

ProtoTRAK® Plus

Programming, Operating & Service Manual

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1.0 Introduction

Congratulations! Your ProtoTRAK is a unique, one-of-a-kind, control system which combines the simplicity of manual machining with the contouring capability of CNC controls.

The ProtoTRAK has been designed to maximize the interplay between manual and automatic machining.

- o It acts like an advanced digital readout in manual machine operation.
- o It acts like a CNC when programmed to do complex contouring jobs.
- o And it acts with the best qualities of each when your job is best done by transitioning back and forth between manual and contouring CNC operations with the powerful DO ONE routines.

Section 2 provides a brief description of the ProtoTRAK.

Section 3 defines some terms and concepts useful in learning to program and operate the ProtoTRAK.

Section 4 describes the digital readout (DRO), jog, and power feed operation of the ProtoTRAK.

Section 5 describes general programming and program run.

Section 6 describes programming and running DO ONE routines.

Section 7 describes the Math Help features built into the ProtoTRAK.

Section 8 provides some suggestions for the proper care and maintenance as well as error messages.

2.0 Description

2.1 Keyboard (Figure 1)

All of the data required to properly program and operate the ProtoTRAK is input through the keyboard. This sealed polycarbonate front panel/keyboard will beep when proper contact has been made with each key.

X, Y, Z: selects axis for subsequent commands.

DO ONE: calls up single cycle routines.

POSN DRILL: calls up the position/drill routine.

BOLT HOLE: calls up bolt hole routine.

MILL: calls up the straight line mill routine.

ARC: calls up the arc mill routine.

CIRCLE: calls up circular pocket or frame routines.

REPEAT: calls up programming of subroutines.

POCKET: calls up rectangular pocket or frame routines.

START: initiates the start of a program or DO ONE.

PWR FEED: activates power feed routines.

FEED[↑]: feedrate override to increase feedrate.

FEED[↓]: feedrate override to decrease feedrate.

INC SET: loads incremental dimensions and general data.

ABS SET: loads absolute dimensions and general data.

IN/MM: causes English to Metric or Metric to English conversion of displayed data.

TAPE/RS232: calls up read or write cassette tape program storage and CAD/CAM interface routines.

INC/ABS: switches all or one axis from incremental readout to absolute or absolute to incremental.

RESTORE: clears an entry, aborts a keying procedure, restores a failure or warning indication, and aborts Math Help.

STOP: halts motion during program or DO ONE run.

GO: continues motion after STOP, actuates jog routine.

MATH HELP: calls up Math Help routines.

EDIT: calls up recall, add event, delete event, and special mode routines.

RECALL DATA: cycles readout through programmed data.

*** :** not used.

0-9, +/-, . : inputs numeric data with floating point format. Data is automatically + unless +/- key is pressed. All input data automatically rounded to the system's resolution.

2.2 Displays (Figure 1)

X, Y, Z: shows current position or data being entered during program or DO ONE input. Non-dimensional program or DO ONE input will always be displayed in Z. A red dot above the +/- display indicates absolute dimensions are being displayed.

EVENT: shows event number and type being programmed or run. D indicates a position/drill event; B for Bolt Hole; M for Mill; A for Arc; R for Repeat, C for Circle, and P for Pocket.

CONVERSATION: shows prompting messages for the operation during program and run.

SERVOS ON: indicates that the DC servo motors and amplifiers are turned on.

IN POSITION: indicates that the table/saddle have stopped moving and the ProtoTRAK awaits further input.

2.3 Pendant Back Panel (Figure 2)

See Figure 2 for a description of the fuses, switches, and connectors on the pendant back panel.

2.4 Power Control Cabinet (Figure 3)

The power control cabinet contains the unique SWI digital servo amplifiers which drive the DC servo motors. See Figure 3 for a description of the connectors located on the side.

2.5 Encoders

The encoders used to provide direct table and quill position feedback to the ProtoTRAK are sealed against typical shop environments and utilize the time proven gage-wheel principal. Model M250C is used all axes.

2.6 Servo Motors

The servo motors are rated 280 in-oz maximum continuous torque which are sufficient for the heaviest cuts.

2.7 Ball Screw Assembly

The normal acme leadscrews are replaced with zero backlash ball bearing leadscrews to provide accurate positioning and precise contouring.

2.8 Tape Cassette Deck (optional)

The cassette deck allows all programs to be saved on tape for future run. The deck is held in a separate enclosure which can be easily moved from one ProtoTRAK to another or used with a TRAK CNC or TRAK CNC 2.

Additional tapes may be obtained by contacting:

Southwestern Industries, Inc.
2605 Homestead Place
Rancho Dominguez, CA 90220
213/608-4422 FAX 213/764-2668

PENDANT FRONT PANEL

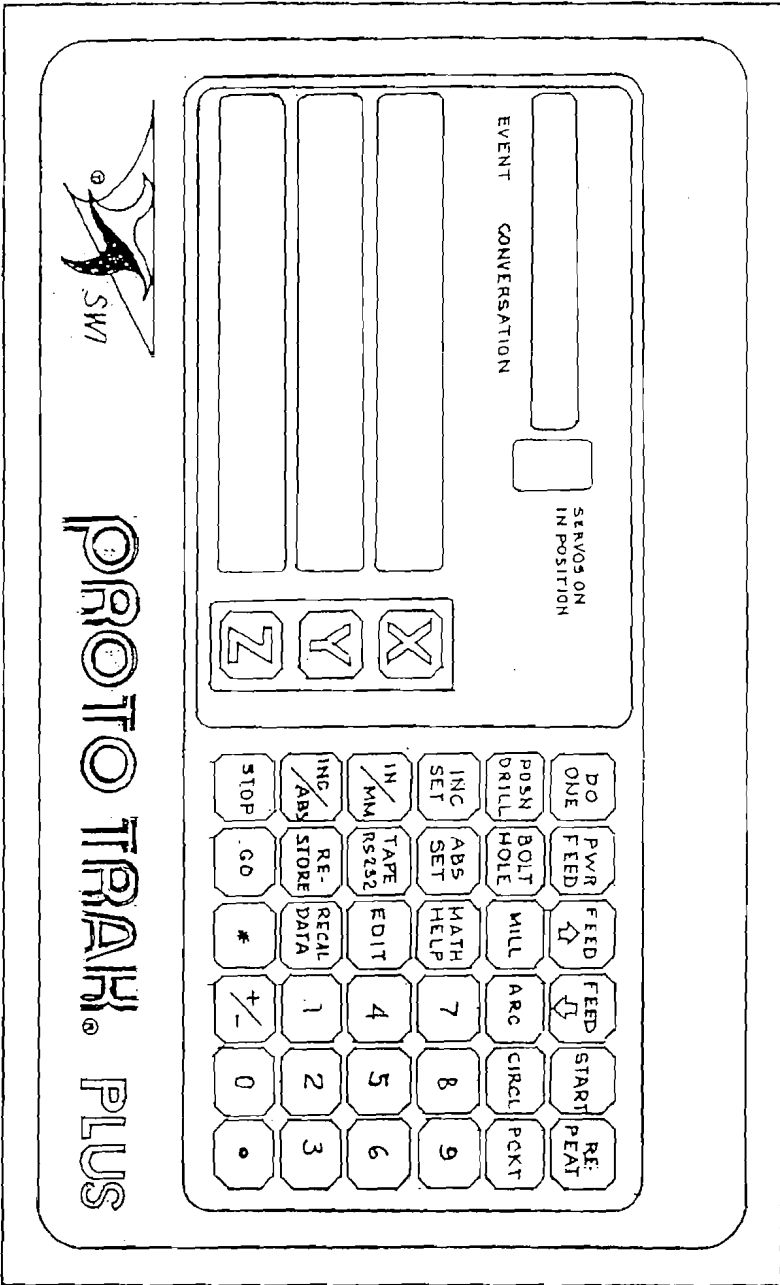


FIGURE 1

PENDANT BACK PANEL
(Rear View)

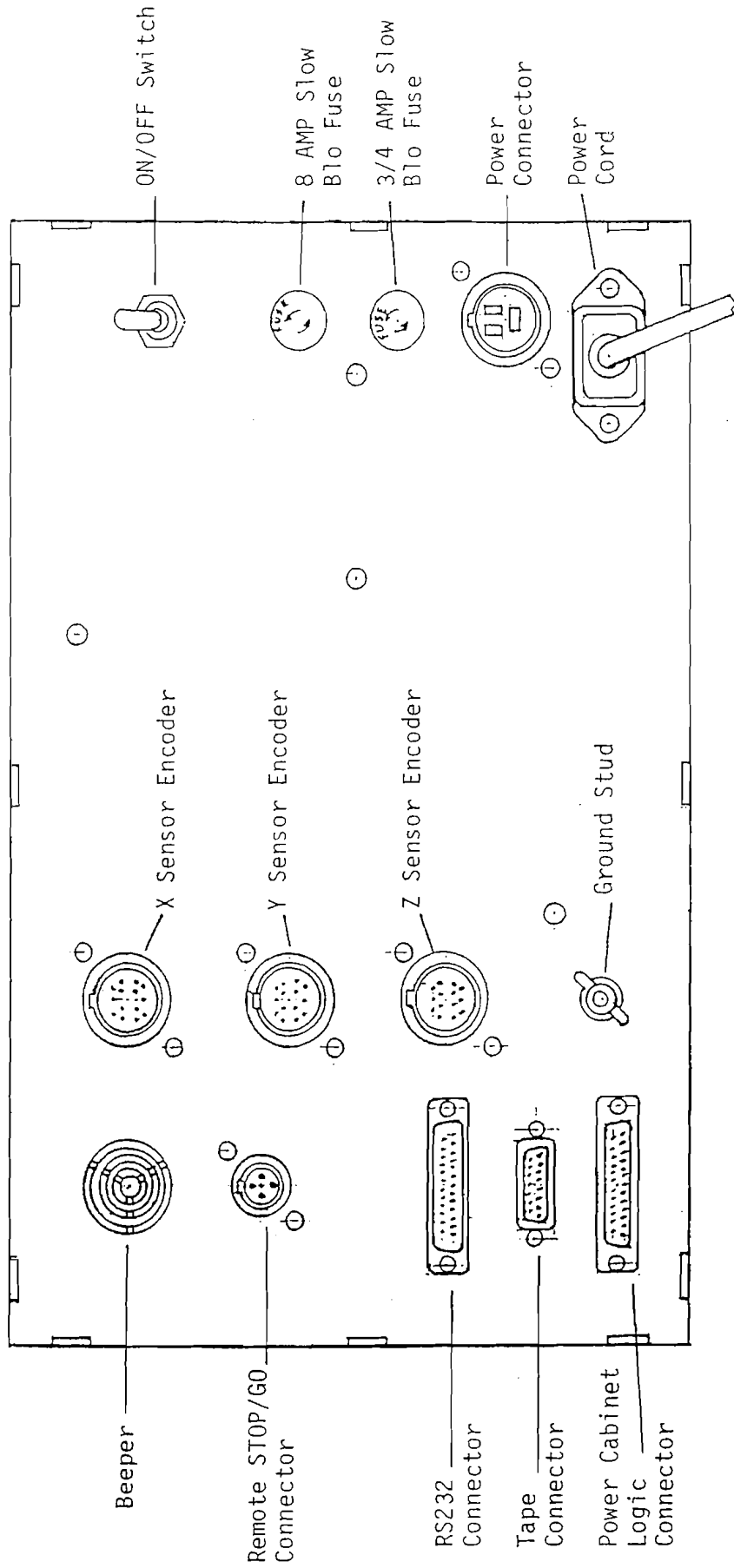


FIGURE 2

POWER CONTROL CABINET (Side View)

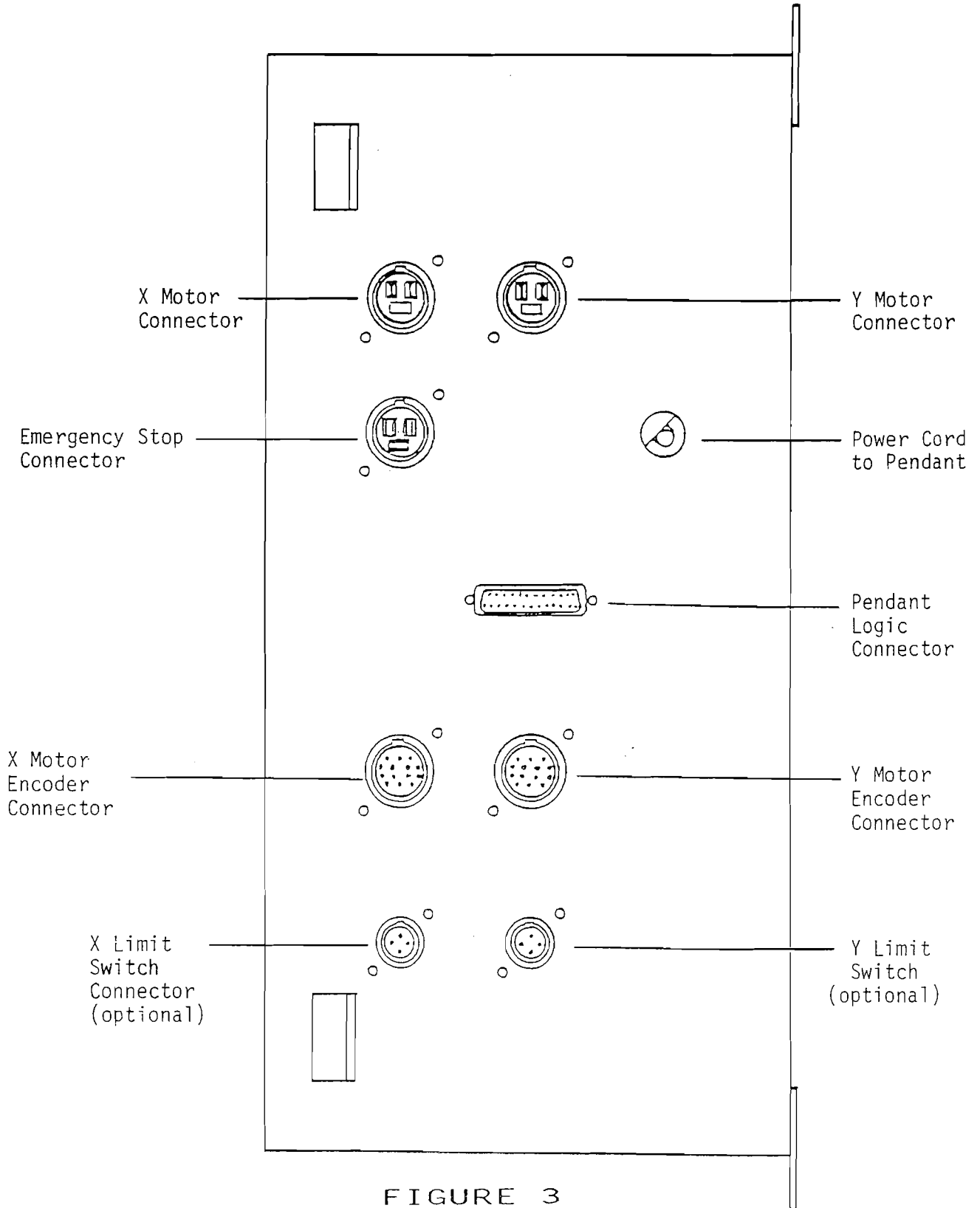


FIGURE 3

3.0 Definitions, Terms, and Concepts

3.1 ProtoTRAK Axis Conventions

X Axis - Positive X axis motion is defined as the table moving to the left when facing the mill. Consequently, measurement to the right is positive on the workpiece.

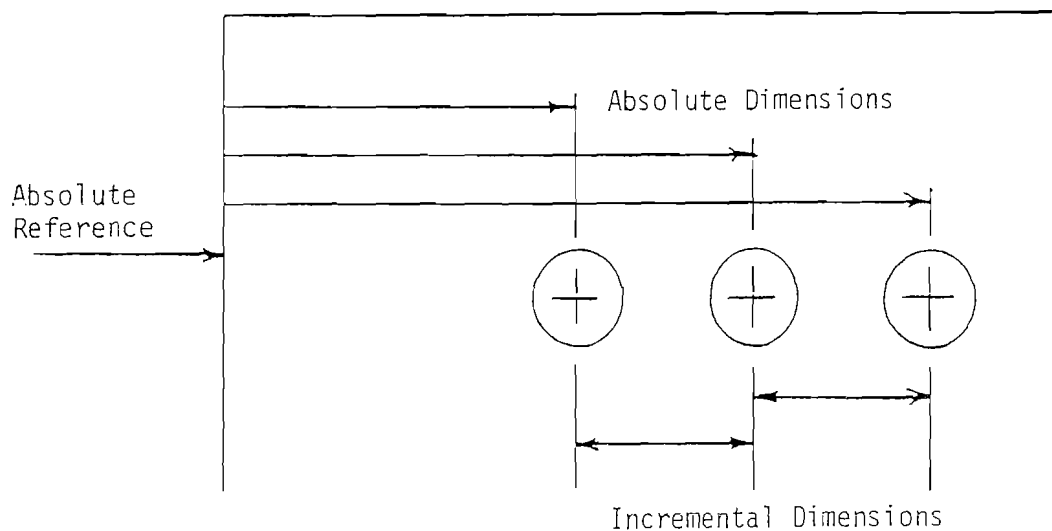
Y Axis - Positive Y axis motion is defined as the table moving toward the operator. Measurement toward the machine (away from operator) is positive on the workpiece.

Z Axis - Positive Z axis motion is defined as moving the quill up. Measurement up is also positive on the workpiece.

3.2 Absolute & Incremental Reference

The ProtoTRAK may be programmed and operated in either (or in a combination) of absolute or incremental dimensions. An absolute reference from which all absolute dimensions are measured (in DRO, DO ONE and program operation) can be set at any point on or even off the workpiece.

To help understand the difference between absolute and incremental position consider the example below:

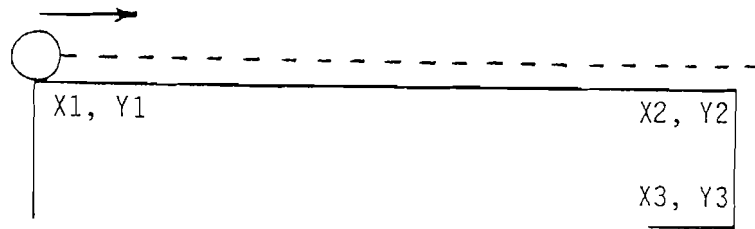


3.3 Referenced and Non-Referenced Data

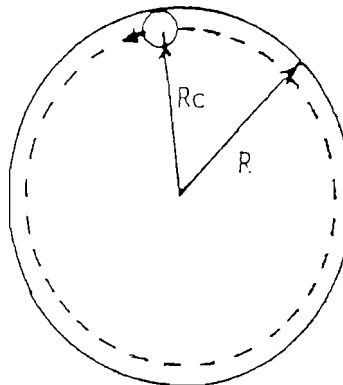
Data is always loaded into the ProtoTRAK by using the INC SET or ABS SET key. In entering any X, Y, or Z position data the operator must note whether it is an incremental or absolute dimension and enter it accordingly. All other information, such as tool diameter, feedrate, etc. is not a position and may, therefore, be loaded with either the INC SET or ABS SET key.

3.4 Tool Diameter Compensation

Tool diameter compensation allows the machined edges shown directly on the print to be programmed instead of the center of the tool. The ProtoTRAK then automatically compensates for the programmed geometry so that the desired results are obtained.

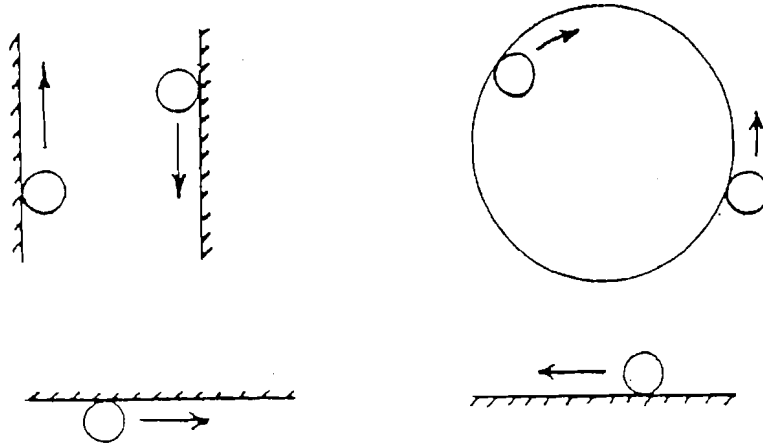


If the cutter in the sketch above is moving from left to right from point X_1, Y_1 to X_2, Y_2 and on to X_3, Y_3 then these actual points can be programmed instead of the center of the cutter.

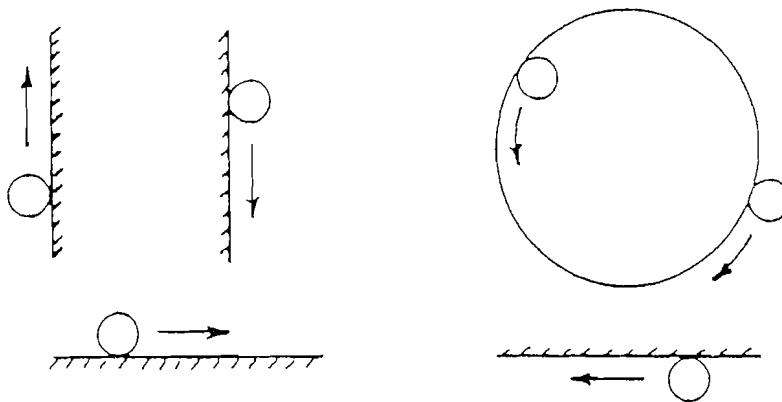


Or for the sketch above the actual desired circle with radius R can be programmed instead of the radius of the center at the cutter R_c .

Tool cutter compensation is always specified as the tool either right or left of the workpiece while looking in the direction of the tool motion. Below are examples of tool right:



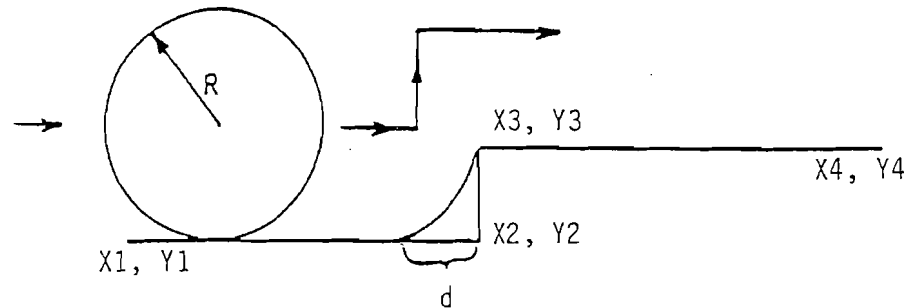
Examples of tool left are:



Tool center means no compensation either right or left. That is, the centerline of the tool will be moved to the programmed points.

3.4.1 Special Small Step Milling Situation

In cases where tool diameter compensation is to be used to mill a connective step whose length is less than the tool radius, an offset distance must be calculated and used to adjust the beginning or ending point (depending on the direction of the milling cut) of the event.



In the figure above, to mill from X_1, Y_1 to X_2, Y_2 to X_3, Y_3 to X_4, Y_4 when the length of the step from X_2, Y_2 to X_3, Y_3 is less than the radius (R) of the tool, point X_2, Y_2 would have to be offset toward point X_1, Y_1 by a distance equal to d . d can be calculated using the following formula:

$$(1) \quad d = (R-L) \left(\sqrt{\frac{L}{2R-L}} \right)$$

where R = tool radius

L = length of step from X_2, Y_2 to X_3, Y_3

- (2) For rough machining d may be estimated quickly by multiplying the tool diameter by 0.15.

CAUTION: Using this method may result in larger than necessary offsets when the step is very small and the tool diameter is very large.

The following examples show how d may be calculated and estimated. Example 2 illustrates how a larger than necessary offset results when a large tool is used and d is estimated.

EXAMPLE 1

Let X1 = 0" ABS
 Y1 = 0" ABS
 X2 = 1.500" ABS 1.462
 Y2 = 0" ABS
 X3 = 1.500" ABS
 Y3 = 0.050" ABS
 X4 = 3.000" ABS
 Y4 = 0.050" ABS
 Tool Diameter = .250"

Using Formula 1 to calculate d:

$$d = (.125 - .050) \left(\sqrt{\frac{.050}{2(.125) - .050}} \right)$$

$$d = (.075) \left(\sqrt{\frac{.050}{.200}} \right)$$

$$d = (.075) \left(\sqrt{.25} \right)$$

$$d = (.075)(.5)$$

$$d = .038$$

Using (2) to estimate d:

By using d calculated X2 would d = (.25)(.15)
 be adjusted to 1.462" ABS for d = .038
 programming

EXAMPLE 2

Let X1 = 0" ABS
 Y1 = 0" ABS
 X2 = 1.500" ABS
 Y2 = 0" ABS
 X3 = 1.500" ABS
 Y3 = 0.010" ABS
 X4 = 3.000" ABS
 Y4 = 0.010" ABS
 Tool Diameter = .750"

Using Formula 1 to calculate d:

$$d = (.375 - .010) \left(\sqrt{\frac{.010}{2(.375) - .010}} \right)$$

$$d = (.365) \left(\sqrt{\frac{.010}{.740}} \right)$$

$$d = (.365) \left(\sqrt{.0135} \right)$$

$$d = (.365)(.116)$$

$$d = .042$$

Using (2) to estimate d:

$$d = (.750)(.15)$$

$$d = .113$$

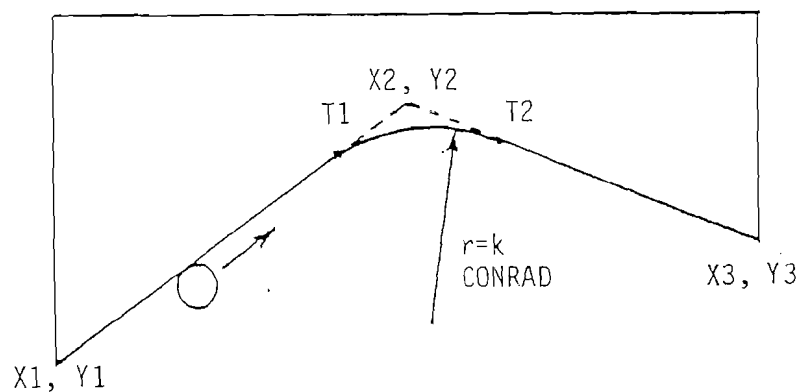
3.5 Connective Events

Connective events occur between two milling events (either MILL or ARC, but not CIRCLE) when the X, Y, and Z ending points of the first event are in the same location as the X, Y, and Z starting points of the next event. In addition, the tool offsets and tool number of both events must be the same.

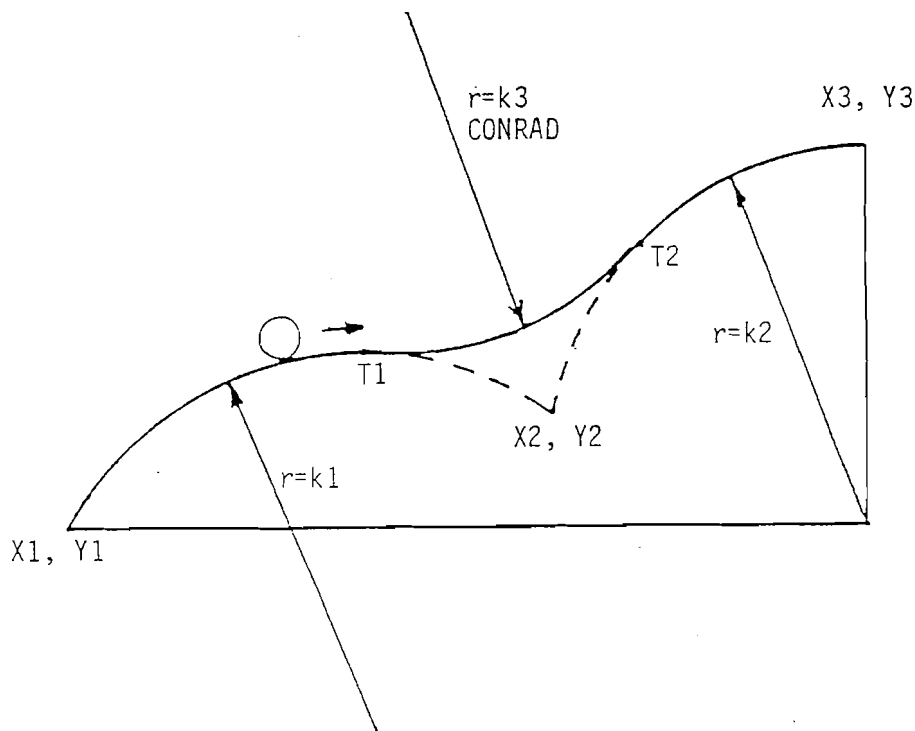
3.6 CONRAD

CONRAD is a unique feature of the ProtoTRAK in that it allows the operator to program a tangentially connecting radius between connective events or tangentially connecting radii for the corners of pockets and frames without the necessity of complex calculations. A few typical examples of CONRAD applications are described below.

For the figure below, the operator simply programs a MILL event from X_1, Y_1 to X_2, Y_2 with tool right offset and another MILL event from X_2, Y_2 to X_3, Y_3 also with tool right offset. During the programming of the first MILL event the system will prompt for CONRAD at which time the operator inputs the numerical value of the tangentially connecting radius ($r=k$). The system will calculate the tangent points T_1 and T_2 and direct the tool cutter to move continuously from X_1, Y_1 through $T_1, r=k, T_2$ to X_3, Y_3 .



For the figure below, the operator simply programs an ARC MILL event from $X1, Y1$ to $X2, Y2$ with tool offset left and another ARC MILL event from $X2, Y2$ to $X3, Y3$ also with tool offset left. During the programming of the first ARC MILL event the system will prompt for CONRAD at which time the operator inputs the numerical value of the tangentially connecting radius $r=K3$. The system will calculate the tangent points $T1$ and $T2$ and direct the tool cutter to move continuously from $X1, Y1$ through $T1, r=K3, T2$ to $X3, Y3$.



NOTE: CONRAD must always be the same or larger than the tool radius for inside corners. If CONRAD is less than the tool radius and an inside corner is machined, the ProtoTRAK will ignore the CONRAD.

4.0 DRO, JOG, POWER FEED Operation

The ProtoTRAK operates in manual operation as a sophisticated three-axis digital readout (DRO) with jog and power feed capability.

4.1 Clear Entry

Press **RESTORE**, then re-enter all keys.

4.2 IN to MM or MM to IN

Press **IN/MM** and observe position of decimal point to determine measurement mode.

4.3 Reset One Axis

Press **X** or **Y** or **Z**, **INC SET**. This zeros the incremental position in the selected axis.

4.4 Preset

Press **X** or **Y** or **Z**, numeric data, **INC SET** to preset selected axis.

4.5 Reset Absolute Reference

Press **X** or **Y** or **Z**, **ABS SET** to set selected axis absolute to zero at the current position. See 4.7 and 4.8 to display this data.

NOTE: This will also reset the incremental dimension if the absolute position is being displayed when it is reset.

4.6 Preset Absolute Reference

Press **X** or **Y** or **Z**, numeric data, **ABS SET** to set the selected axis absolute to a preset location for the current machine position. See 4.7 and 4.8 to display this data.

NOTE: This will also reset the incremental dimension if the absolute position is being displayed when it is preset.

4.7 Recall Absolute Position of All Axes

Press **INC/ABS**. Note presence of red dot above each +/- to determine if the axis is reading incremental (no red dot) or absolute data (red dot). Press **INC/ABS** again to revert to the original reading.

4.8 Recall Absolute Position on One Axis

Press X or Y or Z, INC/ABS. Note presence of red dot above selected axis +/- to determine if the axis is reading incremental data (no red dot) or absolute data (red dot). Repeat to get selected axis back to original reading.

4.9 Feedrate Override

The feedrate may be modified during any program run (including while the table is moving), during Jog operation, and during Power Feed operation (see 4.10 and 4.11 below).

Pressing and holding the FEED↓ key will slow the feed down. The FEED↑ key increases the feed in the same way. The limits are 10 percent to 150 percent of the programmed rate, but not faster than the 100 inches per minute rapid speed. The feedrate change will always stop as it passes 100%. Release the key and press again to continue the change.

While the Feed↑, or Feed↓ key is pressed, and for one second following release, the percent feedrate (or actual feedrate for power feed) will be shown in the conversation display.

4.10 JOG

The servo motors can be used to jog the table. To jog at rapid (100 ipm):

- a) Press and hold for 3 seconds the GO key.
- b) The conversation display will flash "JOG+" or "JOG-" and the Servo On display will be lit.
- c) Press the X key to move at rapid speed in the X direction shown.
- d) Press the Y key to move at rapid speed in the Y direction shown.
- e) Press +/- key to switch between "+" and "-" jog direction.
- f) Press FEED↑, or FEED↓ key to change feedrate. The conversation display will show the percentage feedrate override.
- g) Press RESTORE to cancel jog operation.

For slower jog speeds:

Use the same procedure as above except press a two-digit feedrate (2 7 means to feed at 27 ipm) prior to pressing X or Y. The new feedrate (27 in the above example) can now be modified by the feedrate override. The feedrate can be changed at any time by releasing X or Y, inputting a new two-digit rate, and re-pressing X or Y.

4.11 POWER FEED

The servo motors can be used as a power feed for the table or saddle.

- a) Press PWR FEED. The conversation display will read PWR FEED 100 (PWR FEED 2500 in metric), indicating the applicable feedrate.
- b) Press FEED \uparrow , or FEED \downarrow to adjust the feedrate between rapid and 0.2 inch per minute (5mm per minute).
- c) Press X or Y, the distance to move, and INC SET.
- d) Press GO to begin power feed.
- e) When complete, the IN POSITION light will come on but the servos will be turned off allowing manual X and Y movement.
- f) To power feed again, start at (b) or (c) above.
- g) Press RESTORE to abort power feed operation.

5.0 Programming & Program Run

5.1 Incremental Reference Position

When X and Y data for the beginning position of any event are input as incremental data, this increment must be measured from some known point in the previous event. Following are the positions for each event type from which the incremental moves are made in the subsequent event:

POSITION/DRILL: X and Y programmed

BOLT HOLE: X CENTER and Y CENTER programmed

MILL: X END and Y END programmed

ARC: X END and Y END programmed

CIRCLE: X CENTER and Y CENTER programmed

POCKET: X1 and Y1 corner programmed position

REPEAT: The appropriate reference position for the last event which is being repeated.

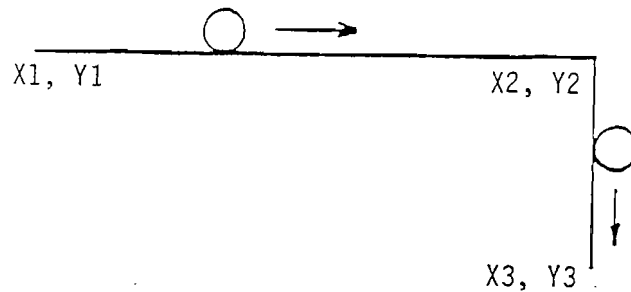
For example, if an ARC event followed a MILL event, a 2.0 inch incremental X BEG would mean that in the X direction the beginning of the ARC event is 2.0 inches from the end of the MILL event.

5.2 CONRAD

5.2.1 For MILL & ARC Events

During programming the ProtoTRAK will prompt for a CONRAD input for each MILL and ARC event. Section 3.6 describes the CONRAD routine and specifies that to have a CONRAD between two events they must be connective—that is the X, Y, and Z at the end of the first event must be the same as the X, Y, Z of the beginning of the second, and the tool compensation direction and number must be the same. When these conditions are met the ProtoTRAK will machine (without stopping) through the first event, through the connecting radius (CONRAD) and through the second event.

However, since no Z data is programmed into the ProtoTRAK it is impossible for the system to determine if all conditions for connective events have been met. Consider the figure below. If two milling events are programmed from X1, Y1 to X2, Y2 and X2, Y2 to X3, Y3 should the program immediately proceed in running the second mill event after the first, or stop in between? How does the ProtoTRAK know if the second cut is at the same or different depth?



The following rules or procedures are used to make the determination:

- 1) If a non-zero CONRAD is programmed by pressing NUMERIC DATA, INC SET or ABS SET the run will automatically machine the connecting radius and proceed through the next event providing all other (non-Z) conditions for a connective event are met.
- 2) If a zero CONRAD is programmed by pressing 0, INC SET, or ABS SET keys the run will also automatically proceed through the next event and generate a zero corner radius within the limit of the tool.
- 3) If a CONRAD is programmed without any numeric data (including 0) by pressing just INC SET or ABS SET the run will stop at the end of the first event and command "SET Z". Note that if the cutter is not raised before pushing GO to mill from X2Y2 to X3Y3, the top of the corner at X2Y2 will be milled off (see Sec. 6.3.). It is always good practice to raise the tool between non-connective events.

5.2.2 For Pocket Events

CONRAD has a slightly different meaning within the POCKET event. Here the term means "corner radius" which is the radius generated at each of the four corners of the rectangular pocket or frame. A connective radius cannot connect a MILL or ARC into a pocket or frame, or used with the CIRCLE or REPEAT events.

5.3 POSITION or DRILL (POSN/DRILL) Events

This event type positions the table at a specified position for subsequent operation (like drilling). The positioning is always at rapid speed (modified by feedrate override) and in the most direct path possible from the previous location.

5.3.1 Position or Drill Program

Displayed Prompt	Definition of Prompt	Keyboard Input
--	--	POSN/DRILL event display indexes by one and is proceeded by D
X	X dimension	NUMERIC DATA, INC SET or ABS SET depending on whether X dimension is incremental or absolute
Y	Y dimension	NUMERIC DATA, INC SET or ABS SET
TOOL #	Input tool number--the same as last event is automatically assumed if there is no numeric input	NUMERIC DATA, SET

5.3.2 Position or Drill Run

When a Position/Drill event is run the following sequences take place:

- a) The table moves at rapid (or less if modified by the feedrate override) to the programmed X and Y along the most direct path.
- b) The actual feedrate is displayed in the conversation display.
- c) When in position, the "IN POSITION" light will turn on.
- d) The conversation display will command "SET Z".
- e) When the event is complete and the tool is clear the operator presses the GO key to proceed to the next event.

5.4 BOLT HOLE EVENTS

5.4.1 BOLT HOLE Program

This event allows a bolt hole pattern to be drilled without needing to compute and move to the positions of each hole.

Displayed Prompt	Definition of Prompt	Keyboard Input
-	-	BOLT HOLE, the event display indexes by one and is proceeded by B
# HOLES	Number of evenly spaced holes (up to 99) in the bolt hole pattern	NUMERIC DATA, SET number of holes in the bolt hole pattern

Displayed Prompt	Definition of Prompt	Keyboard Input
X CENTER	X dimension to center of hole pattern	NUMERIC DATA, INC SET or ABS SET
Y CENTER	Y dimension to center of hole pattern	NUMERIC DATA, INC SET or ABS SET
RADIUS	Dimension from center of hole pattern to center of any hole	NUMERIC DATA, SET
ANGLE	Angle from positive X axis (that is 3 o'clock) to any hole; positive angle is measured counterclockwise from 000.000 to 359.999 degrees	NUMERIC DATA, SET
TOOL #	Input tool number; the same as last event is automatically assumed if there is no numeric input	NUMERIC DATA, SET

5.4.2 BOLT HOLE Run

When a Bolt Hole event is run the following sequences take place:

- a) The table moves at rapid (or less if modified by the feedrate override) to the first hole location along the most direct path.
- b) The actual feedrate is displayed in the conversation display.
- c) When in position, the "IN POSITION" light will turn on.
- d) The conversation display will command "SET Z".
- e) When the first hole is drilled the operator presses GO to move to the next hole.
- f) (a) through (e) are repeated for each hole.
- g) When the last hole is complete and the tool is clear, the operator presses the GO key to proceed to the next event.

5.5 MILL Events

This event allows the operator to mill in a straight line from any one XY point to another including at a diagonal. It may be programmed with a CONRAD if it is connective with the next event.

5.5.1 Mill Program

Displayed Prompt	Definition of Prompt	Keyboard Input
--	--	MILL, event display indexes by one and is proceeded by M
X BEG	X dimension to beginning of mill cut	NUMERIC DATA, INC SET or ABS SET
Y BEG	Y dimension to beginning of mill cut	NUMERIC DATA, INC SET or ABS SET
X END	X dimension to end of mill cut; incremental is X BEG	NUMERIC DATA, INC SET or ABS SET
Y END	Y dimension to end of mill cut; incremental is Y BEG	NUMERIC DATA, INC SET or ABS SET
CONRAD	Dimension of tangential radius to next event (Note: must input 0 or a number if next event is connective, otherwise no numeric input)	NUMERIC DATA, SET
CO R1 L2	Select tool offset to right (1), tool offset to left (2), or tool center--no offset (0), relative to programmed edge and direction of tool cutter movement	0 or 1 or 2, SET (press only SET if same as last event)
FEEDRATE	Milling feedrate in in/min from .1 to 99.9 or mm/min from 5 to 2500	NUMERIC DATA, SET (press only SET if same as last event)
TOOL #	Input tool number--the same as last event is automatically assumed if there is no numeric input	NUMERIC DATA, SET (press only SET if same as last event)
TOOL DIA *	Tool diameter	NUMERIC DATA, SET

* No prompt if the tool has been programmed in a previous event.

5.5.2 Mill Run

When a Mill event is run the following sequences take place:

- a) The table moves at rapid (or less if modified by the feedrate override) to the X BEG and Y BEG location along the most direct path, offset to the left or right by the tool radius as programmed.
- b) The actual feedrate is displayed during all movement in the conversation display.
- c) When in position the "IN POSITION" light will turn on.
- d) The conversation display comments "SET Z".
- e) When Z has been properly positioned the operator presses the GO key.
- f) The table moves in a straight line at the programmed feedrate (or as modified by the percent feedrate override) to the X END and Y END position again offset by the tool radius.
- g) The "IN POSITION" light turns on.
- h) The conversation display comments "SET Z" if the next event uses the same tool or "TOOL N" if the next event uses a different tool, number N.
- i) The operator presses the GO key to proceed to the next event.
- j) Steps (g), (h), and (i) are eliminated when there is a CONRAD (even a zero radius CONRAD) connecting to the next event.

5.6 ARC Events

This event allows the operator to mill with circular contouring any arc (fraction of a circle).

In ARC events, when X CENTER and Y CENTER are programmed incrementally they are referenced from X END and Y END respectively.

5.6.1 Arc Program

Displayed Prompt	Definition of Prompt	Keyboard Input
--	--	ARC, event display indexes by one and is proceeded by A
X BEG	X dimension to beginning of arc cut	NUMERIC DATA, INC SET or ABS SET
Y BEG	Y dimension to beginning of arc cut	NUMERIC DATA, INC SET or ABS SET
X END	X dimension to end of arc cut; incremental is from X BEG	NUMERIC DATA, INC SET or ABS SET
Y END	Y dimension to end of arc cut; incremental is from Y BEG	NUMERIC DATA, INC SET or ABS SET
X CENTER	X dimension to center of arc; incremental is from X END	NUMERIC DATA, INC SET or ABS SET
Y CENTER	Y dimension to center of arc; incremental is from Y END	NUMERIC DATA, INC SET or ABS SET
CONRAD	Dimension of tangential radius to next event (Note: Must input a number or 0 if next event is connective, otherwise no numeric input)	NUMERIC DATA, SET
CW1 CCW2	Select if arc is to be milled in clockwise (1), or counter-clockwise (2) direction	1 or 2, SET
CO R1 L2	Select tool offset to right (1), tool offset to left (2), or tool center--no offset (0), relative to programmed edge and direction of tool cutter movement	0 or 1 or 2, SET (press only SET if same as last event)
FEEDRATE	Milling feedrate in in/min from .1 to 99.9 or mm/min from 5 to 2500	NUMERIC DATA, SET (press only SET if same as last event)
TOOL #	Input tool number--the same as last event is automatically assumed if there is no numeric input	NUMERIC DATA, SET (press only SET if same as last event)
TOOL DIA*	Tool diameter	NUMERIC DATA, SET

* No prompt if the tool has been programmed in a previous event.

5.6.2 Arc Run

When an Arc event is run the following sequences take place:

- a) The table moves at rapid (or less if modified by the feedrate override) to the X BEG and Y BEG location along the most direct path, offset to the left or right by the tool radius as programmed.
- b) The actual feedrate is displayed during all movement in the conversation display.
- c) When in position the "IN POSITION" light will turn on.
- d) The conversation display comments "SET Z".
- e) When Z has been properly positioned the operator presses the GO key.
- f) The table moves along the arc at the programmed feedrate (or as modified by the percent feedrate override) to the X END and Y END position again offset by the tool radius.
- g) The "IN POSITION" light turns on.
- h) The conversation display comments "SET Z" if the next event uses the same tool or "TOOL N" if the next event uses a different tool, number N.
- i) The operator presses the GO key to proceed to the next event.
- j) Steps (g), (h), and (i) are eliminated when there is a CONRAD (even a zero radius CONRAD) connecting to the next event.

5.7 CIRCLE Events

This event allows the operator to mill a circular frame or pocket. A circular frame is machining the circumference only. Frames may be inside (e.g., a circular cutout) or outside (e.g., cleaning up the circumference and sizing the diameter of a round piece). A circular pocket is machining the circumference and all the material within that circumference.

The event also provides for an automatic finish cut.

5.7.1 CIRCLE Event Program

Displayed Prompt	Definition of Prompt	Keyboard Input
-	-	CIRCLE, event display indexes by one and is preceded by C
PK1 FR2	Select if event is a pocket (1) or frame (2)	1 or 2, SET
X CENTER	X dimension to center of circle	NUMERIC DATA, INC SET or ABS SET
Y CENTER	Y dimension to center of circle	NUMERIC DATA, INC SET or ABS SET
RADIUS	Finish radius of circle	NUMERIC DATA, SET
CW1 CCW2	Select if circle is to be milled clockwise (1), or counterclockwise (2) direction	1 or 2, SET
CO R1 L2 (frame only)	Select tool offset to right (1), tool offset to left (2), or tool center--no offset (0), relative to programmed edge and direction of cutter movement	0 or 1 or 2, SET
FIN CUT	Width of finish cut; if 0 is entered no finish cut will be made	NUMERIC DATA, SET
FEEDRATE	Milling feedrate in in/min from .1 to 99.9 or mm/min from 5 to 2500	NUMERIC DATA, SET
TOOL #	Input tool number; the same as last event is automatically assumed if there is no numeric input	NUMERIC DATA, SET (press only SET if same as last event)
TOOL DIA *	Tool diameter	NUMERIC DATA, SET

* No prompt if the tool has been programmed in a previous event.

5.7.2 CIRCLE Run

When a CIRCLE event is run the following sequences take place:

- a) The table moves at rapid (or less if modified by the feedrate override) to a point on the circle closest to the initial position of the tool, and offset to the left or right by the tool radius and finish cut as programmed.

- b) The actual feedrate is displayed in the conversation display during all movement.
- c) When in position, the "IN POSITION" light will turn on.
- d) The conversation display will command "SET Z"
- e) When Z has been properly positioned, the operator presses the GO key.
- f) For CIRCULAR FRAMES the table moves at the programmed feedrate (or as modified by override) to machine complete circle. At completion, it moves to the final dimension and machines the finish cut.
- g) For CIRCULAR POCKETS the table moves at the programmed feedrate (or as modified by the override) to machine inside the circumference leaving the finish cut. The feed continues until the interior of the pocket is complete. Lastly, the finish cut is made to the final programmed dimension.
- h) The conversation display comments "CHECK Z" if the next event uses the same tool or "TOOL N" if the next event uses a different tool, number N.
- i) The operator presses the GO key to proceed to the next event.

5.8 POCKET Events

The POCKET event allows the operator to mill a rectangular frame or pocket. A rectangular frame is machining the circumference only. Frames may be inside (e.g., a cutout) or outside (e.g, cleaning up or sizing the outside of a rectangular block). A rectangular pocket is machining the circumference and all the material within that circumference.

The event also provides for an automatic finish cut and any legitimate corner radius providing it is greater than the tool radius on pockets and inside frames.

5.8.1 Pocket Event Program

Displayed Prompt	Definition of Prompt	Keyboard Input
--	--	POCKET, event display indexes by one and is preceded by P
PK1 FR2	Select if event is a pocket (1) or frame (2)	1 or 2, SET
X1	X dimension to any corner	NUMERIC DATA, INC SET or ABS SET

Displayed Prompt	Definition of Prompt	Keyboard Input
Y1	Y dimension to same corner as X1	NUMERIC DATA, INC SET or ABS SET
X3	X dimension to opposite corner as X1. Incremental from X1	NUMERIC DATA, INC SET or ABS SET
Y3	Y dimension to same corner as X3. Incremental from Y1	NUMERIC DATA, INC SET or ABS SET
CONRAD	Value of tangential radius in each corner	NUMERIC DATA, SET
CW1 CCW2	Select if rectangle is to be milled in clockwise (1) or counterclockwise (2) direction	1 or 2, SET
CO R1 L2 (frame only)	Select if tool offset is right (1), tool offset to left (2), or tool center--no offset (0), relative to programmed edge and direction of tool cutter movement	0 or 1 or 2, SET
FIN CUT	Width of finish cut; if 0 is entered no finish cut will be made	NUMERIC DATA, SET
FEEDRATE	Milling feedrate in in/min from .1 to 99.9 or mm/min from 5 to 2500	NUMERIC DATA, SET
TOOL #	Input tool number; the same as last event is automatically assumed if there is no numeric input	NUMERIC DATA, SET (press SET if same as last event)
TOOL DIA*	Tool diameter	NUMERIC DATA, SET

* No prompt if the tool has been programmed in a previous event.

5.8.2 POCKET Run

When a POCKET event is run the following sequences take place:

- a) The table moves at rapid (or less if modified by the feedrate override) to the X1, Y1 corner offset by the CONRAD, finish cut, and tool radius.
- b) The actual feedrate is displayed in the conversation display during all movement.

- c) When in position, the "IN POSITION" light is turned on.
- d) The conversation display will command "SET Z".
- e) When Z has been properly set, press GO.
- f) For the FRAME option, the table moves at the programmed feedrate (or a modified by the override) to machine the rectangle with proper corners and finish cut offset. At completion it moves to the final dimension and machines the finish cut.
- g) For the POCKET option, the table moves at the programmed feedrate (or as modified by the override) to machine inside the circumference with proper corners and offset by the finish cut. The feed continues until the interior of the pocket is complete. Lastly, the finish cut is made to the final programmed dimension.
- h) The conversation display comments "CHECK Z" if the next event uses the same tool, or "TOOL N" if the next event uses a different tool, number N.
- i) The operator presses GO to proceed to the next event.

5.9 Repeat Events

This event is very useful when a series of identical machining operations are required. This may include a series of evenly spaced holes, a duplication of a set of holes--once for centerdrilling, the second time for drilling, or even entire programs for multiple fixture operation.

Single events or a continuous group of prior events may be repeated up to 99 times. The only restriction is the level of allowable nesting. Specifically, a REPEAT event may contain events which are themselves REPEAT events, but this event may not then be included as an event to be repeated subsequently. For example, if event 3 was a repeat of events 1 and 2, then event 4 could be a repeat of 3 or 1 through 3, but event 9 could not be a repeat including event 4. In programming language this means one level of nesting.

5.9.1 Repeat Program

Displayed Prompt	Definition of Prompt	Keyboard Input
--	--	REPEAT, event display indexes by one and is preceded by R
FROM	The event # of the first event to be repeated	NUMERIC DATA, SET

Displayed Prompt	Definition of Prompt	Keyboard Input
TO	The event # of the last event to be repeated; if only one event is to be repeated, FROM Event # same as TO Event #	NUMERIC DATA, SET
X OFFSET	Incremental X offset from event to be repeated	NUMERIC DATA, INC SET
Y OFFSET	Incremental Y offset from event to be repeated	NUMERIC DATA, INC SET
# REPEATS	Number of times events are to be repeated--up to 99	NUMERIC DATA, SET
TOOL #	Input tool number of tool to be used in first repeated event	NUMERIC DATA, SET
TOOL DIA*	Diameter of first tool of events to be repeated	NUMERIC DATA, SET

*No prompt if the tool has been programmed in a previous event.

5.9.2 Repeat Run

When a Repeat event is run the following sequences take place:

- a) The table moves at rapid (or less if modified by the feedrate override) to the initial beginning location of the first repeated event offset by the programmed offsets and tool compensation.
- b) The ProtoTRAK will complete all repeated events, with their normal commands and instructions, offset by the programmed offsets.
- c) The operator presses the GO key to proceed to the next event.

5.9.3 Finish Cuts

Automatic finish cuts are not a built-in automatic feature of the ProtoTRAK except for the CIRCLE and POCKET events. However, it can be "tricked" into making a finish cut using the following procedure:

- a) Program the event(s) to make the required cuts with some TOOL #.
- b) For the above event(s), "lie" and input a TOOL DIA that is larger than the actual tool used (make the false diameter equal to the true diameter plus 2 times the desired finish cut).
- c) Do a Repeat of the above event(s) calling out a new TOOL # (even if you use the same tool) and the actual true TOOL DIA.

5.10 Start, Stop and Running Several Parts

5.10.1 START

Once a program has been written, loaded into the ProtoTRAK and checked (see Section 5.11 for Editing) it may be run with the following procedure:

- a) Locate the centerline of a tool or the spindle over the programmed absolute zero location on the part.
- b) Press and hold the START key for 3 seconds. This always sets a new absolute zero at this (that is, [a] above) location. If you do not wish to set a new absolute zero, refer to the RESTART Section below.
- c) The conversation display will prompt to load the first tool "TOOL 1".
- d) Press the GO key to initiate the actual run.
- e) The conversation display will comment "RUN OVER" at the completion of the last event.

5.10.2 RESTART

If the operator wishes to start in the middle of a program, say at event 13 then:

- a) Press (but do not hold) START, the display will read AT EVNT #, then press 13.
- b) Then press and hold for 3 seconds START.

NOTE: This will not reset a new absolute zero. The program will use the last absolute zero which was set (either by a 3 second START push as in 5.10.1 (b) above or by a subsequent ABS SET) as reference for continuing the program run.

- c) The conversation will prompt to load the tool associated with event 13.
- d) Press the GO key to initiate run in event 13.

This restart feature allows the operator to do some manual machining (for example, to clean out the inside of a pocket) in the middle of a program and then restart without any initial positioning.

To start at the beginning of a program without resetting a new absolute zero, use this Restart procedure and input 1 when prompted AT EVNT #.

5.10.3 STOP

At any time the program may be halted by pressing the STOP key. This freezes the program at that point. To continue, press the GO key.

5.10.4 Exiting Program or Program Run Operation

To revert the ProtoTRAK to normal DRO operation press the RESTORE key. **Warning:** Do not press RESTORE in the middle of a run unless you wish to completely abort the run.

5.10.5 Running Several Parts

The procedure for starting in Section 5.10.1 above requires the operator to position the spindle over the program absolute position. This is always necessary on the first part, but can be avoided on subsequent parts providing they are positioned when held the same as the first (for example, in a fixture or against a stop).

When the first part is complete the conversation display comments "RUN OVER". The appropriate procedure is:

- a) Change parts—being sure the next is held in the same position as the first.
- b) Press the GO key instead of START.
- c) The conversation display will prompt to load the first tool "TOOL 1".
- d) Press the GO key again.
- e) The table will move from its current position (probably not the programmed absolute zero) to the beginning location of the first event.

5.11 Editing

The ProtoTRAK allows for complete editing of programs including the recall (and correction) of data, adding events in the middle of a program, and deleting events within the program.

5.11.1 Recall and Data Correction

To recall and correct data press the EDIT key. The conversation display will respond RECALL. Press INC SET or ABS SET and the display will ask "EVNT #". Enter the event number to be recalled and press INC SET or ABS SET. The first piece of data in that event will be displayed in the conversation and X, Y, Z displays. Press the RECAL DATA key to sequence to the next data. Continuing to press RECAL DATA will cycle through all

the data and automatically proceed on to the next event. If any data is incorrect it may be reinput while it is displayed. Press RESTORE to abort edit.

The following rules apply to editing data:

- a) Editing any data except Tool Diameter and Feedrate in any event will not edit the data in any other event.
- b) If the Tool Diameter value is edited in any event it will automatically be edited in every event with that same tool number.
- c) If the Feedrate is edited in any event it will automatically be edited in every subsequent and contiguous event with the same Tool number and feedrate. For example, let's say events 5 through 10, and 13 through 16 were all programmed with tool number 2 and 5 inches per minute feedrate. If you edit the feedrate in event 7 to 3 inches per minute, it will automatically change event 8, 9, and 10 also. Events 5, 6, 13, 14, 15, and 16 will not be affected.

Data may also be corrected during programming by re-pressing the event type key (or a different one) and re-inputting all the data for that event.

5.11.2 Adding an Event

Events may be added at the beginning, middle or end of any program one at a time. To do so press the EDIT key twice so the display reads "ADD EVENT". Press INC SET or ABS SET and the display will ask "AFR EVNT" (After Event). Then input the event number which the added event will follow and press INC SET or ABS SET. The new event may now be programmed in the normal way. For example, to add a Mill event between events 13 and 14 the following input is required:

Keyboard Input

```
EDIT
EDIT
INC SET
13
INC SET
MILL
data as prompted
```

NOTE: This new event will be number 14 and the old event number 14 will be automatically shifted to 15 and so on. Data in repeats will also automatically be shifted.

To add an event in front of event 01, input and SET 0 when the display prompts "AFR EVNT". Press RESTORE to abort the Add Event routine.

5.11.3 Deleting Events

Events may be deleted one at a time or in continuous groups. To delete, press the EDIT key three times so the display reads "DLT EVNT". Press INC SET or ABS SET and the display will ask "DLT FROM". Then input the first event number of the group to be deleted and press INC SET or ABS SET (the display will change to read "DLT TO"), input the last event number of the group to be deleted and press INC SET or ABS SET. If only one event is to be deleted, input it for both FROM and TO. For example, to delete events 7 through 15 the following input is required:

```
Keyboard Input
  EDIT
  EDIT
  EDIT
  INC SET
  7
  INC SET
  15
  ABS SET
```

NOTE: The old event number 16 is now switched to event 7 and so on. Data in repeats will also automatically be shifted.

5.11.4 Special Modes

If the EDIT key is pressed a fourth time the display will read "SPEC MOD". Press set to enter into the special mode options. These are special modes of operation which are used in sales demonstrations, installation, service and for special applications. Please press EDIT again to return to RECALL. To enter "SPEC MOD," press INC SET or ABS SET and the display will prompt "CODE."

5.11.4.1 Hysteresis Test

When the ProtoTRAK prompts "CODE", input 1 1 and press SET. The X and Y readout will display the free plus elastic hysteresis in the ballscrew, table, and drive hardware for each axis. In general, this value should be less than 0.0050 inches.

5.11.4.2 Simulation

When the ProtoTRAK prompts "CODE", input 2 2 and press SET. This allows programs (including DO ONE's) to be run without table motion. All prompts, messages, and counting occur normally.

NOTE: The simulation feature will work even if the pendant display is disconnected from the motors, sensors, and power control cabinet.

If the ProtoTRAK is turned off the simulation mode will be aborted.

5.11.4.3 Abort Simulation

When the ProtoTRAK prompts "CODE", input 8 9 and press SET. This aborts the simulation mode (see 5.8.4.2) without the loss of position data (which would occur if the system were turned off).

5.11.4.4 Software I.D.

When the ProtoTRAK prompts "CODE", input 3 3 and press SET. The display will read A=VER . . . which shows the software version or rev. in the A memory device. Press RECALL DATA to read B and C and D. Press RESTORE to abort the software I.D. mode and revert back to DRO operation.

5.11.4.5 Continuous Test Run

When the ProtoTRAK prompts "CODE", input 5 5 and press SET. The tape cassette (with a program) must be properly connected or this mode aborts.

The ProtoTRAK reads the tape program displaying all tape messages and then automatically and continuously runs it without interruptions or stops for operator input (like SET Z).

This mode is primarily used for long-term testing and to set up cycles for troubleshooting.

5.11.4.6 Extended Display

When the ProtoTRAK prompts "CODE", input 4 4 and press SET. This mode extends the readouts from +/-99.9995 to +/-999.999 inches. This mode is aborted if the display is turned off.

5.11.4.7 Trial Run

When the ProtoTRAK prompts "CODE", input 3 5 and press SET. The display will prompt "CHECK Z". Make sure the tool is clear and press GO to run the entire program at rapid speed and with no pauses for tool change, set Z, or check Z. Rapid may be reduced with the feedrate override.

5.11.4.8 Abort Extended Display

When the ProtoTRAK prompts "CODE", input 8 8 and press SET to abort the Extended Display mode, 5.8.4.6.

5.11.4.9 Streamline Programming

When the ProtoTRAK prompts "CODE", input 7 7 and press SET.

When this mode is active the input required for programming connective events is significantly reduced. Whenever a CONRAD is input as 0 or a number X BEG and Y BEG are not prompted and set to 0 INC in the next event; and CO R1 L2, TOOL DIA and TOOL # are not prompted and automatically set with the same value as the current event.

Consider the following example: Event 8 is a MILL event with CONRAD = .25, tool offset right (R1), TOOL DIA = .5 and TOOL # = 3. Because event 8 has a numeric CONRAD (or it could have been 0), then event 9 must be connective with 8 and must be a MILL or ARC event. In either case, X BEG and Y BEG for event 9 will not be prompted and will be loaded as 0 INC; and R1 L2 CO, TOOL DIA, and TOOL # will not be prompted and will be loaded with the same value as in event 8.

All data not prompted and automatically loaded may be recalled and edited.

Once activated, the Streamline Programming Mode will be continuously activated until aborted as described in 5.11.4.10 below. Even turning the ProtoTRAK off for an extended time will not deactivate Streamline Programming.

5.11.4.10 Abort Streamline Programming

When the ProtoTRAK prompts "CODE", input 7 8 and press SET to abort Streamline Programming as described in 5.11.4.9 above.

5.11.4.11 System Initialization

When the ProtoTRAK prompts "CODE", input 9 9 and press SET. This mode completely initializes the ProtoTRAK by erasing all system memory. It also automatically aborts Simulation and Streamline Programming.

5.11.4.12 Sensor Calibration

When the ProtoTRAK prompts "CODE", input 1 2 3 and press SET to calibrate a TRAK Sensor. The procedure is as follows:

Displayed Prompt	Definition of Prompt	Keyboard Input
SELECT AXIS	Select the axis to be calibrated	X or Y or Z
MOVE BEG STD/ THEN INC SET (flashing back & forth)	Move table and touch dial indicator off on one side of the standard	INC SET or ABS SET
MOVE END STD/ THEN INC SET (flashing back & forth)	Move table to other end of the standard. NOTE: The display must read the same or more than the standard length	INC SET or ABS SET
INPUT STD/THEN INC SET (flash- ing back & forth)	Input the length of the standard in inches or mm	NUMERIC DATA, INC SET or ABS SET

If a legitimate calibration is computed (actual divided by standard length) the system will automatically abort to the DRO mode of operation. Repeat the entire procedure for each axis to be calibrated. If the calibration is not legitimate the display will read "CAL ERROR". This occurs if the displayed readout in the calibration procedure was less than the standard length or too much (the maximum allowable is 1% more than the standard). If less, increase the sensor tilt and repeat the calibration procedure. If too much, verify the standard and request SWI or distributor service.

5.12 Tape Cassette Operation

The Cassette Recorder is attached to the ProtoTRAK PLUS through a special 15-pin connector on the back panel of the display. A spare connector is inserted in the display connector and should remain there for protection unless the cassette recorder is plugged in. To do so remove the spare connector and insert the cassette recorder connector.

Keep your Cassette Recorder out of the shop environment when it is not in use. Keep the top to the Cassette Recorder case closed except when loading or unloading a tape.

NOTE: Tapes programmed on the older ProtoTRAK may be run on the ProtoTRAK PLUS, but not vice-versa.

5.12.1 Loading Tapes

To load (or unload) a cassette tape, open the top of the cassette carrying case and open the tape chamber by pressing the release key.

Slide the tape cassette into the side grooves on the underside of the lid of the tape chamber, being careful to place the desired read/write side of the tape face downward with the exposed tape section of the cassette towards the back of the tape chamber.

Store the tapes in their plastic carriers in a clean and safe place.

5.12.2 Write Tape

ProtoTRAK programs are stored on the tape two times and then verified against the program data stored in the display. This allows the program to be reinspected when read back into the display at a later time.

The procedure to store a program is:

- a) Press the TAPE/RS232 key and the display will alternately flash "TAPE=1", "COMM=2".
- b) Press 1 and the conversation will flash back and forth "RECEIVE=1" and "SEND=2".
- c) Press 2.
- d) A small red light on the Tape Cassette Recorder will turn on for one to two minutes and the display will say "SENDING", then
- e) The display will read "GOOD".
- f) Press RESTORE to return to normal non-cassette operations.

NOTE: When a program is written on to a tape it is not lost from the ProtoTRAK memory.

5.12.3 Read Tape

When a program is read from tape into the ProtoTRAK memory it is checked to be sure no reading or storage error has occurred.

The procedure to read a tape is:

- a) Press the TAPE/RS232 key and the display will alternately flash "TAPE=1", "COMM=2".
- b) Press 1, and the conversation will flash back and forth "RECEIVE=1" or "SEND=2".
- c) Press 1.
- d) A small red light on the tape cassette recorder will turn on for one to two minutes and the display will say "RECEIVING", then
- e) The display will read "READY".

f) Press RESTORE to return to normal non-cassette operations.

NOTE: When a program is read from a tape it still remains recorded on the tape. However, all previous data in the ProtoTRAK memory will be erased and replaced with that on the tape.

5.12.4 Tape Cassette Error Messages

The following messages are displayed if there is a problem associated with reading or writing a tape. Also listed is the recommended corrective action.

Cassette Recorder Diagnostic Messages

CASSETTE FUNCTION	MESSAGE	MEANING	ACTION
Read or Write Operation	PLUG (flashing)	Cassette Deck harness not plugged into display; no tape cassette; lid to cassette transport chamber ajar.	1) Check.
	FAIL (flashing)	Broken tape or bad tape deck.	1) Examine cassette for broken tape. 2) Try another cassette. 3) Call for service.
Read Operation	ready	Proper transfer of first pass data from deck to display memory.	1) RSTR for return to normal non-cassette operation.
	ready pass 2	Proper transfer of second pass data from recorder to display memory, but first pass had errors.	1) RSTR for return to normal non-cassette operation. 2) Re-record program at most convenient time. Possibly use new cassette if tape is deteriorating.
	ready pass 3	Proper transfer of third data from recorder to display memory, but first and second pass had errors.	1) RSTR for return to normal non-cassette operation. 2) Re-record program at most convenient time. Possibly use new cassette if tape is deteriorating.
	read error (flashing)	All three passes on tape had errors. Display memory also has errors.	1) Master Clear to clear memory. 2) Clean cassette tape head. 3) Try another cassette. 4) Call for service if not rectified.
	read fail (flashing)	Major difficulty in reading cassette.	1) Try again. 2) Try another cassette. 3) Clean cassette tape head. 4) Call for service if not rectified.
	read bad (flashing)	System cannot read anything on cassette.	1) See if tape is present in cassette. 2) Be sure cassette is not blank. 3) Use cassette tape head.
	Write Operation	read only (flashing)	Write protect tab on cassette has been removed.
good		Program transferred to cassette and verified correctly.	1) RSTR to return to normal non-cassette operation.
record error (flashing)		An error was found in one of the record passes during verification.	1) Re-record. 2) Try another cassette. 3) Clean cassette tape head.
record fail (flashing)		Major difficulty recording on cassette.	1) Re-record. 2) Try another cassette. 3) Clean cassette tape head.
record bad (flashing)		System cannot verify that anything was recorded.	1) Re-record. 2) Try another cassette. 3) Clean tape head.

5.13 ProtoTRAK Plus RS232 Communications

The ProtoTRAK Plus has an RS232 communication port which allows you to interface to CAD/CAM offline programming systems.

For those of you not familiar with CAD/CAM systems, the following is a very brief and basic explanation.

CAD or Computer Aided Design is computer software which helps the user define the geometry of a part. Essentially, it "draws and dimensions" a part in the computer. AUTOCAD is a well-known CAD software system.

CAM or Computer Aided Manufacturing is computer software which, for machining, takes the part defined by CAD and with the assistance of the user decides how to machine the part. In general, it is not common to find CAM only software--usually it is combined with CAD as a complete CAD/CAM package.

A Post-Processor is additional software which customizes the general output of CAM to the particulars of a specific CNC control brand and model. Some CAD/CAM packages allow the operator to write his own post-processor for each of his CNC models. For other packages the post-processors must be or can be provided by the CAD/CAM distributor or manufacturer.

5.13.1 Downloading From CAD/CAM or Retrieving A Program From Your Computer's Floppy Disk

Before attempting to download a program from your CAD/CAM system, be certain you have properly conducted the installation and testing procedures in the ProtoTRAK Plus CAD/CAM Interface manual.

The procedure for downloading a program from the CAD/CAM is as follows:

- a) Delete any program which may already be in the ProtoTRAK.
- b) Press TAPE/RS232 key and the display will alternately flash TAPE=1, COMM=2.
- c) Press 2, and the display will alternately flash "RECEIVE=1", "SEND=2".
- d) Press 1, +/- keys and the display will read "OK TO RCV".
- e) Be certain the communication port is properly configured. For IBM PC compatible computers type MODE COM1:4800,e,7,1,
- f) At the computer, type COPY, the name or number of the part program, COM1 and the ENTER key. For example, if your program was labeled "1234PLUS", then you would type COPY 1234PLUS COM1

then press ENTER for an IBM PC compatible computer. If you have a different computer, use the standard send message.

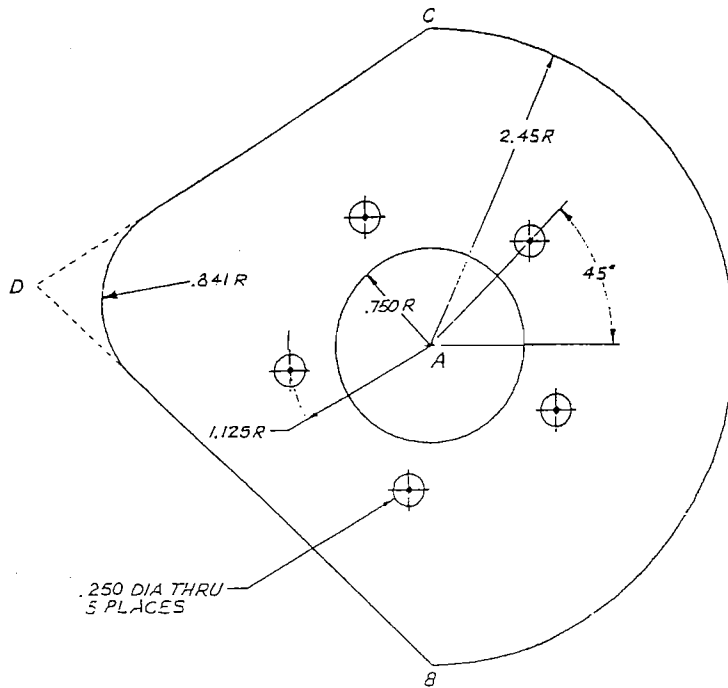
- g) When the program has been completely sent, the ProtoTRAK Plus will read RECEIVE OK.
- h) Press RESTORE and go into EDIT if you wish to review or modify the data.

5.13.2 Saving A Program On Your Computer's Floppy Disk

The procedure for saving a ProtoTRAK Plus program on your computer's floppy disk is as follows:

- a) Press "TAPE/RS232" key and the display will alternately flash "TAPE=1", "COMM=2".
- b) Press 2, and the display will alternately flash "RECEIVE=1", "SEND=2".
- c) Press 2, +/- keys and the display will read "OK TO SEND?".
- d) Be certain the communication port is properly configured. For IBM PC compatible computers type MODE COM1:4800,e,7,1
- e) At the computer, type COPY COM1 and the program name and the "ENTER" key. For example, if your program was labeled "1234PLUS", then you would type COPY COM1 1234PLUS then press ENTER for an IBM PC compatible computer. If you have a different computer, use the standard send message.
- f) At the ProtoTRAK, press the "INC SET" or "ABS SET" key. The program will be sent, and the display will read "SENDING". When complete, the display will read "SEND OK".
- g) Press "RESTORE" to exit this operation.

5.14 Program Sample



	X	Y
A	0	0
B	0	-2.45
C	0	2.45
D	-3.064	.5045

This part will be programmed using point A (the center of the .750 radius circular pocket) as the absolute zero reference. Streamline Programming (see Section 5.11.4.9) will be activated.

The machining sequences will be: center drill the 1.125 radius bolt hole pattern; finish drill the bolt hole pattern. Using a .500 end mill machine the .750 radius circular pocket, including a .010 finish cut. Using the same end mill, machine the perimeter of the part from point B to point C toward point D through the .841 radius and back to point B.

Prompt	Input	Explanation
--	Bolt Hole	To center drill 5 hole bolt hole pattern
# HOLES	5, INC SET	
X CENTER	ABS SET	Zero is assumed when no numeric data is entered
Y CENTER	ABS SET	
RADIUS	1.125, INC SET	
ANGLE	45., INC SET	First hole to be drilled is +45 degrees from the 3 o'clock position

Prompt	Input	Explanation
TOOL #	1, INC SET	Tool #1 is center drill
--	REPEAT	To finish drill the five holes center drilled in Event #1
FROM	1, INC SET	The first event to be repeated is Event #1
TO	1, INC SET	The last event to be repeated is also Event #1
X OFFSET	INC SET	There is no offset since the holes are to be drilled in the same location as the center drilled holes
Y OFFSET	INC SET	
# REPEATS	1, INC SET	
TOOL #	2, INC SET	
TOOL DIA	.25, INC SET	
--	CIRCLE	To machine the .750 radius circular pocket
PK1 FR2	1, INC SET	To select pocket (not frame)
X CENTER	ABS SET	
Y CENTER	ABS SET	
RADIUS	.75, INC SET	Finish radius of circle
CW1 CCW2	2	To select counterclockwise tool path
FIN CUT	.01, INC SET	To machine .010 finish cut
FEEDRATE	8., INC SET	To specify 8 ipm feedrate
TOOL #	3, INC SET	
TOOL DIA	.5 INC SET	To specify .500 end mill
--	ARC	To mill from B to C
X BEG	ABS SET	
Y BEG	-2.45 ABS SET	
X END	ABS SET	
Y END	2.45 ABS SET	

Prompt	Input	Explanation
X CENTER	ABS SET	
Y CENTER	ABS SET	
CONRAD	0, INC SET	To command system to machine a zero radius at point C and continue towards point D
CW1 CCW2	2, INC SET	
CO R1 L2	1, INC SET	To command system to machine to the right of the programmed arc
FEEDRATE	8., INC SET	
TOOL #	3, INC SET	
--	MILL	To mill from C toward D through the .841 radius
X END	-3.064, ABS SET	
Y END	.5045, ABS SET	
CONRAD	.841, INC SET	To connect CD to DB
FEEDRATE	INC SET	No need to reinput data if feedrate remains same as previous event
--	MILL	To mill back to point B
X END	ABS SET	
Y END	-2.45, ABS SET	
CONRAD	INC SET	
FEEDRATE	INC SET	

6.0 DO ONE Operation - Program & Run

The major portion of many jobs can best be done manually with DRO. However, there are often just a few cuts that require excessive time and set-up, for example, long position moves, arcs, or diagonals. DO ONE programming assists the operator in performing these more time-consuming operations without the necessity of detailed programs, etc.

NOTE: DO ONE events may only be programmed and run one at a time. When a DO ONE event has been run it is erased from the ProtoTRAK's memory.

6.1 Incremental Reference Position

The incremental reference position for any DO ONE event is the current position of the tool (or actually the table and saddle). That is, the position at the time the event is run. So an incremental input will move the table by that amount from where it currently is. The absolute reference is unchanged from where it already is.

6.2 DO ONE Program & Run

DO ONE programming and run is nearly identical to the complete part programming described in Section 5. There are, however, a few differences. They are:

- a) Press the DO ONE key before pressing the event key; for example, DO ONE, MILL or DO ONE, PCKT.
- b) The conversation display never prompts for TOOL #. Since it is a program of one event it could only use one tool.
- c) DO ONE Mill and Arc Events will not prompt for CONRAD. There is no second event to connect to. However, the Pocket Event will prompt for CONRAD to define the corner radius.
- d) There cannot be a DO ONE Repeat Event. There are no other events in the program to repeat.

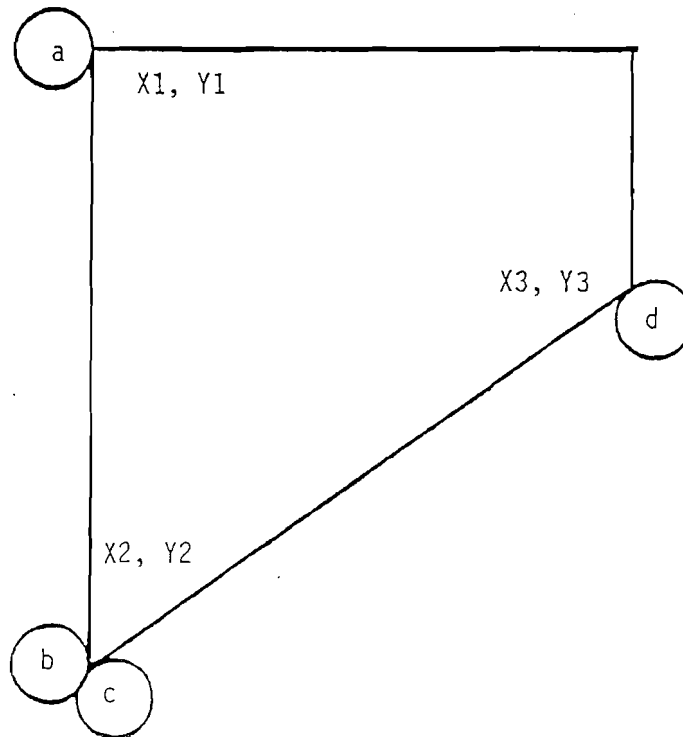
DO ONE program run is identical to complete part program runs (Section 5) with the exception listed below:

- a) When all of the data are programmed, the conversation display will prompt START? It is asking if you want to run the DO ONE program. If you do, press START for three seconds.
- b) After you start, the display will prompt CHECK Z to remind you to raise the quill.
- c) Press GO to begin the event run.

- d) The DO ONE program is run identically to any complete part program except that at its completion, the servos are turned off and the ProtoTRAK reverts to normal DRO operation.

6.3 Cutting Corners

Care must be taken when programming successive DO ONE events at corners.



In the figure above if a DO ONE mill event was programmed from $X1, Y1$ to $X2, Y2$ with tool right offset the cutter would move from a to b . If another DO ONE mill event was programmed from $X2, Y2$ to $X3, Y3$ with tool right offset the cutter would first move from b to c (the end of the first to the beginning of the second with their offsets) then on command from c to d . Note that if the cutter is not raised in moving from b to c the tip of the corner at $X2, Y2$ will be machined off.

It is good practice to always raise the tool between successive DO ONE mill or arc routines.

NOTE: In regular programming (see Section 6) this is not a problem as long as the two mill events are connective. The ProtoTRAK automatically compensates and "walks around the corner."

6.4 DO ONE Editing

Because DO ONE events are singular (that is only one can be programmed and run at a time) and brief, there is no procedure for their recall and edit.

If the operator wishes to edit a DO ONE event he must press the event type (like MILL) and reinput the entire event.

If the operator does not wish to run a DO ONE event after it is partially or wholly programmed he must press DO ONE and RESTORE.

7.0 Math Help

Prints are, unfortunately, not always drawn and labeled in such a way as to provide all of the points necessary for programming. To minimize this problem the ProtoTRAK provides a math help function which can be used to automatically calculate points of intersection, centers of arcs, trig functions, square roots, etc.

7.1 Procedure

The procedure for each calculation is as follows:

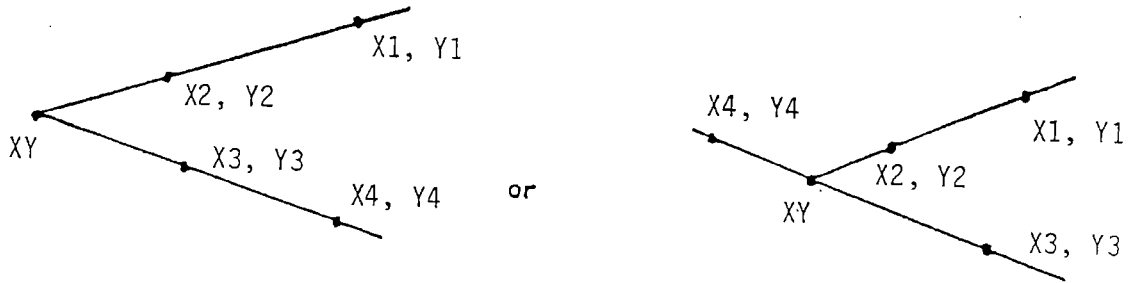
- a) At any time during Program or in DRO operation (except during run, jog, or when non-dimensional data is being prompted), press MATH HELP.
- b) The display will read TYPE--locate in Section 7.2 the type of problem to be solved or data to be acquired and input the number and SET.
- c) The conversation display will prompt for the necessary data specified in Section 7.2--input the numeric information and press ABS SET (all dimensions must be absolute).
- d) For many problems there are two or even more correct solutions (for example, the intersection of a line and a circle). In these cases the display will indicate the number of possible solutions and name them A, B, etc. Press RECALL DATA.
- e) The conversation display will read out which solution is being presented. X and Y positions for the indicated solution will be shown in the X and Y readout. All other data will be shown in the Z readout. Press RECALL DATA to view additional data for the same solution or the data for other possible solutions. Record the data for each solution.
- f) If two or more solutions are given, the operator must decide which is correct or appropriate for his particular problem. In general, the appropriate solution is obvious, but occasionally careful plotting on the print will be necessary to choose.
- g) Press RESTORE if data is incorrectly input and start the MATH HELP routine over. Press RESTORE to abort the MATH HELP subroutine and return to the DRO or Program Mode. After abort the ProtoTRAK will return to the same status as before the MATH HELP key was first pressed.

7.2 Math Help Types

7.2.1 Type 10:

Find the intersection of two lines when any two points are known on each line.

Find XY

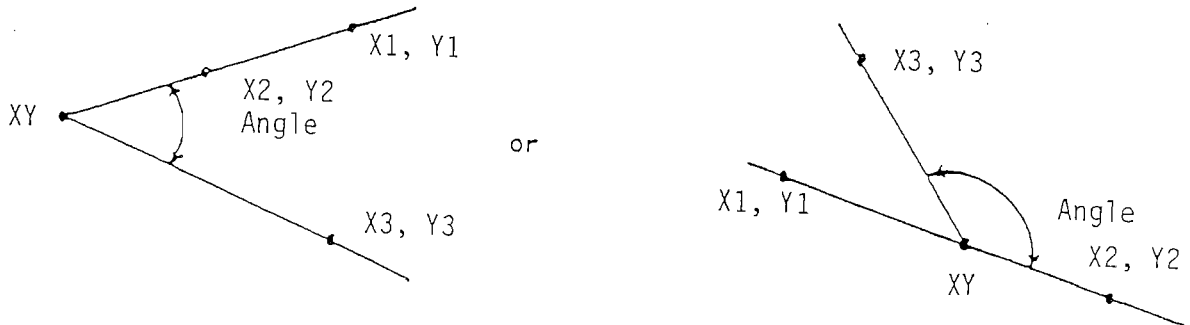


Display prompts: X1, Y1, X2, Y2, X3, Y3, X4, Y4
 Number of possible solutions: 1

7.2.2 Type 11:

Find the intersection of two lines when two points are known on one line, one point is known on the other line and the angle between the lines is known.

Find XY

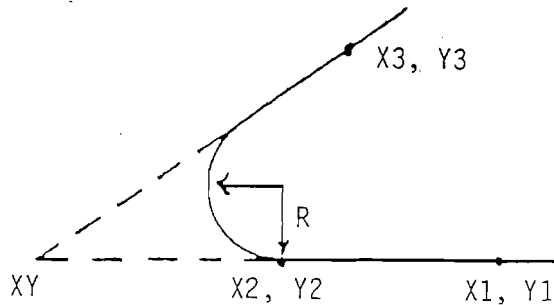


Display prompts: X1, Y1, X2, Y2, X3, Y3, ANGLE
 Number of possible solutions: 2, A and B

7.2.3 Type 12:

Find the intersection of two lines when two points are known on one, one point is known on the other, a radius tangent to both lines is known, and when one of the points on the two known point lines is also on the radius.

Find XY



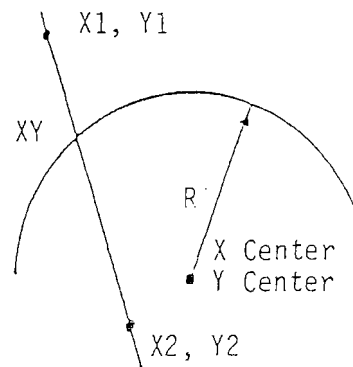
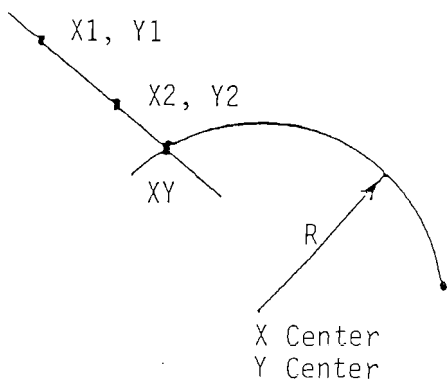
NOTE: Point X2,Y2 is on line X1, Y1-X2, Y2 and on the arc with radius R between the lines

Display Prompts: X1, Y1, X2, Y2, X3, Y3, RADIUS
 Number of possible solutions: 2, A and B

7.2.4 Type 13:

Find the intersection of a line and an arc when 2 points are known on the line and the arc's center and radius are known.

Find XY

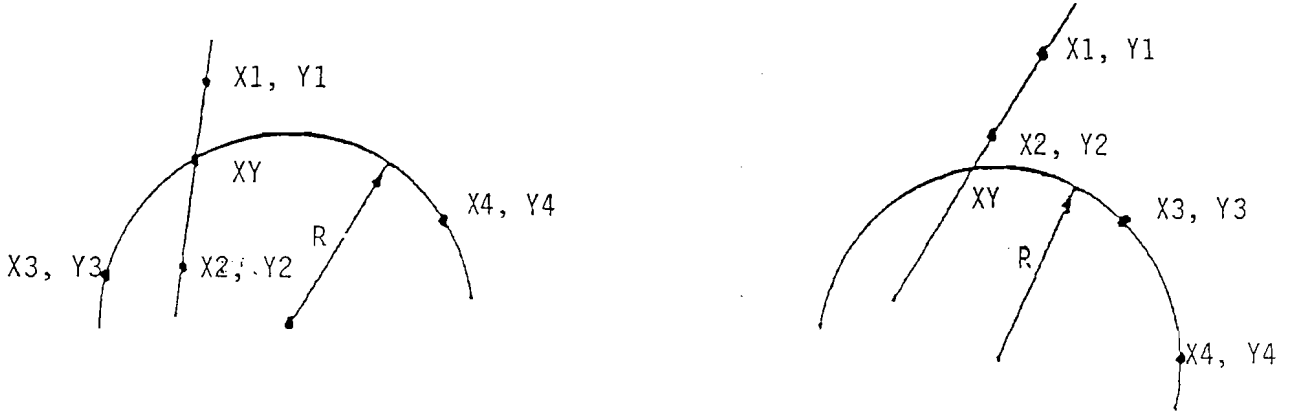


Display Prompts: X1, Y1, X2, Y2, XCENTR, YCENTR, RADIUS
 Number of possible solutions: 2, A and B

7.2.5 Type 14:

Find the intersection of a line and an arc when two points are known on the line, two points are known on the arc, and the arc radius is known.

Find XY

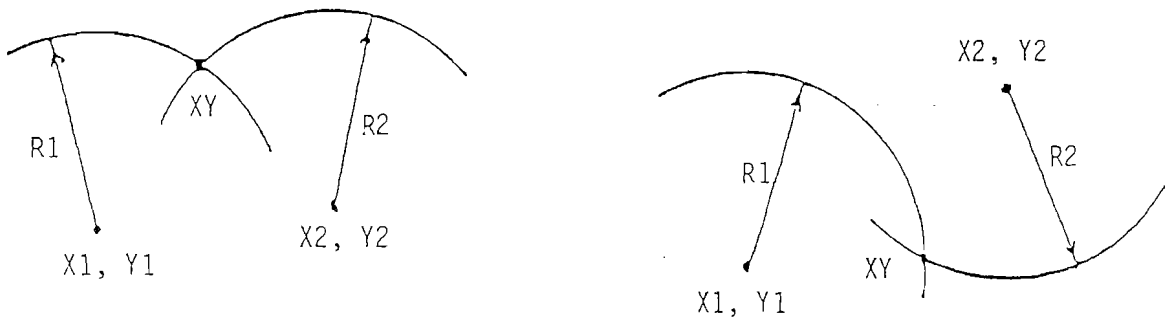


Display Prompts: X1, Y1, X2, Y2, X3, Y3, X4, Y4, RADIUS
 Number of possible solutions: 4; A, B, C, D

7.2.6 Type 15:

Find the intersection of two arcs when the center and radius of each are known.

Find XY

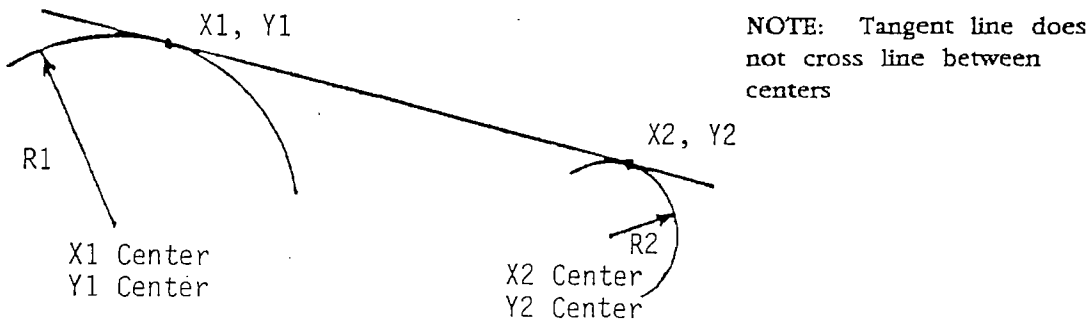


Display Prompts: X1, Y1, R1, X2, Y2, R2
 Number of possible solutions: 2; A and B
 If only one solution is given the circles are tangent.

7.2.7 Type 16:

Find the two intersections of a line tangent to two arcs when the centers and radii of each are known.

Find $X1Y1$ and $X2Y2$

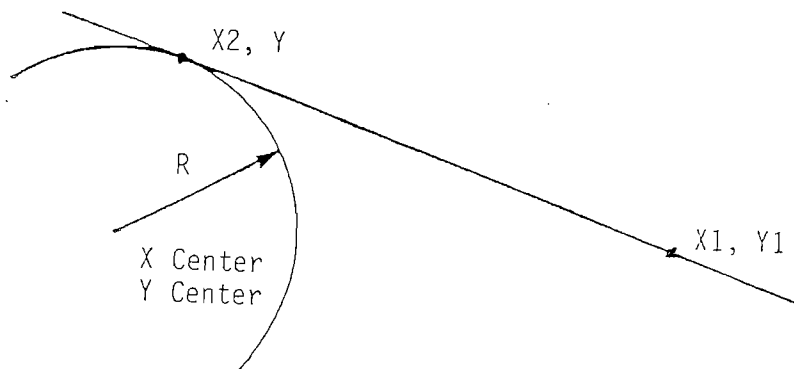


Display Prompts: $X1CNTR$, $Y1CNTR$, $R1$, $X2CNTR$, $Y2CNTR$, $R2$
 Number of possible solutions: 2; A and B for each point

7.2.8 Type 17:

Find the intersection of a line tangent to an arc when one point is known on the line and the arc's center and radius are known.

Find X , Y

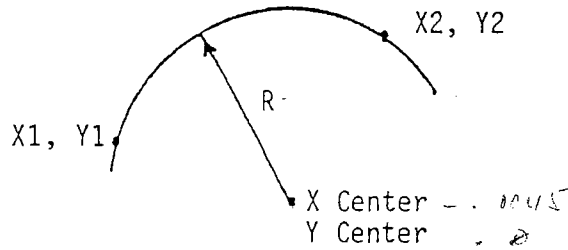


Display Prompts: $X1$, $Y1$, $XCNTR$, $YCNTR$, $RADIUS$
 Number of Possible Solutions, 2; A and B

7.2.9 Type 20:

Calculate the center of an arc when two points on the arc and its radius are known.

Find X CENTR
Y CENTR

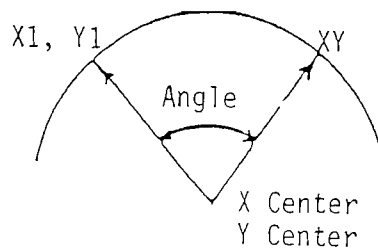


Display Prompts: X1, Y1, X2, Y2, RADIUS
Number of possible solutions: 2; A and B

7.2.10 Type 21:

Calculate a point on an arc when the center, another point on the arc, and the angle between the arc points are known.

Find XY

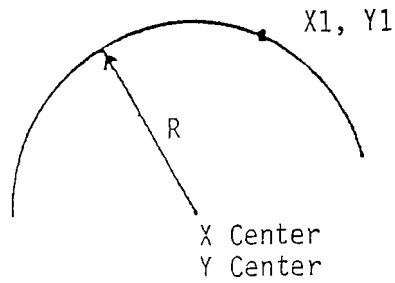


Display Prompts: X1, Y1, XCENTR, YCENTR, ANGLE
Number of possible solutions: 2; A and B

7.2.11 Type 22:

Calculate the radius of an arc or circle when one point on the arc and the center are known.

Find R

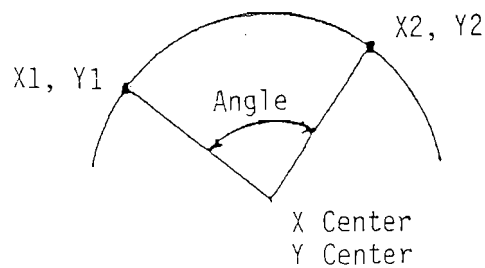


Display Prompts: X1, Y1, XCENTR, YCENTR
 Number of possible solutions: 1

7.2.12 Type 23:

Calculate the center of an arc or circle when two points on the arc and the angle between them are known.

Find X CENTR
 Y CENTR

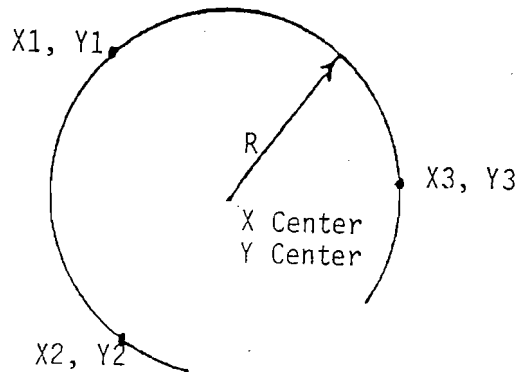


Display Prompts: X1, Y1, X2, Y2, ANGLE
 Number of possible solutions: 2; A and B

7.2.13 Type 24:

Calculate the center and radius of an arc or circle when three different points on the arc or circle are known.

Find R and
X CENTR
Y CENTR

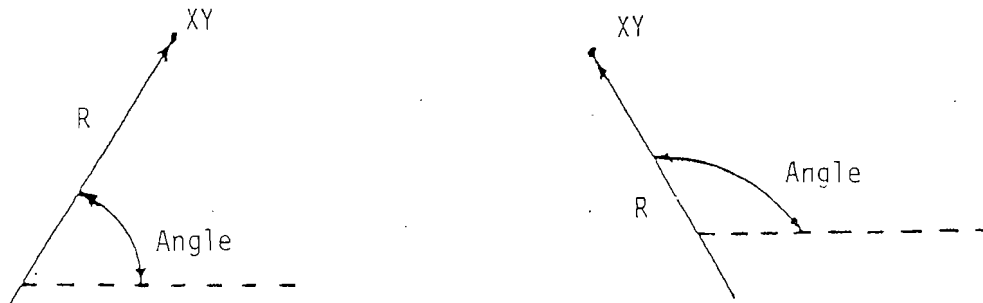


Display Prompts: X1, Y1, X2, Y2, X3, Y3
Number of possible solutions: 1

7.2.14 Type 25:

Calculate the cartesian (X and Y) location when polar (R and angle) coordinates are known.

Find XY



Display Prompts: RADIUS, ANGLE (NOTE: The angle is always measured from positive X axis or 3 o'clock.)
Number of possible solutions: 1

7.2.15 Common Mathematical Numbers

Type	Data Required	Prompt
30	sine	ANGLE
31	cosine	ANGLE
32	tan	ANGLE
33	arc sine	NUMBER
34	arc cosine	NUMBER
35	arc tan	NUMBER
36	square root	NUMBER
37 (to find decimal value)	degrees, minutes, seconds	DEGREES... MINUTES... SECONDS...

8.0 Care & Service

8.1 General System Care

The ProtoTRAK is very rugged and durable but requires some special care in the machine shop environment. The system should not be exposed to excessive vibration or contaminants.

Care should be taken that the mylar face of the control pendant is kept out of the way of excessive chips (especially if hot). The mylar face is resistant to minor abrasion and most common solvents. Heavy abrasive rubbing and a few chemicals may ruin the surface. A typical window cleaner like Windex is recommended. Make sure that the cleaning cloth does not contain metal chips.

The encoder (TRAK Sensor) has been designed and built to withstand the typical machine shop environment. Under normal circumstances, the only maintenance required is a periodic change of the wiper pad (approximately every 6 months) and an occasional recalibration (approximately every 6 months) to minimize machine tool inaccuracies. These typical time periods are greatly dependent upon the actual environment in the encoder area.

8.2 Data Error Messages

Sections 5 and 6 specify several programming rules (listed below) that must be followed. For many of these, the ProtoTRAK has the ability to self check to ensure they have not been violated. When they have, the conversation display will say "DATA ERR ____" specifying which rule has been broken. These error messages will be displayed during program run (where their consequences can be measured by the ProtoTRAK) and NOT during the actual programming.

In every case the corrective action is to press the RESTORE key. Run will abort and the conversation display will read "____ AT EVNT # " to show which event has been programmed incorrectly. Press the RESTORE key a second time and edit the improper data in the program.

Some errors can be detected by the ProtoTRAK immediately upon input. In these cases the conversation display will read "INPUT ERR". This incorrect data will not be loaded into the ProtoTRAK. Press RESTORE, check the data, and re-input it into the system.

Listed below are the data errors, "DATA ERR ____", which may be displayed along with an explanation of the error.

- 01 - Drill event cannot be connective. That is, the event preceding the drill event called for a CONRAD which is not allowed.
- 02 - Repeat event cannot be connective. That is, the event preceding the repeat event called for a CONRAD which is not allowed.
- 03 - The starting event cannot be a repeat event.

- 04 - No double repeat nesting. That is, none of the events to be repeated can be a repeat event of a repeat event.
- 05 - Repeat events can only repeat previous events.
- 06 - In a repeat event, all of the events to be repeated have been deleted and none have been substituted.
- 07 - A CONRAD is programmed but the end point of the first event does not equal the beginning point of the second.

NOTE: This problem may also occur when CAD/CAM generated programs are edited at the ProtoTRAK. When this happens, always be certain that X BEG and Y BEG in the second event are programmed as 0 INC SET at the ProtoTRAK.

- 08 - A CONRAD is programmed but the tool offset (CO R1 L2) of the first event does not equal the tool offset of the second.
- 09 - A CONRAD is programmed but the tool diameter of the first event does not equal the tool diameter of the second.
- 10 - A CONRAD is programmed but the tool number of the first event does not equal the tool number of the second.
- 11 - It is mathematically impossible to define a circle with the XY beginning, end, and center points given. Check accuracy of data including tolerances.
- 12 - Circle event must not be connective.
- 13 - The circle or arc is a point. That is, XY beginning, end, and center are all the same.
- 14 - The mill or pocket event is a point. That is, XY beginning is the same as XY end.
- 15 - The tool diameter is too big. See Section 3.4.1.
- 16 - CONRAD too big. Mathematically impossible to calculate a tangent point on at least one of the mill segments adjacent to the connective segments.
- 17 - Pocket event must not be connective.
- 18 - Finish cut too big. Must be less than or equal to tool radius.
- 19 - Tool diameter is 0
- 20 - Pocket too small. Short side is less than tool diameter plus 2 times finish cut.
- 21 - CONRAD too big in Pocket Event.
- 22 - Tool too big in Arc or Circle Event

8.3 Fault Messages

The ProtoTRAK performs a number of automatic checks on its ability to perform properly (especially when it is first turned on). When problems are identified they are shown on the conversation display as "FAULT _ _".

Listed below are the fault indicators that may be displayed and the recommended action to be taken.

- 01 - The sensor calibration factor of one or more of the sensors has been lost. Recalibrate all sensors. If fault reoccurs call for service.
- 02A Part of the ProtoTRAK's master internal memory has been lost or
02B electronically altered. The system will probably not operate
02C properly. Call for service.
02D
02E
- 03 - Part of the ProtoTRAK's servo drive internal memory has been lost or electronically altered. Call for service.
- 04 - The master microprocessor fails to communicate with the servo drive microprocessor. Press RESTORE, turn the ProtoTRAK off for a minute and try again. If fault persists call for service.
- 05 - The servo drive microprocessor fails to communicate with the master microprocessor. Press RESTORE, turn the ProtoTRAK off for a minute and try again. If fault persists call for service.
- 32 - Total memory clear. This may occur normally when the ProtoTRAK is first powered-up during installation. Press RESTORE.
- 33 - Bad memory integrated circuit.
- X - X axis will not move properly. Press RESTORE. Check to be certain the table is not jammed; check the cables and connections from the motor to the Power Control Cabinet and from the Sensor to the Display Pendant. Be sure they are plugged into their current socket. Try again; if fault persists call for service.
- Y - See X above, but check Y axis.
- XY - Both axis fail. See X above and check both axes. Be sure X and Y cables are not switched when plugged into Power Control Cabinet and/or Pendant.
- CALIBRATE X,Y,Z - The ProtoTRAK sensor encoders have not been calibrated or the calibration correction factor has been lost. Recalibrate the sensor encoder for the axis shown.
- MEM ERR (flashing) - Some or all of the program data has been lost or altered. Press RESTORE. Check and re-input where applicable the entire program.

EEM ERR (flashing) - Press RESTORE. Recalibrate all sensors.

8.4 ProtoTRAK Limited Warranty

TRAK products are warranted to the original purchaser to be free from defects of workmanship and materials for one year.

The warranty period starts on the date of the invoice to the original purchaser from Southwestern Industries, Inc. (SWI) or their authorized distributor.

If a unit under warranty fails it will be repaired or exchanged at our option for a properly functioning unit in similar or better condition. Such repairs or exchanges will be made FOB Factory/Los Angeles or the location of our nearest factory representative or authorized distributor.

8.4.1 Disclaimers of Warranties

1. SWI is not responsible for consequential damages from use or misuse of any of its products.
2. TRAK products are precision electronic-mechanical measurement systems and must be given the reasonable care that these types of instruments require:
 - o Replacement of wipers is the responsibility of the customer.
 - o Accidental damage, beyond the control of SWI, is not covered by the warranty. Thus, the warranty does not apply if an instrument has been abused, dropped, hit, disassembled or opened.
3. Improper installation by or at the direction of the customer in such a way that the product consequently fails, is considered to be beyond the control of the manufacturer and outside the scope of the warranty.
4. Warranty repairs/exchanges do not cover incidental costs such as installation, labor, etc.
5. This warranty is expressly in lieu of any other warranties, express or implied, including any implied warranty of merchantability or fitness for a particular purpose, and of any other obligation or liability on the part of SWI (or any producing entity, if different).

Specifications subject to change without prior notice.)

This product is covered by one or more of the following U.S. Patents: D194,853;3,307,265; 3,311,985; 3,378,929; 3,561,120; 3,561,121; 3,724,082; 3,740,856;3,876,164; 3,877,273; 3,771,288; 3,844,044. Other patents issued and pending in the U.S. and other countries.

