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EFFECTS OF TRIPLE EJECTOR RACK GEOMETRY ON THE PRESSURE DISTRIBUTION OF THE M-117 BOMB

Robert C. May, et al

Auburn University

Prepared for:

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DEPARTMENT OF AEROSPACE ENGINEERING
AUBURN UNIVERSITY

TECHNICAL REPORT AFATL-TR-74-21
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13. ABSTRACT

Pressure data was obtained to investigate the effect of triple ejector rack (TER) geometry on the nose-down pitch of the M-117 bomb. Twelve modifications to TER-9/A and the design currently used were tested. These modifications consisted of blunt and round nose fairing configurations as well as a change to the aft fairing. Variations in TER geometry appeared to have little effect on the normal force and pitching moment distribution for the bomb. In most cases, noticeable effects were confined to the midsection and tail region of the bomb. Final results indicated that the short, blunt nose fairing configurations produced the best reduction in the nose-down pitching tendency.

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Pressure Distribution						
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TER-9/A						
F-4 Aircraft						

Effects Of Triple Ejector Rack Geometry On The Pressure Distribution Of The M-117 Bomb

Robert C. May
Fred W. Martin

1b

FOREWORD

The work described in this report was done during the period from June 1972 through March 1973 by the Department of Aerospace Engineering, Auburn University, Auburn, Alabama, under Contract Number F08635-71-C-0090 with the Air Force Armament Laboratory, Eglin Air Force Base, Florida. Captain Visi Arajs (DLJA) monitored the program for the Armament Laboratory.

All experimental work under this project was accomplished by the Department of Aerospace Engineering, Auburn University, Auburn, Alabama.

This technical report has been reviewed and is approved.

FOR THE COMMANDER:

William F Brockman

WILLIAM F. BROCKMAN, Colonel, USAF
Chief, Munitions Division

ABSTRACT

Pressure data was obtained to investigate the effect of triple ejector rack (TER) geometry on the nose-down pitch of the M-117 bomb. Twelve modifications to TER-9/A and the design currently used were tested. These modifications consisted of blunt and round nose fairing configurations as well as a change to the aft fairing. Variations in TER geometry appeared to have little effect on the normal force and pitching moment distribution for the bomb. In most cases, noticeable effects were confined to the midsection and tail region of the bomb. Final results indicated that the short, blunt nose fairing configurations produced the best reduction in the nose-down pitching tendency.

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TABLE OF CONTENTS

Section

Page

LIST OF FIGURES

LIST OF FIGURES (CONCLUDED)

LIST OF TABLES

LIST OF SYMBOLS

C_M	Pitching moment coefficient, positive nose-up
C_N	Normal force coefficient, positive upward
$\frac{dC_M}{dx}$	Local pitching moment coefficient, positive nose-up
$\frac{dC_N}{dx}$	Local normal force coefficient, positive upward
x	Position along axis of model, nondimensionalized by the diameter of the midsection of the model

SECTION I

INTRODUCTION

The load distribution for external stores mounted on a triple ejector rack (TER) beneath the F-4 aircraft creates an unfavorable nose-down pitch for the released store. This tendency may produce large perturbations in the free fall trajectory of the released store resulting in a significant decrease in delivery accuracy. Previous tests[1] have indicated that the load distribution on some external stores can be altered by changes in the TER geometry. In order to determine the relationship of such changes to changes in the normal force coefficient and the pitching moment coefficient, an investigation was conducted using 18.75 percent models of the M-117 bomb.

Four different TER modifications were used in this investigation. Three of the modifications involved changes to the TER nose fairing that was currently in use, herein referred to as the current TER.[2] The fourth change was made to the aft fairing of the same TER. Tests were also run for the case of three M-117 bombs with no TER and with the TER. The data obtained from these tests with the current TER are used as a reference case for comparison purposes.

---

[1] W. E. Summers, "Separation Trajectories for the SUU-51 B/B Store from the F-4C Aircraft," AEDC-TR-72-91 (AD900328L), June 1972.

[2] TER-9/A

SECTION II

TEST PROCEDURES

Data for this report were obtained from tests run in the low-speed, closed circuit wind tunnel located at the contractor's facility. Three 18.75 percent models, two passive and one active, were mounted with the TER as shown in Figure 1. For these tests, there was no wing or pylon simulation. The active model had 26 pressure orifices at the locations indicated in Figure 2.

Tests were run at a dynamic pressure of 3.5 inches of water which produced a Reynolds number of approximately 800,000/foot. The pressure distribution was read manually from a multiple-manometer board for roll angles that varied from zero to 360° in 20° increments. In addition, the pressures at 90° and 270° were recorded.

The local normal force coefficients, dC_N/dx, were obtained from integration of the pressure distributions around the body and were used to determine the local pitching moment coefficients, dC_M/dx. Integration using plots of these local values along the axis of the model yield the total normal force and pitching moment coefficients.

Figures 3 to 15 show the 13 different configurations used for these tests. Six groupings are used in classifying the 13 configurations. These groupings are summarized in Table I. Group I is the case of the three bomb models alone with no TER. These tests were accomplished to measure the effect on the normal force and pitching moment coefficients obtained by complete removal of the TER, the two passive bomb models being supported by a yoke as shown in Figure 3. Group II, illustrated in Figures 4, 5, 6, and 7, is the design of the currently used TER, TER-9/A. Values of the coefficients for this group are used as a reference for comparison of the other five configurations.

Groups III, IV, and V consist of various designs of the TER nose fairing. The TER nose fairings of Group III, shown in Figures 8 and 9, are considered to be modifications to the shape designated as TER 1. (TER 1 is lengthened to 1.3 inches, and the nose is rounded to give the configuration TER 1A. TER 1B is identical to TER 1 except that it is lengthened to 2.0 inches. The nose of TER 1B is rounded to produce TER 1C.) The configurations of Group III were tested to determine the effect of length and shape of TER 1 on the normal force and pitching moment coefficients of the model.

Figures 10 and 11 show the two TER geometries comprising Group IV. The basic shape for this group, TER 2, represents the mount used for attaching the nose fairing to the remaining portion of the TER. The only modification of TER 2 is TER 2A, a change accomplished by the addition of a rounded nose.

TABLE I. SUMMARY OF TEST GROUPS AND CONFIGURATIONS

Group	Configuration	Remarks
I	No TER	Three stores, no TER
II	Current TER	TER-9/A
III	TER 1 TER 1A TER 1B TER 1C	Changed nose fairings of TER-9/A
IV	TER 2 TER 2A	Removal of nose fairings of TER-9/A with modifications
V	TER 3 TER 3A	Attempts to block flow from region between stores with modified nose fairings
VI	Current TER TER 3 TER 3A	All with aft extension, an altered TER-9/A aft fairing

The TER nose configurations of Group V, shown in Figures 12 and 13, were designed to divert or block airflow from the open region between the bombs. It was intended that this blockage would weaken the negative pitch of the active pressure model. The main difference between TER 3 and TER 3A is that TER 3 consists of plane surfaces while the surfaces of TER 3A are curved.

The aft fairing of the TER is of interest in Group VI. The 8.7-inch extension (Figures 14 and 15) is used in place of the present aft section of the TER and in conjunction with the nose fairings designated as the current TER, TER 3, and TER 3A.

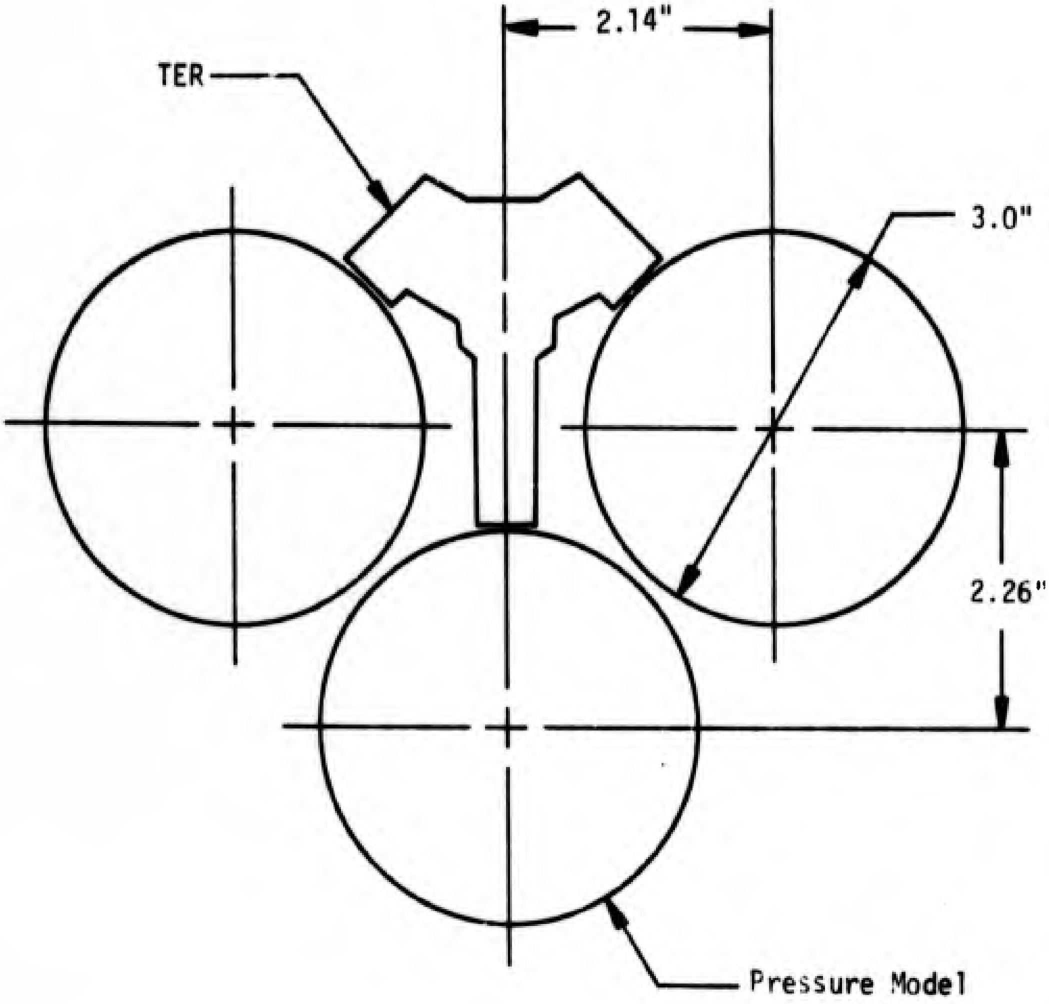
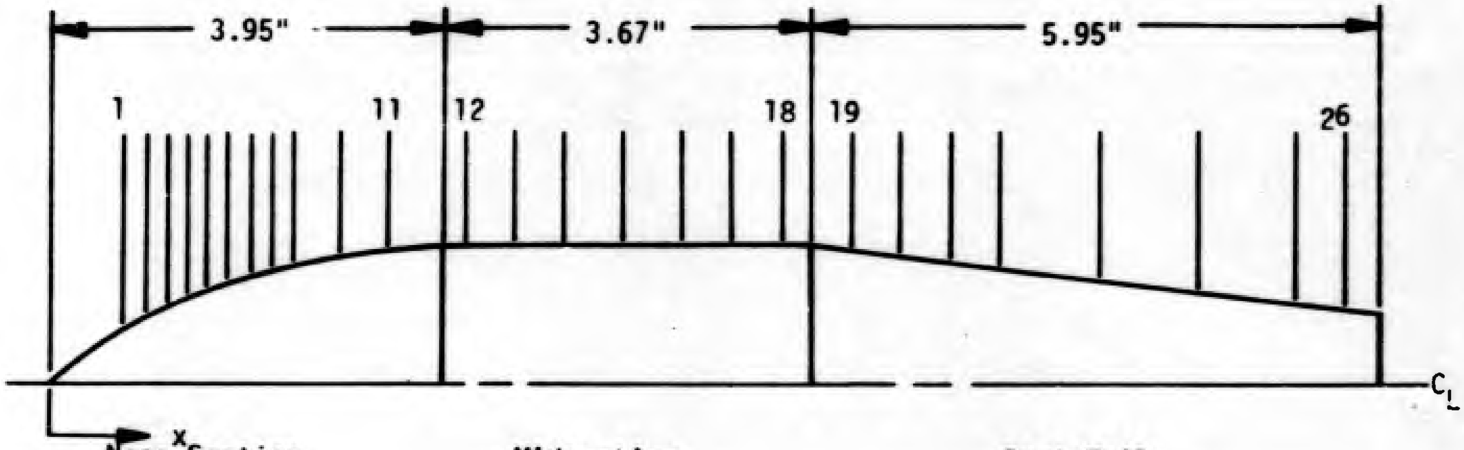


Figure 1. M-117 and TER Arrangement



Nose Section

Tube	x
1	0.241
2	0.327
3	0.392
4	0.458
5	0.529
6	0.601
7	0.673
8	0.747
9	0.825
10	0.984
11	1.139

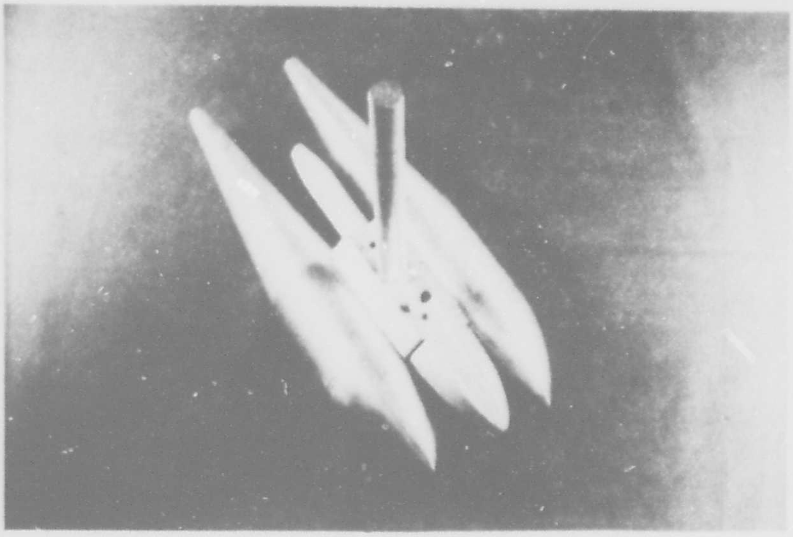
Midsection

Tube	x
12	1.371
13	1.571
14	1.740
15	1.950
16	2.160
17	2.325
18	2.495

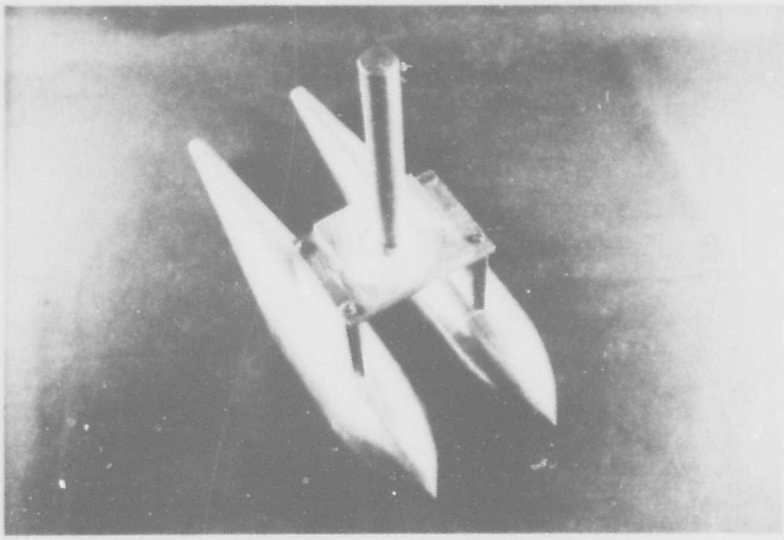
Boat Tail

Tube	x
19	2.720
20	2.880
21	3.050
22	3.220
23	3.550
24	3.881
24	4.050
26	4.220

Figure 2. Pressure Model and Orifice Locations



TER Configurations



No-TER Configuration

Figure 3. Support for TER Configurations
and No-TER Configuration

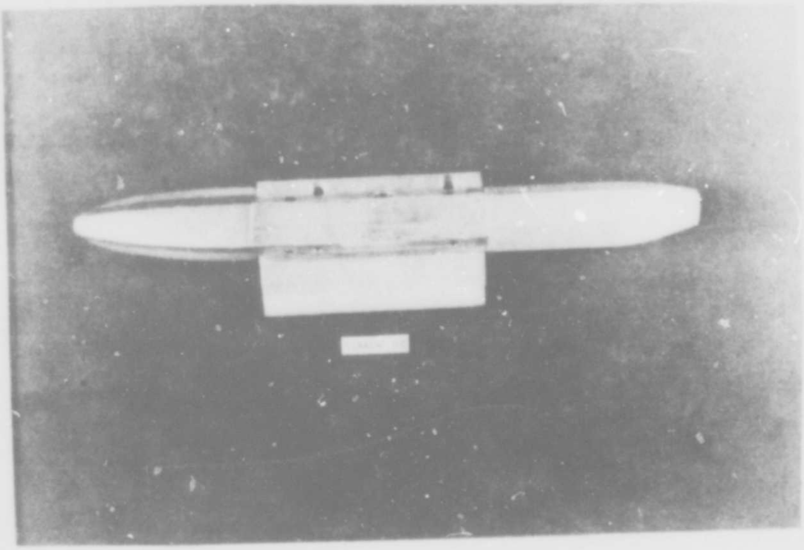


Figure 4. Assembled TER Model

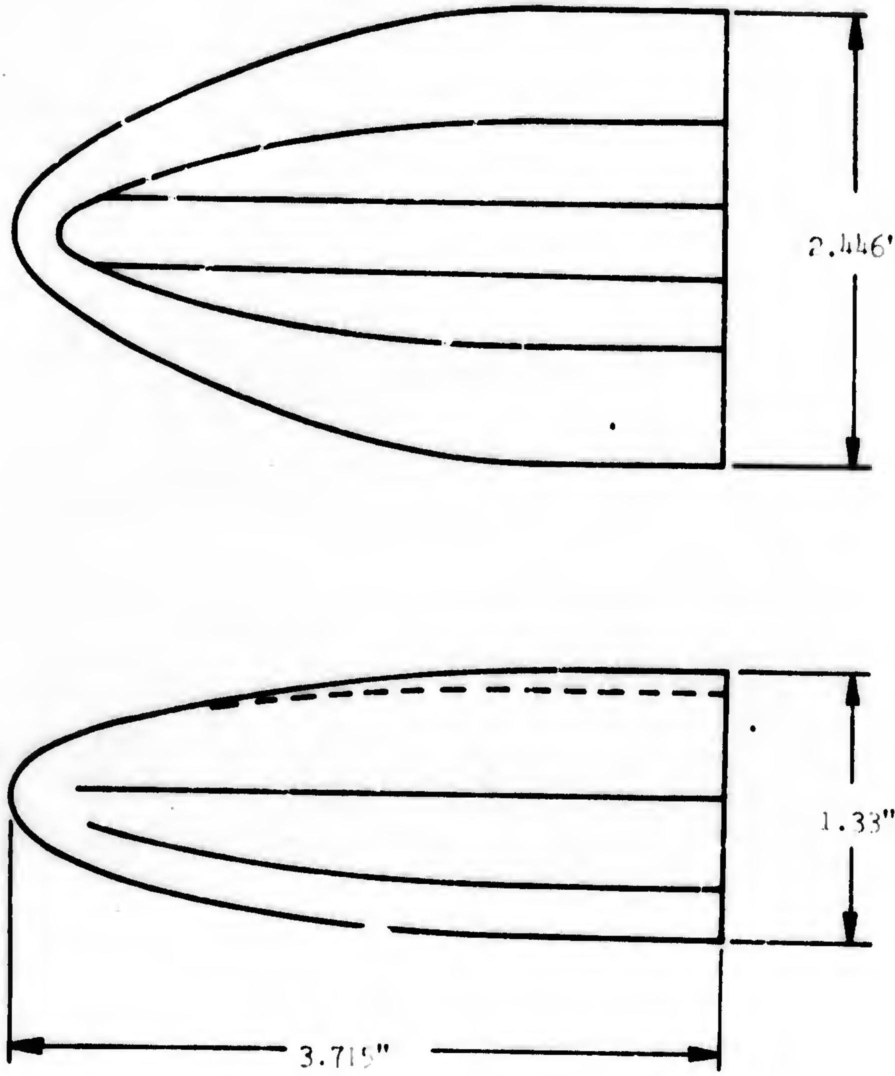


Figure 5. TER, Nose Fairing

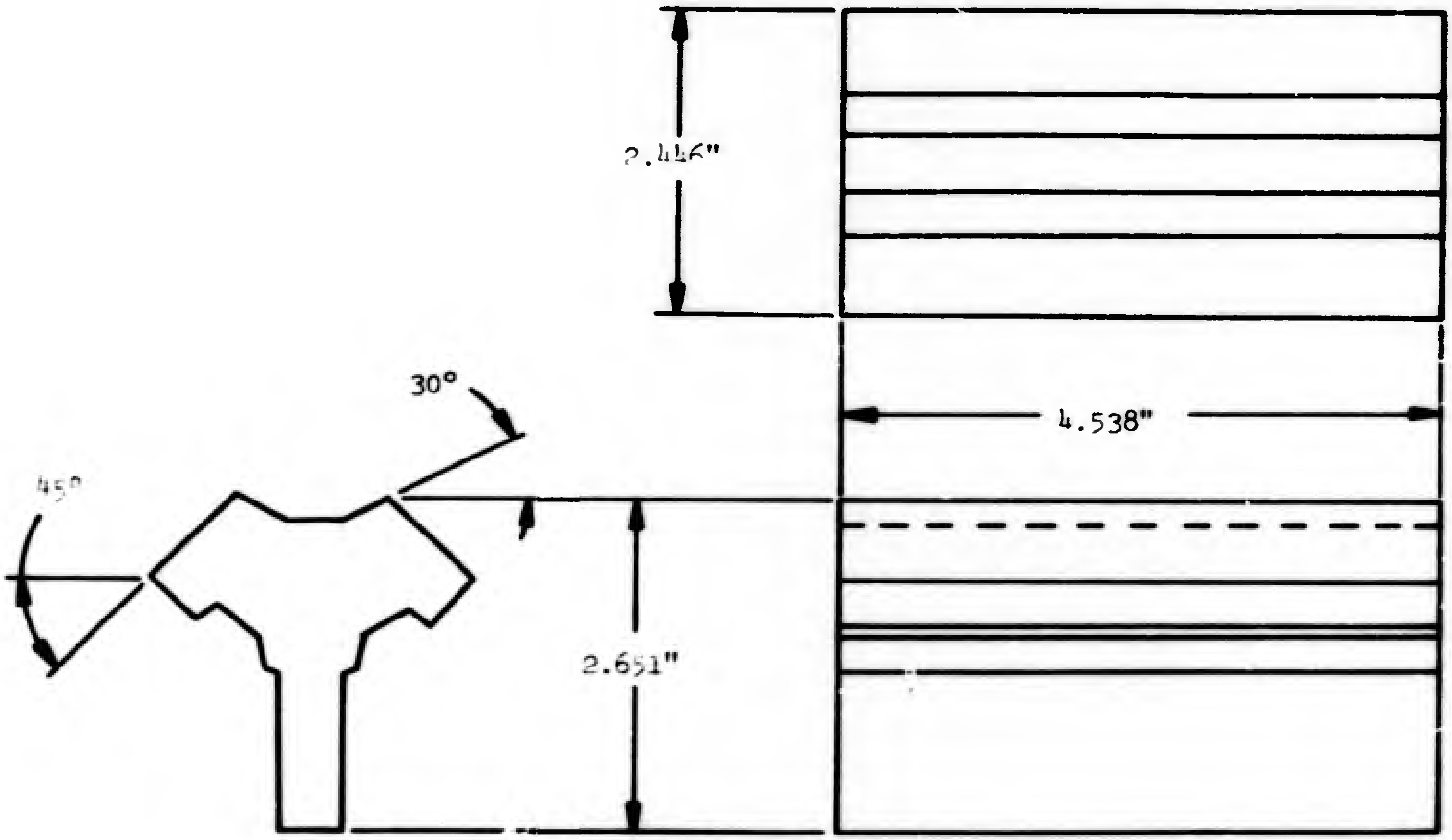


Figure 6. TER, Midsection

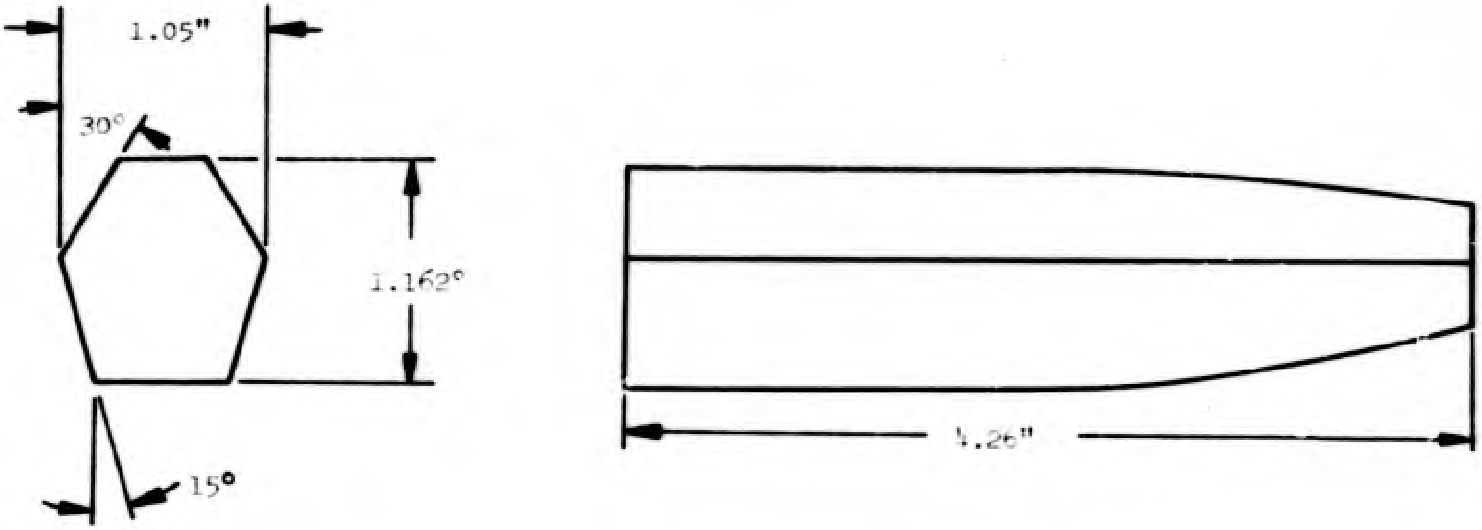


Figure 7, TER, Aft Section

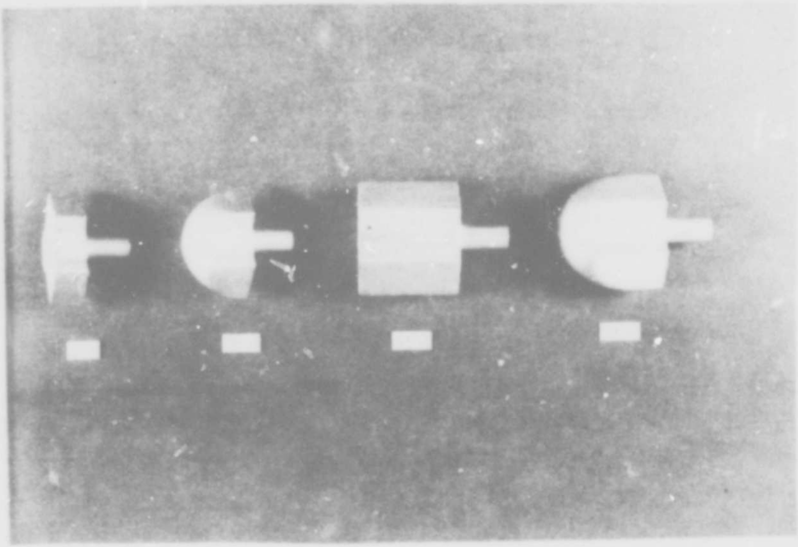


Figure 8. Configurations of Group III

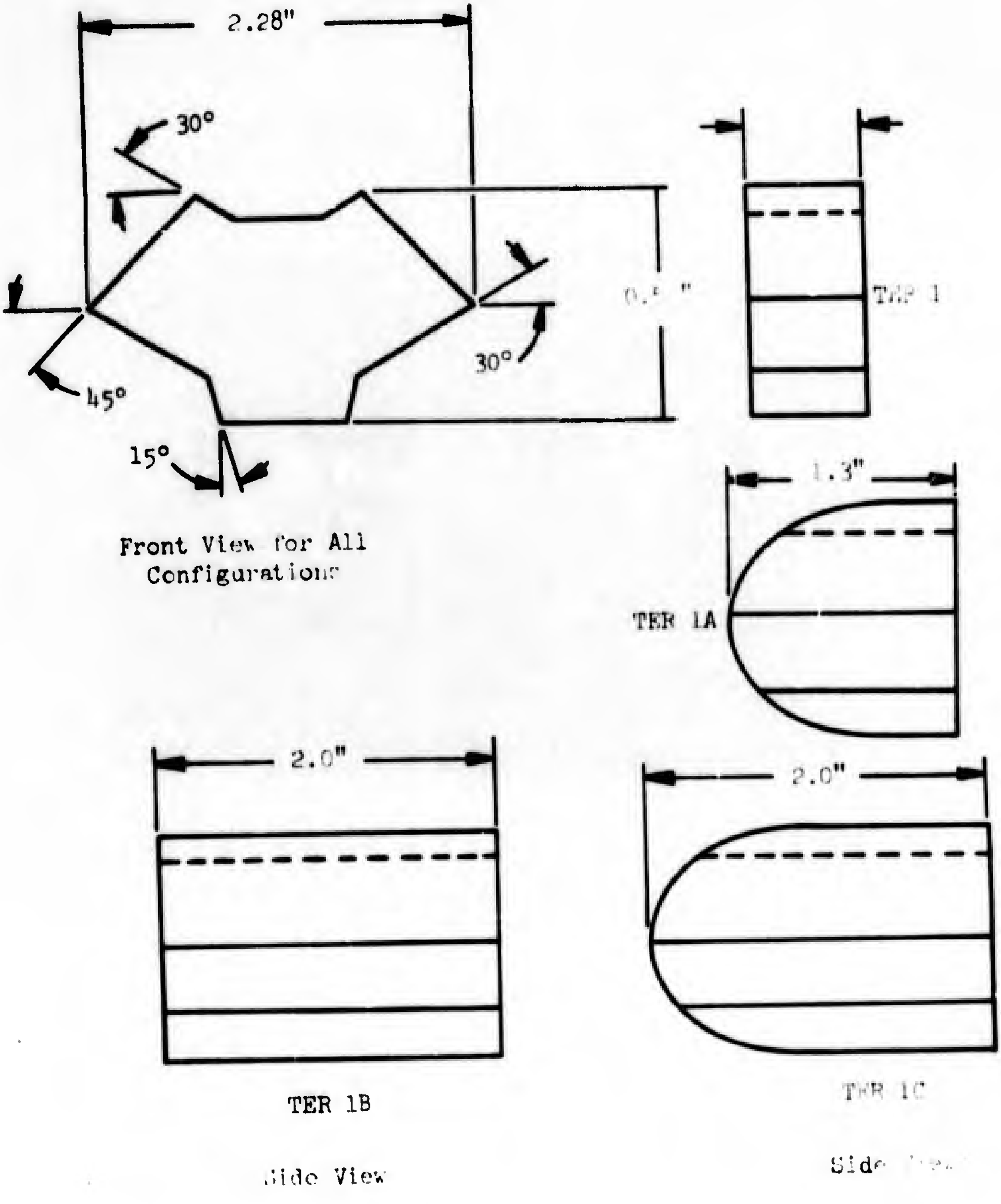


Figure 9. Dimensional Details of Group III, Configurations

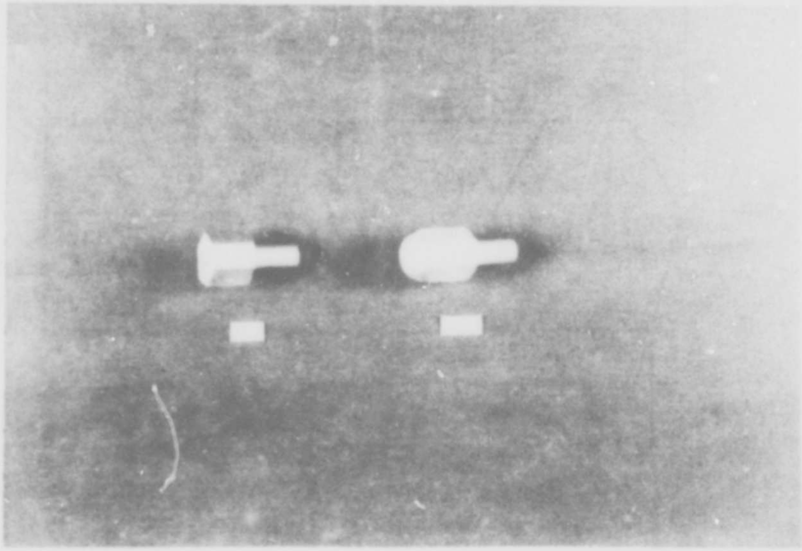
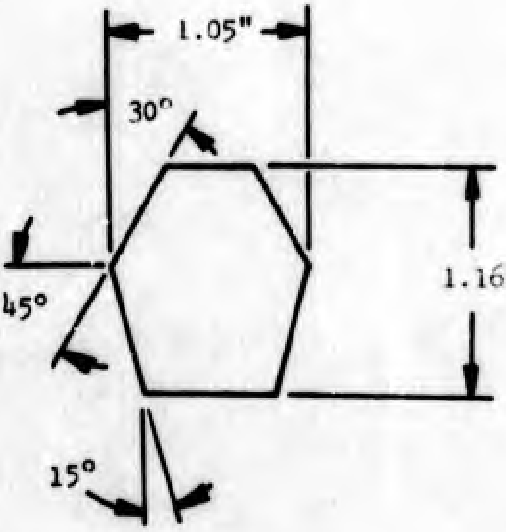
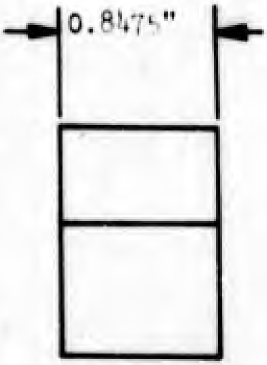


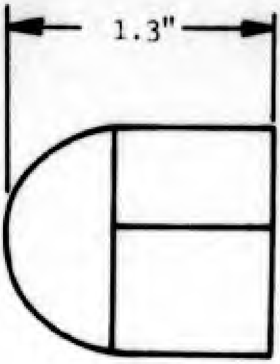
Figure 10. Configurations of Group IV



Front View for Both
Configurations



TER 2



TER 2A

Side Views

Figure 11. Dimensional Details of Group IV, Configurations

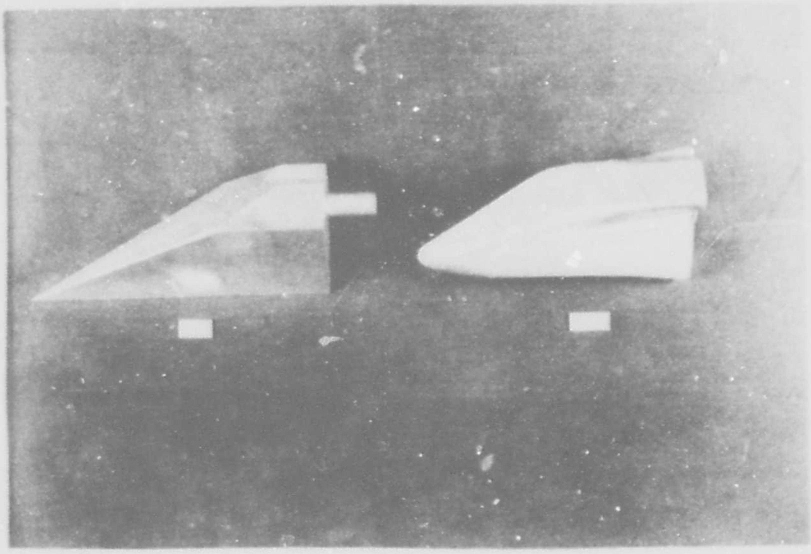
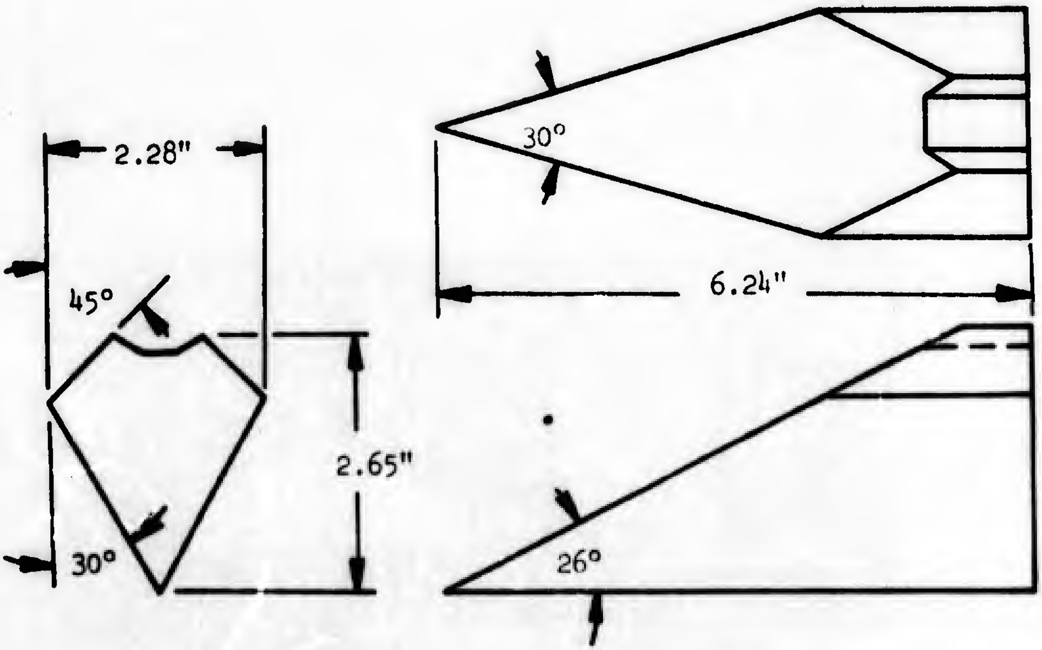
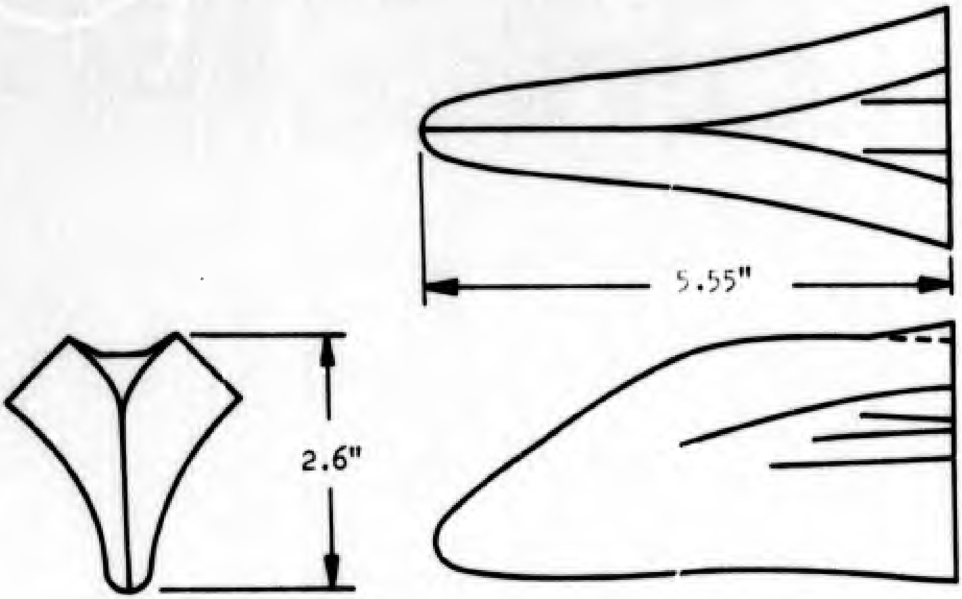


Figure 12. Configurations of Group V



TER 3



TER 3A

Figure 13. Dimensional Details of Group V, Configurations

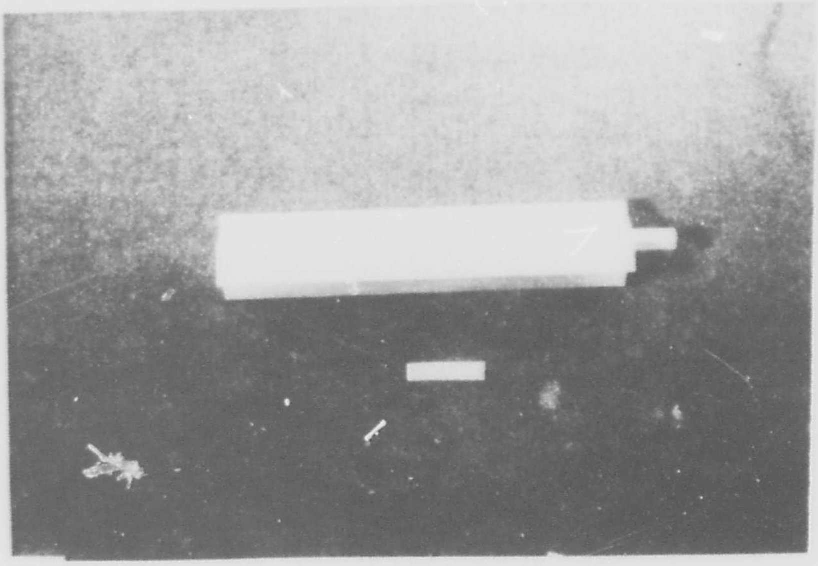
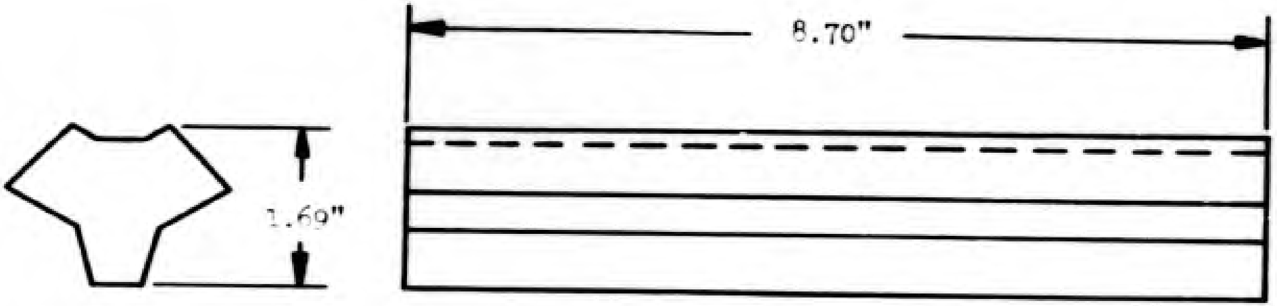


Figure 14. Configuration of Group VI



Aft Extension

Figure 15. Dimensional Details of Group VI, Configurations

SECTION III

TEST RESULTS AND DISCUSSION

Groups I and II

The normal force and pitching moment distributions along the pressure model for the no-TER configuration are similar to those obtained for the current TER configuration. As shown in Figure 16, variations in the magnitude of the local normal force coefficients occur primarily for the nose and midsection of the model. The coefficients for the no-TER case are less than those for the current TER over the entire length. Differences in the values for the two cases are insignificant over the tail section of the model.

Figure 17 indicates the same similarities in the variation of the local pitching moment coefficients for the two configurations. Significant differences in values of the coefficients are confined to the nose and midsection of the model.

Groups III and II

The values of the local normal force coefficient produced using the TER nose fairing geometries of Group III are plotted in Figure 18, along with the values for the TER. Noticeable, but small, variations in the curves of Figure 18 appear both at the latter part of the nose section and at the first part of the midsection of the model. In each of these sections, the local normal force coefficients for TER 1 are greater than those of either the TER or the other three configurations of Group III. The values of the coefficients for all geometries decrease similarly for the midsection and tail section. At the end of the model, the four configurations of Group III have negative local normal force coefficients in contrast to the positive ones for the TER.

The pitching moment coefficient variations for the TER nose geometries of Group III (Figure 19) indicate that the TER 1 configuration yields the best reduction in the negative pitching moment of the model. The effect of all four nose fairings in this group is to decrease the negative moment because of the positive moment contribution produced at the aft end of the model. However, TER 1 is the only geometry to produce larger values of local pitching moment coefficient than the TER both for the latter region of the nose section and for the initial region of the midsection.

Groups IV and II

The effect of the TER nose fairings of Group IV on the local normal force coefficients of the active pressure model is shown in Figure 20. For

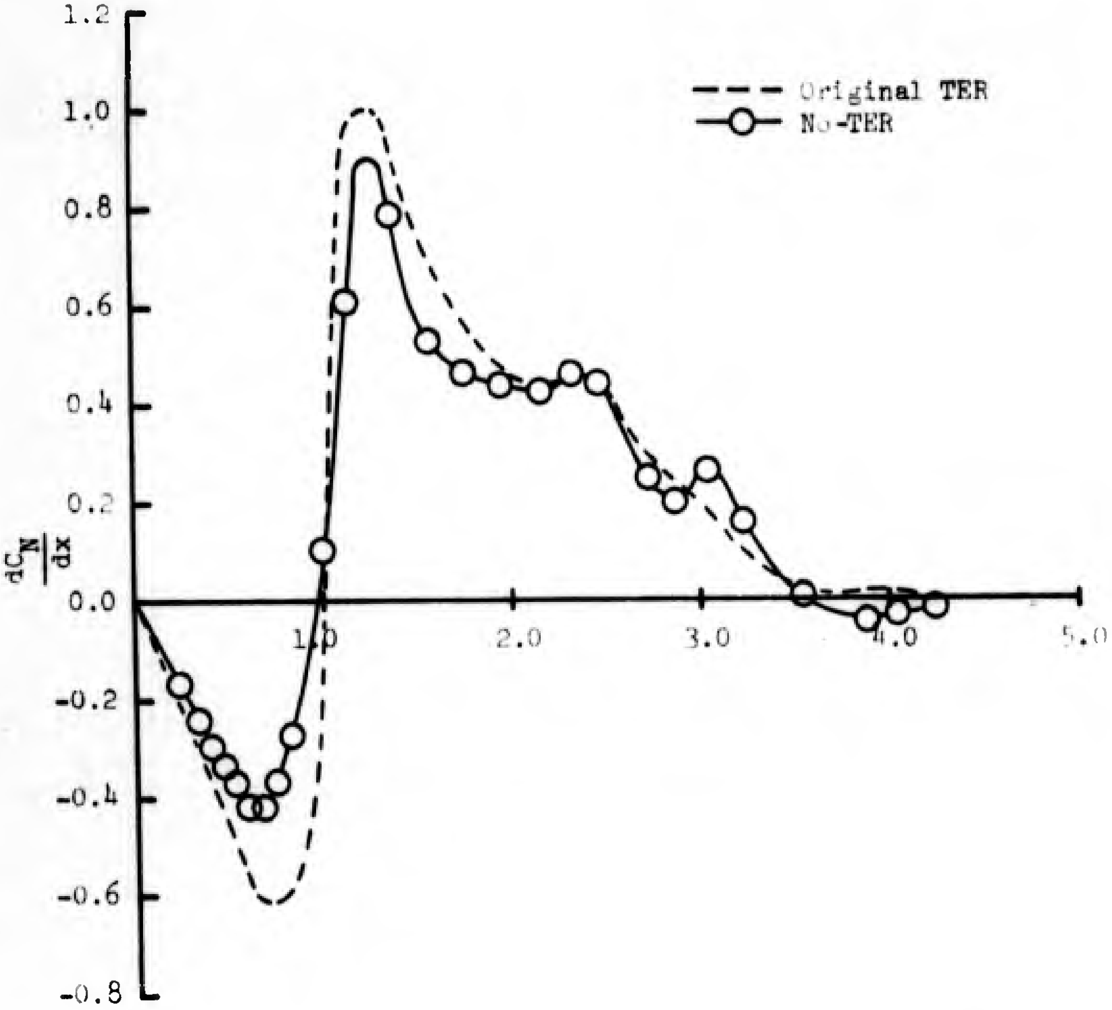


Figure 16. Local Normal Force Coefficients for Group I

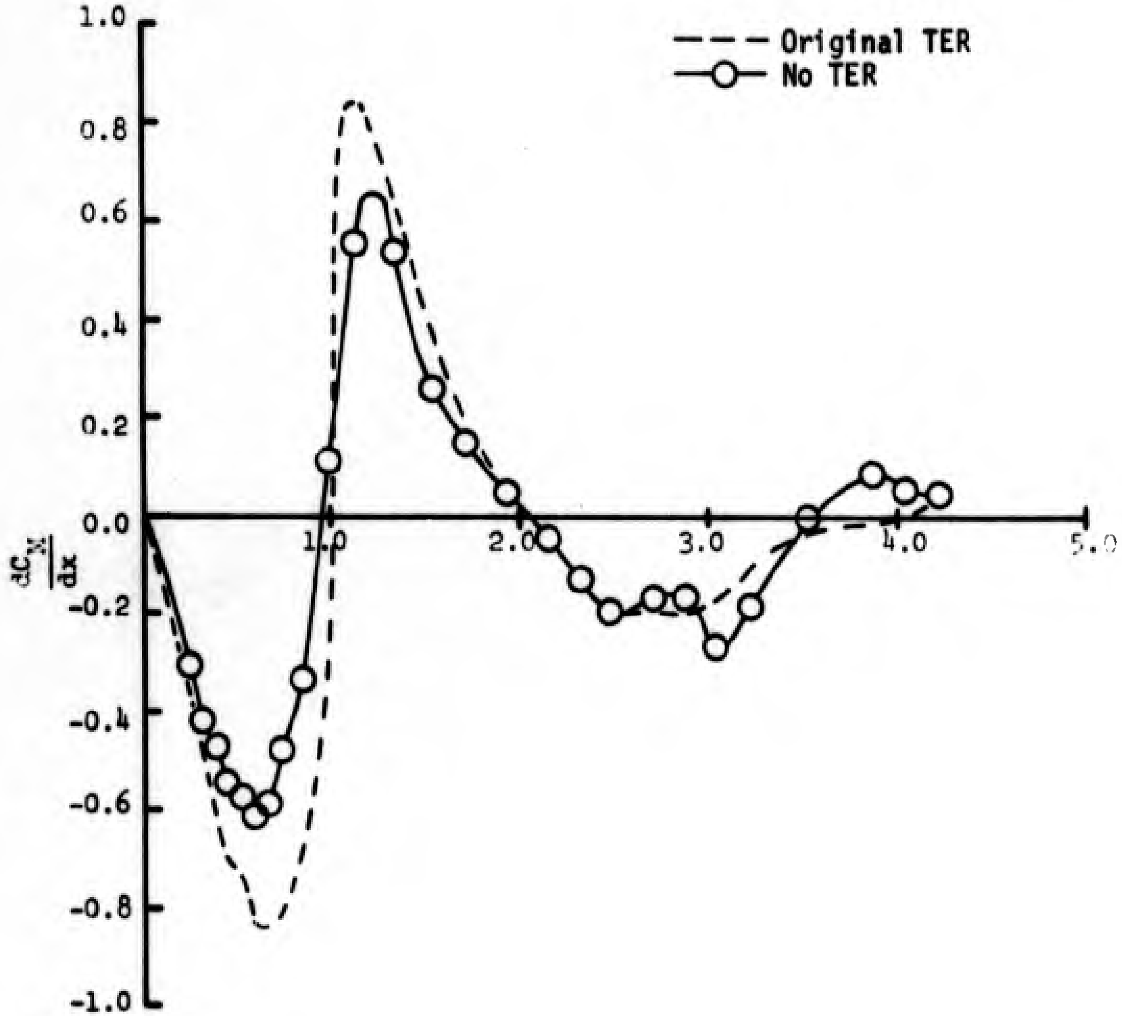


Figure 17. Local Pitching Moment Coefficients for Group 1

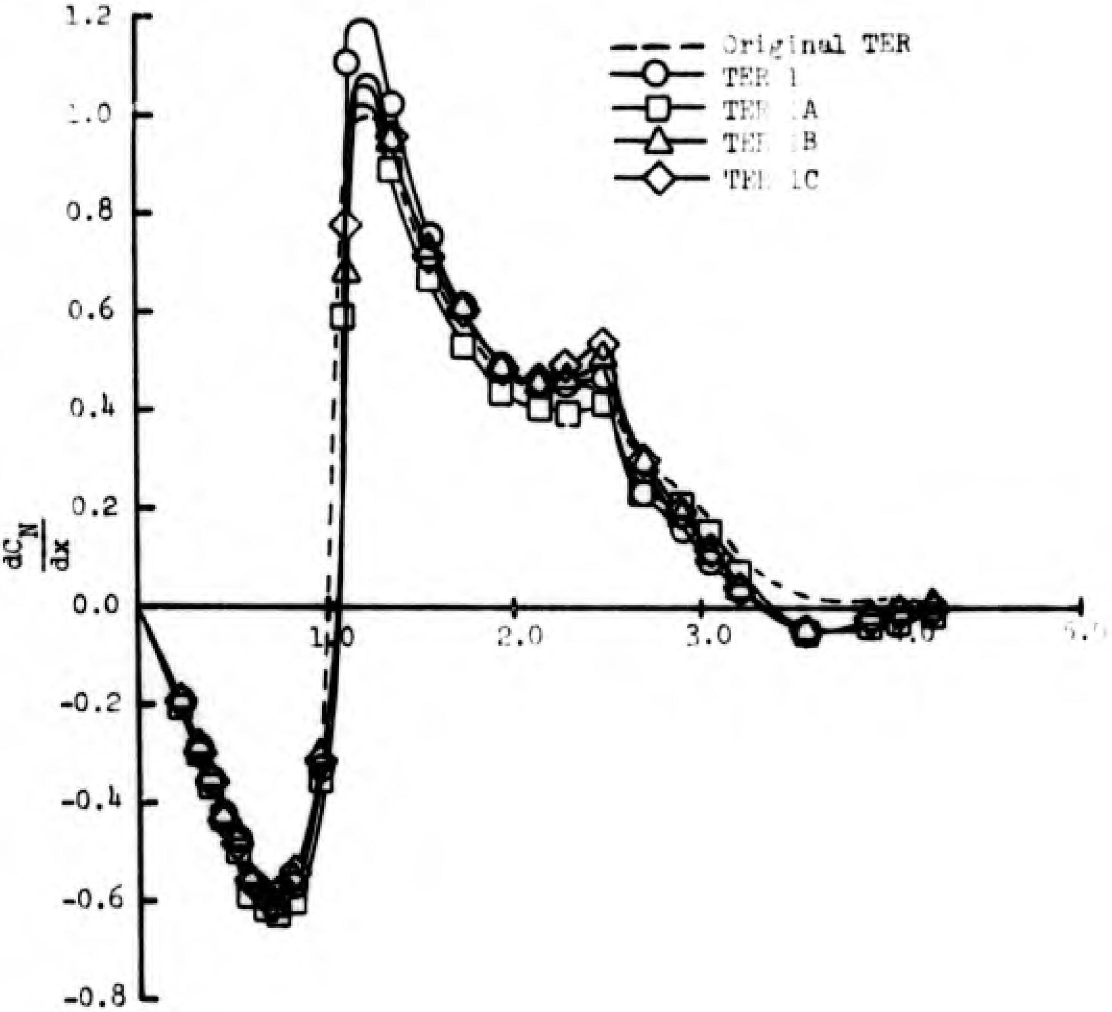


Figure 18. Local Normal Force Coefficients for Group III

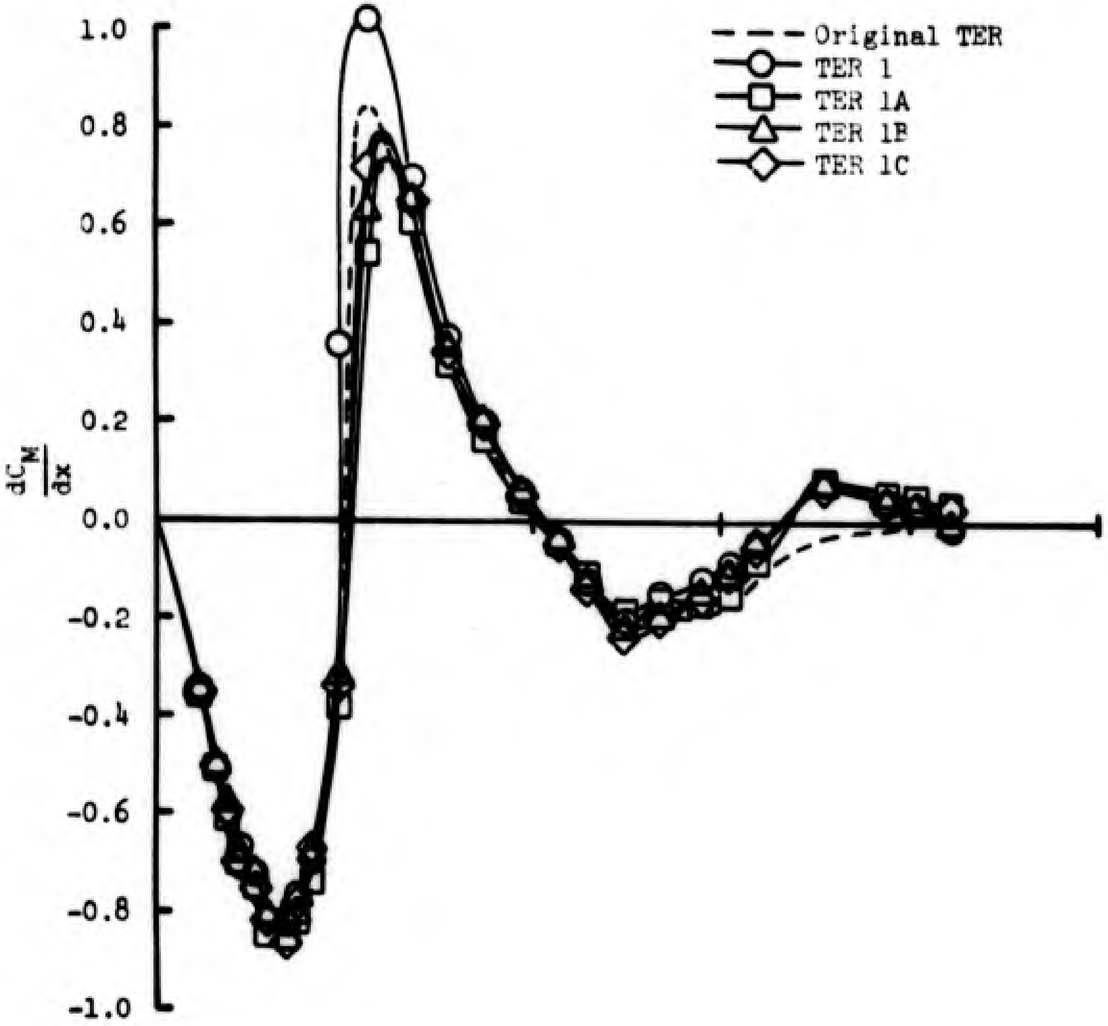


Figure 10. Local Pitching Moment Coefficients for Group III

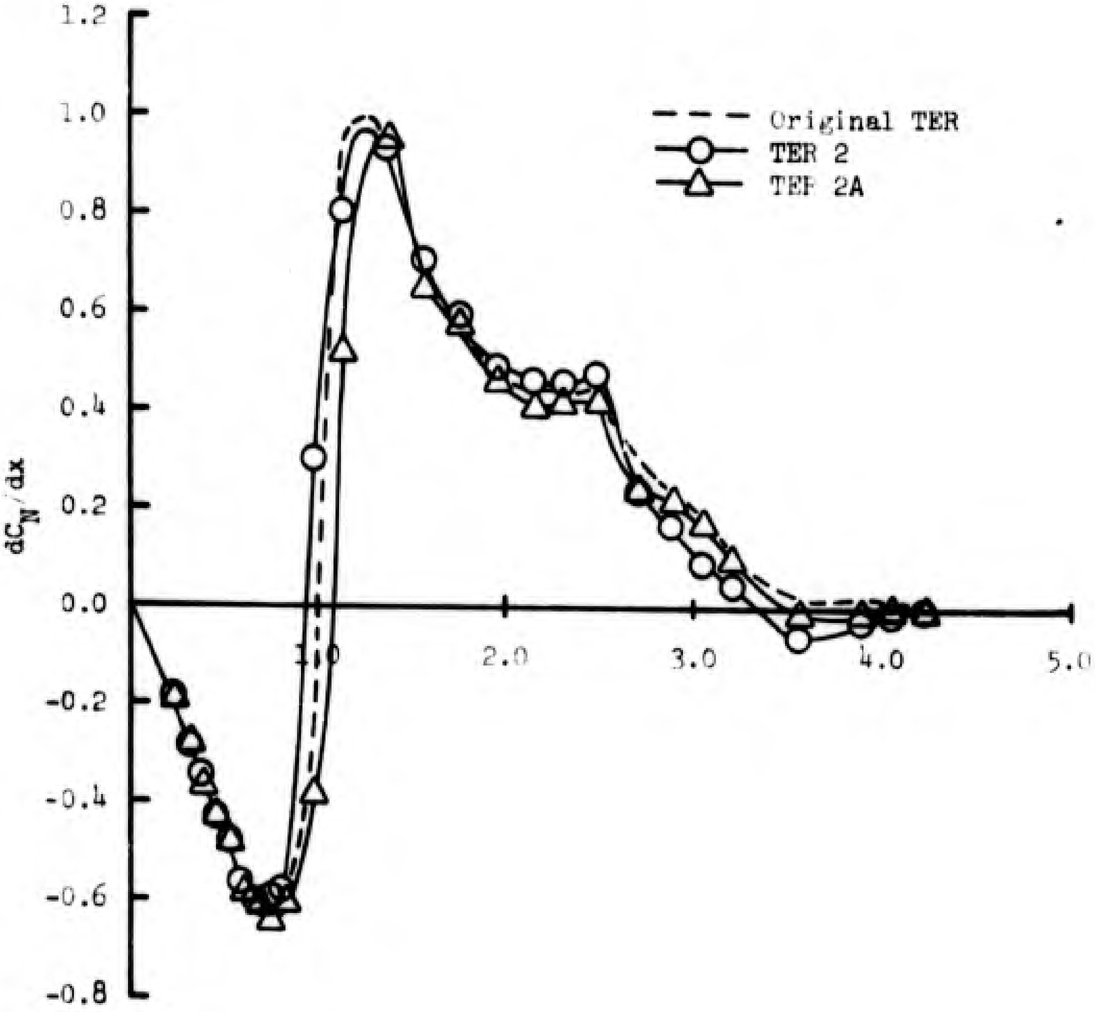


Figure 20. Local Normal Force Coefficients for Group IV

the nose section of the model, the influence of TER 2 and TER 2A on the flow field does not create large changes in the values of the curve that was obtained for the case of the TER. Along the constant radius midsection, the local normal force coefficients for TER 2A are slightly less than those for the TER and TER 2. For the two TER configurations of Group IV, the local normal force coefficients are decreased along the tail section, the values becoming negative for the latter part of the model.

The curves of the local pitching moment coefficient for this group (Figure 21) show that the values for TER 2 and TER 2A are very similar to those obtained for the TER. Variations in the plots occur at the end of the nose section and for the tail section of the model. At the end of the nose section, the values of the local pitching moment coefficient for the configurations of Group IV are less than those obtained for the TER. The configurations, TER 2 and TER 2A, produce positive pitching moment coefficients at the end of the model.

Groups V and II

The TER 3 configuration produces values of the local normal force coefficient for the nose section of the model that are very similar to the ones for the TER (Figure 22). For this same region, TER 3A produces values that are less negative than those produced by the other two configurations. At the point of the maximum local normal force coefficient, TER 3 and TER 3A both produce values less than that of the current TER. The curves in the region of the tail section are similar to those of the current TER except at the aft end of the model where TER 3A produces negative local normal force coefficients. From Figure 22, it can be seen that TER 3 significantly alters the normal force distribution for the tail section of the model. The values of the local normal force coefficient do not approach zero asymptotically as in previous cases.

Figure 23 shows the local pitching moment coefficients produced by the configurations of Group V compared with the ones produced by the TER. The three curves are very similar for the nose and midsection of the model except that values produced by TER 3 and TER 3A are slightly less than those produced by the TER for some axial stations. The curve of values produced by TER 3A is similar to previous curves for the tail section, creating positive pitch at the end of the model. TER 3 produces values of the local pitching moment coefficient that do not approach the axis.

Groups VI and II

For this group, the variations in local normal coefficients (Figures 24, 25, and 26) and local pitching coefficients (Figures 27, 28, and 29) indicate that the aft extension creates very little effect on either. The slight changes produced when the aft extension is used are confined to the midsection and tail section of the model.

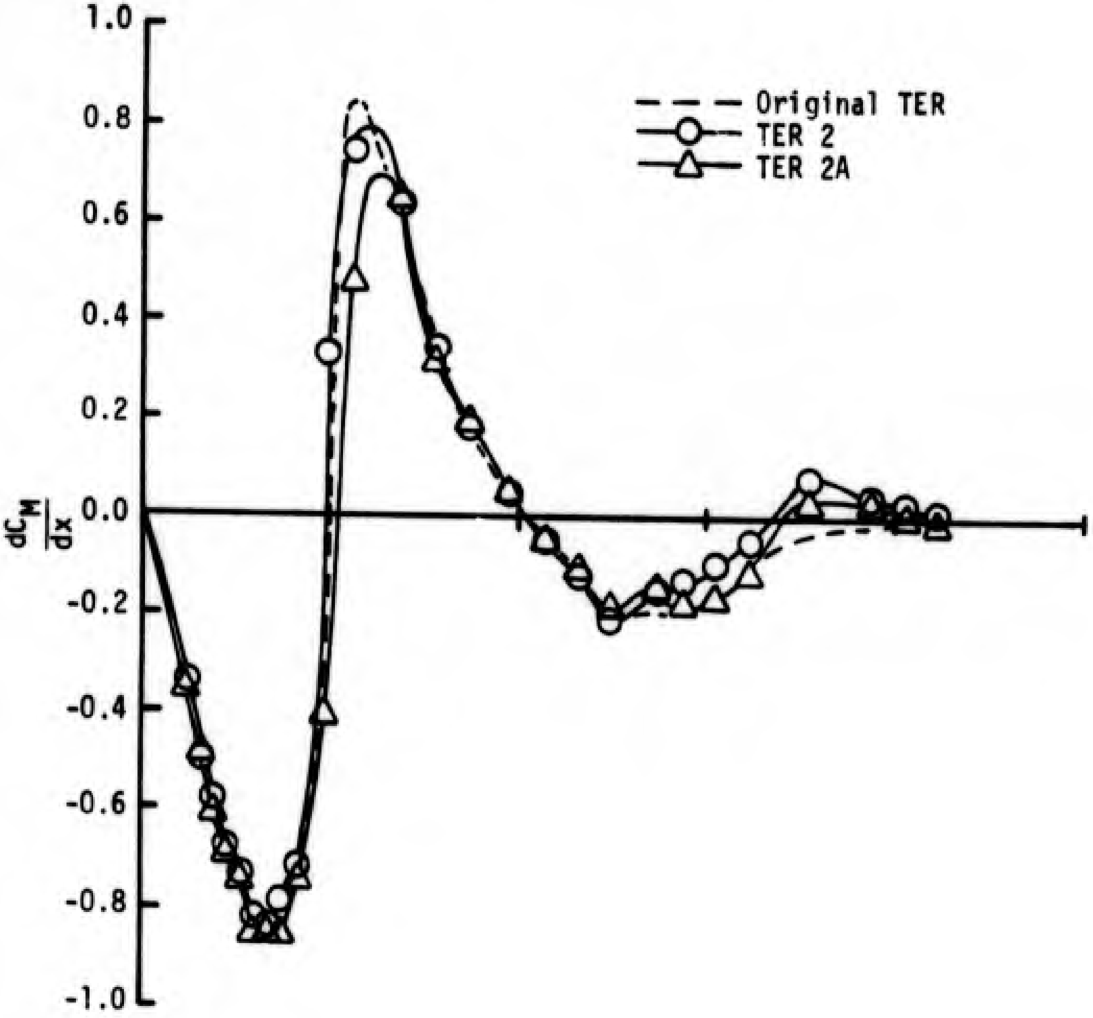


Figure 21. Local Pitching Moment Coefficients for Group IV

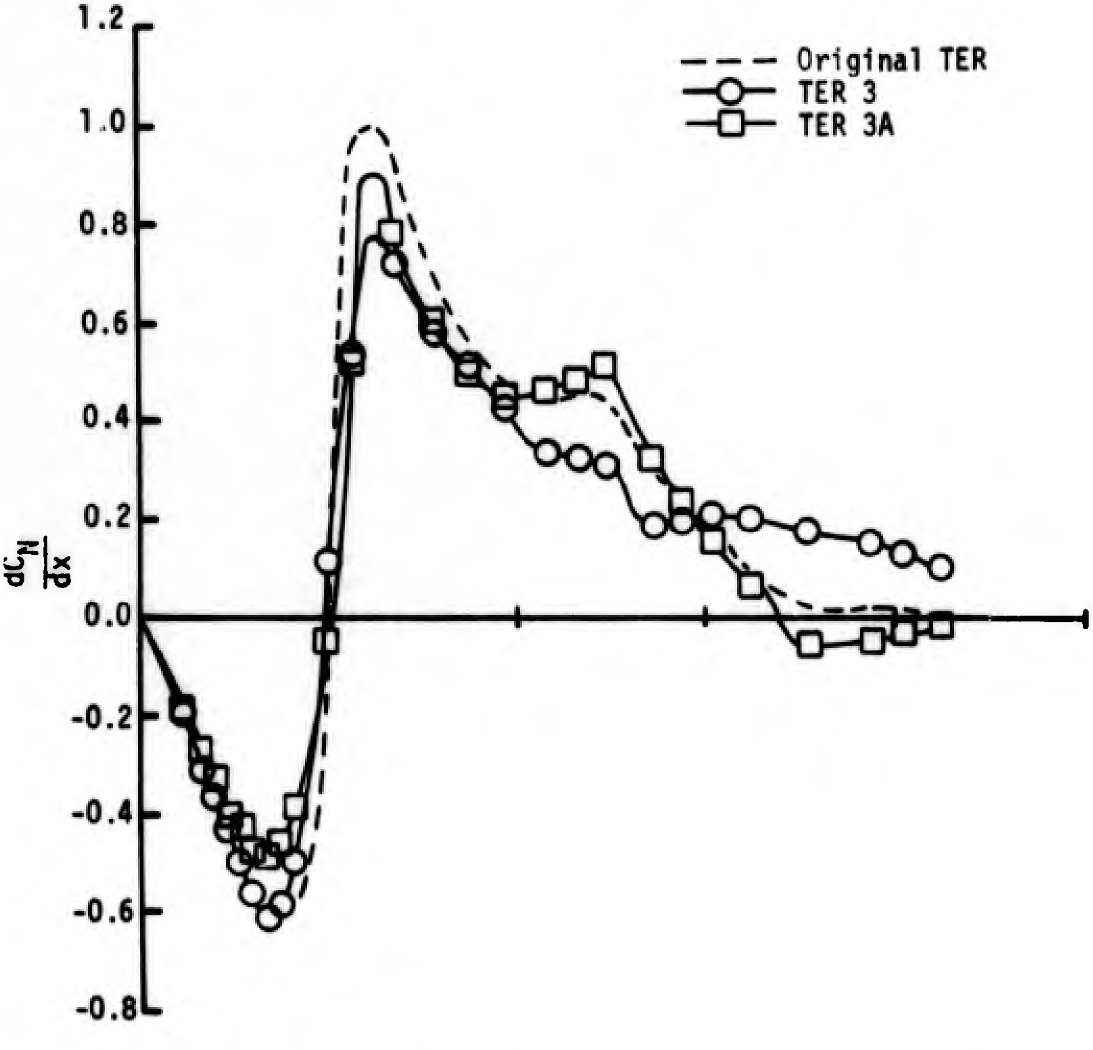


Figure 22. Local Normal Force Coefficients for Group V

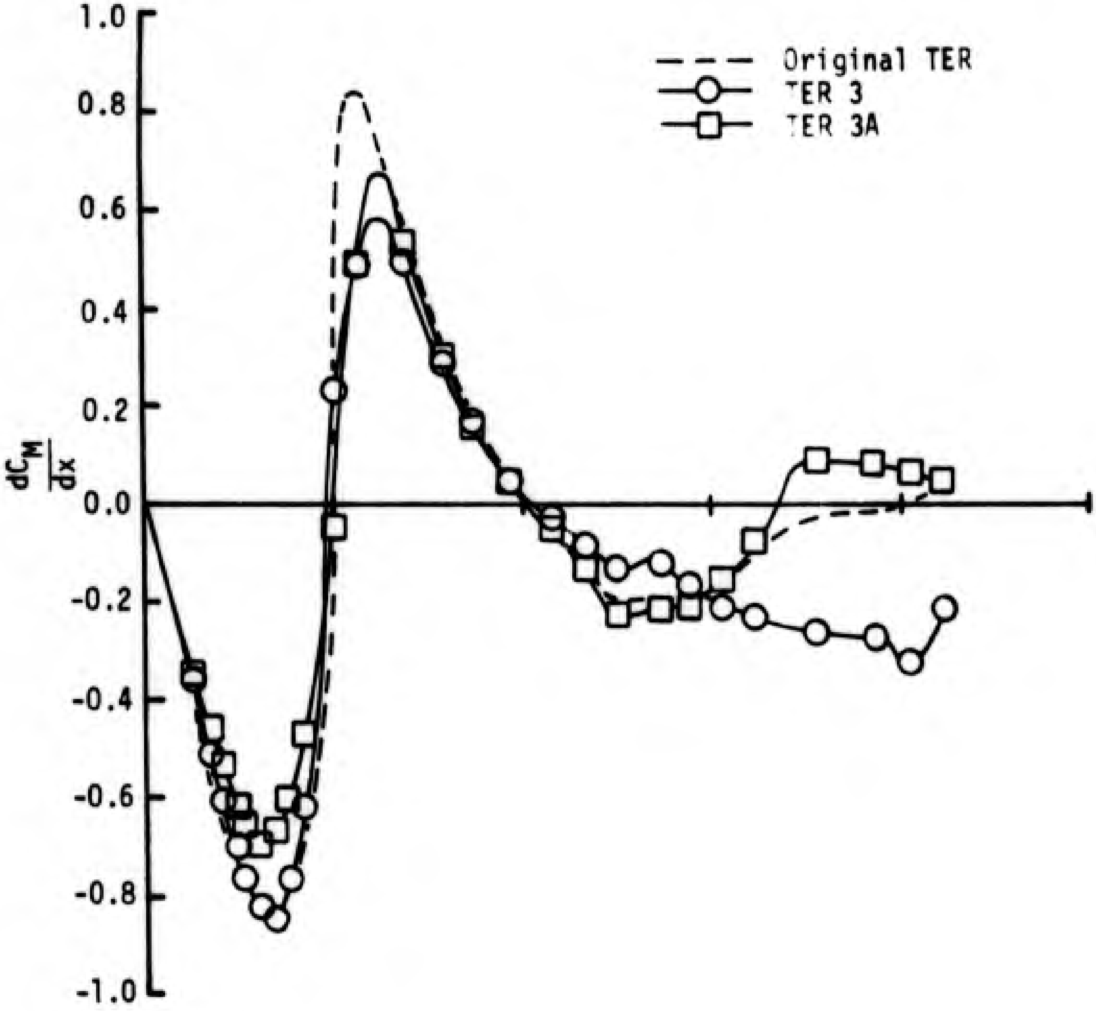


Figure 23. Local Pitching Moment Coefficients for Group V

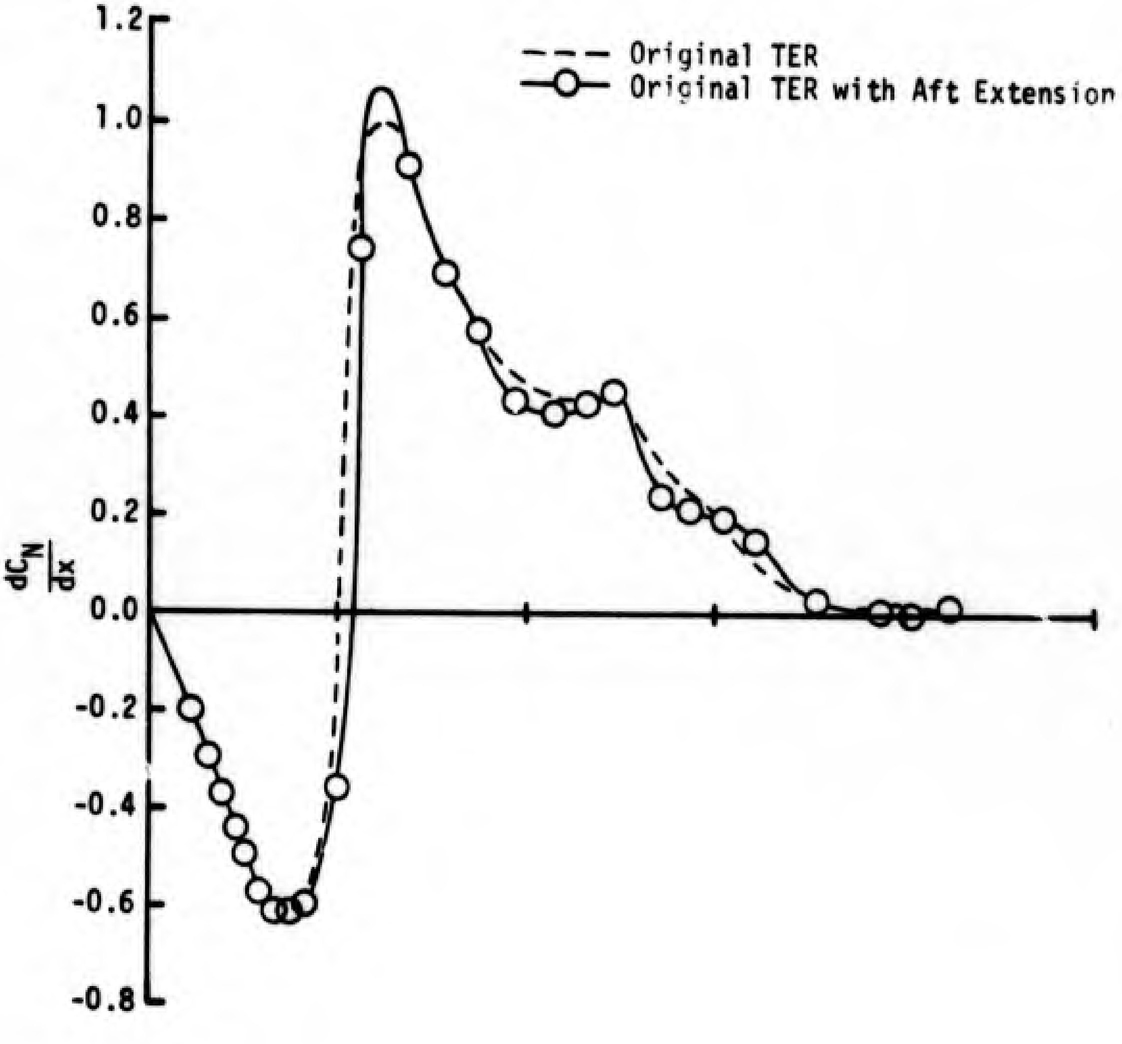


Figure 24. Local Normal Force Coefficients for Original TER with Aft Extension

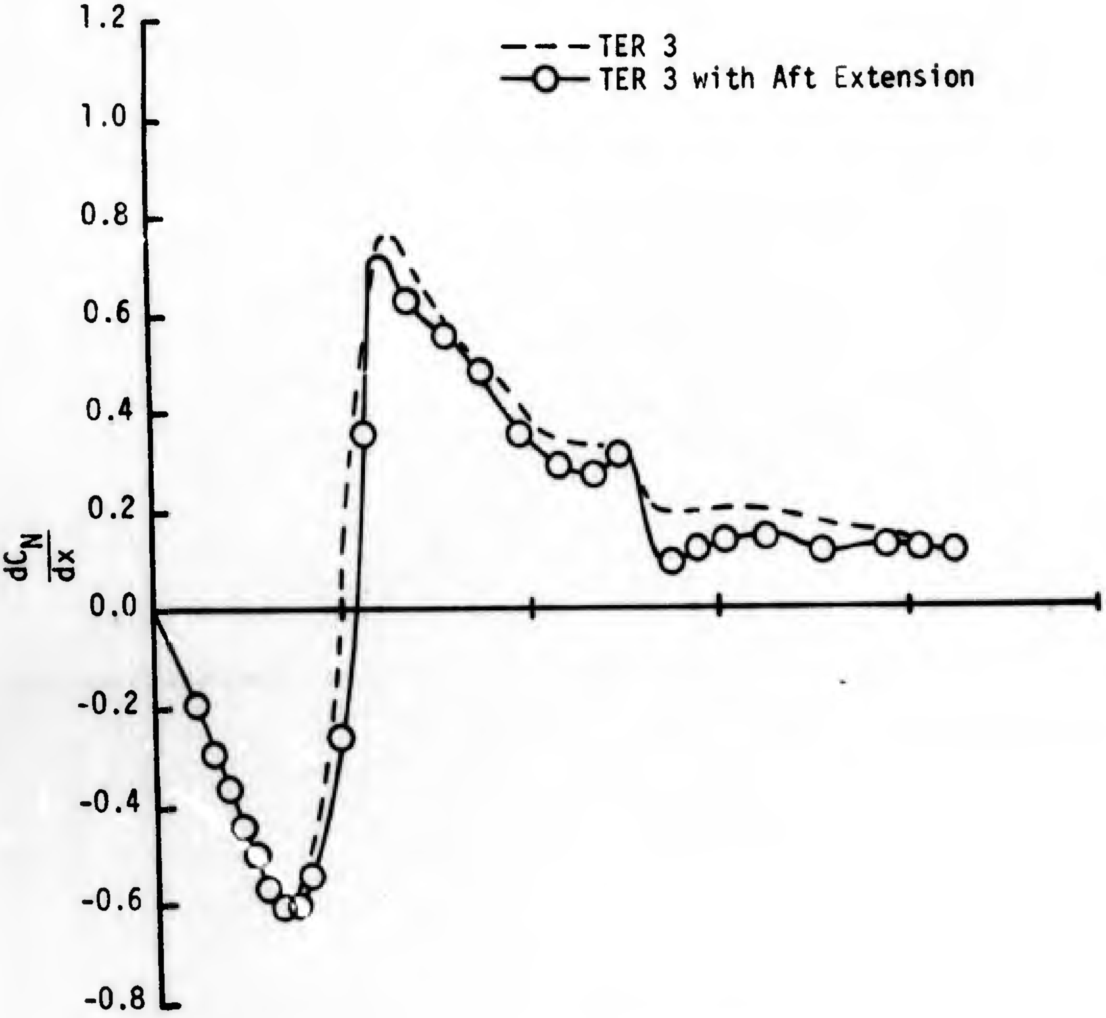


Figure 25. Local Normal Force Coefficients for TER 3 with Aft Extension

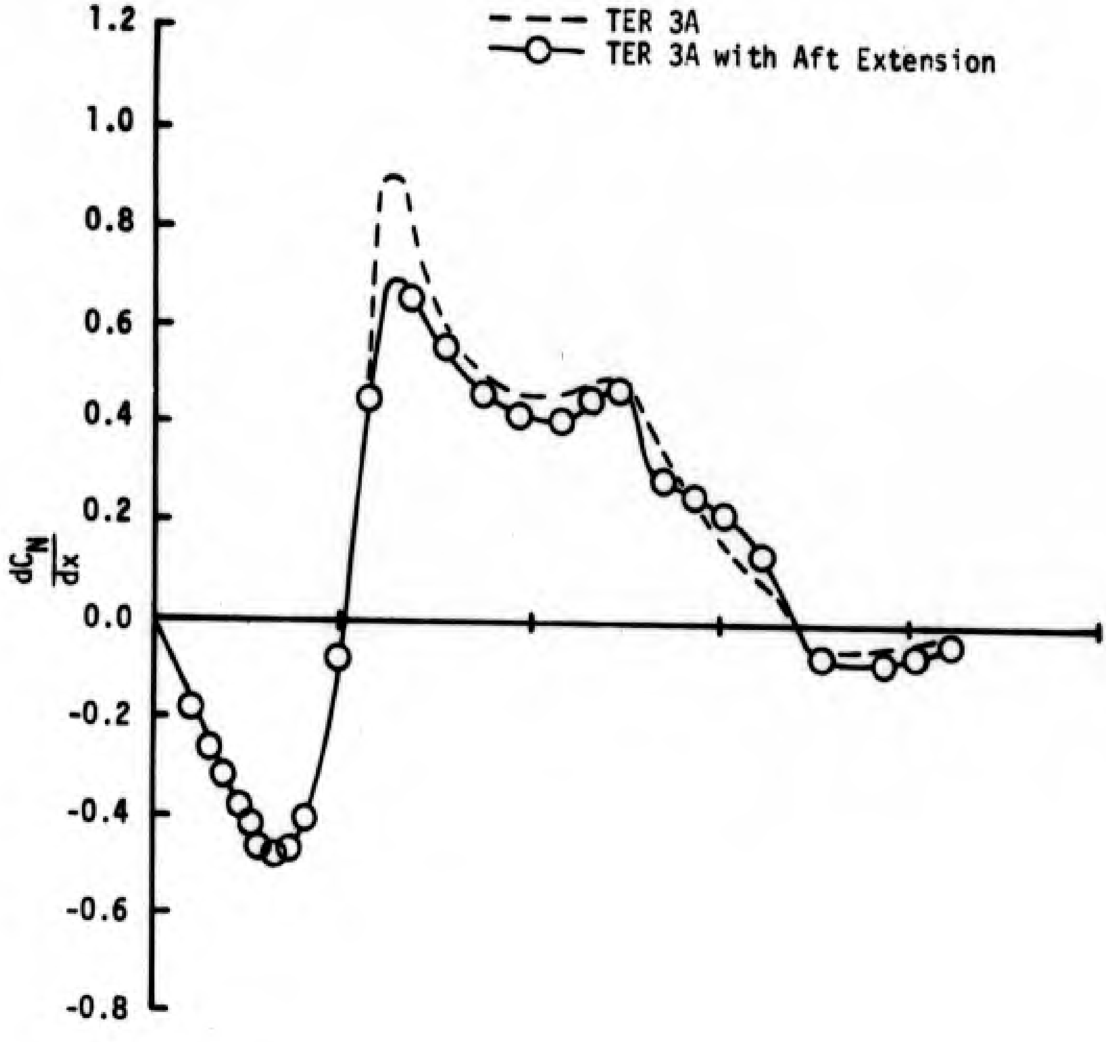


Figure 26. Local Normal Force Coefficients
for TER 3A with Aft Extension

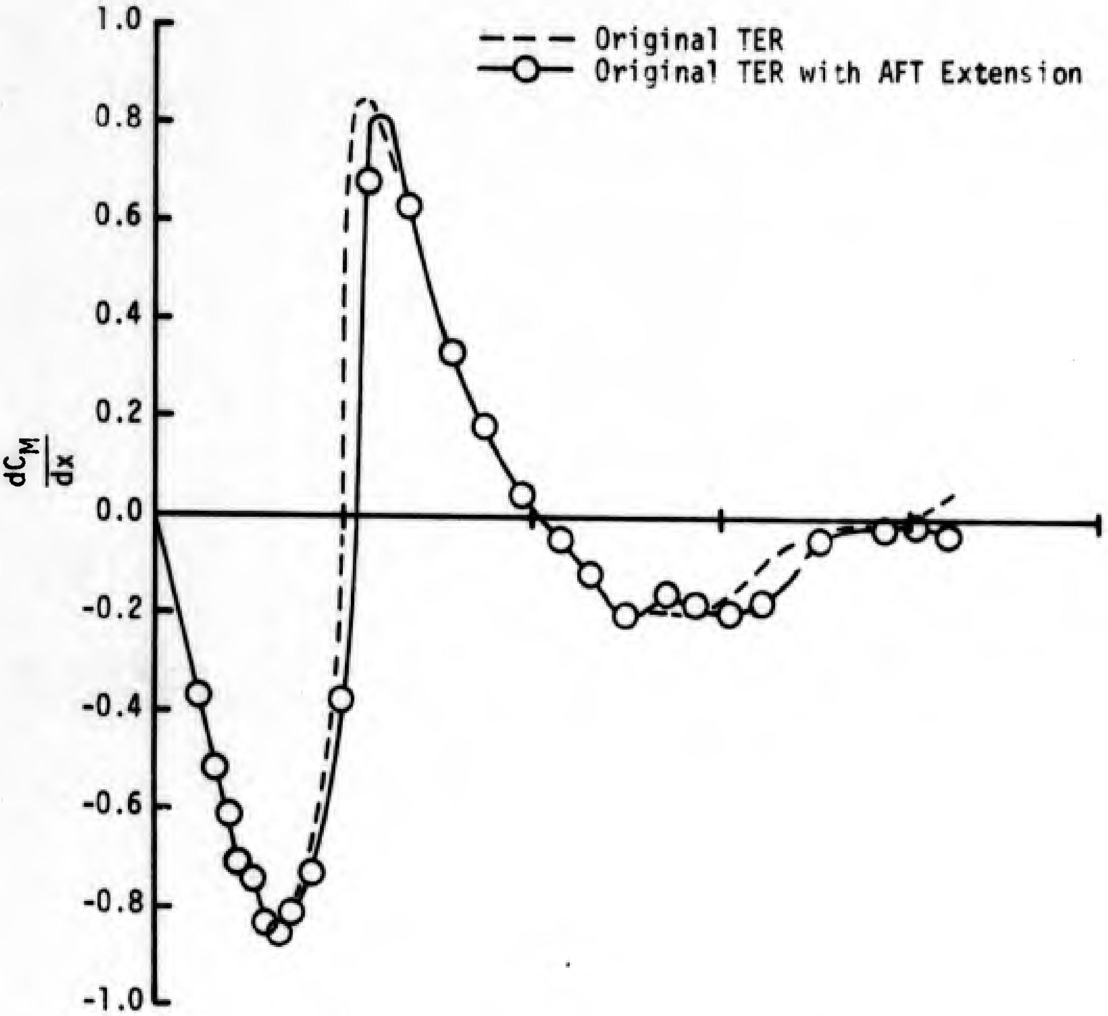


Figure 27. Local Pitching Moment Coefficients for Original TER with Aft Extension

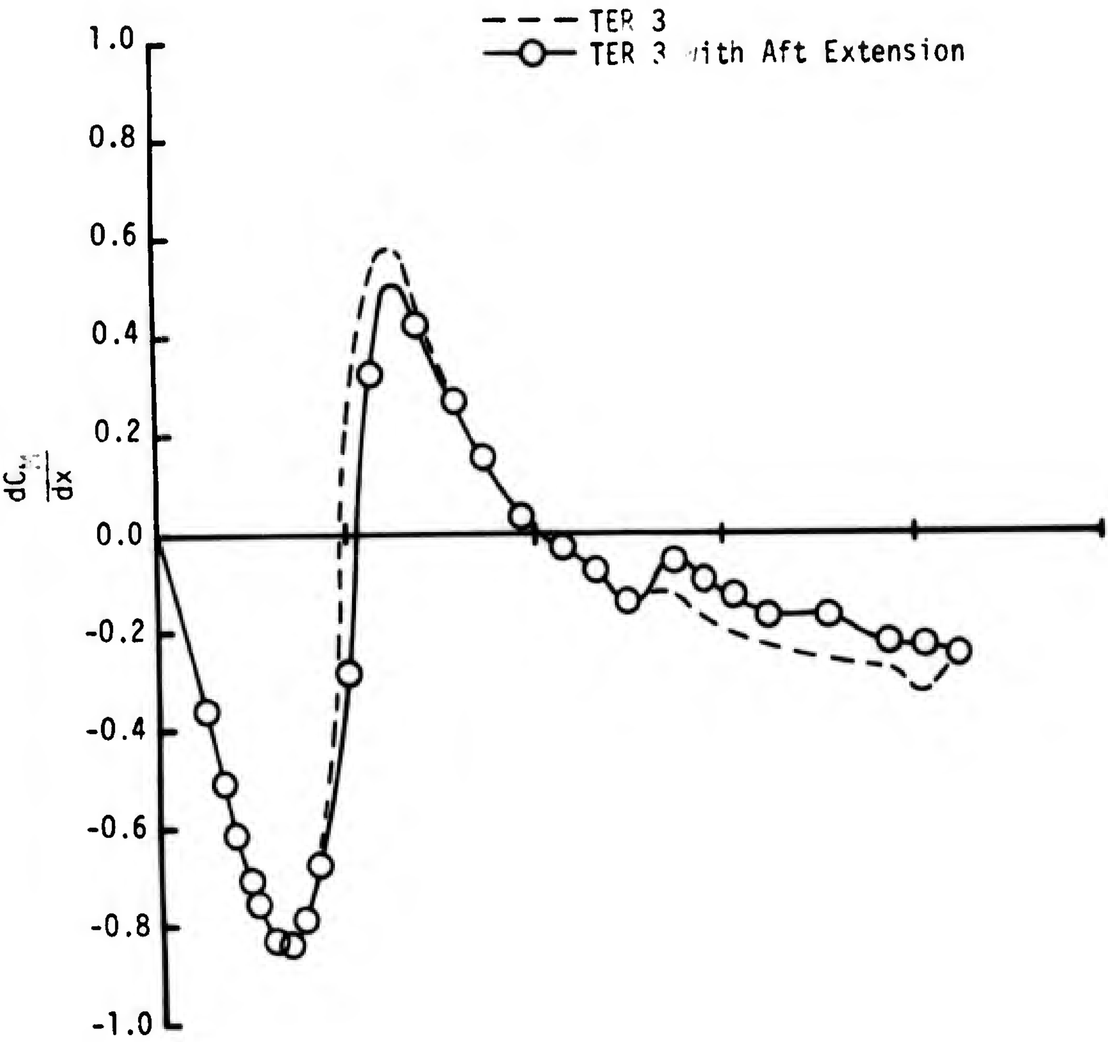


Figure 28. Local Pitching Moment Coefficients for TER 3 with Aft Extension

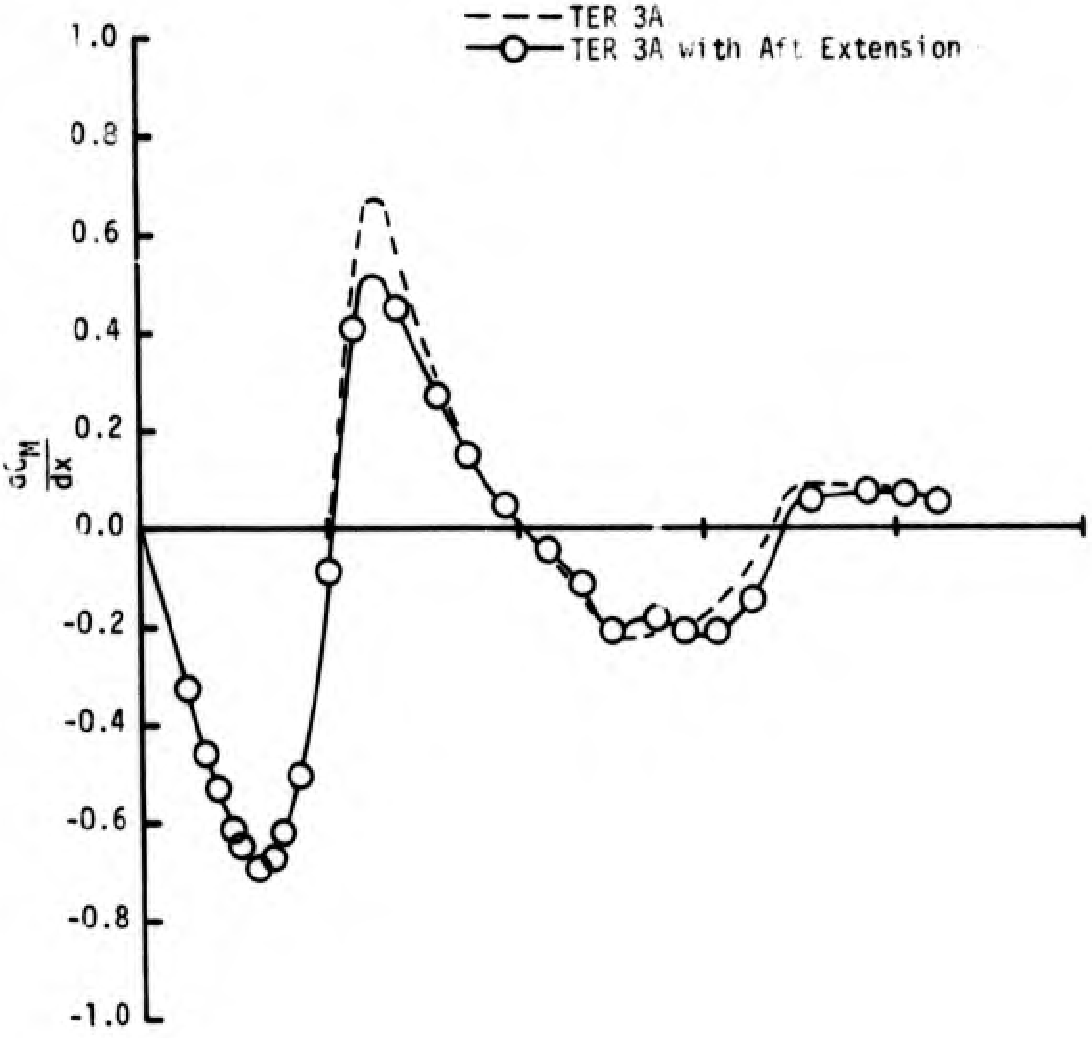


Figure 29. Local Pitching Moment Coefficients for TER 3A with Aft Extension

Table II presents the results for C_N and C_M obtained from integration of the plots in Figures 16 to 29.

TABLE II. NORMAL FORCE AND PITCHING MOMENT COEFFICIENTS

Configuration	C_N	C_M
No TER	0.744	-0.184
Current TER	0.736	-0.3676
TER 1	0.672	-0.084
TER 1A	0.524	-0.284
TER 1B	0.680	-0.240
TER 1C	0.692	-0.248
TER 2	0.720	-0.168
TER 2A	0.576	-0.3616
TER 3	0.720	-0.600
TER 3A	0.684	-0.200
Current TER with Aft Extension	0.684	-0.400
TER 3 with Aft Extension	0.518	-0.540
TER 3A with Aft Extension	0.594	-0.290

SECTION IV

CONCLUSIONS

The preceding plots of the local normal force coefficients and the local pitching moment coefficients indicate that the TER nose fairing configurations (except no-TER and TER 3A) do not affect the values of the local coefficients produced for the initial region of the nose section. For the two exceptions, both coefficients are decreased in this region. The most noticeable effect of the TER geometry is at the aft end of the model where all of the nose fairing modifications except TER 3 changed the sign of the local coefficients as compared to that for the current TER.

The total values of the pitching moment coefficients (Table II) indicate that TER 1 and TER 2, the flat nose configurations, create the largest reduction of the negative pitch of the model. The values produced by Group III indicate that a longer, flat TER nose fairing modification would be more effective in reducing the negative pitching moment of the bomb than a similar round nose modification.

From the values of the pitching moment coefficients for Group V in Table II, diversion of the airflow in the open region by TER 3 appears to increase the nose-down pitch tendency of the active pressure model. In contrast, the use of TER 3A aids slightly in the reduction of the negative pitch.

The addition of the aft extension to either the current TER, TER 3, or TER 3A appears to have very little effect on the pitching moment coefficient. However, this extension tends to decrease the value of the normal force coefficient.

In conclusion, these tests indicate that a short, blunt nose fairing modification to the TER-9/A will reduce the nose-down pitch of the M-117 bomb. Further tests are needed to determine what effect this modification would have on the flight characteristics of the aircraft.