

Copyright Warning & Restrictions

The copyright law of the United States (Title 17, United States Code) governs the making of photocopies or other reproductions of copyrighted material.

Under certain conditions specified in the law, libraries and archives are authorized to furnish a photocopy or other reproduction. One of these specified conditions is that the photocopy or reproduction is not to be “used for any purpose other than private study, scholarship, or research.” If a user makes a request for, or later uses, a photocopy or reproduction for purposes in excess of “fair use” that user may be liable for copyright infringement,

This institution reserves the right to refuse to accept a copying order if, in its judgment, fulfillment of the order would involve violation of copyright law.

Please Note: The author retains the copyright while the New Jersey Institute of Technology reserves the right to distribute this thesis or dissertation

Printing note: If you do not wish to print this page, then select “Pages from: first page # to: last page #” on the print dialog screen

The Van Houten library has removed some of the personal information and all signatures from the approval page and biographical sketches of theses and dissertations in order to protect the identity of NJIT graduates and faculty.

THE GUARDING OF THE PRINCIPAL METALWORKING MACHINES

THE TECHNIQUES, NEED, AND RESPONSIBILITY

BY

PETER JAMES SCHWALJE

A THESIS

PRESENTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE

OF

MASTER OF SCIENCE

AT

NEW JERSEY INSTITUTE OF TECHNOLOGY

This thesis is to be used only with due regard to the rights of the author(s). Bibliographical references may be noted, but passages must not be copied without permission of the College and without credit being given in subsequent written or published work.

Newark, New Jersey
May, 1977

ABSTRACT

This thesis examines the guarding of the principal metalworking machines employed in the economy. The machines selected for consideration comprise the bulk of metal processing equipment utilized in the basic fabrication and manufacturing processes. It has been intuitively recognized that this equipment has been involved in a significant quantity of industrial accidents by the very nature of the hazards created by their normal use. Consequently, a need to develop some form of guarding or means of operator protection is called for.

In order to examine this question the principal metalworking machines are enumerated, their basic operating characteristics set forth, and the hazards associated with their use are identified. The principal methods and techniques of guarding against the created hazards are set forth. An examination of the injury record, both frequency and severity, is conducted and the codes and standards governing the construction, care and use of the equipment are presented. Potential sources of aid and assistance in effecting guarding methods are developed and catalogued.

The conditions found and examined are analyzed in a practical light and a specific philosophy adaptable to all aspects of the industry is derived. A program to accomplish the principles and intents of the philosophy is developed and set forth.

APPROVAL OF THESIS

THE GUARDING OF THE PRINCIPAL METALWORKING MACHINES

THE TECHNIQUES, NEED, AND RESPONSIBILITY

BY

PETER JAMES SCHWALJE

FOR

DEPARTMENT OF INDUSTRIAL & MANAGEMENT ENGINEERING

NEW JERSEY INSTITUTE OF TECHNOLOGY

BY

FACULTY COMMITTEE

APPROVED: _____

Newark, New Jersey
May, 1977

ACKNOWLEDGMENTS

The preparation of this thesis was aided and assisted by many whose names the writer has forgotten but through whose acquaintance the writer has gained some degree of knowledge, insight, experience, and perhaps, hopefully, some wisdom. The writer specifically wishes to acknowledge the help and guidance of Dr. Stan S. Thomas of the Department of Industrial Engineering.

The writer gratefully acknowledges the assistance of his father, Joseph Schwalje, in his desire to transfer and teach the wealth of knowledge and experience he has gathered over the years and of his mother, Helen Schwalje, for her encouragement. The writer further wishes to acknowledge the unwavering support of his mother-in-law, Eleanor Hutchinson, and the practical, sincere, and thoughtful advice of his father-in-law, George Hutchinson. For their dedicated and skillful handling of a difficult typing job, the writer thanks Mrs. Christine Doatch and Mrs. Marie Welsh.

For their sympathetic interest, efficient cooperation, continued support and extraordinary patience, the writer is eternally grateful to his daughter, Lisa, and his wife, Kathleen.

TABLE OF CONTENTS

CHAPTER I	INTRODUCTION.....	page 1.
CHAPTER II	MACHINES UNDER CONSIDERATION.....	page 3.
CHAPTER III	GENERAL PRINCIPLES AND TECHNIQUES OF GUARDING.....	page 29.
CHAPTER IV	MACHINES IN USE AND HISTORY OF INJURY.....	page 45.
CHAPTER V	CODES AND STANDARDS.....	page 50.
CHAPTER VI	AID AND ASSISTANCE IN GUARDING.....	page 57.
CHAPTER VII	SUMMARY, CONCLUSIONS AND RECOMMENDATIONS.....	page 62.
APPENDIX	DEFINITIONS.....	page 75.

LIST OF TABLES

TABLE 1	METALWORKING MACHINE HAZARDS.....	page 27.
TABLE 2	METALWORKING MACHINE POPULATION.....	page 45.
TABLE 3	METALWORKING MACHINE EMPLOYMENT.....	page 46.
TABLE 4	METALWORKING MACHINE ACCIDENT FREQUENCY RATES.....	page 47.
TABLE 5	METALWORKING MACHINE ACCIDENT SEVERITY RATES.....	page 48.
TABLE 6	METALWORKING MACHINE STANDARDS.....	page 52.

CHAPTER I

INTRODUCTION

The heart and soul of basic industry in the United States is intimately connected with the production, forming, fabrication, assembly and marketing of products made of metal. Throughout the years of industrial development numerous types of metal processing machines have been developed in order to accurately and efficiently cut, form, shear, punch, bend, drill, finish, etc. the metallic materials used to produce products. These machines employ various tooling and ingenious operating techniques to accomplish these ends and have provided gainful employment to thousands of workers and resulted in a cornucopia of goods being available to a multitude of people at reasonable costs.

These machines, having contributed so immensely to the standard of living which the population currently enjoys, have extracted a price from those individuals who use and operate the equipment, this price being the injuries sustained by the worker during the performance of the manufacturing process. In the more recent years, society has become more cognizant of this price and conscientious

attempts are being made to minimize and mitigate these adverse effects through improvements in design and construction, application of protective guarding and devices, development of codes and standards, and application of both statutory and tort law.

Consequently, it is the attempt of this thesis to examine the principal representatives of metal working machinery in this light. Investigation of the injuries sustained on the equipment, the codes and standards applicable to the devices, the principals and techniques of guarding employed to prevent injuries and sources of help and assistance are examined. Further, the philosophies which underlie this area are discussed, current conditions assessed, and a concept for future approaches and actions are proposed.

CHAPTER II

MACHINES UNDER CONSIDERATION

For the purposes and intents of this thesis, the following metalworking machines will be considered, namely:

- (1) Mechanical Power Presses
- (2) Press Brakes
- (3) Hydraulic Presses
- (4) Power Punching and Shearing Machines
- (5) Forging Machines
- (6) Forming Rolls and Calenders
- (7) Bending and Forming Machines
- (8) Lathes
- (9) Drilling Machines
- (10) Milling Machines
- (11) Boring Machines
- (12) Cut-Off and Sawing Machines

The potential danger associated with any type of machine is related to the various characteristics of the device. An analysis and evaluation of the machine design, the machine operation, the involvement demanded of the machine operator, and basic inherent hazards must be conducted in order to develop effective means of minimizing

these dangers.

Thus the approach taken consists first of describing the machine's physical characteristics. This is followed by determining the interface or relationship that occurs between the man (operator) and the machine. The hazards which may result therefrom can then be determined. With these relationships formulated, the areas whereby protective devices or guarding would be useful can be derived. There follows a method for analysis of the various machines under consideration.

Mechanical Power Presses

A mechanical power press is a machine that shears, punches, forms, or assembles metal or other material by means of tools or dies attached to slides or rams. The material to be worked is placed on the bottom half of the die and is struck by the upper die half which is attached to the ram. The ram is powered by means of transferring the rotational energy stored by a flywheel to the ram through a clutch and crankshaft arrangement. The flywheel is generally driven by a belt and pulley system connected to the output shaft of an electric motor.

The operator of this equipment is normally responsible for feeding or placing the material into the dies, activating the machine, and removing the completed part. The activation of the machine, causing the press to cycle, is accomplished either through use of palm buttons, a foot pedal, or foot treadle. It is possible, depending upon various other considerations, to convert any of the preceding manual operations to automatic ones.

A power press is utilized in high production manufacturing and generally requires intimate operator involvement in the process. This operator involvement requires the man to work in close proximity to the ram in order to assure proper positioning of the workpiece in the die area. The workpiece is often oil coated, hence slippery, and difficult to grasp. Further, workpieces may contain sharp cutting edges and may be at an elevated temperature.

The machine itself may experience an unintentional repeat and the operator may be exposed to a hazard arising from broken and/or falling machine parts. Because of the repetitious nature of the operation, the operator may be subject to fatigue with those associated problems and all too frequently, is insufficiently and inadequately trained.

The operating controls (i.e. buttons or pedals) are located near the work zone. When the press is used with a foot pedal or treadle accidental cycling of the press may become a potential hazard due to inadvertent operator actuation. On presses which employ mechanical linkages for actuation, a potential hazard for inadvertent actuation may exist through foreign objects striking the mechanism.

The power transmission elements of the press are normally elevated and consequently do not pose any large degree of danger. However, on older machines or the smaller presses, exposed gears, belts or clutches may create hazardous conditions. Slip and fall hazards may occur due to grease and oil leakage from the machine or work pieces.

The greatest hazard occurs at the point of operation and some form of guarding or protection must be employed. Such guards or devices should prohibit the operator from gaining access to the point of operation during press cycling and should be incapable of being bypassed.

All actuation controls should be protected from inadvertent operator activation. Each machine should be provided with suitable emergency shut off devices and

power disconnects.

Each press should be provided with "die blocks" for use during work in the die area, be that work setting of new dies or simple die area repair or alterations.

Press Brake

A press brake is a machine used primarily to bend and form sheet metal by means of tools or dies attached to a slide or ram. The material to be worked is placed on the bottom half of the die and struck at a relatively slow speed by the upper die half which is attached to the movable ram. The brake may be powered either mechanically or hydraulically and is equipped with partial revolution clutches. They are characterized by long beds and the work material is generally hand held. The brake is extremely versatile and is employed to produce a great variety of shapes and bends. This versatility makes it adaptable to both production and prototype work.

This type of metal working machine demands maximum operator involvement in the process with frequent hand holding of the work material and manipulation of same under the dies. Actuation of the machine is accomplished

by means of two hand buttons, foot pedal, or foot treadle with foot activation being by far the most common method employed.

As a brake is used for short production runs, frequent tooling changes are customarily performed with the associated hazards of this operation. The workpieces themselves are frequently large and awkward, making manipulation difficult and awkward, and may be slippery or present a sharp cutting edge. The operator is required to be in close proximity to the point of operation in order to effectively utilize the device.

Like the power press, the machine can experience an unintentional repeat and can present a danger due to broken and/or falling machine parts. Insufficient and inadequate training of personnel as well as fatigue due to a repetitious process may lead to increase potential for injury.

With frequent use of foot pedal actuation, inadvertent operation through reflex action can occur. Operators have a distinct tendency to "ride the pedal", and consequently an unintentional operation may result. Slip and fall hazards may occur from oil leakage from the stock;

the machine and the immediate work area is often cluttered with material.

The point of operation of the machine offers the greatest hazard area. Thus point of operation guarding should be provided whenever possible. This is difficult to accomplish as these guards frequently conflict with successful use of the machine due to their tendency to severely restrict operating ability.

As with the power press, actuation controls of the brake should be protected against inadvertent contact. Likewise, a suitable power disconnect and emergency shut-off mechanism should be provided.

Because of the size of the dies normally used on brakes, a special handling hazard is presented. Proper facilities to accommodate the dies such as lifting and positioning devices should be incorporated in the work place. Further, storage and retrieval facilities should exist for safe and efficient handling of the installation tools.

Hydraulic Presses

A hydraulic press is used to bend, punch, shear or

form metal by means of tools or dies attached to a ram. The material to be worked is placed on the bottom part of the die and struck by the upper die which is attached to the movable ram. The ram is moved up and down by virtue of a connection to a hydraulically powered cylinder. The speed of the ram or slide as well as the force exerted is variable and controlled by adjustment to the hydraulic system. The hydraulic press is a relatively slow speed device and its design permits the stroke to be interrupted anywhere within the cycle. They are particularly suited for deep drawing operations.

Maximum operator involvement through feeding, positioning and removal of workpieces is a characteristic of the machine operation. Operations are infrequently automated due to the nature of the work normally performed. Actuation of the machine is accomplished either through a foot switch or two palm buttons, with the two palm buttons being the more prevalent method.

As with brakes and mechanical power presses, the point of operation of the hydraulic press offers the greatest hazard. Unintentional operation due to inadvertent actuation of controls or through failure of a hydraulic

system component is another encountered hazard.

Handling of the workpieces may constitute a hazard as the result of their size and weight and the likelihood of sharp edges. As the hydraulic system of the press contains numerous hoses, fittings, etc., and the cylinder packings are normally designed for a certain amount of leakage, oil accumulation in and around the machine frequently will occur. This in turn creates potential slip and fall hazards as well as a potential fire hazard.

Point of operation guarding should be provided whenever possible to protect the operator from those hazards. Two hand button operating controls should be located away from the operating zone and foot pedals should be covered or guarded to prevent unintended actuation. Regular and complete maintenance of hydraulic system components must be practiced to eliminate unnecessary leakage and house-keeping around the machine must be performed conscientiously.

Power Punching and Shearing Machines

This type of metalworking machine utilizes movable punches, dies and/or stationary blades to punch or shear

metal. This group of machines encompasses a variety of different representatives including single and double end punches, alligator and guillotine shears, bar shears, and ironworkers. The machines may be powered mechanically, hydraulically, or pneumatically and may be manual, semi-automatic or fully automatic.

Unless the machine is automatic, operator involvement is significant. Stock to be worked must be inserted, the punching or shearing operation performed, and the piece removed, thus placing the operator in close proximity to the point of operation. The actuation system found on the machinery depends on the specific machine and its function. It may include foot switches and pedals, two hand buttons and/or single or two hand actuation levers.

Again the point of operation creates the greatest danger. Manipulation of stock during input and withdrawal may create a hazard due to size and weight, and the existence of sharp edges and oily surfaces. Kickbacks and rapid displacement of workpieces may occur when the operation is performed and, as the pieces are frequently hand held, this may create additional hazards. Shears and punches commonly employ material holddowns and clamps,

which can trap the operator's hands between the workpiece and the machine bed.

Wherever possible a point of operation guard should be provided and in the case of shears, is mandatory. Operating controls should be protected from inadvertent contact and located in such a manner as to minimize operator exposure to the hazard area. Personal protective gear, should be provided operating personnel to minimize workpiece handling hazards. An appropriate emergency stop button and power disconnect should be provided.

Forging Machines

A forging machine is used to work metal which generally has been raised in temperature to increase its plasticity. This class of machine includes power driven and gravity drop hammers, mechanical and hydraulic forging presses, trimming presses, upsetters, forging rolls, ring rolls and bolt head and rivet making machines. The normal forging process entails heating the material to the forging temperature and introducing it to the machine. In the machine it is formed by hammering or rolling into the desired form, the flash removed, and the piece allowed to cool.

The operator is intimately involved in the forging process as generally the workpieces are held by handtools and moved about by the operator to accomplish the process. Machine controls are generally foot pedals or treadles so that the machine may be actuated while leaving the operator's hands free to manipulate the piece.

Forging presents some of the greatest potential hazards of a metalworking process. The material handled is extremely hot presenting these associated hazards. The operator works in close proximity to the point of operation and may be struck by flying sparks or hot metal. The operator is exposed to high ambient noise levels and a variety of hot airborne fumes and particles. Often the areas about the machine are covered with flash and other small particles and a serious tripping hazard can exist.

Because of the nature of the forging process, point of operation guards are impractical and unnecessary. However, some shielding to protect against flying sparks or metal should be employed. Personal protective gear for the operator is an absolute necessity. Adequate engineering controls such as local exhaust systems should be incorporated in the forging facility. Complete and thorough

personnel training must be in effect.

Forming Rolls and Calenders

A forming roll is generally a cold metal working machine. The rolls squeeze or shape the metal by action of mating rolls, which causes the work to be performed as the material passes between the rolls. The process is normally highly automated.

A calender, on the other hand, is not usually classified as a metal working machine but rather as a rubber or plastic working device. In these applications, it is utilized to apply a coating or to control the thickness of a material and normally performs this operation at an elevated temperature. However, in a strict sense, a machine utilizing more than two sets of rolls to perform an operation is classified as a calender and, as such equipment may occasionally be encountered in metalworking, it is included in the category.

With these machines the operator has minimal contact with the danger areas and in general, serves only as a starter and stopper of the system, an observer of operation, and a material handler. The operator may become involved

in roll adjustment and changing which may occur frequently in larger high production operations.

The most common hazard area is that associated with the material handling aspect of the machine operation. Material is often heavy and must be handled by crane. It may also be sharp and present a cutting hazard. Premature cutting of bands on coil stock can create an extremely dangerous condition due to material telescoping or unraveling.

The machine itself may be hazardous if the inrunning nips of the work rolls are exposed to inadvertent operator access. Change-out operations of rolls due to wear may also create a hazard if performed improperly or in an improper manner. A slip and fall hazard may exist around the machine as a consequence of the need to lubricate the work rolls when they work certain materials.

Guards should be provided if possible, and operator access to the point of operation of the rolls limited. The operating station should have visibility of the entire machine area and controls should be clearly marked and protected against the possibility of inadvertent starting.

An emergency stop or stops should be provided as well as a main disconnect device. Good housekeeping around the machine should be practiced and operators instructed in proper material handling procedures.

Bending and Forming Machines

Bending and forming machines are used to cold work stock into various predetermined shapes. This operation may be accomplished by dies, rollers or other types of tooling. The machines used can be mechanically, hydraulically, or pneumatically powered and the operation may be manual, semi-automatic or fully automatic.

As the process becomes more and more automated, operator involvement decreases proportionally. In a manual operation, the operator loads the workpiece, operates the machine and removes the completed part. In an automatic operation, the operator's role is generally no more than a supplier of input pieces and a system observer. The machine may contain no actuation device at all or may contain a foot pedal. In either case, the actuation controls are designed to allow the operator's hands to be free to manipulate the stock.

The greatest hazard to the operator is the possibility of being caught in the dies, forming rollers, or between the workpiece and these devices. Material handling may also present hazards due to size and weight as well as sharp edges and slippery surfaces.

The operating areas of the machine should be provided with guarding if possible to prevent inadvertent operator access to these zones. Operating controls should be protected against unwanted actuation and a suitable emergency stop switch or system provided. A main disconnect device should also be present.

Lathes

Lathes are used to generate cylindrical or tapered cross sections, end drilling, threading, knurling, cam production and a variety of other general purpose operations. As a general rule, a lathe operates by causing the stock to rotate and the tool to be fed into the stock. The tool removes the material as a chip and the work is accomplished. The workpiece is secured in a chuck while the tool is moved and controlled mechanically.

The operator of the machine is intimately involved

with all phases of the machine operation. The operator loads the pieces, selects the tooling, sets speeds and feed, performs the operation, and removes the completed piece. The operator is also responsible for physical measurement of the pieces. Many lathes are automated and/or tape controlled; however, they may still require the operator to supply material, check tooling and remove the product.

Numerous hazards are associated with the equipment. During operation, hot chips are produced and a cooling lubricant is sprayed about. Additionally, both the tooling and workpiece are in motion and create pinch areas. Tools frequently break and particles may fly away and strike the operator.

Guarding of lathes, other than the automatic type, is extremely difficult due to the necessity for operator involvement in the process. However, splash guards and chip breakers may be employed without adversely affecting the operation. Tools, chucks and wrenches should be conveniently located for operator access. Operating controls should be positioned or guarded to prevent inadvertent operation and a main disconnect should be provided.

Automatic machines should and can easily be guarded at the point of operation.

Drilling Machines

A drilling machine is used to produce circular holes in metal workpieces. The work normally is stationary and the hole produced by a drill secured in a rotating chuck. The speed of drill rotation is variable as different speeds are required for drilling of different materials. Special purpose production machines often employ multi-spindle or multi-drill head equipment for the production of several holes simultaneously. However, the single spindle, vertical head drill press is by far the most frequently encountered representative.

The operator normally positions the stock, secures it, performs the operation and removes the piece. The operator also sets the drill speed and controls the rate of feed. Thus, a moderate exposure to hazard will exist.

A hazard exists due to the rotation of the drill bit and possibility of catching clothing, hair, jewelry, etc. on the spindle. Hot chips are generated and if the drill is forced or improper drill speeds are used, the bit may

break and fly out. Further, because of the basic simplicity of the machine, it is frequently improperly used, such as, by the operator attempting to hand hold workpieces. Slip and fall hazards may exist around the machine as the result of spilled cutting oil and/or chip deposits. Belts and pulleys used for drill speed control may be exposed and consequently present a mechanical power transmission hazard.

The point of operation of the machine cannot be effectively guarded. Tools (i.e. drill bits) are frequently and routinely changed and chips generated by drilling must be permitted to escape from the hole. However, suitable clamps or holddown fixtures should be provided to secure the workpiece. Belts and pulleys must be protected so as not to be subject to inadvertent contact by the operator. A main power disconnect should be provided and proper housekeeping practices in the vicinity of the machine should be employed.

Milling Machines

A milling machine utilizes a rotary cutter to remove material from metallic workpieces. The cutter or cutters

are mounted on a driven mandrel which may be either vertical or horizontal. The workpiece is normally secured to a table which is moved into the tool to accomplish the work. The rotational speed of the tools and the workpiece feed rate is adjustable. The machine may be equipped with an infinite variety of tools for performing a variety of precision machine tasks.

The operator must load the workpiece, select the feed and speed rate, actuate the machine, observe and check operation and remove the completed piece. Consequently, the operator is an integral part of the operation, and is exposed to the various point of operation hazards. However, the operator of a milling machine is generally a well trained and an experienced person.

The principal hazard is at the point of operation, where the cutter may catch loose clothing and draw the operator into the machine or the operator may contact the cutter itself. Cooling and lubricating oil is frequently applied and may create a slip hazard and make the workpieces difficult to handle. There is always some danger in that the cutter may fracture, fly apart, and strike the

operator. Additionally, the location of some control levers may subject the machine to a potential of being inadvertently actuated.

It is extremely difficult to guard the point of operation because of the varied types of tooling normally used and the need for the presence of the operator to be in the area. However, guarding of the upper portion of the cutter generally may be accomplished and would offer a significant degree of protection.

A main power disconnect should be provided and operating controls should be protected as much as possible and should clearly be identified as to function. On automatic production type millers, point of operation guards can be and should be incorporated.

Boring Machines

A boring machine is used to produce a hole of accurate shape and diameter in metal workpieces. The machine normally employs a single pointed tool to remove the required material, generally from a predrilled hole. Boring machines may be vertical or horizontal and may be operated at variable feeds and speeds. Either the tool may rotate and

the work remain fixed or the tool remain fixed while the work rotates.

The operator loads and positions the workpiece, sets speeds and feeds, performs measurements, observes the operation, and removes the finished parts. Consequently, he becomes an integral part of the machine operation. However, as boring machine operators control a high precision machine utilized for critical component manufacture, they generally are highly trained and skilled.

The tool performing the boring is normally contained within the workpiece and thus offers minimal hazard. Relative movement between the tool holder, bar and the workpiece may create pinch point or shear hazards. As boring machines are frequently employed to machine large pieces, material handling of the stock may present certain hazards.

Very little guarding of these machines is required by virtue of the boring process itself and that the machine is not a high production device. Nevertheless, suitable disconnects and shut off devices should be provided and operators should be well trained and experienced.

Cut Off and Sawing Machines

A cut off or sawing machine is used to cut off material from piece stock or to otherwise alter its shape such as by notching. The machine accomplishes this through the use of a saw blade or abrasive device which contacts the work and removes material causing the cut to be made. Common examples of such equipment include band saws, power hack saws, and abrasive wheel saws. The machines may be manual or may be fully automatic.

The various types of machines involve various degrees of operator involvement. On some equipment, the operator needs only to set the piece in the machine at the desired length, clamp the piece, and start the machine. It then proceeds automatically to cut the material and shut off when complete. Other machine types require a manual forcing of the wheel or blade through the work, regulating pressure and direction in order to accomplish the cut.

The principal hazard is at or near the point of operation where the hands may contact the cutting blade

or the wheel. Further hazards exist due to the potential for blades to break or wheels to shatter which could result in flying missiles. The cutting action itself causes elevated material temperatures and thus thermal hazards may be created.

Guards should be provided to enclose all but the area of the saw blade actually performing the cutting operation. Blades should be adequately guided to prevent excessive flexure and twisting. Wheels should be enclosed as much as possible and provided with an exhaust system to remove sparks and cut particles. An emergency stop should be provided as well as a main power disconnect. Access to the machine should be restricted to those familiar with its operation.

By study of the general features and operation of each of these machines, the general classes of hazards associated with each can be determined. These hazards are generalized as bending, chemical, cutting, falling or broken components, inrunning nips, power transmission, punching or shearing, reciprocating or transverse, rotational, slipping and falling, shattering, and thermal.

The following matrix illustrates each machine type and the hazards associated with it:

TABLE 1

	Bending	Chemical	Cutting	Falling or Broken Components	In-running Nips	Power Transmission	Punching or Shearing	Reciprocating or Transverse	Rotational	Slipping & Falling	Shattering	Thermal
Mechanical												
Power Press	X		X	X		X	X	X		X		
Press Brake	X		X	X		X	X	X		X		
Hydraulic Presses	X	X	X	X		X	X	X		X		
Punching & Shearing	X		X			X	X	X		X		X
Forging Mach	X	X	X	X	X	X	X	X	X	X		X
Rolls & Calenders					X	X			X	X		X
Bending & Forming Mach	X				X	X			X	X		X
Lathes		X	X	X	X	X		X	X	X	X	X
Drilling Mach		X	X			X		X	X	X		X
Milling Mach		X	X			X		X	X	X		X
Boring Mach		X	X			X		X	X	X		X
Cut Off & Sawing		X	X			X		X	X	X	X	X

Thus, it is possible to obtain a general idea of the potential hazards encountered with each type of equipment. With the general hazards identified and established, means and methods to mitigate their adverse effects can be developed.

CHAPTER III

GENERAL PRINCIPLES AND TECHNIQUES OF GUARDING

The specific types of machine guards which may be produced are as varied and unique as the individuals who design and produce them. There are established, however, certain general classifications and types of machine guards in which all guards may be assigned. The type of guard ultimately developed for an application will depend upon the specific operation being considered but will still fall within the general classifications.

The general classifications of guards recognized as existing in current safety publications and recognized by those involved in this field are:

1. Enclosure Guards
 - a) Fixed Barriers
 - b) Adjustable Barriers
2. Interlocking Guards
 - a) Barrier
 - b) Mechanical gate type
 - c) Automatic gate type
 - d) Photoelectric
 - e) Radio Frequency

3. Automatic Guards
 - a) Sweep devices
 - b) Pull away or pull back devices
 - c) Pressure release
 - d) Stroke limiting devices
4. Remote Control, Placement, Feeding, Ejecting
 - a) Two hand trip devices
 - b) Automatic feeds
 - c) Special holding devices
 - d) Special tools and dies
 - e) Special ejecting devices

Each of these guards are a unique entity possessing different uses and having a series of advantages and limitations. A brief outline of these facets for the general types of guards is as follows:

Fixed Barrier Guard

The fixed barrier guard should be employed whenever possible. This type of guard protects by enclosing a hazard by use of a non-movable shield installed between the operator and the hazard. The barrier may be constructed of various materials including wood, sheet metal,

wire mesh, bars, plexiglas, etc., provided said material can withstand the forces and loads which may be imposed upon it. The barrier should be durable and be made an integral part of the machine. It should be installed and mounted such that it cannot be readily removed or adjusted by the operator.

A fixed barrier guard is adaptable to practically every power transmission device and to machines where integral operator involvement is not required in the hazard area. This type of guard is useful in retaining and/or restraining flying or exploding machine elements. The guard functions to admit the workpiece to the operating zone but prohibits the operator's hands from access.

This type of guard has advantages in that it can be custom tailored to any specific application, can be readily constructed in-plant and is the least expensive guarding method to apply. Further, this guard provides maximum protection while requiring minimum maintenance.

The limitations of the guard are that it is adaptable only where operator involvement in the hazard area is not required. In addition, the guard may present serious

visibility interference and may require removal in order to accomplish machine adjustments or tooling changes.

Adjustable Barrier Guards

An adjustable barrier guard is a guard which encloses a hazard zone with an adjustable shield between the operator and the hazard. It is generally constructed of bar stock so that adjustments to accommodate various size workpieces and machine components may be readily accomplished. It must be strong and durable and be capable of being fixed or locked in position after an adjustment is made. It should be used as a first choice whenever a fixed barrier guard is impractical.

Like the fixed guard this guard can be tailored to numerous specific applications and lends itself to in-plant construction. It also provides maximum operator protection while representing the second least expensive means of positive guarding.

Again, like the fixed guard, it is limited in that it is adaptable only where operator involvement in the hazard area is not required. Although it offers less visibility interference than fixed guards, it requires significantly

more maintenance and adjustment and generally requires removal during machine adjustments or tooling changes. A further limitation is that this type of guard may be subject to tampering and circumvention by the operator.

Interlocking Barrier Guard

An interlocking barrier guard is used where the operator must reach into the hazard area. It protects by enclosing the danger zone with a shield, which is not fixed, interposed between the operator and the hazard. An interlock from the guard with the operating mechanism prohibits operation of the machine when the guard is open or removed.

This type of guard has the advantage of permitting enhanced operator flexibility and does not prohibit the ability of the operator to reach into the hazard area. The guard provides enhanced visibility of the work zone and may be designed to fail safe.

The limitations of the guard are that it requires careful adjustment and proper maintenance. It will not protect against a mechanical repeat and is moderately expensive to install. The use of the guard often results

in decreased rates of production. A failure of the interlock device may go undetected and the operator may falsely feel that he is protected when entering the hazard zone.

Interlocking Mechanical Gates

Where minimum accessibility to the hazard area is required, mechanical interlocking gates may be employed. These guards contain a fixed barrier enclosure with a manually operated gate to allow access. The gate is interlocked either mechanically or electrically with the operating mechanism to prohibit operation of the machine when the gate is open.

The principal advantage is that it provides greater flexibility for the operator and can be fail safe in design.

The limitations are that it requires careful adjustment and maintenance and is moderately expensive to install and fabricate. It also tends to result in decreased rates of production leading to willful attempts to defeat or circumvent.

Interlocking Electrical Gates

When operator involvement in the hazard zone requires

that the hands be free from operation of a guard or gate mechanism, this type guard may be employed. The guard is similar to the mechanical gate except the guard operation is activated by the machine cycle. This is normally accomplished by means of a mechanical interlock.

The advantages of this type guard are that it permits freedom of the operator's hands from opening and closing the mechanism and may be designed to be fail safe.

It possesses the same general limitations as the mechanical gate with the additional limitation that the automatic movement of the gate may catch the operator's hand and result in an injury.

Photoelectric Interlock

This type of guard, known as a presence-sensing device, employs an electric eye interlocked with the machine's operating circuit such that interruption of the photo beam causes the machine to stop. This type of guard is adaptable to machines with slow operating speeds which can be braked quickly. The machine must contain friction or air clutches (i.e. partial revolution) and cannot be used with machines containing full revolution clutches.

The principal advantage is the simplicity of the system. It is limited in that it requires frequent adjustment and maintenance, and commands a high initial expense. Further, the system does not protect against mechanical failure in the machine which would result in a repeat.

Radio Frequency Interlock

This type of guard is identical to the photoelectric interlock except that it employs a radio beam or field to establish the barrier. The guard contains the same advantages and limitation as does the photoelectric interlock.

Automatic Sweep Devices

This guard is a device which consists of a movable barrier connected to the stroking mechanism of the machine. As the machine strokes, the barrier pushes or lifts the operator's hands away from the hazard zone. It is primarily adaptable to machines with moving rams.

The principal advantage is that it permits access to the hazard area for stock manipulation. Its limitations are that it must be carefully adjusted and will function

only when the hands are in the normal position. Further, the guard may interfere with the stock and may create a danger by trapping the hand between the guard and fixed machine elements.

Pull Away or Pull Back Devices

This type guard also finds principal application on machines with moving rams. It consists of cables or ropes which are attached at one end to the operator's hands or arms and on the other end to the machine. A series of pulleys and stands are employed such that as the ram descends, the cables pull the operator's hands from the danger area.

The advantage of this method is that it permits access to the danger area and eliminates the need for auxiliary barriers.

The limitations are that the pull back device requires individual operator adjustment and proper maintenance. Further, the device limits operator movement and obstructs the work area around the machine. This type of guard may also present a compliance problem with the operator who may attempt to circumvent the device or remove it entirely.

Pressure Release Device

This type of guard is principally adaptable to machines with rolls and inrunning nip points. It is a presence sensing device which is attached to the machine near the danger area and interlocked with the circuitry of the machine. Pressure against the device causes it to actuate and the machine to stop, and the rolls to separate or the rolls to reverse.

The advantage of this device is that it does not interfere with the working area of the machine. It is limited in that it can be adapted to only small classes of machines and if not part of the original equipment, expensive to install.

Stroke Limiting Devices

Stroke limiting devices are not guards per se, but rather protect by limiting die travel to 3/8" or less. This small distance of travel precludes body parts from entering the danger area.

The advantage is that no other or additional guards are required and cost is extremely low. The limitation is that only stock of small size can be processed on the

machine making its adaptability restricted.

Two Hand Trip Devices

Two hand trip devices can be used on most machines provided that hand holding or stock manipulation is not required during the work operation. The device functions to require the operator to apply concurrent pressure on two independent buttons in order to affect machine actuation. The buttons may be either mechanically, electrically or pneumatically integrated into the machine control system. This method effects the guarding by forcing the operator's hands to be distant from the hazard area when the machine cycles.

The principal advantage is that they positively remove the hands from the danger area. In addition, they are relatively inexpensive to install and require minimal maintenance.

The two hand trip is limited in that it does not protect against machine repeat and unless properly designed and installed, may be circumvented by blocking or tying down. They are generally further limited in that they must be incorporated in machines that are high

speed and/or shut stroke so that the operator cannot "beat" the system and reach into the danger area before the cycle is complete.

Automatic Feeds

Automatic feeds guard, by virtue of the fact that they remove the operator from the supply aspect of the system, are adaptable to high production machines in which there is no variation in stock. This technique involves supplying stock automatically by means of chutes, hoppers, conveyors, rolls or other devices which obliterate the need for the operator to position stock in the hazard area.

The advantages of the technique are the removal of the operator from the necessity of feeding the system and the economy gained in increased production during large runs.

The principal limitations are that additional guarding is frequently required for total operator protection and that variations in the stock may make the system inoperable or produce defective product. In addition, skilled and thorough maintenance is required to keep the system

operating correctly.

Special Holding Devices

This equipment is not a guard but rather encompasses auxiliary hand tools which permit workpiece adjustment without requiring the operator to place the hands in the hazard area. These devices include tongs, vacuum lifts, magnetic lifts, hooks, pliers, etc.

The advantages are that when used, the hands are remote from the hazard location and that the devices may be employed on various operations without need to change equipment. In addition, the equipment is low priced and is readily available in numerous styles and forms. Further, on some machines and with some processes it represents the only practical form of operator protection.

The limitations are that to be effective, they require training of the user and acceptance by the operator. Compliance with their use is a significant problem and drawback and the equipment is frequently misplaced and damaged.

Special Tools and Dies

This equipment is adaptable where large quantity

runs are made. These devices consist of hand, mechanical, pneumatic and hydraulic feeding and placement equipment, which permit loading remote from the hazard zone. Devices such as sliding bolster plates and circular feed tables are equipment of this classification.

The advantages are that the operator is removed from the hazard zone and additional guarding equipment requirements are reduced or eliminated.

The limitations are high initial cost and that thorough training of the personnel is required. Further, maintenance must be conscientiously performed and consistent supervision must be in effect to assure the device is used properly.

Special Ejecting Devices

This equipment is employed to remove a complete piece from the machine without the necessity of the hands to enter the hazard area. The device utilizes air or mechanical actuation to automatically eject the piece from forming tools. The devices are frequently coupled with other techniques such as automatic feed, and find principal application in large quantity run operations.

The main advantage is removal of operator activity from a portion of the machine cycle. It has limitations in that it is restricted in the size of the workpiece to which it may be adapted and carries a relatively high initial expense. Further, it requires prudent maintenance to assure its continual proper operation.

In any approach to machine guarding, it is important to recognize that the goal is to prevent an operator from inadvertent contact with hazardous areas of a machine. As much as possible, guarding should also serve to prevent operators from conscious attempts to enter a hazard area. However, no matter what the guard developed or employed, it is impossible to prevent the determined individual from circumventing the device for whatever reason individuals seek to do same.

Thus, a sound approach to application of guarding is to first explore the hazard areas of a given machine and evaluate them in light of how an operator might inadvertently contact them. With this evaluation made, the various types and techniques of guards can be studied to determine their suitability and adaptability to the evaluated condition. The specific selection can then be made and

equipment requisitioned. Frequently, multiple techniques may be required to satisfactorily accomplish the degree of protection desired. This approach provides a reasonable system at reasonable cost and is one which has maximum effective benefit to the operators and employers.

References:

- (1) The Principals and Techniques of Mechanical Guarding, U. S. Department of Labor, Occupational Safety and Health Administration, Revised Addition, OSHA 2057, U. S. Government Printing Office, 1972, p. 1-12.
- (2) Accident Preventional Manual for Industrial Operations, Seventh Addition, National Safety Council, Chicago, Illinois, 1974, Chapter 29.
- (3) Guards Illustrated, Third Addition, National Safety Council, Chicago, Illinois, Whole Book, 105 p.

CHAPTER IV

MACHINES IN USE AND THE HISTORY OF INJURY

The history of injury associated with metal working equipment is significant. The following tables provide an indication of the magnitude of the situation. Table 2 (1) shows the number and age of active machines in the United States in 1973.

TABLE 2 (1)

<u>Machine</u>	<u>Under 10 yrs</u>	<u>10-20 yrs</u>	<u>Over 20 yrs</u>	<u>Total</u>
Mechanical Power Press	72,031	117,396	101,552	290,979
Press Brake	17,612	20,638	9,298	47,548
Hydraulic Presses	31,656	29,987	15,156	76,799
Power Punch & Shears	28,996	34,279	25,753	89,028
Forging Mach	6,547	9,337	11,863	27,747
Rolls & Calenders	4,214	5,099	2,942	12,255
Bending & Forming Mach	15,500	21,376	13,887	50,763
Lathes	149,933	192,391	151,123	493,447
Drilling Mach	133,512	176,571	145,632	455,715
Milling Mach	108,992	107,063	72,104	288,159
Boring Mach	16,465	20,453	17,248	54,166
Cut Off & Sawing Mach	75,636	79,073	40,608	195,317

According to the United States Department of Labor, in 1971 the working force engaged directly with employment on machinery of this type was:

TABLE 3 (2)

<u>Machine</u>	<u>No. Employees</u>
Mechanical Power Press	160,630
Press Brakes	23,590
Hydraulic Presses	23,040
Power Punching & Shearing Machines	26,360
Forging Machines	10,700
Forming Rolls & Calenders	6,300
Bending & Forming Machines	15,240
Lathes	144,490
Drilling Machines	105,340
Milling Machines	59,102
Boring Machines	13,020
Cut Off & Sawing Machines	14,230

Employing data developed by the States of California, New York, Ohio, Pennsylvania and Wisconsin, the average accident frequency rates for metalworking machinery over a period of years encompassing 1968 thru 1972 has been determined. This reveals the following:

TABLE 4 (3)

	<u>Cal.</u> <u>Rate</u>	<u>N.Y.</u> <u>Rate</u>	<u>Ohio</u> <u>Rate</u>	<u>Penn</u> <u>Rate</u>	<u>Wis.</u> <u>Rate</u>	<u>Total</u>	<u>Average</u> <u>Rate</u>
Mechanical Power Press	.301	.292	.444	.455	.113	1.605	.321
Press Brake	.061	--	.021	--	.020	.102	.034
Hydraulic Presses	.301	.292	.444	.455	.011	1.503	.301
Power Punch & Shears	.064	.052	.040	.042	.056	.254	.051
Forging Mach	.010	.010	.017	.007	.002	.046	.009
Forming Rolls & Calenders	.039	.017	.018	.005	.017	.096	.019
Bending & Forming Mach	.035	--	.021	.043	.006	.105	.026
Lathes	.162	.055	.069	.084	.046	.416	.083
Drilling Mach	.119	.076	.107	.057	.020	.379	.076
Milling Mach	.070	.049	.034	.021	.030	.204	.041
Boring Mach	.119	.076	.107	.057	.021	.380	.076
Cut Off & Sawing Mach	.094	.050	.037	--	.031	.212	.053

These frequency rates are in forms of lost time injuries per million man hours worked.

Further, the states of New York, Ohio and Wisconsin report for the same time period average accident severity

rates of the following for this class of equipment.

TABLE 5 (4) (5)

	<u>N.Y. Rate</u>	<u>Ohio Rate</u>	<u>Wis. Rate</u>	<u>Total</u>	<u>Average Rate</u>
Mechanical Power Press	.047	.041	.076	.210	.070
Press Brakes	--	.027	.081	.108	.054
Hydraulic Presses	.047	.041	.049	.137	.046
Power Punch & Shears	.032	.025	.040	.097	.032
Forging Machines	.038	.044	.025	.107	.036
Forming Rolls & Calenders	.064	.012	.024	.100	.033
Bending & Forming	--	.049	.052	.101	.051
Lathes	.035	.013	.043	.091	.030
Drilling Machines	.034	.014	.036	.084	.028
Milling Machines	.051	.014	.035	.100	.033
Boring Machines	.034	.014	.048	.096	.032
Cut Off & Sawing	.029	.026	.081	.136	.045

This data clearly demonstrates that this class of machinery accounts for a great amount of accidental injury and injuries of a severe nature. Studies by the National Safety Council, in fact, reveal that approximately 10 per-

cent of all occupational accidents occur in metal working equipment. Thusly, the need for and use of, guarding to mitigate and minimize these occurrences is justifiable and warranted.

References:

- (1) The Eleventh American Machinist Inventory of Metal-working Equipment, 1973. American Machinist, McGraw Hill, Inc., New York, New York, 1973, p. 143-166.
- (2) U. S. Department of Labor, Bureau of Labor Statistics, U. S. Department of Health, Education and Welfare, U. S. Government Printing Office, Publication No. 75-173, 1975, p. 167.
- (3) U. S. Department of Health, Education and Welfare, U. S. Government Printing Office, Publication No. 75-173, 1975, p. 150.
- (4) Method of Recording and Measuring Work Injury Experience, ANSI Z 16.1 - 1967, American National Standards Institute, New York, New York.
- (5) U. S. Department of Health, Education and Welfare, U. S. Government Printing Office, Publication No. 75-173, 1975, p. 152.

CHAPTER V

CODES AND STANDARDS

With the large number of metalworking machines in active service, the great number of individuals employed on such equipment, and the rate of injuries involving the equipment examined, the codes and standards developed to regulate the design, construction and use of the machinery should be examined.

Presently, only the Occupational Safety and Health Administration (OSHA) has promulgated national codes or regulations relating to this type of equipment. Some states, however, have established individual codes relating to specific representative machines of this class.

The American National Standards Institute, which acts as the only recognized source of standards on machine tools, serves to formulate, coordinate and administrate the voluntary standardization system of the country. It provides all segments of the nation with consensus standards relating to all aspects of equipment utilization, i.e. design, construction, care, use and safety aspects.

The institute is comprised of over 1,000 members in-

cluding industry, technical, professional, labor, consumer, and service organizations as well as individual companies and governmental agencies. Standards relating to machine tools fall primarily under the responsibility of the B.11 Committee. This committee oversees numerous subcommittees which are charged with the development and administration of the individual standards applicable to a specific machine type.

The consensus standards produced, as the name implies, represents a compromise agreement between the various groups comprising the subcommittees developing the standard. Consequently, and as set forth in the explanations accompanying the publication, the standards set forth minimal requirements. Adherence to the provisions of the standards should assure that the machine under consideration will be reasonable safe and nonhazardous to use and operate. However, the consensus standards are not intended to represent the ideal or ultimate answer to the problem and improvement and innovations going beyond the standard provisions are neither prohibited nor discouraged.

As of the present date, ANSI standards have been

prepared or are currently being prepared for many metal-working machines herein under consideration. These applicable standards are set forth in Table 6.

TABLE 6

	<u>Published ANSI Standard</u>	<u>Standard In Preparation</u>
Mechanical Power Press	B 11.1 (1)	
Press Brakes	B 11.3 (2)	
Hydraulic Presses		B 11.2
Power Punch & Shears	B 11.4 (3)	
Forging Machines	B 24.1 (4)	
Forming Rolls & Calenders	B 28.1 (5)*	B 11.12
Bending & Forming Mach.	B 11.7 (6)	B 11.12
Lathes		B 11.6, B 11.13
Drilling Machines	B 11.8 (7)	
Milling Machines	B 11.8 (7)	
Boring Machines	B 11.8 (7)	
Cut Off & Sawing	B 7.1 (8) B 11.10 (9)	

*Pertains to equipment used in rubber and plastics industry.

A set of national codes or regulations was established as a result of the enactment of the Williams-Steiger Act of

1970. This Act established the Occupational Safety and Health Administration which promulgated the actual requirements. These requirements or national codes are contained in Subpart O of Section 1910 of the Federal Register.

Review of this subpart reveals that only Mills and Calenders in the Rubber and Plastics Industry, Mechanical Power Presses, Forging Machines, and Mechanical Power Transmission Apparatus are specifically included. Careful study of the portions so included indicates that the regulations are based entirely on the existing ANSI Standards in the same areas. Subpart O does, in Section 1910.212, contain a general discussion of machine guarding for all machinery in which additional metalworking devices are mentioned. Specific requirements and instructions are however omitted.

Various states over the years have developed their own individual codes relating to metalworking equipment. In New Jersey, for example, portions of the Administrative Code were written and aimed specifically toward selected equipment, namely: power presses and mechanical trans-

mission apparatus. With the advent of OSHA the vast majority of these state codes have passed out of existence, primarily due to budgetary and jurisdiction considerations, and can no longer be considered viable.

Consequently and practically, the only standards or codes governing metalworking equipment are those developed under the auspices of ANSI. Therefore, an investigation of these publications will reveal and set forth the current state of regulation.

As a general consideration, the ANSI standards employ a two column per page format, where the left column contains the requirements per se, and the right column contains a series of explanatory or qualifying remarks. The standards contain a Scope Section, a Definition Section and a Requirement Section. The Requirement Sections cover Design and Construction, Care and Use, and Safeguarding.

These standards set forth the basic requirements associated with the particular machine or machines under consideration. The standards further delineate the responsibilities for accomplishing the requirements set forth therein, assigning the various duties to manufacturers or

builders, owners or employers, tooling suppliers, and employees.

In regard to safeguarding, the standards tend to establish philosophies and, with few exceptions, avoid specific requirements and/or performance criteria. The standard may outline the necessity or need for a safeguard but does not provide the information or resources to accomplish that end. Consequently, other reference sources may be required in order to accomplish the intent of the standard's provisions.

References:

- (1) Safety Requirements for the Construction, Care and Use of Mechanical Power Presses, ANSI B11.1 - 1971, American National Standards Institute, New York, New York, 1971, p. 46.
- (2) Safety Requirements for the Construction, Care and Use of Power Press Brakes, ANSI B11.3 - 1973, American National Standards Institute, New York, N.Y., 1973, p. 52.
- (3) Safety Requirements for the Construction, Care and Use of Shears, ANSI B11.4 - 1973, American National Standards Institute, New York, N.Y., 1973, p. 44.
- (4) Safety Requirements for Forging, ANSI B24.1 - 1971, American National Standards Institute, New York, N.Y., 1971, p. 26.
- (5) Safety Specification for Mills & Calenders in the Rubber and Plastics Industry. ANSI B28.1 - 1967, American National Standards Institute, New York, N.Y., 1967, p. 31.

- (6) Safety Requirements for the Construction, Care and Use of Cold Headers and Formers, ANSI B11.7 - 1974, American National Standards Institute, New York, N.Y., 1974, p. 28.
- (7) Safety Requirements for the Construction, Care and Use of Drilling, Milling, Boring and Related Type Machines, ANSI B11.8 - 1974, American National Standards Institute, New York, N.Y., 1974, p. 28.
- (8) Safety Code for the Use, Care and Protection of Abrasive Wheels, ANSI B7.1 - 1970, American National Standards Institute, New York, N.Y., 1970 and 1973, p. 140.
- (9) Safety Requirements for Construction, Care and Use of Metal Sawing Machines, ANSI B11.10 - 1974, American National Standards Institute, New York, N.Y.

CHAPTER VI

AID AND ASSISTANCE IN GUARDING

Because the ANSI standards generally omit specific means and methods of accomplishing guarding of metalworking machinery, a need arises for information on how to perform these functions. There is a wealth of material available, although it may seem to be widely dispersed through various segments of the industry. However, with a minimum of effort, the requisite amount of data required may be obtained. The principal sources include: service organizations, insurance associations, professional societies, trade associations, governmental agencies, safety equipment suppliers and trade publications.

Purely as reference, the following groups may be contacted for assistance in accomplishing guarding instructions. These groups may offer direct assistance or may provide publications and materials useful in accomplishing a specific goal.

1. National Safety Council
425 North Michigan Avenue
Chicago, Illinois 60611

The National Safety Council is concerned

with safety of all equipment. They offer direct assistance or indirect assistance through publications such as, The Accident Prevention Manual for Industrial Operations, The Forging Safety Manual, Guards Illustrated, Handbook of Accident Prevention and The Power Press Safety Manual. A catalogue of publications is available which outlines all publications of the Council.

2. American Society of Mechanical Engineers
New York, New York

The ASME has an active Safety Section and is instrumental in development of codes and standards. They may be used as a source to acquire consulting service.

3. American Mutual Insurance Alliance
20 North Wacker Drive
Chicago, Illinois 60606

This group is an insurance company alliance which maintains a department concerned with accident prevention. They produce numerous useful publications dealing with general safety and machine guarding.

4. American Society of Safety Engineers
850 Busse Highway
Park Ridge, Illinois 60068

This is a professional society of safety engineers which produces various publications and programs. They may be used as a source to acquire consulting service.

5. Industrial Safety Equipment Association, Inc.
2425 Wilson Boulevard
Arlington, Virginia 22201

This is an association of suppliers of safety equipment. The association can direct a questioner to companies capable of supplying their needs.

6. National Association of Manufacturers
1776 F Street N.W.
Washington, DC 20006

The association of manufacturers can direct a questioner to potential consultants or it may supply the questioner with a proposed solution to a specific problem.

7. U. S. Government Agencies

Government agencies and cabinet departments concerned with this area include the Occupational

Safety and Health Administration (OSHA), U. S. Department of Labor, Department of Labor Building, 14th Street and Constitution Avenue, N.W., Washington, DC 20210, National Institute for Occupational Safety and Health (NIOSH), U. S. Department of Health, Education and Welfare, Parklawn Building, 5600 Fishers Lane, Rockville, Maryland and the Bureau of Labor Statistics, U. S. Department of Labor, 441 G Street, N.W., Washington, DC 20212. They publish numerous informational data as well as safety requirements pertinent to specific machines and industrial processes.

8. Various Trade Publications

Publications specific to the industry often contain useful articles as well as advertisements by companies offering specialized products in the field.

The following magazines and publications may provide useful and specific information:

- (1) Journal of the Fabricator
Fabricating Manufacturer's Association, Inc.
7811 North Alpine Road
Rockford, Illinois 61111

- (2) Safety
Greater New York Safety Council
302 Fifth Avenue
New York, N.Y. 10017

- (3) Journal of the American Society of
Safety Engineers
American Society of Safety Engineers
850 Busse Highway
Park Ridge, Illinois 60068

- (4) Factory
McGraw Hill, Inc.
New York, New York 10017

- (5) American Machinist
McGraw Hill, Inc.
New York, N.Y. 10017

CHAPTER VII

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

All too frequently, as the data shown in Chapter 4 illustrates, injuries occur during the use of metalworking machines. The data in Chapter 4 shows that there are vast numbers of machines in use involving the employment of large numbers of people.

The machines considered have been briefly described and the hazards associated with their use listed. The general principles and techniques of guarding have been outlined and set forth. The codes and standards applicable to the devices have been discussed. Additional sources of assistance in the solving of specific problems have been enumerated. With these areas examined, certain conclusions and, consequently certain general recommendations, will be developed.

It is recognized that the point of operation of these machines represents the greatest hazard and the most frequent source of injury to the worker. It is natural to suggest that some form of guarding must be provided in these areas. The general principle underlying all safety work, i.e. the principle of problem recognition, evalu-

ation and control, most clearly points toward this conclusion. What would appear to be the problem in accomplishing this result is the question of "how to" effect guarding and "who" is to provide it.

Of these two questions the "how to" aspect is somewhat simpler to resolve. While information is available to any and all interested parties on the available means of accomplishing this end, the major stumbling block is that the necessary information is located in diverse areas and there exists no central access method available to those seeking such input. A central clearinghouse or source to disseminate this type of information and to assist in the resolution of specific problems is clearly called for.

The question of "who" is to provide the necessary guarding is somewhat more complex. Unquestionably this responsibility must be either with the manufacturer of the equipment or with the employer using the machine. On the surface it would appear that a manufacturer is in a better economic and perhaps technical condition to provide it, but the owner/user of the equipment is in a more practical position to specify the type and specific guard needed.

There appears to be no clearly defined answer to this question. The current codes and standards tend to direct this responsibility to the machine's owner/user. However, recent litigation based on the tort doctrines of strict liability, negligence, and breach of warranty would indicate that this approach is unsatisfactory to the courts.

In the State of New Jersey there are two landmark cases that amplify this trend of the judiciary. These cases are Bexiga vs. Havir Manufacturing Company (60 N.J. 402) and Finnegan vs. Havir Manufacturing Company (60 N.J. 413).

In the Bexiga case, suit was brought against the manufacturer of a mechanical power press (Havir) for injuries sustained during use of the machine in a manufacturing operation. As the press was originally supplied and as was the custom of the industry, it did not contain any operator "safety" devices. The Havir Company maintained that the provision for any such devices was the responsibility and decision of the press user. The plaintiff, Bexiga, argued that the manufacturer could have supplied a two hand actuation device which would have prevented his accident from occurring.

In deciding the case, the New Jersey Supreme Court acknowledged that it was the custom and practice of the industry that such protective devices are to be supplied by the employer. However, the Court went a step further and decided that it would be reasonably foreseeable by the manufacturer that the employer would not install such a device and therefore the manufacturer should have recognized this and provided same as part of the original equipment.

A similar direction was taken by the Court in the Finnegan case. In this matter Finnegan brought suit against Havir for injuries sustained during use of the machine. Finnegan maintained that, had the subject press been equipped with a two hand device for actuation as part of the original equipment, he would not have been injured. As in the Bexiga case, Havir argued that the custom and practice of the industry dictated that any such devices be provided by the employer.

Here again, the Court decided that it would be reasonably foreseeable that the employer would fail to provide any such safety device. In this vain, they held that the manufacturer had a responsibility to provide some such

device to mitigate the possible occurrence of an operator injury. The Court went somewhat further in this decision, as opposed to the Bexiga decision, in that they decided that such a device should be provided by a machine builder provided such a device would not bar any normal operation of the equipment and would not be impractical for the manufacturer to supply.

These two cases form the backbone of current judicial thought on the question. In effect, they impose a duty on the manufacturer of equipment to "foresee" its normal use and application. Further, they establish a concept that in such foreseeability, if a manufacturer can provide a safety device which can avert operator injury, not interfere with the normal operation of the equipment, and not be impractical to provide during original manufacture, then the machine builder is under a legal obligation to provide the device to accomplish this end.

These judicial concepts create a potentially new problem area, namely, how to provide adequate and acceptable safety devices for "new" machines and "old" machines.

The metalworking machines enjoy a rather long and

productive useful life. A given machine may be owned by many individuals and pass through many hands before it reaches the retirement stage. As a machine progresses through various owners, the original builder may lose all track of its whereabouts and condition. These "used" or "old" machines therefore present a specialized and peculiar problem.

Some form of compromise and a clearly defined and workable solution must be developed. Because of the nature of metalworking equipment, a solution could be developed based upon the classification of a machine as either a general purpose device or a special purpose device. A general purpose device would be defined as a machine capable of being equipped with various types and styles of tooling and capable of performing a variety of separate and distinct operations. Such a machine would be of a type where its end use and application would be unknown to the builder when the machine leaves the factory. A special purpose machine would be defined as a machine that performs a specific function or operation. This type of machine would be one for which the end use and application would be known to the builder when the equipment leaves the factory.

Employing these definitions a principle or philosophy may be established whereby point of operation guarding for a special purpose machine would be provided by the machine builder. A corollary to this would be that point of operation guarding on general purpose machines would be provided by the employer. This approach relies on the fundamental and logical assumption that the party having the knowledge of the end use and ultimate application of a machine is in the best position to specify and provide guards to make the use of the machine a minimal hazard to the operator.

The major shortcoming of this approach is that, since the vast majority of the metalworking tools are general purpose devices, it places the major burden for specifying and providing guards on the employer. This group may be ill-equipped, either technically or financially, to accomplish these ends. In addition, this industry element may lack the necessary desire and motivation to incorporate such equipment on their production machines.

Under the proposed concept, all new machines of special purpose design and construction would be provided with point of operation safeguards provided by the manufacturers of the equipment. Likewise, new machines of

general purpose design and operation would be provided with guarding at the point of operation by the employer. Old machines, whether general purpose or special purpose, would be equipped with appropriate point of operation guards provided by the employer.

It is recognized that this concept places a heavy responsibility on the employer due to the fact that the vast majority of machines are general purpose devices and are of "old" vintage. This industry group will require both the technical and financial assistance as well as a motivation of stimulus if the concept presented is to be workable.

The first major source of such assistance could be developed through the present OSHA administration. As it is currently organized, OSHA acts as a compliance agency. This tends to have a negative effect on industry as a whole. If OSHA were restructured so that it would provide technical assistance rather than punitive action to the industry, the deficiencies in the technical implementation of the employer phase of an operator protection program could be significantly reduced. This type of restructuring would permit OSHA to serve as a central clearing house for updated

data on guarding methods, guarding information, and guarding techniques. The agency could also be called upon by those members of industry who do not need or require direct assistance but merely desire current information. Additionally, the agency could act as a development group, supplying specific answers to specific and unique problems as well as being the vanguard of new and innovative techniques in the field.

Secondly, the machine builders themselves should become more actively involved in the development of solutions for point of operation guarding. The lines of communication between employer and machine builder should be opened so that an employer can call upon the technical expertise and experience of the machine builder in the development of workable solutions to guarding problems. Ideally, the machine builder should establish a department or branch to which any employer could turn for production of a guard which he would specify and would be suitable for the specific operation involved.

The financial implications involved in implementation of the concept set forth could be ameliorated through a variety of mechanisms. Federal financing for implementation

could be instituted along the lines governing activities of the Small Business Administration. Modification of the tax laws to permit investment credits, accelerated write-offs, or direct tax liability reduction could be created to provide a painless form of incentive. The institution of these means is justifiable as an extension of Public Policy with the anticipated reduction of machine operator injury being the clear and obvious benefit.

Developing motivation on the part of both the machine builders and employers, as well as creating an environment for compliance, could be assured by a two pronged approach. This approach would involve adopting a modified plan of enforcement of the variety currently being pursued by OSHA and by a modification of existing statutory law.

OSHA could continue to perform its inspection function as it currently does. If a machine were to be found deficient in point of operation guarding a citation would be issued. On a new machine, if deficiently guarded and of special purpose nature, the machine builder would be subject to immediate fine. On new general purpose machines and "old" machines the employer would be given an opportunity to rectify the condition within a reasonable time commensu-

rate with the operation under consideration without monetary penalty. Failure to so comply within the time allotted would result in the removal of the machine from service.

The existing tort law as exemplified in the Bexiga and Finnegan cases provide suitable and ample motivation to a machine builder to conform to the proposal. In the case of the employer, a modification of the Workman's Compensation statutes could be instituted to develop the desired degree of motivation.

The Workman's Compensation statutes in most states were developed to provide compensation (monetary) to individuals injured or made ill as a direct result of their employment. These statutes provide an employee the right to compensation irrespective of the cause of injury. This right effectively eliminates "assumption of risk" or "contributory negligence" as grounds for denial of compensation by an employer to an injured worker. The amount of compensation for a given injury or illness is derived from a prepared schedule and remains constant for the duration of the disability arising from the injury. Consequently, disparities can and do exist for the varied disabilities sustained; inequities arising from the physical age of the injured party

are common. This portion of the compensation system, although not dealt with specifically, is in need of updating and reorganization.

In the terms of the topic under consideration, the Workman's Compensation statutes possess a singularly significant feature. As the employee accepts the right of compensation for a work related injury he surrenders the right of civil action against his employer to collect damages. The law acts as a statutory bar against a worker pursuing civil redress against his employer. Consequently, as inequities occur in the system resulting from the failure to provide an adequate degree of compensation, the injured party is forced to pursue third party action as a means of recovery. These same statutes, in turn, prevent the company named in a third party action from seeking any relief from the original employer. Thus, the Workman's Compensation Laws effectively provide the employer with a statutory guarantee against liability.

The statutes ought to be modified to permit third parties to enjoin employers in liability action and modified to permit employees to institute action directly against employers on grounds of negligence. With the legal

avenue of statutory immunity (previously barred) made open, a great degree of concern and motivation on the part of an employer could be generated.

It is felt that an approach of the nature herein described or one similar would be instrumental in assuring that metalworking machinery would be properly and adequately guarded. Further, such an approach would yield a maximum benefit without placing undue hardship on any single segment of the economy.

It has been shown that a problem relating to metalworking machinery does exist. However, the technology and materials are available to minimize these problems and to assure a reasonable degree of safety to the individuals who earn their livelihood operating this equipment. No real major innovations or discoveries need to be made, rather existing knowledge and techniques must be disseminated and hardware incorporated on machinery. Adequate financial incentive and motivational stimulus must be provided. Both the machine builder and the employer must share in these efforts. If this is accomplished, the use and operation of metalworking equipment need not be considered hazardous, and both the industry and society will benefit.

APPENDIX

DEFINITIONS

1. Actuating Device - The specific equipment which is utilized in order to cause the machine to operate and perform its intended function.
2. ANSI - American National Standards Institute
3. Frequency Rate - The number of disabling injuries (lost time injuries) per million man hours worked.
4. Guard - A method, technique or device utilized to prevent or prohibit an operator from contact with a hazard area.
5. Hazard - Any physical action, motion or condition which creates a source of danger or potential injury to an operator. These hazards include:
 - a) Bending - A hazard created by mechanical action arising from material being subjected to permanent deformation.
 - b) Chemical - A hazard where gases, vapors, particles or liquids may be created which may be injurious to an operator.
 - c) Cutting - An action created by motion or machine elements, materials or tools which may lacerate the operator.
 - d) Falling or Broken Components - A hazard whereby machine parts may become detached and strike the operator.
 - e) Inrunning Nips - A hazard created by the opposite rotation of two rotating machine parts in close proximity.

- f) Power Transmission - A hazard created by portions of a machine where power is transferred from one point to another.
- g) Pinching or Shearing - A hazard created by motion of a ram or punch where relative motion between machine elements occurs.
- h) Reciprocating or Transverse - A hazard created by back and forth or lineal motion of machine elements.
- i) Rotational - A hazard created by motion occurring around a central axis.
- j) Slipping & Falling - A hazard created where objects or liquids may create coefficient of friction differences or elevation differences of which the operator may be unsuspecting.
- k) Shattering - A hazard where a machine component may fragment and fly away at high speed.
- l) Thermal - A hazard where material may become elevated to a temperature significantly above ambient.

- 6. NOISH - National Institute of Occupational Safety and Health.
- 7. Operator - An individual engaged in and responsible for the use and operation of a metalworking machine.
- 8. OSHA - Occupational Safety and Health Administration.
- 9. Point of Operation - The section or area of the machine at which the actual work on the input material is performed.
- 10. Severity Rate - The number of days lost or charged to disabling injuries per million

man hours.

- 11. Tool
 - The component of a metalworking machine which actually performs the cutting or forming operation desired.
- 12. Workpiece
 - The material which is placed into the machine upon which the machine's operation is performed.