

EASIMILL

C.N.C. Turret Mill

Easimill is a 3 axis C.N.C. turret mill designed for small and medium sized components. Full circular interpolation with tool offsets, repeat and edit facility etc. M.D.I. using machinist language programming with mini cassette storage.

GENERAL SPECIFICATIONS

Mechanical

Working Table Surface	180 x 700 mm (7" x 28")
Longitudinal Travel	300 mm (12")
Cross Travel	170 mm (6.7")
Quill Travel	75 mm (3")
Spindle to Table	280 mm (11 1/4")
Spindle to Column	230 mm (9")
Spindle Speeds	180-2850 r.p.m.
Spindle Taper	R8
Traverse Screws	3 Ballscrews
Rapid Traverse	.60"/min 1500 mm/min
Feedrates	infinitely variable
Max M/C Length	1000 mm (39")
Max M/C Width	1320 mm (52")
Height	1910 mm (75")
Weight	550 Kilos

Standard Equipment

Flood Coolant System, Guards, Toolkit and Fully Comprehensive Operation and Instruction Manual.

Electrical

3 Phase Supply (Main Motor)	.380/440v/50Hz
Motor (4 pole)	1.2 kw
1 Phase Supply (Control Unit)	220/250v/50Hz

Control System

Display Method	Three 7 Digit Displays
Mini Cassette Deck	Magnetic Tapes
Motor Drives X-Y-Z	Stepper
Programmable Feed	0.005% to 100%
Keyboard	28 Character
Tool Offsets	Up to 16
Programme Length	400 Blocks (1000 Block Available)
Control System	North East Electronics P.N.C. 2C Control System
Auxiliary Outputs	8 Outputs
Programmable Inputs	8 Programmable Sequence Holds
Pattern Repeats	.99 Times to 4 Levels
Computer Data Link	RS 232C
Joystick	3 Axes Control
Format	Incremental/Absolute Metric/Imperial
Printer Link	Option for hard copy of Programmes

Extra Equipment

Spray Mist Coolant, Collet Attachment, Quick Change Tooling, Programme Printer, Programme Plotter.

Extra Equipment

A full range of optional equipment and accessories is available.

**NOW AVAILABLE WITH OPTIONAL
PROGRAMMABLE SPEED CHANGE**

DENFORD MACHINE TOOLS LIMITED : BIRDS ROYD : BRIGHOUSE : WEST YORKSHIRE : Phone : 0484 712264 : Grams : Denmacto : Telex : 517478

MACHINE TOOLS

DENFORD

EASIMILL CNC PRODUCTION TURRET MILLGENERAL SPECIFICATIONSMECHANICAL

Working Table Surface 180 x 700 mm (7" x 28")
 Longitudinal Travel 375 mm (14 $\frac{3}{4}$ ")
 Cross Travel 175 mm (6.89")
 Quill Travel 70 mm (2 $\frac{3}{4}$ ")
 Spindle to Table 300 mm (12")
 Spindle to Column 230 mm (9")
 Spindle Speeds 180-2850 RPM
 Spindle Taper R8
 Traverse Screws 3 Ballscrews
 Rapid Traverse 1500 m/m min.
 Feedrates Infinitely Variable
 Max. Machine Length 1000 mm (39")
 Max. Machine Width 1450 mm (57")
 Height 1910 mm (75")
 Weight 550 Kilos

Electrical

3 phase Supply 380/440v/50 Hz.
 (Main Motor)
 1 phase Supply 220/250/50 Hz.
 (Control Unit) 110/115/60 Hz.
 Motor (4 pole) 1.2 kW.
 Coolant Motor 0.2 kW.

CONTROL SYSTEM

Display Method . Three 7 digit Displays
 Program Storage .. Mini Cassette Magnetic Tapes
 Drives X-Y-Z ... High Performance Stepper Motors
 Programmable Feed .. ~~0.500%~~ ^{0.005%} to 100%
 Keyboard 28 Character
 Tool Offsets ... up to 16 Pairs
 Program Length . 400 Blocks (Option on 1000)
 Control System .. North Eastern Electronics PNC 2C
 Auxiliary Outputs 8
 Programmable Inputs ... 8 Sequence Holds
 Pattern Repeats . 99 times to 4 levels.
 Tool Diameter Compensation .. Programmable
 Tool Length Offsets Programmable
 Computer Data Link .. RS 232C
 Joystick 3 Axis Control
 Printer Link ... Option for Hard Copy of Programs.
 Format Incremental/Absolute Metric/Imperial

EXTRA EQUIPMENT

Spray Mist Coolant, Collet Attachment, Quick-change Tooling Program Printer.

Continued -

Installation

The Machine should be set on a firm concrete base and fixed using the four bolting down holes located at each corner of the column base, after levelling.

Cleaning

The machine on delivery will have the bright surfaces coated with a protective solution. This must be removed using a kerosene based solvent before any attempt is made to move the slides or operate the machine.

Electrical

The machine requires a 3 phase input (Main Spindle Motor Operation) and a single phase input (Control Unit).

Only a competent Electrical Engineer should complete the electrical installation.

Levelling

Thoroughly clean the table surface and, using a precision machine level, alternately in the longitudinal and the transverse positions, level the machine using levelling screws at the four corners of the machine base.

NB. If the machine is not correctly levelled it is possible that the tolerances and free movement of the slides could be affected.

Initial Lubrication

The Machine is fitted with either a 'one shot' lubrication system or an automatic motorised oiling system. In both cases ensure that the reservoir on the system is filled to the correct level and that oil is being pumped to slides and gears before the machine is operated.

Use S A E 10 for the lubricating system and a good quality machine grease for the knee bracket gears (readily accessible from underside of knee).

The spindle and spindle bearings are lubricated via the oil reservoir located at the front of the machine head, to the operator's left of the speed chart.

The 'Z' axis Ball Screw (vert) is lubricated via the cover tube (oilcan).

Coolant

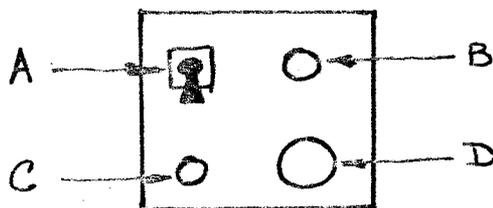
The coolant pump and reservoir is located at the operator's R.H. side of the machine base. Ensure correct fluid for work application and correct level before use.

Continued -

Operating Instructions

Operating Machine in Manual Mode

The Operating Panel on front of the machine houses 4 operating stations.



Switch 'A' (Black) Spindle Speed Selection (High-Low range)

Button 'B' (Green) Spindle Start.

Button 'C' (Orange) Coolant.

Button 'D' (Red) Stop Spindle

Handwheels are provided for moving the table and cross-slide in the manual mode. The knee is moved in the vertical plane by means of the cranked handle to the Operator's left of the machine. Power is not provided to the rise and fall of the knee.

Spindle Speed Selection

Select spindle speed required by referring to the Speed Chart on the front of the pulley guard. Stop machine and select High/Low range on Operating Panel. Loosen lever bolts on both sides of the motor and slacken belt by moving the tension lever (below R.H. Lever bolt). Remove Perspex Guard and move belt to desired grooves on pulleys.

Re-tension the belt and lock both lever bolts and replace Perspex Guard.

Quill Movement - Manual

To move the quill on the 'Z' Axis ballscrew, use the knurled collar beneath the head to the left of the spindle.

Saddle and Knee Clamps

When Milling using the longitudinal feed only, it is advisable to clamp the saddle and knee rigidly. The saddle clamp is located on the left side of the machine. The knee clamp is located on the left of the knee between the oiler system and the splash guard wing.

Lighting

The switch for the light is located on the top of the power control box on the left of the machine.

Continued -

Machine Maintenance

Adjustment of Taper Gibs

The table is provided with a full length hand scraped tapered gib with an adjusting screw at each end.

To adjust the gib, tighten the two screws until a slight drag is felt when moving the machine by hand. If the table is not tight enough loosen the adjusting screw at the small end of the gib and tighten the screw at the other end. Should the feel be too tight then reverse the procedure.

To adjust the feel of the cross and knee slide movements follow the same procedure as above on the saddle and knee gib strips.

-oOo-

GH/JR/120882

PNC 2C

IMPORTANT

Before applying power to the system ensure that a) the input power is at the correct voltage and b) the drives/machine switches and auxiliary connectors are correctly connected.

The PNC 2C should be properly earthed (grounded) at all times.

The stepper motor drive boards in the drive unit may sustain severe damage if the motor connections are made or broken with the power still on.

PNC2C's with integral stepping motor drives are equipped with a fan which keeps the drives cool ensuring high reliability. The fan filter must be kept clear, this may be done by using a vacuum cleaner (do not use an air line) to remove the dust etc. The fan filter outer cover may be unclipped.

The digital cassette unit and cassettes may be adversely affected by dust/swarf etc. in consequence care should be taken to keep the cassettes and cassette unit as free from dust as possible. The cassettes should be stored in their cases after first being rewound to the clear leaders.

The display bezel of the PNC2C is made from a special material which is coated with a substance which does not reflect, the display bezel should be cleaned if necessary carefully using a damp cloth, strong degreasing agents and brasso etc. should not be used or the print and coating will be damaged.

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Introduction.

We are pleased to introduce you to this programmable numerical control, which has been designed, developed and manufactured by North East Electronics Ltd.

This low cost, reliable, accurate system is ideal for a wide range of applications which require precise positioning, for example on a variety of machine tools, drilling, milling, engraving, welding and profile burning by laser or conventional methods using rotary and/or x-y tables.

At the heart of this system is a powerful NEE designed computer which gives the PNC 2C the ability to precisely control up to 4 axes of movement with linear and circular interpolation at programmable feedrates. The PNC 2C can also act as a process controller by giving up to 16 programmable auxiliary outputs and monitoring 8 programmable user assigned input signals.

It is North East Electronics policy to continually review and upgrade its products. This PNC 2C is the latest in a line of controllers whose forerunners are working in diverse applications with no small measure of success.

NEE will be pleased to discuss any application not only on existing machines or in production/batch lines or on original equipment but work at the design stage as well.

PNC 2C

Description.

The PNC 2C is an extremely versatile continuous path, computer based programmable numerical control unit designed to control via stepper motors a wide variety of machinery where precise control and positioning is required. Related processes and functions can also be controlled by the PNC 2C. The programming of stepper motor movements and the process control element is explained fully in this manual. The PNC2C we are confident will be found to be very easy to operate, without the need for the numerous confusing machine codes normally associated with NC equipment.

From the front panel total control is obtained by the following features:

28 - character keyboard for the input of data and commands by an easy to use keyword system.

3 - alpha numeric displays which echo the keyboard entries and during the program execution act as a D.R.O., Digital Readout.

10 - LED, indicators to show machine status.

Integral fast magnetic tape system providing unlimited program storage.

There are various size stepper motor drives which can be supplied, the small size drives can be supplied as in integral feature making the PNC 2C a self contained compact unit. For the larger range of drives an individual housing is required. The PNC 2C is available panel mounted, cabinet mounted or as a free standing unit to suit the customers specific requirements.

North East Electronics provide "tailor made" as well as "standard" control systems by offering a range of optional facilities which will give flexibility over a broad range of applications. The PNC control system is now in use in many different situations ranging from the manufacture of engine components to the manufacture of advanced microchips. The PNC is an ideal system where repeatability of operations are required with accuracy and dependability.

PNC 2C Operations.

The operations possible on the unit are shown in the operations diagram shown on the pages at the end of this manual. This section of the manual describes in detail the operations that the PNC 2C is capable of, we strongly recommend that the potential user spends some time reading this section in conjunction with the operations diagram to ensure that the maximum use is obtained from the control unit. Many facilities make complex programming easy. Some of the facilities described are options.

General Information.

The PNC 2C has been designed with the user in mind. It is a versatile control system which is very easy to use and does not require a special course to learn how to use it.

The PNC 2C has numerous facilities each of which is selected using a Keyword.

The Keywords identify the facility being used, for example to use the cassette system the Keyword is Cassette and the associated PNC 2C Key which selects the cassette is C. Many of the Keys on the keyboard have multiple functions the precise function of each key being dependant on the operation currently being performed or programmed. A list of Keywords follows:-

<u>Auxiliary</u>	<u>Edit</u>	<u>Serial</u>
<u>Absolute</u>	<u>End of block</u>	<u>Store</u>
<u>All</u>	<u>Erase</u>	<u>Load</u>
<u>Alter</u>	<u>imperial</u>	<u>Subroutine</u>
<u>Anticlockwise</u>		<u>toolSet</u>
	<u>Function</u>	
	<u>xyFeed</u>	<u>Offset</u>
<u>ADD</u>	<u>zFeed</u>	<u>print</u>
	<u>dFeed</u>	
		<u>Pause</u>
<u>Cassette</u>		<u>Print</u>
<u>Circle</u>	<u>Input</u>	
<u>Clockwise</u>	<u>Incremental</u>	
<u>Continue</u>	<u>Ignore</u>	<u>Runblock</u>
<u>Cutter</u>		<u>Repeat</u>
<u>metric</u>		<u>Replace</u>
<u>DElete</u>		<u>Rewind</u>

The ACCEPT Key is used to Accept data. When keying in information it is Echoed first on display 1, after verification the data should be 'Accepted'.

The 'E' key is used to end each block or line of instructions.

The 'RESET' key is used to reset after an incorrect entry.

The 'O' key stops the machine movement. . .

NOTE For PNC 2C systems fitted to lathes, in the following examples for Y read Z and for Z read Y.

ZERO facility.

The zero facility is supplied in one of 2 options dependant upon whether the machine to be controlled has fixed datum.

Fixed datum systems.

For machines fitted with a fixed datum the ZERO Key has 2 functions:

- a) It establishes a floating datum on one depression
- b) It instructs the PNC2C to move the machine to its fixed datum point on 2 consecutive depressions.

At power on fixed datum systems display PNC2C and must be zeroed i.e. sent to machine datum before any other machine movements can be made.

The floating datum facility enables a floating datum to be established at any point within the machine limits of movement, this facility enables program data to effectively be offset.

Non Fixed datum systems.

For non fixed datum machines the ZERO Key enables the machine datum to be established at any point within the machine movement limits.

NOTE- If a datum is established at any point other than at the most negative point of machine movement preprogrammed table limits will not be effective. Additionally it is not possible to move to a point more negative than 0,0.

X,Y,Z,T and associated FEED input.

X,Y,Z,T coordinate dimensions and associated FEEDs may be input either as a single block of data which is to be executed immediately (Manual Data Input) or as blocks of data which forms part of a programmed sequence (LOAD facility).

When coordinate dimensions are keyed into the PNC2C a check is made to ensure that the maximum machine movements are not exceeded, should any be exceeded 'dAtA Err' is displayed. RESET restores normal operation.

The required FEED is keyed in as a percentage of the maximum preset feed in the range 0.005% to 100%. Three separate and independant feeds are programmed, one for the XY (XZ for lathes) axis, one for the Z (Y for the lathes) axis and one for the T axis. If no feed is programmed the default feed (which is application dependant) is assumed.

CIRCULAR movements.

Circular movements may be made using the XY (XZ for lathes) axes. Circular movements are defined by defining the end point of the movement in both axes, selecting CIRCLE and either Clockwise or Anticlockwise, and specifying the centre point of the circle in both axes. Circular movements are limited to 1 quadrant per block.

When circular movements of less than one quadrant are being made it is not necessary to precisely know the coordinates of the end point of the movement in both axes. The PNC2C can 'find' one of the coordinates. If this facility is to be used it must be arranged that the movement passes through the coordinate point of the unknown axis dimension before reaching the coordinate point of the known axis dimension at which point movement ceases, e.g. if the present position is X=0,Y=0 and we wish to make a circular clockwise movement to X=1 when Y is unknown, centred on X=3,Y=0 the Y end point programmed should be between Y=0.1 and Y=2.236 the true end point.

If incorrect i.e. impossible end points, are programmed the PNC2C will move the table continuously in a circle attempting to find the programmed end point, the movement may be stopped by depressing either the movement STOP switch or the 0 key on the PNC2C Keyboard.

AUXILIARY FUNCTIONS.

Auxiliary functions allow user assigned devices to be controlled i.e. switched on and off by the 16 integral PNC2C auxiliary functions. Three types of auxiliary functions may be supplied. The PNC2C specification sheet indicates which types have been fitted. The three types are:

- a) ON/OFF
- b) MOMENTARY
- c) PULSED

a) ON/OFF auxiliaries are set when programmed immediately before any associated movement in the same block is made. If the auxiliary is programmed ON it will remain ON until programmed OFF. Such auxiliaries could be used to for example control lubricant.

b) MOMENTARY auxiliaries are switched ON if programmed to be on only when the machine is at a programmed position. When the axes are moving momentary auxiliaries are always OFF. This type of auxiliary can be used to for example provide a table locking signal or to activate the main drilling head on a drilling machine.

c) PULSED auxiliaries provide a pulse output of 20 milliseconds if programmed ON each time the machine completes a program block.

The PNC2C is equipped with 12 conventional relay auxiliaries and 4 solid state auxiliaries. The solid state auxiliaries should be used to switch AC signals and are particularly useful for driving inductive loads in that they are zero voltage switching and generate little or no electrical interference.

INPUT facilities.

The PNC2C is equipped to be able to monitor 8 user assigned input signals from external switches. The condition of the switches may be checked to see if they are open or closed during program execution. If the switches are not in the programmed condition sequence execution waits until the switch signals are as programmed before proceeding. Switch levels may be programmed to be closed (ON), open (OFF) or Ignored (don't care).

The auxiliary outputs and the inputs enable the PNC2C to function not only as a precise positioning control system but also as a sequence controller.

RUN facility.

A program that is in PNC2C memory (indicated by the memory loaded indicator) may be run i.e. executed either from the start of the program i.e. block 1, or from any point i.e. block in the program provided that that block does not define a circular movement. If an attempt is made to run a program from a block defining a circular movement 'NO' will be displayed in display 1, depression of the RESET key restores normal operation.

SERIAL facility

Program data may be Loaded into or Stored from the PNC2C from or to an external VDU or computer via a RS232C 3 wire serial interface.

Three operations are possible using the SERIAL facility they are:

- a) SERIAL LOAD
- b) SERIAL CONTINUE
- c) SERIAL STORE

a) SERIAL LOAD enables a program to be loaded into PNC2C memory from the external device either 1 block at a time or as a full program. Any Program previously contained in PNC2C memory is overwritten i.e. destroyed. The format of the program data is shown below.

b) SERIAL CONTINUE enables additional program to be added to a program that already exists in PNC2C memory via the external device. The format of the program data is shown below.

Upon completion of a SERIAL LOAD or a SERIALCONTINUE the PNC2C displays show the program number, how many blocks there are in memory and how much memory remains, for a period of 3 seconds. PNC2C displays then display normal data.

Should too much data be sent to the PNC2C such that the PNC2C memory becomes full 'FULL' is displayed, normal operation can be restored by using the RESET key, the memory will contain only the data received prior to becoming full.

c) SERIAL STORE enables the contents of PNC2C memory to be transmitted to an external device. The memory contents are transmitted as hexadecimal data formatted as shown below.

PNC2C RS232 Interface Specification

The PNC 2C only needs 3 wires to implement an RS232 link. They are Data Transmit, Data Receive and Signal Ground. The connection to the PNC 2C is via a 7 pin DIN socket using pins 7, 6 and 2 for TxDa, RxDa and Ground respectively.

1. All information on the RS232 link will be in the form of ASCII characters.
2. The PNC2C will recognize the following characters:-

<STX>	02	start of transmission
<ETX>	03	end of transmission
E	45H	
A	41H	
C	43H	
X	58H	
Y	59H	
Z	5AH	
F	46H	
+	2BH	
-	2DH	
.	2EH	
0 to 9	30H to 39H	
L	4CH	
R	52H	
S	53H)	
P	50H)	lathe only
D	44H)	
T	45H)	

3. The PNC2C will use the following ASCII characters when transmitting:-

<ACK>	06	acknowledge
<NAK>	15H	not acknowledge
?	3FH	

4. Any information transmitted to the PNC2C must be preceded by <STX> and terminated by <ETX>.
5. When the PNC2C has processed the data and carried out the instructions contained therein, it will respond with either <ACK> (if everything was okay) or <NAK> if some error occurred.
6. If the PNC2C responds with <ACK> then this also indicates that it is waiting for more data from the interface.
7. If an unrecognised character is received by the PNC2C (see 2, above) then it will cause the PNC2C to transmit a "?" once the <ETX> has been received. In this case the PNC2C will not take any action on the received data but will wait for more data from the interface.

PNC2C RS232 Interface Specification (continued)

8. The PNC 2C will respond with (NAK) if the data received constitutes a move to a position outside the table limits.

9. The maximum amount of data transmitted to the PNC2C in one go will be one program block.

10. A program block can contain any or all of the following (to a maximum of 140 characters):-

<u>Data</u>	<u>Meaning</u>
X<d>	Move in X axis to position <d>
Y<d>	Move in Y axis to position <d>
FX<p>	Set XY feedrate to <p>
Z<d>	Move in Z axis to position <d>
FZ<p>	Set Z feedrate to <p>
A<n>+	Turn auxiliary <n> on
A<n>-	Turn auxiliary <n> off

where <n> is a number in range 0 to 15

<d> is a decimal number in range 0 to table limit

<p> is a decimal number in range 0.005 to 100

Leading and trailing zeroes are not necessary when specifying <n> <d> <p>.

11. If the program block contains L as the last character (i.e. the character before the <ETX>) then that program block will not be directly executed but will be loaded into the next available slot in the PNC2C's memory.

12. If the transmitted data consists of <STX> R <ETX> then the PNC2C will execute the current program held in its memory and will not respond with <ACK> until the program has been successfully run. The PNC2C will respond with <NAK> if any error occurs during program execution.

13. If the program block transmitted to the PNC2C does not contain the character L, then that block will be directly executed and the PNC2C will respond with <ACK> on successful completion of the block or <NAK> if any error occurred.

14. If the transmitted data consists of <STX> E <ETX> then the PNC2C will clear out any program currently in its memory.

PNC2C RS232 Interface Specification (continued)

15. Example

Suppose the following data was transmitted to the PNC2C

<STX> X12.94 Y15F25.7 Z140 F2100 A4+ <ETX>

This would result in the PNC2C moving from its current position to

X = 12.94

Y = 15.0

Z = 140.0

The XY axis would move at a feedrate of 25.7% and the Z axis would move at a feedrate of 100%. Also Auxiliary output 4 would come on at the appropriate time, and the PNC2C would then respond by transmitting <ACK> to the interface.

16. To specify a circular move the following basic format must be adhered to:-

X<d> Y<d> CCX<XCENTRE> Y<YCENTRE> for Clock Wise Moves

or X<d> Y<d> CAX<XCENTRE> Y<YCENTRE> for Anti C.W. Moves

This basic format can be followed by feedrate specifiers, auxiliary moves, Z axis moves, etc in the normal way.

17. If the PNC2C is controlling a lathe then the following format can be used to specify a screwcutting move.

<STX> S<diameter> P<pitch> D<depth> C<no. of cuts> L<length> Z<start posn>
<ETX>

18. If the PNC2C is controlling a lathe then the following format can be used to specify a tool change block.

<STX> T<tool No. 0 to 15> <ETX>

Enhanced RS232 Interface Specification

The enhanced RS232 interface is available as an extra cost option on the standard RS232 interface.

1. Repeat Loops

<STX> R<START BLOCK> E<END BLOCK> N<No. OF TIMES> X<OFFSEST> Y<OFFSET>
Z<OFFSET> FX<FEED> FY<FEED> FZ<FEED> L<ETX>

Note: Repeat loops are only valid when loaded into memory. All offsets and feeds are optional. Offsets will default to zero if not defined. The optional feed may be used to specify the feedrates at which the repeated blocks are executed.

2. Subroutines

i) Defining subroutines bodies

<STX> SL<N><ETX> (Subroutine Load <N>)

<N> can be in the range of 1 to 99

After issuing this instruction all further load blocks will form part of subroutine <N>.

The load subroutine sequence is terminated by:-

<STX> SE<ETX> (Subroutine End)

Note: Only X,Y,Z moves with their associated feedrates, inputs and auxiliary on/off commands are allowed within the subroutine body. All X,Y,Z moves within the subroutine are relative to the X,Y,Z position when the subroutine is called.

ii) Calling a Subroutine

<STX> SC<N> L<ETX> (Subroutine Call <N>)

Subroutine calls are only valid when loaded into memory.

iii) Erasing a Subroutine

<STX> ES<N><ETX> (Erase Subroutine <N>)

Note: <STX> ESA<ETX> erases all subroutines.

3. Extra Functions

i) Program Scaling

<STX> F3<SCALE> L<ETX>

<SCALE> can be in the range 0.01% to 650%

Has the effect of scaling all succeeding moves by the given scale factor at run time.

This is only valid when loaded into memory

ii) Machine Scaling

<STX> F4<SCALE><ETX>

<SCALE> can be in the range of 0.01% to 650%

This is an overall scale factor which allows a complete program (which may include program scales) to be scaled up or down.

This function cannot be loaded into memory.

iii) Reflect in X

<STX> F5L<ETX>

Defines an axis of reflection at the current X position and causes all subsequent X moves to be reflected about this axis at run time.

This is only valid when loaded into memory.

iv) Cancel X Reflect

<STX> F6L<ETX>

Cancels the mirroring function 5.

This is only valid when loaded into memory.

v) Reflect in Y

<STX> F7L<ETX>

Defines an axis of reflection at the current Y position and causes all subsequent Y moves to be reflected about this axis at run time.

This is only valid when loaded into memory.

vi) Cancel Y reflect

<STX> F8L<ETX>

Cancel the mirroring function 7

This is only valid when loaded into memory.

vii) Rotation

<STX> FR<ANGLE> L<ETX> (Rotate clockwise to <ANGLE>)

Defines a point of rotation at the current X,Y. position and causes all subsequent X,Y moves to be rotated clockwise by the given angle at run time. The angle is currently restricted to values of 0, 90, 180, or 270 degrees.

This is only valid when loaded into memory.

4. Offsets

<STX> OX<OFFSET> OY<OFFSET> OZ<OFFSET><ETX>

It is only necessary to specify those offset which are to change e.g.

<STX> OZ 31.9 <ETX>

Offsets have the effect of shifting any program moves by the specified distance. Offsets will not have any effect on moves that have not been loaded to memory.

Offsets cannot be loaded into memory.

LOAD facility

This facility enables PNC2C memory to be 'loaded' using the PNC2C Keyboard. The task to be accomplished is broken down into a sequence of blocks which are then executed consecutively. A block may consist of a point to which the machine should move which is defined using 1,2,3 or 4 coordinates (dependant upon the PNC2C options fitted), and/or the auxiliary setting required and/or the level(s) of input signals required. (Auxiliary functions and the input facility are described elsewhere). A block may also consist of a REPEAT instruction, or a ZERO instruction, or an OFFSET instruction, or a SUBROUTINE call, or a 'PROGRAM SCALE' instruction.

Each block is executed in stages, inputs are first monitored (if included in the block) and when the inputs are as programmed the ON/OFF and momentary auxiliary functions are set (if included in the block) and then the programmed machine movement takes place in all axes simultaneously. When the machine has arrived at the position programmed momentary and pulse auxiliaries operate. We recommend that the program is tabulated in the following manner (PNC2C programming sheets are available for this purpose).

BLK X Y XYF C XC YC Z ZF AUX INPUT

where:

BLK = Block number of instruction

X = X coordinate value of end point of movement

Y = Y coordinate value of end point of movement

XYF = Value which controls the feedrate of the XY axes as a percentage in the range 0.005 (slowest) to 100 (fastest).

C = used if a circular contour is required. If this Key is used the next key must be either C (to define a clockwise contour) or A (to define an anticlockwise contour). The maximum arc possible in 1 block is 1 quadrant.

XC = X coordinate value of circle centre.

YC = Y coordinate value of circle centre.

Z = Z coordinate value of end point of movement.

ZF = value which controls the feedrate of the Z axis as a percentage.

AUX = Auxiliaries setting required.

INPUT= Input signal levels required.

NOTE: Each item of data should first be identified, defined then ACCEPTed when correct, and each block must be ended with E (End of block).

Some program examples are shown at Appendix A.

Three different LOAD operations are possible:

- a) LOAD
- b) LOAD CONTINUE
- c) LOAD ERASE

a) LOAD is used to enter a new program into PNC2C memory. Any previously loaded program is overwritten i.e. destroyed.

b) LOAD CONTINUE enables an existing program to be continued i.e. extended.

Upon completion of a LOAD or a LOAD CONTINUE the PNC2C displays show how many blocks there are in memory and how much memory remains, for a period of 3 seconds after which the PNC2C displays show normal data.

Should too much program data be keyed into the PNC2C such that the memory becomes full 'FULL' is displayed and no more data can be entered, normal operation can be restored by using the RESET Key.

c) LOAD ERASE clears all program data from memory.

CASSETTE operations

The integral magnetic cassette recorder enables programs to be permanently stored for future use

Six different cassette operations are possible:

- a) CASSETTE REWIND
- b) CASSETTE ERASE
- c) CASSETTE LOAD
- d) CASSETTE CONTINUE
- e) CASSETTE STORE
- f) CASSETTE ALTER (to be fitted later)

When the CASSETTE facility is initially selected a check is made to see if there is a cassette in the unit, if not 'NO CASSETTE' is displayed, depression of RESET restores normal operation. If the cassette tape 'clear leader' is detected when a cassette operation is selected the PNC2C runs the cassette for 5 seconds, if the clear leader is still detected 'CASS Er' is displayed, depression of RESET restores normal operation. If the clear leader has passed the cassette read head the selected cassette operation continues. Some cassette tapes have very long clear leaders and it may be necessary to reselect the cassette operation required thus giving the cassette tape a further 5 seconds to pass the clear leader. If the end of tape clear leader is detected during a cassette operation e.g. during CASSETTE LOAD 'CASS Er' is displayed, depression of RESET restores normal operation. Should it be required to STOP the cassette whilst it is in operation (shown by the 'TAPE ON' indicator on the PNC2C front panel being ON) EJECT/RESET should be depressed, depression of RESET restores normal operation.

a) CASSETTE REWIND enables a cassette to be rewound to the start, i.e. to the clear leader, this operation should be performed prior to recording onto a new cassette and it should be performed before a cassette program is loaded into PNC2C memory. The rewind operation may be stopped by pressing the '0' key.

b) CASSETTE ERASE enables a cassette to be erased i.e. cleared of programs. The cassette should first be rewound using CASSETTE REWIND. When a cassette is erased 'P END' is recorded at the start of the cassette to indicate that this is the end of the cassette. The cassette erase operation takes approximately 3 minutes for a 50 ft long cassette tape. We recommend that both sides of new cassettes are initially erased.

c) CASSETTE LOAD.

Cassette Load enables a program which is on the cassette tape to be loaded from the cassette into PNC2C memory. Two depressions of ACCEPT are required to select the load operation at which time P is displayed. The operator may now look for the first cassette program identifier located, by depressing ACCEPT, or alternatively if the cassette program identifier required is known, this may be keyed in, then ACCEPTed at which time the PNC2C will 'read' the cassette tape program identifiers until the desired one is obtained or until a cassette end 'P End' is found or until the cassette end clear leader is found. During the search for the desired cassette program identifier each identifier detected is displayed for 2 seconds.

When the desired identifier is found the cassette unit is stopped and the identifier is displayed. Depression of ACCEPT causes the cassette program to be loaded into PNC2C memory. Depression of any Key other than ACCEPT or RESET causes the PNC2C to locate the next identifier. Depression of RESET restores normal operation.

When data is loaded from the cassette unit into PNC2C memory a check is made on the validity of the data and if an error was detected during the load process 'data Err' is displayed, and the memory will not be loaded. If ACCEPT is depressed the memory will be loaded with suspect data. If RESET is pressed normal operation is resumed.

Cassette data is validated as follows: when a program or an identifier is stored onto the cassette tape an algorithm is computed the result of which is dependant upon the precise data stored. The numerical result of this algorithm is recorded at the end of the data. When the program or identifier data is subsequently loaded into PNC2C memory the same algorithm is computed and the numerical result is compared with the prerecorded value, if a difference is detected 'data Err' is displayed.

d) CASSETTE CONTINUE.

This facility enables program data contained in PNC2C memory to be continued i.e. extended, by a program previously recorded onto tape. This facility enables programs to be 'merged' to form larger programs.

e) CASSETTE STORE

This facility enables program data contained in PNC2C memory to be stored using the integral cassette recorder, onto cassette tape. The program is stored after a cassette identifier has been keyed in and ACCEPTed. The cassette identifier can be from 0 to 6 numerals. If more than 6 numerals are keyed in the last 6 will form the identifier.

Each program is stored as 3 elements separated by blank tape

- i) The cassette program identifier
- ii) The program
- iii) A cassette end 'P End'.

The cassette end is stored to enable the end of the recorded tape to be found when additional programs are to be stored, as each cassette tape can contain many programs. When a program is stored the cassette tape is initially rewound for a short time and then the 3 elements are recorded, this removes any previously recorded cassette end.

f) CASSETTE ALTER (option)

Cassette Alter enables a program which is on the cassette tape to be altered. The procedure is to initially load the required program into PNC2C memory, then to alter the program using the EDIT facilities, then to alter the program on cassette tape using the CASSETTE ALTER facility. When cassette alter is accepted the cassette tape is rewound until the start of the program data is located, the tape is then stopped, run forward and the program is recorded onto tape. Care must be taken to ensure that an altered program is not more than 10 blocks longer than the original program. Note a 'cassette end' is not recorded using this facility.

TOOL offsets.

Tool offsets enable the PNC2C to automatically compensate for variations in distance of the cutting point from the datum point for up to 16 different tools.

The precise procedure required to set the tool offsets is dependant upon the type of application, i.e. whether the PNC2C control unit is fitted to a lathe or a milling machine.

LATHE systems.

The procedure to be followed for lathe systems is shown in the PNC2C OPERATIONS DIAGRAM (LATHE)

When T is depressed the current tool number and its associated X and Z offsets are displayed. The current tool can be changed by using the ACCEPT and L Keys. The tool offset can also be changed to compensate for tool wear, this is accomplished by keying in the tool offset errors (as shown in the operations diagram) only and the PNC2C will adjust the current tool offsets accordingly.

The offset for each tool can be set by using the TOOLSET procedure

MILLING systems. (To be added)

EDIT facility

This facility enables a program that is in PNC2C memory to be edited. When the edit mode is selected the operator may choose to display any block of data. Should a block number which does not exist be requested a '?' will be displayed. The program blocksize can then be found by entering too large a number and then reducing the number to a figure that the PNC2C can accept.

Six operations are possible in Edit mode, they are

- a) ALTER
- b) ADD
- c) DELETE
- d) REPLACE
- e) Increment the displayed block number (ACCEPT)
- f) Decrement the displayed block number (L)

a) ALTER The data programmed in any displayed block can be altered using the ALTER facility. The data to be replaced is keyed in together with its identifier, other data contained in the block will remain unchanged. If an attempt is made to change non existing data 'NO' will be displayed. RESET restores normal edit operation.

b) ADD A new block of data may be added to a programmed sequence using the ADD facility. The data is inserted into the sequence immediately before the block being displayed before ADD was depressed, and all subsequent block numbers in the programmed sequence will be incremented by 1.

If it is desired to add a block or a number of blocks to the end of a programmed sequence the LOAD CONTINUE facility should be used.

c) DELETE. A block of data may be deleted from a programmed sequence using the DELETE facility. The block deleted is the block being displayed when the DELETE command is used.

d) REPLACE The current block displayed may be replaced by the REPLACE facility. This facility differs from the Alter facility in that the replaced block is completely deleted and the new block is inserted.

e) The block number being displayed (the current block) may be incremented by 1 using the ACCEPT Key enabling the operator to step through and examine the sequence programmed.

f) The block number being displayed may be decremented by using the L Key enabling an operator to step back through a programmed sequence.

FUNCTION selection.

The PNC2C can be set to function in either an ABSOLUTE or INCREMENTAL mode and in either IMPERIAL or METRIC units. If desired the mode and/or units may be changed any number of times within a programmed sequence.

OFFSET facility.

The PNC2C offset facility enables programmed dimensions to be offset to any point within the machine movement limits. Separate offsets within and outside the programmed sequence are permitted.

REPEAT facility. The repeat facility enables specified sections of a programmed sequence to be repeated with specified offsets. The repeat facility is only available within a programmed sequence. The data required to specify a repeat is:

- a) The start block number to be repeated
- b) The end block number to be repeated
- c) The number of repeats required
- d) The required offset dimensions with required FEED changes if any.

Repeats may be programmed up to a nested level of 3. should this level be exceeded 'NESt Err' is displayed, RESET restores normal operation.

When each repeat is programmed the PNC2C checks all the dimensions being repeated adding the programmed offset the programmed number of times to ensure that the machine movement limits are not exceeded, this process may take a few seconds. Should the limits be exceeded 'data Err' is displayed, RESET should be depressed and corrected data be Keyed in.

Repeats from a block defining a circular movement are not permitted, if an attempt is made to program such a repeat 'NO' is displayed, RESET restores normal operation.

SUBROUTINES (option)

The PNC2C may be fitted with user programmable subroutines. A subroutine is a small independent program which can be called from the main program. Within the subroutine, X,Y and Z moves are relative with respect to the last X,Y,Z position before the subroutine was called. A subroutine call can be entered in the main program using the S key followed by a number. The subroutine itself can be entered using the Load Sub sequence shown on the flowcharts. Note that within a subroutine, Repeats, Functions, etc. are not permitted.

Once a subroutine has been loaded the editing facilities of the PNC2C can be used to alter it in the usual way. Up to 99 different subroutines can be used at the same time. Subroutines can be loaded and stored from/to cassette if required.

Example

The following example shows how a subroutine can be used to draw a triangle at different points on the table.

SUBROUTINE 1

X	Y	Z
0	0	1
-10	-20	1
10	-20	1
0	0	1
0	0	0

MAIN PROGRAM

X	Y	Z
40	50	2
SUB	1	
70	30	2
SUB	1	
80	20	2
SUB	1	

Note that negative moves are permitted when loading a subroutine. The advantages of using a subroutine is that a subroutine call takes very little space in memory and the moves used in the subroutine need only be keyed in once. Thus subroutines make more efficient use of memory.

PRINTER facility

The optional PRINTER facility enables a user program or a portion of a user program to be printed on a compatible printer. The printer generally used is an EPSON LX80 with RS232 serial interface.

When the printer facility is first used subsequent to the PNC2C being switched ON the PNC2C requests the date which should be keyed in then 'ACCEPTed'. The program number is then displayed, this may be changed if desired by keying in the new program number. The start block (S.bl) is then requested, if 'A' is pressed at this point ALL the program is printed, alternatively a section of the program is printed if a start block number then an end block number is entered.

APPENDIX A

DEMONSTRATION

MANUAL CONTROL OF MACHINE FUNCTIONS

To EXECUTE a single instruction.

It is possible to manually instruct the PNC 2C to execute a single instruction without altering the information stored. This instruction will not be remembered once it has been performed.

Example 1 - press the following keys:

X 1 . 5 ACCEPT E

This instructs the PNC 2C to move the X axis to an absolute position 1.5 units from datum. The PNC 2C display will then respond with 'RUN ?', pressing the ACCEPT key when RUN is displayed makes the PNC 2C execute the instruction. (You will have noticed that as you pressed the keys DISPLAY 1 echoed your keypresses).

Example 2 - press the following keys:

X 2 . 8 ACCEPT Y 1 . 4 ACCEPT F 2 0 ACCEPT E ACCEPT

This instructs the PNC 2C to move the X axis to 2.8, the Y axis to 1.4 at a feed of 20 per cent. Note that E is used to end the information.

Example 3 - press the following keys:

A 4 ADD E ACCEPT

This instructs the PNC 2C to switch 'ON' auxiliary function no.4. Note that AUXILIARY 4 indicator (above display 2) is on.

Example 4 - press the following keys

A 4 DEL E ACCEPT

This instructs the PNC 2C to switch OFF (DELeTE) auxiliary function 4. Auxiliary information can be included with X Y and Z coordinate data if desired in a block e.g.

X 5 ACCEPT Y 1 . 4 ACCEPT A 4 ADD E ACCEPT

Example 5

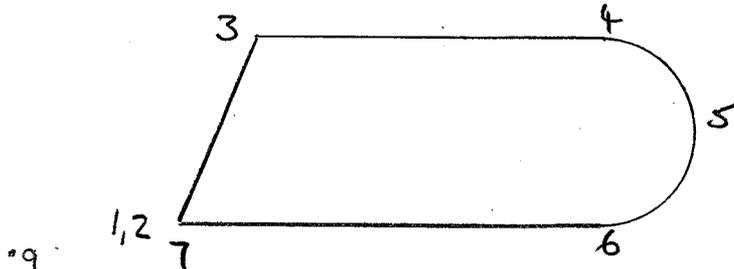
I 0 ADD I 2 ADD E ACCEPT

This instructs the PNC 2C to check if input 0 and input 2 are ON i.e. to check if the switches connected to inputs 0 and 2 are closed. Should input 0 be OFF the PNC 2C will wait for it to become ON whilst displaying 'INPUT 0' in display 1. When input 0 is correct input 2 is checked in a similar manner. The PNC 2C may be 'reset' whilst waiting for an input condition by pressing 'RESET'. As inputs are being 'keyed in' the first eight status indicators echo the levels programmed. The associated LED is ON if the input is programmed to be ON, OFF if the input is programmed to be OFF, and flashes if the input has not been programmed or is programmed to be ignored.

DEMONSTRATION

To 'LOAD' PIC 20 memory from Keyboard

This example demonstrates how the following profile may be programmed:



We recommend that the program is tabulated in the following manner:

BLK X Y XYF C XC YC Z ZF AUX INPUT

where:

- BLK = Block number of instruction
- X = X coordinate value of end point of movement.
- Y = Y coordinate value of end point of movement.
- XYF = Value which controls the feedrate of the XY axes as a percentage in the range 0.0005 (slowest) to 100 (fastest).
- C = used if a circular contour is required. If this Key is used the next Key must be either C (to define a clockwise contour) or A (to define an anticlockwise contour). The maximum arc possible in 1 block is 1 quadrant.
- XC = X coordinate value of circle centre.
- YC = Y coordinate value of circle centre.
- Z = Z coordinate value of end point of movement.
- ZF = value which controls the feedrate of the Z axis as a percentage.
- AUX = Auxiliaries setting required.
- INPUT = Input signal levels required.

NOTE: Each item of data should first be specified then accepted when correct and all lines must be ended with E (End of block).

EXAMPLE :

Press L, ACCEPT, ACCEPT

then key in the following tabulated data: (for 2 axis PIC 20's ignore the Z and ZFEED cols)

BLK	X	Y	XYF	C	XC	YC	Z	ZF	AUX	INPUT
1	7	1	40						0,2,4	
2							0.5	10		
3	7.5	2.0	25							
4	8.5									
5	9	1.5	20	C	8.5	1.5			2-	
6	8.5	1		C	8.5	1.5				
7	7	1	25							
8							0	50		
9	0	0	100						0,2,4	

The 'load' operation is ended by pressing L (Load End) ACCEPT. When the PIC 20 memory will be loaded (note that the 'Memory Loaded' indicator is on).

REPEAT PATTERN facility.

This enables selected areas of a program to be repeated at specified offsets. The area of program to be repeated is selected by keying in the Start Block and End Block.

Example 7. To continue load i.e. 'add to' the program shown in example 6 above by pressing L, C (Load Continue) ACCEPT then enter information.

R.(Repeat), ACCEPT, 1, ACCEPT, 8, ACCEPT, 2, X, 2 ACCEPT Y, 1, ACCEPT, E(End of block). L.(Load End) ACCEPT

L.(Load End) ACCEPT.

This additional block repeats blocks 1 to 8 inclusive twice, offset by X = 2, Y = 1. Note that whilst keying in the repeat the PNC 2C prompts by asking for the S.bl(start block) E.bl(End block) and rep (the number of repeats).

(See Example 8 demonstrating how to repeat a selected number of blocks with both X offsets and Y offsets).

EXAMPLE 8

This example demonstrates repeating a selected number of blocks both with X offsets and Y offsets:

L ACCEPT

BLK	X	Y	XYF	C	XC	YC	Z	ZF	AUX	INPUT
1	0	0	50				0	20		
2	1	0.5								
3							0.6			
4	2	0.6								
5		1.9								
6	1.8									
7		1.5								
8	1	0.5								
9							0			
10	RPT	2-9,	5	XOFF	1.25					
11	RPT	1-10,	2	YOFF	1.5					

L(Load End) ACCEPT

Note. Blocks 2-9 are repeated a total of 17 times as there is a repeat within a repeat i.e. block 10 which is a repeat block, is repeated by block 11. The PNC 2C permits up to 3 levels of repeats within repeats.

DEMONSTRATION

To EDIT a program that is in PNC 2C memory.

To edit or check through a program press E, the display will show "Edit bl", either key in the required block number then ACCEPT or press ACCEPT to see the first block of information.

Each subsequent depression of ACCEPT advances the block displayed by 1. Each depression of L(last) decrements the block displayed by 1.

To ADD an additional block press ADD, ACCEPT, then key in the new block of data required, ending with E.

To DELete a block press DEL, ACCEPT.

To Replace a block press R (Replace) and Key in the new block of data, ending with E.

To Alter any item in a block press A (Alter) ACCEPT and key in new Data.

The edit operation is ended by pressing RESET.

To RUN a programme that is in PNC 2C memory.

When the stored program is correct press R(run) and the PNC will display 'run bl', press ACCEPT to execute program or key in the 'blk number' desired to begin the program, then ACCEPT. Note it is not possible to run a program from a block which has a circular movement in it.

KEY TO SYSTEM DIAGRAMS

LARGE CHARACTER	EG. S, ACCEPT ETC. ARE SINGLE KEYS PRESSED BY OPERATOR.
()	MESSAGE DISPLAYED ON PNC.
 TEXT	FUNCTION OF OPERATION SELECTED
 TEXT	OPERATION AUTOMATICALLY CARRIED OUT BY PNC.
SMALL UNBOXED TEXT	OPERATION TO BE CARRIED OUT BY OPERATOR

DEMONSTRATION

Using the CASSETTE system.

The cassette system enables programs to be quickly stored for future use thus providing unlimited storage.

First rewind the cassette by pressing:

C(CASS) R(CASS rE) ACCEPT

When the cassette will rewind to the beginning. (This operation may take a couple of minutes).

A Program which is in the PNC 2C memory may be stored onto cassette by pressing

C(CASS) S,(CASS St) ACCEPT(Store ?) ACCEPT (C) 1,2,3, ACCEPT.

The program will be stored onto cassette if there is a cassette in the cassette unit with sufficient tape left.

Note 123 is the cassette number! Any 1 to 6 digit number may be used and it functions as a cassette program identifier.

To load the PNC 2C memory from the cassette first rewind the cassette as above then press:

C,(CASS) L, (CASS Ld) ACCEPT (C) 1,2,3, ACCEPT

The PNC 2C will locate the cassette number 123 and then stop the cassette. If ACCEPT is pressed the program will be loaded from the cassette unit to PNC 2C memory, if DEL is pressed the PNC 2C will find the next cassette program number stored if one exists. Should the end of recorded tape be found 'C End' is displayed. Pressing RESET restores normal operation.

During use the correct operation of the cassette is checked by the PNC 2C, should an error be found the PNC 2C displays and status indicators show the error, RESET restores normal operation.

A cassette program may be added to a program in PNC 2C memory using the Cassette Continue facility where L in the previous example is replaced by C.

EXECUTIVE LEVEL

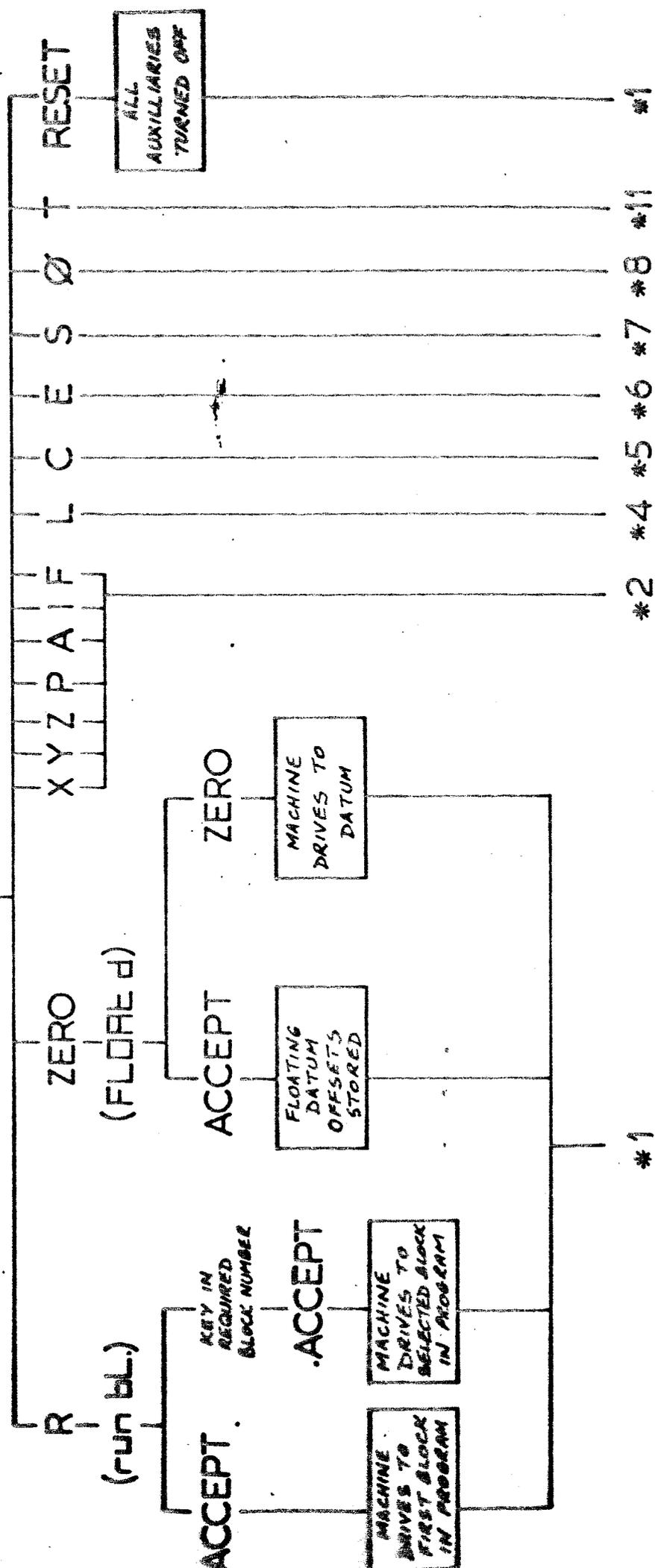
(PNC 2c)

ZERO

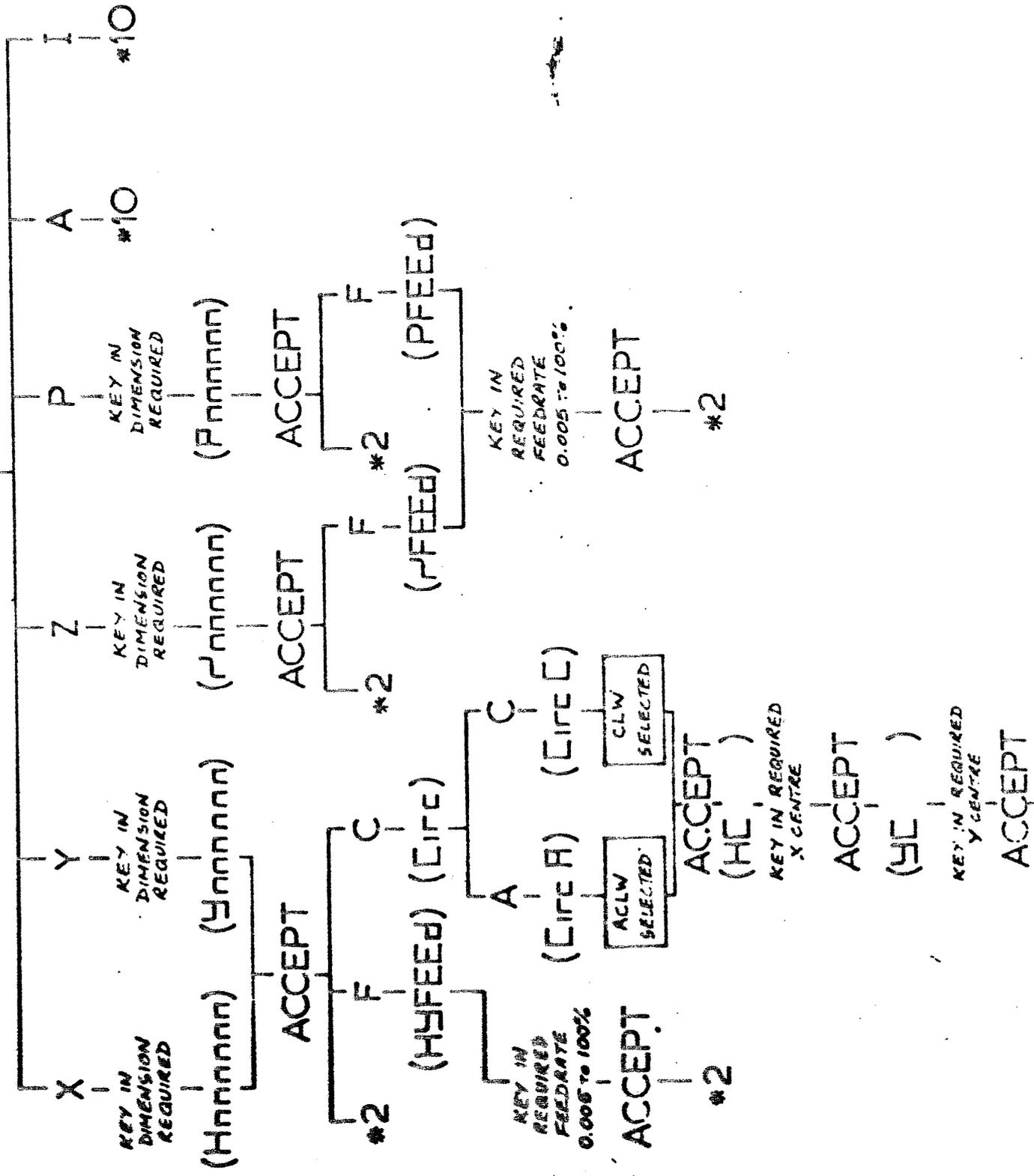
MACHINE
DRIVES TO
DATUM

PNC DISPLAYS
POSITIONAL
DATA

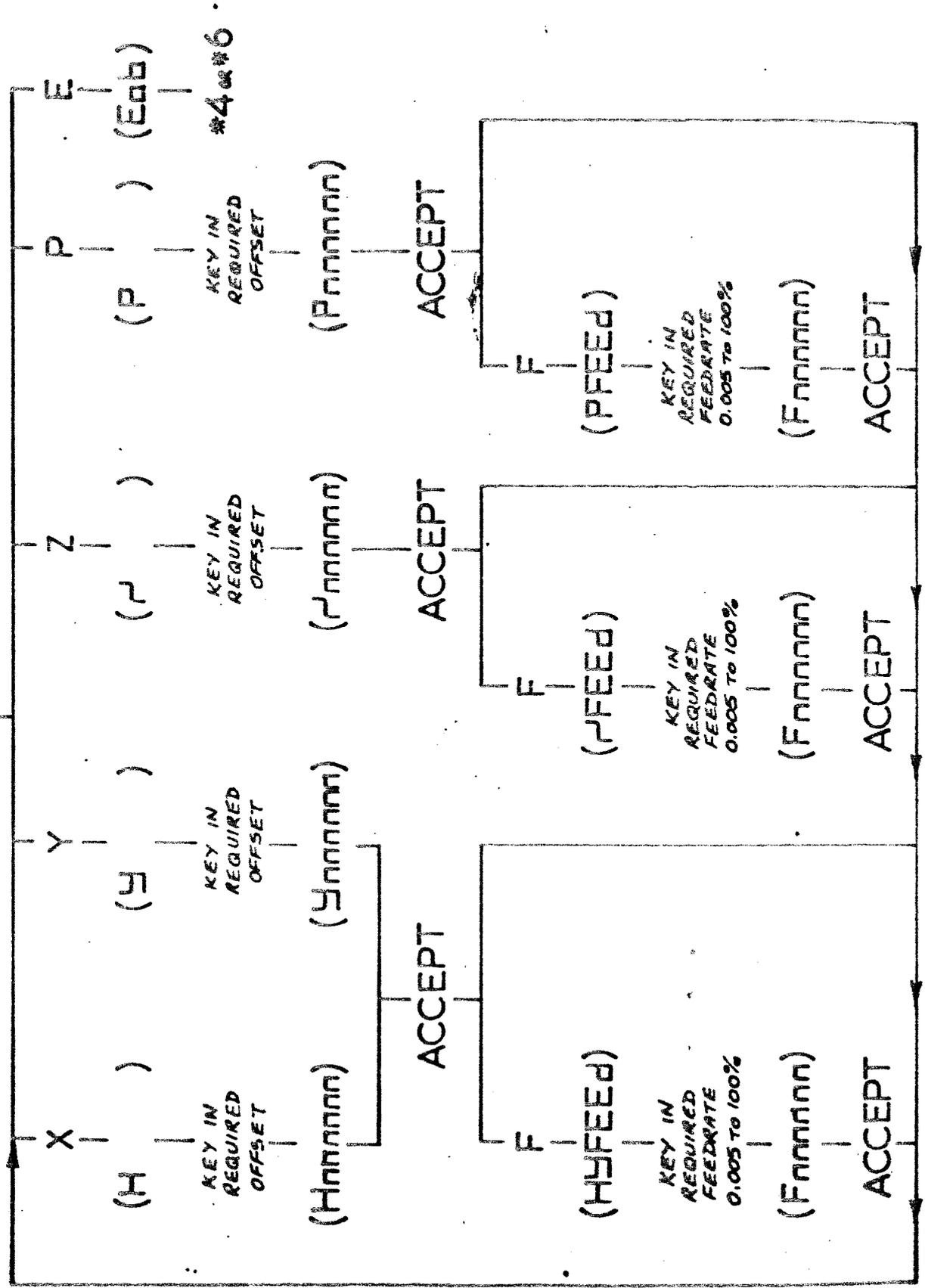
*1



*2B

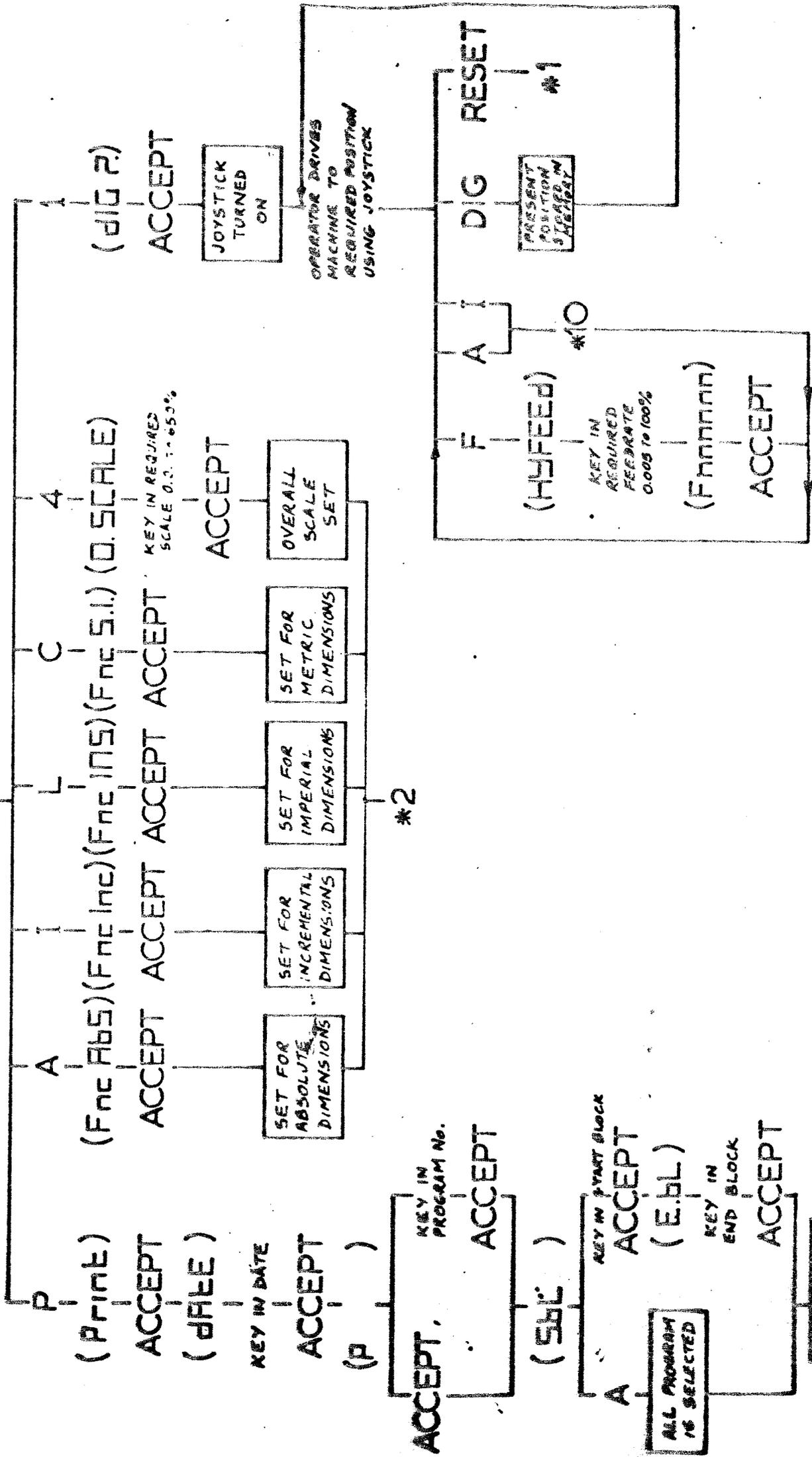


*2C



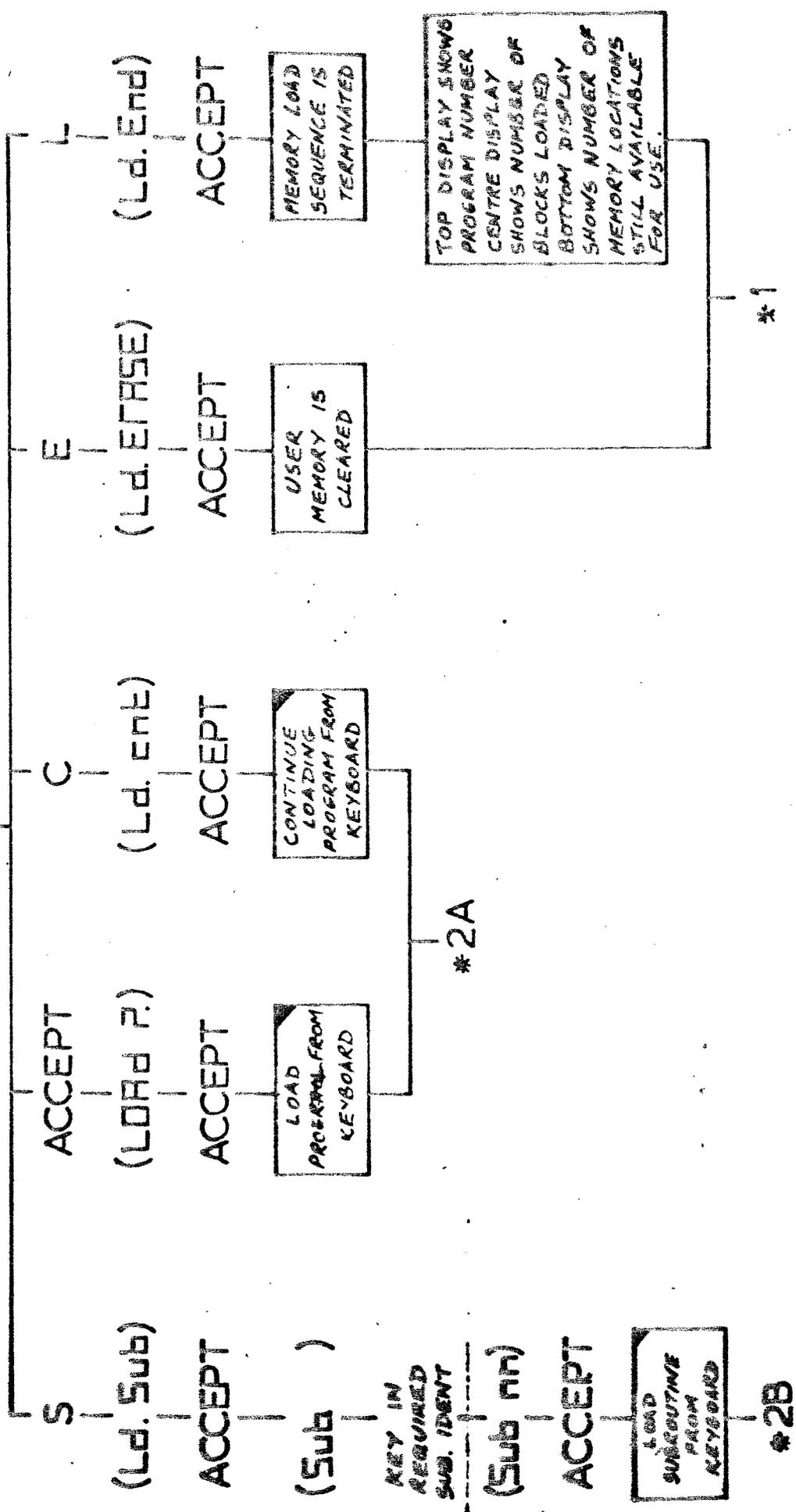
#3

(Fnc)



*4

(LOAD)



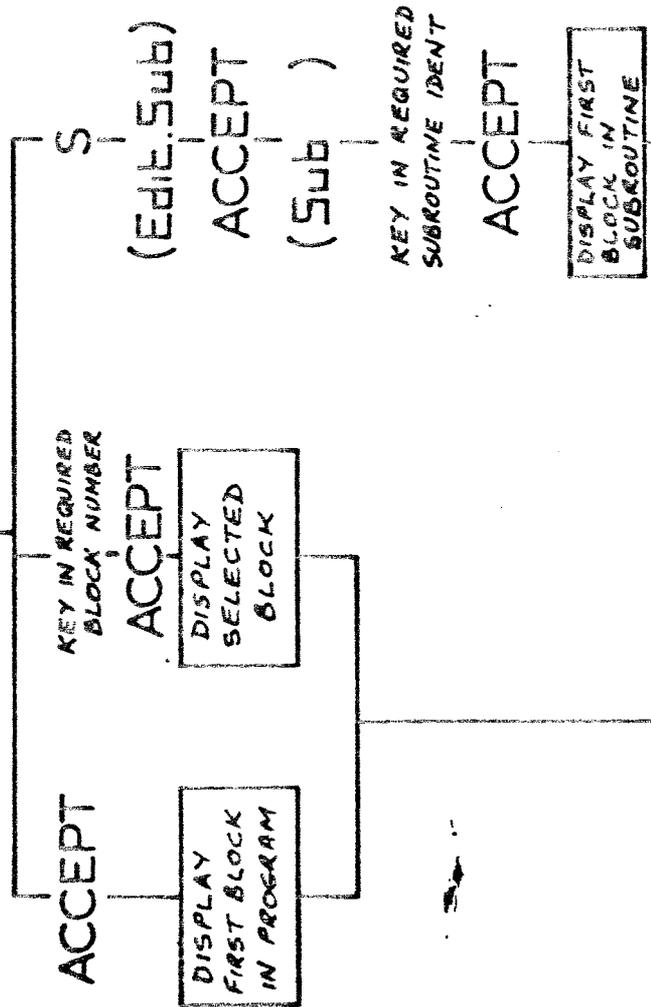
*2A

*2B

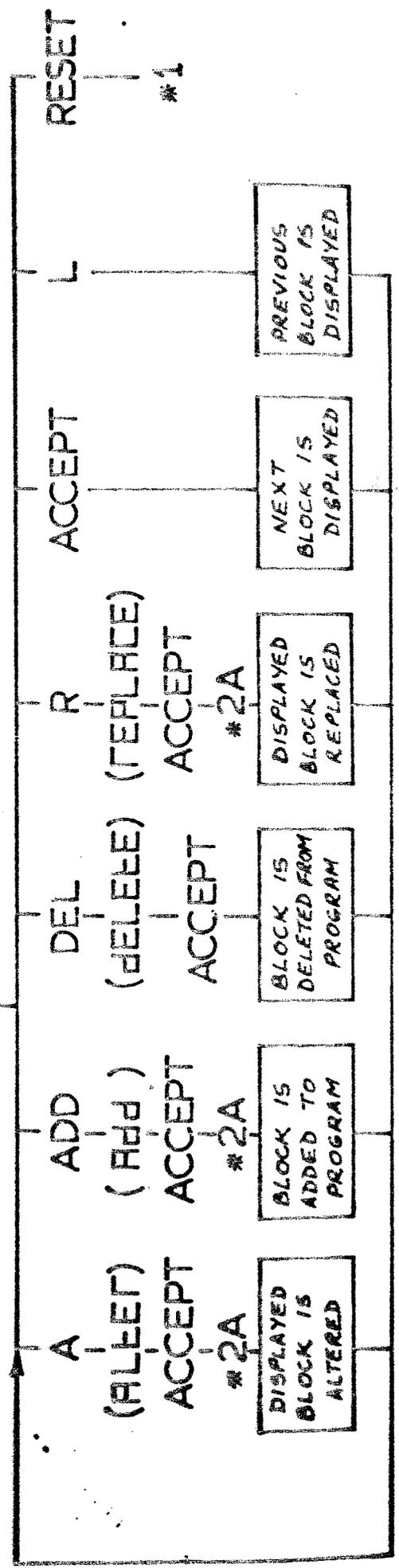
*1

#6

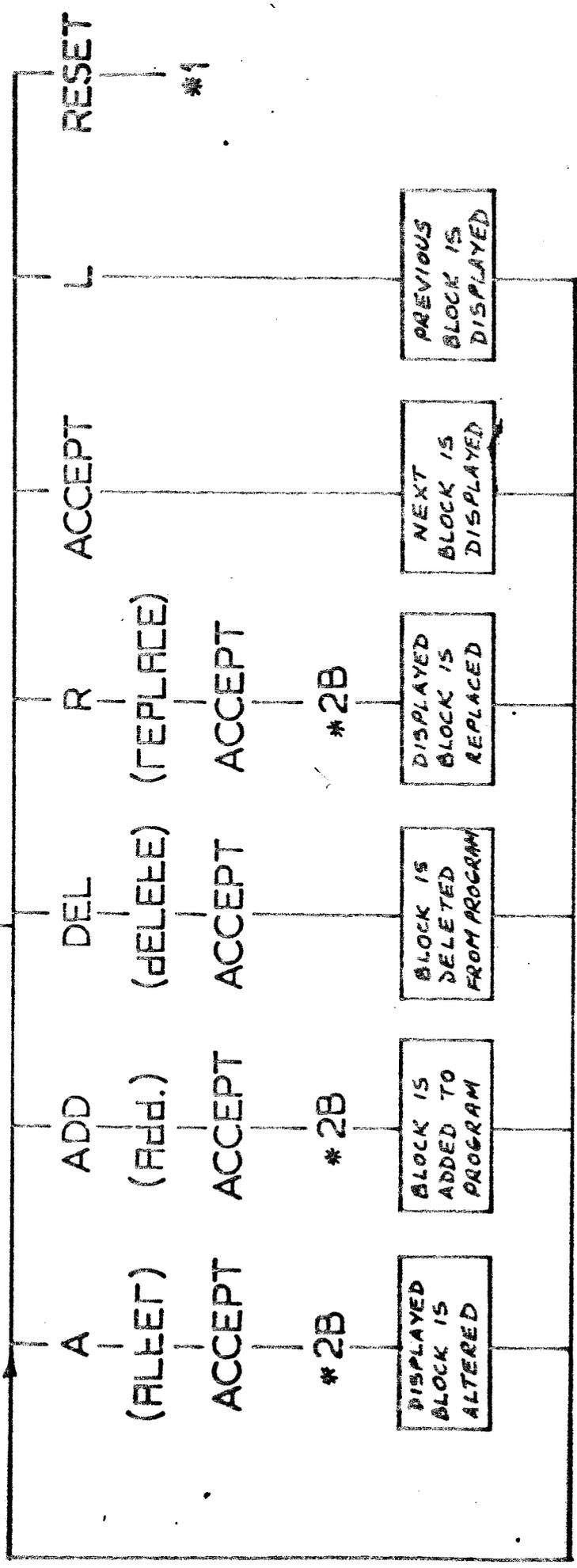
(Edit)

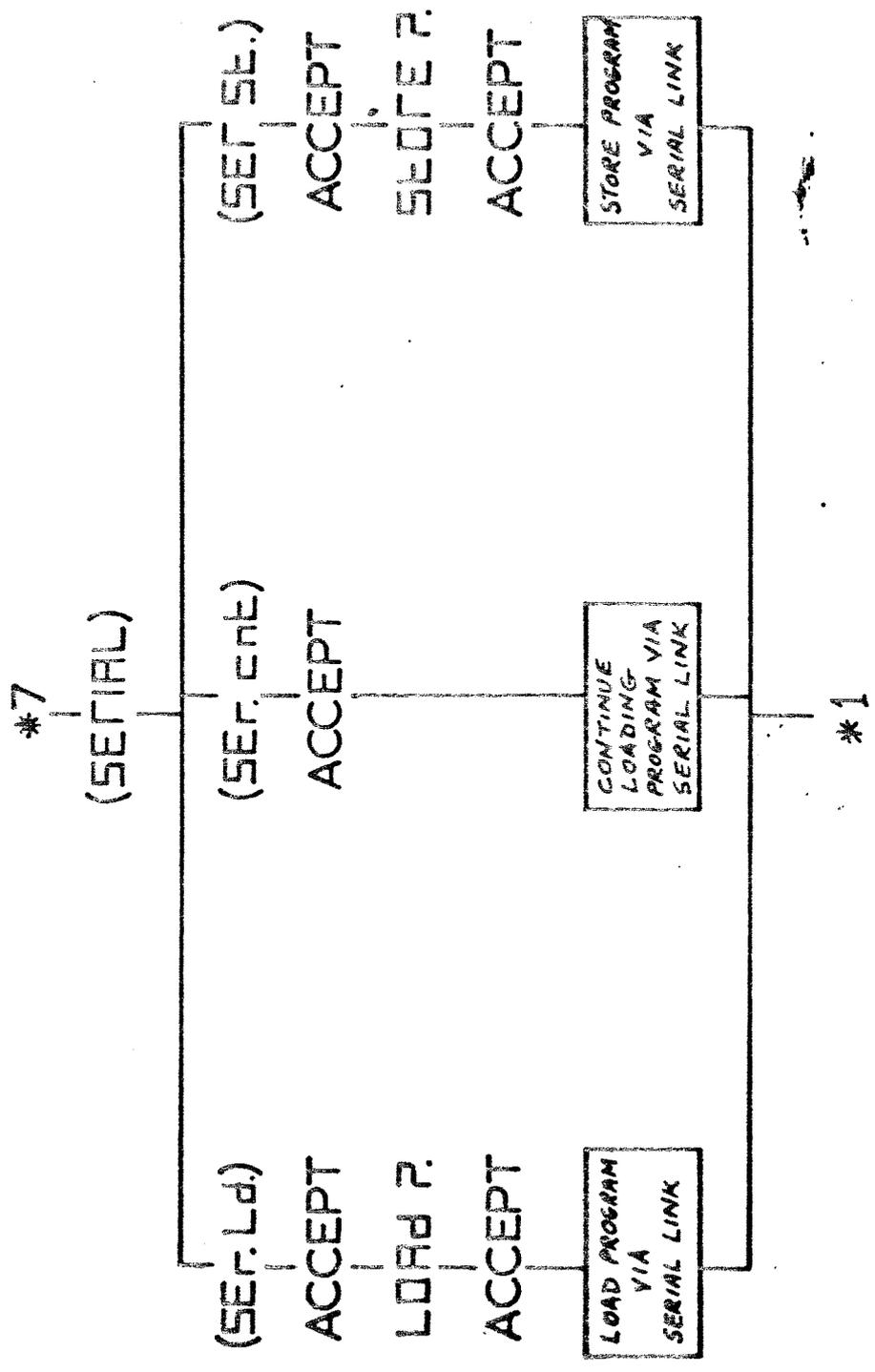


#6A



*6A

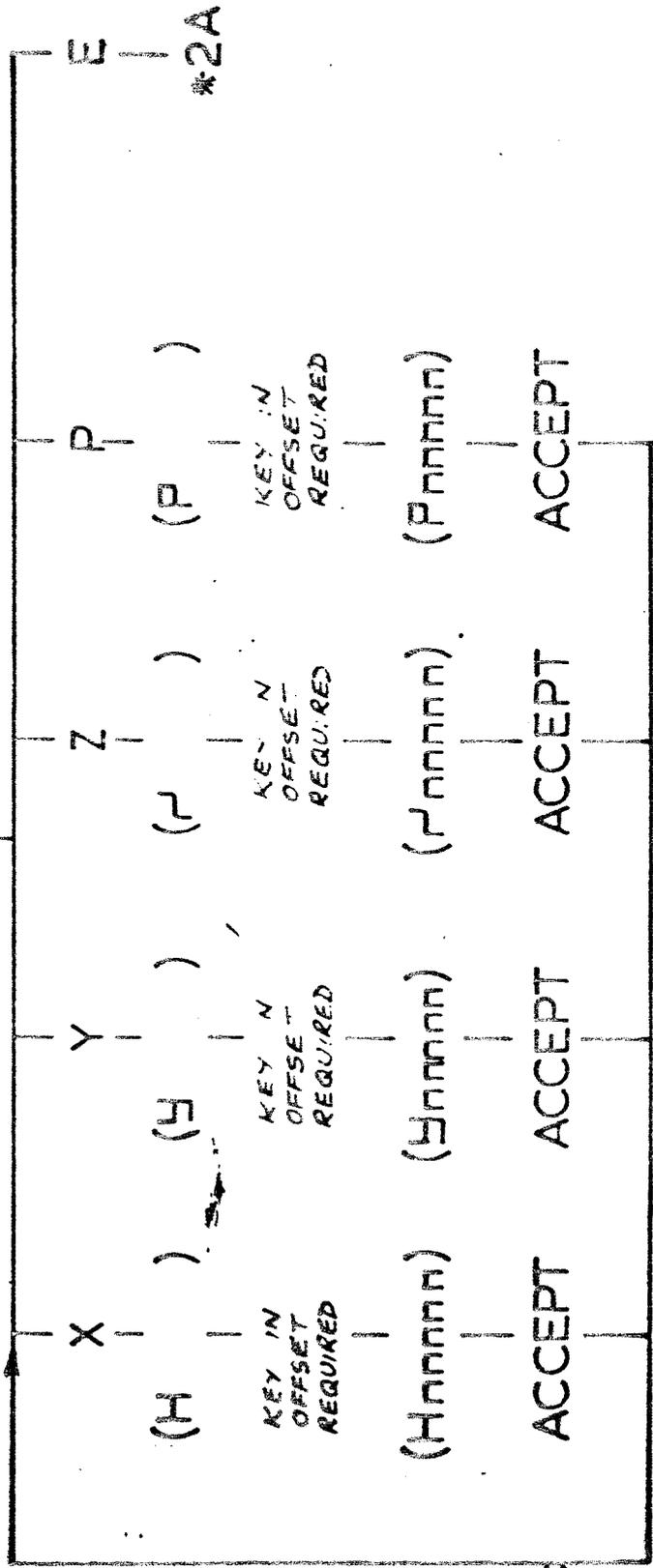




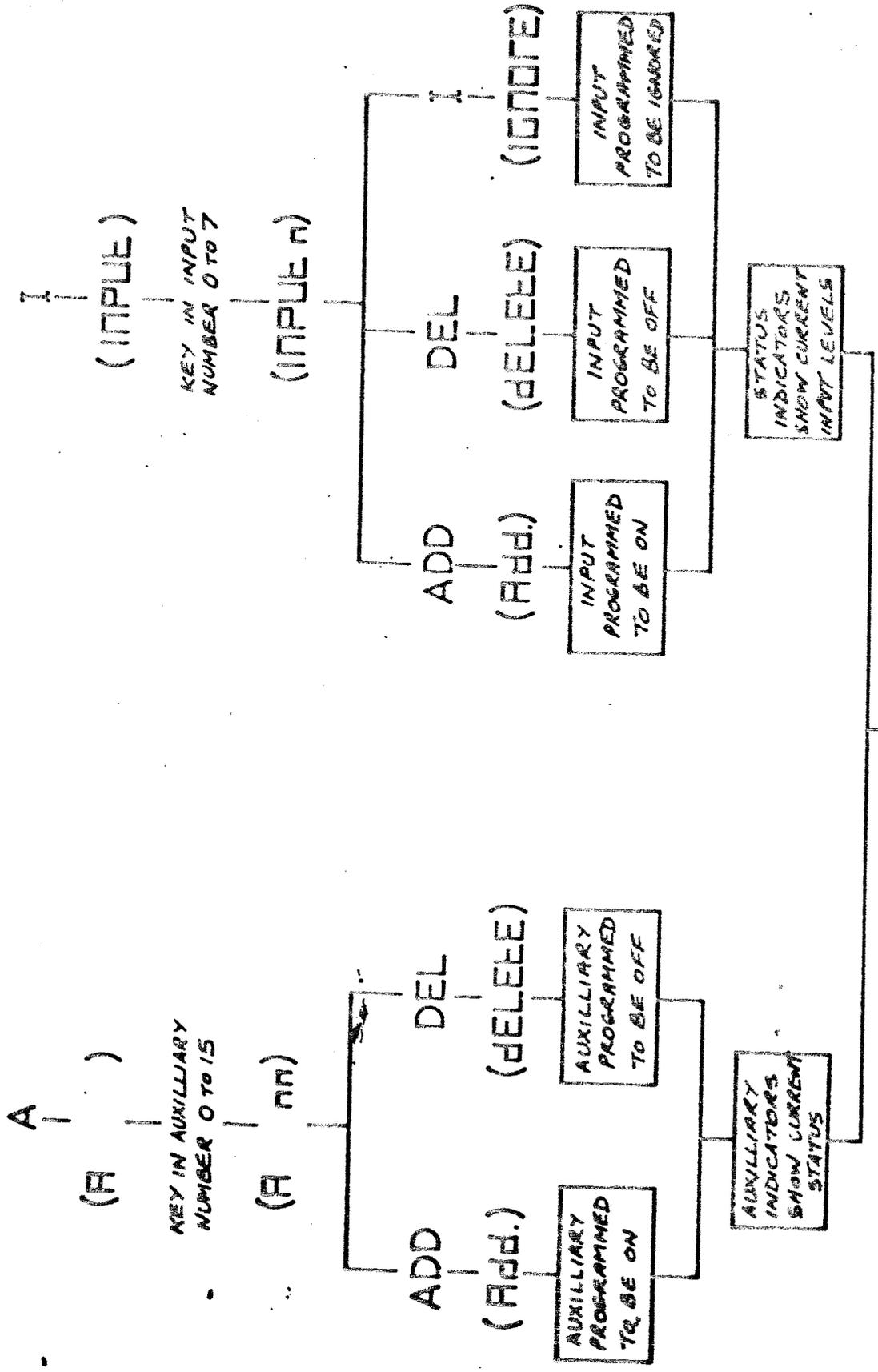
* 8A

(OFFSET)

ACCEPT



#10



#2, #2A, #2B

