INTRODUCTION

This manual describes the operation, applications and field maintenance of the Bridgeport Digital Readout (DRO) Measuring System. The first chapter is written so that anyone without prior DRO experience will understand its operation. Operating examples are in Section 1.4 of Chapter 1. Field maintenance and troubleshooting are in Chapter 2 and Chapter 3.

CHAPTER 1: OPERATION

1.1 SYSTEM DESCRIPTION

1.1.1 General

The DRO system shows the operator the positions of the table and crossfeed at all times. It also allows him to make accurate moves very easily by entering the distance to be moved and then moving the axes until the Readout unit shows zero.

The DRO Measuring System consists of three major components (See Figure 1) and an assortment of installation and interconnection materials.

The major components of the DRO measuring system are:

1. Readout unit (operator's control)
2. X-axis transducer
3. Y-axis transducer

NOTE

Refer to Section 1.2 for definitions of terms.

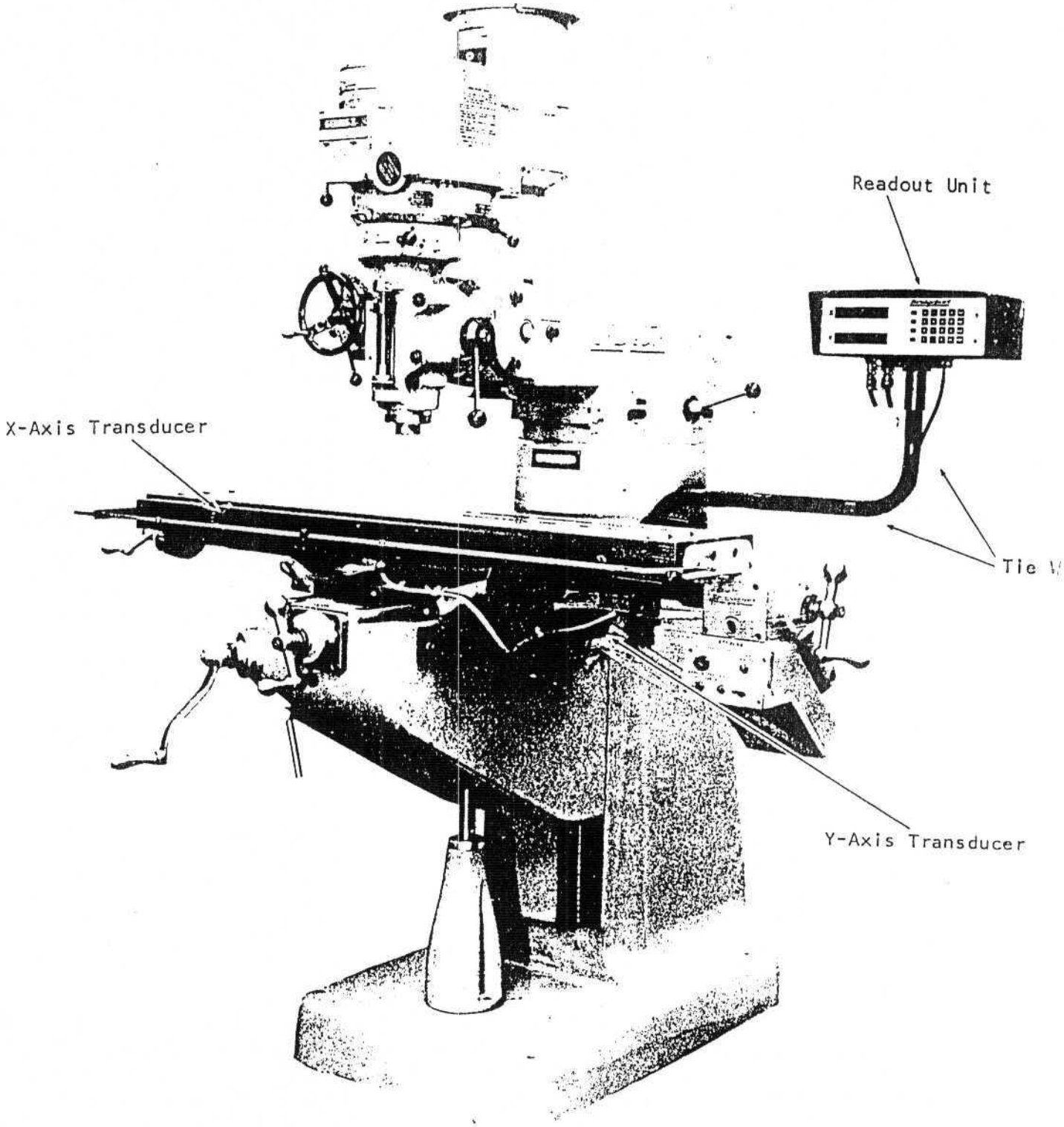


Figure 1: DRO System Components

CAUTION

The customer should make sure that the transducer cables are attached along the Support Arm with tie wraps or adhesive tape (see Figure 1).

1.1.2 Readout Unit

The Readout unit contains two six-digit displays which show machine positions and movements. It also contains controls which enable information to be entered.

1.1.3 Transducers

The X-axis transducer monitors the table position. The Y-axis transducer monitors the crossfeed position. Each transducer sends electrical signals indicating its position to the Readout unit. The Readout unit displays these signals as 6-digit numbers.

Avoid bumping the transducers when operating the machine. Bumping a transducer during operation may misalign it, resulting in inaccurate readings.

The only differences between X and Y-axes transducers are their lengths and their mounting positions.

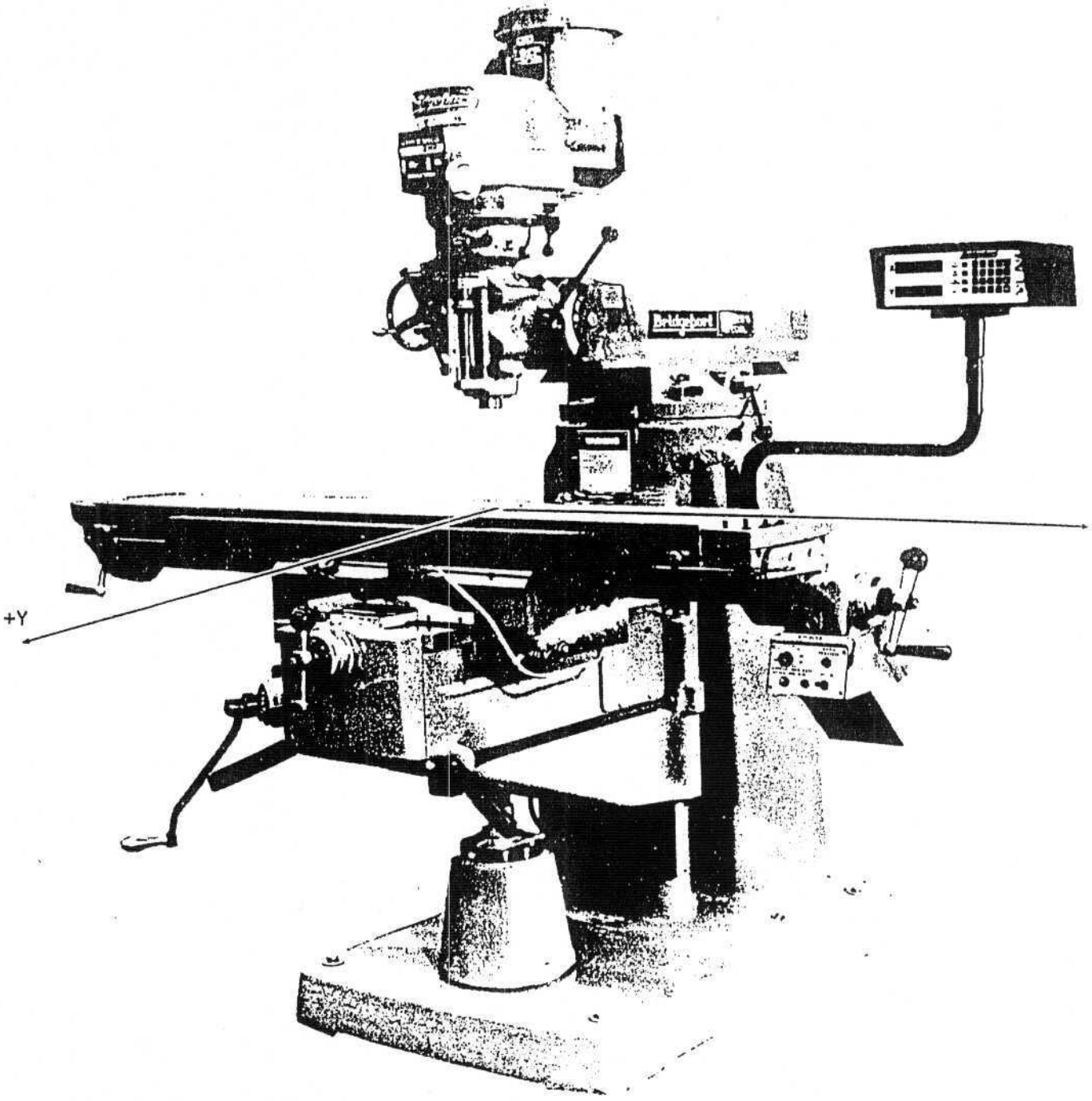


Figure 2: DRO Cocrdinate Axis System

1.2 DEFINITIONS OF TERMS AND READOUT FUNCTIONS

Section 1.2.1 explains four overall concepts that you should understand before proceeding. Sections 1.2.2 through 1.2.7 explain the keys and displays on the Readout unit.

1.2.1 Definitions Of Terms

1. Absolute Zero Point:
   The DRO has one reference point from which all distances are measured. This is called the absolute zero point (see Figure 6). When the DRO is turned on, the absolute zero point is the current position. The absolute zero point can be set to any position desired by moving to that position and pressing the CLR button. The zero position of either axis can be changed individually by pressing the axis select key (X or Y) and then CLR.

2. Absolute mode:
   In this mode the X-display shows the tool position relative to the X-axis zero. The Y-display shows the tool position relative to the Y-axis zero. The Readout is in this mode when the ABS POSITION lamp is lit.

3. Incremental mode:
   In this mode the X and Y-displays show the distance the X and Y-axes have to move to get to the next programmed position. The DRO remembers the absolute zero point internally but does not display it. The Readout is in this mode when the INC MOVE lamp is lit.

4. Direction:
   The Readout displays the X-axis (table) and Y-axis (crossfeed) directions as they appear on the milling machine. To understand the positive and negative directions imagine you are sitting on the part and directing the tools' motion. From this viewpoint the tool will appear to move even though the part is actually moving.

   Figure 2 shows the coordinate system used by the DRO. By turning the table handcrank so that the table moves to the left, you are causing the tool to go right: in a plus (+) direction. Turning the crossfeed handle clockwise so the saddle movement is toward the column you are causing the tool to move in a plus (+) direction, towards the operator.

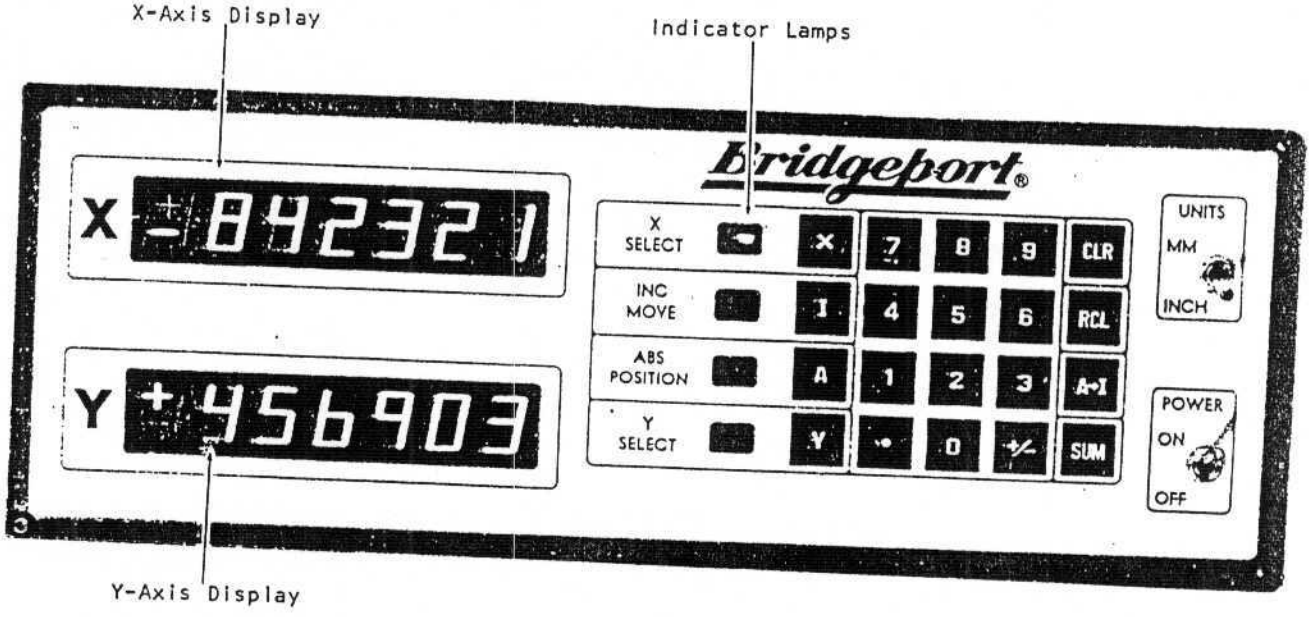


Figure 3: The Readout Unit - Displays and Indicators

1.2.2 Numerical Displays (Refer To Figure 3)

X and Y-axis displays:

These 6-digit displays give the instantaneous position of the tool along the X-axis (table) and Y-axis (crossfeed) in inches or millimeters. When the ABS POSITION lamp is on, the +/- signs indicate which direction the tool is from the absolute zero point. When the INC MOVE lamp is on, the +/- sign indicates the direction the Y or X-axes must move to complete the desired incremental move.

In the Inch mode the Least Significant Digit (LSD) alternates between 0 and 5. Thus the display resolution is .0005 inch. In the Metric mode the LSD counts from 0 to 9. The display resolution is .01 millimeter. (See Section 1.4.1 for an explanation of rounding). When first turned on the sections of the display will light in random order; this is normal.

1.2.3 Indicator Lamps (Refer To Figure 3)

1. X SELECT indicator:

   When this indicator is lit the next input will be associated with the X-axis (table).

2. Y SELECT indicator:

   When this indicator is lit the next input will be associated with the Y-axis (crossfeed).

3. INC (Incremental) MOVE indicator:

   When this indicator is lit, the displays show the distance remaining to complete the most recent incremental move entered.

4. ABS (Absolute) POSITION indicator:

   When this indicator is lit the X and Y-axes displays are showing the table and crossfeed positions relative to the absolute zero point.

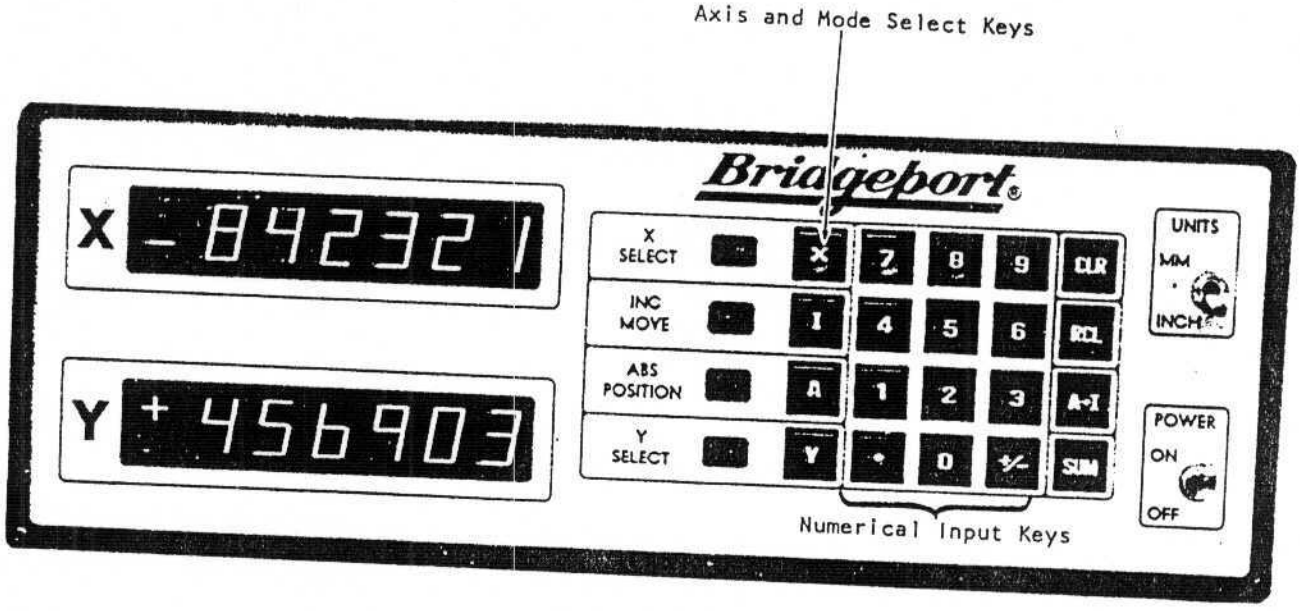


Figure 4: The Readout Unit - Select and Numeric Keys

1.2.4 Axis And Mode Select Keys (Refer To Figure 4)

X - Pressing this key clears the X-axis display and turns on the X-SELECT lamp. The Readout will now accept Incremental (I) or Absolute-to-Incremental (A⟶I) inputs for the X-axis.

I - Incremental: Pressing this key after entering numbers indicates that the numbers just entered represent the next incremental move. This lights the INC MOVE lamp.

A - Absolute: Pressing this key causes both axis displays to show the current absolute position of the table and the saddle. This lights the ABS POSITION lamp.

Y - Pressing this key clears the Y-axis display and turns on the Y-SELECT lamp. The Readout will now accept Incremental (I) or Absolute-to-Incremental (A⟶I) inputs for the Y-axis.

1.2.5 Numerical Input Keys (Refer To Figure 4)

0,1,2...9 - These are keys for entering numbers into the Readout unit.

.(Decimal)- The decimal point is used when entering dimensions. The entered and displayed values range from +/- .0005 to +/- 99.9995.

+/- - The system recognizes all inputs as positive unless a negative sign is entered. Both negative and positive incremental moves can be entered. Negative or positive absolute positions can also be entered in order to change them to incremental moves (See A⟶I).

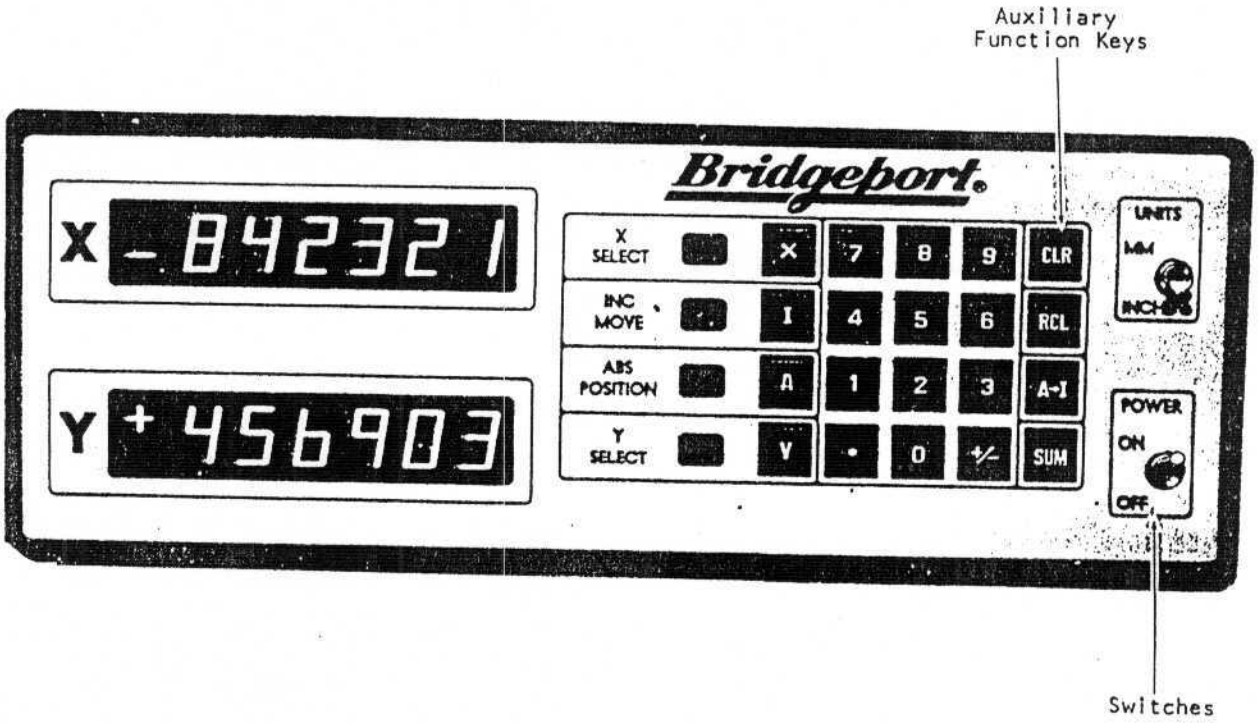


Figure 5: The Readout Unit - Auxilliary Keys and Switches

1.2.6 Auxiliary Function Keys (Refer To Figure 5)

CLR - Clear: Pressing this sets the displays and the position memories to zero and makes the current position the absolute zero point. To clear just the X or Y-axis, press the X or Y button before pressing CLR.

RCL - Recall: This key recalls the most recent incremental entries to the Readout for both axes. To do this for just one axis, press the X or Y button before pressing the RCL button.

A→I - Absolute to Incremental: This key allows the operator to enter absolute positions directly. To use this, press one of the AXIS SELECT keys, enter the absolute position the axis should go to and press the A→I key. The DRO will convert the absolute position to the incremental move needed to get to that position. The display will show this incremental move to the operator.

SUM - Summation: This key is used to add and subtract values. The operator chooses an axis and enters a signed value (+ values add, - values subtract). Pressing the SUM key adds the value to the last incremental value entered.

1.2.7 Switches (Refer To Figure 5)

MM/INCH - Millimeters/Inches: This converts the displayed positions or moves from millimeters to inches and vice versa. The machine makes all internal calculations in millimeters and continuously converts these to inches. This switch may be changed at any time without disturbing the unit's operation. Refer to Section 1.4.1 for an explanation of conversion and rounding error.

ON/OFF - This switch turns the system ON and OFF. During power-up the Readout will clear all displays and memories. It then establishes the current table position as the X-axis zero and the current saddle position as the Y-axis zero.

1.3 OPERATING EXAMPLES

The following five examples explain general operations that the DRO performs. Do each operating example step-by-step until you become familiar with the procedure. Absolute and incremental moves are important concepts that enable full utilization of the DRO. The first two examples cover them in detail.

The DRO is more sensitive to movement than the mechanical counters on the X and Y-axes. Because of this, the X and Y displays of the DRO will show movements that are not normally seen by the operator. To prevent unintentional movements, release the leadscrew tension after making an axis move. To do this, turn the hand-crank a small amount in the opposite direction. Doing this and then applying the table or crossfeed lock will prevent unintentional movements. The continuous AC line voltage must be 115 VAC +/- 10%. Any input voltage outside of this range could damage the equipment and jeopardize the warranty.

1.3.1 Operating Notes

1.3.1.1 Inch Mode -

Do not enter more than two digits to the left of the decimal point when in the Inch mode. Any more than two digits will be truncated by the DRO starting with the Most Significant Digit (MSD). The result of any addition requiring more than two digits to the left of the decimal point will also be truncated starting with the MSD.

Do not enter more than four digits to the right of the decimal point. If a fifth digit is entered, the DRO reacts as though the incremental (I) button had been pressed.

1.3.1.2 Millimeter Mode -

Do not enter more than four digits to the left of the decimal point when in the Millimeter Metric. Any digits more than four to the left of the decimal point will be truncated.

1.3.1.3 Miscellaneous -

The DRO will always keep track of movement/position regardless of the mode.

If a decimal point is not entered, the system places the decimal point to the right of the last digit entered, i.e. Inch mode XX.000, Metric mode XXXX.00. The system inserts trailing zeroes; it is not necessary to include zeroes after the decimal point.

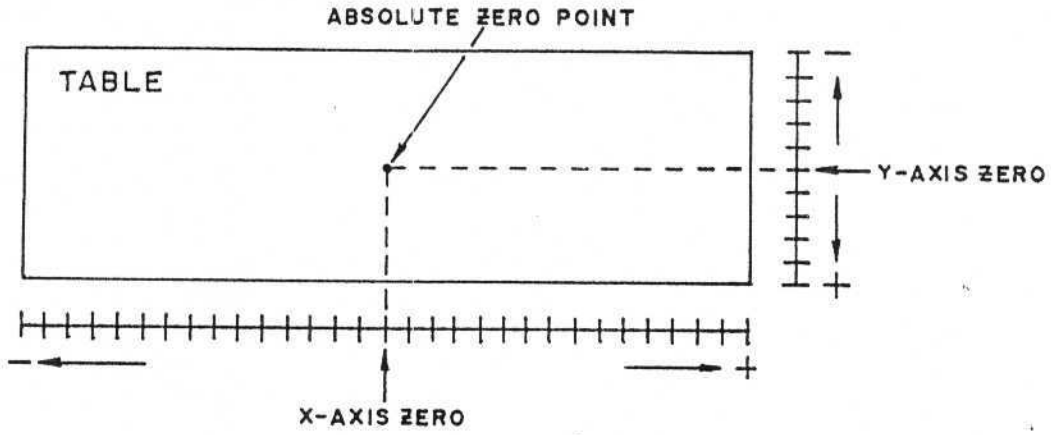


FIGURE 6 ABSOLUTE ZERO POINT

Example 1: Establishing Absolute Zero Position

The DRO establishes the absolute zero point wherever it is turned on. To set the absolute zero point where you want it, move the table to the desired position and press CLR. Both displays will read 0.0000 which is the new absolute zero point.

It is possible to move the absolute zero point on only one axis if desired. Move the axis to be changed (X or Y) to the desired position, then press X and CLR or Y and CLR, as appropriate. Only the selected axis will be zeroed.

Figure 6 shows an absolute zero in the center of the table, with the axes labelled. Plus and minus in the figure refers to the position of the tool. If the tool is to the right of the absolute zero point, the X reading will be positive. If the tool is in front of the absolute zero point the Y reading will be positive.

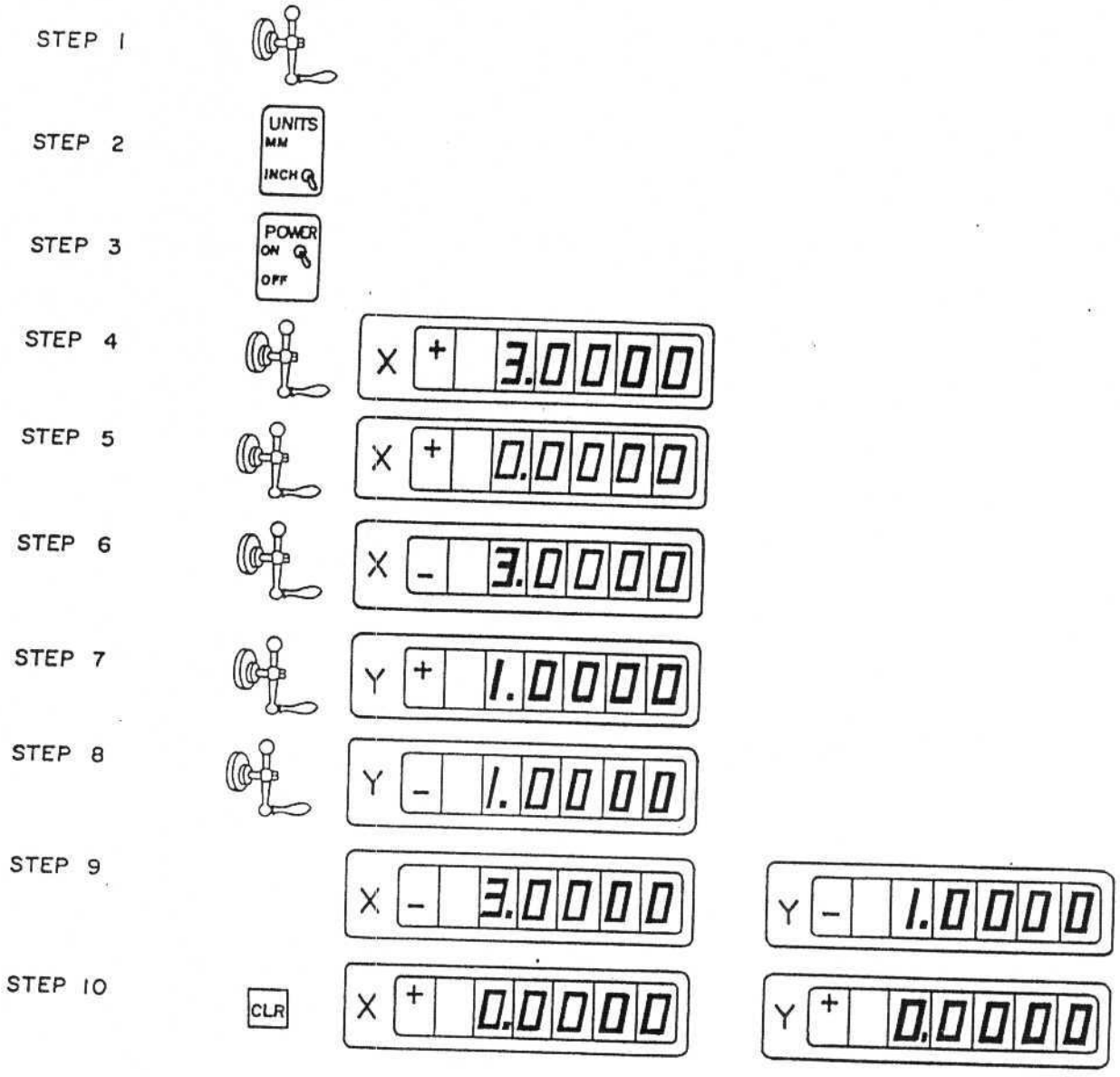


Figure 7: STEPS FOR EXAMPLE 1

Perform each step in the following example to familiarize yourself with absolute moves (Refer to Figure 7).

1. Move the table to about the middle of its travel. Remember to remove tension from the leadscrew after completing each move.

2. Set the UNITS switch on the DRO display unit to INCH.

3. Turn on the POWER switch (lower right-hand corner). As the displays warm up, the digits will come on and read 0.0000. Until you change it, the DRO will consider the present position of the table to be the absolute zero, and it will make all its measurements from there.

4. Move the table to the left until the X-axis display reads 3.0000. This indicates that a positive move of 3.0 inches has been made (positive is table to the left or tool to the right). In the INCH mode DRO measurements are accurate to within 0.0002 inch.

5. Move the table to the right until the display reads +0.0000; you are now back to the absolute zero point.

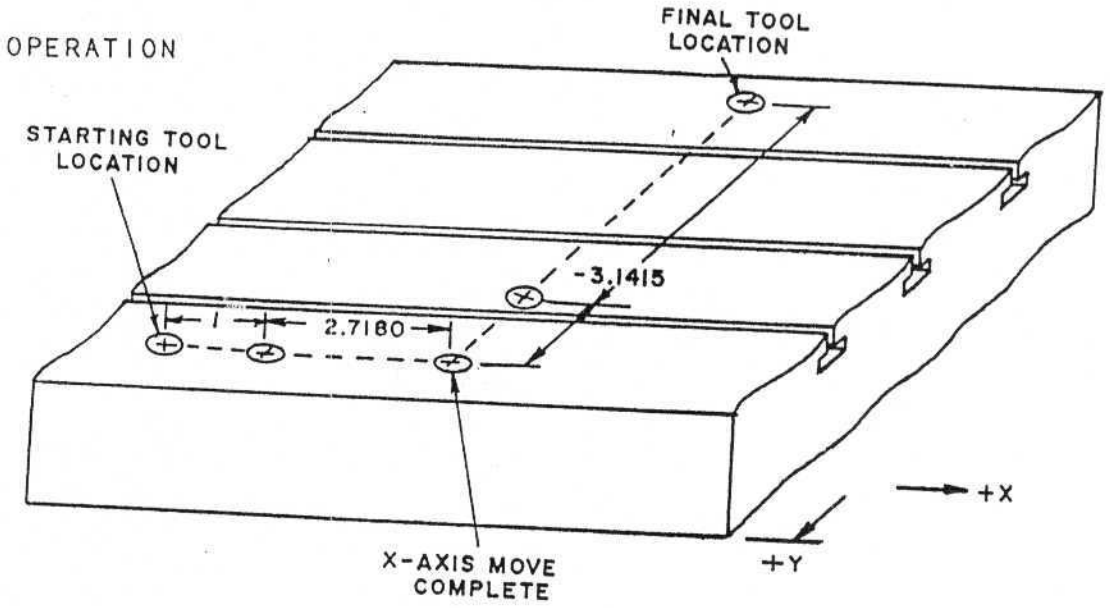
6. Move the table to the right until the X-axis display reads -3.0000. (The + and - signs indicate the direction of tool movement, which is the opposite of table and saddle movement).

7. Move the saddle towards the column until the Y-axis display reads +1.0000.

8. Move the saddle away from the column until the Y-axis display reads -1.0000.

9. Note the X and Y-axes displays now show -3.0000 and -1.0000, respectively. This indicates that the tool is 3.0000 inches to the left and 1.0000 inch in from the absolute zero position.

10. Press the CLR button. The X and Y-axes displays will read +0.0000. This location is now the new absolute zero point. (A new absolute zero point can be established at any time by pressing CLR.)



STEP 1

STEP 2 — CLR

STEP 3 — UNITS MM INCH

STEP 4 — X SELECT | X | 1 | • | 0 | INC MOVE | I

STEP 5 — X + 0.0000

STEP 6 — X SELECT | X | 2 | • | 7 | 1 | 8 | 0 | INC MOVE | I

STEP 7 — X − 0.0000

STEP 8 — Y SELECT | Y | +/− | 1 | • | 0 | INC MOVE | I

STEP 9 — Y + 0.0000

STEP 10 — Y SELECT | Y | +/− | 3 | • | 1 | 4 | 1 | 5 | INC MOVE | I

STEP 11 — Y + 0.0000

STEP 12 — ABS POSITION | A | X + 3.7180 | Y − 4.1415

Figure 8 INCREMENTAL MOVES

Example 2: Incremental Moves

Making incremental moves by using the digital displays instead of the mechanical indicators is one of the most important DRO features.

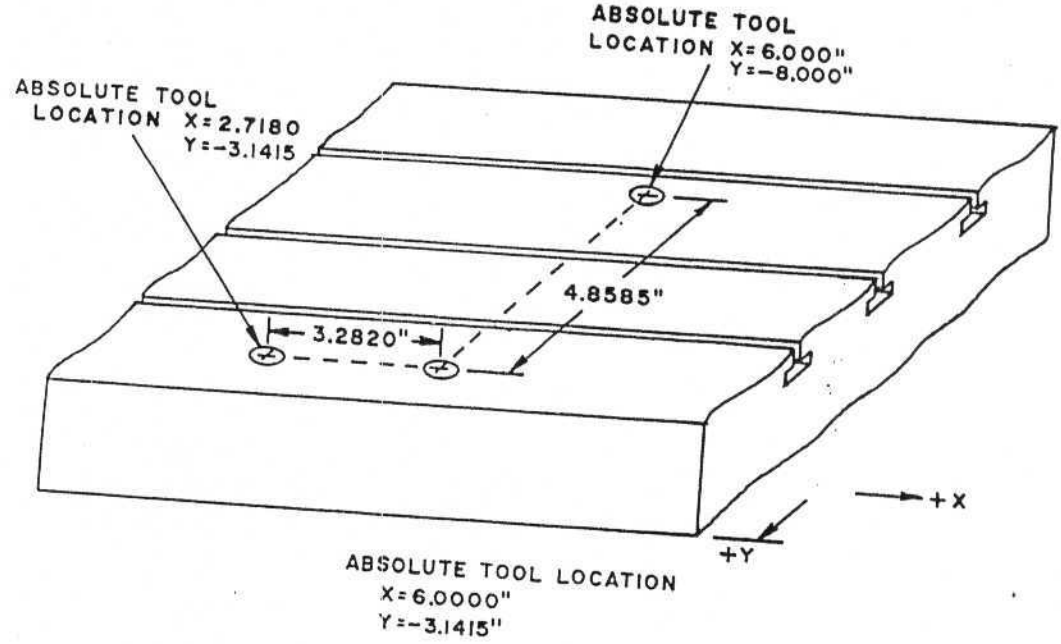
All incremental moves are distances measured from the current tool position to the next selected position. The Readout unit displays these moves when the INC MOVE lamp is lit. To use this feature select the axis to be moved and enter the distance it is to be moved. Move that axis until the display reads zero. This indicates that the incremental move is complete.

An example of the incremental move follows (Refer to Figure 8):

1. Position the tool as shown in Figure 8.
2. Press the CLR button to set the absolute zero point (X=0.0000, Y=0.0000).
3. Set the UNITS switch to INCH.
4. Press the X-button, enter 1.0 and press the I-button.
5. Move the X-axis until the display reads +0.0000. Remember to remove tension from the leadscrew after completing each move.
6. Press the X-button, enter 2.7180 and press the I-button.
7. Move the X-axis until the X-axis Readout display reads -0.0000*. This completes the incremental move in the X-axis direction.
8. Press the Y-button, enter -1.0 and press the I-button.
9. Move the Y-axis until the display reads +0.0000.
10. Press the Y-button, enter -3.1415 and press the I-button.
11. Move the Y-axis until the Y-axis Readout display reads +0.0000. This completes the incremental move in the Y-axis direction.
12. Press the A-button. The X-axis display will show the absolute position, +3.7180 inches, and the Y-axis display will show the absolute position, -4.1415 inches.

---

* The zero position will have a + or - sign associated with it due to the metric to inch conversion algorithm. As soon as a zero (0.0000) appears on the display it should be taken as the zero point, regardless of the sign associated with it.



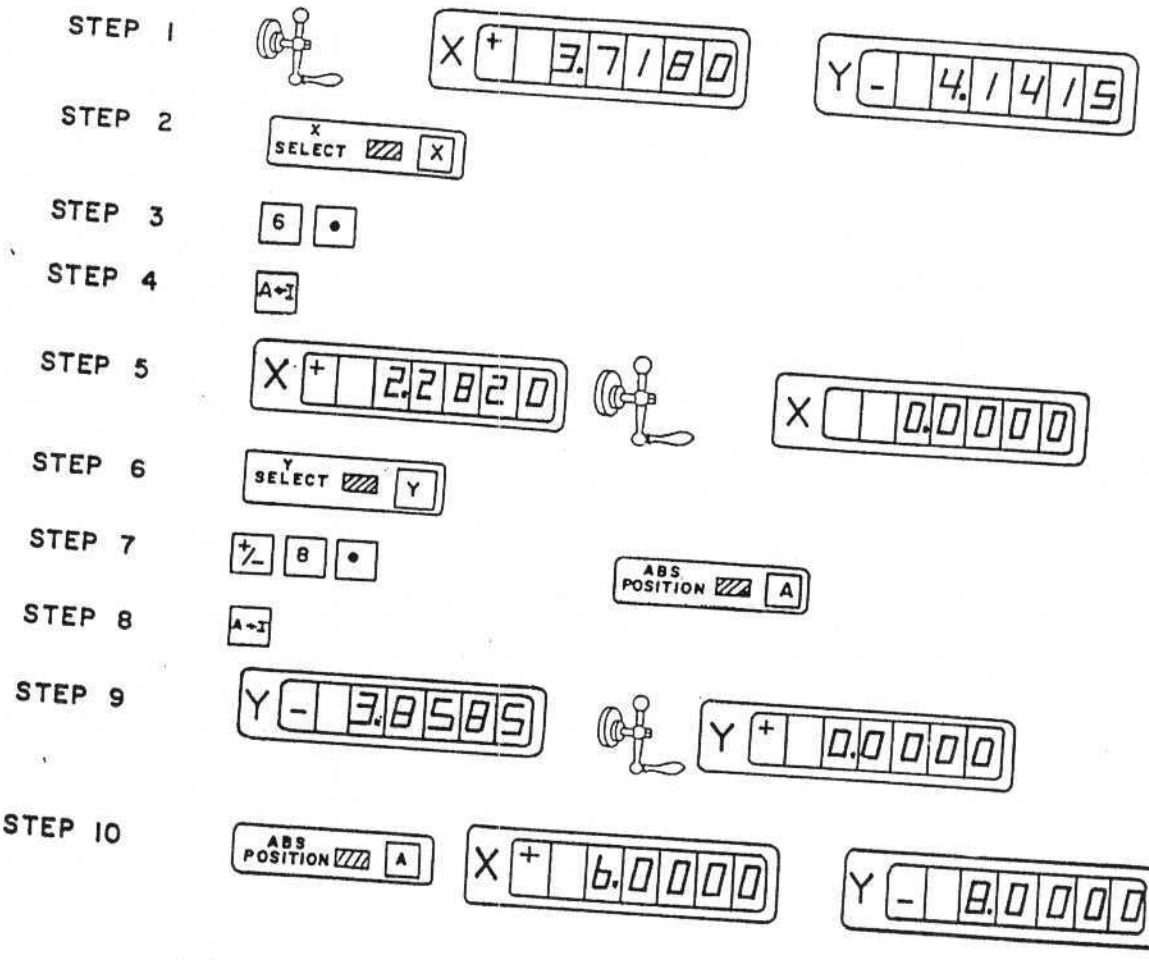


Figure 9 RELATIONSHIP OF ABSOLUTE TO INCREMENTAL DISTANCES

Example 3: Absolute Coordinate Translated to an Incremental Move

Entering incremental moves as described in the previous example is the most direct way of controlling table and crossfeed movement. However, in certain situations all dimensions on a drawing are referenced to a datum point. In that case, it is easier to enter absolute rather than incremental values. The DRO lets the operator do this and then converts the values to incremental moves. In this example, the operator wishes to move the tool to the X and Y-axes absolute positions 6.0000 inches and -8.0000 inches, respectively. Refer to Figure 9.

1. Move axes so the X-axis display reads 3.7180 inches (absolute) and the Y-axis display reads -4.1415 inches (absolute). This is the starting point. If example 2 has just been completed the axes might already be in this position.

2. Press the X-button.

3. Enter the absolute position, 6.0000 (you do not have to enter the zeroes after the decimal point).

4. Press the A⟶I button.

5. The X-display will show +2.2820. This is the incremental distance between the current tool position and +6.0000 inches absolute. Move the X-axis until the X-display reads +0.0000 inch. The incremental move of +2.2820 inches is complete. The final absolute X-axis tool position is +6.0000 inches. Remember to remove the leadscrew tension after completing each move.

6. Press the Y-button.

7. Enter the absolute position, -8.0000 inches.

8. Press the A⟶I button.

9. The Y-display will show -3.8585 inches. This is the incremental distance between the current tool position and -8.0000 inches (absolute). Move the Y-axis until the Y-display reads +0.0000 inch. The incremental move of -3.8585 inches is complete. The final absolute Y-axis tool position is -8.0000 inches.

10. Press the A-button. The X and Y-displays will read the absolute positions, +6.0000 inches and -8.0000 inches, respectively.

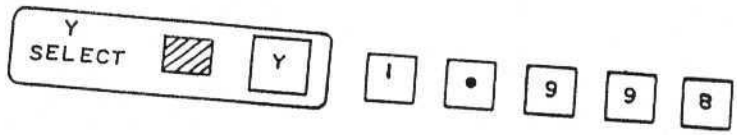
Example 4: The Recall Feature

Pressing the RCL key recalls the last X and Y incremental moves entered into the Readout Unit. This feature is convenient when doing the same operation repeatedly (such as drilling or machining a series of holes with regular spacing).

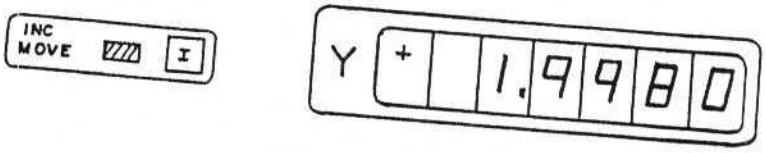
The following example illustrates the Recall feature being used to drill a series of holes on the perimeter of a rectangle (Refer to Figure 10).

1. Position the drill over the first hole.
2. Lock the saddle and press the CLR button. This sets the absolute zero point.
3. Drill the first hole.
4. Press the X-button and enter the X-distance between two holes (6.0220).
5. Press the I-button. This indicates that the value entered is incremental.
6. Move the X-axis until the X-display reads +0..0000.
7. Drill the second (next) hole.
8. Press the RCL button. The X-display will read +6.0220.
9. Repeat steps 6-8 for the three remaining holes.
10. Lock the X-axis and unlock the Y-axis. Press the CLR button to eliminate any table movement recorded while locking and unlocking the axes.

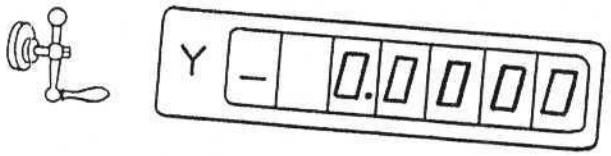
STEP 11



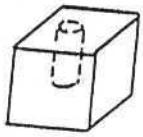
STEP 12



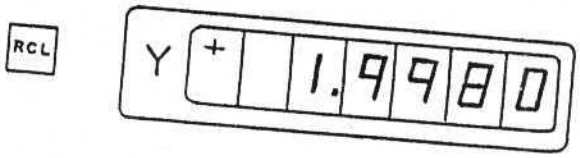
STEP 13



STEP 14



STEP 15



STEP 16 REPEAT 13 – 15

STEP 17 REPEAT 4 – 10

STEP 18 REPEAT 11 – 16

Figure 11 CONCLUDING STEPS FOR EXAMPLE 4

11. Press the Y-button and enter the Y-distance between two holes (1.9980).

12. Press the I-button.

13. Move the Y-axis until the Y-display reads -0.0000*.

14. Drill the hole.

15. Press the RCL button. The Y-display will read +1.9980.

16. Repeat steps 13-15 for the three remaining holes. This completes all movement in the positive axes directions.

    Holes will now be drilled in the negative axes direction.

17. Repeat steps 4-10 substituting -6.0220 inches for 6.0220 inches in step 4.

18. Repeat steps 11-16 substituting -1.9980 for 1.9980 in step 12.

---

* The zero position will have a + or - sign associated with it due to the metric to inch conversion algorithm. As soon as a zero (0.0000) appears on the display it should be taken as the zero point, regardless of the sign associated with it.

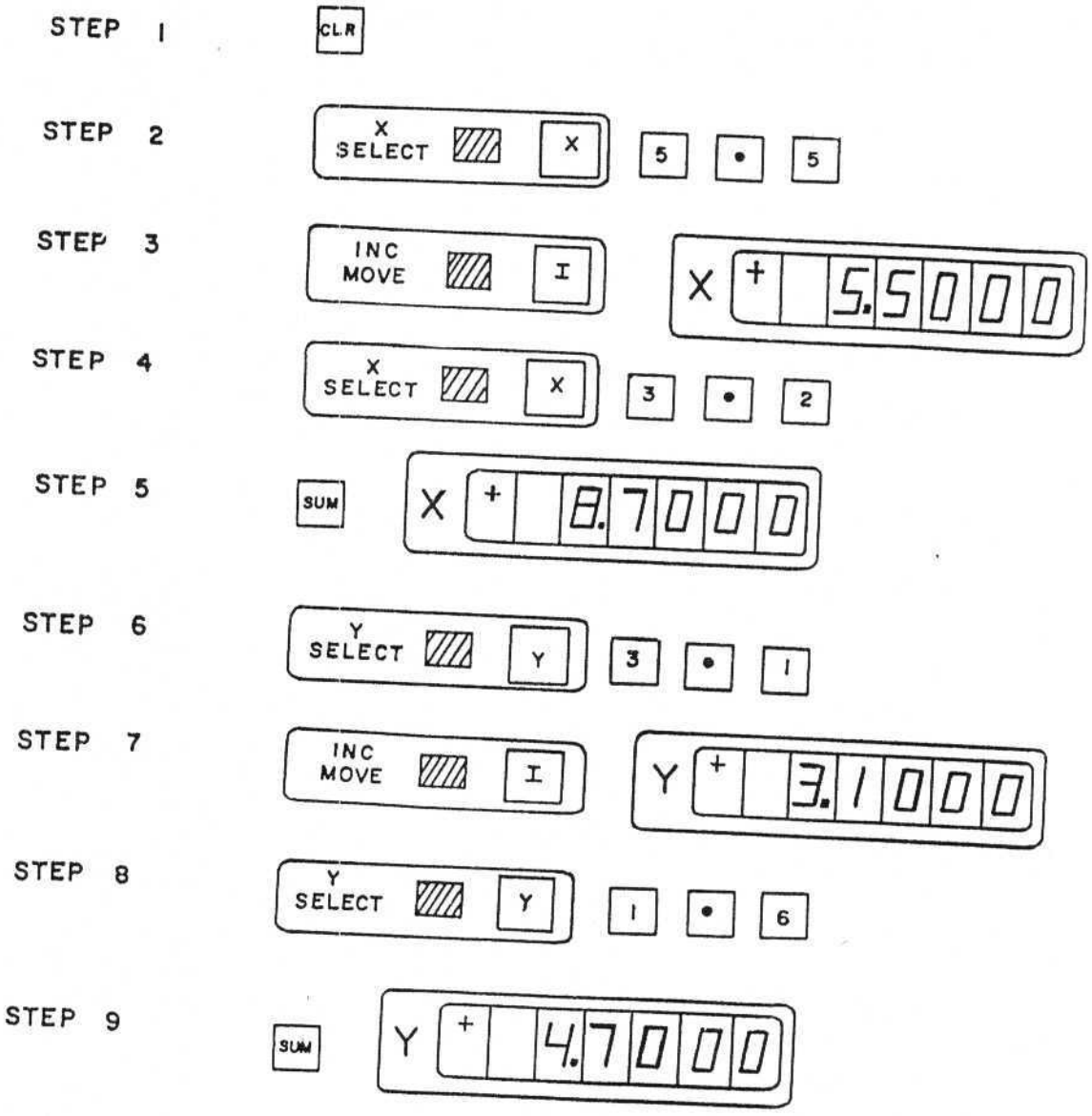


Figure 12 : STEPS FOR EXAMPLE 5

Example 5: The Calculator Feature

The DRO can be used to add and subtract values. Values entered will be added to the most recent incremental move entry for the specified axis. To subtract a number merely change its sign to negative and add it to the most recent incremental input.

An example using the SUM key follows. The operator wants to add several dimensions that are on a drawing. Two dimensions are lengths and result in an X-axis total. Two dimensions are widths and result in a Y-axis total, Refer to Figure 13. The operator should:

1. Press the CLR button.
2. Press the X-button and enter the first incremental dimension, 5.5 inches.
3. Press the I-button. The X-display will read +5.5000.
4. Press the X-button and enter the second incremental dimension, 3.2 inches.
5. Press the SUM key. The display will read +8.7000. This is the total distance of the indented face in the X-direction.
6. Press the Y-button and enter the first incremental dimension, 3.1 inches.
7. Press the I-button. The Y-display will read +3.100.
8. Press the Y-button and enter the second incremental dimension, 1.6 inches.
9. Press the SUM key. The display will read +4.7000. This is the total distance of the indented face in the Y-direction.

This completes the first example of the sum feature showing its use with incremental dimensions.

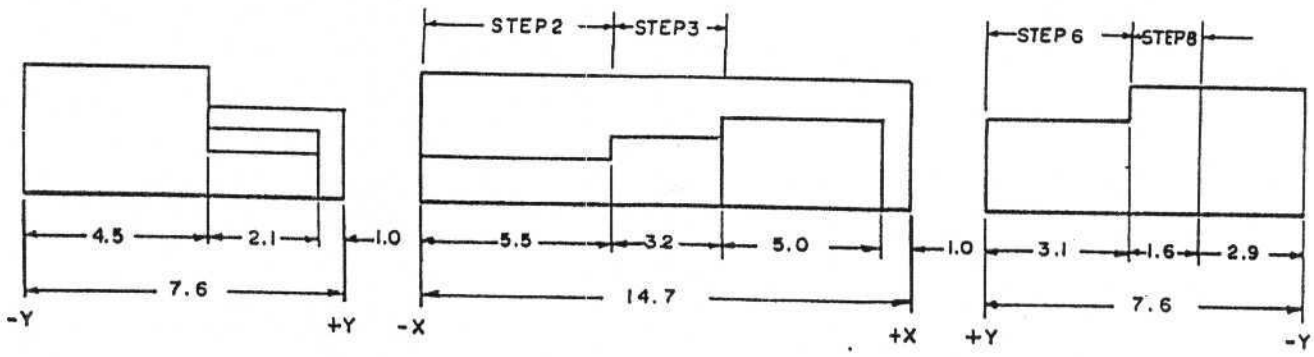
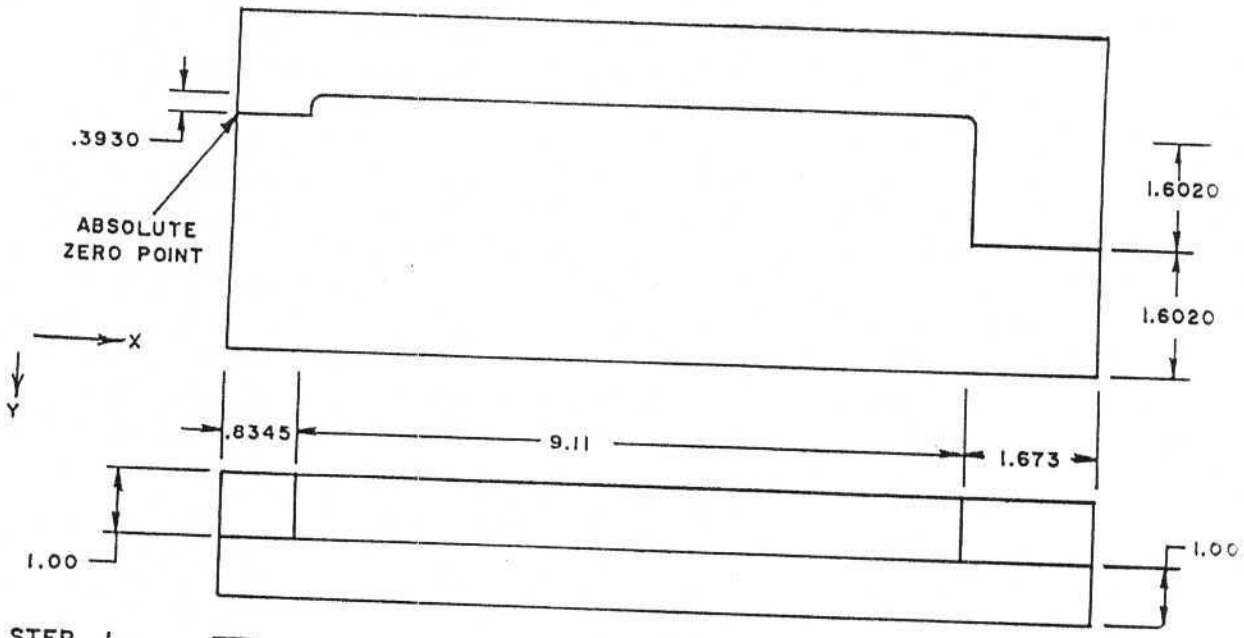


Figure 13 COMPONENT AND DIMENSIONS USED IN EXAMPLE 5



STEP 1 [CLR]

STEP 2 X + 0.8345

STEP 3 Y − 0.3930

STEP 4 [X SELECT] [X] [9] [•] [1] [1]

STEP 5 [INC MOVE] [Σ] X + 9.1100

STEP 6 [X SELECT] [X] [1] [•] [6] [7] [3]

STEP 7 [SUM] X + 10.7830

STEP 8 [ABS POSITION] [A]

STEP 9 [X SELECT] [X]

STEP 10 [•] [8] [3] [4] [5]

STEP 11 [SUM] X + 11.6175

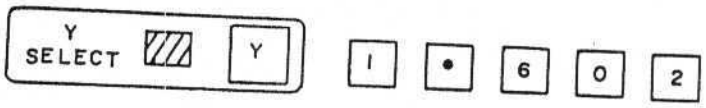
Figure 14 CALCULATING ABSOLUTE DIMENSIONS USING THE SUM KEY

This next example of the sum feature shows that absolute positions can be calculated from the current absolute position using incremental dimensions (Refer to Figure 14). This allows the operator who wants to work in absolute dimensions to calculate them from the incremental dimensions on a print.

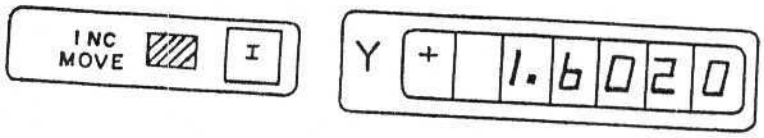
Steps 2 and 3 show X and Y-axes movement. This is to demonstrate that the procedure could be done at any time during the making of a part.

1. Press the CLR button.
2. Move the X-axis until its display shows +.8345 (absolute).
3. Move the Y-axis until its display shows -.3930 (absolute).
4. Press the X-button and enter the first incremental dimension, 9.11.
5. Press the I-button. The X-display will read 9.1100.
6. Press the X-button and enter the second incremental dimension, 1.673.
7. Press the SUM button. The X-display will read 10.7830. This is the total X-incremental distance from the current absolute position that must be moved.
8. Press the A-button and make a note of the current X-absolute position.
9. Press the X-button.
10. Enter the absolute position observed in step 8. In this example it is .8345 inch.
11. Press the SUM key. The X-display will read 11.6175. This is the total absolute distance from the absolute zero to the end of the part along the X-axis.

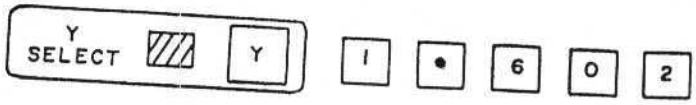
STEP 12



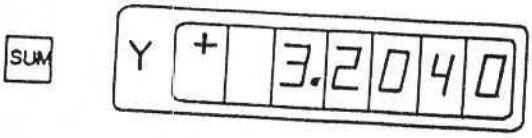
STEP 13



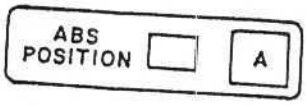
STEP 14



STEP 15



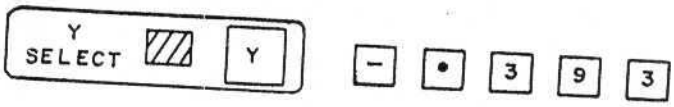
STEP 16



STEP 17

NOTE THE Y ABSOLUTE POSITION

STEP 18



STEP 19

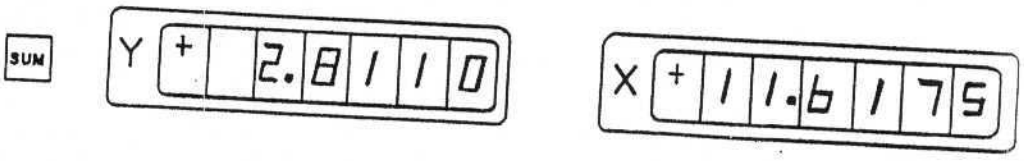


Figure 15 CONCLUDING STEPS FOR EXAMPLE 5

12. Press the Y-button and enter the first Y-incremental dimension, 1.602.

13. Press the I-button. The Y-display will read 1.6020.

14. Press the Y-button and enter the second Y-incremental value, 1.602.

15. Press the SUM button. The Y-display will read 3.2040.

16. Press the A-button.

17. Make a note of the Y-absolute position.

18. Press the Y-button and enter the Y-absolute position, -.3930.

19. Press the SUM button. The display will read 2.8110. This is the total absolute distance from the current tool position to the Y-axis point of interest. Therefore when the cut is complete the absolute axis position will be X=11.6175 inches and Y=-2.8110 inches.

1.4 ADDITIONAL POINTS OF OPERATION

1.4.1 Accuracy

All distance measurements and calculations are done by DRO using the metric system. When millimeters are being displayed, the DRO has a resolution of .01 mm.

When inches are being displayed the DRO makes internal conversions from metric units to English units. This conversion involves some rounding, which can introduce errors of up to .0005 inch. The table below illustrates this rounding error.

DRO Least Significant Digit Rounding in the Inch Mode

ACTUAL LSD	DISPLAYED LSD	RESULTING ERROR
.0009		
.0008	.0010	-.0001
.0007		-.0002
.0006		+.0002
.0005	.0005	+.0001
.0004		.0000
.0003		-.0001
.0002		-.0002
.0001		+.0002
.0000	.0000	+.0001
-.0001		.0000
-.0002		-.0001
-.0003		-.0002
-.0004		+.0002
-.0005	-.0005	+.0001
-.0006		.0000
-.0007		-.0001
-.0008		-.0002
-.0009	-.0010	+.0002
		+.0001

1.4.2 Errors

The DRO system displays all axis motion, whether it is intentional or unintentional (ie. skewing, table curvature). Unintentional motion can be minimized by proper gib adjustments and using sound machining practice.

1.4.2.1 Troubleshooting Errors -

Errors during testing and operation can originate from many sources besides the DRO. Some error sources and solutions are:

1. Temperature Changes:

   Errors caused by temperature change can be reduced by making sure that no drastic temperature changes take place during operation.

2. Mechanical Skewing:

   Mechanical skewing can be minimized by locking the Y-axis when moving or working with the X-axis. Lock the X-axis when moving or working with the Y-axis. (See # 5 this section - a discussion of loose gibs).

3. Human Factors:

   Minor differences in operator machining or checking technique are sufficient to change the results by +/- .0005 inches per reading.

4. Reference Standard Accuracy:

   Making sure that reference standards (gauge blocks, step gauge, dial indicator, etc.) are periodically maintained and calibrated.

5. Machine Errors:

   Machine errors can be caused by loose gibs. The gibs should be properly adjusted. Loose gibs can cause the table, knee and saddle to shift.

6. Leadscrew Tension:

When a table or saddle move is completed tension will ex on the leadscrew. This tension should be relieved by turn the hand crank back approximately .002 inch. If this tens is not relieved, any vibration to the machine will ca table or saddle movement. The DRO will show th tension-vibration induced movement by changing its display.

7. Part Placement:

Best results are obtained when the weight of the part distributed evenly over the table.

8. Readout and Transducer Accuracy Troubleshooting Errors:

The accuracy of the transducers and the Readout ar determinated by testing done in Section 4.2 of the DR Installation Manual, M-116.

1.4.3 Metric To Inch Conversion And Vice Versa

The DRO converts and works with all numbers as they were initially entered. The DRO display, however, will round-off and truncate numbers when converting them from inches to millimeters.

If rounding and truncation of displayed decimals is unacceptable, the operator may avoid this completely by entering and displaying numbers in the metric mode, only.