SLAC-91
UC-28
(EXPI) & (ACC)

TRANSPORT/360
A COMPUTER PROGRAM FOR DESIGNING CHARGED PARTICLE BEAM TRANSPORT SYSTEMS

KARL L. BROWN, SAM K. HOWRY
STANFORD LINEAR ACCELERATOR CENTER
STANFORD UNIVERSITY
Stanford, California 94305

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TRANSPORT FLOW CHART

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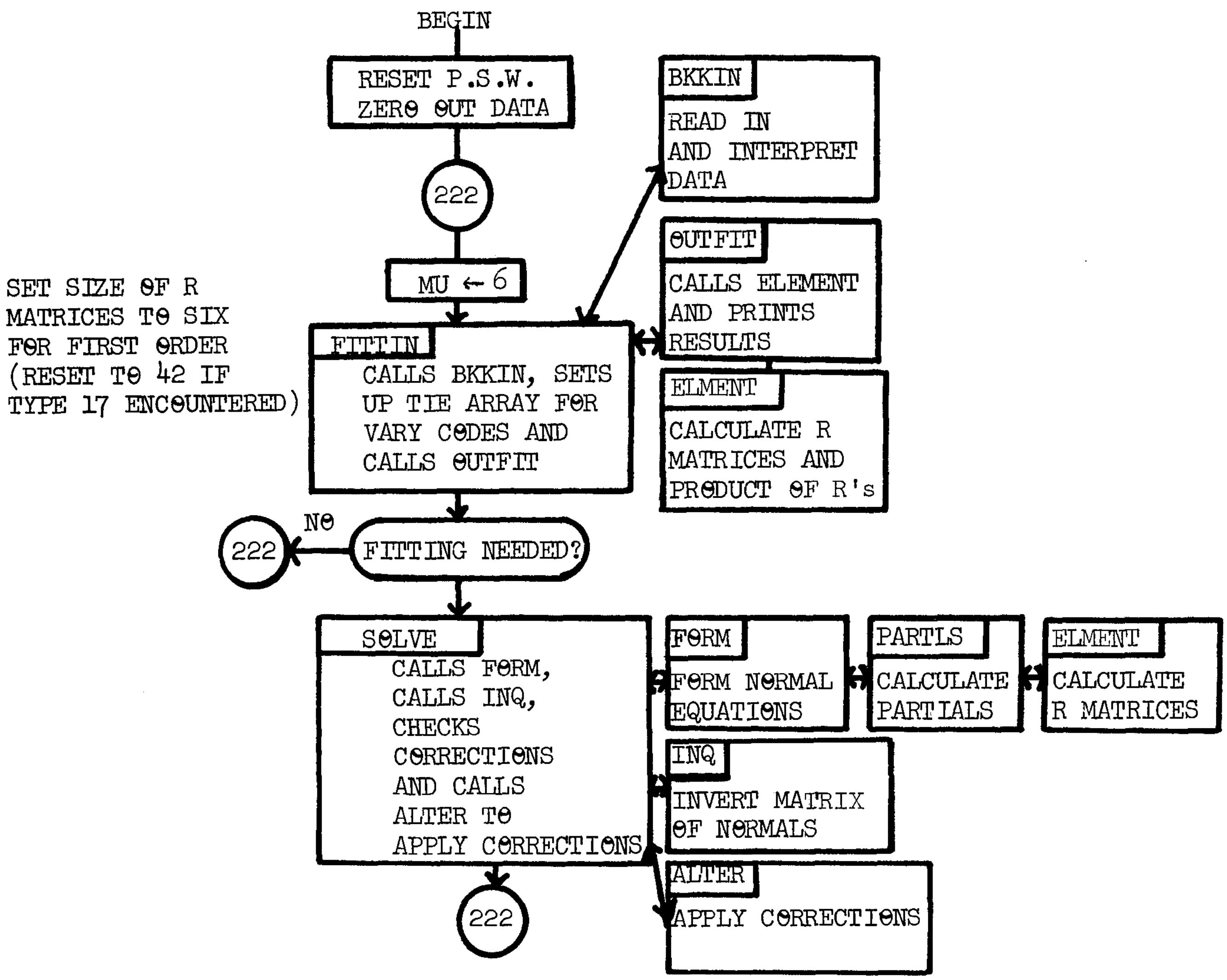
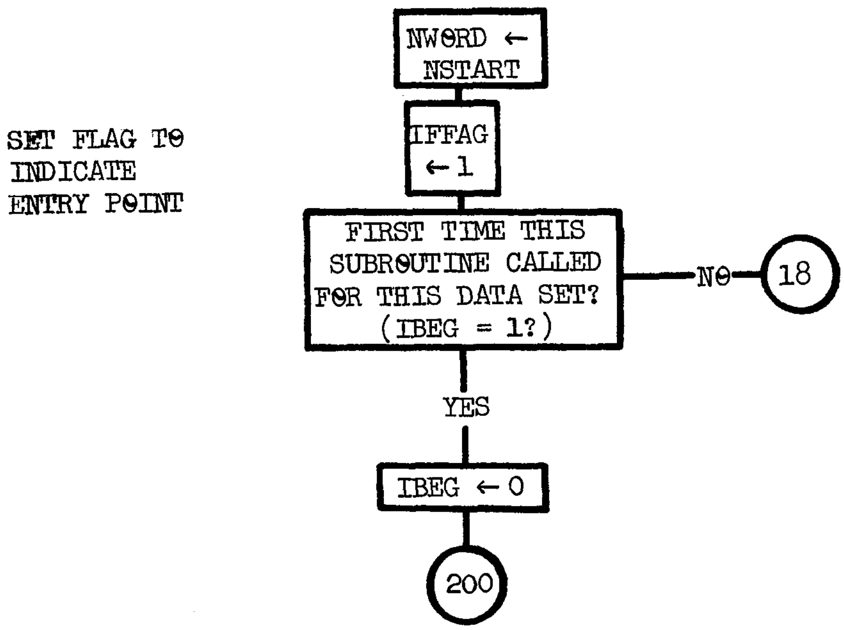
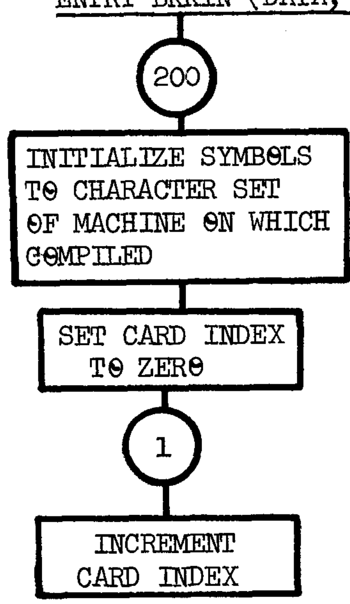

BEGIN
RESET P.S.W.
ZERO OUT DATA
222
MU ← 6
SET SIZE OF R MATRICES TO SIX FOR FIRST ORDER (RESET TO 42 IF TYPE 17 ENCOUNTERED)
FITTIN
CALLS BKKIN, SETS UP TIE ARRAY FOR VARY CODES AND CALLS OUTFIT
BKKIN
READ IN AND INTERPRET DATA
OUTFIT
CALLS ELEMENT AND PRINTS RESULTS
ELMENT
CALCULATE R MATRICES AND PRODUCT OF R's
NO
222
FITTING NEEDED?
SOLVE
CALLS FORM, CALLS INQ, CHECKS CORRECTIONS AND CALLS ALTER TO APPLY CORRECTIONS
FORM
FORM NORMAL EQUATIONS
PARTLS
CALCULATE PARTIALS
ELMENT
CALCULATE R MATRICES
INQ
INVERT MATRIX OF NORMALS
ALTER
APPLY CORRECTIONS
222

ENTRY TRANIN(DATA, VARY, KABLE, NSTART, NSTOP, NWORD, IR)

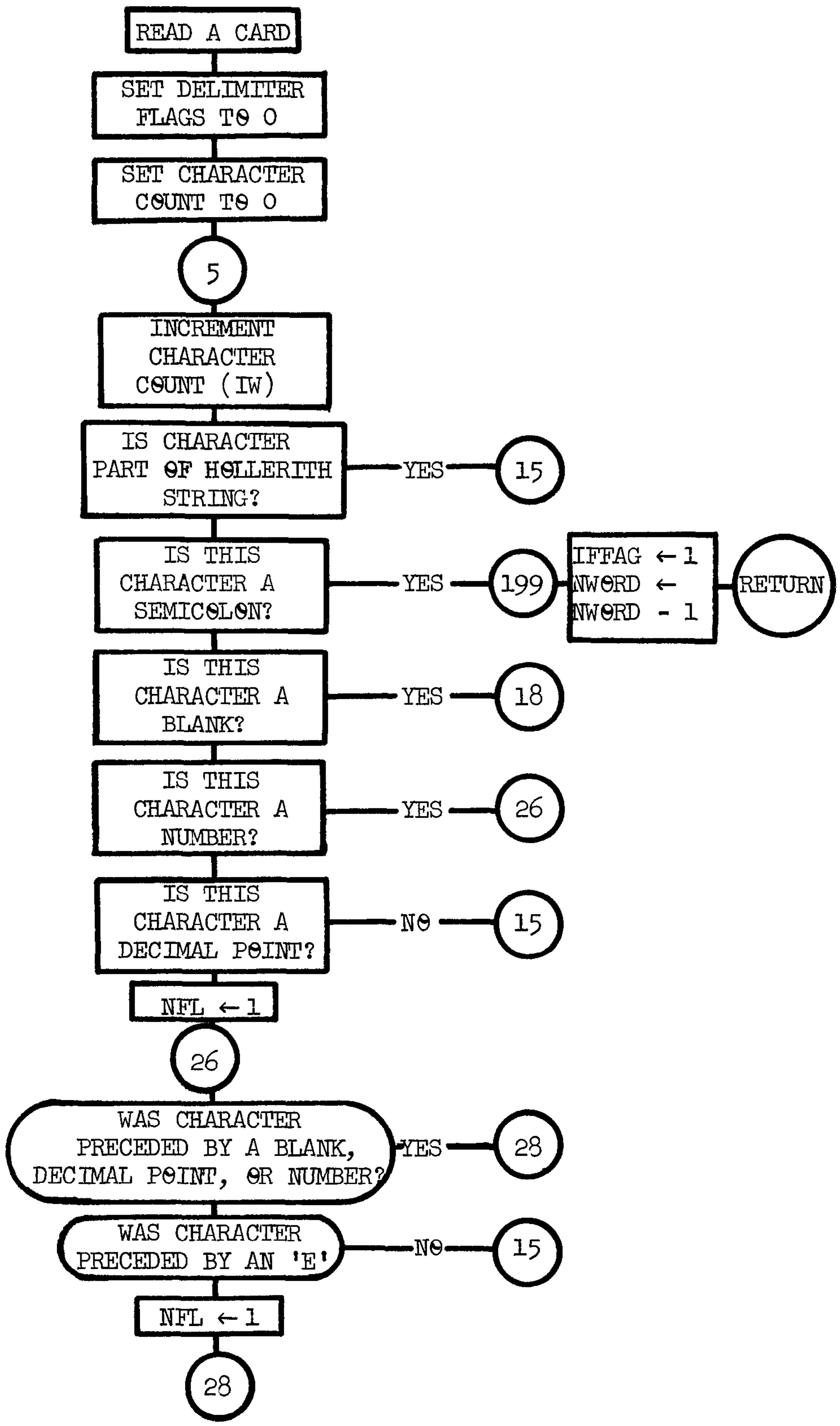


ENTRY BKKIN (DATA, NSTART, NSTOP, NWORD, IR)

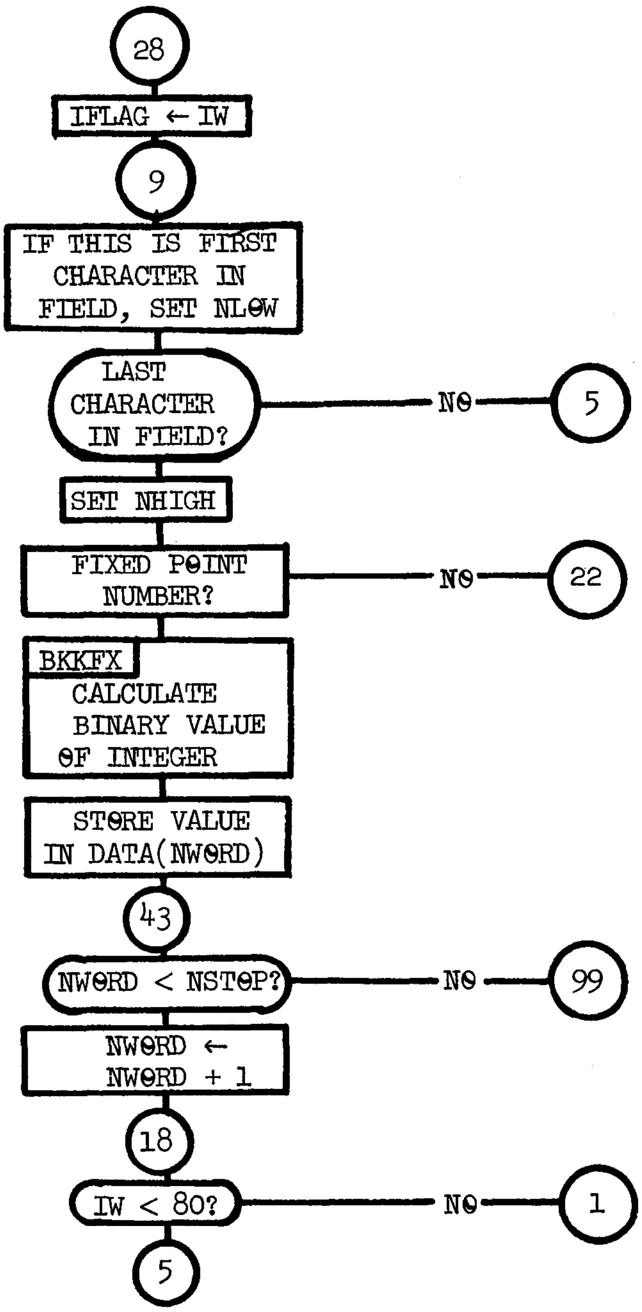


EXAMINE CHARACTER
IN COLUMN IW

SET FLOATING
POINT FLAG

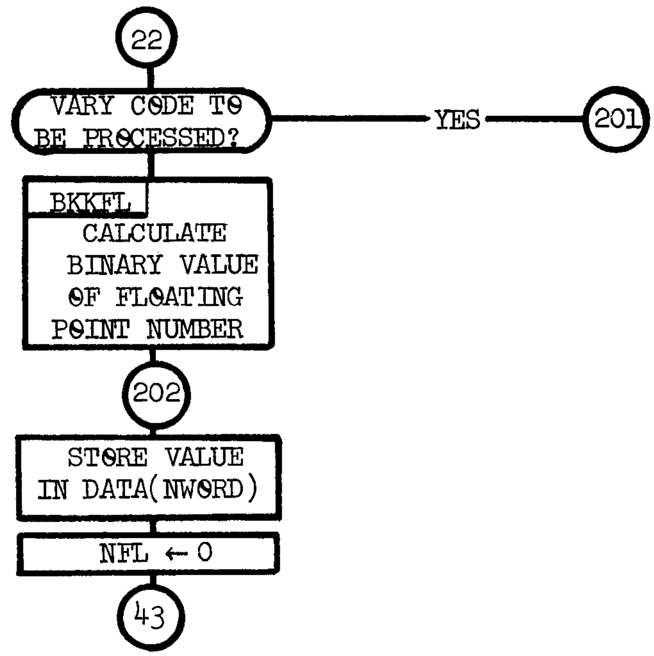


CHARACTER IS PART
OF NUMERIC FIELD

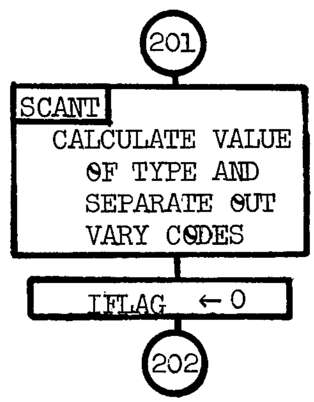


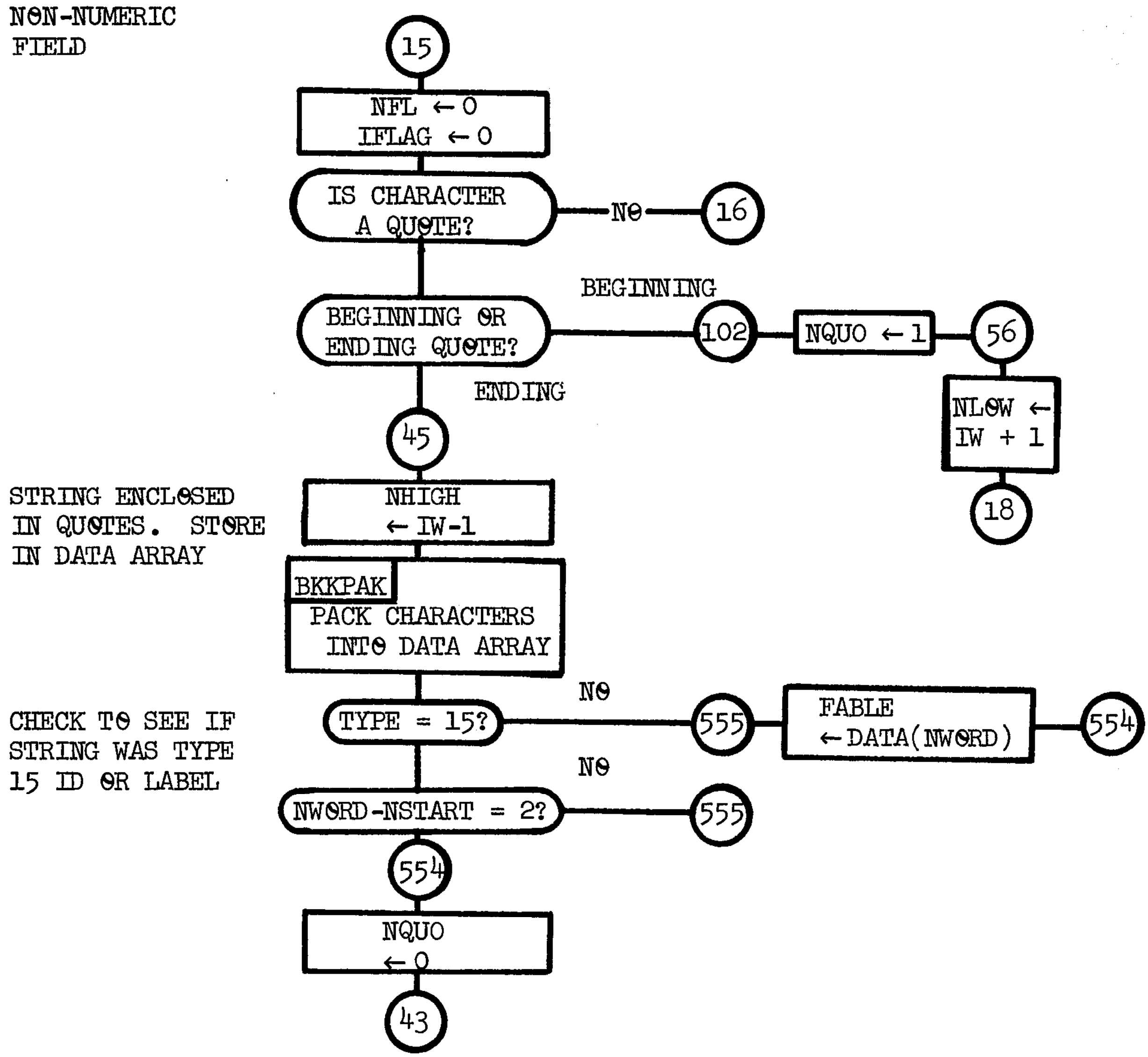
FLOATING POINT
NUMBER

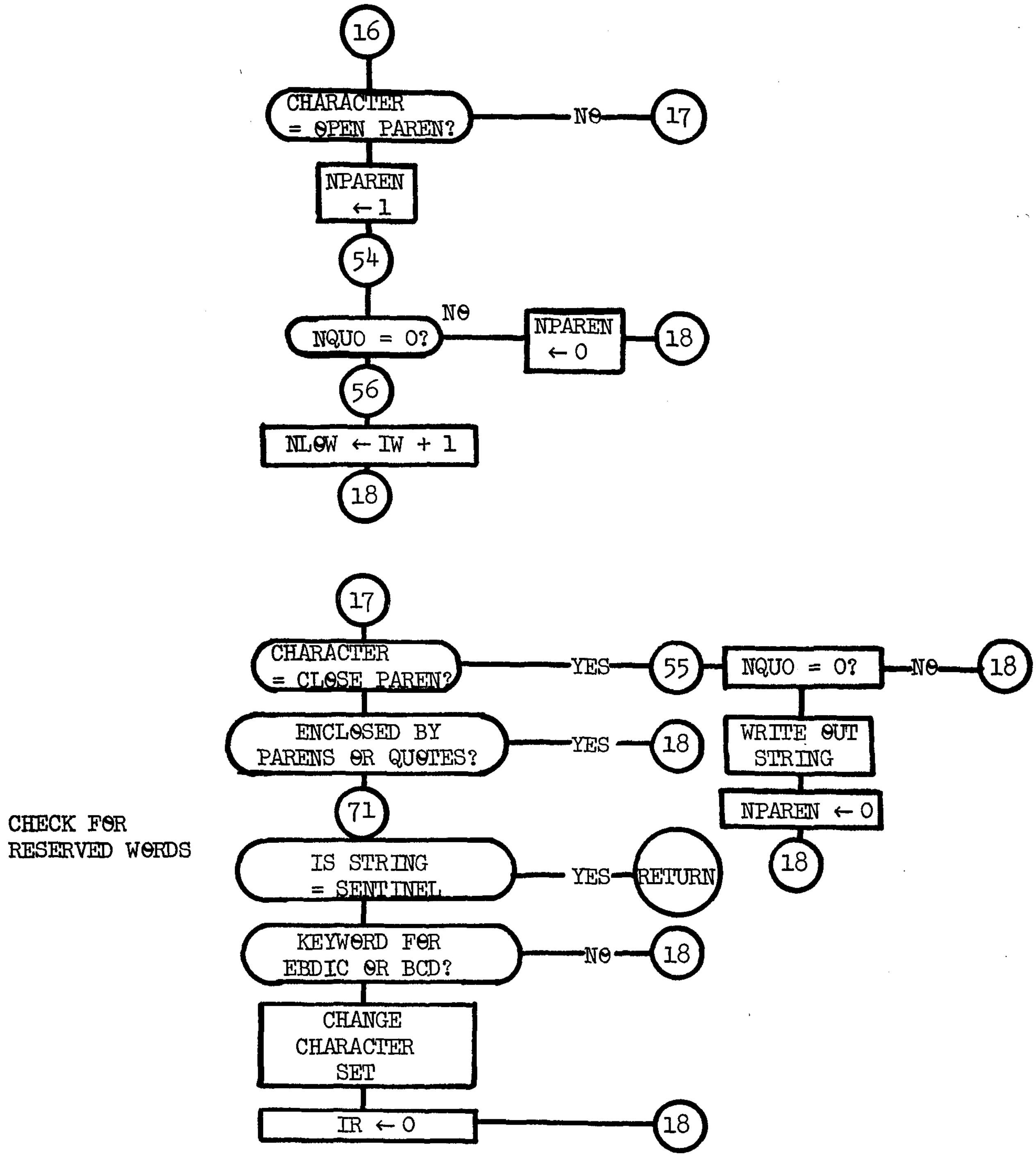
DATA



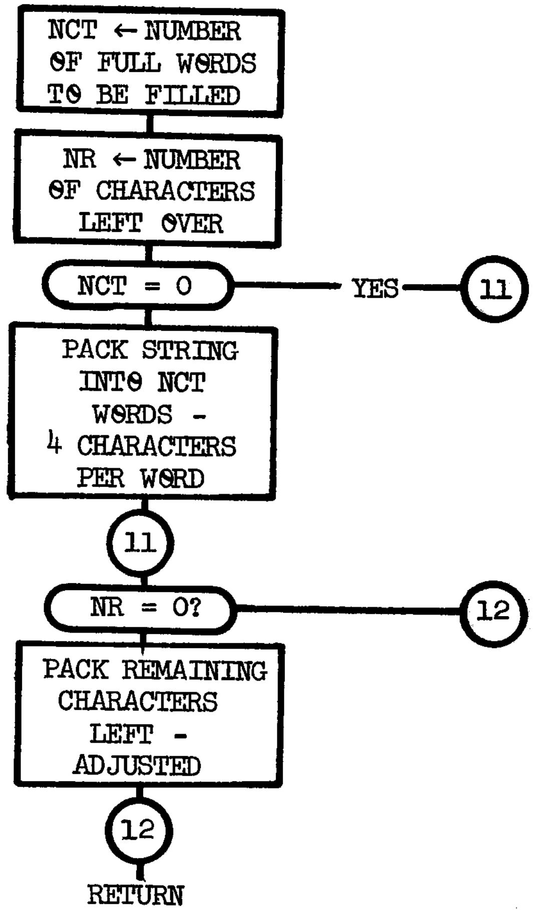
TYPE CODE

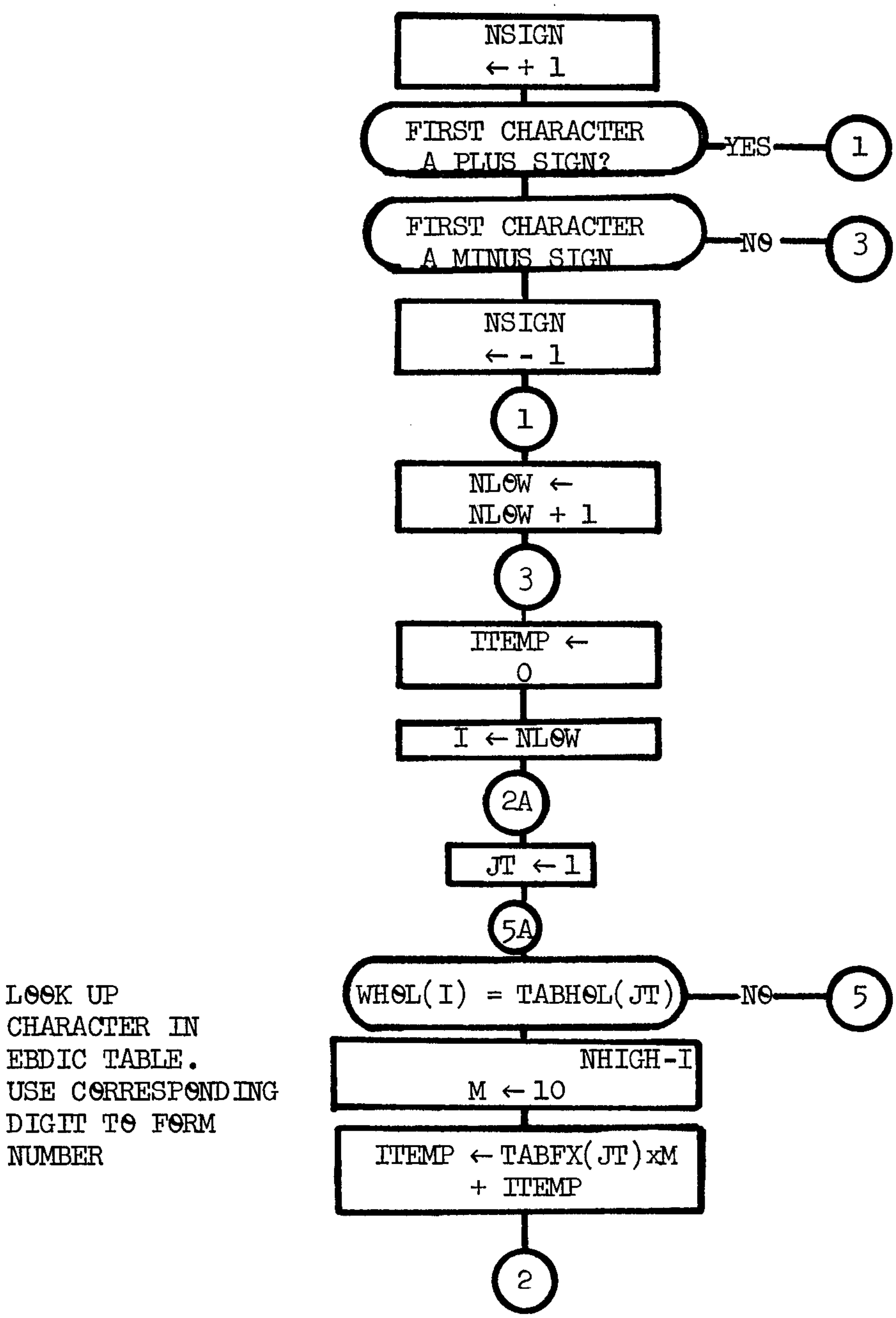



NON-NUMERIC FIELD
15
NFL ← 0
IFLAG ← 0
IS CHARACTER A QUOTE?
NO
16
BEGINNING OR ENDING QUOTE?
BEGINNING
102
NQUO ← 1
56
NLOW ← IW + 1
18
ENDING
45
STRING ENCLOSED IN QUOTES. STORE IN DATA ARRAY
NHIGH ← IW-1
BKKPAK
PACK CHARACTERS INTO DATA ARRAY
CHECK TO SEE IF STRING WAS TYPE 15 ID OR LABEL
TYPE = 15?
NO
555
FABLE ← DATA(NWORD)
554
NWORD-NSTART = 2?
NO
555
554
NQUO ← 0
43

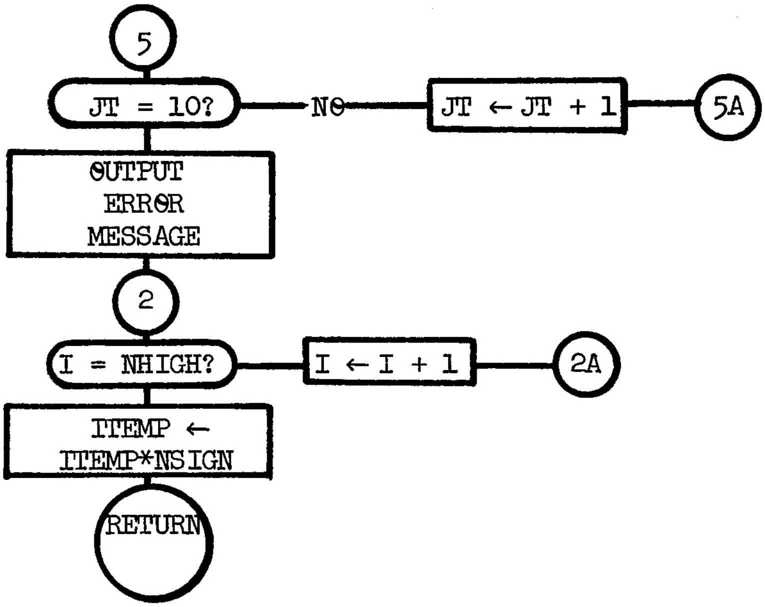

16
CHARACTER = OPEN PAREN?
NO
17
NPAREN ← 1
54
NQUO = 0?
NO
NPAREN ← 0
18
56
NLOW ← IW + 1
18
17
CHARACTER = CLOSE PAREN?
YES
55
NQUO = 0?
NO
18
WRITE OUT STRING
NPAREN ← 0
18
ENCLOSED BY PARENS OR QUOTES?
YES
18
71
CHECK FOR RESERVED WORDS
IS STRING = SENTINEL
YES
RETURN
KEYWORD FOR EBDIC OR BCD?
NO
18
CHANGE CHARACTER SET
IR ← 0
18

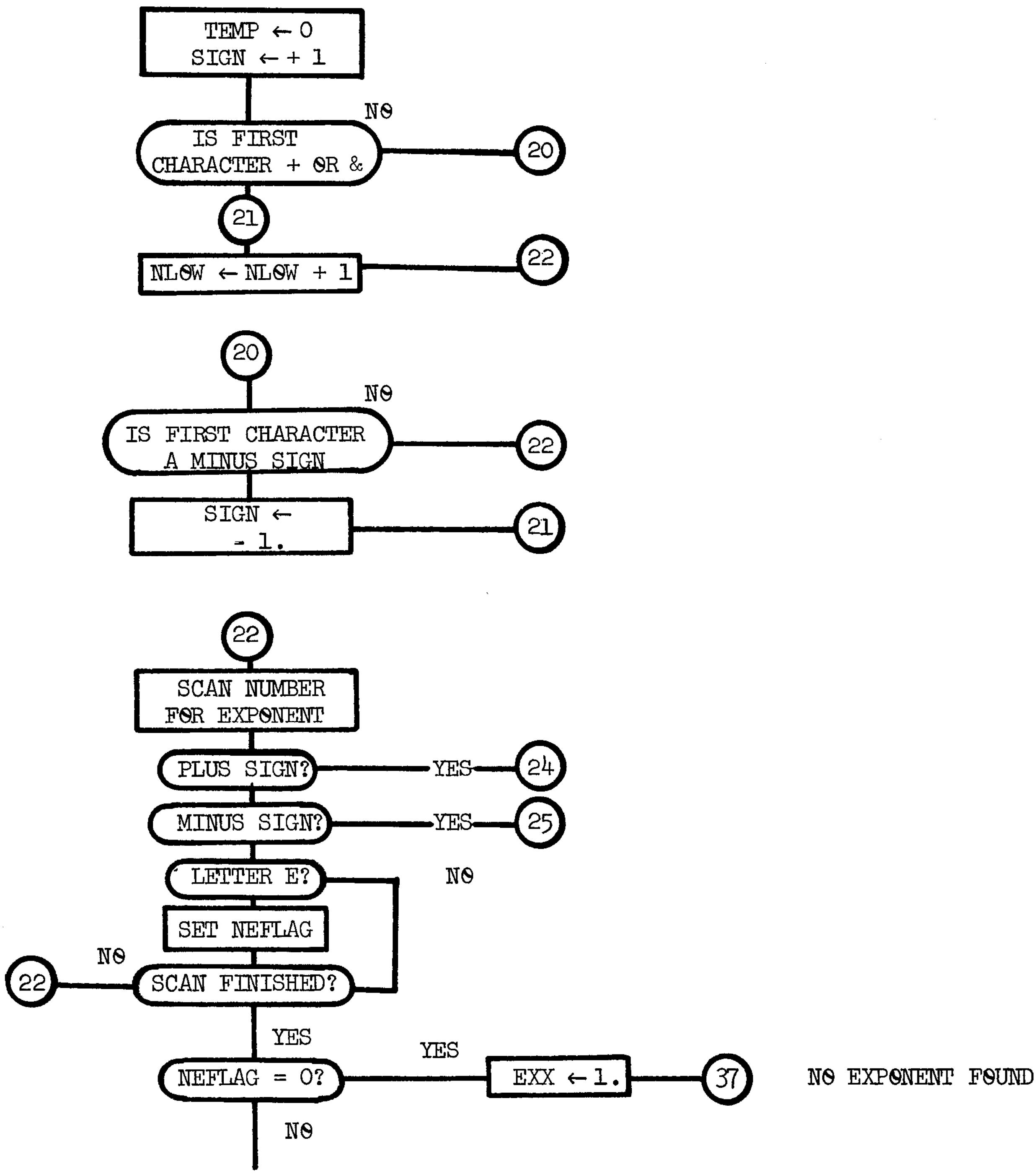
-SUBROUTINE BKKPAK-




NSIGN ← + 1
FIRST CHARACTER A PLUS SIGN?
YES
1
FIRST CHARACTER A MINUS SIGN
NO
3
NSIGN ← - 1
1
NLOW ← NLOW + 1
3
ITEMP ← 0
I ← NLOW
2A
JT ← 1
5A
WHOL(I) = TABHOL(JT)
NO
5
NHIGH-I
M ← 10
ITEMP ← TABFX(JT)xM + ITEMP
2
LOOK UP CHARACTER IN EBDIC TABLE. USE CORRESPONDING DIGIT TO FORM NUMBER

CHARACTER FOUND THAT WAS NOT A NUMBER

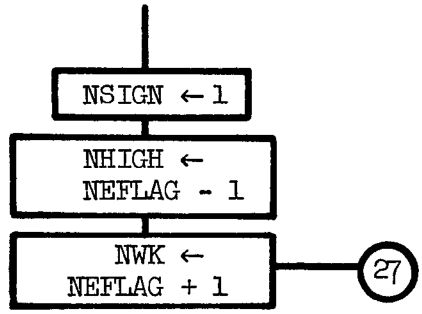



TEMP ← 0
SIGN ← + 1
NO
IS FIRST CHARACTER + OR &
20
21
NLOW ← NLOW + 1
22
20
NO
IS FIRST CHARACTER A MINUS SIGN
22
SIGN ← - 1.
21
22
SCAN NUMBER FOR EXPONENT
PLUS SIGN?
YES
24
MINUS SIGN?
YES
25
LETTER E?
NO
SET NEFLAG
NO
22
SCAN FINISHED?
YES
YES
NEFLAG = 0?
EXX ← 1.
37
NO EXPONENT FOUND
NO

LETTER E FOUND, BUT NO SIGN

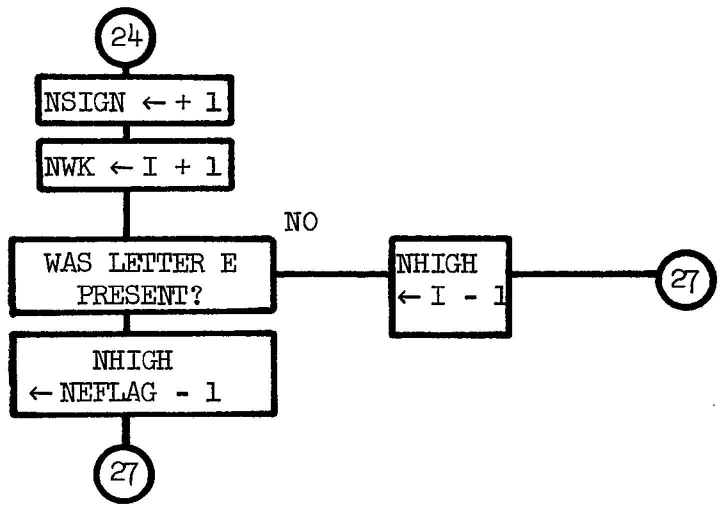
HIGHEST COLUMN OF FRACTION

FIRST COLUMN OF EXPONENT

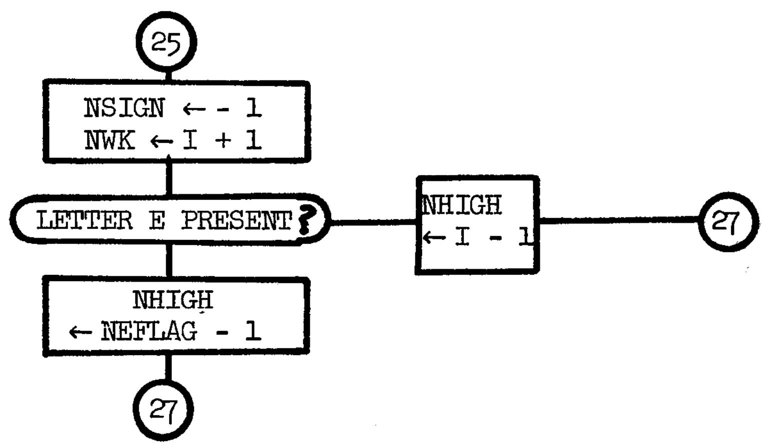


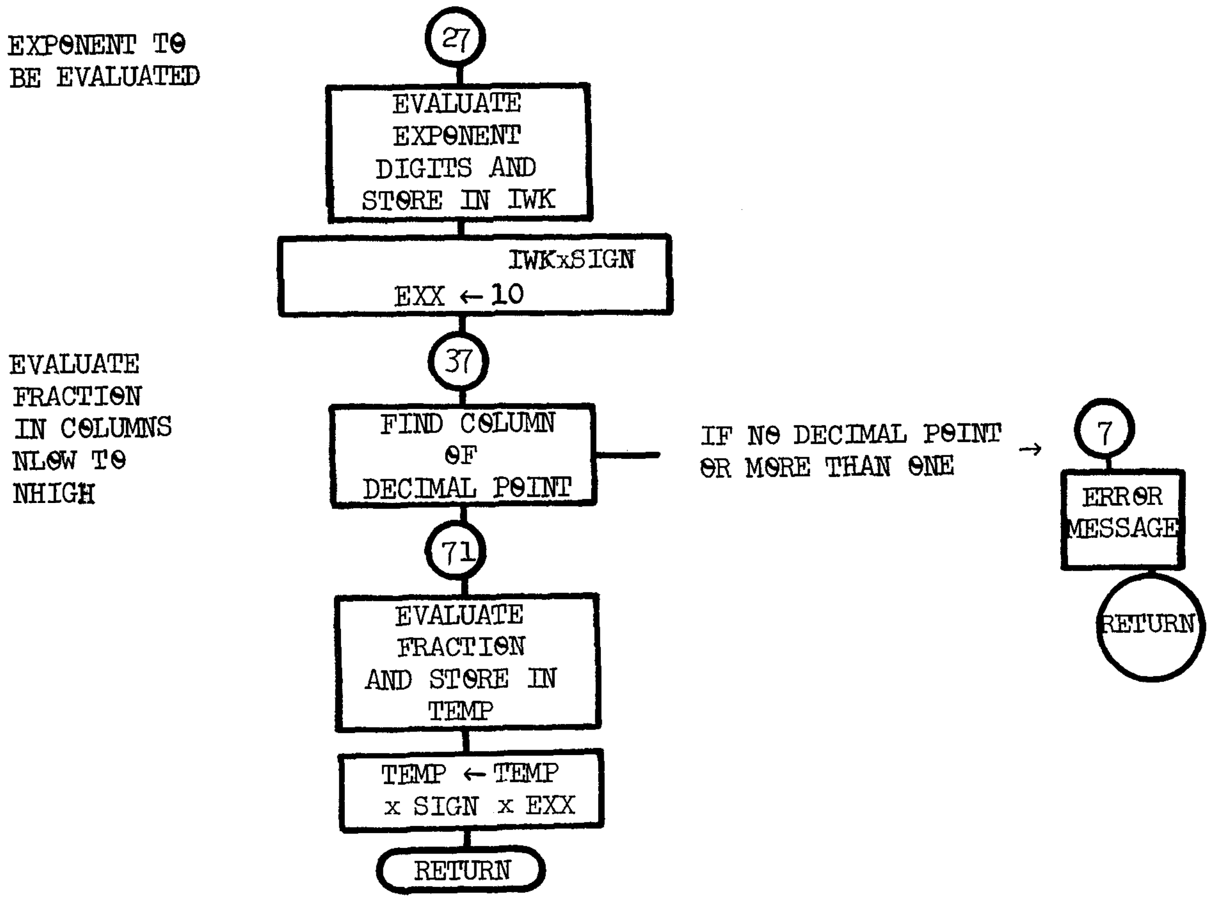
PLUS SIGN

FIRST COLUMN OF EXPONENT

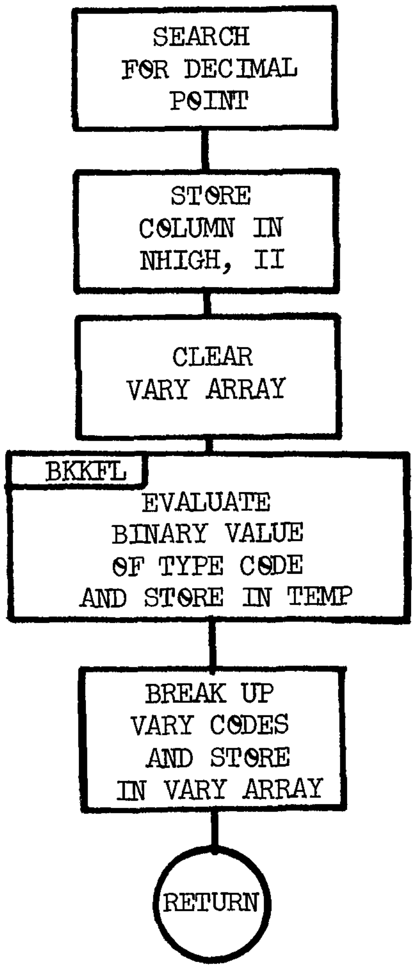


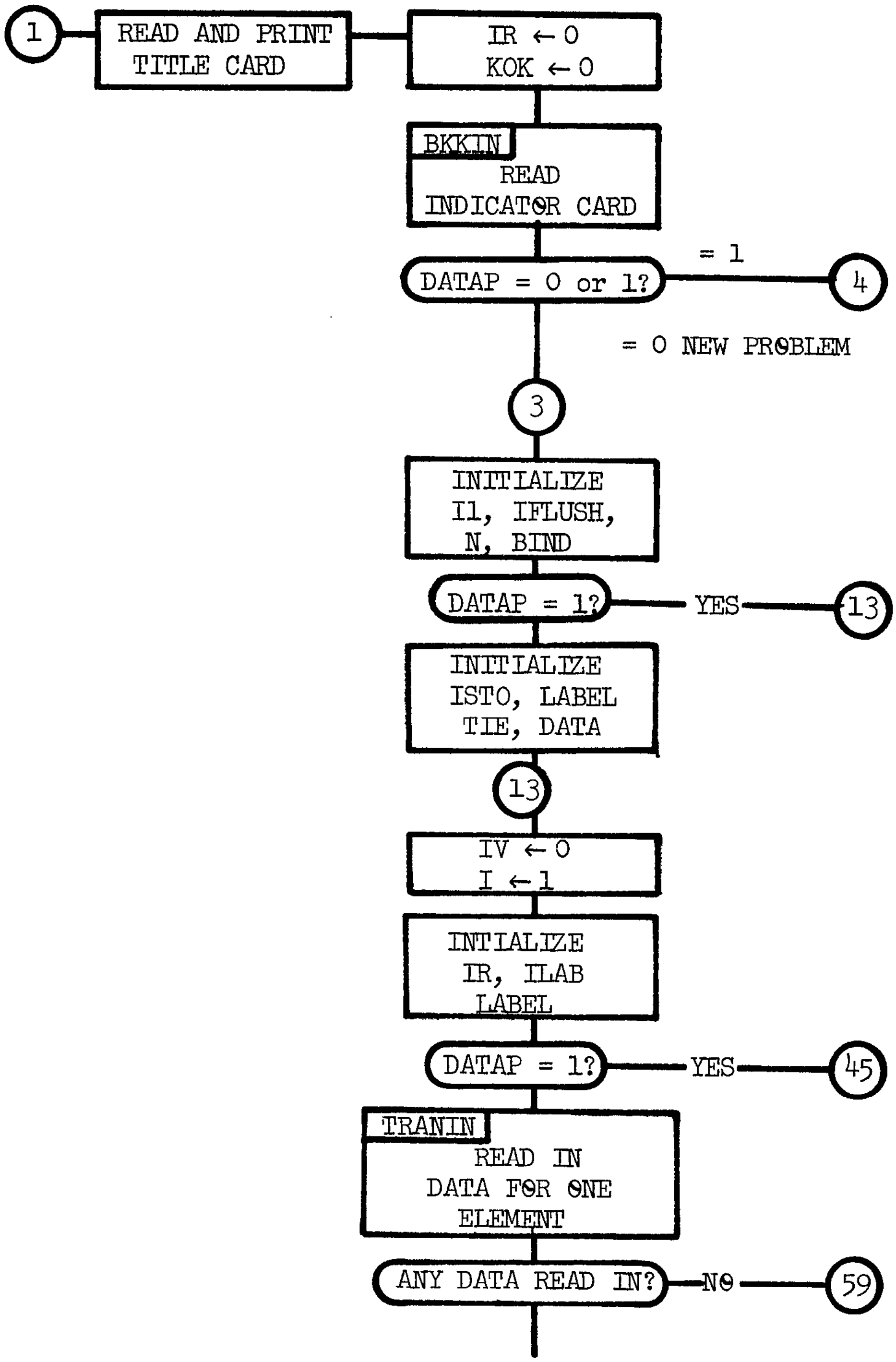
MINUS SIGN

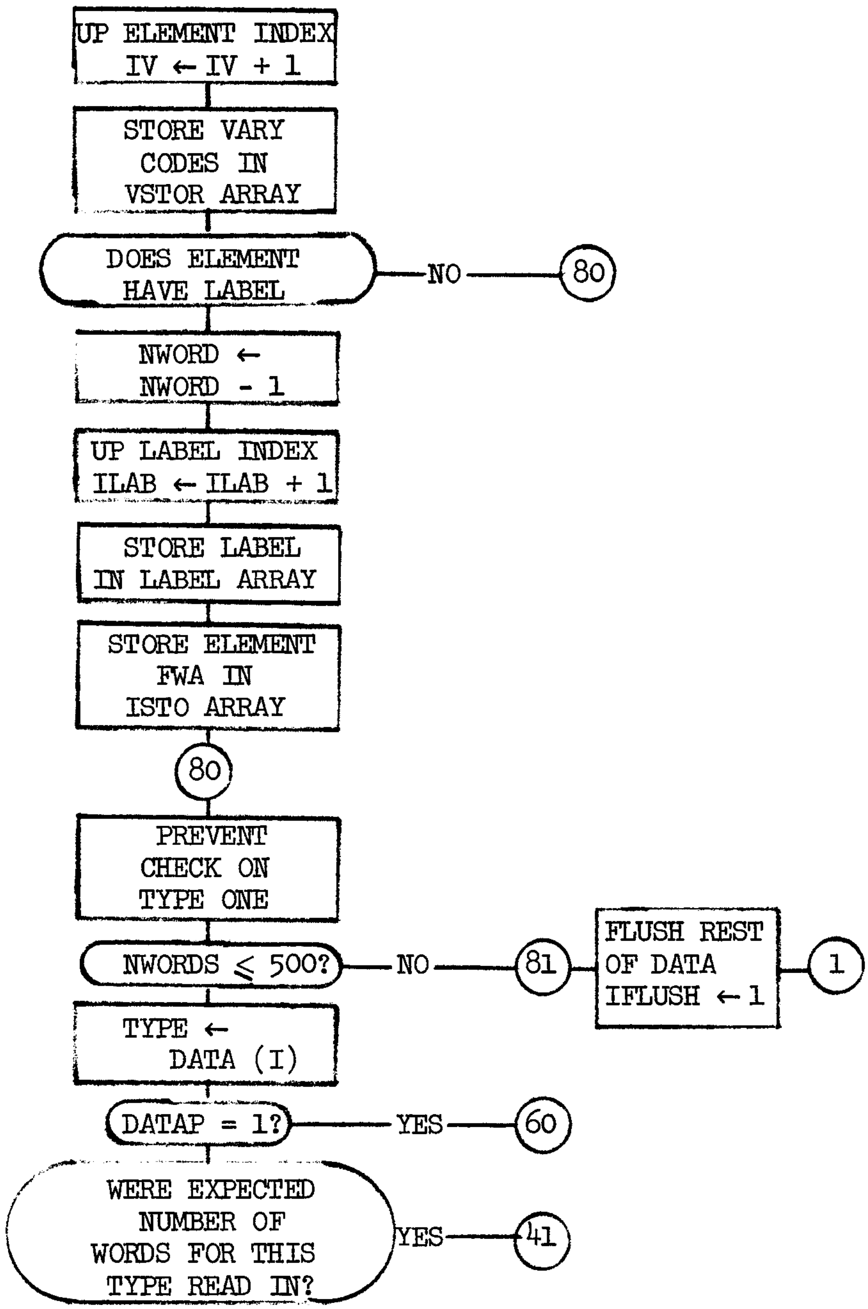



EXPONENT TO
BE EVALUATED
27
EVALUATE
EXPONENT
DIGITS AND
STORE IN IWK
IWKxSIGN
EXX ← 10
EVALUATE
FRACTION
IN COLUMNS
NLOW TO
NHIGH
37
FIND COLUMN
OF
DECIMAL POINT
IF NO DECIMAL POINT
OR MORE THAN ONE
7
ERROR
MESSAGE
RETURN
71
EVALUATE
FRACTION
AND STORE IN
TEMP
TEMP ← TEMP
x SIGN x EXX
RETURN

TYPE CODE.
SEPARATE TYPE CODE
FROM VARY CODES

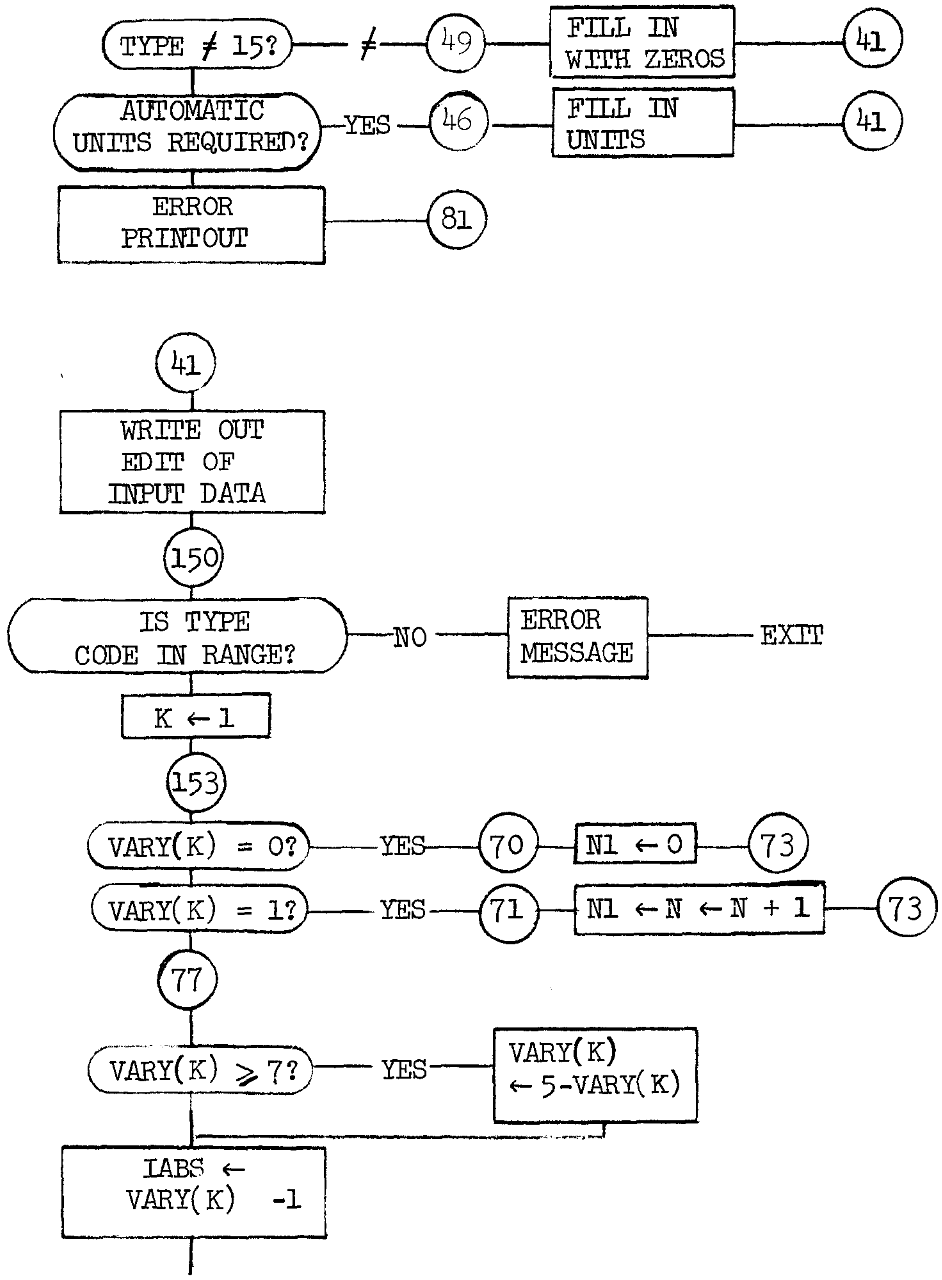



1
READ AND PRINT TITLE CARD
IR ← 0
KOK ← 0
BKKIN
READ INDICATOR CARD
DATAP = 0 or 1?
= 1
4
= 0 NEW PROBLEM
3
INITIALIZE I1, IFLUSH, N, BIND
DATAP = 1?
YES
13
INITIALIZE ISTO, LABEL TIE, DATA
13
IV ← 0
I ← 1
INTIALIZE IR, ILAB LABEL
DATAP = 1?
YES
45
TRANIN
READ IN DATA FOR ONE ELEMENT
ANY DATA READ IN?
NO
59


UP ELEMENT INDEX
IV ← IV + 1
STORE VARY CODES IN VSTOR ARRAY
DOES ELEMENT HAVE LABEL
NO
80
NWORD ← NWORD - 1
UP LABEL INDEX
ILAB ← ILAB + 1
STORE LABEL IN LABEL ARRAY
STORE ELEMENT FWA IN ISTO ARRAY
80
PREVENT CHECK ON TYPE ONE
NWORDS ≤ 500?
NO
81
FLUSH REST OF DATA
IFLUSH ← 1
1
TYPE ← DATA (I)
DATAP = 1?
YES
60
WERE EXPECTED NUMBER OF WORDS FOR THIS TYPE READ IN?
YES
41

FEWER WORDS READ IN

CHECK VARY CODES FOR THIS ELEMENT AND SET UP TIE ARRAY

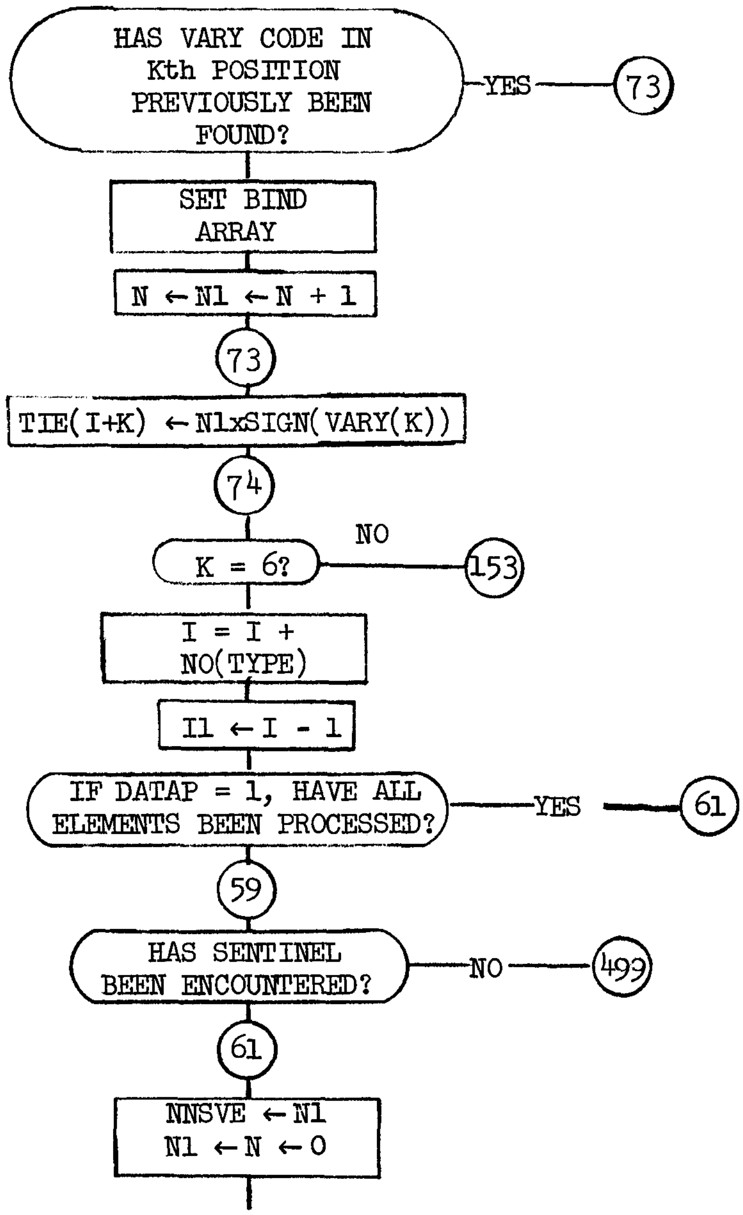


CHECK BIND ARRAY

INCREMENT INDEX OF F.W.A. OF ELEMENTS IN DATA ARRAY

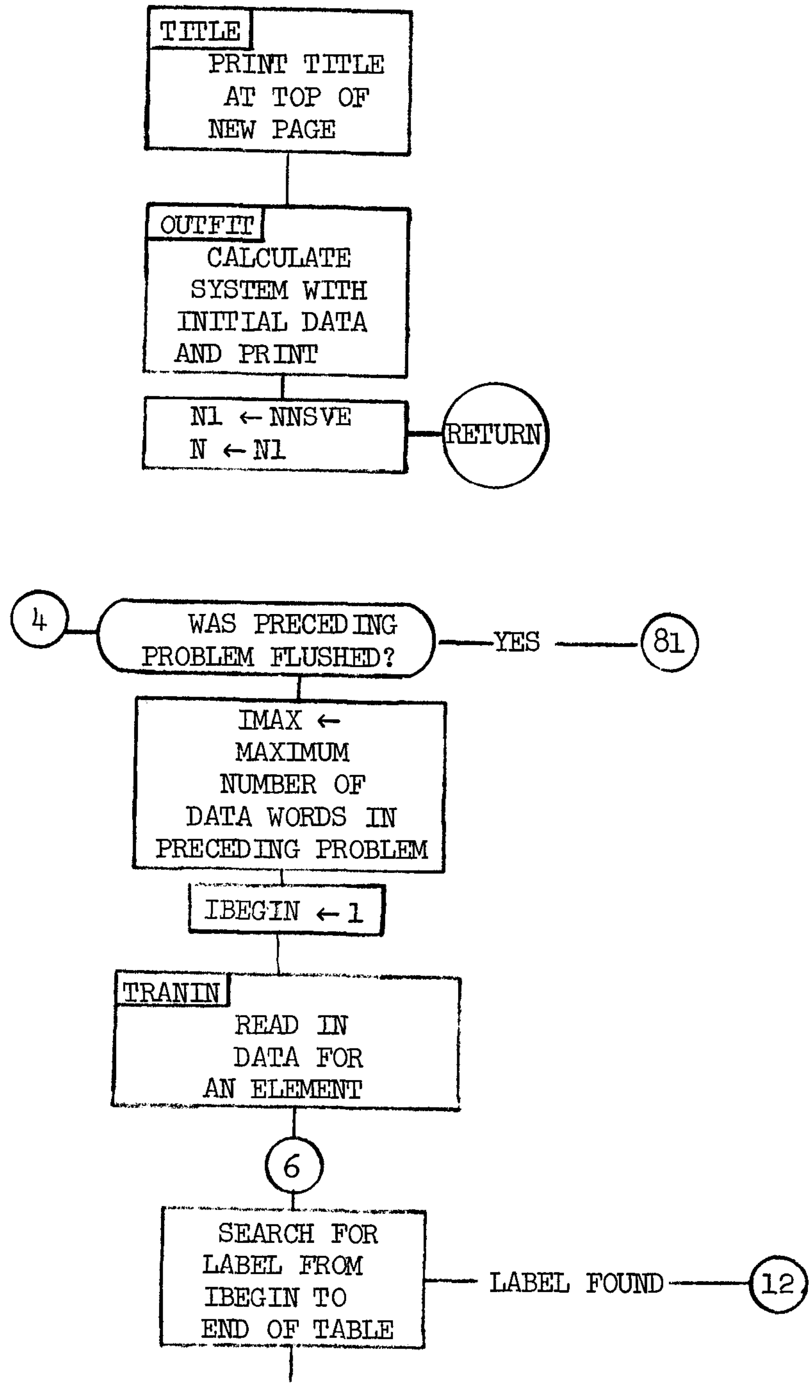
RETURN TO PROCESS ANOTHER ELEMENT

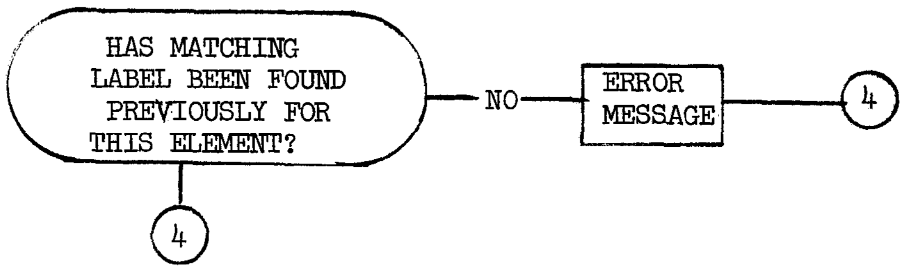
SET N1 TO ZERO SO NO FITTING WILL OCCUR FIRST TIME THROUGH



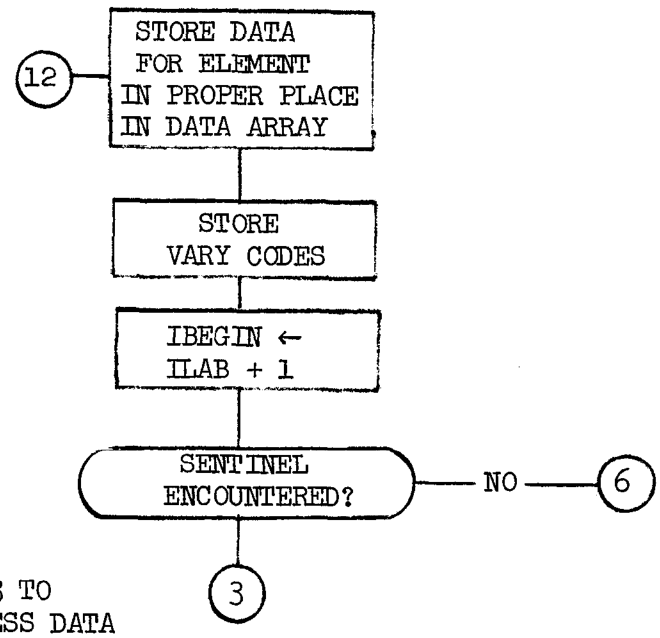
OUTFIT CALLS ELEMENTS WHICH CALCULATES THE R MATRICES FOR THE ELEMENTS

DATAP = 1
READ IN THE CHANGES IN THE DATA ARRAY FROM THE PRECEDING PROBLEM

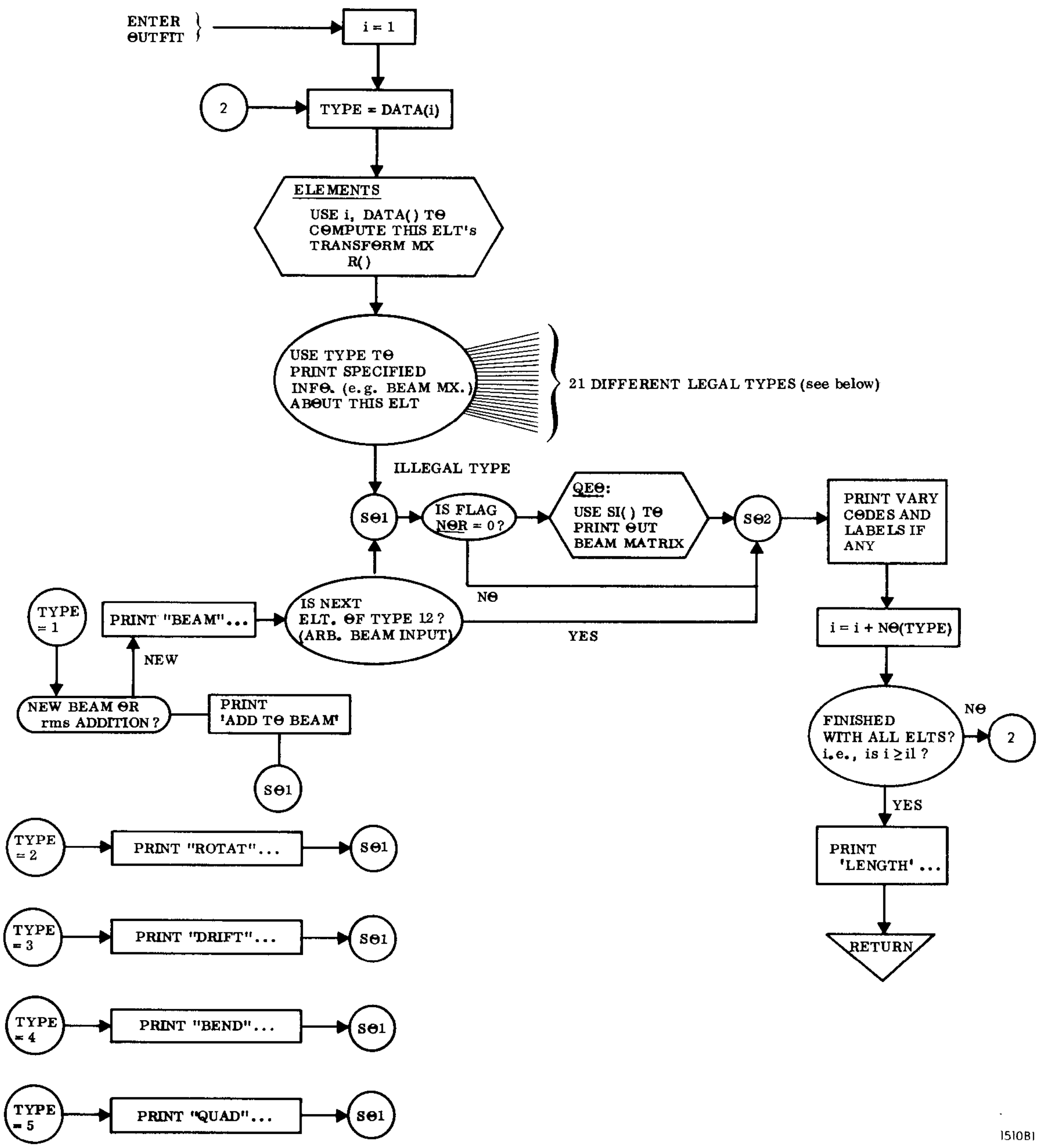


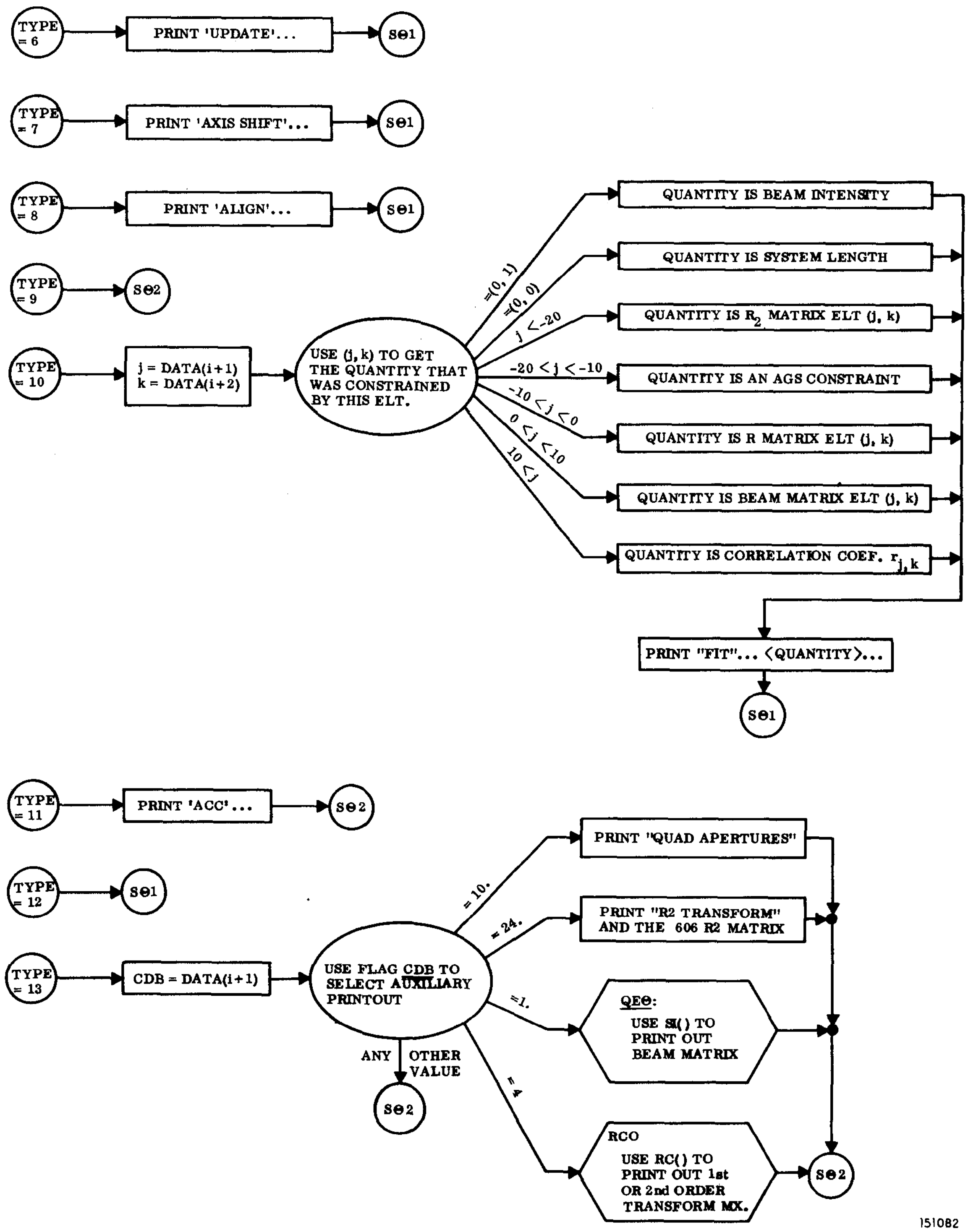


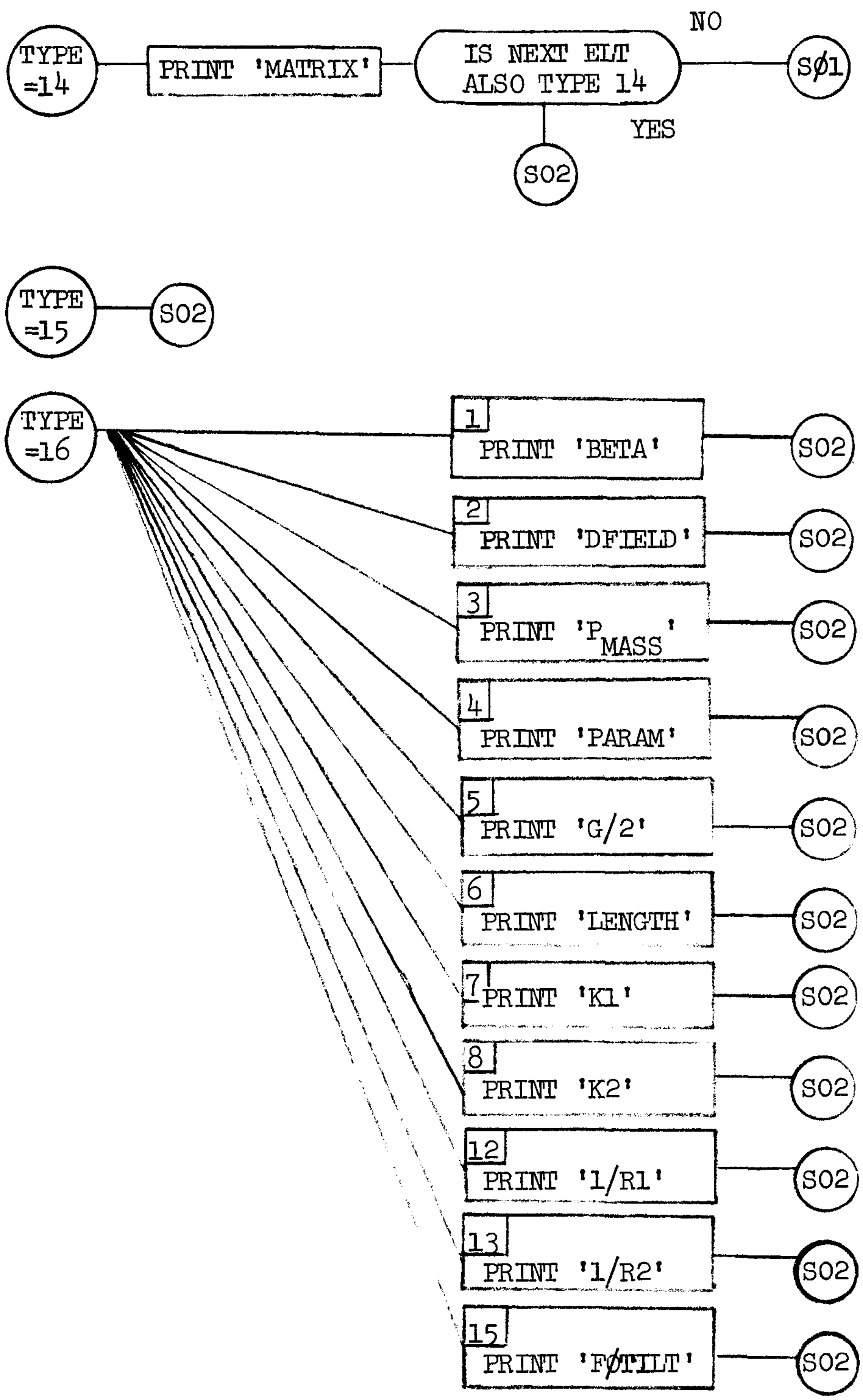
MATCHING
LABEL
FOUND

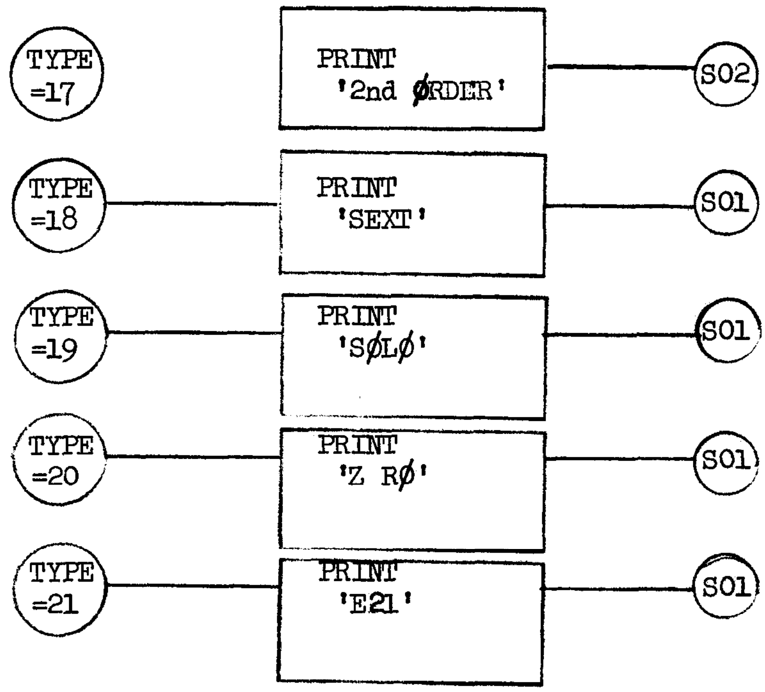


GO TO 3 TO
REPROCESS DATA
ARRAY AND SET
UP TIE CODES

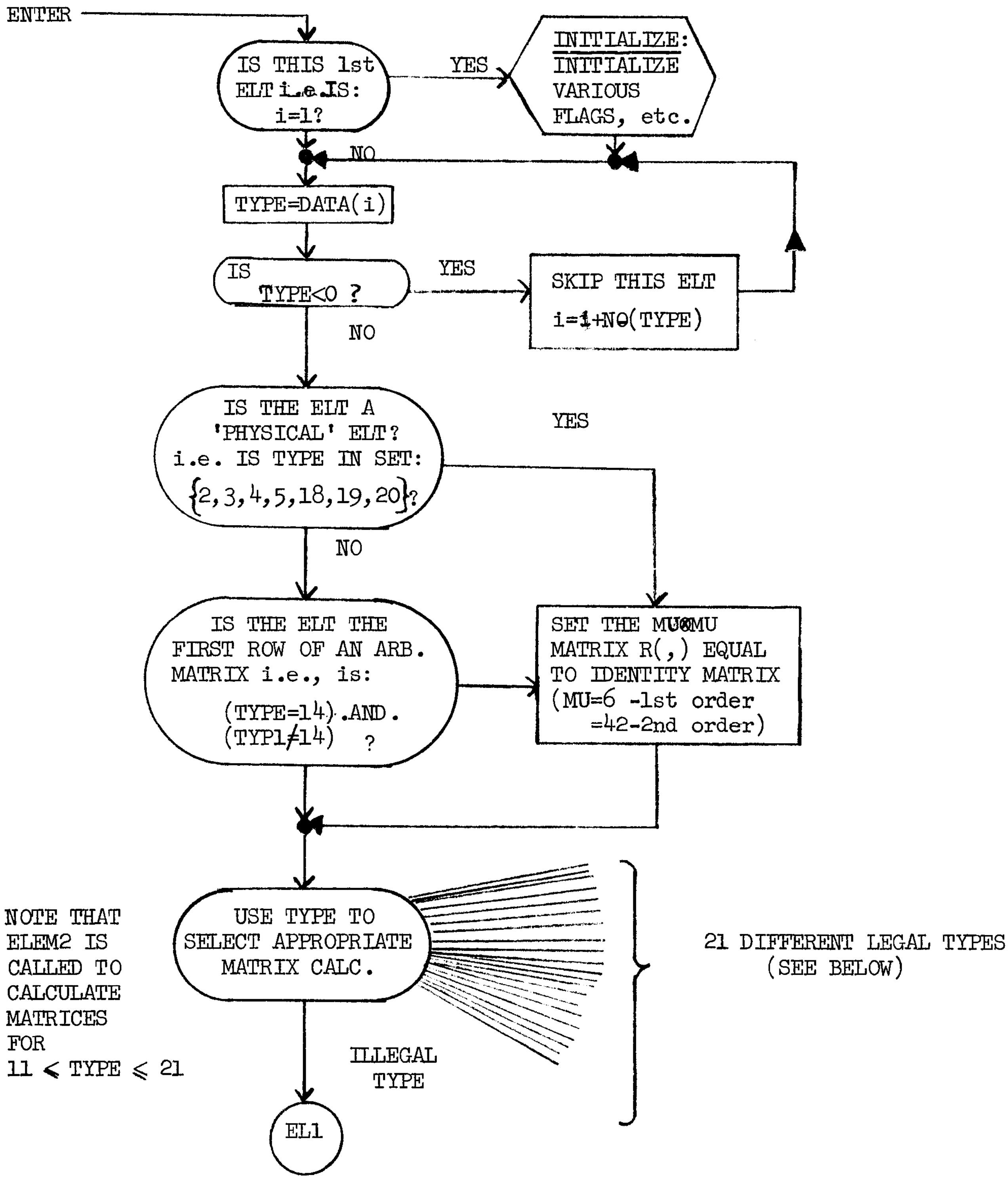

ENTER OUTFIT
i = 1
2
TYPE = DATA(i)
ELEMENTS
USE i, DATA( ) TO COMPUTE THIS ELT's TRANSFORM MX R( )
USE TYPE TO PRINT SPECIFIED INFO. (e.g. BEAM MX.) ABOUT THIS ELT
21 DIFFERENT LEGAL TYPES (see below)
ILLEGAL TYPE
SO1
IS FLAG NOR = 0 ?
QEO:
USE SI( ) TO PRINT OUT BEAM MATRIX
SO2
PRINT VARY CODES AND LABELS IF ANY
NO
TYPE = 1
PRINT "BEAM"...
IS NEXT ELT. OF TYPE 12 ? (ARB. BEAM INPUT)
YES
i = i + NO(TYPE)
NEW
NEW BEAM OR rms ADDITION ?
PRINT 'ADD TO BEAM'
SO1
FINISHED WITH ALL ELTS? i.e., is i ≥ il ?
NO
2
YES
PRINT 'LENGTH' ...
RETURN
TYPE = 2
PRINT "ROTAT"...
SO1
TYPE = 3
PRINT "DRIFT"...
SO1
TYPE = 4
PRINT "BEND"...
SO1
TYPE = 5
PRINT "QUAD"...
SO1
151081

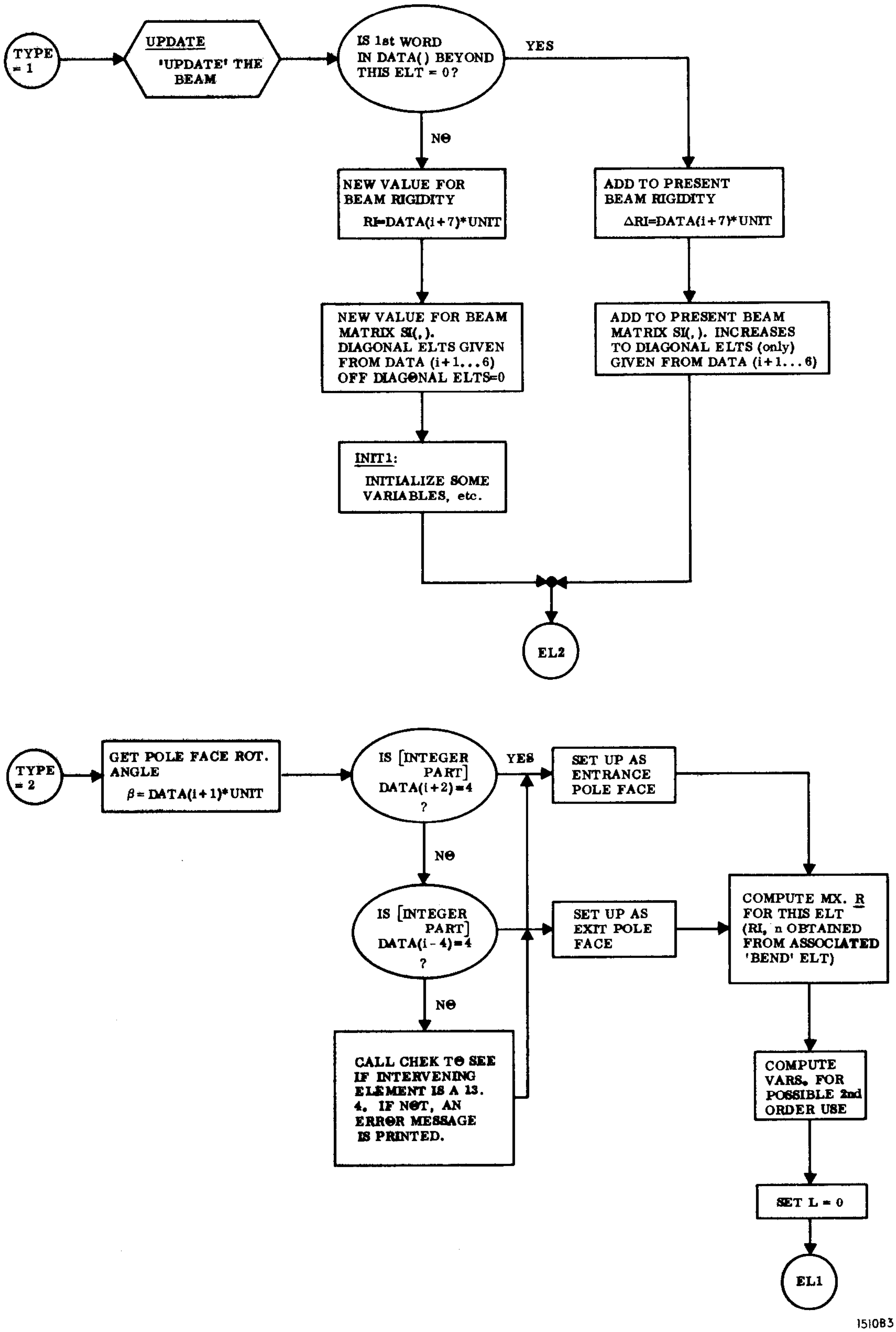

TYPE = 6
PRINT 'UPDATE'...
SΘ1
TYPE = 7
PRINT 'AXIS SHIFT'...
SΘ1
TYPE = 8
PRINT 'ALIGN'...
SΘ1
TYPE = 9
SΘ2
TYPE = 10
j = DATA(i+1)
k = DATA(i+2)
USE (j, k) TO GET THE QUANTITY THAT WAS CONSTRAINED BY THIS ELT.
=(0, 1)
=(0, 0)
j < -20
-20 < j < -10
-10 < j < 0
0 < j < 10
10 < j
QUANTITY IS BEAM INTENSITY
QUANTITY IS SYSTEM LENGTH
QUANTITY IS R2 MATRIX ELT (j, k)
QUANTITY IS AN AGS CONSTRAINT
QUANTITY IS R MATRIX ELT (j, k)
QUANTITY IS BEAM MATRIX ELT (j, k)
QUANTITY IS CORRELATION COEF. rj, k
PRINT "FIT"... <QUANTITY>...
SΘ1
TYPE = 11
PRINT 'ACC'...
SΘ2
TYPE = 12
SΘ1
TYPE = 13
CDB = DATA(i+1)
USE FLAG CDB TO SELECT AUXILIARY PRINTOUT
=10.
=24.
=1.
=4
ANY OTHER VALUE
SΘ2
PRINT "QUAD APERTURES"
PRINT "R2 TRANSFORM" AND THE 606 R2 MATRIX
QEΘ:
USE SI() TO PRINT OUT BEAM MATRIX
RCO
USE RC() TO PRINT OUT 1st OR 2nd ORDER TRANSFORM MX.
SΘ2
151082

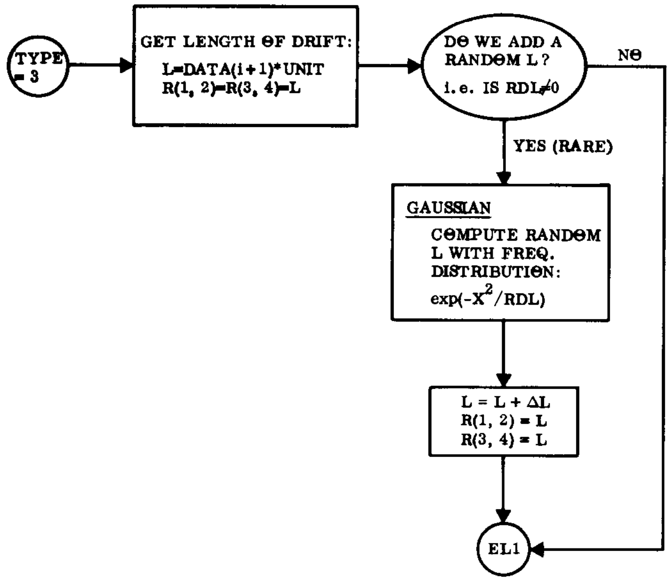

TYPE =14
PRINT 'MATRIX'
IS NEXT ELT ALSO TYPE 14
NO
SØ1
YES
S02
TYPE =15
S02
TYPE =16
1 PRINT 'BETA'
2 PRINT 'DFIELD'
3 PRINT 'P MASS'
4 PRINT 'PARAM'
5 PRINT 'G/2'
6 PRINT 'LENGTH'
7 PRINT 'K1'
8 PRINT 'K2'
12 PRINT '1/R1'
13 PRINT '1/R2'
15 PRINT 'FØTILT'
S02

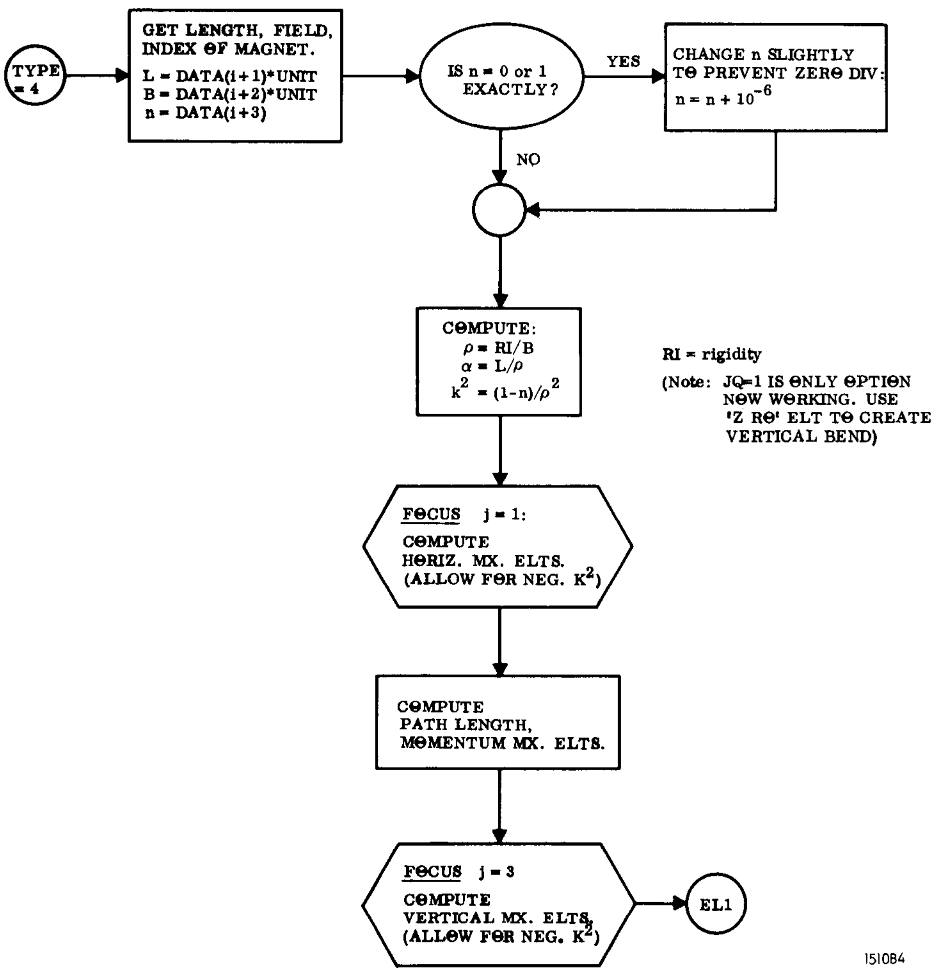

TYPE =17
PRINT '2nd ØRDER'
S02
TYPE =18
PRINT 'SEXT'
S01
TYPE =19
PRINT 'SØLØ'
S01
TYPE =20
PRINT 'Z RØ'
S01
TYPE =21
PRINT 'E21'
S01

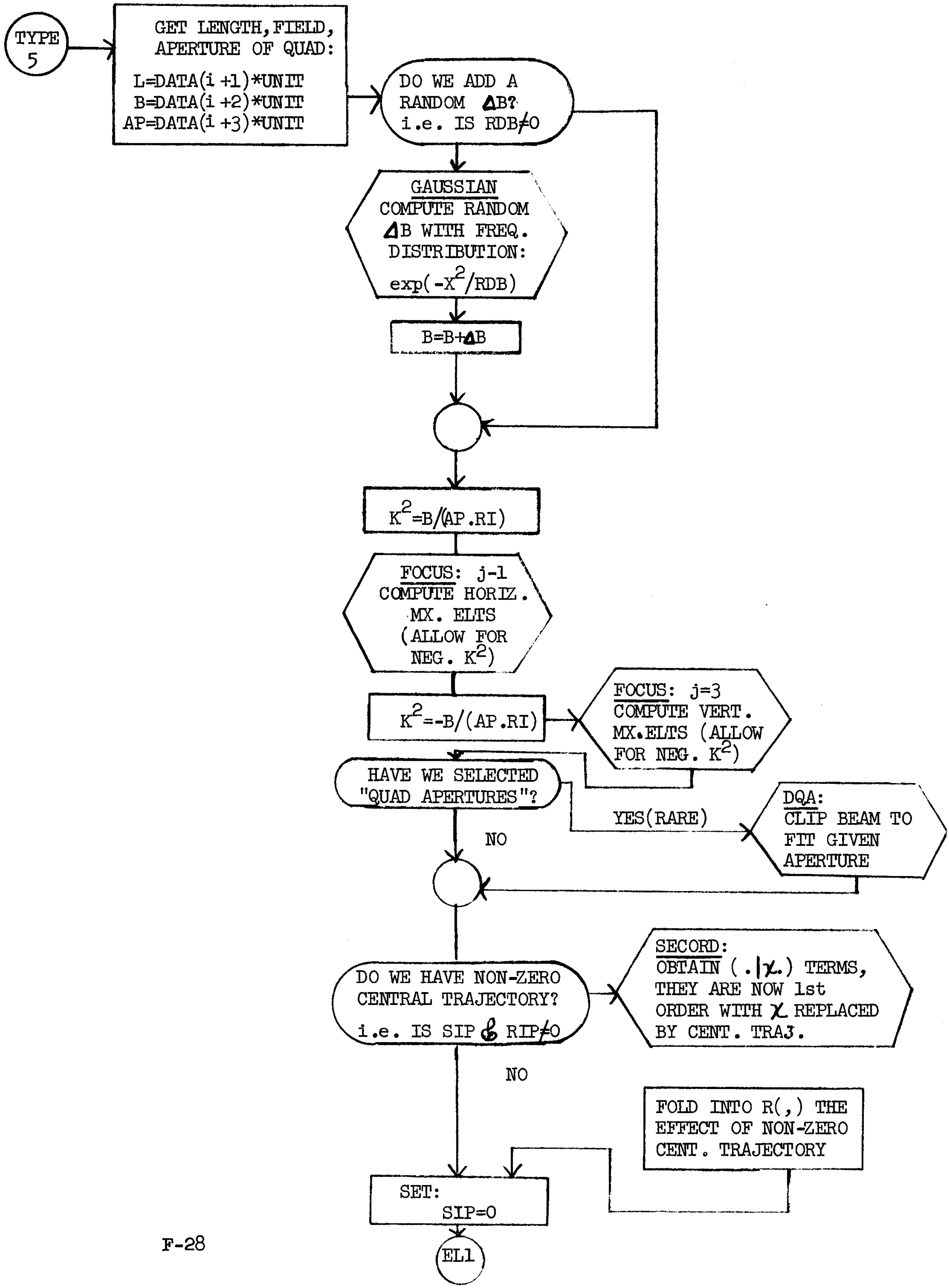
-ELEMENT SUBROUTINE-

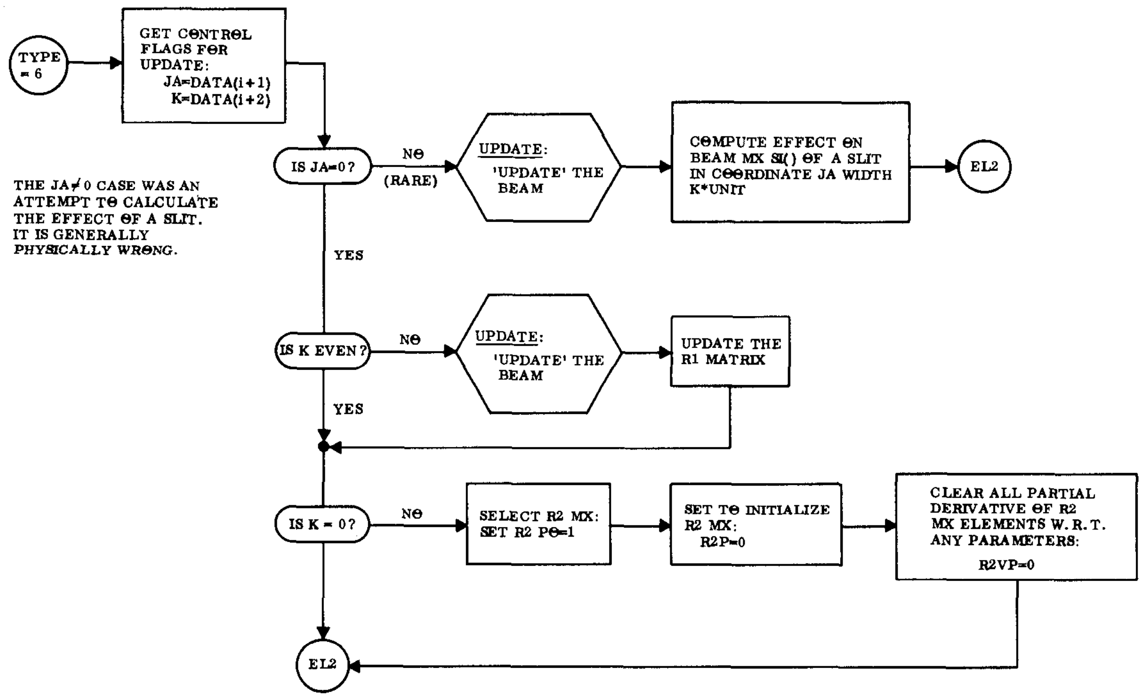


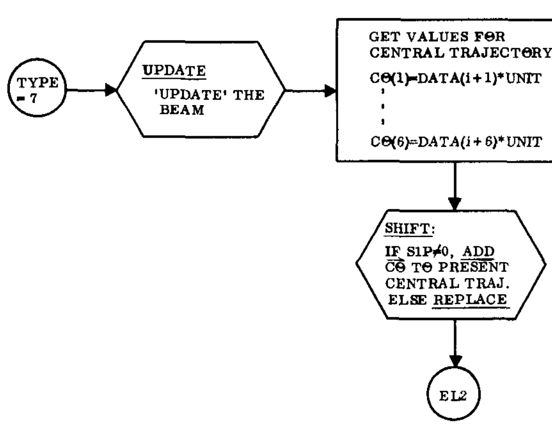

TYPE = 1
UPDATE
'UPDATE' THE BEAM
IS 1st WORD IN DATA( ) BEYOND THIS ELT = 0?
YES
NO
NEW VALUE FOR BEAM RIGIDITY
RI=DATA(i+7)*UNIT
ADD TO PRESENT BEAM RIGIDITY
ΔRI=DATA(i+7)*UNIT
NEW VALUE FOR BEAM MATRIX SI(,). DIAGONAL ELTS GIVEN FROM DATA (i+1...6) OFF DIAGONAL ELTS=0
ADD TO PRESENT BEAM MATRIX SI(,). INCREASES TO DIAGONAL ELTS (only) GIVEN FROM DATA (i+1...6)
INIT1:
INITIALIZE SOME VARIABLES, etc.
EL2
TYPE = 2
GET POLE FACE ROT. ANGLE
β= DATA(i+1)*UNIT
IS [INTEGER PART] DATA(i+2)=4 ?
YES
SET UP AS ENTRANCE POLE FACE
NO
IS [INTEGER PART] DATA(i-4)=4 ?
SET UP AS EXIT POLE FACE
COMPUTE MX. R FOR THIS ELT (RI, n OBTAINED FROM ASSOCIATED 'BEND' ELT)
NO
CALL CHEK TO SEE IF INTERVENING ELEMENT IS A 13. 4. IF NOT, AN ERROR MESSAGE IS PRINTED.
COMPUTE VARS. FOR POSSIBLE 2nd ORDER USE
SET L = 0
EL1
151083


TYPE = 3
GET LENGTH ØF DRIFT:
L=DATA(i+1)*UNIT
R(1, 2)=R(3, 4)=L
DØ WE ADD A RANDØM L ?
i.e. IS RDL≠0
NØ
YES (RARE)
GAUSSIAN
CØMPUTE RANDØM L WITH FREQ. DISTRIBUTIØN:
exp(-X^2/RDL)
L = L + ΔL
R(1, 2) = L
R(3, 4) = L
EL1


TYPE = 4
GET LENGTH, FIELD, INDEX ØF MAGNET.
L = DATA(i+1)*UNIT
B = DATA(i+2)*UNIT
n = DATA(i+3)
IS n = 0 or 1 EXACTLY?
YES
CHANGE n SLIGHTLY TØ PREVENT ZERØ DIV:
n = n + 10^-6
NO
CØMPUTE:
ρ = RI/B
α = L/ρ
k^2 = (1-n)/ρ^2
RI = rigidity
(Note: JQ=1 IS ØNLY ØPTIØN NØW WØRKING. USE 'Z RØ' ELT TØ CREATE VERTICAL BEND)
FØCUS j = 1:
CØMPUTE HØRIZ. MX. ELTS. (ALLOW FØR NEG. K^2)
CØMPUTE PATH LENGTH, MØMENTUM MX. ELTS.
FØCUS j = 3
CØMPUTE VERTICAL MX. ELTS. (ALLØW FØR NEG. K^2)
EL1
151084


TYPE 5
GET LENGTH, FIELD, APERTURE OF QUAD:
L=DATA(i +1)*UNIT
B=DATA(i +2)*UNIT
AP=DATA(i +3)*UNIT
DO WE ADD A RANDOM ΔB? i.e. IS RDB≠0
GAUSSIAN
COMPUTE RANDOM ΔB WITH FREQ. DISTRIBUTION:
exp(-X²/RDB)
B=B+ΔB
K²=B/(AP.RI)
FOCUS: j-1
COMPUTE HORIZ. MX. ELTS (ALLOW FOR NEG. K²)
K²=-B/(AP.RI)
FOCUS: j=3
COMPUTE VERT. MX.ELTS (ALLOW FOR NEG. K²)
HAVE WE SELECTED "QUAD APERTURES"?
YES(RARE)
NO
DQA:
CLIP BEAM TO FIT GIVEN APERTURE
DO WE HAVE NON-ZERO CENTRAL TRAJECTORY? i.e. IS SIP & RIP≠0
SECORD:
OBTAIN (.|χ.) TERMS, THEY ARE NOW 1st ORDER WITH χ REPLACED BY CENT. TRAJ.
NO
FOLD INTO R(,) THE EFFECT OF NON-ZERO CENT. TRAJECTORY
SET: SIP=0
EL1


TYPE = 6
GET CONTROL FLAGS FOR UPDATE: JA=DATA(i+1) K=DATA(i+2)
IS JA=0?
NO (RARE)
UPDATE: 'UPDATE' THE BEAM
COMPUTE EFFECT ON BEAM MX SI() OF A SLIT IN COORDINATE JA WIDTH K*UNIT
EL2
THE JA≠0 CASE WAS AN ATTEMPT TO CALCULATE THE EFFECT OF A SLIT. IT IS GENERALLY PHYSICALLY WRONG.
YES
IS K EVEN?
NO
UPDATE: 'UPDATE' THE BEAM
UPDATE THE R1 MATRIX
YES
IS K = 0?
NO
SELECT R2 MX: SET R2 PO=1
SET TO INITIALIZE R2 MX: R2P=0
CLEAR ALL PARTIAL DERIVATIVE OF R2 MX ELEMENTS W.R.T. ANY PARAMETERS: R2VP=0
EL2

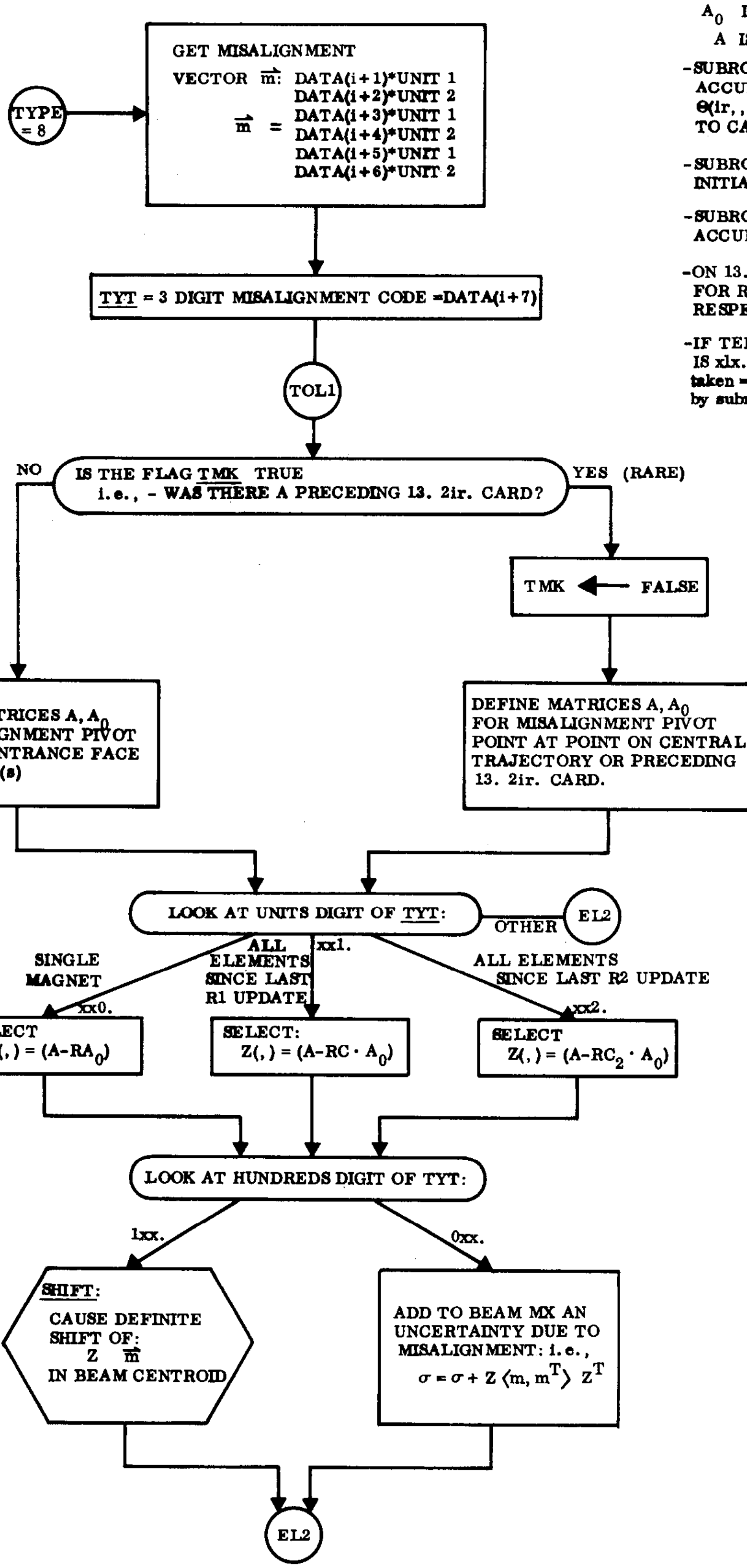

TYPE = 7
UPDATE 'UPDATE' THE BEAM
GET VALUES FOR CENTRAL TRAJECTORY
CO(1)=DATA(i+1)*UNIT
CO(6)=DATA(i+6)*UNIT
SHIFT: IF S1P≠0, ADD CO TO PRESENT CENTRAL TRAJ. ELSE REPLACE
EL2

1510C5

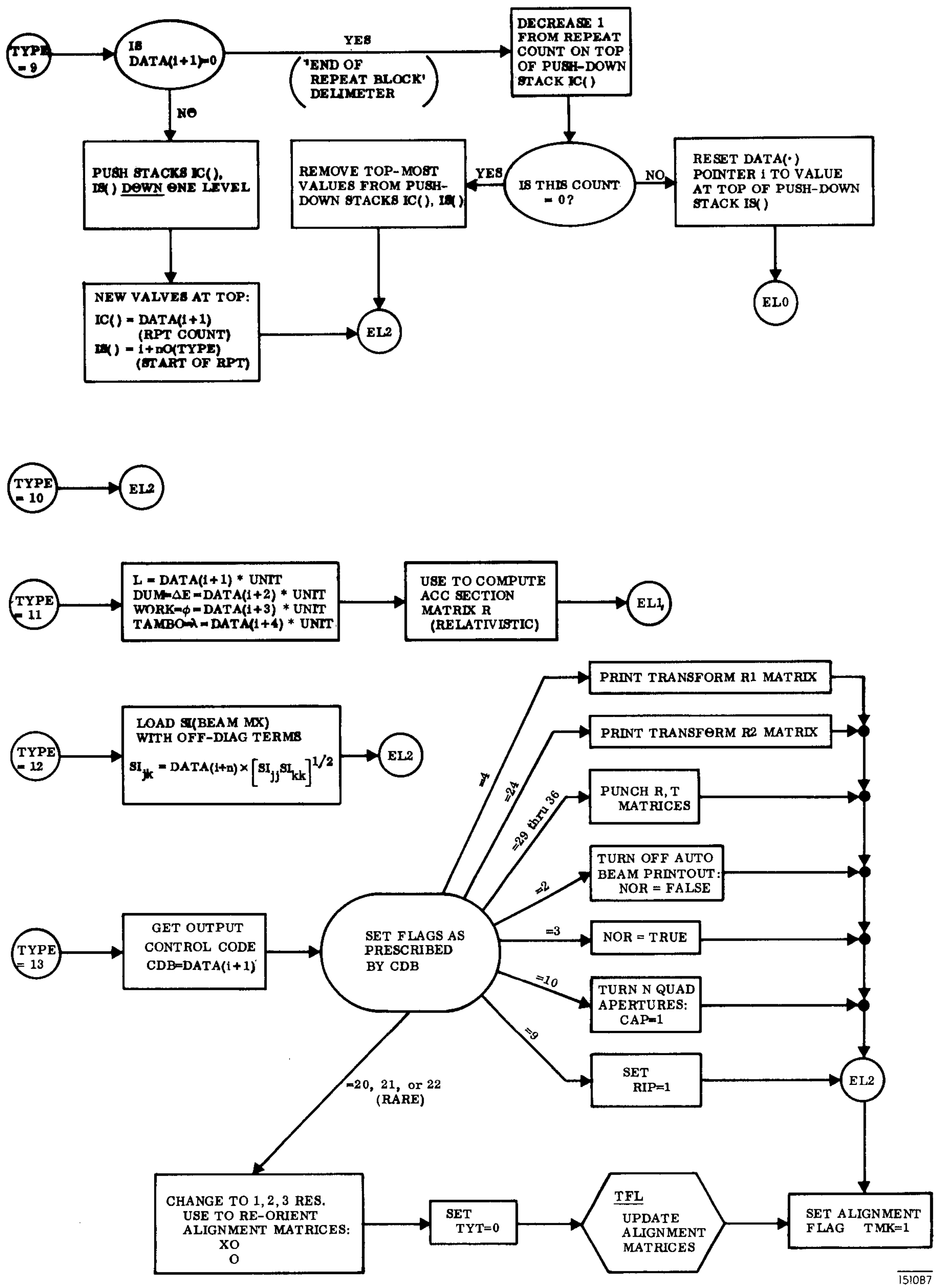
NOTES: IN PROGRAM LISTING:

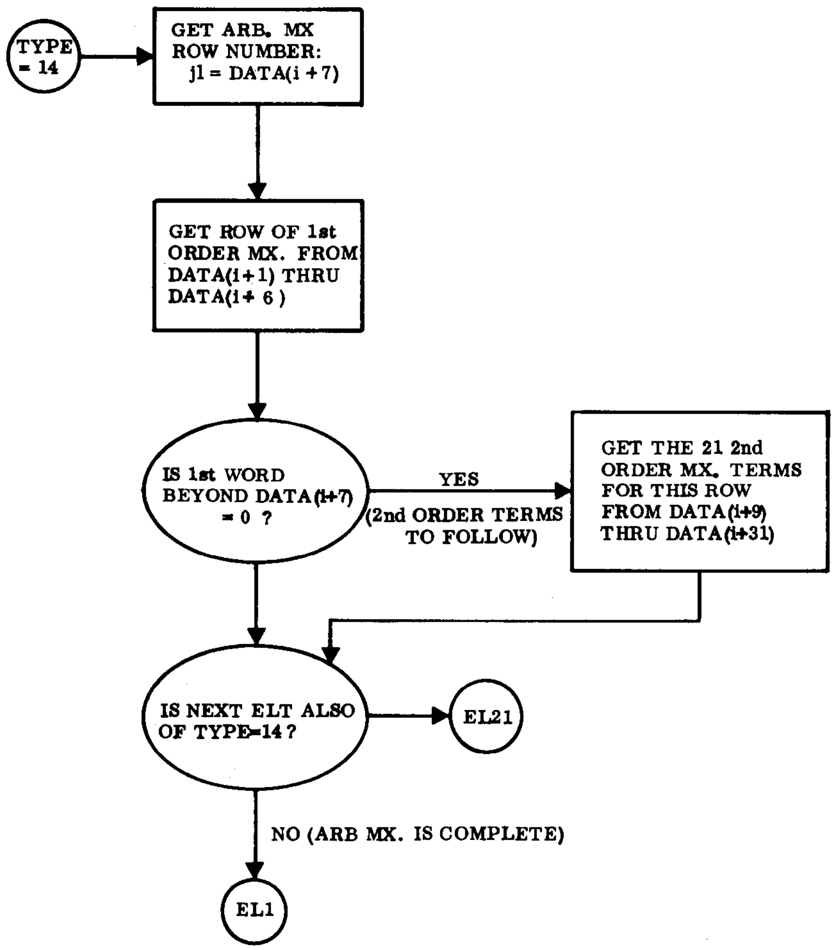
$\vec{m}$ IS DENOTED BY VM( )
A_0 IS " " CTO(,)
A IS " " CT(,)

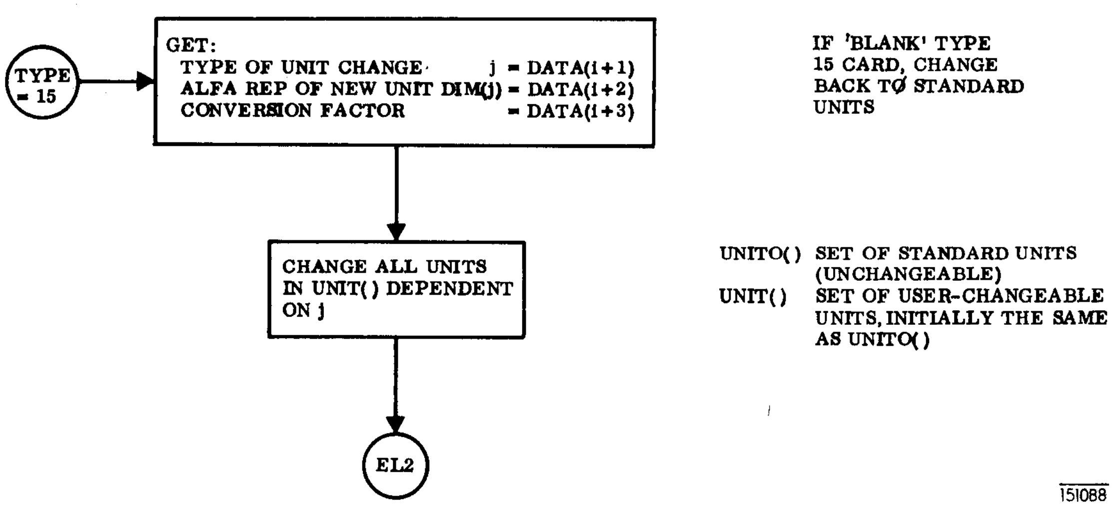
- SUBROUTINE TFL USES ACCUMULATED MATRICES Θ(ir, ,) AND VECTORS XO (ir, ,) TO CALC A(,).
- SUBROUTINE RESET (ir) INITIALIZES THESE ARRAYS.
- SUBROUTINE ADVANCE (ir) ACCUMULATES THESE ARRAYS.
- ON 13. 2ir. CARD, ir = 1, 2, 3 FOR R, RC, RC2 CASES RESPECTIVELY.
- IF TENS DIGIT OF TYT IS x1x. THEN matrix A is taken = (0) (this is executed by subroutine TFL).



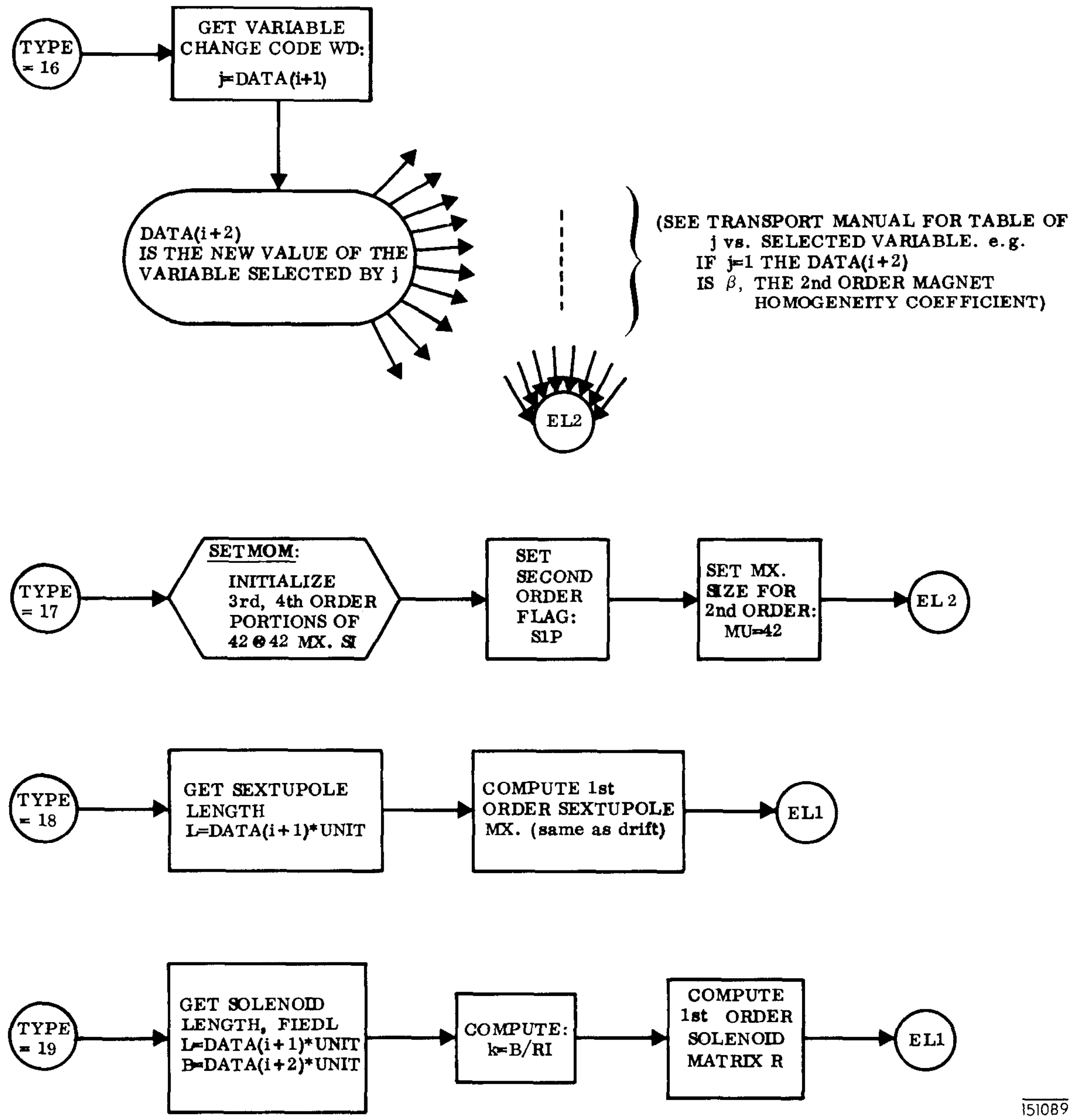
151086

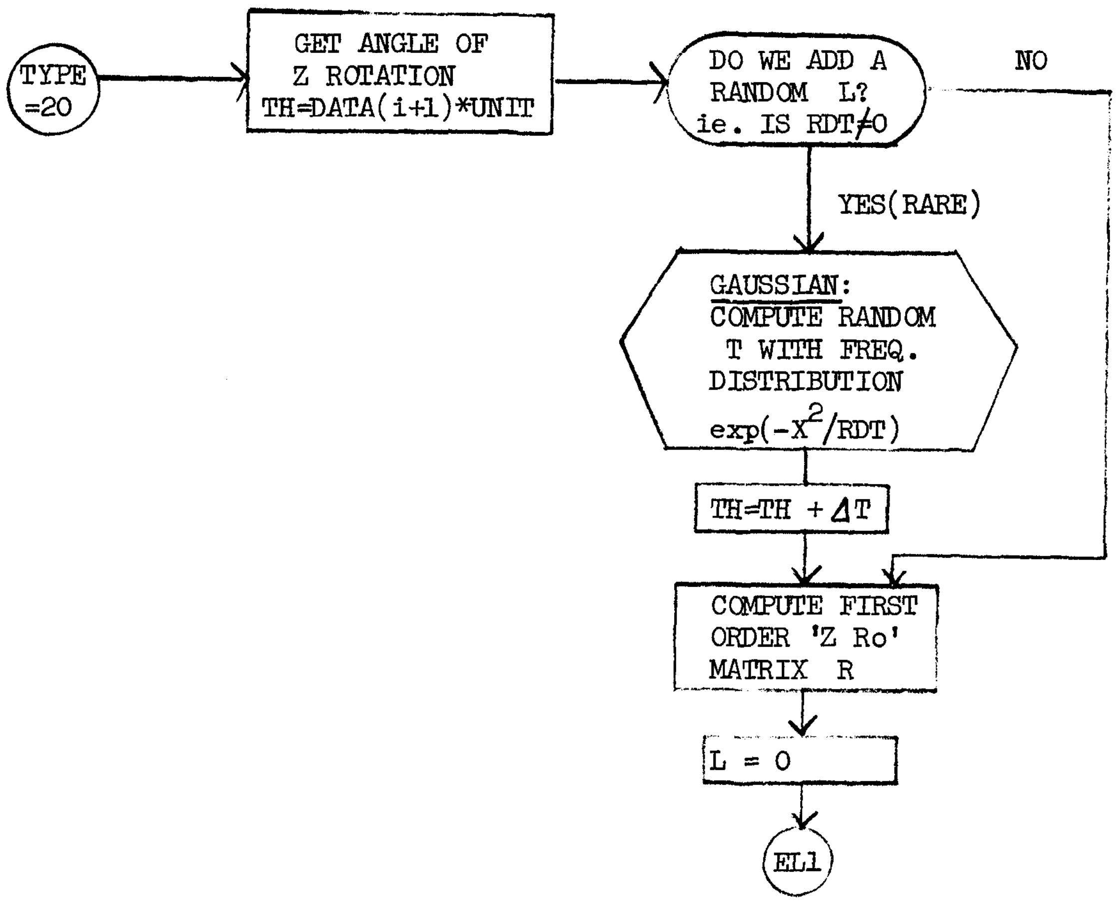

TYPE = 9
IS DATA(i+1)=0
YES
'END OF REPEAT BLOCK' DELIMETER
DECREASE 1 FROM REPEAT COUNT ON TOP OF PUSH-DOWN STACK IC( )
NO
PUSH STACKS IC( ), IS( ) DOWN ONE LEVEL
REMOVE TOP-MOST VALUES FROM PUSH-DOWN STACKS IC( ), IS( )
YES
IS THIS COUNT = 0?
NO
RESET DATA(·) POINTER i TO VALUE AT TOP OF PUSH-DOWN STACK IS( )
EL0
NEW VALVES AT TOP:
IC( ) = DATA(i+1)
(RPT COUNT)
IS( ) = i+nO(TYPE)
(START OF RPT)
EL2
TYPE = 10
EL2
TYPE = 11
L = DATA(i+1) * UNIT
DUM=ΔE=DATA(i+2) * UNIT
WORK=φ=DATA(i+3) * UNIT
TAMBO=λ=DATA(i+4) * UNIT
USE TO COMPUTE ACC SECTION MATRIX R (RELATIVISTIC)
EL1
TYPE = 12
LOAD SI(BEAM MX) WITH OFF-DIAG TERMS
SI_jk = DATA(i+n) × [SI_jj SI_kk]^1/2
EL2
PRINT TRANSFORM R1 MATRIX
PRINT TRANSFORM R2 MATRIX
PUNCH R, T MATRICES
TURN OFF AUTO BEAM PRINTOUT: NOR = FALSE
NOR = TRUE
TURN N QUAD APERTURES: CAP=1
SET RIP=1
EL2
=4
=24
=29 thru 36
=2
=3
=10
=9
TYPE = 13
GET OUTPUT CONTROL CODE CDB=DATA(i+1)
SET FLAGS AS PRESCRIBED BY CDB
=20, 21, or 22 (RARE)
CHANGE TO 1, 2, 3 RES. USE TO RE-ORIENT ALIGNMENT MATRICES: XO O
SET TYT=0
TFL
UPDATE ALIGNMENT MATRICES
SET ALIGNMENT FLAG TMK=1
151087

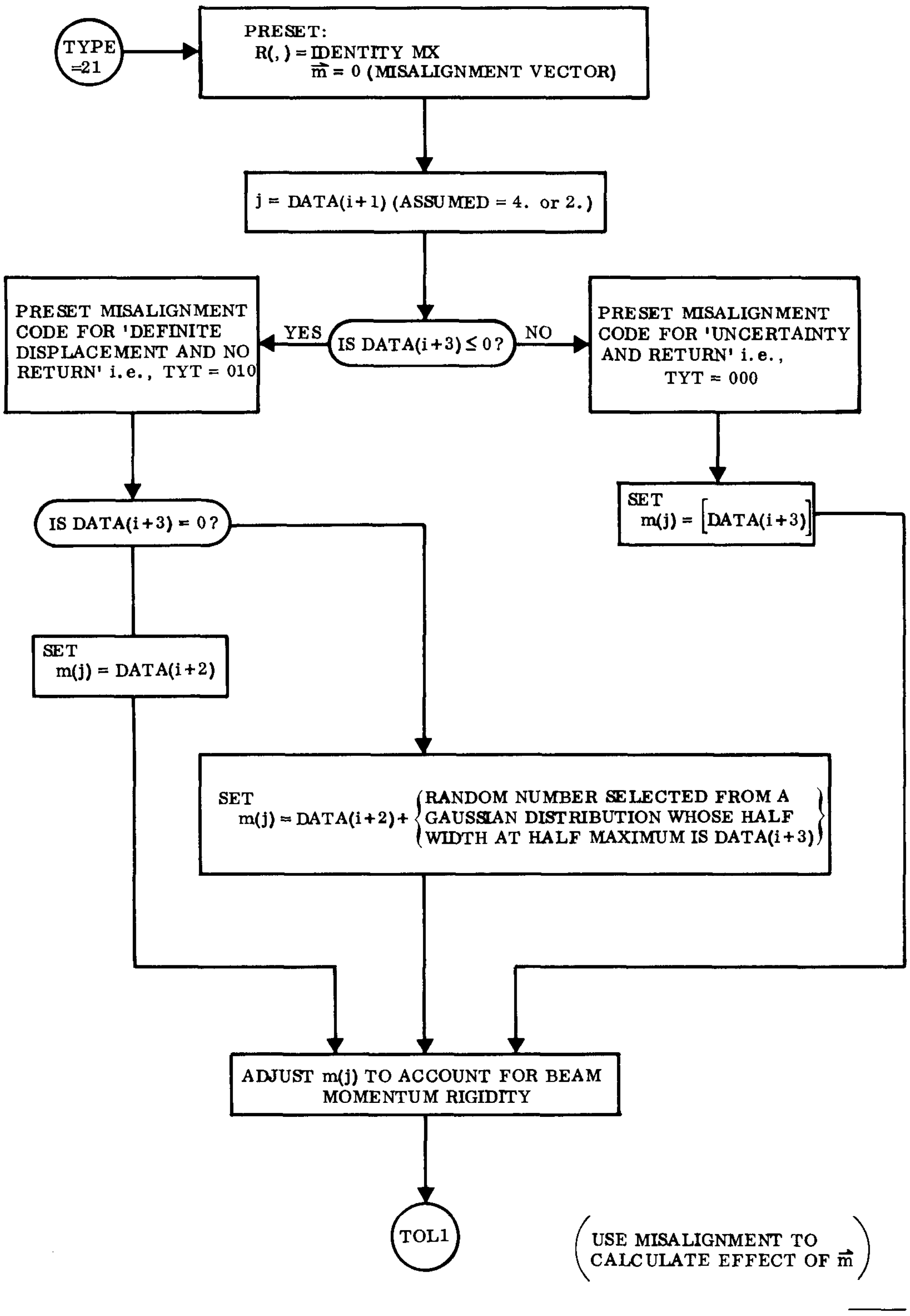

TYPE = 14
GET ARB. MX ROW NUMBER: j1 = DATA(i + 7)
GET ROW OF 1st ORDER MX. FROM DATA(i+1) THRU DATA(i+ 6)
IS 1st WORD BEYOND DATA(i+7) = 0 ?
YES
(2nd ORDER TERMS TO FOLLOW)
GET THE 21 2nd ORDER MX. TERMS FOR THIS ROW FROM DATA(i+9) THRU DATA(i+31)
IS NEXT ELT ALSO OF TYPE=14 ?
EL21
NO (ARB MX. IS COMPLETE)
EL1

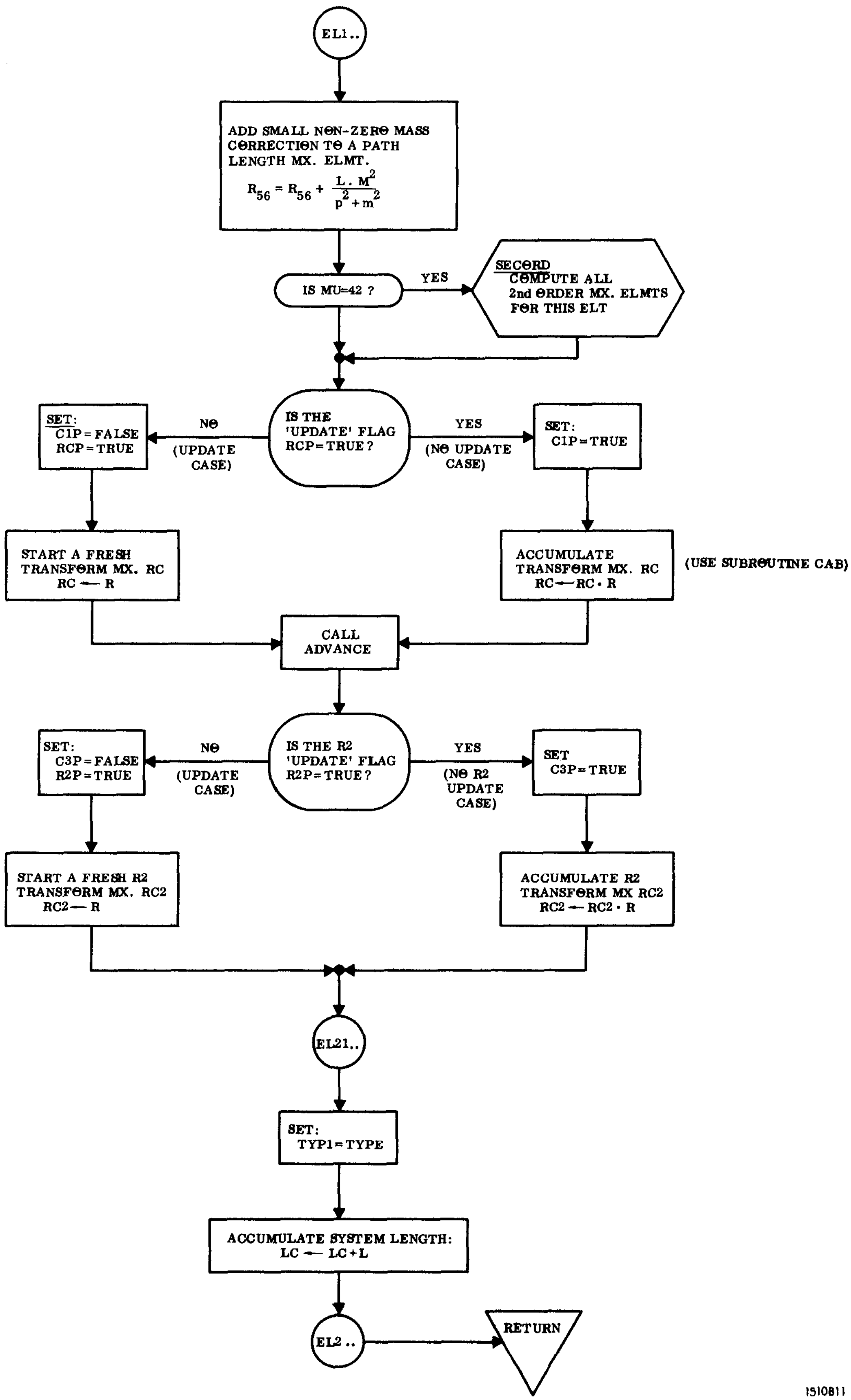

TYPE = 15
GET:
TYPE OF UNIT CHANGE j = DATA(i+1)
ALFA REP OF NEW UNIT DIM(j) = DATA(i+2)
CONVERSION FACTOR = DATA(i+3)
IF 'BLANK' TYPE 15 CARD, CHANGE BACK TØ STANDARD UNITS
CHANGE ALL UNITS IN UNIT( ) DEPENDENT ON j
UNITO( ) SET OF STANDARD UNITS (UNCHANGEABLE)
UNIT( ) SET OF USER-CHANGEABLE UNITS, INITIALLY THE SAME AS UNITO( )
EL2

151088


TYPE = 16
GET VARIABLE CHANGE CODE WD: j=DATA(i+1)
DATA(i+2) IS THE NEW VALUE OF THE VARIABLE SELECTED BY j
(SEE TRANSPORT MANUAL FOR TABLE OF j vs. SELECTED VARIABLE. e.g. IF j=1 THE DATA(i+2) IS β, THE 2nd ORDER MAGNET HOMOGENEITY COEFFICIENT)
EL2
TYPE = 17
SETMOM: INITIALIZE 3rd, 4th ORDER PORTIONS OF 42⊗42 MX. SI
SET SECOND ORDER FLAG: S1P
SET MX. SIZE FOR 2nd ORDER: MU=42
EL 2
TYPE = 18
GET SEXTUPOLE LENGTH L=DATA(i+1)*UNIT
COMPUTE 1st ORDER SEXTUPOLE MX. (same as drift)
EL1
TYPE = 19
GET SOLENOID LENGTH, FIEDL L=DATA(i+1)*UNIT B=DATA(i+2)*UNIT
COMPUTE: k=B/RI
COMPUTE 1st ORDER SOLENOID MATRIX R
EL1
1510B9

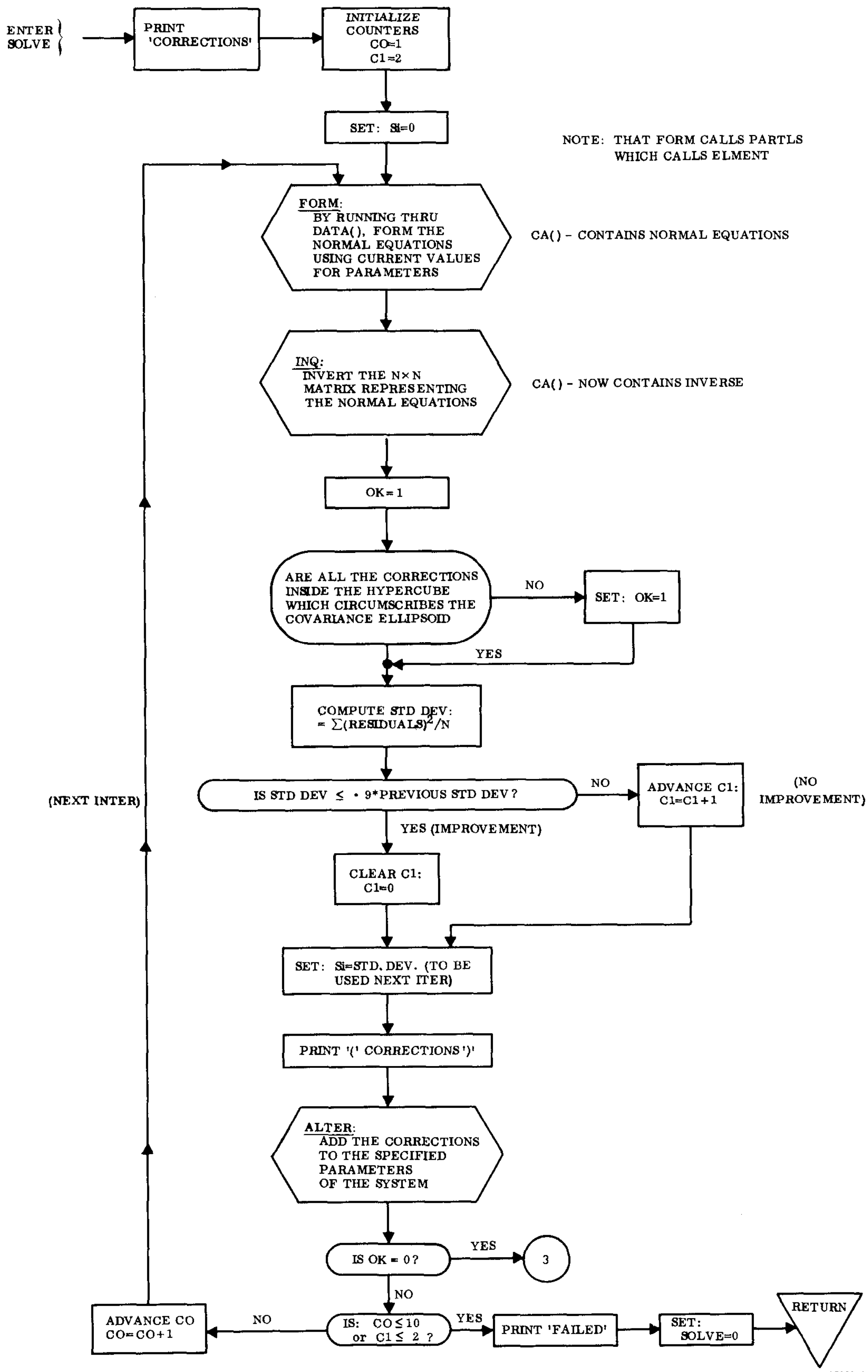

TYPE =20
GET ANGLE OF Z ROTATION TH=DATA(i+1)*UNIT
DO WE ADD A RANDOM L? ie. IS RDT≠0
NO
YES(RARE)
GAUSSIAN: COMPUTE RANDOM T WITH FREQ. DISTRIBUTION exp(-X^2/RDT)
TH=TH + ΔT
COMPUTE FIRST ORDER 'Z Ro' MATRIX R
L = 0
EL1

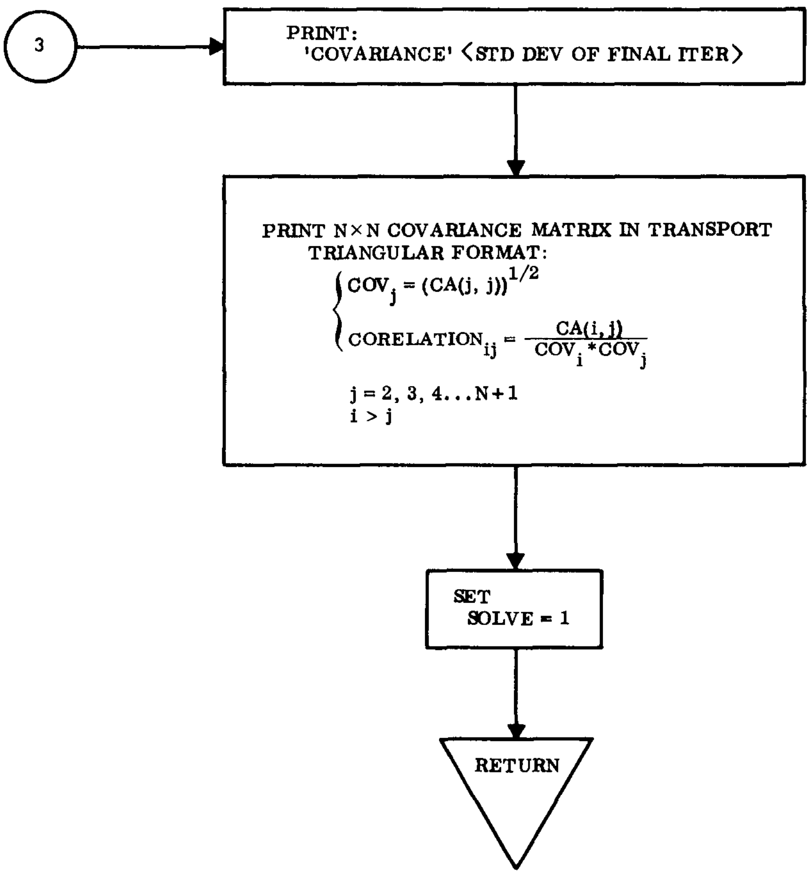

TYPE =21
PRESET:
R(,) = IDENTITY MX
$\vec{m}$ = 0 (MISALIGNMENT VECTOR)
j = DATA(i+1) (ASSUMED = 4. or 2.)
IS DATA(i+3) ≤ 0?
YES
NO
PRESET MISALIGNMENT CODE FOR 'DEFINITE DISPLACEMENT AND NO RETURN' i.e., TYT = 010
PRESET MISALIGNMENT CODE FOR 'UNCERTAINTY AND RETURN' i.e., TYT = 000
IS DATA(i+3) = 0?
SET m(j) = [DATA(i+3)]
SET m(j) = DATA(i+2)
SET m(j) = DATA(i+2)+ {RANDOM NUMBER SELECTED FROM A GAUSSIAN DISTRIBUTION WHOSE HALF WIDTH AT HALF MAXIMUM IS DATA(i+3)}
ADJUST m(j) TO ACCOUNT FOR BEAM MOMENTUM RIGIDITY
TOL1
(USE MISALIGNMENT TO CALCULATE EFFECT OF $\vec{m}$)
1510810


EL1..
ADD SMALL NON-ZERO MASS CORRECTION TO A PATH LENGTH MX. ELMT.
$R_{56} = R_{56} + \frac{L \cdot M^2}{p^2 + m^2}$
IS MU=42 ?
YES
SECORD
COMPUTE ALL 2nd ORDER MX. ELMTS FOR THIS ELT
IS THE 'UPDATE' FLAG RCP=TRUE ?
NO
(UPDATE CASE)
SET: C1P=FALSE RCP=TRUE
YES
(NO UPDATE CASE)
SET: C1P=TRUE
START A FRESH TRANSFORM MX. RC RC ← R
ACCUMULATE TRANSFORM MX. RC RC ← RC · R
(USE SUBROUTINE CAB)
CALL ADVANCE
IS THE R2 'UPDATE' FLAG R2P=TRUE ?
NO
(UPDATE CASE)
SET: C3P=FALSE R2P=TRUE
YES
(NO R2 UPDATE CASE)
SET C3P=TRUE
START A FRESH R2 TRANSFORM MX. RC2 RC2 ← R
ACCUMULATE R2 TRANSFORM MX RC2 RC2 ← RC2 · R
EL21..
SET: TYP1=TYPE
ACCUMULATE SYSTEM LENGTH: LC ← LC+L
EL2 ..
RETURN

1510811

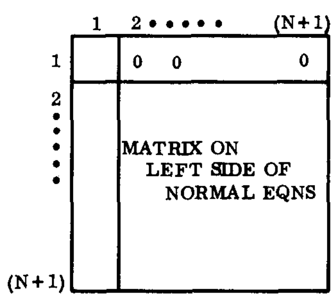
-SOLVE SUBPROGRAM-





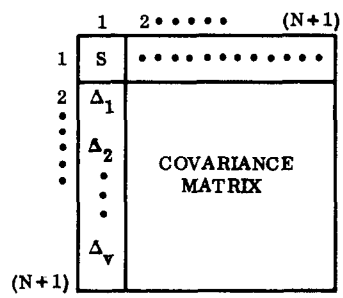
FORMAT OF ARRAY CA(,)

AFTER FORM, BUT BEFORE INQ



COLUMN VECTOR ON RIGHT SIDE OF NORMAL EQUATIONS

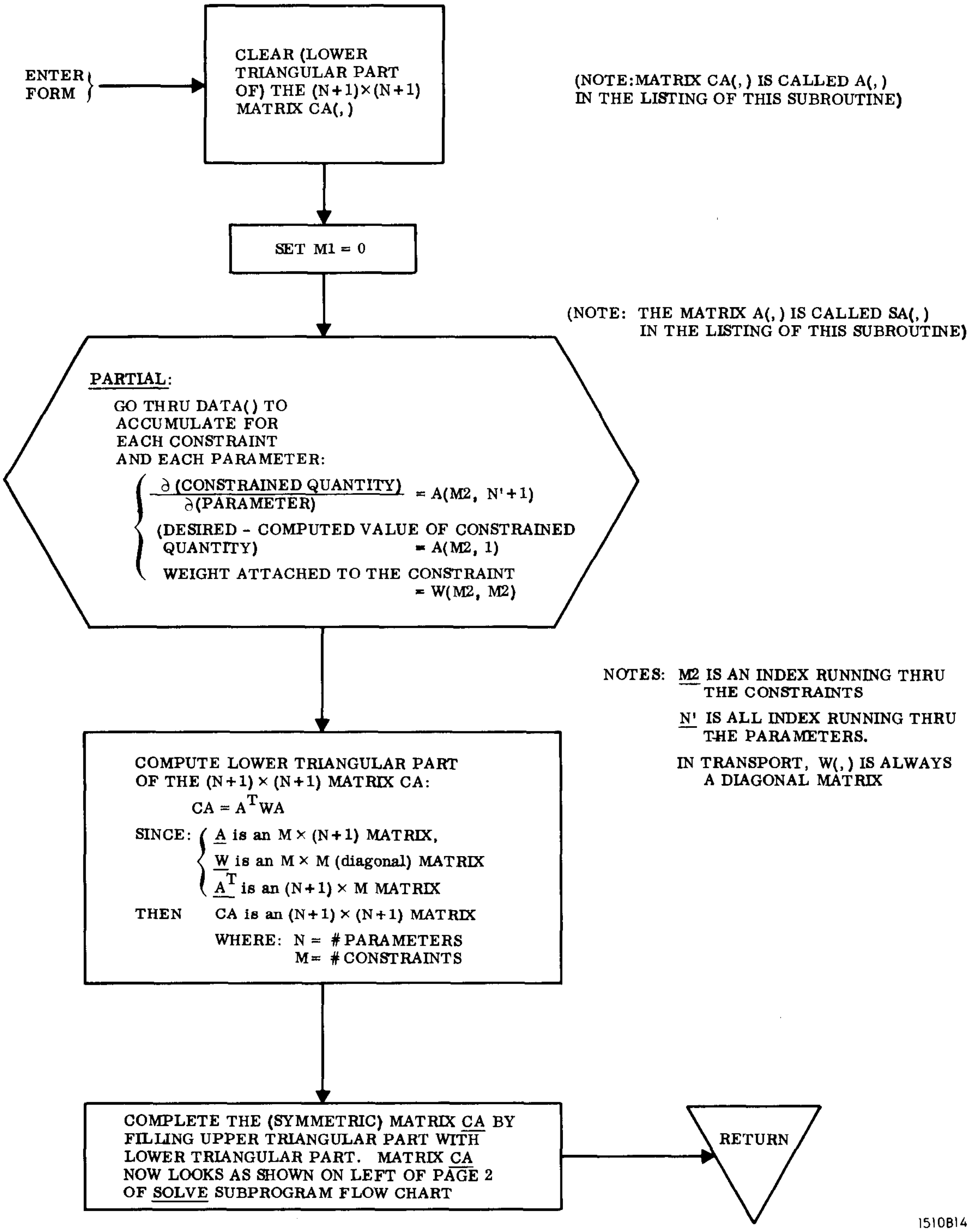
AFTER INQ



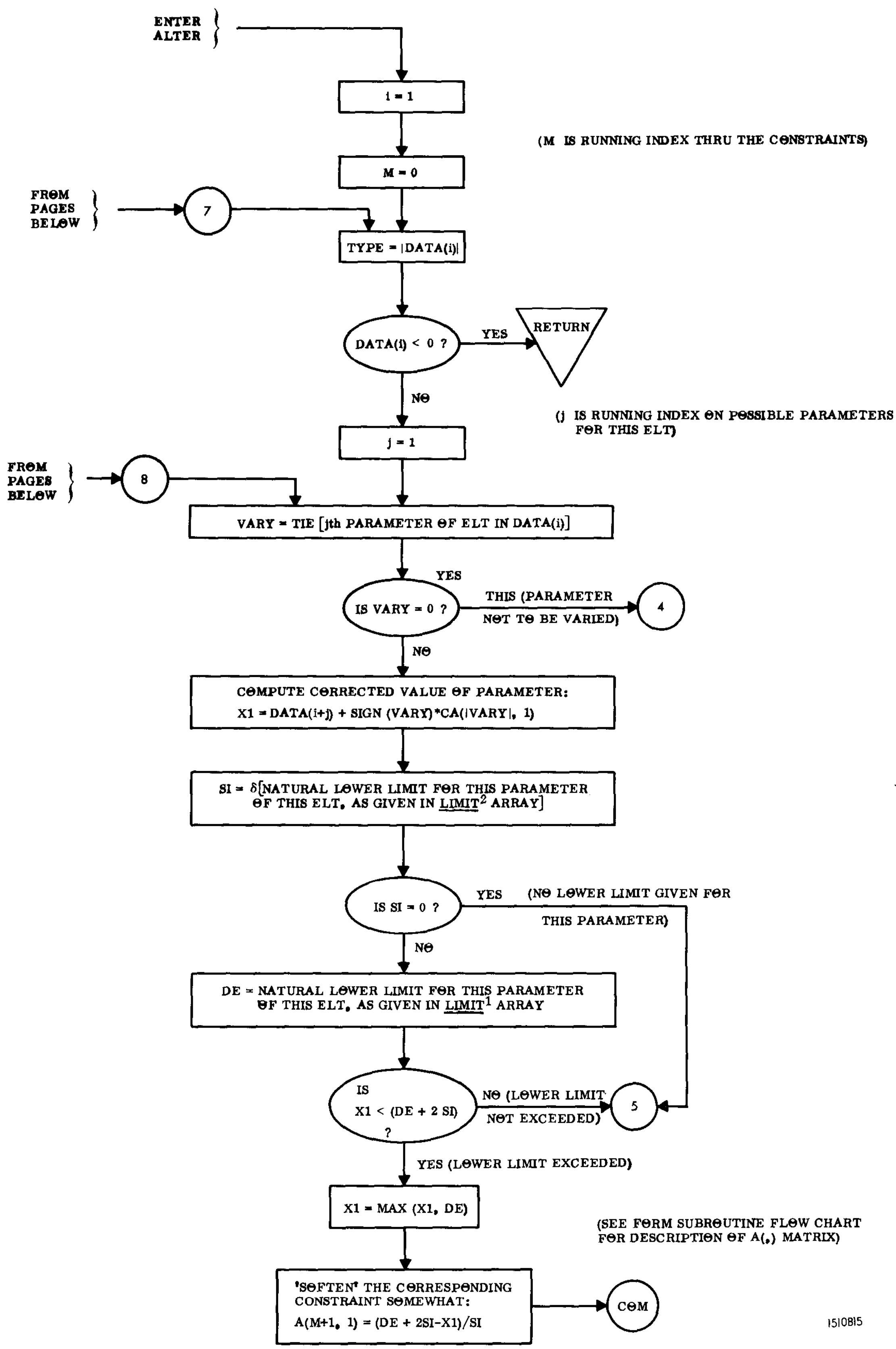
S = SUM OF SQUARES OF THE LEAST SQUARES RESIDUALS

Δ_i = CORRECTION FOUND TO ith PARAMETER

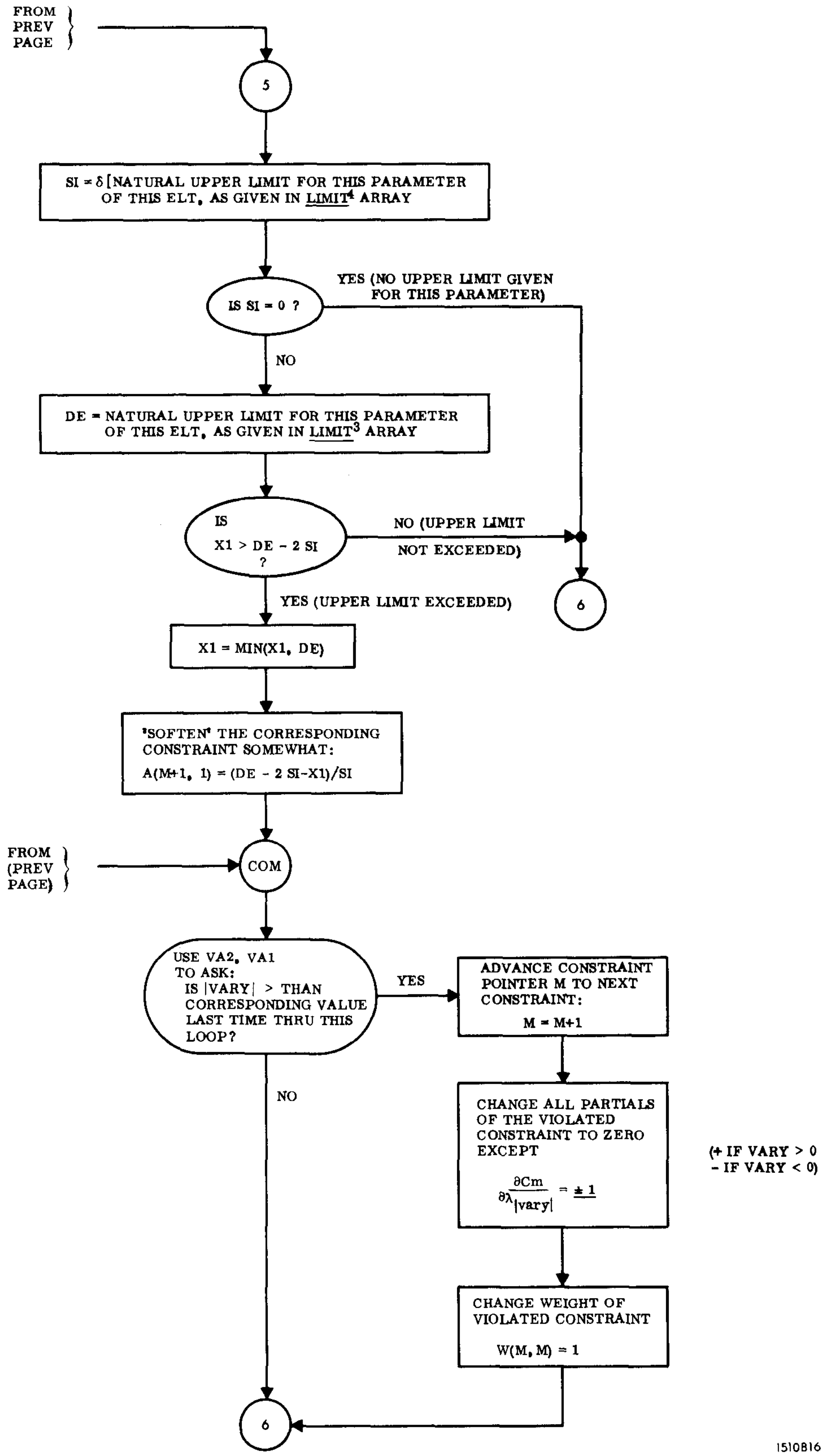
1510813

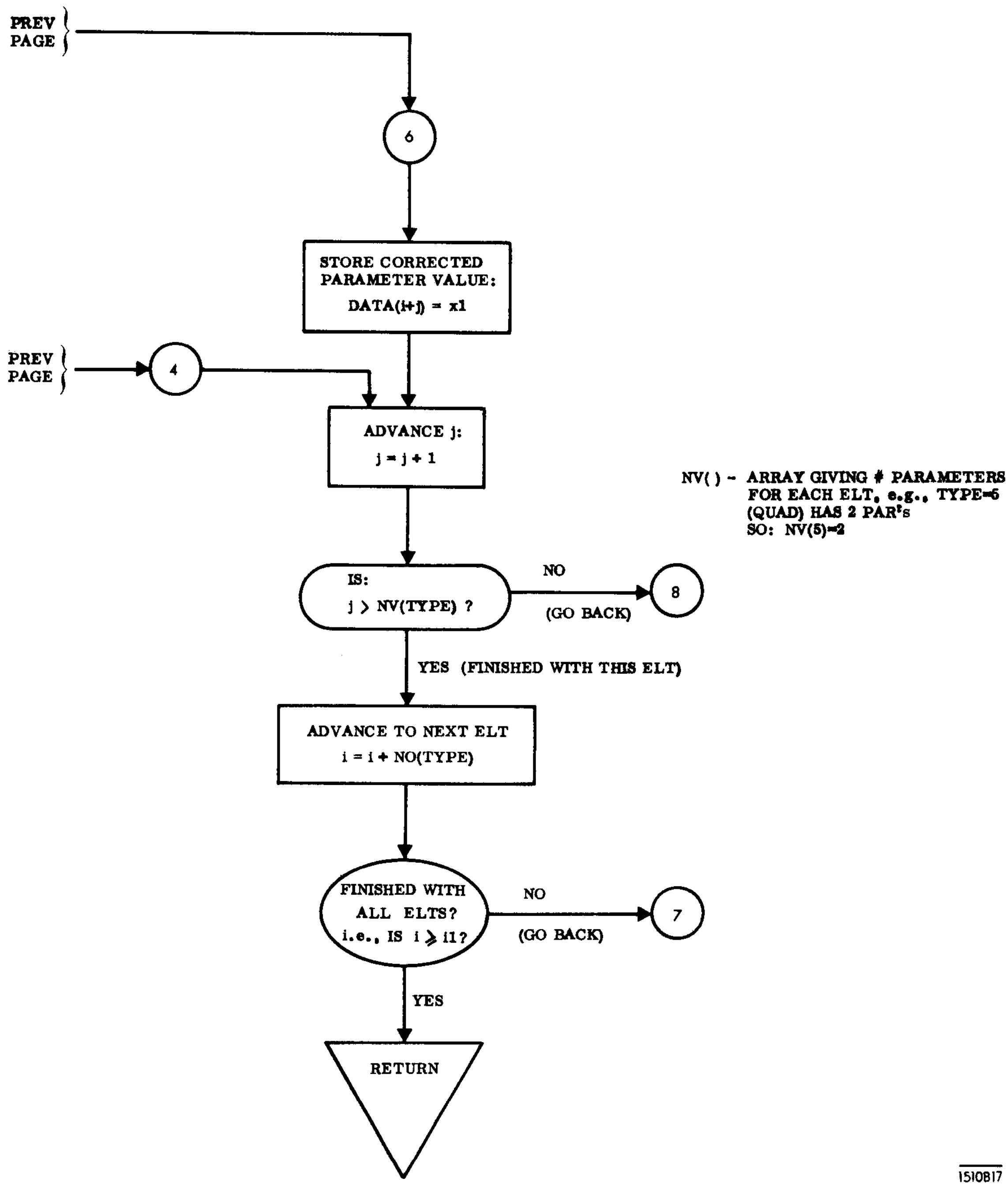

ENTER FORM
CLEAR (LOWER TRIANGULAR PART OF) THE (N+1)×(N+1) MATRIX CA(,)
(NOTE: MATRIX CA(,) IS CALLED A(,) IN THE LISTING OF THIS SUBROUTINE)
SET M1 = 0
(NOTE: THE MATRIX A(,) IS CALLED SA(,) IN THE LISTING OF THIS SUBROUTINE)
PARTIAL:
GO THRU DATA() TO ACCUMULATE FOR EACH CONSTRAINT AND EACH PARAMETER:
∂ (CONSTRAINED QUANTITY) / ∂(PARAMETER) = A(M2, N'+1)
(DESIRED - COMPUTED VALUE OF CONSTRAINED QUANTITY) = A(M2, 1)
WEIGHT ATTACHED TO THE CONSTRAINT = W(M2, M2)
NOTES: M2 IS AN INDEX RUNNING THRU THE CONSTRAINTS
N' IS ALL INDEX RUNNING THRU THE PARAMETERS.
IN TRANSPORT, W(,) IS ALWAYS A DIAGONAL MATRIX
COMPUTE LOWER TRIANGULAR PART OF THE (N+1) × (N+1) MATRIX CA:
CA = A^T WA
SINCE: A is an M × (N+1) MATRIX,
W is an M × M (diagonal) MATRIX
A^T is an (N+1) × M MATRIX
THEN CA is an (N+1) × (N+1) MATRIX
WHERE: N = #PARAMETERS
M= #CONSTRAINTS
COMPLETE THE (SYMMETRIC) MATRIX CA BY FILLING UPPER TRIANGULAR PART WITH LOWER TRIANGULAR PART. MATRIX CA NOW LOOKS AS SHOWN ON LEFT OF PAGE 2 OF SOLVE SUBPROGRAM FLOW CHART
RETURN

1510B14

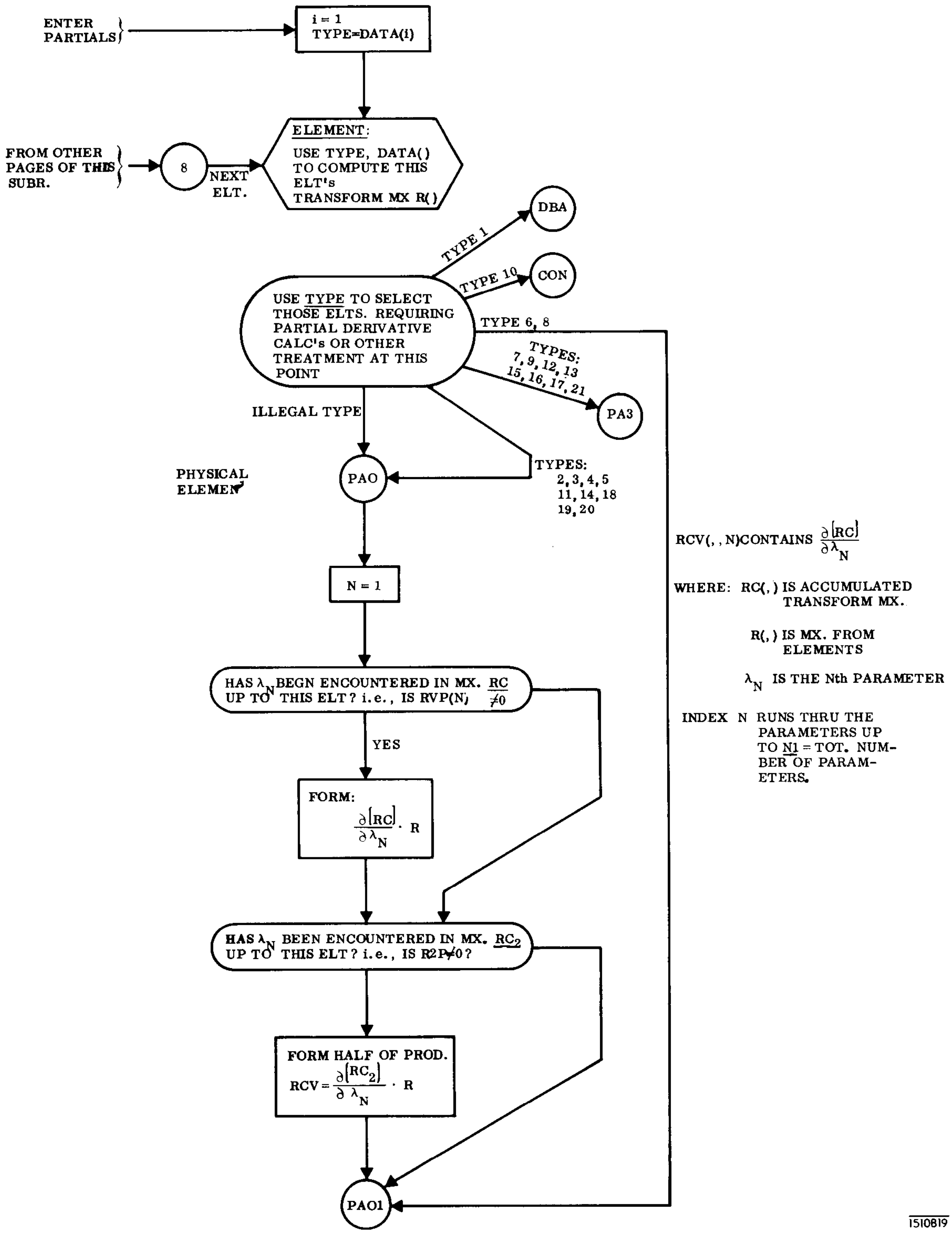

ENTER ALTER
i = 1
(M IS RUNNING INDEX THRU THE CONSTRAINTS)
M = 0
FROM PAGES BELOW
7
TYPE = |DATA(i)|
DATA(i) < 0 ?
YES
RETURN
NO
(j IS RUNNING INDEX ON POSSIBLE PARAMETERS FOR THIS ELT)
j = 1
FROM PAGES BELOW
8
VARY = TIE [jth PARAMETER OF ELT IN DATA(i)]
IS VARY = 0 ?
YES
THIS (PARAMETER NOT TO BE VARIED)
4
NO
COMPUTE CORRECTED VALUE OF PARAMETER:
X1 = DATA(i+j) + SIGN (VARY)*CA(|VARY|, 1)
SI = δ[NATURAL LOWER LIMIT FOR THIS PARAMETER OF THIS ELT, AS GIVEN IN LIMIT2 ARRAY]
IS SI = 0 ?
YES
(NO LOWER LIMIT GIVEN FOR THIS PARAMETER)
NO
DE = NATURAL LOWER LIMIT FOR THIS PARAMETER OF THIS ELT, AS GIVEN IN LIMIT1 ARRAY
IS X1 < (DE + 2 SI) ?
NO (LOWER LIMIT NOT EXCEEDED)
5
YES (LOWER LIMIT EXCEEDED)
X1 = MAX (X1, DE)
(SEE FORM SUBROUTINE FLOW CHART FOR DESCRIPTION OF A(,) MATRIX)
'SOFTEN' THE CORRESPONDING CONSTRAINT SOMEWHAT:
A(M+1, 1) = (DE + 2SI-X1)/SI
COM
1510815

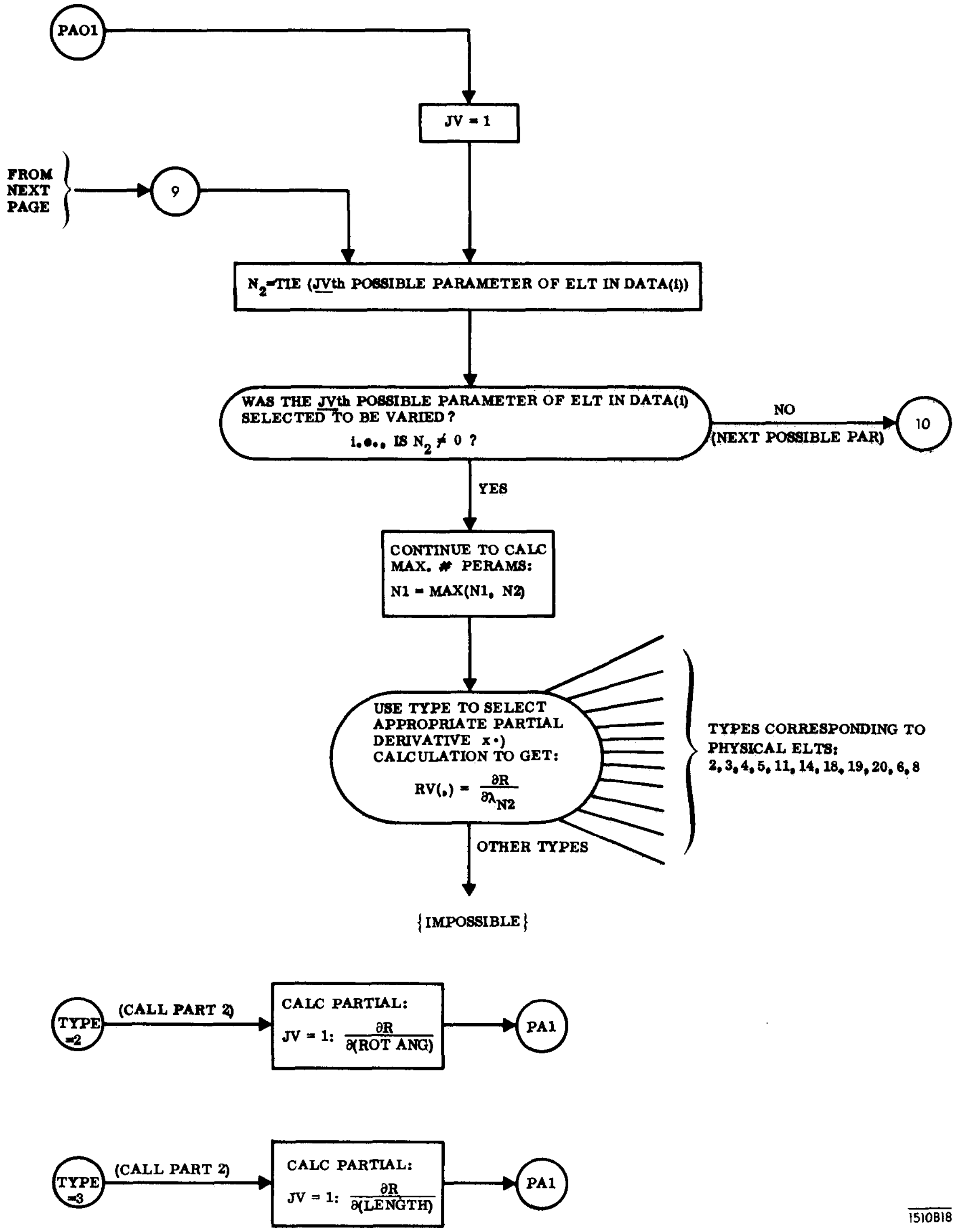
-ALTER SUBROUTINE (2)-

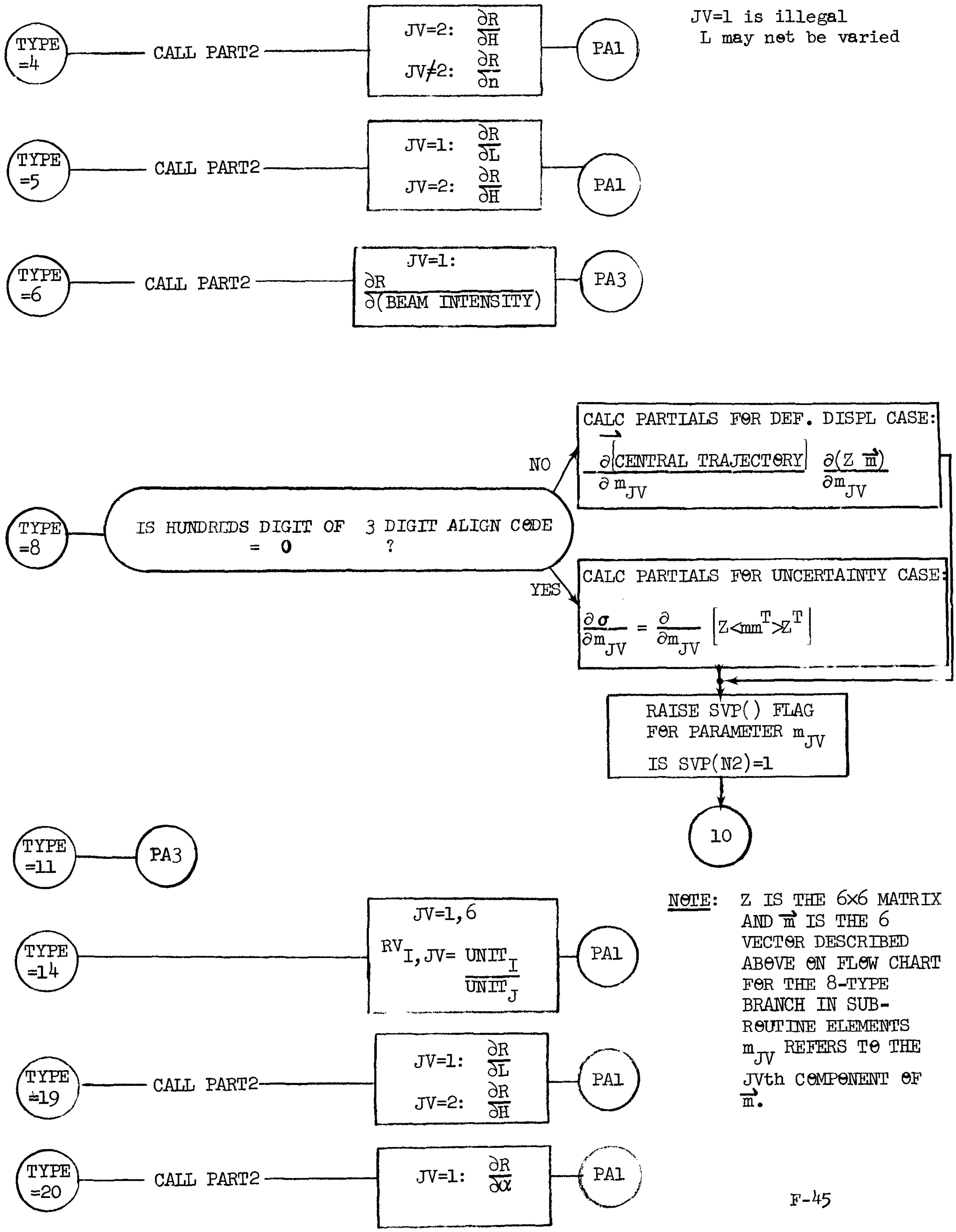



PREV PAGE
6
STORE CORRECTED PARAMETER VALUE:
DATA(i+j) = x1
PREV PAGE
4
ADVANCE j:
j = j + 1
NV( ) - ARRAY GIVING # PARAMETERS FOR EACH ELT, e.g., TYPE=6 (QUAD) HAS 2 PAR's SO: NV(5)=2
IS:
j > NV(TYPE) ?
NO
(GO BACK)
8
YES (FINISHED WITH THIS ELT)
ADVANCE TO NEXT ELT
i = i + NO(TYPE)
FINISHED WITH ALL ELTS?
i.e., IS i ≥ i1?
NO
(GO BACK)
7
YES
RETURN
1510817

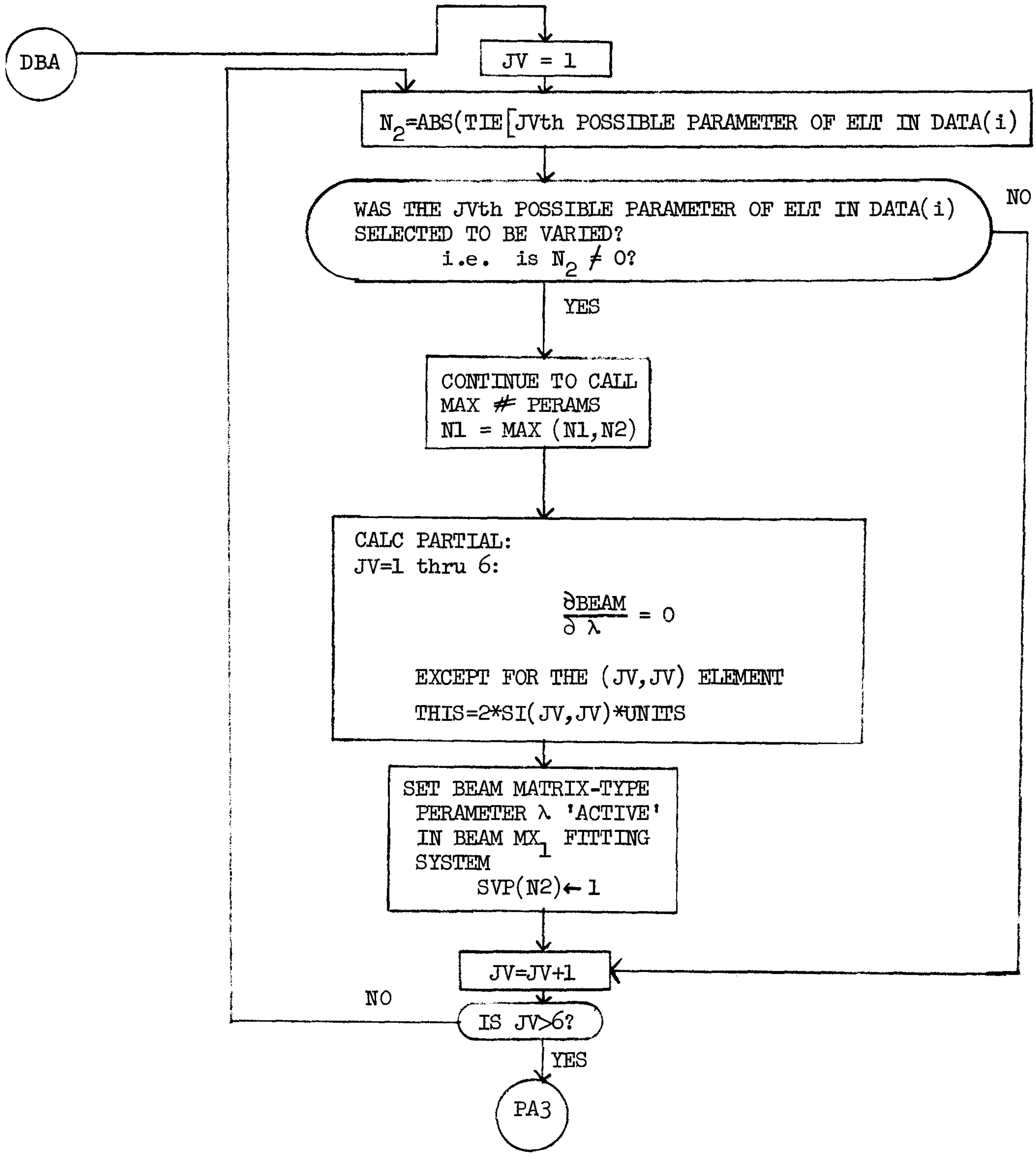
-PARTIALS SUBROUTINE-



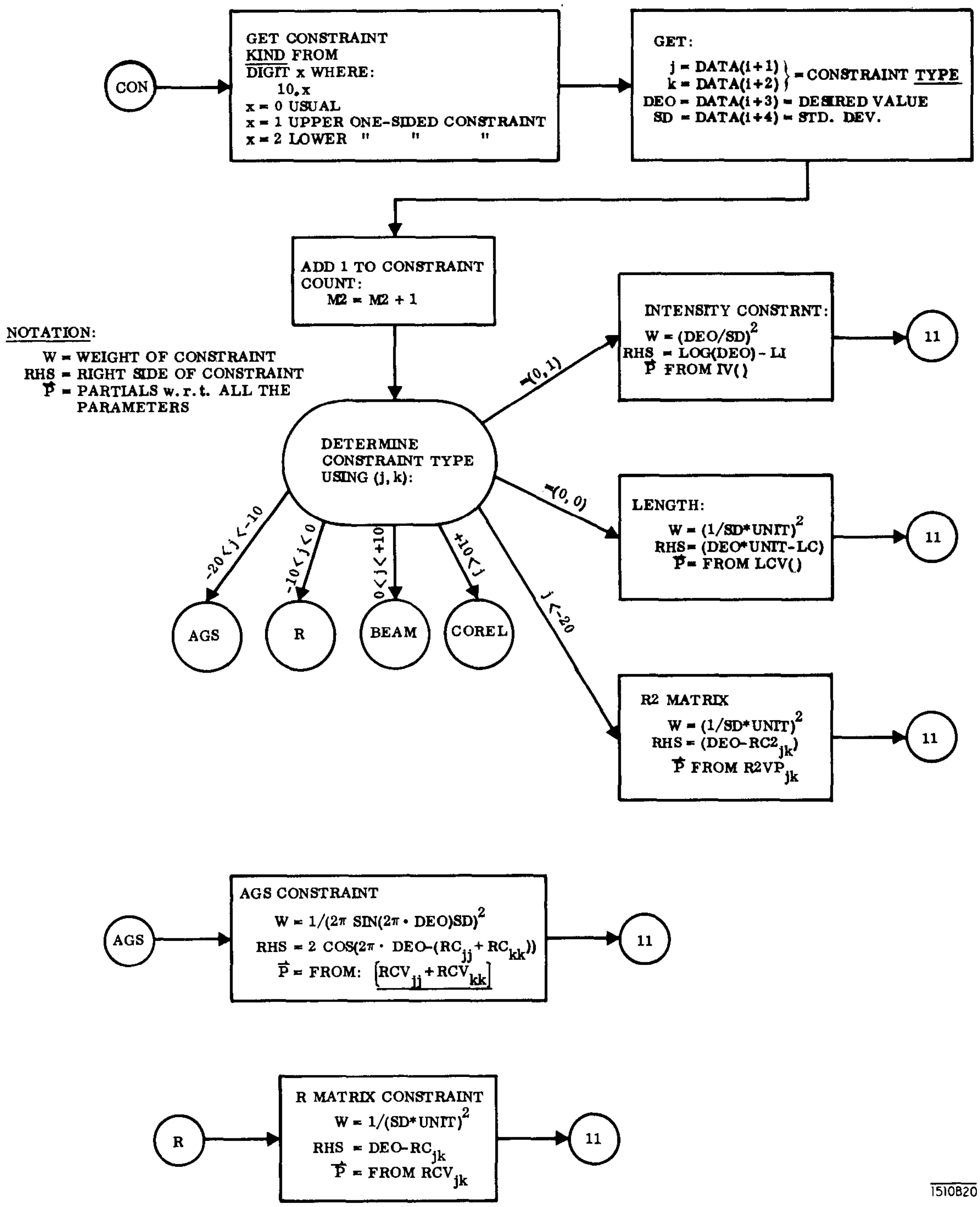

PAO1
JV = 1
FROM NEXT PAGE
9
N2=TIE (JVth POSSIBLE PARAMETER OF ELT IN DATA(I))
WAS THE JVth POSSIBLE PARAMETER OF ELT IN DATA(I) SELECTED TO BE VARIED?
i.e., IS N2 ≠ 0 ?
NO
(NEXT POSSIBLE PAR)
10
YES
CONTINUE TO CALC MAX. # PERAMS:
N1 = MAX(N1, N2)
USE TYPE TO SELECT APPROPRIATE PARTIAL DERIVATIVE x·) CALCULATION TO GET:
RV(,) = ∂R/∂λN2
TYPES CORRESPONDING TO PHYSICAL ELTS:
2, 3, 4, 5, 11, 14, 18, 19, 20, 6, 8
OTHER TYPES
{IMPOSSIBLE}
TYPE =2
(CALL PART 2)
CALC PARTIAL:
JV = 1: ∂R/∂(ROT ANG)
PA1
TYPE =3
(CALL PART 2)
CALC PARTIAL:
JV = 1: ∂R/∂(LENGTH)
PA1
1510B18



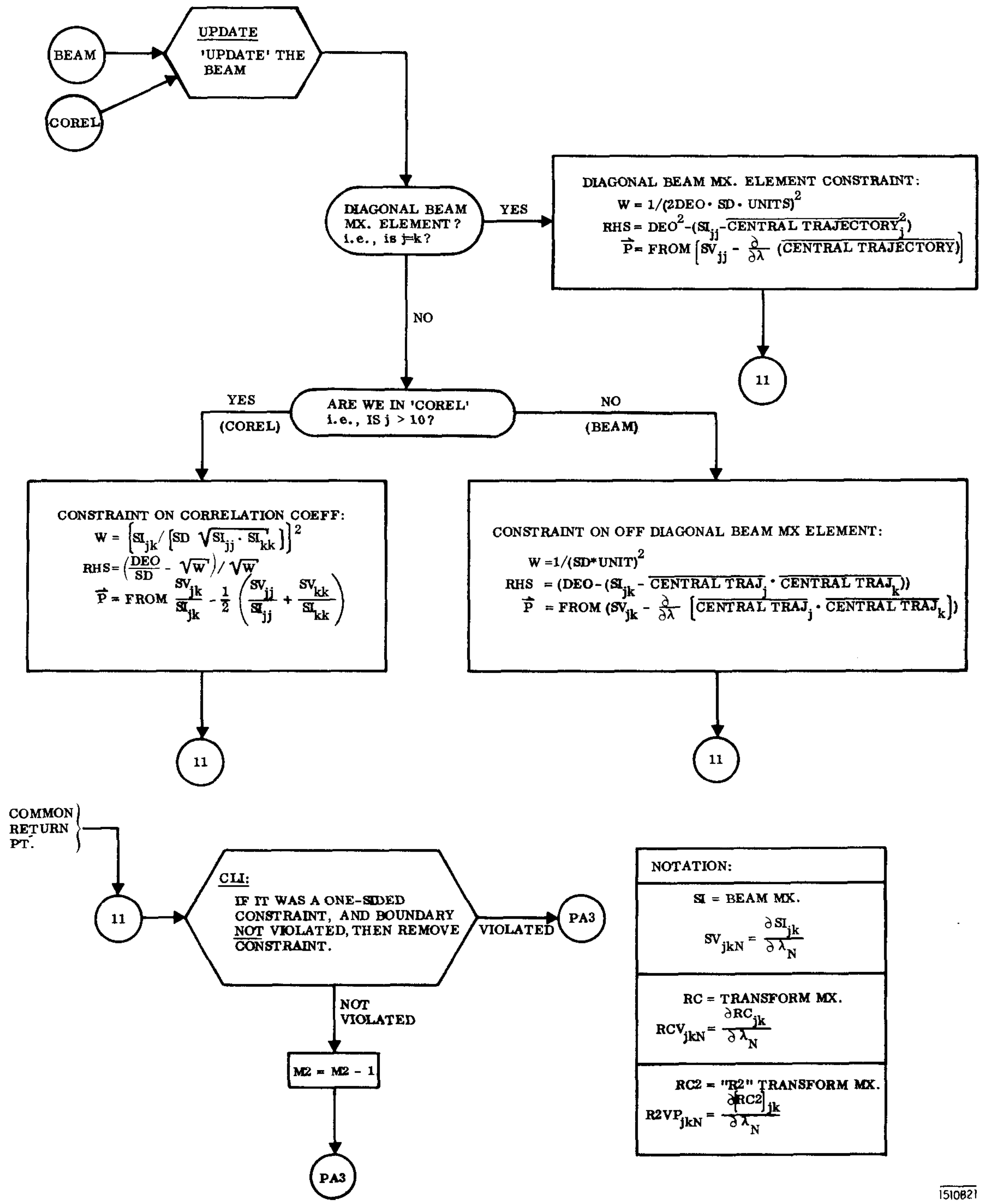
NOTE: Z IS THE 6×6 MATRIX AND $\vec{m}$ IS THE 6 VECTOR DESCRIBED ABOVE ON FLOW CHART FOR THE 8-TYPE BRANCH IN SUBROUTINE ELEMENTS m_{JV} REFERS TO THE JVth COMPONENT OF $\vec{m}$.

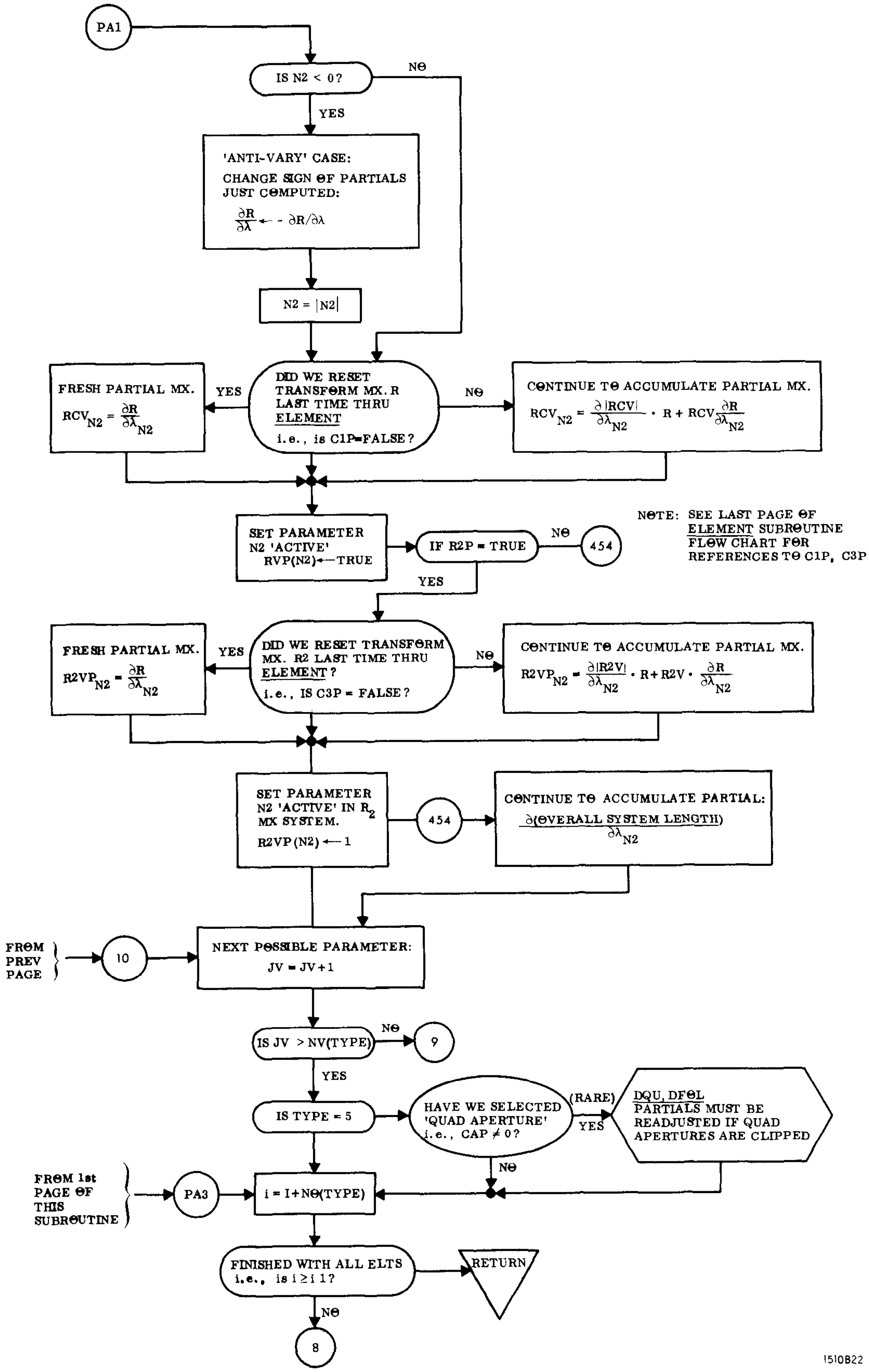

DBA
JV = 1
N2=ABS(TIE[JVth POSSIBLE PARAMETER OF ELT IN DATA(i)
WAS THE JVth POSSIBLE PARAMETER OF ELT IN DATA(i) SELECTED TO BE VARIED? i.e. is N2 ≠ 0?
NO
YES
CONTINUE TO CALL MAX # PERAMS N1 = MAX (N1,N2)
CALC PARTIAL: JV=1 thru 6:
∂BEAM/∂λ = 0
EXCEPT FOR THE (JV,JV) ELEMENT
THIS=2*SI(JV,JV)*UNITS
SET BEAM MATRIX-TYPE PERAMETER λ 'ACTIVE' IN BEAM MX1 FITTING SYSTEM
SVP(N2)← 1
JV=JV+1
NO
IS JV>6?
YES
PA3

-PARTIALS SUBROUTINE (5)-



1510820


BEAM
COREL
UPDATE
'UPDATE' THE BEAM
DIAGONAL BEAM MX. ELEMENT? i.e., is j=k?
YES
DIAGONAL BEAM MX. ELEMENT CONSTRAINT:
W = 1/(2DEO · SD · UNITS)^2
RHS = DEO^2 -(SI_jj - CENTRAL TRAJECTORY_j^2)
P = FROM [SV_jj - ∂/∂λ (CENTRAL TRAJECTORY)]
11
NO
ARE WE IN 'COREL' i.e., IS j > 10?
YES (COREL)
NO (BEAM)
CONSTRAINT ON CORRELATION COEFF:
W = {SI_jk / [SD √(SI_jj · SI_kk)]}^2
RHS = (DEO/SD - √W) / √W
P = FROM SV_jk/SI_jk - 1/2 (SV_jj/SI_jj + SV_kk/SI_kk)
CONSTRAINT ON OFF DIAGONAL BEAM MX ELEMENT:
W = 1/(SD*UNIT)^2
RHS = (DEO - (SI_jk - CENTRAL TRAJ_j · CENTRAL TRAJ_k))
P = FROM (SV_jk - ∂/∂λ [CENTRAL TRAJ_j · CENTRAL TRAJ_k])
11
11
COMMON RETURN PT.
11
CLI:
IF IT WAS A ONE-SIDED CONSTRAINT, AND BOUNDARY NOT VIOLATED, THEN REMOVE CONSTRAINT.
VIOLATED
PA3
NOT VIOLATED
M2 = M2 - 1
PA3
NOTATION:
SI = BEAM MX.
SV_jkN = ∂SI_jk / ∂λ_N
RC = TRANSFORM MX.
RCV_jkN = ∂RC_jk / ∂λ_N
RC2 = "R2" TRANSFORM MX.
R2VP_jkN = ∂[RC2]_jk / ∂λ_N
1510821

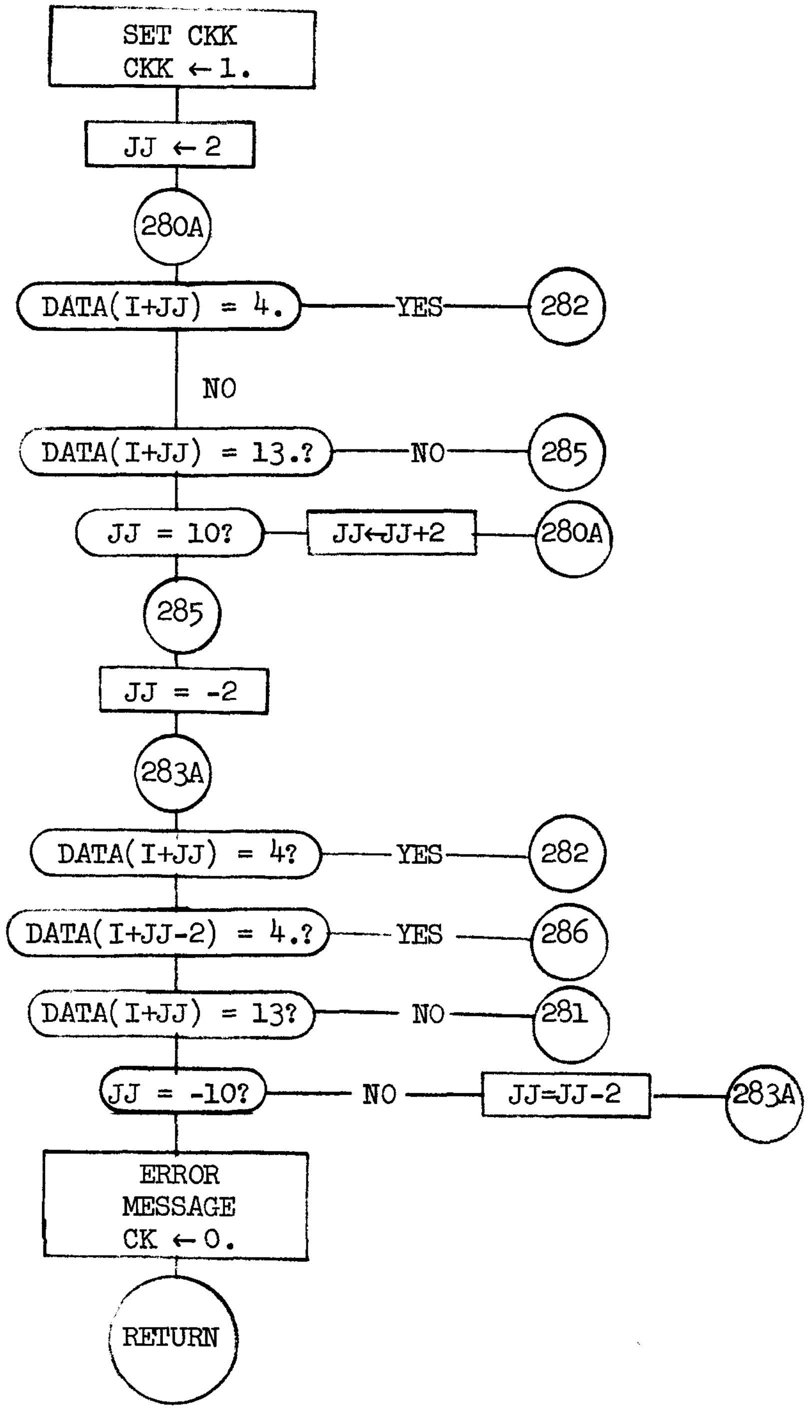

PA1
IS N2 < 0?
NO
YES
'ANTI-VARY' CASE:
CHANGE SIGN OF PARTIALS JUST COMPUTED:
$\frac{\partial R}{\partial \lambda} \leftarrow - \partial R/\partial \lambda$
N2 = |N2|
FRESH PARTIAL MX.
$RCV_{N2} = \frac{\partial R}{\partial \lambda_{N2}}$
YES
DID WE RESET TRANSFORM MX. R LAST TIME THRU ELEMENT
i.e., is C1P=FALSE?
NO
CONTINUE TO ACCUMULATE PARTIAL MX.
$RCV_{N2} = \frac{\partial |RCV|}{\partial \lambda_{N2}} \cdot R + RCV \frac{\partial R}{\partial \lambda_{N2}}$
SET PARAMETER N2 'ACTIVE'
RVP(N2) ← TRUE
IF R2P = TRUE
NO
454
YES
NOTE: SEE LAST PAGE OF ELEMENT SUBROUTINE FLOW CHART FOR REFERENCES TO C1P, C3P
FRESH PARTIAL MX.
$R2VP_{N2} = \frac{\partial R}{\partial \lambda_{N2}}$
YES
DID WE RESET TRANSFORM MX. R2 LAST TIME THRU ELEMENT?
i.e., IS C3P = FALSE?
NO
CONTINUE TO ACCUMULATE PARTIAL MX.
$R2VP_{N2} = \frac{\partial |R2V|}{\partial \lambda_{N2}} \cdot R + R2V \cdot \frac{\partial R}{\partial \lambda_{N2}}$
SET PARAMETER N2 'ACTIVE' IN R_2 MX SYSTEM.
R2VP (N2) ← 1
454
CONTINUE TO ACCUMULATE PARTIAL:
$\frac{\partial(\text{OVERALL SYSTEM LENGTH})}{\partial \lambda_{N2}}$
FROM PREV PAGE
10
NEXT POSSIBLE PARAMETER:
JV = JV + 1
IS JV > NV(TYPE)
NO
9
YES
IS TYPE = 5
HAVE WE SELECTED 'QUAD APERTURE'
i.e., CAP ≠ 0?
(RARE)
YES
DQU, DFOL PARTIALS MUST BE READJUSTED IF QUAD APERTURES ARE CLIPPED
NO
FROM 1st PAGE OF THIS SUBROUTINE
PA3
i = I + NO(TYPE)
FINISHED WITH ALL ELTS
i.e., is i ≥ i 1?
RETURN
NO
8
1510B22

-SUBROUTINE CHEK(1)-

CHECK DATA FOLLOWING POLE FACE ROTATION TO SEE IF IS A BEND OR A PRINTOUT REQUEST

NO BEND FOUND. CHECK PRECEDING DATA

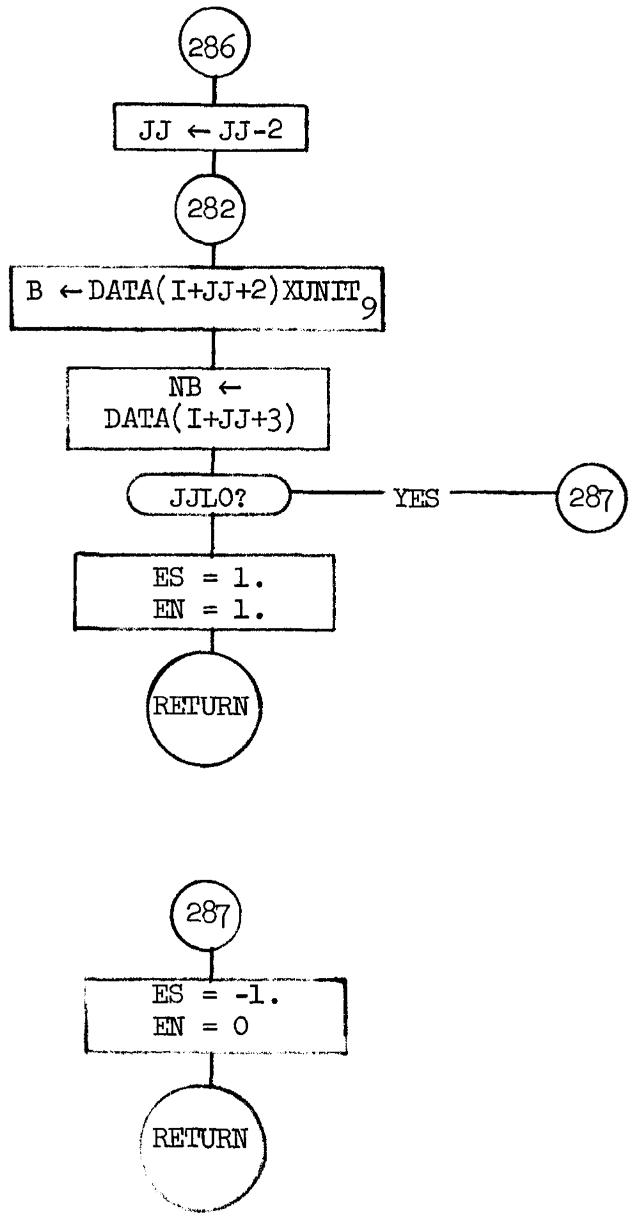
IMPROPER ELEMENT



FIELD

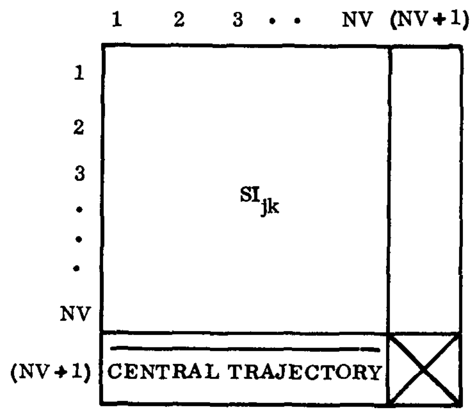
n

SET FAGS FOR POLE FACE ROTATION BEFORE BEND FOR 2ND ORDER CALCULATION



MATRIX FORMAT

SI:



NV=6 (FIRST ORDER RUN)
=42 (SECOND ORDER RUN)

FLAGS:

S1P: CENTRAL TRAJECTORY IS NOT IDENTICALLY=0

1510823

```
BEAM TRANSPORT SYSTEM FOR SLAC BEAM SWITCHYARD END STATION A II

    1

THE SECOND STEP TO FITTING IS TO ALLOW THE FIELDS OF THE FIRST QUAD

DOUBLET,Q1, TO VARY AS WELL AS THE SYMMETRY QUAD IN ORDER TO GET AN IMAGE AT

THE EXIT OF THE SYMMETRY QUAD,Q2, AS WELL AS THE PREVIOUSLY MENTIONED

ACHROMATIC CONDITION.

   1.00000    0.30000   0.10000    0.30000    0.10000    0.30000    1.00000  25.00000

  13.00000    2.00000

   4.00000    5.00000   1.45500    0.0

   2.00000    0.50000

  13.00000    1.00000

   3.00000   80.00000

  13.00000    1.00000

   5.00000    2.00000  -2.20000    5.00000
   VARY CODE  010000
    LABEL = Q1

   3.00000    2.00000

   5.00000    2.00000   2.40000    5.00000
   VARY CODE  010000
    LABEL = Q1

  13.00000    1.00000

   9.00000    4.00000

   3.00000    1.00000

   2.00000    1.50000

   4.00000    3.00000  14.55000    0.0

   2.00000    1.50000

   9.00000    0.0

  13.00000    1.00000

   3.00000   25.70569
   VARY CODE  900000
    LABEL = DR1

   5.00000    2.00000   3.59519   15.00000
   VARY CODE  010000
    LABEL = Q2
```

```
 13.C0000   1.00000

 10.00000  -1.00000   2.00000   0.0        0.00100
   LABEL = FIT1

 10.00000  -3.00000   4.00000   0.0        0.00100
   LABEL = FIT1

 13.00000   4.00000

  3.00000  24.29425
  VARY CODE  400000
   LABEL = CR1

 13.00000   1.00000

  9.C0000   4.00000

  2.0C0C0   1.50000

  4.CC000   3.00C00  14.550CC   0.0

  2.00000   1.50C00

  3.0C0C0   1.00000

  9.CC000   C.0

 13.00000   1.0C000

 10.0C0C0  -1.00000   6.CC000   0.0        0.C0100
   LABEL = FIT2

 10.00000  -2.00000   6.00000   0.0        0.C0100
   LABEL = FIT3

 13.0C000   4.00000

  5.00000   2.00000  -1.9C0C0   5.C000C
   LABEL = Q3

  3.0C000   2.0CC00

  5.0C000   2.00000   1.85000   5.00000
   LABEL = Q3

  3.00000 20C.00C00

 13.0C000   1.00000

-10.00000   1.00000   1.CC0C0   4.C0000    0.10000
  VARY CODE  200000
   LABEL = FIT4

-10.000C0   3.00000   3.CC0C0   1.50000    0.10000
  VARY CODE  200000
   LABEL = FIT4

 13.00000   4.00000
```

```
 13.C0000   1.CCC00

  5.CC000   2.00C00   4.5COCC   5.0000C
   LABEL  =  Q4

  3.CC000   2.00000

 13.0000C   1.00000

  5.0C000   2.00000  -4.2C0C0   5.00000
   LABEL  =  Q4

 13.0C000   1.00C00

  3.0C000  15.00000

 13.00000   1.0CC00

-10.00000   2.000C0   1.CCCC0   0.0        0.00100
   LABEL  =  FIT5

-10.00000   4.00000   3.CC000   C.C        0.00100
   LABEL  =  FIT6

-10.00000   1.00000   1.CCOCC   C.C2000    0.C1000
  VARY CODE  200000
   LABEL  =  FIT7

-10.0C000   3.00000   3.00000   0.C2000    0.C1C00
  VARY CODE  200000
   LABEL  =  FIT7

 13.00000   4.00000

 SENTINEL
```

BEAM TRANSPORT SYSTEM FOR SLAC BEAM SWITCHYARD END STATION A II

```
*BEAM*     1.000000   25.00 GEV
                                                     0.0 M        0.0     0.300 CM
                                                                  0.0     0.100 MR    0.0
                                                                  0.0     0.300 CM    0.0     0.0
                                                                  0.0     0.100 MR    0.0     0.0     0.0
                                                                  0.0     0.300 CM    0.0     0.0     0.0     0.0
                                                                  0.0     1.000 PC    0.0     0.0     0.0     0.0     0.0


*BEND*     4.000    5.00000 M    1.455 KG    0.0000 (    0.500 D )

*ROTAT*    2.0      0.50 D

                                                     5.0 M        0.0     0.305 CM
                                                                  0.0     0.133 MR    0.171
                                                                  0.0     0.304 CM    0.0     0.0
                                                                  0.0     0.100 MR    0.0     0.0     0.164
                                                                  0.0     0.300 CM   -0.009  -0.001   0.0     0.0
                                                                  0.0     1.000 PC    0.071   0.657   0.0     0.0    -0.000

*DRIFT*    3.0     8C.0000 M

                                                    85.0 M        0.0     1.153 CM
                                                                  0.0     0.133 MR    C.965
                                                                  0.0     0.901 CM    0.0     0.0
                                                                  0.0     0.100 MR    0.0     0.0     0.943
                                                                  0.0     0.300 CM   -0.003  -0.001   0.0     0.0
                                                                  0.0     1.000 PC    0.624   0.657   0.0     0.0    -0.000

*QUAD*     5.00    2.00000 M    -2.2000 KG    5.000 CM  (  -9.151 M  )
    VARY CODE = 010000
         LABEL = Q1

*DRIFT*    3.0      2.0000 M

*QUAD*     5.00    2.00000 M     2.4000 KG    5.000 CM  (   9.029 M  )
    VARY CODE = 010000
         LABEL = C1

                                                    91.0 M        0.0     1.675 CM
                                                                  0.0     0.511 MR   -0.999
                                                                  0.0     0.564 CM    0.0     0.0
                                                                  0.0     0.151 MR    0.0     0.0    -0.936
                                                                  0.0     0.300 CM   -0.003   0.003   0.0     0.0
                                                                  0.0     1.000 PC    0.626  -0.616   0.0     0.0    -0.000
```

```
*DRIFT*     3.0      1.0000 M

*ROTAT*     2.0      1.50 D

*BEND*      4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.0      1.50 D

*DRIFT*     3.0      1.0000 M

*ROTAT*     2.0      1.50 D

*BEND*      4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.0      1.50 D

*DRIFT*     3.0      1.0000 M

*ROTAT*     2.0      1.50 D

*BEND*      4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.0      1.50 D

*DRIFT*     3.0      1.0000 M

*ROTAT*     2.0      1.50 D

*BEND*      4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.0      1.50 D


                                                  107.0 M        0.0      2.218 CM
                                                                 0.0      1.824 MR    0.865
                                                                 0.0      0.336 CM    0.0     0.0
                                                                 0.0      0.165 MR    0.0     0.0    -0.841
                                                                 0.0      0.457 CM   -0.715  -0.497   0.0     0.0
                                                                 0.0      1.000 PC    0.954   0.975   0.0     0.0    -0.610


*DRIFT*     3.0     25.7057 M
```

```
    VARY CCDE = 900000
         LABEL = DR1


*QUAD*     5.00   2.00000 M    3.5952 KG  15.000 CM  (  17.734 M  )
    VARY CCDE = 010000
         LABEL = Q2


                                                  134.7 M        0.0     6.672 CM
                                                                 0.0     2.101 MR   -0.989
                                                                 0.0     0.266 CM    0.0     0.0
                                                                 0.0     0.279 MR    0.0     0.0     0.915
                                                                 0.0     0.457 CM   -0.580  0.644   0.0     0.0
                                                                 0.0     1.000 PC    0.998 -0.997   0.0     0.0     -0.610


*FIT*     10.0     -1. 2.    0.0    / 0.001

                        -3.748
         LABEL = FIT1


*FIT*     10.0     -3. 4.    0.0    / 0.001

                        -0.382
         LABEL = FIT1


 *TRANSFORM* 1
           -0.75331  -3.74802   0.0        0.0        0.0        6.65790
           -0.07884  -1.71968   C.0        0.0        0.0       -2.09424
            0.0       0.0      -0.87796   -0.38176    0.0        0.0
            C.0       0.0      -C.78899   -1.48206    0.0        0.0
           -0.21025  -1.92988   0.0        0.0        1.00000   -0.27894
            0.0       0.0       0.0        0.0        0.0        1.00000


*DRIFT*    3.0    24.2942 M
    VARY CCDE = 400000
         LABEL = DR1


                                                  159.0 M        0.0     1.782 CM
                                                                 0.0     2.101 MR   -0.840
                                                                 0.0     0.928 CM    0.0     0.0
                                                                 0.0     0.279 MR    0.0     0.0     0.993
                                                                 0.0     0.457 CM   -0.328  0.644   0.0     0.0
                                                                 0.0     1.000 PC    0.881 -0.997   0.0     0.0     -0.610


*ROTAT*    2.0      1.50 D


*BEND*     4.000    3.000CC M   14.550 KG   0.0000 (   2.999 D )
```

```
*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M

*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M

*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M

*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M


                                                  175.0 M         0.0      1.115 CM
                                                                  0.0      0.174 MR     0.988
                                                                  0.0      1.340 CM     0.0      0.0
                                                                  0.0      0.238 MR     0.0      0.0      0.996
                                                                  0.0      0.495 CM    -0.000   -0.000    0.0      0.0
                                                                  0.0      1.000 PC     0.000    0.000    0.0      0.0     -0.796


*FIT*     10.0     -1. 6.    0.0    / 0.001
                             0.000
        LABEL = FIT2
```

```
*FIT*     10.C    -2. 6.   0.0   / 0.001

                           0.C00
        LABEL = FIT3


 *TRANSFORM* 1
          -1.07C94 -10.67648   0.0       0.0       0.0       0.00001
          -0.C7885  -1.71978   0.C       0.0       0.0       0.00000
           0.0       0.0      -3.95881  -6.20807   0.0       0.0
           C.0       0.0      -C.66630  -1.29747   C.0       0.0
          -0.00000  -0.00001   0.0       0.0       1.00000  -0.39405
           0.0       0.0       C.0       0.0       0.0       1.00000


*QUAD*     5.C0   2.C0000 M   -1.9000 KG   5.000 CM  ( -10.646 M  )
        LABEL = C3


*DRIFT*    3.0     2.0000 M


*QUAD*     5.C0   2.00000 M    1.8500 KG   5.000 CM  (  11.609 M  )
        LABEL = C3


*DRIFT*    3.0   20C.0000 M


                                                        381.0 M        0.0     1.742 CM
                                                                       0.0     0.167 MR    0.995
                                                                       0.0     0.824 CM    0.0     0.0
                                                                       0.0     0.082 MR    0.0     0.0     0.895
                                                                       0.0     0.495 CM    0.000   0.000   0.0     0.0
                                                                       0.0     1.000 PC   -0.000  -0.000   0.0     0.0    -0.796


 *TRANSFORM* 1
           2.77343  15.30110   0.0       0.0       0.0      -0.00001
           C.21337   1.5377C   0.C       0.C       0.0      -0.00000
           0.0       0.0       2.57533  -2.86091   0.0       0.0
           0.0       0.C       C.27C88   0.C8736   0.0       0.C
          -0.00000  -0.00001   0.0       0.C       1.00000  -0.39405
           C.0       0.0       0.0       0.C       0.0       1.00000

                                                        381.0 M        0.0     1.742 CM
                                                                       0.0     0.167 MR    0.995
                                                                       0.0     0.824 CM    0.0     0.0
                                                                       0.0     0.082 MR    0.0     0.0     0.895
                                                                       0.0     0.495 CM    0.000   0.000   0.0     0.0
                                                                       0.0     1.000 PC   -0.000  -0.000   0.0     0.0    -0.796


*QUAD*     5.C0   2.00000 M    4.5000 KG   5.000 CM  (   4.984 M  )
        LABEL = C4
```

```
*DRIFT*    3.0     2.0000 M

                                                          385.0 M         0.0      0.737 CM
                                                                          0.0      3.364 MR   -1.000
                                                                          0.0      1.424 CM    0.0     0.0
                                                                          0.0      1.999 MR    0.0     0.0     1.000
                                                                          0.0      0.495 CM    0.000  -0.000   0.0     0.0
                                                                          0.0      1.000 PC   -0.000   0.000   0.0     0.0    -0.796

*QUAD*     5.00   2.00000 M   -4.2000 KG   5.000 CM  (  -4.645 M  )
        LABEL = Q4

                                                          387.0 M         0.0      0.172 CM
                                                                          0.0      2.478 MR   -0.998
                                                                          0.0      1.520 CM    0.0     0.0
                                                                          0.0      1.070 MR    0.0     0.0    -1.000
                                                                          0.0      0.495 CM    0.000  -0.000   0.0     0.0
                                                                          0.0      1.000 PC   -0.000   0.000   0.0     0.0    -0.796

*DRIFT*    3.0    15.0000 M

                                                          402.0 M         0.0      3.545 CM
                                                                          0.0      2.478 MR    1.000
                                                                          0.0      0.090 CM    0.0     0.0
                                                                          0.0      1.070 MR    0.0     0.0     0.950
                                                                          0.0      0.495 CM   -0.000  -0.000   0.0     0.0
                                                                          0.0      1.000 PC    0.000   0.000   0.0     0.0    -0.796

 *TRANSFORM* 1
          -5.80162 -30.87849   0.0        0.0       0.0        0.00003
          -4.03058 -21.62466   0.0        0.0       0.0        0.00002
           0.0       0.0      -0.23357    0.56217   0.0        0.0
           0.0       0.0      -3.33957    3.75673   0.0        0.0
          -0.00000  -0.00001   0.0        0.0       1.00000   -0.39405
           0.0       0.0       0.0        0.0       0.0        1.00000

 *LENGTH*   401.9993 M

  *CORRECTIONS*

( 1.8837E 03)     0.104    -0.197     0.786    -0.019

( 6.4767E 01)     0.006    -0.008    -0.001     0.002

( 1.0700E-01)     0.000    -0.000    -0.000    -0.000

  *COVARIANCE   ( FIT   0.1 )
 0.000
-0.979  0.000
-0.934  0.952  0.010
-0.572  0.586  0.609  0.000
```

```
*BEAM*     1.000000   25.000 GEV
                                                 0.0 M         0.0     0.300 CM
                                                               0.0     0.100 MR    0.0
                                                               0.0     0.300 CM    0.0     0.0
                                                               0.0     0.100 MR    0.0     0.0     0.0
                                                               0.0     0.300 CM    0.0     0.0     0.0     0.0
                                                               0.0     1.000 PC    0.0     0.0     0.0     0.0     0.0

*BEND*     4.000   5.00000 M    1.455 KG   0.0000 (    0.500 D )

*ROTAT*    2.0      0.50 D

                                                 5.0 M         0.0     0.305 CM
                                                               0.0     0.133 MR    0.171
                                                               0.0     0.304 CM    0.0     0.0
                                                               0.0     0.100 MR    0.0     0.0     0.164
                                                               0.0     0.300 CM   -0.009  -0.001   0.0     0.0
                                                               0.0     1.000 PC    0.071   0.657   0.0     0.0    -0.000

*DRIFT*    3.0    80.0000 M

                                                85.0 M         0.0     1.153 CM
                                                               0.0     0.133 MR    0.965
                                                               0.0     0.901 CM    0.0     0.0
                                                               0.0     0.100 MR    0.0     0.0     0.943
                                                               0.0     0.300 CM   -0.003  -0.001   0.0     0.0
                                                               0.0     1.000 PC    0.624   0.657   0.0     0.0    -0.000

*QUAD*     5.00   2.00000 M   -2.0898 KG   5.000 CM  (  -9.650 M  )
    VARY CODE = 010000
         LABEL = Q1

*DRIFT*    3.0     2.0000 M

*QUAD*     5.00   2.00000 M    2.1943 KG   5.000 CM  (   9.843 M  )
    VARY CODE = 010000
         LABEL = Q1

                                                91.0 M         0.0     1.661 CM
                                                               0.0     0.392 MR   -0.998
                                                               0.0     0.582 CM    0.0     0.0
                                                               0.0     0.147 MR    0.0     0.0    -0.937
                                                               0.0     0.300 CM   -0.003   0.003   0.0     0.0
                                                               0.0     1.000 PC    0.627  -0.613   0.0     0.0    -0.000
```

```
*DRIFT*    3.0      1.0000 M

*ROTAT*    2.C      1.50 D

*BEND*     4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.000C M

*ROTAT*    2.0      1.5C D

*BEND*     4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*    2.0      1.5C D

*DRIFT*    3.C      1.0000 M

*ROTAT*    2.C      1.50 D

*BEND*     4.000    3.0000C M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.000C M

*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*    2.C      1.50 D


                                                  107.0 M        0.0      2.366 CM
                                                                 0.0      1.880 MR     0.873
                                                                 0.0      0.357 CM     0.0      0.0
                                                                 0.0      0.163 MR     0.0      0.0     -0.856
                                                                 0.0      0.471 CM    -0.737   -0.533   0.0      0.0
                                                                 0.0      1.000 PC     0.941    0.986   0.0      0.0     -0.617

*DRIFT*    3.C     24.9203 M
```

```
    VARY CODE = 900000
         LABEL = DR1


*QUAD*     5.C0   2.00000 M    3.5785 KG  15.000 CM  (  17.815 M  )
    VARY CODE = 010000
         LABEL = Q2


                                                133.9 M        0.0      6.823 CM
                                                               0.0      2.117 MR   -0.989
                                                               0.0      0.239 CM    0.0    0.0
                                                               0.0      0.254 MR    0.0    0.C    0.87C
                                                               0.0      0.471 CM   -0.615  0.678  0.0    0.0
                                                               0.0      1.000 PC    1.000 -0.989  0.0    0.0   -0.617


*FIT*     10.C    -1. 2.    0.0    / C.001

                         -0.C00
         LABEL = FIT1


*FIT*     10.0    -3. 4.    0.0    / 0.001

                         -0.000
         LABEL = FIT1


 *TRANSFORM* 1
           -C.33045  -0.CC002   0.C       0.0       0.0       6.82236
           -0.22846  -3.02617   0.C       0.0       0.0      -2.09424
            0.0       0.0      -C.79757  -0.C0002   0.0       0.0
            0.0       0.0      -0.73609  -1.25380   0.0       0.0
           -C.22507  -2.06457   C.0       0.0       1.00000  -0.29037
            0.0       0.0       0.0       0.0       0.0       1.00000

*DRIFT*    3.0    25.C795 M
    VARY CODE = 400000
         LABEL = DR1


                                                159.0 M        0.0      1.765 CM
                                                               0.0      2.117 MR   -0.814
                                                               0.0      0.853 CM    0.0    0.0
                                                               0.0      0.254 MR    0.0    0.0    0.990
                                                               0.0      0.471 CM   -0.338  0.678  0.0    C.0
                                                               0.0      1.000 PC    C.890 -0.989  0.0    0.0   -0.617


*ROTAT*    2.0     1.50  D

*BEND*     4.000   3.00000 M   14.550 KG   0.0000 (   2.999 D )
```

```
*ROTAT*    2.0     1.50 D

*DRIFT*    3.0     1.0000 M

*ROTAT*    2.0     1.50 D

*BEND*     4.000   3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0     1.50 D

*DRIFT*    3.C     1.0000 M

*ROTAT*    2.0     1.50 D

*BEND*     4.000   3.00000 M   14.550 KG   0.C000 (   2.999 D )

*ROTAT*    2.0     1.50 C

*DRIFT*    3.0     1.0000 M

*ROTAT*    2.C     1.50 D

*BEND*     4.000   3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0     1.50 D

*DRIFT*    3.0     1.0000 M


                                                175.0 M      0.0    1.300 CM
                                                             0.0    0.310 MR    0.997
                                                             0.0    1.227 CM    0.0     0.0
                                                             0.0    0.216 MR    0.0     0.0     0.994
                                                             0.0    0.504 CM   -0.000   0.000   0.0     0.0
                                                             0.0    1.000 PC    0.000   0.000   0.0     0.0    -0.804


*FIT*     10.0    -1. 6.    0.0    / 0.001
                            0.000
        LABEL = FIT2
```

```
*FIT*      10.0     -2. 6.    0.0    / 0.001
                                0.000
        LABEL = FIT3


 *TRANSFORM* 1
              -1.26882 -12.42980   0.0         0.0        0.0        0.00001
              -0.22847  -3.02628   C.C         0.C        0.0        0.00000
               0.0       0.0      -3.72852    -5.C3437    0.0        0.0
               C.0       0.0      -0.62031    -1.10576    0.0        0.0
              -0.00000  -0.00001   0.C         0.C        1.00000   -0.40547
               0.0       0.0       C.C         0.0        0.0        1.00000


*QUAD*      5.C0   2.0C000 M   -1.9000 KG    5.000 CM  ( -10.646 M  )
        LABEL = Q3


*DRIFT*     3.0      2.0C00 M


*QUAD*      5.00   2.00000 M    1.85C0 KG    5.000 CM  (  11.609 M  )
        LABEL = Q3


*DRIFT*     3.C   20C.000C M


                                                  381.0 M      0.0     0.620 CM
                                                               0.0     0.125 MR    C.922
                                                               0.0     0.873 CM    0.0    0.0
                                                               0.0     0.079 MR    0.0    0.0    0.902
                                                               0.0     0.5C4 CM    0.000  0.000  0.0    0.0
                                                               0.0     1.000 PC   -0.000 -0.000  0.0    0.0   -0.804


 *TRANSFCRM* 1
               1.49989   4.27131   0.0         0.0        0.0       -0.00001
               C.16754   1.14380   0.C         0.0        0.0       -0.00000
               C.0       0.0       2.62306    -3.78386    0.0        0.0
               C.0       0.0       0.26479    -0.00074    0.0        0.0
              -C.00000  -0.00001   0.C         0.C        1.00000   -0.40547
               0.0       0.0       0.0         0.0        0.0        1.00000

                                                  381.0 M      0.0     0.620 CM
                                                               0.0     0.125 MR    0.922
                                                               0.0     0.873 CM    0.0    0.0
                                                               0.0     0.079 MR    0.0    0.0    0.902
                                                               0.0     0.504 CM    0.000  0.000  0.0    0.0
                                                               0.0     1.000 PC   -0.000 -0.000  0.0    0.0   -0.804

*QUAD*      5.00   2.00000 M    4.5C00 KG    5.000 CM  (   4.984 M  )
        LABEL = Q4
```

```
*DRIFT*    3.0      2.0000 M

                                                          385.0 M        0.0       0.282 CM
                                                                         0.0       1.154 MR   -0.996
                                                                         0.0       1.506 CM    0.0     0.0
                                                                         0.0       2.111 MR    0.0     0.0      1.000
                                                                         0.0       0.504 CM    0.000  -0.000    0.0      0.0
                                                                         0.0       1.000 PC   -0.000   0.000    0.0      0.0     -0.804

*QUAD*     5.00   2.00000 M   -4.2000 KG    5.000 CM  (  -4.645 M  )
        LABEL =  Q4

                                                          387.0 M        0.0       0.098 CM
                                                                         0.0       0.791 MR   -0.923
                                                                         0.0       1.607 CM    0.0     0.0
                                                                         0.0       1.135 MR    0.0     0.0     -1.000
                                                                         0.0       0.504 CM    0.000  -0.000    0.0      0.0
                                                                         0.0       1.000 PC   -0.000   0.000    0.0      0.0     -0.804

*DRIFT*    3.0     15.0000 M

                                                          402.0 M        0.0       1.097 CM
                                                                         0.0       0.791 MR    0.999
                                                                         0.0       0.099 CM    0.0     0.0
                                                                         0.0       1.135 MR    0.0     0.0      0.963
                                                                         0.0       0.504 CM   -0.000  -0.000    0.0      0.0
                                                                         0.0       1.000 PC    0.000   0.000    0.0      0.0     -0.804

 *TRANSFORM* 1
           -2.97423  -6.38180   0.0        0.0       0.0        0.00002
           -2.09122  -4.82334   0.0        0.0       0.0        0.00001
            0.0       0.0      -0.24656    0.65288   0.0        0.0
            0.0       0.0      -3.40280    4.95466   0.0        0.0
           -0.00000  -0.00001   0.0        0.0       1.00000   -0.40547
            0.0       0.0       0.0        0.0       0.0        1.00000

 *LENGTH*   401.9993 M
```

```
'BEAM TRANSPORT SYSTEM FOR SLAC BEAM SWITCHYARD END STATION A IIIA'
1
(IN THE THIRD STEP THE FIRST QUAD DOUBLET,Q1, AND THE SYMMETRY QUAD,Q2,)
(ARE NOT ALLOWED TO VARY.  THE FIELDS OF THE SECOND QUAD DOUBLET,Q3, ARE)
(ALLOWED TO VARY TO GET A CERTAIN BEAM SIZE AT THE ENTRANCE TO THE THIRD QUAD)
(DOUBLET,Q4.)
5.0 'Q1' ;
5.0 'Q2' ;
3.0 'DR1' ;
-10.0 'FIT1' ;
-10.0 'FIT2' ;
-10.0 'FIT3' ;
5.01 'Q3' ;
10.2 'FIT4' ;
SENTINEL
```

BEAM TRANSPORT SYSTEM FOR SLAC BEAM SWITCHYARD END STATICN A IIIA

1

IN THE THIRD STEP THE FIRST QUAD DOUBLET,Q1, AND THE SYMMETRY QUAD,Q2, ARE NCT ALLCWED TO VARY. THE FIELDS OF THE SECOND QUAD DCUBLET,Q3, ARE ALLOWED TO VARY TO GET A CERTAIN BEAM SIZE AT THE ENTRANCE TO THE THIRD QUAD DOUBLET,Q4.

```
  1.00000   C.30000   0.10000   0.30000   0.10000   0.30000   1.00000  25.00000
 13.00000   2.00000
  4.00000   5.00000   1.45500   0.C
  2.00000   C.50000
 13.00000   1.00000
  3.00000  80.00000
 13.00000   1.00000
  5.00000   2.00000  -2.08981   5.00000
   LABEL = Q1
  3.00000   2.00000
  5.00000   2.00000   2.19428   5.00000
   LABEL = Q1
 13.00000   1.00000
  9.00000   4.00000
  3.00000   1.00000
  2.00000   1.50000
  4.00000   3.00000  14.55000   0.0
  2.00000   1.50000
  9.00000   0.0
 13.00000   1.00000
  3.00000  24.92036
   LABEL = DR1
  5.00000   2.00000   3.57851  15.00000
   LABEL = Q2
 13.00000   1.00000
-10.00000  -1.00000   2.00000   0.0       0.00100
   LABEL = FIT1
```

```
-10.00000  -3.00000   4.00000   0.0        0.00100
   LABEL = FIT1

 13.00000   4.00000

  3.00000  25.07953
   LABEL = DR1

 13.00000   1.00000

  9.00000   4.00000

  2.00000   1.50000

  4.00000   3.00000  14.55000   0.0

  2.00000   1.50000

  3.00000   1.00000

  9.00000   0.0

 13.00000   1.00000

-10.00000  -1.00000   6.00000   0.0        0.00100
   LABEL = FIT2

-10.00000  -2.00000   6.00000   0.0        0.00100
   LABEL = FIT3

 13.00000   4.00000

  5.00000   2.00000  -1.90000   5.00000
  VARY CODE  010000
   LABEL = Q3

  3.00000   2.00000

  5.00000   2.00000   1.85000   5.00000
  VARY CODE  010000
   LABEL = Q3

  3.00000 200.00000

 13.00000   1.00000

 10.00000   1.00000   1.00000   4.00000   0.10000
  VARY CODE  200000
   LABEL = FIT4

 10.00000   3.00000   3.00000   1.50000   0.10000
  VARY CODE  200000
   LABEL = FIT4

 13.00000   4.00000

 13.00000   1.00000

  5.00000   2.00000   4.50000   5.00000
   LABEL = Q4
```

```
  3.00000    2.00000

 13.00000    1.00000

  5.00000    2.00000  -4.20000   5.00000
    LABEL  =  Q4

 13.00000    1.00000

  3.00000   15.00000

 13.00000    1.00000

-10.00000    2.00000   1.00000   0.0        0.00100
    LABEL  =  FIT5

-10.00000    4.00000   3.00000   0.0        0.00100
    LABEL  =  FIT6

-10.00000    1.00000   1.00000   0.02000    0.01000
  VARY CODE  200000
    LABEL  =  FIT7

-10.00000    3.00000   3.00000   0.02000    0.01000
  VARY CODE  200000
    LABEL  =  FIT7

 13.00000    4.00000

 SENTINEL
```

BEAM TRANSPORT SYSTEM FOR SLAC BEAM SWITCHYARD END STATICN A IIIA

```
*BEAM*      1.C00000    25.0C GEV
                                                          0.0 M        0.0      0.300 CM
                                                                       0.0      0.100 MR    0.0
                                                                       0.0      0.300 CM    0.0     0.0
                                                                       0.0      0.100 MR    0.0     0.0     0.0
                                                                       0.0      0.300 CM    0.0     0.0     0.0     0.0
                                                                       0.0      1.000 PC    0.0     0.0     0.0     0.0     0.0

*BEND*     4.000    5.00000 M    1.455 KG    0.0000 (   0.500 D )

*ROTAT*    2.0      0.50 D

                                                          5.0 M        0.0      0.305 CM
                                                                       0.0      0.133 MR    0.171
                                                                       0.0      0.304 CM    0.0     0.0
                                                                       0.0      0.100 MR    0.0     0.0     0.164
                                                                       0.0      0.300 CM   -0.009  -0.001   0.0     0.0
                                                                       0.0      1.000 PC    0.071   0.657   0.0     0.0    -0.000

*DRIFT*    3.0     80.0000 M

                                                         85.0 M        0.0      1.153 CM
                                                                       0.0      0.133 MR    0.965
                                                                       0.0      0.901 CM    0.0     0.0
                                                                       0.0      0.100 MR    0.0     0.0     0.943
                                                                       0.0      0.300 CM   -0.003  -0.001   0.0     0.0
                                                                       0.0      1.000 PC    0.624   0.657   0.0     0.0    -0.000

*QUAD*      5.00   2.00000 M   -2.C898 KG    5.000 CM  (  -9.650 M  )
        LABEL = Q1

*DRIFT*    3.0      2.000C M

*QUAD*      5.00   2.00000 M    2.1943 KG    5.000 CM  (   9.843 M  )
        LABEL = Q1

                                                         91.0 M        0.0      1.661 CM
                                                                       0.0      0.392 MR   -0.998
                                                                       0.0      0.582 CM    0.0     0.0
                                                                       0.0      0.147 MR    0.0     0.0    -0.937
                                                                       0.0      0.300 CM   -0.003   0.003   0.0     0.0
                                                                       0.0      1.000 PC    0.627  -0.613   0.0     0.0    -0.000

*DRIFT*    3.0      1.0000 M
```

```
*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M   14.550 KG   0.0000 (    2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M

*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M   14.550 KG   0.0000 (    2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M

*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M   14.550 KG   0.0000 (    2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M

*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M   14.550 KG   0.0000 (    2.999 D )

*ROTAT*    2.0      1.50 D


                                                    107.0 M        0.0      2.366 CM
                                                                   0.0      1.880 MR    0.873
                                                                   0.0      0.357 CM    0.0     0.0
                                                                   0.0      0.163 MR    0.0     0.0    -0.856
                                                                   0.0      0.471 CM   -0.737  -0.533   0.0     0.0
                                                                   0.0      1.000 PC    0.941   0.986   0.0     0.0    -0.617


*DRIFT*    3.0    24.9203 M
        LABEL = DR1
```

```
*QUAD*     5.00   2.00000 M    3.5785 KG  15.000 CM  (  17.815 M  )
      LABEL = Q2

                                        133.9 M      0.0    6.823 CM
                                                     0.0    2.117 MR   -0.989
                                                     0.0    0.239 CM    0.0     0.0
                                                     0.0    0.254 MR    0.0     0.0     0.870
                                                     0.0    0.471 CM   -0.615   0.678   0.0     0.0
                                                     0.0    1.000 PC    1.000  -0.989   0.0     0.0    -0.617


 *TRANSFCRM* 1
         -C.33045  -0.00002   0.0       0.0       0.0       6.82236
         -C.22846  -3.02617   0.C       0.0       0.0      -2.09424
          0.0       C.0      -C.79757  -0.00002   0.0       0.0
          0.0       0.0      -0.73609  -1.25380   C.0       0.0
         -C.22507  -2.C6457   C.C       0.C       1.00000  -0.29037
          C.0       0.0       0.0       0.C       0.0       1.00000

*DRIFT*    3.0    25.0795 M
      LABEL = DR1

                                        159.0 M      0.0    1.765 CM
                                                     0.0    2.117 MR   -0.814
                                                     0.0    0.853 CM    0.0     0.0
                                                     0.0    0.254 MR    0.0     0.0     0.990
                                                     0.0    0.471 CM   -0.338   0.678   0.0     0.0
                                                     0.0    1.000 PC    0.890  -0.989   0.0     0.0    -0.617

*ROTAT*    2.0     1.5C D

*BEND*     4.000   3.000C0 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.C     1.50 D

*DRIFT*    3.0     1.0000 M

*ROTAT*    2.0     1.50 D

*BEND*     4.000   3.00000 M   14.550 KG   0.C000 (   2.999 D )

*ROTAT*    2.0     1.50 D

*DRIFT*    3.0     1.0C0C M

*ROTAT*    2.0     1.50 D
```

```
*BEND*     4.000   3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0     1.50 D

*DRIFT*    3.C     1.0000 M

*ROTAT*    2.0     1.50 D

*BEND*     4.000   3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0     1.50 D

*DRIFT*    3.C     1.0000 M

                                                      175.0 M         0.0     1.300 CM
                                                                      0.0     0.310 MR    0.997
                                                                      0.0     1.227 CM    0.0      0.0
                                                                      0.0     0.216 MR    0.0      0.0     0.994
                                                                      0.0     0.504 CM   -0.000    0.000   0.0     0.0
                                                                      0.0     1.000 PC    0.000    0.000   0.0     0.0    -0.804

 *TRANSFORM* 1
           -1.26882 -12.42980   0.0        0.0        0.0        0.00001
           -0.22847  -3.02628   0.0        0.0        0.0        0.00000
            0.0       0.0      -3.72852   -5.03437    0.0        0.0
            0.0       0.0      -0.62031   -1.10576    0.0        0.0
           -0.00000  -0.00001   0.0        0.0        1.00000   -0.40547
            0.0       0.0       0.0        0.0        0.0        1.00000

*QUAD*     5.00   2.00000 M   -1.9000 KG   5.000 CM  ( -10.646 M  )
    VARY CODE = 010000
         LABEL = Q3

*DRIFT*    3.0     2.0000 M

*QUAD*     5.00   2.00000 M    1.8500 KG   5.000 CM  (  11.609 M  )
    VARY CODE = 010000
         LABEL = Q3

*DRIFT*    3.0   200.0000 M

                                                      381.0 M         0.0     0.620 CM
                                                                      0.0     0.125 MR    0.922
```

```
                                                                                0.0      0.873 CM    0.0    0.0
                                                                                0.0      0.079 MR    0.0    0.0    0.902
                                                                                0.0      0.504 CM    0.000  0.000  0.0    0.0
                                                                                0.0      1.000 PC   -0.000 -0.000  0.0    0.0    -0.804


*FIT*     10.0     1. 1.    4.000 / 0.100

                            0.620
    VARY CODE = 200000
         LABEL = FIT4


*FIT*     10.0     3. 3.    1.500 / 0.100

                            0.873
    VARY CODE = 200000
         LABEL = FIT4


 *TRANSFORM* 1
             1.49989   4.27131   0.0       0.0       0.0      -0.00001
             0.16754   1.14380   0.0       0.0       0.0      -0.00000
             0.0       0.0       2.62306  -3.78386   0.0       0.0
             0.0       0.0       0.26479  -0.00074   0.0       0.0
            -0.00000  -0.00001   0.0       0.0       1.00000  -0.40547
             0.0       0.0       0.0       0.0       0.0       1.00000

                                                        381.0 M     0.0      0.620 CM
                                                                    0.0      0.125 MR    0.922
                                                                    0.0      0.873 CM    0.0    0.0
                                                                    0.0      0.079 MR    0.0    0.0    0.902
                                                                    0.0      0.504 CM    0.000  0.000  0.0    0.0
                                                                    0.0      1.000 PC   -0.000 -0.000  0.0    0.0    -0.804

*QUAD*     5.00   2.00000 M    4.5000 KG   5.000 CM  (   4.984 M  )
        LABEL = Q4

*DRIFT*    3.0    2.0000 M


                                                        385.0 M     0.0      0.282 CM
                                                                    0.0      1.154 MR   -0.996
                                                                    0.0      1.506 CM    0.0    0.0
                                                                    0.0      2.111 MR    0.0    0.0    1.000
                                                                    0.0      0.504 CM    0.000 -0.000  0.0    0.0
                                                                    0.0      1.000 PC   -0.000  0.000  0.0    0.0    -0.804

*QUAD*     5.00   2.00000 M   -4.2000 KG   5.000 CM  (  -4.645 M  )
        LABEL = Q4


                                                        387.0 M     0.0      0.098 CM
```

```
                                                                                          0.0      0.791 MR   -0.923
                                                                                          0.0      1.607 CM    0.0     0.0
                                                                                          0.0      1.135 MR    0.0     0.0    -1.000
                                                                                          0.0      0.504 CM    0.000  -0.000   0.0     0.0
                                                                                          0.0      1.000 PC   -0.000   0.000   0.0     C.0     -0.804

*DRIFT*    3.0    15.000C M

                                                                        402.0 M           0.0      1.097 CM
                                                                                          0.0      0.791 MR    0.999
                                                                                          0.0      0.099 CM    0.0     0.0
                                                                                          0.0      1.135 MR    0.0     0.0     0.963
                                                                                          0.0      0.504 CM   -0.000  -0.000   0.0     0.0
                                                                                          0.0      1.000 PC    0.000   0.000   0.0     0.0     -0.804

 *TRANSFCRM* 1
            -2.33281   3.1320C   0.0       0.0       0.0       0.0
            -1.58390   1.65786   0.C       0.0       0.0       0.0
             0.0       0.0      -0.17269   C.77960   0.0       0.0
             C.0       0.0      -1.30944   0.12067   0.0       0.0
             0.0       0.0       0.C       0.0       1.00000   0.0
             C.0       0.0       0.C       0.C       0.0       1.00000

 *LENGTH*   401.9993 M

  *CORRECTIONS*

( 1.4240E 01)    -0.790     1.228

( 2.4036E 02)     0.308    -C.526

( 6.1862E 01)     0.181    -C.277

( 1.3562E 01)     0.073    -C.1C7

( 1.7670E C0)     0.013    -0.C19

( 5.1883E-02)     0.000    -0.C01

  *COVARIANCE  ( FIT   0.1 )
 0.010
-0.805  0.009
```

BEAM TRANSPORT SYSTEM FOR SLAC BEAM SWITCHYARD END STATION A IIIA

```
*BEAM*      1.000000    25.00 GEV
                                                              0.0 M          0.0      0.300 CM
                                                                             0.0      0.100 MR    0.0
                                                                             0.0      0.300 CM    0.0     0.0
                                                                             0.0      0.100 MR    0.0     0.0     0.0
                                                                             0.0      0.300 CM    0.0     0.0     0.0     0.0
                                                                             0.0      1.000 PC    0.0     0.0     0.0     0.0     0.0


*BEND*      4.000    5.00000 M    1.455 KG    0.0000 (    0.500 D )

*ROTAT*     2.0      0.50 D

                                                              5.0 M          0.0      0.305 CM
                                                                             0.0      0.133 MR    0.171
                                                                             0.0      0.304 CM    0.0     0.0
                                                                             0.0      0.100 MR    0.0     0.0     0.164
                                                                             0.0      0.300 CM   -0.009  -0.001   0.0     0.0
                                                                             0.0      1.000 PC    0.071   0.657   0.0     0.0    -0.000

*DRIFT*     3.0      80.0000 M

                                                             85.0 M          0.0      1.153 CM
                                                                             0.0      0.133 MR    0.965
                                                                             0.0      0.901 CM    0.0     0.0
                                                                             0.0      0.100 MR    0.0     0.0     0.943
                                                                             0.0      0.300 CM   -0.003  -0.001   0.0     0.0
                                                                             0.0      1.000 PC    0.624   0.657   0.0     0.0    -0.000

*QUAD*      5.00   2.00000 M   -2.0898 KG    5.000 CM  (  -9.650 M  )
        LABEL = Q1

*DRIFT*     3.0      2.0000 M

*QUAD*      5.00   2.00000 M    2.1943 KG    5.000 CM  (   9.843 M  )
        LABEL = Q1

                                                             91.0 M          0.0      1.661 CM
                                                                             0.0      0.392 MR   -0.998
                                                                             0.0      0.582 CM    0.0     0.0
                                                                             0.0      0.147 MR    0.0     0.0    -0.937
                                                                             0.0      0.300 CM   -0.003   0.003   0.0     0.0
                                                                             0.0      1.000 PC    0.627  -0.613   0.0     0.0    -0.000

*DRIFT*     3.0      1.0000 M
```

```
*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M

*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M

*ROTAT*    2.C      1.50 D

*BEND*     4.000    3.0000C M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M

*ROTAT*    2.C      1.50 D

*BEND*     4.000    3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0      1.50 D


                                                  107.0 M        0.0     2.366 CM
                                                                 0.0     1.880 MR     0.873
                                                                 0.0     0.357 CM     0.0      0.0
                                                                 0.0     0.163 MR     0.0      0.0    -0.856
                                                                 0.0     0.471 CM    -0.737  -0.533    0.0      0.0
                                                                 0.0     1.000 PC     0.941   0.986    0.0      0.0     -0.617


*DRIFT*    3.0    24.9203 M
      LABEL = DR1
```

```
*QUAD*     5.00   2.00000 M    3.5785 KG  15.000 CM  (  17.815 M  )
         LABEL = Q2

                                                      133.9 M       0.0      6.823 CM
                                                                    0.0      2.117 MR   -0.989
                                                                    0.0      0.239 CM    0.0     0.0
                                                                    0.0      0.254 MR    0.0     0.0     0.870
                                                                    0.0      0.471 CM   -0.615   0.678   0.0     0.0
                                                                    0.0      1.000 PC    1.000  -0.989   0.0     0.0    -0.617


 *TRANSFORM* 1
          -0.33045  -0.00002   0.0       0.0       0.0       6.82236
          -0.22846  -3.02617   0.0       0.0       0.0      -2.09424
           0.0       0.0      -0.79757  -0.00002   0.0       0.0
           0.0       0.0      -0.73609  -1.25380   0.0       0.0
          -0.22507  -2.06457   0.0       0.0       1.00000  -0.29037
           0.0       0.0       0.0       0.0       0.0       1.00000


*DRIFT*    3.0    25.0795 M
         LABEL = DR1

                                                      159.0 M       0.0      1.765 CM
                                                                    0.0      2.117 MR   -0.814
                                                                    0.0      0.853 CM    0.0     0.0
                                                                    0.0      0.254 MR    0.0     0.0     0.990
                                                                    0.0      0.471 CM   -0.338   0.678   0.0     0.0
                                                                    0.0      1.000 PC    0.890  -0.989   0.0     0.0    -0.617

*ROTAT*    2.0     1.50 D

*BEND*     4.000   3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0     1.50 D

*DRIFT*    3.0     1.0000 M

*ROTAT*    2.0     1.50 D

*BEND*     4.000   3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0     1.50 D

*DRIFT*    3.0     1.0000 M

*ROTAT*    2.0     1.50 D
```

```
*BEND*      4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.0      1.50 D

*DRIFT*     3.0      1.0000 M

*ROTAT*     2.0      1.50 D

*BEND*      4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.0      1.50 D

*DRIFT*     3.0      1.0000 M

                                                 175.0 M        0.0     1.300 CM
                                                                0.0     0.310 MR    0.997
                                                                0.0     1.227 CM    0.0     0.0
                                                                0.0     0.216 MR    0.0     0.0     0.994
                                                                0.0     0.504 CM   -0.000   0.000   0.0     0.0
                                                                0.0     1.000 PC    0.000   0.000   0.0     0.0    -0.804

 *TRANSFORM* 1
          -1.26882 -12.42980   0.0        0.0        0.0        0.00001
          -0.22847  -3.02628   0.0        0.0        0.0        0.00000
           0.0       0.0      -3.72852   -5.03437    0.0        0.0
           0.0       0.0      -0.62031   -1.10576    0.0        0.0
          -0.00000  -0.00001   0.0        0.0        1.00000   -0.40547
           0.0       0.0       0.0        0.0        0.0        1.00000

*QUAD*      5.00    2.00000 M   -2.1150 KG    5.000 CM  (  -9.532 M  )
    VARY CODE = 010000
         LABEL = Q3

*DRIFT*     3.0      2.0000 M

*QUAD*      5.00    2.00000 M    2.1487 KG    5.000 CM  (  10.044 M  )
    VARY CODE = 010000
         LABEL = Q3

*DRIFT*     3.0    200.0000 M

                                                 381.0 M        0.0     4.000 CM
                                                                0.0     0.299 MR    1.000
```

```
                                                        0.0       1.500 CM    0.0     0.0
                                                        0.0       0.113 MR    0.0     0.0     0.984
                                                        0.0       0.504 CM    0.000   0.000   0.0      0.0
                                                        0.0       1.000 PC   -0.000  -0.000   0.0      0.0     -0.804


*FIT*     10.0     1. 1.    4.COO / 0.100

                            4.000
    VARY CODE = 200000
         LABEL = FIT4


*FIT*     10.C     3. 3.    1.500 / 0.100

                            1.500
    VARY CODE = 200000
         LABEL = FIT4


 *TRANSFORM* 1
           4.77122  37.35149   0.C       0.0       0.0      -0.00003
           0.33310   2.81727   0.0       0.0       0.0      -0.00000
           C.0       0.0       4.S9109  -0.89239   0.0       0.0
           0.0       0.C       0.37533   0.13324   0.0       0.0
          -C.00000  -0.00001   0.0       0.0       1.00000  -0.40547
           0.0       0.0       0.0       0.C       0.0       1.00000

                                              381.0 M      0.0       4.000 CM
                                                           0.0       0.299 MR    1.000
                                                           0.0       1.500 CM    0.0     0.0
                                                           0.0       0.113 MR    0.0     0.0     0.984
                                                           0.0       0.504 CM    0.000   0.000   0.0      C.0
                                                           0.0       1.000 PC   -0.000  -0.000   0.0      0.0     -0.804

*QUAD*     5.00   2.00000 M    4.5000 KG   5.000 CM  (   4.984  M  )
         LABEL = Q4

*DRIFT*    3.C     2.0000 M

                                              385.0 M      0.0       1.665 CM
                                                           0.0       7.789 MR   -1.000
                                                           0.0       2.582 CM    0.0     0.0
                                                           0.0       3.612 MR    0.0     0.0     1.000
                                                           0.0       0.504 CM    0.000  -0.000   0.0      0.0
                                                           0.0       1.000 PC   -0.000   0.000   0.0      0.0     -0.804

*QUAD*     5.00   2.00000 M   -4.20C0 KG   5.000 CM  (  -4.645  M  )
         LABEL = C4

                                              387.0 M      0.0       0.347 CM
```

0.0	5.828 MR	-1.000					
0.0	2.754 CM	0.0	0.0				
0.0	1.951 MR	0.0	0.0	-1.000			
0.0	0.504 CM	0.000	-0.000	0.0	0.0		
0.0	1.000 PC	-0.000	0.000	0.0	0.0	-0.804	

DRIFT   3.0   15.0000 M

402.0 M	0.0	8.395 CM					
	0.0	5.828 MR	1.000				
	0.0	0.173 CM	0.0	0.0			
	0.0	1.951 MR	0.0	0.0	0.996		
	0.0	0.504 CM	-0.000	-0.000	0.0	0.0	
	0.0	1.000 PC	0.000	0.000	0.0	0.0	-0.804

TRANSFORM 1

-2.33281	3.13200	0.0	0.0	0.0	0.0
-1.58390	1.69786	0.0	0.0	0.0	0.0
0.0	0.0	-0.17269	0.77960	0.0	0.0
0.0	0.0	-1.30944	0.12067	0.0	0.0
0.0	0.0	0.0	0.0	1.00000	0.0
0.0	0.0	0.0	0.0	0.0	1.00000

LENGTH   401.9993 M

```
'BEAM TRANSPORT SYSTEM FOR SLAC BEAM SWITCHYARD END STATION A IIIB'
1
(IN THIS CASE THE VARY CODES FOR THE QUAD DOUBLET,Q3, ARE TURNED OFF, AND)
(THE THIRD QUAD DOUBLET,Q4, IS ALLOWED TO VARY TO GET A WAIST WITH A CERTAIN)
(SPOT SIZE AT THE TARGET.)
5.0 'Q3' ;
5.01 'Q4' ;
10.0 'FIT5' ;
10.0 'FIT6' ;
10.2 'FIT7' ;
SENTINEL
```

```
BEAM TRANSPORT SYSTEM FOR SLAC BEAM SWITCHYARD END STATION A IIIB
    1
IN THIS CASE THE VARY CODES FOR THE QUAD DOUBLET,Q3, ARE TURNED OFF, AND
THE THIRD QUAD DOUBLET,Q4, IS ALLOWED TO VARY TO GET A WAIST WITH A CERTAIN
SPOT SIZE AT THE TARGET.
   1.00000   0.30000   0.10000   0.30000   0.10000   0.30000   1.00000  25.00000
  13.00000   2.00000
   4.00000   5.00000   1.45500   0.0
   2.00000   0.50000
  13.00000   1.00000
   3.00000  80.00000
  13.00000   1.00000
   5.00000   2.00000  -2.08981   5.00000
   LABEL = Q1
   3.00000   2.00000
   5.00000   2.00000   2.19428   5.00000
   LABEL = Q1
  13.00000   1.00000
   9.00000   4.00000
   3.00000   1.00000
   2.00000   1.50000
   4.00000   3.00000  14.55000   0.0
   2.00000   1.50000
   9.00000   0.0
  13.00000   1.00000
   3.00000  24.92036
   LABEL = DR1
   5.00000   2.00000   3.57851  15.00000
   LABEL = Q2
  13.00000   1.00000
 -10.00000  -1.00000   2.00000   0.0       0.00100
   LABEL = FIT1
 -10.00000  -3.00000   4.00000   0.0       0.00100
```

```
  LABEL = FIT1

 13.00000   4.00000

  3.00000  25.07953
  LABEL = DR1

 13.00000   1.00000

  9.00000   4.00000

  2.00000   1.50000

  4.00000   3.00000  14.55000   0.0

  2.00000   1.50000

  3.00000   1.00000

  9.00000   0.0

 13.00000   1.00000

-10.00000  -1.00000   6.00000   0.0        0.00100
  LABEL = FIT2

-10.00000  -2.00000   6.00000   0.0        0.00100
  LABEL = FIT3

 13.00000   4.00000

  5.00000   2.00000  -2.11497   5.00000
  LABEL = Q3

  3.00000   2.00000

  5.00000   2.00000   2.14873   5.00000
  LABEL = Q3

  3.00000 200.00000

 13.00000   1.00000

 10.00000   1.00000   1.00000   4.00000   0.10000
 VARY CODE  200000
  LABEL = FIT4

 10.00000   3.00000   3.00000   1.50000   0.10000
 VARY CODE  200000
  LABEL = FIT4

 13.00000   4.00000

 13.00000   1.00000

  5.00000   2.00000   4.50000   5.00000
 VARY CODE  010000
  LABEL = Q4

  3.00000   2.00000
```

```
13.C0000   1.C0000

 5.00000   2.00000  -4.20000   5.00000
 VARY CODE  010000
  LABEL = Q4

13.000C0   1.00C00

 3.00000  15.00000

13.00000   1.C0000

10.00000   2.00000   1.00000   0.0       0.00100
  LABEL = FIT5

10.0C000   4.00000   3.C000C   0.0       0.00100
  LABEL = FIT6

10.00000   1.00000   1.CC00C   0.C2000   0.C1000
 VARY CODE  200000
  LABEL = FIT7

10.QC000   3.00000   3.0C000   0.02000   0.C1000
 VARY CODE  200000
  LABEL = FIT7

13.0C000   4.00000

SENTINEL
```

```
*BEAM*     1.C00000   25.00 GEV
                                                  0.0 M        0.0     0.300 CM
                                                               0.0     0.100 MR    0.0
                                                               0.0     0.300 CM    C.0      0.0
                                                               0.0     0.100 MR    0.0      0.0      0.0
                                                               0.0     0.300 CM    0.0      0.0      0.0      0.0
                                                               0.0     1.000 PC    0.0      0.0      0.0      0.0      0.0


*BEND*     4.000   5.00000 M    1.455 KG   0.0000 (   0.500 D )

*ROTAT*    2.0     0.50 D

                                                  5.0 M        0.0     0.305 CM
                                                               0.0     0.133 MR    0.171
                                                               0.0     0.304 CM    0.0      0.0
                                                               0.0     0.100 MR    0.0      0.0      0.164
                                                               0.0     0.300 CM   -0.009   -0.001    0.0      0.0
                                                               0.0     1.000 PC    0.071    0.657    0.0      0.0     -0.000

*DRIFT*    3.0    80.0000 M

                                                 85.0 M        0.0     1.153 CM
                                                               0.0     0.133 MR    0.965
                                                               0.0     0.901 CM    0.0      0.0
                                                               0.0     0.100 MR    0.0      0.0      0.943
                                                               0.0     0.300 CM   -0.003   -0.001    0.0      C.0
                                                               0.0     1.000 PC    0.624    0.657    0.0      0.0     -0.000

*QUAD*     5.00    2.00000 M   -2.0898 KG   5.000 CM  (  -9.650 M  )
        LABEL = Q1

*DRIFT*    3.0     2.000C M

*QUAD*     5.00    2.00000 M    2.1943 KG   5.C00 CM  (   9.843 M  )
        LABEL = Q1

                                                 91.0 M        0.0     1.661 CM
                                                               0.0     0.392 MR   -C.998
                                                               0.0     0.582 CM    0.0      0.0
                                                               0.0     0.147 MR    0.0      0.0     -0.937
                                                               0.0     0.300 CM   -0.003    0.003    0.0      0.0
                                                               0.0     1.000 PC    0.627   -0.613    0.0      C.0     -0.000

*DRIFT*    3.0     1.0000 M
```

```
*ROTAT*     2.0      1.50 D

*BEND*      4.000    3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*     2.0      1.50 D

*DRIFT*     3.0      1.0000 M

*ROTAT*     2.0      1.50 D

*BEND*      4.000    3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*     2.0      1.50 D

*DRIFT*     3.0      1.0000 M

*ROTAT*     2.0      1.50 D

*BEND*      4.000    3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*     2.0      1.50 D

*DRIFT*     3.0      1.0000 M

*ROTAT*     2.0      1.50 D

*BEND*      4.000    3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*     2.0      1.50 D


                                                  107.0 M        0.0      2.366 CM
                                                                 0.0      1.880 MR     0.873
                                                                 0.0      0.357 CM     0.0     0.0
                                                                 0.0      0.163 MR     0.0     0.0    -0.856
                                                                 0.0      0.471 CM    -0.737  -0.533   0.0     0.0
                                                                 0.0      1.000 PC     0.941   0.986   0.0     0.0    -0.617


*DRIFT*     3.0    24.9203 M
        LABEL = DR1
```

```
*QUAD*     5.00   2.00000 M    3.5785 KG  15.000 CM  (  17.815 M  )
        LABEL = C2

                                                        133.9 M         0.0      6.823 CM
                                                                        0.0      2.117 MR   -0.989
                                                                        0.0      0.239 CM    0.0     0.0
                                                                        0.0      0.254 MR    0.0     0.0     0.870
                                                                        0.0      0.471 CM   -0.615  0.678   0.0     0.0
                                                                        0.0      1.000 PC    1.000 -0.989   0.0     0.0     -0.617


 *TRANSFORM* 1
           -0.33045  -0.00002   0.0       0.0       0.0        6.82236
           -0.22846  -3.02617   0.0       0.0       0.0       -2.09424
            0.0       0.0      -0.79757  -0.00002   0.0        0.0
            0.0       0.0      -0.73609  -1.25380   0.0        0.0
           -0.22507  -2.06457   0.0       0.0       1.00000   -0.29037
            0.0       0.0       0.0       0.0       0.0        1.00000

*DRIFT*    3.0    25.0795 M
        LABEL = DR1

                                                        159.0 M         0.0      1.765 CM
                                                                        0.0      2.117 MR   -0.814
                                                                        0.0      0.853 CM    0.0     0.0
                                                                        0.0      0.254 MR    0.0     0.0     0.990
                                                                        0.0      0.471 CM   -0.338  0.678   0.0     0.0
                                                                        0.0      1.000 PC    0.890 -0.989   0.0     0.0     -0.617

*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M

*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M

*ROTAT*    2.0      1.50 D
```

```
*BEND*     4.000   3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0     1.50 D

*DRIFT*    3.0     1.0000 M

*ROTAT*    2.0     1.50 D

*BEND*     4.000   3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0     1.50 D

*DRIFT*    3.0     1.0000 M

                                                 175.0 M        0.0     1.300 CM
                                                                0.0     0.310 MR    0.997
                                                                0.0     1.227 CM    0.0     0.0
                                                                0.0     0.216 MR    0.0     0.0     0.994
                                                                0.0     0.504 CM   -0.000   0.000   0.0     0.0
                                                                0.0     1.000 PC    0.000   0.000   0.0     0.0    -0.804

 *TRANSFORM* 1
           -1.26882 -12.42980   0.0        0.0        0.0        0.00001
           -0.22847  -3.02628   0.0        0.0        0.0        0.00000
            0.0       0.0      -3.72852   -5.03437    0.0        0.0
            0.0       0.0      -0.62031   -1.10576    0.0        0.0
           -0.00000  -0.00001   0.0        0.0        1.00000   -0.40547
            0.0       0.0       0.0        0.0        0.0        1.00000

*QUAD*     5.00    2.00000 M   -2.1150 KG   5.000 CM  (  -9.532 M  )
         LABEL = Q3

*DRIFT*    3.0     2.0000 M

*QUAD*     5.00    2.00000 M    2.1487 KG   5.000 CM  (  10.044 M  )
         LABEL = Q3

*DRIFT*    3.0   200.0000 M

                                                 381.0 M        0.0     4.000 CM
                                                                0.0     0.299 MR    1.000
                                                                0.0     1.500 CM    0.0     0.0
                                                                0.0     0.113 MR    0.0     0.0     0.984
```

```
                                                                                    0.0       0.504 CM    0.000  0.000  0.0     0.0
                                                                                    0.0       1.000 PC   -0.000 -0.000  0.0     0.0     -0.804

*FIT*      10.0      1. 1.    4.000 / 0.100

                              4.000
    VARY CODE = 200000
         LABEL = FIT4

*FIT*      10.0      3. 3.    1.500 / 0.100

                              1.500
    VARY CODE = 200000
         LABEL = FIT4

 *TRANSFORM* 1
             4.77122  37.35149   0.0       0.0       0.0      -0.00003
             0.33310   2.81727   0.0       0.0       0.0      -0.00000
             0.0       0.0       4.99109  -0.89239   0.0       0.0
             0.0       0.0       0.37533   0.13324   0.0       0.0
            -0.00000  -0.00001   0.0       0.0       1.00000  -0.40547
             0.0       0.0       0.0       0.0       0.0       1.00000

                                                              381.0 M       0.0       4.000 CM
                                                                            0.0       0.299 MR    1.000
                                                                            0.0       1.500 CM    0.0    0.0
                                                                            0.0       0.113 MR    0.0    0.0    0.984
                                                                            0.0       0.504 CM    0.000  0.000  0.0     0.0
                                                                            0.0       1.000 PC   -0.000 -0.000  0.0     0.0     -0.804

*QUAD*      5.00    2.00000 M    4.5000 KG   5.000 CM  (   4.984 M  )
    VARY CODE = 010000
         LABEL = Q4

*DRIFT*     3.0      2.0000 M

                                                              385.0 M       0.0       1.665 CM
                                                                            0.0       7.789 MR   -1.000
                                                                            0.0       2.582 CM    0.0    0.0
                                                                            0.0       3.612 MR    0.0    0.0    1.000
                                                                            0.0       0.504 CM    0.000 -0.000  0.0     0.0
                                                                            0.0       1.000 PC   -0.000  0.000  0.0     0.0     -0.804

*QUAD*      5.00    2.00000 M   -4.2000 KG   5.000 CM  (  -4.645 M  )
    VARY CODE = 010000
         LABEL = Q4

                                                              387.0 M       0.0       0.347 CM
```

```
                                                                       0.0     5.828 MR   -1.000
                                                                       0.0     2.754 CM    0.0     0.0
                                                                       0.0     1.951 MR    0.0     0.0    -1.000
                                                                       0.0     0.504 CM    0.000 -0.000  0.0     0.0
                                                                       0.0     1.000 PC   -0.000  0.000  0.0     0.0    -0.804

*DRIFT*    3.0    15.0000 M

                                                          402.0 M      0.0     8.395 CM
                                                                       0.0     5.828 MR    1.000
                                                                       0.0     0.173 CM    0.0     0.0
                                                                       0.0     1.951 MR    0.0     0.0     0.996
                                                                       0.0     0.504 CM   -0.000 -0.000  0.0     0.0
                                                                       0.0     1.000 PC    0.000  0.000  0.0     0.0    -0.804

*FIT*     10.0      2. 1.    0.0   / 0.001

                             48.931
        LABEL = FIT5

*FIT*     10.0      4. 3.    0.0   / 0.001

                             0.336
        LABEL = FIT6

*FIT*     10.0      1. 1.    0.020 / 0.010

                             8.395
    VARY CODE = 200000
        LABEL = FIT7

*FIT*     10.0      3. 3.    0.020 / 0.010

                             0.173
    VARY CODE = 200000
        LABEL = FIT7

 *TRANSFORM* 1
          -2.33281    3.13200    0.0        0.0        0.0        0.0
          -1.58390    1.69786    0.0        0.0        0.0        0.0
           0.0        0.0       -0.17269    0.77960    0.0        0.0
           0.0        0.0       -1.30944    0.12067    0.0        0.0
           0.0        0.0        0.0        0.0        1.00000    0.0
           0.0        0.0        0.0        0.0        0.0        1.00000

 *LENGTH*   401.9993 M

  *CORRECTIONS*
```

(7.4658E C4)	-0.780	0.213
(1.9C87E 04)	-0.431	0.237
(5.0201E C3)	-0.240	0.163
(1.3456E C3)	-0.131	0.095
(3.7784E C2)	-0.068	0.045
(1.0482E 02)	-C.032	0.018
(1.6754E 01)	-0.007	0.003
(3.2649E-01)	-C.000	0.000

```
  *COVARIANCE  ( FIT   0.3 )
 0.000
-0.793  0.000
```

BEAM TRANSPORT SYSTEM FOR SLAC BEAM SWITCHYARD END STATICN A IIIB

```
*BEAM*     1.C00000   25.0C GEV
                                                      0.0 M       0.0     0.300 CM
                                                                  0.0     0.100 MR   0.0
                                                                  0.0     0.300 CM   0.0     0.0
                                                                  0.0     0.100 MR   0.0     0.0     0.0
                                                                  0.0     0.300 CM   0.0     0.0     0.0     0.0
                                                                  0.0     1.000 PC   0.0     0.0     0.0     0.0     0.0


*BEND*     4.000   5.0CCCC M    1.455 KG    0.0000 (    0.500 D )

*ROTAT*    2.0     0.50 D

                                                      5.0 M       0.0     0.305 CM
                                                                  0.0     0.133 MR   0.171
                                                                  0.0     0.304 CM   0.0     0.0
                                                                  0.0     0.100 MR   0.0     0.0     0.164
                                                                  0.0     0.300 CM  -0.009  -0.001   0.0     0.0
                                                                  0.0     1.000 PC   0.071   0.657   0.0     0.0    -0.000

*DRIFT*    3.0    8C.0000 M

                                                     85.0 M       0.0     1.153 CM
                                                                  0.0     0.133 MR   0.965
                                                                  0.0     0.901 CM   0.0     0.0
                                                                  0.0     0.100 MR   0.0     0.0     0.943
                                                                  0.0     0.300 CM  -0.003  -0.001   0.0     0.0
                                                                  0.0     1.000 PC   0.624   0.657   0.0     0.0    -0.000

*QUAD*     5.00   2.00000 M   -2.C898 KG    5.000 CM  (  -9.650 M  )
        LABEL = C1

*DRIFT*    3.0     2.0000 M

*QUAD*     5.00   2.00000 M    2.1943 KG    5.000 CM  (   9.843 M  )
        LABEL = C1

                                                     91.0 M       0.0     1.661 CM
                                                                  0.0     0.392 MR  -0.998
                                                                  0.0     0.582 CM   0.0     0.0
                                                                  0.0     0.147 MR   0.0     0.0    -0.937
                                                                  0.0     0.300 CM  -0.003   0.003   0.0     0.0
                                                                  0.0     1.000 PC   0.627  -0.613   0.0     0.0    -0.000

*DRIFT*    3.0     1.0000 M
```

```
*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M

*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M

*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M

*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0      1.50 D


                                                  107.0 M      0.0     2.366 CM
                                                               0.0     1.880 MR    0.873
                                                               0.0     0.357 CM    0.0      0.0
                                                               0.0     0.163 MR    0.0      0.0     -0.856
                                                               0.0     0.471 CM   -0.737   -0.533    0.0      0.0
                                                               0.0     1.000 PC    0.941    0.986    0.0      0.0    -0.617


*DRIFT*    3.0    24.9203 M
        LABEL = DR1
```

```
*QUAD*      5.00    2.00000 M     3.5785 KG   15.000 CM   (   17.815 M   )
        LABEL = Q2

                                                                133.9 M          0.0       6.823 CM
                                                                                 0.0       2.117 MR    -0.989
                                                                                 0.0       0.239 CM     0.0     0.0
                                                                                 0.0       0.254 MR     0.0     0.0      0.870
                                                                                 0.0       0.471 CM    -0.615   0.678    0.0      0.0
                                                                                 0.0       1.000 PC     1.000  -0.989    0.0      0.0     -0.617

 *TRANSFORM* 1
          -0.33045  -0.00002   0.0        0.0        0.0        6.82236
          -0.22846  -3.02617   0.0        0.0        0.0       -2.09424
           0.0       0.0      -0.79757   -0.00002    0.0        0.0
           0.0       0.0      -0.73609   -1.25380    0.0        0.0
          -0.22507  -2.06457   0.0        0.0        1.00000   -0.29037
           0.0       0.0       0.0        0.0        0.0        1.00000

*DRIFT*     3.0     25.0795 M
        LABEL = DR1

                                                                159.0 M          0.0       1.765 CM
                                                                                 0.0       2.117 MR    -0.814
                                                                                 0.0       0.853 CM     0.0     0.0
                                                                                 0.0       0.254 MR     0.0     0.0      0.990
                                                                                 0.0       0.471 CM    -0.338   0.678    0.0      0.0
                                                                                 0.0       1.000 PC     0.890  -0.989    0.0      0.0     -0.617

*ROTAT*     2.0      1.50 D

*BEND*      4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.0      1.50 D

*DRIFT*     3.0      1.0000 M

*ROTAT*     2.0      1.50 D

*BEND*      4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.0      1.50 D

*DRIFT*     3.0      1.0000 M

*ROTAT*     2.0      1.50 D
```

```
*BEND*     4.000    3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M

*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M


                                                  175.0 M        0.0      1.300 CM
                                                                 0.0      0.310 MR     0.997
                                                                 0.0      1.227 CM     0.0     0.0
                                                                 0.0      0.216 MR     0.0     0.0     0.994
                                                                 0.0      0.504 CM    -0.000   0.000   0.0     0.0
                                                                 0.0      1.000 PC     0.000   0.000   0.0     0.0    -0.804


 *TRANSFORM* 1
           -1.26882 -12.42980   0.0       0.0       0.0       0.00001
           -0.22847  -3.02628   0.0       0.0       0.0       0.00000
            0.0       0.0      -3.72852  -5.03437   0.0       0.0
            0.0       0.0      -0.62031  -1.10576   0.0       0.0
           -0.00000  -0.00001   0.0       0.0       1.00000  -0.40547
            0.0       0.0       0.0       0.0       0.0       1.00000

*QUAD*     5.00   2.00000 M   -2.1150 KG   5.000 CM  (  -9.532 M  )
        LABEL = Q3

*DRIFT*    3.0     2.0000 M

*QUAD*     5.00   2.00000 M    2.1487 KG   5.000 CM  (  10.044 M  )
        LABEL = Q3

*DRIFT*    3.0   200.0000 M

                                                  381.0 M        0.0      4.000 CM
                                                                 0.0      0.299 MR     1.000
                                                                 0.0      1.500 CM     0.0     0.0
                                                                 0.0      0.113 MR     0.0     0.0     0.984
```

```
                                                                                  0.0      0.504 CM    0.000  0.000  0.0     0.0
                                                                                  0.0      1.000 PC   -0.000 -0.000  0.0     0.0     -0.804


*FIT*     10.0     1. 1.   4.000 / C.100

                           4.000
   VARY CODE = 200000
        LABEL = FIT4


*FIT*     10.C     3. 3.   1.500 / 0.100

                           1.500
   VARY CODE = 200000
        LABEL = FIT4


 *TRANSFORM* 1
            4.77122   37.35149   0.0        0.0        0.0        -0.00003
            0.33310    2.81727   C.0        0.0        0.0        -0.00000
            0.0        0.0       4.99109   -0.89239    0.0         0.0
            0.0        0.C       0.37533    0.13324    0.0         0.0
           -0.00000   -0.00001   0.C        0.0        1.00000    -0.40547
            C.0        0.0       0.0        0.0        0.0         1.00000

                                                    381.0 M       0.0      4.000 CM
                                                                  0.0      0.299 MR    1.000
                                                                  0.0      1.500 CM    0.0    0.0
                                                                  0.0      0.113 MR    0.0    0.0    0.984
                                                                  0.0      0.504 CM    0.000  0.000  0.0     0.0
                                                                  0.0      1.000 PC   -0.000 -0.000  0.0     0.0     -0.804


*QUAD*     5.00   2.00000 M    2.8115 KG   5.000 CM  (   7.759 M  )
   VARY CODE = 010000
        LABEL = Q4


*DRIFT*    3.0     2.0000 M

                                                    385.0 M       0.0      2.551 CM
                                                                  0.0      4.896 MR   -1.000
                                                                  0.0      2.179 CM    0.0    0.0
                                                                  0.0      2.242 MR    0.0    0.0    1.000
                                                                  0.0      0.504 CM    0.000 -0.000  0.0     0.0
                                                                  0.0      1.000 PC   -0.000  0.000  0.0     0.0     -0.804


*QUAD*     5.00   2.00000 M   -3.4253 KG   5.000 CM  (  -5.765 M  )
   VARY CCDE = 010000
        LABEL = C4


                                                    387.0 M       0.0      1.948 CM
```

```
                                                                                     0.0        1.298 MR    -1.000
                                                                                     0.0        2.255 CM     0.0      0.0
                                                                                     0.0        1.503 MR     0.0      0.0     -1.000
                                                                                     0.0        0.504 CM     0.000 -0.000    0.0      0.0
                                                                                     0.0        1.000 PC    -0.000  0.000    0.0      0.0     -0.804

*DRIFT*    3.0    15.0000 M

                                                                    402.0 M          0.0        0.023 CM
                                                                                     0.0        1.298 MR     0.000
                                                                                     0.0        0.020 CM     0.0      0.0
                                                                                     0.0        1.503 MR     0.0      0.0     -0.000
                                                                                     0.0        0.504 CM    -0.000 -0.000    0.0      0.0
                                                                                     0.0        1.000 PC     0.000  0.000    0.0      0.0     -0.804

*FIT*      10.0      2. 1.    0.0   / 0.001

                                  0.000
        LABEL = FIT5

*FIT*      10.0      4. 3.    0.0   / 0.001

                                 -0.000
        LABEL = FIT6

*FIT*      10.0      1. 1.    0.020 / 0.010

                                  0.023
    VARY CODE = 200000
        LABEL = FIT7

*FIT*      10.0      3. 3.    0.020 / 0.010

                                  0.020
    VARY CODE = 200000
        LABEL = FIT7

 *TRANSFORM* 1
           -0.23010   3.08075   0.0        0.0        0.0        0.0
           -0.44764   1.64740   0.0        0.0        0.0        0.0
            0.0       0.0      -0.07421    0.99798    0.0        0.0
            0.0       0.0      -1.02264    0.27718    0.0        0.0
            0.0       0.0       0.0        0.0        1.00000    0.0
            0.0       0.0       0.0        0.0        0.0        1.00000

 *LENGTH*   401.9993 M
```

```
'BEAM TRANSPORT SYSTEM FOR SLAC BEAM SWITCHYARD END STATION A IIIC'
1
(IN THE FOURTH STEP THE LAST TWO QUAD DOUBLETS ARE BOTH ALLOWED TO VARY)
(FOR A FINAL ADJUSTMENT TO GET THE WAIST AND THE SPOT SIZE AT THE TARGET.)
5.01 'Q3' ;
SENTINEL
```

```
BEAM TRANSPORT SYSTEM FOR SLAC BEAM SWITCHYARD END STATICN A IIIC

    1

IN THE FOURTH STEP THE LAST TWO QUAD DOUBLETS ARE BOTH ALLCWED TC VARY

FOR A FINAL ACJUSTMENT TO CET THE WAIST AND THE SPOT SIZE AT THE TARGET.

   1.00000   C.30000   0.10000   0.30000   0.10000   0.30000   1.00000  25.00000

  13.00000   2.00000

   4.00000   5.00000   1.455CC   0.0

   2.00000   C.50000

  13.00000   1.00000

   3.CC000  80.00000

  13.CC000   1.00000

   5.CC000   2.00000  -2.C8981   5.00000
    LABEL = Q1

   3.C0000   2.00000

   5.0C000   2.00000   2.19428   5.C0000
    LABEL = Q1

  13.00000   1.0CC00

   9.00000   4.00000

   3.00000   1.C0000

   2.000C0   1.50000

   4.0CC00   3.00000  14.55000   0.0

   2.C0000   1.50000

   9.00000   0.0

  13.00000   1.00000

   3.00000  24.92036
    LABEL = DR1

   5.00000   2.00000   3.57851  15.C0000
    LABEL = Q2

  13.00000   1.00000

 -10.0C000  -1.00000   2.00000   0.0       0.00100
    LABEL = FIT1

 -10.00000  -3.00000   4.00000   0.0       0.00100
    LABEL = FIT1
```

```
 13.00000    4.00000

  3.00000  25.07953
    LABEL = DR1

 13.00000    1.00000

  9.00000    4.00000

  2.00000    1.50000

  4.00000    3.00000  14.55000    0.0

  2.00000    1.50000

  3.00000    1.00000

  9.00000    0.0

 13.00000    1.00000

-10.00000  -1.00000   6.00000    0.0       0.00100
    LABEL = FIT2

-10.00000  -2.00000   6.00000    0.0       0.00100
    LABEL = FIT3

 13.00000    4.00000

  5.00000    2.00000  -2.11497    5.00000
  VARY CODE  010000
    LABEL = Q3

  3.00000    2.00000

  5.00000    2.00000   2.14873    5.00000
  VARY CODE  010000
    LABEL = Q3

  3.00000 200.00000

 13.00000    1.00000

 10.00000    1.00000   1.00000    4.00000   0.10000
  VARY CODE  200000
    LABEL = FIT4

 10.00000    3.00000   3.00000    1.50000   0.10000
  VARY CODE  200000
    LABEL = FIT4

 13.00000    4.00000

 13.00000    1.00000

  5.00000    2.00000   2.81145    5.00000
  VARY CODE  010000
    LABEL = Q4

  3.00000    2.00000
```

```
13.00000   1.00000

 5.00000   2.00000  -3.42531   5.00000
 VARY CODE  010000
  LABEL = Q4

13.00000   1.00000

 3.00000  15.00000

13.00000   1.00000

10.00000   2.00000   1.00000   0.0       0.00100
  LABEL = FIT5

10.00000   4.00000   3.00000   0.0       0.00100
  LABEL = FIT6

10.00000   1.00000   1.00000   0.02000   0.01000
 VARY CODE  200000
  LABEL = FIT7

10.00000   3.00000   3.00000   0.02000   0.01000
 VARY CODE  200000
  LABEL = FIT7

13.00000   4.00000

SENTINEL
```

BEAM TRANSPORT SYSTEM FOR SLAC BEAM SWITCHYARD END STATION A IIIC

```
*BEAM*      1.C00000   25.0C GEV
                                                              0.0 M          0.0      0.300 CM
                                                                             0.0      0.100 MR    0.0
                                                                             0.0      0.300 CM    0.0     0.0
                                                                             0.0      0.100 MR    0.0     0.0     0.0
                                                                             0.0      0.300 CM    0.0     0.0     0.0     0.0
                                                                             0.0      1.000 PC    0.0     0.0     0.0     0.0     0.0


*BEND*      4.000   5.0000C M    1.455 KG   0.0000 (   0.500 D )

*ROTAT*     2.C      0.50 D

                                                              5.0 M          0.0      0.305 CM
                                                                             0.0      0.133 MR    0.171
                                                                             0.0      0.304 CM    0.0     0.0
                                                                             0.0      0.100 MR    0.0     0.0     0.164
                                                                             0.0      0.300 CM   -0.009  -0.001   0.0     0.0
                                                                             0.0      1.000 PC    0.071   0.657   0.0     0.0    -0.000

*DRIFT*     3.0     80.0000 M

                                                             85.0 M          0.0      1.153 CM
                                                                             0.0      0.133 MR    C.965
                                                                             0.0      0.901 CM    0.0     0.0
                                                                             0.0      0.100 MR    0.0     0.0     0.943
                                                                             0.0      0.300 CM   -0.003  -0.001   0.0     0.0
                                                                             0.0      1.000 PC    0.624   0.657   0.0     0.0    -0.000

*QUAD*      5.00   2.00000 M   -2.C898 KG   5.000 CM  (  -9.650 M  )
          LABEL = Q1

*DRIFT*     3.0      2.000C M

*QUAD*      5.00   2.00000 M    2.1943 KG   5.000 CM  (   9.843 M  )
          LABEL = Q1

                                                             91.0 M          0.0      1.661 CM
                                                                             0.0      0.392 MR   -0.998
                                                                             0.0      0.582 CM    0.0     0.0
                                                                             0.0      0.147 MR    0.0     0.0    -0.937
                                                                             0.0      0.300 CM   -0.003   0.003   0.0     0.0
                                                                             0.0      1.000 PC    0.627  -0.613   0.0     0.0    -0.000

*DRIFT*     3.0      1.000C M
```

```
*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.000C M

*ROTAT*    2.0      1.50 D

*BEND*     4.C00    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*    2.C      1.50 D

*DRIFT*    3.0      1.0000 M

*ROTAT*    2.C      1.50 D

*BEND*     4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*    2.0      1.5C D

*DRIFT*    3.C      1.0000 M

*ROTAT*    2.C      1.50 D

*BEND*     4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*    2.C      1.50 D


                                                        107.0 M        0.0      2.366 CM
                                                                       0.0      1.880 MR     0.873
                                                                       0.0      0.357 CM     0.0      0.0
                                                                       0.0      0.163 MR     0.0      0.0     -0.856
                                                                       0.0      0.471 CM    -0.737   -0.533    0.0      0.0
                                                                       0.0      1.000 PC     0.941    0.986    0.0      C.0     -0.617

*DRIFT*    3.C    24.9203 M
       LABEL = DR1
```

```
*QUAD*     5.00   2.00000 M    3.5785 KG  15.000 CM  (  17.815 M  )
      LABEL = Q2

                                                133.9 M        0.0      6.823 CM
                                                               0.0      2.117 MR   -0.989
                                                               0.0      0.239 CM    0.0    0.0
                                                               0.0      0.254 MR    0.0    0.0    0.870
                                                               0.0      0.471 CM   -0.615  0.678  0.0    0.0
                                                               0.0      1.000 PC    1.000 -0.989  0.0    0.0   -0.617

 *TRANSFORM* 1
          -C.33045  -0.00002   0.0       0.0       0.0       6.82236
          -0.22846  -3.02617   0.0       0.0       0.0      -2.09424
           0.0       0.0      -C.79757  -0.00002   0.0       0.0
           0.0       0.0      -0.73609  -1.25380   C.0       0.0
          -C.22507  -2.06457   C.C       0.C       1.00000  -0.29037
           C.0       0.0       0.0       0.C       0.0       1.00000

*DRIFT*    3.0    25.C795 M
      LABEL = DR1

                                                159.0 M        0.0      1.765 CM
                                                               0.0      2.117 MR   -0.814
                                                               0.0      0.853 CM    0.0    0.0
                                                               0.0      0.254 MR    0.0    0.0    0.99C
                                                               0.0      0.471 CM   -0.338  0.678  0.0    C.0
                                                               0.0      1.000 PC    0.890 -C.989  0.0    0.0   -0.617

*ROTAT*    2.0     1.50 D

*BEND*     4.000   3.000CC M   14.550 KG   0.0000 (    2.999 D )

*ROTAT*    2.C     1.50 D

*DRIFT*    3.0     1.000C M

*ROTAT*    2.0     1.50 D

*BEND*     4.000   3.00000 M   14.550 KG   0.C000 (    2.999 D )

*ROTAT*    2.0     1.5C D

*DRIFT*    3.0     1.C00C M

*ROTAT*    2.C     1.50 D
```

```
*BEND*      4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.0      1.50 D

*DRIFT*     3.0      1.0000 M

*ROTAT*     2.0      1.50 D

*BEND*      4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.0      1.50 D

*DRIFT*     3.0      1.0000 M


                                                     175.0 M        0.0      1.300 CM
                                                                    0.0      0.310 MR     0.997
                                                                    0.0      1.227 CM     0.0      0.0
                                                                    0.0      0.216 MR     0.0      0.0      0.994
                                                                    0.0      0.504 CM    -0.000    0.000    0.0      0.0
                                                                    0.0      1.000 PC     0.000    0.000    0.0      0.0     -0.804


 *TRANSFORM* 1
           -1.26882 -12.42980    0.0         0.0         0.0         0.00001
           -0.22847  -3.02628    0.0         0.0         0.0         0.00000
            0.0       0.0       -3.72852   -5.03437     0.0         0.0
            0.0       0.0       -0.62031   -1.10576     0.0         0.0
           -0.00000  -0.00001    0.0         0.0         1.00000    -0.40547
            0.0       0.0        0.0         0.0         0.0         1.00000


*QUAD*      5.00    2.00000 M    -2.1150 KG    5.000 CM  (   -9.532 M   )
    VARY CODE = 010000
         LABEL = Q3


*DRIFT*     3.0      2.0000 M


*QUAD*      5.00    2.00000 M     2.1487 KG    5.000 CM  (   10.044 M   )
    VARY CODE = 010000
         LABEL = Q3


*DRIFT*     3.0    200.0000 M


                                                     381.0 M        0.0      4.000 CM
                                                                    0.0      0.299 MR     1.000
```

```
                                                                                        0.0       1.500 CM     0.0      0.0
                                                                                        0.0       0.113 MR     0.0      0.0      0.984
                                                                                        0.0       0.504 CM     0.000    0.000    0.0      0.0
                                                                                        0.0       1.000 PC    -0.000   -0.000    0.0      0.0     -0.804


*FIT*      10.0      1. 1.    4.000 / 0.100

                              4.000
    VARY CODE = 200000
         LABEL = FIT4


*FIT*      10.C      3. 3.    1.500 / C.100

                              1.500
    VARY CODE = 200000
         LABEL = FIT4


 *TRANSFORM* 1
           4.77122   37.35149   0.0        0.0        0.0        -0.00003
           0.33310    2.81727   0.C        0.C        0.0        -0.00000
           0.0        0.0       4.99109   -0.89239    0.0         0.0
           C.0        0.0       0.37533    0.13324    0.0         0.0
          -0.00000   -0.00001   0.C        0.0        1.00000    -0.40547
           0.0        0.C       0.C        0.C        0.0         1.00000

                                                                381.0 M         0.0       4.000 CM
                                                                                0.0       0.299 MR     1.000
                                                                                0.0       1.500 CM     0.0      0.0
                                                                                0.0       0.113 MR     0.0      0.0      0.984
                                                                                0.0       0.504 CM     0.000    0.000    0.0      0.0
                                                                                0.0       1.000 PC    -0.000   -0.000    0.0      0.0     -0.804


*QUAD*      5.00    2.00000 M     2.8115 KG    5.000 CM  (    7.759 M  )
    VARY CCDE = 010000
         LABEL = Q4

*DRIFT*     3.0      2.0000 M


                                                                385.0 M         0.0       2.551 CM
                                                                                0.0       4.896 MR    -1.000
                                                                                0.0       2.179 CM     0.0      0.0
                                                                                0.0       2.242 MR     0.0      0.0      1.000
                                                                                0.0       0.504 CM     0.000   -0.000    0.0      0.0
                                                                                0.0       1.000 PC    -0.000    0.000    0.0      0.0     -0.804


*QUAD*      5.00    2.00000 M    -3.4253 KG    5.000 CM  (   -5.765 M  )
    VARY CCDE = 010000
         LABEL = Q4
```

```
                                              387.0 M      0.0     1.948 CM
                                                           0.0     1.298 MR  -1.000
                                                           0.0     2.255 CM   0.0    0.0
                                                           0.0     1.503 MR   0.0    0.0   -1.000
                                                           0.0     0.504 CM   0.000 -0.000  0.0    0.0
                                                           0.0     1.000 PC  -0.000  0.000  0.0    0.0   -0.804

*DRIFT*    3.0    15.0000 M

                                              402.0 M      0.0     0.023 CM
                                                           0.0     1.298 MR   0.000
                                                           0.0     0.020 CM   0.0    0.0
                                                           0.0     1.503 MR   0.0    0.0   -0.000
                                                           0.0     0.504 CM  -0.000 -0.000  0.0    0.0
                                                           0.0     1.000 PC   0.000  0.000  0.0    0.0   -0.804


*FIT*     10.0     2. 1.   0.0   / 0.001

                           0.000
        LABEL = FIT5


*FIT*     10.0     4. 3.   0.0   / 0.001

                          -0.000
        LABEL = FIT6


*FIT*     10.0     1. 1.   0.020 / 0.010

                           0.023
    VARY CODE = 200000
        LABEL = FIT7


*FIT*     10.0     3. 3.   0.020 / 0.010

                           0.020
    VARY CODE = 200000
        LABEL = FIT7


 *TRANSFORM* 1
          -0.23010   3.08075   0.0       0.0       0.0       0.0
          -0.44764   1.64740   0.0       0.0       0.0       0.0
           0.0       0.0      -0.07421   0.99798   0.0       0.0
           0.0       0.0      -1.02264   0.27718   0.0       0.0
           0.0       0.0       0.0       0.0       1.00000   0.0
           0.0       0.0       0.0       0.0       0.0       1.00000

 *LENGTH*   401.9993 M
```

CORRECTIONS

```
( 1.3621E-01)     0.0       C.000     0.000    -0.000

 *COVARIANCE  ( FIT   0.1 )
0.0
0.0    0.001
0.0   -0.0C3  0.000
0.0   -0.753 -0.CC7  C.CCO
```

```
BEAM TRANSPORT SYSTEM FOR SLAC BEAM SWITCHYARD END STATION A IIIC


*BEAM*      1.000000    25.00 GEV
                                                            0.0 M.        0.0      0.300 CM
                                                                          0.0      0.100 MR     0.0
                                                                          0.0      0.300 CM     0.0     0.0
                                                                          0.0      0.100 MR     0.0     0.0     0.0
                                                                          0.0      0.300 CM     0.0     0.0     0.0     0.0
                                                                          0.0      1.000 PC     0.0     0.0     0.0     0.0     0.0



*BEND*      4.000    5.00000 M     1.455 KG    0.0000 (    0.500 D )

*ROTAT*     2.0       0.50 D

                                                            5.0 M         0.0      0.305 CM
                                                                          0.0      0.133 MR     0.171
                                                                          0.0      0.304 CM     0.0     0.0
                                                                          0.0      0.100 MR     0.0     0.0     0.164
                                                                          0.0      0.300 CM    -0.009  -0.001   0.0     0.0
                                                                          0.0      1.000 PC     0.071   0.657   0.0     0.0    -0.000

*DRIFT*     3.0     80.0000 M

                                                           85.0 M         0.0      1.153 CM
                                                                          0.0      0.133 MR     0.965
                                                                          0.0      0.901 CM     0.0     0.0
                                                                          0.0      0.100 MR     0.0     0.0     0.943
                                                                          0.0      0.300 CM    -0.003  -0.001   0.0     0.0
                                                                          0.0      1.000 PC     0.624   0.657   0.0     0.0    -0.000

*QUAD*      5.00    2.00000 M    -2.0858 KG    5.000 CM  (  -9.650 M   )
        LABEL = Q1

*DRIFT*     3.0      2.0000 M

*QUAD*      5.00    2.00000 M     2.1943 KG    5.000 CM  (   9.843 M   )
        LABEL = Q1

                                                           91.0 M         0.0      1.661 CM
                                                                          0.0      0.392 MR    -0.998
                                                                          0.0      0.582 CM     0.0     0.0
                                                                          0.0      0.147 MR     0.0     0.0    -0.937
                                                                          0.0      0.300 CM    -0.003   0.003   0.0     0.0
                                                                          0.0      1.000 PC     0.627  -0.613   0.0     0.0    -0.000

*DRIFT*     3.0      1.0000 M
```

```
*ROTAT*     2.0       1.50 D

*BEND*      4.000     3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.0       1.50 D

*DRIFT*     3.0       1.0000 M

*ROTAT*     2.0       1.50 D

*BEND*      4.000     3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.0       1.50 D

*DRIFT*     3.0       1.0000 M

*ROTAT*     2.0       1.50 D

*BEND*      4.000     3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.0       1.50 D

*DRIFT*     3.0       1.0000 M

*ROTAT*     2.0       1.50 D

*BEND*      4.000     3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.0       1.50 D


                                                  107.0 M        0.0     2.366 CM
                                                                 0.0     1.880 MR    0.873
                                                                 0.0     0.357 CM    0.0     0.0
                                                                 0.0     0.163 MR    0.0     0.0    -0.856
                                                                 0.0     0.471 CM   -0.737  -0.533   0.0     0.0
                                                                 0.0     1.000 PC    0.941   0.986   0.0     0.0    -0.617


*DRIFT*     3.0    24.9203 M
         LABEL = DR1
```

```
*QUAD*      5.00   2.00000 M    3.5785 KG  15.000 CM  (  17.815 M  )
        LABEL = Q2

                                                  133.9 M        0.0      6.823 CM
                                                                 0.0      2.117 MR   -0.989
                                                                 0.0      0.239 CM    0.0    0.0
                                                                 0.0      0.254 MR    0.0    0.0    0.870
                                                                 0.0      0.471 CM   -0.615  0.678  0.0    0.0
                                                                 0.0      1.000 PC    1.000 -0.989  0.0    0.0   -0.617

 *TRANSFORM* 1
           -C.33045  -0.00002   0.0       0.C       0.0       6.82236
           -C.22846  -3.02617   C.C       0.0       0.0      -2.09424
            0.0       0.0      -C.79757  -0.00002   0.0       0.0
            C.0       0.0      -C.73609  -1.25380   C.0       0.0
           -0.22507  -2.06457   0.0       0.0       1.00000  -0.29037
            C.0       0.C       C.C       0.0       0.0       1.00000

*DRIFT*     3.C    25.C795 M
        LABEL = DR1

                                                  159.0 M        0.0      1.765 CM
                                                                 0.0      2.117 MR   -0.814
                                                                 0.0      0.853 CM    0.0    0.0
                                                                 0.0      0.254 MR    0.0    0.0    0.990
                                                                 0.0      0.471 CM   -0.338  0.678  0.0    0.0
                                                                 0.0      1.000 PC    0.890 -0.989  0.0    0.0   -0.617

*ROTAT*     2.0      1.50 D

*BEND*      4.000    3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*     2.0      1.50 D

*DRIFT*     3.C      1.0000 M

*ROTAT*     2.0      1.50 D

*BEND*      4.000    3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*     2.0      1.50 D

*DRIFT*     3.C      1.0000 M

*ROTAT*     2.C      1.50 D
```

```
*BEND*     4.000   3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0     1.50 D

*DRIFT*    3.0     1.0000 M

*ROTAT*    2.0     1.50 D

*BEND*     4.000   3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0     1.50 D

*DRIFT*    3.0     1.0000 M


                                        175.0 M     0.0    1.300 CM
                                                    0.0    0.310 MR   0.997
                                                    0.0    1.227 CM   0.0     0.0
                                                    0.0    0.216 MR   0.0     0.0     0.994
                                                    0.0    0.504 CM  -0.000   0.000   0.0    0.0
                                                    0.0    1.000 PC   0.000   0.000   0.0    0.0   -0.804


 *TRANSFORM* 1
          -1.26882 -12.42980   0.0        0.0       0.0       0.00001
          -0.22847  -3.02628   0.0        0.0       0.0       0.00000
           0.0       0.0      -3.72852   -5.03437   0.0       0.0
           0.0       0.0      -0.62031   -1.10576   0.0       0.0
          -0.00000  -0.00001   0.0        0.0       1.00000  -0.40547
           0.0       0.0       0.0        0.0       0.0       1.00000

*QUAD*     5.00   2.00000 M   -2.1150 KG   5.000 CM  (  -9.532 M  )
    VARY CODE = 010000
         LABEL = Q3

*DRIFT*    3.0     2.0000 M

*QUAD*     5.00   2.00000 M    2.1487 KG   5.000 CM  (  10.044 M  )
    VARY CODE = 010000
         LABEL = Q3

*DRIFT*    3.0   200.0000 M

                                        381.0 M     0.0    4.000 CM
                                                    0.0    0.299 MR   1.000
```

```
                                                                              0.0     1.500 CM    0.0    0.0
                                                                              0.0     0.113 MR    0.0    0.0    0.984
                                                                              0.0     0.504 CM    0.000  0.000  0.0    0.0
                                                                              0.0     1.000 PC   -0.000 -0.000  0.0    0.0    -0.804

*FIT*     10.0     1. 1.   4.000 / 0.100

                           4.000
    VARY CODE = 200000
         LABEL = FIT4

*FIT*     10.0     3. 3.   1.500 / 0.100

                           1.500
    VARY CODE = 200000
         LABEL = FIT4

 *TRANSFORM* 1
            4.77126   37.35184   0.0        0.0        0.0       -0.00003
            0.33310    2.81729   0.0        0.0        0.0       -0.00000
            0.0        0.0       4.99107   -0.89241    0.0        0.0
            0.0        0.0       0.37533    0.13324    0.0        0.0
           -0.00000   -0.00001   0.0        0.0        1.00000   -0.40547
            0.0        0.0       0.0        0.0        0.0        1.00000

                                                       381.0 M        0.0     4.000 CM
                                                                      0.0     0.299 MR    1.000
                                                                      0.0     1.500 CM    0.0    0.0
                                                                      0.0     0.113 MR    0.0    0.0    0.984
                                                                      0.0     0.504 CM    0.000  0.000  0.0    0.0
                                                                      0.0     1.000 PC   -0.000 -0.000  0.0    0.0    -0.804

*QUAD*     5.00   2.00000 M    2.8115 KG   5.000 CM  (   7.759 M  )
    VARY CODE = 010000
         LABEL = Q4

*DRIFT*    3.0    2.0000 M

                                                       385.0 M        0.0     2.551 CM
                                                                      0.0     4.896 MR   -1.000
                                                                      0.0     2.179 CM    0.0    0.0
                                                                      0.0     2.242 MR    0.0    0.0    1.000
                                                                      0.0     0.504 CM    0.000 -0.000  0.0    0.0
                                                                      0.0     1.000 PC   -0.000  0.000  0.0    0.0    -0.804

*QUAD*     5.00   2.00000 M   -3.4253 KG   5.000 CM  (  -5.765 M  )
    VARY CODE = 010000
         LABEL = Q4
```

```
                                                              387.0 M        0.0      1.948 CM
                                                                             0.0      1.298 MR   -1.000
                                                                             0.0      2.255 CM    0.0    0.0
                                                                             0.0      1.503 MR    0.0    0.0    -1.000
                                                                             0.0      0.504 CM    0.000 -0.000  0.0    0.0
                                                                             0.0      1.000 PC   -0.000  0.000  0.0    0.0    -0.804

*DRIFT*    3.0    15.0000 M

                                                              402.0 M        0.0      0.023 CM
                                                                             0.0      1.298 MR   -0.000
                                                                             0.0      0.020 CM    0.0    0.0
                                                                             0.0      1.503 MR    0.0    0.0    0.000
                                                                             0.0      0.504 CM   -0.000 -0.000  0.0    0.0
                                                                             0.0      1.000 PC    0.000  0.000  0.0    0.0    -0.804

*FIT*     10.0     2. 1.   0.0   / 0.001

                          -0.000
         LABEL = FIT5

*FIT*     10.0     4. 3.   0.0   / 0.001

                           0.000
         LABEL = FIT6

*FIT*     10.0     1. 1.   0.020 / 0.010

                           0.023
    VARY CODE = 200000
         LABEL = FIT7

*FIT*     10.0     3. 3.   0.020 / 0.010

                           0.020
    VARY CODE = 200000
         LABEL = FIT7

 *TRANSFORM* 1
           -0.23010    3.08075    0.0        0.0        0.0        0.0
           -0.44764    1.64740    0.0        0.0        0.0        0.0
            0.0        0.0       -0.07421    0.99798    0.0        0.0
            0.0        0.0       -1.02264    0.27718    0.0        0.0
            0.0        0.0        0.0        0.0        1.00000    0.0
            0.0        0.0        0.0        0.0        0.0        1.00000

 *LENGTH*   401.9993 M
```

```
'UNCERTAINTY IN MISALIGNMENT OF MAGNETIC TRIPLET'
0
(THIS IS AN EXAMPLE OF AN UNCERTAINTY IN THE MISALIGNMENT OF A TRIPLET.)
(ZERO PHASE SPACE IS USED.  IT IS SIMILAR TO EXAMPLE THREE IN SECTION EIGHT OF)
(SLAC 91.  THE UNCERTAINTIES APPEAR IN THE PHASE SPACE ELLIPSE PRINTOUT.)
1.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0 ;
3.0 3.66 ;
6.0 0.0 2.0 ;
5.0 0.45730 -14.50800 10.15 ;
3.0 0.15250 ;
6.0 0.0 1.0 ;
5.0 0.91400 8.39750 10.15 ;
3.0 0.15250 ;
5.0 0.45730 -14.50800 10.15 ;
8.0 0.1 0.1 0.1 0.1 0.1 0.1 000.0 ;
8.0 0.1 0.1 0.1 0.1 0.1 0.1 001.0 ;
8.0 0.1 0.1 0.1 0.1 0.1 0.1 002.0 ;
3.0 2.13500 ;
13.0 4.0 ;
SENTINEL
```

UNCERTAINTY IN MISALIGNMENT OF MAGNETIC TRIPLET

0

THIS IS AN EXAMPLE OF AN UNCERTAINTY IN THE MISALIGNMENT OF A TRIPLET.
ZERO PHASE SPACE IS USED. IT IS SIMILAR TO EXAMPLE THREE IN SECTION EIGHT OF
SLAC 91. THE UNCERTAINTIES APPEAR IN THE PHASE SPACE ELLIPSE PRINTOUT.

```
  1.00000   0.0       0.0       0.0       0.0       0.0       0.0       1.00000
  3.00000   3.66000
  6.00000   0.0       2.00000
  5.00000   0.45730 -14.50800  10.15000
  3.00000   0.15250
  6.00000   0.0       1.00000
  5.00000   0.91400   8.39750  10.15000
  3.00000   0.15250
  5.00000   0.45730 -14.50800  10.15000
  8.00000   0.10000   0.10000   0.10000   0.10000   0.10000   0.10000   0.0
  8.00000   0.10000   0.10000   0.10000   0.10000   0.10000   0.10000   1.00000
  8.00000   0.10000   0.10000   0.10000   0.10000   0.10000   0.10000   2.00000
  3.00000   2.13500
 13.00000   4.00000
 SENTINEL
```

UNCERTAINTY IN MISALIGNMENT OF MAGNETIC TRIPLET

```
*BEAM*      1.C00000     1.0C GEV
                                                      0.0 M         0.0      0.0   CM
                                                                    0.0      0.0   MR    0.0
                                                                    0.0      0.0   CM    0.0    0.0
                                                                    0.0      0.0   MR    0.0    0.0    0.0
                                                                    0.0      0.0   CM    0.0    0.0    0.0    0.0
                                                                    0.0      0.0   PC    0.0    0.0    0.0    0.0    0.0

*DRIFT*     3.0      3.660C M
                                                      3.7 M         0.0      0.0   CM
                                                                    0.0      0.0   MR    0.0
                                                                    0.0      0.0   CM    0.0    0.0
                                                                    0.0      0.0   MR    0.0    0.0    0.0
                                                                    0.0      0.0   CM    0.0    0.0    0.0    0.0
                                                                    0.0      0.0   PC    0.0    0.0    0.0    0.0    0.0

 *UPCATE*    6.00   (0.)             2.00
                                                      3.7 M         0.0      0.0   CM
                                                                    0.0      0.0   MR    0.0
                                                                    0.0      0.0   CM    0.0    0.0
                                                                    0.0      0.0   MR    0.0    0.0    0.0
                                                                    0.0      0.0   CM    0.0    0.0    0.0    0.0
                                                                    0.0      0.0   PC    0.0    0.0    0.0    0.0    0.0

*QUAD*      5.C0    0.45730 M  -14.5080 KG  10.150 CM  (   -0.441 M  )
                                                      4.1 M         0.0      0.0   CM
                                                                    0.0      0.0   MR    0.0
                                                                    0.0      0.0   CM    0.0    0.0
                                                                    0.0      0.0   MR    0.0    0.0    0.0
                                                                    0.0      0.0   CM    0.0    0.0    0.0    0.0
                                                                    0.0      0.0   PC    0.0    0.0    0.0    0.0    0.0

*DRIFT*     3.0      0.1525 M
                                                      4.3 M         0.0      0.0   CM
                                                                    0.0      0.0   MR    0.0
                                                                    0.0      0.0   CM    0.0    0.0
                                                                    0.0      0.0   MR    0.0    0.0    0.0
                                                                    0.0      0.0   CM    0.0    0.0    0.0    0.0
                                                                    0.0      0.0   PC    0.0    0.0    0.0    0.0    0.0

 *UPCATE*    6.00   (0.)             1.00
                                                      4.3 M         0.0      0.0   CM
                                                                    0.0      0.0   MR    0.0
                                                                    0.0      0.0   CM    0.0    0.0
                                                                    0.0      0.0   MR    0.0    0.0    0.0
                                                                    0.0      0.0   CM    0.0    0.0    0.0    0.0
                                                                    0.0      0.0   PC    0.0    0.0    0.0    0.0    0.0

*QUAD*      5.00    0.91400 M    8.3975 KG  10.150 CM  (    C.640 M  )
                                                      5.2 M         0.0      0.0   CM
```

```
                                                                          0.0     0.0  MR   0.0
                                                                          0.0     0.0  CM   0.0    0.0
                                                                          0.0     0.0  MR   0.0    0.0    0.0
                                                                          0.0     0.0  CM   0.0    0.0    0.0    0.0
                                                                          0.0     0.0  PC   0.0    0.0    0.0    0.0    0.0


*DRIFT*    3.0      0.1525 M
                                                              5.3 M       0.0     0.0  CM
                                                                          0.0     0.0  MR   0.0
                                                                          0.0     0.0  CM   0.0    0.0
                                                                          0.0     0.0  MR   0.0    0.0    0.0
                                                                          0.0     0.0  CM   0.0    0.0    0.0    0.0
                                                                          0.0     0.0  PC   0.0    0.0    0.0    0.0    0.0


*QUAD*     5.00   0.45730 M  -14.5080 KG  10.150 CM  (   -0.441 M  )
                                                              5.8 M       0.0     0.0  CM
                                                                          0.0     0.0  MR   0.0
                                                                          0.0     0.0  CM   0.0    0.0
                                                                          0.0     0.0  MR   0.0    0.0    0.0
                                                                          0.0     0.0  CM   0.0    0.0    0.0    0.0
                                                                          0.0     0.0  PC   0.0    0.0    0.0    0.0    0.0


*ALIGN*    8.000000  0.100 CM  0.10 MR  0.100 CM  0.10 MR  0.100 CM  0.10 MR    CD*    0.0
                                                              5.8 M       0.0     0.048 CM
                                                                          0.0     2.266 MR  1.000
                                                                          0.0     0.042 CM  0.0    0.0
                                                                          0.0     1.680 MR  0.0    0.0    1.000
                                                                          0.0     0.0   CM  0.0    0.0    0.0    0.0
                                                                          0.0     0.0   PC  0.0    0.0    0.0    0.0    0.0


*ALIGN*    8.000000  0.100 CM  0.10 MR  0.100 CM  0.10 MR  0.100 CM  0.10 MR    CD*    1.0
                                                              5.8 M       0.0     0.204 CM
                                                                          0.0     3.418 MR  0.884
                                                                          0.0     0.187 CM  0.0    0.0
                                                                          0.0     3.200 MR  0.0    0.0   -0.713
                                                                          0.0     0.0   CM  0.0    0.0    0.0    0.0
                                                                          0.0     0.0   PC  0.0    0.0    0.0    0.0    0.0


*ALIGN*    8.000000  0.100 CM  0.10 MR  0.100 CM  0.10 MR  0.100 CM  0.10 MR    CD*    2.0
                                                              5.8 M       0.0     0.210 CM
                                                                          0.0     3.535 MR  0.889
                                                                          0.0     0.363 CM  0.0    0.0
                                                                          0.0     3.526 MR  0.0    0.0   -0.685
                                                                          0.0     0.0   CM  0.0    0.0    0.0    0.0
                                                                          0.0     0.0   PC  0.0    0.0    0.0    0.0    0.0

*DRIFT*    3.0      2.1350 M
                                                              7.9 M       0.0     0.946 CM
                                                                          0.0     3.535 MR  0.995
                                                                          0.0     0.569 CM  0.0    0.0
                                                                          0.0     3.526 MR  0.0    0.0    0.885
```

0.0	0.0	CM	0.0	0.0	0.0	0.0			
0.0	0.0	PC	0.0	0.0	0.0	0.0	0.0		

TRANSFORM 1

1.00000	0.21350	C.C	0.0	0.0	0.0
0.0	1.C0000	0.0	0.0	0.0	0.0
C.0	0.C	1.C0000	0.21350	0.0	0.0
0.0	0.0	0.0	1.00000	0.0	0.0
0.0	0.0	C.0	0.0	1.00000	0.0
0.0	0.0	0.0	0.0	0.0	1.00000

LENGTH 7.9286 M

```
'DELIBERATE DISPLACEMENT OF A TRIPLET'
0
(THIS IS AN EXAMPLE OF A KNOWN DISPLACEMENT IN A TRIPLET.  A FINITE PHASE)
(SPACE IS ENTERED,AND THE DISPLACEMENT APPEARS IN THE BEAM CENTROID.)
1.0 0.1 0.2 0.3 0.4 0.50 0.6 7.0 ;
3.0 3.66 ;
6.0 0.0 2.0 ;
5.0 0.45730 -14.50800 10.15 ;
3.0 0.15250 ;
6.0 0.0 1.0 ;
5.0 0.91400 8.39750 10.15 ;
3.0 0.15250 ;
5.0 0.45730 -14.50800 10.15 ;
8.0 0.1 0.1 0.1 0.1 0.1 0.1 100.0 ;
8.0 0.1 0.1 0.1 0.1 0.1 0.1 101.0 ;
8.0 0.1 0.1 0.1 0.1 0.1 0.1 102.0 ;
3.0 2.13500 ;
13.0 4.0 ;
SENTINEL
```

DELIBERATE DISPLACEMENT OF A TRIPLET

```
    0
THIS IS AN EXAMPLE OF A KNOWN DISPLACEMENT IN A TRIPLET.  A FINITE PHASE
SPACE IS ENTERED,AND THE DISPLACEMENT APPEARS IN THE BEAM CENTROID.
   1.00000   0.10000   0.20000   0.30000   0.40000   0.50000   0.60000   7.00000
   3.00000   3.66000
   6.00000   0.0       2.00000
   5.00000   0.45730 -14.50800  10.15000
   3.00000   0.15250
   6.00000   0.0       1.00000
   5.00000   0.91400   8.39750  10.15000
   3.00000   0.15250
   5.00000   0.45730 -14.50800  10.15000
   8.00000   0.10000   0.10000   0.10000   0.10000   0.10000   0.10000 100.00000
   8.00000   0.10000   0.10000   0.10000   0.10000   0.10000   0.10000 101.00000
   8.00000   0.10000   0.10000   0.10000   0.10000   0.10000   0.10000 102.00000
   3.00000   2.13500
  13.00000   4.00000
  SENTINEL
```

DELIBERATE DISPLACEMENT OF A TRIPLET

```
*BEAM*     1.000000    7.00 GEV
                                                        0.0 M       0.0     0.100 CM
                                                                    0.0     0.200 MR    0.0
                                                                    0.0     0.300 CM    0.0     0.0
                                                                    0.0     0.400 MR    0.0     0.0     0.0
                                                                    0.0     0.500 CM    0.0     0.0     0.0     0.0
                                                                    0.0     0.600 PC    0.0     0.0     0.0     0.0     0.0

*DRIFT*    3.0     3.6600 M
                                                        3.7 M       0.0     0.124 CM
                                                                    0.0     0.200 MR    0.591
                                                                    0.0     0.334 CM    0.0     0.0
                                                                    0.0     0.400 MR    0.0     0.0     0.439
                                                                    0.0     0.500 CM    0.0     0.0     0.0     0.0
                                                                    0.0     0.600 PC    0.0     0.0     0.0     0.0     0.0

 *UPDATE*    6.00   (0.)              2.00
                                                        3.7 M       0.0     0.124 CM
                                                                    0.0     0.200 MR    0.591
                                                                    0.0     0.334 CM    0.0     0.0
                                                                    0.0     0.400 MR    0.0     0.0     0.439
                                                                    0.0     0.500 CM    0.0     0.0     0.0     0.0
                                                                    0.0     0.600 PC    0.0     0.0     0.0     0.0     0.0

*QUAD*     5.00   0.45730 M  -14.5080 KG  10.150 CM  (  -3.497 M  )
                                                        4.1 M       0.0     0.138 CM
                                                                    0.0     0.510 MR    0.959
                                                                    0.0     0.321 CM    0.0     0.0
                                                                    0.0     0.822 MR    0.0     0.0    -0.891
                                                                    0.0     0.500 CM    0.0     0.0     0.0     0.0
                                                                    0.0     0.600 PC    0.0     0.0     0.0     0.0     0.0

*DRIFT*    3.0     0.1525 M
                                                        4.3 M       0.0     0.145 CM
                                                                    0.0     0.510 MR    0.963
                                                                    0.0     0.310 CM    0.0     0.0
                                                                    0.0     0.822 MR    0.0     0.0    -0.882
                                                                    0.0     0.500 CM    0.0     0.0     0.0     0.0
                                                                    0.0     0.600 PC    0.0     0.0     0.0     0.0     0.0

 *UPDATE*    6.00   (0.)              1.00
                                                        4.3 M       0.0     0.145 CM
                                                                    0.0     0.510 MR    0.963
                                                                    0.0     0.310 CM    0.0     0.0
                                                                    0.0     0.822 MR    0.0     0.0    -0.882
                                                                    0.0     0.500 CM    0.0     0.0     0.0     0.0
                                                                    0.0     0.600 PC    0.0     0.0     0.0     0.0     0.0

*QUAD*     5.00   0.91400 M    8.3975 KG  10.150 CM  (   3.246 M  )
                                                        5.2 M       0.0     0.167 CM
```

```
                                                                        0.0      0.121 MR   -0.154
                                                                        0.0      0.290 CM    0.0     0.0
                                                                        0.0      0.497 MR    0.0     0.0     0.551
                                                                        0.0      0.500 CM    0.0     0.0     0.0     0.0
                                                                        0.0      0.600 PC    0.0     0.0     0.0     0.0     0.0

*DRIFT*    3.0      0.1525 M
                                                            5.3 M       0.0      0.167 CM
                                                                        0.0      0.121 MR   -0.143
                                                                        0.0      0.294 CM    0.0     0.0
                                                                        0.0      0.497 MR    0.0     0.0     0.569
                                                                        0.0      0.500 CM    0.0     0.0     0.0     0.0
                                                                        0.0      0.600 PC    0.0     0.0     0.0     0.0     0.0

*QUAD*     5.00   0.45730 M  -14.5080 KG   10.150 CM  (   -3.497 M  )
                                                            5.8 M       0.0      0.177 CM
                                                                        0.0      0.477 MR    0.972
                                                                        0.0      0.288 CM    0.0     0.0
                                                                        0.0      0.662 MR    0.0     0.0    -0.778
                                                                        0.0      0.500 CM    0.0     0.0     0.0     0.0
                                                                        0.0      0.600 PC    0.0     0.0     0.0     0.0     0.0

*ALIGN*    8.000000  0.100 CM   0.10 MR   0.100 CM   0.10 MR   0.100 CM   0.10 MR    CD*   100.0
                                                            5.8 M      -0.007    0.177 CM
                                                                       -0.292    0.477 MR    0.972
                                                                        0.006    0.288 CM    0.0     0.0
                                                                        0.268    0.662 MR    0.0     0.0    -0.778
                                                                        0.0      0.500 CM    0.0     0.0     0.0     0.0
                                                                        0.0      0.600 PC    0.0     0.0     0.0     0.0     0.0

*ALIGN*    8.000000  0.100 CM   0.10 MR   0.100 CM   0.10 MR   0.100 CM   0.10 MR    CD*   101.0
                                                            5.8 M       0.007    0.177 CM
                                                                       -0.215    0.477 MR    0.972
                                                                       -0.006    0.288 CM    0.000   0.0
                                                                        0.256    0.662 MR    0.000   0.000  -0.778
                                                                        0.0      0.500 CM    0.0     0.0     0.0     0.0
                                                                        0.0      0.600 PC    0.0     0.0     0.0     0.0     0.0

*ALIGN*    8.000000  0.100 CM   0.10 MR   0.100 CM   0.10 MR   0.100 CM   0.10 MR    CD*   102.0
                                                            5.8 M      -0.013    0.177 CM
                                                                       -0.472    0.477 MR    0.972
                                                                        0.024    0.288 CM    0.0    -0.000
                                                                        0.447    0.662 MR   -0.000  -0.000  -0.778
                                                                        0.0      0.500 CM    0.0     0.0     0.0     0.0
                                                                        0.0      0.600 PC    0.0     0.0     0.0     0.0     0.0

*DRIFT*    3.0      2.1350 M
                                                            7.9 M      -0.114    0.277 CM
                                                                       -0.472    0.477 MR    0.988
                                                                        0.119    0.199 CM   -0.000  -0.000
                                                                        0.447    0.662 MR   -0.000  -0.000  -0.416
```

0.0	0.500 CM	0.0	0.0	0.0	0.0	
0.0	0.600 PC	0.0	0.0	0.0	0.0	0.0

TRANSFORM 1

1.00000	0.21350	0.0	0.0	0.0	0.0
0.0	1.C000C	0.C	0.0	0.0	0.0
C.0	0.0	1.00000	0.21350	0.0	0.0
C.0	0.C	0.0	1.C0000	0.0	0.0
C.0	0.C	0.C	0.0	1.00000	0.0
C.0	0.0	0.0	0.C	0.0	1.00000

LENGTH 7.9286 M

IHC217I FIOCS - END OF DATA SET ON UNIT 5

TRACEBACK FOLLOWS- ROUTINE	ISN	REG. 14	REG. 15	REG. 0	REG. 1
IBCOM		000755FC	0007D0E8	00000001	00065FD4
BKKIN	0013	40066060	00075248	00000000	00065FD4
TITLE	0029	4007BD6A	00065F50	00000000	0007B83C
FITTIN	0046	4007B56A	0007B628	0000000F	0007B414
MAIN		00015C8A	0107B338	FD000008	C00ADFF8

ENTRY POINT= 0107B338

SUMMARY OF ERRORS FOR THIS JOB	ERROR NUMBER	NUMBER OF ERRORS
	217	1

FOREWORD

This report (SLAC-91) represents the completion of an extensive documentation of the first- and second-order theory of Beam Transport Optics and of the associated computer program (TRANSPORT) that has evolved at SLAC over the past several years. This report contains the following:

1) A Users Manual describing how to prepare data sets for a TRANSPORT computation.

2) Specific Examples of simple and complex TRANSPORT computations to illustrate first-order fitting techniques.

3) A set of Flow Charts for the benefit of the beginning user who needs to know what the program does.

4) An Appendix containing the underlying optics theory behind the program that is not adequately covered by other existing references. This also serves to introduce the user to TRANSPORT notation.

In addition to this report, other pertinent documents that may be useful to TRANSPORT users are the following:

5) SLAC-75: A First- and Second-Order Matrix Theory for the Design of Beam Transport Systems and Charged Particle Spectrometers.

6) A Matrix Element Test Deck (obtained from the SLAC program librarian). This has been prepared for the new user and is designed to check all of the first- and second-order matrix elements contained in the TRANSPORT program.

7) A TRANSPORT listing (also obtained from the SLAC program librarian).

For NEW users of TRANSPORT who desire a copy of the program and the appropriate backup documentation, please send your requests to:

Linda Lorenzetti
Program Librarian
SLAC
P.O. Box 4349
Stanford, California 94305

If all you require is the TRANSPORT manual (SLAC Report No. 91) send your requests to:

Reports Distribution Office
SLAC
P.O. Box 4349
Stanford, California 94305

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INTRODUCTION

TRANSPORT/360 is a computer program for the design of static-magnetic beam transport systems.

This report (SLAC-91) supercedes the original TRANSPORT instruction manual issued in October, 1963 by C. H. Moore, S. K. Howry, and H. S. Butler. Since the issuance of the original manual, several important modifications and additions have been made to the TRANSPORT program, among them are:

a) The second-order portion of the program has been extended to include the fringing-fields of bending magnets, second-order curvatures on the entrance and exit faces of bending magnets, and the second-order aberrations of solenoids. All of the second-order portion of the program has been thoroughly de-bugged using appropriate magnetic optical theorems, direct comparisons with hand calculations, and comparisons with results from ray-tracing programs.

b) Fringing-field corrections to the first-order transverse-optics of bending magnets have been added to the program via the Type Code 16. elements.

c) The program has been translated from the original Balgol version to Fortran. (We hereby wish to acknowledge the important contribution made by Stan Kowalski of M.I.T. in effecting this translation).

d) A complete free-field format for data input has been added to the Fortran version thereby considerably simplifying the use of the program.

e) A relativistically-correct first-order matrix for a traveling-wave linear accelerator section has been added to the program via Type Code 11.0.

f) Provision has been made to introduce second-order corrections (curvatures) to the input and output faces of bending magnets via Type Code 16. elements to facilitate correcting for various second-order aberrations.

g) Provision has also been made, via the Type Code 16. elements, to enable the user to rotate to the focal plane of a system and print-out the second-order aberrations along this plane.

For the benefit of the new users of TRANSPORT, we shall now review briefly the mathematical basis of the program. From the outset, it is important to emphasize that TRANSPORT is not a ray tracing program in the usual sense, but rather is based upon a first- and second-order matrix theory of beam transport optics(1,2).

Mathematical Formulation of TRANSPORT(*)

The following of a charged particle through a system of magnetic lenses may be reduced to a process of matrix multiplication. At any specified position in the system an arbitrary charged particle is represented by a vector (single column matrix), X, whose components are the positions, angles, and momentum of the particle with respect to a specified reference trajectory.

$$\text{i. e.} \qquad X = \begin{bmatrix} x \\ \theta \\ y \\ \varphi \\ \ell \\ \delta \end{bmatrix}$$

Definitions:

x = the radial displacement of the arbitrary ray with respect to the assumed central trajectory.

θ = the angle this ray makes in the radial plane with respect to the assumed central trajectory.

y = the transverse displacement of the ray with respect to the assumed central trajectory.

φ = the transverse angle of the ray with respect to the assumed central trajectory.

(*) For a more complete description of the mathematical basis of TRANSPORT, refer to SLAC Report 75, the Appendix of this report and to other References listed at the end of this report.

ℓ = the path length difference between the arbitrary ray and the central trajectory

δ = $\Delta P/P$ is the fractional momentum deviation of the ray from the assumed central trajectory.

The magnetic lens is represented by a square matrix, R, which describes the action of the magnet on the particle coordinates. Thus the passage of a charged particle through the system may be represented by the equation:

$$X[1] = R\,X[0] \tag{1}$$

where $X[0]$ is the initial coordinate vector and $X[1]$ is the final coordinate vector of the particle under consideration; R is the transformation matrix for all such particles traversing the system (one particle differing from another only by its initial coordinate vector $X[0]$).

The traversing of several magnets and interspersing drift spaces is described by the same basic equation but with R now being the product matrix $R = R(n)\ldots R(3)R(2)R(1)$ of the individual matrices of the system elements. The following of a charged particle via TRANSPORT through a system of magnets is thus analogous to tracing rays through a system of optical lenses except that TRANSPORT is a matrix calculation which truncates the problem to either first or second-order in a Taylor's expansion about a central trajectory. For studying beam optics to greater precision than a second-order TRANSPORT calculation permits, ray-tracing programs which directly integrate the basic differential equation of motion are recommended(6).

In accelerator and beam transport systems, the behavior of an individual particle is often of less concern than is the behavior of a bundle of particles (the BEAM) of which an individual particle is a member. An extension of the matrix algebra of equation(1) provides a convenient means for defining and manipulating this BEAM. TRANSPORT assumes that the bundle of rays constituting a BEAM may correctly be represented in coordinate phase-space by an ellipsoid whose coordinates are the position, angle, and momentum coordinates of the arbitrary rays in the beam about an assumed central trajectory. Particles in a BEAM are assumed to lie within the boundaries of the ellipsoid with each point within the ellipsoid representing a possible ray. The sum total of all phase points, the phase space volume, is commonly referred to as the "phase space" occupied by the BEAM. The validity and interpretation of this phase ellipse formalism must be ascertained for each system being designed. However, in general, for charged particle beams in, or emanating, from accelerators, the first-order phase ellipse formalism of TRANSPORT is a reasonable representation of physical reality; but for other applications, such as charged particle spectrometers, caution is in order in its use and interpretation.

The equation of an n-dimensional ellipsoid may be written in matrix form as follows:

$$X[0]^T \sigma[0]^{-1} X[0] = 1 \qquad (2)$$

where $X[0]^T$ is the transpose of the coordinate vector $X[0]$, and $\sigma[0]$ is a real, positive definite, symmetric matrix.

The volume of the n-dimensional ellipsoid defined by sigma is $\frac{\pi^{\frac{n}{2}}}{\Gamma(\frac{n}{2}+1)} (\det \sigma)^{1/2}$, the area of the projection in one plane is $A = \pi (\det \sigma)^{1/2}$. This is the "phase space" occupied by the beam.

As a particle passes through a system of magnets, it undergoes the matrix transformation of equation(1). Combining this transformation with the equation of the initial ellipsoid, and using the identity $RR^{-1} = I$ (the unity matrix), it follows that:

$$X[0]^T (R^T R^{T^{-1}}) \sigma[0]^{-1} (R^{-1} R) X[0] = 1$$

from which:

$$(RX[0])^T (R\sigma[0] R^T)^{-1} (RX[0]) = 1 \qquad (3)$$

The equation of the new ellipsoid after the transformation becomes:

$$X[1]^T \sigma[1]^{-1} X[1] = 1 \qquad (4)$$

where:

$$\sigma[1] = R\sigma[0]R^T \tag{5}$$

It can readily be shown that the square roots of the diagonal terms of the sigma matrix are a measure of the "beam size" and the off-diagonal terms are a measure of the orientation of the ellipsoid in n-dimensional space (for TRANSPORT n = 6).* Thus, we may specify the beam at any point in the system via equation(5), given the initial "phase space" represented by the matrix elements of $\sigma[0]$.

Several types of physical elements have been incorporated in the program to facilitate the design of very general beam transport systems, included are: an arbitrary drift distance, bending magnets, quadrupoles, sextupoles, solenoids, and an accelerator section (to first-order only). Provision is made in the program to vary some of the physical parameters of the elements comprising the system and to impose first-order fitting conditions upon either the TRANSFORM (R) matrix representing the transformation of an arbitrary ray through the system and/or to impose first-order fitting conditions upon the phase ellipse (Sigma) matrix representing the transformation of a bundle of rays through the system. Thus, in principle, the program is capable of searching for and finding the first-order solution to any physically-realizable problem. In practice, life is not quite so

---

* See the appendix of this report for a derivation of these statements.

simple, the user will find that an adequate knowledge of geometric magnetic optics principles is a necessary prerequisite to the successful use of TRANSPORT. In other words, the program is superb at solving the mathematics of the problem but not the physics. The user must provide a reasonable physical input if he expects complete satisfaction from the program. For this reason a brief review of magnetic optics along with a list of pertinent reprints and references and some representative TRANSPORT calculations are given in the appendix of this manual to provide assistance to the inexperienced as well as the experienced user.

A thorough understanding of the first-order matrix algebra of beam transport optics and of the physical interpretation of the various matrix elements is an essential prerequisite to the successful use of this program.

INPUT FORMAT FOR TRANSPORT/360

The input format for TRANSPORT/360 is quite similar to that of the previous versions of the program. The input DATA SET consists of three kinds of cards: the TITLE card, the INDICATOR card, and the DATA cards.

The TITLE card has single quotes punched in any two columns on the card. Any information punched between the quotes will be used as a heading in the output of the TRANSPORT run.

The second card of the input is the INDICATOR card. If the data which follows describes a new problem, a zero(0) is punched in any column on the card. If the data which follows describes changes to be made in the previous problem, a one(1) is punched in any column on the card.

The rest of the cards in a deck contain the DATA describing a beam and the physical elements of the magnetic system. Each data set must be terminated by the word SENTINEL; the word SENTINEL need not be punched on a separate card. The input format of these cards is "free-field" which is described below. Each element uses a type code number which identifies the element; a field which indicates which physical parameters of the element are to be varied if there is to be any fitting; the parameters necessary to describe the physical element, such as length, magnetic field strength, etc. and, optionally, a one-to-four character label (enclosed between single quotes). The type code numbers and their interpretations are summarized in TABLE I. If the type code number is negative, the element will be ignored in the calculation which follows, but may be used in a succeeding calculation.

The vary field is punched immediately to the right of the decimal point of the type code number. The meaning is exactly the same as it was in the 7090 version of the TRANSPORT program. See section under Type Code 10. for an explanation of the use of vary codes.

The data parameters describing the element are punched in the order given in TABLE I, in the same order as has been required for previous versions of TRANSPORT. Each data entry must contain a decimal point unless it is equal to zero.

The label, if present, is enclosed by single quotes. It may contain up to four characters. It will be printed in the output during the calculation and can be useful in problems with many elements and/or when sequential fitting is used. **Labels are essential if the data associated with the element is to be changed in succeeding problems.**

Provision has been made in the program to allow the user to introduce comments before any type code entry in the data deck. This is accomplished by enclosing the comments made on each card with single parentheses.

The data associated with each type-code entry must be followed by a semi-colon. If the program encounters a semi-colon before the expected number of parameters has been read in, the rest of the parameters are set to zero if the indicator card was a zero(0). If the indicator card was a one(1) then the numbers on the card are substituted for the numbers from the previous solution, but the remaining numbers are unchanged.

The "free-field" input format of the data cards make it considerably easier to prepare input than the standard fixed-field formats of

FORTRAN. Numbers may be punched anywhere on the card. They must be separated by one or more blanks. A single number must be all on one card; it may not continue from one card to the next. The program is limited to 500 data number entries and 200 type code entries.

A floating-point number e.g.(2.47) may be represented in any of the following ways:

2.47

.00247+3

.0247E+02

247.E-2

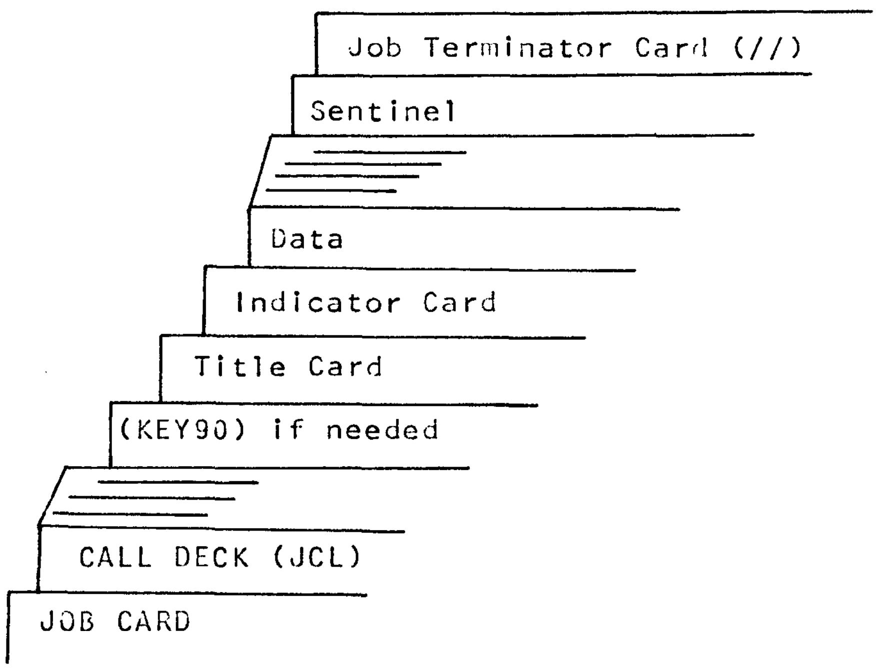
247000.-5

The sample problem input which is included below causes TRANSPORT to do a first order calculation with fitting and then to do a second order calculation with the data that is the result of the fitting. The type ten element which specifies the fitting condition is labeled FIT1. It is active for the first order calculation but is turned off for the second order calculation. The vary codes for elements DR1 are set to zero for the second-order problem. The second order element, SEC1, is ineffective during the fitting, but causes the program to compute the second-order matrices in the second calculation. The word SENTINEL need not be punched on a separate card.

An Example of a TRANSPORT/360 Input Deck

```
'FORTRAN  H CHECK ON BETA FIT'
0
1.  .5  1.  .5  1.  .5  1.  1.  ;
-17. 'SEC1'  ;
3.3  2.745  'DR1'  ;
2.  0.  ;  4.  9.879  10.  .5  ;  2.  0.  ;
3.3  2.745  'DR1'  ;
13.  4.  ;
10.  -1.  1.  0.  .0001  'FIT1'  ;
SENTINEL
'SECOND ORDER'
1
17.  'SEC1'  ;
3.0 'DR1'  ;
-10.  'FIT1'  ;
SENTINEL
```

The figure below shows the 360 TRANSPORT deck setup. If the data are punched on an 026 keypunch instead of an 029 keypunch, one should precede the title card with a card on which the characters KEY90 are punched in any column. No imbedded blanks are allowed in this control statement.



Note that as many problems as one wishes may be stacked in one job.

TABLE I

PHYSICAL ELEMENT	TYPE CODE	2nd ENTRY	3rd ENTRY	4th ENTRY	5th ENTRY	6th ENTRY	7th ENTRY	8th ENTRY	9th ENTRY
BEAM	1.vvvvvv0	x (cm)	θ (mr)	y (cm)	φ (mr)	ℓ (cm)	δ (percent)	P_o	
R.M.S. ADDITION TO BEAM ENVELOPE	1.	Δx (cm)	$\Delta\theta$ (mr)	Δy (cm)	$\Delta\varphi$ (mr)	$\Delta\ell$ (cm)	$\Delta\delta$ (percent)	ΔP_o (GeV/c)	0
POLE FACE ROTATION	2.v	ANGLE OF ROTATION Degrees)							
DRIFT	3.v	LENGTH (meters)							
BENDING MAGNET	4.0vv	LENGTH(meters)	FIELD (kg)	FIELD GRADIENT (n-value)					
QUADRUPOLE	5.vv0	LENGTH(meters)	FIELD (kg)	HALF-APERTURE (cm)					
TRANSFORM 1 UPDATE	6.	0.	1.						
TRANSFORM 2 UPDATE	6.	0.	2.						
BEAM CENTROID SHIFT	7.	SHIFT(x)(cm)	SHIFT(θ)(mr)	SHIFT(y)(cm)	SHIFT(φ)(mr)	SHIFT(ℓ)(cm)	SHIFT(δ)(percent)		
ALIGNMENT TOLERANCE	8.vvvvvv0	DISPLACEMENT(x)cm	ROTATION(θ)mr	DISPLACEMENT(y)cm	ROTATION(φ)mr	DISPLACEMENT(ℓ)cm	ROTATION(α)mr	CODE NUMBER	
REPEAT CONTROL	9.	NUMBER OF REPEATS							
FITTING CONSTRAINTS	10.	$\pm$ I	J	DESIRED VALUE OF (I,J) MATRIX ELEMENTS	ACCURACY OF FIT				
Note: + I is used for fitting a beam (σ) matrix element. - I is used for fitting an R1 matrix element. - (I + 20) is used for fitting an R2 matrix element.									
ACCELERATOR	11.	LENGTH(meters)	E(energy gain) (GeV)	φ (phase lag) (Degrees)	(WAVELENGTH)(cm)				
BEAM (Rotated Ellipse)	12.	THE FIFTEEN CORRELATIONS AMONG THE SIX ELEMENTS (This entry must be preceded by a Type Code 1. entry).							
INPUT/OUTPUT OPTIONS	13.	CONTROL CODE NUMBER							
ARBITRARY R MATRIX	14.vvvvvv0	R(J,1)	R(J,2)	R(J,3)	R(J,4)	R(J,5)	R(J,6)	J	
UNITS CONTROL (Transport Dimensions)	15.	CODE	LABEL	SCALE FACTOR (if required)					
QUADRATIC TERM OF BENDING FIELD	16.	1.	$\epsilon(1) = \beta\left(\frac{x}{\rho}\right)^2$ (dimensionless) x = 1						
MASS OF PARTICLES IN BEAM	16.	3.	M/m (dimensionless)						
HALF-APERTURE OF BENDING MAG. in x PLANE	16.	4.	w/2 (cm)						
HALF-APERTURE OF BENDING MAG. in y PLANE (gap)	16.	5.	g/2 (cm)						
LENGTH OF SYSTEM	16.	6.	L. (meters)						
FRINGE FIELD CORR-ECTION COEFFICIENT	16.	7.	K1 (dimensionless)						
FRINGE FIELD CORR-ECTION COEFFICIENT	16.	8.	K2 (dimensionless)						
CURVATURE OF ENTRANCE FACE OF BENDING MAGNET	16.	12.	(1/R1) (1/meters)						
CURVATURE OF EXIT FACE OF BENDING MAGNET	16.	13.	(1/R2) (1/meters)						
FOCAL PLANE ROTATION	16.	15.	angle of focal plane rotation (Degrees) See section 16 for details.						
SECOND ORDER CALCULATIONS	17.								
SEXTUPOLE	18.	LENGTH(meters)	FIELD (kg)	HALF-APERTURE (cm)					
SOLENOID	19.vv	LENGTH(meters)	FIELD (kg)						
BEAM ROTATION	20.v	ANGLE OF ROTATION(Degrees)							
STRAY FIELD	21.	See later section of report.							

Note: The v's following the type codes indicate the parameters which may be varied. See section under type code 10.0 for a detailed explanation of Vary Codes. The units are standard TRANSPORT units (as shown) unless changed via type code 15.0 entries.

For Stanford TRANSPORT Users:

TRANSPORT is stored on disc in the program libraries of both the SLAC 360/91 and the Stanford Campus 360/67 computers. The call decks for these cases are listed below:

For batch or CRBE runs on the 360/91, use the following JCL if you wish the output to be printed on the line printers:

```
//jobname  JØB   userid,bin#,CLASS=E¹
//JØBLIB DD DSNAME=SYS1.USERLIB,DISP=SHR
//STEP1 EXEC PGM=TRANS
//FT04F001 DD SYSØUT=B
//FT06F001 DD SYSØUT=A
//FT05F001 DD *
```

If you wish the output to be returned to the terminal for a CRBE run change SYSØUT=A to SYSØUT=R on line 5 of JCL.

If you desire to use the Campus 360/67 for either a Batch or Wylbur run, the JCL is as follows:

```
//jobname   JØB   (acct#,bin#,1.0,05,001,,1,,X),'your name',MSGLEVEL=1
//JØBLIB  DD  DSNAME=SYS2.PRØGLIB,DISP=(ØLD,PASS)
//STEP1  EXEC PGM=TRNSPØRT
//FT06F001 DD SYSØUT=A
//FT04F001 DD UNIT=SYSCP,DCB=(RECFM=F,BLKSIZE=80)
//FT05F001 DD *
```

The job terminator card for the 360/67 has a /* in columns 1,2.

---

1) ,TIME=(m,ss) should be included if your run will take over 30 seconds of CPU time. This will rarely be necessary, even if a large number of problems are included in the run. This JCL is valid for MVT, Release 18, HASP.

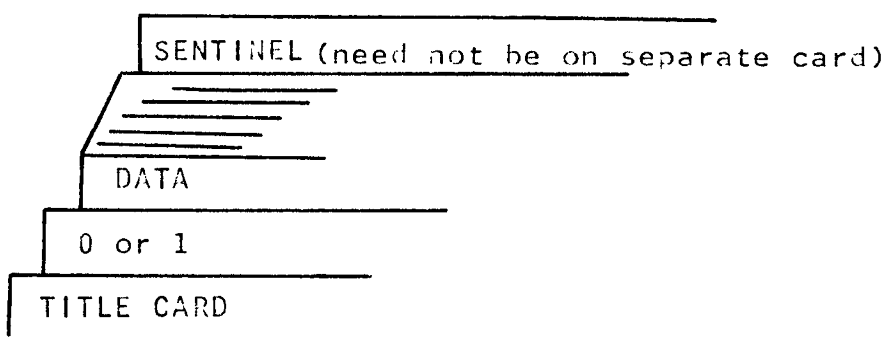
TITLE CARD

The title card is the first card in every TRANSPORT data set. The Title Card is always required and must be followed by a 0 or 1 card (see next section) to indicate whether the data to follow is new (0 card) or a continuation of a previous data set (1 card).

The title must be enclosed within single quotation marks on a single card. For TRANSPORT/360, the quotes may be entered in any column (Free field format).

Example of a DATA SET:

1st card	'SLAC 20/GeV/c SPECTROMETER'
2nd card	0
	data
Last card	SENTINEL



INDICATOR CARD (0 or 1)

The second card of the input is the indicator card. If the data which follow describe a new problem, a zero(0) is punched in any column on the card. If the data which follow describe changes to be made in the previous problem, a one(1) is punched in any column on the card. No other entries are allowed on this card.

The sample problem input which is included below causes TRANSPORT to do a first order calculation with fitting (0 indicator card) and then to do a second order calculation (1 indicator card) with the data that is the result of the fitting.

```
'FORTRAN H CHECK ON BETA FIT'
0  (Indicator Card)
1.  .5  1.  .5  1.  .5  1.  1.  ;
-17.  'SEC1'  ;
3.3  2.745  'DR1'  ;
2.  0.  ;  4.  9.879  10.  .5  ;  2.  0.  ;
3.3  2.745  'DR1'  ;
13.  4.  ;
10.  -1.  2.  0.  .0001  'FIT1'  ;
SENTINEL
'SECOND ORDER'
1  (Indicator Card)
17.  'SEC1'  ;
3.0 'DR1'  ;
-10.  'FIT1'  ;
SENTINEL
```

COMMENT CARDS

Comment cards may be introduced in the data deck before any type code entry by inclosing the comments made on each card by single parentheses. No parentheses or quotation marks are allowed within the parentheses of any comment card.

Example of the use of comment cards in a data set:

```
'Title Card'
0
(THIS IS A TEST PROBLEM TO ILLUSTRATE THE)
(USE OF COMMENT CARDS)
data
(COMMENTS MAY ALSO BE MADE BETWEEN)
(TYPE CODE ENTRIES OF THE DATA SET)
data
SENTINEL
```

INPUT BEAM Type Code 1.0

This element specifies the phase space and the average momentum of the input beam for a TRANSPORT calculation. The input is specified by the semi-axes of a 6-dimensional erect* beam ellipsoid representing the phase space variables $x, \theta, y, \varphi, \ell,$ and δ. Each of these six parameters is entered as a positive quantity, but should be thought of as $\pm x$, $\pm\theta$, etc; hence, the total beam width is $2x$, the total horizontal beam divergence is 2θ and so forth.

Normally, the BEAM card is the third card in the deck if standard TRANSPORT units are to be used; otherwise it should immediately follow any special units cards (Type Code 15.) chosen for the calculation to be made. Standard TRANSPORT units for $x, \theta, y, \varphi, \ell,$ and δ are cms, mr, cms, mr, cms, and percent. The standard unit for the momentum P(0) is GeV/c.

There are eight entries (all positive) to be made on the BEAM card.

1- The Type Code 1.0 (Specifies a BEAM entry follows)

2- One-half the horizontal beam extent (x) (cms in standard units)

3- One-half " " " divergence (θ) (mr).

4- One-half the vertical beam extent (y) (cms).

5- One-half " " " divergence (φ) (mr).

6- One-half the longitudinal beam extent (ℓ) (cms).

7- One-half the momentum spread (δ) (in units of percent $\Delta P/P$)

8- The momentum of the Central Trajectory (P(0)) (GeV/c).

---

*For a rotated (non-erect) phase ellipsoid input, see Type Code 12.

All eight entries must be made even if they are zero(0) and the last entry must be followed by a semicolon. Thus a typical BEAM entry might be.

1.0 0.5 2.0 1.3 2.5 0. 1.5 10.0 ;

meaning, $x = \pm 0.5$ cms, $\theta = \pm 2.0$ mr, $y = \pm 1.3$ cms, $\varphi = \pm 2.5$ mr, $\ell = \pm 0.0$ cms, $\delta = \pm 1.5$ percent $\Delta P/P$, and the central momentum $P(0) = 10.0$ GeV/c.

The units of the tabulated matrix elements in either the 1st order R or sigma matrix or second order T matrix of a TRANSPORT printout will correspond to the units chosen for the BEAM card. For the above example, the $R(12) = (x/\theta)$ matrix element will have the dimensions of cms/mr; and the $T(236) = (\theta/y\delta)$ matrix element will have the dimensions mr per cm per percent $\Delta P/P$ and so forth.

The longitudinal extent ℓ is useful for pulsed beams. It indicates the spread in length of particles in a pulse. It does not interact with any other component and may be set to zero if the pulse length is not important.

The phase ellipse (sigma matrix) beam parameters are normally printed as output after each data entry unless suppressed by a (13. 2. ;) type code entry. The projection of the semi-axes of the ellipsoid upon each of its six coordinate axes is printed in a vertical array and the correlations among these components indicating the phase ellipse orientations are printed in a triangular array (see the following pages).

THE PHASE ELLIPSE BEAM MATRIX

The beam matrix carried in the computer has the following construction:

	x	θ	y	φ	ℓ	δ
x	$\sigma(11)$					
θ	$\sigma(21)$	$\sigma(22)$				
y	$\sigma(31)$	$\sigma(32)$	$\sigma(33)$			
φ	$\sigma(41)$	$\sigma(42)$	$\sigma(43)$	$\sigma(44)$		
ℓ	$\sigma(51)$	$\sigma(52)$	$\sigma(53)$	$\sigma(54)$	$\sigma(55)$	
δ	$\sigma(61)$	$\sigma(62)$	$\sigma(63)$	$\sigma(64)$	$\sigma(65)$	$\sigma(66)$

The matrix is symmetric so that only a triangle of elements is needed.

In the printed output this matrix has a somewhat different format for ease of interpretation:

			x	θ	y	φ	ℓ
x	$\sqrt{\sigma}(11)$	CM					
θ	$\sqrt{\sigma}(22)$	MR	r(21)				
y	$\sqrt{\sigma}(33)$	CM	r(31)	r(32)			
φ	$\sqrt{\sigma}(44)$	MR	r(41)	r(42)	r(43)		
ℓ	$\sqrt{\sigma}(55)$	CM	r(51)	r(52)	r(53)	r(54)	
δ	$\sqrt{\sigma}(66)$	PC	r(61)	r(62)	r(63)	r(64)	r(65)

where: $r(ij) = \dfrac{\sigma(ij)}{\left[\sigma(ii)\ \sigma(jj)\right]^{1/2}}$

As a result of the fact that the σ matrix is positive definite, the r(ij)'s satisfy the relation

$$|r(ij)| \leqslant 1$$

The full significance of the σ(ij)'s and the r(ij)'s are discussed in detail in Appendix I ("Description of Beam Matrix"). The units are always printed with the matrix.

In brief, the meaning of the $\sqrt{\sigma}$(ii)'s is as follows:

$\sqrt{\sigma}(11) = x_{max}$ = The maximum (half)-width of the beam envelope in the x(bend) plane at the point of the printout.

$\sqrt{\sigma}(22) = \theta_{max}$ = The maximum (half)-angular divergence of the beam envelope in the x(bend) plane.

$\sqrt{\sigma}(33) = y_{max}$ = The maximum (half)-height of the beam envelope.

$\sqrt{\sigma}(44) = \varphi_{max}$ = The maximum (half)-angular divergence of the beam envelope in the y(non-bend)-plane.

$\sqrt{\sigma}(55) = \ell_{max}$ = 1/2 the longitudinal extent of the bunch of particles.

$\sqrt{\sigma}(66) = \delta$ = The half-width 1/2 (ΔP/P) of the momentum interval being transmitted by the system.

The units appearing next to the $\sqrt{\sigma}$(ii)'s in the TRANSPORT printout sheet are the units chosen for coordinates x, θ, y, φ, ℓ and $\delta = \Delta P/P$ respectively.

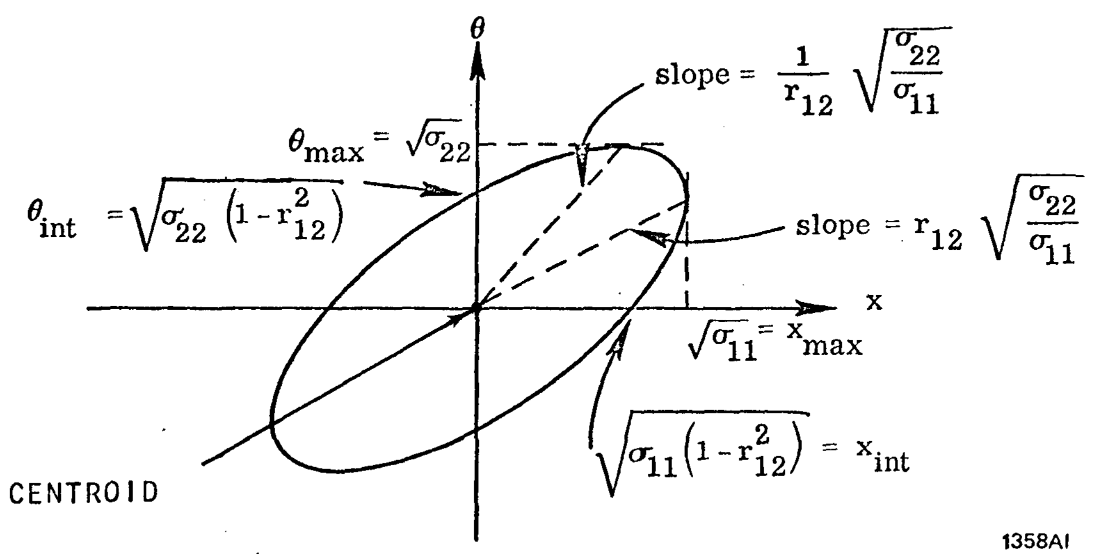
To the immediate left of the listing of the beam envelope size in a TRANSPORT printout, there appears a column of numbers whose values will normally be zero. These numbers are the coordinates of the centroid of the beam phase ellipse (with respect to the initially assumed central trajectory of the system). They may become non-zero under one of three circumstances:

1) When the misalignment (Type Code 8.) is used.

2) When a Beam Centroid shift (Type Code 7.) is used.

or 3) When a 2nd-order calculation (Type Code 17.) is used.

To aid in the interpretation of the phase ellipse parameters listed above, an example of an (x,θ) plane ellipse is illustrated below. For further details the reader should refer to the appendix of this report.



A Two Dimensional BEAM Phase Ellipse

The area of the ellipse is given by:

$$A = \pi(\det \sigma)^{1/2} = \pi X_{max}\,\theta_{int} = \pi X_{int}\,\theta_{max}$$

rms ADDITION TO THE BEAM   Type Code 1.0

To allow for physical phenomena such as multiple-scattering, provision has been made in the program to permit an rms addition to the beam envelop to be made. There are nine entries to be included:

1 - Type Code 1.0 (specifying a BEAM entry follows)

2 - one-half the rms addition to the horizontal beam extent (Δx)(cms).

3 - one-half the rms addition to the horizontal beam divergence ($\Delta\theta$)(mr).

4 - one-half the rms addition to the vertical beam extent (Δy)(cms).

5 - one-half the rms addition to the vertical beam divergence ($\Delta\varphi$)(mr).

6 - one-half the rms longitudinal beam extent ($\Delta\ell$)(cms).

7 - one-half the rms momentum spread ($\Delta\delta$) (in percent $\Delta P/P$).

8 - the momentum change in the central trajectory ($\Delta P(0)$) in (GeV/c).

9 - the code digit 0. indicating an rms addition to to the beam is being made.

The units for the r.m.s. addition are the same as those selected for a regular beam Type Code 1.0 entry. Thus a typical r.m.s. addition to the beam would appear as follows:

1.0 0.1 0.2 0.15 0.3 0. 0.13 -0.1 0.0 ;

where the last entry (0.0) preceding the semicolon signifies an r.m.s. addition to the beam is being made and the next to the last entry indicates a central momentum change of -0.1 GeV/c.

FRINGING FIELDS and POLE-FACE ROTATIONS Type Code 2.0

To provide for fringing fields and/or pole-face rotations on bending magnets, the Type Code 2.0 element is used.

There are two parameters:

1 - Type Code 2.

2 - angle of pole-face rotation (degrees).

The Type Code 2. element must either immediately precede a bending magnet (Type Code 4.) element (in which case it indicates an entrance fringing field and pole-face rotation) or immediately follow a Type Code 4. element (exit fringing field and pole-face rotation) with no other data entries between.* A positive sign of the angle on either entrance or exit pole-faces corresponds to a transverse focusing action and radial defocusing action.

For example, a symmetrically oriented rectangular bending magnet whose total bend is 10 degrees would be represented by the three entries: 2. 5. ; 4. --- ; 2. 5. ;

The angle of rotation may be varied. For example, the element 2.1 5. ; would allow the angle to vary from an initial guess of 5 degrees to a final value which would, say, satisfy a vertical focus constraint imposed upon the system. See the Type Code 10. section for a complete discussion of vary codes.

Even if the pole-face rotation angle is zero, 2. 0. ; entries must be included in the data set before and after a Type Code 4.0 entry if fringing-field effects are to be calculated.

---

* It is extremely important that no data entries be made between a Type Code 2. and a Type Code 4. entry. If this occurs, it may result in an incorrect matrix multiplication in the program and hence an incorrect physical answer.

A single Type Code 2. entry that follows one bending magnet and precedes another will be associated with the latter.

Should it be desired to misalign such a magnet, an update must be forced prior to the first type 2. code entry and the convention appropriate to misalignment of a set of elements applied, since, indeed, three separate transformations are involved. See section under Type Code 8. for a discussion of misalignment calculations.

The type code signifying a rotated pole-face is 2.0. The input format is:

```
              ┌──────── Label (if desired)
              ↓
2.0 β. 'RO'  ;
```

The units for β are degrees.

POLE-FACE ROTATION MATRIX

The first-order R matrix for a pole-face rotation used in a TRANSPORT calculation is as follows:

$$R = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ \frac{\tan\beta}{\rho} & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & -\frac{\tan(\beta-\psi)}{\rho} & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

Definitions: β = angle of rotation of pole-face (see figure on following page for sign convention of β)

ρ = bending radius of central trajectory

g = total gap of magnet

ψ = correction term resulting from finite extent of fringing fields.**

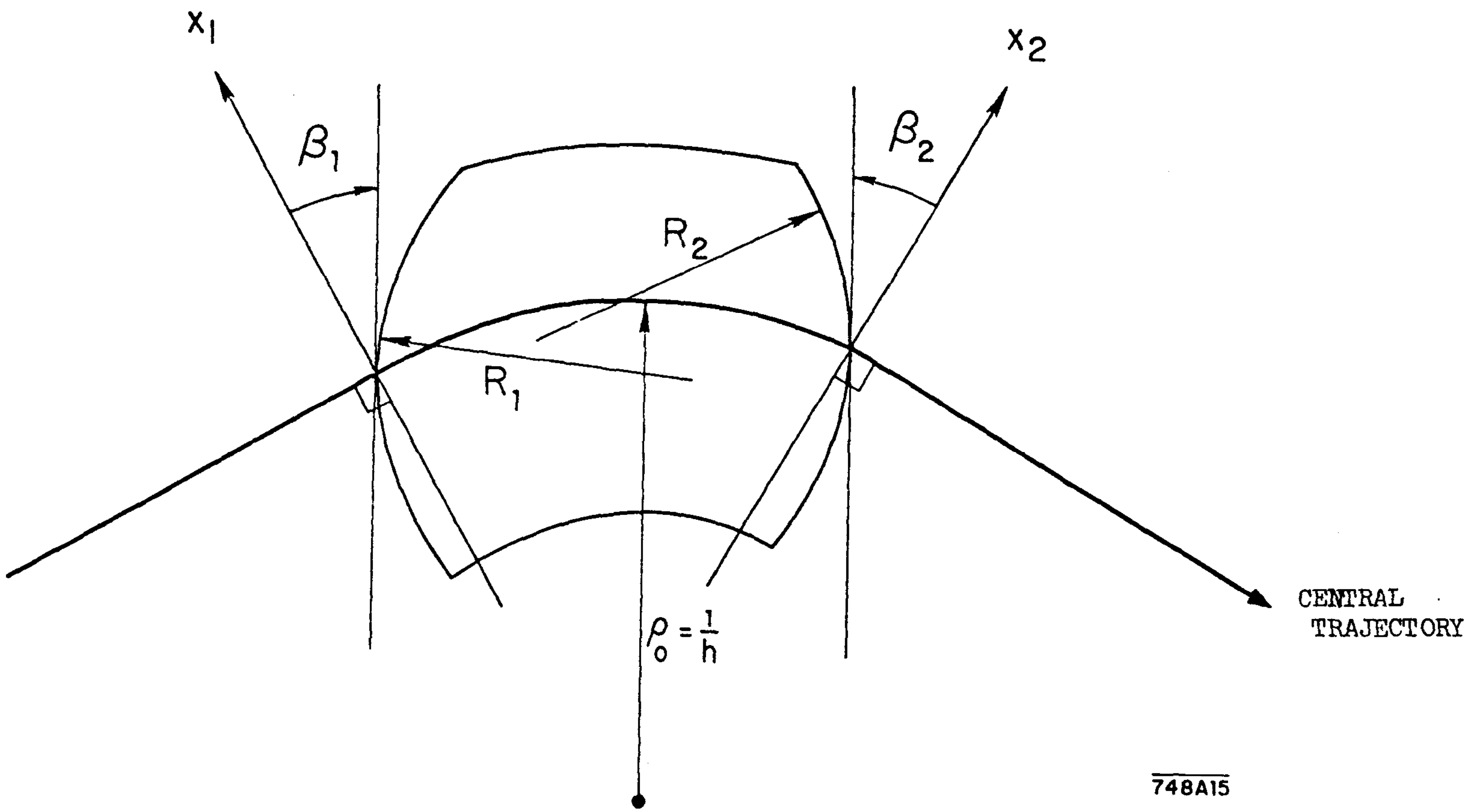
where

$$\psi = K_1 \left(\frac{g}{\rho}\right)\left(\frac{1 + \sin^2\beta}{\cos\beta}\right) \left[1 - K_1 K_2 \left(\frac{g}{\rho}\right) \tan\beta\right]^*$$

---

*See Type Code 16. for input formats for g, K(1), and K(2) TRANSPORT entries.

** See SLAC-Report No. 75 (page 74) for a discussion of ψ.



FIELD BOUNDARIES FOR BENDING MAGNETS

The TRANSPORT sign conventions for x, β, R and h are all positive as shown in the figure. The positive y direction is out of the paper. Positive β's imply transverse focusing. Positive R's (convex curvatures) represent negative sextupole components of strength $S = (-\frac{h}{2R}) \sec^3 \beta$. (See SLAC-75, page 71).

DRIFT Type Code 3.0

A drift space is a field-free region through which the beam passes. There are two parameters:

1 - Type Code 3. (specifying a drift length).

2 - (effective) drift length (meters).

Typical Input Format for a DRIFT

```
                 ┌──────── Label (if desired) (not to
                 │         exceed 4 spaces between
                 ↓         quotes)
3.0 6.0 'D1'  ;
```

DRIFT SPACE MATRIX

The first-order R matrix for a DRIFT space is as follows:

$$\begin{pmatrix} 1 & L & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & L & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

where

L = the length of the drift space.

The dimensions of L. are those chosen for longitudinal length via a

units symbol

scale factor (if needed)

15. 8. ' ' ; type code entry (if used) preceding the BEAM (Type Code 1.) card. If no 15. 8. entry is made, the units of L. will automatically be in METERS (Standard TRANSPORT/360 units).

WEDGE BENDING MAGNET Type Code 4.0

A wedge bending magnet implies that the central trajectory of the beam enters and exits perpendicularly to the pole-face boundaries (to include fringing-field effects and non-perpendicular entrance or exit boundaries--see Type Codes 2.0 and 16.0).

There are four first-order parameters to be specified for the wedge magnet via Type Code 4.0**

1 - Type Code 4.0 (specifying a wedge bending magnet)

2 - The (effective) length L of the central trajectory. (meters)

3 - The central field strength B(0) in KG,

$B(0) = 33.356\ (P/\rho)$

where P is the momentum in GeV/c and ρ is the bending radius of the central trajectory in meters.

4 - The field gradient (n-value) dimensionless; where n is defined by the equation $B_y(x,0,t) = B_y(0,\ 0,\ t)[1-nhx+\ \ldots]$,

where

$h = \frac{1}{\rho_o}$. See SLAC-75 (page 31).

B(0), and n may be varied for 1st order fitting (see section 10.0 for a discussion of vary codes).

A typical first-order TRANSPORT/360 input for a wedge magnet is:

```
              ┌──────Label (not to exceed 4 spaces)
              ↓
4.0 L. B. n. '    ' ;
```

** See Type Code 16. for special parameter entries affecting fringing field and/or second-order calculations for bending magnets.

If fringing field effects are to be included, a Type Code 2. entry must precede and follow the pertinent Type Code 4. entry (even if there are no pole-face rotations.)** Thus a typical TRANSPORT/360 input for a bending magnet including fringing fields might be:

```
              ┌──────── Labels (not to exceed 4 spaces) if desired
              ↓
2. 0. '  ' ;
4. L. B(0). n. '  ' ;
2. 0. '  ' ;
```

For non-zero pole-face rotations a typical data input might be:

```
2.  10.  ;  4.  L.  B(0).  n.  ;  2.  20.  ;
```

note that the use of labels is optional and that all data entries may be made on one line if desired.

The sign conventions for bending magnet entries are illustrated in the following figure (748A15). For TRANSPORT/360, a positive bend is to the right looking in the direction of particle travel. To represent a bend in another sense, the coordinate rotation matrix (Type Code 20.) should be used as follows:

A bend up is represented by rotating the (x, y) coordinates by - 90.0 degrees about the (z) beam axis as follows:

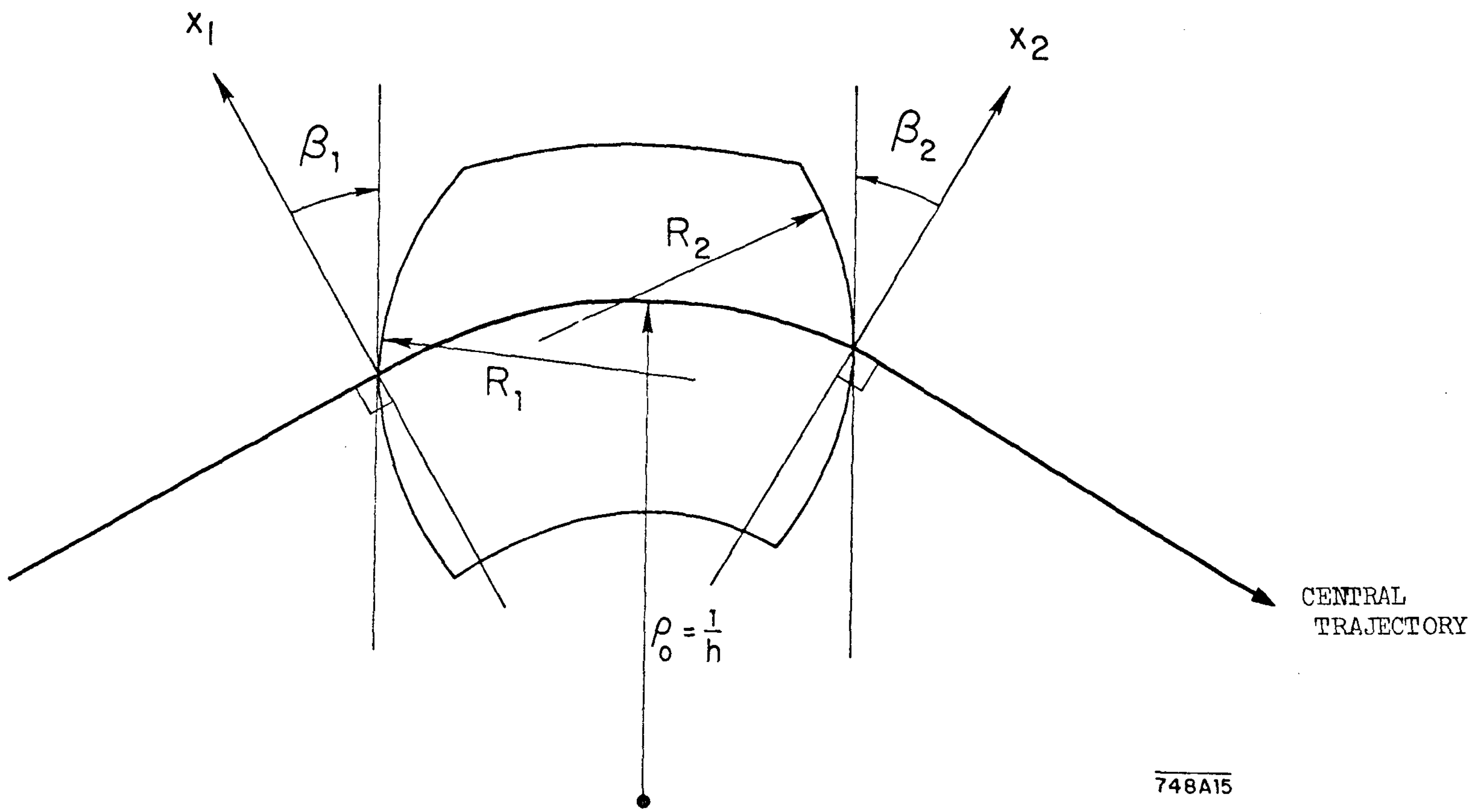
```
               ┌──────Labels (not to exceed 4 spaces) if desired
               ↓
20.  -90.  '  '  ;
2.0  β(1).  '  '  ;
4.0  L.  B.  n.  '  '  ;
2.0  β(2).  '  '  ;
20.  +90.  '  '  ;  (returns coordinates to their initial
                      orientation)
```

A bend down is accomplished via:

```
20.  +90.  '  '  ;
2.
4.
2.
20.  -90.  '  '  ;
```

A bend to the left (looking in the direction of beam travel) is accomplished by rotating the x, y coordinates by 180 degrees, e.g.

```
20.  180.  '  '  ;
2.
4.
2.
20.  -180  '  '  ;
```



FIELD BOUNDARIES FOR BENDING MAGNETS

The TRANSPORT sign conventions for x, β, R and h are all positive as shown in the figure. The positive y direction is out of the paper. Positive β's imply transverse focusing. Positive R's (convex curvatures) represent negative sextupole components of strength $S = (-\frac{h}{2R})\sec^3\beta$. (See SLAC-75, page 71).

1st ORDER
WEDGE BENDING MAGNET MATRIX

$$
\begin{bmatrix}
\cos k_x L & \frac{1}{k_x}\sin k_x L & 0 & 0 & 0 & \frac{h}{k_x^2}[1-\cos k_x L] \\
-k_x \sin k_x L & \cos k_x L & 0 & 0 & 0 & (\frac{h}{k_x})\sin k_x L \\
0 & 0 & \cos k_y L & \frac{1}{k_y}\sin k_y L & 0 & 0 \\
0 & 0 & -k_y \sin k_y L & \cos k_y L & 0 & 0 \\
-\frac{h}{k_x}\sin k_x L & -\frac{h}{k_x^2}[1-\cos k_x L] & 0 & 0 & 1 & -\frac{h^2}{k_x^3}[k_x L-\sin k_x L] \\
0 & 0 & 0 & 0 & 0 & 1
\end{bmatrix}
$$

Definitions: $h = \frac{1}{\rho_o}$, $k_x^2 = (1-n)h^2$, $k_y^2 = nh^2$

$\alpha = hL$ = The angle of bend

L = path length of the central trajectory

The field expansion for the midplane of a bending magnet is taken from eq(18) page 31 of SLAC-75 thereby defining the dimensionless quantities n and β as follows:

$$B_y(x,o,t) = B_y(o,o,t)\ [1-nhx + \beta h^2x^2 + \gamma h^3x^3 + \ldots] \qquad (18)$$

The type code signifying a BEND is 4.0. The input format for a TRANSPORT/360 calculation is:

Label (not to exceed 4 spaces)

4.0 L. B. n. ' ' ;

If n is not included in the data entry, the program assumes it to be zero. A β entry for a second order calculation is made via the 16. 1. element. (Do Not confuse this β with a pole-face rotation)

The standard units for L. and B. are Meters and KG. If desired, these units may be changed by 15. 8. and 15. 9. type code entries preceding the BEAM Card.

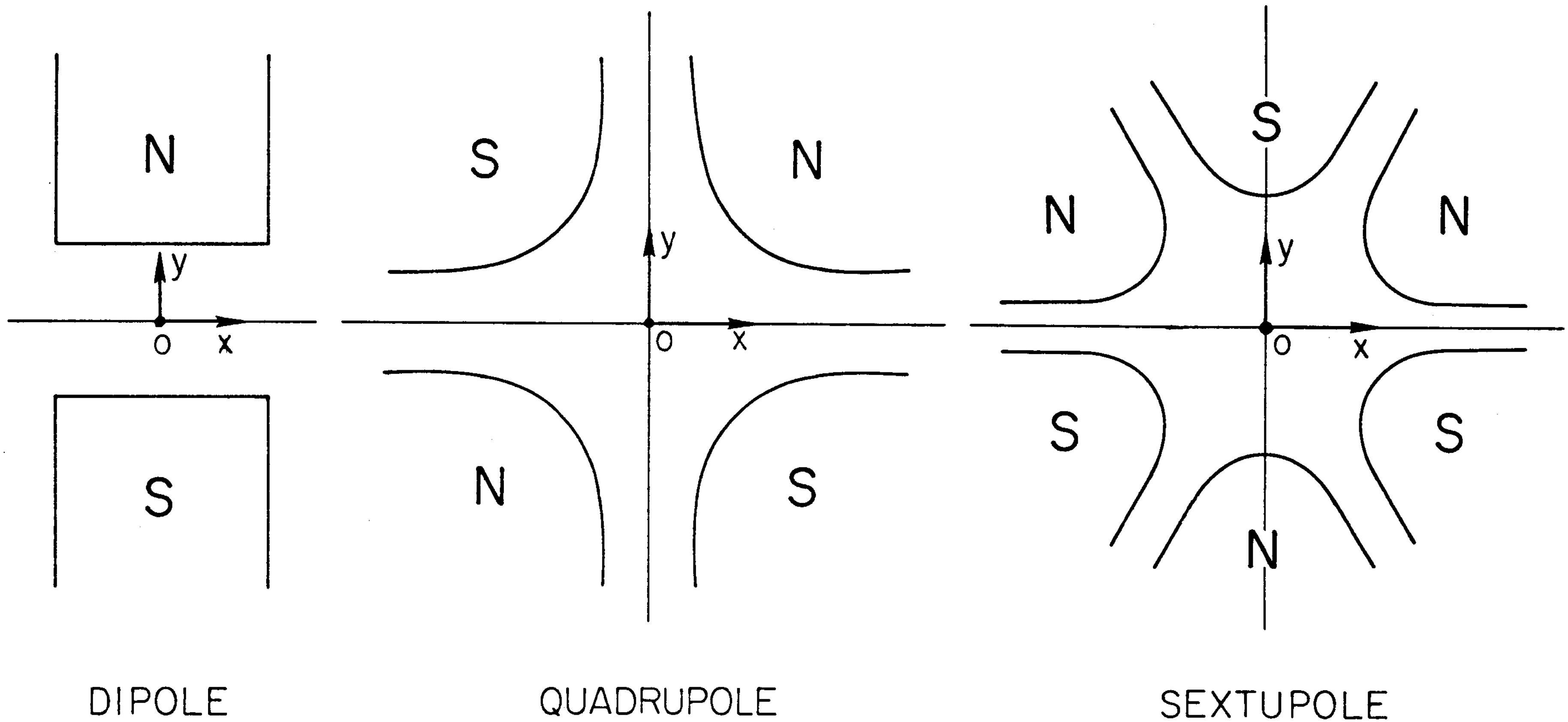


ILLUSTRATION OF THE MAGNETIC MIDPLANE (x AXIS) FOR DIPOLE, QUADRUPOLE AND SEXTUPOLE ELEMENTS. THE MAGNET POLARITIES INDICATE MULTIPOLE ELEMENTS THAT ARE POSITIVE WITH RESPECT TO EACH OTHER.

QUADRUPOLE   Type Code 5.0

A quadrupole provides focusing in one transverse plane and defocusing in the other.

There are four parameters to be specified for a TRANSPORT calculation:

1 - Type Code 5. (specifying a quadrupole).

2 - (effective) magnet length L (in meters).

3 - Field at pole tip B (in KG). A positive field implies horizontal focusing; a negative field, vertical focusing.

4 - Half-aperture a (in cm). Radius of the circle tangent to the pole tips.

The strength of the quadrupole is computed from its field, aperture and length. The horizontal focal length is printed as output; a positive focal length indicates horizontal focusing and a negative focal length indicates horizontal defocusing.

The type code for a QUAD is 5.0. The input format for a typical data set is:

```
                 ┌──────── Label (if desired) not to exceed 4 spaces
                 │                   between quotes
                 ↓
5.0 L. B. a. '     ' ;
```

The data may be entered in FREE FIELD format. The standard TRANSPORT/360 units for L. B. and a. are Meters, KG, and cms respectively. If other units are desired they must be chosen via the appropriate 15. type code entries preceding the BEAM (Type Code 1.) card.

1st ORDER
QUADRUPOLE MATRIX

$$\begin{bmatrix} \cos k_q L & \frac{1}{k_q} \sin k_q L & 0 & 0 & 0 & 0 \\ -k_q \sin k_q L & \cos k_q L & 0 & 0 & 0 & 0 \\ 0 & 0 & \cosh k_q L & \frac{1}{k_q} \sinh k_q L & 0 & 0 \\ 0 & 0 & k_q \sinh k_q L & \cosh k_q L & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

These elements are for a quadrupole which focuses in the horizontal (x) plane (B positive). A vertically (y plane) focusing quadrupole (B negative) has the two partial matrices interchanged.

Definitions: L = the effective length of the quadrupole

a = the radius of the aperture

B_o = the field at radius a

$$k_q^2 = \left(\frac{B_o}{a}\right)\left(\frac{1}{B\rho}\right)$$

where $(B\rho)$ = the magnetic rigidity (momentum) of the central trajectory.

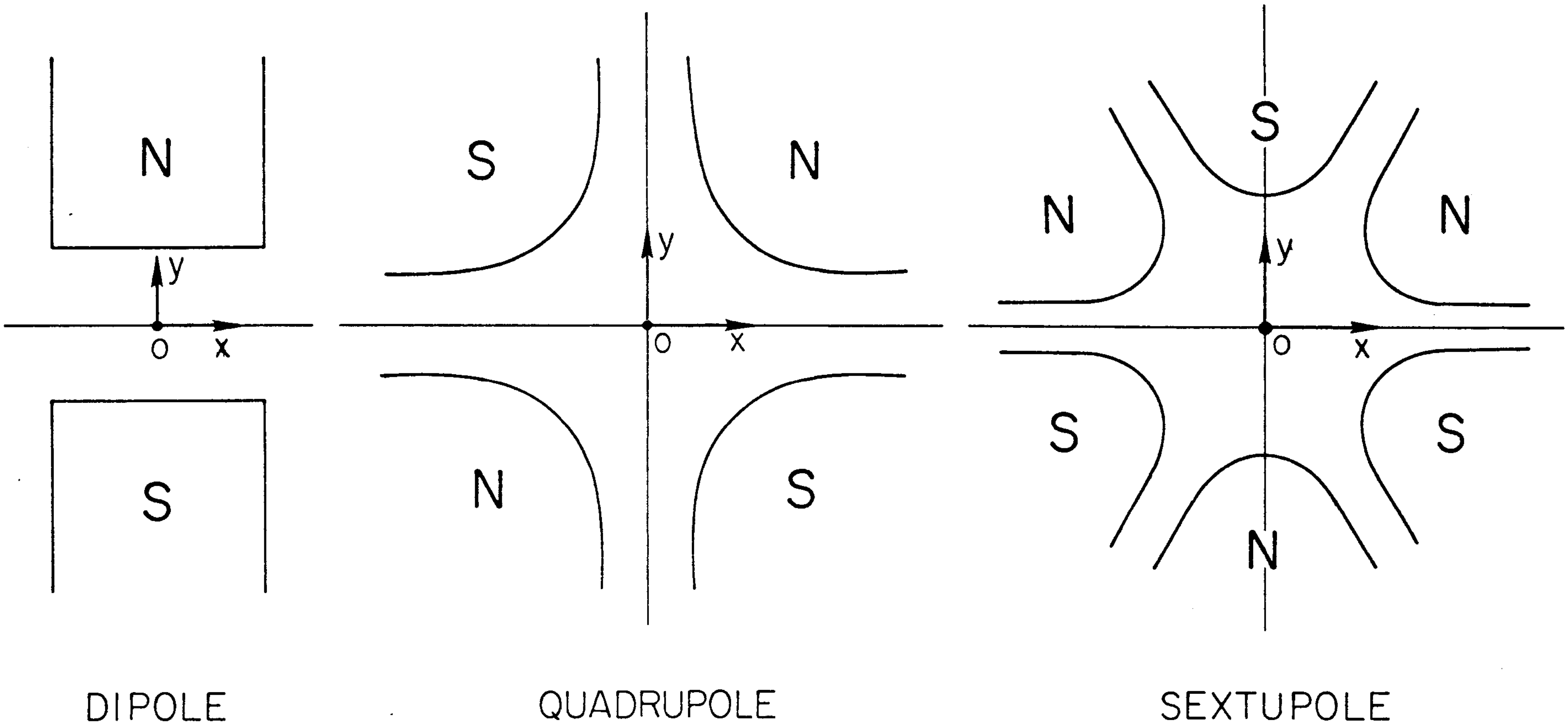


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ILLUSTRATION OF THE MAGNETIC MIDPLANE (x AXIS) FOR DIPOLE, QUADRUPOLE AND SEXTUPOLE ELEMENTS. THE MAGNET POLARITIES INDICATE MULTIPOLE ELEMENTS THAT ARE POSITIVE WITH RESPECT TO EACH OTHER.

TRANSFORM 1 UPDATE* Type Code 6. 0. 1.

To provide a facility for updating TRANSFORM 1 (the product of the R matrices, R1) use Type Code 6.0. Thus a (6. 0. 1. ;) forces an update of the R1 matrix and initiates the accumulation of a new product matrix initialized from the point of the update. This facility is useful in conjunction with misaligning a set of magnets or fitting only a portion of a system.

The complete list of elements which update TRANSFORM 1 is:

1) The (6. 0. 1. ;) entry
2) Any fitting constraint imposed upon the beam (sigma) matrix (See Type Code 10. for a discussion of this)
3) A misalignment Type Code 8.0 entry
4) A beam Type Code 1.0 entry

A TRANSFORM 1 matrix will be printed at any position in the data set where a (13. 4. ;) entry is inserted.

See the following section for the introduction of an auxiliary transformation matrix R2 (TRANSFORM 2) to circumvent the problems arising from TRANSFORM 1 updates.

---

* By "updating" we mean initiating a new starting point for the accumulation (multiplication) of the R matrix. i.e. at the point of update, the R matrix is assumed to be reset to the unity matrix and all previous accumulations are forgotten.

AUXILIARY TRANSFORMATION MATRIX (R2)   Type Code 6. 0. 2.

To circumvent the difficulties caused by frequent beam updates and consequent redefinition of the cumulative transformation matrix, R1, provision has been made for introducing an independent transformation matrix, the R2 matrix.

This matrix is not normally accumulated, and must be introduced by defining its starting point with a (6. 0. 2. ;) card. This variant of the Type 6.0 code also serves to redefine the starting point of the R2 matrix (update it) when desired.

R2 has no effect upon the BEAM (sigma) matrix as does R1 nor do any constraints imposed upon the BEAM (sigma) matrix react upon it. It is solely a convenience for the user. It may be printed by a (13. 24. ;) entry. Any components of R2 may be constrained by a Type Card 10. entry with code digits: -(i + 20.) and j.

For example, 10. -1. 2. 0. .01 ; and 10. -21. 2. 0. .01 ; are identical constraints applied to the R1 and R2 matrices, respectively.

R2 is updated by a beam (1.) element, provided R2 has been introduced, but by no other elements. No provision has been made for suppressing R2 once it is introduced.

SHIFT IN THE BEAM CENTROID Type Code 7.0

Sometimes it is convenient to redefine the BEAM centroid** such that it does not coincide with the TRANSPORT reference trajectory. Provision has been made for this possibility via Type Code 7.0. Seven parameters are required:

1 - Type Code 7.

(2 to 7)- the coordinates x, θ, y, φ, ℓ, and δ defining the initial conditions of the new beam centroid with respect to the reference trajectory. The units for x, θ, y, φ, ℓ, δ are the same as those chosen for the beam (Type Code 1.0 entry), normally cm, mr, cm, mr, cm, and percent.

Only the beam (σ) matrix is affected by this code. The transformation matrices R1 and R2 are unaffected.

In order for this code to function properly, the initial BEAM entry (Type Code 1.0) must have a non-zero phase space volume.

e.g. a

```
1.  0  0  0  0  0  0  P(0).  ;
```

beam entry is not permissible when calculating a shift in the beam centroid; whereas a

```
1.0  1.  1.  1.  1.  1.  1.  P(0).  ;
```

entry (finite phase volume) will work.

** By "Beam Centroid" we mean the center of the beam ellipsoid.

MAGNET ALIGNMENT TOLERANCES   Type Code 8.0

The misalignment of a magnet to first order affects only the centroid of the beam. Two situations are commonly encountered: the magnet is displaced and/or rotated by a known amount; or the actual position of the magnet is uncertain within a given tolerance. Both these effects may be simulated through use of the 'align' element.

There are eight parameters to be specified:

1 - Type Code 8. (specifying alignment).

2 - the magnet displacement in the horizontal direction (cm).

3 - a rotation about the horizontal axis (mr).

4 - a displacement in the vertical direction (cm).

5 - a rotation about the vertical axis (mr).

6 - a displacement in the beam direction (cm).

7 - a rotation about the beam direction (mr).

8 - a three digit code number (defined below) specifying the type of misalignment.

The coordinate system employed is that to which the beam is referred at the point it enters the magnet. For example, a rotation of a bending magnet about the beam direction (parameter 7 above) is referred to the direction of the beam where it enters the magnet. The units employed are the standard TRANSPORT units shown above unless redefined by Type Code 15. entries. If the units are changed, the units of the misalignment displacements are those determined by the 15. 1. type code entry; the units for the misalignment rotations are those determined by the 15. 2. type code entry.

Only the misalignments of bending magnets or quadrupoles may be simulated. The Type Code 8.0 align element(s) must directly follow the magnetic element(s) to be misaligned.

When the actual position of the magnet(s) is uncertain within a given tolerance, the BEAM card entry at the beginning of the system should correspond to a zero phase space input, i.e., the BEAM card should appear as follows:

1.0 0. 0. 0. 0. 0. 0. P(0) ;

The phase ellipse printouts following the misalignment will then possess a finite phase volume which represents the uncertainty in the position of the beam centroid resulting from the uncertainty in the knowledge of the positioning of the magnet(s).

When the misalignment is a known amount, the BEAM card entry at the beginning of the system should possess a non-zero phase volume. (e.g. a

1.0 1. 1. 1. 1. 1. 1. P(0). ;

is a permissible Type Code 1.0 entry.)

The beam centroid printouts following the misalignment will then show a definite shift in the position of the beam centroid resulting from the misalignment of the magnet(s).

An align element updates the BEAM (sigma) matrix and the R1 matrix but not the R2 matrix.

The following three digit code numbers provide several alternative misalignment situations:

A. The units position distinguishes between a single type code entry and a set of entries:

CODE NUMBER	INTERPRETATION
XX0.	In this case, the 0 means that the information contained on the align card refers only to the <u>single</u> magnet (type code entry) immediately preceding it.
XX1.	With this option the 1 means that all of the type code elements since the last R1 matrix update (a BEAM CARD entry, a constraint upon the BEAM (sigma) matrix or a 6. 0. 1. ; type code entry) are treated as a unit and the misalignment information on the card is applied to the unit as a whole. This option should be used for the misalignment of a bending magnet when fringing-fields or pole face rotations (Type Code 2.0) are included. See Examples 1 and 2 below for an illustration of this. Only <u>one</u> bending magnet may be included in the array. Another example of the use of this option is in the misalignment of an array of quadrupoles. By successive application of align elements, for example, the elements of a quadrupole doublet could be misaligned relative to each other and then the doublet as a whole could be misaligned.

XX2. With this option the 2 means that all of the type code elements since the last R2 matrix update (a 6. 0. 2. ; type code entry) are treated as a unit. This code digit, for example, is necessary for studying misalignment of quadrupole triplets and other combinations involving more than two quadrupole magnets. It makes use of the fact that the R2 matrix remains unaffected by the usual update codes.

B. The tens position defines the system axis along which the succeeding magnets are positioned:

X0X. The 0 means they are positioned along the same axis as if the magnet were not displaced.

X1X. The 1 means they are positioned along the axis defined by the magnetic axis of the displaced magnet.

For instance, if a quadrupole is rotated, the remainder of the system may be left alone (X0X.) or rotated with the quadrupole X1X.

C. The hundreds position distinguishes between an uncertainty in position (0XX.) or a known displacement (1XX.).

Any combination of digits may be used to define the exact circumstances intended. Thus, code 111. (= 1. + 10. + 100.) indicates the deliberate displacement of a set of magnets and the remainder of the system (referred to the point the beam enters the set). Code 101. would leave the remainder of the system alone.

Typical code numbers for magnet alignment tolerances might be:

Code Number	Interpretation
000.	The reference trajectory is unchanged. Only the preceding magnet is misaligned and by an uncertain amount (but within the specified tolerances).
001.	The reference trajectory is unchanged. All magnets (type code entries) between the last R1 matrix update and the Type Code 8. entry are misaligned by an uncertain amount (but within the specified tolerances).
002.	Same as above except replace R1 with R2 in the statement
100.	The reference trajectory is unchanged. Only the preceding magnet is misaligned by the specified amount.
101.	The reference trajectory is unchanged. All magnets between the last R1 matrix update and the type code 8 entry are misaligned by the specified amount.
102.	Same as above except replace R1 with R2 in the statement

111. The axis of the misaligned magnet(s) is the new reference trajectory for all subsequent magnets. All magnets between the last R1 matrix update and the type code 8 alignment entry are misaligned by the specified amount

The tolerances may be varied. Thus, type-vary code 8.111111 permits any of the six parameters (2 through 7 above) to be adjusted to satisfy whatever BEAM constraints may follow. (See the section under Type Code 10. for a discussion of the use of vary-codes.)

Example No. 1: A misaligned bending magnet

A bending magnet (including fringing-fields) misaligned by a known amount might be represented as follows:

```
3.0  L(1).  ;
6.  0.  1.  ;
2.0  0.0  ;  4.0  L.  B.  n.  ;  2.0  0.0  ;
8.0  0.0  0.0  0.0  0.0  0.0  2.0  101.  ;
3.0  L(2).  ;
```

This represents a known rotation of the bending magnet about the incoming beam direction (z-axis) by 2.0 mr. The result of this misalignment will be a definite shift in the beam centroid. The 6. 0. 1. ; transform 1 update is necessary because of the use of the 2.0 0.0 ; entries before and after the bending magnet. The code number

XX1. is required because the magnetic array (bending magnet + fringing-fields) consists of three type code elements instead of one.

Example No. 2: A misaligned bending magnet

A bending magnet having an uncertainty of 2 mr in its angular positioning about the incoming beam (z-axis) would be represented as follows:

```
3.0  L(1)  ;
6.  0.  1.  ;
2.0  0.0  ;  4.0  L.  B.  n.  ;  2.0  0.0  ;
8.0  0.0  0.0  0.0  0.0  0.0  2.0  001.  ;
3.0  L(2)  ;
```

The result of this misalignment will be an uncertainty in the knowledge of the outcoming beam centroid - hence to observe this, the input Beam Card should have zero phase space volume as follows:

```
1.0  0.  0.  0.  0.  0.  0.  P(0)  ;
```

Example No. 3: A misaligned quadrupole triplet

One typical use of the R2 matrix is to permit the misalignment of a triplet. For example, an uncertainty in the position of the following triplet

```
5.  1.  -8.  10. ;
5.  2.  +7.  10. ;
5.  1.  -8.  10. ;
```

may be induced by appropriate 8. elements as noted.

```
6.  0.  2. ;
5.  1. -8.  10. ;
6.  0.  1. ;
5.  2. +7.  10. ;
5.  1. -8.  10. ;
8. --- ---  ---  ---  ---  ---  000. ;
8. --- ---  ---  ---  ---  ---  001. ;
8. --- ---  ---  ---  ---  ---  002. ;
```

The first 8. card in the list refers to misalignment of the third magnet only. The second 8. refers to misalignment of the second and third magnets as a unit via the R1 matrix update (the 6. 0. 1. ; entry). The last 8. refers to misalignment of the whole triplet as a unit via the R2 matrix update (the 6. 0. 2. ; entry).

The BEAM card (Type Code 1.0 entry) should have zero phase space volume as shown in Example 2 above.

REPETITION Type Code 9.0

Many systems include a set of elements that are repeated several times. To minimize the chore of input preparation, a 'repeat' facility has been added.

There are two parameters:

1 - Type Code 9.

2 - code digit. If non-zero, it states the number of repetitions desired from the point it appears. If zero it marks the end of a repeating unit.

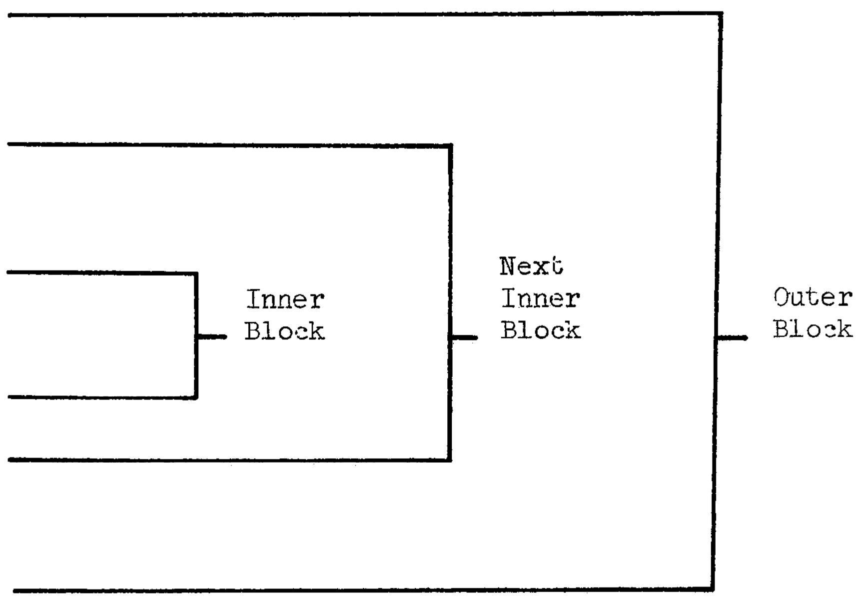
For example, a total bend of 12 degrees composed of four 3-degree bending magnets each separated by 0.5 meters could be represented by 9.0 4. ; 4. --- ; 3. .5 ; 9. 0. ; Those elements (in this case a bend and drift) between the 9. 4. ; and 9. 0. ; would be employed four times.

There is no indication of the 9. cards in the printed TRANSPORT output, save the repeated listing of the elements they control. Vary codes may be used within a repeating unit in the usual fashion.

Repeat cards may be nested four deep. By "nesting" we mean a repeat within a repeat. An example is given below.

Example of Nesting:

```
9.   2.  ;
3.  10.  ;
9.   3.  ;
3.  20. ;
9.   4.  ;
3.  50.  ;
9.   0.  ;
9.   0.  ;
3.   1.5 ;
9.   0.  ;
```



The total length of this sequence is:

2*(10. + 3*(20 + 4* 50) + 1.5) = 1343.

FIRST-ORDER VARY CODES AND FITTING CONSTRAINTS

Type Code 10.

TRANSPORT/360 has the capability to vary some (not all) of the physical parameters of the elements comprising a beam transport system in order to fit selected matrix elements of either the R1 or R2 transformation matrices or the BEAM (sigma) matrix to prescribed values. Special constraints are also available. The physical parameters to be varied are selected via 'Vary Codes' attached to the Type Codes of the elements comprising the system; and the fitting constraints imposed upon the R and/or σ matrix elements are selected via Type Code 10. entries made at the location in the system where the constraint is to be imposed.

Vary Codes

Associated with the physical elements comprising a system is a vary code which specifies which physical parameters of the element may be varied. This code occupies the fraction portion of the type code specifying the element. It has one digit for each parameter, the digits having the same order in the code as the physical parameters have on the card. A '0' indicates the parameter may not be varied; a '1' that it may be. For instance, 3.0 is the combined type(3) and vary code(0) for a drift length which is to remain fixed; 3.1 indicates a drift length that may be varied (by the virtue of the .1). The type code 4.010 indicates a bending magnet with a variable magnetic field. In punching the code 3.0, the zero need not be punched. In punching the 4.010 code, the first zero must be punched but the second zero need not be.

The following parameters may be varied (0 or 1 may be placed in positions marked v; only 0 may be placed in positions marked 0):

BEAM.... 1.vvvvvv - all components of the input beam may be varied.

ROTAT... 2.v - the pole-face angle of a bending magnet may be varied.

DRIFT... 3.v - the drift length may be varied.

BEND.... 4.0vv - the length may not be varied; the field (first v) and/or the n-value (second v) may be varied.

QUAD.... 5.vv0 - the length may be varied; the field may be, the aperture may <u>not</u> be.

ALIGN.... 8.vvvvvv0 - any of the alignment parameters may be varied.

MATRIX....14.vvvvvv0 - any of the matrix elements may be varied.

SOLENOID.... 19.vv - the length and/or field may be varied.

BEAM ROTATION.... 20.v - the angle of rotation may be varied.

The use of the permissive 'may' rather than the imperative 'will' in discussing variables is meaningful. The program will choose the parameters it <u>will</u> vary from among those that it <u>may</u> vary. In general it chooses to vary those parameters that have the greatest influence upon the conditions to be fit.

Coupled Vary Codes

It is possible to apply the same correction to each of several variables. This may be done by replacing the digit 1 in the vary code with one of the digits 2 through 9. All variables whose vary digit has one of these values (and appears in the same position within the vary code) will receive the same correction. For example, the three type-vary codes (5.02, 5.01, 5.02) might represent a symmetric triplet. The same correction will be made to the first and third quadrupoles, guaranteeing that the triplet will remain symmetric. Variables whose vary digits appear in different positions will not be tied together (the vary digit positions are completely independent). Thus, the codes (8.666666, 3.6) apply the same correction to the drift length as to the horizontal misalignment, but do not restrict the six misalignment parameters with respect to each other. (Such a combination would never arise in practice.)

If the vary digit 9 is used, the correction associated with the vary digit 4 will be subtracted rather than added to this variable. Thus, the type-vary codes (3.4, 5.01, 3.9) will slide the quadrupole back and forth within a prescribed drift length, but will not change the total drift length. The vary digits (8 and 3), and (7 and 2) are coupled in a similar manner as are (9 and 4). This option may not be used with Type Code elements 1. or 8.

The total number of independent variables in a run is limited to 10 by reasons of the mathematical method of fitting. So far as this limit is concerned, variables that are tied together count as one variable. Also note that variables within repeat elements (Type Code 9.) count only once.

R1 MATRIX FITTING CONSTRAINTS

There are five parameters to be specified when imposing a constraint upon the (i, j) element of an R1 matrix.

1 - Type Code 10. (specifying that a fitting constraint follows)

2 - code digit (-i).

3 - code digit (j).

4 - desired value of the (i, j) matrix element.

5 - desired accuracy of fit (standard deviation).

Some typical R1 matrix constraints are as follows:

Desired Optical Condition	Typical Fitting Constraint
point to point focus:	
Radial plane R(12) = 0	10. -1. 2. 0. .0001 'F1' ;
Transverse plane R(34) = 0	10. -3. 4. 0. .0001 'F2' ;
'parallel' to point focus:	
Radial plane R(11) = 0	10. -1. 1. 0. .0001 'F3' ;
Transverse plane R(33) = 0	10. -3. 3. 0. .0001 'F4' ;
achromatic beam:	
Radial plane R(16) = R(26) = 0	10. -1. 6. 0. .0001 'F5' ;
	10. -2. 6. 0. .0001 'F6' ;

Note that any fitting constraint on an R1 matrix element is from the preceding update of the R1 matrix. An R1 matrix is updated by a (6. 0. 1. ;) entry or by any fitting constraint imposed upon the σ (beam) matrix.

R2 MATRIX FITTING CONSTRAINTS

There are five parameters to be specified when imposing a constraint upon the (i, j) element of an R2 matrix.

1 - Type Code 10.

2 - Code digit -(20 + i).

3 - Code digit (j).

4 - desired value of the (i, j) matrix element.

5 - desired accuracy of fit (standard deviation).

Some typical R2 matrix constraints are as follows:

Desired Optical Condition	Typical Fitting Constraint
point to point focus:	
Radial plane R(12) = 0	10. -21. 2. 0. .0001 'F1' ;
Transverse plane R(34) = 0	10. -23. 4. 0. .0001 'F2' ;
'parallel' to point focus:	
Radial plane R(11) = 0	10. -21. 1. 0. .0001 'F1' ;
Transverse plane R(33) = 0	10. -23. 3. 0. .0001 'F2' ;
achromatic beam:	
Radial plane R(16) = R(26) = 0	10. -21. 6. 0. .0001 'F3' ;
	10. -22. 6. 0. .0001 'F4' ;

Note that the R2 matrix is updated by a (6. 0. 2. ;) type code entry only.

σ(BEAM) MATRIX FITTING CONSTRAINTS

There are five parameters to be specified when imposing a constraint upon the (i, j) element of a σ(BEAM) matrix.

1 - Type Code 10.n

2 - Code digit (i). $(i \geqslant j)$

3 - Code digit (j).

4 - desired value of the (i, j) matrix element.

5 - desired accuracy of fit (standard deviation).

(n) is normally zero or blank. If n = 1, then entry 4 is taken to be a lower limit on the matrix element. If n = 2, entry 4 is taken to be an upper limit. If i = j, then the value inserted in entry 4 is the desired beam size $(\sigma(ii))^{1/2}$ e,g. X(max) = $(\sigma(11))^{1/2}$ etc.

Note:

Any constraint imposed upon the σ(BEAM) matrix has an important side effect, it always updates the R1 matrix (but not the R2 matrix) at the location where the constraint is imposed.

Some typical σ matrix constraints are as follows:

Desired Optical Condition	Typical Fitting Constraint
Beam Waist	
Radial Waist $\sigma(21)$ = 0	10. 2. 1. 0. .001 'F1' ;
Transverse Waist $\sigma(43)$ = 0	10. 4. 3. 0. .001 'F2' ;
Fit Beam size to X(max) = 1cm	10. 1. 1. 1. .001 'F3' ;
Fit Beam size to Y(max) = 2cm	10. 3. 3. 2. .001 'F4' ;
Limit Max beam size to X = 2cm	10.2 1. 1. 2. .01 'F5' ;
Limit Min beam size to Y = 1cm	10.1 3. 3. 1. .01 'F6' ;

In general, it will be found that achieving a satisfactory 'beam' fit with TRANSPORT is more difficult than achieving an R matrix fit. When difficulties are encountered, it is suggested that the user 'help' the program by employing sequential (step by step) fitting procedures when setting up his data set. More often than not a "failure to fit" is caused by the user requesting the program to find a physically unrealizable solution.

System Length Constraint

A running total of the lengths of the various elements encountered is kept by the program and may be fit. The code digits are i = 0., j = 0.

Thus the element (10. 0. 0. 150. 5. ;) would make the length of the system prior to this element equal to 150 ± 5 meters. Presumably there would be a variable drift length somewhere in the system. By redefining the cumulative length via the (16. 6. L. ;) element, partial system lengths may be accumulated and fit.

AGS Machine Constraint*

Provision has been made in the program for fitting the betatron phase shift angle, μ, associated with usual AGS treatment of magnet systems.

In the horizontal plane: use code digits i = -11., j = 2. and specify:

$$\Delta = \frac{1}{2\pi} \cos^{-1} \left[0.5 \, (R_{11} + R_{22})\right] = \frac{\mu}{2\pi} \text{ (horiz)}$$

$$= \text{freq/(no. of periods)}.$$

In the vertical plane: i = -13., j = 4., and

$$\Delta = \frac{1}{2\pi} \cos^{-1} \left[0.5 \, (R_{33} + R_{44})\right] = \frac{\mu}{2\pi} \text{ (vert)}$$

For example, if there are 16 identical sectors to a proposed AGS machine and the betatron frequencies per revolution are to be 3.04 and 2.14 for the horizontal and vertical planes respectively, then the last element of the sector should be followed by the constraints:

```
10.   -11.   2.   .190   .0001   ;
10.   -13.   4.   .134   .0001   ;
```

i.e. $\frac{3.04}{16} = 0.190$ and $\frac{2.14}{16} = 0.134$

* See Courant and Snyder "Theory of the Alternating-gradient synchrotron", Annals of Physics 3; pp1-48 (1958).

For example: A typical data listing might be:

```
9.0    16.0    ;
5.01   ---     ;
3.0    ---     ;
5.01   ---     ;

10.   -11.   2.   0.190   .0001   ;
10.   -13.   4.   0.134   .0001   ;

9.0    0.0     ;
```

First Moment Constraint

Misalignments and second order effects cause the center (centroid) of the phase ellipsoid to be shifted from the reference trajectory, i.e., they cause the beam to have a non-zero first moment. The first moments appear in a vertical array to the left of the vertical array which give the $\sqrt{\sigma(ii)}$'s The units of the corresponding quantities are the same.

It is perhaps helpful to emphasize that the origin always lies on the reference trajectory. First moments refer to this origin. However, the ellipsoid is defined with respect to its center, so the covariance matrix, as printed, defines the second moment about the mean.

First moments may be fitted. The code digits are i = 7. and j, where j is the index of the quantity being fit. Thus 10. 7. 1. .1 .01 ; constrains the horizontal (1.) displacement of the ellipsoid to be 0.1 + 0.01 cm.

This constraint is useful in deriving the alignment tolerances of a system or in warning the system designer to offset the element in order to accommodate a centroid shift.

Internal Constraints

A set of upper and lower bounds on the value of each type of parameter is in the memory of the program. If a correction is computed for a parameter which would take its value outside this range, it is reset to the limit of the range, and a constraint constructed to keep it within range. The current limits are:

Type Code	Limits
3.0	0.1 < drift < 1000 (m)
5.0	.01 < quad length < 10 (m)
5.0	-14 < quad field < 14 (kg)
4.0	-20 < bend field < 20 (kg)
4.0	-500 < bend gradient < 500
2.0	-60 < pole-face rotation < 60 (deg)
8.0	-1 < alignment displacement < 25 (cm)
8.0	-50 < alignment rotation < 50 (mr)
1.0	0.01 < input beam < 1000 (for all parameters)
20.0	-360 < beam rotation < 360 (deg)

These limits apply only when a parameter is being varied. Fixed values that exceed this range may be used as desired.

These constraints were included to avoid physically meaningless solutions. However, they are rather ineffective since systems that require values outside these limits usually have some basic design difficulty.

The limits are not adjusted for different input units. So if drift lengths are expressed in inches, the effective limits are 0.1 < drift < 1000 (in.) etc.

ACCELERATION Type Code 11.0

An energy gain is reflected in both the divergence and the width of the beam. This element provides a simulation of a traveling wave linear accelerator energy gain over a field free drift length. (i.e. no externally applied magnetic field)

There are five parameters:

1 - Type Code 11.

2 - accelerator length (meters).

3 - energy gain (GeV).

4 - φ (phase lag in degrees).

5 - λ (wavelength in cms).

The new beam energy is printed as output.

The energy of the reference trajectory is assumed to increase linearly over the entire accelerator length. If this is not the case, an appropriate model may be constructed by combining separate 11. elements. An 11. element with a zero energy gain is identical to a drift length.

None of the parameters may be varied.

Second order matrix elements have not been incorporated in the program for the accelerator section.

ACCELERATOR SECTION MATRIX

$$
\begin{bmatrix}
1 & \left[L\,\dfrac{E_o}{\Delta E\cos\varphi}\,\ell n\left(1+\dfrac{\Delta E\cos\varphi}{E_o}\right)\right] & 0 & 0 & 0 & 0 \\[2ex]
0 & \dfrac{E_o}{E_o+\Delta E\cos\varphi} & 0 & 0 & 0 & 0 \\[2ex]
0 & 0 & 1 & \left[L\,\dfrac{E_o}{\Delta E\cos\varphi}\,\ell n\left(1+\dfrac{\Delta E\cos\varphi}{E_o}\right)\right] & 0 & 0 \\[2ex]
0 & 0 & 0 & \dfrac{E_o}{E_o+\Delta E\cos\varphi} & 0 & 0 \\[2ex]
0 & 0 & 0 & 0 & 1 & 0 \\[1ex]
0 & 0 & 0 & 0 & \left(\dfrac{\Delta E\sin\varphi}{E_o+\Delta E\cos\varphi}\right)\left(\dfrac{2\pi}{\lambda}\right) & \dfrac{E_o}{E_o+\Delta E\cos\varphi}
\end{bmatrix}
$$

Definitions:

L = effective length of accelerator sector

E_o = particle energy at start of sector

ΔE = energy gain over sector length

φ = phase lag of the reference particle behind the crest of the accelerating wave. i.e., if φ is positive then for some $z > 0$ the particles having this value are riding the crest of the wave. The units of φ are degrees.

λ = wave length of accelerating wave. The units of λ are those of z (normally cm).

This matrix element assumes that $E_o \gg m_o c^2$ (fully relativistic).

BEAM (ROTATED ELLIPSE)   Type Code 12.0

To allow the output beam from some point in a system to become the input beam of some succeeding system, provision has been made for re-entering the correlation matrix which appears as a triangular matrix in the beam output. (See section under Type Code 1.0 and/or the appendix for definitions.)

There are 16 parameters:

1 - Type Code 12.

2 to 16 - the 15 correlations (r(ij)'s) among the 6 beam components - in the order printed (by rows).

Several cards may be used to insert the 15 correlations, if necessary.

Since this element is solely an extension of the beam input, a 12. element must be preceded by a 1. (beam) element entry.

<u>OUTPUT PRINT CONTROL INSTRUCTIONS   Type Code 13.0</u>

A number of control codes which transmit output print instructions to the program have been consolidated into a single type code:

There are two parameters:

1 - <u>Type Code 13.</u>

2 - code number.

The effects of the various code numbers will be described below (not in numerical order).

<u>PRINTED OUTPUT CONTROLS 1., 2., 3., 4., 24.</u>

Several codes are available to control various aspects of the printed output. Most type codes produce a line of output that advertises their existence. Those that do not, usually have an obvious effect upon the remainder of the output and thus make their presence clear.

(13. 2. ;): This code instructs the program to suppress the printing of the beam (σ) matrix.

(13. 1. ;): This code temporarily overrides the (13. 2. ;) suppress code. It causes a single beam matrix to be printed at that point in the system.

(13. 3. ;): This code permanently overrides the (13. 2. ;) suppress code and restores the normal code in which every beam matrix is printed.

(13. 4. ;): This code instructs the program to print the current transformation matrix R1 (TRANSFORM 1). If the program is computing a second order matrix, this second order transformation matrix will be included in the print out. This matrix is cumulative from the last R1 (TRANSFORM 1) update. The units of the elements of the printed matrix

are consistent with the input units associated with the Type Code 1. (BEAM) entry.

(13. 24. ;): This code causes the TRANSFORM 2 matrix, R2, to be printed. The format and units of R2 are identical with those of R1 which is printed by the (13. 4. ;) code. The calculation of the R2 matrix is started by a 6. 0. 2. ; entry (see Type Code 6.).

The units of the tabulated matrix elements in either the 1st order R or sigma matrix or second order T matrix of a TRANSPORT printout will correspond to the units chosen for the BEAM card. For example, the R(12) = (x/θ) matrix element will have the dimensions of cms/mr; and the T(236) = $(\theta/y\delta)$ matrix element will have the dimensions mr per cm per percent $\Delta P/P$ and so forth.

PUNCHED OUTPUT CONTROLS 29, 30, 31, 32, 33, 34, 35, 36

If the control is equal to 29, all of the terms in the first order matrix and the x and y terms of the second order matrix are punched.

If the control is equal to 30, all of the terms of the first order matrix and all second order matrix elements are punched out.

If the control, n, is greater than 30, all of the first order terms are punched and the second order matrix elements which correspond to (n-30.) i.e., if n = 32, the second order theta matrix elements are punched out. If n = 31, the second order X matrix elements are punched and so forth.

ARBITRARY TRANSFORMATION INPUT   Type Code 14.0

To allow for the use of empirically determined fringing fields and other specific (perhaps non-phase-space-conserving) transformations, provision has been made for reading in an arbitrary transformation matrix. The first-order 6 X 6 matrix is read in row by row.

There are eight parameters for each row of a first-order matrix entry:

1 - Type Code 14.

2 to 7 - the six numbers comprising the row. The units must be those used to print the transfer matrix; in other words, consistent with the BEAM input/output.

8 - row number (1. to 6.)

A complete matrix must be read and applied one row at a time. Rows that do not differ from the unit transformation need not be read.

For example, (14. -.1 .9 0. 0. 0. 0. 2. ;) introduces a transformation matrix whose second row is given but which is otherwise a unit matrix. Note that this transformation does not conserve phase space because R(22) = 0.9 i.e. the determinant of $R \neq 1$.

Any of the components of a row may be varied; however, there are several restrictions.

Type Code 14. elements that immediately follow one another will all be used to form a single transformation matrix. If distinct matrices are desired, another element must be inserted to separate the Type Code 14. cards. Several do-nothing elements are available; for example, a zero length drift (3. 0. ;) is a convenient one.

Note that

$$\begin{pmatrix} 1 & 0 \\ a_{21} & a_{22} \end{pmatrix} \begin{pmatrix} a_{11} & a_{12} \\ 0 & 1 \end{pmatrix} \neq \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}$$

Hence, a matrix formed by successive 14. (3. 0. ;), 14. - elements is not always equal to the one formed by leaving out the (3. 0. ;) element.

If components of a 14. card are to be varied it must be the last 14. card in its matrix. This will force a matrix to be split into factors if more than one row has variable components.

If it is desired to read in the second-order matrix coefficients for the ith row, then the following 22 additional numbers may be read in:**

9 - continuation Code 0.

10 to 30 - the twenty-one coefficients:

T(i11) T(i12) T(i13) T(i14) T(i15) T(i16)

T(i22) T(i23) T(i24) T(i25) T(i26) T(i33)

T(i34) T(i35) T(i36) T(i44) T(i45) T(i46)

T(i55) T(i56) T(i66)

in that order, where i is the row number. It is necessary to read in the first order matrix row which corresponds to the second order matrix row being read in.

**This feature frees the user from making repetitive, expensive, second-order runs through a fixed portion of his system while experimenting with other magnets. This is done by reading the full matrix of this portion (obtained from a previous run) back into the machine as a single "arbitrary matrix."

As in the first-order case, full rows not different from the identity matrix (i.e., R(ii) = 1, all other R(ij) = 0, and all T(ijk) = 0) need not be read in.

INPUT - OUTPUT UNITS   Type Code 15.0

TRANSPORT is designed with a standard set of units that have been used throughout this manual. However, to accommodate other units conveniently and to relieve certain parameter-fitting problems, provision has been made for redefining the units to be employed. This is accomplished with the following type code elements.

There are 4 parameters to be specified:

1 - Type Code 15.

2 - code digit

3 - the abbreviation of the unit. (see examples below) This will be printed on the output listing. It must be enclosed in single quotes and is a maximum of 3 characters long (4 for energy).

4 - the scale factor (if needed) that multiplies a parameter expressed in the new units to convert it to the appropriate reference unit. The examples and tables below should clarify this point.

The various units that may be changed are:

Code Digit	Quantity	Standard Reference Unit	Symbols used in SLAC-75
1.	horizontal and vertical transverse dimensions	cm	x, y
2.	horizontal and vertical angles	mr	θ,φ
3.	vertical beam extent (only)	cm	y
4.	vertical beam divergence (only)	mr	φ
5.	pulsed beam length	cm	ℓ
6.	momentum spread	% (PC)	δ
7.	undefined		
8.	length (longitudinal)	meters (M)	t
9.	magnetic fields	kg	B
10.	mass	electron mass	m
11.	momentum	GeV/c	P(0)

Units are not normally restored at the end of a run. Once changed, they remain the same for all succeeding runs in an input deck, unless specifically changed. The units may be reset to standard units at any time by inserting a (15. ;) Type Code entry. The 15. elements are normally the first cards in a deck, (immediately following the title card and the 0 or 1 indicator card) or perhaps the last cards--in the event units are being restored to avoid disturbing succeeding runs.

Example: To change length to feet, width to inches, and momentum to MeV/c, add to the front of the deck the elements

```
15.  8.   ' FT'  0.3048;
15.  1.   ' IN'  2.54;
15.  11.  'MEV' 0.001;
```

The scale factor, 0.3048, multiplies a length expressed in the new unit, feet, to convert it to the reference unit, meters etc.

For the conventional units listed below, it is sufficient to stop with the label; (the conversion factor is automatically calculated by the program). If units other than those listed below are desired, then your label and the appropriate conversion factor must be included. If the automatic feature is used, there must be no blank spaces between the quotes and the labels.

INPUT-OUTPUT UNITS (Type Code 15.0)

CONVERSION FACTORS FOR DIMENSION CHANGES VS. CODE DIGIT AND LABEL

LABEL	CODE DIGIT										
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
'CM'	1.	---	1.	---	1.	---	---	.01	---	---	---
'M'	100.	---	100.	---	100.	---	---	1.	---	---	---
'IN'	2.54	---	2.54	---	2.54	---	---	.0254	---	---	---
'FT'	30.48	---	30.48	---	30.48	---	---	.3048	---	---	---
'MM'	.1	---	.1	---	.1	---	---	.001	---	---	---
'R'	---	1000.	---	1000.	---	---	---	---	---	---	---
'MR'	---	1.	---	1.	---	---	---	---	---	---	---
'PC'	---	---	---	---	---	1.	---	---	---	---	---
'P/10'	---	---	---	---	---	.1	---	---	---	---	---
'N'	---	---	---	---	---	100.	---	---	---	---	---
'MEV'	---	---	---	---	---	---	---	---	---	---	.001
'GEV'	---	---	---	---	---	---	---	---	---	---	1.
'KG'	---	---	---	---	---	---	---	---	1.	---	---
'G'	---	---	---	---	---	---	---	---	.001	---	---

SPECIAL INPUT PARAMETERS Type Code 16.0

A number of constants are used by the program which do not appear as parameters on any of the other type code element cards. A special element has been provided to allow the designer to set their values. These special parameter entries must always precede the physical element(s) to which they apply. Once introduced, they apply to all succeeding elements in a data set unless reset to zero or to new values.

There are three parameters:

1 - Type Code 16.

2 - code digit

3 - value of constant

A number of such constants have been defined in this manner. All have a normal value that is initialized at the beginning of each run.

<u>Code Digit</u>

1. $\epsilon(1)$ - a second-order measure of magnetic field inhomogeneity in bending magnets. If

$$B(x) = B(0)\left[1 - n\left(\frac{x}{\rho}\right) + \beta\left(\frac{x}{\rho}\right)^2 - \ldots\right]$$

is the field expansion in the median (y = 0) plane). Then $\epsilon(1)$ (dimensionless) is defined as

$$\epsilon(1) = \beta\left(\frac{x}{\rho_o}\right)^2$$

evaluated at x = 1 (in units of horizontal beam width - normally cm.). This parameter affects second-order calculations only. Normally the value is 0.

3. (M/m) - Mass of the particles comprising the beam, in units of the electron mass; normally 0. A non-zero mass introduces the dependence of pulse length on velocity, an important effect in low energy pulsed beams.

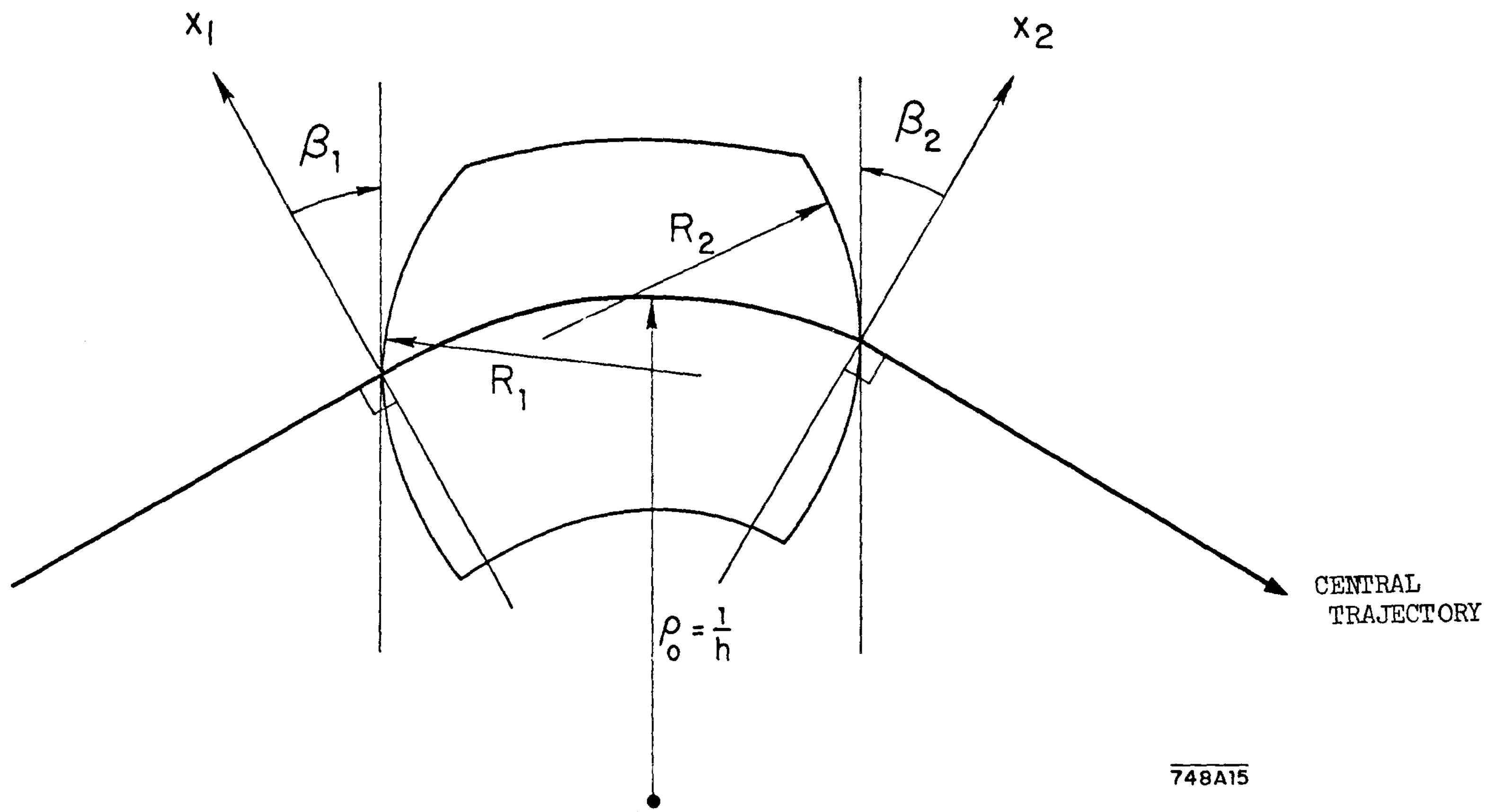
4. W/2 - Horizontal half-aperture of bending magnet, in the same units as horizontal beam width. normally 0. (i.e., effect of finite horizontal half aperture is ignored).

5. g/2 - Vertical half-aperture of bending magnet, in the same units as vertical beam height; this parameter must be inserted if the finite extent of the fringing fields upon transverse focusing is to be taken into account. (see Type Codes 2.0 and 4.0 as a cross reference) normally 0.

6. L - Cumulative length of system, in the same units as system length. It is set to zero initially, then increased by the length of each element, and finally printed at end of system. This element allows the cumulative length to be reset as desired.

12. 1/R1 - Where R1 is the radius of curvature (in units of longitudinal length, normally meters) of the entrance face of bending magnets. (See Fig. 748A15 page 2-4)

13. 1/R2 - Where R2 is the radius of curvature (in units of system length such as meters) of the exit face of bending magnets. (See Fig. 748A15, page 2-4)



FIELD BOUNDARIES FOR BENDING MAGNETS

The TRANSPORT sign conventions for x, β , R and h are all positive as shown in the figure. The positive y direction is out of the paper. Positive β's imply transverse focusing. Positive R's (convex curvatures) represent negative sextupole components of strength $S = (-\frac{h}{2R}) \sec^3 \beta$. (See SLAC-75, page 71).

R1 and R2 affect the system only in second-order, creating an effective sextupole component in the neighborhood of the magnet. If the parameters are not specified, they are assumed to be zero, i.e., no curvature and hence no sextupole component.

Programming for Fringe-Field Corrections to the Transverse Focal Length

Insert: 16. 5. g/2 element, then

16. 7. k(1). [k(1) = 1/2 if 16. 7. element is not inserted but 16. 5. element is inserted.]

16. 8. k(2). [k(2) = 0 if 16. 8. element is not inserted.]

where

$$\frac{1}{f_y} = -\frac{1}{\rho}\tan(\beta-\psi)$$

and

$$\psi = \frac{1+\sin^2\beta}{\cos\beta}\left[k_1\left(\frac{g}{\rho}\right) - k_2\left(\frac{k_1 g}{\rho}\right)^2 \tan\beta\right]^*$$

Fringing-field corrections will only be made where the pole-face rotation element (2. β. ;) has been inserted in conjunction with a bending magnet (4. . . . . element.)

* See SLAC-75, page 74 for a discussion of ψ and a definition of k(1).

Typical values of k1 and k2 are given below for three types of fringing field boundaries:

a) a linear drop-off of the field.

b) a clamped "Rogowski" fringing-field.

and c) a "square-edged" non-saturating magnet.

Model	Linear	Clamped Rogowski	Square Edged Magnet
k1	1/6	0.3 to 0.4	0.45
k2	3.8	4.4	2.8

Tilt-to-Focal Plane (16. 15. α. ;) element

Very often it is desired to have a listing of the second order aberrations along the focal plane of a system rather than perpendicular to the optic axis i.e. along the x coordinate. If the focal plane makes an angle alpha with respect to the x axis (measured clockwise) then provision has been made to rotate to this focal plane and print out the second-order aberrations. This is achieved by the following procedures:

Alpha is the focal-plane tilt angle (in degrees) measured from the perpendicular to the optic axis (α is normally zero).

The programming procedure for a tilt in the x (bend)-plane (rotation about y axis) is:

```
16.  15.  α.  ;
 3.   0.  ;   (a necessary do-nothing element)
13.   4.  ;
16.  15.  -α.  ;  (Rotate back to zero)
 3.   0.  ;   (a necessary do-nothing element)
16.  15.  0.  ;  (to turn off rotation element)
```

The programming procedure for a tilt in the y-plane (rotation about x axis) is:

```
16.  15.  α.  ;
20.  90.  ;
 3.   0.  ;
20. -90.  ;
13.   4.  ;
16.  15.  -α.  ;  (Rotate back to zero)
 3.   0.  ;
16.  15.  0.  ;  (to turn off rotation element)
```

SECOND ORDER CALCULATION   Type Code 17.0

A second order calculation may be obtained provided neither parameter fitting nor alignment elements are employed. A special element instructs the program to calculate the second order matrix elements. It must be inserted immediately following the beam (1. element).

Only one parameter need be specified:

1 - Type Code 17. ; (signifying a 2nd order calculation is to be made)

The values of the BEAM (sigma) matrix components may be perturbed from their first order value by the second order aberrations. To print out the second order T matrix terms at a given location in the system, the (13. 4. ;) print control card is used. The update rules are the same as those for the R1 first-order matrix.

See SLAC-75 for definitions of subscripts in the second order T(ijk) matrix elements.

Second-order matrices are included in the program for quadrupole, bending magnets (including fringing-fields), sextupoles, and solenoids. They have not been calculated for the acceleration (Type Code 11.0) element.

SEXTUPOLE   Type Code 18.0

Sextupole (Hexapole) magnets are used to modify second-order aberrations in beam transport systems. The action of a sextupole on beam particles is a second and higher order effect, so in first order runs (absence of the 17. card) this element will act as a drift space.

There are 4 parameters:

1 - Type Code 18.

2 - effective length (meters).

3 - field at pole tips (kg). Both positive and negative fields are possible (see figures below).

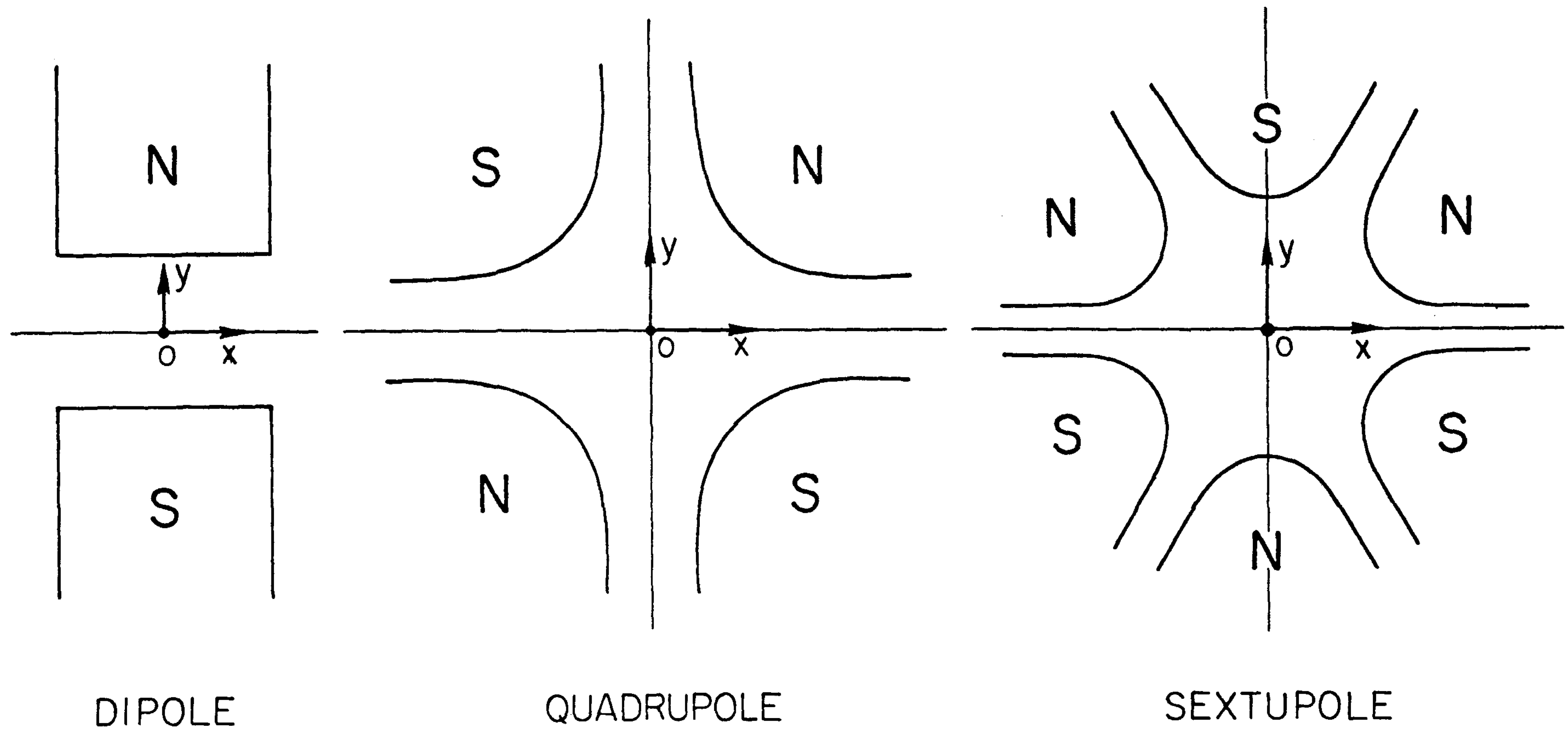
4 - Half-aperture (cm). Radius of circle tangent to pole tips.

Other orientations of the sextupole may be obtained using the beam rotation element (Type Code 20.). None of the parameters of the sextupole may be varied since it is a second order element.

See SLAC-75 for a tabulation of sextupole matrix elements.

The TRANSPORT input format for a typical data set is:

```
              ┌────Label if desired (not to exceed 4 spaces)
              ↓
18. L. B. a. '  ' ;
```



748A10

ILLUSTRATION OF THE MAGNETIC MIDPLANE (x AXIS) FOR DIPOLE, QUADRUPOLE AND SEXTUPOLE ELEMENTS. THE MAGNET POLARITIES INDICATE MULTIPOLE ELEMENTS THAT ARE POSITIVE WITH RESPECT TO EACH OTHER.

SOLENOID Type Code 19.0

The solenoid is most often used as a focusing element in systems passing low energy particles. Particles in a solenoidal field travel helical trajectories. The solenoid fringing field effects necessary to produce the focusing are included.

There are three parameters:

1 - Type Code 19.0

2 - effective length of the solenoid (meters)

3 - the field (kg). A positive field by convention points in the direction of positive z for positively charged particles.

The length and the field may be varied by using 19.1 or 19.01 vary codes respectively. Both 1st and 2nd order matrix calculations are available for the solenoid.

A typical input format is:

```
           ┌──Label if desired (not to exceed 4 spaces)
           ↓
19. L. B. '  ' ;
```

1ST ORDER

SOLENOID MATRIX ELEMENTS

Solenoid R Matrix

Definitions: L = effective length of solenoid

K = B(0)/(2Bρ) where B(0) is the field inside the solenoid and (Bρ) is the (momentum) of the Central Trajectory.

C = cos KL

S = sin KL

For a derivation of this transformation see SLAC-4 report by R. Helm.

Alternate Forms of Matrix Representation of the Solenoid.

$$R(\text{Solenoid}) = \begin{pmatrix} C^2 & \frac{1}{K}SC & SC & \frac{1}{K}S^2 & 0 & 0 \\ -KSC & C^2 & -KS^2 & SC & 0 & 0 \\ -SC & -\frac{1}{K}S^2 & C^2 & \frac{1}{K}SC & 0 & 0 \\ KS^2 & -SC & -KSC & C^2 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

Rotating the transverse coordinates about the z axis by an angle = -KL decouples the x and y 1st order Terms, i.e.

$$
R(-KL)\ .\ R(\text{Solenoid}) = \begin{pmatrix} C & \frac{1}{K}S & 0 & 0 & 0 & 0 \\ -KS & C & 0 & 0 & 0 & 0 \\ 0 & 0 & C & \frac{1}{K}S & 0 & 0 \\ 0 & 0 & -KS & C & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}
$$

BEAM ROTATION Type Code 20.0

The transverse beam coordinates x and y may be rotated through an angle α about the z axis (the axis tangent to the central trajectory at the point in question).** Thus a rotated bending magnet, quadrupole, or sextupole may be inserted into a beam transport system by preceding and following the element with the appropriate coordinate rotation. (See examples below). The positive sense of rotation is clockwise about the positive z axis.

There are two parameters to be specified for a Beam Rotation:

1 - Type Code 20. (signifying a beam coordinate rotation)

2 - the angle of rotation α. (degrees)

The angle of rotation may be varied in a 1st order fitting (see Vary Codes Section 10.)

Note

This transformation assumes that the units of (x and y) and (θ and φ) are the same. This is always true unless a 15. 3. or a 15. 4. type code has been used.

** See SLAC-75, page 45 and Fig. 4, page 12 for definitions of x, y, and z coordinates.

Examples:

For a bending magnet, the Beam Rotation matrix may be used to specify a rotated magnet.

Example No. 1

A bend up is represented by rotating the x, y coordinates by -90.0 degrees as follows:

Labels (not to exceed 4 spaces) if desired

```
20.  -90.   ' '  ;
2.0  β(1).  ' '  ;
4.0  L.  B.  n.  ' '  ;
2.0  β(2).  ' '  ;
20.  +90.   ' '  ; (returns coordinates to their initial
                    orientation)
```

A bend down is accomplished via a +90 degree rotation.

```
20.  +90.   ' '  ;
2.
4.
2.
20.  -90.   ' '  ;
```

A bend to the left (looking in the direction of beam travel) is accomplished by rotating the x, y coordinates by 180 degrees, e.g.,

```
20.  180.   ' '  ;
2.
4.
2.
20.  -180.  ' '  ;
```

Example No. 2

A quadrupole rotated clockwise by 60 degrees about the positive z axis would be specified as follows:

```
20.  60.  ' '  ;
5.  L.  B.  a.  ' '  ;
20.  -60.  ' '  ;
```

BEAM ROTATION MATRIX

$$R = \begin{pmatrix} C & & S & & & \\ & C & & S & & \\ -S & & C & & & \\ & -S & & C & & \\ & & & & 1 & \\ & & & & & 1 \end{pmatrix}$$

Where $C = \cos \alpha$

$S = \sin \alpha$

α = angle of coordinate rotation about the beam axis.

Blank spaces are zeros.

e.g.; for $\alpha = +90$ degrees, this matrix interchanges rows 1 and 2 with 3 and 4 of the accumulated R matrix as follows:

$$\begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \end{bmatrix} \begin{bmatrix} R(11) & R(12) & R(13) & R(14) \\ R(21) & R(22) & R(23) & R(24) \\ R(31) & R(32) & R(33) & R(34) \\ R(41) & R(42) & R(43) & R(44) \end{bmatrix} = \begin{bmatrix} R(31) & R(32) & R(33) & R(34) \\ R(41) & R(42) & R(43) & R(44) \\ -R(11) & -R(12) & -R(13) & -R(14) \\ -R(21) & -R(22) & -R(23) & -R(24) \end{bmatrix}$$

(The rest of the matrix is unchanged).

STRAY MAGNETIC FIELD Type Code 21.0

1 - Element No. 21.

2 - Code No. n. n = 4: horizontal deflection

n = 2: vertical deflection

3 - $\langle \overline{BL} \rangle$ mean value of $\int Bdz$

4 - ± $\langle \delta BL \rangle$ +: gaussian random number generator; effects beam first moment.

-: uncertainty in $\int Bdz$ - effects beam second moment.

Uses the misalignment element (8.) to calculate an angular deflection equal to $\frac{\int Bdz}{(B\rho)}$

Random number generator

16. 14. (2n + 1.).

The odd number (2n + 1) resets the random number generator to a specified initial point in the r. n. sequence.

SENTINEL

Each data set must be terminated with the word SENTINEL. The word SENTINEL need not be on a separate card.

REFERENCES

1. K. L. Brown, "A First and Second-Order Matrix Theory for the Design of Beam Transport Systems and Charged Particle Spectrometers" SLAC Report No. 75 (revised), July 1967.

2. S. Penner, "Calculations of Properties of Magnetic Deflection Systems," Rev. Sci. Instr. 32, No. 2, 150-160 (February 1961).

3. A. P. Banford, The Transport of Charged Particle Beams, (E. and F. N. Spon, Ltd., London, 1966).

4. K. L. Brown (with R. Belbeoch and P. Bounin), "First- and Second- Order Magnetic Optics Matrix Equations for the Midplane of Uniform-Field Wedge Magnets, Rev. Sci. Instr. 35, 481 (1964).

5. K. G. Steffen, High Energy Beam Optics, Interscience Monographs and Tests in Physics and Astronomy, Vol. 17 (John Wiley and Sons, 1965).

6. Harold Enge and Stan Kowalski at M.I.T. have developed an effective Ray Tracing program using essentially the same terminology as TRANSPORT. Hence any experienced user of TRANSPORT should find it relatively easy to adapt to the M.I.T. program.

EXAMPLES

Table of Contents

```
USE TRIPLET TC FOCUS BEAM FRCM SOURCE ONTO TARGET
    0
THIS PROBLEM HAS A UNITS CONVERSION FOR THE BEAM EXTENT FRCM CM TO IN AND
FOR THE LENGTH FRCM METERS TO FEET.  THE OUTER TWO QUADRUPCLES CF THE QUAD
TRIPLET HAVE VARY CODES SUCH THAT THEIR FIELDS WILL VARY TOGETHER.  THE FIELD
OF THE CENTER QUADRUPOLE IS ALLOWED TO VARY INDEPENDENTLY.  THE FITTING
CONDITIONS SPECIFY A FOCUS IN BOTH DIMENSIONS CN THE TARGET.
  15.0C0CC    1.00000  IN           2.540CC
  15.00000    8.00000  FT           0.30480
   1.0C000    0.50000  17.49998   0.50000  17.49998   0.0       3.00000   1.05000
   3.0C000   12.00000
   5.00000    1.5000C  -1.00000   4.C0000
   VARY CODE  020000
   3.00000    C.50000
   5.0C00C    3.00000   1.00000   4.00000
   VARY CODE  010000
   3.0C000    C.50000
   5.000C0    1.5000C  -1.00000   4.C0000
   VARY CODE  020000
   3.0C000    7.00C00
  10.00000   -1.00000   2.CC000   0.0        0.C0100
    LABEL  =  FIT1
  10.C0000   -3.000C0   4.0000C   0.C        0.C0100
    LABEL  =  FIT2
  13.00000    4.CCC00
 -15.C0C00    0.0                  0.0
    LABEL  =  UNT
  SENTINEL
```

```
'USE TRIPLET TO FOCUS BEAM FROM SOURCE ONTO TARGET'
0
(THIS PROBLEM HAS A UNITS CONVERSION FOR THE BEAM EXTENT FROM CM TO IN AND)
(FOR THE LENGTH FROM METERS TO FEET.  THE OUTER TWO QUADRUPOLES OF THE QUAD)
(TRIPLET HAVE VARY CODES SUCH THAT THEIR FIELDS WILL VARY TOGETHER.  THE FIELD)
(OF THE CENTER QUADRUPOLE IS ALLOWED TO VARY INDEPENDENTLY.  THE FITTING)
(CONDITIONS SPECIFY A FOCUS IN BOTH DIMENSIONS ON THE TARGET.)
15.0 1.0 'IN' ;
15.0 8.0 'FT' ;
1.0 0.5 17.5 0.5 17.5 0.0 3.0 1.05 ;
3.0 12.0 ;
5.02 1.5 -1.0 4.0 ;
3.0 0.5 ;
5.01 3.0 1.0 4.0 ;
3.0 0.5 ;
5.02 1.50 -1.0 4.0 ;
3.0 7.0 ;
10.0 -1.0 2.0 0.0 .001 'FIT1' ;
10.0 -3.0 4.0 0.0 .001 'FIT2' ;
13.0 4.0 ;
-15.0  'UNT' ;
SENTINEL
```

```
USE TRIPLET TO FOCUS BEAM FROM SOURCE ONTO TARGET



*BEAM*     1.000000    1.05 GEV
                                                         0.0 FT      0.0     0.500 IN
                                                                     0.0    17.500 MR    0.0
                                                                     0.0     0.500 IN    0.0     0.0
                                                                     0.0    17.500 MR    0.0     0.0     0.0
                                                                     0.0     0.0   CM    0.0     0.0     0.0     0.0
                                                                     0.0     3.000 PC    0.0     0.0     0.0     0.0     0.0

*DRIFT*    3.0    12.0000 FT
                                                        12.0 FT      0.0     2.569 IN
                                                                     0.0    17.500 MR    0.981
                                                                     0.0     2.569 IN    0.0     0.0
                                                                     0.0    17.500 MR    0.0     0.0     0.981
                                                                     0.0     0.0   CM    0.0     0.0     0.0     0.0
                                                                     0.0     3.000 PC    0.0     0.0     0.0     0.0     0.0

*QUAD*     5.00   1.50000 FT  -1.0000 KG   4.000 IN  ( -25.287 FT )
    VARY CODE = 020000
                                                        13.5 FT      0.0     2.958 IN
                                                                     0.0    26.373 MR    0.994
                                                                     0.0     2.801 IN    0.0     0.0
                                                                     0.0     8.991 MR    0.0     0.0     0.938
                                                                     0.0     0.0   CM    0.0     0.0     0.0     0.0
                                                                     0.0     3.000 PC    0.0     0.0     0.0     0.0     0.0

*DRIFT*    3.0     0.5000 FT
                                                        14.0 FT      0.0     3.115 IN
                                                                     0.0    26.373 MR    0.994
                                                                     0.0     2.851 IN    0.0     0.0
                                                                     0.0     8.991 MR    0.0     0.0     0.940
                                                                     0.0     0.0   CM    0.0     0.0     0.0     0.0
                                                                     0.0     3.000 PC    0.0     0.0     0.0     0.0     0.0

*QUAD*     5.00   3.00000 FT   1.0000 KG   4.000 IN  (  13.282 FT )
    VARY CODE = 010000
                                                        17.0 FT      0.0     3.665 IN
                                                                     0.0     4.422 MR    0.842
                                                                     0.0     3.511 IN    0.0     0.0
                                                                     0.0    29.016 MR    0.0     0.0     0.996
                                                                     0.0     0.0   CM    0.0     0.0     0.0     0.0
                                                                     0.0     3.000 PC    0.0     0.0     0.0     0.0     0.0

*DRIFT*    3.0     0.5000 FT
                                                        17.5 FT      0.0     3.687 IN
                                                                     0.0     4.422 MR    0.844
                                                                     0.0     3.685 IN    0.0     0.0
                                                                     0.0    29.016 MR    0.0     0.0     0.997
```

```
                                                                                0.0      0.0   CM    0.0     0.0     0.0     0.0
                                                                                0.0      3.000 PC    0.0     0.0     0.0     0.0     0.0


*QUAD*     5.00   1.50000 FT  -1.C000 KG   4.000 IN  ( -25.287 FT )
    VARY CODE = 020000
                                                                  19.0 FT       0.0      3.864 IN
                                                                                0.0     16.179 MR    0.990
                                                                                0.0      4.093 IN    0.0     0.0
                                                                                0.0     16.330 MR    0.0     0.0     0.991
                                                                                0.0      0.0   CM    0.0     0.0     0.0     0.0
                                                                                0.0      3.000 PC    0.0     0.0     0.0     0.0     0.0


*DRIFT*    3.0      7.0000 FT
                                                                  26.0 FT       0.0      5.213 IN
                                                                                0.0     16.179 MR    C.995
                                                                                0.0      5.455 IN    0.0     0.0
                                                                                0.0     16.330 MR    0.0     0.0     0.995
                                                                                0.0      0.0   CM    0.0     0.0     0.0     0.0
                                                                                0.0      3.000 PC    0.0     0.0     0.0     0.0     0.0


*FIT*      10.0     -1. 2.    0.0    / C.001

                                  0.297
         LABEL = FIT1


*FIT*      10.0     -3. 4.    0.0    / 0.001

                                  0.311
         LABEL = FIT2


 *TRANSFORM* 1
             0.94920    0.29666    0.0        0.0        0.0        0.0
            -C.41306    0.92442    0.C        0.C        0.0        0.0
             0.0        0.0        C.95425    0.31054    0.0        0.0
             0.0        0.0       -0.35299    0.93307    0.0        0.0
             0.0        0.0        0.C        0.C        1.00000    0.0
             0.0        0.0        0.0        0.C        0.0        1.00000


 *LENGTH*     26.0000 FT

  *CORRECTIONS*

( 3.0368E 02)   -18.939     17.940

( 2.1660E C3)     2.929    -12.179

( 7.1664E 02)     2.C78      1.313

( 1.5780E 02)     0.399      C.313
```

```
( 6.2308E 00)     0.024     C.011

( 1.6005E-02)     0.000     0.000

  *COVARIANCE  ( FIT   0.0 )
 0.014
-0.869  0.004
```

USE TRIPLET TO FOCUS BEAM FROM SOURCE ONTO TARGET

```
*BEAM*      1.000000     1.C5 GEV
                                                      0.0 FT      0.0      0.500 IN
                                                                  0.0     17.500 MR    0.0
                                                                  0.0      0.500 IN    0.0     0.0
                                                                  0.0     17.500 MR    0.0     0.0     0.0
                                                                  0.0      0.0   CM    0.0     0.0     0.0     0.0
                                                                  0.0      3.000 PC    0.0     0.0     0.0     0.0     0.0

*DRIFT*     3.C     12.000C FT
                                                     12.0 FT      0.0      2.569 IN
                                                                  0.0     17.500 MR    0.981
                                                                  0.0      2.569 IN    0.0     0.0
                                                                  0.0     17.500 MR    0.0     0.0     0.981
                                                                  0.0      0.0   CM    0.0     0.0     0.0     0.0
                                                                  0.0      3.000 PC    0.0     0.0     0.0     0.0     0.0

*QUAD*      5.00    1.50000 FT -14.5080 KG   4.000 IN  (  -1.533 FT )
    VARY CODE = 020000
                                                     13.5 FT      0.0      4.099 IN
                                                                  0.0    164.756 MR    1.000
                                                                  0.0      1.818 IN    0.0     0.0
                                                                  0.0     94.749 MR    0.0     0.0    -0.999
                                                                  0.0      0.0   CM    0.0     0.0     0.0     0.0
                                                                  0.0      3.000 PC    0.0     0.0     0.0     0.0     0.0

*DRIFT*     3.0      C.5000 FT
                                                     14.0 FT      0.0      5.C88 IN
                                                                  0.0    164.756 MR    1.000
                                                                  0.0      1.250 IN    0.0     0.0
                                                                  0.0     94.749 MR    0.0     0.0    -0.997
                                                                  0.0      0.0   CM    0.0     0.0     0.0     0.0
                                                                  0.0      3.000 PC    0.0     0.0     0.0     0.0     0.0

*QUAD*      5.00    3.00000 FT   8.3975 KG   4.000 IN  (   2.166 FT )
    VARY CODE = 010000
                                                     17.0 FT      0.0      5.005 IN
                                                                  0.0    168.545 MR   -1.000
                                                                  0.0      1.966 IN    0.0     0.0
                                                                  0.0    111.721 MR    0.0     0.0     0.999
                                                                  0.0      0.0   CM    0.0     0.0     0.0     0.0
                                                                  0.0      3.000 PC    0.0     0.0     0.0     0.0     0.0

*DRIFT*     3.0      C.5000 FT
                                                     17.5 FT      0.0      3.994 IN
                                                                  0.0    168.545 MR   -1.000
                                                                  0.0      2.636 IN    0.0     0.0
                                                                  0.0    111.721 MR    0.0     0.0     1.000
```

```
                                                                                  0.0      0.0   CM     0.0     0.0     0.0     0.0
                                                                                  0.0      3.000 PC     0.0     0.0     0.0     0.0     0.0


*QUAD*      5.00   1.50000 FT -14.5080 KG   4.000 IN  (  -1.533 FT )
    VARY CODE = 020000
                                                                    19.0 FT       0.0      2.338 IN
                                                                                  0.0     28.627 MR   -0.991
                                                                                  0.0      3.327 IN     0.0     0.0
                                                                                  0.0     40.489 MR     0.0     0.0    -0.998
                                                                                  0.0      0.0   CM     0.0     0.0     0.0     0.0
                                                                                  0.0      3.000 PC     0.0     0.0     0.0     0.0     0.0


*DRIFT*     3.0      7.0000 FT
                                                                    26.0 FT       0.0      0.318 IN
                                                                                  0.0     28.627 MR     0.273
                                                                                  0.0      0.231 IN     0.0     0.0
                                                                                  0.0     40.489 MR     0.0     0.0     0.351
                                                                                  0.0      0.0   CM     0.0     0.0     0.0     0.0
                                                                                  0.0      3.000 PC     0.0     0.0     0.0     0.0     0.0


*FIT*      10.0     -1. 2.    0.0    / 0.001

                                -0.000
         LABEL = FIT1


*FIT*      10.0     -3. 4.    0.0    / 0.001

                                 0.000
         LABEL = FIT2


 *TRANSFORM* 1
            -0.63548  -0.00000   0.0        0.0        0.0        0.0
           -15.63603  -1.57364   0.0        0.0        0.0        0.0
             0.0       0.0       0.46156    0.00000    0.0        0.0
             0.0       0.0      28.41595    2.16653    0.0        0.0
             0.0       0.0       0.0        0.0        1.00000    0.0
             0.0       0.0       0.0        0.0        0.0        1.00000


 *LENGTH*     26.0000 FT
```

```
'USE TRIPLET TO PUT WAIST ON TARGET'
1
(THIS PROBLEM DIFFERS FROM THE PRECEDING ONE IN THAT A WAIST ON THE TARGET)
(IS REQUESTED.  NOTE THE USE OF THE 1 AS THE INDICATOR CARD SIGNIFYING)
(THAT THIS RUN IS A CONTINUATION OF THE PREVIOUS ONE. )
10.0 2.0 1.0 0.0 .001 'FIT1' ;
10.0 4.0 3.0 0.0 .001 'FIT2' ;
SENTINEL
```

USE TRIPLET TO PUT WAIST ON TARGET

```
    1
```

THIS PROBLEM CIFFERS FROM THE PRECEDING ONE IN THAT A WAIST ON THE TARGET

IS REQUESTEC. NOTE THE USE OF THE 1 AS THE INDICATOR CARD SIGNIFYING

THAT THIS RUN IS A CONTINUATICN OF THE PREVIOUS ONE.

```
  15.0CC00   1.00000  IN          2.54C00

  15.0C000   8.00000  FT          0.30480

   1.00000   C.50000  17.49998   0.50000  17.49998   0.0       3.00000   1.05000

   3.0C000  12.00C00

   5.00000   1.50000 -14.508C0   4.C0000
   VARY CODE  020000

   3.00000   C.50000

   5.00000   3.00000   8.39750   4.C0000
   VARY CODE  010000

   3.0C000   C.50000

   5.0C000   1.50000 -14.5C80C   4.00000
   VARY CODE  02C000

   3.CC0C0   7.C0000

  10.00000   2.00CC0   1.C0000   0.0       0.00100
    LABEL = FIT1

  10.0C000   4.C0000   3.C0000   0.0       0.00100
    LABEL = FIT2

  13.00000   4.00000

 -15.C0000   C.0                 0.0
    LABEL = UNT

  SENTINEL
```

USE TRIPLET TO PUT WAIST ON TARGET

```
*BEAM*     1.000000    1.05 GEV
                                                      0.0 FT        0.0     0.500 IN
                                                                    0.0    17.500 MR    0.0
                                                                    0.0     0.500 IN    0.0      0.0
                                                                    0.0    17.500 MR    0.0      0.0      0.0
                                                                    0.0     0.0   CM    0.0      0.0      0.0      0.0
                                                                    0.0     3.000 PC    0.0      0.0      0.0      0.0      0.0

*DRIFT*    3.0    12.0000 FT
                                                     12.0 FT        0.0     2.569 IN
                                                                    0.0    17.500 MR    0.981
                                                                    0.0     2.569 IN    0.0      0.0
                                                                    0.0    17.500 MR    0.0      0.0      0.981
                                                                    0.0     0.0   CM    0.0      0.0      0.0      0.0
                                                                    0.0     3.000 PC    0.0      0.0      0.0      0.0      0.0

*QUAD*     5.00   1.50000 FT -14.5080 KG   4.000 IN  (  -1.533 FT )
    VARY CODE = 020000
                                                     13.5 FT        0.0     4.099 IN
                                                                    0.0   164.756 MR    1.000
                                                                    0.0     1.818 IN    0.0      0.0
                                                                    0.0    94.749 MR    0.0      0.0     -0.999
                                                                    0.0     0.0   CM    0.0      0.0      0.0      0.0
                                                                    0.0     3.000 PC    0.0      0.0      0.0      0.0      0.0

*DRIFT*    3.0     0.5000 FT
                                                     14.0 FT        0.0     5.088 IN
                                                                    0.0   164.756 MR    1.000
                                                                    0.0     1.250 IN    0.0      0.0
                                                                    0.0    94.749 MR    0.0      0.0     -0.997
                                                                    0.0     0.0   CM    0.0      0.0      0.0      0.0
                                                                    0.0     3.000 PC    0.0      0.0      0.0      0.0      0.0

*QUAD*     5.00   3.00000 FT   8.3975 KG   4.000 IN  (   2.166 FT )
    VARY CODE = 010000
                                                     17.0 FT        0.0     5.005 IN
                                                                    0.0   168.545 MR   -1.000
                                                                    0.0     1.966 IN    0.0      0.0
                                                                    0.0   111.721 MR    0.0      0.0      0.999
                                                                    0.0     0.0   CM    0.0      0.0      0.0      0.0
                                                                    0.0     3.000 PC    0.0      0.0      0.0      0.0      0.0

*DRIFT*    3.0     0.5000 FT
                                                     17.5 FT        0.0     3.994 IN
                                                                    0.0   168.545 MR   -1.000
                                                                    0.0     2.636 IN    0.0      0.0
                                                                    0.0   111.721 MR    0.0      0.0      1.000
```

```
                                                                                          0.0      0.0   CM     0.0     0.0     0.0     0.0
                                                                                          0.0      3.000 PC     0.0     0.0     0.0     0.0     0.0

*QUAD*     5.00    1.50000 FT -14.5080 KG   4.000 IN  (  -1.533 FT )
    VARY CODE = 020000
                                                                       19.0 FT            0.0      2.338 IN
                                                                                          0.0     28.627 MR    -0.991
                                                                                          0.0      3.327 IN     0.0     0.0
                                                                                          0.0     40.489 MR     0.0     0.0    -0.998
                                                                                          0.0      0.0   CM     0.0     0.0     0.0     0.0
                                                                                          0.0      3.000 PC     0.0     0.0     0.0     0.0     0.0

*DRIFT*    3.0      7.0000 FT
                                                                       26.0 FT            0.0      0.318 IN
                                                                                          0.0     28.627 MR     0.273
                                                                                          0.0      0.231 IN     0.0     0.0
                                                                                          0.0     40.489 MR     0.0     0.0     0.351
                                                                                          0.0      0.0   CM     0.0     0.0     0.0     0.0
                                                                                          0.0      3.000 PC     0.0     0.0     0.0     0.0     0.0

*FIT*      10.0      2. 1.    0.0    / 0.001

                              2.485
         LABEL = FIT1

*FIT*      10.0      4. 3.    0.0    / 0.001

                              3.279
         LABEL = FIT2

 *TRANSFORM* 1
           -0.63548  -0.00000   0.0        0.0        0.0        0.0
          -15.63603  -1.57364   0.0        0.0        0.0        0.0
            0.0       0.0       0.46156    0.00000    0.0        0.0
            0.0       0.0      28.41595    2.16653    0.0        0.0
            0.0       0.0       0.0        0.0        1.00000    0.0
            0.0       0.0       0.0        0.0        0.0        1.00000

 *LENGTH*    26.0000 FT

  *CORRECTIONS*

( 2.9092E 03)     0.063    -0.026

( 1.1744E 02)     0.003    -0.001

( 8.0844E-01)     0.000    -0.000

( 3.0664E-01)    -0.000     0.000
```

```
  *COVARIANCE  ( FIT   0.3 )
 0.000
-0.786  0.000
```

```
USE TRIPLET TO PUT WAIST ON TARGET



*BEAM*     1.C00000    1.C5 GEV
                                                  0.0 FT         0.0      0.500 IN
                                                                 0.0     17.500 MR     0.0
                                                                 0.0      0.500 IN     0.0      0.0
                                                                 0.0     17.500 MR     0.0      0.0      0.0
                                                                 0.0      0.0   CM     0.0      0.0      0.0      0.0
                                                                 0.0      3.000 PC     0.0      0.0      0.0      0.0      0.0

*DRIFT*    3.0     12.000C FT
                                                 12.0 FT         0.0      2.569 IN
                                                                 0.0     17.500 MR     0.981
                                                                 0.0      2.569 IN     0.0      0.0
                                                                 0.0     17.500 MR     0.0      0.0      0.981
                                                                 0.0      0.0   CM     0.0      0.0      0.0      0.0
                                                                 0.0      3.000 PC     0.0      0.0      0.0      0.0      0.0

*QUAD*     5.00   1.5000C FT -14.4423 KG   4.000 IN  (  -1.541 FT )
    VARY CODE = 020000
                                                 13.5 FT         0.0      4.093 IN
                                                                 0.0    164.000 MR     1.000
                                                                 0.0      1.822 IN     0.0      0.0
                                                                 0.0     94.316 MR     0.0      0.0     -0.999
                                                                 0.0      0.0   CM     0.0      0.0      0.0      0.0
                                                                 0.0      3.000 PC     0.0      0.0      0.0      0.0      0.0

*DRIFT*    3.0      C.5C00 FT
                                                 14.0 FT         0.0      5.C77 IN
                                                                 0.0    164.000 MR     1.000
                                                                 0.0      1.257 IN     0.0      0.0
                                                                 0.0     94.316 MR     0.0      0.0     -0.997
                                                                 0.0      0.0   CM     0.0      0.0      0.0      0.0
                                                                 0.0      3.000 PC     0.0      0.0      0.0      0.0      0.0

*QUAD*     5.00   3.00000 FT   8.37C6 KG   4.000 IN  (   2.170 FT )
    VARY CODE = 010000
                                                 17.0 FT         0.0      5.001 IN
                                                                 0.0    167.517 MR    -1.000
                                                                 0.0      1.931 IN     0.0      0.0
                                                                 0.0    110.245 MR     0.0      0.0      0.999
                                                                 0.0      0.0   CM     0.0      0.0      0.0      0.0
                                                                 0.0      3.000 PC     0.0      0.0      0.0      0.0      0.0

*DRIFT*    3.0      C.5000 FT
                                                 17.5 FT         0.0      3.996 IN
                                                                 0.0    167.517 MR    -1.000
                                                                 0.0      2.592 IN     0.0      0.0
                                                                 0.0    110.245 MR     0.0      0.0      1.000
```

```
                                                                          0.0       0.0  CM     0.0      0.0      0.0      0.0
                                                                          0.0       3.000 PC    0.0      0.0      0.0      0.0      0.0

*QUAD*     5.00    1.50000 FT -14.4423 KG    4.000 IN  (   -1.541 FT )
    VARY CCDE = 020000
                                                              19.0 FT     0.0       2.355 IN
                                                                          0.0      27.784 MR   -0.991
                                                                          0.0       3.283 IN    0.0      0.0
                                                                          0.0      38.993 MR    0.0      0.0     -0.998
                                                                          0.0       0.0  CM     0.0      0.0      0.0      0.0
                                                                          0.0       3.000 PC    0.0      0.0      0.0      0.0      0.0

*DRIFT*    3.C      7.0000 FT
                                                              26.0 FT     0.0       0.315 IN
                                                                          0.0      27.784 MR    0.000
                                                                          0.0       0.224 IN    0.0      0.0
                                                                          0.0      38.993 MR    0.0      0.0     -0.000
                                                                          0.0       0.0  CM     0.0      0.0      0.0      0.0
                                                                          0.0       3.000 PC    0.0      0.0      0.0      0.0      0.0


*FIT*     10.C      2. 1.    0.0    / 0.001

                                     0.000
        LABEL = FIT1


*FIT*     10.0      4. 3.    0.0    / 0.001

                                    -0.000
        LABEL = FIT2


 *TRANSFORM* 1
           -C.60539   0.0C497   C.C        0.0       0.0       0.0
          -15.34218  -1.52592   C.C        0.C       0.0       0.0
             0.0      0.0       C.41949   -0.00456   0.0       0.0
             C.0      0.C      27.71928    2.C8264   0.0       0.0
             0.0      0.0       0.C        0.0       1.00000   0.0
             0.0      0.0       0.0        0.C       0.0       1.00000


 *LENGTH*    26.0000 FT
```

```
'USE TRIPLET TO FIT CERTAIN SIZE BEAM ONTO TARGET'
1
(THIS PROBLEM IS THE SAME AS THE TWO PRECEDING ONES EXCEPT A PARTICULAR)
(SIZE OF THE BEAM IS ASKED FOR.  THE BLANK TYPE 15 CARD WHICH RESETS THE UNITS)
(IS TURNED ON.)
10.0 1.0 1.0 0.6 .001 'FIT1' ;
10.0 3.0 3.0 0.6 .001 'FIT2' ;
15.0  'UNT' ;
SENTINEL
```

```
USE TRIPLET TC FIT CERTAIN SIZE BEAM ONTO TARGET

    1

THIS PROBLEM IS THE SAME AS THE TWO PRECEDING ONES EXCEPT A PARTICULAR

SIZE OF THE BEAM IS ASKED FOR.  THE BLANK TYPE 15 CARD WHICH RESETS THE UNITS

IS TURNED CN.

  15.0C000    1.0C000   IN           2.5400C

  15.0C000    8.00000   FT           0.30480

   1.0C000    C.50000  17.49998   C.50000  17.49998   0.0        3.00000   1.05000

   3.0C000   12.00CC0

   5.0C000    1.50000 -14.4423C   4.C0000
   VARY CODE  020000

   3.00000    C.50000

   5.00000    3.00000   8.37058   4.C0000
   VARY CODE  010000

   3.00000    C.50000

   5.00000    1.50000 -14.4423C   4.C0000
   VARY CODE  020000

   3.0C000    7.00C00

  10.00000    1.00000   1.00000   0.60000   0.00100
    LABEL = FIT1

  10.00000    3.00000   3.0000C   0.60000   0.C0100
    LABEL = FIT2

  13.00000    4.00000

  15.00000    0.0                  0.0
    LABEL = UNT

  SENTINEL
```

```
USE TRIPLET TC FIT CERTAIN SIZE BEAM ONTO TARGET



*BEAM*     1.C00000    1.C5 GEV
                                                  0.0 FT        0.0     0.500 IN
                                                                0.0    17.500 MR    0.0
                                                                0.0     0.500 IN    0.0     0.0
                                                                0.0    17.500 MR    0.0     0.0     0.0
                                                                0.0     0.0   CM    0.0     0.0     0.0     0.0
                                                                0.0     3.000 PC    0.0     0.0     0.0     0.0     0.0

*DRIFT*    3.0    12.000C FT
                                                 12.0 FT        0.0     2.569 IN
                                                                0.0    17.500 MR    0.981
                                                                0.0     2.569 IN    0.0     0.0
                                                                0.0    17.500 MR    0.0     0.0     0.981
                                                                0.0     0.0   CM    0.0     0.0     0.0     0.0
                                                                0.0     3.000 PC    0.0     0.0     0.0     0.0     0.0

*QUAD*     5.00   1.50000 FT -14.4423 KG   4.000 IN  (  -1.541 FT )
    VARY CODE = 020000
                                                 13.5 FT        0.0     4.093 IN
                                                                0.0   164.000 MR    1.000
                                                                0.0     1.822 IN    0.0     0.0
                                                                0.0    94.316 MR    0.0     0.0    -0.999
                                                                0.0     0.0   CM    0.0     0.0     0.0     0.0
                                                                0.0     3.000 PC    0.0     0.0     0.0     0.0     0.0

*DRIFT*    3.0     C.500C FT
                                                 14.0 FT        0.0     5.077 IN
                                                                0.0   164.000 MR    1.000
                                                                0.0     1.257 IN    0.0     0.0
                                                                0.0    94.316 MR    0.0     0.0    -0.997
                                                                0.0     0.0   CM    0.0     0.0     0.0     0.0
                                                                0.0     3.000 PC    0.0     0.0     0.0     0.0     0.0

*QUAD*     5.C0   3.00C00 FT   8.37C6 KG   4.000 IN  (   2.170 FT )
    VARY CODE = 010000
                                                 17.0 FT        0.0     5.001 IN
                                                                0.0   167.517 MR   -1.000
                                                                0.0     1.931 IN    0.0     0.0
                                                                0.0   110.245 MR    0.0     0.0     0.999
                                                                0.0     0.0   CM    0.0     0.0     0.0     0.0
                                                                0.0     3.000 PC    0.0     0.0     0.0     0.0     0.0

*DRIFT*    3.0     C.5000 FT
                                                 17.5 FT        0.0     3.996 IN
                                                                0.0   167.517 MR   -1.000
                                                                0.0     2.592 IN    0.0     0.0
                                                                0.0   110.245 MR    0.0     0.0     1.000
```

```
                                                                                          0.0       0.0   CM     0.0      0.0      0.0      0.0
                                                                                          0.0       3.000 PC     0.0      0.0      0.0      0.0      0.0


*QUAD*     5.00    1.50000 FT -14.4423 KG    4.000 IN  (   -1.541 FT )
    VARY CODE = 020000
                                                                          19.0 FT         0.0       2.355 IN
                                                                                          0.0      27.784 MR    -0.991
                                                                                          0.0       3.283 IN     0.0      0.0
                                                                                          0.0      38.993 MR     0.0      0.0    -0.998
                                                                                          0.0       0.0   CM     0.0      0.0      0.0      0.0
                                                                                          0.0       3.000 PC     0.0      0.0      0.0      0.0      0.0


*DRIFT*    3.0      7.0000 FT
                                                                          26.0 FT         0.0       0.315 IN
                                                                                          0.0      27.784 MR     0.000
                                                                                          0.0       0.224 IN     0.0      0.0
                                                                                          0.0      38.993 MR     0.0      0.0    -0.000
                                                                                          0.0       0.0   CM     0.0      0.0      0.0      0.0
                                                                                          0.0       3.000 PC     0.0      0.0      0.0      0.0      0.0


*FIT*      10.0      1. 1.    0.600 / 0.001

                              0.315
         LABEL = FIT1


*FIT*      10.0      3. 3.    0.600 / 0.001

                              0.224
         LABEL = FIT2


 *TRANSFORM* 1
            -0.60539   0.00497    0.0        0.0        0.0        0.0
           -15.34218  -1.52592    0.0        0.0        0.0        0.0
             0.0       0.0        0.41949   -0.00456    0.0        0.0
             0.0       0.0       27.71928    2.08264    0.0        0.0
             0.0       0.0        0.0        0.0        1.00000    0.0
             0.0       0.0        0.0        0.0        0.0        1.00000


         LABEL = UNT

 *LENGTH*      7.9248 M

  *CORRECTIONS*

( 2.3856E 02)      5.266     -1.786

( 1.7593E 03)      1.335     -0.401

( 1.4466E 02)      0.115     -0.018

( 1.4665E 01)      0.012     -0.001
```

```
( 2.5497E-C1)      0.000      C.COO

  *COVARIANCE  ( FIT   0.3 )
 0.001
-0.918  0.001
```

USE TRIPLET TO FIT CERTAIN SIZE BEAM ONTO TARGET

```
*BEAM*      1.000000    1.05 GEV
                                                        0.0 FT        0.0      0.500 IN
                                                                      0.0     17.500 MR    0.0
                                                                      0.0      0.500 IN    0.0      0.0
                                                                      0.0     17.500 MR    0.0      0.0      0.0
                                                                      0.0      0.0   CM    0.0      0.0      0.0      0.0
                                                                      0.0      3.000 PC    0.0      0.0      0.0      0.0      0.0

*DRIFT*     3.0     12.0000 FT
                                                       12.0 FT        0.0      2.569 IN
                                                                      0.0     17.500 MR    0.981
                                                                      0.0      2.569 IN    0.0      0.0
                                                                      0.0     17.500 MR    0.0      0.0      0.981
                                                                      0.0      0.0   CM    0.0      0.0      0.0      0.0
                                                                      0.0      3.000 PC    0.0      0.0      0.0      0.0      0.0

*QUAD*      5.00    1.50000 FT  -7.7144 KG   4.000 IN  (  -3.073 FT )
    VARY CODE = 020000
                                                       13.5 FT        0.0      3.507 IN
                                                                      0.0     90.977 MR    1.000
                                                                      0.0      2.296 IN    0.0      0.0
                                                                      0.0     46.559 MR    0.0      0.0     -0.997
                                                                      0.0      0.0   CM    0.0      0.0      0.0      0.0
                                                                      0.0      3.000 PC    0.0      0.0      0.0      0.0      0.0

*DRIFT*     3.0      0.5000 FT
                                                       14.0 FT        0.0      4.053 IN
                                                                      0.0     90.977 MR    1.000
                                                                      0.0      2.017 IN    0.0      0.0
                                                                      0.0     46.559 MR    0.0      0.0     -0.996
                                                                      0.0      0.0   CM    0.0      0.0      0.0      0.0
                                                                      0.0      3.000 PC    0.0      0.0      0.0      0.0      0.0

*QUAD*      5.00    3.00000 FT   6.1646 KG   4.000 IN  (   2.671 FT )
    VARY CODE = 010000
                                                       17.0 FT        0.0      3.995 IN
                                                                      0.0     93.798 MR   -1.000
                                                                      0.0      1.574 IN    0.0      0.0
                                                                      0.0     19.690 MR    0.0      0.0      0.959
                                                                      0.0      0.0   CM    0.0      0.0      0.0      0.0
                                                                      0.0      3.000 PC    0.0      0.0      0.0      0.0      0.0

*DRIFT*     3.0      0.5000 FT
                                                       17.5 FT        0.0      3.432 IN
                                                                      0.0     93.798 MR   -1.000
                                                                      0.0      1.687 IN    0.0      0.0
                                                                      0.0     19.690 MR    0.0      0.0      0.965
```

```
                                                                                      0.0     0.0   CM    0.0     0.0     0.0     0.0
                                                                                      0.0     3.000 PC    0.0     0.0     0.0     0.0     0.0


*QUAD*     5.00   1.50000 FT  -7.7144 KG   4.000 IN  (  -3.073 FT )
    VARY CCDE = 020000
                                                                   19.0 FT            0.0     2.422 IN
                                                                                      0.0    22.958 MR   -0.988
                                                                                      0.0     1.638 IN    0.0     0.0
                                                                                      0.0    24.827 MR    0.0     0.0    -0.977
                                                                                      0.0     0.0   CM    0.0     0.0     0.0     0.0
                                                                                      0.0     3.000 PC    0.0     0.0     0.0     0.0     0.0


*DRIFT*    3.0      7.0000 FT
                                                                   26.0 FT            0.0     0.600 IN
                                                                                      0.0    22.958 MR   -0.772
                                                                                      0.0     0.600 IN    0.0     0.0
                                                                                      0.0    24.827 MR    0.0     0.0     0.809
                                                                                      0.0     0.0   CM    0.0     0.0     0.0     0.0
                                                                                      0.0     3.000 PC    0.0     0.0     0.0     0.0     0.0


*FIT*     10.0      1. 1.    0.600 / C.001

                             0.600
         LABEL = FIT1


*FIT*     10.C      3. 3.    0.600 / 0.001

                             0.600
         LABEL = FIT2


 *TRANSFORM* 1
            -C.46318   0.03163   0.0        0.0        0.0        0.0
           -13.21902  -1.25632   C.C        0.0        0.0        0.0
             0.0       0.0      -C.86633   -0.C2372    0.0        0.0
             C.0       0.C      -8.82873   -1.39605    C.0        0.0
             C.0       0.0       0.0        0.0        1.00000    0.0
             C.0       0.0       0.0        0.0        0.0        1.00000


         LABEL  = UNT

 *LENGTH*     7.9248 M
```

```
'BEAM SWITCHYARD END STATION A ALL FITTING AT ONCE'
(THIS SYSTEM WAS ONE OF THE DESIGNS FOR THE SWITCHYARD ELEMENTS WHICH)
(TRANSPORT THE SLAC BEAM TO END STATION A.  THE AUTOMATIC BEAM PRINTOUT IS)
(TURNED OFF BY THE 13. 2. ELEMENT.  THE MAGNETIC SYSTEM BEGINS WITH A BENDING)
(MAGNET WHICH DIVERTS THE BEAM BY .5 DEGREES.  THIS MAGNET IS FOLLOWED BY AN)
(EIGHTY METER DRIFT TO ALLOW THE BEAM TO CLEAR SUFFICIENTLY THE ACCELERATOR)
(CENTER LINE TO ALLOW THE INSTALLATION OF A QUADRUPOLE DOUBLET.  THE DOUBLET)
(IS FOLLOWED BY FOUR BENDING MAGNETS WHICH ARE ENTERED WITH THE USE OF THE TYPE)
(NINE REPEAT CODE.  THE INITIAL QUAD DOUBLET,Q1, IS ALLOWED TO VARY SO THAT A)
(FOCUS IS OBTAINED AT THE EXIT OF THE SYMMETRY QUADRUPOLE,Q2.  BOTH THE)
(POSITION AND THE FIELD OF Q2 ARE ALLOWED TO VARY SO AS TO GET AN ACHROMATIC)
(CONDITION AT THE EXIT OF THE SECOND FOUR BENDING MAGNETS.  A SECOND DOUBLET,Q3)
(IS ALLOWED TO VARY TO PRODUCE A CERTAIN BEAM SIZE AT THE ENTRANCE TO THE FINAL)
(DOUBLET,Q4.  THIS DOUBLET IS ALLOWED TO VARY TO GET A WAIST AND A CERTAIN SPOT)
(SIZE AT THE TARGET.)
(THIS IS AN EXAMPLE OF A PROGRAM WHICH WILL NOT FIT ALL OF THE CONSTRAINTS)
(AT ONCE.  THE SUBSEQUENT EXAMPLES SHOW THE USE OF SEQUENTIAL FITTING AND THE)
(USE OF THE TYPE ONE INDICATOR CARD.)
0
1.0 0.3 0.1 0.3 0.1 0.3 1.0 25.0 ;
13.0 2.0 ;
2.0 0.0 ;
4.0 5.0 1.45500 0.0 ;
2.0 0.5 ;
13.0 1.0 ;
3.0 80.0 ;
13.0 1.0 ;
5.01 2.0 -2.2 5.0 'Q1' ;
3.0 2.0 ;
5.01 2.0 2.4 5.0 'Q1' ;
13.0 1.0 ;
9.0 4.0 ;
3.0 1.0 ;
2.0 1.5 ;
4.0 3.0 14.55 0.0 ;
2.0 1.5 ;
9.0 0.0 ;
13.0 1.0 ;
3.9 30.0 'DR1' ;
5.01 2.0 5.0 15.0 'Q2' ;
13.0 1.0 ;
10.0 -1.0 2.0 0.0 0.001 'FIT1' ;
10.0 -3.0 4.0 0.0 0.001 'FIT1' ;
13.0 4.0 ;
3.4 20.0 'DR1' ;
13.0 1.0 ;
9.0 4.0 ;
2.0 1.5 ;
4.0 3.0 14.55 0.0 ;
2.0 1.5 ;
3.0 1.0 ;
9.0 0.0 ;
13.0 1.0 ;
10.0 -1.0 6.0 0.0 0.001 'FIT2' ;
10.0 -2.0 6.0 0.0 0.001 'FIT3' ;
13.0 4.0 ;
5.01 2.0 -1.9 5.0 'Q3' ;
3.0 2.0 ;
5.01 2.0 1.85 5.0 'Q3' ;
```

```
3.0 200.0 ;
13.0 1.0 ;
10.2 1.0 1.0 4.0 0.1 'FIT4' ;
10.2 3.0 3.0 1.5 0.1 'FIT4' ;
13.0 4.0 ;
13.0 1.0 ;
5.01 2.0 4.5 5.0 'Q4' ;
3.00 2.0 ;
13.0 1.0 ;
5.01 2.0 -4.2 5.0 'Q4' ;
13.0 1.0 ;
3.0 15.0 ;
13.0 1.0 ;
10.0 2.0 1.0 0.0 0.001 'FIT5' ;
10.0 4.0 3.0 0.0 0.001 'FIT6' ;
10.2 1.0 1.0 0.02 0.01 'FIT7' ;
10.2 3.0 3.0 0.02 0.01 'FIT7' ;
13.0 4.0 ;
SENTINEL
```

BEAM SWITCHYARD END STATION A ALL FITTING AT ONCE

THIS SYSTEM WAS ONE OF THE DESIGNS FOR THE SWITCHYARD ELEMENTS WHICH TRANSPORT THE SLAC BEAM TO END STATION A. THE AUTOMATIC BEAM PRINTOUT IS TURNED OFF BY THE 13. 2. ELEMENT. THE MAGNETIC SYSTEM BEGINS WITH A BENDING MAGNET WHICH DIVERTS THE BEAM BY .5 DEGREES. THIS MAGNET IS FOLLOWED BY AN EIGHTY METER DRIFT TO ALLOW THE BEAM TO CLEAR SUFFICIENTLY THE ACCELERATOR CENTER LINE TO ALLOW THE INSTALLATION OF A QUADRUPOLE DOUBLET. THE DOUBLET IS FOLLOWED BY FOUR BENDING MAGNETS WHICH ARE ENTERED WITH THE USE OF THE TYPE NINE REPEAT CODE. THE INITIAL QUAD DOUBLET,Q1, IS ALLOWED TO VARY SO THAT A FOCUS IS OBTAINED AT THE EXIT OF THE SYMMETRY QUADRUPOLE,Q2. BOTH THE POSITION AND THE FIELD OF Q2 ARE ALLOWED TO VARY SO AS TO GET AN ACHROMATIC CONDITION AT THE EXIT OF THE SECOND FOUR BENDING MAGNETS. A SECOND DOUBLET,Q3 IS ALLOWED TO VARY TO PRODUCE A CERTAIN BEAM SIZE AT THE ENTRANCE TO THE FINAL DOUBLET,Q4. THIS DOUBLET IS ALLOWED TO VARY TO GET A WAIST AND A CERTAIN SPOT SIZE AT THE TARGET.

THIS IS AN EXAMPLE OF A PROGRAM WHICH WILL NOT FIT ALL OF THE CONSTRAINTS AT ONCE. THE SUBSEQUENT EXAMPLES SHOW THE USE OF SEQUENTIAL FITTING AND THE USE OF THE TYPE ONE INDICATOR CARD.

```
    0
  1.00000   0.30000   0.10000   0.30000   0.10000   0.30000   1.00000  25.00000
 13.00000   2.00000
  2.00000   0.0
  4.00000   5.00000   1.45500   0.0
  2.00000   0.50000
 13.00000   1.00000
  3.00000  80.00000
 13.00000   1.00000
  5.00000   2.00000  -2.20000   5.00000
  VARY CODE  010000
   LABEL = Q1
  3.00000   2.00000
```

```
 5.00000   2.00000   2.40000   5.00000
 VARY CODE  010000
  LABEL = Q1

13.00000   1.00000

 9.00000   4.00000

 3.00000   1.00000

 2.00000   1.50000

 4.00000   3.00000  14.55000   0.0

 2.00000   1.50000

 9.00000   0.0

13.00000   1.00000

 3.00000  30.00000
 VARY CODE  900000
  LABEL = DR1

 5.00000   2.00000   5.00000  15.00000
 VARY CODE  010000
  LABEL = Q2

13.00000   1.00000

10.00000  -1.00000   2.00000   0.0       0.00100
  LABEL = FIT1

10.00000  -3.00000   4.00000   0.0       0.00100
  LABEL = FIT1

13.00000   4.00000

 3.00000  20.00000
 VARY CODE  400000
  LABEL = DR1

13.00000   1.00000

 9.00000   4.00000

 2.00000   1.50000

 4.00000   3.00000  14.55000   0.0

 2.00000   1.50000

 3.00000   1.00000

 9.00000   0.0

13.00000   1.00000

10.00000  -1.00000   6.00000   0.0       0.00100
  LABEL = FIT2
```

```
10.00C00  -2.00C00   6.00000   0.0        0.C0100
  LABEL = FIT3

13.00000   4.00000

 5.C0000   2.00000  -1.90000   5.C0000
 VARY CODE  010000
  LABEL = Q3

 3.00000   2.00000

 5.00000   2.00000   1.85000   5.C0000
 VARY CODE  010000
  LABEL = Q3

 3.0C000 2C0.000C0

13.000C0   1.00000

10.00000   1.00000   1.0C000   4.00000   0.10000
 VARY CODE  2C0000
  LABEL = FIT4

10.0C000   3.0CC00   3.00000   1.50000   0.10000
 VARY CODE  200000
  LABEL = FIT4

13.0000C   4.00000

13.00000   1.00000

 5.00000   2.00000   4.5C0CC   5.C0000
 VARY CODE  010000
  LABEL = Q4

 3.0C0C0   2.00000

13.00000   1.00CC0

 5.00000   2.00000  -4.2000C   5.C0000
 VARY CODE  010000
  LABEL = Q4

13.0C000   1.00000

 3.00000  15.00C00

13.00000   1.00000

10.00000   2.00000   1.C0000   0.C        0.00100
  LABEL = FIT5

10.00000   4.00000   3.0C000   0.0        0.C0100
  LABEL = FIT6

10.CC000   1.00000   1.C0000   0.02000   0.C1000
 VARY CODE  200000
  LABEL = FIT7

10.00000   3.00000   3.C0000   0.C2000   0.C1000
```

```
 VARY CODE  200000
  LABEL = FIT7

13.00000    4.00000

SENTINEL
```

```
*BEAM*     1.C00000   25.0C GEV
                                                    0.0 M        0.0     0.300 CM
                                                                 0.0     0.100 MR    0.0
                                                                 0.0     0.300 CM    0.0     0.0
                                                                 0.0     0.100 MR    0.0     0.0     0.0
                                                                 0.0     0.300 CM    0.0     0.0     0.0     0.0
                                                                 0.0     1.000 PC    0.0     0.0     0.0     0.0     0.0


*ROTAT*    2.0     0.0  D

*BEND*     4.000   5.C0C00 M    1.455 KG   0.0000 (   0.500 D )

*ROTAT*    2.C     0.50 D

                                                    5.0 M        0.0     0.305 CM
                                                                 0.0     0.133 MR    0.171
                                                                 0.0     0.304 CM    0.0     0.0
                                                                 0.0     0.100 MR    0.0     0.0     0.164
                                                                 0.0     0.300 CM   -0.009  -0.001   0.0     0.0
                                                                 0.0     1.000 PC    0.071   0.657   0.0     0.0    -0.000

*DRIFT*    3.0    8C.000C M

                                                   85.0 M        0.0     1.153 CM
                                                                 0.0     0.133 MR    0.965
                                                                 0.0     0.901 CM    0.0     0.0
                                                                 0.0     0.100 MR    0.0     0.0     0.943
                                                                 0.0     0.300 CM   -0.003  -0.001   0.0     0.0
                                                                 0.0     1.000 PC    0.624   0.657   0.0     0.0    -0.000

*QUAD*     5.00   2.00000 M   -2.2000 KG   5.000 CM  (  -9.151 M  )
    VARY CODE = 010000
         LABEL = C1

*DRIFT*    3.0     2.0000 M

*QUAD*     5.00   2.00000 M    2.4000 KG   5.000 CM  (   9.029 M  )
    VARY CODE = 010000
         LABEL = C1

                                                   91.0 M        0.0     1.675 CM
                                                                 0.0     0.511 MR   -0.999
                                                                 0.0     0.564 CM    0.0     0.0
                                                                 0.0     0.151 MR    0.0     0.0    -0.936
```

```
                                                                                0.0       0.300 CM   -0.003  0.003  0.0     0.0
                                                                                0.0       1.000 PC    0.626 -0.616  0.0     0.0    -0.000

*DRIFT*    3.0     1.0000 M

*ROTAT*    2.0     1.50 D

*BEND*     4.000   3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0     1.50 D

*DRIFT*    3.0     1.0000 M

*ROTAT*    2.0     1.50 D

*BEND*     4.000   3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0     1.50 D

*DRIFT*    3.0     1.0000 M

*ROTAT*    2.0     1.50 D

*BEND*     4.000   3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0     1.50 D

*DRIFT*    3.0     1.0000 M

*ROTAT*    2.0     1.50 D

*BEND*     4.000   3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0     1.50 D

                                                                 107.0 M        0.0       2.218 CM
                                                                                0.0       1.824 MR    0.865
                                                                                0.0       0.336 CM    0.0     0.0
                                                                                0.0       0.165 MR    0.0     0.0    -0.841
                                                                                0.0       0.457 CM   -0.715 -0.497  0.0     0.0
                                                                                0.0       1.000 PC    0.954  0.975  0.0     0.0    -0.610
```

```
*DRIFT*    3.C    3C.0000 M
    VARY CODE = 900000
         LABEL = DR1


*QUAD*     5.00   2.00000 M     5.0000 KG  15.000 CM  (  12.848 M  )
    VARY CCDE = 010000
         LABEL = C2


                                                       139.0 M          0.0      7.236 CM
                                                                        0.0      4.163 MR   -C.998
                                                                        0.0      0.329 CM    0.0     0.0
                                                                        0.0      0.384 MR    0.0     0.0     0.971
                                                                        0.0      0.457 CM   -0.573  0.605   0.0     0.0
                                                                        0.0      1.000 PC    0.997 -1.000   0.0     C.0    -0.610


*FIT*     10.0    -1. 2.    0.C    / 0.00l

                             -5.150
         LABEL = FIT1


*FIT*     10.0    -3. 4.    0.0    / 0.001

                             -1.010
         LABEL = FIT1


 *TRANSFORM* 1
             -C.93476  -5.14981   0.C       0.C       0.0       7.21223
              0.24797   0.29632   C.C       0.0       0.0      -4.16246
              C.0       0.0      -1.04482  -1.01024   0.0       0.0
              C.0       0.0      -1.C8980  -2.01081   0.0       0.0
             -C.21025  -1.92988   0.C       0.0       1.00000  -0.27894
              0.0       0.0       0.C       0.C       0.0       1.00000

*DRIFT*    3.C    20.0000 M
    VARY CODE = 40C000
         LABEL = DR1


                                                       159.0 M          0.0      1.210 CM
                                                                        0.0      4.163 MR    C.915
                                                                        0.0      1.090 CM    0.0     0.C
                                                                        0.0      0.384 MR    0.0     0.0     0.997
                                                                        0.0      0.457 CM    0.735  0.605   0.0     0.0
                                                                        0.0      1.000 PC   -0.920 -1.000   0.0     0.0    -0.610


*ROTAT*    2.0     1.50 D


*BEND*     4.000   3.0000C M   14.550 KG   0.0000 (   2.999 D )
```

```
*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M

*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.C      1.0000 M

*ROTAT*    2.C      1.50 D

*BEND*     4.000    3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.C      1.50 D

*DRIFT*    3.C      1.000C M

*ROTAT*    2.C      1.5C D

*BEND*     4.000    3.000CC M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.C      1.50 D

*DRIFT*    3.C      1.000C M


                                                    175.0 M        0.0      6.005 CM
                                                                   0.0      2.070 MR    0.996
                                                                   0.0      1.664 CM    0.0     0.0
                                                                   0.0      0.334 MR    0.0     0.0     0.999
                                                                   0.0      0.588 CM   -0.824  -0.843   0.0     0.0
                                                                   0.0      1.000 PC   -0.998  -0.999   0.0     0.0     0.838


*FIT*     10.0    -1. 6.    0.0    / 0.001
                         -5.991
          LABEL = FIT2
```

```
*FIT*      10.0     -2. 6.    0.0    / C.001

                            -2.068
        LABEL = FIT3



 *TRANSFORM* 1
           -0.04222  -4.C8323   C.C        0.C        0.0       -5.99086
            C.24796   0.29627   C.C        0.0        0.0       -2.06827
            C.0       0.C      -4.85194   -8.C6319    0.0        0.0
            0.0       0.0      -0.94335   -1.77381    0.0        0.0
           -C.15728  -1.02203   0.C        0.0        1.000C0    0.49253
            0.0       0.0       0.0        0.C        0.0        1.00000


*QUAD*     5.00   2.00000 M    -1.9000 KG    5.000 CM  ( -10.646 M  )
    VARY CCDE = 010000
         LABEL = C3


*DRIFT*    3.0     2.000C M


*QUAD*     5.00   2.00000 M     1.85C0 KG    5.000 CM  (  11.609 M  )
    VARY CODE = 010000
         LABEL = C3


*DRIFT*    3.0   2CC.000C M


                                      381.0 M       0.0    6.365 CM
                                                    0.0    0.211 MR   -0.543
                                                    0.0    0.620 CM    0.0    0.0
                                                    0.0    0.049 MR    0.0    0.0   -0.138
                                                    0.0    0.588 CM   -0.854  0.545  0.0    0.0
                                                    0.0    1.000 PC   -0.943  0.790  0.0    0.0    C.838



*FIT*      10.0     1. 1.    4.C00 / C.100

                            6.365
    VARY CODE = 200000
         LABEL = FIT4



*FIT*      10.C     3. 3.    1.500 / C.100

                            0.620
    VARY CODE = 200000
         LABEL = FIT4



 *TRANSFORM* 1
            3.42958  18.46803   0.0        0.0        0.0       -6.00397
            0.16690   1.19030   0.C        0.C        0.0        0.16643
```

```
            0.0        0.0       -0.30513  -6.13656   0.0       0.0
            0.0        0.0        0.16271  -0.C0492   0.0       0.0
           -C.15728   -1.02203    0.C       0.0       1.00000   0.49253
            0.0        0.0        0.0       0.0       0.0       1.00000


                                                       381.0 M        0.0      6.365 CM
                                                                      0.0      0.211 MR    -0.543
                                                                      0.0      0.620 CM     0.0    0.0
                                                                      0.0      0.049 MR     0.0    0.0    -0.138
                                                                      0.0      0.588 CM    -0.854  0.545   0.0     0.0
                                                                      0.0      1.000 PC    -0.943  0.790   0.0     0.0     0.838


*QUAD*     5.00   2.00000 M    4.5000 KG   5.000 CM  (   4.984 M  )
    VARY CODE = 010000
         LABEL = Q4


*DRIFT*    3.0     2.0000 M


                                                       385.0 M        0.0      2.447 CM
                                                                      0.0     12.863 MR    -0.999
                                                                      0.0      1.044 CM     0.0    0.0
                                                                      0.0      1.431 MR     0.0    0.0     1.000
                                                                      0.0      0.588 CM    -0.851  0.855   0.0     0.0
                                                                      0.0      1.000 PC    -0.935  0.947   0.0     0.0     0.838


*QUAD*     5.00   2.00000 M   -4.2000 KG   5.000 CM  (  -4.645 M  )
    VARY CODE = 010000
         LABEL = Q4


                                                       387.0 M        0.0      0.232 CM
                                                                      0.0     10.281 MR    -0.881
                                                                      0.0      1.108 CM     0.0    0.0
                                                                      0.0      0.813 MR     0.0    0.0    -0.999
                                                                      0.0      0.588 CM    -0.721  0.857   0.0     0.0
                                                                      0.0      1.000 PC    -0.696  0.953   0.0     0.0     0.838


*DRIFT*    3.C    15.000C M


                                                       402.0 M        0.0     15.217 CM
                                                                      0.0     10.281 MR     1.000
                                                                      0.0      0.119 CM     0.0    0.0
                                                                      0.0      0.813 MR     0.0    0.0     0.950
                                                                      0.0      0.588 CM     0.857  0.857   0.0     0.0
                                                                      0.0      1.000 PC     0.955  0.953   0.0     0.0     0.838


*FIT*     10.0     2. 1.   0.0   / 0.001

                         156.438
         LABEL = FIT5
```

```
*FIT*     10.C     4. 3.    0.0   / 0.001

                            0.092
        LABEL = FIT6


*FIT*     10.C     1. 1.    0.C20 / 0.010

                           15.217
    VARY CODE = 200000
        LABEL = FIT7


*FIT*     10.0     3. 3.    0.020 / 0.010

                            0.119
    VARY CODE = 200000
        LABEL = FIT7
```

TRANSFORM 1

-2.33281	3.132CC	0.C	0.C	0.0	0.0
-1.58390	1.65786	0.0	0.0	0.0	0.0
C.0	0.0	-0.17269	C.77960	0.0	0.0
C.0	0.0	-1.30944	0.12067	0.0	0.C
0.0	0.C	0.C	0.0	1.00000	0.0
0.0	0.0	0.C	0.0	0.0	1.00000

LENGTH   4C1.9995 M

CORRECTICNS

(1.8965E C5)	0.152	-0.247	0.0	0.0	0.0	0.050	-0.C97	0.0
(4.7894E C4)	0.009	-0.CC8	0.0	0.0	-0.040	0.042	0.0	0.C
(1.3659E C4)	0.022	-C.C47	0.0	-1.439	-0.099	0.131	0.0	0.0
(1.9515E C5)	-0.CC9	0.017	0.0	0.391	C.0	0.0	-0.046	0.0
(5.5914E C4)	0.005	-C.C10	0.0	-0.402	0.0	0.369	0.194	0.0
(4.2568E 05)	0.003	-C.000	0.0	0.221	0.0	0.0	-0.007	0.C85
(2.1816E C5)	-0.002	C.C00	0.0	-0.226	C.0	-0.233	-0.029	0.012
(2.8178E C5)	-0.002	0.003	0.0	0.258	0.0	0.0	-0.016	0.0
(9.1541E 04)	0.002	-0.003	0.0	-0.247	0.0	-1.646	-0.454	-0.115
(9.1299E 05)	0.C97	-C.C38	0.0	-0.266	C.0	0.0	-0.003	0.003

FAILED

```
BEAM SWITCHYARD END STATION A ALL FITTING AT ONCE


*BEAM*      1.000000   25.00 GEV
                                                            0.0 M         0.0      0.300 CM
                                                                          0.0      0.100 MR    0.0
                                                                          0.0      0.300 CM    0.0     0.0
                                                                          0.0      0.100 MR    0.0     0.0     0.0
                                                                          0.0      0.300 CM    0.0     0.0     0.0     0.0
                                                                          0.0      1.000 PC    0.0     0.0     0.0     0.0     0.0



*ROTAT*     2.0      0.0  D


*BEND*      4.000    5.00000 M    1.455 KG   0.0000 (    0.500 D )


*ROTAT*     2.0      0.50 D

                                                            5.0 M         0.0      0.305 CM
                                                                          0.0      0.133 MR    0.171
                                                                          0.0      0.304 CM    0.0     0.0
                                                                          0.0      0.100 MR    0.0     0.0     0.164
                                                                          0.0      0.300 CM   -0.009  -0.001   0.0     0.0
                                                                          0.0      1.000 PC    0.071   0.657   0.0     0.0    -0.000


*DRIFT*     3.0     80.0000 M

                                                           85.0 M         0.0      1.153 CM
                                                                          0.0      0.133 MR    0.965
                                                                          0.0      0.901 CM    0.0     0.0
                                                                          0.0      0.100 MR    0.0     0.0     0.943
                                                                          0.0      0.300 CM   -0.003  -0.001   0.0     0.0
                                                                          0.0      1.000 PC    0.624   0.657   0.0     0.0    -0.000

*QUAD*      5.00    2.00000 M   -1.9227 KG   5.000 CM  ( -10.517 M  )
    VARY CODE = 010000
         LABEL = Q1

*DRIFT*     3.0      2.0000 M

*QUAD*      5.00    2.00000 M    2.0662 KG   5.000 CM  (  10.431 M  )
    VARY CODE = 010000
         LABEL = Q1

                                                           91.0 M         0.0      1.625 CM
                                                                          0.0      0.356 MR   -0.998
                                                                          0.0      0.615 CM    0.0     0.0
                                                                          0.0      0.094 MR    0.0     0.0    -0.856
```

```
                                                      0.0      0.300 CM   -0.003  0.003  0.0    0.0
                                                      0.0      1.000 PC    0.627 -0.611  0.0    0.0    -0.000

*DRIFT*    3.0     1.0000 M

*ROTAT*    2.0     1.50 D

*BEND*     4.000   3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0     1.50 D

*DRIFT*    3.0     1.0000 M

*ROTAT*    2.0     1.50 D

*BEND*     4.000   3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0     1.50 D

*DRIFT*    3.0     1.0000 M

*ROTAT*    2.0     1.50 D

*BEND*     4.000   3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0     1.50 D

*DRIFT*    3.0     1.0000 M

*ROTAT*    2.0     1.50 D

*BEND*     4.000   3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0     1.50 D


                                      107.0 M         0.0      2.385 CM
                                                      0.0      1.898 MR    0.878
                                                      0.0      0.477 CM    0.0    0.0
                                                      0.0      0.111 MR    0.0    0.0    -0.824
                                                      0.0      0.470 CM   -0.737 -0.542  0.0    0.0
                                                      0.0      1.000 PC    0.939  0.989  0.0    0.0    -0.617
```

```
*DRIFT*    3.0    30.0000 M
    VARY CODE = 900000
         LABEL = DR1


*QUAD*     5.00   2.00000 M    3.2909 KG  15.000 CM  (  19.342 M  )
    VARY CODE = 010000
         LABEL = Q2


                                                 139.0 M         0.0       7.830 CM
                                                                 0.0       2.304 MR    -0.993
                                                                 0.0       0.287 CM     0.0     0.0
                                                                 0.0       0.168 MR     0.0     0.0     0.783
                                                                 0.0       0.470 CM    -0.612   0.663   0.0     0.0
                                                                 0.0       1.000 PC     1.000 -0.994   0.0     0.0    -0.617


*FIT*      10.0    -1. 2.    0.0    / 0.001

                          -0.405
         LABEL = FIT1


*FIT*      10.0    -3. 4.    0.0    / 0.001

                           2.223
         LABEL = FIT1


 *TRANSFORM* 1
           -0.42470  -0.40498   0.0       0.0       0.0       7.82867
           -0.16137  -2.50845   0.0       0.0       0.0      -2.29023
            0.0       0.0      -0.60594   2.22344   0.0       0.0
            0.0       0.0      -0.54673   0.35586   0.0       0.0
           -0.22360  -2.05654   0.0       0.0       1.00000  -0.28970
            0.0       0.0       0.0       0.0       0.0       1.00000

*DRIFT*    3.0    20.0000 M
    VARY CODE = 400000
         LABEL = DR1


                                                 159.0 M         0.0       3.301 CM
                                                                 0.0       2.304 MR    -0.959
                                                                 0.0       0.588 CM     0.0     0.0
                                                                 0.0       0.168 MR     0.0     0.0     0.953
                                                                 0.0       0.470 CM    -0.525   0.663   0.0     0.0
                                                                 0.0       1.000 PC     0.984 -0.994   0.0     0.0    -0.617


*ROTAT*    2.0     1.50 D


*BEND*     4.000   3.00000 M   14.550 KG   0.0000 (   2.999 D )
```

```
*ROTAT*    2.0     1.50 D

*DRIFT*    3.0     1.0000 M

*ROTAT*    2.C     1.50 D

*BEND*     4.000   3.00000 M   14.550 KG   0.0000 (    2.999 D )

*ROTAT*    2.0     1.50 D

*DRIFT*    3.C     1.0000 M

*ROTAT*    2.C     1.50 D

*BEND*     4.000   3.000C0 M   14.550 KG   0.0000 (    2.999 D )

*ROTAT*    2.C     1.50 D

*DRIFT*    3.C     1.000C M

*ROTAT*    2.C     1.5C D

*BEND*     4.000   3.000CC M   14.550 KG   0.0000 (    2.999 D )

*ROTAT*    2.C     1.50 D

*DRIFT*    3.0     1.000C M


                                                  175.0 M        0.0      1.686 CM
                                                                 0.0      0.322 MR   -C.030
                                                                 0.0      0.827 CM    0.0     0.0
                                                                 0.0      0.143 MR    0.0     0.C     0.967
                                                                 0.0      0.787 CM   -0.706   0.616   0.0     0.0
                                                                 0.0      1.000 PC    0.809  -0.609   0.0     C.0    -0.922


*FIT*     10.0    -1. 6.    0.0    / 0.001
                            1.365
       LABEL = FIT2
```

```
*FIT*     10.0    -2. 6.   0.0   / 0.001

                          -0.196
        LABEL = FIT3


 *TRANSFORM* 1
              -1.00555  -9.43406   0.0       0.0       0.0       1.36466
              -0.16138  -2.50852   0.0       0.0       0.0      -0.19597
               0.0       0.0      -2.51335   3.40842   0.0       0.0
               0.0       0.0      -0.47030   0.23991   0.0       0.0
              -0.04173  -0.52722   0.0       0.0       1.00000  -0.72547
               0.0       0.0       0.0       0.0       0.0       1.00000


*QUAD*     5.00   2.00000 M   -2.0393 KG   5.000 CM  (  -9.897 M  )
    VARY CODE = 010000
        LABEL = Q3


*DRIFT*    3.0     2.0000 M


*QUAD*     5.00   2.00000 M    0.5624 KG   5.000 CM  (  37.404 M  )
    VARY CODE = 010000
        LABEL = Q3


*DRIFT*    3.0   200.0000 M


                                                  381.0 M        0.0     24.547 CM
                                                                 0.0      1.106 MR    1.000
                                                                 0.0      9.523 CM    0.0    0.0
                                                                 0.0      0.502 MR    0.0    0.0    1.000
                                                                 0.0      0.787 CM   -0.528 -0.512  0.0    0.0
                                                                 0.0      1.000 PC    0.630  0.615  0.0    0.0   -0.922


*FIT*     10.0     1. 1.   4.000 / 0.100

                          24.547
    VARY CODE = 200000
        LABEL = FIT4


*FIT*     10.0     3. 3.   1.500 / 0.100

                           9.523
    VARY CODE = 200000
        LABEL = FIT4


 *TRANSFORM* 1
            -17.43910-183.25438   0.0       0.0       0.0      15.47083
             -0.79310  -8.39143   0.0       0.0       0.0       0.67966
```

```
          C.0         0.0         27.77695 -46.C9175   0.0         0.0
          C.0         0.C          1.47038  -2.40389   0.0         0.0
         -0.04173    -0.52722     C.C        0.0       1.00000    -0.72547
          C.0         0.C         0.0        0.0       0.0         1.00000

                                                   381.0 M          0.0     24.547 CM
                                                                    0.0      1.106 MR    1.000
                                                                    0.0      9.523 CM    0.0    0.0
                                                                    0.0      0.502 MR    0.0    0.0    1.000
                                                                    0.0      0.787 CM   -0.528 -0.512  0.0    C.0
                                                                    0.0      1.000 PC    0.630  0.615  0.0    C.0   -0.922

*QUAD*     5.00   2.00000 M    4.0428 KG   5.000 CM  (   5.506 M  )
    VARY CODE = 010000
         LABEL = Q4

*DRIFT*    3.0      2.0000 M

                                                   385.0 M          0.0     11.409 CM
                                                                    0.0     43.685 MR   -1.000
                                                                    0.0     15.594 CM    0.0    0.0
                                                                    0.0     20.287 MR    0.0    0.0    1.000
                                                                    0.0      0.787 CM   -0.527  0.528  0.0    0.0
                                                                    0.0      1.000 PC    0.630 -0.631  0.0    0.0   -0.922

*QUAD*     5.C0   2.00000 M   -4.2154 KG   5.000 CM  (  -4.627 M  )
    VARY CODE = 010000
         LABEL = Q4

                                                   387.0 M          0.0      4.456 CM
                                                                    0.0     28.165 MR   -1.000
                                                                    0.0     16.335 CM    0.0    0.0
                                                                    0.0     13.128 MR    0.0    0.0   -1.000
                                                                    0.0      0.787 CM   -0.525  0.529  0.0    0.0
                                                                    0.0      1.000 PC    0.628 -0.631  0.0    0.0   -0.922

*DRIFT*    3.C     15.000C M

                                                   402.0 M          0.0     37.791 CM
                                                                    0.0     28.165 MR    1.000
                                                                    0.0      3.356 CM    0.0    0.0
                                                                    0.0     13.128 MR    0.0    0.0    1.000
                                                                    0.0      0.787 CM    0.529  0.529  0.0    0.0
                                                                    0.0      1.000 PC   -0.632 -0.631  0.0    0.0   -0.922

*FIT*     10.0      2. 1.   0.C   / 0.001

                          1064.395
         LABEL = FIT5
```

```
*FIT*      10.C      4. 3.    0.0    / 0.0C1

                              44.C64
         LABEL = FIT6


*FIT*      10.C      1. 1.    0.C2C / C.010

                              37.791
     VARY CCDE = 200000
          LABEL = FIT7


*FIT*      10.C      3. 3.    0.02C / C.010

                               3.356
     VARY CODE = 200000
          LABEL = FIT7


 *TRANSFORM* 1
            -1.68385   3.20353   0.C        0.0        0.0        0.0
            -1.22568   1.73799   0.0        0.0        0.0        0.0
             0.0       0.0      -0.39221    0.75345    0.0        0.0
             0.0       0.0      -1.38436    0.10974    0.0        0.0
             0.0       0.0       0.0        0.0        1.00000    0.0
             0.0       0.0       0.0        0.0        0.0        1.00000

 *LENGTH*   401.9955 M
```

```
'BEAM TRANSPORT SYSTEM FOR SLAC BEAM SWITCHYARD END STATION A I'
0
(THE FIRST STEP TO FITTING IS TO ALLOW ONLY THE POSITION AND FIELD OF THE)
(SYMMETRY QUAD,Q2, TO VARY IN ORDER TO GET AN ACHROMATIC CONDITION BETWEEN THE)
(FIRST SET OF BENDING MAGNETS AND THE SECOND QUAD DOUBLET,Q3.)
1.0 0.3 0.1 0.3 0.1 0.3 1.0 25.0 ;
13.0 2.0 ;
4.0 5.0 1.45500 0.0 ;
2.0 0.5 ;
13.0 1.0 ;
3.0 80.0 ;
13.0 1.0 ;
5.0 2.0 -2.2 5.0 'Q1' ;
3.0 2.0 ;
5.0 2.0 2.4 5.0 'Q1' ;
13.0 1.0 ;
9.0 4.0 ;
3.0 1.0 ;
2.0 1.5 ;
4.0 3.0 14.55000 0.0 ;
2.0 1.5 ;
9.0 0.0 ;
13.0 1.0 ;
3.9 30.0 'DR1' ;
5.01 2.0 5.0 15.0 'Q2' ;
13.0 1.0 ;
-10.0 -1.0 2.0 0.0 0.001 'FIT1' ;
-10.0 -3.0 4.0 0.0 0.001 'FIT1' ;
13.0 4.0 ;
3.4 20.0 'DR1' ;
13.0 1.0 ;
9.0 4.0 ;
2.0 1.50 ;
4.0 3.0 14.55000 0.0 ;
2.0 1.5 ;
3.0 1.0 ;
9.0 0.0 ;
13.0 1.0 ;
10.0 -1.0 6.0 0.0 0.001 'FIT2' ;
10.0 -2.0 6.0 0.0 0.001 'FIT3' ;
13.0 4.0 ;
5.0 2.0 -1.9 5.0 'Q3' ;
3.0 2.0 ;
5.0 2.0 1.85000 5.0 'Q3' ;
3.0 200.0 ;
13.0 1.0 ;
-10.2 1.0 1.0 4.0 0.1 'FIT4' ;
-10.2 3.0 3.0 1.5 0.1 'FIT4' ;
13.0 4.0 ;
13.0 1.0 ;
5.0 2.0 4.5 5.0 'Q4' ;
3.0 2.0 ;
13.0 1.0 ;
5.0 2. -4.2 5.0 'Q4' ;
13.0 1.0 ;
3.0 15.0 ;
13.0 1.0 ;
-10.0 2.0 1.0 0.0 0.001 'FIT5' ;
-10.0 4.0 3.0 0.0 0.001 'FIT6' ;
-10.2 1.0 1.0 0.02000 0.01000 'FIT7' ;
-10.2 3.0 3.0 0.02000 0.01000 'FIT7' ;
13.0 4.0 ;
SENTINEL
```

```
BEAM TRANSPORT SYSTEM FOR SLAC BEAM SWITCHYARD END STATICN A I

    0

THE FIRST STEP TO FITTING IS TO ALLOW ONLY THE POSITION AND FIELD OF THE

SYMMETRY QUAC,Q2, TO VARY IN ORDER TO GET AN ACHROMATIC CONDITION BETWEEN THE

FIRST SET OF BENDING MAGNETS AND THE SECOND QUAD DOUBLET,Q3.

   1.00000   C.30000   0.10000   0.30000   0.10000   0.30000   1.00000  25.00000

  13.00000   2.00000

   4.00000   5.00000   1.45500   0.0

   2.00000   0.50000

  13.00000   1.00000

   3.00000  80.00000

  13.00000   1.00000

   5.00000   2.00000  -2.20000   5.00000
    LABEL = Q1

   3.00000   2.00000

   5.00000   2.00000   2.40000   5.00000
    LABEL = Q1

  13.00000   1.00000

   9.00000   4.00000

   3.00000   1.00000

   2.00000   1.50000

   4.00000   3.00000  14.55000   0.0

   2.00000   1.50000

   9.00000   0.0

  13.00000   1.00000

   3.00000  30.00000
   VARY CODE  900000
    LABEL = DR1

   5.00000   2.00000   5.00000  15.00000
   VARY CODE  010000
    LABEL = Q2

  13.00000   1.00000

 -10.00000  -1.00000   2.00000   0.0       0.00100
    LABEL = FIT1
```

```
-10.00000  -3.00000   4.00000   0.0       0.00100
   LABEL = FIT1

 13.00000   4.00000

  3.0C000  20.00000
  VARY CODE  400000
   LABEL = DR1

 13.00000   1.00000

  9.0C000   4.00000

  2.00000   1.50000

  4.0C000   3.00000  14.55000   0.0

  2.00000   1.50000

  3.0C000   1.00000

  9.CC000   C.0

 13.00000   1.00000

 10.00000  -1.00000   6.00000   0.0       0.C0100
   LABEL = FIT2

 10.00000  -2.00000   6.00000   0.0       0.C0100
   LABEL = FIT3

 13.00000   4.00000

  5.00000   2.00000  -1.90000   5.00000
   LABEL = Q3

  3.0C000   2.00000

  5.0C000   2.00C00   1.85000   5.00000
   LABEL = C3

  3.00000 20C.00000

 13.00000   1.00C00

-10.00000   1.00000   1.00000   4.00000   0.10000
  VARY CODE  200000
   LABEL = FIT4

-10.00000   3.00C00   3.C0000   1.50000   0.10000
  VARY CODE  200000
   LABEL = FIT4

 13.00000   4.00000

 13.00000   1.00000

  5.00000   2.00000   4.5C00C   5.C0000
   LABEL = C4
```

```
  3.00000   2.C0000

 13.00000   1.00000

  5.00000   2.00000  -4.20000   5.C0000
   LABEL  =  Q4

 13.0C000   1.00000

  3.00000  15.00C00

 13.0C000   1.00000

-10.00000   2.C0000   1.C0000   0.C        0.C0100
   LABEL  =  FIT5

-10.00000   4.00000   3.CC000   0.0        0.00100
   LABEL  =  FIT6

-10.00000   1.00000   1.00000   0.02000    0.C1000
  VARY CODE   200C00
   LABEL  =  FIT7

-10.00000   3.00000   3.CC0CC   0.02000    0.C1000
  VARY CODE   200000
   LABEL  =  FIT7

 13.0C000   4.00000

 SENTINEL
```

BEAM TRANSPORT SYSTEM FOR SLAC BEAM SWITCHYARD END STATICN A I

```
*BEAM*      1.C00000    25.CO GEV
                                                          0.0 M          0.0      0.300 CM
                                                                         0.0      0.100 MR    0.0
                                                                         0.0      0.300 CM    C.0     0.0
                                                                         0.0      0.100 MR    0.0     0.0     0.0
                                                                         0.0      0.300 CM    0.0     0.0     0.0     0.0
                                                                         0.0      1.000 PC    0.0     0.0     0.0     0.0     0.0


*BEND*      4.000    5.0000C0 M    1.455 KG    0.0000 (    0.500 D )

*ROTAT*     2.0      0.50 D

                                                          5.0 M          0.0      0.305 CM
                                                                         0.0      0.133 MR    0.171
                                                                         0.0      0.304 CM    0.0     0.0
                                                                         0.0      0.100 MR    0.0     0.0     0.164
                                                                         0.0      0.300 CM   -0.009  -0.001   0.0     0.0
                                                                         0.0      1.000 PC    0.071   0.657   0.0     0.0    -0.000

*DRIFT*     3.0      80.0000 M

                                                         85.0 M          0.0      1.153 CM
                                                                         0.0      0.133 MR    C.965
                                                                         0.0      0.901 CM    0.0     0.0
                                                                         0.0      0.100 MR    0.0     0.0     0.943
                                                                         0.0      0.300 CM   -0.003  -0.001   0.0     0.0
                                                                         0.0      1.000 PC    0.624   0.657   0.0     0.0    -0.000

*QUAD*      5.00    2.00000 M    -2.2000 KG    5.000 CM  (   -9.151 M   )
         LABEL = Q1

*DRIFT*     3.0      2.000C M

*QUAD*      5.00    2.00000 M     2.4000 KG    5.000 CM  (    9.029 M   )
         LABEL = Q1

                                                         91.0 M          0.0      1.675 CM
                                                                         0.0      0.511 MR   -0.999
                                                                         0.0      0.564 CM    0.0     0.0
                                                                         0.0      0.151 MR    0.0     0.0    -0.936
                                                                         0.0      0.300 CM   -0.003   0.003   0.0     C.0
                                                                         0.0      1.000 PC    0.626  -0.616   0.0     0.0    -0.000

*DRIFT*     3.0      1.000C M
```

```
*ROTAT*     2.0      1.50 D

*BEND*      4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.0      1.50 D

*DRIFT*     3.0      1.0000 M

*ROTAT*     2.0      1.50 D

*BEND*      4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.C      1.50 D

*DRIFT*     3.0      1.0000 M

*ROTAT*     2.0      1.50 D

*BEND*      4.000    3.000CC M    14.550 KG    0.0000 (    2.999 D )

*RUTAT*     2.0      1.50 D

*DRIFT*     3.0      1.000C M

*ROTAT*     2.0      1.50 D

*BEND*      4.000    3.000C0 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.0      1.50 D


                                                  107.0 M        0.0      2.218 CM
                                                                 0.0      1.824 MR    0.865
                                                                 0.0      0.336 CM    0.0     0.0
                                                                 0.0      0.165 MR    0.0     0.0    -0.841
                                                                 0.0      0.457 CM   -0.715  -0.497   0.0     0.0
                                                                 0.0      1.000 PC    0.954   0.975   0.0     0.0    -0.610


*DRIFT*    3.0    30.0000 M
    VARY CODE = 900000
         LABEL = DR1
```

```
*QUAD*     5.00    2.00000 M     5.0000 KG  15.000 CM  (  12.848 M  )
    VARY CODE = 010000
         LABEL = Q2

                                                                 139.0 M          0.0      7.236 CM
                                                                                  0.0      4.163 MR   -0.998
                                                                                  0.0      0.329 CM    0.0     0.0
                                                                                  0.0      0.384 MR    0.0     0.0     0.971
                                                                                  0.0      0.457 CM   -0.573   0.605   0.0      0.0
                                                                                  0.0      1.000 PC    0.997  -1.000   0.0      0.0     -0.610

 *TRANSFORM* 1
            -0.93476  -5.14981   0.0       0.0       0.0       7.21223
             0.24797   0.29632   0.0       0.0       0.0      -4.16246
             0.0       0.0      -1.04482  -1.01024   0.0       0.0
             0.0       0.0      -1.08980  -2.01081   0.0       0.0
            -0.21025  -1.92988   0.0       0.0       1.00000  -0.27894
             0.0       0.0       0.0       0.0       0.0       1.00000

*DRIFT*    3.0     20.0000 M
    VARY CODE = 400000
         LABEL = DR1

                                                                 159.0 M          0.0      1.210 CM
                                                                                  0.0      4.163 MR    0.915
                                                                                  0.0      1.090 CM    0.0     0.0
                                                                                  0.0      0.384 MR    0.0     0.0     0.997
                                                                                  0.0      0.457 CM    0.735   0.605   0.0      0.0
                                                                                  0.0      1.000 PC   -0.920  -1.000   0.0      0.0     -0.610

*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M

*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M   14.550 KG   0.0000 (   2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M
```

```
*ROTAT*    2.C      1.50 D

*BEND*     4.000    3.COOCC M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*    2.C      1.50 D

*DRIFT*    3.0      1.CCOC M

*ROTAT*    2.C      1.5C D

*BEND*     4.000    3.000CC M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.000C M


                                                          175.0 M         0.0     6.005 CM
                                                                          0.0     2.070 MR     0.996
                                                                          0.0     1.664 CM     0.0     0.0
                                                                          0.0     0.334 MR     0.0     0.0     0.999
                                                                          0.0     0.588 CM   -0.824 -0.843   0.0     0.0
                                                                          0.0     1.000 PC   -0.998 -0.999   0.0     0.0     0.838


*FIT*     10.0    -1. 6.    0.0    / 0.001
                           -5.991
        LABEL = FIT2


*FIT*     10.0    -2. 6.    0.0    / C.001
                           -2.C68
        LABEL = FIT3


 *TRANSFORM* 1
           -0.04222  -4.C8323   0.C       0.C       0.0      -5.99086
            0.24796   0.29627   0.0       0.C       0.0      -2.06827
            0.0       0.0      -4.85194  -8.C6319   0.0       0.0
            0.0       0.0      -0.94335  -1.77381   0.0       0.0
           -0.15728  -1.02203   0.C       0.0       1.00000   0.49253
            0.0       0.0       0.0       0.0       0.0       1.00000

*QUAD*     5.00    2.00000 M    -1.9000 KG    5.000 CM  ( -10.646 M  )
```

```
        LABEL = Q3

*DRIFT*    3.C     2.000C M

*QUAD*     5.00   2.00000 M    1.8500 KG   5.000 CM  (  11.609 M  )
        LABEL = Q3

*DRIFT*    3.0   200.0000 M

                                                381.0 M        0.0      6.365 CM
                                                               0.0      0.211 MR   -0.543
                                                               0.0      0.620 CM    0.0     0.0
                                                               0.0      0.049 MR    0.0     0.0    -0.138
                                                               0.0      0.588 CM   -0.854   0.545   0.0     0.0
                                                               0.0      1.000 PC   -0.943   0.790   0.0     0.0     0.838

 *TRANSFCRM* 1
            3.42958  18.46803   C.C       0.0       0.0       -6.00397
            C.1669C   1.19030   0.C       0.C       0.0        0.16643
            C.0       0.0      -0.30513  -6.13656   0.0        0.0
            C.0       0.C       0.16271  -0.C0492   0.0        0.0
           -0.15728  -1.02203   0.0       0.0       1.00000    0.49253
            0.0       0.0       0.C       0.C       0.0        1.00000

                                                381.0 M        0.0      6.365 CM
                                                               0.0      0.211 MR   -0.543
                                                               0.0      0.620 CM    0.0     0.0
                                                               0.0      0.049 MR    0.0     0.0    -0.138
                                                               0.0      0.588 CM   -0.854   0.545   0.0     C.0
                                                               0.0      1.000 PC   -0.943   0.790   0.0     0.0     0.838

*QUAD*     5.00   2.0000C M    4.5000 KG   5.000 CM  (   4.984 M  )
        LABEL = C4

*DRIFT*    3.0     2.000C M

                                                385.0 M        0.0      2.447 CM
                                                               0.0     12.863 MR   -0.999
                                                               0.0      1.044 CM    0.0     0.0
                                                               0.0      1.431 MR    0.0     0.0     1.000
                                                               0.0      0.588 CM   -0.851   0.855   0.0     0.0
                                                               0.0      1.000 PC   -0.935   0.947   0.0     0.0     0.838

*QUAD*     5.C0   2.00000 M   -4.2000 KG   5.000 CM  (  -4.645 M  )
        LABEL = C4

                                                387.0 M        0.0      0.232 CM
                                                               0.0     10.281 MR   -0.881
```

0.0	1.108 CM	0.0	0.0			
0.0	0.813 MR	0.0	0.0	-0.999		
0.0	0.588 CM	-0.721	0.857	0.0	0.0	
0.0	1.000 PC	-0.696	0.953	0.0	0.0	0.838

DRIFT 3.0 15.0000 M

402.0 M

0.0	15.217 CM					
0.0	10.281 MR	1.000				
0.0	0.119 CM	0.0	0.0			
0.0	0.813 MR	0.0	0.0	0.950		
0.0	0.588 CM	0.857	0.857	0.0	0.0	
0.0	1.000 PC	0.955	0.953	0.0	0.0	0.838

TRANSFORM 1

-7.47783	-39.35443	0.0	0.0	0.0	14.52741
-5.14875	-27.23064	0.0	0.0	0.0	9.79230
0.0	0.0	0.17954	1.05592	0.0	0.0
0.0	0.0	0.41918	8.03487	0.0	0.0
-0.15728	-1.02203	0.0	0.0	1.00000	0.49253
0.0	0.0	0.0	0.0	0.0	1.00000

LENGTH 401.9995 M

CORRECTIONS

(4.4815E 03) 2.801 -1.453

(1.5177E 02) 1.457 0.043

(1.5083E 01) 0.037 0.005

(1.2714E-02) -0.000 0.000

*COVARIANCE (FIT 0.0)

0.011

0.480 0.000

```
*BEAM*     1.C00000   25.0C GEV
                                               0.0 M         0.0     0.300 CM
                                                             0.0     0.100 MR    0.0
                                                             0.0     0.300 CM    0.0     0.0
                                                             0.0     0.100 MR    0.0     0.0     0.0
                                                             0.0     0.300 CM    0.0     0.0     0.0     0.0
                                                             0.0     1.000 PC    0.0     0.0     0.0     0.0     0.0

*BEND*     4.000   5.00000 M    1.455 KG   0.0000 (    0.500 D )

*ROTAT*    2.0      0.50 D

                                               5.0 M         0.0     0.305 CM
                                                             0.0     0.133 MR    0.171
                                                             0.0     0.304 CM    0.0     0.0
                                                             0.0     0.100 MR    0.0     0.0     0.164
                                                             0.0     0.300 CM   -0.009  -0.001   0.0     0.0
                                                             0.0     1.000 PC    0.071   0.657   0.0     0.0    -0.000

*DRIFT*    3.C    8C.0000 M

                                              85.0 M         0.0     1.153 CM
                                                             0.0     0.133 MR    0.965
                                                             0.0     0.901 CM    0.0     0.0
                                                             0.0     0.100 MR    0.0     0.0     0.943
                                                             0.0     0.300 CM   -0.003  -0.001   0.0     0.0
                                                             0.0     1.000 PC    0.624   0.657   0.0     0.0    -0.000

*QUAD*     5.00   2.0C000 M   -2.2000 KG   5.000 CM  (  -9.151 M  )
        LABEL = Q1

*DRIFT*    3.C      2.000C M

*QUAD*     5.00   2.00000 M    2.4000 KG   5.000 CM  (   9.029 M  )
        LABEL = Q1

                                              91.0 M         0.0     1.675 CM
                                                             0.0     0.511 MR   -0.999
                                                             0.0     0.564 CM    0.0     0.0
                                                             0.0     0.151 MR    0.0     0.0    -0.936
                                                             0.0     0.300 CM   -0.003   0.003   0.0     0.0
                                                             0.0     1.000 PC    0.626  -0.616   0.0     0.0    -0.000

*DRIFT*    3.C      1.000C M
```

```
*ROTAT*     2.0      1.50 D

*BEND*      4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.0      1.50 D

*DRIFT*     3.0      1.0000 M

*ROTAT*     2.0      1.50 D

*BEND*      4.C00    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.0      1.50 D

*DRIFT*     3.0      1.000C M

*ROTAT*     2.C      1.50 D

*BEND*      4.000    3.000C0 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.C      1.50 D

*DRIFT*     3.0      1.000C M

*ROTAT*     2.C      1.50 D

*BEND*      4.000    3.0000C M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.0      1.50 D


                                                  107.0 M         0.0      2.218 CM
                                                                  0.0      1.824 MR    0.865
                                                                  0.0      0.336 CM    0.0      0.0
                                                                  0.0      0.165 MR    0.0      0.0     -0.841
                                                                  0.0      0.457 CM   -0.715   -0.497    0.0      0.0
                                                                  0.0      1.000 PC    0.954    0.975    0.0      0.0     -0.610


*DRIFT*     3.C     25.7C57 M
    VARY CCDE = 900000
         LABEL = CR1
```

```
*QUAD*     5.C0   2.00000 M    3.5952 KG  15.00C CM  (  17.734 M  )
    VARY CODE = C10000
         LABEL = Q2

                                                                      134.7 M         0.0      6.672 CM
                                                                                      0.0      2.101 MR    -0.989
                                                                                      0.0      0.266 CM     0.0     0.0
                                                                                      0.0      0.279 MR     0.0     0.0      0.915
                                                                                      0.0      0.457 CM    -0.580   0.644    0.0      0.0
                                                                                      0.0      1.000 PC     0.998  -0.997    0.0      0.0     -0.610

 *TRANSFORM* 1
           -C.75331  -3.74802   0.0        0.0        0.0         6.65790
           -0.07884  -1.71968   0.0        0.0        0.0        -2.09424
            C.0       0.C      -C.87796  -0.38176     0.0         0.0
            0.0       0.0      -C.78899  -1.48206     0.0         0.0
           -C.21025  -1.92988   0.0        0.0        1.00000    -0.27894
            C.0       0.C       0.C        0.C        0.0         1.00000

*DRIFT*    3.0    24.2942 M
    VARY CCDE = 400000
         LABEL = DR1

                                                                      159.0 M         0.0      1.782 CM
                                                                                      0.0      2.101 MR    -0.840
                                                                                      0.0      0.928 CM     0.0     0.0
                                                                                      0.0      0.279 MR     0.0     0.0      0.993
                                                                                      0.0      0.457 CM    -0.328   0.644    0.0      0.0
                                                                                      0.0      1.000 PC     0.881  -0.997    0.0      0.0     -0.610

*ROTAT*    2.0      1.50 D

*BEND*     4.000    3.00000 M   14.550 KG    0.0000 (    2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M

*ROTAT*    2.0      1.5C D

*BEND*     4.000    3.00000 M   14.550 KG    0.0000 (    2.999 D )

*ROTAT*    2.0      1.50 D

*DRIFT*    3.0      1.0000 M
```

```
*ROTAT*     2.0      1.50 D

*BEND*      4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.0      1.50 D

*DRIFT*     3.0      1.0000 M

*ROTAT*     2.0      1.50 D

*BEND*      4.000    3.00000 M    14.550 KG    0.0000 (    2.999 D )

*ROTAT*     2.0      1.50 D

*DRIFT*     3.0      1.0000 M


                                                          175.0 M       0.0      1.115 CM
                                                                        0.0      0.174 MR     0.988
                                                                        0.0      1.340 CM     0.0     0.0
                                                                        0.0      0.238 MR     0.0     0.0     0.996
                                                                        0.0      0.495 CM    -0.000  -0.000   0.0     0.0
                                                                        0.0      1.000 PC     0.000   0.000   0.0     0.0    -0.796


*FIT*      10.0    -1. 6.    0.C    / C.001

                             0.C00
         LABEL = FIT2


*FIT*      10.0    -2. 6.    0.0    / 0.001

                             0.000
         LABEL = FIT3


 *TRANSFORM* 1
           -1.07094 -10.67648    0.0        0.0        0.0        0.00001
           -C.07885  -1.71978    0.C        0.C        0.0        0.00000
            0.0       0.0       -3.95881   -6.20807    0.0        0.0
            0.0       0.0       -0.66630   -1.29747    C.0        0.0
           -0.00000  -0.00001    0.C        0.0        1.00000   -0.39405
            0.0       0.0        0.0        0.0        0.0        1.00000

*QUAD*      5.00    2.00000 M   -1.9000 KG    5.000 CM  ( -10.646 M  )
```

```
        LABEL = Q3

 *DRIFT*    3.0      2.0000 M

 *QUAD*     5.00   2.00000 M     1.8500 KG    5.000 CM  (  11.609 M  )
        LABEL = Q3

 *DRIFT*    3.0   200.0000 M

                                                   381.0 M          0.0       1.742 CM
                                                                    0.0       0.167 MR    0.995
                                                                    0.0       0.824 CM    0.0     0.0
                                                                    0.0       0.082 MR    0.0     0.0     0.895
                                                                    0.0       0.495 CM    0.000   0.000   0.0     0.0
                                                                    0.0       1.000 PC   -0.000  -0.000   0.0     0.0    -0.796

  *TRANSFORM* 1
           2.77343  15.30110   0.0       0.0       0.0      -0.00001
           0.21337   1.53770   0.0       0.0       0.0      -0.00000
           0.0       0.0       2.57533  -2.86091   0.0       0.0
           0.0       0.0       0.27088   0.08736   0.0       0.0
          -0.00000  -0.00001   0.0       0.0       1.00000  -0.39405
           0.0       0.0       0.0       0.0       0.0       1.00000

                                                   381.0 M          0.0       1.742 CM
                                                                    0.0       0.167 MR    0.995
                                                                    0.0       0.824 CM    0.0     0.0
                                                                    0.0       0.082 MR    0.0     0.0     0.895
                                                                    0.0       0.495 CM    0.000   0.000   0.0     0.0
                                                                    0.0       1.000 PC   -0.000  -0.000   0.0     0.0    -0.796

 *QUAD*     5.00   2.00000 M     4.5000 KG    5.000 CM  (   4.984 M  )
        LABEL = Q4

 *DRIFT*    3.0      2.0000 M

                                                   385.0 M          0.0       0.737 CM
                                                                    0.0       3.364 MR   -1.000
                                                                    0.0       1.424 CM    0.0     0.0
                                                                    0.0       1.999 MR    0.0     0.0     1.000
                                                                    0.0       0.495 CM    0.000  -0.000   0.0     0.0
                                                                    0.0       1.000 PC   -0.000   0.000   0.0     0.0    -0.796

 *QUAD*     5.00   2.00000 M    -4.2000 KG    5.000 CM  (  -4.645 M  )
        LABEL = Q4

                                                   387.0 M          0.0       0.172 CM
                                                                    0.0       2.478 MR   -0.998
```

```
                                                                  0.0      1.520 CM    0.0     0.0
                                                                  0.0      1.070 MR    0.0     0.0    -1.000
                                                                  0.0      0.495 CM    0.000  -0.000   0.0     0.0
                                                                  0.0      1.000 PC   -0.000   0.000   0.0     C.0    -0.796

*DRIFT*    3.C     15.000C M

                                                     402.0 M      0.0      3.545 CM
                                                                  0.0      2.478 MR    1.000
                                                                  0.0      0.090 CM    0.0     0.0
                                                                  0.0      1.070 MR    0.0     0.0     0.950
                                                                  0.0      0.495 CM   -0.000  -0.000   0.0     0.0
                                                                  0.0      1.000 PC    0.000   0.000   0.0     0.0    -0.796

*TRANSFORM* 1
          -5.80162 -30.87849   0.0       0.0       0.0       0.00003
          -4.03058 -21.62466   C.0       0.0       0.0       0.00002
           C.0       0.C      -C.23357   0.56217   0.0       0.0
           0.0       0.0      -3.33957   3.75673   0.0       0.0
          -C.00000  -0.00001   0.C       0.C       1.00000  -0.39405
           0.0       0.0       0.C       0.0       0.0       1.00000

*LENGTH*   401.9993 M
```

```
'BEAM TRANSPORT SYSTEM FOR SLAC BEAM SWITCHYARD END STATION A II'
1
(THE SECOND STEP TO FITTING IS TO ALLOW THE FIELDS OF THE FIRST QUAD)
(DOUBLET,Q1, TO VARY AS WELL AS THE SYMMETRY QUAD IN ORDER TO GET AN IMAGE AT)
(THE EXIT OF THE SYMMETRY QUAD,Q2, AS WELL AS THE PREVIOUSLY MENTIONED)
(ACHROMATIC CONDITION.)
5.01 'Q1' ;
10.0 'FIT1' ;
SENTINEL
```