Chapter 1

Jigs and Fixtures

Jigs and fixtures are devices used to facilitate production work, making interchangeable pieces of work possible at a savings in cost of production. Both terms are frequently used incorrectly in shops. A *jig* is a guiding device and a *fixture* a holding device.

Jigs and fixtures are used to locate and hold the work that is to be machined. These devices are provided with attachments for guiding, setting, and supporting the tools in such a manner that all the workpieces produced in a given jig or fixture will be exactly alike in every way.

The employment of unskilled labor is possible when jigs and fixtures can be used in production work. The repetitive layout and setup (which are time-consuming activities and require considerable skill) are eliminated. Also, the use of these devices can result in such a degree of accuracy that workpieces can be assembled with a minimum amount of fitting.

A jig or fixture can be designed for a particular job. The form to be used depends on the shape and requirement of the workpiece to be machined.

Jigs

The two types of jigs that are in general use are (1) clamp jig and (2) box jig. A few fundamental forms of jigs will be shown to illustrate the design and application of jigs. Various names are applied to jigs (such as drilling, reaming, and tapping) according to the operation to be performed.

Clamp Jig

This device derives its name from the fact that it usually resembles some form of clamp. It is adapted for use on workpieces on which the axes of all the holes that are to be drilled are parallel.

Clamp jigs are sometimes called *open jigs*. A simple example of a clamp jig is a design for drilling holes that are all the same size—for example, the stud holes in a cylinder head (Figure 1-1).

As shown in Figure 1-1, the jig consists of a ring with four lugs for clamping and is frequently called a *ring jig*. It is attached to the cylinder head and held by U-bolt clamps. When used as a

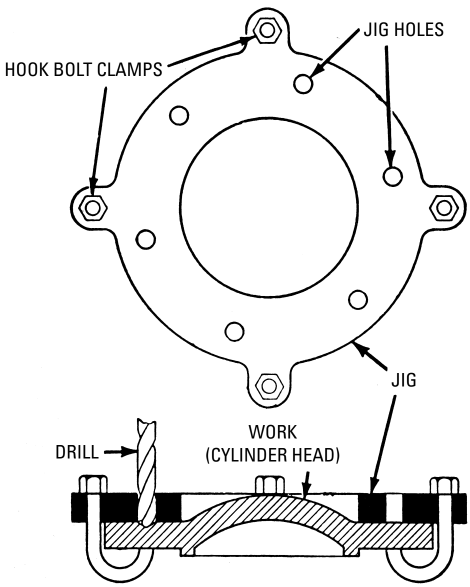

Figure 1-1 A plain ring-type clamp jig without bushings.

guide for the drill in the drilling operation, the jig makes certain that the holes are in the correct locations because the holes in the jig were located originally with precision. Therefore, laying out is not necessary.

A disadvantage of the simple clamp jig is that only holes of a single size can be drilled. Either *fixed* or *removable* bushings can be used to overcome this disadvantage. Fixed bushings are sometimes used because they are made of hardened steel, which reduces wear. Removable bushings are used when drills of different sizes are to be used, or when the drilled holes are to be finished by reaming or tapping.

A *bushed clamp jig* is illustrated in Figure 1-2. In drilling a hole for a stud, it is evident that the drill (tap drill) must be smaller in size than the diameter of the stud. Accordingly, two sizes of twist drills are required in drilling holes for studs. The smaller drill (or *tap drill*) and a drill slightly larger than the diameter of the stud are required for drilling the holes in the cylinder head. A bushing can be used to guide the tap drill.

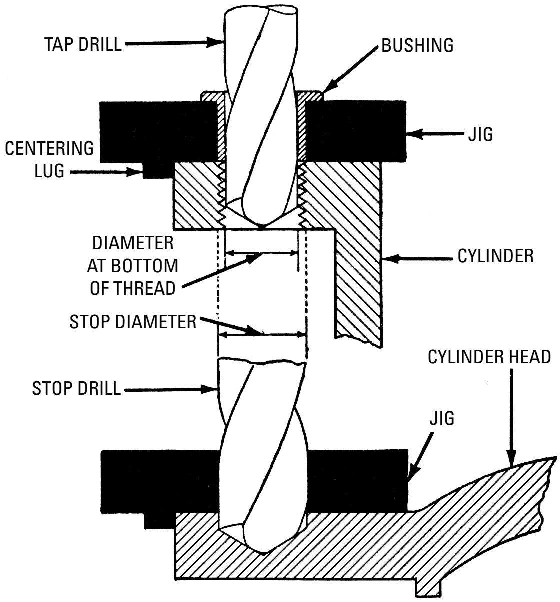

Figure 1-2 A clamp jig, with the tap drill guided by a bushing, designed for drilling holes in the cylinder (top); the operation for a hole for the cylinder head (bottom).

The jig is clamped to the work after it has been centered on the cylinder and head so that the axes of the holes register correctly. Various provisions (such as stops) are used to aid in centering the jig correctly. The jig shown in Figure 1-2 is constructed with four lugs as a part of the jig. As the jig is machined, the inner sides of the lugs are turned to a diameter that will permit the lugs to barely slip over the flange when the jig is applied to the work.

A *reversible clamp jig* is shown in Figure 1-3. The distinguishing feature of this type of jig is the method of centering the jig on the cylinder and head. The position of the jig for drilling the cylinder is shown at the top of Figure 1-3. An annular projection on the jig fits closely into the counterbore of the cylinder to locate the jig concentrically with the cylinder bore.

The jig is reversed for drilling the cylinder head. That is, the opposite side is placed so that the counterbore or circular recessed part of the jig fits over the annular projection of the cylinder head at the bottom of Figure 1-3.

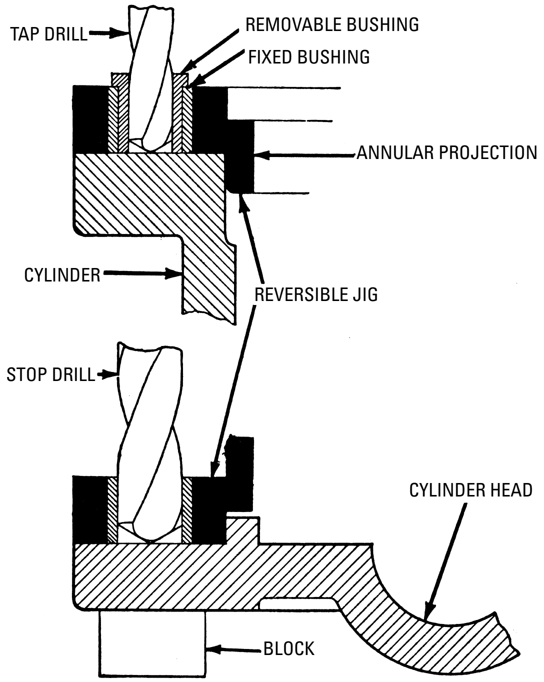

Figure 1-3 Note the use of a reversible clamp jig for the tap drill operation (top), and reversing the jig to drill the hole for the stud in the cylinder head (bottom).

This type of jig is often held in position by inserting an accurately fitted pin through the jig and into the first hole drilled. The pin prevents the jig from turning with respect to the cylinder as other holes are drilled.

A simple jig that has locating screws for positioning the work is shown in Figure 1-4. The locating screws are placed in such a way that the clamping points are opposite the bearing points on the work. Two setscrews are used on the long side of the work, but in this instance, because the work is relatively short and stiff, a single lug and setscrew (*B* in Figure 1-4) is sufficient.

This is frequently called a *plate jig* since it usually consists of only a plate that contains the drill bushings and a simple means of clamping the work in the jig, or the jig to the work. Where the jig is clamped to the work, it sometimes is called a *clamp-on jig*.

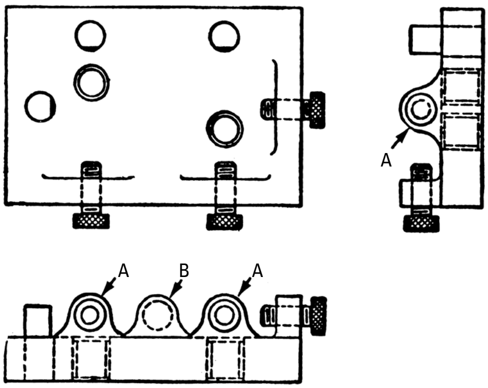

Figure 1-4 A simple jig that uses locating screws to position the work.

Diameter jigs provide a simple means of locating a drilled hole exactly on a diameter of a cylindrical or spherical piece (Figure 1-5).

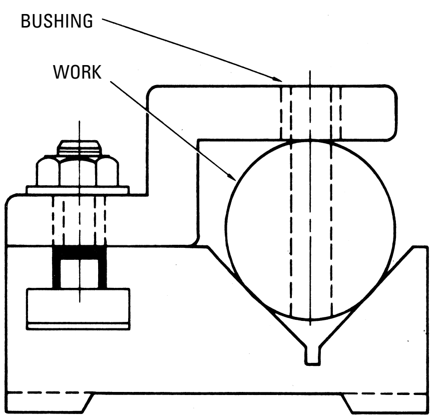

Figure 1-5 Diameter jig.

Another simple clamp jig is called a *channel jig* and derives its name from the cross-sectional shape of the main member, as shown in Figure 1-6. They can be used only with parts having fairly simple shapes.

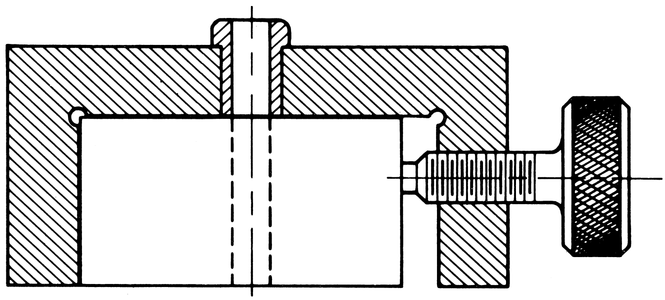

Figure 1-6 Channel jig.

Box Jig

Box jigs (sometimes called *closed jigs*) usually resemble a boxlike structure. They can be used where holes are to be drilled in the work at various angles. Figure 1-7 shows a design of box jig that is suitable for drilling the required holes in an engine link. The jig is built in the form of a partly open slot in which the link is moved up against a stop and then clamped with the clamp bolts *A*, *B*, and *C*.

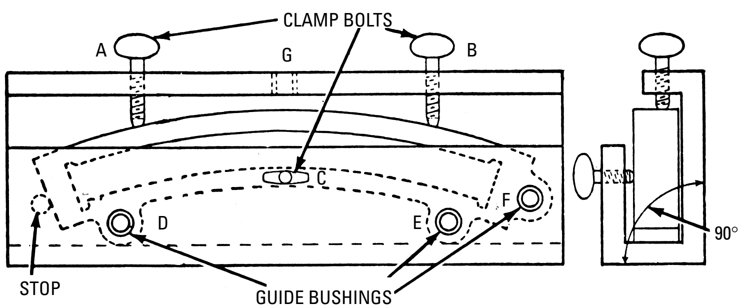

Figure 1-7 Using the box jig for drilling holes in an engine link.

The bushings *D* and *E* guide the drill for drilling the eccentric rod connections, and the bushing *F* guides the drill for the reach rod connections. The final hole, the hole for lubrication at the top of the link, is drilled by turning the jig 90°, placing the drill in the bushing *G*.

This type of jig is relatively expensive to make by machining, but the cost can be reduced by welding construction, using plate metal. In production work, the pieces can be set and released quickly.

A box jig with a hinged cover or leaf that may be opened to permit the work to be inserted and then closed to clamp the work into position is usually called a *leaf jig* (Figure 1-8). Drill bushings are usually located in the leaf. However, bushings may be located in other surfaces to permit the jig to be used for drilling holes on more than one side of the work. Such a jig, which requires turning to permit work on more than one side, is known as a *rollover jig*.

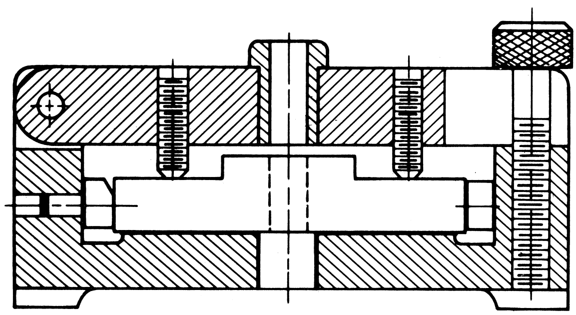

Figure 1-8 Leaf jig.

A box jig for angular drilling (Figure 1-9) is easily designed by providing the jig with legs of unequal length, thus tilting the jig to the desired angle. This type of jig is used where one or more holes are required to be drilled at an angle with the axis of the work.

As can be seen in Figure 1-9, the holes can be drilled in the work with the twist drill in a vertical position. Sometimes the jig is mounted on an angular stand rather than providing legs of unequal length for the jig. Figure 1-10 shows a box jig for drilling a hole in a ball.

In some instances, the work can be used as a jig (Figure 1-11). In the illustration, a bearing and cap are used to show how the work can be arranged and used as a jig. After the cap has been planed and fitted, the bolt holes in the cap are laid out and drilled. The cap is clamped in position, and the same twist drill used for the bolt holes is used to cut a conical spot in the base. This spotting operation provides a starting point for the smaller tap drill (*A* and *B* in Figure 1-11).

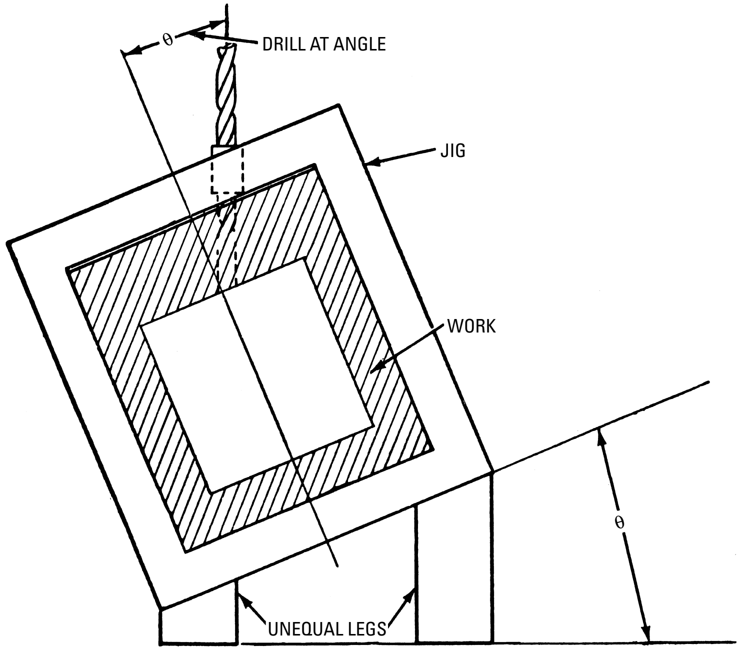

Figure 1-9 A box jig with legs of unequal length, used for drilling holes at an angle.

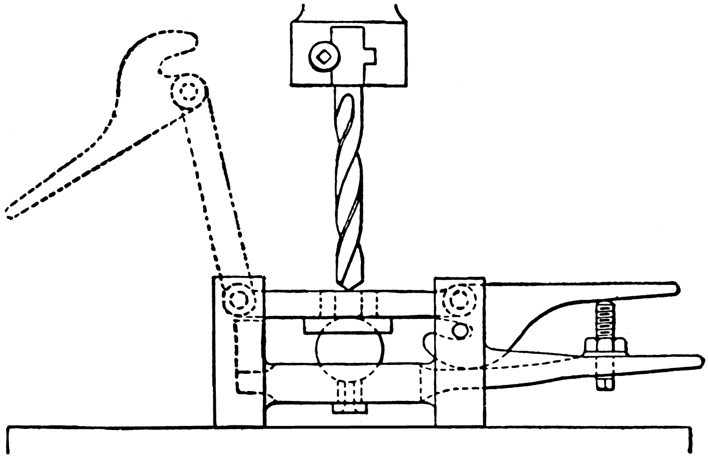

Figure 1-10 A box jig used for drilling a hole in a ball.

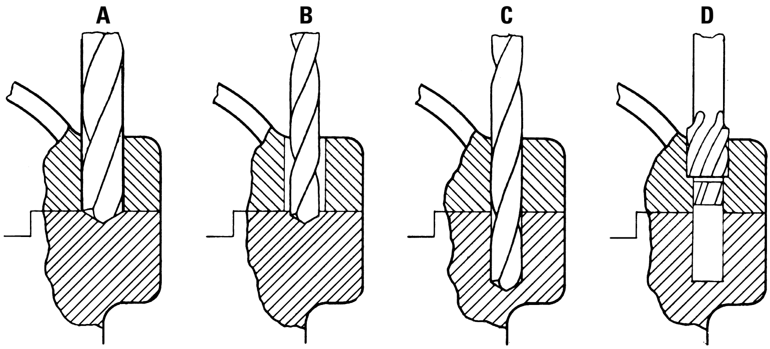

Figure 1-11 Using the work as a jig. In (A) the same drill used for the bolt holes is used to cut a conical spot in the base. This forms a starting point for the smaller tap drill, as shown in (B). In (C), the cap and bearing are clamped together and drilled by means of a tap drill, after which the tap drill is removed and a counterbore is used to enlarge the holes for the bolts, as shown in (D).

Also, both parts can be clamped together and drilled with a tap drill (*C* in Figure 1-11). Then, the tap drill can be removed and the holes for the bolts enlarged by means of a counterbore (*D* in Figure 1-11).

Following are some factors of prime importance to keep in mind with jigs:

- Proper clamping of the work
- Support of the work while machining
- Provision for chip clearance

When excessive pressure is used in clamping, some distortion can result. If the distortion is measurable, the result is inaccuracy in final dimensions. This is illustrated in an exaggerated way in Figure 1-12. The clamping forces should be applied in such a way that will not produce objectionable distortion.

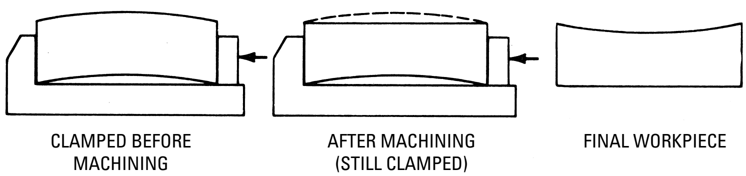

Figure 1-12 Effects of excessive pressure.

It is also important to design the clamping force in such a way that the work will remain in the desired position while machining, as shown in Figure 1-13.

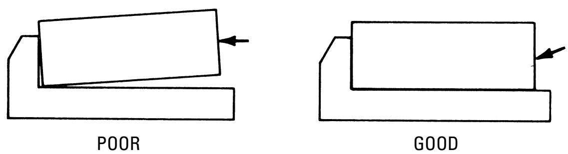

Figure 1-13 Effects of clamping force.

Figure 1-14 shows the need for the jig to provide adequate support while the work is being machined. In the example shown in Figure 1-12, the cutting force should always act against a fixed portion and not against a movable section. Figure 1-13 illustrates the need to keep the points of clamping as nearly as possible in line with the cutting forces of the tool. This will reduce the tendency of these forces to pull the work from the clamping jaws. Support beneath the work is necessary to prevent the piece from distorting. Such distortion can result in inaccuracy and possibly a broken tool.

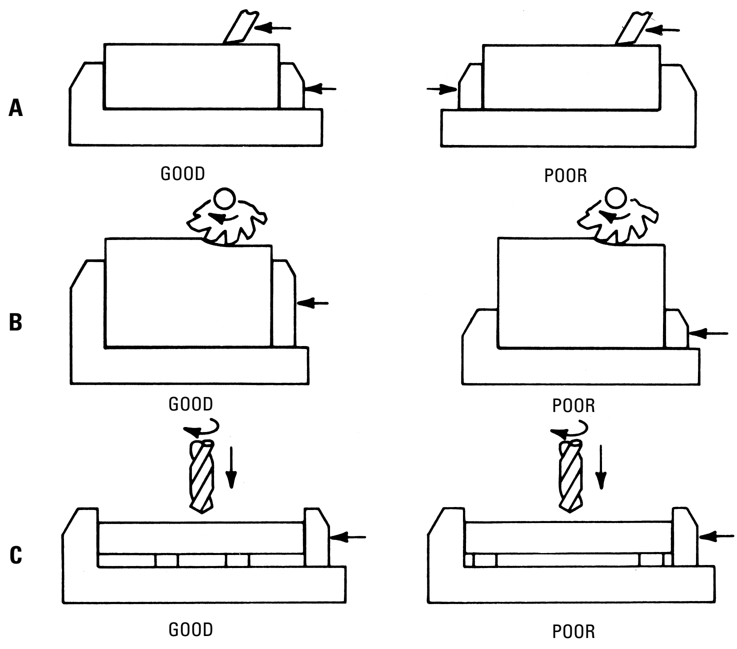

Figure 1-14 Support for work during machining.

Adequate provision must be made for chip clearance, as illustrated in Figure 1-15. The first problem is to prevent the chips from becoming packed around the tool. This could result in overheating and possible tool breakage. If the clearance is not great enough, the chips cannot flow away. If there is too much clearance, the bushing will not guide the tool properly.

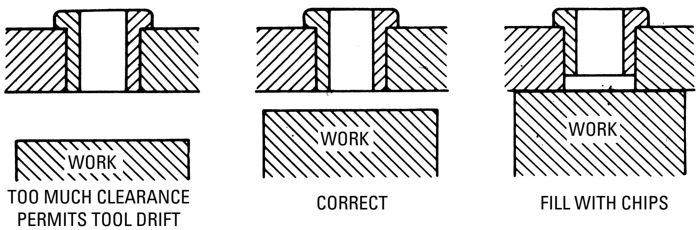

Figure 1-15 Provision for chip clearance.

The second factor in chip clearance is to prevent the chips from interfering with the proper seating of the work in the jig, as shown in Figure 1-16.

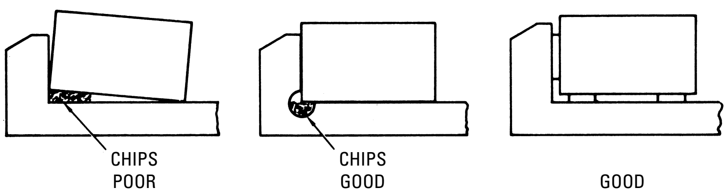

Figure 1-16 Provision for chip clearance.

Fixtures

As mentioned previously, a fixture is primarily a *holding* device. A fixture anchors the workpiece firmly in place for the machining operation, but it does not form a guide for the tool.

It is sometimes difficult to differentiate between a jig and a fixture, since their basic functions can overlap in the more complicated designs. The best means of differentiating between the two devices is to apply the basic definitions, as follows:

- The jig is a *guiding* device.
- The fixture is a *holding* device.

A typical example of a fixture is the device designed to hold two or more locomotive cylinders in position for planing (Figure 1-17). This fixture is used in planing the saddle surfaces. In the planing operation, two or more cylinders are placed in a single row, the fixture anchoring them firmly to the planer bed.

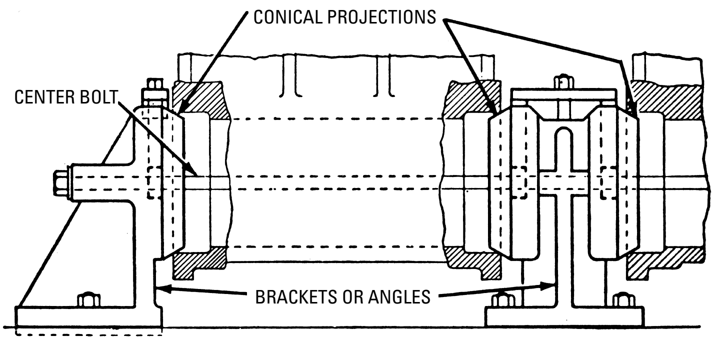

Figure 1-17 A fixture used to hold locomotive cylinders in position for planing the surfaces of the saddles.

The fixture consists of heavy brackets or angles, with conical projections that permit the bores of the cylinders to be aligned accurately with each other. The end brackets are made with a single conical flange; the intermediate brackets are made with double conical flanges. A bolt through the center of the flanges aligns the cylinder bores when it is tightened. The legs of the 90°-angle brackets at the ends are bolted firmly to the planer table. The intermediate brackets are also bolted to the planer table and aid in holding the assembly in firm alignment for the machining operation. The use of fixtures can result in a considerable saving in the time required to set the work, and they also ensure production of accurate work.

An *indexing fixture* can be used for machining operations that are to be performed in more than one plane (Figure 1-18). It facilitates location of the given angle with a degree of precision.

A disc in the indexing fixture is held in angular position by a pin that fits into a finished hole in the angle iron and into one of the holes in the disc. The disc is clamped against the knee by a screw and washer while the cut is being taken. Since the holes are properly spaced in the disc (index plate), the work attached to the disc can be rotated into any desired angular position. Radial drilling

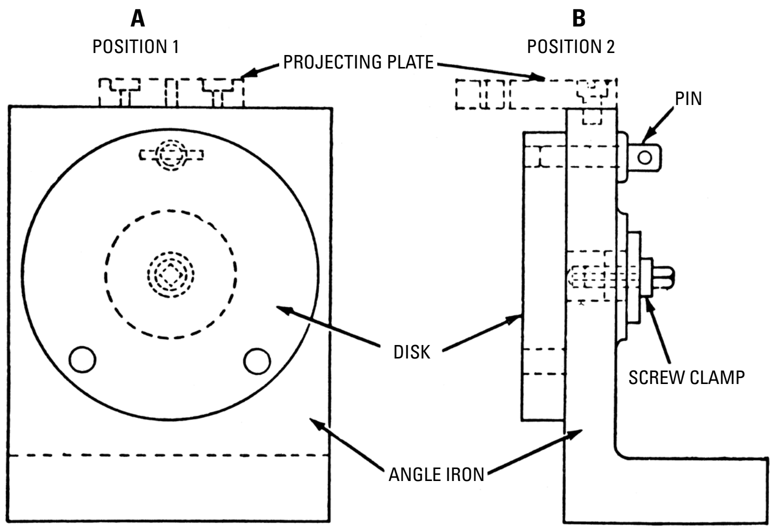

Figure 1-18 A simple type of indexing fixture that can be used to facilitate machining at accurately spaced angles.

operations can be performed when a projecting plate is provided with a jig hole.

The same general principles concerning clamping, support while machining, and chip clearance as covered in jigs apply as well to fixtures.

Summary

Jigs and fixtures are devices used to locate and hold the work that is to be machined. A jig is a guiding device, and a fixture is a holding device. A jig or fixture can be designed for a particular job. The form to be used depends on the shape and requirements of the workpiece that is to be machined.

There are generally two types of jigs used: the clamp jig and the box jig. Various names are applied to jigs (such as drilling, reaming, and tapping) according to the operation to be performed. Clamp jigs are sometimes called open jigs. Frequently, jigs are named for their shape, such as plate, ring, channel, and leaf.

A fixture anchors the workpiece firmly in place for the machining operation, but it does not form a guide for the tool. It is sometimes difficult to differentiate between a jig and a fixture, since their basic functions can overlap in the more complicated designs.

A plate jig consists of a plate, which contains the drill bushings, and a simple means of clamping the work in the jig, or the jig to the work. Where the jig is clamped to the work, it sometimes is called a clamp-on jig.

An indexing fixture can be used for machining operations that are to be performed in more than one plane. It facilitates location of the given angle with a degree of precision.

Review Questions

1. What are jigs and fixtures?
2. What does a jig do?
3. What is another name for a clamp jig?
4. What is the purpose of a fixture?
5. What is the disadvantage of a simple clamp jig?
6. What is another name for a box jig?
7. What can excessive jig pressure do?
8. What is an indexing fixture used for?
9. The fixture is primarily a _________ device.
10. The jig is primarily a ___________ device.