-0.005	-0.010
10	-4.1	1.2	0.037	-0.31	-0.12	0.004	0.014	0.010	-0.11	-0.04	-0.002	-0.009
11	-2.0	3.2	0.016	-0.14	-0.04	-0.003	0.011	0.009	-0.01	0.00	0.000	-0.008
12	-2.0	3.0	0.018	-0.14	-0.04	-0.001	0.011	0.009	0.00	0.00	0.000	-0.008
13	0.0	5.0	0.011	0.00	0.04	-0.008	0.013	0.006	0.09	0.05	0.003	-0.008
14	2.1	7.0	0.008	0.20	0.11	-0.006	0.020	0.001	0.21	0.10	0.003	-0.010
15	4.1	9.0	0.012	0.37	0.20	-0.012	0.033	-0.004	0.33	0.15	0.000	-0.013
16	6.1	11.2	0.019	0.52	0.28	-0.012	0.048	-0.010	0.44	0.21	-0.004	-0.018
17	8.2	13.2	0.025	0.70	0.35	-0.028	0.069	-0.020	0.56	0.27	-0.010	-0.026
18	10.2	15.2	0.041	0.86	0.43	-0.032	0.094	-0.034	0.68	0.33	-0.017	-0.035
19	12.3	17.2	0.060	1.01	0.50	-0.036	0.124	-0.047	0.80	0.40	-0.025	-0.048
21	0.1	5.0	0.009	0.23	-0.10	-0.031	0.016	0.004	0.11	0.05	0.003	-0.009

Table 5.- Concluded.

Run 33 Tip No 8 Tip Incidence Angle = -5.0^o

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	-4.8	0.008	-0.04	-0.05	-0.036	0.016	0.003	-0.16	-0.07	-0.012	-0.008
3	-4.1	-8.8	0.031	-0.34	-0.20	-0.043	0.049	-0.002	-0.37	-0.17	-0.012	-0.021
4	-2.1	-6.8	0.018	-0.21	-0.12	-0.026	0.023	0.001	-0.27	-0.13	-0.012	-0.011
5	0.0	-4.8	0.011	-0.05	-0.03	-0.020	0.016	0.003	-0.15	-0.07	-0.011	-0.008
6	2.0	-2.8	0.005	0.11	0.04	-0.021	0.012	0.004	-0.03	-0.02	-0.010	-0.007
7	4.1	-0.8	0.006	0.26	0.13	-0.021	0.011	0.006	0.08	0.03	-0.008	-0.006
8	6.1	1.2	0.010	0.42	0.20	-0.025	0.015	0.008	0.19	0.08	-0.006	-0.008
9	8.2	3.2	0.018	0.62	0.27	-0.029	0.021	0.009	0.32	0.14	-0.005	-0.010
10	10.2	5.2	0.030	0.76	0.35	-0.038	0.032	0.009	0.44	0.19	-0.006	-0.014
11	12.3	7.2	0.047	0.92	0.42	-0.040	0.047	0.006	0.58	0.26	-0.008	-0.020
12	14.3	9.2	0.065	1.06	0.47	-0.057	0.064	0.001	0.69	0.31	-0.010	-0.028
13	16.3	11.3	0.087	1.12	0.54	-0.073	0.086	-0.006	0.80	0.37	-0.014	-0.038
14	18.3	13.3	0.143	1.10	0.52	-0.089	0.112	-0.013	0.89	0.41	-0.016	-0.049
15	20.3	15.3	0.192	1.07	0.52	-0.116	0.150	-0.020	0.99	0.46	-0.022	-0.068
16	22.2	17.3	0.269	0.79	0.44	-0.152	0.191	-0.027	0.96	0.45	-0.038	-0.084
19	0.0	-4.8	0.009	-0.01	-0.05	-0.039	0.015	0.003	-0.14	-0.07	-0.012	-0.008

Run 36 Tip No 8 Tip Incidence Angle = -2.0^o

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
3	0.0	-1.8	0.007	-0.01	-0.05	-0.035	0.015	0.004	-0.14	-0.07	-0.014	-0.008
5	-4.1	-5.8	0.031	-0.33	-0.18	-0.035	0.046	-0.001	-0.36	-0.17	-0.014	-0.020
6	-2.1	-3.8	0.021	-0.25	-0.07	-0.018	0.022	0.002	-0.26	-0.12	-0.014	-0.011
7	0.0	-1.8	0.012	-0.08	0.00	-0.013	0.015	0.003	-0.14	-0.07	-0.013	-0.008
8	2.0	0.2	0.008	0.13	0.03	-0.010	0.011	0.005	-0.03	-0.02	-0.011	-0.007
9	4.1	2.2	0.007	0.26	0.14	-0.009	0.010	0.006	0.10	0.03	-0.009	-0.007
10	6.1	4.2	0.013	0.44	0.20	-0.016	0.015	0.008	0.21	0.09	-0.006	-0.008
11	8.2	6.2	0.020	0.59	0.29	-0.019	0.023	0.008	0.32	0.14	-0.005	-0.011
13	10.2	8.2	0.034	0.78	0.33	-0.023	0.032	0.008	0.46	0.20	-0.007	-0.015
14	12.2	10.2	0.047	0.89	0.42	-0.039	0.048	0.006	0.58	0.25	-0.009	-0.021
15	14.3	12.2	0.065	1.03	0.49	-0.039	0.066	0.002	0.69	0.31	-0.012	-0.029
16	16.3	14.3	0.090	1.10	0.53	-0.055	0.087	-0.006	0.81	0.36	-0.015	-0.038
17	18.3	16.3	0.137	1.07	0.51	-0.076	0.113	-0.012	0.88	0.40	-0.018	-0.050
18	20.3	18.3	0.191	1.02	0.53	-0.096	0.152	-0.020	0.99	0.46	-0.025	-0.068
20	24.2	22.3	0.294	0.81	0.44	-0.161	0.231	-0.036	1.02	0.48	-0.054	-0.103
21	25.2	23.3	0.309	0.81	0.48	-0.154	0.246	-0.042	1.06	0.50	-0.054	-0.111
22	0.0	-1.8	0.011	0.01	-0.05	-0.028	0.013	0.004	-0.13	-0.06	-0.013	-0.008

Table 6 .- Non-Dimensional Aerodynamic Coefficients for Configuration 3: Aspect Ratio 10.02 Wing with a $0.233m$ Span Rectangular Tip.

Run 32 Tip No 8 Tip Incidence Angle = 0.0°

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	0.2	0.005	0.02	0.00	-0.032	0.011	0.005	-0.02	-0.01	-0.006	-0.007
3	-6.1	-5.8	0.053	-0.46	-0.23	-0.040	0.032	0.003	-0.37	-0.16	-0.009	-0.015
4	-4.1	-3.8	0.032	-0.35	-0.13	-0.016	0.019	0.004	-0.26	-0.11	-0.008	-0.010
5	-2.1	-1.8	0.017	-0.19	-0.05	-0.003	0.014	0.004	-0.15	-0.07	-0.008	-0.007
6	0.0	0.2	0.011	-0.02	0.01	-0.005	0.011	0.005	-0.03	-0.01	-0.006	-0.007
7	2.0	2.2	0.006	0.13	0.09	-0.012	0.012	0.005	0.08	0.04	-0.004	-0.007
8	4.1	4.2	0.007	0.27	0.18	-0.013	0.017	0.005	0.20	0.09	-0.003	-0.009
9	6.1	6.2	0.014	0.50	0.23	-0.020	0.024	0.006	0.33	0.15	-0.003	-0.011
10	8.2	8.2	0.021	0.65	0.32	-0.024	0.039	0.004	0.45	0.20	-0.005	-0.017
11	10.2	10.2	0.035	0.81	0.38	-0.026	0.054	0.000	0.58	0.26	-0.007	-0.023
12	12.3	12.2	0.053	0.98	0.46	-0.047	0.074	-0.005	0.71	0.33	-0.011	-0.033
13	14.3	14.3	0.070	1.06	0.56	-0.052	0.096	-0.011	0.82	0.38	-0.014	-0.043
14	16.3	16.3	0.102	1.14	0.59	-0.069	0.124	-0.020	0.94	0.44	-0.019	-0.057
15	18.3	18.3	0.154	1.12	0.57	-0.092	0.155	-0.027	1.01	0.48	-0.022	-0.072
17	20.3	20.3	0.193	1.02	0.57	-0.114	0.193	-0.035	1.06	0.51	-0.029	-0.091
19	23.2	23.3	0.298	0.84	0.44	-0.150	0.273	-0.051	1.09	0.53	-0.061	-0.126
20	22.2	22.3	0.287	0.82	0.45	-0.157	0.251	-0.043	1.07	0.51	-0.055	-0.115
21	0.0	0.2	0.010	-0.03	0.03	-0.030	0.010	0.005	-0.04	-0.02	-0.007	-0.006

Run 34 Tip No 8 Tip Incidence Angle = 5.0°

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	5.0	0.006	0.06	0.04	-0.038	0.014	0.005	0.13	0.06	0.001	-0.007
3	-10.1	-4.8	0.128	-0.49	-0.27	-0.053	0.040	0.012	-0.41	-0.18	0.000	-0.019
4	-8.1	-2.8	0.102	-0.53	-0.24	-0.038	0.021	0.012	-0.34	-0.14	-0.005	-0.011
5	-6.1	-0.8	0.055	-0.47	-0.14	-0.018	0.014	0.010	-0.23	-0.10	-0.006	-0.008
6	-4.1	1.2	0.031	-0.31	-0.09	-0.008	0.011	0.008	-0.11	-0.04	-0.004	-0.007
7	-2.0	3.2	0.014	-0.17	0.00	-0.009	0.011	0.006	0.00	0.00	-0.002	-0.006
8	0.0	5.0	0.009	-0.01	0.07	-0.015	0.014	0.005	0.12	0.06	0.001	-0.007
9	2.1	7.0	0.006	0.20	0.14	-0.019	0.023	0.003	0.24	0.11	0.002	-0.011
10	4.1	9.0	0.012	0.36	0.22	-0.019	0.034	0.001	0.36	0.17	0.001	-0.015
11	6.2	11.2	0.019	0.56	0.27	-0.027	0.049	-0.002	0.49	0.23	-0.003	-0.022
12	8.2	13.2	0.030	0.71	0.36	-0.031	0.073	-0.006	0.62	0.29	-0.006	-0.031
13	10.2	15.2	0.047	0.87	0.45	-0.038	0.096	-0.012	0.74	0.35	-0.009	-0.041
15	12.3	17.3	0.064	1.00	0.49	-0.049	0.124	-0.021	0.86	0.41	-0.014	-0.055
16	14.3	19.3	0.082	1.08	0.61	-0.062	0.152	-0.030	0.97	0.47	-0.020	-0.069
17	16.3	21.3	0.123	1.14	0.62	-0.078	0.188	-0.040	1.06	0.51	-0.026	-0.087
18	18.3	23.3	0.168	1.12	0.54	-0.112	0.222	-0.048	1.04	0.51	-0.049	-0.105
20	20.3	25.3	0.210	0.99	0.52	-0.131	0.255	-0.053	0.87	0.44	-0.094	-0.121
21	0.0	5.0	0.008	0.05	0.07	-0.037	0.013	0.004	0.14	0.06	0.001	-0.007
22	0.0	5.0	0.009	0.09	0.01	-0.037	0.014	0.005	0.13	0.06	0.000	-0.007

Table 6.- Concluded.

Run 20 Tip No 2 Tip Incidence Angle = -5.0^o

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	-4.8	0.011	-0.08	-0.06	-0.033	0.024	0.002	-0.23	-0.11	-0.014	-0.011
3	-6.1	-11.1	0.084	-0.52	-0.24	-0.054	0.131	-0.006	-0.53	-0.26	0.047	-0.058
4	-4.1	-8.8	0.054	-0.42	-0.16	-0.029	0.085	-0.001	-0.45	-0.22	-0.001	-0.037
5	-2.1	-6.8	0.033	-0.29	-0.10	-0.014	0.050	0.001	-0.37	-0.18	-0.015	-0.021
6	0.0	-4.8	0.017	-0.13	-0.03	-0.006	0.024	0.002	-0.24	-0.12	-0.013	-0.011
8	2.0	-2.8	0.011	0.06	0.02	-0.005	0.016	0.003	-0.12	-0.06	-0.012	-0.008
9	4.1	-0.8	0.008	0.22	0.10	-0.005	0.011	0.005	0.01	0.00	-0.010	-0.006
10	6.1	1.2	0.009	0.37	0.18	-0.011	0.011	0.006	0.13	0.05	-0.008	-0.006
11	8.2	3.2	0.016	0.56	0.24	-0.012	0.015	0.009	0.26	0.11	-0.006	-0.007
12	10.2	5.2	0.027	0.68	0.34	-0.021	0.022	0.010	0.38	0.16	-0.006	-0.010
13	12.2	7.2	0.044	0.85	0.39	-0.022	0.031	0.010	0.54	0.23	-0.006	-0.013
14	14.3	9.3	0.056	0.99	0.47	-0.032	0.044	0.008	0.65	0.29	-0.007	-0.020
15	16.3	11.3	0.083	1.06	0.53	-0.042	0.061	0.005	0.77	0.35	-0.009	-0.028
16	18.3	13.3	0.131	1.04	0.53	-0.065	0.084	-0.001	0.86	0.40	-0.011	-0.039
19	0.0	-4.8	0.012	-0.08	-0.06	-0.031	0.022	0.002	-0.23	-0.11	-0.014	-0.010

Run 19 Tip No 2 Tip Incidence Angle = -2.0^o

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
3	0.0	-1.8	0.007	-0.03	-0.04	-0.035	0.015	0.003	-0.13	-0.06	-0.011	-0.007
4	-6.1	-8.0	0.068	-0.49	-0.25	-0.050	0.087	0.000	-0.48	-0.23	0.002	-0.037
6	-4.1	-5.8	0.045	-0.37	-0.18	-0.018	0.052	0.002	-0.39	-0.18	-0.013	-0.022
7	-2.1	-3.8	0.023	-0.24	-0.11	-0.005	0.023	0.002	-0.28	-0.13	-0.012	-0.011
8	-2.1	-3.8	0.022	-0.21	-0.11	-0.009	0.023	0.002	-0.28	-0.13	-0.012	-0.011
9	0.0	-1.8	0.015	-0.07	-0.04	-0.010	0.015	0.003	-0.15	-0.07	-0.011	-0.007
10	2.0	0.2	0.009	0.09	0.05	-0.007	0.011	0.004	-0.03	-0.02	-0.010	-0.006
12	4.1	2.2	0.008	0.29	0.12	-0.007	0.010	0.005	0.10	0.04	-0.008	-0.006
13	6.1	4.2	0.012	0.41	0.21	-0.014	0.014	0.006	0.23	0.10	-0.005	-0.007
14	8.2	6.2	0.021	0.61	0.25	-0.008	0.022	0.007	0.37	0.16	-0.005	-0.010
15	10.2	8.2	0.031	0.78	0.36	-0.024	0.032	0.008	0.52	0.23	-0.006	-0.014
16	12.3	10.3	0.044	0.89	0.41	-0.034	0.046	0.006	0.63	0.28	-0.007	-0.021
17	14.3	12.3	0.061	1.04	0.47	-0.046	0.062	0.004	0.76	0.35	-0.009	-0.029
18	16.3	14.3	0.093	1.12	0.52	-0.053	0.083	-0.002	0.87	0.40	-0.011	-0.039
19	16.3	14.3	0.131	1.01	0.46	-0.041	0.073	-0.006	0.94	0.44	-0.012	-0.036
20	20.3	18.3	0.180	0.98	0.56	-0.099	0.139	-0.014	1.02	0.49	-0.019	-0.067

Table 7 .- Non-Dimensional Aerodynamic Coefficients for Configuration 4: Aspect Ratio 10.19 Wing with a $0.312m$ Span Rectangular Tip.

Run 17 Tip No 2 Tip Incidence Angle = 0.0°

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	0.2	0.008	0.01	0.02	-0.026	0.011	0.003	0.00	0.00	-0.006	-0.006
3	-6.1	-5.8	0.051	-0.46	-0.20	-0.029	0.032	0.005	-0.38	-0.17	-0.011	-0.015
4	-4.1	-3.8	0.034	-0.32	-0.13	-0.010	0.018	0.005	-0.27	-0.12	-0.010	-0.009
5	-2.0	-1.8	0.017	-0.17	-0.06	-0.005	0.013	0.004	-0.14	-0.06	-0.008	-0.006
7	0.0	0.2	0.010	0.01	-0.01	-0.006	0.010	0.004	-0.01	0.00	-0.006	-0.006
8	2.0	2.2	0.006	0.16	0.11	-0.006	0.010	0.004	0.11	0.05	-0.005	-0.006
9	4.1	4.2	0.007	0.33	0.16	-0.006	0.017	0.004	0.25	0.11	-0.002	-0.008
10	6.1	6.2	0.013	0.52	0.24	-0.018	0.028	0.005	0.38	0.17	-0.003	-0.012
11	8.2	8.2	0.024	0.65	0.32	-0.019	0.040	0.005	0.50	0.23	-0.005	-0.017
12	10.2	10.3	0.037	0.82	0.39	-0.026	0.056	0.003	0.64	0.30	-0.006	-0.025
13	12.3	12.3	0.057	0.98	0.46	-0.039	0.075	-0.002	0.78	0.36	-0.009	-0.035
14	14.3	14.3	0.068	1.06	0.54	-0.052	0.094	-0.005	0.89	0.42	-0.011	-0.045
15	15.3	15.3	0.082	1.09	0.60	-0.052	0.107	-0.008	0.96	0.45	-0.013	-0.052
16	0.0	0.2	0.006	0.04	0.00	-0.030	0.009	0.004	-0.01	0.00	-0.006	-0.005

Run 21 Tip No 2 Tip Incidence Angle = 5.0°

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
3	0.0	5.0	0.009	0.12	0.07	-0.035	0.016	0.002	0.20	0.10	0.002	-0.008
4	-11.1	-5.8	0.137	-0.50	-0.25	-0.031	0.046	0.009	-0.43	-0.19	-0.004	-0.021
7	-8.1	-2.8	0.092	-0.50	-0.21	-0.021	0.016	0.010	-0.30	-0.13	-0.006	-0.008
8	-6.1	-0.8	0.049	-0.41	-0.13	0.000	0.012	0.008	-0.19	-0.08	-0.005	-0.006
9	-4.1	1.2	0.028	-0.28	-0.05	-0.003	0.012	0.006	-0.06	-0.02	-0.003	-0.006
10	-2.0	3.2	0.017	-0.10	0.04	0.001	0.010	0.004	0.07	0.04	-0.001	-0.006
12	2.1	7.0	0.010	0.24	0.16	-0.011	0.026	0.002	0.33	0.15	0.002	-0.012
13	4.1	9.2	0.016	0.42	0.25	-0.008	0.039	-0.001	0.47	0.22	0.000	-0.018
14	6.2	11.2	0.022	0.58	0.32	-0.024	0.063	-0.003	0.60	0.29	-0.002	-0.027
15	8.2	13.3	0.034	0.74	0.39	-0.028	0.083	-0.006	0.72	0.34	-0.005	-0.037
17	12.3	17.3	0.070	1.05	0.53	-0.053	0.133	-0.015	0.98	0.47	-0.012	-0.063
18	14.3	19.3	0.086	1.05	0.67	-0.066	0.152	-0.021	1.06	0.52	-0.018	-0.075
19	14.3	19.3	0.086	1.12	0.62	-0.063	0.151	-0.020	1.06	0.52	-0.017	-0.075
20	0.0	5.0	0.010	0.11	0.06	-0.032	0.015	0.002	0.20	0.10	0.001	-0.008

Table 7.- Concluded.

Run 40 Tip No 3 Tip Incidence Angle = 0.0°

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	0.2	0.006	0.02	0.00	-0.032	0.012	0.003	-0.03	-0.01	-0.002	-0.004
3	-6.1	-6.0	0.049	-0.46	-0.23	-0.038	0.032	-0.004	-0.40	-0.18	0.019	-0.011
4	-4.1	-4.0	0.033	-0.35	-0.12	-0.012	0.017	-0.001	-0.29	-0.13	0.013	-0.006
5	-2.1	-2.0	0.016	-0.18	-0.06	-0.005	0.012	0.001	-0.16	-0.07	0.006	-0.005
7	0.0	0.2	0.004	0.12	-0.07	-0.015	0.011	0.003	-0.02	-0.01	-0.002	-0.004
8	2.0	2.2	0.006	0.15	0.08	-0.006	0.012	0.003	0.08	0.04	-0.008	-0.004
9	4.1	4.2	0.006	0.29	0.17	-0.009	0.016	0.004	0.21	0.09	-0.014	-0.005
11	6.1	6.2	0.011	0.49	0.24	-0.014	0.025	0.003	0.33	0.15	-0.022	-0.008
12	8.2	8.3	0.020	0.64	0.32	-0.019	0.038	0.000	0.48	0.22	-0.035	-0.012
13	10.2	10.3	0.036	0.78	0.40	-0.026	0.053	-0.005	0.61	0.28	-0.047	-0.017
14	12.3	12.3	0.053	0.94	0.48	-0.031	0.069	-0.012	0.73	0.34	-0.059	-0.024
15	14.3	14.3	0.072	1.14	0.57	-0.045	0.094	-0.022	0.90	0.42	-0.076	-0.035
17	16.3	16.3	0.102	1.16	0.57	-0.065	0.112	-0.034	0.97	0.46	-0.086	-0.044
18	18.3	18.3	0.145	1.10	0.55	-0.094	0.136	-0.044	1.02	0.49	-0.095	-0.055
19	19.3	19.4	0.182	1.06	0.52	-0.087	0.155	-0.052	1.07	0.52	-0.109	-0.064
20	20.3	20.4	0.244	0.90	0.47	-0.125	0.178	-0.051	1.03	0.51	-0.117	-0.074
21	0.0	0.2	0.008	0.00	0.01	-0.028	0.010	0.003	-0.02	-0.01	-0.002	-0.004
22	0.0	0.2	0.008	0.02	-0.01	-0.030	0.011	0.003	-0.03	-0.01	-0.002	-0.004

Table 8 .- Non-Dimensional Aerodynamic Coefficients for Configuration 5: Aspect Ratio 10.19 Wing with a $0.312m$ Span, 20^o Swept Rectangular Tip.

Run 31 Tip No 5 Tip Incidence Angle = -5.0^o

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	-4.8	0.011	-0.06	-0.10	-0.039	0.023	0.002	-0.26	-0.12	-0.018	-0.011
3	-4.1	-9.0	0.047	-0.40	-0.22	-0.058	0.098	0.001	-0.51	-0.23	0.005	-0.045
4	-2.1	-6.8	0.031	-0.28	-0.15	-0.035	0.058	0.002	-0.42	-0.19	-0.018	-0.027
5	0.0	-4.8	0.015	-0.14	-0.06	-0.014	0.024	0.002	-0.27	-0.13	-0.018	-0.012
6	2.0	-2.8	0.007	0.05	0.01	-0.018	0.014	0.003	-0.14	-0.07	-0.016	-0.008
7	4.1	-0.8	0.004	0.23	0.07	-0.018	0.010	0.005	-0.01	-0.01	-0.014	-0.006
10	6.1	1.2	0.008	0.42	0.13	-0.017	0.011	0.008	0.13	0.05	-0.012	-0.006
11	8.2	3.2	0.016	0.58	0.25	-0.020	0.015	0.012	0.26	0.10	-0.009	-0.007
12	10.2	5.2	0.027	0.73	0.34	-0.031	0.020	0.016	0.41	0.17	-0.007	-0.009
13	12.3	7.2	0.049	0.95	0.38	-0.041	0.031	0.018	0.57	0.24	-0.007	-0.013
14	14.3	9.3	0.058	1.04	0.46	-0.047	0.043	0.019	0.69	0.29	-0.007	-0.019
15	16.3	11.3	0.086	1.12	0.51	-0.054	0.058	0.016	0.81	0.35	-0.007	-0.026
16	18.3	13.3	0.132	1.12	0.51	-0.075	0.081	0.012	0.93	0.41	-0.008	-0.037
18	20.3	15.3	0.171	1.04	0.51	-0.095	0.109	0.008	1.01	0.45	-0.011	-0.050
19	22.2	17.3	0.255	0.81	0.45	-0.135	0.156	0.004	1.01	0.46	-0.029	-0.068
20	24.2	19.3	0.282	0.82	0.46	-0.149	0.191	-0.005	1.09	0.50	-0.036	-0.084
21	25.2	20.3	0.294	0.85	0.44	-0.133	0.206	-0.010	1.12	0.52	-0.040	-0.092
22	26.2	21.3	0.319	0.85	0.49	-0.154	0.224	-0.015	1.16	0.55	-0.042	-0.101
23	0.0	-4.8	0.011	0.01	-0.17	-0.041	0.021	0.002	-0.26	-0.12	-0.018	-0.011

Run 30 Tip No 5 Tip Incidence Angle = 0.0^o

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	0.2	0.006	0.03	0.00	-0.037	0.011	0.004	0.01	0.00	-0.008	-0.005
3	-6.1	-5.8	0.056	-0.46	-0.21	-0.039	0.032	0.005	-0.40	-0.17	-0.015	-0.016
5	-4.1	-3.8	0.032	-0.33	-0.14	-0.019	0.013	0.004	-0.28	-0.12	-0.013	-0.007
6	-2.0	-1.8	0.019	-0.17	-0.07	-0.011	0.011	0.004	-0.15	-0.06	-0.011	-0.006
7	0.0	0.2	0.009	-0.04	0.06	-0.010	0.010	0.003	-0.02	-0.01	-0.009	-0.005
8	2.0	2.2	0.006	0.15	0.12	-0.012	0.012	0.004	0.12	0.05	-0.007	-0.005
9	4.1	4.2	0.006	0.32	0.18	-0.013	0.019	0.006	0.26	0.11	-0.004	-0.008
11	8.2	8.2	0.023	0.68	0.33	-0.025	0.040	0.010	0.54	0.24	-0.005	-0.017
12	10.2	10.3	0.037	0.85	0.39	-0.031	0.054	0.010	0.68	0.30	-0.005	-0.023
13	12.3	12.3	0.056	1.03	0.50	-0.050	0.074	0.010	0.86	0.38	-0.006	-0.033
14	14.3	14.3	0.070	1.06	0.56	-0.047	0.090	0.008	0.93	0.42	-0.007	-0.042
15	16.3	16.3	0.099	1.16	0.60	-0.063	0.114	0.005	1.06	0.48	-0.008	-0.054
16	18.3	18.3	0.153	1.16	0.55	-0.093	0.147	0.001	1.15	0.52	-0.011	-0.070
17	20.3	20.3	0.194	1.06	0.54	-0.110	0.184	-0.004	1.19	0.55	-0.020	-0.087
18	0.0	0.2	0.010	-0.01	0.03	-0.031	0.009	0.004	0.00	0.00	-0.009	-0.005
19	0.0	0.2	0.009	0.05	-0.01	-0.031	0.009	0.004	0.00	0.00	-0.009	-0.005

Table 9 .- Non-Dimensional Aerodynamic Coefficients for Configuration 6: Aspect Ratio 10.51 Wing with a $0.312m$ Span, 0.6 Tapered Tip.

Run 41 Tip No 5 Tip Incidence Angle = 5.0°

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	5.2	0.008	0.09	0.07	-0.039	0.017	0.004	0.20	0.09	-0.001	-0.008
4	-10.1	-4.8	0.125	-0.49	-0.26	-0.041	0.037	0.012	-0.43	-0.18	-0.007	-0.017
5	-8.1	-2.8	0.094	-0.49	-0.24	-0.030	0.017	0.011	-0.34	-0.14	-0.011	-0.008
6	-6.1	-0.8	0.050	-0.49	-0.10	-0.015	0.013	0.008	-0.22	-0.09	-0.010	-0.006
7	-6.1	-0.8	0.052	-0.48	-0.12	-0.012	0.013	0.008	-0.23	-0.09	-0.010	-0.006
8	-4.1	1.2	0.020	-0.19	-0.12	-0.009	0.012	0.005	-0.07	-0.02	-0.007	-0.005
9	-2.0	3.2	0.012	-0.11	0.00	-0.012	0.012	0.004	-0.05	0.03	-0.004	-0.005
10	0.0	5.2	0.007	0.03	0.11	-0.018	0.018	0.004	0.18	0.09	-0.001	-0.008
11	2.1	7.0	0.008	0.21	0.17	-0.017	0.026	0.004	0.31	0.14	0.001	-0.011
12	4.1	9.0	0.011	0.40	0.23	-0.020	0.037	0.005	0.45	0.20	0.000	-0.016
13	6.2	11.2	0.018	0.60	0.30	-0.025	0.059	0.006	0.60	0.27	-0.001	-0.024
14	8.2	13.3	0.028	0.76	0.39	-0.032	0.078	0.005	0.75	0.34	-0.002	-0.033
15	10.2	15.3	0.045	0.91	0.49	-0.041	0.100	0.003	0.90	0.41	-0.003	-0.044
16	12.3	17.3	0.070	1.11	0.56	-0.054	0.129	0.000	1.05	0.49	-0.006	-0.059
17	14.3	19.3	0.086	1.15	0.64	-0.064	0.149	-0.005	1.13	0.52	-0.009	-0.071
18	16.3	21.3	0.113	1.19	0.59	-0.094	0.192	-0.013	1.05	0.51	-0.066	-0.089
20	18.3	23.3	0.175	1.08	0.55	-0.115	0.230	-0.019	0.97	0.49	-0.098	-0.109
21	0.0	5.2	0.009	0.12	0.05	-0.038	0.018	0.004	0.19	0.09	-0.001	-0.007

Table 9.- Concluded.

Run 39 Tip No 4 Tip Incidence Angle = 0.0°

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	0.2	0.008	0.03	0.00	-0.030	0.011	0.003	0.00	0.00	-0.008	-0.003
3	-6.1	-6.0	0.050	-0.46	-0.22	-0.041	0.025	-0.004	-0.40	-0.17	0.034	-0.009
4	-4.1	-4.0	0.036	-0.32	-0.12	-0.018	0.016	-0.002	-0.28	-0.12	0.020	-0.004
5	-2.0	-2.0	0.024	-0.18	-0.06	-0.009	0.011	0.001	-0.15	-0.06	0.007	-0.003
7	2.0	2.2	0.010	0.14	0.10	-0.015	0.013	0.004	0.11	0.05	-0.019	-0.004
8	4.1	4.2	0.011	0.30	0.18	-0.017	0.018	0.004	0.25	0.11	-0.033	-0.005
10	6.1	6.2	0.018	0.51	0.23	-0.019	0.029	-0.002	0.38	0.17	-0.049	-0.007
12	8.2	8.3	0.026	0.65	0.32	-0.027	0.040	-0.002	0.52	0.23	-0.069	-0.011
15	10.2	10.3	0.042	0.83	0.38	-0.024	0.053	-0.009	0.66	0.30	-0.088	-0.015
16	12.3	12.3	0.057	0.98	0.47	-0.038	0.068	-0.020	0.79	0.36	-0.107	-0.019
17	14.3	14.3	0.076	1.11	0.53	-0.053	0.088	-0.033	0.92	0.42	-0.126	-0.027
18	16.3	16.3	0.105	1.13	0.58	-0.075	0.109	-0.046	1.02	0.47	-0.143	-0.035
19	18.3	18.4	0.149	1.07	0.59	-0.092	0.135	-0.058	1.07	0.50	-0.154	-0.047
20	20.3	20.4	0.193	1.07	0.53	-0.114	0.169	-0.071	1.14	0.54	-0.178	-0.062
21	21.3	21.4	0.210	1.02	0.58	-0.113	0.189	-0.078	1.18	0.56	-0.192	-0.071
23	0.0	0.2	0.012	0.05	-0.01	-0.040	0.011	0.003	-0.01	0.00	-0.008	-0.003

Table 10 .- Non-Dimensional Aerodynamic Coefficients for Configuration 7: Aspect Ratio 10.51 Wing with a $0.312m$ Span, 0.6 Tapered, 30° Swept Tip.

Run 28 Tip No 6 Tip Incidence Angle = -5.0^{o}

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	-4.8	0.009	-0.06	-0.08	-0.036	0.018	0.004	-0.23	-0.11	-0.017	-0.008
3	-4.1	-8.8	0.042	-0.39	-0.20	-0.042	0.085	0.008	-0.48	-0.21	-0.005	-0.038
4	-2.1	-6.8	0.025	-0.28	-0.13	-0.024	0.042	0.006	-0.40	-0.18	-0.020	-0.020
5	0.0	-4.8	0.012	-0.11	-0.05	-0.011	0.019	0.004	-0.25	-0.12	-0.017	-0.009
6	2.0	-2.8	0.007	0.03	0.04	-0.013	0.011	0.005	-0.11	-0.05	-0.015	-0.006
7	4.1	-0.8	0.006	0.24	0.10	-0.011	0.009	0.006	0.03	0.00	-0.012	-0.005
8	6.1	1.2	0.009	0.40	0.18	-0.018	0.010	0.009	0.17	0.06	-0.009	-0.004
9	8.2	3.2	0.017	0.57	0.25	-0.018	0.014	0.013	0.30	0.11	-0.006	-0.006
10	10.2	5.2	0.028	0.72	0.34	-0.018	0.021	0.016	0.44	0.17	-0.004	-0.008
11	12.2	7.2	0.045	0.89	0.39	-0.036	0.030	0.018	0.60	0.24	-0.002	-0.012
12	14.3	9.2	0.056	1.01	0.47	-0.040	0.041	0.019	0.71	0.29	-0.001	-0.017
13	16.3	11.3	0.080	1.14	0.50	-0.059	0.058	0.017	0.85	0.35	0.000	-0.024
16	20.3	15.3	0.168	1.02	0.50	-0.095	0.107	0.012	1.02	0.43	-0.001	-0.044
17	22.2	17.3	0.235	0.79	0.47	-0.112	0.158	0.007	1.04	0.45	-0.023	-0.062
18	24.2	19.3	0.280	0.82	0.43	-0.138	0.190	-0.001	1.10	0.48	-0.029	-0.076
19	25.2	20.3	0.294	0.82	0.45	-0.136	0.205	-0.005	1.13	0.50	-0.032	-0.082
20	26.2	21.3	0.314	0.84	0.46	-0.155	0.223	-0.008	1.15	0.51	-0.038	-0.091
21	0.0	-4.8	0.008	-0.06	-0.08	-0.042	0.018	0.005	-0.24	-0.11	-0.017	-0.008

Table 11 .- Non-Dimensional Aerodynamic Coefficients for Configuration 8: Aspect Ratio 10.77 Wing with a $0.312m$ Span, 0.3 Tapered Tip.

Run 27 Tip No 6 Tip Incidence Angle = 0.0°

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	0.2	0.006	0.02	0.00	-0.037	0.009	0.004	-0.01	-0.01	-0.008	-0.004
3	-6.1	-5.8	0.052	-0.45	-0.24	-0.033	0.034	0.008	-0.43	-0.18	-0.015	-0.016
4	-4.1	-3.8	0.034	-0.35	-0.13	-0.018	0.013	0.006	-0.31	-0.13	-0.013	-0.007
6	-2.0	-1.8	0.017	-0.17	-0.08	-0.004	0.011	0.004	-0.17	-0.07	-0.011	-0.005
7	0.0	0.2	0.011	-0.03	0.03	-0.009	0.009	0.004	-0.02	-0.01	-0.008	-0.004
9	2.0	2.2	0.006	0.16	0.08	-0.010	0.012	0.004	0.11	0.05	-0.005	-0.005
10	4.1	4.2	0.008	0.32	0.16	-0.013	0.019	0.006	0.24	0.10	-0.003	-0.007
11	6.1	6.2	0.014	0.48	0.24	-0.017	0.027	0.009	0.40	0.16	-0.001	-0.010
13	6.1	6.2	0.013	0.52	0.22	-0.016	0.027	0.009	0.39	0.16	-0.001	-0.010
14	8.2	8.2	0.021	0.68	0.30	-0.018	0.038	0.011	0.54	0.23	-0.001	-0.014
15	10.2	10.0	0.035	0.85	0.40	-0.020	0.051	0.012	0.69	0.29	0.001	-0.020
16	12.3	12.1	0.055	0.99	0.46	-0.038	0.066	0.013	0.82	0.35	0.001	-0.026
17	14.3	14.1	0.068	1.12	0.53	-0.043	0.084	0.012	0.96	0.41	0.002	-0.035
19	18.3	18.1	0.147	1.14	0.57	-0.087	0.137	0.006	1.16	0.50	0.002	-0.058
20	20.3	20.3	0.193	1.09	0.50	-0.115	0.175	0.003	1.20	0.52	-0.011	-0.074
21	22.2	22.3	0.289	0.86	0.46	-0.143	0.255	-0.001	1.19	0.52	-0.063	-0.107
22	24.2	24.3	0.307	0.85	0.40	-0.170	0.357	0.018	1.01	0.41	-0.127	-0.162
24	16.3	16.1	0.097	1.14	0.59	-0.061	0.106	0.010	1.07	0.46	0.002	-0.044
25	0.0	0.2	0.009	0.06	-0.04	-0.033	0.012	0.003	-0.02	-0.01	-0.008	-0.005
26	0.0	0.2	0.010	0.03	-0.02	-0.032	0.012	0.003	-0.02	-0.01	-0.008	-0.005

Table 11.- Continued.

Run 29 Tip No 6 Tip Incidence Angle = 5.0°

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	5.0	0.011	0.09	0.05	-0.008	0.014	0.005	0.19	0.09	0.002	-0.007
3	-10.1	-4.8	0.121	-0.52	-0.28	-0.048	0.030	0.015	-0.45	-0.18	-0.006	-0.015
4	-8.1	-2.8	0.095	-0.51	-0.25	-0.024	0.014	0.014	-0.36	-0.14	-0.009	-0.007
5	-6.1	-0.8	0.052	-0.47	-0.11	-0.010	0.008	0.011	-0.23	-0.09	-0.009	-0.005
6	-4.1	1.2	0.029	-0.28	-0.09	-0.007	0.009	0.007	-0.09	-0.03	-0.005	-0.005
7	-2.0	3.2	0.012	-0.13	0.02	-0.013	0.010	0.005	0.04	0.02	-0.002	-0.005
8	0.0	5.0	0.009	0.06	0.08	-0.013	0.015	0.005	0.18	0.08	0.002	-0.007
9	2.1	7.0	0.007	0.23	0.15	-0.015	0.025	0.006	0.32	0.14	0.004	-0.010
11	4.1	9.0	0.012	0.44	0.21	-0.018	0.040	0.007	0.46	0.20	0.004	-0.016
12	6.2	11.0	0.020	0.63	0.30	-0.026	0.057	0.009	0.64	0.28	0.006	-0.022
14	8.2	13.0	0.029	0.77	0.37	-0.025	0.073	0.009	0.76	0.33	0.006	-0.029
15	10.3	15.1	0.049	0.97	0.46	-0.036	0.096	0.009	0.94	0.41	0.006	-0.039
16	12.3	17.1	0.063	1.06	0.50	-0.046	0.113	0.007	1.03	0.45	0.006	-0.046
17	14.3	19.1	0.081	1.12	0.64	-0.062	0.140	0.003	1.14	0.50	0.004	-0.059
18	14.3	19.1	0.084	1.16	0.61	-0.059	0.140	0.003	1.15	0.50	0.004	-0.059
19	16.3	21.3	0.118	1.19	0.60	-0.069	0.188	-0.004	1.11	0.50	-0.051	-0.080
20	17.3	22.3	0.150	1.13	0.53	-0.098	0.231	-0.002	1.02	0.45	-0.083	-0.101
23	0.0	5.0	0.007	0.10	0.04	-0.036	0.014	0.005	0.19	0.09	0.001	-0.007

Table 11.- Concluded.

Run 24 Tip No 7 Tip Incidence Angle = -5.0^{o}

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	-5.0	0.009	-0.05	-0.08	-0.039	0.023	0.003	-0.23	-0.11	0.023	-0.008
3	-4.1	-9.1	0.042	-0.34	-0.22	-0.042	0.075	0.003	-0.50	-0.22	0.060	-0.030
4	-2.1	-7.0	0.030	-0.27	-0.11	-0.012	0.039	0.002	-0.38	-0.17	0.042	-0.015
5	0.0	-5.0	0.015	-0.07	-0.07	-0.010	0.023	0.002	-0.23	-0.11	0.023	-0.008
6	2.0	-3.0	0.011	0.07	0.05	-0.009	0.015	0.004	-0.11	-0.06	0.009	-0.004
7	4.1	-0.8	0.008	0.22	0.10	-0.008	0.010	0.005	0.02	0.00	-0.005	-0.003
8	6.1	1.2	0.013	0.37	0.21	-0.015	0.011	0.007	0.14	0.05	-0.017	-0.003
9	8.1	3.2	0.019	0.55	0.25	-0.014	0.015	0.007	0.27	0.10	-0.032	-0.003
10	10.2	5.2	0.027	0.75	0.31	-0.022	0.021	0.004	0.43	0.17	-0.052	-0.003
11	12.2	7.3	0.044	0.88	0.37	-0.030	0.029	-0.002	0.56	0.23	-0.069	-0.005
12	14.3	9.3	0.059	1.01	0.46	-0.042	0.039	-0.012	0.69	0.29	-0.085	-0.007
13	16.3	11.3	0.082	1.12	0.51	-0.044	0.053	-0.025	0.82	0.34	-0.102	-0.010
14	18.3	13.3	0.126	1.10	0.48	-0.063	0.073	-0.038	0.90	0.38	-0.113	-0.016
16	22.2	17.3	0.245	0.81	0.40	-0.116	0.138	-0.058	0.97	0.43	-0.151	-0.039
19	0.0	-5.0	0.011	-0.05	-0.07	-0.041	0.025	0.002	-0.25	-0.12	0.025	-0.009

Run 25 Tip No 7 Tip Incidence Angle = -2.0^{o}

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	-2.0	0.008	-0.01	-0.04	-0.032	0.015	0.003	-0.14	-0.07	0.013	-0.005
3	-6.1	-8.1	0.066	-0.50	-0.26	-0.043	0.083	0.005	-0.54	-0.24	0.068	-0.033
4	-4.1	-6.0	0.043	-0.40	-0.16	-0.015	0.045	0.004	-0.43	-0.19	0.047	-0.017
5	-2.1	-4.0	0.022	-0.24	-0.08	-0.002	0.025	0.003	-0.30	-0.13	0.031	-0.009
6	0.0	-2.0	0.014	-0.10	0.01	-0.005	0.016	0.003	-0.15	-0.07	0.013	-0.004
7	2.0	0.2	0.007	0.07	0.07	-0.008	0.011	0.004	-0.03	-0.02	0.000	-0.003
8	4.1	2.2	0.006	0.22	0.15	-0.006	0.009	0.005	0.09	0.03	-0.013	-0.002
9	6.1	4.2	0.011	0.44	0.19	-0.011	0.013	0.005	0.24	0.09	-0.028	-0.002
10	8.2	6.2	0.020	0.60	0.27	-0.016	0.021	0.003	0.36	0.15	-0.044	-0.004
11	10.2	8.3	0.032	0.76	0.34	-0.017	0.029	-0.002	0.51	0.21	-0.063	-0.005
12	12.2	10.3	0.047	0.89	0.44	-0.032	0.040	-0.011	0.64	0.27	-0.080	-0.007
13	14.3	12.3	0.062	1.07	0.47	-0.036	0.053	-0.021	0.77	0.33	-0.096	-0.011
14	16.3	14.3	0.085	1.10	0.58	-0.051	0.070	-0.039	0.91	0.39	-0.115	-0.015
16	20.3	18.3	0.174	1.07	0.48	-0.090	0.118	-0.064	1.06	0.46	-0.141	-0.031
17	22.2	20.3	0.271	0.84	0.37	-0.128	0.211	-0.007	0.97	0.39	-0.168	-0.091
18	23.2	21.3	0.283	0.83	0.38	-0.135	0.234	-0.004	0.98	0.39	-0.176	-0.100
19	0.0	-2.0	0.010	-0.02	-0.06	-0.028	0.015	0.003	-0.15	-0.07	0.013	-0.004
20	0.0	-2.0	0.010	-0.02	-0.06	-0.033	0.015	0.003	-0.15	-0.07	0.012	-0.004

Table 12 .- Non-Dimensional Aerodynamic Coefficients for Configuration 9: Aspect Ratio 10.77 Wing with a $0.312m$ Span, 0.3 Tapered, 35^{o} Swept Tip.

Run 23 Tip No 7 Tip Incidence Angle = 0.0°

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	0.2	0.005	0.01	-0.01	-0.009	0.008	0.005	-0.02	-0.01	-0.001	-0.003
3	-6.1	-6.0	0.052	-0.50	-0.19	-0.028	0.030	0.006	-0.44	-0.19	0.048	-0.013
4	-4.1	-4.0	0.030	-0.32	-0.14	-0.010	0.016	0.005	-0.29	-0.13	0.030	-0.006
5	-2.0	-2.0	0.014	-0.18	-0.06	-0.005	0.011	0.004	-0.15	-0.07	0.014	-0.003
6	0.0	0.2	0.009	-0.03	0.02	-0.012	0.008	0.004	-0.02	-0.01	-0.001	-0.003
7	2.0	2.2	0.005	0.16	0.08	-0.013	0.010	0.004	0.10	0.04	-0.013	-0.003
8	4.1	4.2	0.006	0.31	0.16	-0.012	0.016	0.002	0.24	0.10	-0.030	-0.004
9	6.1	6.2	0.015	0.47	0.25	-0.022	0.025	-0.002	0.38	0.16	-0.048	-0.005
10	8.2	8.3	0.021	0.66	0.31	-0.025	0.036	-0.008	0.51	0.22	-0.066	-0.008
12	12.3	12.3	0.047	0.95	0.45	-0.044	0.062	-0.030	0.79	0.34	-0.101	-0.013
13	14.3	14.3	0.066	1.10	0.51	-0.049	0.079	-0.044	0.91	0.39	-0.117	-0.018
15	16.3	16.3	0.094	1.18	0.54	-0.061	0.096	-0.060	1.01	0.44	-0.132	-0.024
16	18.3	18.3	0.143	1.12	0.50	-0.104	0.176	0.004	1.00	0.39	-0.147	-0.080
17	20.3	20.3	0.197	1.06	0.47	-0.120	0.221	0.014	1.01	0.38	-0.163	-0.098
18	22.2	22.3	0.278	0.80	0.40	-0.137	0.268	0.012	0.98	0.38	-0.191	-0.115
19	10.2	10.3	0.034	0.86	0.40	-0.052	0.044	-0.016	0.68	0.29	-0.087	-0.009
20	0.0	0.2	0.010	0.15	-0.11	-0.032	0.006	0.004	-0.02	-0.01	-0.001	-0.002

Table 12.- Continued.

Run 26 Tip No 7 Tip Incidence Angle = 5.0°

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	5.2	0.008	0.10	0.04	-0.037	0.015	0.001	0.17	0.08	-0.021	-0.004
3	-10.1	-5.1	0.122	-0.52	-0.28	-0.054	0.036	0.012	-0.46	-0.19	0.054	-0.014
5	-8.1	-3.0	0.098	-0.53	-0.24	-0.035	0.019	0.011	-0.36	-0.15	0.039	-0.006
6	-6.1	-1.0	0.053	-0.47	-0.11	-0.006	0.011	0.009	-0.23	-0.09	0.022	-0.003
7	-4.1	1.0	0.027	-0.27	-0.07	-0.008	0.012	0.007	-0.09	-0.03	0.008	-0.003
8	-2.0	3.2	0.013	-0.16	0.02	-0.011	0.010	0.005	0.01	0.01	-0.004	-0.003
9	0.0	5.2	0.008	0.01	0.09	-0.013	0.015	0.002	0.15	0.07	-0.018	-0.004
10	2.1	7.2	0.006	0.22	0.14	-0.016	0.027	-0.003	0.29	0.13	-0.036	-0.006
11	4.1	9.2	0.010	0.39	0.23	-0.012	0.038	-0.010	0.43	0.19	-0.054	-0.009
12	6.2	11.3	0.018	0.60	0.27	-0.019	0.053	-0.020	0.59	0.26	-0.075	-0.011
13	8.2	13.3	0.030	0.73	0.39	-0.020	0.070	-0.032	0.72	0.32	-0.093	-0.016
14	10.2	15.3	0.043	0.89	0.47	-0.038	0.087	-0.047	0.86	0.38	-0.111	-0.020
15	12.3	17.3	0.060	1.06	0.50	-0.044	0.109	-0.064	0.99	0.44	-0.130	-0.027
16	14.3	19.3	0.092	1.12	0.56	-0.073	0.185	0.000	0.98	0.39	-0.145	-0.082
17	15.3	20.3	0.111	1.11	0.63	-0.083	0.209	0.010	1.00	0.39	-0.156	-0.092
18	16.3	21.3	0.129	1.17	0.59	-0.094	0.230	0.017	1.00	0.38	-0.163	-0.100
19	17.3	22.3	0.169	1.14	0.54	-0.102	0.250	0.021	1.00	0.37	-0.172	-0.107
20	18.3	23.3	0.186	1.11	0.52	-0.116	0.267	0.025	0.98	0.36	-0.179	-0.113
21	19.3	24.3	0.210	1.09	0.48	-0.125	0.281	0.026	0.96	0.35	-0.185	-0.117
22	20.3	25.3	0.221	1.02	0.47	-0.117	0.296	0.026	0.94	0.34	-0.189	-0.123
23	0.0	5.2	0.008	0.09	0.04	-0.035	0.015	0.001	0.16	0.07	-0.020	-0.004
24	0.0	5.2	0.009	0.09	0.06	-0.032	0.015	0.001	0.16	0.08	-0.020	-0.004

Table 12.- Concluded.

Run 42 Tip No 9 Tip Incidence Angle = 0.0°

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	0.2	0.006	0.02	-0.01	-0.036	0.014	0.007	-0.02	-0.01	-0.002	-0.006
3	2.0	2.2	0.007	0.17	0.06	-0.020	0.014	0.004	0.11	0.04	-0.020	-0.005
4	4.1	4.2	0.010	0.31	0.17	-0.013	0.019	0.002	0.23	0.10	-0.036	-0.005
5	6.1	6.2	0.013	0.53	0.21	-0.019	0.029	-0.002	0.40	0.17	-0.059	-0.006
6	8.2	8.3	0.020	0.66	0.30	-0.024	0.040	-0.007	0.53	0.23	-0.079	-0.008
7	10.2	10.3	0.035	0.83	0.38	-0.025	0.051	-0.016	0.66	0.29	-0.099	-0.011
8	12.3	12.3	0.055	1.00	0.45	-0.041	0.068	-0.028	0.81	0.35	-0.121	-0.015
9	14.3	14.3	0.071	1.11	0.51	-0.048	0.085	-0.041	0.92	0.41	-0.141	-0.021
11	0.0	0.2	0.008	0.06	-0.03	-0.035	0.014	0.006	-0.02	-0.01	-0.002	-0.006
13	-4.1	-4.0	0.030	-0.33	-0.15	-0.034	0.024	0.008	-0.32	-0.14	0.037	-0.013
14	-2.0	-2.0	0.017	-0.18	-0.08	-0.020	0.016	0.007	-0.17	-0.08	0.019	-0.009
15	0.0	0.2	0.010	-0.05	0.02	-0.016	0.013	0.006	-0.03	-0.02	0.000	-0.006

Table 13 .- Non-Dimensional Aerodynamic Coefficients for Configuration 10: Aspect Ratio 10.77 Wing with a 0.312m Span, 0.3 Tapered, 35° Swept Tip with a 20° Tip Leading Edge Droop.

Run 37 Tip No 8 Tip Incidence Angle = 0.0° Tip Gap Taped

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	0.2	0.006	0.02	-0.03	-0.035	0.014	0.001	-0.02	-0.01	-0.005	-0.006
3	-6.1	-5.8	0.054	-0.46	-0.23	-0.041	0.065	0.058	-0.38	-0.16	-0.010	-0.049
4	-4.1	-3.8	0.036	-0.32	-0.14	-0.014	0.043	0.043	-0.27	-0.12	-0.009	-0.038
5	-2.0	-1.8	0.019	-0.18	-0.06	-0.009	0.025	0.034	-0.15	-0.07	-0.009	-0.027
6	0.0	0.2	0.009	-0.07	0.05	-0.013	-0.014	-0.005	-0.03	-0.01	-0.006	0.001
7	2.0	2.2	0.006	0.15	0.09	-0.011	-0.012	-0.025	0.08	0.03	-0.004	0.009
8	4.1	4.2	0.006	0.34	0.14	-0.013	0.007	-0.041	0.21	0.09	-0.002	0.008
9	6.1	6.2	0.011	0.47	0.25	-0.017	0.018	-0.046	0.32	0.14	-0.002	0.002
10	8.2	8.2	0.021	0.63	0.31	-0.018	0.026	-0.041	0.44	0.19	-0.004	-0.010
11	10.2	10.2	0.037	0.80	0.39	-0.023	0.039	-0.029	0.58	0.26	-0.006	-0.030
12	12.3	12.2	0.054	0.93	0.44	-0.034	0.062	-0.016	0.69	0.31	-0.008	-0.050
13	14.3	14.3	0.070	1.09	0.52	-0.047	0.095	0.000	0.81	0.36	-0.011	-0.076
14	16.3	16.3	0.103	1.11	0.55	-0.065	0.138	0.011	0.90	0.41	-0.014	-0.101
15	18.3	18.3	0.148	1.10	0.57	-0.087	0.184	0.019	1.00	0.46	-0.017	-0.128
16	20.3	20.3	0.194	1.02	0.51	-0.112	0.221	0.018	1.04	0.48	-0.029	-0.148
17	22.2	22.3	0.276	0.84	0.46	-0.156	0.254	0.019	1.05	0.49	-0.030	-0.166
18	0.0	0.2	0.008	0.00	0.01	-0.032	-0.008	-0.030	-0.03	-0.01	-0.006	0.007
19	0.0	0.2	0.008	0.02	-0.03	-0.033	-0.004	-0.028	-0.03	-0.01	-0.005	0.005

Run 38 Tip No 8 Tip Incidence Angle = 0.0° Tip Gap Greased

NO	ALFW	ALFT	CDW	CLW	CLLW	CLNW	CDT	CYT	CLT	CLLT	CMT	CLNT
2	0.0	0.2	0.006	0.03	-0.02	-0.036	0.012	0.009	-0.02	-0.01	-0.007	-0.007
3	-4.1	-3.8	0.026	-0.30	-0.16	-0.032	0.019	-0.006	-0.27	-0.12	-0.011	-0.010
4	-2.0	-1.8	0.018	-0.18	-0.07	-0.022	0.012	0.001	-0.16	-0.07	-0.010	-0.008
5	0.0	0.2	0.010	-0.03	0.02	-0.015	0.012	0.008	-0.04	-0.02	-0.007	-0.007
6	2.0	2.2	0.006	0.16	0.07	-0.012	0.013	0.013	0.09	0.04	-0.005	-0.007
7	4.1	4.2	0.008	0.30	0.17	-0.015	0.017	0.014	0.20	0.09	-0.003	-0.009
8	6.1	6.2	0.015	0.48	0.24	-0.016	0.024	0.013	0.32	0.14	-0.002	-0.012
9	8.2	8.2	0.021	0.65	0.31	-0.023	0.038	0.009	0.46	0.20	-0.004	-0.017
10	10.2	10.2	0.037	0.80	0.38	-0.030	0.054	0.009	0.57	0.26	-0.007	-0.023
11	12.3	12.2	0.054	0.95	0.49	-0.036	0.074	-0.003	0.71	0.32	-0.011	-0.032
12	14.3	14.3	0.070	1.10	0.52	-0.057	0.099	-0.012	0.82	0.38	-0.015	-0.044
13	16.3	16.3	0.113	1.12	0.55	-0.071	0.153	-0.038	0.86	0.40	-0.059	-0.063
14	18.3	18.3	0.163	1.05	0.54	-0.110	0.189	-0.049	0.87	0.42	-0.078	-0.079
15	0.0	0.2	0.009	0.00	0.01	-0.035	0.012	0.006	-0.03	-0.01	-0.008	-0.006

Table 14 .- Non-Dimensional Aerodynamic Coefficients for Configuration 3 with Sealed Tip Gap: Aspect Ratio 10.02 Wing with a $0.233m$ Span, Rectangular Tip.

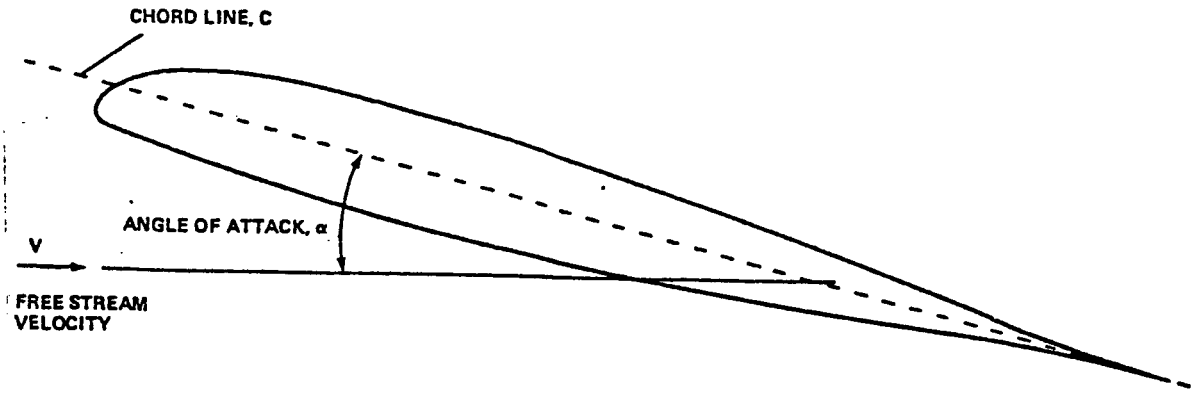
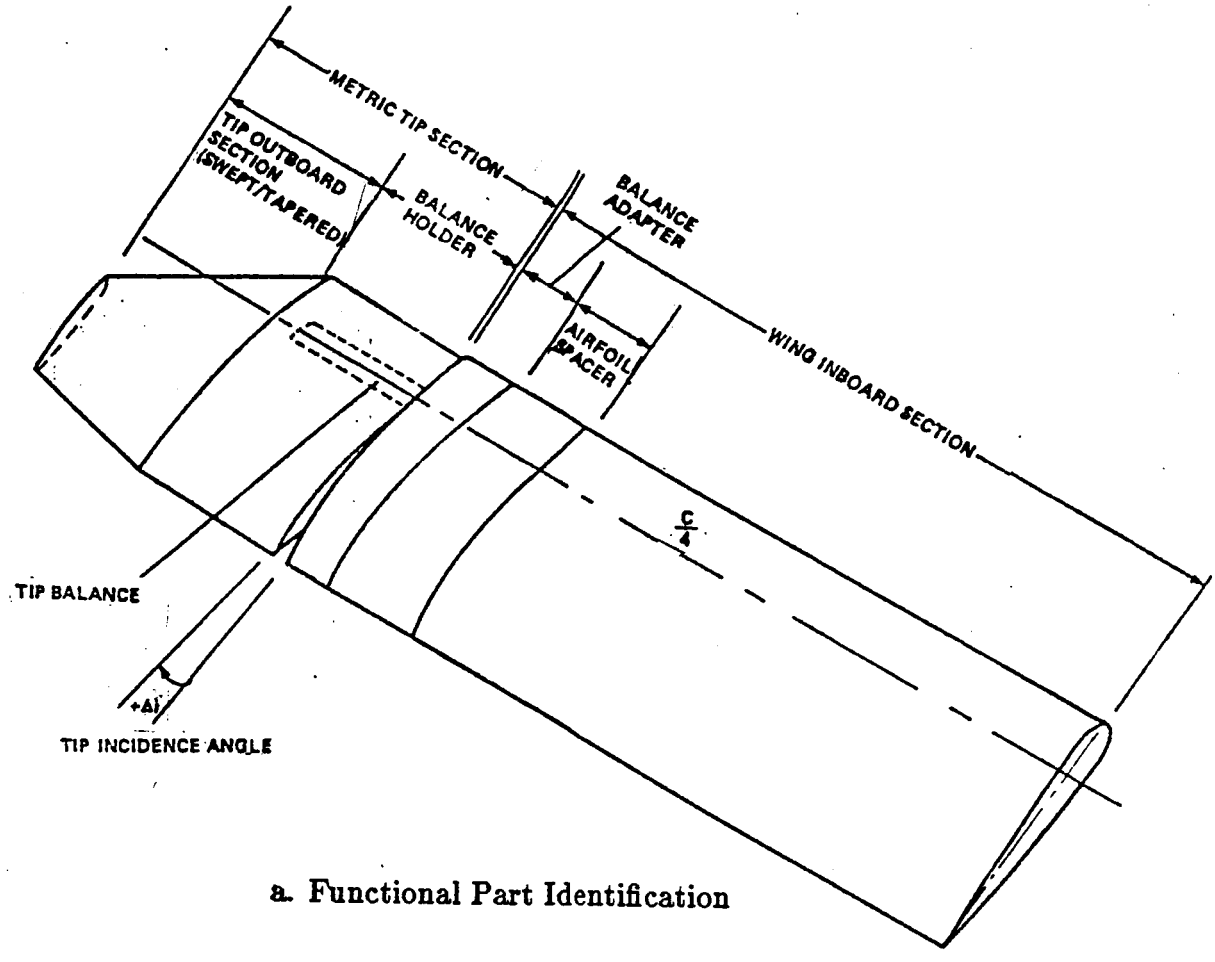
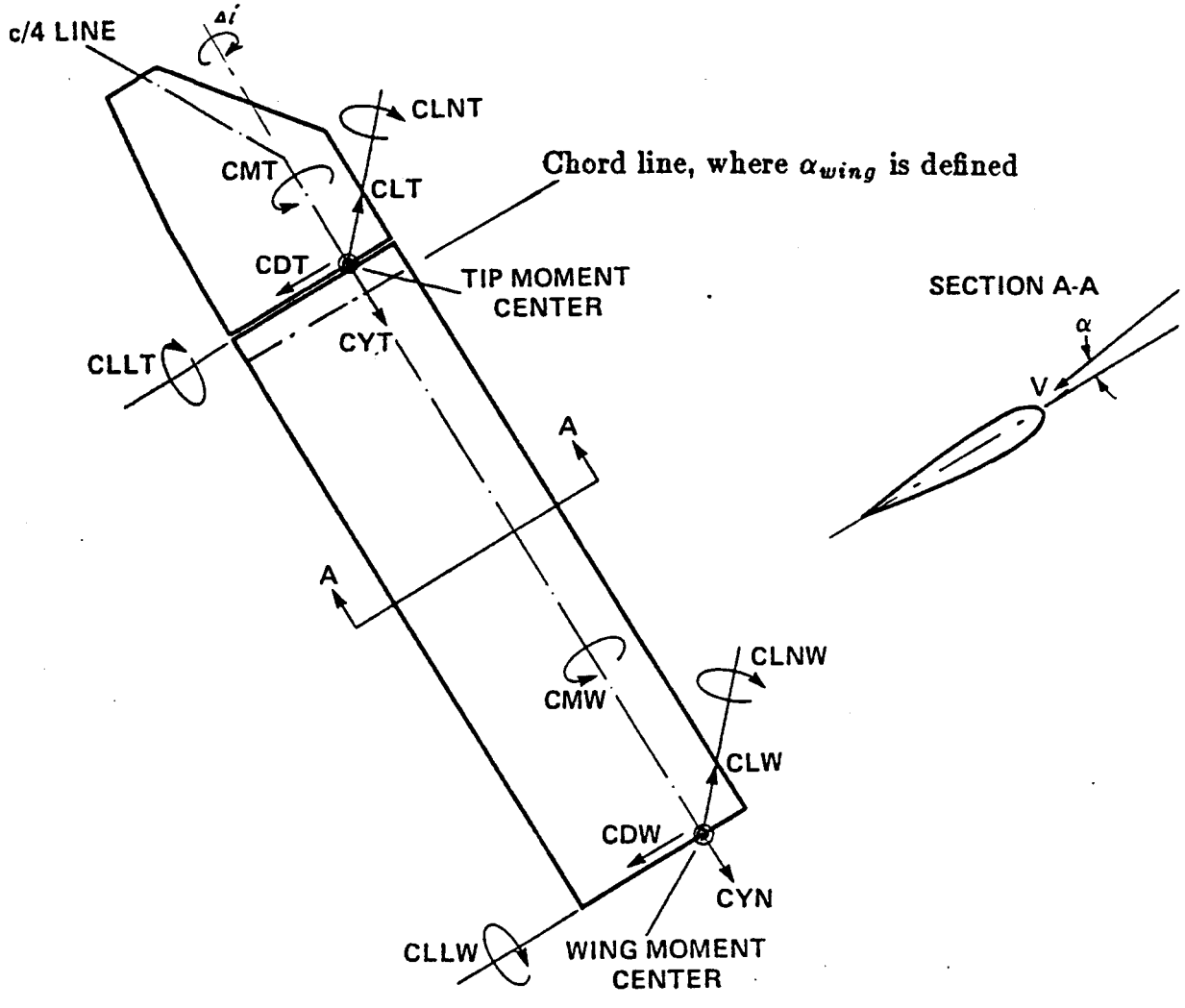


Figure 1.- Definition of Chordline and Angle of Attack.



a. Functional Part Identification

Figure 2.- Semi-Span Wing with Indexed Tip.

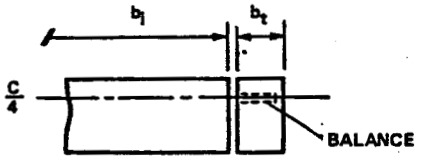


NOTE: Left wing configuration. Arrows indicate positive direction of forces, moments, and angular displacements.

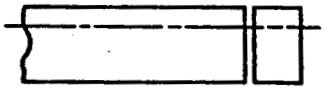
b. Definition of Forces, Moments, and Angular Displacements

Figure 2.- Semi-Span Wing with Indexed Tip.

CONF.	m	ft	m	ft
1	0.751	2.463	0.149	0.490
2	0.913	2.994	0.149	0.490
3	0.811	2.661	0.233	0.766
4↔10	0.751	2.463	0.312	1.023

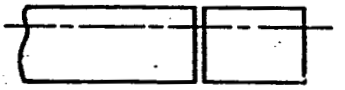


CONFIGURATION 1: SMALL, RECTANGULAR TIP ON ASPECT RATIO 8.63 WING

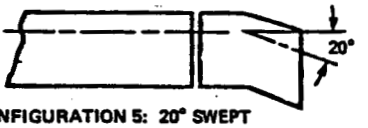


CONFIGURATION 2: SMALL, RECTANGULAR TIP ON ASPECT RATIO 10.18 WING

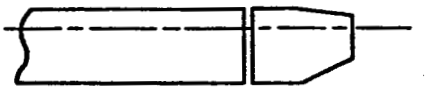
CONFIGURATION 3: MEDIUM RECTANGULAR TIP



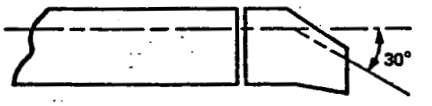
CONFIGURATION 4: LARGE RECTANGULAR TIP



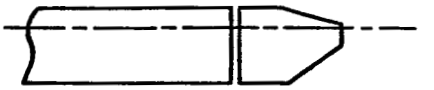
CONFIGURATION 5: 20° SWEPT RECTANGULAR TIP



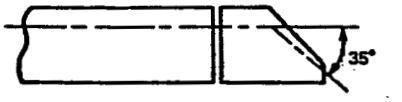
CONFIGURATION 6: 0.6 STRAIGHT TAPERED TIP



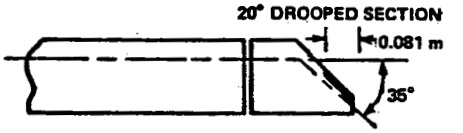
CONFIGURATION 7: 30° SWEPT, 0.6 TAPERED TIP



CONFIGURATION 8: 0.3 STRAIGHT TAPERED TIP

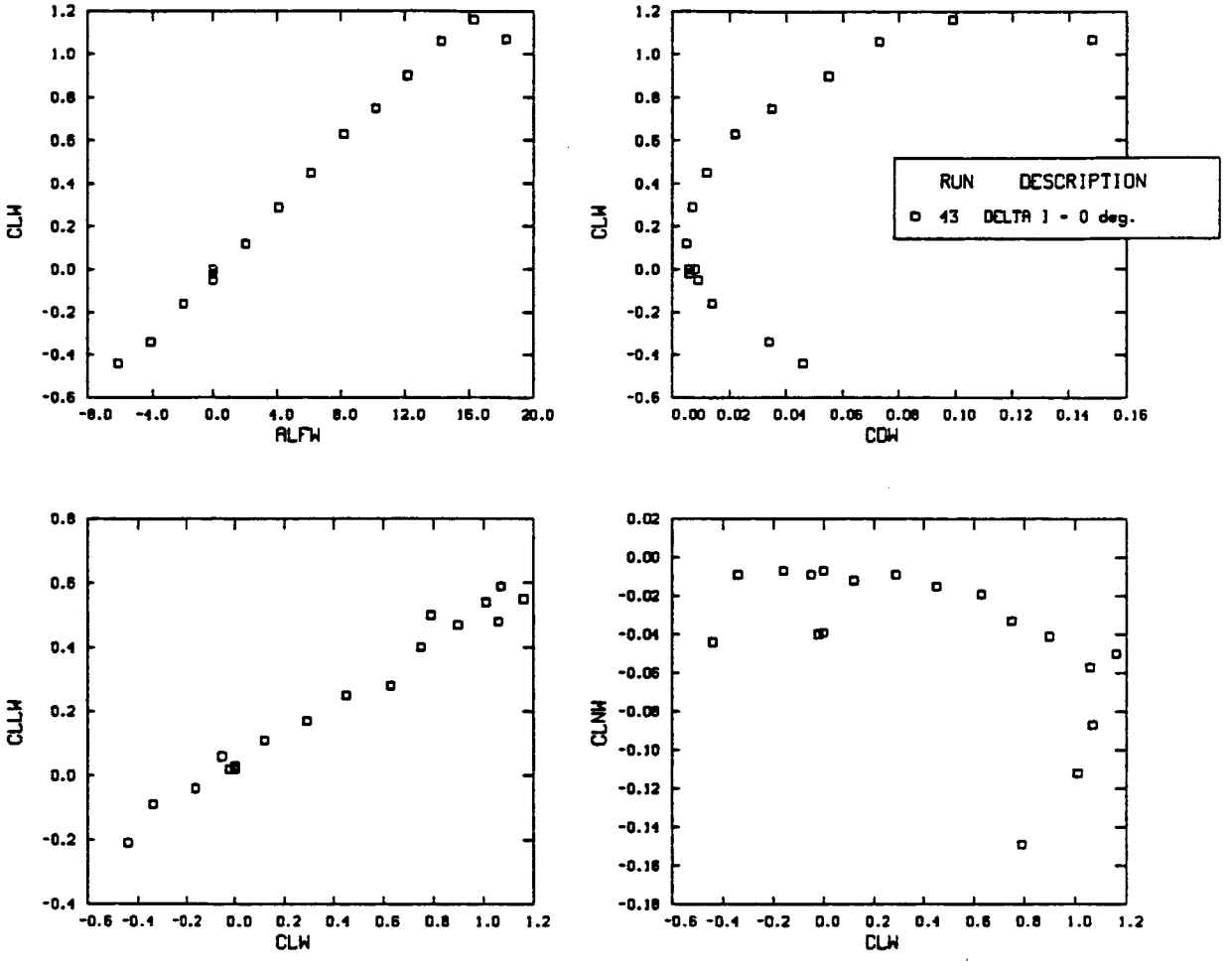


CONFIGURATION 9: 35° SWEPT 0.3 TAPERED TIP



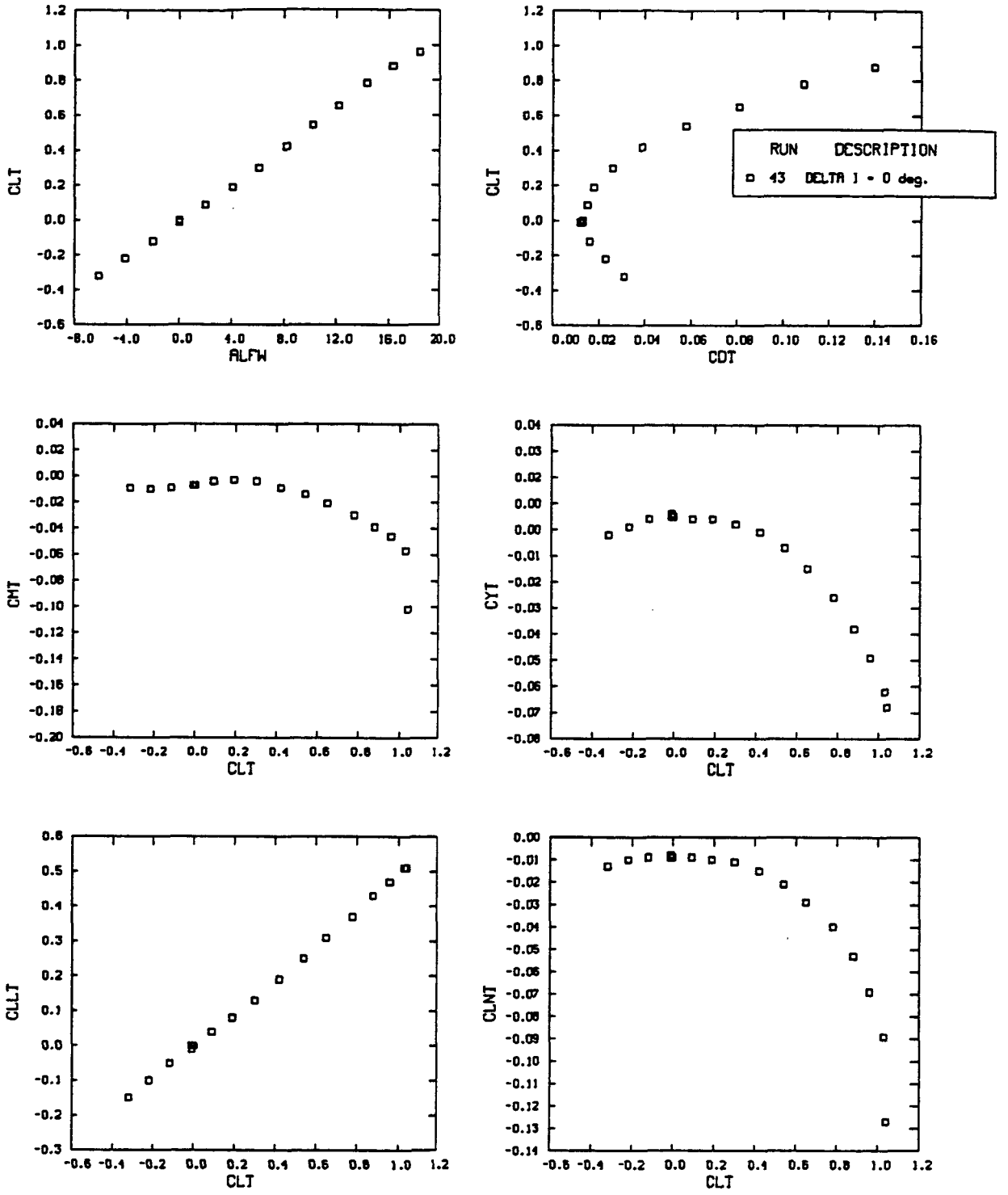
CONFIGURATION 10: 35° SWEPT 0.3 TAPERED TIP WITH 20° TIP LEADING EDGE DROOP

Figure 3.- Wing-Tip Configurations 1 through 10.



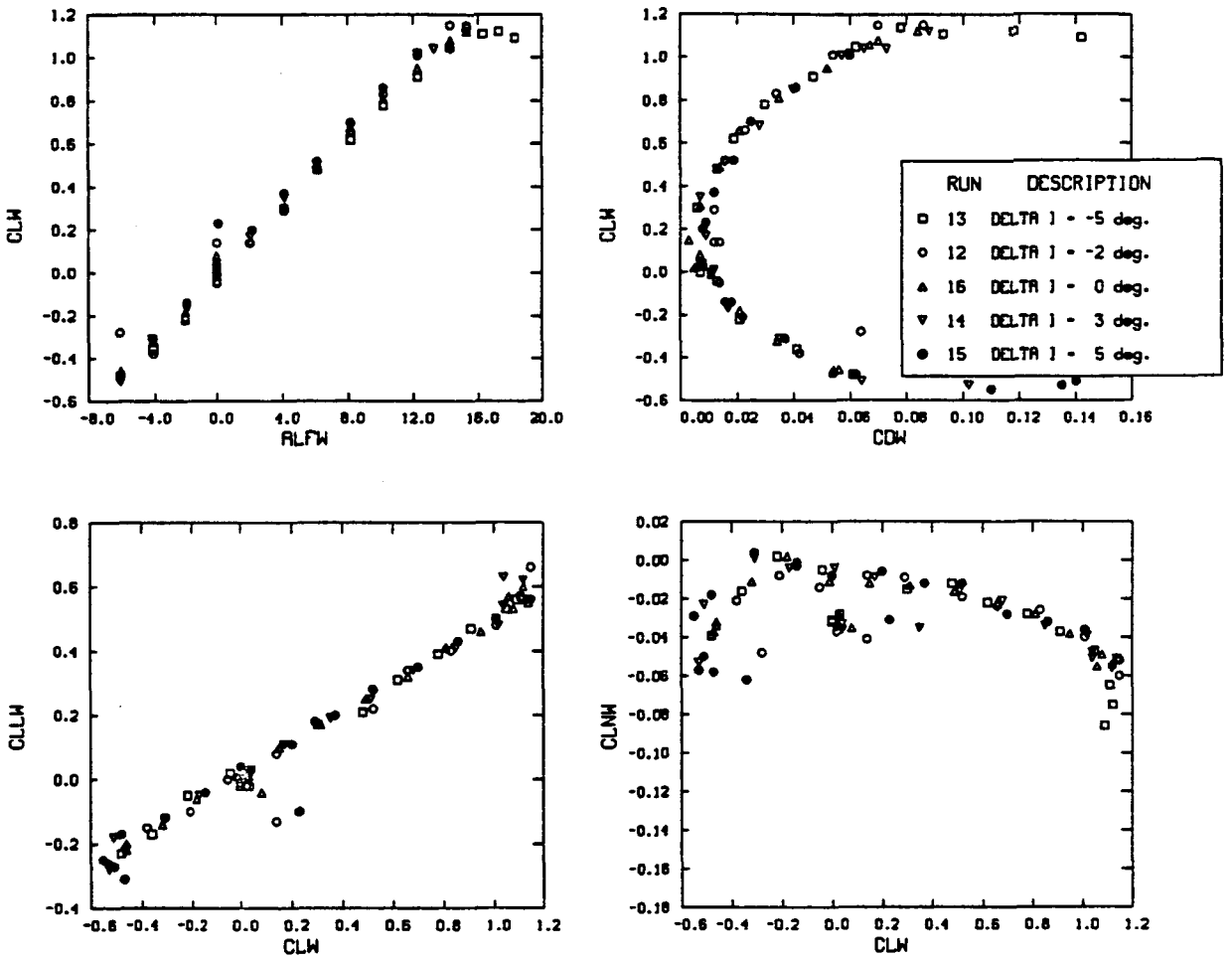
a. Wing Characteristics

Figure 4.- Wing and Tip Aerodynamic Characteristics for Configuration 1: Aspect Ratio 8.63 Wing with a 0.149m Span Rectangular Tip.



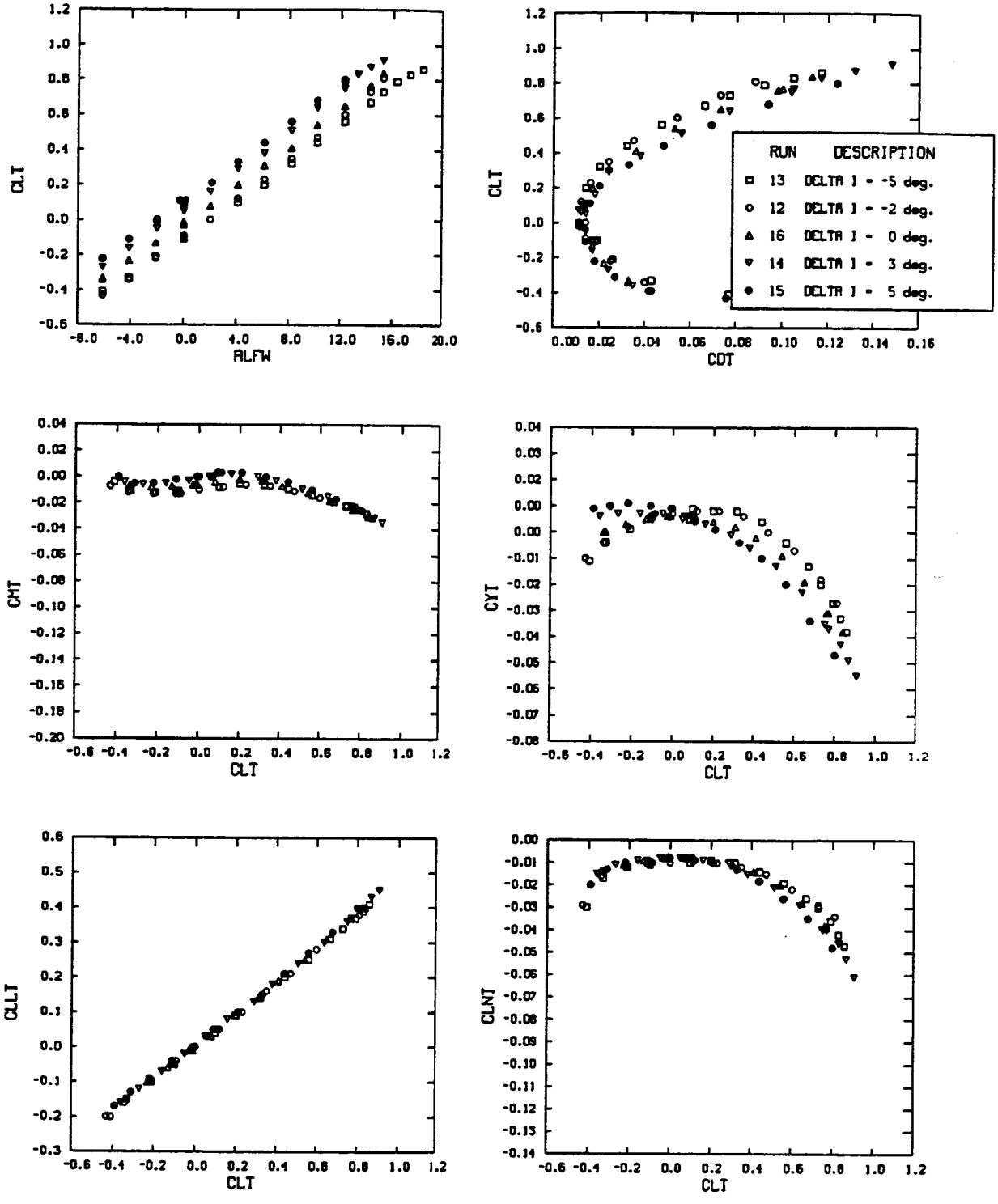
b. Tip Characteristics

Figure 4.- Concluded.



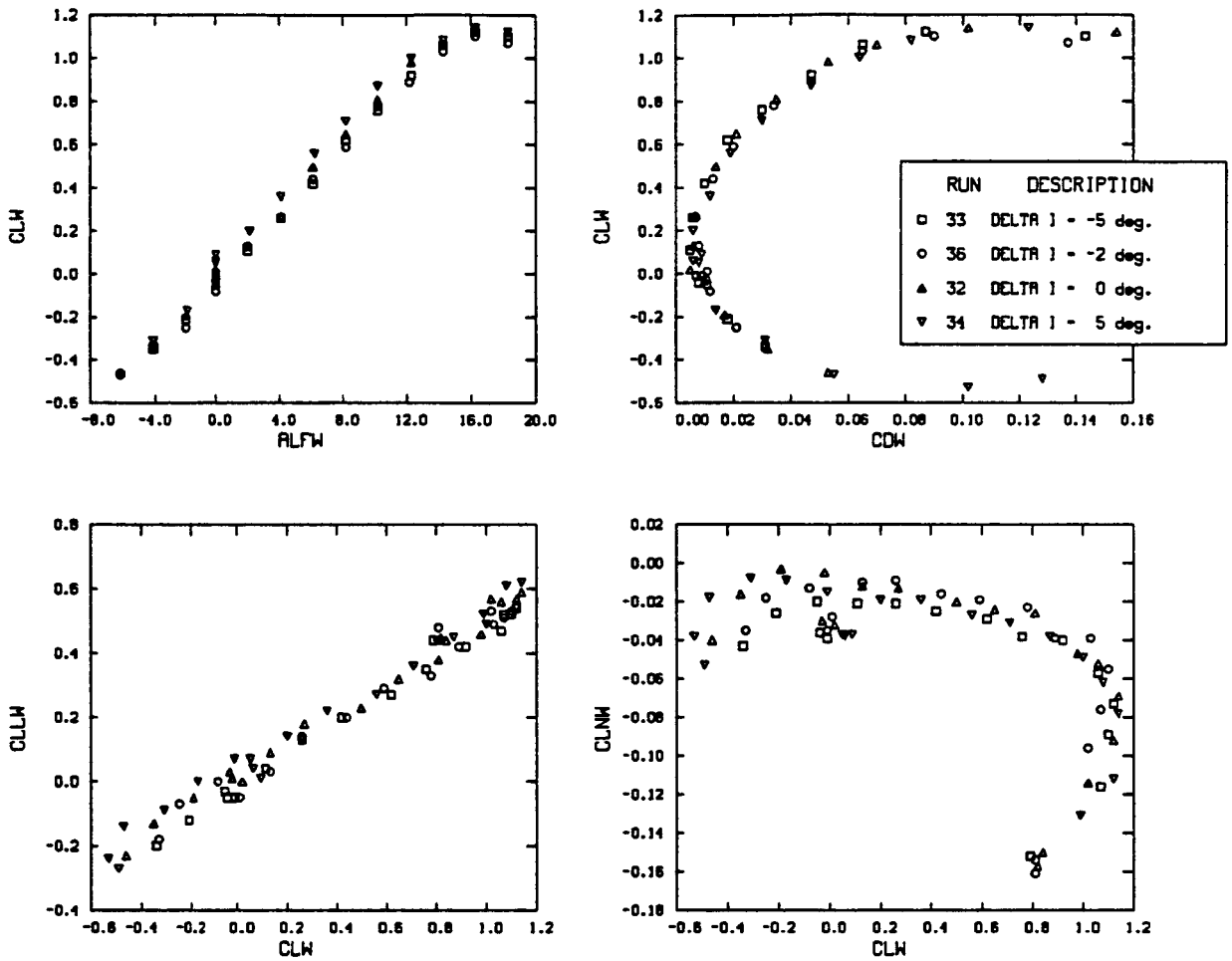
a. Wing Characteristics

Figure 5.- Wing and Tip Aerodynamic Characteristics for Configuration 2: Aspect Ratio 10.19 Wing with a 0.149m Span Rectangular Tip.



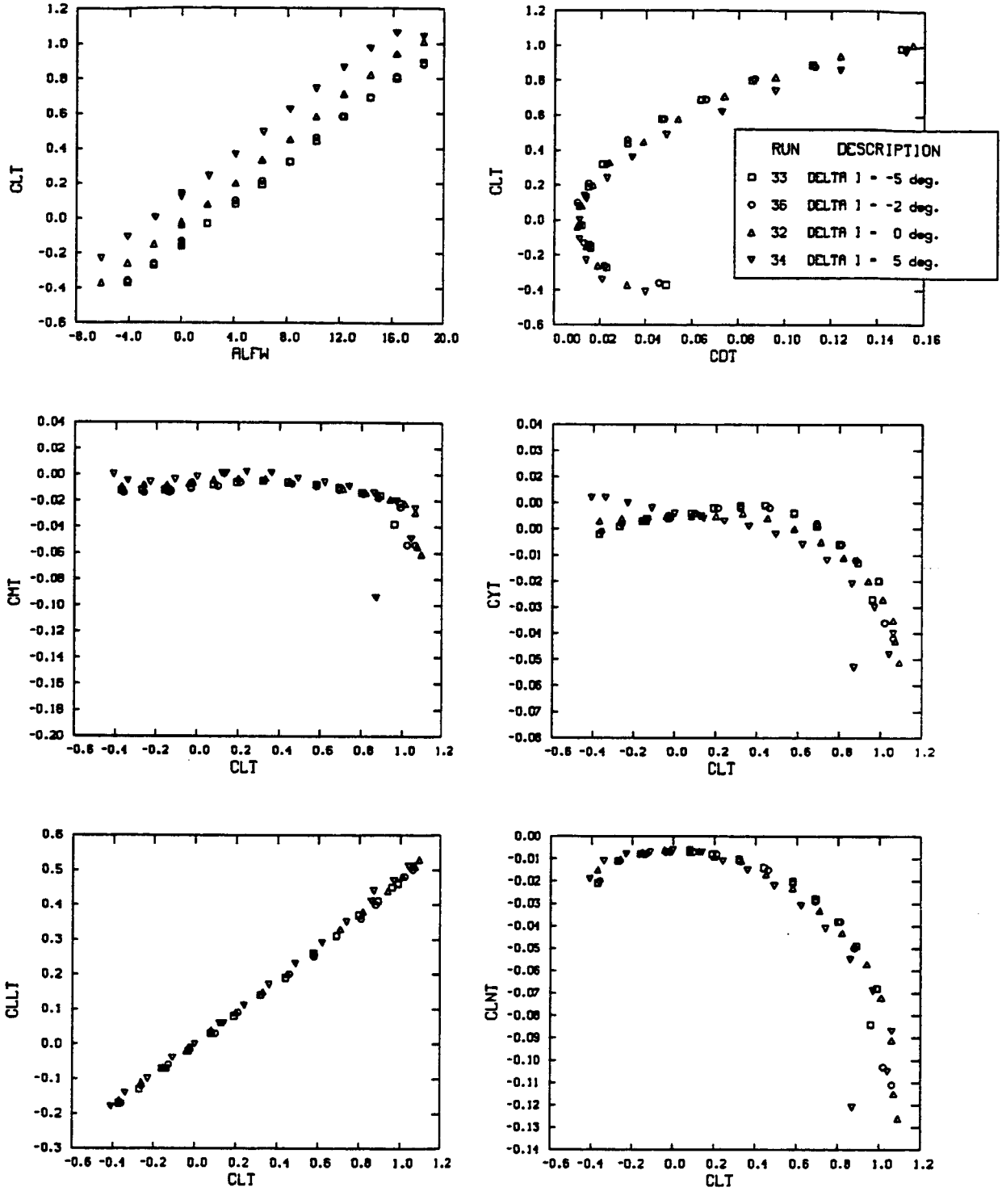
b. Tip Characteristics

Figure 5.- Concluded.



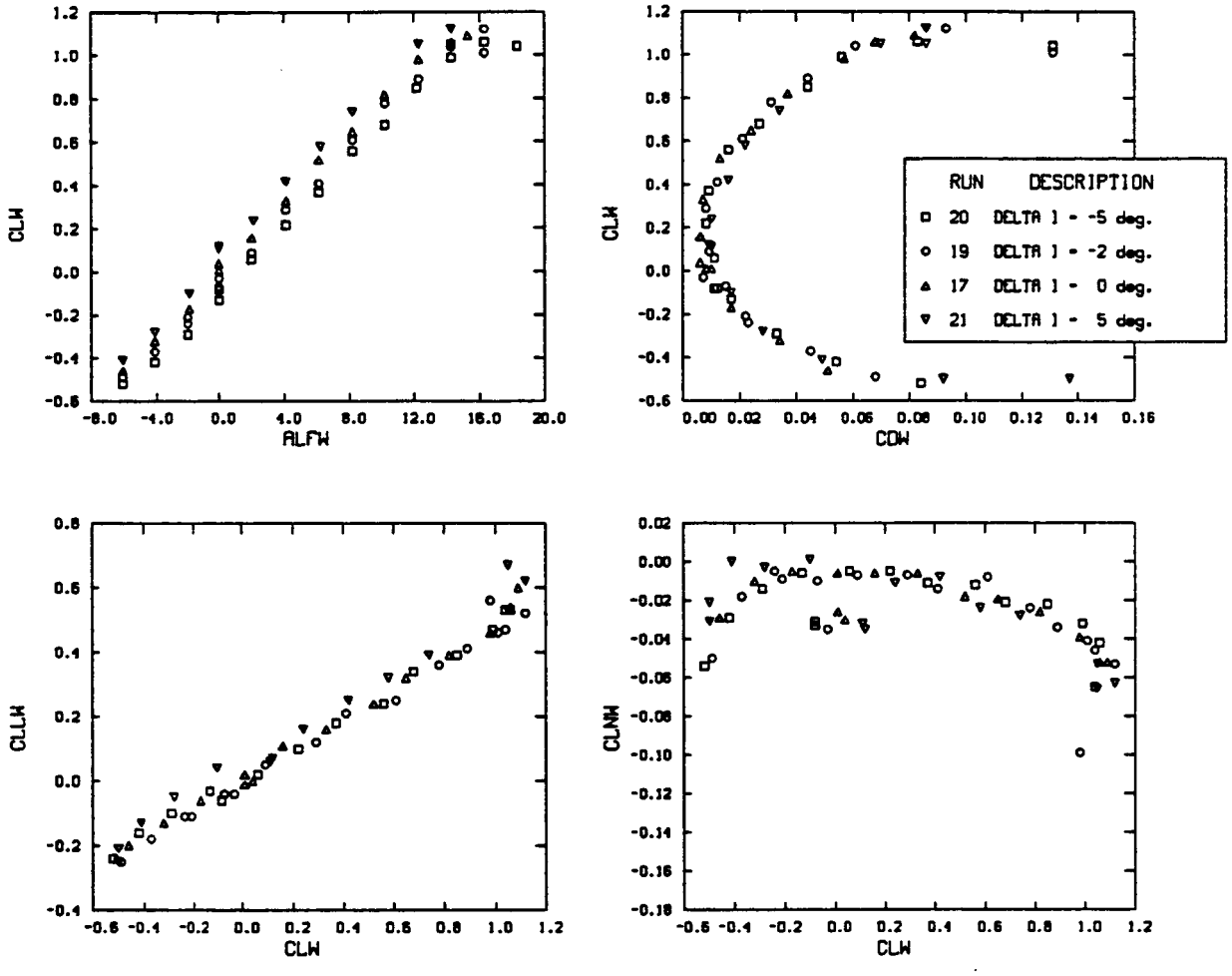
a. Wing Characteristics

Figure 6.- Wing and Tip Aerodynamic Characteristics for Configuration 3: Aspect Ratio 10.02 Wing with a 0.233m Span Rectangular Tip.



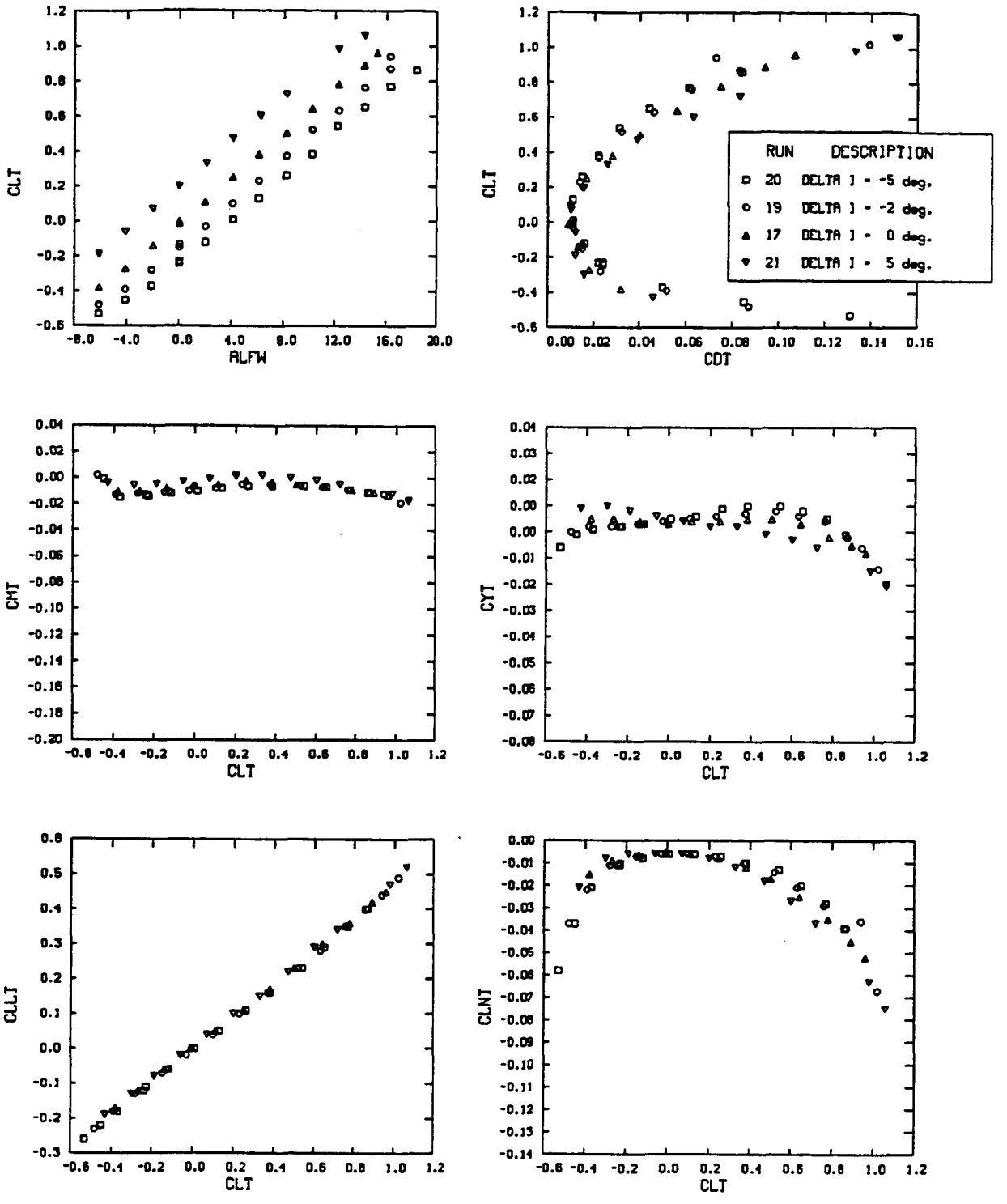
b. Tip Characteristics

Figure 6.- Concluded.



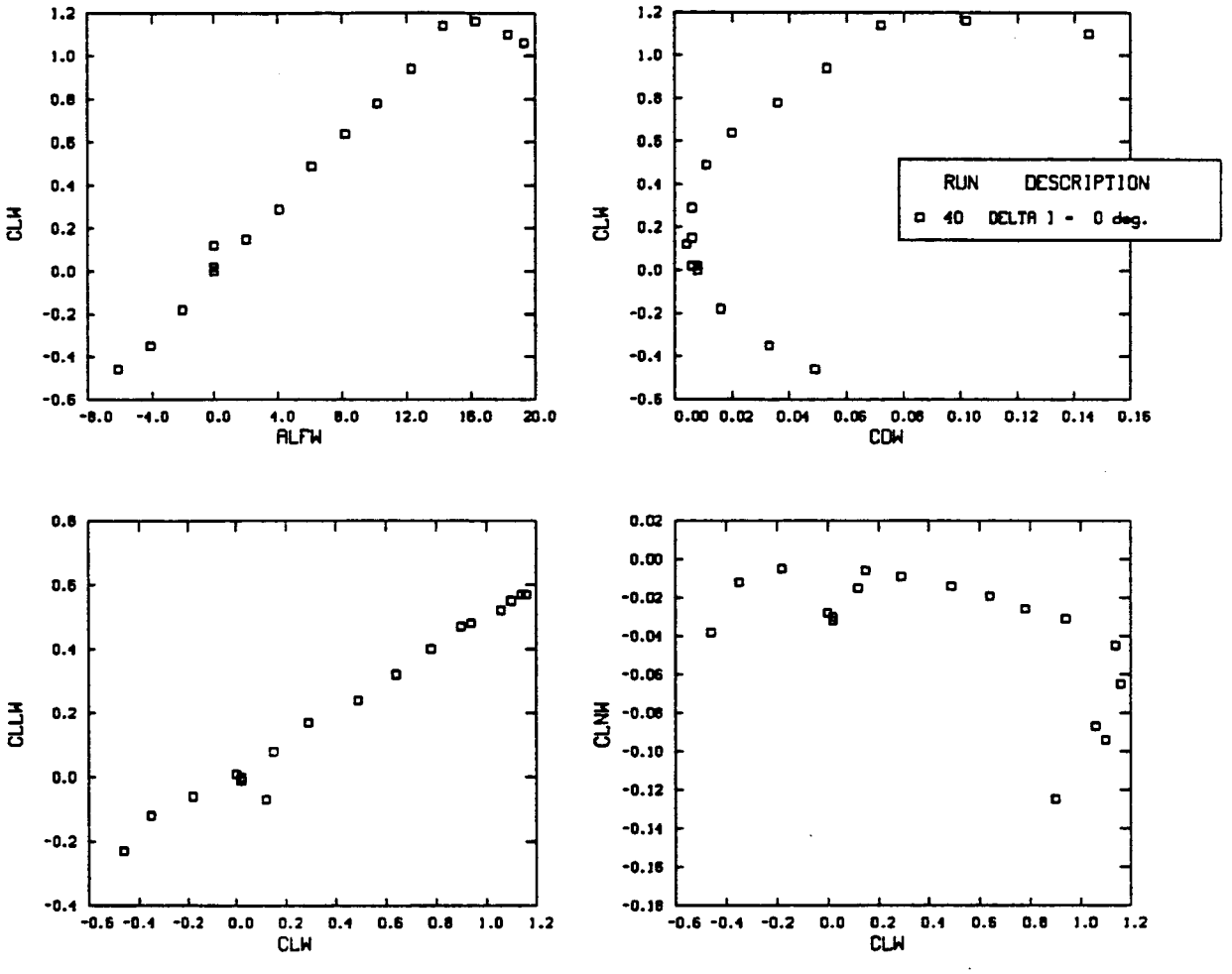
a. Wing Characteristics

Figure 7.- Wing and Tip Aerodynamic Characteristics for Configuration 4: Aspect Ratio 10.19 Wing with a 0.312m Span Rectangular Tip.



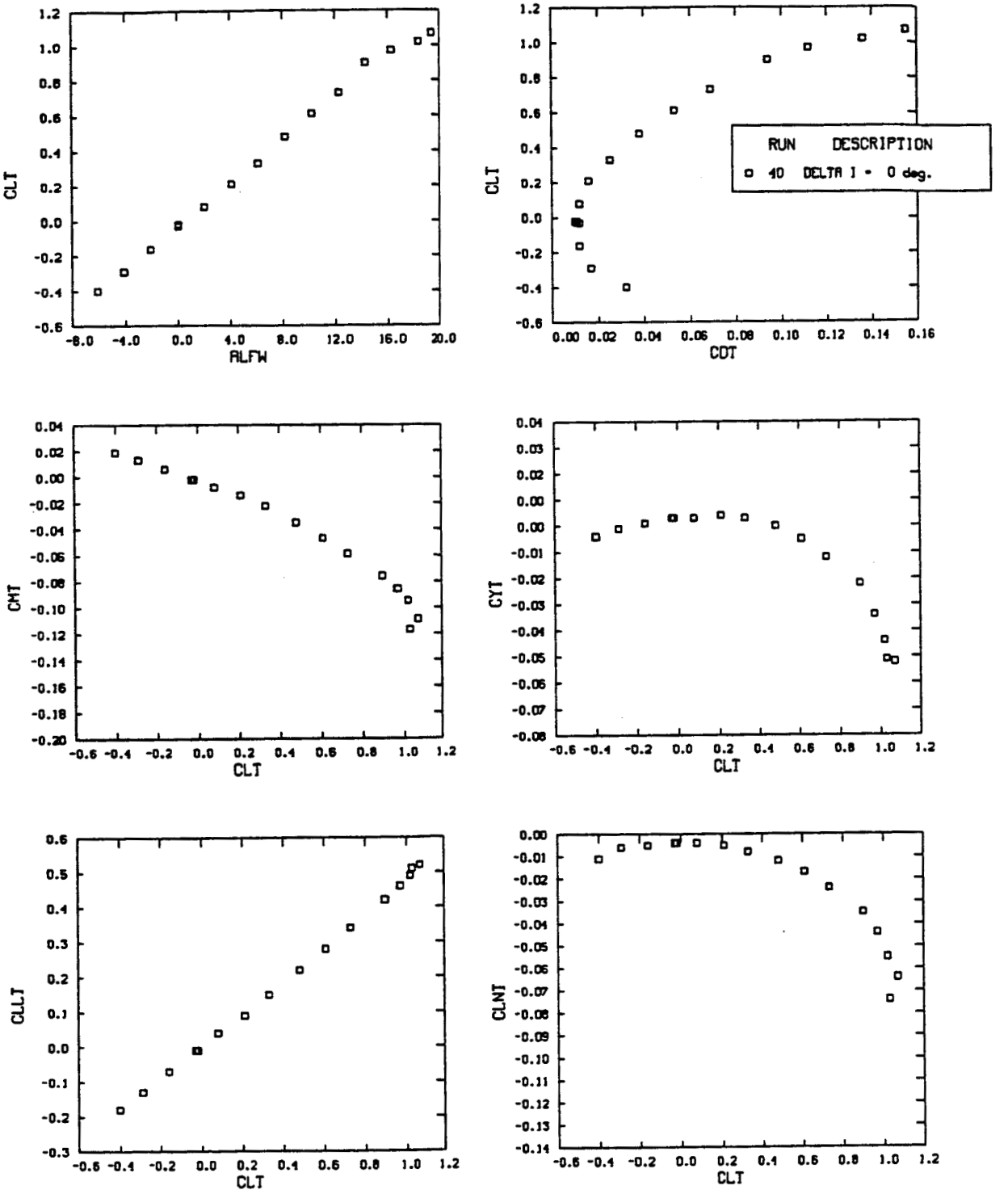
b. Tip Characteristics

Figure 7.- Concluded.



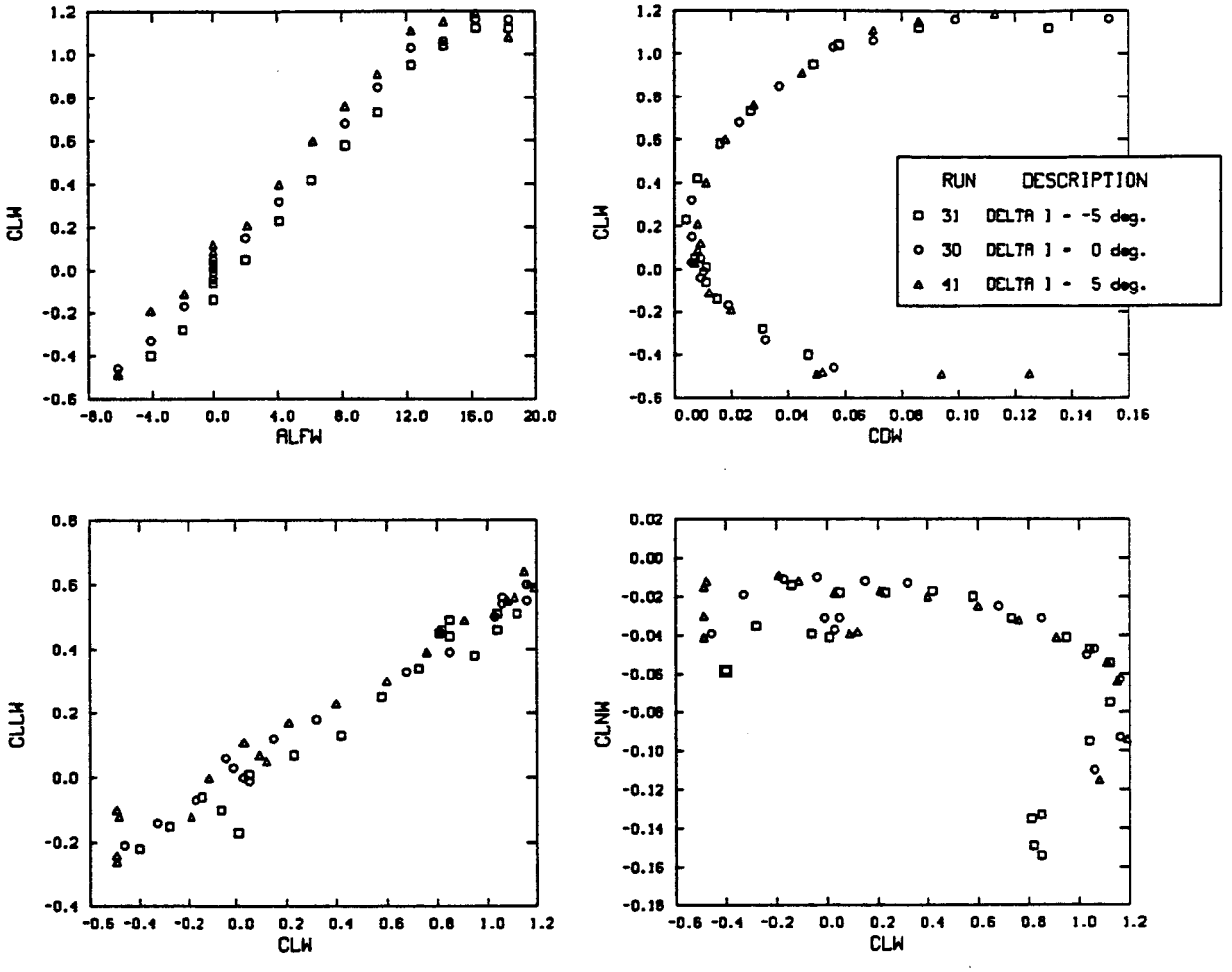
a. Wing Characteristics

Figure 8.- Wing and Tip Aerodynamic Characteristics for Configuration 5: Aspect Ratio 10.19 Wing with a 0.312m Span, 20 deg. Swept, Rectangular Tip.



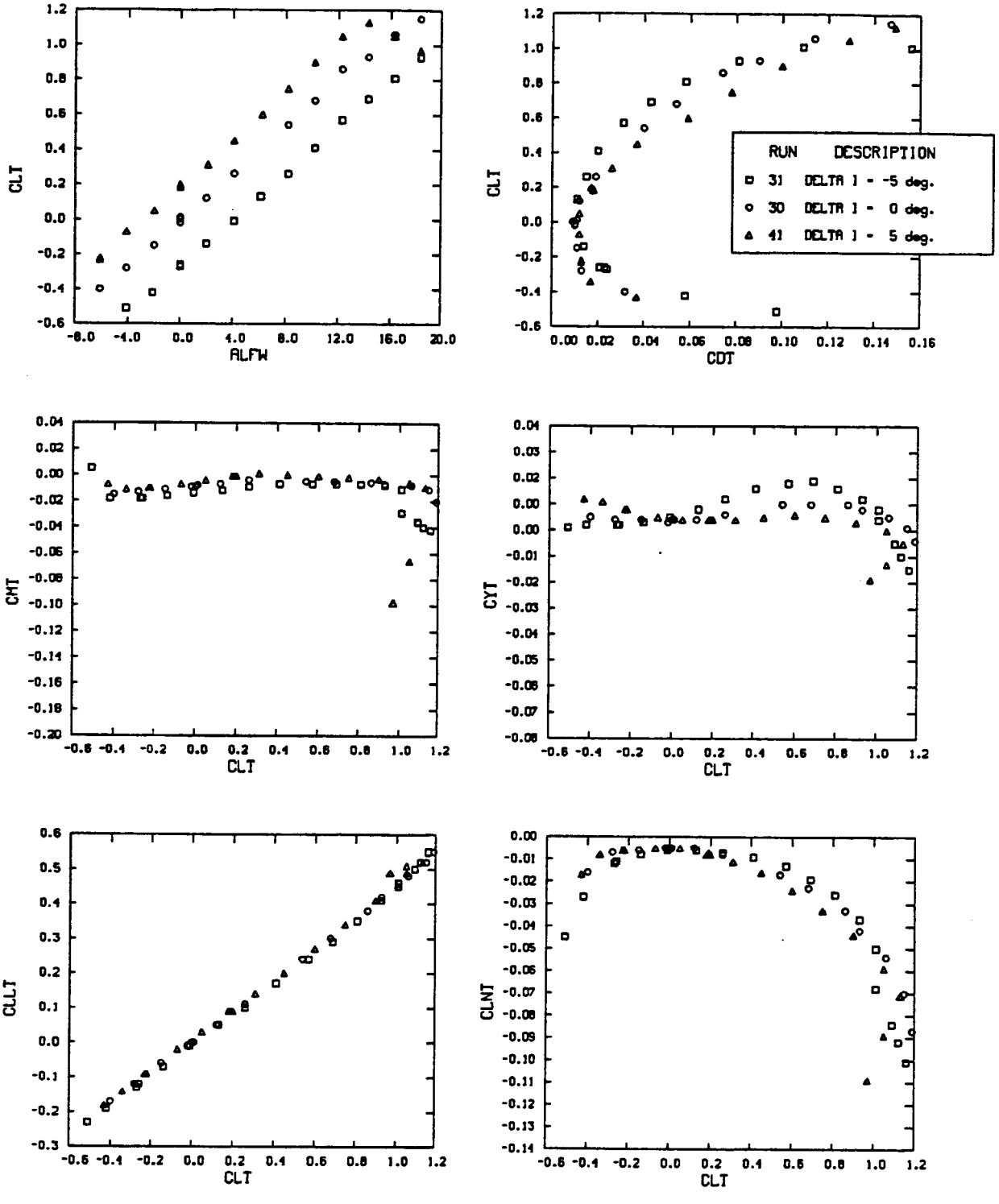
b. Tip Characteristics

Figure 8.- Concluded.



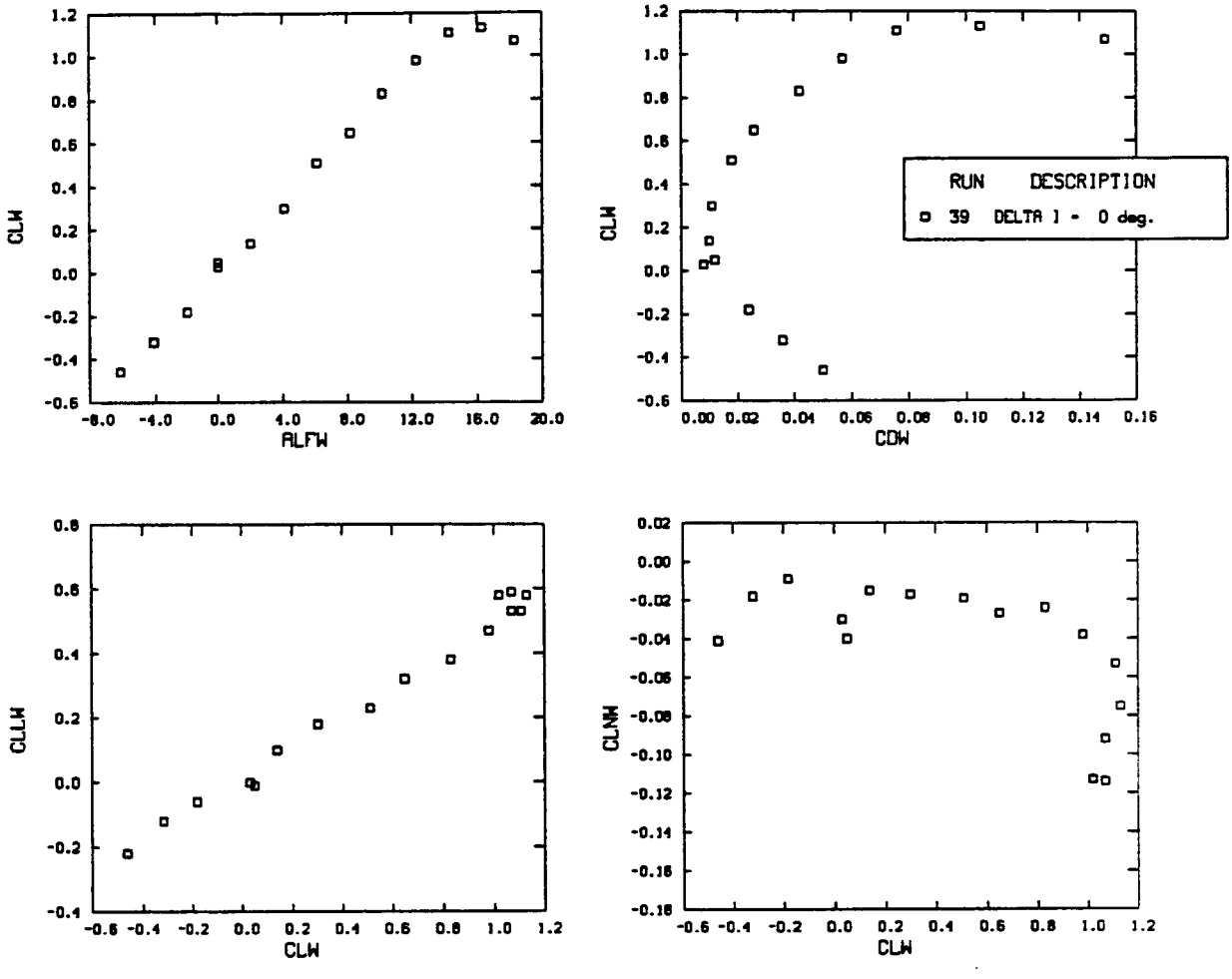
a. Wing Characteristics

Figure 9.- Wing and Tip Aerodynamic Characteristics for Configuration 6: Aspect Ratio 10.51 Wing with a 0.312m Span, 0.6 Tapered Tip.



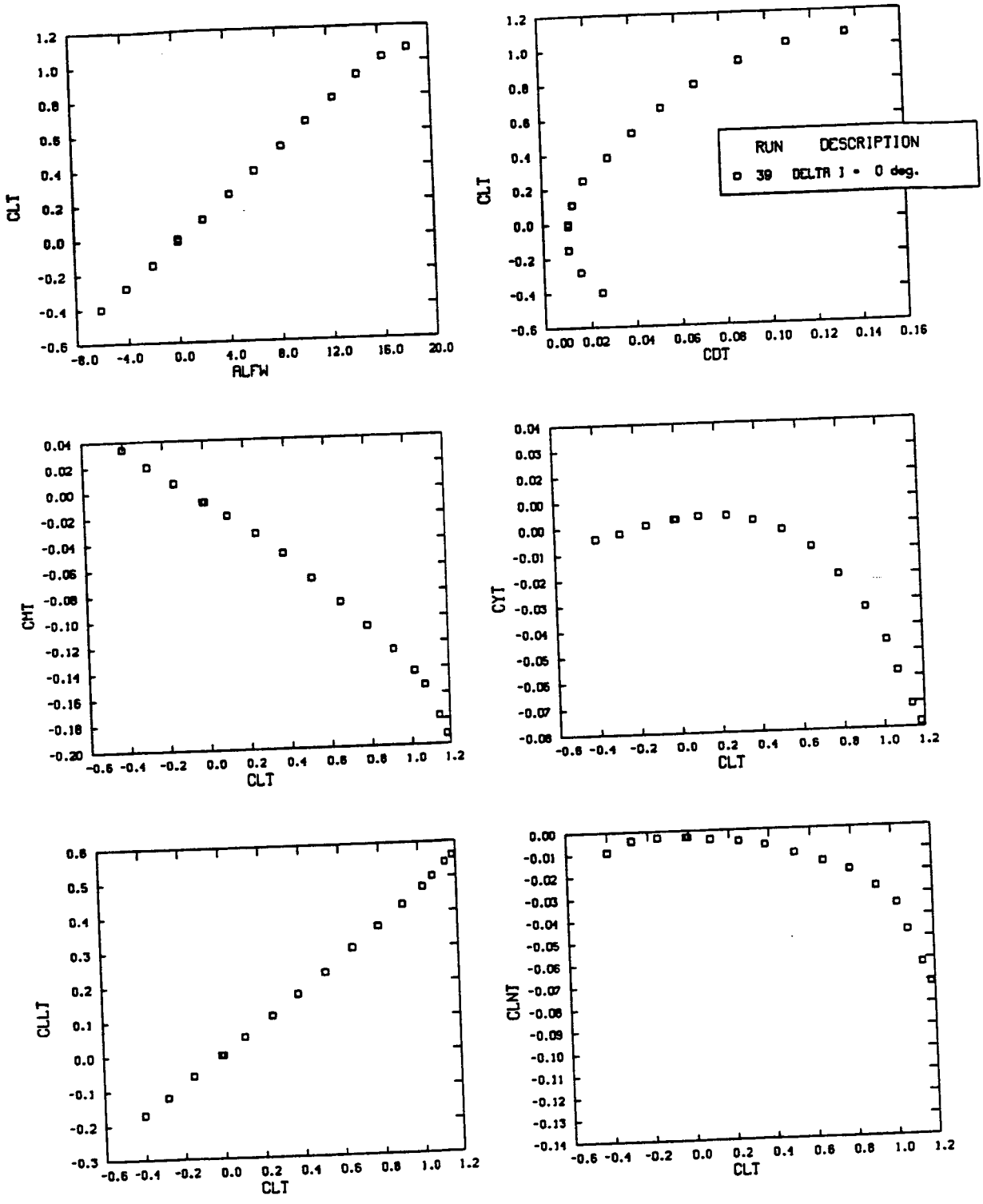
b. Tip Characteristics

Figure 9.- Concluded.



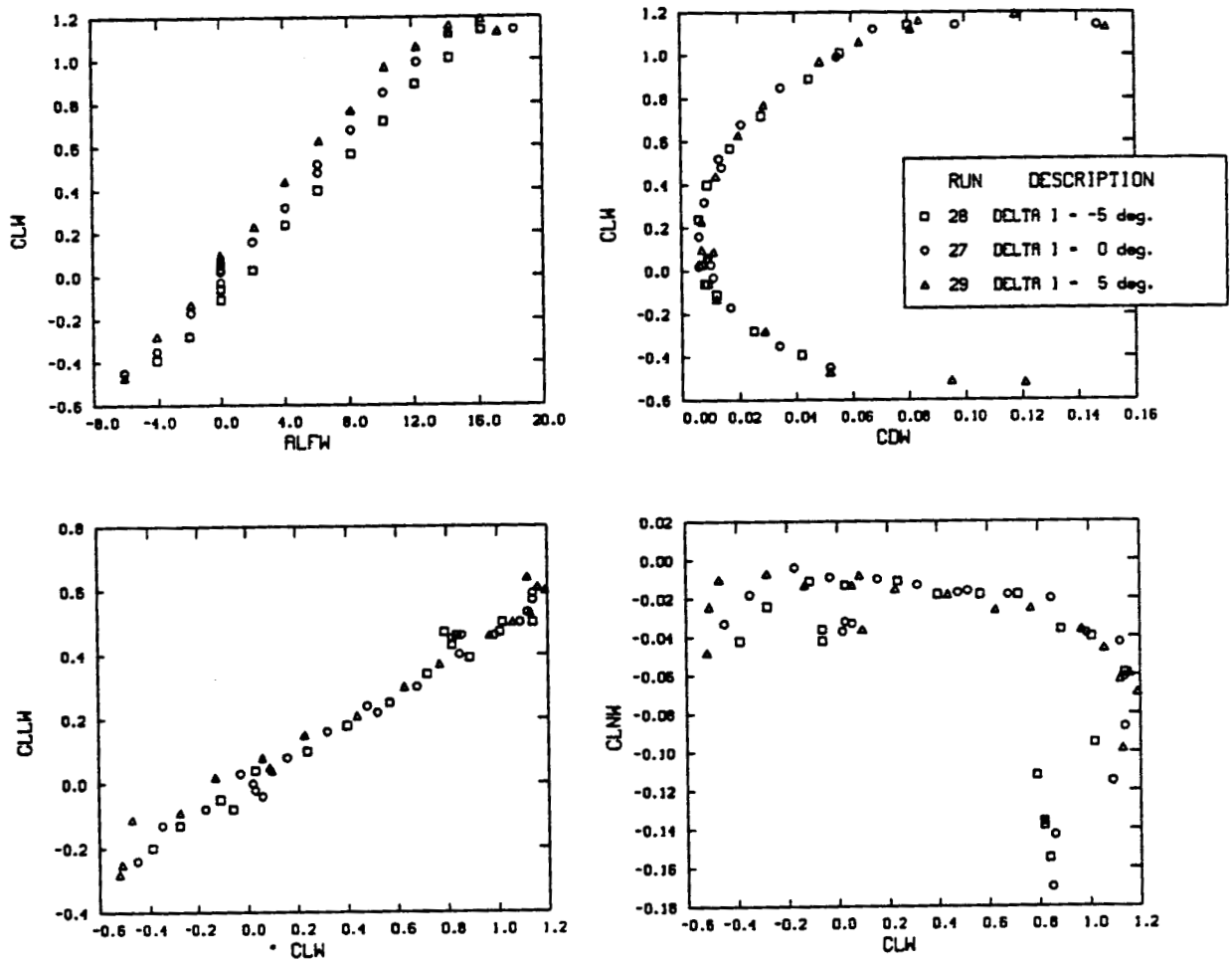
a. Wing Characteristics

Figure 10.- Wing and Tip Aerodynamic Characteristics for Configuration 7: Aspect Ratio 10.51 Wing with a 0.312m Span, 0.6 Tapered, 30 deg. Swept Tip.



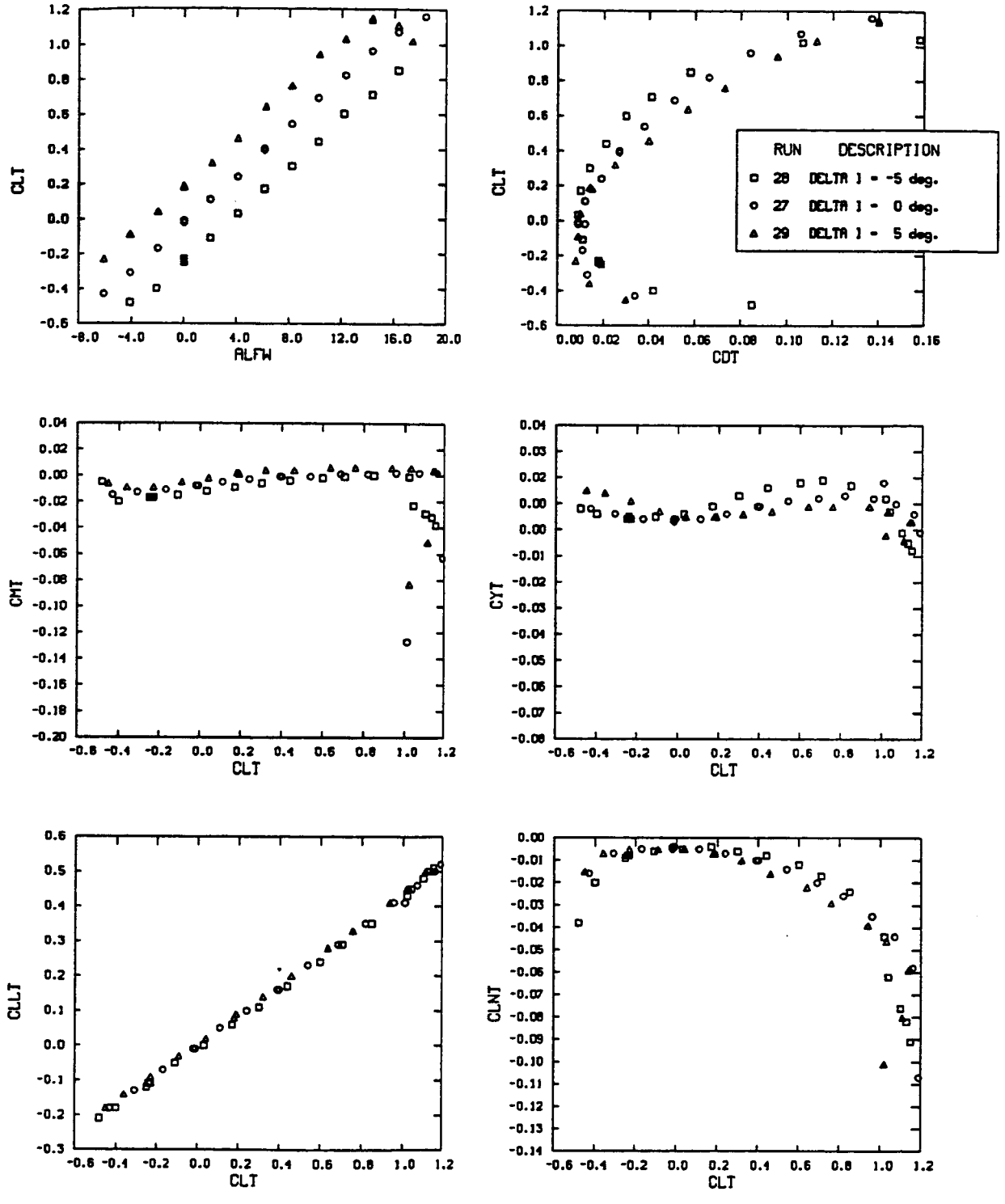
b. Tip Characteristics

Figure 10.- Concluded.



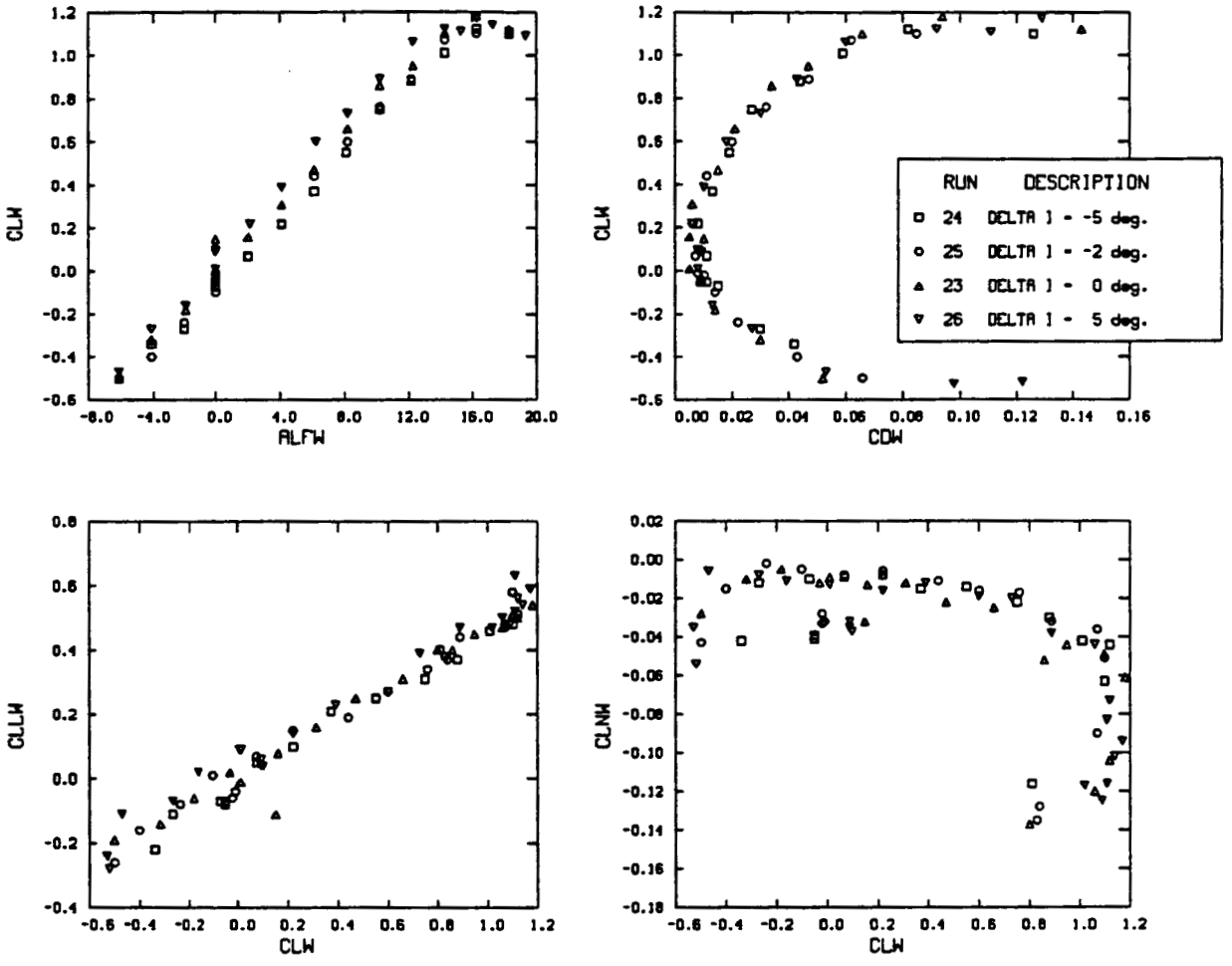
a. Wing Characteristics

Figure 11.- Wing and Tip Aerodynamic Characteristics for Configuration 8: Aspect Ratio 10.77 Wing with a 0.312m Span, 0.3 Tapered Tip.



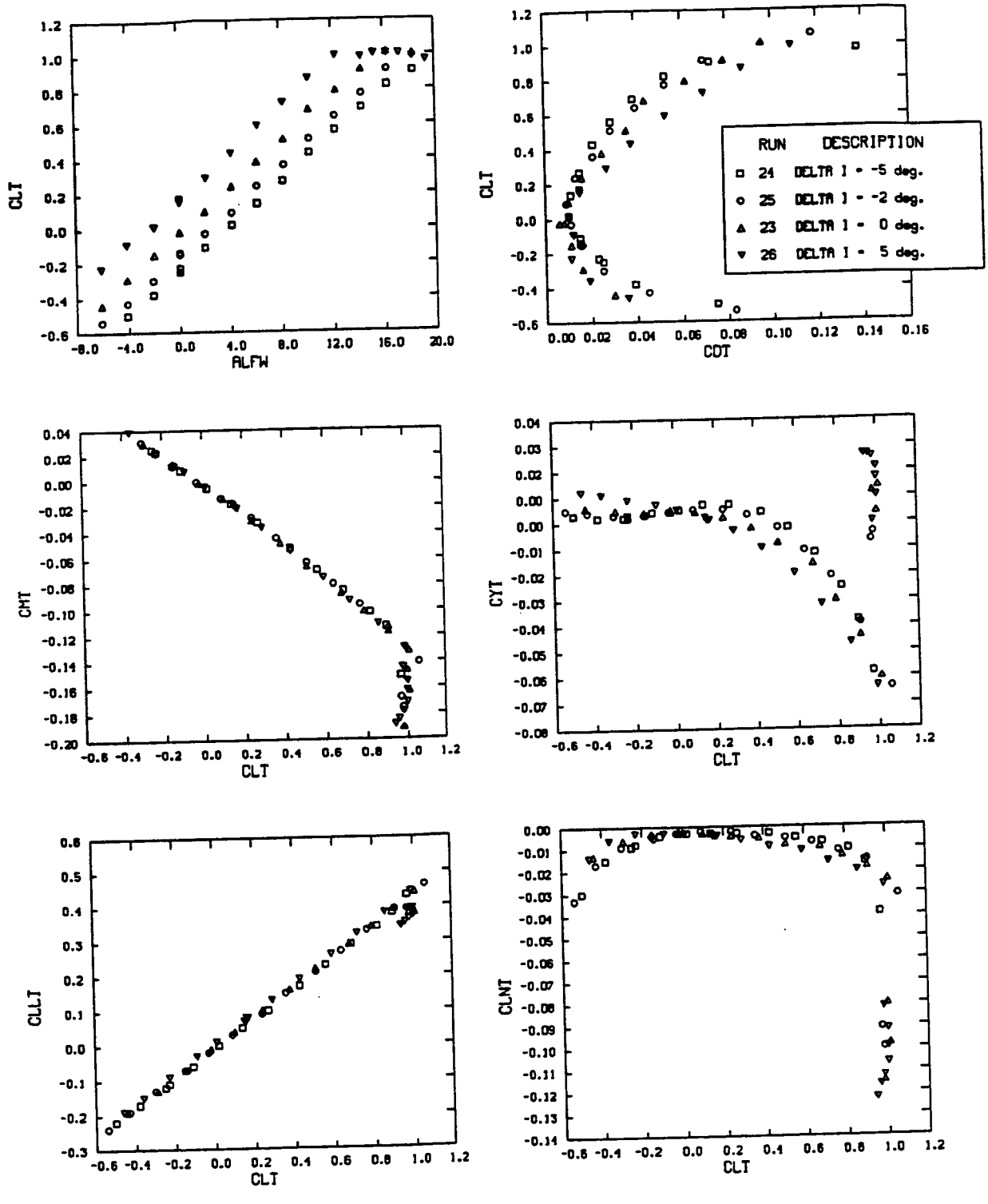
b. Tip Characteristics

Figure 11.- Concluded.



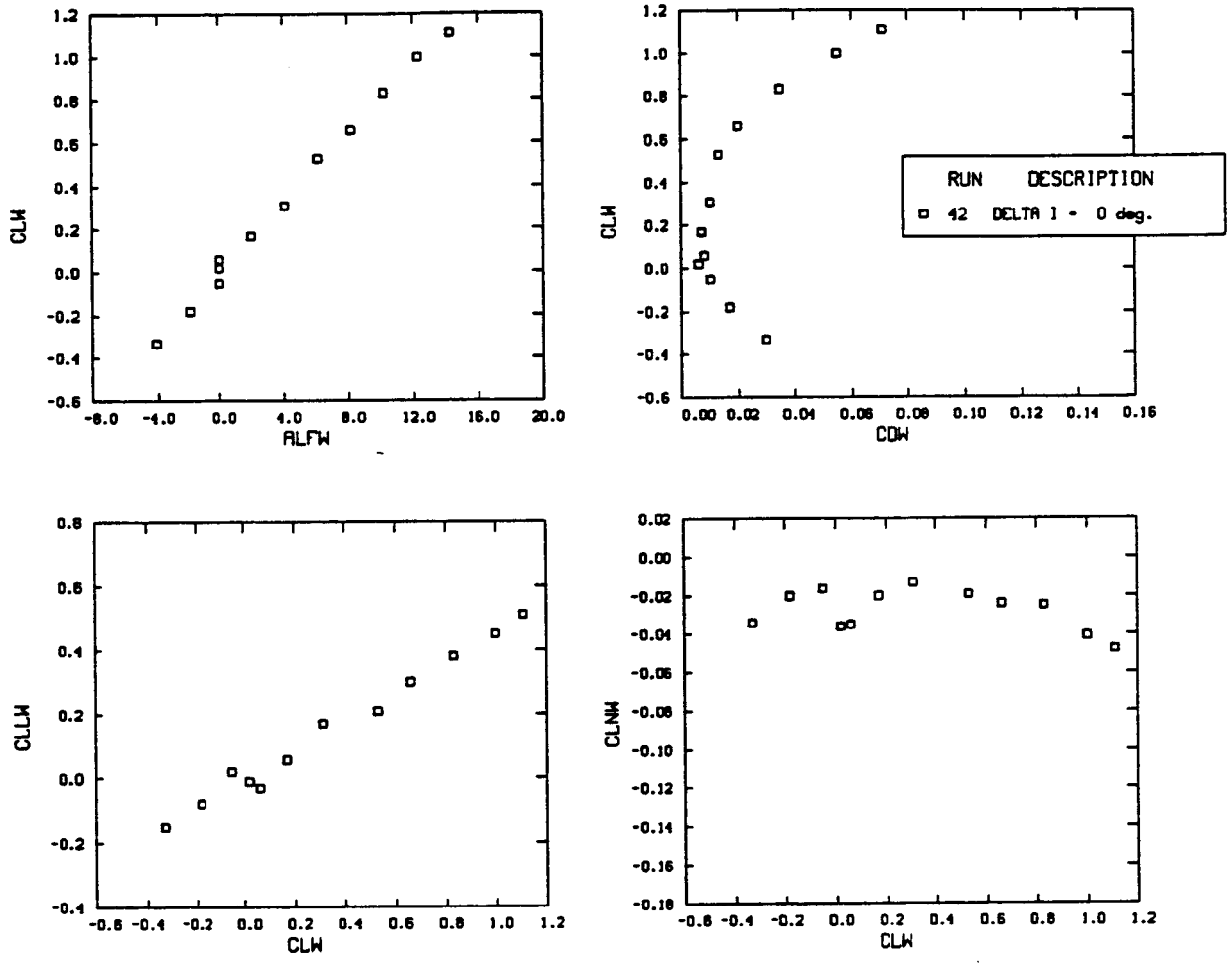
a. Wing Characteristics

Figure 12.- Wing and Tip Aerodynamic Characteristics for Configuration 9: Aspect Ratio 10.77 Wing with a 0.312m Span, 0.3 Tapered 35 deg. Swept Tip.



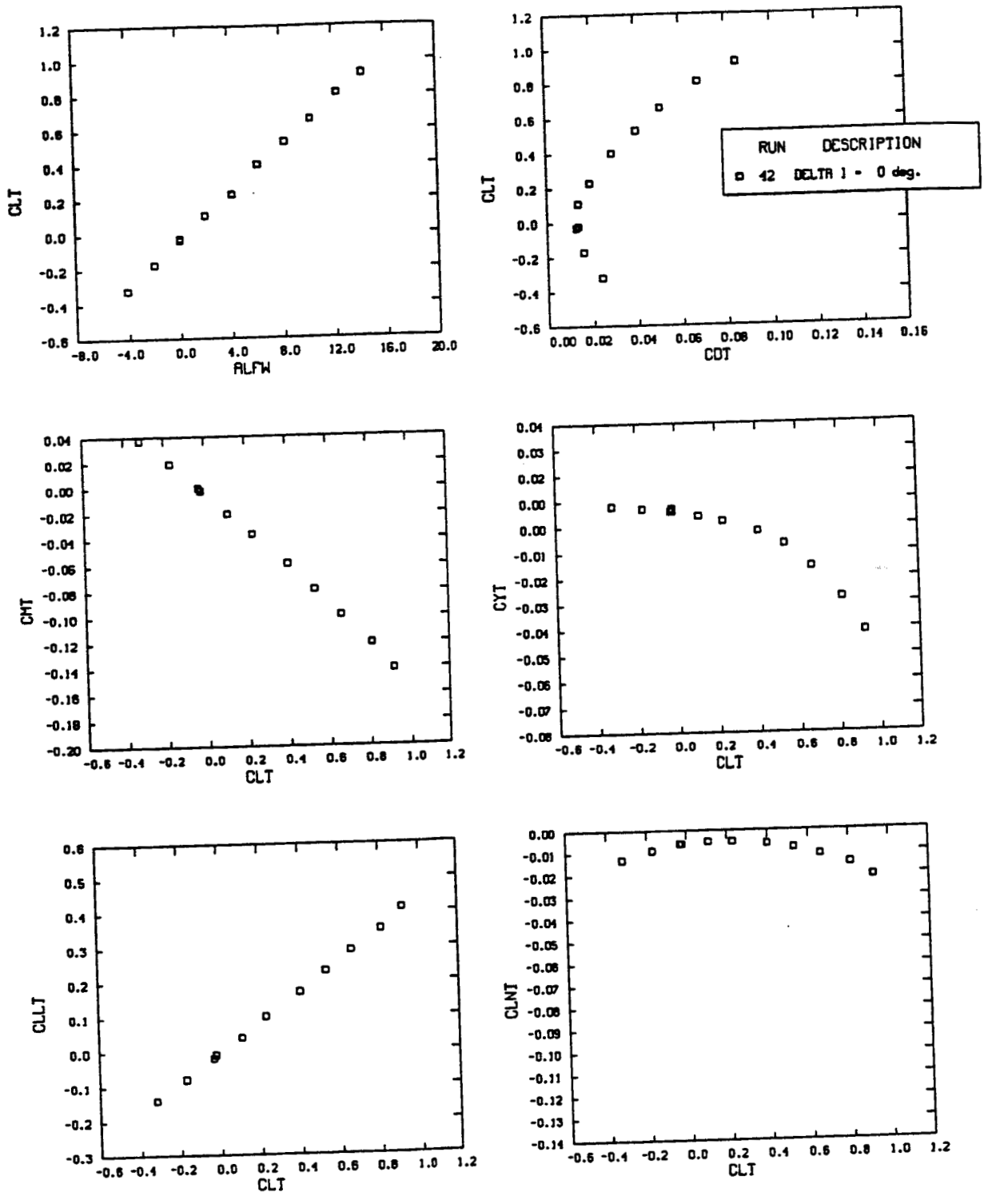
b. Tip Characteristics

Figure 12.- Concluded.



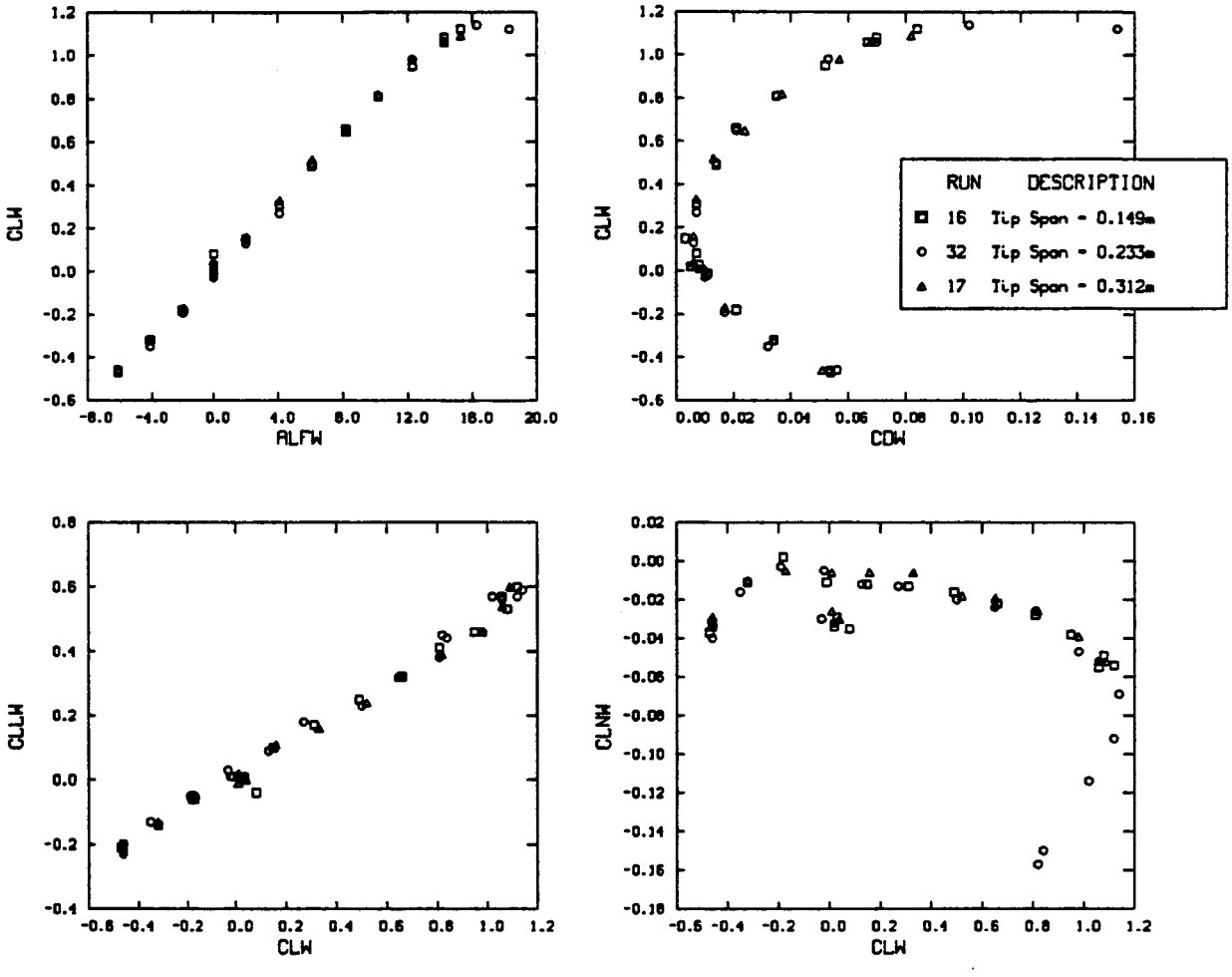
a. Wing Characteristics

Figure 13.- Wing and Tip Aerodynamic Characteristics for Configuration 10: Aspect Ratio 10.77 Wing with a 0.312m Span, 0.3 Tapered, 35 deg. Swept Tip with a 20 deg. Tip Leading Edge Droop.



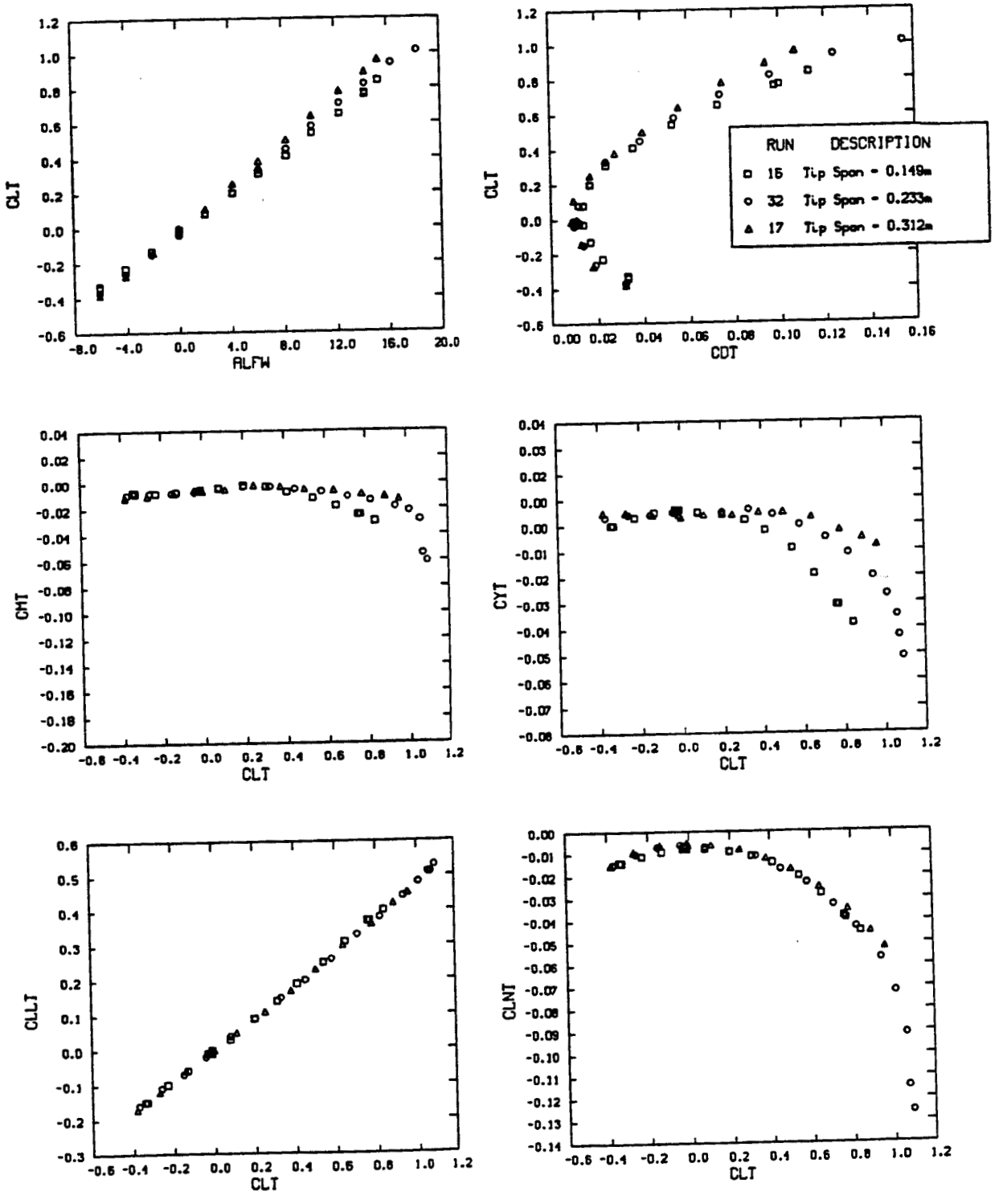
b. Tip Characteristics

Figure 13.- Concluded.



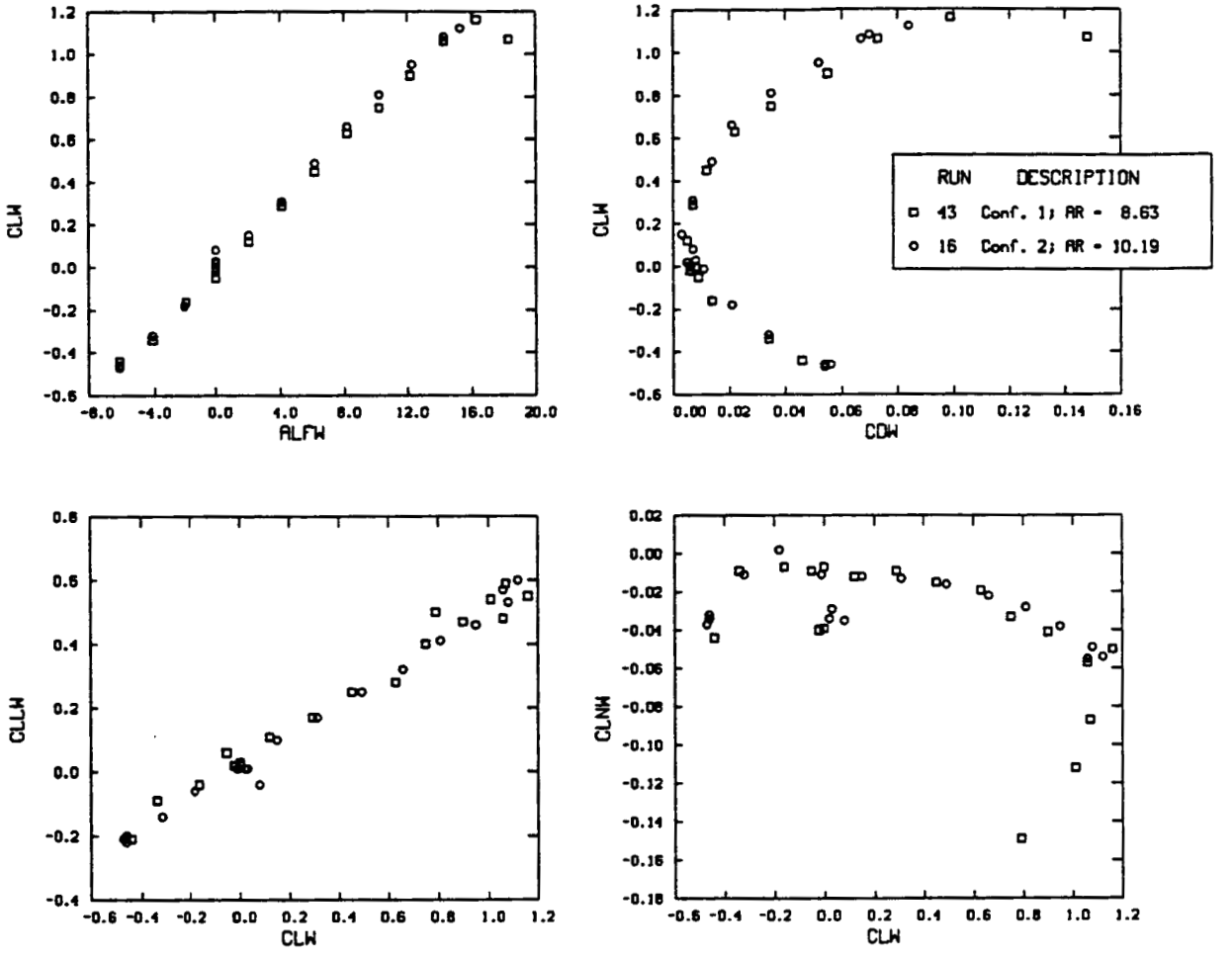
a. Wing Characteristics

Figure 14.- Effect of Metric Tip Span on the Wing and Tip Aerodynamic Characteristics of an Aspect Ratio 10.19 Wing (DELTA I - 0 deg.).



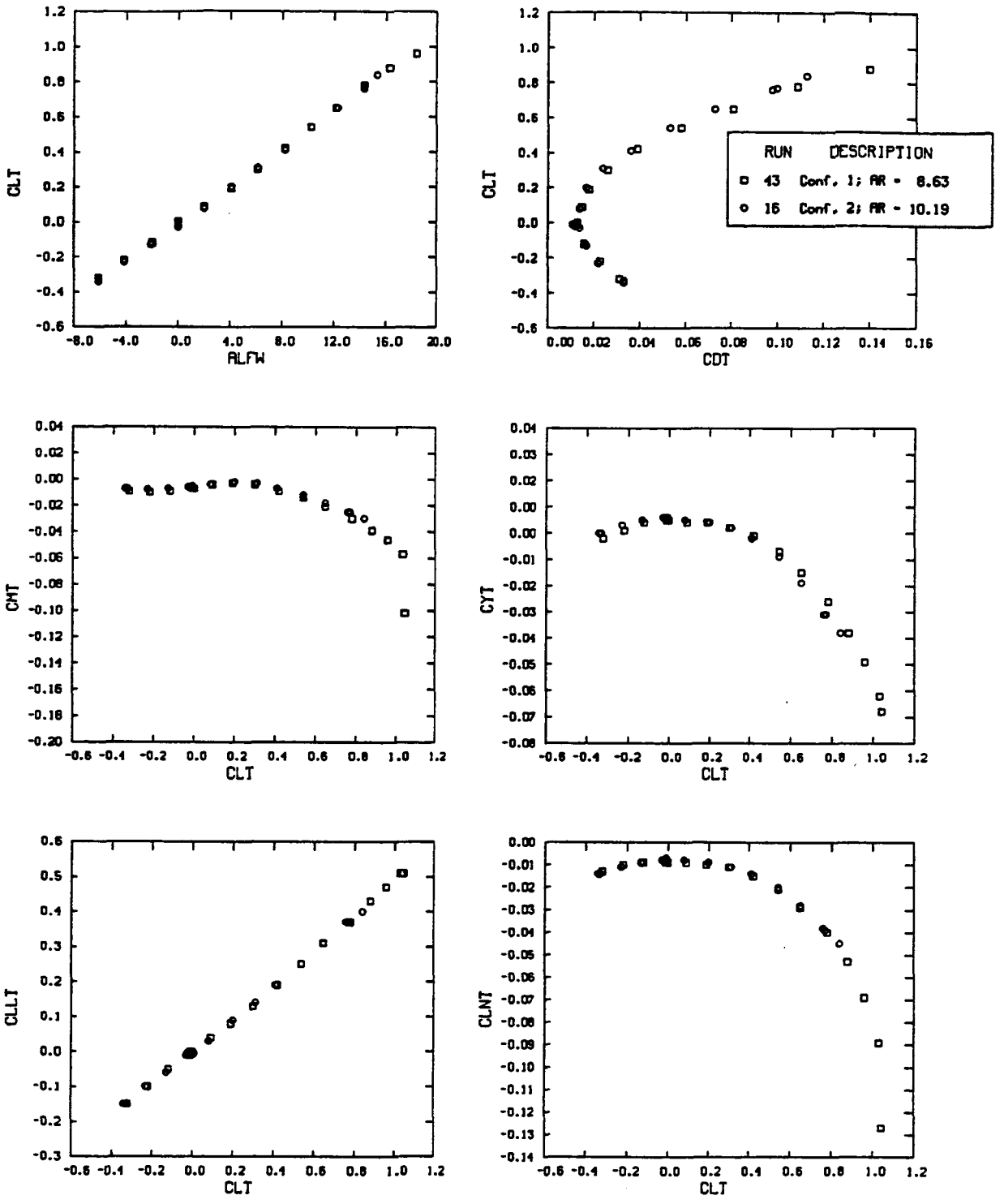
b. Tip Characteristics

Figure 14.- Concluded.



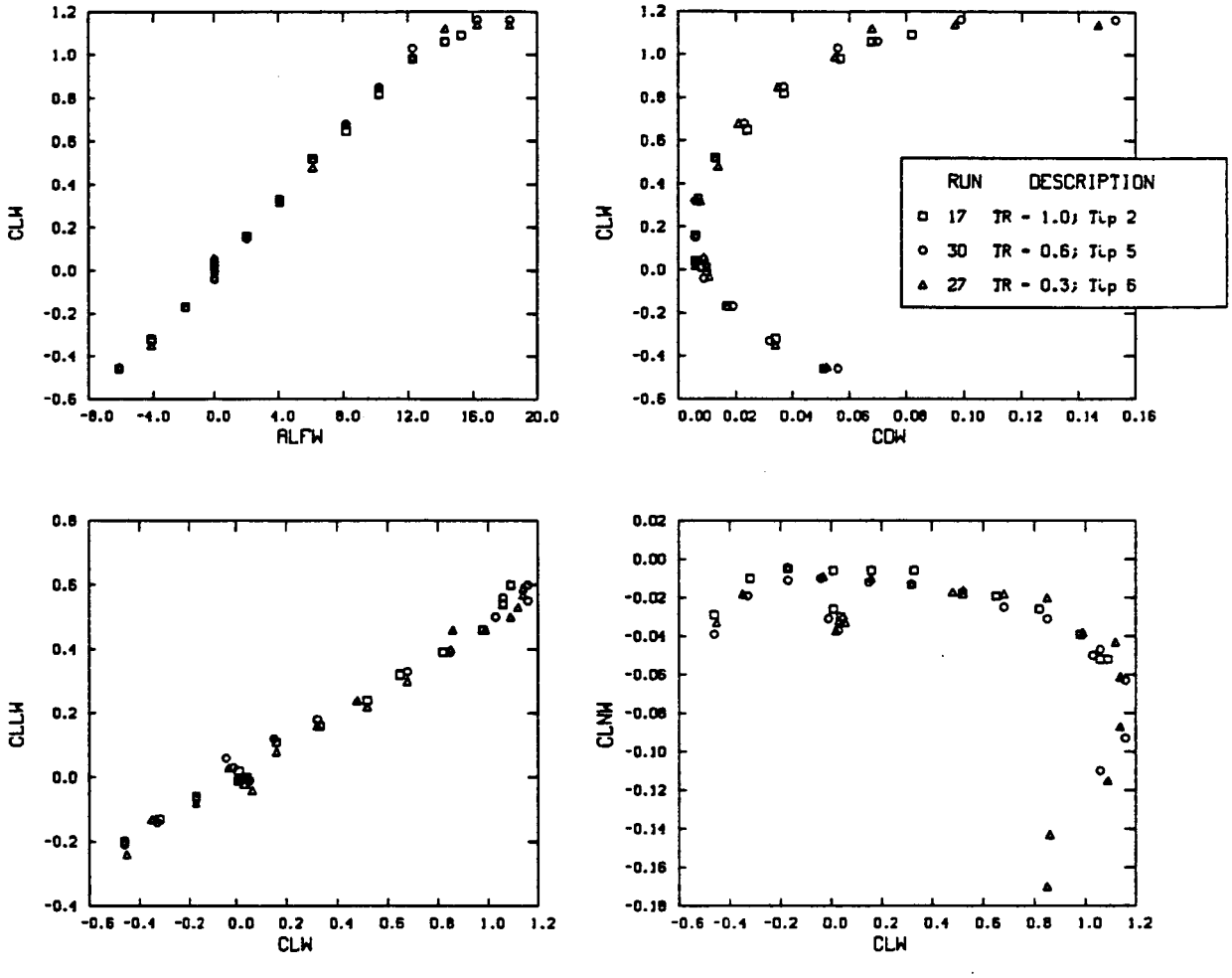
a. Wing Characteristics

Figure 15.- Effect of Aspect Ratio on a Semi-Span Wing with a 0.149m Span Rectangular Tip (DELTA 1 = 0 deg.).



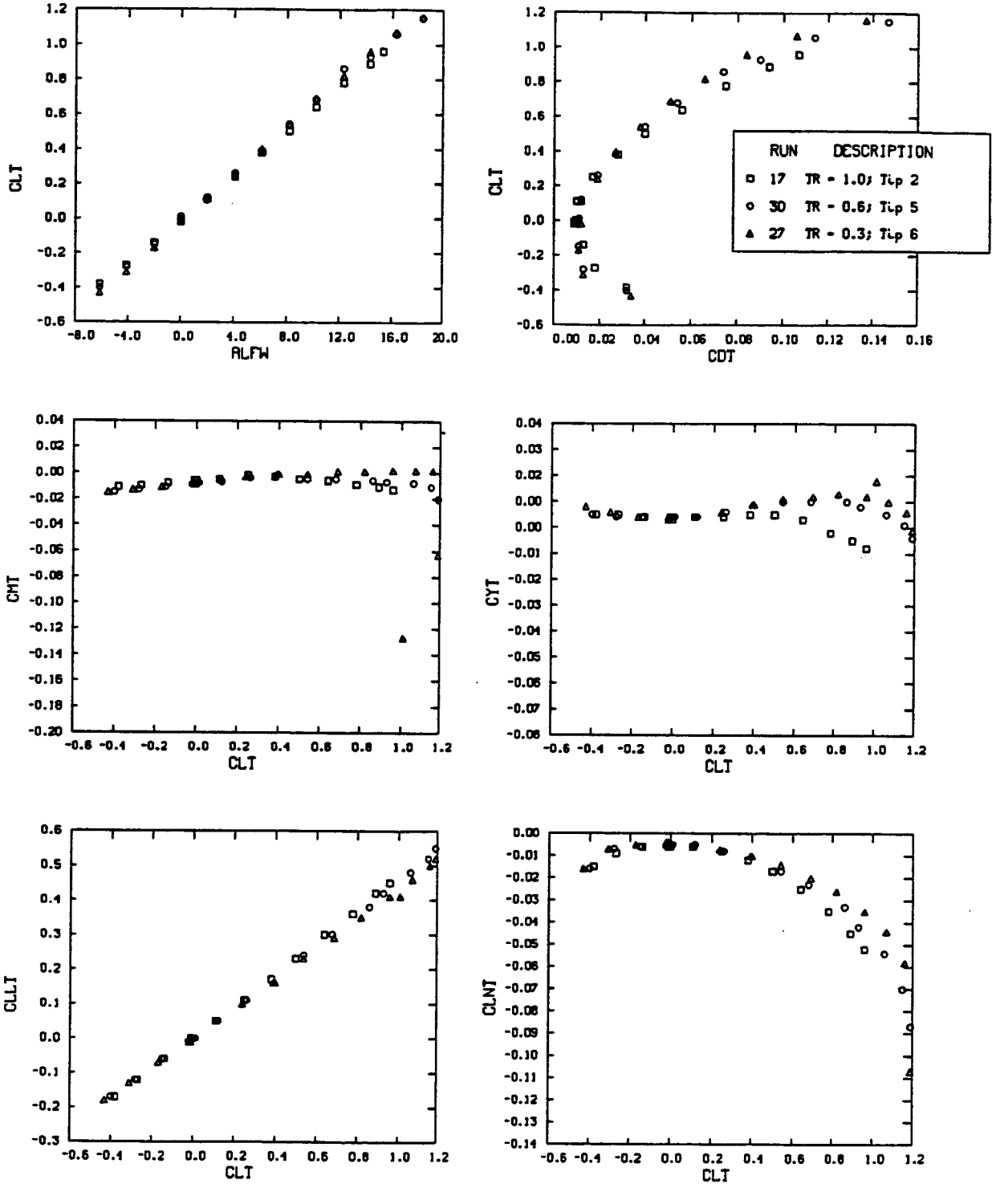
b. Tip Characteristics

Figure 15.- Concluded.



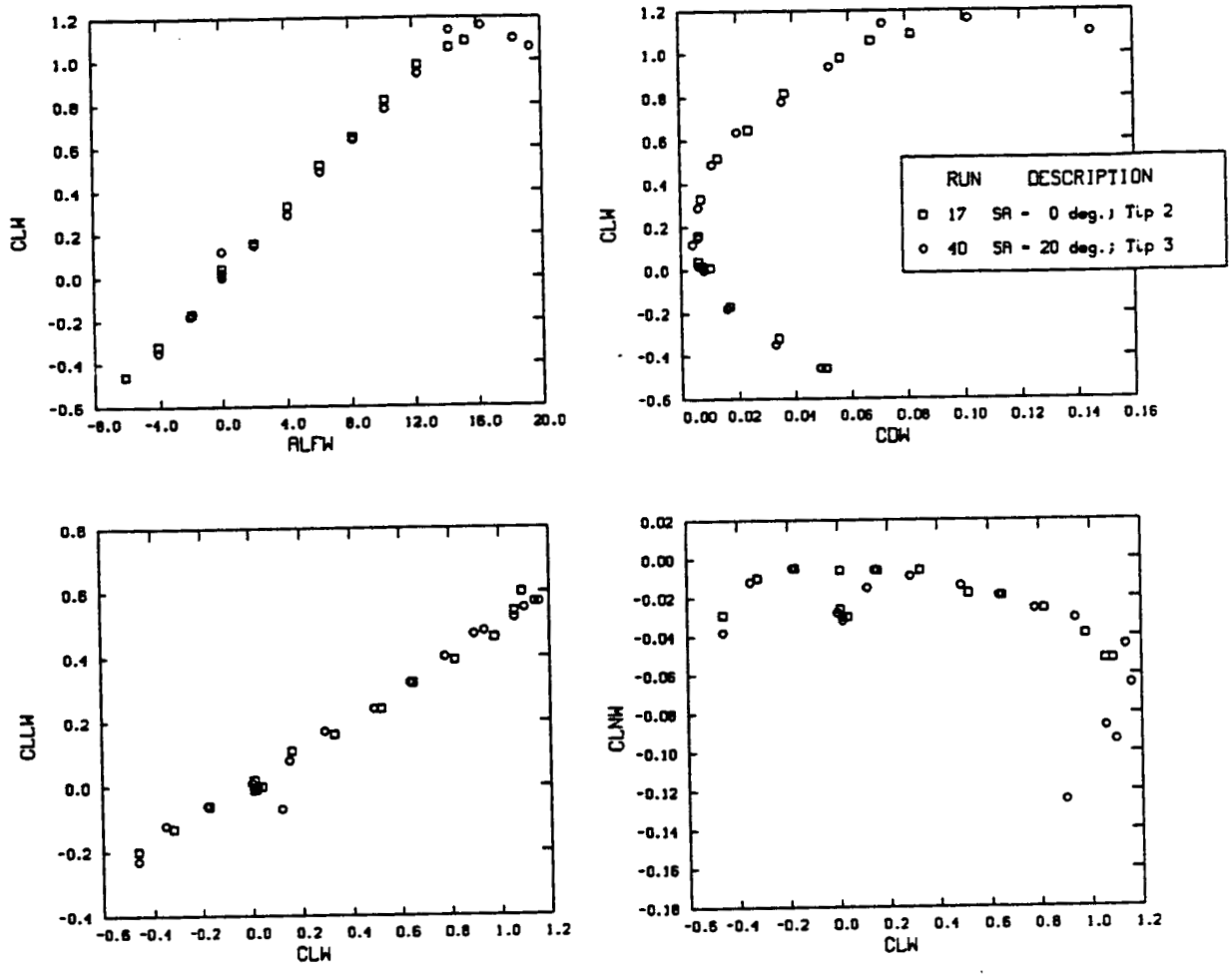
a. Wing Characteristics

Figure 16.- Effect of Straight Taper on the Wing and Tip Aerodynamic Characteristics of an Aspect Ratio 10.5 Wing with a 0.312m Span Tip (DELTA I = 0 deg).



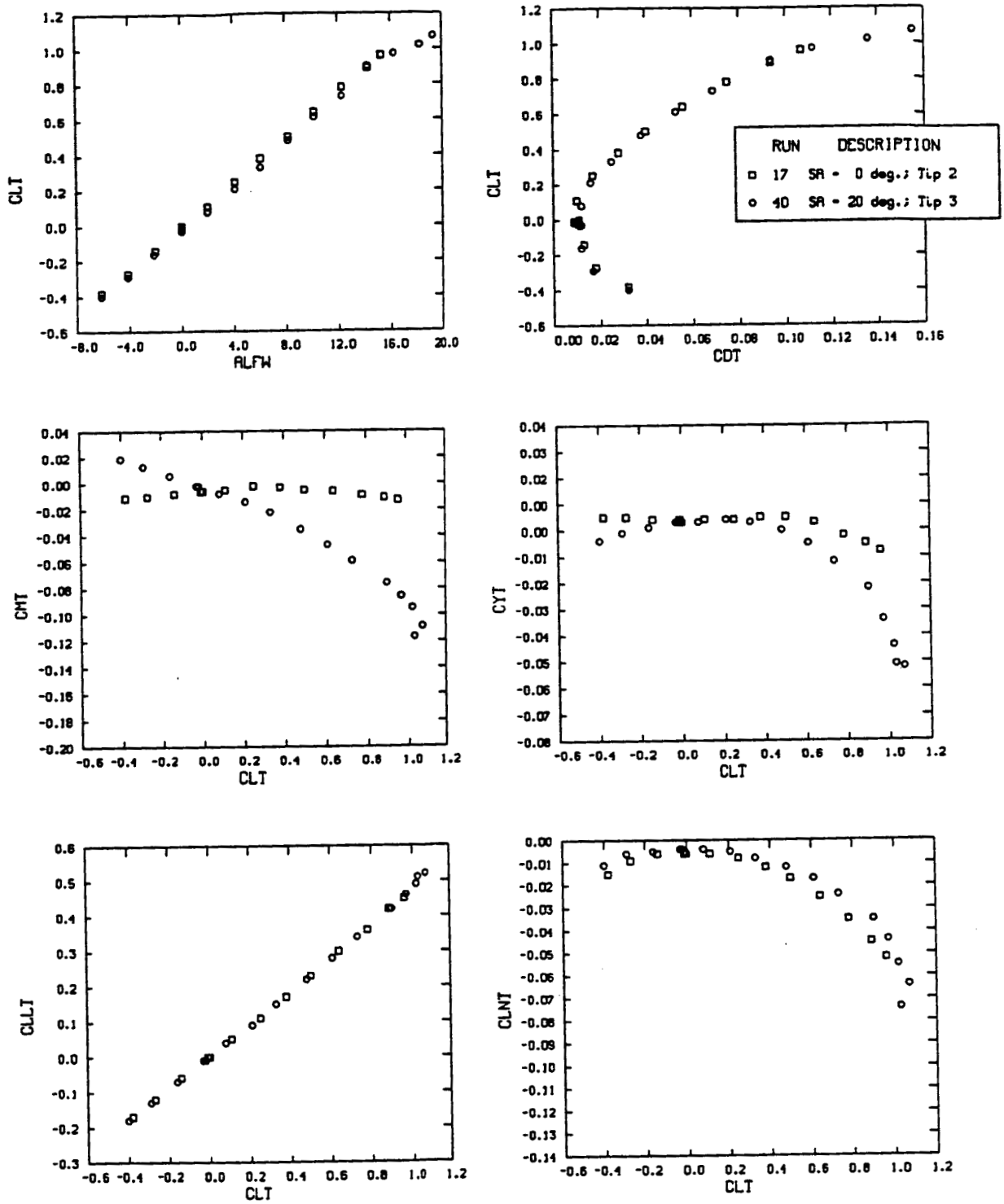
b. Tip Characteristics

Figure 16.- Concluded.



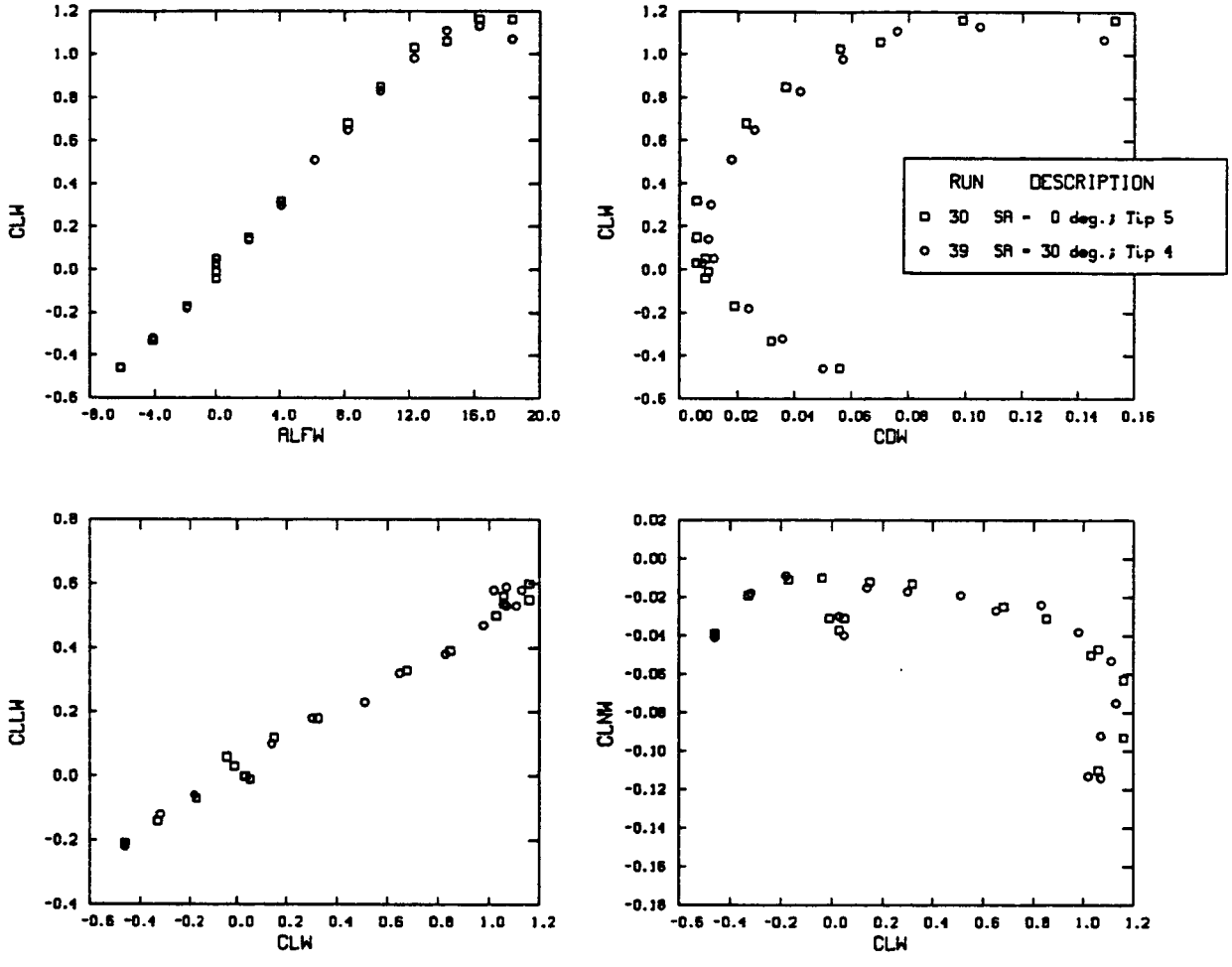
a. Wing Characteristics

Figure 17.- Effect of 20 deg. Tip Sweep on the Wing and Tip Aerodynamic Characteristics of an Aspect Ratio 10.19 Wing with a 0.312m Span Rectangular Tip (DELTA 1 = 0 deg.).



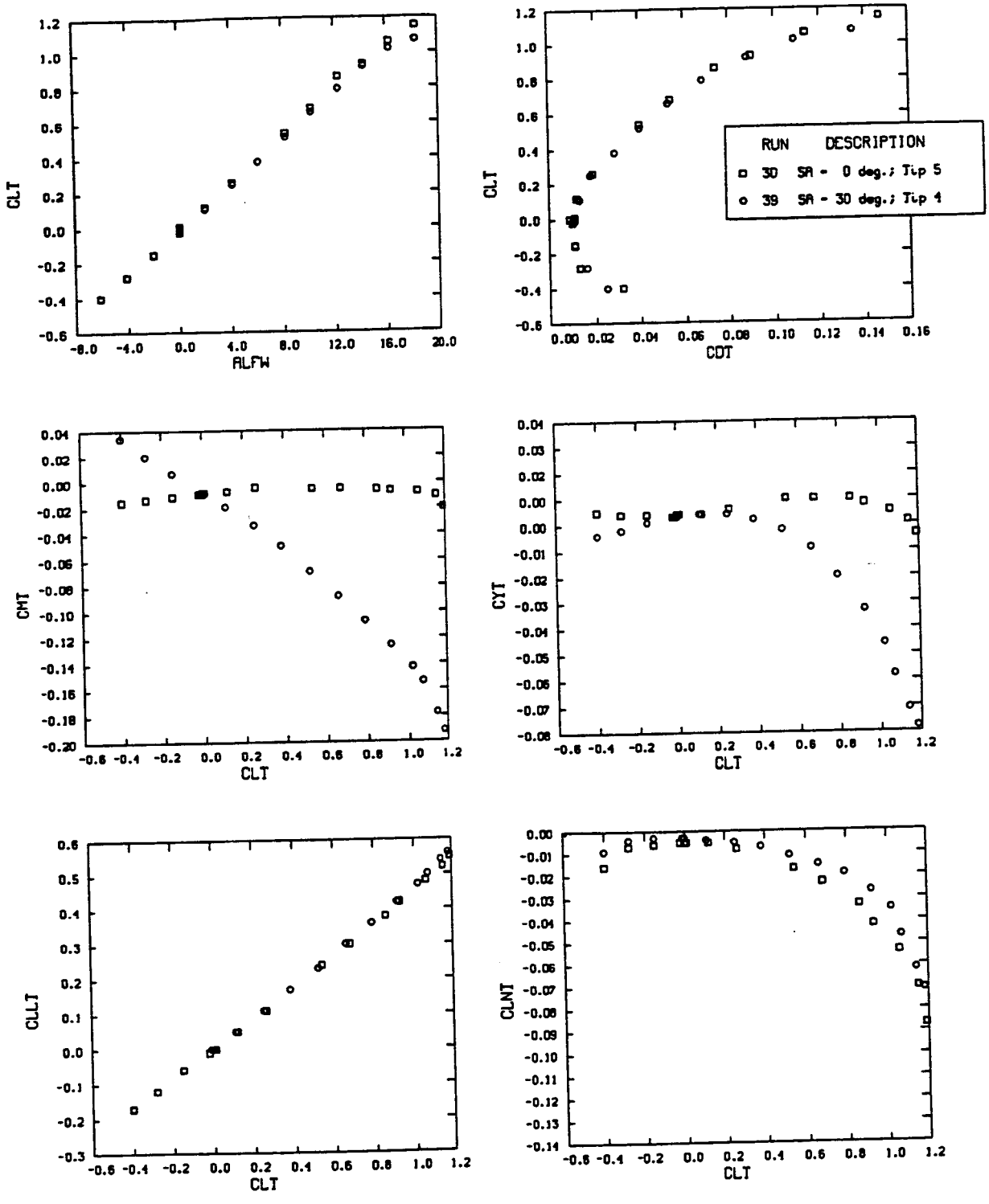
b. Tip Characteristics

Figure 17.- Concluded.



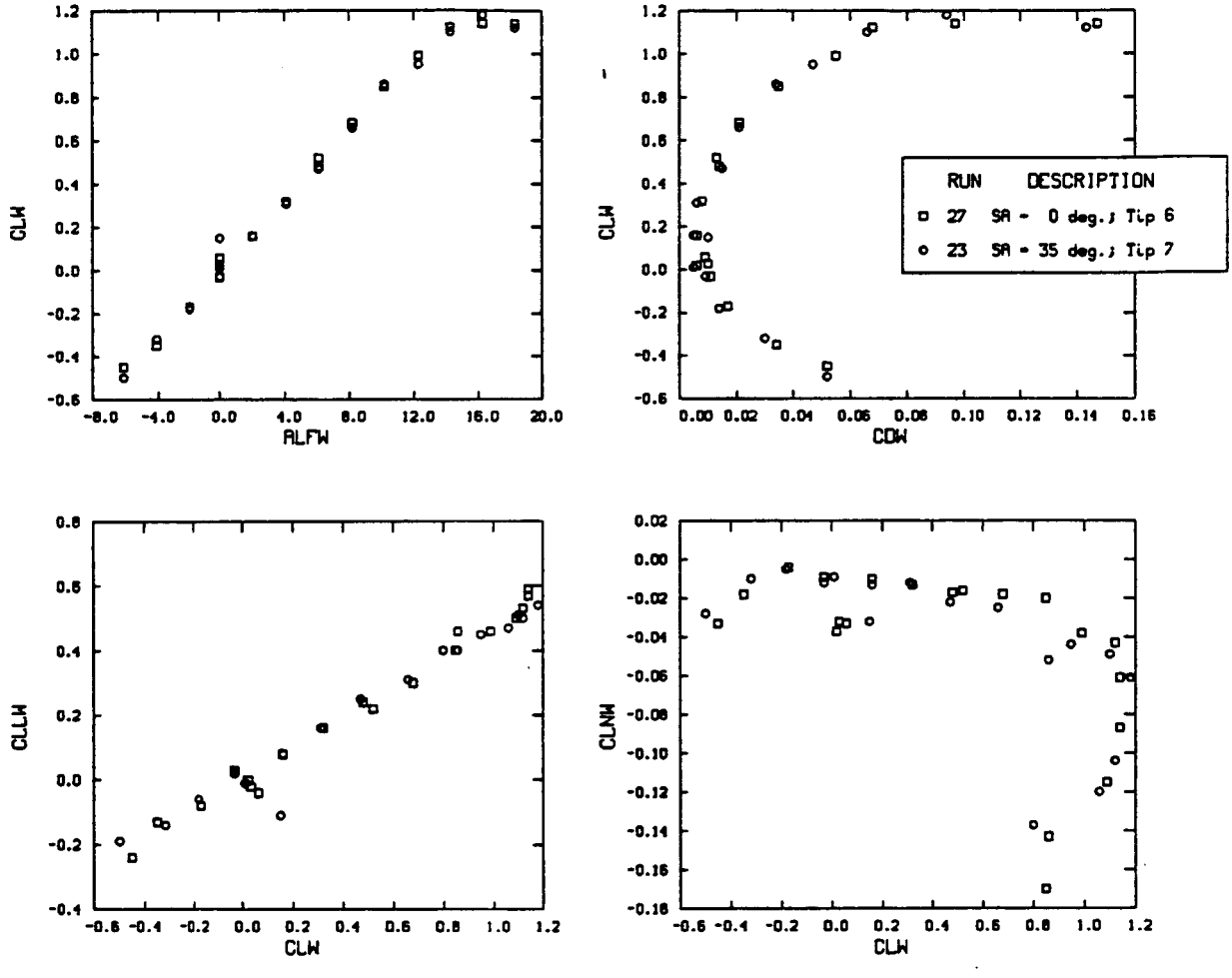
a. Wing Characteristics

Figure 18.- Effect of 30 deg. Tip Sweep on the Wing and Tip Aerodynamic Characteristics of an Aspect Ratio 10.51 Wing with a 0.312m Span, 0.6 Tapered Tip. (DELTA 1 = 0 deg.).



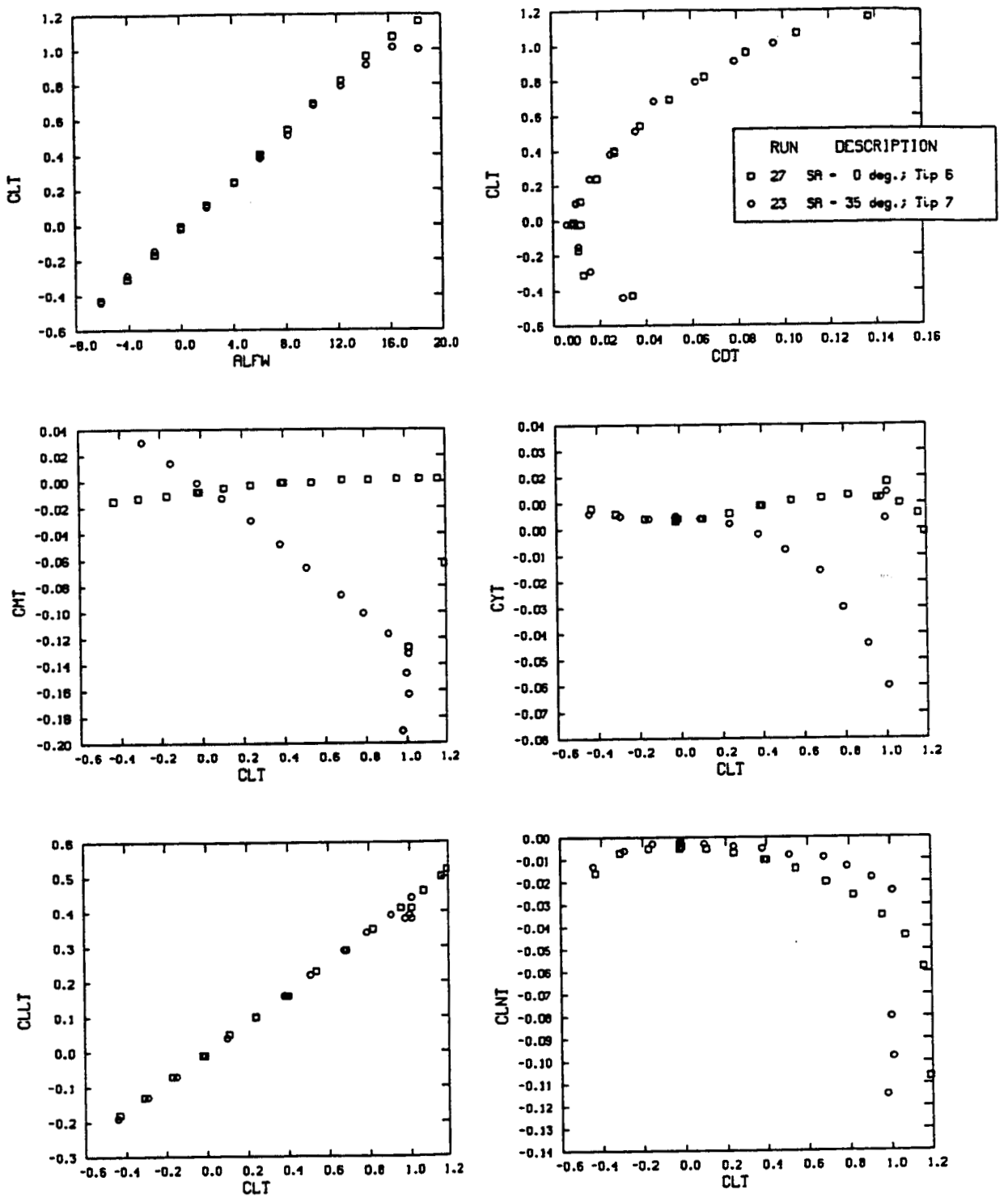
b. Tip Characteristics

Figure 18.- Concluded.



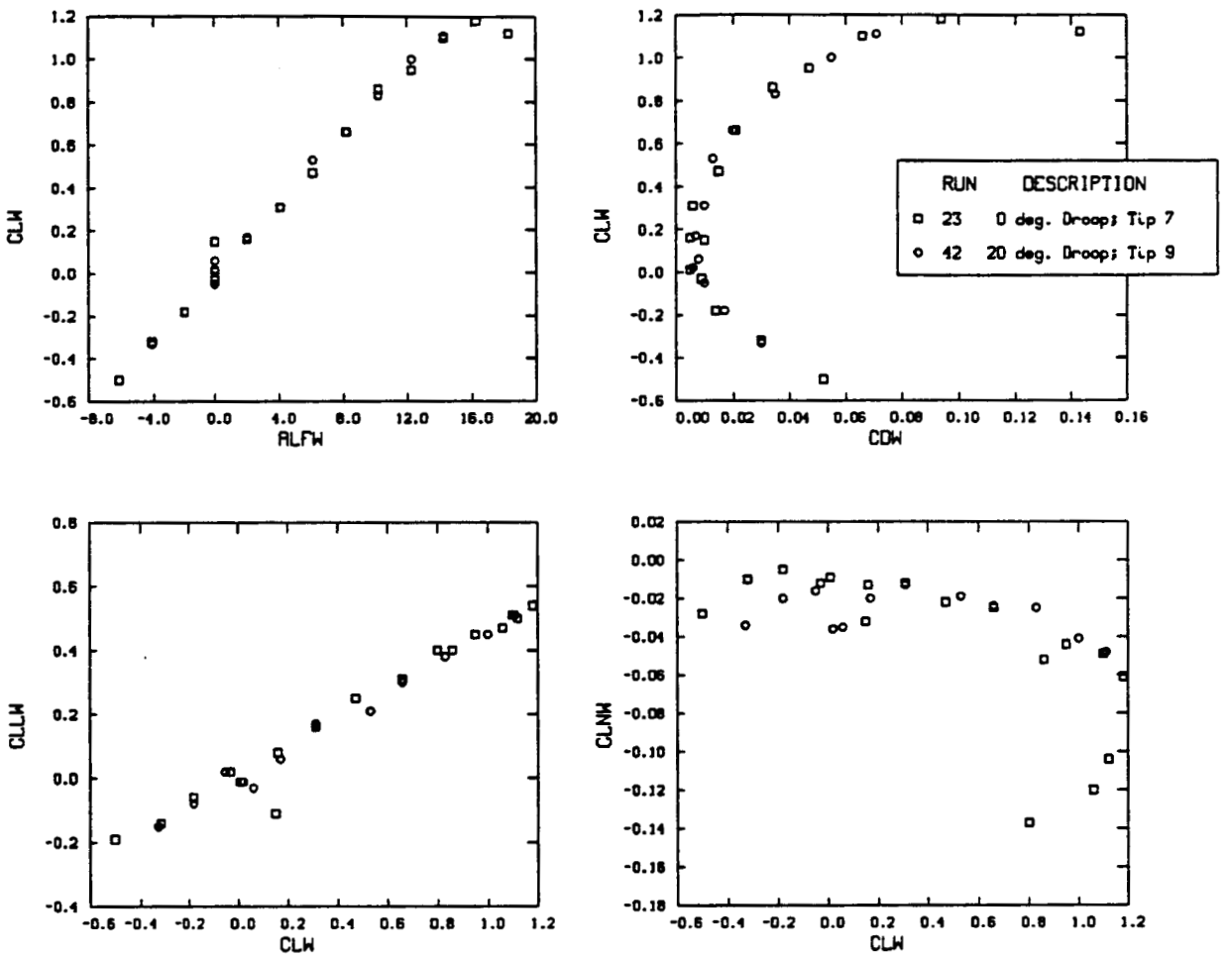
a. Wing Characteristics

Figure 19.- Effect of 35 deg. Tip Sweep on the Wing and Tip Aerodynamic Characteristics of an Aspect Ratio 10.77 Wing with a 0.312m Span, 0.3 Tapered Tip (DELTA I = 0 deg.).



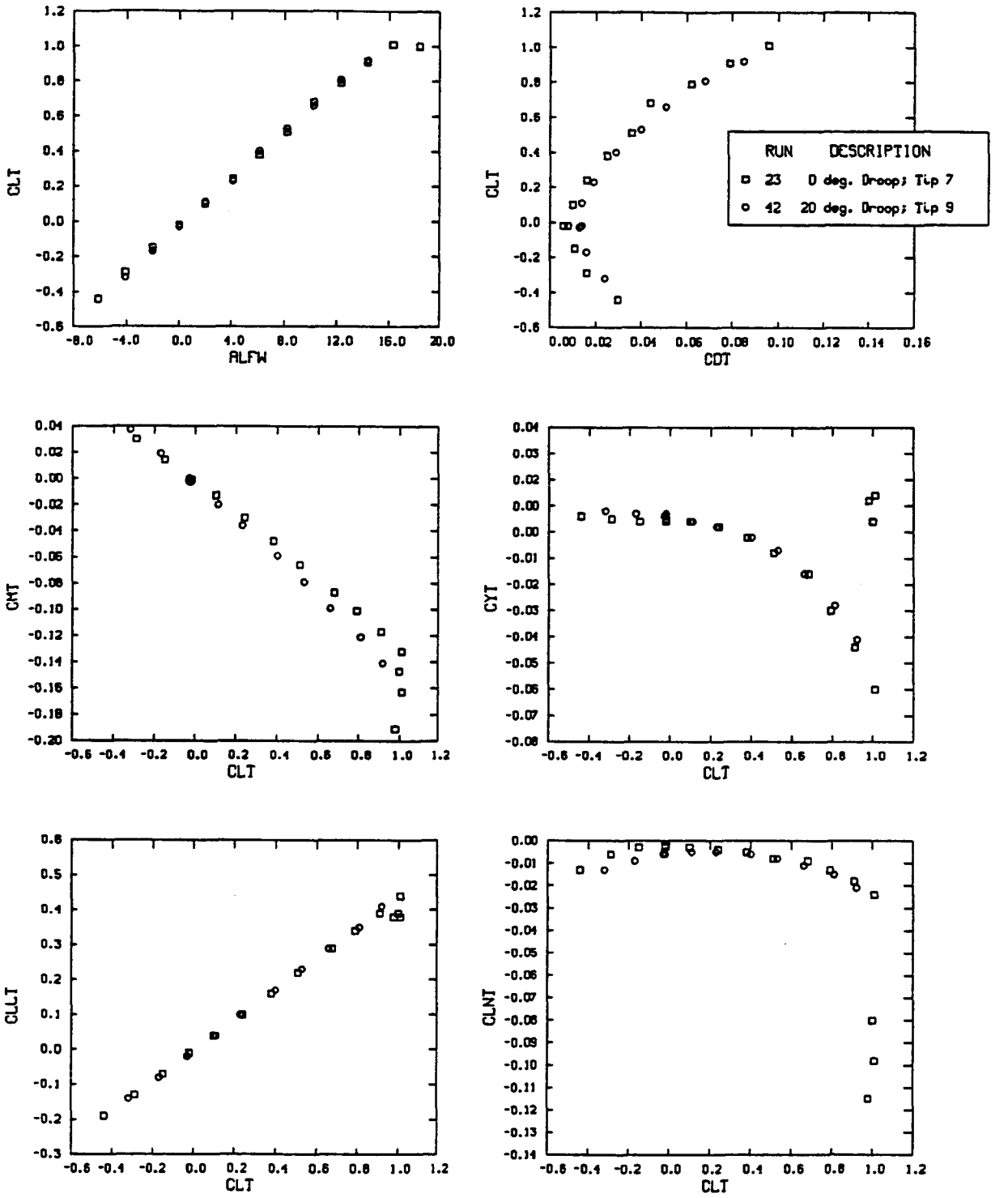
b. Tip Characteristics

Figure 19.- Concluded.



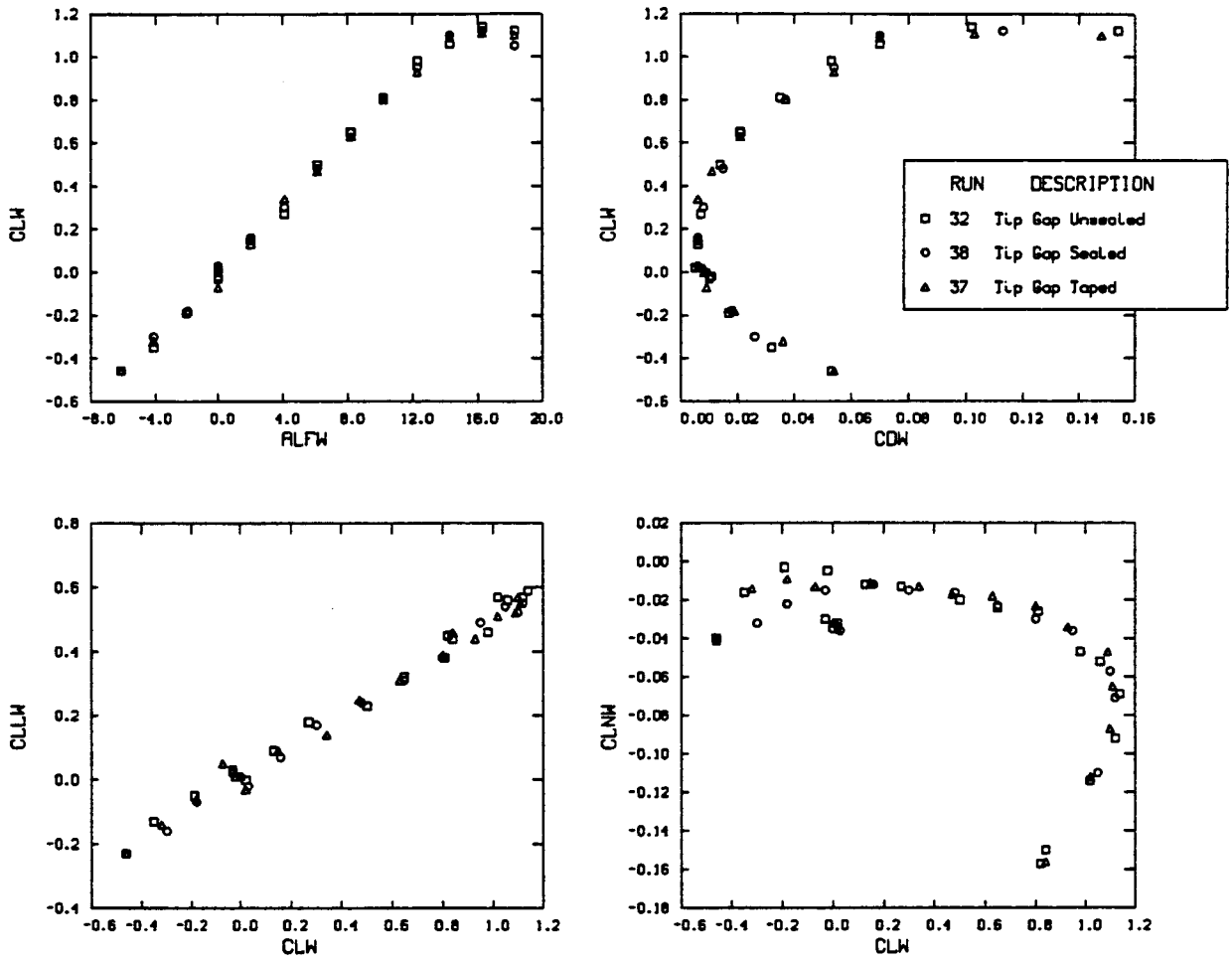
a. Wing Characteristics

Figure 20.- Effect of 20 deg. Tip Leading Edge Droop on the Wing and Tip Aerodynamic Characteristics of an Aspect Ratio 10.77 Wing with a 0.312m Span, 0.3 Tapered, 35 deg. Swept Tip (DELTA 1 = 0 deg.).



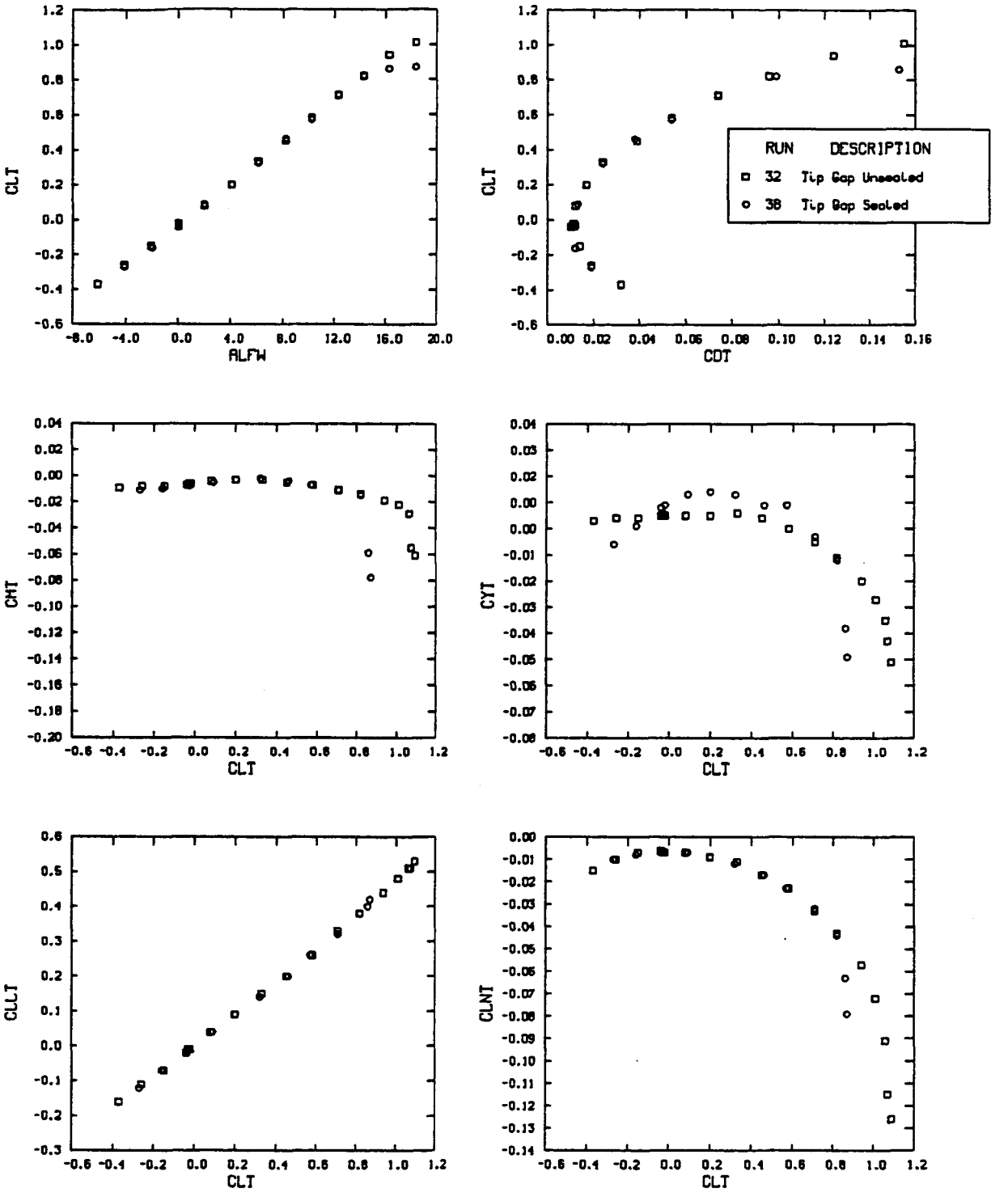
b. Tip Characteristics

Figure 20.- Concluded.



a. Wing Characteristics

Figure 21.- Effect of Sealing the Tip Gap on the Wing and Tip Aerodynamic Characteristics of an Aspect Ratio 10.02 Wing with a 0.233m Span Rectangular Tip (Tip 8; DELTA I = 0 deg.).



b. Tip Characteristics

Figure 21.- Concluded.

APPENDIX: APPLIED TEST DATA CORRECTIONS

A.1. Tip Angle of Attack Corrections

Due to intial angular offset of the tip indexing mechanism, and the deformation of this mechanism and the tip balance itself under the aerodynamic loading the following corrections to the tip angle of attack were necessary:

$$\alpha_t = \alpha_w + \Delta i + \Delta\alpha_{initial} + \Delta\alpha_{deformation}$$

where α_t = tip angle of attack

α_w = wing angle of attack

Δi = tip incidence angle

$\Delta\alpha_{initial}$ = initial angular offset

$= 0.07^o$

$\Delta\alpha_{deformation} = 0.0258 PM_{tip} + \Delta Slop$

with PM_{tip} = tip pitching moment in ft-lbs.

$\Delta Slop$ = angle change due to slop in tip indexing mechanism

$= 0.20$ if $PM_{tip} > 0$

$= 0.00$ if $PM_{tip} \leq 0$

A.2. Static Load Corrections

No static load corrections were necessary for the tip balance forces and moments as the tip balance was mounted vertically and the angle of attack rotation was around the vertical axis. Thus, the tip orientation relative to the gravitational field did not change.

The following static load corrections were made to the scale data to correct for weight tares of the wing model and balance frame when rotating them over a wing angle of attack α_w

Lift: $L_{static} = 1.3 - 0.0406\alpha_w \quad (lbs)$

Drag: $D_{static} = 0.5 + 0.025\alpha_w (lbs)$

Rolling Moment: $RM_{static} = -19.81\alpha_w \quad (ft - lbs.)$

Yawing Moment: $YM_{static} = 12 + 1.3\alpha_w + 0.17\alpha_w^2 \quad (ft - lbs.)$

As mentioned in the main text the accurary of measuring the wing side force and the wing pitching moment was poor and these measurements are therefore not reported. It should also be noted here that the change in model weight due to the various wooden tip planforms was negligible compared to the weight of the rest of the model (steel) and the balance frame. Thus, above given static load corrections for the wing apply to all configurations.

A.3. Tunnel Wall Corrections

The wing and tip aerodynamic coefficients were corrected for tunnel wall effects and wake blockage according to the methods outlined in Reference A.1.

The solid blocking corrections for the three-dimensional tunnel flow were based upon the frontal area of the wing with deflected tip (if $\Delta i \neq 0^\circ$) and the rectangular ground board. The total velocity increment ξ due to solid blocking and downwash corrections is given by:

$$\xi = 1/280[0.0684((b_w - b_t)cos\alpha_w + b_t cos\alpha_t) + (S_w - S_t)sin\alpha_w + S_t sin\alpha_t + 0.311cos(45^\circ - |\alpha_w|) + 0.052cos\alpha_w + 0.213sin\alpha_w + 0.031]$$

The corrected coefficients and angles are then calculated as given below (subscript "corr" indicates corrected value):

Corrected free stream velocity $V_{corr} = V(1 + \xi)$

Corrected dynamic pressure $q_{corr} = q(1 + 2\xi)$

In the following the coefficients, angles, reference lengths, and areas apply to either the tip section or the total semi-span wing.

$$C_{L_A} = C_L(1 - 2\xi)$$
$$C_{L_{corr}} = C_{L_A}(1 - 0.00013S)$$
where S is the reference area (wing or tip)
$$C_{D_{corr}} = C_D(1 - 2\xi) + 0.00204SC_{L_{corr}}^2$$
$$C_{Y_{corr}} = C_Y(1 - 2\xi)$$
$$C_{m_{corr}} = C_m(1 - 2\xi) + 0.25(C_L - C_{L_A})$$
$$C_{\ell_{corr}} = C_\ell(1 - 2\xi)$$
$$C_{n_{corr}} = C_n(1 - 2\xi)$$
$$\alpha_{corr} = \alpha + 0.119SC_{L_A}$$

A.4. References

A.1. Pope, Alan: "Wind Tunnel Testing." Second Edition, John Wiley and Sons, Inc., 1954.

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16. Abstract

An experimental investigation to determine the aerodynamic load characteristics of a series of wing tips, varying in size and planform, on a semi-span wing was conducted in the NASA Ames 7- by 10-foot Low Speed Wind Tunnel at a Mach number of 0.178, and a Reynolds number of 0.867 million based upon an aerodynamic chord of 0.209 meters. The wing had a V23010-1.58 airfoil section. The wing tip could be indexed from -5^{o} to $+5^{o}$ in pitch angle relative to the wing inboard section. Aerodynamic loading of both wing and wing tip are presented in tables and in graphs.

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