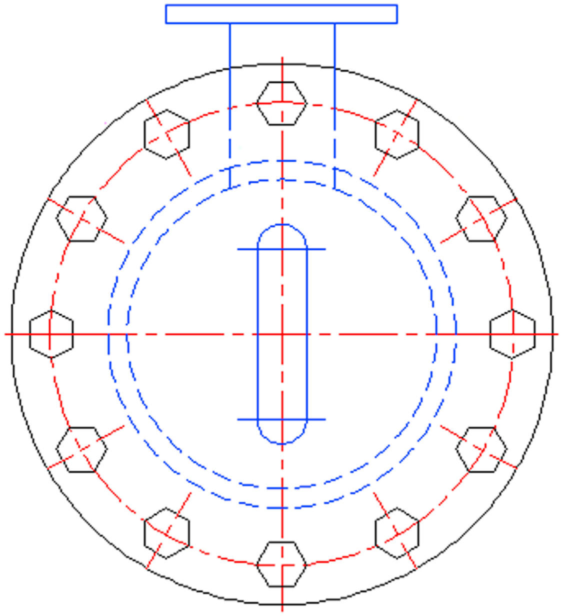
Chapter 8

Polar, Rectangular, and Path Arrays



Learning Objectives

In this chapter, we introduce the concept of an array and discuss the following:

- Creating a polar array
- Object, center, quantity, and degrees
- Additional operations with polar arrays
- The legacy polar array
- Creating a rectangular array
- Object, rows and columns, and distances
- Additional operations with rectangular arrays
- Legacy rectangular array
- Creating a path array
- Additional operations with path arrays

At the end of this chapter you will be able to create polar, rectangular, and path arrays. You then start a new in-class mechanical project.

Estimated time for completion of this chapter (lesson and project): 3 hours.

Arrays are very useful tools in AutoCAD to create patterns of objects. These patterns can be of a circular, linear, or path type, hence the polar array, rectangular array, and path array discussions that follow. In a strict sense, these tools are not something entirely new but merely automate what you can do (albeit tediously) by regular commands learned in Chapter 1, AutoCAD Fundamentals—Part I, and they are huge time-savers.

The array command underwent a major rework in AutoCAD 2012, with some additional minor enhancements for 2013 and 2014. If you are using this textbook to refresh your skills and have used older versions of AutoCAD, you are in for a surprise. Not only has an entirely new type of array been added (path array), but the tool is now command-line activated,

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with the Ribbon assisting with modifications, or almost entirely Ribbon driven. For better or for worse, the familiar Array dialog box is gone (though it can still be recalled), and a whole new set of possibilities is opened up.

This chapter introduces the various arrays by assuming that the student is new to AutoCAD and has never used or seen the older, legacy version of the command. It is, however, referred to and described, just in case you end up using a pre-2012 AutoCAD at some point in the future.

8.1 POLAR ARRAY

A polar array is a collection of objects around some common point arranged in a circle (or part thereof). An example in architecture is a group of chairs arranged around a circular table. The idea is to draw the table, then one chair, and after positioning the chair exactly where it will be in relation to the table, use a polar array to copy it around the table to create, let us say, ten of them, as seen in Fig. 8.1 on the left. The array command copies and rotates them into position and spaces them out evenly, a task that would have taken a while to do one chair at a time.

In mechanical engineering, an example may be the teeth of a sprocket gear. You draw the circle representing the wheel of the gear; put in one tooth properly drawn, detailed, and centered on top; then array to get the full gear. Fig. 8.1 shows illustrations of what was just discussed. There are, of course, many other examples.

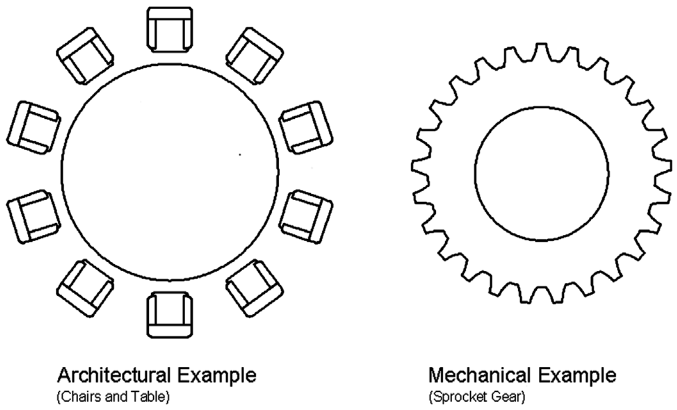


FIGURE 8.1 Polar array examples.

Steps in Creating a Polar Array

First of all, we need to create something to array. So go ahead and draw a circle of any size to represent the table just discussed, then create a convincing-looking chair. You may want to make a block out of it after you are done for convenience.

Next, position the chair at the top of the table, as seen in Fig. 8.2. Be sure to line it up perfectly on the vertical axis, or else the array will be skewed off center; and move it back a bit from the table with Ortho on. What does AutoCAD need to know to do the array? The following four items are critical to a polar array; although note that only the first two items are explicitly asked for by AutoCAD as you create the array:

- It needs to know *what object(s)* to array (that would be the chair, not the table).
- It needs to know *the center point* of the array (center of the table).

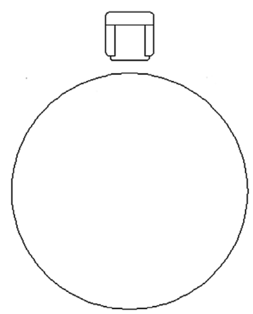


FIGURE 8.2 Chair and table, initial setup.

- It needs to know *how many objects* to create (let us stick to ten or so).
- It needs to know if the pattern goes all the way around (i.e., is it 360° or less).

It is useful to memorize these steps and realize what you need to do before even starting up the array command; that way you have a clear idea of what to do and what data to enter as you get going. Once you have the table and chair drawn, follow the steps shown to create the polar array.

Keyboard: Type in **arraypolar** and press Enter
Cascading menus: Modify→Array→Polar Array
Toolbar icon: Array_Toolbar
Ribbon: Home tab→Modify→Polar Array

Step 1. Start up the array command via any of the preceding methods (it is recommended to have the Ribbon turned on).
- AutoCAD says: `Select objects:`

Step 2. Select the chair block.
- AutoCAD says: `1 found`

Step 3. Press Enter.
- AutoCAD says: `Type = Polar Associative = Yes`
  `Specify center point of array or [Base point/Axis of rotation]:`

Step 4. You successfully selected the *object to array*. You now need to specify the *center point of the array*. Simply select the center of the large circle (the table) using the CENter OSNAP. AutoCAD creates a set of chairs around the table.
- AutoCAD says: `Enter elect grip to edit array or [ASsociative/Base point/Items/Angle between/Fill angle/ROWs/Levels/ROTate items/eXit]<eXit>:`

Step 5. Note a few things at this point. The array is automatically associative (look for that button to be active in the Ribbon). This means all the pieces are linked and not separate, a very desirable new property of arrays. Also note the details shown in the Ribbon. Here, you can modify the number of items (chairs) and the angle to fill under the Items tab. Make sure you have ten chairs for this exercise.

Step 6. Your array is essentially done, so just press Enter to accept. If you wish, experiment with some of the variables such as Fill and Between. Also note how the chairs are rotated to face the table via the Rotate Items button that was automatically set (under Properties tab). You can, of course, turn that feature off. The completed polar array is shown in Fig. 8.3.

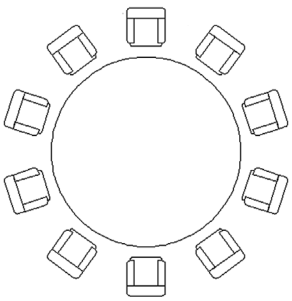


FIGURE 8.3 Polar array completed.

Additional Operations With Polar Array

Your new array behaves like a block (assuming Associative is set), a major difference first introduced in AutoCAD 2012, prior to which the new pieces of the array were not connected in any way. Click on one of the chairs with your mouse and it becomes selected, with several varieties of grips visible. If you hover your mouse over the chair grip, you see a menu of additional options. Finally, a new Ribbon Array tab appears. All of this is seen in Fig. 8.4. Let us take a closer look at the Ribbon and the Grip menu.

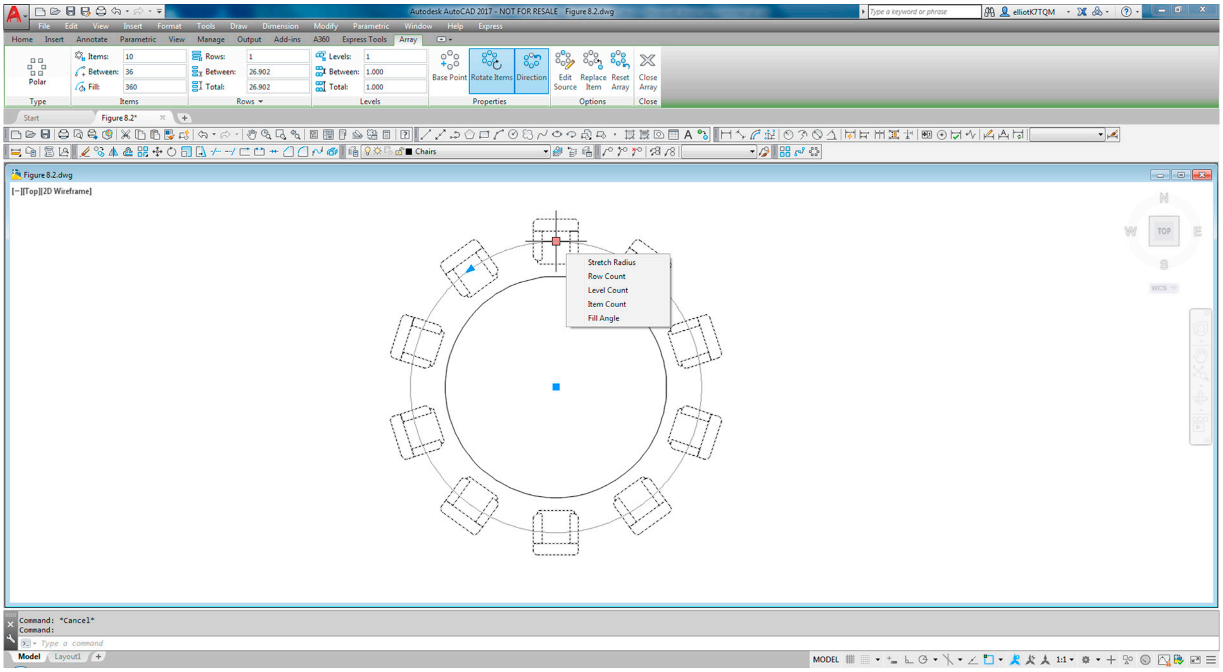


FIGURE 8.4 Polar array editing.

The Polar Array Ribbon has three areas of interest, the Items, Properties, and the Options/Close category, as seen in Fig. 8.5. The Items category we already mentioned and it is relatively self-explanatory. Top to bottom, the first value (`10`) is the number of items in the array, and you can change it for an instant update. Below that is the angle between all the objects (`36°`), and finally, below that, the total angle filled (`360°`, or a full circle). This should make sense as 36 × 10 = 360.

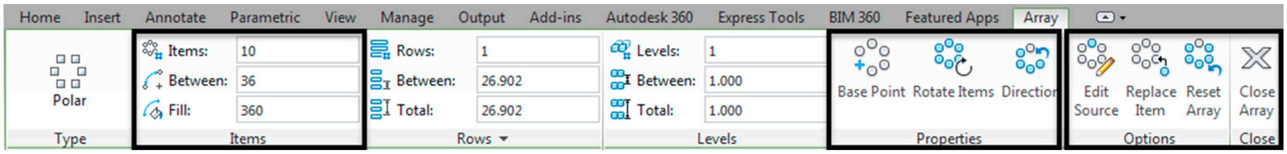


FIGURE 8.5 Polar array tab: Items, Properties, and Options/Close.

The Properties category's first button allows you to select a different base point for the rotation, useful if you did not quite get the first one right. The second button rotates the objects to face the rotation point as opposed to them all facing in one direction. The last button changes the direction of the array, from clockwise to counterclockwise, or vice versa. The last two buttons may be activated already on your sample table/chair array.

The Options category's tools are a bit more involved. They are therefore described in more detail next:

- *Edit Source*: This option allows you to edit and modify the source object. These changes are then reflected in the overall array. If you forget which object was the original source, it does not matter; you can pick any of the chairs and work on it. Execute the command, say "Yes" if you see the Array editing State dialog box, select the object, modify it, and when done, type in `arrayclose`, or click on Save Changes on the Ribbon at the far right. Fig. 8.6 shows Edit Source in progress.
- *Replace Item*: If editing the source is too time consuming, then just replace it with another design via this option. AutoCAD asks you to select the replacement object and a base point. Use the Key Point option to pick a point on the replacement object. Finally, select an item (or several items) in the array to replace. Fig. 8.7 shows Replace Item in action as squares replace the chair symbol.
- *Reset Array*: This is an easy one. Autodesk figured you will mess up a few arrays while learning this tool (speaking from experience, of course) and included a Reset button. Its function is apparent immediately upon use, though it is limited to just restoring erased items and some overrides.

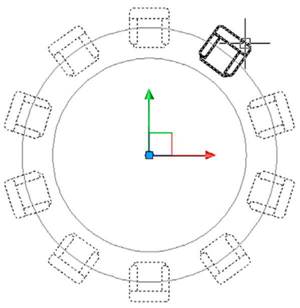


FIGURE 8.6 Edit Source.

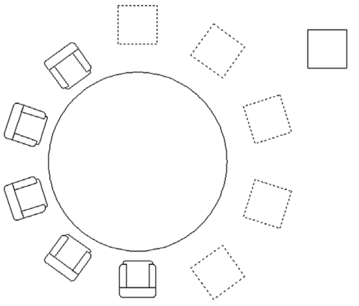


FIGURE 8.7 Replace Item in progress.

Next, we have the menu seen when the mouse is held over the chair grip. Run through all the options as you read the descriptions. It contains the following tools:

- *Stretch Radius*: This option simply expands the radius of the overall array. The effect is the same as if you just activate the grip and move the mouse. Stretch Radius in action is seen in Fig. 8.8.
- *Row Count*: This option adds another set of row(s) of items in front or behind the main row, as seen in Fig. 8.9.
- *Level Count*: This option adds 3D levels and its discussion is not be included in this 2D-only chapter.
- *Item Count*: This option adds or deletes items (similar to the Ribbon function), or it can just be used to tell you how many items there are in the array, also a useful feature.
- *Fill Angle*: This option (also via the triangle grip) changes the included angle, currently set to 360°. An example is shown in Fig. 8.10, where the fill angle has been rolled back to 270°.

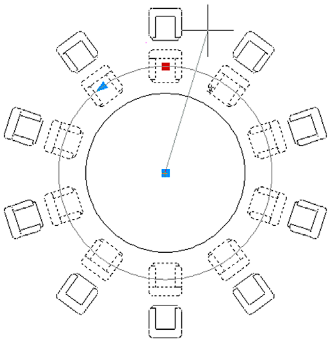


FIGURE 8.8 Stretch Radius in progress.

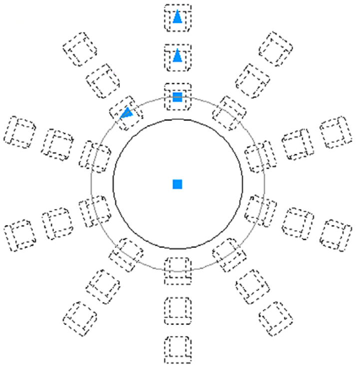


FIGURE 8.9 Row Count in progress.

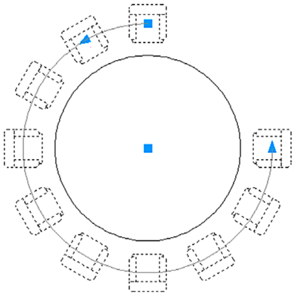


FIGURE 8.10 Fill Angle in progress.

Go over all these features until you are comfortable working with them. Be aware that you also can explode the array, which makes it behave like the "legacy" array, where each piece is separate. A short discussion of the legacy tools follows.

Legacy Polar Array (Pre-AutoCAD 2012)

Because the array command was so heavily redesigned for the 2012 release of AutoCAD, it makes sense to briefly mention the legacy polar array tool encountered via a dialog box prior to that release. If you have AutoCAD 2011 or any of the older versions still in common use, then the polar array can be accessed by typing in `array` and pressing Enter, or using the usual toolbar, cascading menus, or Ribbon (if available) methods. For the latest version of AutoCAD, you can still access this dialog box by typing in `arrayclassic`.

What you then see is the classic Array dialog box (Fig. 8.11, taken from AutoCAD 2011). You first need to make sure you have selected the Polar Array radio button at the very top. Then, run through the same steps outlined in the beginning of this chapter and shown here again:

- Select the object to array (button at top right).
- Select the center point of the array (button center top right).

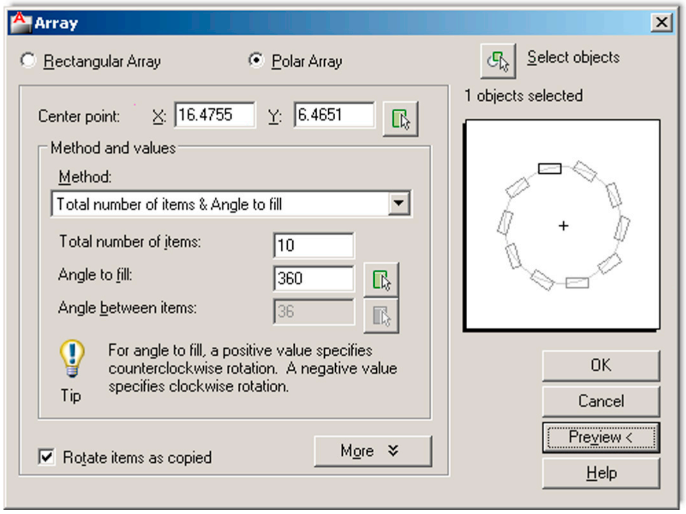


FIGURE 8.11 Legacy Polar Array dialog box (AutoCAD 2011).

- Enter how many objects to create (in the middle).
- Enter how many degrees to fill (just below the previous entry).

Preview the array via the Preview < button and press OK to finish off the array. Note that the entire array is not a block, just a collection of objects; and to redo the whole thing, you need to erase all the copies, leaving just the table and the original chair, then repeat everything. That is why the Preview button is so important. Do not be so quick to press OK. This array, of course, has none of the editing options introduced in AutoCAD 2012 and continued with AutoCAD 2017.

8.2 RECTANGULAR ARRAY

The idea behind a rectangular array is not fundamentally different from a polar one. We are looking to replicate objects, but this time in rows (horizontal) and columns (vertical). In 3D, you can also do levels, which we do not address here. An example, as shown in Fig. 8.12, may be columns of a warehouse. If they are spread out evenly, then this is the perfect tool to create them. You simply draw one I-beam column, make a block out of it, and array it up and across the appropriate area.

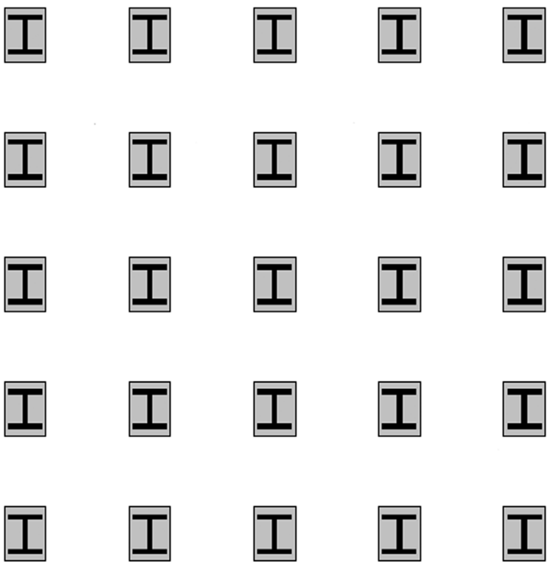


FIGURE 8.12 Rectangular array example.

Steps in Creating a Rectangular Array

The first thing to do is to draw a convincing-looking I-beam. Because we need actual distances, you cannot just randomly draw any object; use known sizing this time around. With one of the columns in Fig. 8.12 as a model, create a 20" wide by 26" tall rectangle. Inside of it, put an I-beam drawn with basic linework and a solid hatch fill, and shade the background a light gray (Fig. 8.13). Finally, make a block out of it. That sets up the column for an array.

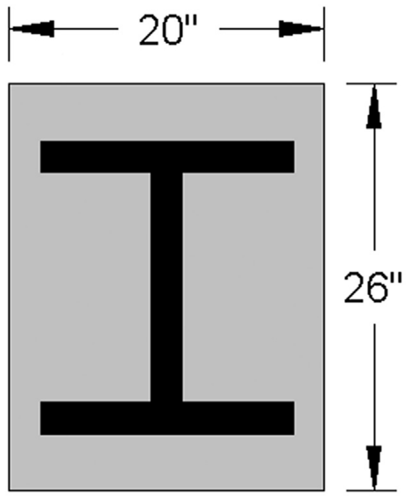


FIGURE 8.13 I-beam for column.

Now, what does AutoCAD need to know to create a rectangular array? The following three items are critical to a rectangular array; although, note that only the first item is explicitly asked for by AutoCAD as you create the array:

- It needs to know *what object(s)* to array (the I-beam column).
- It needs to know *how many rows* and *columns* to create (rows = across, columns = up and down).
- It needs to know the *distance between the rows and the columns* (from centerline to centerline).

Keyboard: Type in **arrayrec** and press Enter
Cascading menus: Modify→Array→Rectangular Array
Toolbar icon: Array_Toolbar
Ribbon: Home tab→Modify→Rectangular Array

Step 1. Start up the array command via any of the preceding methods (it is recommended to have the Ribbon turned on).
- AutoCAD says: `Select objects:`

Step 2. Select the I-beam column block.
- AutoCAD says: `1 found`

Step 3. Press Enter. A small array of items are created, with grips visible.
- AutoCAD says: `Type = Rectangular Associative = Yes Select grip to edit array or [ASsociative/Base point/COUnt/Spacing/COLumns/Rows/Levels/eXit]<eXit>:`

Step 4. You have now successfully created the basic rectangular array. You still need to define the exact number of rows and columns, however, as well as the distance between them, as this current array is rather arbitrary. You can do this either via command line, dynamically (using grips), or via the Ribbon. Fig. 8.14 shows how you can pull the items diagonally in a dynamic fashion using the center grip. You can also do this via the outer arrow grips. This dynamic method is not really appropriate for setting distances between the columns, which are random values for now, but it does make creating the pattern very easy.

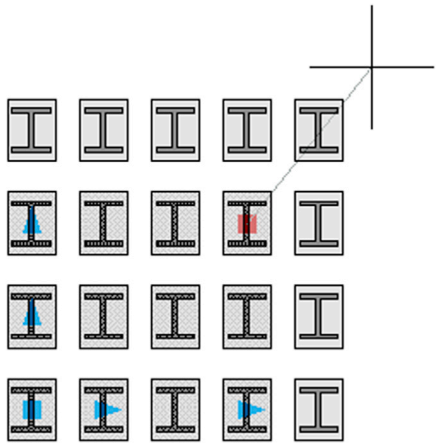


FIGURE 8.14 Creating a rectangular array dynamically.

Step 5. If you have the Ribbon up, then you just enter values. We want to create a 5 × 5 array, so start by entering those values into the Ribbon's Columns: and Rows: fields. For distances between the columns, use the value `72`.

Step 6. If using the command line, you just have to follow the prompts for Columns, Rows, and Spacing. Regardless of which you start with (Rows or Columns), AutoCAD asks you for the spacing as needed. Press Enter when done. Your rectangular array should look like Fig. 8.12.

Additional Operations With Rectangular Array

After a lengthy discussion on additional operations with the polar array, you will find these options with the rectangular array to be quite familiar. Click on the new array of I-beam column, and notice a set of grips, a menu, and an Array tab in the Ribbon, all similar to the earlier polar array (Fig. 8.15).

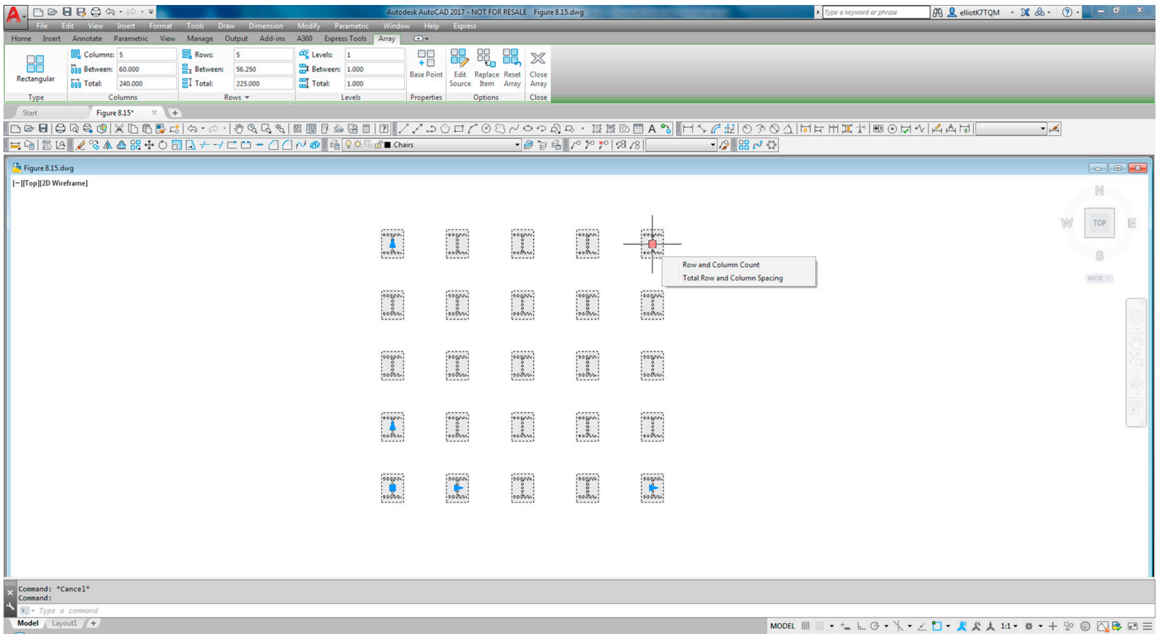


FIGURE 8.15 Rectangular array editing.

The Rectangular Array Ribbon also has three areas of interest: the Columns, Rows, and Option/Closes categories, as seen in Fig. 8.16. The Columns category allows you to adjust the number of columns, the distance between them, and the total distance. The Rows category is the exact same thing but for rows. Finally, in the Options category, we already discussed the functionality of Edit Source, Replace Item, and Reset Array. They are all exactly the same as with the polar array.

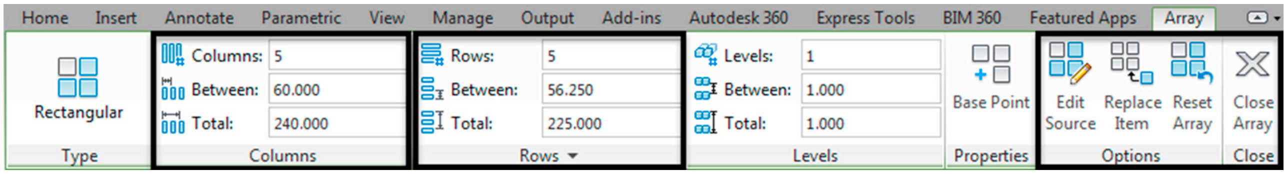


FIGURE 8.16 Rectangular array tab: Columns, Rows, and Options/Close.

Next, we have the menu seen when the mouse is held over the top right I-beam column grip. The two choices are Row and Column Count and Total Row and Column Spacing. Their functions should be relatively easy to see by just trying them out. If you activate the first choice and move the mouse, the number of rows and columns increases, but the spacing remains the same. If you activate the second choice, the spacing increases but not the number of rows and columns.

Finally, try out the other grips on the array, specifically the ones in the lower left corner. You find that the square grip moves the entire array and the inner triangles increase the spacing. The outer triangle grips (toward the edges of the array), however, are used to increase the count. Experiment with all the options.

Legacy Rectangular Array (Pre-AutoCAD 2012)

The legacy rectangular array is accessed via the same methods as the legacy polar array. Do not forget that, for the latest version of AutoCAD, you can still access this dialog box by typing in `arrayclassic`. When the dialog box appears, make sure the Rectangular array radio button is selected and you see what is shown in Fig. 8.17 (also taken from AutoCAD 2011). The procedure remains basically the same. You must select the object, then enter the number of rows and columns, followed by the distances between those rows and columns. Do a preview and press OK.

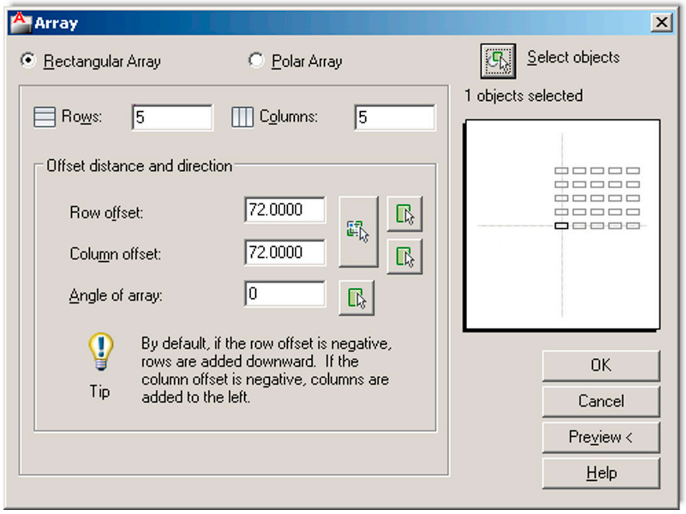


FIGURE 8.17 Legacy Rectangular Array dialog box (AutoCAD 2011).

Note again that the entire array is not a block, just a collection of objects; and to redo the whole thing, you need to erase all the copies, leaving just one I-beam column and repeat everything. This array, of course, has none of the editing options introduced in AutoCAD 2012 either.

In general, polar arrays are used more often than the rectangular ones, but both are important to know.

8.3 PATH ARRAY

The path array is the (relatively) new kid on the block. Requested by users, this feature was finally added in AutoCAD 2012 along with the general redesign of the array command. The idea is simple, and it is surprising that this feature was not added earlier. A path array creates a pattern along any *predetermined pathway*, of any shape, as opposed to a strictly circular or linear one. This path can be an arc, a pline, or a spline. Because plines and splines have not yet been discussed (a Chapter 11, Advanced Linework topic), we focus on arcs as the pathways. A path array can also be created in 3D, but we do not get into that right now. An example of a path array in progress is shown in Fig. 8.18.

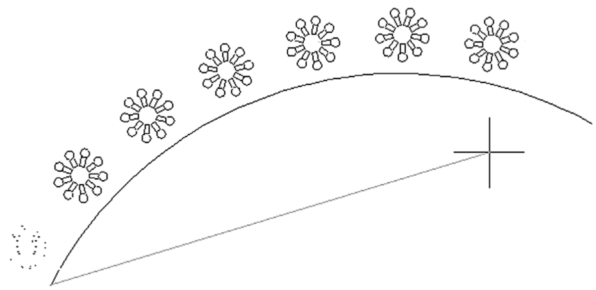


FIGURE 8.18 Path Array in progress.

Steps in Creating a Path Array

Boiled down to its essence, the path array just needs an *object to array* and a *path to follow*. Much like the previous two arrays, the objects can be spread out dynamically with mouse movements (as seen being done in Fig. 8.19) or with an input of a specific value. All other options flow from this basic approach. Let us give it a try. Create an arc and some random object to array; a rectangle will do, as seen in Fig. 8.19.

FIGURE 8.19 Setup for a Path Array.

So, what does AutoCAD need to know to do the array?

- It needs to know *what object(s)*to array (the rectangle).
- It needs to know *the path* (the arc).
- It needs to know *how many objects* to create (let us stick to ten or so).

Keyboard: Type in **arraypath** and press Enter
Cascading menus: Modify→Array→Path Array
Toolbar icon: Array_Toolbar 
Ribbon: Home tab→Modify→Path Array 

Step 1. Start up the array command via any of the preceding methods.
- AutoCAD says: `Select objects:`

Step 2. Select the rectangle.
- AutoCAD says: `1 found`

Step 3. Press Enter.
- AutoCAD says: `Type = Path Associative = Yes Select path curve:`

Step 4. You successfully selected the *object to array*. Now, select the *path* by clicking on the arc. A number of copies of the rectangle appear along the arc.
- AutoCAD says: `Select grip to edit array or [ASsociative/Method/Base point/Tangent direction/Items/Rows/Levels/Align items/Z direction/eXit]<eXit>:`

Step 5. You have essentially created the basic path array, but you can do a tremendous amount of modification to this basic layout. The easiest way to modify it is via the Ribbon. Under the Items: tab you have the most basic of the "mods," such as total number of items and the distance between them. Also note how you can alter the path array via dynamic movement of the grips. Be sure to keep the array associative, as with the previous examples. The completed array is seen in Fig. 8.20.

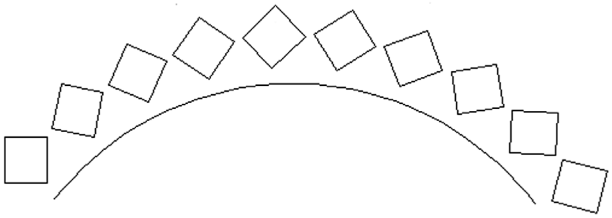


FIGURE 8.20 Path Array completed.

Additional Operations With Path Array

Just as with the previous two arrays, the path array has its own Ribbon tab, which is revealed by selecting one of the elements in the array, as well as its own menu, revealed as you hover the mouse over the grip, as seen in Fig. 8.21.

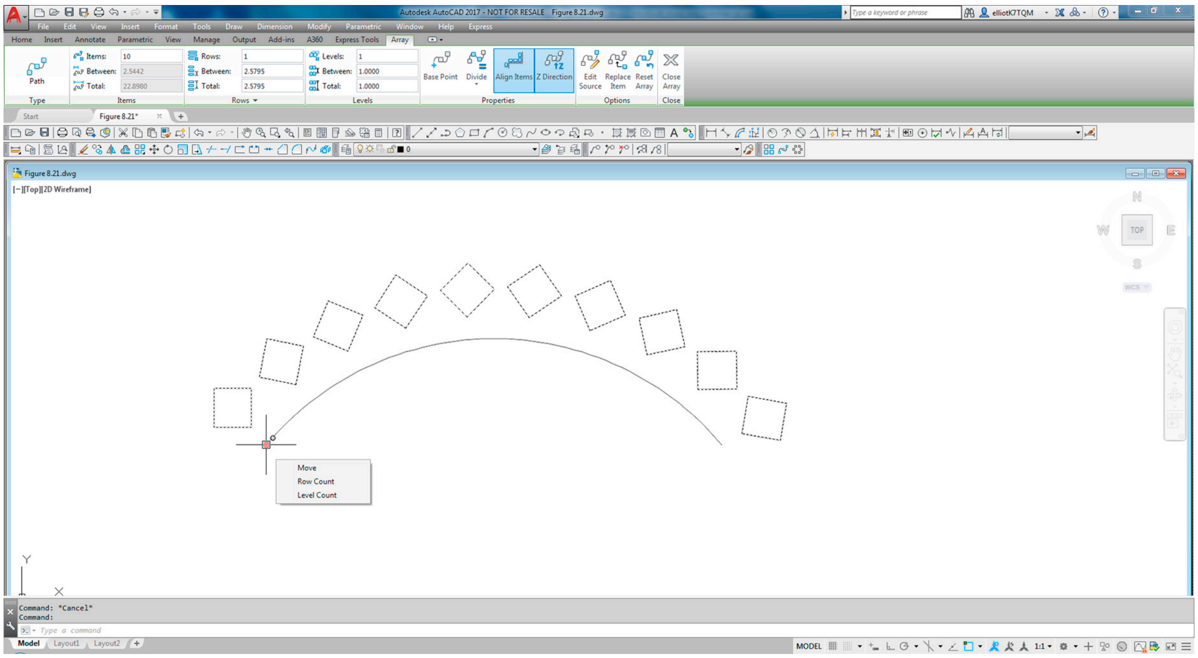


FIGURE 8.21 Path Array editing.

The Items category is of some interest and at this point should be familiar. You can vary the number of elements, distances between them, and total distance. Under the Properties category, experiment with redefining the base point—this shifts your pattern around. Also check out Align Items—this makes all your elements face the same direction versus angling with the curve. Edit Source, Replace Item, and Reset Array all have the same meanings as with the previous polar and rectangular arrays. Spend a few moments understanding the cause and effect of these options.

Finally, let us take a look at the grip menu. It also should be more familiar after your experiences with the previous two arrays. Move moves the array away from its originating path and triggers a warning along the way (Fig. 8.22). You may have seen the warning with earlier arrays as well, if you tried to move them around. Simply press Continue and carry on.

Row Count creates additional rows of the pattern, as seen in Fig. 8.23. This option also repeats what is available with the other arrays. Level Count is not covered here, as it is a 3D function.

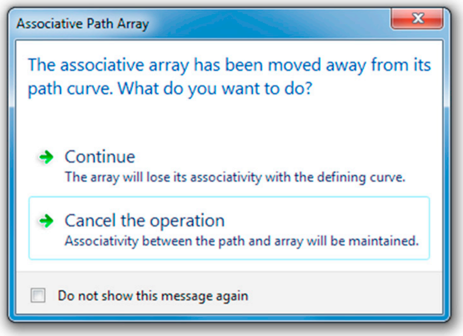


FIGURE 8.22 Associative Path Array warning.

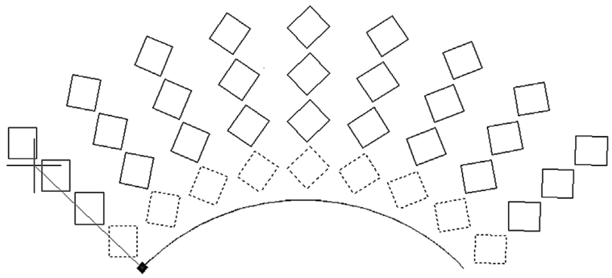


FIGURE 8.23 Row Count in progress.

8.4 IN-CLASS DRAWING PROJECT: MECHANICAL DEVICE

Let us now put what you learned to use by drawing a mechanical gadget (a suspension strut of sorts), created years ago for a class. Although what it is exactly is still debatable, the gadget proved to be an excellent drawing example and features quite a bit of what we covered in this and preceding chapters as well as a few minor nuances of AutoCAD drafting that, once learned, raise your skill levels considerably. The trick is to make your drawing look exactly like the example. If you approximate and cut corners, you miss out on some of the important concepts that give a more professional look to your drawings.

A full-page view of the completed device is found toward the end of the chapter, see Fig. 8.33. Take a good look at it and decide on a strategy to draw it. Over the course of the next few pages, you will see a step-by-step process to actually do it. Follow the steps carefully, and do not worry about the thick border; i.e., a polyline, to be covered in Level 2. The title block is otherwise just a simple collection of lines and text.

Step 1. For starters open a new file, give it a name (Save As…), and set up your layers. We need, at a minimum,
M-Part, Color: Green (for most of the parts of the device).
M-Text, Color: Cyan.
M-Dims, Color: Cyan (for the dimensions).
M-Hidden, Color: Yellow, Linetype: Hidden (for all hidden lines).
M-Center, Color: Red, Linetype: Center (for the main centerlines).
M-Hatch, Color: 9 (a gray for cross-section cutaways).
You may also want additional layers for the spring and the title block. You can decide on the exact layers and their colors; the preceding is just a guide. Also, the images in this chapter remain black and white, for clarity on a white page.

Step 2. Set up all the necessary items for smooth drafting, such as the Text Style (Arial, .20), the Dim Style, and Units (either Architectural or Mechanical is fine), and get rid of the UCS icon if you do not like it.

Step 3. To begin the drawing itself, we need to start with the hex bolts. Go ahead and draw one of them according to the information in Fig. 8.24. Be very careful, all sizes are diameters not radiuses; you must tell AutoCAD this by pressing `d` for `Diameter` while making a circle. This has tripped up many students in the past. Also do not forget to make layer M-Part current. If the bolt is anything but green in color, you missed this step. The dimensions are only for your reference for now; there is no need to draw them.

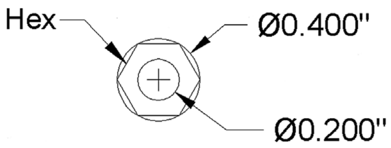


FIGURE 8.24 Bolt layout.

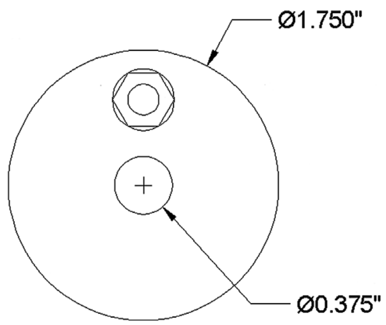


FIGURE 8.25 Bolt array.

Step 4. Now make a block out of the bolt, calling it `Bolt - Top View`.

Step 5. Complete the rest of the top view by drawing the remaining circles and positioning the bolt at the top, as shown in Fig. 8.25. Use accuracy (OSNAPs), although the bolt can be any distance from the top of the circle. Be careful to use diameter, as indicated.

Step 6. Array the bolt around the top view four times, as shown in Fig. 8.26.

Step 7. You now have to project the main body of the part based on this top view. The best way is by drawing two horizontal guidelines, of any length, starting from the top and bottom quadrants of the big circle; then, draw an arbitrary vertical line to mark the beginning of the part on the right, as shown in Fig. 8.27.

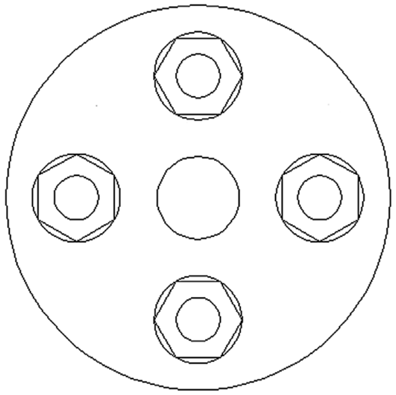


FIGURE 8.26 Bolt array completed.

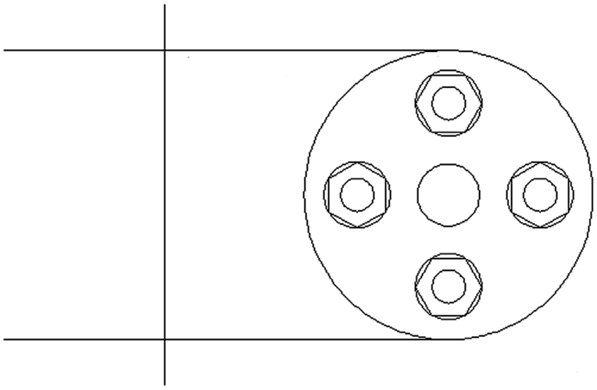


FIGURE 8.27 Projection lines.

Step 8. Trim or fillet the main vertical guideline and continue offsetting, based on the given geometry, to "sketch out" the basic outline of the shape, as seen in Fig. 8.28. Do not yet add dimensions; they are for construction only.

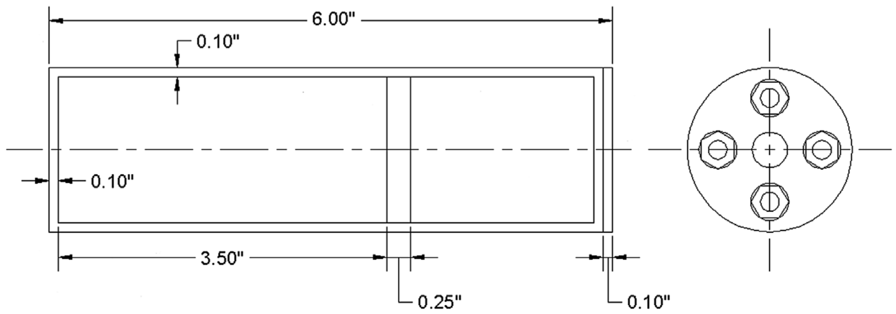


FIGURE 8.28 Body of part.

Step 9. Continue adding the basic geometry to the side view, as well as hidden and centerlines, as shown in Fig. 8.29. Set LTSCALE to .4.

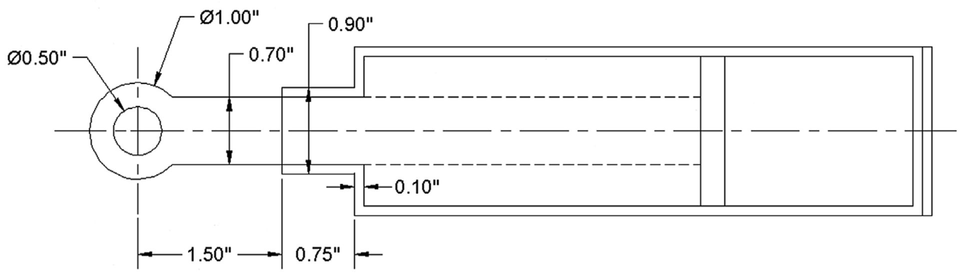


FIGURE 8.29 Creating side view.

Step 10. Add the bolt projections, as seen in Fig. 8.30 (the depth into the side view can be approximated). Finally, add hatch patterns, using the Angle option to reverse the hatch directions, which is a common technique in mechanical design to differentiate the parts from each other in a cross section.

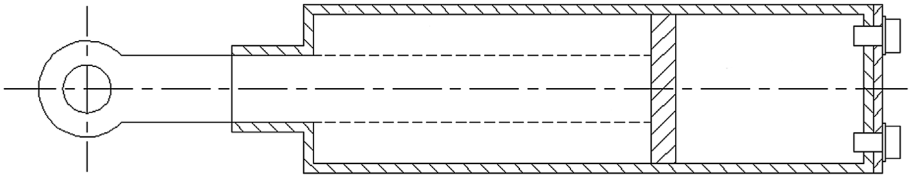


FIGURE 8.30 Hatching side view.

Step 11. Now, how do you do the spring? Well, this is where the Circle/TTR comes in. Although we have not practiced this version of the circle command, it is very simple to do. Start it up and select the TTR option. Then, pick the vertical and the horizontal lines where the circle needs to go (seen in Fig. 8.31) and specify a radius (`0.10"`). One way of proceeding is to draw a straight arbitrary line down from the center of that circle, rotate the line 15° about that center point, then offset 0.1" in each direction, erase the original line, extend the two new ones to the bottom (if necessary), and repeat the process, as seen in Fig. 8.31. Once a set is done, you can mirror the rest and trim carefully to create the impression of a coiled spring.

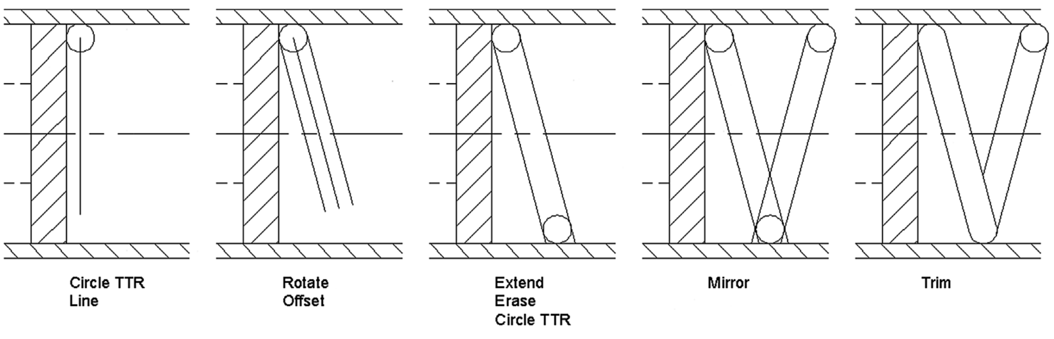


FIGURE 8.31 Drawing the spring.

Step 12. Finally, add dimensions (Fig. 8.32) and a title block (Fig. 8.33) by use of rectangles. The title block and its contents are typical of a mechanical engineering drawing.

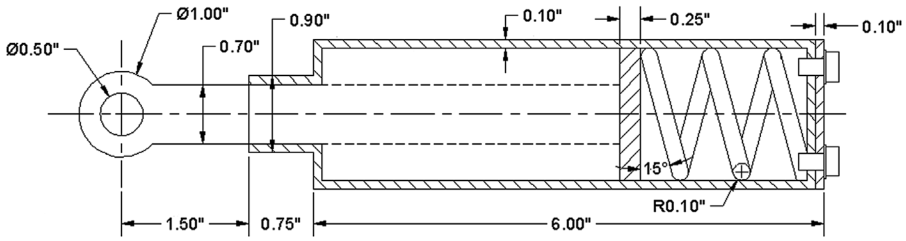


FIGURE 8.32 Completed side view.

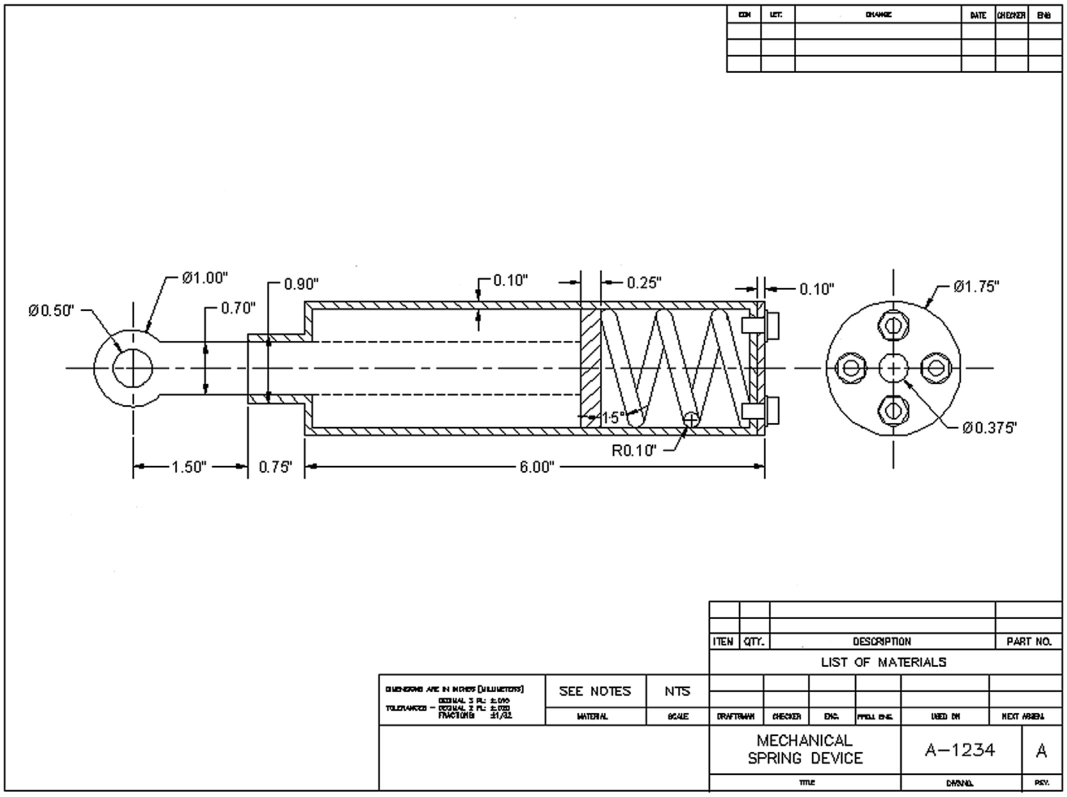


FIGURE 8.33 Mechanical project—final.

8.5 SUMMARY

You should understand and know how to use the following concepts and commands before moving on to Chapter 9, Basic Printing and Output:

- Polar array
  - Select object
  - Select center point of array
  - Number of objects to create
  - Angle to fill
  - Additional operations and options
- Rectangular array
  - Select object
  - Number of rows and columns
  - Distance between rows and columns
  - Additional operations and options

- Path array
  - Select object
  - Select path
  - Additional operations and options

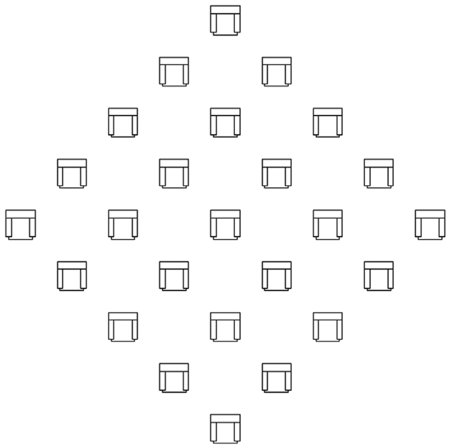
Review Questions

Answer the following based on what you learned in this chapter:

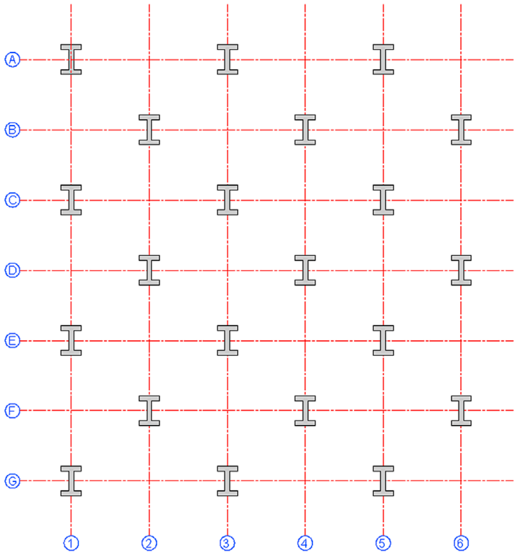
1. List the three types of arrays available to you.
2. What steps are needed to create a polar array?
3. To array chairs around a table, where is the center point of the array?
4. What steps are needed to create a rectangular array?
5. What steps are needed to create a path array?

Exercises

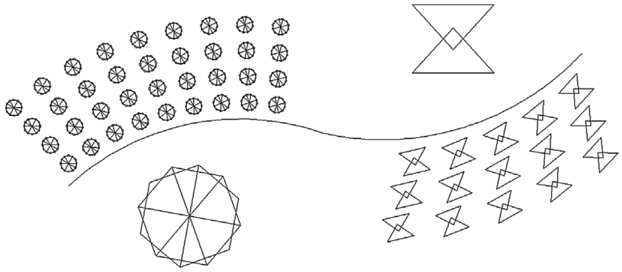
1. In a new file, draw the following five row by five column rectangular array. The chairs are 20" by 20" and the offset between them is 50". The array is also at a 45° angle. (Difficulty level: Easy; Time to completion: <10 minutes.)



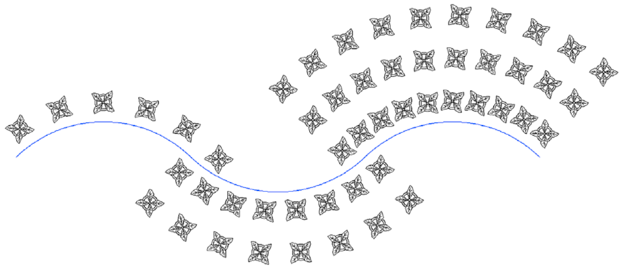
2. In a new file, draw the following seven rows by six column rectangular array, including the centerline grid and the grid lettering and numbering. The I-beams and the offset between them can be of any appropriate size, but approximate everything to look like the image shown. (Difficulty level: Easy; Time to completion: 10–15 minutes.)



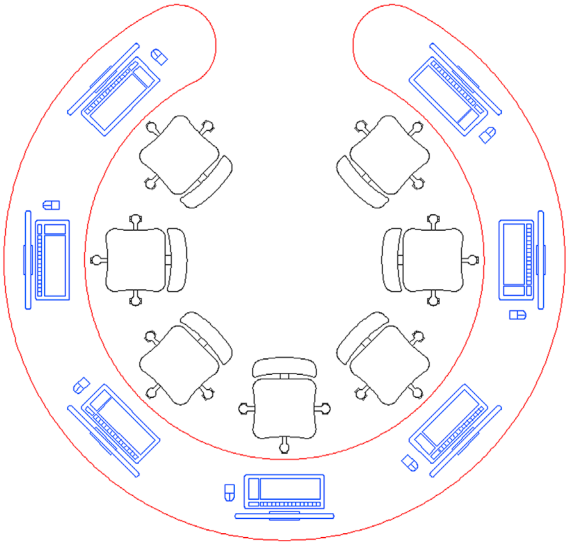
3. In a new file, draw the following set of path arrays with multiple rows. The two paths are simple arcs, and the symbols used are scaled up and shown next to the patterns. (Difficulty level: Easy; Time to completion: <15 minutes.)



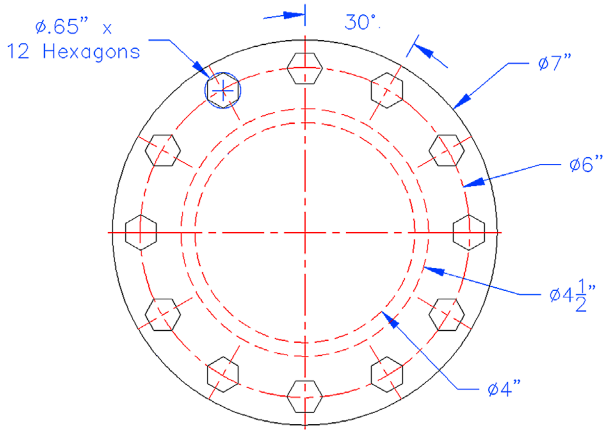
4. In a new file, draw the following set of path arrays with multiple rows. The three paths are simple arcs, and the symbols used are basic top view sketches of a flower pot. (Difficulty level: Easy; Time to completion: <15 minutes.)



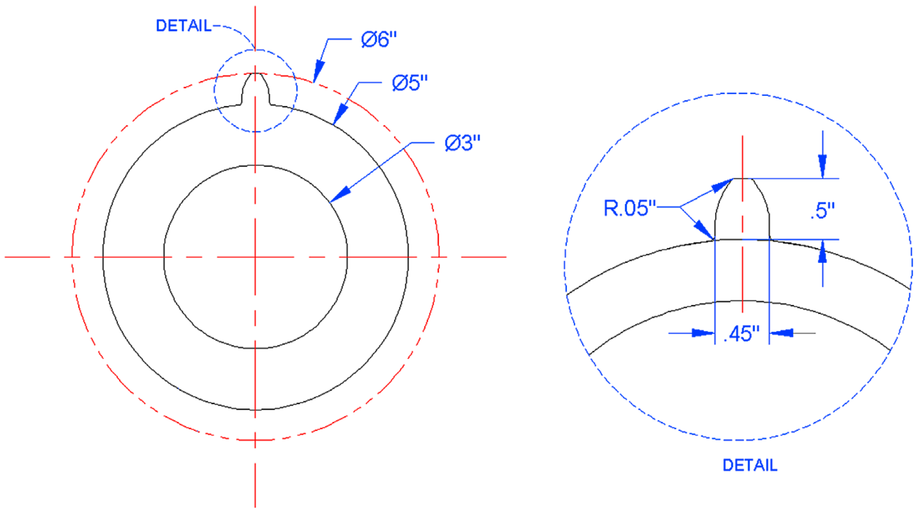
5. In a new file, draw the following *polar* array, made up of a table, chairs, and computers. No sizing is given and all elements can be approximated. Place each element on the appropriate layer, and make a block out of it prior to using it in the array. (Difficulty level: Moderate; Time to completion: <20 minutes.)

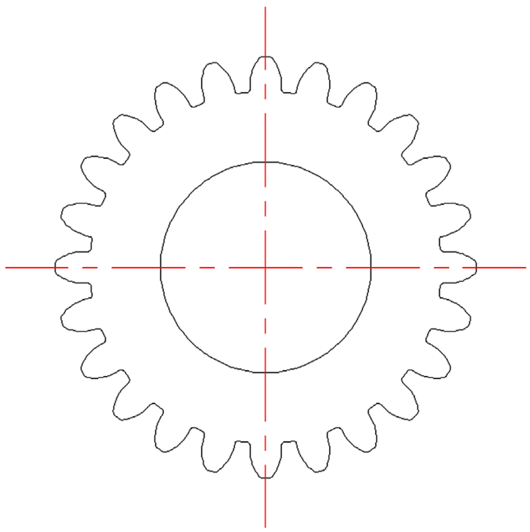


6. In a new file, draw this slightly altered version of the image found at the opening of this chapter, shown here with all the necessary dimensions. For practice, add the dimensioning as well. (Difficulty level: Easy; Time to completion: 15–20 minutes.)

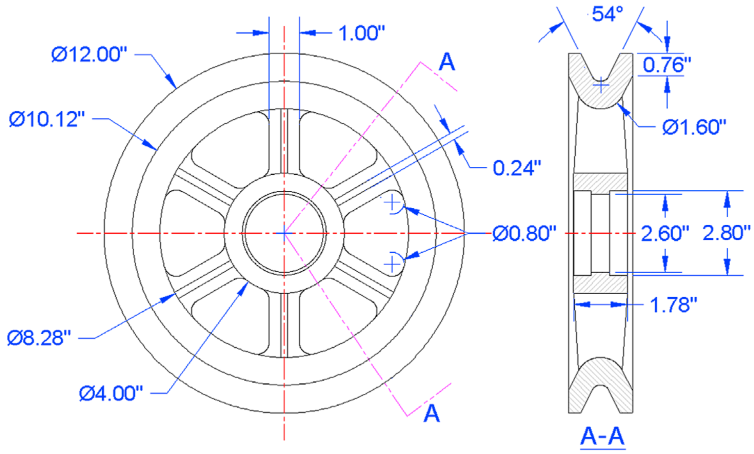


7. In a new file, draw the following gear array. Begin with circles of the indicated diameter. Then, focus on creating the first tooth, as seen in the detail. Make sure it is centered and aligned. Finally, array the tooth (24 teeth are used in the example) and clean up the design with trimming. The final result follows. (Difficulty level: Moderate; Time to completion: <20 minutes.)

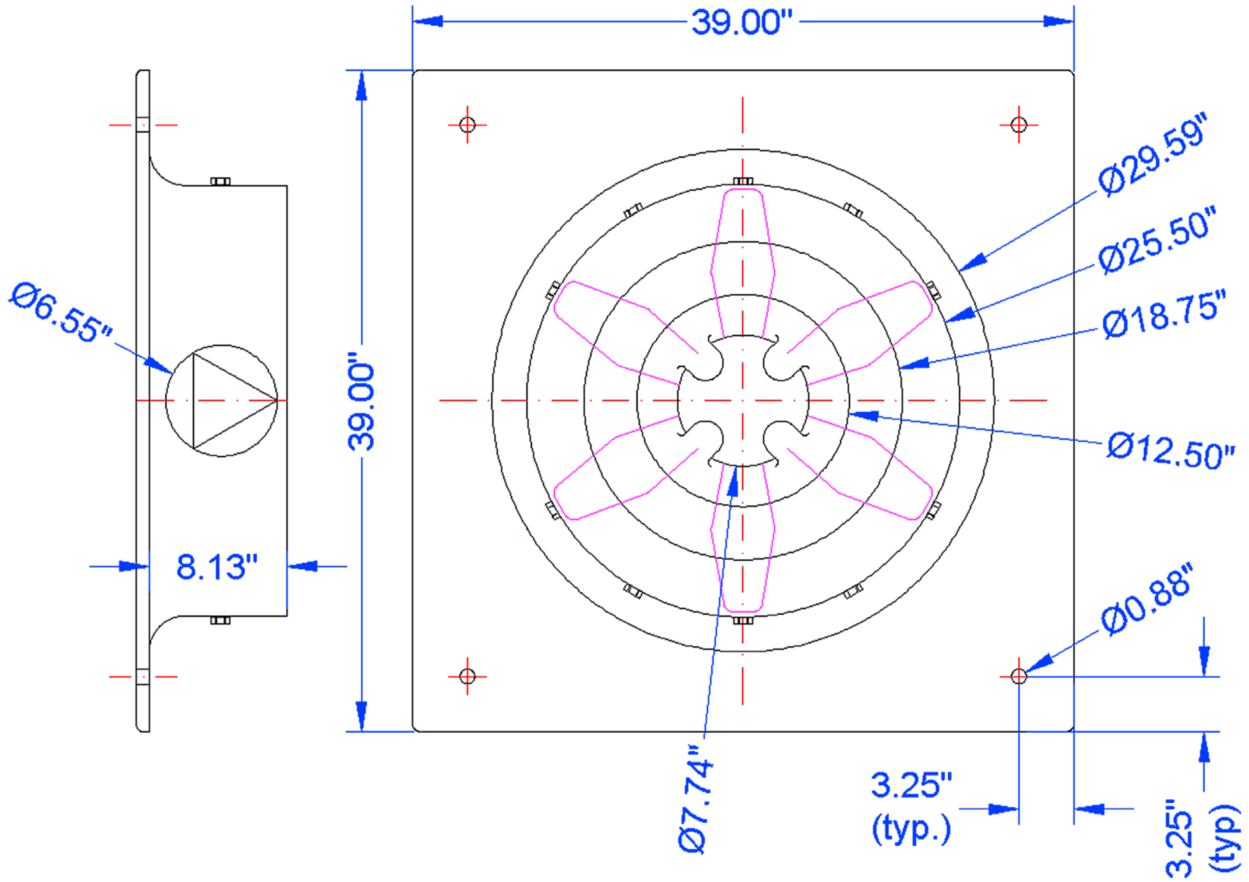




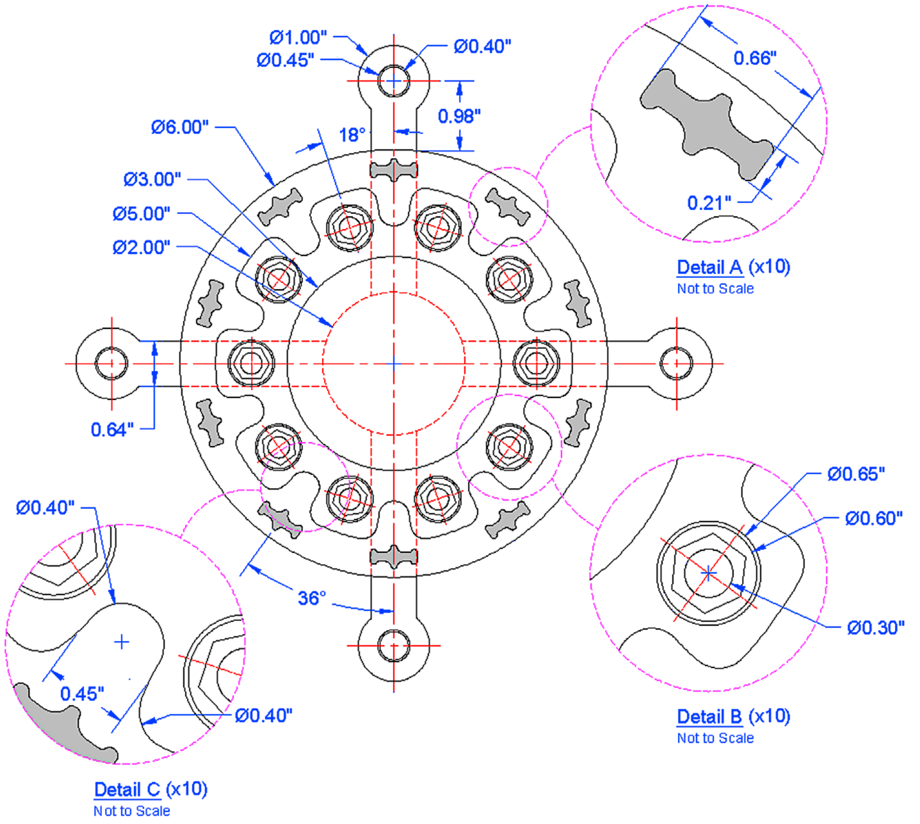
8. In a new file, draw the following pulley and its section view using polar array. All necessary diameters and widths are given. Load the center and phantom linetypes and set units and dims to Decimal (accuracy 0.00, with a " suffix). (Difficulty level: Moderate; Time to completion: 30–45 minutes.)



9. In a new file, draw the following fan and its side view using polar array. All necessary diameters and widths are given. Load the center linetype and set units and dims to Decimal (accuracy 0.00, with a " suffix). (Difficulty level: Moderate; Time to completion: 30–45 minutes.)



10. In a new file, draw the following mechanical device utilizing several polar arrays. All necessary diameters are given. Load the Center2 and Hidden2 linetype and set units and dims to Decimal (accuracy 0.00, with a " suffix). The details are nothing more than scaled up copies of the circled areas; be sure to draft them as well. (Difficulty level: Moderate/Advanced; Time to completion: 60–90 minutes.)



Spotlight On: Electrical Engineering

Electrical engineering is the branch of engineering that deals with electricity and its applications. This can be on a large scale, such as power generation and transmission or small scale, such as the design of chips and consumer electronics, sometimes referred to as *electronics engineering*. The profession appeared in the mid-1800s, as major advancements in the understanding of electrical phenomena were put forward by Ohm, Tesla, Faraday, Maxwell, and others. Today, electrical engineering is a wide-ranging profession vital to our society. Few human-made devices are without any electrical components, and electrical engineering figures prominently in virtually every product or device you see before you. Electrical engineers held about 318,700 jobs in 2009, making this the second largest branch of the U.S. engineering community (behind software engineering).

Just some of electrical engineering's specialties include power, controls, electronics, microelectronics, signal processing, telecommunication, and computer engineering. Electrical engineers need a mastery of a wide variety of engineering sciences, such as basic and advanced circuit theory, electromagnetics, embedded systems, signal processing, controls, solid state physics, and computer science and programming, among others.

Education for electrical engineers starts out similar to that for the other engineering disciplines. In the United States, all engineers typically have to attend a 4-year ABET-accredited school for their entry level degree, a Bachelor of Science. While there, all students go through a somewhat similar program in their first 2 years, regardless of future specialization. Classes taken include extensive math, physics, and some chemistry courses, followed by statics, dynamics, mechanics, thermodynamics, fluid dynamics, and material science. In their final 2 years, engineers specialize by taking courses relevant to their chosen field. For electrical engineering, this includes courses in most or all of the sciences just listed.

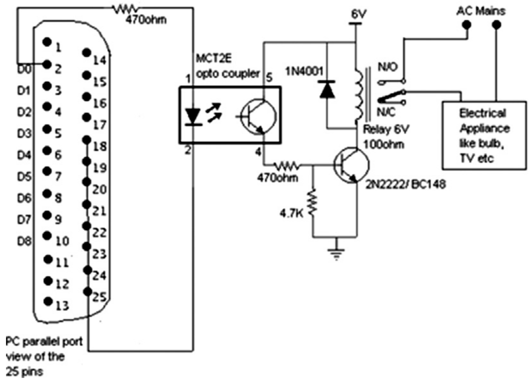


FIGURE 1 Electrical schematic.

Upon graduation, electrical engineers can immediately enter the workforce or go on to graduate school. Though not required, some engineers choose to pursue a Professional Engineer (P.E.) license. The process first involves passing a Fundamentals of Engineering (F.E.) exam, followed by several years of work experience under a registered P.E., and finally sitting for the P.E. exam itself.

In 2009, electrical engineers received starting salaries averaging $61,420 with a bachelor's degree and $72,340 with a master's degree. The median pay in 2014 was $95,780. This, of course, depends highly on market demand and location. A master's degree is highly desirable and required for many management spots. The job outlook for electrical engineers was projected as good, with a 6% growth rate per year through 2020. The profession is extremely diversified; and by selecting a specialization carefully, an engineer can join one of many growing fields, such as controls, nano-engineering, robotics, and other such career paths.

So how do electrical engineers use AutoCAD and what can you expect? Industry wide, AutoCAD enjoys a significant amount of use for the simple reason that most electrical work is 2D in nature and plays into AutoCAD's strength. AutoCAD layering is far simpler in electrical engineering than in architecture. There is no AIA standard to follow, only an internal company standard. As always, the layer names should be clear as to what they contain. The overall standard for much of electrical engineering work is provided by the IEEE, which may include CAD standards as well.

In electrical engineering, you will not likely need advanced concepts such as paper space and Xrefs, but often you need to build attributes that hold information on connectors and wires. You also need to have a library of standard electrical symbols handy, so very little needs to be drawn from scratch every time. The key in electrical engineering drafting is accuracy (lines straight and connected), as the actual CAD work is quite simple. A related field, network engineering, is similar. Here, you may use plines or splines that indicate cables going into routers and switches. Shown in Figs. 1 and 2 are examples of electrical schematics. Notice the extensive use of symbols for capacitors, diodes, transformers, and switches.

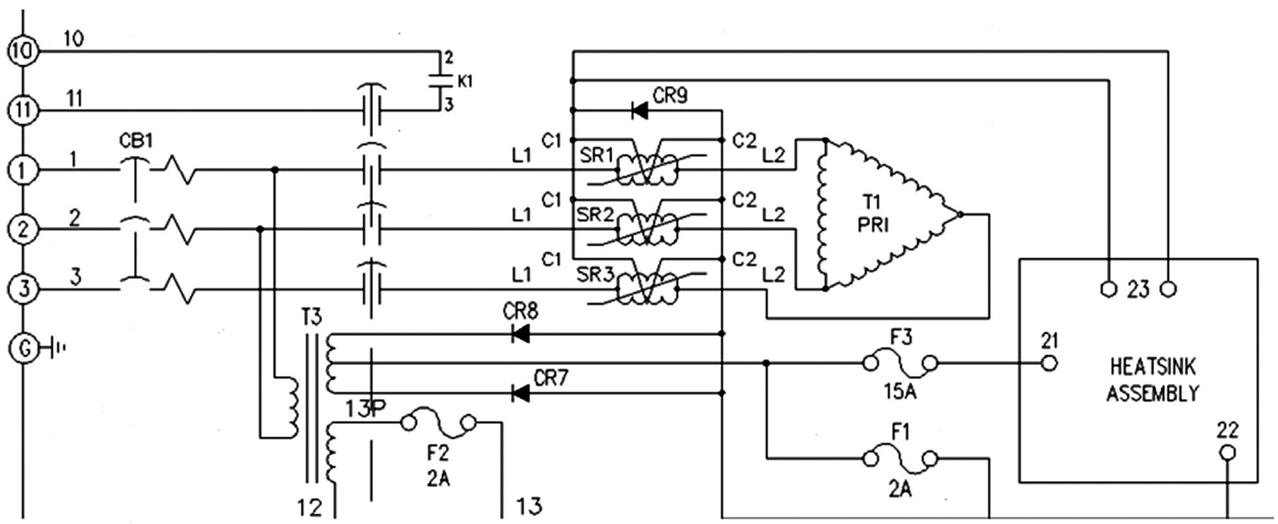


FIGURE 2 Electrical schematic.

Fig. 3 is an example of some racked equipment in a network/electrical engineering drawing. There is nothing complex in this image, just careful drafting and a lot of copying. You will see this example again when wipeout is discussed. Fig. 4 shows some power transmission equipment from a substation.

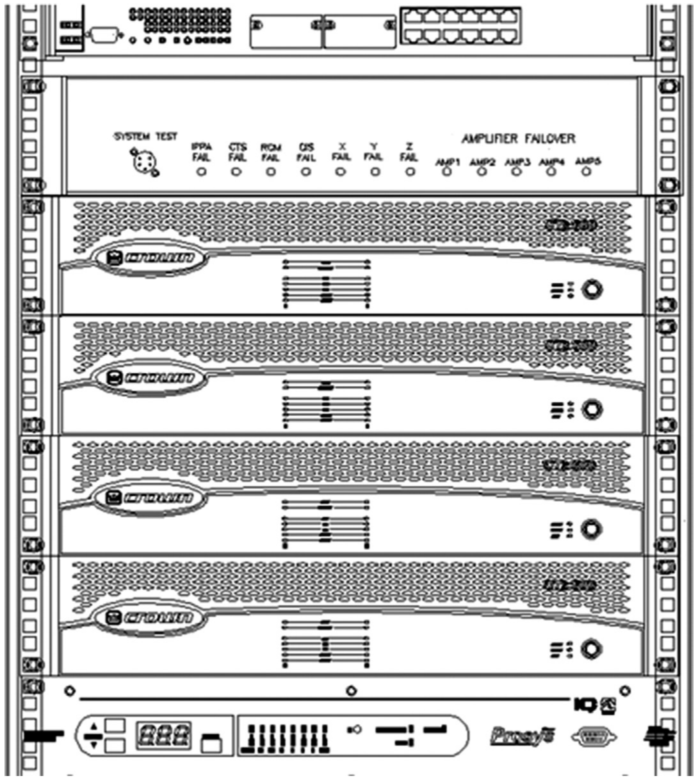


FIGURE 3 Racked equipment.

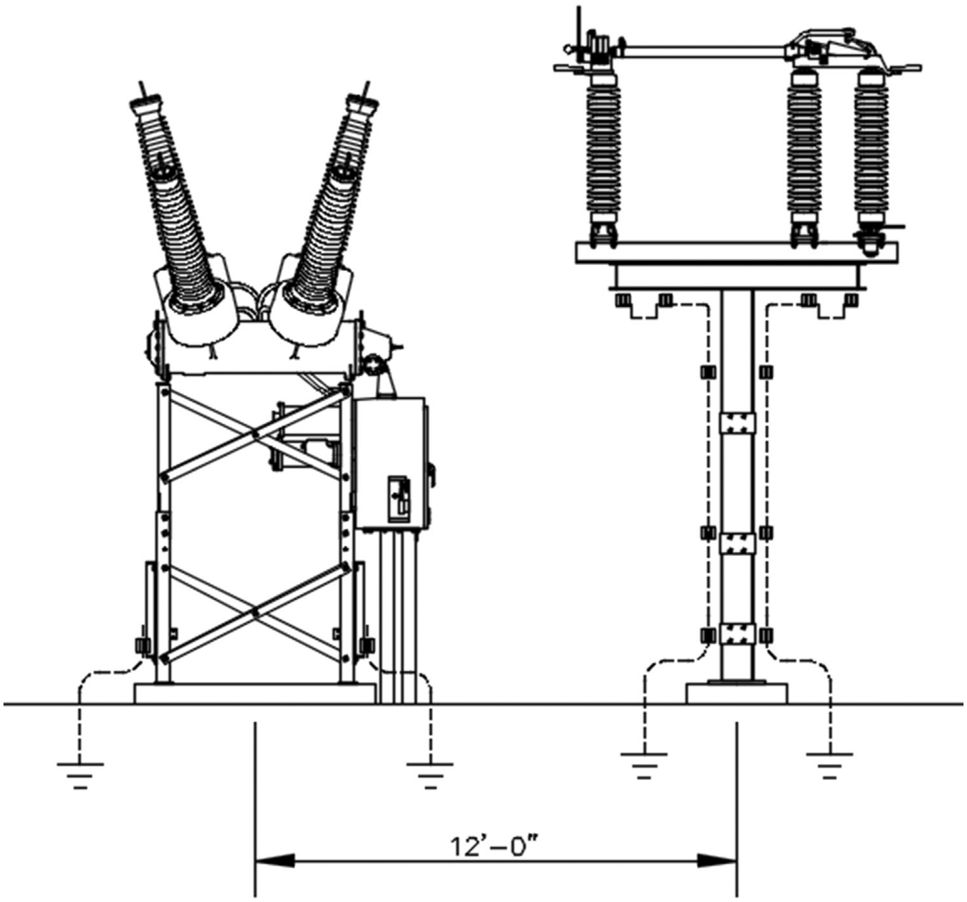


FIGURE 4 Substation power equipment.