Audel™

Automated Machines and Toolmaking

All New 5th Edition

Rex Miller
Mark Richard Miller

Wiley Publishing, Inc.

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Mark Richard Miller finished his B.S. degree in New York and moved on to Ball State University where he obtained the master's and went to work in San Antonio. He taught in high school and went to graduate school in College Station, Texas, finishing the doctorate. He took a position at Texas A&M University in Kingsville, Texas, where he now teaches in the Industrial Technology Department as a Professor and Department Chairman. He has coauthored seven books and contributed many articles to technical magazines. His hobbies include refinishing a 1970 Plymouth Super Bird and a 1971 Roadrunner. He is also interested in playing guitar, which he did while in college as lead in The Rude Boys band.

Introduction

The purpose of this book is to provide a better understanding of the fundamental principles of working with metals in many forms, but with emphasis upon the machining—utilizing both manually operated and automated machines. It is the beginner and the advanced machinist alike who may be able to profit from studying the procedures and materials shown in these pages.

One of the chief objectives has been to make the book clear and understandable to both students and workers. The illustrations and photographs have been selected to present the how-to-do-it phase of many of the machine shop operations. The material presented here should be helpful to the machine shop instructor, as well as to the individual student or worker who desires to improve himself or herself in this trade.

The proper use of machines and the safety rules for using them have been stressed throughout the book. Basic principles of setting the cutting tools and cutters are dealt with thoroughly, and recommended methods of mounting the work in the machines are profusely illustrated. The role of numerically controlled machines is covered in detail with emphasis upon the various types of machine shop operations that can be performed by them.

Some of the latest tools and processes are included. New chapters have been added with updated information and illustrations whenever appropriate. This book, in it's all new fifth edition, has been reorganized into more logical units that can be digested much more easily.

This book has been developed to aid you in taking advantage of the trend toward vocational training of young adults. An individual who is ambitious enough to want to perfect himself or herself in the machinist trade will find the material presented in an easy-to-understand manner, whether studying alone, or as an apprentice working under close supervision on the job.

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

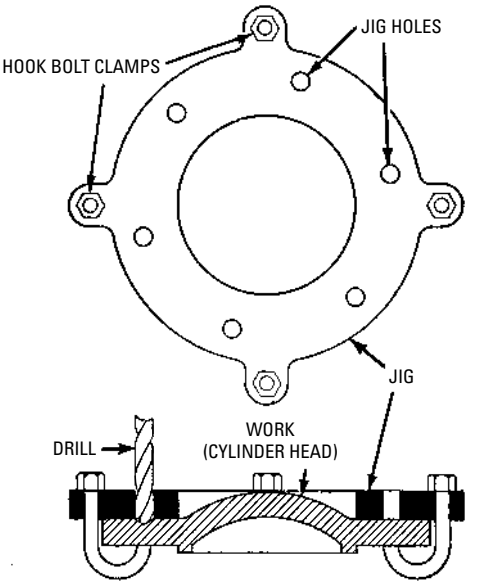

Figure 1-1 A plain ring-type clamp jig without bushings.

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.

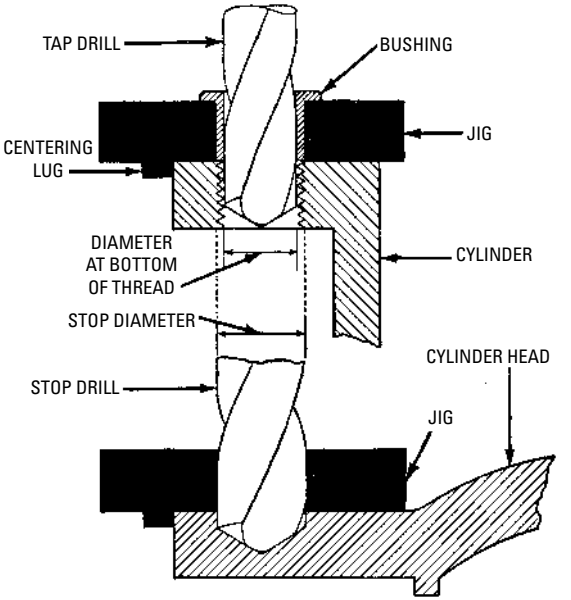

Figure 1-2 A clamp jig, with the tap drill guided by a bushing, designed for drilling holes in the cylinder (top); the operation for a hole for the cylinder head (bottom).

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.

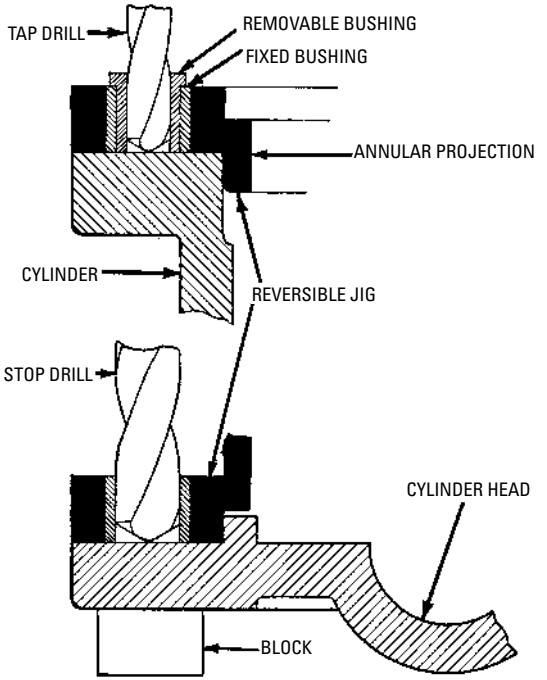

Figure 1-3 Note the use of a reversible clamp jig for the tap drill operation (top), and reversing the jig to drill the hole for the stud in the cylinder head (bottom).

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*.

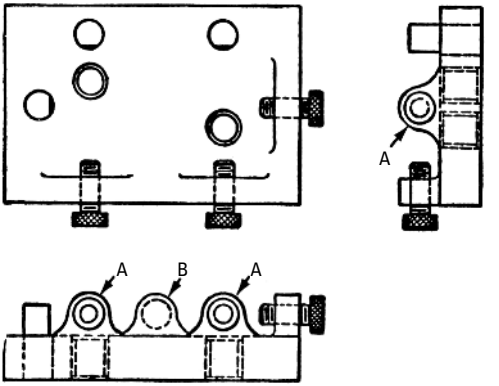

Figure 1-4 A simple jig that uses locating screws to position the work.

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

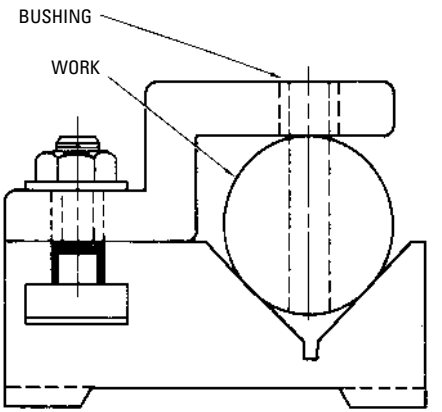

Figure 1-5 Diameter jig.

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.

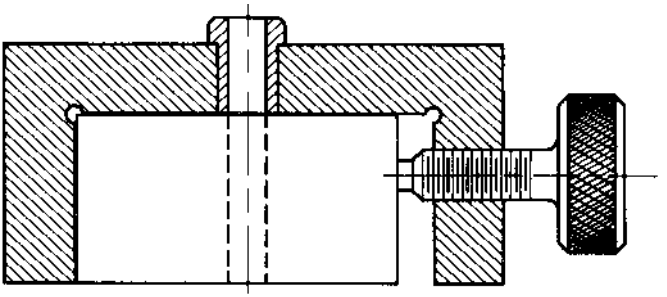

Figure 1-6 Channel jig.

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*.

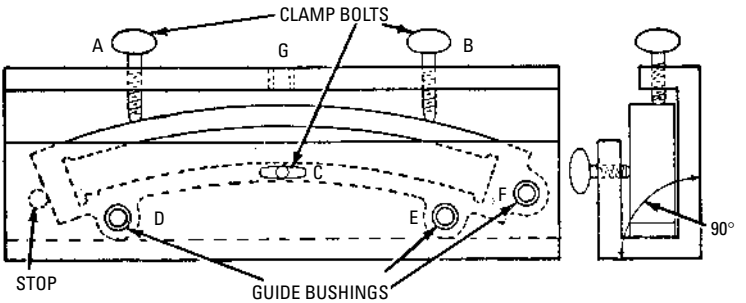

Figure 1-7 Using the box jig for drilling holes in an engine link.

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*.

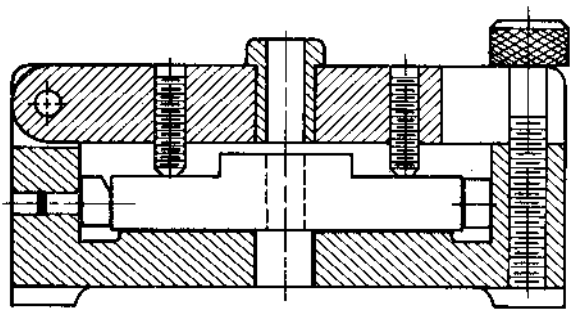

Figure 1-8 Leaf jig.

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).

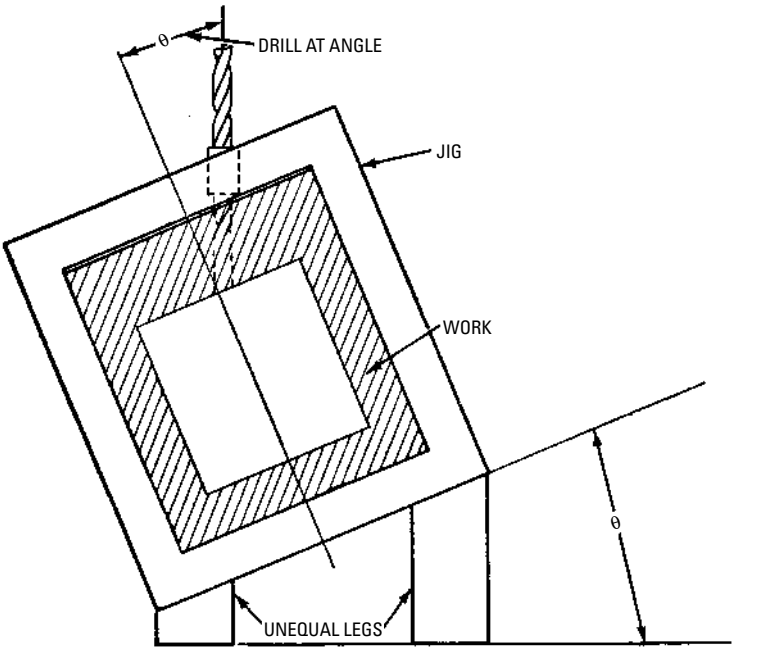

Figure 1-9 A box jig with legs of unequal length, used for drilling holes at an angle.

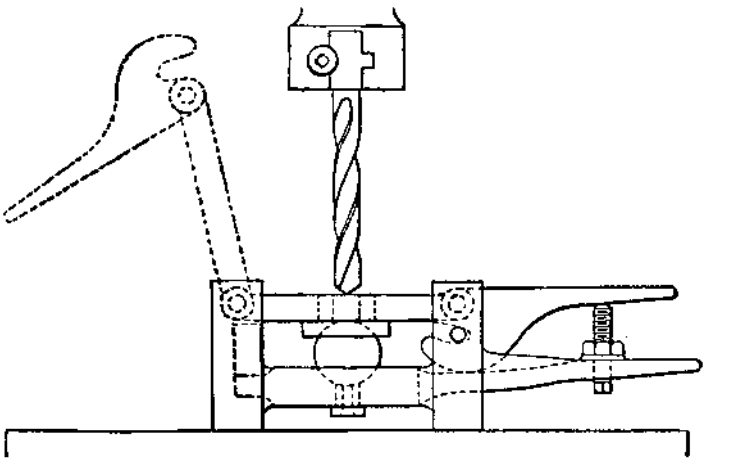

Figure 1-10 A box jig used for drilling a hole in a ball.