TRIAC

PROGRAMMING INSTRUCTION
AND
MAINTENANCE   MANUAL

INDEX

INTRODUCTION

TRIAC utilizes the latest advances in microprocessor technology. These advances can be combined with a full backup facility, extra equipment, quick change tooling systems, and work holding accessories to provide a powerful and very versatile machine tool.

Other important features of TRIAC include computer software which enables the simulated running of programs for error detection, which can save valuable production time. Tool path graphics for program simulation, with four available views. Inputs and outputs can be monitored to enable TRIAC to work with robots in a flexible manufacturing system. The RS232 link allows DNC operation to be a standard feature of the machine, thus allowing direct programming from a host computer. CAD/CAM systems utilize this function to the full.

TRIAC is fitted with a parallel printer port, to offer the user full or part program hard copy printouts.

TRIAC's programming format is to the International Standard incorporating G and M codes. Alternatively function keys can be used in their place to ease programming. These functions keys offer a simple machine shop language so programming can be accomplished successfully by operators having no CNC experience of G or M code format.

Error messages are built into the system to help the operator to drastically reduce the amount of erroneous data being programmed.

As with any CNC machine tool, the programmer and operator should have a good knowledge of machine shop practice and be familiar with machine shop terminology. The quality of components produced is only a reflection on the programmer.

SECTION 1

THE CNC CONTROL UNIT

PNC 3 DESCRIPTION

TRIAC's control the PNC 3 is an extremely versatile continuous path, computer based programmable numerical control unit designed to control up to 3 axis of movement where precise control and positioning is required. Related processes and functions can also be controlled by the PNC 3. The programming of stepper motor movements and the process control element is explained fully in this manual. The PNC 3 we are confident will be found to be very easy to operate.

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

An easy to use keyboard for the input of data and commands by the a) keyword system b) ISO G and M code programming. -* Switch a) and b).

The 7" and 12" screens provide the user with:-

1. A display of the complete machine status
2. Prompts to assist the user in using the control system
3. Sections of the program during program loading, editing and execution
4. Machine, Control Unit and Program error information
5. Tool path graphics

Integral control unit memory stores typically 750 blocks.

Programming facilities include, repeat loops, fixed/floating datums, dwells, program offsets, inch/metric and absolute/incremental programming with any mix, program scaling, mirror imaging, tool diameter and length compensation, integral spindle control, circular, rectangular and drilling canned cycles.

The integral fast magnetic tape system provides unlimited program storage space, with each cassette side storing up to 3000 program blocks.

Jog system giving manual control in all axes with plus and minus keys for feedrate override control.

Integral high power stepper motor drives.

CNC CONTROL SYSTEM SPECIFICATION

1. Green on Black 7" VDU with Anti-glare screen and 12" VDU screen with outlet to external TV Monitor.

2. Alpha numeric keyboard allowing full manual Data Input.

3. Mini Magnetic Cassette Unit for Multi Program Storage.

4. RS232C Interface 7 Din Pin connection to computers and paper tape punch units.

5. Parallel Printer Interface for obtaining hard copy of programs.

6. ISO Format - allowing 'G' and 'M' Code Programming from DIN 66025 extract.

7. Full 'G' and 'M' Code Listings on VDU when required to assist programming.

8. Single Mode Selection Keys.

9. Axis Jog on All Axes with variable feedrate and 0.01 mm step.

10. Feedrate override from 1 mm/min to 585 mm/min.

11. Programmable Spindle Speed 0-2500 RPM.
    Programmable Feedrate 0-1000 mm/min.

12. Linear Interpolation on 3 axes with vectorially correcting feedrates.

13. Circular Interpolation on X-Y Plane.

14. Absolute/Incremental, Inch/mm programming throughout program build-up.

15. Manual and Programmable Program Stops.

16. Repeat facility allowing re-execution of specific program blocks with nesting up to 4 levels

17. Floating Datum Facility.

18. 750 Block Memory.

19. Tool length Offsets for up to 16 tools.

20. Tool diameter compensation.

21. Programmable Dwell from 0.1 to 9999.99 seconds.

22. Four Auxiliary Outputs.

23. Six Programmable Inputs.

24. Mirror Imaging on X and Y planes simultaneously.

25. Program Scaling and Component Scaling from 0.01%-650%.

26. Program Offset allowing dry run facility.

27. System resolution 0.01 mm (0.0004").

28. On screen tool path graphics with four views and cutter path.

SECTION 2

TECHNICAL SPECIFICATIONS

AXES TRAVEL

LONGITUDINAL TRAVEL	(X)	290 MM – (11½")
CROSS TRAVEL	(Y)	170 MM – (6½")
VERTICAL TRAVEL	(Z)	235 MM – (9¼")

SPINDLE

SPINDLE BORE – R8 TAPER WITH EASYCHANGE HOLDER

SPINDLE SPEEDS

1. INFINATELY VARIABLE BETWEEN 100-2500 RPM

SPINDLE DRIVE

½ HP 0.371 KW 240V AC

AXES DRIVE MOTORS

HIGH POWER STEPPER MOTORS

X AXIS STEPPER MOTOR – 200 STEPS/REV
Y AXIS STEPPER MOTOR – 200 STEPS/REV
Z AXIS STEPPER MOTOR – 200 STEPS/REV

FEED RATES   – RAPID TRAVERSE ON ALL AXES G00=1000 MM/MIN (40 INS/MIN)
FEED RATES INFINATELY VARIABLE ON ALL AXES
0-1000 MM/MIN (0-40 IN/MIN)

MECHANICAL RESOLUTION – 0.01 MM (0.0004")

LINEAR INTERPOLATION   – ON X, Y AND Z AXIS WITH VECTORICALLY CORRECTED FEED
RATES

CIRCULAR INTERPOLATION – ON X AND Y PLANES

3

FIXED ZERO REFERENCE POSITION

LOOKING AT THE TABLE

        X=ZERO   WHEN THE TABLE IS AT THE RIGHT HAND SIDE OF THE SPINDLE

        Y=ZERO   WHEN THE SPINDLE AT THE FRONT EDGE OF THE TABLE

        Z=ZERO   WHEN THE SPINDLE NOSE IS AT ITS MAXIMUM DOWNWARD TRAVEL

TABLE

TABLE LENGTH	- 500 MM
TABLE WIDTH	- 160 MM
SPINDLE TO TABLE	- 280 MM

TABLE SLOTS — - 10 MM TEE SLOTS

MACHINE DIMENSIONS

LENGTH - 990 MM	(39")
WIDTH - 710 MM	(28")
HEIGHT - 980 MM	(38½")
WEIGHT - 240 KILO	(528 LBS)

TOOL LENGTH OFFSETS — - 16 TOOLS

TOOL DIAMETER COMPENSATION — - 16 TOOLS

STANDARD EQUIPMENT

Quick Change R8 Easychange Toolholder

Table Guards

Tool Kit

Halogen Lo Vo Light

Operation and Instruction Manual

Automatic Lubrication System

7" and 12" VDU Screens

1 TOOL BOX

1 OIL CAN

2 SCREW DRIVERS

4 ALLEN KEYS 3, 4, 5 AND 6

4 SPANNERS, 12/13, 14/15, 16/17 AND 19 RING

1 MINI CASSETTE

1 POT OF PAINT

1 FUSE 20 MM 250 V 5A

1 FUSE 20 MM 3.15 ANTI SURGE

1 FUSE 20 MM 1.6A

EXTRA EQUIPMENT

Spray Mist Coolant

Printer

CAD/CAM and Off Line Computer Programming

Desk Top Programmer

Robots

SAFETY FEATURES

Table Guard

Axis Limit Switches

Diagnostic Fault Finder

Key Operated Emergency Stop

INSTALLATION

LIFTING

The machine can be lifted via the two sling hooks on either side of the main casting. Check to ensure that the lifting slings are of the correct capacity to lift the weight of the machine and that the slings are in good condition.

548 lb / 248,5 kg
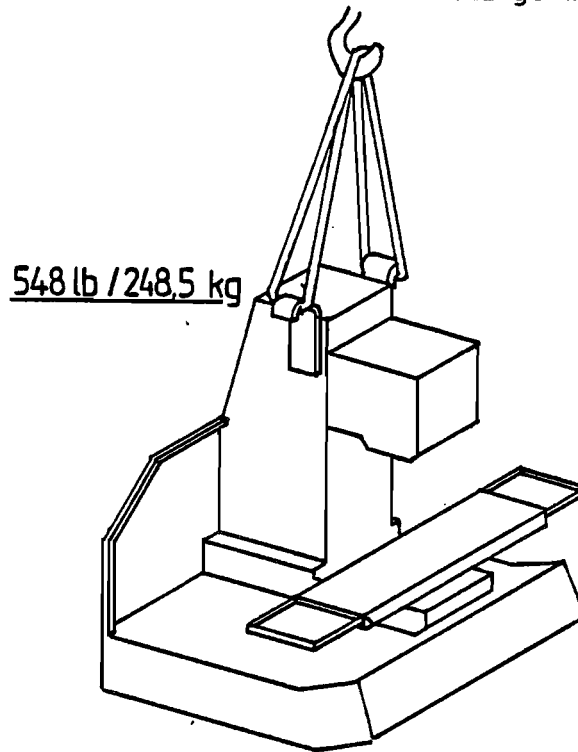
LOCATION

The machine should be located on a table or bench suitable to take the weight of the Triac machine.

MAX WORKING AREA OF TRIAC
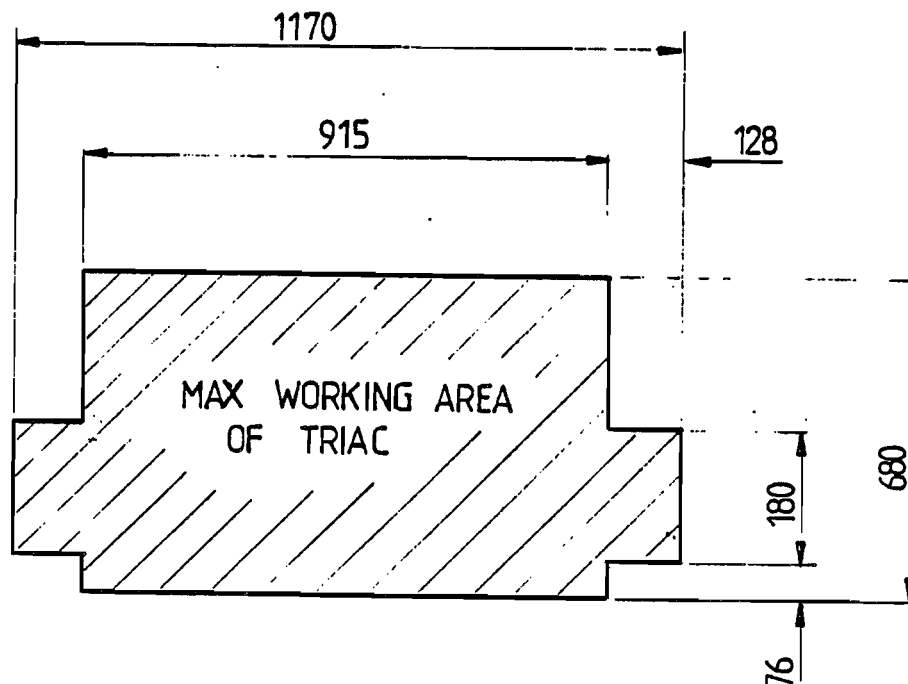
LEVELLING

Once the machine has been levelled using the necessary packing it is recommended to stand the machine on a suitable rubber mat to prevent vibration.

LUBRICATION

The milling machine is fitted with an automatic lubrication system. The reservoir on the system should be filled to the correct level and a check to see if oil is being pumped to the slides and ballscrews before the machine is operated.

Use SAE 10 for the lubricating system and a good quality machine grease for the headstock bearings accessible underneath the headstock casting.

LUBRICATION		
	SHELL	CASTROL
	VITREA 68	PERFECTO NN
	VITREA 68	PERFECTO NN
	ALVANIA Nº 3	SPHEEROL AP3

CLEANING

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

SECTION 4

MAINTENANCE

Routine inspection and maintenance should be carried out to the following schedule:-

PERIOD	MAINTENANCE REQUIRED
DAILY	Check oil reservoir. Clean away swarf.
WEEKLY	Clean machine thoroughly.
SIX MONTHLY	Check head, cross slide and saddle strips.
ANNUALLY	Check machine alignments and accuracy. Check axis drive belts.

ADJUSTMENT OF GIB

1. The table is provided with a full length, hard scraped, tapered gib on the front side of the saddle. There is an adjusting screw at each end. To adjust the gib, tighten the screw slightly to remove any play.

ADJUSTMENT OF SADDLE AND HEADSTOCK GIBS

1. To properly adjust the feel of the cross movement and the vertical movement, follow the same procedure as described above.

MACHINE AXIS FORMAT

TRIAC is a three axis mill. The illustration shows the positive and negative, indicating the direction of the tool movement. This is an important concept to understand. Because all programming is done with this idea in mind, that is all motion programmed is the movement of the tool, not the movement of the table.

Z+

Y+

X-   X+

Y-

Z-
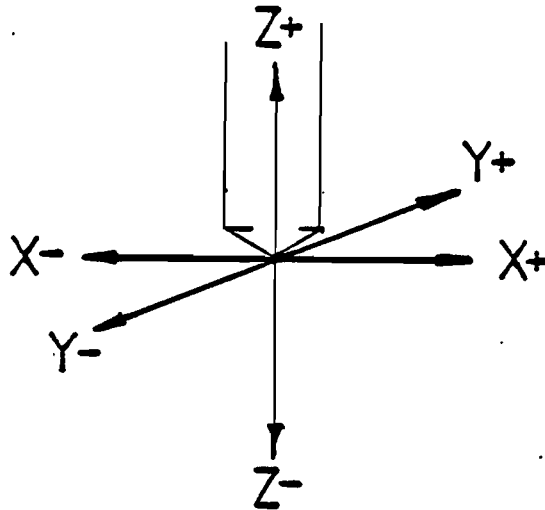
ABSOLUTE TOOL MOVEMENT FROM G55 DATUM POSITION

X AXIS DIRECTION FROM DATUM

X-   X +
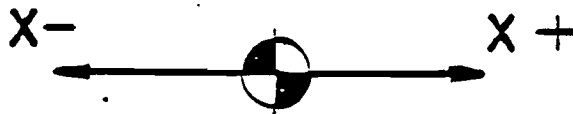
X- LEFT FORWARD MOVEMENT OF TOOL
X+ RIGHT FORWARD MOVEMENT OF TOOL

Y AXIS DIRECTION FROM DATUM

Y +

Y —
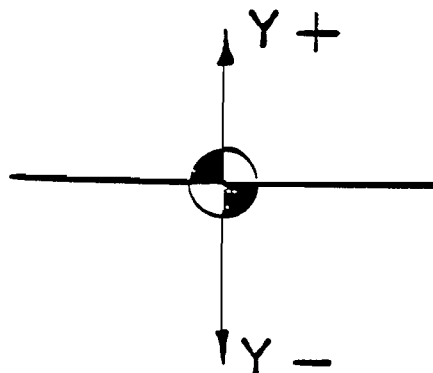
Y+ TOOL MOVES AWAY FROM THE OPERATOR
Y- TOOL MOVES TOWARDS THE OPERATOR

Z AXIS DIRECTION
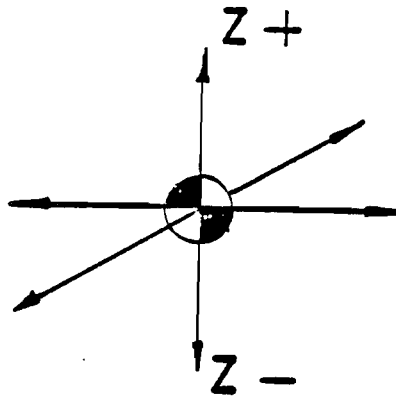
Z- DOWNWARD MOVEMENT OF THE HEADSTOCK

Z+ UPWARD MOVEMENT OF THE HEADSTOCK

MACHINE AXIS FIXED DATUM

Initially starting TRIAC from a cold start, operation cannot commence until the machine has been datumed. Each axis is driven to a limit switch, Z, Y and X axis respectively. Each limit switch position is maximum positive motion for that axis. From this position the control can establish the parameter of movement for each axis.

All movements programmed are positive. Any negative sign will respond. "MOVE EXCEEDS MACHINE LIMIT." The machine origin being the bottom left hand corner of the table for X and Y axis. Z axis origin being when the head is at maximum distance from the machine table.

Y+

PLAN

X+

CCW   CW

Z+

X+

FRONT

Z+

Y+

L.H. SIDE
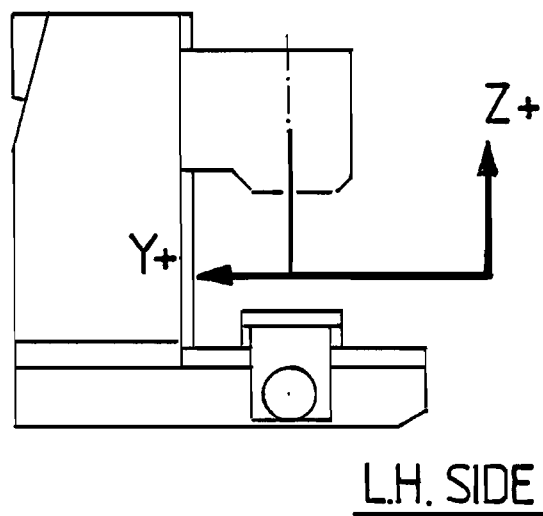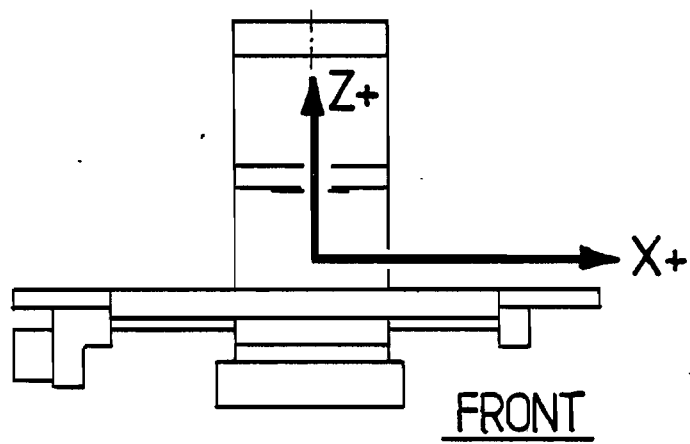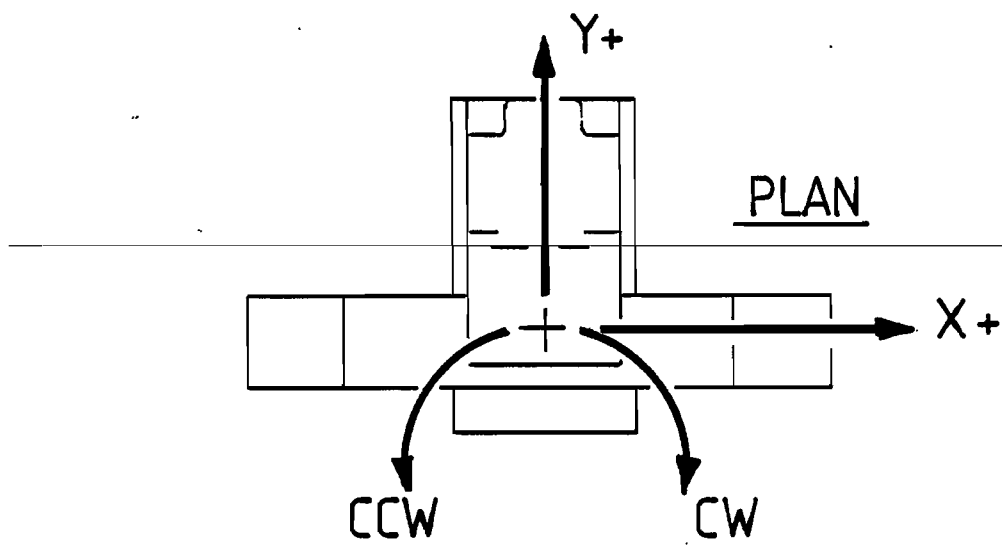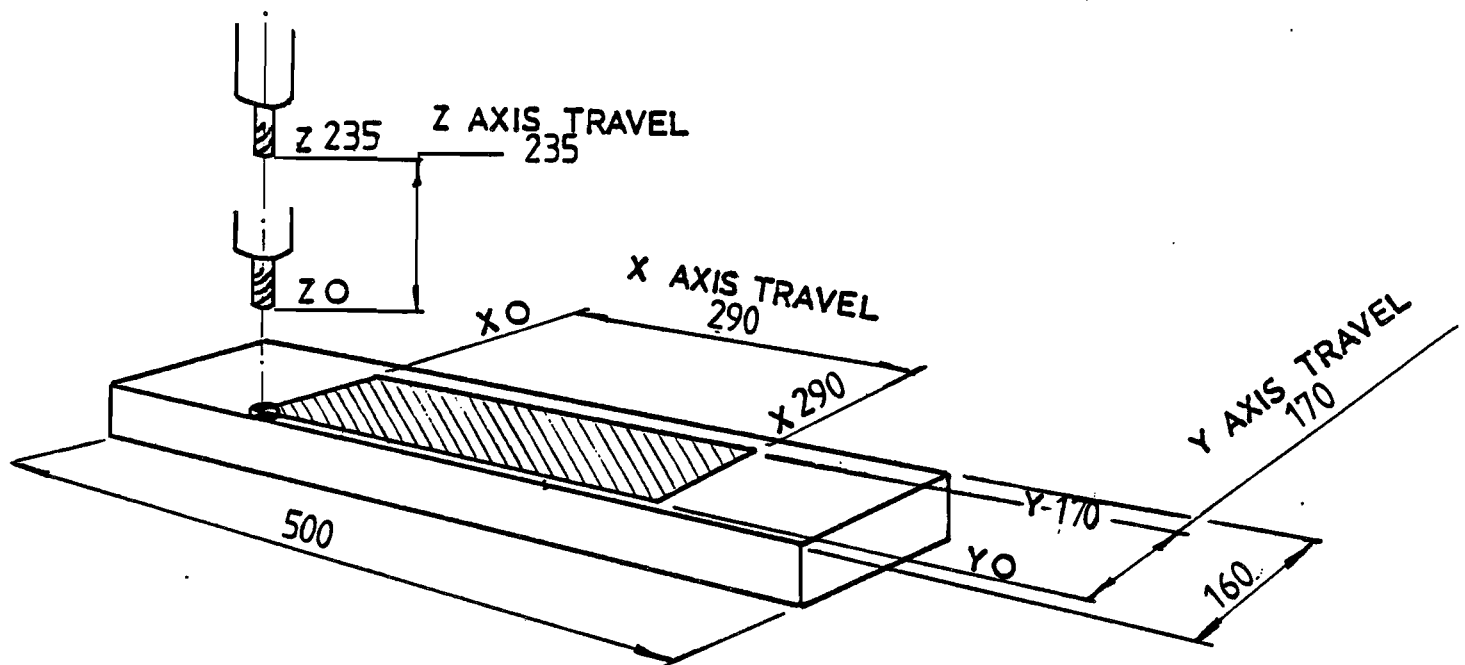
X AXIS AND Y AXIS = 0   When the head is at a point near the front left hand corner of the table.

Z AXIS   = 0   When the head is at maximum distance from the headstock.

X+   =   Left forward movement of the table.

Y+   =   Forward movement of the table towards the operator.

Z+   =   Upward movement of the head.

DENFORD MACHINE TOOLS

ON

EXT MONITOR

EXT VID1   PRINTER   AUX-I/P

EXT VID2

220-240 V AC

R 232

TRIAC

POWER & DRIVE

TRIAC

15
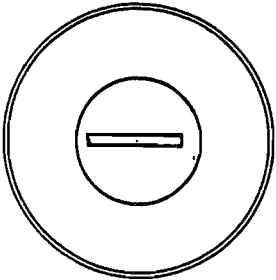
KEY	FUNCTION
ON	MACHINE POWER L.E.D.
ON (ON)	DRIVE ON BUTTON. THIS BUTTON ENERGIZES DRIVE MOTORS, SPINDLE DRIVE MOTOR, AUTOMATIC LUBRICATION PUMP.
	EMERGENCY STOP EACH TIME EMERGENCY STOP IS USED IT WILL KILL POWER TO ALL DRIVE MOTORS. THE MACHINES MEMORY IS NOT AFFECTED. POWER IS TURNED BACK ON BY UNLOCKING THE BUTTON AND PRESSING "DRIVE ON" BUTTON. IF THE BUTTON IS DEPRESSED AND THE KEY REMOVED, THE MACHINE CAN BE PROGRAMMED AND SIMULATED USING THE TOOL PATH GRAPHICS. BUT THE MACHINE CAN NOT BE RUN. THIS IS A USEFUL SAFETY FEATURE FOR INEXPERIENCED USERS. IF THE KEY IS DEPRESSED WHILST A PROGRAM IS BEING ENTERED THE DRIVES CANNOT BE TURNED ON AFTER THE STOP BUTTON HAS BEEN RELEASED. THE ONLY WAY TO TURN ON THE DRIVES IS TO END THE PROGRAM LOAD.

DENFORD

CONTROL

TRIAC

```
┌════════════════════ CONTROL ════════════════════┐
│                                                  │
│   ┌──────┐ ┌──────┐        ┌──────┐ ┌──────┐     │
│   │      │ │CYCLE │        │CYCLE │ │SINGLE│     │
│   │ STOP │ │START │        │ STOP │ │ STEP │     │
│   └──────┘ └──────┘        └──────┘ └──────┘     │
│                                                  │
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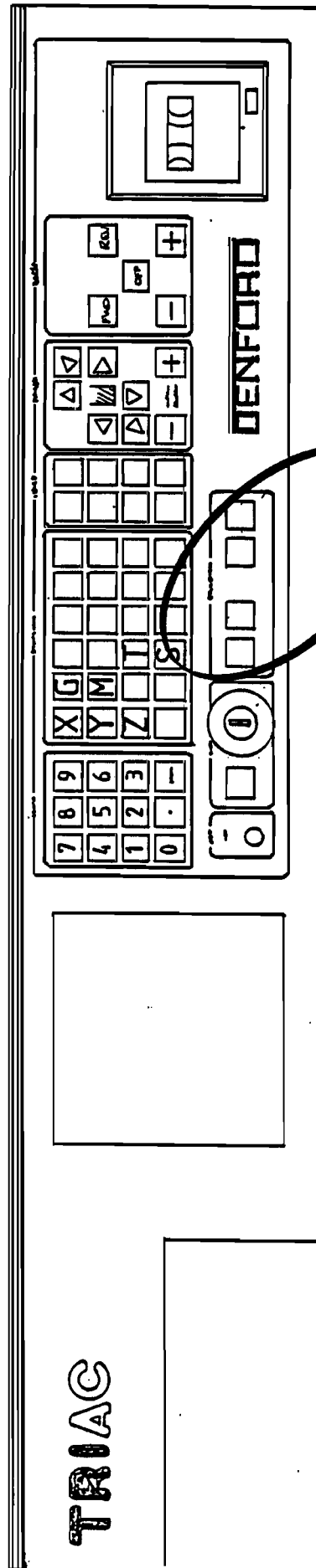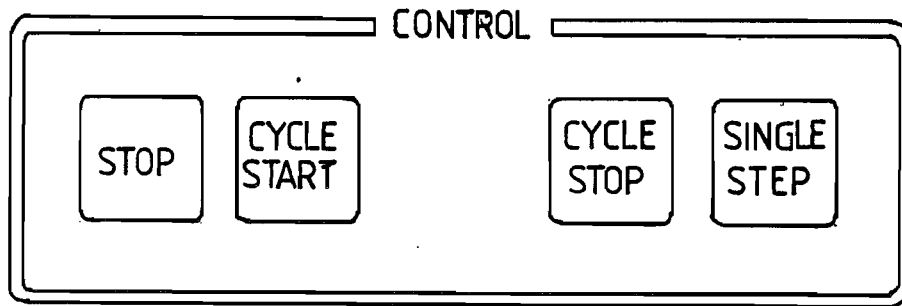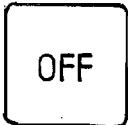
KEY	FUNCTION
STOP	DEPRESSING THE STOP BUTTON WILL HALT THE AXIS MOVEMENT IN THE CURRENT BLOCK. EXECUTION CAN BE RESTARTED BY PRESSING THE "CYCLE START" BUTTON. DEPRESSING THE STOP BUTTON WILL KILL ANY MDI MOVE AND CLEAR THE BLOCK.
CYCLE START	THE CYCLE START BUTTON WILL START THE EXECUTION OF THE CURRENT PROGRAM IN MEMORY.
CYCLE STOP	CYCLE STOP HALTS THE PROGRAM EXECUTION. IT CAN BE RESTARTED BY DEPRESSING THE "CYCLE START" BUTTON.
SINGLE STEP	THIS BUTTON CAUSES THE PROGRAM TO BE EXECUTED BLOCK BY BLOCK, I.E. EACH DEPRESSION OF THE KEY WILL CAUSE THE NEXT BLOCK TO BE EXECUTED.

SPINDLE

REV OFF FWD

DENFORD

TRIAC

7 8 9
4 5 6
1 2 3
0 . −

X G
Y M
Z T
S
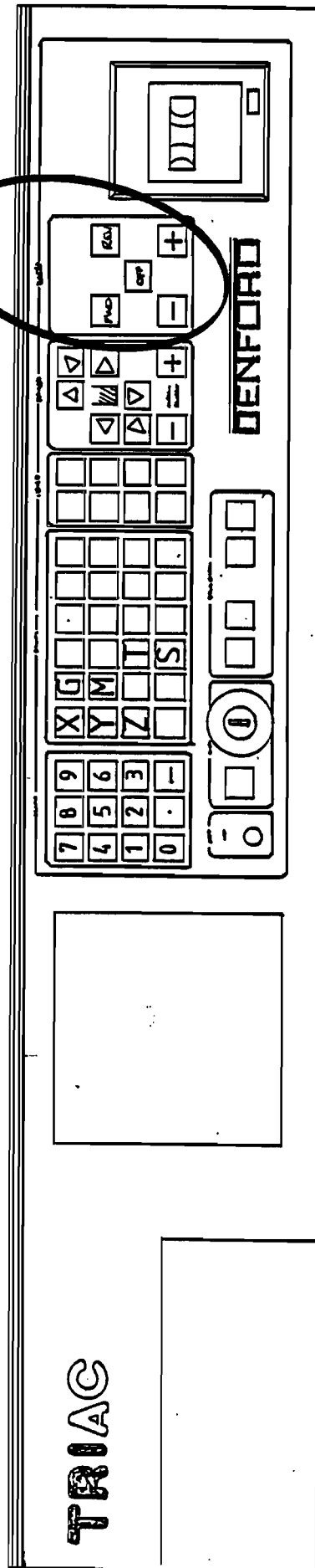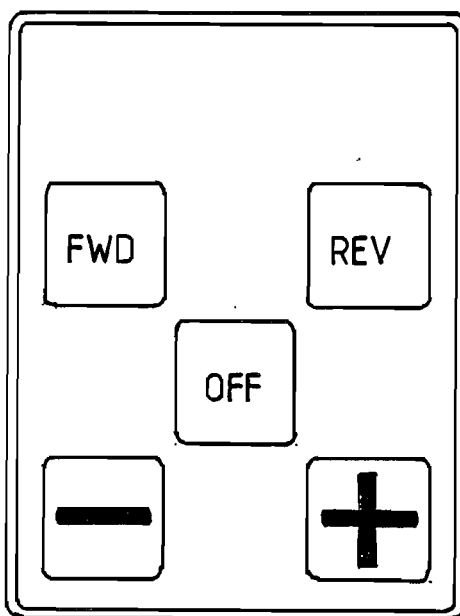
⊐ SPINDLE ⊏

KEY	FUNCTION
FWD	SELECTS FORWARD ROTATION OF SPINDLE. WHEN IN PROGRAM LOAD MODE, PRESSING FWD KEY WILL SELECT M03 COMMAND AND THE VDU'S WILL PROMPT THE USER TO INPUT AN RPM VALUE.
REV	SELECTS REVERSE ROTATION OF SPINDLE. WHEN IN PROGRAM LOAD MODE, PRESSING REV KEY WILL SELECT M04 COMMAND AND THE VDU'S WILL PROMPT THE USER TO INPUT AN RPM VALUE.
OFF	SELECTS SPINDLE OFF. WHEN IN PROGRAM LOAD MODE, PRESSING OFF BUTTON WILL ACTION A M05 SPINDLE OFF COMMAND.
—	WILL MANUALLY DECREASE THE SPINDLE SPEED. CAN BE USED WHILST PROGRAM IS RUNNING TO OVERRIDE THE PROGRAMMED SPEED.
+	WILL MANUALLY INCREASE THE SPINDLE SPEED. CAN BE USED WHILST PROGRAM IS EXECUTING TO OVERRIDE THE PROGRAMMED SPEED.

MANUAL

DENFORD

TRIAC
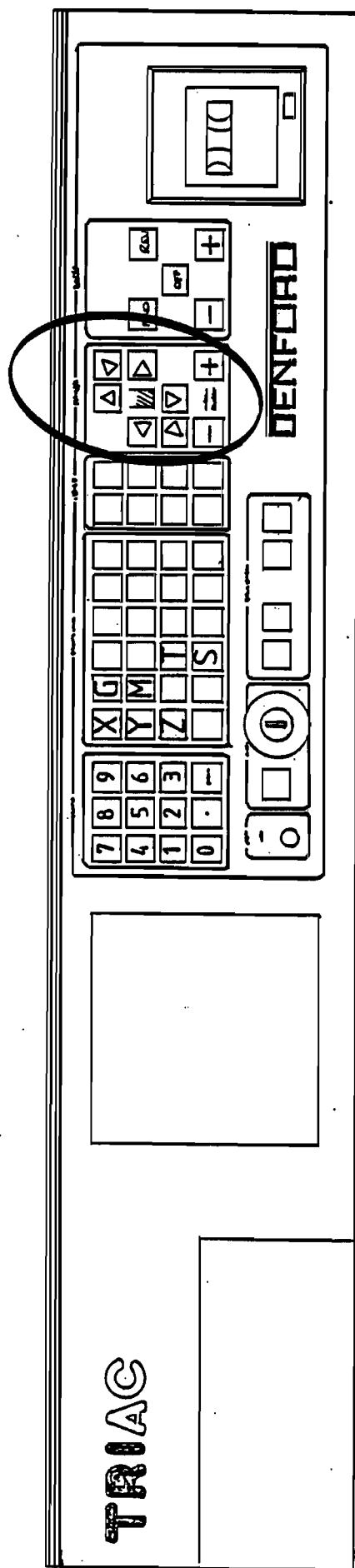
MANUAL
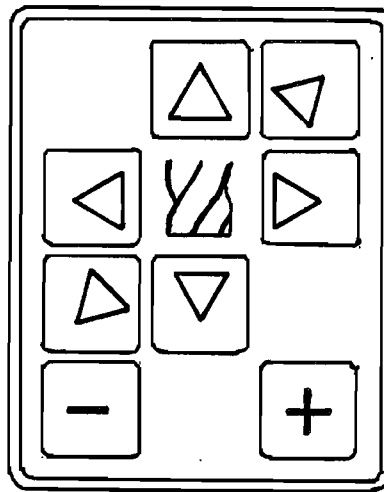
KEY	FUNCTION
△	PRESS THIS KEY TO MOVE THE SPINDLE UP (Z+ DIRECTION). MOVEMENT WILL ONLY OCCUR AS LONG AS THE KEY IS DEPRESSED.
▽	PRESS THIS KEY TO MOVE THE SPINDLE DOWN (Z- DIRECTION). MOVEMENT WILL ONLY OCCUR AS LONG AS THE KEY IS DEPRESSED.
▷	PRESS THIS KEY TO MOVE THE TABLE TO THE LEFT (SPINDLE TO THE RIGHT) (X+ DIRECTION).
◁	PRESS THIS KEY TO MOVE THE TABLE TO THE RIGHT (SPINDLE TO THE LEFT) (X- DIRECTION).
◁	PRESS THIS KEY TO MOVE THE TABLE TOWARDS THE OPERATOR (SPINDLE TOWARDS THE COLUMN) (Y+ DIRECTION).
△	PRESS THIS KEY TO MOVE THE TABLE TOWARDS THE OPERATOR (SPINDLE TOWARDS THE OPERATOR) (Y- DIRECTION).
− +	THE +, − KEYS INCREASE OR DECREASE THE MANUAL JOG FEED. HOLD DOWN THE APPROPRIATE JOG KEY, AT THE SAME TIME PRESS THE + KEY AND HOLD IT DOWN TO RAMP THE FEED UP TO ITS MAXIMUM OF 583 MM/MIN. THE + AND − KEYS CAN ALSO ACT AS FEEDRATE OVERRIDE WHILST THE PROGRAM IS EXECUTING. THE INCREASED OR DECREASED FEED WILL REVERT BACK WHEN IT SEES ANOTHER FEEDRATE IN THE PROGRAM.
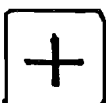
MODE

DENFORD

TRIAC

23
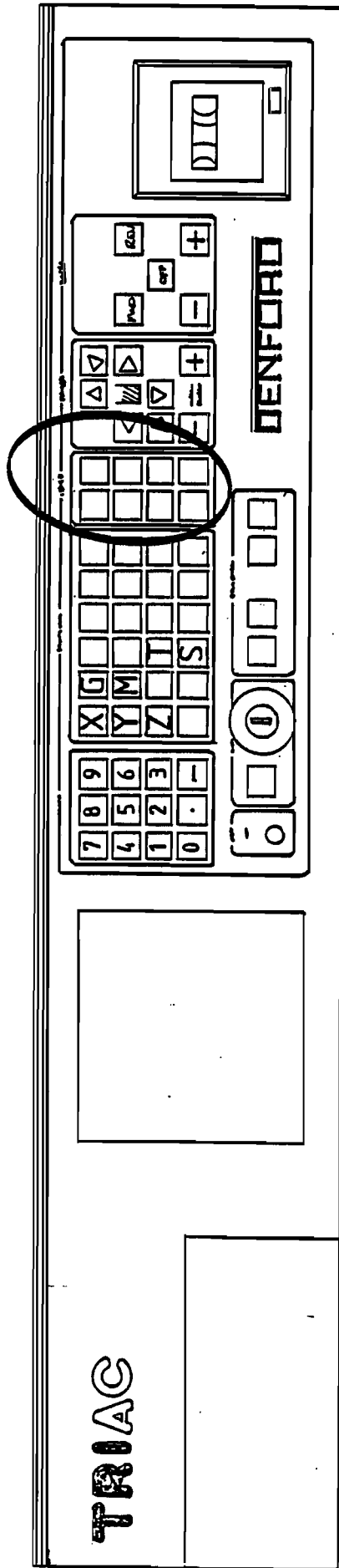
MODE
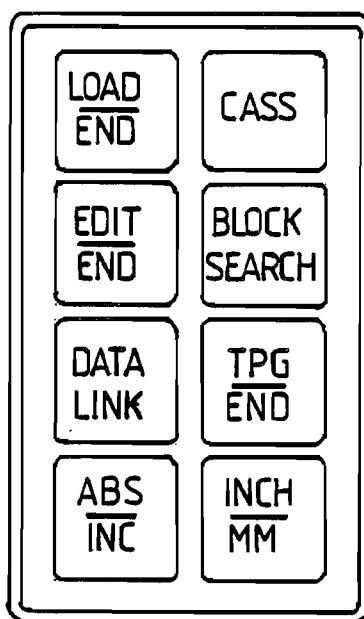
KEY	FUNCTION
LOAD END	**PROGRAM LOAD KEY – PROGRAM LOAD END KEY** TO ENTER A PROGRAM INTO MEMORY OR END A PROGRAM LOADING SEQUENCE.
CASS	**CASSETTE KEY** PRESS CASS KEY AND A MENU OF CASSETTE FUNCTIONS WILL BE LISTED ON THE SCREEN. (SEE SECTION 35)
EDIT END	**EDIT KEY** PRESSING THIS KEY TO ALLOW FOR FULL EDITING OF A PROGRAM. THE SAME KEY WILL EXIT FROM THE EDITING FUNCTION. (SEE SECTION 33)
BLOCK SEARCH	THIS KEY WILL ALLOW THE PROGRAM TO BE EXECUTED FROM A SPECIFIC BLOCK IN THE PROGRAM. (SEE SECTION 36)
DATA LINK	SELECTS A DATA LINK TO EXTERNAL EQUIPMENT. E.G. PRINTER, EXTERNAL COMPUTER, TO SEND AND RECEIVE PROGRAMS. (SEE SECTION 37)

KEY	FUNCTION
TPG / **END**	THIS KEY ENTERS THE TOOL PATH GRAPHIC FUNCTION WHICH ALLOWS FOR THE FULL SIMULATION OF A PROGRAM PRIOR TO EXECUTION. (SECTION 34)
ABS / **INC**	SELECTS ABSOLUTE CO-ORDINATES OR INCREMENTAL INPUT <u>NOTE</u>: ALLOWS INCREMENTAL INPUT BUT ALWAYS DISPLAYS AS ABSOLUTE.
INCH / **MM**	SELECTS IMPERIAL OR METRIC UNITS.

FUNCTION
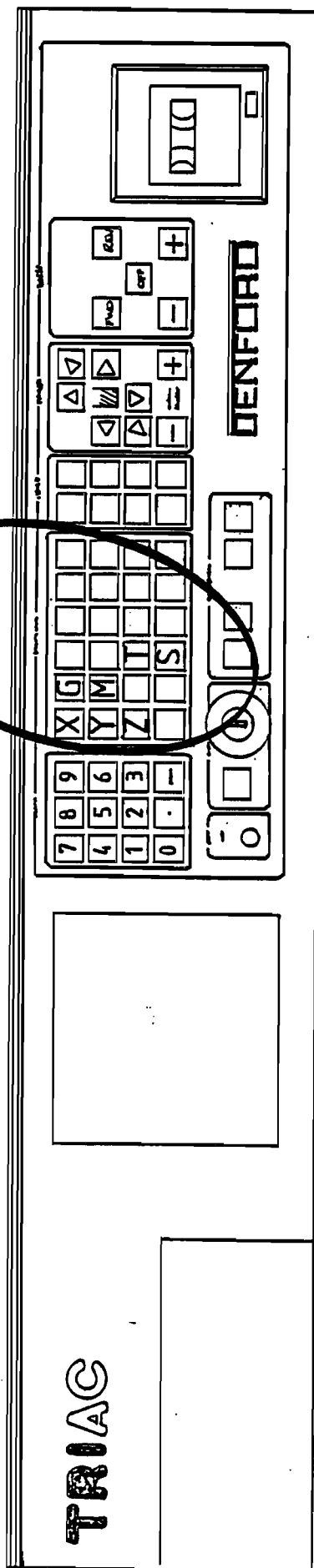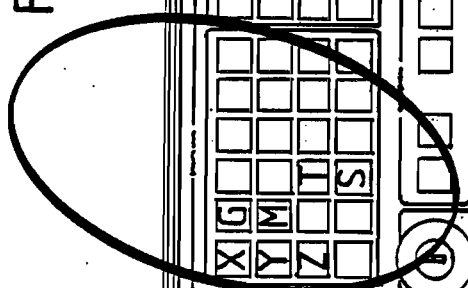
═══════════════ ⊐ FUNCTION ⊏ ═══════════════

X	G	CLW	REPEAT	AUX INPUT	RESET
Y	M	CCLW	DWELL	OFFSET	COMP
Z	FEED	T	MIRROR X	SCALE	FLOAT DATUM
ENTER	E.O.B	S	MIRROR Y	PROG STOP	ABS DATUM

KEY	FUNCTION
X	X AXIS KEY FOR X AXIS MOVES.
Y	Y AXIS KEY FOR Y AXIS MOVES.
Z	Z AXIS KEY FOR Z AXIS MOVES.
G	PREPARATORY FUNCTIONS REFERRED TO AS G FUNCTION. PRESS THE G KEY FOLLOWED BY ENTER TO GAIN A LIST OF G CODES AVAILABLE OUTSIDE PROGRAM LOAD. PERFORM THE SAME OPERATION WHILST IN PROGRAM LOAD MODE FOR COMPLETE LIST.
M	MISCELLANEOUS FUNCTIONS. REFERRED TO AS M FUNCTIONS. PRESS THE M KEY FOLLOWED BY ENTER TO GAIN A LIST OF M CODES AVAILABLE OUTSIDE PROGRAM LOAD. PERFORM THE SAME OPERATION WHILST IN PROGRAM LOAD MODE FOR A COMPLETE LIST.

KEY	FUNCTION
FEED	FEED KEY. USED TO SELECT A FEEDRATE TO EXECUTE A MOVEMENT. FEEDRATES FROM 0 TO 1000 MM/MIN. FEEDRATES FROM 0 TO 40 IN/MIN.
CLW	CIRCULAR INTERPOLATION IN A CLOCKWISE DIRECTION IS SELECTED USING THIS KEY. AFTER DEFINING THE END POINTS FOR THE CIRCULAR MOVE, PRESS THE KEY ONCE MORE TO INPUT THE CENTRE CO-ORDINATES XC AND YC. INITIALLY PRESS THE KEY TWICE TO DEFINE AN ARC BY DEGREES.
CCLW	CIRCULAR INTERPOLATION IN A COUNTER CLOCKWISE DIRECTION IS SELECTED USING THIS KEY. AFTER DEFINING THE END POINTS FOR THE CIRCULAR MOVE, PRESS THE KEY ONCE MORE TO INPUT THE CENTRE CO-ORDINATES XC AND YC. INITIALLY PRESS THE KEY TWICE TO DEFINE AN ARC BY DEGREES.
T	IF THE CONTROL IS SET TO MDI AND THE T KEY IS PRESSED, A TOOL SELECTION MENU WILL BE DISPLAYED FOR TOOL SETTING AND TOOL OFFSET EDITING. (SEE SECTION 21) WHEN THE T KEY IS PRESSED IMMEDIATELY AFTER APPLYING POWER TO THE MACHINE, A SYSTEM TEST WILL BE PERFORMED CHECKING INPUT SIGNALS AND MACHINE MOUNTED SWITCHES.
S	PRESSING THIS KEY UPON STARTING FROM COLD BEFORE THE DRIVES ARE TURNED ON, WILL GIVE A CHECK OF THE SYSTEM SOFTWARE ALONG WITH A SOFTWARE DATE AND VERSION NUMBER.
REPEAT	REPEAT FACILITY ENABLES SPECIFIC BLOCKS OF A PROGRAM TO BE REPEATED UP TO 99 TIMES WITH SPECIFIC OFFSETS AND NESTING UP TO 4 LEVELS. (SEE SECTION 26)
DWELL	SELECT A PROGRAMMABLE DWELL G04 IN THE RANGE OF 0.1 TO 9999.9 SECONDS. ALL OTHER OPERATIONS WILL BE SUSPENDED AS THE DWELL IS PERFORMED.
MIRROR X	CAUSES THE MACHINE TO ESTABLISH AN AXIS OF SYMMETRY ABOUT ITS CURRENT TOOL POSITION. ALL SUCCEEDING BLOCKS ARE REFLECTED ABOUT THE X AXIS.

KEY	FUNCTION
MIRROR Y	CAUSES THE MACHINE TO ESTABLISH AN AXIS OF SYMMETRY ABOUT ITS CURRENT TOOL POSITION. ALL SUCCEEDING BLOCKS WILL BE REFLECTED ABOUT THE Y AXIS.
AUX INPUT	<u>AUXILIARY OUTPUTS.</u> THIS ALLOWS ANY OF THE FOUR AUXILIARY OUTPUT RELAYS TO BE OPERATED. <u>AUXILIARY INPUTS.</u> THIS INSTRUCTION ALLOWS THE PROGRAM TO BE HALTED BETWEEN MACHINING OPERATIONS. THE PROGRAM WILL THEN ONLY PROCEED WHEN ONE OF THE AUXILIARY INPUTS ARE PROGRAMMED TO RECEIVE AN INPUT SIGNAL.
OFFSET	SELECTS A MACHINE OFFSET OF G55 WHICH ALLOWS THE DATUM TO BE SHIFTED TO A POINT CHOSEN BY THE OPERATOR. PROGRAM OFFSET CAN BE USED TO OFFSET PARTS OF THE PROGRAM DURING PROGRAM LOAD SEQUENCE. THESE OFFSETS ARE RESET TO ZERO EVERY TIME THE PROGRAM IS EXECUTED.
SCALE	PROGRAM SCALE OR MACHINE SCALE. SCALING RANGES FROM 0.01% TO 650%. 100% BEING FULL SIZE. PROGRAM SCALE G20 ALLOWS A SCALE INSIDE THE PROGRAM. MACHINE SCALE OR OVERALL SCALE IS SET OUTSIDE THE PROGRAM AND SCALES PROGRAM AND ANY MACHINE OFFSETS.
PROG STOP	PROGRAM STOP BUTTON OR FEED HOLD. WHEN A PROGRAM IS EXECUTING THE "PROG STOP" KEY CAUSES THE SLIDE MOVEMENTS TO STOP. EXECUTION CAN RESTART BY PRESSING THE START KEY.
RESET	TO RESET FROM THE CURRENT MODE OR CANCEL THE MOST RECENT ENTRY.
COMP	SELECTS TOOL RADIUS COMPENSATION. G40 CANCEL CUTTER COMPENSATION. G41 CUTTER COMPENSATION LEFT IN DIRECTION OF TRAVEL. G42 CUTTER COMPNESATION RIGHT IN DIRECTION OF TRAVEL. CUTTER COMPENSATION SETS UP A NEW TOOL PATH AROUND THE PROGRAM TOOL PATH ON THE LEFT OR RIGHT SIDE OF THE LINE. (SEE SECTION 30)

29

KEY	FUNCTION
FLOAT DATA	A FLOATING DATUM BLOCK G99 WILL CAUSE THE CONTROL TO ESTABLISH A DATUM POSITION. X AND Y AXES ARE SET TO ZERO ABOUT THE CURRENT TOOL POSITION. THIS FUNCTION IS ONLY PERMITTED AS PART OF A PROGRAM LOAD. THE DISPLAYED POSITION WILL BE RELATIVE TO THIS DATUM POSITION IF MACHINE OFFSETS (G55) ARE ZERO.
ABS DATUM	THIS FUNCTION IS USED TO DATUM THE MACHINE. THE MACHINE WILL DRIVE TO ITS MAXIMUM TRAVEL IN EACH AXIS. FROM A COLD START YOU WILL NOT BE ABLE TO PROCEED UNTIL THE MACHINE HAS BEEN DATUMED USING THIS KEY.
ENTER	INFORMATION IS ACCEPTED INTO THE CONTROL AFTER THE ENTER HAS BEEN PRESSED.
E.O.B	END OF CURRENT LINE OF INFORMATION. (END OF BLOCK)

DATA

TRIAC

DENFORD
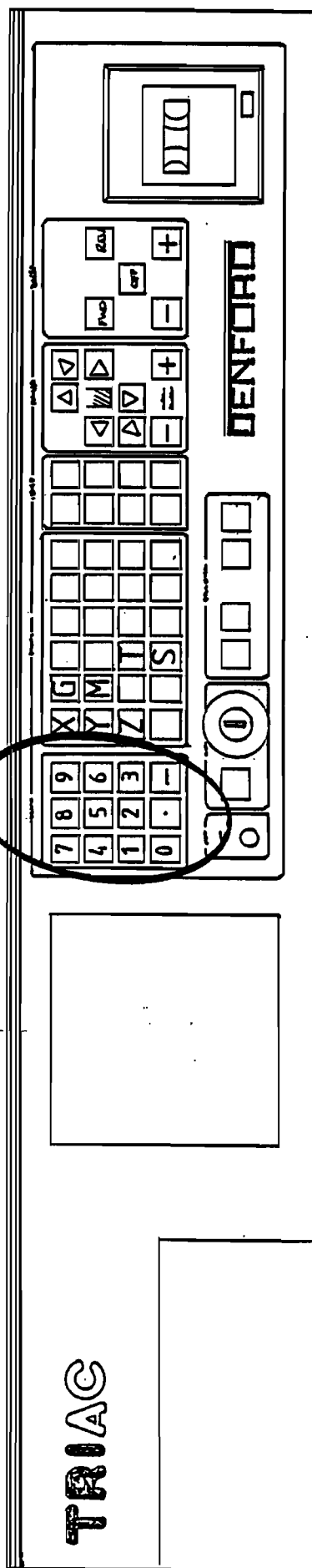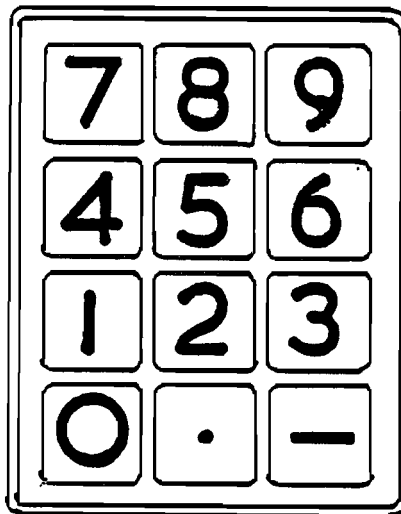
DATA

KEY	FUNCTION
⓪ TO ⑨	NUMERICAL DATA KEYS.
⊙	DECIMAL POINT KEY.
—	MINUS SIGN KEY.

MACHINE CODES (M FUNCTION AND G CODES)

The PNC 3 can be programmed by using both M and G codes or programmed direct using the dedicated keys (keyword system). A complete list of M and G codes follows, some of these codes are option dependant.

M functions for use outside of Program

M03 Spindle Forward
M04 Spindle Reverse
M05 Spindle Stop
M06 Tool Change
M20 Auxiliaries
M21 Input

M functions available inside the Program

M00 Program Stop
M02 End of Program
M03 Spindle Forward
M04 Spindle Reverse
M05 Spindle Stop
M06 Tool Change
M20 Auxiliaries
M21 Input

G codes for use outside of Program

G00 Linear Rapid Traverse
G01 Linear
G02 Circular CLW
G03 Circular CCLW
G04 Dwell
G21 Machine Scale
G40 Cancel Tool Comp
G41 Cutter Comp Left
G42 Cutter Comp Right
G55 Machine Offset
G70 Imperial Units
G71 Metric Units

G90 Absolute Input

G91 Incremental Input

G98 Absolute Datum (Machine Reference Point)

G codes for use inside the Program

G00 Linear Rapid Traverse

G01 Linear

G02 Circular CLW

G03 Circular CCLW

G04 Dwell

G10 Mirror X

G11 Cancel Mirror X

G12 Mirror Y

G13 Cancel Mirror Y

G20 Program Scale (replaces G21)

G40 Cancel Tool Comp

G41 Cutter Comp Left

G42 Cutter Comp Right

G54 Program Offset (replaces G55)

G70 Imperial Units

G71 Metric Units

G79 Re-enable Cycle

G80 De-activate Cycle

G81 Repeat Function

G82 Circular Cycle

G83 Drilling Cycle

G84 Rectangular Cycle

G90 Absolute Input

G91 Incremental Input

G98 Absolute Datum (Machine Reference Point)

G99 Floating Datum

MISCELLANEOUS FUNCTIONS

One M function is permitted per block.

M and G codes cannot be entered on the same line.

M00 Programme Stop

When a program stop occurs then no further motion occurs until the cycle start key is depressed. Spindle speed remains unaffected by this function.

M02 or M2

This function will end the program. On reaching this point the spindle will stop and the tool will retract to its home position.

M03 or M3

This function starts the spindle rotation in clockwise direction. The desired rpm value can be entered. It is cancelled by M06, M05 or M02. Spindle direction cannot be changed whilst the spindle is rotating.

M04 or M4

This function starts the spindle rotation in counter-clockwise direction. The desired rpm value can be entered. It is cancelled by M06, M05 or M02.

M06 or M6 Tool Change

This function causes the spindle to stop and retract to its maximum position, before tool changing can be accomplished. Previous spindle speed will be stored in memory. M06 and the tool number calls up the appropriate tool length offset from the tool library.

M20

This function allows any of the four integral relays to be controlled either ON or OFF.

M21

This function allows the control to monitor four user assigned input signals.

PREPARATORY FUNCTION G CODE

One G code is permitted per block.

M and G codes cannot be entered on the same line.

G00 or G0   Rapid Traverse

All motions rapid traverse in linear mode.

G01 or G1   Linear Interpolation

Is the mode of program to move the tool in a straight line that is parallel to an axis or at some angle to an axis. Depressing X, Y or Z key will default to G01 linear mode.

G02 or G2   Circular Clockwise

Is to be used when the tool is to follow the path of a circular arc while moving in a clockwise direction for X and Y axis.

G03 or G3   Circular Counterclockwise

Is to be used when the tool is to follow the path of a circular arc while moving in a counter-clockwise direction for X and Y axis.

G04 or G4   Dwell

No movement will occur while a timed dwell is performed.

G10   Mirror X

For changing over the positive and negative direction of the X axis, X mirror will cancel cutter compensation. M02 will cancel all mirrors.

G11   Cancel Mirror X

This function cancels X mirror function.

G12   Mirror Y

For changing over the positive and negative direction of the Y axis. Y mirror will cancel cutter compensation. M02 will cancel all mirrors.

G13   Cancel Mirror Y

This function cancels Y mirror function.

G20   Program Scale

This function allows a program scale 0.01% to 650% to be entered into the program. Program scales are cancelled with a new scale 100% or M02 end of programme for X and Y.

G21   Machine Scale

This function is set outside the program and scales the memory and any machine offsets, for X and Y axis, Z axis is unaffected. Scaling range 0.01 to 650%.

G40   Cancel Cutter Comp

This function is to cancel cutter compensation, program returns to centre line co-ordinates.

G41   Cutter Compensation Left

This function compensates the program for a new programmed path, on the left hand side of the line in the direction of travel. It is cancelled by G40, G42, G10, G11, G12, G13, G20 G54, G81, G98, G99, M06 and M02.

G42   Cutter Compensation Right

This function compensates the program for a new programmed path on the right hand side of the line in the direction of travel. It is cancelled by G40, G41, G10, G11, G12, G13, G20, G54, G81, G98, G99, M06 and M02.

G54   Program Offset

This function allows an incremental offset within the program. It is cancelled by M02.

G70   Imperial Units

This function selects imperial units for the program.

G71   Metric Units

This function selects metric units for the program.

G81   Repeat Function

This function selects a repeat loop which will allow a programmed sequence to be repeated with specified offsets. G81 repeat loop will cancel cutter compensation.

G90   Absolute Input

This function selects absolute format.

G91 Incremental Input

This function selects incremental mode, and allows incremental input with absolute display.

G98 Absolute Datum (Machine Reference Point)

This function allows the control to establish its machine reference position for each axis in turn at a predetermined feed rate.

G99 Floating Datum

This function allows the control to establish a position where all axes are zero. Floating datum block will cancel cutter compensation.

CANNED CYCLES

G79 Re-enable Cycle

This function will re-activate a canned cycle held in the memory of TRIAC. The machine will retain the last cycle to be executed.

G80 De-activate Cycle

This function will de-activate a canned cycle after execution. This function must be executed immediately after the cycle has been done.

G82 Circular Cycle

This function will produce a circular pocket to the parameters specified by the operator.

G83 Drilling Cycle

This function provides the operator with a deep hole drilling cycle.

G84 Rectangular Cycle

This function will produce a rectangular pocket to the parameters specified by the operator.

STARTING THE MACHINE

Initially starting TRIAC from a cold start.

1. Switch "ON" the power to CNC control (figure 1). This switch is located at the rear of control unit, a red LED on the front panel will indicate power is on.

FIGURE 1

REAR VIEW
CNC CONTROL UNIT

TRIAC REAR VIEW
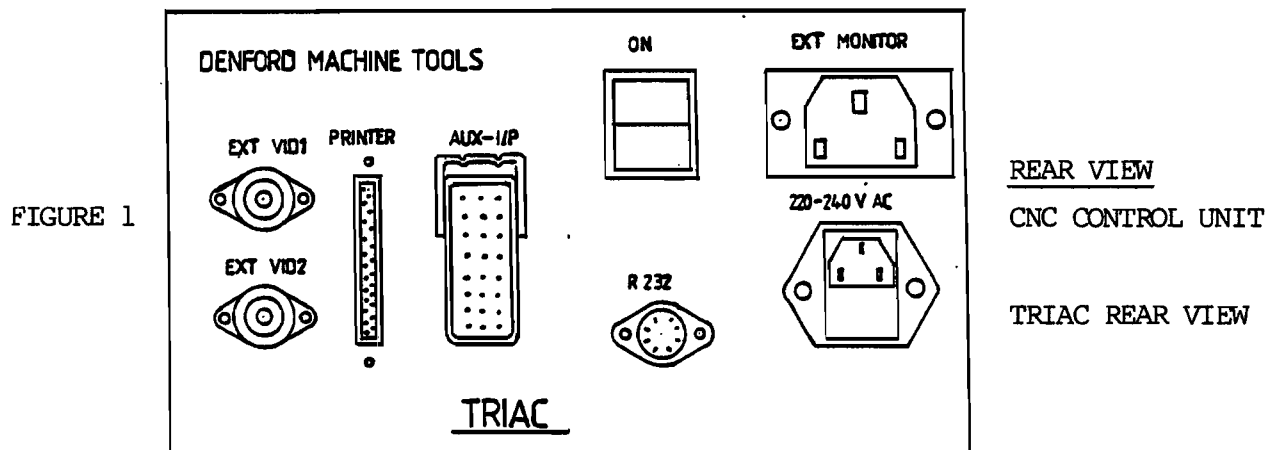
The VDU will prompt the user to press ⟨ABS DATUM⟩ to datum the machine.

2. Unlock the emergency stop button on front panel.

3. Depress the square green drives on button for power to axis drive motors and spindle motor.

4. Depress ⟨ABS DATUM⟩
    This drives Z, Y and X respectively to machine limit, the maximum movement on each axis. The control has built in machine limits from this position. The parameters of working area are defined X290, Y170 and Z235.
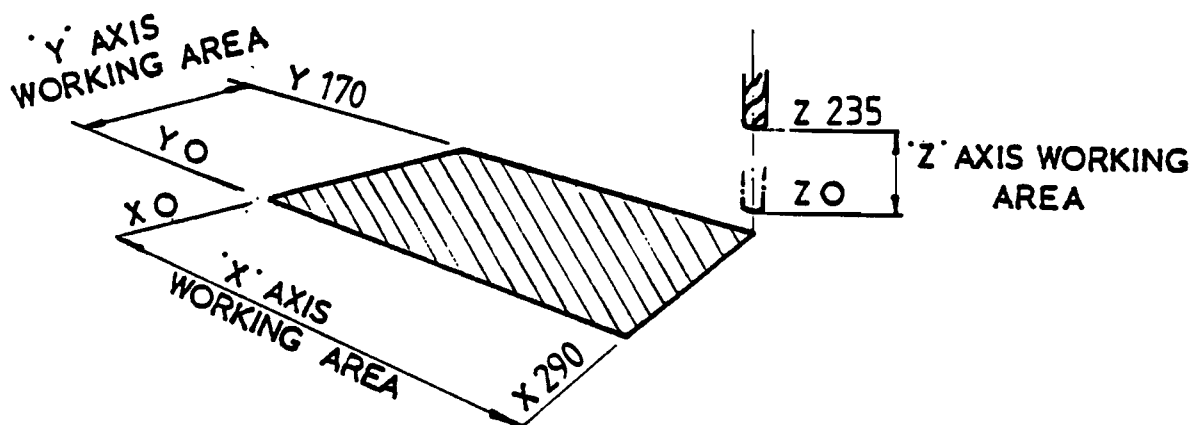
Working Area for Each Axis

290 mm for X,

170 mm for Y,

235 mm for Z.

For a manual move to drive X and Y to zero dimension depress keys
<u>G01</u> <u>ENTER</u> <u>X0</u> <u>ENTER</u> <u>Y0</u> <u>ENTER</u> <u>F1000</u> <u>ENTER</u> <u>EOB</u>.

G01   = Linear interpolation

X0   = Machine fixed datum position for X

Y0   = Machine fixed datum position for Y

ENTER = Enter data into control

F1000 = Feed rate 1000 mm/min

EOB   = End of block. When in MDI mode this key executes the command

THE TOOL IS AT THIS POSITON

MOVEMENTS AND ASSOCIATED FEED INPUT
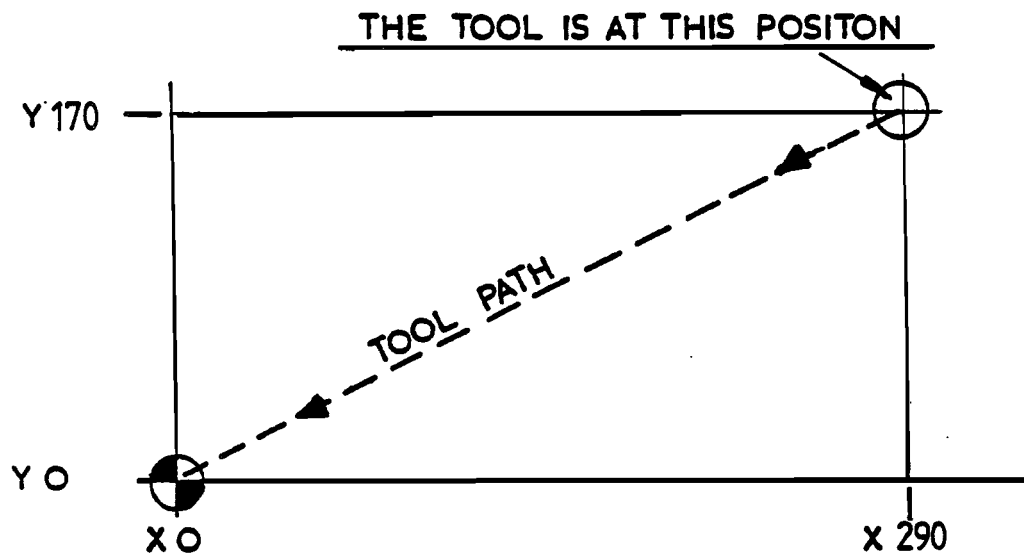
A movement in one or more axes can be input by pressing the desired axis key followed by the required dimensions. These co-ordinate dimensions and associated FEEDS may be input either as a single block of data which is to be executed immediately or as blocks of data which forms part of a programmed sequence.

Before co-ordinate dimensions keyed into the TRIAC are executed a check is made to ensure that the machine parameters are not exceeded, should this be the case a warning message is displayed. RESET restores normal operation.

The required FEED is keyed in as millimetres per minute or inches per minute.

If no feed is programmed the default feed of 234 mm/min is assumed.

MANUAL MOVE IN ABSOLUTE MODE FROM MACHINE FIXED DATUM

P2
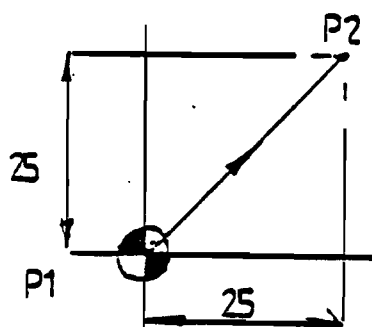
P_1 = machine fixed datum

P_2 = A point X25 and Y25 from origin

A manual move from P_1 to P_2 at

150 mm/min

25

P1   25   Proceed as follows:-

Press keys X25 ENTER Y25 ENTER F150 ENTER EOB

P3

P2

35 25
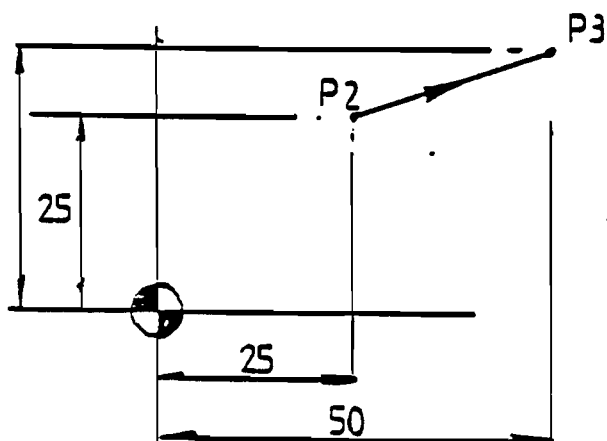
A manual move from P_2 to P_3 at

500 mm/min

Press keys X50 ENTER Y35 ENTER F500 ENTER EOB

25

50

* NOTE: X and Y manual data entries are always co-ordinates from the machine fixed datum, therefore X and Y data entries are always in the positive quadrant and any negative dimension would be outside machine limits.

CIRCULAR INTERPOLATION
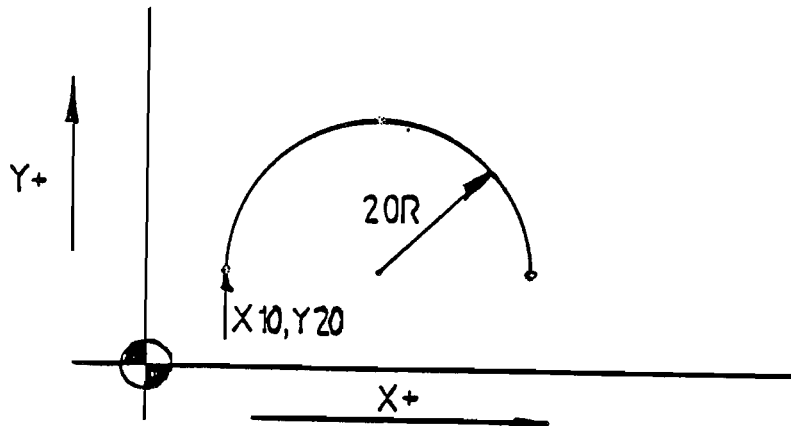
Absolute

1. G01 ENTER X10 ENTER Y20 ENTER F250 ENTER EOB
2. G02 ENTER X30 ENTER Y40 ENTER F150 ENTER CW/CCW ENTER 30 ENTER 20 ENTER EOB
3. G02 ENTER X50 ENTER Y20 ENTER F150 ENTER CW/CCW ENTER 30 ENTER 20 ENTER EOB

Incremental

1. G01 ENTER X10 ENTER Y20 ENTER F250 ENTER EOB
2. G02 ENTER X20 ENTER Y20 ENTER F150 ENTER CW/CCW ENTER 20 ENTER 0 ENTER EOB
3. G02 ENTER X20 ENTER Y-20 ENTER F150 ENTER CW/CCW ENTER 0 ENTER - 20 ENTER EOB

CIRCULAR INTERPOLATION BY ANGLE

CIRCULAR MOVEMENTS

Circular movements for X and Y axes are defined by using G02 for clockwise or G03 for counter-clockwise and are limited to quadrant boundaries OR, by using CW/CCW key, alternative depression of the key changes the code from clockwise to counter-clockwise. Define the end points of the circular movement. Press CW/CCW key and input the circle centre origin co-ordinates (XC and YC).

If you are programming in absolute mode the circle centre origin is the measured distance from the program datum to the circle centre. Alternatively, if you are programming in incremental the + OR - of the circle centre dimension is determined by the incremental distance from start point to arc centre.

When a circular block is to be entered, G02 for clockwise or G03 counter-clockwise. Enter G02 OR G03 and the code is given on the screen, depress the enter key to continue. The program block grid will then appear on the screen and input can commence.

Enter first the end points, X and Y and a feedrate. To input the circle centre origin, about which the circular movement is to act, press CW/CCW key, the prompt will then request the input of circular centre XC and YC. When complete, the EOB key is used to signify the end of input for that block.

If incorrect or impossible end points are programmed, the control will respond with error in circle centre OR, during operation, the table will move continuously in a circle attempting to find the programmed end point. The movement may be stopped by depressing PROG STOP key or red stop button.

NOTE: When calculating end points and circle centres these must be accurate to ∓0.003 mm. Make sure that the radius at the start is equal to the radius at the end point. Circle centres can be established outside machine limits, although the start point and end points must be within the machine limits.

'X' END POINT

'Y' END POINT

P 2

P I

YC

XC

INCREMENTAL

X & Y END POINT

YC

XC

44
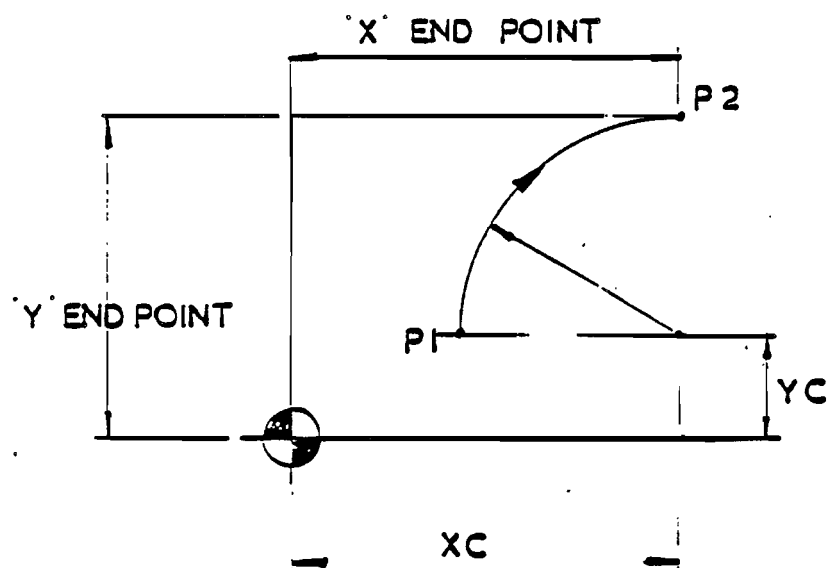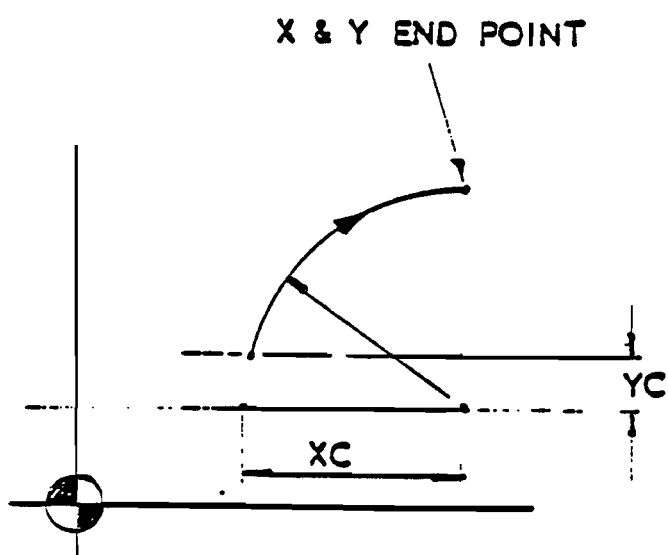
This facility enables the user to input circular moves by specifying the angle. The angle is specified within a circular block after the direction has been defined using the CLW or CCLW keys, the arc can be input by using the same keys, this is indicated by "ARC" being prompted in place of the "X" and "Y". The angle of the arc ·is used by the controller to define the end point of the circle movement relative to the previous X and Y co-ordinates. Pressing CLW or CCLW will then allow the input of the circle centre co-ordinates.

NB. As this is only a keyboard input facility the circular movements calculated are stored as normal clockwise or counter clockwise moves. The arc input can be up to 360 degrees, therefore up to 5 circular moves can be calculated in one input. This facility is only available within a programmed sequence.

EXAMPLE
G01 X80 Y80
G02 ARC 72 XC10 YC80
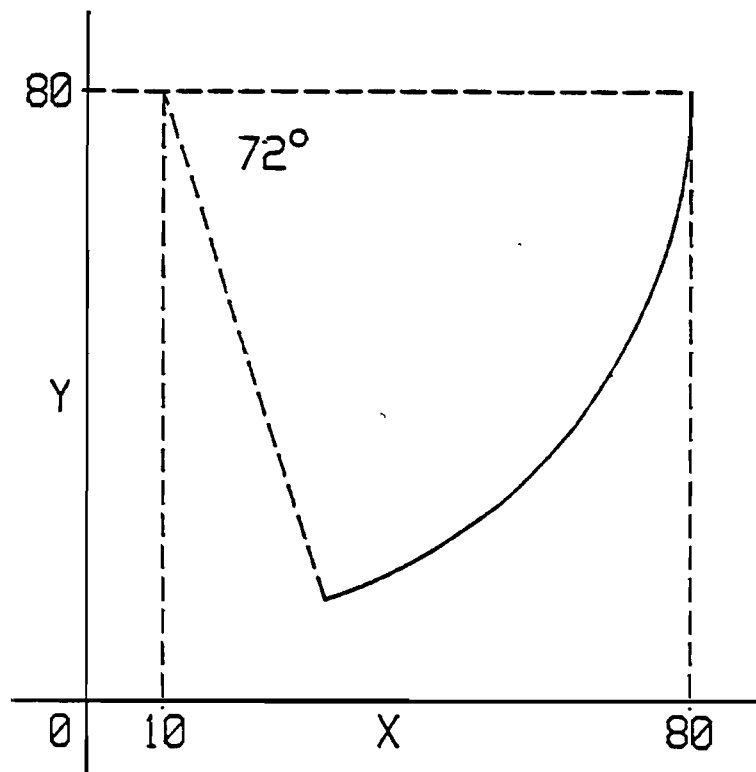
COMPLETE CIRCLE PROGRAMMING

Full circle programming can be accomplished on TRIAC by using the arc by angle facility.

In the example below only the start of the arc, the angle (360°) and centre point is specified. The four quadrant blocks are calculated automatically by the machine.
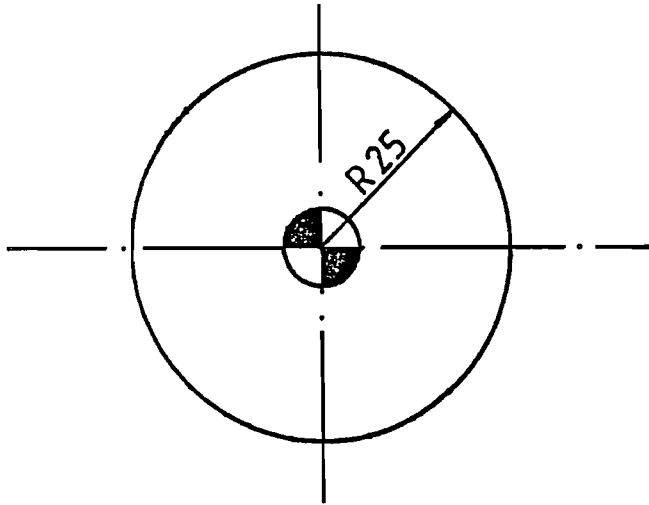
1. M06   TOOL 1
2. M03   1500 RPM
3. G00   X0   Y25   Z2
4. G01   Z-1   F50
5. G02   ARC 360°
          XC0   YC0
6. G00   Z2
   M02

NOTE! Should the above procedure be edited into a progrma any existing repeat facilities will have to be manually renumbered due to the inclusion of the extra program blocks.

THE RESULTING PROGRAM IS SHOWN BELOW

1. M06   TOOL 1
2. M03   1500 RPM
3. G00   X0   Y25   Z2
4. G01   Z-1   F50
5. G02   X25   Y0
          XC0   YC0
6. G02   X0   Y-25
          XC0   YC0
7. G02   X-25 Y0
          XC0   YC0
8. G02   X0   Y25
          XC0   YC0
   M02

G02 CLOCKWISE
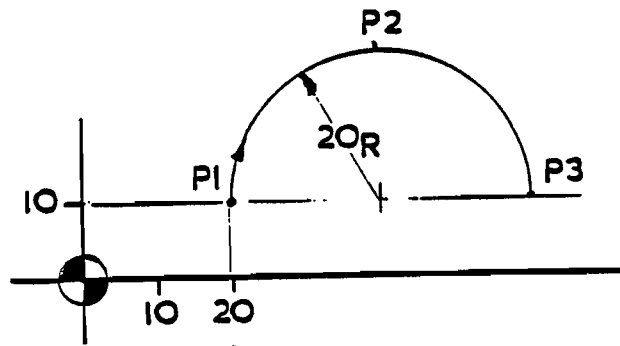
Absolute

P1 = G01 X20 Y10 F500

P2 = G02 X40 Y30 F150 CW/CCW XC40 YC10

P3 = G02 X60 Y10 F150 CW/CCW XC40 YC10

Incremental (Control will allow incremental input, executes and displays in absolute format.)

P1 = G01 X20 Y10 F500

P2 = G02 X20 Y20 F150 CW/CCW XC20 YC0

P2 = G02 X20 Y-20 F150 CW/CCW XC0 YC-20
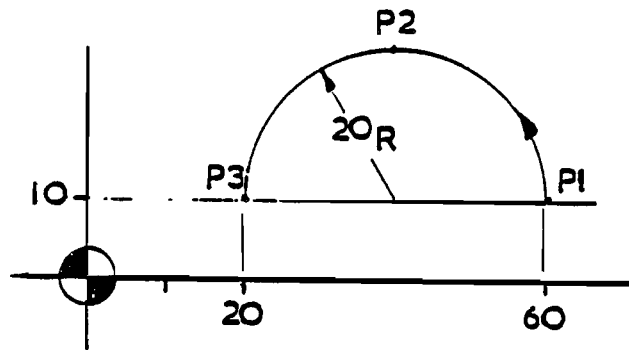
Absolute

P1 = G01 X60 Y10 F500

P2 = G03 X40 Y30 F150 CW/CCW XC40 YC10

P3 = G03 X20 Y10 F150 CW/CCW XC40 YC10

Incremental

P1 = G01 X60 Y10 F500

P2 = G03 X-20 Y20 F150 CW/CCW XC-20 YC0

P3 = G03 X-20 Y-20 F150 CW/CCW XC0 YC-20

48
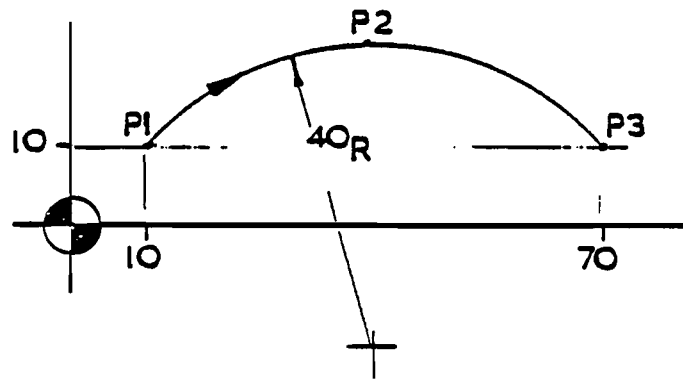
Absolute

P1 = G01 X10 Y10 F500

P2 = G02 X40 Y23.542 F150 CW/CCW XC40 YC-16.457

P3 = G02 X70 Y10 F150 CW/CCW XC40 YC-16.457

Incremental

P1 = G01 X10 Y10 F500

P2 = G02 X30 Y13.542 F150 CW/CCW XC30 YC-26.457

P3 = G02 X30 Y-13.542 F150 CW/CCW XC0 YC-40

49

equal to the radius at the end point to an accuracy of ±0.5 motor steps (ie, ±0.003125 mm). Programmers who are involved in writing post-processors for the PNC 3 are particularly advised to be aware of this fact.

SETTING AN ABSOLUTE ZERO

G55 machine offset is only permitted <u>outside</u> a program load mode. A machine offset offsets the program in memory and does not affect manual data moves.

To set a zero or datum from the component the user must enter the machine offset G55 required for the zero position. These values can be taken from the digital readout on the screen.

Assuming a component 150 long x 75 wide requires a datum from the bottom left hand corner.
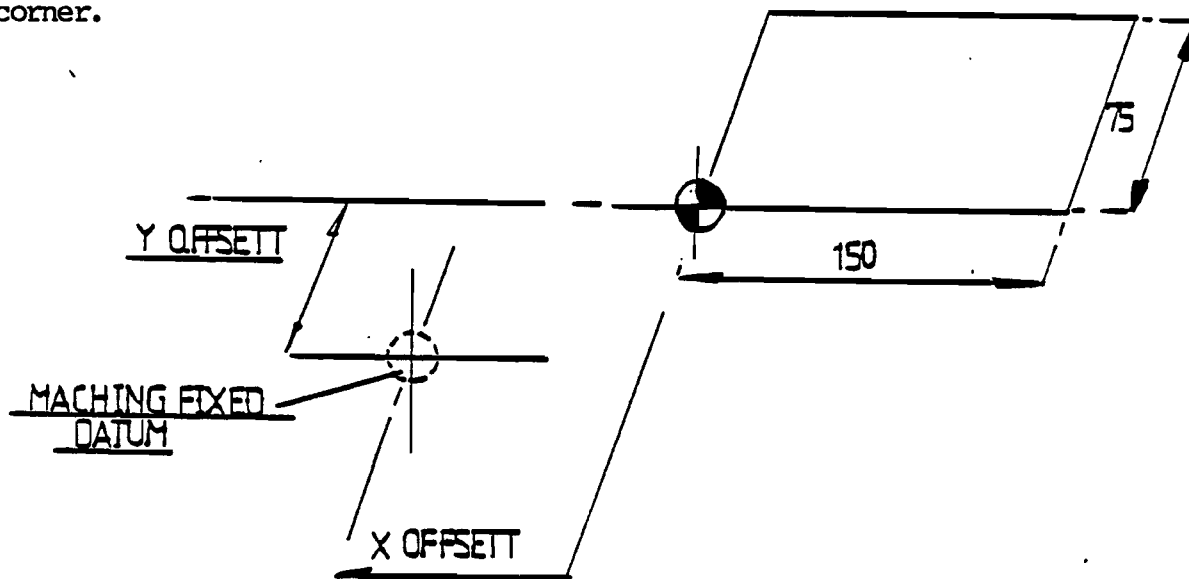
With a test bar, wobble bar or setting probe in the spindle, use the axis jog keys to align the test bar against one edge of the component. Assuming the left hand edge on the Y axis after completion of this procedure. Note the reading on the digital readout for X axis. Add the radius of the test bar to the dimension. Record this new dimension as the offset value required to set X zero. Enter this dimension into the control as G55 X offset.
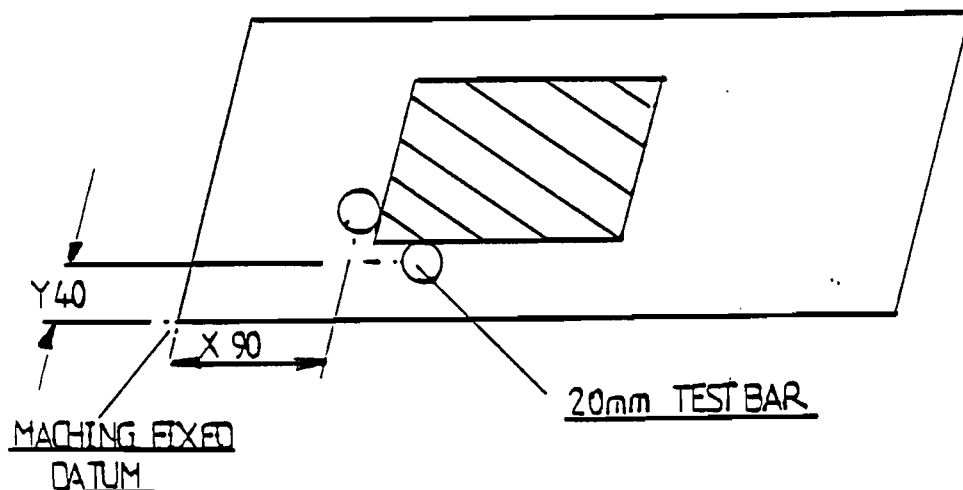
Example using 20 mm diameter test bar.

Reading taken from digital readout:-

      X axis readout value = X90 +

      Radius test bar   =   <u>10</u>

      Offset for X   = X100

Enter offset into the control for X.

Press <u>G55</u> <u>ENTER</u> <u>X100</u> <u>ENTER</u> <u>EOB</u>

Repeat this procedure for Y offset.

Align the test bar against the front edge on the component, take the reading from digital readout for Y axis, add the radius of the test bar to this dimension as the offset value requires for Y zero.

      <u>Example</u>

      Y readout value   = Y40

      Radius test bar   = <u>10</u>

                          Y50

Enter the offset into the control for Y.

Press <u>G55</u> <u>ENTER</u> <u>Y40</u> <u>ENTER</u> <u>EOB</u>

The offsets G55, X100, Y50 are the values required to set a zero or absolute datum relative to the component.

<u>NOTE</u>: G55 machine offsets must be entered into the control <u>after</u> the program is loaded into memory. When entering a new program all previous G55 machine offsets are reset to zero.

      G55 machine offsets only affect the program in memory. All manual data entries are calculated and executed from machine fixed zero.

      A G55 value will not be saved on cassette with the program in memory.

FIXED M/C DATUM

50

Y O

X O

100

NEW DATUM
POSITION :–
G55   X100 , Y50

NEW PROGRAM PARAMETERS

DEFINE WORKING AREA

Y 170

Y WORKING AREA

Y +120

Y+

X–   X+   Y O

Y 50

Y –50

Y–

Y O

FIXED
M/C DATUM   X O   X 290

X –100   X+190

X WORKING AREA

G98 ABSOLUTE DATUM/MACHINE REFERENCE POINT

An absolute datum block G98 can be programmed to cause the control to seek its machine reference point for each axis in turn, (ie, the maximum parameter for each axis.)   This is executed at a predetermined feedrate and cannot be increased via feedrate override.

G98 ABSOLUTE DATUM
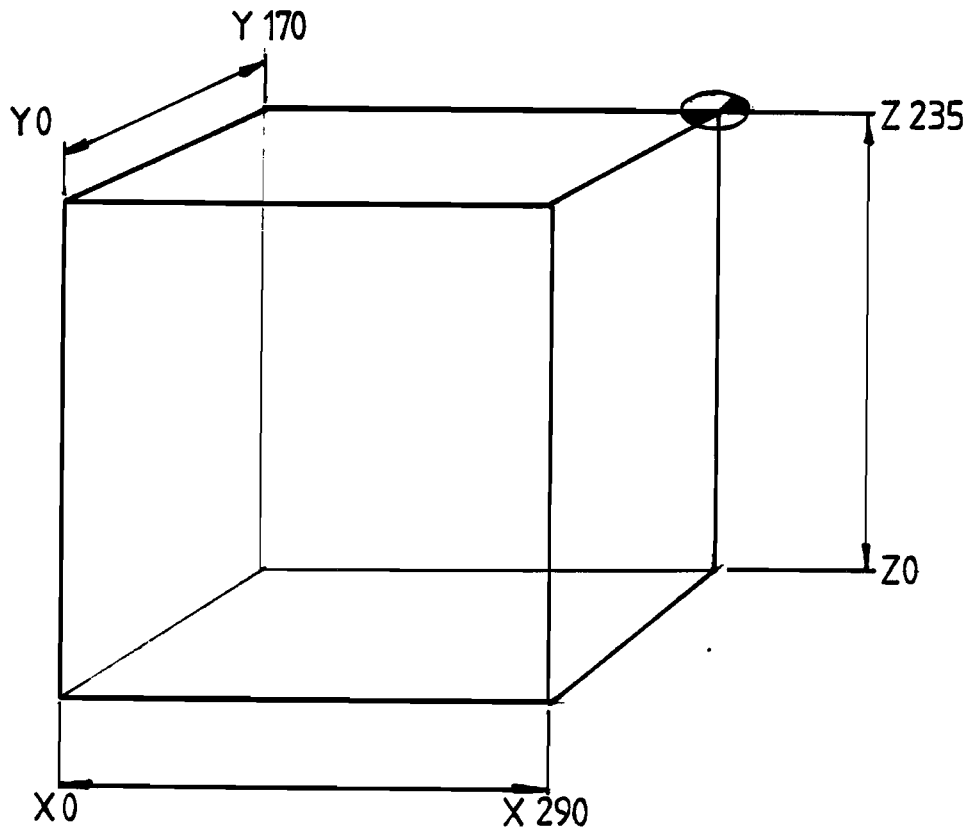
PROGRAMMABLE WORKING AREA

Pressing the zero key during a program load sequence will select a G98 absolute datum block to be entered.   At this point in the program the machine will return to its absolute Datum X290 Y170 Z235.

SECTION 19

CANNED CYCLES FACILITY

The canned cycle facilities are only available within a programmed sequence. The following canned cycles are available on this controller.

G79	RE-ENABLE CYCLE	G82	CIRCULAR CYCLE
G80	DE-ACTIVATE CYCLE	G83	DRILLING CYCLE
		G84	RECT-LAR CYCLE

IMPORTANT NOTES CONCERNING CANNED CYCLES

The canned cycle is centred around the position specified by its previous X and Y axes co-ordinates. The depth of the pocket is incrementally negative from the Z axis co-ordinate prior to the canned cycle block.

Cutter compensation is automatically used in the circular and rectangular cycles. When the cycles are executed the current tool offsets are used. If the tool diameter has not been set an error will be given.

Once entered a canned cycle remains active until it is shut off with a G80 DE-ACTIVATE CYCLE or another canned cycle is entered. Only one canned cycle can be active at a time when a canned cycle is cancelled by the G80 DE-ACTIVATE CYCLE it remains in storage so that it can be re-activated by a G79 RE-ENABLE CYCLE.

CIRCULAR CYCLE

The data required to specify a circular cycle is:-

1. The radius of the circular pocket.
2. The feed rate of the X and Y axes when in cycle.
3. The total depth of the pocket.
4. The feed rate of the Z axis when in cycle.
5. The number of cycles in which to reach the specified depth of the pocket.

RECTANGULAR CYCLE

The data required to specify a rectangular cycle is:-

1. The length of the pocket along the X axis.
2. The length of the pocket along the Y axis.

3. The feed rate of the X and Y axes when in cycle.

4. The total depth of the pocket.

5. The feed rate of the Z axis when in cycle.

6. The number of cycles in which to reach the specified depth of the pocket.

DRILLING CYCLE

The data required to specify a drilling cycle is:-

1. The total depth of the hole.

2. The feed rate of the Z axis when in cycle.

3. The number of cycles to reach the total depth.

G82 CIRCULAR CYCLE

— · — · — · — CUTTER PATH

RADIUS

DEPTH
CYCLE

DEPTH

G84 RECT-LAR CYCLE

Y SIDE
LENGTH

X SIDE LENGTH

DEPTH
CYCLE

DEPTH
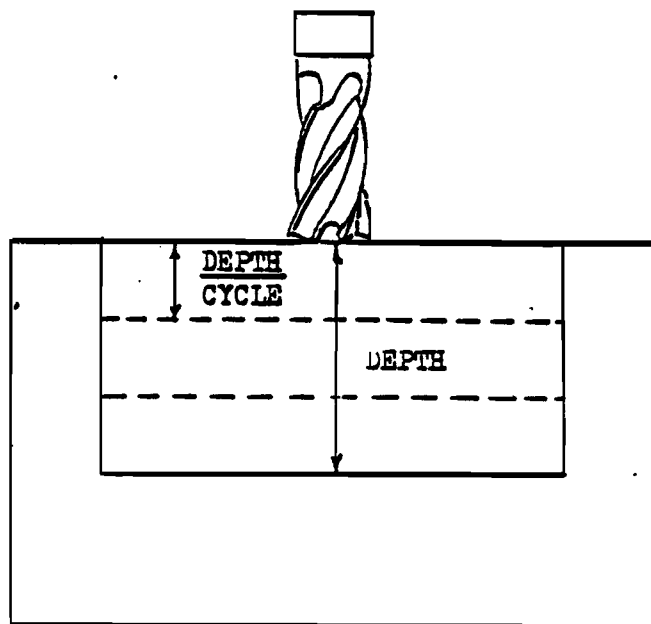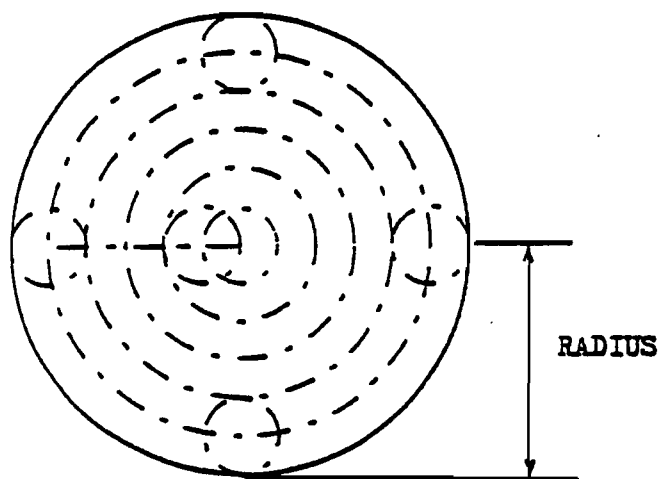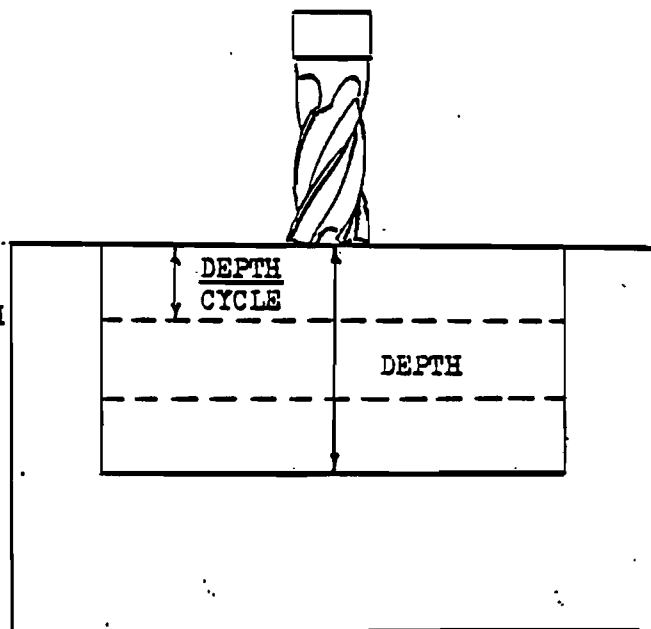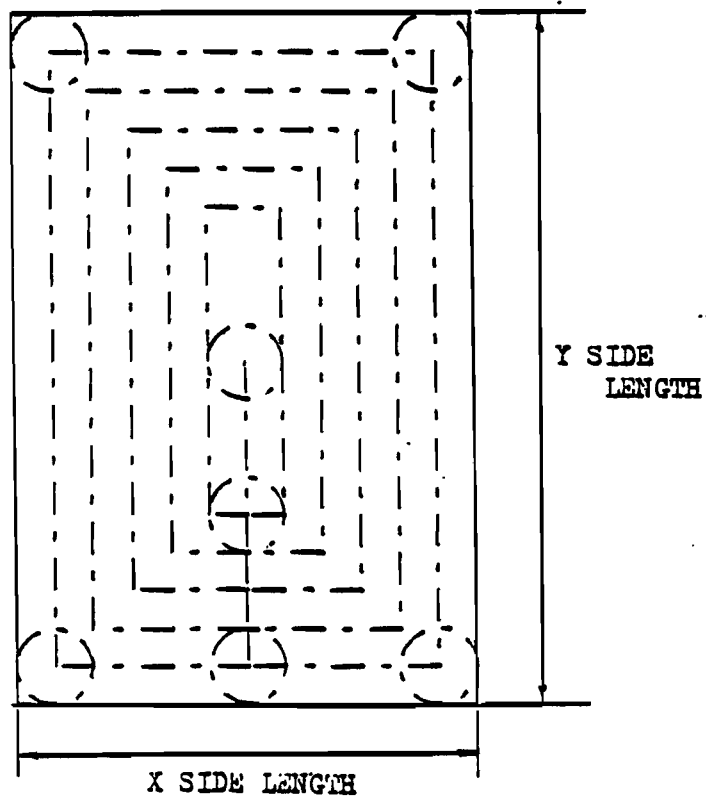
- - - - → RAPID RATE

———————→ FEED RATE

DEPTH
CYCLE

DEPTH
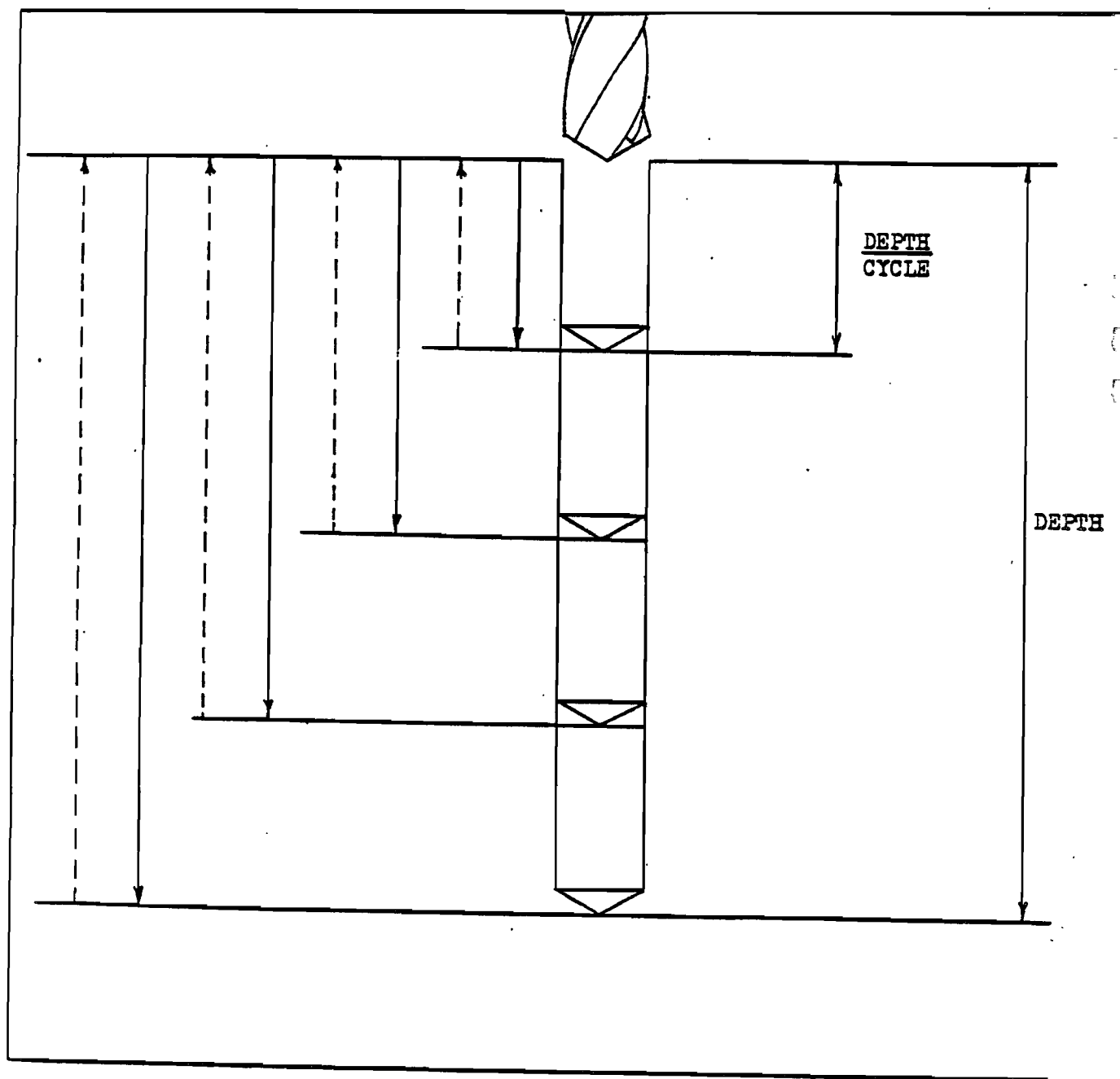
FLOAT DATUM G99

Float datum is only permitted as part of program load sequence.

Float datum allows the programmer to set up a secondary datum within the program. A float datum block will establish a datum position with both X and Y axes set to zero about its current position. All subsequent blocks will be relative to this datum position. The digital readout will be relative to this datum position. If G55 machine offsets are zero Z0 tool length offsets will also be relative to this datum position.

NOTE: G99 float datum will only affect X and Y axes.

Assuming the previous block X50, Y50, Z3, position is followed by G99 float datum block. Then the X and Y axes are set to zero about that position. Calling up a float datum will deactivate cutter compensation.

MILL AROUND PROFILE
3mm DEEP

Z0 FOR TOOL 1=TOP OF
WORK SURFACE

FLOAT DATUM POINT

1. M06 1	16. G00 X30 Y25
2. M03 1000	17. G99
3. G00 X30 Y10 Z3	18. G00 X0 Y10
4. G41	19. G42
5. G00 X30 Y10	20. G00 X10 Y10
6. G01 Z-3 F60	21. G01 Z-6 F60
7. G01 X10 F100	22. G2 X10 Y0 F100 XC0 YC0
8. G01 Y30	23. G2 X10 Y-10 XC0 YC0
9. G01 X20 Y40	24. G2 X-10 Y0 XC0 YC0
10. G01 X40	25. G2 X0 Y10 XC0 YC0
11. G01 X50 Y30	26. G00 Z0
12. G01 Y10	27. G40
13. G01 X25	28. G00 X-30 Y-25
14. G00 Z3	29. M05
15. G40	M02

TOOL LENGTH OFFSETS

Tool length offsets are described as a measured distance from the machine fixed zero to a plane at which the part is programmed, usually the top of the workpiece.

The ability exists to use several tools with independant lengths in one program. To program the Z axis we must know where the tip of the tool is at all times. This is done by the program loading up tool number and using the tool length offsets stored in the tool library. The control automatically adds or subracts the tool length and places the tool point at the desired location.

If a move Z-3 is programmed using tool 1 the tool moves -3 from Z0.

Similarly if a move Z6 is programmed the tool moves +6 from Z0.

This feature eliminates the need for preset tooling, each tool offset may be measured on the machine.

SETTING AND RECORDING THE TOOL LENGTHS

Put the longest tool in the spindle and move the head to a retract plane above the work surface, usually a position of maximum dimension.

To set a Z0 for tool 1 where Z0 = top of the worksurface:

    1. depress T key.

    Displays a tool setting menu:-

        1. display and edit tool offsets,

        2. set tool offset,

        3. change current tool.

    Choose mode 2 from the menu (set tool offset).

The VDU will prompt the user to enter the number of the tool to be set.

When the number is entered the current offsets for that tool will be displayed and the prompt will change to ⟨ PRESS ENTER ⟩ to fix offset. Using the axis JOG keys advance the tool until it just touches the surface of the workpiece. Pressing the ⟨ ENTER ⟩ key causes the actual Z position of the tool to be loaded as the Z offset for that tool, and consequently the Z axis digital readout, changes to ZERO for Z axis.

The prompt will now change to "ENTER tool offset changes D" and the user can enter the current tool diameter. The tool diameter cannot be less than ZERO, and if the user tries to enter a negative diameter then the control automatically sets the diameter offset to ZERO. When the diameter has been entered, the prompt will change to "Press <EOB> " to accept data. When <EOB> is pressed the control exits from the toolsetting mode.

Follow this sequence for each tool.

Reset returns to the previous menu.

For example, if Z offset for tool 1 = 60 then the parameters of movement for that tool are:-

        Z+175 to Z-60 = 235 mm movement on the head.

TOOL 1 10 MM DRILL

TOOL 1 -Z 50

MACHINE FIXED Z ZERO

235 TRAVEL

Z 235

Z 50

Z 25

Z O

WORK SURFACE

Z O   FOR TOOL 1

Z-25

COMPONENT

WORK TABLE

Z 235

Z 60

Z 48

Z 30

Z O

+ 10
– 60
TOOL
1

TOOL
2

TOOL
3

TOOL
4

Z 57
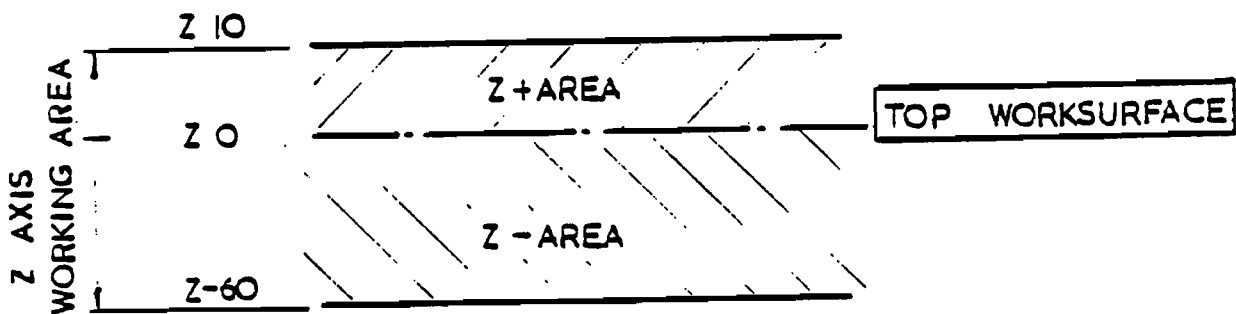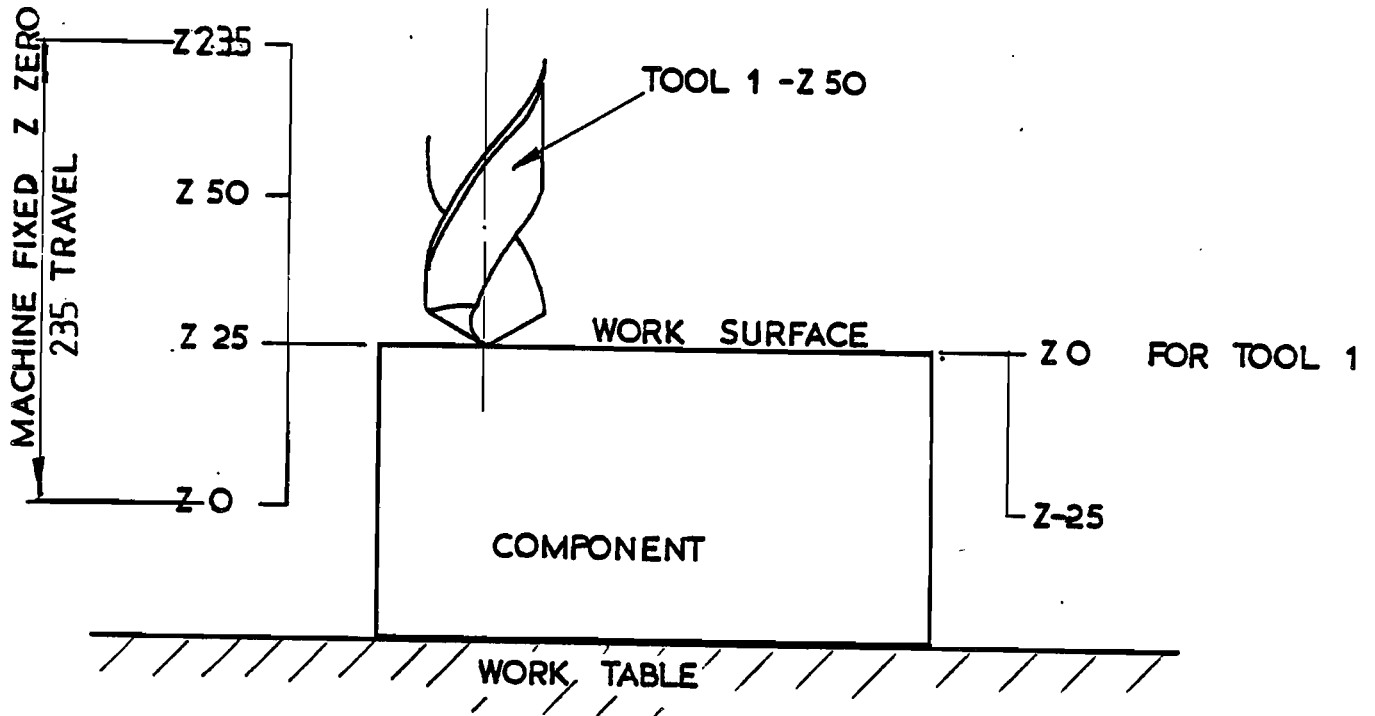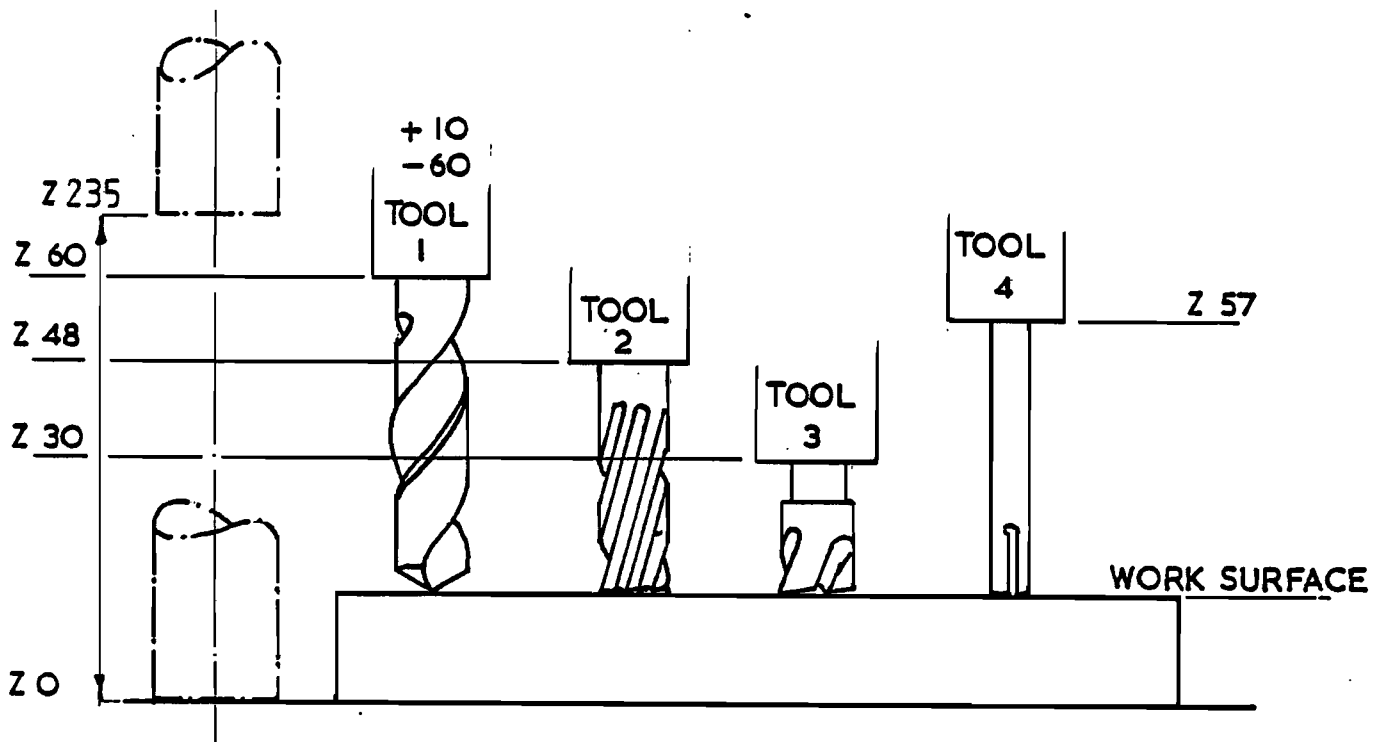
WORK SURFACE

PARAMETERS MOVEMENT FOR TOOLS SET FOR WORKSURFACE

T_1 = Z+10 POSITIVE   Z–60 NEGATIVE

T_2 = Z+22 POSITIVE   Z–48 NEGATIVE

T_3 = Z+40 POSITIVE   Z–30 NEGATIVE

T_4 = Z+13 POSITIVE   Z–57 NEGATIVE

DISPLAY AND EDIT TOOL OFFSETS

The current tool offsets can be displayed by pressing the T key followed by selection 1 from the menu. Each tool has its own length (Z) and diameter offset.

All 16 pairs of offsets will be displayed and the control will prompt the user to enter a tool number.

If the user does not want to edit any of the tool offsets, then simply pressing reset at this point will return to the previous menu.

Tool offset editing can be accomplished by entering the tool number to be edited and pressing enter.

The selected tools offset will then appear on the screen and the prompt will change to "ENTER TOOL OFFSET changes" followed by "Z" indicating the axis to be changed. Values entered at this point are <u>incremental</u> and will be added <u>OR</u> subtracted to the current offset.

If it is required to reduce the offset then a negative value must be entered. To increase the offset then a positive value must be entered.

When enter is pressed the prompt will change to "DIA" and the offset value can be changed in the same way.

Tool diameter offsets cannot be negative and if the user tries to enter an offset change value which would result in a negative diameter. The control will automatically enter a total diameter offset of ZERO.

NOTE: When a tool is edited the control also assumes that the tool is to become the current tool and the digital readout will change and display position will change accordingly.

SPINDLE SPEED CONTROL

TRIAC incorporates a variable spindle control, and the following codes can be used.

M03   Spindle Foward
M04   Spindle Reverse
M05   Spindle Stop

Additionally these features can be selected by using the dedicated spindle keys FWD, REV, OFF situated at the right hand side of the keyboard.

When FWD or REV or M03 or M04 is selected the control will prompt the user to enter a spindle speed in RPM. It will also display the allowable speed range as part of the prompt. If the user tries to execute a spindle forward block while the spindle is already turning in reverse (or vise-versa) an error message will be displayed indicating that the spindle must be stopped first. Spindle speed changed can be executed at any time providing the direction of rotation is kept the same.

Also the spindle speed override keys (marked +, -) can be used at any time to increase or decrease the spindle speed. If the + key is used to start the spindle from rest, the direction will be the same as when it was last rotating, (with a default to forward when the control is first powered up).

PROGRAMMING

ABSOLUTE/INCREMENTAL G90/G91

The mode of the machine can be altered to and from absolute and incremental by pressing the abs/inc key or stating the appropriate G code. The default condition is always absolute format. The current mode of the machine is displayed in the top right hand area of the screen, along with the current units <u>inch</u> or <u>mm</u>. In absolute mode all co-ordinates refer to absolute positions from the origin.

In incremental mode any keyed in co-ordinates are added to the previous co-ordinates or the current position, therefore it is incremental input with absolute display and execution.

During EDIT mode, the new data keyed in will be related to the data in the previous block.

ENTERING A NEW PROGRAM

TRIAC's memory will store 750 blocks of information. To enter a new program into memory depress the LOAD key.
                                                    END

The VDU will prompt the user for a program number which will be assigned to the new program. This can be any number with a maximum of six digits. Key in the new number and press enter to accept the data. The control is now set to load mode, this enables the control memory to be loaded with a series of blocks which will be executed consecutively when the program is run. To end the program load sequence, depress the LOAD key, or enter M02 which will end
                                      END
program loading.

Two different load operations are possible when the memory is loaded. Depress the LOAD key and depress enter key, the VDU will prompt the user:-
   END

    1. load memory from keyboard,

    2. continue memory load from keyboard.

1. Load is used to enter a new program into memory. Any previously loaded program is overwritten, ie destroyed.

2. Continue memory load from keyboard, enables an existing program to be continued, ie extended, and will cancel the end program code, loading will commence from the last block in memory.

Upon completion of a load or a continue memory load, the control displays the program number, how many blocks there are in memory and how much memory remains for a period of six seconds after which the control displays normal data. Any key pressed clears the memory status display.

Should too much program data be keyed into the control, such that the memory becomes full, "memory is full" is displayed and no more data can be entered. The reset key will restore normal operation.

Once EOB has been entered it is not possible to step back and update erroneous data without ending the loading sequence and calling up edit mode. (See Edit Section Page 92.)

See edit text.

REPEAT G81

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

1. The start block number to be repeated, this must be <u>linear block</u> with <u>all</u> axes defined. X, Y and Z dimension within the start block.

2. The end block number to be repeated.

3. The number of repeats required.

4. The required offset dimension, this being incremental offset for each repeat loop.

5. Feed. Entering a feed into the repeat loop will change all feeds programmed within the loop to the new feedrate.
   Omitting a feedrate value will leave all feeds as initially programmed.

Repeats may be programmed up to a nested level of four with a maximum repeat loop 99 times.

Should this level be exceeded "Nest error in repeat levels" is displayed. The reset key restores normal operation.

When each repeat is programmed the control <u>checks</u> all the dimensions being repeated, adding the programmed offset to the number of repeats to ensure that the machine limits are not exceeded. This process may take a few seconds. Should the limits be exceeded, "Move exceed machine limit" is displayed, the reset key restores normal operation and corrected data keyed in before program can continue.

Calling up a G81 repeat block will deactivate cutter compensation.

Below is the information required for a repeat block.

G81 REPEAT FROM....TO....REP....OFFSET....FEED....

    G81   - REPEAT CODE

    FROM   - START BLOCK FROM WHERE REPEATING WILL COMMENCE

    TO   - END BLOCK OF REPEAT LOOP

    REP   - ENTER THE NUMBER OF REPEATS, MAXIMUM 99

    OFFSET - ENTER X, Y OR Z INCREMENTAL OFFSET FOR EACH LOOP

    FEED   - ENTERING A FEEDRATE VALUE WILL REPLACE ALL FEEDRATES WITHIN THE
              LOOP

G20 Program Scale, does not effect the offset within the repeat loop. The offset values remain uneffected by any program scale factor active in the program.
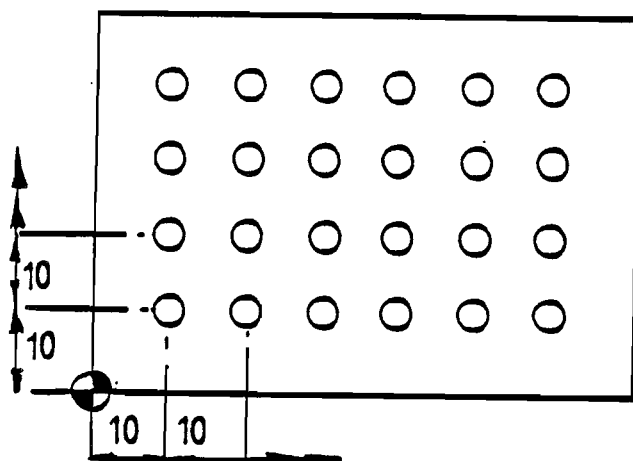
DRILL 24 HOLES
EQUI SPACED 6mm DEEP

1.   M03
2.   G00 Z3
3.   G00 X10 Y10 Z3
4.   G01   Z-6 F100
5.   G00   Z3
6.   G81 FROM 3 TO 5 REP 5 X+10
7.   G81 FROM 3 TO 6 REP 3 Y+10
8.   G00 X0 Y0
9.   M05
10. M02

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MIRROR IMAGE FACILITY

Mirror image facility is only permitted as part of a program load sequence acting upon memory.

Mirror images are defined by using the mirror key or the appropriate G code.

Depress either the respective G codes or the mirror key and the mirror menu appears on the screen:-
1. G10 mirror X,
2. G11 cancel mirror X,
3. G12 mirror Y,
4. G13 cancel mirror Y.

Mirror is only available for X and Y axes.

Calling up a mirror in the program causes the control to establish an axis of symmetry about its current position.

All succeeding blocks are reflected about this axis.

This function uses the actual position from the previous blocks as its axis of symmetry, taking into account all scaling factors and offsets including repeats.

Calling up a mirror or cancel mirror mode will deactivate cutter compensation.

EXAMPLE SHOWING MIRRORS

REPEAT TRIANGLE IN NEGATIVE QUADRANT.
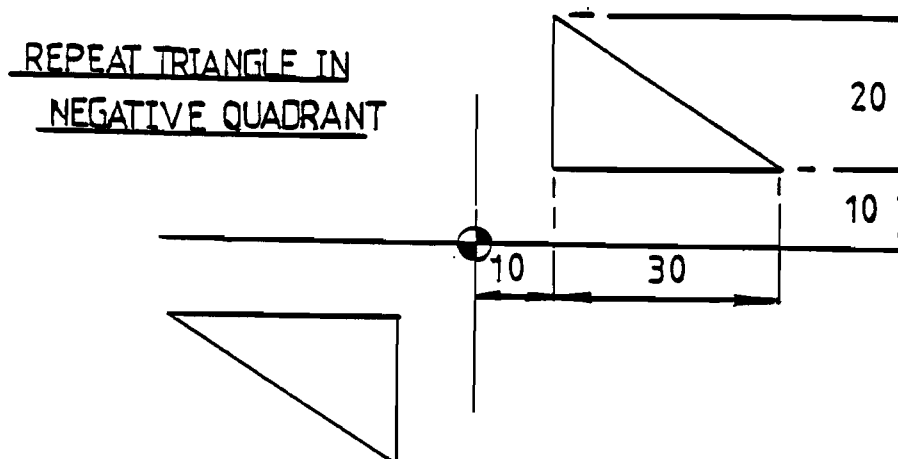
1.	G00 X0 Y0 Z3	13.	G10
2.	M03	14.	G12
3.	G00 X25 Y10 Z3	15.	G81 FROM 3 TO 12 REP 1
4.	G42	16.	M05
5.	G01 Z-3 F75	17.	G11
6.	G01 X10 F75	18.	G13
7.	G01 Y30	19.	G00 X-50 Y0
8.	G01 X40 Y10		M02
9.	G01 X23		
10.	G00 Z3		
11.	G40		
12.	G00 X0 Y0		

SCALE FACILITY

Program scale   G20

Machine scale   G21

Scale range   0.01%-650%   100% = Actual size

Program scaling can be accomplished outside of a program. This is called machine scaling G21. Or inside a program loading sequence. This is called program scale G20. Program scale and machine scale allows the user to key in a value in the range of 0.01% to 650% as a scale factor for all subsequent X and Y dimensions. Z axis dimension remain unchanged.

Its effect can be cancelled by inserting a program scale of 100%, where 100% = full size.

Machine scale G21 permitted outside program loading sequence allows the user to key in a value in the range 0.01% to 650% as a scale factor for the complete program, data is automatically scaled. Entering a new program into memory will cancel any machine scale.

NOTE: Any program scale active in the program will be further scaled by the machine scale function so dimensions can be reduced by up to 0.01%x0.01%. Example 10,000 times or increased by up to 6.5x6.5 example 42.25 times.

Program Scale does not effect the offsets within a repeat block, any offsets remain uneffected by the scale factors within the program.

RECTANGLE 60x30 mm

AREA 1 = 50%

AREA 2 = 75%
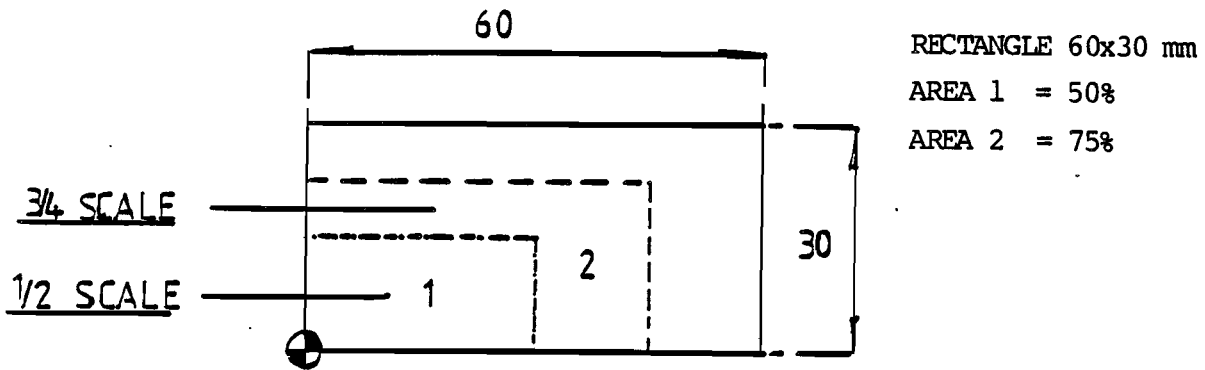
```
 1.  M03
 2.  G20 50                      PROG SCALE 50%
 3.  G00 X0  Y0  Z3
 4.  G01          Z-3 F150
 6.  G01 X60      F150
 7.  G01     Y30
 8.  G01 X0
 9.  G01     Y0
10.  G20 75                      PROG SCALE 75%
11.  G81 FROM 3 TO 9 REP 1
12.  G20 100                     PROG SCALE 100%
13.  G81 FROM 3 TO 9 REP 1
```

OFFSET FUNCTION

OFFSET FACILITY

Two offset functions are permitted, G55 is a machine offset, set outside the program and will act upon the memory allowing the start position to be established at any point within the machine limits and used to offset the entire program. This facility can be used to establish a datum on the component or used as a dry run facility. Entering a new program into memory will automatically reset any previous machine offsets, G55 to zero.

Program offset G54 can be used inside a program loading sequence to offset parts of the program and is incremental in operation.

For example, if block 1 is G54 X10 mm and block 2 is G1 X5 mm, programmed moves from block 3 onwards will be offset by a total of 15 mm. If a program offset appears as a block within a repeat loop then the offset will be added onto the total offset everytime the repeat loop is executed. Should you wish to cancel the offset, then a new offset could be inserted into the program.

If an equal value but the opposite sign, example G54 X-10 will cancel out the positive offset. Program offsets are reset to zero everytime the program is executed from the start.
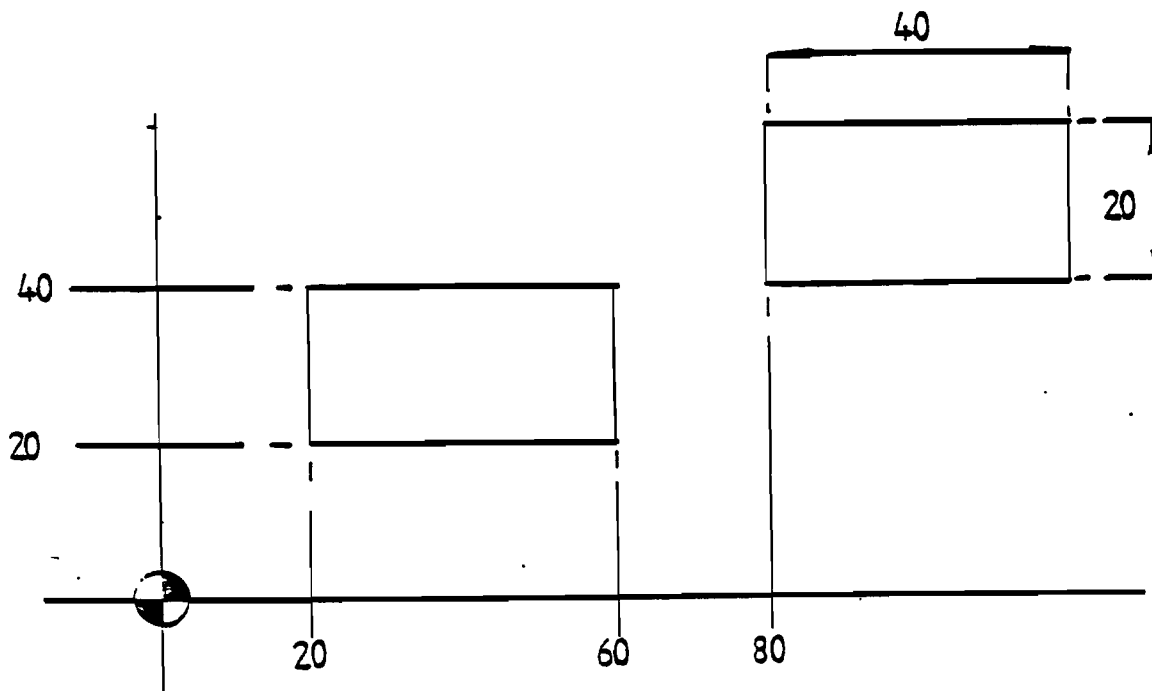
```
 1.  M03
 2.  G00 X0    Y0         Z20
 3.  G00 X20   Y20        Z3
 4.  G01                  Z-3 F150
 5.  G01 X60        F150
 6.  G01       Y40
 7.  G01 X20
 8.  G01       Y20
 9.  G00                  Z3
10.  G54 X60   Y20
11.  G81 FROM 3 TO 9 REP 1
12.  G00 X-60 Y-20        Z20
     M02
```

CUTTER DIAMETER COMPENSATION

Tool diameter compensation (or automatic cutter offset calculation) allows the control to compensate for the diameter of the current tool. This means the program need only specify the true dimension of the desired finished product. This facility is obtained by pressing the COMP key; either inside or outside a program load sequence. Alternatively the appropriate G code can be used. The control will generate a new cutter path at all times equidistant from the programmed tool path. The distance the new path is separate from the programmed path is equal to half the tool diameter. For example, if Tool 1 was set as 10 mm diameter during toolsetting. The control will generate a cutter path 5 mm equidistant from the original programmed path.

G40 - cancel cutter compensation.

G41 - Turns cutter compensation on and compensates to the left of the original cutter path in the direction the tool is moving.

G42 - Turns cutter compensation on and compensates to the right of the original tool path in the direction the tool is moving.

Examples

G 41

G 42
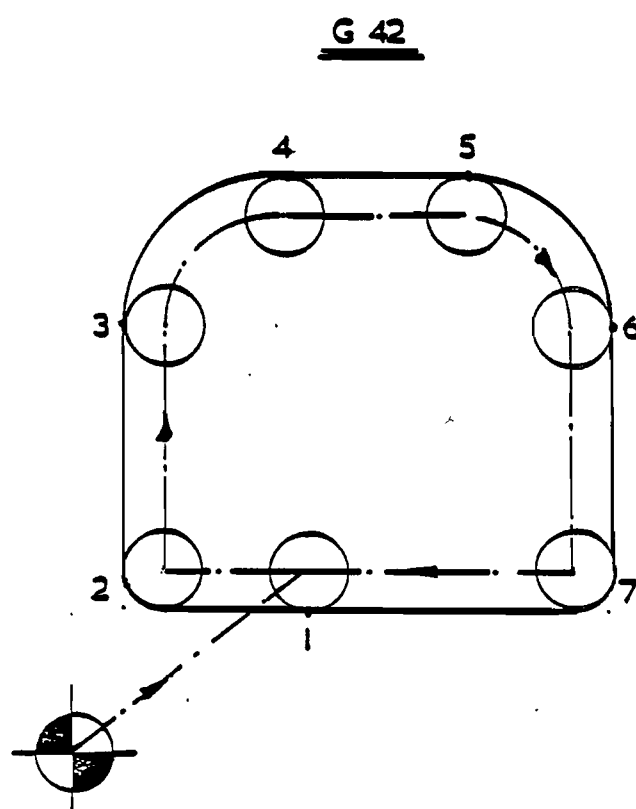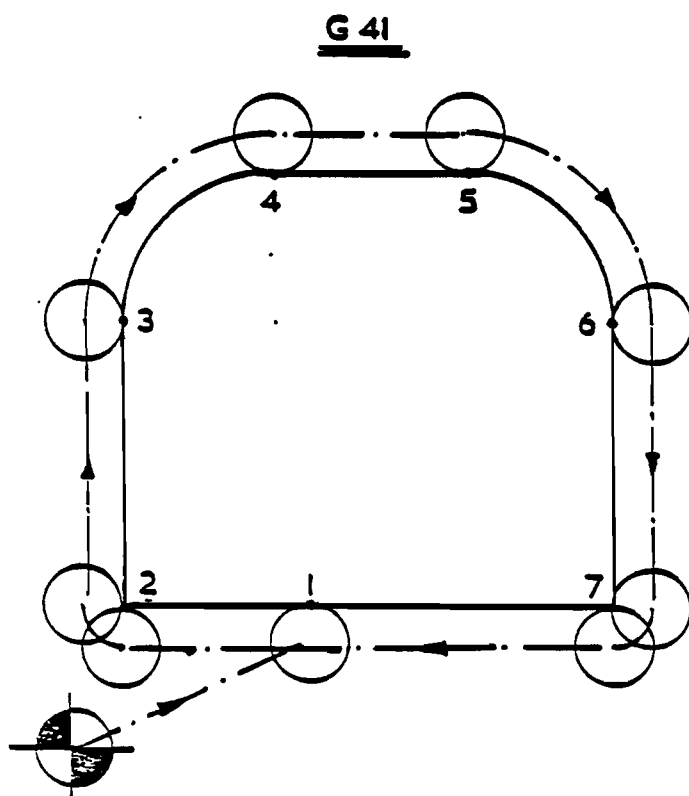
When cutter compensation is activated the control checks through the program and determines the new tool path and compensates the offset taking up a new position perpendicular to its present position. Therefore, before calling up cutter compensation in the program, the previous block must position the tool at a clearance plane above the workpiece to avoid damage to the workpiece or tool.

Consequently, before cancelling tool compensation, retract the tool clear of the workpiece to avoid damage to the workpiece when the tool offsets are deactivated.

NOTE: Do not call cutter compensation at a corner, but part way along a straight line. The action of the control on an external corner is to roll around it in an arc, creating a burr-free corner.

TOOL 1 10 MM SLOT DRILL

Z0 FOR TOOL 1 = TOP WORKSURFACE

DATUM POSITION
G55 X=100 Y=50
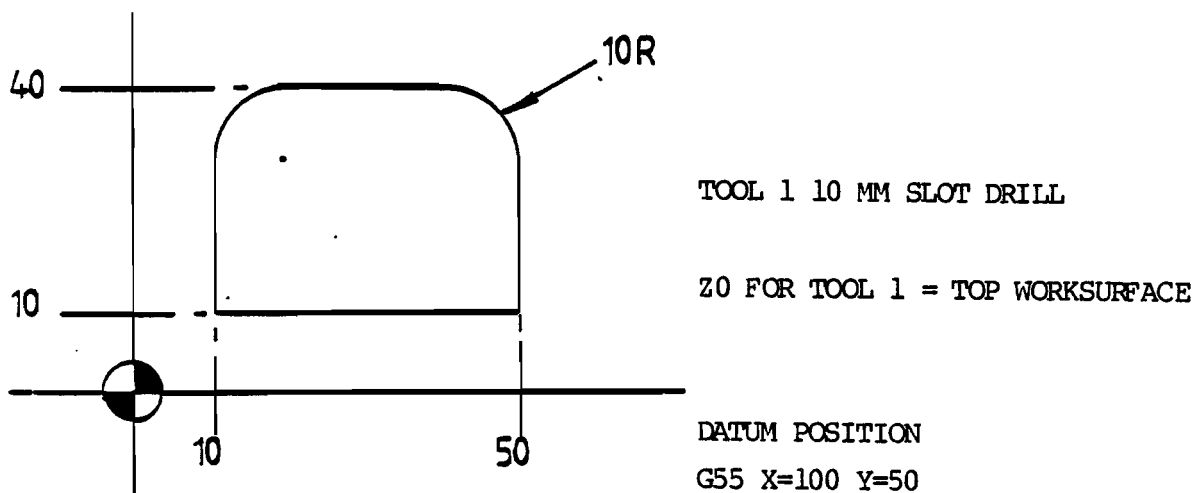
1.	M06 1			– CALL UP TOOL 1
2.	G00		Z3	– SETS T1 CLEAR OF WORKSURFACE
3.	M03 800			– SPINDLE STARTS AT 800 RPM
4.	G00 X30	Y10		– DRIVE TO POSITION ON PROFILE
5.	G41			– ACTIVATE TOOL COMPENSATION LEFT
6.	G00 X30	Y10		– STATE SAME X AND Y CO-ORDINATES SO TOOL TAKES UP COMPENSATED POSITION
7.	G01		Z-3 F50	– SINK IN THREE DEEP
8.	G01 X0	F100		– CUT TO CORNER
8.	G01	Y30		– POSITION TO START RADIUS USING PREVIOUS FEED
9.	G02 X10	Y40	XC20 YC30	– CIRCULAR INTERPOLATION
10.	G01 X40			– POSITION TO START RADIUS
11.	G02 X50	Y30	XC40 YC30	– CIRCULAR INTERPOLATION
12.	G01	Y10		– POSITION TO BOTTOM CORNER
13.	G01 X28			– POSITION WHERE MILL STARTED
14.	G00		Z3	– RESTRACT TOOL ABOVE WORKSURFACE
15.	G40			– CANCEL CUTTER COMPENSATION
16.	M05			– STOP SPINDLE
17.	G00 X-50	Y0		– TOOLCHANGE POSITION
	M02			
	G55 X150	Y60	Z0	– DATUM POSITION

EFFECTS OF CUTTER OFFSETS

In the following section all possible combinations of two adjacent blocks will be considered. For the purpose of the examples the current block will be known as block 1 moving from point P1 to point P2 and the next block will be known as block 2 moving from point P2 to point P3. The user must appreciate that in order for the TRIAC to calculate the correct offset path it must "look ahead" from its current block to the next block. In fact the PNC looks ahead until it finds a block defining an X, Y position which is different from the X, Y position in its current block. This feature allows Input and Auxiliary blocks to be effectively ignored when calculating the offset path. Note that if scaling factors, mirror imaging or repeats (or any similar function) are currently in use, the cutter offset calculations will be carried out first, acting on the raw program data and then the other functions will be performed. This is particularly important when using mirror imaging because they use the TRIAC's present X, Y position to define their axes of symmetry or point of rotation. It is necessary therefore, to deactivate cutter offsets before including the mirror imaging block. The cutter offsets can be reactivated in the normal way.

In the following examples the terms internal and external corner will be used. They are defined as follows:

External Corner - When the angle between the two blocks is greater the 180° on the side of the material being worked, ie making a left turn when working on the right hand side of the material, or making a right turn when working on the left hand side of the material.

Internal Corner - When the angle between the blocks is less than 180°, ie making a right turn when working on the right hand side of the material or making a left turn when working on the left hand side of the material.

As will be seen from the following examples, the TRIAC's action on encountering an external corner is to move around it in an arc of radius equal to the cutter radius about a centre located at point P2. During this circular motion the tool will always be in contact with point P2 thus creating a burr-free corner.
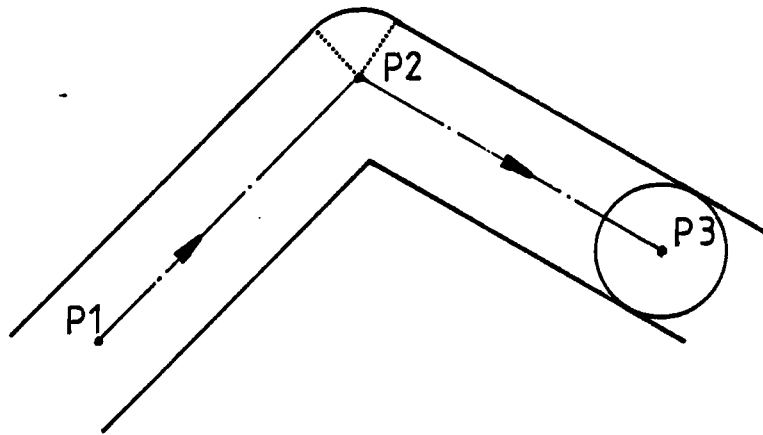
In the extreme case where block 2 actually doubles back onto itself this will always be taken as an external corner independent of whether a right hand or a left hand offset is being used.

Example
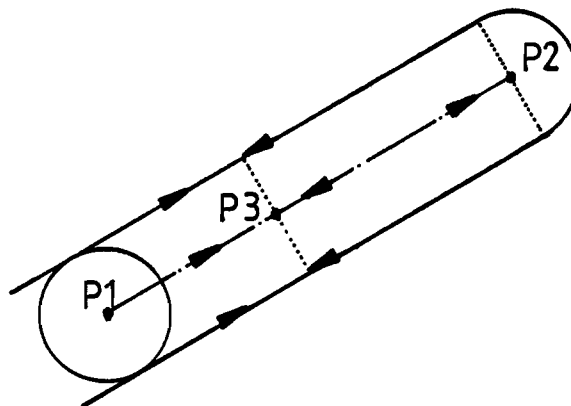
The PNC will cope with any kind of Line to Arc intersection except where no intersection is possible.

Example
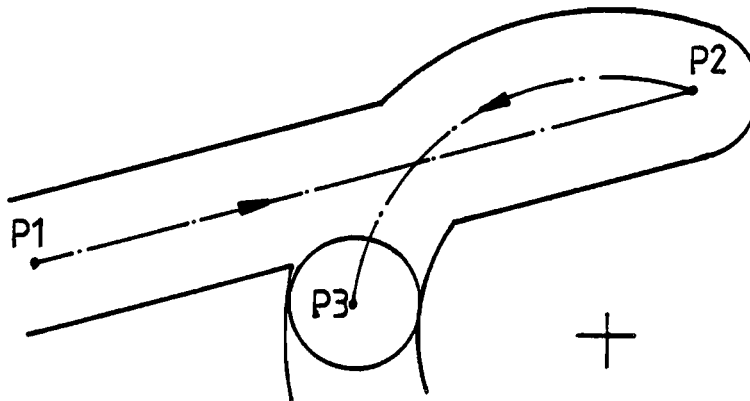
In which case there will be a pause during the calculation period, followed by an error message on the display indicating that perhaps the wrong tool diameter has been input. Note that in this case if the cutter diameter is small enough an intersection may be possible.
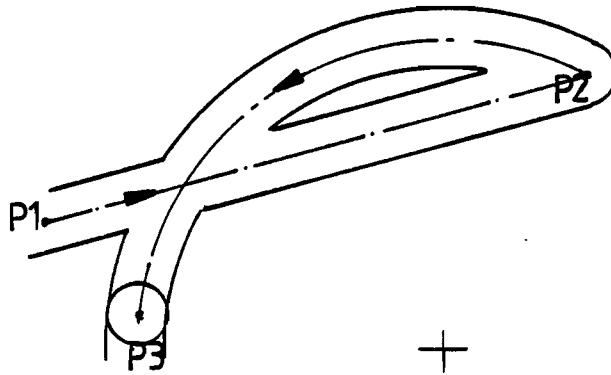
Example

Note that in both the previous examples if a right hand (or positive) offset is applied the P2 will be taken as an external corner and the following will result:
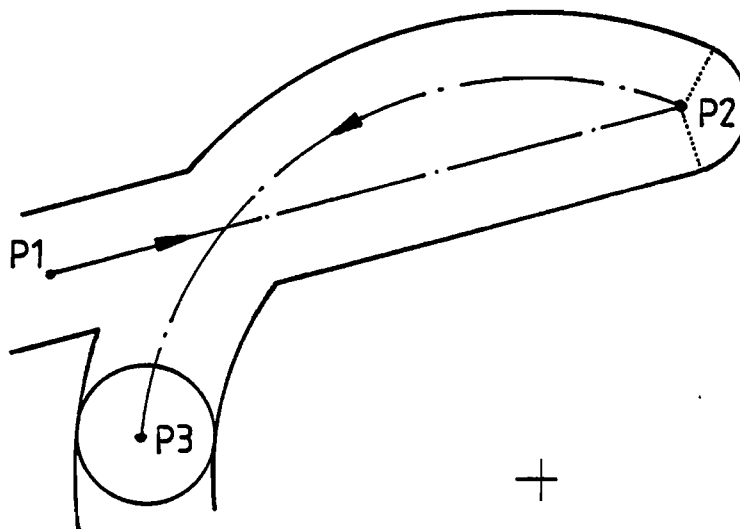
The TRIAC will cope with any kind of Arc to Arc intersection except where no intersection is possible.

Examples
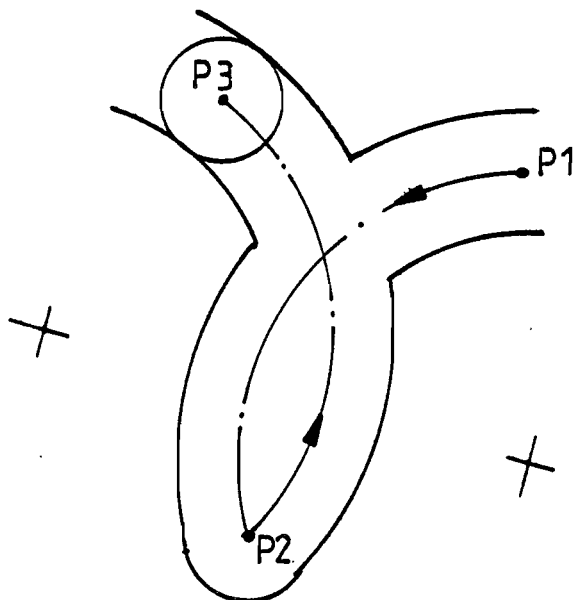
In which case there will be a pause while the PNC tries to find an intersect following by an error message on the display indicating that perhaps the wrong tool diameter has been input. Note that in this case if the cutter diameter is small enough an intersection may be possible.
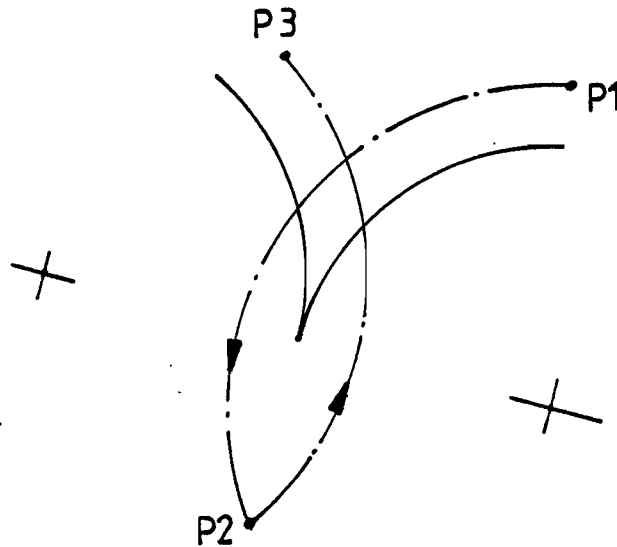
Example

Note that in both the previous examples if a right hand (or positive) offset is applied the P2 will be taken as an external corner and the following will result.
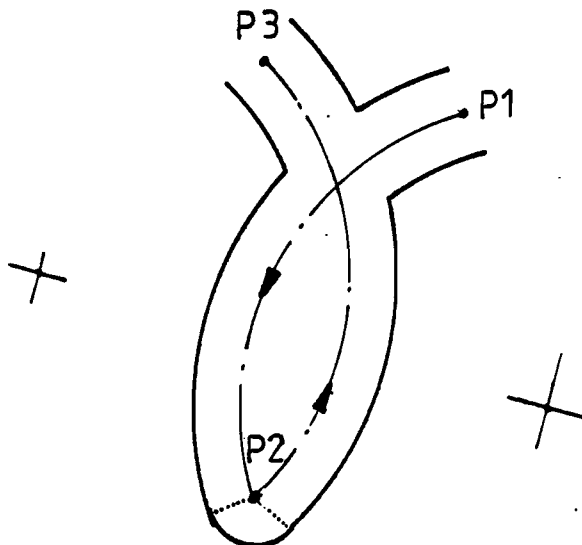
FIRST OFFSET AFTER ACTIVATION

When the cutter offset has just been activated it will take up a position perpendicular to the point P1 at a distance of the cutter radius away from it.

Example
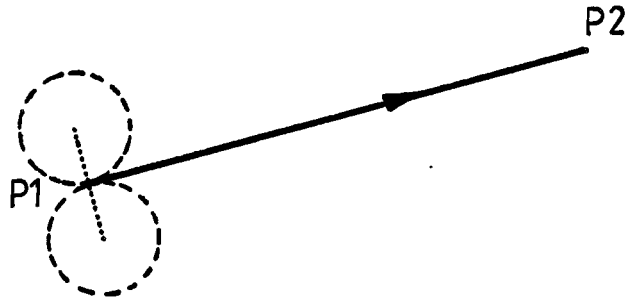
or if the line P1 to P2 is circular:-
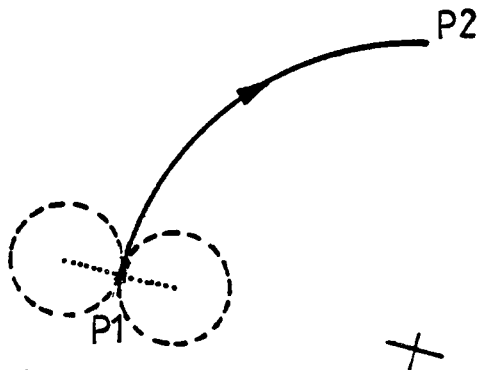
LAST OFFSET WHEN DEACTIVATED

Apart from a G40 Cancel Tool Comp block the following types of block will all deactivate the cutter offset.

M06 Tool Change

G10 Mirror X

G11 Cancel Mirror X

G12 Mirror Y

G13 Cancel Mirror Y

G20 Program Scale

G54 Program Offset

G81 Repeat Block (although the Start block of the repeat may reactivate)

G98 Absolute Datum/Machine Reference Point

G99 Floating Datum

Also the last block in any program will automatically deactive cutter offsets.

When the cutter offset has just been deactivated it will take up a position perpendicular to the point P3 at a distance of the cutter radius away from it.
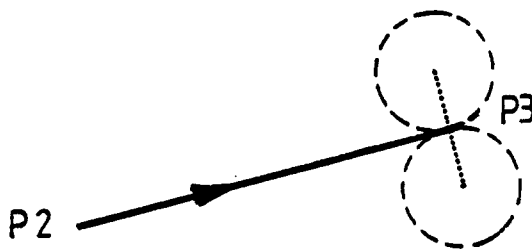
Example

or if the line P2 to P3 is circular.
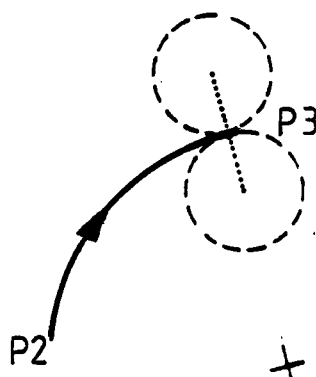
ERROR CONDITION

In addition to the condition mentioned in the examples where an intersect is called for which is impossible to calculate, the error display may result if ever the PNC calculates an offset path which moves in the opposite direction to the programmed line. This condition will only arise if the user is trying to mill out an internal corner which is tool small for the cutter diameter.

In all cases where the error display occurs, the program can be successfully re-run with a smaller diameter cutter being specified.

SECTION 32

DWELL FUNCTION

When a G04 dwell preparatory function is called up, a variable time delay from 0.1 to 9999.9 seconds can be programmed and signifies that no movement of the machine is to occur while this block is being performed.

It may be used for spot face cycle or boring cycle, example:- M03

                                                    G01 Z-20 F100

                                                    G04 2

                                                    G01 Z3   F150

In the example the tool travels 20 mm and dwells for two seconds before retracting.

G04 dwells can be programmed inside a program load sequence or outside the programmed sequence.

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EDIT FACILITY

The edit facility enables a program in memory to be edited. To select edit mode depress the <u>Edit</u> key. When edit mode is selected the user may choose to

END
display any block of data. Key in the desired block number to be edited and depress enter key. Seven edit functions are permitted in edit mode.

They are:-
1. Previous
2. Next
3. Replace
4. Delete
5. Add
6. Alter
7. Search.

During edit mode three blocks will be displayed, the current block and the two previous blocks plus the system editor, along the bottom of the screen. The selected function is performed on the bottom block.

FUNCTIONS

1. <u>Previous</u>   Depression of key 1 - Decrease the block numbers displayed by 1. Therefore each time key 1 is depressed the previous block will be displayed.

2. <u>Next</u>   Depress key 2 - Increments the block numbers displayed by 1. Therefore each time key 2 is depressed the next block will be displayed.

3. <u>Replace</u>   Depress key 3 - Replace function. The current block displayed can be replaced by a new block on the same line number. Keying in the new block and accepting the data with EOB key.

4. <u>Delete</u>   Depress key 4 - The current block displayed will be deleted from the program and all block numbers will decrease by one.
   <u>Action</u>   All blocks will automatically be renumbered but block numbers, within a repeat block G81, are not updated.

5. __Add__   Depress key 5 – Add a new block into the program. A new block will be inserted into the program on the current line number. The current block will move down one and all block numbers after the current block will automatically be renumbered.

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.

__Note__ Block numbers are automatically renumbered except those within a repeat G81 block.

6. __Alter__   Depress key 6 – To alter the current block. This allows the user to alter existing data. Alter mode cannot change the status of a block, ie G01 cannot be altered into G02. If any attempt is made to alter data that is not permitted, the system will display "use replace function", the reset key will restore normal edit mode.

Feed notes cannot be altered directly as any one of the accompanying X, Y or Z data must be keyed in first before the feed can be accepted.

7. __Search__   Depress key 7 – Block search. The system will display the number of blocks in the program. Key in the appropriate block number and depress enter and that block will be displayed.

8. __EDIT__   The __EDIT__ key will END edit mode and return to normal operation.
   __END__   __END__

TOOL PATH GRAPHICS TPG/END KEY

When you enter Tool Path Graphics mode you will notice that the two displays now show different information (the larger screen we call the Graphics display and the other the Triac display).

The Graphics display has a machine status area similar to that on the Triac display showing the status of Tool, Spindle, Auxiliaries and Inputs, also the present program number is displayed. The extra information shown on the Graphics display is the direction of view the magnification factor and the cutter path switch setting, all of which are described in this section.

Tool Path Graphics enables the program in memory to be tested prior to cutting metal. This pre-run will give full error detection, identical to that given at run time. A graphical representation of the programmed profile can be given in four views - plan, side, front and isometric also with an added feature of drawing the cutter and the cutter path.

Any point on the graphics display may be enlarged to bring out the detail of the programmed profile. When in the tool path graphics mode a copy of the graphics display may be produced on a printer.

CURSOR MOVEMENT

The graphics display has a cursor which is moved around the screen using the MANUAL keys. The position of the cursor is displayed at the bottom of the graphics screen, the axes in which the cursor position is displays is dependent upon the view, (no cursor position is given in Isometric). The cursor is also used in magnifying, for the display is magnified about the cursor position.

MAGNIFY

Magnify allows selected parts of the plotted program to be enlarged by a factor between 1 to 99. To select an area to be enlarged the cursor must be placed in the centre of this area. Then by selecting the magnify option and entering the required factor of enlargement, the screen is firstly centralized around the cursor and magnified about the centre of the display area. The loaded program is then plotted to the graphics display.

INITIALISE

Returns the cursor to the centre of the graphics display and the cutter option is turned off. The magnification factor is reset to 1, which allows all of the table area to be displayed on the graphics screen. The loaded program is then plotted to the graphics display starting from the Absolute Datum position.

VIEW

View displays a menu of viewing directions of the programmed profile:-

1. PLAN VIEW
2. SIDE VIEW
3. FRONT VIEW
4. ISOMETRIC

When an option is selected the relevant view is displayed in the machine status area of the graphics screen.

CUTTER

Cutter switches the cutter facility. When this facility is not active only the programmed profile is plotted on the screen. This is shown by a solid line when the tool is cutting (which is calculated by a -ve position in the Z axis) and a dotted line is used when the tool is not cutting.

Cutter is displayed in the machine status area, when this facility is activated. With cutter activated the program is always shown by a two pass plot. The first pass being the tool path, which is always shown by a chained line. A circle is drawn after each plot of a linear or a circular block which is to represent the cutter diameter. The plot on the second pass as described above represents the programmed profile.

CONTINUOUS

Continuous continues the program plot from the present block, each block is displayed on the Triac screen and the path is plotted on the graphics display. The plot can be stopped by pressing the ⟨ RESET ⟩ key, and restarted by either a single step or another continuous.

X   163.555 Y   57.765   m.m.

Tool 2 Spindle OFF   SIDE VIEW
Program No. 111112 Magnify 7
AUX
INPUT
_____

        Y   53.970 Z   213.725   m.m.

X   159.020 Z   213.725   m.m.

X   161.080 Y   59.000   m.m.
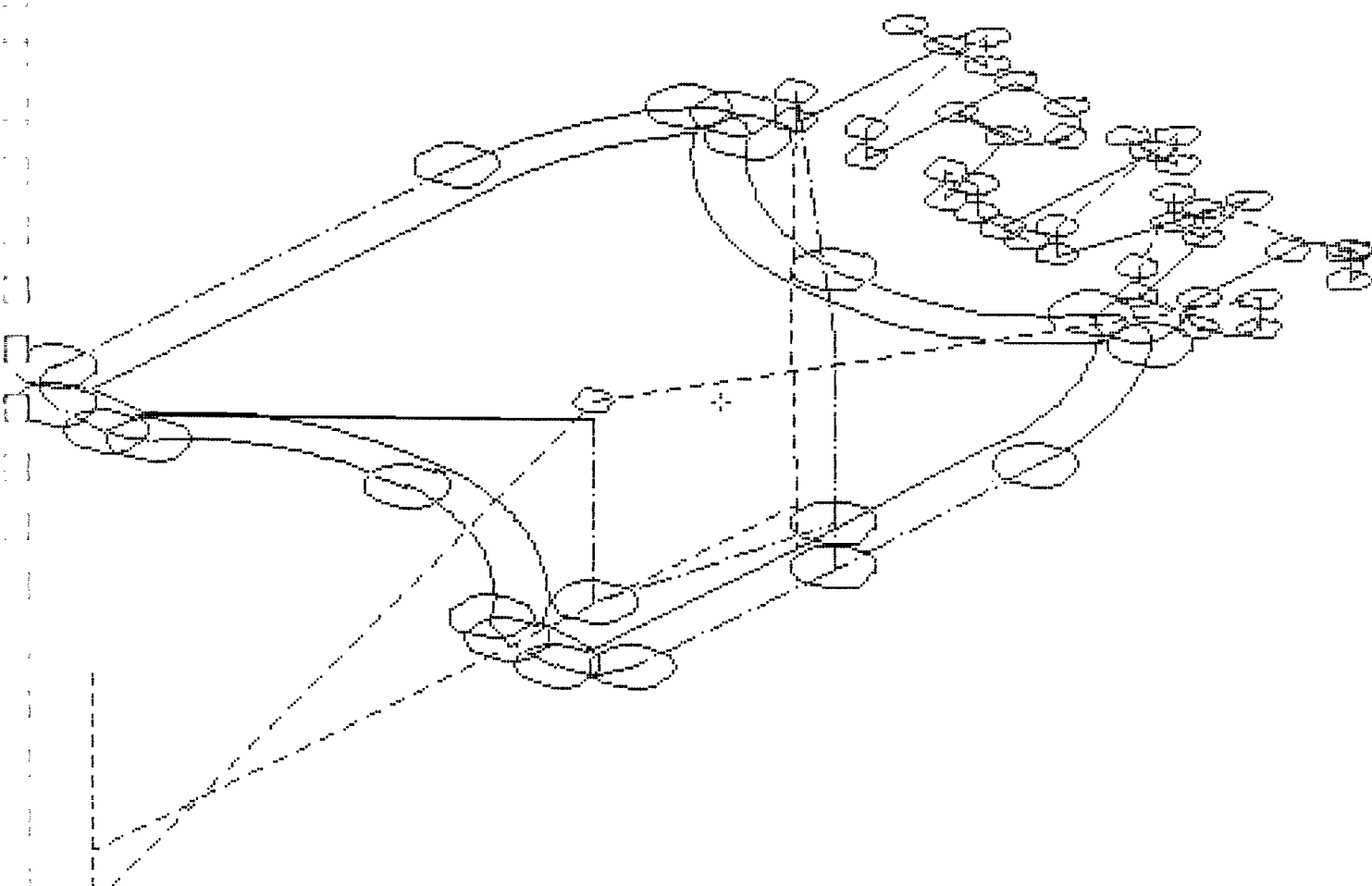
SINGLE STEP

Single Step executes the same as continuous but stopping after each block, and waiting for either another single step or a continuous.

PRINTER

Printer gives the facility to produce a copy of the graphics screen on a Epson RX80 or RX100 printer.

To exit from the graphics mode press the TPG/END key.

CASSETTE OPERATIONS

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

Six different cassette operations are possible:

1. Rewind cassette
2. Erase cassette
3. Find the end of cassette data
4. Load program from cassette
5. Continue program load from cassette
6. Store program to cassette.

When the CASSETTE facility is initially selected a check is made to see if there is a cassette in the unit, if not "NO TAPE LOADED" is displayed, depression of RESET restores normal operation. If the cassette tape "clear leader" is detected when a cassette operation is selected the TRIAC runs the cassette for five seconds, if the clear leader is still detected Tape Error 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 five seconds to pass the clear leader. If the end of tape clear leader is detected during a cassette operation, eg during a cassette load "TAPE ERROR" is displayed, depression of RESET restores normal operation.

1. REWIND CASSETTE enables a cassette to be rewound to the start, ie 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 PNC 3 memory. The rewind operation may be stopped by pressing the RESET key.

   If important data is to be stored which must not be overwritten, cassettes can be protected by punching out two holes at the top of the cassette.

   If a cassette having had the two holes made is placed in the PNC 3 and effort is made to record a program, the message "CASSETTE IS WRITE PROTECTED" will be displayed.

2. ERASE CASSETTE enables a cassette to be erased, ie cleared of programs. The cassette should first be rewound using option 1, ie rewind cassette. When a cassette is erased "PROGRAM 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 three minutes for a 50 ft long cassette tape.

3. FIND END OF CASSETTE DATA. This command brings the tape to the end of the recorded programs, ie to the message "Program end found", the cassette is then ready for other programs to be stored. Depress the RESET key, returns to cassette menu.

4. LOAD PROGRAM FROM CASSETTE enables a program which is on the cassette tape to be loaded from the cassette into PNC 3 memory. The operator may now look for the next cassette program identifier located by depressing key 4. The program number is requested and by giving the program number and pressing the ENTER Key TRIAC will search for the number, displayed in turn the numbers of the programs on tape which are found, until the program required is found or until the tape end is found. Depressing ENTER key will load the program into memory.

If the program number is not known, by pressing key 4 followed by ENTER the first program on tape will be found and its program number displayed. Press ENTER key to load into memory or press any other key to proceed to the next program on tape. This procedure may be carried on until tape end is found. Depression of RESET restores the cassette menu.

When data is loaded from the cassette unit into TRIAC memory, a check is made on the validity of the data and if an error was detected during the load process "TAPE ERROR" is displayed, and the memory will not be loaded. 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 recorded at the end of the data. When the program or identifier data is subsequently loaded into TRIAC's memory the same algorithm is computed and the numerical result is compared with the pre-recorded value, if a difference is detected "TAPE ERROR" is displayed.

5. CONTINUE PROGRAM LOAD FROM CASSETTE. This facility enables program data contained in TRIAC's memory to be continued, ie extended, by a program previously recorded onto tape. This facility enables programs to be "merged" to form larger programs.

6. STORE PROGRAM TO CASSETTE. This facility enables program data contained in TRIAC's memory to be stored using the integral cassette recorder onto cassette tape. The program is stored after a cassette identifier has been keyed in. The cassette identifier (Program number) can be from one to six numerals.

Each program is stored as four elements separated by blank tape.
  i) The cassette program identifier.
  ii) The program.
  iii) The tool offsets associated with the program.
  iv) A cassette end "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 three elements are recorded, this removes any previously recorded cassette END.

It is strongly recommended that more than one recording of the program is made in case one copy becomes corrupted.

BLOCK SEARCH FACILITY

A program that is in TRIAC memory may be run, i.e. executed, either from the start of the program, i.e. block 1, or from any point in the program using the block search facility.

This facility is useful for continuing a program after some interruption, e.g. replacing a broken cutter. To use, press the Block Search key and enter the desired block number. The TRIAC will display all blocks from block 1 up to the block before the desired block. This "pre-run" enables the TRIAC to calculate the correct position and also the status of the spindle. TRIAC will also raise the cutter out of the job at maximum speed to its upper limit. When the correct position and status of the block before the desired block has been found, the TRIAC will move to that position and bring on the spindle and coolant if necessary, and then bring the cutter to the correct depth. It will then execute the desired block.

SECTION 37

DATA LINK FACILITY

Four operation are possible using the Data Link. They are:-

1. Load program from data link. (RS232C serial link).

2. Continue program load from data link. (RS232C serial link).

3. Store program to data link. (Enhanced RS232C option only).

4. Print program, ie transmit program to printer. (Centronics compatible parallel link.)

Note: 2, 3 and 4 are possible only if the PNC 3 memory is loaded.

1. Enables a program to be loaded into PNC 3 memory from an external device either one block at a time or as a full program. Any program previously contained in PNC 3 memory is overwritten, ie destroyed. The format of the program data is shown in the RS232C interface specification.

2. Enables an additional program from an external device to be added to a program that already exists in PNC 3 memory. The format of the program data is shown in the RS232C interface specification.

3. Enables the contents of PNC 3 memory to be transmitted to an external device. The memory contents are transmitted as "ASCII" characters in a similar format to that used by 1. and 2. above.

4. Enables the contents of PNC 3 memory to be transmitted to any printer with 80 columns or more which has a standard Centronics parallel interface.

    If 1. or 2. is selected, the user will be prompted to specify either Host Computer or Paper Tape. The difference between these two options is explained in section 40 entitled "TRIAC Enhanced RS232C Interface Specification".

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AUXILIARY FUNCTIONS

Auxiliary functions allow user assigned devices to be controlled i.e. switched on and off by the four integral TRIAC auxiliary relays. Three types of auxiliary functions are supplied.

The three types are:-

a) ON/OFF   Auxiliaries 3 and 4
b) MOMENTARY   Auxiliary 2
c) PULSED   Auxiliary 1

a) ON/OFF auxiliaries are set when programmed. If the auxiliary is programmed ON it will remain ON until programmed OFF. Such auxiliaries could be used, for example, to control lubricant.

b) MOMENTARY auxiliaries are swtiched 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, for example, to provide a table locking signal or to activate the main drilling head on a drilling machine.

c) PULSED auxiliaries provide a pulse output of 50 milliseconds (if programmed ON) each time the machine completes a program block.

To program auxiliaries, key in M20 or press the AUX/INPUT key once followed by ⟨ENTER⟩. The TRIAC will prompt the user to select the auxiliaries that are to be programmed ON. If more than one auxiliary is to be on, the "." (decimal point) key can be used to separate the numbers being input. Pressing ⟨ENTER⟩ will cause the prompt to change to invite the user to select auxiliaries that are to be programmed OFF. More than one auxiliary can be programmed off by repeatedly entering numbers. When the auxiliaries have been set to ON or OFF as desired, pressing ⟨EOB⟩ will end that block of information.

INPUT FACILITIES

The TRIAC is equipped to monitor four 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 state, the TRIAC waits until the switch signals are as porgrammed before proceeding. Switch levels may be programmed to be closed (ON) or open (OFF). These inputs could be used, for example, to check if safety guards are in the correct position before movement, or to check the position of an auxiliary controlled hydraulic ram, or to make the TRIAC wait for some external signal from a robot before proceeding.

To program inputs, key in M21 or press the AUX/INPUT key twice followed by ⟨ENTER⟩. The inputs to be ON are entered first, in the same way as auxiliaries, using the "." key as a separator if necessary. When ⟨ENTER⟩ is pressed the inputs to be OFF can be entered in the same way. Pressing ⟨EOB⟩ will end that block of information.

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

SECTION 40

TRIAC ENHANCED RS232 INTERFACE SPECIFICATION

SECTION A - INPUT TO TRIAC

The enhanced RS232 interface allows a host computer to use all the facilities of the TRIAC. The enhanced specification includes comprehensive error message transmission. Each block must start with $\langle$ STX $\rangle$ and end with $\langle$ CR $\rangle$ but these characters have been omitted from the following text for clarity.

(NB. STX = 02H, CR = 0DH)

Important: The TRIAC will only accept data with a 7 bit word length, 1 stop bit and even parity. If a parity error occurs, an error 01 will be sent from the TRIAC.

Eight different baud rates are available with the TRIAC. These range from 75 to 9600 and are selected by DIP switches on the printed circuit board (see the section on "switch settings" in this manual). To assist the user, the current baud rate is displayed on the TRIAC's screen during the loading and storing operations.

The TRIAC only needs three wires to implement an RS232 link. They are Data Transmit, Data Receive and Signal Ground. The connection to the TRIAC is via a seven pin DIN socket (fitted to the unit rear) using pins 6, 7 and 2 for TxDa, RxDa and Ground respectively. TxDa is the output from the TRIAC and RxDa is the input to the TRIAC.

All information on the RS232 link is in the form of ASCII characters.

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

General operation is as follows:-

a) Operator selects serial load from host computer.

b) Host sends 1 block, e.g. $\langle$ STX $\rangle$ G01X23 $\langle$ CR $\rangle$

c) TRIAC executes that block.

d) Host must wait for a response from TRIAC (e.g. $\langle$ ACK $\rangle$) before sending next block.

e) Repeat b) c) d) until done.

f) Host may optionally send $\langle$ STX $\rangle$ M02L $\langle$ CR $\rangle$ to cause TRIAC to exit RS232 mode and return to manual operation.

The following paragraphs define the exact data format required by TRIAC.

The TRIAC will ignore the following characters:-

Null	00H
Tab	09H
Space	20H
Delete	7FH

Also if the first character after the $\langle STX \rangle$ is N, the TRIAC will ignore any digits following the N. This is to allow users to number the blocks being transmitted. Note that the numbers are ignored and the TRIAC will automatically number its blocks during a load sequence.

Blocks with "L" as the last character before the $\langle CR \rangle$ will not be executed directly but will be loaded into the TRIAC's internal memory.

Linear Moves

G01 Xnnnn Ynnnn FXnnnn Znnnn FZnnnn

Circular Moves

G02 Xnnnn Ynnnn FXffff Znnnn FXffff CXcccc Ycccc

Counter Clockwise

G03 Xnnnn Ynnnn FXffff Znnnn FZffff CXcccc Ycccc

nnnn = X, Y or Z position in mm or inches
ffff = Feed rate in mm/min or ins/min
cccc = XY or XZ circle centre point in mm or inches

Dwell

G04 Ddddd
Where dddd - dwell time in the range 0.1 to 9999.9 seconds

Mirror Functions

Mirror X
G10L

Cancel Mirror X
G11L

Mirror Y
G12L

Cancel Mirror Y
G13L

Note that these blocks cannot be executed directly but must be part of a program load.

Scaling Function

Program Scale   (NOTE! Only available as part of a program load)
G20 SsssssL

Machine Scale   (NOTE! Not available as part of a program load)
G21 Sssss

Where ssss is the percentage scaling required in the range 0.01% to 650%.

Cutter Radius Compensation

Cancel Tool Compensation
G40

Tool Compensation Right
G41

Tool Compensation Left
G42

Offsets   (NOTE! Only available as part of a program load)

Program Offsets
G54 Xnnnn Ynnnn Znnnn L

Machine Offsets
G55 Xnnnn Ynnnn Znnnn

Imperial Units
G70

Metric Units
G71

Repeat Loops   (NOTE! Only available as part of a program load)

Mill

G81R⟨start blk⟩E⟨end blk⟩N⟨no of times⟩Xnnnn Ynnnn FXffff Znnnn FZffff L

Where the X, Y and Z dimensions are optional incremental offsets and the FX and FZ values are optional feed rates.

Absolute Units

G90

Incremental Units

G91

Absolute Datum

G98

Floating Datum   (NOTE! Only available as part of a program load)

G99L

Program Stop   (NOTE! Only available as part of a program load)

M00L

Spindle Speed Control

Spindle Forward

M03 S⟨spindle speed forward rpm⟩

Spindle Reverse

M04 S⟨spindle speed reverse rpm⟩

Spindle Stop

M05

Tool Change

M06 T⟨tool number⟩

Auxiliary Output and Input Control

Aux Outputs

To turn auxiliary ⟨n⟩ on

M20 A⟨n⟩+

To turn auxiliary ⟨n⟩ off

M20 A⟨n⟩-

Combination of different auxiliaries to be on/off can be built up,

e.g.

M20 A1+A2-A3+A4-

will turn on Aux 1 and Aux 3 and turn off Aux 2 and Aux 4.

Note: The auxiliaries do not necessarily have to be input in order.

Inputs

To wait for input ⟨n⟩ to be high

M21 I⟨n⟩+

To wait for input ⟨n⟩ to be low

M21 I⟨n⟩-

Combinations of conditions can be tested,

e.g.

M21 I1+I2+I3-I4-

will wait until Inputs 1 and 2 are high and Inputs 3 and 4 are low.

Note: The inputs do not necessarily have to be input in order.

Canned Cycles

Re-enable Cycle

G79L

De-activate Cycle

G80L

Circular Cycle

G82 R⟨radius of pocket⟩FX⟨feed of X & Y axes⟩ Z⟨depth of pocket⟩Fz⟨feed of Z axis⟩C⟨number of cycles⟩L

Drilling Cycle

G83 Z⟨depth of hole⟩FZ⟨feed of Z axis⟩C⟨number of cycles⟩L

Rectangular Cycle

G84 X⟨length of pocket⟩FZ⟨feed of Z axis⟩C⟨number of cycles⟩L

To Run A Program

B	will cause the whole program to be executed
B⟨nnnn⟩	will cause the program to be executed from block nnnn

<u>To Erase a Program</u> (i.e. to clear TRIAC memory)

    E   will erase the program

<u>To End the Load Sequence</u>

M02 When this block is seen by the TRIAC it will exit from the DATA LINK facility and return to MDI mode.

<u>SECTION B - OUTPUT FROM TRIAC</u>

<u>Host Computer</u>

1. Providing the TRIAC has received valid data as specified in Section A it will respond with the character ⟨ACK⟩

   ⟨ACK⟩ = 06H

   This signified that the TRIAC is ready to receive more data.

2. If some error has occured, the TRIAC will respond with the following:-

   ⟨NAK⟩nn

   where nn is a two digit error code

   ⟨NAK⟩ = 15H

   The TRIAC will then be ready to receive more data.

   The error codes are defined in the following table.

3. If reset is pressed on the TRIAC while in RS232c mode with the TRIAC waiting for data then it will transmit a ⟨BEL⟩(07H) and return to MDI mode.

NOTE: That if some baud rate mismatch or other error prevents TRIAC from recognizing ⟨STX⟩ and ⟨CR⟩ then no respond codes will be sent.

When serial load from tape is selected, the TRIAC will operate using an Xon/Xoff type protocol as follows.

1. When the TRIAC is ready to read a block from the serial link it will transmit a $\langle$DC1$\rangle$ character (=11H).

2. The TRIAC will read characters until it reads a $\langle$CR$\rangle$, whereupon it will transmit a $\langle$DC3$\rangle$ character (=13H).

3. Once the block has been decoded, the TRIAC will transmit either an $\langle$ACK$\rangle$ character or a $\langle$NAK$\rangle$ followed by a error code number.

4. The TRIAC will then continue as in step 1 by transmitting a $\langle$DC1$\rangle$ character.

5. The exception to the above sequence is when an M02 block is received by the TRIAC, in which case no $\langle$DC1$\rangle$ is transmitted and the TRIAC returns to MDI mode.

If the TRIAC is to be used with a Portazip type paper tape reader, the following connections should be used.

TRIAC 7 PIN DIN	SIGNAL	PORTAZIP 25 WAY D TYPE
2		Ov COMMON 7
6	DATA FROM TRIAC	3
7	DATA TO TRIAC	2

NB. These connections are only suitable for reading paper tape using Serial Load. For tape punching useing Serial Store see the relevant section of this manual.

TRIAC RS232 ERROR CODES (Enhanced specification only)

Error No.	Meaning
01	Parity error in received character
02	Illegal G code received
03	Illegal M code received
04	Illegal character for this block
05	Move exceeds machine limits
06	Block not completed successfully
07	This block not allowed to execute immediately (Must be ended with L)
08	This block not allowed in a program
09	Attempt to run to non existant block
10	TRIAC memory full
11	Block too big for input buffer
12	X axis drive system fault
13	Y axis drive system fault
14	Z axis drive system fault
15	W axis drive system fault
16	Incomplete block received
17	Error in input co-ordinate
18	Error in input feedrate
19	X and Y moves not present in circular move
20	Position not known machine must be driven to datum
21	Circular move not within a quadrant
22	Dwell value error
23	Scale value error
24	Tool number error
25	Auxiliary selection error
26	Input selection error
27	Repeat start block error
28	Repeat end block error
29	Number of repeats error
30	Nest error in repeat levels

Error No.	Meaning
31	Error in Repeat offsets
32	Error in offset block
33	Spindle speed input exceeds limits
34	Spindle direction is opposite to present direction (Stop spindle first)
35	Error when driving to datum
38	Spindle drive system error
39	Number of cycles error

When function 4 is selected in the DATA LINK Menu, the TRIAC responds with a menu:-

1. COMPLETE PROGRAM
2. PART OF PROGRAM

If 1 is selected then the whole of the program in memory is transmitted via the RS232c link.

If 2 is selected then the user is required to enter the start and end blocks. When this has been done, the portion of the program selected is transmitted via the RS232c link.

(NB. During transmission the message "Storing to RS232c Serial Data Link" is displayed.)

The data transmitted by the TRIAC is exactly the same as it expects to receive when loading from the RS232c link, including block numbers at the start of each block.
i.e.
〈STX〉 Nnnnnn G——————— 〈CR〉〈LF〉
where nnnnn is the block number

During transmission the RxDa line is used as a busy signal thus:-

if RxDa is high (4V to 12V) then the TRIAC will transmit
if RxDa is low (-12V to 0V) then transmission is inhibited at the end of the current character and the TRIAC will wait for a low level before continuing to transmit.

After the last block in the program has been sent to the serial link, the TRIAC will transmit an M02 block to signify the end of the program.

If the TRIAC is to be used with a Portazip type paper tape punch, the following connections should be used.

TRIAC 7 PIN DIN		PORTAZIP SIGNAL	25 WAY D TYPE
2	Ov COMMON	7	
6	DATA FROM TRIAC	3	
7	BUSY LINE	4	

NB. These connections are only suitable for storing to paper tape.

ERROR MESSAGES

This section gives a list of the TRIAC's error messages, a description of why the error occured and, where applicable, a possible solution to the error.

No Program Loaded

CAUSE: The TRIAC displays this message if an attempt is made to execute a program by pressing 〈 CYCLE START 〉 or 〈 SINGLE STEP 〉 without a program being loaded into memory.

SOLUTION: Load a program into memory using either the keyboard, cassette or RS232 data link.

Memory Full

This error message is displayed if an attempt is made to enter more blocks than the TRIAC's memory can hold.

Machine did not get to correct position

CAUSE: This error message is displayed when the TRIAC executes a circular move which reaches the desired position in only one of the X and Y axes.

SOLUTION: Re-calculate the circle end-points and amend the block which caused the error.

Move Exceeds Machine Limit

CAUSE: A move which takes the TRIAC outside the machine limits will cause this message to be displayed.

SOLUTION: Make sure that all moves are within the machine limits (remembering to add on offsets, compensate for scaling, etc.).

Machine Limit Exceeded in X/Y/Z

The TRIAC has detected an overtravel condition in the specified axis i.e. it has driven past the machine limits. The only action that can be taken after an overtravel fault is to datum the machine.

Motor Drive Fault in X/Y/Z

CAUSE: This message is displayed if the motor drive unit appears to be faulty.

The error could be due to several factors:-

1. There is no power supply to the motor drive.
2. The motor drive has been overloaded. In this case, the top red LED on the specified drive unit will be illuminated.
3. There has been a supply failure. This will cause the second red LED to be illuminated.
4. The motor drive unit has overheated. This causes the third red LED to be illuminated.
5. The motor drive has recently been powered down and powered up in quick succession.

SOLUTION: If more than one of the red LEDs is illuminated, the drive is almost certainly faulty. If the supply failure LED is illuminated and the supply to the motor drive is correct, the drive is faulty. If the overload LED is illuminated, disconnect the motor and switch on again. If the overload LED still comes on, the drive is faulty. If not, check for short circuits or crossed connections on the motor leads. If the overtemperature LED is on, switch off the motor drive unit and allow plenty of time for it to cool down.

Spindle Drive System Error

This error message is displayed if the spindle does not reach the programmed speed.

Spindle direction cannot be changed whilst spindle moving

CAUSE: This message will be displayed if an attempt is made to execute a SPINDLE FWD block while the spindle is moving in reverse, or a SPINDLE REV block while the spindle is moving forward.

SOLUTION: Execute a SPINDLE OFF block before the required spindle move block.

Repeat Start block must be linear with all axes defined

CAUSE: During the input of a repeat block, if an attempt is made to specify a start block which is either non-linear or in which all axes are not defined, the above message is displayed. This error can also occur while running a program if the program has been edited in such a way as to cause the start block to become non-linear or not to have all axes defined.

SOLUTION: Make sure that the start blocks of any repeat blocks used are linear with all axes defined. During editing, if any blocks are added or deleted before the start of the repeat loop, amend the start and end block parameters to reflect the new block numbers.

Nest Error in Repeat Levels

CAUSE: The TRIAC will only implement four nested repeat loops at any time (A "nested" repeat is a repeat of a repeat). This error indicates that a fifth level of nesting has been attempted.

SOLUTION: Simplify the program.

Tape is Write Protected

CAUSE: If the "write enable" tab on the tape currently in the cassette unit has been removed, it is impossible for the TRIAC to store data on the tape.

SOLUTION: Put a "write enable" tab on the tape housing.

e.g. by placing a small piece of sticky tape over the tab position.

No Tape Loaded

CAUSE: This message is displayed if an attempt is made to access the TRIAC's cassette functions while there is no tape in the cassette unit.

SOLUTION: Put a tape in the cassette unit before using the TRIAC's cassette functions.

Tape Error

CAUSE: When reading a paper tape and a parity error occurs or an invalid block is decoded. Or when reading a cassette the TRIAC cannot get into synchronization with the program header on the tape. This could be caused by tape stretching or data corruption due to magnetic fields etc.

SOLUTION: Try reading the tape again. Remember always to store the program 3 times on the cassette.

Data Error

CAUSE: The data stored on the tape is invalid. This could be caused by tape stretching or data corruption due to magnetic fields.

SOLUTION: Try reading the tape again. Remember always to store the program 3 times on the cassette.

Invalid Block for this Machine

CAUSE: This message is displayed if an attempt is made to load in a block from the tape which the TRIAC does not recognise.

SOLUTION: Make sure that the program being loaded is valid for the TRIAC in use.

Lathe Tape

A program which has been stored on a PNC 3 lathe cannot be loaded into a TRIAC.

Printer Error

CAUSE: This message is displayed if there is no printer connected to the TRIAC or the printer is off line i.e. not ready to receive data.

SOLUTION: Connect a printer to the TRIAC and make sure it is on line.

Error in Circle Input

CAUSE: All circular moves must be confined to a single quadrant. This error indicates that the start and end points of a circular move are not within the same quadrant as relative to the given centre point.

SOLUTION: If a circular move between two points in different quadrants must be executed, break it up into smaller moves which end on the intervening quadrant boundaries.

X and Y Axes must be Defined

CAUSE: The X and Y axes must be defined before the circle centre may be keyed in, otherwise the above error message is displayed.

SOLUTION: Key in the X and Y co-ordinates before attempting to input the circle centre co-ordinates.

Centre must be Defined

CAUSE: This error message is displayed if the EOB key is pressed before the circle centre is defined.

SOLUTION: Define the centre before pressing EOB.

This type of block cannot be Altered (use replace if necessary)

CAUSE: The alter function (in edit) can only be used to alter linear or circular blocks. If an attempt is made to ALTER any other type of block, the above error message is displayed.

SOLUTION: Use REPLACE instead.

Already Selected

This error message is displayed if an attempt is made to re-select an auxiliary or input which has already been selected during input.

No Changes so Block Ignored

This message is displayed if an M20 AUXILIARIES block is loaded which is identical to the last auxiliaries block in the program or an M21 INPUTS block is entered without any parameters.

Value not in Range

This error occurs if a value which is outside the allowed range is keyed in.

Scaled move out of Range

If a scaling operation causes a subsequent move to exceed the machine limits, the above message is displayed.

Cutter Diameter too Big

If the TRIAC's cutter compensation facility is being used and the compensation produces a move which is in the opposite direction to the original move, the above message is displayed. See section entitled "Effects of Cutter Offsets".

EXAMPLES

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200 %

100 %

50%

15 R

30

30

SCALE PROGRAM

30

10

20

MIRROR X

WITH OFFSET
OF X10

ORIGINAL

MIRROR X & Y

WITH NO OFFSETS

MIRROR Y

WITH NO OFFSETS

MIRROR PROGRAM

					XY	CIRCULAR MOVEMENT				
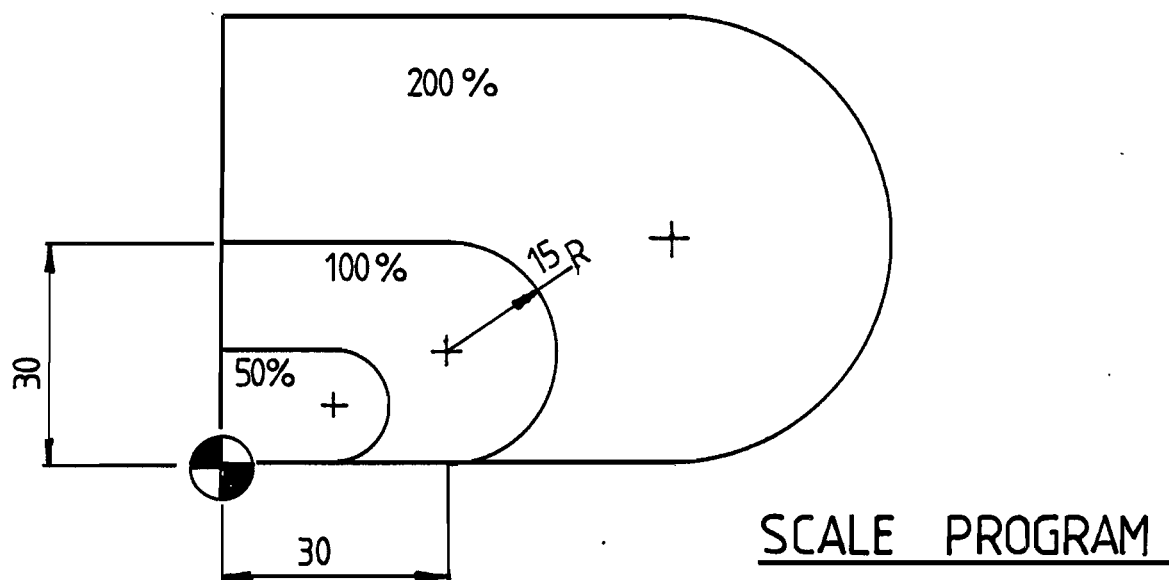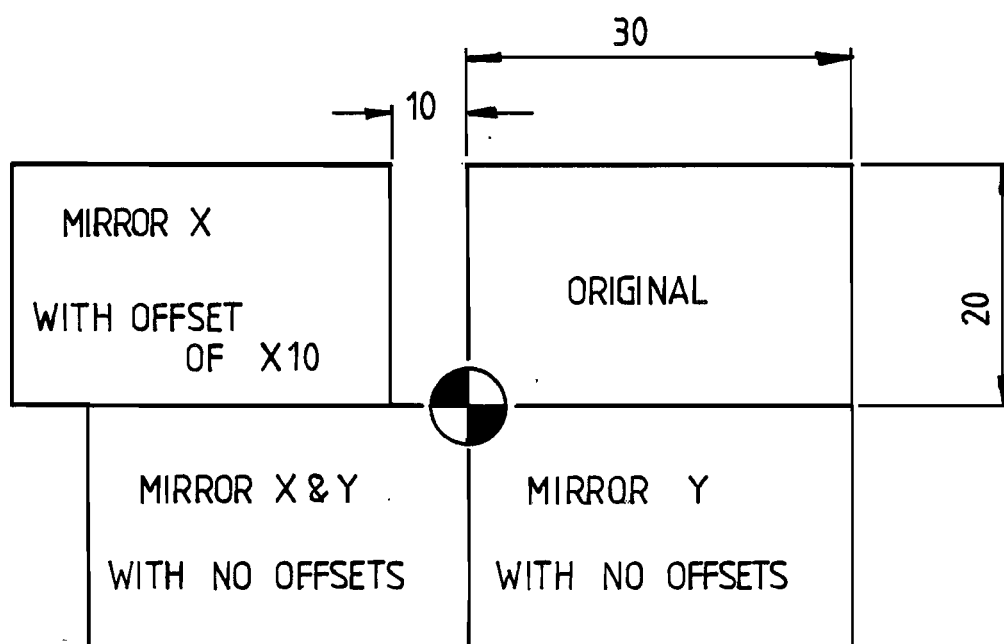
DRAWING No. FIG 10 — TOOLING & SETTING DATA

DESCRIPTION SCALE PROGRAM

PROGRAMME No.

MATERIAL

PROGRAMME BY S. CROWTHER

DATE

TOOL 1   3mm S/DRILL

TRIAC

N	G	M	X	Y	XY FEED	XC	YC	Z	Z FEED	REMARKS
1		06								TOOL 1
2		03								1500 RPM
3	00		0	0				3		
4	01							-1	50	
5	01			30	100					
6	01		30							
7	02		45	15		30	15			
8	02		30	0		30	15			
9	01		0							
10	20		50%							PROGRAM SCALE
11	81		REPEAT	FROM 3 TO 9 REPEATS 1						
12	20		200%			.				PROGRAM SCALE
13	81		REPEAT	FROM 3 TO 9 REPEATS 1						
		02								

DRAWING No.	FIG 11		TOOLING & SETTING DATA
DESCRIPTION	MIRROR PROGRAM		
PROGRAMME No.			TOOL 1 3mm S/DRILL
MATERIAL	ALUMINIUM		
PROGRAMME BY	S. CROWTHER		
DATE			

N	G	M	X	Y	XY FEED	CIRCULAR MOVEMENT		Z	Z FEED	REMARKS
						XC	YC			
1		06								TOOL 1
2		03								1500 RPM
3	00		0	0				3		
4	01							-1	50	
5	01			20	100					
6	01		30							
7	01			0						
8	01		0							
9	00							3		
10	10									MIRROR X
11	81		REPEAT	FROM 3 TO 8	REPEATS 1					
			OFFSET X 10							
12	12									MIRROR Y
13	81		REPEAT	FROM 3 TO 8	REPEATS 1					
14	11									CANCEL MIRROR X
15	81		REPEAT	FROM 3 TO 8	REPEATS 1					
		02								

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FIG 12

125

DRAWING No.	FIG 12	TOOLING & SETTING DATA

DESCRIPTION	
PROGRAMME No.	

TOOL 1   6mm S/DRILL
TOOL 2   8mm S/DRILL
TOOL 3   4mm S/DRILL

MATERIAL	ALUMINIUM
PROGRAMME BY	S. CROWTHER
DATE	

N	G	M	X	Y	XY FEED	CIRCULAR MOVEMENT XC	CIRCULAR MOVEMENT YC	Z	Z FEED	REMARKS
1		06								TOOL 1
2		03								1000 RPM
3	00		0	40						
4	41									TOOL COMP LEFT
5	00		0	40						
6	01							−3	50	
7	01			60	100					
8	01		30							
9	02		50	80	80	50	60			
10	02		70	60		50	60			
11	01		100		100					
12	01			20						
13	02		80	0	80	80	20			
14	01		12		100					
15	01		0	20						
16	01			45						
17	00							3		
18	40									CANCEL TOOL COMP
19		06								TOOL 2
20	00		50	60				1		
21	01							0	30	
22	82	RAD 15, FEED 100, DEPTH 2, Z FEED 30, CYCLES 2								CIRCULAR CYCLE
23	80									DEACTIVATE CYCLE
24	00		20	35						
25	01							0	30	
26	84	X SIDE 20, Y SIDE 30, FEED 100, DEPTH 5, FEED 30, CYCLES 3								RECTANGULAR CYCLE
27	80									DEACTIVATE CYCLE
28		06								TOOL 3
29		03								1200 RPM
30	00		60	30				1		
31	01							0	30	
32	83	DEPTH 0, FEED 40, CYCLES 3								DRILLING CYCLE
33	00		80	40				0		CYCLE REPEATED
34	00		80	20				0		CYCLE REPEATED
		02								

FIG 13

60

10

5·0 RAD

10

18

50

100

1

3

2

5

ZO
PLANE

TOOL Nº I
IO DIA SLOT DRILL

	DRAWING No.		FIG 13		**TOOLING & SETTING DATA**					

DRAWING No.	FIG 13
DESCRIPTION	
PROGRAMME No.	1
MATERIAL	
PROGRAMME BY	
DATE	.

TOOLING & SETTING DATA

TRIAC

N	G	M	X	Y	XY FEED	CIRCULAR MOVEMENT		Z	Z FEED	REMARKS
						XC	YC			
	55		X 100	Y 100						DATUM POSITION
01			X -50	Y 0	F 1500			Z 0	F 1500	SAFE POSITION
02		06								TOOL 1
03		03								SPINDLE ON
04										
05			X 10	Y -10						
06		.						Z -5	F 75	
07	.		X 60		F 75					1
08				Y -18						2
09			X 10	Y -10						3
10								Z 3	F 1000	
11		05								SPINDLE OFF
12			X -50	Y 0	F 1500			.		SAFE POSITION
13		02								END.

FIG 14

5 DEEP

DATUM POSITION   G55   X120   Y50
TOOL Nº1 6 DIA SLOT DRILL
ZO DIMENSION = TOP OF WORKSURFACE

DRAWING No.			FIG 14			TOOLING & SETTING DATA

DESCRIPTION	
PROGRAMME No.	2
MATERIAL	
PROGRAMME BY	
DATE	

TOOLING & SETTING DATA

T1 = 6mm SLOT DRILL

TRIAC

N	G	M	X	Y	XY FEED	CIRCULAR MOVEMENT		Z	Z FEED	REMARKS
						XC	YC			
01			X -50	Y 0	F 1500			Z 0	F 1500	SAFE POSITION
02		06								TOOL 1
03		03								SPINDLE ON
04								Z 3		
05	42									CUTTER COMP.
06			X 0	Y 20						
07								Z -5	F 60	SINK 5 DEEP
08				Y 0	F 70					
09			X 5							
10	02		X 25	Y 10		25	-15			
11	02		X 45	Y 0		25	-15			
12			X 50							
13				Y 40						
14	03		X 45	Y 55		25	40			
15	02		X 25	Y 45		25	70			
16	02		X 5	Y 55		25	70			
17	03		X 0	Y 40		25	40			
18				Y 0						
19				Y 22						
20								Z 3	F 1500	
21		05								SPINDLE OFF
22	40									CANCEL COMP.
23			X -50	Y 0	F 1500					
24		02								END.

FIG 15

DRAWING No.	FIG 15
DESCRIPTION	
PROGRAMME No.	3
MATERIAL	
PROGRAMME BY	
DATE	

TOOLING & SETTING DATA

TRIAC

T1 = 8mm SLOT DRILL

Z0 DIMENSION = TOP WORKSURFACE

DATUM POSITION G55 X100 Y90

N	G	M	X	Y	XY FEED	CIRCULAR MOVEMENT XC	YC	Z	Z FEED	REMARKS
01		03								SPINDLE ON
02			X 0	Y 0	F 1500			Z 3	F 1500	
03	41									CUTTER COMP.
04			X 0	Y 0						
05								Z −3	F 100	SINK IN 3 DEEP
06				Y 15	F 100					
07			X 20							
08	02		X 50	Y 28.544		50	−11.456			
09	02		X 80	Y 15		50	−11.456			
10			X 100							
11				Y 0						
12								Z 3		
13	40									CANCEL COMP.
14	54		X 108							PROGRAM OFFSET 108MM
15	10									MIRROR X
16	12									MIRROR Y
17	81		FROM 2 TO 14	REPEAT 1						
18								Z 10		
19		05								SPINDLE OFF
20	13									CANCEL MIRROR Y
21	10									CANCEL MIRROR X
22			X −50	Y 0						SAFE POSITION
23		02								END.

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GLOSSARY OF TERMS

A

A AXIS - The axis of rotary motion of a machine tool member or slide about the X axis.

ABSOLUTE ACCURACY - Accuracy as measured from a reference which must be specified.

ABSOLUTE DIMENSION - A dimension expressed with respect to the initial zero point of a co-ordinate axis.

ABSOLUTE POINT (Robots) - Equivalent to absolute co-ordinates in NC machines. The co-ordinates of a data point are defined in relation to an absolute zero.

ABSOLUTE PROGRAMMING - Programming using words indicating absolute dimensions.

ABSOLUTE READOUT - A display of the true slide position as derived from the position commands within the control system.

ABSOLUTE SYSTEM - NC system in which all positional dimensions, both input and feedback, are measured from a fixed point of origin.

ACCANDEC - (Acceleration and deceleration) Acceleration and deceleration in feedrate; it provides smooth starts and stops when operating under NC and when changing from one feedrate value to another.

ACCEPTANCE TEST - A series of tests which evaluate the performance and capabilities of both software and hardware.

ACCESS TIME - The time interval between the instant at which information is: 1. called for from storage and the instant at which delivery is completed, i.e., the read time. 2. Ready for storage and the instant at which storage is completed, i.e., the write time.

ACCUMULATOR - A part of the logical-arithmetic unit of a computer. It may be used for intermediate storage to form algerbraic sums, or for other intermediate operations.

ACCURACY - 1. Measured by the difference between the actual position of the machine slide and the position demanded. 2. Conformity of an indicated value of a true value, i.e., an actual or an accepted standard value. The accuracy of a control system is expressed as the deviation or difference between the ultimately controlled variable and its ideal value, usually in the steady state or at sampled instants.

ACTIVE STORAGE - That part of the control logic which holds the information while it is being transformed into motion.

ADAPTIVE CONTROL - A technique of automatically adjusting feeds and/or speeds to an optimum by sensing cutting conditions and acting upon them.

ADDRESS - A character or group of characters at the beginning of a word what identifies the data of allowing in the word.

ADDRESS BLOCK FORMAT - A block format in which each word contains an address.

ALGOL - (Algorithmic Language) Language used to develop computer programmes by algorithm.

ALGORITHM - A rule or procedure for solving a mathematical problem that frequently involves repetition of an operation.

ALPHANUMERIC OR ALPHAMERIC - A system in which the characters used are letters A through Z, and numerals 0 to 9.

ALPHANUMERIC DISPLAY - Equipment, such as a CRT, which is capable of displaying only letters, digits and special characters.

AMPLIFIER - A signal gain device whose output is a function of its input.

AMPLITUDE - Term used to describe the magnitude of a simple wave or simple part of a complex. The largest or crest value measured from zero.

ANALOG - In NC the term applies to a system which utilizes electrical voltage magnitudes or ratios to represent physical axis positions.

ANALOG DATA - The information content of an analog signal as conveyed by the value of magnitude of some characteristics of the signal such as the amplitude, phase, or frequency of a voltage, the amplitude or duration of a pulse, the angular position of a shaft, or the pressure of a fluid.

ANALOG-TO-DIGITAL (A/D) CONVERTER - A device that changes physical motion or electrical voltage into digital factors.

ANALOG SIGNALS - Physical variables (e.g., distance, rotation) represented by electrical signals.

AND - A logical operator which has the property such that if X and Y are two logic variables, then the function 'X and Y' is defined by the following table:

X	Y	X AND Y
0	0	0
0	1	0
1	0	0
1	1	1

The AND operator is usually represented in electrical rotation by a centred dot '.', and in FORTRAN programming notation by an asterisk '*' within a Boolean expression.

AND-GATE - A signal circuit with two or more inputs. The output produces a signal only if all inputs received coincident signals.

APT - (Automatically Programmed Tools) A universal computer-assisted programme system for multi-axis contouring programming. APT III - Provides for five axes of machine tool motion.

APPLICATION PROGRAMMES - Computer programmes designed and written to value a specific problem.

ARC CLOCKWISE - An arc generated by the co-ordinated motion of two axes in which curvature of the path of the tool with respect to the workpiece is clockwise, when viewing the plane of motion from the positive direction of the perpendicular axis.

ARC COUNTERCLOCKWISE - (Substitute 'Counterclockwise' for 'Clockwise' in 'Arc Clockwise' definition.)

ARCHITECTURE - Operating characteristics of a control system, or control unit, or computer.

ASCII - (American Standard Code for Information Interchange) A data transmission code which has been established as an American Standard by the American Standards Association. It is a code in which 7 bits are used to represent each character. Also USASCII.)

ASSEMBLY - The fitting together of a number of parts to create a complete unit.

ASSEMBLY DRAWING - The drawing of a number of parts which shows how they fit together to construct a complete unit.

ASYNCHRONOUS TRANSMISSION - The transmission of information in irregular sections, with the time interval of each transmission varying and each section being identified by a stop and stop signal.

ASYNCHRONOUS - Without any regular time relationship.

ATTRIBUTE - A quality that is characteristic of a subject.

AUTOMATED ASSEMBLY - The application of automation to assembly.

AUTOMATION - The technique of making a process or system automatic. Automatically controlled operation of an apparatus, process, or system, especially by electronic devices. In present day terminology, usually used in relation to a system whereby the electronic device controlling an apparatus or process also is interfaced to and communcates with a computer.

AUXILIARY FUNCTION - A function of a machine other than the control of the co-ordinates of a workpiece or cutter - usually on-off type operations.

AXIS - 1. A principle direction along which a movement of the tool or workpiece occurs. 2. One of the reference lines of a co-ordinate system.

AXIS (Robots) - A moving element of a robot or manipulator.

AXIS INHIBIT - Prevents movement of the selected slides with the power on.

AXIS INTERCHANGE - The capability of inputting the information concerning one axis into the storage of another axis.

AXIS INVERSION - The reversal of normal plus and minus values along an axis which makes possible the machining of a left-handed part from right-handed programming or vice-versa. Same as mirror image.

B

B AXIS - the axis of rotary motion of a machine tool member or slide about the Y axis.

BACKGROUND - In computing the execution of low priority work when higher priority work is not using the computer.

BACKGROUND PROCESSING - The automatic execution of computer programmes in background.

BACKLASH - A relative movement between interacting mechanical parts, resulting from looseness.

BAND - The range of frequencies between two defined limits.

BASE - A number base. A quantity used implicitly to define some system of representing numbers by positional notation. Radix.

BATCH - A number of items being dealt with as a group.

BATCH PROCESSING - A manufacturing operation in which a specified quantity of material is subject to a series of treatment steps. Also, a mode of computer operations in which each programme is completed before the next is started.

BAUD - A unit of signalling speed equal the number of discrete conditions or signal events per second; 1 bit per second in a train of binary signals, and 3 bits per second in an octal train of signals.

BEHIND THE TAPE READER - A means of inputting data directly into a macine tool control unit from an external source connected behind the tape reader.

BENCHMARK - A standard example against which measurements may be made.

BINARY - A numbering system based on 2. Only the digits 0 and 1 are used when written.

BINARY CIRCUIT - A circuit which operates in the manner of a switch, that is, it is either 'on' or 'off'.

BINARY CODED DECIMAL (BCD) - A number code in which individual decimal digits are each represented by a group of binary digits; in the 8-4-2-1 BCD notation, each decimal digit is represented by a four-place binary number, weighted in sequence as 8, 4, 2 and 1.

BINARY DIGIT (BIT) - A character used to represent one of the two digits in the binary number system, and the basic unit of information or data storage in a two-state device.

BILL OF MATERIALS - A listing of all the parts that constitute an assembled product.

BLOCK - A set of words, characters, digits, or other elements handled as a unit. On a punched tape, it consists of one or more characters or rows across the tape that collectively provide enough information for an operation. A 'word' or group of words considered as a unit separated from other such units by an 'end of block' character (EOB).

BLOCK DELETE - Permits selected blocks of tape to be ignored by the control system at discretion of the operator with permission of the programmer.

BLOCK DIAGRAM - A chart setting forth the particular sequence of operations to be performed for handling a particular application.

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BLOCK FORMAT - The arrangement of the words, characters and data in a block.

BODE DIAGRAM - A plot of log amplitude ratio and phase angle as functions of log frequency, representing a transfer function.

BOOLEAN ALGEBRA - An algebra named for George Boole. This algebra is similar in form to ordinary algebra, but with classes, propositions, yes/no criteria, etc., for variables rather than numeric quantities, it includes the operator's AND, OR, NOT, EXCEPT, IF THEN.

BOOTSTRAP - A short sequence of instructions, which when entered into the computer's programmable memory will operate a device to load the programmable memory with a larger, more sophisticated programme - usually a loader programme.

BUFFER STORAGE - 1. A place for storing information in a control for anticipated transference to active storage. It enables control system to act immediately on stored information without waiting on tape reader. 2. A register used for intermediate storage for information in the transfer sequence between the computer's accumulators and a peripheral device.

BULK MEMORY - A high capacity auxiliary data storage device such as a disc or drum.

BUG - An error or mistake.

BUS - A conductor used for transmitting signals or power between elements.

BYTE - A sequence of adjacent bits, usually less that a word, operated on as a unit.

C

C AXIS - The axis of rotary motion of a machine tool member or slide about the Z axis.

CALIBRATION - Adjustment of a device, such that the output is within a specified tolerance for particular values of the input.

CANCEL - A command which will discontinue any canned cycles or sequence commands.

CANNED CYCLE - A preset sequence of events initiated by a single NC command, e.g., G84 for NC tap cycle. Also fixed cycle.

CANONICAL FORM - A standard numerical representation of data.

CARD PUNCH - Device for punching holes in a card in accordance with a standard code.

CARD READER - Equipment for sensing and transmitting recorded instructions from a pattern of holes on a punched card.

CARD TO TAPE CONVERTER - A device which converts information directly from punched cards to punched or magnetic tape.

CARTESIAN CO-ORDINATES - Means whereby the position of a point can be defined with reference to a set of axes at right angles to each other.

CATHODE RAY TUBE (CRT) - A display device in which controlled electron beams are used to present alphanumeric or graphical data on a luminescent screen.

CENTRAL PROCESSING UNIT (CPU) - The portion of a computer system consisting of the arithmetic and control units and the working memory.

CHAD - Pieces of material removed in card or tape punching operation.

CHAD DETECTOR - A circuit built into a numerical control system to check for Chad in the holes of punched tape.

CHANNEL - A communication path.

CHARACTER - One of a set of symbols. The general term to include all symbols such as alphabetic letters, numerals, punctuation marks, mathematic operators, etc. Also, the coded representation of such symbols.

CHIP - A single piece of silicon which has been cut from a slice by scribing and breaking. It can contain one or more circuits but is packaged as a unit.

CIRCULAR INTERPOLATION - 1. Capability of generating up to 90 degrees of arc using one block of information as defined by EIA. 2. A mode of contouring control which uses the information contained in a single block to produce an arc of a circle.

CLDATA - Cutter location data.

CLEAR - To erase the contents of a storage device by replacing the contents with blanks or zeros.

CLEARANCE DISTANCE - The distance between the tool and the workpiece when the change is made from rapid approach to feed movement to avoid tool breakage.

CLFILE - Cutter location file (see CLDATA).

CLOCK - A device which generates periodic synchronization signals.

CLOSED LOOP - A signal path in which outputs are fed back for comparison with desired values to regulate system behaviour.

CNC - Computer (Computerized) Numerical Control - A numerical control system wherein a dedicated, stored programme computer is used to perform some or all of the basic numerical control functions.

COMMAND - An operative order which initiates a movement or a function.

COMPATIBILITY - The interchangeability of items.

COMPILER - A programme which translates from high-level problem-oriented computer languages to machine-oriented instructions.

COMPONENT - One of the parts of which an entity is composed.

COMPUTER - A device capable of accepting information in the form of signals or symbols, performing prescribed operations on the information, and providing results as outputs.

COMPUTER AIDED ENGINEERING (CAE) - The use of computing facilities in the integration of all aspects of design and manufacture to create an integrated engineering facility.

COMPUTER AIDED DESIGN (CAD) - A process which uses a computer in the creation or modification of a design.

COMPUTER AIDED MANUFACTURE (CAM) - A process which uses a computer in the management, control or operation of a manufacturing facility.

COMPUTER AIDED DESIGN/COMPUTER AIDED MANUFACTURE (CADCAM) - The integration of computer aided design with computer aided manufacture.

COMPUTER PART PROGRAMMING - The preparation of a part programme to obtain a machine programme using a computer and appropriate processor and part processor.

CONFIGURATION - The manner in which items are arranged.

CONTINUOUS PATH OPERATION - An operation in which rate and direction of relative movement of machine members is under continuous numerical control. There is no pause for data reading.

CONTOURING - An operation in which simultaneous control of more than one axis is accomplished.

CONTOURING CONTROL SYSTEM - An NC system for controlling a machine (milling, drafting, etc.) in a path resulting from the co-ordinated, simultaneous motion of 2 or more axes.

CONTROLLED PATH (Robots) - The straight line motion of a defined offset tool point between programmed points. All robot axes are interpolated through the programmed span.

CONTROL TAPE - A tape on which a machine programme is recorded.

CO-ORDINATE DIMENSIONING - A system of dimensioning based on a common starting point.

CO-ORDINATE DIMENSIONING WORD - 1. A word in a block of machining information that provides instruction for one of the machine's axes. 2. A word defining an absolute dimension.

CORE MEMORY - A high speed random access data storage device utilizing arrays of magnetic ferrite cores, usually employed as a working computer memory.

CORE RESIDENT - Pivotal programmes permanently stored in core memory for frequent execution.

COUNTER - A device or memory location whose value or contents can be incremented or decremented in response to an input signal.

CURSOR - Visual movable pointer used on a CRT by an operator to indicate where corrections or additions are to be made.

CUTTER DIAMETER COMPENSATION - A system in which the programmed path may be altered to allow for the difference between actual and programmed cutter diameters.

CUTTER OFFSET - 1. The distance from the part surface to the axial centre of a cutter. 2. An NC feature which allows an operator to use an oversized or undersized cutter.

CUTTER PATH - The path described by the centre of a cutter.

CYCLE - 1. A sequence of operations that is repeated regularly. 2. The time it takes for one such sequence to occur.

CYCLE TIME - The period required for a complete action. In particular, the interval required for a read and a write operation in working memory, usually taken as a measure of computer speed.

CYCLING CONTROL - A fundamental level machine control which programmes the machine through dial or plugboard input.

D

DAMPING - A characteristic built into electrical circuits and mechanical systems to prevent rapid or excessive corrections which might lead to instability or oscillatory conditions.

DATA - Facts or information prepared for processing by, or issued by, a computer.

DATA BASE - Comprehensive files of information having a specific structure such that they are suitable for communication, interpretation and processing by both human and automatic means.

DATA POINT - A programmed point which contains tool plant co-ordinate data and functional information.

DEAD BAND - The range through which an input can be varied without initiating response, usually expressed in percent of span.

DEAD TIME - The interval between initiation of a stimulus change and the start of the resulting response.

DEAD ZONE - A range of inputs for which no change in output occurs.

DEBUG - To detect, locate, and remove mistakes from computer software or hardware.

DECADE - A group of assembly of ten units.

DECADE SWITCHING - Use of a series of switches each with ten positions with values of 0 to 9, in which adjacent switches have a ratio of value of 10:1.

DECIMAL CODE - A code in which each allowable position has one of 10 possible states. (The conventional decimal number system is a decimal code.)

DECODER - A circuit arrangement which receives and converts digital information from one form to another.

DEDICATED - Devoted to a particular function or purpose.

DEVIATION - The error or difference between the instantaneous value of the controlled variable and the setpoint.

DIAGNOSTIC ROUTINE - A programme which locates malfunctions in hardware or software.

DIGITAL - Representation of data in discrete or numerical form.

DIGITAL COMPUTER - A computer that operates on symbols representing data, by performing arithmetic and logic operations.

DIGITAL-TO-ANALOG (D-A) CONVERSION - Production of an analog signal, whose instantaneous magnitude is proportional to the value of a digital input.

DIGITIZE - To obtain the digital representation of a measured quantity or continuous signal.

DIRECTOR - A term used to designate an NC control unit.

DESCRETE - State of being separate or distinct, as opposed to a continuously varying state or condition.

DISCRETE COMPONENT CIRCUIT - An electrical circuit, implemented with individual transistors, resistors, diodes, capacitors, or other components.

DISK - A device on which information is stored.

DISK MEMORY - A non-programmable, bulk storage, random access memory consisting of a magnetizable coating on one or both sides of a rotating thin circular plate.

DISPLAY - Lights, annunciators, numerical indicators, or other operator output devices at consoles or remote stations.

DISTRIBUTED COMPUTER NETWORK - A collection of computers which can communicate with each other.

DISTRIBUTED PROCESSING - The processing of information on a distributed computer network in such a manner as to improve the overall efficiency of the task.

DITHER - An electrical oscillatory signal of low amplitude and of a predetermined frequency imparted to a servo valve to keep the spool from sticking.

DNC - (Direct Numerical Control) Numerical control of machining or processing by a computer.

DOCUMENTATION - The group of techniques necessarily used to organize, present, and communicate recorded specialized knowledge.

DOUBLE PRECISION - The use of two computer words to represent a number.

DOWNTIME - The interval during which a device is inoperative.

DRIFT - An undesired change in output over a period of time, which is unrelated to input, operating conditions, or load.

DRIVER - A programme or routine that controls external peripheral devices or executes other programmes.

DUMP - To copy the present contents of a memory onto a printout or auxiliary storage.

DWELL - A timed delay of programmed or established duration, not cyclic or sequential, i.e., not an interlock or hold.

DYNAMIC GAIN - The magnitude ratio of a steady state output to a sinusoidal input signal.

E

EBCDIC - Extended binary coded decimal interchange code.

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EDIT - To modify a programme, or alter stored data prior to output.

EDITOR - A computer programme which provides the ability to edit.

EIA STANDARD CODE - Any one of the Electronics Industries Association standard codes for positioning, straight-cut, and contouring control systems.

ELECTROMAGNETIC INTERFERENCE (EMI) - Unwanted electrical energy or noise induced in the circuits of a device, due to the presence of electromagnetic fields.

EMULATOR - A device or programme which behaves like another system, and produces identical results.

ENCODER - An electromechanical transducer which produces a serial or parallel digital indication of mechanical angle or displacement.

END EFFECTOR (Robots) - The general term used to describe a gripper or other tool used on a robot.

END OF BLOCK CHARACTER - 1. A character indicating the end of a block of tape information. Used to stop the tape reader after a block has been read. 2. The typewriter function of the carriage return when preparing machine control tapes.

END OF PROGRAMME - A miscellaneous function (m02) indicating completion of a workpiece. (Stops spindle, coolant and feed after completion of all commands in the block. Used to reset control and/or machine.)

END OF TAPE - A miscellaneous function (m30) which stops spindle, coolant and feed after completion of all commands in the block. (Used to reset control and/or machine.)

END POINT - An extremity of a span.

ERROR - The difference between the indicated and desired values of a measured signal.

ERROR DETECTING - A data code in which each acceptable term conforms to certain rules, such that if transmission or processing errors occur, false results can be detected.

ERROR SIGNAL - Difference between the output and input signals in a servo system.

EXCLUSIVE OR - A logical operator, which has the property such that if X and Y are two logic variables, then the function is defined by the following table:

X	Y	Function
0	0	0
0	1	1
1	0	1
1	1	0

The logical operator is usually represented in electrical notation by an encircled plus sign '+'. There is no equivalent FORTRAN symbol.

EXECUTE - To carry out an instruction or to run a programme.

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EXECUTIVE - Software which controls the execution of programmes in the computer, based on established priorities and real-time or demand requirements.

EXTENDED ARITHMETIC ELEMENT - A CPU logic element, which provides hardware implemented multiply, divide, and normalize functions.

F

FEEDBACK - The signal or data fed back to a commanding unit from a controlled machine or process to denote its response to the command signal. The signal representing the difference between actual response and desired response that is used by the commanding unit to improve performance of the controlled machine or process.

FEEDBACK CONTROL - Action in which a measured variable is compared to its desired value, with a function of the resulting error signal used as a corrective command.

FEEDBACK DEVICE - An element of a control system which converts linear or rotary motion to an electrical signal for comparison to the input signal. E.g., resolver, encoder, inductosyn.

FEEDBACK LOOP - A closed signal path, in which outputs are compared with desired values to obtain corrective commands.

FEEDBACK RESOLUTION - The smallest increment of dimension that the feedback device can distinguish and reproduce as an electrical output.

FEEDBACK SIGNAL - The measurement signal indicating the value of a directly controlled variable, which is compared with a setpoint to generate a correction command.

FEED ENGAGE POINT - The point where the motion of the Z axis changes from rapid traverse to a programmed feed (usually referred to as the 'R' dimension).

FEEDFORWARD (ANTICIPATORY) CONTROL - Action in which information concerning upstream conditions is converted into corrective commands to minimize the effect of the disturbances.

FEED FUNCTION - The relative motion between the tool or instrument and the work due to motion of the programmed axis or axes.

FEEDRATE BY-PASS - A function directing the control system to ignore programmed feedrate and substitute selected operational rate.

FEEDRATE NUMBER - A coded number read from the tape which described the feedrate function. Usually denoted as the 'F' word.

FEEDRATE OVERRIDE - A variable manual control function directing the control system to reduce or increase the programmed feedrate.

FINAL CONTROL ELEMENT - A valve, motor, or other device which directly changes the value of the manipulated variable.

FIRMWARE - Programmes or instructions stored in read only memories.

FIRST GENERATION - 1. In the NC industry, the period of technology associated with vacuum tubes and stepping switches. 2. The period of technology in computer design utilizing vacuum tubes, electronics, off-line storage on drum or disc, and programming in machine language.

FIXED BLOCK FORMAT - A format in which the number and sequence of **words** and **characters** appearing in successive **blocks** is constant.

FIXED HEADS - Rigidly mounted reading and writing transducers on bulk memory devices.

FIXED SEQUENCE FORMAT - A means of identifying a word by its location in a block of information. Words must be presented in a specific order and all possible words preceding the last desired word must be present in the block.

FLIP FLOP - A bi-stable device. A device capable of assuming two stable states. A bi-stable device which may assume a given stable state depending upon the pulse history of one or more input points and having one or more output points. The device is capable of storing a bit of information; controlling gates; etc. A toggle.

FLOPPY DISK - A flexible disk used for storing information.

FLOW CHART - A graphical representation of a problem or system in which interconnected symbols are used to represent operations, data, flow, and equipment.

FLUIDICS - The technique of control that uses only a fluid as the controlling medium. All control is performed without moving elements.

FOREGROUND PROCESSING - Execution of real-time or high priority programmes, which can pre-empt the use of computing facilities.

FORMAT - The arrangement of data.

FORMAT CLASSIFICATION - A means, usually in an abbreviated notation, by which the motions, dimensional data, type of control system, number of digits, **auxiliary functions**, etc. for a particular system can be denoted.

FORMAT DETAIL - Describes specifically which words of what length are used by a specific system in the **format classification.**

FORTRAN - Acronym for Formula Translator, an algebraic procedure oriented computer language designed to solve arithmetic and logic programmes.

FOURTH GENERATION - In the NC industry, the change in technology of control logic to include computer architecture.

FREQUENCY RESPONSE ANALYSIS - A method of analyzing systems based on introducing cyclic inputs and measuring the resulting output at various frequencies.

FREQUENCY RESPONSE CHARACTERISTIC - The amplitude and phase relation between steady state sinusoidal inputs and the resulting sinusoidal outputs.

FULL DUPLEX - Allows the simultaneous transmission of information in both directions.

FULL PROPORTIONAL SERVO - A system with complete proportionality between output and input.

FULL RANGE FLOATING ZERO - A characteristic of a numerical machine tool control permitting the zero point on an axis to be shifted readily over a specified range. The control retains information on the location of 'permanent' zero.

G

G CODE - A word addressed by the letter G and followed by a numerical code defining preparatory functions or cycle types in a numerical control system.

GAIN - The ratio of the magnitude of the output of a system with respect to that of the input (the conditions of operation and measurements must be specified, e.g., voltage, current or power).

GATE - A device which blocks or passes a signal depending on the presence or absence of specified input signals.

GAUGE HEIGHT - A predetermined partial retraction point along the Z axis to which the cutter retreats from time to time to allow safe X-Y table travel.

GENERAL PURPOSE COMPUTER - A computer designed and capable of carrying out a wide range of tasks.

GENERAL PURPOSE PROCESSOR - A computer programme which carries out computations on the part programme and prepares the author location data for a particular part without reference to machines on which it might be made.

GRAPHICS - The use of a computer to interactively create a drawing displayed on a terminal.

GRAY CODE - A binary code, in which successive values differ in one place only.

GROUP TECHNOLOGY - The grouping of machines and of parts based on similarities in production requirements such that the parts may be produced more efficiently.

H

HALF DUPLEX - Allows the transmission of information one way at a time.

HARD COPY - Any form of computer produced printed document. Also, sometimes punched cards or paper tape.

HARDWARE - Physical equipment.

HEAD - A device, usually a small electromagnet on a storage medium such as magnetic tape or a magnetic drum, that reads, records, or erases information on that medium. The block assembly and perforating or reading fingers used for punching or reading holes in paper tape.

HOLLERITH - A 12 bit code used for recording characters in punched paper cards.

HOUSEKEEPING - The general organisation of programmes stored to ensure efficient system response.

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HYSTERESIS - The difference between the response of a system to increasing and decreasing signals.

I

IEEE - Institute of Electrical and Electronic Engineers.

IC - Integrated circuit.

INCREMENTAL DIMENSION - A dimension expressed with respect to the preceding point in a sequence of points.

INCREMENTAL FEED - A manual or automatic input of preset motion command for a machine axis.

INCREMENTAL PROGRAMMING - Programming using words indicating incremental dimensions.

INCREMENTAL SYSTEM - Control system in which each co-ordinate or positional dimension is taken from the last position.

INDEXING - Movement of one axis at a time to a precise point from numeric commands.

INDUCTOSYN SCALE - A precision data element for the accurate measurement and control of angles or linear distances, utilizing the inductive coupling between conductors separated by a small air gap.

INHIBIT - To prevent an action or acceptance of data by applying an appropriate signal to the appropriate input.

INITIALIZE - To cause a programme or hardware circuit to return a programme, a system, or a hardware device to an original state or to selected points with a computer programme.

INPUT - A dependent variable applied to a control unit or system.

INPUT RESOLUTION - The smallest increment of dimension that can be programmed as input to the system.

INSTABILITY - The state of property of a system where there is an output for which there is not corresponding input.

INSTRUCTION - A statement that specifies an operation and the values or locations of its operands.

INSTRUCTION SET - The list of machine language instructions which a computer can perform.

INTEGRATED CIRCUIT (IC) - A combination of interconnected passive and active circuit elements incorporated on a continuous substrate.

INTEGRATOR - A device which integrates an input signal, usually with respect to time.

INTELLIGENT TERMINAL - A terminal which has its own local processing power.

INTERACTIVE GRAPHICS - Ability to carry out graphics tasks with immediate response from the computer.

INTERFACE - 1. A hardware component or circuit for linking two pieces of electrical equipment having separate functions. E.g., tape reader to data processor or control system to machine. 2. A hardware component or circuit for linking the computer to external I/O device.

INTERFEROMETER - An instrument that uses light interference phenomena for determination of wavelength, spectral fine structure, indices of refraction, and very small linear displacements.

INTERLOCK - To arrange the control of machines or devices so that their operation is interdependent in order to assure their proper co-ordination.

INTERLOCK BY-PASS - A command to temporarily circumvent a normally provided interlock.

INTERPOLATION - 1. The insertion of intermediate information based on assumed order or computation. 2. A function of a control whereby data points are generated between given co-ordinate positions to allow simultaneous movement of two or more axes of motion in a defined geometric pattern. E.g., linear, circular and parabolic.

INTERPOLATOR - A device which is part of a numerical control system and performs interpolation.

INTERRUPT - A break in the execution of a sequential programme or routine, to permit processing of high priority data.

I/O - (Input/Output) Input or output or both.

ITERATION - A set of repetitive computations, in which the output of each step is the input to the next step.

J

JCL - Job control programme.

JOB - An amount of work to be completed.

JOG - A control function which provides for the momentary operation of a drive for the purpose of accomplishing a small movement of the driven machine.

K

KEYBOARD - The keys of a teletype-writer which have the capability of transmitting information to a computer but not receiving information.

L

LAG - Delay caused by conditions such as capacitance, inertia, resistance or dead time.

LANGUAGE - A set of representations and rules used to convey information.

LAYOUT - A visual representation of a complete physical entity usually to scale.

LEVEL - 1. Formerly a channel of punched tape. 2. The average amplitude of a variable quantity applying particularly to sound or electronic signals expressed in decibels, volts, amperes, or watts. 3. The degree of subordination in a hierarchy.

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LIGHT PEN - A photo sensing device similar to an ordinary fountain pen which is used to instruct CRT displays by means of light sensing optics.

LINEAR INTERPOLATION - A function of a control whereby data points are generated between given co-ordinate positions to allow simultaneous movement of two or more axes of motion in a linear (straight line) path.

LINE PRINTER - A printing device that can print an entire line of characters all at once.

LINKAGE - A means of communicating information from one routine to another.

LOCKOUT SWITCH - A switch provided with a memory, which protects the contents of designated segments from alteration.

LOG - A detailed record of actions for a period of time.

LOG OFF - The completion of a terminal session.

LOG ON - The beginning of a terminal session.

LOGIC - 1. Electronic devices used to govern a particular sequence of operations in a given system. 2. Interrelation or sequence of facts or events when seen as inevitable or predictable.

LOGIC LEVEL - The voltage magnitude associated with signal pulses representing ONES and ZEROS in binary computation.

LOOP TAPE - A short piece of tape, containing a complete programme of operation, with the ends joined.

LSI - Large Scale Integration - A large number of interconnected integrated circuits manufactured simultaneously on a single slice of semi-conductor material (usually over 100 gates or basic circuits, with at least 500 circuit elements).

M

MACHINE LANGUAGE - A language written in a series of bits which are understandable by, and therefore instruct, a computer. The 'first level' computer language, as compared to a 'second level' assembly language or a 'third level' compiler language.

MACHINE PROGRAMME - an ordered set of instructions in automatic control language and format recorded on appropriate input media and sufficiently complete to effect the direct operation of an automatic control system.

MACHINING CENTRE - A machine tool, usually numerically controlled, capable of automatically drilling, reaming, tapping, milling and boring multiple faces of a part and often equipped with a system for automatically changing cutting tools.

MACRO - A source language instruction from which many machine language instructions can be generated (see compiler language).

MAGNETIC CORE - An element for switching or storing information on magnetic memory elements for later use by a computer.

MAGNETIC CORE STORAGE - The process of storing information on magnet memory elements for later use by a computer.

MAGNETIC DISK STORAGE - a storage device or system consisting of magnetically coated metal disks.

MAIN FRAME - See central processing unit.

MANUAL DATA INPUT (MDI) - A means of inserting data manually into the control system.

MANUAL FEEDRATE OVERRIDE - Device enabling operator to reduce or increase the feedrate.

MANUAL PART PROGRAMMING - The manual preparation of a manuscript in machine control language and format to define a sequence of commands for use on an NC machine.

MANUSCRIPT - Form used by a part programmer for listing detailed manual or computer part programming instructions.

MEMORY - A device or media used to store information in a form that can be understood by the computer hardware.

MEMORY BULK - Any non-programmable large memory, i.e., drum, disk.

MEMORY CYCLE TIME - The minimum time between two successive data accesses from a memory.

MEMORY PROTECT - A technique of protecting stored data from alteration, using a guard bit to inhibit the execution of any modification instruction.

MANAGEMENT INFORMATION SERVICE (MIS) - An information feedback system from the machine to management and implemented by a computer.

MICROPROCESSOR - A single integrated circuit which forms the basic element of a computer.

MICROPROGRAMMING - A programming technique in which multiple instruction operations can be combined for greater speed and more efficient memory use.

MICROSECOND - One millionth of a second.

MILLISECOND - One thousandth of a second.

MISCELLANEOUS FUNCTION - An off-on function of a machine such as Clamp or Coolant on. (See Auxiliary Function.)

MINEMONIC - An alphanumeric designation, designed to aid in remembering a memory location or computer operation.

MODEM - A contraction of modulator demodulator. The term may be used with two different meanings: 1. The modulator and the demodulator of a modem are associated at the same end of a circuit. 2. The modulator and the demodulator of a modem are associated at the opposite ends of a circuit to form a channel.

MODULE - An independent unit which may be used on its own or in conjunction with other units to form a complete entity.

MONITOR - A device used for observing or testing the operations of a system.

MOVABLE HEADS - Reading and writing transducers on bulk memory devices which can be positioned over the data locations.

MSI - Medium Scale Integration. (See LSI.) Smaller than LSI, but having at least 12 gates or basic circuits with at least 100 circuit elements.

MULTIPLEXER - A hardware device which handles multiple signals over a single channel.

N

NAND - A combination of the Boolean logic functions NOT and AND.

NAND GATE - A component which implements the NAND function.

NANOSECOND - One thousandth of one microsecond.

NEGATIVE LOGIC - Logic in which the micro negative voltage represents the one (1) state; the less negative voltage represents the zero (0) state.

NIXIE LIGHT OR TUBE - A glow lamp which converts a combination of electrical impulses into a visible number.

NOISE - An extraneous signal in an electrical circuit capable of interfering with the desired signal. Loosely, any disturbance tending to interfere with the normal operation of a device or system.

NOR GATE - A component which implements the NOR function.

NOT - a logic operator having property that if P is a logic quantity then quantity 'NOT P' assumes values as defined in the following table:

P	NOT P
0	1
1	0

The NOT operator is represented in electrical notation by an overline, e.g. $\overline{P}$ and in FORTRAN by a minus sign '-' in a Boolean expression.

NUMERICAL CONTROL (NC) - A technique of operating machine tools or similar equipment, in which motion is developed in response to numerically coded commands.

NUMERICAL DATA - Data in which information is expressed by a set of numbers that can only assume discrete values.

O

OBJECT PROGRAMME - The coded output of an assembler or compiler.

OCTAL - A characteristic of a system in which there are eight elements, such as a numbering system with a radix of eight.

OFF-LINE - Operating software or hardware not under the direct control of a central processor, or operations performed while a computer is not monitoring or controlling processes or equipment.

OFFSET - The steady state deviation of the controlled variable from a fixed setpoint.

ON-LINE - A condition in which equipment or programmes are under direct control of a central processor.

ONE - One of the two symbols normally employed in binary arithmetic and logic, indicating binary one and the true condition, respectively.

OPEN LOOP - A signal path without feedback.

OPEN LOOP SYSTEM - A control system that has no means of comparing the output with the input for control purposes (no feedback).

OPERATING SYSTEM - Software which controls the execution of computer programmes and the movement of information between peripheral devices.

OPTIMIZATION - A process whose object is to make one or more variables, assume in the best possible manner, the value best suited to the operation in hand dependent on the values of certain other variables which may be either predetermined or sensed during the operation.

OPTIMIZE - To establish control parameters which maximize or minimize the value of performance.

OPTIONAL STOP - A Miscellaneous Function command similar to 'Program Stop' except that the control ignores the command unless the operator has previously pushed a button to validate the command. (m01).

OR - A logic operator having the property that if P and Q are logic quantities then the quantity 'P or Q' assumes values as defined by the following table:

P	Q	P OR Q
0	0	0
0	1	1
1	0	1
1	1	1

The OR operator is represented in both electrical and FORTRAN terminology by a '+', i.e., P + Q.

OR GATE - A device which implements the OR function.

ORIENTATION (Robots) - The angular position of the wrist axes.

OUTPUT - Dependent variable signal produced by a transmitter, control unit or other device.

OUTPUT IMPEDANCE - The impedance presented by a device to the load.

OUTPUT SIGNAL - A signal delivered by a device, element, or system.

OVERLAY - A technique of repeatedly using the same area of computer store when actioning different stages of a problem.

OVERSHOOT - The amount that a controlled variable exceeds its desired value after a change of input.

P

PARABOLA - A plane curve generated by a point moving so that its distance from a fixed second point is equal to its distance from a fixed line.

PARABOLIC INTERPOLATION - Control of cutter path by interpolation between three (3) fixed points by assuming the intermediate points are on a parabola.

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PARALLEL - The simultaneous transfer and processing of all bits in a unit of information.

PARAMETER - A characteristic of a system or device, the value of which serves to distinguish various specific states.

PARITY CHECK - A test of whether the number of ONES or ZEROS in an array of binary digits is odd or even to detect errors in a group of bits.

PART PROGRAMME - An ordered set of instructions in a language and in a format required to cause operations to be effected under automatic control, which is either written in the form of a machine programme on an input media or prepared as input data for processing in a computer to obtain a machine programme.

PART PROGRAMMER - A person who prepares the planned sequence of events for the operation of a numerically controlled machine tool.

PASSWORD - A word the operator must supply in order to meet the security requirements and gain access to the computer.

PATCH - Temporary coding used to correct or alter a routine.

PERIPHERAL - Auxiliary equipment used for entering data into or receiving data from a computer.

PERIPHERAL EQUIPMENT - The auxiliary machines and storage devices which may be placed under control of the central computer and may be used on-line or off-line. E.g., card reader and punches, magnetic tape feeds, high speed printers, CRTs and magnetic drums or discs.

PICOSECOND - One millionth of one microsecond.

PITCH (Robots) - A rotation of the payload or tool about a horizontal axis on the end of a robot arm which is perpendicular to the longitudinal axis of the arm.

PLANNING SHEET - A list of operations for the manufacture of a part, prepared before the part programme.

PLOTTER - A device used to make a drawing of a display.

POINT-TO-POINT CONTROL SYSTEM - An NC system which controls motion only to reach a given end point but exercises no path control during the transition from one end point to the next.

POLAR AXES - The fixed lines from which the angles made by radius vectors are measured in a polar co-ordinates system.

POLAR CO-ORDINATES - A mathematical system for locating a point in a plane by the length of its radius vector and the angle this vector makes with a fixed line.

POSITION SENSOR - A device for measuring a position, and converting this measurement into a form convenient for transmission.

POSITION STORAGE - The storage media in an NC system containing the co-ordinate positions read from tape.

POSITION READOUT - A display of absolute slide position as derived from a position feedback device (transducer usually) normally attached to the lead screw of the machine. (See Command Readout.)

POSITIVE LOGIC - Logic in which the more positive voltage represents the one (1) state.

POST-PROCESSOR - A computer programme which adapts the output of a processor into a machine programme for the production of a part on a particular combination of machine tool and controller.

PRECISION - The degree of discrimination with which a quantity is stated, e.g., a three-digit numeral discriminates among 1000 possibilities. Precision is contrasted with accuracy, i.e., a quantity expressed with 10 decimal digits of precision may only have one digit of accuracy.

PREPARATORY FUNCTION - An NC command on the input tape changing the mode of operation of the control. (Generally noted at the beginning of a block by 'G' plus two digits.)

PREPROCESSOR - A computer programme which prepares information for processing.

PREVENTATIVE MAINTENANCE - Maintenance specifically designed to identify potential faults before they occur.

PRINTED CIRCUIT - A circuit for electronic components made by depositing conductive material in continuous paths from terminal to terminal on an insulating surface.

PROCESSOR - A computer programme which processes information.

PROGRAMME - A plan for the solution of a problem. A complete programme includes plans for the transcription of data, coding for the computer, and plans for the absorption of the results into the system. The list of coded instructions is called a routine. To plan a computation or process from the asking of a question to the delivery of the results, including the integration of the operation into an existing system. Thus, programming consists of planning and coding, including numerical analysis, systems analysis, specification of printing formats, and any other functions necessary to the integration of a computer in a system.

PROGRAMMABLE - Capable of being set to operate in a specified manner, or of accepting remote setpoint or other commands.

PROGRAMMED ACCELERATION - A controlled velocity increase to the programmed feedrate of an NC machine.

PROGRAMMED DWELL - The capability of commanding delays in programme execution for a programmable length of time.

PROGRAMME STOP - A **Miscellaneous Function** (m00) command to stop the spindle coolant and feed after completion of the dimensional move commanded in the **block**. To continue with the remainder of the programme, the operator must initiate a restart.

PROTOCOL - Set of rules governing message exchange between two devices.

PUNCHED CARD - A piece of lightweight cardboard on which information is represented by holes punched in specific positions.

PUNCHED PAPER TAPE - A strip of paper on which characters are represented by combinations of holes.

PULSE - A short duration change in the level of a variable.

Q

QUADRANT - Any of the four parts into which a plane is divided by rectangular co-ordinant axes lying in that plane.

QUADRATURE - Displaced 90 degrees in phase angle.

R

R DIMENSION - (See Feed Engage Point.)

RANDOM ACCESS MEMORY (RAM) - A storage unit in which direct access is provided to information, independent of memory location.

RASTER DISPLAY - A display in which the entire display surface is scanned at a constant refresh rate.

RASTER SCAN - Line-by-line sweep across the entire display surface to generate elements of a display image.

READ - to acquire data from a source. To copy, usually from one form of storage to another, particularly from external or secondary storage to internal storage. To sense the meaning of arrangements of hardware. To sense the presence of information on a recording medium.

READER - A device capable of sensing information stored in an off-line memory media (cards, paper tape, magnetic tape) and generating equivalent information in an on-line memory device (register, memory locations).

READ ONLY MEMORY (ROM) - A storage device generally used for control programme, whose content is not alterable by normal operating procedures.

REAL TIME CLOCK - The circuitry which maintains time for use in programme execution and event initiation.

REAL TIME OPERATION - Computer monitoring, control or processing functions performed at a rate compatible with the operation of physical equipment or processes.

REFERENCE BLOCK - A block within an NC programme identified by an 'O' or 'H' in place of the word address 'N' and containing sufficient data to enable resumption of the programme following an interruption. (This block should be located at a convenient point in the programme which enables the operator to reset and resume operation.)

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REFRESH - CRT display technology which requires continuous restroking of the display image.

RELOCATABLE POINT/SEQUENCE OF POINT (Robots) - A point or sequence in a robot which can be relocated in space.

REPAINT - Redraws a display on a CRT to reflect its current status.

REPEATABILITY - The closeness of agreement among multiple measurements of an output, for the same value of the measured signal under the same operating conditions, approaching from same direction, for full range traverses.

REPRODUCTIBILITY - The closeness of agreement among repeated measurements of the output for the same value of input, made under the same operating conditions over a period of time, approaching from either direction.

RESOLUTION - 1. The smallest distinguishable increment into which a signal or picture, etc. is divided in a device or system. 2. The minimum positioning motion which can be specified.

RESOLVER - 1. A mechanical to electrical transducer (see Transducer) whose input is a vector quantity and whose outputs are components of the vector. 2. A transformer whose coupling may be varied by rotating one set of windings relative to another. It consists of a stator and rotor, each having two distributed windings 90 electrical degrees apart.

RETROFIT - Work done to an existing machine tool from simply adding special jigs or fixtures to the complete re-engineering and manufacturing, and often involving the addition of a numerical control system.

ROBOT - An automatic device which performs functions ordinarily ascribed to human beings.

ROLL (Robots) - A rotation of the payload or tool about the longitudinal axis of the wrist.

ROUTINE - A series of computer instructions which performs a specified task.

RUN - The execution of a programme on a computer.

S

SAMPLE AND HOLD - A circuit used to increase the interval during which a sampled signal is available, by maintaining an output equal to the most recent input sample.

SAMPLES DATA - Data in which the information content can be, or is, ascertained only at discrete intervals of time. (Can be analog or digital.)

SAMPLING PERIOD - The interval between observations in a periodic sampling control system.

SCALE - To change a quantity by a given factor, to bring its range within prescribed limits.

SCALE FACTOR - A coefficient used to multiply or divide quantities in order to convert them to a given magnitude.

SCANNER - The equipment used to digitize co-ordinate information from a master and convert it to punched tape for later recreation of the master shape on an NC machine.

SCHEDULE - A programme or timetable of planned events or of work.

SECOND GENERATION - 1. In the NC industry, the period of technology associated with transistors (solid state). 2. The period of technology in computer design utilizing solid state circuits, off-line storage, and significant development in software, the assembler.

SECURITY - Prevention of unauthorized access to information or programmes.

SENSITIVITY - The ratio of a change in steady state output to the corresponding change of input, often measured in percent of span.

SENSOR - A unit which is actuated by a physical quantity and which gives a signal representing the value of what physical quantity.

SEQUENCE (Robots) - Part of a robot programme which consists of a point or series of points the performance of which will be dependent on defined input/flag conditions existing.

SEQUENCE CONTROL - A system of control in which a series of machine movements occurs in a devised order, the completion of one movement initiating the next, and in which the extent of the movements is not specified by numeric data.

SEQUENCE NUMBER - A number identifying the relative location of blocks or groups of blocks on a tape.

SEQUENCE READOUT - A display of the number of the block of tape being read by the tape reader.

SERIAL - The transfer and processing of each bit in a unit of information, one at a time.

SERVO AMPLIFIER - The part of the servo system which increases the error signal and provides the power to drive the machine slides or the servo valve controlling a hydraulic drive.

SETPOINT - The position established by an operator as the starting point for the programme on an NC machine.

SIGN - The symbol or bit which distinguishes positive from negative numbers.

SIGNAL - Information conveyed between points in a transmission or control system, usually as a continuous variable.

SIGNIFICANT DIGIT - A digit than contributes to the precision of a numeral. The number of significant digits is counted beginning with the digit contributing the most value, called the most significant digit, and ending with the one contributing the least value, called the least significant digit.

SIMULATOR - A device or computer programme that performs simulation.

SKEWING - Refers to time delay or offset between any two signals in relation to each other.

SOFTWARE - The collection of programmes, routines, and documents associated with a computer.

SOURCE IMPEDANCE - The impedance presented to the input of a device by the source.

SOURCE LANGUAGE - The symbolic language comprising statements and formulas used to specify computer processing. It is translated into object language by an assembler or compiler, and is more powerful than an assembly language in that it translates one statement into many items (see macro).

STABILITY - Freedom from undesirable deviation, used as a measure of process controllability.

STANDBY POWER SUPPLY - An energy generation or storage system, that can permit equipment to operate temporarily or shut down in an orderly manner.

STATIC GAIN - The ratio of steady state output to input change.

STEADY STATE - A characteristic or condition exhibiting only negligible change over an arbitrarily long period of time.

STEPPING MOTOR - A bi-directional permanent magnet motor which turns in finite steps.

STEP RESPONSE - The time response of an instrument subjected to an instantaneous change in input.

STEP RESPONSE TIME - The time required for an element output to change from an initial value to a specified percentage of a steady state, either before or in the absence of overshoot, after an input step change.

STORAGE - A memory device in which data can be entered and held, and from which it can be retrieved.

STORAGE TUBE - A CRT which retains an image for a considerable period of time without redrawing.

STRAIGHT CUT SYSTEM - A system which has feedrate control only along the axes and can control cutting action only along a path parallel to the linear (or circular) machine ways.

STYLUS - A hand-held device by which co-ordinate information may be input to a display unit.

SUB PROGRAMME - A segment of a machine programme which can be called into effect by the appropriate machine control command.

SUBROUTINE - A series of computer instructions to perform a specific task for many other routines. It is distinguishable from a main routine in that it requires, as one of its parameters, a location specifying where to return to the main programme after its function has been accomplished.

SUMMING POINT - A point at which signals are added algebraically.

SYNCHRO - A transformer having a polyphase primary winding and single phase secondary winding which can be rotated. The voltage induced into the secondary may be controlled in phase by turning the secondary coil.

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W

WINDUP – Lost motion in a mechanical system which is proportional to the force or torque applied.

WIRE-FRAME – A 3-dimensional drawing created by the projection of the points of intersection of the geometry.

WORD ADDRESS FORMAT – Addressing each word in a block by one or more characters which identify the meaning of the word.

WORD LENGTH – The number of bits or characters in a word.

WORLD CO-ORDINATES (Robots) – The co-ordinate system by which a point in space is defined in three cartesian co-ordinates and three orientation or polar co-ordinates.

WRIST (Robots) – The element of a robot which applies orientation to a tool.

X

X AXIS – Axis of motion that is always horizontal and parallel to the word-holding surface.

Y

Y AXIS – Axis of motion that is perpendicular to both the X and Z axes.

YAW (Robots) – A rotation of a payload or tool about a vertical axis that is perpendicular to the pitch axis of the wrist.

Z

Z AXIS – Axis of motion that is always parallel to the principle spindle of the machine.

ZERO – One of the two symbols normally employed in binary arithmetic and logic, indicating the value zero and the false condition, respectively.

ZERO OFFSET – A characteristic of a numerical machine tool control permitting the zero point on an axis to be shifted readily over a specified range. (The control retains information on the location of the 'permanent' zero.)

ZERO SHIFT – A characteristic of a numerical machine tool control permitting the zero point on an axis to be shifted readily over a specified range. (The control does **not** retain information on the location of the 'permanent' zero.)

ZERO SUPPRESSION – The elimination of non-significant zeros to the left of significant digits usually before printing.

ZERO SYNCHRONIZATION – Z technique which permits automatic recovery of a precise position after the machine axis has been approximately positioned by manual control.