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BRL

TECHNICAL NOTE No. 902

The Effect Of Nose Truncation On The Aerodynamic Properties Of 9-Caliber Long Army-Navy Spinner Rocket Models Near Sonic Velocity

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DEPARTMENT OF THE ARMY PROJECT No. 503-05-011
ORDNANCE RESEARCH AND DEVELOPMENT PROJECT No. TB3-0240

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A B E R D E E N P R O V I N G G R O U N D, M A R Y L A N D

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EJRoschke/jmc
Aberdeen Proving Ground, Md.
January 1955

THE EFFECT OF NOSE TRUNCATION ON THE AERODYNAMIC PROPERTIES OF 9-CALIBER LONG ARMY-NAVY SPINNER ROCKET MODELS NEAR SONIC VELOCITY

ABSTRACT

The results of a limited program to determine the effect of nose truncation on the aerodynamic properties of the 9-caliber long Army-Navy spinner rocket shape near sonic velocities are given.

INTRODUCTION

In order to study the motions of spinner rockets in launchers and the effects of various launching characteristics on subsequent flight it was necessary to modify the noses of the rockets. This nose modification consisted of a truncation for the purpose of attaching a flat, circular mirror. These experiments were conducted by Dr. J. W. Cell and his associates of North Carolina State University; firings were done at Redstone Arsenal.

The question then arose whether truncation of the nose appreciably affected the aerodynamics of the configuration, especially near sonic velocity. Past experience indicated that in this region of velocities the aerodynamics could be quite sensitive to even relatively small modifications of shape.

To test this a limited program was fired in the Aerodynamics Spark Range utilizing six surplus 20mm diameter, 9-caliber long AN rocket models from a previous program [1]. Four of these were modified[1] as described above (Fig. 1). Table 1 gives the physical properties of the six models.

TREATMENT OF DATA

Due to the limited number of models fired data from other sources had to be relied upon to interpret the results properly. Those aerodynamic coefficients affected by center of gravity position were corrected to a common center of gravity to facilitate data comparison with unmodified shape.

Curves of the various aerodynamic coefficients versus Mach number were plotted in order to compare results of the two types of models. No transonic data for unmodified 9-caliber long rocket models was available. It became necessary to determine curves for unmodified models with just three points, the two determined in this program and one extrapolated from 9-caliber supersonic data [1] at $M = 1.2$. To deal with this difficulty the three points were faired as well as possible with trends similar to that of existing 7-caliber transonic data [2]. While this method assumes that the curve trends of the 7 and 9-caliber models are similar in the transonic region, it is probably justifiable as a rough approximation. Points for unmodified rounds were plotted in a second series of curves and the two sets were then compared.

It should be noted that the curves for the unmodified models were drawn intuitively considering errors of individual points. The data were insufficient to accomplish more than to establish trends. Coefficients for all model rounds came from sufficient swerve with the exception of round 3241, an unmodified model. Values of coefficients obtained from the swerve reduction of this round were inconsistent with the other data.

1 A normal head-length of 2 calibers for unmodified models was reduced by 0.65 caliber for the modified models.

RESULTS

Results are presented in Tables 2 and 3 and the accompanying curves Figs. 2-7. Table 2 gives a tabulation of basic data. Table 3 indicates the percentage differences due to modification at two Mach Nos. Results are not corrected for yaw.

Drag

This parameter was the best determined and probably the most significant. Deviation of the curves becomes greater with increasing Mach No.; drag coefficients were 8% to 15% greater for modified models.

Normal Force

Although individual points were fairly well determined the overall curves were not, particularly for modified models. The actual trends of the curves may be different than shown. Normal force coefficients were approximately 3% greater for modified models.

Overturning Moment

These coefficients were corrected to a common center of gravity. The effect of decreasing physical length was to decrease the overturning moment coefficient. The coefficients were less for modified models, the decrease being from 9% to 15% over the velocity range fired. The center of pressure of the modified models moved rearward, as compared to unmodified models, by an amount of one-half to one caliber.

Spin Deceleration

The absence of spin data for the high Mach No. modified model made it difficult to predict what occurred in that region. The high end of the modified curve is thus poorly determined. Spin deceleration coefficients were 9% to 11% greater for the modified models.

Magnus Moment

These coefficients were corrected to a common center of gravity. At a Mach No. of 0.95 Magnus moment coefficients were about 9% greater for modified models. The value of K_T for modified models was twice that for unmodified models but of opposite sign at a Mach No. of 1.18. The center of pressure of the Magnus force was poorly determined. It is estimated to have moved slightly forward, perhaps one-quarter or one-third of a caliber, due to modification.

Damping Moment

It was found to be impossible to correct this quantity exactly for center of gravity due to lack of knowledge of the corresponding force. No attempt was made to fair in between the extremities of the curves; they would seem to cross. Modified models produced the lower coefficients

(about 17%) for the subsonic case, while the converse was true for the supersonic case.

CONCLUSIONS

On the whole, truncating the nose of the 9-caliber long AN Spinner rocket model to a méplat diameter of 0.45 caliber produced changes in such aerodynamic coefficients as K_D and K_M of a nature to be expected. In addition, the magnus moment coefficient, K_T, also experienced a marked change. Other coefficients, in view of the uncertainty of the data, were not appreciably affected; at least there was no evidence of drastic change. Figs. 8 and 9 are shadow graphs of models in subsonic and supersonic flight respectively.

E. J. Roschke

E. J. ROSCHKE

TABLE 1

Physical Characteristics

Round	Wt.-gms.	A gm.-in.^{2}	B gm.-in.^{2}	c.g. (cal. from base)
3238	194.6	16.22	458.0	3.929
3239	194.9	16.23	460.2	3.931
3243	301.0	22.67	737.1	3.094
3240	301.3	22.67	745.7	3.101
3242*	195.8	16.24	470.7	3.943
3241*	195.5	16.24	470.7	3.943

* Unmodified Models

TABLE 2

a) Table of Data

Round	M	K_D	K_N	K_T	K_A	K_M	K_H	$\overline{\delta^2}$ (square deg.)
3238	.948	.1536	1.02	0.18	.0127	2.61	10.7	6.43
3239	.956	.1591	1.04	0.11	.0124	2.56	10.5	7.66
3243	1.043	.2083	1.12	0.43	.0121	3.53	10.6	3.87
3240	1.184	.2190	1.01	0.40	-	3.57	19.9	1.39
3242*	.924	.1287	1.00	0.11	.0118	2.75	12.5	5.93
3241*	.966	.1475	1.00	0.32	.0115	2.92	17.3	0.31

b) Aerodynamic coefficients corrected to a center of gravity 5.05 calibers from the theoretical nose.

Round	M	K_T	K_M	$[K_H]$
3238	.948	0.18	2.60	10.6
3239	.956	0.11	2.54	10.4
3243	1.043	0.20	2.52	7.6
3240	1.184	0.21	2.71	16.8
3242*	.924	0.11	2.75	12.5
3241*	.966	0.32	2.92	17.3

* Unmodified Models

TABLE 3

Percent Changes, Relative to Unmodified Rounds

	M = 0.95	M = 1.18
K_D	+ 8%	+ 15%
K_N	+ 3	+ 3
K_M	- 9	- 15
K_A	+ 9	+ 11
K_T	+ 9	(see curve discussion)
$[K_H]$	- 17	+ 14

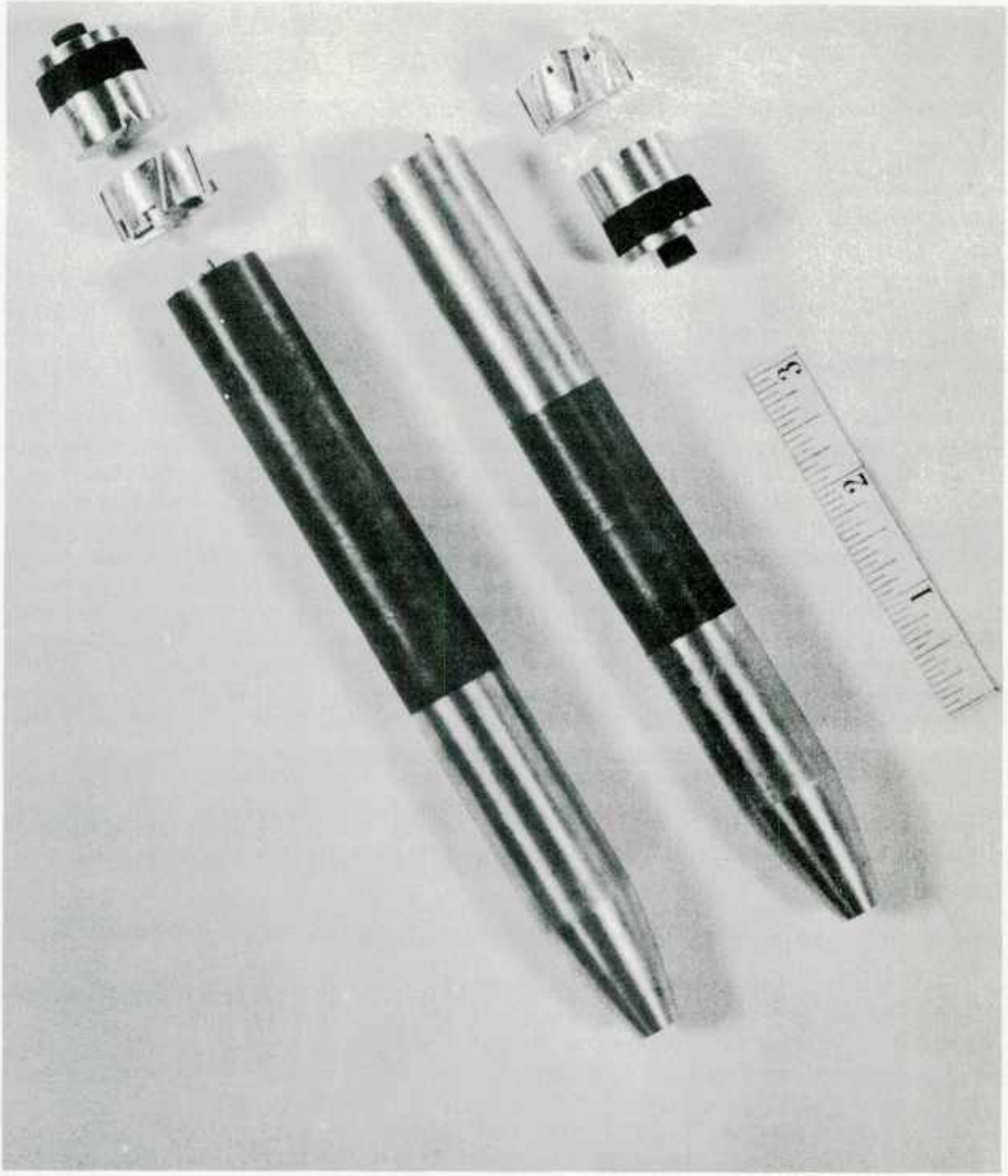

FIG. 1. Truncated Spinner Rocket Models

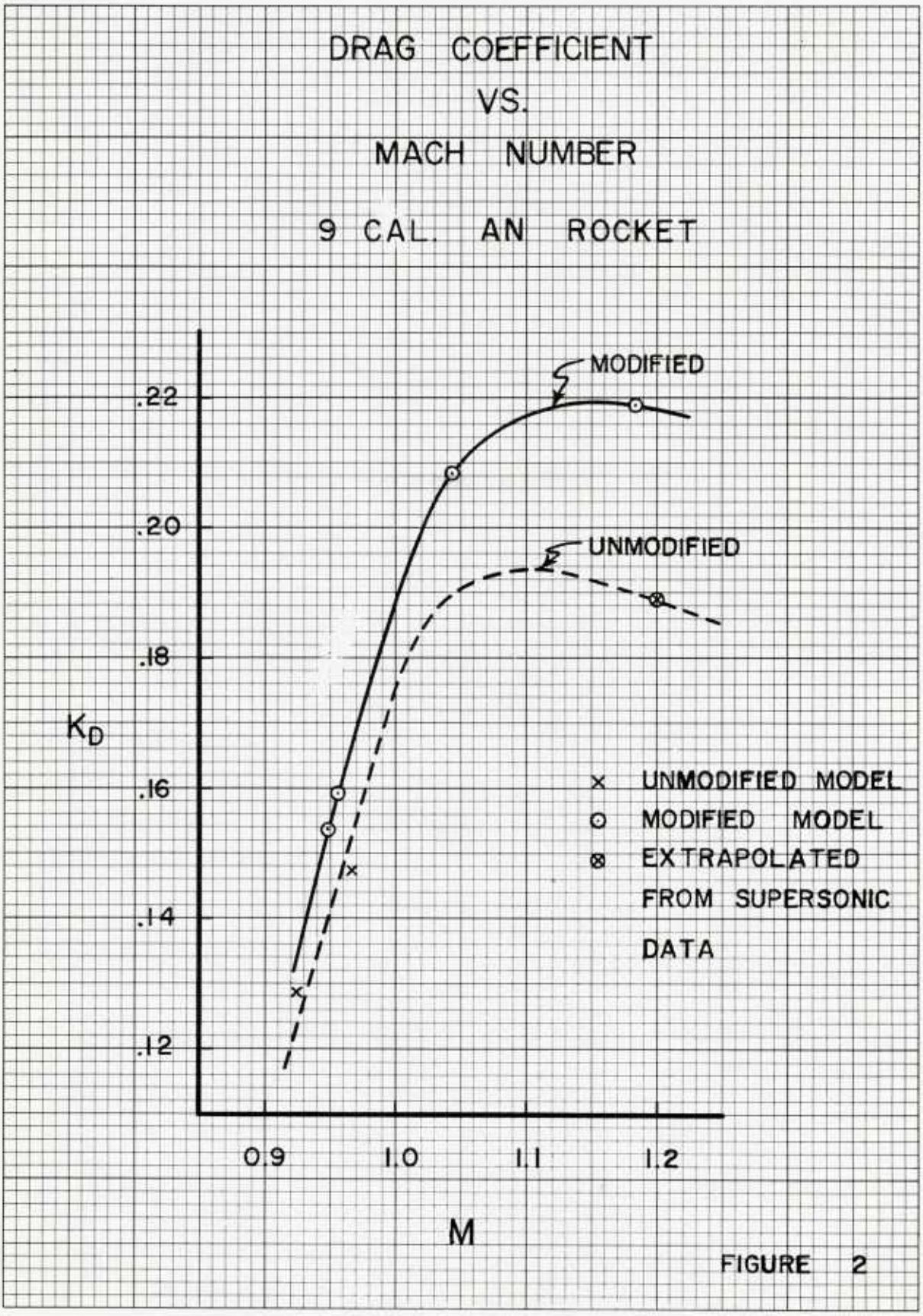
DRAG COEFFICIENT
VS.
MACH NUMBER
9 CAL. AN ROCKET
MODIFIED
UNMODIFIED
.22
.20
.18
.16
.14
.12
K_D
0.9
1.0
1.1
1.2
M
× UNMODIFIED MODEL
⊙ MODIFIED MODEL
⊗ EXTRAPOLATED FROM SUPERSONIC DATA

FIGURE 2

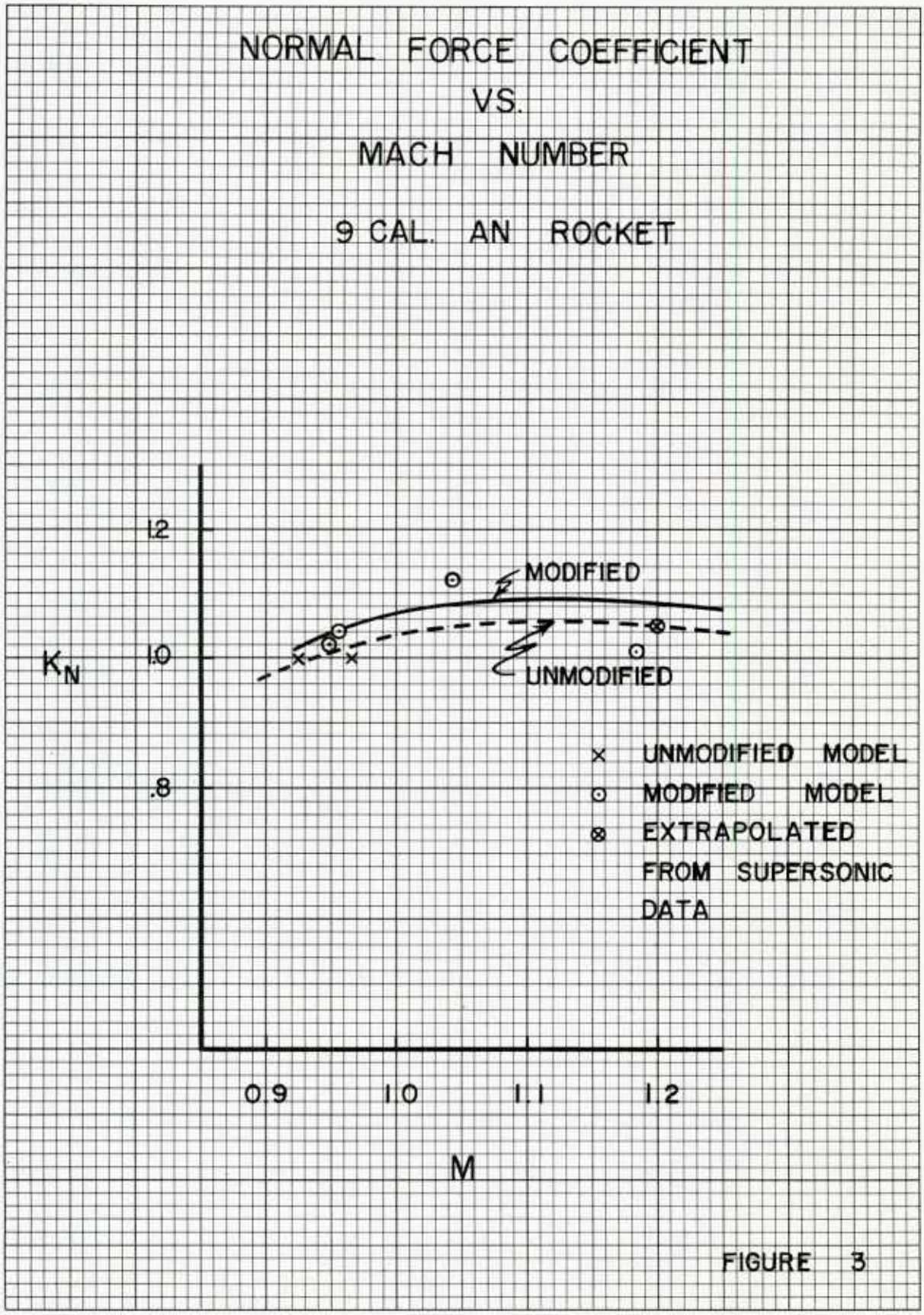
NORMAL FORCE COEFFICIENT
VS.
MACH NUMBER
9 CAL. AN ROCKET
1.2
1.0
.8
K_N
MODIFIED
UNMODIFIED
× UNMODIFIED MODEL
⊙ MODIFIED MODEL
⊗ EXTRAPOLATED FROM SUPERSONIC DATA
0.9
1.0
1.1
1.2
M

FIGURE 3

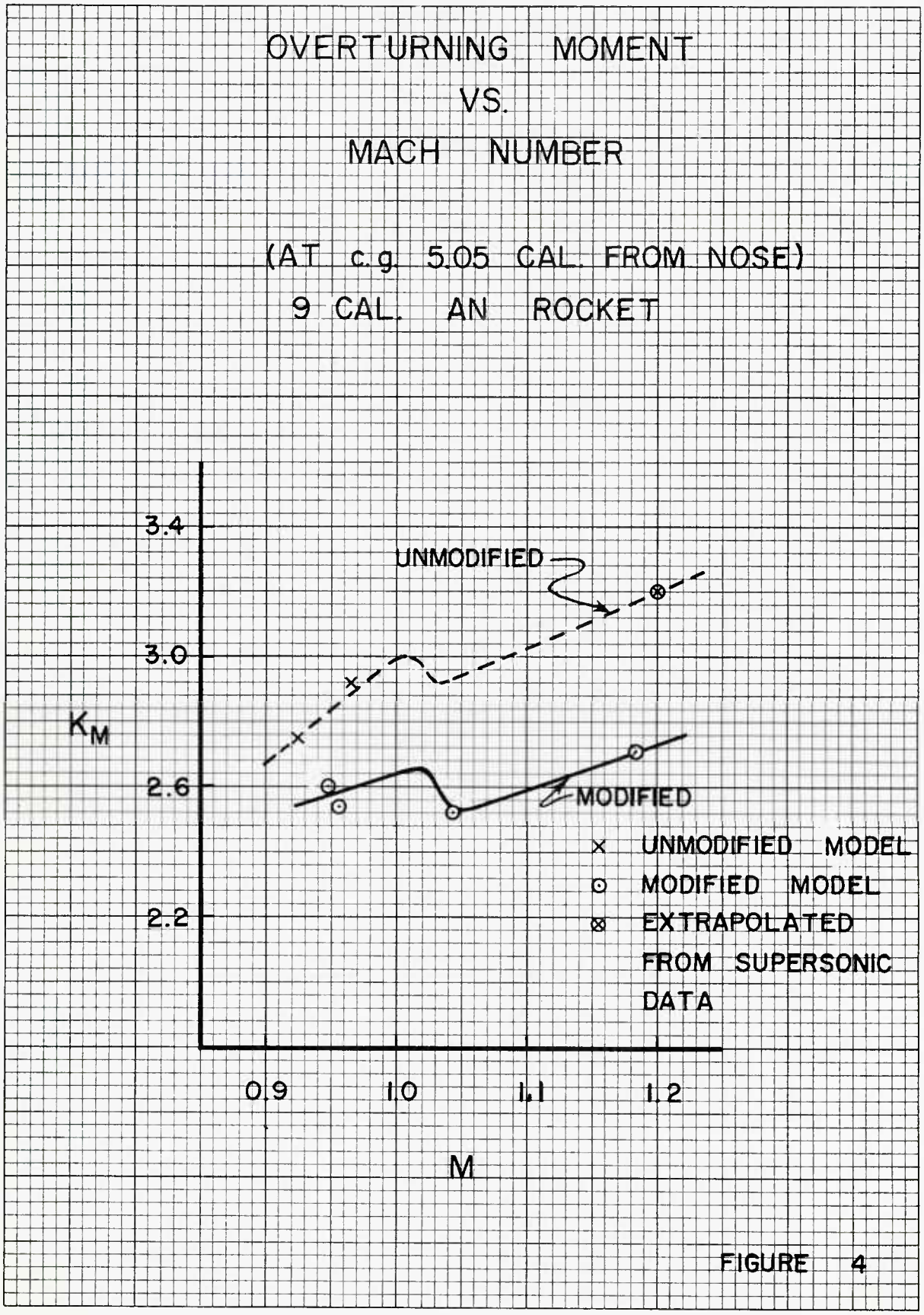
OVERTURNING MOMENT
VS.
MACH NUMBER
(AT c.g. 5.05 CAL. FROM NOSE)
9 CAL. AN ROCKET
3.4
3.0
2.6
2.2
K_M
UNMODIFIED
MODIFIED
× UNMODIFIED MODEL
⊙ MODIFIED MODEL
⊗ EXTRAPOLATED FROM SUPERSONIC DATA
0.9
1.0
1.1
1.2
M

FIGURE 4

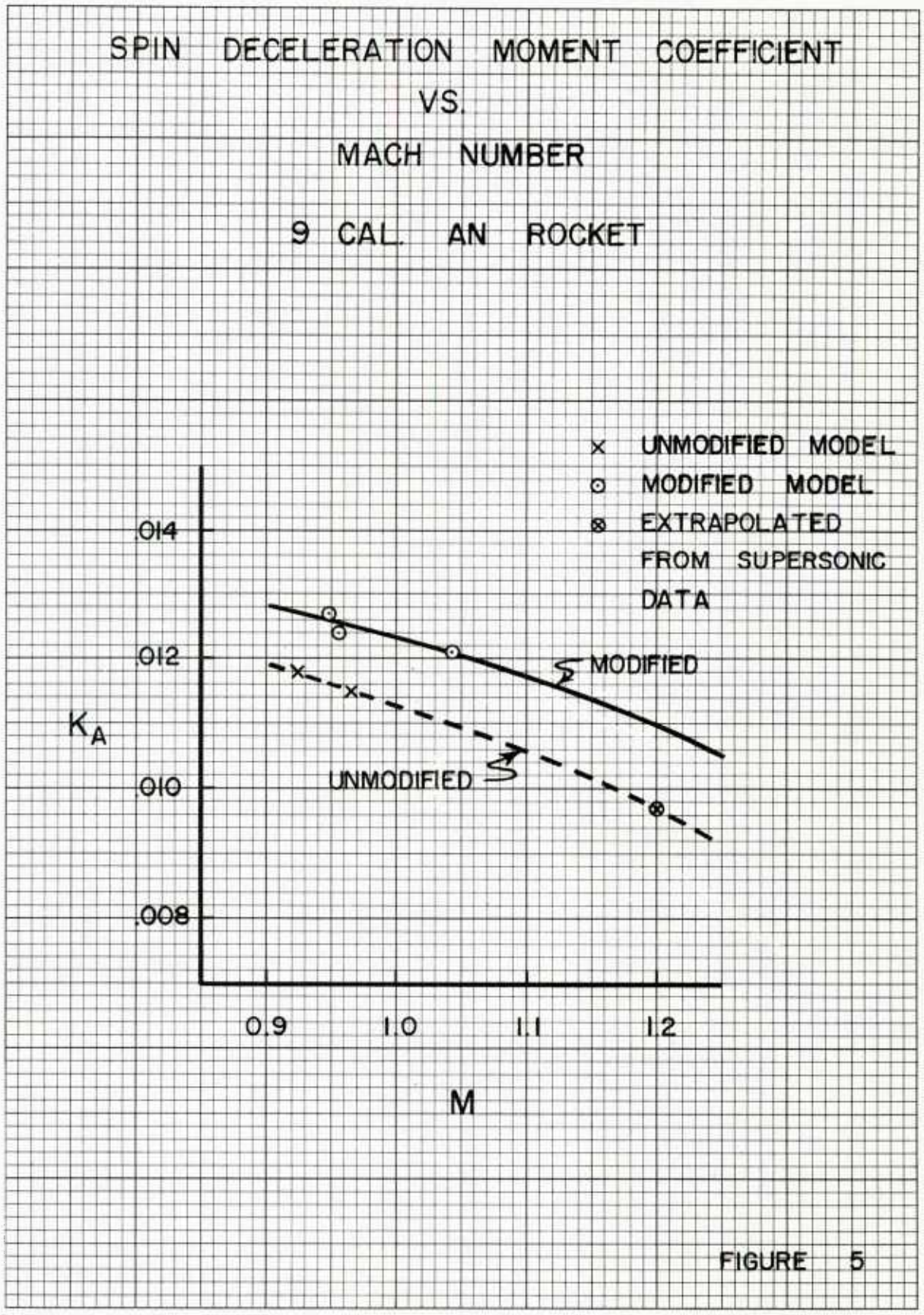
SPIN DECELERATION MOMENT COEFFICIENT
VS.
MACH NUMBER
9 CAL. AN ROCKET
× UNMODIFIED MODEL
⊙ MODIFIED MODEL
⊗ EXTRAPOLATED FROM SUPERSONIC DATA
.014
.012
.010
.008
K_A
MODIFIED
UNMODIFIED
0.9
1.0
1.1
1.2
M

FIGURE 5

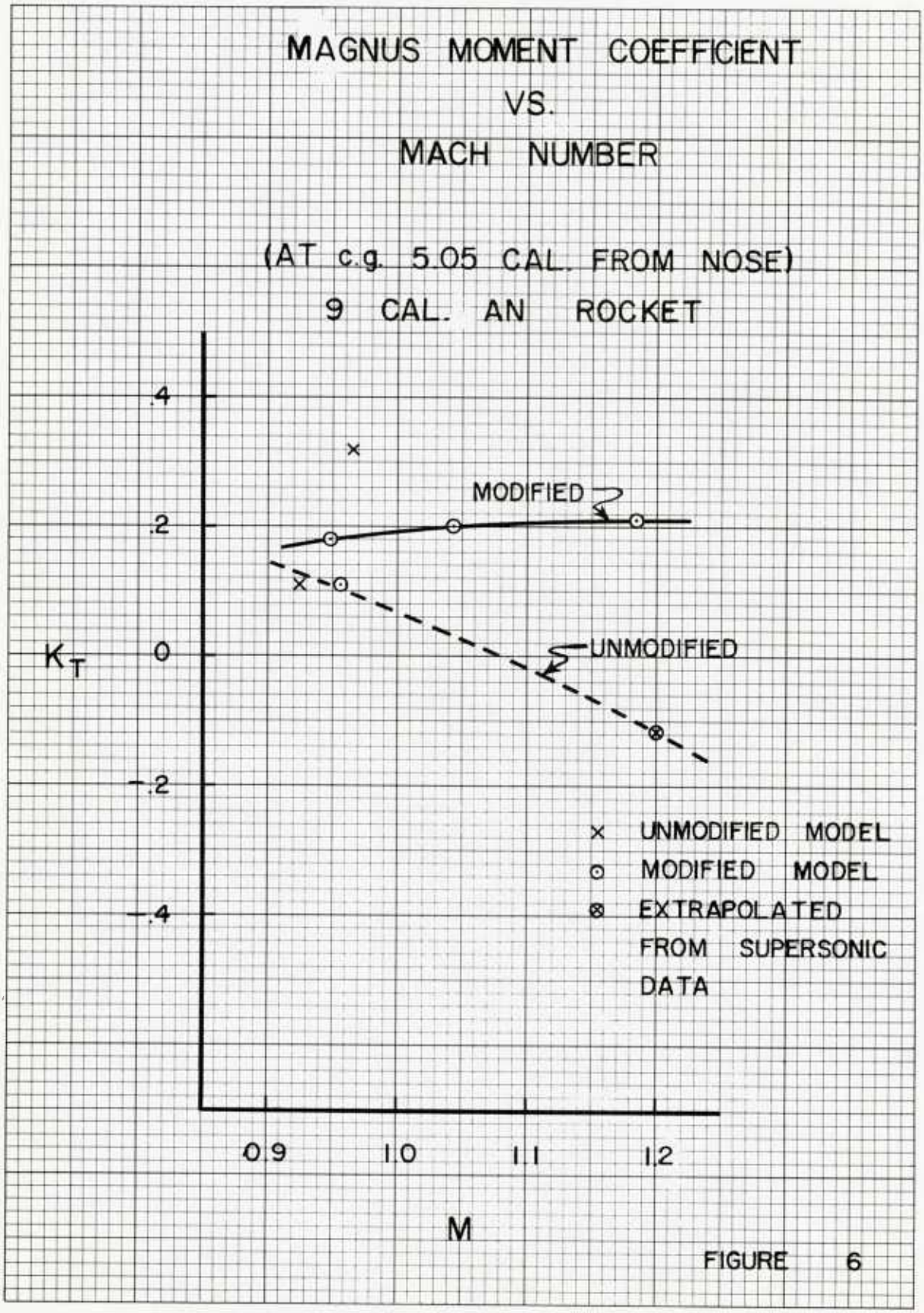
MAGNUS MOMENT COEFFICIENT
VS.
MACH NUMBER
(AT c.g. 5.05 CAL. FROM NOSE)
9 CAL. AN ROCKET
.4
.2
0
-.2
-.4
K_T
MODIFIED
UNMODIFIED
× UNMODIFIED MODEL
⊙ MODIFIED MODEL
⊗ EXTRAPOLATED FROM SUPERSONIC DATA
0.9
1.0
1.1
1.2
M

FIGURE 6

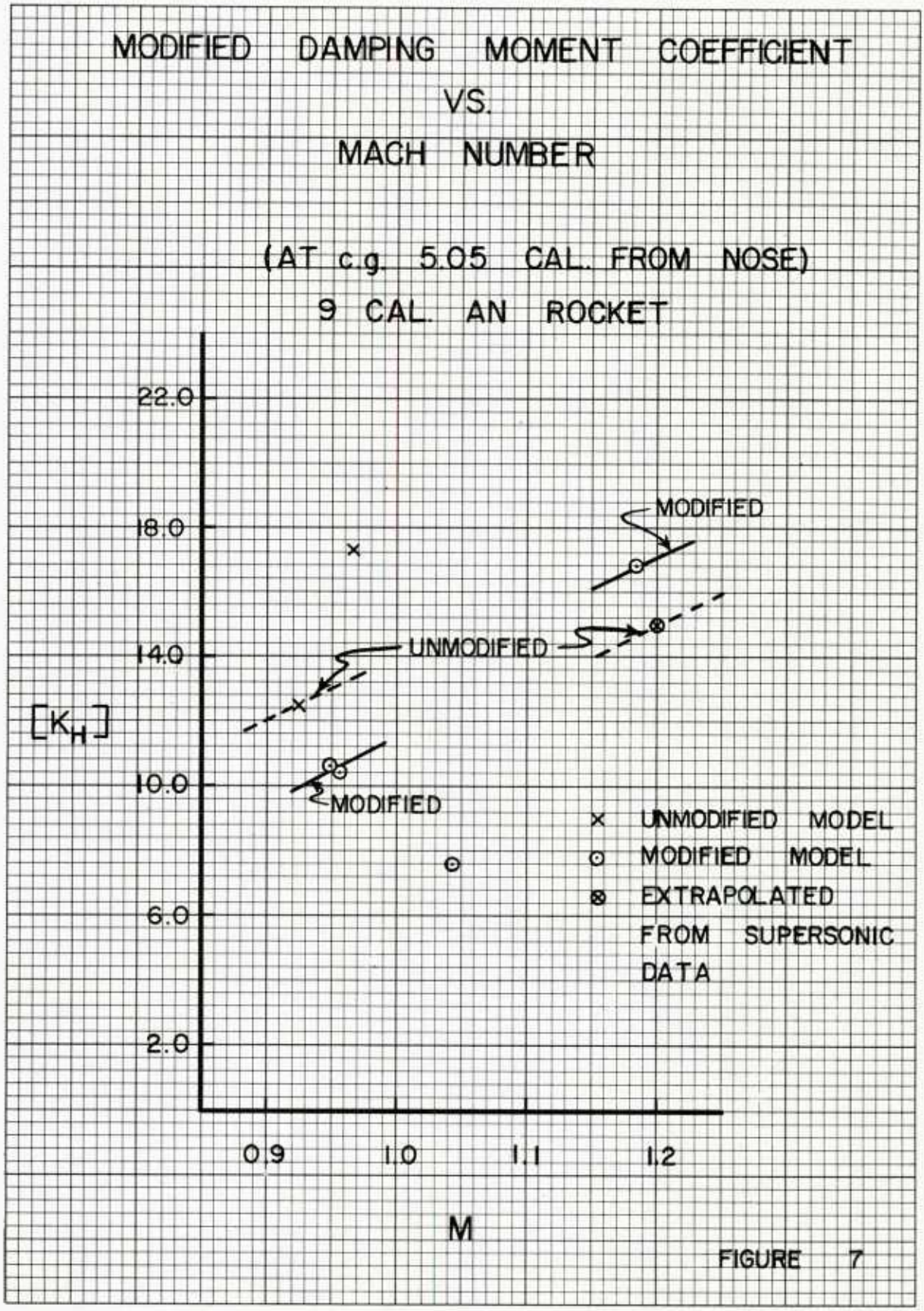

FIGURE 7

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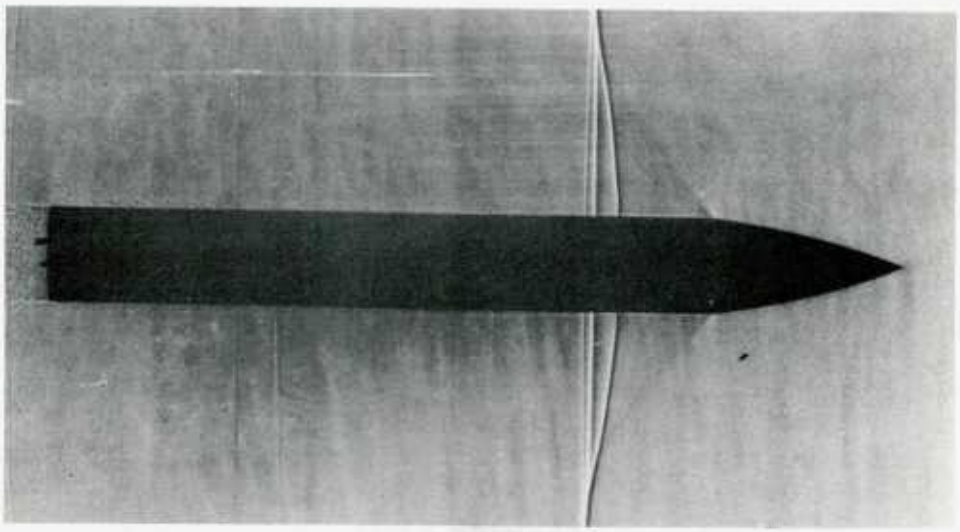
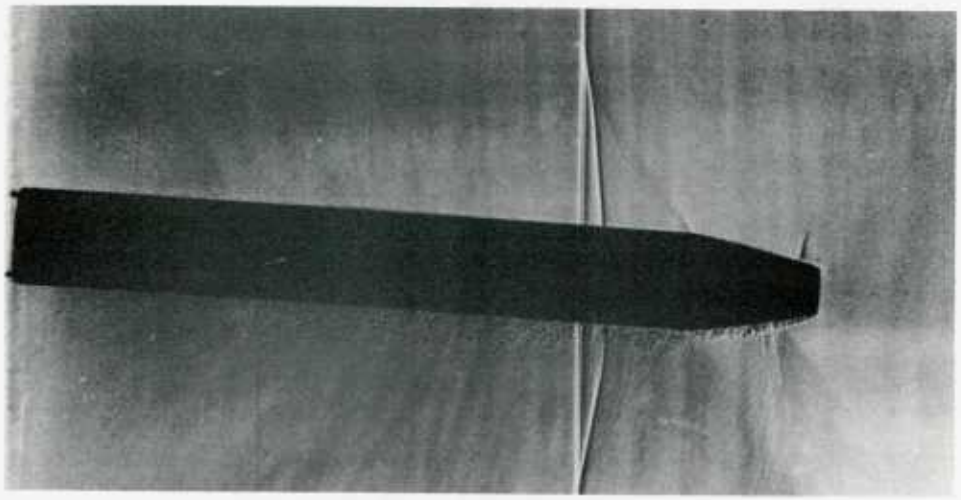
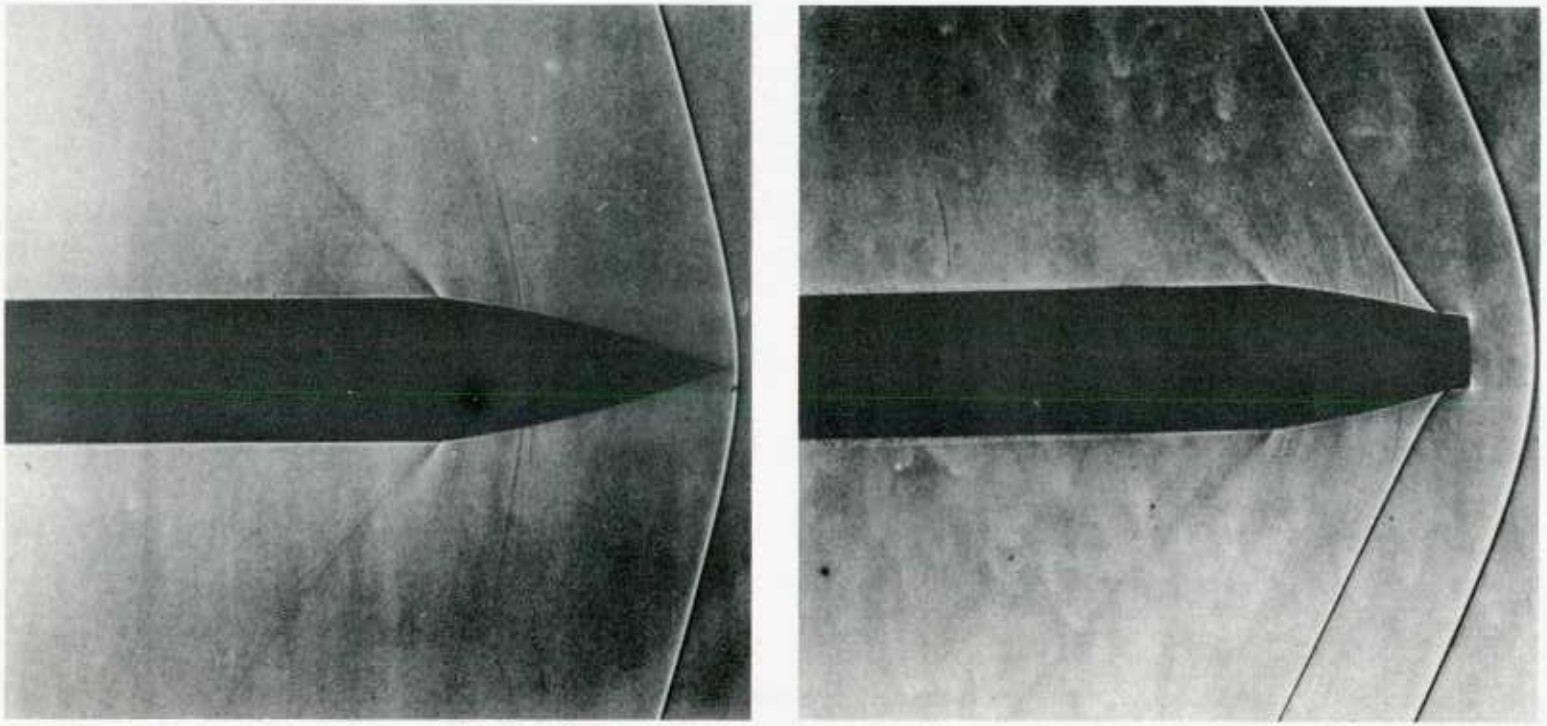


A. Unmodified Model, M=.97



B. Modified Model, M=.95

FIG. 8. Models in Subsonic Flight



A. Unmodified Model, M=1.09

B. Modified Model, M=1.19

FIG. 9. Models In Supersonic Flight

REFERENCES

1. C. H. Murphy, L. E. Schmidt, "The Effect of Length on the Aerodynamic Characteristics of Bodies of Revolution in Supersonic Flight", BRL Report 876, (Confidential) August 1953.

2. L. E. Schmidt, C. H. Murphy, "The Aerodynamic Properties of the 7-Caliber Army-Navy Spinner Rocket in Transonic Flight", BRLM No. 775.

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