KICK 1 OUTPUT FORMAT

CARD NO. \ WORD NO.	1	2	3	4	5	6	7	8
MASTER	ℓ_1	x_1^f	y_1^f	z_1^f	n_x'	n_y'	n_z'	2ND WORD DEDX MASTER	SN XXXXXXXXC± 0

K INTERPRETATION

1	Δp_-^m	Δp_+^m	ℓ_0	ℓ_-	ℓ_+	$P_+'(\Lambda)$ $P_+'(K)$	IDT	JWDM	"	1
2	φ_+^0	φ_-^0	φ_0^0	λ_+^0	λ_-^0	λ_0^0			"	2
3	p_0^0	p_-^0	p_+^0	Δp^0	p_+^m	p_-^m			"	3
4	φ_+^c	φ_-^c	φ_0^c	λ_+^c	λ_-^c	λ_0^c	χ_1^2		"	4
5	p_0^c	p_-^c	p_+^c	Δp^c	$\Delta\chi_c^2$	χ_c^2	NO. OF ITERATIONS		"	5
6	δp_0^ν	$\delta\lambda_0^\nu$	$\delta\varphi_0^\nu$	$\delta p_0\,\delta\lambda_0$	$\delta p_0\,\delta\varphi_0$	δp_+^ν	δp_-^ν	γ_1	"	6
7	γ_2	γ_3	γ_4	γ_5	γ_6	γ_7		γ_8	"	7

λ INTERPRETATION

-1	Δp_-^m	Δp_+^m	ℓ_0	ℓ_-	ℓ_+	$P_-'(\Lambda)$ $P_-'(K)$	IDT	JWDM	"	1
-2	φ_+^0	φ_-^0	φ_0^0	λ_+^0	λ_-^0	λ_0^0			"	2
-3	p_0^0	p_-^0	p_+^0	Δp^0	p_+^m	p_-^m			"	3
-4	φ_+^c	φ_-^c	φ_0^c	λ_+^c	λ_-^c	λ_0^c	χ_1^2		"	4
-5	p_0^c	p_-^c	p_+^c	Δp^c	$\Delta\chi_c^2$	χ_c^2	NO. OF ITERATIONS		"	5
-6	δp_0^ν	$\delta\lambda_0^\nu$	$\delta\varphi_0^\nu$	$\delta p_0\,\delta\lambda_0$	$\delta p_0\,\delta\varphi_0$	δp_+^ν	δp_-^ν	γ_1	"	6
-7	γ_2	γ_3	γ_4	γ_5	γ_6	γ_7		γ_8	"	7

ERROR CARDS

8	PUNCHED WHEN DEDX CARDS OUT OF ORDER					CT	- SN(DEDX)	"	8
9	p_-^m	p_+^m	PUNCHED WHEN $p_-^m>0$ & $p_+^m<0$					"	9

RADIATION LABORATORY UNIVERSITY OF CALIFORNIA

SUBJECT: KICK 1 - IBM PROGRAM

NAME: R.T. HARVEY

DATE: 6-19-58

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DESCRIPTION OF OUTPUT FORMAT.

All full word (10 digit) data are punched out in machine language, normalized floating point form (1000000051 = 1.0). The half word data, x_1^f, y_1^f, z_1^f, δp_+^v, δp_-^v are in five digit floating point of the form xxxee, with 10051 = 1.0.

Lengths are in cm., momenta in mev/c and angles are in radians.

SN - the KICK serial number - is a revised DEDX serial number. The right-most three digits are replaced by et = event type and n, the card number. Card numbers +1 to +7 are for the K interpretation and those from -1 to -7 are for the 1 interpretation.

IDT is a three digit identification number namely,

634 for type 60 events
545 for the 1st V of a type 50 (tracks 3,4,5)
567 for the 2nd V of a type 50 (tracks 2,6,7)

7WDM is the last seven digits of word 7 on the DEDX master card.

CT in word 6 of error card 8 is the card track number which is out of order.

PURPOSE OF KICK 1:

From observed data on a bubble chamber event, one would like to determine what particles actually made the tracks. The observed data referred to is, in this case, output from $DEDX_1$. KICK 1 is designed to do a least squares analysis of single and double V's[2] (type 60 and 50) for two separate interpretations. The first interpretation is the K; $K^0 \rightarrow \pi^+ + \pi^-$ and the second is the Λ; $\Lambda^0 \rightarrow p + \pi^-$. In the case of a type 50 event, the complete analysis is done for each V.

METHOD: In this analysis we are concerned with eight variables, namely: p_-, p_+ the momenta of the charged tracks; ϕ_0, ϕ_-, ϕ_+, λ_0, λ_-, λ_+, the azimuth and dip angles of the neutral and both charged tracks of the V. For a given interpretation, KICK 1 proceeds to find the best* values of these eight variables (labeled x_i) subject to three constraints F_l, $(l = 1,2,3)$. of energy momentum balance.
The method used is that described in previous Eng. Notes by H. TAFT and F. SOLMITZ and will be briefly outlined below.
Let $M \equiv \chi^2 = \sum_{i=1}^{8} \frac{(x_i - x_i^m)^2}{w_i}$, where the x_i^m are the measured values of the eight variables and the w_i the respective errors on the x_i^m.

* best is meant in the sense of least squares.

1: Ref: Eng. note 4310-03 LA 8.
2: See Eng. note 4312-07 M33 for event types.

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Expand the constraints to first order

$$F_\eta(x^{\nu+1}) = F_\eta(x^\nu) + \sum_{i=1}^{8} F_{i\eta}(x^\nu)\,[x_i^{\nu+1} - x_i^\nu] = 0$$

where $F_{i\eta} \equiv \dfrac{\partial F_\eta}{\partial x_i}$.

The problem may be written as

$$\text{Minimize } M + \sum_{\eta=1}^{3} \alpha_\eta F_\eta$$

u_i, F_λ, $F_{\lambda i}$
α, x^is, $H_{\lambda\mu}$
$H^{-1}_{\lambda\mu}$

ie, solve $\dfrac{\partial M}{\partial x_i} + 2\sum_{\eta=1}^{3} \alpha_\eta F_{i\eta} = 0$

which may be written as

$$x_i = x_i^m - u_i \sum_{\eta=1}^{3} \alpha_\eta F_{i\eta}$$

Thus $\sum_{\eta=1}^{3} \alpha_\eta \sum_{i=1}^{8} u_i F_{i\eta} F_{i\gamma} = F_\gamma + \sum_{i=1}^{8} F_{i\gamma}(x_i^m - x_i)$

Define $H_{\eta\gamma} = \sum_{i=1}^{8} u_i F_{i\eta} F_{i\gamma}$ and $b_\eta = F_\eta + \sum_{i=1}^{8} F_{i\eta}(x_i^m - x_i)$

it follows that

$$b_\eta = \sum_{\gamma=1}^{3} \alpha_\gamma H_{\eta\gamma} \quad \text{or} \quad \alpha_\gamma = \sum_{\eta=1}^{3} b_\eta H^{-1}_{\eta\gamma}$$

Also $\overline{\delta x_i\, \delta x_j} = u_i\left[\delta_{ij} - u_j \sum_{\eta,\gamma=1}^{3} F_{i\eta} F_{j\gamma} H^{-1}_{\eta\gamma}\right]$ (++)

An iterative procedure is developed from the above by taking the measured values of the x_i as x_i^0 (the 1st approx) and defining

$$x_i^{\nu+1} = x_i^m - u_i \sum_{\eta=1}^{3} \alpha_\eta^{\nu+1} F_{i\eta}^{\nu}$$

where $x_i^{\nu+1}$ is the $(\nu+1)^{st}$ approx. to the x_i, and $F_{i\eta}^{\nu} \equiv F_{i\eta}(x^\nu)$.

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$$H_{\eta\mu}^{\nu+1} = \sum_{i=1}^{8} w_i F_{i\eta}^{\nu} F_{i\mu}^{\nu}$$

$$b_\eta^{\nu+1} = F_\eta^{\nu} + \sum_{i=1}^{8} F_{i\eta}^{\nu} (X_i^m - X_i^{\nu}) \quad ; \quad F_\eta^{\nu} \equiv F_\eta(X^{\nu})$$

$$\alpha_\mu^{\nu+1} = \sum_{\eta=1}^{3} b_\eta^{\nu+1} \cdot H_{\eta\mu}^{-1\,\nu+1} \quad , \quad F^{\nu} \equiv \left[\sum_{\eta=1}^{3} (F_\eta^{\nu})^2 \right]^{1/2}$$

The sequence of operations is as follows: Starting with X_i^0 compute F_1, F, $F_{i\eta}$, H, H^{-1}, b_1, α_1, and finally X_i. Iterations are continued until $F < 1$ (converged) or $F > 1$ and KICK has done n iterations. This iteration bound n is in drum location 1010. Tests have shown that $n = 15$ is large enough to give KICK a "fair" chance and still not waste machine time.

Once out of the iteration cycle, KICK computes the errors and cross correlations for the final values of the X_i according to formula (**).

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HOW TO USE KICK1

The KICK1 deck is self loading. The first few cards are a short load routine which reads into drum locations 8-19. The last card of the deck is a transfer card which transfers control to location 1200, the first instruction of the program. The remainder of the deck is the program proper, punched 7 words to a card. The load routine is destroyed once KICK reads in the first event.

Below are the settings for the 650 Console:

70 0951 0951 on storage entry switches.
Overflow to stop.
Error to stop.
Display to program register
Half cycle to run
Program to run
Control to run

To use KICK1, the following steps are necessary:

1. Use the standard 80-80 board in the 533 read-punch unit.
2. Set up the 650 console as directed above.
3. Load the punch hopper of the 533 with blank IBM cards and press the start button on the punch side.
4. Place KICK1 followed by DEDX data cards in the read hopper.
5. Press computer reset, then program

start buttons on the 650 Console.

6. Press the start button on the read unit.

Should it become necessary to get off the 650 before the final event is read in from the read hopper, simply turn the program switch to program stop. When the analysis of the event then in the machine is complete, KICK 1 will come to a program stop with 01 1200 1200 in the program register. To restart the program, turn the switch to run and press the program start button.

In spite of the fact that KICK 1 has been subjected to rigorous tests, unforseen situations may arise which would cause a machine stop. (eg. overflow light on, etc.) One may then attempt to proceed to the nxt event by executing a manual transfer control to location 1200. It is advisable to first record the contents of the program register, distributor, upper and lower accumulator as well as error lights on at the time. This information will aid in locating the difficulty. Of course, repeated stops indicate real trouble and it is best to get off the machine.

Any part of the drum can be dumped out 7 words to a card by setting the storage entry switches to 07 xxxx yyyy + and transferring to location 1961.

KICK 1 output should be listed on the 407 with all control switches set to normal.

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DETAILED WRITE UP OF THE PROGRAM

READ: The first instructions initialize the error routine to exit to MSS2 which is the start of the 1 interpretation. KICK 1 then searches for a DEDX master card. With a master card located, the following event initialization takes place. The output card number is set for positive cards and SN is constructed and placed in word 8 of the punch band (loc. 0977-0984) The second word of the DEDX master card is put in word 7 of the punch band and the 7th word on the master card is placed in temporary storage T7. The four cards which make up track 1 are read in and the quantities, l_1, x_1^f, y_1^f, z_1^f, n_{x_1}, n_{y_1}, n_{z_1}, are floated and stored in the punch band. The KICK 1 master card is punched out and a test is made to determine the event type. (50 or 60). The appropriate value of IDT and digits 7-10 of T7 are fused and placed in word 7 of the punch band. EACTR is set to zero for type 60 or to +1 for type 50 events. For type 50 events, control is transferred to TYPE. Analysis on type 60 events proceeds as follows. Tracks 2, 3, and 4 are read in and the following quantities are floated and stored. l_i = track length; T_i = track type; p_{1i}, p_{Ki} = momenta of tracks for 1 and K interpretation respectively; $\frac{\Delta p}{p}_{1i}$, $\frac{\Delta p}{p}_{Ki}$ for the 1 and K interpretation and n_{xi}, n_{yi}, n_{zi} the direction cosines. ($i = 2, 3, 4$). The quantities $P_+'(1) P_+'(K)$ and $P_-'(1) P_-'(K)$ are stored as read into locations TP_+ and TP_-.

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MASS 1: $\left(\frac{\Delta p}{p}\right)_{K_i}$ and p_{K_i} $(i=2,3)$ are placed in proper locations for MSBR. (ie; $p_{K_2} \rightarrow p_-$, $p_{K_3} \rightarrow p_+$ etc.) The following masses are assigned for the K interp. $m_0 = 494.4$, $m_- = 139.63$, $m_+ = 139.63$.

ANGLE: $k_+ = 1/p_+$, $k_- = 1/p_-$. The dip and azimuth angles are computed from:

$$\lambda_t^m = \tan^{-1}\left[\left(\frac{n_z}{n_y}\right)_t \sin\varphi_t\right]; \quad \varphi_t^m = \tan^{-1}\left(\frac{n_y}{n_x}\right)_t \quad (t = +,-,0)^*$$

ERROR: The errors in the angles are given by:

$$(\Delta\varphi)_t = \frac{0.02}{l_t \cos\lambda} = \frac{0.02/2}{R} \qquad l = \frac{2R}{\cos\lambda}$$

$$(\Delta\lambda)_t = \begin{cases} \left(\frac{0.2}{l_t}\right)\left(\frac{1-n_{z_t}^2}{n_{y_t}}\right) & \text{for normal tracks} \\ \left(\frac{0.4}{l_t}\right)(1-n_{z_t}^2)^{1/2} & \text{for alternate tracks} \end{cases}$$

Any of $(\Delta\varphi)_t, (\Delta\lambda)_t$ which are less than .00524 are replaced by .00524.

The quantities Δp_+, Δp_-, Δk_+, Δk_- are computed from:

$$\Delta p_\pm = p_\pm \left(\frac{\Delta p}{p}\right)_\pm, \qquad \Delta k_\pm = -\frac{1}{p_\pm^2}\Delta p_\pm$$

Card number 1 is then punched.

MADRS: This routine defines the measured values as the 1st approximation to the variables X_i. (ie; $X_1^\circ = \varphi_+^m$, $X_2^\circ = \varphi_-^m$, $X_3^\circ = \varphi_0^m$, $X_4^\circ = \lambda_+^m$, $X_5^\circ = \lambda_-^m$, $X_6^\circ = \lambda_0^m$, $X_7^\circ = k_+^m$, $X_8^\circ = k_-^m$).

* The positive, negative and neutral tracks are labeled +, −, 0 respectively.

At this point tests are made to see that $p_+^m > 0$ and $p_-^m < 0$. If both p_+^m and p_-^m have wrong signs, error card 9 is punched and the event rejected. If only one p has the wrong sign the corresponding X° (ie. X_1° or X_2°) is changed for the initial approximation only.
Card 2 is punched and the quantities u_i $(i = 1, \cdots 8)$ are computed from:

$$u_1 = (\Delta\phi_+)^2,\ u_2 = (\Delta\phi_-)^2,\ u_3 = (\Delta\phi_0)^2,\ u_4 = (\Delta\lambda_+)^2,$$
$$u_5 = (\Delta\lambda_-)^2,\ u_6 = (\Delta\lambda_0)^2,\ u_7 = (\Delta k_+)^2,\ u_8 = (\Delta k_-)^2.$$

The three counters CNTR, CNTR2, CNTR3 are set to zero, F is set to $.99999999 \times 10^{99}$ and the F_{ij} are all set to zero.

MSBR: The following quantities are computed (with $\nu = 0$ the 1st time).

$$p_+^\nu = 1/X_1^\nu,\quad p_-^\nu = -1/X_2^\nu,\quad E_+^\nu = (p_+^{\nu 2} + m_+^2)^{1/2},\quad E_-^\nu = (p_-^{\nu 2} + m_-^2)^{1/2}$$

$$p_0^{\nu 2} = (E_+^\nu + E_-^\nu)^2 - m_0^2$$

If $p_0^{\nu 2} < 0$, then at least one of p_+^m, p_-^m must be less than 206 for the K interp. or 100 for the λ interp. and ① for $\nu > 0$, control is transferred to CUT STEP, ② for $\nu = 0$, p_+° or p_-°, or both, are replaced by 206 or 100 depending on the interpretation. When $p_0^{\nu 2} > 0$, computation is continued by forming:

$$p_0^\nu = (p_0^{\nu 2})^{1/2},\quad E_0^\nu = (p_0^{\nu 2} + m_0^2)^{1/2}$$

$$\beta_+ = p_+/E_+,\quad \beta_- = p_-/E_-,\quad \beta_0 = p_0/E_0$$

$$p_{0,+} \equiv \frac{\partial p_0}{\partial p_+} = \frac{p_+ + E_-\beta_+}{p_0},\quad p_{0,-} \equiv \frac{\partial p_0}{\partial p_-} = \frac{p_- + E_+\beta_-}{p_0}$$

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Current values of the constraints are computed from:

$$F_1^\nu = p_+ \cos\lambda_+ \cos\phi_+ + p_- \cos\lambda_- \cos\phi_- - p_0 \cos\lambda_0 \cos\phi_0$$

$$F_2^\nu = p_+ \cos\lambda_+ \sin\phi_+ + p_- \cos\lambda_- \sin\phi_- - p_0 \cos\lambda_0 \sin\phi_0$$

$$F_3^\nu = p_+ \sin\lambda_+ + p_- \sin\lambda_- - p_0 \sin\lambda_0$$

Next, the quantity $F^{\nu+1} = (\sum_1^4 F_i^\nu)^{\nu+1}$ is computed. KICK 1 insists that $F^{\nu+1} < F^\nu$ at each step and if not, control is transferred to CUT STEP. If $F^{\nu+1} < F^\nu$, the quantities F_{i1} are computed from:

$$F_{11} = -p_+ \cos\lambda_+ \sin\phi_+ \qquad F_{12} = p_+ \cos\lambda_+ \cos\phi_+$$

$$F_{21} = -p_- \cos\lambda_- \sin\phi_- \qquad F_{22} = p_- \cos\lambda_- \cos\phi_-$$

$$F_{31} = p_0 \cos\lambda_0 \sin\phi_0 \qquad F_{32} = -p_0 \cos\lambda_0 \cos\phi_0$$

$$F_{41} = -p_+ \sin\lambda_+ \cos\phi_+ \qquad F_{42} = -p_+ \sin\lambda_+ \sin\phi_+$$

$$F_{51} = -p_- \sin\lambda_- \cos\phi_- \qquad F_{52} = -p_- \sin\lambda_- \sin\phi_-$$

$$F_{61} = p_0 \sin\lambda_0 \cos\phi_0 \qquad F_{62} = p_0 \sin\lambda_0 \sin\phi_0$$

$$F_{71} = -p_+^{\nu 2}[\cos\lambda_+ \cos\phi_+ - p_{0,+} \cos\lambda_0 \cos\phi_0] \qquad F_{72} = -p_+^{\nu 2}[\cos\lambda_+ \sin\phi_+ - p_{0,+} \cos\lambda_0 \sin\phi_0]$$

$$F_{81} = p_-^{\nu 2}[\cos\lambda_- \cos\phi_- - p_{0,-} \cos\lambda_0 \cos\phi_0] \qquad F_{82} = p_-^{\nu 2}[\cos\lambda_- \sin\phi_- - p_{0,-} \cos\lambda_0 \sin\phi_0]$$

$$F_{13} = F_{23} = F_{33} = 0, \quad F_{43} = p_+ \cos\lambda_+, \quad F_{53} = p_- \cos\lambda_-, \quad F_{63} = -p_0 \cos\lambda_0$$

$$F_{73} = -p_+^{\nu 2}[\sin\lambda_+ - p_{0,+} \sin\lambda_0], \quad F_{83} = p_-^{\nu 2}[\sin\lambda_- - p_{0,-} \sin\lambda_0]$$

A test is made to see if the current values of the x_i satisfy the constraints within a chosen bound "c". (ie, we test to see if $F^{\nu+1} < c$). If so - KICK 1 will take <u>one</u> more step. A value of 1.0 for c was satisfactory.

<u>PRINT:</u> If $\nu = 0$ card number 3 is punched out. If $\nu = N$, current values of x_i and x_i^ν (value of x^ν at the 1st step) are punched on card 4 and the

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Cards 6 and 7 are punched. Control is transferred to:

(1) MASS 2, if 1 interpretation not completed.

(2) READ, for new event.

(3) RT 67, for 2nd V of type 50 event.

TYPE: Track 2 is read and data stored in temporary locations. IDT is set to 545 and tracks 3,4,5 are read in as 0, −, + resp. EACTR is set to +1.

RT 67: With analysis complete on tracks 3,4,5, the data on track 2 is stored in locations corresponding to the neutral track. Card count and SN are reset positive and tracks 6 and 7 read in as − and + tracks resp. Control is transferred to MASS 1.

MASS 2: This routine does the initialization for the 1 analysis. $m_+ = 938.21$, $m_- = 139.63$, $m_0 = 1115.20$ Card count is set negative and proper exit stored for the DELTA routine. (ie, READ for type 60, RT 67 for 50's)

CUT STEP: This routine cuts the size of the step in half. ie, $X_i^{\nu+1} = X_i^{\nu} + \frac{X_i^{\nu+1} - X_i^{\nu}}{2}$ $(i = 1, \cdots, 8)$.

The cutting factor (2 is now used) is in location 0324 and may be changed.

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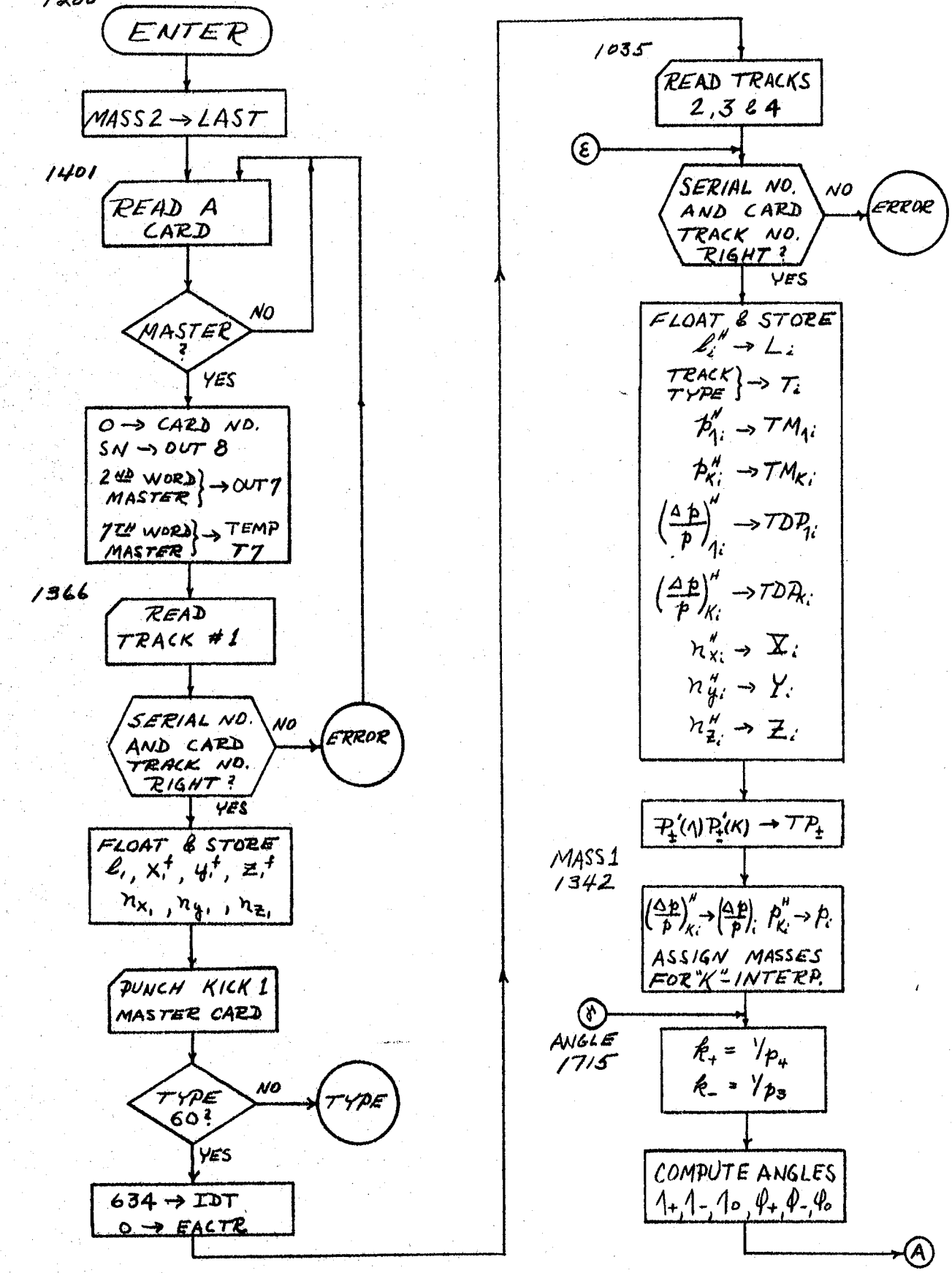
FLOW CHARTS



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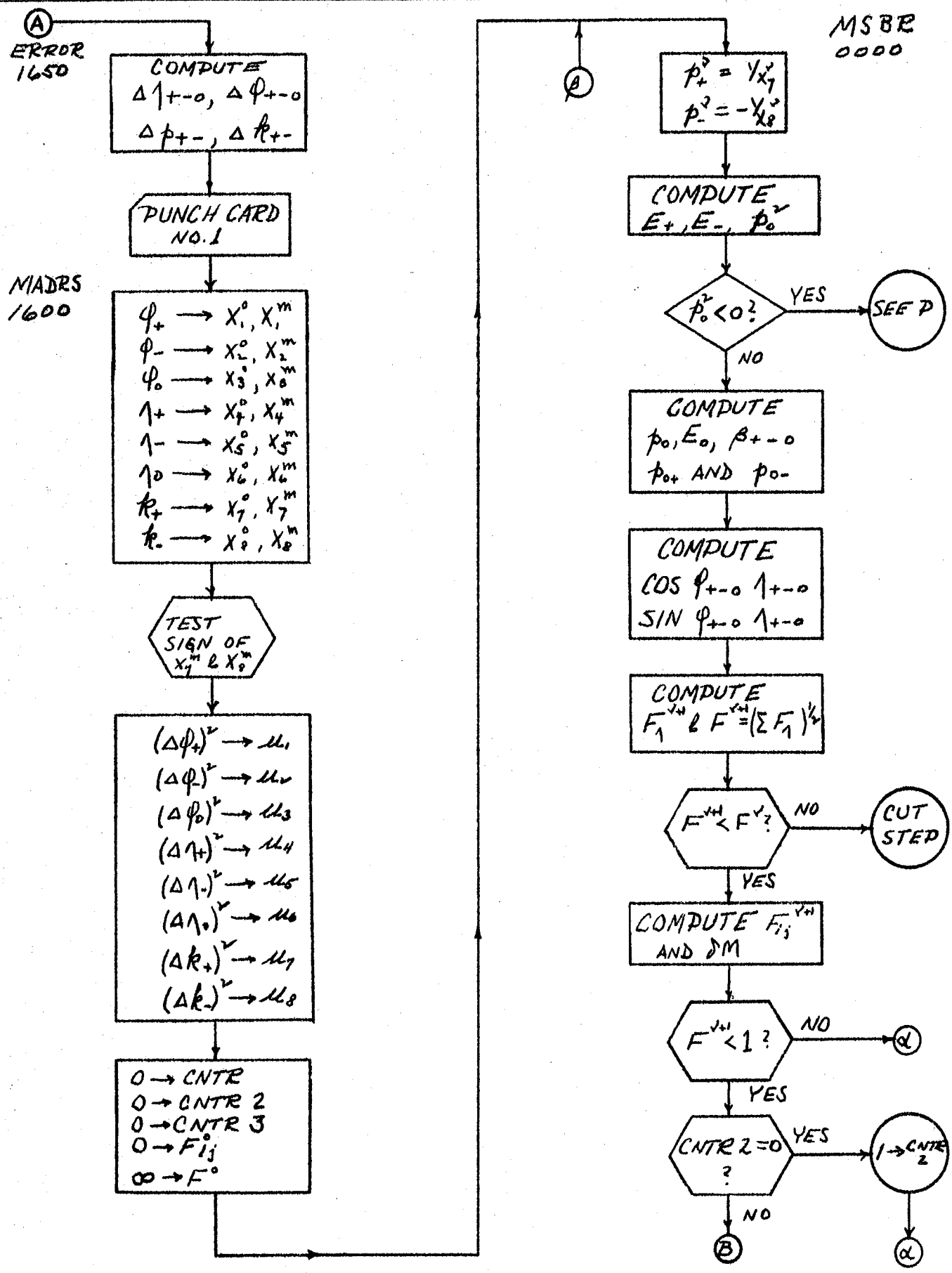

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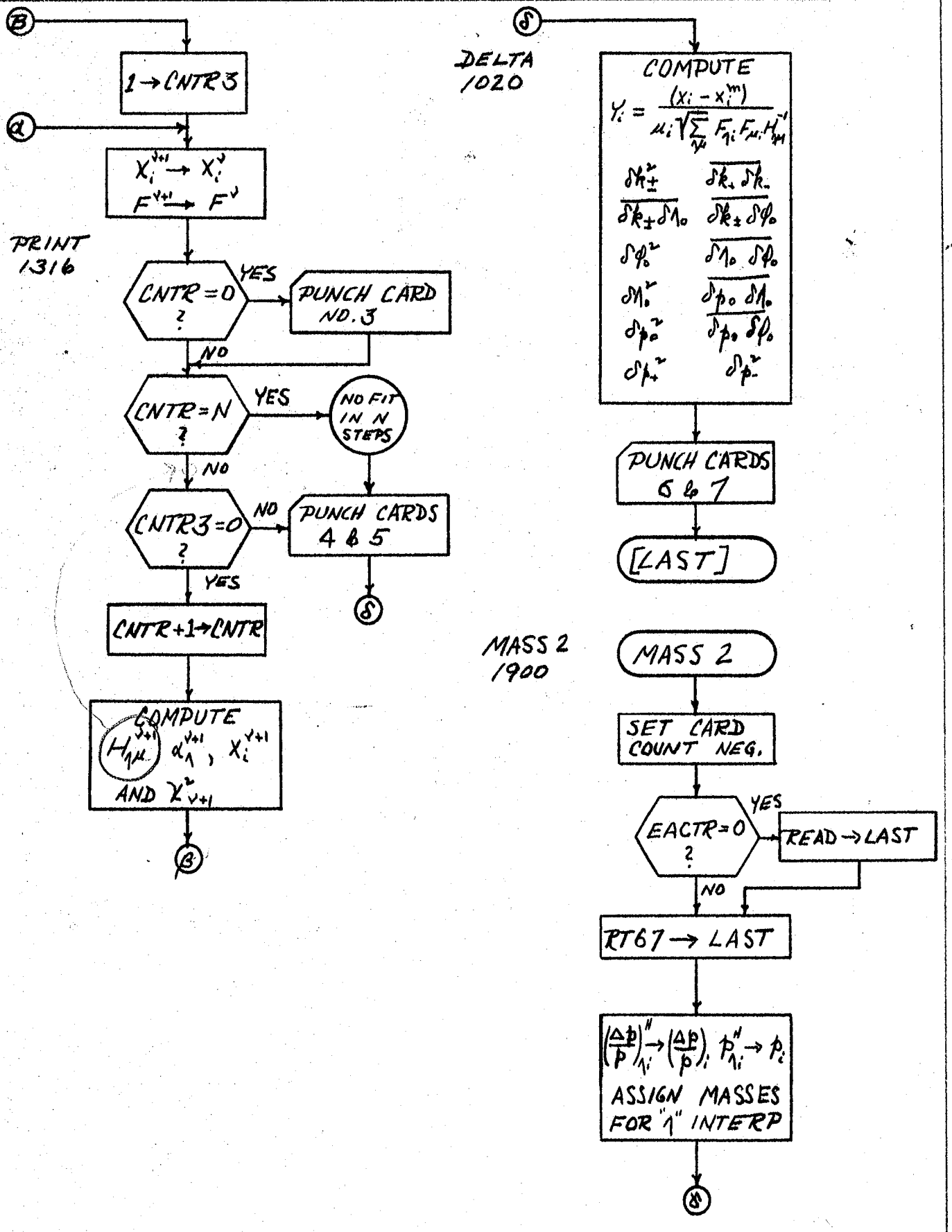

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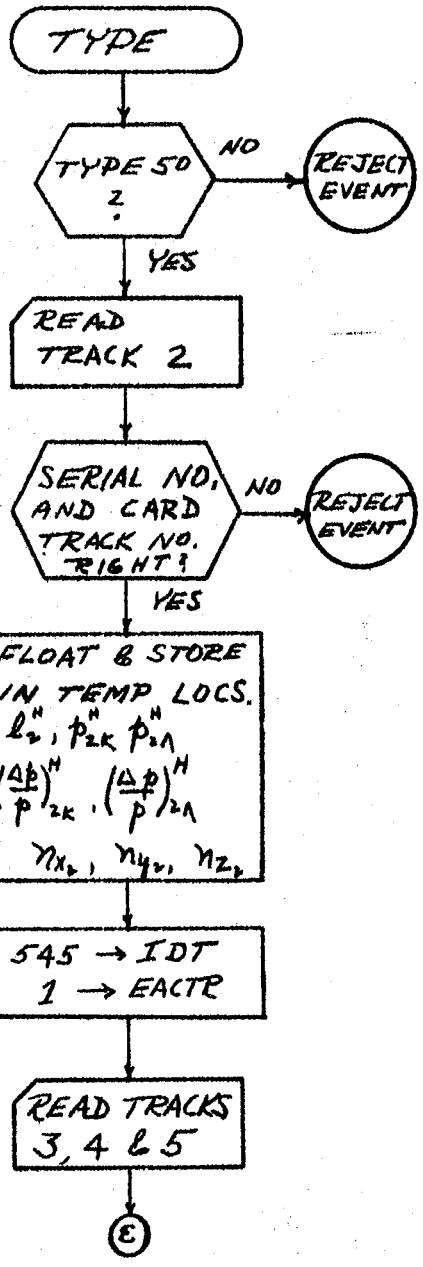
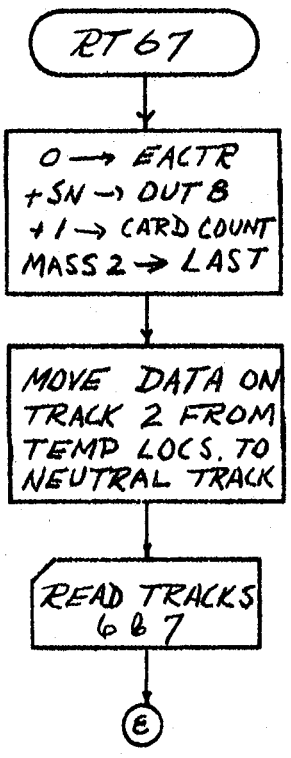
TYPE 1701



1500



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