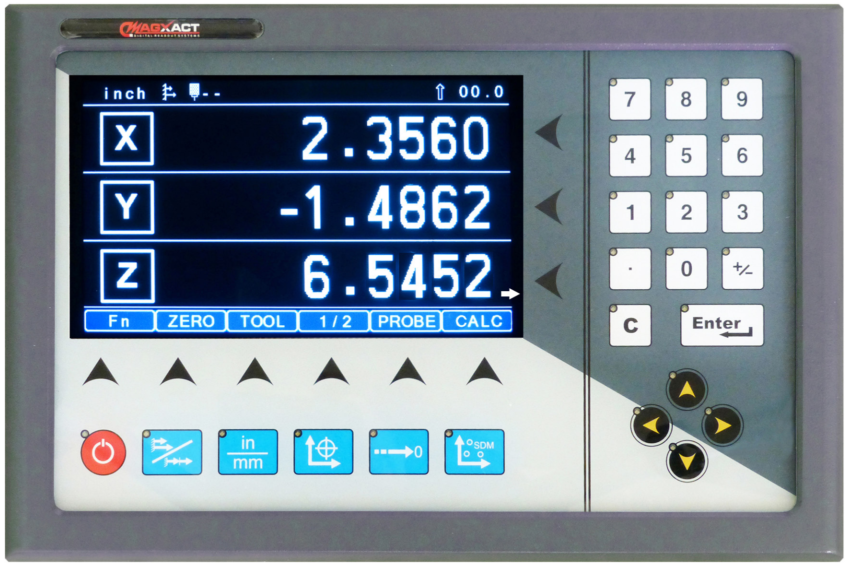
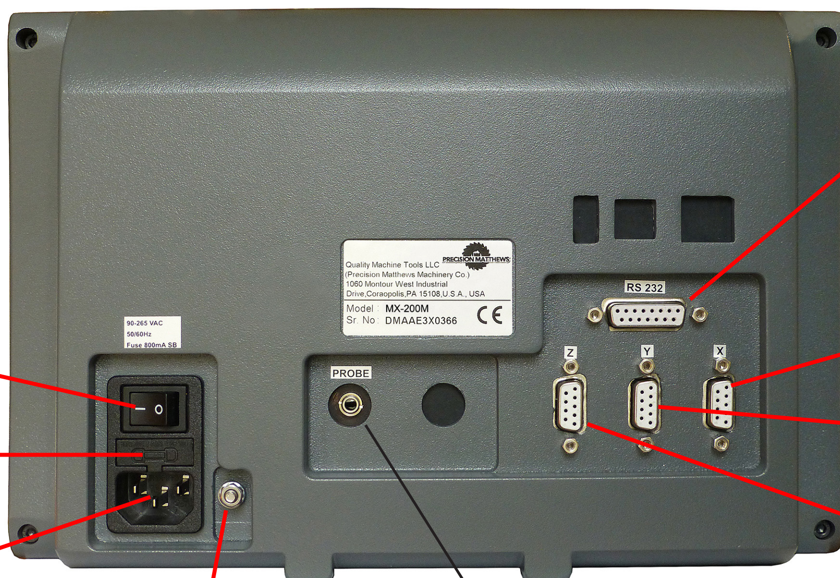
MagXact MX-200M MILL DRO





The MagXact MX-200M mill DRO is a 3-axis unit with magnetic scales, 5 micron resolution. The procedure for installing the scales is described in other Precision Matthews publications, and is not repeated here.

First use

1. Connect the three scales on the mill as shown above.
2. Connect 110Vac power to the DRO through a ***surge protector.***
3. If the 110Vac outlet is not reliably grounded, connect a ***ground wire*** between the mill and DRO.

The system should now be immediately functional, with the three numerical displays responding to machine movements.

Power-up display

The model number on the display should read **MX-200M**, followed by a firmware version number (**Ver**) depending on the date of manufacture.

FAQ Why does the display report machine motion incorrectly?

The standard MagXact package for the mill has 5 micron (0.005 mm = 0.0002") resolution scales. If you have installed a special-order package with 1 micron (0.001 mm) scales, the display will report 5X actual movement. See **Setup**, following page.

FAQ Do the numerical displays work like this?

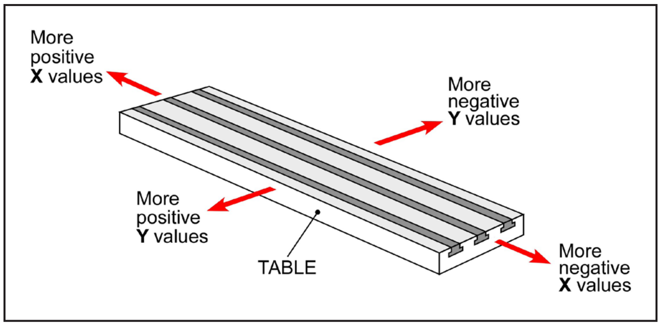


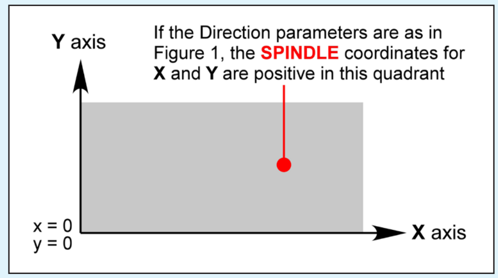
Figure 1 **A suggested sign convention**

In Figure 1 the X value becomes more positive as the table moves to the left; similarly, the Y value becomes more positive as the table moves forward, toward you. For everyday work, this is entirely a matter of choice, not an industry-wide convention (there isn't one). The only time to be concerned about ***display direction vs. table motion*** is when you are running a pre-programmed macro routine such as PCD (hole circle) — this will give unexpected results if you are not set up as in the diagram. See **Setup**, following page.

The coordinate sign contradiction

Coordinate sign is a source of much confusion. Figure 1 shows the displayed value becoming more positive when the table moves to the left. Why is this, when we usually think of a leftward motion as "becoming less"? Shouldn't it be the other way around?

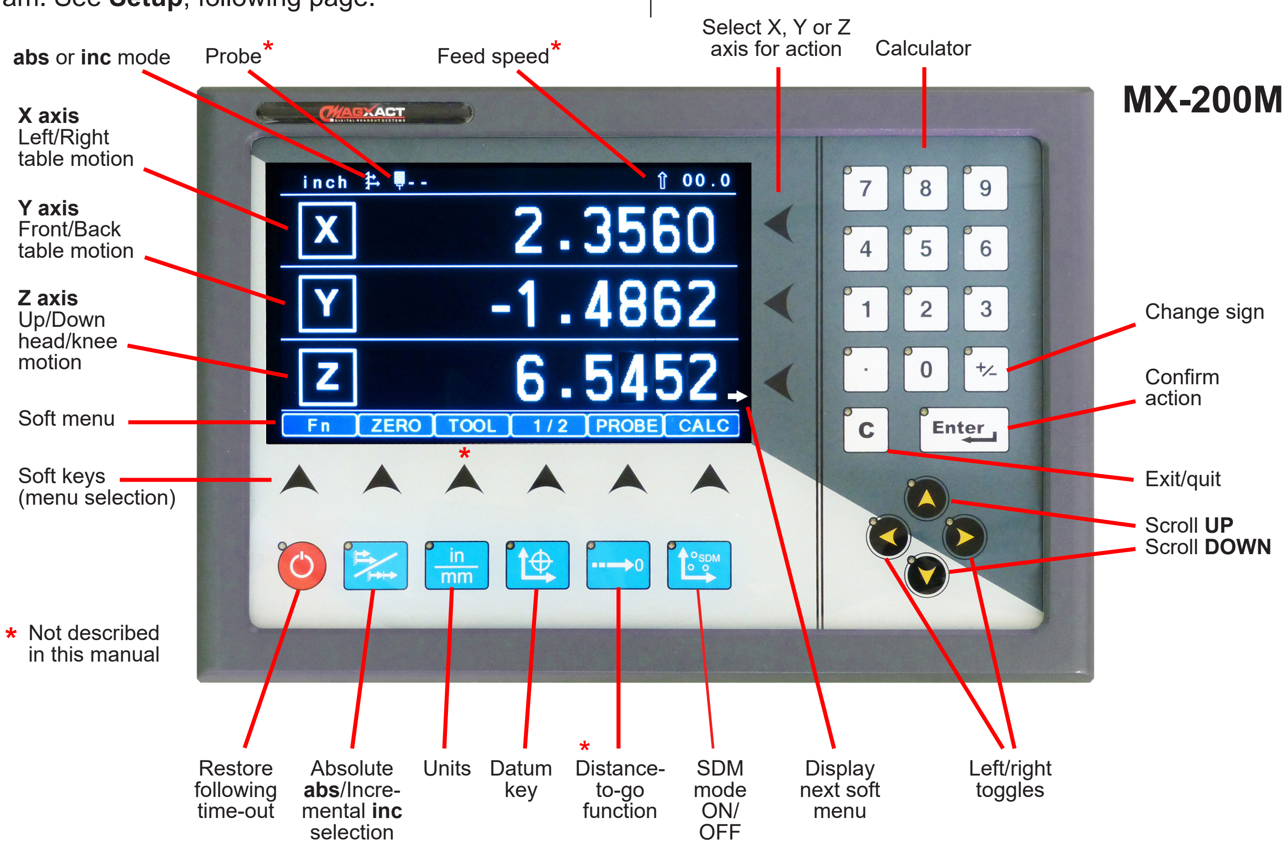
The answer is ***NO***. Forget table motion as viewed by you in the ordinary way, facing the machine. Imagine instead that you are looking down from the cutting tool as it travels across the workpiece. From this viewpoint a left-moving table has the tool in effect moving to the right, which is the conventional positive direction in coordinate geometry.



DRO Touchscreen

The entire front panel is touch-sensitive, meaning that a light pressure on an icon or numeral does the job of a physical push-button. An advantage of this system is that the panel can easily be cleaned using a mild detergent or Windex. Until you get used to "virtual push-buttons" the **Key Beep** function can be helpful, see **Setup**, following page.

MX-200M



Coordinates define locations on the workpiece

In everyday life we use coordinates to specify a location on a map — for instance, how far east is it from a point of reference, and how far north? In milling machine terms, think of the map lying flat on the table, with south toward you. Westerly or easterly travel on the map corresponds to longitudinal motion of the table, the ***X axis***. Similarly, the north/south ***Y axis*** corresponds to the other direction of table movement, toward you, or back.

It follows that a pair of X and Y values, the XY coordinates, completely define a point in the "XY plane”"— in other words, the mill table. If the project is simply to drill holes in a flat workpiece, all you need are X and Y coordinate pairs, as many pairs as there are holes. But for less straightforward projects, we need the “third dimension” to specify (say) depth of the holes, or the vertical distance between two horizontal surfaces. This is the ***Z axis*** dimension, which has to do with the height of the milling cutter or drill chuck relative to the workpiece.

A second Z factor is quill position — think "drill-press action". This is not reported on a three-axis DRO because it is totally independent of headstock height (some mills have a separate quill DRO in the headstock).

Relating coordinates to real-life measurements

In any discussion to do with "direction" and "coordinates" we always need to be specific about which is relative to what. For example, your sense of positive or negative can depend on your choice of workpiece datum — left side or right side, front or back, see Figure 2.

There are two other variables to consider:

1. How the scales were installed on the mill. The Y axis scale could be on either the left or right of the saddle. Ditto the Z axis scale, left or right of the column or knee. The X axis scale is mostly — but not in every case — at the back of the table.

2. No matter how the scales were installed, how the DRO handles output from the scales depends on your setting of the **Axis Direction** parameter, see **SETUP**, see next page.

What it comes down to is this: for routine shop work go with whichever direction setup you prefer. It really doesn’t matter, unless you are using sub-datums, or one of the DRO’s pre-programmed macros, such as Bolt Hole Circle (PCD, pitch circle diameter). For these actions, use the sign convention shown in Figure 1.

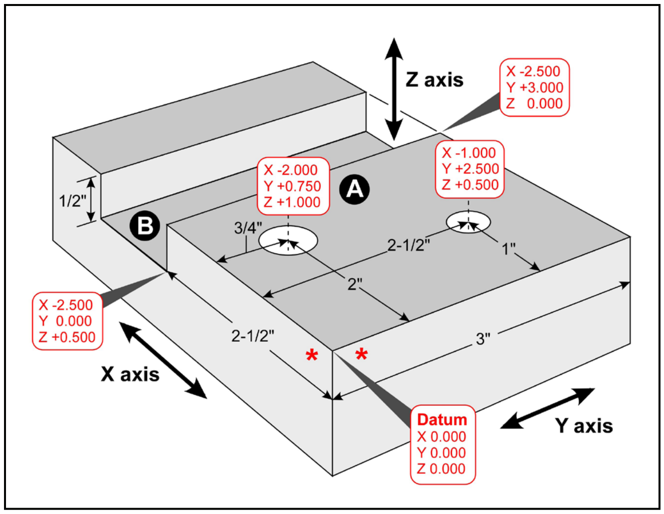


Figure 2 **Real-life measurements and coordinate equivalents**
By using an edge finder on the asterisked surfaces, the lower right corner of the workpiece has been defined in this example as the datum, the point where X and Y values are both zero. The Z axis is assumed to be zeroed at the point where the cutting tool just touches the workpiece. The Z coordinates shown here indicate that the Z display goes positive as the cutting depth increases, from surface A to surface B. This a user preference.

The two holes have negative X and positive Y coordinates. Referring to Figure 1, this is because positioning the spindle over these locations calls for the table to be moved to the right (X), and brought forward (Y). If the DRO is set up with a different sign convention, the sign of one or both of the X and Y values will also change. ***This also applies if the datum is chosen to be at a different location, such as lower left.***

SETUP

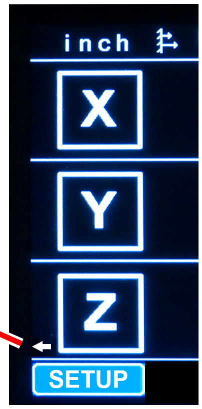
Recommended: Start by selecting the unit of measurement, inches or millimeters, by pressing the **in/mm** key to the right of the circular **RED** button (the selected unit, **inch** or **mm**, shows at top left of the screen). Assuming you have 5 micron scales (standard for a mill), "inches" will show 4 digits after the decimal point, **0.0000**. "Millimeters" will show 3 digits **0.000**.

If all axes are displaying machine motions in the directions you like (**Axis Direction** parameter), and are also reporting travel distances correctly (**Scale Resolution** parameter), there is nothing to set up at this point, aside from **Key Beep**, which is optional.

The following notes cover the setup procedure only for the three variables listed above, plus one that was not previously mentioned, namely **Display Resolution**. Other parameters are described in later sections.

SETUP *(continued)*

1. Note the small white arrow at bottom right of the numerical display. Touch the ► (right) toggle below the calculator keypad to display a second menu, this one with only one option, **SETUP**.



This left-facing arrow means there is a previous menu, see page 2. Press the ◄ toggle to return to that menu.

2. Press the soft key below **SETUP** to display the choice of **User Setup** and **Factory Setup**.

3. With the screen arrow alongside **User Setup**, press the soft key below **SEL** (select).

4. Scroll down ▼ to **Key Beep Enable**, then press the soft key below **ON** (recommended for early experiments).

5. Scroll down ▼ to **Select Axis**, then press the soft key below **X**, **Y** or **Z**, whichever axis you are concerned with (all three must be dealt with separately if any have resolution or direction issues.)

6. Scroll down ▼ to **Scale Resolution**. This is in microns (µm or um), 1 µm = approximately 0.00004 inches. The default resolution for mills is **5 µm** = 0.0002 inches. ***Skip this parameter*** if the selected axis is reporting travel distance correctly. If not, soft-key select another value from the six displayed (plus an additional four on the next menu page). 1 µm is a likely alternate choice for special-package installations.

7. Scroll down ▼ to **Display Resolution**. Also in microns (µm or um). ***Skip this parameter*** if you like the display to report motion in 0.0002 inch increments. If this is too sensitive, consider reducing the display resolution to 50 µm, 0.002 inches, three digits right of the decimal instead of four.

8. Scroll down ▼ to **Axis Direction** (do the numbers go positive or negative for a given motion of the table or headstock?) The direction parameter may report either LEFT or RIGHT. ***Skip this parameter*** if you like how the selected axis displays numbers, see Figure 1. If you prefer the "other" direction, soft-key select **LEFT** or **RIGHT** accordingly.

9. Scroll down ▼ to **Save & Exit**. Soft-key select **SAVE** if you have made changes. This will return you to the **Select Axis** menu line, allowing you to repeat the resolution and direction choices for the other axes if necessary.

10. When you have completed the axis-specific settings, scroll down ▼ to **Save & Exit** on the main menu.

OTHER SETUP MENU ITEMS

Grayed-out items are not described in this manual. Contact Precision Matthews if you have questions about them.

If you make any changes to the items in black type, scroll down to **Save & Exit** before returning to the regular numerical display.

Sleep mode time Enter the desired time in minutes from the keypad
Key Beep enable (**ON** recommended)

OFF ON

Zero approach beep (**ON** recommended)
Diagnostics

Select Axis

X Y Z

Axis type LINEAR
Scale resolution see Item 6 opposite
Display resolution see Item 7 opposite
Axis direction see Item 8 opposite
Machine reference
Zero approach distance
Calibrate axis
Apply compensation
Soft limit settings ***Recommended**: Select **EDIT**, then turn this function **OFF***
Vibration filter

Serial communications
Recall OEM settings
Machine model MILL

PREVENT DAMAGE TO THE SCALES

MagXact scales are very robust — far more so than optical scales — but the reading head must not be allowed to contact the scale's plated end-caps. **Stop at least 1/2" short!** Mark the machine in some way as a reminder, or if possible, set mechanical stops.

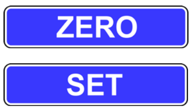
BASIC DRO FUNCTIONS

INCHES vs. METRIC UNITS

Press the **in/mm** key at any time to switch the display system inches to millimeters, and vice versa.

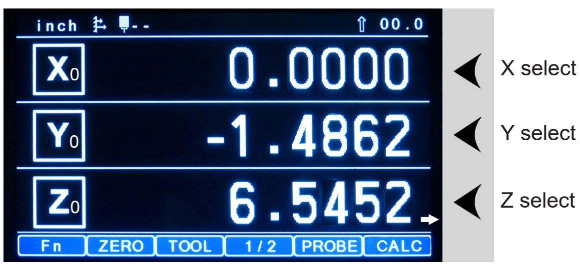
ZEROING THE DISPLAY

Pressing the soft key below the menu **ZERO** (page 2 photo) switches **ZERO** to **SET**. (Repeated pressing of the key alternates between the two choices.)



When **ZERO** is pressed the **X Y Z** characters on the display change to **Xo Yo Zo**, but nothing happens to the displayed numerals.

If you now press the "axis select" arrow ◀ to the right of the X numerals, the X axis is zeroed.

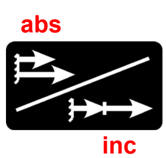


The Y and Z axes are zeroed in a similar way.

The **SET** function is described on page X, see **PRECISE REPOSITIONING OF THE TABLE**.

CHOICE OF ABSOLUTE OR INCREMENTAL MODE

(The usual shorthand for these terms is **abs** for Absolute Mode, **inc** for Incremental Mode.) Switch from one to the other by pressing the "arrows" key.



NOTE: In some versions of the MX-200M the arrow symbols on the key are replaced by plain language characters **abs** and **inc**. This applies also to the mode indication at top left of the display — plain-language abs/inc, or symbols mimicking the arrows key diagram here.

Superficially, the **abs** and **inc** modes seem to be similar — both display X, Y and Z coordinates in the same way, and the displays in either case can be zeroed by pressing the **ZERO** key followed by one or more of the "Select Axis" keys, see above.

The **abs** (absolute) coordinate frame is generally thought of as being fixed relative to the workpiece datum. The **inc** (incremental) coordinate frame is set arbitrarily at any time in the machining process: in other words, **inc** has no fixed relationship to **abs**.

! Some users are content with whatever mode the DRO happens to be in when switched on. Many users set up **abs** coordinates at the beginning of a work session, and thereafter work in the **inc** mode — knowing that the starting coordinates ***can be recalled at any time*** simply by switching back to **abs** — highly recommended.

The following example illustrates one possible way of using a combination of **abs** and **inc** modes:

1. Select a workpiece datum. In Figure 3 the bottom right hand corner has been "found" in the **abs** mode, and the XY coordinates have been set to zero.
2. In **abs** mode drill Hole A at X - 0.350, Y + 0.300.
3. For Hole B move the table 1.15 right to display X - 1.5 (-0.35 -1.15), and forward to Y + 0.6 (0.3 + 0.3). This is easy math, so stay in **abs** mode.
4. The group of smaller holes C, D, E is located by reference to Hole B. One possibility is to stay in ABS mode and move to C, D, E using mental arithmetic as before — but it's easier to switch to **inc** mode, then zero X and Y at the B location.
5. In **inc** mode Hole C is +0.5 away from B in X, and +0.25 in Y. Drill Hole C, then zero X and Y at C before moving on to D and E.

None of the above affects the abs datum, so the starting point can be recaptured at any time.

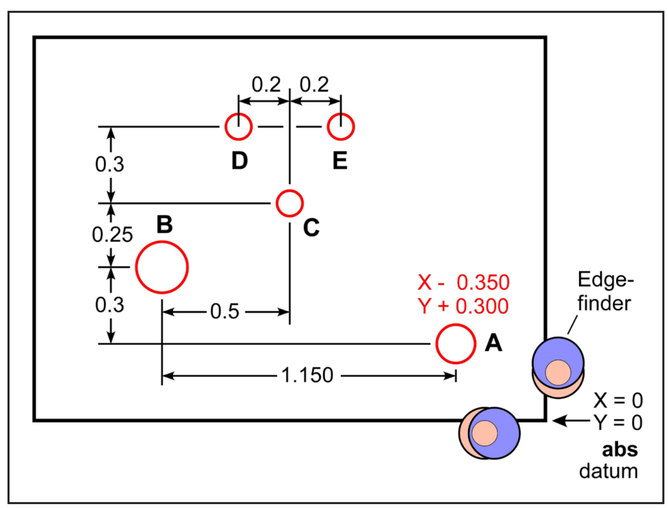


Figure 3 **Using abs and inc modes**

CENTER FIND

Locating the exact center of a workpiece is one of the most used applications of the DRO. These examples show a conventional edge finder with spring-loaded tip; when the tip just touches the workpiece edge it kicks out suddenly — edge "found". It helps to use a high spindle speed for edge finding.

(1) Center of rectangular workpiece

1. With the DRO in **inc** mode, and the edge finder positioned as Figure 4(A), run the table slowly forward to the point where the edge finder tip kicks out at the leading edge of the workpiece.
2. Zero the Y axis (see previous page for X example).
3. Raise the edge finder clear of the workpiece.
4. Taking care not to disturb the table's X position, raise the spindle, then the table forward to locate the edge finder behind the workpiece.
5. Lower the edge finder, inset Figure 4(B).
6. Move the table away from you to "find" the back edge of the workpiece, then press the **1/2** soft key, followed by the Y axis select key ◄.

1 / 2

The Y axis value is now ***one-half*** of the workpiece's front-to-back dimension (plus 2X the edge finder's tip radius). Now move the table backward until the Y display reads **0.0000**. At this point the spindle is ***exactly*** over the mid-point between front and back edges.

Repeat the above steps at left and right edges of the workpiece to find the X axis mid-point.

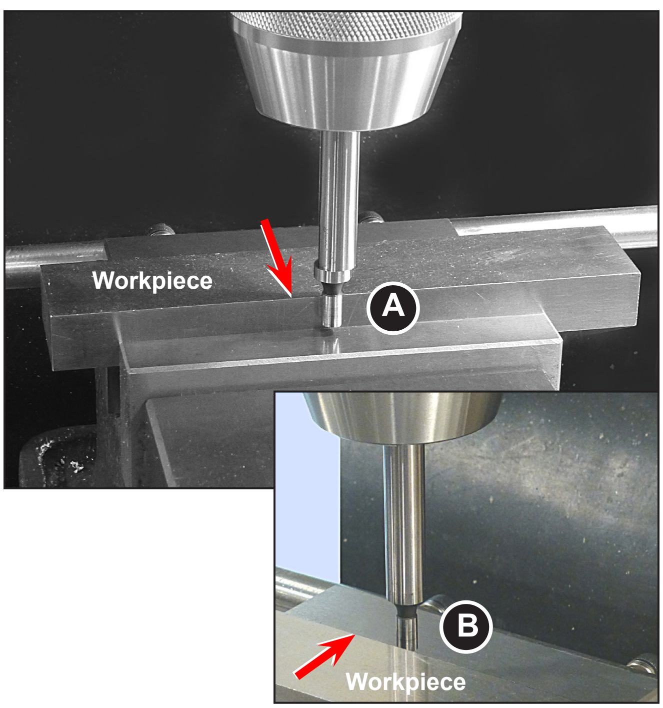
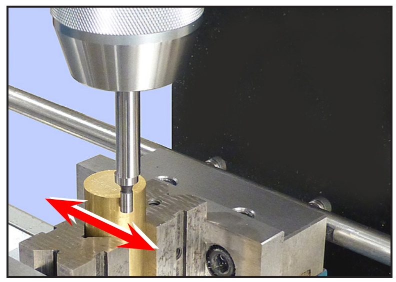


Figure 4 **Finding the Y axis center on a rectangular workpiece**

(2) Center of circular objects

Mid-point locating as described above is not only for rectangular objects. It can also be used to find the center of ***circular objects***. Examples: 1. Locating the center of a circular bar, maybe to center-drill it for lathe work, Figure 5, and; 2. Locating the center of a hole to be enlarged, Figure 6.

Locate the edge finder as near to the estimated centerline as possible before touching the edge. It does not have to be exactly on center, but the "other axis" ***must not move*** when you traverse from one side of the feature to the other — clamp it if necessary.



! ***The workpiece must be truly circular for a reliable result***

Figure 5 **Finding the X axis center on a circular bar**
*Be sure the Y axis location of the table is **exactly the same** when finding the left and right edges of the bar.*

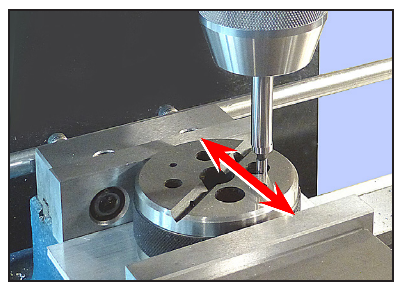


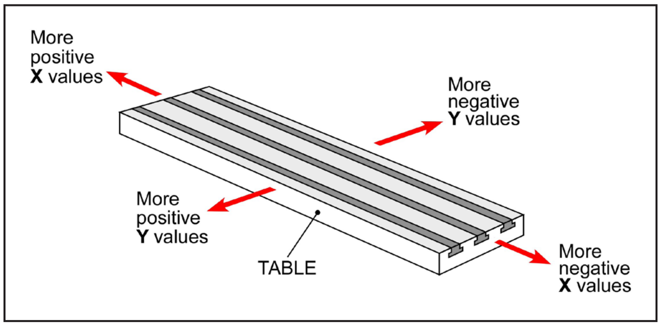
Figure 6 **Finding the Y axis center of a circular hole**
*Be sure the X axis location of the table is **exactly the same** when finding the front and back edges of the hole.*

PRECISE REPOSITIONING OF THE TABLE

The DRO can easily be set up to count down to zero from the table's current XY position to a specified new location. The headstock (Z axis) can be precisely relocated in a similar way.

Provided you do this in the **inc** mode, the **abs** zero will not be affected.

Table movement vs. display direction is important for this action, see Figure 1, repeated here:



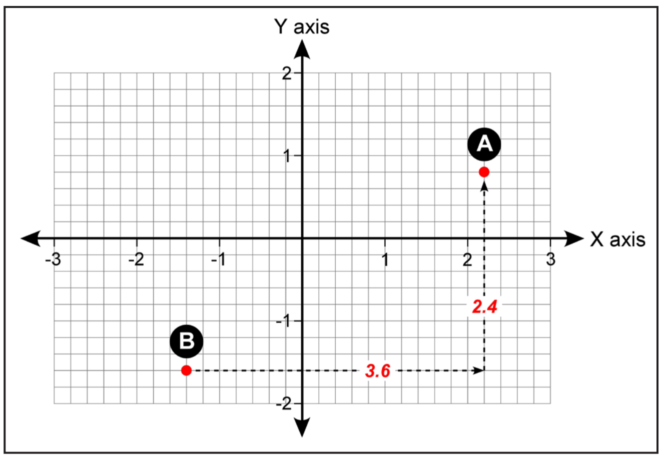
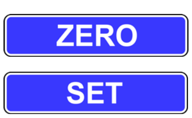


Figure 7 **Repositioning the table by exact amounts**

Referring to Figure 7, suppose the ***Mill Spindle*** is at point **A** and you wish to move the table to position the spindle over point **B.** In coordinate geometry terms B is "more negative" than A in both axes. According to the ***table direction vs. sign convention*** (upper diagram), this calls for the table to be moved to your right, and back, away from you.

1. Switch to (or stay in) the **inc** mode.

2. Press the **ZERO** or the **SET** soft key as needed to display **X**, **Y** and **Z**. (If **Xo Yo Zo** are displayed, press the key again.)



3. Press the "X select" key to the right of the X axis numerals. This will switch the display to the set-up mode, with a single zero:

4. Using the keypad enter the X value, ***3.6***, the distance from A to B, then press the **Enter** key to confirm. The X display now reads **3.6000**.

5. Press the **Y** key to select the Y axis.

6. Using the keypad enter the Y value, ***2.4***, the distance from A to B, then press the **Enter** key to confirm. The Y display now reads **2.4000**.

7. We are not concerned with the Z axis here, so the data entry is complete.

8. Move the table right, and back, to zero the X and Y axes.

Reverse direction

If the spindle is at point **B**, and you wish to re-position it to point **A**, the procedure is similar, except that the values for X and Y will be negative. Enter ***3.6 -*** for X, ***2.4 -*** for Y.

MACHINING PROGRAMS (MACROS)

The DRO has a full complement of ***macros***, pre-programmed routines that automate frequently used processes in the machine shop.

BOLT-HOLE #1 (drilling)* — Full Circle divided into equal sectors

BOLT-HOLE #2 (drilling)* — Arc of a Circle, divided into equal sectors, start and end angles specified

BOLT-HOLE #3 (drilling)* — Custom Arc of a Circle, start and end angles specified, sector angles individually specified

* Sometimes referred to as PCD (Pitch Circle Diameter) drilling.

Line Hole drilling — Equally spaced holes along a line at a specified angle

Grid drilling — Rectangular grid of holes, in line with X and Y axes, or rotated by a specified angle

The following are ***contouring*** macros, used to "nibble" a series of overlapping holes around the perimeter of a rectangle or arc, either inside or outside the perimeter, or centered on the line. Smoothness of the nibbled outline is controlled by the ***maximum cut*** parameter, which limits the size of step between one hole center and the next — the smaller the maximum step, the smoother the line.

Essentially, the contouring macro generates a "best fit" "series of equally-spaced holes to span the arc or line in question. In every case, the spacing between holes is always equal to or less than the specified maximum cut.

Frame (contouring) — Nibbling a rectangle, side lengths and tilt angle specified

Arc (contouring) — Nibbling an arc, start and end angles specified

R-function (contouring) — Nibbling a 90 degree arc starting wherever the spindle is located when the R-function is initiated (by selecting RUN). Start and end radii are always aligned with the X or Y axis. A total of eight macros provides for clockwise and counter-clockwise sweeps in the 4 quadrants, NE, NW, SW and SE.

Pocket (contouring) — This is similar to **Frame**, above, with the difference that it calls for repeated passes to convert the frame outline into a cavity. The pocket function is not covered in this manual, because most users prefer simply to rout out a frame, in the ordinary way, then remove the enclosed area without DRO guidance.

Slot — Nibbling a slot, length and tilt angle specified

COMMON FEATURES OF MACROS

! *Read this first!*

- Work in either **abs** or **inc** modes.
- Macros are usually run in the **X-Y** plane, in other words, the plane of the mill table. Most macros in the MX-200M can also be run in the **X-Z** and **X-Z** planes.
- In the **X-Y** plane **Co-ordinate 1** is the X-axis coordinate, and **Co-ordinate 2** is the Y-axis coordinate.
- Data entry error: Press the **C** key.
- Change sign by pressing the **+/-** key before or after the numerical value.
- Hole depth can be specified, but this is meaningful only if downward motion of the cutter — drill or end mill — can be displayed on the DRO's Z axis. It usually isn't, because quill movement is independent of the headstock elevation. If a hole depth is entered, this ***will apply to all holes in the macro***.
- Macros are not saved in the DRO memory. If at any time you press **EXIT** the macro is erased.
- To select a hole out of sequence, press **JUMP** followed by a number on the keypad, then **ENTER**.
- To edit a macro in mid-stream, press **OPEN** to re-open the setup menu. This is typically used when dry-running the macro, pre-machining, allowing you to change (say) the radius, number of holes, etc.
- Press **COUNT** to see the regular 3-axis numerical display. When in the COUNT mode, press **GRAPH** to return to the graphical display, or **OPEN** to edit the setup.

BOLT-HOLE DRILLING — FULL CIRCLE

Select the **Fn** (FUNCTION) label on the soft menu:

Fn

This displays a list of choices, starting with **BOLT HOLE**, default choice **CIRCLE**. (Other choices are **ARC** and **CUSTM** = custom, described later.)

Select **NEW** on the soft menu:

NEW

The bolt-hole program is referenced to X=0 and Y=0 in ***absolute*** or ***incremental*** mode, whichever you prefer. Make sure that the reference point (Xo, Yo) is at the desired location on the workpiece. The numerical values in bold italics refer to the example, Figure 11, following page. The following assumes you are working in the X-Y plane.

1. Using the keypad enter the X coordinate of the circle center, ***1.75***, then press the down arrow ▼ to proceed.

2. Key in the Y coordinate of the circle center, ***1.25***, then press the down arrow ▼.

3. Key in the radius, ***0.95***, then press the down arrow ▼.

4. Key in the starting angle, ***20***, then press the down arrow ▼. ***Angles are measured counter-clockwise from the X axis, pointing East.***

5. Key in the number of holes, ***6***, then press the down arrow ▼.

6. Specify hole depth (not usually possible because quill motion is not displayed on the Z axis.

7. Assuming that no depth has been entered, and the plane is the default X-Y, the macro can be run immediately following the number-of-holes entry.

8. Select **RUN** on the soft menu to display the macro, Figure 8:

   RUN

9. Press the right toggle ► to step through the macro, moving the table at each step to zero **X** and **Y**.

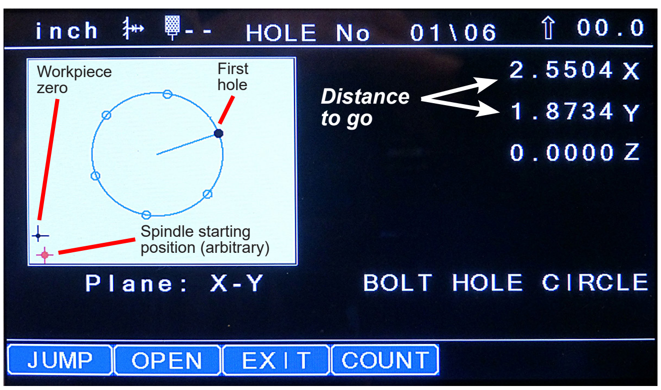


Figure 8 **First hole location** *(No. 1 of 6)*

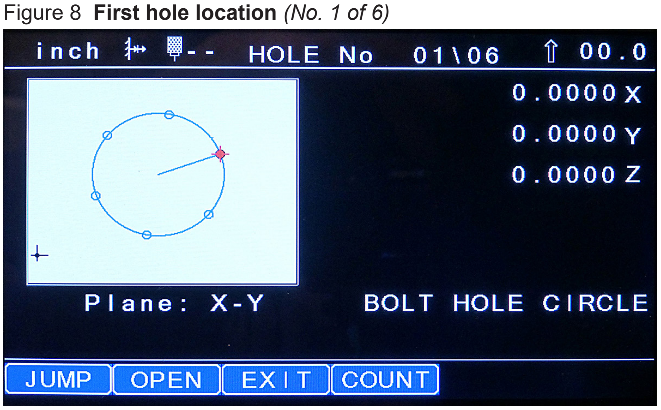


Figure 9 **Spindle moved to first hole location**
Precise location is indicated by the zero values for X and Y

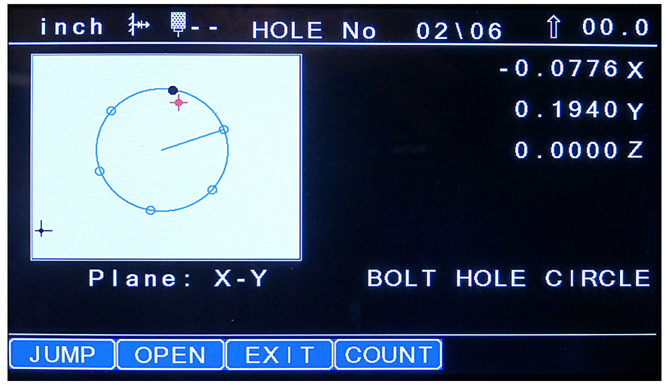


Figure 10 **Spindle nearing second hole location**

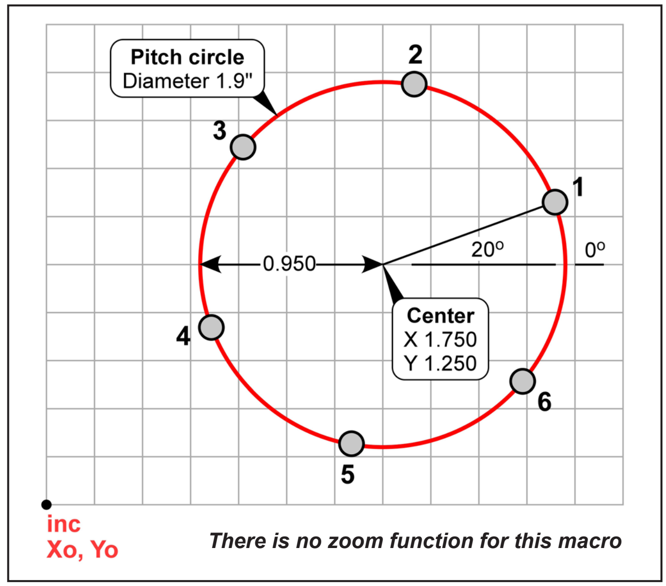


Figure 11 **Example of full circle bolt-hole drilling**
Note that the 20 degree angle is measured counter-clockwise

BEFORE CUTTING METAL!

This is a caution for all macro routines

Check that the hole configuration calculated by the DRO is as expected. Always do a dry run by marking the rough coordinates of the holes on the workpiece with a fiber tip pen, then run the macro for comparison — maybe even doing a trial run on scrap material. If the hole layout is flipped in either the X or Y axis, or both, it may be that the ***axis direction*** parameters need attention, page 4.

BOLT-HOLE DRILLING — ARC

The Arc macro sets out a number of evenly spaced holes along a circular arc with specified start and end angles. Entry of the **end angle** is in fact the only difference between Arc and the Full Circle routine described on the previous page.

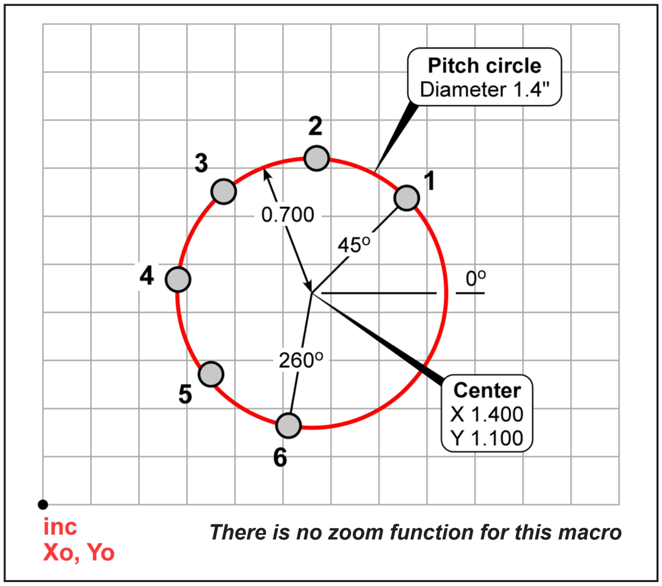


Figure 12 **Example of arc bolt-hole drilling**

Select the **Fn** (FUNCTION) label on the soft menu, then select **ARC** from the soft menu, followed by **NEW**.

NEW | EXIT | CIRCL | ARC | CUSTM

▲

To reproduce the example of Figure 12, enter the following (scroll with down arrow ▼):

Co-ord 1 of center (X) ***1.4***
Co-ord 2 of center (Y) ***1.1***
Radius of arc ***0.7***
Start angle ***45***
End angle ***260***
Number of holes ***6***

Select **RUN** on the soft menu to display the macro. Press the right toggle ► to step through the macro, moving the table at each step to zero **X** and **Y**.

BOLT-HOLE DRILLING — CUSTOM

The Custom macro, Figure 13, is a special version of the Arc function, with hole angles ***individually specified***. Initial steps are as in the previous examples, except for the bolt-hole type, **CUSTM**, followed by **NEW**.

NEW | EXIT | CIRCL | ARC | CUSTM

▲

To reproduce the example of Figure 13, enter the following (scroll with down arrow ▼):

Co-ord 1 of center (X) ***1.25***
Co-ord 2 of center (Y) ***1.05***
Radius of arc ***0.7***
Number of holes ***6***
Bolt Hole Angles, then **ENTER**. Key in as follows:

Hole 1 angle ***30***
Hole 2 angle ***80***
Hole 3 angle ***120***
Hole 4 angle ***195***
Hole 5 angle ***250***
Hole 6 angle ***290***

Select **RUN** on the soft menu to display the macro. Press the right toggle ► to step through the macro, moving the table at each step to zero **X** and **Y**.

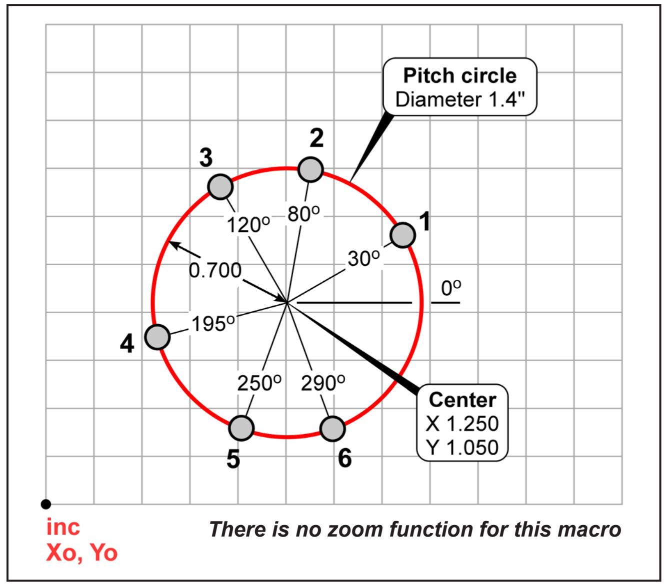


Figure 13 **Example of custom bolt-hole drilling**

LINE HOLE DRILLING

The Line Hole macro sets out a number of evenly spaced holes along a line at a specified angle relative to the X axis.

The Line-Hole program is referenced to X=0 and Y=0 in ***absolute*** or ***incremental*** mode, whichever you prefer. Make sure that the reference point (Xo, Yo) is at the desired location on the workpiece.

Two examples are illustrated here:
(1) Line angle less than 90º, Figure 14; (2) Line angle greater than 90º, on the negative side of the Y axis, Figure 17.

Select the **Fn** (FUNCTION) label on the soft menu:

Fn

This displays a list of choices, starting with **BOLT HOLE**. Using the down arrow ▼, scroll down to Line Hole, then select **NEW** on the soft menu:

NEW

(This displays the setup menu for the Line Hole macro. Note the Select Plane entry at the bottom of the page. This de-

faults to X-Y, which means the plane of the mill table. Other choices are X-Z and X-Z. The following assumes X-Y.

In the X-Y plane Co-ord 1 is the X-axis coordinate, and Co-ord 2 is the Y.)

Example (1) Figure 14

To reproduce this example, enter the following:
Co-ord 1 of starting point (X) ***0.45***
Co-ord 2 of starting point (Y) ***0.65***
Pitch ***0.5***
Angle ***30***
Number of holes ***6***

Select **RUN** on the soft menu to display the macro, see also Figures 8 and 9. Press the right toggle ► to step through the macro, moving the table at each step to zero **X** and **Y**.

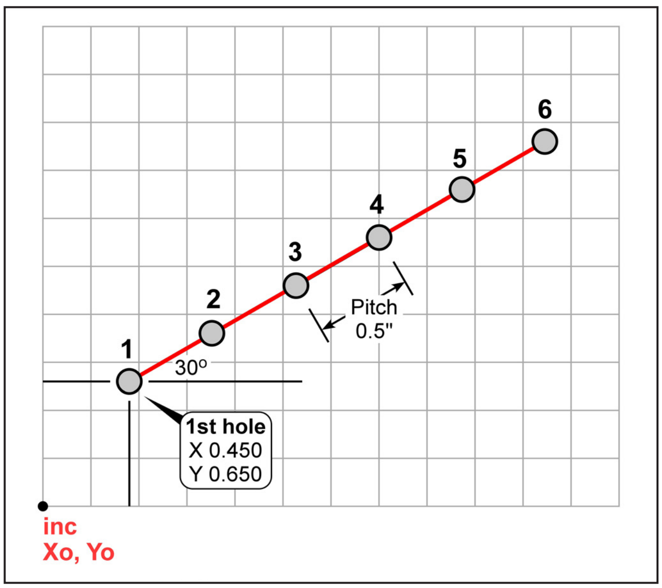


Figure 14 **Example (1) of Line Hole drilling**

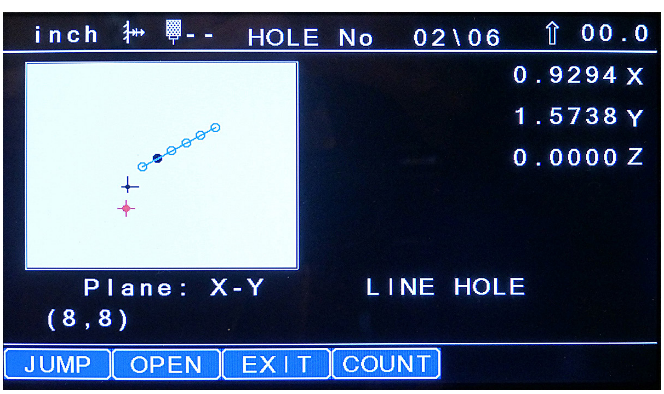


Figure 15 **Screen shot of Line Hole drilling Example (1)**
The figures 8, 8 at lower left indicate the zoom level of the display. Press the Up arrow ▲ to enlarge the view, Figure 9. Press the Down arrow ▼ to reduce.

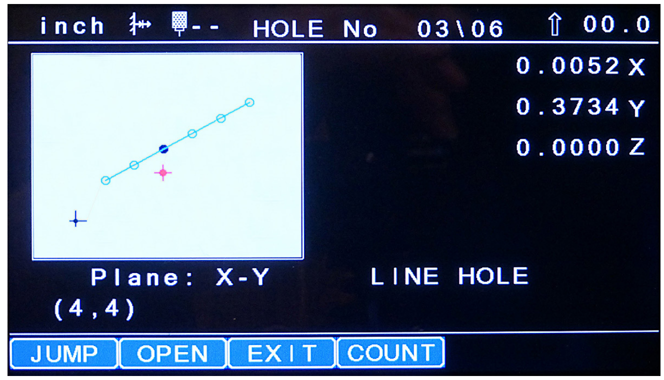


Figure 16 **Zoomed view of Line Hole drilling Example (1)**
The zoom level is indicated by the figures 4, 4 at lower left.

Example (2) Figure 17

To reproduce this example, enter the following:
Co-ord 1 of starting point (X) ***-0.75***
Co-ord 2 of starting point (Y) ***0.75***
Pitch ***0.7***
Angle ***135***
Number of holes ***4***

Select **RUN** on the soft menu to display the macro. Press the right toggle ► to step through the macro, moving the table at each step to zero **X** and **Y**.

Use the ***zoom function*** ▲ for a better view of detail — the present location of the cutter moves to the center of the screen.

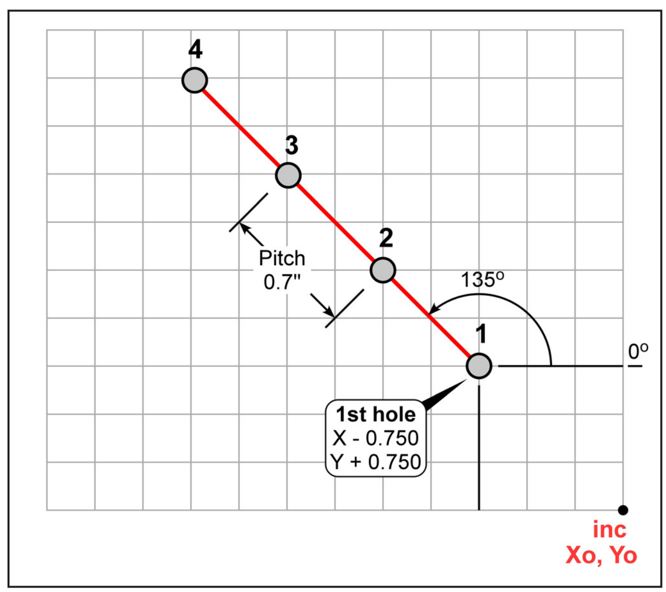


Figure 17 **Example (2) of Line Hole drilling**

GRID DRILLING

The Grid macro sets out a rectangular grid of holes, in line with the X and Y axes, or rotated by any angle.

The Line-Hole program is referenced to X=0 and Y=0 in ***absolute*** or ***incremental*** mode, whichever you prefer. Make sure that the reference point (Xo, Yo) is at the desired location on the workpiece.

Two examples are illustrated here:
(1) A rectangular grid with different X and Y pitches, rotated by 15º, Figure 18; (2) A square (symmetrical) grid rotated by 45º, Figure 20.

Select the **Fn** (FUNCTION) label on the soft menu:

Fn

This displays a list of choices, starting with **BOLT HOLE**. Using the down arrow ▼, scroll down to Grid, then select **NEW** on the soft menu:

NEW

(This displays the setup menu for the Grid macro. Note the Select Plane entry at the bottom of the page. This defaults to X-Y, which means the plane of the mill table. Other choices are X-Z and X-Z. The following assumes X-Y.

In the X-Y plane Co-ord 1 is the X-axis coordinate, and Co-ord 2 is the Y.)

Example (1) Figure 11

To reproduce this example, enter the following:
Co-ord 1 of starting point (X) ***0.0***
Co-ord 2 of starting point (Y) ***0.25***
Pitch Distance 1 (X) ***0.5***
Pitch Distance 2 (Y) ***0.3***
Angle ***15***
Number of holes 1 (X) ***5***
Number of holes 2 (Y) ***4***

Select **RUN** on the soft menu to display the macro. Press the right toggle ► to step through the macro, moving the table at each step to zero **X** and **Y**.

The hole number reported on the top line of the display starts at **01/01**. When the ► toggle is pressed, this changes to **02/01**, which means hole #2 of the "X leg" of the grid, and so on through **05/01**. The following numbers will be **05/02**, **04/02**, etc., as the DRO works back down the X leg above. The final hole number in this example is **05/04**.

The graphical display of the macro, Figure 19, makes all of the above clear. Like the Line Hole macro, the Grid program has a ***zoom function*** for better viewing of detail, see Figure 16.

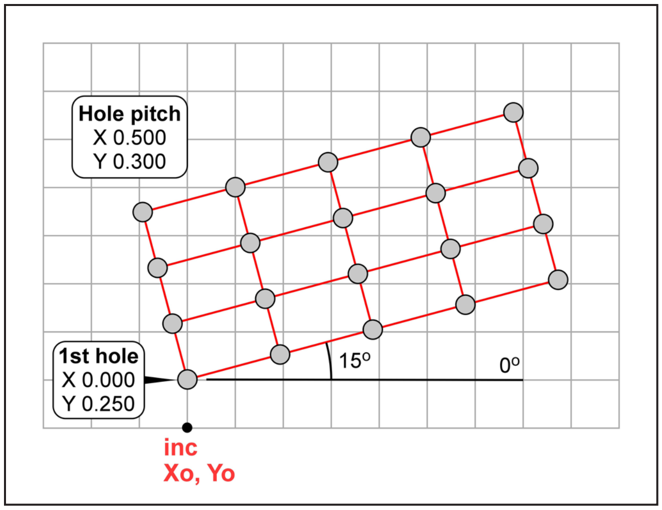


Figure 18 **Example (1) of Grid drilling**

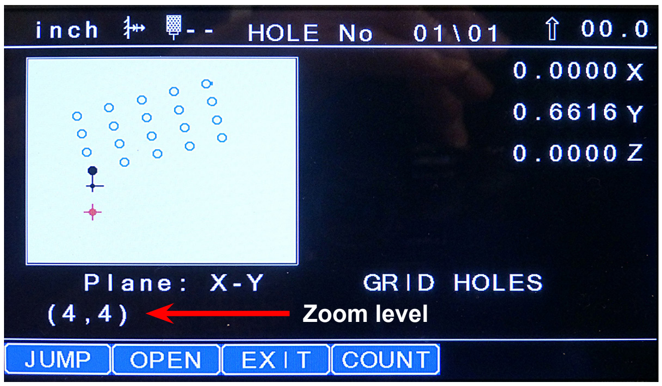


Figure 19 **Screen shot of Grid drilling Example (1)**

Example (2) Figure 20

To reproduce this example, enter the following:
Co-ord 1 of starting point (X) ***0.0***
Co-ord 2 of starting point (Y) ***0.25***
Pitch Distance 1 (X)* ***0.35***
Pitch Distance 2 (Y)* ***0.35***
Angle ***45***
Number of holes 1 (X) ***5***
Number of holes 2 (Y) ***5***

* [**Q**: How can we tell which axis is X and which is Y? With a 45 degree rotation, isn't this ambiguous?
A: For these entries, ***zero degree rotation*** is assumed.]

Select **RUN** on the soft menu to display the macro. Press the right toggle ► to step through the macro, moving the table at each step to zero **X** and **Y**.

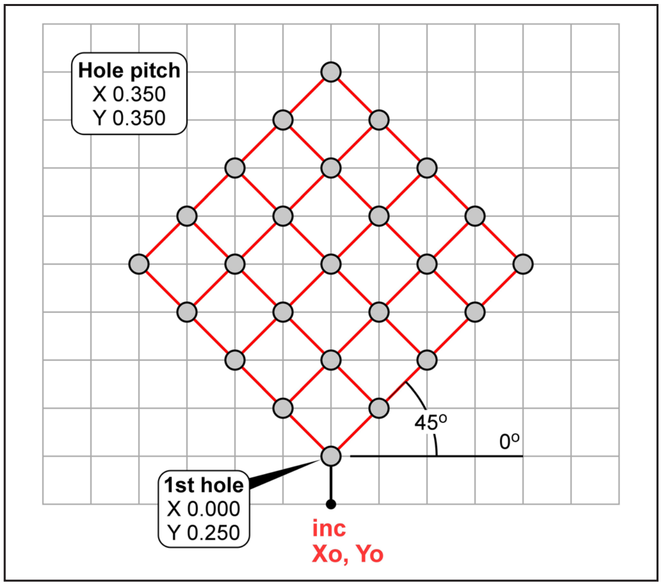


Figure 20 **Example (2) of Grid drilling**

CONTOURING MACROS — General

Contouring is the process of "nibbling" an arc by step-drilling, or plunge-milling, in small increments. These macros are similar in many respects to the regular drilling programs; however, instead of setting out a series of discrete holes, the contouring program calculates a series of overlapping hole positions in increments small enough to cut a smooth line, if desired. Step size is determined by a ***maximum cut*** parameter, which dictates the maximum size of step between one hole and the next. This does not mean that every step will be of the maximum size. In practice, the DRO calculates a series of ***evenly-spaced*** holes to fit exactly between the end points of arc or line.

Setting the maximum cut parameter is a matter of choice. Too large means a notchy machined edge; smaller gives a better edge, but at the expense of extra time to mill a larger number of steps.

Standard twist drills are not recommended for contouring because they cannot hold position reliably if the step size is less than about 75% of the drill diameter. A better nibbling tool in most cases is a center-cutting end mill.

SLOT MACRO

This is the simplest of the nibbling macros, Figure 21. Setup is similar to the Line Hole macro

Select the **Fn** (FUNCTION) label on the soft menu:

Fn

This displays a list of choices, starting with **BOLT HOLE**. Using the down arrow ▼, scroll down to Slot, then select **NEW** on the soft menu:

NEW

(This displays the setup menu for the Slot macro. Note the Select Plane entry at the bottom of the page. This defaults to X-Y, which means the plane of the mill table. Other choices are X-Z and X-Z. The following assumes X-Y.

In the X-Y plane Co-ord 1 is the X-axis coordinate, and Co-ord 2 is the Y.)

To reproduce the example of Figure 21, enter the following:
Co-ord 1 of starting point (X) ***0.60***
Co-ord 2 of starting point (Y) ***0.75***
Angle *25*
Slot length *1.75*
Tool diameter *0.1875*
Maximum cut *0.1*

The slot will be milled on the centerline as shown in the diagram. There are no other choices, unlike Frame and Arc Contouring macros.

Select **RUN** on the soft menu to display the macro. Press the right toggle ► to step through the macro, moving the table at each step to zero **X** and **Y**.

Use the ***zoom function*** ▲ for a better view of detail — the present location of the cutter moves to the center of the screen.

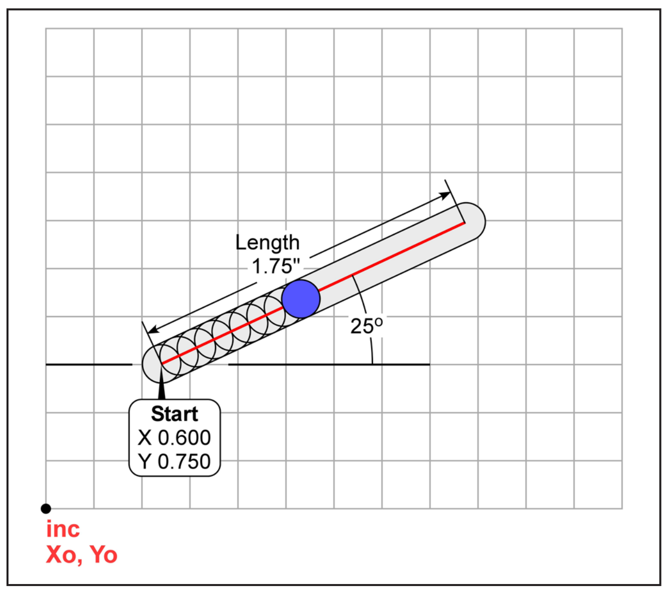


Figure 21 **Slot cutting**

FRAME MACRO

In woodworking terms, a "frame" is an outline you might cut with a router. The difference here is that you don't sweep the router along a straight edge; instead, the frame is milled in a series of overlapping steps, as directed by the DRO.

Select the **Fn** (FUNCTION) label on the soft menu:

Fn

This displays a list of choices, starting with **BOLT HOLE**. Using the down arrow ▼, scroll down to Frame, then select **NEW** on the soft menu:

NEW

(This displays the setup menu for the Frame macro. Note the Select Plane entry at the bottom of the page. This defaults to X-Y, which means the plane of the mill table. Other choices are X-Z and X-Z. The following assumes X-Y.

In the X-Y plane Co-ord 1 is the X-axis coordinate, and Co-ord 2 is the Y.)

To reproduce the example of Figure 22, enter the following:

Co-ord 1 of starting point (X) ***0.25***
Co-ord 2 of starting point (Y) ***0.25***
Angle ***15***
Length 1 (X) ***2.0***
Length 2 (Y) ***1.0***
Tool diameter ***0.25***
Maximum cut ***0.1*** *(Scroll ▼ to next page)*
Machined on the CENTER line
(This is the default setting. Options are INSIDE the frame, or EXTERNAL, see the soft menu.)

INT | **EXT** | **CENTE**
▲

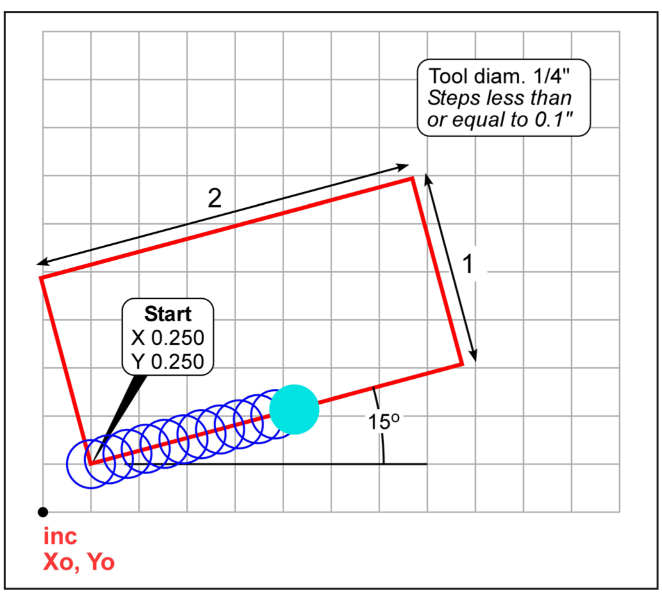


Figure 22 **Frame contouring**

Use the ***zoom function*** ▲ for a better view of detail — the present location of the cutter moves to the center of the screen.

ARC CONTOURING MACRO

Select the **Fn** (FUNCTION) label on the soft menu:

Fn

This displays a list of choices, starting with **BOLT HOLE**. Using the down arrow ▼, scroll down to Arc Contouring, then select **NEW** on the soft menu:

NEW

(This displays the setup menu for the Arc Contouring macro. Note the Select Plane entry at the bottom of the page. This defaults to X-Y, which means the plane of the mill table. Other choices are X-Z and X-Z. The following assumes X-Y.

In the X-Y plane Co-ord 1 is the X-axis coordinate, and Co-ord 2 is the Y.)

To reproduce the example of Figure 23, enter the following:

Co-ord 1 of starting point (X) ***1.5***
Co-ord 2 of starting point (Y) ***1.2***
Radius ***0.85***
Start angle ***30***
End angle ***120***
Tool diameter ***0.1875***
Maximum cut ***0.1*** *(Scroll ▼ to next page)*
Machined on the CENTER line
(This is the default setting. Other selections are INSIDE the arc, and EXTERNAL to the arc. Select from the soft menu.)

INT | **EXT** | **CENTE**
▲

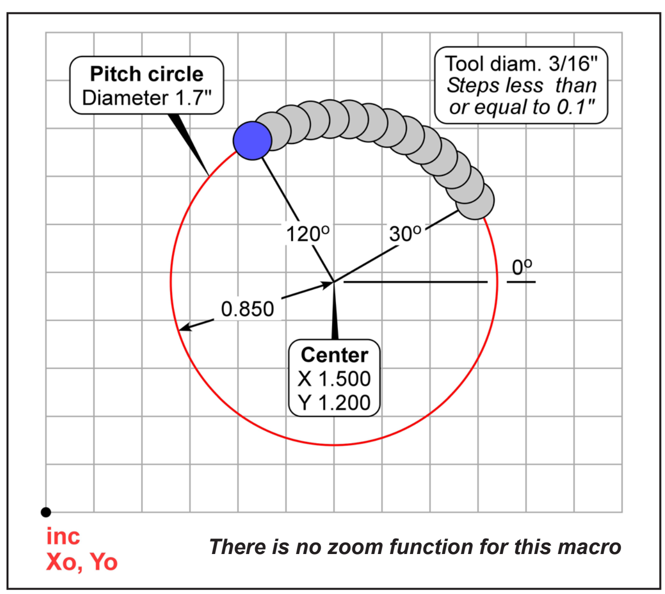


Figure 23 **Arc contouring**

Select **RUN** on the soft menu to display the macro. Press the right toggle ► to step through the macro, moving the table at each step to zero **X** and **Y**.

R-FUNCTIONS (CONTOURING)

These are nibbling functions of a special type. The main differences between R-functions and other contouring macros are:

1. The starting location of any R-function is wherever the spindle happens to be when the function is launched, by pressing the RUN key.
2. R-functions are ***90 degree arcs*** (but there is nothing to stop you terminating the function at some intermediate point, perhaps based on a specific hole count).
3. There are eight R-functions, designated by type number, providing for clockwise and counter-clockwise sweeps in the 4 quadrants, NE, NW, SW and SE, Figure 24.

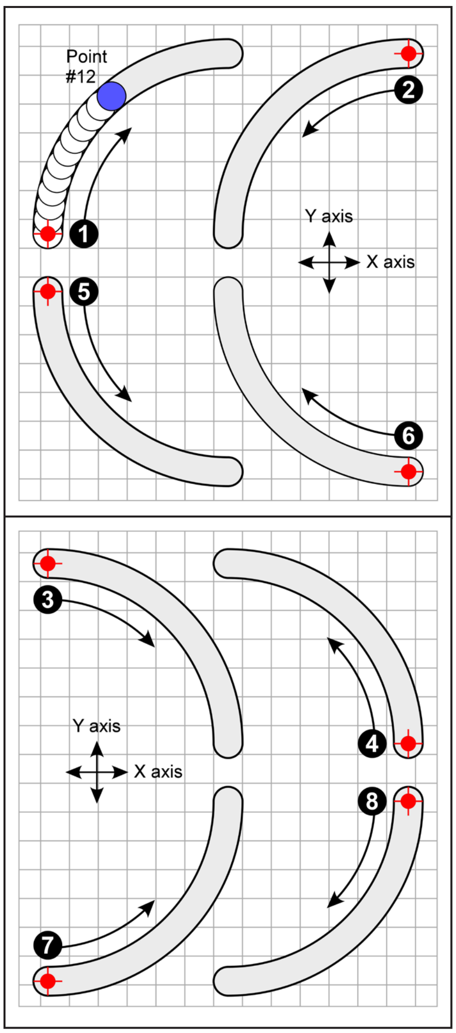


Figure 24 **Eight R-function types**
Start and end points are always aligned with the X or Y axis, but you can end at any mid-point, e.g., at point #12 in the Type 1 example.

Select the **Fn** (FUNCTION) label on the soft menu:

Fn

This displays a list of choices, starting with **BOLT HOLE**. Using the down arrow ▼, scroll down to R-Function, then select **NEW** on the soft menu:

NEW

(This displays the setup menu for the R-functions macro. Note the Select Plane entry at the bottom of the page. This defaults to X-Y, which means the plane of the mill table. Other choices are X-Z and X-Z. The following assumes X-Y.

In the X-Y plane Co-ord 1 is the X-axis coordinate, and Co-ord 2 is the Y.)

The only choices necessary to run an R-function are the following:

Arc Type Choose a number from 1 to 8, Figure 16
Radius
Tool diameter
Maximum cut

R-functions are **Machined only on the CENTER line**. *INSIDE the arc, and EXTERNAL to the arc* options are not available. There is no zoom function for this macro.

CALCULATOR

The MX-200M calculator is like a basic handheld, except that it has no memory. It can be used in the ordinary way for all basic math functions.

CALC

Press the CALC key on the soft menu to activate the calculator. This brings up a blank screen, Figure 25, with a new soft menu: **+ — x / 1/x EXIT**

The numbers at top right of the display are real-time X, Y and Z axis readings. They have nothing to do with the calculator.

! The fastest way to correct mistakes is the "start over" method — press **EXIT** then **CALC**

! Press the **C** key to erase a wrongly entered number

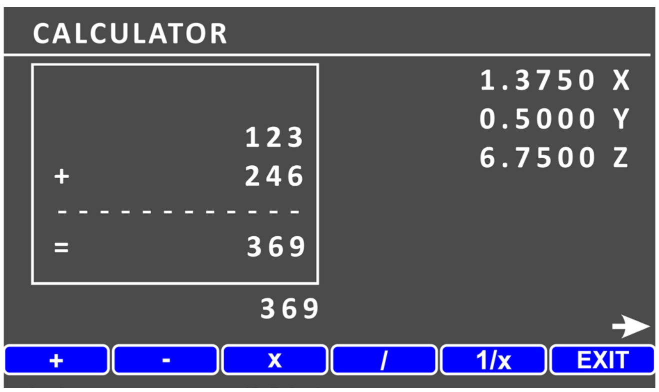


Figure 25 **Calculator display: Page 1**

The small arrow at bottom right means that another soft menu is available. Press the right arrow ▶ to display it, Figure 26.

Examples

Calculate 123 + 246

- Key in **1 2 3**, then press the **+** key.
- Key in **2 4 6**, then press the **+** key again. Result: **369**
- If you need to add a third number, say **357**, key in **3 5 7**, followed again by the **+** key. Result: **726**

- To multiply the result by **4**, press the **x** key
- Key in **4** then press **Enter**. Result: **2904**

Calculate (10 + 15 + 20) x 5

- Key in **1 0**, then press the **+** key.
- Key in **1 5**, then press the **+** key again.
- Key in **2 0**, then press the **+** key again.
- Key in **2 5**, then press the **+** key again. Result: **45**
- Press the **x** key
- Key in **5**, then press **Enter**. Result: **225**

Calculate 875 - 764 - 11

- Key in **8 7 5** then press the **-** key.
- Key in **7 6 4**, then press the **-** key again.
- Key in **1 1** then press the **-** key for the third time. Result: **100**

- To divide that result by 17, press the **/** key
- Key in **1 7**, then press **Enter**. Result: **5.882 ...**

Reciprocal of 123

- Key in **1 2 3**, then press the **1/x** key. Result: **0.00813**

Calculate π x 0.375

- Key in **0 . 3.7 5**, then press the **x** key.
- Press the right arrow ▶ to display the Page 2 menu:

Figure 26 **Calculator display: Page 2 menu**

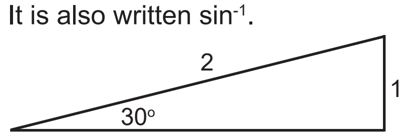
- Press the **PI** key. Result: **1.1780 ...**

Calculate 9 ÷ cos 30

- If on Page 2 (Figure 26), Press the left arrow ◀ to display Page 1 (Figure 25)
- Key in **9**, then press the **/** key.
- Press the right arrow ▶ to display Page 2
- Key in **3 0**, then press the **cos** key (**0.8660 ...**)
- Press **Enter** for 9 / 0.866. Result: **10.3923 ...**

Inverse trig functions

Example: **Asin**, short for **arcsine**, is the inverse sine function. It is also written $\sin^{-1}$.



Example: sin 30° = 1/2 = 0.5   arcsine 0.5 = 30°

Acos and **Atan** are available on the Page 3 menu:

Figure 27 **Calculator display: Page 3 menu**

SUB-DATUM SYSTEM

The **abs** (absolute) coordinate frame is generally thought of as being fixed relative to the workpiece datum. The **inc** (incremental) coordinate frame is set arbitrarily at any time in the machining process. **inc** has no fixed relationship to **abs**.

The DRO provides the means of setting up a number of secondary **abs** coordinate frames known as ***sub-datums*** (up to 1000 of them in fact). They behave in exactly the same way as the "native" **abs**, and ***are referenced to the abs datum***.

This means that if abs is re-zeroed at a new location, all sub-datums are moved in lock-step.

Sub-datums, **SDMs**, are helpful in machining operations calling for more than one point of reference. If the sub-datum function did not exist, "virtual datums" could be established by zeroing in the INC mode at any time in the machining process. The shortcoming of that approach, compared to true sub-datums, is that virtual datums are not related to each other in a specific way, nor are they related to the **abs** datum, other than by the offset numbers (which you will have remembered to make a hand-written record of, or maybe not?).

Sub-datum values can be established in two different ways, referred to as **"Learn" method** and **"Direct Entry" method**.

In the "Learn" method the table is moved to bring the spindle to each of the SDMs in turn. In the "Direct Entry" method the SDM coordinates, relative to the **abs** datum, are entered directly from the numeric keypad.

The following illustrations refer to Figure 28. Here, the **abs** datum is at bottom left. This is arbitrary: in practice the **abs** datum could be established at any corner, or at any other location chosen to simplify the machining process. ***But bear in mind*** the effect this may have on coordinate signs.

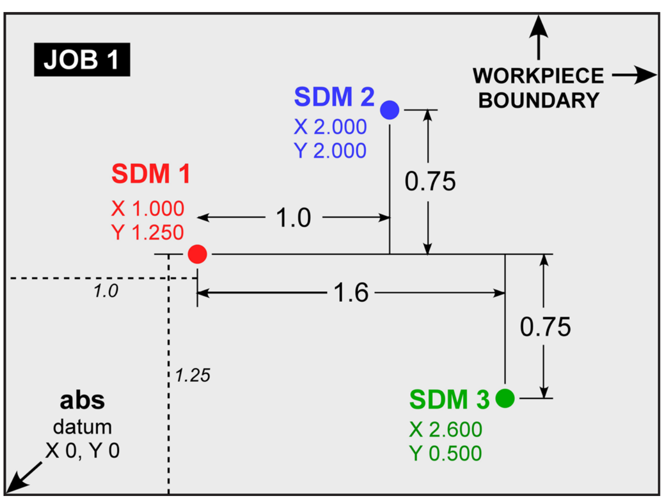
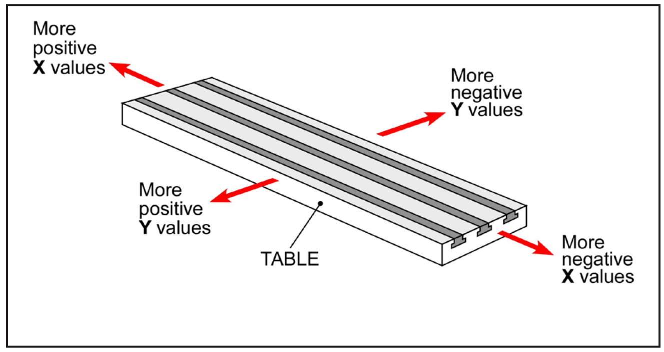


Figure 28 **SDM example: Job 1 with three SDMs**

! Table movement vs. display direction (positive or negative going), is important. The convention used in these examples is as Figure 1, repeated below.



! Regardless of how you set up your SDMs, it is a good idea to mark their approximate locations on the workpiece. A few seconds with a magic marker can help avoid gross mistakes due to sign errors. ***Always dry run*** the SDMs before beginning to machine.

The Z axis display is ignored in the following illustrations.

MX-200M SDM REFERENCING SYSTEM

In the MX-200M, SDMs are indexed as ***Jobs***, numbered 1 through 50. A job number might refer to a specific client, or to single large-scale project calling for a number of separate machined components, each requiring a number of datum points. Each of the 50 jobs can contain up to 20 SDMs, for a grand total of 1000.

The following "Learn" method illustrations show Job 1 with three SDMs, and Job 2, with two SDMs.

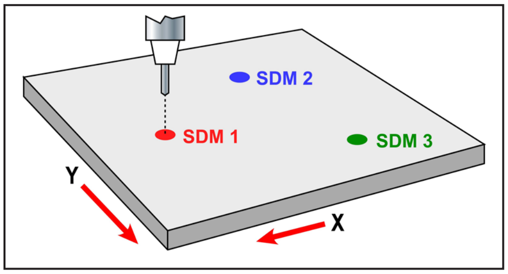
SDM "LEARN" Method
Setting up Job 1

SDM key

1. Select **abs** mode.
2. Establish the workpiece **abs** datum by edge finding or other means. In Figure X the lower left corner is the chosen point for **abs** zero. Zero the X and Y axis numerical displays.
3. Staying in the **abs** mode, press the **SDM** key. The screen displays **SDM-JOB: 1** at lower right. The information bar above the screen displays **STEP: 0/0**, meaning that no values have been saved.

4. Press the **EDIT** key. The ***abs*** datum shows as a ***black dot*** with cross-hairs at the center of the display. Superimposed on the datum is the spindle marker, a small ***red circle*** with cross-hairs.

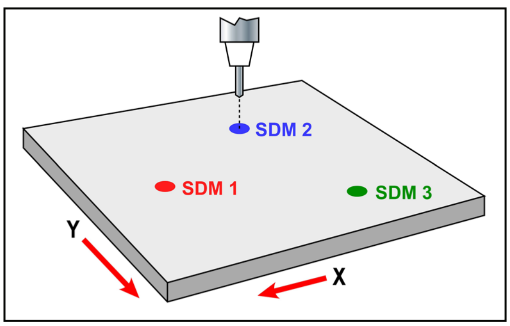
5. Move the table left 1.0", forward 1.25", displaying **X 1.0000**, **Y 1.2500** at top right. To bring the spindle marker back into view, zoom out by pressing the down arrow ▼ repeatedly to display **4, 4** at lower left. (4, 4 is a measure of screen magnification, ranging from the highest mag 0.5, 0.5 to the lowest mag 16, 16.)



Left movement increases X value, Forward movement increases Y

6. Press the **NEXT** key. This registers SDM1, as indicated by **STEP: 1/1** on the information bar.

7. Move the table left a further 1.0", forward 0.75", displaying **X 2.0000**, **Y 2.0000** at top right.

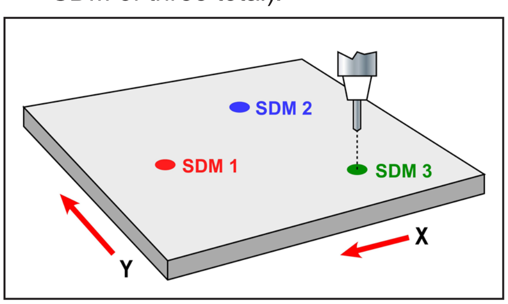


Left movement increases X value, Forward movement increases Y

8. Press the **NEXT** key. This registers SDM2, as indicated by **STEP: 2/2** on the information bar (this means the second SDM of a total of two saved so far).

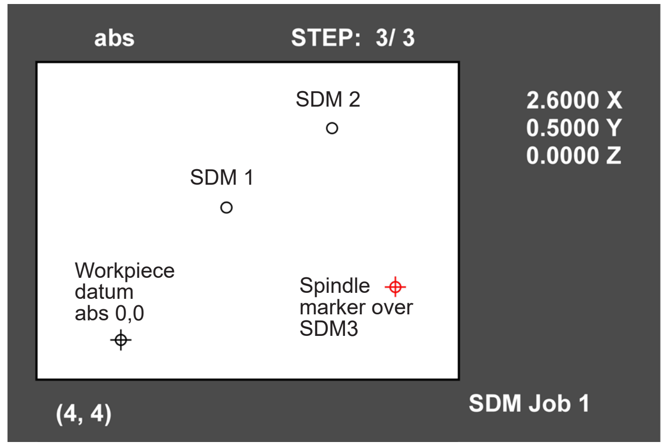
9. Move the table left a further 0.6", back 1.5", displaying **X 2.6000**, **Y 0.5000** at top right.

10. Press the **NEXT** key. This registers SDM3, indicated by **STEP: 3/3** on the information bar (the third SDM of three total).



Left movement increases X value, Backward movement decreases Y

11. Press the **SAVE** key. This displays the three SDMs as shown in the following diagram.



12. Press the **EXIT** key twice (repeat: ***twice***. The information bar now reports **SDM JOB: 1/1** (the first job of a jobs total of one).

Setting up Job 2

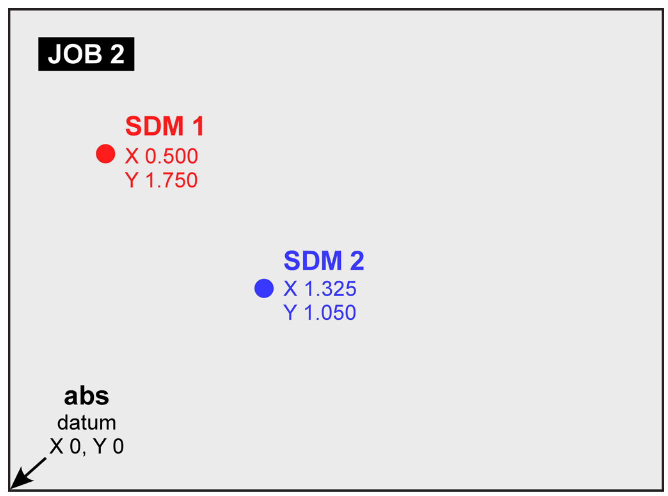


Figure 29 **Job 2 with two SDMs**

The following assumes Job 2 is a continuation of the Job 1 setup, spindle at 2.6000 X, 0.5000 Y.

1. Select (or stay in) the **abs** mode. Return the spindle to the workpiece **abs** datum, X = 0, Y = 0.

2. To proceed to Job 2, Figure 29, press **NEW**. The screen comes up blank, except for the workpiece datum marker (black cross hairs) and the spindle marker (red cross hairs). For a better view, zoom the display to 8, 8 using the ▲▼ arrows.

3. Press the **EDIT** key, then move the table left to display **0.5000 X**, forward to **1.7500 Y**.

4. Press the **NEXT** key. This registers SDM1, indicated by **STEP: 1/1** on the information bar.

5. Move the table left to **1.3250 X**, back to **1.0500 Y**.

6. Press the **NEXT** key to register SDM2 (**STEP: 2/ 2**).
7. Press the **SAVE** key, then press the **EXIT** key twice.

Adding an SDM to a Job

Editing a Job to add or delete SDMs is a simple extension of the setup procedure. Here, we add a third SDM to Job 2.

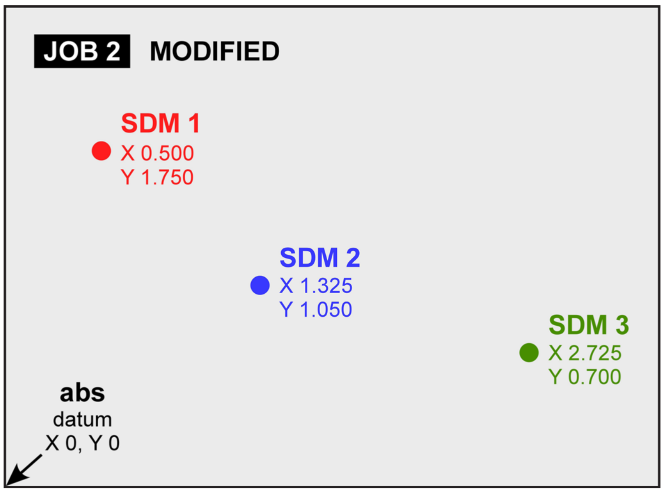


Figure 30 **Adding a third SDM to Job 2**

1. Select (or stay in) the **abs** mode. Return the spindle to the workpiece **abs** datum, X = 0, Y = 0.
2. If you are no longer in the SDM function, press the **SDM** key.
3. Scroll down to **Job 2** using the ▼ arrow, then press the **OPEN** key.
4. Select Step 2 using the ► arrow, then press the **EDIT** key.
5. Mode the table left to **2.7250 X**, back to **0.7000 Y**.
6. Press the **NEXT** key to register SDM3 (**STEP: 3/ 3**).
7. Press the **SAVE** key, then press the **EXIT** key twice.

Deleting and modifying specific SDMs

In this illustration we delete SDM2 from Job 1, and then make small changes to the coordinates of SDM1.

Deleting SDM2 from Job 1

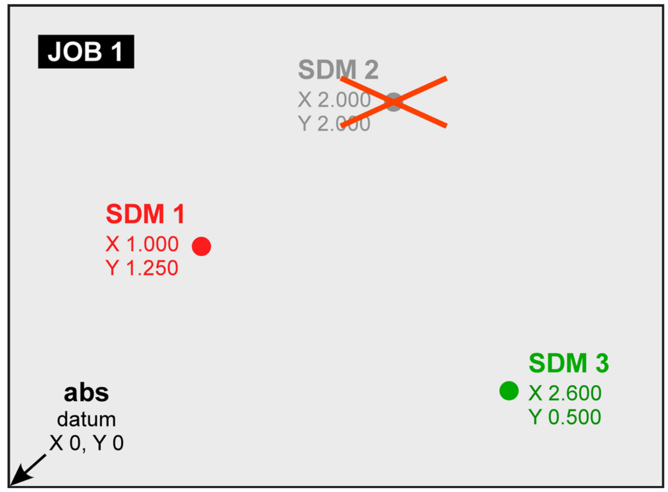


Figure 31 **Deleting SDM2 from Job 1**

1. Select (or stay in) the **abs** mode. Return the spindle to the workpiece **abs** datum, X = 0, Y = 0.
2. If you are no longer in the SDM function, press the **SDM** key.
3. Scroll up/down to **Job 1** using the ▼ or ▲ arrows, then press the **OPEN** key.
4. Use the ► or ◄ arrows to select Step 2 (that's SDM2), showing **STEP: 1/ 3** on the information bar.
5. Press the **EDIT** key, followed by the **DELETE** key.
6. Press the **YES** key to confirm. The information bar should now read **STEP: 1/ 2**, confirming that job now has only two SDMs.
7. Press the **SAVE** key, then press the **EXIT** key twice.

Modifying SDM1 of Job 1

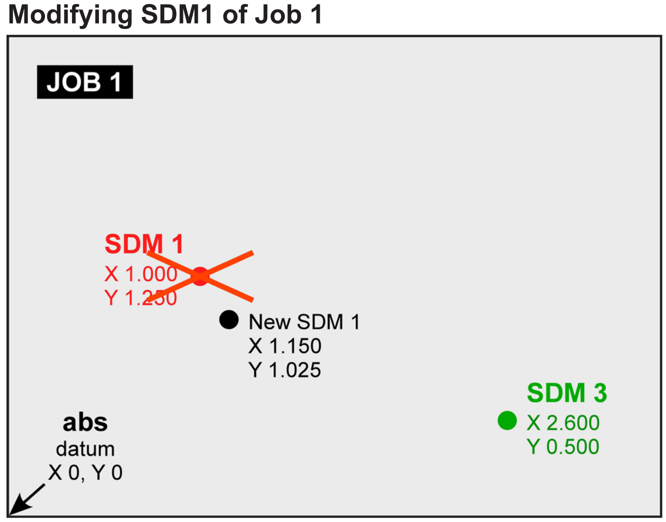


Figure 32 **Modifying Job 1: SDM1**

1. Use the ► or ◄ arrows to select Step 1.

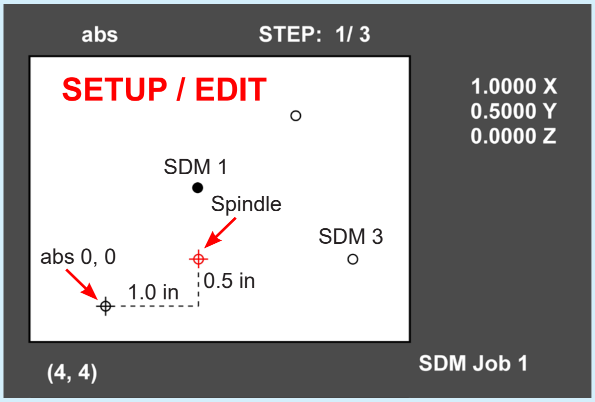
2. Press the **EDIT** key, then move the table left to **1.1500 X**, back to **1.0250 Y**.

3. Press the **SAVE** key, then press the **EXIT** key twice.

WHAT THE NUMBERS MEAN

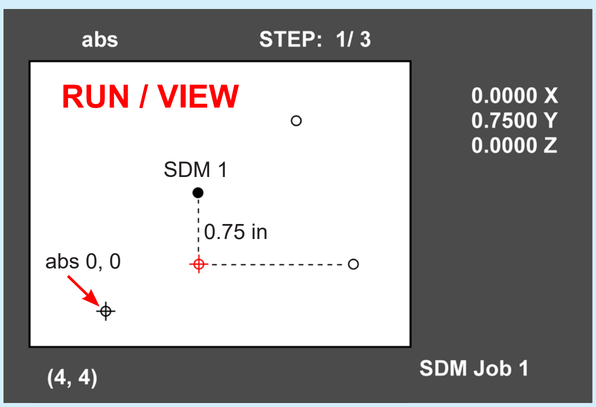
(1) SETUP and EDIT

In SDM setting-up or editing actions, the X and Y values at top right of the screen signify the spindle position — its coordinates — relative to the workpiece abs datum (0, 0), ***provided the spindle was at that location*** when you pressed the **SDM** key.



In the above illustration, see also Figure X, the spindle is at the same Y axis value as SDM3, 0.5" above the abs datum. It is also at the same X axis value as SDM1, 1.0" right of the datum. These are the numbers reported at top right.

(2) RUN and VIEW



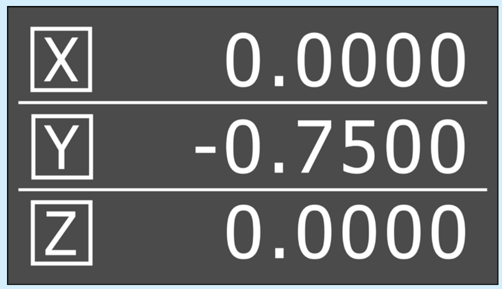
(1) RUN and VIEW continued

In the **RUN** and **VIEW** modes, for using or viewing SDMs, the numbers have a different meaning.

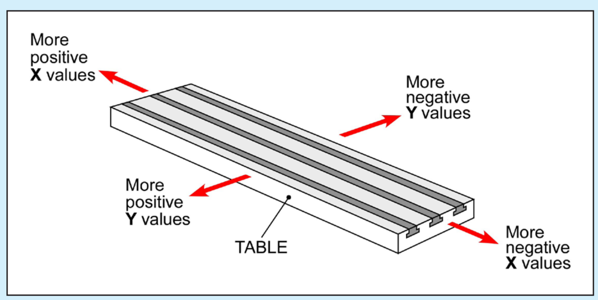
In the illustration at lower left the spindle is in the same location as before: Y axis value same as SDM3 (0.5" above the abs datum), X axis value in line with SDM1.

This puts the spindle 0.75" below SDM1 (coordinates of SDM1 are 1.0 X and 1.25 Y). In other words, the top-right numbers represent ***distances-to-go***, to the selected SDM, the filled-in circle.

If you press the **SDMON** key, distances-to go can also be viewed on the regular numerical display, below:



Here, the **X 0.0000** says that you are already at the selected value, left-to-right. **Y - 0.7500** means that you need to move the table forward 3/4", reducing the Y value to zero as you arrive at the selected SDM. (Keep in mind the convention for table movement vs. display direction, Figure 1 and below.) Press the **SDM** key again to return to the graphic display.



SDM "DIRECT ENTRY" Method

If you have worked your way through Jobs 1 and 2 on the preceding pages, this will be Job 3.

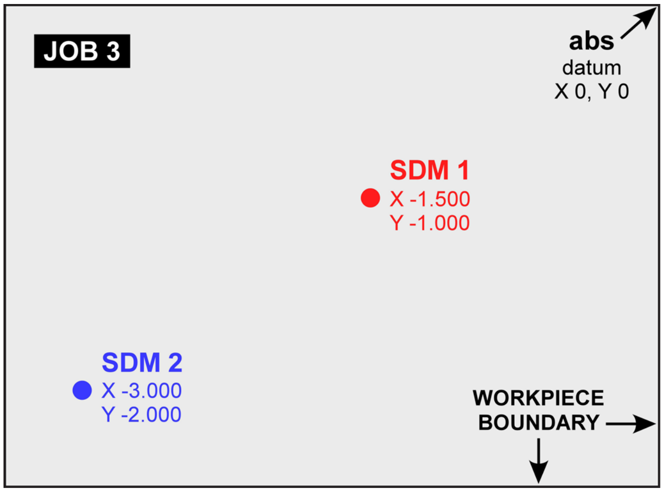


Figure 33 **Job 3: New workpiece datum**

The key difference between this job, Figure 33, and Jobs 1 and 2 is the location of the workpiece datum, here at the top right of the diagram. In line with conventional coordinate geometry, X and Y coordinates in this quadrant are ***negative***.

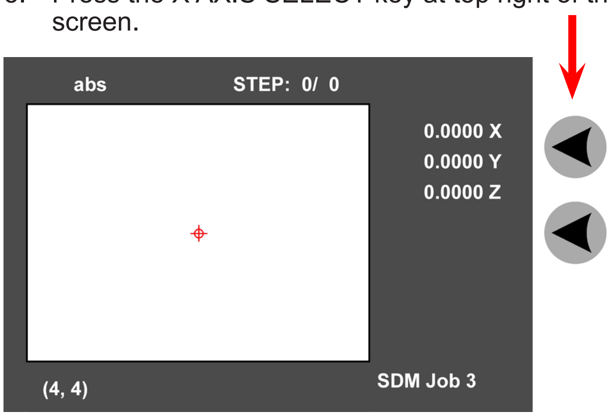
1. Select (or stay in) the **abs** mode. Set the spindle over the workpiece **abs** datum, X = 0, Y = 0.

2. If you are no longer in the SDM function, press the **SDM** key.

3. Scroll down to **Job 3** using the ▼ arrow, then press the **OPEN** key.

4. Press the EDIT key.

5. Press the X AXIS SELECT key at top right of the screen.



6. Using the keypad enter **1.5** followed by the **minus** sign, then **Enter**.

7. Press the Y AXIS SELECT key, next arrow down, then key in **1**, followed by the **minus** sign, then **Enter**.

8. Press the **NEXT** key to register SDM1 (**STEP: 1/1**).

9. Press the X AXIS SELECT then key in **3**, followed by the **minus** sign, then **Enter**.

10. Press the Y AXIS SELECT key, then key in **2**, followed by the **minus** sign, then **Enter**.

11. Press the **NEXT** key to register SDM2 (**STEP: 2/2**).

12. Press the **SAVE** key, then press the **EXIT** key twice.

CORRECTING KEY-IN ERRORS

If you make a mistake when entering a coordinate from the keypad, press the **C** key to clear the entry, one character at a time.

RECALLING & USING SDMs

This is described under ***(2) RUN and VIEW*** in the inset panel (blue), page 21.

To recall a specific SDM, press the **SDM** key, then use the ▼ or ▲ arrows to scroll up/down to the job in question, then press the **OPEN** key.

Use the ► or ◄ arrows to select the desired Step (SDM). If there are many SDMs in the job, it may faster to press the **JUMP** key, followed the step number, followed by **Enter**.

ZERO APPROACH WARNING

As the spindle approaches a selected SDM you will hear a warning chirp that increases in frequency — urgency — as the spindle nears the SDM. The chirping ceases altogether when the spindle is "at zero".

This is an optional feature. To disable it, exit the SDM mode , then press the **SETUP** key, see page 4, then select User Setup. Use the ▼ arrow to scroll down to **Zero Approach Beep**, select **OFF**, then scroll down to **Save & Exit**, followed by the **SAVE** key.

POWER-OFF RECOVERY (Datum recall)

Mill work usually starts with establishing an absolute (**abs**) workpiece datum, X=0, Y=0, Z=0.

Provided the machine is not touched when power is off, the abs datum is saved by the DRO, and is unaffected.

If follows that in everyday milling operations, with no power interruptions likely, there is no need to make an **abs** datum recoverable — you start the job by setting **abs** to zero at a specific location on the workpiece (perhaps also with the headstock or knee at a specific elevation). Thereafter you can work in **inc** or **abs**, whichever is the more convenient.

However, in cases where the machining process takes more than a single work session, you may have to return to the job after powering down overnight, or after a power interruption during the regular workday.

Here's the potential problem with that situation — if any machine axis is accidentally moved during power-down, the **abs** datum is lost — simply nudging a leadscrew handwheel can result in a small, non-obvious error. This problem can be eliminated if, at the start of the job, the abs datum is set with reference to a known XY location of the table — in other words, if the mill is set up for power-off recovery.

Magnetic markers enable power-off recovery
Each MagXact scale has two separate magnetic tracks, "main" and "reference":
1. The ***main track*** is the source of position data displayed on the DRO.
2. The ***reference track*** is a series of magnetic markers every 50 mm (about 2 inches).

Setting up the DRO for power-off recovery is simply a matter of relating one of these reference magnetic markers to a specific physical location on the mill. This is a ***one-time operation***: it sets up approximate "visual reference locations" for the X, Y and Z axes that can be physically marked on the machine (e.g., with a fiber-tip pen). In future work sessions these approximations are used, for each axis, to capture the ***precise location*** of the nearby magnetic marker.

1. LOCATING X-AXIS REFERENCE MARKERS

The following procedure will show you where the reference markers are located on the X axis, allowing you to mark a few of them on the machine as a reminder. Use a fiber tip pen (or other non-damaging means) to mark the table, and/or the adjacent base casting, each time a reference marker is detected.

1. Select, or stay in, the **abs** mode
2. Move the table about 12" to the right of its central location
3. Press the **Datum** key 
4. The information bar reads **Select Action**
5. Press the **REFS** key
6. Select the **X axis** by pressing the ◄ right of the X numerical display. The display reads **Homing ...**
7. Move the table slowly left until the DRO chirps, indicating that you have arrived at a reference marker (at this point, the X display begins to count, starting at 0.0000)
8. Mark the table and/or base casting
9. Move the table about 1/2" more to the left (not critical, just well clear of the reference marker)
10. Press the **Datum** key again
11. Press the **REFS** key again
12. Move the table left until the DRO chirps again, indicating that you have arrived at a second reference marker
13. Mark the table and/or base casting
14. If necessary, repeat steps 10 through 13

Q: Why are repeat marker findings necessary?
A: They may not be: this depends on the workpiece's location on the table (also, where its **abs** datum will be) relative to the reference markers. When the mill spindle is over the **abs datum Xo**, the reading head needs to be well clear (by 1/2" or so) of the nearest reference marker, Figure 34. Because workpiece location and choice of datum will vary from job to job, a number of alternative marker locations may be helpful.

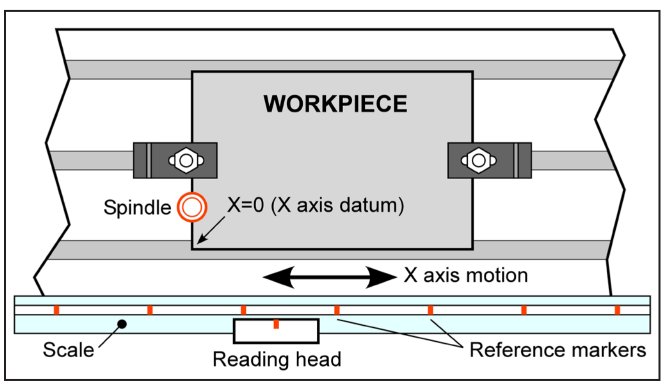


Figure 34 **Spindle at Xo: Reading head clear of reference marker**
*To enable a solid datum recall after power-off, be sure to position the workpiece on the table so that when the spindle is over the workpiece **abs** datum, the X reading head is well clear of any reference marker. This applies also to the Y axis, following paragraph.*

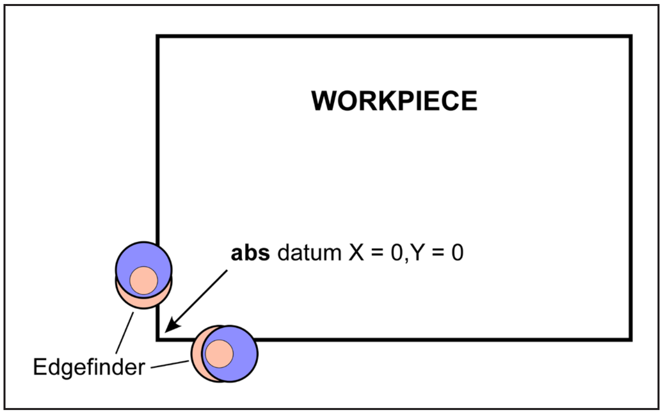


Figure 35 **Workpiece datum example**
If using a mechanical edge finder or probe, be sure to add in the tip radius to position the spindle centerline exactly at Xo and Yo.

2. LOCATING Y & Z-AXIS REFERENCE MARKERS

Repeat the above procedure to find the reference markers on the other two scales. Referring to Figure 34, bear in mind that the Y-axis reading head needs to be 1/2" clear of the nearest reference marker when the mill spindle is over the **abs datum Yo**.

3. SETTING UP FOR POWER-OFF RECOVERY

Check the workpiece datum position, Figure 34. Move the table so that both X and Y axis reading heads are well clear of any reference markers.

- Press the **Datum** key 
- The information bar reads **Select Action**
- Press the **MARK** key
- Select the X axis by pressing the ◄ right of the X numerical display. The display reads **Homing ...** [This is exactly the same action that occurs in Paragraph (1), "Locating X-axis reference markers"]
- Move the table slowly left or right until the DRO chirps, indicating that you are at a reference marker. This could be any of the reference markers you found earlier, but you ***have to remember which one***.
- Move the table to set the spindle over the X axis workpiece datum, Figure 35. How far this is away from the selected reference marker doesn't matter. If you are using a regular mechanical edge finder or probe, allow for the tip radius, then adjust the table by that amount to position the spindle centerline exactly at the edge.
- Press the **DATUM** soft key to record the distance between reference marker and the X axis datum.

Recommended: Make a note of this value, and the specific reference marker it relates to, so you can validate what comes up in the ***Recall Procedure***, Paragraph (4) below.

- Repeat the process for the Y axis.

4. RECALLING THE DATUM AFTER POWER-OFF

First, move the table in both axes to be sure the X and Y reading heads are about 1/2" away from the ***specific reference markers*** you chose (by pressing the **MARK** key) in the Setup Procedure, Paragraph (3). Start the recall with the X axis.

- Select, or stay in, the **abs** mode
- Press the **Datum** key 
- The information bar reads **Select Action**
- Press the **RCALL** key
- Select the X axis by pressing the ◄ right of the X numerical display. The display reads **Homing ...** This is to find the reference marker chosen in "Setting up for power-off recovery" procedure
- Move the table slowly left or right until the DRO chirps, indicating that you are at the reference marker. At this point the X axis value will be ***exactly what it was*** when the **DATUM** soft key was pressed prior to the power-off event
- Move the table as necessary to zero the X display. ***You are now at the original datum, Xo.***
- Repeat for the Y axis.