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METAL
FABRICATION:
A Practical Guide

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*Board of Cooperative Educational Services
of Suffolk County, New York*

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PREFACE

The student observer, when watching the experienced and skilled crafts-person performing a task, has for the most part focused attention on the obvious manipulative skills needed to produce any particular item. Thus the student of welding watches the way the instructor holds and manipulates the rod and torch. The apprentice machinist zeros in on the method of aligning the cutting tool in the tool post holder. The sheet metal mechanic, too, is observing the accurate forming of a precision chassis component in the press brake. Similarly, in drafting classes and engineering labs, theories and principles are being learned that ultimately take shape in the production shop.

That such specialization of skills has served our industrial system well needs no elaboration here. However, what is to be considered is the changeable nature of industrial systems and how such change can affect those specialists who work within the system as well as those students who have elected to follow a career path in metal fabrication.

The motivation to create this metal fabrication text stems from three concluding observations made after years of classroom and shop teaching, as well as years spent working as metal fabricators. The first observation relates to the need to differentiate between "training" and "education." A student can be trained to operate a wide variety of machines or to perform either a singular or a sequential operation. In highly methodized and repetitive manufacturing, this is not only desirable but relatively easy to accomplish. "Education," on the other hand, implies something more abstract, more elusive, and ultimately more valuable. By knowing, understanding, and intelligently applying specific training, the fabricator cannot only deal with subtle variations in the manufacturing process, but can also improve, sophisticate, and expand that process to make the work even more productive and personally rewarding. Specifically, it is the aim of this text not only to show how tools and machines are used in certain ways, but to explain and demonstrate the reasons why.

The second observation has to do with the fact that basic knowledge and skills always seem to be taught separate and apart from the realities of

the shop. Mathematics and the associated computational skills, for instance, which may have been only exercises in chalk dust, take on new and critically important meaning to the student faced with the task of learning a marketable skill. The areas of general science also take on new dimensions when viewed in the light of practical applications so common in metal work. Here, too, the text will not only show how to work with materials using specific tools and methods, but also instruct and reinforce knowledge in those basic sciences that are an intrinsic component to modern and not-so-modern industrial processes.

The final purpose and aim of this text is to shorten what the philosopher John Lachs called "psychic distance." In his reference to the separation between thought and action, we draw on the analogy of the designer engineer contemplating a fabricated structure with no thought of the actual physical and mechanical requirements needed to make the part, and the shop fabricator who must execute the design autonomously and even robotically, each hoping and tenaciously betting that the other person knows what he or she is doing. Similarly, it is the purpose here to attempt to shorten the distance between the engineer, the designer, the draftsman, the fabricator, and the student by treating each as an equal recipient of those basic competencies and skills common to all metalworking disciplines.

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Chapter

1

FABRICATING SAFETY

That lecture, given by a hard-faced but grandfatherly looking old foreman years ago, may seem a little melodramatic by today's standards. As movies and television give us our daily dose of make-believe and not so make-believe blood and gore, the safety lecture becomes something to think about for the moment but mostly just something to be endured until the real work and the real learning begins.

True enough, the safety lecture does come at the beginning and a good curriculum will continue to include it in specific instances as it progresses. Then, on the job, the safety posters and slogans are dutifully hung, and although many of the larger companies have active safety programs and campaigns, we sometimes forget the lecture that came so early in our training.

Then one day it happens. Over the thump of the heavy presses and the whine of high-speed automatic equipment, a scream ricochets off the walls of the shop. Little by little the sounds of pumps and motors die out and a spinning flywheel, like a carnival wheel of fortune, creeps to a stop. Everyone looks, craning their necks, as co-workers walk the unlucky one out of the shop. On the floor are spots of blood that dripped from the rag that was quickly wrapped around the mangled hand. That day you will look at the machine and remember the safety lecture—for a moment, anyway.

This chapter describes the various hazards of mechanical motion. On particular machines and during certain process situations, the specific danger will be explained in the appropriate chapter as the text progresses. The three basic danger areas of moving parts are:

1. The point of operation—where the tool actually touches the work
2. Power transmission—at the flywheel, the pulley, various cranks, levers, spindles, and gears
3. Auxiliary mechanisms—the reciprocating, rotating, and transverse moving parts that are part of feed mechanisms and accessory devices

All these items represent motions and actions that are potentially haz-

ardous to the operator. They are typical of nearly all machines and power tools; therefore, recognizing them is the first step in protecting yourself. The basic motions and actions are:

Rotating
 Reciprocating
 Transverse
 Cutting
 Punching
 Shearing
 Bending

Each of these will be discussed briefly.

ROTATING HAZARDS

Rotating either fast or slowly, collars, couplings, cams, clutches, flywheels, shaft ends, spindles, and horizontal or vertical shafting can be the cause of many accidents in the shop.

Loose-fitting clothing, unbuttoned cuffs, exposed shirttails, and longer-styled hair can be gripped by these turning parts. The hazard is increased when setscrews, bolt heads, and locking keys are exposed and are turning with the shaft or spindle (see Fig. 1-1). Of particular danger with rotating equipment is the "pinch" or "nip point." This is where either two rotating parts or one turning and one stationary part come in contact or very close to each other. Figure 1-2 shows some of these hazards that are found in every shop.

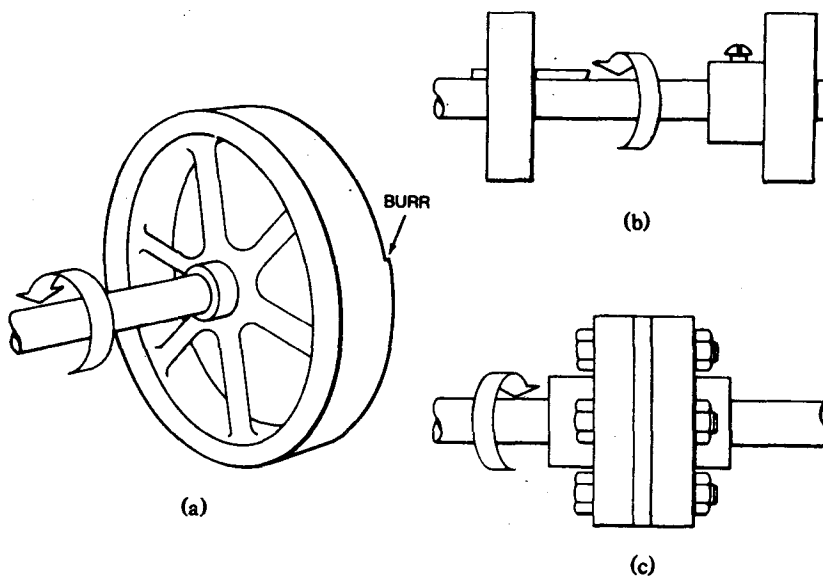


Figure 1-1 Rotating hazards: (a) rotating pulley with spokes and a projecting burr on the face of the pulley; (b) rotating shaft and pulleys with projecting key and set screw; (c) rotating coupling with projecting bolt heads.

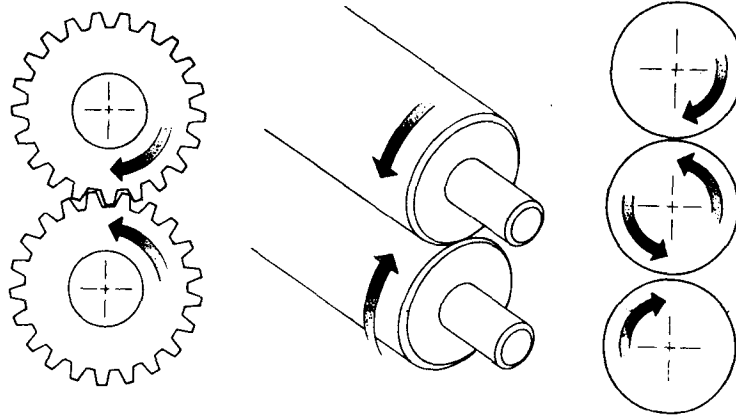


Figure 1-2 Nip points of close-fitting rotating parts.

RECIPROCATING HAZARDS

These dangers occur when machinery beds, toolholders, or auxiliary components move either back and forth or up and down. The worker may be struck by the moving part or be caught between it and a stationary part of the machine. Figure 1-3 depicts situations where these hazards are common.

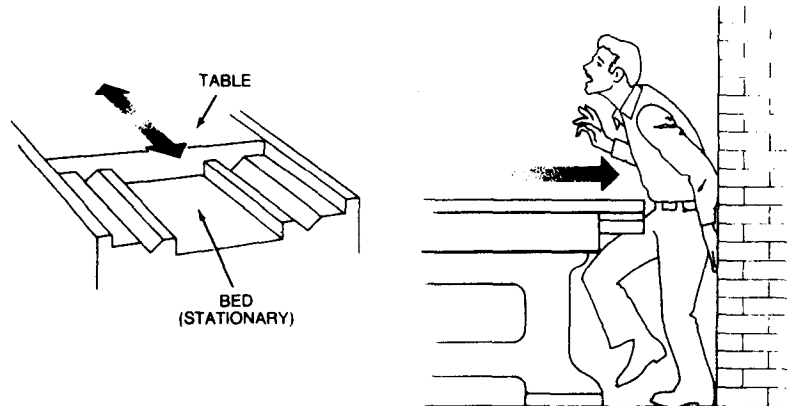


Figure 1-3 Reciprocating hazard.

TRANSVERSE MOTIONS

These are motions traveling in a long, continuous straight line. Usually horizontal, the distances traveled are such that the danger of the motion tends to appear to be minimal. Long continuous grinding and sanding belts and chain drives with projecting connection links can grab hands or clothing and drag them along to "running-in" nip points, as shown in Figure 1-4.

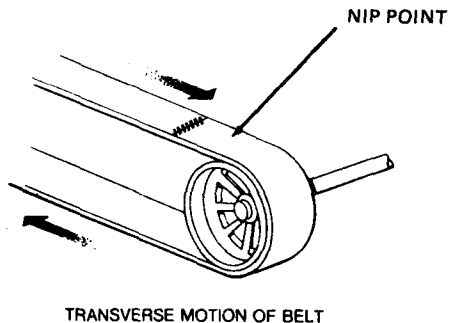


Figure 1-4 Transverse motion hazards.

**POINT-OF-
OPERATION
ACTIONS**

Cutting, shearing, punching, and bending become hazardous when either the hands or fingers come in direct line with the movement of the tool or when capacities are exceeded, and a structural failure occurs on the equipment.

The specific hazard is in the insertion, holding, and removal of stock between machine cycles. There is also danger when, due to the action of the machine on the stock, material flies into the face of the operator or those standing nearby (see Fig. 1-5).

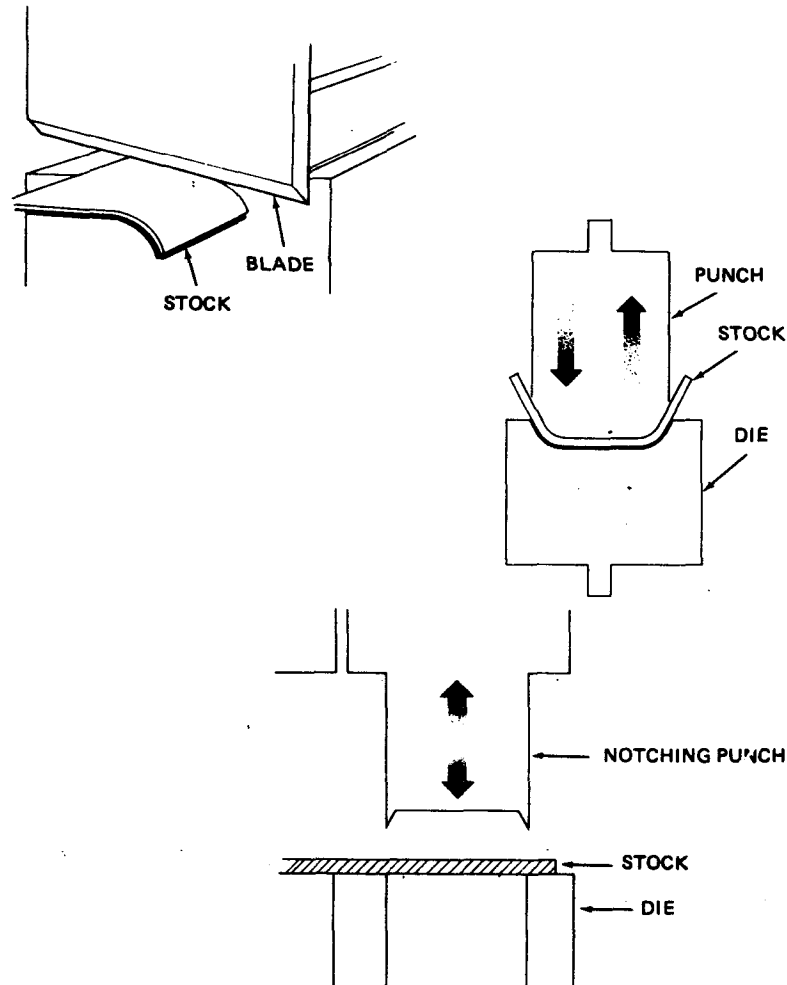


Figure 1-5 Point-of-action hazards.

**NONMECHANICAL
HAZARDS**

A safety concern, sometimes neglected, involves those aspects of shop operation which, although secondary to production, can be just as dangerous as the machinery.

Electrical power in a shop is widely distributed through wall-hung bus ducts and hanging drop cords. Input power can be 110, 220, 440 or even 600 volts. These distribution lines are therefore extremely dangerous. Even a shock from a 110-volt line can kill under the "right" conditions. Areas to be checked include not only conduit condition and connection, but also machine grounding. Another danger is in the fact that many machines are wired for three-phase electrical input, which means that component rotation is affected by the electrical hookup. Usually, strategically placed arrows will indicate the rotational direction of the equipment.

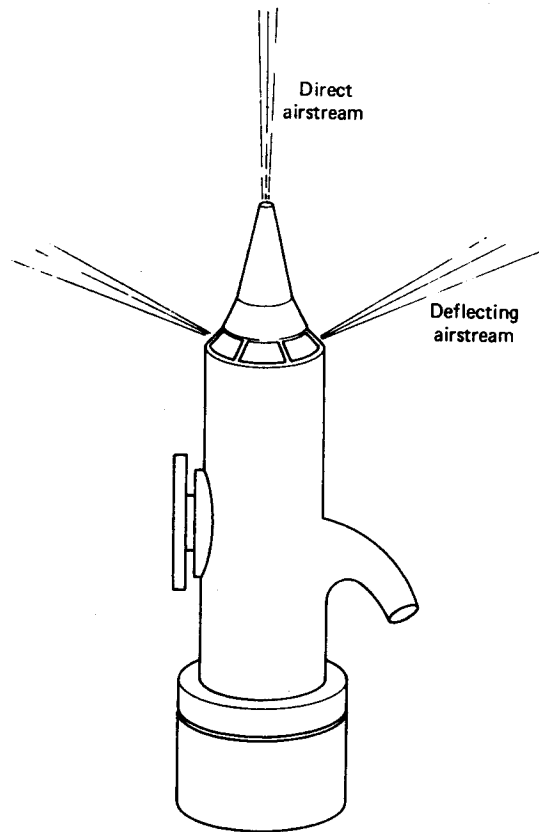


Figure 1-6 Air nozzle with a deflecting shield.

Compressed air is used in shops for powering pneumatic machinery, spraying, automatic piece ejection in stamping operations, and in hand tools such as drills and riveting guns. Chip removal and general cleanup operations are all accomplished with air hoses and various nozzle types.

Shop personnel should never underestimate the force of compressed air. One has only to recall the childhood prank of partially obstructing the faucet of a drinking fountain and seeing how far the water will squirt as the pressure builds up behind it. So it is with compressed air, as it is distributed in small-diameter lines, with even smaller orifice guns and nozzles, with usually 80 to 100 pounds of pressure behind it. Such a blast of air can cause permanent damage to the unprotected eyeball. A relatively small laceration can be ripped open while using compressed air to dry hands and arms. Small chips and debris can be blown with unbelievable velocity into the face and eyes.

Figure 1-6 shows an air nozzle approved by the Occupational Safety and Health Administration (OSHA). The side jets allow the pressure at the orifice to be reduced for adequate but safer pressure while providing a shield so that debris forced back toward the operator is deflected. Pressure to hoses and fittings should always be turned off or bled down before being connected or disconnected.

USE OF HAND TOOLS

Elsewhere in the text, the proper use of various hand tools is discussed. But in general, the smaller hand tools are not often addressed directly. Both powered and hand-operated, such tools still present hazards in much larger proportions to their actual size.