Development of Capabilities for Stall/Spin Research

NSG 1189

Final Report

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by

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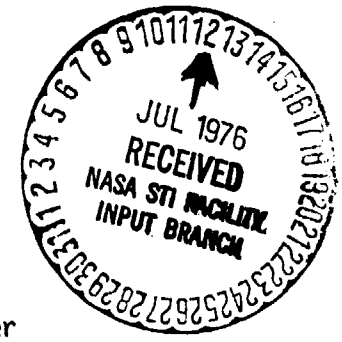


The NASA Technical Officer for this Grant is James S. Bowman, Jr., Langley Research Center

SUMMARY

Apparatus and techniques were developed for measuring in a low-speed wind tunnel the static and dynamic (rotary balance) aerodynamic data pertinent to spin behavior of a general aviation aircraft.

The main results were:

1. Collection of static force and moment data for several airplane configurations at angles of attack from 0 to 90 degrees and angles of sideslip from 0 to 40 degrees.

2. Difficulties, shortcomings and unsuitability of some aspects of the rotary balance mount as constructed were discovered and identified for avoidance in a new design for a mount.

The principal objective - the development of research capability in spin investigation - has been achieved.

THE RESULTING FACILITY

A. The Model

The photographs and drawing of figures 1, 2, and 3 show a model whose configuration is representative of a low wing general aviation aircraft. It incorporates a six-component strain gage balance buried within the fuselage at a force and moment center at the quarter chord of the mean aerodynamic chord longitudinally and 22% chord above the plane of the mean aerodynamic chord vertically.

Two tail cone sleeves were fabricated for initial testing to determine the effect of tail cone cross section shape on the forces and moments. The altered shapes are shown in figure 4. Modeling clay was used to fair the sleeves into basic model fuselage contours at the front and rear ends of the sleeves, which were at the wing trailing edge juncture with the fuselage and the leading edge of the horizontal tail juncture with the fuselage respectively.

The model also provides for complete removal of the empennage assembly for testing in a "tail-off" configuration, as well as other placement of the vertical and horizontal placement of the horizontal trail.

B. The Static Test Mount

Figure 3 shows the model as mounted in the wind tunnel. The sting is bolted to the turntable of the tunnel so as to keep the model centered while sweeping through a range of angle of attack. Sideslip is manually adjustable between tunnel runs by rotating the model with respect to the probe.

C. The Rotary Balance Mount

Inspection of the mount as used, as portrayed in figure 5, explains in hindsight, why aerodynamic interference was encountered between the model and the vertical portion of the mount. The proximity of the model (about 1.7 span lengths) to the support and instrumentation structure caused a pressure field which showed up as a cyclic variation in the forces and moments as the model was made to rotate. The efffct was measured at 45 degree increments in azimuth around the circle of rotation by halting the model at each angle. Minimum - very near zero - interference was noted when the model was in the exact nose-down (wings horizontal) position, so that orientation was used as a "tare" position for all data runs with the rotary balance. But a low level of confidence resulted from the ignorance as to whether the dynamic interference was significant. Consequently, the first priority for future work is to extend the mount to at least 2.5 to 3 times the span length in front of any mount struts.

Other lessons learned for incorporation in the rig are:

1. Data reduction from the oscillograph traces is speeded and simplified if the model is mass-balanced as closely as possible at all angles of attack, to minimize cyclic perturbations in force and moments.

2. Driving the rotation with a chain and sprocket tends to excite vibration in the model, producing another unwanted component in the data traces. Either direct or belt drive will replace the chain and sprocket in the redesign.

3. The mount as used had a lower limit of 30 degrees for angle of attack and an upper limit of 90 degrees. This should be altered to accommodate angles of attack down to as near zero degrees as possible.

With these alterations incorporated, apparatus should not get in the way of measuring rotary balance data on a new mount.

THE DATA OBTAINED

A. Static Data

Figures 6 through 38 present moment data for several configurations of the model. The data were quite repeatable and show reasonable trends, and thus are thought to be valid.

The Reynolds number of approximately 300,000 corresponds to a tunnel dynamic pressure of 15 lbs./in.^{2}, which was the value agreed upon by the NASA project monitor and the author.

B. Rotary Balance Data

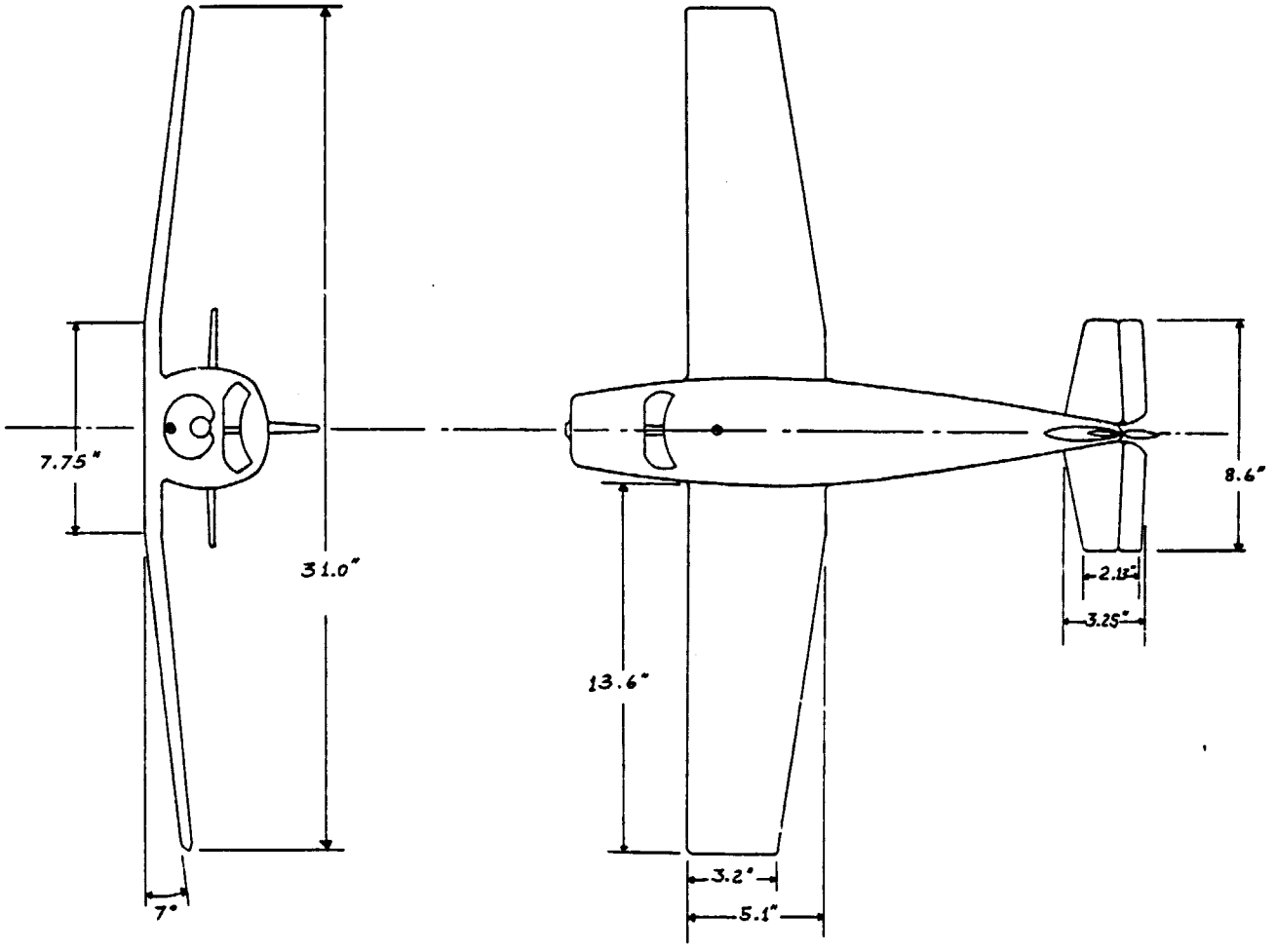
Only two plots are shown, figures 39 and 40, and they should be considered as being for illustration purposes, because of the difficulty with the aerodynamic interference. Although the data were, like the static data, repeatable and the trends are reasonable, no other data were retained, for lack of confidence in their validity.

CONCLUSION

It is felt that the desired goal of achieving a capability to perform spin research has been realized. With the construction of a new mount for rotary balance testing, the facility will permit pursuit of an understanding of the mechanisms of spin behavior.

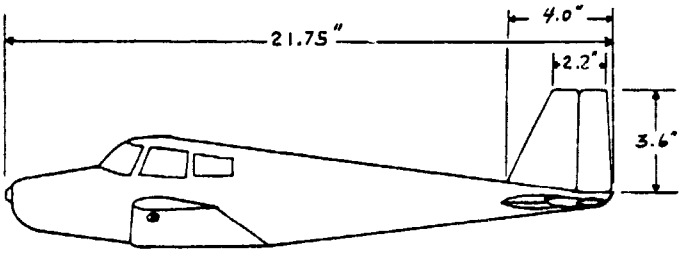
Two other tools have been acquired or developed to help that cause: a hydrogen bubble machine for flow visualization at normal tunnel speeds, and a bouyant-model "swimming pool" technique for the same purpose.

Support by this grant has made possible continued spin research at Wichita State University.



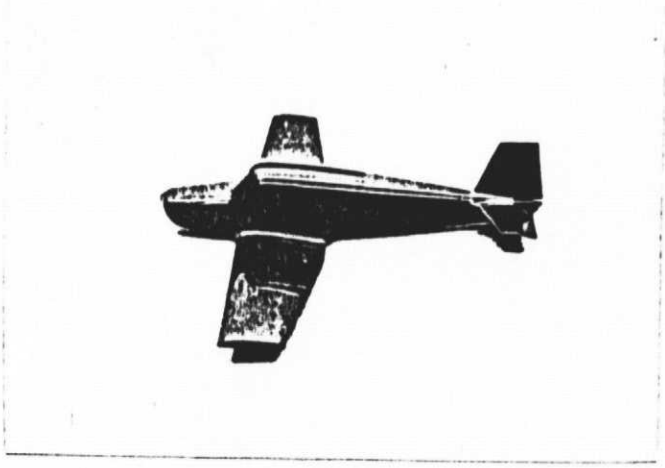
Wing area = 135 sq. in.

Mean area chord = 4.36 in.



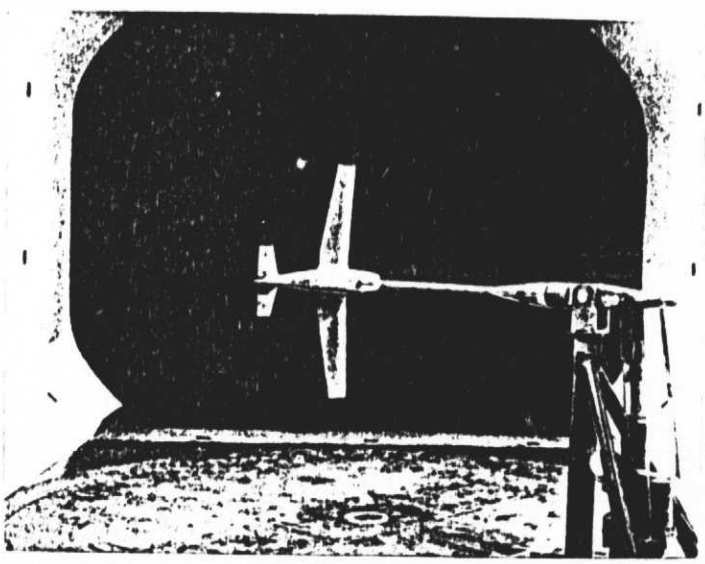
Three-view drawing of model airplane.

Figure 1



Revised Model Geometry

Figure 2



Model as Mounted in Tunnel

Figure 3

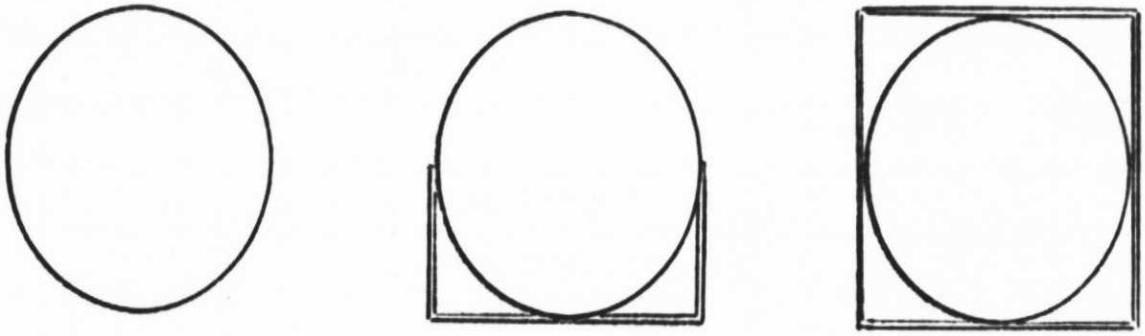


Figure 4 Tail Cone Cross Section Shapes

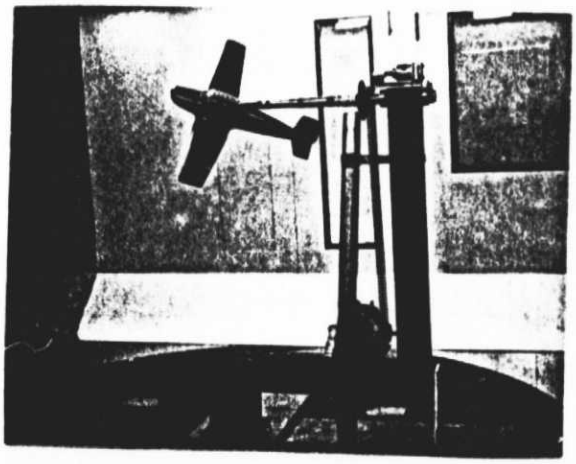


Figure 5 Rotary Balance Mount

ROLLING MOMENT VARIATION WITH TAIL CONFIGURATION

BETA = 0.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES

RN = 0.3081E 06

TAIL CONFIGURATION	SYMBOL
BASIC MODEL, TAIL OFF	X
BASIC MODEL, TAIL ON	*

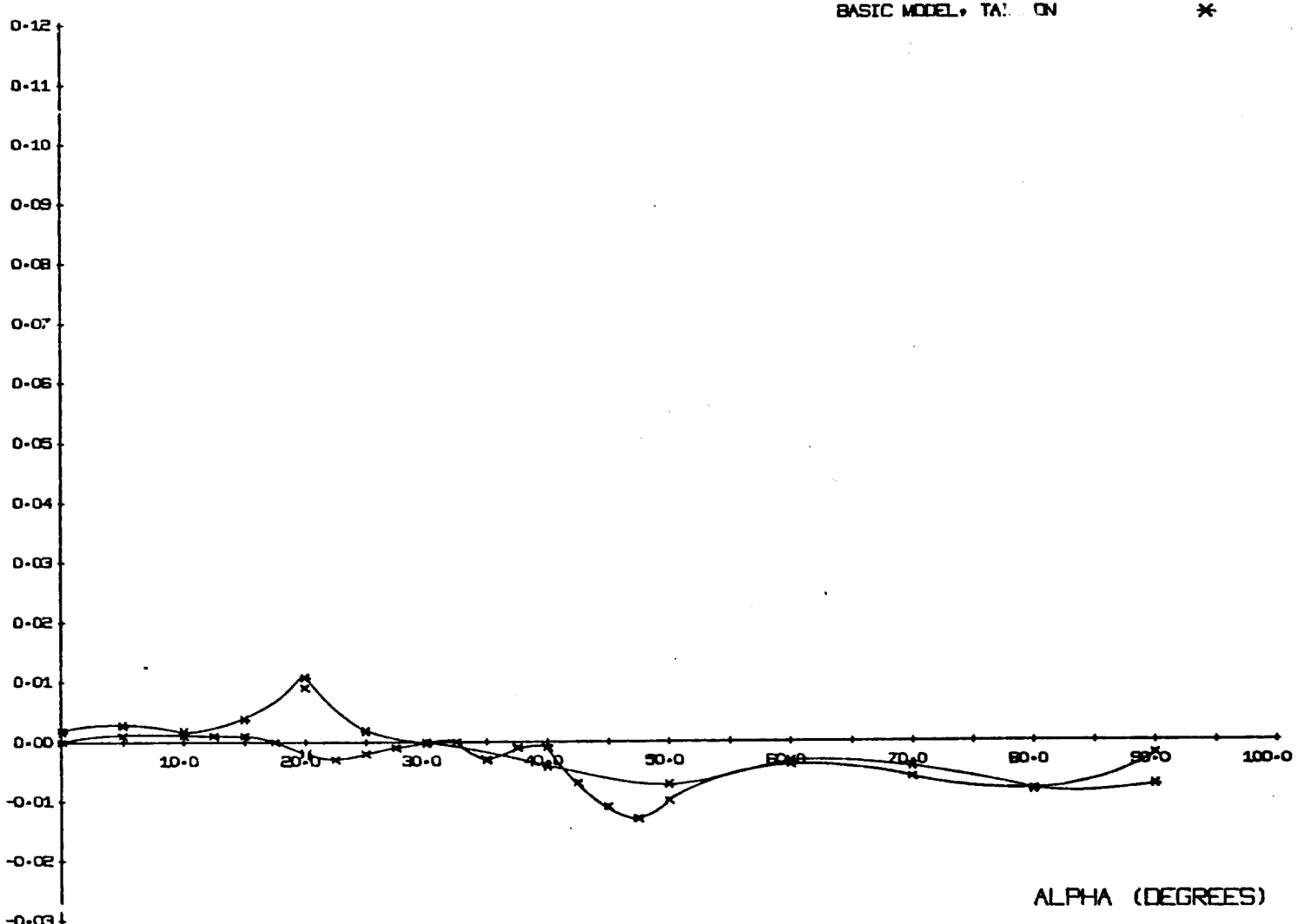


Figure 6

ROLLING MOMENT VARIATION WITH TAIL CONFIGURATION

BETA = -10.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES

RN = 0.3093E 06

TAIL CONFIGURATION	SYMBOL
BASIC MODEL, TAIL OFF	X
BASIC MODEL, TAIL ON	*

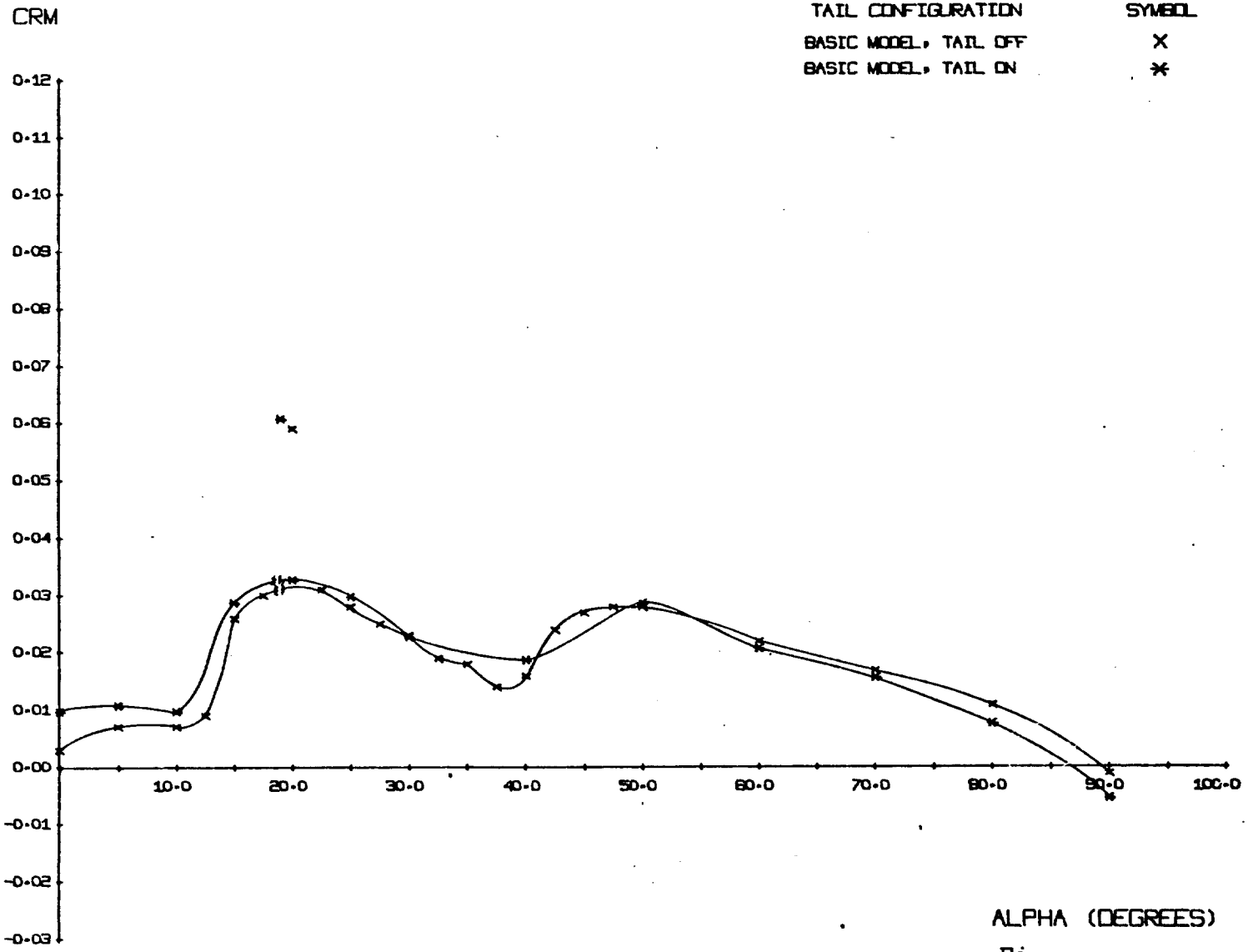


Figure 7

ROLLING MOMENT VARIATION WITH TAIL CONFIGURATION

BETA = -20.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES

RN = 0.2933E 06

TAIL CONFIGURATION	SYMBOL
BASIC MODEL, TAIL OFF	X
BASIC MODEL, TAIL ON	*

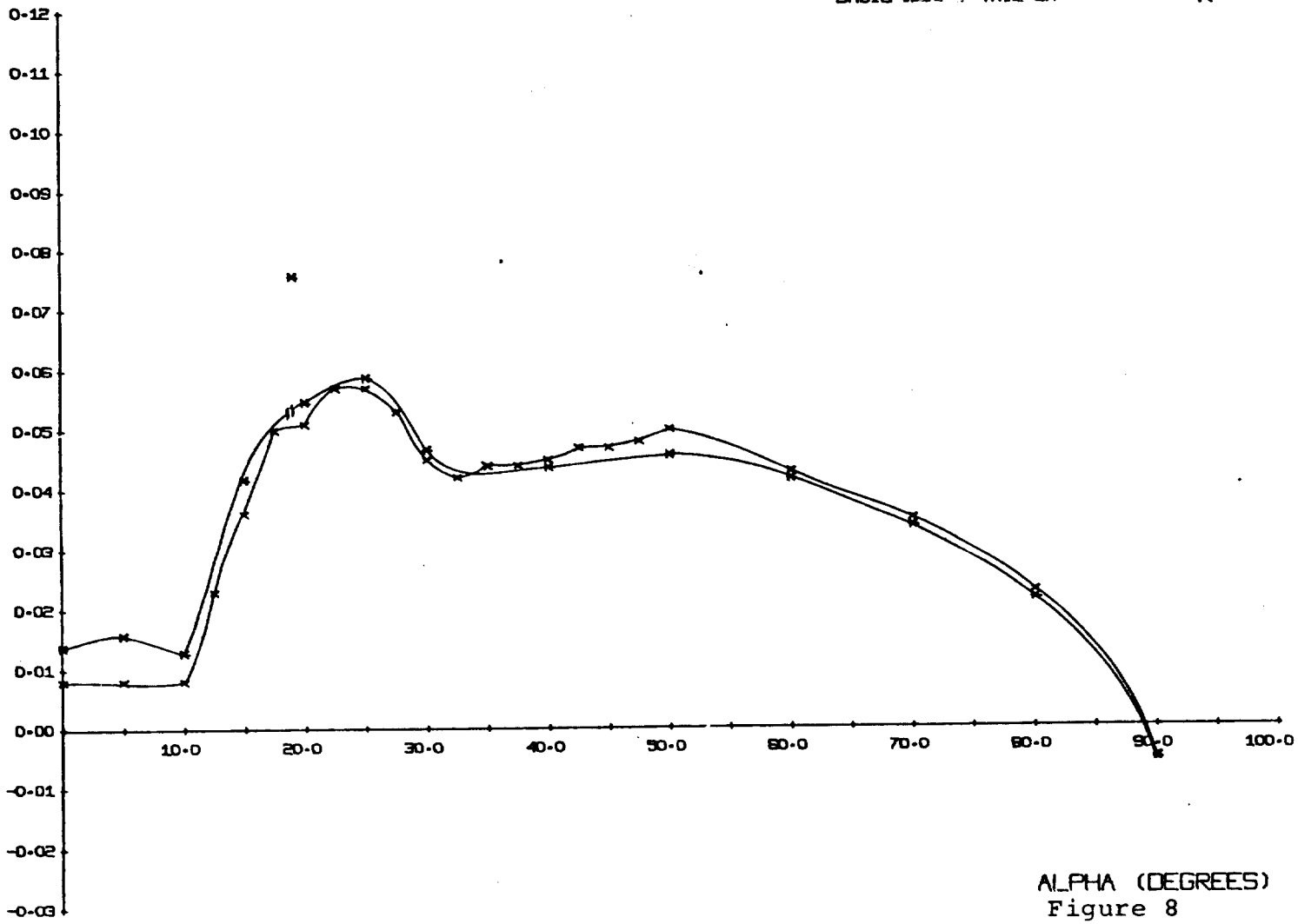


Figure 8

ROLLING MOMENT VARIATION WITH TAIL CONFIGURATION

BETA = -30.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES

RN = 0.29E5E 06

TAIL CONFIGURATION	SYMBOL
BASIC MODEL, TAIL OFF	X
BASIC MODEL, TAIL ON	*

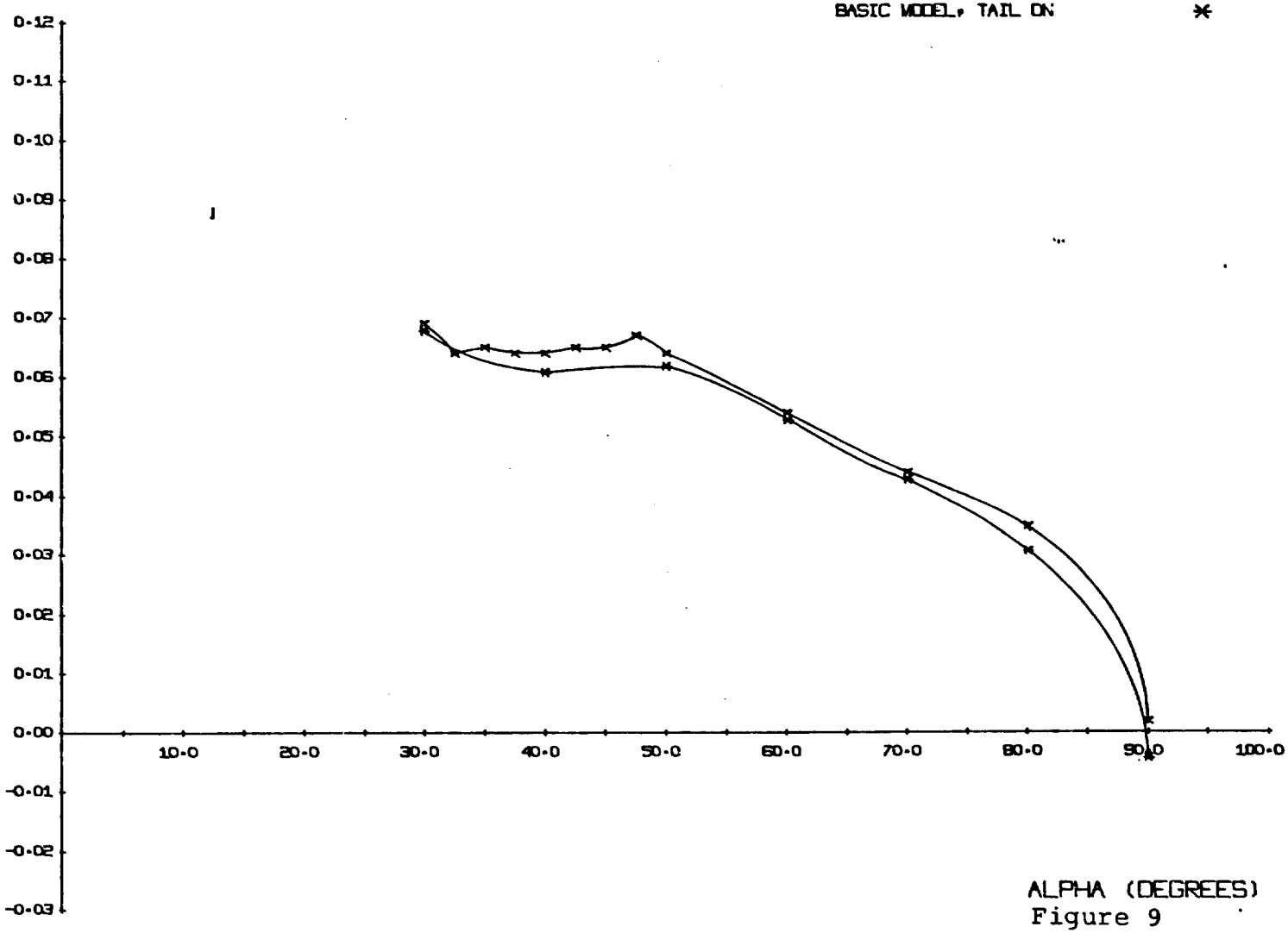


Figure 9

ROLLING MOMENT VARIATION WITH TAIL CONFIGURATION

BETA = -40.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES

RN = 0.2927E 06

TAIL CONFIGURATION	SYMBOL
BASIC MODEL, TAIL OFF	X
BASIC MODEL, TAIL ON	*

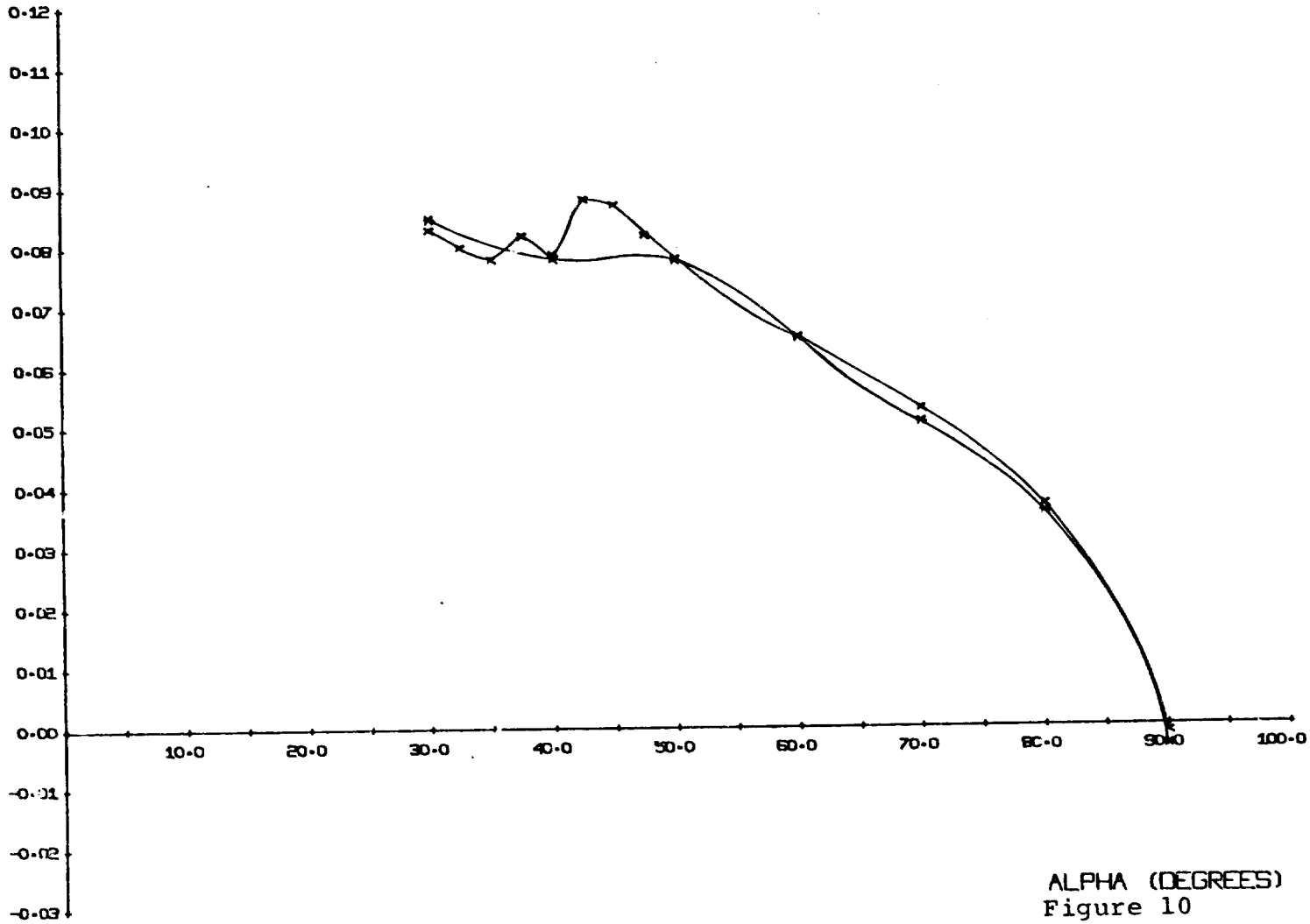


Figure 10

ROLLING MOMENT VARIATION WITH TAIL CONFIGURATION

BETA = 0.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES

RN = 0.2961E 06

TAIL CONFIGURATION	SYMBOL
BASIC MODEL WITH SQUARE TAIL CONE	X
BASIC MODEL WITH HALF SQUARE TAIL CONE	*
BASIC MODEL WITHOUT SQUARE TAIL CONE	+

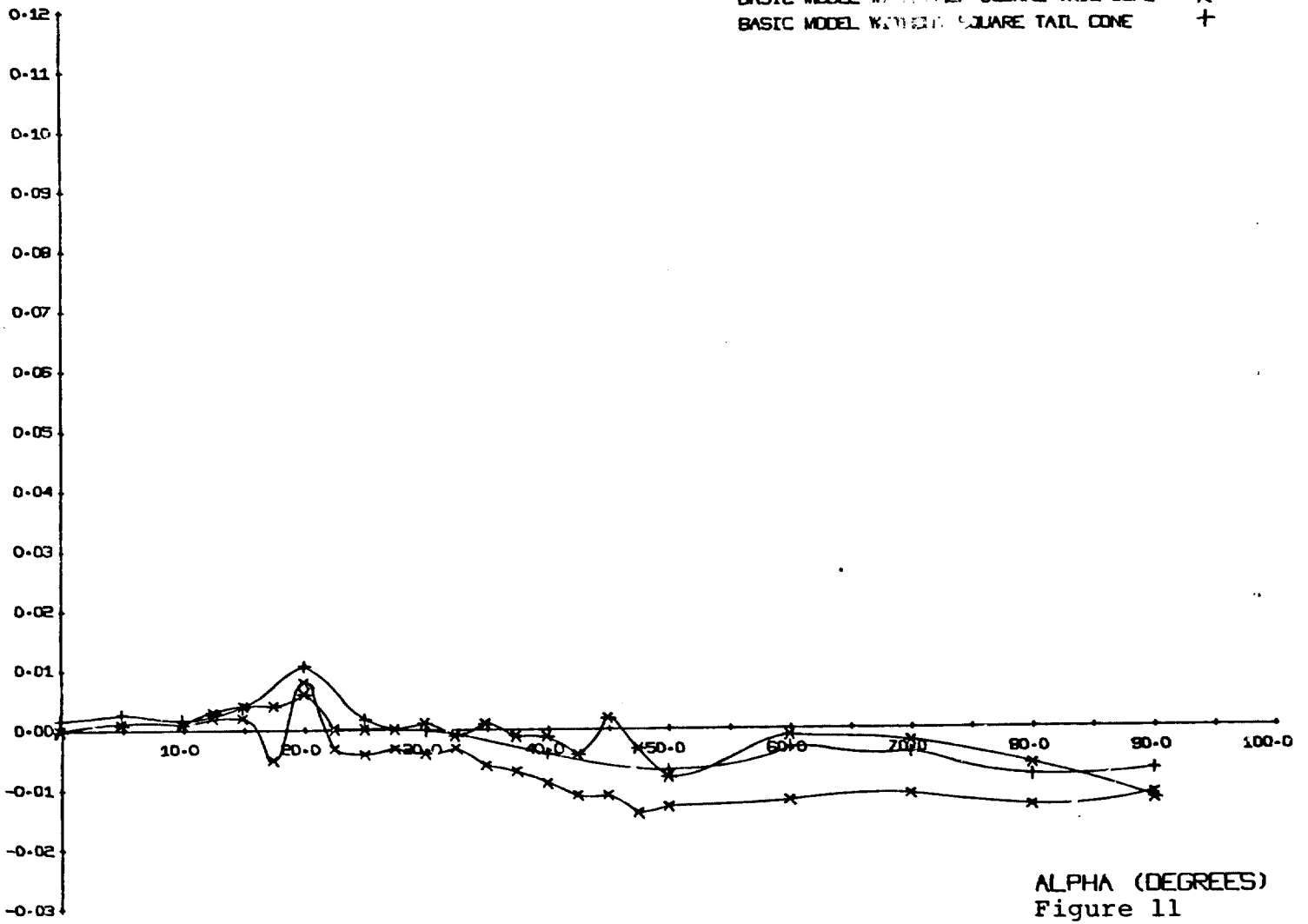


Figure 11

ROLLING MOMENT VARIATION WITH TAIL CONFIGURATION

BETA = -10.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES

RN = 0.2938E 06

TAIL CONFIGURATION	SYMBOL
BASIC MODEL WITH SQUARE TAIL CONE	×
BASIC MODEL WITH HALF SQUARE TAIL CONE	✳
BASIC MODEL WITHOUT SQUARE TAIL CONE	+

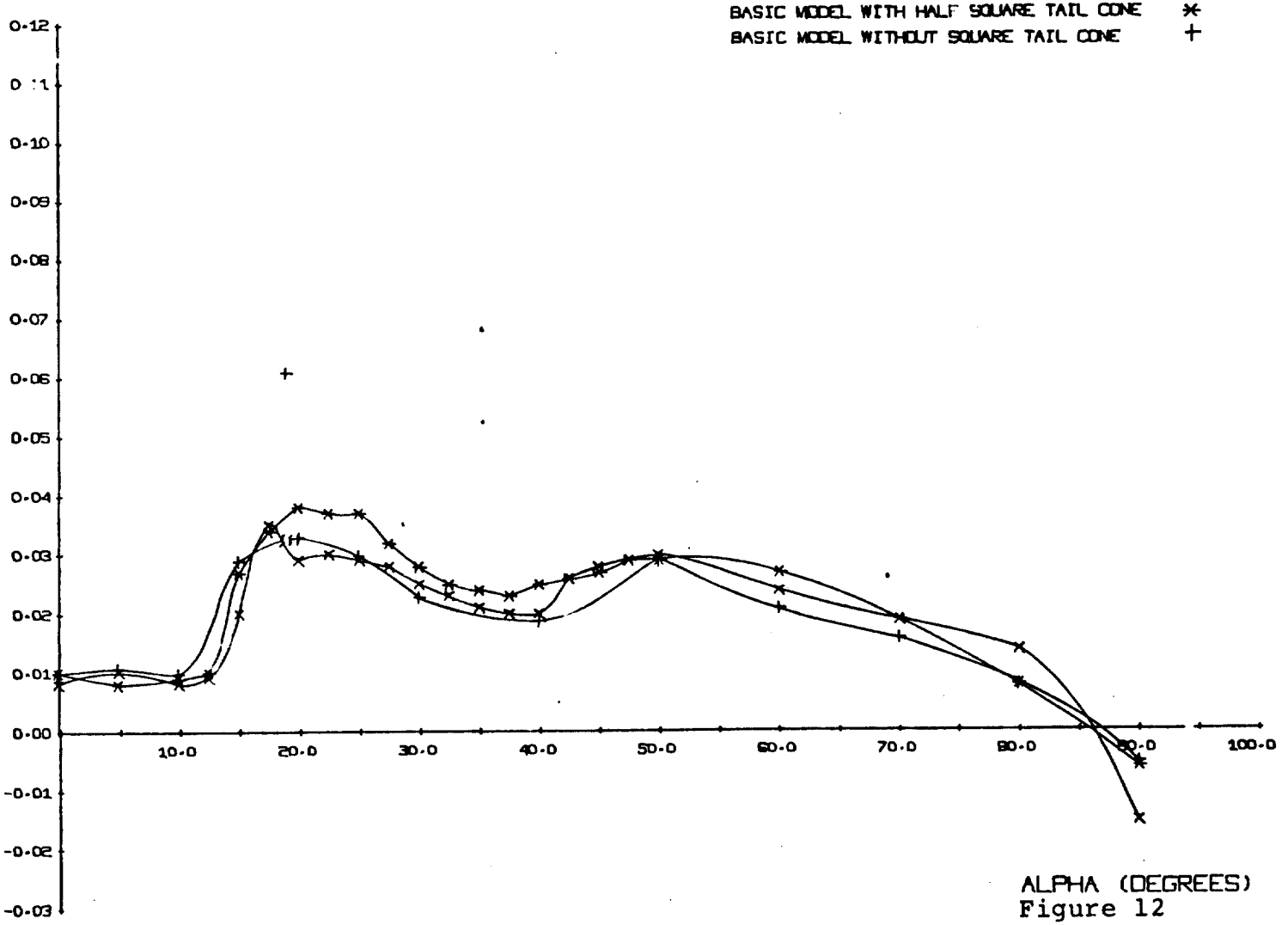


Figure 12

ROLLING MOMENT VARIATION WITH TAIL CONFIGURATION

BETA = -20.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES

RN = 0.2925E 06

TAIL CONFIGURATION	SYMBOL
BASIC MODEL WITH SQUARE TAIL CONE	X
BASIC MODEL WITH HALF SQUARE TAIL CONE	*
BASIC MODEL WITHOUT SQUARE TAIL CONE	+

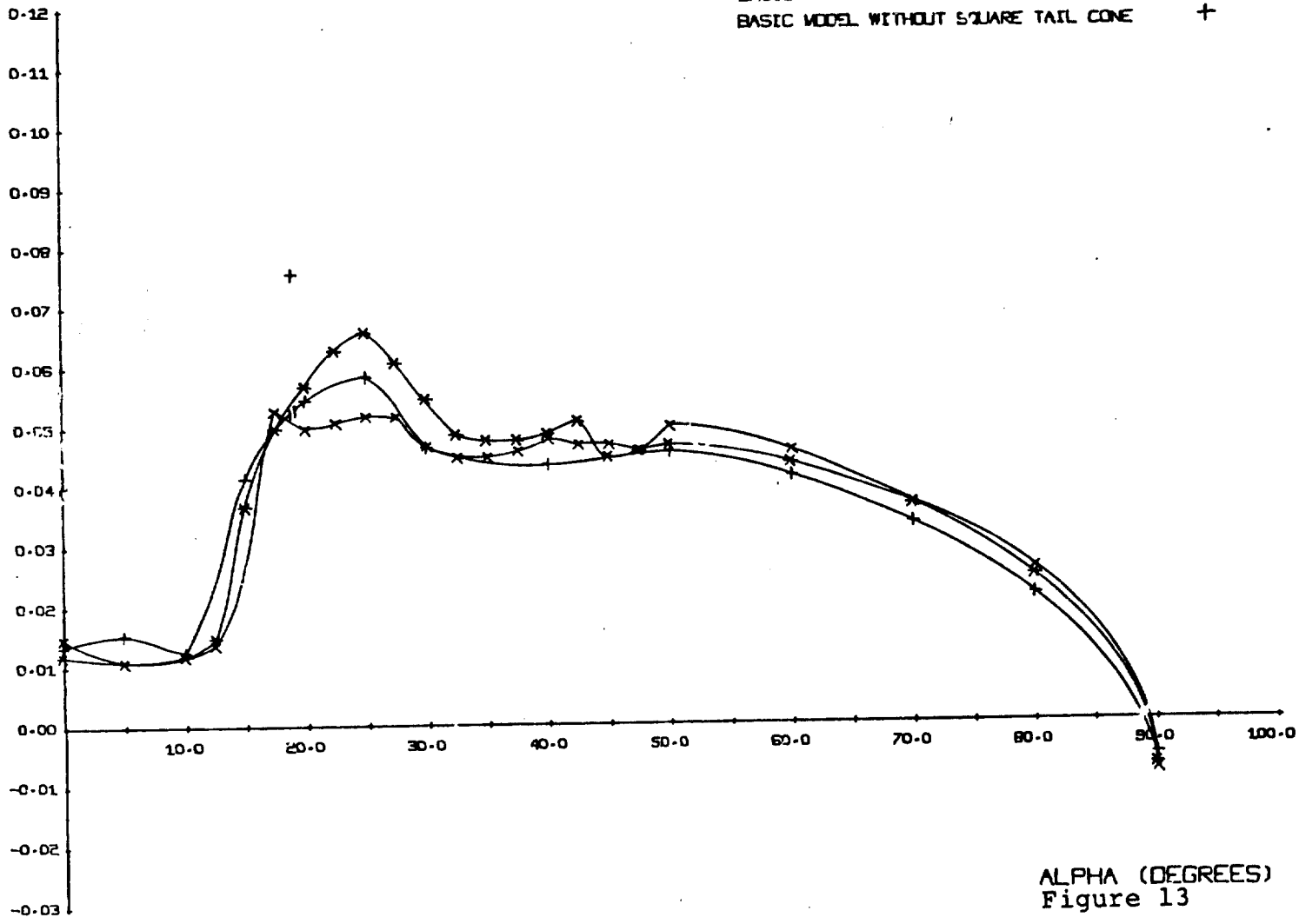


Figure 13

ROLLING MOMENT VARIATION WITH TAIL CONFIGURATION

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ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES

RN = 0.2920E 06

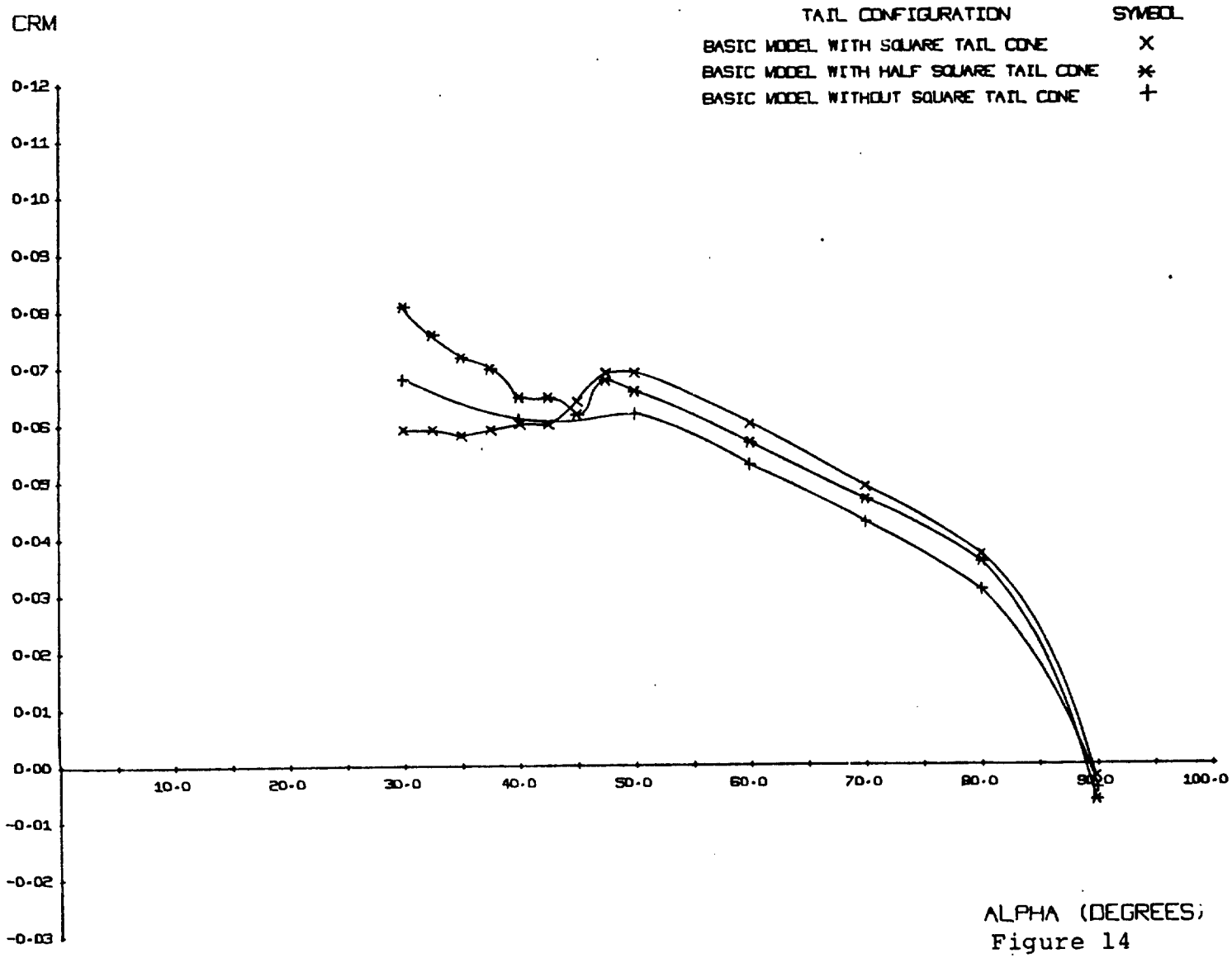


Figure 14

ROLLING MOMENT VARIATION WITH TAIL CONFIGURATION

BETA = -40.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES

RN = 0.2924E 06

TAIL CONFIGURATION	SYMBOL
BASIC MODEL WITH SQUARE TAIL CONE	X
BASIC MODEL WITH HALF SQUARE TAIL CONE	*
BASIC MODEL WITHOUT SQUARE TAIL CONE	+

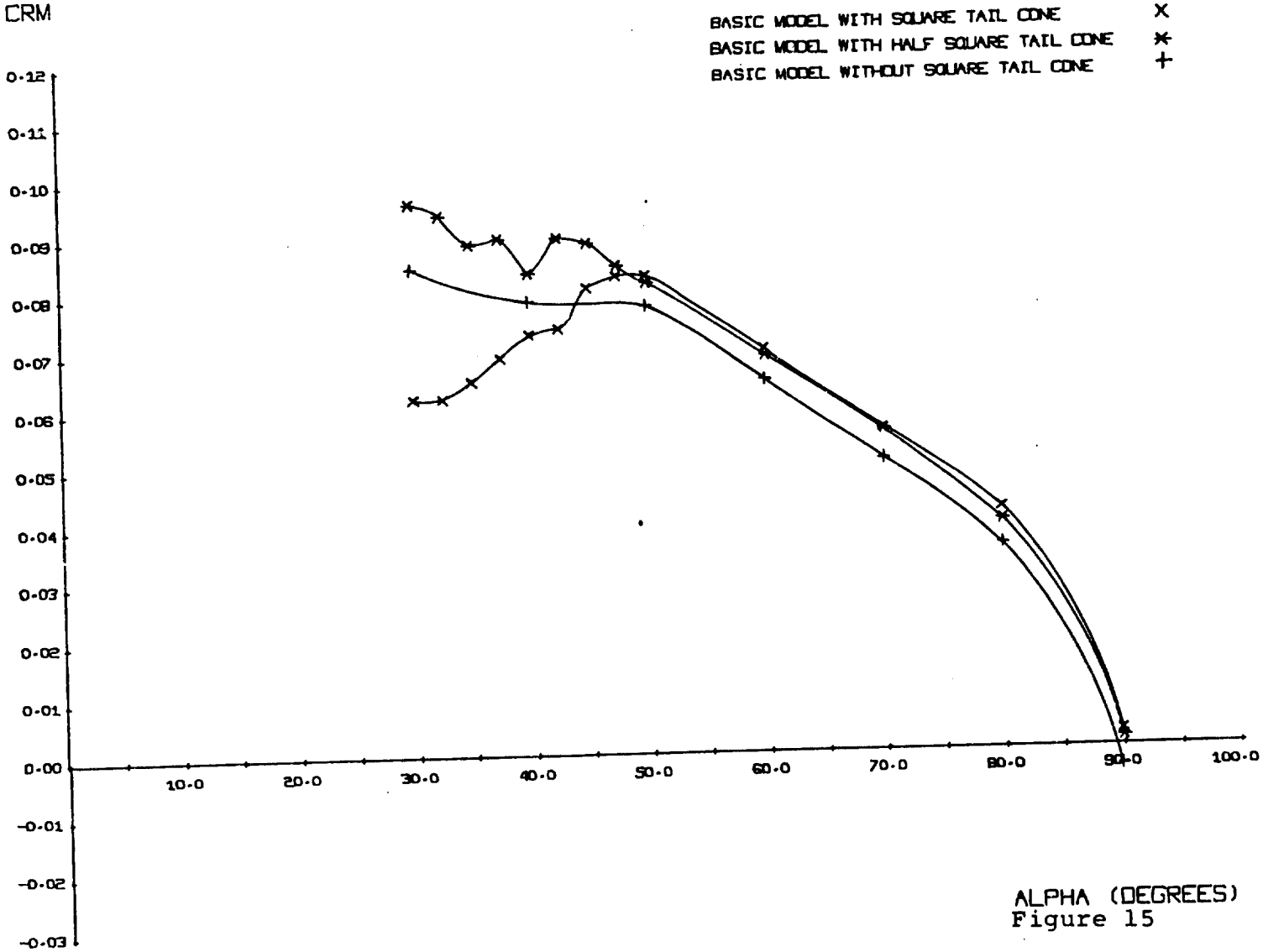


Figure 15

ROLLING MOMENT VARIATION WITH TAIL CONFIGURATION

BETA = -20.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES

RN = 0.2952E 06

TAIL CONFIGURATION	SYMBOL
BASIC MODEL WITH SQUARE TAIL CONE, TAIL OFF	X
BASIC MODEL WITH SQUARE TAIL CONE, TAIL ON	*

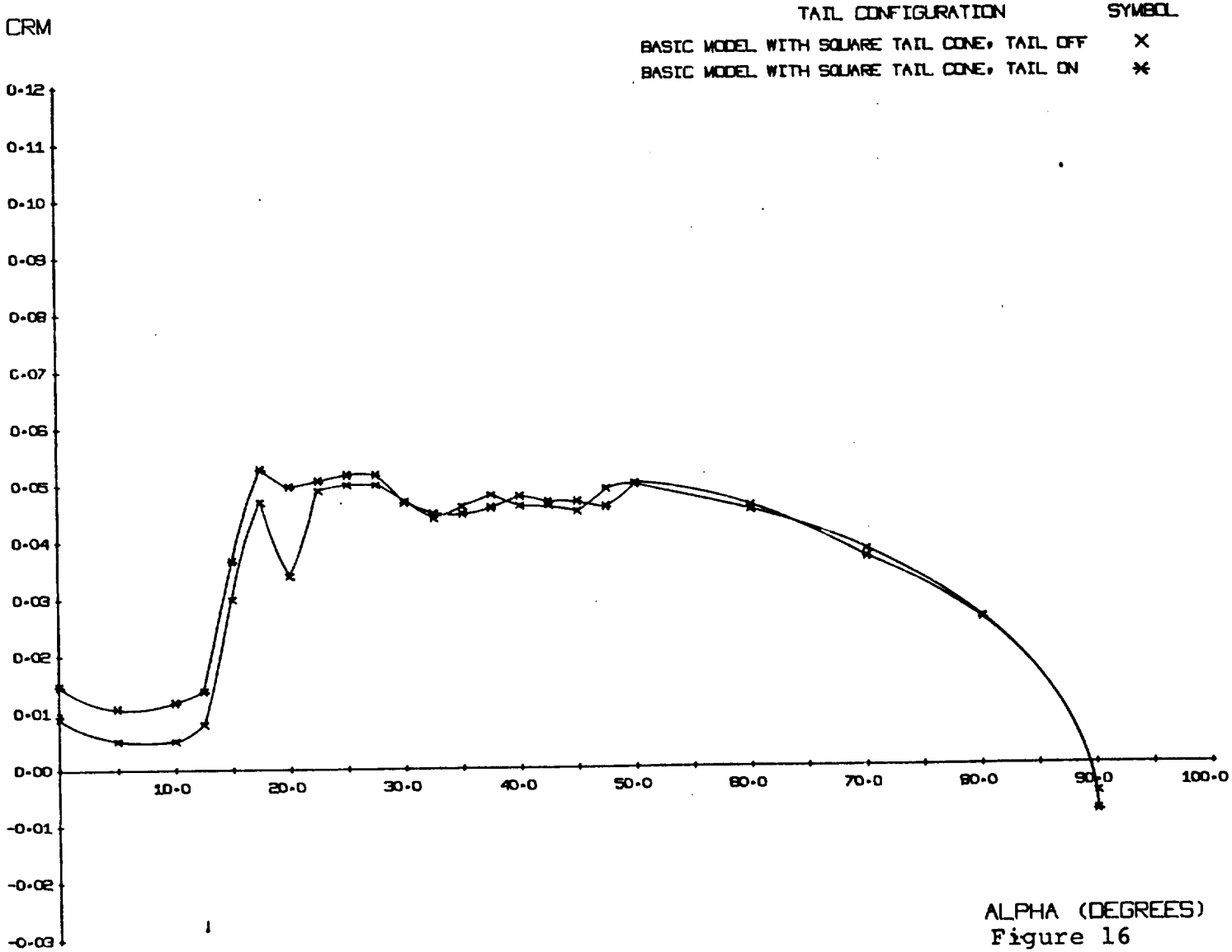
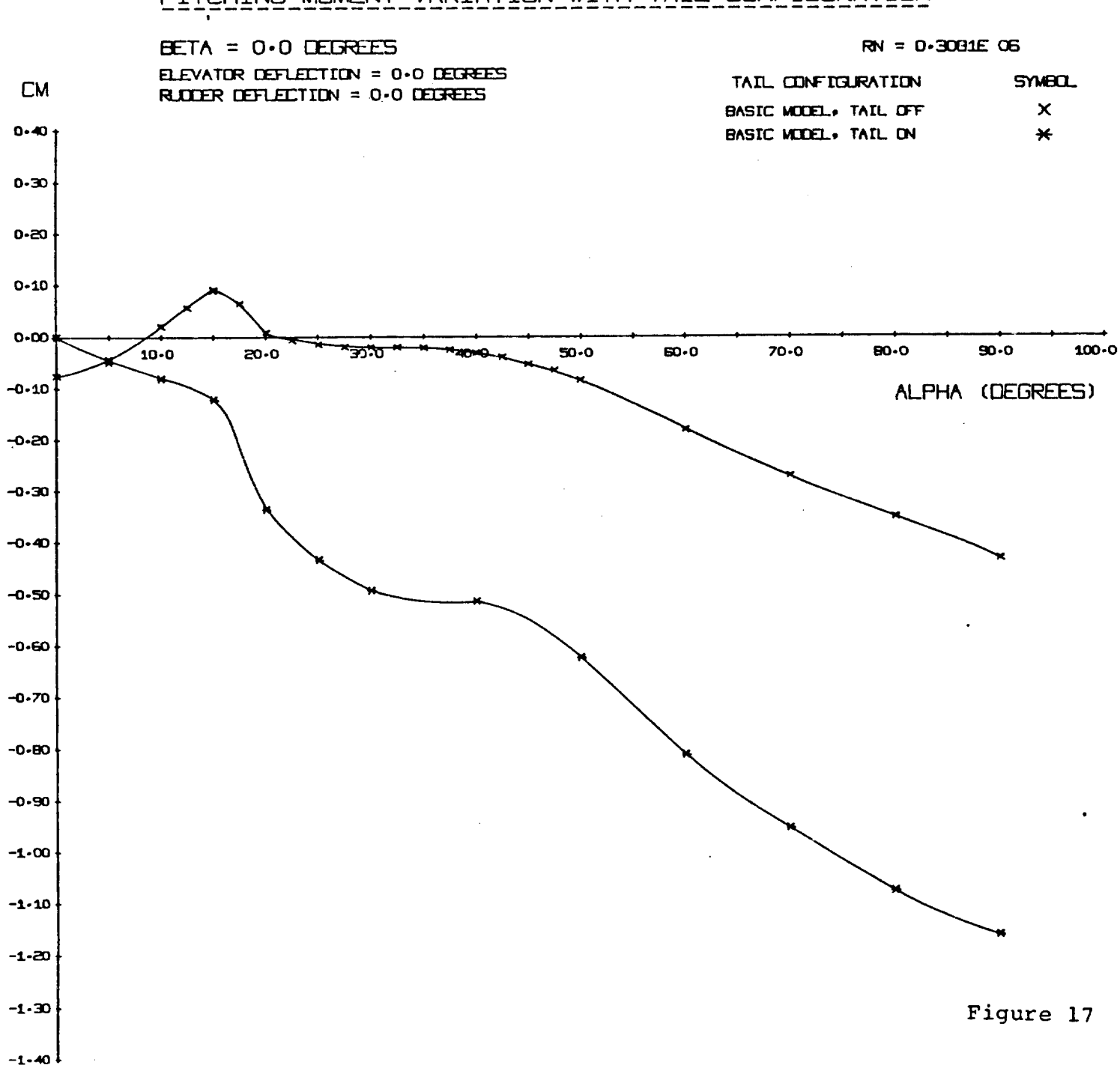


Figure 16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RUDDER DEFLECTION = 0.0 DEGREES
RN = 0.3081E 06
TAIL CONFIGURATION
SYMBOL
BASIC MODEL, TAIL OFF
X
BASIC MODEL, TAIL ON
*
CM
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0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
-1.20
-1.30
-1.40
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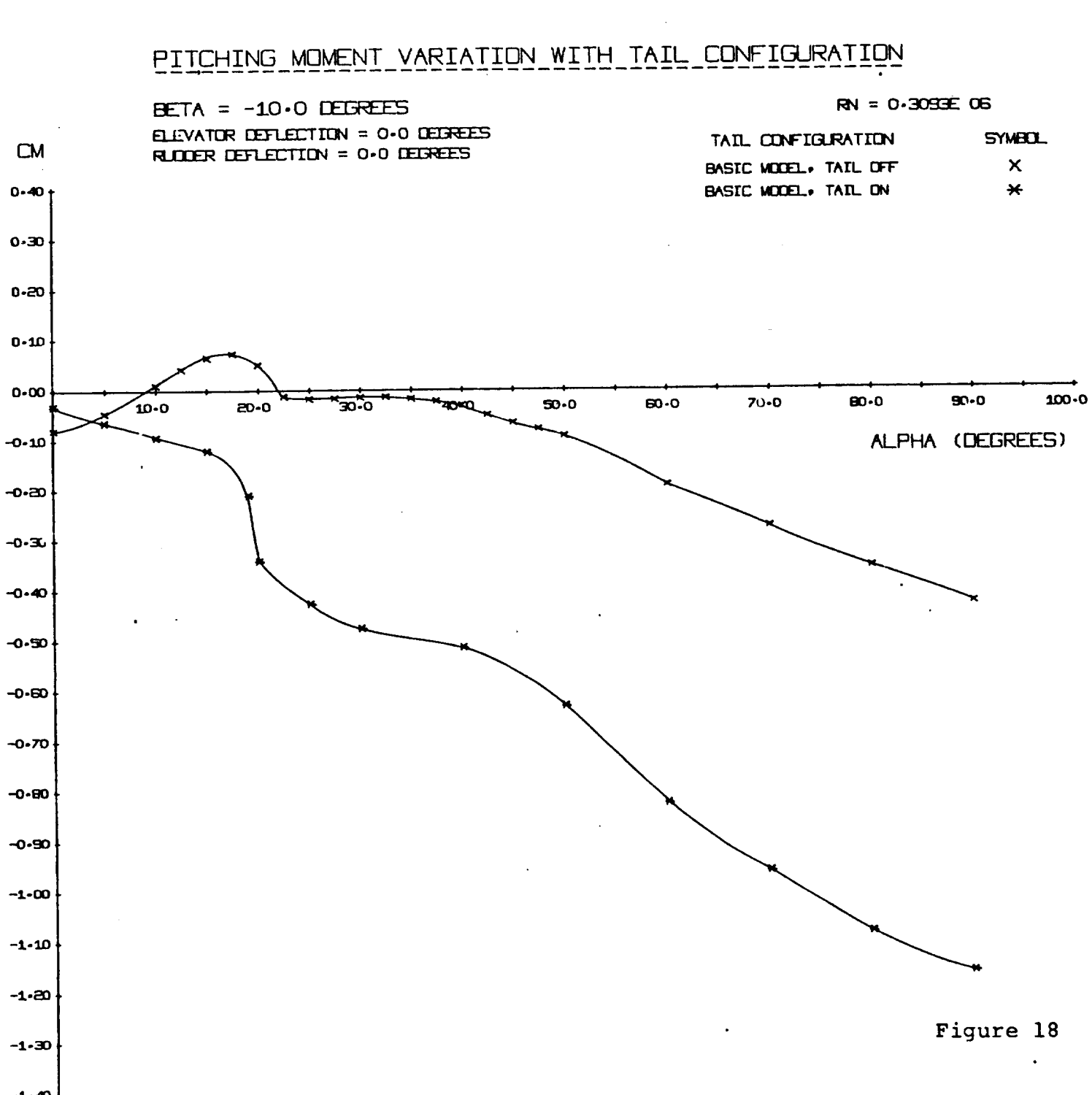
100.0
ALPHA (DEGREES)

Figure 17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RUDDER DEFLECTION = 0.0 DEGREES
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X
BASIC MODEL, TAIL ON
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-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
-1.20
-1.30
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20.0
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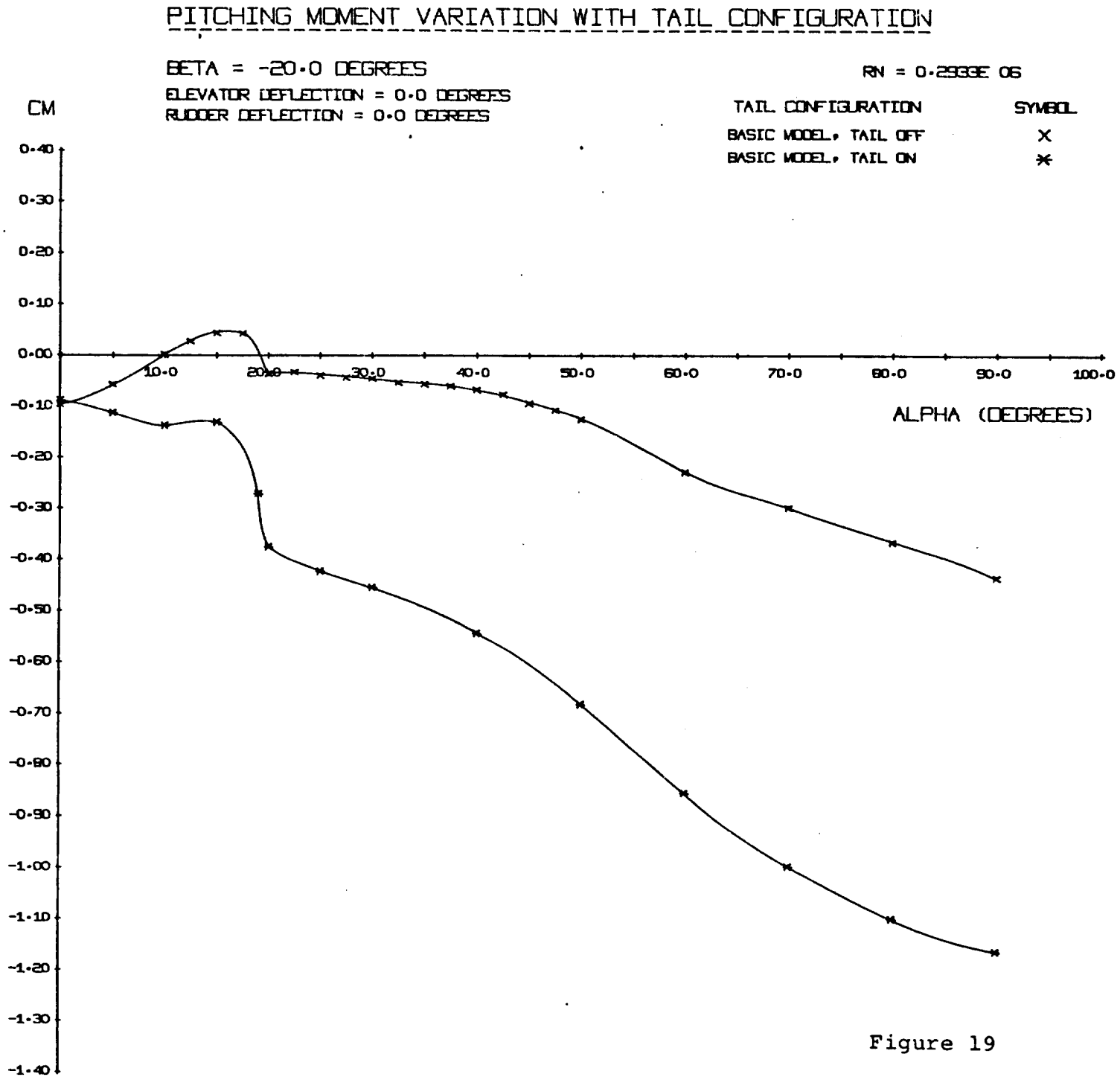
60.0
70.0
80.0
90.0
100.0
ALPHA (DEGREES)

Figure 18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RUDDER DEFLECTION = 0.0 DEGREES
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TAIL CONFIGURATION
SYMBOL
BASIC MODEL, TAIL OFF
X
BASIC MODEL, TAIL ON
*
CM
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0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
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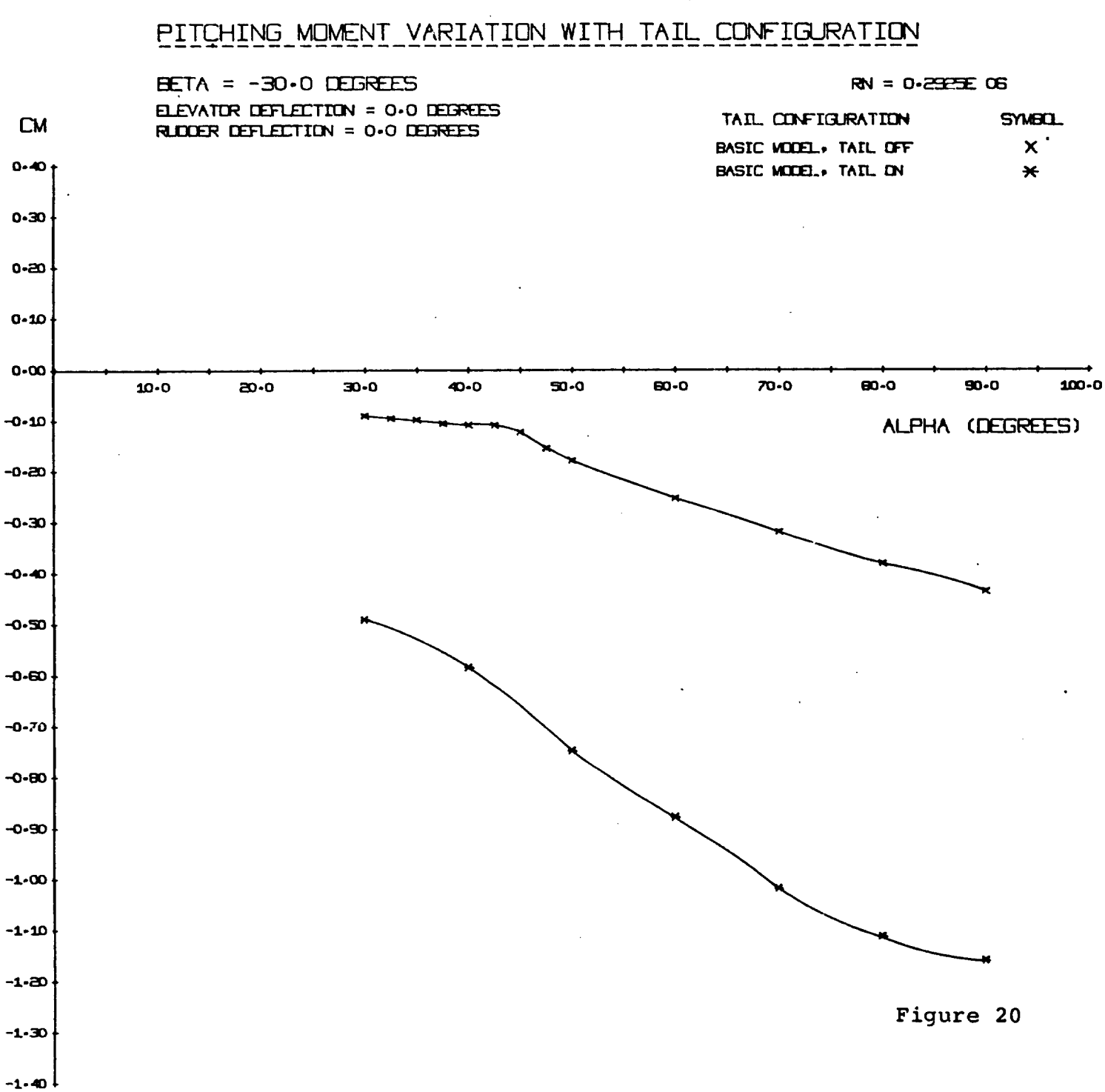
100.0
ALPHA (DEGREES)

Figure 19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ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES
RN = 0.2925E 06
TAIL CONFIGURATION
SYMBOL
BASIC MODEL, TAIL OFF
X
BASIC MODEL, TAIL ON
*
CM
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0.30
0.20
0.10
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-0.40
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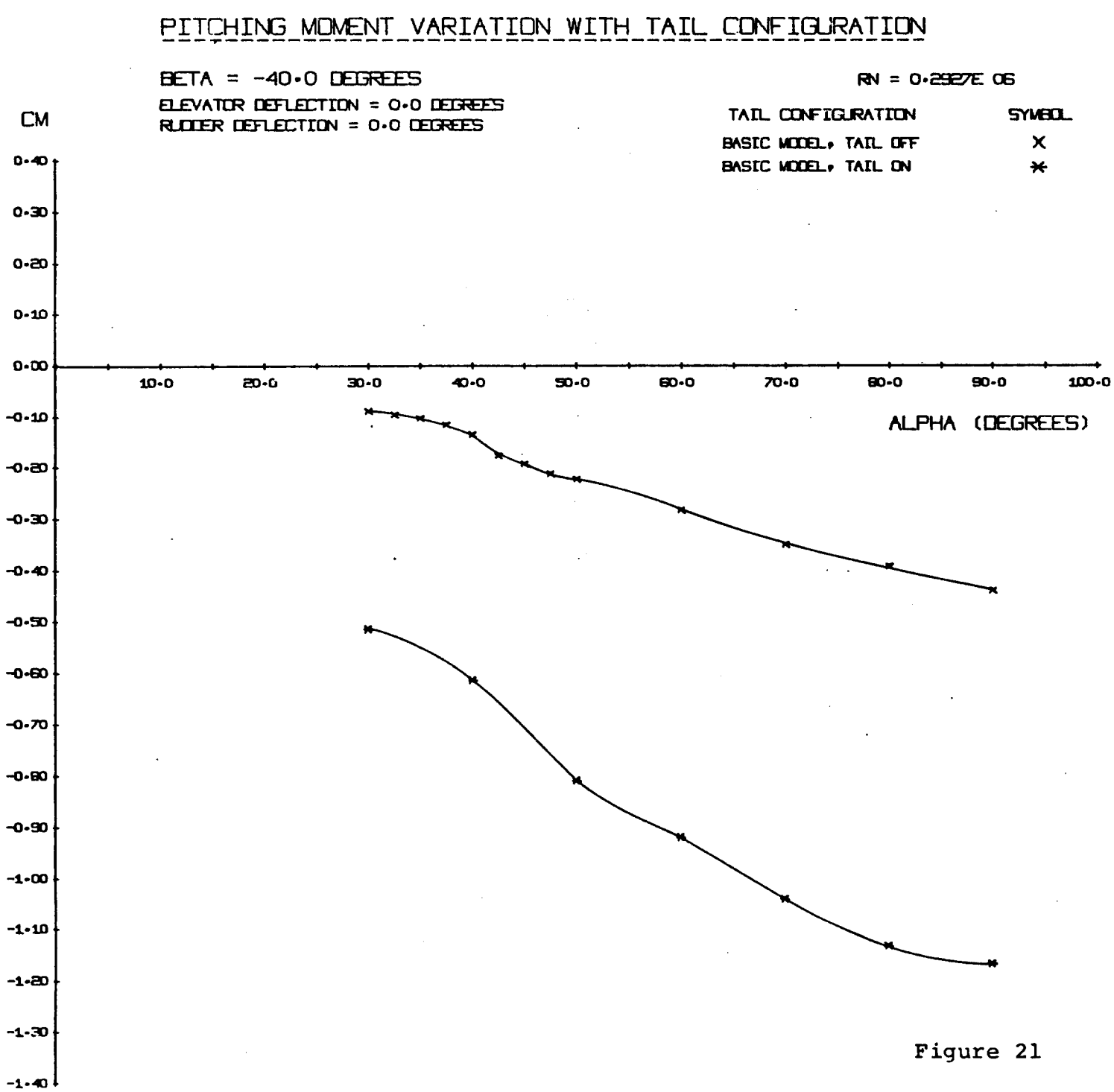
ALPHA (DEGREES)

Figure 20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RN = 0.2927E 06
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES
TAIL CONFIGURATION
SYMBOL
BASIC MODEL, TAIL OFF
X
BASIC MODEL, TAIL ON
*
CM
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0.30
0.20
0.10
0.00
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-0.20
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-0.40
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-1.40
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
ALPHA (DEGREES)

Figure 21

PITCHING MOMENT VARIATION WITH TAIL CONFIGURATION

BETA = 0.0 DEGREES

RN = 0.2561E 06

ELEVATOR DEFLECTION = 0.0 DEGREES

RUDDER DEFLECTION = 0.0 DEGREES

TAIL CONFIGURATION	SYMBOL
BASIC MODEL, PLUS FULL SQUARE TAIL CONE	X
BASIC MODEL, PLUS HALF SQUARE TAIL CONE	*
BASIC MODEL	+

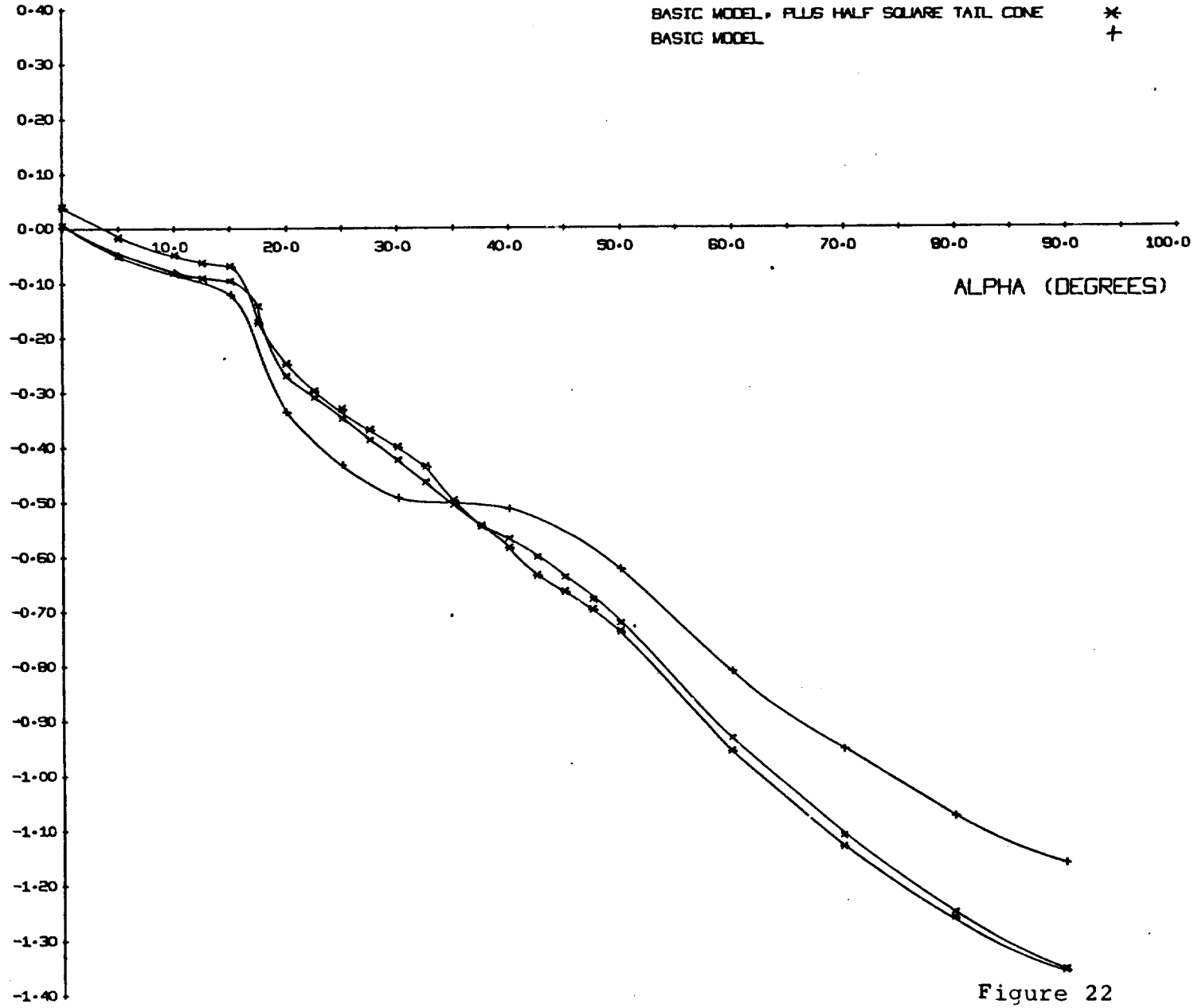


Figure 22

PITCHING MOMENT VARIATION WITH TAIL CONFIGURATION

BETA = -10.0 DEGREES

ELEVATOR DEFLECTION = 0.0 DEGREES

RUDDER DEFLECTION = 0.0 DEGREES

RN = 0.2932E 06

TAIL CONFIGURATION	SYMBOL
BASIC MODEL, PLUS FULL SQUARE TAIL CONE	X
BASIC MODEL, PLUS HALF SQUARE TAIL CONE	*
BASIC MODEL	+

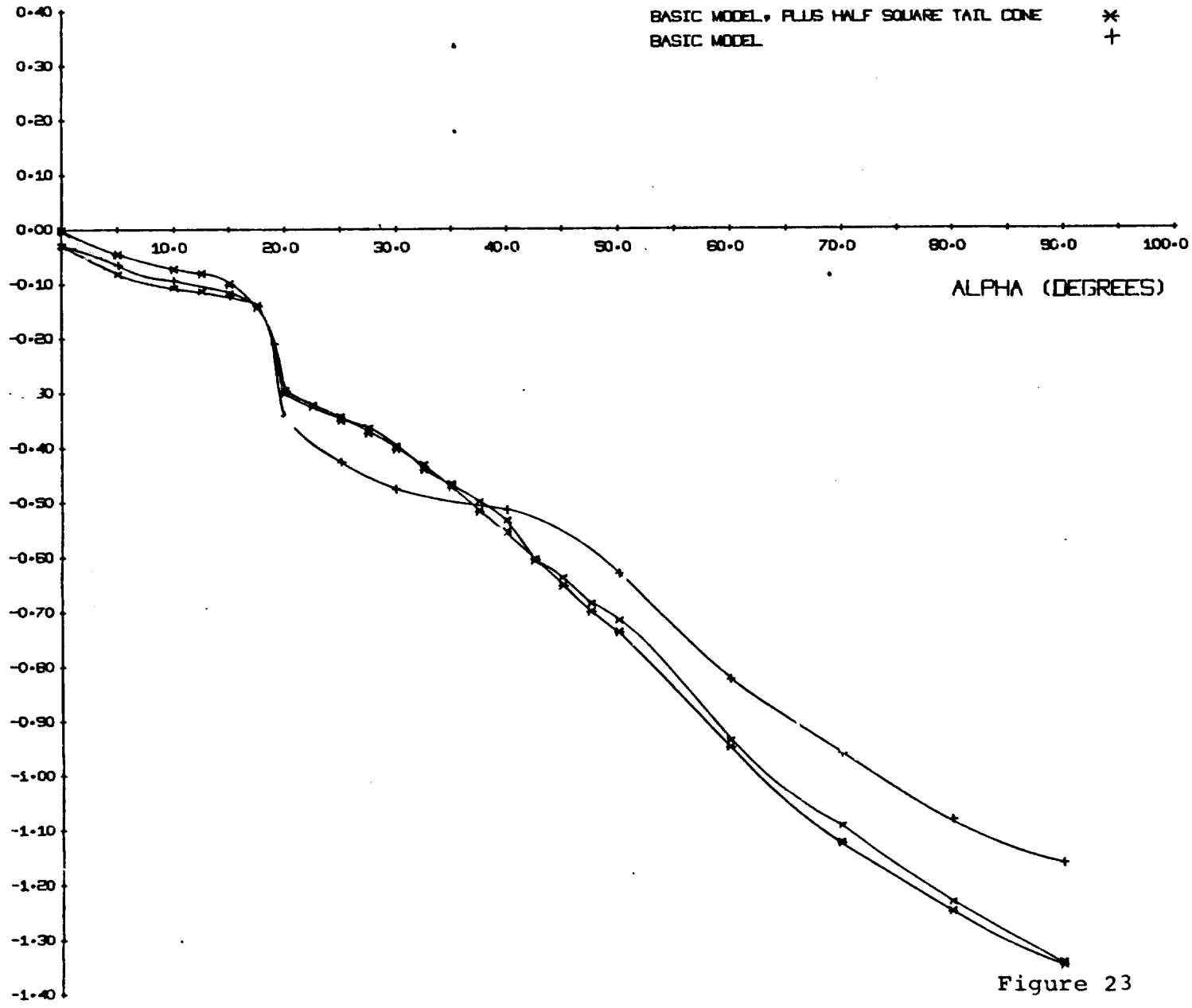
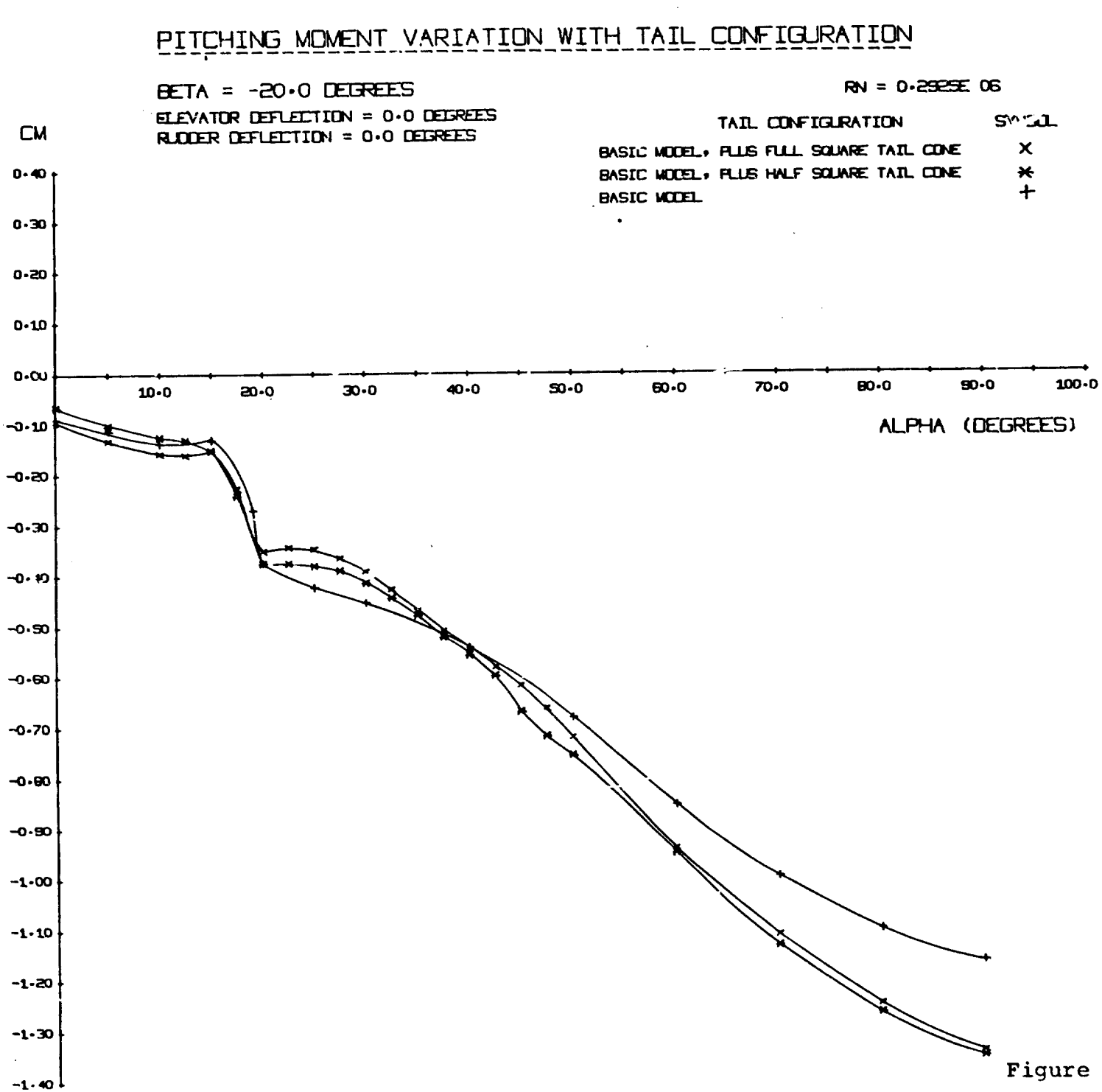


Figure 23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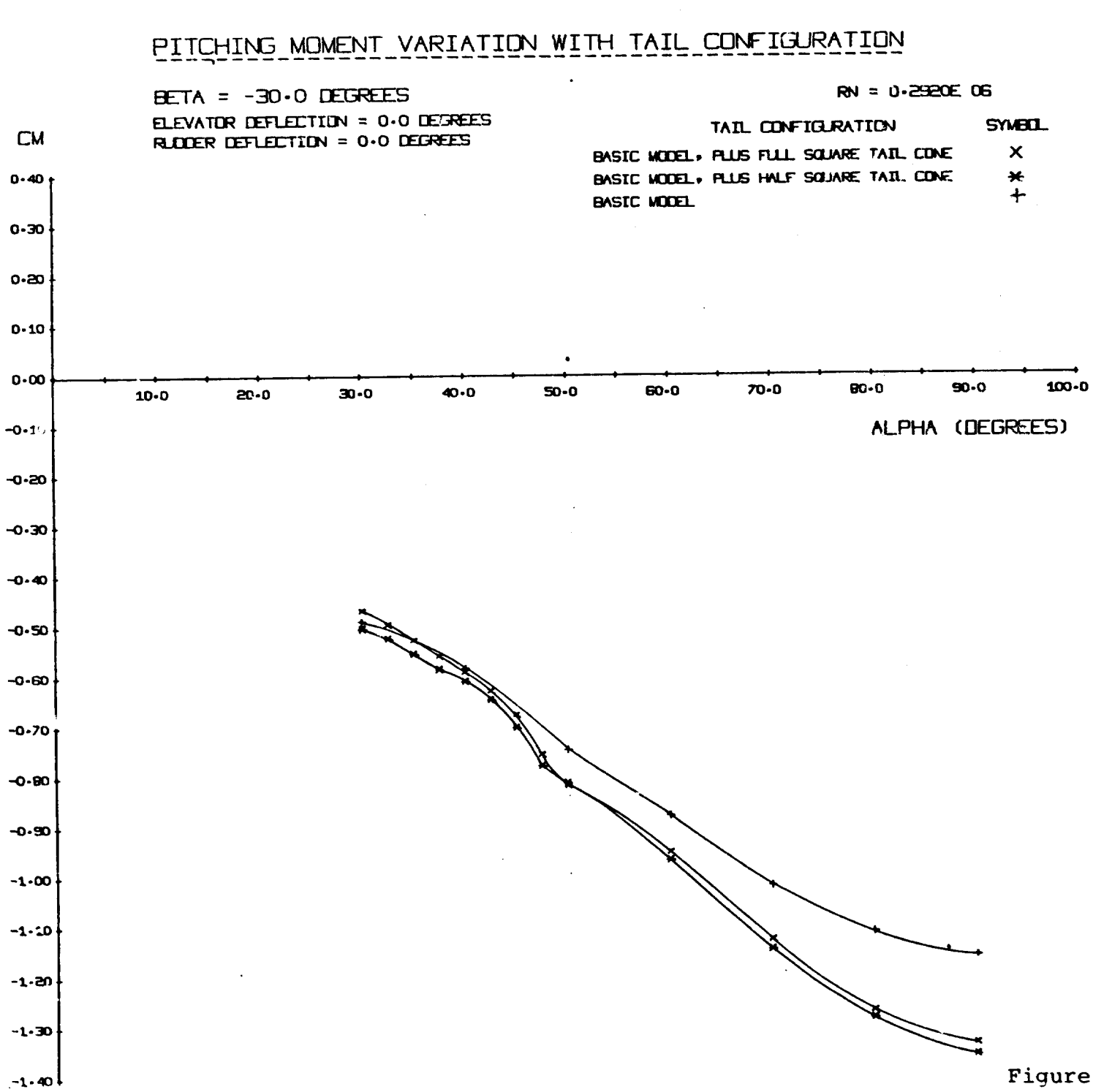
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES
RN = 0.2925E 06
TAIL CONFIGURATION
BASIC MODEL, PLUS FULL SQUARE TAIL CONE
BASIC MODEL, PLUS HALF SQUARE TAIL CONE
BASIC MODEL
CM
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
-1.20
-1.30
-1.40
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
ALPHA (DEGREES)

Figure 24


PITCHING MOMENT VARIATION WITH TAIL CONFIGURATION
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ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES
RN = 0.2920E 06
TAIL CONFIGURATION
SYMBOL
BASIC MODEL, PLUS FULL SQUARE TAIL CONE
BASIC MODEL, PLUS HALF SQUARE TAIL CONE
BASIC MODEL
CM
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
-1.20
-1.30
-1.40
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
ALPHA (DEGREES)

Figure 25

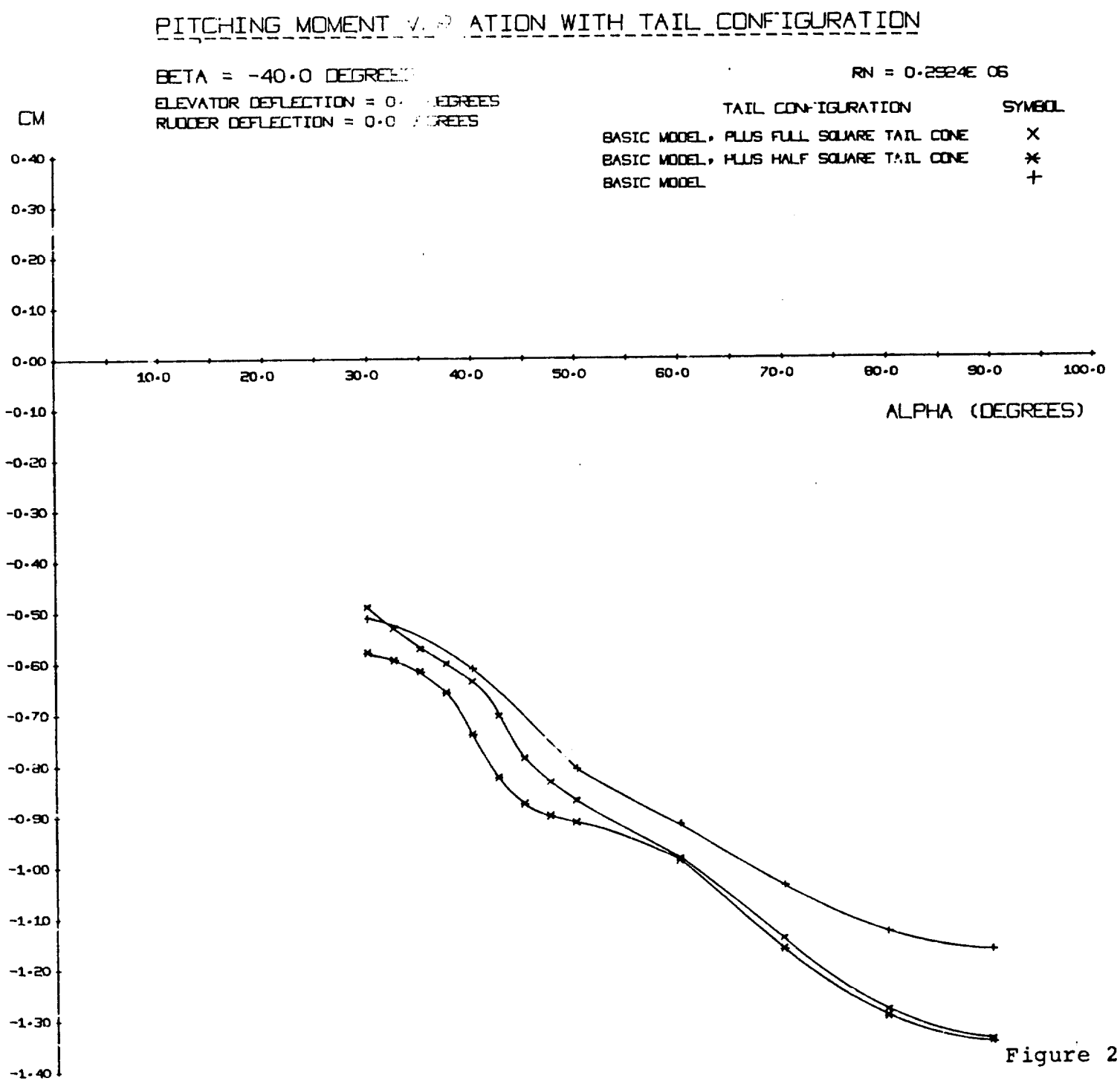
PITCHING MOMENT V.. ATION WITH TAIL CONFIGURATION
BETA = -40.0 DEGREES
RN = 0.2924E 06
ELEVATOR DEFLECTION = 0. EGREES
RUDDER DEFLECTION = 0.0 REES
TAIL CONFIGURATION
SYMBOL
BASIC MODEL, PLUS FULL SQUARE TAIL CONE
BASIC MODEL, PLUS HALF SQUARE TAIL CONE
BASIC MODEL
CM
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
-1.20
-1.30
-1.40
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
ALPHA (DEGREES)

Figure 26

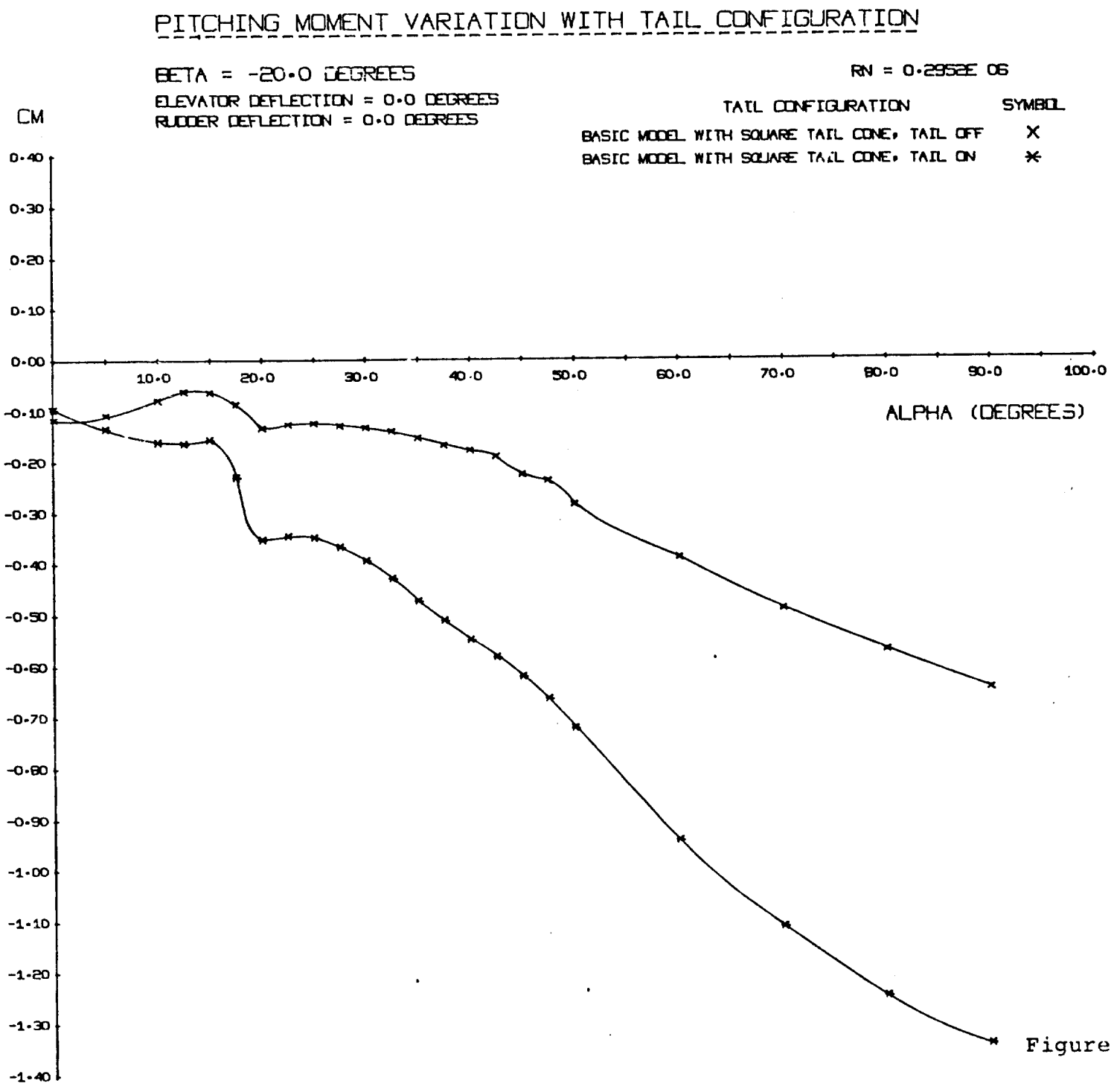
PITCHING MOMENT VARIATION WITH TAIL CONFIGURATION
BETA = -20.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES
RN = 0.2952E 06
TAIL CONFIGURATION
SYMBOL
BASIC MODEL WITH SQUARE TAIL CONE, TAIL OFF X
BASIC MODEL WITH SQUARE TAIL CONE, TAIL ON *
CM
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
-1.20
-1.30
-1.40
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
ALPHA (DEGREES)

Figure 27

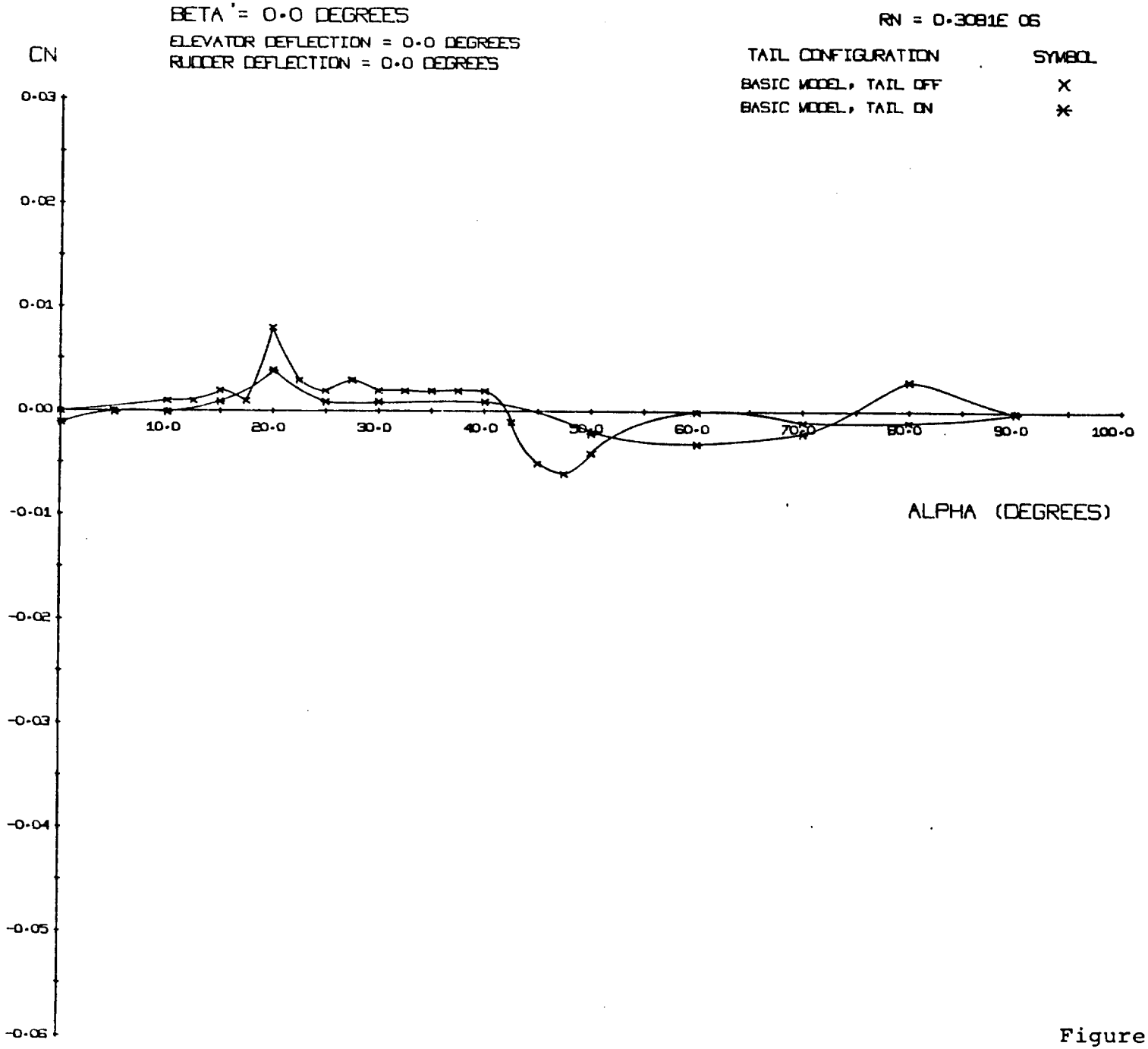
YAWING MOMENT VARIATION WITH TAIL CONFIGURATION
BETA = 0.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES
RN = 0.3081E 06
TAIL CONFIGURATION
SYMBOL
BASIC MODEL, TAIL OFF
BASIC MODEL, TAIL ON
CN
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
ALPHA (DEGREES)

Figure 28

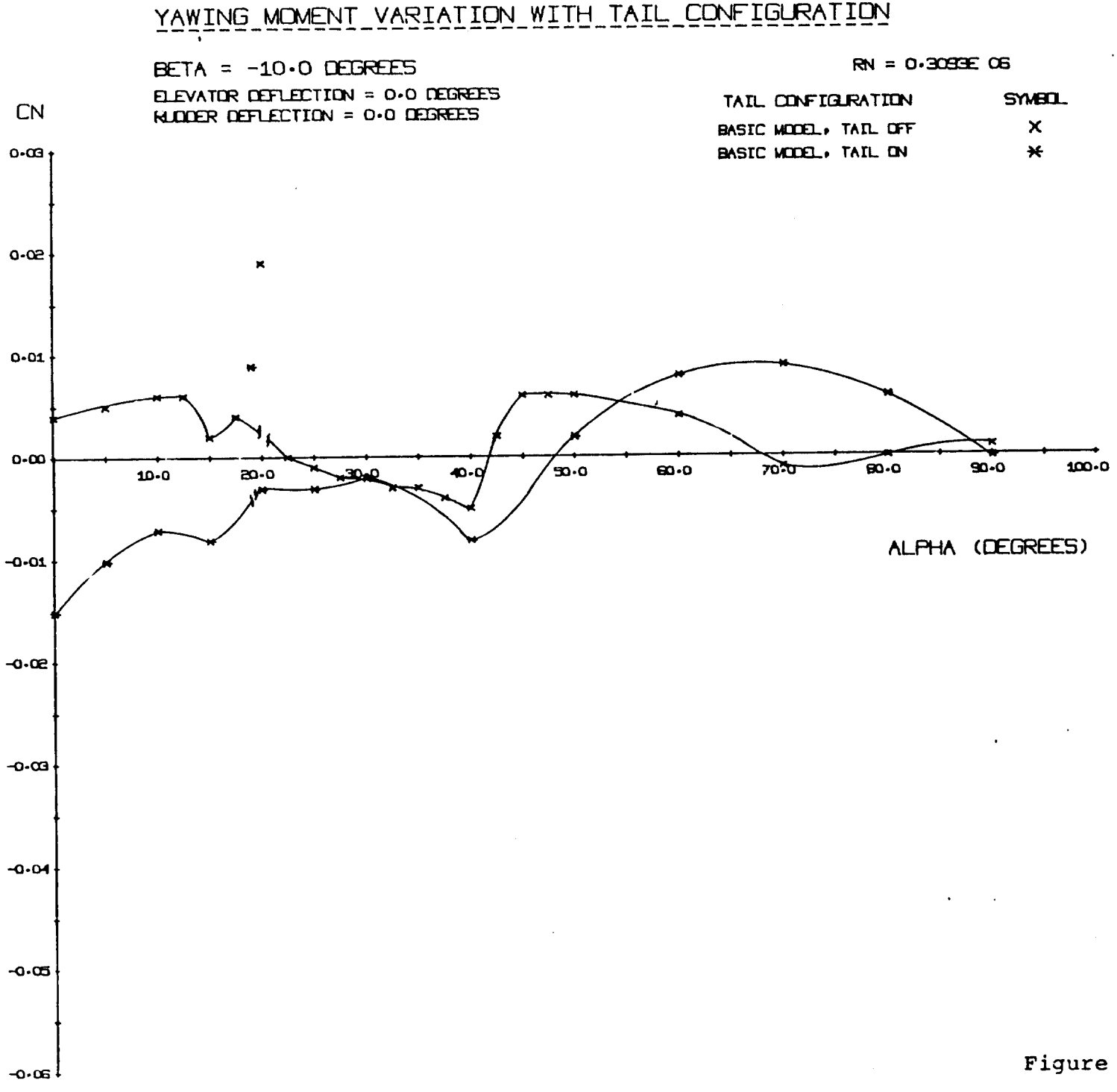
YAWING MOMENT VARIATION WITH TAIL CONFIGURATION
BETA = -10.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES
RN = 0.3093E 06
TAIL CONFIGURATION
SYMBOL
BASIC MODEL, TAIL OFF
BASIC MODEL, TAIL ON
CN
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
ALPHA (DEGREES)

Figure 29

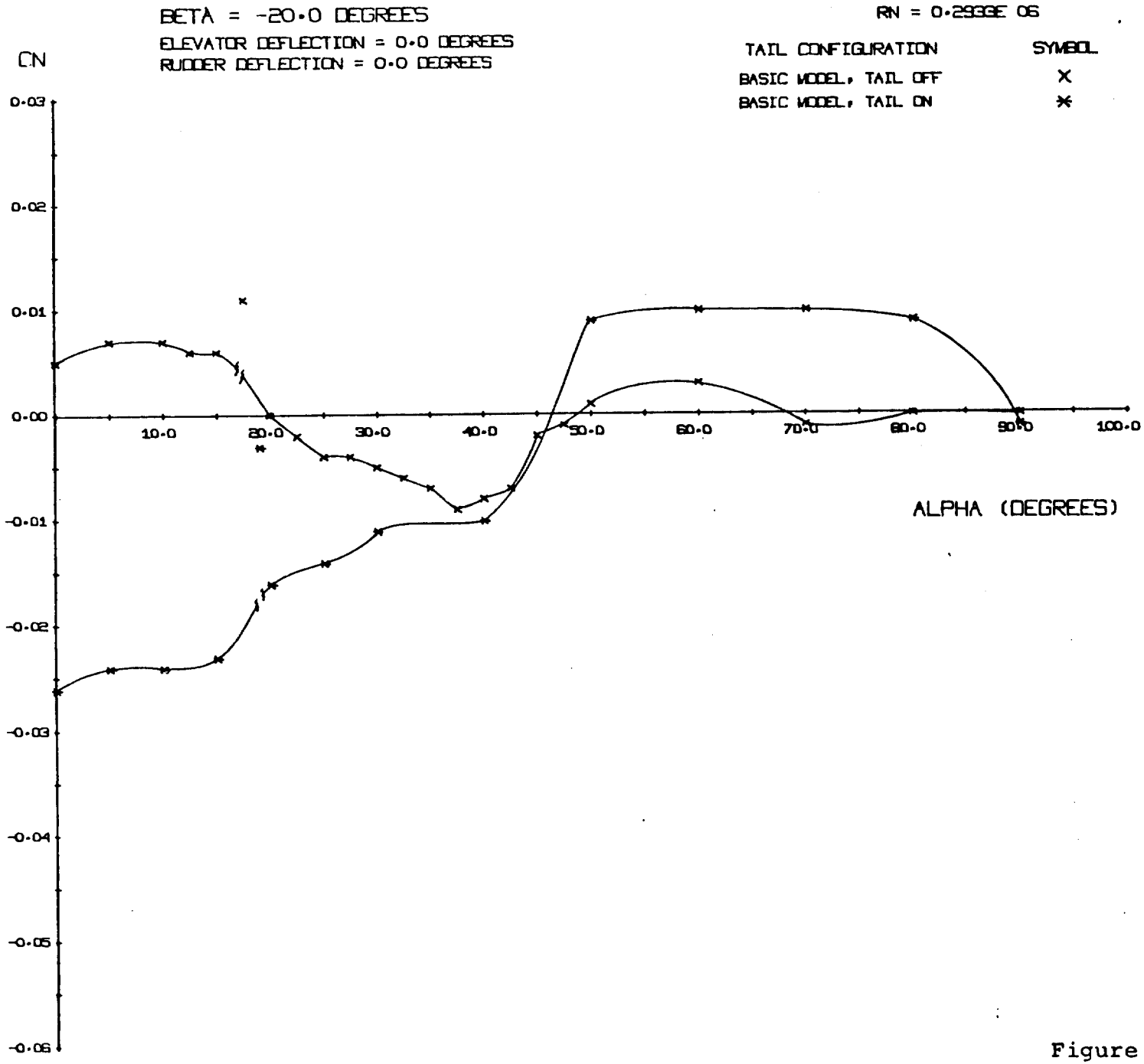
YAWING MOMENT VARIATION WITH TAIL CONFIGURATION
BETA = -20.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES
RN = 0.2933E 06
TAIL CONFIGURATION
SYMBOL
BASIC MODEL, TAIL OFF
BASIC MODEL, TAIL ON
CN
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
ALPHA (DEGREES)

Figure 30

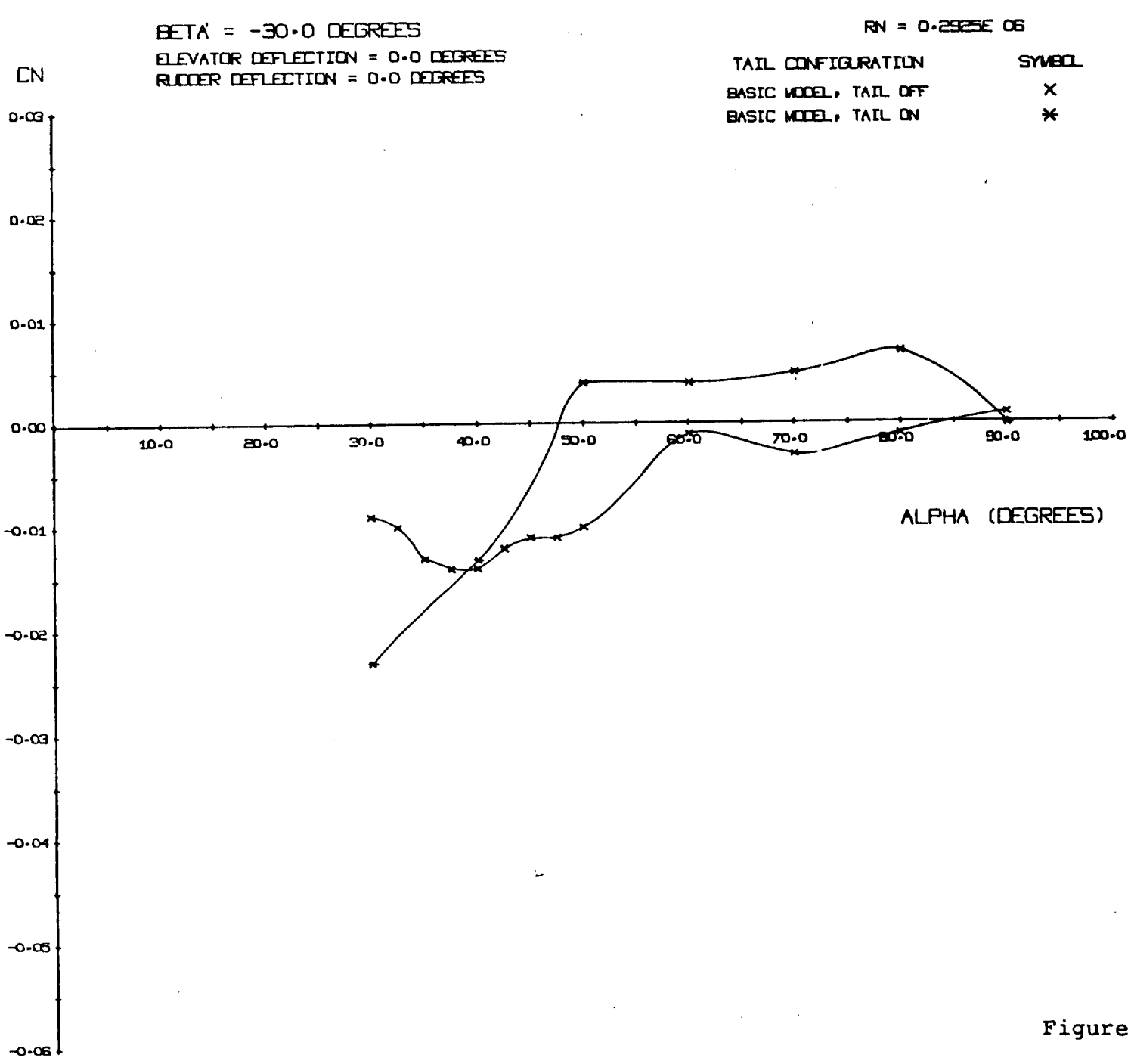
YAWING MOMENT VARIATION WITH TAIL CONFIGURATION
BETA = -30.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES
RN = 0.2925E 06
TAIL CONFIGURATION
SYMBOL
BASIC MODEL, TAIL OFF
BASIC MODEL, TAIL ON
CN
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
ALPHA (DEGREES)

Figure 31

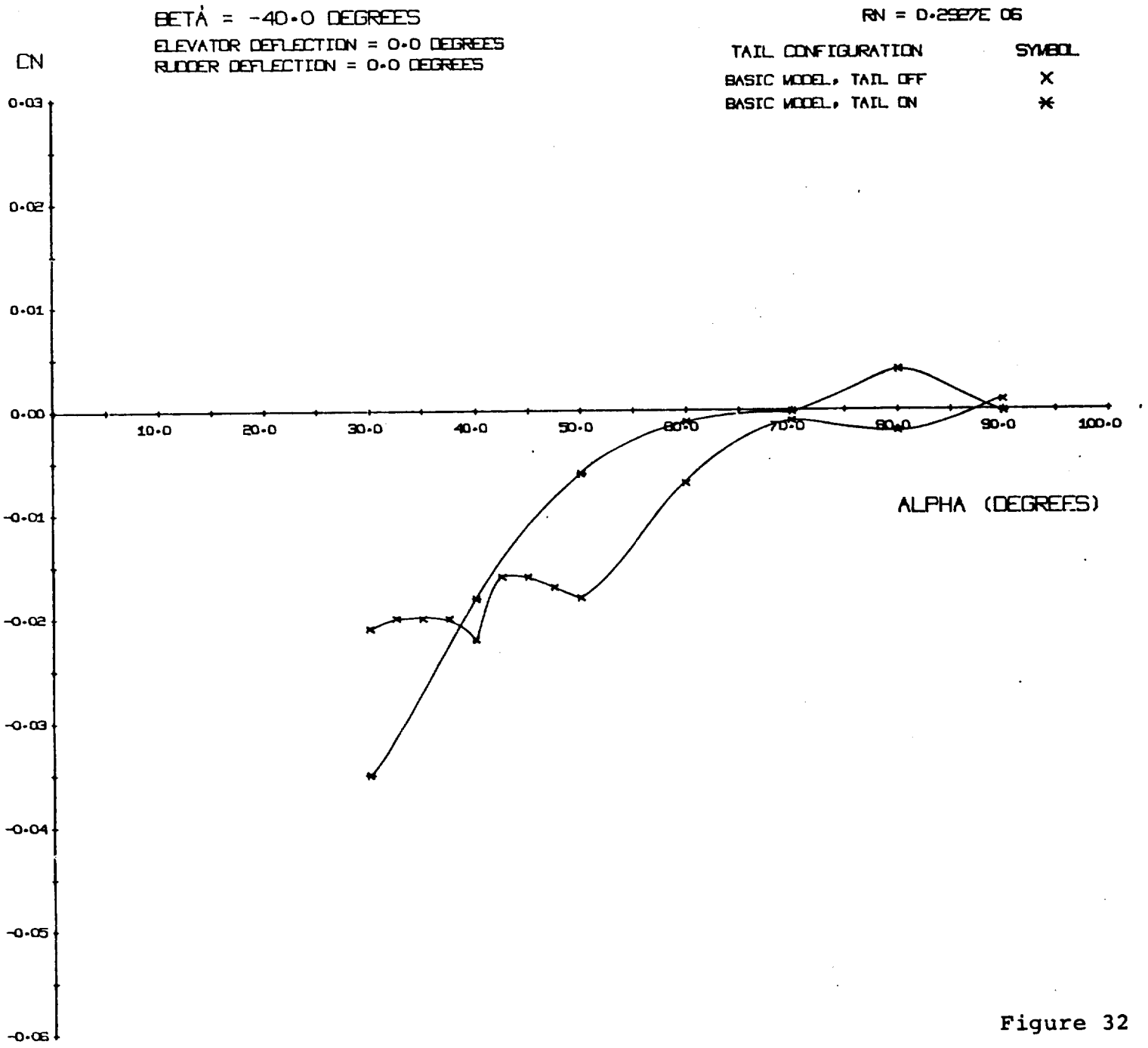
YAWING MOMENT VARIATION WITH TAIL CONFIGURATION
BETA = -40.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES
RN = 0.2927E 06
TAIL CONFIGURATION
SYMBOL
BASIC MODEL, TAIL OFF
X
BASIC MODEL, TAIL ON
*
CN
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
ALPHA (DEGREES)

Figure 32

YAWING MOMENT VARIATION WITH TAIL CONFIGURATION

BETA = 0.0 DEGREES

ELEVATOR DEFLECTION = 0.0 DEGREES

RUDDER DEFLECTION = 0.0 DEGREES

RN = 0.2361E 06

TAIL CONFIGURATION	SYMBOL
FULL SQUARE TAIL CONE	X
HALF SQUARE TAIL CONE	*
BASIC MODEL	+

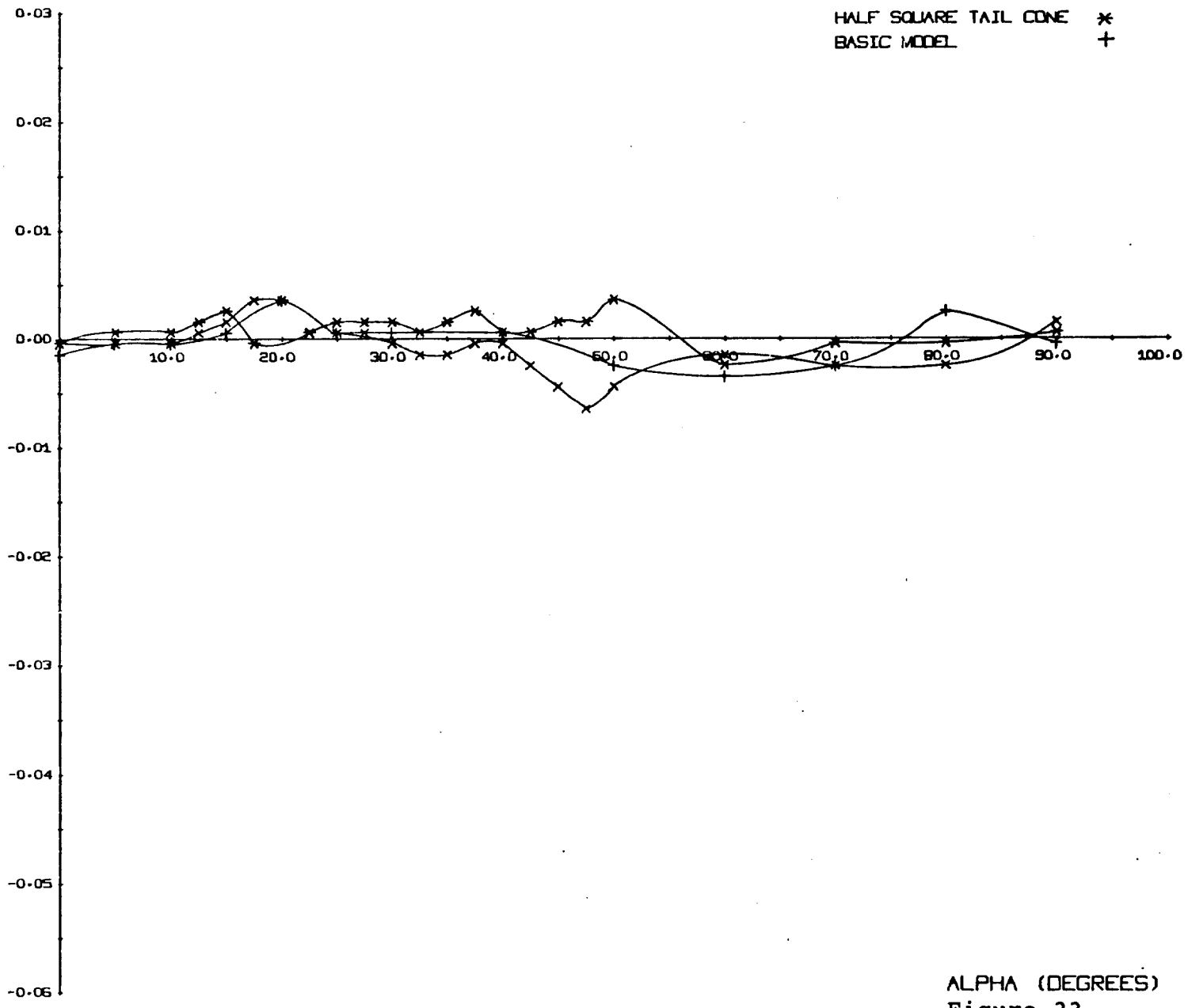

Figure 33

YAWING MOMENT VARIATION WITH TAIL CONFIGURATION

BETA' = -10.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES

RN = 0.2932E 06

TAIL CONFIGURATION	SYMBOL
FULL SQUARE TAIL CONE	X
HALF SQUARE TAIL CONE	*
BASIC MODEL	+

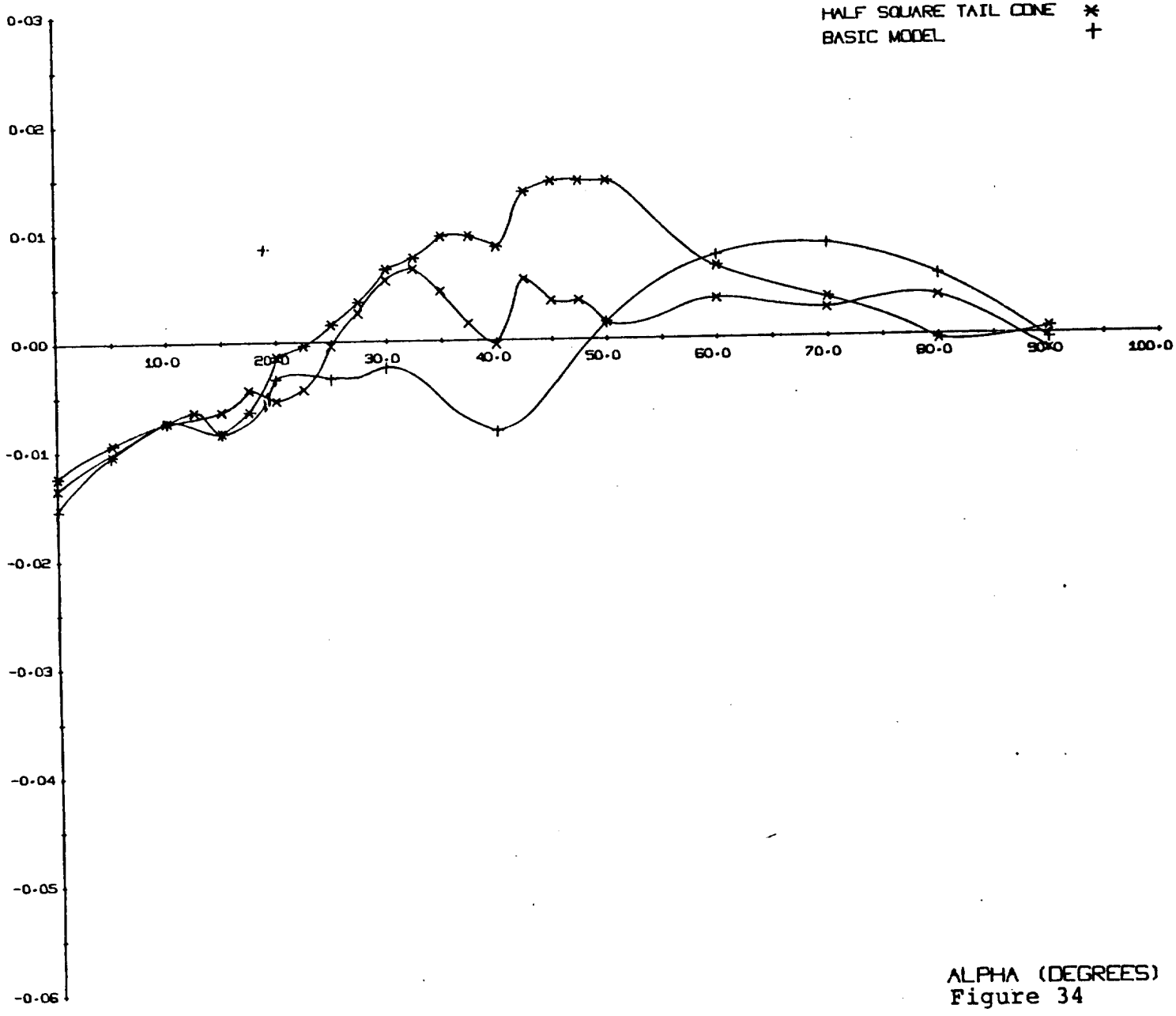

Figure 34

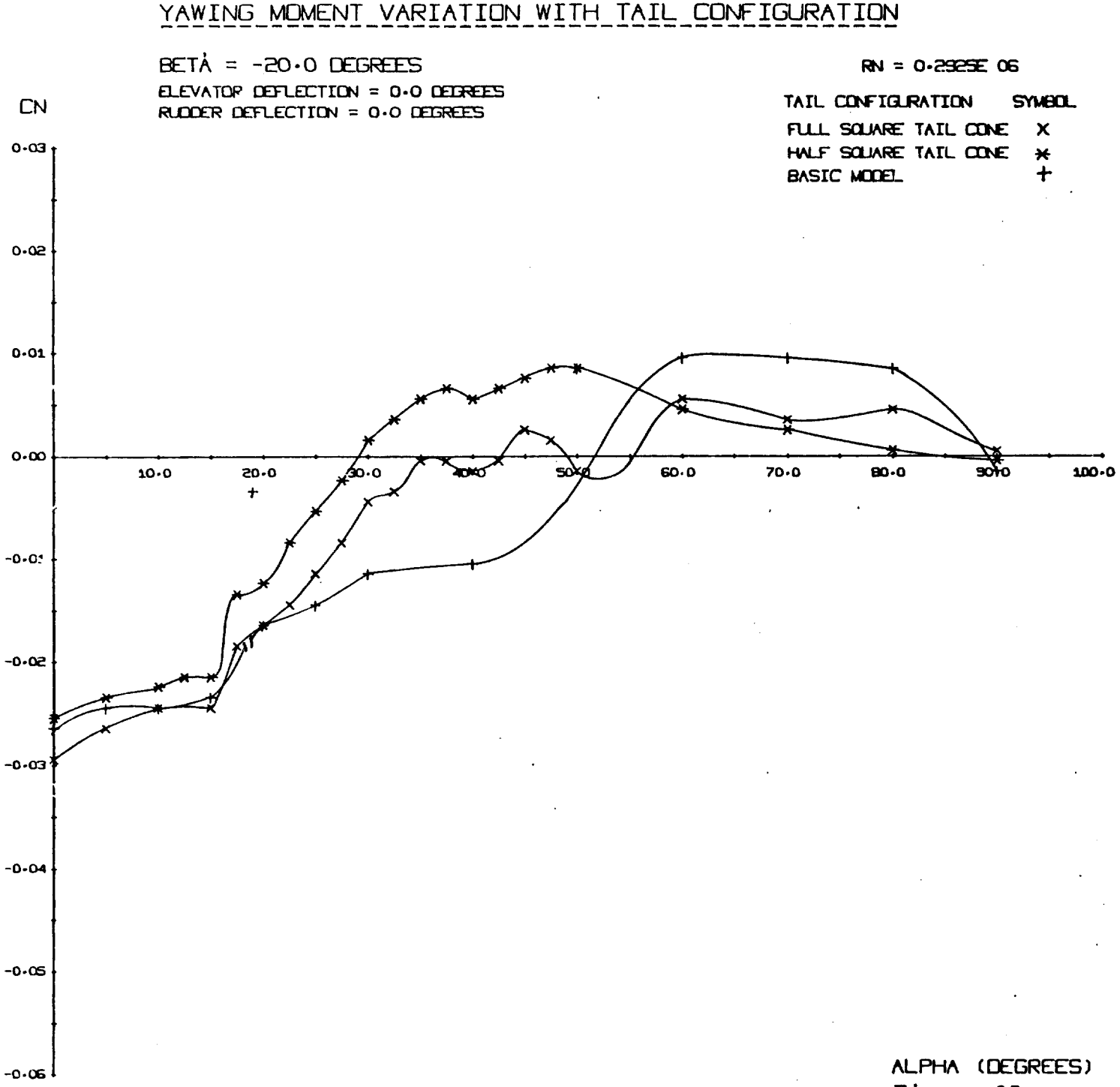
YAWING MOMENT VARIATION WITH TAIL CONFIGURATION
BETA = -20.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES
RN = 0.2925E 06
TAIL CONFIGURATION SYMBOL
FULL SQUARE TAIL CONE X
HALF SQUARE TAIL CONE *
BASIC MODEL +
CN
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
ALPHA (DEGREES)

Figure 35

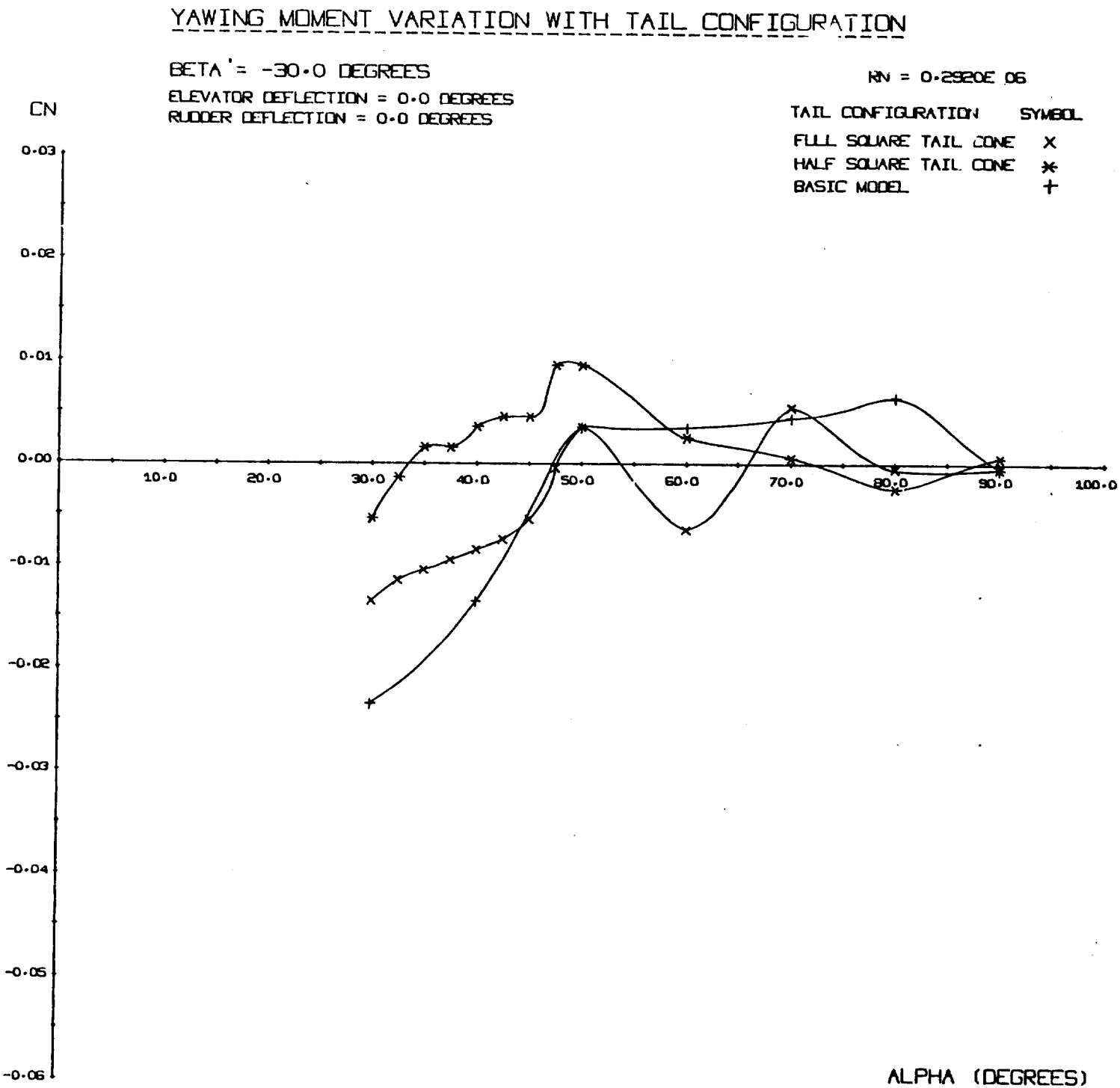
YAWING MOMENT VARIATION WITH TAIL CONFIGURATION
BETA = -30.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES
RN = 0.2920E 06
TAIL CONFIGURATION SYMBOL
FULL SQUARE TAIL CONE X
HALF SQUARE TAIL CONE *
BASIC MODEL +
CN
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
ALPHA (DEGREES)

Figure 36

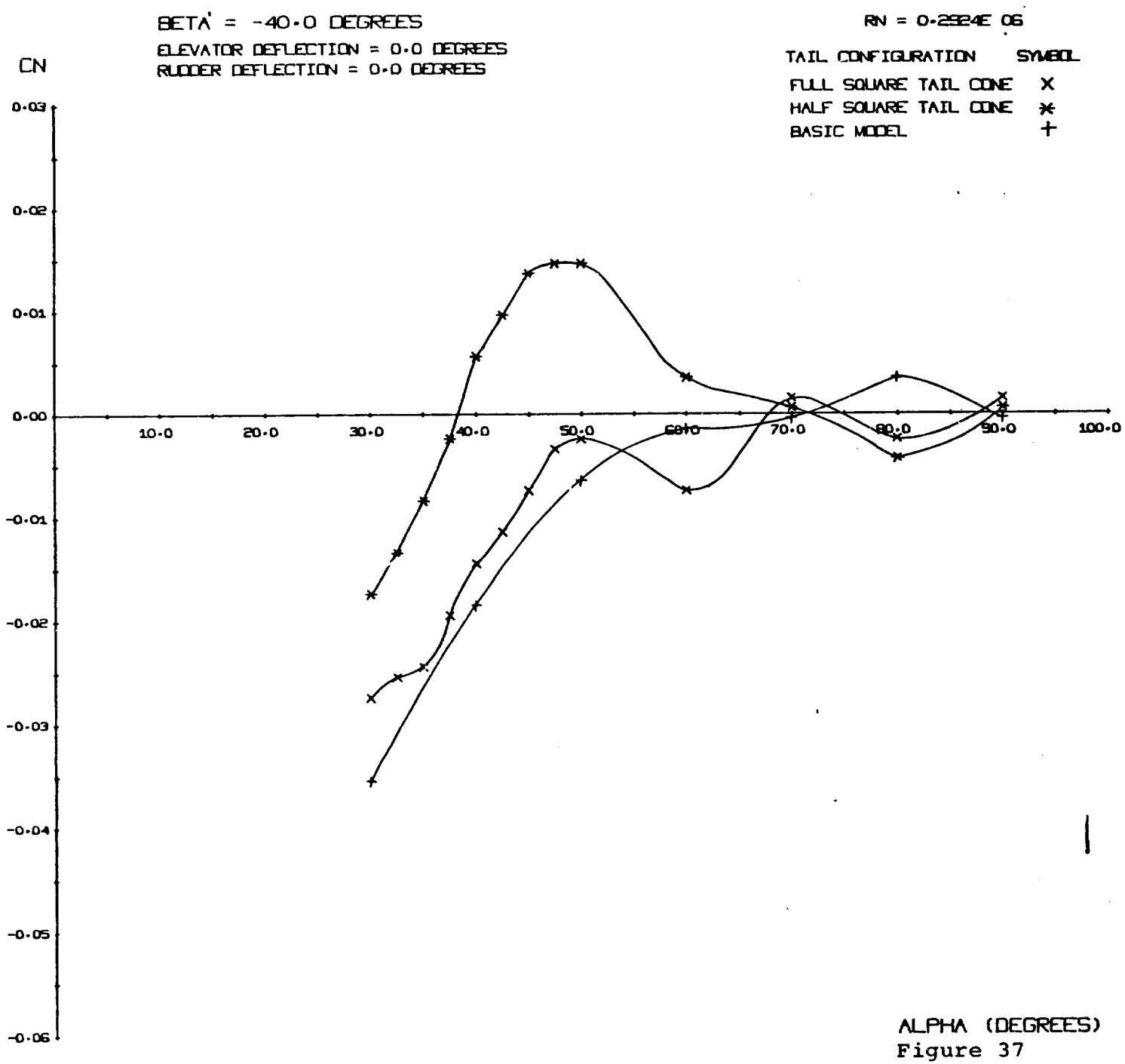
YAWING MOMENT VARIATION WITH TAIL CONFIGURATION
BETA = -40.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES
RN = 0.2824E 06
TAIL CONFIGURATION SYMBOL
FULL SQUARE TAIL CONE X
HALF SQUARE TAIL CONE *
BASIC MODEL +
CN
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
ALPHA (DEGREES)

Figure 37

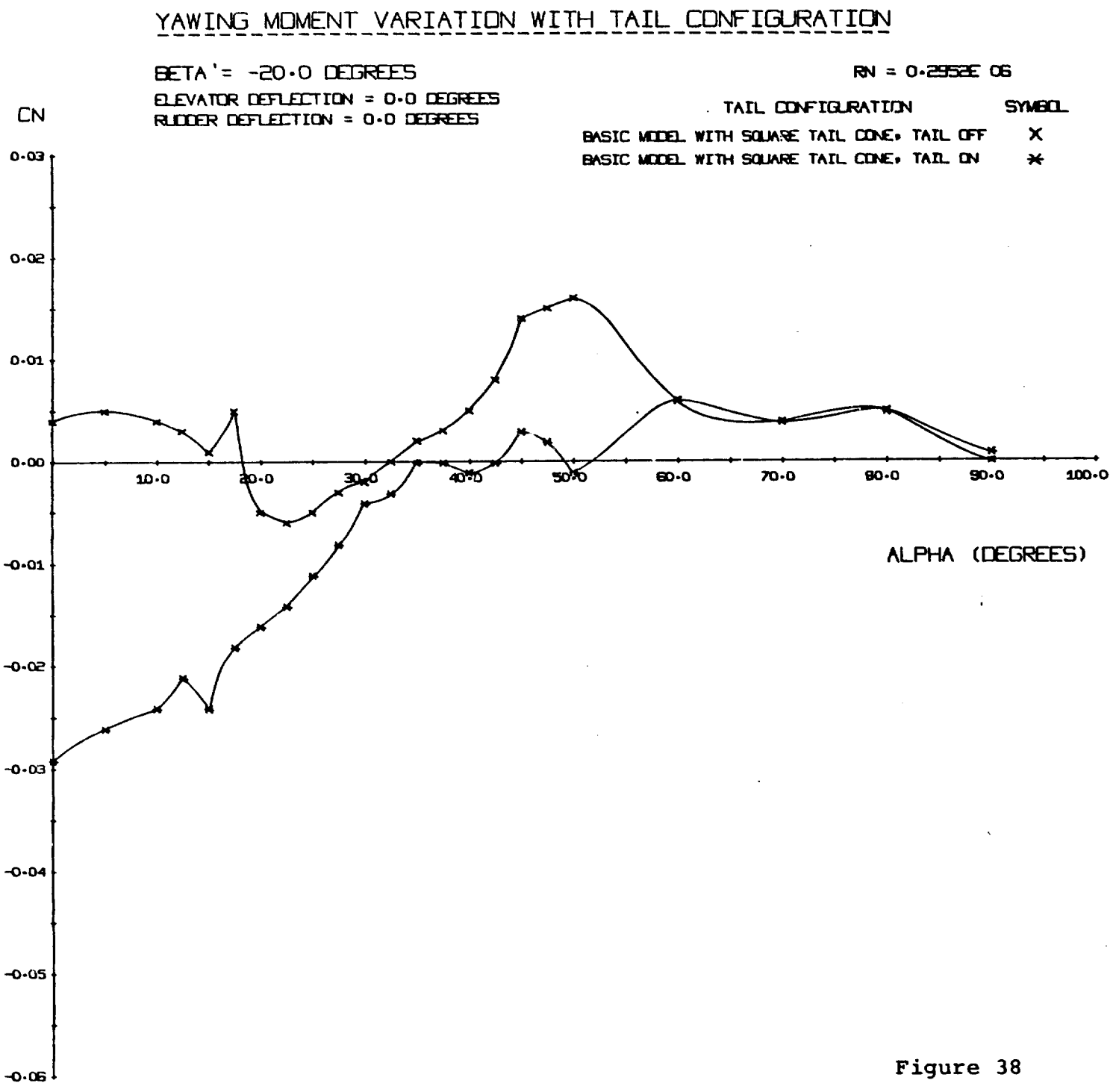
YAWING MOMENT VARIATION WITH TAIL CONFIGURATION
BETA = -20.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES
RN = 0.2952E 06
TAIL CONFIGURATION
SYMBOL
BASIC MODEL WITH SQUARE TAIL CONE, TAIL OFF X
BASIC MODEL WITH SQUARE TAIL CONE, TAIL ON *
CN
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
ALPHA (DEGREES)

Figure 38

$C_{l,rb}$ VARIATION WITH $\frac{\omega b}{2V}$

BASIC MODEL

BETA = 0.0 DEGREES

ELEVATOR DEFLECTION=0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES

R_n = 0.3304 E 06

ALPHA	X	*	+	O	Y	Δ	∇
DEGREES	30	40	50	60	70	80	90

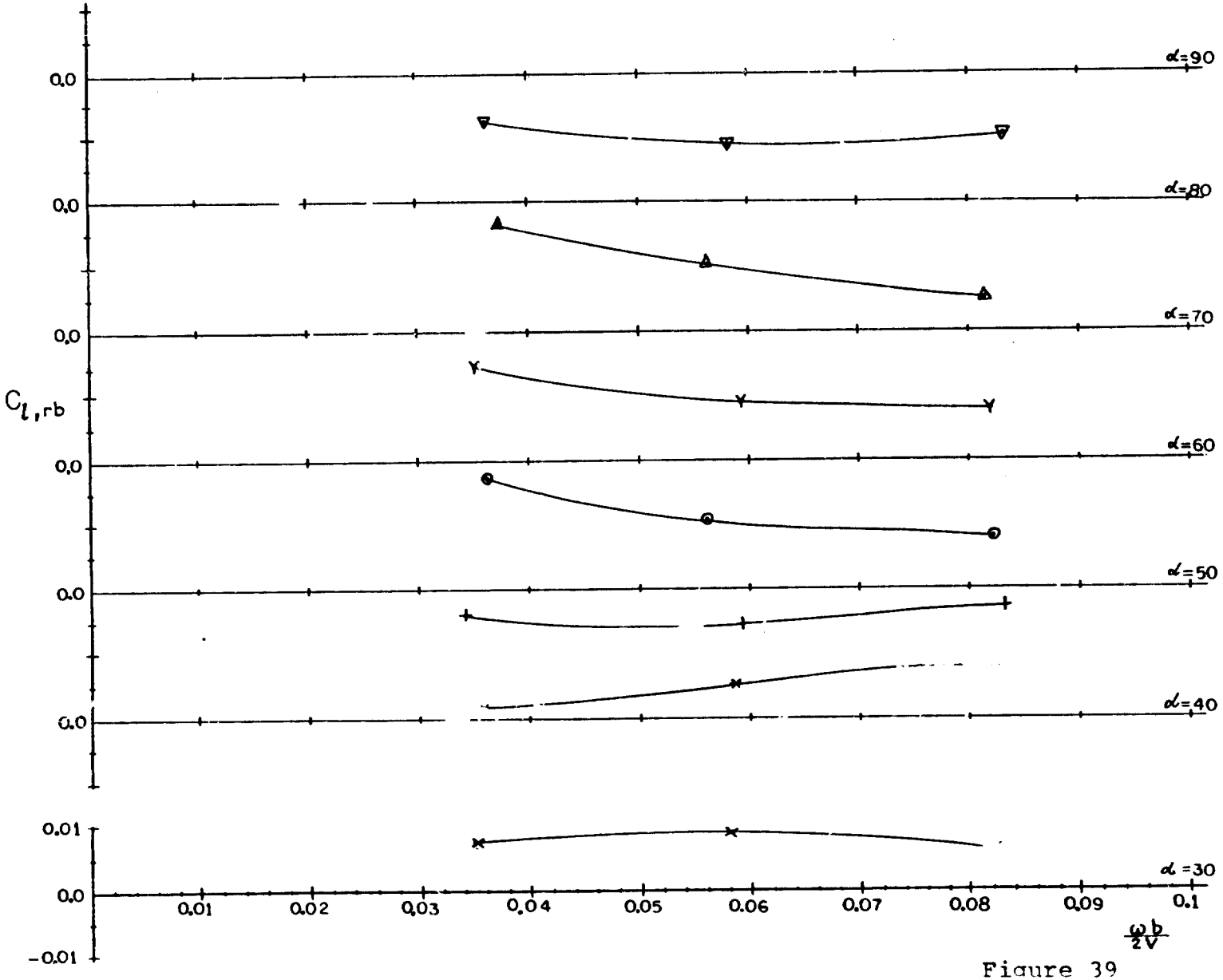

Figure 39

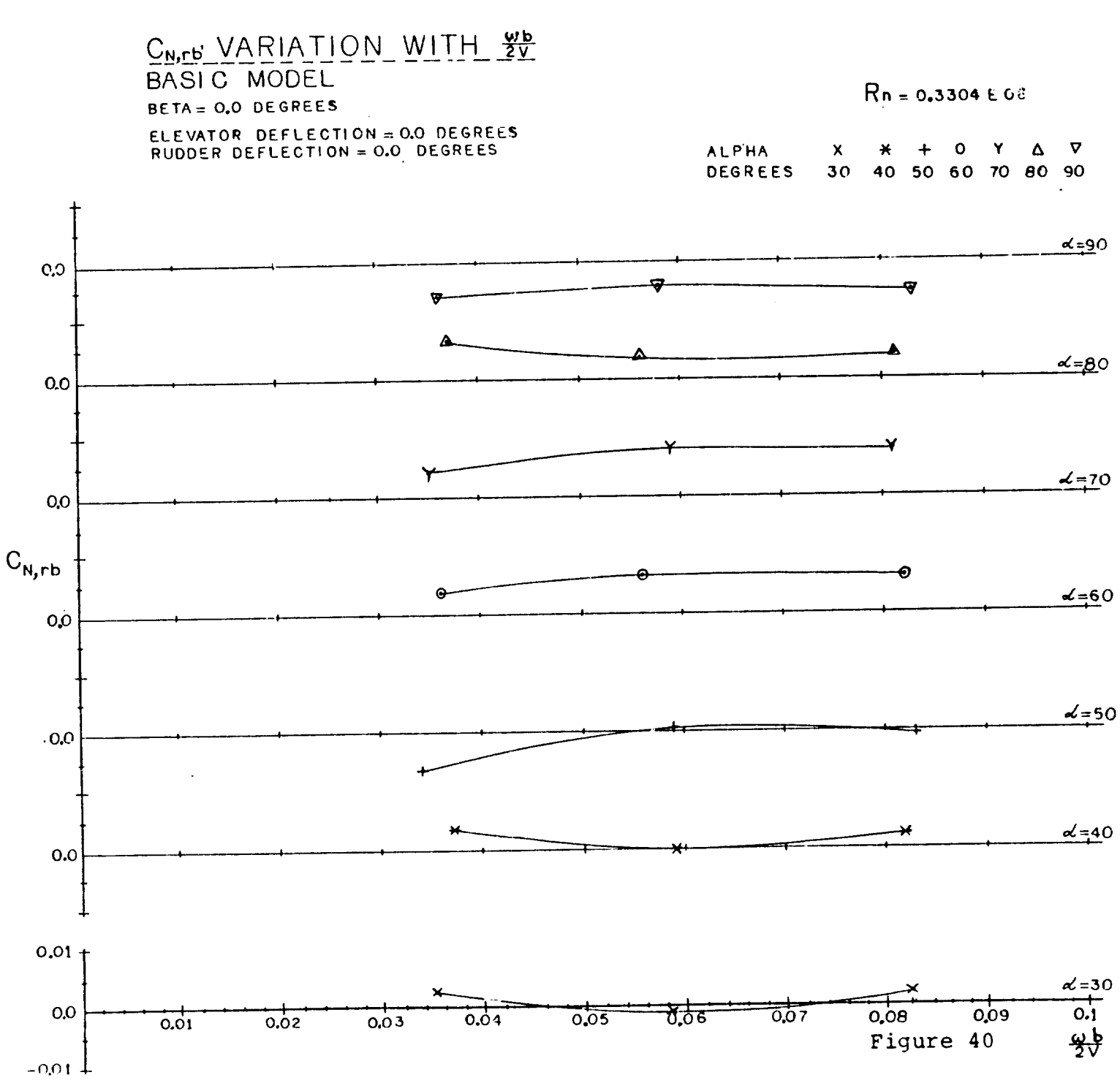
$C_{N,rb}$ VARIATION WITH $\frac{\omega b}{2V}$
BASIC MODEL
BETA = 0.0 DEGREES
ELEVATOR DEFLECTION = 0.0 DEGREES
RUDDER DEFLECTION = 0.0 DEGREES
Rn = 0.3304 E 06
ALPHA X * + 0 Y Δ ∇
DEGREES 30 40 50 60 70 80 90
α=90
α=80
α=70
α=60
α=50
α=40
α=30
$C_{N,rb}$
0.0
0.01
-0.01
0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1
$\frac{\omega b}{2V}$

Figure 40