MANUAL FOR

REDUCTION OF DATA

EIGHT-FOOT TUNNELS BRANCH

LANGLEY RESEARCH CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

A MANUAL FOR THE

REDUCTION OF DATA FROM THE

8-FOOT TRANSONIC PRESSURE TUNNEL

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This manual is prepared in looseleaf form in order to insure its flexibility. In the event that additional items are added or present items deleted or changed, new sheets or replacement sheets will be furnished.

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REFERENCE PRESSURES

I. IDENTIFICATION AND REFERENCE PRESSURES

Item No.	Symbol and Units	Description	Input and Format: Type	Chan.	Dec.	Format
1	TEST		Digital	37	0	Positive integer
2	RUN		"	38	0	"
3	M, nominal Mach number		"	42	3	x.xxx
4	CONFIG.		"	41	0	Positive integer
5	POINT		"	34	0	"
6	PTC, psf, test-chamber static pressure		"	43	1	xxxx.x
7	PTINF, psf, free-stream total pressure		"	44	1	xxxx.x

8 $MTC = \sqrt{\frac{2}{\gamma - 1}\left[\left(\frac{PTINF}{PTC}\right)^{\frac{\gamma - 1}{\gamma}} - 1\right]}$, test- chamber Mach number

$$\equiv 2.2360679 \sqrt{\left(\frac{PTINF}{PTC}\right)^{.28571428} - 1} \qquad \gamma = 1.4$$

9 MINF, free-stream Mach number from tunnel calibration. MTC vs MINF programmed at ACD (slope intercept). List with three decimals.

10 $PINF = \frac{PTINF}{\left(1 + \frac{\gamma - 1}{2} MINF^2\right)^{\frac{\gamma}{\gamma - 1}}}$, free-stream static pressure lb/sq ft

$$\equiv \frac{PTINF}{\left(1 + .2MINF^2\right)^{3.5}}$$

11 $QINF = \frac{\gamma}{2} PINF(MINF)^2$, free-stream dynamic pressure, lb/sq ft

12 TEMP, counts, free-stream total temperature, digital channel 61

13 TEMP, $^{\circ}F = 25 + 0.125$ (counts), Please list only in whole degrees.

DATA ACQUIS. SYSTEM

Item No. 2. DATA ACQUISITION SYSTEM

14

a. Calibrate Ratios

At this point calibrate ratios, CR, appear in the computations for the first time. They are calculated at ACD, for each analog channel, from fifteen data points - usually the first fifteen good calibrate points on each tape. (Points to be deleted will have been designated on load sheets.) The first five are 0, the next five, +8000, the last -8000.

Two calibrate ratios must be determined for each analog channel, one for positive readings and one for negative readings. Note that in the reduction of data, it is necessary that readings in counts including zero reading as they come from the tape, not delta readings, are to be multiplied by the calibrate ratios.

These relationships will be programmed and from input at the beginning of each tape, these two CR values will be calculated at ACD and ready for use in further calculations.

It is essential that capability be provided for using either:

1. The CR as determined from counts in the fifteen points noted above.
2. CR = 1.00.

It should be automatic that if no CR is taken at the beginning of a tape or if the CR is erroneous (i.e. not $\cong 1.0$) a value of 1.00 will be used in order to prevent total loss of the data.

It is requested that the values of the CR as calculated and used be printed on the input for all analog channels in use.

Method of determining calibrate ratios:

For positive readings: $$\frac{+8000}{\text{Avg of 5 pos. cal. rdgs - Avg 5 zero cal. rdgs}}$$

For negative readings: $$\frac{-8000}{\text{Avg of 5 neg. cal. rdgs - Aug 5 zero cal. rdgs}}$$

Item No. b. Code for Calibrator Level, Mode, Program

15 Code in digital channel 35 gives general information as to how the data acquisition system is used.

Digital location	Code	Explanation
10^4	0	Not used
10^3		Calibrator level:
	0	Calibrator off
	1	Calibrator on zero
	2	Calibrator +
	3	Calibrator -
10^2		System mode:
	1	System calibrate
	3	Scanivalve data
	5	Averaging mode for force or force-pressure combination
10^1	0	Not used
10^0	1	Only Program 1 is used

Examples of readings in Channel 35:

For the CR points (usually calibrate points 1-15) designation must be:

01101 for points 1-5, zero
02101 ~~01201~~ for points 6-10, calibrator +
04101 01401 for points 11-15, calibrator -

For data points, typical examples are given below:

00301 for pressures from scanivalves. Will read one frame per port number
00501 for force, or force-pressure-combination. Averaging mode. Will call for program to average n number of frames (may vary from 1-48)

16 c. System Full-Scale Voltage Range

Programer : Please put a check in program to make sure that on all analog channels the first of the five digits is 1. If it has some other value please notify 8-Foot Computing Office.

Item No. Engineer: It is strongly advised that as consistently as possible all testing be held to the full-scale range of 12.5 MV. It is recognized that the system has the built-in capability of varying the range in groups of nine channels and coding in this locating to indicate range (12.5, 23, 50, 100 MV being represented by 1, 2, 4, 8 respectively). However, the alternative of adjusting the instrumentation instead to feed into a fixed range of 12.5 MV will forestall many foreseeable errors.

17 d. Power Supply Voltage Reference

8-Foot Computing Staff: Channel 33, voltage reference, normally should remain almost constant (for example ≅5780 counts representing 6 volts). If counts in this channel vary more than by ±5 during one test, data will be in question and shift engineer and project engineer should be notified in order that steps be taken immediately to correct the situation.

BALANCE INPUT

Item No.

3. BALANCE INPUT

a. Initial Loads on Model, lb and in-lb

(1) Uncorrected for balance interactions (input on load sheets in counts):

It is not necessary to apply calibrate ratio either at 8-Foot or ACD; however, the span-check values will have been divided by the CR before being entered on load sheets.

Note for 8-Foot Computing Staff:

(a) For pitch or parameter runs:

With model tested in upright position, balance upright in model, N INITIAL (when reduced to pounds) will be <u>negative</u> and equal in value to the weight of the model.

With model tested in an inverted position, N INITIAL will be <u>positive</u> and equal in value to the weight of the model.

(b) For yaw runs, right wing down:

With model in testing position, right wing down, balance upright in model, Y INITIAL when reduced to pounds will be <u>positive</u> and equal in value to the weight of the model.

With model rotated 180° (left wing down), Y INITIAL will be <u>negative</u> and equal in value to the weight of the model.

Note also that when the model is tested in an inverted position, the initial loads naturally are reversed, still following the relationship "model in testing position - model rotated 180°."

18 $$\text{N INITIAL} = \frac{\begin{pmatrix}\text{N, counts with model} \\ \text{in testing position}\end{pmatrix} \text{KN} - \begin{pmatrix}\text{N, counts, model} \\ \text{rotated } 180^{\circ}\end{pmatrix} \text{KN}}{2}$$, initial load for normal force, lb

Item No.

Similarly for:

19 A INITIAL, axial force, lb

20 M INITIAL, pitching moment, in-lb

21 ROLL INITIAL, rolling moment, in-lb

22 YAW INITIAL, yawing moment, in-lb

23 SIDE INTIAL, side force, lb

To correct initial loads for balance interactions: using the loads as determined in items 18-23 as input, the interactions on each "initial load" component are computed by the following equations. The equations are to be iterated as many times as required to obtain the necessary accuracy.

(2) Correction to initial loads due to balance interactions:

24
```
EPSILON N O = N(K1+K7N+ K8A+ K9M +K10 ROLL+K11 YAW+K12 SIDE)
                    +A( K2+K13A+K14M +K15 ROLL+K16 YAW+K17 SIDE)
                         +M(K3 +K18M +K19 ROLL+K20 YAW+K21 SIDE)
                            +ROLL(K4 +K22 ROLL+K23 YAW+K24 SIDE)
                                       +YAW(K5 +K25 YAW+K26 SIDE)
                                               +SIDE(K6+K27 SIDE)
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Similarly for:

25 EPSILON A O

26 EPSILON M O

27 EPSILON ROLL O

28 EPSILON YAW O

29 EPSILON SIDE O

(3) Initial Loads Corrected for Balance Interactions:

30 N O = N INITIAL - EPSILON N O

31 A O = A INITIAL - EPSILON A O

32 M O = M INITIAL - EPSILON M O

33 ROLL O = ROLL INITIAL - EPSILON ROLL O

Item No.

34 YAW O = YAW INITIAL - EPSILON YAW O

35 SIDE O = SIDE INITIAL - EPSILON SIDE O

b. Main Loads on the Model

(Forces and moments for each data point input, in analog counts, from channels 1-6.)

Provision should be made in the program to use for the zero reading:

1. values from a specified data point
2. values from the average of two or more specified data points
3. a table of values furnished on load sheets to use for zero readings
4. staggered or prorated zeroes.

(1) Main loads uncorrected for balance interactions:

36 N 1 = (N RDG)(CR)(KN) - (N ZERO)(CR)(KN)

37 A 1 = (A RDG)(CR)(KA) - (A ZERO)(CR)(KA)

38 M 1 = (M RDG)(CR)(KM) - (M ZERO)(CR)(KM)

39 ROLL 1 = (ROLL RDG)(CR)(K ROLL) - (ROLL ZERO)(CR)(K ROLL)

40 YAW 1 = (YAW RDG)(CR)(K YAW) - (YAW ZERO)(CR)(K YAW)

41 SIDE 1 = (SIDE RDG)(CR)(K SIDE) - (SIDE ZERO)(CR)(K SIDE)

(2) Main loads uncorrected for initial loads + initial loads corrected for balance interactions:

42 N 2 = N 1 + N O

43 A 2 = A 1 + A O

44 M 2 = M 1 + M O

45 ROLL 2 = ROLL 1 + ROLL O

46 YAW 2 = YAW 1 + YAW O

47 SIDE 2 = SIDE 1 + SIDE O

Item No.

(3) Correction to total loads due to balance interactions:

Using items 42-47 as input, the balance interactions on each component are computed by the following equations:

48 EPSILON N = N(K1+K7N+ K8A+ K9M +K10 ROLL+K11 YAW+K12 SIDE)
+A(K2+K13A+K14M +K15 ROLL+K16 YAW+K17 SIDE)
etc.

Similarly for:

49 EPSILON A

50 EPSILON M

51 EPSILON ROLL

52 EPSILON YAW

53 EPSILON SIDE

(4) Main loads corrected for balance interactions:

The corrected net forces and moments are referenced to the balance-axes system and represent the changes in the total loads from the values that existed at the time the zero readings were taken. These total loads are composed of the aerodynamic and weight tare (attitude) loads.

54 N 3 = N 1 - (EPSILON N - EPSILON N O)

55 A 3 = A 1 - (EPSILON A - EPSILON A O)

56 M 3 = M 1 - (EPSILON M - EPSILON M O)

57 ROLL 3 = ROLL 1 - (EPSILON ROLL - EPSILON ROLL O)

58 YAW 3 = YAW 1 - (EPSILON YAW - EPSILON YAW O)

59 SIDE 3 = SIDE 1 - (EPSILON SIDE - EPSILON SIDE O)

Since the next computations involving forces and moments require the use of functions of computed angles, the computation of angles will be considered next.

ALPHA, BETA, PHI

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by temporary
copies dated 6-17-70

4. COMPUTATION OF ANGLES

6-17-70

(Equations are based on model attitude being set with respect to the balance centerline. See explanation of DELTA for case where test is made with respect to body reference line, rather than balance centerline.)

a. Angle of sideslip, BETA or β

60 BETA 1 D, digital counts, channel 62

61 BETA 1 D, deg = (BETA RDG)(K BETA) − (BETA ZERO)(K BETA)
(Ch 62)(K 28) (Ch 62)(K 28)

and/or

62 BETA 1 A, analog counts, channel 17

63 BETA 1 A, deg = (BETA RDG)(CR)(K BETA) − (BETA ZERO)(CR)(K BETA)
(Ch 17)(CR)(K 94) (Ch 17)(CR)(K 94)

64 BETA 2 D = angle of sideslip corrected for sting bending, used for computing WC and BETA 3

BETA 2 D, deg = (BETA 1 + K SIDE BETA) (Y 3) + K YAW BETA (YAW 3)
(K 32) (K 34)

(signs of K SIDE BETA and K YAW BETA always negative)

65 BETA 2 A ≡ BETA 1 A

66 For parameter runs: (wings horizontal)

BETA ≡ BETA 3 = sin^{-1} [(SIN BETA 2)(COS ALPHA 2)] −BETA A (in hor. plane)
(includes coupling angle)

For yaw runs: (wings vertical)

BETA ≡ BETA 3 = BETA 2 + BETA 0 − BETA A (in vertical plane)

b. Angle of attack, ALPHA, or α

67 ALPHA 1 D, digital counts, channel 63

68 ALPHA 1 D, deg = (ALPHA RDG)(K ALPHA) − (ALPHA ZERO)(K ALPHA)
(Ch 63) (K 33) (Ch 63) (K 33)

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and/or 6-17-70

69 ALPHA 1 A, analog counts, channel 18

70 ALPHA 1 A, deg = (ALPHA RDG)(CR)(K ALPHA) - (ALPHA ZERO)(CR)(K ALPHA)
(Ch 18)(CR)(K 27) (Ch 18)(CR)(K 27)

Note: If model is tested in an inverted position (e.g. for determining flow angularity or for other reasons) the sign of KALPHA (or KBETA as the case may be) will be reversed. However, this will be taken into account at 8-Foot and correct sign entered on load sheets. No change is required in programming.

71 ALPHA 2 D = ALPHA 1 D + KN ALPHA(N3) + KM ALPHA(M3), angle of
(K 30) (K 31)

attack corrected for sting bending, used for computing WC, and ALPHA 3

(signs of KN ALPHA and KM ALPHA always positive)

72 ALPHA 2 A = ALPHA 1 A (no correction necessary)

73 For parameter runs: (wings horizontal; ALPHA varying for fixed values of BETA)

$$\text{ALPHA 3} = \tan^{-1}\frac{\text{TAN ALPHA 2}}{\text{COS BETA 2}} + \underset{(K\ 71)}{\text{ALPHA 0}} - \underset{(K\ 111)}{\text{ALPHA A}} - \underset{(K\ 74)(CN)}{\text{ALPHA WI}}$$

(vertical plane)

$$- \underset{(K\ 72)}{\text{THETA M}} + \underset{(K\ 75)}{\text{DELTA}},$$

For yaw runs: (wings vertical; BETA varying for fixed values of ALPHA)

ALPHA 3 = ALPHA 2 + ALPHA 0 - ALPHA A - ALPHA WI - THETA M + DELTA
(Horizontal plane)

angle which may be used for computing stability-axes coefficients and for listing: (from this point the equations are identical and both analog and digital angles should be programmed, even if only one is requested for listing)

(This angle fully corrected when used for computing coefficients will be designated ALPHA in the standard or fixed testing; the other, if listed, as either ALPHA A or ALPHA D, as the case may be.)

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Values of the following possible adjustments to ALPHA 2 and BETA 2, indicated above, will be furnished on load sheets:

74 ALPHA 0, angle $\neq$ 0 at which model may be set (by using a coupling) and instruments zeroed. Considered to be positive when, with model upright, nose of model is up and, with model inverted, nose of model is down.

75 BETA 0, angle $\neq$ 0 at which model may be set (by using a coupling) when rolled 90° and instruments zeroed.

76 ALPHA A, or BETA A, angle of angularity of flow between the relative wind and test reference line with model in zero testing position (CN = 0, or in the case of yaw runs CY = 0, or some constant value of CN or CY, e.g. CN CRUISE, CY CRUISE) Considered to be positive where relative wind has a downflow to the test reference line. Values determined from results of a series of runs made during test with

(1) Model upright (Downflow is indicated if with the testing position model upright ALPHA A is positive; upflow if ALPHA A is negative.
(2) Model inverted (Downflow is indicated if with the testing position Model inverted ALPHA A is negative; upflow if ALPHA A is positive.

$$\text{ALPHA A} = \frac{(\text{ALPHA 3, model in testing position} - \text{ALPHA 3, model rotated } 180^{\circ})}{2}$$

at constant values of CN, from plots of CN vs ALPHA.
Similarly for BETA A, for yaw runs. (ALPHA A = 0 for yaw runs, BETA = 0 for pitch and parameter runs.)

77 ALPHA WI, wall interference correction to ALPHA, = CN(KWI)

KWI will be positive, constant for a test; a positive CN will then decrease ALPHA 3. Used only in computing ALPHA with wings horizontal.

Either use a different value for KWI, or let KWI = 0, for yaw runs (wings vertical)
(No correction to BETA for wall interference, since slots are only in top and bottom of tunnel, not on sides)

Item No.

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78 THETA M, angle of misalinement between balance and model reference lines = ALPHA BAL - ALPHA MODEL. Considered to be positive when balance center line is at a more positive angle of attack than the model reference line. Used in changing from balance to body axis and in computing ALPHA 3

79 DELTA = ALPHA BAL - ALPHA OTHER REF, angle of difference between balance center line and some other reference line which might have been used purposely or inadvertently to set model for testing. Considered to be positive when balance center line is at a more positive angle of attack than the reference line.

Possible cases:

1. DELTA = 0^{o}, angle set by balance center line, preferable mode of testing.
2. DELTA = THETA M, angle set by model reference line, and both values must be put into computations
3. DELTA = ALPHA BAL - ALPHA OTHER REF, angle set by some other reference.

Item No.

80 ALPHA 4 = ALPHA 3 + IW, computed when it is desired that an angle other than ALPHA 3 be listed. For example, it may be desirable to plot the coefficients (which have been computed using functions of ALPHA 3) against some different angle
e.g. ALPHA 4 = ALPHA 3 + wing incidence angle

If it is desirable to list both ALPHA 3 and ALPHA 4, special instructions should be given to programer. Otherwise ALPHA 3 will be used to compute coefficients and ALPHA 4 will be listed as ALPHA on the top or standard row.

c. Angle of roll, PHI or Ø

81 PHI 1, channel 64, digital counts

82 PHI 1 = (PHI RDG)(K PHI) - (PHI ZERO)(K PHI), deg
and/or (Ch 64)(K 29) (Ch 64)(K 29)

83 PHI 1, channel 19, analog counts

84 PHI1 = (PHI RDG)(CR)(K PHI) = (PHI ZERO)(CR)(K PHI), deg
(Ch 19)(CR)(K 29) (Ch 19)(CR)(K 29)

BASE PRESSURES

Item No. 5. BASE PRESSURES

If there are pressure measurements, the computations should be done at this point in the program and the values stored for use in further calculations and/or for listing. For each pressure from transducers in analog channels 9-16, or from transducers in spare channels, the following equations will apply:

85 P,N = [(P RDG,CTS)(CR)-(P ZERO RDG,CTS)(CR)] KP,N + P REF,lb/sq ft ,

where:

N, as a subscript, refers to any single pressure

P REF will almost invariably be PTC

KP,N, instrument sensitivity constant, will vary with calibration of instrument in use, and will be furnished on load sheets. For base pressures only one set of sensitivity constants will be furnished with the same constants applying to both positive and negative counts. However, CR values will be computed and applied as usual at ACD in computing the pressures.

86 DELTA P,N = (P,N - PINF), lb/ft^2

a. Pressure coefficients from individual pressure measurements

87 $$CP,N = \frac{DELTA\ P,N}{QINF}$$

Because, in tests in the 8-foot transonic pressure tunnel, models may have model components such as the fuselage or nacelles which have base areas the normals of which are at angles of incidence to the model axis, this angle, or angles as the case may be, must be taken into account in computing the base normal force, base axial force, base lift force and base drag force and base pitching moment as indicated in the following equations:

b. Forces computed from individual pressure measurements, lb and in-lb

88 NB,N = - [- (DELTA P,N)S,N] SIN THETA C,N, base normal force for individual pressures, lb

89 S,N, base or chamber area, sq ft

Item No.

90 THETA C, the angle between a line perpendicular to the base and the model x-axis. Values of THETA C furnished on load sheets and may differ for each nacelle and/or base. THETA here is defined as the angle between the ℄ (or a line perpendicular to the base if they are not the same) of the nacelle or some other component on which base pressure is being measured, and the model ℄ or reference line.

The sign convention used is that if this line with respect to the horizontal or relative wind makes a more positive angle than ALPHA, then THETA is positive. Usually this will mean that the nose of the nacelle is up from the horizontal.

By the same token, if this line is below the model reference line, or at a more negative angle than ALPHA, THETA is negative. Usually this will mean that the nose of the nacelle is down.

91 AB,N = - [(DELTA P,N)S,N] COS THETA C, N, base axial force, lb

92 MB,N = - [(NB,N) X BASE] + [(AB,N)Z BASE]

93 X BASE, in., distance from center of pressure of base pressure force (assumed to be at center of area of base) to moment reference point, measured parallel to model X-axis.

94 Z BASE, in., distance from center of pressure of base pressure force (assumed to be at center of area of base) to moment reference point, measured parallel to model Z-axis.

If THETA C = 0°, NB = 0, so X BASE will drop out anyhow, but Z BASE will still be needed in computations since AB will have a value $\neq 0$.

95 LB,N = -[- (DELTA P,N)S,N] SIN(ALPHA 3 + THETA C,N), base lift, lb

96 DB,N = [- (DELTA P,N)S,N] COS(ALPHA 3 + THETA C,N), base drag, lb

c. Forces and moments computed from total pressure measurements

97 $$\text{NB} = \sum_{1}^{M} \text{NB,N} \qquad \text{(Where N varies from 1 to M)}$$

Item No.

98 $$AB = \sum_{1}^{M} AB,N$$

99 $$MB = \sum_{1}^{M} MB,N$$

100 $$LB = \sum_{1}^{M} LB,N$$

101 $$DB = \sum_{1}^{M} DB,N$$

d. Base force and moment coefficients based on individual pressure measurements

102 $$CNB,N = \frac{NB,N}{QINF(S)}$$

103 $$CAB,N = \frac{AB,N}{QINF(S)}$$

104 $$CMB,N = \frac{MB,N}{QINF(S)(C)}$$

105 $$CLB,N = \frac{LB,N}{QINF(S)}$$

106 $$CDB,N = \frac{DB,N}{QINF(S)}$$

Item No.

e. Base coefficients based on total pressure measurements

107 $$CNB = \frac{NB}{QINF(S)}$$

108 $$CAB = \frac{AB}{QINF(S)}$$

109 $$CMB = \frac{MB}{QINF(S)(C)}$$

110 $$CLB = \frac{LB}{QINF(S)}$$

111 $$CDB = \frac{DB}{QINF(S)}$$

Note that provision should be made in the program for the following alternatives:

1. Using all the pressures measured to calculate a correction to axial force (and therefore to related components)
2. Using only specified pressures
3. Computing and listing CAB,N and CDB,N (individual values)
4. Computing and listing CAB and CDB (total or summed values)
5. Computing and listing CP, pressure coefficient only, from some of the measured pressures not used as a correction to axial force.
6. Accepting a table of values of CP on load sheets, from which to compute a correction to axial force.

BALANCE – AXES DATA

6. AERODYNAMIC FORCES AND MOMENTS ABOUT THE BALANCE AXES

Item No.	
112	WC,N = (ALPHA 2)(KW ALPHA,N) + (BETA 2)(KW BETA,N) , lb
113	WC,A = (ALPHA 2)(KW ALPHA,A) + (BETA 2)(KW BETA,A) , lb
114	WC,M = (ALPHA 2)(KW ALPHA,M) + (BETA 2)(KW BETA,M) , in-lb
115	WC,ROLL - equations similar to above.
116	WC,YAW
117	WC,SIDE
	Balance upright in model
118	N 4 = N 3 - WC,N
119	A 4 = A 3 - WC,A
120	M 4 = M 3 - WC,M
121	ROLL 4 = ROLL 3 - WC,ROLL
122	YAW 4 = YAW 3 - WC, YAW
123	SIDE 4 = SIDE 3 - WC, SIDE
	Balance inverted in model
124	N 4 = - (N 3 - WC,N)
125	A 4 = A3 - WC,A same as for upright
126	M 4 = - (M 3 - WC,M)
127	ROLL 4 = ROLL 3 - WC, ROLL same as for upright
128	YAW 4 = - (YAW 3 - WC,YAW)
129	SIDE 4 = - (SIDE 3 - WC, SIDE)

Note to programer : This sign change is presently effected in the program by reversing the signs of N,M,YAW, and SIDE immediately after interactions have been taken into account, if the balance is mounted inverted in the model.

BODY – AXES DATA

Item No. 7. AERODYNAMIC FORCES AND MOMENTS ABOUT THE BODY AXES

Moments corrected for longitudinal and vertical misalinement of model reference and balances axes. (X and Z are referenced to the body axes and not balance axes; that is, X distance is measured parallel to X body axis and Z distance parallel to Z body axis)

(The subscript UNC will indicate that the forces and moments are uncorrected for measured base pressure. The subscript CORR will indicate that the forces and moments are corrected for measured base pressure. When there is an angle of misalinement, rotate first, then translate or transfer)

130 N BODY UNC = N 4(COS THETA M) - A 4(SIN THETA M)
(This rotates the forces)

131 N BODY CORR = N BODY UNC - NB

132 A BODY UNC = A 4(COS THETA M) + N 4(SIN THETA M)

133 A BODY CORR = A BODY UNC - AB

134 M BODY UNC = M4 - N BODY UNC (X) - A BODY UNC (Z)
(this translates or transfers the moments)

135 M BODY CORR = M BODY UNC - MB

136 ROLL BODY, DISPLACED = ROLL 4(COS THETA M + YAW 4(SIN THETA M))

137 YAW BODY, DISPLACED = YAW 4(COS THETA M - ROLL 4(SIN THETA M))

138 ROLL BODY = ROLL BODY, DISPLACED - SIDE 4(Z)

139 YAW BODY = YAW BODY, DISPLACED - SIDE 4(X)

140 SIDE BODY ≡ SIDE 4 ≡ SIDE 3

BODY COEFFICIENTS

8. BODY-AXES COEFFICIENTS

Item No.

141 $$CN\ UNC = \frac{N\ BODY\ UNC}{QINF(S)}$$

142 $$CN = \frac{N\ BODY\ CORR}{QINF(S)}$$

143 $$CA\ UNC = \frac{A\ BODY\ UNC}{QINF(S)}$$

144 $$CA = \frac{A\ BODY\ CORR}{QINF(S)}$$

145 $$CM\ UNC = \frac{M\ BODY\ UNC}{QINF(S)(C)}$$

146 $$CM = \frac{M\ BODY\ CORR}{QINF(S)(C)}$$

147 $$C\ ROLL\ B = \frac{ROLL\ BODY}{QINF(S)(B)}$$

148 $$C\ YAW\ B = \frac{YAW\ BODY}{QINF(S)(B)}$$

149 $$C\ SIDE = \frac{SIDE\ BODY}{QINF(S)}$$

NON-ROLL COEFFICIENTS

9. NON-ROLL-AXES COEFFICIENTS

Item No.

For cases where the balance and model are both rolled as a unit, the following equations will resolve the coefficients to non-roll axes ($\phi = 0^o$).

150 CN NR UNC = CN UNC(COS PHI 3) - C SIDE(SIN PHI 3)

151 CN NR = CN(COS PHI 3) - C SIDE(SIN PHI 3)

152 CA NR UNC ≡ CA UNC

153 CA NR ≡ CA

154 CM NR UNC = CM UNC(COS PHI 3) - C YAW UNC(SIN PHI 3)

155 CM NR = CM(COS PHI 3) - C YAW(SIN PHI 3)

156 C ROLL NR = C ROLL B

157 C YAW NR UNC = (C YAW B)(COS PHI 3) + CM UNC(SIN PHI 3)

158 C YAW NR = (C YAW B)(COS PHI 3) + CM(SIN PHI 3)

159 C SIDE NR UNC = C SIDE(COS PHI 3 + CN UNC(SIN PHI 3)

160 C SIDE NR = C SIDE(COS PHI 3) + CN(SIN PHI 3)

For cases where the model is rolled and the balance remains fixed, the following equations will resolve the coefficients to roll or model axes. (Note that equations are identical to preceding except for signs in CN, CM, CSIDE.)

161 CN MODEL UNC = CN UNC(COS PHI 3) + C SIDE(SIN PHI 3)

162 CN MODEL = CN(COS PHI 3) + C SIDE (SIN PHI 3)

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163	CA MODEL UNC = CA UNC
164	CA MODEL = CA
165	CM MODEL UNC = CM UNC(COS PHI 3) + CN UNC(SIN PHI 3)
166	CM MODEL = CM(COS PHI 3) + CN(SIN PHI 3)
167	C ROLL MODEL = C ROLL B
168	C YAW MODEL UNC = (C YAW B UNC)(COS PHI 3) + CM UNC(SIN PHI 3)
169	C YAW MODEL = (C YAW B)(COS PHI 3) + CM(SIN PHI 3)
170	C SIDE MODEL UNC = C SIDE(COS PHI 3) - CN UNC(SIN PHI 3)
171	C SIDE MODEL = C SIDE(COS PHI 3) - CN(SIN PHI 3)

STABILITY COEFFICIENTS

10. STABILITY-AXES COEFFICIENTS

Item No.

172 CL UNC = CN UNC(COS ALPHA 3) - CA UNC(SIN ALPHA 3)

173 CL UNC^2

174 CL = CN(COS ALPHA 3) - CA(SIN ALPHA 3)

175 CL^2

176 $\text{CDI} = \text{B1} + \text{B2}(\text{ALPHA } 3) + \text{B3}(\text{ALPHA } 3)^2 + \text{B4}(\text{ALPHA } 3)^3$, a third-order equation calculated from a curve fit program. Values of B will be furnished in tables in ascending order of Mach number. They will vary with Mach number and possibly with configuration

177 CD, buoyancy furnished as a table on 8-foot load sheets

178 CD UNC = CA UNC(COS ALPHA 3) + CN UNC(SIN ALPHA 3) - CDI - CD, buoyancy

179 CD = CA(COS ALPHA 3) + CN(SIN ALPHA 3) - CDI - CD, buoyancy

180 $\text{L/D UNC} = \dfrac{\text{CL UNC}}{\text{CD UNC}}$

181 $\text{L/D} = \dfrac{\text{CL}}{\text{CD}}$

182 CM same as for body axes

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	NOTE:	As a usual practice, the lateral coefficients CROLL and CYAW will be computed and listed about the body axes and these lateral coefficients about the stability axis will not be presented. However, for the cases when they will be requested, the capability of computing and space for listing should be provided in the program
183	C ROLL S = C ROLL B(COS ALPHA 3) + C YAW B(SIN ALPHA 3)	
184	C YAW S = C YAW B(COS ALPHA 3) + C ROLL B(SIN ALPHA 3)	
185	C SIDE (same as for body axis)	

MISCELLANEOUS

11. ADDITIONAL EQUATIONS TO BE PROGRAMED

Item No.

186 Reynolds Number, R

$$R \times 10^{-6} = L\ (1.798)\ QINF \left(\frac{1 + .2\ MINF^2}{MINF} \right) \left[\frac{T\ TINF + 198.6\ (1 + .2\ MINF^2)}{T\ TINF^2} \right]$$

where:
T TINF, total temperature, $^{\circ}R$ = TEMP, $^{\circ}F$ + 459.67°. L, reference dimension, ft, entered on load sheets (If R/ft is desired, L = 1.0)

187 Buffet Data

$$MWSG = KWSG \left(\frac{\text{Gain cal., cts}}{\text{Gain, cts}} \right) (\text{Strain-gage cts}),$$ wing-root bending moment, in-lb

where the following are furnished on load sheets:

KWSG, wing strain-gage sensitivity from calibration, $\frac{\text{in-lb}}{\text{ct}}$.
(KWSG 1 in loc 35, KWSG 2 in loc 78)

Gain cal., gain at which calibration was made, cts.
(Gain cal. 1 in loc 76
Gain cal. 2 in loc 83)

Gain, cts = (DC amplifier, cts) (Integrator, cts), coded in channel 45

Strain-gage, cts, input in channel 31 or 32

Note that channel 45 contains not a definite value of gain (which is the inverse of attenuation) but a code by which the two factors of gain and the channel or channels in use for strain-gage counts are to be selected and the value of gain computed from them. For example: the five digits in channel 45 (the first digit, always 0, to be ignored):

ignore	32	31	32	31	
0	0	2	0	9	only channel 31 in use
0	2	0	9	0	only channel 32 in use
0	2	3	4	9	both 31 and 32 in use

Item No.

Code for the five digits in channel 45

Digits: 1	2	3	4	5
Not used	Ch 32 Gage 2	Ch 31 Gage 1	Ch 32 Gage 2	Ch 31 Gage 1
	DC Amplifier		Integrator	
	0	off	0	off
	1	200	1	1
	2	500	2	2
	3	1000	3	3
			4	5
			5	10
			6	20
			7	30
			8	50
			9	100

(It is desirable that channels 31, 32, 45, counts, appear on pre-edit.)

$$CMWSG = \frac{MWSG}{Q}$$, wing-root bending-moment coefficient

Item No.

188 Dew Point Temperature, ^{o}F

(Charts posted in control room for determining limits.)

Dew Point = (counts in ch 48 - 500) KDPN

KDP1 = .214286 deg/ct for + cts
KDP2 = .230769 deg/ct for - cts

(It is desirable that channel 48, counts, appear on pre-edit.)

189 Center of Pressure, XCP

$$\text{XCP, pitch plane, in.} = A + B \left(\frac{CM}{CN}\right)$$

$$\text{XCP, yaw plane, in.} = A + B \left(\frac{C\ YAW}{C\ SIDE}\right)$$

where the following are furnished on load sheets:

A, in, locates the position of the moment reference center relative to the center-of-pressure reference location (e.g. distance from base, or nose, or wing-leading or trailing edge to the moment reference center)

B does two things:

1. Its sign determines the direction of the XCP reference location forward or rearward of the moment reference center.
   Normally + for missiles (e.g. forward of base if the base is the moment reference center)
   - for aircraft (e.g. behind nose, wing-leading edge, etc.)

2. Its magnitude may relate $\frac{CM}{CN}$ to some reference other than the moment reference (e.g. model length, in which case $B = \pm \frac{\text{reference dimension}}{\text{Model length}}$)

   If XCP is based on reference dimension, $B = \pm 1$

190 Beta derivatives (C ROLL BETA, C YAW BETA, C SIDE BETA)
Obtained by special program at ACD.

11. ADDITIONAL EQUATIONS TO BE PROGRAMED

Item No.