CONFIDENTIAL

Copy 408
RM L55H01

NACA RM L55H01

Classification changed to declassified
effective 1 April 1963
authority of NASA
J. J. Carroll.

NACA

RESEARCH MEMORANDUM

THE ORIGIN AND DISTRIBUTION OF SUPERSONIC STORE INTERFERENCE FROM MEASUREMENT OF INDIVIDUAL FORCES ON SEVERAL WING-FUSELAGE-STORE CONFIGURATIONS

III.- SWEPT-WING FIGHTER-BOMBER CONFIGURATION WITH LARGE AND SMALL STORES. MACH NUMBER, 1.61

By Norman F. Smith and Harry W. Carlson

Langley Aeronautical Laboratory
Langley Field, Va.

LIBRARY COPY
JUN 11 1963
LANGLEY RESEARCH CENTER
LIBRARY, NASA
LANGLEY STATION
HAMPTON, VIRGINIA

CLASSIFIED DOCUMENT

This material contains information affecting the National Defense of the United States within the meaning of the espionage laws, Title 18, U.S.C., Secs. 793 and 794, the transmission or revelation of which in any manner to an unauthorized person is prohibited by law.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON

September 15, 1955

CONFIDENTIAL

NASA Technical Library
3 1176 01438 0514

UNCLASSIFIED

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

THE ORIGIN AND DISTRIBUTION OF SUPERSONIC STORE INTERFERENCE FROM MEASUREMENT OF INDIVIDUAL FORCES ON SEVERAL WING-FUSELAGE-STORE CONFIGURATIONS

III.- SWEPT-WING FIGHTER-BOMBER CONFIGURATION WITH LARGE AND SMALL STORES. MACH NUMBER, 1.61

By Norman F. Smith and Harry W. Carlson

SUMMARY

A supersonic wind-tunnel investigation of the origin and distribution of store interference has been performed in the Langley 4- by 4-foot supersonic pressure tunnel at a Mach number of 1.61 in which separate forces on a store, a fuselage, a swept wing, and a swept-wing-fuselage combination were measured. The store was separately sting-mounted on its own six-component internal balance and was traversed through a wide systematic range of spanwise, chordwise, and vertical positions. This report presents data on a configuration which simulated a fighter-bomber airplane with a large and a small external store.

The interference effects measured for the fighter-bomber configuration were similar in character and magnitude to those reported previously for a heavy-bomber configuration having the same swept wing. Hence, the wing is shown to be the predominant component in the production of interference, with the fuselage secondary. The differences in interference which are measured can be explained in general on the basis of the analysis and force breakdown information presented herein and in NACA Research Memorandums L55A13a and L55E26a.

INTRODUCTION

Reference 1 describes in detail an experimental investigation in the Langley 4- by 4-foot supersonic pressure tunnel aimed at supplying data on stores interference which is general in nature and which provides

[redacted]

an improved understanding of the source of interferences. The investigation consists of measurement of individual forces and moments (six components) on various sting-mounted stores in the vicinity of several fuselage, wing, and wing-fuselage combinations. Individual forces and moments (four components) were measured on the wing and fuselage combinations.

References 1 and 2 present the force information obtained at a Mach number of 1.61 on a swept-wing heavy-bomber-type airplane and a large store (or nacelle). The present report presents similar force information at $M = 1.61$ on a swept-wing fighter-bomber configuration with a large and a small store. The data are presented with a very limited analysis in order to expedite publication.

SYMBOLS

C_D drag coefficient of wing or wing-fuselage combination indicated by subscripts, $\frac{\text{Drag}}{qS}$

C_L lift coefficient of wing or wing-fuselage combination as noted by subscripts, $\frac{\text{Lift}}{qS}$

C_m pitching-moment coefficient of wing or wing-fuselage combination as noted by subscripts, $\frac{\text{Pitching moment}}{qS\bar{c}}$

C_{D_s} drag coefficient of store, $\frac{\text{Drag}}{qF}$

$C_{D_{B_s}}$ base drag coefficient of store, $-P_{B_s}\frac{A}{F}$

C_{L_s} lift coefficient of store, $\frac{\text{Lift}}{qF}$

C_{m_s} pitching-moment coefficient of store, $\frac{\text{Pitching moment}}{qFl}$

C_{Y_s} side-force coefficient of store, $\frac{\text{Side Force}}{qF}$.

C_{n_s} yawing-moment coefficient of store, $\frac{\text{Yawing moment}}{qFl}$

C_{D_t} total drag coefficient of complete configuration (wing-fuselage plus store) based on wing area, $C_{D_{wf}} + C_{D_s}\frac{F}{S}$

C_{L_t} total lift coefficient of complete configuration (wing-fuselage plus store) based on wing area, $C_{L_{wf}} + C_{L_s}\frac{F}{S}$

$\bar{c}$ mean aerodynamic chord of wing, 6.58 in.

A area of store base

S total area of wing semispan, 0.5 sq ft

F maximum frontal area of store

q dynamic pressure, lb/sq ft

P_{B_s} pressure coefficient on store base, $\frac{p - p_o}{q_o}$

b/2 wing semispan, 12 in.

l store length

x chordwise position of store midpoint, measured from arbitrary point 0.652 in. behind fuselage nose (see fig. 1), in.

y spanwise position of store center line, measured from fuselage center line, in.

z vertical position of store center line, measured from wing chord plane, positive downward, in.

β cotangent of Mach angle, $\sqrt{M^2 - 1}$

Subscripts:

o	free stream
w	wing
wf	wing-fuselage combination
s	store
t	total, for complete configuration (wing fuselage plus store)

APPARATUS AND TESTS

The models and general arrangement of the test setup are shown in figure 1. Figure 2 shows photographs of the models and boundary-layer bypass plate. Complete dimensions of the models are given in figure 1 and tables I and II. Reference 1 describes in detail the models, equipment and test methods. The model investigated herein employed the same swept wing which was used in references 1 and 2. A fuselage of greater diameter and lower overall fineness ratio was designed (using the Sears-Haack shape of ref. 3) to produce a midwing configuration typical of the proportions of a fighter-bomber airplane. (Although of lower overall fineness ratio, the fighter-bomber fuselage has a nose and afterbody of higher fineness ratio than the heavy bomber.) The models of the fighter-bomber configuration of the present tests and the heavy-bomber configuration of references 1 and 2 are compared in figure 3. It will be noted that the two models (including stores) are actually of different scale when referred to the size of the corresponding full-scale airplanes. The results of tests of these two models may therefore be compared to obtain some information on the effects of changing fuselage shape and size, or can be considered as research data on different-scale models of different types of airplanes.

It should also be noted in comparing the two configurations that the fighter-bomber was a midwing configuration (fig. 3) while the heavy bomber was a high-wing configuration with the wing located at 25 percent of the fuselage diameter above the fuselage center line.

Along with the large store used in the reference reports, a smaller geometrically similar store (see fig. 2(b) and table I) was investigated for a range of store positions in the vicinity of the wing.

All tests were run with boundary-layer transition fixed on all surfaces as described in reference 1. The angle of attack of the wing-fuselage combination was varied from 0° to 4°, with the store remaining

at $\alpha = 0^{\circ}$. The relative accuracies of the data in this report are the same as those listed in references 1 and 2, and are given in the following table:

x, in.	±0.025
y, in.	±0.05
z, in.	±0.05
Store:	
C_{D_s}	±0.005
C_{L_s}	±0.010
C_{m_s}	±0.005
C_{Y_s}	±0.010
C_{n_s}	±0.005
α_s, deg	±0.2
Wing-fuselage:	
C_D	±0.0005
C_L	±0.005
C_m	±0.002
α, deg	±0.1

The tests were performed in the Langley 4- by 4-foot supersonic pressure tunnel at a Mach number of 1.61 corresponding to a Reynolds number per foot of 4.2×10^6.

RESULTS AND DISCUSSION

Basic Data

Isolated store and wing-fuselage data.- The forces and moments on the isolated store are presented in references 1 and 2. The data for the isolated swept wing and for the isolated fighter-bomber wing-fuselage combination are presented in figure 4. (The forces on the isolated fighter-bomber fuselage were not measured.)

Chordwise plots of force coefficients.- The basic data for the large store in the presence of the wing-fuselage combination are presented in figures 5 to 10. Data for the wing-fuselage combination in the presence of the large store are given in figures 11 to 13. Drag and lift of wing-fuselage plus store configurations are given in figures 14 and 15. Basic

data for the large store in the presence of the wing alone and for the wing alone in the presence of the large store will be found in references 1 and 2. No data have been obtained for the store in the presence of the fighter-bomber fuselage alone.

The data are presented in the form of plots of coefficients against a chordwise-position parameter which is a function of the position of the midpoint of the store. Offset vertical and horizontal scales are used as described in detail in reference 1. Technique for plotting the data prevents crossing of the curves and permits fairing of the chordwise variations of coefficients as a "family," thereby obtaining a more accurate fairing of the test points. On each figure is shown a sketch of the configuration involved. The spanwise and chordwise positions at which measurements were obtained are indicated by the appropriate symbol on the grid.

The store and wing-fuselage drag data presented have been corrected to correspond to a base pressure equal to free-stream static pressure. The base drag coefficients for the store are presented in figure 6. The store pitching-moment and yawing-moment data are presented with reference to the store nose in the basic data figures.

Curves for wing-fuselage forces (figs. 11 to 15) are shown dashed between test points for $x = 6$ and $x = 12$ because of the presence of store sting interference on wing-fuselage forces at these store positions. This interference was also present at $x = 18$ in references 1 and 2 but was eliminated in the present tests by utilizing a different sting at $x = 18$.

Presented in figures 16 to 24 are the basic data for the small store in the presence of the wing-fuselage combination and for the wing-fuselage combination in the presence of the small store. Drag and lift of wing-fuselage plus store configurations are given in figures 25 and 26. The existence of only three data points for each chordwise plot makes fairing of the curves difficult and somewhat arbitrary. The fairings shown are based on experience gained in fairing more complete plots for the large store and the result of comparisons of the data for the small and the large store (to be presented in a later section).

Analysis

References 1, 2, and 4 have presented analyses of the data for the heavy-bomber configuration, including contour mapping of the forces, contribution of components to interferences and the effect of various parameters such as angle of attack and store vertical height. In order to expedite publication of the data presented herein, no such analysis has been prepared. Using the basic data plots presented, however, the same sort of analysis can be prepared as desired.

The analysis presented herein will be limited to some comparisons of the forces on both store and wing-fuselage for the heavy-bomber (from refs. 1 and 2) and the fighter-bomber configurations and some comparisons of forces measured for the fighter-bomber configuration with a large and a small store.

Comparison of forces on large store in presence of heavy- and fighter-bomber configuration.- The drag, lift, and side force of the store in the presence of the swept-wing alone (from refs. 1 and 2), the fighter-bomber and heavy-bomber configurations are shown in figures 27 to 30.

It was pointed out in reference 1 that the peak of the drag interferences produced by the wing were reduced by the (heavy-bomber) fuselage because the interference pressure fields of the wing and fuselage tend to oppose one another. In general, adding the fighter-bomber fuselage is seen from figure 27 to similarly reduce the interferences produced by the wing, although to a lesser extent. Figure 28 has been prepared to show more clearly these effects. The contribution of the fighter-bomber fuselage to store drag is seen to be generally less than that of the heavy-bomber fuselage except for some of the more forward store positions and except for $y = 3.0$, where the larger diameter of the fighter-bomber fuselage produces closer proximity between fuselage and store. The aforementioned smaller interference drags on the store are a consequence of the smaller pressure gradients produced by the greater fineness ratio of the fighter-bomber fuselage nose and afterbody. These interference effects would not be expected to remain smaller at lower (particularly transonic) Mach numbers because of the greater fuselage frontal area involved.

The curves for store lift (fig. 29) are in very close agreement. As pointed out in the discussion of model breakdown data in references 1 and 2, the store lift interferences are due almost entirely to the wing. The differences produced by the two fuselages would therefore be expected to be small.

As would be expected, the effect of fuselage configuration on store side force (fig. 30) is small for store positions toward the wing tip, but quite large for store positions near the fuselage. Reference 2 shows that adding the fuselage contributes significant store side force particularly for the inboard store positions.

Comparison of forces on heavy- and fighter-bomber configurations in presence of large store.- The wing-fuselage lift and drag and total configuration (wing-fuselage plus store) lift and drag in the presence of the large store are shown in figures 31 to 33. The lift curves (fig. 33) are all essentially of the same shape and, in general, little important difference between the interferences incurred by the two configurations is noted.

Examination of the drags for the two isolated wing-fuselage combinations (fig. 2 of ref. 1 and fig. 4 of present report) shows that the drag coefficient for the fighter-bomber is approximately 0.0012 higher (based on the same wing area) than that for the heavy bomber, principally as a result of the larger fuselage frontal area of the former. This difference must be taken into account in comparing the interference of the large store on the two wing-fuselage configurations, since for equal interference the fighter-bomber and heavy-bomber curves (fig. 31) would be separated by a constant increment of 0.0012. Figure 32 shows the incremental drag produced by the store for the two configurations. It will be seen that the drag incurred by the fighter-bomber configuration is less in the region of the drag peak (which has been shown previously to be due primarily to store-wing interference). This fact points to decreased adverse interference of the store on this fuselage. Immediately ahead of this region, the drag incurred by the fighter-bomber configuration is generally higher. This fact points to decreased beneficial interference of the store on this fuselage in this region. The decreases in interferences thus indicated are believed to be a consequence of the more gradual surface slope of the fighter-bomber fuselage (compared with the heavy-bomber fuselage) which consequently presents a smaller local projected frontal area on which the store pressure field can act.

As a consequence of the higher wing-fuselage and store drags over the ranges just discussed, the total drags of the complete (wing-fuselage plus store) fighter-bomber configuration are shown in figure 31 to be higher than for the heavy-bomber configuration over the entire range of store positions.

Comparison of forces on large and small store in presence of fighter-bomber configuration.- Drag, lift, and side-force coefficients for the small and large stores in the presence of the fighter-bomber configuration are compared in figure 34. Although there is a resemblance between the curves for small and large stores, some shifting is in evidence and very much larger changes in forces are generally measured for the small store. The peaks tend to be narrower and the gradients become somewhat larger. This same phenomenon is pointed out in reference 4 for the same stores in the presence of the heavy-bomber configuration. These effects are explained by the fact that the small store can be more completely submerged in a region in which force is generated (due to pressure gradient or flow deviation or both) in one direction. The large store, on the other hand, tends to extend through several such regions so that lower peak values of force coefficients result. A detailed discussion and analysis of the flow fields from the standpoint of drag is presented in reference 1 and from the standpoint of the other forces in reference 2.

Comparison of forces on fighter-bomber configuration in presence of large and small store.- The lift and drag of the wing-fuselage combination is shown in figure 35 to be influenced to a lesser degree by

the small store than by the larger store. The horizontal shift which is evident between the two curves is a result of the displacement of the store and its pressure field due to a change in store length. The smaller maximum interference effects of the small store are the result of decreased extent of the store pressure field.

CONCLUSIONS

The results of a supersonic wind-tunnel investigation at a Mach number of 1.61 in which separate forces were measured on a swept wing fighter-bomber configuration and on two sizes of external stores for a very wide range of store positions provide the following conclusions, based on a limited analysis of the data:

1. The interference effects of the fighter-bomber on the store, as well as the store on the fighter-bomber, were similar in character to those reported previously for a heavy-bomber-store configuration using the same swept wing and store.

2. The differences in interference which are measured can be explained in general on the basis of the analysis and force breakdown information presented herein and in NACA Research Memorandums L55A13a and L55E26a.

3. The drag interferences (both favorable and unfavorable) produced on the store by the fuselage appear, in general, to be smaller for the fighter-bomber configuration than for the heavy-bomber configuration as a result of reduced pressure gradients produced by the higher fineness ratio fighter-bomber fuselage nose and tail sections. Similarly, the drag interferences produced on the fuselage by the store are generally smaller as a result of smaller slopes of the fuselage surface upon which the interference pressures can act.

4. The small store incurred larger maximum interference forces (in coefficient form) than did the large store. The maximum interferences produced on the wing-fuselage combination by the small store were generally smaller than those produced by the large store.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., July 15, 1955.

REFERENCES

1. Smith Norman F., and Carlson, Harry W.: The Origin and Distribution of Supersonic Store Interference From Measurement of Individual Forces on Several Wing-Fuselage-Store Configurations. I.- Swept-Wing Heavy-Bomber Configuration With Large Store (Nacelle). Lift and Drag; Mach Number, 1.61. NACA RM L55A13a, 1955.

2. Smith, Norman F., and Carlson, Harry W.: The Origin and Distribution of Supersonic Store Interference From Measurement of Individual Forces on Several Wing-Fuselage-Store Configurations. II.- Swept-Wing Heavy-Bomber Configuration With Large Store. Lateral Forces and Pitching Moments; Mach Number, 1.61. NACA RM L55E26a, 1955.

3. Sears, William R.: On Projectiles of Minimum Wave Drag. Quarterly Appl. Math., vol. IV, no. 4, Jan. 1947, pp. 361-366.

4. Smith, Norman F., and Carlson, Harry W.: Some Effects of Configuration Variables on Store Loads at Supersonic Speeds. NACA RM L55E05, 1955.

TABLE I

PERTINENT MODEL DIMENSIONS

Fuselage:	
Maximum diameter, in.	3.942
Maximum frontal area (semicircle), sq ft	0.0424
Base diameter, in.	2.844
Base area (semicircle), sq ft	0.0226
Overall length, in.	37.452
Nose fineness ratio	6.1
Afterbody fineness ratio	3.4
Overall fineness ratio	9.5
Swept Wing:	
Semispan, in.	12
Mean aerodynamic chord, in.	6.580
Area, semispan, sq ft	0.500
Sweep (c/4), deg	45
Aspect ratio	4
Taper ratio	0.3
Center line chord, in.	9.23
Section	NACA 65A-006

Store:	Small	Large
Maximum diameter, in.	1.1	1.5
Maximum frontal area, sq ft	0.0066	0.0123
Base diameter, in.	0.704	0.96
Base area, sq ft	0.0027	0.005
Overall length, in.	8.8	12.0
Nose fineness ratio	3	3
Afterbody fineness ratio	1.82	1.82
Overall fineness ratio	8	8

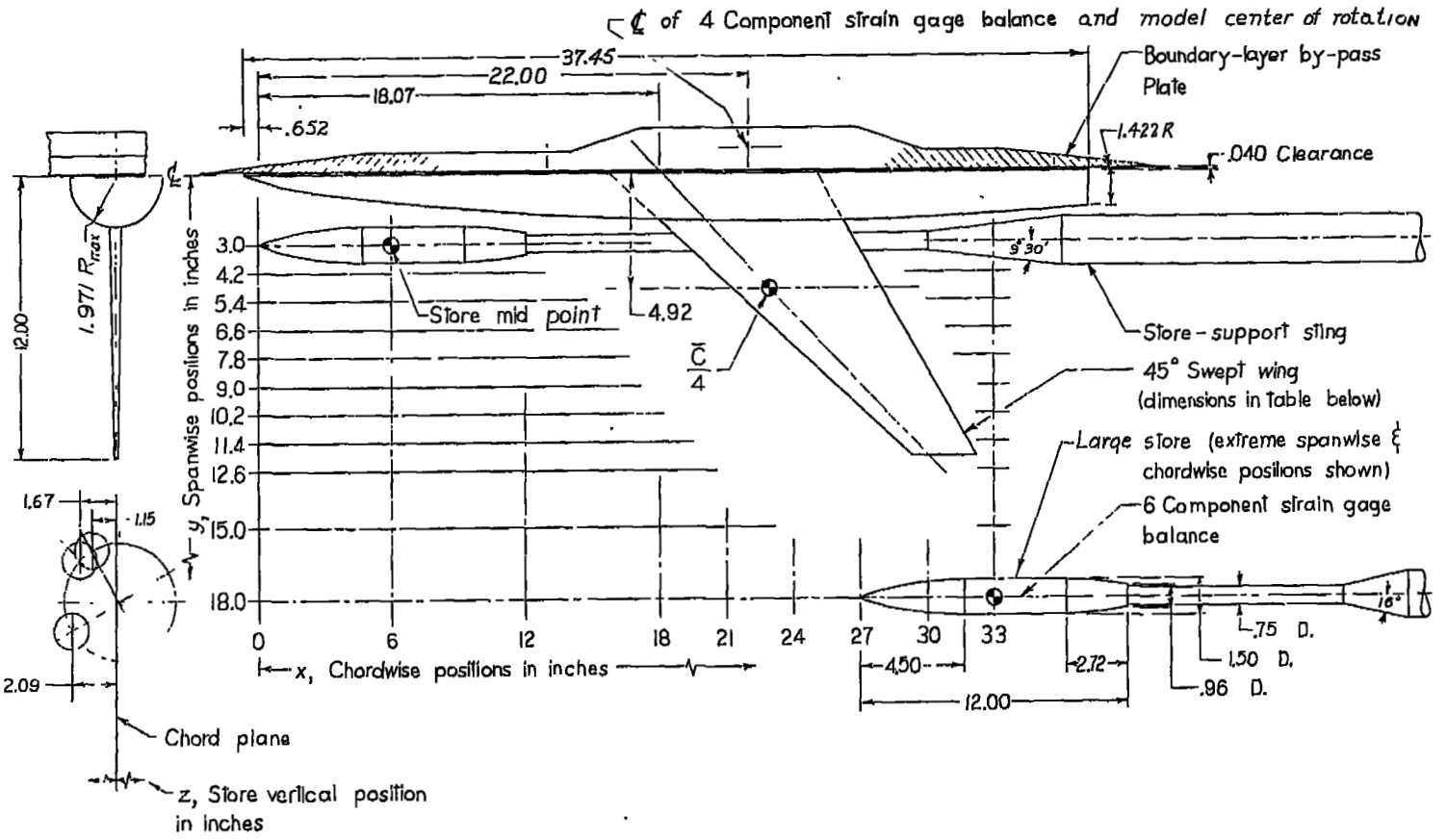
UNCLASSIFIED

TABLE II

FIGHTER-BOMBER FUSELAGE ORDINATES

x, in.	radius, in.
-0.652	0.000
.204	.271
1.061	.450
1.917	.601
2.778	.736
3.635	.857
4.491	.968
5.347	1.070
6.204	1.164
7.060	1.251
7.921	1.333
8.778	1.407
9.634	1.477
10.490	1.541
11.347	1.600
12.203	1.654
13.064	1.704
13.921	1.749
14.777	1.789
15.633	1.826
16.490	1.858
17.346	1.887

x, in.	radius. in.
18.207	1.910
19.064	1.930
19.920	1.946
20.777	1.958
21.633	1.966
22.489	1.970
23.345	1.971
24.207	1.967
25.063	1.960
25.920	1.949
26.776	1.933
27.632	1.914
28.489	1.891
29.349	1.864
30.206	1.832
31.063	1.797
31.919	1.757
32.775	1.713
33.632	1.665
34.493	1.611
35.349	1.553
36.206	1.490
36.798	1.422



Notes:

1. Store nose and afterbody are ogive bodies of revolution. Center section is cylindrical.
2. Small store is 1.1 inches diameter, geometrically similar to large store.
3. Fuselage is Sears - Haack shape of reference 3.
4. All dimensions in inches.

Wing dimensions

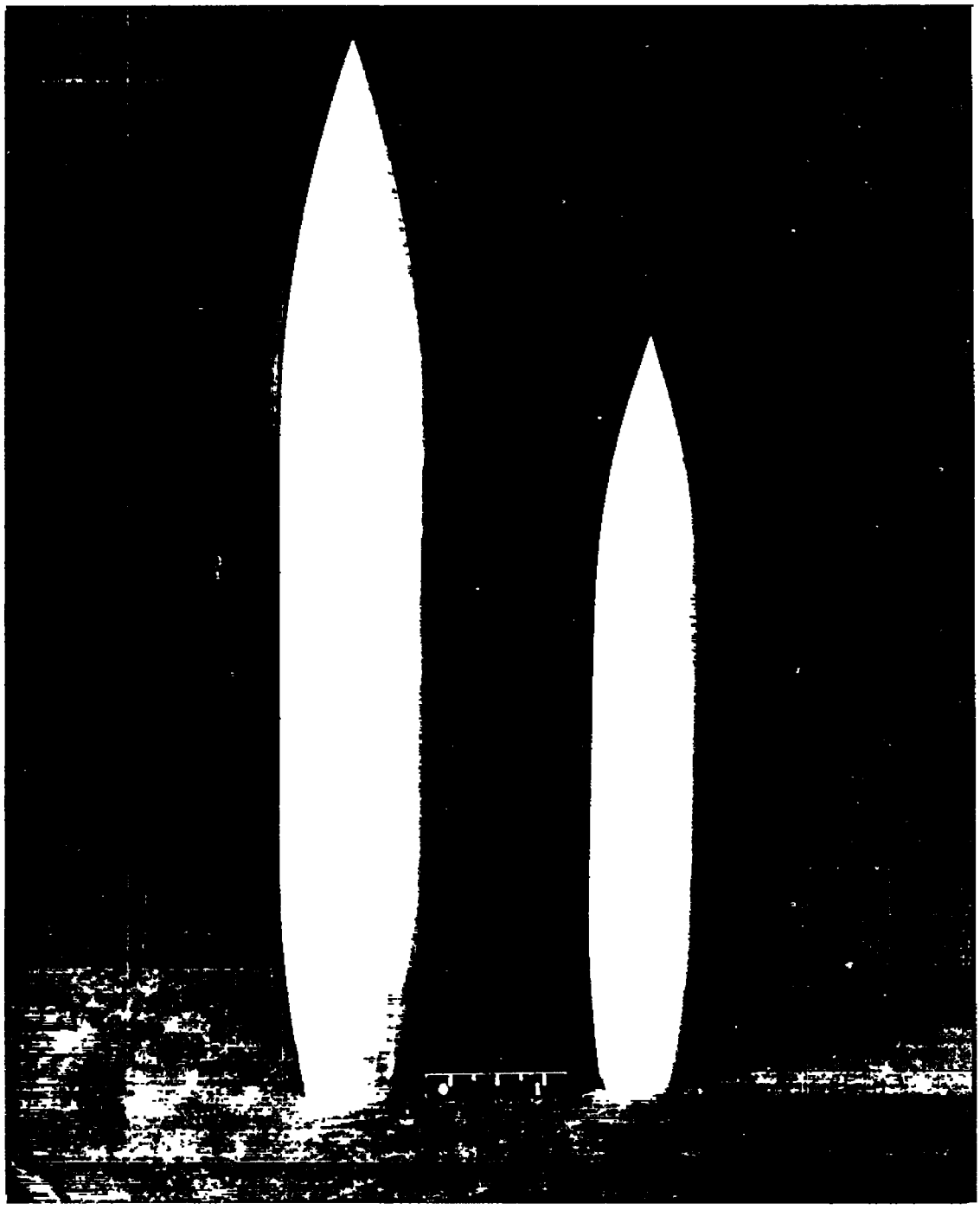
Semi-span	12
Sweep $\frac{c}{4}$	45°
Aspect ratio	4
Taper ratio	0.3
℄ Chord	9.23
Section	65A-006

Figure 1.- Layout of models showing dimensions of components and ranges of store positions investigated.

L-87526

(a) Models mounted on support plate.

Figure 2.- Photograph of models. Boundary-layer transition strips not shown.



L-89219

(b) Large and small stores.

Figure 2.- Concluded.

[redacted]

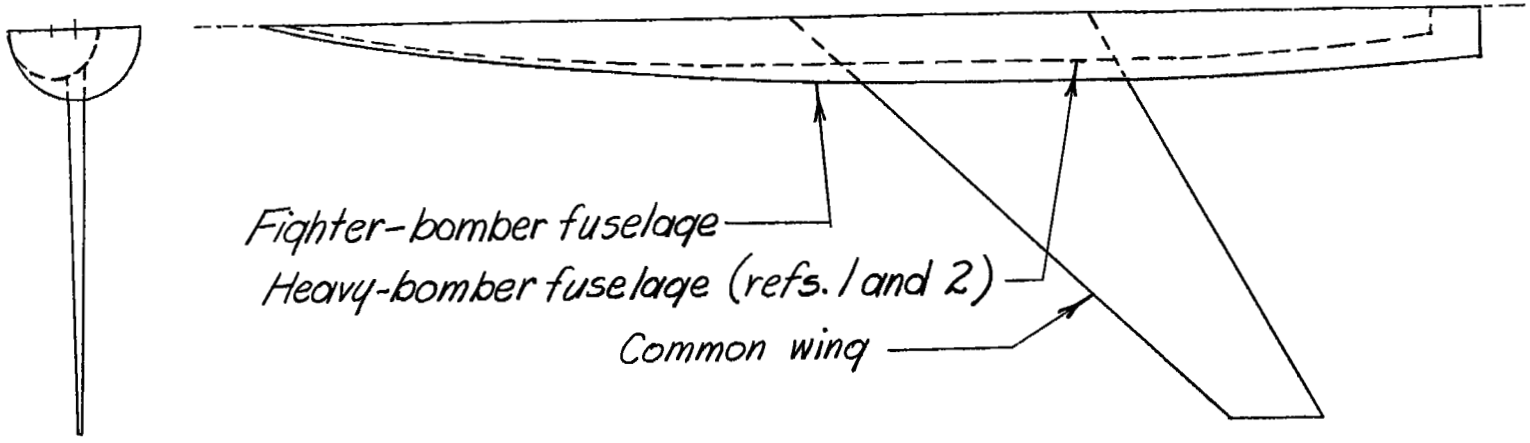


Figure 3.- Comparison of fighter-bomber fuselage of present report with heavy-bomber fuselage of references 1 and 2.

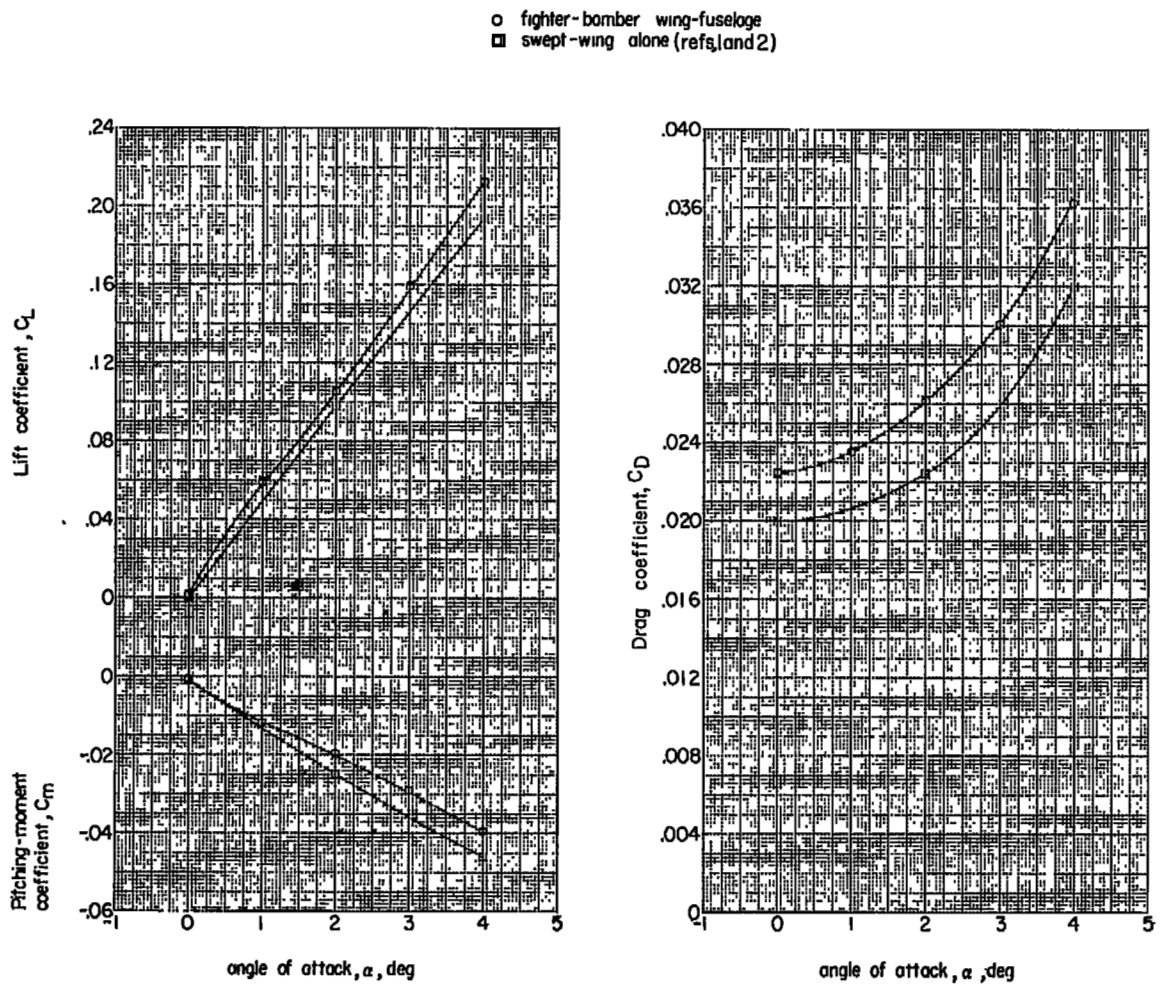
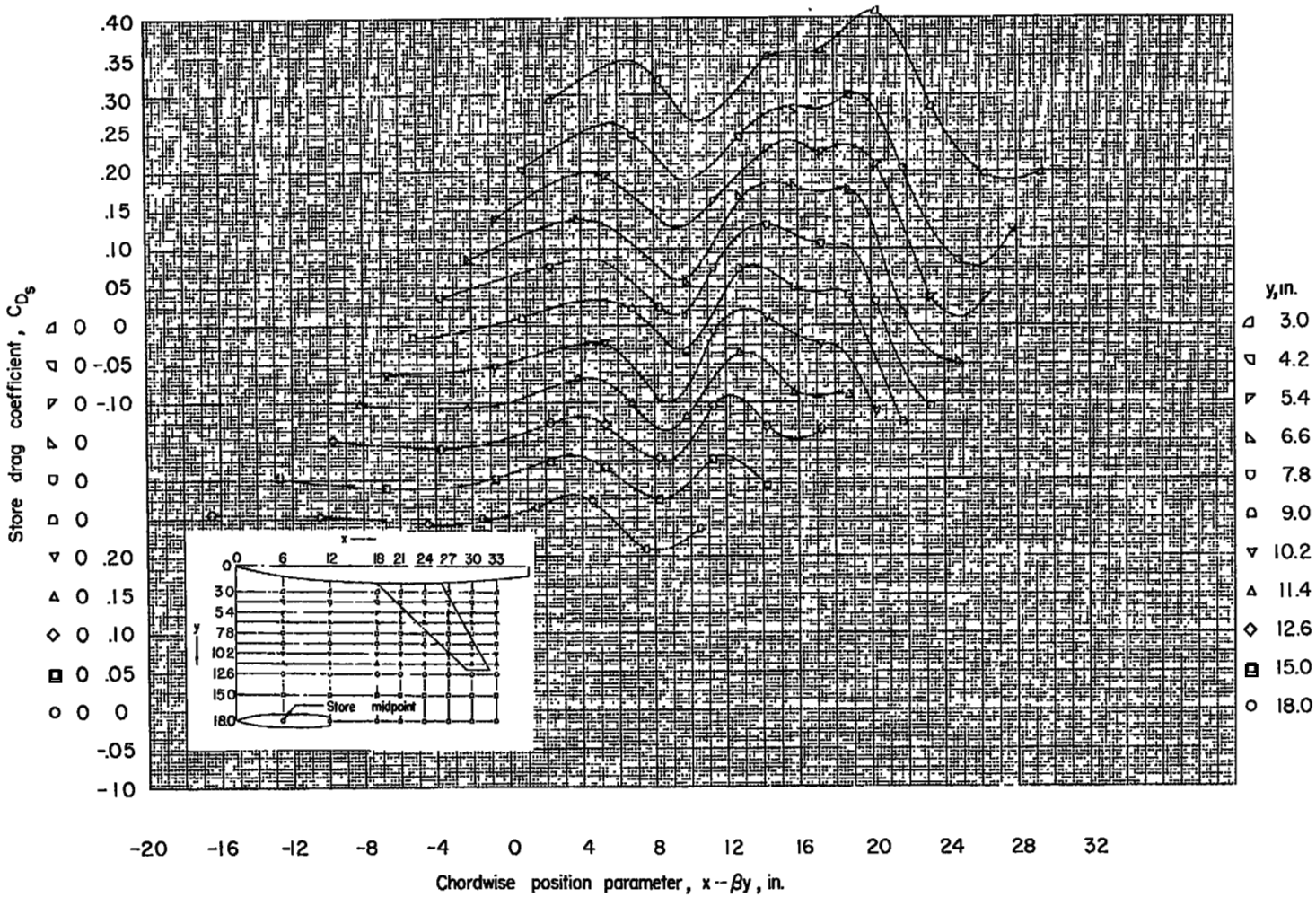
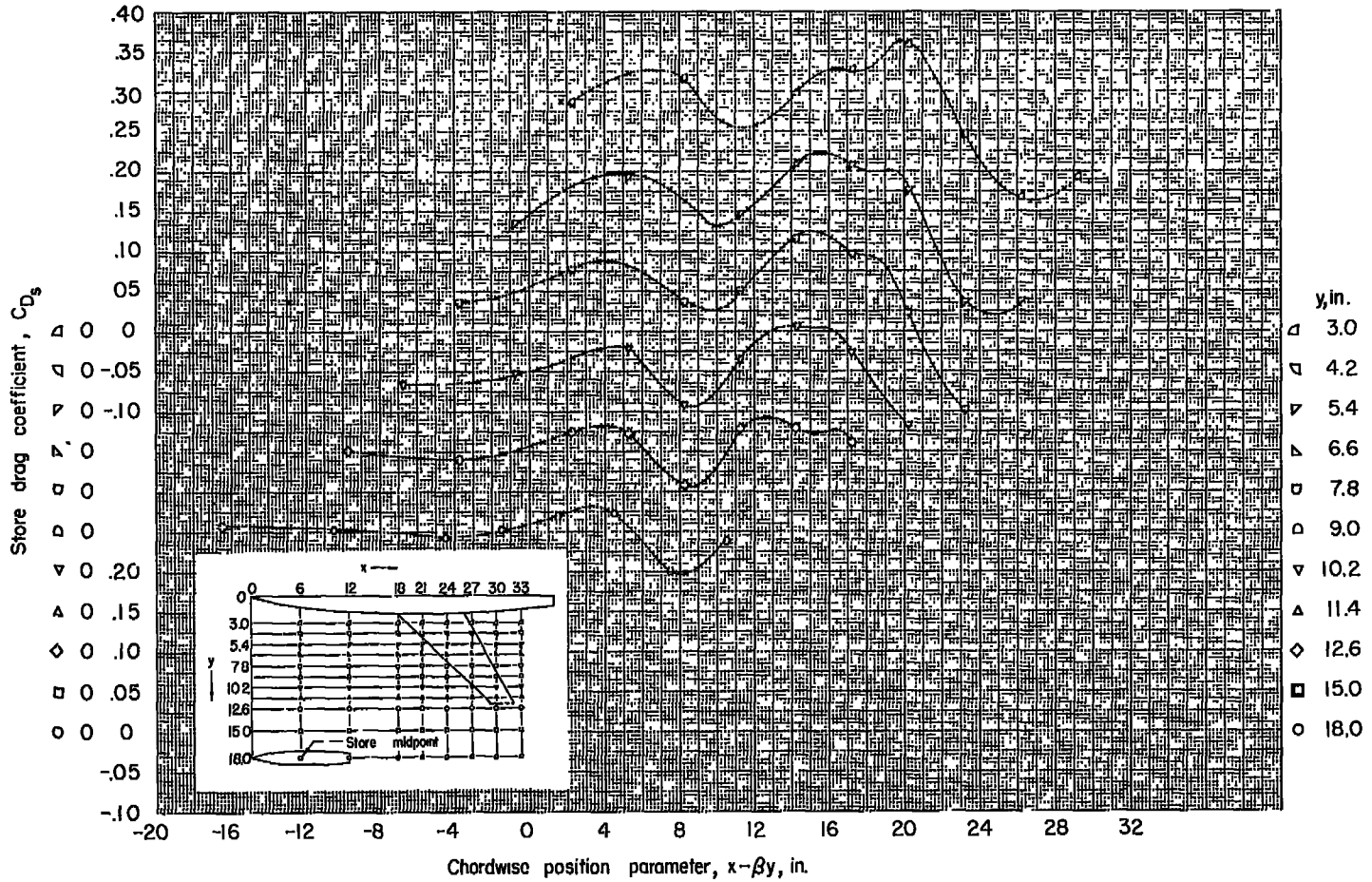


Figure 4.- Lift, drag, and pitching-moment characteristics of the isolated swept wing and isolated fighter-bomber wing-fuselage combination. M = 1.61.



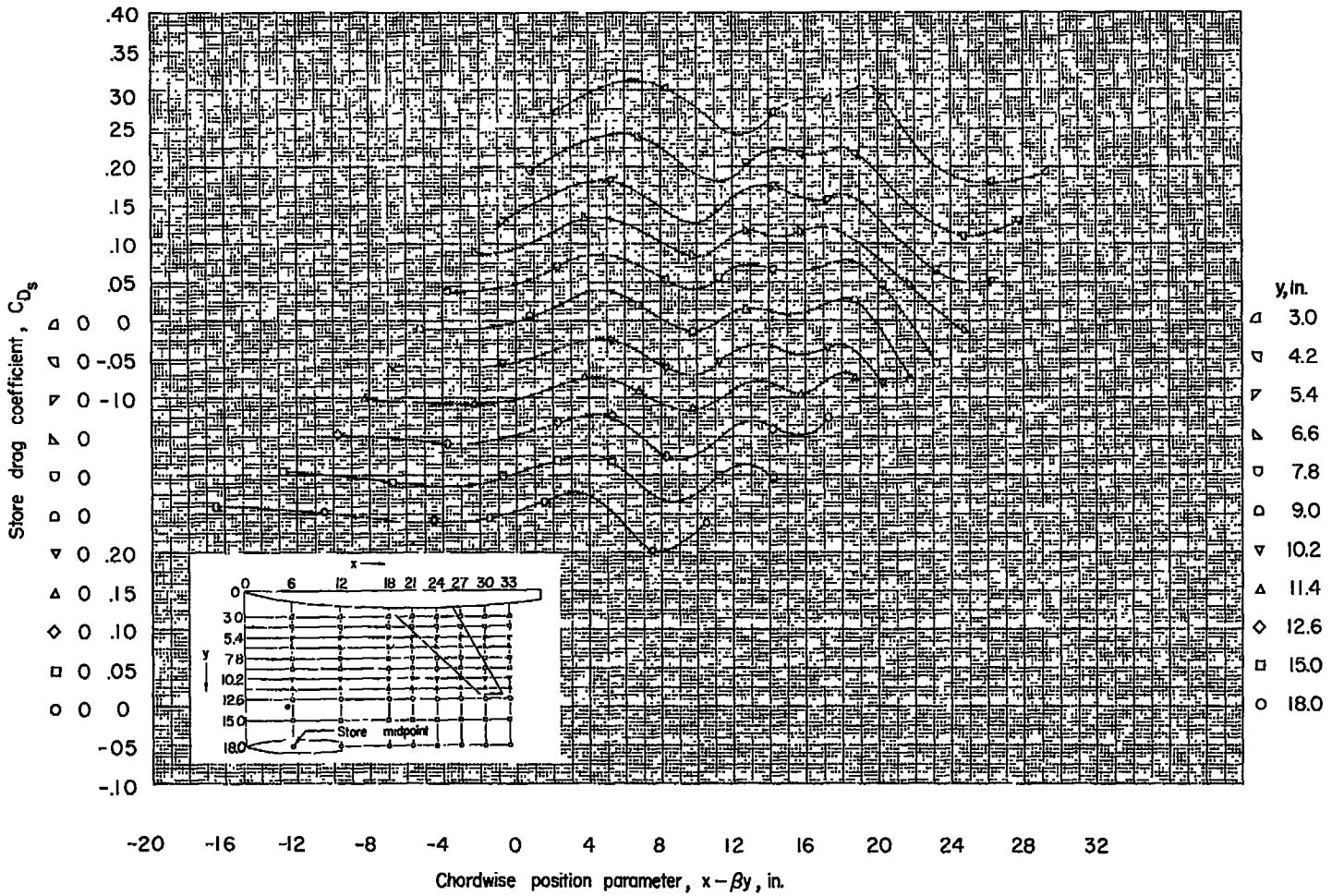
(a) $z = 1.15$ inches; $\alpha = 0^{\circ}$.

Figure 5.- Drag of large store in presence of wing-fuselage combination. (Drag corrected for base pressure.) $M = 1.61$.



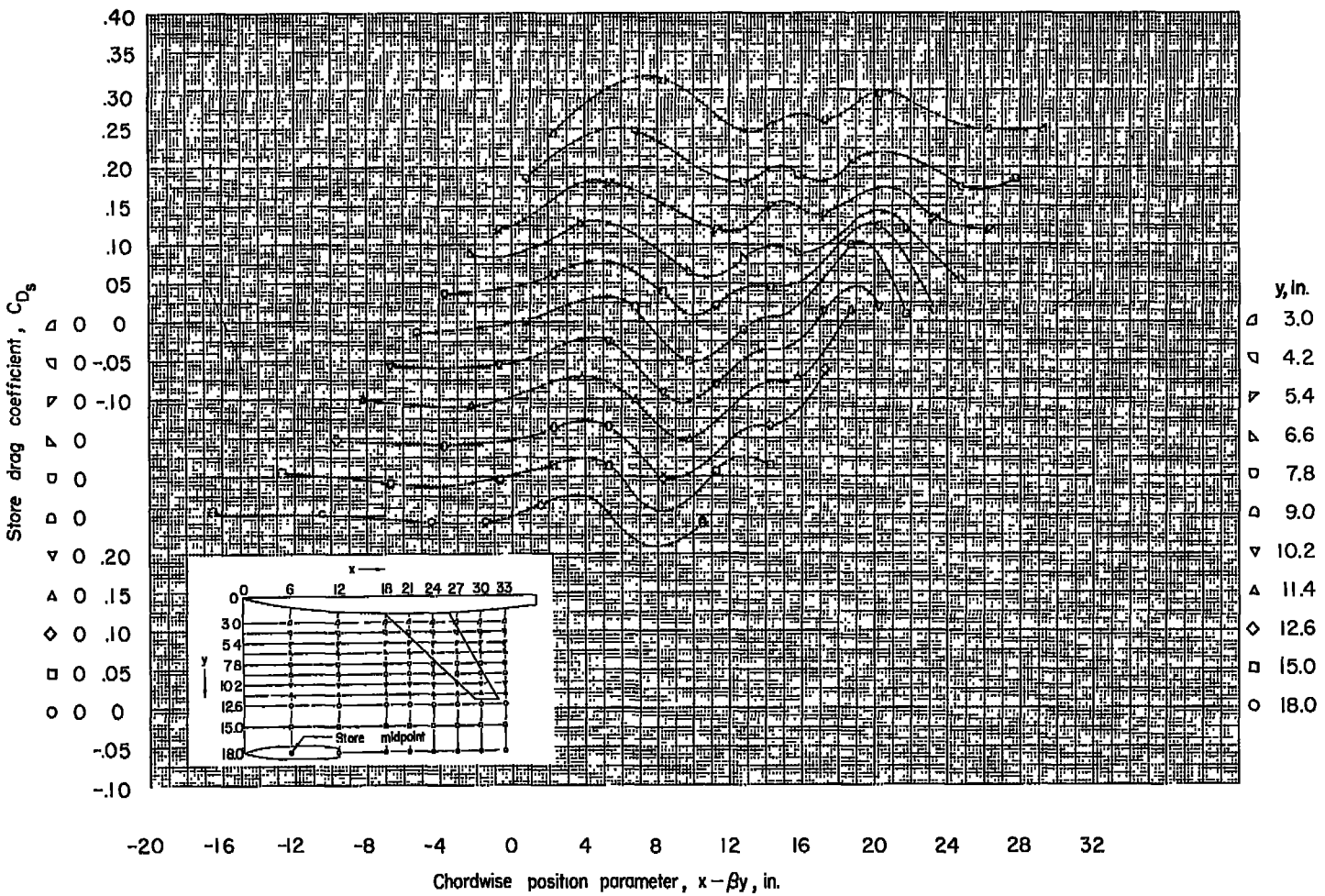
(b) z = 1.67 inches; $\alpha = 0^{\circ}$.

Figure 5.- Continued.



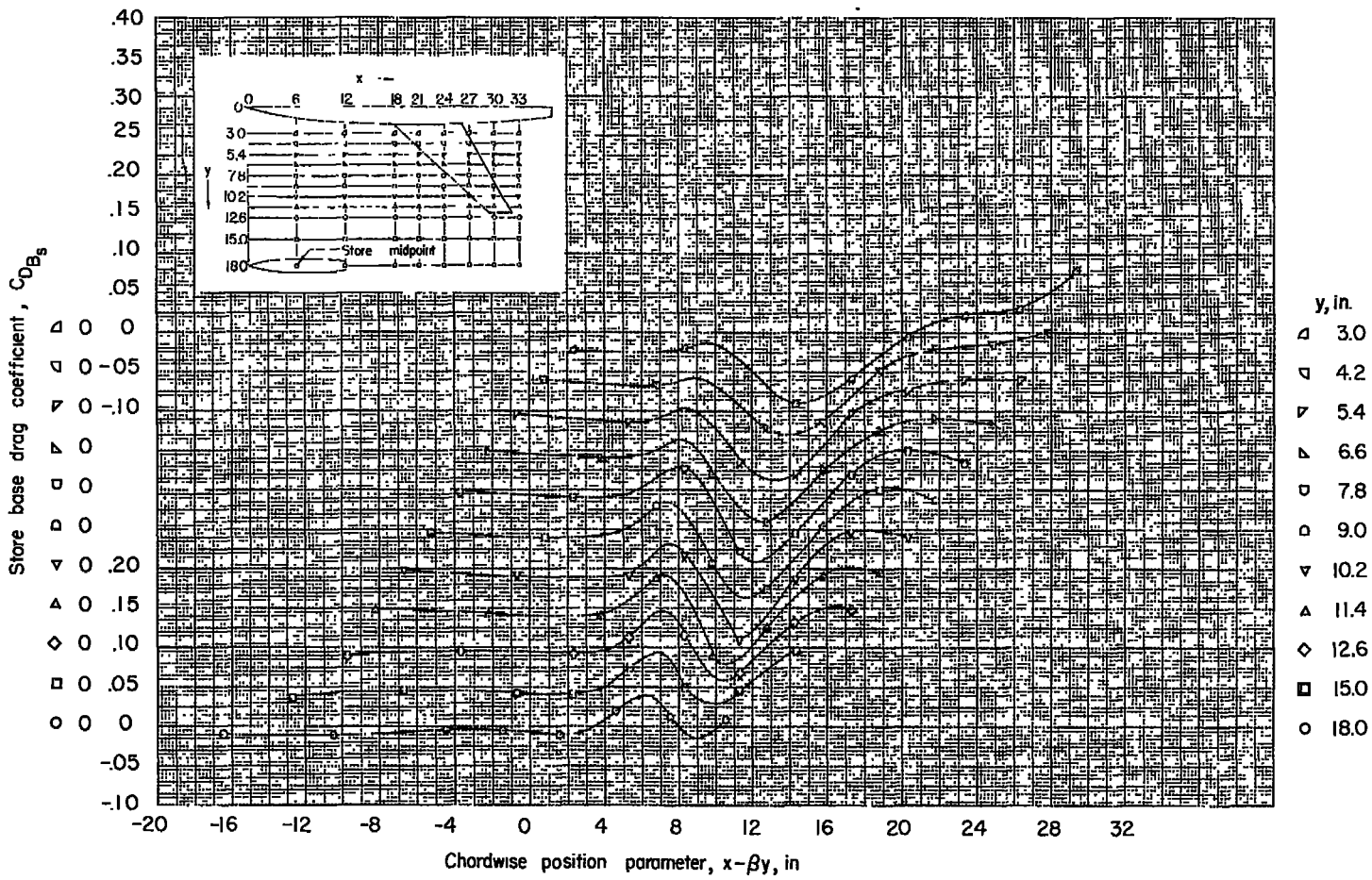
(c) $z = 2.09$ inches; $\alpha = 0^{\circ}$.

Figure 5.- Continued.



(d) z = 2.09 inches; $\alpha = 4^{\circ}$.

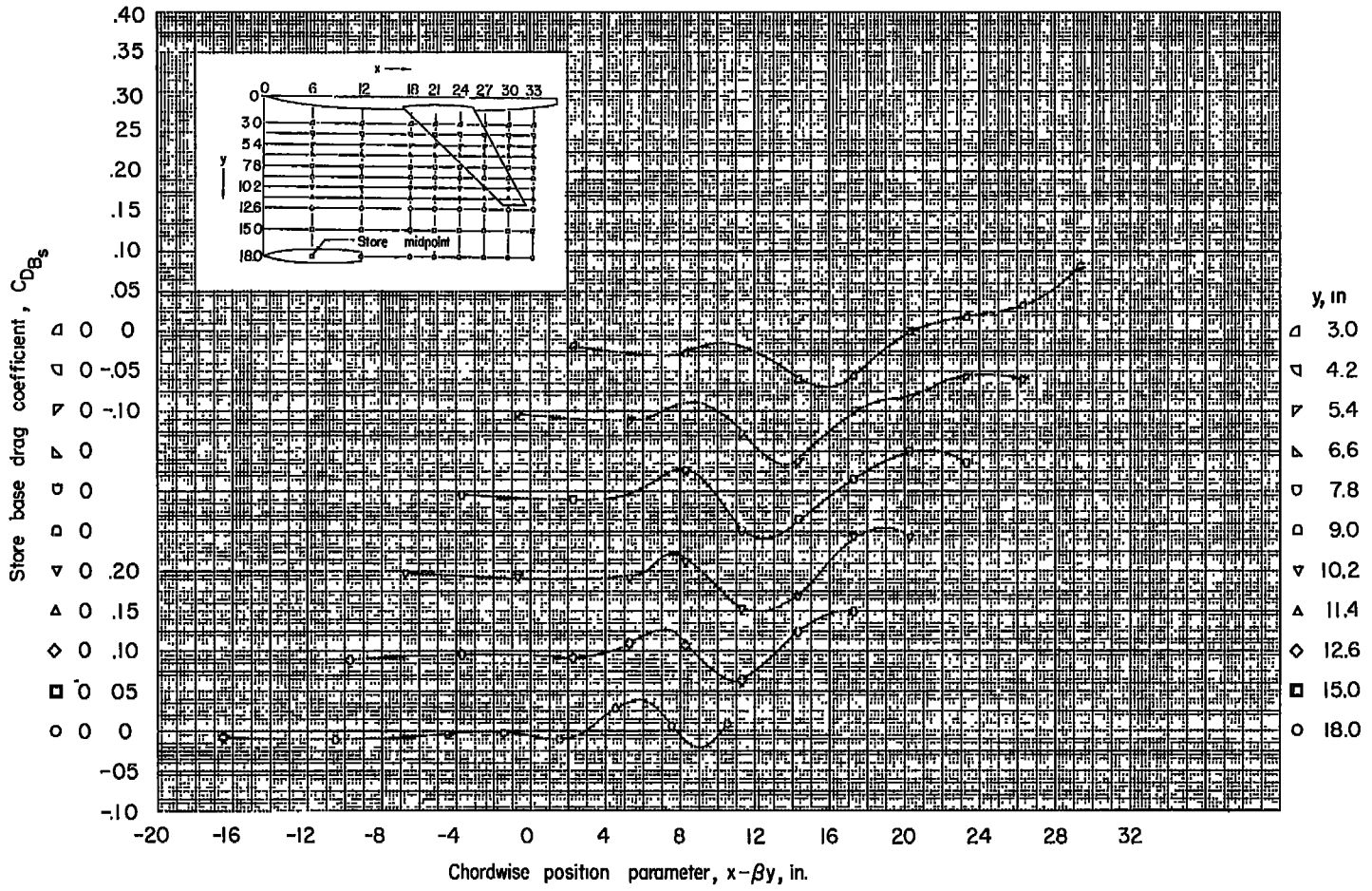
Figure 5.- Concluded.



(a) z = 1.15 inches; $\alpha = 0^{\circ}$.

Figure 6.- Base drag of large store in presence of wing-fuselage combination. M = 1.61.

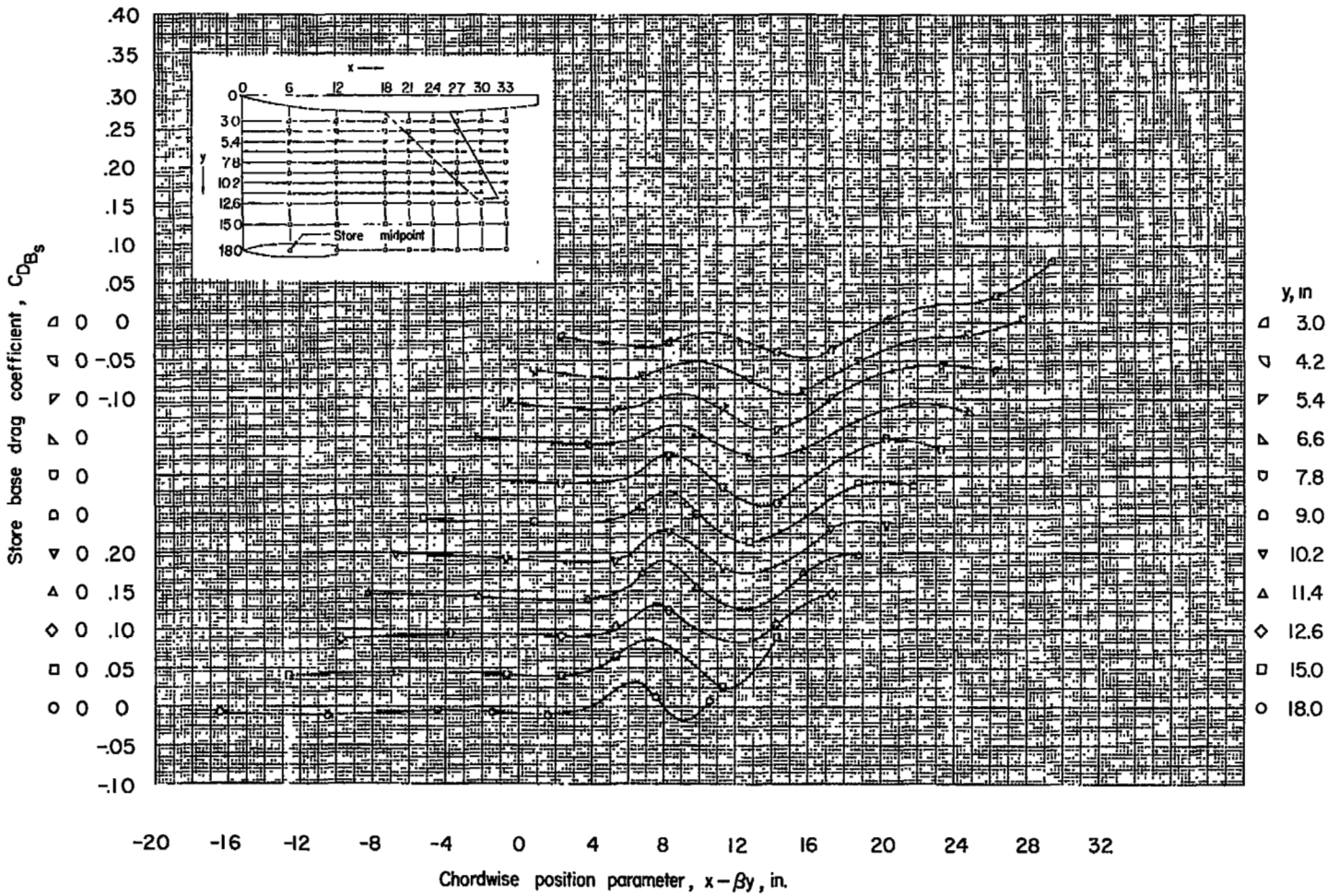
[redacted]



(b) z = 1.67 inches; $\alpha = 0^{\circ}$.

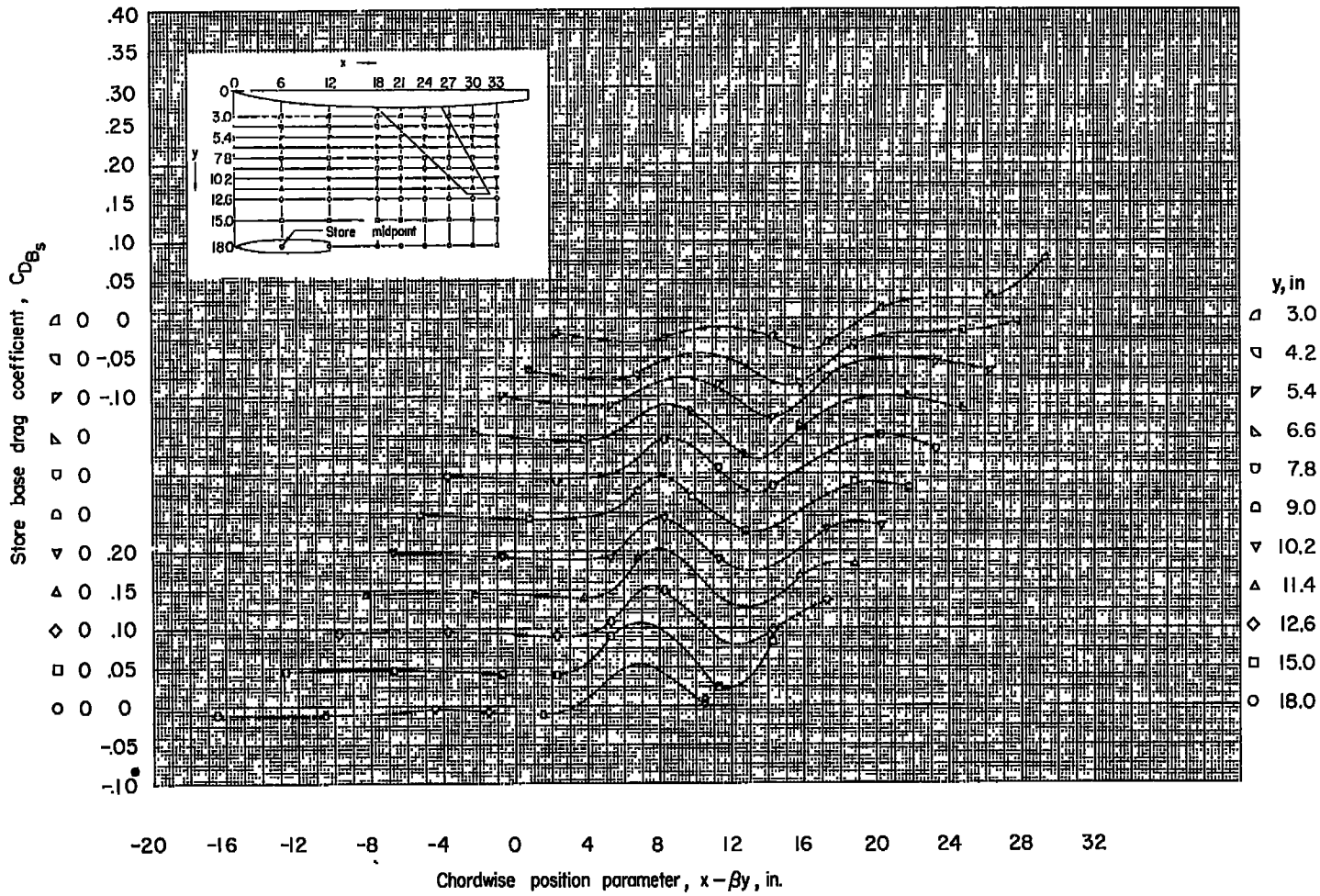
Figure 6.- Continued.

CONFIDENTIAL



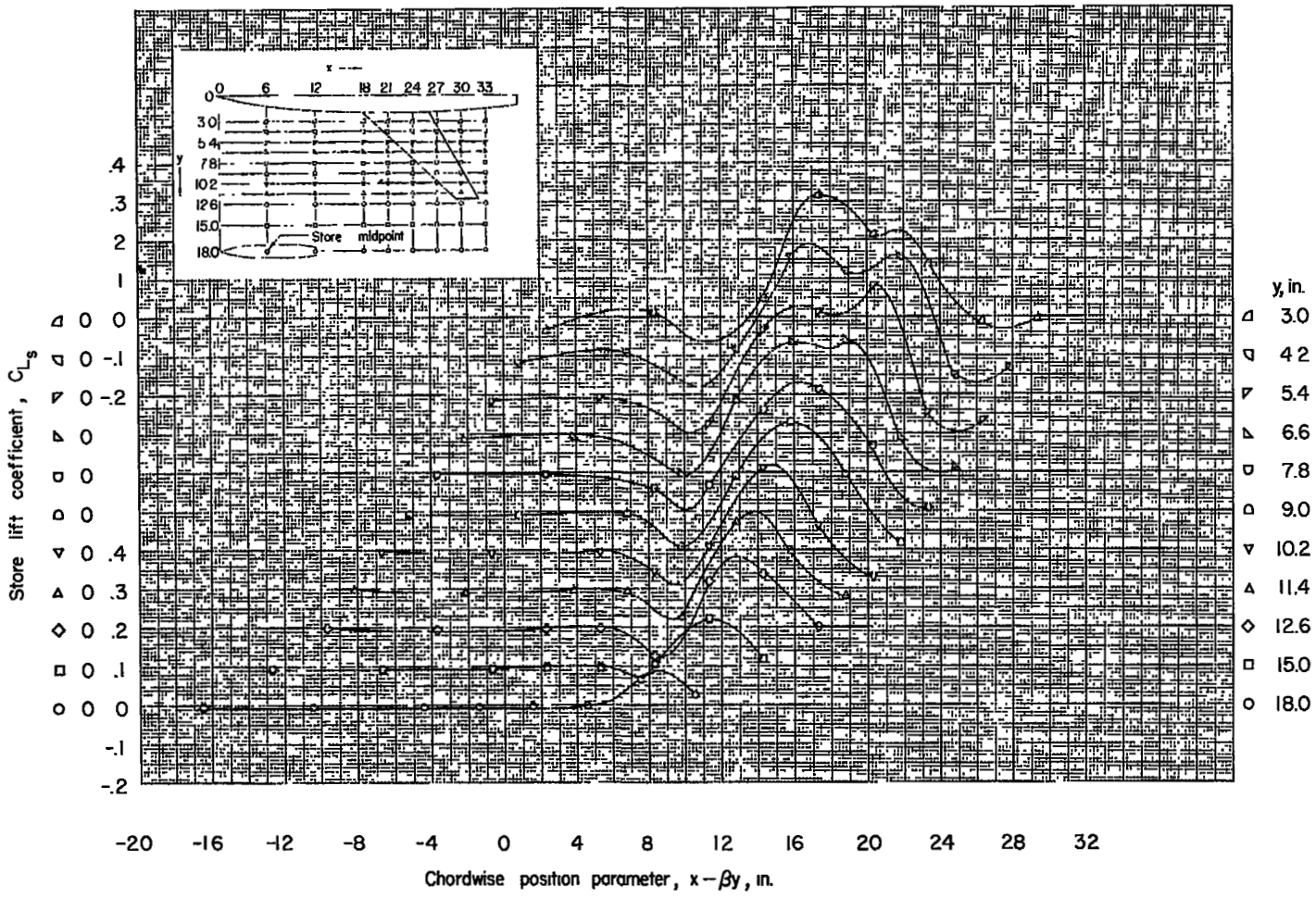
(c) z = 2.09 inches; $\alpha = 0^{\circ}$.

Figure 6.- Continued.



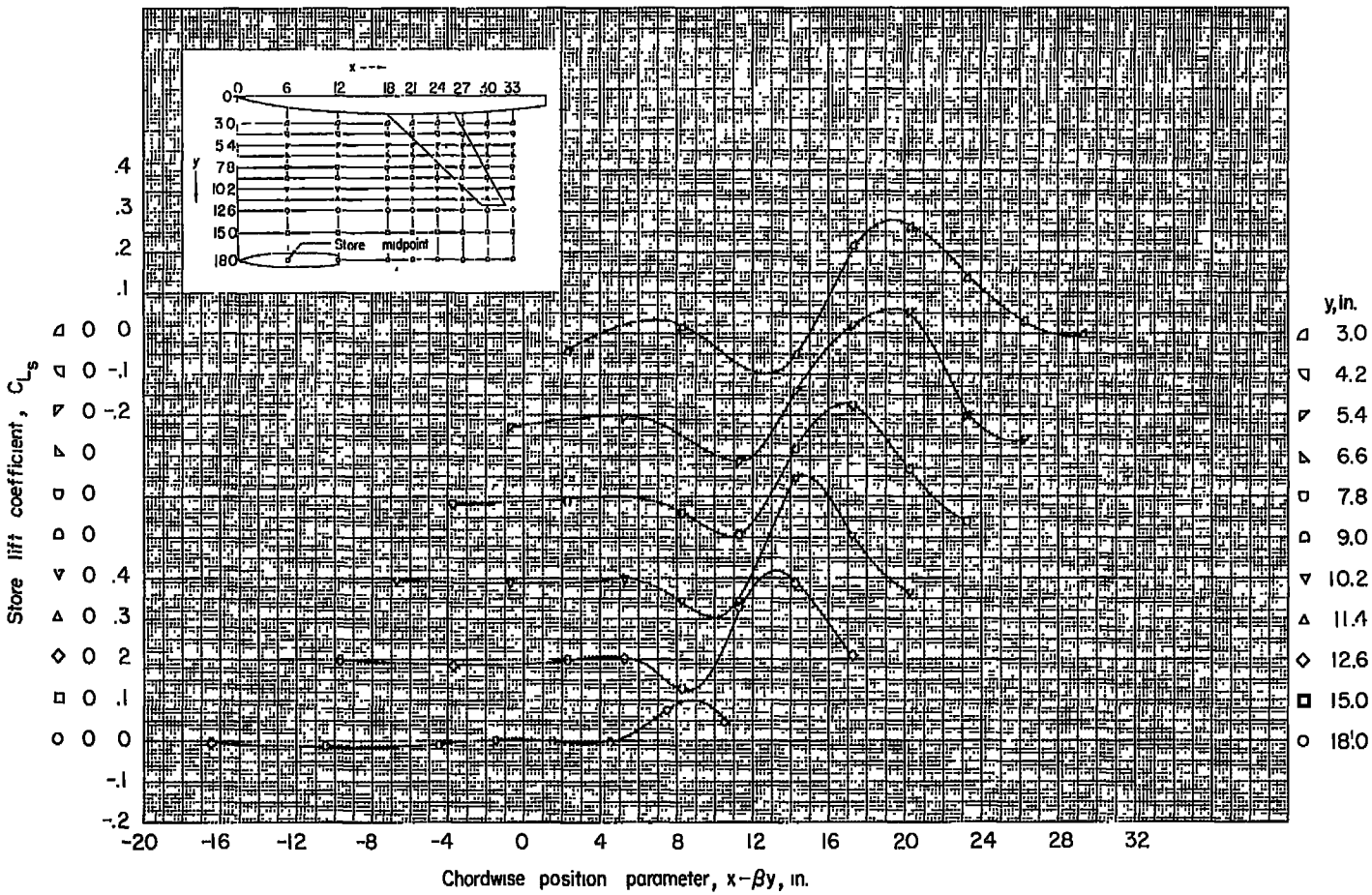
(d) z = 2.09 inches; $\alpha = 4^{\circ}$.

Figure 6.- Concluded.



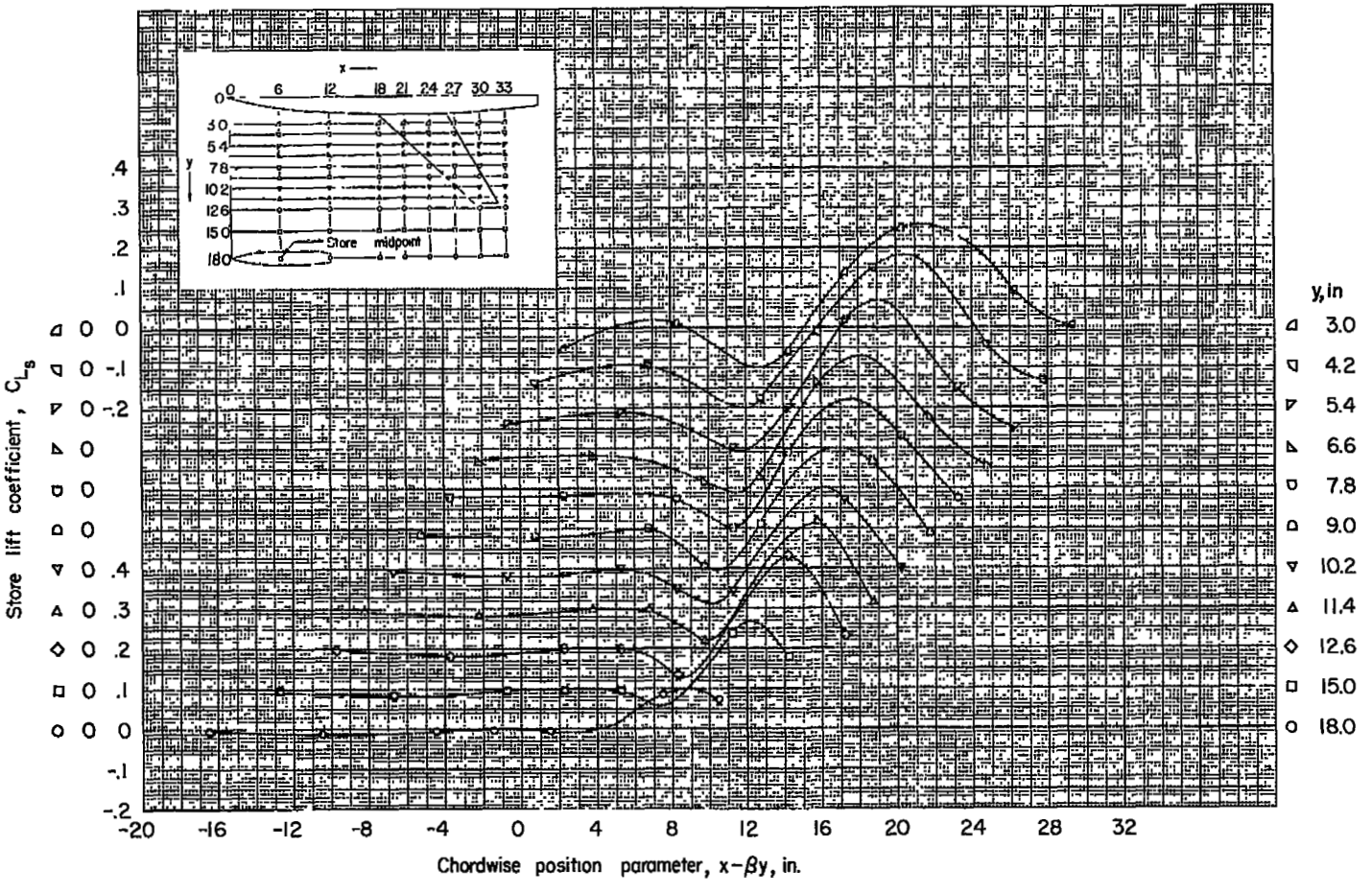
(a) z = 1.15 inches; $\alpha = 0^{\circ}$.

Figure 7.- Lift of large store in presence of wing-fuselage combination. M = 1.61.



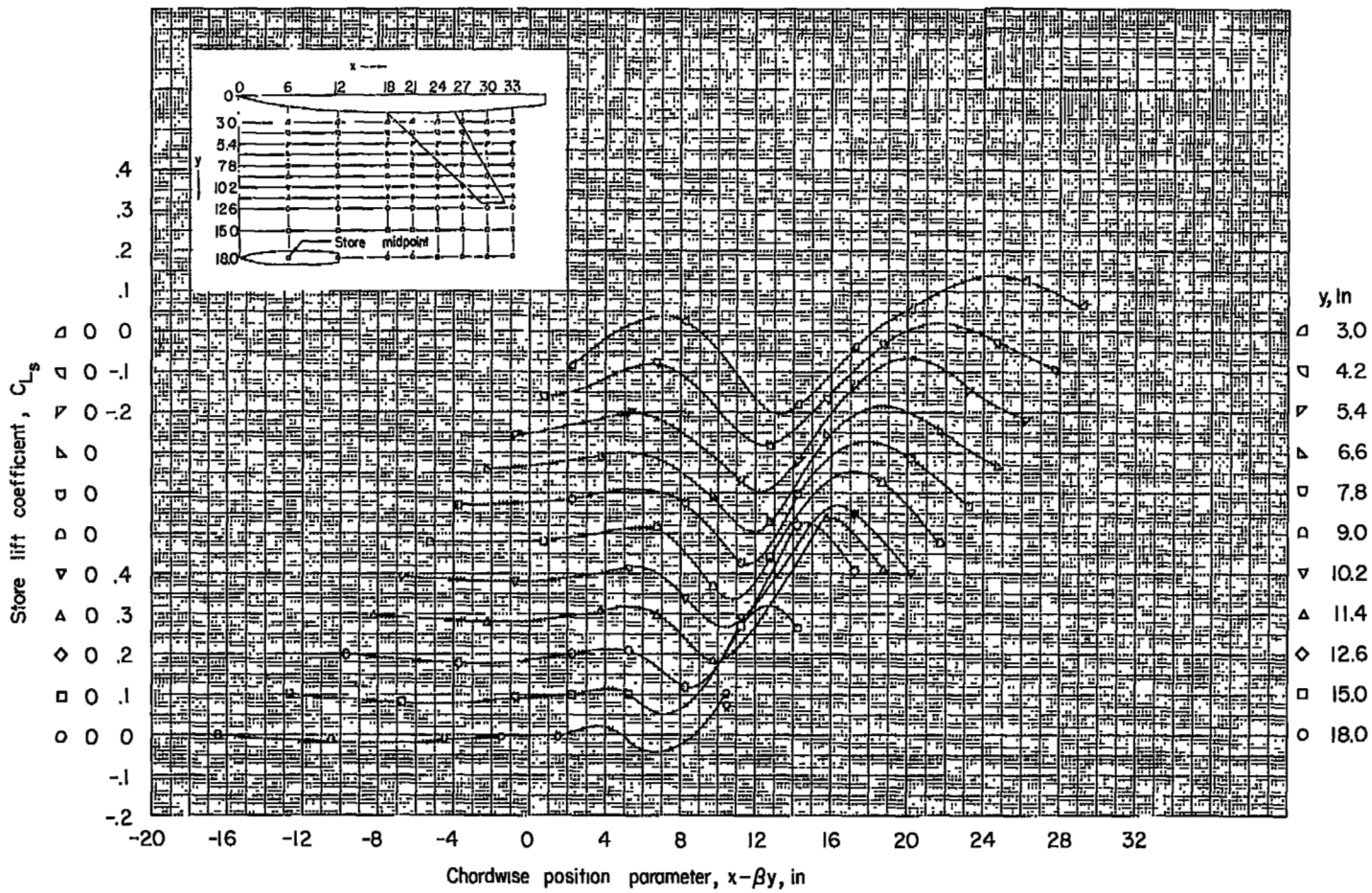
(b) z = 1.67 inches; $\alpha = 0^{\circ}$.

Figure 7.- Continued.



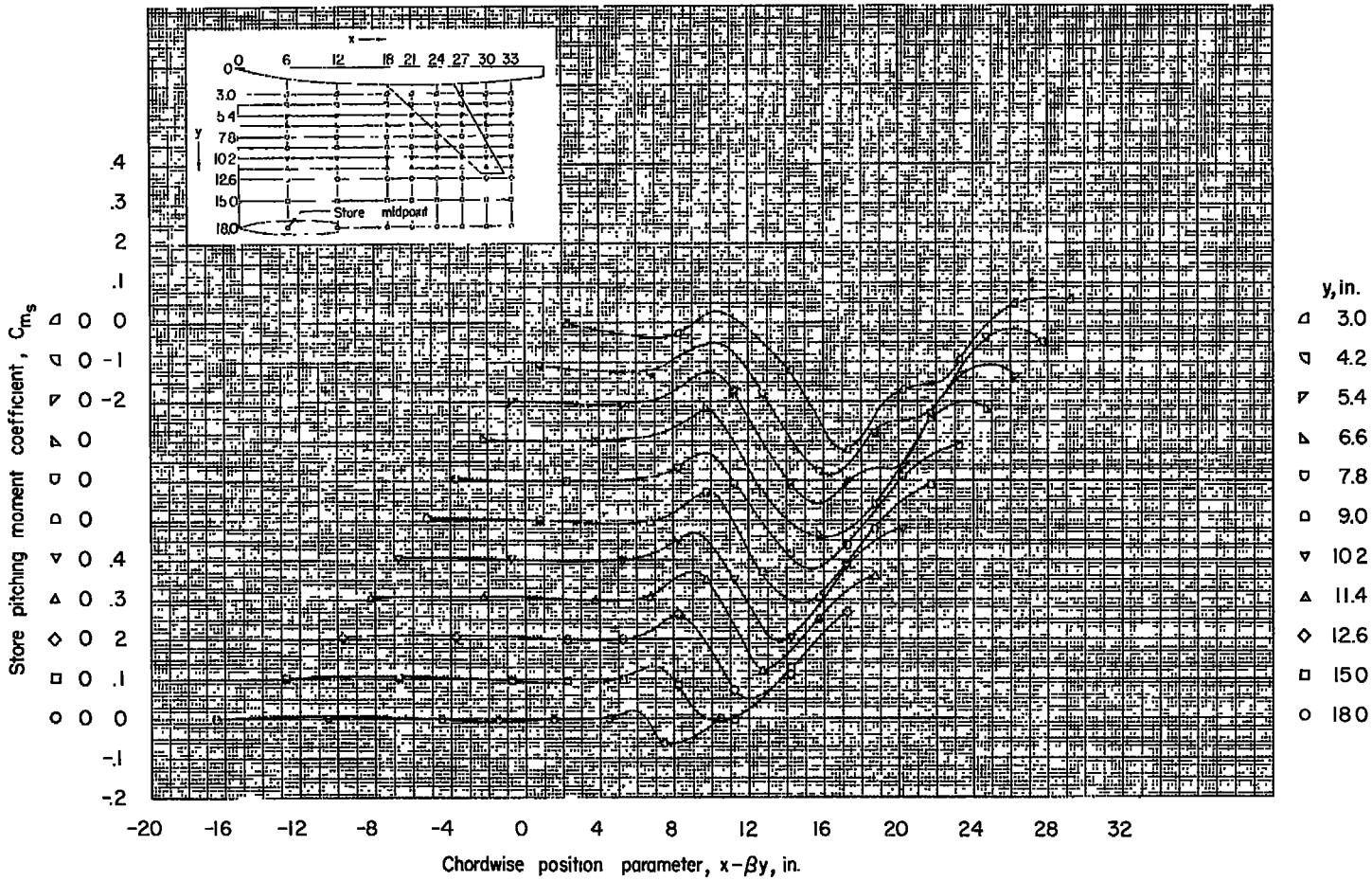
(c) z = 2.09 inches; $\alpha = 0^{\circ}$.

Figure 7.- Continued.



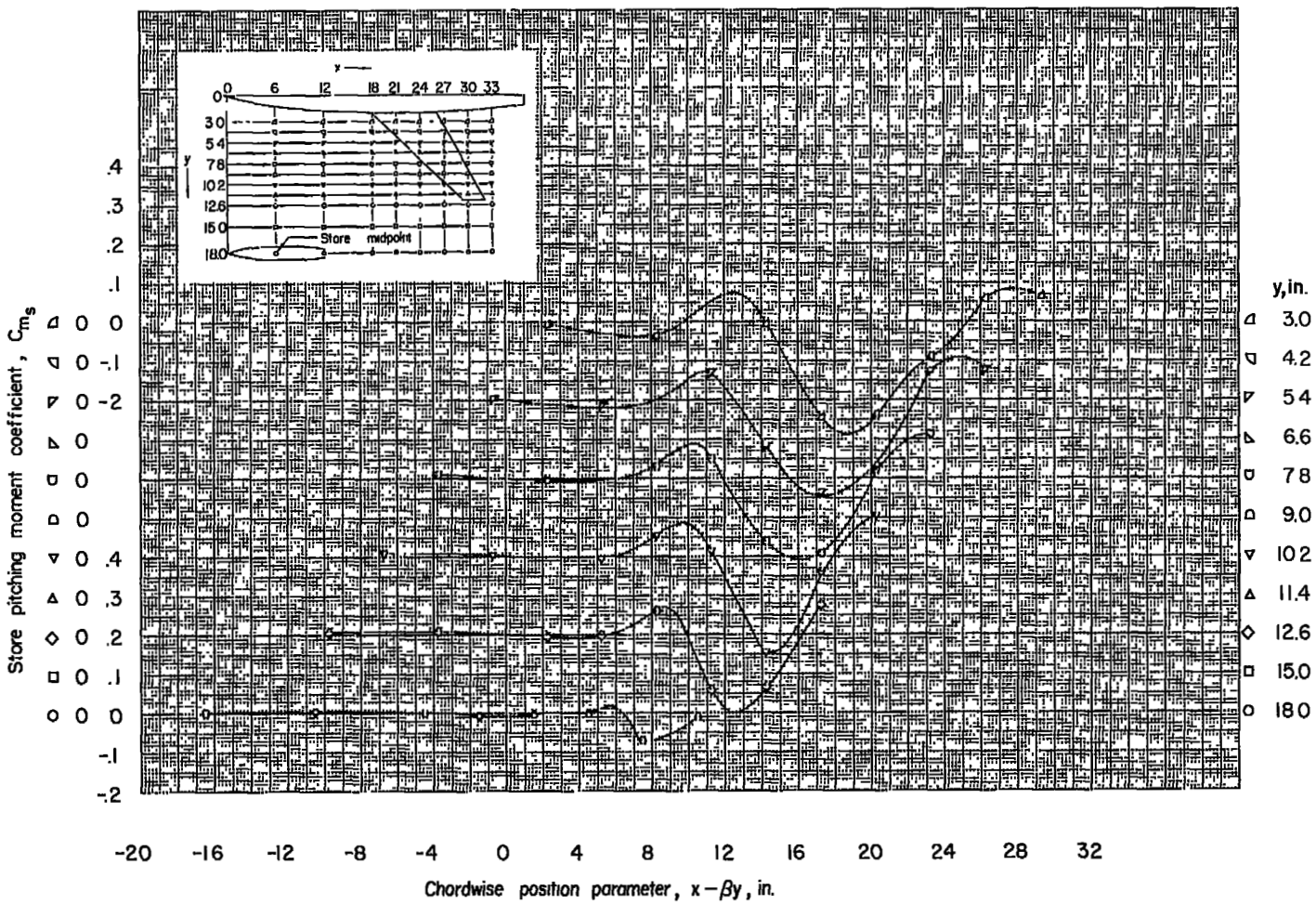
(d) z = 2.09 inches; $\alpha = 4^{\circ}$.

Figure 7.- Concluded.



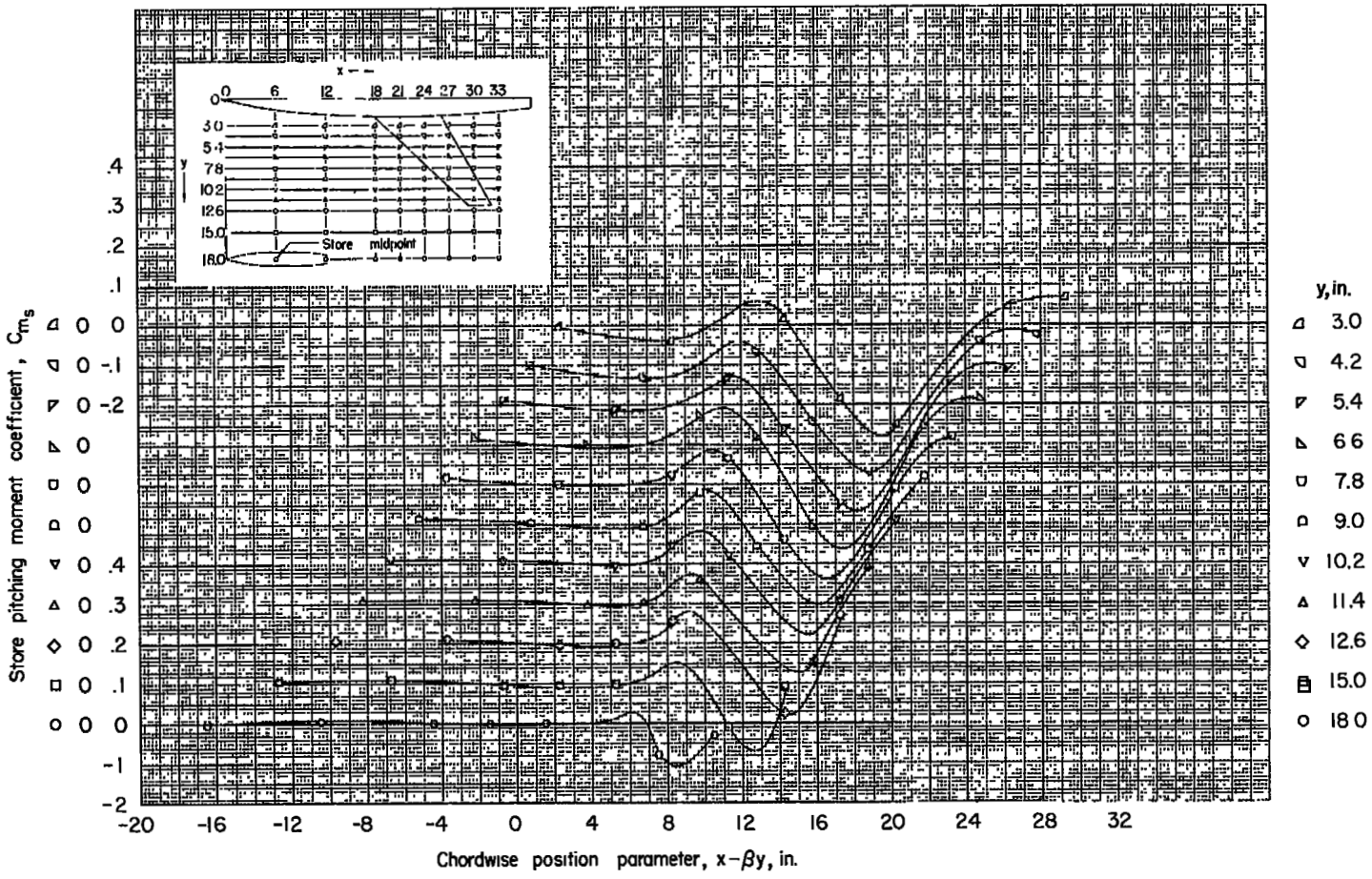
(a) z = 1.15 inches; α = 0°.

Figure 8.- Pitching moment of large store in presence of wing-fuselage combination. (Center of moments is store nose.) M = 1.61.



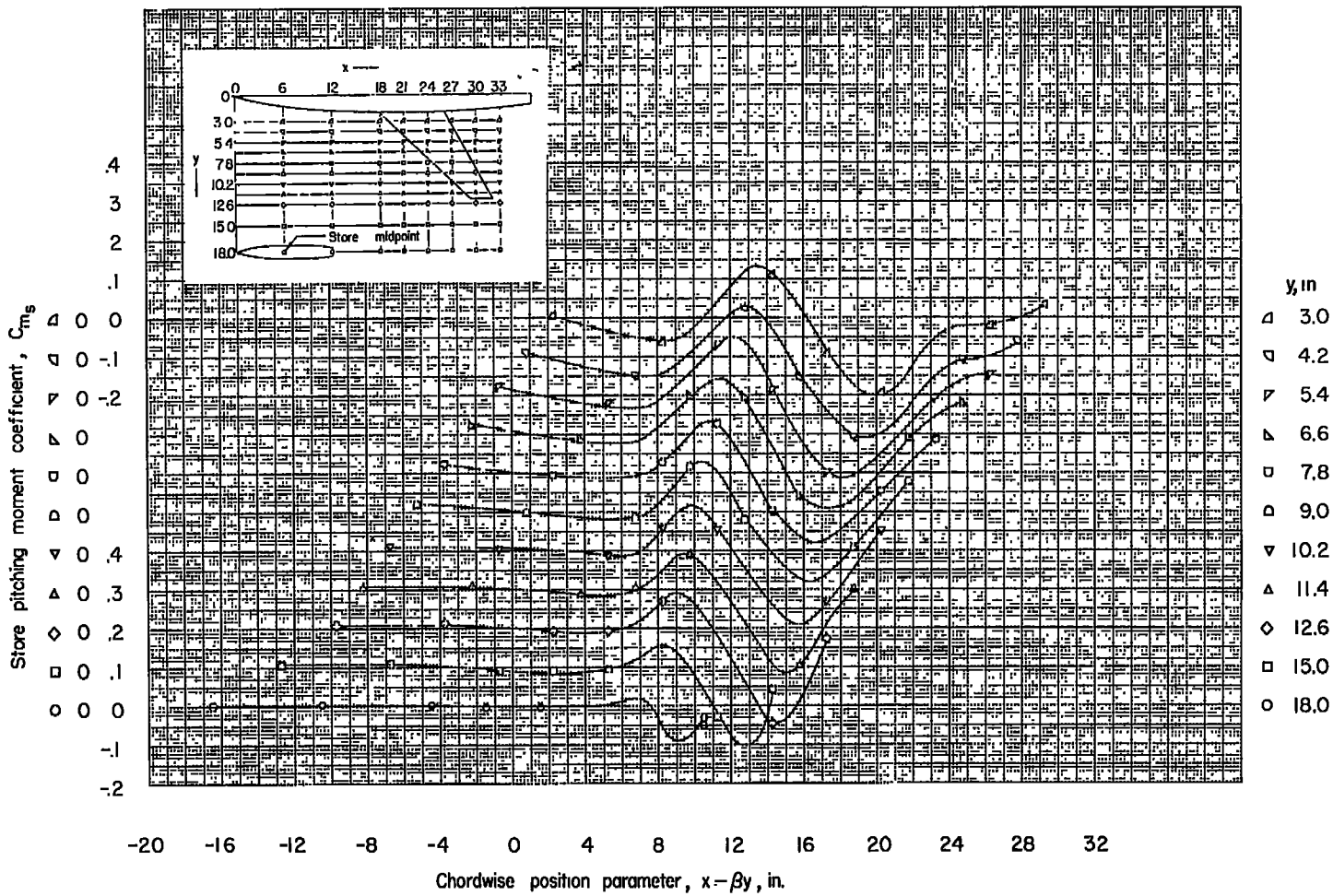
(b) z = 1.67 inches; $\alpha = 0^{\circ}$.

Figure 8.- Continued.



(c) z = 2.09 inches; $\alpha = 0^{\circ}$.

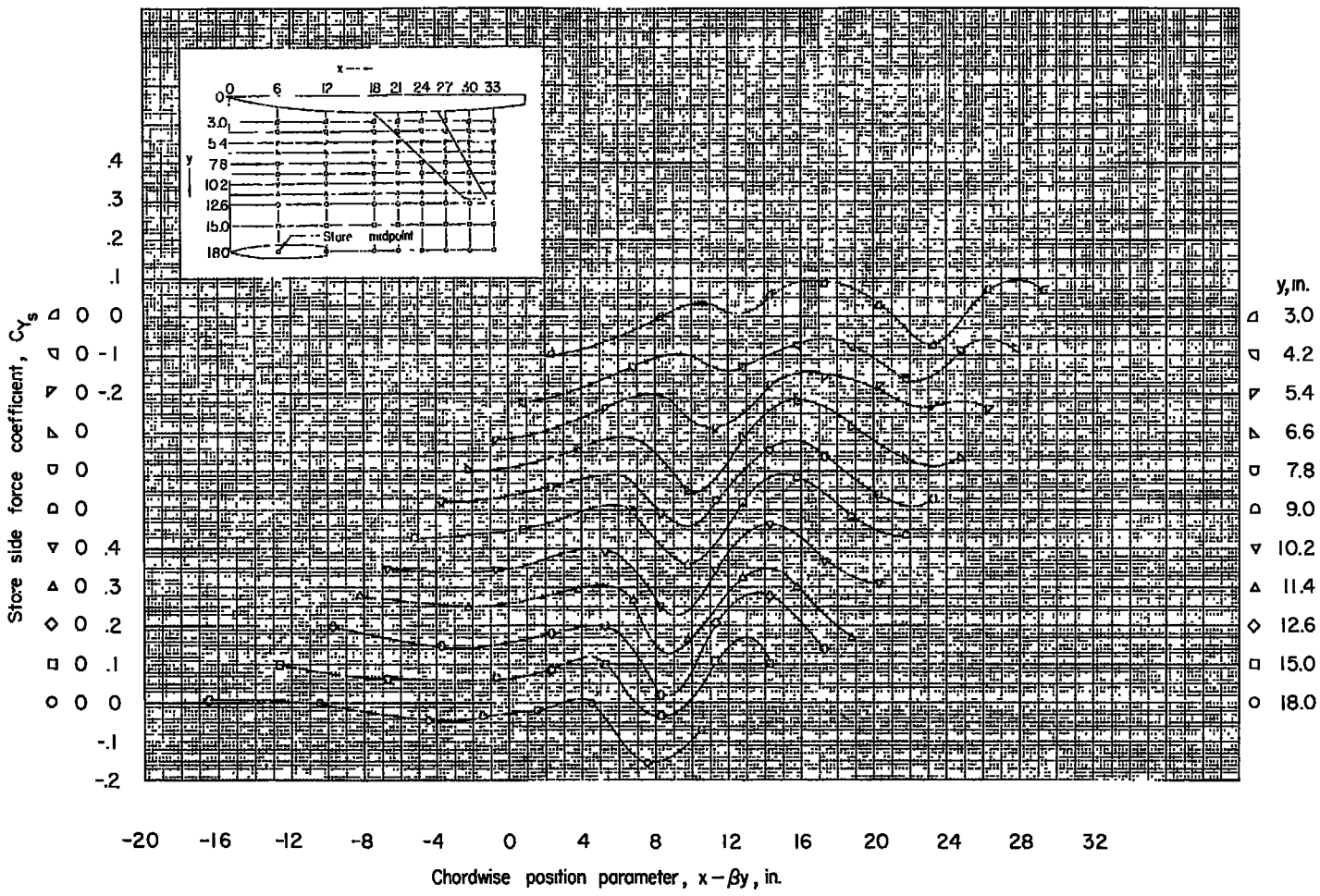
Figure 8.- Continued.



(d) z = 2.09 inches; $\alpha = 4^{\circ}$.

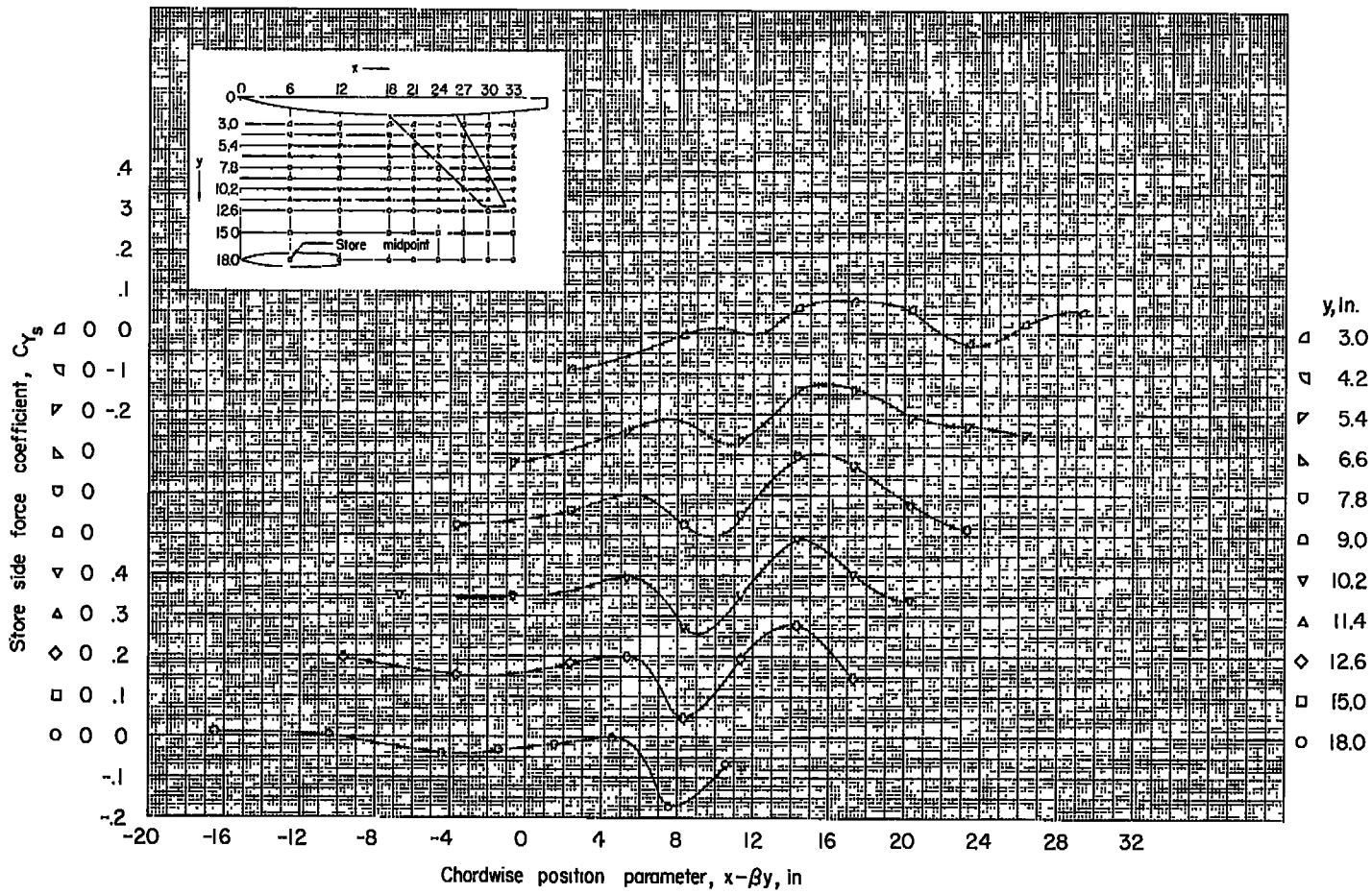
Figure 8.- Concluded.

CONFIDENTIAL



(a) $z = 1.15$ inches; $\alpha = 0^{\circ}$.

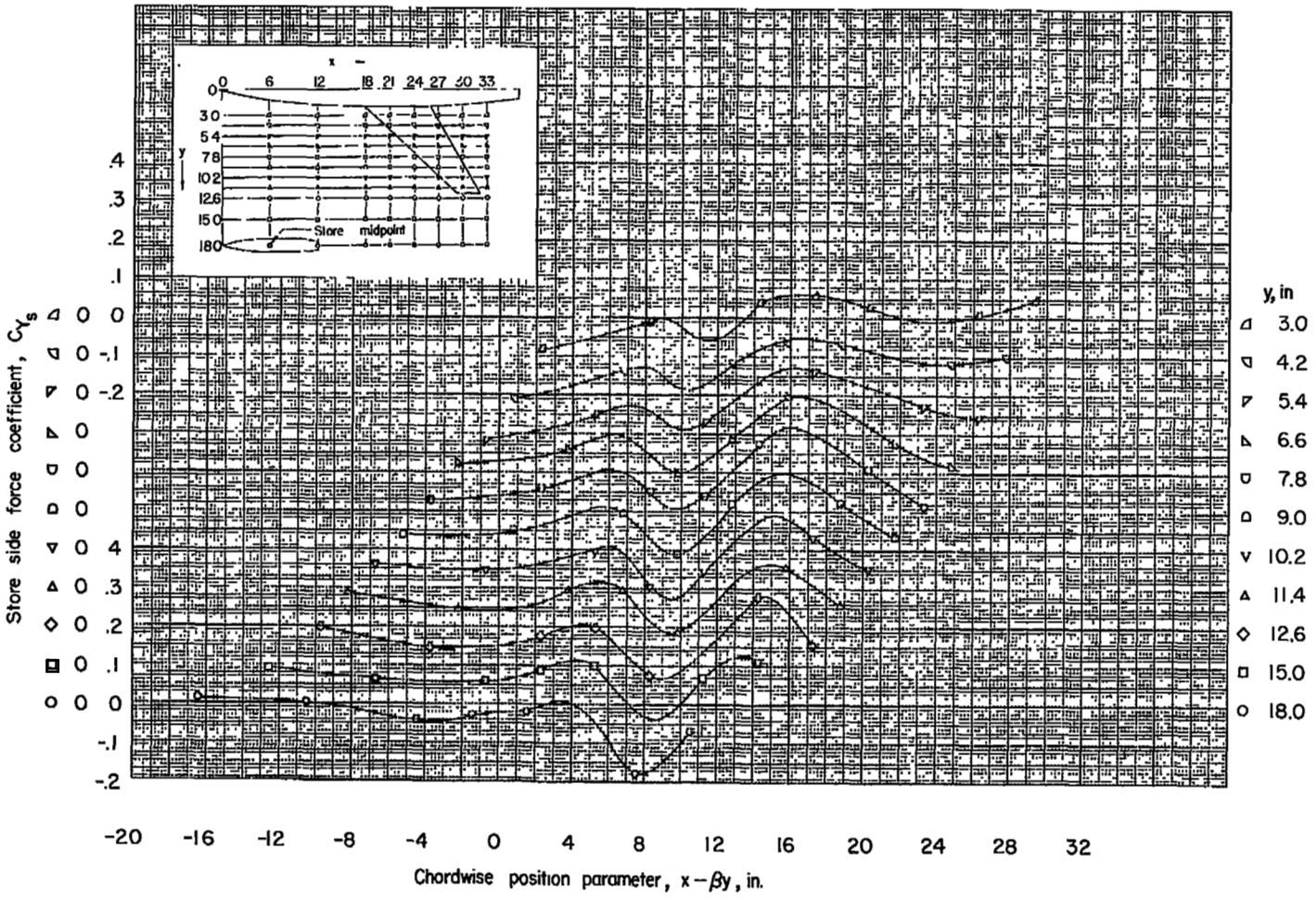
Figure 9.- Side force of large store in presence of wing-fuselage combination. $M = 1.61$.



(b) z = 1.67 inches; $\alpha = 0^{\circ}$.

Figure 9.- Continued.

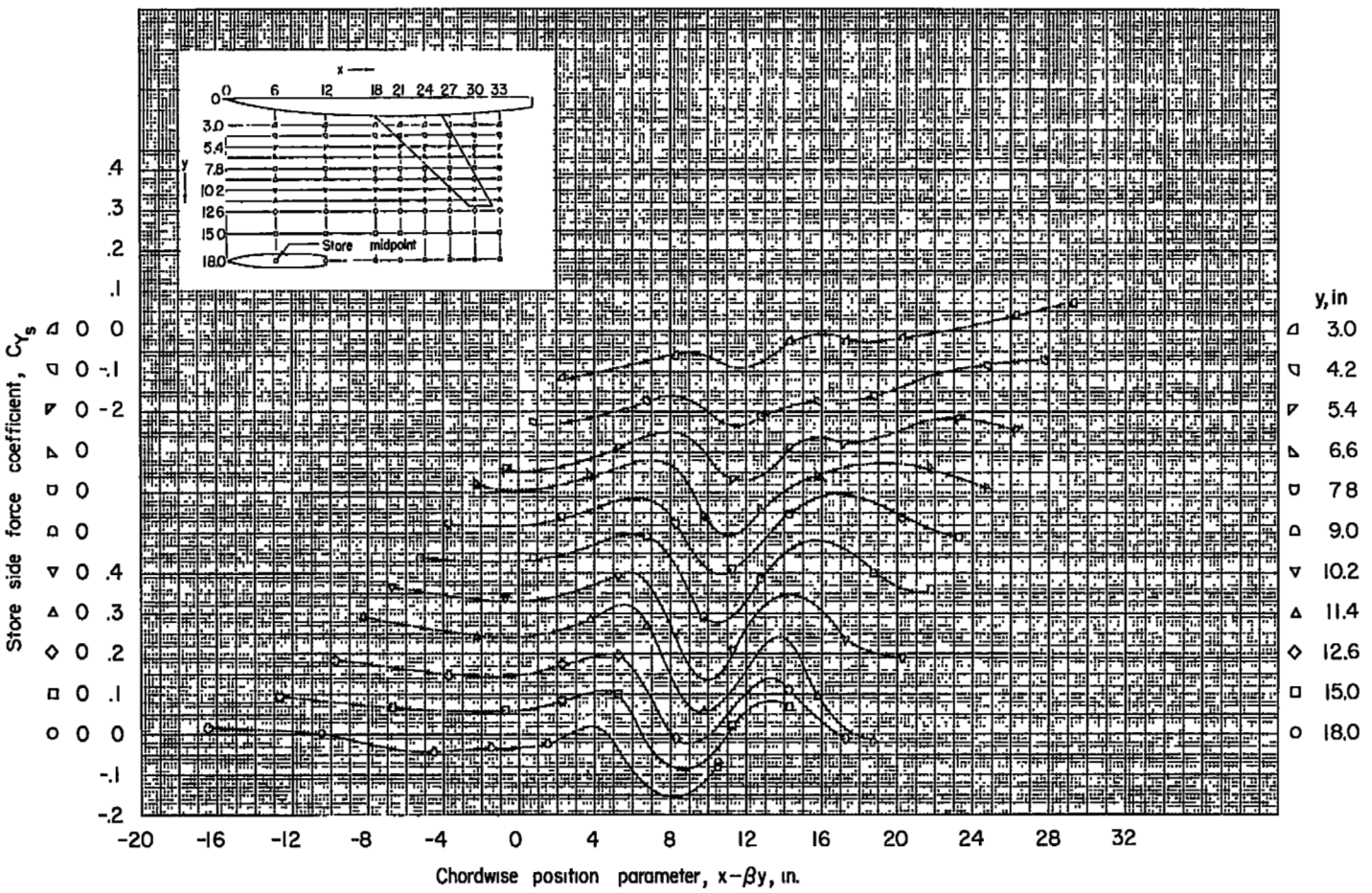
[redacted]



(c) $z = 2.09$ inches; $\alpha = 0^{\circ}$.

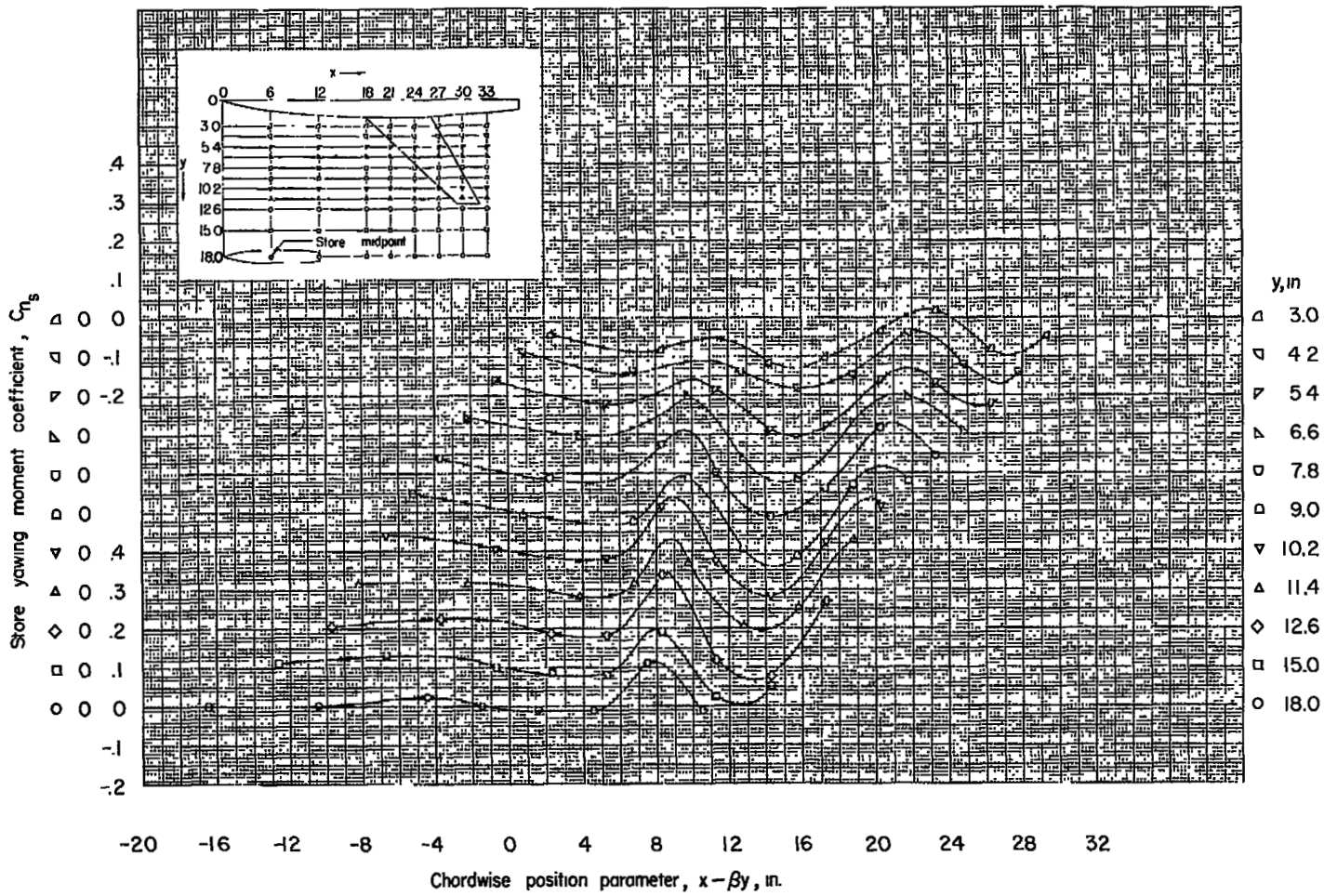
Figure 9.- Continued.

[redacted]



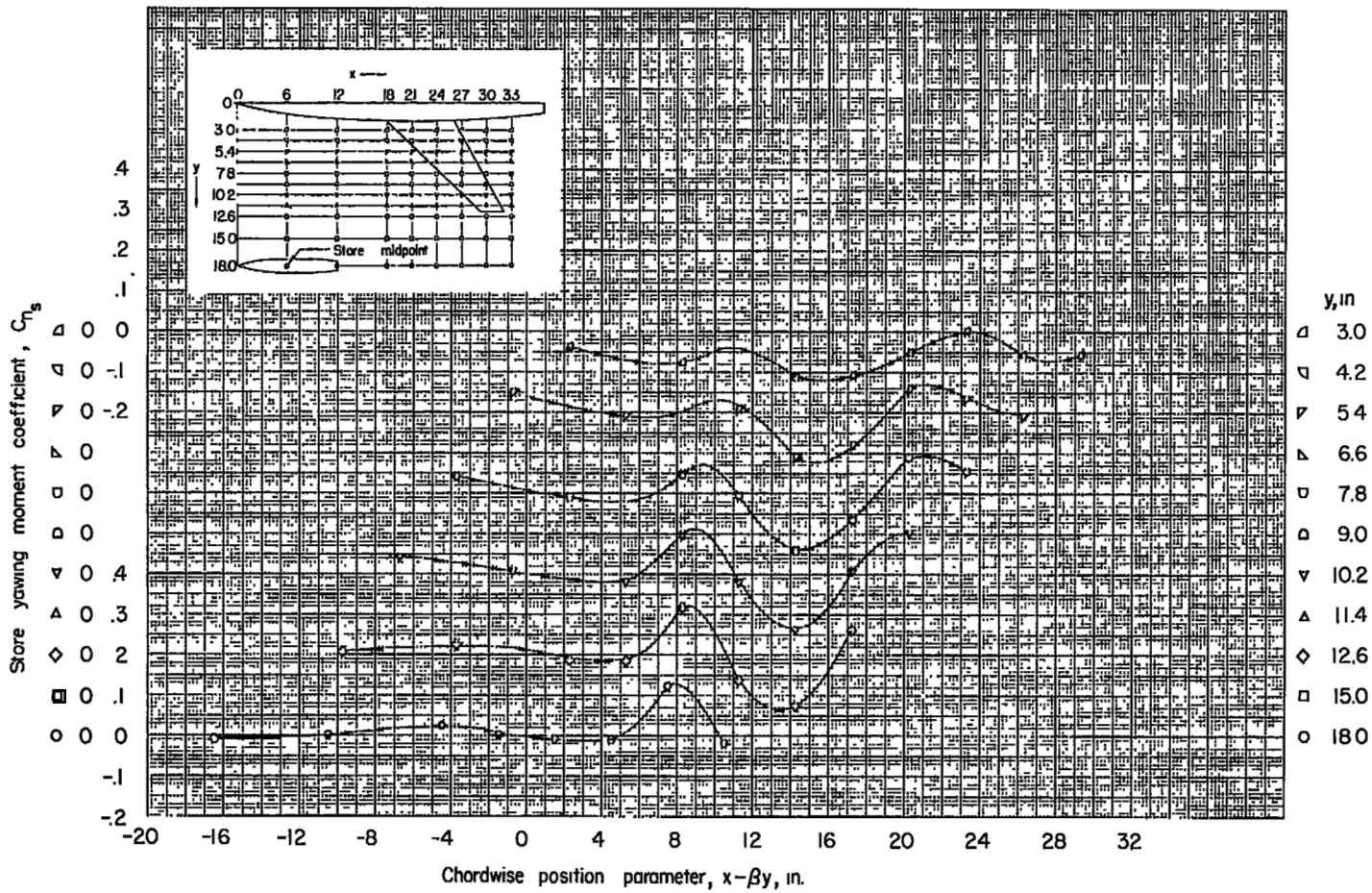
(d) z = 2.09 inches; $\alpha = 4^{\circ}$.

Figure 9.- Concluded.



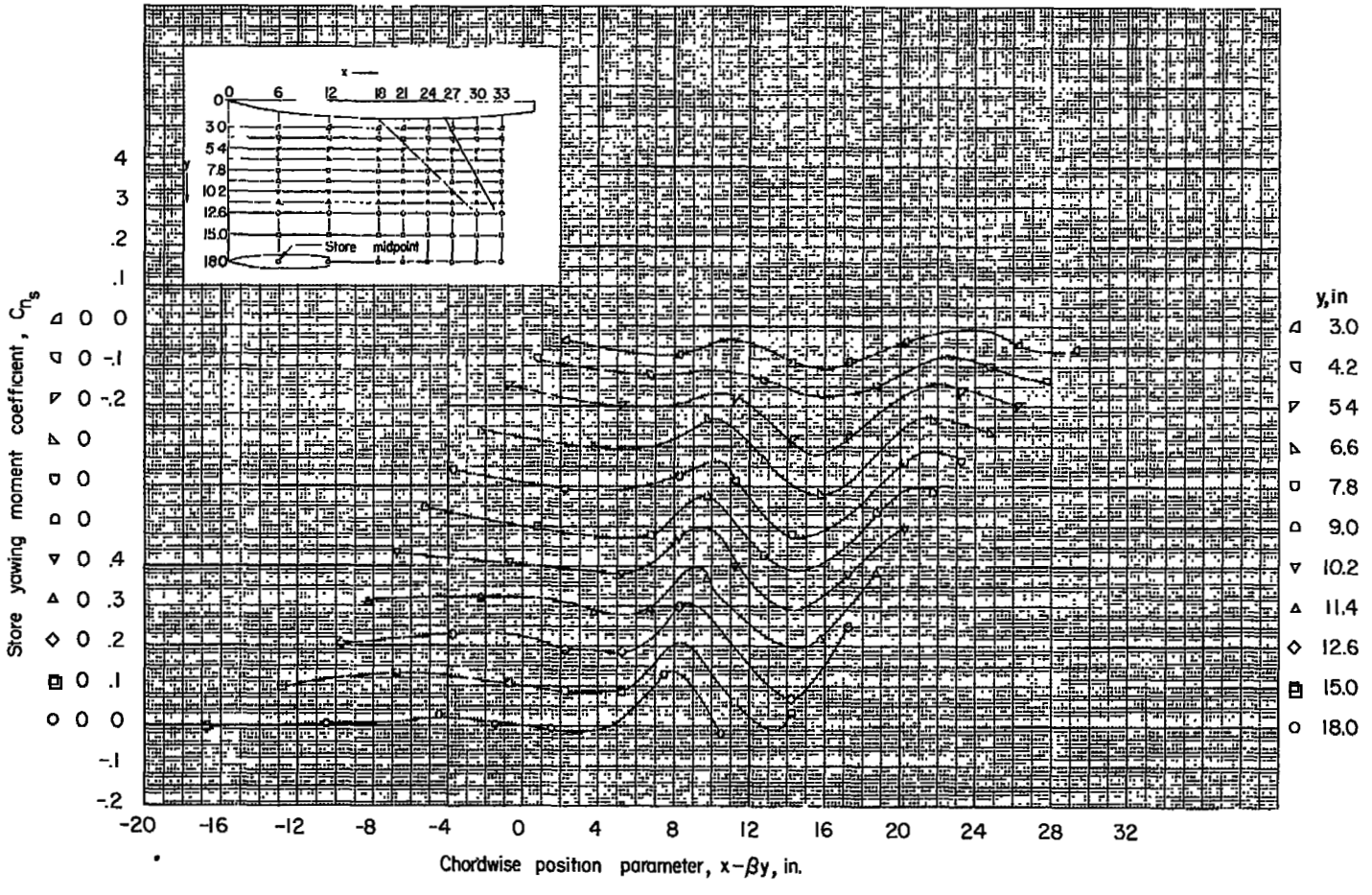
(a) z = 1.15 inches; $\alpha = 0^{\circ}$.

Figure 10.- Yawing moment of large store in presence of wing-fuselage combination. (Center of moments is store nose.) M = 1.61.



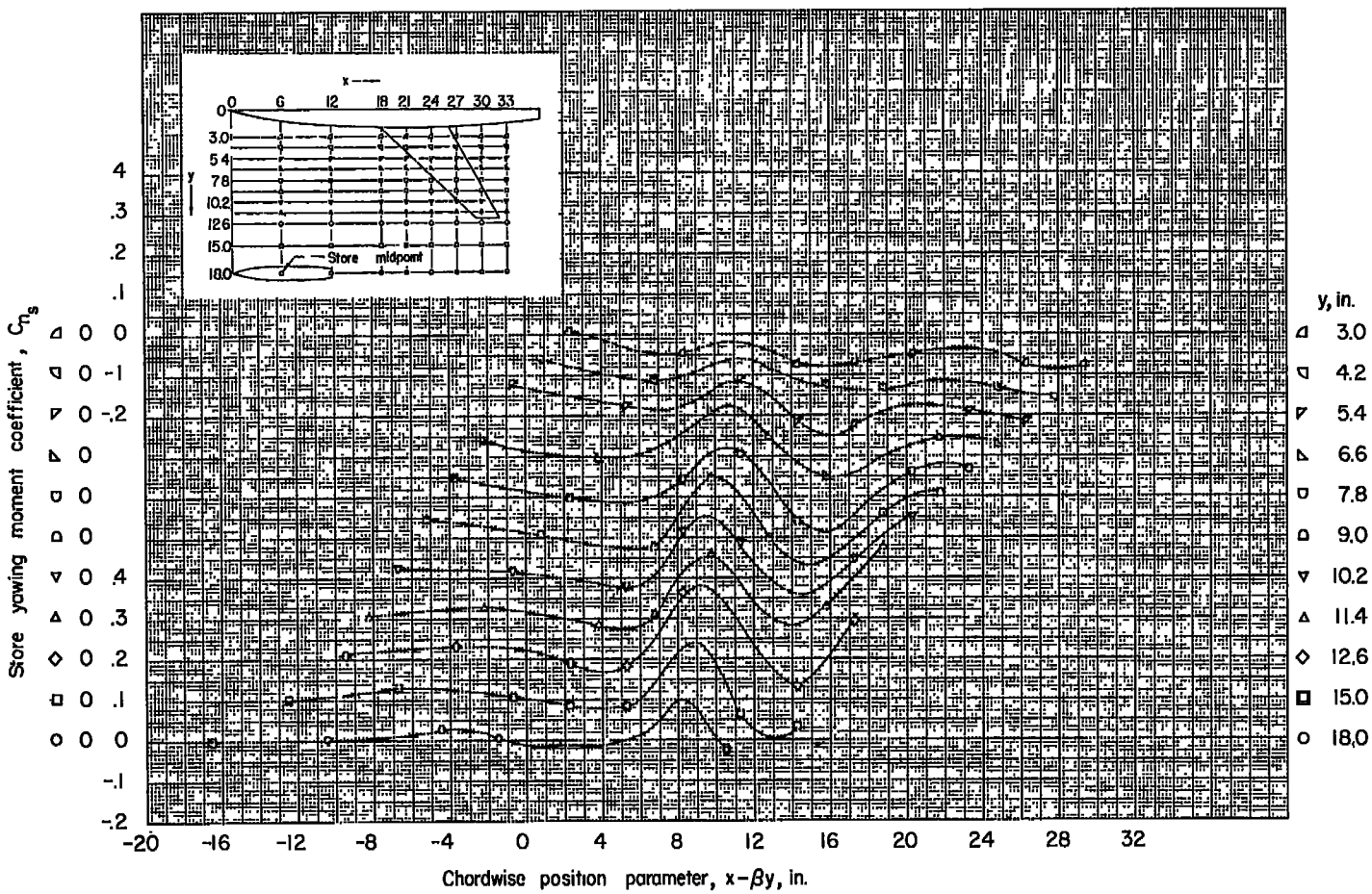
(b) z = 1.67 inches; $\alpha = 0^{\circ}$.

Figure 10.- Continued.



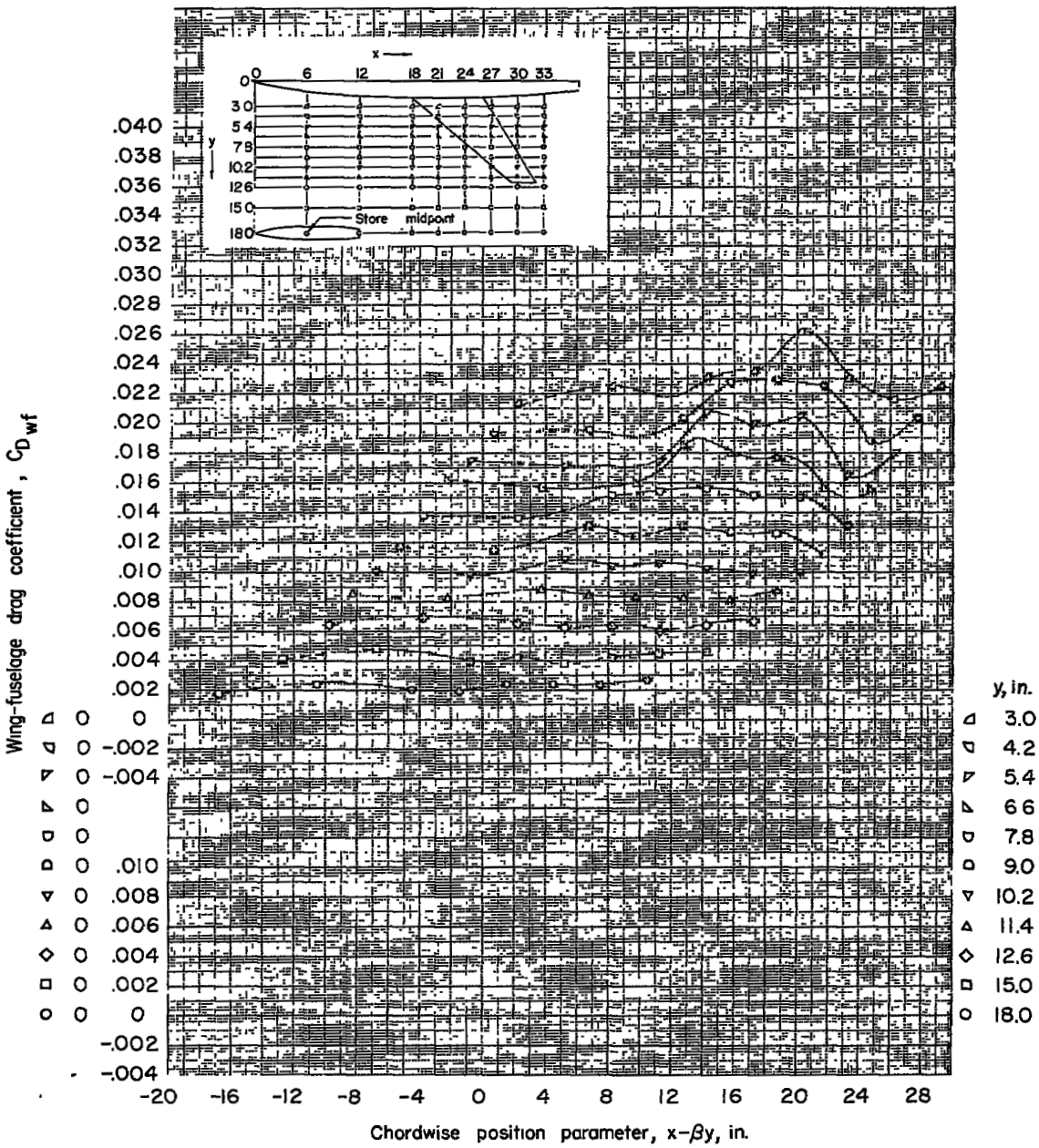
(c) z = 2.09 inches; $\alpha = 0^{\circ}$.

Figure 10.- Continued.



(d) z = 2.09 inches; $\alpha = 4^{\circ}$.

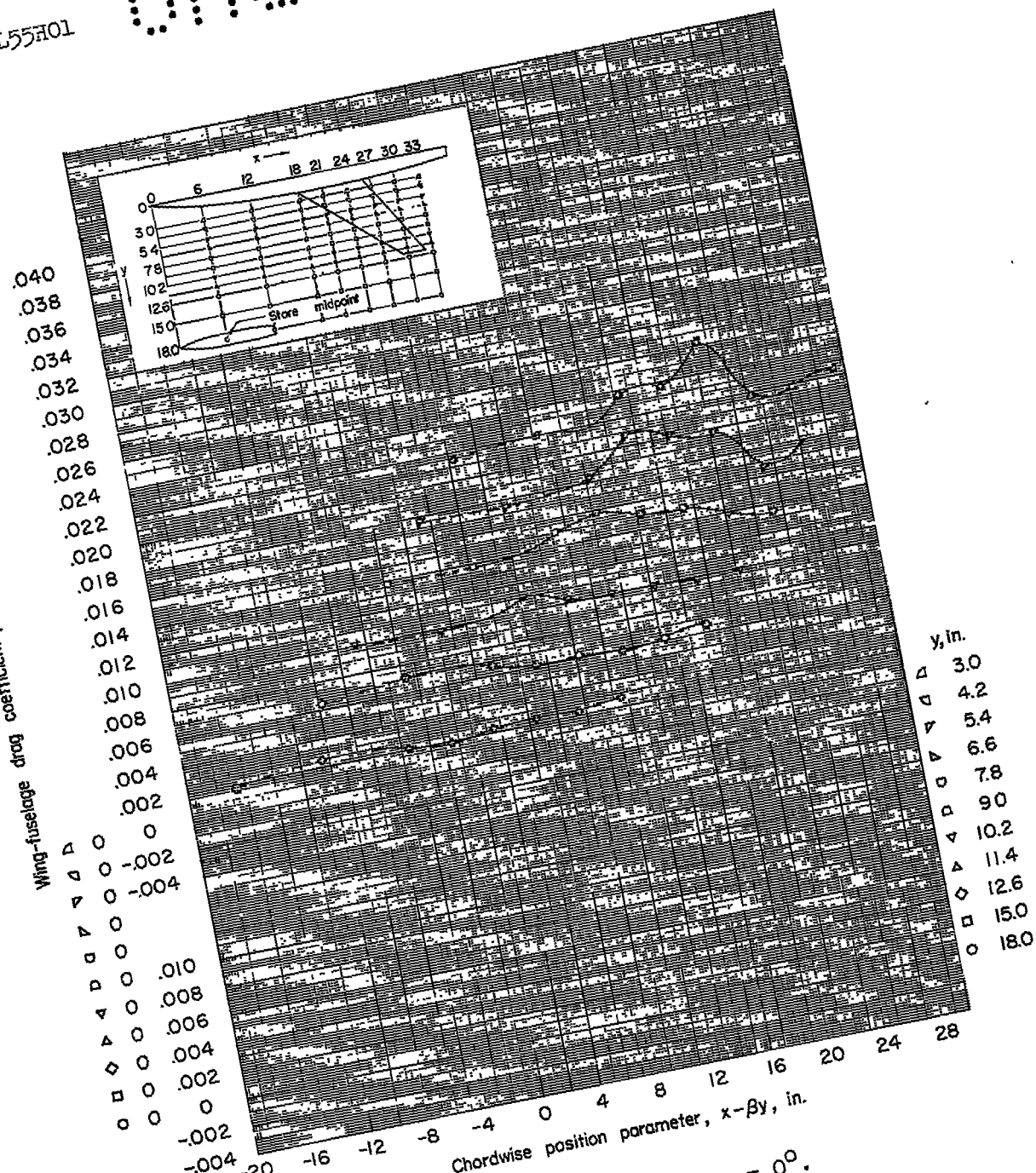
Figure 10.- Concluded.



(a) z = 1.15 inches; $\alpha = 0^{\circ}$.

Figure 11.- Drag of wing-fuselage combination in presence of large store. (Drag corrected for fuselage base pressure.) M = 1.61.

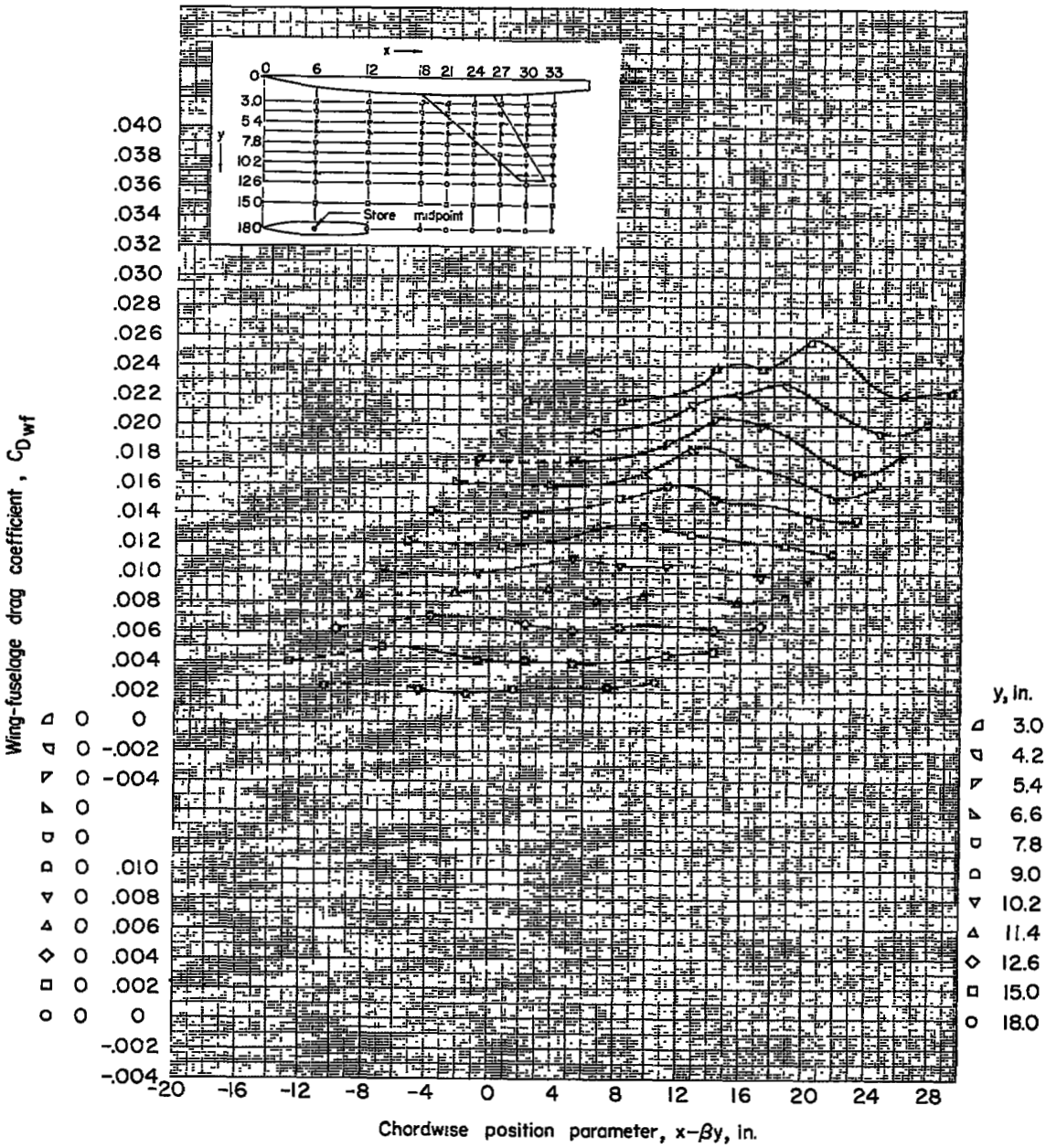
UNC[redacted]AL



(b) z = 1.67 inches; $\alpha = 0^{\circ}$.

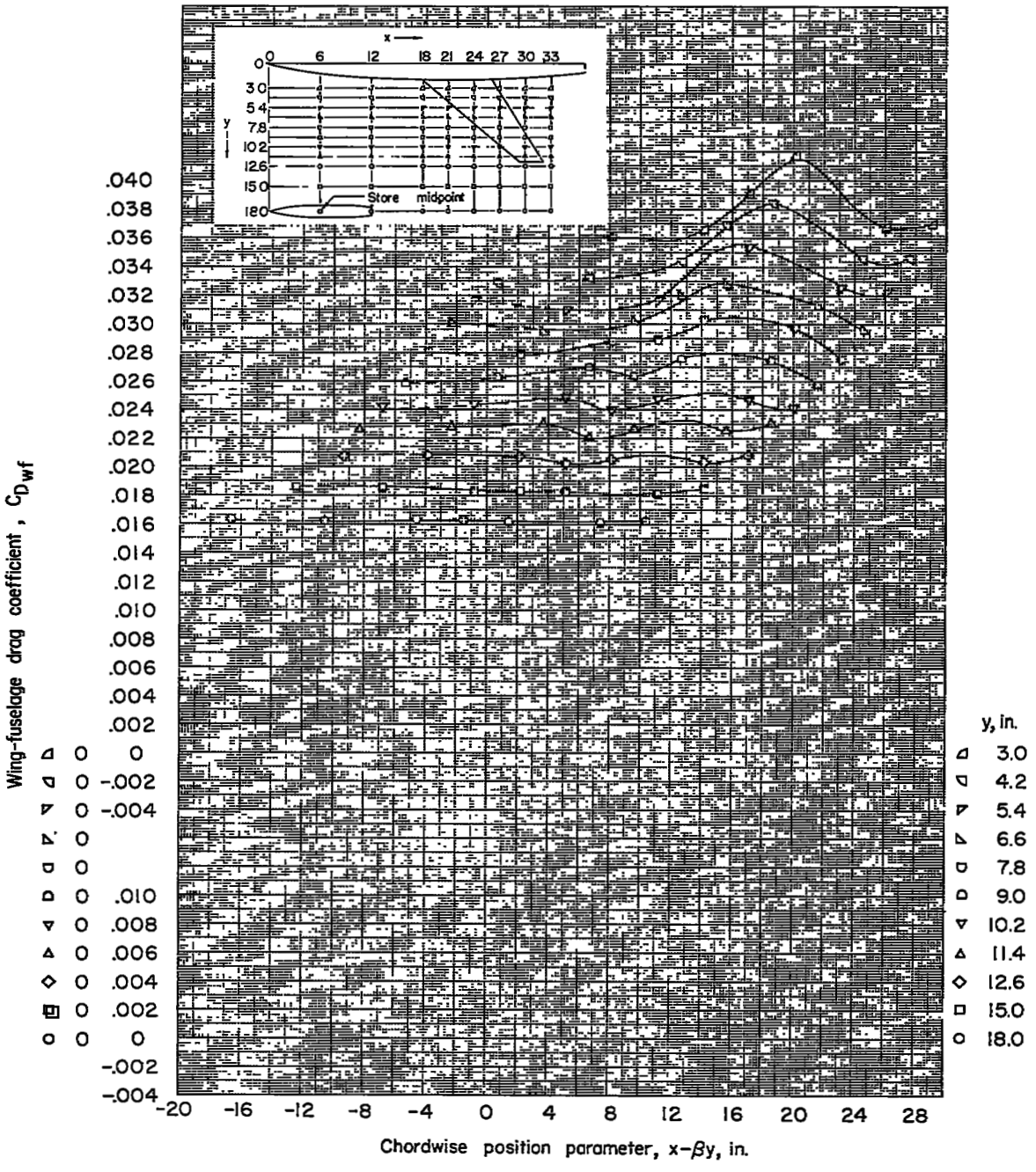
Figure 11.- Continued.

CO[redacted]L



(c) z = 2.09 inches; $\alpha = 0^{\circ}$.

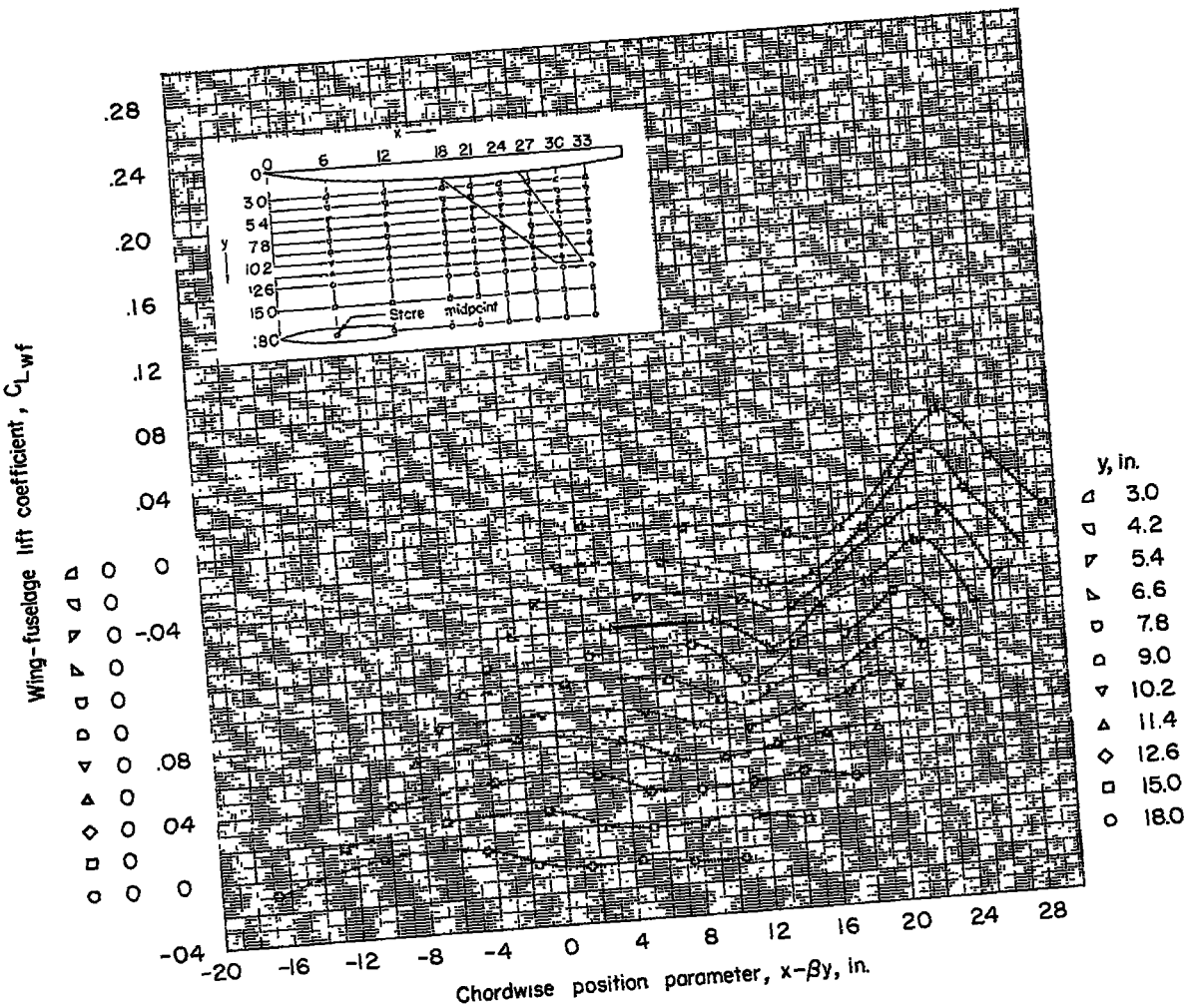
Figure 11.- Continued.



(d) z = 2.09 inches; $\alpha = 4^{\circ}$.

Figure 11.- Concluded.

UNCLASSIFIED

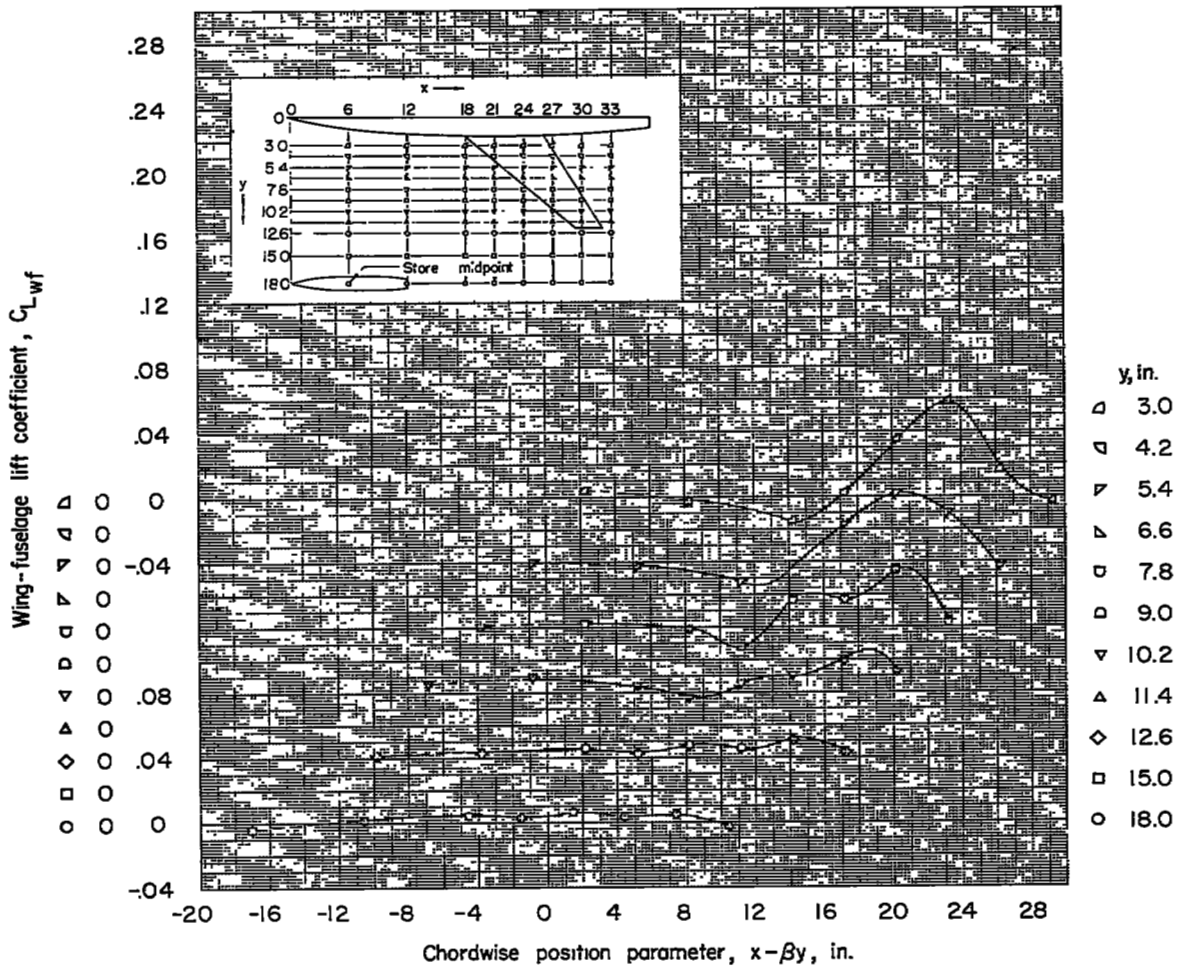


(a) z = 1.15 inches; $\alpha = 0^{\circ}$.

Figure 12.- Lift of wing-fuselage combination in presence of large store. M = 1.61.

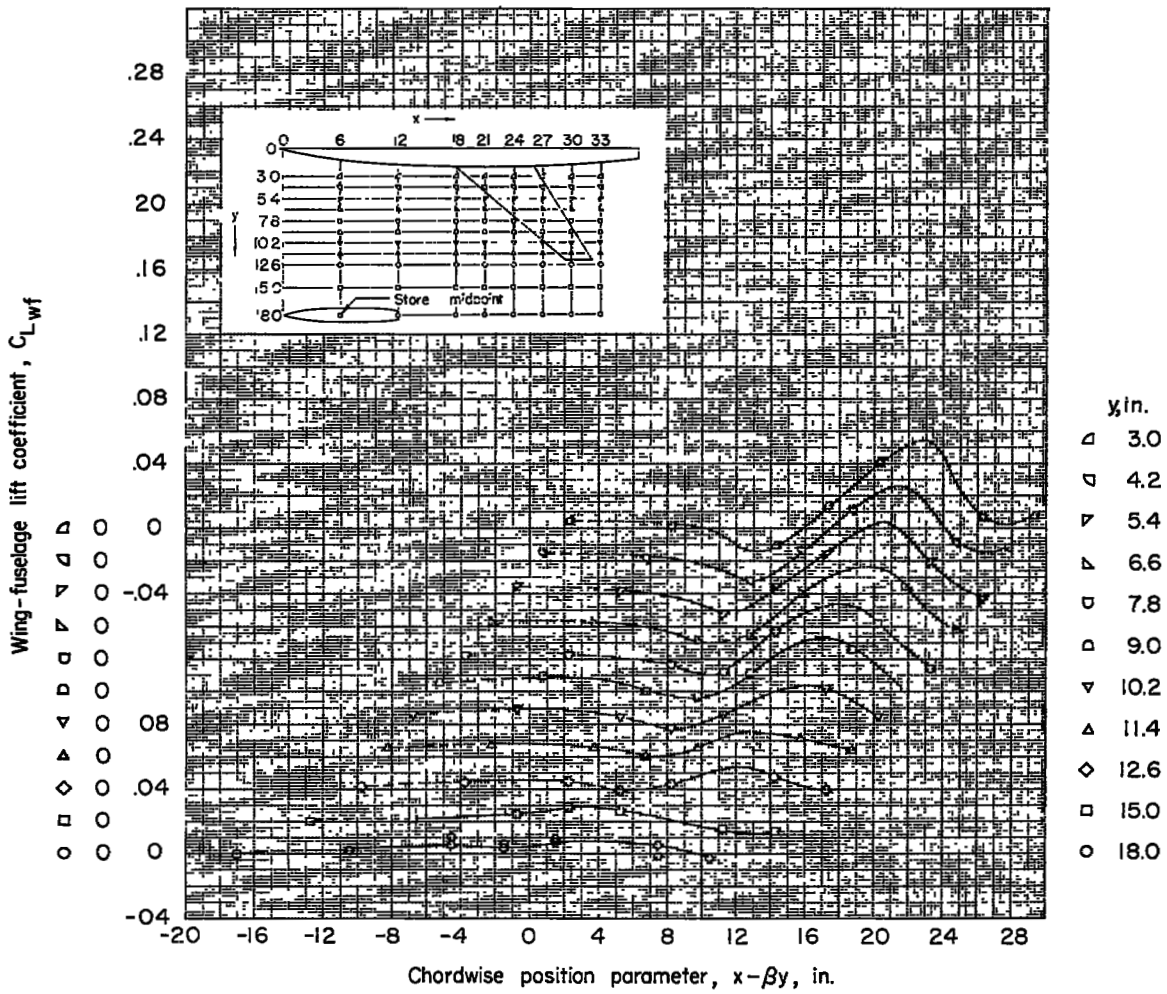
[redacted]

UNCLASSIFIED



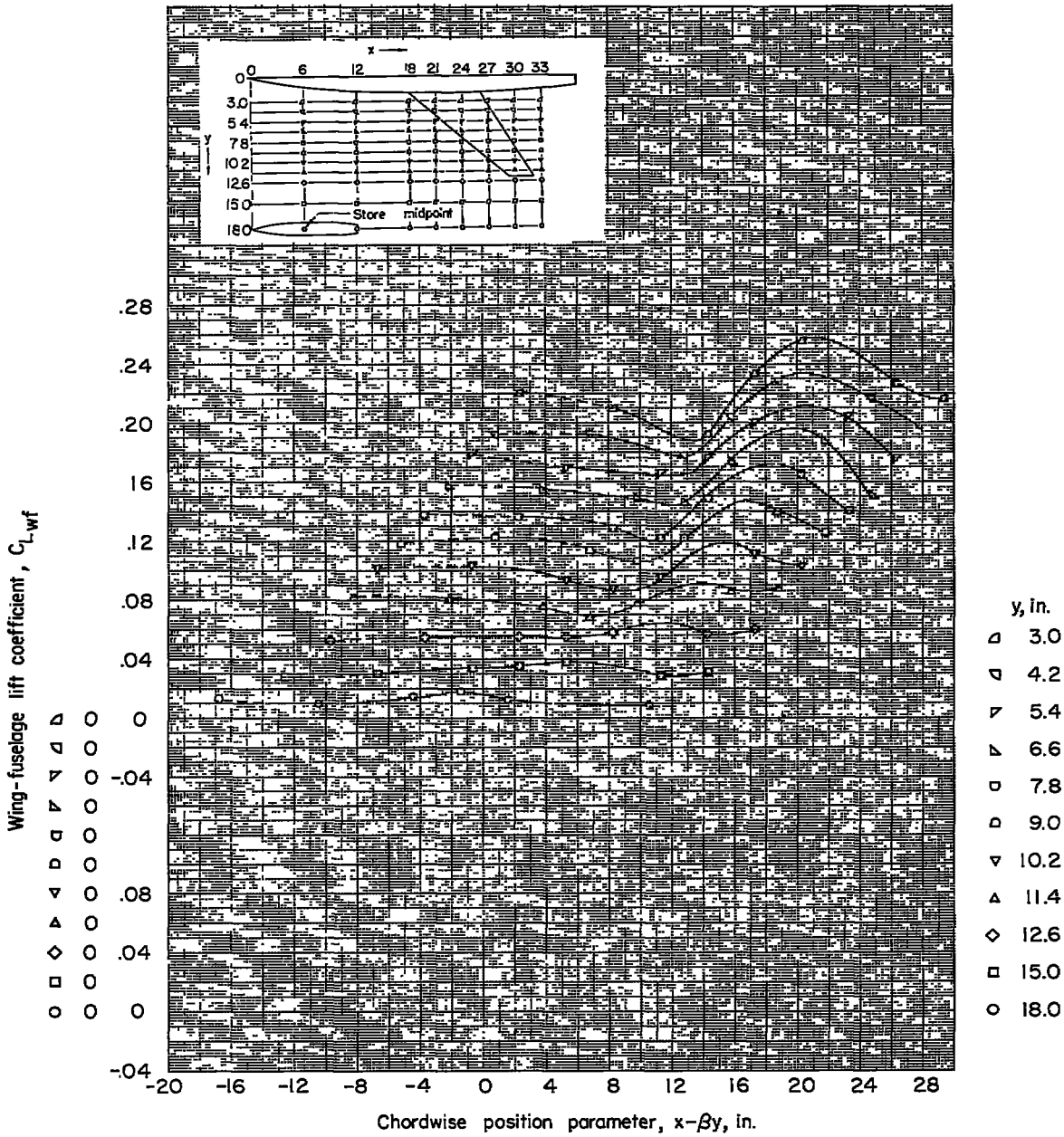
(b) z = 1.67 inches; $\alpha = 0^{\circ}$.

Figure 12.- Continued.



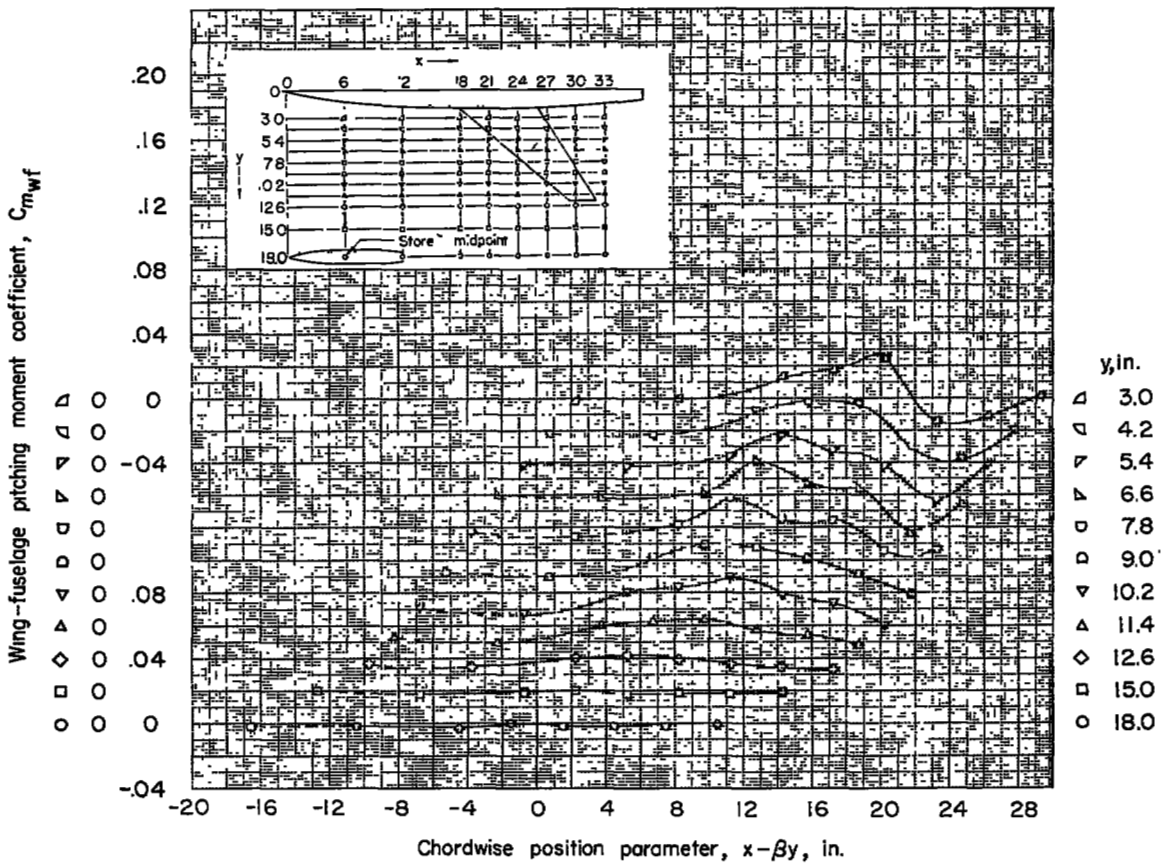
(c) z = 2.09 inches; $\alpha = 0^{\circ}$.

Figure 12.- Continued.



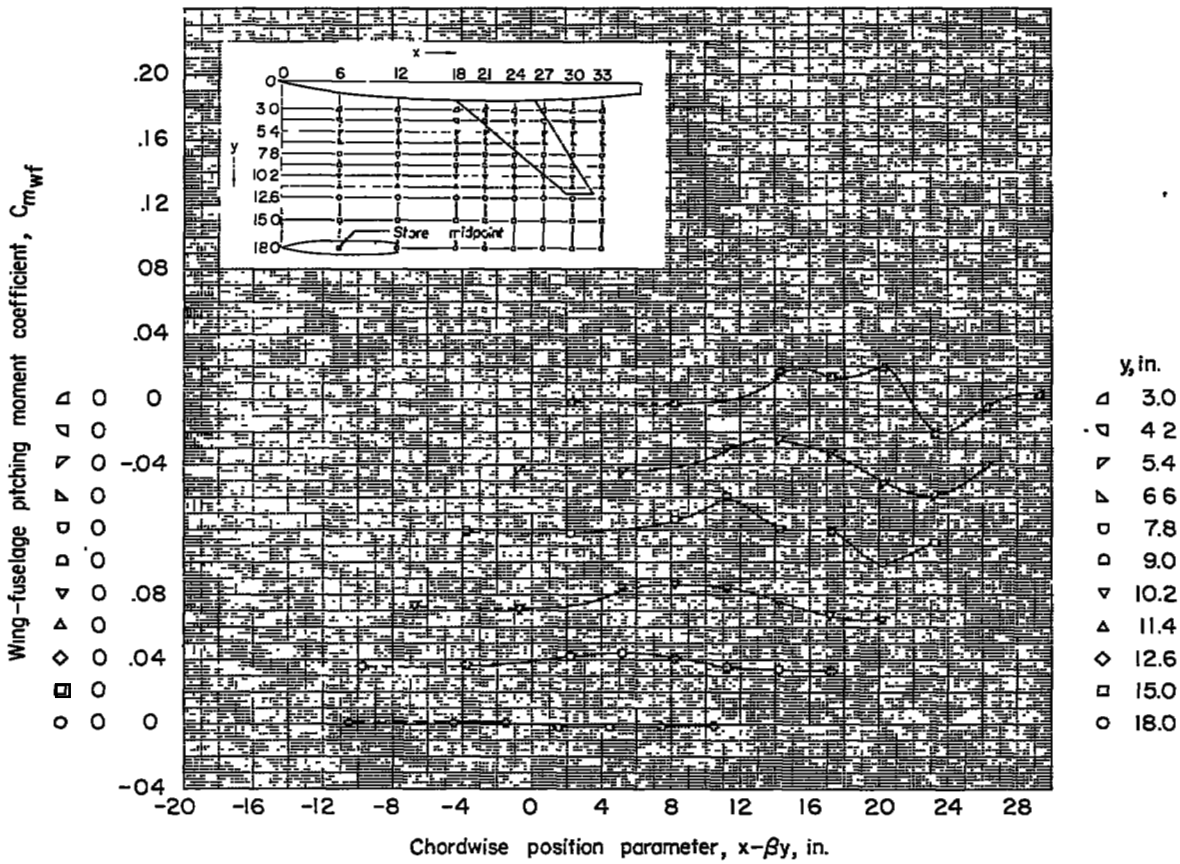
(d) z = 2.09 inches; $\alpha = 4^{\circ}$.

Figure 12.- Concluded.



(a) z = 1.15 inches; $\alpha = 0^{\circ}$.

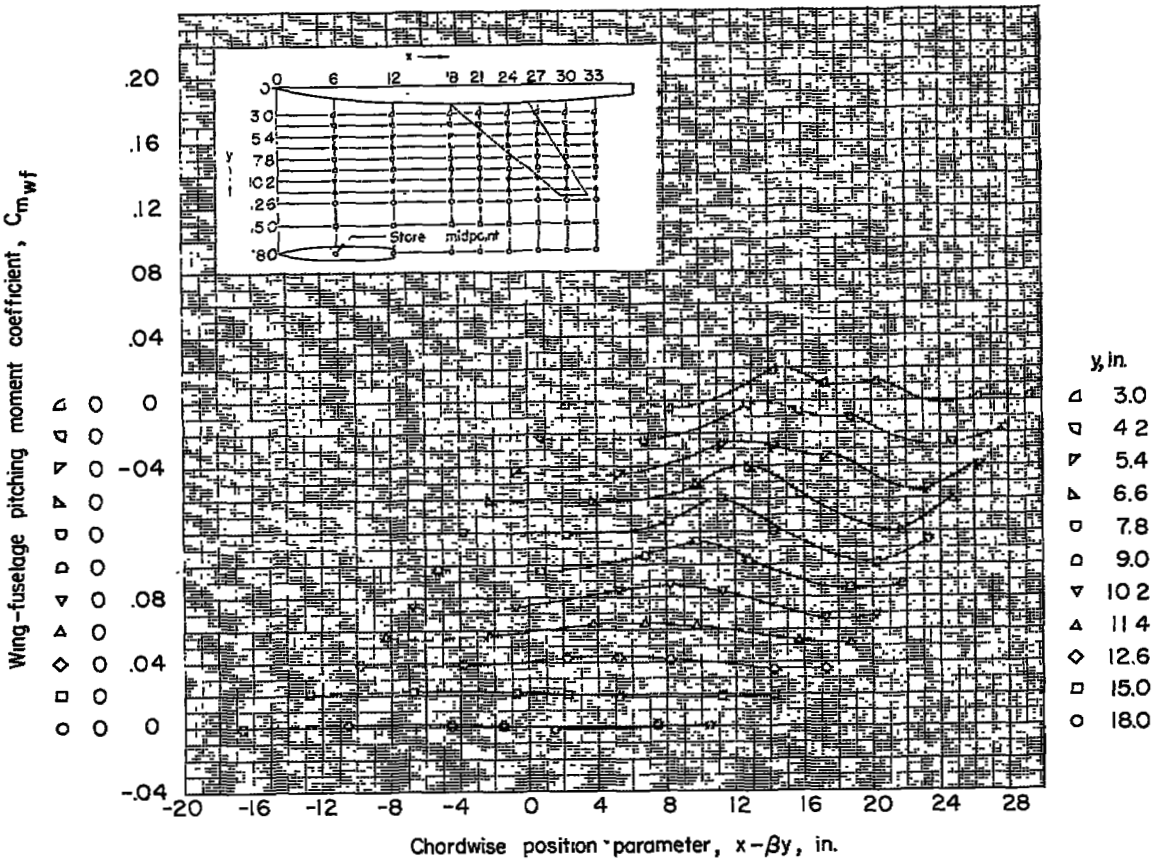
Figure 13.- Pitching moment of wing-fuselage combination in presence of large store. (Center of moments is $\bar{c}/4$ of wing.) M = 1.61.



(b) z = 1.67 inches; $\alpha = 0^{\circ}$.

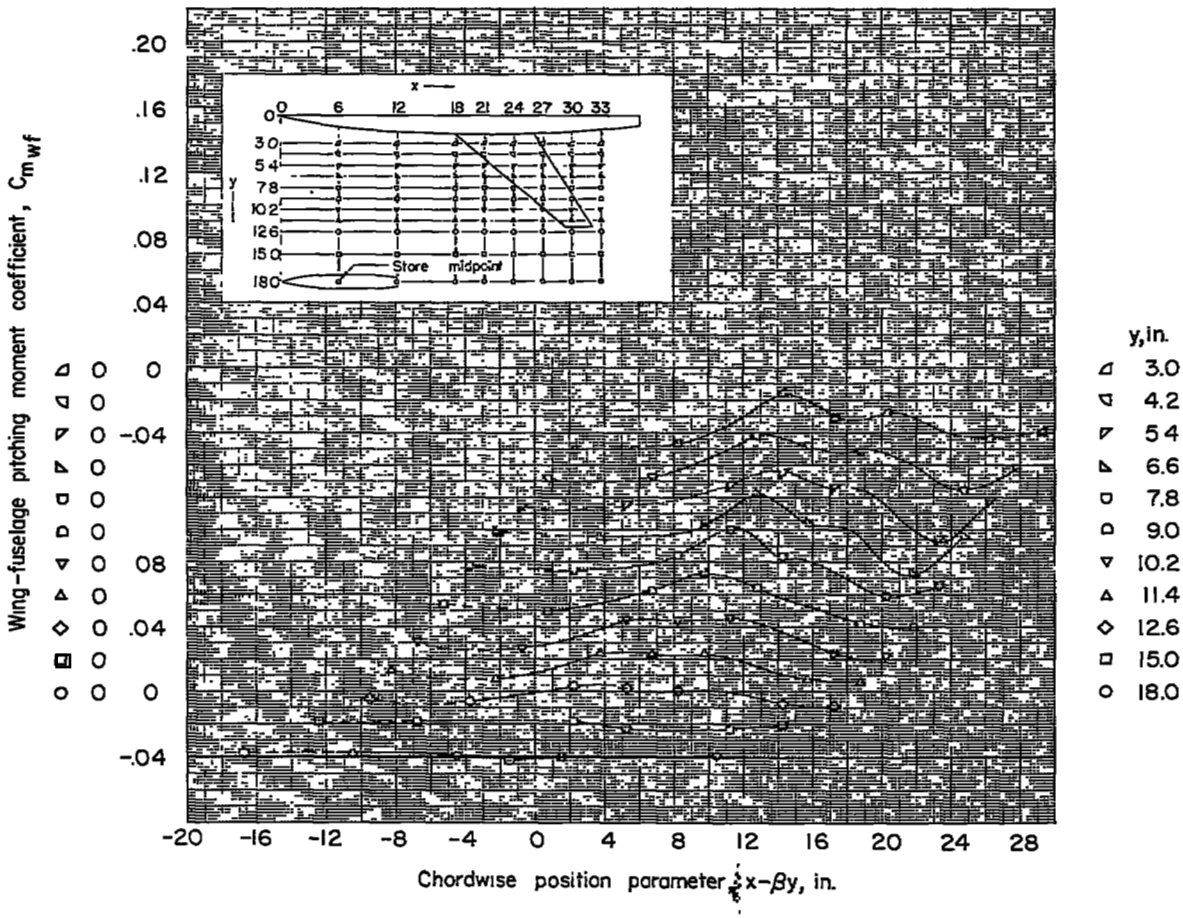
Figure 13.- Continued.

[redacted]



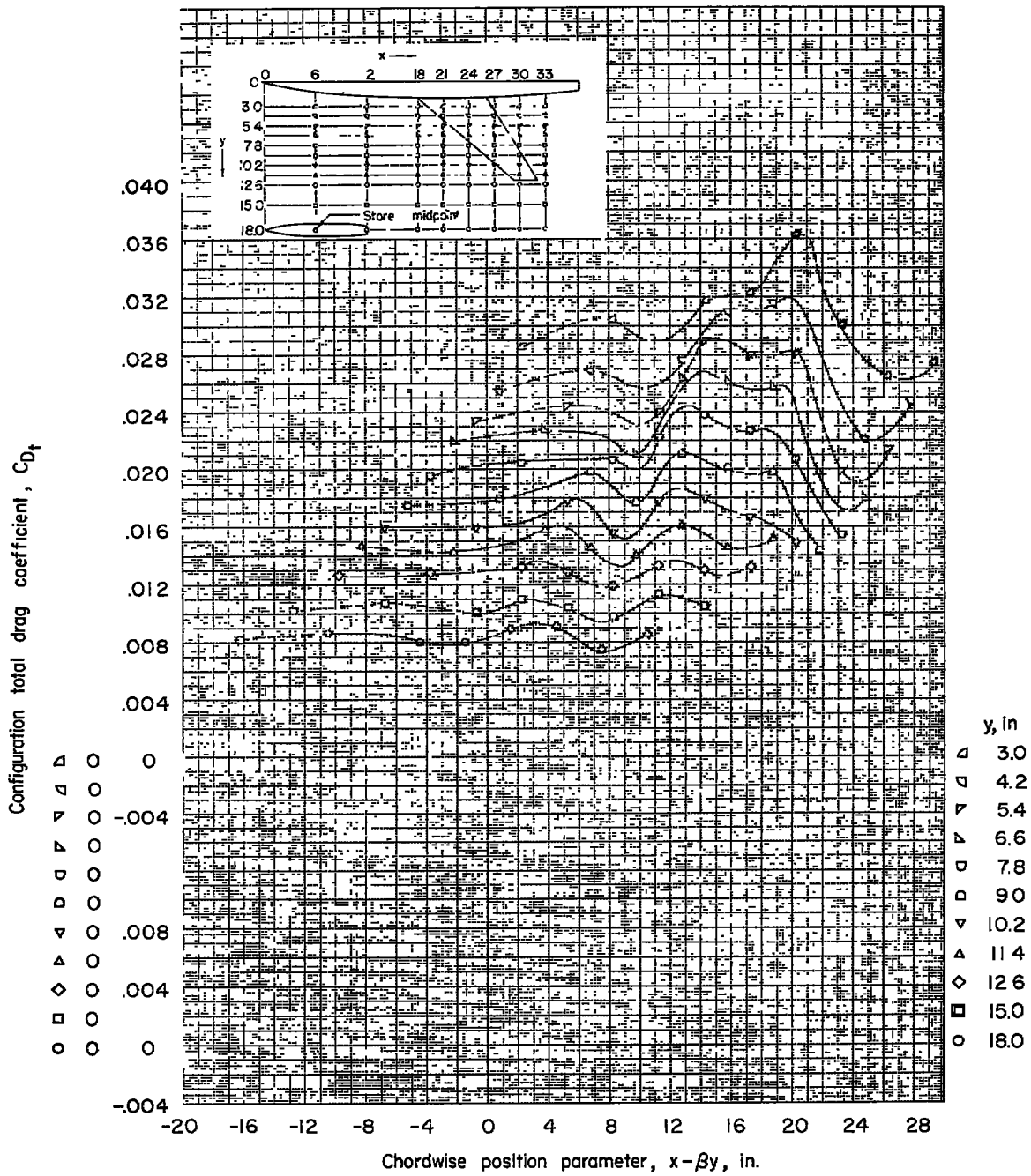
(c) z = 2.09 inches; $\alpha = 0^{\circ}$.

Figure 13.- Continued.



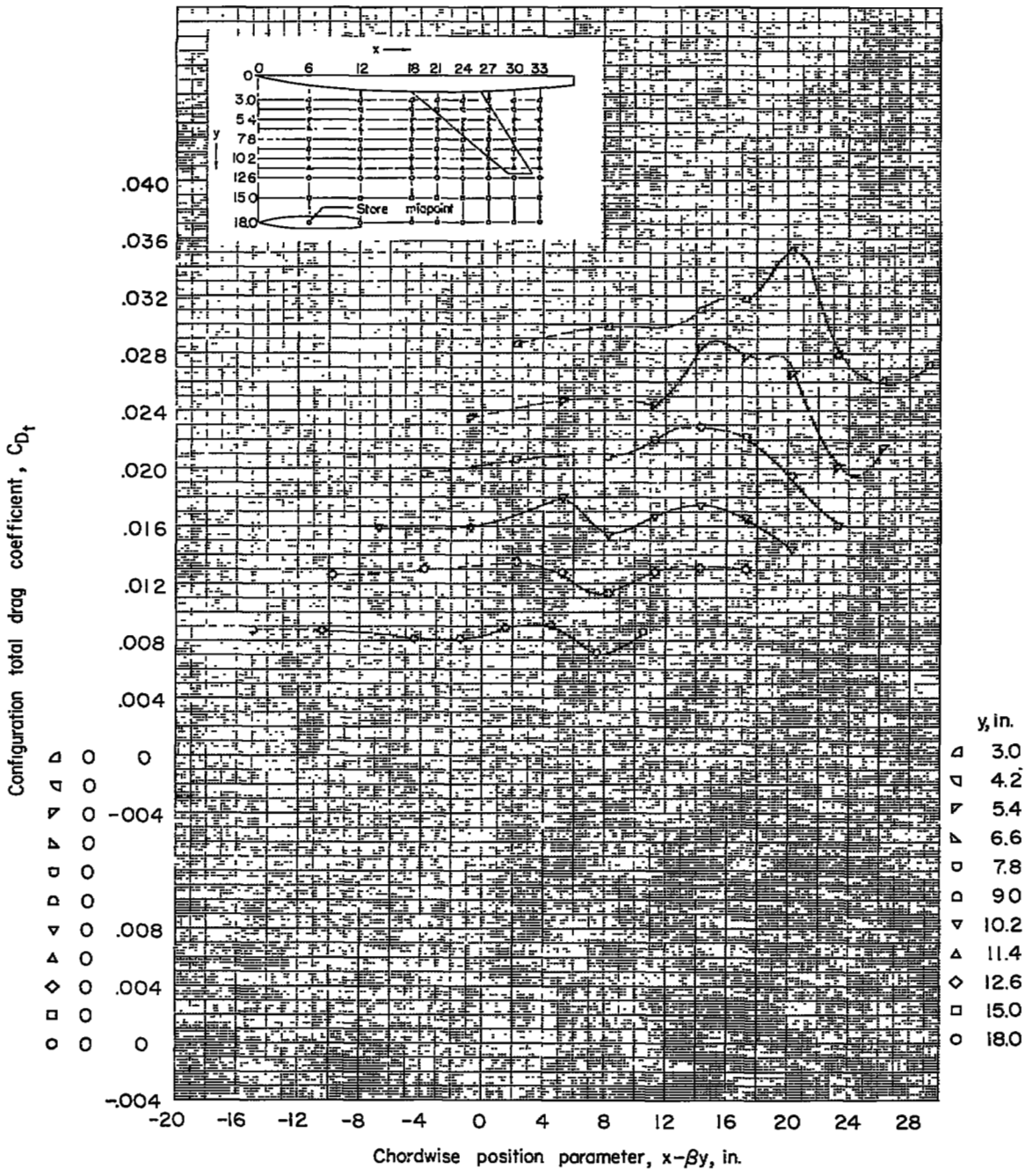
(d) z = 2.09 inches; $\alpha = 4^{\circ}$.

Figure 13.- Concluded.



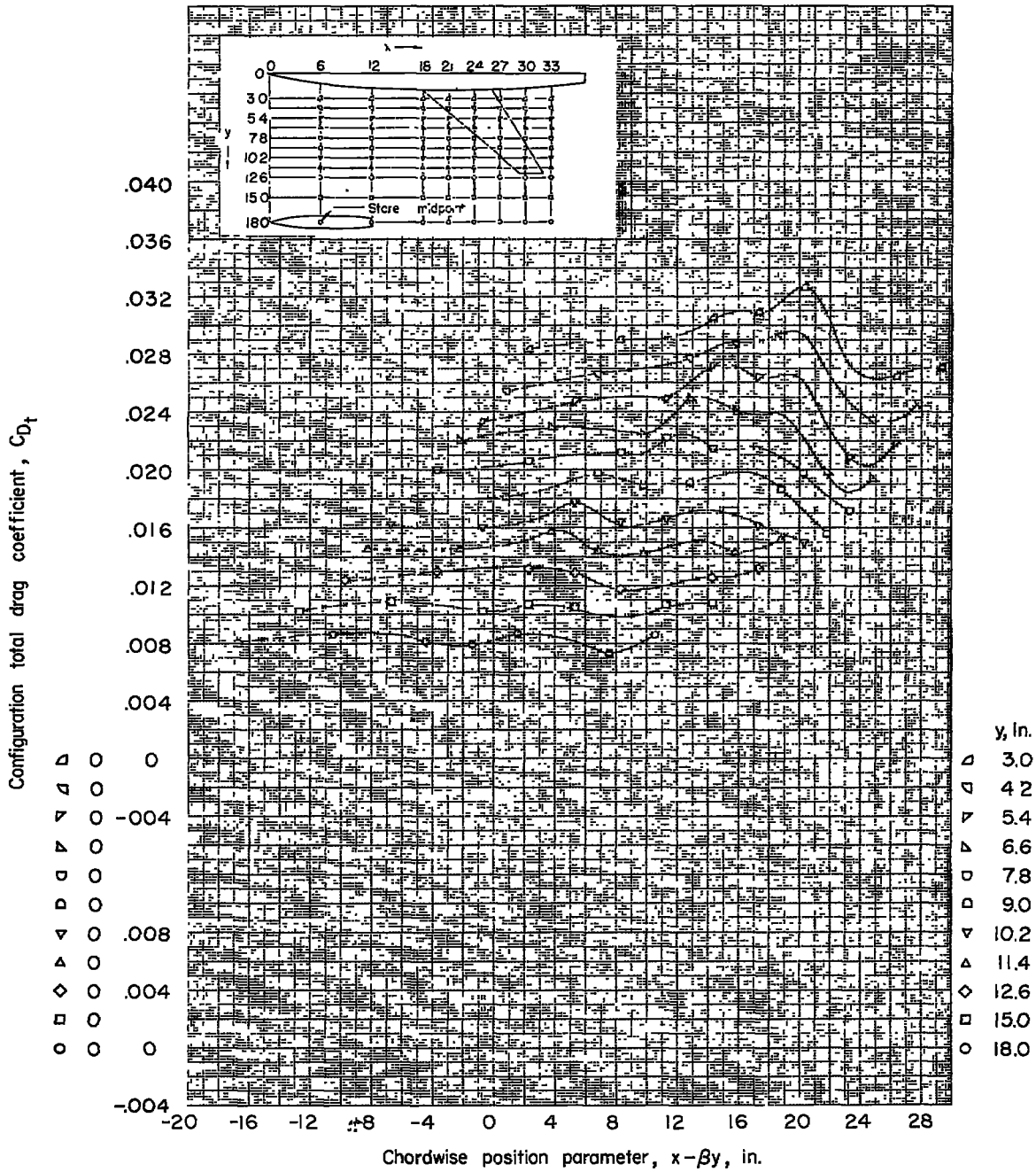
(a) z = 1.15 inches; $\alpha = 0^{\circ}$.

Figure 14.- Total drag of the complete configuration (wing-fuselage plus large store). (Drags corrected for base pressures.) M = 1.61.



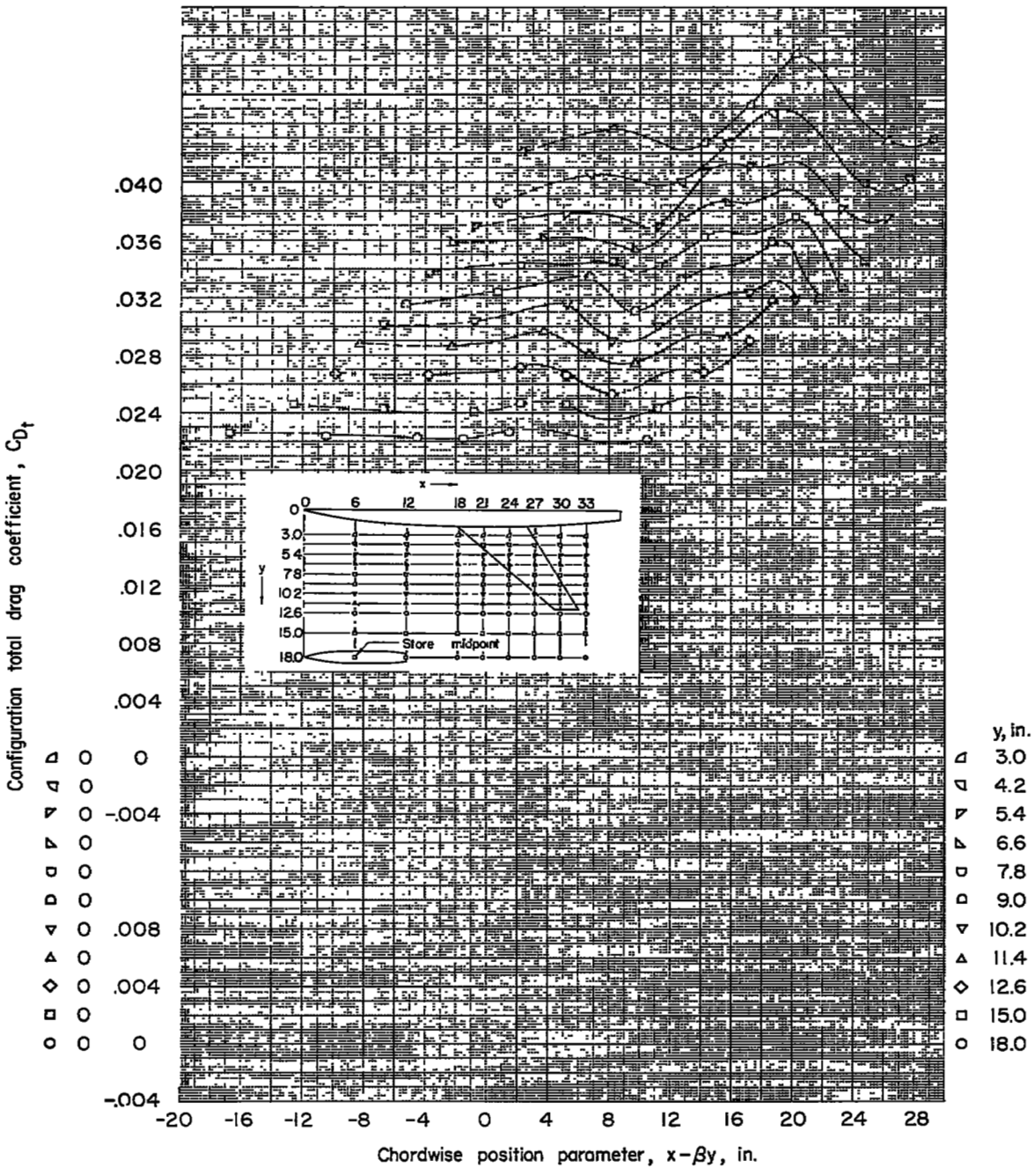
(b) z = 1.67 inches; $\alpha = 0^{\circ}$.

Figure 14.- Continued.



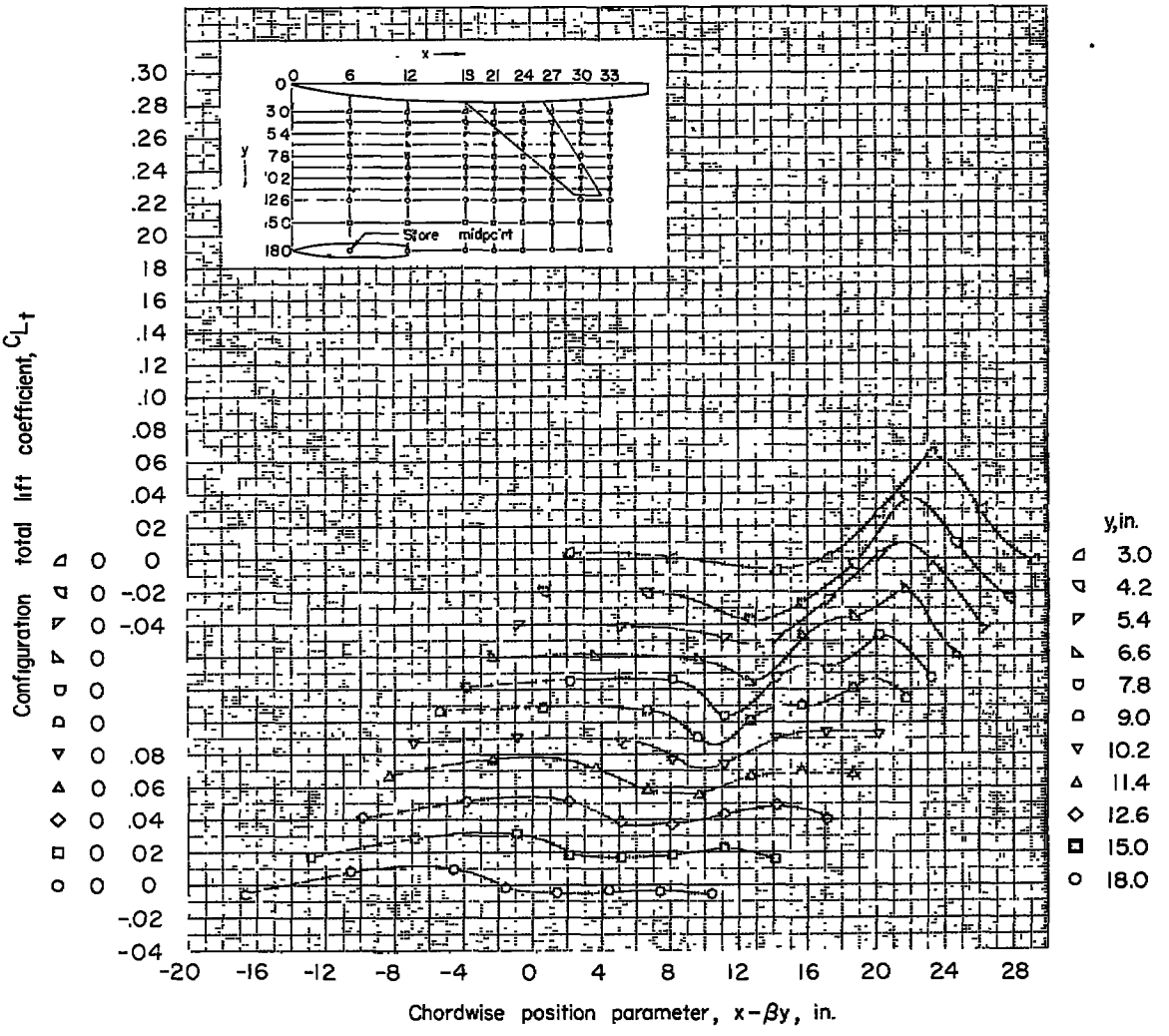
(c) z = 2.09 inches; $\alpha = 0^{\circ}$.

Figure 14.- Continued.



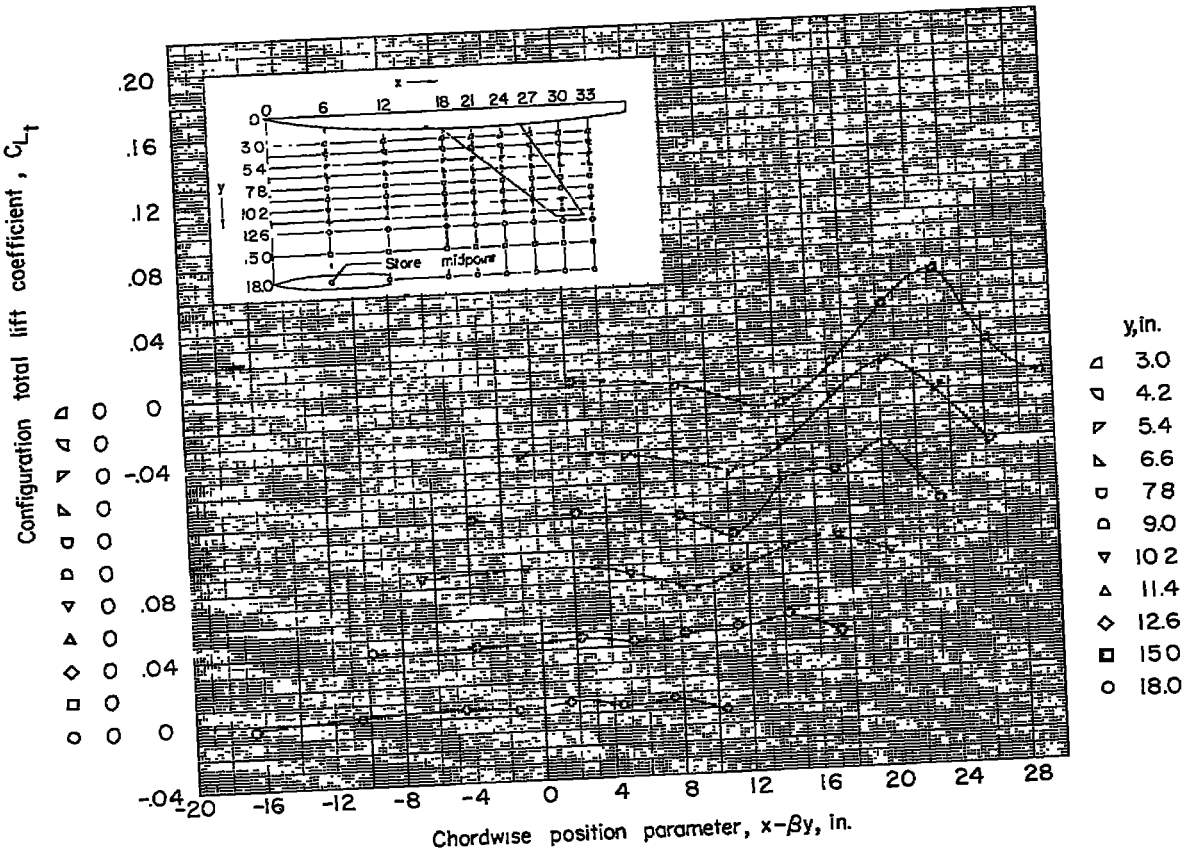
(d) z = 2.09 inches; $\alpha = 4^{\circ}$.

Figure 14.- Concluded.



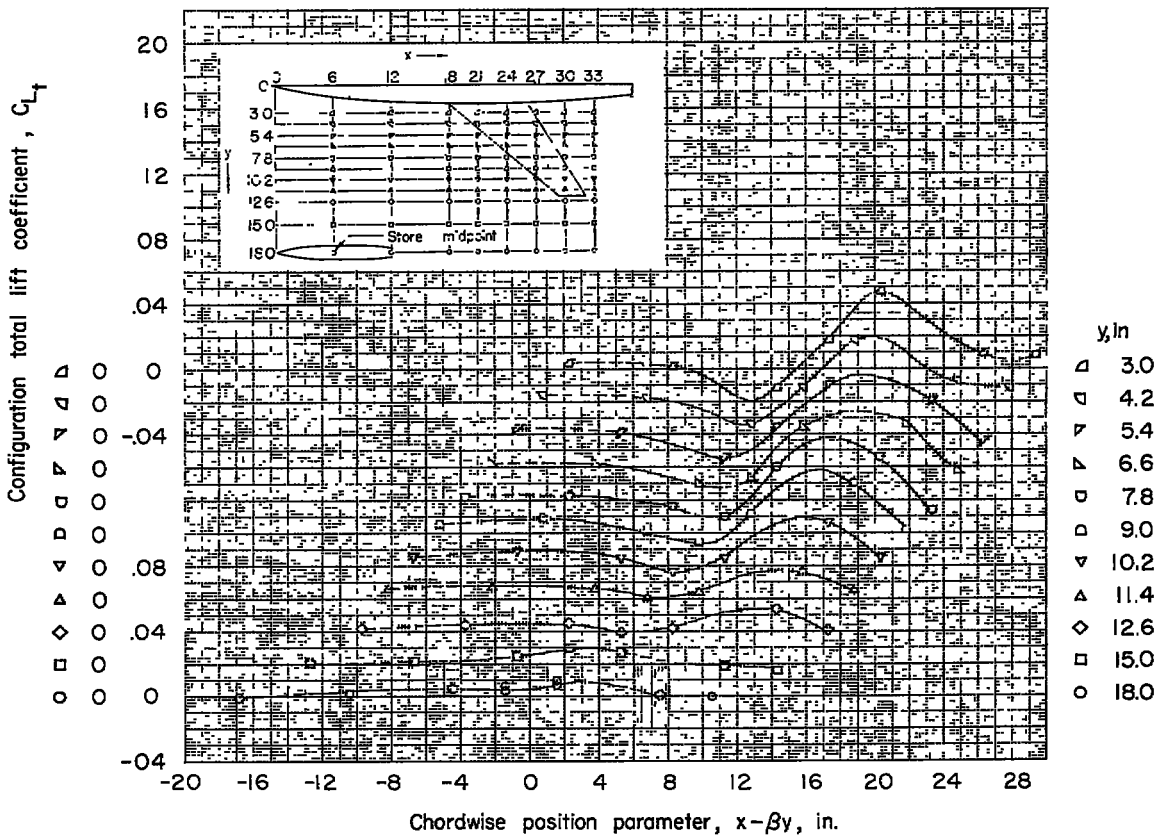
(a) z = 1.15 inches; $\alpha = 0^{\circ}$.

Figure 15.- Total lift of the complete (wing-fuselage plus large store) configuration. M = 1.61.



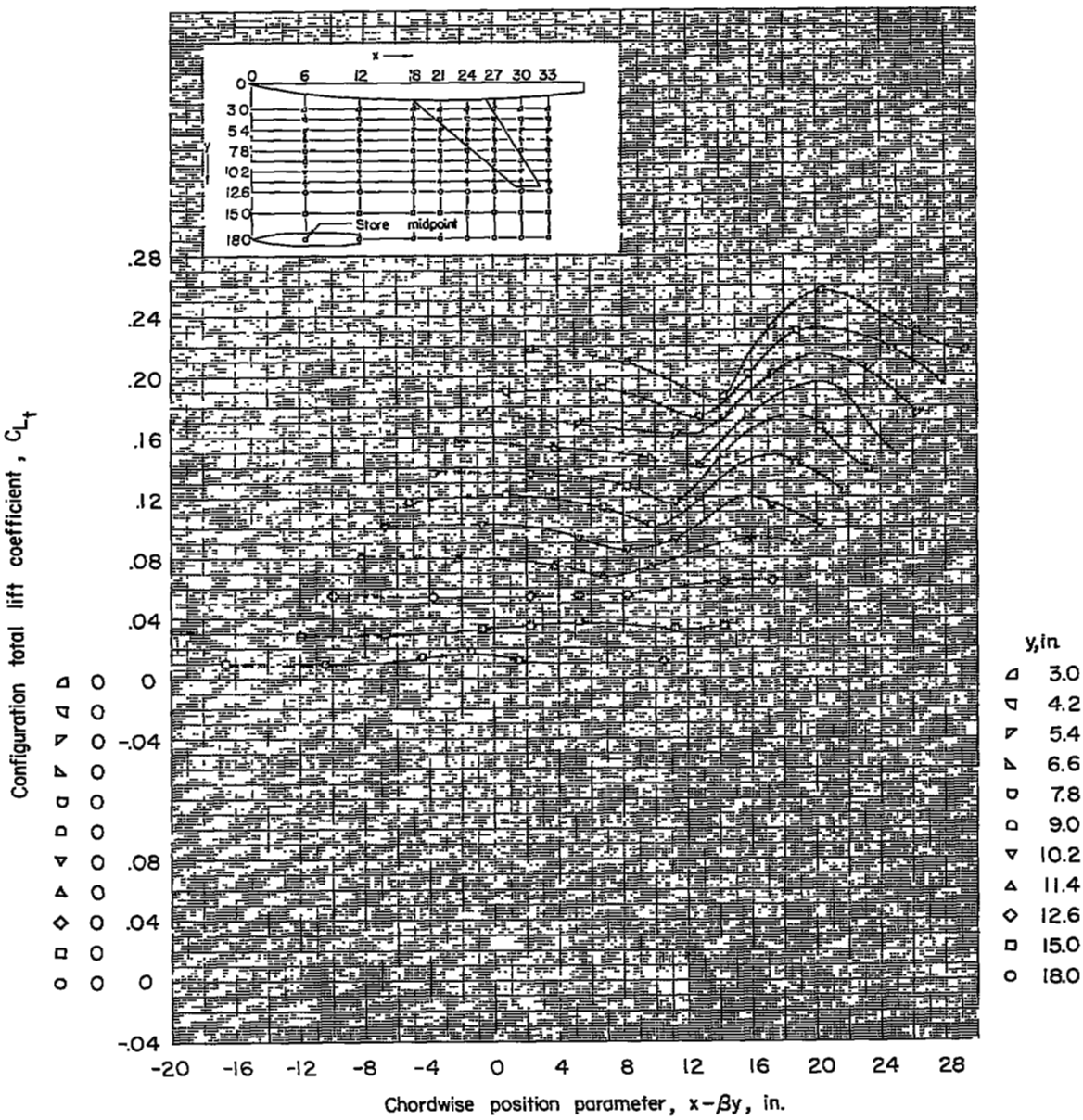
(b) z = 1.67 inches; $\alpha = 0^{\circ}$.

Figure 15.- Continued.



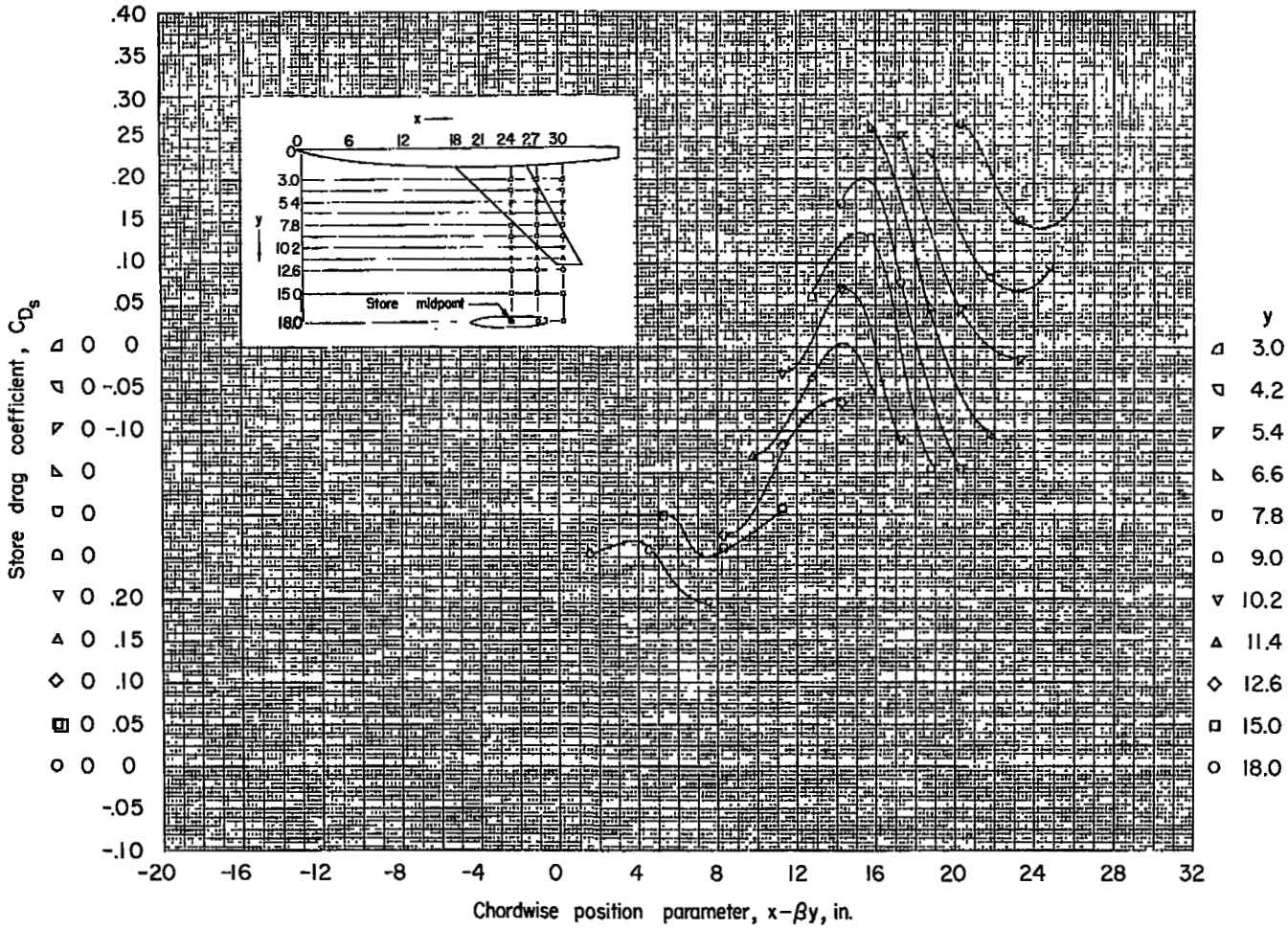
(c) z = 2.09 inches; $\alpha = 0^{\circ}$.

Figure 15.- Continued.



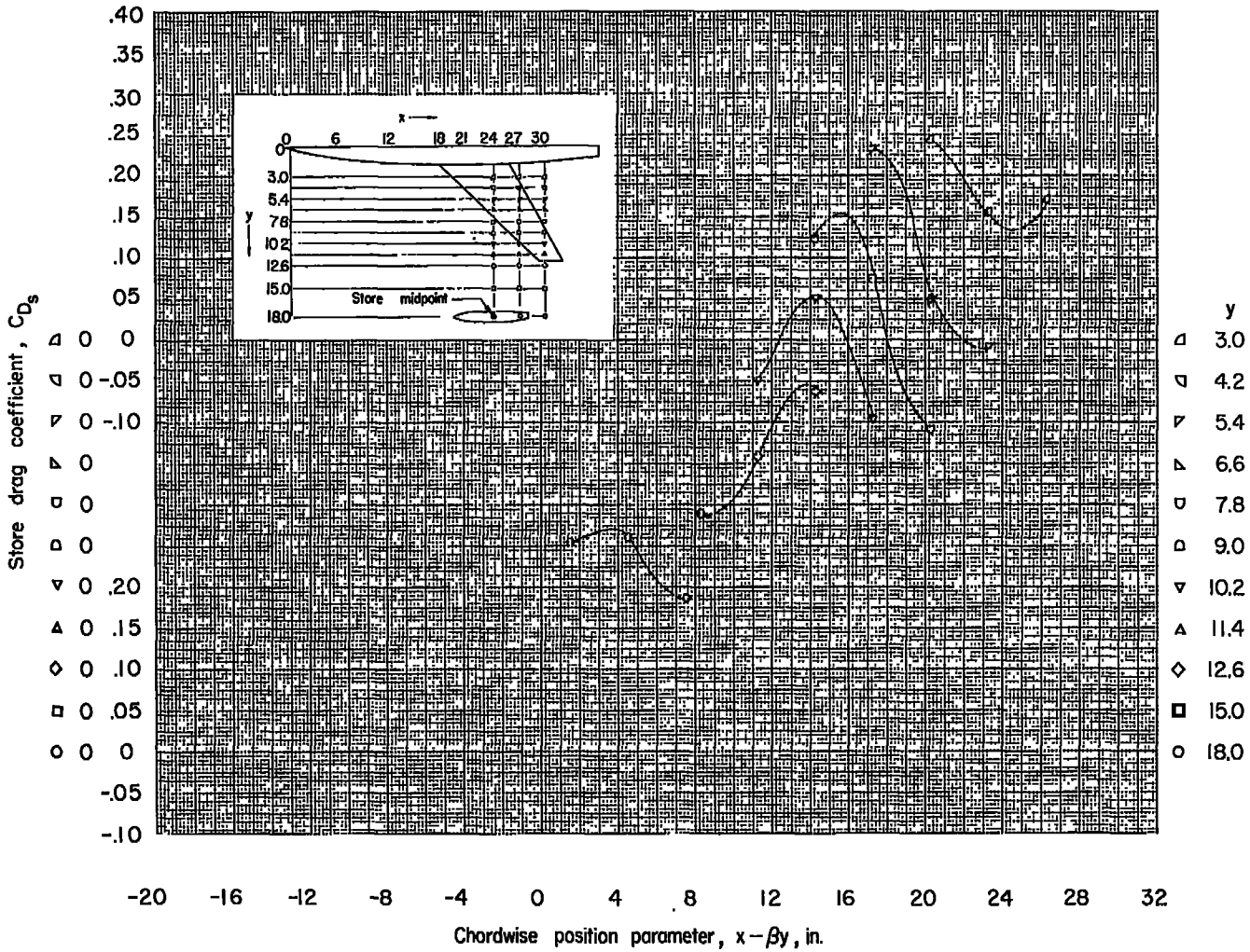
(d) z = 2.09 inches; $\alpha = 4^{\circ}$.

Figure 15.- Concluded.



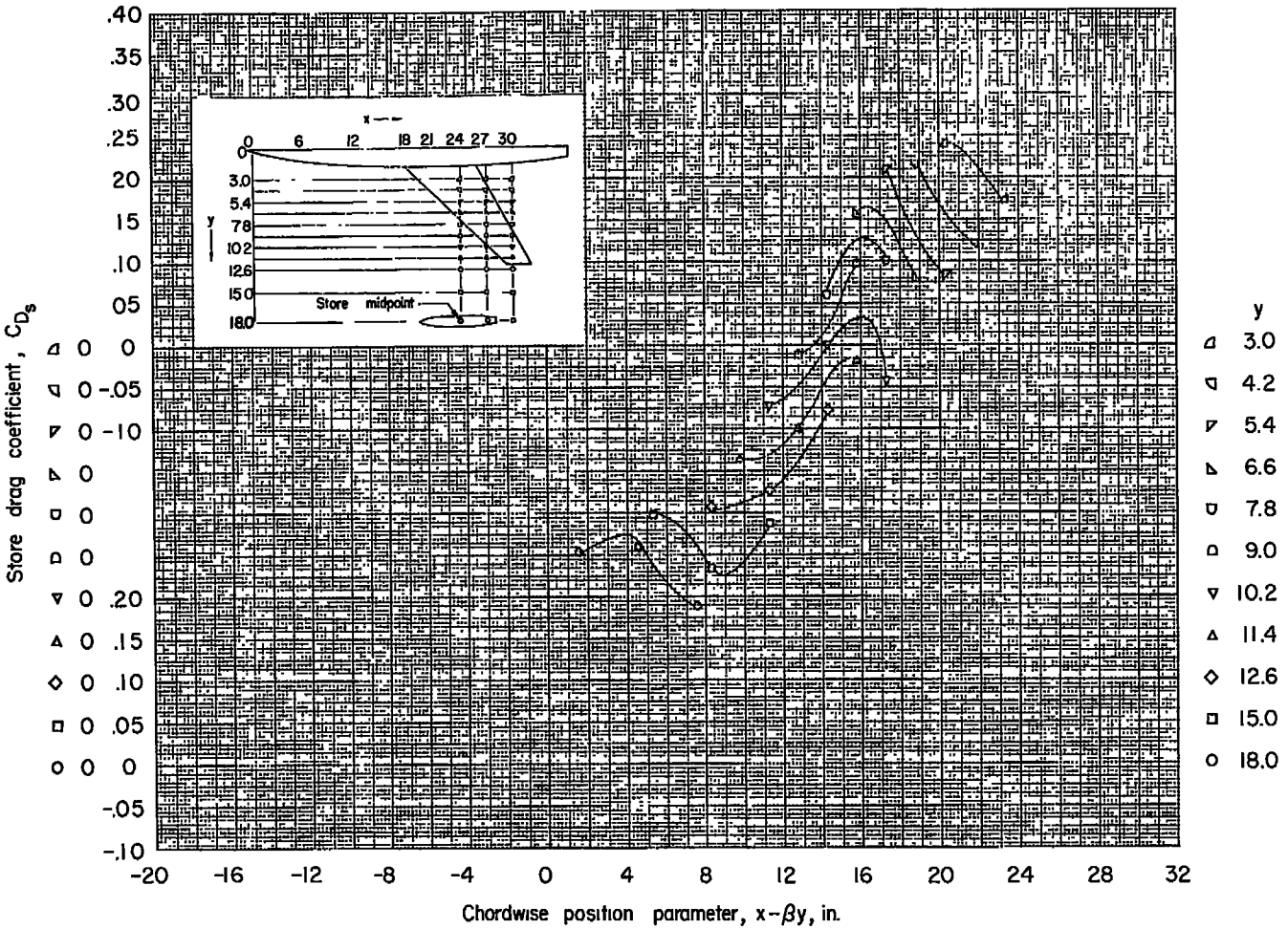
(a) z = 1.15 inches; $\alpha = 0^{\circ}$.

Figure 16.- Drag of small store in presence of wing-fuselage combination. (Drag corrected for base pressure.) M = 1.61.



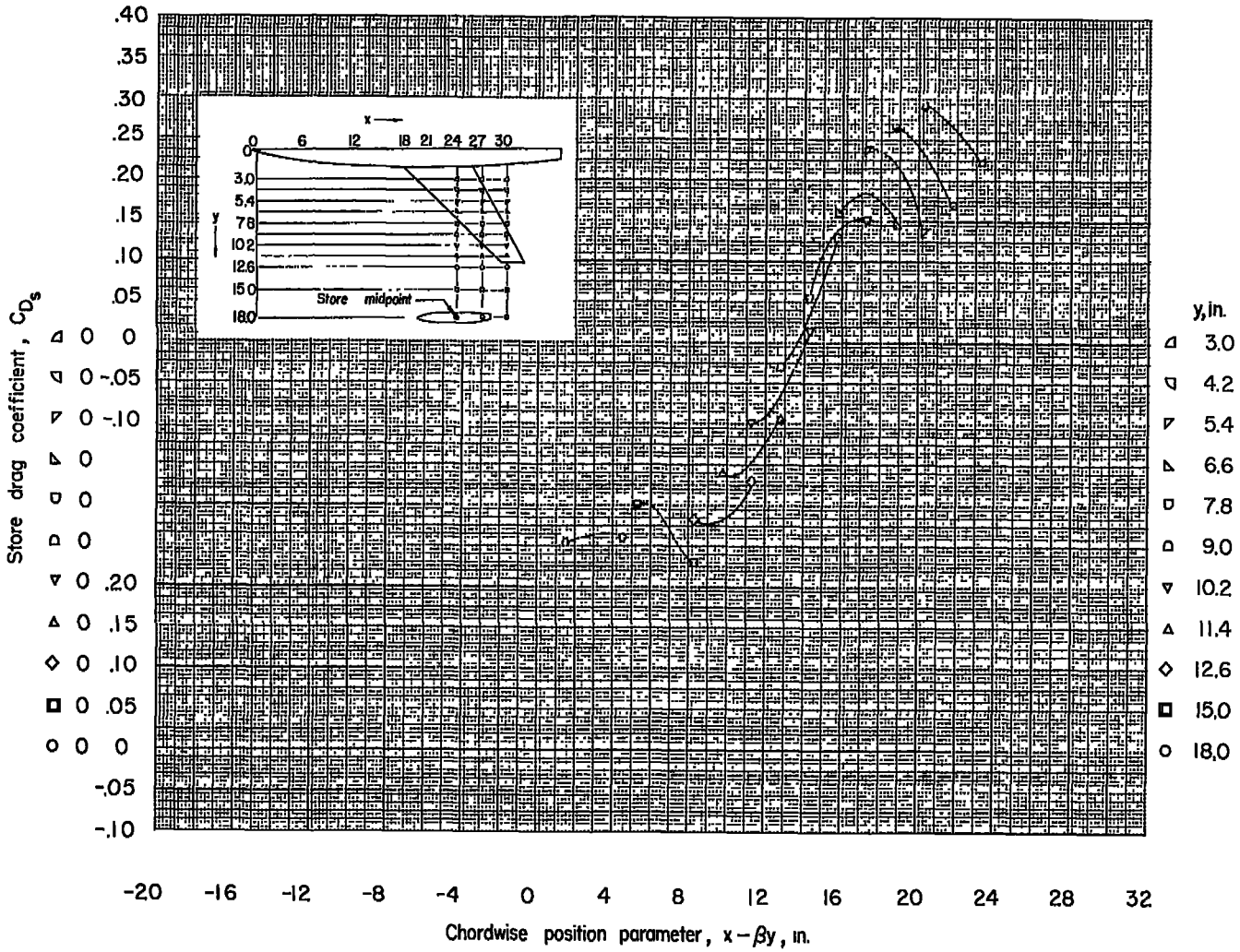
(b) z = 1.67 inches; $\alpha = 0^{\circ}$.

Figure 16.- Continued.



(c) z = 2.09 inches; $\alpha = 0^{\circ}$.

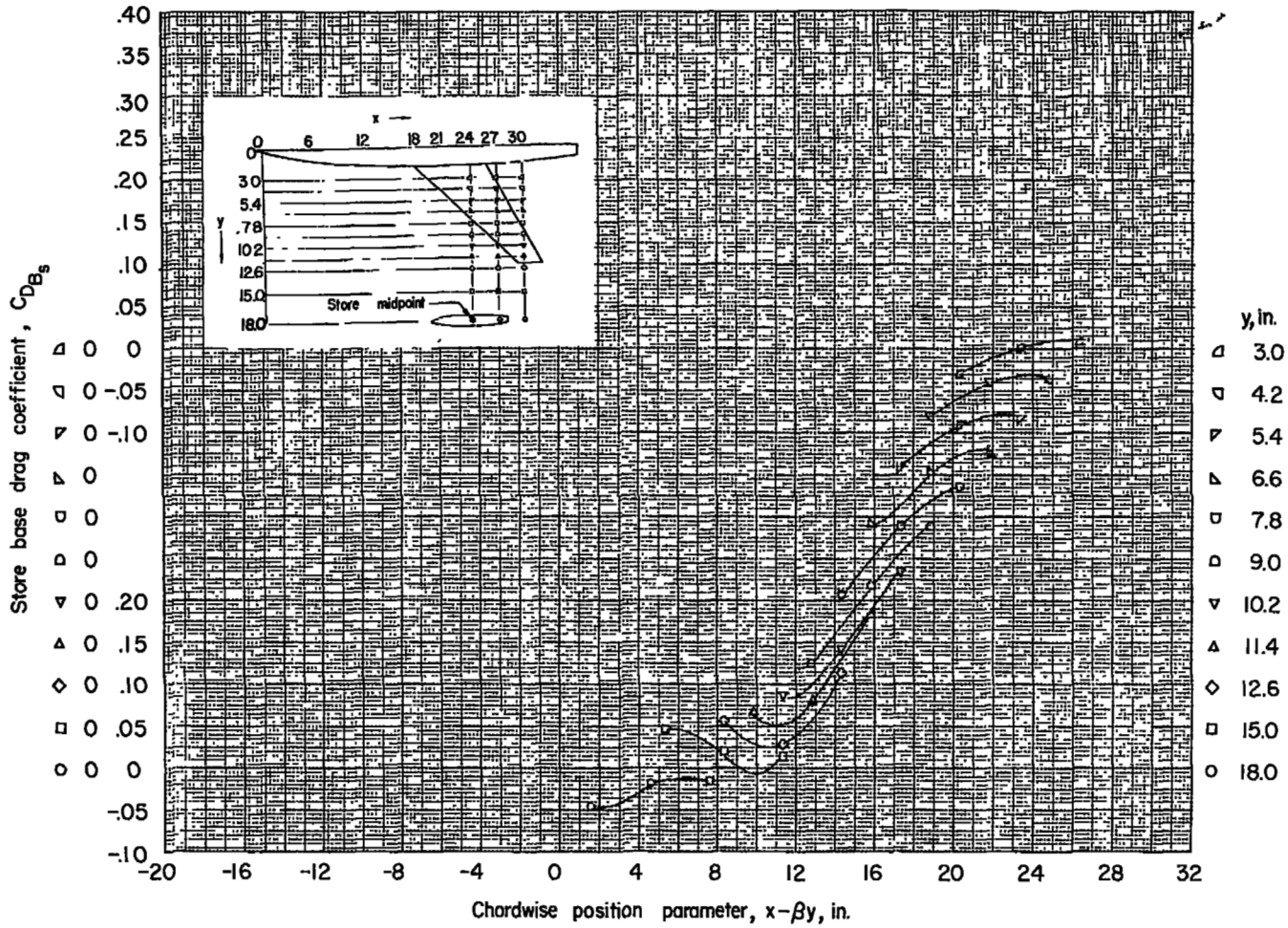
Figure 16.- Continued.



(d) z = 2.09 inches; $\alpha = 4^{\circ}$.

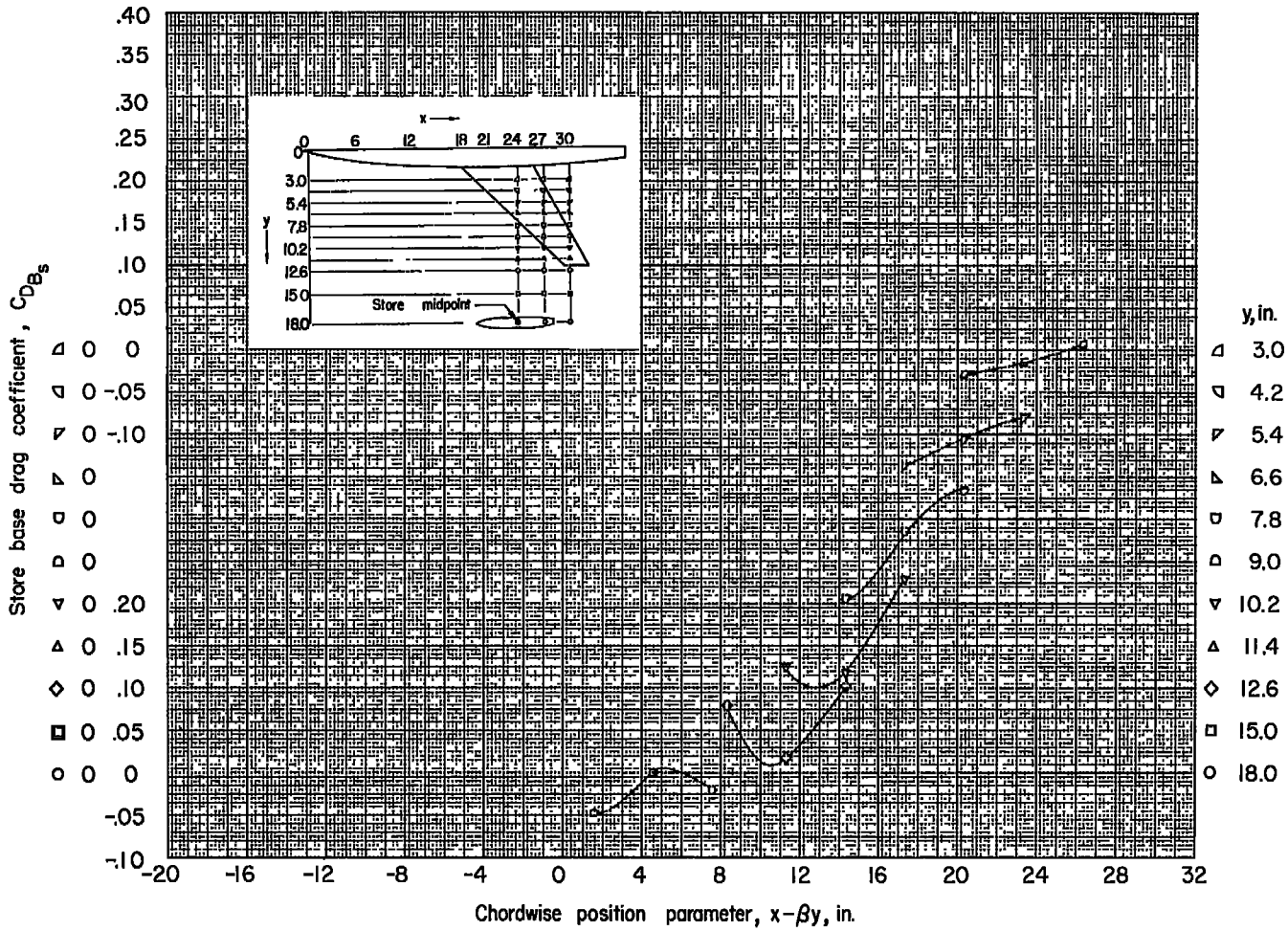
Figure 16.- Concluded.

[redacted]



(a) z = 1.15 inches; $\alpha = 0^{\circ}$.

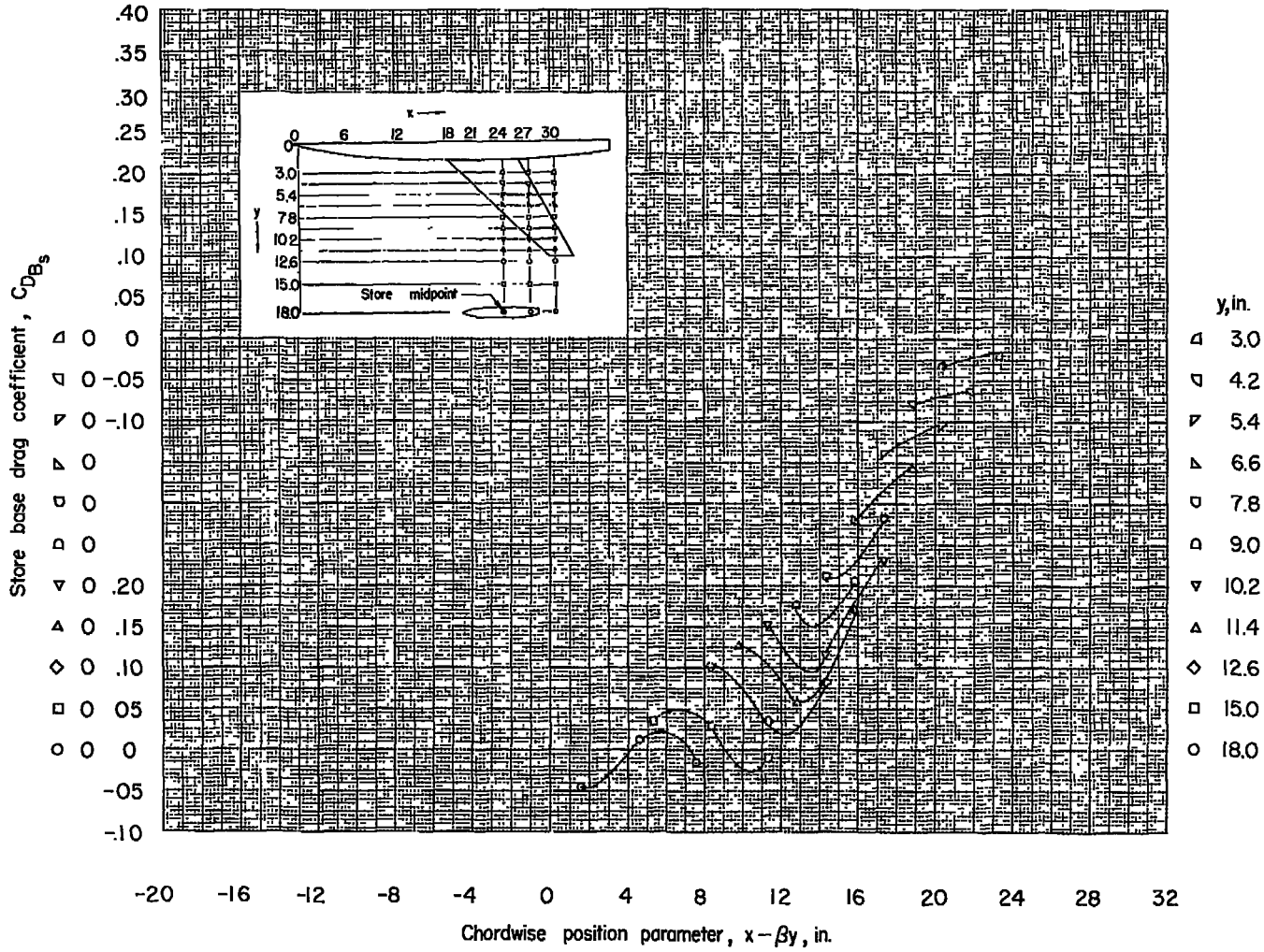
Figure 17.- Base drag of small store in presence of wing-fuselage combination. M = 1.61.



(b) z = 1.67 inches; α = 0°.

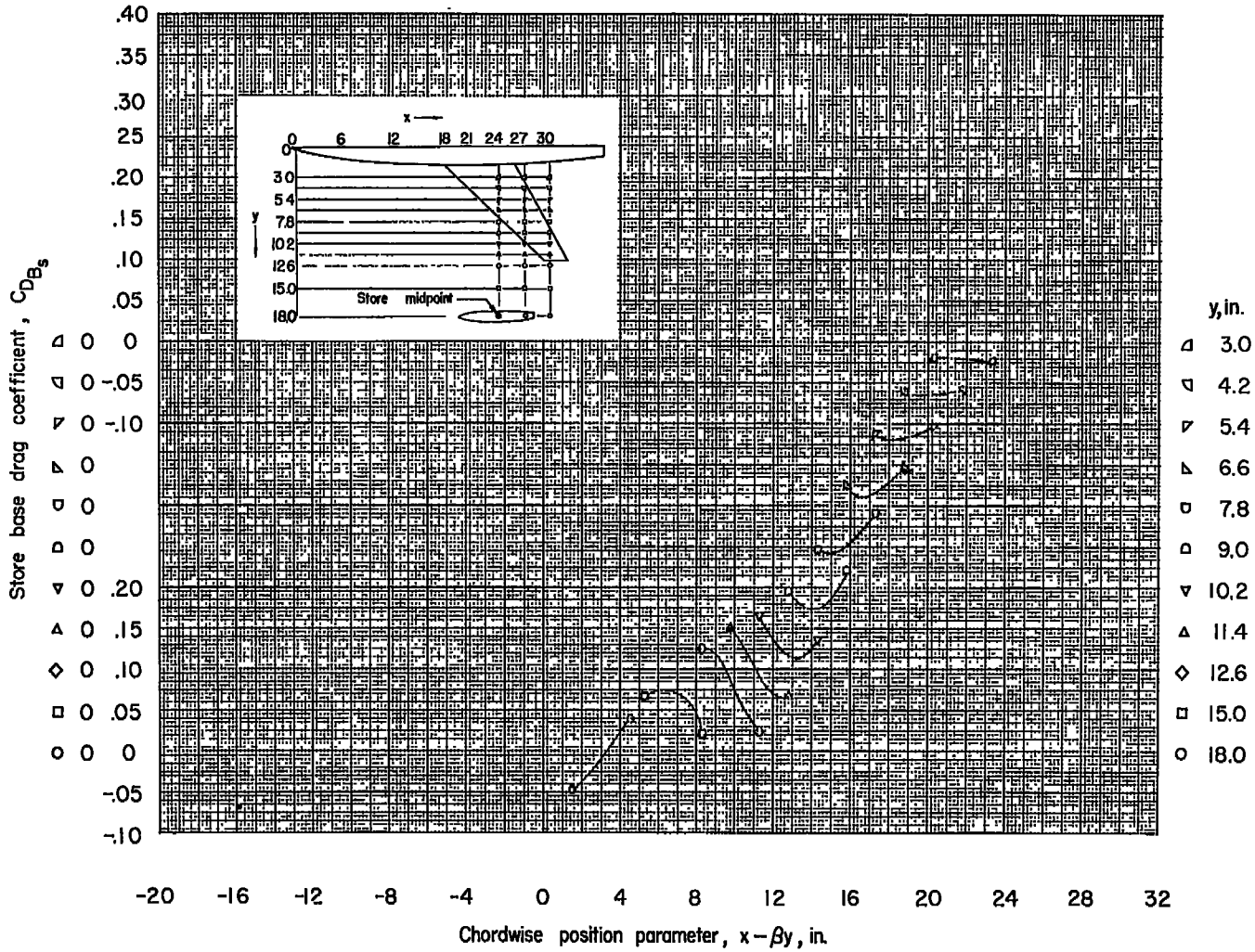
Figure 17.- Continued.

[redacted]



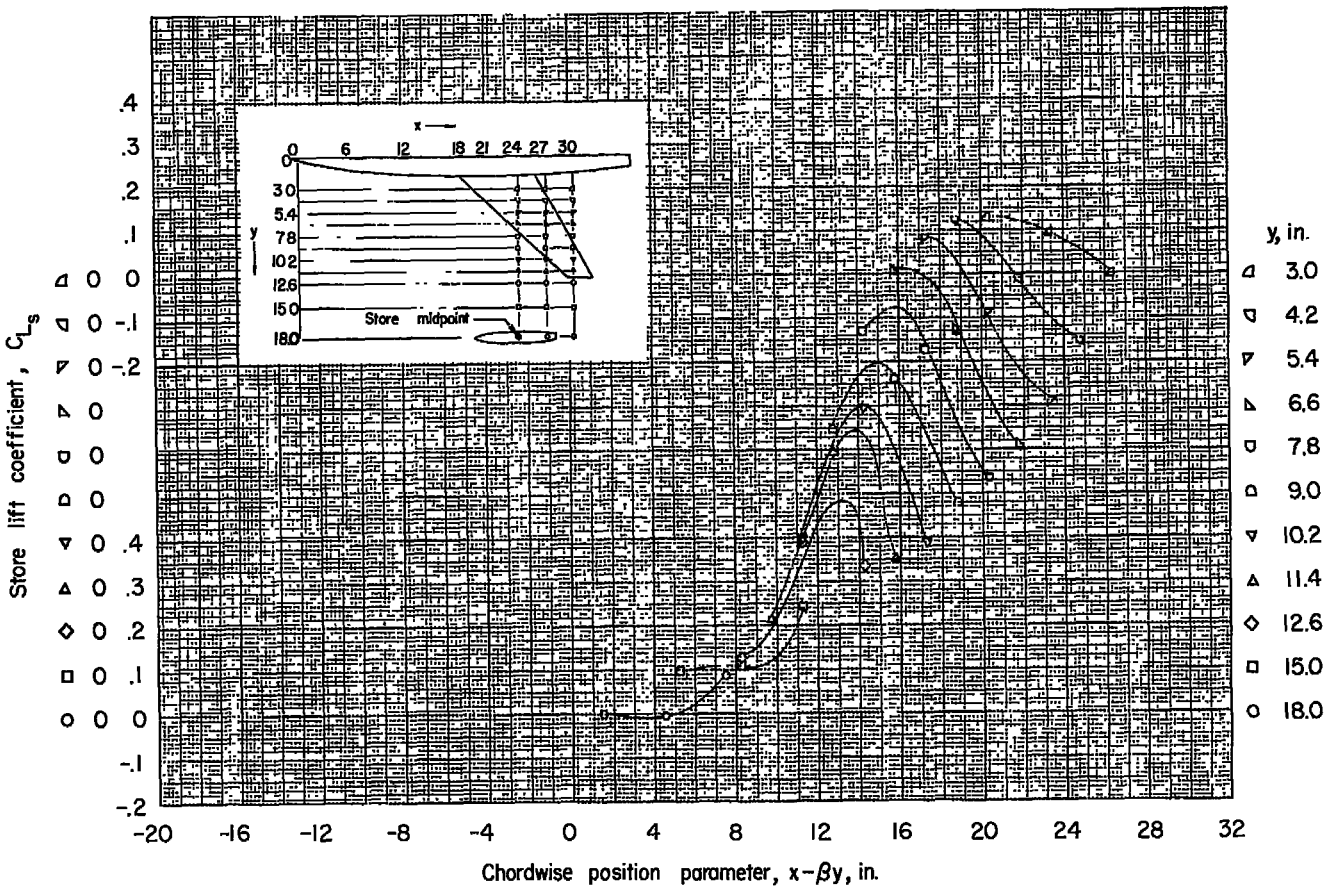
(c) z = 2.09 inches; $\alpha = 0^{\circ}$.

Figure 17.- Continued.



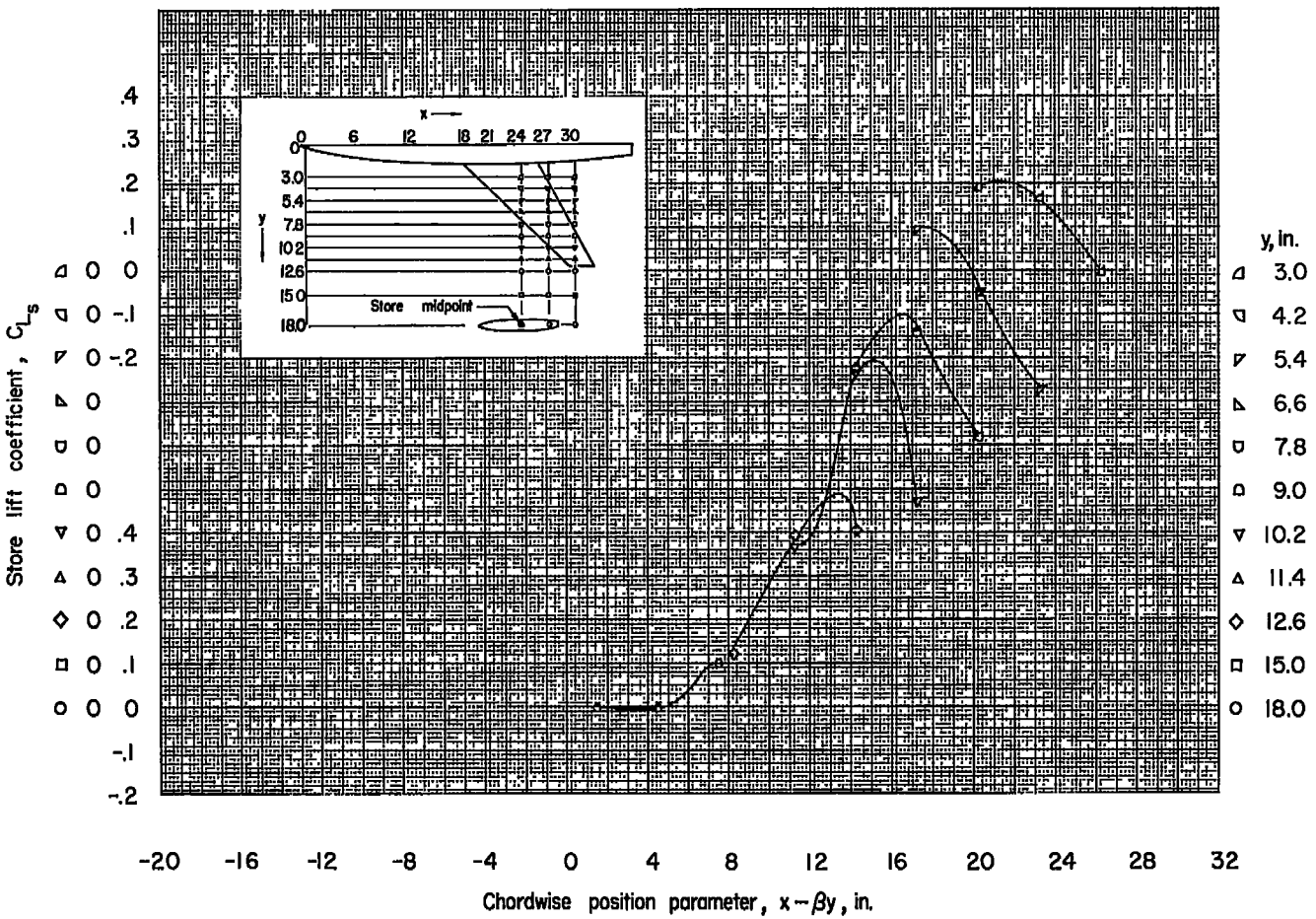
(d) z = 2.09 inches; $\alpha = 4^{\circ}$.

Figure 17.- Concluded.



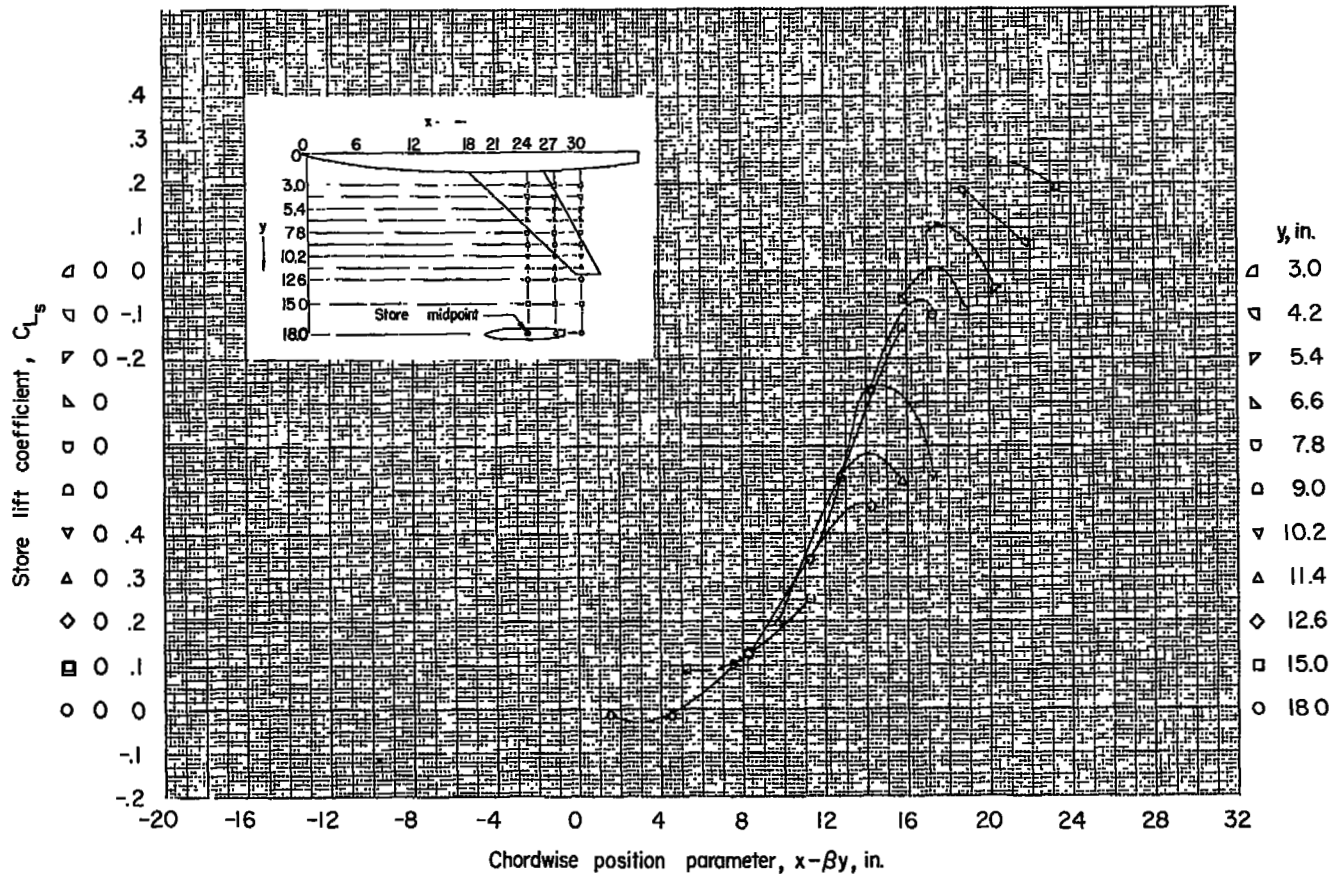
(a) z = 1.15 inches; $\alpha = 0^{\circ}$.

Figure 18.- Lift of small store in presence of wing-fuselage combination. M = 1.61.



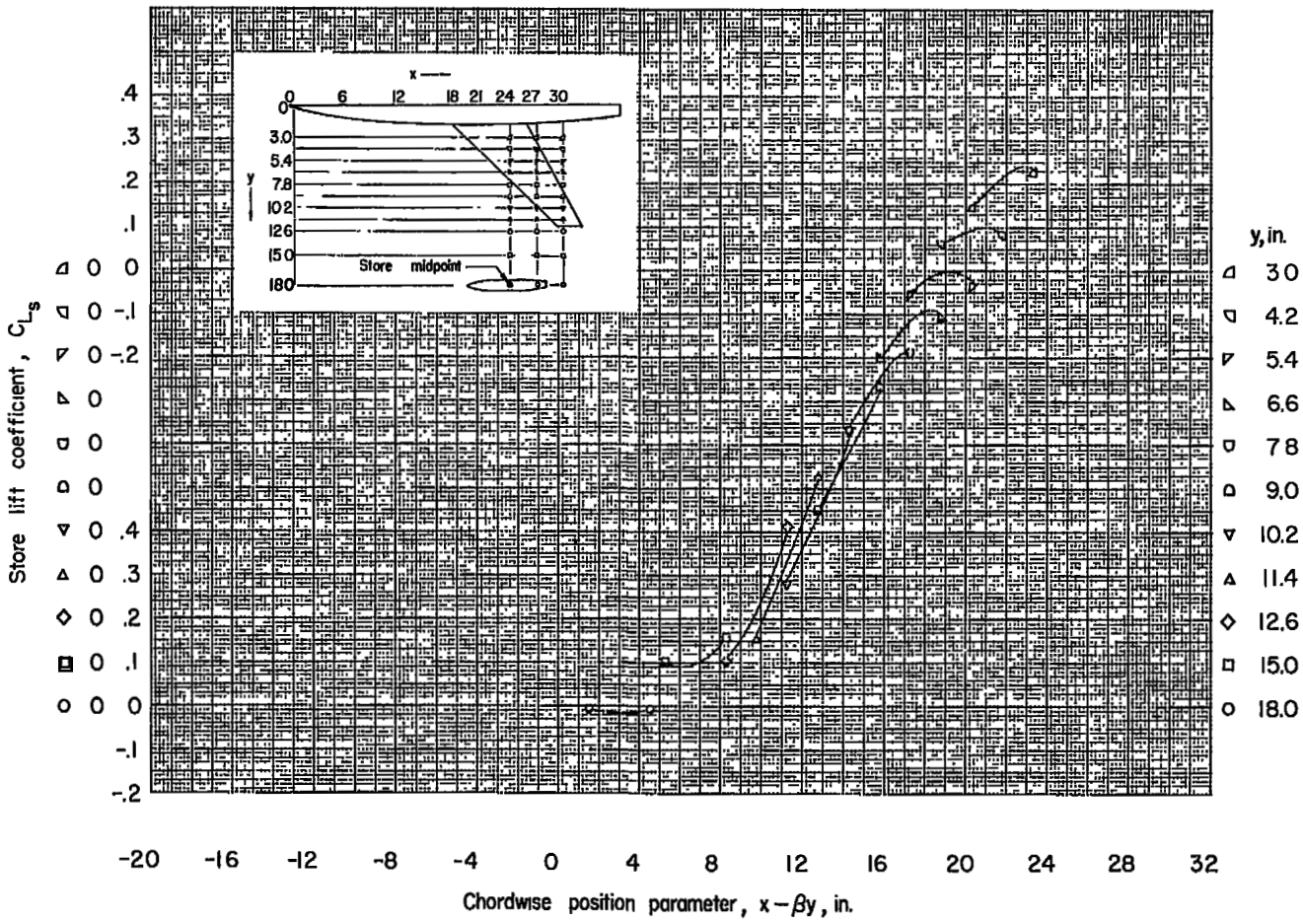
(b) z = 1.67 inches; $\alpha = 0^{\circ}$.

Figure 18.- Continued.



(c) z = 2.09 inches; $\alpha = 0^{\circ}$.

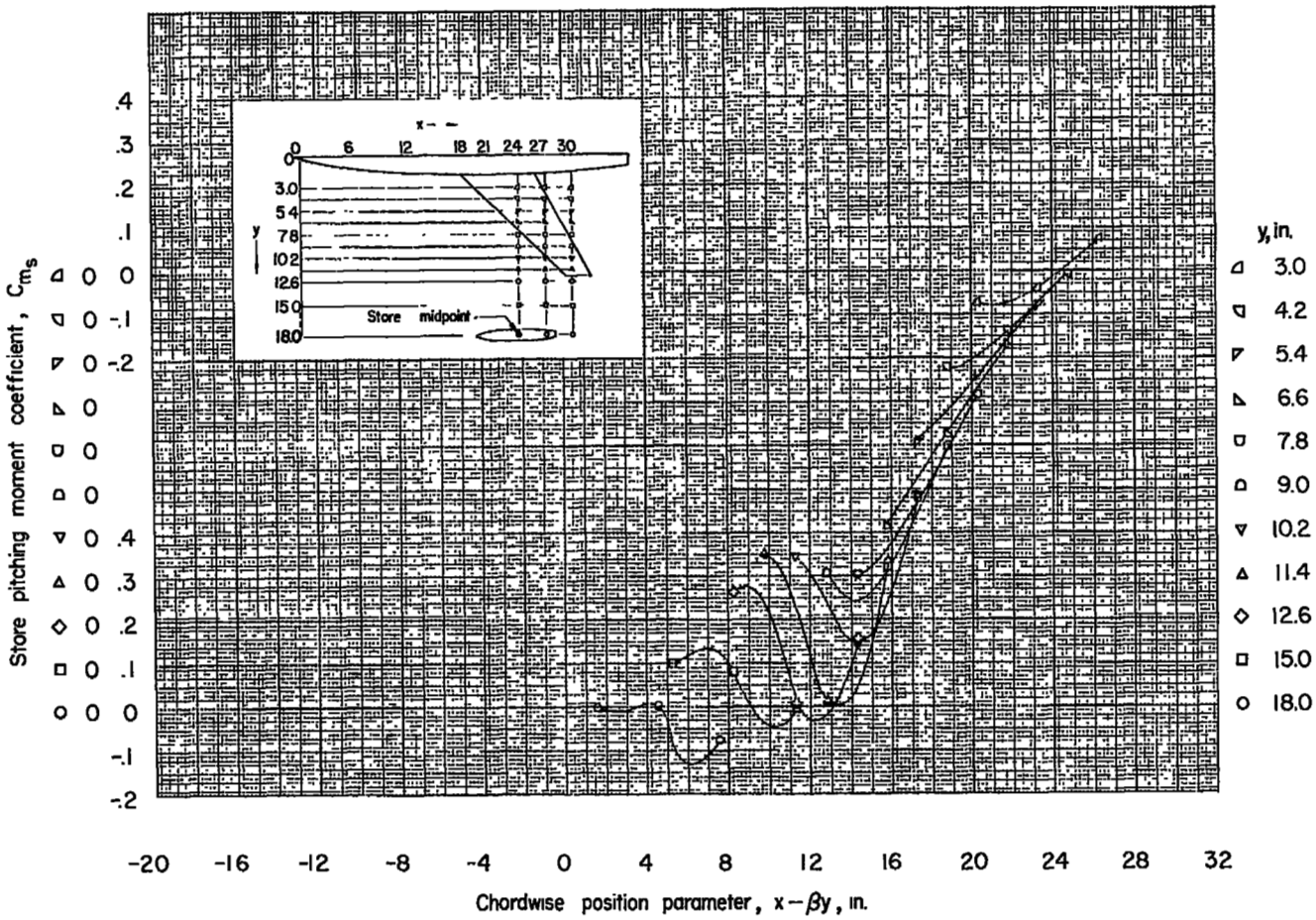
Figure 18.- Continued.



(d) z = 2.09 inches; $\alpha = 4^{\circ}$.

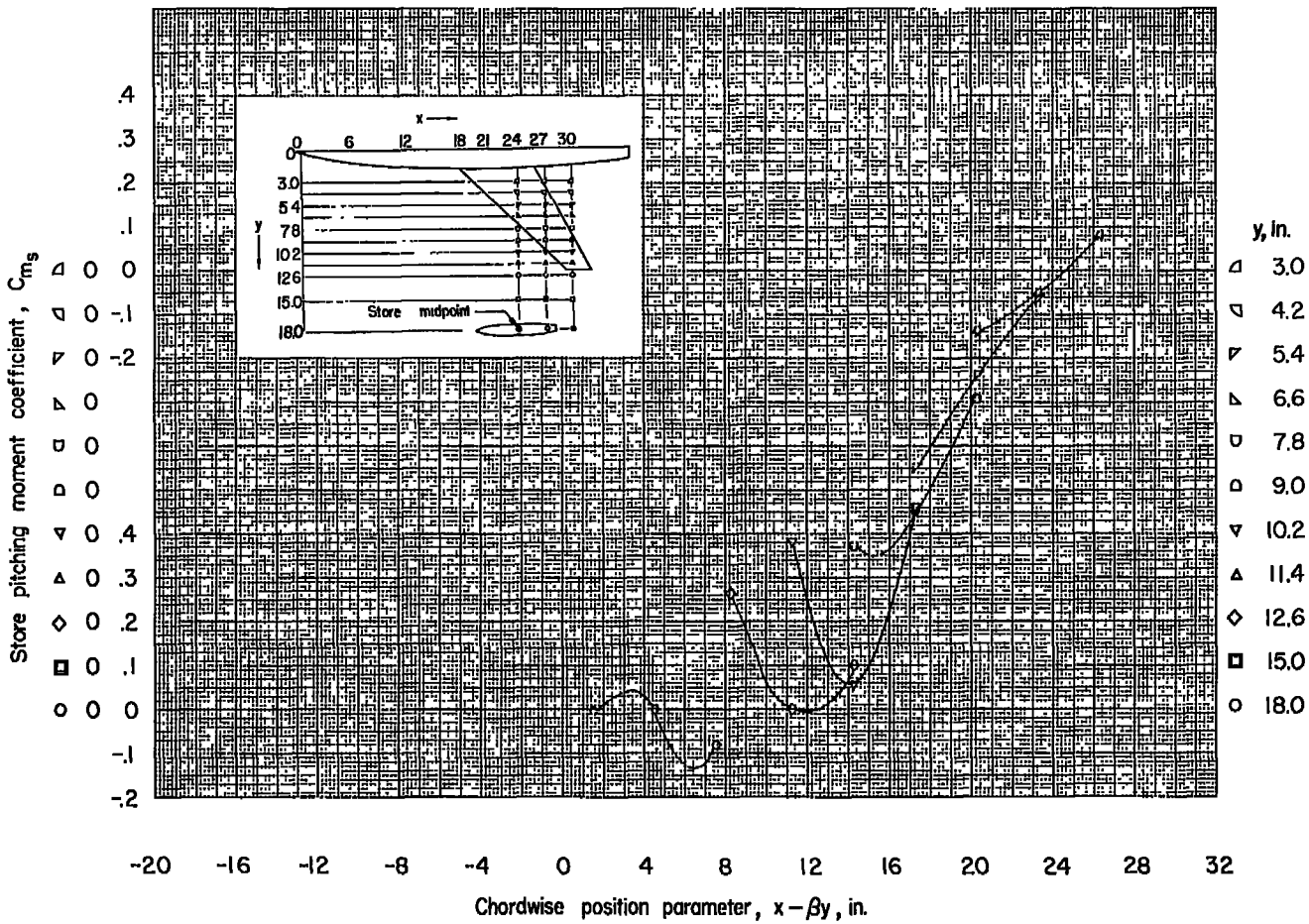
Figure 18.- Concluded.

[redacted]



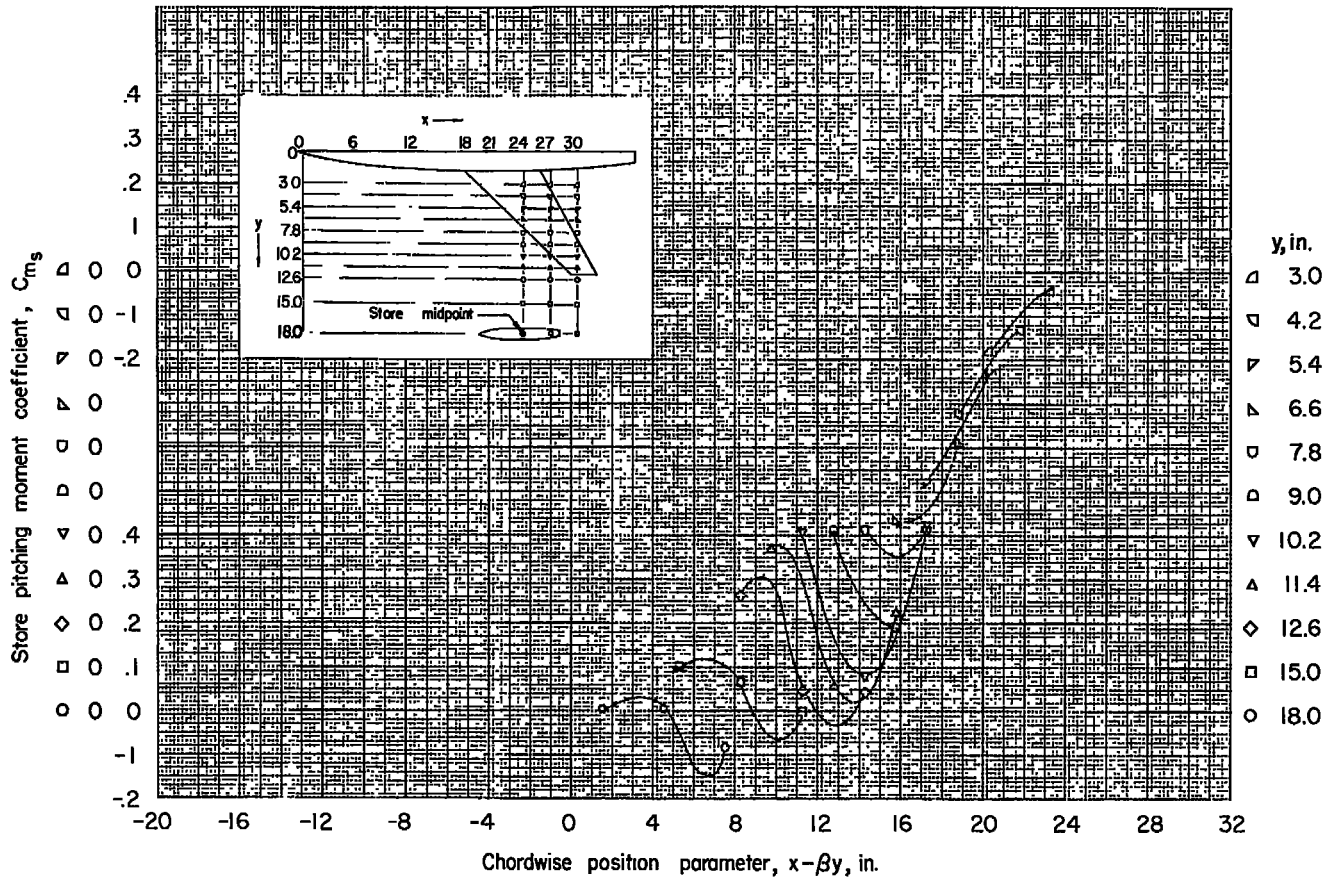
(a) z = 1.15 inches; $\alpha = 0^{\circ}$.

Figure 19.- Pitching moment of small store in presence of wing-fuselage combination. (Center of moments is store nose.) M = 1.61.



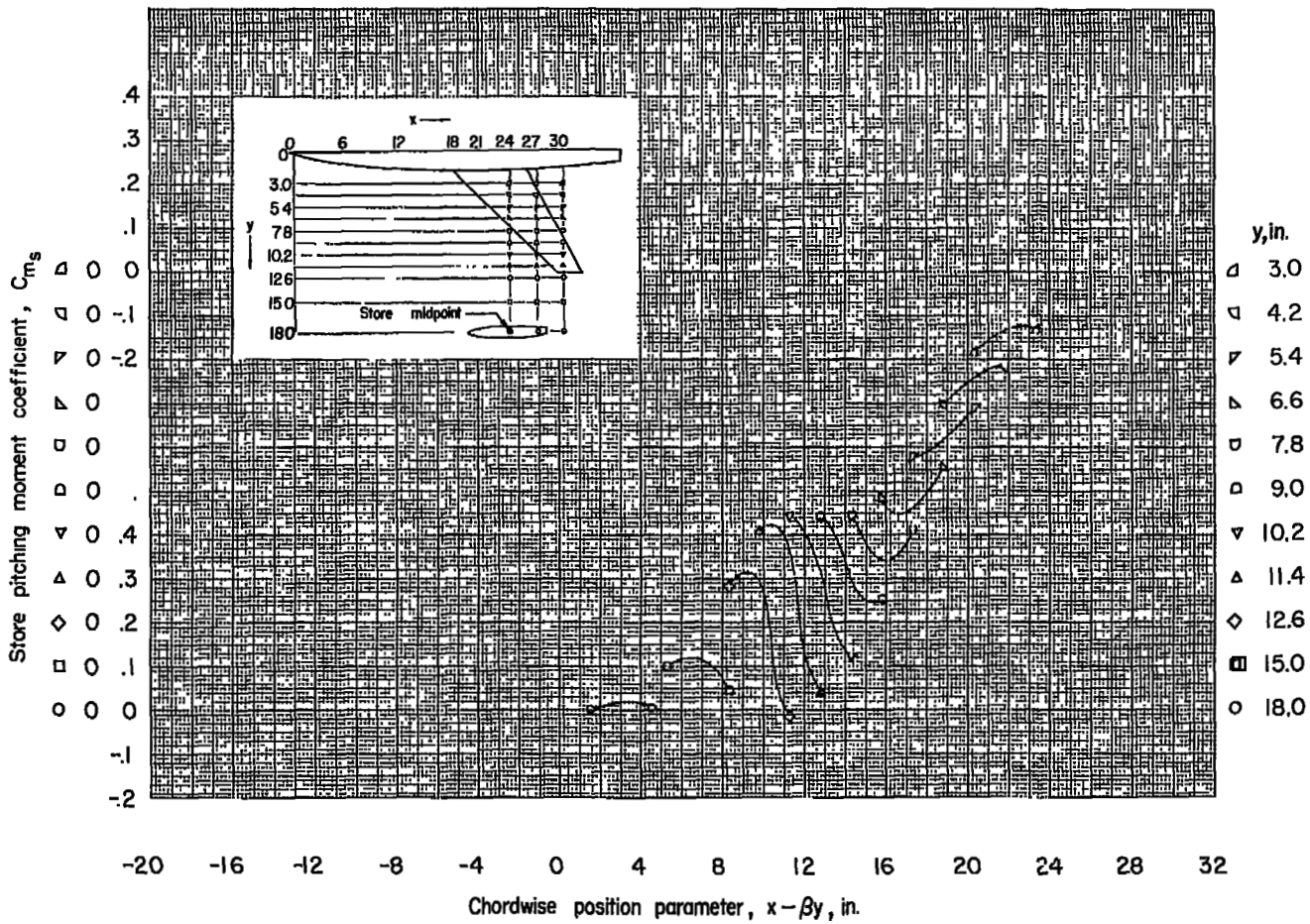
(b) z = 1.67 inches; $\alpha = 0^{\circ}$.

Figure 19.- Continued.



(c) z = 2.09 inches; $\alpha = 0^{\circ}$.

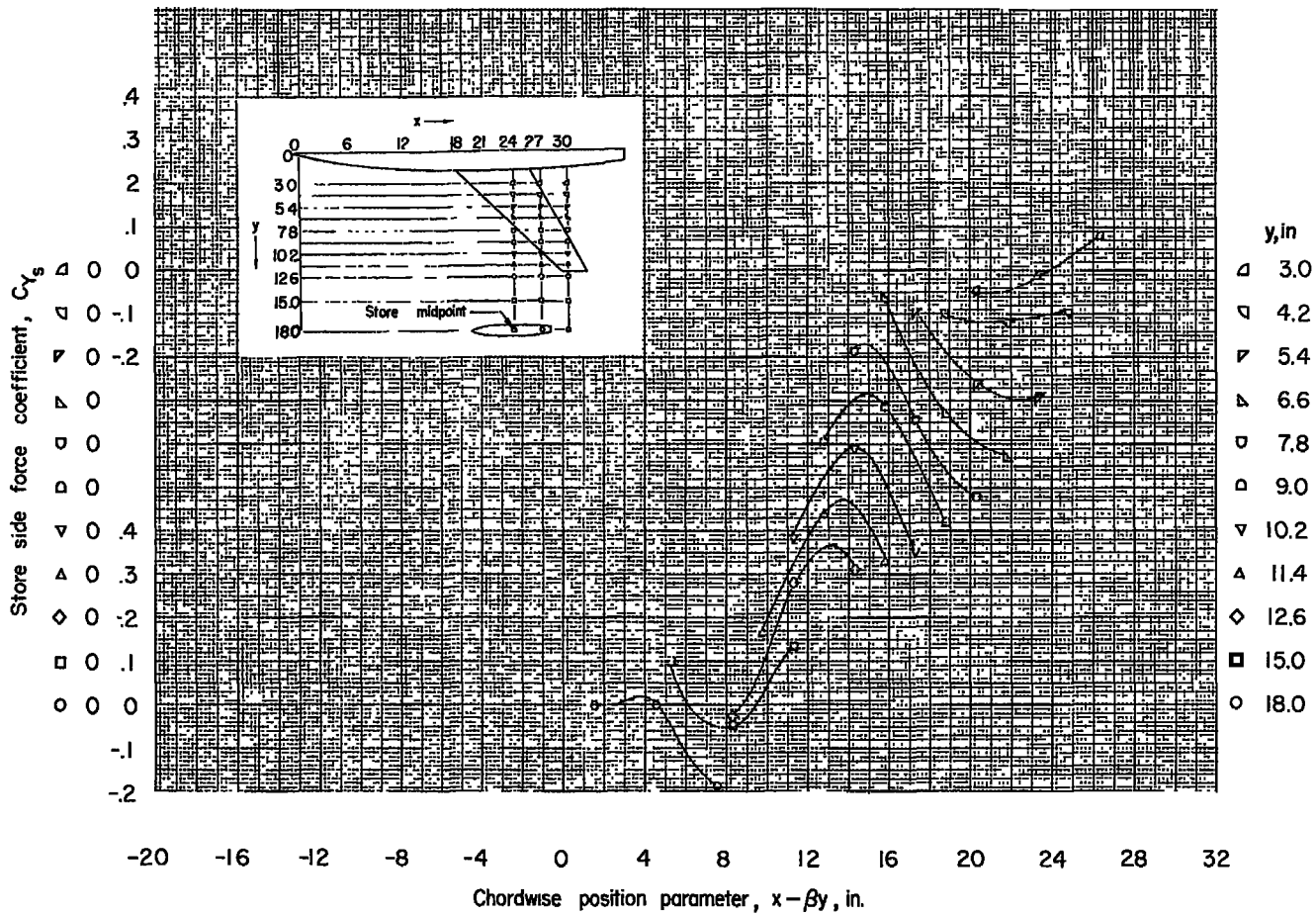
Figure 19.- Continued.



(d) z = 2.09 inches; $\alpha = 4^{\circ}$.

Figure 19.- Concluded.

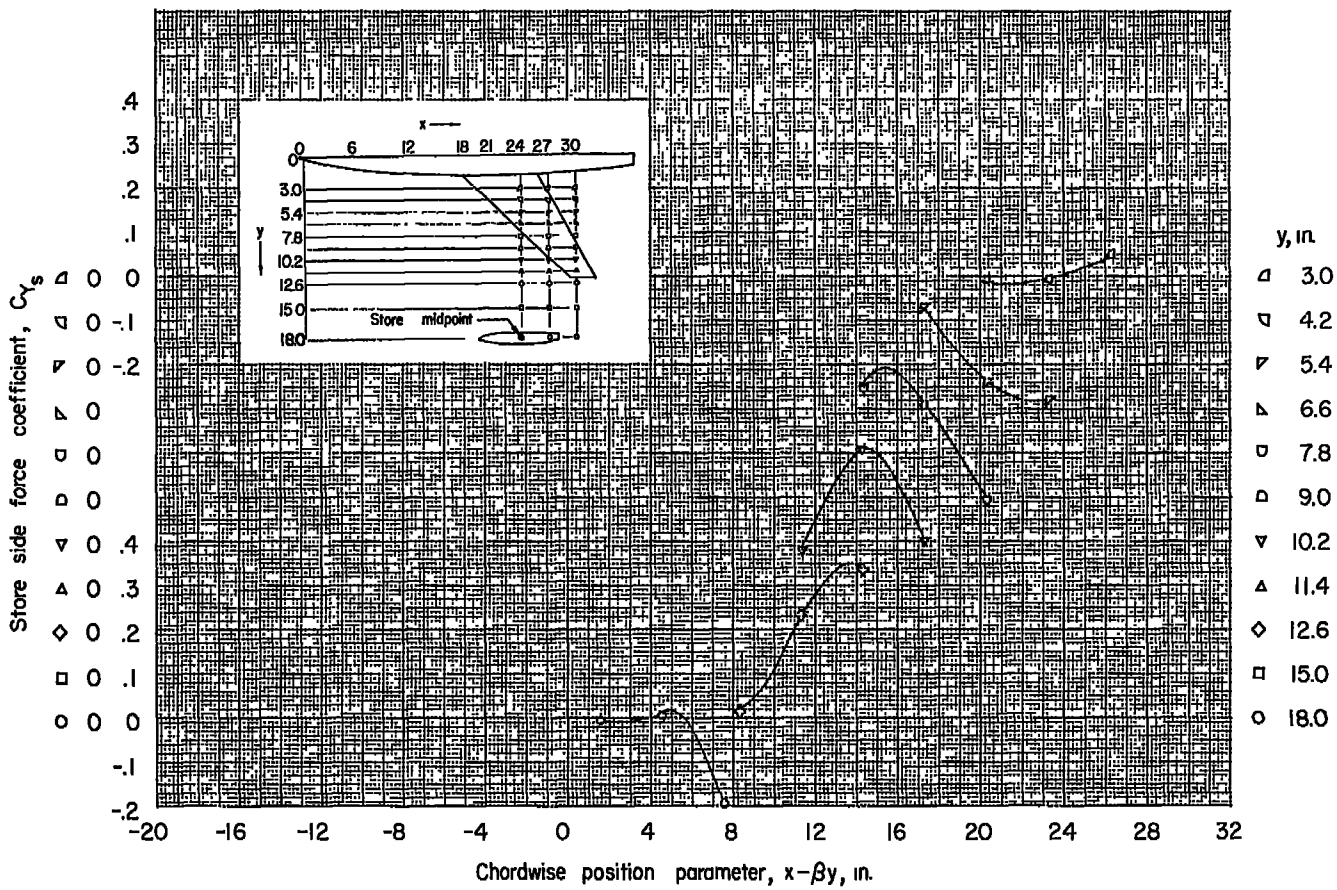
[redacted]



(a) z = 1.15 inches; $\alpha = 0^{\circ}$.

Figure 20.- Side force of small store in presence of wing-fuselage combination. M = 1.61.

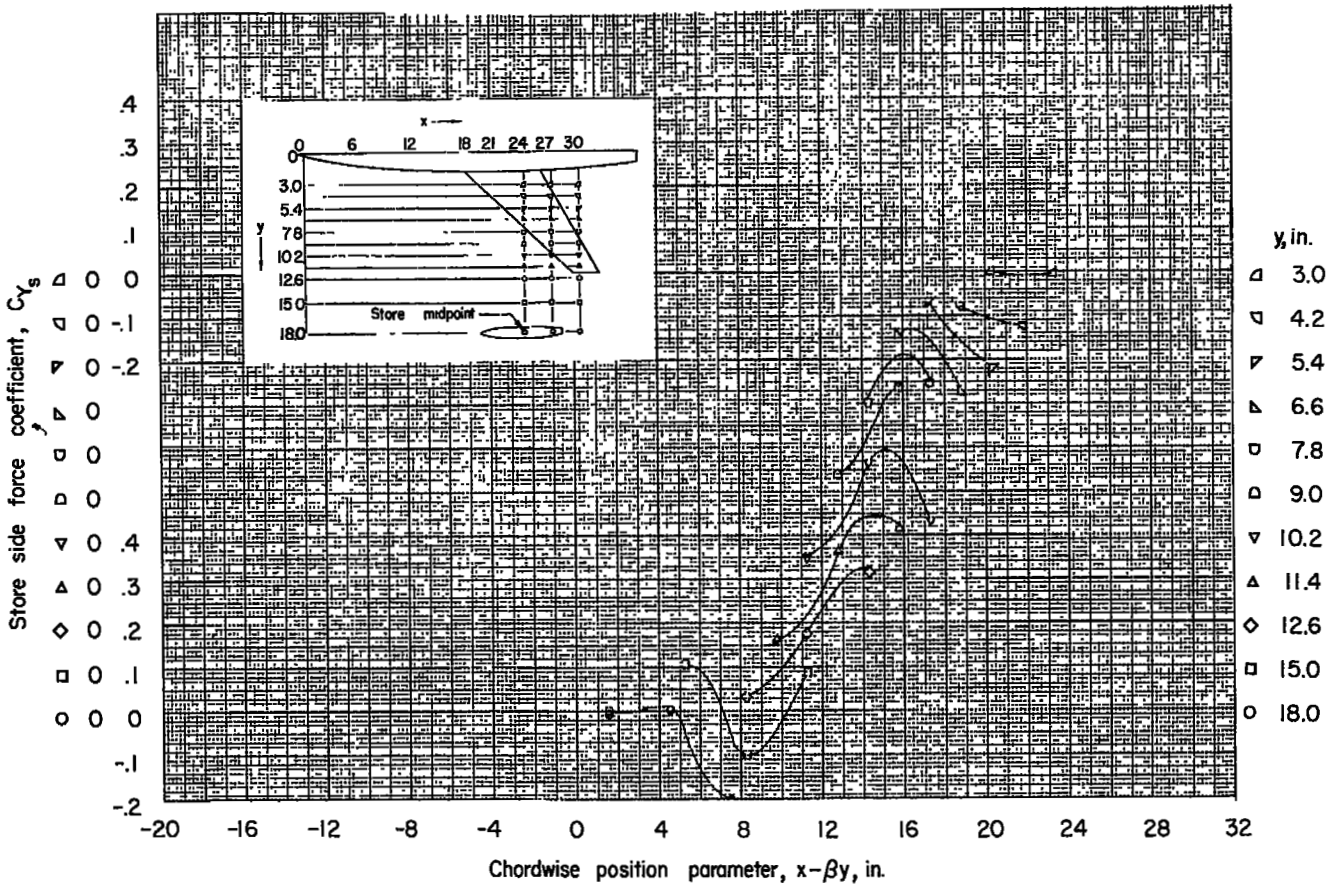
CONFIDENTIAL



(b) z = 1.67 inches; $\alpha = 0^{\circ}$.

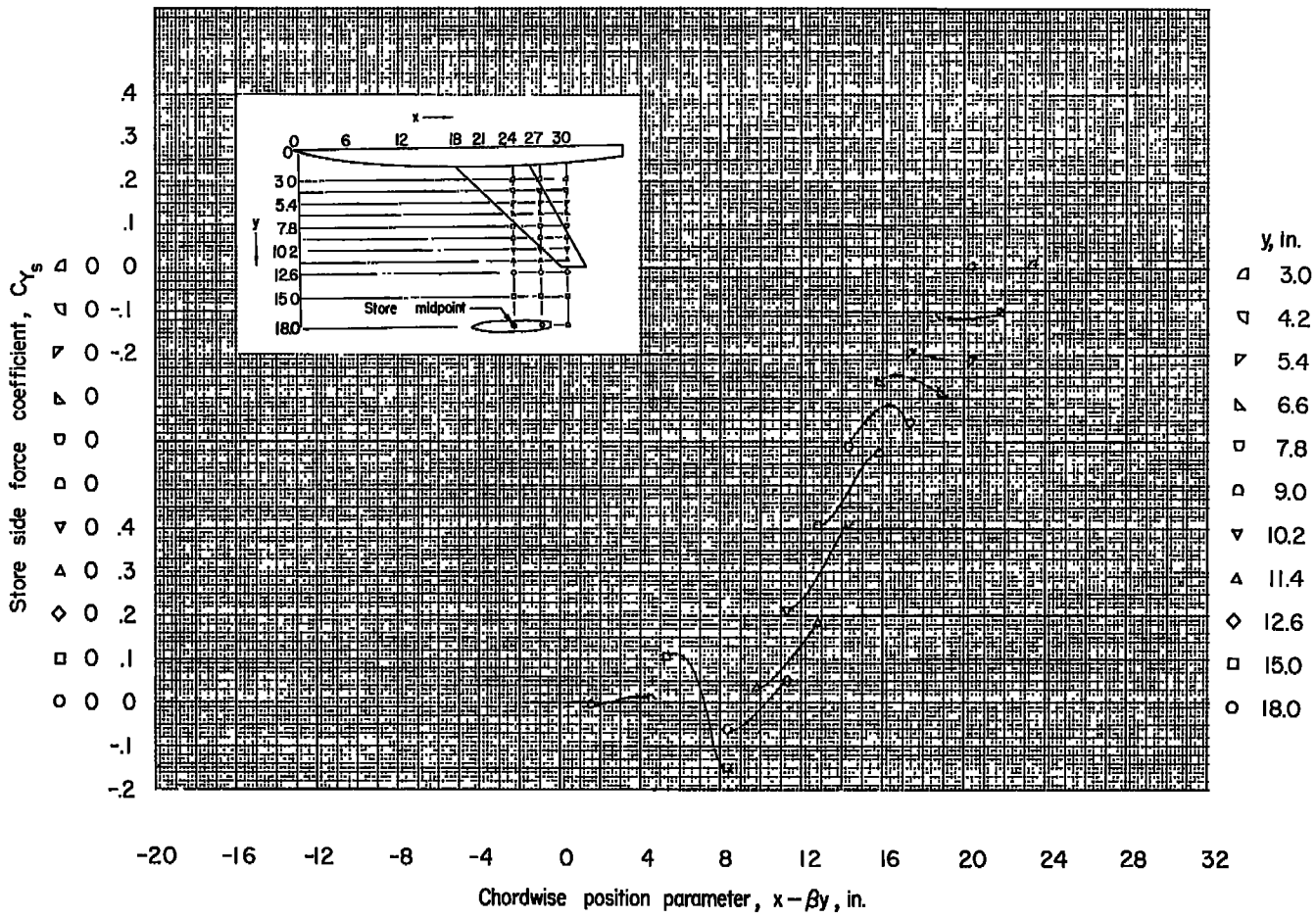
Figure 20.- Continued.

CONFIDENTIAL



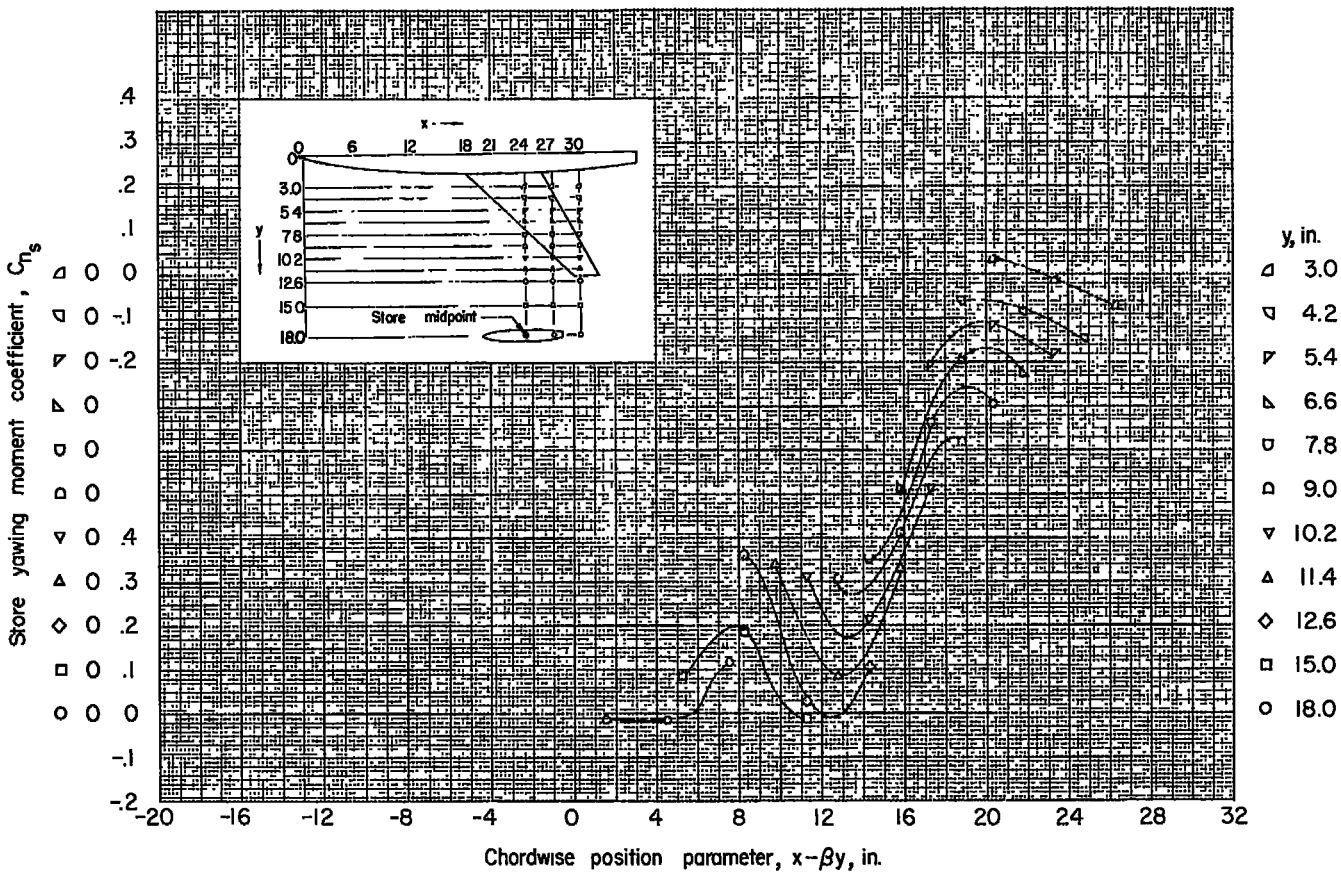
(c) z = 2.09 inches; $\alpha = 0^{\circ}$.

Figure 20.- Continued.



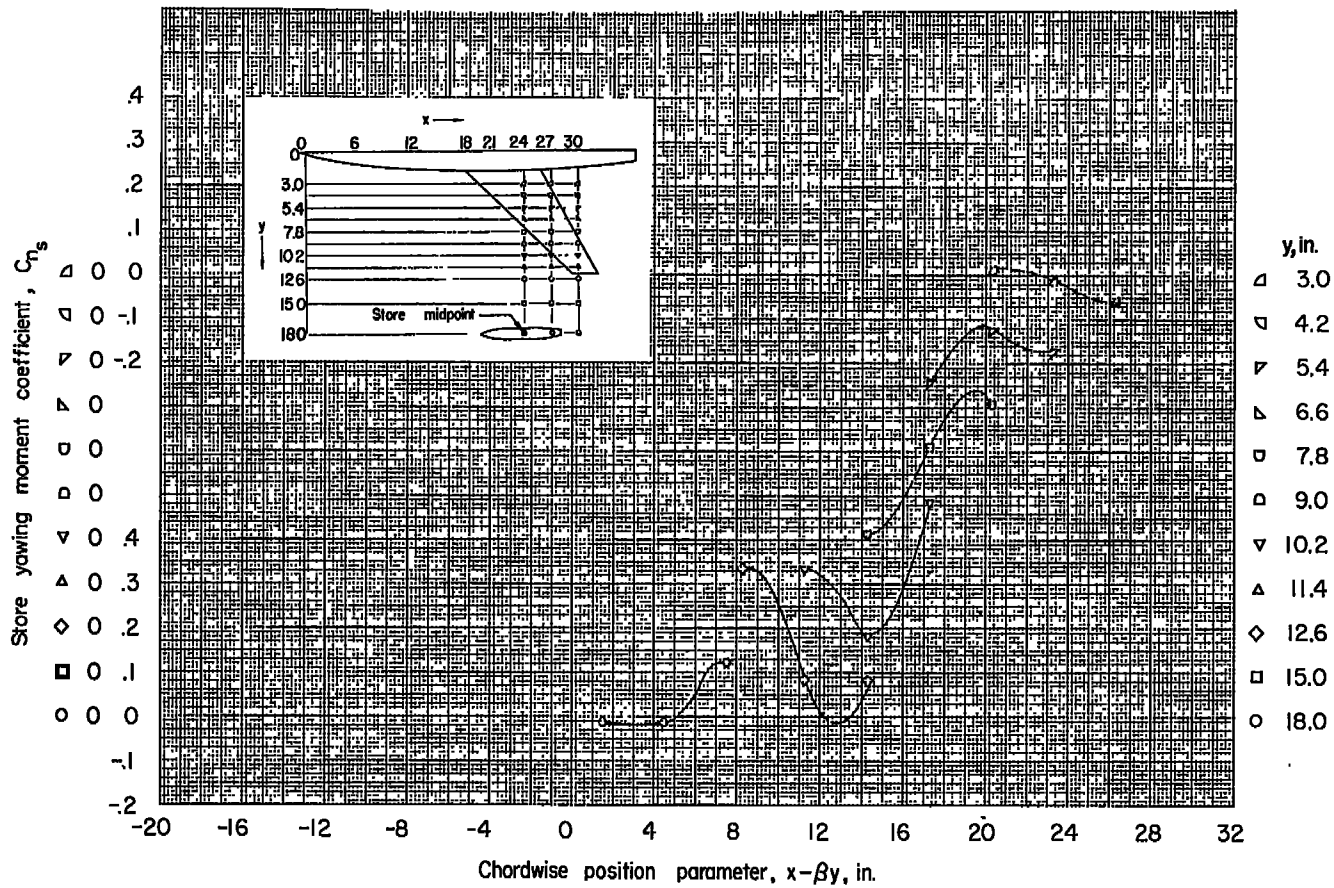
(d) z = 2.09 inches; $\alpha = 4^{\circ}$.

Figure 20.- Concluded.



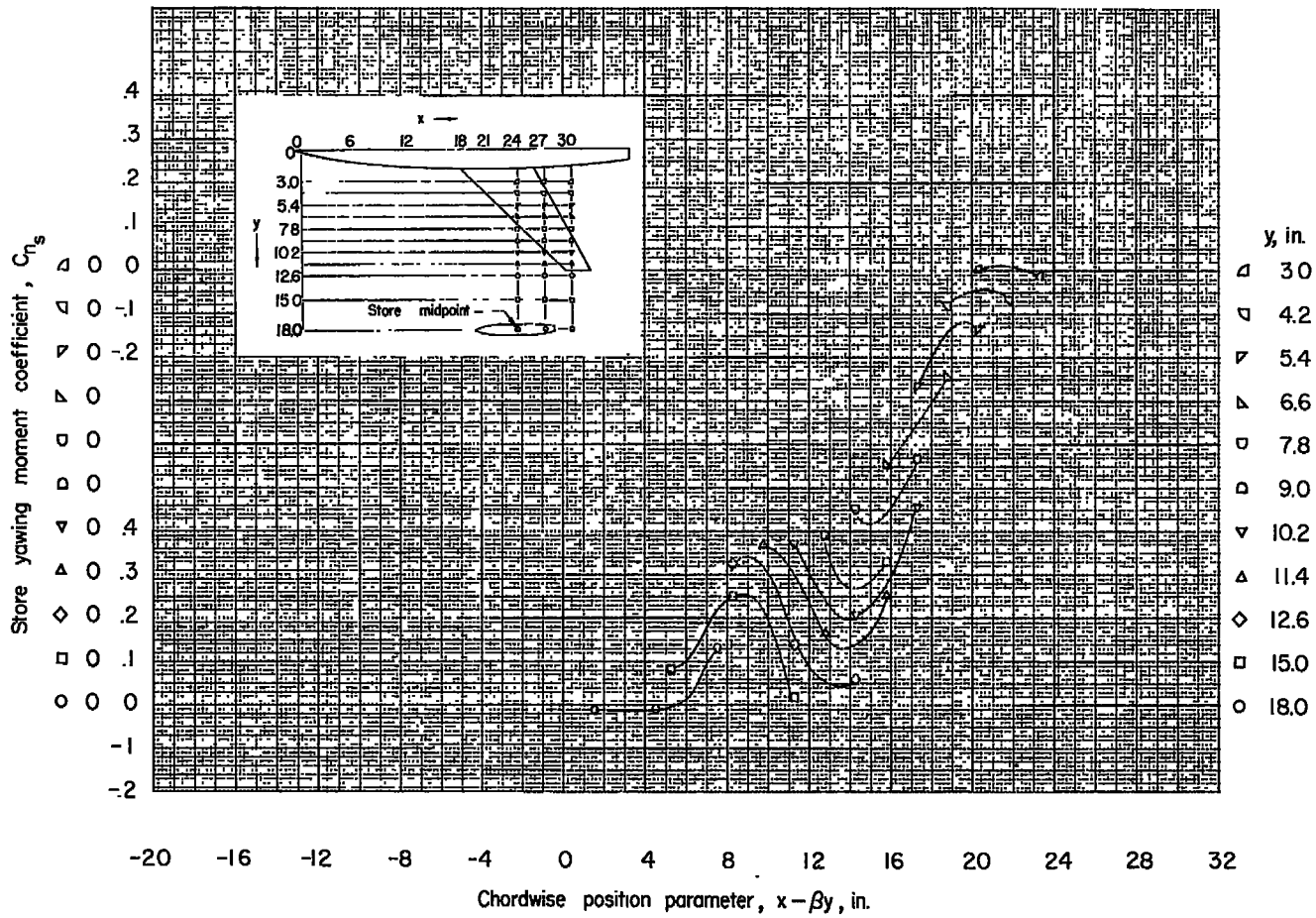
(a) z = 1.15 inches; $\alpha = 0^{\circ}$.

Figure 21.- Yawing moment of small store in presence of wing-fuselage combination. (Center of moments is store nose.) M = 1.61.



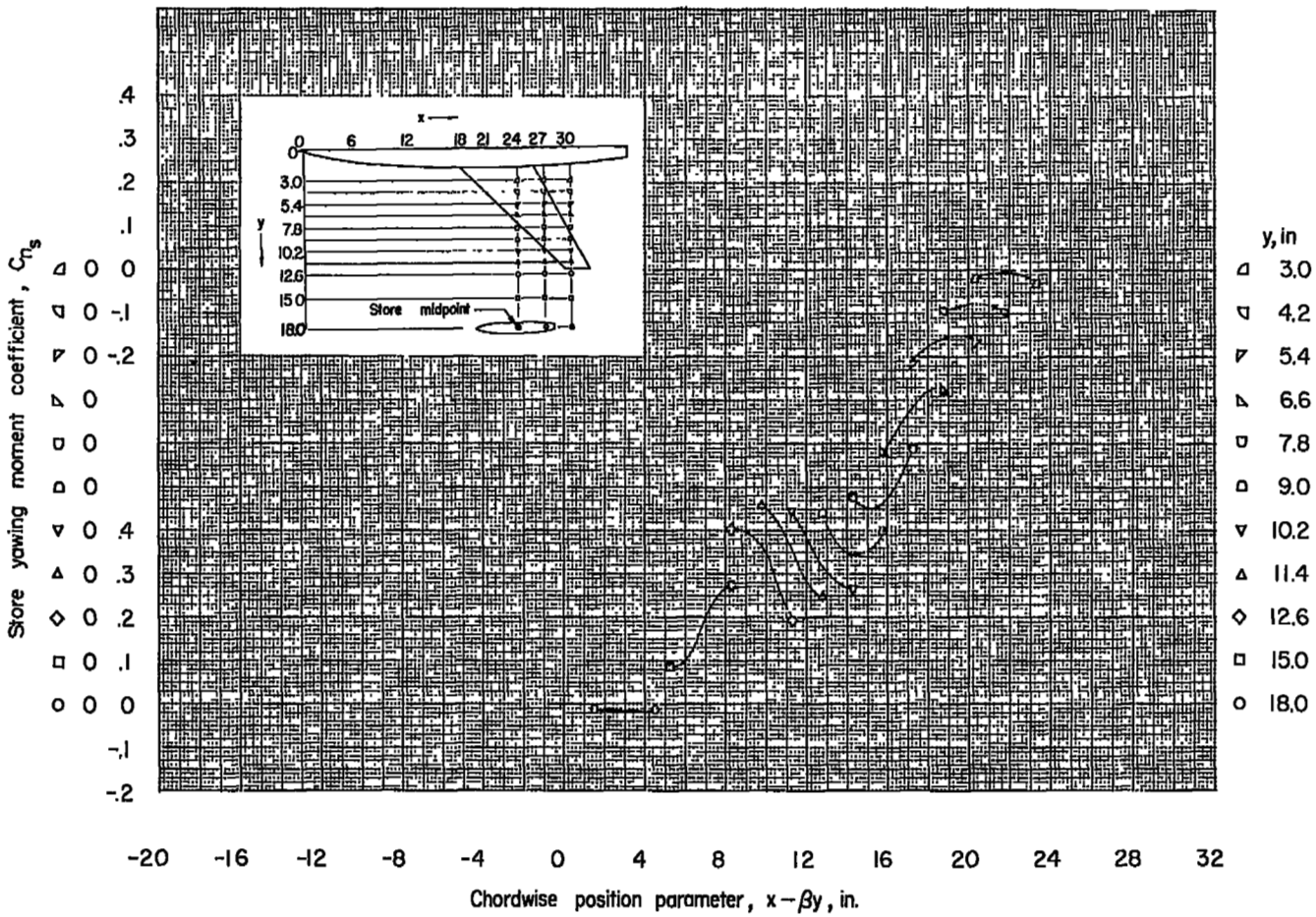
(b) z = 1.67 inches; $\alpha = 0^{\circ}$.

Figure 21.- Continued.



(c) z = 2.09 inches; $\alpha = 0^{\circ}$.

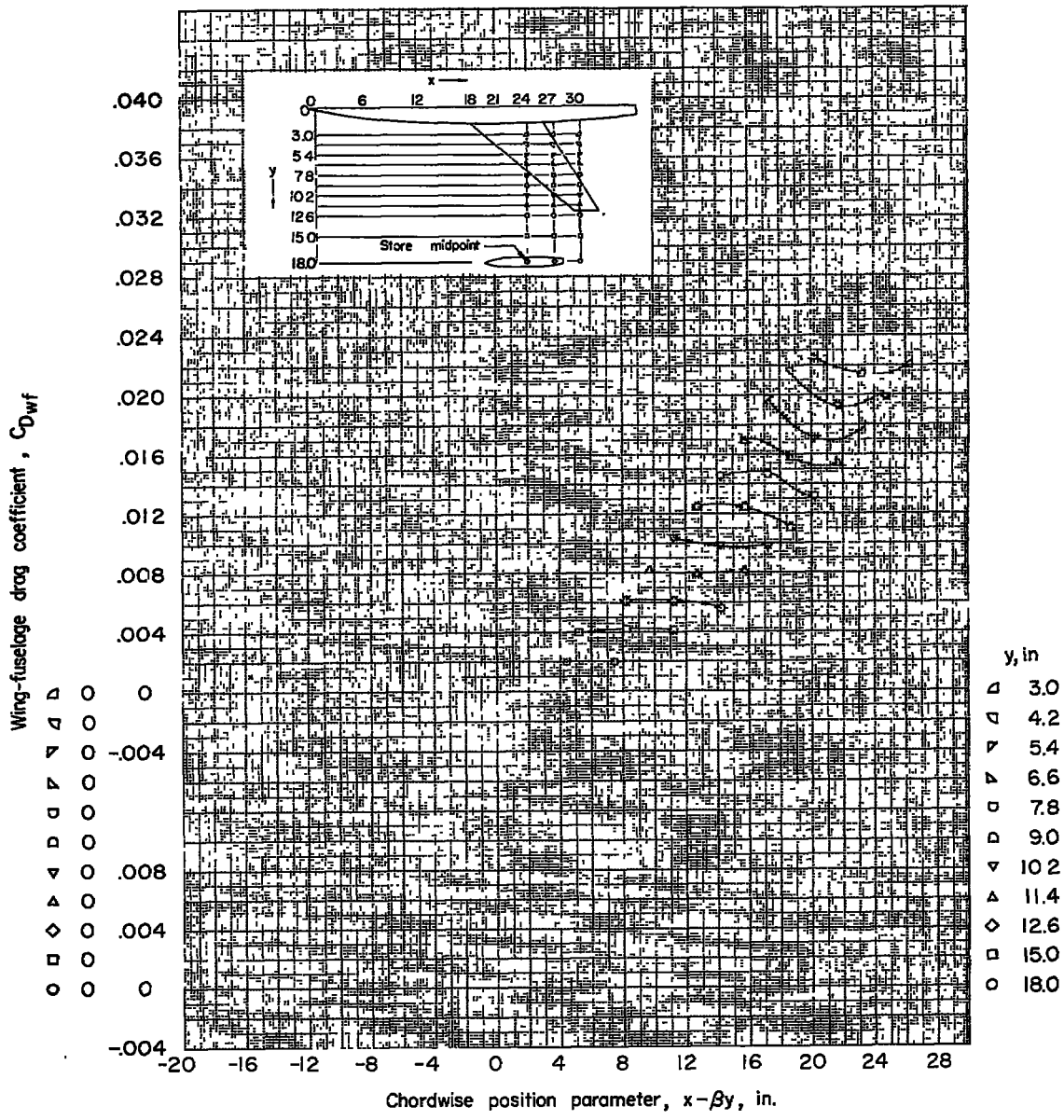
Figure 21.- Continued.



(d) z = 2.09 inches; $\alpha = 4^{\circ}$.

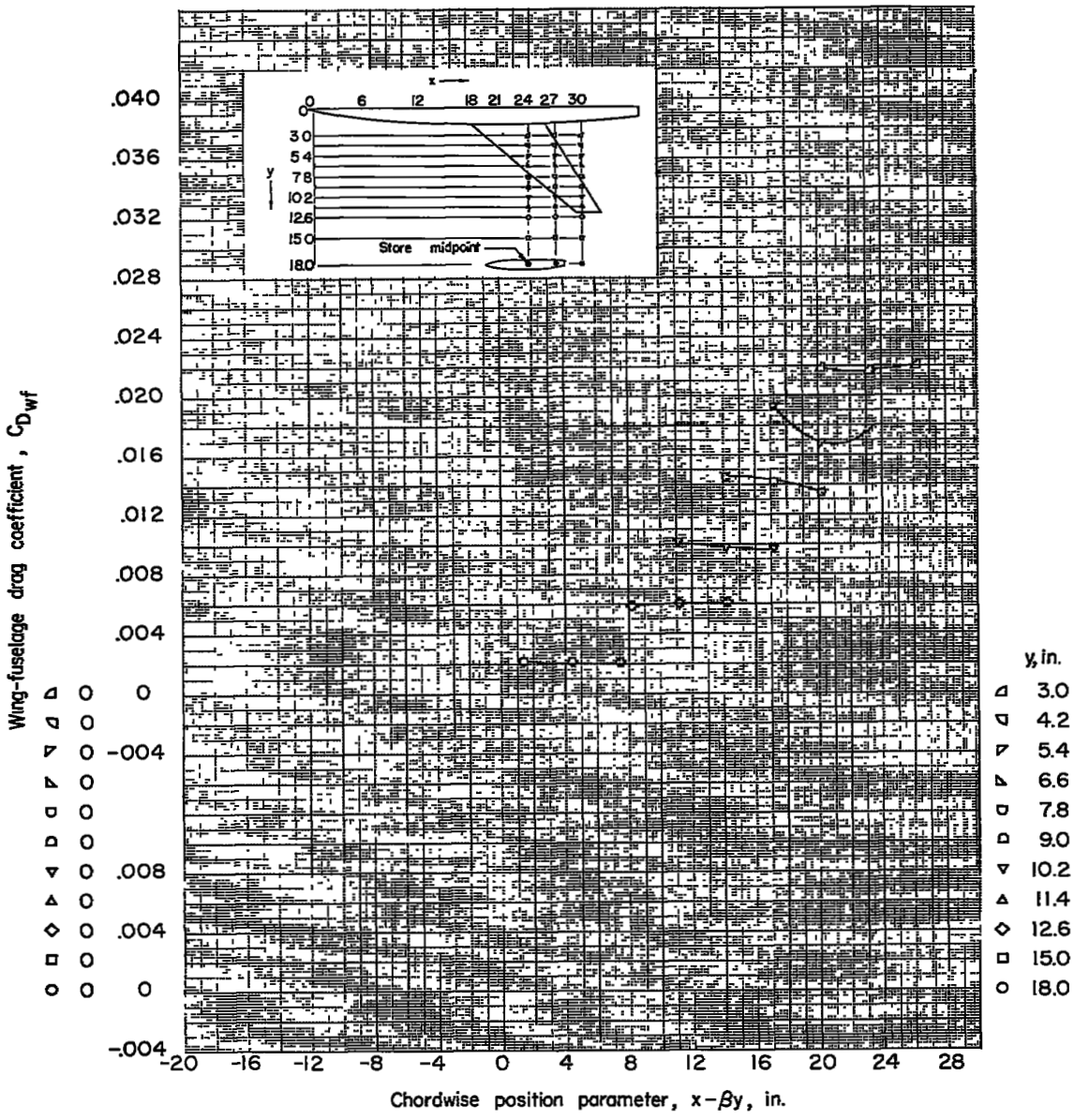
Figure 21.- Concluded.

[redacted]



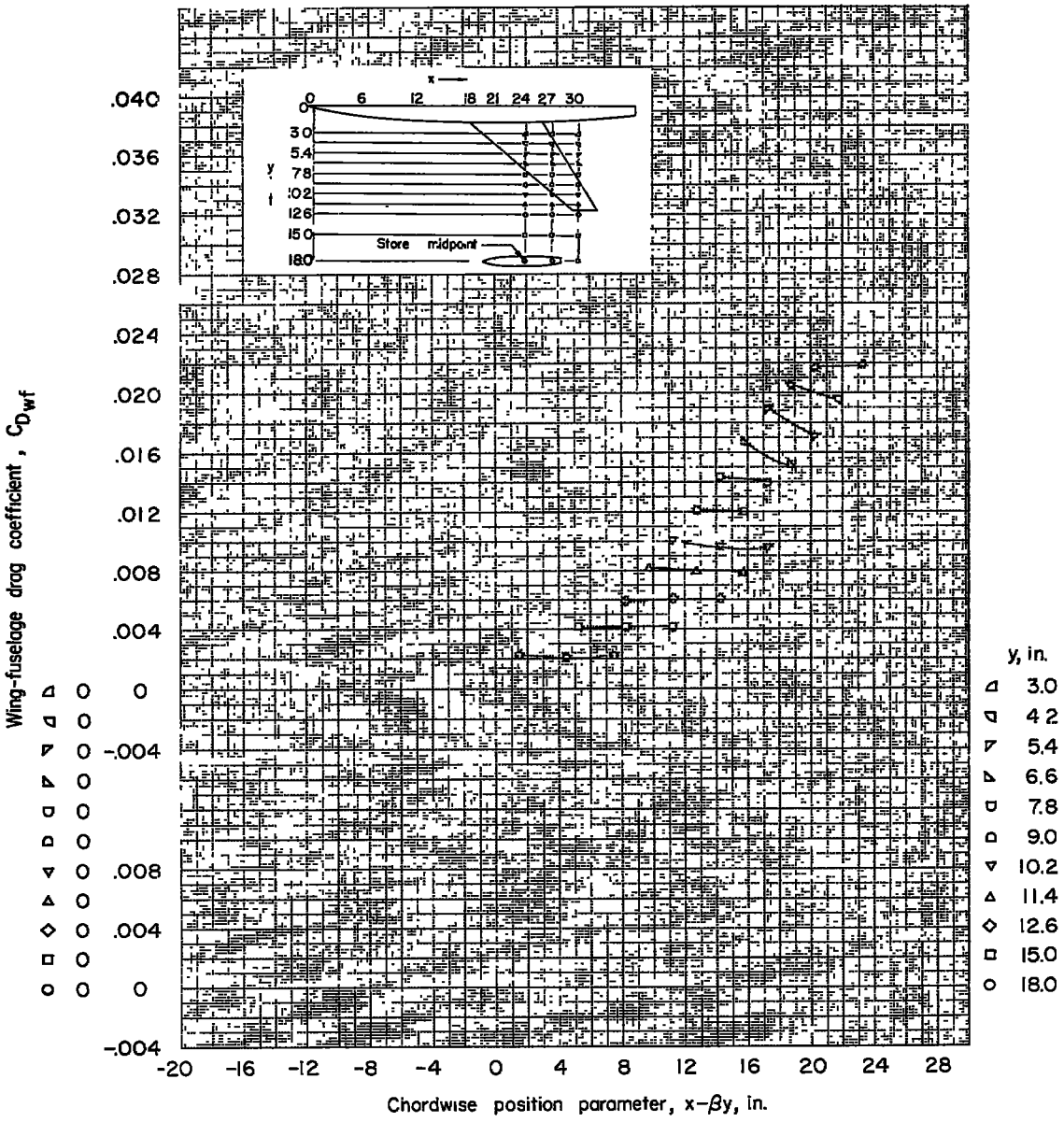
(a) z = 1.15 inches; $\alpha = 0^{\circ}$.

Figure 22.- Drag of wing-fuselage combination in presence of small store. (Drags corrected for fuselage base pressures.) M = 1.61.



(b) z = 1.67 inches; $\alpha = 0^{\circ}$.

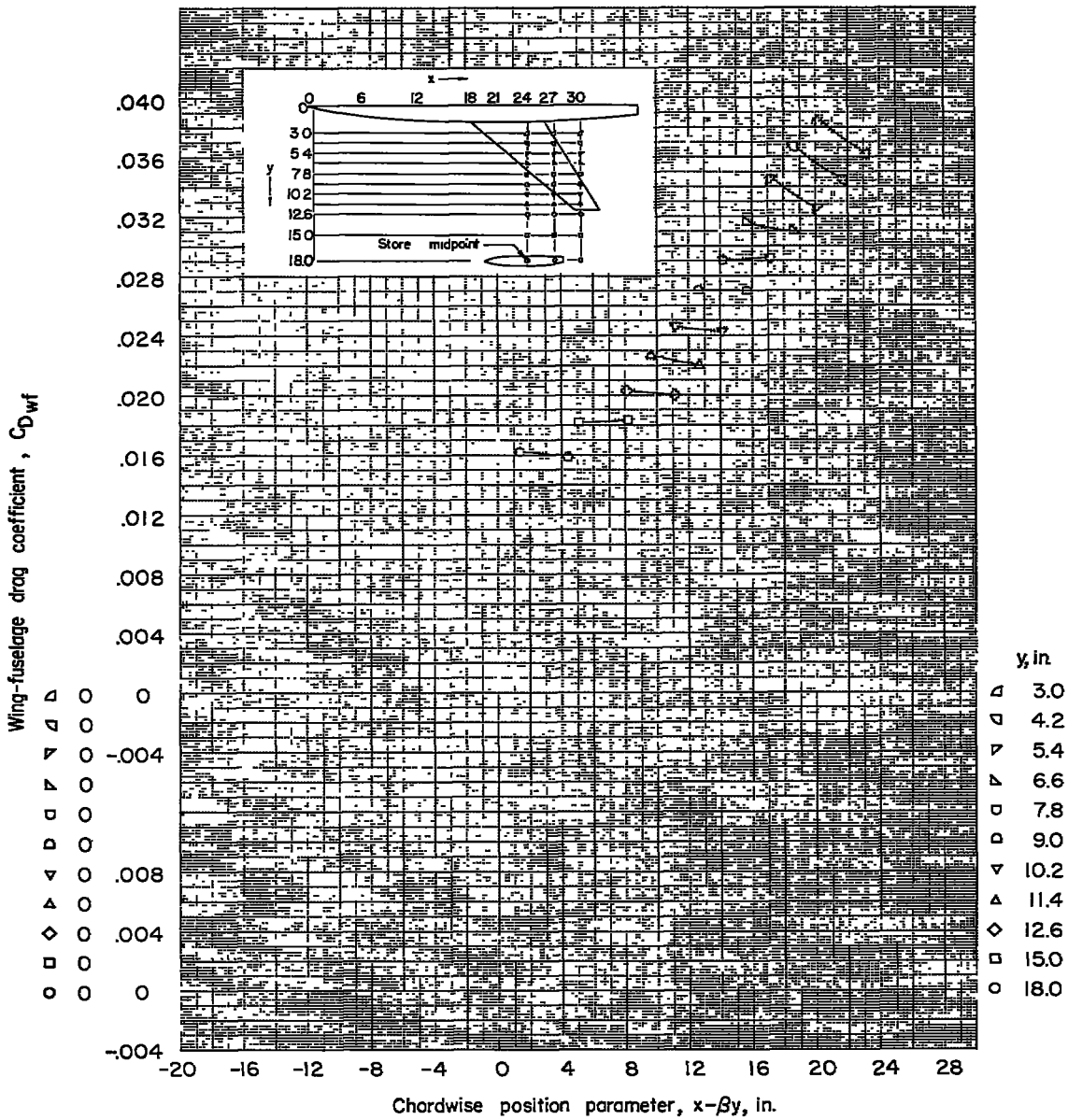
Figure 22.- Continued.



(c) z = 2.09 inches; $\alpha = 0^{\circ}$.

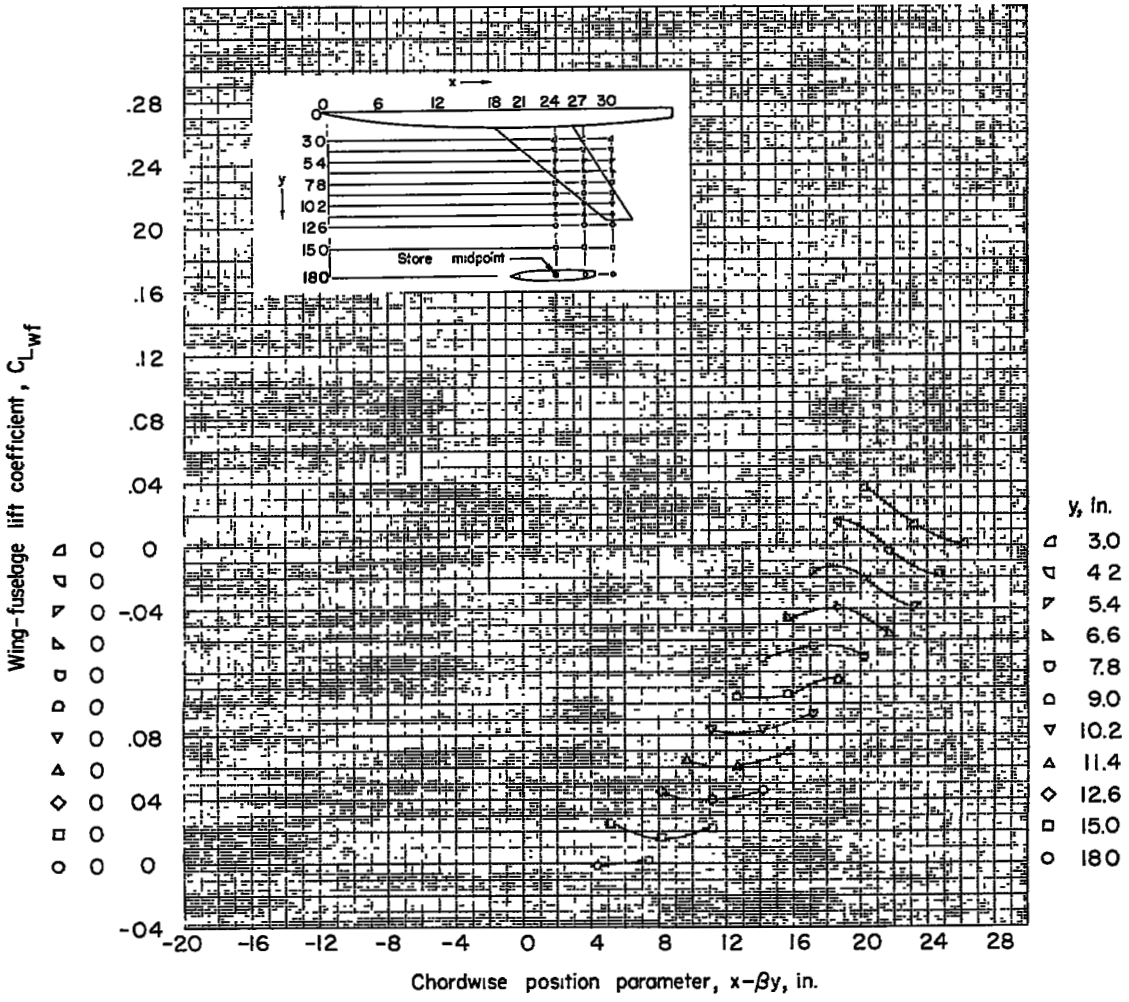
Figure 22.- Continued.

UNCLASSIFIED



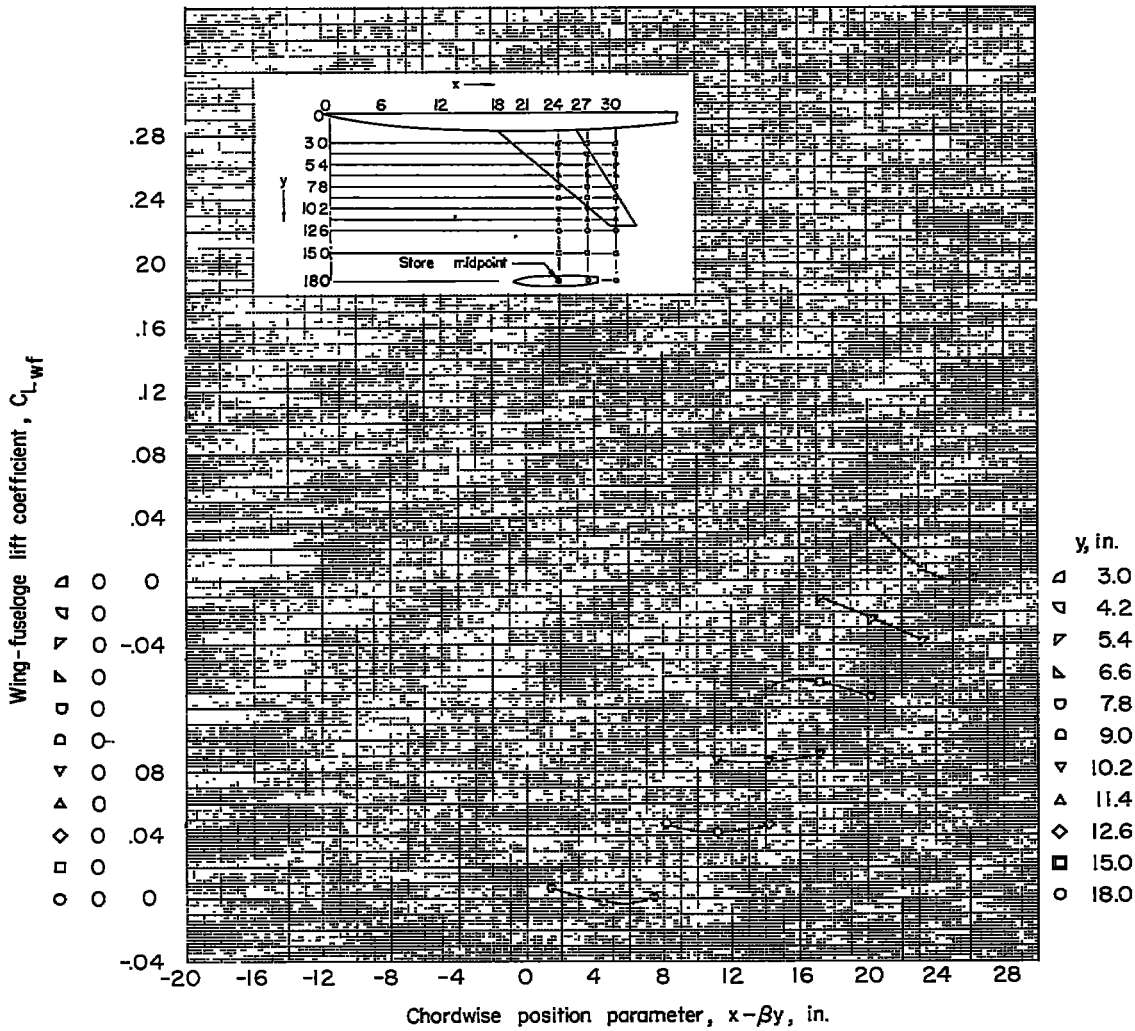
(d) z = 2.09 inches; $\alpha = 4^{\circ}$.

Figure 22.- Concluded.



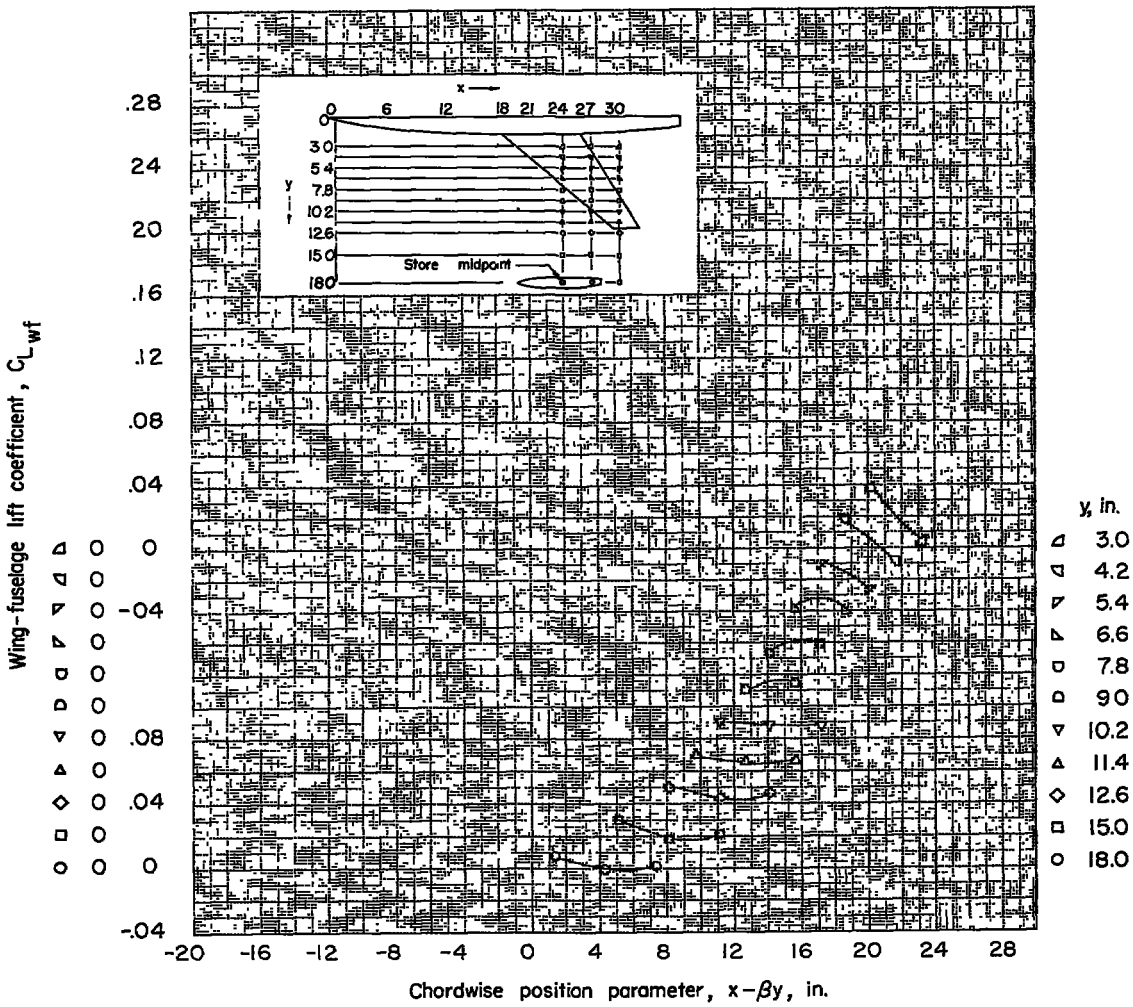
(a) z = 1.15 inches; α = 0°.

Figure 23.- Lift of wing-fuselage combination in presence of small store. M = 1.61.



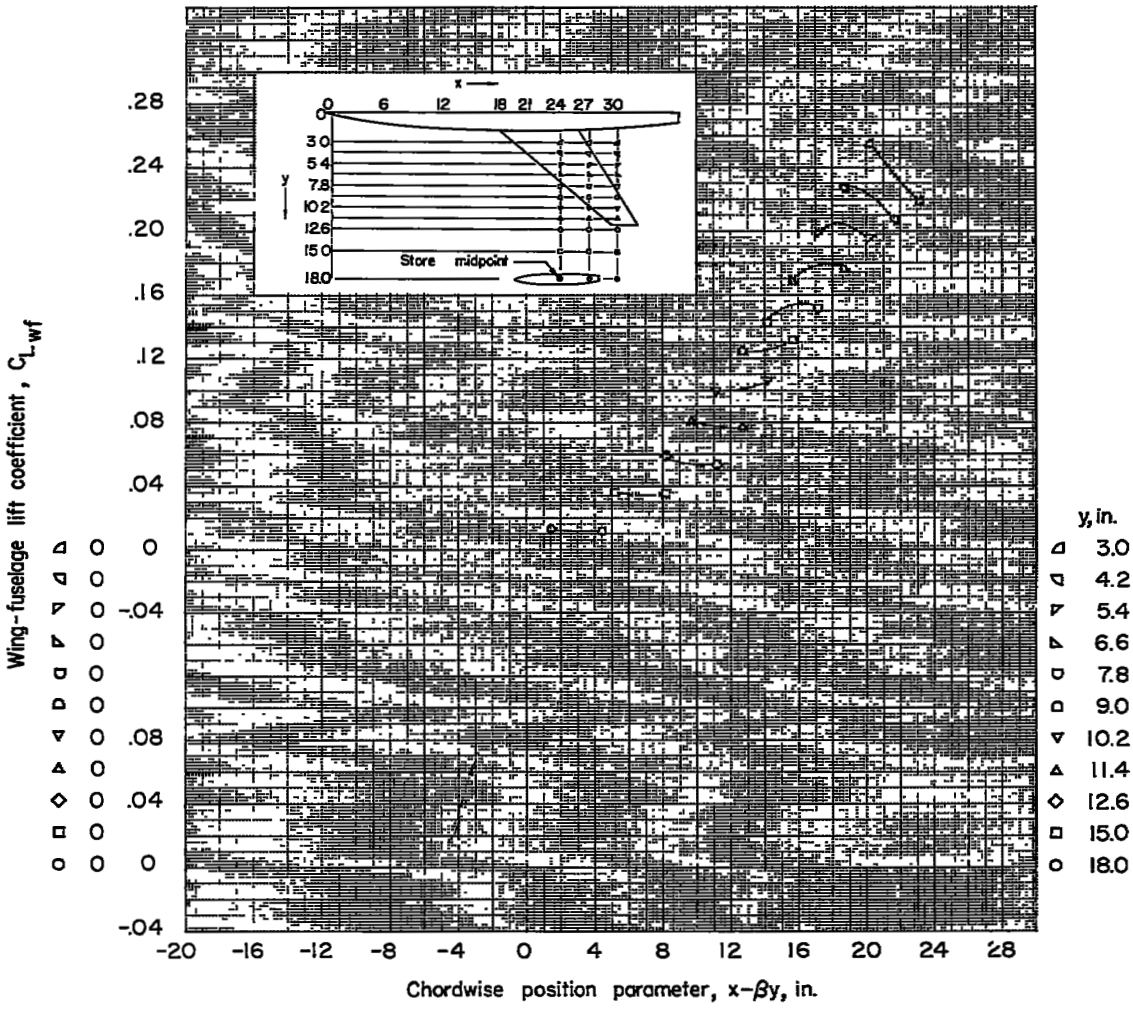
(b) z = 1.67 inches; $\alpha = 0^{\circ}$.

Figure 23.- Continued.



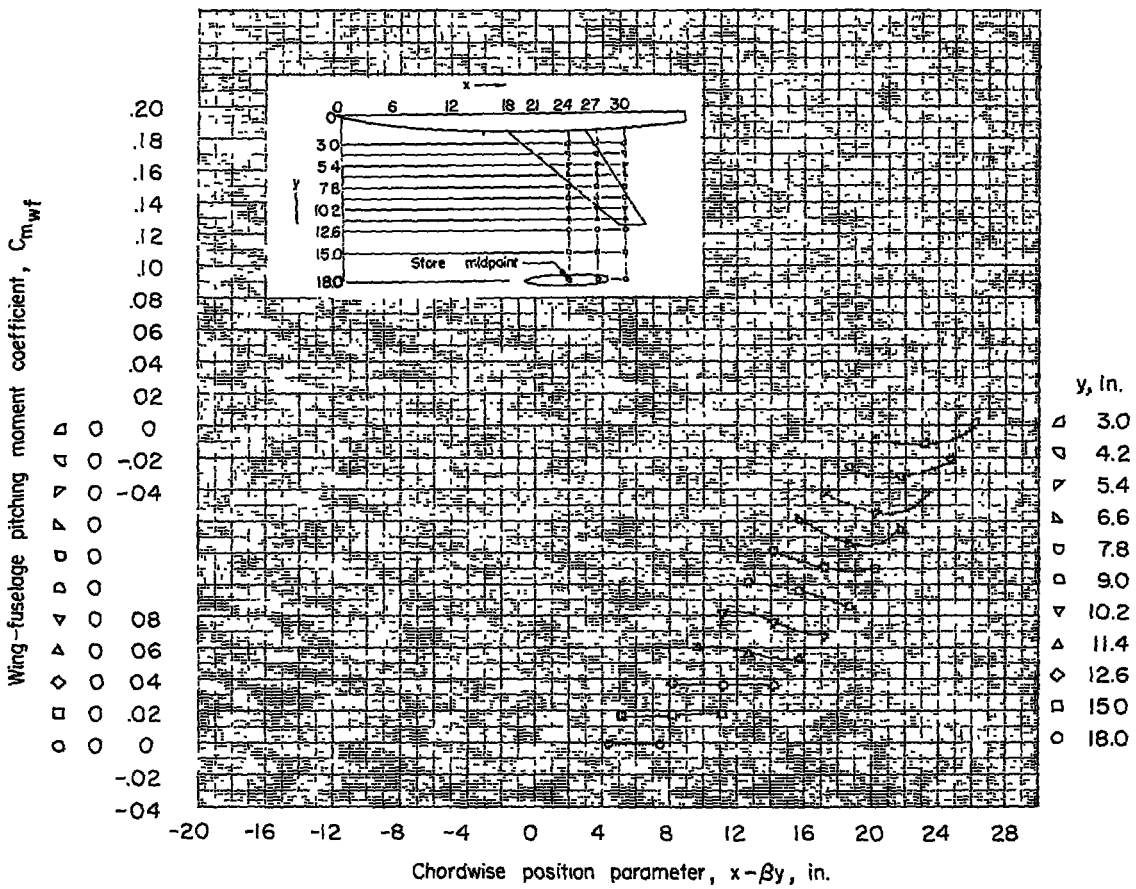
(c) z = 2.09 inches; $\alpha = 0^{\circ}$.

Figure 23.- Continued.



(d) z = 2.09 inches; $\alpha = 4^{\circ}$.

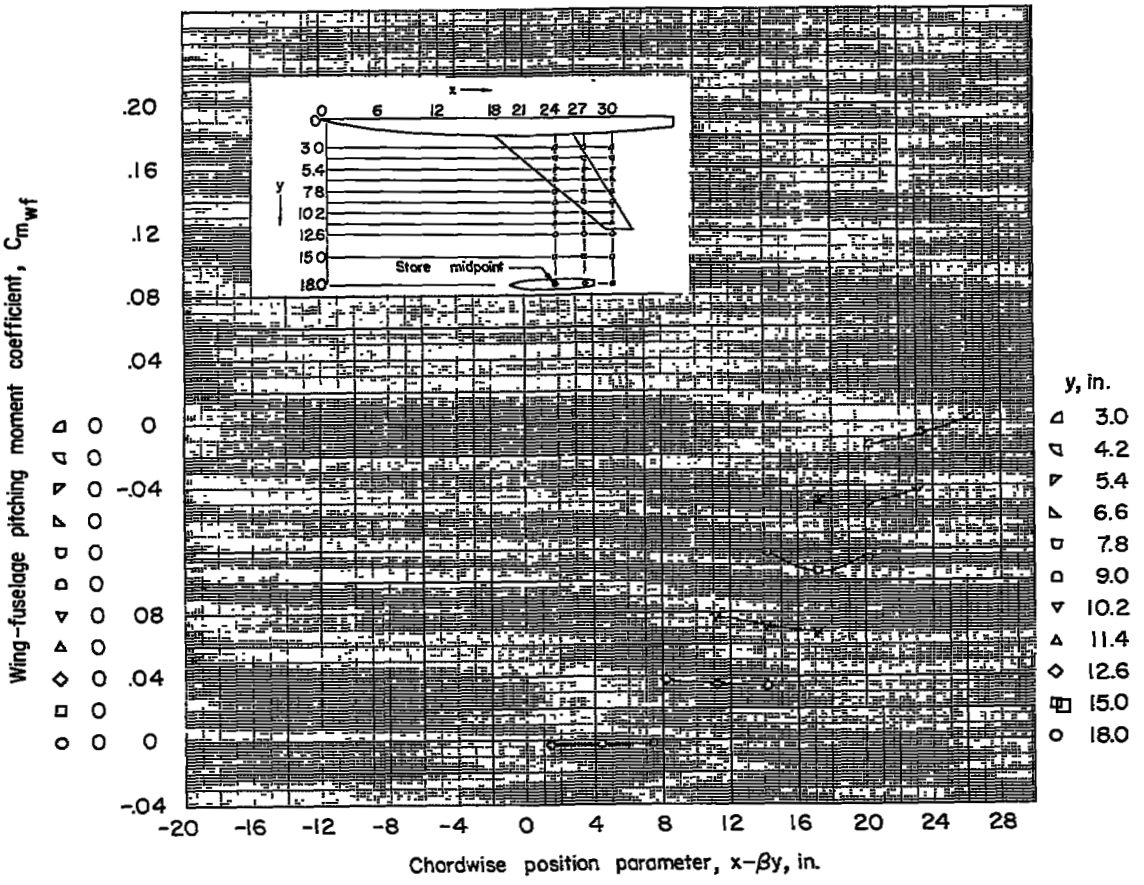
Figure 23.- Concluded.



(a) $z = 1.15$ inches; $\alpha = 0^{\circ}$.

Figure 24.- Pitching moment of wing-fuselage combination in presence of small store. (Center of moments is $\bar{c}/4$ of wing.) $M = 1.61$.

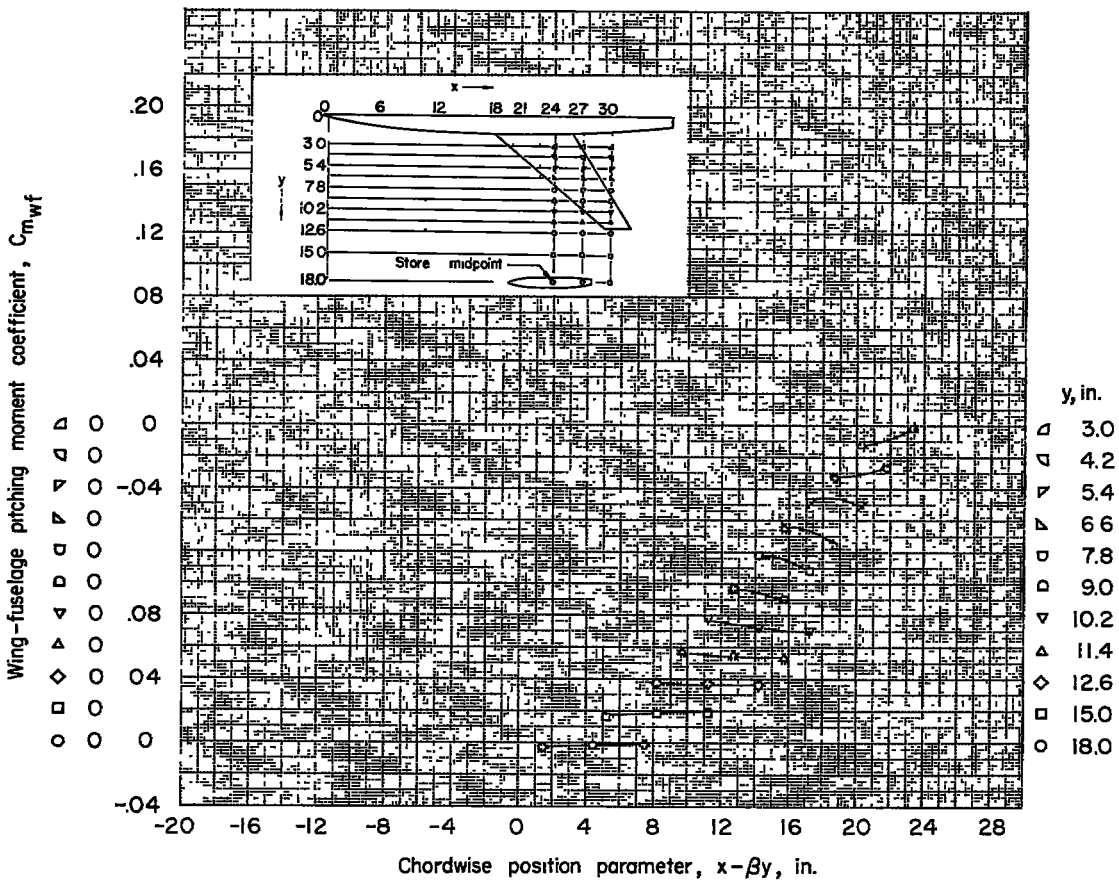
UNCLASSIFIED



(b) z = 1.67 inches; α = 0°.

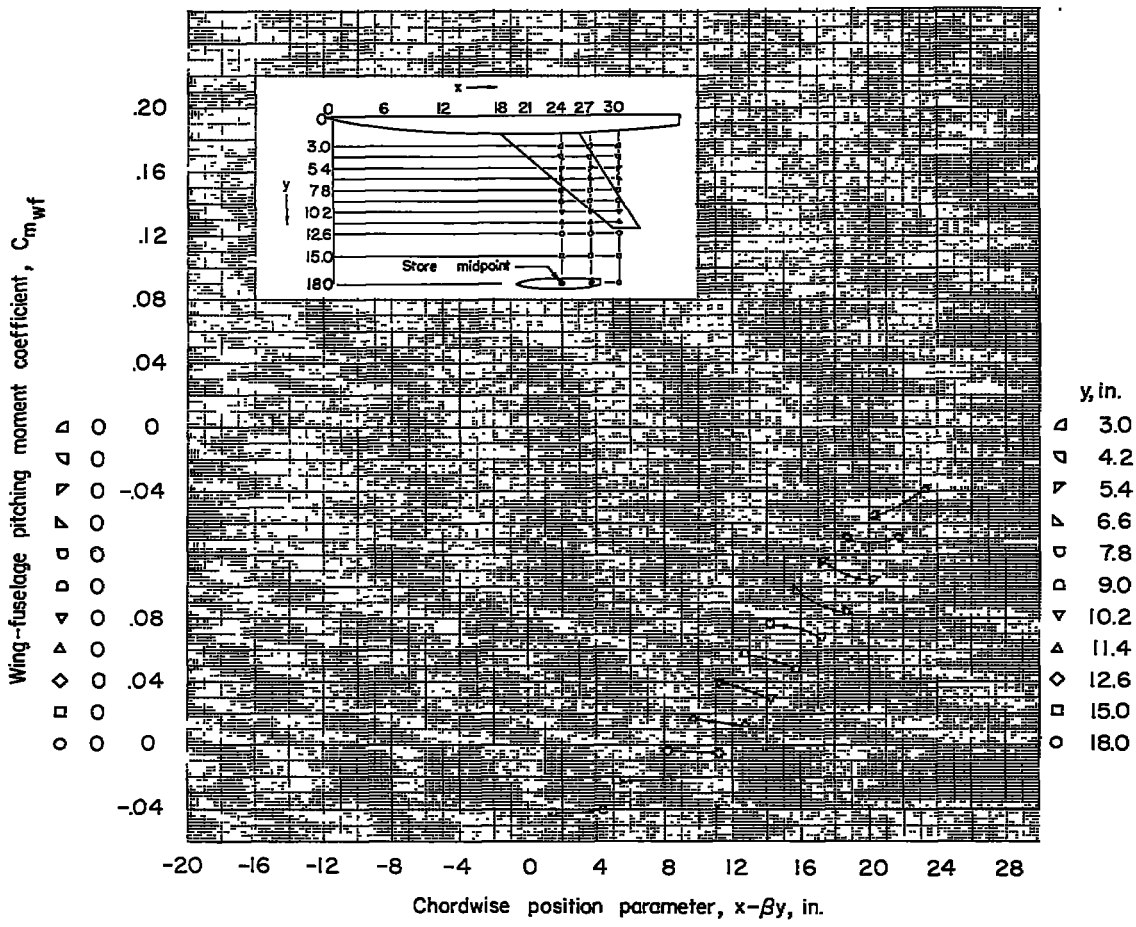
Figure 24.- Continued.

[redacted]



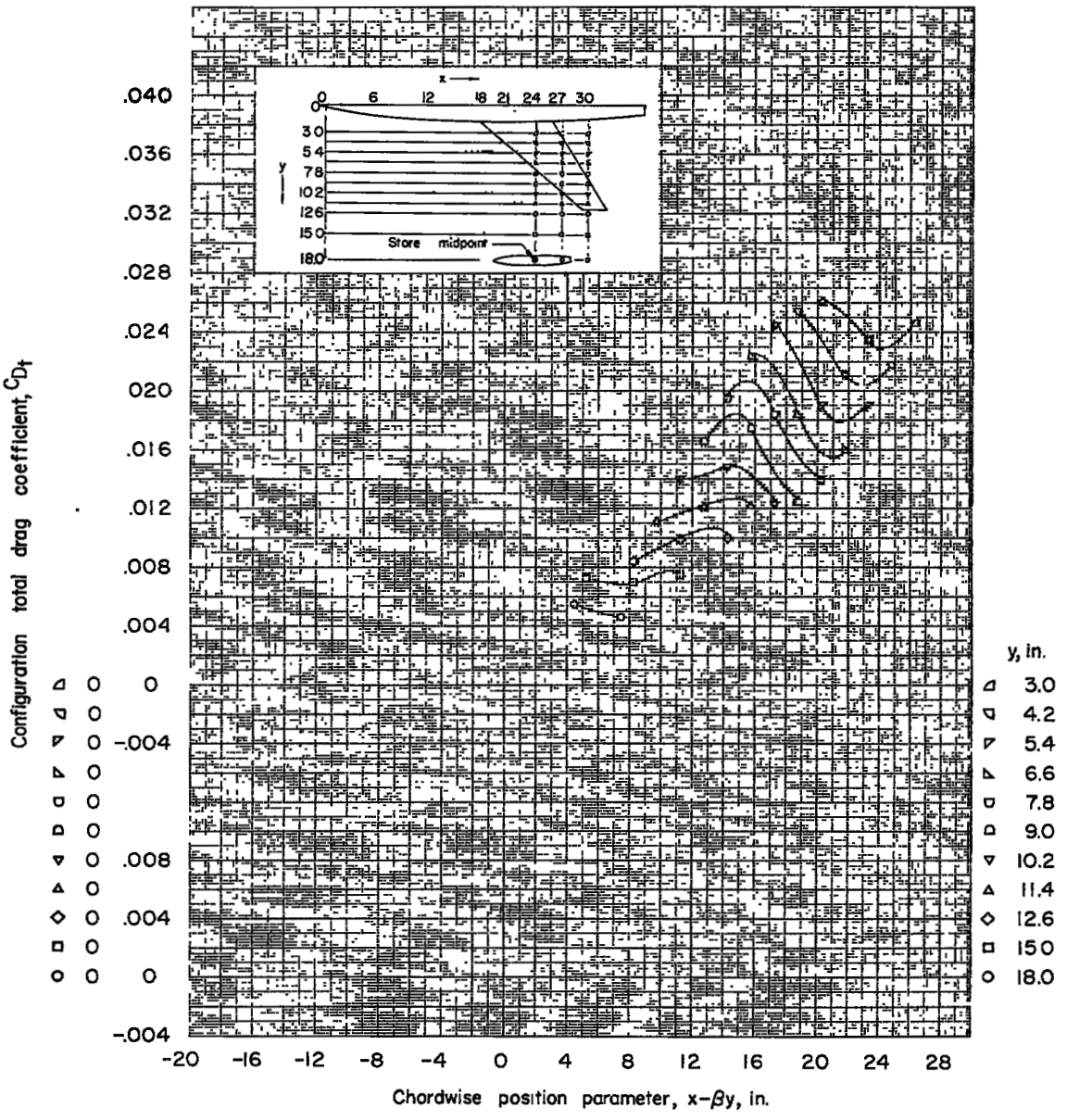
(c) z = 2.09 inches; $\alpha = 0^{\circ}$.

Figure 24.- Continued.



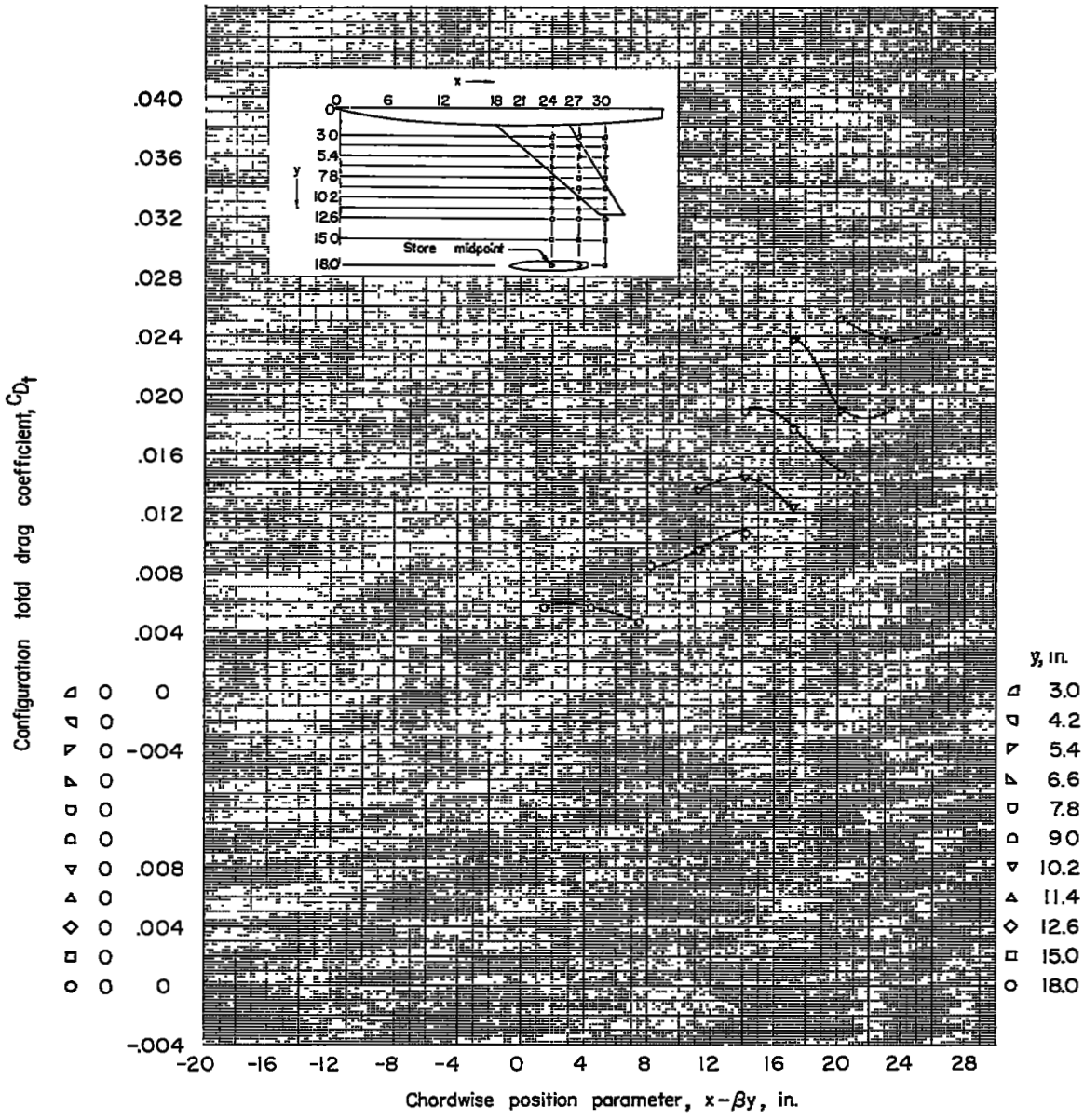
(d) z = 2.09 inches; $\alpha = 4^{\circ}$.

Figure 24.- Concluded.



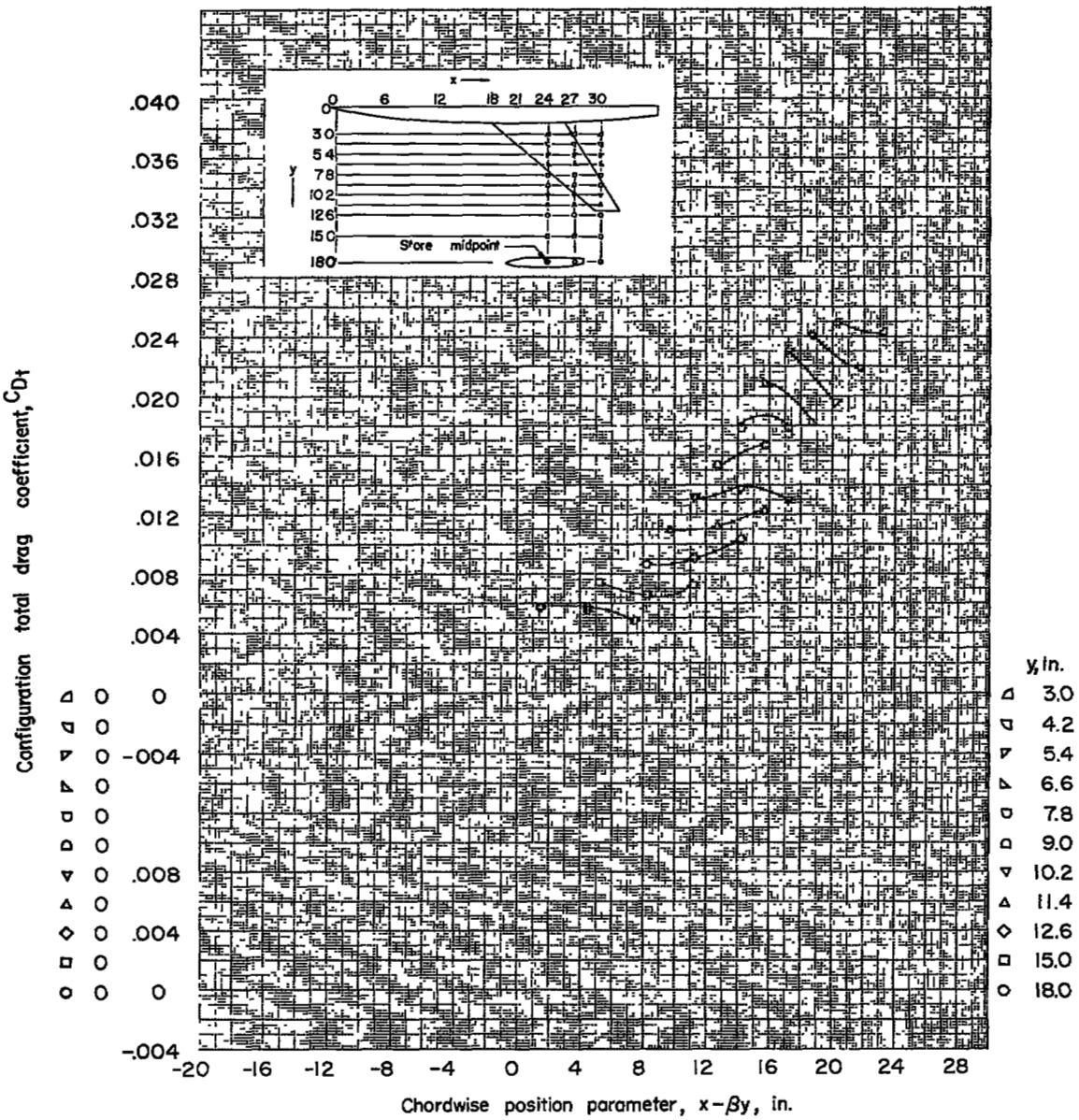
(a) z = 1.15 inches; $\alpha = 0^{\circ}$.

Figure 25.- Total drag of the complete configuration (wing-fuselage plus small store). (Drags corrected for base pressures.) M = 1.61.



(b) z = 1.67 inches; $\alpha = 0^{\circ}$.

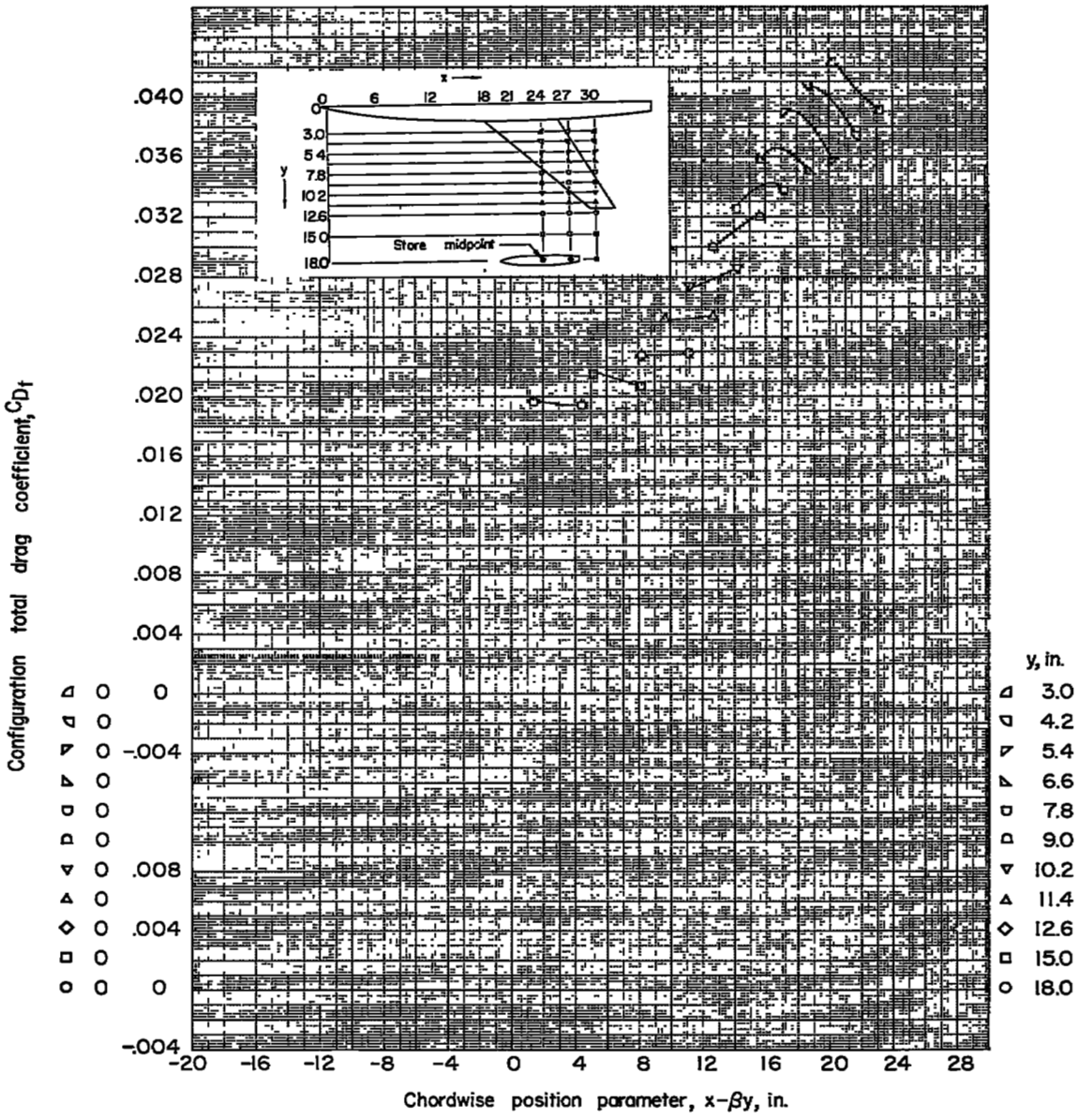
Figure 25.- Continued.



(c) z = 2.09 inches; $\alpha = 0^{\circ}$.

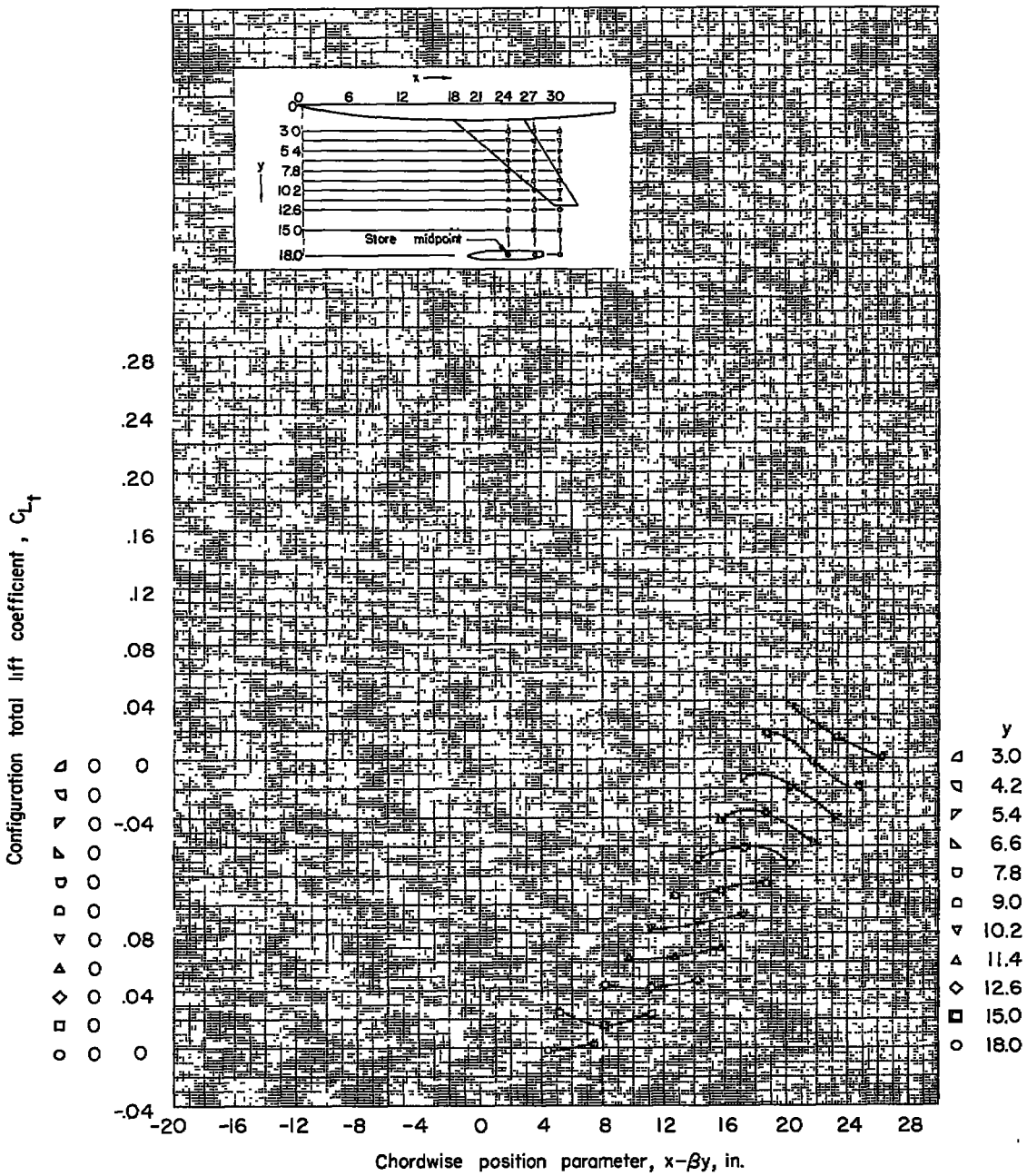
Figure 25.- Continued.

UNCLASSIFIED



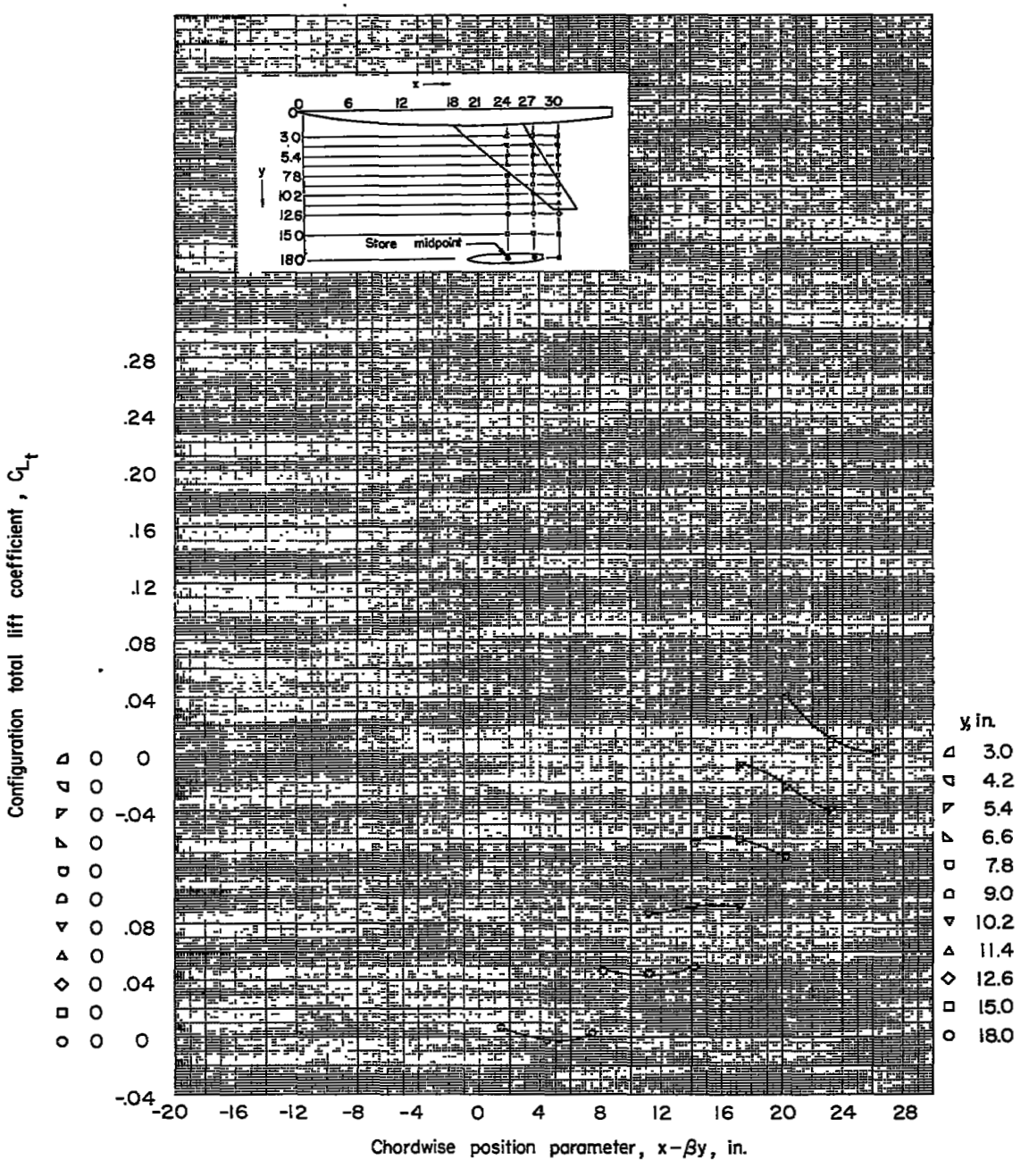
(d) z = 2.09 inches; $\alpha = 4^{\circ}$.

Figure 25.- Concluded.



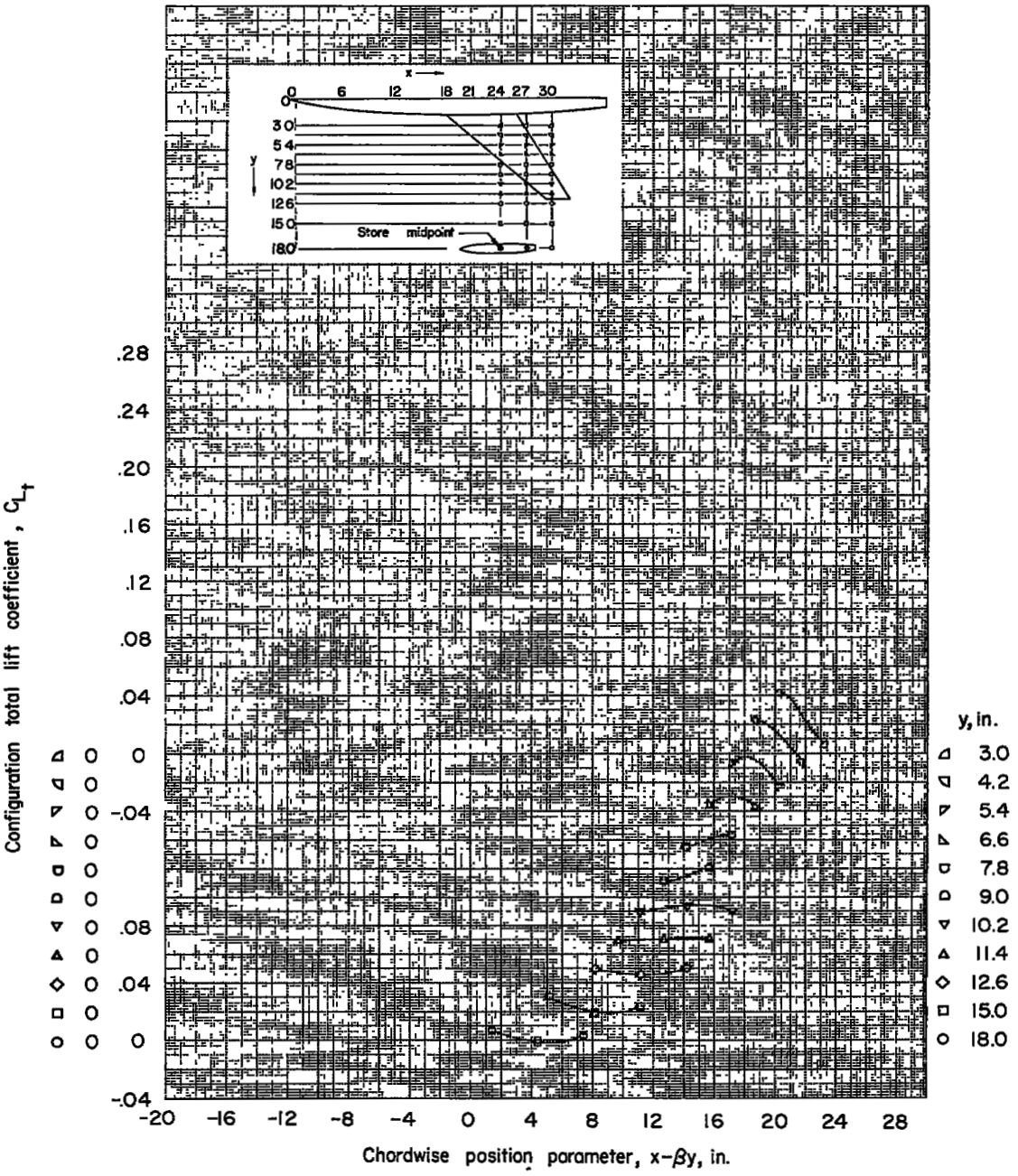
(a) z = 1.15 inches; $\alpha = 0^{\circ}$.

Figure 26.- Total lift of the complete (wing-fuselage plus small store) configuration. M = 1.61.



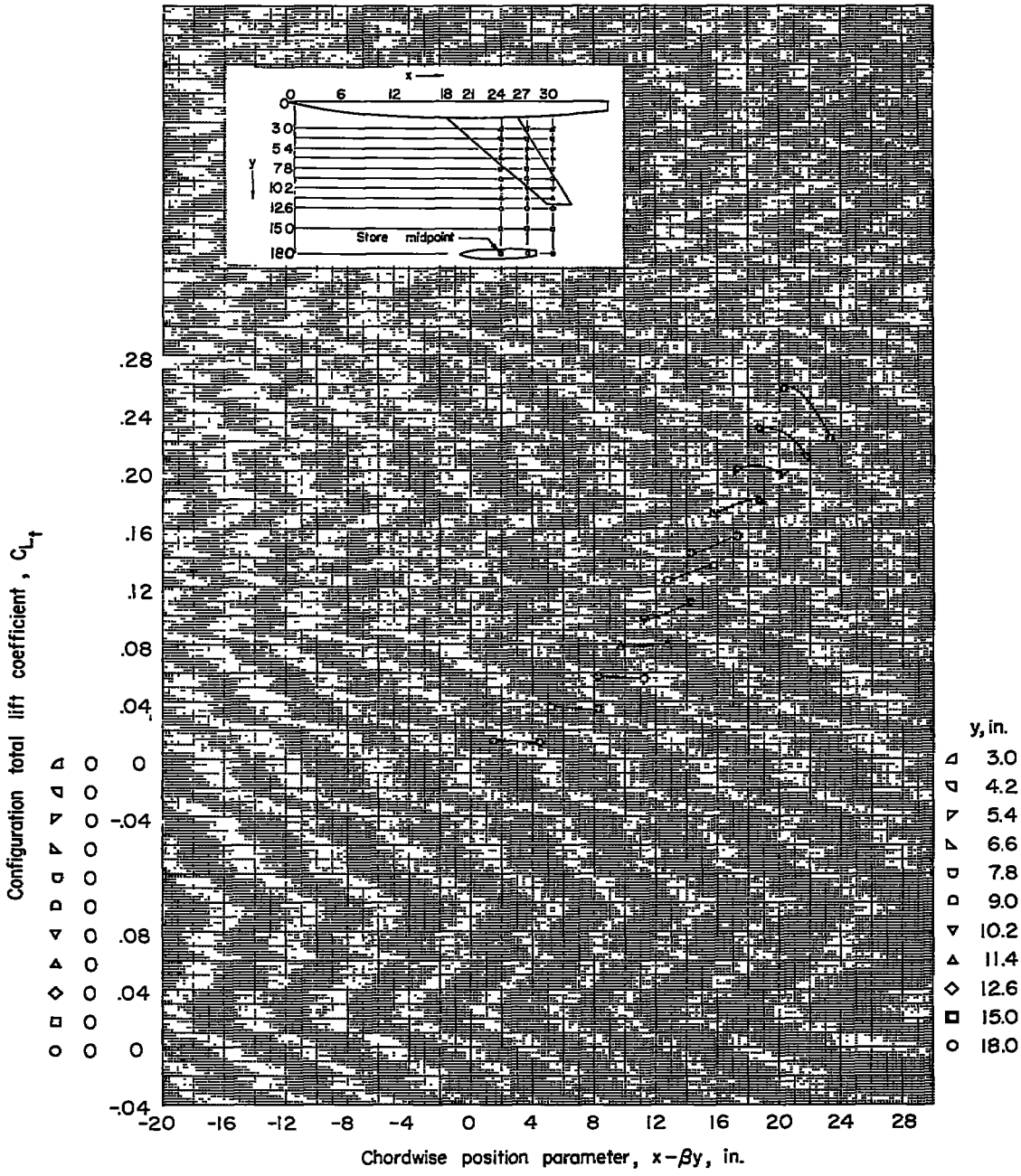
(b) z = 1.67 inches; $\alpha = 0^{\circ}$.

Figure 26.- Continued.



(c) z = 2.09 inches; $\alpha = 0^{\circ}$.

Figure 26.- Continued.



(d) $z = 2.09$ inches; $\alpha = 4^{\circ}$.

Figure 26.- Concluded.

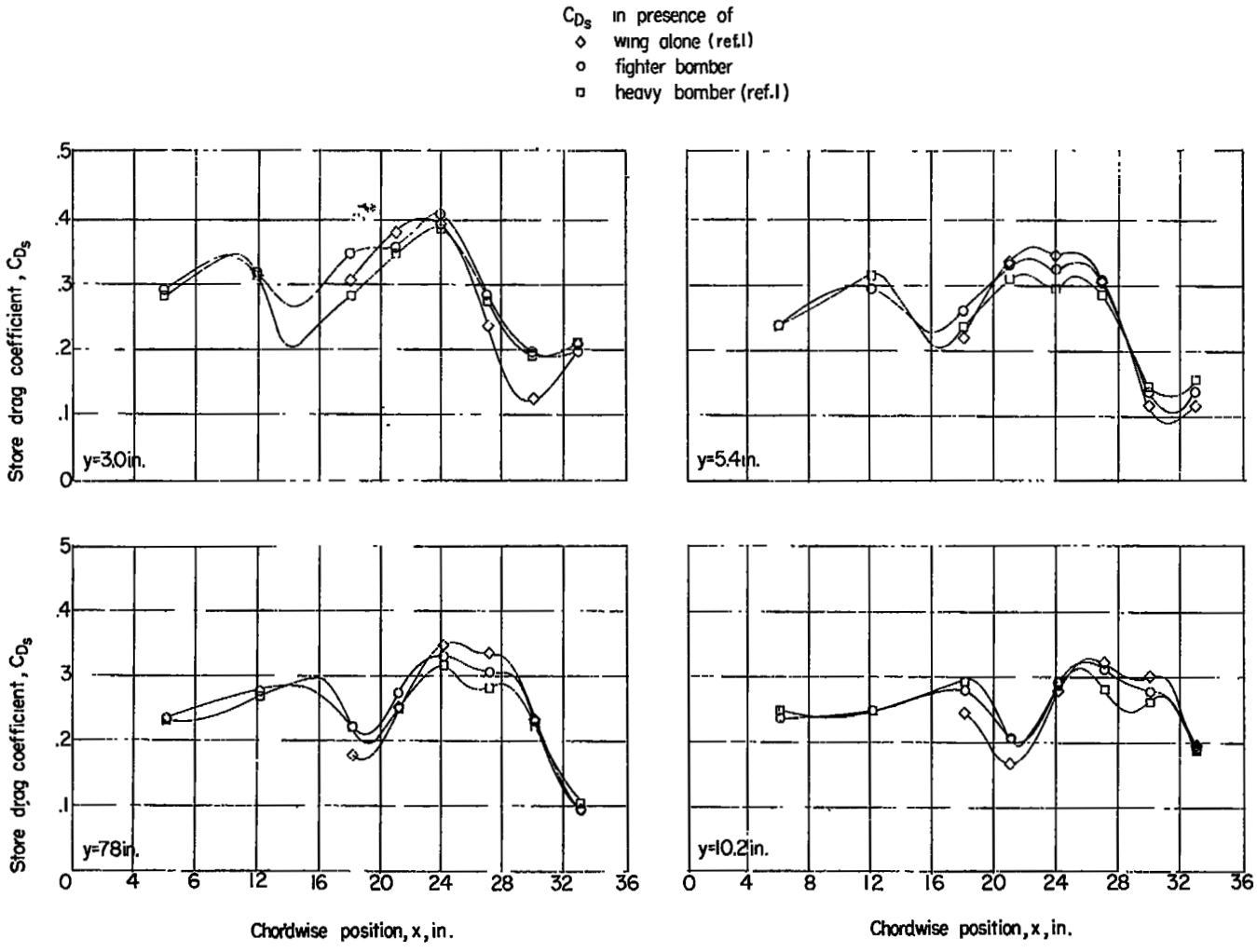


Figure 27.- Comparison of drag of large store in presence of swept wing alone and heavy-bomber and fighter-bomber configurations. $z = 1.15$ inches; $\alpha = 0^{\circ}$. C_{D_s} of isolated store is 0.254.

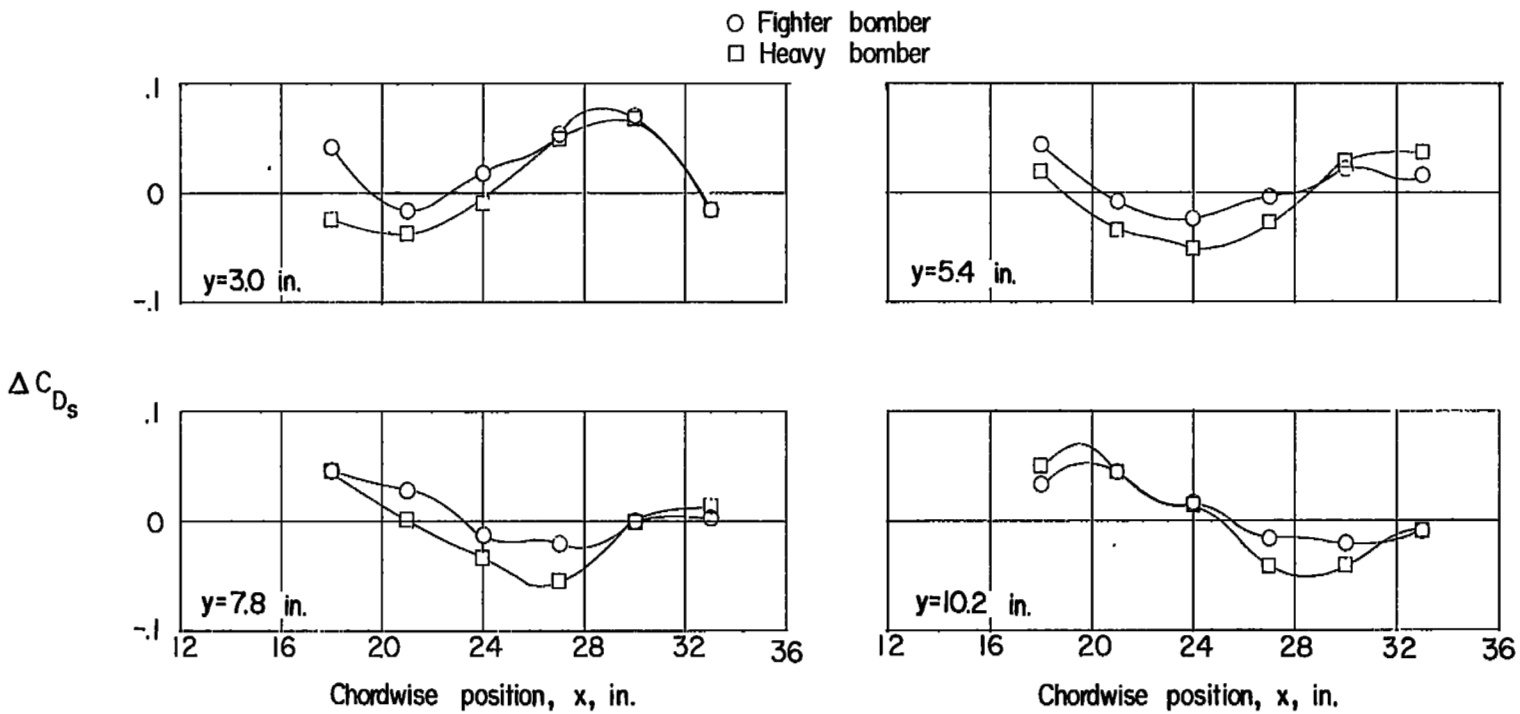


Figure 28.- Contribution of fuselage (in presence of wing) to interference drag on large ogive-cylinder store. C_{D_s} in presence of wing-fuselage minus C_{D_s} in presence of wing, from figure 27.

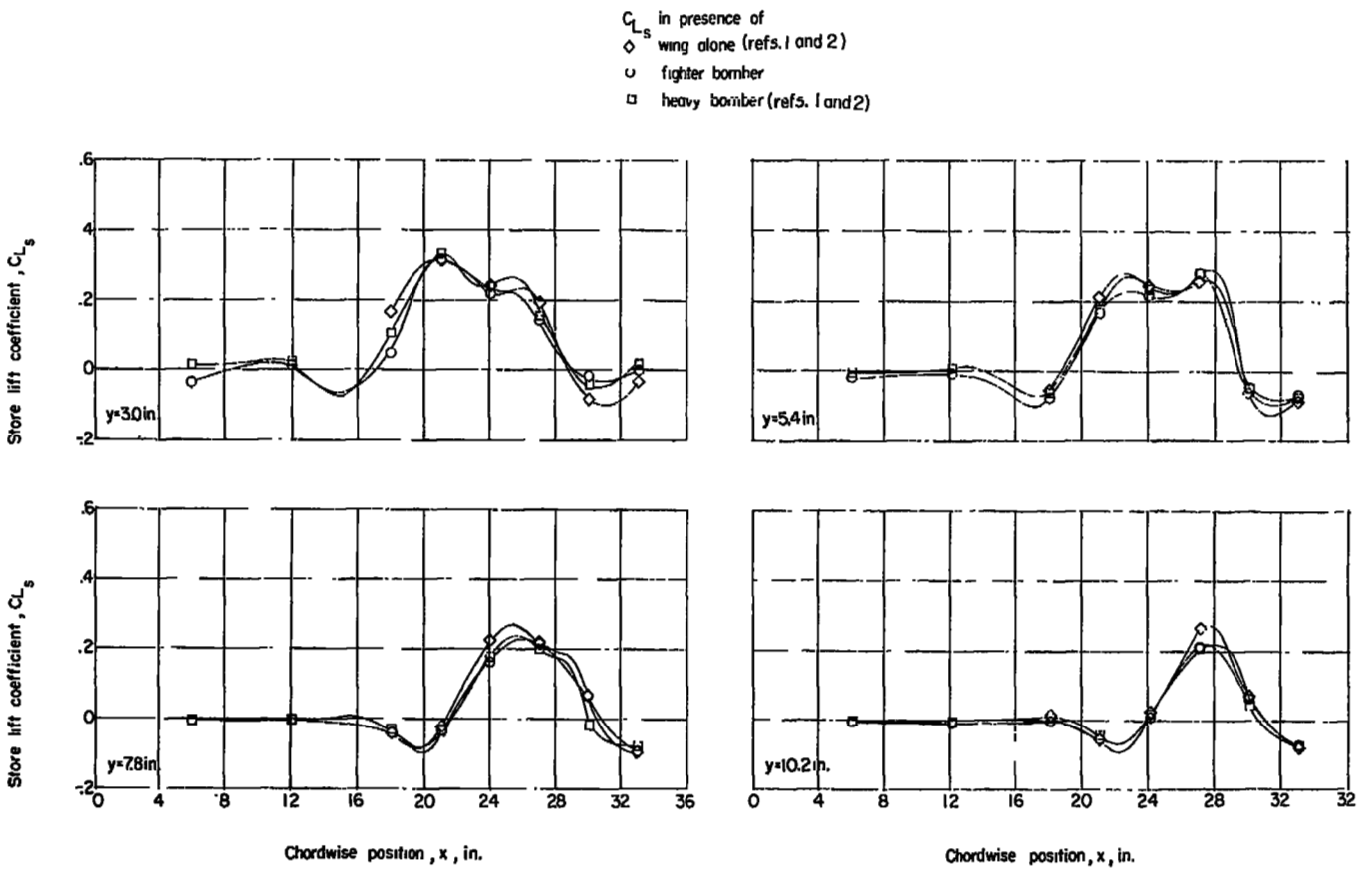


Figure 29.- Comparison of lift of large store in presence of swept wing alone and heavy-bomber and fighter-bomber configurations. $z = 1.15$ inches; $\alpha = 0^{\circ}$.

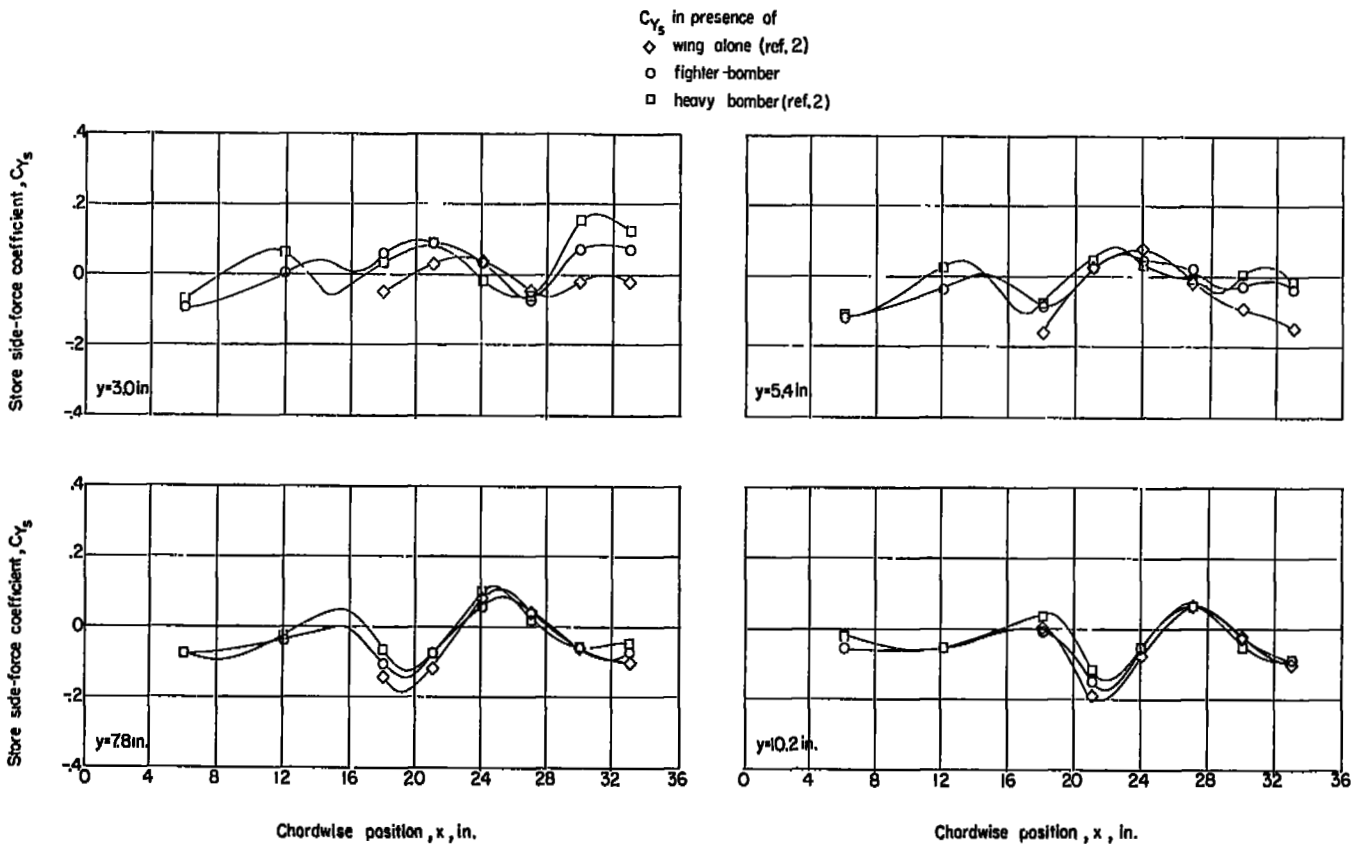


Figure 30.- Comparison of side force of large store in presence of swept-wing alone and heavy-bomber and fighter-bomber configurations. $z = 1.15$ inches; $\alpha = 0^{\circ}$.

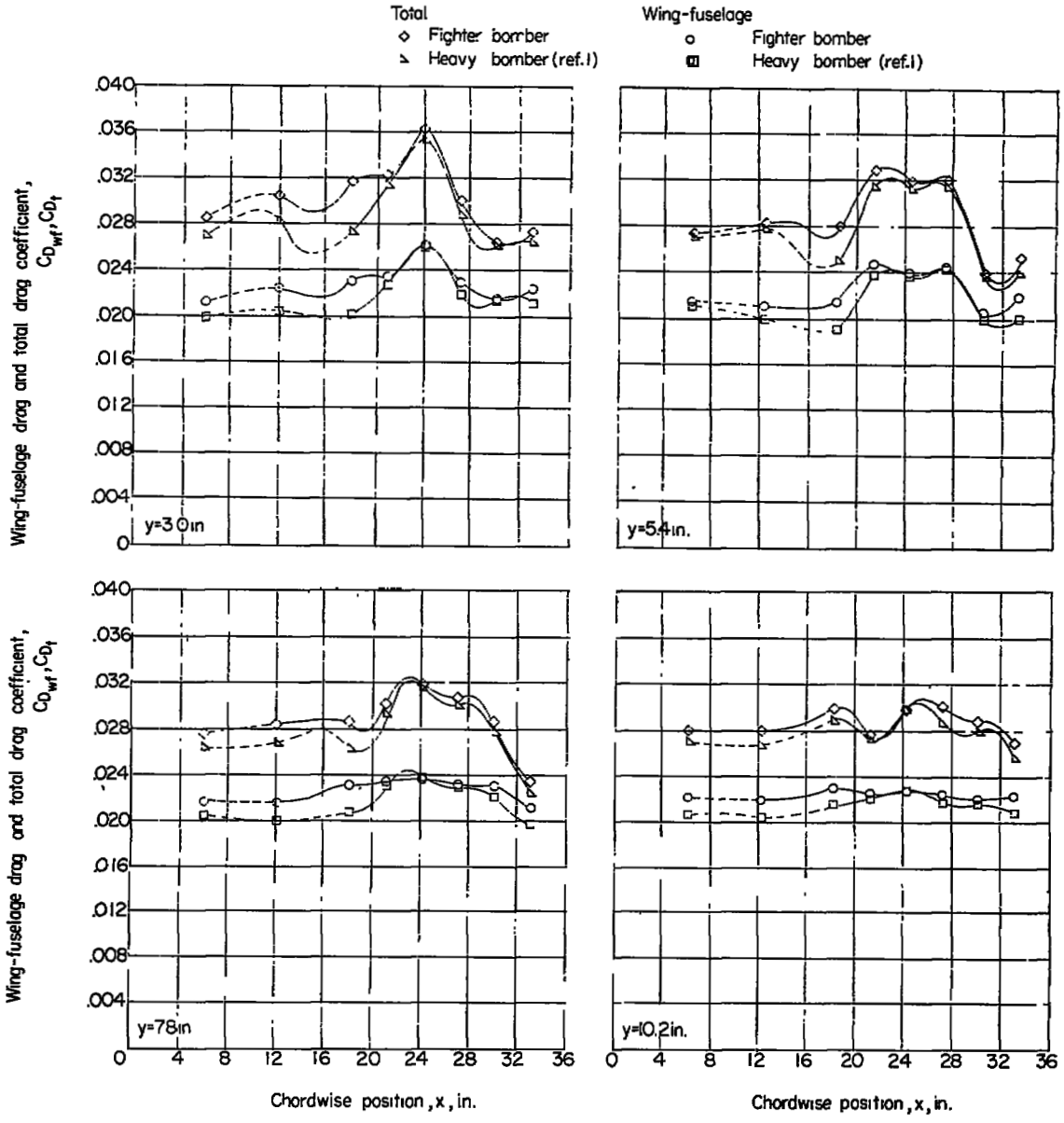


Figure 31.- Comparison of wing-fuselage drag and total configuration (wing-fuselage plus store) drag for heavy-bomber and fighter-bomber configurations with large store. $\alpha = 0^{\circ}$; $z = 1.15$ inches.

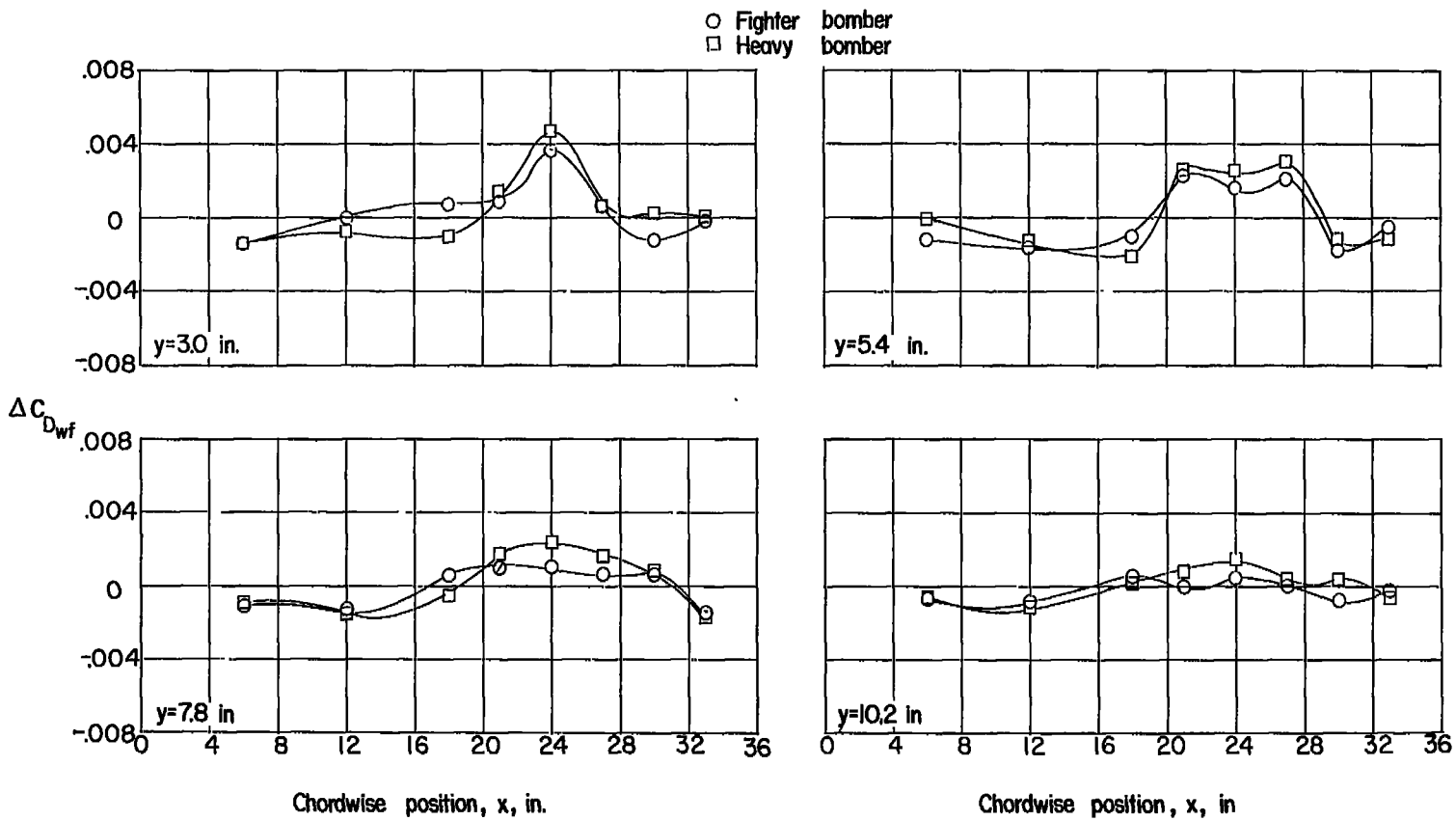


Figure 32.- Interference drag of wing-fuselage combinations produced by large ogive-cylinder store. $C_{D_{wf}}$ (from fig. 31) minus $C_{D_{wf}}$ of isolated wing-fuselage.

[redacted]

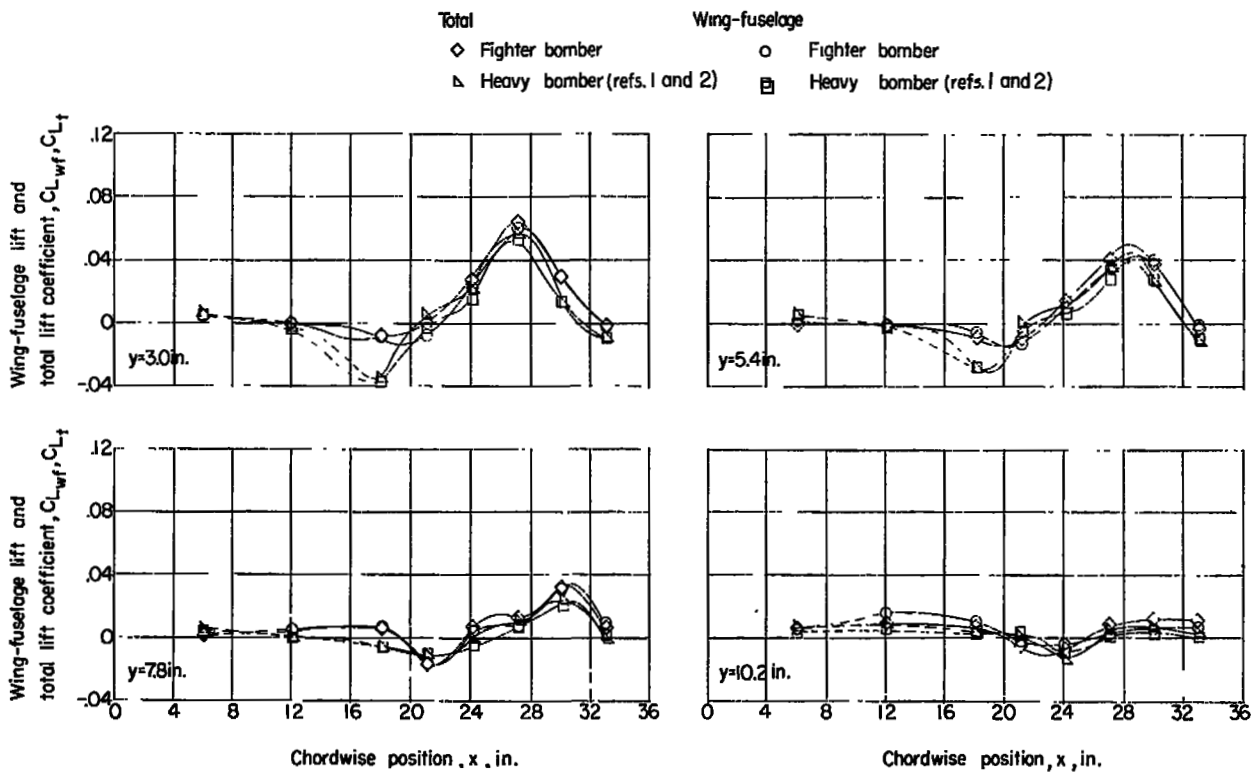


Figure 33.- Comparison of wing-fuselage lift and total configuration (wing-fuselage plus store) lift for heavy-bomber and fighter-bomber configurations with large store. $\alpha = 0^{\circ}$; $z = 1.15$ inches.

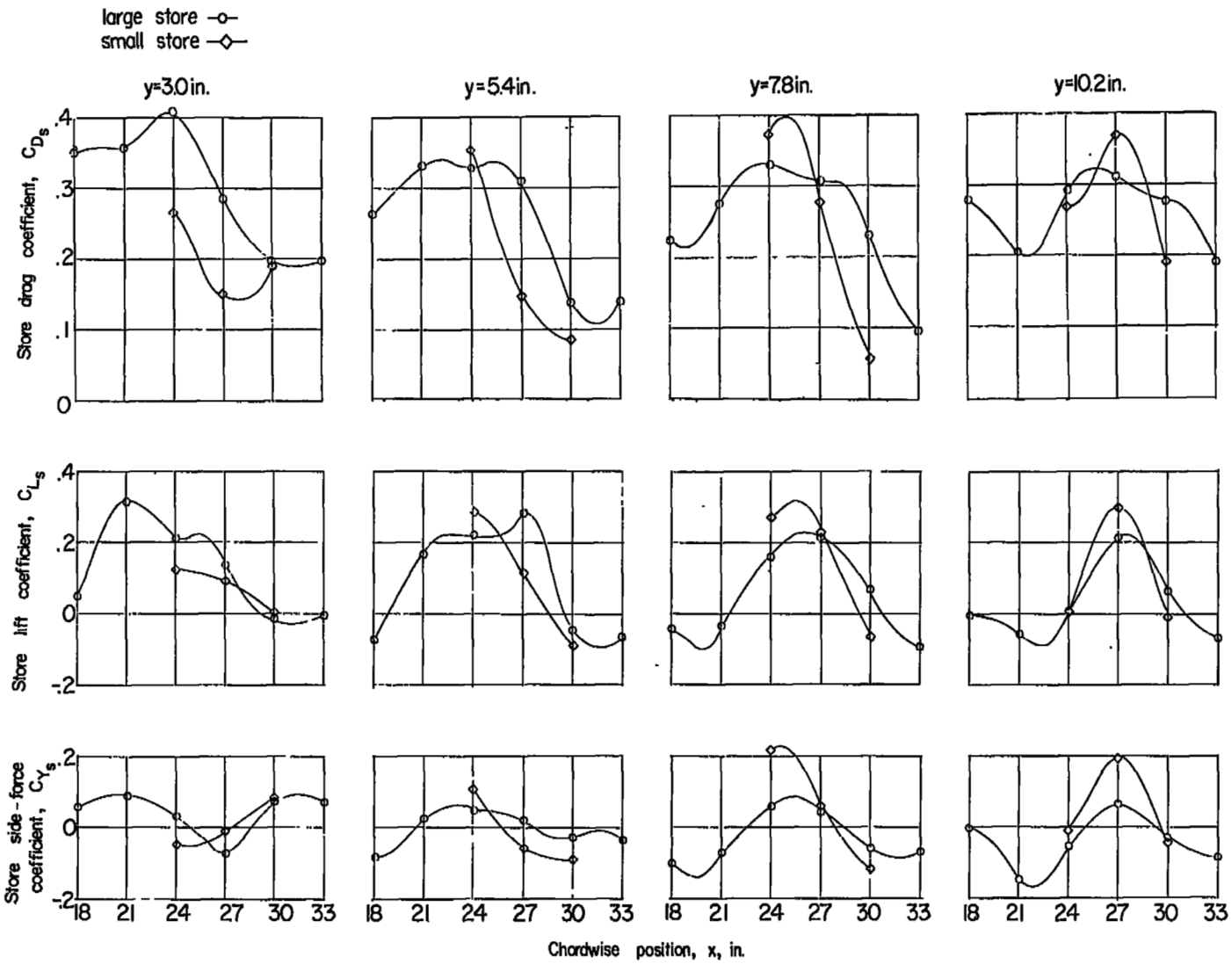


Figure 34.- Comparison of forces on large and small stores in presence of fighter-bomber configuration. $\alpha = 0^{\circ}$; $z = 1.15$ inches.

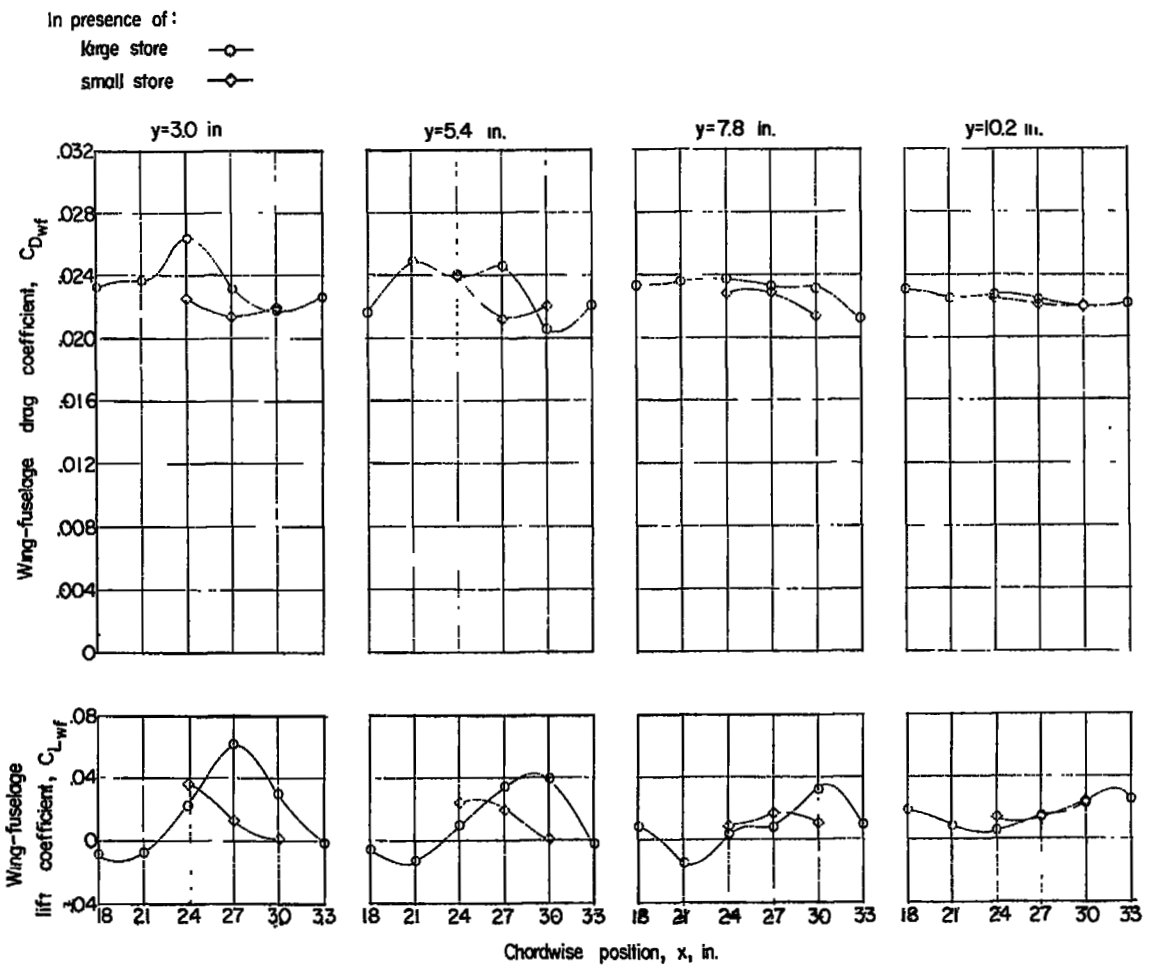


Figure 35.- Comparison of forces on fighter-bomber configuration in presence of large and small stores. $\alpha = 0^{\circ}$; z = 1.15 inches.

NASA Technical Library
3 1176 01438 0514

CONFIDENTIAL