1401 Fortran

Detailed Explanation of Processor

This document is designed for persons requiring a thorough knowledge of the 1401 Fortran processor. Each phase of the processor is described in a different section. Information enclosed in parentheses and capitalized refer to symbolic labels present in the listing.

General

The reader should be acquainted with certain key work areas addressed throughout the processor.

1. PARAMA - The hundreds position of the machine size specified on the control card when located in storage.
   a. PARAMA+2 - The size of the machine
   b. PARAMA+4 - The modules
   c. PARAMA+6 - The mantissa and later in the processor, the mantissa plus two.
2. FAILSW - A word mark is set at this location when the processor detects an error which would make object time unrewarding.

NXTOP - The next available location at object time from the top (leftmost) part of storage. It is located at 086.

NXBTM - The next available location at object time from the bottom (right-most) part of storage. It is located at 083.

Snapshot Routine (00)

This routine exists in storage through the entire compilation and object time. It produces snapshots of storage whenever control is transferred to it. The snapshot displays each century of storage on a separate line with appropriate trimmings to assist in checking programs.

If sense switch F is on, the dump is not performed and only the message "Phase name" EXECUTED is printed. If sense switch G is up the routine halts after execution. The print area (locations 200-332) is neither printed nor saved.

This is a closed subroutine and control is transferred after execution, to the next sequential instruction after the branch to the snapshot routine. Snapshot uses index registers 1 and 3 for execution. These registers are saved at the beginning of execution and restored at the end.

If the index registers have zoning over the tens position, the display of the registers will be incorrect due to the logic which moved the values to the print area (HLDXT, HLD32, HLD31).

System Monitor and Parameter Card (01)

Up to 19 positions have been allowed for the control card (PRMCD). Currently, only 15 positions are used.

Upon completion of each phase of the compiler, control is transferred to the system monitor (MONTER). The monitor clears the previous phase (ACLEAR) and then reads the next phase from cards or tape (MONTOR). The location MONTOR is NOPed by the Loader Phase, if system input is from tape.

Prior to transferring control to the monitor, each phase initializes certain operands of the monitor. This initialization is accomplished by the FENDX macro.

TCLEAR - The highest address to be cleared by the monitor.

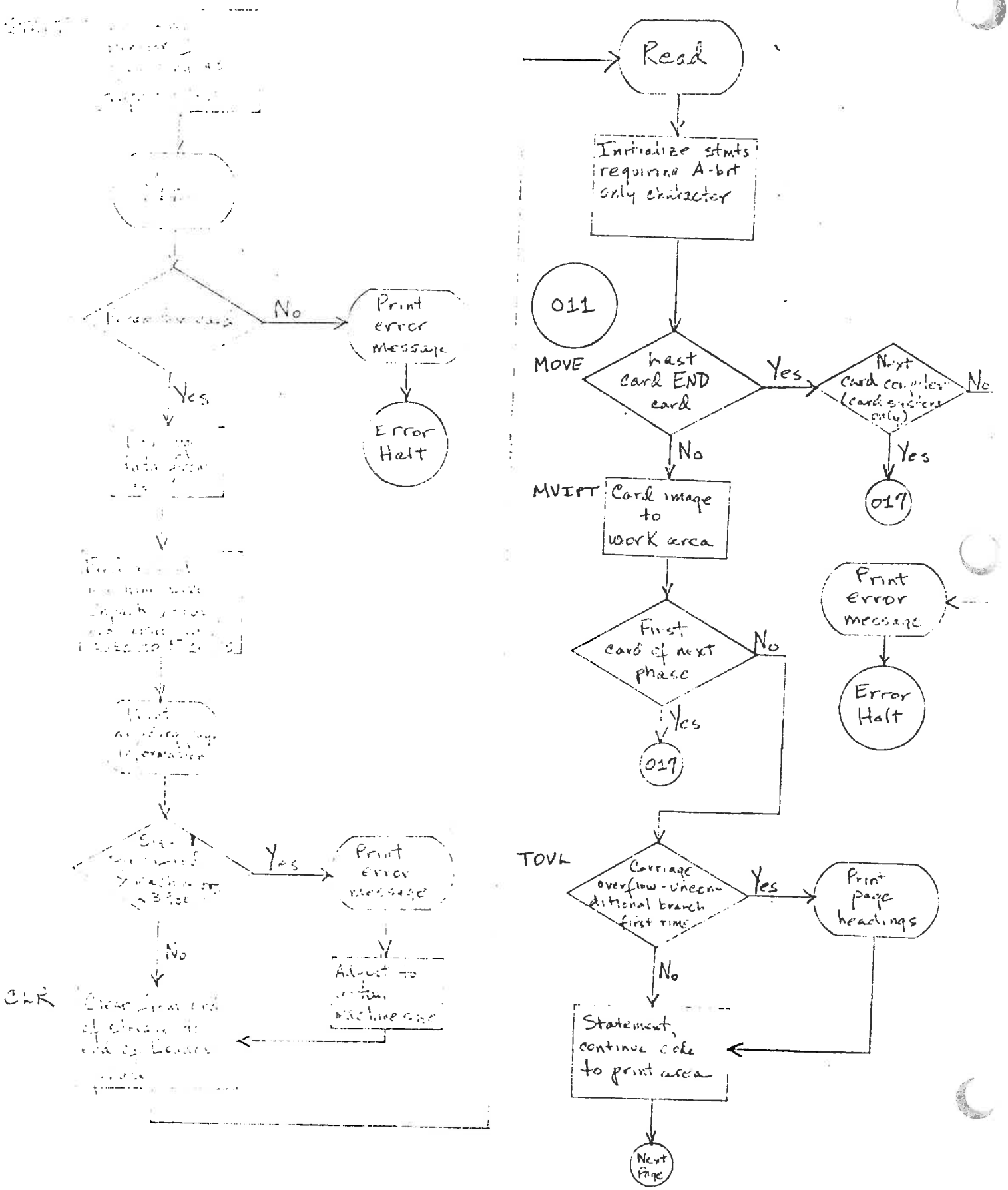
BCLEAR - The lowest address to be cleared by the monitor.

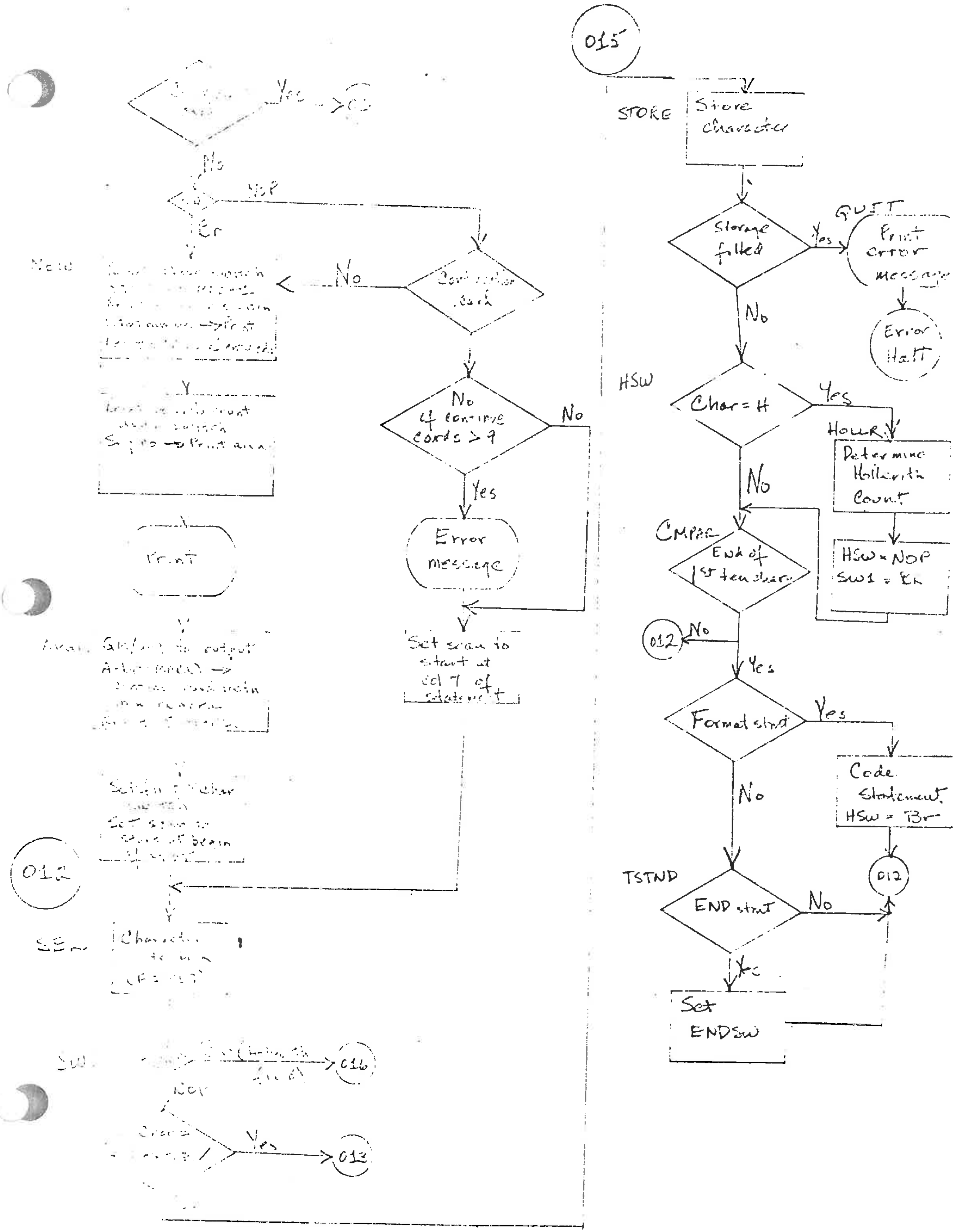
INITAP/6 - The address into which the next phase is to be read where operating as a tape system.

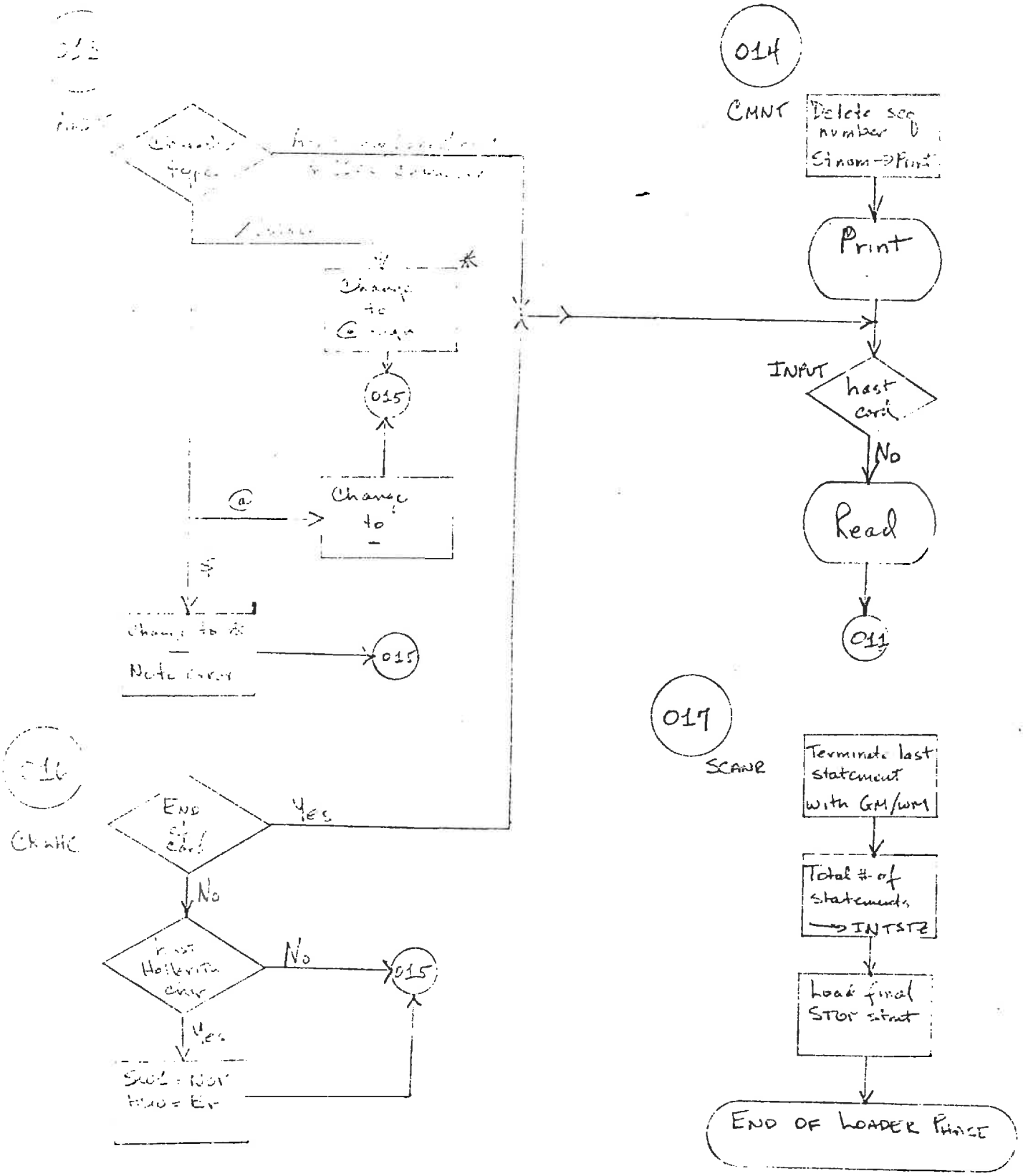
INITXT/3 - The address to which the monitor branches after reading the next phase. This is handled by the XFR card in the card system.

If any of these operands are the same as the previous phase, they are not reinitialized.

LOADER PHASE

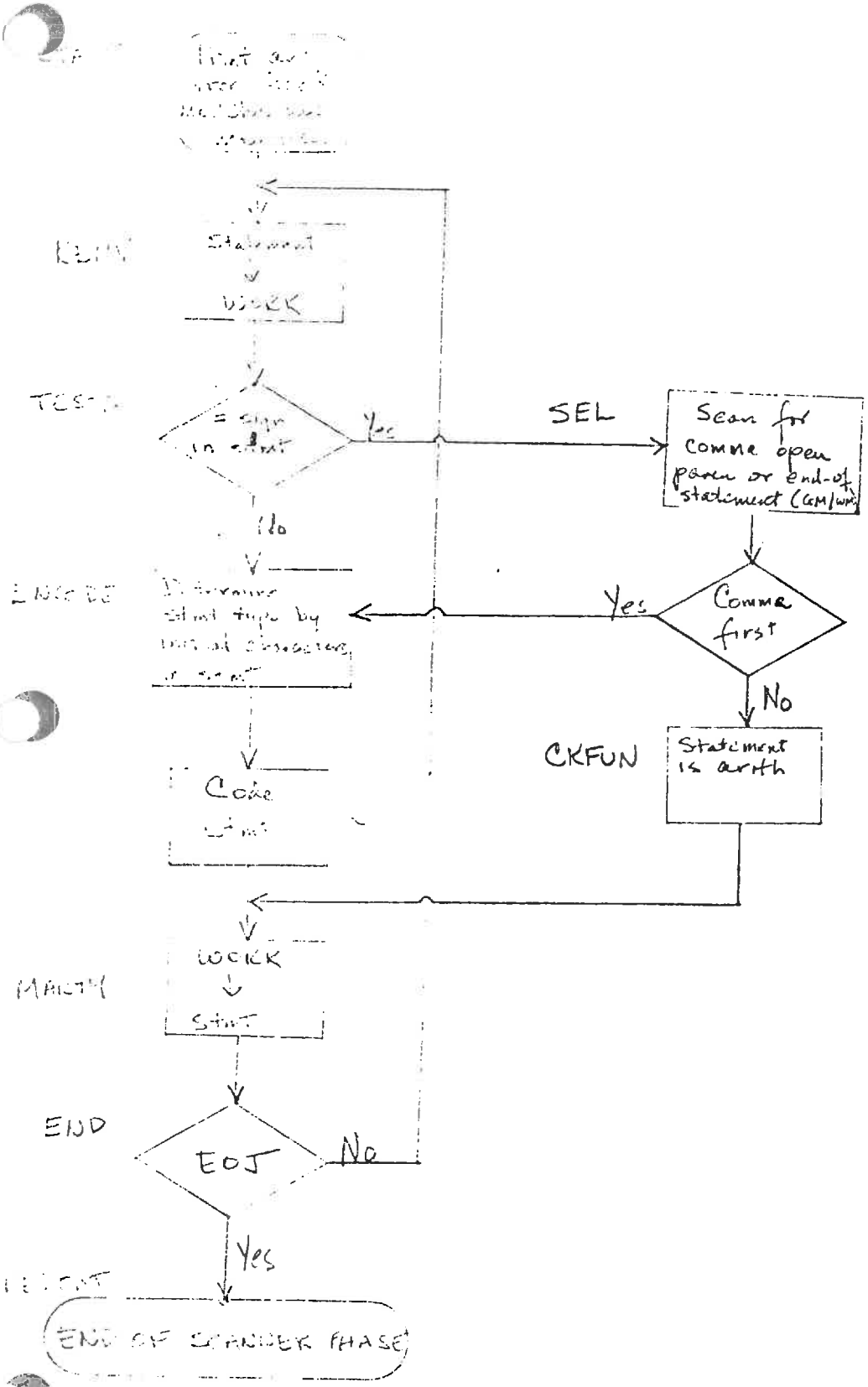



015
STORE
Store Character
Storage filled
Yes
QUIT
Print error message
Error Halt
No
HSW
Char = H
Yes
HOLLR
Determine Hollerith Count
HSW = NOP
SW1 = Er
No
CMPAR
End of 1st ten char
No
012
Yes
Format stmt
Yes
Code Statement
HSW = Br
No
012
TSTND
END stmt
No
Yes
Set ENDSW
No
No of continue cards > 9
No
Yes
Error message
Set scan to start at col 7 of statement
Print
012

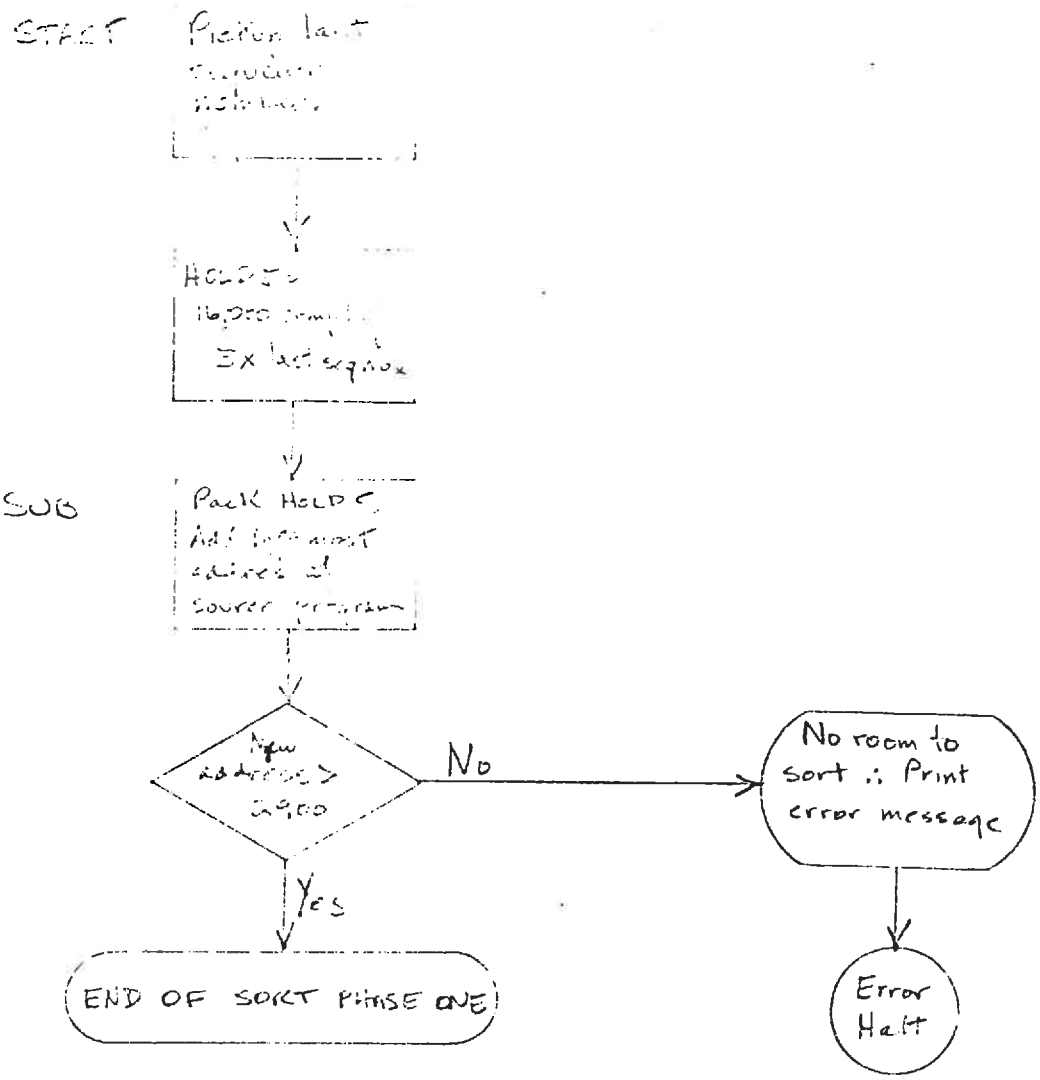


* Note: The input character / is changed to @ (4-8) because the compiler must distinguish between addresses containing / and the operator /.

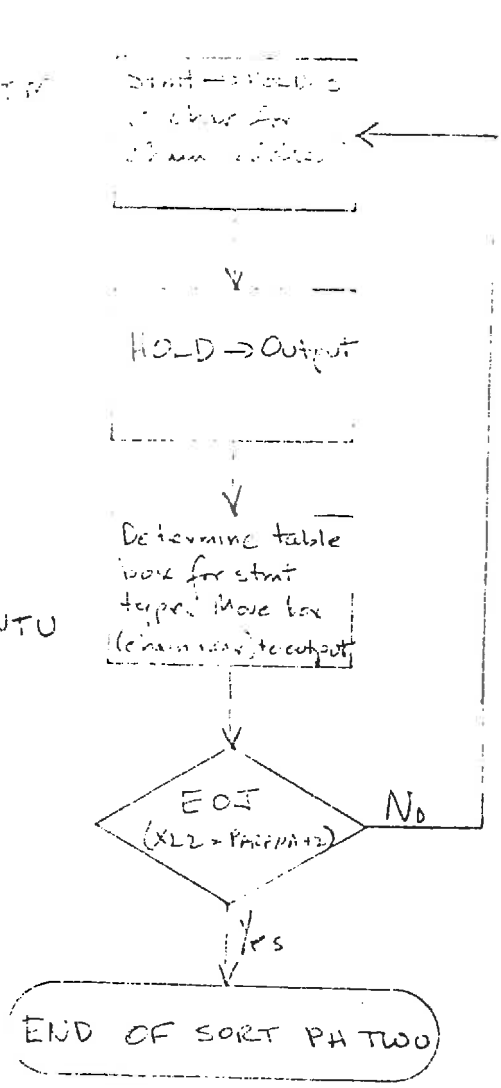
SCANNER PHASE



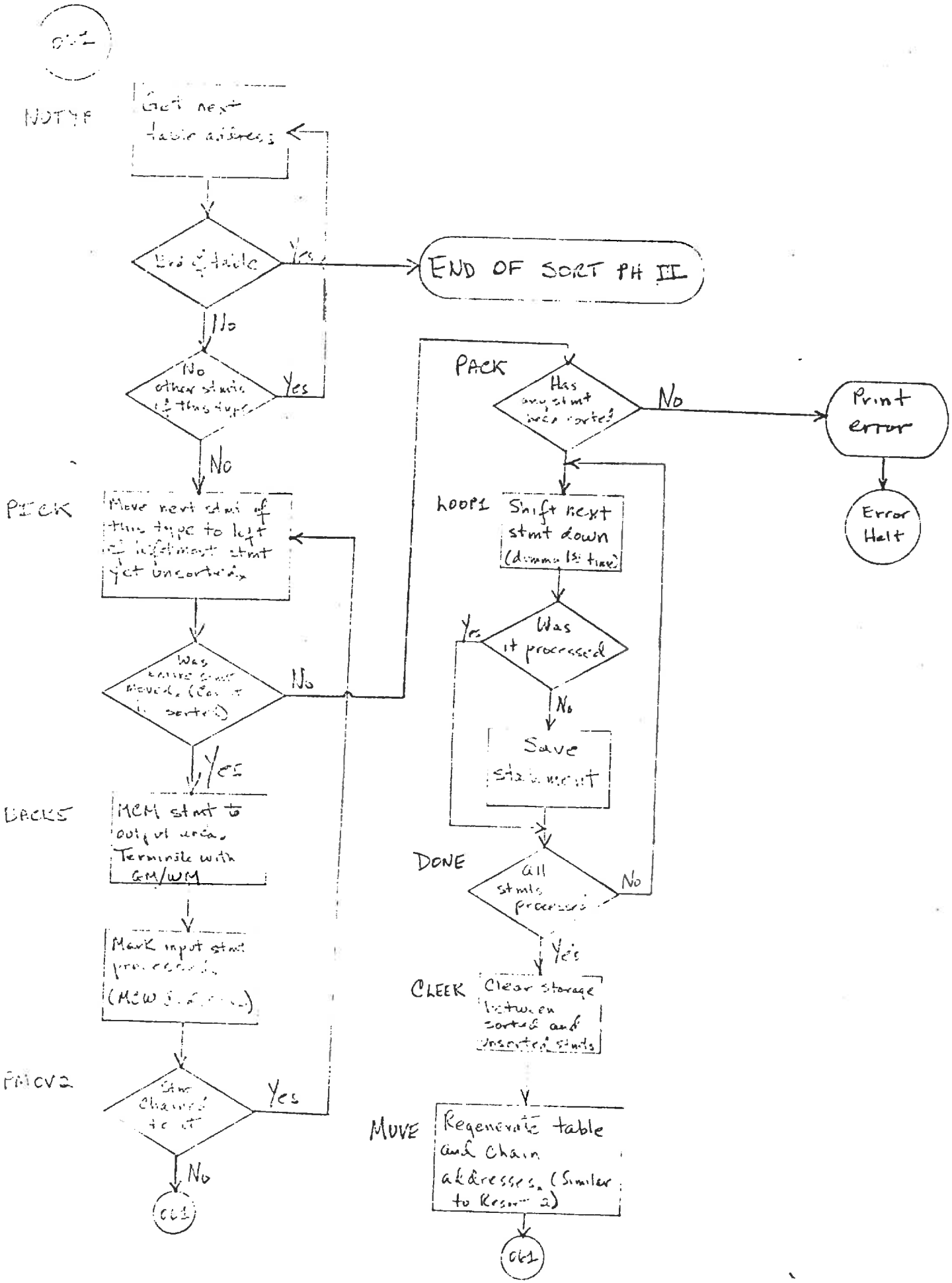
SORT PHASE ONE



SORT PHASE TWO



SORT PHASE THREE

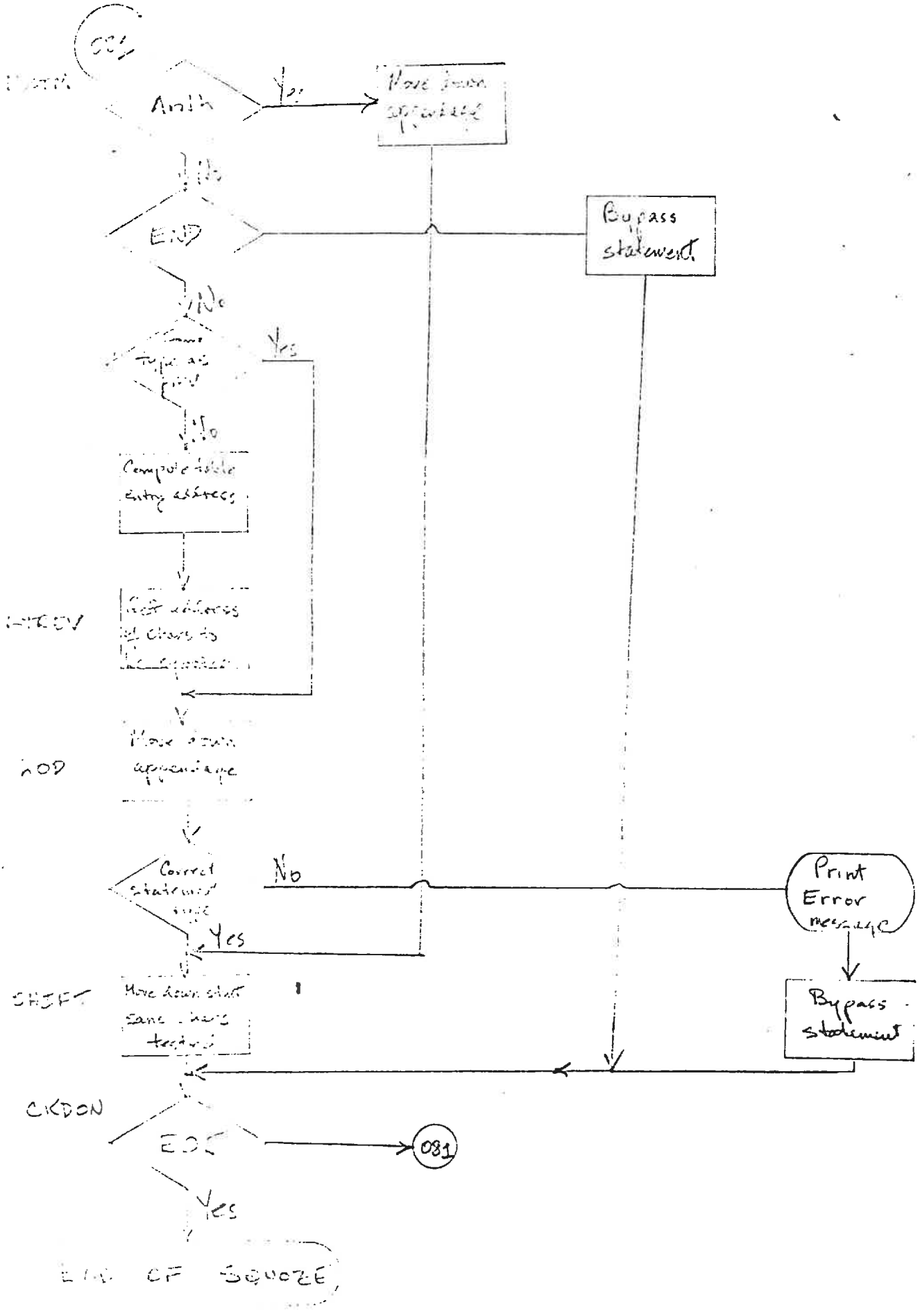


INSERT GROUP MARK PHASE

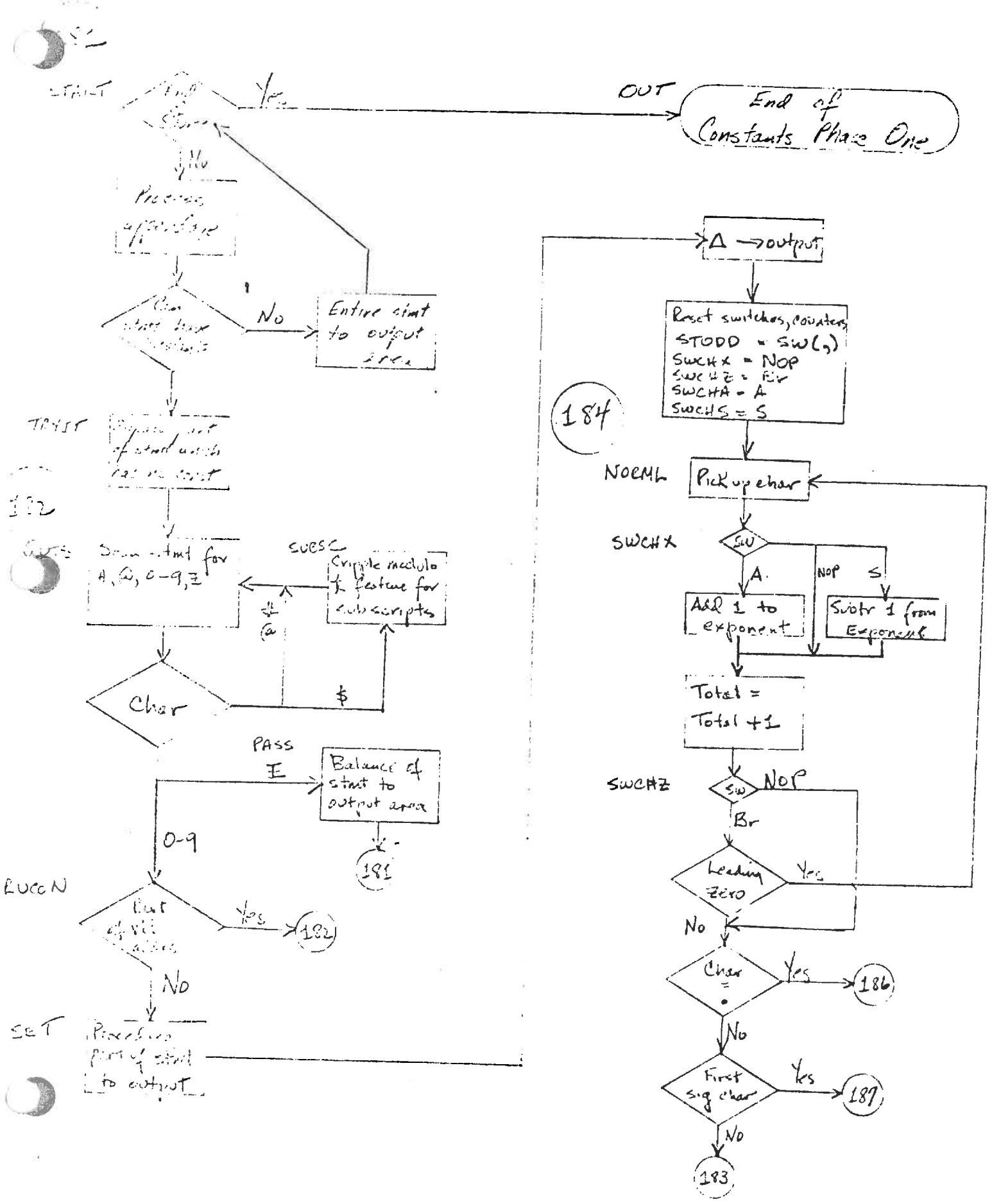
All 6-8 characters within the range of the source program are converted to group mark/word mark. This character appears between the body of the statement and its appendage.

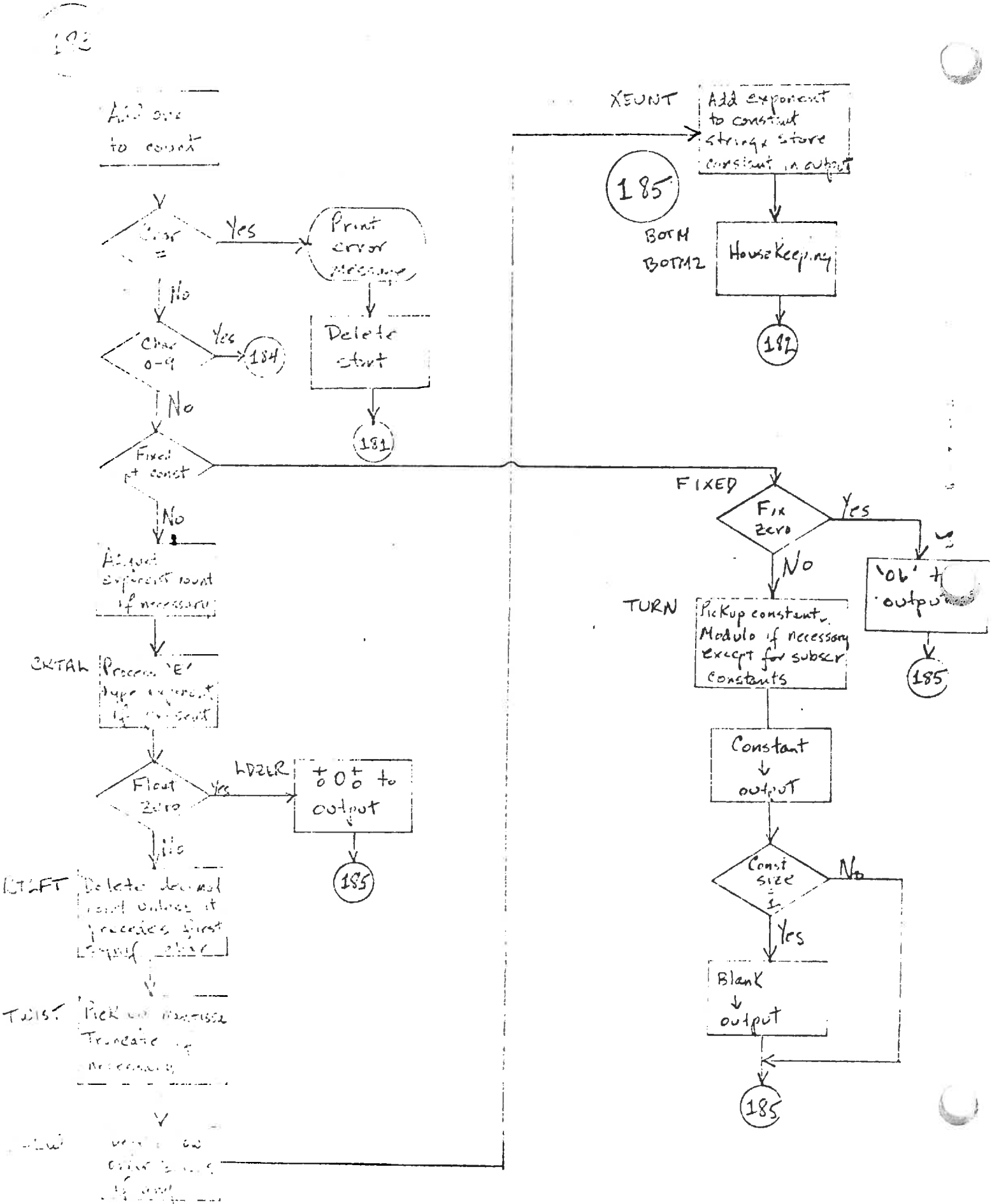
This phase is terminated by reaching the character blank (BTEST). This test is NOPed when the statement is FORMAT (ISFMT).

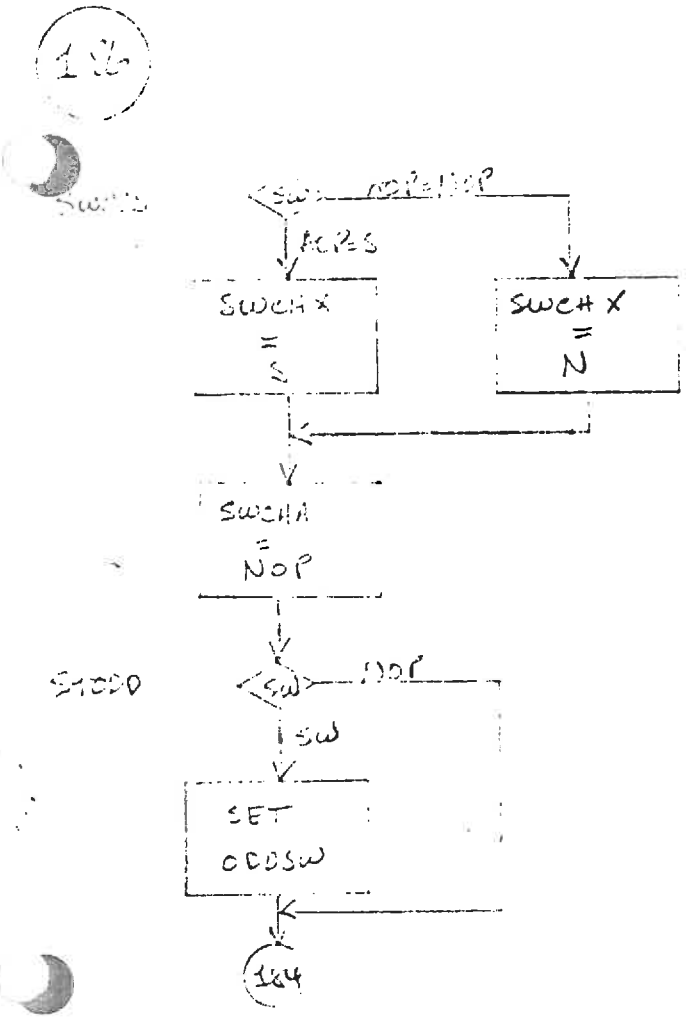
SQUOZE PHASE

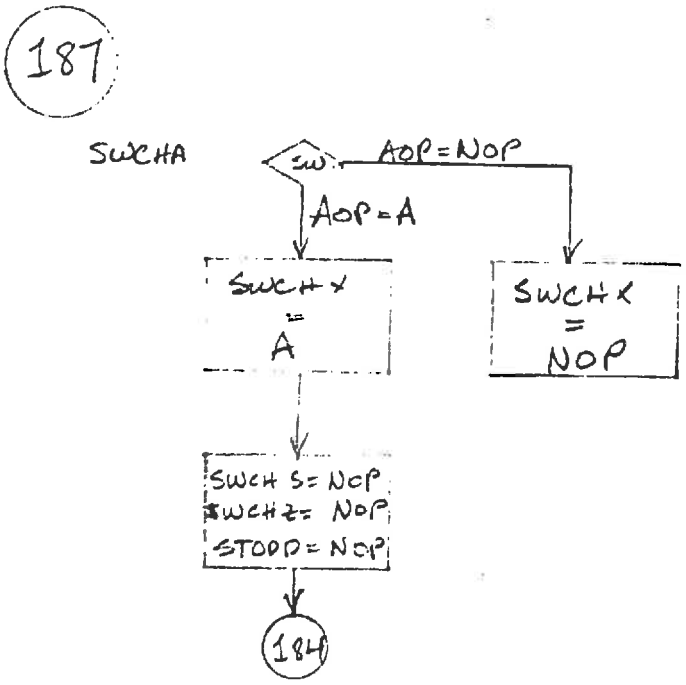


CONSTANTS PHASE ONE

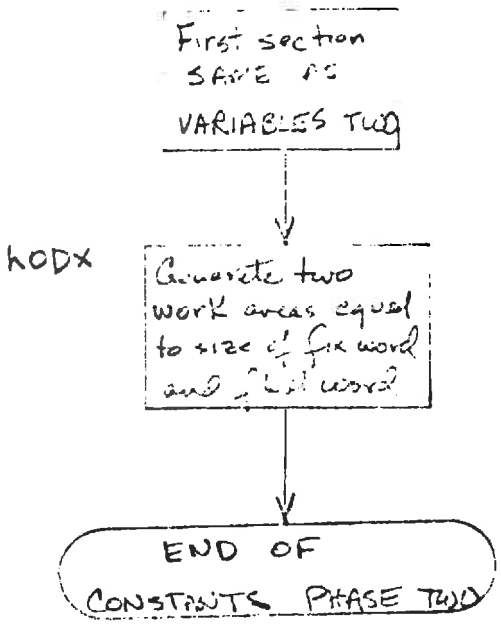



182
Add one to count
Error =
Yes
Print error message
No
Char 0-9
Yes
184
Delete char
No
Fixed pt const
181
No
Adjust exponent count if necessary
CKTAL
Process 'E' type exponent if present
Float Zero
Yes
HDZER
±0.0± to output
185
No
LSTLFT
Delete decimal point unless it precedes first significant char
TRUNC
Pick up mantissa Truncate if necessary
XEUNT
Add exponent to constant string store constant in output
185
BOTH
BOTM2
Housekeeping
182
FIXED
Fix Zero
Yes
'0' to output
185
No
TURN
Pick up constant Modulo if necessary except for subscr constants
Constant
output
Const size = 1
No
Yes
Blank
output
185

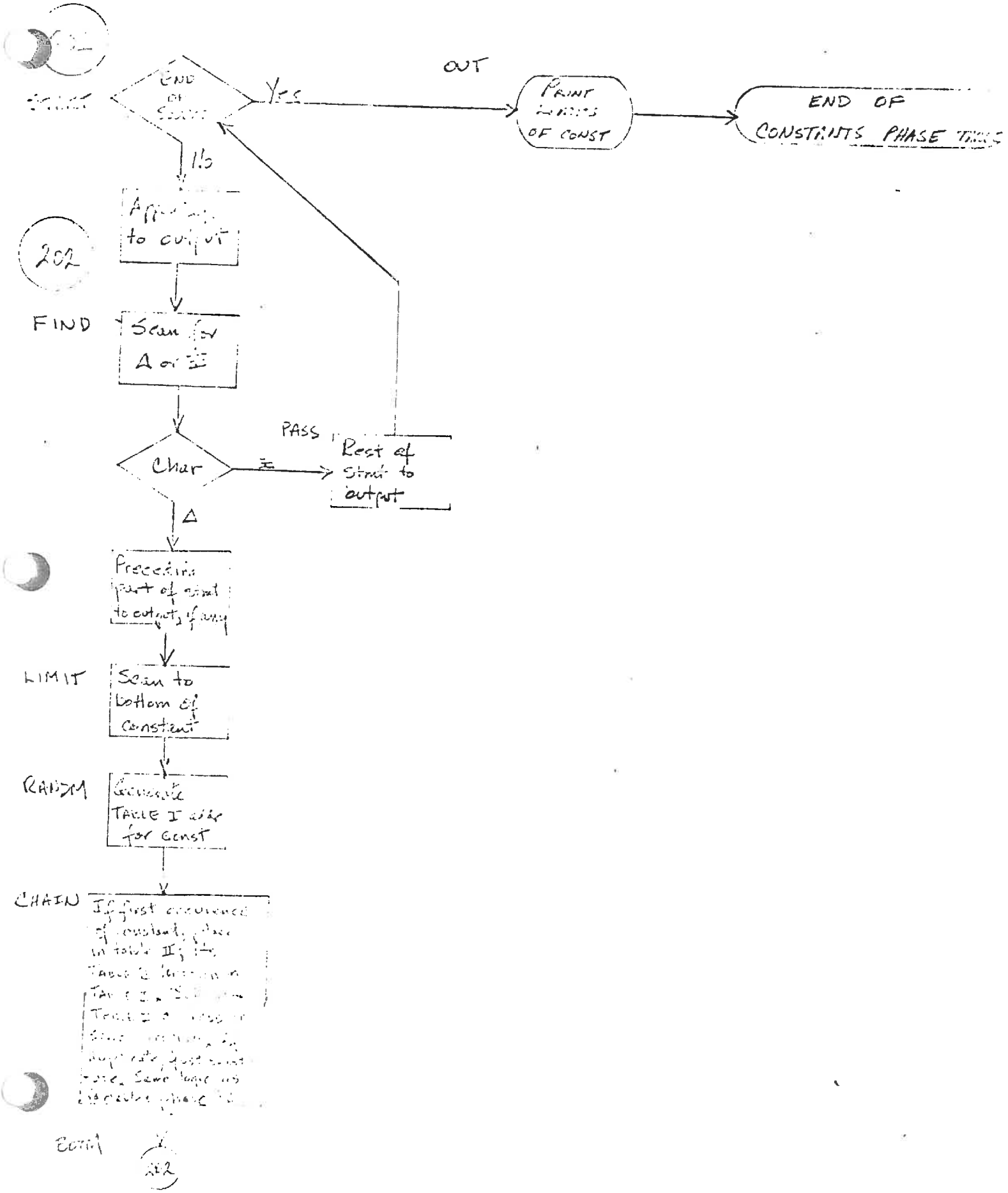

186
SWCH S
SW
NOP=NOP
A=RS
SWCH X
=
S
SWCH X
=
N
SWCHA
=
NOP
STOPP
SW
NOP
SW
SET
OPPSW
184


187
SWCHA
SW
AOP=NOP
AOP=A
SWCH X
=
A
SWCH X
=
NOP
SWCH S= NOP
SWCH Z= NOP
STOPP = NOP
184

CONSTANTS PHASE TWO



CONSTANTS PHASE THREE



SUBSCRIPTS PHASE

This phase cleans up subscripts, eliminating the commas and asterisks necessary for proper processing of subscript constants.

The end result is the subscript parameters as they will exist at object time.

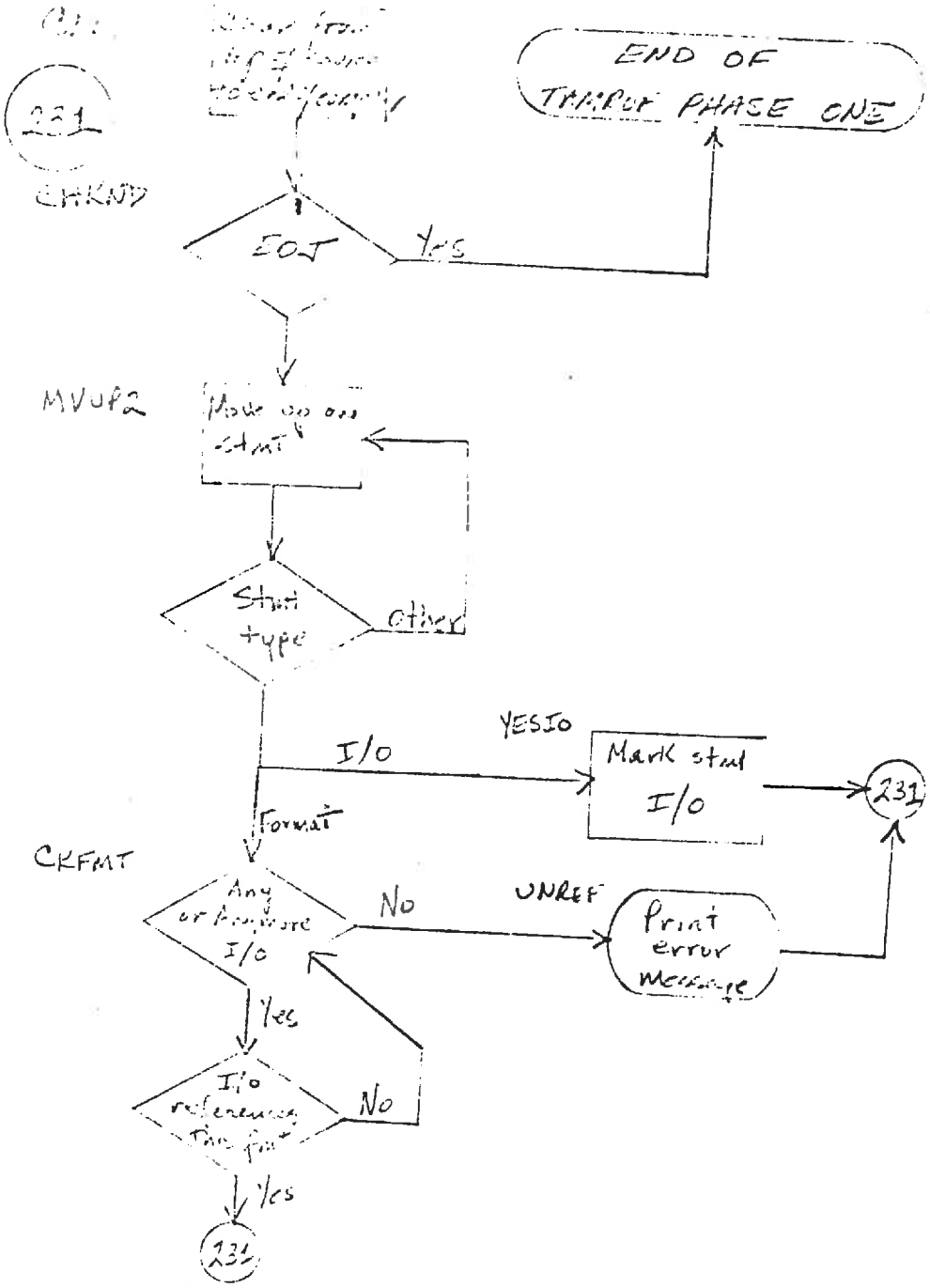
STATEMENT NUMBERS PHASE ONE

Processing in this phase is straightforward. All statement numbers are converted to unique three character representations. A table of 50 characters (TABLE) is used. The literal 50 is subtracted from the second and third, and fourth and fifth positions of each statement number. If the result is positive for the latter, one (1) is added to the first character. If the former is positive, two (2) is added to the first character. The characters in the table replace the three sections of the original statement number.

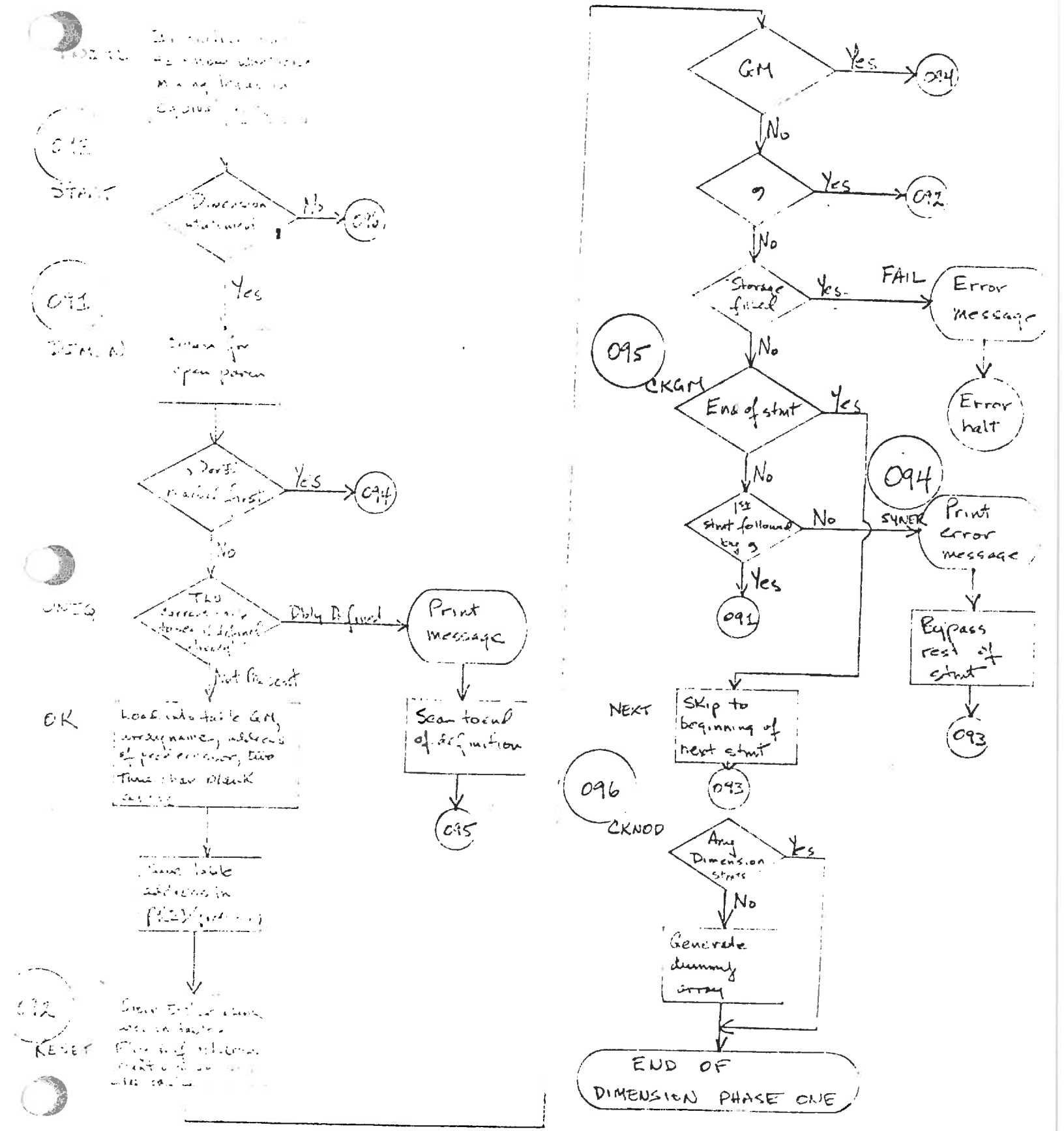
Each statement type is processed separately due to the different locations for statement numbers. The unique representations for the statement numbers are placed at the beginning (rightmost) part of the statement and terminated with a comma.

Adequate error checking is provided to check syntax and to insure that all required statement numbers are present.

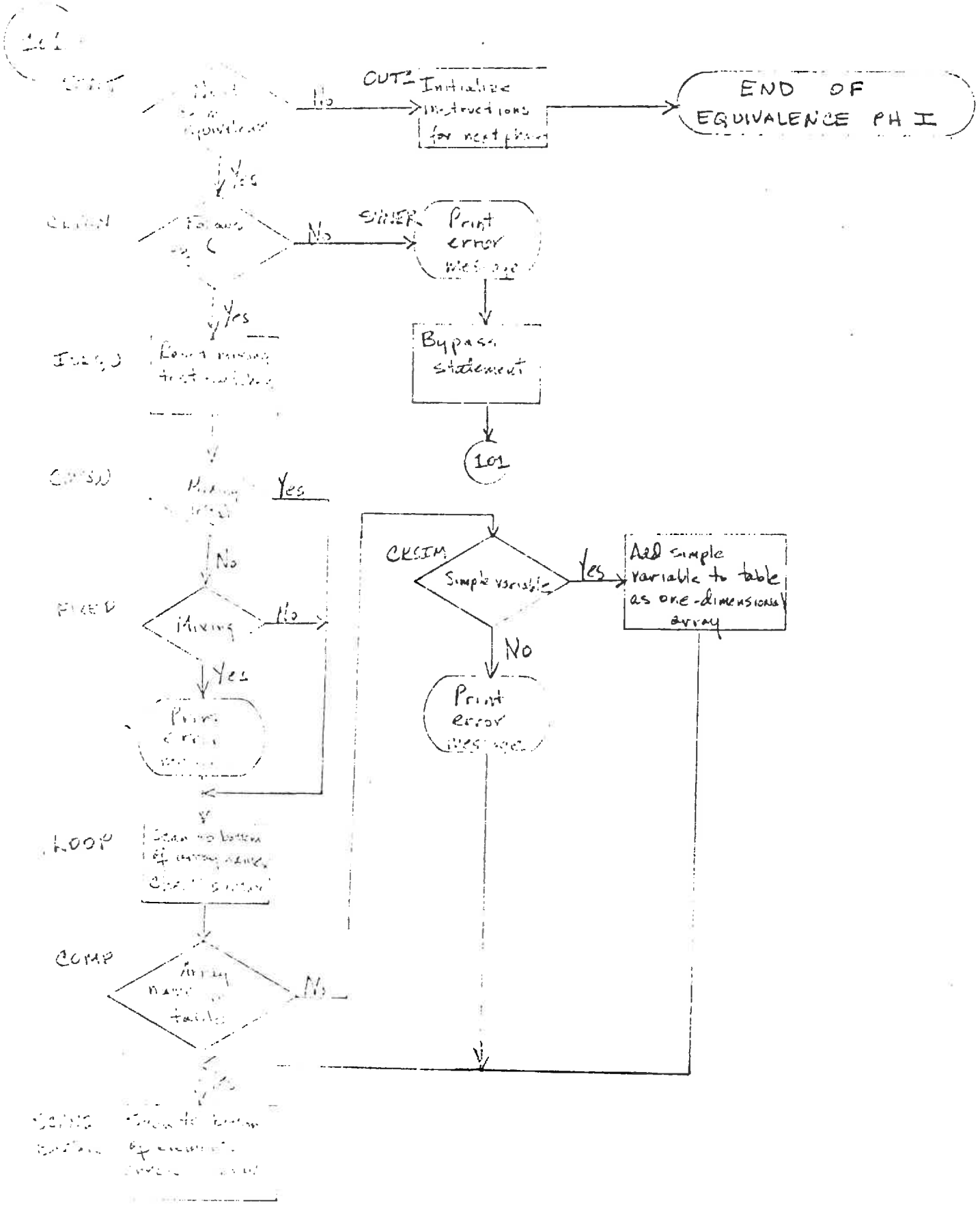
TAMPOF PHASE ONE



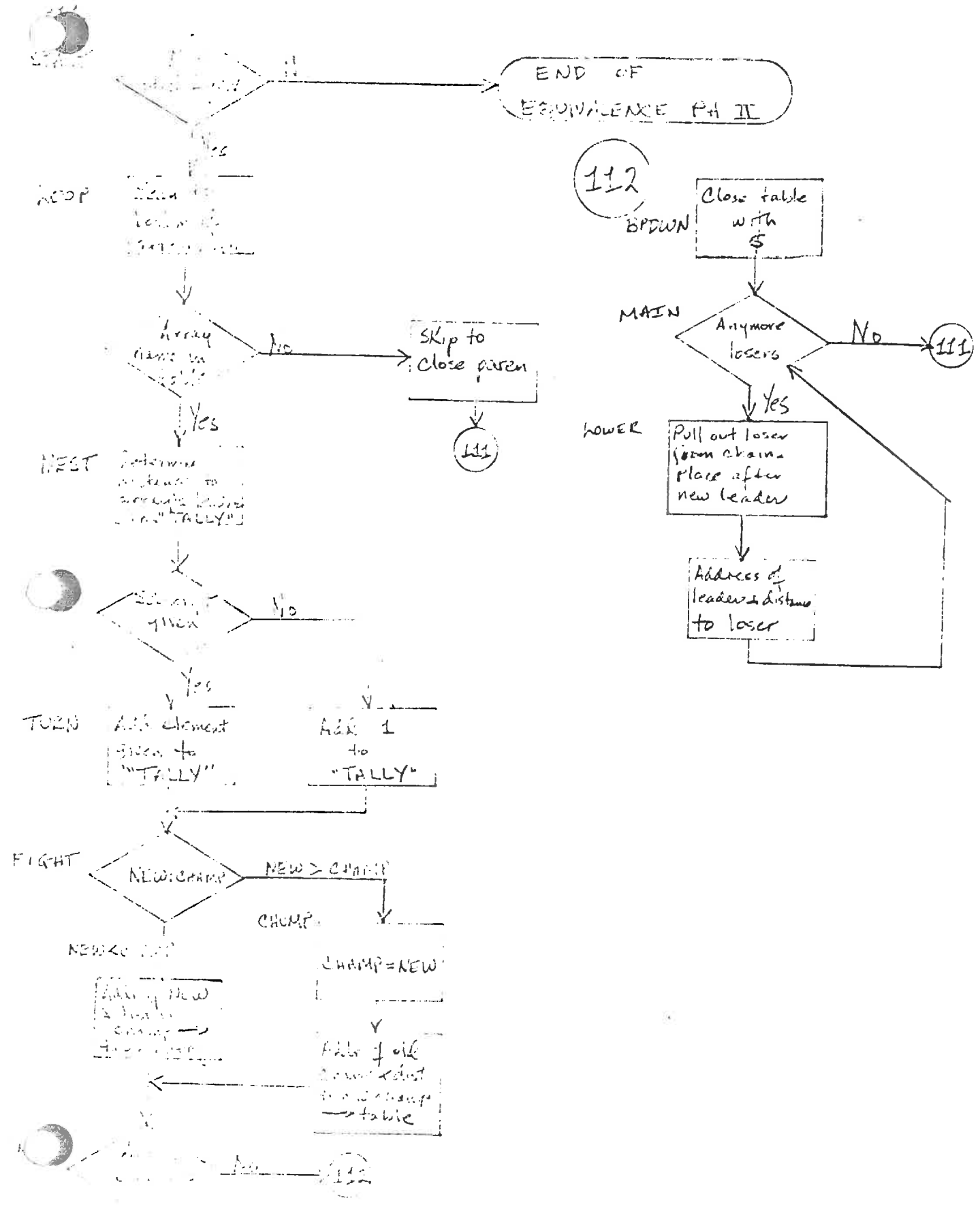
DIMENSION PHASE ONE



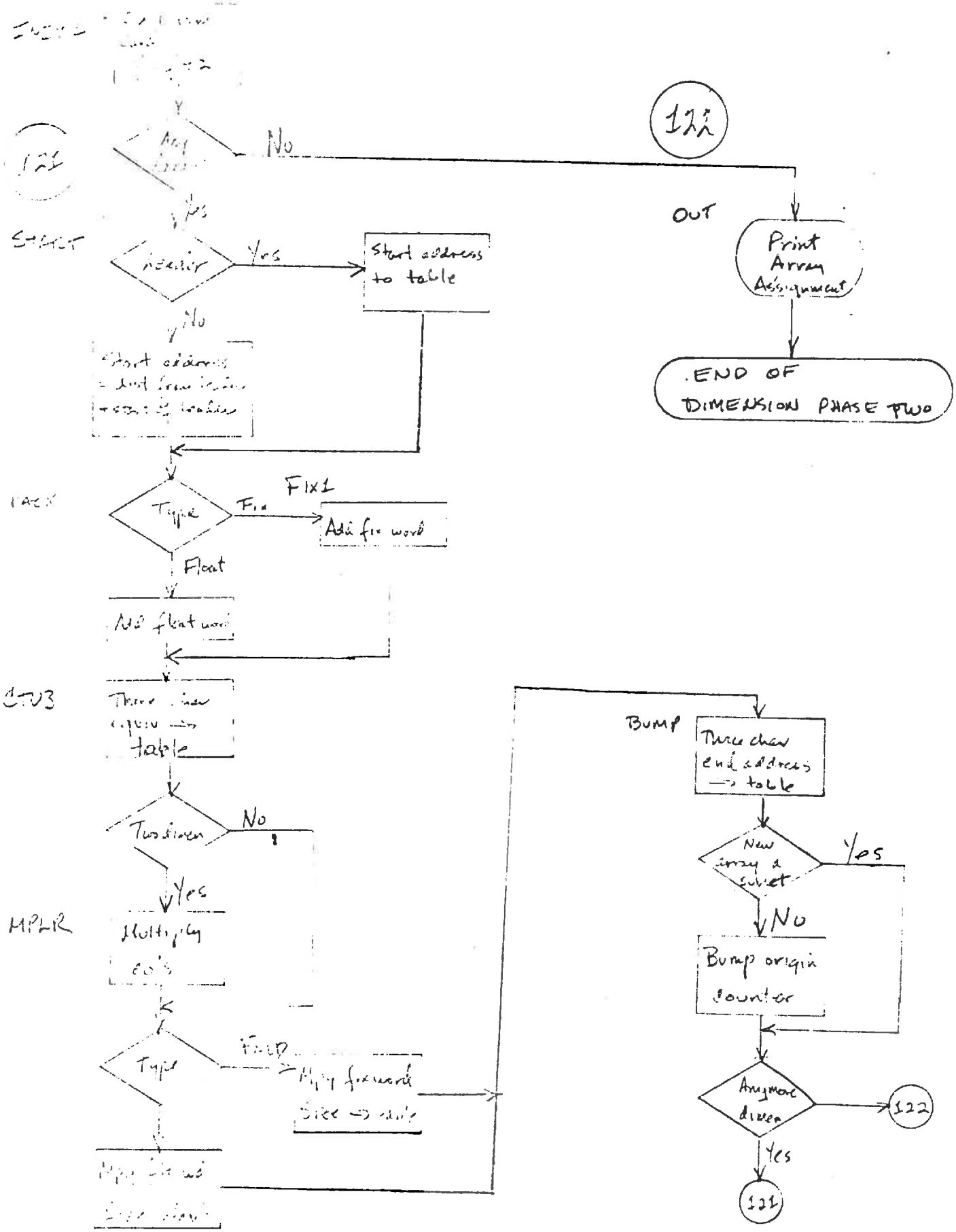
EQUIVALENCE PHASE ONE



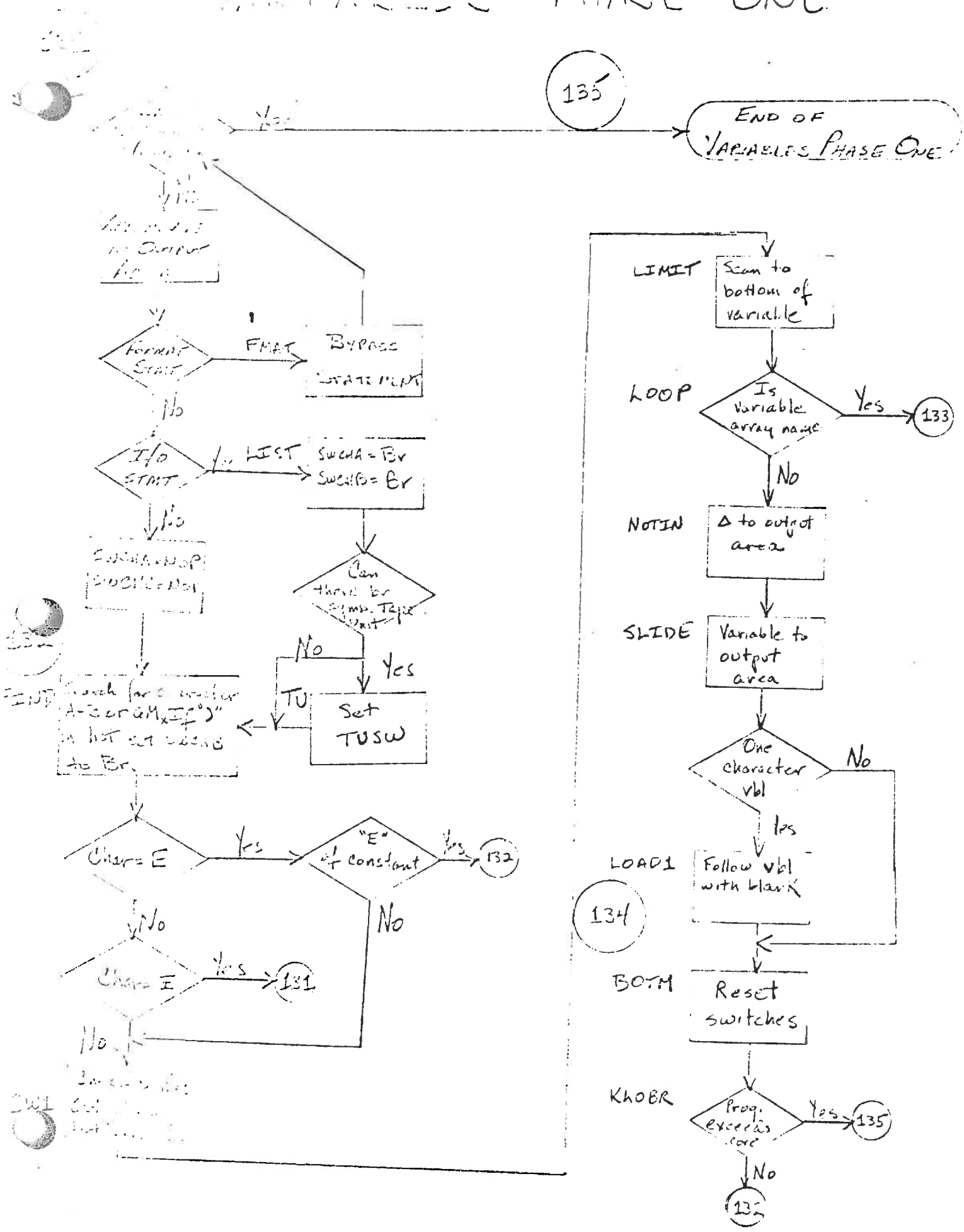
EQUIVALENCE PHASE TWO

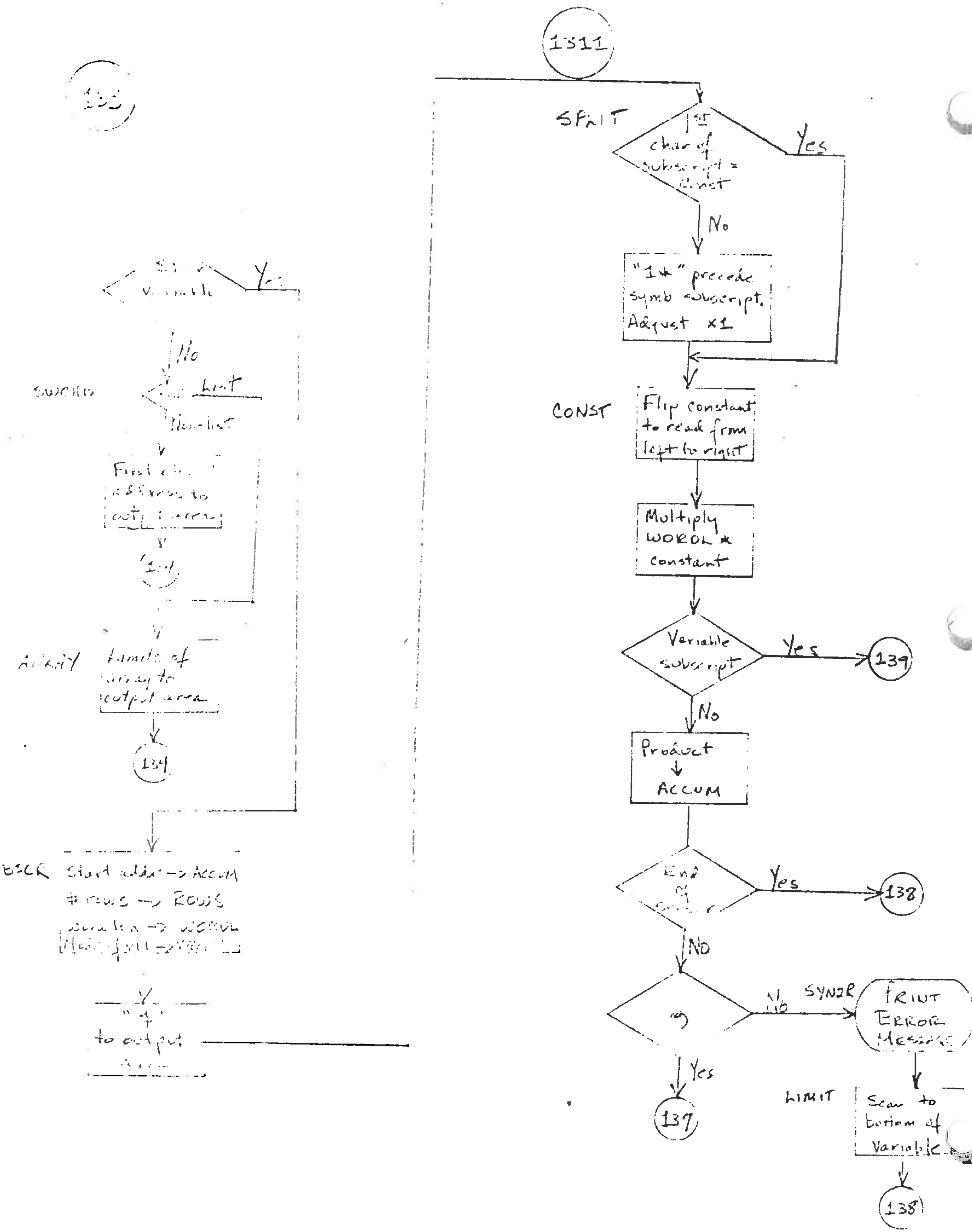


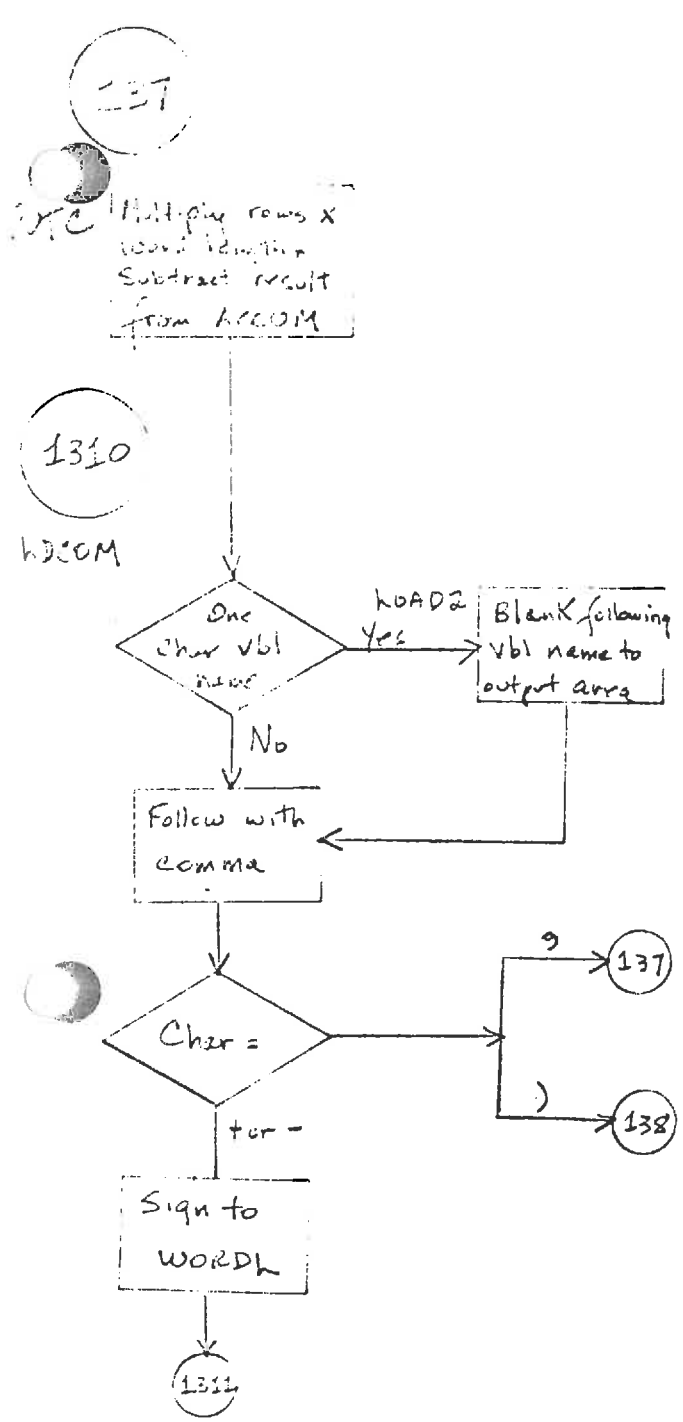
DIMENSION PHASE TWO

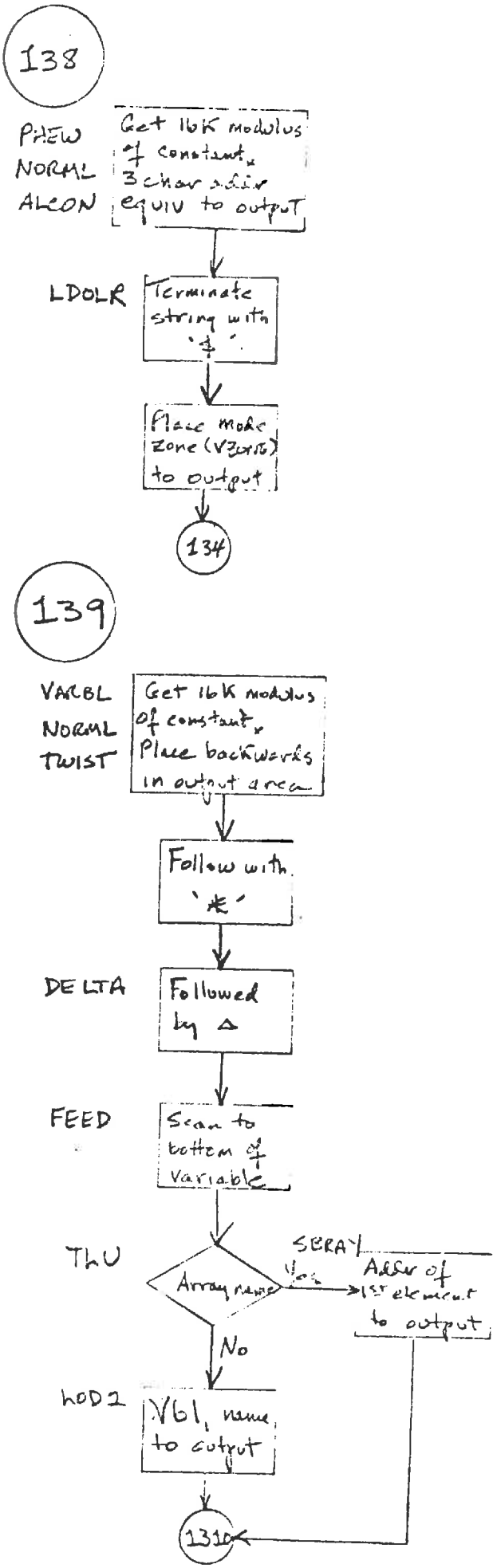


VARIABLES PHASE ONE

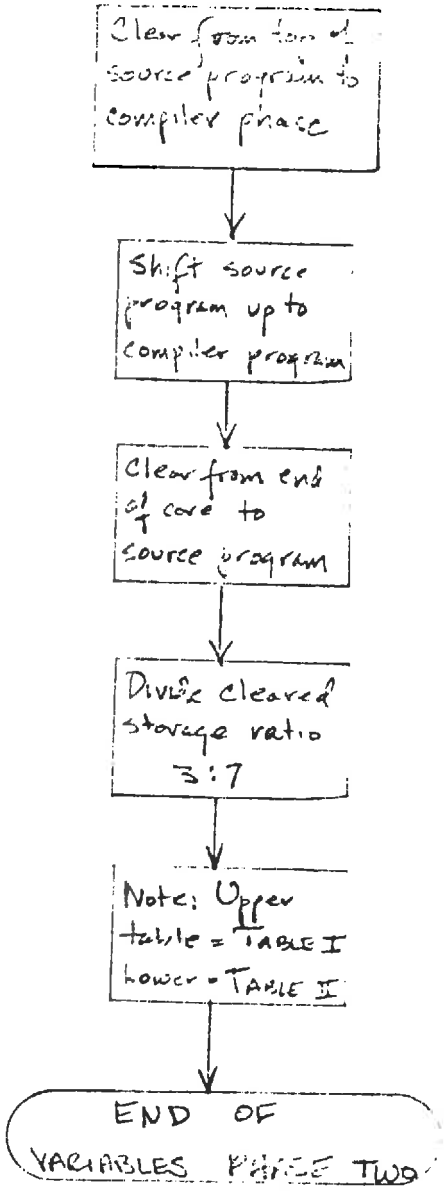



1311
SPLIT
1st char of subscript = Const
Yes
No
"1*" precede symb subscript. Adjust x1
CONST
Flip constant to read from left to right
Multiply WORDL * constant
Variable subscript
Yes
139
No
Product → ACCUM
Yes
138
NO
No
SYNER
PRINT ERROR MESSAGE
Yes
137
LIMIT
Scan to bottom of Variable
138
Yes
No
List
ARRAY
134
Start addr → Accum
rows → ROWS
to output


137
Multiply rows x word length
Subtract result from ARCOM
1310
ADCOM
One char vbl name
LOAD2
Yes
Blank following vbl name to output area
No
Follow with comma
Char =
9
137
)
138
+ or -
Sign to WORDL
1311


138
PHEW
NORML
ALCON
Get 16K modulus of constant, 3 char addr equiv to output
LDOLR
Terminate string with '4'
Place mode zone (VZONE) to output
134
139
VARBL
NORML
TWIST
Get 16K modulus of constant, Place backwards in output area
Follow with '*'
DELTA
Followed by Δ
FEED
Scan to bottom of variable
THU
Array name
SCRAY
Yes
Addr of 1st element to output
No
LOD2
Vbl, name to output
1310

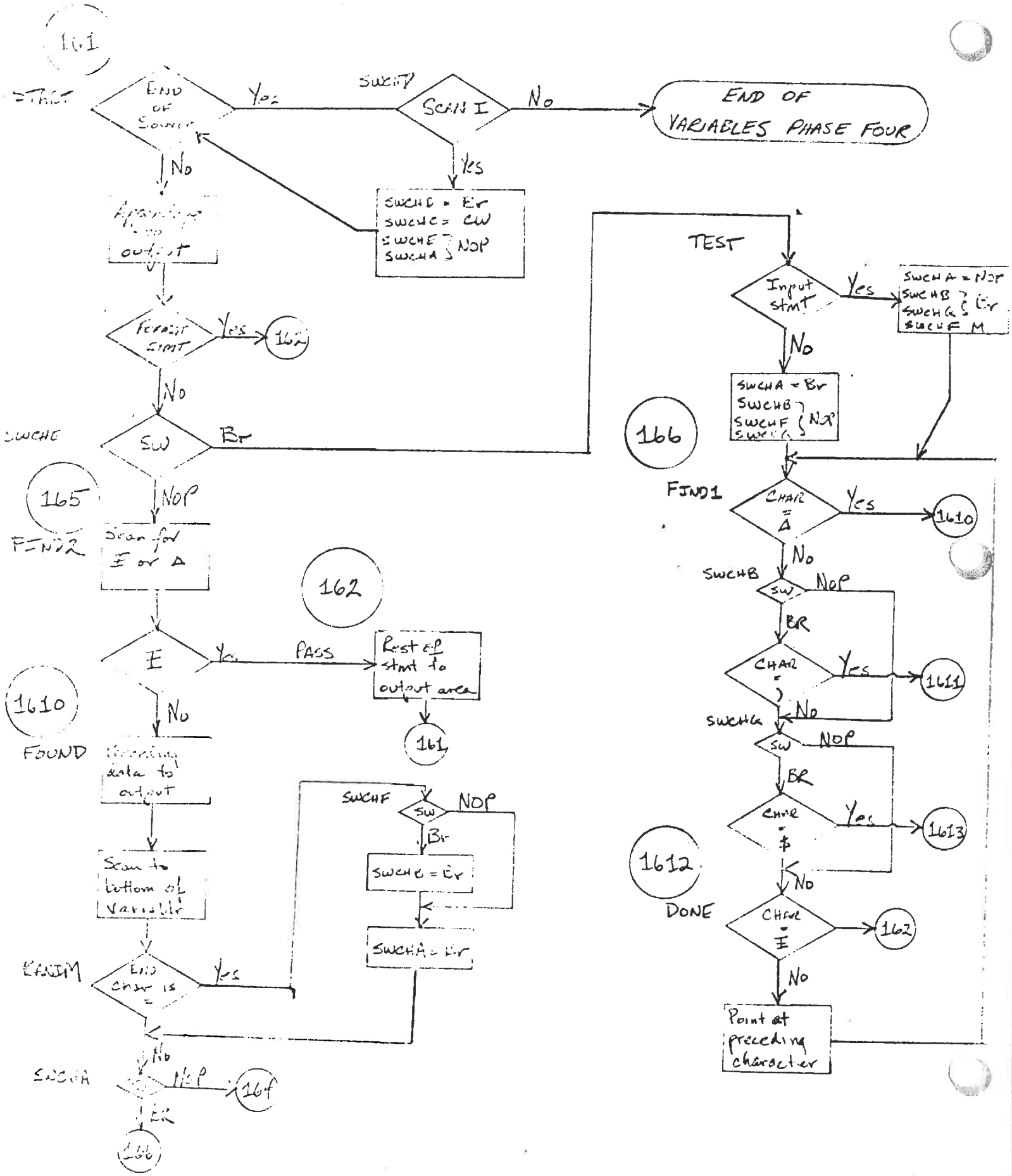
VARIABLES PHASE TWO

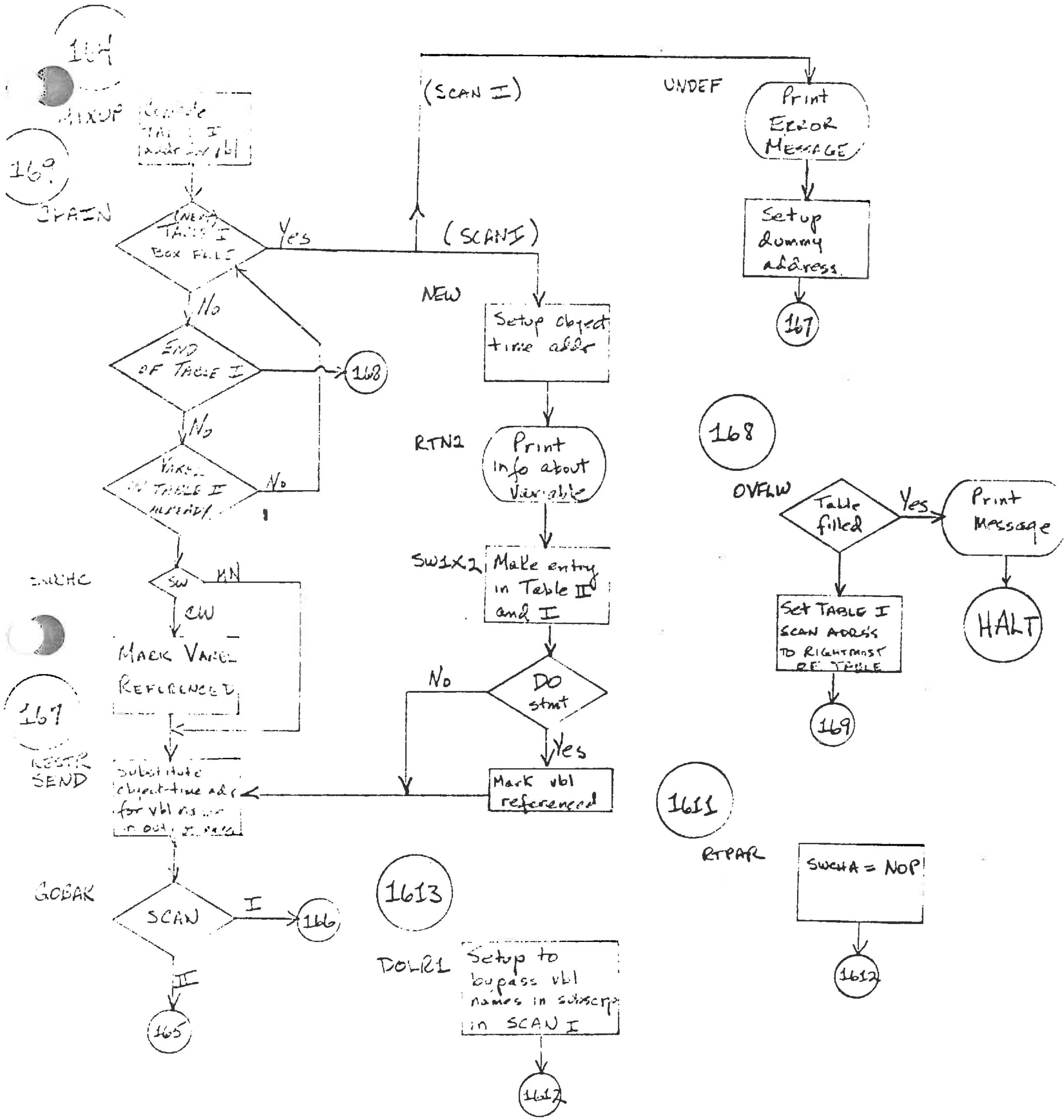


VARIABLES PHASE THREE

A housekeeping phase. The heading line "Storage Assignment - Simple Variables" is printed. NXTOP is converted to five characters and is stored in WORK$.

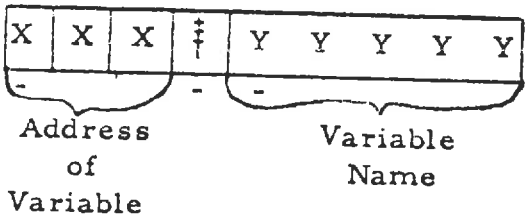
VARIABLES PHASE FOUR




164
MIXUP
169
CHAIN
(NEW) TABLE I BOX FULL
Yes
(SCAN I)
No
END OF TABLE I
168
No
VARBL IN TABLE II ALREADY
No
SW
KN
CW
MARK VARBL REFERENCED
167
SEND
Substitute object-time adr for vbl name in out. area
GOBAK
SCAN
I
166
II
165
UNDEF
Print ERROR MESSAGE
Setup dummy address
167
NEW
Setup object time addr
RTN2
Print info about Variable
SW1X2
Make entry in Table II and I
DO stmt
No
Yes
Mark vbl referenced
168
OVFLW
Table filled
Yes
Print Message
HALT
Set TABLE I SCAN ADRSS TO RIGHTMOST OF TABLE
169
1611
RTPAR
SWCHA = NOP
1612
1613
DOLR1
Setup to bypass vbl names in subscrp in SCAN I
1612

VARIABLES PHASE FIVE

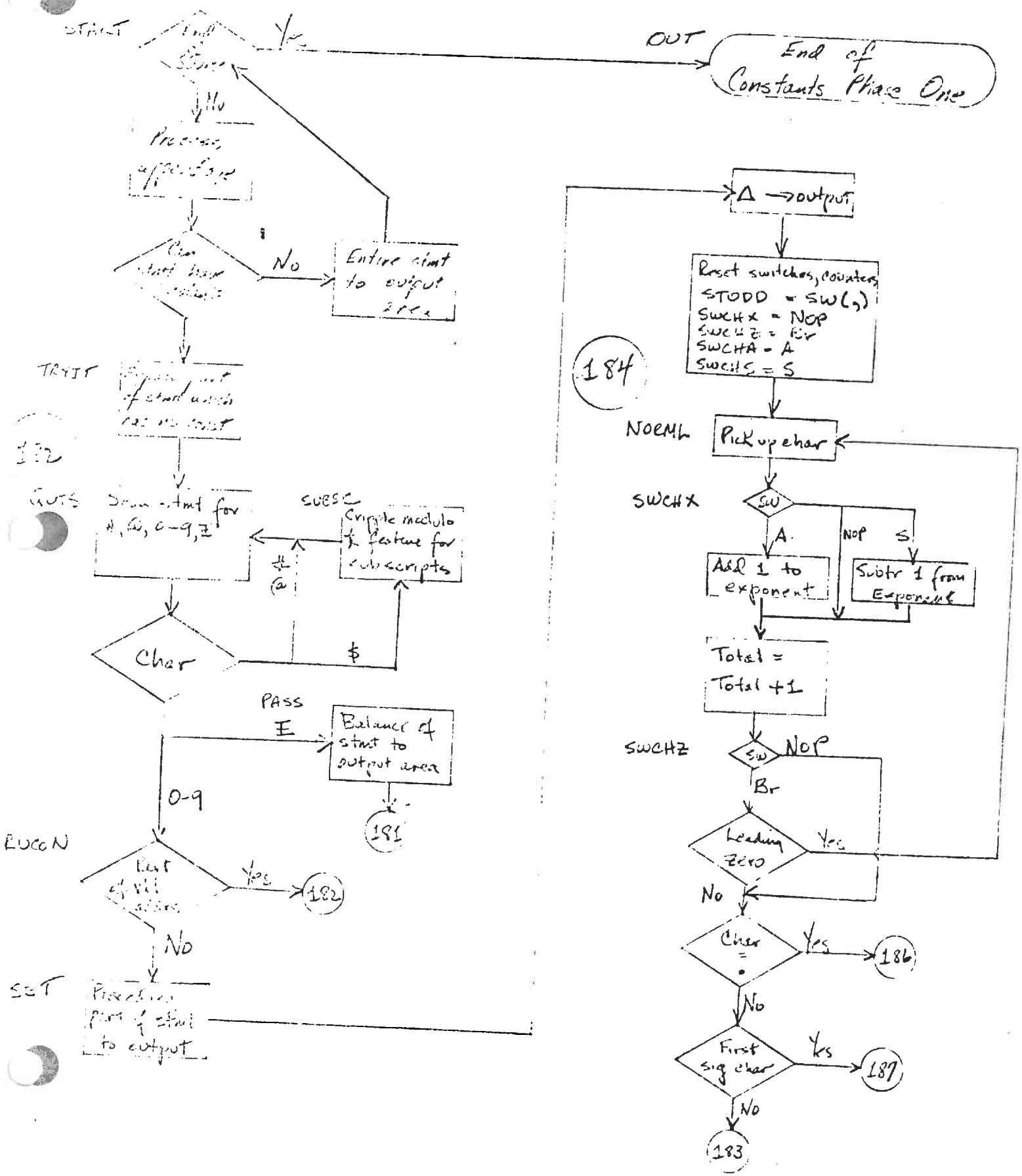
This phase scans for unreferenced variables. Each element in Variables Table II has the following format:

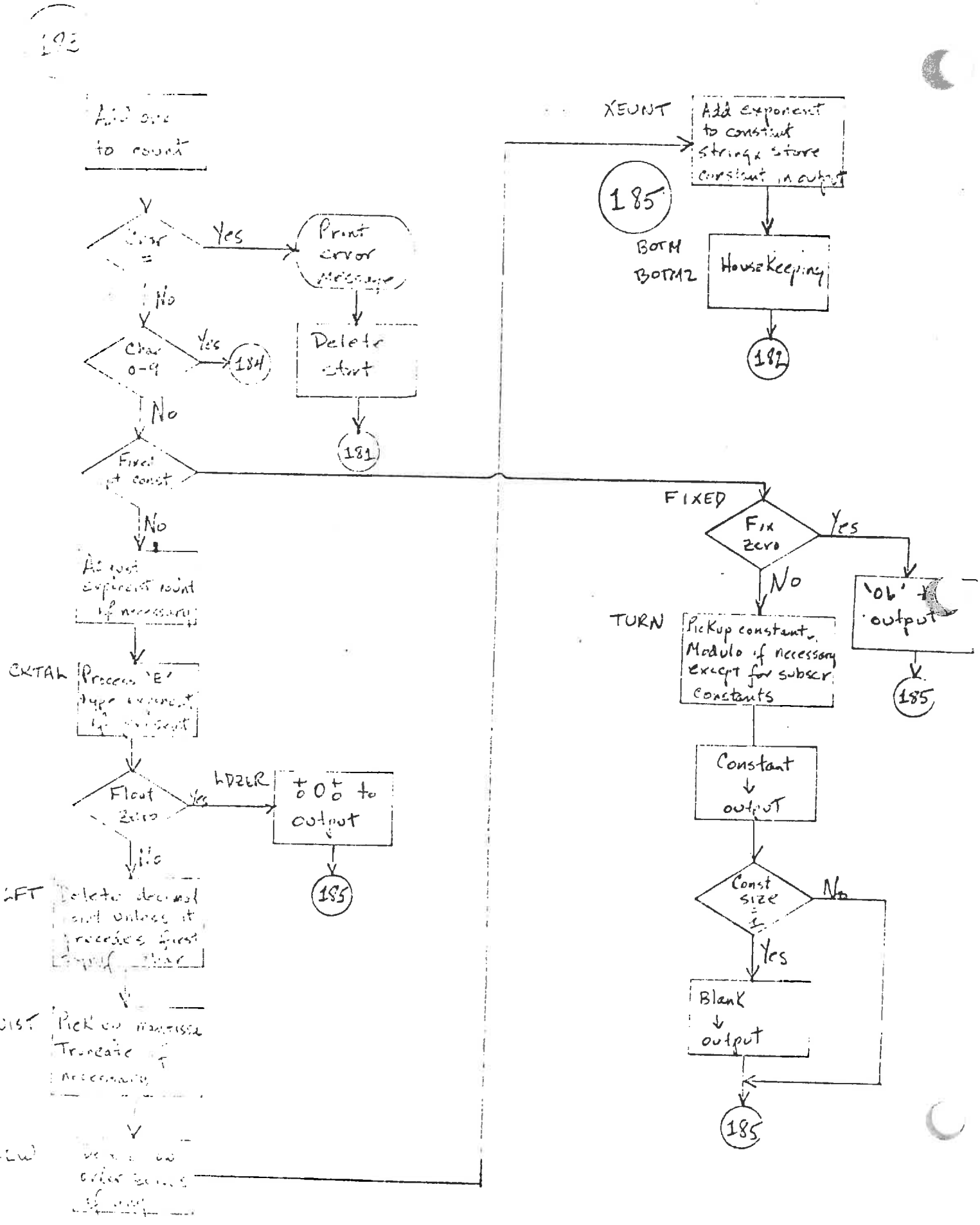


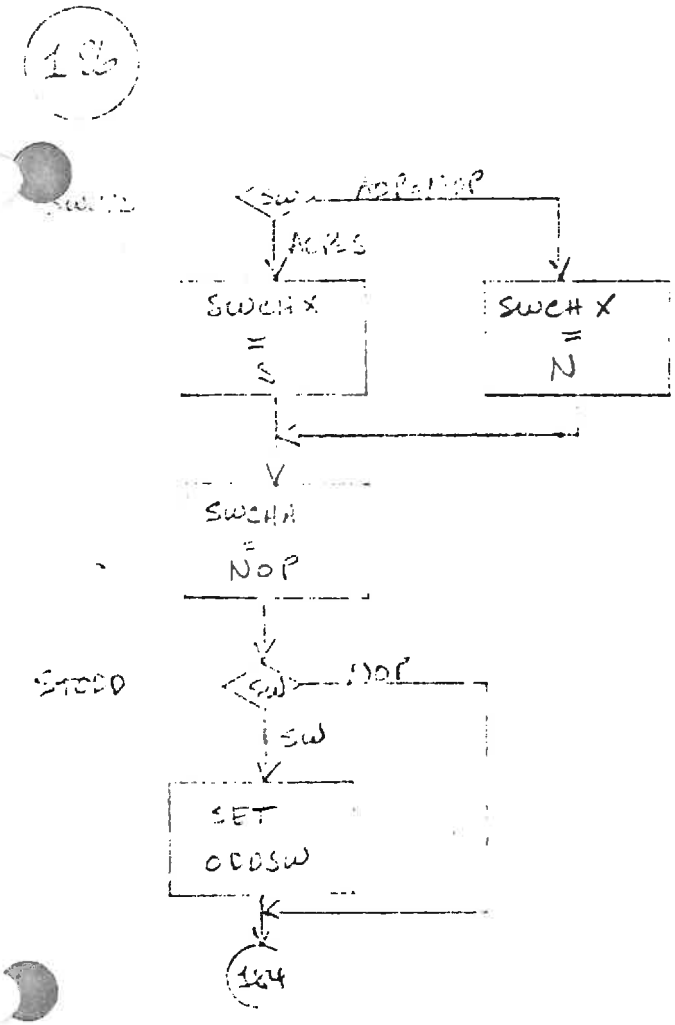
The word mark is cleared fron the group mark in Variables Phase Four (SWCHC) when a variable is referenced.

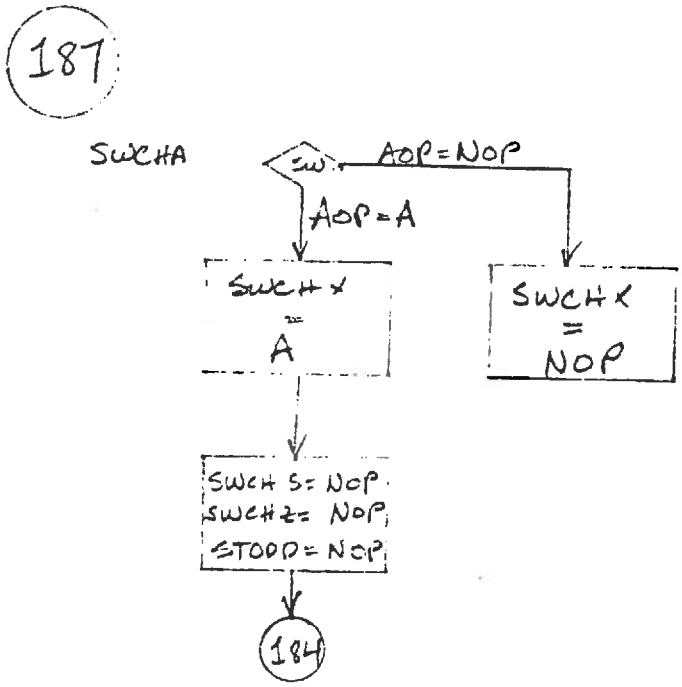
This phase scans Table II for entries where the word mark still exists.

CONSTANTS PHASE ONE

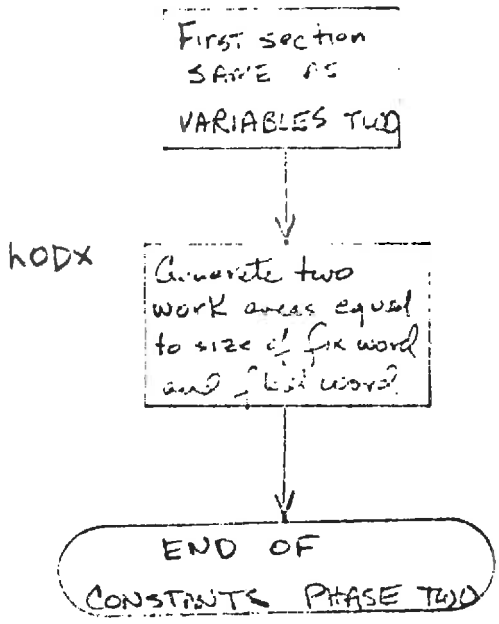



182
Add one to count
Char =
Yes
Print error message
No
Char 0-9
Yes
184
Delete start
181
No
Fixed pt const
No
Adjust exponent point if necessary
CKTAH
Process 'E' type exponent
Float Zero
Yes
HDZER
+0.0+ to output
185
No
CTAFT
Delete decimal point unless it precedes first
TWIST
Pick up mantissa Truncate if necessary
XEUNT
Add exponent to constant string & store constant in output
185
BOTH
BOTM2
Housekeeping
182
FIXED
Fix Zero
Yes
'0b' to output
185
No
TURN
Pick up constant, Modulo if necessary except for subscr constants
Constant
output
Const size
No
Yes
Blank
output
185

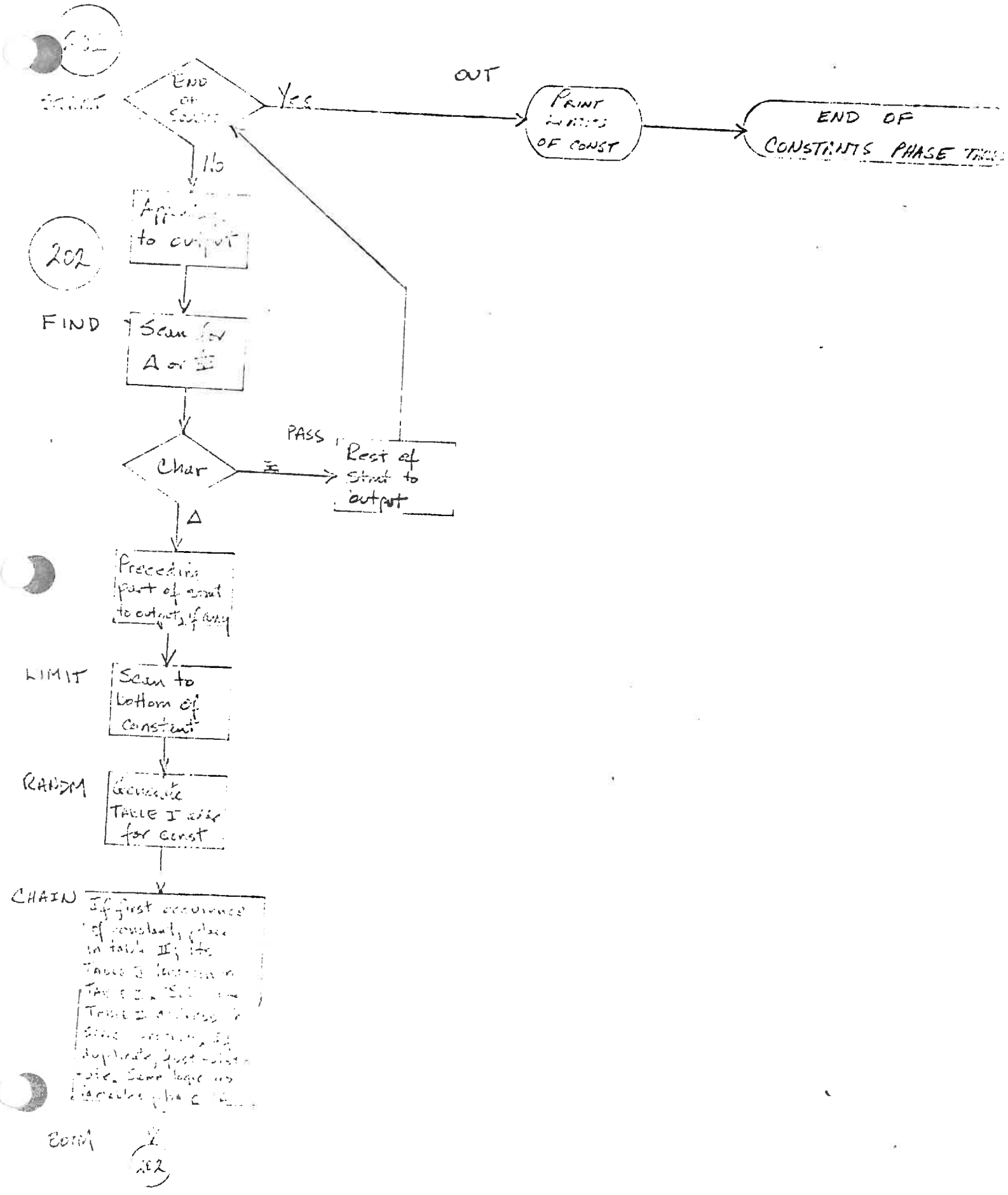

186
SWCH
SW = AOP=NOP
AOP=A
SWCH X = A
SWCH X = NOP
SWCH = NOP
STOOD
SW = NOP
SW
SET ODDSW
184


187
SWCHA
SW
AOP=NOP
AOP=A
SWCH X = A
SWCH X = NOP
SWCH 5 = NOP
SWCH 2 = NOP
STOOD = NOP
184

CONSTANTS PHASE TWO



CONSTANTS — PHASE THREE



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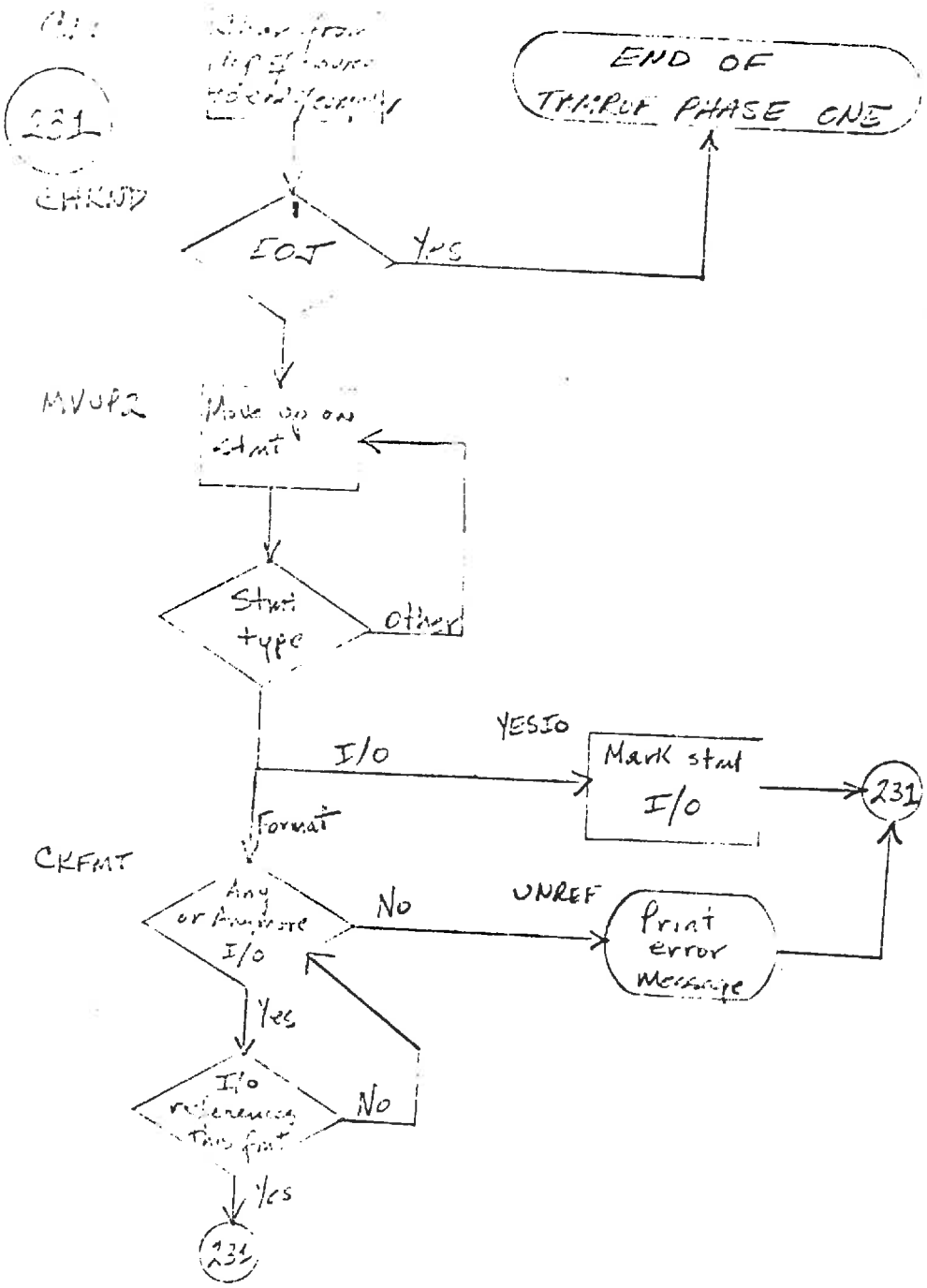
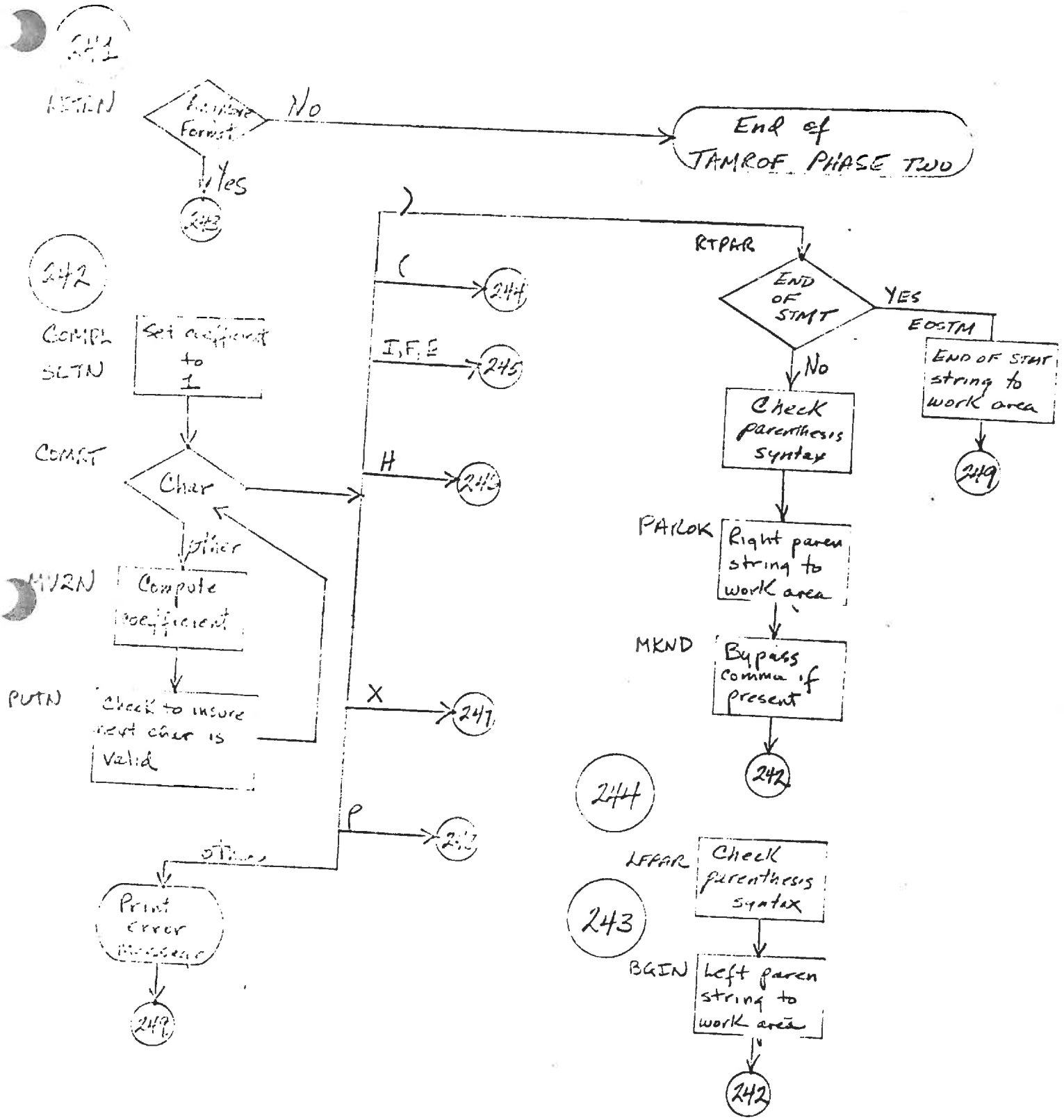
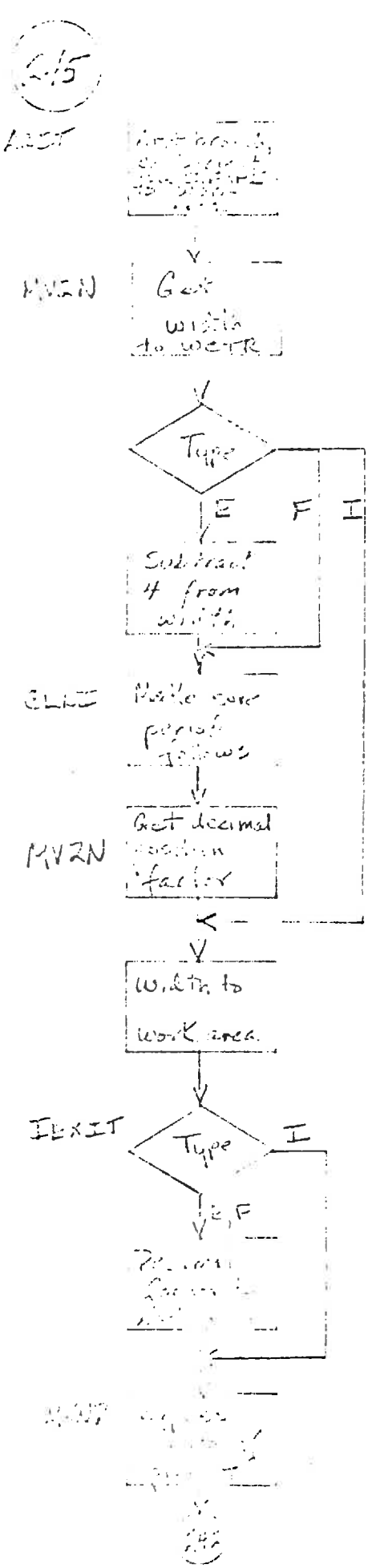
TAMROF PHASE ONE

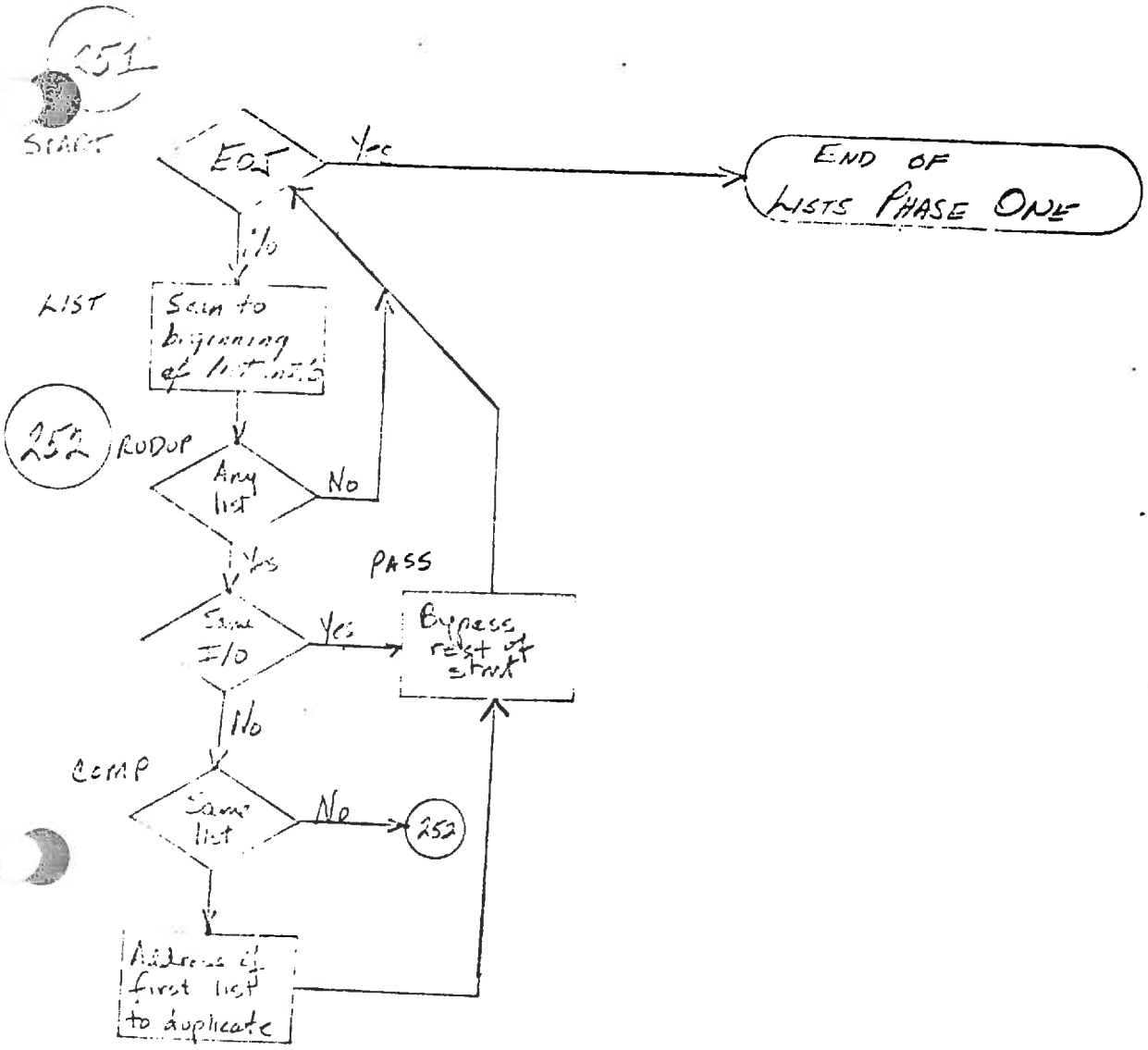


TAMROF PHASE TWO

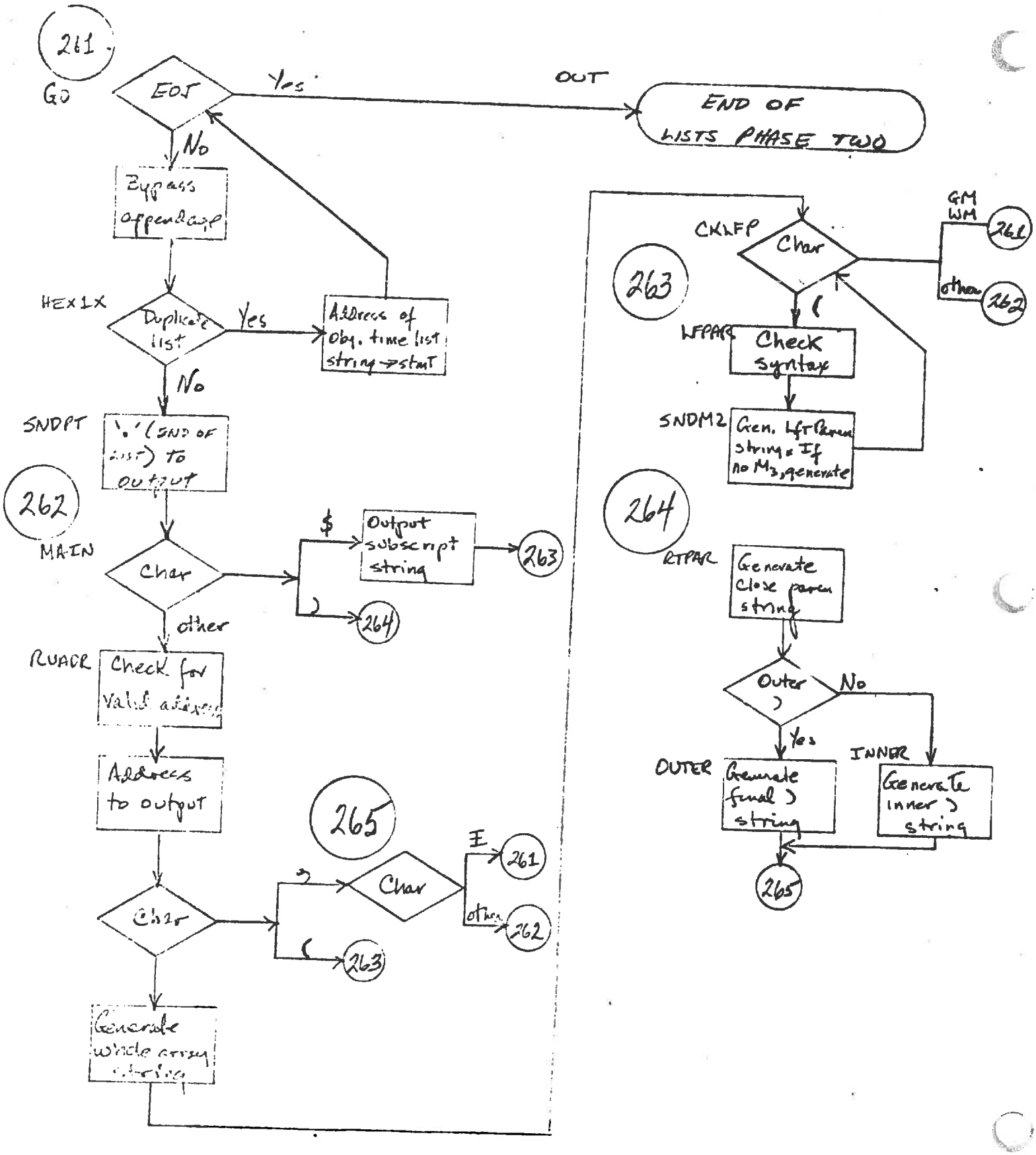



245
MV2N
Get width to WORK
Type
E
F
I
Subtract 4 from width
Make sure period follows
Get decimal position factor
Width to work area
IEXIT
Type
I
E, F
246
HNOT
LINKAGE TO OBJ FORMAT TO WORK AREA
FLIP
Hollerith chars to WORK AREA
MKND
Bypass comma if present
242
247
XNOT
Generate in-line proced in work area
248
PGET
Width, 'P' linkage to work area
249
FINIS
Work area to output
IOWK
Substitute addr of string in I/O stmt which references it
241

LISTS PHASE ONE



LISTS PHASE TWO



LISTS PHASE THREE

This phase squeezes out extraneous characters from I/O statements, reducing each to the address of the format string (if any), the last string (a dummy address if no list) and the tape unit number (where applicable).

STATEMENT NUMBER PHASE THREE

The logic for placing in the Statement Number Table the three character equivalence for external statement numbers is identical to Variables Phase Four and Constants Phase Three.

Only the statement numbers within the body of the statement are placed in the table. The address ~~when~~ where it is placed is substituted for the three character equivalence in the body of the statement.

STATEMENT NUMBERS PHASE FOUR

The external statement numbers are matched against the Table of Statement Numbers that were present in the body of the statements. If there is an entry in the table, this entry is replaced by the internal sequence number of the statement which it references.

To illustrate the progress of statement numbers, consider these two statements:

1. GO TO 20
2. 20 STOP 1 2 3

Prior to Statement Numbers Phase One, these two statements have been reduced to:

1. ± 02 ± G 012 ±
2. ± 321 ± 025016 ±

In Statement Numbers Phase One, the number "20" (appears as "02" above) is converted to a three-character unique representation:

1. ± XYZ ± G012 ±
2. ± 321 ± XYZS016 ±

In Statement Numbers Phase Three, "XYZ" is placed in a statement numbers table by virtue of the GO TO expression. The table location is substituted for XYZ in the GO TO statement.

1. ∓ G4Z ∓ G012 ∓
2. ∓ 321 ∓ XYZS016 ∓
3. XYZ
   ↑
   └— location G4Z

In Statement Numbers Phase Four, the table entry XYZ is located when processing the STOP statement. The internal sequence number of the STOP is substituted in the table

1. ∓ G4Z ∓ G012 ∓
2. ∓ 321 ∓ SG4Z ∓
3. 016

The compiler has now established for future phases that the GO TO statement will transfer control to internal sequence number 016.

Do statements receive special treatment in the phase. The compiler requires that each Do statement have an entry in the statement number table.

If a Do statement has no external statement number, or if this number is unreferenced, an entry is placed in the table (PSUDO).

This phase also detects unreferenced and multiply defined statement numbers. Unreferenced statement numbers are those which have no table entry. Upon referencing a table entry in Table II, the three character representation is placed in Table I. If another statement occurs with the same representation, it is detected as multiply defined.

STATEMENT NUMBERS PHASE FIVE

This phase checks for Undefined Statement Numbers. This occurs when an entry in the Statement Number Table was unreferenced by the previous phase.

Note that Dimension, Equivalence and Format statements have been eliminated prior to the statement number phases. As a consequence, all references to these statements will produce an error message.

INPUT/OUTPUT PHASE ONE

All I/O statements except Rewind, Backspace and End File are reduced to their object time procedure string.

B W 72 X A A A B B B

Where "BW72" is executed by the machine as branch to 1672, the location of the format package; X appears as the I/O type

* - Print

\+ - Read

\- - Punch

or the numeric portion represents the tape unit number and the zone indicates the I/O type.

NZ - Read tape

A - Write tape

B - Read Input tape

AB - Write Output tape

If the tape unit numbers is symbolic, the above string is preceded by an instruction which is symbolically represented as

MN[more space] III, X + 5

where III is the address of the fixed point non-subscripted variables.

ARITH PHASE TWO

This phase scans arithmetic and IF statements for function names. Where they exist, the name is deleted and a one character code is substituted.

ARITH PHASE THREE

Key work areas and subroutines

TRAP - value of the temporary store substring

STOR - initially TRAP; bumped by one to create additional temporary store strings.

NORTH - If this location contains a word mark, there are no arith statements.

TP1SW - If no wordmark then exponentiation encountered.

TP2SW - If no wordmark then multiplication/division encountered.

TP3SW - If no wordmark then addition/subtraction encountered.

STAR 2 - Starting address of mult/div string

STAR 3 - Starting address of add/sub string

PREV - Previous operator to mult/div string (used to force negate or invert function)

Subroutines

INRMO - This subroutine constitutes the main portion of this phase. It breaks down the hierarchy of execution.

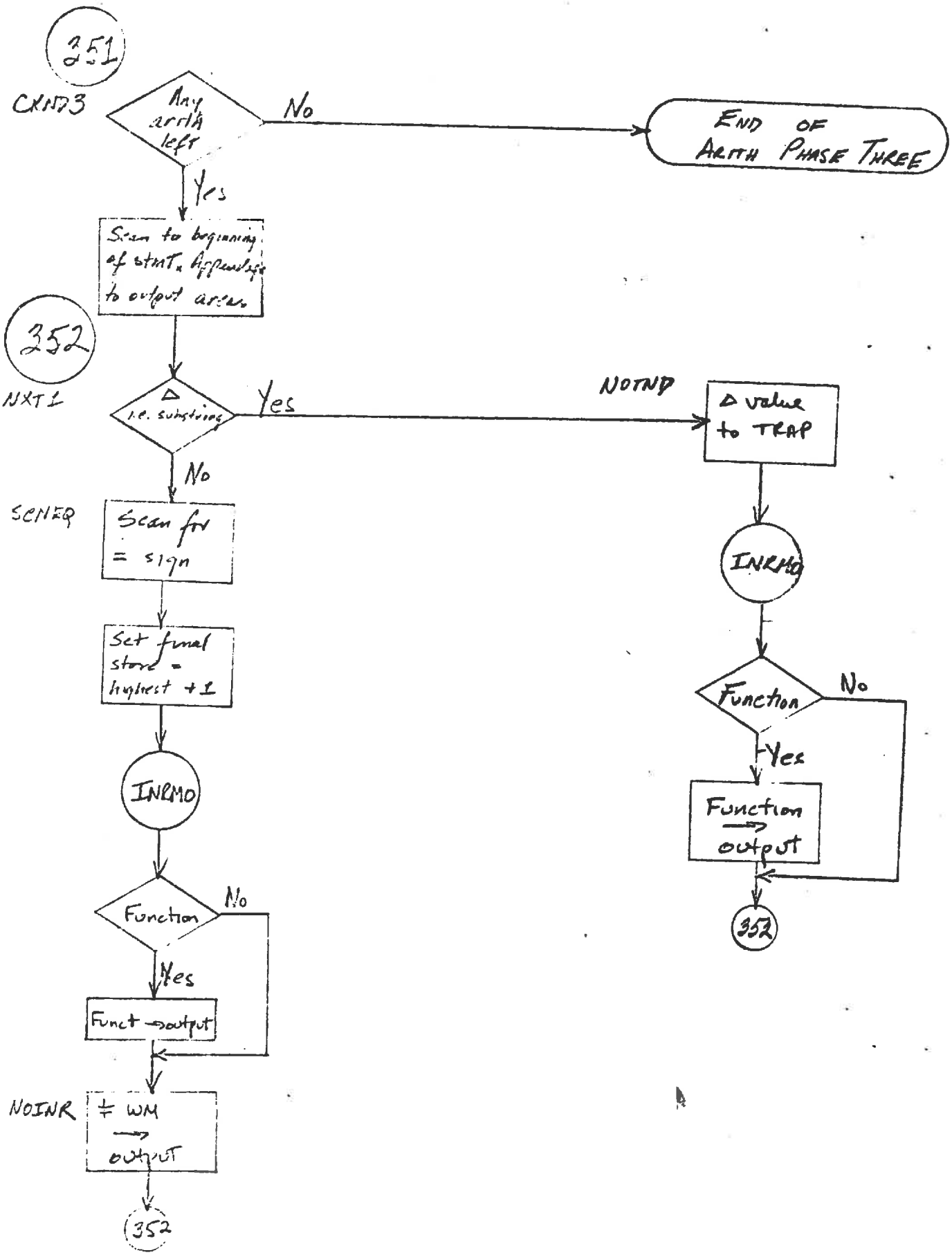
GETNX - Gets next operand and operator. This is the most used subroutine within INRMO. It places the operator preceding the operand being analyzed in OP and the succeeding operator in OP2.

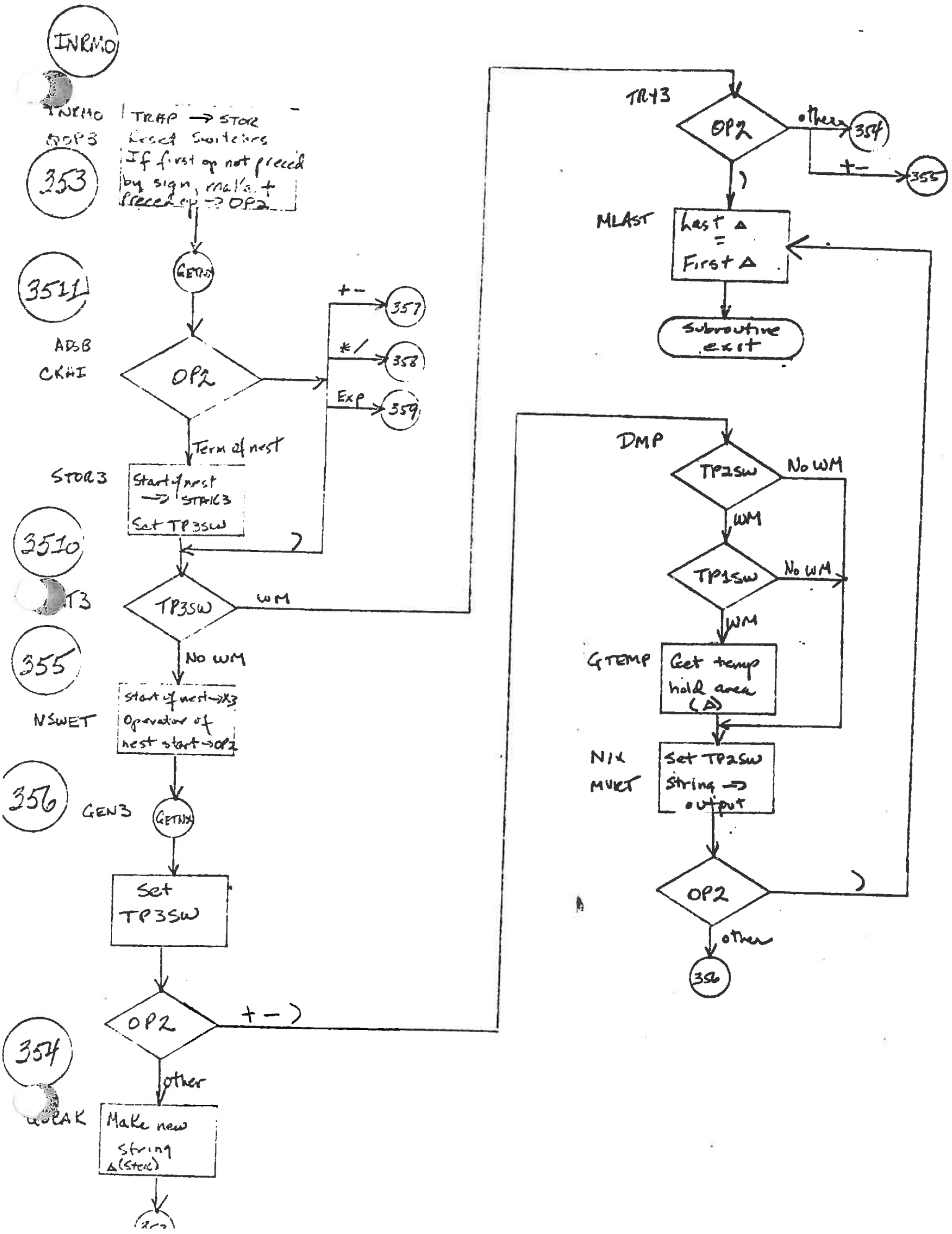
GTEMP - Where additional substrings must be created due to hierarchy, this subroutine generates another temporary work area and places it in the output area.

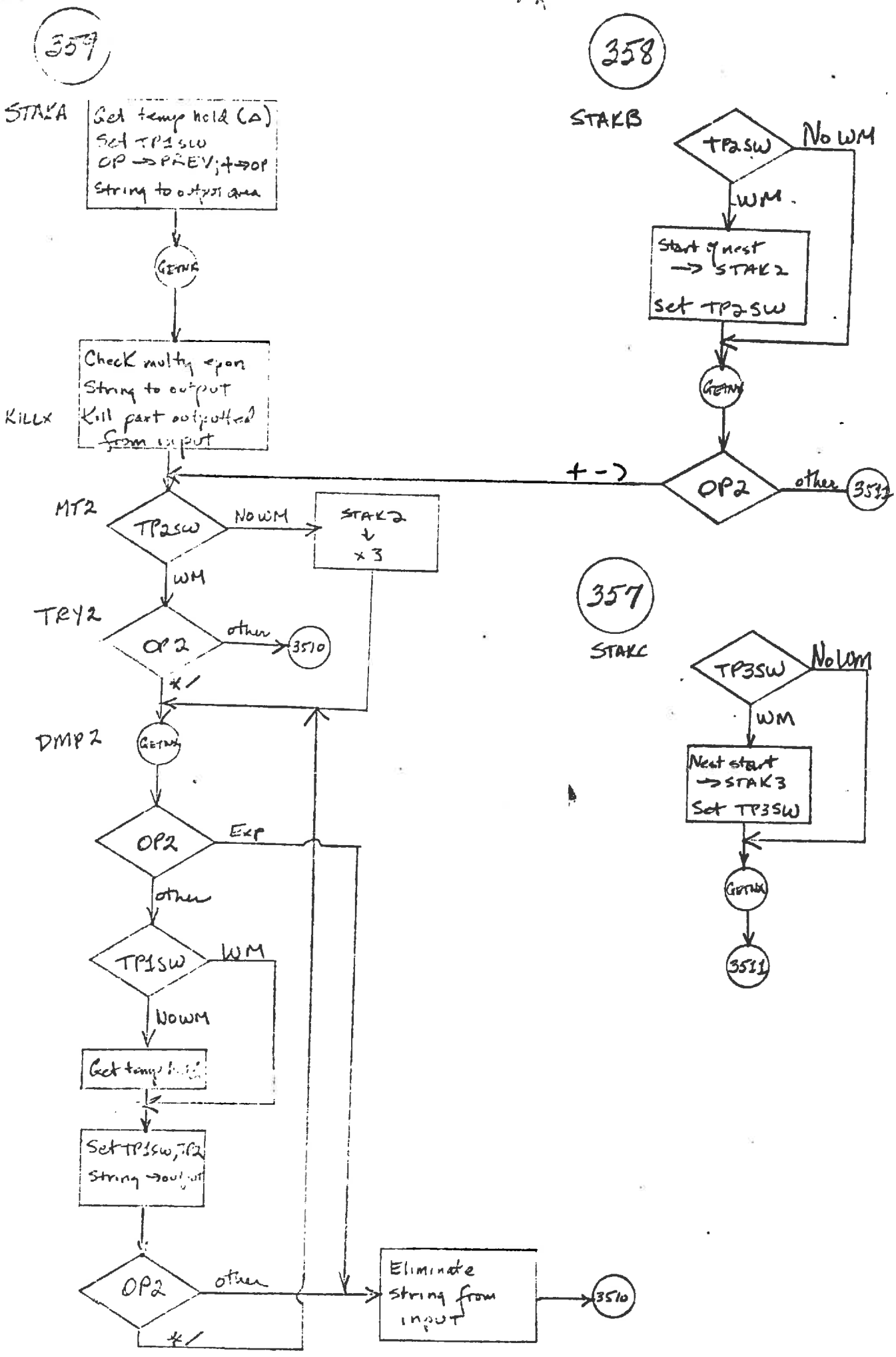
STATEMENT NUMBER PHASE TWO

Same as Variables Phase Two.

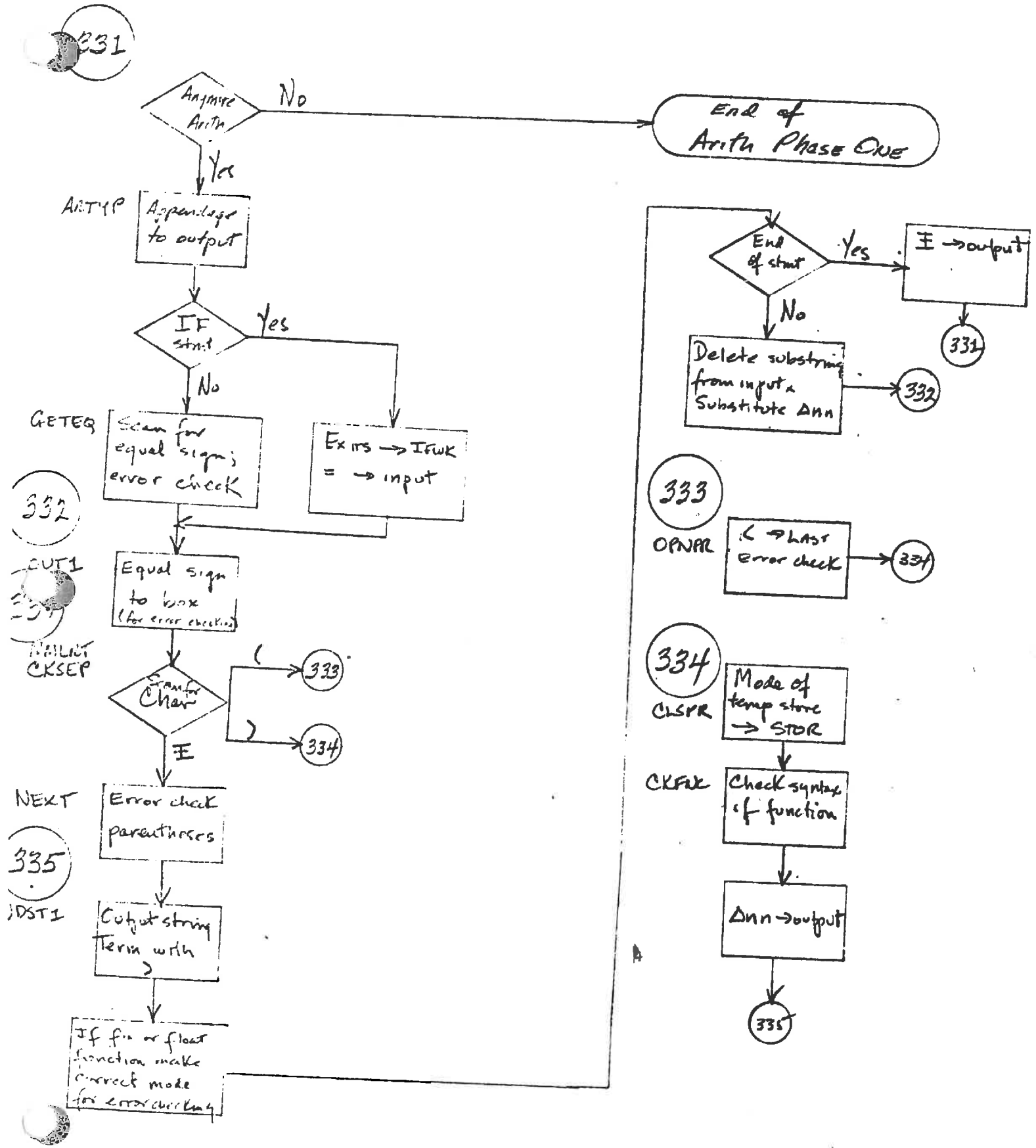
ARITH PHASE THREE

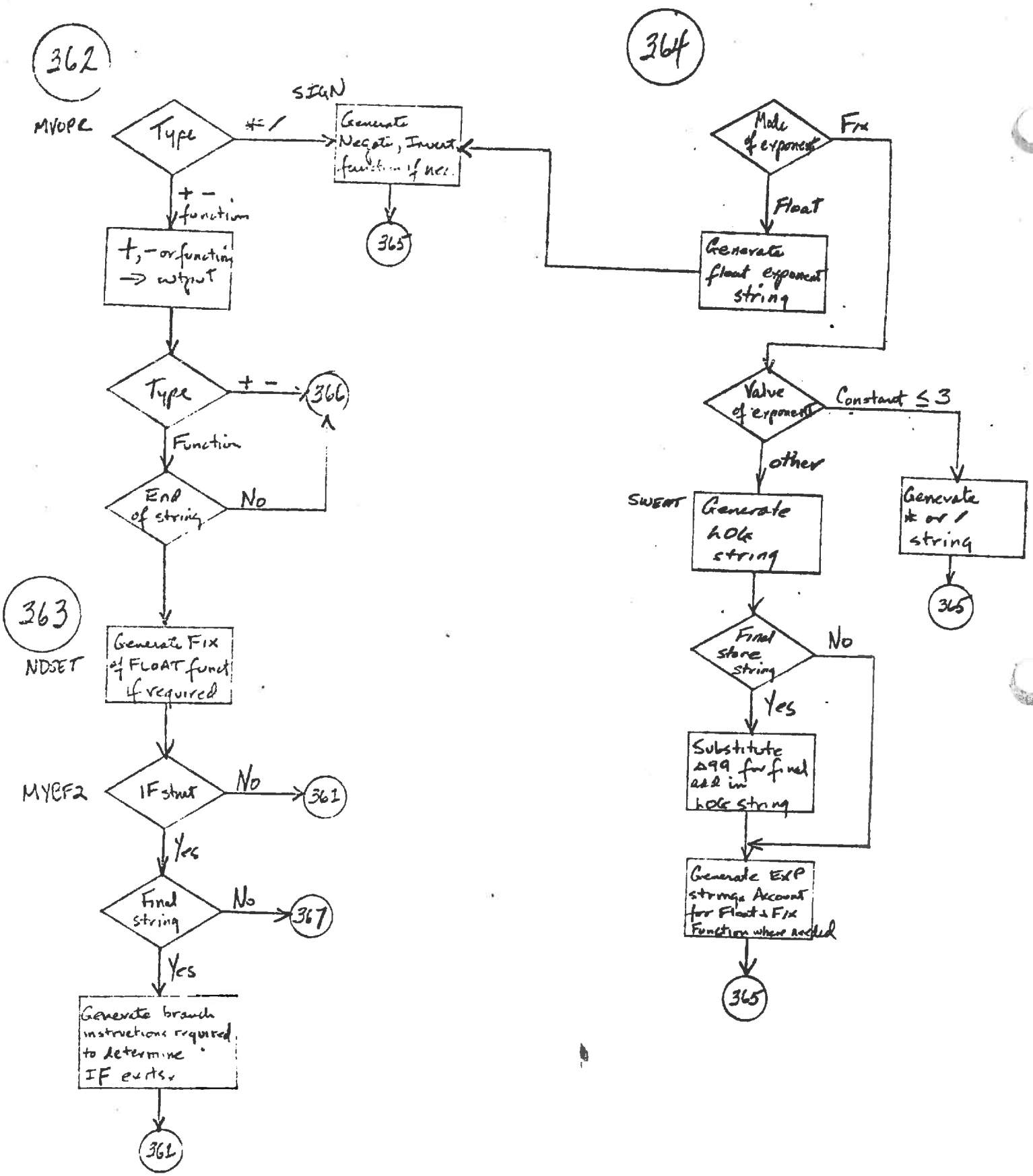



INRM0
INRM0
TRAP → STOR
Reset Switches
If first op not preced by sign, make + preced op → OP2
OP3
353
GETNX
3511
ADSB
CKHI
OP2
+ − → 357
*/ → 358
Exp → 359
Term of nest
STOR3
Start of nest → STAK3
Set TP3SW
3510
T3
TP3SW
WM
No WM
355
NSWET
Start of nest → X3
Operator of nest start → OP2
356
GEN3
GETNX
Set TP3SW
OP2
+ −
other
354
Make new string Δ(Stck)
TRY3
OP2
other → 354
+ − → 355
MLAST
last Δ = First Δ
Subroutine exit
DMP
TP2SW
No WM
WM
TP1SW
No WM
WM
GTEMP
Get temp hold area (Δ)
NIX
MUKT
Set TP2SW
String → output
OP2
other
356

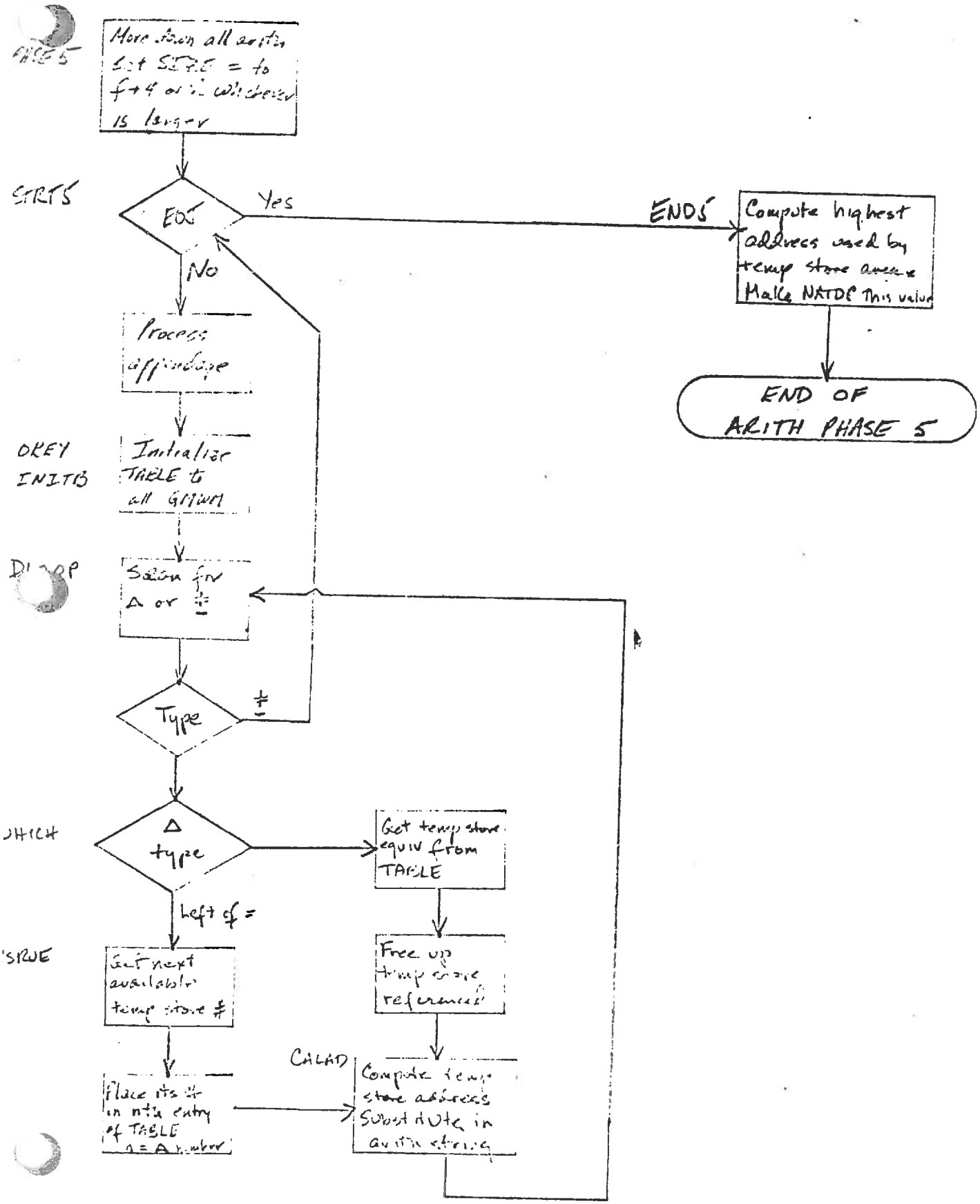

359
STAKA
Set temp hold (a)
Set TP1SW
OP → PREV; t → OP
String to output area
GETNX
Check multy epon
String to output
KILLX
Kill part outputted from input
MT2
TP2SW
NO WM
WM
STAK2 ↓ x3
TRY2
OP2
other
3510
*/
DMP2
GETNX
OP2
Exp
other
TP1SW
WM
NO WM
Get temp hold
Set TP1SW, TP2
String → output
OP2
other
*/
Eliminate string from input
3510
358
STAKB
TP2SW
NO WM
WM
Start of next → STAK2
Set TP2SW
GETNX
OP2
+ -)
other
3511
357
STAKC
TP3SW
NO WM
WM
Next start → STAK3
Set TP3SW
GETNX
3511

ARITH PHASE ONE




362
MVOPE
Type
SIGN
*/
Generate Negate, Invert function if nec.
365
+ − function
+, − or function → output
Type
+ −
366
Function
End of string
No
363
NDSET
Generate FIX of FLOAT funct if required
MYEF2
IF stmt
No
361
Yes
Final string
No
367
Yes
Generate branch instructions required to determine IF exits.
361
364
Mode of exponent
Fix
Float
Generate float exponent string
Value of exponent
Constant ≤ 3
other
SWEMT
Generate LOG string
Generate * or / string
365
Final store string
No
Yes
Substitute Δ99 for final add in LOG string
Generate EXP string; Account for Float & Fix Functions where needed
365

ARITH PHASE FIVE



ARITH PHASE SIX

This phase ~~plans~~ scans arith statements for function codes and sets the switches to call ~~to~~ in the required function in the Function/Subroutine Loader Phase.

INPUT/OUTPUT PHASE TWO

Through

CONTINUE PHASE

These phases generate the required in-line instructions for proper execution of the various statement types involved.

Input/Output Phase two

Rewind:

U% U_nR

Backspace:

U% U_nB

End File:

U% U_nM

where n is the tape unit number specified. If the tape designated is symbolic, the above instructions are preceded by an instruction which is symbolically represented as

MN III, X + 4

Computed Go to Phase

This phase operates the instructions

BCE XXX, III, A

BCE XXX, III, B

H

B XXX - 8

where XXX and YYY are the exits and III is the fixed point non-subscripted variable. If the value of the variable exceeds the number of exits, the machine enters the halt loop at object time.

Go To Phase

This phase generates

B XXX

for Go To statements

Stop/Pause Phase

this phase generates

1. NOP nnn
2. H
3. B XXX - 8

for stop statements, where nnn is the halt number specified or 000 if no number is specified. Pause statements are identical except that instruction 3 is not generated.

Sense Light Phase

These lights are represented by work marks in locations 081-084. The presence of a word mark indicates the light is off.

Sense Light 0

, 082084,

Sense Light 1 - 4

H08n

when n is the ~~same~~ sense light number

If (Hardware) Phase

This phase generates the in-line coding for If Sense Light and If Sense Switch statements. For If Sense Light, the instructions generated are

VXXX08n 1108n BYYY

where XXX is the exit if the light is off; n is the ~~same~~ sense light number; and YYY is the exit if the sense light is on.

For If Sense Switch, the instructions are

BXXXCBYYY

where XXX is the exit if the switch is on; YYY is the exit if the switch is off; and C is a function of the sense switch number, switches 1-6 represented as B - G.

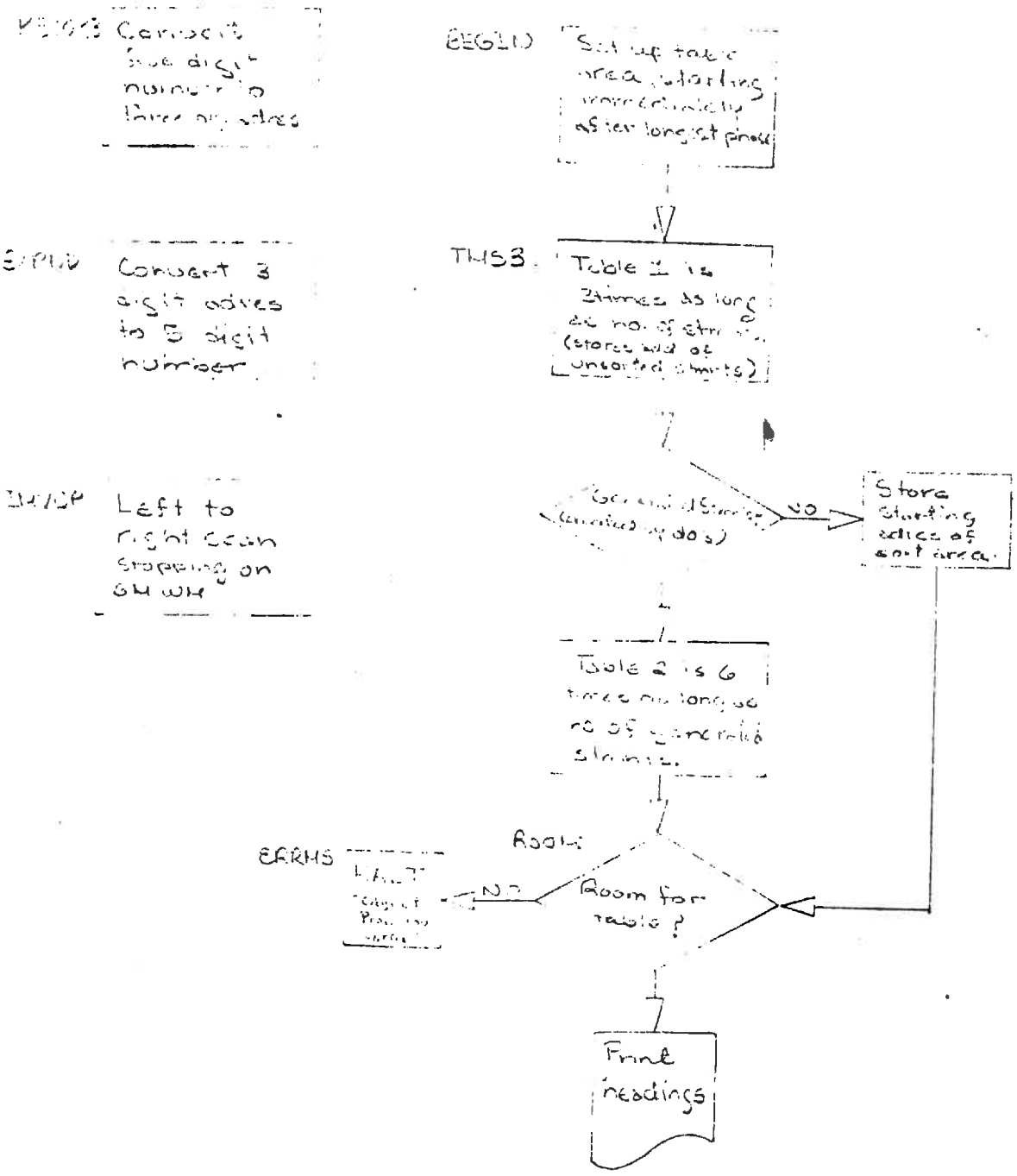
If the exit is to the next sequential statement when the sense light is on or the sense switch is off, the unconditional branch which terminates each string is omitted.

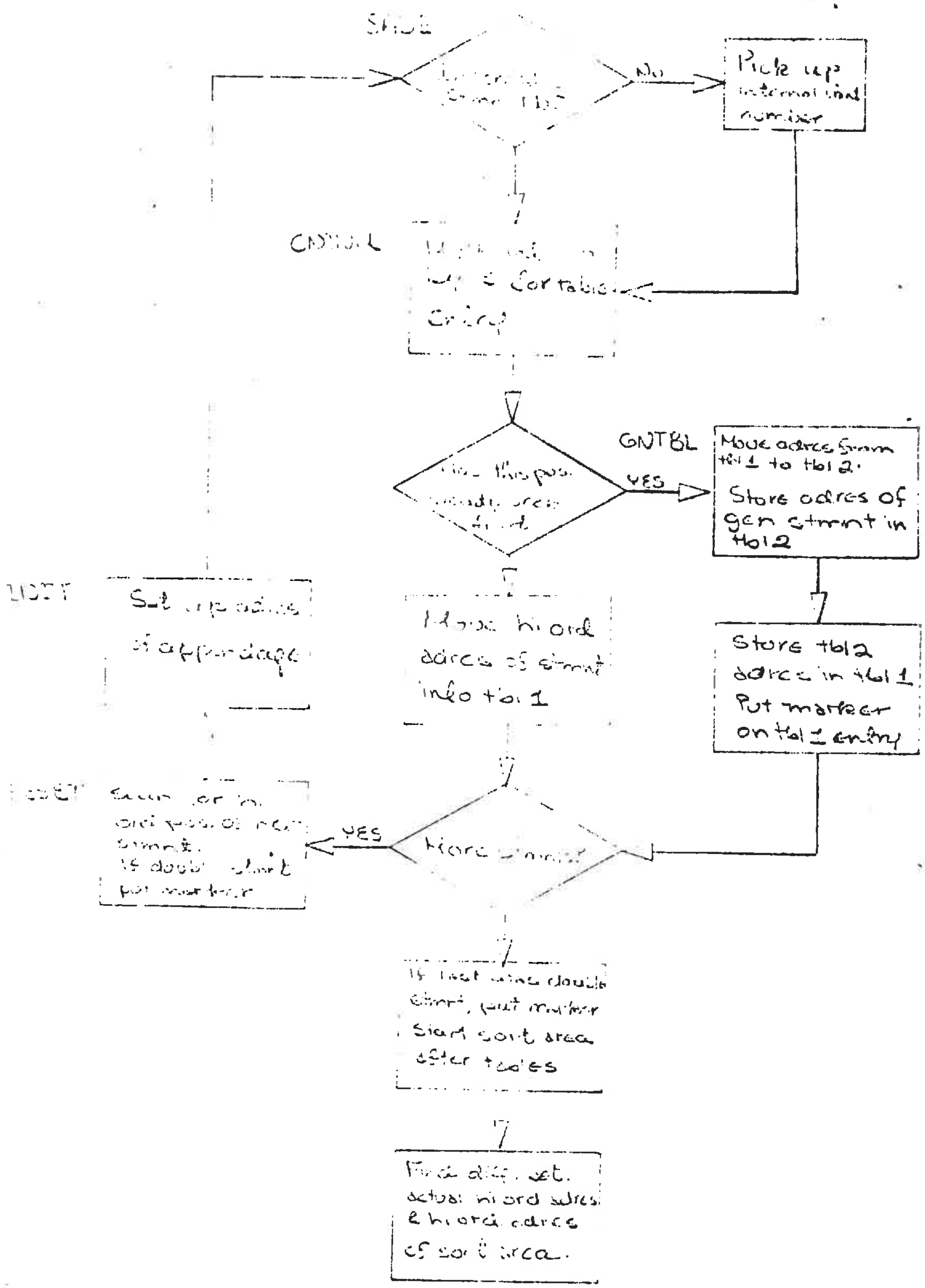
Continue Phase

Reproduces the input to the output area.

FLOWCHART

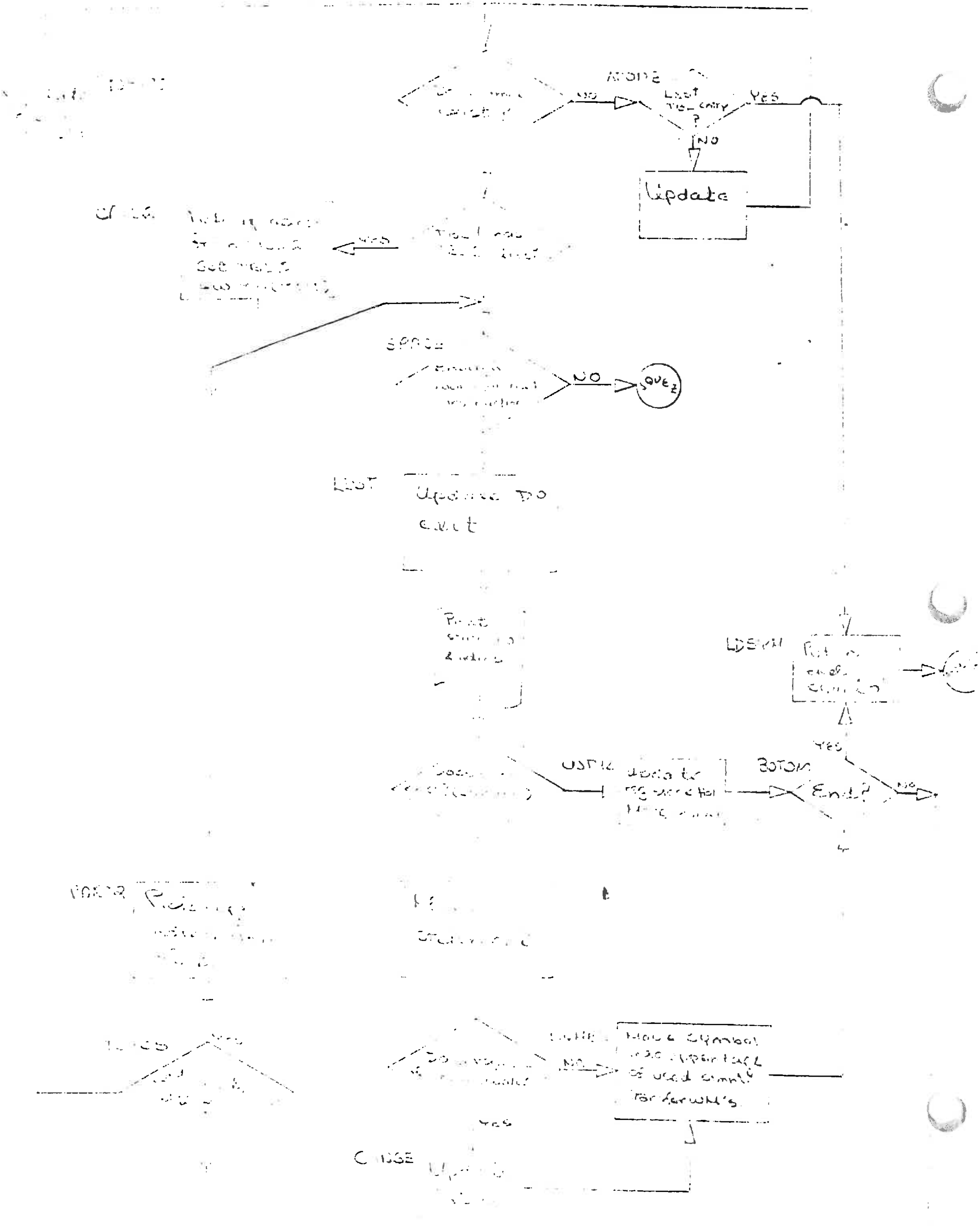
Phase I



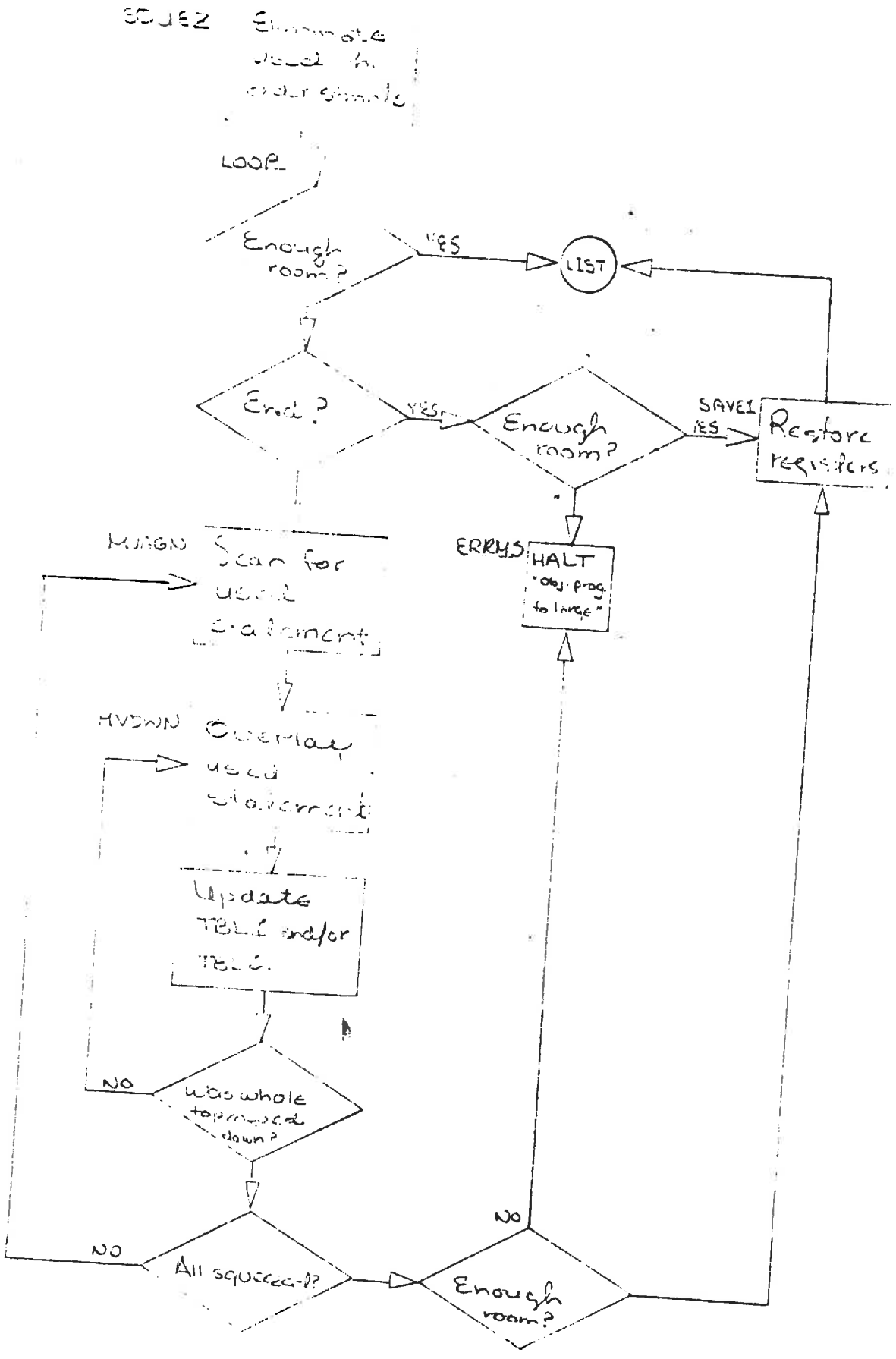


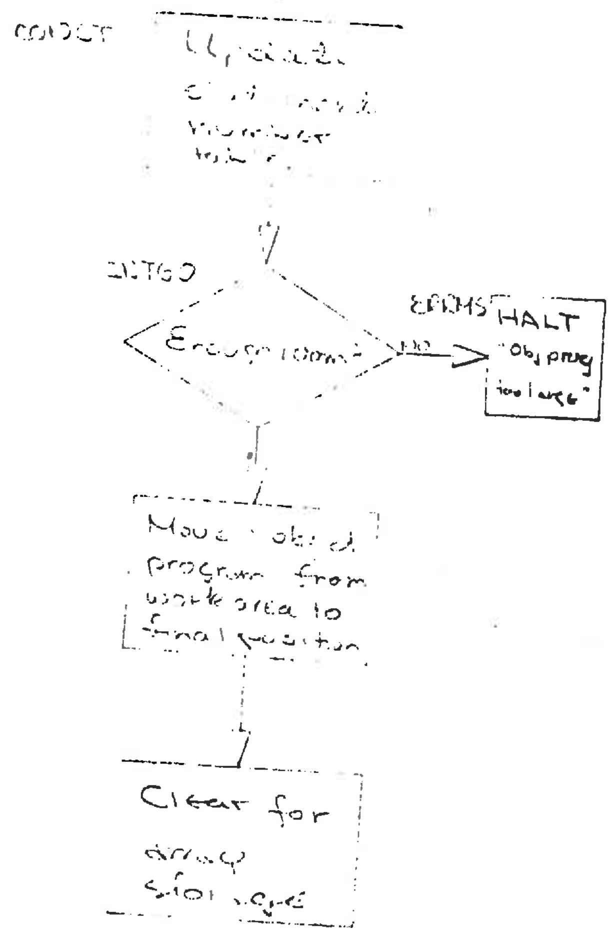
Pick up international number
No
Move adrcs from tbl 1 to tbl 2. Store adres of gen stmnt in tbl2
GNTBL
YES
Move hi ord adres of stmnt info tbl 1
Store tbl2 adres in tbl 1. Put marker on tbl 1 entry
YES
If last was double stmnt, put marker. Start sort area after tables
Find diff. set. actual hi ord adres & hi ord adres of sort area.

Phase 3

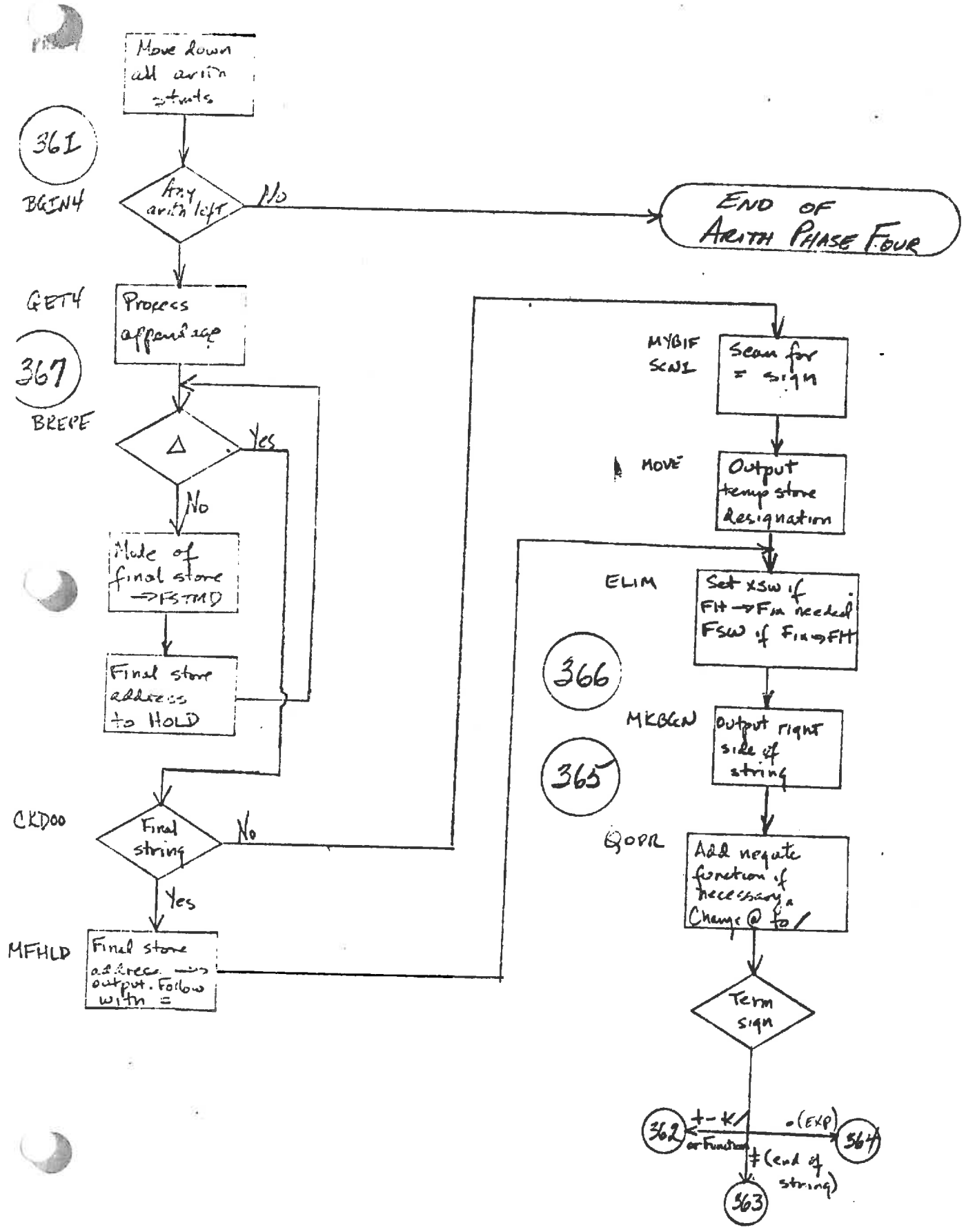


NO
Last TBL entry ?
YES
NO
Update
YES
SPACE
NO
LAST
BOTOM
End?
YES
NO
NO
YES


SQUEZ
LOOP
Enough room?
YES
LIST
End?
YES
Enough room?
SAVE1
YES
Restore registers
MAIN
Scan for used statements
ERRMS
HALT
"obj. prog. to large"
MVDWN
Overlay used statements
Update TELL and/or TELL
NO
Was whole program moved down?
NO
All squeezed?
NO
Enough room?


Enough room?
NO
ERRMS
HALT
"Obj prog too large"
Move object program from work area to final position
Clear for array storage

ARITH PHASE FOUR



REPLACE PHASE ONE

This phase scans the generated source program twice. The first time it scans for subscript strings. When encountered, it sets word marks in the hundredth position of each parameter and unzones the tens position of all parameters except the first.

The second scan looks at the procedure section for the following characters which have word marks: X, T, ≠ and for operands of instructions which have AB zoning in the tens position.

≠ word mark

If followed by a character with a word mark (PSKIP) the statement is arith and is bypassed (SKIP).

T word mark

If the statement is a Do, the tens position of all parameters is unzoned and the exit address is generated.

X word mark

These are the instructions which terminate the range of Do statements which are not the innermost Do. The proper branch address is generated.

Operands with AB zoning

These are the "* ± nnn" type operands whose correct address is relative to itself. The ~~progress~~ proper address is substituted.

DO PHASE

Each Do statement generates two output statements; the Do statement itself and an unconditional branch which follows the statement that terminates the Do. The Do string generated is

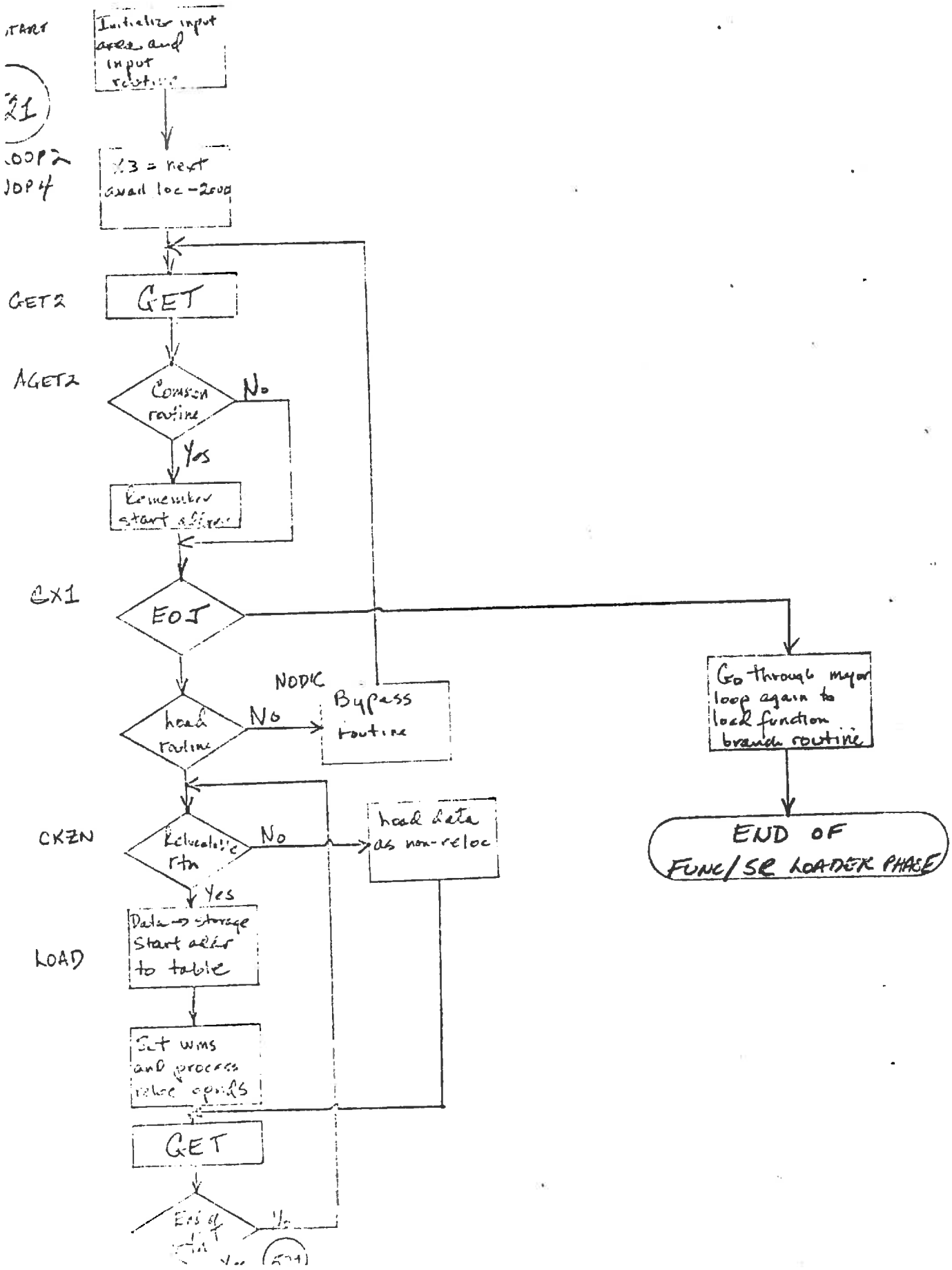
BXXXBYYYAAABBBCCCDDDEEE

where XXX is the address of the relocatable routine which initializes the index; YYY is the address of the relocatable routine which initializes the test for satisfaction of the Do; AAA is the address of M_1; BBB is M_2; CCC is M_3; DDD is the index variable; and EEE is the exit address when the Do is satisfied.

The Do Phase processes these statements backwards, i. e. the last Do first, and analyses the relationship of the Do being processed to the other Do statements. If the Do being processed is the innermost, the unconditional branch generated after the last statement of the Do is a branch to the relocatable routine which tests whether it is satisfied. Otherwise, the branch generated is to the second unconditional branch of the Do string (indicated above).

If more than one Do terminates at the same statement, the exit address EEE for the inner one references the second unconditional branch instruction in the string of the next outermost Do. Otherwise the exit address is to the next executable statement following the range of the Do.

FUNCTION/SUBROUTINE LOADER



REPLACE PHASE TWO

This phase scans the procedure and format sections for "T" operation codes and for operands with 11-5-8 or 11-6-8 characters in their hundredths positions.

T-op codes

These instructions are those which branch to the relocatable routines. Their A/I operands reference the table generated by the Function/Subroutine Loader Phase. When encountered, the T op code is changed to B and the address of the relocated routine is substituted in the operand.

Special operands

The operands with 11-5-8 and 11-6-8 combinations represent those which reference the two work areas generated in Constants Phase Two equal to the size of fixed word (k) and float word ($f + 2$). The units position of the operand represents character adjustment of these work areas relative to their units position. This phase substitutes the appropriate address in the operands which reference them.

SNAPSHOT PHASE

Through

ARITH PACKAGE

Snapshot Phase

Essentially a copy of the debugging aid, this phase prints out storage starting at the beginning of variable storage when requested and if there are no input errors.

Condensed Deck Phase One

Punches the clear storage and bootstrap cards.

Condensed Deck Phase Two

Punches the cards which

1. Initialize sense lights and index registers
2. The parameter card constants required at object time.
3. The debugging ~~board~~ aid and arith package.
4. Four cards which initialize the arith package.

Condensed Deck Phase Three

Punches out storage from the first executable statement to the end of storage, bypassing unused storage.

Geaux Phase One

Prints end of job messages.

Geaux Phase Two and Arith Package

Reads in the Arith Package and initializes four operands of this routine. The printer carriage is then restored displaying the end of job messages.