

PART 1 OF MACHINE AND CONTROLLER.

1. The controller, modes, clearing memory, line numbers, shift key.
2. Axes and HOME position.
3. The SET UP position. (or REF. position)
4. Z MAX and Z CLEAR
5. The PROBE - entering probe thickness to controller.
6. Program structure
 1. START KEY
 2. TOOL DIAMETER
 3. FEEDRATE KEY
 4. SET UP KEY
 5. END KEYEnter mode
7. Running a simple program
8. SET UP in RUN MODE

1. THE CONTROLLER

The controller is simply a device that stores instructions, up to 900 of them and when asked to, will start to execute them sequentially. Most of these instructions are tool moves, some are instructions to the controller and some are functions which execute a variety of complex moves to save the user the effort to figure them out. A PROGRAM is just a sequence of instructions. All the instructions are single keystrokes on the controller.

You can see the current instruction through the alphanumeric display. The display may ask questions (?) and you have to answer with the YES or NO keys or it may indicate by nnn or nn or n that it needs a numeric value. In some cases the entry is obviously numeric so no prompting is involved. You tell the controller by touching the NEXT key that the entry was finished. The first three numbers on the display usually indicate the LINE NUMBER. It starts at 000, 001, 002,..... and continues up to 900. A program can begin on any line number but in the examples that follow we start at line 000.

You will notice four keys at the top left side next to the display with lights beside each key. These we call MODE keys. Selection of one tells the controller what you want to do. The light will come on. The modes are :

- 1) PROGRAM ENTER. This is for entering instructions to make a program.
- 2) PROGRAM RUN. After entering a program, locate the line number at the start of the program and go into the program run mode. The controller will start executing the instructions.
- 3) LINE NO. Allows the entry of line number - you can't alter the line number in program enter mode. It allows also line insertion, deletion program, clearing and RS232C communications.
- 4) MANUAL. Used for manual control of the machine, entering probe height, measuring tool offsets and machine diagnostics.

To explain how this particular mode, keystroke or function works we use a simple flowchart. They are usually self evident as the choice is dictated by the YES/NO key and the exit by the NEXT key or a MODE key.

EXAMPLE 1

When you have just switched a new machine on, answered yes to ready and it has initialized, it is best to clear all the 900 lines in the memory.

At MODE? press LINE NO. (a mode key), press CLEAR and the display will show CLEAR MEMORY? Press the YES key.

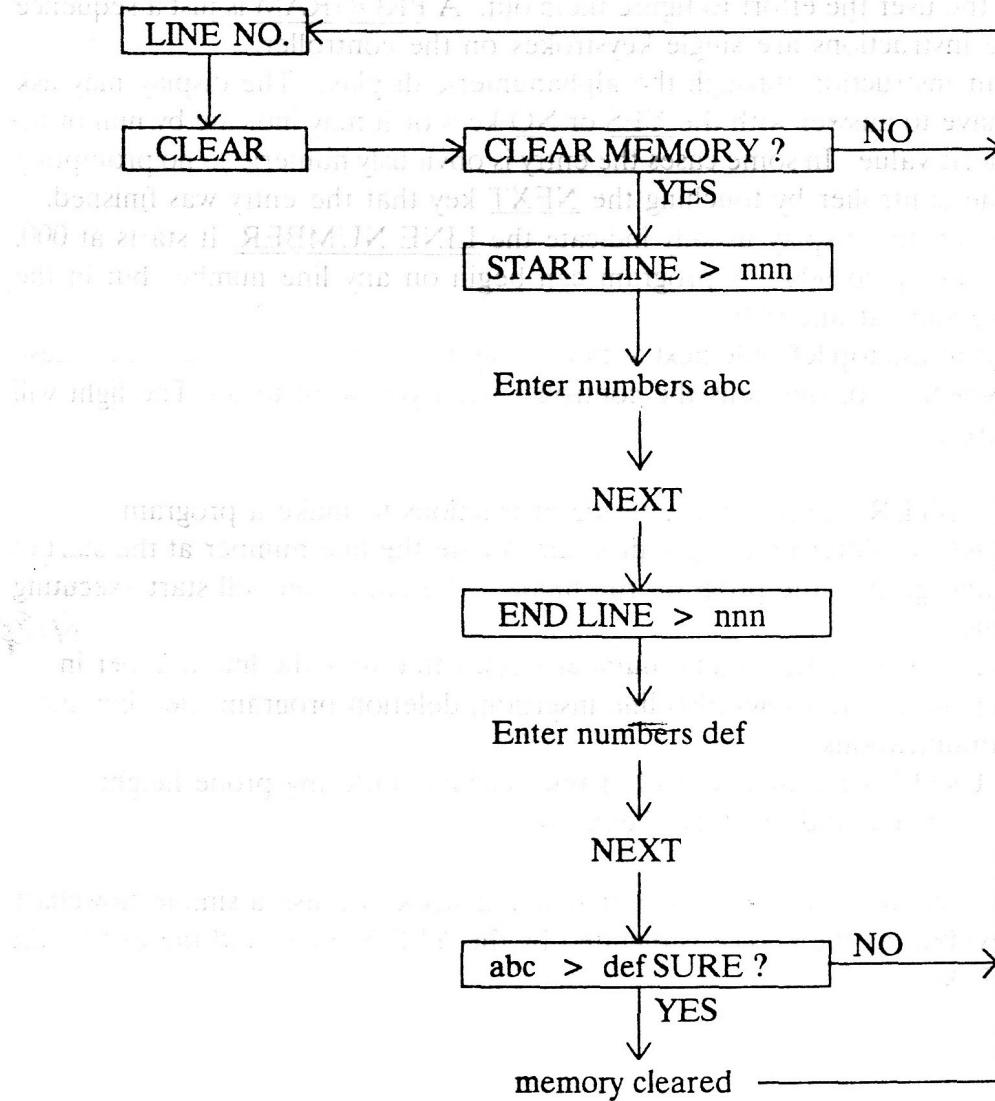
The display will show START LINE > nnn. Enter 0,0,0 then press the NEXT key.

The display will then show END LINE > nnn. Enter 9,0,0 then press the NEXT key.

The display will then show 000 > 900 SURE?, press the YES key and line numbers 000 to 900 will be cleared.

We can re-write this as a flowchart:

CLEARING MEMORY (OR A PROGRAM) IN THE CONTROLLER



EXAMPLE 2

SELECTING A LINE NUMBER

You want to enter a program at line number 100 and run it. Do this:

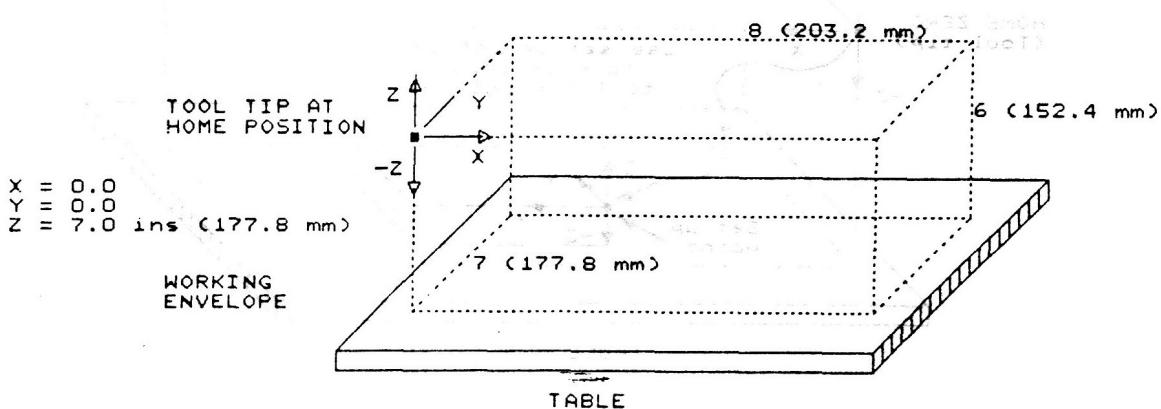
LINE NO (MODE KEY)	enter 1, 0, 0 (NUMBER KEYS)	PROGRAM ENTER (MODE KEY)
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You are now ready to enter a program at line 100. If the program ends at 122 you have to go back (previous key, 22 times) or go to LINE NO mode, enter 100, then press PROGRAM RUN to run it.

The SHIFT key is at the bottom on the left column. It is actually a shift down key to access the blue keys existing underneath the horizontal line on some of the keys. The light will come on when touched. All the functions are located here. Once the key is pressed the shift down is cancelled.

2. AXES AND HOME POSITION

When the machine has initialized to the limit switches it is at its HOME position. You will see that the spindle head will go up to the top and the table will position itself such that the lower left side is underneath the center of the spindle. We can put an axes here with the origin at the tool tip, like so :



IN ALL MOVEMENTS you consider the TOOL TIP AS MOVING, NOT THE AXES.

You can see that the only movement possible on Z is a negative downwards move. X and Y moves can only be positive. The size of the box - the work envelope is fixed in X and Y. It is the maximum travel on these axes. The Z side of the box depends on the length of the tool. Be careful, with a long tool, the work envelope box can go UNDER the table. The U AXIS refers to the rotary table option. There is no home position for it.

To exercise the machine on each axis - over the envelope, see if you can enter this program at line 000 in program enter mode.

000 **START** INS 00 Use the START KEY - answer YES to INCHES.
Enter 0,0 for program number.

001 **FR** **X Y Z** 30 Use the FEED RATE KEY enter xyz then 3,0
002 **GO** c **X** 8 Use Go ABS KEY with axis & COMEBACK key

003 **GO** c **Y** 6

004 **GO** c **Z** 0

005 **SKIP TO** 002

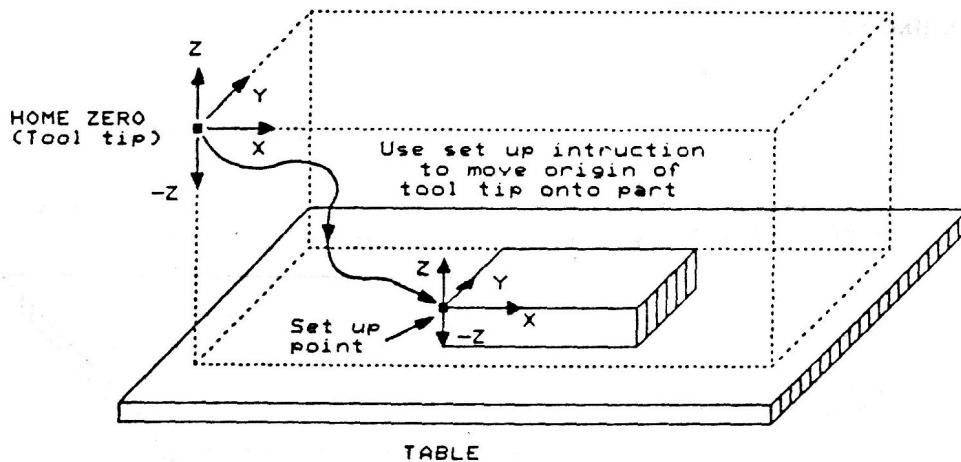
You will skip back to line 002

Answer NO twice to get END.

Go to program run with display to 000. To stop hit HALT key, to continue, hit the NEXT key.

3. SET UP POINT

Trying to machine a part from the HOME POSITION would be somewhat painful in calculating all the distances involved so what we do is to move the origin by means of the SET UP instruction. This instruction is put into the program before we begin cutting the part. When the controller starts running the program it will stop and allow the user to move the tool tip by means of jogging in each axis (or to slowly run each axis to the probe). This SET UP point becomes the origin for subsequent moves. Usually the choice of SET UP point will correspond to the point on the drawing where all the measurements are taken. So we have :-

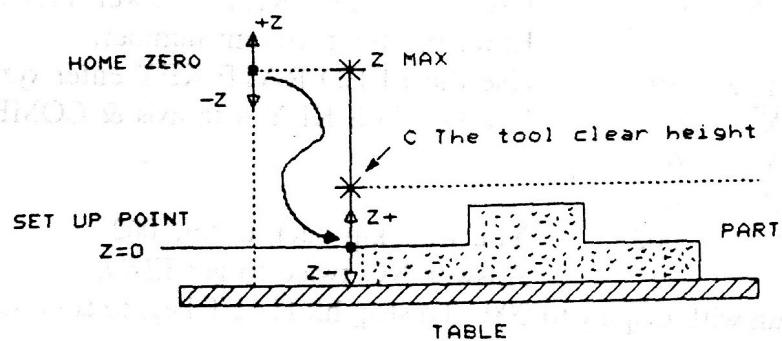


If the part is to be cut out of a block then X and Y set up points need not be accurate - only Z really matters.

This SET UP point is sometimes called the REFERENCE ZERO and the axes the REFERENCE COORDINATES. (as on a drawing). All the functions are referenced to this SET UP point.

4. C OR Z CLEAR

During the SET UP of X Y Z you will also have to set up C. It is simply the height of the tool above Z = 0 (the set up point) which will clear the part completely so you can move X and Y anywhere across the part. If you don't set this point C it will default to Z max, that is the spindle goes to the top at home zero.



There is one key that has 2 instructions on it

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Z ---> Z CLEAR The display shows
Z ---> Z MAX

Z > C
Z > Z MAX
the **Z = C** point or **Z MAX** point.

When run these will move the tool tip vertically up to the Z = C point or Z MAX point.

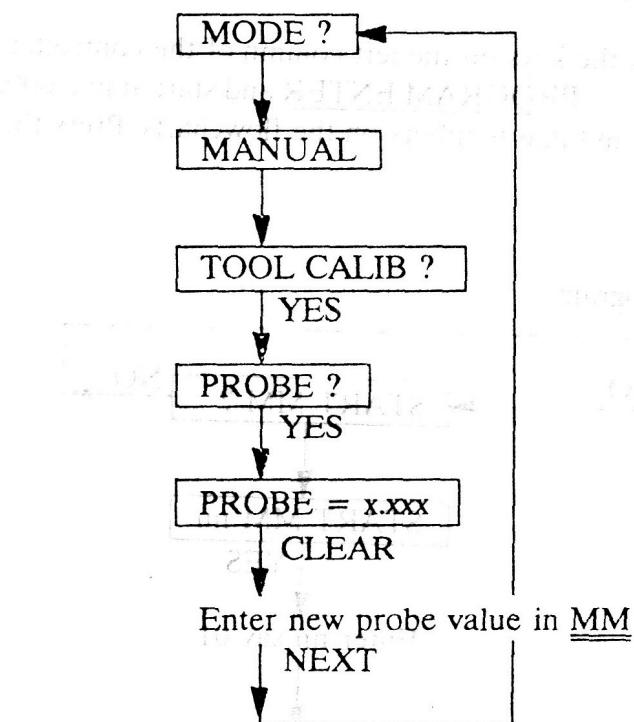
5. THE PROBE

An electronic probe is recommended to find the Z reference position and to measure the Z offsets of several tools.

It is clearly difficult to position the tool accurately on the surface of the part and if the tool has to be centered exactly on the lower left corner of the part the situation is even more difficult. It is also clearly difficult to measure the Z offsets of several tools (i.e. the height difference) if they are to be used in one program. The procedure to measure this is called TOOL CALIBRATION.

That is why the probe is required. It detects the tool electronically and stops the appropriate axis at the correct value. It has its own offset or height which must be measured in MM or in inches and multiplied by 25.4 .

This value is entered into the controller as follows:



The old values should be cleared out and the new measurement put in.
The probe is now ready to be used. It is plugged in at the right side of the machine.

6. PROGRAM STRUCTURE

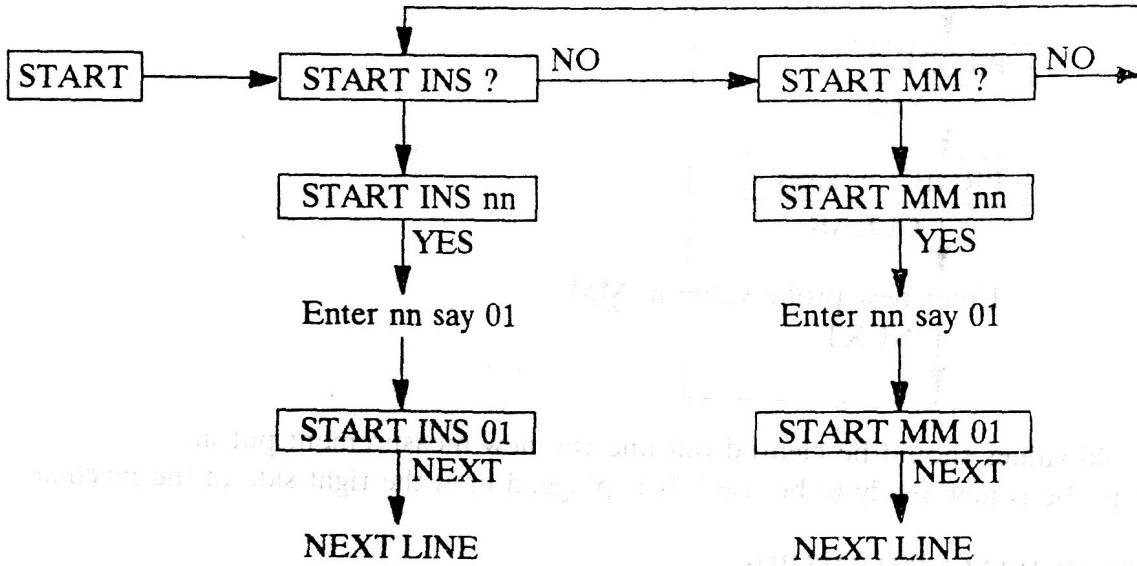
A program to machine a part must consist of three sections and a typical program will look like this:

LINE NO	INSTRUCTION	Comments
START SECTION	000 START INS 01 001 TD = .125 002 FR XYZ = 10.0 003 SET UP > zcxyu	This section contain all of the required machine parameters such as, program no., dimension system, tool diameter, feed rates, and set up instruction.
MIDDLE SECTION	004 GO X 1.0000 005 GO Y 1.0000 006 GO Z -0.1250 007 GO Y 2.0000 008 GO X 3.0000 009 GO Y 1.0000 010 GO X 1.0000 011 Z > C	This section contains instructions for machine moves, zero-ing coordinates and functions.
END SECTION	012 END NEWPART	This section contains either the END instruction or variations of the END instructions to allow the user to replicate or repeat the program.

You will see that the first four instructions follow the keys on the left column of the controller. The END instruction is also there. On MODE? go to PROGRAM ENTER and start at line 000. We will go into detail on these instructions. We omit line numbers on the flowcharts. Press the keys and try the options.

START INSTRUCTION (START KEY)

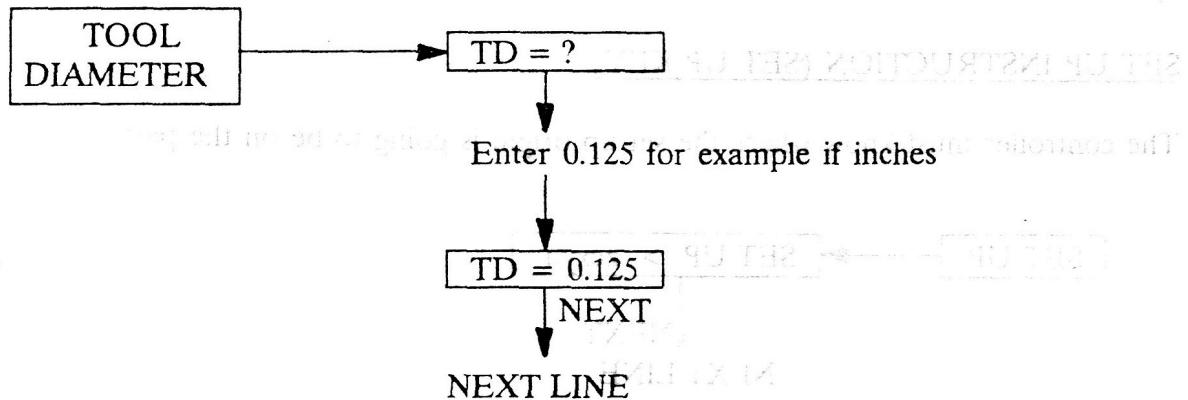
Must always be at the beginning of a program



- 1) The entire program must either be in INCHES or METRIC using one of two ways off. (I METRIC has 3 numbers after the decimal point)
- 2) nn is a program ID number. It can be 00, 01, 02....99 and is strictly a user convenience.
- 3) At any time CLEAR will clear out this instruction

TOOL DIAMETER INSTRUCTION (TOOL DIAMETER KEY)

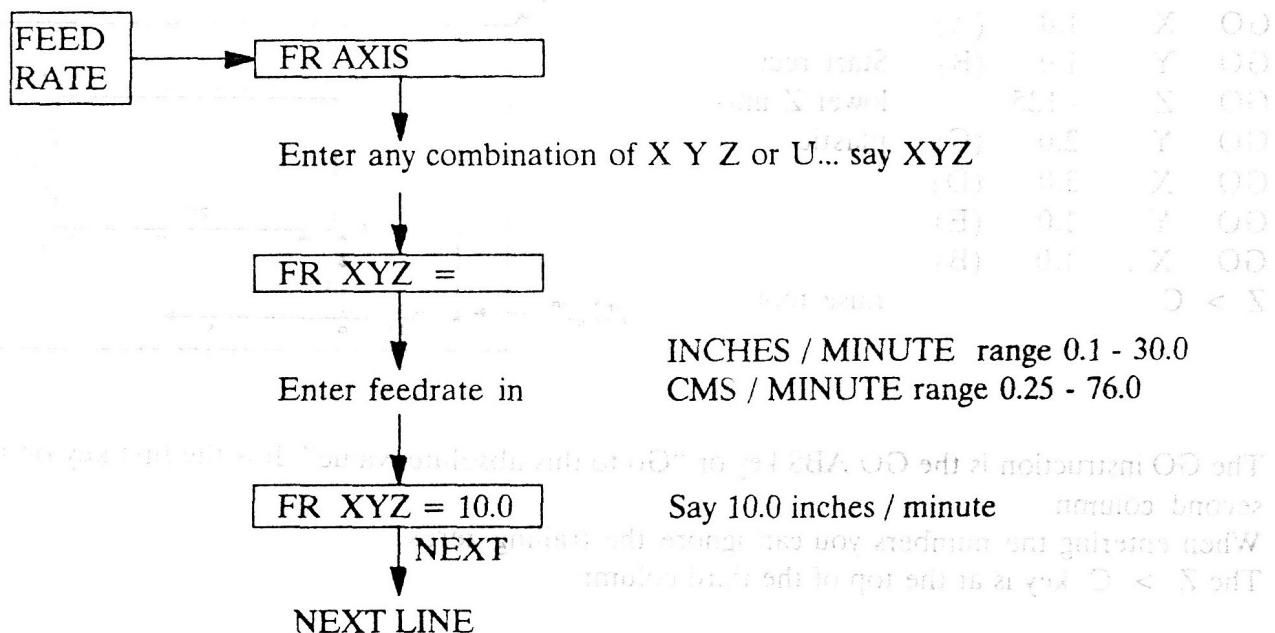
The controller must know the tool diameter (except when drilling).



- 1) For each subsequent TOOL CHANGE you must enter a new tool diameter.
- 2) If START is in metric, the diameter has to be in metric, if inches then the diameter is in inches as well.
- 3) Again the CLEAR key will clear out this instruction.

FEED RATE INSTRUCTION (FEEDRATE KEY)

The controller needs to know how fast you want to go.



INCLES / MINUTE range 0.1 - 30.0
CMS / MINUTE range 0.25 - 76.0

Say 10.0 inches / minute

- 1) The axis can be any group out of XYZU.
- 2) For ultra slow movement you can enter 0.05 INS/MIN only or 0.13 CM / MIN only.
- 3) If no feed rate is specified the default is 8 INS/MIN or 20.3 CM/MIN.
- 4) The leading zero must be entered for fractional speeds.
- 5) This instruction can be entered as many times as required.
- 6) It is customary to go slower on Z for tool entry into the work, so you can have 2 instructions.

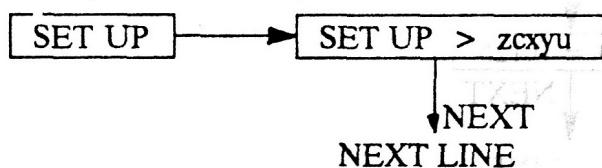
002 FR XY = 10.0
003 FR Z = 2.0

for example.

- 7) Use CLEAR to clear this instruction.

SET UP INSTRUCTION (SET UP KEY)

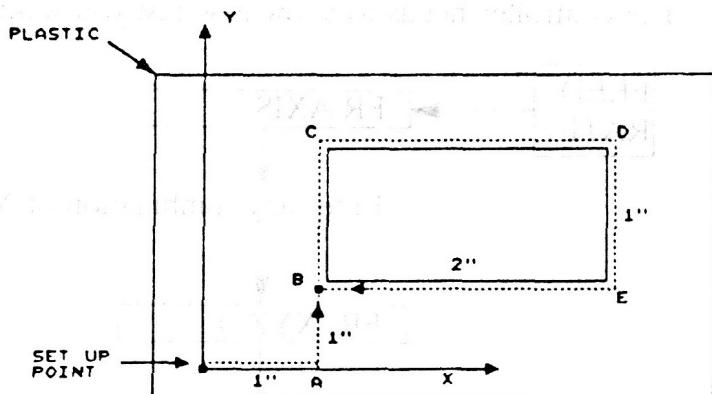
The controller must know where the set up origin is going to be on the part.



You simply enter this instruction in PROGRAM ENTER MODE. It only becomes operational in PROGRAM RUN MODE when you are ready to cut the part. The controller will start looking at the jog keys and the probe at this instruction.

After this instruction we have the move instructions or pre-programmed functions, tool changes etc. or a mixture. These will be covered in the following section but we can easily try entering these instructions to cut a simple rectangle on 1/4" thick acrylic with a 1/8" tool. Let us move the tool as follows :

GO X 1.0 (A)	
GO Y 1.0 (B)	Start rect.
GO Z -.125	lower Z into
GO Y 2.0 (C)	plastic
GO X 3.0 (D)	
GO Y 1.0 (E)	
GO X 1.0 (B)	
Z > C	raise tool



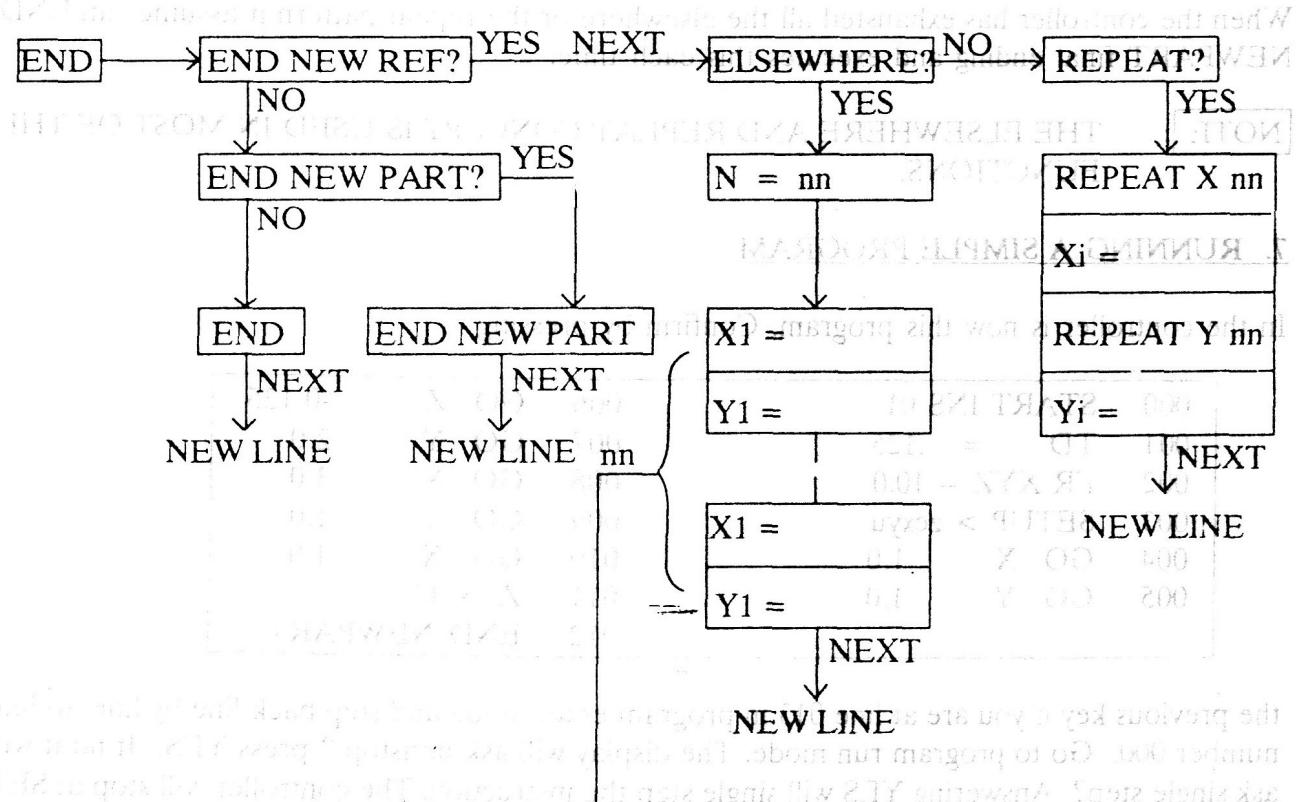
The GO instruction is the GO ABS key or "Go to this absolute value". It is the first key on the second column.

When entering the numbers you can ignore the trailing zeros.

The Z > C key is at the top of the third column.

END INSTRUCTION (END KEY)

All programs must end with this instruction and it has several variations that allow repetitive production (END NEWPART), repeat of the entire program (END NEW REF) either at random or in a periodic way in X and Y.



COORDINATES OF nn TEMPORARY
NEW SET UP POINTS WITH RESPECT
TO THE FIRST SET UP

1) END This is the simplest (press NO key twice). When the controller executes this, the tool will return to the home position, Z up first, then X and Y. Touch any mode key to exit from program run mode. The display will stay at this instruction. To re-run go back to program start. The SET UP location is not stored so you will have to re - setup.

2) END NEWPART To "re - run" choose this ending (press NO,YES). When executed by the controller, the tool will go home, Z > Z MAX first, then X Y to home. It will check its position at home and the tool will then move in X and Y out to the original SET UP point in X and Y. The controller goes back to the SET UP instruction in the program.

The user can then insert a fresh part, press NEXT and the program will recycle or he can change temporarily (for this cycle) the SET UP position which will revert back to the original position on the next cycle.

3) END NEW REF The program can be replicated on the same work piece in two ways assuming that Z (=0) and Z CLEAR remain constant.

- a) ELSEWHERE** Here you enter nn (how many temporary new set up points you require all referenced from the original set up position) followed by the nn X and Y pairs of coordinates.
- b) REPEAT** The X nn is how many times along X and xi = the interval distance. Likewise for Y.

When the controller has exhausted all the elsewhere or the repeat pattern it assumes an END NEWPART final ending and executes this each time.

NOTE : THE ELSEWHERE AND REPEAT CONCEPT IS USED IN MOST OF THE FUNCTIONS.

7. RUNNING A SIMPLE PROGRAM

In the controller is now this program. Confirm by pressing

000	START INS 01	006	GO Z	-0.125
001	TD = .125	007	GO Y	2.0
002	FR XYZ = 10.0	008	GO X	3.0
003	SETUP > zcxu	009	GO Y	1.0
004	GO X 1.0	010	GO X	1.0
005	GO Y 1.0	011	Z > C	
		012	END NEWPART	

the previous key if you are at line 013 in program enter mode and step back line by line, to line number 000. Go to program run mode. The display will ask nonstop? press YES. If no it will ask single step? Answering YES will single step the instruction. The controller will stop at SET UP.

8. SET UP IN RUN MODE

The instruction is SET UP > zcxu and the controller is waiting for your input. Press NO and the display will cycle one step, press again and again the axes will cycle. This is the selection process for choice of axis. Thus two NO's will give SET UP > xyuzc.

The jog keys now move the tool along the X axis. They are marked on the controller. The top two are for continuous jog, press to start, press to stop. The bottom two $\Delta \uparrow, \Delta \downarrow$ increment .001" (.025 MM) or decrement the same amount at each key press.

Select a point on the part and move the tool to it along the X axis. Press the key SET UP REF. The x goes to big X indicating that you have SET SETUP on X. Press NO and do likewise for the tool along the y axis. Since there is no u axis (the rotary table), press NO again so the arrow is pointing at z c X Y u. Place the probe on the part and press for Z to come down on continuous jog. The tool tip should come down on the probe's circular button, go in, back out then come down very slowly to touch. The display will go from z to Z showing that Z SET UP has been set. The controller adds in the probe thickness to get the final Z set up point. Slide out the probe.

To set Z clear or C, press NO so the arrow points at c. Jog up on Z until the tool tip clears the part, then press SET UP REF key. Small c will go to big C.

At any time you can clear the set up point on an axis by touching the CLEAR key. It will de-capitalize the axis. Once capitalized you can still jog back and forth on this axis - the set up point is remembered. You can use the probe for set up by continuously jogging the tool diameter to the probe tip with the probe lying vertically against the workpiece, provided the controller knows the tool diameter.

Do not crash the tool in continuous jog. You will have to re-run the program from the beginning.

At any time during set up you can display the coordinate from the HOME position by pressing the DISPLAY key. Obviously you can precede the SET UP instruction with GO X and GO Y with these displayed values so the tool will move to the SET UP coordinates in X and Y and you will only have to SET UP z and c. You still have to capitalize X and Y. If you don't capitalize then the controller will default to the HOME position.

Once NEXT is pressed the controller will de-capitalize the letters but it will still remember the set up positions. Make sure the spindle is running before pressing NEXT. Usually SPINDLE ON/OFF instruction is added after SET UP but for the moment since the spindle is in LOCAL you have to turn it off and on.

As soon as the controller reaches END NEWPART, Z will go to Z max, X and Y will go HOME and return to the SET UP position. Check that the display shows the SET UP instruction. Change the part then press the NEXT key to re-cycle.